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Contrast and phonological computation in prime learning: Raising vowel harmonies analyzed with emergent primes in Radical Substance Free Phonology

Paolo Danesi

► **To cite this version:**

Paolo Danesi. Contrast and phonological computation in prime learning: Raising vowel harmonies analyzed with emergent primes in Radical Substance Free Phonology. Linguistics. Université Côte d'Azur, 2022. English. NNT : 2022COAZ2040 . tel-04047121

HAL Id: tel-04047121

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THÈSE DE DOCTORAT

Le contraste et la computation phonologique dans l'apprentissage des primitives phonologiques

Une analyse des harmonies vocaliques de rehaussement basée sur
des primitives émergentes en Radical Substance Free Phonology

par

Paolo DANESI

UMR 7320 : Bases, Corpus, Langage—Nice

Présentée en vue de l'obtention

du grade de docteur en Sciences du Langage
d'Université Côte d'Azur

Dirigée par :

Tobias Scheer, DR CNRS

Diana Passino, Professeure, Université Côte
d'Azur

Soutenue le : 13 décembre 2022

Devant le jury, composé de :

Diana Passino, Professeure, Université Côte d'Azur

Tobias Scheer, DR CNRS

Bert Vaux, Professeur, University of Cambridge

Laura Bafile, Professeure associée, Università di Ferrara

B. Elan Dresher, Professeur émérite, University of Toronto

Charles Reiss, Professeur, Concordia University

Contrast and phonological computation in prime learning: Raising vowel harmonies analyzed with emergent primes in Radical Substance Free Phonology

Ph.D. committee

Laura Bafile, Professeure associée, Università di Ferrara	member
B. Elan Dresher, Professeur émérite, University of Toronto	pré-rapporteur
Charles Reiss, Professeur, Concordia University	président du jury
Bert Vaux, Professeur, University of Cambridge	pré-rapporteur
Diana Passino, Professeure, Université Côte d'Azur	co-director
Tobias Scheer, DR CNRS	co-director

Contrast and phonological computation in prime learning:
Raising vowel harmonies analyzed with emergent primes in Radical Substance
Free Phonology
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October, 2022

Abstract

This thesis focuses on Raising Vowel Harmony (RVH) and its formalization in phonological theory. In a cross-linguistic survey of RVH, the specific properties of raising harmonies are identified, some of which seem to resist formal analyses across frameworks. It is argued that only a theory that uses emergent substance free primes with arbitrary phonetic correlates can account for them. The workings of phonological analysis with substance-free primes (α , β , γ , .) is studied based on raising harmony patterns, and different theories of prime emergence/learning are evaluated. Questions discussed include: what is the role of contrast and phonological processing in prime-emergence? Is there a hierarchy between the two factors? Are emergent primes required to be contrastive? Does the task of learning primes require the SDA (Dresher 2009) or is evidence from phonological alternations enough?

RVH is a harmonic process that affects the height of vowels. In the presence of high vowels, the mid (and sometimes low) vowels of a word raise. Raising harmonies display a peculiar property which is absent, from other harmonic patterns (based on frontness, labiality or ATRness): raising may be scalar or complete. Scalar harmonies raise vowels by a degree of height (mid-low becomes mid-high, mid-high becomes high), while complete harmonies turn any vowel into a high vowel regardless of its lexical height (mid-low raises to high, mid-high raises to high).

Raising harmonies may also be asymmetric: this is when not all expected triggers actually trigger the harmony, and / or not all expected targets are affected. For instance, a high vowel may not initiate the process though being high, or a mid vowel may not raise although all other mid vowels do. In a specific case of asymmetry called parasitism, some targets undergo harmony only if they share some property with the trigger. Thus in the case of Camuno discussed in more detail below, unrounded vowels only raise if the high vowel that acts as a trigger is also unrounded. The cross-linguistic properties of RVH are explored through a typological survey carried out in chapter II, which describes most of the patterns found in Bantu and Romance languages, where RVH is most common, but also in languages of other families. Chapter III focuses on the dialectal varieties spoken in Eastern Lombardy (northern Italy): original fieldwork on Eastern Lombard varieties shows that three quite similar dialects display slightly different harmonic patterns. In Bresciano, harmony applies symmetrically (all mid vowels are affected by raising); in Bergamasco harmony is asymmetric, targeting only rounded mid vowels. The third case is Camuno, where the harmonic process is parasitic: rounded vowels undergo raising whenever they are followed by high vowels, while unrounded vowels do so only if the triggering high vowel is also unrounded.

The goal of the thesis is to identify a phonological theory that is able to account for the main aspects of RVH identified by the typological survey and the dialectological analysis of Eastern Lombard varieties:

- raising is scalar or complete.
- raising exhibits asymmetries, including parasitism.
- raising often appears to be morphologically conditioned (e.g. is only found in verbs, or only in nominal paradigms).

Chapter IV proposes a survey of theories that have been used to analyze RVH. It is shown that theories which are able to formalize asymmetries typically encounter problems with scalar raising patterns, while theories that address the scalar/complete nature of raising are unable to handle asymmetric harmonies.

Chapter V argues that asymmetries and especially parasitic patterns are a specific form of crazy rules (Bach & Harms 1972): the phonetically uniform class of mid vowels splits into a subset that undergoes raising and another that does not. Like in other crazy rules (Chabot 2021), this requires the existence of

phonologically active classes (Mielke 2008), rather than of phonetically natural classes: natural classes are defined by a shared phonetic property; active classes only follow from phonological processing.

It is argued that raising harmonies can only be described when phonological patterning alone defines which segments share a given prime.

Given this background, it appears that the origin of the difficulties encountered by existing analyses of RVH is the shared assumption that melodic primes as well as their phonetic correlates are universal and innate. Most theories follow SPE and ensuing approaches in that they assume the existence of a fixed set of primes that is universal and innate, where the phonetic correlate of every prime is given at birth and is the same in all languages (e.g. the feature [+round] correlates with lip protrusion etc...).

The alternative is a theory based on emergent primes, which argues that both primes and their phonetic correlates are learned. In this view, there is no set of primes at the initial state: children are born with the knowledge that there are melodic primes and that they will need to construct them based on environmental information. This means that primes are language-specific and have an arbitrary correlation with phonetics, which exclusively depends on contrast and phonological behavior of segments in phonological processing (Mielke 2008, Drescher 2014). Chapter V introduces Radical Substance Free Phonology (RadSFP), a theoretical approach in development, which assumes emergent primes and thus differs from Substance Free Phonology (Hale & Reiss 2008) where primes and their phonetic correlates are universal and innate.

The final chapter VI compares different models of prime emergence. Building on Drescher (2014), Sandstedt (2018) subscribes to the Contrastivist Hypothesis, while Odden (2022) does not. The Contrastivist Hypothesis states that only primes which have a contrastive role can be active in phonological processing. Both proposals consider contrast and phonological processing as factors in prime emergence. They differ, though, in that for Drescher (2014) and Sandstedt (2018) contrast and processing are equally important, while for Odden (2022) processing enjoys a logical precedence over contrast.

Before prime-emergence approaches can be compared, it is shown that in a substance-free environment where substance-free primes such as $|\alpha|$, $|\beta|$ and $|\gamma|$ are used, different theories of computation may produce radically different prime specifications. In other words, for a given set of phonemes and a given set of phonological processes, depending on whether i) addition ($\alpha \rightarrow (\alpha+\beta) / X$), ii) subtraction ($\alpha\beta \rightarrow (\alpha\beta-\beta) / X$), and iii) substitution ($\alpha \rightarrow \beta / X$) are all permitted or only a subset of them are, prime specifications will vary widely.

Authors discuss the representational side of prime emergence, but barely dwell on how computation works. This thesis argues for an approach to phonological computation where only i) and ii) are allowed. This corresponds to the state of computation in a classical autosegmental environment where primes may be either linked (addition) or delinked (subtraction).

On the representational side, this thesis endorses unary primes. It remains to be seen whether binary primes produce significantly different results.

Given these settings, it is shown that while Sandstedt's model fails to account for scalar raising patterns, Odden's approach can build the required sets of phonological representations for both asymmetric/parasitic and scalar/complete raising harmonies. It can also account for morphologically conditioned processes based on the fact that emergent primes entail phonetic arbitrariness, i.e. an interface between phonetics and phonology where mappings are arbitrary (as at the interface between phonology and morpho-syntax). Another property of Odden's approach to prime learning is that it is formally simpler than the other proposals: processing alone guides the learner to all or almost all prime specifications without recurring to the SDA, the Contrastivist Hypothesis or other additional assumptions.

In sum, this thesis makes the following contributions:

1) It offers a typological survey of Raising Vowel Harmonies and a dialectological analysis (based on original fieldwork) of the dialects spoken in Eastern Lombardy.

2) It argues that a theory of phonology where the set of primes and their phonetic correlates are universal and innate is unfit to account for raising harmonies. A phonology where primes are learned alongside their correlation with phonetics is a valid alternative.

3) It shows how phonological analyses may be done in an environment where primes are substance-free and emergent. This is not a trivial issue: previous work in Substance-Free Phonology was based on universal and innate primes, which has led to the use of familiar substance-laden primes that exhibit the label of their phonetic correlate (e.g. [+round] for a prime whose phonetic correlate is labiality). The consequences of using actual substance-free primes in phonological analysis are made explicit and further discussed.

4) Finally, the quite recent perspective of Radical Substance Free Phonology raises new questions that could not be addressed before, among which the workings of prime learning. A comparison of existing approaches based on RVH patterns concludes that, following Odden (2022), processing plays a major role in prime emergence, while contrast is rather ancillary.

Résumé

Cette thèse enquête sur les harmonies vocalique fermantes (Raising Vowel Harmony-RVH) et leur formalisation dans la théorie phonologique. Dans un survol typologique de la RVH, les propriétés spécifiques des harmonies fermantes sont identifiées, dont certaines semblent résister aux analyses formelles dans les cadres traditionnels. Je soutiens que seule une théorie qui utilise des primitives émergentes et sans substance avec des corrélats phonétiques arbitraires peut rendre compte des RVH. Le fonctionnement de l'analyse phonologique avec des primitives sans substance (α , β , γ , ...) est étudié sur la base des harmonies fermantes, puis différentes théories de l'émergence/apprentissage des primitives sont évaluées. Les questions abordées incluent : quel est le rôle du contraste et de la computation phonologique dans l'apprentissage des primitives ? Existe-t-il une hiérarchie entre les deux facteurs ? Faut-il que les primitives émergentes soient contrastives ? La tâche d'apprentissage des primitives nécessite-t-elle le SDA (Dresher 2009) ou les alternances phonologiques sont-elles suffisantes ?

RVH est un processus harmonique qui affecte la hauteur des voyelles. En présence de voyelles hautes, les voyelles moyennes (et parfois aussi les voyelles basses) d'un mot s'élèvent. Les harmonies fermantes (ou de rehaussement) présentent une propriété particulière, absente des autres harmonies (de labialité, de palatalité ou d'ATRité): le rehaussement peut être scalaire ou complet. Les harmonies scalaires ferment les voyelles d'un degré de hauteur (mi-bas devient mi-haut, mi-haut devient haut), tandis que les harmonies complètes transforment n'importe quelle voyelle en voyelle haute quelle que soit sa hauteur lexicale (mi-bas devient haut, mi-haut devient haut).

Les RVH peuvent également être asymétriques : ce cas se présente lorsque tous les déclencheurs attendus ne déclenchent pas l'harmonie, et/ou que toutes les cibles attendues ne sont pas affectées. Par exemple, une voyelle haute peut ne pas déclencher le processus bien qu'étant phonétiquement haute, ou une voyelle moyenne peut ne pas se fermer bien que toutes les autres voyelles moyennes le fassent. Dans un cas spécifique d'asymétrie, appelé parasitisme, certaines cibles ne subissent l'harmonie que si elles partagent une propriété avec le déclencheur. Ainsi, dans le cas du Camuno discuté plus en détail ci-dessous, les voyelles non-arrondies ne se ferment que si la voyelle haute qui agit comme un déclencheur est également non-arrondie. Les propriétés des RVH sont explorées à travers une enquête typologique

réalisée au chapitre II, qui décrit la plupart des harmonies de rehaussement trouvées dans les langues bantoues et romanes, où les RVH sont fréquentes, mais aussi dans d'autres familles. Le chapitre III se concentre sur les variétés dialectales parlées en Lombardie orientale (nord de l'Italie) : les données originales obtenues lors d'une enquête de terrain montrent que trois dialectes voisins présentent des harmonies légèrement différentes. Dans le dialecte de Brescia, l'harmonie s'applique symétriquement (toutes les voyelles moyennes sont affectées par le processus) ; à Bergame, l'harmonie est asymétrique, ciblant uniquement les voyelles moyennes arrondies. Le troisième cas est celui du Camuno, où le processus harmonique est parasitique : les voyelles arrondies se ferment lorsqu'elles sont suivies par des voyelles hautes, tandis que les voyelles non-arrondies ne réagissent que si la voyelle haute déclenchante est également non arrondie.

L'objectif de la thèse est d'identifier une théorie phonologique capable de rendre compte des principaux aspects des RVH identifiés par l'enquête typologique et l'analyse dialectologique des variétés de la Lombardie orientale :

- le rehaussement est scalaire ou complet.
- le rehaussement présente des asymétries, dont le parasitisme.
- le rehaussement est souvent conditionné par la morphologie (par exemple, ne s'applique que dans les verbes, ou uniquement dans les paradigmes nominaux).

Le chapitre IV propose un tour d'horizon des théories qui ont été utilisées pour analyser les harmonies vocaliques. Il est montré que les théories qui sont capables de formaliser les asymétries typiquement rencontrent des problèmes avec les harmonies scalaires, tandis que les théories qui traitent de la nature scalaire/complète du rehaussement sont incapables de gérer les harmonies asymétriques.

Le chapitre V soutient que les asymétries, et en particulier celles qui sont parasitiques, sont une forme spécifique de règles folles (Bach & Harms 1972) : la classe phonétiquement uniforme des voyelles moyennes se divise en un sous-ensemble qui subit l'harmonie et un autre qui ne réagit pas. Comme dans d'autres règles folles (Chabot 2021), cela nécessite l'existence de classes phonologiquement actives (Mielke 2008), plutôt que de classes naturelles : les classes naturelles sont définies par une propriété phonétique partagée, alors que les classes actives ne découlent que de la computation phonologique.

Au chapitre V il est montré que les RVH ne peuvent être décrites que lorsque les classes phonologiquement actives sont définies par le seul comportement des segments dans lors de la computation phonologique.

Dans ce contexte, il apparaît que l'origine des difficultés rencontrées par les analyses existantes de RVH est l'hypothèse partagée que les primitives mélodiques ainsi que leurs corrélats phonétiques sont universels et innés. La plupart des théories ainsi suivent SPE et les approches subséquentes en supposant que les primitives font partie d'un ensemble fixe qui est universel et inné, où le corrélat phonétique de chaque primitive est donné à la naissance et est le même dans toutes les langues (par exemple, le trait [+arrondi] est associé à la protrusion des lèvres).

L'alternative est une théorie basée sur les primitives émergentes, qui soutient que les primitives et leurs corrélats phonétiques sont acquis lors de l'acquisition L1. Dans cette optique, il n'y a pas d'ensemble de primitives à l'état initial de l'apprentissage : les enfants naissent avec la connaissance qu'il existe des primitives mélodiques et qu'ils doivent les construire à partir des informations environnementales à leur disposition. Cela signifie que les primitives sont spécifiques à chaque langue et ont des corrélats phonétiques arbitraires, qui dépendent exclusivement du contraste et du comportement phonologique des segments lors de la computation phonologique (Mielke 2008, Drescher 2014).

Enfin, le chapitre V présente le cadre théorique Radical Substance Free Phonology (RadSFP), une approche théorique en développement, qui accepte que les primitives soient émergentes et ainsi diffère de la Substance Free Phonology (Hale & Reiss 2008) où les primitives et leurs corrélats phonétiques sont universels et innés.

Le dernier chapitre VI compare différents modèles d'émergence des primitives. S'appuyant sur Dresher (2014), Sandstedt (2018) souscrit à l'hypothèse contrastiviste (Contrastivist Hypothesis), contrairement à Odden (2022). L'hypothèse contrastiviste prévoit que seules les primitives qui ont un rôle contrastif peuvent être actives dans la computation phonologique. Toutes les approches mentionnées considèrent que les primitives émergent sous l'influence du contraste et de la computation phonologique. Ils diffèrent cependant en ce que pour Dresher (2014) et Sandstedt (2018) le contraste et la computation sont également importants, tandis que pour Odden (2022) la computation est primaire et le contraste, secondaire.

Avant de pouvoir comparer les approches de l'apprentissage des primitives, il est montré que dans un environnement « sans substance » où des primitives sans substance comme $|\alpha|$, $|\beta|$ et $|\gamma|$ sont utilisées, différentes théories de la computation peuvent produire des spécifications phonologiques radicalement différentes. Ainsi pour un ensemble donné de phonèmes et un ensemble donné de processus phonologiques, selon que i) l'addition ($\alpha \rightarrow (\alpha+\beta) / X$), ii) la soustraction ($\alpha\beta \rightarrow (\alpha\beta-\beta) / X$), et iii) la substitution ($\alpha \rightarrow \beta / X$) sont tous autorisés ou seulement un sous-ensemble d'entre eux, les représentations phonologiques produites varieront considérablement.

La littérature discute le côté représentationnel de l'émergence des primitives, mais s'attardent peu ou pas sur le fonctionnement de la computation. Cette thèse plaide pour une approche de la computation phonologique où seuls i) et ii) sont permis. Cela correspond à l'état de la computation dans l'environnement autosegmental classique où les primitives peuvent être associées (addition) ou désassociées (soustraction).

Du côté de la représentation, cette thèse utilise des primitives monovalentes. Il reste à voir si les primitives binaires produisent des résultats sensiblement différents.

Dans l'environnement décrit, il est montré que le modèle de Sandstedt ne peut rendre compte des harmonies scalaires, alors que l'approche d'Odden peut construire les ensembles requis de représentations phonologiques pour les harmonies de rehaussement asymétriques/parasitiques et scalaires/complètes. Il peut également analyser les processus conditionnés par la morphologie, en profitant du fait que les primitives émergentes impliquent l'arbitraire phonétique, c'est-à-dire une interface entre la phonétique et la phonologie où les associations entre objets phonologiques et phonétiques sont arbitraires (à l'instar de l'interface entre la phonologie et la morpho-syntaxe). Une autre propriété de l'approche d'Odden est qu'elle est formellement simple : la computation seule guide l'enfant vers toutes ou presque toutes les spécifications phonologiques sans recourir au SDA, à l'hypothèse contrastiviste ou à d'autres mécanismes supplémentaires.

En somme, cette thèse propose les contributions suivantes :

1) Du côté empirique, elle effectue une étude typologique des harmonies de rehaussement et une analyse dialectologique (basée sur un travail de terrain original) des dialectes parlés en Lombardie orientale.

2) Elle soutient qu'une théorie de la phonologie où l'ensemble des primitives et leurs corrélats phonétiques sont universels et innés est inapte à rendre compte des harmonies de rehaussement. Une phonologie où les primitives et leurs corrélats phonétiques sont appris est une alternative viable.

3) Elle montre comment les analyses phonologiques peuvent être faites dans un environnement où les primitives sont sans substance et émergentes. Cela n'est pas une question triviale : les travaux antérieurs en Substance Free Phonology étaient basés sur des primitives universels et innés, ce qui a conduit à l'utilisation de primitives familières basées sur la substance qui présentent l'étiquette de leur corrélat phonétique (par exemple [+arrondi] pour un trait dont le corrélat phonétique est la labialité). Les conséquences de l'utilisation des primitives sans substance dans une analyse phonologique sont explicitées et discutées en détail.

4) Enfin, la perspective récente de Radical Substance Free Phonology soulève de nouvelles questions qui ne pouvaient être abordées auparavant, parmi lesquelles le mécanisme de l'apprentissage des primitives. Une comparaison des approches existantes basées sur les RVH conclut que la computation phonologique joue un rôle majeur dans l'émergence des primitives, tandis que le contraste est plutôt accessoire.

*To Anna and Luca,
who (who knows how) are acquiring phonology as we speak*

Acknowledgments

If I managed to get to the bottom of this, I owe it mainly to my directors, Diana Passino and Tobias Scheer, who guided me through every step of the way. I thank you for your extreme patience and for the care you have taken towards me. If this thesis isn't a complete mess it's largely thanks to your supervision.

I want to thank Alex Chabot, who has had a huge influence on my studies. Thank you very much for making me understand that I knew nothing about phonology: learning it again was an adventure.

Francesco, thanks for the company, for that risotto and for the laughs.

I owe a debt of gratitude to all the people who attended the Laboratoire BCL and the Campus St Jean d'Angely with me: Jonathan, Miriam, Sophie, Raphaëlle, Laura, Cecile, Camille, Ismael, Alex, Mustapha, Emma, Saveria and anyone else I may have forgotten. Even when I was grumpy and unpleasant, like a bear in a cage, you were helpful and kind. Thanks for including me in your adventures.

To the professors and students who attended the EGG summer schools with me. I had fun, drank too much and learned a ton. Is there anything better?

I must also express my gratitude to the native speakers who were kind enough to participate in my research. It has been a privilege to hear your experiences in your native tongue.

To my colleagues from the collège Jean Giono: Krystelle, Jenny, Solenne, Melissa, Charlenne, Alain, Quentin, Mme Cauvin and Mm Merle. What you taught me about work and the world of school are precious gifts that I will not forget.

To my family, a safe haven, and to my friends from Brescia and Padova, too often ignored during these years of work. I apologize for the absence and thank you for the support. Thanks in particular to Giacomo, for the cards, for the beers and for being there even at my worst.

There are no words to express the gratitude I feel towards Marta, who endured and supported me even in the darkest moments. I swear that going forward, I will try to be a better version of myself. You deserve it. Maybe I do too.

p.s.

A preventive excuse to all readers. My English is really bad. You have been warned.

Brescia, October 2022

Acronyms

AP	Autosegmental Phonology
AL	Asymmetric Licensing
AUG	Augmentative
ATR	Advanced Tongue Root
BL	Bridge Licensing
CH	Contrastivist Hypothesis
CSa	Concordia School approach
DIM	Diminutive
DP	Dependency Phonology
EL	Eastern Lombardy
ET	Element Theory
F	Feminine
GP	Government Phonology
LC	Licensing Constraints
M	Masculine
MCS	Modified Contrastive Specification
MPI	Morphosyntax-to-Phonology Interface
NEN	No Ex Nihilo
PL	Plural
PPI	Phonology-to-Phonetics Interface
PTA	Paradigmatic Transduction Algorithm
OT	Optimality Theory
RcvP	RadicalCVPhonology
RadSFP	Radical Substance Free Phonology
RTR	Retracted Tongue Root
RVH	Raising Vowel Harmony
SDA	Successive Division Algorithm
SFP	Substance Free Phonology
S	Singular
STA	Sintagmatic Transductional Algorithm
VH	Vowel Harmony
7VSA	Seven-vowel system: type A
7VSB	Seven-vowel system: type B

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Chapter I. The Ins and Outs of Vowel Harmony

1.1 Introduction

This chapter provides a description of the phenomenon known in the literature as Vowel Harmony, an assimilatory process that applies at a distance and can influence the vowels of a word. The main goal of this chapter is to define the properties and specific features of Vowel Harmony in a pre-theoretical manner, give a general typology of this family of processes and specify the phonetic properties of vowels it can affect. At the end of this chapter, I hope to have defined clearly what a vowel harmony is, why it is an interesting topic in phonological research and what challenges it poses to phonological analysis. A detailed introduction of the phenomenon of disharmony is proposed, with a focus on asymmetric patterns, which will be central in following chapters.

This general survey of vowel harmonies sets the stage for a more detailed description of raising harmonies, which will be featured in chapters II and III. No reference to theoretic matter will be given here (except for the basic theoretic introduction to feature theory provided in §1.2.3). All theory-dependent matters will be considered later, in chapters IV, V and VI.

1.2 Defining properties of Vowel Harmony

1.2.1 What is Vowel Harmony?

Vowel harmony (hereafter VH) is a phonological process that operates over a string of multiple segments, forcing the vowels of a given domain (in most cases the word) to share the same characteristic, or the same set of characteristics. Harmonies show a behavior similar to other assimilatory processes, in that a segment (the trigger) shares its phonetic properties with another (the target). The characteristic that sets VH apart from other assimilations is the fact that VH applies at a distance, whereas in most assimilations target and trigger are adjacent (Rose & Walker 2011: 240).

A general definition and description of VH and its main properties can be found (amongst many others) in Archangeli & Pulleyblank (2007), Gafos & Dye (2011), Krämer (2003), Vago (1980), van der Hust & van de Weijer (1995). Entries in linguistics encyclopedias treating VH are Anderson (1980), Reiss (2006) and van der Hulst (2016). Monographs and PhD theses regarding Vowel Harmony include van der Hulst (2018), Nevins (2010), Polgardi (1998), Cobb (1997), Mahanta (2007) and Sandstedt (2018).

A good theory-neutral definition of this phenomenon is the following (van der Hulst 2018: 8): “VH occurs when there is a requirement in a given language for vowels of a word to agree in a particular phonetic property such as lip rounding or tongue position (along the dimension of front/back, high/low and so on).”

Ohala (1994) hypothesized that VH is caused by co-articulation. Co-articulation is an extremely common phonetic phenomenon that cause a speech sound to assume some phonetic characteristics of a neighboring sound that precedes or that follows it. In VH, this happens between vowels in adjacent syllables across intervening consonants. When those effects become perceptually noticeable, speakers begin to give phonological relevance to the alternation, and start to treat the co-articulation as a mandatory feature of the language (Ohala 1994: 491).

Let us consider Tuvan backness harmony as an example. Tuvan (Harrison 1999), a Turkic language spoken in Russia (Tuvan Republic), western Mongolia and northwestern China (Xinjiang), displays a

simple harmonic pattern that involves fronting. In this language, all vowels of a word must share the same tongue position when it concerns the front/back dimension.

(1) Backness harmony in Tuvan

a. Tuvan vowel system

	Front		Back	
	non-Round	Round	non-Round	Round
High	i	y	ɨ	u
non-High	e	ø	a	o

b. Vowel distribution in Tuvan

Polysyllabic roots in Tuvan: all vowels agree for backness	ivi				'deer'
	xøømej				'throat singing'
	eeren				'totem'
	idegel				'hope'
	ajɨl				'danger'
	ulu				'dragon'
Monosyllabic roots: suffixes harmonize	Root	Plural	class 1	Abl.	
	is	ter	im	den	'footprint'
	at	tar	im	dan	'name'
	Root	Negative	Past 2.	sing	
	esker	be	di	m	'notice'
	udu	va	di	m	'sleep'

In the first section of the table in (1b) are listed some polysyllabic roots (nominatives in Tuvan do not feature an inflectional morpheme). All vowels in roots share the same value of backness. They are either part of the set of front vowels (i,e,ø,y) or back (a,o,ɨ,u): words with both front and back vowels appear to be disallowed in Tuvan. Even though this kind of regularity holds for almost all roots in the language¹ it does not prove the presence of an active harmonic process. Harmonic activity becomes evident when we consider alternations in the affixes. Examples in the second section of the table in (1b) demonstrate the activity of the process. Suffixes alternate between a front and a back form, depending on the value of backness of the root. When vowels in the root are back, all vowels in suffixes are back. When vowels in the root are front, suffixes display front vowels. That is due to the effect of VH, which forces vowels of a word to agree in a phonetic property.

To sum up, harmony makes it so that vowels in a given domain systematically agree with each other with regard to a phonetic property. The trigger of a VH is usually referred to as the dominant vowel, the targeted vowels are also known as dependents, and the property on which all vowels must harmonize is said to be the harmonic property. The domain of application of VH (henceforth, harmonic domain) is

¹ As we shall see in §4 and §5, many harmonies that may seem perfectly regular at a first glance display various cases of disharmony. In Tuvan some roots, especially in loanwords, fail to harmonize.

generally comprised of the word,² but it can also extend beyond the word and affect a bigger portion of the phrase (van der Hulst 2018: 46).

1.2.2 Difficulties in the definition of VH

Giving a definition of VH that covers all attested patterns and is accepted by the linguistic community in its entirety is not an easy task. Harmonic patterns that involve vowels are extremely varied, and some generally shared features of VH may not be common to all harmonic patterns on record. Ultan (1973) and Clements (1976) proposed two different lists of properties that broadly define VH as a phonological process. While most of them are the norm, they cannot be considered universal features of VH (Anderson 1980, Mahanta 2007).

Ultan's (1973: 39) list of defining properties of VH:

- a) The trigger is a vowel.
- b) The trigger belongs to a stem/ root.
- c) The domain of application for VH is the phonological or morphological word
- d) VH systematically affects all grammar classes
- e) There must be at least two alternating classes of vowels in any VH system which are mutually exclusive of one another.

Clements's (1976) list of defining property of VH:

- a) Vowel harmony involves the spreading of a phonetically definable feature.
- b) VH is root controlled (the trigger belongs to the stem)
- c) VH is bidirectional, and always affects vowels in both prefixes and suffixes
- d) VH applies in an unbounded manner³
- e) VH is not optional

In the course of this dissertation, we will encounter harmonic patterns that contravene some of the principles listed here. Those lists of criteria are empirically not true, since they are not consistent with data on VH: there are harmonies that are solely regressive (most raising harmonies are), and that affect only some grammatical categories (contra Ultan *b,d*; contra Clements *b,c,e*). Harmonies that display a different harmonic domain to that of the phonological word also exist (contra Ultan *c*), as well as harmonies that are bounded (cf. metaphonies and umlauts contra Clements *d*), and harmonies that display occasional or systematic disharmonic patterns (asymmetric harmonies, cf. §5)

In general, we can say that harmony is a phonological assimilation that involves only vowels and (typically) leaves consonants unaffected. Other properties of VH (unboundedness, directionality) must be considered within the single phenomenon analyzed.

² In most harmonies, the harmonic domain coincides with the word, but there are cases in which harmony does not apply to prefixes or to suffixes (cf. van der Hulst 2018: 46).

³ With the term *unbounded*, the literature on harmony refers to the property of most harmonies of affecting all vowels of a domain, without exception. If we consider the harmonic property to be only the marked value of a feature (cf. the discussion in §2.4), unboundedness follows from iterativity, cf. §4.2.4.

1.2.3 Phonological primes and the representation of vowels

In phonology, phenomena such as assimilations and VH are formalized as processes that modify the internal structure of segments. Segments are viewed as complex objects composed of smaller units, referred to here as primes. Those primes are cognitive categories, and represent the internal characteristics of phonological segments. They ensure contrast between segments (each segment must have a different prime composition from the others, cf. Dresher 2009 for an overview of the relevance of contrast in phonology)⁴, and they divide segments in sets that behave similarly when they are affected by a process, or when they trigger one (Natural Classes, Odden 2013: 49). The list and characteristics of primes varies greatly among theoretical approaches, but the core idea of segments being composed of smaller units is one of the few concepts shared by virtually all theories of phonology.

A phonological process, as conceived in generative phonology (Chomsky & Halle 1968), transforms the underlying phonological form of a string of morphemes into its surface form. Phonological processes take the underlying form as an input, operate over its primes and structural components and give as an output the surface representation. Following this definition, harmony is a process that modifies the internal structure of vowels so that they all share the same prime. If we divide the vowels of a language into two sets according to a given property, harmony requires the vowels of a word to share that same property, i.e. being part of the same Natural Class.

Primes were conceived as binary units (distinctive features, Jakobson 1939, Jakobson, Fant & Halle 1952) they come with an assigned value, + or -, that defines either the presence or the absence of a given property.

Not all features are equally relevant in a phonological representation. Segments do not need a specification for all the features to be distinguished from each other. Underlying representations must reduce to some minimum the phonological information used to distinguish lexical items. Since predictable distinctive features and feature specifications are effectively redundant information, they can be omitted from underlying representations. This is the core idea behind the concept of underspecification. Underlying representations are in some way “defective”, redundant information is filled in later, so that surface representations can be interpreted by phonetics.

Another idea brought to phonology by underspecification theories (Radical Underspecification, Steriade 1995) assumes only one value ‘+’ or ‘-’ as underlyingly specified for a binary feature, while the other value is “filled in” at a later stage. Some properties (such as labiality or nasality) play a role in phonology only when they are “positive”: [+nasal] segments behave as a natural class, while [-nasal] segments never do. The same can be said about labial vowels: [+labial] defines a natural class, [-labial] never does. For what concerns those features, they may as well be unary, and not binary.

This idea has been taken to its extreme by various approaches, which assume all primes to be unary entities. This concept formalizes the idea that one value of a feature may never be phonologically active because it does not exist. Where binary features assume a positive value (i.e. the presence of a property) and a negative value (its absence), purely unary primes consider only active properties.

⁴The concept of contrast lies at the base of modern linguistics since Saussure : *Ce qui importe dans le mot, ce n'est pas le son lui-même, mais les différences phoniques qui permettent de distinguer ce mot de tous les autres*. The sound of a word is not in itself important, but the phonetic contrasts that allow us to distinguish that sound from any other. Translation by Harris (Saussure 1916 [1986] :116).

Different approaches treat primes as solely unary: Dependency Phonology (Anderson & Ewen 1987) Government Phonology (henceforth GP; Kaye, Lowenstamm & Vergnaud 1985), which calls its primes Elements (Element Theory, Backley 2011) and Particle Phonology (Schane 1984) all developed representational accounts based solely on unary primes.

This kind of primes (I will refer to them collectively as unary primes) differ from distinctive features in that they correlate with multiple phonetic properties⁵, and they can be independently pronounced.

Traditionally, binary theories consider the correlate of the feature to be articulatory (Chomsky & Halle 1968⁶); binary articulatory-based features that distinguish vowels are: [±back], [±round], [±low], [± high], [±ATR] (Advanced Tongue Root), [±RTR] (Retracted Tongue Root)⁷. Their phonetic correlate is articulatory in kind, and refers to the position of the tongue body [back, low, high] and its root [ATR, RTR], or to the shape of the lips during pronunciation [round]. Unary prime theories generally conceive vowels as composed of three primes: |I|, |U| and |A|⁸. Since they are independently pronounceable, they correspond to [i], [u] and [a] respectively⁹.

1.2.4 Two ways of conceiving VH

The difference between distinctive features and unary primes is not relevant for this thesis. However, assumptions concerning phonological primes have consequences for the way VH can be formalized.

If we assume an approach based on binary features and we consider both values to always be relevant (i.e. if we refuse the concept of underspecification), both values of a feature are active in a process of VH. In other words, the harmonic property corresponds to both values of a feature.

Consider as an example the case of Tuvan discussed in (1). The dominant vowel is in the root, and the harmonic feature is [±back]. Dependent vowels in suffixes must assume the value for the harmonic feature of the dominant vowel. In [is-ter-im-den] the root /is/ contains the dominant vowel, which is specified as [-back], so following suffixes assume the value ‘-’ for the feature [±back]. In [at-tar-im-dan] the root /at/ contains /a/, [+back], so following suffixes assume the value ‘+’ for the harmonic feature.

If we assume a unary approach, based either on unary primes or on features in which one value of a binary feature is underspecified, only the active property is present in the lexicon, and takes part in the phonological process. The harmonic property corresponds to a unary prime or to one value of a binary feature. Tuvan harmony would thus be formalized differently. Assuming unary elements (Backley 2011), in [is-ter-im-den] the dominant vowel contains the harmonic feature |I|, and harmony applies as spreading of |I| from the dominant to the dependent vowels. In [at-tar-im-dan] the “dominant vowel” does not contain any prime referring to backness, so harmony does not apply. If we assume binary features and

⁵ For example, the unary element |U| in standard Element Theory (Backley 2011: 79ff.) relates both to backness and to roundness in vowels, while it relates to labiality and velarity in consonants.

⁶ Jakobson, Fant & Halle (1952) proposed a set of features with both articulatory and acoustic correlates. From Chomsky & Halle (1968) onwards, most theories consider features to be articulatory.

⁷ Of course, the way vowels are represented in different phonological theories varies enormously, and thus the analysis of a harmonic process as involving one feature or another may depend on the analyst’s theoretical choice. In particular the choice of considering [±ATR] and [±RTR] as two opposing values of the same feature or as two different features (cf. Steriade 1995, Li 1996) bears great consequences in the way harmony can be analyzed.

⁸ Here I am assuming the notation proposed by Backley (2011).

⁹ The correlation of holistic unary primes used in Element Theory (Backley 2011) with phonetic categories is less strict from the way distinctive features correlate with articulatory properties, especially in vowels. For example, a prime composition such as |IA| can correspond to [e] in one language and to [ɛ] in another. Cf. Backley (2011: 40, 44) and Scheer (2014: 265; 2015a), as well as §V.4.3.3.

apply underspecification, [is-ter-im-den] has a dominant vowel specified for [-back], which triggers harmony; [at-tar-im-dan] has a dominant vowel underspecified for [back], so harmony does not apply, and vowels in the word surface with the default value for [back] filled in.

This distinction, which is irrelevant for cases such as Tuvan harmony, will turn out to be central in the analysis of raising and lowering harmonies and tongue root based harmonies (cf. §3.2.3), and in the treatment of neutral vowels (cf. §4.2.2). The overwhelming majority of phonologists considers features to be binary, at least for what concerns primes that are relevant in the definition of vowels. Most approaches dealing with VH tend to use underspecification (Samuels 2009) and thus consider active (and harmonic) only one value of a binary feature. The process is often formalized as spreading of the harmonic property from a vowel that has the specification for the harmonic feature to one that is underspecified.

1.3 General typology of VH

In the opening of this chapter, VH was defined as a process that forces a vowel to agree for a given phonetic characteristic. The phonetic properties that identify vowels are:

1. Tongue position on the horizontal axis (front/back).
2. Tongue position on the vertical axis (high/low)
3. Position of the tongue root
4. Rounding of the lips during pronunciation
5. Modality (vowels can be oral or nasal)
6. Length
7. Tone

Among those properties, all of them can be involved in a harmonic process except for length. A hypothetical Harmony involving vocalic length, like a VH that forces all vowels to have the same length, never occurs in the empirical record.

Length differs from other vocalic properties because it is not melodic (i.e. represented by phonological primes, also segmental), but structural. Melodic properties are represented by primes, while length (at least since the advent of Autosegmental Phonology, henceforth AP; Goldsmith 1976) is not.

(2) AP representation

		<i>Syllabic/Prosodic tier</i>
		<i>Skeletal tier</i>
		<i>Melodic tier</i>

Length is represented associating melodic material of a segment to two skeletal slots (marked with x in 2). Lack of length harmonies suggest that VH is inherently a melodic process, and involves the internal composition of vowels. It can affect all, but only, melodic properties of vowels. Other non-melodic

properties related to vowels are not involved in harmony: while such properties may constitute a harmonic trigger or target (van der Hulst 2018: 436) they never behave as harmonic properties.

Tones represent a problematic case. They were initially thought akin to other melodic properties, but are nowadays mostly considered supra-segmental (i.e. non-melodic) units. Tones are often involved in a process known as Tonal harmony (Odden 1995, Yip 1995), in which tones spread to an adjacent position. While tones can spread from a vowel to another, no language has been found in which the tone of a dominant vowel propagates to all vowels of a given domain (van der Hulst 2018: 42, also Hyman 2002: 2). Hence, tones and tonal harmonies are generally considered unrelated to VH, and treated separately.

In addition, Nasal harmonies that refer to the feature [\pm nasal] do exist, but are in general long-distance processes that involve both consonants and vowels. It is thus not properly considerable as a VH, but instead as a Vowel-Consonant harmony (Rose & Walker 2011:245).

We can conclude that proper VH involves properties that are purely melodic (are under the skeletal tier), and not suprasegmental, prosodic, syllabic or structural.

1.3.2 Typological survey

In this section, a basic typological division of VH is proposed. The criteria for the categorization of VH is based on the harmonic property that spreads from the dominant vowel, which is the vowel that triggers harmony, to the targets of harmonization.

1.3.2.1 Backness harmony

Backness harmonies involve the position of the tongue on the horizontal axis. Harmonies of this kind are often referred to as palatal harmonies (Rose & Walker 2011: 251). The feature involved in this kind of VH is [\pm back], while in unary terms |I| represent the harmonic property¹⁰. In most cases, only the negative value of the feature is considered actively harmonic, while back vowels are generally considered to be targets of the fronting process.

Backness harmonies are a pervasive feature of Uralic and Altaic languages, mostly from the Turkic branch (Krämer 2003: 6). Virtually all languages of those families display either an active backness harmony or traces of an ancient harmonic process involving the backness of the tongue body. The most famous cases of backness VH, frequently reported in the literature as canonical examples of VH, are Turkish (Clements & Sezer 1982, Charette & Goskel 1996, Kabak 2011 amongst many others), Hungarian (Polgardi 1998, Dienes 2000, Ozburn 2019) and Finnish (Pöchtrager 2018, Kiparsky & Pajusalu 2003, Campbell 1980).

Linebaugh (2007) notes that backness harmonies rarely occur outside of the Uralic and Altaic language families. Nonetheless, backness harmony patterns are also found in: Chamorro (Polynesian language, Latta 1972), Kera (Chadic, Odden 1994), Tunica (Odden 1991), Bezhta (Caucasian) and Romanian (Polgardi 1998). Also, Germanic Umlaut¹¹(Cercignani 1980) often involves harmonization of the stressed vowel to the degree of backness of the final unstressed vowel.

¹⁰ As in §2.3, I will use the notation commonly used in Element Theory when referring to holistic primes involved in harmony

¹¹ Umlaut and metaphony, treated at length in §II.3.3, are formally the same process, an assimilation of the stressed vowel triggered by the final unstressed vowel. Umlaut is used in the literature as the collective name of non-iterative harmonic patterns active throughout the history of Germanic languages (Cercignani 1980, Lodge 1989), while metaphony is the label for stress dependent harmonies in Romance languages. While generally umlauts in Germanic cause an assimilation for

As an example of backness harmony, consider Turkish VH. The dominant vowel is in the root, and suffixes must adapt to its backness value.

(3) Turkish VH Example of Turkish backness harmony (Clements & Sezer 1982, Mahillot & Reiss 2007, Charette & Göksel 1996, Kabak 2011)¹².

a. Turkish vowel system

	<i>Front</i>		<i>Back</i>	
	<i>non-Round</i>	<i>Round</i>	<i>non-Round</i>	<i>Round</i>
<i>High</i>	i	y	ɯ	u
<i>non-High</i>	e	ø	ɑ	o

b. Backness harmony in Turkish: suffixes harmonize with vowels in roots

<i>Nom sg. (Root)</i>	<i>Nom pl.</i>	<i>Gen sg.</i>	<i>Gen pl.</i>	
ip	ip – ler	ip – in	ip - ler – in	'rope'
kuuz	kuuz – lar	kuuz - un	kuuz - lar - un	'girl'
sap	sap – lar	sap - un	sap - lar - un	'stalk'
jyz	jyz –ler	jyz – in	jyz -ler – in	'face'
son	son – lar	son - un	son - lar - un	'end'

In the table in 3) two suffixes are applied to the root. The plural suffix /-ler/-/ -lar/ and the genitive suffix /-in/-/ -un/. They come in two different forms, which are in complementary distribution depending on the value of backness of the vowel of the root. If the root has a front vowel, vowels in suffixes are also front, otherwise they are back. The process affects all suffixes attached to the root.

1.3.2.2 Labial harmony

Rounding harmonies are VH in which the harmonic feature is [±round]. As for backness harmony, the harmonic feature in labial harmony is generally considered only the positive feature value, [+rounded]. In unary terms, it is the element |U| that acts as harmonic.

Kaun (1995; 2004) and Moskal (2018) present detailed typological surveys for labial harmony in Altaic languages, where this process is extremely frequent: most examples of labial harmony reported in the literature concern Altaic languages, and almost all languages of this family display a kind of rounding harmony. Nonetheless, labial harmonies are also found in other language families, including Germanic languages (u-umlaut cf. note 11 in §3.2.1) as well as in Native American languages (e.g. Yowlumne, also known as Yawelmani, (Cole & Trigo 1988, Archangeli 1984, Kenstowicz 1994: 108, van der Hulst 2018: 234), and in Palestinian Arabic (Kenstowicz 1981), among others.

Languages displaying solely labial harmony seem to be quite rare (van der Hulst and van de Weijer 1995: 520): most Altaic languages from all three branches display rounding harmony alongside backness harmony (Turkic languages) or tongue root harmonies (Mongolic and Tungusic languages). Often, labial

backness, they may also involve raising (i-mutation, similar to some metaphonies where raising and fronting coincide, cf. §II.3.3.3.4), lowering (a-umlaut) and rounding (u-umlaut).

¹² Different authors represent the vowel system of Turkish using different IPA symbols. Here I follow the vowel system proposed in Kabak 2010.

harmony operates in narrower contexts if compared to other harmonies (Kaun 2004, Moskal 2018). Labial harmonies often need to satisfy some conditions to apply, i.e. they are often asymmetric (cf. §5).

(4) Example of labial harmony: Labial VH in Yakut (Shaka) Sezer & Wetzels (1986), also Sandstedt (2018: 78)¹³

a. Yakut vowel system

	<i>Front</i>		<i>Back</i>	
	<i>non-Round</i>	<i>Round</i>	<i>non-Round</i>	<i>Round</i>
<i>High</i>	i	y	i	u
<i>non-High</i>	e	ø	a	o

b. Labial harmony in Yakut

<i>Root (Nominative)</i>	<i>Accusative</i>	
tynnyk	tynnyk-y	'window'
kinige	kingie-ni	'book'
murum	murun-u	'nose'
børø	børø-ny	'wolf'
oyo	oyo-nu	'child'
aya	aya-ni	'father'

Some examples from Yakut are given in (4), where vowels in suffixes (here the accusative) alternate depending on the vowel in the root. As noted earlier, round harmonies tend to occur in tandem with other harmonies. In this case, the suffix agree for both backness and roundness. This means that the vowel of the accusative suffix may surface as one of four different vowels, depending on the vowel in the root. A front rounded vowel requires the suffix -ny [tynnyk-y]¹⁴, [børø-ny], a front unrounded vowel requires -ni [kingie-ni]. Rounded back vowels require -nu [oyo-nu], and back unrounded vowels require -ni [aya-ni].

1.3.2.3 Tongue-root harmony

Harmonies of this group create alternations in the tongue root position. This articulatory property is represented in phonology using two different distinct features: ATR (advanced tongue root) and RTR (retracted tongue root). Modern unary theories lack a feature that correspond to the tongue root position¹⁵.

A feature involving the position of the tongue root was first proposed in Stewart (1967)'s analysis of Akan VH. There is still an open debate over the nature of the features RTR and ATR (Steriade 1995: 27, van der Hulst & van de Weijer 1995: 14). Two possibilities have been proposed: either RTR and ATR are two distinct features, or they are two opposing values for the same feature. Steriade (1995) and van

¹³ Yakut will be considered also in §5.4, where the focus will shift from the harmonic feature to the nature of the condition on rounding.

¹⁴ The nasal of the suffix is lost when preceded by a consonant.

¹⁵ (Kaye, Lowenstamm & Vergnaud 1985) proposed a feature [H], correlated to [ə] that has been used to distinguish between vowels that differ in tongue root position. Nowadays, at least in Element Theory, the distinction for tongue root is generally represented through the concept of headedness (Backley 2011: 40), also cf. §IV.5.4.

der Hulst & van de Weijer (1995) rightfully notice that any one of the two features is sufficient in the formal representation of each tongue root process, and that a double representation is redundant.

The controversy involves the phonetic correlate of those features (Ko, Joseph & Whitman 2014) and their phonological behavior. Casali (2003), discussing various tongue root harmonies in Bantu languages, finds a correlation between the vocalic system and the tongue root feature that behaves as harmonic. In languages with a tongue root contrast among high vowels (such as Akan: /i, ɪ, e, ε, o, ɔ, u, a/ (Stewart 1967, Clements 1981, O’Keefe 2003) the harmonic feature is [+ATR], while in systems where only mid vowels have a tongue root contrast (e.g. Yoruba: /i, u, e, ε, o, ɔ, a/ Przedziecki 2005, Archangeli and Pulleyblank 1989) the harmonic feature is [-ATR] (or [+RTR], cf. van der Hulst 2018:41).

Harmonies involving the tongue root position are extremely common in the languages of Africa, where examples of the process can be found in all major language families of the continent. Casali (2008) describes in detail the distribution of the process in the continent. For a general overview of tongue root harmonies in African language cf. Hyman (1999), Casali (2002) and van der Hulst (2018: 331-64). Tongue root harmonies have been found in many Niger-Congo languages, e.g: Akan (Clements 1981, O’Keefe 2003); Ogori (van der Hulst 2018: 337); Wolof (Upseth 2009, van der Hulst 2018); Ijo (Oetelmate 2003), C’lela (van der Hulst 2018), Zulu (Tabuse 2017); Kinande (Odden 1991); Yoruba (Przedziecki 2005, Archangeli & Pulleyblank 1989).

According to Casali, within Nilo-Saharan languages ATR harmony is typical of Nilotic languages (Masaai, van der Hulst 2018: 351) and it is frequent in Afro Asiatic languages like Somali, (Ultan 1973) and Tangale (Samuels 2009, van der Hulst & van de Weijer 1995).

Languages that belong to the Mongolic and Tungusic branches of the Altaic language family are considered to have RTR harmony. Examples of languages with RTR harmony patterns include Halh Mongolian (Svantesson et al. 2008), Oroqen (Dresher & Nevins 2017), Manchu (Ard 1984) and Evenki (Nedjalkov 1997).

Other languages displaying tongue root harmony include Nez Perce (Aoki 1966) Assamese (Indo-Aryan, Mahanta 2007) Telugu (Dravidian, Kolachina 2016), and Korean. Some scholars include also Natal Brazilian Portuguese (Cobb 1997) and northern Spanish dialects (Hualde 1989)¹⁶.

(5) Example of tongue root harmony (ATR harmony) from Ogori/Oko (Bantu, spoken in Nigeria) (van der Hulst 2018 : 337)

a. Ogori vowel system

		<i>Front</i>	<i>Back</i>
<i>High</i>	<i>ATR</i>	i	u
<i>Mid</i>		e	o
	<i>RTR</i>	ε	ɔ
<i>Low</i>		a	

¹⁶ Some authors may consider some harmony patterns, such as metaphony (Calabrese 2011) or raising in some Bantu languages, as being tongue root based. In §II.2 the problem of distinguishing height related and tongue root related patterns is developed further. For what concerns the tongue-root harmony in Ibero-Romance varieties spoken in northern Spain (named Centralizing Harmony, cf. §II.3.2.2.1), there is reason to believe it does not exactly conform to the definition of a tongue-root harmony.

b. Tongue root harmony in Ogori

	<i>ATR roots</i>		<i>RTR roots</i>	
<i>I singular</i>	i-je	'call'	ε-nε	'fling'
<i>I plural</i>	ti-je		tε-nε	
<i>II singular</i>	u-je		ɔ-nε	
<i>II plural</i>	ni-je		nε-nε	
<i>I singular</i>	i-su	'have'	ε-jɔ	'go'
<i>I plural</i>	ti-su		tε-jɔ	
<i>II singular</i>	u-su		ɔ-jɔ	
<i>II plural</i>	ni-su		nε-jɔ	

In the table in (5b) personal prefixes alternate between an ATR form ([i-], [ti-], [u-], [ni-]) and a RTR form ([ε-], [tε-], [ɔ-], [nε-]). The sets are in complementary distribution. The ATR form is selected whenever the following root is ATR [i-je] *[i-nε], otherwise the chosen form belongs to the RTR set of prefixes [ε-nε] * [ε-je].

1.3.2.4 Height harmony, raising and lowering patterns

Height harmony refers to VH that involves the position of the tongue on the vertical dimension. From an articulatory perspective, the height dimension is conceived as the degree of opening of the articulatory apparatus, with the high vowels being close and the low vowels being open at the end of the continuum. For this reason, more than one feature is necessary in order to represent many height related patterns: [±high] and [±ATR]¹⁷. Furthermore, advancing and retracting of the tongue root, typical of tongue root harmonies, inevitably leads to raising or lowering of the tongue body respectively.

Some scholars proposed different analyses of Height harmonies that combine tongue root features ([±ATR], [±RTR]) and height features ([±high], [±low]) as components of a single phonological property, defined in different approaches as height, openness or aperture. Van der Hulst (2018) choose to group together height harmonies and tongue root harmonies in a variety of VH he calls Aperture Harmony. Clements (1991), Schane (1984), Parkinson (1996), Goad (1993) and Salting (1998), have proposed similar strategies. They claim that height and tongue root position/tenseness are actually phonetic manifestation of a single phonological category, which is impossible to represent through a binary contrast. The formal strategy those authors apply will be considered in detail in §IV.2. The shared insight is that vowel height must be represented through a complex structure in which features that concur in height definition are nested within each other.

Some occurrences of height harmony display a scalar behavior, where vowels of different relative height (e.g. mid low vowels /ε,ɔ/ and mid high vowels /e,o/, low vowel /a/) undergo raising in a different manner. In the example below, mid-high vowels raise to high, mid-low vowels to mid-high, and low vowel [a] is raised to mid-low [ε]. The harmonic process operates differently depending on the relative height of targets. Regarding the trigger, only high vowels (in the case of Nzebi, reported in (6) below, only /i/, since /u/ does not appear in final position) trigger harmony. This means that a vowel that is higher than the target but not high (i.e. mid vowel /e/, which is mid-high) does not trigger raising for

¹⁷ In §II.2 and §IV.2.1, the concept of scalarity in harmonic processes will be presented in more detail, alongside some analysis that solve this problem using unary primes, following an intuition based on Particle Phonology (Maiden 1991: 136).

targets that are relatively lower, such as mid-low or low vowels. The fact that only high vowels trigger raising is the main diagnostic applied to tell tongue root harmonies and raising harmonies apart.

(6) Nzebi Height harmony (Parkinson 1996: 55)

a. Vowel system of Nzebi

	<i>Front</i>	<i>Central</i>	<i>Back</i>
<i>High</i>	i		u
<i>Mid-High</i>	e	ə	o
<i>Mid-Low</i>	ɛ		ɔ
<i>Low</i>		a	

b. Height harmony in Nzebi

<i>Target vowels</i>	<i>Base Form</i>	<i>Yotized form</i>	
e	betə	biti	'carry'
	bexə	bixi	'foretell'
o	βoomə	βuumi	'breathe'
	kolən	kulin	'go down'
ɛ	sebə	sebi	'laugh'
	βɛɛdə	βeedi	'give'
	suemə	suemi	'hide'
ɔ	tɔdə	toodi	'arrive'
	mɔnə	moni	'see'
a	salə	sɛli	'work'
	baadə	bɛedi	'be'

Nzebi is a Bantu language, spoken between Gabon and RDC, in western sub-Saharan Africa (Clements 1991, Parkinson 1996). Raising is triggered by suffixal /-i/, added in the so called “yotized form” (Parkinson 1996: 55), produced in extra-careful speech and when followed by an enclitic (van der Hulst 2018: 264). According to Odden (2015), raising is conditioned by the tense suffix /-i/ associated with the “perfective stem” in Bantu. In Nzebi, mid-high vowels /e,o/ raise to high [i,u], mid-low vowels /ɛ,ɔ/ to mid-high [e,o] and the low vowel /a/ raises to mid-low [ɛ]. The trigger is invariably a high vowel /i/. Traditional feature representations of vowels consider the contrast between mid-low vowels and mid-high vowels to be based on the position of the tongue root¹⁸, while raising of [a] involves a change in height, affecting both [high] and [low], as well as fronting. In contrast to other harmonies, Height harmony may involve changes in more than one feature. Contextually, the harmonic feature that defines the dominant vowel is always [+high].

Harmonies involving height are divided into two sets: raising harmonies (triggers are high vowels that raise mid and/or low vowels) and lowering harmonies (triggers are non-high or low vowels that lower

¹⁸ Calabrese (1985, 1998, 2011), suggests the use of ATR in the analysis of raising metaphonies in central Italian dialects. We will discuss at length the possible ways to describe raising patterns that involve a scalar raising (Maiden 1991, Parkinson 1996), and the possible involvement of the feature ATR in harmonies of this group. Lowering harmonies in Bantu may also be considered as cases of RTR harmonies, if we follow the results of Casali (2003) survey.

high vowels). The general theme of this dissertation is the formalization of raising harmonies, and for this reason the typological generalization and general description for raising patterns is taken into account separately and in more depth in chapter II. The distinction of these two sets (as in the case for ATR and RTR harmonies) follows from the fact that the process does not result in singular agreement for height. Consider the examples of Nzebi in (6). When the central mid vowel [ə] is in the dominant position (last vowel), both high, mid and low vowels are accepted: [betə], [sɛbə] are both grammatical in Nzebi. An analysis that requires agreement for any value of the harmonic feature cannot work here. Agreement is forced upon targets only when the dominant vowel is [+high] (or [-high] in lowering harmonies). In this case an analysis that applies underspecification is necessary (recall §2.4): in raising harmonies [+high] is the harmonic property, while in lowering harmonies it is [-high].

Both raising and lowering harmonies are frequent in African languages of all families, and are typical features of Bantu languages (Parkinson 1996, Hyman 1999) where height harmonies involving both raising and lowering are extremely common. Otherwise, lowering harmonies are present in Tigré (Semitic, Palmer 1956), Itelment (language spoken in Kamchatka, Bobaljik 2009), Germanic languages (a-umlaut Cercignani 1980) and Buchan scot (Paster 2004). Raising harmonies are a common feature of Romance Languages, mainly in Italian (Maiden 1991, Sanchez-Miret 1998) and northern Spanish dialects (Hualde 1989), and are present in Australian aboriginal languages Warlpiri (Nash 1980, van der Hulst & Smith 1985) and Djingili (Chadwick 1975, van der Hulst & Smith 1985), Tibetic languages (Lhasa Tibetan, Parkinson 1996, Hill 2010) and Basque (Hualde 1991, Egurtzeki 2014). It is also featured in many Bantu languages (Parkinson 1996). A more detailed analysis and typology of raising harmony will be given in the survey proposed in §II.3.

For an example of raising harmony, consider Nzebi VH above. For a case of lowering harmony, consider Shona (Beckman 1997) shown in (7). The underlying form of the suffix contain a high vowel /i/, which lowers when preceded by a mid-vowel¹⁹.

(7) Shona lowering harmony

a. Shona vowel system

	<i>Front</i>	<i>Back</i>
<i>High</i>	i	u
<i>Mid</i>	e	o
<i>Low</i>	a	

¹⁹ The nature of the underlying vowel is easily deduced observing the behavior of suffixes preceded by a low vowel [a]. Low vowels behave as neutral (cf.§4.2.2) in Shona (Beckman 1997), meaning that they do not play a role in the harmonic pattern.

b. Lowering harmony in Shona

<i>Roots</i>		<i>Verbs</i>	
pera	'end'	per-era	'end in'
sona	'sew'	son-era	'sew for'
tonda	'face'	tond-esa	'make to face'
oma	'be dry'	om-esa	'cause to get dry'
ipa	'be evil'	ip-ira	'be evil for'
bvuma	'agree'	bvum-isa	'make agree'
pinda	'pass'	pind-irira	'to pass right through'
tarisa	'look at'	taris-ika	'easy to look at'
pamha	'do again'	pamh-isa	'make do again'

The height of the vowel in the verbal suffixes varies depending on the height of the vowel in the root. The underlying quality of the suffixal vowel that undergoes lowering can be determined looking at roots where only /a/ appears (/a/ does not participate in harmony, i.e. it is neutral, cf. §4.2.2). The high vowel /i/ is thus the underlying form, and mid-vowels in the root lower it to [e] when they precede it: [taris-ika], [per-era] *[per-ira] [tond-esa], *[tond-isa].

Interestingly, as far as I am aware, no harmony involves spreading of the feature [±low]. Lowering harmonies are better represented using [-high], and raising patterns have [+high] as the harmonic property.

1.3.2.5 Vowel-copy harmony

Another category of VH works as a harmonic assimilation at a distance for all melodic properties of the vowel, meaning that the dominant vowel is copied in recessive positions. Harmonies of this kind are often limited to certain contexts, in which intervening consonants between triggers and targets of harmony must have a certain feature specification for harmony to apply (Rose & Walker 2011: 256). Those harmonies are known in the literature as complete harmonies, or vowel-copy harmonies.

Harmonies of this kind are found in some Afro-Asiatic languages (Jibbali Semitic, Iraqw Cushitic) as well as in Pulaar (Rose & Walker 2011: 256), and similar processes has been found in stress-dependent harmonies in central Italian dialects (Walker 2003, 2005, Nibert 1998, Canalis 2008: 49). Here post-tonic non-final vowels in proparoxitones copy the prime specification of final unstressed vowel. Rose and Walker (2011) notice that harmonies of this kind tend to apply only across certain consonants, and cannot apply in all consonantal contexts, as most VH. Under (8) is presented vowel-copy harmony in Umbertide, a dialect spoken in central Italy, where post-tonic non-final vowels copy the final vowel iff between them occurs a liquid consonant /l/ or /r/. In this specific example consonants interplay with vowel-copy harmony.

(8) Copy harmony in the Italian dialect of Umbertide (Canalis 2008: 52)

<i>Singular</i>	<i>Plural</i>	
ko'kom:oro	ko'kom:iri	'watermelon'
'sigoro	'sigiri	'cigar'
'skatala	'skatele	'box'
'fragwala	'fragwele	'strawberry'
'sabito		'Saturday'
do'menica		'Sunday'
'stombiko		'stomach'
<i>Others</i>		
'mit:ulu		'put it (M)'
'mit:ili		'put them (M)'

The high vowel [i] is the only vowel accepted in post-tonic non-final position ([sabito], [domenika], [stombiko]), unless the vowel is followed by a liquid consonant /l,r/. In this case, the post-tonic vowel assumes the feature specification of the final unstressed vowel. When the final vowel changes (i.e. applying the plural suffix, or clitics), the post tonic non-final vowel copies all features specifications of the final vowel.

1.4. Other issues concerning VH

1.4.1 Directionality of the process

Harmonies, as other melodic assimilations, can be progressive (rightward, i.e. proceeding from left to right), regressive (leftward, i.e. proceeding from right to left) or bidirectional (Rose & Walker 2011: 279; Mahanta 2007). The directionality of the harmonic process is generally considered a byproduct of the morphological structure (Bakovic 2000): the morphological nature of the syllable in which the dominant vowel sits and the presence of prefixes or suffixes define the direction of VH.

Two types of harmony have been distinguished in regards to the direction of the process: root controlled harmonies and dominant-recessive (sometimes simply called dominant) harmonies (van der Hulst 2018: 39; Rose & Walker 2011: 279). Root-controlled harmonies are those in which the trigger (i.e. the dominant vowel) appears in the root, while vowels in affixes are subject to the harmonic process and alternate accordingly. Harmonies of this kind can be progressive (if only suffixes are affected), regressive (if only prefixes are affected) or bidirectional. Dominant harmonies are those where the trigger is not in the root, but in an affix, typically the suffix²⁰. Dominant harmonies are normally regressive (and affect the vowel/s of the root) but they can also be progressive or bidirectional, if a suffix other than the last one affects both the root that precedes it and any following suffix, or if the vowel of a prefix acts as the dominant vowel

In the preceding section, we observed cases of progressive root-controlled harmonies (Tuvan, Turkish, Yakut, Shona), a case of regressive root controlled harmony (Ogori/Oko) and a dominant-recessive regressive pattern (Nzebi). To complete the typology of VH directionality, consider a case of root-

²⁰ While dominant prefixes are attested (as in Kinande tongue root harmony), they are typologically rare compared to dominant suffixes, which are rather common in both tongue root and height harmonies (Hyman 2002: 23).

controlled bidirectional harmony (Masaai, van der Hulst 2018: 352) and a case of dominant bidirectional tongue root harmony (Kalenjin, Lodge 1995; van der Hulst 2018: 39).

(9) Bidirectional root-controlled harmony in Masaai

a. Masaai vowel system

		Front	Back
High	ATR	i	u
	RTR	ɪ	ʊ
Mid	ATR	e	o
	RTR	ɛ	ɔ
Low	RTR		a

b. Bidirectional root-controlled tongue-root harmony in Masaai

3rd p.sing.	Root	Motion towards	
e-	dot	-u	'he/she pulls towards'
ɛ-	jɪn	-ʊ	'he/she enters'
ɛ-	lak	-ʊ	'he/she unties'
3rd p.sing.	Root	Intransitive	
e-	ɲor	-iʃo	'he/she hunts'
ɛ-	ɔŋ	-iʃo	'he/she bites'
ɛ-	raŋ	-iʃo	'he/she sings'
Plural	Root	Extra Future	
ki-	norr	-u	'they will love'
ki-	ɪdim	-ʊ	'they will be able'

The dominant vowel in the root defines the tongue root value for both prefixes and suffixes. The third person prefix /e-, ɛ-/ and the intransitive suffix /iʃo-, iʃo-/alternate between an advanced and a retracted form, which are selected depending on the vowel in the root, which extends its harmonic domain to the whole word.

(10) Kalenjin bidirectional dominant-recessive VH

Prefixes		Root	Suffixes	Surface form	
-		ke:r	ʊn	[ke:run]	'see it from here'
		'see'	DIR.		
-		kʊ:t	ʊn	[kʊ:ton]	'blow it here'
		'blow'	DIR.		
ka	a	kʊ:t	e	[ka:yu:te]	'I was blowing'
PAST.	I sg.	'blow'	CONT.		
ki	a	un	kej	[kiɛungej]	'I washed myself'
PAST.	I sg.	'wash'	REFL.		

As in the case of Masaai presented in (9), in Kalenjin, shown in (10), the process affects both prefixes and suffixes. The dominant vowel in Kalenjin may be in the root or in a suffix. If a vowel in the suffix is ATR, all vowels of the word surface as ATR (in the last example the dominant vowel is the one of the root). The process is thus defined as dominant-recessive (i.e. the dominant vowel may not be the one of the root, but may be a suffixal vowel), and bidirectional, since it can affect both preceding and following vowels.

Hyman (2002) suggests that the default direction for harmonic processes is regressive, as is the case for most segmental assimilations, since left-to right vowel-to-vowel co-articulation seems to be more robust (Hyman 2002: 16). According to Hyman, progressive and bidirectional harmonies are the result of prominence effects. Hyman considers to be among the prototypical features of what he calls a “canonical VH” the fact that harmonic triggers sit in prominent positions²¹. Prominence may depend on prosodic reasons (the syllable bearing stress is more prominent than unstressed ones) or on morphological conditions (a syllable in a root is more prominent than a syllable in an affix). While VH is supposed to be regressive, the morphological structure of the word may create progressive or bidirectional patterns.

The frequency of progressive harmony would thus derive from the typological frequency of suffixes and the relative rarity of prefixes. Regarding the possible patterns, all three directionality parameters have been found in root controlled harmonies, while dominant-recessive VHs seem to be only regressive or bidirectional. Purely progressive dominant-recessive harmonies do not appear in the literature²². The table in (11) summarizes the possible directionalities of harmonic processes.

(11) Possible directionalities in VH

	<i>Progressive</i>	<i>Regressive</i>	<i>Bidirectional</i>
<i>Root-controlled</i>	Tuvan, Turkish	Ogori	Masaai
<i>Dominant recessive</i>	?	Nzebi	Kalenjin

1.4.2 Disharmony

In the previous sections, VH has been described as an infallible process that affects all vowels within a domain in which the harmonic conditions are met. The reality, however, is far more complex: most VH do not behave as Turkish backness harmony (that is in itself more complex than what appears in the example, as we shall see in §4.2.1 and §5.2) but instead display numerous disharmonies. Disharmonies correspond to failings in the application of the harmonic rule due to lexicalization of forms that do not conform to the harmonic pattern (disharmonic roots cf. §4.2.1) or to the behavior of single vowels in the system (neutral vowels cf. §4.2.2) or to special conditions imposed on the harmonic rule (asymmetries cf. §5)

²¹ Such a property has been formalized in OT quarters (e.g. Kaun 1995; Beckman 1997, Bacovic 2000) through Positional Faithfulness, a constraint that requires segments in prominent positions (root-initial, stressed...) to keep their feature specification, and thus behaving as dominant vowels in VH. The direction of the process depends then only on the position of targets in relation to that of the trigger.

²² Dominant prefixes are typologically quite rare. In Tunen (Mous 1986, van der Hulst 2018), the pronominal suffix may contain the dominant vowel and modify the following root, but in most cases, the dominant vowel sits in the suffix. For this reason, even if dominant prefixes are present and attested in Tunen, the harmony cannot be considered purely progressive, but bidirectional.

I.4.2.1 Disharmonic morphemes: roots and affixes that do not undergo VH

Most languages with a regular VH display some idiosyncrasies, cases in which harmony simply does not apply. In most languages where a VH is active, some roots and affixes may refuse to follow the harmonization rule, and maintain their non-harmonized nature (van der Hulst 2018: 185).

Disharmonic roots are usually introduced in the language by loanwords, which are often not adapted to the harmonic rule, and maintain the same vowel arrangement of the language it came from. Such a vowel arrangement may not conform to the harmonic requirement of the host language, and thus result in a disharmonic root, displaying a sequence of normally unaccepted vowels. Languages such as Turkish (Clements & Sezer 1982), Halh Mongolian (Puthuval 2013, Svantesson et al. 2008) Finnish and Wolof (Upseth 2009) display numerous cases of disharmonic roots caused by lack of loanword adaptation. Idiosyncrasies of this kind are present in most languages with an active VH. Let us take once again Turkish as an example.

(12) Disharmonic roots and morphemes in Turkish²³

a. Turkish vowel system

	Front		Back	
	non-Round	Round	non-Round	Round
High	i	y	u	u
non-High	e	ø	a	o

b. Disharmonic roots and morphemes in Turkish

Disharmonic roots	Plural	Poss.	
hamsi	-ler	-im	'anchovies'
takvim	-ler	-im	'calendar'
ustakoz	-lar	-um ²⁴	'lobster'
Roots	Progressive (disharmonic morpheme)	To be (1.sg. Pres.)	
gyl	-y ^j or	-um	'I am laughing'
gel	-i ^j or	-um	'I am coming'
ar	-u ^j or	-um	'I am searching'
it ^j	-i ^j or	-um	'I am drinking'
Roots	Noun forming (disharmonic morpheme)	Plural	
yt ^j	-gen	-ler	'triangles'
altu	-gen	-ler	'hexagons'

In Turkish vowels are required to agree in backness and roundness (cf. §3.2.2). Within disharmonic roots and disharmonic morphemes (marked in gray in the table in 12b) harmony does not apply, since the requirement to share the same value for backness and roundness is not fulfilled. Consider as an example the progressive morpheme, which exhibits three different surface forms: [-y^jor], [-i^jor], [-u^jor].

²³ Data comes from Clements & Sezer (1982), adapted to follow Kabak's (2011) take on Turkish vowel inventory.

²⁴ The plural and the possessive suffixes are not rounded due to the asymmetry present in Turkish labial harmony, cf. §1.5.1.

It appears that only the first vowel in the progressive suffix undergoes harmony, while the second one is invariably [o], regardless of the backness and roundness value of the preceding vowel: [gyl-yjor-um] *[gyl-yjør-ym] and [gel-ijor-um] *[gel-ijer-im]. Harmonic suffixes that follow the disharmonic morpheme (either a root or a suffix) keeps the value for backness and roundness of the vowel that does not undergo harmony.

In this case, the disharmonic vowel behaves as the dominant one, projecting the harmonic property onwards²⁵. Harmonic suffixes following a disharmonic root assume the backness value of the vowel that does not undergo harmony (i.e. [o] in *itf-ijor-um* *[*itf-ijer-im*]; [e] in *altu-gen-ler* *[*altu-gan-lar*]). This is the behavior of most disharmonic roots and morphemes in most harmonies (van der Hulst 2018: 47).

Disharmonic roots and morphemes are idiosyncratic exceptions to the harmonic rule. They differ from other disharmonies discussed in later paragraphs, which are instead systematic exceptions and thus need a phonological justification for their behavior. Disharmony in disharmonic roots and morphemes is generally considered a lexical property of specific items stored in long-term memory.

1.4.2.2 Neutral vowels

Neutral vowels are vowels that systematically refuse to undergo harmony. They are one of the most widely discussed topics concerning VH. Discussion regarding their nature and behavior can be found in multiple sources, including: Rose & Walker (2011); Gafos & Dye (2011); van der Hulst (2018); Goldsmith (1985); Ringen (1988); Archangeli & Pulleyblank (1994); Pulleyblank (1996); Kiparsky & Pajusalu (2003); Krämer (2003); Archangeli & Pulleyblank (2007); Nevins (2010); Tohsaku (1983).

There are two kind of neutral vowels, divided according to their behavior in phonological processing. Transparent vowels, which are not affected by the harmonic process but allow following (or preceding, in regressive harmonies) vowels to undergo VH, and opaque/blocking vowels, which not only ignore the harmonic rule, but also halt the propagation of the harmonic property beyond them.

1.4.2.3 Transparent vowels

Transparent vowels are neutral vowels that allow the process to apply to following or preceding targets. One of the most known cases of transparency in VH is that of Finno-ugric languages, especially Finnish (Kiparsky & Pajusalu 2003). Finnish displays backness/fronting harmony, much like Turkish; but in contrast to Turkish, not all vowels behave as a trigger or as a target.

(13) Backness harmony in Finnish: (Pöchtrager 2018, data from Karlsson 1983)

<i>Stem</i>	<i>Partitive</i>	<i>Possessive</i>	
kylä	kylä-ä	kylä-ni	'village'
täti	täti-ä	täti-ni	'aunt'
isä	isä-ä	isä-ni	'father'
nalle	nalle-a	nalle-ni	'bear'
melu	melu-a	melu-ni	'noise'
talo	talo-a	talo-ni	'house'
keli	keli-ä	keli-ni	'weather'

²⁵ As we shall see in §4.2.4 the vowels in the disharmonic morpheme behave as opaque.

Front vowels /e/ and /i/, while phonetically front (and thus specified as [-back]), do not behave as triggers²⁶, and do not change when preceded by a [+back] target. They are able to appear in any context: words that display disharmony, if the disharmonic segments are [i] and [e], are grammatical in Finnish. In sum, they act as neutral vowels for what concerns Finnish backness harmony. /i/ and /e/ in Finnish are ignored by the process, but let the harmonization process apply in neighboring vowels without affecting it. If a neutral /i/ or /e/ intervenes between a [-back] dominant vowel and an eligible target, /i/ and /e/ do not assign their value of backness to other dependent vowels, which assume the feature value of the preceding valid trigger. This distinguishes the behavior of transparent vowels from that of vowels in disharmonic roots. Consider the example [melu] reported in (13): a neutral vowel [e] is followed by a back vowel [u]. The suffix agrees in backness with the second vowel: [melu-a], as it does in Turkish, when a disharmonic root is followed by a suffix (cf. §4.2.1). In [nalle], where the position of the back and neutral vowels is swapped, the dominant vowel is the preceding back one, and the process ignores the neutral vowel: [nalle-a], *[nalle-ä].

1.4.2.4 Opaque vowels, blockers

Transparent vowels behave as if they ignore VH. The other kind of neutral vowels, while still unaffected by the process, interact with VH, blocking the application of the process when they intervene between a trigger and a valid target.

In many African languages with tongue-root VH and height VH, the low vowel [a] acts as neutral, and is unaffected by harmony. Consider Tangale tongue root harmony in (13) as an example. In contrast to the case of Finnish considered earlier, in Tangale the harmonic process takes into account the fact that there is an “intruder” in the vocalic string, and does not apply.

(14) Tongue root harmony in Tangale (van der Hulst & van de Weijer 1995)

<i>Roots</i>	<i>Imperfect</i>		
seb	-u		'look (imp.)'
kɛn	-ɔ		'enter (imp.)'
dob	-um	-gu	'called us'
<i>Roots</i>	<i>Participle</i>		
peer	-na		'compelled'
pɛd	-na		'untied'
dib	-na	-mgɔ	'called you (pl.)'

In the last example [dib-na-mgɔ], the participial suffix /-na/, which contains the neutral vowel /a/, forces the following vowel to surface as [-ATR], when the dominant vowel hosted in the root, /i/, is [+ATR]. In practice, it stops the effect of dominant /i/, and forces the following suffix to surface as [ɔ] becoming dominant itself.

²⁶ Interestingly, when a root contains two front neutral vowels (cf. the stem [keli]) the suffix surfaces as front (Kiparsky & Pajusalu 2003). However, when they appear with another vowel they behave as transparent, and do not require the following vowel to surface as front.

In §2.4 we discussed how VH can be considered either as a process that forces agreement with any value of a harmonic feature or as the propagation of one active property (one of the two values of the binary feature). In the first case, blocking vowels act as a sort of secondary trigger, forcing dependent vowels that are not reached by the proper dominant vowel to assume their value for the harmonic feature. If instead we assume the unary approach based on Underspecification, considering just [+ATR] as being present in the underlying form and [-ATR] as filled in later, the neutral vowel does not undergo harmony and blocks [+ATR] harmony triggered by the vowel /i/ from affecting the vowel in the suffix.

Thus, opaque vowels demonstrate a property of VH known as iterativity, whereby the dominant vowel is the preceding or following vowel, which in turn affects the following vowel, and so on. The process advances in the vowel sequence, affecting vowels in order. This means that a target affected by the process actually behaves as a trigger for subsequent targets²⁷: in (14) above, [dob-um-gu], the dominant vowel in the root, which is [+ATR], affects the following vowel in the imperfect suffix, which surfaces as [-um] which itself triggers VH for the following suffix.

Iterativity presupposes the conception of VH as a local process: while consonants can be skipped and normally do not halt VH, vowels are never skipped, and are affected by VH in order. Distance is a factor only where consonants are concerned, not when vowels are involved. A dominant vowel affects the closest vowel in the harmonic direction, which in turn propagates the “harmonic wave” onward (or backward, in regressive harmonies). Within this framework, opaque vowels are those that systematically do not allow the wave to pass through them.

This of course opens a question regarding neutral transparent vowels. Are transparent vowels skipped by harmony? Alternatively, does VH actually pass through them? Formal strategies of VH representation that deal with this question will be taken into account in chapter IV.

1.4.2.5 Correlation between neutral vowels and vowel systems

A valuable insight regarding the behavior of neutral vowels comes from the analysis of vowel systems of languages that display a VH that is not fully combinative (i.e. a VH where there are neutral vowels). In the examples reported in (13) and (14), the behavior of neutral vowels may be deduced from the vowel system of the languages considered. Both /i/ and /e/ in Finnish and /a/ in Tangale lack a counterpart that has the opposite value for the harmonic feature. Consider Finnish vowel system first, reported in (15):

(15) Finnish vowel system. Finnish lacks back non-rounded high and mid vowels

	<i>Front</i>		<i>Back</i>	
	<i>Non-Round</i>	<i>Round</i>	<i>Non-Round</i>	<i>Round</i>
<i>High</i>	i	y		u
<i>Mid</i>	e	ö		o
<i>Low</i>	ä		a	

²⁷Nevins (2010) was the first to apply the term iterativity to his model of VH analysis. Vowels that lack the specification for a feature (are underspecified) seek it from the nearest source. If the process already applied once, an affected target can have the feature specification a subsequent target is seeking. Formal analyses of VH are left aside for the time being, and will be discussed later. Nonetheless, iterativity can be considered a pre-theoretical property of VH, once the definition of VH as a propagating process is accepted.

We know from (13) that Finnish display progressive backness harmony, in which non-initial vowels receive the specification for backness from preceding vowels. Since /i/ and /e/ lack a [+back] counterpart (in gray in the table in 15), the specification [-back] for those vowels is not relevant for contrast. This means that it is not needed to differentiate the two neutral vowels from other vowels of the language. In other words, the specification for the feature [±back] is predictable for /i/ and /e/: even without a specification for backness the only possible segment in Finnish that is high and non-round is /i/, and the only segment that is mid and non-round is /e/.

In the same way, the vowel system of Tangale does not have a [+ATR] counterpart for [a]²⁸. Consider the vowel system of Tangale in (16).

(16) Tangale vowel system

	<i>Front</i>		<i>Back</i>	
	<i>[+ATR]</i>	<i>[-ATR]</i>		<i>[+ATR]</i>
<i>High</i>	i	ɪ	ʊ	u
<i>Mid</i>	e	ɛ	ɔ	o
<i>Low</i>		a		

This is the standard assumption about neutral vowels, normally formalized through the means of Underspecification (Archangeli 1988, Steriade 1995, Dresher 2009). A vowel will not participate in VH if it lacks a harmonic counterpart in the inventory.

This generalization holds true for most languages, and most scholars assume it either implicitly or explicitly (Ozburn 2019). In Bantu languages without an ATR harmonic counterpart for the low vowel, [a] behaves as neutral. The same can be said about /i/ in Balto-Finnic languages (cf. van der Hulst 2018: §4; Kiparsky & Pajusalu 2003), which behave as neutral in languages of this branch²⁹.

While most scholars generally assume this view, it often does not seem to suffice in accounting for the behavior of non-harmonizing vowels. As an example, I briefly anticipate an argument that will be discussed in chapter IV. Languages with similar vowel systems and the same harmonic feature may differ in the treatment of neutral vowels. Consider Kikuria and Basà (Parkinson 1996): they share the same 7-vowel system, in which [a] seems to lack a harmonic counterpart, but while [a] is opaque in Kikuria (it is not raised by a final high vowel) it behaves as harmonic in Basaa, raising to [e].

²⁸ In the table in (5), /a/ also lacks specification for backness. [+low] is sufficient to individuate and distinguish /a/ from other vowels in Tangale.

²⁹ Both Kiparsky & Pajusalu (2003) and Van der Hulst (2018: §4) describe various harmonic patterns in Balto-Finnic languages and notice that /i/ and /e/ (when they lack a harmonic counterpart) behave as neutral. Different languages of course display different details, and the behavior of /i/ is in some cases that of a transparent vowel and in others that of an opaque vowel.

(17) Languages with similar vowel systems display different harmonic behavior wrt. neutral vowels

a. Vowel system in Kikuria³⁰ (Parkinson 1996, Chacha & Odden 1998) and Basaa³¹ (Parkinson 1996)

		[-back]	[+back]
[+ATR]	[+high]	i	u
	[-high]	e	o
[-ATR]	[+low]	ɛ	ɔ
			a

b. Harmony in Kikuria and Basà

<i>Kikuria regressive raising VH</i>	<i>Infinitive</i>	<i>Agentive</i>	
	oko-rɔg-a	omo-rog-i	‘witch’
	oko-gɔɔg-a	omo-goog-i	‘slaughter’
	oko-terɛk-a	omo-terek-i	‘brew’
	oko-sook-a	umu-suuk-i	‘respect’
	ogo-takor-a	omo-takur-i	‘untie’
<i>Basà regressive height VH</i>	<i>Root</i>	<i>Applied</i>	
	ɓak	ɓeg-el	‘weave’
	pɛp	peb-el	‘winnow’
	hɛk	heg-el	‘believe’
	jɔŋ	jon-ol	‘take’
	seŋ	sin-il	‘rub’
	top	tub-il	‘sing’

The generalization that links asymmetry in the vowel system to neutral behavior generally holds true³², but some examples show that the situation may be more complex. Furthermore, the actual behavior of neutral vowels may differ from language to language, and it is not possible to derive directly from the vowel system³³. I refer to Ozburn (2019) for an account of neutral vowels in Hungarian, where /a/ behaves as harmonic while lacking a counterpart in front vowels.

1.5 Asymmetries in VH

Asymmetric VH are harmonic processes that apply differently in different contexts. In general, asymmetric VH are those in which the harmonic rule is applied only if the trigger, the target or both fulfill a given condition. Conditions of this kind revolve around the prime composition of the vowels involved in the harmonic process.

The condition limiting VH application can affect only the trigger, only the target, or affect the selection of both terms. In the latter case, both trigger and target must have a specific feature

³⁰ Tones, which are irrelevant for what concerns the VH, are not reported.

³¹ Raising in Basaa is triggered by any higher vowel than the target, hence mid-high /e/ raises mid-low and low vowels.

³² As we shall discuss in §IV.3, this generalization is related to the contrastive hierarchy of features (cf. Dresher 2009).

³³ Van der Hulst (2018) claims that his model can indeed predict the behavior of neutral vowels, and not pose it as a parameter. Nonetheless, it seems to me that the explanation of neutral vowels in Finno-Ugric languages he proposed is parametric, and not entirely predictable. A more detailed discussion of van der Hulst’s (2018) analysis will be given in §IV.6.

configuration for VH to happen. Asymmetric patterns seem to be frequent in labial VH of Altaic languages (cf. Moskal 2018, Kaun 2004, Korn 1969), but can also be found in harmonic patterns of other groups. A condition imposed on the selection of triggers and targets allows for a simplification in the definition of neutral vowels.

1.5.1 Conditions limiting the selection of targets

Some VH apply only to a subset of the possible targets. In patterns of this kind, VH applies to a group of potentially valid targets, while it does not apply otherwise. A simple example of this kind of asymmetry is Turkish labial harmony. Alongside backness harmony, which is fully combinative (cf. Rose & Walker 2010: 252), Turkish displays a Labial harmony pattern that rounds high-unrounded vowels. Non-high unrounded vowels are not affected, and behave as neutral. They cannot be considered simple neutral vowels for two reasons: they are not neutral for what concerns backness harmony (they behave as harmonic in regards to the fronting pattern) and they have a rounded counterpart, in contrast to neutral vowels. This asymmetry is evident when labial harmony is applied to the plural and the genitive suffixes. Data reported in (18b), derived from Clements & Sezer (1982: 216), show the asymmetry of labial harmony in Turkish. The plural suffix (which alternates between [-ler],[-lar]) is never rounded, while the genitive suffix (which alternates between [-in], [-un], [-yn], [-un]) is subject to labial harmony.

(18) Labial harmony is asymmetric in Turkish vowel system

a. Turkish vowel system

	[-back]		[+back]	
	[-round]	[+round]	[-round]	[+round]
[+high]	i	y	u	u
[-high]	e	ø	a	o

b. Asymmetric labial harmony in Turkish

Condition: targets of labial VH must be [-high]			
Root	Plural		
jyz	jyz-ler	*jyz-lør	face
kjøj	kjøj-ler	*kjøj-lør	village
pul	pul-lar	*pul-lor	stamp
son	son-lar	*son-lor	end
Root	Genitive		
jyz	jyz-yn		face
kjøj	kjøj-yn		village
pul	pul-un		stamp
son	son-un		end

The condition that makes Turkish labial harmony asymmetric, explicated in (18b), limits the selection of the viable targets for the process. [+high] vowels undergo rounding while [-high] vowels do not. The plural suffix alternates between a non-high front vowel /e/ and a non-high back vowel /a/, as predicted by the application of backness harmony. Labial harmony, however, do not applies to non-high vowels.

Non-high vowels behave as neutral with regards to labial harmony, while they behave as valid targets for backness harmony.

1.5.2 Conditions limiting the selection of triggers

In contrast to harmonies such as labial VH in Turkish, some harmonic processes may pose a limiting condition on the selection of triggers. In these harmony patterns, only a subset of potentially valid triggers actually trigger the process. Such cases are found in some raising harmonies in Italian dialects, where only front high vowels trigger raising, while back rounded high vowels do not. An example of this pattern is metaphony, regressive raising harmonies triggered by final unstressed high vowels affecting stressed mid vowels. Metaphony will be described in detail in §II.3.3.

All VH displaying such asymmetries in Italia dialects are opaque, since they do not display rounded high vowels in triggering position (cf. Grado in 19), or are completely morphologized (cf. Lugo in 20). The underlying form of final vowels is deduced from their phonological behavior. I refer to Maiden (1991: 153) for a detailed analysis of the evolution of final vowels in Italian dialects. Also §II.3.3.2 provides a discussion on the same topic. Applications of VH are in gray in the following tables.

(19) Raising harmony in Grado (Walker 2005, Calabrese 2011)

	<i>Singular</i>	<i>Plural</i>	
<i>M</i>	vero	vir i	'true'
(<i>M</i>)	tempo	tim pi	'time'
<i>M</i>	roso	rus i	'red'
<i>M</i>	sordo	sur di	'deaf'
<i>M</i>	belo	b eli	'beautiful'
<i>F</i>	bela	bele	
<i>M</i>	morto	m orti	'dead'
<i>F</i>	morta	morte	

In the Italian dialect of Grado, Proto-romance *u in final position has lowered to [o], therefore high rounded vowel [u] never appears in final position. Mid-high vowels /e,o/ are raised to high [i,u] respectively when followed by a final high vowel /i/, while mid-low and low vowels are left untouched. Consider the alternations in (19): [vero], [viri], [sordo] [surdi] but [bello] [belli] *[belli].

(20) Raising harmony in Lugo, Romagna (Pelliciardi 1977)

	<i>Singular</i>	<i>Plural</i>	
<i>M</i>	spos	spus	'groom'
<i>F</i>	spoza	spoz(i)	'bride'
<i>M</i>	ner	nir	'black'
<i>F</i>	nera	ner(i)	
<i>M</i>	mo ^a rt	murt	'dead'
<i>F</i>	mo ^a rta	mo ^a rt(i)	
<i>M</i>	b ^e l	b ^e a ^l	'beautiful'
<i>F</i>	bela	b ^e l(i)	

In the variety of Lugo, final unstressed vowels have been lost altogether. Raising applies only in masculine plural nouns, and not in masculine singulars. The suffix for masculine plural in Proto-Romance was *i, while it was *u for the masculine singular, suggesting that only *i activated the process, while *u could not: /sposu/ → [spos], /sposi/ → [spus]. Feminine plural is vocalized as [i] < *e by some speakers, but is often dropped.

In the example of Nzebi raising harmony displayed in (6) only /i/ triggers raising. The high back rounded vowel /u/ is part of the phonemic inventory of Nzebi, but it does not appear as the vowel of a suffix that appear in final position. The same can be said about Grado metaphony. Metaphony in Lugo is even more complex, since both triggers are not present in the surface form, meaning that considerations on the nature of the process are dependent on the analysis.

There are indeed cases in which harmony poses a condition on the selection of the trigger (alongside a condition on the selection of targets, cf. §5.4) but cases in which the restriction involve only triggers and not targets seem rather rare.

1.5.3 Condition on both triggers and targets

Conditions may affect both the selection of triggers as well as the selection of targets. A famous case of asymmetry of this kind comes from the analysis of Halh (Khalkha) Mongolian (Svantesson et al. 2008). Here, two progressive harmonies are active at the same time: a tongue-root harmony and a Labial harmony. Halh tongue-root harmony is progressive, symmetric and (almost) fully combinative. The process affects all vowels except for /i/, which behaves as a transparent neutral vowel. Labial harmony, on the other hand, displays a limitation, since it applies only when both target and triggers are [-high].

(21) Asymmetric labial harmony in Halh Mongolian (Svantesson et al. 2008:47)

a. Halh Mongolian vowel system

	[-RTR]		[+RTR]	
	[-round]	[+round]	[-round]	[+round]
[+high]	i	u		ɔ
[-high]	e	o	a	ɔ

Condition on labial harmony: triggers and targets must be [-high]

b. Suffixes harmonize

Direct past /-lʒE/	Causative /-Ulʒ/	Potential /-xUic ^h /	
it-lʒa	it-ulʒ	it-xuic ^h	'eat'
uc-lʒe	uc-ulʒ	uc-xuic ^h	'see'
ʊʊɾf-lʒa	ʊʊɾf-ʊʒ	ʊʊɾf-xʊic ^h	'evaporate'
xeelʒ-lʒe	xeelʒ-ulʒ	xeelʒ-xuic ^h	'decorate'
og-lʒo	og-ulʒ	og-xuic ^h	'give'
ɔɾ-lʒɔ	ɔɾ-ʊʒ	ɔɾ-xʊic ^h	'enter'
saat ^h -lʒa	saat ^h -ʊʒ	saat ^h -xʊic ^h	'be delayed'

c. Multiple vowel sequences: Causative-Direct past

it-uḷ-lʒe	*it-uḷ-lʒo	‘eat’
uc-uḷ-lʒe	*uc-uḷ-lʒo	‘see’
uʊrʃ-uḷ-lʒa	*uʊrʃ-uḷ-lʒo	‘evaporate’
xeelʒ-uḷ-lʒe	*xeelʒ-uḷ-lʒo	‘decorate’
og-uḷ-lʒe	*og-uḷ-lʒo	‘give’
ɔr-uḷ-lʒa	*ɔr-uḷ-lʒo	‘enter’
saat ^h -uḷ-lʒa	*saat ^h -uḷ-lʒo	‘be delayed’

d. /i/ behaves as transparent for Tongue Root harmony

t ^h axʲi-lʒa	‘to be bent’
ɠuwtʃ ^h i/lʒa	‘to be hollow’
ɔḷʲi/lʒo	‘squint’

In the examples in (21b), the processes of RTR harmony and Labial harmony is displayed. The past tense suffix becomes rounded only when the trigger is [-high]. The suffix for past tense is lexically [-high], and does not become rounded if preceded by a [-high] rounded vowel (e.g. [uc-ʒe], *[uc-ʒo]; [uʊrʃ-ʒa], *[uʊrʃ-ʒo]). The trigger and the target agree for the tongue root position (RTR harmony applies), but they do not agree for roundness, because they do not share the feature [-high]. When preceded by a [-high] trigger, the [-high] trigger agrees for both tongue root position and roundness (e.g. [xeelʒ-ʒe], [og-ʒo], [ɔr-ʒo]).

The causative suffix is lexically rounded, but the examples in (21c) show that it does not permit harmony to pass it and affect the past tense suffix, which remains non-rounded in both examples, albeit being preceded by a [-high] trigger in the root (which we defined as a valid trigger for [-high] vowels). Formally speaking, all high vowels behave as they were all neutral vowels for Labial harmony. /i/ lacks a counterpart for RTR, and thus behaves as transparent for tongue root harmony (21d), following the generalization proposed earlier in §4.2.5. High vowels, both rounded and unrounded, behave as blockers for labial harmony, albeit being phonetically rounded.

1.5.4 Condition on triggers and targets: Parasitism

Parasitic harmonies are a group of asymmetric VH patterns in which trigger and target must share a feature, otherwise the target does not undergo harmony (Cole & Trigo 1988). In this sense, the harmonic feature behaves somewhat as a “parasite” for a non-harmonic feature, using it as a host to pass from the trigger to the target.

Parasitic harmonies are treated separately from other asymmetric patterns due to the nature of the condition limiting the process. In the asymmetry of Halh Mongolian presented earlier, the condition is different from the one typical of parasitism: rounding harmony in Halh Mongolian only applies to a subset of segments, namely low vowels, while high vowels are not subject to harmony altogether. The whole class of high vowels behave as opaque in regards to labial harmony: rounding is not caused by nor applied to high vowels in Halh Mongolian. In parasitic harmonies, all vowels participate in VH, if the conditions are met.

There are two kinds of parasitic harmonies divided according to the type of condition: in the first kind, partial or mild parasitism (cf. §5.4.1), triggers are divided into two sets: one set of triggers does not have

any limitation (does not have any limiting conditions), while the other set does. In total parasitism (cf. §5.4.2) the condition concerns all triggers.

I.5.4.1 Partial parasitism

Let us take Yakut as an example. Yakut (Turkic, spoken in northeastern Russia, also known as Sakha) exhibits an asymmetric labial harmony. In §3.2.2 Yakut labial harmony was presented as an example of standard labial VH, and the examples shown were selected because they do not display cases of disharmony. Here the harmonic pattern of Yakut is described in more detail. In this language, [-high] vowels require a [-high] trigger to affect them while high targets are affected by all rounded vowels, regardless of their specification for [±high]. As in Turkish, backness harmony is also active in Yakut, and is not subject to the same limitation that Labial harmony is.

(22) Yakut labial harmony (Sezer & Wetzels 1986, Sandstedt 2018: 78)

a. Yakut vowel system

	[-back]		[+back]	
	[-round]	[+round]	[-round]	[+round]
[+high]	i	y	ɨ	u
[-high]	e	ø	ɑ	o

Condition: If the trigger is [+high], the target also must be [+high], otherwise VH does not apply³⁴.

b. Labial harmony applies regularly to [-high vowels]

Root	3 p. present	3.pres. Plural	
kel	kel-el	kel-el-ler	'come'
kør	kør-øl	kør-øl-lør	'see'
bar	bar-al	bar-al-lar	'go'
olor	olor-ol	olor-ol-lor	'dwell'

c. Labial harmony fails to apply: [+high] triggers do not affect [-high] targets

Root	3 p. preterit	3 pret. Plural	
kel	kel-li	kel-li-ler	'come'
kør	kør-dy	kør-dy-ler	'see'
bar	bar-du	bar-du-lar	'go'
olor	olor-du	olor-du-lar	'dwell'

As evident from the examples in (22b), non-high vowels of the plural and 3rd person present suffixes receive the round feature from the preceding ([-high]) vowel, but when a high vowel intervenes (as in the case of the 3rd person preterit in 22c), the process is blocked and does not affect following non-high vowels. On the other hand, high vowels are always affected by labial harmony. In sum, when the target

³⁴ The condition posed on parasitic harmonies can be also phrased the other way around. For Yakut the condition can be rewritten as: If the target is [-high], the trigger also must be [-high], otherwise VH does not apply.

is [-high], an identity condition between target and trigger must be met otherwise VH does not apply. When the target is high, rounding applies without further requirements.

Another way of representing this asymmetry may be to consider high triggers as “weaker” in their rounding effect, for what concerns this language. [-high] rounded vowels affect all targets, regardless of their value for the feature [±high], while [+high] rounded vowels can affect only [+high] targets (cf. Kaun 2004: 2).

Parasitic harmonies of the type of Yakut are frequent in Bantu lowering harmonies. In many Bantu languages mid vowels lower following high vowels /i/ and /u/. While /o/ lowers both /i/ and /u/ to [e] and [o] respectively, /e/ can lower only front high vowel /i/, leaving /u/ untouched. (Archangeli, Mielke & Pulleyblanck 2012: 3; Sandstedt 2018: 10, Hyman 1999).

In (23) the vowel system and harmonic pattern of Mbunda (Bantu, spoken in southeastern Angola and Zambia) is presented. In Mbunda (Sandstedt 2018: 10) there is a root-controlled lowering harmony triggered by mid and low vowels alike, which lowers following high vowels. /u/ is lowered only by rounded mid vowels and is unaffected by /e/ and /a/ (which in turn are able to lower the high vowel /i/). Lowering is parasitic on rounding (or backness). Similar patterns are typical in many Bantu languages, such as Chewa, Shona, Kisa, Gungu, and Ndendeule³⁵. In (23b) the applicative suffix /-il/ lowers if preceded by any non-high vowel. In (23c) the reversive /-ul/ lowers only if preceded by /o/.

(23) Mbunda parasitic lowering harmony

a. Mbunda vowel system

	<i>[-back]</i>	<i>[+back]</i>
<i>[+high]</i>	i	u
<i>[-high]</i>	e	o
	a	

Condition: If the trigger is [+back], target also must be [+back], otherwise VH does not apply

b. /i/ in the applicative lowers whenever preceded by any non-high vowel

<i>Root</i>	<i>Applicative</i>	<i>Final vowel</i>	
lum	il	a	‘cultivate’
nen	el	a	‘bring’
kwat	el	a	‘hold’
tung	il	a	‘build’
oc	el	a	‘roast’

³⁵ While parasitism is frequent in lowering harmonies of Bantu languages, there are many differences in the details of those patterns. Low vowel /a/ is a trigger in Mbunda, while it normally behaves as a blocker in most Bantu harmonies (as it does in Chewa, Shona and Gungu). Cf. Sandstedt (2018) and Hyman (1999) for a detailed description of the harmonic patterns involving lowering in Bantu languages.

c. /u/ in the reversive suffix lowers if preceded by /o/

<i>Root</i>	<i>Reversive</i>	<i>Final vowel</i>	
zit	ul	a	'untie'
tek	ul	a	'draw water'
nang	ul	a	'warn'
kup	ul	a	'bail out'
tomb	ol	a	'uproot'

Mid vowels in the root require vowels in the suffix to lower, when they are high. Two vowels behave as triggers: front unrounded mid-vowel /e/ and back rounded mid-vowel /o/. Both of them are specified as [-high], which appears to be the harmonic property. The low vowel /a/, which lacks a [+high] counterpart, appears to behave as neutral, and does not lower a following high vowel. When the applicative suffix /-il/ follows a root containing any mid vowel, underlying /i/ surfaces as [e]. When the reversive suffix /-ul/ follows a root with a mid-vowel, two outcomes are possible. If the trigger is rounded (i.e. if trigger and target share the same value for [±round]), harmony applies, and underlying /u/ surfaces as [o]. If the trigger is non-rounded, harmony does not apply, and /u/ surfaces as [u].

1.5.4.1.1 Partial parasitism in Turkic languages

Turkic languages display both labial and backness harmony. The latter does not display any asymmetry, while the former does. Moskal (2018) describes at length the different harmonic patterns of labial harmony in Altaic languages, and notes that often rounding happens more easily in combination with harmonic fronting caused by backness harmony. In other words, the process is systematically parasitic on backness. When the triggers and targets are both front (i.e. undergo backness harmony), labial harmony applies regularly. Otherwise, a specific condition must be met for labial harmony to apply. I report some examples and tables from Moskal (2018)³⁶, alongside her classification, in order to show the various forms conditions can take in parasitic patterns. All of them are partially parasitic, but also display an ulterior condition when backness harmony does not apply.

In Kyzyl Khakass labial harmony applies symmetrically when vowels are front (i.e. are fronted by backness harmony), while only high back vowels are subject to labial VH triggered by high rounded vowels. Alongside partial parasitism on backness, a condition similar to the one of Halh Mongolian is true for back vowels: both triggers and target must be high, otherwise they do not participate in VH.

³⁶ Vowel systems of Turkic languages greatly resemble each other. (Moskal 2018, Kaun 2004, Korn 1969). For all the patterns discussed in this section, the vowel system of Yakut presented in (22a) can be generalized.

(24) Kyzyl Khakass, (datas from Korn 1969: 102) - Type C in Moskal (2018) classification

Condition: If trigger and target are [+back] (i.e. backness VH does not apply) trigger and target must both be [+high].

	<i>Root</i>	<i>Suffixes</i>		
<i>Front vowels in the root</i>	kyn	gø		'to the sun'
	øɭ	zø		'if (he) dies'
	kyn	nyŋ		'of the day'
	tøɭ	duŋ		'of posterity'
	myn	gøn		'who mounted'
<i>Back vowels in the root</i>	kus	ka	*kus-ko	'to the bird'
	pol	za	*pol-zo	'if (he) is'
	kus	tuŋ		'of the bird'
	told	ir	*told-ur	'to fill'

In Altai-B the process is symmetric when triggers and targets are front, while in back vowels labial harmony applies only when an identity condition is met. High vowels are rounded by all rounded triggers, low back vowels are affected only by low triggers.

(25) Altai-B (Korn 1969: 101) - Type G in Moskal (2018) classification

Condition: if trigger is [+back] and [+high], target also must be [+back] and [+high].

	<i>Roots</i>	<i>Suffixes</i>		
<i>Front vowels in the root</i>	kyn	do		'in the day'
	køs	tør		'eyes'
	kyn	dy		'day ACC.'
	køɭ	dy		'lake ACC.'
<i>Back vowels in the root</i>	uc	ar	*uc-or	'which will fly'
	kol	do		'from the hand'
	tud	un		'to restrain'
	ton	du		'fur coat ACC.'

Labial harmony in Kazakh behaves symmetrically when triggers and targets are front, while it applies to high vowels only when they are back. When vowels are back, labial harmony must meet a limiting condition similar to that of Turkish: rounding applies only to high vowels and not to low vowels.

(26) Kazakh (Korn 1969: 101) - Type F in Moskal (2018) classification

Condition: if trigger and target are [+back], target must also be [+high], otherwise VH does not apply.

	<i>Roots</i>	<i>Suffixes</i>		
<i>Front vowels in the root</i>	yj	dø		'house LOC'
	køł	dø		'lake LOC'
	yj	dy		'house ACC'
	køł	dy		'lake ACC'
<i>Back vowels in the root</i>	kul	da	*kul-do	'at the servant'
	son	dan	*son-don	'rubble ACC'
	kul	du		'servant ACC'.
	koj	du		'sheep ACC'

Conditions on the application of VH can apply only to a subset of triggers and targets, and rounding applies without limitation in tandem with fronting. However, this is not the case for all Turkic languages. In other languages of the same family (as Turkish and Yakut, discussed earlier) labial harmony is asymmetric without consideration of backness harmony.

1.5.4.2 Strict/Total parasitism: Yawelmani labial harmony

Yawelmani (or Yolumnwe), a Yokuts language spoken in southern California (Cole & Trigo 1988, Archangeli 1984, Steriade 1986; Kenstowicz 1994: 108, van der Hulst 2018: 234), poses another condition on the labial harmonic process similar to that presented for other parasitic harmonies. Here the condition is imposed on both high and low vowels, meaning that the rounding process applies only when trigger and target share the same value for the height feature [\pm high]. The vowel system is comprised of four vowels that contrast for length: /i/,/u/,/o/,/a/.

(27) Yawelmani rounding harmony

Condition: Trigger and target must share the same feature specification for the feature [\pm high]

<i>Root</i>	<i>Aorist</i>	<i>Gerundive</i>	<i>Dubitative</i>	<i>Participative</i>	
xat	xal-hin	xat-mi	xat-al	xat-xa	'eat'
bok	bok-hin	bok-mi	bok-ol	bok-xo	'find'
xil	xil-hin	xil-mi	xil-al	xil-xa	'tangle'
dub	dub-hun	dub-mu	dub-al	dub-xa	'lead by hand'

Suffixes surface as rounded when preceded by a rounded vowel in the root only if trigger and target share the same value for the height feature. This case of parasitism is different from the one considered earlier. The condition in Yawelmani is double: high triggers affect only high targets, and [-high] triggers only [-high] targets. As far as I know, Yawelmani is the sole language reported that displays total parasitism. A similar condition can be considered for Shor-A, another Turkic language, which exhibits, alongside partial parasitism on backness (i.e. when both triggers and targets are [-back] labial harmony applies without limitation), a condition similar to that we found in Yawelmani, but only for [+back] vowels. Labial harmony applies to back vowels only when both triggers and targets share the same degree of height.

(28) Shor-A (data from Korn 1969: 101)-Type D in Moskal (2018) classification

Condition: If trigger and target are back (i.e. backness VH did not apply), they also must share the same specification for the feature [±high]

	<i>Root</i>	<i>Suffixes</i>		
<i>Front vowels in the root</i>	kylyk	tø		'at the brave mans'
	søs	tøy		'from the word'
	myn	yp		'having mounted'
	køk	tyn		'of the sky'
<i>Back vowels in the root</i>	ug	ar	*ug-or	'which will grasp'
	pol	zo		'If he is'
	kuf	tun		'of the bird'
	coj	nij	*coj-nuj	'of the people'

The second section of the table in (28) displays labial harmony only when trigger and target are either both [+high] or both [-high]: [pol-zo], [kuf-tun]. When triggers and targets are mismatched for height, labial harmony does not apply: [ug-ar] *[ug-or].

1.5.4.3 Summary of harmonic patterns discussed

Three general patterns of VH have been discussed so far: Symmetric VH, which applies without restrictions; VH with neutral vowels and Asymmetric VH, in which the process applies only if a given condition must be met. The table in (29) summarizes and describes the harmonic patterns discussed and the examples shown in the chapter.

(29) Symmetric and Asymmetric harmonies

Symmetric vowel harmony:	Regular VH	Harmony applies without any restriction to all vowels.	Tuvan 1.2 (1), Turkish backness harmony §3.2.1 (3)
	VH with transparent vowels.	Harmony applies to most vowels, but it ignores those that lack a harmonic counterpart. These vowels do not behave as dominant for other vowels, and allow harmony to traverse it.	Finnish §4.2.3 (13), Halh Mongolian tongue-root harmony §5.3 (21)
	VH with opaque/blocking vowels.	Harmony applies to most vowels, but it ignores those that lack a harmonic counterpart. These vowels behave as dominant for other vowels, assigning their value to other dependent vowels.	Tangale §4.2.4 (14), Nzebi §3.2.4 (6), Shona §3.2.1 (7), Kikuria §4.2.5 (17).
Asymmetric harmony: Harmony applies	condition on the trigger	Only a subset of eligible triggers behave as such.	Turkish §5.1 (18),
	condition on the target	Only a subset of eligible targets behave as such.	Grado §5.2 (19), Lugo §5.2 (20)

only if a condition is met.	condition on both triggers and targets.	Harmony regards only a subset of the vowel system.	Halh Mongolian §5.3 (21)
	Parasitic harmonies: the behavior of vowels variate according to the context.	Partially parasitic harmony: for one set of vowels, harmony is contingent upon agreement on a non-harmonic property (e.g. [-high] targets require a [-high trigger]).	Yakut §5.4.1 (22), Mbunda §5.4.1 (23), Turkic languages in §5.4.1.1
	Totally parasitic harmonies.	Total parasitic harmony: Harmony is contingent upon agreement on a non-harmonic property. (e.g. triggers and targets must share the same value for [±high], otherwise labial harmony does not apply).	Yawelmani §5.4.2 (27)

1.5.5 Conditions on VH: non-identity conditions are absent from the record

In asymmetries of the kind in Halh Mongolian and in parasitic harmonies, the conditions that must be fulfilled for VH to apply involve a relation of identity between the trigger and the target.

In Halh Mongolian, both trigger and target must be [-high], in Yakut and other partial parasitic harmonies the “weaker” trigger can affect only the subset of targets that share a feature with it, and in total parasitic harmonies all triggers must agree in height with the targets (and vice versa), i.e. having the same value for the feature [±high].

We could ask whether there are conditions on VH application that are not based on identity. For example, an asymmetric VH which is “anti-parasitic”, i.e. where target and trigger must be different in the specification of a feature for the process to apply. In other words, if asymmetric and parasitic harmonies described so far base their condition on identity, is there a VH which bases its condition on non-identity? As far as I know, no pattern has been found in which triggers and targets must display a mismatch in a given feature for VH to apply (e.g. rounding applies only if triggers and targets do *not* share the same degree of height). Phonological processes that are based on non-identity conditions do exist (Reiss 2003: 225), but it appears that no VH is among them.

1.5.6 Parasitism based on two different features: the case of Arcevia

While an anti-parasitic harmony does not seem to be attested in the literature, some harmonic patterns must fulfill conditions that do not rely on a relation between trigger and target in order to apply.

Interesting (yet problematic) data from raising patterns in Italian dialects suggests that VH applies if a condition that appears to be unnatural is fulfilled. In a small group of metaphonies, triggers can raise different sets of targets. Underlying /i/ seems to be a more effective trigger, and is able to affect all eligible targets, while /u/ is subject to more limitations. Maiden (1991: 110) proposes a typological survey for asymmetric metaphonies, and considers cases in which front high /i/ triggers metaphony in all valid contexts, while /u/ raises only vowels of a certain class. In the dialect spoken in the town of Arcevia, harmony applies to all targets when the trigger is /i/, while if the trigger is /u/, harmony applies only when the target is [-ATR]. High /u/ acts as a trigger on mid-low vowels /ɛ/ and /ɔ/, but not on mid-high vowels /e/ and /o/, which is unexpected. Data on this variety are presented in (30).

The process is opaque: final high vowels have been lowered to [e] < /i/ and [o] < /u/. Nonetheless, we can recover the underlying form of final vowels from the activation of metaphony. In nouns, both the singular and the plural form of the masculine display metaphony, suggesting that surface [o] and [e] are underlyingly /u/ and /i/ respectively. Mid-low vowels do not raise, but diphthongize instead³⁷ (diphthongizing metaphony, cf. §II.3.3.3.2).

(30) Asymmetric raising harmony in Arcevia (Crocioni 1906)

a. Vowel system of the dialect spoken in Arcevia

		[-back]	[+back]
[+ATR]	[+high]	i	u
	[-high]	e	o
[-ATR]	[-low]	ɛ	ɔ
	[+low]	a	

Condition: If the trigger is [+round], target must be [-ATR], otherwise VH does not apply.

b. Metaphony in Arcevia

	Singular	Plural	
M	'bwono	'bwone	good
F	'bɔna	'bɔne	
M	'solo	'sule	alone
F	'sola	'sole	
M	'nero	'nire	black
F	'nera	'nere	
M	'vjekkjo	'vjekkje	old
F	'vɛkkja	'vɛkkje	
M	ko'kommero	ko'kummere	watermelon
F	'krotʃe	'krutʃe	cross
M	'mese	'mise	month
M/F	'fɔrte	'fworte	strong
M	'pɛte	'pjete	foot

As in §5.2, the process is rendered opaque by vowel reduction (cf. Maiden 1991: 153,154). Underlying final unstressed /i/ lowers to mid-high [e], while final unstressed /u/ lowers to [o]. Underlying /u/ affects only mid-low vowels, leaving unaffected mid-high vowels, which in turn are subject to metaphony when triggered by /i/: /bɔnu/ → [bwono], /bɔni/ → [bwone]; /solu/ → [solo] *[sulo], /soli/ → [sule].

As in the case of Yakut, a class of triggers changes its behavior according to the internal structure of the target. However, while in other parasitic harmonies VH applies when the terms of the operation share

³⁷The diphthongization of mid-low vowels is attested in Crocioni (1906), but is nowadays in strong regression. In addition, not all forms display diphthongization (cf. the verbal example [dɔrmo]-[dorme]). For what concerns the discussion at hand, Crocioni reports that mid high vowels are not raised in contexts where mid-low vowels are, notably when followed by the masculine singular suffix /-o/<*u.

the same specification for an orthogonal feature, the condition is arbitrary in Arcevia. Underlying /u/ acts as a trigger for mid-low [-ATR] vowels and do not for mid-high [+ATR] vowels.

Cases similar as the pattern of Arcevia are extremely infrequent, and as far as I can tell, no other pattern of this nature is documented outside a rather small number of examples, in areas in which the dialectal variation is very high (cf. Northern Gargano³⁸, Apulia, Carosella 2005; Southern Salento, Apulia, Grimaldi & Calabrese 2017). Nonetheless, since patterns of this kind seem to exist, we can conclude that asymmetries can depend on restrictions that are not based on the identity between triggers and targets, but instead on arbitrary restrictions that do not appear to make any sense phonetically.

1.5.7 Typology of asymmetric VH

From the discussion in this section, we can draw a typology of asymmetric patterns in VH, based on the conditions VH must meet in order to be applied.

Restrictions on the selection of targets or the selection of triggers limit the application of the process to a single context. A subset of valid targets (or triggers) do not participate in VH, i.e. they behave as neutral vowels. Similarly, in asymmetries that require both trigger and target to display a specific feature specification (e.g. Halh Mongolian, where both triggers and targets must be [-high] for labial VH to apply) the class of high vowels is treated as neutral in all contexts.

In those patterns, the restriction limiting the application of VH distinguishes a set of neutral vowels, which behave as opaque in all contexts. This is not the case for parasitic harmonies.

Consider the cases of Yakut (partially parasitic) compared to the case of Halh Mongolian. In Mongolian, high vowels systematically behave as opaque, blocking the process when they appear in the harmonic chain. On the other hand, high vowels regularly act as a target in Yakut, but they can behave as a trigger only if the identity condition is met. The behavior of high vowels in Mongolian is invariable, while in Yakut it is variable: /u/ is a viable trigger for high vowels, but not for low vowels. At the same time, the low vowel [a] is targeted when preceded by /o/, while it is a blocker when preceded by /u/.

Parasitic harmonies (both total and partial) form a group of asymmetric patterns in which some vowels change their behavior according to the context. The following are the different patterns of asymmetric VH that are documented in the available record.

³⁸ Data reported for varieties in this area are problematic. Cf. the discussion in §II.3.3.5.2.

(31) Summary of the typology of asymmetric harmonies

Symmetric VH	Regular VH	The process applies regularly; all vowels take part in the harmonic process, either as triggers or as targets		
	VH with neutral vowels	The process applies regularly; all vowels take part in the harmonic process, either as triggers or as targets (except for systematically neutral vowels).		
Asymmetric VH	Condition on triggers or targets	Condition on targets	All valid triggers (i.e. segments containing the harmonic feature) behave as such, targets must meet a condition to undergo harmony (as in Turkish labial harmony, targets must be low).	
		Condition on triggers	All valid targets behave as such, while only some of the eligible triggers activate the harmonic process (as in Lugo metaphony, underlying /i/ triggers raising while underlying /u/ does not.)	
	Condition on both triggers and targets	Basic	VH matters only for a subset of the vowel system, it is triggered and targets only a subset of vowels.	
		Parasitic VH: Trigger and target must share a non-harmonic prime.	Partial parasitic VH	The restriction limits only a subset of trigger-target combinations
			Total parasitic VH	The restriction limits all trigger-target combinations
		Improper parasitic VH	Asymmetric VH applies only if a condition that do not regard the relation between triggers and targets is met.	

1.6 Concluding remarks

In this chapter, the main features of Vowel Harmony were described. First, the process (or rather this family of processes) known as Vowel Harmony was defined in a theory-neutral manner (or at least as close to theory-neutral as possible). Only the concept of prime, central in any phonological theory, was presented as the formal means linguists use to define sets of linguistically meaningful sounds, as well as their internal properties. In §3 a typological survey of VH has been proposed. The properties that can be involved in VH are limited to phonological melody, i.e. non-structural and non-suprasegmental properties that are represented by primes. The subdivisions of the survey are based on the features manipulated by harmony: backness VH operates over the feature [±back], labial VH affects [±round] while tongue root VH and height harmonies involve respectively [±ATR;±RTR] and [±high]. In §4.1 is presented a brief discussion on directionality of VH. The rest of the chapter deals with cases of disharmony: Disharmonic affixes and roots (§4.2.1), neutral vowels (§4.2.2) and Asymmetric VH (§5). Regarding Asymmetric VH, different patterns have been described and exemplified, and a typology of asymmetry in VH has been drawn. A group of asymmetric harmonies (proper parasitic harmonies and improper parasitic harmonies) has been set aside from other patterns for a special characteristic they share: the behavior of vowels may vary according to the context of application of the harmonic rule. This means that the internal composition of some vowel is not sufficient in defining whether a vowel will behave as harmonic or as neutral.

In the following chapter, the focus shifts to raising harmony, for which an in-depth analysis will be provided. The topics introduced in chapter I will be applied to the more narrow context of raising harmonies, with the goal of defining the aspects that set aside raising patterns from other height-related harmonies such as lowering harmony and tongue root harmony. Some topics that are often considered typical of VH have not been considered here. I refer to the matter of Harmonic domain (where does the VH apply? The phonological word? The prosodic word?) and to the concepts of locality and underspecification. All three of those concepts, while deserving a place in most introductions to VH, depend on theory-based assumptions on the way sounds are represented in the mind.

Chapter II. Raising Vowel Harmony

II.1 Introduction

The focus of the chapter shifts from harmonic processes in general to a specific group of harmonies, namely the harmonic patterns involving raising. The typological survey on raising harmony, which fills the entirety of section 3, forms the bulk of this chapter. It is introduced by section §2, which discusses the problematic relationship between tongue root harmonies and raising harmonies, and the properties of vowel height as a phonetic and phonological attribute of sounds.

The typological survey presented in §3 collects various raising processes reported in the literature. Most of the examples come from Bantu and Romance languages, where height seems to play a central role in vowel systems. The survey is not meant to be read cover to cover, but to be consulted according to the needs of the reader. Each sub-section has its own introduction, its concluding remarks, and a summary of the processes covered within it. §3.1 focuses on raising harmonies in Bantu languages. First, the general properties of the vowel systems of Bantu varieties are analyzed, alongside the main harmonic processes they exhibit. Then, raising harmonies belonging to the Bantu family are presented and discussed (§3.1.3.1-14). In §3.2, harmonies found in Ibero-Romance languages are discussed, and section §3.3 covers the topic of metaphonies in Italian dialects, which form what is probably the most studied corpus of harmonic phenomena involving raising. Introducing it, an analysis of the vowel system of Italian dialects. In §3.4 are presented other non-metaphonic raising processes that appear in Italian varieties and that may interact with metaphonies in complex height alternations. Section §3.5 closes the survey, presenting raising harmonies that do not belong to the aforementioned language families (Romance and Bantu), and that may display interesting or unexpected properties. The survey covers most of the processes reported in the literature and recognized as harmonies involving raising or metaphonies, which I treat programmatically as a subgroup of VH. Raising vowel harmonies of Eastern Lombard dialects, which complete the survey on raising harmonies, are treated separately in chapter III.

The ultimate goal of this chapter is to define the theoretical requirements of a comprehensive model able to formalize the process of raising harmony. Throughout the survey, three features of Raising Vowel Harmonies (henceforth RVH) are identified: scalar raising, asymmetries, and morphological conditions. Following chapters will present the way those problematic features are treated in different approaches.

II.2 Vowel height: a multi-layered property

In the first chapter, we distinguished between various types of harmonies depending on the vocalic property they affect. Fronting/backness harmonies involve the position of the tongue in the horizontal dimension, labial harmony involves the protrusion of the lips, tongue-root harmonies involve the position of the base of the tongue (i.e., the aperture of the pharynx). Height harmonies involve modifications in the relative height of a vowel: lowering harmonies lower the target vowel while raising harmonies have the opposite effect.

We also noted that height harmonies might affect more than one prime, namely those that solely refer to height and those that also refer to the position of the tongue root. This property appears to be unique to height related harmonies. Other harmonies we discussed may have asymmetries that depend on other features, but the definition of the harmonic property is clear, and the structural modification caused by the harmonic process involves just the prime correlated with said harmonic property. In height harmony, instead, the harmonic property of a trigger (in raising harmonies normally being high, generally

represented phonologically using the prime [+high]) may cause a structural modification in a target that does not involve the prime correlated with the harmonic property. Recall the case of Nzebi treated in §1.3.2.4 (and presented below in §3.1.3.1). There, final high vowels raise preceding non-high vowels. Assuming a standard set of binary features used in most standard approaches (e.g., Clements & Hume 1995), the process changes mid-high vowels to high ([-high], [+ATR] becomes [+high] [+ATR]), mid-low vowels to mid-high ([-high], [-ATR] becomes [-high], [+ATR]) and low vowel /a/ to mid-low vowel [ɛ] ([-high], [-ATR], [+low] becomes [-high], [-ATR], [-low]). Considering the phonetic outcome of the process, we can safely say that Nzebi exhibits raising. The process applies gradually, as if vowel height was a staircase: harmony raises each non-high vowel of a step.

From an articulatory point of view, height-related primes correlate to the position of the tongue relative to the roof of the mouth and to the aperture of the jaw. Higher vowels are pronounced with the jaw relatively closed, and with the tongue close to the roof of the mouth. On the other hand, lower vowels are pronounced with the jaw more opened, and the tongue in a lower position relative to the roof. From an acoustic standpoint, vowel height correlates with the first formant (F1). Vowel height is inverse to the frequency of the first formant: in high vowels, the frequency for F1 is low, while it is particularly high in low vowels such as [a].

Height is one of the basic parameters for the definition of vowels, together with backness and roundness. It appears that languages of the world tend to distinguish various degrees of height, while they make much more limited use of the front-back and rounded-unrounded dimensions, which usually supports only binary oppositions. In most vowel systems, there is a three or four-way height-based opposition, while there is a systematic two-way opposition for backness and roundness (Lindau 1978: 547). The most common vowel system is composed of five vowels, {i, e, a, o, u}, divided into 3 degrees of height: high vowels, {i, u}, mid vowels {e, o} and low vowels {a}. A vowel system comprised of seven vowels such as {i, e, ɛ, a, ɔ, o, u} distinguishes between 4 degrees of height, namely high, mid-high, low, and mid-low. The diagram of vowels represented in the IPA chart, largely inspired by Daniel Jones's works (Jones 1917), is structured around seven different degrees of height. As far as I know, no language has seven vowels that contrast only for height, but there are instances where up to five different degrees of height may be relevant in a single language (cf. Sotho-Tswana languages, §3.1.3.5).

Lindau (1978) considers four to be the largest number of contrasts based on height. However, it remains true that the phonological property of vowel height behaves as if it is structured around multiple levels. This sort of scalarity appears to be only related to height. Other vocalic properties do not display any scalar behavior in phonological processing. Consider the property of roundness as an example: the phonetic degree of roundness is different across rounded vowels of different heights, with higher vowels being more rounded than non-high vowels (Kaun 1995). From a phonological standpoint, however, this relative "roundedness" bears no meaning: a [y] may be "rounder" than a mid-vowel [ø] if we look at phonetic properties, but if they are both phonologically defined as [+round], we expect them to behave similarly in a process triggered by (or that targets) [+round] vowels³⁹. In other words, there is no scalar assimilation of rounding.

³⁹ Kaun (2004) considers the frequent appearance of parasitism related to roundness in Altaic languages as a consequence of this relative difference in roundness of high and non-high vowels. However, while the phonetic difference in rounding may be considered the origin of a different behavior among rounded vowels, the process never behaves as scalar, and the phonological property of roundness is never treated as "partial" in the way height is. A rounded vowel triggers rounding or it

The front-back dimension may actually support a ternary opposition between front vowels, back vowels and central vowels (e.g., [i], [ɨ], [u]). However, this opposition, as far as I know, is never treated as a gradient property in a phonological process. There is no phonological process that results in a passage from a back vowel to a central vowel, or from a central vowel to a front vowel (Lindau 1978: 547). This is, instead, what we see in Nzebi harmony in regard to vowel height, as well as in other height-related processes.

All phonetic phenomena are gradient in nature, while phonological processes (and classes, and hence primes) are categorical by definition. There is no gradience in phonology, no way to say that a vowel is "somewhat round" from a phonological standpoint. Phonological primes are binary or unary properties that define groups of linguistically meaningful sounds. The relative height, roundness and backness of a vowel are phonologically relevant only in the sense that they define a vowel as part of a natural class. However, some processes that involve the modification of height (and as we shall see only those that involve raising) apply in a scalar manner, meaning that a low vowel may be raised by one degree (becoming a mid-vowel) or by two degrees (becoming high) et cetera.

Multiple features are thus necessary to capture oppositions based on vowel height. Given a standard set of features as the one proposed in Clements & Hume (1995), three features are related to height, and those are the features that can be affected in a height harmony: [high], [low] and [ATR]. In the case of Nzebi considered above, VH involves the height features [high]/[low] and the feature [ATR]. /e, o/ raise to [i, u] respectively, changing their specification for height from [-high] to [+high]. /ɛ, ɔ/, instead, maintain the feature [-high], but change their specification for the feature [ATR], becoming [+ATR]. Harmonies that behave this way are referenced as scalar harmonies. In sum, height harmonies stand as a unicum among harmonic processes. Harmonies of any other kind have a well-defined harmonic property, captured in phonological theory as a single prime, which is present in triggers and is received by targets that undergo VH. In a labial VH, [+round] vowels trigger rounding for [-round] vowels, which assume the specification of the trigger and thus become [+round]. The harmonic property manipulated by the process of VH is represented in phonology by the single prime [round]. The same can be said about all other properties of vowels, except for height. Vowel height does not correlate only to one of the standard sets of primes, but requires more primes to be represented. In standard theories, those primes are those related to height ([high] and [low]) plus the prime that relates to the position of the tongue root (ATR). As a consequence, the definition of a harmonic process as height harmony or tongue root harmony (hereafter TR harmony) may be problematic, since they both operate on the prime [ATR]⁴⁰.

II.2.1 Height vs. Tongue root harmonies

In §I.3.2.3, the binary feature [±ATR] (more rarely its counterpart [±RTR]) was presented as the prime necessary to distinguish between contiguous degrees of height, meaning that a vowel distinction between mid-high and mid-low vowels such as [ɛ] and [e] is marked phonologically using the feature [±ATR].

Phonologists that focused their attention on height-related phenomena tend to represent vowel height in a different manner, choosing a strategy of representation based on multiple iterations of a height-

does not. Relative phonetic roundness may affect the set of triggers and targets, but cannot affect the outcome of the process. There is no "partial rounding" in the record, and no rounding process affects more than one prime in a labial harmony.

⁴⁰ Theories based on unary primes are less susceptible to this problem. Vowel height is represented through the presence (or absence) of |A|, while ATR is either represented with another prime (H in Kaye, Lowenstamm & Vergnaud 1985) or through headedness (cf. Backley 2011: 40)

related prime (cf. Clements 1991, Parkinson 1996, Shane 1984). Their strategy and motivations are explored in more detail in §IV.2 but are seldom applied outside the context of height related phenomena. Other authors (Calabrese 2005, 2011; Odden 1991) encode the distinction between mid-high and mid-low in terms of ATRness.

That being said, Ladefoged and Maddieson (1996) point out some issues regarding the use of [ATR] as the feature to signal the contrast between vowels with a different degree of height. Before the use of tongue root features, the distinction between main (high, mid, low) and secondary (mid-high, mid-low) height degrees were captured using features such as [tense/lax]. Ladefoged and Maddieson (1996: 304) note “[...] there is no common setting of the tongue root for the so-called lax vowels that distinguishes them from the so-called tense vowels”. They also go on and claim that the reference to the position of the tongue root may not be the best way to describe a distinction between tense and lax vowels in all languages. Calabrese (2005) argues otherwise that ATR is perfectly suited to capture the distinction between mid-high and mid-low vowels, and that the apparent dislocation of the tongue body (articulatory related to height) is due to the fact that the tongue is an elastic mass, and advancement of the tongue root results in a raising and fronting of the tongue body.

Stewart (1967) was the first to propose the binary feature [\pm ATR] to account for the harmonic process of Akan (Ghana). The vowel system of Akan is divided into two sets, which contain vowels from all phonemic degrees of height (as shown in the table 1a). ATR was thus a way to capture the distinction between the group 1 set and the group 2 set of vowels. Harmonic alternations in Akan are shown in (1b).

(1) Akan vowel harmony (O’Keefe 2003: 11)

a. Vowel system of Akan

<i>Height</i>	<i>Advanced</i>		<i>Retracted</i>	
<i>High</i>	i	u	ɪ	ʊ
<i>Mid</i>	e	o	ɛ	ɔ
<i>Low</i>	(æ) ⁴¹		a	

b. Vowel harmony in Akan

<i>Root: /di/ to eat</i>		<i>Root: /di/ to be called</i>	
mi-di	<i>I eat</i>	mɪ dɪ	<i>I am called</i>
wu-di	<i>you eat</i>	wʊ dɪ	<i>you are called</i>
o di	<i>he eats</i>	ɔ dɪ	<i>He is called</i>
ye di	<i>we eat</i>	yɛ dɪ	<i>we are called</i>

In Akan, vowels of all heights affect the outcome of harmony. A prime that does not necessarily relate to height is thus necessary to capture the harmonic behavior of VH in Akan. In the examples under (1), regressive harmony triggered by vowels in the root affects the vowel in the prefix, and is triggered by vowels of any relative height, as shown in the following examples from (1b): [mi-di] ‘I eat’ [mɪ-dɪ] ‘I am called’ [ye-di] ‘we eat’ [yɛ-dɪ] ‘we are called’

⁴¹ Advanced vowel [æ] does not surface in all Akan dialects and has been often treated as an allophone (or variant) of /a/. It is thus not considered to be phonemic (O’Keefe: 2003: 6).

Tongue root features correlate, unsurprisingly, with the position of the root of the tongue, which is physiologically related to the degree of constriction of the pharynx and the position of the tongue body (cf. §1.3.2.4). This is the very reason that allows considering tongue-root primes as a possible way to encode height distinctions. A prime such as $[\pm\text{ATR}]$ is a theoretical necessity for any theory of phonological representation: in languages such as Akan, $[\pm\text{ATR}]$ individuates an active class, and, since its phonetic correlate is physiologically related to vowel height, it can capture a distinction based on relative height (mid-low vs. mid-high vowels). Assuming a single feature for two properties is an advantage in economical terms since it avoids the proliferation of features, which is argued to be a positive property in a theory of phonological representation (cf. Backley 2011:10, Bafle 2017: 7).

This may lead to confusion about the nature of the processes that manipulate the prime $[\pm\text{ATR}]$. In the survey, the following diagnostic has been used to tell apart Tongue-root (TR) and Height harmonies. A process is considered a TR-harmony if vowels of different heights are affected or they trigger it. Otherwise, I consider it a height-harmony. TR-harmonies are those that do not interact whatsoever with vowel height: vowels of all relative heights behave either as triggers or as targets. I define as raising harmonies all the VH in which higher vowels affect lower vowels, and change their internal structure affecting the primes $[\pm\text{ATR}]$ and/or $[\pm\text{high}]$.

Following this diagnostic, Akan is clearly a tongue-root harmony, because the harmonic process affects vowels of all heights, and vowels of all heights can behave as triggers. On the contrary, Nzebi (cited above and described in §1.3.2.4 and §3.1.3.1 below) exhibits height harmony involving raising. Only high vowels behave as triggers, and the structural modifications involve the primes $[\pm\text{high}]$ and $[\pm\text{low}]$, as well as $[\pm\text{ATR}]$.

As we shall see, not all processes turn out to be that easy to label. Some processes may be defined as Tongue-root harmonies or Height harmonies only on the base of theoretic assumptions, which I am trying to reduce to the bare minimum in this first section of the thesis.

II.3 Typological survey: raising vowel harmonies in the languages of the world

The bigger part of this chapter is dedicated to the typological survey on Raising vowel harmonies (RVH). Various raising patterns are presented, in order to observe and discuss the properties that characterize raising harmonies, and to define what are the issues a theory of raising harmony must answer to.

The survey covers the entire literature on raising harmonies, and it builds on the typological works of Parkinson (1996), Clements (1991), van der Hulst (2018), Maiden (1991), Savoia (2015) and Hualde (1998), Torres-Tamarit, Linke & Oostendorp (2016). Literature on height related harmonies is rich in regards to Bantu languages and Romance (namely Ibero-Romance and Italian) dialects. For this reason, the greater part of the survey covers languages of those families. For the rest, Parkinson (1996) and van der Hulst (2018) offer the most typologically complete review on harmonies related to height outside the Romance-Bantu domain, and were at the base of my research for ulterior cases of RVH. Cases of VH involving height that do not involve raising are not comprised in the present survey. While there is no doubt that many RVH may have been left out, the present is, to my knowledge, the most detailed survey on height harmonies involving raising.

The survey is organized as follows:

- [II.3.1: Raising in harmonies of Bantu languages.](#)
- [II.3.2: Raising in Ibero-Romance varieties.](#)

- [II.3.3: Metaphony in Italo-Romance dialects.](#)
- [II.3.4: Non metaphonic raising in Italo-Romance dialects](#)
- [II.3.5: Raising harmonies in non-Bantu and non-Romance languages.](#)

The last section contains raising patterns of language families where raising patterns seem to appear seldom, or has not been considered as a systematic phenomenon (and therefore it has not been treated as a harmonic process in the literature). To the present list must be added the description of Eastern Lombard RVH, treated separately in chapter III.

II.3.1 Raising in Bantu languages

The first section of the survey is dedicated to raising processes in Bantu languages, a large group of languages spoken throughout sub-Saharan Africa that comprises circa 500 languages (Bostoen & van de Velde 2019). Within the Niger-Congo Language family, Bantu forms the most widespread group. Bantu languages are spoken from the southern part of Cameroon to South Africa and from the Atlantic coast (except for the deserted zone of Kalahari Desert) to the coast of the Indian Ocean. The spreading of Bantu languages in such a large and diverse area is due to the so-called “Bantu Expansion”, a migratory phenomenon that involved the Bantu population between roughly 5000 and 1500 years ago. Proto-Bantu speaking populations, probably moved from the borderland of South-Eastern Nigeria and Western Cameroon to all corners of sub-Saharan Africa.

Among the phonological processes that are typical of Bantu languages, VH is one of the most studied phenomena. Harmonies in Bantu languages often relate to vowel height, and it is not exceptional to find languages where several harmonic patterns conspire, creating complex height related alternations. A general description of lowering patterns is given in §.3.1.2 while the list of raising harmonies found in Bantu languages is presented in the following sections.

II.3.1.1 Bantu vowel systems

Comparative studies on Bantu varieties led to some generalizations that are assumed to be proper to Proto-Bantu, the reconstructed common ancestor of all Bantu languages (Meinhof 1932, Guthrie 1967-71). Proto-Bantu had a vowel system composed of seven vowels, traditionally considered to be structured around four degrees of height (Maddieson & Sands 2019). There are ongoing discussions over the phonetic realization and the IPA symbols that should be used in the representation of the Proto-Bantu vowel system. In table (2) three options frequently proposed in the literature as the reconstructed Proto-Bantu vowel system are reported.

(2) Reconstruction of the Proto-Bantu vowel system

a		b		c	
i	u	i	u	ɨ	ɯ
ɪ	ʊ	e	o	i	u
e ɛ	o ɔ	ɛ	ɔ	e	o
a		a		a	

The vowel system in (2c) corresponds to the traditional reconstruction proposed by Guthrie (1965-71), where the symbols ɨ and ɥ correspond to “super-high” or “super-close” vowels, a term intended to reflect the property of those vowels to spirantize preceding stops (Odden 2015: 2). More recently, some analysts (Odden 2015: 2, and Hyman 1999: 12) suppose that the notational symbols used in the system in (2c) are meant to symbolize the phonetically transcribed vowels of the system in (2a)⁴², suggesting that the super-high vs. high vowel contrast is encoded in terms of ATRness. The vowel system in (2a) is nowadays assumed as the vowel system of Proto-Bantu, from which the modern Bantu languages evolved their own systems. I refer to the discussions in Hyman (1999: 246) for a more complete picture of the reconstruction of Proto-Bantu.

Different evolutionary paths gave rise to different systems:

- Reduction path: According to Hyman (2019: 131) most Bantu languages developed a five-vowel system from the seven-vowel system of Proto-Bantu under (2a). The five-vowel system is generally obtained merging the two highest sets of vowels. Assuming the system in (2a) for Proto-Bantu, the merger involved the vowels [i, ɨ] and [u, ɥ], which merged into /i,u/. The general five vowel system is thus {i, ε, a, ɔ, u}, and is structured around three degrees of height. High vowels /i,u/, mid vowels /ε,ɔ/ and the low vowel /a/. The phonetic nature of the mid vowels is generally closer to mid-low vowels than to mid-high vowels. (Odden 2015: 2) In a five-vowel system of Bantu, the prime [±ATR] does not have a contrastive role.
- Equivalent path: Many languages kept a seven-vowel system, similar to the one reconstructed for Proto-Bantu. There are two forms of seven vowel systems that are common in Bantu languages. The first, widely attested in eastern Bantu languages, corresponds to the one presented in (2a), repeated in (3).

(3) Seven-vowel system, type A, frequent in east Bantu⁴³

<i>Height-1</i>	i	u
<i>Height-2</i>	ɨ	ɥ
<i>Height-3</i>	ε	ɔ
<i>Height-4</i>	a	

Traditionally, the vowel system in (3) is considered as structured around four height degrees. The contrast between Height-1 and Height-2 vowels is encoded phonologically in terms of ATRness (Height1=[+ATR], Height2=[-ATR]). The second vowel system, which is more common in western Bantu languages, corresponds to the system reconstructed for proto-Bantu reported in (2b), shown again in (4).

⁴² Super-high vowels are reported to still be part of the vowel systems in some Bantu varieties, where they are produced as “fricated vowels”, as explained in Maddieson and Sands (2019: 89). In addition, as we shall see later in the survey, those symbols are used to refer to super-high vowels, which appear in the vowel systems of some Sotho-Tswana languages, as well as of Phuthi. The phonetic nature and the possible phonological representations for those sounds is discussed in §3.1.3.4.

⁴³ For what concerns Bantu raising harmonies, I report the vowel system of each variety as structured around different height degrees, as common in the literature regarding Bantu languages. This way, I avoid referring to ATRness, and I can describe height harmonies in a more direct way. This approach, however, is simply descriptive. Theories of phonological representation still have to address the problem of height vs. ATRness and the difference between Tongue-root and Height harmonies, as discussed in §2.

(4) Seven-vowel system, type B, frequent in west Bantu (Hyman 2019: 128).

<i>Height-1</i>	i	u
<i>Height-2</i>	e	o
<i>Height-3</i>	ɛ	ɔ
<i>Height-4</i>	a	

Once again, this vowel system is generally treated as structured around four height degrees. However, while in the vowel system in (3) (henceforth 7VS: A) ATRness encoded the distinction between Height-1 and Height-2 vowels, in the vowel system in (4) (henceforth 7VS: B) it is the contrast between Height-2 and Height-3 to be encoded by the prime that relate to ATRness.

- Augmentation path: while less frequent, some Bantu languages developed a vowel system that exhibits more than seven vowels. Most of the augmented systems display a nine-vowel system of the kind shown in (5) (Hyman 2019: 130).

(5) Nine-vowel system:

<i>Height-1</i>	i	u
<i>Height-2</i>	ɪ	ʊ
<i>Height-3</i>	e	o
<i>Height-4</i>	ɛ	ɔ
<i>Height-5</i>	a	

Those languages have two contrasts based around the feature ATR: Height-1= [+high, +ATR] vs. Height-2= [+high, -ATR] and Height-3= [-high, +ATR] vs. Height-4=[-high, -ATR]. This brief overview does not cover the full situation. Naturally, vowel systems may display many other properties that are not represented by the three options proposed here. However, the systems listed here are sufficient to capture the general properties of Bantu vowels.

Several researchers (cf. Hyman 1999: 247) noted that the systems 7VS:A and 7VS:B are often hard to tell apart. Referencing living languages that kept a seven-vowel system, Odden (2015:2) notes that the third height degree (Height 3) is generally closer to [ɛ,ɔ] than to [e,o], while the exact phonetic nature of the second degree, which is often reported to be very close to the first degree of height (Maddieson & Sands 2019) is hard to assess.

A typical property of Bantu vowel systems, which I am going to ignore here, is the presence of contrastive tone systems and tonal harmonies (Yip 1995, Odden 2015, Marlo & Odden 2019). In the various examples in the survey, tones are not reported. Tones does not appear to interact with the harmonic patterns: there are no VH reported in the literature that apply differently depending on the tonal contour of the vowels involved in the process.

II.3.1.2. Lowering Harmonies in Bantu

Vowel harmonies that affect vowel height are extremely common in Bantu languages. One harmonic pattern involving lowering is especially frequent, to the point that it is considered a prominent feature of Proto-Bantu, inherited by most Bantu languages (Hyman 1999: 236). Since lowering harmonies often co-exist with the raising harmonies (the main focus of this survey), I think it is useful to present at least

the most common harmonic pattern of Bantu. In addition, a description of this lowering harmony, that will be referred to from here on out as Canonical Lowering, allows us to compare raising harmonies and lowering harmonies in the Bantu language family, and it is useful in the definition of the properties of raising.

Canonical lowering in Bantu languages is a progressive lowering harmony triggered by mid vowels /ε, ɔ/, which targets high vowels, lowering them to mid. In a language with a 7VS:A vowel system, vowels of the Height 2 set (derived from Proto-Bantu *ɪ, *ʊ) undergo lowering, becoming [ε, ɔ] when they follow a mid-vowel /ε,ɔ/.

The process is asymmetric: a condition posed on the selection of targets individuates only [-ATR] vowels as valid targets, while Height 1 vowels /i, u/ (which are [+ATR]) are mostly unaffected. Notice, however, that the process appears also in languages that exhibit the 7VS:B.

In many 5V Bantu languages, high vowels derived from original Proto-Bantu *ɪ and *ʊ undergo harmony, while those that derive from original *i and *u do not. There are, however, cases in which the process is generalized to all high vowels, regardless of the diachronic evolution of the vocalic system. The process is generally parasitic, with an asymmetry between front and back/rounded vowels. While the back/rounded vowel [o] triggers lowering for both front and back/rounded high vowels, front vowel [e] lowers only front target [i]. This process of lowering generally ignores the low vowel [a], which in most cases behaves as opaque⁴⁴.

Hyman (1999) discusses some of the general properties of Bantu Lowering Harmony. I report here the main generalizations he finds in his survey of 134 Bantu varieties (Hyman 1999: 238):

- 1) Harmony displays an asymmetry between the lowering of front and back vowels, such that the front vowel [ɪ] lowers to [e] after both [e] and [o], whereas the back vowel [u] only lowers after [o] (in the terms we posed in the previous chapter, it means that harmony is partially parasitic for backness/rounding).
- 2) Lowering is not triggered by the low vowel /a/, but only by mid vowels of the third degree of height /ε,ɔ/.
- 3) The low vowel /a/ generally behaves as a blocker when it intervenes between a trigger and a target, and does not trigger lowering.
- 4) Lowering generally ignores the final vowel morpheme /-a/, which occurs in verbs and expresses aspect and tense. It appears also in derivational morphology (Hyman 1999: 238).
- 5) Lowering applies within roots and in suffixes. It generally ignores vowels in prefixes. The process is root controlled and progressive.

According to Hyman's survey, 57 out of 134 languages display all those properties. Among those, there are languages displaying both seven and five vowels in their phonemic systems. Languages displaying the most common patterns are mostly located in the central and eastern parts of the Bantu region. Tables (6) and (7) report two examples of Canonical lowering. This process appears in languages with a seven-vowel system (Nyamwezi in 6) or a five-vowel system (Shona in 7). The table in (6) shows that the applicative suffix /-ɪl/ and the reversive transitive suffix /-ʊl/ of Nyamwezi (7VSA) alternate with lower forms (/ -eɪ/ and / -ɔɪ/ respectively) when preceded by roots with a mid-low vowel. In (7) the applicative /ira/ and the causative /isa/ of Shona (5VS) alternate with /-era/ and /-esa/ when preceded by a mid-vowel.

⁴⁴ In some cases, for example in Mbunda (Sandstedt 2018: 10), /a/ actually behaves as a valid trigger for lowering.

(6) Example of canonical lowering in Nyamwezi (F 22.) from Hyman (1999: 237)

<i>Applicative suffix: /-il/</i>		<i>Reversive transitive suffix: /-ol/</i>	
βɔn-ɛl-a	'see'	hɔŋ-ɔl-a	'break off'
zɛɛŋ-ɛl-a	'build'	zɛɛŋ-ɔl-a	'build'
βis-il-a	'hide'	βis-ɔl-a	'find out'
pɪnd-il-a	'bend'	pɪnd-ɔl-a	'overturn'
gub-il-a	'put on lid'	gub-ɔl-a	'take off lid'

(7) Example of canonical lowering VH in Bantu in Shona (S 10) from Beckman (1997:10 data derived from Fortune 1955)

<i>Roots</i>		<i>Roots + Applicative /-ira/</i>	
pera	'end'	per-era	'end in'
pona	'sew'	son-era	'sew for'
tsveta	'stick'	tsvet-era	'stick to'
sona	'sew'	son-era	'sew for'
ipa	'be evil'	ip-ira	'be evil for'
bata	'hold'	bat-ira	'hold for'
svetuka	'jump'	svetuk-ira	'jump for'
<i>Roots</i>		<i>Roots + Causative /-isa/</i>	
tonda	'face'	tond-esa	'make to face'
shoŋga	'adorn self'	shoŋg-esa	'make adorn'
oma	'be dry'	om-esa	'cause to get dry'
bvuma	'agree'	bvum-isa	'make agree'
pamha	'do again'	pamh-isa	'make do again'
shamba	'wash'	shamb-isa	'make wash'

I refer to (Hyman 1999) for a detailed description of various lowering patterns that may differ from the canonical lowering harmony described in this section.

II.3.1.3 Raising in Bantu

In this large section, the harmonic processes involving raising found in Bantu languages are discussed. As already mentioned, tones are not reported in any of the examples. When necessary, I refer to the classes of prefixes that may undergo or trigger harmony. For each language in this section of the survey, I signal the country or the region where it is spoken and its Guthrie code (Guthrie 1967)⁴⁵.

II.3.1.3.1 Nzebi: Gabon, Congo (B52)

Nzebi displays an eight-vowel system, that can be considered an augmented version of the seven-vowel system of the type 7VS:B. Vowel distribution in Nzebi is severely limited (Parkinson 1996: 55).

⁴⁵ Bantuists make use of a referential classification, created by Malcolm Guthrie, in which every language is identified by a code (Guthrie code), which gives an indication of the language's geographical location. As in the vast majority of the more recent literature on Bantu languages, I will use the revised notation from Maho (2009).

Within a stem, the first vowel (V_1) may be each one of the vowels of the vowel system, while the second vowel (V_2) is always [ə], which in turn never appears in first position. A stem will thus be structured like this: CV_1CV_2 : $V_1=\{i, e, \varepsilon, a, \text{ɔ}, o, u\}$, $V_2=\{\text{ə}\}$. Nzebi has a pattern of alternation in verbs conditioned by the presence of the fleeting suffix vowel /-i/ (that Parkinson calls “yotized form”, Parkinson 1996: 55), which is overtly pronounced only in extra-careful speech and when it is followed by an enclitic (Clements 1991: 48; van der Hulst 2018: 264)⁴⁶. The raising effect displays itself as a regressive harmony that raises vowels to one degree of height, so that low vowels raise to mid-low, mid-low vowels raise to mid-high, and mid-high vowels raise to high. The trigger is invariably a high vowel /i/, since /u/ does not appear in a potential triggering position. Examples from Nzebi given in §I.3.2.4 are repeated here for completeness.

(8) Nzebi Height harmony
a. Nzebi vowel system

	<i>Front</i>	<i>Central</i>	<i>Back</i>
<i>Height-1</i> ⁴⁷	i		u
<i>Height-2</i>	e	ə	o
<i>Height-3</i>	ε		ɔ
<i>Height-4</i>		a	

b. Alternations in Nzebi

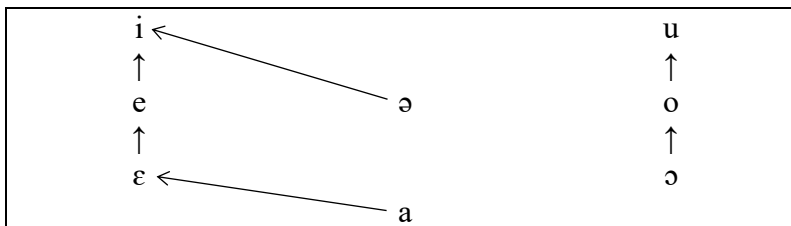
<i>Target vowels</i>	<i>Base Form</i>	<i>Yotized form</i>	
e	betə	biti	‘carry’
	bexə	bixi	‘foretell’
o	βoomə	βuumi	‘breathe’
	kolən	kulini	‘go down’
ε	sebə	sebi	‘laugh’
	βεədə	βeedi	‘give’
	suemə	suemi	‘hide’
ɔ	tɔdɔ	toodi	‘arrive’
	mɔnə	moni	‘see’
a	salə	səli	‘work’
	baadə	bæedi	‘be’

Raising applies to all non-high vowels. It is not clear whether /u/ may act as a valid trigger. When a centralized V_2 raises/is raised, the outcome of the process is a high vowel /i/ (cf. [kolən] – [kulini]). To sum up, the raising pattern operates raising all non-high vowels by a degree, i.e., it behaves as scalar.

⁴⁶ Van der Hulst (2018) and Parkinson (1996) disagree on the nature of the segments that in the table above are treated as mid-high vowels. I followed Parkinson’s analysis, while van der Hulst (2018) swaps mid-high vowels [e,o] with high lax [ɪ, ʊ]. The process still behaves as a case of raising harmony as described in the text, and not as tongue root harmony, since only the high vowel /i/ triggers the process, while vowels of other heights do not.

⁴⁷ The vowel systems of Bantu varieties are represented around height degrees, and not on the traditional [±high] [±low] [±ATR] features. This allows for a presentation of data that does not commit to a single representational theory.

(9) Scalar raising in Nzebi raising harmony



II.3.1.3.2. Kinande: Uganda (J[D]42)

Kinande (Hyman 1989, Clements 1991, Mutaka 1995, van der Hulst 2018) displays a 7VS:A structured as follows: /i, ɪ, ε, a, ɔ, ʊ, u/. As in Nzebi, vowel distribution is restricted. In disyllabic roots of the form CV₁CV₂, the second vowel (V₂) must agree in height with the preceding vowel, unless it is /a/, which can occur in all contexts. Vowels different than /a/ must agree with the height degree of the preceding vowel. The restriction posed on the second vowels of the root creates vowel sequences of this kind:

CV {i,u} CV {i,u,a} CV {ɪ,ʊ} CV {ɪ,ʊ,a} CV {ε,ɔ} CV {ε,ɔ,a}

This distribution can be considered as the application of a height harmony that applies within the stem and that spreads the values for the height features [±high] and [±ATR] from V₁ to V₂. This process, however, does not create alternations, but reflects a process that was active at an earlier stage: in other words, it is lexicalized.

Kinande also displays a scalar regressive raising harmony, which affects vowels of the second and third degree of height in prefixes followed by a high vowel /i/ in the stem. The process is structure-preserving⁴⁸ when it targets /ɪ/ and /ʊ/, raising them to [i] and [u] respectively. It is allophonic when it targets mid low vowels [ε] and [ɔ]. They raise to [e] and [o] respectively, but the latter vowels do not occur distinctively in Kinande.

Raising is scalar, and affects vowels of the second and third height degree when followed by a Height-1 vowel. The low vowel /a/ seems unaffected by the process. Hyman (1989) argues that the low vowel actually undergoes allophonic raising, raising to [ə]. This quality of the low vowel becomes audible only in contexts where the low vowel is long, so that a single [a] appears to be transparent. Hyman (1989), Mutaka (1995) and Archangeli & Pulleyblank (2002) actually consider this process as a tongue root-harmony, since the process affects only the feature [±ATR] and not the other height features, while Clements (1991) treats it as an instance of raising. In the table below, alternations in prefixes and in roots are presented⁴⁹. Vowels in roots behave as triggers for preceding augments /ε/ and /ɔ/ and for the prefix /-rɪ/. Final suffix /-i/ in the agentive behaves as a trigger for preceding vowels in the root.

⁴⁸ Structure-preserving means that the outcome of a phonological rule is a vowel that is already in the phonemic system of the language (Kiparsky 1985). It is the opposite of an allophonic rule. An allophonic rule defines a process that applies regularly and creates an alternation between a phonemic vowel and a vowel that never occurs in the language, except for when it is the outcome of that same rule.

⁴⁹ Clements (1991) and Mutaka (1995) disagree in the behavior of augments (or pre-prefixes) in harmonic contexts. Nouns in Kinande have the following general structure: Augment (or pre-prefix) – Nominal prefix – Stem. The variety of Kinande considered by Mutaka (1995) does not display raising in the augments: the harmonic process, which in pre-prefix applies optionally, generally ignores them. The variety of Kinande considered by Clements (1991), instead, displays alternations in both the prefix and the pre-prefix. The examples I reported all come from Clements (1991), and thus display alternations in both the pre-prefix and in the prefixes.

In (10a) is reported the vowel system of Kinande. As assumed by Clements (1991:56), I treat raised Height-3 vowels as allophonic vowels, and not as distinct phonemes of the language. (10b) reports alternations caused by raising. The first column shows infinitives formed from the prefix sequence /ε-ri/. Both vowels raise if followed by a Height-1 vowel. The second column shows agentive nouns, which have the prefixes /o-mu/. The agentive suffix is a Height-1 vowel /i/, therefore the prefixes always surface as [o-mu].

(10) Raising harmony in Kinande (Clements 1991:56)

a. Kinande vowel system⁵⁰

	<i>Clements (1991)</i>		<i>IPA notation</i>	
	<i>Front</i>	<i>Back</i>	<i>Front</i>	<i>Back</i>
<i>Height-1</i>	i	ɯ	i	u
<i>Height-2</i>	ɪ	u	ɪ	ʊ
<i>Raised Height-3</i>	ɛ̥	ɔ̥	e	o
<i>Height-3</i>	e	o	ɛ	ɔ
<i>Height-4</i>	a		a	

b. Harmonic alternations in Kinande

<i>Root</i>	<i>Verb</i>		<i>Agentive</i>	
lim	e-ri-lim-a	'to exterminate'	o-mu-lim-i	'exterminator'
lib	e-ri-lib-a	'to cover'	o-mu-lib-i	'coverer'
huk	e-ri-huk-a	'to cook'	o-mu-huk-i	'cook'
lim	ε-ri-lim-a	'to cultivate'	o-mu-lim-i	'farmer'
hɔm	ε-ri-hɔm-a	'to beat'	o-mu-hum-i	'beater'
hɛk	ε-ri-hɛk-a	'to carry'	o-mu-hek-i	'porter'
bɔh	ε-ri-bɔh-a	'to tie'	o-mu-boh-i	'tier'
kar	ε-ri-kar-a	'to force'	o-mu-kar-i	'forcer'
sat	ε-ri-sat-a	'to dance'	o-mu-sat-i	'dancer'

If we agree with Clements' analysis, in which pre-prefixes undergo harmony, the process appears to be iterative, as in [e-ri-lim-a] 'to exterminate'. According to Mutaka (1995), pre-prefixes are generally neutral to VH, and are often left untouched: cf. 'to cover': [e-ri-lib-a] (Clements 1991) vs. [ε-ri-lib-a] (Mutaka 1995). Examples among agentive forms, in which the suffix always triggers raising, appear to confirm the iterative nature of harmony. cf. 'farmer': [o-mu-lim-i] (Clements 1991) vs. [ɔ-mu-lim-i] (Mutaka 1995). In this last example taken from Mutaka, even though the pre-prefix does not undergo harmony, the process triggered by the final vowel affects the height of both the root vowel and that of the prefix.

To sum up, Kinande has a scalar raising harmony triggered by Height-1 vowels, which targets Height-2 and Height-3 vowels, raising them by a degree. Height-2 raising outcome is a Height-1 vowel, while

⁵⁰ I reinterpreted the symbols Clements used in his examples using IPA symbols. The correspondence between the symbols I used and those used by Clements is shown in the table.

Height-3 raising is allophonic, and surfaces as a mid-high allophone of a mid-low vowel, considered by Clements (1991:56) to be distinct from Height-2 vowels.

II.3.1.3.3. Zulu-Nguni (South Africa, S42)

Zulu has a five-vowel system, with three height distinctions: high vowels /i, u/, mid vowels /ε, ɔ/, low vowel /a/. In Zulu is active a process of regressive raising harmony that affects mid vowels (Height-2 vowels) raising them from /ε,ɔ/ to [e,o]. The process is allophonic, since it raises mid-vowels (mid-low) to phonetically mid-high vowels, which are otherwise absent from the language⁵¹. The process seems to be not iterative (cf. the third section of the table b. under 11).

(11) Zulu raising harmony (cf. Harris 1987, Parkinson 1996 and Tabuse 2017)

a. Zulu vowel system

	Front	Back	
Height 1	i	u	
Raised H2	(e)	(o)	*non phonemic
Height 2	ε	ɔ	
Height 3	a		

b. Harmonic alternations in Zulu

<i>I Root internal VH Harris (1987:269)</i>	izi-nceku	'chiefs'	ama-gεja	'hoes'
	izi-yoni	'birds'	izi-nyɔka	'snakes'
	izi-ndlovu/indlɔvu	'elephants'	ama-zwe	'countries'
	ama-bubesi	'lions'	izi-ngubɔ	'blankets'
	umɔŋgi	'a nurse'	umgɛɛ	'a cave'
	ulwembu	'spider web'	gɔna	'hug'
	igovu	'German dog'	izi-kelɔ	'scissors'
<i>II VH in derived forms Harris (1987: 269), Parkinson (1996: 81)</i>	phɛk-a	'cook (verb)'	um-phɛk-i	'cook (noun)'
	ŋɛn-a	'enter'	ŋɛn-is-a	'bring in'
	ɔn-a	'sin'	is-on-i	'sinner'
	bɔn-a	'see'	bon-is-a	'show'
	bɔn-a	'see'	si bon il ε	'we saw'
	lɛ:l-ɔ	'that'	lɛ:l-i	'this'
	ɛ:d-a	'finish'	si-ed-il-ε	'we finished'
khɔ:mmb-a	'point'	si-khommb-il-ε	'we pointed'	

⁵¹ Mid-high vowels surface in Zulu also as the result of a process of coalescence (Harris 1987: 270). Hiatuses composed by /a/ and a high vowel /u/ or /i/ give rise to mid vowels. If the high vowel involved in the coalescence is short, the result of coalescence is a mid-low vowel (which behaves as a valid target for raising). If the high vowel involved is high, the result is invariably a mid-high vowel, regardless of the height degree of the vowel that follows. Still, there are no lexical mid-high vowels that are not the result of a phonological process triggered by /i/ and /u/.

<i>III Multiple vowel sequences (Tabuse 2017: 18)</i>	phɛlɛlisa	‘make complete’
	izikɛlemu	‘worms’
	fɔkosi	‘little bush’
	ɛlovu	‘a place name’
	ɛmɔjeni	‘in the air’

Zulu raising affects the mid vowels /ɛ/ and /ɔ/, raising them allophonically by a degree so that they surface as mid-high [e] and [o]. The examples in the third section of (11.b) display cases of multiple mid-vowels mismatched for relative height (i.e., mid-low vowels followed by mid-high vowels). Mid-high vowels are the result of harmony, triggered by a following high vowel. Mid-low vowels are not subject to raising, showing that the process is not iterative. Notice that harmony does not reach the leftmost mid-vowels, which surfaces as mid-low even when followed by a raised mid-vowel: [izikɛlemu], *[izikelemu] ‘worms’; [fɔkosi], *[fokosi] ‘little bush’. Besides showing the non-iterative nature of harmony in Zulu, I believe those examples justify the labelling of Zulu harmony as a case of raising. Mid-high vowels, the result of harmony, do not trigger the process because they are not high. If the process were a tongue-root harmony we would expect [+ATR] mid-high vowels to behave as valid trigger for a preceding [-ATR] mid-low vowel.

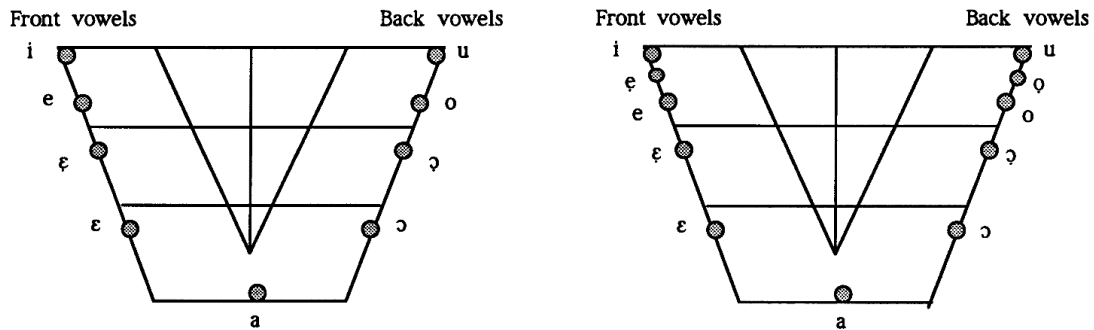
II.3.1.3.4 SeSotho: South Africa, Lesotho (S33)

Sesotho (or simply Sotho) is a Sotho-Tswana language spoken in South Africa and Lesotho, where it is the national language. The vowel system of Sotho-Tswana languages tend to be rather complex in regards to the definition of height contrasts.

Traditional studies dealing with Sesotho and Tswana treat the vowel systems of these languages as formed by seven vowels (cf. the discussion in Khabayane 1991), while eleven vowels appear on the surface. Mid-high vowels are often considered allophones of mid-low vowels. Mid-high vowels normally appear only as a result of raising of mid-low vowels. Khabayane (1991) and Parkinson (1996) argue otherwise, and demonstrate that not all occurrences of the allophonic mid-vowels are limited to harmonic contexts. They consider mid-high vowels [e] and [o] to be phonologically distinct, and not only the result of /ɛ/ and /ɔ/ raising. In the following table are reported the underlying and surface vowel system of Sesotho according to Khabayane and Parkinson. The phonetic realization of vowels in Sesotho appears to be very intricate throughout the literature. I refer to Khabayane (1991: 12ff) for an in-depth phonetic analysis of vowels in Sesotho, and to Parkinson (1996: Appendix A) for a summary of the treatment of the Sesotho vowel system. Parkinson and Khabayane, while agreeing in the general analysis, describe with different symbols the complex vowel system of Sesotho and other Sotho-Tswana languages. In the table in (12a) and (12b) I report both versions of the vowel system, in order to allow a comparison between the two.

(12) Vowel system of SeSotho

a. Underlying vowels (left) and surface vowels (right) of SeSotho in Khabayane (1991)



b. Vowel system of SeSotho in Khabayane and Parkinson analyses

	<i>Parkinson (1996)</i>		<i>Khabayane (1991)</i>		
<i>Height-1</i>	i	u	i	u	
<i>Raised H2</i>	i	u	ɛ	ɔ	*non phonemic
<i>Height-2</i>	ɪ	ʊ	e	o	
<i>Height-3</i>	e	o	ɛ	ɔ	
<i>Height-4</i>	ɛ	ɔ	ɛ	ɔ	
<i>Height-5</i>	a		a		

Under (13) are shown some minimal pairs that exhibit the phonemic status of Height-3 vowels. Height-4 vowels (ɛ,ɔ) contrast with Height-3 vowels (e,o/ɛ,ɔ).

(13) Height-3 vowels are phonemic

ena	<i>these</i>	ɛna	<i>become rich</i>
sela	<i>that yonder (Noun class 4)</i>	sɛla	<i>buy food</i>
hona	<i>this (Noun class 7)</i>	hɔna	<i>it (Noun class 7)</i>

Setting aside discussion of the vowel system of Sotho-Tswana languages, raising in SeSotho applies to Height 4 and Height 2 vowels, and raises them by a degree. In the case of mid-low vowels, they raise to mid-high (which are rare, but phonemic in Sotho, as just discussed). This process is structure-preserving, and is triggered by both Height-1 and Height-2 vowels: in other words, Height-1 and Height-2 vowels trigger Height-4 raising. No example of Height 3 raising is reported in the literature. This may be due to the fact that, even though Height-3 vowels are phonemic in SeSotho, they are not frequent in the language. Raising also affects Height-2 vowels when followed by Height-1 vowels. This process is allophonic, since the results of Height-2 raising are not phonemic. [i,u]/[ɛ,ɔ] only appear in Sesotho as the result of raising, and never in the lexicon. Under (14) alternations in Sesotho are shown. In the table I chose to report forms using the vowel system described in Parkinson (1996) (P 96) and Khabayane (1991) (K 91).

(14) Raising harmony in Sesotho

a. Raising of Height-4 vowels

Target vowels	Roots		Alternations caused by Height-1 and Height-2 vowels		
			P 96	K 91	
ε	fɛl-a	'come to an end'	fel-ɿsa	fɛl-is-a	'finish'
	rɛm-a	'chop down'	rem-ɿle	rɛm-il-e	'have chopped down'
	mɛm-a	'invite'	mem-ɿs-a	mɛm-is-a	'cause to invite'
	bɛtl-a	'sharpen'	betl-ɿw-e	bɛtl-uw-ɛ	'has been sharpened'
ε	ɛp-a	'dig'	ɛp-oll-a	ɛp-oll-a	'dig out'
	qɛk-a	'entice'	qɛk-oloh-a	qɛk-oloh-a	'avoid'
	ɛm-a	'stand'	em ɪ	ɛm e	'standing'
ɔ	bɔn a	'see'	sɪ bon ɿ	se bɔn i	'thing that sees'
	rɔk a	'praise'	sɪ rok ɿ	se rɔk i	'poet'
			rok ɿl e	rɔk il e	'praised'
bɔl a	'rot'	sɪ bod ɿ	se bɔd u	'rotten thing'	
ɔ	pɔt a	'go round'	pot ɪ	pɔt e	'not go around'
	kɔb a	'bend'	kob ɔll a	kɔb oll a	'unbend'

b. Raising of Height-2 vowels

Target vowels	Roots			Alternations caused by Height-1 vowels		
				P 96	K 91	
ɪ/e	lɪm-a	lem-a	'cultivate'	mulimɿ	moɓemi	'cultivator'
	bɪl-a	bel-a	'boil'	bid ɿle	bɛd il e	'boiled'
				bid ɿs a	bɛd is a	'cause to boil'
lɪf-a	lef-a	'pay'	lif ɿw e	lɛf uw ɛ	'has been paid'	
ʊ/o	tsum-a	tsum-a	'hunt'	sɪ tsum ɿ	sɪ tsɔm i	'hunter'
	nɔk-a	nok-a	'season'	nukɿwe	nɔkuwɛ	'has been seasoned'

Harmony in Sesotho is regressive and scalar. There are no clear signs of asymmetry. We could consider lack of raising in Height-3 vowels (which both Parkinson and Khabayane treat as phonemic) as the result of a condition on the selection of targets disallowing Height-3 vowels from raising, but as already noted this may be due solely to the low frequency of underlying Height-3 vowels in Sesotho. The only vowel that does not participate in harmony is the low vowel /a/, which lacks a harmonic counterpart.

Khabayane (1991) also reports raising of Height-2 vowels caused by palatal and velar consonants, which may be the result of an ancient assimilatory process triggered by the nowadays lost *i and *u.

In addition, in some morphemes mid-vowels are always realized as raised. Harris (1987) considers this as a sort morphological effect on raising, but it can be considered as an ulterior proof that mid-high vowels are actually phonemic in SeSotho.

II.3.1.3.5. *SeTswana: Botswana, South Africa (S31)*

A harmonic pattern akin to that presented for SeSotho is active in all Sotho-Tswana languages, SeTswana (Parkinson 1996: 56) and Northern Sotho. Sotho-Tswana languages share generally the same vowel system, and display the same harmonic pattern already discussed for SeSotho. Consider, alongside Parkinson (1996), also Cole (1955: 18) for a discussion of the vowel system of Tswana. Here I employ the representation system used in Parkinson (1996): the process turns Height-4 vowels /ε,ɔ/ into Height-3 vowels [e,o] and Height-2 vowels /i,u/ into their raised alternant (which is assumed to be allophonic) [i,u].

In addition to high vowels, according to Cole (1955) and Mielke (2008) the same raising process can be triggered also by nasals (m,n, ŋ ɲ) and sibilants (ts^h, tʃ^h, ts', tʃ', s, ʃ). An interesting property of Tswana is that raised mid-high vowels [e,o], which result from raising of mid-low vowels /ε,ɔ/, behave as triggers for preceding mid-low vowels, as shown in (15b): raising propagates to both mid-vowels, not only to the first one.

(15) SeTswana vowel harmony (Parkinson 1996: 64)

a. *Raising in SeTswana: Height-4 vowels raise to Height-3, Height-2 vowels surface as allophonic [i,u]*

Root		Raised alternant	
εm-e	<i>stand</i>	ki-em-i	<i>I am standing</i>
rɛk-a	<i>buy</i>	xa-ki-rɛk-i	<i>I do not buy</i>
bɔf-a	<i>tie</i>	bof-ɔlɔl-a	<i>untie</i>
rɛk-a	<i>buy</i>	mɔ-rɛk-i	<i>one who buys</i>
lɔw-a	<i>bewitch</i>	mɔ-low-i	<i>witch</i>
lif-a	<i>pay</i>	mu-lif-i	<i>one who pays</i>
xɔ-rɔk-a	<i>to sew</i>	mu-ruk-i	<i>tailor</i>

b. *Iterative raising in Se-Tswana*

xɔɔxa	<i>arrive, come home</i>	xorots ^h a	<i>bring home</i>
bɛlexa	<i>carry</i>	bɛlesa	<i>cause to carry</i>

The VH of Tswana is identical to the one discussed above found in SeSotho. In both cases, high vowels (Height-1 and Height-2) raise preceding mid-vowels, while super-high vowels (Height-1) appear to raise preceding high vowels (Height-2). Examples under (15) follow the Parkinson/Clements analysis of the vowel system of Sotho-Tswana languages. Cole (1955: 17) considers eleven surface vowels grouped into seven phonemes, suggesting that all the raised alternants are allophonic.

The vowel system of Sotho-Tswana languages and their raising harmonies are hard to capture using a standard set of primes, as we have done up until now. Five height degrees appear to be relevant phonemically, and a sixth one is necessary to allow a result of raising that differs between Height-1 and Height-2 vowels, as shown in the table under (16b). The three primes I have been using up until now are not able to capture the height distinctions of Sotho-Tswana languages. If we are to trust either Parkinson's or Khabayane's rendition of Sotho-Tswana vowel systems, we remain short of primes, or we need to alter the prime specification of other vowels (i.e., requiring mid-low vowels ε,ɔ to be [+low][+ATR] and

push up by a degree the other prime specifications) in order to capture the complete picture. This is shown in (16).

(16) Prime specification in binary features of the vowel system of Sotho-Tswana languages

	<i>Parkinson (1996)</i>		<i>Feature assignation</i>	<i>Khabayane (1991)</i>		<i>Feature assignation</i>
<i>Height-1</i>	i̥	ɯ	?	i	u	[+high][+ATR]
<i>Raised H2</i>	i	u	[+high][+ATR]	ɛ̥	ɔ̥	?
<i>Height-2</i>	ɪ	ʊ	[+high][-ATR]	e	o	[-high][+ATR]
<i>Height-3</i>	e	o	[-high][+ATR]	ɛ̣	ɔ̣	?
<i>Height-4</i>	ɛ	ɔ	[-high][-ATR]	ɛ	ɔ	[-high][-ATR]
<i>Height-5</i>	a		[-high][+low][-ATR]	a		[-high][+low][-ATR]

The same problem arises when Elements of the standard Element Theory (Backley 2011) are applied. Such a number of contrasts is not representable through the sole presence/absence of the prime [A].

In §IV.2 are presented some representational models that solve the problem posed by Sotho-Tswana vowel systems. They are strategies that represent height as a complex system based on multiple iteration of a single prime. A relevant aspect that may be important to anticipate here, and that will prove to be central later, is the fact that complex height systems such as the one reported in (16) force linguists to make a binary choice regarding the nature of phonological representation:

- The set of prime (whichever we choose) must be able to represent a 5-way contrast based on height (i.e., new primes must be added to the set of innate primes. But which ones?)
- The representation of height in SeSotho or in SeTswana is not the same of the representation of height in, say, Nzebi, English or Italian. It follows that phonological representation must be, at least partially, language specific.

II.3.1.3.6 Phuthi, South Africa, Lesotho (S404)

Phuthi is a Nguni language spoken between South Africa and the Southern Lesotho border. It is closely related to SiSwati, spoken in Eswatini, but has been strongly influenced by neighboring SeSotho and Xhosa. Phuthi vowel system is comprised of nine vowels: /i̥, i, ɯ, u, e, o, a, ɛ, ɔ/. Donnely (1999) notes that mid-low vowels /ɛ, ɔ/ and mid-high vowels /e, o/ are almost in complementary distribution, depending on the mechanism of the regressive harmony. The vowel system of Phuthi closely resembles that of Sotho-Tswana languages treated above. Both systems distinguish between high and super-high vowels: the super-high vowels occur almost exclusively in Sotho loanwords and in harmony processes set up by these root vowels. Again, as was the case for Sotho-Tswana languages, the phonetic realization of high vowels in Phuthi is not entirely clear. Donnely (1999: 87) considers the distinction between high and super-high vowels to be based on tongue root position, but does not give an in-depth phonetic analysis of the realization of vowels in Phuthi.

If Donnely's analysis is correct, Height-1 vowels /i̥/ and /ɯ/ would be considered to be [+high] and [+ATR] (corresponding to the more common high vowel [i] and [u]), while Height-2 vowels should be represented as [+high] [-ATR] (i.e. more in line with [ɪ, ʊ]). In all the examples reported in (18, 19, 20), the graphic rendition of vowels follows the data proposed by Donnely (1999), and the description of Phuthi vowel system reported in (17).

(17) Phuthi vowel system.

	<i>Front</i>	<i>Back</i>
<i>Height 1</i>	i	ɯ
<i>Height 2</i>	ɪ	u
<i>Height 3</i>	e	o
<i>Height 4</i>	ɛ	ɔ
<i>Height 5</i>	a	

Phuthi displays two different harmonic processes involving vowel height. The first one is a progressive harmony that raises high vowels in suffixes when preceded by a super-high vowel in the root. Super-high root-vowels require all adjacent suffixes containing a high vowel to be super-high too. Prefixes do not follow this requirement, suggesting that the process is purely progressive. Harmony does not seem to be sensitive to morphological class. Intervening non-high vowels behave as blockers for this harmony.

Donnelly’s (1999) analysis of progressive raising harmony is based on a modification in the specification for the feature [±ATR], but only high vowels seem affected (as both triggers and targets) by the process. There is no agreement for ATRness between mid-vowels, nor any ATR adjustment for mid vowels preceded by a super-high vowel. As for other problematic cases, I follow the generalization given in §2, and consider Phuthi harmonies as based on height.

Under (18) and (19) are shown alternations in Phuthi. (18) shows that all suffixes added to a root containing a Height-1 vowel harmonize in height. In (19) the same suffixes are added to Height-2 roots. In (20) are shown roots with Height-3 vowels with some suffixes, to show the underlying height of suffixes. Suffixes are underlyingly Height-2, and surface as Height-1 when affected by a Height-1 vowel in the root (as in 18).

(18) Progressive raising in Phuthi: roots containing super-high vowels (Height-1).

<i>Infinitive</i>	ku-thɯɯs-a	‘to help’	ku-bɿɿt-a	‘to call’
<i>Causative</i>	ku-thɯɯs-ɿɿs-a	‘to cause to help’	ku-bɿɿt-ɿɿs-a	‘to make call’
<i>Intensive</i>	ku-thɯɯs-ɿsɿs-a	‘to help intensively’	ku-bɿɿt-ɿsɿs-a	‘to call intensively’
<i>Present negative</i>	aba-thɯɯs-i	‘they are not helping’	aba-bɿɿt-ɿ	‘they are not calling’
<i>Perfective</i>	ba-thɯs-ɿɿje	‘they have helped’	ba-bɿt-ɿɿje	‘they have called’
<i>Perfective passive</i>	ba-thɯs-ɯɯwɛ	‘they have been helped’	ba-bɿt-ɯɯwɛ	‘they have been called’
<i>Intensive + perfective</i>	ba-thɯs-ɿsɿs-ɯɯwɛ	‘they have been helped intensively’	ba-bɿt-ɿsɿs-ɯɯwɛ	‘they have been called intensively’
<i>Reversive</i>			ku-bɿt-ɯlll-a ⁵²	‘to be disrespectful to one’s name’

⁵² [l] represents “syllabic” [l].

<i>Applied+causative</i>	ba-ya-thuṣ-el-iis-a	<i>'they cause to help for'</i>	ba-ya-biṭ-el-iis-a	<i>'they help call for'</i>
<i>Reciprocal + causative</i>	ba ya thuṣ an iis a	<i>'they cause heach other to get help'</i>	ba ya biṭ an iis a	<i>'they help call each other'</i>

(19) Progressive raising in Phuthi: roots containing high vowels (Height-2)

<i>Infinitive</i>	ku-ḍziin-a	<i>'to dress'</i>	ku-kguubḥ-a	<i>'to dig'</i>
<i>causative</i>	ku-ḍzin-iis-a	<i>'to help dress'</i>	ku-kgubḥ-iis-a	<i>'to cause to dig'</i>
<i>intensive</i>	ku-ḍzin-isiis-a	<i>'to dress intensively'</i>	ku-kgubḥ-isiis-a	<i>'to dig intensively'</i>
<i>present negative</i>	aba-ḍziin-i	<i>'they are not getting dressed'</i>	aba-kgubḥ-i	<i>'they are not digging'</i>
<i>perfective</i>	ba-ḍzin-iije	<i>'they have gotten dressed'</i>	ba-kgubḥ-ii-je	<i>'they have dug up'</i>
<i>perfective passive</i>	ti-ḍzin-uuwe	<i>'they have been put out'</i>	ti-kgujḥ-uuwe	<i>'they have been dug up'</i>
<i>intensive + perfective</i>	ti-ḍzin-isis-uuwe	<i>'they have been intensively put on'</i>	ti-kgujḥ-isis-uuwe	<i>'they have been intensively dug'</i>
<i>reversive</i>	ku-ḍzin-uḷll-a	<i>'to get undressed'</i>	ku-kgubḥ-uḷlla	<i>'to dig up'</i>
<i>applied+causative</i>	ba-ja-ḍzin-el-iisa	<i>'they help dress for'</i>	ba-ja-kgbḥ-el-iis-a	<i>'they help dig for'</i>

(20) Roots containing mid vowels (Height-3/ Height-4).

ku-jeet-a	<i>'do,make'</i>	ku-khookh-a	<i>'to take out'</i>
ku-jet-iis-a	<i>'to help make'</i>	ku-khokh-iis-a	<i>'to help take out'</i>
ba-jet-iije	<i>'they have made'</i>	ba-khokh-iije	<i>'they have taken out'</i>
ti-jet-uuwe	<i>'they have been made'</i>	ba-khokh-uuwe	<i>'they have been taken out'</i>

Tables (18) and (19) show roots containing super-high and high vowels respectively followed by suffixes that agree in height with the roots. The examples given in (20), where mid vowels in the root are followed by high vowels in the suffixes, show the underlying nature of suffixes: vowels in suffixes are high, and surface as superhigh only when preceded by a super-high vowel in the root.

Progressive harmony of Phuthi appears to be limited both in the selection of triggers (only Height-1 can trigger harmony) and in the selection of targets (only Height-2 vowels can undergo harmony).

Alongside progressive raising, another height related process is present and active in Phuthi (Donnelly 1999: 92). It is a regressive lowering harmony triggered by final mid vowels, which always surface as mid-low vowels [ɛ,ɔ] (this can be noted also in the examples provided in tables 18, 19 and 20). Donnelly treats this process, as the process of raising discussed above, as a case of tongue-root harmony. Preceding mid vowels harmonize in their degree of height with final mid-low vowels. Interestingly, all other vowels behave as blockers for lowering agreement.

In sum, mid-high vowels (Height-3 vowels) surface as mid-low (Height-4) when they are followed by them. High vowels (Height-2 vowels) behave as blockers for this process of regressive lowering⁵³.

(21) Regressive lowering harmony in Phuthi.

ku-yeet-a	<i>to make</i>
ba-yεεt-ε	<i>they should make</i>
ba-yεt-εεnε	<i>they have made each other</i>
ku-khookh-a	<i>to take out</i>
ba-khɔɔkh-ε	<i>they should take out</i>
ba-khɔɔkh-εel-ε	<i>they should take out for</i>
ku-khokh-eel-a	<i>to take out for</i>
ku-khokh-el-aan-a	<i>to take out for each other</i>
ba-khokh-el-aan-ε	<i>they should take out for each other</i>
ba-khokh-el-iis-ε	<i>they should help take out for</i>

The definition of this harmony as Tongue-root harmony or as height-harmony is outside the scope of the chapter, since we are not directly interested in lowering processes. However, this harmony pattern sheds some light on the process of progressive raising exemplified in the tables (19) and (20). Recall that Donnelly (1999) considers both harmonies as tongue root-based, suggesting that Height-1 and Height-2 vowels differ for their specification for [±ATR]. If Donnelly’s (1999) analysis is correct, the process exemplified in (19) would be an ATR harmony that ignores mid-vowels (Height-3 and Height-4 vowels). Similarly, the regressive harmony reported in (21) would be considered an ATR harmony that ignores high and super-high vowels (i.e., a process in which their specification for ATR would be irrelevant).

However, if we take into account the diagnostic discussed in II.2, we would expect vowels of all heights as actors in a Tongue-root harmony. This is not the case in Phuthi, where advanced and retracted vowels of different heights do not participate in both harmonic patterns. Height-1 and Height-2 vowels are subject to the progressive harmony, while Height-3 and Height-4 vowels are subject to the regressive harmony presented in (21). In other words, If Height-2 vowels were the [-ATR] version of Height-1 vowels (as suggested by Donnelly), we would expect them to participate in regressive harmony since they would share with the triggers the [-ATR] specification. The fact that they do not constitutes evidence that progressive harmony cannot be captured in terms of ATRness. Similarly, I also argue for a treatment of Phuthi regressive harmony as a lowering harmony, and not as a Tongue-root harmony. This conclusion, however, forces us to confront again the problems noted in §3.1.3.4 regarding Sotho-Tswana vowel systems. What theory of representation can make sense of the Phuthi vowel system? (cf. §IV.2).

II.3.1.3.7 Logoori: Tanzania (J[E]41)

Logoori has a vowel system of the type 7VS: A, displayed in (22).

⁵³ According to Donnelly (1999: 99) the low vowel /a/ displays an erratic behavior, behaving sometimes as transparent and sometimes as a blocker. Donnelly defines /a/ as “weakly transparent” in regards to this harmonic process. Still, it never behaves as a trigger. I refer to the source material for additional information about Phuthi regressive lowering.

(22) Logoori vowel system.

	<i>Front</i>	<i>Back</i>
<i>Height-1</i>	i	u
<i>Height-2</i>	ɪ	ʊ
<i>Raised Height-3</i>	(e)	(o)
<i>Height-3</i>	ɛ	ɔ
<i>Height-4</i>	a	

Mid-high vowels [e,o] are present in the surface as the result of a process of allophonic raising that targets mid-low vowels (Height-3) and raises them to become mid-high. As was the case for Kinande raising, this process may as well be considered a case of tongue-root harmony triggered by the only [+ATR] vowels that are phonemic in Logoori, which are /i, u/. In the examples in (23), raising is triggered by the causative suffix /-iz/.

(23) Allophonic regressive raising in Logoori.

ari-gaj-iz-a	<i>he will make prohibit</i>
ara-kaav-iz-a	<i>he will make search</i>
ku-deek-iz-a	<i>to make cook</i>
va-cherev-iz-i	<i>they made late</i>

High suffixes (as the causative /-iz/) raise preceding mid-low vowels, so that roots such as /-dɛɛk-/ surface as /-deek-/ when followed by the suffix /-iz/. The Height-2 vowel /ɪ/ is often a suffixal vowel, but its raising power in regressive raising cannot be tested, since it is contextually the target of a lowering harmony triggered by mid-low vowels.

In fact, Height-2 /ɪ/ surfaces as Height-3 [ɛ] when preceded by a Height-3 vowel. Lowering harmony affects only front /ɪ/, leaving unaffected higher vowels such as /i/ and /u/. This lowering process corresponds to the Canonical Bantu lowering harmony discussed earlier in §3.1.2. It appears that the parasitic asymmetry between front and back/rounded vowels typical of Canonical Bantu lowering evolved into a more general asymmetry in Logoori: the process applies only to front vowels and not to back/rounded vowels. For this lowering process, the low vowel [a] does not act as a trigger, but is instead transparent.

(24) Progressive lowering of /ɪ/ in Logoori.

ku-chab-a	<i>'to beat'</i>	ku-chab-ɪr-a	<i>'to beat for'</i>
ara-ɣɪ-ɪŋ-a	<i>'he will lift'</i>	ara-ɣɪŋ-ɪr-a	<i>'he will lift for'</i>
ku-dɛɛk-a	<i>'to cook'</i>	ku-dɛɛk-ɛr-a	<i>'he will cook for'</i>
vaa-cherev-a	<i>'they will speak'</i>	vaa-cherev-ɛr-a	<i>'they were late on'</i>
ara-mɔrɔm-a	<i>'they will speak'</i>	ara-mɔrɔm-ɛr-a	<i>'they will speak for'</i>
yaakɔ-kɔɔŋ-a	<i>'he helped'</i>	yaakɔ-kɔɔŋɛr-a	<i>'he helped for'</i>

In (24) the causative suffix /-ɪr/ lowers to [-ɛr] when preceded by a Height-3 vowel. Lowering does not affect higher vowels /i,u/, which in turn trigger allophonic raising of mid vowels (the process discussed above and exemplified in 23).

To sum up, Height-1/i,u/ vowels in suffixes trigger regressive (allophonic) raising of Height-3 vowels in roots. Height-3 vowels in roots trigger progressive lowering of Height 2 vowel /ɪ/ in the causative suffix, as shown in (24).

Progressive lowering generally ignores the final word vowel, which often has a specific morphological status in Bantu languages (cf. §3.1.2). Nonetheless, vowel alternation in the final vowel is reported for three different suffixes. Those suffixes are the deverbal adjective suffix, the imbricated perfective suffix and the subjunctive suffix. Examples in (25) show the behavior of underlying /ɛ/ in the in the subjunctive suffix.

(25) Harmony in the subjunctive suffix.

m-aa-dɛɛk-ɛ	'he will cook'	ma-va-babɪr-ɪ	'they will get dirty'
ma-va-rɔr-ɛ	'they will see'	ma-va-rɪnd-ɪ	'they will watch'
nɪ-va-vɔhɔɔll-ɛ	'they will untie'	ma-kɪ-gɔrɪzw-ɪ	'it will be sold'
kɔmaa-kɔ-kɔɔɲ-ɛ	'we will help'	ma-va-dɔɔɲ-ɪ	'they will look sad'
vaan-guumbɛɛll-ɛ	'let them hug me'	vamaa-va-sugum-ɪ	'they will push'

When the preceding vowel in the root is /ɛ/ or /ɔ/, the subjunctive suffix is realized as [-ɛ]. After /ɪ/, /o/, /i/ and /u/, the final suffix appears as [-ɪ]. Recall that the process seems to be limited only to a handful of suffixes, and not generalized to all mid-low vowels in final position.

Odden notes that the subjunctive suffix regularly appears as [ɛ] after a low vowel /a/, and it may surface as [ɪ] in some limited contexts⁵⁴. Odden reconstructs /ɛ/ as the underlying form of the subjunctive suffix, and thus consider the process reported in (25) as a case of raising.

To sum up, in Logoori three different harmony patterns are found:

- Progressive lowering, which lowers /ɪ/ to [ɛ] when it follows a mid-vowel.
- Allophonic raising harmony, which raises mid-low vowels /ɛ,ɔ/ to [e,o] when followed by a high vowel (raising caused by Height-2 vowels cannot be tested, since they undergo progressive lowering).
- Final-vowel progressive raising harmony. This process raises underlying /ɛ/ to [ɪ] when preceded by any high vowel (both Height-1 and Height-2 vowels trigger this harmony). This process may be limited only to a handful of suffixes, and may not apply to all final vowels.

⁵⁴ Instances with final [ɪ] after surface penult [a] predominantly occur when the consonants intervening between the penult and final vowels are *ll* or *ny*; after these consonants (with preceding [a]) you get [ɪ] (there may be some speaker disagreement: one speaker ML has [e] some of the time for *vamaa viigalli*). The reason is that [ɪ] is underlying /ɪr/, so /saangaar-ɪr-e/ undergoes raising to become *saangaarɪrɪ*, and then haplology gives you [saangaalli].

Other occurrences of [ɪ] when the preceding vowel is mid or low derive from underlying high vowels in intervening morphemes; cf. Odden (<https://sites.google.com/view/oddenlinguistics/logoori>) for a detailed account of the alternations in Logoori.

II.3.1.3.8 Tsonga: South Africa, Zimbabwe, Mozambique (S53)

Tsonga has a system of the type 7VS: B made up as follows: /i,e,ε,a,o,u/. Tsonga displays regressive raising harmony triggered by high vowels, which targets preceding mid-low vowels, making them mid-high.

Mid-high vowels behave as blockers; they do not undergo harmony and block the application of harmony when they intervene between a trigger and a target, as does low vowel [a]. This behavior of mid-high vowels is evident from the last example in (26b), where a raised mid-low vowel /ε/ becomes [e], and does not allow harmonization to reach the preceding mid-low vowel.

Data provided in Harris (1987: 263) and Parkinson (1996: 83) do not clearly state whether mid-high vowels appear solely as the outcome of mid-low vowel raising (as in Zulu) and thus the process may be considered allophonic, or whether they appear also in other contexts.

(26) Raising harmony in Tsonga (Harris 1987, Parkinson 1996)

a. Tsonga vowel system

	Front	Back
Height-1	i	u
Height-2	e	o
Height-3	ε	ɔ
Height-4	a	

b. Harmonic alternations in Tsonga

Root internal harmony	ndlel-a	'path'	si-kwa	'old woman'
	yingwe	'leopard'	tiko	'country'
	hweti	'month'	noyi	'sorcerer'
	si-lepfu	'chin'	homu	'head of cattle'
VH in derived forms	hel a	'end'	hel-ili	'ended'
			hel-is-a	'cause to end'
	kok a	'pull'	kok-ili	'pulled'
			kok-is-a	'let pull'
	hɔn a	'sin'	ʃi-hon-i	'sinner'
	sihɛŋge	'pineapple'	esihɛŋgen-i	'at the pineapple'
	ndɛb ε	'ear'	ndeben-i	'at the ear'

The process is regressive and it is of the dominant-recessive type. Vowels in roots alternate between Height-3 (mid-low vowels) and Height-2 (mid-high vowels) when followed by a high vowel in a suffix. /u/, being absent from suffixes, does not appear in any case of raising. For this reason, a possible limitation in the selection of triggers cannot be tested.

II.3.1.3.9 Kikuria: Kenya, Tanzania (E40)

Kikuria has a rich system of alternations related to vowel height. Chacha & Odden (1998) count up to four height-related harmonies coexisting in Kikuria, three regressive harmonies and one progressive harmony. This situation creates complex patterns of height related alternations.

Kikuria displays a seven-vowel system of the type 7VS:B structured as follows: /i, e, ε, a, ɔ, o, u/. Height-1 vowels are /i,u/, Height-2 vowels are /e,o/, Height-3 vowels are /ε,ɔ/ and the only Height-4 vowel is /a/.

The first harmony discussed is a regressive raising harmonic pattern that affects mid vowels in prefixes. The clearest context of application for this raising harmony are noun class-prefixes followed by a high vowel in the stem. In Bantu languages, nouns have somewhat arbitrary genders, which are marked with singular versus plural class prefixes. They are conventionally numbered from 1 to 22, and generally paired so that nouns with a singular in Class 1 have a plural in Class 2, a singular in Class 3 has a plural in Class 4 and so on. I refer to Odden (2015: 3) for a complete list of the Class prefixes reconstructed for Proto-Bantu (which determines the numeration from 1 to 22), and to Chacha & Odden (1998: 130) for the list of relevant class prefixes of Kikuria.

In Kikuria, noun-class prefixes may host high vowels, mid-high vowels or the low vowel [a]. Mid-low vowels do not appear in Class prefixes. Mid-high vowels in prefixes alternate with high vowels when followed by a high vowel in roots. Examples of harmonization of vowels in noun-class prefixes are reported in (27).

(27) Regressive Raising, mid-high to high: alternation in noun prefixes.

<i>Noun class prefixes</i>	<i>[-high] root vowels</i>		<i>[+high] root vowels</i>	
<i>Class 1 /omo-/</i>	omoo-nto	'person'	umu-riisja	'boy'
	omo-saatʃa	'male'	umu-mura	'young man'
<i>Class 2 /aba-/</i>	aba-saacha	'males'	aba-riisja	'boys'
	abaa-nto	'people'	aba-mura	'young men'
<i>Class 3 /omo-/</i>	omo-te	'tree'	umu-si	'sugar cane'
	omo-goondo	'plowed field'		
<i>Class 4 /eme-/</i>	eme-re	'trees'	imi-si	'sugar canes'
	eme-goondo	'plowed fields'		
<i>Class 5 /iri-/</i>	ibi-tɔkɛ	'banana'	ibi-hiindi	'corn cob'
<i>Class 6 /ama-/</i>	ama-tɔkɛ	'bananas'	ama-hiindi	'corn cobs'
<i>Class 7 /ege-/</i>	ege-te	'chair'	igi-tuumbe	'stool'
	ege-saka	'stream'	iki-muune	'deer'
	egee-nto	'thing'	iki-ruunguuri	'soft porridge'
<i>Class 8 /ibi-/</i>	ibi-te	'chairs'	ibi-muune	'deers'
<i>Class 9 /e-/</i>	e-seese	'dog'	i-tiiñi	'animal'
	e-ng'aamwi	'cat'	iin-gurube	'pig'
<i>Class 10 /ichiin-/</i>	ichiin-seese	'dogs'	ichi-tiiñi	'animals'
	ichiin-ng'aamwi	'cats'	ichiin-gurube	'pigs'
<i>Class 11 /oro-/</i>	oro-te	'stick'	uru-siri	'rope'
	oro-gena	'grinding stone'	uru-guta	'wall'
<i>Class 14 /obo-/</i>	obo-beebe	'badness'	ubu-kima	'corncake'
<i>Class 20 /ogo-/</i>	ogo-gena	'huge stone'	ugu-siri	'huge rope'
	ogo-gabo	'huge basket'		

Various noun prefixes have mid-high vowels in their underlying form. However, they surface as high when they are followed by a high vowel in the stem. Most class prefixes display multiple vowels of the same nature. In all cases both vowels undergo raising, suggesting that this harmony is iterative.

The iteration of this raising process is particularly evident when the infinitive prefix⁵⁵ /oko-/ and the object prefix are both attached to a verbal root. Examples of this fact are reported in (28). Object prefixes vary according to the class noun they refer to. Consider the infinitive form [oko-bara] ‘to count’: when an object prefix is attached to this form, it must be accorded to the noun class of the object it is referring to. [oko-go-bara] ‘to count it (cl. 3)’; [oko-ge-bara] ‘to count it (cl. 4)’; [oko-re-bara] ‘to count it (cl. 5)’...

When the object prefix contains a high vowel, the preceding prefix undergoes harmony: [uku-bi-bara] ‘to count it (cl. 8)’. If the object prefix has a mid-vowel and the root has a high vowel, regressive raising applies iteratively, first to the vowel in the object prefix and then to the vowels in the infinitive prefix.

(28) Iterative mid-high raising in Kikuria (Chacha & Odden 1998: 134)

oko-ba-suraanga	<i>‘to praise them’</i>	uku-gu-suraanga	<i>‘to praise you (sg.)’</i>
oko-mo-ba-suraangera	<i>‘to praise them for him’</i>	oko-ba-mu-surangera	<i>‘to praise him for them’</i>
oko-mo-go-gesera	<i>‘to harvest it (cl.3) for him’</i>	uku-gu-suraanga	<i>‘to praise it (cl.3)’</i>
oko-ge-bara	<i>‘to count it (cl.4)’</i>	uku-gi-suraanga	<i>‘to praise it (cl.4)’</i>
oko-re-bara	<i>‘to count it (cl.5)’</i>	uku-ri-suraanga	<i>‘to praise it (cl.5)’</i>
uku-bi-bara	<i>‘to count it (cl.8)’</i>		
uku-chi-bara	<i>‘to count it (cl.10)’</i>		

The low vowel /a/ behaves as a blocker for this harmony, as exemplified in (28): the object prefix for the third person plural /ba-/ blocks raising in [oko-ba-suraanga] *[uku-ba-suraanga], [oko-mo-ba-surangera] *[uku-mu-ba surangera], [oko-ba-mu-surangera] *[uku-ba-mu-surangera].

This raising process is invariably regressive, and can be both root-controlled and dominant-recessive, meaning that the trigger can be either in the root or in an affix. Consider the case of [uku-gu-suraanga] ‘to praise it (cl.3)’ shown in (28): here the high vowel of the root causes the preceding mid vowel in the object prefix to surface as high. This raised vowel allows harmony to propagate towards the infinitive prefix /oko/, that surfaces as [uku]. In [uku-bi-bara] ‘to count it (cl.8)’ the trigger is in the object prefix for the 8th noun class /-bi-/which triggers raising of the preceding infinitive prefix /oko/→[uku]. The trigger of this process of regressive raising can thus be either in the root or in a prefix.

The trigger for this process can also appear in a suffix. Consider the examples given in (29): here the agentive suffix /-i/ (which nominalizes verbs) cause the mid vowel present in the root to surface as high, and consequently forces the class-prefix /omo/ to surface as [umu]. The process “starts” in the suffix, and climbs its way back reaching the infinitive prefix, passing through the root and affecting all mid vowels in its way.

⁵⁵ Underlying k in a prefix appears as g when the following syllable contains a voiceless consonant (Chacha & Odden 1998: 130). Thus, whenever the first syllable of the root contains a voiceless consonant, the infinitive prefix /oko/ surfaces as [ogo].

(29) Dominant recessive raising of mid-high vowels within roots

umu-rim-i	'farmer'	oko-rem-a	'to cultivate'
umu-tigit-i	'one who is late'	ogo-teget-a	'to be late'
umu-hiitok-i	'rememberer'	oko-heetok-a	'to remember'
umu-rum-i	'biter'	oko-rom-a	'to bite'

In [umu-rim-i] 'farmer' the trigger is the applicative suffix /-i/, which first raises the mid vowel of the root (cf. [oko-rem-a] 'to cultivate'), and then reaches the mid vowels of the class noun prefix (in this case /omo/) raising them to [umu-].

To sum up, this process can be either root-controlled or dominant-recessive. In the following examples, the original trigger (the vowel that kickstarts regressive raising and which is underlyingly high) is underlined. The trigger can be in a prefix (/oko-b_i-bara/ → [uku-b_i-bara] 'to count it (cl.8), or in a suffix (/omo-rem-i/ → [umu-rim-i] 'farmer' in (29)).

A second harmonic process of Kikuria is similar to the one described in the tables (27), (28) and (29), but appears to have a slightly different context of application. This second harmony raises mid-low vowels in the stem to mid-high when followed by a high vowel in a suffix. The process is evident confronting the infinitive form of the verb with the noun derived applying the applicative suffix /-i/. This suffix raises preceding mid-low vowels in the stem. The same process is detected when the causative suffix is attached to a verb (Chacha & Odden: 1998: 138). This suffix, which probably contains /i/ in its underlying form, surfaces as [-ja].

A similar context is presented above in (29), where mid-high vowels surface as high due to the agentive suffix. We may thus expect that the two processes can be considered as one single process of raising that targets both mid-high and mid-low vowels. Raising-to-high and raising-to-mid are presented as separate processes due to the behavior of mid-vowels in prefixes. Granted mid-low vowels are extremely rare in prefixes (the only example noted being the negative /toko/), it appears that prefixes are unaffected by this second raising process (raising-to-mid), while they are affected by the first raising process presented earlier (raising-to-high). The mid-high vowel /o/ present in the negative suffix /-toko/ surfaces as [u] when followed by a high vowel in the root, but this raising does not affect the mid-low /o/: /toko/ → [toku], *[toku]. This suggests the fact that this second process of raising (that affects mid-low vowels only) applies only in roots, and not in prefixes, as the first raising process does. Consider the examples in (30).

(30) Regressive raising: Mid-low to mid-high vowels

Infinitive		Causative		Applicative	
ogo-tereka	'to brew'	ogo-terek-ya	'to make brew'	omo-terek-i	'brewer'
oko-gesa	'to harvest'	oko-ges-ya	'to make harvest'	omo-ges-i	'harvester'
ogo-tɛɛma	'to hunt mushrooms'	ogo-teem-ya	'to make hunt'	omo-teem-i	'mushroom hunter'
oko-rɔga	'to bewitch'	oko-rog-ya	'to make bewitch'	omo-rog-i	'witch'
oko-gɔɔta	'to hold'	oko-goot-ya	'to make hold'	omo-goot-i	'holder'

ogo-toko-rema	<i>'to not cultivate'</i>	
ogo-togu-suraanga	<i>'to not praise'</i>	

A high vowel in the suffix raises to mid-high the mid-low vowel of the root. Consider, as an example, the alternation in the verbal root /tɛrɛk/ in the infinitive [ogo-tɛrɛk-a] and in the applicative [ogo-tɛrɛk-i]. Mid-low vowels surface as mid-high if followed by high vowels.

Other properties of mid-low raising in Kikuria are the fact that it also applies to mid-low vowels in initial position in the stem, which are generally left untouched by other harmonies of Kikuria (Chacha & Odden 1998: 139), and that it affects all mid-low vowels of a root, when multiple mid-low vowels are present. This is shown in (31).

(31) Mid-low raising in multiple mid-low vowels within a root (Chacha & Odden 1998:139)

erem-ya	<i>'make swim!'</i>	ɛrɛm-a	<i>'swim'</i>
uku-eegek-ya	<i>'to prop up'</i>	ukw-ɛɛgek-a	<i>'to be propped up'</i>
oyokya	<i>'make greedy!'</i>	ɔyɔk-a	<i>'be greedy'</i>
ok-ooyokya	<i>'to make greedy'</i>	ok-ɔyɔka	<i>'to be greedy'</i>
orokya	<i>'verify!'</i>	ɔrɔka	<i>'come out!'</i>

This is rather interesting. We presented in §2.1 the main diagnostic to distinguish between Tongue-root and Height harmonies⁵⁶: when triggers and/or targets belong to sets of vowels of different heights, the process is a Tongue-root harmony. When only vowels of a given height are active in a process (i.e., only high vowels raise mid-low vowels to mid-high), the process is treated as height-harmony. In the examples given in (31), a series of two mid-low vowels undergo raising, even though the result of mid-low raising is not a high vowel: /ɛrɛm-a/ → [erem-ja] *[erem-ja]; /ok-ɔyɔk-a/ → [ok-oojok-ja] *[ok-ɔyɔk-ja].

If we are to consider this raising process as iterative (i.e., applying regressively to one vowel at a time), we are forced to consider mid-high vowels as valid triggers for mid-low raising. This could suggest the labelling of this process as tongue-root harmony, since both high and mid vowels, which are [+ATR], trigger the process that turns mid-low vowels to mid-high. To test this analysis, we should consider the behavior of mid-low vowels followed by mid-high vowels. However, this context cannot be found in Kikuria, because of a lowering process that applies to mid-high vowels triggered by preceding mid-low vowels. This lowering harmony corresponds to the Canonical Bantu lowering described earlier in §3.1.2, and is the third harmonic process involving height in Kikuria. Recall that Canonical Bantu lowering, as reconstructed by Hyman (1999), does not target all high vowels, but only Height-2 vowels, which in Kikuria correspond to mid-high vowels. High vowels are thus unaffected by progressive lowering.

A fourth harmonic process involving lowering is active in Kikuria. This last process targets high vowels, lowering them to mid-high when followed by mid-high vowels. To sum up, there are four

⁵⁶ This is always valid only if we assume a standard feature-based representation that considers both [high] and [ATR] to be related to vowel height. This is implied throughout this first section of the thesis, but it is important to reiterate the concept from time to time. The classification of a process as Tongue root harmony or height harmony strongly depends on the nature of the phonological representation assumed, i.e. it is theory-dependent.

different harmonic patterns in Kikuria: two regressive raising harmonies (the first one raises mid-high vowels to high vowels, and applies in all morphological contexts, while the second one raises mid-low vowels. It applies iteratively within roots, but ignores prefixes), and two lowering harmonies, one progressive (derived from the Proto-Bantu Canonical lowering harmony) and one regressive. The two lowering harmonies of Kikuria are exemplified in (32)⁵⁷.

(32) Progressive and regressive lowering in Kikuria

<i>Regressive lowering:</i>	<i>Mid-high vowels in suffixes lower preceding high vowels in the root</i>	ugu-siik-a	<i>to close</i>	ogo-seek-er-a	<i>to close for</i>
		ugu-siind-a	<i>to fold</i>	ogo-seend-er-a	<i>to fold for</i>
		uku-rug-a	<i>to cook</i>	oko-rög-er-a	<i>to cook for</i>
<i>Progressive lowering:</i>	<i>Mid-low vowels in roots lower following mid-high vowels in suffixes</i>	oko-ges-a	<i>to harvest</i>	oko-ges-era	<i>to harvest for</i>
		ogo-seens-a	<i>to winnow</i>	ogo-seens-era	<i>to winnow for</i>
		oko-rög-a	<i>to bewitch</i>	oko-rög-era	<i>to bewitch for</i>

Regressive lowering applies to roots, and is triggered by suffixes containing mid-high vowels. Examples for this are the applied⁵⁸ /-er-/, the statives /-ek-/ and /-ok-/, and the reversive /-or-/ (Chacha & Odden 1998: 141). When they are attached to a root containing high vowels, they trigger lowering, making vowels in the root surface as mid-high.

Consider the first example in (32): [ugu-siik-a], [ogo-seek-er-a]. The underlying form of the verbal stem is /siik/. High vowels in the root raise preceding vowels in the infinitive prefix, as in the examples presented in (30), so that /oko-siik-a/ surface as [ugu-siik-a]. When the applied suffix is attached to the root, high vowels lower to mid-high, so that /oko-siik-er-a/ surfaces as [ogo-seek-er-a]. Regressive lowering applies to roots and is triggered by suffixes. It is regressive and it erases the context of application for regressive raising discussed earlier.

The vowels that appear in those suffixes that trigger regressive lowering of high vowels are affected by the process of progressive lowering triggered by mid-low vowels in roots. They are underlyingly mid-high, but surface as mid-low when preceded by a root containing mid-low vowels. In the second section of the table in (32) the applied suffix is attached to roots containing mid-low vowels. /oko-rög-a/ → [oko-rög-a]; /oko-rög-er-a/ → [oko-rög-er-a]. This process of lowering is progressive, and affects only mid-high vowels (high vowels are not affected by lowering, and instead trigger raising of preceding mid-low vowels). This process makes it impossible to find a context of application for the process of regressive

⁵⁷ An analysis able to reduce those four patterns to one phonological process is naturally desirable, instead of an explanation based of four different harmonic processes. In this section of the thesis, however, only data matters and thus I chose to present the complex patterns of the alternations of Kikuria as they are described in Chacha & Odden (1998).

⁵⁸ The term “applied suffix” refers to a verbal extension (a morpheme attached to the verb stem in Bantu languages that adds semantic information) that occurs with two or more distinct semantic relations. It may have various functions in different Bantu languages (Trithart 1983).

raising triggered by mid-high vowels. All possible non-high [+ATR] triggers for the process of regressive raising which targets mid-low vowels (that as we have seen applies iteratively within roots, but not to the negative prefix) are preventively lowered by the same mid-low vowels that may be subject to raising.

The four harmonies of Kikuria conspire to create an extremely complex pattern of alternations, where lowering harmonies may counterfeed the application for raising and vice-versa. To sum up, four different harmonic patterns can be described for Kikuria: two regressive raising processes, a regressive lowering and a progressive lowering. The different contexts of applications for each one of those harmonies makes it hard to coalesce them into a single process of vowel harmony, and forces us to consider four different harmonic patterns, all related to vowel height.

Here is the summary of the four harmonies of Kikuria:

- Mid-to-high regressive raising: mid-high vowels raise to high vowels when followed by a high vowel. This process applies to prefixes and roots alike, and can be triggered by both affixes and roots.
- Mid-low-to-mid-high regressive raising: mid-low vowels raise to mid-high vowels when followed by a high vowel. This process does not seem to apply to prefixes, but it appears to apply iteratively within roots, thus suggesting that mid-high vowels can behave as valid triggers for mid-low raising. The power of mid-high vowels to trigger raising cannot be tested, due to the effects of the progressive lowering harmony described below.
- Progressive lowering harmony: this harmony turns mid-high vowels into mid-low vowels after a mid-low vowel. The process appears to be exclusively root controlled and progressive, since mid-high vowels in prefixes do not alternate with mid-low vowels when followed by mid-low vowels.
- Regressive lowering harmony: This height-related process applies only within the stem, and lowers a high vowel to a mid-high vowel when the high vowel is followed by a mid-high vowel in a suffix. The process does not affect high vowels in prefixes, and applies exclusively from left to right. The trigger is invariably in a suffix and the target is in a root.

II.3.1.3.10 Basaa: Cameroon (A44)

Basaa, which is spoken over a large area to the north-east and east of the coastal city of Douala in Cameroon, has a seven vowel system of the type 7VS:B composed of the vowels /i, e, ε, a, ɔ, o, u/. In some verbal tenses and aspects, only the vowels [i, e, o, u] appear. Schmidt (1994) considers this situation to be the result of a raising harmony that targets all non-high vowels /e, ε, a, ɔ, o/ raising them by one step. Basaa exhibits a process of regressive scalar raising, which applies to verbs in two specific contexts: in the applied form and in the indirect causative form. In this second case, the surface form of the suffix /ha/ contains a low vowel /a/. In the first case, that of the applied form, vowels in the root raise by a degree (except for /a/, which raises to [e], skipping the mid-low degree of height), and then the vowel of the suffix assumes the same form of the vowel in the root.

Consider the examples reported in (33). In the case of the indirect causative, raising applies even though the triggering context does not contain any high vowel. In the case of the applied, an additional process of vowel-copy harmony hides the underlying form of the suffix. The process triggers in a specific morphological context, regardless of the presence of a triggering dominant vowel. Raising in Basaa is thus a case of morphologically conditioned harmony (Parkinson 1996: 91).

(33) Raising in Basaa (Schmidt 1994)

<i>Root</i>	<i>Applied</i>	<i>Indirect causative</i>	
ɓak	ɓeg-el	ɓeg-ha	'weave'
pɛp	peb-el	peb-ha	'winnow'
hɛk	heg-el	heg-ha	'believe'
jɔŋ	jon-ol	jon-ha	'take'
seŋ	sin-il	sin-ha	'rub'
top	tub-ul	tub-ha	'sing'
nip	nib-il	nib-ha	'fly'
mil	mil-il	mil-ha	'swallow'
lɔp	lob-ol	lob-ha	'fish'
ɓom	ɓum-ul	ɓum-ha	'roast'

All non-high vowels alternate with a higher vowel in roots, the low vowel /a/ included. As already suggested, the process does not seem to be assimilatory, at least on the surface, since the vowels in the suffix do not contain high vowels. However, the raising pattern is extremely similar to the pattern exemplified for Nzebi in II.3.1.3.1. From the base form of the root, in the first column of the table in (33), all non-high vowels undergo raising. The low vowel /a/ raise to [e], as well as the mid-low vowel /ɛ/. Mid-low /ɔ/ raises to [o], mid-high /e,o/ surface respectively as [i] and [u]. The only noticeable difference with raising in Nzebi, which we covered in §3.1.3.1, is the outcome of low-vowel raising. Low vowel /a/ appears to “skip” a height degree when subject to raising: /ɓak/ → [ɓeg-el], *[ɓeg-ɛl]; /ɓak/ → [ɓeg-ha], *[ɓeg-ha].

The applied suffix appears to be sensitive to both the height and the roundness of the vowel in the root. The applied suffix is high when the preceding vowel in the stem is high, and mid when the vowel in the stem is mid. In addition, when the vowel in the root is rounded, the applied suffix surfaces as rounded. /ɓak/ → [ɓeg-el]; /pɛp/ → [peb-el]; /jɔŋ/ → [jon-ol]; /seŋ/ → [sin-il]; /top/ → [tub-ul].

In other words, the insertion of the suffix of the applied form triggers regressive scalar raising, while another progressive process of vowel-copy harmony affects the vowel of the suffixes, making them surface as copies of the preceding vowels. Root-vowels in Basaa, then, behave as targets of the raising process and as triggers of the vowel-copy harmony. Conversely, vowels in the applied suffix behave as triggers for the regressive raising harmony and as targets for the vowel-copy harmony.

II.3.1.3.11 Bakweri: western Cameroon (A231)

Bakweri displays a typical 7VS:B system based on four heights: /i, e, ɛ, a, ɔ, o, u/. Mid-high vowels cannot co-occur with mid-low vowels in Bakweri, since a lowering harmony targets mid-high vowels, lowering them to mid-low when followed (or preceded) by mid-low vowels. This process of lowering has effects within the roots (disallowing a series of mid vowels mismatched for height/ATRness), and also affects prefixes attached to the root. This lowering harmony is thus root-controlled and regressive. The examples reported in (34) show that mid-high vowels in class prefixes⁵⁹ lower when followed by a mid-low vowel in the root.

⁵⁹ Cf. §3.1.3.9 and Odden (2015: 3) for a brief overview on class prefixes in Bantu languages.

(34) Regressive lowering harmony in Bakweri (Hawkingson 1986)

<i>Class 3 prefix</i>	/mo-lɔmbi/	[mɔlɔmbi]	'worm'
	/mo-lɛli/	[mɔlɛli]	'food'
	/mo-ɔmbɔ/	[mɔɔmbɔ]	'plantain leaf'
<i>Class 4 prefix</i>	/me-lɔmbi/	[mɛlɔmbi]	'worms'
	/me-lɛli/	[mɛlɛli]	'foods'
<i>Class 7 prefix</i>	/e-tɛndɛ/	[ɛtɛndɛ]	'scars'
<i>Class 8 prefix</i>	/ve-ɔlɛ/	[vɛɔlɛ]	'animal legs'

Besides the lowering harmony exemplified in (34), other alternations appear to be related to vowel height in Bakweri. The final-vowel, which is underlyingly a low vowel /a/, surfaces as mid-low when preceded by a mid-low vowel. When the vowel in the root is ϵ final /a/ surfaces as [ɛ] and when the vowel in the root is ɔ , final /a/ surfaces as [ɔ]. This process may be viewed as a raising process, but it involves also fronting and rounding, rendering it more similar to a process of vowel-copy harmony. Surprisingly, it appears to have severe limitations in the selection of triggers and targets, since this process targets only the final low vowel /a/ and is triggered only by mid-low vowels. When other vowels precede /a/, the process does not apply. Examples of this process are reported in (35).

(35) Progressive /a/ raising/copy harmony (Hawkingson 1986: 32)

<i>Final /a/ harmonizes after mid-low vowels</i>		<i>Final /a/ does not harmonize</i>	
kɔm-ɔ	'greet'	fend-a	'lock'
vɛny-ɛ	'insult'	sos-a	'wash'
		lib-a	'slap'
		tum-a	'pick'
		vav-a	'sprinkle'

This harmonic process can be represented either as a raising harmony or as vowel-copy harmony. The fact that the target assumes, besides the height of the trigger, also its frontness (becoming [ɛ] if preceded by /ɛ/) or its roundness (becoming [ɔ] if preceded by /ɔ/) suggests this is better understood as a vowel-copy harmony, rather than a case of scalar raising. However, it appears that height is a relevant property in the selection of triggers. Only mid-low vowels are valid triggers for final vowel harmony: /kɔm-a/ → [kɔm-ɔ] 'greet'; /vɛny a/ → [vɛny-ɛ], 'insult'; [fend-a], *[fend-e] 'lock'.

A third vowel harmony is active in Bakweri. This third harmony is a regressive root-controlled raising harmony that applies in a specific context. In Bakweri, neighboring vowels tend to coalesce. Vowel coalescence is the process whereby two vowels "fuse" into one when they occur in contact. In Bakweri, this happens in most word boundaries. The second of the two juxtaposed vowels takes precedence over the first, so that a sequence of two vowels V_1V_2 will result in a coalesced form V_2 . Coalescence can apply, although less frequently and optionally, between morphemes. The process of vowel coalescence in Bakweri is exemplified in (36).

(36) Examples of vowel coalescence in Bakweri (Hawkingson 1986: 35)

<i>Vowel sequence (without intervening consonants): V₁V₂ → V₂</i>					
na	ma	e	ɛn	ɛ	na-mɛɛne
subject	tense	object	verb	final vowel	‘I saw it’
e		ɛkɛ		ɛkɛ	
Class 7 prefix		noun		‘black hawk’	

Prefixes in Bakweri may come in three different forms due to coalescence: the regular form, the strong form and the weak form. The regular form applies to words beginning in a consonant, i.e., where coalescence never applies. The strong form applies to words beginning in vowel where coalescence does not apply. The weak form applies to words beginning in a vowel where coalescence applies.

The strong form of the prefix attached to a word starting with vowel is a valid context of application for regressive raising harmony, which raises mid-high vowels to high. This process applies to prefixes that are in direct contact with a vowel (i.e., in a context that may trigger coalescence). It does not apply if a consonant intervenes between the vowels: [mu-umbu], [mondindi], *[mundindi]. This process, then, applies only in contact, and not at a distance as most harmonies. The table in (37) reports cases of strong forms of class prefixes where the vowel in the prefix is raised by one degree when immediately followed by a high vowel in the root. Examples with a root starting with consonant certify the underlying form of the class prefix.

(37) Raising in the strong form of prefixes.

	<i>Underlying form</i>	<i>Surface form</i>	
<i>Class 3 prefix</i>	/mo-umbu/	[muumbu]	‘lip’
	/mo-ndindi/	[mondindi]	‘thumb piano’
	/mo-(w)ulu/	[mu(w)ulu]	‘breath’
<i>Class 4 prefix</i>	/me-umbu/	[miumbu]	‘lips’
	/me-ndindi/	[mendindi]	‘thumb pianos’
<i>Class 8 prefix</i>	/ve-ulu/	[viulu]	‘puddles’
	/ve-tulu/	[vetulu]	‘lamps’

As was the case for Kikuria in §3.1.3.9, mid-low vowels do not seem to appear in prefixes, so that the raising effects on mid-low vowels cannot be tested. This third raising process exemplified in (37) behaves somewhat as a hybrid between a regular Vowel Harmony (both trigger and target of the process are vowels) and a simple case of assimilation, where the segments involved in the process are required to be in direct contact.

To sum up, Bakweri exhibits three harmonic processes involving alternation in height. The first is a lowering harmony that affects mid-high vowels in prefixes. The second is a progressive harmony that creates alternations between the low vowel [a] and mid-low vowels [ɛ] and [ɔ]. The third is a case of regressive raising, which appears to be sensitive to morphological and structural conditions. It applies solely in the context in which two vowels appear in contact (namely between a prefix and a vowel-initial noun), and only if coalescence does not apply, allowing prefixes to surface in their strong form.

II.3.1.3.12 Ikoma: Tanzania (part of the E40 group)

The vowel system of Ikoma displays seven phonemic vowels of the type 7VS: B: /i, e, ε, a, ə, o, u/. Vowel length is contrastive in Ikoma, and affects the application of raising harmony (Higgins 2012: 74).

Various phonological processes involving vowel height are active in Ikoma, and they conspire to create complex patterns of alternation. In this section, the various processes are treated separately.

First, a process that affects mid vowels in prefixes is treated and exemplified in (38). Then a regressive process of harmonization triggered by suffixes is described through the examples proposed in (39) and (40). Besides those two processes, various suffixes undergo progressive lowering. Lowering harmonizations of suffixes are exemplified in (41) and (42). The contexts of application of those processes sometimes overlap, and as a result, it may be complex to assess the underlying nature of the vowels affected.

Within noun stems, mid-low vowels [ε] and [ə] do not co-occur with higher vowels [i, e, o, u]. Higgins (2012) suggests that a harmonic process of raising raised mid-low vowels followed by high vowels within noun stems. This process is no longer productive.

An active pattern of height-alternation concerns the process of raising in prefixes. Table (38) reports alternations in class prefixes. Noun class prefixes display alternation between mid and high vowels. Mid-vowels occur when the vowel in the root is high or mid-high. Conversely, when the vowel in the root it is low or mid-low, the vowel in the prefix is high (Higgins 2012: 138). This harmonic pattern does not seem to be assimilatory, but is instead more similar to a dissimilation, with some relevant distinction that will be discussed under the table in (38).

(38) (Dis)-Harmony in Ikoma prefixes.

Class 7 prefix	eke-mira	'mucus'	eki-hεεno	'fever'
	eye-yiro	'thing'	eki-rεnge	'foot'
	eke-mero	'throat'	eγi-kombε	'shoulder blade'
	eye-tfuri	'chick'	eγi-təoke	'banana'
	eye-hoore	'skull'	eγi-sare	'twin'
	eye-kundi	'fist'	eγi-yambo	'language'
Class 1 prefix	omo-remi	'farmer'	omu-sεse	'sleave'
	omo-sino	'widow'	omu-γaβo	'medicine man'
Class 3 prefix	omo-yondo	'farm'	omu-hεtə	'trap'
Class 4 prefix	eme-yondo	'farms'	emi-hεtə	'traps'
Class 7 prefix	eye-tumbe	'chair'	eγi-sentʃə	'cup'
Class 8 prefix	eβe-tumbe	'chairs'	eβi-ɲana	'kid'
Class 11 prefix	oro-siri	'rope'	oru-hεmbε	'horn'
Class 14 prefix	oβo-rere	'bed'	oβu-rεesa	'beard'
Class 19 prefix	ehe-tumbe	'small chairs'	ehi-təoti	'small bracelets'
Class 20 prefix	oγo-tumbe	'large chair'	oγu-jo	'large gourd'
	oγo-siri	'large rope'	oγu-yaate	'large bread'

The process exemplified in (39) has the same context of application for regressive mid-high raising in Kikuria. The main difference between the two processes is that while in Kikuria (and in most raising

processes reported in the literature) raising applies when the mid-vowel is followed by a high vowel, here alternation between mid-high and high appears to be disharmonic. High vowels are required when the root contains a mid-low or a low vowel. Mid-high vowels are expected when followed by a mid-high or high vowel.

This process is not easy to categorize. It is not a regular dissimilation, since mid-high vowels in roots do not require a different vowel in the prefix: [eke-mero] *[eki-mero] ‘throat’; [omo-yondo] *[omu-yondo] ‘farm’. Instead, it seems that lower vowels trigger raising of mid-high vowels. Due to other harmonies in Ikoma, roots exhibiting both mid-low and mid-high vowels appear to be ungrammatical. However, the low vowel /a/ appears to be neutral to the tongue root harmony proposed by Higgins, and it can co-occur with mid-high or high vowels. This further complicates the picture. Why should [+low] vowels require preceding mid-high vowels to surface as high in prefixes, if this process is a simple dissimilation?

Leaving aside the regressive (dis-)harmony, other height related patterns are present in Ikoma.

A process of scalar raising affects mid-low vowels in verbal roots. Mid-low vowels raise when followed by any higher vowels: both high vowels /i,u/ and mid-high vowels /e,o/ can behave as triggers for this kind of raising. Higgins (2012) claims that raising is categorical when it affects front vowels, while it is only gradient when it involves back/rounded vowels. The process is thus structure-preserving when it involves /ε/, which raises to [e], and it is allophonic when it raises /ɔ/. In the following table, the outcome of /ɔ/-raising is represented as [ɔ̄], to represent that the outcome of mid-low harmonization is phonetically different from [o]. In (39), suffixes containing a high vowel affect preceding mid vowels in the roots. The low vowel /a/ is unaffected. The infinitive form in the first column displays the underlying nature of the target vowel. Following columns show how mid-low vowels alternate.

(39) Harmony in Ikoma: regressive harmony in roots raise mid-low vowels to mid-high when followed by high and mid-high vowels (Higgins 2012: 201)

<i>Root</i>	<i>Infinitive</i>	<i>Causative</i>	<i>Passive</i>	<i>Perfective</i>	<i>Agentive</i>	
i	ɣo-tʃiβ-a	ɣo-tʃiβ-i	ɣo-tʃiβ-u	n-to-tʃiβ-iri	omo-tʃiβ-i	‘to weed’
e	ko-reh-a	ko-reh-i	ko-reh-u	n-to-reh-iri	omo-reh-i	‘to pay’
ε	ɣu-ɣeɣ-a	ɣu-ɣeɣ-i	ɣu-ɣeɣ-u	n-tu-ɣeɣ-iri	omu-ɣeɣ-i	‘to carry’
u	ɣo-tuk-a	ɣi-tuk-i	ɣo-tuk-u	n-to-tuk-iri	omo-tuk-o	‘to dig’
o	ko-rok-a	ko-rok-i	ko-rok-u	n-to-rok-iri	omo-rok-i	‘to weave’
ɔ	ɣu-kɔr-a	ɣu-kɔr-i	ɣu-kɔr-u	n-tu-kɔr-iri	omu-kɔr-i	‘to do’
a	ɣu-ɣaβ-a	ɣu-ɣaβ-i	ɣu-ɣaβ-u	ɣu-ɣaβ-iri	omu-ɣaβ-i	‘to inherit’

High vowels trigger raising of preceding mid-low vowels without exception. However, mid-high vowels are also supposed to trigger regressive raising. In (40) is exemplified the peculiar case of the subjunctive suffix in Ikoma, which hosts a mid-high vowel /e/ in its underlying form. The subjunctive suffix surfaces as a mid-high vowel [e] in all contexts, except when it follows /ɔ/. In this case, the subjunctive suffix surfaces as the mid-low vowel [ε].

When /ε/ in roots is followed by the suffixal /-e/ of the subjunctive suffix, the mid-low vowel in the root raises to [e], due to the assimilatory process that involves raising. However, it appears that in Ikoma a process of progressive lowering is also active that interacts with regressive raising.

In fact, the mid-low vowel /ɔ/ (which, recall from the examples in 39 raises allophonically) triggers a process of progressive lowering that affects the mid-high vowel /e/ of the subjunctive suffix, which surfaces as [ɛ]. The mid-high vowel in the subjunctive suffix /-e/, then, behaves at the same time as a target for the progressive lowering harmony triggered by preceding /ɔ/, and as a trigger for regressive raising harmony that targets /e/. Table (40) exemplify both cases.

The subjunctive suffix surfaces as [e] when preceded by any vowel other than /ɔ/. It triggers regressive raising when it follows a mid-low vowel in the root (consider the token [tu-ɣey-e] < /ɣey/). It undergoes progressive lowering when it is preceded by a rounded mid-low vowel /ɔ/.

(40) Alternations in the subjunctive suffix in Ikoma

<i>Root Vowel</i>	<i>Subjunctive</i>		
i	e	to-tʃiβ-e	'let's weed'
e	e	to-reh-e	'let's pay'
ɛ	e	tu-ɣey-e	'let's carry'
u	e	to-tuk-e	'let's dig'
o	e	to-rok-e	'let's weave'
ɔ	ɛ	to-kɔr-ɛ	'let's do'
a	e	tu-ɣaβ-e	'let's inherit'

The process of progressive lowering appears to be asymmetric, since the mid-low vowel /e/ does not trigger it, but only rounded /ɔ/ does. However, recall that mid-low /e/ in roots is invariably raised to [e] by a regressive raising harmony triggered by the subjunctive suffix itself, so it would never be in a condition to trigger the lowering of a following /e/.

In other words, the asymmetric nature of this progressive lowering may not be systematic, but contingent on the fact that /e/ undergoes raising when followed by a mid-high vowel. The fact that the rounded mid-low vowel /ɔ/ undergoes regressive raising only phonetically may explain why it displays such a behavior as a trigger for the subjunctive suffix. Rounded /ɔ/ raises only phonetically, but maintains its phonological status of a mid-low vowel able to trigger progressive lowering in the subjunctive suffix. Non-rounded /e/, instead, undergoes regressive raising triggered by higher vowels (both high and mid-high vowels, including /e/): in this case the process is phonological, and turns /e/ into [e], which is thus unable to trigger lowering of the following /e/. In sum, /e/ in roots is affected by regressive raising (exemplified in 40), and thus cannot behave as a trigger for progressive lowering. /e/ behaves as a trigger of regressive raising and also as a target for progressive lowering triggered by /ɔ/, /ɔ/ undergoes regressive raising only phonetically, and behaves as a trigger for progressive lowering.

Other suffixes undergo height harmony in Ikoma. In (41), the applicative suffix surfaces as [-er] in all contexts, except when it is preceded by mid-high vowels [e] and [o], where it surfaces as [-er]. We can assume that a process of raising (or of tongue root assimilation) causes mid-low vowels to surface as mid-high when preceded by mid-high vowels in the root. Notice that in this case only mid-high vowels behave as triggers, while high vowels do not.

(41) Alternation in the applicative suffix in Ikoma

<i>Root vowel</i>	<i>Applicative</i>		
i	ɛr	ɣo-tʃiβ-ɛr-a	'to weed for'
e	er	ko-reh-er-a	'to pay for'
ɛ	ɛr	ɣu-ɣɛɣ-ɛr-a	'to carry for'
u	ɛr	ɣo-tuk-ɛr-a	'to dig for'
o	er	ko-rok-er-a	'to weave for'
ɔ	ɛr	ɣu-kɔr-ɛr-a	'to do for'
a	ɛr	ɣu-ɣaβ-ɛr-a	'to inherit for'

The vowels /e/ and /o/ require the applicative suffix to surface with a mid-high vowel [e], while all other vowels make it surface as [ɛr]. This alternation can be considered as the result of a raising harmony or of a tongue-root harmony. Regardless of the analysis chosen, it is surprising to notice that high vowels (which here I am assuming to be specified as [+high] and [+ATR]) do not require the harmonization of the suffix, which surface as [-ɛr]: [ɣo-tʃiβ-ɛr-a], *[ɣo-tʃiβ-er-a] 'to weed for'; [ɣo-tuk-ɛr-a], *[ɣo tuk er a] 'to dig for'.

Another alternation involves the reversive suffix, which displays a back rounded vowel that varies according to the height of the preceding vowel in the root, as shown in (42). It surfaces as [or/ok] when preceded by any mid-high vowel and /i/. It surfaces as [ur/uk] when preceded by /u/ and /a/. After /ɔ/, it surfaces as [ɔr]. The reversive suffix can thus appear in one of the following three forms:

- [or]/[ok] when preceded by a [+ATR] mid vowel and the high vowel /i/: [ko riŋ or a] 'unwrap'; [ɣo seb ok a] 'to sprout'; [ɣo soɣ or a] 'limp'.
- [ur]/[uk] when preceded by /u/ and /a/: [ko huŋ ur a] 'uncover'; [ku naar ur a] 'unfold'.
- [ɔr]/[uk] when preceded by a [-ATR] back rounded mid vowel /ɔ/: [ɣu kɔr ɔr a] 'cough'.

(42) Alternations in the reversive suffix in Ikoma

<i>Root Vowel</i>	<i>Reversive</i>		
i	or	ko-ring-or-a	'unwrap'
e	or	ɣo-seb-ok-a	'sprout'
ɛ	or	ɣo-teɣ-or-a	'remove, undress'
o	or	ɣo-soɣ-or-a	'limp'
u	ur	ko-huŋ-ur-a	'uncover'
a	ur	ku-naar-ur-a	'unfold'
ɔ	ɔr	ɣu-kɔr-ɔr-a	'cough'

Similarly to the case of the subjunctive, mid-low vowel /ɛ/ never surfaces in roots that precede the reversive suffix. This is once again due to the process of regressive raising harmony, which targets mid-low vowels in roots. Since the form of the reversive is [ur] when preceded by a low vowel /a/, and the behavior of low vowels seems to be consistently neutral, I believe the underlying form for the reversive suffix is /ur/, and that two degrees of lowering affect it. The first kind of lowering is triggered by mid-high vowels and, surprisingly, by the high vowel /i/, and has a mid-high vowel [o] as an outcome: [ko

ring or a] ‘unwrap’. The second kind of lowering is triggered by the mid-low vowel /ɔ/, which result in mid-low vowel [ɔ].

To sum up, different height related assimilations affect vowels in Ikoma.

- Regressive root-controlled raising, which targets mid-high vowels in class noun prefixes and is triggered, strangely, by low and mid-low vowels in roots. Examples for this alternation are in (38).
- Regressive dominant-recessive raising (or asymmetric tongue-root assimilation), which causes mid-low vowels to raise when followed by any [+ATR] vowel: /i,u, e,o/. This process is structure-preserving when it targets /ɛ/ while it is allophonic (or gradual, in Higgins’ terms) when it targets ɔ (39). Tables (40) and (42) show the raising effect of this process on underlying /ɛ/ in contexts where mid-high vowels act as triggers.
- Progressive height alternations, which affect vowels in suffixes.
 - Progressive raising of mid-low /ɛ/ to [e] when preceded by a mid-high vowel in the Applicative (41).
 - Progressive lowering of mid-high /ɛ/ in the Subjunctive suffix to mid-low [ɛ] when preceded by a mid-low vowel /ɔ/ in the root (40). The same subjunctive suffix behaves as a trigger for the process of regressive raising.
 - Progressive lowering of high vowel /u/ in the Reversive suffix to mid-high [o] (triggered by preceding /e,ɛ,o,i/) or to mid-low [ɔ], triggered by preceding /ɔ/ (42).

II.3.1.3.13. About raising in Bantu

The list of harmonies proposed here contains most of the raising patterns found in the literature. There are surely relevant processes that the review has missed out on, mainly because they may have been categorized as tongue root harmonies in the literature. Nonetheless, I think the set of processes reviewed is large and diverse enough to notice some frequent properties (as well as some particularities) of raising harmonies in Bantu languages.

As already suggested multiple times in this section, raising often applies in a scalar or gradient fashion. Parkinson (1996) dedicates large parts of his thesis to describe height-related harmonies and considers scalarity as one of the defining properties of raising. He distinguishes between partial harmony (which I previously called scalar) and complete harmony. The distinction between the two is based on the height degree of the triggers and the height degree of the outcomes. A harmonic process where the height of the trigger consistently matches the height of the outcome is defined as a complete height harmony. When the degree of height may differ, the process is defined as partial (or scalar).

All raising patterns found in Bantu, with the exception of regressive mid-high raising in Kinande (§3.1.3.2, 9), can be described as scalar.

On what concerns asymmetries, the parasitism typical of Canonical Bantu lowering appears to be absent from raising patterns of Bantu. Back and front vowels usually undergo raising in similar fashion, with the only exception being the different raising of mid-low vowels in Ikoma (§3.1.3.12). In Ikoma, raising applies “categorically” to front mid-low vowels, and “allophonically” to back rounded mid-low vowels.

Most limitations on raising appear to be morphological in nature. Often the process applies only in specific morphological contexts, as in Bakweri (§3.1.3.11), Basaa (§3.1.3.10) or Ikoma. Specifically, raising may be limited (or negated, like regressive mid-low raising in Kikuria) in prefixes. Noun class

prefixes, which generally host mid-high vowels in Bantu languages, are often the context of application for raising harmonies.

Another interesting property of raising in Bantu is the fact that it often applies allophonically (e.g., Zulu, Sotho-Tswana raising, among others).

Most harmonic patterns regarding raising are regressive, while progressive raising seems to be rare. Nonetheless, sporadic cases of progressive raising are present in some languages considered in this survey: (cf. Logoori §3.1.3.7 and Phuthi §3.1.3.6). The table in (43) summarizes the main properties of the raising patterns described in the section of the survey dedicated to raising harmonies in Bantu languages.

(43) Summary of raising patterns in Bantu languages.

<i>Language</i>	<i>Directionality</i>	<i>Raising mechanism</i>	<i>Morphological effects on raising</i>	<i>Asymmetries</i>
§II.3.1.3.1 Nzebi: Gabon, Congo (B52)	Regressive	Scalar	None detected	None detected. All non-high vowels undergo raising
§II.3.1.3.2 Kinande: Uganda (J[D]42)	Regressive	Scalar: Height-2 raising is structure preserving, Height-3 raising is allophonic	None detected	None detected. Low vowel /a/ behave as neutral
§II.3.1.3.3. Zulu (Nguni) (South Africa, S42)	Regressive	Scalar and allophonic. Height-2 vowels /ε, ɔ/ are raised to non-phonemic [e, o]	None detected	None detected. Low vowel /a/ behave as neutral
§II.3.1.3.4 SeSotho South Africa, Lesotho (S33)	Regressive	Scalar, and partially allophonic.	None detected	Height-3 vowels never appear to be raised, but it may be due to a frequency effect
§II.3.1.3.5 SeTswana: Botswana, South Africa (S31)	Regressive	Scalar, and partially allophonic.	None detected	None detected
§II.3.1.3.6 Phuthi: South Africa, Lesotho (S404)	Progressive, only root controlled	Not defined	None detected	Only Height-2 vowels are raised by super-high vowels
§II.3.1.3.7 Logoori: Tanzania (J[E]41)	Regressive raising	Scalar and allophonic. Mid low vowels are raised to non-	None detected	Height-2 vowels (which are [+high]) do not appear to behave

		phonemic [e,o] when followed by a high vowel /i,u/		as triggers However, progressive lowering may affect the context of application
	Progressive raising	Structure preserving Height 3 to Height 2: /ε/→[ɪ]	Only a handful of suffixes are subject to raising	The pool of targets is influenced by the morphology
<i>§II.3.1.3.8 Tsonga: South Africa, Zimbabwe, Mozambique (S53)</i>	Regressive raising	Scalar, possibly allophonic. Mid-low vowels become mid-high when followed by high vowels	None detected	Only mid-low vowels are valid targets, but the process may be allophonic.
<i>§II.3.1.3.9 Kikuria: Kenya, Tanzania (E40)</i>	Regressive, mid-high raising	Scalar/Complete	It applies to both roots and prefixes, and can be root-controlled or triggered by a high vowel in a suffix	Only mid-high vowels are valid targets
	Regressive, mid-low raising	Scalar	Mid-low raising does not apply in prefixes	Only mid-low vowels are valid targets
<i>§II.3.1.3.10 Basaa: Cameroon (A44)</i>	Regressive	Scalar	The process appears to be morphologically activated, since it applies in contexts where high vowels are absent on the surface.	None detected
<i>§II.3.1.3.11 Bakweri: west Cameroon (A231)</i>	Regressive	Scalar/Complete	It applies only to prefixes appearing in the strong form.	Only examples with mid-high vowels are found, but lack of mid-low vowels in prefixes may be the reason for this lack of data
<i>§II.3.1.3.12 Ikoma: Tanzania (part of the E40 group)</i>	Regressive, root controlled	It behaves somewhat as a disharmony: high vowels may not	It applies in prefixes	Only examples with mid-high vowels are found, but lack of mid-

		appear when followed by a high or mid-high vowel in the root.		low vowels in prefixes may be the reason for this lack of data
	Progressive		Only the applicative suffix is subject to root controlled raising	
	Regressive, dominant recessive raising	Scalar raising		Only mid-low vowels are valid targets

It appears that most Bantu raising harmonies lack specific requirements, making them symmetric, with low vowels behaving as neutral in most cases.

As noted earlier, raising harmonies in Bantu lack the typical parasitism of Canonical Bantu lowering. When asymmetries are detected (as in Phuthi or Ikoma), they are generally based on limitation on the selection of targets: raising affects only mid-low or mid-high vowels. On various occasions, especially when raising concerns mid-vowels in prefixes, the general absence of mid-low vowels in prefixes makes it hard to assess whether the process is symmetrical, and data is to be blamed for the absence of mid-low raising, or asymmetrical. In some cases, various harmonies conspire to create complex patterns of vowel alternation. For example, in Kikuria raising and lowering harmonies apply in similar contexts, and depending on the theory assumed by the analyst different proposals about the nature of the various patterns can be made. Here, following the conservative opinion of Chacha & Odden (1998) I kept divided the harmonic patterns. Recall that the difference in the two raising harmonies of Kikuria lays principally in the lack of raising of mid-low vowels in prefixes. For this reason, a process that could have been a regular symmetric harmony (targeting all mid vowels) is split in the description as two raising processes, the first targeting only mid-high vowels and the second one targeting only mid-low vowels.

II.3.2. Raising in Ibero-Romance varieties

This second large section of the survey is dedicated to RVH in Ibero-Romance varieties. The main sources for this section are Hualde's (1989) analysis of Asturian and Cantabrian dialects and Jimenez & Lloret's (2011) description of raising in Catalan varieties. I will first cover Catalan raising patterns in §3.2.1, while raising in Asturian and Cantabrian, which is more often covered in the literature regarding harmonic patterns, is described in §3.2.2.

II.3.2.1. Raising in Catalan dialects

Catalan dialects do not display alternations that allow one to see clearly the effects of an active harmony. Nonetheless, they do show some traces of height-related processes, which are evident if we compare tokens from different dialects of Catalan.

Catalan varieties exhibit traces of vowel reduction. In stressed position all of the vowels that compose the seven-vowel system of Catalan (i.e., /i, e, ε, a, ɔ, o, u/) may appear, while in unstressed syllables only three vowels can appear, namely [i], [u] and the non-phonemic central vowel [ə], which is the reduced form of non-rounded mid and low vowels. This situation is different in new words, such as direct loans, orthographic loans, acronyms or truncated forms. Bonet, Lloret & Mascaró (2006) derive two systems,

which they call the Narrow system and the Extended system of vowel reduction, that apply to different sets of words in the Catalan lexicon. The two systems are displayed in the table under (44).

(44) Narrow and Extended systems of vowel reduction in Standard Catalan

a. Narrow system

<i>Stressed vowels</i>	i	e	ɛ	a	ɔ	o	u
<i>Unstressed vowels</i>	i	(ə)			u		

b. Extended system

<i>Stressed vowels</i>	i	e	ɛ	a	ɔ	o	u
<i>Unstressed vowels</i>	i	a		ə	o		u

Interestingly, within words where the extended system applies, a process of raising harmony forces mid-vowels to share the same degree of height (or the same tongue root specification⁶⁰).

This process applies to forms where vowel reduction does not apply, and it seems to behave as an optional process. The result of this process is always a sequence of mid-high vowels, where an unstressed mid-high vowel affects preceding mid-low vowels. The opposite process, whereby mid-low vowels affect mid-high vowels, is not present. Therefore, instead of considering this a process of tongue-root assimilation, I am more inclined to consider it as a case of raising triggered by mid-high vowels, which targets mid-low vowels.

This harmony applies only within words that belong to the set of newly-introduced words, where the extended system of vowel reduction applies. It affects the pronunciation of words only in the cases in which reduction does not happen. The outcome of a sequence of mid vowels mismatched for tongue root position may result either in a reduced sequence (following the extended system) or in a harmonized sequence, applying optional regressive raising. Interestingly, high [+ATR] vowels /i/ and /u/ do not seem to require mid-low vowels to harmonize. Examples of this process of raising are reported in (45).

(45) Optional regressive raising harmony in Catalan (Bonet, Lloret & Mascaró 2006, Jimenez & Lloret 2011)

<i>Underlying representation</i>	<i>Examples displaying optional raising</i>			<i>Accepted sequences</i>
*/ɛ e/	[ellen]	[repetit]	[efe]	[e e]/[ɛ ə]
*/ɔ o/	[boston]	[logotip]		[o o]/[ɔ u]
*/ɛ o/	[nespor]	[ewro]	[unesco]	[e o]/[ɛ u]
*/ɔ e/	[opel]	[poster]	[professor]	[o e]/[ɔ ə]

The process of optional raising in Catalan can also be described as a tongue root assimilation, a problem we discussed at length in §3.1. I prefer to classify it as a special raising process, since [+ATR] high vowels do not seem to trigger this raising process (cf. the accepted form [u'nescu]).

⁶⁰ As is the case for Bantu, tongue root does not seem to have a phonetic role in Catalan. Nonetheless, it is widely used in the definition of the distinction between mid-vowels. As for similar cases in Bantu languages, I treat this process as a raising harmony. Of course, the choice of a theoretical background over another may affect the choice of the label.

II.3.2.1.1 Raising in Valencian Catalan

The variety of Catalan spoken in the area of Valencia displays progressive raising of the final low vowel /a/ when preceded by mid-low vowels /ε, ɔ/. Valencian (as all varieties of Catalan) displays the seven-vowel system presented earlier, based on four degrees of height. Only mid-low vowels trigger raising (and contextual fronting/rounding), while other mid and high vowels do not trigger harmony. Recall that a similar raising/copying process has been described for the Bantu variety of Bakweri (cf. §3.1.3.11).

(46) Progressive /a/ raising/copy harmony in Valencian Catalan.

Trigger	Standard Catalan	Valencian Catalan	Cullera	Borriana	
ε	tera	tere	tere	tera	'earth'
	tela	tele	tele	tela	'canvas'
	pela	pele	pele	pela	'peel'
	perla	perle	perle	perla	'pearl'
ɔ	kɔza	kɔzɔ	kɔza	kɔzɔ	'thing'
	mɔra	mɔrɔ	mɔra	mɔrɔ	'blackberry'
	tɔva	tɔvɔ	tɔva	tɔvɔ	'soft'
	vɔra	vɔrɔ	vɔra	vɔrɔ	'edge'

Different varieties of Valencian Catalan may restrict raising to only one context. Catalan spoken in Cullera applies raising only when front vowel /ε/ triggers the process, while in the dialect of Borriana raising applies only when the trigger is the rounded mid-low vowel /ɔ/. Different varieties of Catalan thus display different conditions on the trigger, resulting in different application of raising/copying. While this process is not solely related to raising, I chose to consider it in the survey, since it pairs with other raising processes that target the low vowel /a/ in other varieties, namely Ikoma, discussed in §3.1.3.12), and other varieties treated later in the survey (the dialect of Teramo §3.4.3 and Basque §3.5.3).

II.3.2.1.2 Raising harmony in Tortosa Catalan

In the Catalan dialect of Tortosa an optional raising harmony is active that raises mid-high vowels followed by high vowels. Consider the examples in (47): here mid-vowels optionally alternate with high vowels if followed by another high vowel.

(47) Optional raising in Tortosa Catalan (Jimenez & Lloret 2011)

<i>Accepted forms: e/i alternations</i>			<i>Accepted forms: o/u alternations</i>		
milic	melic	'belly button'	absolut	absolut	'absolute'
incriible	increible	'incredible'	brumur	bromur	'bromide'
dilicat	delicat	'delicate'	cunsumir	consumir	'to consume'
binicarlo	benicarlo	'proper name'	lucutora	locutora	'speaker F'
dispidir	despedir	'dismiss'	upurtu	oportu	'appropriate'
bitum	betum	'bitumen'	ambutir	embotir	'stuffing'
minut	menut	'small'	angullir	engollir	'to swallow'
piluca	peluca	'wig'	avurrir	avorrir	'bored'
sigur	segur	'sure'	butiga	botiga	'shop'

Harmony tends to be less effective within vowel sequences that involve a different place of articulation. It appears that the Tortosa dialect is developing (or has developed) some form of parasitism in its VH, since cases of applied harmony are less frequent (or completely limited) unless trigger and target do not share the same place of articulation. Sequences like /e...u/ → [i..u] are reduced to a handful of words, while, sequences like /o...i/ → [u..i] are found only in fossilized forms (Jimenez & Lloret 2011: 56). In addition, the process does not apply if trigger and target are not in adjacent syllables. Consider the examples from Tortosa Catalan in (48).

(48) Failure to raise in Tortosa Catalan: Jimenez & Lloret (2011: 56)

privi'ledzi	*privilidzi	'privileges'
kol'ledzi	*kollidzi	'colleges'
'centim	*cintim	'penny'
pre'terit	*priterit	'past'
e'fenika	*ifenika	'scenic'
ne'gotʃi	*nigotʃi	'shops'
dze'rani	*dzirani	'geraniums'
melo'dia	*milodia	'melody'
re'moli	*rimoli	'remold'

Due to the limitation presented above, the only regular and active context of raising applies in the sequence /e...i/. The examples in (48) show another limitations to the application of the process. Raising applies only to unstressed mid vowels followed by a high vowel, and only if trigger and target are in contact (i.e., other vowels are opaque to the process). In the examples, /o/ behaves as a blocker, but this may be due to its status of stressed vowel, and not to the asymmetry noted in Jimenez & Lloret (2011: 55).

II.3.2.2 Raising in dialects of Asturian and Cantabrian dialects

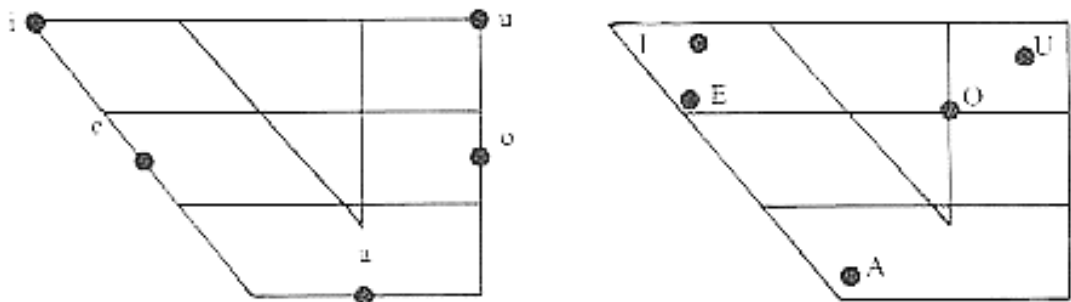
Asturian and Cantabrian varieties are often cited in the literature for the harmonic patterns they exhibit. Two kinds of harmonies are present, but only one of them directly involves raising. Raising harmony in Asturian and Cantabrian dialects can be triggered by both stressed and unstressed vowels,

depending on the variety at hand. As will be the case for Italian Metaphonies (§3.3), the context of application may be influenced by morphology or by prosody, suggesting an interaction between the melodic and prosodic domains (Hualde 1989). Rural varieties of Cantabrian are referred, both by speakers and in the literature, as ‘Montañes’, while rural varieties of Asturian are referred as ‘Bable’. The three varieties described here, for which I refer to Hualde (1989) and Penny (2009) are Tudanca and Pasiego Montañes, and Lena Bable.

II.3.2.2.1 Tudanca Montañes

Montañes varieties have a vowel system structured around five vowels. Each one of them may surface in two forms, the centralized form and the non-centralized form. The selection of one form or the other depends on the application of Centralizing harmony, a typical feature of Cantabrian varieties.

(49) Vowel system of Tudanca: Non-centralized (left) vs. centralized (right) vowels (Hualde 1989: 777).



Cantabrian dialects, alongside raising, display a different kind of harmony, referred to in the literature as “centralizing harmony” (Hualde 1989, Penny 2009). At first glance, it may appear as a tongue root harmony; however, the results of this process of “centralization” are not always coherent with the results expected with a tongue root harmony. Cantabrian varieties have a vowel system that distinguishes symmetrically centralized versus non-centralized vowels.

From a phonetic perspective, centralization does not apply evenly to all five non-centralized vowels. Hualde (1989: 777) notes from the schema in (49) that the centralized version of /o/ is far more “central” than the centralized version of its corresponding /e/. In addition, the “centralized” version of /a/ is raised and fronted, becoming [æ]. Neither Hualde nor Penny give an IPA-based description for the centralized vowels of Tudanca. I will follow Hualde’s notation, marking the non-centralized vowels using the IPA symbols {i, e, a, o, u} and the centralized vowels with capital letters {I, E, A, O, U}. Mid-low vowels are absent from this variety.

In Tudanca Montañes, centralizing harmony applies in the following fashion. Final unstressed high vowels are non-contrastively centralized in all occurrences (meaning that they always surface as centralized when they appear in final position). They trigger a regressive process that targets preceding vowels. This process applies in all contexts, regardless of the place of articulation of the triggers (i.e., both front and back high vowels are valid triggers for centralization). Interestingly, final underlying /i/ and /e/ are both centralized to [ə], but only underlying /i/ triggers the process.

(50) Centralizing harmony in Tudanca

<i>Centralized forms</i>		<i>Non centralized forms</i>	
'pIntU	'male calf'	'pinta	'female calf'
'cIkU	'boy'	'cika	'girl'
'sEkU	'dry M'	'seka	'dry F'
'kEsU	'cheese'	'kesos	'cheeses'
aham'brAU	'hungry M'	aham'braa	'hungry F'
'OhU	'eye'	'ohos	'eyes'
'sOIU	'alone M'	'sola	'alone F'
'bjUdU	'widower'	'bjuda	'widow'
<i>Centralization-based alternations: Imperatives vs. 3 sing. Present.</i>			
/abri/[Abrə]	'open!'	/abre/[abrə]	'he opens'
/meti/[mEtə]	'put in!'	/mete/[metə]	'he puts in'
/komi/[kOmə]	'eat!'	/kome/[komə]	'he eats'

The process of centralization applies regularly to stressed and post-tonic vowels. In pre-tonic position harmony applies only if some additional requirements are fulfilled. In order to surface as centralized, a pre-tonic vowel must be either a mid-vowel [e,o] or be part of a word with a centralized stressed vowel; in other words, it must be part of a word in which centralizing harmony applies. In addition, for pre-tonic centralization to apply the mid vowel must be in contact with a labial consonant.

In the following table under (51), various occurrences of harmonizing words are reported, and the behavior of pre-tonic mid vowels can be fully exemplified. Pre-tonic vowels surface as centralized only if in direct contact with a labial consonant ([bO'nuka],[bE'rAkU]), otherwise centralization does not apply.

Consider that when a mid-vowel is in pretonic position and in contact with a labial vowel, it may be centralized also when the following vowel is not centralized itself. Thus, the pre-tonic mid vowels in words such as [bOnuka] are not actually undergoing a harmonic process.

(51) Non-centralization of pre-tonic vowels in Tudanca Montañes.

anti'gwIsImU	'very old'
'kArAbU	'tawny owl'
'hIgAdU	'liver'
o'rEgAnU	'oregano'
'pOrtIkU	'hall'
'pUlplItU	'pulpit'
'θAngAnU	'drone'
ra'kItIkU	'rachitic'
bO'nuka	'weasel'
bE'rAkU	'boar'

Centralization has been introduced to justify the particular notation, comprised of minuscule and capital letters. What justifies the insertion of Tudanca in this survey is the presence of a proper raising

process, triggered by stressed high vowels, or glides immediately preceding the stressed vowel. This process is iterative and unbounded (reaches all pre-tonic vowels of the word), but generally leaves untouched the initial syllable /re-/ and /es-/, which are prefixes in Spanish dialects. The low vowel /a/ is reported to be neutral to the process. This process, exemplified in (52), applies independently from centralization.

(52) Tudanca raising harmony.

<i>Non-raised forms</i>		<i>Raised forms</i>	
'θera	'wax'	θi'rja	'match'
'seka	'dryness'	si'kura	'thirst'
meren'dar	'to have a snack'	mi'rjenda ⁶¹	'snack'
'mEdjU	'middle'	mI'djAnU	'medium'
ko'θer	'to boil'	ku'θina	'kitchen'
mo'ler	'to grind'	mu'ljenda	'grinding'
'hOrnU	'oven'	hur'nija	'stove'

Stressed high vowels /i/ and /u/ force pre-tonic mid vowels to surface as high. Since Tudanca lacks mid-low vowels, we can consider Tudanca raising as a case of complete raising harmony. This process is independent from centralization, and it applies to both centralized and non-centralized vowels: [mI'djAnU] 'medium'; [ku'θina] 'kitchen'.

II.3.2.2.2 Pasiego Montañes

Pasiego Montañes displays similar harmonic patterns to those found in Tudanca. The same vowel system can be considered for both Tudanca and Pasiego (cf. 49).

In both varieties, final high vowels are obligatorily centralized, and when they are, all vowels of the word must agree in surfacing in their centralized form. Between Tudanca and Pasiego there are two main differences in the application of centralizing harmony:

- In Tudanca, all underlying final high vowels behave as triggers for centralization. In Pasiego only back rounded /u/ triggers the process. Final underlying /i/, as in Tudanca, surfaces as /ə/, same as underlying final /e/, and does not trigger centralization.
- While in Tudanca centralization was limited in its application (it was stress conditioned, or conditioned by other requirements), in Pasiego centralization applies to all vowels of the word, including articles, clitics and prepositions.

Centralizing harmony in Pasiego Montañes is exemplified in (53).

⁶¹ In this token (as well as in the following) raising is caused by the pre-tonic glide j. /me.'rjen.da/ → [mi'rjenda] ; /me.'dja.nu/ → [mI'djAnU].

(53) Centralizing harmony in Pasiego

AtrIstOnAU	'sad'
IskAlOfrjAU	'shivering'
rIfrjAtlkU	'sensitive to cold'
kUn Il mAjIstrU	'with the teacher'
nIgrU	'black'
kUrdIrU	'lamb'
gUrdU	'fat'
blAnkU	'white'
gAtU	'cat'
pAxArU	'bird'

Pasiego also exhibits raising harmony, triggered by final high vowels that raise stressed preceding mid-vowels. Only mid-vowels are affected, while high vowels behave as neutral. The process applies only to stressed vowels, and leaves unaffected intervening unstressed vowels, which behave as transparent. Raising is thus rather different in the varieties of Pasiego and Tudanca. While in Tudanca raising is triggered by stressed vowels and targets pre-tonic vowels, in Pasiego it is triggered only by final vowels and targets only stressed vowels. In the table in (54) are reported alternations based on the countable vs. uncountable form of nouns. Pasiego differentiates the form of words when they are countable or uncountable. In a sentence like “I want some cheese”, the uncountable form for the word “cheese” is selected. This form is [kesU], without application of raising (nor centralization). In the sentence “I want one goat cheese”, the same word is selected in the countable form [kIsU], in which both the centralizing and the raising harmony apply.

Hualde (1989) marks as [ʊ] the surface form for an underlying unstressed non-centralized /o/ in plurals and uncountable nouns. It does not trigger centralization of preceding vowels, further suggesting that centralization is not completely assimilable to a tongue-root harmony.

(54) Raising harmony in Pasiego

<i>M. sing. Countable</i>	<i>M.s Uncountable</i>	
kIsU	keso	'cheese'
pIIU	pelu	'hair'
gwInU	gwenʊ	'good'
nwlstrU	nwestrʊ	'our'
flUxU	floxʊ	'limp'
gUrdU	gordo	'thick'
rAbjUsU	rabjosu	'bitter'
<i>M. sing. countable</i>	<i>M. plural</i>	
prImIrU	primerus	'first'
bAbIrU	baberos	'bib'
biθjUsU	biθjosus	'vicious'
rApUsU	raposus	'fox'
nUbUsU	nubosus	'cloudy'

Given the rules and diachronic evolution of Spanish varieties, /i/ seldom appears in final position. For this reason, only the forms in which the rounded vowel U triggers raising are reported. However, I do not believe that this is enough to consider harmony in Pasiego as asymmetric. The lack of raising caused by /i/ is due to causes that are external to phonology and have more to do with derivational morphology.

II.3.2.2.3 Lena Bable (Asturian) raising harmony

The Asturian variety of Lena displays a harmonic pattern of raising similar to the harmony found in Pasiego. Here the vowel system is formed by five vowels /i, e, a, o, u/, and there is no proof of an active centralizing VH⁶².

Alternations in Lena are evident in nominal paradigms. Consider the alternations in (55).

(55) Raising harmony in Lena Bable

<i>Masculine Singular</i>	<i>Masculine Plural</i>	<i>Feminine singular</i>	
'getu	'gatos	'gata	'cat'
sentu	'santos	'santa	'saint'
ben'tenu	ben'tanos	ben'tana	'window'
tsa'mergu	tsa'margos	tsa'marga	'muddy lake'
'ʃenu	'ʃanos	'ʃana	'diligent worker'
'pelu	'palos		'stick'
ka'biθu ⁶³	ka'beθos	ka'beθa	'head'
'ninu	'nenos	'nena	'child'
kor'diru	kor'deros	kor'dera	'lamb'
kal'diru	kal'deros	kal'dera	'pot'
'tsubu	'tsobos	'tsoba	'wolf'
'kuku	'kokos		'worm'
'kufu	'kojos	'koja	'cripple'
bur'wibanu	bur'webanos		'wild strawberry'

In the table in (55), raising in Lena is exemplified in noun inflection. Masculine forms display a final high vowel /u/, which is a valid trigger for raising. All non-high vowels are subject to raising. The low vowel /a/ raises to mid-high [e], while mid-high vowels /e, o/ raise to high [i, u] respectively. No mid-low vowel is present in Lena.

The same kind of alternation based on height can be found in pronouns and adjectives. Interestingly, adjectives and participles, which generally have the final vowel /u/, end in /o/ when they agree with an uncountable “mass” noun. Alternation in the height of the stressed vowel can thus be seen also in countable vs. uncountable adjectives and participles, as exemplified in (56).

⁶² Penny (2009) suggests that traces of the centralizing harmony may be present in Asturian dialects as well, but that data are not clear enough to postulate a process of harmony as is done for Tudanca and Pasiego Montañes.

⁶³ In some cases, masculine versions of feminine nouns (such as head-[kabeθa] or window-[bentana]) assume a diminutive meaning (Hualde 1989: 802, note 13)

(56) Raising applies in adjectives associated to countable nouns, and not to adjectives associated with mass nouns.

<i>Masculine Singular</i>	<i>Feminine Singular</i>	<i>Mass</i>	
'blenku	'blanku	'blanko	'white'
'eltu	'alta	'alto	'tall'
'gwepu	'gwapa	'gwapo	'handsome'
mo'jeu	mo'ja	mo'jao	'Wet'
'fertu	'farta	'farto	'Stuffed'
an'deu	an'da	an'dao	'Walked'
'bunu	'bona	'bono	'good'
'bwino	'bwena	'bweno	'good'
'fundu	'fonda	'fondo	'deep'
re'undu	re'onda	re'ondo	'round'
'tuntu	'tonta	'tonto	'stupid'
fluSu	floSa	floSo	'lazy, loose'
'fiu	'fea	'feo	'ugly'
fon'diru	fon'dera	fon'dero	'lower'
'siku	'seka	'seko	'dry'

Final /i/ is rather rare in Lena, but the few items that exhibit unstressed /i/ in final position display alternations. Demonstratives, shown in (57), are a good example.

(57) Behavior of final /i/ as trigger for raising harmony in the system of demonstratives.

Masculine singular	Feminine singular	
isti	esta	'this'
isi	esa	'that'

Pre-tonic vowels are not affected by raising, which does not seem to go past the stressed vowel. Unstressed vowels intervening between a trigger and the stressed vowels are treated as transparent, and do not undergo raising. Consider alternations in proparoxitones in the examples shown in (58) below.

(58) Intervening unstressed vowels are transparent to harmony in Lena.

<i>Masculine Singular</i>	<i>Masculine Plural</i>	<i>Feminine singular</i>	
'pesaru	'pasaros	pasara	'bird'
'kekabu	'kakabos		'wreck'
'kendanu	'kandanos		'dry branch'
'sebanu	'sabanos	sabana	'sheet'
'trwibanu	'trwebanos		'beehive'

The stressed vowel undergoes raising in the masculine singular form, while unstressed intervening vowels, being disharmonic, allow harmony to apply.

Raising in Pasiego Montañés and in Lena Bable are extremely similar to the harmonic patterns that are described in §3.3, namely Italian metaphonies. It is interesting to notice that the three varieties considered here (Tudanca, Pasiego and Lena) share some features, but actually display extremely variable harmonic patterns.

Tudanca raising is triggered by stressed vowels only, and affects preceding unstressed vowels. Pasiego, along with Lena, while being extremely similar to Tudanca (to the point of sharing a similar “centralizing harmony”), has a completely different harmonic pattern, one which raises exclusively stressed vowels and is triggered only by final high vowels.

II.3.2.3 Summary of Raising harmonies in Ibero-Romance languages

Two groups of raising harmonies are reported in the literature concerning Ibero-Romance varieties. The first group involves raising patterns (often optional) in Catalan dialects, while the second involves raising harmonies in Northern Spain varieties, which are all triggered by final high vowels and target stressed mid vowels, much as in Italian metaphony.

On some occasions, raising in Catalan (cf. optional raising in Tortosan Catalan and raising in minor varieties of Valencian Catalan) applies in different manners to front or back/rounded mid vowels. Raising in Valencian Catalan is limited in the selection of targets (i.e., only /a/ is subject to raising) and in the selection of triggers (only mid-low vowels can trigger /a/ raising-copying). As an ulterior requirement, the variety of Valencian Catalan spoken in Cullera requires only front mid-low vowel /ɛ/ as trigger of the process, while in the variety of Borriana it is only the back rounded vowel /ɔ/ that triggers harmonization.

In Tortosan Catalan the process seems less likely to apply in contexts where triggers and targets are mismatched for place of articulation, therefore suggesting the presence of a sort of parasitism (Jimenez & Lloret 2011: 55). However, data gathered on this process suggest that in the past it was also applied to mismatched forms, since traces of raising triggered by /i/ that targets /o/ are still found in fossilized forms. We can thus conclude that some form of parasitic phenomenon may be at work, limiting the application of the process in newer forms, but the process had to be more symmetric at an earlier stage, hence the presence of fossilized forms with mid-vowels raised by triggers mismatched for place of articulation.

No specific asymmetries are detected in Northern Iberian dialects, even though the vast majority of examples involve a back rounded high vowel as the trigger. This is not due to a condition in the selection of triggers, as noted in §3.2.2.3, but to the evolution of paradigms in Spanish dialects. Sporadic forms in which /i/ appears in a valid triggering position follow the rules of a symmetric harmony.

All the languages analyzed in this section are reported in the summary table under (59) below.

(59) Summary on raising harmonies in Ibero-Romance languages

<i>Language</i>	<i>Directionality</i>	<i>Raising mechanism</i>	<i>Morphological effects on raising</i>	<i>Asymmetries</i>
<i>§II.3.2.1 Catalan</i>	Regressive	Optional raising	None detected.	None detected. /a/ behaves as neutral.
<i>§II.3.2.1.1 Valencian Catalan</i>	Progressive	Scalar raising/copying. The low vowel /a/ raises to [ɛ] when /ɛ/ triggers VH, to [ɔ] when /ɔ/ does it.	None detected.	Valencian: /a/ is the only valid target. Mid low vowels are the only valid triggers. Cullera: /a/ is the only valid target, /ɛ/ is the only trigger. Borriana: /a/ is the only valid target, /ɔ/ is the only trigger.
<i>§II.3.2.1.2 Tortosan Catalan</i>	Regressive	Optional. Raising applies to unstressed mid vowels directly followed from high vowels.	None detected.	Total parasitism. Originally, the process must have been more symmetrical.
<i>§II.3.2.2.1 Tudanca Montañes</i>	Regressive	Raising applies only to mid vowels in pre-tonic position, and is triggered by stressed high vowels.	None detected.	None detected. Low vowel /a/ behaves as neutral.
<i>§II.3.2.2.2 Pasiego Montañes</i>	Regressive	Raising applies only to mid vowels in stressed position.	None detected.	None detected. Low vowel /a/ behaves as neutral.
<i>§II.3.2.2.3 Lena Bable</i>	Regressive	Raising applies only to mid vowels in stressed position.	None detected.	None detected. Unlike other Ibero-Romance varieties, /a/ undergoes raising.

II.3.3 Harmonies in Italian dialects

In this section, I will cover raising harmonies in Italian varieties. Raising processes are a pervasive feature of dialects in Italy, mainly in the form of metaphony, a special kind of raising harmony that is present in most (but not all) dialectal varieties spoken throughout Italy.

With the term metaphony, linguists define a kind of raising harmony in which an unstressed high vowel, normally an inflectional suffix in final position, raises a preceding stressed vowel. The term metaphony served as a translation of the German term *umlaut*, sound alteration, but while *umlaut* refers to the regressive harmonic agreement in backness of vowels of the same word typical of Germanic languages (cf. §1.3.2.1), metaphony involves agreement in height. Both German *umlaut* and Romance metaphony affect the stressed vowel and have a final unstressed vowel as trigger.

Metaphony is a common feature of Italian dialects and it has been one of the main research topics for dialectologists, who inquired into the origin of this process, its variation and its distribution on the Italian Peninsula. Rohlfs (1966), Maiden (1987, 1991), Calabrese (1985, 1998, 2011, 2016), Savoia (1997, 2015), Walker (2005, 2011) Loporcaro (2011a), and the collection of papers edited by Torres-Tamarit et al (2016) are just a fraction of the authors that have treated the topic of Italian metaphonies in their works.

In this survey, I treat metaphonies in the present section separated from the other raising processes of Italian varieties. This choice is due to the enormous body of work done on metaphonies and on the variation of metaphonic configurations between different dialects. In §3.4 are covered the non-metaphonic raising processes present in Italian varieties.

II.3.3.1. Vowel systems and variation among Italian dialects

All Italian dialects display vowel systems that derived from one of two historical vocalic patterns, referred to in the literature as Common Romance and Sardinian. They both derive from the vowel system of Latin, which was composed of five vowels (traditionally marked in capital letters I, E, A, O, U). In Latin, vowel length was contrastive, while in Common Romance varieties this trait lost its contrastive value⁶⁴. Latin distinguished ten vocalic segments (Ī, Ĭ, Ē, Ĕ, Ā, Ă, Ō, Ŏ, Ū, Ū⁶⁵), while Romance varieties reduced the number of contrasts to seven (in the case of the Common Romance) or five (in the case of Sardinian).

From the Common Romance (sometimes referred to as Western, cf. Maiden 1997: 7) vowel system developed the vowel systems of western Romance languages and of all Italian dialects⁶⁶ (with the exception of Sardinian). For what concerns Italian varieties, all vowel systems developed from three major systems. They are Sardinian, proper to most dialects spoken in the island of Sardinia; Common Romance, that formed the baseline for all varieties spoken in most peninsular Italy; and Sicilian, which displays high vowels as the development of long Ē and Ō.

In a restricted area between the administrative regions of Basilicata and Calabria (known in the literature as *Mittelzone* or Lausberg Area, Lausberg 1939), dialects exhibit a vowel system that coincides

⁶⁴ In dialects where vowel length is distinctive, this property has been restored, and not preserved from Classical Latin.

⁶⁵ Length distinction in Latin is traditionally marked using a line above the capital letter. Long vowels are marked with a macron; short vowels with a breve. Latin Ā is a long vowel (i.e., [aa], [a:]), while Ă is short (i.e., [a]).

⁶⁶ While Italian dialects south of the La Spezia-Rimini line are part of the Eastern Romance group, their vowel system developed from the Common Romance/Western vowel system discussed above, and not from the Eastern vowel system, which gave rise to the system of Romanian and other eastern Romance languages.

with that of Sardinia⁶⁷. To be more specific, within the Lausberg area most dialects have the Sardinian vowel system, while others show a peculiar system that shares properties with both the Sardinian and the Sicilian system. Some dialects close to the Lausberg Area also display a vowel system that coincides with that of Romanian. I refer to Fanciullo (1988) and Trumper (1997) for a more detailed discussion of the vowel systems of dialects of the Lausberg Area.

In the table in (60) the three main vowel systems relevant to Italian dialectology are presented, alongside the evolutionary path that describes their development.

(60) Evolution of Romance vowel systems found in Italy (Maiden 1997)

	<i>Latin</i>	<i>Sardinian</i>	<i>Common Romance (Tuscan)</i>	<i>Sicilian</i>	
Ī	VĪNUM	'vinu	'vi:no	'vinu	'wine'
Ī	NĪVEM	'nive	'ne:ve	'nivi	'snow'
Ē	MĒNSEM	mese	'me:se	'misi	'month'
Ē	SĒPTEM	'sette	'sette	'setti	'seven'
Ā	CĀRUM	'caru	'ca:ro	'caru	'dear'
Ā	CĀPUT	'capu	'ca:po	'capu	'head'
Ō	PŌRTUM	'pɔrtu	'pɔrto	'pɔrtu	'port'
Ō	SŌLEM	'sole	'so:le	'sul	'sun'
Ū	SŪRDUM	'surdu	'sordo	'surdu	'deaf'
Ū	MŪRUM	'muru	'mu:ro	'muru	'wall'

Each dialectal variety may have had further developments. As we shall see in some examples later, varieties such as those spoken in the north of the Gargano peninsula (northern Apulia) or in the Abruzzi region exhibit vowels that are extremely different from those that appear in the Common Romance system they originated from. What tends to remain constant throughout different dialects is the system of contrasts. Dialects that derived their vowel system from Common Romance tend to maintain a seven-way contrast in stressed position, while dialects that derived their vowel system from the Sardinian or Sicilian vowel system normally have a five-way contrast in stressed position. Gallo-Italic dialects, spoken in the north of the peninsula, developed front rounded vowels, augmenting the contrastive vowels found in stressed position from seven to nine, as we shall see in detail in the following chapter, where three varieties of Eastern Lombard are discussed.

In unstressed position, the situation is more variable. Unstressed position displays a reduced contrast system, with fewer vowels than those accepted in stressed position. This situation is common to all Italo-Romance varieties. Central varieties have a five-way distinction in unstressed position, both final and non-final. The only contrast that is lost is the one between mid-vowels of different height. This is exemplified in (61).

⁶⁷ Fanciullo (1988: 676-80) argues that the vowel system of this area, while superficially similar to the Sardinian one, must have been more similar to the Common-Romance system, since metaphony affected differently original mid-low and mid-high vowels.

(61) Vowel system in central varieties.

<i>Stressed position</i>	i	e	ɛ	a	ɔ	o	u
<i>Non-final unstressed position</i>	i	e		a	o		u
<i>Final unstressed position</i>	i	e		a	o		o (u)

Tuscan varieties, as well as many other dialects of central Italy, developed a system where final *u is lost in favor of [o], reducing the contrast for final vowels from five ([i, e, a, o, u]) to four ([i, e, a, o]). High rounded [u] is still present in a handful of varieties on the surface level, and there are signs that suggest its role in the underlying representation: in all varieties where metaphony is active, the behavior of a final [o] < *u as trigger of metaphonic raising suggests that /u/ may be still present underlyingly in final position⁶⁸.

Southern varieties with a vowel system derived from the Common Romance system normally exhibit traces of a complete neutralization in unstressed position, both final and non-final. In most dialects of southern Italy, all unstressed vowels are liable to reduction to [ə]. The low vowel /a/ is not usually reduced when pre-tonic⁶⁹ (Maiden 1997: 10). Also, Maiden (1997) notes that there are southern dialects where not only /a/, but also /u/ appears to resist reduction in pre-tonic position. The situation is summarized in (62).

(62) Vowel system in southern varieties.

<i>Stressed position</i> ⁷⁰	i	e	ɛ	a	ɔ	o	u
<i>Pre-tonic position</i>	ə			a	u		
<i>Non-final post-tonic position</i>	ə						
<i>Final unstressed position</i>	ə						

⁶⁸ Another possibility, which is discussed more at length in §IV.7, is that metaphony is a morphologically conditioned process.

⁶⁹ Maiden (1997: 10) notes that /a/ often resists reduction in all positions that precede the syllable that carries the principal phrasal stress. He gives some examples from the southern variety of Agnone (Molise) where pre-tonic /a/ is maintained not only in word-internal pre-tonic position, but also in all positions that precede the phrasal stress (represented with "): [marga'rojɬə] > */marga'rita/ (daisy); [kata'fworkjə] > */katafɔrkju/ (caterpillar); [la 'tɛr:a "sandə] > */la 'tɛrra "santa] (the holy land).

⁷⁰ In the table in (62) I am ignoring the possible modification to the stressed syllables due to the effects of metaphony, so the vowels represented in the first row of table (62) are to be considered as the stressed vowels in non-metaphonic contexts.

Northern varieties that are part of the group of Gallo-Italic varieties, with the exception of Ligurian, lost all final unstressed vowels, except for [a]. This seems to have eliminated the context of application for metaphony, which is rare in northern varieties, appearing only in some conservative alpine dialects, in Emilian and Romagna dialects and in southern Veneto. Ligurian dialects and Venetan dialects (which are not Gallo-Italic⁷¹) maintained final vowels different than [a]. For a general analysis of the vowel systems of the Gallo-Italic variety consider section §III.2.1 in the following chapter, where the case of Eastern Lombard dialects is described in detail.

Extreme southern varieties with five vowels in stressed position normally have only three vowels in unstressed and final position: the cardinal vowels [i, u, a]. Consider the vowel system of extreme southern varieties shown in (63).

(63) Vowel system in extreme southern varieties (Sicilian vowel system).

<i>Stressed position</i>	i	ε	a	ɔ	u
<i>Non final unstressed position</i>	i		a	u	
<i>Final unstressed position</i>	i		a	u	

Varieties displaying a Sardinian vowel system developed two different systems for unstressed vowels, the Campidanese system (which is present in dialects spoken in the southern side of the island) and Logudurese, more frequent in the north. Consider the summary table in (64).

(64) Vowel systems in the varieties spoken in Sardinia.

<i>Stressed position</i>	i	ε	a	ɔ	u
<i>Non final unstressed position Logudurese⁷²</i>	i ⁷³	ε	a	ɔ	u
<i>Final unstressed position Logudurese</i>	i	ε	a	ɔ	u
<i>Non-final unstressed position Campidanese</i>	i		a	ɔ	u

⁷¹ Ligurian varieties are usually considered as part of the Gallo-Italic group, even though they exhibit some peculiar properties (they still maintain the final vowel, whereas most Gallo-Italic and Gallo-Romance varieties lost final vowels). Varieties spoken in Veneto, while sharing some properties with Gallo-Italic dialects, are generally treated as being a different group. This issue is developed in more detail in the following chapter.

⁷²A much more detailed analysis and description of Sardinian dialects and their vowel systems is given in Jones (1997).

⁷³ In Logudurese Sardinian [i] is the regular outcome for unstressed Latin short Ī in both final and non-final position.

<i>Final unstressed position Campidanese</i>	i	a	ɔ	u
--	---	---	---	---

The general description of vowel systems of Italian dialects presented here is primarily based on Loporcaro (2009) and Maiden (1997, 1991:153f). I refer to those sources for a more in-depth analysis of each path of development. This section serves as an introduction for the description of metaphonic processes in Italian dialects, covered in the following section.

II.3.3.2 Metaphonies in Italian dialects

Now that the vowel systems of Italian dialects have been described, we can properly introduce the process of metaphony. In its basic form, metaphony can be described as a raising process that affects stressed mid-vowels, targeted by final unstressed high vowels. Since both /i/ and /u/ are often inflectional endings, the process displays itself in many paradigmatic alternations.

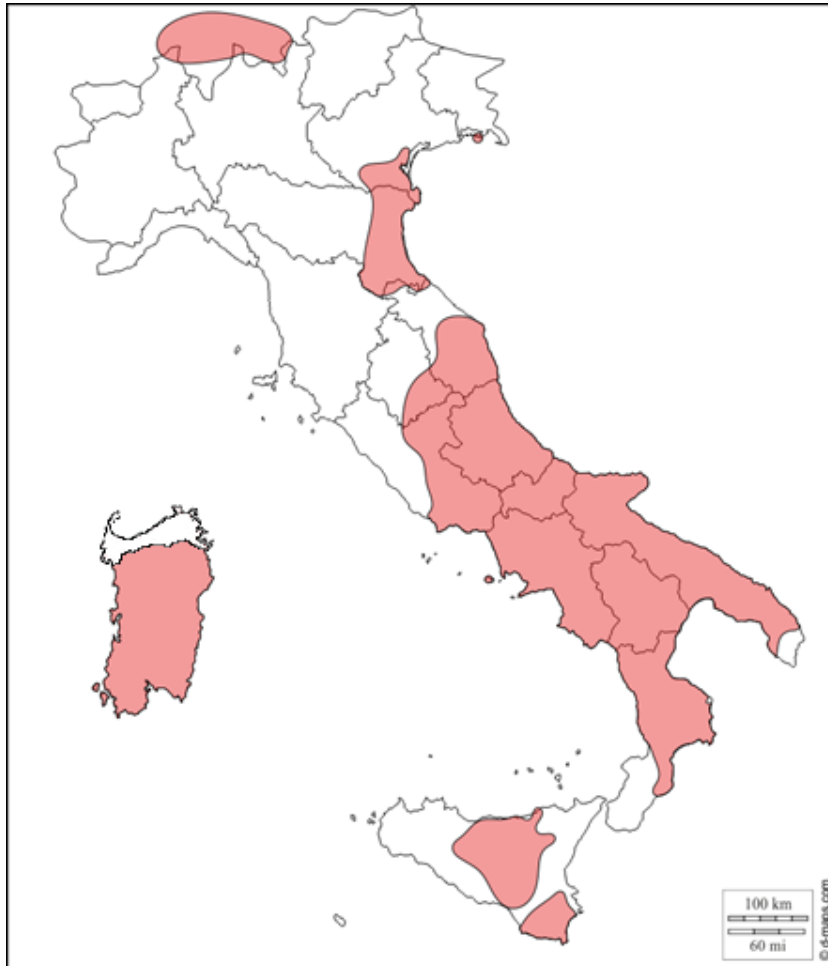
Metaphony is part of the group of dominant-recessive harmonies. The trigger is invariably an unstressed post-tonic vowel in a suffix, while the target is a stressed vowel in the root. All non-high vowels may be affected by metaphony. However, in the vast majority of occurrences, the low vowel /a/ behaves as neutral, and is not subject to raising. Vowels in pre-tonic position are generally not affected by metaphony, and in this sense, the process can be defined as non-iterative (but cf. §3.3.4.7 below). Vowels that intervene between the trigger and the stressed vowel normally act as transparent and are, for the most part, unaffected by metaphony. Different occurrences of metaphony display a wide array of varying configurations. The map under (65b) shows the areas where dialects that exhibit active metaphonic alternations are spoken. (65a) shows for comparison a map of Italy's main regions, so that during the discussion the areas where varieties are spoken can be referenced.

(65) Distribution of metaphony in Italian dialects (based on Maiden 1987: 41)

a. The administrative regions of Italy



b. Distribution of dialects with active metaphonic patterns in Italy



Metaphony is a pervasive feature of Italian dialects. In Northern Italy, it is present in dialects spoken in southern Veneto, in most dialects of Romagna and in some alpine varieties, where metaphonic alternation was not lost due to vowel reduction. For what concerns central varieties, metaphony is present in many dialects in the Marche region and in eastern and southern Umbria and Lazio (east of the Tiber River). Notably, it is absent in Tuscan varieties⁷⁴. For this reason, metaphony does not appear in Standard Italian. Metaphony is present in almost all southern varieties, with the exception of western Sicily, the extreme south of Calabria and Salento, and some localities around the Basilicata region. In addition, it is present in most dialects spoken in central and southern Sardinia (Savoia & Maiden 1997: 16).

As an example of regular metaphony, which follows the general description given here, we can take the case of Mascioni (L'Aquila, Abruzzi region). Here, mid-high vowels are raised to high vowels and mid-low vowels are raised to mid-high when in final unstressed position is present a high vowel. High vowels are endings in masculine singular nouns and adjectives /-u/, in masculine plural nouns and adjectives /-i/ and in verbs, mainly in the 2P.SG of the Present tense. Metaphonic alternations in the dialect of Mascioni are shown in (66).

⁷⁴ Traces of metaphony were found in the medieval dialect of Arezzo (Maiden 1987) and in the small and reclusive area of Garfagnana, (Venturelli 1975). Other varieties spoken in Tuscany were unaffected by metaphony.

(66) Metaphony in nouns and adjectives in Mascioni (Savoia & Maiden 1997: 15; Manzini & Savoia 2005: 210)

<i>Nouns and Adjectives I class</i>		<i>Singular</i>	<i>Plural</i>	
	<i>M</i>	'veccu	'vecci	'old'
	<i>F</i>	'vecca	'vecce	
	<i>M</i>	'vitou		'widower'
	<i>F</i>	'vetoa		'widow'
	<i>M</i>	'kurtu	'kurti	'short'
	<i>F</i>	'korta	'korte	
	<i>M</i>	'ou	'oa	'egg'
<i>Verbs: Present tense</i>		<i>1 sg.</i>	<i>2 sg.</i>	
		'ormo	'ormi	'sleep'
		'kofo	'kufi	'sew'
		'krejo	'kriji	'believe'
		me ʃʃakkwo	te ʃʃakkwi	'rinse'

Mid-low vowels raise to mid-high, while mid-high vowels raise to high. In this case, metaphony behaves as a scalar raising harmony. The low vowel /a/ generally acts as neutral, and does not activate nor undergo raising, even though some cases in which /a/ participates in metaphony are discussed in section §3.3.5. Consider the last example in the table (66). The final high vowel does not cause any modification in the stressed vowel /a/: [te ʃʃakkwi] *[te ʃʃekkwɪ].

In all its occurrences, metaphony behaves as a dominant harmony, meaning that the vowel that triggers the process is invariably part of a suffix, while the target of raising is the stressed vowel that sits in the root. The process is also invariably regressive. Non-regressive raisings in Italy are discussed in section §3.4, and are not considered cases of metaphony.

The nature of the metaphonic triggers tends to set metaphony aside from other more regular harmonic patterns. Metaphonic triggers are always post-tonic unstressed vowels, while in most harmonic processes the trigger tends to be stressed, or at least prosodically or morphologically relevant (Walker 2005, also cf. §1.4.1). Pre-tonic vowels are not always subject to metaphony, which only affects the stressed vowel. Cases where raising also affects pre-tonic vowels are treated in §3.4. In some dialects metaphony seems to behave iteratively, affecting post-tonic non-final vowels before affecting the stressed vowel (cf. §3.3.4.7).

Savoia & Maiden (1997) notice that cross-dialectal variation in metaphony depends on three general parameters: input, conditioning and output. In other words, processes of metaphony may vary regarding the conditioning context (the possible triggers), the vowels that are affected by the process (the targets) and the possible outcomes of the process.

In this section, the process of metaphony is presented loosely following those three parameters. In §3.3.3 are discussed the possible outcomes of metaphony. In §3.3.4 are considered the conditioning contexts for metaphony and their relations with the modern vowel systems of Italian dialects. In §3.3.5 the focus shifts to asymmetries, and the metaphonic configurations individuated by Maiden (1987, 1991) are presented and discussed.

II.3.3.3 The output: different effects of metaphony on stressed vowels

Traditionally, metaphonies are divided into two sets depending on the outcome of mid-low vowels. The first group is comprised of the so-called Raising Metaphonies. Metaphonies of this group are regular scalar raising processes similar to the case of Mascioni discussed in the example above in (66), and not too different from other raising processes of Bantu languages described in §3.1: mid-high vowels raise to high, while mid-low vowels raise to mid-high.

The second group is that of Diphthongizing Metaphonies. In this group of harmonies, the outcome for mid-high vowels is a high vowel, while the outcome for mid-low vowels is a descending diphthong composed of a semivowel followed by a mid-high vowel: [je], [wo]⁷⁵. Diphthongizing metaphonies thus have two different effects on their targets: raising and diphthongization.

II.3.3.3.1. Scalar raising metaphonies

The case of Mascioni presented earlier in (66) displays a perfect case of scalar raising. Another case of raising metaphony that is often discussed in the literature is that of Servigliano (central Marche). In (67) are discussed some alternations recorded for this variety, taken from Camilli (1929), Nibert (1998) and Walker (2003). Other alternations concerning Servigliano are provided in §VI.6.

(67) Scalar raising metaphony in the dialect of Servigliano

'metto	'I put'	'mitti	'you put'
'pesa	'it weighs'	'pisu	'weight (noun)'
'poce	'fly'	'puci	'flies'
'spōsa	'wife'	'sposu	'husband'
mo'desta	'modest F.'	mo'destu	'modest M.'
'pettene	'comb'	'pettini	'combs'
'predoko	'I preach'	'prediki	'you preach'
'mōre	'he dies'	'mori	'you die'
'mōja	'depressed F.'	'mofu	'depressed M.'

Another good example of scalar raising comes from Amandola (Marche region, central Italy). In (68) metaphonic alternations are shown in verbal paradigms, in nouns and in adjectives.

(68) Metaphony in Amandola (Savoia 2015: 216)

Verbs: Present tense	1 sg.	2 sg.	
	'kreðo	'kriði	'to believe'
	'moŋno	'muŋpi	'to milk'
	'kotʃo	'kotʃi	'to cook'
	1 sg.	3 pl.	
	'veŋgo	'veŋgu	'to come'

⁷⁵ This is the most common outcome for mid-low vowel diphthongization. However, cf. §3.3.3.2 for the complete list of possible outcomes.

<i>Nouns</i>	<i>Singular</i>	<i>Plural</i>	
	'prete	'preti	
<i>Adjectives</i>	<i>Feminine sg.</i>	<i>Masculine sg.</i>	
	'bōna	'bonu	

As noted above, scalar metaphonies closely resemble some of the raising processes previously encountered in the description of Bantu patterns. Raising applies in different ways to vowels of different relative heights. Within systems with a seven-vowel contrast in stressed position (i.e., systems that derive directly from Common Romance), we must use multiple primes to account for the three degrees of height. If we assume a standard set of binary features, the primes involved in scalar metaphonies are [\pm high] and [\pm ATR]. [\pm ATR] is necessary to distinguish between mid-high [+ATR] and mid-low [-ATR] vowels. It appears, then, that scalarity is a common property of raising processes which appears in raising harmonies of unrelated language families.

II.3.3.3.2 Diphthongizing metaphony

Diphthongizing metaphonies mostly behave as scalar metaphony, with the only difference being the outcome of mid-low vowels. Instead of raising, they undergo diphthongization. Diphthongizing metaphony is a pervasive feature of southern varieties that have the vowel system presented in (62). Recall that in those varieties word-final unstressed vowels generally undergo reduction. So underlying final high vowels normally surface as [ə]. The context of application for metaphony is thus rendered opaque by vowel reduction of the suffixal vowel. In the examples reported in (69), the marker for the masculine singular in both nouns and adjectives is considered to be an unstressed underlying /u/, while underlying /i/ is the suffix for masculine plural. The table in (69) shows metaphonic alternation in the dialect of Arpino.

(69) Diphthongizing metaphony in Arpino (southern Lazio, Calabrese 1995: 17 and references, Parodi 1982)

	<i>Singular</i>	<i>Plural</i>	
<i>M</i>	'sulə	'sulə	'alone'
<i>F</i>	'sola	'solə	
<i>M</i>	'nirə	'nirə	'black'
<i>F</i>	'nera	'nerə	
<i>M</i>	'bwonə	'bwonə	'good'
<i>F</i>	'bōna	'bōnə	
<i>M</i>	'vjekkjə	'vjekkjə	'old'
<i>F</i>	'vekkja	'vekkjə	

Calabrese (2011: 6) notes that diphthongizing metaphonies are more widespread than raising metaphonies in the Italian peninsula. Diphthongization is a feature of most metaphonic processes in southern Italy, while scalar metaphonies are the norm in central varieties. However, various exceptions exist, and it is not impossible to encounter diphthongizing metaphonies in an area where all neighboring dialects display a raising pattern, or vice versa.

The diphthongized result of metaphony can vary slightly from case to case, depending on the variety under scrutiny. All the following diphthongs may be the result of metaphony targeting a mid-low vowel: [je jɛ iə] may derive from [ɛ]; [wo, wɔ, we, wɛ, uə] from [ɔ]. In central varieties that display diphthongization the outcome is always [je, wo] (Savoia & Maiden 1997: 18).

Loporcaro (2009: 122f) considers diphthongizing metaphony as an innovating variant of the more archaic scalar raising. Under this idea, metaphony was primarily a purely raising process, which evolved developing a diphthongized form in place of the mid-high vowel as an outcome for mid-low vowel raising.

II.3.3.3.3 Complete raising (Hypermetaphony)

Besides scalar raising and diphthongizing, some varieties display complete raising. Recall from §3.1.3.13 that in Parkinson’s (1996) definition, complete raising is the result of a process whereby the targets assume the same degree of height as the triggers. Since only high vowels are valid triggers for metaphony, this means that both mid-low and mid-high vowels surface as high vowels when undergoing a complete-raising metaphony.

Processes of this nature are referred to as hypermetaphonies, in the literature on Italian dialects (Valente 1975 in Maiden 1991: 174). Carosella (2005: 94), discussing the varieties of Northern Gargano (northern Apulia) considers such cases as an ulterior evolution of diphthongizing metaphonies in which the diphthongal result of mid-low metaphony underwent monophthongization, ending up in a high vowel. If we combine this hypothesis with the one presented above, hypermetaphonies are the final stage of the evolution of scalar metaphonies, which first became the diphthongizing type, and then became hypermetaphonies. Note that the definition of metaphonies as scalar, diphthongizing and complete hinges solely on the outcome of mid-low targets, since in all three patterns mid-high targets regularly raise to high.

The table in (70) reports alternation in the Apulian dialect of Foggia, where all stressed mid-vowels result in high vowels when followed by a final unstressed high vowel.

(70) Metaphony in the dialect of Foggia (Northern Apulia, Calabrese 1995:400, and references)

	<i>Singular</i>	<i>Plural</i>	
<i>M</i>	muʃʃu		'soft'
<i>F</i>	moʃʃa		
<i>M</i>	kjinu		'full'
<i>F</i>	kjena		
<i>M</i>	grussu		'big'
<i>F</i>	grɔssa		
<i>M</i>	pete	piti	'foot'

The complete effect of raising is evident in the plural of [pɛte] ‘foot’, which surface as [piti] ‘feet’, with the low vowel /ɛ/ surfacing as [i] when followed by the final unstressed /i/ of the masculine plural. Similarly, final /u/ triggers complete raising of mid-low vowel /ɔ/ in the masculine/feminine alternation [grɔssa] ‘big, f.’ [grussu] ‘big, m.’. When the target of metaphony is a mid-high vowel, the outcome of the process is the same in scalar, diphthongizing and complete harmony: /o/→[u], as in

masculine/feminine alternation in the adjective [moʃʃa] ‘soft, f.’ and [muʃʃu] ‘soft, m.’ /e/→[i] as in the alternation between [kjena] ‘full, f.’ and [kjinu] ‘full, m.’

A similar case of hypermetaphony appears in the dialect of Francavilla Fontana (Foggia, Apulia. Maiden 1991: 223), exemplified in (71). Here metaphony is activated only by unstressed final /i/, and only in verbal paradigms⁷⁶.

(71) Complete raising in the verbal paradigm in Francavilla Fontana (present tense).

<i>1.sg</i>	<i>2.sg</i>	
'dɔrmu	'durmi	'sleep'
'lɛddʒu	'liddʒi	'read'
'kɔsu	'kusi	'sew'

II.3.3.3.4 Fronting in metaphonies

Some metaphonic processes, alongside raising, also affect stressed vowels by fronting them. Metaphonies of this type are typical of varieties where only /i/ activates metaphony, and underlying /u/ is not a valid trigger. The result of metaphony is not only raised or diphthongized, but also fronted, suggesting that two features proper to the trigger /i/ are harmonic in those dialects: [+high] and [-back]. Fronting metaphonies are especially frequent in alpine dialects, spoken in Northern Italy, which display in their vowel systems rounded front vowels. Fronting of back vowels can also be found in some southern varieties (cf. §3.3.5; Carosella 2005: 90) but it is a rather rare feature, that appears only in marginal contexts. In (72) the case of the Romance-Swiss dialect of Cevio is presented. In Cevio the activation of metaphony is rendered opaque by apocope of final /i/ in the case of the masculine plural (in the first part of the table) and by the generalization of final [i] in verbal forms (in the second section of the table). In nouns and adjectives, metaphony applies in the plural of the masculine forms, in verbs metaphony applies in the second person singular of the present tense.

⁷⁶ Maiden presents hypermetaphony as an optional process applied only by verbal suffixes, while regular diphthongizing/raising metaphony also occurs when the process is activated by nominal suffixes. The case of Foggia does not follow Maiden’s analysis, since complete raising of mid-low vowels applies in both verbal and nominal paradigms. The issue of morphological condition on metaphony is discussed in greater length in section §3.3.4.5.

(72) Fronting metaphony in Cevio (Ticino canton, southern Switzerland, Canalis 2016)

a. Fronting metaphony in nouns and adjectives

<i>Singular</i>	<i>Plural</i>	
ku'lur	ku'lyr	'color'
'ʃtumi	'ʃtymi	'stomach'
'møl	'møl	'soft, squashy'
'kørp	'kørp	'body'
'krøvat	'krøvat	'spruce'
'tavul	'tevul	'table'
a'legar	a'ligar	'happy'
'ʃpørk	'ʃpyrk	'dirty'

b. Fronting metaphony in verbs: present tense

<i>I sing.</i>	<i>II sing.</i>	
ris'pund	ris'pynd	'answer'
ad'ņus	ad'ņys	'know'
'trøvi	'trøvi	'find'
'vali	'veli	'be worth'
'bevi	'bevi	'drink'
'gødi	'gødi	'enjoy'
'vend	'vind	'sell'

In the examples reported in (72) all vowels undergo metaphony, including the low vowel /a/ and the high-rounded vowel /u/. Front mid-vowels result in a higher vowel (displaying a scalar behavior, since mid-low vowel /ε/ surfaces as mid-high [e]), back vowels result in higher advanced vowels. The process also affects the back rounded vowel /u/, which in Cevio is a valid target for metaphony. The complete schema of outcomes of metaphony in Cevio is summarized below:

- /e/ → [i] [vend] 'I sell' - [vind] 'you sell'; [alegar] 'happy' - [aligar] 'happy (pl.)'
- /ε/ → [e] [bevi] 'I drink' - [bevi] 'you drink'
- /ø/ → [y] [ʃpørk] 'dirty' - [ʃpyrk] 'dirty (pl.)'
- /ɔ/ → [ø] ['møl] 'soft' - ['møl] 'soft (pl.)' ['kørp] 'body' - ['kørp] 'bodies'
- /u/ → [y] ['ʃtumi] 'stomach' - ['ʃtymi] 'stomachs'
- /a/ → [ε] [vali] 'I am worth' [veli] 'you are worth'

In vowels that are already front, the process only raises the target, and in vowels that are already high (i.e., /u/), metaphony behaves solely as a fronting process. In non-high, back targets, the metaphonic process acts on both primes, resulting in an outcome which is relatively higher and fronted: /ɔ/ → [ø].

To sum up the section §3.3.3, in which are presented the possible outcomes of metaphonies, we can say that the process of metaphony can be implemented through three different structural modifications: raising (both scalar and complete raising), diphthongization, and fronting. It is relevant to notice that

raising is always part of the metaphonic process: in diphthongizing metaphonies, mid-high vowels still undergo raising, and in the fronting harmony of Cevio front vowels still undergo metaphony through scalar raising. In this sense, metaphony appears as a raising process that can also exhibit additional effects on the target. The different outcomes of the process has been one of the central issues related to metaphony in the specialized literature. Metaphonies display a wide variety of possible outcomes, even though the context of application and the prime composition of targets and triggers remain roughly the same.

II.3.3.4 Contexts of application: variation in the nature of metaphonic triggers

Metaphony belongs to the group of dominant harmonies (cf. §1.4.1), in which the vowel of a suffix behaves as the trigger for the vowels of the root. As is the case for all other processes described in this survey, alternations are evident in inflectional paradigms, when the selection of an inflectional suffix changes the nature of the unstressed final vowel, creating alternations. In this sense, metaphony has always been a shared interest between phonologists and morphologists. Varieties that display metaphony normally exhibit alternations in both nominal and verbal paradigms.

Nominal paradigms in Standard Italian and in Italian dialects can be roughly divided into two groups⁷⁷. The first one contains masculine nouns whose endings are suffixal /-o/ (singular), and /-i/ (plural): e.g. [ors-o], [ors-i] ‘bear,s’; [libr-o], [libr-i] ‘book,s’. It also contains feminine nouns whose endings are suffixal /-a/ (singular) and /-e/ (plural): e.g. [rɔs-a], [rɔs-e] ‘rose,s’; [bors-a], [bors-e] ‘bag,s’. Adjectives of the first class share the same endings presented for the nouns: [bell-o] ‘beautiful, m.s.’ [bell-a] ‘f.s.’ [bell-i] ‘m.p’ [bell-e] ‘f.p.’. In the tables concerning metaphonies, I refer to this group (both nouns and adjectives of the first class) as Class I.

The second group contains nouns whose singular is marked as /-e/, while the plural is /-i/. This class contains both masculine and feminine nouns: [kan-e], [kan-i] ‘dog,s M’; [notf-e], [notf-i] ‘nut,s F’. Adjectives of this group share the same endings with nouns: [fort-e], [fort-i] ‘strong’; [semplitf-e], [semplitf-i] ‘simple’. Nouns and adjectives of this class are referred to as Class II. (73) summarizes the division between nouns and adjectives of the first and of the second class. The examples come from standard Italian, where metaphony is not present.

(73) Noun and adjective categories in Italian.

			Singular	Plural	
Class I	Nouns	M	orso	orsi	bear
		F	rɔsa	rɔse	rose
	Adjectives	M	bello	belli	beautiful
		F	bella	belle	
Class II	Nouns	M	kane	kani	dog
		F	notfe	notfi	nut
	Adjectives	M	semplitf-e	semplitf-i	simple
		F			

⁷⁷ A third group of nouns can be added, namely that of nouns that have a masculine ending in the singular form and a feminine plural form that ends in [a]. Italian nouns such as [dito] [dita] (finger,s), [brattfo] [brattfa] (arm,s) are part of this group. The masculine singular ending of those noun is a valid context of metaphony, since it coincides perfectly with the masculine singular of Class I nouns.

The suffixes [-o] and [-i] reported in the table above (i.e., the singular masculine for nouns and adjectives of the first class plus masculine plurals of the first class and all plurals of the second class) are, in most cases, valid triggers of metaphony. The suffixal [-o] of nouns and adjectives of the first class derives from Latin *U, and, since it is a valid trigger in most dialects that display metaphony, it is reconstructed as an underlying /u/.

In verbs, the most common trigger is the high vowel in the suffix of the second person singular of the present tense, which surfaces as [-i], and thus most of the examples concerning alternation in verbal roots are shown using only the present tense. Notice that other morphological contexts may exhibit metaphony, if the suffix contains a high vowel. Besides the suffix that concerns nouns and adjectives, only /i/ may appear in verbal suffixes. Most of the examples report nominal alternation in order to assess the symmetric or asymmetric nature of the process (i.e., to check whether both /i/ and /u/ are triggers or if only one of them is).

To sum up, triggers for metaphony are underlying /i/ and /u/ in final unstressed position. In most Italian dialects, the suffixes whose vowels trigger metaphony are:

- Class I nouns and adjectives:
 - Masculine singular suffix.
 - Masculine plural suffix.
- Class II nouns and adjectives:
 - Masculine and feminine plural suffixes.
- Verbs:
 - Suffix for the second person singular of the present tense.

As discussed in §3.3.1, vowels in unstressed final position underwent reduction in different ways throughout the Italian peninsula. This changed the surface form of final unstressed vowels, the triggers of metaphony.

Some dialects spoken in central Italy (southern Marche and Umbria, Northern Abruzzo and southwestern Lazio) still display a five-vowel system in post-tonic position, i.e., can display a metaphonic environment where both [u] and [i] appear as triggers. In dialects of this area, metaphony is not made opaque by vowel reduction and applies regularly.

In most (but not all) northern varieties, the evolution of final vowels had an impact on the context of application of metaphony. In Venetan dialects, [u] never appears in final position, hence only [i] triggers the process. This is not due to a particular asymmetry in the phonemic system, but rather to the absence of [u] in triggering contexts in the varieties of southern Veneto (cf. §3.3.5.1). Similarly, most (but not all) Gallo-Italic dialects lost final vowels different from [a], *de facto* losing all possible context for metaphonic application. Nowadays, metaphony is recorded only in few areas of northern Italy. Some traces of an ancient metaphony are still found in the lexicon of numerous varieties, but the process is inactive, with the exception of some Emilian-Romagnol varieties and of some conservative alpine dialects.

Other Italian dialects generally underwent a severe restructuring of the vowel system in final position. The same topic already discussed in §3.3.2 is reconsidered in the following paragraphs, in light of the effects that the restructuring of the system of contrasts in final vowels has on metaphony. The process of vowel reduction modifies the system of oppositions that makes metaphony surface-true, resulting in configurations in which the nature of the trigger is not immediately evident from the analysis of its surface form.

II.3.3.4.1 Lowering of final vowels: Central Italian dialects

In some Central dialects (between Lazio, Marche, Umbria and south-east Tuscany) final high vowels merged with mid vowels, resulting in a system of final vowels structured around three options: [o], [e] and [a]. Metaphonic alternations are still found in both nominal and verbal paradigms, but only in those cases in which the final mid-vowel corresponds to an etymological high-vowel.

For example, in the dialect of Sonnino reported in (74) below, vowels in suffixes that traditionally trigger metaphony lowered to [o] < *u and [e] < *i, but metaphony still applies even though the context of application appears to be lost. Metaphony in Sonnino is scalar, and is triggered by both underlying /u/ and /i/.

(74) Metaphonic alternations in Sonnino (province of Latina, southern Lazio. Savoia 2015: 249-250)

a. Metaphony in Sonnino: alternations in nominal paradigms

		<i>Singular</i>	<i>Plural</i>	
<i>Class I nouns and adjectives</i>	<i>M</i>	'niro	'nire	<i>black</i>
	<i>F</i>	'nero	'nere	
	<i>M</i>	'sulo	'sule	<i>alone</i>
	<i>F</i>	'sola	'sole	
	<i>M</i>	'novo	'nove	<i>new</i>
	<i>F</i>	'nɔva	'nɔve	
	<i>M</i>	'vecco	'vecce	<i>old</i>
	<i>F</i>	'vecca	'vecce	
<i>Class II nouns and adjectives</i>		<i>Singular</i>	<i>Plural</i>	
	<i>F</i>	'noʃe	'nuʃe	<i>nut</i>
	<i>M</i>	'mese	'mise	<i>month</i>
	<i>M</i>	'pete	'pete	<i>foot</i>

b. Metaphony in Sonnino: alternations in verbs

<i>Verbs: Present tense</i>	<i>I sing.</i>	'perdo	<i>I lose</i>
	<i>II sing.</i>	'pirde	<i>you lose</i>
	<i>III sing.</i>	'perde	<i>She/he/it loses</i>
	<i>I sing.</i>	'vedo	<i>I see</i>
	<i>II sing.</i>	'vide	<i>you see</i>
	<i>III sing.</i>	'vede	<i>She/he/it sees</i>

In nouns and adjectives that are part of the second class, the masculine singular suffix [-e] < *EM⁷⁸ is not an eligible trigger for raising, while the plural suffix [-e] > *I/IS, which is underlyingly /-i/, is a valid trigger: the singular nouns ['noʃe] 'nut' and ['mese] 'month' have /e/ as their final vowel, which does not trigger raising. However, their plural forms ['nuʃe] 'nuts' ['mise] 'months' have the plural ending /i/, which surfaces as [e] due to vowel lowering.

⁷⁸ Here and below, capital letters are used to refer to Latin etymologies.

It appears that the restructuring of the vowel system in unstressed position does not affect the contexts of application of metaphony, suggesting that the contrast between mid and high vowels is still relevant in the underlying forms.

II.3.3.4.2 Final vowel raising: extreme southern varieties

In varieties where the vowel system evolved following the Sicilian vowel system (cf. §3.3.1), final unstressed mid-vowels of Common Romance are neutralized in favor of high vowels [i] and [u].

On some occasions, the system of oppositions in final vowels resulting from vowel reduction actually increased the number of metaphonic contexts. This can be seen in the examples reported in the tables under (75) and (76). In the Sicilian varieties of Ragusa (Maiden 1991: 159, Piccitto 1941) and Modica (Savoia 2015: 257), metaphony applies in the feminine plurals of Class I nouns ([-i]>*e) and the first person singular of verbs ([-u]>*o). Generally, those morphological contexts are not metaphonic in other Italian varieties. The fact that in Ragusa and Modica they are so suggests that vowel reduction had an effect on the underlying form of final vowels.

(75) Metaphony in the dialect of Ragusa (Sicily, Maiden 1991: 159).

Class I adjectives		Singular	Plural	
	M	'bbwɔnu	'bbwɔni	
F	'bbɔna	'bbwɔni	'open'	
M	a'pjɛrttu	a'pjɛrtti		'strong'
F	a'pɛrtta	a'pjɛrtti	'foot'	
Class II nouns and adjectives	M/F	'foɾtti		'fwoɾtti
	M	'pɛri	'pjɛri	

(76) Metaphony in the dialect of Modica (Sicily, Savoia 2015: 257)

Class I Adjectives		Singular	Plural	
	M	'vjɛttʃu	'viɛttʃi	
F	'vɛttʃa	'viɛttʃi	'big'	
M	'rwɔssu	'rwɔssi		
F	'rɔssa	'rwɔssi		
Verbs: present tense	I sing.	'pjɛddu		'I lose'
	II sing.	'pjɛddi		'you lose'
	III sing.	'pɛddi		'he loses'
	I sing.	'rwɔmmu		'I sleep'
	II sing.	'rwɔmmi		'you sleep'
	III sing.	'rɔmmi		'she sleeps'

In Ragusa and Modica the process of metaphony is present in morphological contexts where it is normally absent, namely the feminine plural of nouns and adjectives of the first class. Consider the

alternation in adjectives of the first class in the tables (75) and (76). Normally, metaphony applies to the masculine singular and plural, while it does not apply in the feminine. In (75) and (76) only the feminine singular (marked by final /a/) exhibits stressed mid vowels in the root, suggesting that the underlying form for the plural feminine suffix is an underlying /i/, which is a valid trigger for metaphony. Consider the singular vs. plural alternation between the adjectives [bbɔna] ‘good f.s’ [bboni] ‘good, F.PL’ in table (75) and [ˈrɔssa] ‘big, F.S’ and [ˈrɔssi] ‘big, F.PL.’ in table (76). Metaphony consistently applies in the feminine plurals in the dialects of both Modica and Ragusa because the process of vowel reduction that formed the Sicilian vowel system from the Common Romance vowel system modified the underlying form of the feminine plural exponent of nouns and adjectives.

That being said, it appears that metaphony in the two Sicilian varieties under scrutiny is not completely surface-true. Masculine nouns and adjectives of the second class, that have Common Romance *e as their last vowel and exhibit [-i] as the final vowel in (76), do not display metaphony: [ˈfoɾtti] ‘strong M.S’ *[ˈfwoɾtti]; [ˈperi] ‘foot’ *[ˈpjeri]. In addition, in verbs of the III pers. singular, in the present tense, there is no metaphonic raising while the final vowel surfaces as [i]: [rɔmmi] ‘he sleeps’. We can conclude that in nouns and adjectives of Class II and in third person verbs, the final vowel surfaces as [i], but it must be still /e/ in its underlying form (maintaining the nature it had in Common Romance), since metaphony does not take place in those contexts.

This partial generalization of the contexts of application is not common to all areas where mid vowels do not appear in final position. For example, in Mormanno (Northern Calabria, in the Lausberg Area), mid-vowels raised to high in final position. The system of contrasts for final vowels is thus the same of the varieties presented earlier: [i, a, u]. However, in Mormanno, exemplified in the table under (77), the process applies only when the high vowel on the surface correspond to an etymological high vowel. In (77) is reported the effect of metaphony on mid-low vowels (raised to mid-high) when followed by original Common Romance *i and *u. When the final high vowel derives from an original mid-vowel (i.e., in the feminine plural [i]<*e), the process of metaphony does not apply.

(77) Mormanno, northern Calabria (Savoia 2015: 255)

	<i>Singular</i>		<i>Plural</i>		
	<i>M</i>	<i>F</i>	<i>M</i>	<i>F</i>	
<i>Class I Adjectives</i>	<i>M</i>	'veccu	'vecci		<i>old</i>
	<i>F</i>	'vecca	'vecci		
	<i>M</i>	'novu	'novi		<i>new</i>
	<i>F</i>	'nɔva	'nɔvi		
<i>Class I Nouns</i>	<i>M</i>	'lettu	'letti		<i>bed</i>
	<i>F</i>	'rɔta	'rɔti		<i>wheel</i>
	<i>M</i>	'occu	'occi		<i>eye</i>
	<i>F</i>	'seddʒa	'seddʒi		<i>chair</i>
					VĚTŮLUM ⁷⁹
					NŮVUM
					LĚCTUM
					RŎTAM
					ŎCULUS
					*SEDIULA

⁷⁹ Most of the names in the Italian lexicon derive from the Latin accusative form and not from the Latin nominative form. In the examples where the Latin etymology of a noun (or an adjective) is relevant, examples are reported in the accusative form.

In Mormanno, at least for what concerns nominal paradigms (cf. §3.3.4.5), metaphony applies only in contexts where high vowels correspond to etymological high vowels. The restructuring of contrasts in final position did not affect metaphony in this case.

In dialects where mid-vowels were lost in final position in favor of high vowels, there are two possible metaphonic behaviors that are exemplified in this section. The process can be partially generalized, resulting in dialects where raising/diphthongization applies in unexpected morphological contexts (as in Modica and Ragusa). In other varieties, the restructuring of the vowel system does not modify the morphological context of application, suggesting that there are varieties in which final mid-vowel raising is effective only in the surface. In Mormanno, the distinction between underlying mid-vowels and underlying high vowels in final position is still relevant in nominal paradigms.

II.3.3.4.3 Final vowel centralization

In most of southern Italy (most of Campania, western Abruzzo, Molise, northern Apulia, northern Calabria and a small portion of southern Marche), final unstressed vowels have been reduced to [ə]. This pattern is the norm in Upper-Southern Italian dialects. However, even though no high vowel surfaces in final unstressed position, metaphony still applies, but only when the surface [ə] correspond to an original Common Romance high vowel. In other words, the process of metaphony applies only in the morphological contexts noted in §3.3.4 (i.e., masculine singulars and plurals of nouns and adjectives of the I class, masculine plurals in nouns and adjectives of the II class and 2nd person in present tense verbs).

Instead of repeating the same tables twice, I refer to the examples already given in the tables under (68-69), which are cases of metaphony that applies regularly in those varieties, albeit having lost the system of contrasts in final position.

II.3.3.4.4 Final vowel apocope

As already anticipated, most northern Italian dialects do not exhibit metaphony. This is probably a consequence of the loss of all final vowels except for /a/. Nonetheless, some varieties, mainly those especially conservative that are spoken in some secluded valleys in the Alps, and dialects in the Emilia-Romagna region, exhibit metaphonic alternations. Consider once again the case of Cevio presented earlier in table (72) or the case of Lugo (Ravenna, Emilia-Romagna) in (78). Here the final vowel is lost, but metaphony still applies, marking a difference between singular and plural in nominal paradigms (only in masculines).

(78) Metaphony in the dialect of Lugo (Romagna, Pellicciardi 1977)⁸⁰.

	<i>Singular</i>	<i>Plural</i>	
<i>M</i>	'spos	'spus	'groom'
<i>F</i>	'spoza	'spoz(i)	'bride'
<i>M</i>	'ner	'nir	'black'
<i>F</i>	'nera	'ner(i)	
<i>M</i>	'mo ^a rt	'murt	'dead'
<i>F</i>	'mo ^a rta	'mo ^a rt(i)	
<i>M</i>	'bɛl	'be ^a l	'beautiful'
<i>F</i>	'bela	'bɛl(i)	

In the dialect spoken in Lugo the actual contexts of application are reduced, since metaphony does not apply in masculine singular nouns and adjectives. However, in contexts where final *I can be reconstructed, metaphony still applies. In this case, we can consider metaphony to be asymmetric, being activated only by final underlying /i/ (present in plurals) and not by final /u/ (cf. §3.3.5.1, 87). Unfortunately, nothing guarantees that /u/ is actually the underlying form of masculine singular nouns and adjectives of the first class in Lugo and other neighboring varieties. Further discussions of the asymmetric patterns in metaphonies is carried out in section §3.3.5.

The reduction of contrasts in final position rarely affected metaphony, since in most cases the restructuring of the vowel system did not result in a different set of morphological contexts of application of metaphony. While some exceptions exist, in most occasions metaphony remains the sole exponent of a morphologically relevant alternation, suggesting that final vowels in metaphonic contexts may be underlyingly high even when they surface as mid-vowels or centralized vowels.

II.3.3.4.5 Metaphony and morphology

From the discussion carried on in the previous section, we can conclude that the context of application of metaphony is more or less consistent in most Italian dialects. The surface nature of its triggers generally does not matter, since the process applies in the same morphological contexts, regardless of the vowel that appears in final position⁸¹. The typical metaphonic triggers have been identified in §3.3.4 as the masculine singular and the masculine plural suffixes of nouns and adjectives that belong to Class I, masculine and feminine plural suffixes of nouns and adjectives belonging to Class II and the suffix for the second person singular of the present tense.

This fact has led many scholars to consider metaphony as a process more related to morphology than other harmonies. Some believe that metaphony is itself triggered by morphological information (cf. §IV.7.3), and not necessarily by any underlying high vowel.

This position is strengthened by the presence of metaphonies that appear to define their context of application solely on a morphological basis, and not a phonological one, or that modify their behavior according to the morphological nature of the suffix that contains the trigger.

⁸⁰ Metaphony is activated for plural nouns. The suffix for plural derives from Common Romance *i. Feminine plural is sometimes vocalized as [i] < *e, but is often dropped. Here it is represented between parenthesis.

⁸¹ Naturally, this generalization is to be taken with a grain of salt: we have already seen some exceptions in §3.3.4.2, and other cases will be presented in §3.3.5.

Consider the case of the morphologically conditioned metaphony in Cervara, where both a scalar raising and a complete raising metaphony are present. Maiden (1991) discusses cases of hypermetaphony in which the outcome of the process varies according to the morphological category of the word where the process applies. Stressed mid-low vowels undergo scalar raising in nouns and adjectives, while they undergo hypermetaphony (complete raising) in verbs. It means that the context of application is contemporarily phonological (the trigger is always a final unstressed high vowel) and morphological (the relative outcome of the process depends on the nature of the word it applies to). This phenomenon is reported in the dialect of Cervara (Merlo 1922). Here, rounded high vowels in final position underwent lowering in nouns. However, metaphony still applies in masculine singular nouns and adjectives, regardless of the surface realization of inflectional endings. In addition, in Cervara the suffix of the third person plural of the verb in the present tense exceptionally acts as a valid trigger for metaphony. Consider the alternations reported under (79) from the dialect of Cervara (Lazio, central Italy).

(79) Hypermetaphony in Cervara (Merlo 1922)

Class I Adjectives		<i>Singular</i>	<i>Plural</i>	
	<i>M</i>	'b:eλλo	'b:eλλi	
<i>F</i>	'b:ella	'b:elle		
<i>M</i>	'b:ono	'b:oni	'good'	
<i>F</i>	'b:ona	'b:one		
Verbs: Present tense	<i>I sing.</i>	'korro		'I run'
	<i>II sing.</i>	'kurri		'you run'
	<i>III sing.</i>	'korre		'he/she/it runs'
	<i>III plur.</i>	'kurru		'they run'
	<i>I sing.</i>	'vedo		'I see'
	<i>II sing.</i>	'vidi		'you see'
	<i>III sing.</i>	'vede		'he/she/it sees'
	<i>III plur.</i>	'vidu		'they see'
	<i>I sing.</i>	'kɔλλo		'I pick'
	<i>II sing.</i>	'kuλλi		'you pick'
	<i>III sing.</i>	'kɔλλe		'he/she/it picks'
	<i>III plur.</i>	'kuλλu		'they pick'
	<i>I sing.</i>	'meto		'I reap'
	<i>II sing.</i>	'miti		'you reap'
	<i>III sing.</i>	'mete		'he/she/it reaps'
	<i>III plur.</i>	'mitu		'they reap'

Mid-low vowels undergo scalar raising, as shown in the examples in the first section of the table in (79): mid-low vowels surface as mid-high vowels in metaphonic contexts. Metaphony creates an alternation between feminine and masculine adjectives with non-mid-low vowels in feminine and mid-high vowels in masculine. ['bbɔna] 'good (f.)' becomes ['bbono] in the masculine form.

The same is not true for the examples in the second section of the table, which involve alternations in verbs. Mid-low vowels undergo complete raising in verbs: final /i/ and /u/ raise them not to mid-high

vowels, but to high vowels. Mid-low vowels in the first person singular become high in the second person: ['kɔλλo] ‘I pick’ ['kuλλi] ‘You pick’, “jumping” the intermediate step of mid-high vowel seen in mid-low raising in adjectives: ['kuλλi], *['koλλi].

We can consider metaphony in Cervara as composed of two raising processes. The first involves scalar raising of stressed mid-vowels in nouns and adjectives, the second involves complete raising of stressed mid-vowels in verbs. The context of application, from a phonological standpoint, is the same: underlying final unstressed high vowels trigger raising. In other words, the same phonological object (final underlying high vowel) has two different behaviors, albeit being part of the same phonological context. The only difference in the application of those two processes is morpho-syntactic in nature.

Another example of morphologically conditioned metaphony is the case of Mormanno, which has been briefly discussed in §3.3.4.2, where the process of metaphony seems to apply only in nouns and adjectives, and not in verbs. Nouns and adjectives display metaphonic alternations, while final high vowels in verbs (whether etymologically high or not) never trigger metaphony. The only difference between the final original high vowel in masculine plural nouns and final original high vowel in verbal suffixes is morphological in nature. Phonology has no way to represent a structural difference between the two objects. As for the case of Cervara Hypermetaphony, both the active and inactive suffixes should have the proper features to activate raising/diphthongization. Metaphonic alternations in the dialect of Mormanno are reported in (80) below.

(80) Metaphony in Mormanno (Savoia 2015: 255)

<i>Class I Adjectives</i>	<i>M</i>	<i>Singular</i>	<i>Plural</i>		'old'	VĚŤŮLUM
	<i>F</i>	'veccu	'vecci			
	<i>M</i>	'vecca	'vecci		'new'	NŮVUM
	<i>F</i>	'novu	'novi			
<i>Class I Nouns</i>	<i>M</i>	'nova	'novi		'bed'	LĚCTUM
	<i>F</i>	'lettu	'letti			
	<i>M</i>	'rɔta	'rɔti		'wheel'	RŮTAM
	<i>F</i>	'occu	'occi			
<i>Verbs: Present tense</i>		<i>I sing.</i>	<i>II sing.</i>	<i>III sing.</i>	<i>III plur.</i>	
		'krɛðu	'krɛðisi	'krɛði	kre'dinu	'believe'
		'vɛŋgu	'venisi	'veni	vɛ'ninu	'come'
		'dɔrmu	'dɔrmisi	'dɔrmi	dɔr'minu	'sleep'

Final high vowels trigger scalar raising in nouns and adjectives, but not in verbs: ['veccu] ‘old M’ ['vecca] ‘old F’; ['krɛðu] ‘I believe’ *['krɛðisi] ‘you believe’, *['krɛðu] ‘I believe’ *['krɛðisi].

Contexts of application that are expected to be phonologically identical turn out to be subject to different rules in regards to metaphony. In Mormanno, final high /i/ triggers metaphony in nouns and adjectives but it does not do so in verbs, where forms such as ['krɛðisi] ‘you believe’ and ['krɛði] ‘he believes’, which should be valid contexts of application for metaphony, do not display raising nor diphthongization. Speakers of the dialect of Mormanno apply the process in nouns and adjectives, and do not apply it in verbs. Similarly, Speakers of the Cervara dialect apply scalar metaphony to adjectives

and nouns and hypermetaphony to verbs. In the examples presented in this subsection, morphology directly interacts with the mechanisms of metaphony.

Loporcaro (2011), Maiden (1991) and Calabrese (2016) all agree (whilst displaying different approaches) that some occurrences of metaphony cannot be considered proper phonological processes. Pöchtrager & Kaye (2014) share this same view. The relation between phonology and the other domains of the language faculty is treated more extensively in §IV.7, and the various proposals we only hinted at here will be developed further. For the moment, it is relevant to note that numerous metaphony processes seem to have close links with the morphological nature of the context of application.

II.3.3.4.6 Phonological activity of metaphony

Both the reduction of final vowels discussed in §3.3.4.4 and the cases of morphologically conditioned metaphonies treated in §3.3.4.5 introduce a concern regarding the activity of metaphony. Is it an active process or it has become a lexicalized property of Italian dialects? Dialectological sources, often dated, seldom approach the argument of phonological productivity, and data collections often do not allow us to be sure about the activity of a process. The question of productivity bears clear consequences for the goals of this thesis. Naturally, a fossilized process that is no longer active does not have the same phonological status as an active one, and a theory of phonology that tries to understand the properties of a cognitive module of phonology (cf. §V.2.1) has an obligation to account for active processes, but inactive ones need no explanation, on a generative point of view.

Most of the examples reported here offer multiple paradigmatic alternations, which reduces the doubt that metaphonic alternations are lexicalized. Since the process of metaphony (as well as most raising harmonies) affects stressed vowels in roots, it would be necessary to assume that all words that alternate have two lexicalized roots, one alternant that shows up in non-metaphonic contexts, the other in metaphonic contexts.

Recent analyses and data collections certify that metaphony is still active and productive in certain dialects. Among them, Grimaldi and Calabrese (2017) carry on a detailed analysis of metaphony in the dialect of Tricase (spoken in Salento, the southern tip of the Apulia region in southeastern Italy). In their work, the authors analyze not only synchronic alternations, but also the phonetic nature of metaphonic outcomes, as well as the way those outcomes are perceived by speakers. They conclude that the allophonic variation generated by metaphony is part of the phonological grammar acquired by the Tricase speakers.

Concerning the fact that many metaphonies do not display on the surface the high nature of triggers (i.e. that in many varieties metaphony is opaque), there are ways in which phonological theories can account for this, which are discussed in §IV.7. In addition, data from some varieties show that surface [ə] actually corresponds to other vowels. For example, consider the dialect of San Valentino Citeriore (Abruzzi, Passino & Pescarini 2019). Here metaphony applies (even if it is triggered only by /i/), and all final vowels surface as [ə]. However, in some contexts (noun phrases), some final vowels [a, i, u], may resist reduction and surface as full vowels. Consider the following examples from Pescarini & Pascetta (2014):

- a. koss einə nu bellu parlə` ‘*This is something good to say/hear*’
- b. m'aripwörti təu ? ‘*Are you bringing me back home ?*’
- c. na bbella kəsə ‘*A nice house*’

At least for some varieties, then, the underlying nature of final vowels can be observed.

The issue of morphologically conditioned metaphonies is treated in more depth in §IV.7 and §VI.7.

II.3.3.4.7 Behavior of non-final unstressed vowels. Is metaphony iterative or not?

In the literature concerning vowel harmonies, the term iterativity indicates the property of most VH to affect vowels of a word “one at a time”. The trigger affects a vowel that can then affect another one etc., creating a harmonic chain, in which a targeted vowel behaves itself as a trigger. In §3.3.2, where the mechanisms of metaphony were first introduced, metaphony was defined as a non-iterative process, mainly because pre-tonic vowels are generally not affected by it. Metaphony is for the most part a process in which a single trigger (the final unstressed vowel) affects a single target (the stressed vowel). Italian and its dialects do not have a fixed position for the word stress, which can appear freely in any of the last three syllables of the word. The most common position for stress is the penultimate syllable. When this is the case, the trigger and the target of metaphony appear in neighboring syllables.

Words in which the stress falls in the antepenultimate syllable, however, have an unstressed vowel intervening between the trigger and the stressed target. Different varieties where metaphony applies may treat differently this intervening non-final post-tonic vowel (henceforth referred to as simply post-tonic).

In most metaphonies, post-tonic vowels behave as transparent. Consider the cases of Gravina (81) and Mascioni (82) as examples. In those two varieties, post-tonic vowels behave as transparent in regards to metaphony, regardless of their underlying nature.

(81) Transparent behavior of post-tonic vowels: Gravina (Apulia, Savoia 2015: 232)

	<i>Singular</i>	<i>Plural</i>	
<i>F</i>	'pɛkərə	'pɛkərə	'sheep'
<i>M</i>	'prɛvətə	'priəvətə	'priest'
<i>M</i>	'ɔmənə	'uəmənə	'man'

(82) Transparent behavior of post-tonic vowels: Mascioni (Abruzzo, Savoia 2015: 240)

	<i>Singular</i>	<i>Plural</i>	
<i>M</i>	'fɛketu		'liver'
<i>M</i>	'sɔrɛtʃɛ	'sɔrɛtʃi	'mouse'
<i>F</i>	'olepe	'ulepi	'fox'
<i>M</i>	'sulɛku	'sulɛki	'hole'
<i>F</i>	'lɛbbɛrɛ	'lɛbbɛrɪ	'hare'
<i>M</i>	'pɛttɛno	'pɛttɛni	'comb'
<i>F</i>	'pɛkɔrɔ	'pɛkɔrɛ	'sheep'

In Gravina the underlying nature of post-tonic vowels is masked by the centralization of post-tonic vowels discussed in §3.3.1. In Mascioni, previously treated in (66), post-tonic vowels that intervene between the final trigger and the stressed target appear to be valid targets for raising, since they are mid vowels. Their behavior is clearly not harmonic, since they do not raise, but they allow raising to apply to the preceding stressed vowel: ['pɛttɛno] ‘comb’ (not metaphonic) ['pɛttɛni] ‘combs’ (metaphonic), *['pɛttɛni]. In the variety of Mascioni, then, mid-vowels in post-tonic position behave as transparent wrt metaphony.

However, there are Italian dialects where post-tonic vowels participate in metaphony. In Amandola (Marche region, Savoia 2015: 240-282), for example, intervening vowels appear to be subject to

metaphony. Post-tonic vowels in this variety, and in other cases throughout central Italy (cf. Umbertide §I.3.2.5 and Servigliano §3.3.3.1), often copy the features of final vowels. The specific behavior of Amandola post-tonic vowels is the following: /a/ undergoes vowel-copy harmony (Savoia 2015: 282), while mid-vowels in post-tonic position undergo raising when followed by a high vowel. Mid-vowels are thus subject to metaphony in Amandola, and assume the height value of final vowels. Consider the alternations reported under (83).

(83) Post tonic vowels behave as harmonic in Amandola (Savoia 2015: 240-282)

Class I and Class II Nouns		<i>Singular</i>	<i>Plural</i>	
	<i>F</i>	'lebbere	'lebbiri	'hare'
	<i>M</i>	'pettene	'pettini	'comb'
	<i>M</i>	'sorretʃe	'surrɪtʃi	'mouse'
	<i>M</i>	'tsinguru	'tsingiri	'gipsy'
	<i>F</i>	'tsengara	'tsengere	
Verbs: present tense		<i>Ip. sing</i>	<i>Iip. Sing.</i>	
		'preðeko	'preðiki	'preach'
		ko'noʃfo	ku'nuʃfi	'know'

In (83) all tokens share the same vowel structure: $V_1V_2V_3$, with V_1 bearing the stress. When V_3 is high, metaphony is active. V_2 vowels are subject to two different harmonies. /a/ (which is neutral for the metaphonic process in Amandola), becomes a copy of the final vowel: /tsengaru/ → [tsinguru], /tsengari/ → [tsingiri], /tsengara/ → [tsengara], /tsengere/ → [tsengere].

Post-tonic non-final mid-vowels are not subject to copying harmony ([preðeko], *[preðoko]. Also, consider words such as [sabbitu] 'Saturday' and [pekora] 'sheep' Savoia 2015: 282) but are instead subject to metaphony, and raise when followed by a high vowel. All non-final unstressed vowels in Amandola are thus subject to a harmonic process. /a/ undergoes copying harmony, while other vowels follow the rules of metaphony, that in this case does not affect only the stressed vowel, but all vowels preceding the final one, up to the stressed one.

It follows that non-final post-tonic vowels are harmonic in Amandola, and not transparent as in Gravina and Mascioni. In light of this analysis, Amandola harmonic alternations can be considered iterative: final unstressed high vowels affect post-tonic vowels (either raising them or forcing them to assume all their features in copy harmony), and the result of this first process raises a preceding mid-vowel in stressed position: ['lebbere] 'hare' ['lebbiri] 'hares'; ['sorretʃe] 'mouse' ['surrɪtʃi] 'mice'; ['tsingiri] 'gypsies M' ['tsengere] 'gypsies F.'

In the extreme southern variety of Jacurso (Calabria, Savoia 2015: 239) mid-vowels are absent from unstressed position: only high and low vowels can occur without stress. In Jacurso, post-tonic non-final vowels behave as triggers for raising when they are high, and as blockers when they are low. The diphthongs [iə] and [uə] are the result of metaphony of mid-low vowels (the only kind of vowels expected in this extreme southern variety, cf. §3.3.4.2). In this case the trigger is not required to be a final vowel, but any post-tonic vowel can behave as a trigger.

(84) Post-tonic vowels behave as triggers or blockers in Jacurso (Savoia 2015: 239)

<i>Singular</i>	<i>Plural</i>	
'piertika		'perch'
'prievite	'prievidi	'priest'
'jennaru		'son in law'
'omani	'uemu	'man'

The same happens in the Sardinian variety of Paulilatino, where high vowels trigger raising for preceding stressed vowels. Recall that mid vowels in Sardinian varieties never appear as mid-high, unless metaphony raises them. In Paulilatino, raising is scalar and allophonic, since it raises mid-low vowels to mid-high.

(85) Post tonic vowels behave as triggers for metaphony in Paulilatino (Savoia 2015: 239)

'femmina	'woman'
'mrekkurizi	'Wednesday'
'ommine	'man'
'bettsa	'old F'
'noa	'new F'

Consider that, given the vowel system of extreme-southern varieties and Sardinian varieties⁸², we expect mid-low vowels only in stressed position. Since they surface as mid-high when followed by any high vowel, we can deduce that metaphony applies in a scalar fashion (and also allophonically, since mid-high vowels do not have a contrastive role in the two varieties considered).

To sum up this subsection, it appears that post-tonic vowels do not display a unitary behavior in Italian dialects, when it comes to their relation with metaphony. They generally behave as transparent, as exemplified in Mascioni (82) and Gravina (81), but they can also behave as harmonic (as in Amandola, 83), and also as metaphonic triggers (Jacurso and Paulilatino 84, 85).

Pre-tonic vowels are generally not affected by metaphony, which suggests that metaphony is non-iterative. In §3.4 the case of other regressive raising harmonies in Italian dialects, where the pre-tonic vowels are indeed affected by raising, will be discussed. Consider, however, that there is good evidence that pre-tonic raising is independent from metaphony. Does this mean that metaphony is not at all iterative? No. As discussed in this paragraph, there are occasions in which post-tonic vowels may participate in metaphony, showing a partially iterative behavior. We can conclude that metaphony may affect vowels up to the stressed vowel and that it *can* affect an unstressed vowel contained between the final trigger and the stressed target.

II.3.3.5. Asymmetries in Italian metaphony

In this paragraph, the various asymmetries found in the literature about metaphonies are presented and discussed. For the time being, the discussion carried on in §3.3.4.5 regarding morphological conditioning is left to the side. Talking about asymmetries in vowel harmony requires the definition of regular triggers,

⁸² Metaphony applies also in Campidanese varieties of Sardinia (Frigeni 2003), as we shall discuss in §IV.3.2.6.

targets and of their phonological structure. The natural triggers of metaphony are the high vowels /i/ and /u/, which share the harmonic prime [+high], while targets, which are mid (and sometimes low) vowels, all share the prime [-high].

Considering the pervasive nature of metaphony in Italian dialects, it is not surprising that there are many cases of asymmetry when it comes to metaphonic alternations. Recall that by asymmetric harmony I refer to patterns in which a segment (or groups of segments) acts as a neutral vowel in certain contexts, even though its prime composition would suggest otherwise. We can have asymmetries in the selection of targets as well as asymmetries in the selection of triggers.

Generally speaking, metaphony is not an iterative process (but cf. §3.3.4.7 for a discussion on the matter), so the behavior of vowels can only be tested in a consistent manner when they occur in stressed position (if they are targets) or in final unstressed position (if they are triggers).

Maiden (1987, 1991) carried out a detailed analysis of the process of metaphony in Italian dialects, describing a great number of different asymmetric patterns. Observing in detail the variation in trigger and target selection, he distinguished sixteen different configurations of asymmetric metaphonies that vary along three parameters: the set of targets, the set of triggers and the nature of the syllable the stressed vowel sits in.

Before listing the configurations, there are two relevant considerations regarding Maiden (1991) that should be acknowledged.

In his discussion of asymmetry, Maiden (1991) does not distinguish between raising, diphthongizing and fronting metaphonies. He also does not distinguish among varieties that display different vowel systems or that developed a reduced system of contrasts for final vowels. For the reason explained in §3.3.4, not all the asymmetries are immediately evident from a surface analysis of the process. As a result, the generalizations he makes about the raising power of front vs. back/rounded vowels are largely based on the morphological contexts where metaphony applies. Maiden considers as back-rounded high vowels the underlying triggers of processes that apply in masculine singular nouns and adjectives of Class I, and as front high vowels /i/ the underlying triggers for plurals and in verbal paradigms. However, the lack of application of metaphony may be due to a morphological condition, like the ones discussed previously in §3.3.4.5, and not to actual asymmetries as in the cases we considered in the first chapter. Depending on the position of the reader regarding the nature of metaphony, as a purely phonological process, (that needs a purely phonological input) or as a process that mixes together morphology and phonology, the conclusions of Maiden may be considered valid or only partially correct. For now, I will consider the examples below as purely phonological asymmetries, meaning that to a certain morphological context corresponds a fixed phonological form, which is responsible for the application of metaphony. This phonologic form is invariably a final unstressed /i/ or /u/.

Data sets proposed as examples by Maiden are sometimes problematic. Some of the asymmetric configurations seem to appear only in a rather selected group of dialects spoken in the Gargano peninsula (Northern Apulia). Variation in metaphonic processes in this area is striking, and gives raise to extremely complex harmonic patterns. Maiden's main source for data on those varieties is the study carried out by Melillo (1926). Maiden himself recognizes that a more recent survey (Melillo 1979) “[...] offers a more confusing picture, where several configurations appear to overlap” (Maiden 1991: 138).

Commenting on the issue, Calabrese (2011: 7, 1999: 32) expresses some doubts on data regarding different applications of metaphony in different syllabic contexts, suggesting that those data are “not very robust”.

Carosella (2005) gathered new data on the metaphonic patterns of northern Gargano dialects, and while she identifies various asymmetries, they do not correspond perfectly to the configurations expressed by Maiden. Here I describe the metaphonic configurations as Maiden did, but I also discuss the discrepancies between his analysis and Carosella's more recent data.

In the list of asymmetric configurations given in §3.3.5.1, I report all the entries proposed in Maiden (1991, 1987). I give examples of the asymmetric alternations, when possible, and comment the details of the processes, when necessary. The goal of this section is to discuss over the generalization proposed about asymmetry in Italian metaphonies by Maiden (1991 §6.2.3), and take a glance at the extreme variety of asymmetries found in metaphonic alternations.

II.3.3.5.1 Metaphonic configurations according to Maiden's analysis

Type 1: Metaphony applies only to mid-high vowels, and is triggered only by final /i/. Metaphonies of this type appear in Southern Veneto and in the island of Grado in southwestern Friuli (Walker 2005, Calabrese 2011).

(86) Asymmetric metaphony in Grado: configuration 1.

	<i>Singular</i>	<i>Plural</i>	
<i>M</i>	'vero	'viri	'true'
(<i>M</i>)	'tempo	'timi	'time'
<i>M</i>	'roso	'rusi	'red'
<i>M</i>	'sordo	'surdi	'deaf'
<i>M</i>	'bello	'bèli	'beautiful'
<i>F</i>	'bella	'bèle	
<i>M</i>	'mòrto	'mòrti	'dead'
<i>F</i>	'mòrta	'mòrte	

Metaphony in Grado limits both the selection of triggers and the selection of targets. The lack of raising in singular masculine nouns and adjectives may be due to the evolution of the vowel system, which ended up lowering all final high-rounded vowels in Venetan dialects. There is no way to clearly define whether Grado displays asymmetry (/u/ is prevented from behaving as a trigger by a phonological condition) or simply lacks /u/ from the set of vowels that can occur in final unstressed position.

Type 2: Metaphony applies only to mid-high vowels, it is triggered by final /i/ and /u/ in open syllable, only by /i/ in closed syllable. Maiden (1987: 40, note 3) proposes the dialect of Apricena (Northern Gargano, Apulia) as an example of this pattern. However, Carosella (2005) shows that the metaphonic configuration of Apricena is slightly different.

When the targets are mid-high, metaphony applies regularly when triggered by /i/, while it is severely limited when triggered by /u/, especially in adjectives (Carosella 2005: 88). For what concerns metaphony of mid-low vowels, she notices that metaphony is in strong regression, and that it almost never applies in contexts where /u/ is the trigger, while it may apply when triggered by /i/ (Carosella 2005: 94). Regarding the nature of the syllable of the stressed vowel, she reports that metaphony of mid-low vowels in closed syllables is present exclusively in verbs. The outcome of metaphony of mid-low

vowels in those limited cases is a high vowel. She does not argue for a case of hypermetaphony, suggesting that diphthongs produced by the regular application of Neapolitan-type metaphony are monophthongized.

To sum up, metaphony applies when triggered by final unstressed /i/, and, when it targets mid-low vowels in closed syllable, only in verbs. However, exceptions are frequent. Cases of metaphony triggered by /u/ can be found occasionally (cf. ['cinə]>PLĒNUM), as well as cases of underapplication (Carosella 2005: 88).

(87) Asymmetric metaphony in Apricena: configuration 2*

<i>Adjectives and nouns I class</i>	<i>Singular</i>	<i>Plural</i>	
<i>M</i>	'cenə/cinə	'cinə	'full'
<i>F</i>	'cenə	'cenə	
<i>M</i>	'bællə ⁸³	'bællə	'beautiful'
<i>F</i>	'bællə	'bællə	
<i>M</i>	'nerə	'nirə	'black'
<i>M</i>	'pilə	'pilə	'hair'
<i>M</i>	'occə	'occə	'eye'
<i>M</i>	'tæmbə	'tæmbə	'time'
<i>Verbs: present tense</i>	<i>I p. sg.</i>	<i>II p. sg.</i>	
	*'prædəkə ⁸⁴	'pridəkə	'preach'
	*'mæɾətə	'mirətə	'deserve'
	*'pændzə	'pindzə	'think'
	*'jəkə	'jukə	'play'

The metaphonic configuration 2, as reconstructed by Maiden, is thus not confirmed. However, Apricena exhibits a peculiar asymmetric pattern. On one side metaphony is (almost) only triggered by /i/ (but consider the two masculine singulars [cinə] and [pilə], where metaphony raises an underlying mid-high vowel in a context where underlying /u/ is expected). On the other, the behavior of mid-low vowels as targets depends on both the syllabic context and on the morphological nature of the word in which the process applies.

Type 3: Metaphony is limited to mid-high vowels and is triggered by both /i/ and /u/. This pattern is found in some villages of the aforementioned area of Northern Gargano (Northern Apulia): Carpino, Peschici and Cagnano Varano (Melillo 1926, Loporcaro 1997). Let us consider the dialect of Carpino as an example. Data provided in Carosella show a different situation, in which metaphony applies to mid-

⁸³ Underlying mid-low front vowels surface as low vowel [æ] in Apricena and in the neighboring variety of San Nicandro (Carosella 2005: 114).

⁸⁴ Carosella (2005) does not report any active alternations for verbs. She describes the alternation pattern and discusses the contexts of application, but does not always report forms where metaphony does not apply to assess the nature of the underlying target. The forms reported in the table (87) are reconstructed from the analysis she proposes. I can only assume that the metaphonized forms she proposes as examples are paired with non-metaphonic alternants. In the following tables built using the same data, tokens preceded by an asterisk are reconstructed.

high vowels regularly, while it applies in more restricted contexts to mid-low vowels. According to Carosella (2005) it applies in the same contexts described for Apricena (87), that is to say only in verbs and only in closed syllables. Data reported in (88) do not correspond to the description of “type 3 asymmetry” as presented by Maiden, but instead exhibits evident traits that morphology has a central role in the application of metaphony.

(88) Asymmetric metaphony in Carpino: configuration 3

<i>Adjectives and nouns class I</i>	<i>Singular</i>	<i>Plural</i>	
<i>M</i>	'nirə	'nirə	'black'
<i>F</i>	*'nerə		
<i>M</i>	'friddə	'friddə	'cold'
<i>F</i>	*'freddə		
<i>M</i>	'strittə	'strittə	'narrow'
<i>M</i>	'putsə	'putsə	'wrist'
<i>M</i>	'covə	'cuvə	'nail'
<i>M</i>	kollə	kollə	'neck'
<i>M</i>	mərtə	mərtə	'dead/corpse'
<i>Verbs: present tense</i>	<i>I p. sg.</i>	<i>II p. sg.</i>	
	*'vedə	'vidə	'see'
	*'mettə	'mittə	'put'
	*'pəndzə	'pindzə	'think'
	*'jəkə	'jukə	'play'

The only difference between the pattern of Carpino and that of Apricena is the fact that /u/ is a valid trigger for metaphony of mid-high vowels. Since underlying /u/ is expected only in nominal forms and that metaphony of mid-low vowels applies only in verbs, there is no way to define whether it could be a valid trigger for mid-low vowels.

Type 4: Metaphony targets all mid vowels and is activated only by final /i/. This kind of metaphony is found in some areas of Gargano, in Romagna and parts of eastern Emilia. As an example, consider the case of Lugo (Ravenna, northern Romagna, cf. §3.3.4.4). Here final unstressed vowels have been lost; however, metaphony is applied in masculine plural nouns and adjectives, and not in masculine singulars, which is expected to be /u/. Feminine plural is sometimes vocalized as [i]<*e, but is often dropped. This optional [i] does not trigger metaphony.

(89) Asymmetric metaphony in Lugo (Pelliciardi 1977): configuration 4.

	<i>Singular</i>	<i>Plural</i>	
<i>M</i>	'spos	'spus	'groom'
<i>F</i>	'spoza	'spoz(i)	'bride'
<i>M</i>	'ner	'nir	'black'
<i>F</i>	'nera	'ner(i)	
<i>M</i>	'mo ^a rt	'murt	'dead'
<i>F</i>	'mo ^a rta	'mo ^a rt(i)	
<i>M</i>	'beł	'be ^a ł	'beautiful'
<i>F</i>	'bela	'beł(i)	

Type 5: Metaphony is regular for mid-low vowels, while mid-high vowels are raised only by [i]. Maiden reports metaphonies of this kind in parts of southern Marche. Traces of this pattern are also found in the Piedmontese Alps.

Consider metaphony in Arcevia (Marche Crocioni 1906, also §I.5.6) as an example. Here the process is opaque: final high vowels have been lowered to [e]</i/ and [o]</u/. Nonetheless, we can recover the underlying form of final vowels from the activation of metaphony. In nouns, both the singular and the plural form of the masculine display metaphony, suggesting that surface [o] and [e] are underlyingly /u/ and /i/ respectively. Metaphony in Arcevia diphthongizes preceding mid-low vowels⁸⁵.

(90) Asymmetric metaphony in Arcevia: configuration 5

<i>Nouns and adjectives I class</i>	<i>Singular</i>	<i>Plural</i>	
<i>M</i>	'bwono	'bwone	'good'
<i>F</i>	'bōna	'bōne	
<i>M</i>	'solo	'sule	'alone'
<i>F</i>	'sola	'sole	
<i>M</i>	'nero	'nire	'black'
<i>F</i>	'nera	'nere	
<i>M</i>	'vjekkjo	'vjekkje	'old'
<i>F</i>	'vëkkja	'vëkkje	
<i>M</i>	ko'kommero	ko'kummere	'watermelon'
<i>Nouns and adjectives II class</i>	<i>Singular</i>	<i>Plural</i>	
<i>F</i>	'krotʃe	'krutʃe	'cross'
<i>M</i>	'mese	'mise	'month'
<i>M/F</i>	'fōrte	'fworte	'strong'
<i>M</i>	'pēte	'pjete	'foot'

⁸⁵Diphthongizing metaphony is rather exceptional in the area. Neighboring varieties all display scalar raising metaphony. The diphthongization of low vowels is attested in Crocioni (1906), but is nowadays in strong regression. In addition, not all forms display diphthongization (cf. the verbal example [dōrmo]-[dorme]). For what concerns the discussion at hand, Crocioni reports that mid-high vowels are not raised in contexts where mid-low vowels are, notably when followed by the masculine singular suffix /-o/<*u.

<i>Verbs: present tense</i>		
<i>I sing.</i>	'kredo	<i>I believe</i>
<i>II sing.</i>	'kride	<i>you believe</i>
<i>III sing.</i>	'krede	<i>he believes</i>
<i>I sing.</i>	'dormo	<i>I sleep</i>
<i>II sing.</i>	'dorme	<i>you sleep</i>
<i>III sing.</i>	'dorme	<i>she sleeps</i>

Type 6: Metaphony is regular for mid-high vowels, while mid-low vowels are affected by the process only when /i/ is the trigger and when the stressed syllable is open. Maiden notes cases of this kind, once again, only in northern Gargano, in the villages of Torremaggiore and Lesina. According to Carosella (2005), the behavior of metaphony in Lesina corresponds to that of Carpino, presented earlier in (88). Carosella (2005) reports for the dialect of Lesina the same examples for the two varieties (alongside many other dialects of Northern Gargano). As we discussed earlier, both the dialect of Apricena and that of Carpino exhibit mid-low metaphony only in verbs, which do not have inflectional endings in /u/. As already mentioned, therefore, this kind of asymmetry may only be a byproduct of the special role morphology plays in the alternations, and not an actual phonological condition posed on the process.

Type 7: Metaphony triggered by both /i/ and /u/ affects mid-high vowels, while only metaphony triggered by /i/ affects mid low-vowels. Metaphonies of this group are reported in southern Marche and once again in Northern Gargano (villages of Ischitella and Rodi Garganico). Data provided by Maiden (1991: 163) and Carosella (2005: 96) are not consistent. Maiden reports alternations in nouns and adjectives of Class I and Class II, while Carosella reports also verbs. Data proposed by Maiden suggest that raising of mid-low vowels applies regularly, if and only if the trigger is an underlying /i/. Data proposed by Carosella (2005) is more in line with what we already presented in (87) and (89) about other varieties of the same geographic area: mid-low vowels in closed syllables are raised only in verbs, and only by final /i/.

(91) Asymmetric metaphony in Ischitella (Maiden 1991: 163)

<i>Nouns and adjectives class I</i>	<i>Singular</i>	<i>Plural</i>	
<i>M</i>	'lupə	'lupə	'wolf'
<i>F</i>	'lopə		
<i>M</i>	'friddə	'friddə	'cold'
<i>F</i>	'freddə		
<i>M</i>	'grössə	'gruwssə	'large'
<i>F</i>	'grössə		
<i>M</i>	a'pirtə	a'pirtə	'open'
<i>F</i>	a'pirtə		
<i>Nouns and adjectives Class II</i>	<i>Singular</i>	<i>Plural</i>	
<i>F</i>	'krotʃə	'krutʃə	'cross'
<i>M</i>	'dendə	'dijndə	'tooth'

(92) Metaphony in Ischitella, additional data from Carosella (2005: 96)

<i>Nouns and adjectives class I</i>	<i>Singular</i>	<i>Plural</i>	
<i>M</i>	'strittə	'strittə	'narrow'
<i>M</i>	kəllə	kəllə	'neck'
<i>M</i>	'sylə	'sylə	'alone'
<i>F</i>	*solə		
<i>M</i>	*pəskətorə	pəskə'tyrə	'fisherman'
<i>M</i>	'təmbə	'təmbə	'time'
<i>M</i>	'ferrə	'ferrə	'iron'
<i>M</i>	'mɛdəkə	'mɛdəkə	'doctor'

The pattern number 7, as it is proposed by Maiden, behaves as the mirror image of the pattern of type 5 (90). /i/ is a more effective trigger for raising than /u/, which is unable to trigger metaphony in mid-low vowels. If we consider data gathered by Carosella, the asymmetric nature of this metaphony cannot be defined with certainty. Once again, mid-low vowels seem to raise consistently only in verbs (and only in open syllable).

An interesting property of Ischitella metaphony is the presence of front back vowels as the result of metaphony of back mid vowels, but only in open syllable⁸⁶ (Carosella 2005: 90). Whereas in most neighboring varieties the process manifests itself as based purely on raising, here back vowels undergo fronting as well, but only when back targets sit in open syllables.

Concerning the effects of metaphony on mid-low vowels in dialects of the Northern Gargano area, Carosella (2005: 94) notices that the process is in strong regression. Mid-low metaphony triggered by /u/ almost never appears, and also raising caused by /i/ appears to be extremely rare in nouns and adjectives, to the point that the application of the process seems the exception to the rule. This does not occur in verbs, where, if the syllable is open, raising applies regularly, as we have seen in Type 2 (87), Type 3 (88) and type 7 (91, 92). That being said, it appears that the picture proposed by Maiden regarding asymmetric metaphonies in northern Gargano varieties is inconsistent with the data collected by Carosella. Differences between patterns are more nuanced than what the analysis in Maiden (1991) suggests.

Type 8: Metaphony applies regularly to both mid-high and mid-low vowels when the trigger is [i]. Mid-low vowels fail to undergo harmony when /u/ is the trigger, if they sit in a closed syllable. This pattern is present in Veroli, a village in southern Lazio. Maiden himself (Maiden 1991: 139) notices that metaphony of mid-low vowels triggered by /u/ operates sporadically also in open syllables, but is blocked in closed syllables. In general, metaphony of low mid vowels by /u/ tends not to occur (so that this dialect

⁸⁶ Considering all the examples given in Carosella (2005: 90) it appears that a post-tonic non-final [ə] makes the preceding open syllable count as closed, as suggested by words such as [puləpə] 'octopus' [*pyləpə], [suləkə] 'hole' [*syləkə] (Carosella 2005, 90). Harmony applies as raising when back vowels are in closed syllables and when a post tonic vowel intervenes between trigger and target, it applies as both raising and fronting when they are in open syllables without intervening vowels.

might also be viewed as belonging to the type 7 discussed above), but in the few cases where it does, it is indeed restricted to open syllables (e.g., CAELUM > [tʃelu] ‘sky’, SĚRUM > [seru] ‘whey’, PŌSSUNT [poto] ‘they can’).

Data on closed syllable is more reliable, and shows that mid-low vowels never raise when the trigger is /u/, while they do in the context of unstressed final /i/. Mid-high vowels regularly raise when followed by all high vowels. Raising applies as scalar, with mid-low vowels (when undergoing metaphony) that surface as mid-high, while mid-high vowels surface as high.

(93) Metaphony in the dialect of Veroli (Southern Lazio, Vignoli 1922)

<i>Nouns and adjectives class I</i>	<i>Singular</i>	<i>Plural</i>	
<i>F</i>	'veduva	'veduve	<i>widow</i>
<i>M</i>	'viduvu		<i>widower</i>
<i>F</i>	'pera		<i>pear</i>
<i>M</i>	'piru		
<i>F</i>	'freske		<i>chill</i>
<i>M</i>	'frisku		
<i>F</i>	'lenta	'lente	<i>slow</i>
<i>M</i>	'lentu	'lenti	
<i>F</i>	'vekkja	'vekkje	<i>old</i>
<i>M</i>	'vekkju		
<i>M</i>	'okkju	'okki	<i>eye</i>
<i>M</i>	'kørnu	'korni	<i>horn</i>
<i>F</i>	pe'losa		<i>hairy</i>
<i>M</i>	pe'luso		
<i>F</i>	'sposa	'spose	<i>wife</i>
<i>M</i>	'spuso	'spusi	<i>husband</i>
<i>M</i>	'lettu		<i>bed</i>
<i>Nouns class II</i>	<i>Singular</i>	<i>Plural</i>	
<i>M</i>	'mesu	'misi	<i>month</i>
<i>M</i>	pa'iesu	pa'isi	<i>village</i>
<i>M</i>	'prete	'preti	<i>priest</i>
<i>F</i>	'serpe	'serpi	<i>snake</i>

In the examples proposed in the table (93), /i/ and /u/ appear to have a different raising effect on mid vowels. /i/ raises all valid targets in all occurrences, while /u/ appears to not raise preceding stressed mid-low vowels: e.g. ['lettu] *['lettu] ['kørnu] *['kornu]. Final /i/ instead acts as a valid trigger for mid-low vowels.

Sporadic occurrences of raised mid-low vowels may suggest that /u/ has no effect on mid-low vowels only in closed syllables, but evidence of mid-low raising triggered by /u/ in open syllable is scarce, and no cases of alternation are presented in Vignoli (1922), which is the only source for this variety.

Data suggest that the description proposed for the 7th asymmetric configuration is more suited for Veroli dialect than the one proposed for the 8th: metaphony in Veroli is conditioned by a limitation that

requires a front trigger for mid-low raising, while the process can apply freely when it targets mid-high vowels. It behaves as a mirror of the 5th configuration presented earlier.

Type 9: Metaphony is triggered by both final unstressed /i/ and /u/, and it targets all mid vowels. This is the most common pattern of metaphony, and it corresponds to the general rule of metaphony presented in §3.3.2. Multiple examples of this pattern have already been discussed. Servigliano (67) offers a valid example of this metaphonic pattern.

Type 10: Metaphony targets only mid-low vowels and is triggered only by /i/. In southern Garfagnana (northern Tuscany) final /i/ raises only stressed front mid-low vowel ϵ . (Maiden 1987: 40, Maiden 1991: 122). Data proposed in Venturelli (1975) and referred to by Sanchez Miret (1998) show traces of a metaphony of this kind. However, I was not able to find clear alternations to certify the activity of this pattern.

Type 11: Metaphony is limited to mid-low vowels and triggered by both /i/ and /u/. Traces of this process are found in northern Lazio, as well as in Old Romanesco. The process does not seem to be active in any of those varieties anymore. Some traces of this pattern are also found in some alpine regions, mainly in the Grigioni Canton (Switzerland), according to Maiden (1987: 68).

Type 12: Metaphony of mid-low vowels is limited to open syllables. Maiden reports this configuration for varieties in southeast, and possibly northwest, Tuscany and northeast Umbria (Maiden 1987: 68), but occurrences of this pattern are probably not active anymore. Furthermore, Maiden does not provide alternations for this pattern.

Type 13: Metaphony affects all vowels, but is triggered only by final /i/, and not by final underlying /u/. Metaphonic alternations of this kind are found in Canton-Ticino (Switzerland), in eastern Abruzzo and in central Romagna. Consider that the final vowels in all of the varieties where metaphonies of this kind can be found underwent reduction. Maiden proposes the case of regressive metaphony in Teramo (Passino 2016, Maiden 1991: 162) as an example. Metaphony in Teramo is opaque, since all unstressed vowels surface as [ə]. In addition, metaphony in the dialect of Teramo applies as complete raising: all raised vowels surface as high. In the table in (94), the etymological origin of the targeted vowels is reported. This allows us to compare the metaphonic alternations of Teramo with other varieties, since the surface vowel system of Teramo appears to be extremely different from the vowel system found in most central and southern Italian dialects (cf. Passino 2016: 151ff). Data reported in (94) is taken from Maiden (1991: 163).

(94) Asymmetric metaphony in Teramo

<i>Targets</i>		<i>Singular</i>	<i>Plural</i>	
Ă, Ā	M	'kænə	'kinə	'dog'
	M	'asənə	'isənə	'donkey'
	F	'asənə	'asənə / 'isənə!	
Ĕ	M	'bellə	'billə	'beautiful'
	F	'bellə	'bellə / billə!	
Ē	M	'mɛsə	'misə	'month'
	M	'pələ	'pilə	'hair'
Ĭ	M	'nɛrə	'nirə	'black'
	F	'nɛrə	'nɛrə / 'nirə!	
Ŏ	M	'bɔnə	'bunə	'good'
	F	'bɔnə	'bɔnə / 'bunə!	

All final unstressed vowels surface as [ə], so the asymmetry is deduced from the lack of application of metaphony in singular masculine nouns and adjectives of the first class. Consider alternations such as ['asənə]-['isənə] 'donkey'; ['bellə]-['billə] 'beautiful'; ['bɔnə]-['bunə] 'good'. Normally, metaphony is expected in both masculine singular and masculine plural, but in the dialect of Teramo metaphony is visible only in plurals (both masculine and feminine, according to data from Maiden 1991: 163⁸⁷).

Type 14: Metaphony is triggered by both underlying /i/ and /u/ when the targets are mid-low vowels, while it is triggered only by /i/ when the targets are mid-high vowels or /a/. This pattern is reported only in the Piedmontese alps according to Maiden (1991, 1987). In (95) are reported alternations from the dialect of Valle Anzasca. This dialect is one of those varieties where the process of metaphony combines raising and fronting (cf. §3.3.3.4). Front vowels are raised while back rounded vowels are fronted and raised. Metaphony in the dialect of Valle Anzasca is opaque, since final vowels (except [a]) were lost in final position, as it is common in northern varieties.

(95) Asymmetric metaphony in Valle Anzasca (Savoia & Maiden 1997: 23)

	<i>Singular</i>	<i>Plural</i>	
<i>M</i>	'ʃpus	'ʃpys	'spouse'
<i>F</i>	'ʃpuza		
<i>M</i>	'grɔs	'grɔs	'big'
<i>F</i>	'grɔsa	'grɔs	
<i>M</i>	'bil	'bil	'beautiful'
<i>F</i>	'bela	'bɛl	
<i>M</i>	'bjank	'bjɛnk	'white'
<i>F</i>	'bjanka	'bjank	

⁸⁷ Data reported in Maiden (1991: 163) and derived from De Lollis (1891) show both metaphonic and non-metaphonic results for feminine plurals in both nouns and adjectives.

Data provided in Savoia & Maiden (1997: 23) do not allow us to fully recover the effect of underlying /u/ on mid-high vowels. Interestingly, final /i/ has an effect on all other vowels, not only mid vowels, as apparently /u/ does. /i/ raises the low vowel /a/ (which surfaces as [ɛ] when subject to metaphony: ['bjank] 'white'-'[bjenk]'white PL') and fronts the back high vowel /u/, which is at the same time a valid trigger for metaphony (['bɛla] 'beautiful F.' ['bil] 'beautiful M'), and a target for fronting ([ʃpus] 'spouse M.PL.' [ʃpys] 'spouse M.PL.').

Type 15: Metaphony is triggered by all high vowels when it targets mid vowels. It is triggered only by /i/ when it targets /a/. Metaphonies of this kind are found in Abruzzo and Molise and in the variety of Castro de Volsci (Lazio). Examples provided in (96) are taken from the dialect of Agnone (Molise).

(96) Asymmetric metaphony in Agnone (Maiden 1991:164)

		<i>Singular</i>	<i>Plural</i>	
<i>Nouns and adjectives class I</i>	<i>M</i>	'liupə	'liupə	'wolf'
	<i>F</i>	'lawpə	'lawpə	
	<i>M</i>	'hrwossə	'hrwossə	'large'
	<i>F</i>	'hrɔssə	'hrɔssə	
	<i>M</i>	'vjekkjə	'vjekkjə	'old'
	<i>F</i>	'vɛkkjə	'vɛkkjə	
	<i>M</i>	'asənə	'ɛsənə	'donkey'
	<i>F</i>	'asənə	'asənə	
<i>Nouns class II</i>	<i>F</i>	'krawtʃə	'kriutʃə	'cross'
	<i>M</i>	'majʃə	'moijʃə	'month'
	<i>M</i>	'kean	'kjen	'dog'

Here the only difference between /i/ and /u/ appears to be the effect on the low vowel /a/. They both trigger metaphony (which in the examples above applies as raising /diphthongizing in all mid vowels), but only /i/ is a valid trigger for the low vowel /a/. This is shown in the alternation between /asinu/ ['asənə] 'donkey'; /asini/ ['ɛsənə] 'donkeys'.

Type 16: Metaphony is triggered by all high vowels and targets equally all non-high vowels. This final configuration is found in Ischia (Campania) and in an area to the north of the Bay of Naples. Metaphony of this kind is not asymmetric and represents the only true symmetric case of metaphony, since it applies to all vowels and is triggered by all final high vowels. As typical of dialects of this area, unstressed vowels surface as /ə/, so that the process is opaque. Metaphony in Ischia belongs to the group of diphthongizing metaphonies.

(97) Metaphony in Ischia (Maiden 1991: 165)

		<i>Singular</i>	<i>Plural</i>	
<i>Nouns and adjectives class I</i>	<i>M</i>	'surdə	'surdə	<i>deaf</i>
	<i>F</i>	'sordə	'sordə	
	<i>M</i>	'tswoppə	'tswoppə	<i>lame</i>
	<i>F</i>	'tsəppə	'tsəppə	
	<i>M</i>	'sikkə	'sikkə	<i>dry</i>
	<i>F</i>	'səkkə	'səkkə	
	<i>M</i>	kajə'netə	kajə'netə	<i>brother in law</i>
	<i>F</i>	kajə'natə	kajə'natə	<i>sister in law</i>
<i>Nouns class II</i>	<i>F</i>	'rautʃə	'rutʃə	<i>cross</i>
	<i>M</i>	'kanə	'kenə	<i>dog</i>

With this example, we have exhausted the list of metaphonic configurations discussed in Maiden (1987: 40; 1991: 112). The sixteen metaphonic configurations discussed in this section are summarized in the tables (98) and (99) below.

(98) Asymmetries in metaphony according to Maiden

<i>Type 1</i>	Grado	Metaphony affects only mid-high vowels, /u/ does not trigger harmony	Asymmetry may depend on vowel system restructuring
<i>Type 2</i>	Apricena	Metaphony affects only mid high vowels, /u/ does so only in open syllable	Data are inconsistent. Metaphony seems to exhibit traces of morphological activation
<i>Type 3</i>	Carpino	Metaphony affects only mid-high vowels	Data are inconsistent. Metaphony seems to exhibit traces of morphological activation
<i>Type 4</i>	Lugo	Metaphony affects all mid-vowels, /u/ does not trigger harmony	Final vowels are absent in the surface, the nature of underlying final vowels is reconstructed
<i>Type 5</i>	Arcevia	Metaphony affects all mid-vowels, /u/ does not trigger raising for mid-high vowels	
<i>Type 6</i>	Lesina	Metaphony affects all mid-vowels, but only if /i/ triggers it and only in open syllable	Data are inconsistent. Metaphony seems to exhibit traces of morphological activation
<i>Type 7</i>	Ischitella	Metaphony affects all mid-vowels, /u/ does not trigger harmony for mid-low vowels	Data are inconsistent. Metaphony seems to exhibit traces of morphological activation
<i>Type 8</i>	Veroli	Metaphony affects all mid-vowels, /u/ does not trigger harmony in mid-low vowels in closed syllable	Data suggest that /u/ never triggers mid-low vowel harmony
<i>Type 9</i>	Servigliano	Metaphony affects all mid-vowels	

<i>Type 10</i>	X	Metaphony affects only mid-low vowels, /u/ does not trigger harmony	Only traces in Lombard alps
<i>Type 11</i>	X	Metaphony affects only mid-low vowels	Only traces, no alternation reported
<i>Type 12</i>	X	Metaphony affects only mid-low vowels, and only in open syllables	Only traces, no alternation reported
<i>Type 13</i>	Teramo	Metaphony affects all non-high vowels, /u/ does not trigger harmony	
<i>Type 14</i>	Valle Anzasca	Metaphony affects all non-high vowels, /u/ triggers harmony only for mid-low vowels	
<i>Type 15</i>	Agnone	Metaphony affects all non-high vowels, /u/ does not trigger harmony in low vowels	
<i>Type 16</i>	Ischia	Metaphony affects all non-high vowels	

In (99) is reported a simplified schema that summarizes the way metaphony applies in each one of the metaphonic configurations reported in (98). Varieties spoken in northern Gargano, which are problematic for the various reasons noted in this section, are not included in this schema. I also excluded those asymmetric patterns that are not reported to be active anymore, namely the types 10, 11 and 12, which are reported in Maiden's list, but for which no data based on active evident alternation has been proposed.

(99) Asymmetry in metaphonies: schema of applications

	Targets	Trigger /i/	Trigger /u/	
Grado Type 1	e	☺	X	
	ε	X	X	
	o	☺	X	
	ɔ	X	X	
	a	X	X	
	i	X	X	
	u	X	X	
Lugo Type 4	e	☺	X	
	ε	☺	X	
	o	☺	X	
	ɔ	☺	X	
	a	X	X	
	i	X	X	
	u	X	X	
Arcevia Type 5	e	☺	X	
	ε	☺	☺	
	o	☺	X	
	ɔ	☺	☺	
	a	X	X	
	i	X	X	
	u	X	X	

Veroli Type 8	e	☺	☺	Metaphony of mid-low vowels triggered by /u/ appears to be regular only in open syllable
	ε	☺	X*	
	o	☺	☺	
	ɔ	☺	X*	
	a	X	X	
	i	X	X	
	u	X	X	
Servigliano Type 9	e	☺	☺	
	ε	☺	☺	
	o	☺	☺	
	ɔ	☺	☺	
	a	X	X	
	i	X	X	
	u	X	X	
Teramo Type 13	e	☺	X	
	ε	☺	X	
	o	☺	X	
	ɔ	☺	X	
	a	☺	X	
	i	X	X	
	u	X	X	
Valle Anzasca Type 14	e	☺	X	Metaphony in Valle Anzasca involves both raising and fronting, for this reason /u/ is included in the eligible targets
	ε	☺	☺	
	o	☺	X	
	ɔ	☺	☺	
	a	☺	X	
	i	X	X	
	u	☺	X	
Agnone Type 15	e	☺	☺	
	ε	☺	☺	
	o	☺	☺	
	ɔ	☺	☺	
	a	☺	X	
	i	X	X	
	u	X	X	
Ischia Type 16	e	☺	☺	
	ε	☺	☺	
	o	☺	☺	
	ɔ	☺	☺	
	a	☺	☺	
	i	X	X	
	u	X	X	

II.3.3.5.2 Discussing the asymmetric configurations and Maiden's (1991) implicational hierarchies

Considering the configurations presented above, Maiden deduced three implicational hierarchies, meant to describe the application of metaphony in Italian dialects.

- Metaphony applies more easily to relatively higher vowels. Metaphony of /a/ presupposes metaphony of mid-low vowels /ɛ,ɔ/, which in turn presupposes metaphony of /e,o/. This means that a process of metaphony that affects low vowels must also affect mid-low and mid-high vowels, and a metaphony that affects mid-low vowels must also affect mid-high vowels.
- Metaphony in closed syllables presupposes metaphony in open syllables. As already noted, there are doubts about the effects of syllabic structure in metaphony. Maiden (1991) proposes, contra Rohlf's (1966), that metaphony can be sensitive to syllable structure and that there are dialects in which it applies in open syllables but not in closed syllables. However, Calabrese (1999: 32) expresses some doubts about the data concerning different activations of metaphony in different syllabic contexts.
- Metaphony caused by /u/ presupposes metaphony caused by /i/. /i/ acts as the universal trigger, while /u/ is often limited in its raising effect. Maiden defines the processes triggered by both /i/ and /u/ as U-metaphony. He refers to I-metaphonies when talking about metaphonies caused only by /i/.

An interesting question could be whether those implicational hierarchies are valid only within the limited context of metaphonies, or whether they are general rules about raising.

Concerning the first implicational hierarchy, Maiden himself finds some occurrences where mid-low vowels are better targets for metaphony than mid-high vowels (configurations 10,11,12). All those cases are probably inactive (i.e., metaphony does not generate alternations anymore), but traces of a similar effect are found. The case of Arcevia (type 5, table 90) is a case in which mid-low vowels are the preferred targets for metaphony, since they undergo both metaphony triggered by /i/ and metaphony triggered by /u/. While mid-high vowels are generally more common targets, it appears that nothing excludes the possibility of mid-low vowels being more easily targeted by metaphony. If we take into account raising processes in other languages, it appears that this implicational hierarchy is not consistent with data. Raising processes may target mid-low vowels and leave untouched mid-high vowels (as progressive raising in Logoori, cf. §3.1.3.7). Furthermore, raising may also target only low vowels and ignore mid-vowels, as we shall see later when considering the cases of Basque raising (§3.5.3) and progressive raising in the Italian dialect of Teramo (§3.4.3).

Regarding the second hierarchy, the role of syllabic context in metaphony has been treated with doubt in the literature (Calabrese 1999: 32). The cases presented in Maiden's survey do not seem robust enough to propose a strong claim about the role of syllabic structure in metaphony or other harmonies (however, cf. §3.4.5 for another case of raising in an open syllable being preferred to raising in a closed syllable). A more structured study of Northern Gargano varieties and a thorough examination of their metaphonic patterns is necessary to discern the role of syllabic structure in those peculiar varieties.

The third hierarchy, which regards the different raising effects of front and round high vowels, seems to hold true, and not only in data from Italian dialects but also from raising in other languages. There are no occurrences of /i/ being a worse trigger than /u/ in any raising process, while data of /u/ being unable to raise valid targets in certain contexts is frequent and robust. In the whole survey proposed in this

chapter, no raising process activated solely by /u/ has been found⁸⁸, while there are cases in which only /i/ acts as the trigger for raising and /u/ cannot. Besides the configurations presented in §3.3.5.1, the cases of Bergamo and Camuno raising harmony (§III.7.3, 7.4) display /u/ as a worse trigger for raising than /i/.

II.3.3.6 Concluding remarks and summary on metaphonies in Italian dialects

Section 3.3 dealt with the topic of variation in metaphonic configurations in the dialects of Italy.

The overall content of this section is summarized in (100). The summary table is divided into five columns. In the first column are listed the varieties exemplified in the section. In the second column is described the output of the process. In the third column is reported the nature of the triggers, both their underlying form (between bars) and their surface form (between square brackets). The fourth column refers to the morphological context of application for metaphony. When the process applies in all the morphological contexts discussed in §3.3.4 (i.e., masculine singular and plurals in Class I nouns and adjectives, plurals in Class II nouns and adjectives, II person singular of the indicative present tense in verbs), I simply marked “*Regular*”, and described the exceptions when relevant. In the fifth column are discussed the asymmetric patterns. All occurrences of metaphony are regressive without exception.

(100) Metaphony in Italian dialects.

<i>Variety</i>	<i>Structural modification</i>	<i>Underlying vs. Surface triggers</i>	<i>Morphological context</i>	<i>Asymmetries</i>
<i>Mascioni (66-82)</i>	Scalar raising	/u/,/i/- [o], [i]	Regular	/a/ is neutral
<i>Servigliano (67)</i>	Scalar raising	/u/,/i/- [o], [i]	Regular	/a/ is neutral
<i>Amandola (68-83)</i>	Scalar raising and copy harmony of post-tonic non final vowels	/u/,/i/- [o], [i]	Regular	/a/ is neutral
<i>Arpino (69)</i>	Diphthongization	/u/,/i/- [ə]	Regular	/a/ is neutral
<i>Foggia (70)</i>	Complete raising	/u/,/i/- [ə]	Regular	/a/ is neutral
<i>Francavilla Fontana (71)</i>	Complete raising	/i/ - [ə]	Metaphony applies only in verbs	/a/ is neutral
<i>Cevio (72)</i>	Scalar raising + Fronting	/i/ - 0 (all vowels are lost in final position)	Metaphony does not apply in masculine singular nouns and adjectives	All non-high vowels are affected. Metaphony does not apply in contexts in which final /u/ is expected
<i>Sonnino (74)</i>	Scalar raising	/u/,/i/- [o], [e]	Regular	/a/ is neutral

⁸⁸ In some examples only /u/ is shown as the trigger of raising. However, this is not due to an asymmetry by which /u/ is a better trigger than /i/, but only to the nature of the morphemes of the language. /u/ appears as a final vowel in Spanish varieties, while /i/ does not. Even though they are few, some alternations show that /i/ is able to raise preceding mid vowels, showing that Maiden’s generalization holds also for Ibero-Romance varieties.

<i>Ragusa (75)</i>	Diphthongization	/u/,/i/ -[u],[i]	Metaphony applies also in feminine plurals	/a/ is neutral
<i>Modica (76)</i>	Diphthongization	/u/, /i/ - [u], [i]	Metaphony applies also in feminine plurals	/a/ is neutral
<i>Mormanno (77-80)</i>	Scalar raising	/u/, /i/ - [u],[i]	Metaphony applies only in nouns, and not in verbs	/a/ is neutral
<i>Lugo (78-89)</i>	Scalar raising	/i/ - 0 all vowels are lost in final position	Regular	/a/ is neutral. Metaphony does not apply in contexts in which final /u/ is expected
<i>Cervara (79)</i>	Scalar raising/ Complete raising	/u/,/i/ - [o], [i]	Metaphony applies as scalar raising in nouns and adjectives, and as hypermetaphony in verbs	/a/ is neutral
<i>Gravina (81)</i>	Diphthongization	/u/,/i/ - [ə]	Regular	/a/ is neutral
<i>Jacurso (84)</i>	Diphthongization	/u/, /i/ - [u], [i]	Post-tonic high vowels behave as triggers for preceding stressed vowels.	/a/ is neutral
<i>Paulilatino (85)</i>	Scalar raising	/u/, /i/ - [u],[i]	Post-tonic high vowels behave as triggers for preceding stressed vowels	/a/ is neutral
<i>Grado (86)</i>	Complete raising	/i/ - [i]	Raising does not apply in contexts where final unstressed /u/ is expected	Only mid-high vowels are affected by metaphony in Grado. Vowels derived from Common Romance *u do not trigger raising
<i>Apricena (87)</i>	Complete raising	/i/ -[i]	Mid-low vowels appear to be raised by /i/ in	For Maiden, metaphony affects only mid high vowels, /u/

			verbs, but only in open syllable	does so only in open syllable. Data from Carosella (2005) suggest that metaphony of mid-low vowels is active in specific contexts
<i>Carpino (88)</i>	Complete raising	/u/,/i/ - [ə]	Mid-low vowels appear to be raised by /i/ in verbs, but only in open syllable	For Maiden, metaphony affects only mid high vowels. Data from Carosella (2005) suggest that metaphony of mid-low vowels is active in specific contexts, and that /u/ rarely behaves as trigger
<i>Arcevia (90)</i>	Diphthongization	/u/, /i/ - [o],[i]	Regular	Metaphony affects all mid-vowels, /u/ does not trigger raising for mid-high vowels
<i>Ischitella (91)</i>	Complete raising and fronting of back vowels	/u/,/i/ - [ə]	Mid-low vowels appear to be raised by /i/ in verbs, but only in open syllable	For Maiden, metaphony affects all mid-vowels, /u/ does not trigger harmony for mid-low vowels. Data from Carosella suggest that /u/ rarely, if ever, behaves as a trigger
<i>Veroli (93)</i>	Scalar raising	/u/,/i/ - [u],[i]	Regular	For Maiden metaphony triggered by /u/ is unable to raise mid-low vowels in closed

				syllables. In general, it appears that /u/ rarely, if ever, triggers raising of mid-low vowels, while it regularly triggers raising of mid-high vowels
<i>Teramo (94)</i>	Scalar raising	/i/-[ə]	Metaphony applies in both masculine and feminine nouns and adjectives	All non-high vowels are subject to metaphony. Only /i/ acts as a trigger
<i>Valle Anzasca (95)</i>	Complete raising and fronting of back and low vowels	/u/, /i/ - 0 all vowels are lost in final position	Regular	Metaphony affects all non-high vowels, /u/ triggers harmony only for mid-low vowels
<i>Agnone (96)</i>	Diphthongization	/u/, /i/ -[ə]	Regular	Metaphony affects all non-high vowels, /u/ does not trigger harmony in low vowels
<i>Ischia (97)</i>	Diphthongization	/u/, /i/ - [ə]	Regular	Metaphony affects all non-high vowels

II.3.4. Non-metaphonic raising in Italian dialects

Italian dialects also display height-related harmonic patterns that are not assimilable to metaphony. Sanchez Miret (1998) gives a general survey of harmonic patterns in Italian dialects, considering as a whole group metaphonic and non-metaphonic processes. The examples given are mostly cases of copy harmony, where a vowel spreads all its features to a weak position (generally the pre-tonic or the post-tonic non-final position). Processes of this kind are not instances of raising harmonies per-se and for this reason are not reported in this survey. This section covers non-metaphonic raising harmonies in Italian dialects. In §3.4.1 are described some cases of regressive harmony where the stressed vowel behaves as trigger, and pre-tonic unstressed vowels are the targets of raising. In §3.4.2 is presented the group of processes thoroughly described in Schirru (2012) for the varieties spoken in the area of Monti Aurunci and the Valley of the Aniene in southern Lazio, where different harmonies (including regressive harmonies and metaphonies) co-occur creating complex harmonic patterns. In §3.4.3 I report a particular case of progressive raising that targets the low vowel in the dialect of Teramo, which displays evident similarities with the other few cases of progressive raising found in other language families.

II.3.4.1. Raising of unstressed pre-tonic vowels in central Italian dialects

In many varieties throughout the Italian peninsula, harmonic processes force the pre-tonic vowel to alternate in its height degree according to the nature of the stressed vowel. Similar processes are reported for many central varieties, such as those of Servigliano (cf. 67) Amandola (101) and Monte Giberto and Amelia (102), all villages in the region of Marche, as reported by Savoia (2015: 284f). In the examples below, a mid-vowel in pre-tonic position raises when followed by a stressed high vowel. High vowels do not undergo lowering when followed by a stressed mid or low vowel, proving that the process only involves raising, and not general height agreement. In those varieties, regular metaphony is active. The outcome of a metaphonic raising is a valid trigger for pre-tonic raising: in other words, metaphony feeds pre-tonic raising.

(101) Raising of pre-tonic vowels in Amandola (Marche, central Italy).

<i>Verbs:</i> <i>Present tense.</i>	<i>I person</i>	<i>II person</i>	<i>IV person</i>	<i>V person</i>	
	'preðeko	'preðiki	priði'kimo	preðe'kete	'preach'
	'dormo	'dormi	dur'mimo	dor'mete	'sleep'
	ko'noŋfo	ku'nuŋfi	kunuŋ'fimo	kono'fete	'know'
	'diko	'ditfi	di'tfimo	di'tfete	'say'
	'ftuto	'ftuti	ftu'timo	ftu'tete	'turn off'
<i>Nouns</i>	<i>Singular</i>		<i>Plural</i>		
	kor'tello	'knife'	kurti'l'li	'knife DIM'	
	me'lo	'melon'	mi'lu ⁸⁹	'melons'	
	ma'ritu	'husband'			

(102) Raising of pre-tonic vowels in Monte Giberto and Amelia (Marche, central Italy)

<i>Monte Giberto</i>			
kor'tellu	'knife'	kurti'l'luttSu	'knife DIM'
me'lo	'melon'	mi'lu	'melons'
'meto	'I reap'	mi'tuto	'reaped'
ve'ðemo	'we see'	vi'ðio	'I used to see'
'kofo	'I sew'	ku'fitu	'sewn'
<i>Amelia</i>			
me'lone	'melon'	mi'luni	'melons'
ko'noŋfo	'I know'	ku'nuŋfi	'you know'
ve'nemo	'we come'	vi'nuto	'came'
'dormo	'I sleep'	'durmi	'you sleep'
re'nocce	'frog F.DIM'	ri'nucco	'frog M.DIM'

⁸⁹ Metaphony applies to the word, albeit the final unstressed vowel being lost. A comparison with the Italian /melone/-/meloni/ reveals that the final unstressed vowel of singular is /e/ and the final unstressed vowel of the plural is /i/. This is coherent with the activation of metaphony we expect (and find) in this context.

Examples such as [priði'kimo] ‘we preach’, [dur'mimo] ‘we sleep’ (from Amandola), [kurtil'luttʃu] (from Monte Giberto), show that the process is iterative, and that a raised pre-tonic vowel can act as a trigger for preceding mid vowels. Considering alternations such as [kortellu] ‘knife’ – [kurtil'luttʃu] ‘knife DIM’; [koʃo] ‘I sew’ – [ku'ʃitu] ‘sewed’ may suggest that the process is unbounded and bidirectional, or that metaphony directly affects vowels beyond the stressed one.

Notice, however, that pre-tonic raising also applies when the stressed vowel is underlyingly high and followed by a final low or mid vowel, indicating that raising of the pre-tonic vowel applies in contexts where metaphony does not. The two processes, metaphony and pre-tonic raising, are actually in a feeding relation, whereby metaphony feeds the application of pre-tonic raising.

This can be seen observing verbal conjugations in the present tense in Amandola, as shown in the table under (101). Consider the alternation in the pre-tonic vowel between the two forms [ko'noʃfo] ‘I know’ and [ku'nuʃfi] ‘you know’. In the second person, metaphony (triggered by the final high vowel /i/ in the verbal suffix), raises the stressed vowel /o/ to [u], which in turn is able to raise the preceding vowel [o]. In [kunuʃfimo], instead, there is no trace of metaphony. The final vowel is /o/, which is not a trigger for raising. Raising is caused by the /i/ in the stress-bearing suffix for the 4th person, /-imo/. Pre-tonic raising, then, applies in contexts where metaphony does not apply. Metaphony, in turn, may feed pre-tonic raising.

II.3.4.2 Harmonic patterns in central and southern Lazio

Schirru (2012) describes some interesting height related harmonies in rural varieties in the Valley of the Aniene (central Lazio, central Italy) and in the area of the Aurunci Mountains (Southern Lazio). He finds interesting the fact that the two areas are not in geographic contact, but they display a very similar set of harmonic processes that involve raising triggered by the stressed vowel which are absent in other neighboring dialects.

Alternations provided in (103) display the context of pre-tonic raising in Cervara (central Lazio), which applies as discussed in the previous section: pre-tonic vowels undergo raising when followed by a high stressed vowel. Metaphony, which is active in all the varieties of the areas under scrutiny, feeds the process, but pre-tonic raising applies also in non-metaphonic contexts.

A way to know whether pre-tonic raising and metaphony are independently necessary (as was demonstrated for Amandola earlier), is to consider verbal paradigms where a suffix that bears the accent is attached to a root with a stressed mid vowel.

Consider the alternations in (103a): the infinitive suffix of certain verbs derives from Latin *IRE, and it bears stress. Preceding mid-vowels undergo raising, which applies in a non-metaphonic context (since it is not the unstressed final vowel that triggers the process). The fact that stressed /i/ raises preceding underlying mid-vowels even though it is not itself the outcome of raising proves that pre-tonic raising is independent from metaphony.

(103) Harmony in the pre-tonic domain (Cervara, Merlo 1922, Schirru 2012: 160)

a. Independent pre-tonic raising (i.e. triggered by a lexical stressed high vowel)

'ferne	'he/she/it ends'	fir'ni	'to end'
'doremo	'I sleep'	duri'mi	'to sleep'

b. Raising in the pre-tonic domain fed by metaphony

ni'puti	'nephews'	ne'pote	'nephew'
sut'tʃidi	'you happen'	so'tʃede	'it happens'
frel'lenka	'vulva (vulg.)'	fril'linku	'penis (vulg.)'
ku'luri	'colors'	ko'lore	'colors'

II.3.4.2.1 Varieties of the Aniene Valley: metaphony and pre-tonic raising co-occur with a process of progressive lowering

Varieties in this area display also another harmony involving progressive lowering triggered by stressed mid-vowels, which targets the final vowel in masculine nouns. When the stressed vowel is high or low, the final vowel in singular masculine nouns is [u], while it is [o] when a mid-vowel is in stressed position. Such a process resembles the progressive lowering harmony that is typical of Bantu languages (§3.1.2), even though here only rounded vowel /u/ is targeted by lowering, while /i/ does not seem to be affected. This is relevant since the common asymmetry in Bantu lowering (that we presented as a case of parasitism) worked the other way around: /i/ acts as the best target for lowering (lowered by both triggers /e/ and /o/), while /u/ is lowered only by /o/.

Consider the alternations from the dialect of Vallepietra⁹⁰ in the table under (104). The underlying vowel in the suffix for Class I nouns and adjectives is /u/. It surfaces as [u] when preceded by high or low stressed vowels (104a), while it surfaces as mid when preceded by stressed mid-vowels (104b). (104c) shows some verbs conjugated in the 1st person singular. The suffix for the 1st person suffix at the present tense is /-o/, and surfaces as [o] in all contexts, regardless of the height degree of the preceding stressed vowel.

(104) Progressive Lowering in Vallepietra (southern Lazio, Schirru 2012: 162)

a. Final /-u/ surfaces as [u]

ju'ditu	'the finger'
ju tau'linu	'the table DIM'
ju 'suleku	'the furrow'
'kulemu	'full'
ju 'maneku	'the handle'
j 'arberu	'the tree'

⁹⁰ In Vallepietra the regressive raising caused by high stressed vowels does not apply (Schirru: 2012: 161).

b. Final /-u/ surfaces as [o] due to progressive lowering

ju 'vedovo	'the widow'
ju ka'retto	'the car DIM'
nu 'pettso	'a piece'
l 'oλλo	'the oil'
ju ddzi'nokkjo	'the knee'
j 'okkjo	'the eye'

c. Underlying /o/ surfaces as [o] regardless of the height degree of the stressed vowel

'sattʃo	'I know'
'maŋŋo	'I eat'
'diko	'I say'
'imo	'we go'
'tɛŋgo	'I have'
'vɔλλo	'I want'
arak'konto	'I tell'

Metaphony, regressive pre-tonic raising and progressive lowering of unstressed vowels often interact in dialects of the Aniene Valley. Schirru (2012) covers the complex processes involving vowel height in the dialects spoken in the villages of Subiaco and Cervara. Here, multiple processes involving raising conspire to create complex patterns of raising and lowering. In Cervara, alongside metaphony/hypermetaphony (cf. 81) and raising harmony of pre-tonic vowels (cf. 103), progressive lowering also applies.

The table in (105) reports lexically related words, and examines the way regressive raising (initially triggered by metaphony) interplays with progressive lowering of /u/. The first column reports words where neither regressive nor progressive harmony apply. In II are listed words where progressive lowering applies, while in III are listed the cases of regressive raising.

The trigger of this regressive raising is the final vowel, which causes raising of the stressed vowel (metaphony) and of the post-tonic vowel. Words that are lexically related are reported in the same line, so that alternations caused by the different harmonies can be better examined. When the context allows for it, metaphony applies. The various sections of the table in (105) are commented on below.

(105) Height-related harmonies interplay in Cervara (Schirru 2012: 164; Merlo 1922)

	<i>I: Harmony does not apply: vowels exhibit their underlying nature</i>		<i>II: Progressive lowering: Final underlying /u/ surfaces as [o] due to progressive lowering</i>		<i>III: Regressive raising: Metaphony⁹¹ raises post tonic and stressed vowels. Eventual pre-tonic mid vowels raise when metaphony raises underlying mid-vowels to high</i>	
a.	'pɛtteno	'I comb'			'pittini ⁹²	'you comb'
	'mottfeko	'I bite'			'muttʃiki	'you bite'
	'lɛpere	'hare'			'lepiri	'hares'
	'kolema	'full F'			'kulimu	'full M'
	'koleka	'lying down F'			'kuliku	'lying down M'
	'soretʃe	'mouse'			'suritʃi	'mice'
b.	ne'pote	'nephew'			ni'puti	'nephews'
	frel'lenka	'vulva (vulg.)'			fril'linku	'penis (vulg.)'
	ko'lore	'colors'			ku'luri	'colors'
c.			'pertseko	'peach'	'pertsiki	'peaches'
			'toneto	'thunder'	'tuniti	'thunders'
			'tʃekojo	'pimple'	'tʃekuji	'pimples'
	'λλɔmmera	'clew PL'	'λλɔmmero	'clew PL'		
d.					'labiru	'lip'
					'labbiri	'lips'
					'suliku	'groove'
					'suliki	'groove'

As discussed above, there are multiple height harmonies at play in Cervara, and their co-occurrence makes it hard to understand what is happening.

Underlying mid-vowels in stressed position undergo raising caused by final high vowels, i.e., they undergo metaphony. Mid-vowels that intervene between the stressed vowel and the metaphonic trigger harmonize in height with the final vowel as well. Observe the alternation ['lɛpere]-['lepiri] 'hare/s': the mid-low vowel in stressed position surfaces as mid-high, due to raising caused by the final /i/ in the plural. The intervening /e/ in post-tonic position also raises to [i], due to the effect of the final vowel. The same pattern can be observed in the alternations reported in (105a): ['kolema] 'full F' ['kulimu] 'full M'; ['koleka] 'lying down F' ['kuliku] 'lying down M'; ['mottfeko] 'I bite' ['muttʃiki] 'you bite'.

⁹¹ Recall that in Cervara nouns and adjectives display regular scalar metaphony, while verbs display complete raising (i.e., both /e/ and /ɛ/ raise to [i]).

⁹² Schirru (2012:164) reports ['pettini], but the original data from Merlo (1922: 48) reports [pittini], following the observation made in §3.3.5 about hypermetaphony in Cervara. When it applies in verbs, metaphony applies as complete raising, so the raised alternant of /e/ in a verb is [i], while it is [e] in a noun (cf. the alternation [lɛpere] [lepiri] in 105).

The outcome of metaphony, if high, can trigger raising of preceding unstressed mid vowels. Take the alternation [ne'pote] ‘nephew’ [ni'puti] ‘nephews’. Here, the final high vowel of the plural suffix /-i/ triggers raising of stressed /o/ to [u], which in turns raises the pre-tonic mid-high vowel /e/ to [i]. Similar examples are reported in (105b)

The harmonic pattern becomes more confusing once progressive lowering applies and co-occurs with metaphony, as exemplified in (105c). Stressed mid-low vowels affect the final unstressed high vowel /u/, lowering it to [o]. However, underlying /u/ is also a viable trigger for metaphony, so the stressed vowel is actually affected by metaphony, and raises to mid-high. The fact that final [o] derived from /u/ lowering is still a metaphonic trigger is confirmed by the alternation [ˈʎʎɔmmɛra] ‘wool ball F’ [ˈʎʎɔmmɛro] ‘wool ball M’. In this example, the stressed vowel is underlyingly /ɔ/. Final underlying /u/ triggers metaphony, raising stressed /ɔ/ to [o]. Since metaphony applies as scalar in nouns, the outcome of the process is a mid-vowel, which is a viable trigger for /u/-lowering.

In the other alternations reported in (105c), such as [ˈpɛrtseko] ‘peach’ [ˈpɛrtsiki] ‘peaches’ and [ˈtoneto] ‘thunder’ [ˈtoniti] ‘thunders’, the underlying nature of the stressed vowel is that of a mid-low vowel, which never surfaces. Both terms of each alternation are affected by metaphony, since both /i/ and /u/ (here lowered to [o]) are valid metaphonic triggers.

Tokens in the column (105II) display a mid-high stressed vowel, which are the outcome of raising of mid-low vowels caused by final /u/. Similarly, tokens under (105III) have a mid-high stressed vowel, which are outcomes of metaphony caused by final /i/. We can thus assume that all tokens under (105b) have a mid-low vowel /ɛ/ or /ɔ/ in stressed position in their underlying form. First, metaphony applies (triggered by final /i/ and /u/), which raises mid-low vowels to mid-high. Then, progressive lowering of /u/ triggered by mid vowels applies.

Tokens in (105cII) and (105cIII) display a different treatment of post-tonic non-final vowels. Recall that in Cervara post-tonic vowels agree in height with final vowels (i.e., it appears as if they are affected by metaphony). However, when progressive lowering applies, the post-tonic vowel surfaces as mid, suggesting that the agreement in height with the final vowel applies after metaphony and after progressive lowering. Consider the token [ˈpɛrtseko] ‘peach’: in this word, three harmonies co-occur, and apply in feeding order. First, metaphony raises the stressed mid-low vowel to mid-high: /ɛ/ → [e]. Then, the stressed mid-vowel lowers final /u/ to [o]. Finally, the post-tonic vowel assumes the height specification of the final vowel, which after the application of progressive lowering is mid. The plural [ˈpɛrtsiki] ‘peaches’ works in a similar fashion: metaphony affects the underlying mid-low vowel /ɛ/, which raises to [e]. This mid-vowel would trigger lowering of final /u/, but this process is asymmetric, and does not affect final /i/. The post-tonic vowel assumes the height of the final vowel, which in this case is high.

In sum, there are four harmonic processes active simultaneously in the dialect of Cervara: metaphony (discussed previously in §3.3.4.5), Pre-tonic regressive raising (exemplified in 103), progressive lowering of final /u/ (shown in isolation in 104 in the dialect of Vallepietra) and post-tonic vowel height agreement to the final vowel. The complex interplay of those harmonies in Cervara is shown in the table under (106). The table in (106) is meant to be read from left to right. The various processes that apply in order are shown in the first row: first metaphony applies, which feeds pre-tonic raising. Progressive lowering of final /u/ applies, and then post-tonic non-final vowels agree in height with the final vowel.

(106) Height harmonies in Cervara

<i>Underlying forms</i>	<i>Stressed mid-vowels raise (metaphony)</i>	<i>Pre-tonic mid-vowels raise (pre-tonic raising)</i>	<i>Final /u/ lowers to [o] (Progressive lowering)</i>	<i>Post-tonic non-final vowels harmonize with the final vowel</i>	<i>Outcome</i>	
/ˈkorri/	/ˈkurri/				[ˈkurri]	‘you run’
/neˈpoti/	/neˈputi/	/niˈputi/			[niˈputi]	‘nephews’
/ˈleperi/	/ˈleperi/			/ˈlepiri/	[ˈlepiri]	‘hares’
/ˈλλommeru/	/ˈλλommeru/		/ˈλλommero/	/ˈλλommero/	[ˈλλommero]	‘wool ball’
/ˈtʃekoju /	/ˈtʃekoju /		/ˈtʃekojo /	/ˈtʃekojo /	[ˈtʃekojo]	‘pimple’
/ˈtʃekoji /	/ˈtʃekoji /			/ˈtʃekuji /	[ˈtʃekuji]	‘pimples’

A similar situation is present in Affile (Schirru 2012: 165). Here, as in many other areas of the Valley of the Aniene, the opposition between final /o/ and /u/ is lost, so that they both surface as [o], which marks the masculine singular outcome in both nouns and adjectives of Class I.

Schirru (2012) claims that, in Affile, metaphony does not apply. He thus considers three different kinds of application of raising harmony, which here are represented in different columns of the table under (107). In (107I) are listed words where harmony does not apply. In (107II) harmony is triggered by the final vowel, and triggers the preceding post-tonic non-final vowel (crucially, not the stressed vowel, otherwise it would be a process of metaphony). In (107III), according to Schirru, harmony is triggered by the stressed high vowel, which raises the following post-tonic non-final vowel (i.e., progressive raising harmony from the stressed vowel to the following unstressed non-final vowel). In (107IV), harmony is triggered by both the stressed and the final vowel.

(107) Harmonic alternations in Affile according to Schirru (2012) analysis: metaphony does not apply

<i>I. Harmony does not apply</i>		<i>II. Harmony triggered only by final vowel</i>		<i>III. Harmony is triggered by stressed vowel</i>		<i>IV. Harmony is triggered by both stressed and final vowels</i>	
'pettine	‘comb’	'pettini	‘combs’				
'arbero	‘tree’	'arbiri	‘trees’				
'kolema	‘full F’			'kulimo	‘full M’	'kulimi	‘full M.PL’
				'ulimo	‘elm tree’	'ulimi	‘elm trees’
'olepa	‘fox’					'ulipi	‘foxes’
'soleka	‘furrow’			'suliko	‘furrow’	'suliki	‘furrows’

Another possible analysis, that I think better suits the data proposed in Schirru (2012), considers both the examples in (107III) and in (107IV) as words where a regular metaphony applies. This would imply a raising process triggered by a final [o], derived by an original final /u/. The process, in this case, would be triggered by both final [i] < /i/ in plural masculine nouns and final [o], derived from final /u/. Given the data proposed in Schirrus’s article, I am inclined to choose this second option. This analysis is exemplified in the table in (108).

This analysis avoids the need to propose a progressive rule of raising, and instead considers all raising harmonies as triggered by the same segment, the final high vowel.

(108) Harmonic alternations in Affile: metaphony applies, surface [o] < /u/ behaves as a valid trigger

<i>I. Metaphony does not apply</i>		<i>II. Metaphony triggers raising of the stressed vowel and harmonization of the post-tonic vowel</i>		<i>III. /u/ acts as a valid trigger, but surfaces as [o].</i>	
'pettene	'comb'	'pettini	'combs'		
'arbero	'tree'	'arbiri	'trees'		
'kolema	'full f.'	'kulimi	'full pl.'	'kulimo	'full m.'
		'ulimi	'elm trees'	'ulimo	'elm tree'
'olepa	'fox'	'ulipi	'foxes'		
'soleka	'groove f.'	'suliki	'grooves'	'suliko	'groove'

Patterns that are similar to those discussed in the previous section have been found in the area of the Aurunci Mountains (Southern Lazio), that interestingly is not in geographic contact with the area of the Valley of the Aniene. This suggests that either harmonies were a common feature of dialects in Lazio, nowadays present only in those varieties that were less affected by Italianization, or that both areas developed similar harmonic patterns.

The area of the Aurunci Mountains is close to the Campania region, where all dialects display a consistent pattern of vowel reduction that centralizes all non-stressed vowels (cf. §3.3.1). Dialects spoken in the Aurunci Mountains, instead, display a vowel system that is more in line with dialects of Central Italy, where five vowels can be found in unstressed position: [i, e, a, o, u]. Schirru (2012: 166) reports alternations for the dialect of Minturno, proposed in (109). (109a) exhibits alternations where pre-tonic vowels raise when followed by a stressed high vowel. (109b) shows cases where the final vowel /u/ lowers to [o] when preceded by a stressed mid-vowel, but not when preceded by a stressed high or low vowel. In (109c) are shown cases of metaphony.

(109) Harmony in Aurunci Mountains (Minturno, Southern Lazio, Schirru 2012: 166)

a. Raising of pre-tonic vowel

ri'tiʎʎu	'little finger'	re'tone	'inch'
fi'rita	'wound'	mottse'ka	'to bite'
fit'tutʃa	'tape'	tet'tsone	'ember'
kup'pinu	'ladle'	koʃʃone	'thigh'
dur'mi	'to sleep'	koʃ'tata	'rib'

b. Final /u/ lowering

'letto	'bed'	'sangu	'blood'
'petto	'chest'	'nasu	'nose'
'vekkjo	'old'	'vinu	'wine'
'ε b'bono	'it's good'	'ritu	'finger'
'okkjo	'eye'	'surdu	'deaf'

c. Post-tonic raising alongside metaphony

'piritu	'fart'	'pereta	'farts'
'ʃkavudzu	'barefoot'	'kavodza	'sock'
'maskuru	'male'	'femmena	'female'
'ʃtrundzulu	'vulgar insult'	'vottsola	'goiter'

Regressive raising of the pre-tonic vowel applies to underlying mid vowels, and raises them to high when followed by a stressed high vowel.

II.3.4.3 Progressive low-vowel raising in the dialect of Teramo

In the table in (94), examples from the metaphony of Teramo (Abruzzi region) were presented. In the dialect of Teramo, metaphony affects all non-high vowels in stressed position, and is triggered only by final underlying /i/, and not by underlying /u/. In this dialect another raising harmony is active, one that uniquely targets stressed low vowels. This process is triggered by both pre-tonic /i/ and pre-tonic /u/, and affects following stressed /æ/. This process is thus a case of progressive raising. In the literature, this process is referred as Progressive metaphony in Passino (2016); Rohlf's (1966 §25); Giammarco (1979: 29); Sanchez Miret (1998).

The vowel system of the dialect spoken in Teramo appears as extremely different from the vowel system of other southern Italian dialects considered up until now. In (110) is reported the vowel system of the dialect of Teramo in stressed position, as well as the reduction pattern of those vowels in pre-tonic position.

(110) Vowel system of Teramano in Passino (2016: 151-157)

Common Romance	i	e	ɛ	a	o	ɔ	u
Stressed syllable (non-metaphonic context)	ɪ	ɐ	ɛ	æ	ɔ	ɑ	ʊ
Stressed syllable (metaphonic context)	ɪ	i	i	i	u	u	ʊ
Pre-tonic syllable	ə	ə	ə	a	ʊ	ʊ	ʊ

Unstressed vowels in pre-tonic position undergo vowel reduction in Teramano following the pattern shown in (110), so the actual nature of the trigger of progressive harmony must be reconstructed. Only underlying pre-tonic high vowels can trigger raising of following /æ/.

In order to observe the mechanism of progressive raising, we can consider the verbal alternation between the present tense (1st person) and infinitive forms of the same verbs. The suffix for the infinitive /-æ/ < ARE, bears lexical stress. When it is attached to a root, it assumes the stress of the word, forcing the preceding vowels to reduce.

Forms with a stressed high vowel in the present tense will have a reduced vowel in the infinitive, but retain the underlying vowel of the present tense. Suffixal /-æ/ surface as [i] when preceded by an underlying high vowel /i/ and /u/. Consider the data in (111) below:

(111) Progressive raising of stressed low vowels in the dialect of Teramo

<i>Present tense 1 s.</i>	<i>Infinitive</i>		<i>Etyma infinitives</i>
fa'tɪ:jə	fatə'ji	'work'	FATI(C)ĀRE
kʊ'tʃi:nə	kʊʃə'ni	'cook'	COQUINĀRE
'kja:mə	kja'mæ	'call'	CLAMĀRE
ab'brʊʃə	abbrə'ʃi	'burn'	*brusiare
'ʃtrillə	ʃtrəl'li	'scream'	*stridulare < STRĪDULUS
jə'frʊstə	fros'ti	'whip'	
jə'pɔrtə	pɔr'tæ	'bring'	PORTĀRE

Additional data from Bellante (a village that neighbors Teramo) further show the effect of progressive raising⁹³.

⁹³ Data for Teramo come from Passino (2016), while data for Bellante are from (Rholfs 1949: [1966: 49-50]).

(112) Progressive raising in Bellante (Rohlf's 1949 [1966]: 49f)

fə'li	FILĀRE	'to spin'
sə'di	SUDĀRE	'to sweat'
a'mæ	AMĀRE	'to love'
krə'fiæ	CREĀRE	'to create'
kun'dæ	COM(PU)TĀRE	'to count'

Data provided in Passino (2016: 157) suggest that the process of /æ/-raising only applies in the context of an open syllable. When the target sits in a closed syllable, the process does not apply: [kə'tærrə] *[kə'tirrə] 'guitar' (tool to make spaghetti) vs. /pɪŋ'jæ:tə/ > [pɛŋ'jitə] 'casserole.

Passino (2016: 148) considers progressive raising in the dialect of Teramo to be optional, since words in which the process does not apply are grammatical. However, she also notes that the phenomenon is extremely frequent and productive. She suggests that the optionality may be due to the influence of Standard Italian.

The process of progressive raising is evidently asymmetric, since only low vowels are subject to it, and mid-vowels are unaffected. The asymmetry condition requires the target to be low, so that all other vowels behave as unaffected by the process. Mid-vowels that appear in stressed position are not raised by preceding underlying high vowels, but are instead raised by metaphony, suggesting that the two processes, while having effect on the stressed vowel, are not related. The outcome of progressive raising is invariably a high vowel [i], regardless of the nature of the trigger. Raising is thus not scalar, but complete: the height of the outcome matches that of the triggers of harmony.

As we shall see in §3.5.3, a similar process of low vowel progressive raising is found in various Basque dialects, where the same asymmetry in the selection of the target is found. Instances of progressive raising are found in some Bantu languages, as discussed in §3.1.3.6. (raising in Phuthi), §3.1.3.7 (progressive asymmetric raising in Logoori), §3.1.3.12 (raising of the applicative suffix in Ikoma). Other progressive raising harmonies are found only in Lhasa Tibetan, treated below in §3.5.1. To my knowledge, those are the only instances of progressive raising harmony reported in the literature.

The fact that the process applies only in open syllables recalls the problematic cases presented above in §3.3.6.1, which suggested that metaphony in open syllables applies more easily than in closed syllables (Maiden 1991: 114). We discussed in §3.3.5.2 how most data on the subject turned out to be rather problematic. However, progressive raising in the Teramo dialect hints once again at the fact that there may be a relation between raising and syllabic structure, a topic that should be expanded in future research.

II.3.4.4 Concluding remarks on metaphonies and other raising harmonies in Italian dialects

Raising processes are surely one of the main phonological features of Italian dialects. The variety of raising patterns and configurations, both metaphonic and non-metaphonic, is striking.

For what concerns metaphony, we have seen that it may exhibit three different outcomes, all triggered in the same phonological context: raising, diphthongization and fronting apply when a final high vowel precedes a non-high stressed vowel. Focusing only on the raising effect, we have seen that the nature of raising may vary from dialect to dialect, since we encountered both cases of scalar and complete raising.

For what concerns the context of application of metaphony, it appears that morphology plays a relevant role. Even though most of the Italian dialects underwent severe vowel reduction, especially in final position, metaphony tends to apply in the context where an underlying high vowel can be

reconstructed. There are also cases in which morphology overcame the phonological nature of metaphonic harmony: in §3.3.5.5 were presented cases in which two identical phonological contexts resulted in different applications of metaphony, showing clear signs of morphological conditioning.

Regarding asymmetries in metaphonic processes, we can conclude that the selection of targets may involve different degrees of relative height, and more rarely differences in the front/back dimension (i.e., metaphony may affect only mid-high or mid-low vowels, more rarely, if ever, it affects only front vowels or back/rounded vowels). This is relevant for cases such as Arcevia (§3.3.5.1, 90) which, as already noted in §1.5.6 behave formally as a parasitic harmony while lacking a conditional requirement based in identity. In addition, there are cases in which raising seems to apply only in a certain syllabic context. Metaphony seems more frequent in an open syllable, but the cases in which the syllabic nature of the context is relevant are not always consistent, and their relevance has been questioned.

The asymmetric selection of triggers generally prefers front unrounded vowels. This is clear in metaphonies, and it happens also in other raising processes throughout the survey.

Non-metaphonic raising processes are less frequent in Italian dialects, but still present. They are generally triggered by stressed vowels, as is most common for vowel harmonies, and tend to be regressive. However, there are cases (such as Teramano progressive raising) in which the direction of the process goes the other way around.

Table (113) summarizes the non-metaphonic processes of raising discussed in this section. The processes of progressive lowering of Vallepietra, Cervara and Minturno are not mentioned in the summary, since they are not raising processes but instead involve lowering of the final vowel.

(113) Summary of section II.3.4

<i>Dialect</i>	<i>Directionality</i>	<i>Raising mechanism</i>	<i>Morphological effects on raising</i>	<i>Asymmetries</i>
<i>Amandola (101)</i>	Regressive	Scalar	None detected	None detected. Low vowel /a/ behaves as neutral
<i>Amelia, Monte Giberto (102)</i>	Regressive	Scalar	None detected	None detected. Low vowel /a/ behaves as neutral
<i>Cervara (103,105)</i>	Regressive	Scalar	None detected	None detected. Low vowel /a/ behaves as neutral
<i>Minturno (109)</i>	Regressive	Scalar	None detected	Height 3 vowels never appear to be raised, but it may be due to a frequency effect
<i>Teramo (111)</i>	Progressive	Complete harmony	None detected	Only /a/ is subject to progressive raising. Both /u/

				and /i/ trigger the process.
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II.3.5. Raising vowel harmony in other language families

In this section, that concludes the survey on raising harmonies, various cases of harmony are collected that involve raising from various unrelated language families. The cases listed here do not form a cohesive group of processes, such as raising in Bantu or in Romance varieties. However, they round up the final information needed to define the characteristics of raising harmony as a phonological process.

II.3.5.1 Raising harmony in Lhasa Tibetan

Lhasa Tibetan (Sino-Tibetan, spoken in Tibet) has a twelve-vowel system, and exhibits different harmonic processes. The system is composed by two series of vowels distinguished by the feature $[\pm\text{ATR}]$ ⁹⁴.

(114) Vowel system of Lhasa Tibetan (Parkinson 1996: 122, Dawson 1985)

	<i>Front</i>	<i>Front-Rounded</i>	<i>Central</i>	<i>Back</i>
<i>High ATR</i>	i	y		u
<i>High RTR</i>	ɪ			ʊ
<i>Mid ATR</i>	e	ø	ə	o
<i>Mid RTR</i>	ɛ			ɔ
<i>Low</i>			a	

Parkinson (1996: 122) considers raising in Tibetan as a case of complete harmony. This process is regressive: it targets all non-high vowels in roots and is triggered by high vowels in suffixes. All high vowels appear to be valid triggers for raising. /i/ acts as a trigger in the suffix for future /-ki/ (/qi/ in Dawson and Parkinson), /u/ appears in the negative suffix /-ku/ and /y/ appears in the suffix /-tyy/. All of them trigger raising of preceding non-high vowels.

Raising also applies within compound words, where it applies progressively. The three contexts of raising in Lhasa Tibetan are exemplified in the table under (115). (115a) shows raising caused by the suffix /-qi/, while (115b) shows raising caused by rounded high vowels, and (115c) exhibits progressive raising in compounds.

(115) Raising in Lhasa (Parkinson 1996: 123, Dawson 1985, Salting 1988)

a. Regressive raising caused by the suffix /-qi/

<i>Verbal root</i>	<i>Future tense</i>	
ʃaa	ʃəə-qi	'leave'
jaa	jəə-qi	'borrow'
sɛ	sɪ-qi	'hear (honorific)'
ɲɛɛ	ɲɪ-qi	'sleep'

⁹⁴ Consult Dawson (1985:159) for a discussion on the nature of the difference between the two sets of vowels in Lhasa Tibetan.

tee	tii-qi	'give'
kee	kii-qi	'be born'
lɔɔ	lɔɔ-qi	'read'
ʃɔɔ	ʃɔɔ-qi	'lose'
qho	qhu-qi	'hear'
phøø	phɔɔ-qi	'flee'
qhø	qhɔ-qi	'wear'
nii	nii-qi	'find'
thuu	thuu-qi	'drink'
tsyy	tsyy-qi	'offer'

b. Regressive raising caused by the suffixes /-ku/ and /-tyy/

Root	Negative	"when"	
Naa	nəə-ku	nəə-tyy	do
Tee	tii-ku	tii-tyy	give
ɲɛɛ	ɲii-ku	ɲii-tyy	sleep
Tsoo	tsuu-ku	tsu-tyy	sell
phøø	phyy-ku	phyy-tyy	flee
lɔɔ	lɔɔ-ku	lɔɔ-ku	read

c. Progressive Raising in Lhasa compounds

ri	tse	ri-tsi
mountain	peak	mountain top
qu	tshe	qu-tsi
body	life	life (honorific)
u	ɲɛɛ	u-ɲii
head	pillow	pillow (honorific)
qu	lɔɔ	qu-lɔɔ
body	lungs	lungs (honorific)
u	ta	u-tə
head	hair	hair (honorific)

Lhasa Tibetan displays raising that triggers all non-high vowels of its vowel system. The pattern of raising applies following the schema shown in (116) below.

(116) Raising pattern in Lhasa Tibetan.

i		y		u
↑	ɪ	↑		ʊ
e	↑	ø	ə	↑
	ɛ		↑	ɔ
			a	

The pattern of raising of Lhasa Tibetan suggests two interesting facts. First, it appears that this particular process cannot be defined as strictly complete, contra Parkinson (1996: 122). The outcome of low-vowel raising is not a high vowel, but instead a central mid-vowel. However, there is no scalarity effect in Lhasa Tibetan. We do not encounter the pattern typical of scalar harmonies where a mid-low vowel raises to mid-high and a mid-high vowel raise to high. Instead, we encounter a pattern that looks complete, when it concerns mid-vowel raising, but where /a/ raises to [ə], which is not a high vowel.

Another observation regards the role of [±ATR] as a prime related to vowel height. Differently from other raising patterns considered before, Lhasa Tibetan does not mix the tongue root position with vowel height. The vowel system of Lhasa Tibetan clearly has a division between advanced and retracted vowels and the process of raising that applies in the language does not interact with this grouping. Retracted mid vowels do not turn to advanced mid vowels (i.e., mid-low does not become mid-high). Similarly, retracted high vowels do not raise to advanced high.

While in most cases the prime ATR has to be included in the structural modification caused by raising, in Lhasa Tibetan only the [±high] and [±low] primes are involved in the height harmony, while ATR appears to have only a contrastive role.

It appears, then, that different languages can treat the primes related to the position of the tongue root in different ways. [±ATR] is a height related feature in Romance varieties as well as in many Bantu languages, since it is actively manipulated by raising harmony, it is not related to height in Lhasa Tibetan, where it is ignored by the raising process.

The presence of asymmetry in Lhasa Tibetan RVH cannot be assessed with certainty, based on the data I was able to find. In none of the examples the trigger is a retracted high vowel /ɨ/ or /ʊ/. There could be an asymmetry, caused by a limitation in the selection of triggers, that impedes retracted high vowels to trigger raising⁹⁵, but further research would be necessary to assess this behavior. As is evident from the tables under (115), raising in Lhasa Tibetan can apply regressively or progressively. It behaves as regressive when the trigger is in a suffix, while it is progressive when it applies in a compound.

II.3.5.2 Raising in Woleaian

Woleaian (Sohn 1971, Parkinson 1996: 73) is a Micronesian language spoken in the Woleaian atoll (Micronesia). Its vowel system is shown in (117).

(117) Vowel system of Woleaian

	<i>Front</i>	<i>Central</i>	<i>Back</i>
<i>High</i>	i	ɨ	u
<i>Mid</i>	e		o
<i>Low</i>		a	

Woleaian exhibits a particular raising pattern observed by Sohn (1971: 31). RVH targets only the low vowel /a/, and applies only when said low vowel is both preceded *and followed* by a high vowel. The outcome of the process is invariably a mid-vowel [e], regardless of the backness value of the vowel that

⁹⁵ If this were the case, ATR would be relevant in the selection of triggers, but it would still not be actively participating in raising harmony: It would behave as the height feature does in labial harmonies in Altaic languages, as we have seen in the examples from Turkish in §I.5.1. Also, cf. Moskal (2018) for an overview on the relation between height and roundness in Turkic languages.

triggers the process. Woleaian harmony is considered a raising process and not a fronting harmony because mid vowel /e/, being front, does not behave as a trigger, while the back high vowel /u/ acts as a valid trigger. I will not describe in detail the complex rules of word formation in Woleaian, for which I refer to Sohn (1971). In (118) are shown some examples of alternations where it is evident that /a/ is raised to [e] when preceded and followed by a high vowel.

The peculiar feature of Woleaian harmony is that a single neighboring high vowel (preceding or following) does not act as a trigger. Only a configuration in which high vowels surround a low vowel /a/ causes the process to apply.

(118) Raising in Woleaian

a. Raising of /a/ in the causative prefix /-ga-/ (Sohn 1971:128)

[ligamwelimwel]	'liar'	/li/(agent) /ga/ (causative) /mwelimwel/ (to lie)
[ligesuburaara]	'spider'	/li/ (agent) /ga/ (causative) /sub/ (to be born) /raara/ (branchy)

b. Raising of /a/ in the time/space marker /-ga-/ (Sohn 1971:129)

[buileiuga]	'this particular place'
[builiugeij]	'this area I am in'
[buileiugawe]	'this particular place we know'

c. Additional cases of /a/ raising (Sohn 1971: 31)

/wilima-ji/	[ilimej]	my drinking object
/wilima-mu/	[ilimem ^w]	your drinking object
/wilima-ca/	[ilimaʃ]	our drinking object
/iuwali/	[iuweli]	neck of
/iuwala/	[iuwale]	his neck

Woleaian displays an asymmetric raising harmony. The process is subject to a limitation in the selection of the target, since only the low vowel /a/ is affected by raising, while other vowels are unaffected. To sum up, Woleaian exhibits a unique asymmetric raising patterns that involve a preceding and a following trigger for raising to apply.

II.3.5.3 Raising processes in Basque

Basque is an isolated language spoken in the *Pays Vasco* region in northeastern Spain, and in some areas of southeastern France. Basque varieties display a five-vowel system with three degrees of height: /i,u/ high vowels, /e,o/ mid vowels, /a/ low vowel.

Many Basque dialects exhibit an assimilatory raising process triggered by a high vowel that targets the low vowel /a/. When preceded by any high vowel, /a/ raises to [e]. Raising applies also when /a/ is preceded by a glide /j/ or /w/, which may also affect the height of /a/ when absent in the underlying representation, but derived by a process of glide formation⁹⁶.

⁹⁶ As will be the case for mid-vowel raising, glide formation rules intertwine with low vowel raising, and are a source of inter-dialectal variation. I refer to Hualde (1991) for an in-depth analysis of rule ordering in Basque dialects.

Raising in Basque is asymmetric, since it targets only the low vowel /a/, and ignores other non-high vowels.

Raising is present in various Biscayan, Guipuzcoan and Navarrese dialects, but it is distributed quite irregularly in the area where Basque is spoken. Depending on the variety examined, the morphological context of application may vary: /a/-raising never applies at word boundary or in compounds, and each variety has a set of morphemes or special lexical items where raising does not apply. I refer to Hualde (1991: 32) for a more detailed introduction on this topic.

In different varieties of Basque, raising may co-occur with other phonological processes, and give rise to different outcomes according to the way the processes interplay⁹⁷. Under (119a) the standard variety of Basque is compared with the Baztan variety. In this variety, /a/ raises to [e] when preceded by a high vowel. (119b) shows alternations in some derivational morphemes: the underlying form of the morpheme is given above, and below alternations are shown. In (119c) are shown some cases where /a/ raising does not apply in Baztan Basque.

(119) Progressive /a/- raising in Baztan (Hualde 1991: 25ff)

a. Root internal raising

<i>Standard Basque</i>	<i>Baztan Basque</i>		
fabrika	fabrike		'factory'
muga	muge		'limit'
ikaratu	ikeratu		'frighten'
irabazi	idebazi		'to earn'
belaunikatu	belauniketu		'to kneel'
ikatz	iketz		'coal'
kirats	kirets		'stench'
ikasi	ikesi		'to learn'
izan	izen		'to be'
bihar	bier		'tomorrow'
usain	usein		'smell'
hura	ure		'that'
urtarril	urterril		'January'
urte	urte	*urti	'year'
izen	izen	*izin	'name'
izerdi	izerdi	*izirdi	'sweat'
bide	bide	*bidi	'path'

b. Alternations in derivational morphemes

<i>i. Raising in the diminutive suffix /ska/</i>			
ařari-xke	<i>little dinner</i>	larra-xka	'little prairie'

⁹⁷ Hualde (1991) dedicates an entire chapter to rule ordering in Basque varieties, and to how the interplay between rules should be analyzed. The entire discussion is not relevant here, where we are interested mainly in the typological variation of raising. Here are only reported the variations in the application of low vowel raising.

mendi-xke	'little mountain'		
<i>ii. Raising in the suffix /lari/ (profession)</i>			
tratu-leri	'dealer'	eske-lari	'beggar'
<i>iii. Raising in the adverbial suffix /ka/</i>			
aldiz-ke	'by turns'	laster-ka	'quickly'
<i>iv. Raising in the suffix /tσα/-[tza] (activity)</i>			
lagun-tze	'help'	arran-tza	'fishing'
<i>v. Raising in /-la/ (that)</i>			
dugu-le	'that we have'	dire-la	'that they are'
<i>vi. Raising in /ta/ (past participle)</i>			
itzuli-te	'turned'	etzan-ta	'lied'
<i>Raising in the singlual article /-a/</i>			
itzuli-e	'the turned'	erran-a	'the said' (what has been said)

c. Morphological exceptions to progressive /a/-raising

<i>/gařen/-[garren] ordinal</i>		
bi-garren	*bi-gerren	'second'
iru-garren	*iru-gerren	'third'
lau-garren	*lau-gerren	'fourth'
<i>/tař/-[tar]/[dar] origin</i>		
mendi-tar	*mendi-ter	'mountain dweller'
aiřkun-dar	*aiřkun-dar	'inhabitant of Ariskun'
<i>/ago/ more</i>		
argi-ago	*argi-ego	'clearer'
trankil-ago	*trankil-ego	'quieter'

In (119a), cases of raising in roots are presented. The Standard variety of Basque is confronted with the Baztan variety. Standard Basque always has /a/ surfacing as [a], while in Baztan Basque underlying /a/ surfaces as [e] if a high vowel precedes it, as shown in (119a). (119b) shows the activity of the process in various contexts.

Both phonemic high vowels trigger the process, which affects vowels in roots and in affixes. The process is invariably progressive, and affects only the low vowel /a/, i.e., it displays an asymmetry in the selection of targets. Additionally, there are disharmonic morphemes, in which /a/ surfaces as [a] even when preceded by a high vowel in the root.

Besides progressive /a/-raising, another process involving raising of a non-high vowel is active in some Basque varieties. This second process raises mid-vowels when immediately followed by another vowel. In a sequence V₁V₂, where V₁ is a mid-vowel /e,o/ and V₂ is any vowel (high, mid or low), V₁ surfaces as high. This second process of raising applies only if V₁ and V₂ are in direct contact, meaning that any intervening consonant blocks raising. Since all vowels appearing in V₂ behave as triggers and direct contact appears to be an obligatory requirement for this process, raising of this kind does not seem to be a proper harmonic process, or any kind of assimilation for that matter. The context of application is positional (two vowels in contact) rather than harmonic or based on an assimilation, since the height of V₂ is not relevant in the application of this process. I refer to this process as non-assimilatory raising

in the rest of the paragraph. Different dialects of Basque differ depending on the way harmonic raising and non-harmonic raising co-occur.

In Markina (Eastern Biscay), for example, non-assimilatory raising affects mid vowels /e/ and /o/, which raise to [i] and [u] respectively whenever directly followed by another vowel. Differently from Baztan, in Markina a raised mid-vowel is an active trigger for progressive low vowel raising (Hualde 1991: 34). In other words, non-assimilatory raising feeds progressive low-vowel raising in Markina, but it does not in Baztan. Consider the behavior of the article /-a/ in different contexts shown in (120).

(120) Different configurations of /a/ raising according to the application of mid-vowel non-assimilatory raising in Baztan Basque and Markina Basque

<i>Underlying form</i>	<i>Baztan</i>	<i>Markina</i>	
/egun-a/	eyune	eyune	'the day'
/gison-a/	gisona	gisona	'the man'
/buru-a/	burue	burue	'the head'
/asto-a/	astua	astue	'the donkey'
/mendi-a/	mendie	mendise	'the mountain'
/etse-a/	etsia	etsie	'the house'

Forms such as /egun-a/ 'the day' and /buru-a/ 'the head', are valid contexts for low-vowel raising in both varieties: an underlying high vowel triggers raising of the following /a/, which is not in contact with the trigger: /egun-a/ → [eyune] 'the day', /buru-a/ → [burue] 'the head'.

In /asto-a/ 'the donkey' and /etse-a/ 'the house', the behavior of the process of low-vowel raising differs from one variety to the other. Non-assimilatory raising takes place in both varieties: both /o/ and /e/ which are in the final position of the root, surface as [u] and [i] respectively. However, their behavior as triggers for harmonic raising differs in Baztan and Markina. They behave as valid triggers in Markina (/asto-a/ → [astue] 'the donkey'; /etse-a/ → [etsie] 'the house'), while they behave as neutral vowels in Baztan (/asto-a/ → [astua] 'the donkey'; /etse-a/ → [etsia] 'the house').

The interactions between progressive harmonic low-vowel raising and non-assimilatory raising, which are rather straightforward in the examples proposed in (120), can be extremely complex in other Basque varieties⁹⁸. Cf. Hualde (1991: 40-54-63) for an in-depth analysis of Basque progressive /a/ raising, and for a detailed description of the way this process interacts with other phonological processes.

II.3.5.4 Raising in Imonda

Imonda (Seiler 1985) is a Papuan language spoken in New Guinea that exhibits a regressive raising process. Imonda has a complex vowel system composed of twelve vowels shown in (121).

(121) Imonda vowel system.

⁹⁸ The varieties of Ondarroa and Guernika display raising patterns that are extremely interesting for the way low-vowel raising interacts with other phonological processes, such as non-assimilatory raising, glide formation and [z] insertion. A thorough explanation of those patterns would require a long analysis of Basque phonology and morphology, and would take the discussion away from the description of the raising process. I refer to Hualde (1991) and Egurtzeki (2014) for an in-depth analysis of Basque phonology.

i	ɪ	ʉ	u
e	ə		o
ɛ			ɔ
æ	a		ɒ

Imonda displays an interesting raising pattern, that does not appear clearly as harmonic, but that displays a property that relates it to other raising processes described up until now. In this language the most common strategy for marking subject plural is by raising the ultimate stem vowel of the verb. This raising (that also involves fronting) operates in a scalar way. Consider the examples in (122).

(122) Raising in Imonda (Seiler 1985: 16)

<i>Singular forms</i>	<i>Plural forms</i>	
se	si	'cut'
fe	fi	'make, do'
la	læ	'light fire'
sah	sæh	'call'
sah	səh	'search'
nagla	nagle	'see'
tas	tes	'clean'
ɒ	ɔ	'say'
lɒl	lɔl	'talk'
kulɒ	kulɔ	'roll up'
sə	si	'wash after birth'
nəl	nil	'pick fruit'
səh	sih	'search'
pos	pus	'dig'

Back vowels /ɒ/ and /o/ raise one step, becoming respectively [ɔ] and [u]. Front mid-vowel /e/ raises to [i]. Central vowels /a/ and /ə/ display a different behavior: /ə/ becomes front mid [i], while low vowel /a/ can either front to [æ] or front and raise to [ɛ].

Raising is not harmonic per-se (similarly for what we have discussed earlier in §3.1.3.10 for raising in Basaa), but it presents some features in the raising mechanism that we have encountered in other raising processes. Raising follows the general scalar behavior, and a development that includes fronting when raising targets low vowels, similar to what happens in metaphonies, where [ɛ] is the most common outcome for metaphony of /a/.

II.3.5.5 Asymmetric Raising in Chechen

The last case of raising harmony in this survey is the process reported in the literature as Chechen Umlaut. Chechen, a northeast Caucasian language mostly spoken in the Chechen Republic (Chechenya, southern Russia), displays a case of regressive harmony that targets stressed vowels and is triggered by final high vowels. This process involves rounding, fronting and raising, and it seems to display a specific asymmetric behavior.

Chechen has, according to Dotton & Wagner (2017:6) at least 26 surface vowels. Nichols (1997: 945) considers only five of them to be etymologically relevant (and phonemic) in Chechen: *i, *e, *o, *a, *u. The complete vowel system of Chechen is presented in (123). The surface forms of the etymological vowels of Chechen are marked in boldface, while the others surface only as the result of the process of umlaut.

(123) Chechen vowel system (Nichols 1997)⁹⁹

	<i>Short</i>	<i>Long</i>	<i>Short</i>	<i>Long</i>	<i>Short</i>	<i>Long</i>
<i>High</i>	i	i:	y	y:	u	u:
<i>Mid</i>	je	ie	ɥø	yø	wo	uo
	e	e:			o	o:
<i>Low</i>	æ	æ:			a (ə)	a:

Length is phonologically distinctive in Chechen: each vowel can come in either long or short form, as reported in the table above. Virtually all vowels can also appear as nasalized in determined morphological contexts: all instances of nasalization are morphologically predictable and reflect the presence of an etymological *n, which was present in the infinitive, the genitive and the nominative endings (Nichols 1997: 946). In addition, all vowels are considerably distorted when in contact with a pharyngeal consonant. This distortion gives rise to various allophonic alternations: /i/ and /e/ vowels surface as slightly backed, /u/ and /o/ surface as slightly fronted, the diphthongs /je/, /wo/ can undergo metathesis and surface as [ej], [ow].

The status of the syllable affects the way vowels are realized. Only a small group of the vowels reported in (123) seems to be accepted in closed syllables (Dotton & Wagner: 2017:8).

Besides the diphthongs reported in (123), Chechen has a handful of other diphthongs, in which the second component continues an original consonant: /uj/, /aj/, /woj/, /ew/, /ow/. The diphthongs in (123) all derive from an etymological singleton vowel, or are the outcome of the process of umlaut. Those other diphthongs are instead the result of a consonant lenition, which produced a glide.

The astounding number of surface vowels in Chechen is the result of lengthening, nasalization, allophonic distortion caused by pharyngeal consonants and glide formation, which resulted in a plethora of different allophones for each one of the vowels reported in the table above.

The process of Chechen Umlaut¹⁰⁰ is triggered by suffixal /i/ and /u/, and forces harmonization of vowels in the root. Umlaut in Chechen involves three different phenomena: rounding, fronting, and raising. The mechanism of Chechen Umlaut varies greatly from dialect to dialect, to the point that it serves as the main diagnostic for defining the Chechen variety at hand (Nichols (1997: 941).

⁹⁹ In the table under (123) I chose to report the initial component of the short diphthong derived from etymological *e as ‘j’, while Nichols uses the symbol ‘y’. Her choice stems from the desire to differentiate between the first component of the diphthong /je/ and the glide /j/. Since I am not treating consonants, I chose to report in (123) the vowels of Chechen using IPA symbols, and thus avoid the use of ‘y’ (which throughout this thesis indicates a high front-rounded vowel) as a substitute for a front glide.

¹⁰⁰ The graphic rendition of vowels in Chechen in the two works I consulted is not always consistent: Nichols (1997) uses ü, ä and ö, while I used the corresponding IPA symbols [y], [æ] and [ø]. Both Nichols (1997) and Dotton & Wagner (2017) maintain that the singleton /a/ is realized as [ə]. All the examples in the following tables come from Nichols (1997).

The triggers of the process are high vowels /i/ and /u/ in suffixes, which respectively front and round all preceding vowels. In addition, they also raise non-high vowels that precede them, but the behavior of targets varies according to the context, i.e. the process of raising applies asymmetrically.

Consider the alternations presented in (124), which come from the Standard variety of Chechen. The effects of umlaut are evident in the inflection of verbs. Cells where the umlaut involves raising are highlighted in gray.

(124) Umlaut (involving rounding, fronting and raising) in Standard Chechen (Nichols 1997: 948)

<i>Root vowel</i>	<i>Infinitive /-aⁿ/</i>	<i>Present /-u/</i>	<i>Aorist /-ira/</i>	<i>Converb /-ina/¹⁰¹</i>	
i	ʕilla ⁿ	ʕyllu	ʕillira	ʕillina	'lie'
i:	di:ca ⁿ	dy:cu	di:cira	di:cina	'say'
u	duza ⁿ	duzu	dyzira	dyzina	'fill'
u:	du:xa ⁿ	du:xu	dy:xira	dy:xina	'dress'
ie	dieʃa ⁿ	dyøʃu	di:ʃira	di:ʃina	'read'
je/ CC	djelxa ⁿ	dʒølxu	dilxira	dilxina	'cry'
uo	tuoxa ⁿ	tu:xu	tyxira ¹⁰²	tʃøxna	'strike'
wo/ CC	hwotta ⁿ	huttu	hʉøttira	hʉøttina	'stand up'
a	mala ⁿ	molu	melira	melina	'drink'
a:	a:la ⁿ	o:lu	e:lira	ælla	'say'
ow	lowza ⁿ	lowzu	lewzira	lewzina	'play'

Nichols claims that there may be no verbs with short root /je/ or /wo/ in Chechen. The only examples with phonetic short [je] and [wo] found by Nichols (1997) and reported in (124) appear before geminates or consonant clusters, i.e. in closed syllables, an environment that shortens vowels, and makes it impossible to determine whether the underlying diphthongs in roots are /je, wo/ or /ie, uo/.

All vowels are affected in some measure by umlaut. Non-rounded vowels are always rounded, back vowels are always fronted. Fronting and rounding are therefore exceptionless, and symmetrical in their application. Raising instead displays an asymmetrical pattern. It appears that front mid vowels /je/ and /ie/ raise only when followed by /i/, while /wo/ raises only when followed by /u/. The long diphthong /uo/ undergoes raising when followed by /u/, and it appears to front and raise when followed by /i/. The mid vowel of the diphthong /ow/, that undergoes fronting, is not affected in its height either by /u/ or /i/.

The low vowel undergoes raising as well as fronting/rounding in all cases in which it is followed by a high vowel, except in the converb, where it is only fronted.

The mechanism of raising in this case appears to be affected by a requirement that limits the selection of both triggers and targets. /u/ cannot raise front unrounded vowels /ie/, /je/, while /i/ cannot raise the mid rounded vowel /wo/. An exception to this rule is the outcome of /uo/ followed by /i/. Data provided by Nichols (1997) show the outcome of /uo/ to be a short [y], while Dotton & Wagner (2017) report the form [y:].

¹⁰¹ In the converb the vowel /i/ is often lost to create a cluster that shortens the preceding syllable. When this happens, the shortening affects the application of raising.

¹⁰² Dotton & Wagner (2017:28) report the following alternation: [tuoxa]-[tyyxi], where /uo/ undergoes raising, and maintains its status of long vowel.

The case of the converb is slightly more complex. The underlying form of the converb suffix is /-ina/, but the /i/ in the suffix is often dropped. This creates a consonant cluster, which makes the preceding vowel (the one that may be targeted by umlaut) short, if it was long. When this shortening applies, raising is halted. In the examples reported in (124), this can be seen for the token [tʰəxna] ‘strike (converb)’ and [ælla] ‘say (converb)’. In those examples /i/ triggers fronting for the preceding vowels, but not raising.

In (125) I summarize the different ways raising caused by umlaut affects mid and low vowels in Standard Chechen.

(125) Raising caused by umlaut in Standard Chechen

Targets (infinitive forms)	Outcome when /-i/ triggers umlaut	Outcome when /-u/ triggers umlaut		
/ie/	i:	yø		/i/ triggers raising, /u/ does not trigger raising
dieʃa ⁿ	di:ʃira	dyøʃu	‘read’	
/je/	i	ʉø		/i/ triggers raising, /u/ does not trigger raising
djelxa ⁿ	dilxira	dʉølxu	‘cry’	
/uo/	y	u:		/i/ triggers raising, /u/ triggers raising
tuoxa ⁿ	tyxira	tu:xu	‘strike’	
/wo/	ʉø	u		/i/ does not trigger raising, /u/ triggers raising
hwotta ⁿ	hʉøttira	huttu	‘stand up’	
/a/	e	o		Both /i/ and /u/ trigger raising.
mala ⁿ	melira	molu	‘drink’	
/a:/	e:	o:		Both /i/ and /u/ trigger raising.
a:la ⁿ	e:lira	o:lu	‘say’	

/i/ behaves as a valid trigger for raising for all preceding vowels except for /wo/. /u/ behaves as a valid trigger for raising for the low vowel /a/ and for rounded targets, but not for front unrounded targets, which are unaffected by raising when /u/ follows.

The process of Chechen Umlaut, if we consider solely the raising aspect of the process, crosses the line between two of the asymmetric patterns described in §1.5.7. If we leave aside the case of /uo/, the mechanism of raising in Chechen Umlaut appears to behave similarly to the Yawelmani rounding harmony discussed in §1.5.4.2 which was defined as a case of total parasitism: a kind of asymmetry that requires all triggers to share a property with the target. In Chechen, front high vowel /i/ raises front mid vowels, and rounded high /u/ raises only round mid-vowels. The long vowel /uo/ disproves the definition of Chechen Umlaut as a case of total parasitism: both /i/ and /u/ affect /uo/, while if the process were truly a case of total parasitism only /u/ should be able to affect it.

If instead we ignore /wo/, the process appears as a partially parasitic harmony, where /i/ acts as a valid trigger for all preceding targets, while /u/ cannot trigger raising if preceded by front non-rounded vowels.

Additional data on the behavior of rounded vowels in Chechen would be necessary to assess the specific nature of this process. While raising in Chechen does not behave as a perfect total parasitic harmony (as the one discussed in §1.5.4.2), it displays a strong asymmetry where both front and back

triggers are limited in their raising effects. Raising in Chechen differs from the total parasitic pattern in two aspects.

- The low vowel /a/ undergoes both raising and fronting-rounding in all occasions, even though the target and the triggers do not share another property.
- /uo/ actually undergoes raising in all contexts. Both /u/ and /i/ are proper triggers for this target, unless the context of application is affected by shortening: shortened /uo/ patterns with /wo/ in that it is raised by high round trigger /u/ while it is only fronted (and not raised) by the trigger /i/.

Chechen Umlaut is a unicum in the context of raising patterns because of its peculiar asymmetry. In all other occurrences of asymmetries with limitation in the selection of triggers, /i/ acts as a trigger in all contexts where /u/ does. In §III.7.4 the case of Camuno will be discussed. Camuno displays a perfect case of partially parasitic harmony, where /i/ triggers raising in all valid contexts, while /u/ does so only when the targets are round vowels. Chechen, instead, offers an example in which both /i/ and /u/ are limited in their raising power. /u/ raises the low vowel /a/ and all preceding rounded vowels. /i/, besides /a/, can also raise all preceding vowels except for the short rounded diphthong /wo/.

Raising caused by Chechen umlaut is a very close example of a total parasitic raising harmony. The behavior of /i/, which appears to regularly raise preceding /uo/, makes it so that this process does not precisely match the definition of total parasitic harmony. Still, the fact that it cannot raise preceding /wo/ shows that /i/ is not the ‘universal trigger’ of raising, as claimed by Maiden (1991).

II.3.5.6 Summary: the main properties of Raising Vowel Harmonies in non-Bantu and non-Romance varieties

This last collection of harmonic processes does not form a cohesive group of VH that belongs to a specific language family. Nonetheless, even though it is not possible to draw some unitary conclusions from the group of harmonies reported in this section, a summary of the last harmonies of the survey is proposed in (126).

(126) Raising harmonies in non-Bantu and non-Romance varieties

<i>Language</i>	<i>Directionality</i>	<i>Raising mechanism</i>	<i>Morphological effects on raising</i>	<i>Asymmetries</i>
Lhasa Tibetan, §II.3.5.1	Regressive when it involves suffixes, progressive in compounds	Scalar, but the low vowel /a/ raises to [ə]	None detected	None detected
Woleaian, §II.3.5.2	The targets must be between high vowels for raising to apply	Scalar (/a/ raises to [e])	None detected	Only /a/ undergoes raising
Basque, §II.3.5.3	Progressive	Scalar (/a/ raises to [e])	Some morphemes do not harmonize	Only /a/ undergoes raising
Imonda, §II.3.5.4	Regressive	Scalar	Raising marks plural in nouns	None detected

Chechen §II.3.5.5	Regressive	Scalar (in that the low vowel raises to mid)	None detected	/u/ acts as a trigger for /a/ and for rounded vowels and diphthongs. /i/ acts as a trigger for all eligible targets except for the short diphthong /wo/.
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II.3.6 Concluding remarks

Raising as a harmonic phenomenon appears to have some unique properties, which sets it aside from other harmonies.

Primarily, the aforementioned scalarity of raising is a feature that belongs uniquely to height-related harmonies, and is extremely frequent in raising patterns. Parkinson (1996) considers scalarity as a defining feature of raising processes, and claims that lowering harmonies are never scalar.

I believe this behavior of raising is a byproduct of the fact that vowel height can support more than a simple binary opposition. Theories of phonology that use phonological primes are forced to correlate more than one prime with vowel height, so in most representational accounts, height-related processes affect more than one phonological prime. The most common scalar behavior found in raising harmonies appears to be linked to mid-low/mid-high raising. Mid-high vowels normally raise to high (complete raising), while the outcome of mid-low raising is generally a mid-high vowel. Examples of this kind are frequent in Bantu languages (provided they exhibit the vowel system 7 VS:B) and in Italian dialects¹⁰³.

The ATR prime often has a prominent role in the distinction of different height degrees, which results in raising harmony being able to manipulate it: consider as examples languages such as Nzebi (§3.1.3.1) or Servigliano (§3.3.3.1). In those languages, the prime [±ATR] distinguishes between two degrees of height of mid vowels, and it is manipulated by RVH that affects mid-low vowels. In SeSotho (§3.1.3.4) the vowel system is structured around five degrees of height, so even the use of [ATR] as a height-related prime is not enough to capture the system of alternations that are relevant in this language.

Lhasa Tibetan (§3.5.1) gives the opposite example, that of a language in which [ATR] does not have any role in the definition of relative height, and does not interact whatsoever with raising harmony, but instead appears to have a more relevant contrastive role in the vowel system, since ATRness creates distinctive opposition for all vowels.

We can thus conclude that while [ATR] is, together with [high] and [low], one of the features manipulated by raising harmony, it is not consistently implemented as a height-related prime in the languages of the world. The problematic aspects of representing vowel height are presented in more detail in §IV.2.

¹⁰³ When fronting or diphthongization also occur the process may become more complex, and the label of scalar harmony may not apply precisely. It is noteworthy that in cases of diphthongizing metaphony (§3.3.3.2) mid-high and mid-low vowels undergo harmony in a different manner, much like in scalar metaphony. Even though the scalar nature of the process is lost, the difference in application remains present.

Another property of raising harmonies that appears to be typical is their regressive directionality. In the entire survey proposed, only a few harmonic processes exhibit a progressive (left to right) pattern, while the vast majority is clearly regressive (right to left). Furthermore, progressive harmonies often have an additional requirement, either morphological (cf. Logoori, §3.1.3.7 Lhasa Tibetan, §3.5.1) or based on asymmetry (Teramo, §3.4.3, Basque, §3.5.3). Consider also the peculiar case of Woleaian (§3.5.2), in which raising requires a particular sequence of segments in order to apply. Overall, it seems that raising is generally regressive.

On what concerns asymmetries in raising harmonies, we have encountered many limitations in the selection of targets. /a/ is often unaffected by raising, while mid-vowels tend to participate in raising harmony. There are only a handful of cases in which the selection of targets involves the front/back dimension: the Italian dialect of Veroli (93) Chechen (§3.5.5) and the case of Bergamasco and Camuno (treated later in §III.7.3 and §III.7.4 respectively) are the only languages where raising applies differently in front and back targets.

Asymmetry in the selection of triggers generally goes in one way only. If there is an asymmetry in the selection of triggers between front and back vowels (or rounded vs. unrounded vowels), the limitation usually affects the back/rounded vowels. In general, the front unrounded high vowel /i/ appears to be a better trigger for raising than other high vowels. The only occasion where an asymmetry on the trigger limits the raising power of /i/ is the case of Chechen¹⁰⁴, where /i/ cannot raise rounded short vowels, while /u/ can. Still, even in the peculiar case of Chechen raising, /i/ turns out to be a better trigger than /u/ for raising. Raising in Ibero-Romance varieties treated in §3.2 is triggered almost exclusively by /u/, but it was argued in §3.2.2.3 that this is probably due to the absence of /i/ in final position, and not the consequence of an asymmetry in the harmonic pattern.

We also discussed in §I.5.5 and later in §3.3.5.1 that some asymmetries may involve a special sort of parasitism, which we named Improper Parasitism. As far as I am aware, this peculiarity has been reported only for the raising process of Arcevia.

In the table under (127), the typology of asymmetries described in §I.5.7 is reported, alongside various examples from the survey. Within the context of raising harmonies, almost all kinds of asymmetries can be found.

¹⁰⁴ This does not mean that /i/ raises all vowels in all occasions. If an asymmetry limits the selection of targets, i.e. in Grado, where only mid-high vowels are eligible triggers, /i/ cannot raise them. However, in all asymmetries where the selection of triggers is involved, /i/ is never limited, except for raising in Chechen.

(127) Asymmetric harmonies in the RVH domain

Symmetric VH	Regular VH	Lena (§3.2.2.3) Ischia (97), Lhasa Tibetan (§3.5.1)		
	VH with neutral vowels	Kinande (§3.1.3.2), Tudanca (§3.2.2.1), Servigliano (67)		
Asymmetric VH	Condition on triggers or targets	Condition on targets	Basque (§3.5.3), Kikuria (§3.1.3.9) Bergamasco (§III.7.3), Tsonga (§3.1.3.8)	
		Condition on triggers	Lugo (§3.3.4.4), Teramo (94)	
	Condition on both triggers and targets	Basic	Grado (86), Kikuria (§3.1.3.9): only [+ATR] vowels participate in VH.	
		Partial parasitic VH	Camuno (§III.7.4)	
		Total parasitic VH ¹⁰⁵	Tortosan Catalan (§3.2.1.2), Chechen ¹⁰⁶ (§3.5.5)	
		Improper parasitic VH	Arcevia (90)	

Another frequent issue encountered in the survey regards the relation between RVH and morphology. The fact that a phonological process is limited only in a given morphological context is not unexpected, nor novel in any way. Approaches such as Lexical Phonology (Kiparsky 1985) frequently deal with phenomena that are relevant only in a particular morphological domain. The problem with those approaches arises when considering the interfaces between different modules of the language faculty (cf. §V.2.2). Some problematic cases only shown in this chapter will be discussed in more detail in §IV.7.3 and later in §VI.7.

The ultimate goal of this chapter was to identify the theoretical requirements, the ingredients, of a comprehensive model of raising harmonies. In other words, what does a theory of raising need in order to account for all (or at least most of) the data presented in this survey?

- The theory must be able to represent both the scalar raising that is typical of scalar patterns and complete raising.
- The theory must account for various kind of asymmetries.
- An optimal theory must find a way to integrate the role of phonology and morphology in the activation of raising processes

The following chapter analyzes in detail three raising patterns in three similar varieties of Eastern Lombard, an Italian dialect spoken in northern Italy. Once the three patterns of raising in Bresciano, Bergamasco and Camuno will be analyzed, the survey will be complete. I chose to treat separately those

¹⁰⁵ Neither Tortosan Catalan nor Chechen are perfect cases of total parasitism. They are, however, the closest example to the total parasitic harmony I was able to find in the literature, except for harmony in Yawelmani, which is, as far as I know, the only proper case of total parasitic harmony.

¹⁰⁶ The precise behavior of vowels in Chechen raising challenges the typology proposed in (127). Raising clearly displays traces of a parasitic behavior that is more radical than the one that belongs to partial parasitic harmonies. All triggers are limited in their effect on preceding mid vowels, not only one of them (as happens in partial parasitic harmonies).

three varieties because I personally gathered data on them, and I hope to give a more in-depth analysis of the varieties where those raising harmonies are found.

Chapter IV will be dedicated to the various proposals advanced in the literature that may serve to satisfy one or more of the conditions laid down here. Those proposals will be tested against some of the data presented in this chapter and in the following, and their adequacy in representing the process of raising harmony will be evaluated.

Chapter III. Raising Harmonies in Eastern Lombard dialects

III.1 Introduction

This chapter is dedicated to the description of the process of vowel harmony in Eastern Lombard dialects. Three different patterns are identified and analyzed in the chapter: the harmony found in the dialect of Brescia, the dialect of Bergamo and the dialect of Camonica Valley, hereafter referred to as Camuno. The harmonic processes described are similar in their mechanism, and appear to differ only in the kind of asymmetry they display: Raising Vowel Harmony (henceforth RVH) in Eastern Lombard dialects is a regressive harmony, triggered by the stressed high vowels /i/, /u/, and (indirectly) /y/, which target preceding pre-tonic mid vowels.

In a sense, this chapter can be considered as a paragraph from section §II.3.4 of the previous chapter. Where in chapter II various languages in which RVH appears were analyzed in general, here we discuss in detail some linguistic varieties, those spoken in eastern Lombardy, on which specific fieldwork and research has been carried out.

In Bresciano, the dialect spoken in the city of Brescia, the process applies symmetrically (symmetric harmony cf. §I.5.7). All mid vowels in pre-tonic position are subject to raising when they precede a high vowel. In Bergamasco the process is asymmetric (asymmetric harmony with a condition in the selection of targets cf. §I.5.7). All high vowels trigger raising, but the process affects only mid-rounded vowels, while non-rounded mid-vowels behave as neutral. In Camuno, raising applies in a way that coincides with the partial parasitic patterns discussed in §I.5.4.1. When the trigger is non-round, all mid vowels are subject to raising. When the trigger is round, the process applies only to round targets. This seems to be the only case of a partial parasitic harmony among processes of raising on record.

The first part of this chapter focuses on the description of Eastern Lombard dialects, and on the definition of the three varieties in which the three harmonies are attested, Camuno, Bresciano and Bergamasco. The vowel system of each one of them is described both in its evolution from Latin and in its synchronic behavior. Specific properties of the three varieties are also discussed, as well as the traits that distinguish them from each other (paragraphs from §3 to §6).

The second part of the chapter further details the processes of raising vowel harmony in eastern Lombardy. In §7.1 the harmonic pattern of Bresciano is treated. In §7.2, data from fieldwork aimed at certifying the role of RVH in the main dialectal variety of the area is presented. In section §7.3 the raising harmony of Bergamasco and neighboring varieties is described, while RVH in Camuno is described in §7.4. As for the case of Bresciano, data collection was carried out for Camuno, and the results of the fieldwork are discussed in §7.5. Section §7.8 summarizes the description of Eastern Lombard raising harmonies and completes the typological survey started in the second chapter.

The conclusion of this chapter takes up the reflections of the previous chapter, and enriches them with the data from the Lombard dialects. In particular, it will be noted how, in addition to the different types of raising and the frequent asymmetries, the RVH processes can also show cases of parasitism, such as that of Camuno, which in the course of chapter IV will be central in the discussion of the analyses proposed in the literature.

III.2 Italian dialects

In this chapter, three different Italo-Romance dialects, varieties of the Eastern Lombard group are considered. While it was not discussed at length in the previous chapter, the use of the word dialect is not without controversy, especially while dealing with varieties spoken in Italy. The term dialect defines a non-standardized variety, which is not used in “formal situations”. A dialect, has (generally) no official recognition, and has no standardized form to the point that normally (but not always) it does not even have a written form. In addition, it is usually restricted in its use to a local community, and to non-official and non-formal contexts (Loporcaro 2009: 3).

According to a famous quote¹⁰⁷, a language is just a dialect with an army and a navy, implying that there is no inherent difference between a language and a dialect, but they are set apart on a social and political basis. Literary/standard varieties, generally called languages, and non-standard varieties referred to as dialects are both equally valid linguistic systems that have a grammar. The difference between a language and a dialect is not substantial, but sociopolitical in kind.

In linguistics, the term dialect defines a language spoken in an area where it is not the official/standardized idiom, but instead is in a relation of social subordination to a *Dachsprache*, or “roof language” (Kloss 1967). A roof language is the official/standard language spoken in an area. It usually acts as the principal model for lexical innovations in subordinated dialects. It may also act as the model towards which deviant behaviors of dialects are corrected.

Still, the term dialect can have many different meanings depending on the context. Coseriu (1981) distinguished three different kind of uses for the term dialect: primary, secondary and tertiary dialect. Each one of those labels refers to the relation a dialect entertains with its roof language.

In Coseriu’s view, a primary dialect is a variety that existed before the diffusion of a common language. Primary dialects evolved contemporarily to the dialect on which a standard language is based. Secondary dialects, on the other hand, are varieties arising from the diatopic differentiation of the standard language¹⁰⁸. So dialects like the ones we are dealing with are primary Italian dialects, Italo-Romance varieties, which are the result of the uninterrupted evolution of Latin diatopic varieties in the Italian Peninsula (i.e. the outcome of the evolution of secondary dialects of Latin). One of these dialects, Florentine, provided the linguistic basis for standard Italian, the common language. The differentiation of the common language, Italian, following its diffusion in the different regions of the peninsula after political unification yielded secondary dialects, also referred to as “Regional varieties of Italian” or “Regional Italians” in the literature.

All the examples reported in the survey in sections §II.3.3 and §II.3.4 come from varieties that can be defined as primary dialects, and never as secondary dialects, so they are linguistic systems independent from Italian. All varieties explored evolved thus in parallel with the Florentine vernacular that gave rise

¹⁰⁷ This quote is often attributed to the Yiddish scholar Max Weinreich, who reports having heard it from a member of the audience during one of his lectures, but it has also been attributed to Antoine Meillet.

¹⁰⁸ Coseriu presents the concepts of primary and secondary dialect while analyzing the situation in the Iberian Peninsula. He defines as the primary dialects of Spanish the Asturian-Leonese and the Navarro-Aragonese varieties, which developed in the peninsula alongside Castilian, the baseline for modern Spanish. He then defines as secondary dialects Canarian Spanish and Andalusian Spanish. He also presents the concept of tertiary dialect: a tertiary dialect develops when different norms are established within a common language. Coseriu recognizes as different (tertiary) dialects the Spanish spoken in Spain and the Spanish spoken in Argentina. For an interesting take on the Coserian classification of dialects applied to Italy, cf. Regis 2017.

to modern Italian, and are not derived from it. Accordingly, the expression ‘Italian dialects’ is used in this thesis meaning dialects of Italy, not dialects of Italian.

Normally, a language and a dialect are in a relationship of diglossia, meaning that the standard language and the dialect are used in different social situations, the dialect being the Low variety used in more familiar contexts and the standard language the High, used in the more formal contexts. However, the situation in Italy is different. Here the two language systems (Italian and dialects) are normally both used in conversation, and the distance between the standardized language and the dialect used is often not that far apart. Berruto (1993: 5) defines the linguistic situation in Italy as a “*bilinguismo a bassa distanza strutturale con dilalia*”, which may be translated as “Endogen bilingualism with small structural difference between varieties, with dilalia”. This definition is meant to depict the fact that Italian and the dialects of Italy are structurally closer than languages that are usually found in classical bilingualism situations. The bilingualism found in the Italian Peninsula is endogen in the sense that it is internal to the community of speakers and does not originate from migrations. Finally, both Italian and the dialects may be used in contexts restricted to the Low variety in diglossic situations, as is indicated by the term *dilalia*.

There are also contexts in which the line between dialect and Regional Italian blurs even further, with frequent code-switches and borrowings from the dialect. Berruto (1993) gives a detailed analysis of the different varieties that are at disposal for a speaker, in Italy. This aspect of mutual influence (and interference) naturally also goes the other way around. The dialects are in strong regression in their use¹⁰⁹, due to the overwhelming influence of Italian. Monolingual speakers of dialect are nowadays extremely rare, and people that use dialect as their prime form of communication are getting older, and tend not to use the dialect with younger generations. I will come back on this topic in §7.2 when presenting the data collected in Brescia.

III.2.1 Defining Eastern Lombard dialects and their main features

In §II.3.3 was introduced the common Romance vowel system from which Italian dialects developed. That section was mostly focused on central and southern varieties, where metaphonies are common and attested. Since raising processes and metaphonies are rarer in northern varieties, only a handful of examples were taken from northern Italian dialects. Italian dialects are conventionally classified in three main groups: Northern, Central (plus Tuscan, which is treated as its own category) and Southern.

The primary dialects of Italy form a geographic continuum in which linguistic and geographic distance are directly related. As the distance increases, the difference between linguistic varieties also increases proportionally. The classification of Italian dialects in three macro-areas follows the lines of two main bundles of isoglosses; the La Spezia-Rimini Line conventionally divides northern from central and southern varieties, which in turn are differentiated from each other through the Rome-Ancona Line (Wartburg 1950). Dialects within the three main groups are further divided according to internal subdivisions, many of which have been described in §II.3.3.2 (consider the distinction between southern vs. extreme southern varieties, as well as the Tuscan vs. non-Tuscan varieties).

Since the goal of this chapter is the description of Eastern Lombard raising VH, we will solely concentrate on Italian dialects spoken in northern Italy, i.e. dialects spoken north of the La Spezia-Rimini Line. Besides its role in Italian dialectology, the la Spezia-Rimini Line is conventionally considered one

¹⁰⁹ Dialects are still in use, but more in the south than in the north of the country, and more by older people than younger. In addition dialects are more spoken in rural areas, and less used (and/or understood) in bigger centers (Berruto 1993: 7).

of the main divides in European Romance, since it divides Western Romance (northern Italian dialects, French, Occitan, Rhaeto-Romance, Franco-Provençal, Ibero-Romance) and Eastern Romance (central-southern Italian dialects, Dalmatian, Daco-Romance), respectively (cf. Bossong 2016 for a summary).

Lombard dialects are spoken north of this line, and are traditionally included in the group of Gallo-Italic varieties, alongside other northern Italian dialects (Piedmontese varieties, Aemilian varieties etc...). Some varieties spoken in northern Italy are not generally included in the Gallo-Italic categories, such as Venetian and Rhaeto-Romance varieties¹¹⁰.

Lombard dialects are those Gallo-Italic varieties spoken in the area that corresponds loosely with the administrative region of Lombardy, in northern Italy, together with the some areas in southern Switzerland (Tessin and Grisons). They are also spoken in southwestern Trentino, close to the border with Lombardy, and around the town of Novara, in Piedmont, which was under the political and cultural control of Milan between the 12th and the 18th century. In the map in (1), the area in pink indicates the diffusion of Lombard dialects within the area where Gallo-Italic varieties are spoken, which is contained within the red line¹¹¹.

(1) Lombard dialects within the Gallo-Italic domain



The following list, adapted from Sanga (1984, 1997), illustrates the main phonological process that characterized the evolution from Latin to Common Lombard, the stage Sanga (1997: 253) refers to as *Lombard koine*, the linguistic stage prior to the differentiation that led to the distinction of the various

¹¹⁰ As for Gallo-Italic, the classification of Rhaeto-Romance languages as within or outside the group of Gallo-Romance languages is disputed.

¹¹¹ This and other maps proposed this chapter have been drawn by the autor.

Lombard dialects. When not otherwise specified, the examples reported are from modern Milanese, the dialect spoken in Milan.

(2) Common Lombard features

- a. Weakening of intervocalic voiceless consonants, which become voiced. Following examples are from Bergamasco.

SĒTA(M) > ['sida] ‘silk’

FORMĪCA(M) > [fur'miga] ‘ant’

- b. Labial voiceless consonants underwent a more severe weakening that resulted in total loss (Sanga 1979: 295).

LŪPA(M) > *lyba > ['lya] ‘she-wolf’

APE(M) > [aɛ] ‘bee’

On some occasions the hiatus resulting from total loss of labial voiceless consonants was resolved with the insertion of a velar stop:

LEPORE(M) > *[leor] > [legor] ‘hare’ (Bresciano)

CEPULLA(M) > *[siola] > [sigola] ‘onion’ (Bresciano).

- c. Post-tonic intervocalic voiced stops were lost altogether, following an intermediate spirantization:

FĀBA(M) > ['faa] ‘bean’

CAUDA(M) > ['kua] ‘tail’

STRĪGA(M) > ['strea] ‘witch’

- d. Degemination of long consonants, except for dental affricates, which have only recently been shortened¹¹².

STŪPPA(M) > ['stupa] ‘tow’,

CATTA(M) > [gata] ‘cat F’

VACCA(M) > [vaka] ‘cow’

but PLĀTĒA(M) > ['pjattsa] ‘square’

- e. Devoicing of obstruents in final position:

COLŪMBUS > [ko'lomp] ‘pigeon’ m.’ (Bresciano) cf. the feminine COLOMBA > [ko'lomba]¹¹³ ‘pigeon F’

- f. Weakening of post-tonic nasals. Stressed vowels were nasalized in a later stage:

PĀNE(M) > [pā:] ‘bread’

- g. In infinitives, we observe the fall of final [r]:

CANTĀRE > [kan'ta] ‘to sing’

- h. Weakening of intervocalic [v] > [w]:

RĀPA(M) > *['rava] > ['rawa] ‘turnip’

Intervocalic [v] falls when followed by any back vowel, instead of weakening.

PĀVŌNE(M) > [pau:] ‘peacock’

¹¹² The processes in (4a, b, c) collectively suggest a general process of consonant weakening in intervocalic position. This consonant-weakening pattern (Carvalho 2008: 208ff) proceeds as following: geminates shorten, voiceless stops become voiced and voiced stops are lost.

¹¹³ I anticipate here a phonetic property of Eastern Lombard dialects treated. Final /a/ has a back phonetic outcome. Cresci (2015) reports all final /a/ as [ɔ] in her description of Camuno, while Sanga (1979) notes that /a/ in final position surfaces as [ɑ] in the dialect of Cigole. Brescia lines up with Cigole, and exhibits [ɑ] as the surface form of final /a/.

- i. Vocalization of root-final [l] in masculine plurals:
 *['gallu] - *['galli] > [gal] ‘cockerel’ - [gaj] ‘cockerel pl.’
- j. Loss of word-final vowels other than [a]. This property is shared with all other Gallo-Romance varieties.
 VŌCE(M) > [vu:s] (Milanese) [us] (Bresciano) ‘voice’
 ŌCULU(M) > [øʃ] ‘eye’
 DŌMINA(M) > ['dona] ‘lady’;
 FOEMINA(M) > [fonna] (Bergamasco), [fonna] (Bresciano) ‘woman’
- k. In all Lombard varieties, remnants of metaphony caused by final *-i are encountered. In some varieties spoken in Ticino traces of metaphony are more robust, even though in those areas the process mostly behaves as a palatal harmony (cf. §II.3.3.3.4). In the rest of Lombardy, we encounter forms such as [kəl] ‘that (m.sg.)’ vs. [ki:] ‘those (m.pl.)’, where the height of the stressed vowel seems to derive from the application of an ancient metaphonic process.
- l. Latin long Ū evolved into the front rounded vowel [y]. According to Sanga (1997) the evolution followed this pattern: Ū > * [u] > [y].
 LŪNA(M) > *['luna] > ['lyna] ‘moon’.
- m. Latin short Ō developed into front round [ø] following this pattern: Ō > * [ɔ] > [ø].
 FŌCU(M) > [føk] ‘fire’
 NŌCTE(M) > [nøʃ] ‘night’
 *['fɔrte] > Ticinese [fɔrt] ‘strong SG’ - *['fɔrti] > [fɔrt] ‘strongPL’
 *['fi1jɔ1u] > [fjø1] ‘boy’ but ['fjɔla] ‘girl’;
- n. Palatalization of the Latin cluster *[kt] to [ʃ], probably passing from an intermediate stage *[jt].
 LĀCTE(M) > [laʃ] ‘milk’.
 Intervocalic CL of Latin yields voiced [dʒ].
 MĀC(U)LA(M) > ['maʒa] ‘stain’.¹¹⁴

III.2.2 The internal division of Linguistic Lombardy

If compared with dialects of neighboring areas, the situation of Lombard dialects appears to be rather fragmented. The differences between dialects in Lombardy tend to be more pronounced than those found in regions that used to be politically united for a long period of time and with a strong capital city able to impose a linguistic model. Cases in point are the region of Veneto and Piedmont, where the varieties spoken in Venice and Turin highly influenced the languages spoken under their control. While other northern regions such as modern Piedmont and Veneto were a unitary (and independent) political entity, the territories nowadays comprising Lombardy never formed a political unity, until the creation of the modern administrative region. From most of its history the “Linguistic Lombardy” (this is how I will refer to the area that contain Lombard dialects, as we defined them) was politically divided. During the Middle Ages, the principal cities of the area were governed as free commons. Later, between the 1426 and 1797, the Adda River (which divides the provinces of Bergamo and Milan) was the border between the Duchy of Milan and the Venetian Republic. Some scholars (Sanga 1997: 253, Bonfadini 1990: 43) advanced the idea that before the 13th century a vernacular based around the language spoken in Milan

¹¹⁴ This outcome of Latin clusters is typical of Western and some Eastern dialects. In §4.4 the different outcome of the cluster [kt] in Bresciano and Bergamasco will be discussed.

acted as a ‘*koine*’ for the territory where the Lombard dialects are now spoken. Later, a clear distinction between Eastern and Western varieties arose, around the thirteenth century, when the areas of influence of Milan and Bergamo were not divided by a border, but were free commons under the (rather weak) control of the Holy Roman Empire. Documents from this century written in Old Bergamasco, Old Bresciano, Old Cremonese, Cremasco, and Mantuan¹¹⁵ are reported to be linguistically homogeneous (Sanga 1997: 257), and exhibit clear differences from the language used in texts written in Old Milanese.

A noticeable difference between an eastern and a western Lombard language was also noted by Dante in his treaty on vernacular Italian varieties, *De Vulgari Eloquentia*¹¹⁶. The goal of the author was to identify an illustrious vernacular variety, among the many varieties spoken in Italy at the time, and support its use as a literary language. While listing the various vernaculars spoken in northern Italy (which he deemed were to be avoided in literary use), he distinguishes between a Milanese and a Bergamasco language, suggesting that a noticeable difference between Eastern and Western Lombard varieties may have been already established while Dante was writing.

Biondelli (1853) was the first linguist to formally describe the differences between Western and Eastern Lombard dialects. Merlo (1960) also wrote on the subject, and added a third group to the list of Lombard varieties, that of Alpine dialects which is composed of all the Lombard dialects that escaped both Eastern and Western innovations.

Lurati (1988) added a fourth group to the list of Lombard dialects (Lurati 1988: 424f), that of *dialetti di crocevia* (crossroad dialects). This group is formed by all the Lombard dialects spoken in peripheral areas where frequent contacts from neighboring Romance varieties is evident, in particular Ligurian, Piedmontese, and Emilian varieties. To sum up, Lombard dialects are traditionally divided in 4 groups:

- Western Lombard dialects (L01 in the map in 3) hereafter WL. Dialects of this group were strongly influenced by Milanese. All Lombard varieties spoken west of the Adda River are considered Western Lombard alongside the Romance dialects spoken in southern Tessin in Switzerland.
- Eastern Lombard dialects (L02), hereafter EL. Dialects of this group share some general features and evolved in parallel with western dialects under the influence of the varieties spoken in Brescia and Bergamo. They are spoken in the territories coinciding with the provinces of Brescia and Bergamo, and in the north of the province of Cremona and Mantua.
- Alpine Lombard (L04, hereafter AL). Within this group are contained all the varieties that have undergone neither the innovations typical of Milanese nor those of the eastern dialects, and have therefore developed in isolation. Many of them were also affected by influences from Rhaeto-Romance languages such as Ladin and Romansch. Dialects spoken in High Valtellina, northern Ticino and the Elvetic canton of Grigioni are alpine varieties of Lombard. Varieties of some valleys in the Eastern domain such as Giudicarie, Val di Ledro, and Val Rendena in

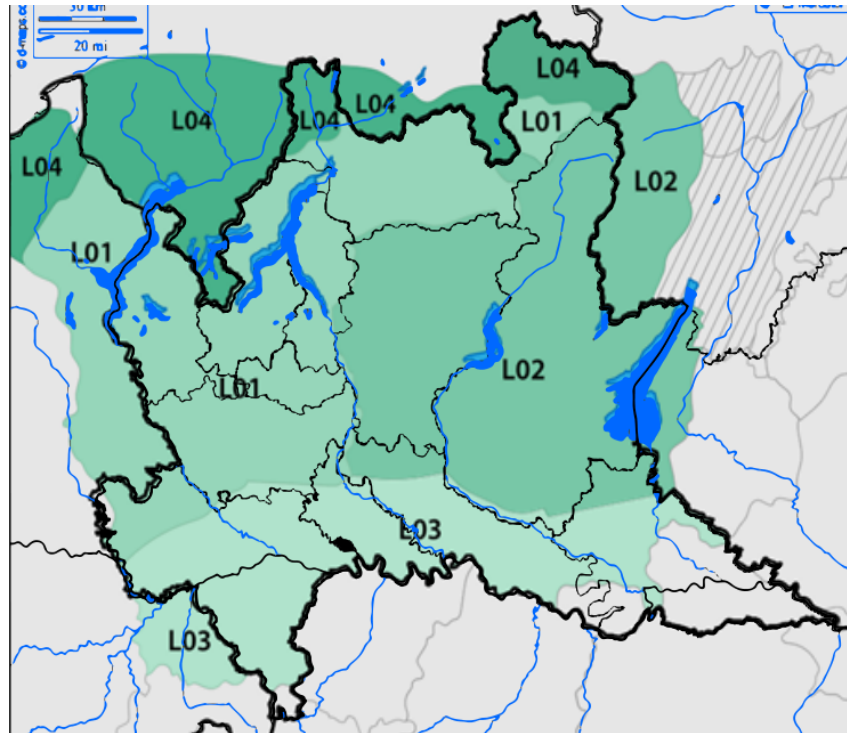
¹¹⁵ Respectively, the dialects spoken in the cities of Cremona, Crema and Mantua, the main centers of south-eastern Lombardy.

¹¹⁶«Post quos [scil. Romanos et incolas Anconitane Marchie] Mediolanenses atque Pergameos eorumque finitimos eruncemus, in quorum etiam improperium quendam cecinisse recolimus: enter l’ora del vesper, ciò fu del mes d’occhiover» . « After these let us root out the Milanese, the people of Bergamo, and their neighbors; I recall that somebody has written a derisive song about them too[?]: *Enter l’ora del vesper, ciò fu del mes d’occhiover*” (Botterill 1996).

the region of Trentino are also considered part of this group since they lack the evolutionary traits of Eastern Lombard.

- Transitional Lombard, or “Crossroad dialects” (L03). This term covers dialects that show some features typical of neighboring varieties, and are mostly spoken in southern Lombardy.

(3) Traditional division of Lombard dialects



III.3 Eastern Lombardy

Now that the main classification of Lombard dialects has been presented, I will concentrate on the properties typical of Eastern Lombard dialects, where the process of Raising VH is attested.

Eastern Lombard varieties are spoken in the area nowadays occupied by the provinces of Brescia and Bergamo, and in a small part of the Trento autonomous province. As we have already discussed, a clear distinction between western and eastern Lombard was acknowledged beginning in the 13th century. The political separation of this area from the rest of Lombardy further exacerbated the differences between western and eastern varieties that already existed, cf. Sanga (1987) and Bonfadini (1990: 66).

III.3.1 General features of Eastern Lombard

The system of consonants of EL varieties is, for the most part, uniform. The chart shown in (4) is representative of the consonantal system of all eastern varieties. Deviations from the table are reported in the discussion of specific varieties.

(4) Phonological segments common to Eastern Lombard dialects

	<i>LABIAL</i>	<i>LABIO-DENTAL</i>	<i>DENTAL/ALVEOLAR</i>	<i>ALVEO-PALATAL</i>	<i>PALATAL</i>	<i>VELAR</i>	<i>GLOTTAL</i>
<i>PLOSIVES</i>	p b		t d			k g	
<i>FRICATIVES</i>		f v	s z / *ð	ʃ			*h
<i>AFFRICATES</i>				tʃ dʒ			
<i>NASALS</i>	m				ɲ		
<i>LIQUIDS</i>			l r				
<i>GLIDES</i>	w				j		

The asterisks in the chart refer to a sound change discussed later in (9d). For now it suffices to note that systems where s-debuccalization took place display [h] instead of [s] and [ð] instead of [z].

The vowel system of EL dialects is comprised of nine vowels, as shown in (5).

(5) Vowel system of Lombard dialects

	<i>Front</i>		<i>Back</i>	
	<i>Non-round</i>	<i>Round</i>	<i>Non-round</i>	<i>Round</i>
<i>High</i>	i	y		u
<i>Mid-high</i>	e	ø		o
<i>Mid-low</i>	ɛ			ɔ
<i>Low</i>			a	

The differences between the general vowel system in stressed position of WL and EL is shown in the table in (6) and exemplified in the tables under (7) and (8). The outcome of unstressed vowels appears to vary more drastically within eastern varieties; for this reason the vocalism of each eastern variety is treated in detail in sections §4, §5 and §6, and all references to unstressed vowels are reported there. Those sections discuss both the evolution of the vowel systems as well as their behavior in synchrony.

(6) The evolution of stressed vowels in Lombard dialects¹¹⁷.

LATIN	Ī	Ī̃	Ē	Ē̃	Ā	Ā̃	Ō	Ō̃	Ū	Ū̃
Proto-Romance	i	e	ɛ	a	ɔ	o	u			
Western-Eastern Lombard	i	e	a	ø	u	y				
Western-Eastern (Closed Syllable)	i-e	ɛ	a	ɔ	u	y-ø				

¹¹⁷ Data for the Milanese dialect are from Sanga (1997: 255) and Massariello-Merzagora (1998: vol.5). In table (7) the examples for WL are taken from Milanese, while examples for EL are from Bresciano. Where only one entry is present, Milanese and Bresciano share the same outcome.

(7) Evolution of the vowel system of Lombard dialects in Stressed Open syllables.

Open Syllable	Latin	Proto-Romance	Western Lombard	Eastern Lombard		
FĪCU(M)	i:	i	i	i	'fik	'fig'
PĪRU(M)	i	e	e	e	'per	'pear'
DĒCE(M)	e	ɛ	e	e	'des	'ten'
ACĒTU(M)	e:	e	e	e	a'zet	'vinegar'
LĀCU(M)	a	a	a	a	'lak	'lake'
AMĀRU(M)	a:	a	a	a	'amar	'bitter'
NŌVUM(M)	o /	ɔ	ø	ø	'nøf	'new'
BŌNU(M)	o/ _n	ɔ	u	u	'bu	'good M'
HŌMINE(M)	o/ _m	ɔ	ɔ	ɔ	'ɔm	'man'
FLŌRE(M)	o:	o	u	u	'fjur	'flower'
CRŪCE(M)	u	o	u	u	'krus	'cross'
MŪRU(M)	u:	u	y	y	'myr	'wall'
PAUCUS	Au	ɔ	o	o	'pok	'a bit'

(8) Evolution of the vowel system of Lombard dialects in Stressed Closed syllables.

Closed syllable	Latin	Proto-Romance	Western Lombard	Eastern Lombard		
ERĪCIU(M)	i:	i	i	e	'ris - 'res	'hedgeh og'
SĪCCU(M)	i	e	ɛ	ɛ	'sek	'dry'
TĒCTU(M)	e:	e	ɛ	ɛ	'tet	'roof'
FĒRRU(M)	e	ɛ	ɛ	ɛ	'fer	'iron'
DĀMNU(M)	a	a	a	a	'dan	'damage'
ĀLTERU(M)	a/ _lT	a	o	o	'olter	'high'
CŌRPU(M)	o/ _r	ɔ	o	o	'korp	'body'
CŌSTA(M)	o	ɔ	ɔ	ɔ	'kɔsta	'rib'
COGNŌSCO	o:	o	u	u	ko'jus	'I know'
MŪSCA(M)	u	o	o	o	'muska	'fly'
FRŪCTU(M)	u:	u	y	ø	'fryt - 'frøt	'fruit'

The main difference between the two vowel systems concerns the evolution of Latin long Ī and Ū in closed syllables: they evolved as [ɛ] and [ø] in most EL dialects, while they became [i] and [y] in other Lombard varieties.

The distribution of the front non-round mid vowels [ɛ] and [e] derive from the syllabic context of the vowel in Latin. In other words, at some point in the path from Latin to modern Lombard dialects, [ɛ] and

[ɛ] were in complementary distribution. Originally, closed syllables hosted mid-low vowels, while originally open syllables hosted mid-high vowels. Nowadays the syllabic context may vary resulting in a system that is not synchronically predictable, i.e. [e] and [ɛ] are two distinct phonemes, for what concerns the stressed position. Take the pair [set] < SĪTEM ‘thirst’ [sɛk] < SĪCCUM ‘dry’ from the Eastern Lombard dialect of Brescia as an example. Both words are monosyllabic, and host a front non-round vowel in a closed syllable. The same vowel Ī developed in two different ways, depending on whether it was the nucleus of an open or a closed syllable. After the application of final vowel apocope (cf. 2j) the original syllabic context changed for the word [set], but the vowel remained the same.

III.3.2 Typical properties of Eastern Lombard dialects

The set of properties that are common in Eastern Lombard dialects and absent in other Lombard dialects is reported in (9) below. Consider however, that the terms Western Lombard, Alpine Lombard, and Eastern Lombard should be viewed as labels for varieties that share some (and not all) their linguistic features. Of the following list of characteristics, not all of them are present in all eastern varieties, but each is a clue that helps the analyst define the dialect as Eastern Lombard. Most of them concern phonology, but (9h,i,j) concern morpho-syntactic properties.

(9) Processes and characteristics that identify EL varieties

- a. Loss of vowel length distinction. Vowel length is distinctive in WL and many AL varieties¹¹⁸.

NASU(M) > [na:s] ‘nose’ vs. *[naskere] > [nas] ‘to be born’,

but NANA(M) > [ˈnana] ‘dwarf F’ and *[ˈnanna] > [ˈnana] ‘lullaby’ (Sanga (1984).

This feature was probably shared by all Lombard dialect at some point (cf. Sanga 1997: 254), but outside of WL is nowadays found only in some AL dialects, and rarely in a few peripheral eastern varieties where it seems to have survived. In most EL dialects, vocalic length is not contrastive. Below the same lexical items are compared. In Milanese (WL) vowel length is contrastive, in Bresciano (EL) it is not.

NASU(M) > [na:s] ‘nose’ vs. *[naskere] > [nas] ‘to be born’ (Milanese)

NASU(M) > [nas] is the same as *[naskere] > [nas] (Bresciano)

- b. Loss of coda nasals

PANE(M) > [pa] ‘bread’

VINU(M) > [(v)i]

In most varieties [n] is lost also in all internal codas that are in immediate post-tonic position.

TEMPUS > [tɛp] ‘time’

PONTE(M) > [put] ‘bridge’

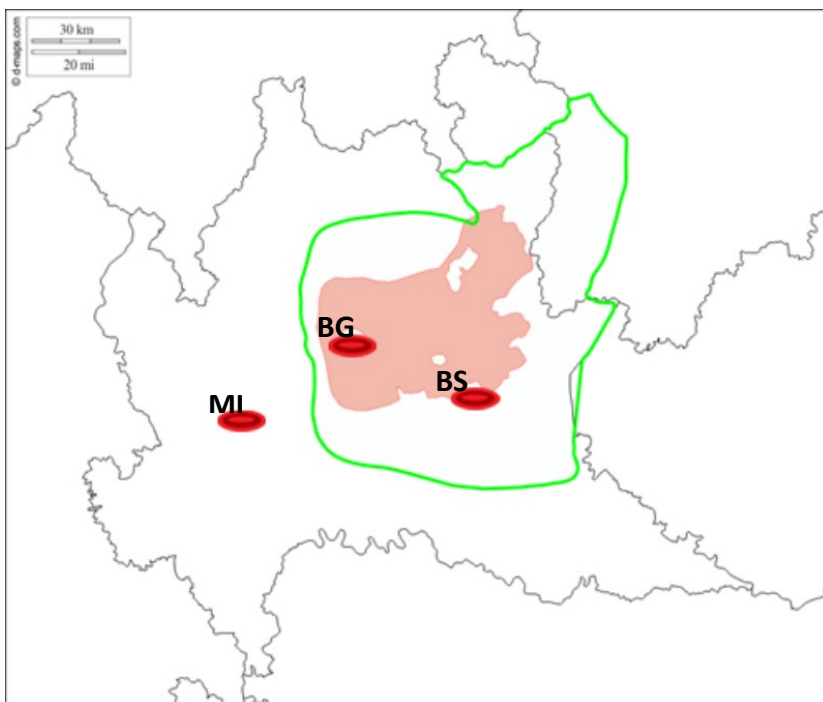
CAMPUS > [kap] ‘field’

For a more detailed analysis of this process, cf. Cresci (2014: 100) and Cresci (2014b). In rural varieties in the plains south of Brescia cases such as those are attested, according to Sanga (1979), but in Brescia most speakers pronounce the nasal. Forms such as [put] ‘bridge’ instead of [pont] are rarely attested, and judged as a rural trait by speakers of the city.

¹¹⁸ This feature, while generally present and attested in most WL varieties, is fading in some peripheral areas of West Lombardy (areas in Canton Ticino, cf. Loporcaro 2015: 152)

- c. Loss of intervocalic [v] in sandhi. Recall from (2h) that weakening of intervocalic [v] is a typical feature of Lombard dialects (*pauone > [pau] in both Milanese and Bresciano). In Eastern Lombard [v] falls also in sandhi, as exemplified below.
[el vi] 'the wine' vs. [de i] 'some wine'.
- d. In many areas within the EL domain, the outcomes of *s and *z are respectively [h] and [ð] in all contexts (presumably since the eighteenth century¹¹⁹): SĀLE(M) > [hal] 'salt', *[basatone] > [bah'tu] 'stick', *genüćulum > [ðenøtʃ], ĀSĪNUM > [aðeŋ]. In the map reported below the area of diffusion of the sound change involving debuccalization/fronting (*s > [h], *z > [ð]: marked in red in the map) within Eastern Lombardy is represented (green line in the map).

Area of diffusion of debuccalization/fronting (*s > [h], *z > [ð])¹²⁰.



- e. Eastern varieties display lowering of high front vowels in syllables that were closed in Latin. The pattern of lowering is the following: $\bar{I} > [i] > [e]$, $\bar{U} > [y] > [\emptyset]$.
ERĪCIU(M) > *[ris] > ['res] 'hedgehog' vs. (O)RYZA(M) > *[ri:s] > ['ris] 'rice'
*[bruttu] > *[bryt] > ['brøt] 'ugly' vs. LŪNA(M) > ['lyna] 'moon'.

¹¹⁹ Bonfadini (1987: 464ff) reports a detailed analysis of the evolution of alveolar segments in Lombard dialects. According to Bonfadini, in an earlier stage there were three pairs of contrastive alveolar segments in all Eastern Lombard varieties: [t]/[d], [ts]/[dz], [s]/[z]. Later, the system simplified to [t]/[d], [s]/[z] in the urban varieties of Brescia and Bergamo, while an intermediate system with the original three-way contrast was maintained in more rural dialects: [t]/[d], *θ/*ð, [s]/[z]. From this stage he proposes the application of the following processes: 1. *θ > [s] > [h], 2. [z] > [ð]. The system of alveolar segments is thus reduced to [t][d]/[h][ð]. According to Bonfadini, some residual varieties show traces of the intermediate three-way distinction (Locatello in Valle Imagna, Ponte di Legno and Presaglio in Valle Camonica).

¹²⁰ The acronyms BS, BG and MI in the map above (as they will in the maps below) stand for Brescia (BS), Bergamo (BG) and Milano (MI), and indicate the position of the three main cities in Lombardy.

- f. Coronal consonants are palatalized when followed by etymological or Proto-Romance *i. The process creates alternations in plurals, where the plural suffix /-i/ palatalized preceding [n], [t] and [l] to [ɲ], [tʃ] and [j] respectively, before undergoing the process of apocope discussed in (2j).

CĀTTU(M) > ['gat] 'cat', ['gatʃ] 'cats'

ĀSĪNU(M) > ['azɛn] 'donkey', ['azɛɲ] 'donkeys'

GĀLLU(M) > ['gal] 'rooster', ['gaj] 'roosters'

- g. Proto-Romance [a] developed as [o] in closed syllable when followed by [l]

ĀLTERUM > ['olter-'oter].

- h. The feminine plural is not phonologically marked in WL, while it is in most EL varieties.

[la 'vaka] 'cow' vs. [i 'vak] 'cows' (Milanese)

[la 'aka] 'cow' vs [le 'ake] 'the cows'(Bresciano).

- i. The final /t/ in past participles was lost in WL dialects, and as a result they end in a long vowel. EL dialects, instead, maintained the final /t/.

PARLATUM > [par'la:] 'spoken' (Milanese)

PARLATUM > [par'lat] 'spoken' (Bresciano)

- j. The definite article for feminine plural substantives is [le] in (most) EL, while it is [i] in WL (and in Bergamasco, cf. §4.4 and §5.4)

[i 'vak] 'cows' (Milanese)

[le 'ake] 'the cows'(Bresciano)

[i 'vake] 'the cows' (Bergamasco)

Besides the properties discussed in (9), EL dialects exhibit also a series of active phonological processes. Once again, notice that not all EL dialects display all of the processes listed in (10), but all EL dialects display at least some of them.

(10) Phonological processes that are generally active in Eastern Lombard dialects

- a. All varieties of Eastern Lombard exhibit alternations $\emptyset \sim /ɛ/$ to avoid a final cluster. Below, two examples from Bresciano are proposed.

['azɛn] 'donkey', [az'ni] 'donkey DIM', *[azn]

['kɔrɛn] 'horn', [korna'zi] 'horn DIM', *[kɔrn]

- b. Varieties where nasals were lost in all post-tonic coda positions (and hence display forms such as ['mut] 'mountain' or ['put] 'bridge', cf. 9b) exhibit alternations $\emptyset \sim /n/$ when a stressed morpheme eliminates the context for nasal loss. Below an example from Camuno is proposed.

['det] 'tooth'

[din'ti] 'tooth DIM.' *[diti]

- c. In EL varieties a process of regressive assimilation in sandhi is active whereby a sequence such as $C_1\#C_2$ becomes $C_2\#C_2$. Final obstruents [p], [t], [k] are totally assimilated to the following consonants. Below examples from Dalpedri (2013: 14) are proposed:

/sen'tet zo/ → [sentez'zo] 'sit down!'

/sik fik madyr/ → [siffimma'dyr] 'five mature figs'

This process is in a counterbleeding relation with respect to the process of weakening of /v/ reduction discussed in (2c), as shown below.

/get vest/ → [gev'vest] ‘have you seen?’ vs. /go vist/ → [go 'ist] ‘I have seen’.

In [gev'vest] final /t/ of the first word assimilates with /v/ and results in a geminate that does not undergo reduction. When /v/ appears in intervocalic position (even in sandhi) it is lost.

- d. Nasals share place of articulation with following consonants.

/lɛŋgwa/ → [l'ɛŋgwa] ‘tongue’

This process is also active in sandhi

/ɛn ka'al/ → [ɛŋ ka'al] ‘a horse’

/ɛn pa'u/ → [ɛm pa'u] ‘a peacock’

When the process of consonant assimilation discussed in (10c) applies, the nasal consonant assimilates with the place of the following consonant (Dalpedri 2013: 15). Examples are shown below:

/fank frɛsk/ → [fam'frɛsk] ‘cold mud’

/sang blø/ → [sam'blø] ‘blue blood’

/lonk fes/ → [lom'fes] ‘very long’.

- e. Pre-tonic mid-low vowels undergo vowel reduction and turn to mid-high when they pass from a stressed to unstressed position. Consider the following alternations from Bresciano

[vɛtʃo] ‘old man’; [vɛtʃa'si] ‘old man DIM’

[nɛdra] ‘duck’; [nɛdrət] ‘duckling’

[ɔrp] ‘blind’; [orbati] ‘blind man DIM’

[sɛk] ‘dry’; [sɛ'kat] ‘dried’

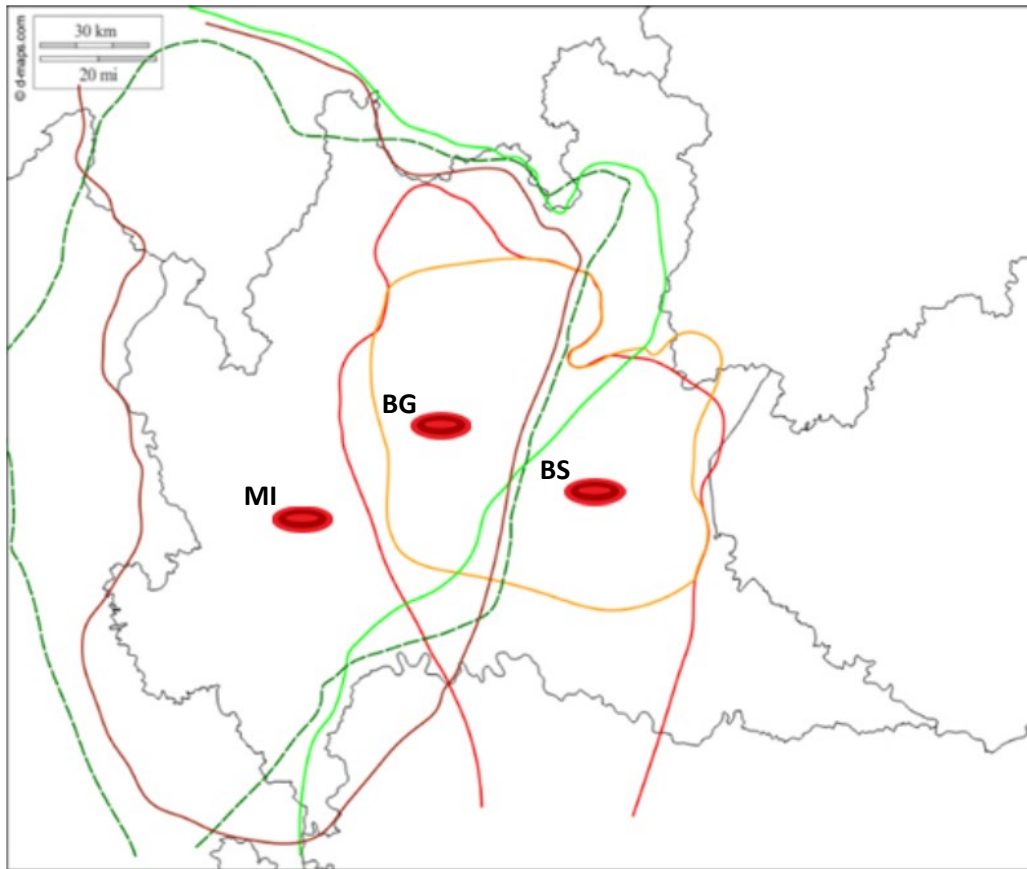
In the following sections, the distribution of mid-vowels in pre-tonic position is discussed further for each variety.

Finally, as anticipated in the introduction, EL varieties exhibit a process of regressive raising triggered by stressed high vowels and affecting preceding unstressed mid vowels. The description of raising patterns in EL is the focus of the chapter, and will be the topic of section §7. As noted in the introduction, this process does not appear to be evenly distributed. At least three specific raising mechanism can be found in EL. In Bresciano RVH, harmony behaves as a regular symmetric harmony that targets all unstressed pre-tonic mid vowels. In Bergamasco the process applies only to round mid vowels, displaying a limitation in the selection of targets (cf. §I.5.7). In Camuno, raising harmony appears to be parasitic on rounding. To my knowledge, this is the only case of RVH parasitic on rounding documented in the cross-linguistic record on VH.

III.3.3 Internal division within Eastern Lombardy

The previous section presented various linguistic properties that distinguish EL varieties from other Lombard dialects. In the map presented in (11) the geographic distribution of some of the main properties of EL is shown.

(11) Main phonological and morphological isoglosses internal to Lombardy

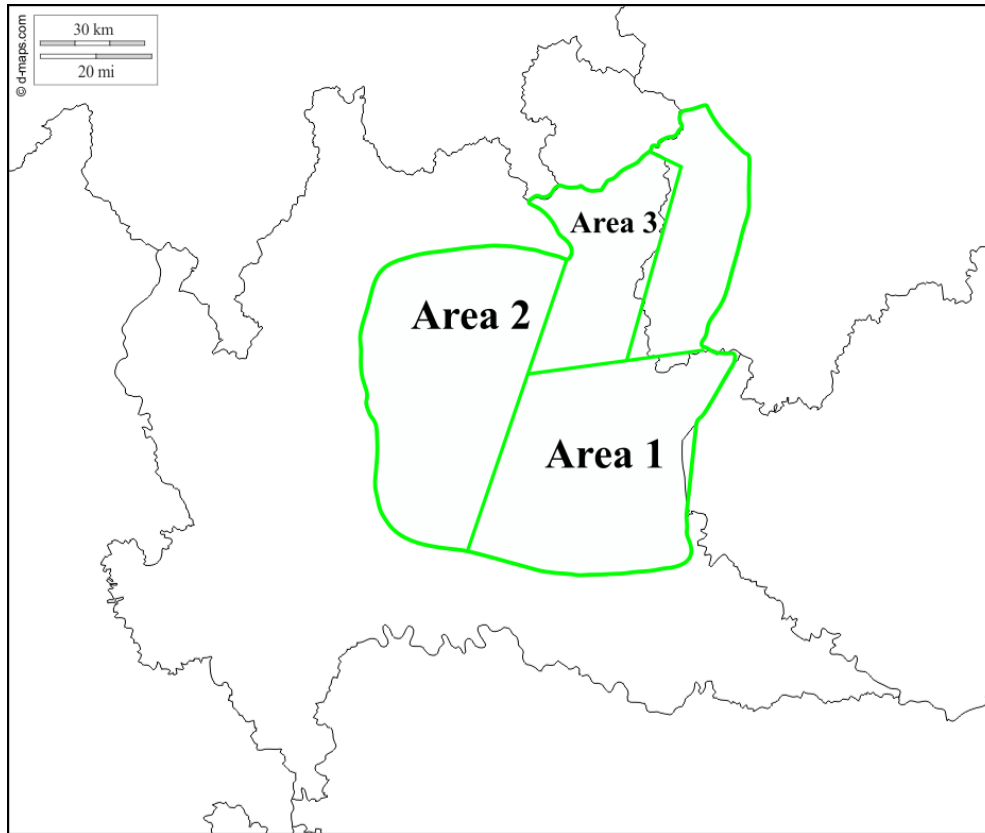


- Stressed $\bar{U} > [y] > [\emptyset]$ in closed syllables (9e)
- Stressed $\bar{I} > [i] > [e]$ in closed syllables (9e)
- *CL $> [dʒ]$ (cf. 22b), as in WL.
- Plural feminine definite article [i] (9j) as in WL.
- Lack of desinence for infinitives in *ERE (cf. 22c) as in WL.

The isoglosses presented in (11) identify three major areas within Eastern Lombardy, loosely represented in the map in (12)¹²¹.

¹²¹ The area of south-western Trentino, in which an Eastern Lombard dialect is spoken, is not considered here. Very little has been written on the dialects spoken in this area, and the distribution of isoglosses suggest that it differs greatly from other Eastern dialects, to the point that south-western Trentino dialects may be considered more akin to Alpine varieties, since they lack so many of the typical eastern properties. I refer to Bonfadini (1990: 65) for an overview on the dialects spoken in this area.

(12) Main areas of Eastern Lombardy



- Area 1. In this area the vowel system corresponds to the typical Eastern vowel system, where stressed I and U lowered in closed syllables. Western traits are absent in this region. The main variety of Area 1 is Bresciano, treated in §4.
- Area 2. In this area the vowel system corresponds to the typical Eastern vowel system. Within this area some phonological and morphological traits that are typical of WL permeated. Bergamasco, the main dialect spoken in Area 2, is treated in §5.
- Area 3. This area corresponds with the Camonica Valley (Valle Camonica), the area where Camuno is spoken. The main developments of EL vowel systems did not permeate here. As a result, at least in stressed position, the vowel system resembles that of WL varieties. However, the western properties of Area 2 also did not permeate. The only *trait-d'union* with WL is the vowel system of dialects of this area, which lack the innovations that belong to EL. Since both western and eastern features hardly affected the dialect of this area, the inclusion of Camuno in the group of Eastern Lombard dialects may be put in doubt. In section §6 I justify my position in considering it a peculiar but proper Eastern Lombard dialect.

For each area, the most representative dialect has been selected, and its vowel system analyzed. The three varieties are Bresciano (Area 1), Bergamasco (Area 2), and Camuno (Area 3). As already established, the process of Raising Vowel Harmony common to all EL dialects behaves differently in those varieties. In section §4, §5 and §6 the specific varieties are presented, while in §7 the discussion focuses strictly on the process of vowel harmony active in those varieties.

III.4 Specific phonological traits of Bresciano

In this section, I present the main phonological properties of the dialect spoken in the city of Brescia. In §4.1 the vowel system in stressed syllables is considered. Since it is extremely relevant for the behavior of the process of raising VH, the system of pre-tonic vowels is tackled in §4.2. Other observations about the phonology of Bresciano and the features that differentiate it from other EL dialects are presented in §4.4.

III.4.1 Vowel system of Bresciano: stressed vowels

The tables in (13) and (14) display the evolution of stressed vowels from Latin to Bresciano in original open syllables (i.e. in syllables that were originally open in Latin). (13) shows the general evolution of each vowel, while (14) provides examples and clarifications.

(13) Evolution of stressed vowels in open syllables in Bresciano:

LATIN	Ī	Ĭ	Ē	Ĕ	Ā	Ă	Ŏ	Ō	Ū	Ū
Proto-Romance	i	e	ε	a	ɔ	o	u			
Bresciano	i	e	a	ø	u	y				

(14) Stressed vowels in open syllables in the dialect of Brescia.

Open Syllable	Latin	Proto-Romance	Bresciano		
FĪLU(M)	i:	i	i	'fil	'yard'
PĪRU(M)	i	e	e	'per	'pear'
DĒCEM	e	ε	e	'des	'ten'
ACĒTU(M)	e:	e	e	a'zet	'vinegar'
ĀPE(M)	a	a	a	'aa	'bee'
AMĀRU(M)	a:	a	a	a'mar	'bitter'
NŌVU(M)	o	ɔ	ø	'nøf	'new'
ŌVU(M)	o	ɔ	ø	'øf	'egg'
BŌNU(M)	o/_n	ɔ	u	'bu	'good M.'
STŌMACU(M)	o/_m	ɔ	ɔ	'stømek	'stomach'
SŌLE(M)	o:	o	u	'sul	'sun'
CRŪCE(M)	u	o	u	'krus	'cross'
MŪRU(M)	u:	u	y	'myr	'wall'
FŪMU(M)	u:/_N	u	ø	'føm	'smoke'
PAUCUS	au	ɔ	o	'pok	'a bit'
FAENU(M)	ae	e	e	'fe	'hay'
AD POENA	oe	e	e	a'pena	'at most'

While the table in (13) shows the general evolution of vowels, the examples in (14) display a more complex situation. The front rounded vowel [ø] is not the only evolution of Proto-Romance short Ō. It develops as [u] when followed by a nasal [n], and when followed by [m] it develops as [ɔ] (cf. BŌNU(M) > [bu] * [bø]; STŌMACU(M) > [stømək] * [stømək]). In addition, stressed long Ū of Latin develops as [ø] when followed by a nasal consonant, e.g. FŪMU(M) > [føm] *[fym]).

The tables in (15) and (16) discuss the evolution of stressed vowels in original closed syllables.

(15) Evolution of stressed vowels in closed syllables in Bresciano

LATIN	Ī	Ī	Ē	Ē	Ā	Ā	Ō	Ō	Ū	Ū
Proto-Romance	i	e	ε	a	ɔ	o	u			
Bresciano	e	ε	a	ɔ	o	ø				

(16) Stressed vowels in closed syllables in the dialect of Brescia

	Latin	Proto-Romance	Bresciano		
FĪXU(M)	i:	i	e	'fes	'a lot'
SĪCCU(M)	i	e	ε	'sɛk	'dry'
TĒCTU(M)	e:	e	ε	'tɛt	'roof'
FĒRRU(M)	e	ε	ε	'fɛr	'iron'
DĀMNNU(M)	a	a	a	'dan	'damage'
ĀLTU(M)	a/_IT	a	o	'olt	'high' ¹²²
MĀLTA(M)	a/_IT	a	o	'molta	'mortar'
ARĀNEU(M)	a:	a	a	'raɲ	'spider'
MŌRTU(M)	o/_r	ɔ	o	'mort	'dead'
SŌL(I)DU(M)	o/_l	ɔ	o	'soltʃ	'money'
CŌSTA(M)	o	ɔ	ɔ	'kɔsta	'rib'
COGNŌSCO	o:	o	o	ko'nose	'I know'
ŌRDINE(M)	o:/_r	o	u	'urden	'order'
GENŪC(U)LU(M)	o/_Palatal C		ø	ze'nɔtʃ	'knee'
MŪSCA(M)	u	o	o	'moska	'fly'
FRŪCTU(M)	u:	u	ø	'frɔt	'fruit'

¹²² Recall from (9g) that a/_IC comes out as [o]. The same happens in Bergamasco and Camuno. However, forms such as ['alter] 'other' or ['alt] 'high' (derived from the Italian ['altro] 'other' and ['alto] 'high'), may be used by speaker in free distribution alongside the expected forms ['oter] and ['olt].

As already noticed when discussing stressed vowels in open syllables, it appears that some rounded vowels were influenced by neighboring vowels during their evolution.

Proto-Romance *o <Ō,Ū normally developed as [o] in Bresciano, except when it precedes a palatal consonant such as [tʃ] or [r]. In the first case the outcome is [ø] (e.g. GENŪC(U)LU(M) > [zenøtʃ]), in the second one it is [u] (e.g. cf. ŌRDINEM > [urden]).

Proto-Romance *ɔ <Ŏ, which normally developed as [ɔ], becomes [o] when followed by a liquid consonant [l] or [r]: MŎRTU(M) > [mort], *[mɔrt]; SOL(I)DU(M) > [soltʃ]¹²³ *[sɔltʃ].

The main peculiarities of the Bresciano Vowel System and its main differences from the general Romance evolution of stressed vowels are summarized in (17).

(17) Main peculiarities of the Bresciano Vowel System

- a Stressed Ū > y as in other Gallo-Romance languages, but Ū > ø in closed syllables. WL dialects have [y] in both open and closed syllables (cf. 9e).
- b Ī > e in closed syllables, while WL dialects have [i] in both open and closed syllables (cf. 9e).
- c Rounded vowels appear to be sensitive to following sonorants:
 - Nasals in open syllables: Ō > u / _nV ['bu], Ŏ > ɔ / _mV ['ɔm], Ū > ø / _NV ['føm]
 - Rhotics in closed syllables: Ō > o / _rC ['mort], Ŏ > o / _lC ['soltʃ], Ō,Ū > u / _rC ['turta].

III.4.2. Vowel system of Bresciano: vowels in unstressed position

In this section, the system of pre-tonic vowels in the dialect of Brescia is presented. The pre-tonic system is considered in isolation since it forms the set of possible targets for the process of RVH discussed in section §7. Post-tonic vowels followed for the most part the same evolutionary path, even though they are relatively rare in Lombard dialects. This is due to the phenomenon of final vowel apocope, discussed in (2j), which is responsible for the scarcity of post-tonic unstressed vowels in Lombard dialects. Regarding vowels in final position, we expect to find only two vowels: /a/ (which surfaces as [a], alongside the plural form of the feminine suffix in nouns and adjectives, which is /-e/, [e]. In the modern dialect some forms also display a masculine morpheme [-o] in final position, alongside its plural form [-i]: [vɛtʃo] ‘old man’ [vɛtʃi] ‘old men’, [nono] ‘grandfather’ [noni] ‘grandfathers’. Both morphemes are borrowed from Italian. (18) shows the general path of evolution of vowels in unstressed pre-tonic position from Latin to Bresciano. (19) provides examples and clarifications.

(18) Evolution of unstressed pre-tonic vowels of Bresciano:

LATIN	Ī	Ī	Ē	Ĕ	Ā	Ă	Ŏ	Ō	Ū	Ū
Proto-Romance	i		e		a			o		u
Bresciano (Open Syllable)	i		e		a			o		ø/y
Bresciano (Closed Syllable)	i		ɛ		a			o		ø/y

¹²³ *Pluralis tantum*. The plural morpheme /-i/ palatalizes the preceding coronal consonant (cf. 9f).

(19) Unstressed pre-tonic vowels in the dialect of Brescia.

	Latin	Proto-Romance	Bresciano		
FILĀRE	i:	i	i	fi'la	'to spin'
VINDĒMIA(M)	i	e	ɛ [_CC]	ɛn'demja	'peach'
VITĒLLU(M)	i	e	e [_CV]	e'dɛl	'calf'
LAETĀMEN	e	e	e	le'dam	'manure'
BĀSIĀRE	a	a	a	ba'za	'to kiss'
NATĀLE(M)	a	a	e	ne'dal	'christmas'
RORĀRE	a	o	o	ro'zadɔ	'dew'
CŌLŪMBUS	a	o	o	ko'lomp	'pidgeon'
PŌRCĒLLU(M)	a	o	o	por'sɛl	'pig'
*Iucerta(m)	u	u	ø	lø'zertɔ	'lyzard' ¹²⁴
CURĀRE	u:	u	y	ky'ra	'to cure'

Notable developments from the regular Proto-Romance system regarding unstressed vowels in Bresciano are the following:

a. The distribution of front mid vowels in unstressed syllables seems to depend on the syllabic context: [e] is limited to open syllables, [ɛ] to closed ones. There are no minimal pairs based on the tense-lax alternation in unstressed contexts. Front non-round mid-vowels in post-tonic position are [-ATR] when in closed syllable, they are [+ATR] when they are in open syllable. In pre-tonic position, their distribution does not seem to be entirely predictable.

Sanga (1979) transcribes all unstressed front mid vowels as [e], both in pre-tonic and in post-tonic position. Cresci (2015: 47) notes that unstressed [ɛ] is allowed in closed syllables in the Camuno variety, and this led me to check what the situation was in the Bresciano. According to my own observations, in the dialect of Brescia the distribution of front non-round mid-vowels is predictable in post-tonic position: [ɛ] in closed syllables, [e] in open syllables ([ˈpɛtɛn], [ˈpasɛr], [ˈlagremɔ] etc...). In pre-tonic position, the situation is much less clear. In the fieldwork discussed in §7.2, some speakers exhibit different behaviors regarding certain words. The word [lɛn'sɔl] 'bedsheet' and [pɛr'sɔt] 'ham' are always pronounced with a mid-low vowel in pre-tonic position, while alternating forms (such as [ne'drɔt]/[nɛ'drɔt] 'duckling' and [sɛn'tɛr]/[sen'tɛr] 'trail') appear in the survey from time to time. From what I observed, the preference for mid-low or mid-high vowels in pre-tonic position generally follows the same rule of the distribution of mid-low vowels in post-tonic positions. Mid-low vowels appear in closed syllables of the tokens [pɛr'sɔt] and [lɛn'sɔl], while in open syllables the mid-high vowel is preferred. The forms [sɛn'tɛr] and [ne'drɔt], are preferred to the alternative forms [sen'tɛr] and [nɛ'drɔt]. This issue is further explored in §4.3.

¹²⁴ In the AIS atlas the outcome is [ly'zertɔ], but nowadays (as reported in Sanga 1979 and in my own data collection in §7.2) is [lø'zertɔ].

b. The outcome of long high vowels is variable. Regarding the evolution of unstressed \bar{U} , Sanga (1979) believes the different outcomes $[\emptyset]$ and $[y]$ are the result of the alternation between ryzotonic and aryzotonic verbal forms, which contributed to create the current “fluid situation” (Sanga 1979: 253). During my own fieldwork (cf. §7.2), most speakers exhibited $[\emptyset]$ for words such as $[\text{l}\emptyset\text{'zert}\alpha]$ ‘lizard’ or $[\text{l}\emptyset\text{'maga}]$ ‘snail’, but some of them produced also forms with $[y]$. The same double outcome of unstressed long \bar{U} is also present in Bergamasco (Sanga 1987).

c. The phonetic realization of final vowels (recall that only Vulgar Latin $*a$ survived apocope, cf. 2j) is retracted, and surfaces as a back vowel $[\alpha]$.

d. According to Sanga (1979: 251) pre-tonic $[a]$ developed as $[e]$ in some specific words. This outcome, which is different from the expected one (reported in table 19), is due to different (and often contradictory) phenomena, according to the author. I report his proposal as he stated it. Unstressed pre-tonic A from Latin develops as $[e/\varepsilon]$ due to:

- Assimilation of $/a/$ to a following mid-high vowel $[e]$, so that $/a/ \rightarrow [e]$: e.g. $[\text{segres'ta}] < *sacrestanu(m)$;
- Dissimilation of $/a/$ to $[e]$ to avoid a sequence with two $[a]$ s: e.g. $[\text{ne'dal}] < natale(m)$;
- Fronting caused by a following front vowel $*i$ $[\text{ze'ner}] < *ianuariu(m)$.

Also, it appears that post-tonic non-final $[a]$ developed as $[\varepsilon]$ in a series of words such as $[\text{'stom}\varepsilon\text{k}] < st\ddot{o}m\ddot{a}cu(m)$ ‘stomach’, $[\text{'spare}\varepsilon] < asparagus$ ‘asparagus’.

III.4.3. Synchronic Vowel system of Bresciano

The vowel system of Bresciano (and of all other EL varieties) corresponds to that reported in (5) and reprised in (20) for convenience.

(20) Vowels of Bresciano

	<i>Front</i>		<i>Back</i>	
	<i>non-round</i>	<i>Round</i>	<i>non-round</i>	<i>round</i>
<i>High</i>	i	y		u
<i>Mid-high</i>	e	\emptyset		o
<i>Mid-low</i>	ε			ɔ
<i>Low</i>			a	

All of the nine vowels presented in (20) can appear in stressed syllables, while, for what concerns closed syllables, a process of vowel reduction is active, which was mentioned in the previous section and presented in (21) below. Simply put, in Bresicano and other EL dialects, mid-low vowels reduce to mid-high whenever they pass from a stressed to an unstressed syllable. The process is especially evident when a stress-bearing suffix is added to a root with a stressed mid-low vowel, as reported in (21).

(21) Alternation between mid-low and mid-high vowels

<i>Stressed mid-low vowels</i>		<i>Mid-low vowels pass from stressed to unstressed position</i>	
[ˈsɛk]	‘dry’	[sɛˈkat]	‘dried’
[ˈɔrp]	‘blind’	[orbəˈti]	‘blind DIM’
[ˈnɛdra]	‘duck’	[nɛˈdrɔt]	‘duckling’ ¹²⁵

Cases of vowel reduction of this kind, where a mid-low vowel turns mid-high when unstressed, are rather common in Italian dialects, as discussed in §II.3.3.1.

As reported in §4.2, the distribution of front mid-low vowels in pre-tonic position is hard to assess with certainty, with forms with both mid-high and mid-low vowels accepted, such as [senˈter]/[sɛnˈter] ‘trail’, [nɛdrɔt] [nɛdrɔt] ‘duckling’.

As noted in §4.2b, there are no minimal pairs based on the tense-lax alternation in unstressed positions. Furthermore, the process of raising that affects mid-vowels in Bresciano and in other EL varieties applies in the same fashion to both mid-low and mid-high vowels, turning both of them into high vowels.

For those reasons, I argue that [e] and [ɛ] actually correspond to a single underlying /e/ in unstressed position, and that the mid-low counterpart [ɛ] is to be expected in closed syllables. This is matched with by the overwhelming majority of speakers of Bresciano that pronounce [perˈsɔt]/[lɛnˈsɔl] (with [ɛ] in pre-tonic closed syllable) and [sɛnˈter]/[nɛdˈrɔt].

The process of vowel reduction exemplified in (21) interplays with the raising process treated in §7.1. Alternations are observed when a stress-bearing suffix containing a high vowel affects preceding mid-vowels, and thus many mid-low vowels are reduced to mid-high before undergoing raising.

III.4.4. Typical features of Bresciano

Under (22) I report some of the main linguistic characteristics that are specific to Bresciano, and that distinguish it from other EL varieties. Data are derived from Sanga (1979) and Bonfadini (1990).

(22) Linguistic features that distinguish Bresciano from Bergamasco

- a. The Latin cluster CT is reduced to [t] in Bresciano, while it yields [tʃ] in Bergamasco and in Western Lombard dialects:

*[ˈlakte] > [lat] ‘milk’

- b. The intervocalic cluster CL, inherited from Latin, becomes a voiceless affricate [tʃ] in Bresciano, while it results in a voiced affricate in Bergamasco and in other western Lombard varieties.

MAC(U)LA(M) > [ˈmatʃa] ‘stain’ (Bresciano)

MAC(U)LA(M) > [ˈmadʒa] ‘stain’ (Bergamasco/WL)

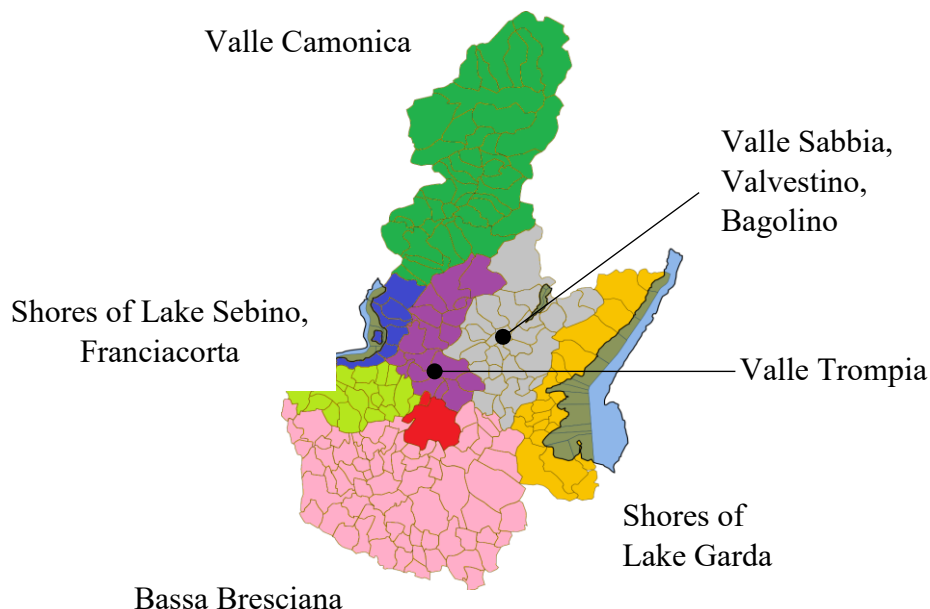
Both a) and b) are traits that Bresciano shares with dialects spoken in the neighboring Veneto region, while Bergamasco displays outcomes that more resemble those of WL, according to Bonfadini (1990).

¹²⁵ Some speakers treated this word as the augmentative form for nɛdra ‘duck’. Others considered it the word for duckling.

- c. Infinitives of verbs of the third group, that in Latin ended in *ĒRE*, end in [-er] in Bresciano, while they end in [i] in Bergamasco.
 BAT(U)ERE > ['bater] 'to beat' (Bresciano)
 BAT(U)ERE > ['bati] 'beat' (Bergamasco)
- d. Verbs conjugated at the first person plural in the present tense end in [-om] in Bresciano. Bergamasco, instead, employs an impersonal form.
 [kan'tom] 'we sing' (Bresciano)
 ['kanta] 'we sing' (Bergamasco)
- e. Bresciano employs the definite masculine article [el], while in Bergamo (as well as in some varieties spoken in the mountainous regions of the administrative province of Brescia) [ol] is employed.
 [el bas'tu] 'the stick' (Bresciano)
 [ol bas'tu] 'the stick' (Bergamasco)
- f. In Bresciano the feminine plural definite article is [le], while in Bergamasco it is [i] (cf. 9h).
 [le fonne] 'the women' (Bresciano)
 [i fonne] 'the women' (Bergamasco)

Within the Area 1 identified in §3.3, the dialects spoken from place to place may vary in some aspects. In the following paragraphs, I describe the specific dialectal varieties spoken in the province of Brescia, which loosely corresponds with Area 1, with the notable exception of the dialect spoken in Valle Camonica, which is treated separately. Most of the observations made below follow the description of varieties of the Bresciano dialect discussed in Bonfadini (1990). Some additional information based on specific dialectological works and dictionaries have been added to Bonfadini's general overview. The image under (23) shows a linguistic division of the administrative province of Brescia.

(23) Traditional division of the administrative province of Brescia.



III.4.4.1 Southern plains (Bassa Bresciana)

Sanga (1979) and Dalpedri (2013) present the characteristics of two varieties spoken in the plains south of the city of Brescia, that of Cigole and of Pavone sul Mella. As already noted by Sanga (1979: 197), the variety of the city center and that of rural areas of the southern lowlands are for the most part identical. The same observation is reported in Bonfadini (1990). Sanga (1979: 197ff) notes the existence of two dialect registers, a rural variety and a more refined one. This second register is, according to Sanga, completely homogeneous with the variety spoken in the main city center. The only differences between the two registers are lexical in nature, and there are rare terms that are unknown to speakers from the city¹²⁶.

As far as the raising vowel harmony is concerned, no differences have been detected between that found in this area and the pattern found in Brescia. Both Sanga (1979) and Dalpedri (2013) present the harmonic pattern in the same way it behaves in Brescia according to my analysis (cf. §7.2).

III.4.4.2. Garda shores

The Garda Lake forms the eastern border of the Brescia province, and is divided between the area of influence of Lombard dialects, on the western shore, and of Venetian dialects on the eastern.

The dialect spoken on the western shore of Lake Garda shows some features that distinguish it from the variety spoken in Brescia. This is to be expected, since this area has been an autonomous territory inside the Venetian Republic for centuries. The main phonological differences between the dialect spoken on the lake shore and the dialect spoken in Brescia are discussed below. Examples are derived from Bonfadini (1990: 54).

- Intervocalic [v] is maintained in dialects of this area, while it is lost in other EL varieties (cf. 9c)
[ava] ‘bee’ (Garda shores) vs. [aa] ‘bee’ (Bresciano)
[pever] ‘pepper’ (Garda shores) vs. [peer] ‘pepper’ (Bresciano)
- Dialects spoken on the shores of the Garda Lake did not developed the vowel system typical of EL varieties. In EL stressed \bar{I} in closed syllable developed as [e]. In the area under scrutiny, the outcome matches that of WL varieties: stressed \bar{I} in closed syllable developed as [i].
CUNĪCLUS > [ku'nitʃ] ‘rabbit’ (Garda shores) vs. [ko'netʃ] ‘rabbit’ (Bresciano)
ERICĪUM > [ˈris] ‘hedgehog’ (Garda shores) vs. [ˈres] ‘hedgehog’ (Bresciano)
- Dialects of this area lost the consonant [t] in final position. The dialect of Brescia, instead, maintained it.
[kan'ta] ‘sung’ (Garda shores) vs. [kan'tat] ‘sung’ (Bresciano)
[skun'di] ‘hidden’ (Garda shores) vs. [skun'dit] ‘hidden’ (Bresciano)
[fi'ga] ‘liver’ (Garda shores) vs. [figat]¹²⁷ ‘liver’ (Bresciano)

¹²⁶ Another possible difference is the treatment of nasal codas, which are maintained in the urban variety of Brescia and fall in rural varieties (cf. 9b). Sanga reports the process as frequent and active in the dialect of Cigole, but I observed an almost complete absence of this trait in the dialect of Brescia. Of course, this may be due to the chronologic distance between the respective fieldwork projects, since Sanga carried out his work around the late seventies, while I performed my data collection in Brescia between 2018 and 2019.

¹²⁷ Some speakers report the form [fidek] for ‘liver’

The northern shore dialects (Bonfadini refers to the dialects of the villages of Limone and Tremosine) maintained the outcome [y] of unstressed \bar{U} in closed syllable, and did not develop the typical Eastern outcome [ø] (cf. 9e).

*'bruttu > ['bryt] 'ugly' (Limone/Tremosine) *'bruttu > ['brøt] 'ugly' (Bresciano)

This suggests that varieties of this area maintained a more conservative dialect that was not affected by the innovation of Brescia and Bergamo. In addition, the loss of final [r] in infinitives, typical of Eastern Lombard dialects did not happen in this restricted area, according to Bonfadini (1990: 55).

[kan'tar] 'to sing' (Limone/Tremosine) vs. [kan'ta] 'to sing' (Bresciano)

In general, the lexicon of varieties spoken of the shores of Lake Garda shows a strong presence of words from neighboring Venetian dialects (cf. Bonfadini 1990: 54).

The raising harmony appears to be present in the dialects spoken in this area at present. Razzi (1984), who wrote a dictionary of the dialect specifically spoken in Salò (one of the main centers of this area), reports the following alternations:

[bi'røtʃ] 'two wheel gig' [biru'tʃi] 'two wheel gig DIM.'

[bor'sa] 'bag' [bur'si] 'bag DIM.'

[ka'sa] 'box' [kasi'tu] 'box AUG.'

[furmin'tu] 'rye flour' [for'ment] 'wheat'

['nebjɑ] 'fog' [ni'bjʊ] 'fog AUG.'

['peten] 'comb' [pitini'na] 'comb DIM.'

The alternations reported are consistent with the application of the process of RVH as it applies in Brescia (cf. §7.2). Pre-tonic mid-vowels raise to high when followed by a stressed high vowel. Still, some lexical exceptions are found in the dictionary: e.g. [bene'di] 'to bless', [pe'ru] 'fork'.

III.4.4.3. Valle Sabbia, Valvestino, Bagolino

The mountainous area that surrounds the small basin of Lake Idro (which corresponds to the area in gray in the image in 23) is fairly isolated from the rest of the province, and thus dialects spoken in this area display some peculiarities.

In the northern part of Valle Sabbia are encountered some of the features already discussed for some varieties of the Garda area. Bonfadini (1990: 56) notices that many varieties of the area are nowadays very similar to the dialect spoken in Brescia. A few features differentiate the varieties spoken in the valley bottom from the one spoken in Brescia (final [t] is lost in dialects spoken in this area, while it is maintained in Bresciano, intervocalic [v] is maintained in dialects of this area, while it is lost in Bresciano)

Dialects of this area show the presence of [e] derived from Latin ATUS-I. Compare the examples below.

*ex cappati > [ska'pe] 'escaped PL' (Valle Sabbia) vs. [ska'patʃ] 'escaped PL' (Bresciano)

PRĀTI > ['pre] 'meadows' (Valle Sabbia) vs. ['pratʃ] 'meadows' (Bresciano)

NĀTI > ['ne] 'born PL' (Valle Sabbia) vs. ['natʃ] 'born PL' (Bresciano)

According to Bonfadini (1990: 57) dialects spoken in the areas of Bagolino and Valle Caffaro, which are more isolated, show unique features in regards to other Eastern varieties. "Bagosso" (the dialect of Bagolino) displays typical Eastern Lombard features (fall of [v], loss of coda nasals and lowering of \bar{I} and \bar{U} in closed syllables, typical of Eastern varieties, discussed in (9e) alongside conservative features typical of Alpine Lombard as well as unique developments, listed below.

- The Latin clusters C+L are maintained in Bagosso, while in Bresciano they are not. This feature is more common in Alpine dialects, which are generally more conservative.
GLACEU(M) > ['glastʃ] 'ice' (Bagosso) vs. ['dʒas] 'ice' (Bresciano)
*PLUVERE ['plover] 'to rain' (Bagosso) vs. ['pjøer] 'to rain' (Bresciano)
- Velar stops [k] and [g] palatalized before front rounded vowels [y] and [ø].
[en'tʃø] 'today' (Bagosso) vs. [enkøj] 'today' (Bresciano)
[tʃyl] 'ass' (Bagosso) vs. [kyl] 'ass' (Bresciano)

To assert the presence of the raising harmony in those areas I consulted two different dictionaries: Bonomi (1995), which covers the dialect spoken in the Valle Sabbia, and Bazzani-Melzani (1988), which describes the dialect of Bagolino.

In Bonomi (1995) are reported a few forms that allow us to hypothesize that raising is not active in Valle Sabbia.

- [bajo'flu] 'braggart'
- [kode'gi] 'kind of sausage' (Valle Sabbia) vs. [kudi'gi] 'kind of sausage' (Bresciano)
- [løzer'du] 'lizard AUG.' (Valle Sabbia) vs. [lyzir'tu] 'lizard AUG' (Bresciano)
- [oze'li] 'bird DIM.' (Valle Sabbia) vs. [uzi'li] 'bird DIM' (Bresciano)

The forms reported in Bonomi (1995) suggest that the harmonic process is not active in the dialect spoken in Valle Sabbia.

For what concerns the dialect spoken in Bagolino, the situation is less clear. This area is rather isolated from the rest of the region, and isolation helped the Bagosso dialect preserve some features that are absent in neighboring varieties. In Bazzani-Melzani (1988) many words that do not adhere to the harmonic pattern are reported:

- [formen'tu] 'buckwheat'
- [frøs'ku] 'cool AUG.'
- [lø'mi] 'wick DIM.'
- [løzer'tu] 'lyzard AUG.'
- [negol'ti] 'a little nothing'

However, there are cases in which the vocabulary displays a "double entry":

- [mon'tu]-[mun'tu] 'mutton'
- [malmos'tus]-[malmus'tus] 'angry'
- [por'tu]-[pur'tu] 'door AUG.'

More studies would be needed to define the fine-grained differences between the dialect of this section of Eastern Lombardy and Bresciano.

III.4.4.4. Valle Trompia

Valle Trompia consists of the valleys of the river Mella and its tributaries, north of the city of Brescia. Bonfadini (1990: 58) notices that nowadays the dialects of the lower part of the valley tend to conform to the dialect spoken in Brescia

Typical of Lumezzane (the main center of the area) and neighboring villages is the process that turned *[s] and *[z] into [h] and [ð] respectively (cf. 9d). Bonfadini (1990: 60) reports that some varieties spoken in the mountains display certain conservative features already mentioned in the previous section (the aforementioned conservation of CL Latin clusters is found in varieties of this area, together with the outcome [e] for Latin ĀTUS-I, already shown in varieties of Valle Sabbia).

Ferrari (2007) and Loporcaro (2015) report the survival of contrastive vowel length in dialects of this area (cf. 9a).

Regarding the raising harmonic pattern, the dictionary written by Seneci (2004) about the dialect of Lumezzane reports some alternating forms such as ['boka] 'mouth', [bu'ku] 'mouthful', [kudi'gi] 'kind of sausage' but [formen'tu] 'buckwheat' *[furmin'tu], which may indicate the presence of a symmetric raising pattern similar to the one of Brescia.

III.4.4.5. Franciacorta and Sebino shores

In the western area of the province of Brescia the variety spoken closely resembles the urban dialect. Marked Bergamasco features are generally absent from this area, and the only evident difference between the variety of Brescia and that of Franciacorta and of the shores of Lake Sebino is the fact that in those latter varieties, the sound change involving debuccalization/weakening of /s,z/ took place (cf. 9d). I anticipate here that this same situation is reported also for the area west of Lake Sebino, within the Bergamo administrative province, but exhibiting a dialect more similar to Bresciano than to Bergamasco (Bonfadini 1987b).

III.5 Specific phonological traits of Bergamasco

In this section is described in detail the dialect spoken in the second largest city of Eastern Lombardy, Bergamo. I will focus primarily on properties that are typical of the dialect of Bergamo and neighboring varieties, and that are absent in Bresciano, so that the differences between the two main representatives of EL dialects can be compared. In §5.1 I treat the vowel system of Bergamasco in stressed position, while §5.2 treats the system of unstressed pre-tonic vowels. In §5.4 dialectal micro-variation within the province of Bergamo is discussed, similarly to §4.4 for the administrative province of Brescia.

III.5.1 Vowel system of Bergamasco in stressed position

The vowel system of Bergamasco for the most part conforms to the observations made in §4.1 regarding the dialect of Brescia. Still, some minimal differences between the vowel system of Bergamasco and the system of Bresciano can be identified. Table (24) displays the general development of vowels in stressed open position from Latin to Bergamasco, while (25) provides some examples.

(24) Bergamasco Stressed vowels in Open syllables

LATIN	Ī	Ī	Ē	Ĕ	Ā	Ă	Ō	Ō	Ū	Ū
Proto-Romance	i	e	ε	a	ɔ	o	u			
Bergamasco	i	i/e	e	a	ø	u	y			

(25) Vowels in stressed open syllables in the dialect of Bergamo.

	Latin	Proto-Romance	Bergamasco		
FORMICA(M)	i:	i	i	fyr'miga	'ant'
NIVE(M)	i	e	i	'nif	'snow'
PILUS	i	e	e	'pel	'hair'

DECE(M)	e	ɛ	e	'des	'ten'
TELA(M)	e:	e	i	'tila	'canvas'
MĀLE(M)	a	a	a	'mal	'evil n.'
PRĀTU(M)	a:	a	a	'prat	'field'
FŌCU(M)	o	ɔ	ø	'føk	'fire'
RŌTA(M)	o	ɔ	ø	'røda	'wheel'
BŌNU(M)	o/_n	ɔ	u	'bu	'good M.'
HŌMINE(M)	o/_m	ɔ	ɔ	'ɔm	'man'
STŌMACU(M)	o/_m	ɔ	ɔ	'stɔmɛk	'stomach'
NEPŌTE(M)	o:	o	u	'neut	'nephew'
CRUCE(M)	u	o	u	'krus	'cross'
MURU(M)	u:	u	y	'myr	'wall'
FŪMU(M)	u:/_N	u	ø	'føm	'smoke'
CA(P)UT	au		o	'ko	'head'
FAENU(M)	ae	e	e	'fe	'hay'
AD POENA	oe	e	e	a'pena	'at most'

Proto-Romance [ɔ] developed as [ø] in all positions when it was not followed by a nasal. When followed by [n], it developed as [u] (e.g. BŌNU(M) > ['bu]), and when followed by [m] it remained [ɔ]. As in Brescia, Latin Ō and Ū became [ø] when followed by [m]. This appears to be a shared property of the vowel system of Bresciano and Bergamasco. The presence of nasal consonants affected the development of rounded vowels.

In Sanga (1987), the evolution of Latin short Ī and long Ē is considered to be uniquely [i]. This is considered by the author as one of the main differences between the vowel system of Bresciano and Bergamasco. However, forms in which a mid-vowel [e] derived from short Ī and long Ē are rather common in the dialect of Bergamo. This variation may be due to the general Italianization of the dialect: an original [i] is substituted by [e] under the effect of the Italian lexicon. Let us now look at tonic vowels in closed syllables, shown in (26) and (27).

(26) Bergamasco stressed vowels in closed syllable

LATIN	Ī	Ī	Ē	Ē	Ā	Ā	Ō	Ō	Ū	Ū
Proto-Romance	i	e	ɛ	a	ɔ	o	u			
Closed Syllable	e	ɛ	a	ɔ	o	ø				

(27) Vowels in stressed closed syllables in the dialect of Bergamo

	Latin	Proto-Romance	Bergamasco		
FĪXU(M)	i:	i	e	'fes	'a lot'

LIGNU(M)	i	e	ɛ	'lɛŋ	'wood'
CAPILLU(M)	i	e	ɛ	ka'ɛl	'hair'
TECTU(M)	e:	e	ɛ	'tɛt	'roof'
FERRU(M)	e	ɛ	ɛ	'fɛr	'iron'
DAMNU(M)	a	a	a	'dan	'damage'
ALTERU(M)	a/l	a	o	olter	'other'
NAVIS	a:	a	a	'naf	'ship'
FORTIA(M)	o/_r	ɔ	o	'fort	'dead'
SOMNU(M)	o	ɔ	ɔ	'sɔŋ	'dream'
COSTA(M)	o	ɔ	ɔ	'kɔsta	'rib'
COGNOSCO	o:	o	o	ko'nose	'I know'
ORDINE(M)	o:/_r	o	u	'urden	'order'
PEDUCULUS	u	o/_Palatal C	ø	pi'øtʃ	'louse'
GUTTA(M)	u	o	o	'gota	'fly'
*bruttus	u:	u	ø	'brøt	'ugly'

As in Bresciano, [a] followed by [l] in a closed syllable often developed as [o]: e.g. ALTERU(M) > [olter]-[oter]. Other deviations from the general schema are the outcomes of Ō, Ū and Ū when followed by [r]: o/_r developed as [o], o/_r developed as [u]: (FORTIA(M) > [fort] ORDINE(M) > [urden]). When the Proto-Romance [o] is followed by a palatal consonant (tʃ, dʒ) it surfaces as [ø] (PEDUCULUS > piøtʃ). All of those aspects are identical to what we already discussed for Bresciano.

III.5.2 Vowel system of Bergamasco in unstressed position

As for Bresciano, I focus primarily on pre-tonic vowels, which are relevant for the process of raising vowel harmony. Regarding post-tonic vowels, I simply repeat the general observation made about Bresciano in §4.2, since they apply perfectly also to Bergamasco. Final vowels other than [a] are not allowed in final position, except for the feminine plural [e] and in some Italianisms, where the masculine suffix [-o] and the masculine plural [-i] are found. Those forms are not originally dialectal, and are the result of the influence of Italian over the dialect.

The system of pre-tonic vowels of Bergamasco deserves a specific description, both for the differences between it and the system of Bresciano, and for the description of it by Sanga (1987). As it will be clear below, his claims about the vocalic system in pre-tonic position deserve to be challenged. Before dealing with that, consider the descriptive facts in the table (28) below.

(28) Vowel system of Bergamasco in unstressed pre-tonic position.

LATIN	Ī	Ī̃	Ē	Ē̃	Ā	Ā̃	Ō	Ō̃	Ū	Ū̃
Proto-Romance	i		e		a		o			U
Open Syllable	i/e		e		a		o			∅
Closed Syllable	i/ε		ε		a		o			∅

(29) Vowels in unstressed pre-tonic syllables in the dialect of Bergamo.

	Latin	Proto-Romance	Bergamasco		
VĪCĪNUS	i:	i	i	vi'si	'close'
VĪNDĒMIA(M)	i	e	ε [_CC]	en'demja	'peach'
VĪTELLU(M)	i	e	e [_CV]	ve'del	'calf'
NĒC GŪTTA(M)	e	e	e	ne'got	'nothing'
BĀSIĀRE	a	a	a	ba'za	'to kiss'
*rosiata	o	o	o	ro'zadɔ	'dew'
EXFŌLIARE	o	o	o	sfo'ja	'unwrap'
FURNĀRIU(M)	u	o	o	for'ner	'baker'
*lucertam	u	u	∅	lɔ'zerta	'lyzard'
CŪRARE	u	u	y	ky'ra	'to cure'

According to Sanga (1987), the vowel phonemes of Bergamasco in unstressed position are [a] [e] [o] [∅]. In his opinion, occurrences of high vowels in unstressed position are only due to the process of RVH, which we focus on in §7.3. While considering the evolution of unstressed long Ī, Sanga considers [e] to be the regular outcome, even though he recognizes that in many cases [i] is attested and phonologized. The reason for the phonologization of the process are, according to the author, the harmonic pattern of raising vowel harmony on one side and the influence of alternations between rhizotonic and arhizotonic forms such as ['fila] '(he)spins' [fi'la] 'to spin'. Regardless of the original outcome of Latin long unstressed Ī, in the modern dialect of Bergamasco, [i] appears to be the most common outcome for unstressed long Ī, even when the following vowel is not high (i.e. in contexts where raising is not expected): [pi'ka] 'to beat'; [sim'patek] 'funny', [bi'tfer] 'glass', [mi'ola] 'marrow', [despi'rat] 'desperate', [dispia'ser] 'displeasure'. In my opinion, since forms in which unstressed [i] appear to be lexical, both high and mid vowels are to be considered possible in pre-tonic position in Bergamasco.

III.5.3. Synchronic vowel system of Bergamasco

From the discussion under (29), we can conclude that the vowel system of Bergamasco strongly resembles that of Bresciano. Consider the table in (30), that reports the general vowel system of Bergamasco.

(30) Vowels of Bergamasco

	<i>Front</i>		<i>Back</i>	
	<i>non-round</i>	<i>Round</i>	<i>non-round</i>	<i>round</i>
<i>High</i>	i	y		u
<i>Mid-high</i>	e	ø		o
<i>Mid-low</i>	ɛ			ɔ
<i>Low</i>			a	

All nine vowels in (30) appear in stressed position, while the presence of mid-low vowels is limited in unstressed position. The rounded mid-low vowel [ɔ] never appears in unstressed position, while the data that will be discussed in §7.3 suggest that, similarly to Bresciano, Bergamasco exhibits a process of vowel reduction whereby stressed mid-low vowels reduce to mid-high when they become unstressed.

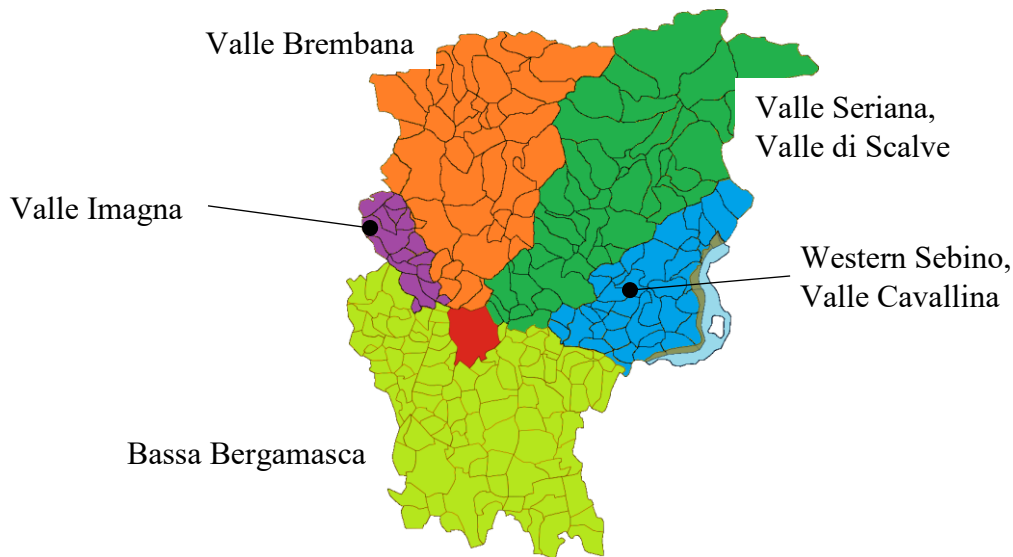
This process is evident from couplets such as [pa'dɛla] 'pan' [pade'lina] 'pan DIM'. The mid-low vowel in stressed position undergoes vowel reduction when it passes from a stressed to an unstressed position.

Differently from other EL varieties, non-rounded mid vowels surface as mid even when followed by a stressed high vowel, since they are not affected by the process of raising harmony.

III.5.4 Typical features of Bergamasco and its neighboring varieties

The main differences between Bresciano and Bergamasco are covered in §4.4. Data on Bergamasco and all the EL spoken within the borders of its administrative region come from the collection of articles published under the direction of Sanga in 1987, under the title *Lingua e dialetto di Bergamo e delle valli* (Language and dialect of Bergamo and neighboring valleys). Following the information reported in the book, I present the main differences in the phonological systems of rural varieties and the dialect of Bergamo.

(31) Traditional division of the administrative province of Bergamo.



III.5.4.1 Valle Seriana and Valle Gandino

Data from this area are derived from Agazzi (1987: 153ff) and Bernini (1987: 216ff). In the lower part of the Seriana valley the most noticeable difference from the variety of Bergamo is the sound change *s > [h], unless preceded by a consonant:

- ['kalsa] 'sock' *[kalha]
- [hu'ni] 'pig' vs. [su'ni] (Bergamasco)

The process is particularly evident in sandhi:

- [hu'ni] 'pig'; [ol su'ni] 'the pig'

In the mid and high part of the Valle Seriana the alveolar fricatives [s] and [z] are found instead of the debuccalized [h] and [ð], evidence that the phonetic change did not affect the varieties in the higher parts of the valley.

Varieties spoken in the mid part of the Valle Seriana and in Valle Gandino (a tributary valley of the Seriana valley¹²⁸), show some trace of contrastive length, which is normally absent in EL dialects, while still present in WL and in some Alpine varieties (2a).

Bernini (1987: 216) notes the presence of two distinctive long vowels, [a:] and [ø:], which contrast with short vowels in a handful of minimal pairs:

- [na:s] 'he is being born', [nas] 'nose',
- [pa:s] 'peace', [pas] 'step',
- [tø:t] 'taken', [tøt] 'all',
- [lø:s] 'unflavored', [l øs] 'the doorstep'.

A peculiarity of dialects of the Gandino valley is the fact that in some villages the contrast between mid-high vowels and mid-low vowels is lost in stressed position preceding a rC cluster. The same thing also happens (only when the mid-vowel is front) in NC clusters¹²⁹. The outcome is a mid-low vowel in

¹²⁸ A map of the Gandino valley is provided in §7.3.

¹²⁹ r=rhotic [r], N= any nasal, C=Consonant.

the villages of Gazzaniga (GZ) and Vertova (VE), while it is a mid-high vowel in Lefte (LE) Gandino (GN) Casnigo (CA).

- a ['bergem] ‘Bergamo’ [ser'pɛnt] ‘snake’ ['ort] ‘vegetable garden’ . (GZ, VE).
- b [''bergem] ‘Bergamo’ [ser'pɛnt] ‘snake’ ['ɔrt] ‘vegetable garden’ . (LE, GN, CA).
- c ['bergem] ‘Bergamo’ [ser'pɛnt] ‘snake’ ['ort] ‘vegetable garden’ . (Bergamo and other EL varieties).

Consider that in closed syllables only [ɛ] is expected in “regular” EL dialects (cf. 7) while on the contrary [o] is the expected form when a rounded mid-vowel precedes an rC cluster.

Within the same area, the central part of the Seriana valley and its tributary Gandino valley, Raising Vowel Harmony exhibits some peculiar behaviors, covered in more depth in §7.3.

III.5.4.2 Val Cavallina

Data for this area are derived from Bonfadini (1987). In this valley, as in most rural varieties of the Bergamo province, we observe the pair [h]-[ð] results from the sound change discussed above in (9d).

Here some traces of distinctive vowel length remain in the difference between long and short [a] in original long and closed syllables

- [nah] ‘he is being born’ [na:h] ‘nose’
- [kar] ‘car’ [ka:r] ‘dear’.

Regarding the behavior of RVH in dialects of this area, Bonfadini describes a pattern similar to that of Brescia, in which all unstressed mid vowels are subject to raising (Bonfadini 1987: 347ff). He observes many exceptions when the target of the process is [e], suggesting that /o/ is a preferable target for harmony. However, the process is still attested for all mid vowels, as shown in the examples below.

- ['godʒa] ‘needle’ [u'dʒi] ‘needle DIM’
- ['boka] ‘mouth’, [bu'ku] ‘a mouthful’
- ['pegra] ‘sheep’, [pi'gri] ‘lamb’
- [strea] ‘witch’, [stri'u] ‘sorcerer’. *accento su strea per far sapere se è iato o monosillabo*

III.5.4.3 Valle Imagna

The dialect spoken in this area (Bonfadini 1987c) displays a particular distribution of the front non-round vowels and the presence of coronal fricatives not present in other Lombard dialects:

- a Where in Bergamo we observe [i] as the reflex of Latin Ē, Ī in open syllable, here [i] is also the reflex for Ě in open syllable and in final position.

- ['mil] < MĚL
- ['dis] < DĚCE(M) ‘ten’
- ['pigora] < PĚCORAM ‘sheep’
- [dri] < ‘behind’ DE RĚTRO (in Bergamo [pegora] and [dre] are found).

- b In the lowest part of the valley, there is a system in which alveolar fricatives [s] and [z] contrast with interdental fricatives [θ] and [ð], reflexes of Latin clusters CL > θ, GL > ð¹³⁰.

The RVH process is synchronically active, and affects all mid vowels, even though many exceptions are found. Some alternations are shown below.

¹³⁰ Bonfadini (1987c: 439-466) describes in detail the dental/alveolar fricatives of Valle Imagna. The outcome of Latin CL and GL varies in different part of the lower Imagna Valley. He uses the symbols $\text{z} \neq$ for “strong dental fricatives” and th (often pronounced as post-dental approximants $\text{t} \text{ } \text{d}$) for interdental fricatives.

[reθ] ‘hedgehog’, [rispur'ki] ‘porcupine’
 ['tʃona] ‘sow’, [tʃu'ni] ‘pig’
 [strea] ‘witch’, [stri'u] ‘sorcerer’

This suggests that harmony in this area applies to all mid vowels, as in Bresciano, and not only to round vowels as in Bergamasco (cf. §7.3).

III.5.4.4 Valle Brembana and Bergamo low lands (*Bassa bergamasca*)

The dialect of Valle Brembana is similar to the variety spoken in Bergamo. The only relevant difference is the aforementioned sound change *s>[h] and *z>[ð] in the lower part of the valley, which is absent in the urban variety.

About the dialect spoken in the low lands, Massariello Merzagora (1998) notes the fall of final [t] in the variety of Treviglio (one of the main centers of this area), which is instead maintained in most EL varieties. Additionally, it appears that the development of stressed Ū and Ī in closed syllables typical of EL dialects is absent from the variety of Treviglio, making its vowel system more similar to that of WL varieties.

III.5.4.5 Western shores of Sebino

As previously mentioned in §4.4.5, the dialectal variety spoken in this area is rather homogeneous to that spoken in the western side of the province of Brescia. The vowel system of the shores of Lake Sebino is reported to be identical that of Bresciano. The harmonic pattern is reported also by Bonfadini (1987b) to behave as it does in Brescia.

III.6 The Phonology of Camuno

The Camuno dialect is the EL dialect spoken in what was identified as Area 3 in §3.3. Geographically, this linguistic area corresponds with Valle Camonica, one of the largest valleys of the central Alps. Almost the entire valley is included in the administrative territory of the province of Brescia, except for a small south-western portion (comprising Lovere, Rogno, Costa Volpino and the area of Val di Scalve) which belong to the province of Bergamo. From a linguistic standpoint, the dialects of the valley displays some properties that are typical of Bresciano and other Area 1 dialects, and others that are more common in Bergamasco and Area 2 dialects.

III.6.1 Vowel system of Camuno in stressed syllables

The first relevant aspect of the phonology of Camuno concerns the vowel system of Camuno. The tables in (32) and (34) summarize the evolution of the vowel system from Latin to modern Camuno in open syllables and in closed syllables respectively.

(32) Vowel system of Camuno: Stressed vowels in Open syllables.

LATIN	Ī	Ī	Ē	Ĕ	Ā	Ă	Ŏ	Ō	Ū	Ū
Proto-Romance	i	e		ɛ	a		ɔ	o		u
Open Syllable	i	e			a		ø	u		y

(33) Vowels in stressed open syllables in the dialect of Valle Camonica (examples for this and following tables concerning Camuno are taken from Cresci 2014).

	Latin	Proto-Romance	Camuno		
FĪLU(M)	i:	i	i	'fil	'yard'
NĪVE(M)	i	e	e	'nef	'snow'
DĒCE(M)	e	ɛ	e	'deh	'ten'
ACĒTU(M)	e:	e	e	a'zet	'vinegar'
LĀCU(M)	a	a	a	'lak	'lake'
AMĀRU(M)	a:	a	a	a'mar	'bitter'
NŌVU(M)	o	ɔ	ø	'nøf	'new'
ŌVU(M)	o	ɔ	ø	'øf	'egg'
SŌNAT	o/_n	ɔ	u	'hunɔ	'it sounds'
STŌMĀCU(M)	o/_m	ɔ	ɔ	'htɔmɛk	'stomach'
SŌLE(M)	o:	o	u	'hul	'sun'
CRŪCE(M)	u	o	u	'kruh	'cross'
LŪCE(M)	u:	u	y	'lys	'light'
PAUCUS	au	ɔ	o	'pok	'a bit'
FAĒNU(M)	ae	e	e	'fe	'hay'
AD PŌENA	oe	e	e	a'penɔ	'at most'

(34) Vowel system of Camuno: Stressed vowels in closed syllables

LATIN	Ī	Ī	Ē	Ĕ	Ā	Ă	Ō	Ō	Ū	Ū
Proto-Romance	i	e	ɛ	a	ɔ	o	u			
Closed Syllable	i	ɛ	a	ɔ	o	y				

(35) Vowels in stressed closed syllables in the dialect of Valle Camonica

	Latin	Proto-Romance	Camuno		
*cun <u>i</u> clus	i:	i	i	ku'nitʃ	'rabbit'
CAP <u>i</u> LLU(M)	i	e	ɛ	ka'ɛl	'hair'
ST <u>e</u> LLA(M)	e:	e	ɛ	htɛlɔ	'star'
V <u>i</u> T <u>e</u> LLU(M)	e	ɛ	ɛ	e'dɛl	'calf'
D <u>a</u> MNU(M)	a	a	a	'dan	'damage'
N <u>a</u> VIS	a:	a	a	'naf	'ship'
C <u>o</u> RPU <u>s</u>	o/_r	ɔ	o	'korp	'body'
<u>o</u> CTO	o	ɔ	ɔ	'ɔt	'eight'
P <u>o</u> NTE(M)	o/_n	ɔ	u	'put	'bridge'
*t <u>o</u> rta	o:/_r	o	u	turtɔ	'kake'
M <u>u</u> SCA(M)	u	o	o	'moskɔ	'fly'
FR <u>u</u> CTU(M)	u:	u	y	'fryt	'fruit'

As already noted for Bresciano and Bergamasco, Proto-Romance [ɔ] and [o] have a different outcome in a closed syllable when followed by [r] or [l]: CORPUS > ['korp]; *torta > ['turta].

The Camuno vowel system in stressed syllables displays some differences from that of other EL varieties, since it does not display the evolution of long high vowels in closed syllables: we encounter $\bar{I} > i$ and $\bar{U} > y$ in both open and closed syllables (cf. 9e). The vowel system of Camuno is, at least in regards to this aspect, more similar to the vowel system of Milanese and other Western and Alpine Lombard dialects.

*'bruttu > [bryt] 'ugly' (Camuno) vs. [brɔt] 'ugly' (Bresciano)
 FRŪCTŪS > [fryt] 'fruit' (Camuno) vs. [frɔt] 'fruit' (Bresciano)
 [ist] 'seen' (Camuno) vs. [est] 'seen' (Bresciano)

This may suggest that Camuno should not be considered an EL variety at all, but instead a western variety (like dialects spoken in Val Tellina, just north of Valle Camonica) or an Alpine dialect. While an argument for such a classification could be made, the placement of Camuno in the group of eastern dialects is justified by the presence of numerous typically eastern properties.

Such properties are the loss of [v] in intervocalic position (cf. 9c), the loss of [n] in internal coda (cf. 9b) and the sound change that turned *s>[h] discussed in (9d), which is pervasive in the southern portion of the valley. All those features are typical of dialects of Eastern Lombardy, and are absent from dialects that belong to the Alpine group or to the Western group. Among the properties that Camuno shares with Eastern Lombard dialects and especially relevant for our purposes, is the presence of a raising vowel harmony that affects pre-tonic mid-vowels. The harmonic pattern of Camuno, which is the main focus of the chapter, is treated in §7.4.

III.6.2 Vowel system of Camuno in unstressed syllables

Tables (36) and (37) show the general evolution of vowels in pre-tonic position in Camuno. As discussed at length in §4.2 and §5.2 while presenting the distribution of unstressed vowels in Bresciano

and Bergamasco respectively, post-tonic vowels are rather exceptional in Lombard dialects, due to the process of final vowel apocope (cf. 2j). Final /a/ (which surfaces as [ɔ], cf. Cresci 2015: 47) and [e], which marks the plural feminine suffix, are the expected unstressed vowels in final position. Occurrences of [o] and [i] may derive from Italian borrowings. The distribution of mid-low vowels in pre-and post-tonic position is discussed below.

(36) Pre-tonic vowels of Camuno.

LATIN	Ī	Ī̃	Ē	Ē̃	Ā	Ā̃	Ō	Ō̃	Ū	Ū̃
Proto-Romance	i	e		a		o			u	
Open Syllable	i	e		a		o			y	
Closed Syllable	i	ɛ		a		o			y	

(37) Vowels in pre-tonic positions in the dialect of Valle Camonica.

	Latin	Proto-Romance	Camuno		
FĪLĀRE	i:	i	i	fi'la	'to spin'
VĪNDĒMIA(M)	i	e	ɛ [_CC]	ɛn'demjɔ	'grape harvest'
VĪTĒLLU(M)	i	e	e [_CV]	e'dɛl	'calf'
BĀSIĀRE	a:	a	a	ba'za	'to kiss'
RŌRĀRE	o:	o	o	ro'zadɔ	'dew'
PŌRCĒLLU(M)	o	o	o	por'sɛl	'pig'
*lucerta(m)	u	u	y	ly'zertɔ	'lyzard'
CŪRĀRE	u:	u	y	ky'ra	'to cure'

Unstressed [ɛ] is allowed in closed syllables (Cresci 2015: 47). The distribution of front mid-low vowels is predictable: mid-high vowels occur in open syllables, mid-low vowels in closed syllables.

There are no extreme differences between the pre-tonic vowel system of Camuno and that of Bresciano and Bergamasco. The only noticeable difference is in the absence of front rounded mid vowels in pre-tonic position. While in Bresciano and Bergamasco the distribution of [ø/y] in pre-tonic position is somewhat erratic (cf. §4.2), in Camuno only [y] is reported in this position.

As in Bresciano and Bergamasco: an epenthetic [ɛ] vowel is inserted between two consonants in order to avoid a cluster at the end of the word, as noted by Cresci (2014: 46).

The outcome of [a] in final position deserves to be mentioned. Cresci reports the pronunciation of this vowel as a back round mid vowel [ɔ], while my direct observations during my second fieldwork project (discussed below in §7.2) suggests that this final vowel is more similar to a back low vowel [ɑ]. Most of the examples reported in this section are taken from Cresci (2014), and thus exhibit [ɔ] as the final vowel.

Cresci (2014: 49) suggests that /ø/ normally appears if stressed, but she also notices that there are occasions where it surfaces also in unstressed position.

Regarding RVH, Camuno exhibits a parasitic pattern. Front unround high vowels behave as universal triggers, raising all preceding unstressed mid vowels. Round high vowels, on the contrary, affect only preceding round vowels.

III.6.3 Synchronic vowel system of Camuno:

In synchrony the vowel system of Camuno displays more or less the same properties discussed in §4.3 and §5.3 about the vowel systems of Bresciano and Bergamasco. The vowel system reported in (38) is identical to those already discussed in the previous sections concerning the other two varieties.

(38) Vowels of Camuno

	<i>Front</i>		<i>Back</i>	
	<i>non-round</i>	<i>Round</i>	<i>non-round</i>	<i>round</i>
<i>High</i>	i	y		u
<i>Mid-high</i>	e	ø		o
<i>Mid-low</i>	ɛ			ɔ
<i>Low</i>			a	

All nine vowels are expected in stressed position. For what concerns the unstressed position, mid-low vowels alternate with mid-high vowels when passing from a stressed to an unstressed position (in open syllable). This corresponds to the same process of vowel reduction active in Bresciano and Bergamasco, whereby mid-low vowels alternate with mid-high vowels (cf. §4.3 and §5.3). This gives rise to alternations such as the following, where the addition of a stress-bearing suffix affects the pre-tonic mid-low vowels, which now appears in open pre-tonic syllable and is thus pronounced as mid-high.

- [pi'tokol] 'beggar' [pito'ka] 'to beg' * [pito'ka]. ɔ > o
 [be'rɛt] 'cap' [bere'tu] 'cap AUG' * [bere'tu]. ɛ > e
 ['hɛk] 'dry [hekat] 'dried' * [hɛ'kat]. ɛ > e

Besides the process of raising discussed in §7.4, this is the only active synchronic phonological process that concerns vowels.

While in other EL dialects /ø/ appears in both stressed and unstressed contexts, Cresci started her fieldwork under the impression that ø appears only in stressed position in Camuno, but later found out that there are traces of it in unstressed position, cf. Cresci (2014: 49), §7.7. Some minimal pairs certify the contrastive role of /ø/, for instance:

- ['møɫɔ 'grindstone' vs. ['myɫɔ] 'mule F'
 ['høɫ] 'attic' ['hul] 'sun
 ['øt] 'empty' vs. ['bot] 'barrel'
 ['køɾ] 'heart' ['koreɳ] 'horn'
 [øɫ] 's/he wants' ['or] 'gold'
 ['øt] 'empty' vs. ['ɔt] 'eight'

III.6.4 Dialectal variation in Valle Camonica

Bonfadini (1990:60-65) proposes a division of the Camonica Valley into two parts, the Lower and mid valley and the Upper valley, based on some characteristic evolutionary traits. The division is shown in the map under (39).

Dialects spoken in the lower part of the valley display some traits typical of Bergamasco mixed with some innovations more typical of Bresciano.

Some dialects spoken in the upper part of the valley show some conservative features, typical of Alpine Lombard dialects. This division does not influence the harmonic pattern, which according to Cresci (and my own observations, cf. §7.5) is the same throughout the valley. The division between upper and lower varieties runs close to the villages of Berzo Demo and Malonno. The division of the valley in two sections is useful from a classificatory standpoint, but it should be noted that the Camuno dialect is sufficiently uniform to be considered as one variety of Eastern Lombard. The division reflects some minor variations that are often typical of single villages.

(39) Upper and Lower Valle Camonica:



The lower part of the valley displays some features that are typical of the dialect spoken in Bergamo, while others are more typical of Bresciano. The presence of linguistic properties common to Bergamo alongside properties of Brescia reflects the geographic position of the valley, which is equally far from Bergamo and Brescia. The list under (40) presents the main properties of the dialect spoken in the lower part of the valley, as well as some specific traits of isolated areas.

(40) Lower Valle Camonica: specific features

- a The outcome of clusters CL > [dʒ], which is a feature typical of dialects spoken in the vicinity of Bergamo (cf. 22b, Bonfadini 1990: 61):
AURĪC(Ū)LA > [oredʒɔ] ‘ear’ (Camuno) vs. [oretʃa] ‘ear’ (Bresciano)
- b The first person plural of the present indicative is conjugated as in Bergamo, with an impersonal form (Bonfadini 1990: 61).
[an 'kantɔ] ‘we sing’ (Camuno) vs. [kan'tom] ‘we sing’ (Bresciano)
- c The masculine definite article is [el], as in Bresciano, while in Bergamasco is [ol]¹³¹
[el bahtu] ‘the stick’ (Camuno) vs. [ol bastu] ‘the stick’ (Bergamasco)
- d The outcome of cluster CT > [t] (cf. 22a)
LACTEM > [lat] ‘milk’ (Camuno) vs. [latʃ] ‘milk’ (Bergamasco)
- e In addition, a typical feature of this part of the valley is the aforementioned sound change *s>[h], *z> [ð]¹³², which is shared by some rural dialects between Brescia and Bergamo (cf. 9d).
[hɛk] ‘dry’ (Camuno) vs. [sɛk] ‘dry’ (Bresciano)
[hkɔlɔ] ‘school’ (Camuno) vs. [skɔlɔ] ‘school’ (Bresciano)
[lɛn'hɔl] ‘bed sheet’ (Camuno) vs. [lɛnsɔl] ‘bed sheet’ (Bresciano)
[hɛn'tɛr] ‘mountain trail’ (Camuno) vs. [sɛn'tɛr] ‘mountain trail’ (Bresciano)

Within this section of the valley, single villages may display some peculiarities. Bonfadini (1990: 60ff) described in detail the various dialectal properties of various villages situated in the southern part of the valley, and noted the following features listed in (41)

(41) Linguistic peculiarities in isolated varieties of Lower Valle Camonica

- a The peripheral villages of Pescarzo, Cimbergo and Paspardo maintain the Consonant+L clusters, which is a trait shared with more conservative AL dialects.
[ˈflamɔ] ‘flame’ (Pescarzo) vs. [ˈfjamɔ] ‘flame’ (Camuno/Bresciano)
[ˈplɔf] ‘it rains’ (Pescarzo) vs. [ˈpjɔf] ‘it rains’ (Camuno/Bresciano).
- b Initial [f] > [h] in the village of Borno and surrounding areas
FARINA(M) > [ha'rinɔ] ‘flour’ (Borno) vs. [fa'rinɔ] ‘flour’ (Camuno)
FŌCUS > [ˈhɔk] ‘fire’ (Borno) vs. [ˈfɔk] ‘fire’ (Camuno)
- c The dialect of Borno also displays the palatal affricates [tʃ] and [dʒ] as developments of Latin clusters PL and BL.
*blancu(s) > [ˈdʒank] ‘white’ (Borno) vs. [ˈbjank] ‘white’ (Camuno)
PLĒNUS > [tʃɛ] ‘full’ (Borno) vs. [pjɛ] ‘full’ (Camuno)
- d Proto-Romance [ɛ] in closed syllables becomes [œ] in Cevo, Paspardo, and Cimbergo.

¹³¹ Bonfadini (1990: 77) himself notice that some [ol] is present in some residual areas, and that in the village of Cimbergo the AL article [al] is present.

¹³² In the lower part of the valley the [h] instead of [s] is generally present in all varieties of Camuno, while [ð] derived from *z is present in only a subsection of the area. Cresci (2014: 27) distinguishes between a Camuno-z and a Camuno-ð.

The dialect spoken in the uppermost part of the valley displays some characteristics that are typical of Western and Alpine Lombard varieties. If we assume the framework proposed earlier in §2.2, we may consider those features to be directly inherited from the common koiné probably spoken in Lombardy before the split between Eastern and Western dialects (cf. Sanga 1997: 253).

Some conservative features of Upper Camuno include those in the list proposed in (42) below.

(42) Upper Valle Camonica: specific features

- a The uppermost villages of the valley (Monno, Incudine, Vezza d'Oglio and Temù) display a palatal outcome of *k+*i,e.
 ['tʃena] 'dinner' (Upper Camuno) vs. ['sena] 'dinner' (Bresciano)
 ['bratʃ] 'arm' (Upper Camuno) vs. ['bras] 'arm' (Bresciano)
- b The villages of Corteno and Sonico¹³³ and Corteno display an Interdental [θ] as the outcome of [k]+[i,e].
 ['θena] 'dinner'
 [braθ] 'arm'
- c Maintaining of Latin CL clusters in various villages (Canè, Villa d'Alegno, Prescaglio and Pezzo).
- d Maintenance of intervocalic [v]. This is typical of more isolated areas, where in bigger villages [v] tends to fall as in other Eastern Lombard dialects (cf. 9c).

Not all the features presented in the list above are typical of the entire area, but rather are characteristics of single varieties spoken in single villages or specific places. As time goes by, those features may tend to fade in favor to outcomes more in line with the dialects spoken in Brescia or Bergamo.

The discussion of specific varieties spoken in Valle Camonica ends the first section of this chapter, which described in detail the dialectal variation of Eastern Lombard dialects. The following sections focus on the process of harmonic raising found in most EL dialects.

III.7 Raising Vowel Harmony in Eastern Lombard varieties

EL dialects exhibit a raising harmony triggered by stressed high vowels which targets pre-tonic mid vowels. As mentioned in the introduction, the three varieties of EL distinguished in section §3.3 display three slightly different harmonic patterns that apply in similar contexts but differ in the way they select triggers and/or targets. Within this section the three harmonic patterns are described and discussed.

III.7.1 Raising Harmony in Bresciano

The first pattern considered is that of Bresciano, which displays a regular symmetric pattern of raising.

Here, all unstressed mid vowels raise when followed by a stressed high vowel. The process applies iteratively: high vowels raise mid vowels which in turn become able to raise the preceding mid vowels and so on.

¹³³ Similar properties are found also in the dialects of Valle Imagna, discussed above in §5.4.3. In my data collection, carried out near the village of Sonico (which is discussed in §7.5), I did not find this particular property.

All mid-vowels are valid targets for the process. Recall from section §4.3 that mid-low vowel [ɛ] is the only one appearing in pre-tonic position, and only in closed syllables. The process of vowel reduction discussed in §4.3 interacts with harmony, in that it affects stressed mid-low vowels which reduce to mid-high, and are then subject to raising, if followed by a stressed high vowel. Vowels that may raise are [e], [ɛ], [o] and [ø]. Their raising results in [i] (which is the result of both /e/ and /ɛ/ raising), [u] and [y], respectively. Possible triggers are the high vowels [i], [u] and [y]. Unfortunately, [ø] does not appear often in a possible raising context, and most importantly, [y] does not appear in any morpheme that carries stress. For this reason the raising power of [y] cannot be assessed with certainty, but only when a raised [ø] is preceded by an unstressed mid vowel.

Another problem that will be considered in section §7.7 concerns the outcome of raised [ø]. The raised alternant of [ø] varies between [y] and [u].

With that being said, in the instances in which /y/ (the outcome of ø-raising) follows a mid-vowel, raising applies. Therefore, I consider /y/ as a valid trigger of the process.

In order to observe the raising power of both [i] and [u], the diminutive suffixes /-i, -'inɔ/ and the augmentative suffixes /-u, -'unɔ/ will be examined.

III.7.2. Fieldwork in Brescia

The first analysis of this process for a variety spoken in the Brescia province was done by Sanga (1979) and deals with the dialect of Cigole. Another analysis of the variety of Pavone sul Mella was proposed by Dalpedri (2013). Both Cigole and Pavone sul Mella are small villages in the southern Lowlands within the province of Brescia (cf. §4.4.1). In order to verify the productivity of this process and check all possible contexts of application, I conducted a fieldwork project on the dialect spoken in Brescia.

The fieldwork was carried out between December 2018 and February 2019. Stimuli were chosen based on the dictionary of the dialect of Cigole in Sanga (1979), with the objective of detecting the result of the harmonic process in every syllabic configuration and for both the possible triggers, i.e. stressed /i/ and /u/.

Eleven speakers were selected from among native speakers of the Bresciano dialect. Nine of the participants were adults, born and raised in Brescia. Two of the speakers were born in the southern plains, but moved to the city when they were young. The age of participants ranges between 75 and 91 years. Younger speakers were contacted to participate in the survey, but were not confident in their use of the dialect and preferred not to be interviewed.

Berruto (1993), defining the linguistic situation of Italy, uses the words “Endogen bilingualism with small structural difference between varieties, with dilalia”. Virtually all speakers of dialects are also speakers of Italian. Consider that the close similarities and the reciprocal influences between Italian (which in this context has to be identified as the secondary dialect defined as “Regional Italian”) and the various Italian dialects do not permit a clear boundary to be drawn between an “Italianized” dialect and a “dialectalized” regional Italian.

According to official statistics¹³⁴, Italian dialects are currently spoken by 14% of the entire population¹³⁵, with great variation regarding the area of analysis and the level of education of speakers. The result of the last ISTAT research concerning the use of dialects in each region showed a sharp difference between northern and southern regions: dialects are still mostly spoken in the southern regions, while they are in strong recession in the north (with the notable exception of Veneto, where dialectal use is still frequent). According to data collected by ISTAT in 2015 and published in 2017, dialects in Lombardy are spoken at home by 5.6% of the population (national average 14.1%), with close friends 4.9% (national average 12.1%), and with strangers only 1.1% (national average 4.2%). The situation varies if we are referring to the use of dialect mixed with Italian. In the following tables the result of the last ISTAT research about the use of dialect in Italy. The situation of Lombardy is compared with that of Italy in general.

(43) Language used by speakers (older than 6) in different contexts (2015)

	With family				
	Only or almost only Italian	Only or almost only dialect	Italian and dialect	Other language	Other
Lombardy	59.8%	5.6%	26.1%	7.5%	0.4%
Italy	45.9%	14.1%	32.2%	6.9	0.3%
	With friends				
	Only or almost only Italian	Only or almost only dialect	Italian and dialect	Other language	Other
Lombardy	66.4%	4.9%	22.0%	5.6%	0.5%
Italy	49.6%	12.1%	32.1%	5.1%	0.4%
	With strangers				
	Only or almost only Italian	Only or almost only dialect	Italian and dialect	Other language	Other
Lombardy	89.4%	1.1%	5.7%	2.2%	0.8%
Italy	79.5%	4.2%	12.9%	2.2%	0.4%

It appears that the dialect is used almost exclusively in informal contexts, and it is specifically avoided when speaking with strangers. In general, the table in (43) suggests that dialects in Lombardy are less spoken than in most of Italy. This may be due to the specific situation of Milan, the most populous city of Lombardy, which has been exposed to huge influxes of immigrants from other parts of Italy. As a result, the dialectal varieties that were once spoken by most people in the city were lost, in favor of a language that could be understood by all citizens, i.e. Italian. It is possible that in Eastern Lombardy,

¹³⁴ Istituto Nazionale di Statistica: L'USO DELLA LINGUA ITALIANA, DEI DIALETTI E DELLE LINGUE STRANIERE. https://www.istat.it/it/files//2017/12/Report_Uso-italiano_dialetti_altrelingue_2015.pdf

¹³⁵ This data is referenced to the use of dialects with relatives and close friends. The percentages change when referencing the use of dialects with strangers. Cf. ISTAT (2015) data collection.

where I carried out my data collection, dialects are spoken more frequently than the table in (43) may suggest.

Dialects are rarely spoken in the city centers, and when they are, the influence of Italian tends to be stronger. The use of dialects is more prominent in peripheral areas, mostly in the countryside and in the mountainous areas¹³⁶. As a consequence, dialectal speakers of Brescia and Bergamo are fewer than dialectal speakers in more rural parts of eastern Lombardy. This fact clearly influenced the way data was gathered during the fieldwork. In Brescia, most adults that grew up in the area are able to have a conversation in Bresciano, but very few are actually native speakers. Most dialect-speaking parents chose to avoid the use of Bresciano with their children, and commonly forced themselves to speak in Italian with them. As a result, most speakers between 40 and 60 years old tend to speak dialect only with close relatives, and in a rather Italianized form. Younger generations may have a passive knowledge of the dialect, but are rarely able to sustain a complete conversation with their grandparents. Nowadays, virtually no one learns Bresciano as a first language.

Another social aspect that had an effect on the data collection was the habit of older speakers to avoid using the dialect while talking with someone younger. Most of them tend to prefer Italian when speaking to younger speakers, and use the dialect with peers. This is probably a consequence of the fact that dialect lost ground to Italian in the last decades, so that younger speakers of dialects are less and less common.

As concerns my personal experience, speakers often needed to be reminded to use dialect, when answering to the questions of the survey, since I am younger than all the speakers interviewed.

While I do understand Bresciano dialect, and I am able to speak it (admittedly with low proficiency), speakers had a tendency to shift back to Italian to clarify and be sure I was following. Since the goal of the task was to observe the application of a phonological process, the application of raising to an “italianized” stem is still relevant. One may argue even more so, since the Italian lexical item is modified applying a dialectal phonological process. Cases of this type confirm the activity of RVH in Bresciano. An example of this case is the forms [kar'tʃɔfo] > [kartʃu'fi] [kartʃu'fu], ‘artichoke’, where the Italian word [kar'tʃɔfo] has been produced instead of the expected dialectal form [artitʃɔk]. This and other similar cases are discussed in the text later in this section. Sometimes, however, the existence of a diminutive form in Italian that is extremely similar to that of Bresciano may have influenced the application of the process. For instance, consider the case of the Italian form [bikkjerino] ‘small glass’ which is the diminutive form of the word [bikkjere]. The Italian superstratum may be the reason why many speakers did not produced a raised form [bitʃer]>[bitʃiri] ‘glass DIM’ but instead the form [bitʃer]>[bitʃeri].

III.7.2.1 Data collection: the elicitation task.

Speakers were asked to perform a picture elicitation task. A series of images were shown to speakers, who were asked to name the object in the image, and then to apply the diminutive and augmentative form (e.g. “What do you see in this image? A dog. How do you call this when it is big/small?”). The images submitted represented countable nouns, mostly of animals and common objects.

Speakers were instructed in Italian, but when possible the language used was the dialect itself (mostly to remind the speakers that they had to answer in Bresciano, and not in Italian)

¹³⁶ Cf. Sanga (1984) for a detailed discussion of the relationship between dialect and regional Italian in Lombardy and a description of the different diaphasic varieties of regional Italian. In addition, a more detailed description of the linguistic situation of Lombardy can be found in Massariello Merzagora (1988).

Words were selected in order to observe the behavior of unstressed pre-tonic mid vowels in various contexts.

The main objective of the research was to make sure that both [i] and [u] are valid triggers for all preceding unstressed mid vowels, and that all unstressed mid vowels behave alike in Bresciano, i.e. they all undergo raising when followed by a stressed high vowel. Alongside words that contain one or more mid vowels in the root, some distractors were selected. Distractors were useful for teaching the task to speakers without influencing the answers. Their presence also allowed for the behavior of /a/ to be verified.

The result of the research confirmed the expectations, as shown in the table below. Data reported in (44) correspond to the most common answer given by speakers of Brescia. The complete set of answers given by each speaker is reported in the Appendix.

(44) Results of the fieldwork carried out in Brescia.

<i>Targets</i>		<i>Stimulus</i>	<i>Base form</i>	<i>Diminutive</i>	<i>Augmentative</i>
a.	e	<i>church</i>	[ˈtʃeza]	[tʃiˈzina]	[tʃiˈzuna]
		<i>cup</i>	[ˈkikera]	[kikiˈrina]	[kikeˈruna]
		<i>saw</i>	[ˈrazeɡa]	[raziˈɡi]	[raziˈɡu]
		<i>glass shard</i>	[ˈvedre]	[viˈdri]	[viˈdru]
		<i>glass</i>	[bitʃer]	[bitʃiri]	[bitʃiˈru] ¹³⁷
		<i>rock</i>	[ˈpreda]	[priˈdina]	[priˈduna]
		<i>priest</i>	[ˈpret]	[pretaˈsi]	[pretaˈsu]
		<i>pear</i>	[ˈper]	[piˈri]	[piˈru]
b.	ε	<i>candle</i>	[kanˈdela]	[kandiˈlina]	[kandiˈluna]
		<i>bed</i>	[let]	[liˈti]	[liˈtu]
		<i>duck</i>	[ˈnedra]	[niˈdri]	[niˈdru]
		<i>sock</i>	[kalˈset]	[kalsiˈti]	[kalsiˈtu]
		<i>pan</i>	[paˈdela]	[padiˈli]	[padiˈlu]
		<i>ring bell</i>	[kampaˈnel]	[kampaniˈli]	[kampaniˈlu]
		<i>dustpan</i>	[paˈleta]	[paliˈtina]	[paliˈtuna]
		<i>little owl</i>	[siˈeta]	[siiˈtina]	[siituna]
		<i>tooth</i>	[ˈdent]	[dinˈti]	[dinˈtu]
		<i>chariot</i>	[kaˈret]	[kariˈti]	[kariˈtu]
		<i>brother</i>	[fraˈdɛl]	[fradiˈli]	[fradiˈlu]
		<i>fish</i>	[ˈpɛs]	[pisiˈti]	[pisiˈtu]
<i>cherry</i>	[saˈreza]	[sariˈzina]	[sariˈzuna]		

¹³⁷ Some speakers regularly applied the diminutive and the augmentative as reported in the table, but for most speakers both the augmentative and the diminutive of this word failed to undergo harmony. The specific case of the word [biˈtʃer] is treated later in the text.

		<i>fog</i>	[ˈgɛba]	[giˈbina]	[giˈbuna]
		<i>brick</i>	[kwaˈdrɛl]	[kwadriˈli]	[kwadriˈlu]
		<i>boy</i>	[naˈrɛl]	[nariˈli]	[nariˈlu]
		<i>toilet</i>	[ˈtʃɛso]	[tʃiˈsi]	[ˈtʃiˈsu]
		<i>wood</i>	[ˈlɛɲ]	[liˈni]	x
b. ¹	ɛ (epenthetic)	<i>book</i>	[ˈlibɛr]	[libˈri]	[libˈru]
		<i>donkey</i>	[ˈazɛn]	[azˈni]	[azˈnu]
c.	o	<i>apple</i>	[ˈpom]	[puˈmi]	[puˈmu]
		<i>nail</i>	[ˈtʃot]	[tʃuˈdi]	[tʃuˈdu]
		<i>goose</i>	[ˈoka]	[uˈkina]	[uˈkuna]
		<i>mushroom</i>	[ˈfons]	[funˈzi]	[funˈzu]
		<i>mouth</i>	[ˈboka]	[buˈkina]	[buˈkuna]
		<i>bag</i>	[ˈborsa]	[burˈsina]	[burˈsuna]
		<i>fly</i>	[ˈmoska]	[musˈki]	[musˈku]
		<i>door</i>	[ˈporta]	[purˈtina]	[purˈtu]
		<i>lady</i>	[ˈfonna]	[funˈnina]	[funˈnu]
		<i>knot</i>	[ˈgrop]	[gruˈpi]	[gruˈpu]
		<i>devil</i>	[ˈdjaol]	[djauˈli]	[djauˈlu]
d.	ɔ	<i>artichoke</i>	[artiˈtʃɔk]	[artitʃuˈki]	[artitʃuˈku]
		<i>dumpling</i>	[ˈɲɔk]	[ɲuˈki]	[ɲuˈku]
		<i>belly</i>	[ˈbɔdʒa]	[buˈdʒina]	[buˈdʒuna]
		<i>plum</i>	[ˈbrɔɲa]	[bruˈɲina]	[bruˈɲuna]
		<i>crow</i>	[ˈkɔrf]	[kurˈvi]	[kurˈvu]
		<i>blind man</i>	[ˈɔrp]	[orbaˈti]	[orbaˈtʃu]
e.	ø	<i>apron</i>	[bigaˈrø]	[bigaruˈli]	[bigaruˈlu]
		<i>funnel</i>	[tyrtaˈrø]	[tyrtaruˈli]	[tyrtaruˈlu]
		<i>fingernail</i>	[ˈøndʒa]	[ynˈdʒina]	[ynˈdʒuna]
		<i>strawberry</i>	[maˈøla]	[mayˈlina]	[mayˈluna]
		<i>eye</i>	[ˈøtʃ]	[yˈtʃi]	[yˈtʃu]
		<i>egg</i>	[ˈøf]	[øfaˈzi]	[øfaˈzu]
f.	e_e	<i>mountain trail</i>	[senˈtɛr]	[sintiˈri]	[sintiˈru]
g.	e_ɛ	<i>cap</i>	[beˈrɛt]	[biriˈti]	[bereˈtu]
		<i>calf</i>	[veˈdɛl]	[vidiˈli]	[vidiˈlu]
		<i>brain</i>	[serˈvɛl]	[sirviˈli]	[sirviˈlu]
h.	ɛ_ɛ	<i>comb</i>	[ˈpɛtɛn] ¹³⁸	[pitiˈni]	[pitiˈnu]

¹³⁸ Speakers AA2, AI and VM produced instead the form [pɛtɛn]. This base form, when undergoing raising, results in 212

		<i>peach</i>	['pɛrsek]	[pɪrsi'gi]	[pɪrsi'gu]
i.	e_o	<i>hare</i>	['legor]	[ligu'rɪnɔ]	[ligu'rɪnɔ]
		<i>sheep</i>	['pegorɔ]	[pɪgu'rɪnɔ]	[pɪgu'rɪnɔ]
j.	ɛ_o	<i>pendulum clock</i>	['pɛndɔl]	[pɪndu'li]	[pɪndu'lu]
k.	ɛ_ø	<i>sheet</i>	[lɛn'sɔl]	[lɪnsu'li]	[lɪnsu'lu]
		<i>ham</i>	[pɛr'sɔt]	[pɪrsu'ti]	[pɪrsu'tu]
l.	o_e	<i>rabbit</i>	[ko'netʃ]	[kuni'tʃi]	[kuni'tʃu]
		<i>foal</i>	[po'ledɛr]	[puli'dri]	[puli'dru]
m.	o_ɛ	<i>bird</i>	[o'zɛl]	[uzi'li]	[uzi'lu]
		<i>ear</i>	[o'retʃɔ]	[uri'tʃi]	[uri'tʃu]
		<i>sister</i>	[so'rɛlɔ]	[suri'lɪnɔ]	[suri'lɪnɔ]
		<i>umbrella</i>	[om'brɛl]	[umbri'li]	[umbri'lu]
		<i>knife</i>	[kor'tɛl]	[kurti'li]	[kurti'lu]
		<i>pig</i>	[por'sɛl]	[pursi'li]	[pursi'lu]
		<i>mouse</i>	[so'rek]	[suri'gi]	[suri'gu]
		<i>horn</i>	['kɔrɛn]	[kur'ni]	[kur'nu]
		<i>pruning knife</i>	[po'dɛt]	[pudi'ti]	[pudi'tu]
n.	o_o	<i>tomato</i>	[pon'dɔr]	[pundu'ri]	[pundu'ru]
o.	ø_ɛ	<i>lizard</i>	[lø'zɛrdɔ]	[lyzir'dɪnɔ]	[lyzir'du]
		<i>zucchini</i>	[sø'kɛl]	[syki'li]	[zyki'lu]
		<i>porringer</i> ¹³⁹	[skø'dɛlɔ]	[skydi'li]	[skydi'lu]
p.	a.	<i>dog</i>	['ka]	[ka'ni]	[ka'nu]
		<i>hand</i>	['ma]	[ma'nɪnɔ]	[ma'nɪnɔ]
		<i>chair</i>	['skɔnɔ]	[ska'ni]	[ska'nu]
		<i>tree</i>	['pjɔntɔ]	[pjan'tɪnɔ]	[pjan'tɪnɔ]
		<i>cow</i>	['akɔ]	[a'kɪnɔ]	[a'kɪnɔ]
		<i>trousers</i>	['brɛʒ]	[bra'ʒɪnɔ]	[bra'ʒɪnɔ]
		<i>mustaches</i>	['bafi]	[bafi'ti]	[ba'fu]
		<i>cat</i>	['gat]	[ga'ti]	[ga'tu]
		<i>goat</i>	['kavɔ]	[kav'ri]	[kav'ru]
		<i>bread</i>	['pa]	[pa'ni]	[pa'nu]
		<i>key</i>	['tʃɔf]	[tʃai'tɪnɔ]	[tʃai'tɪnɔ]
		<i>cock</i>	['gal]	[gali'ti]	[gali'tu]
		<i>leg</i>	['gambɔ]	[gam'bɪnɔ]	[gam'bɪnɔ]

harmonic tokens [pitini] (AA2, AI, VM) and [pitinu] (AA2).

¹³⁹ This token was not expected in the list. However, many of the speakers interviewed gave [skødɛlɔ] as their entry for the “cup” stimulus, and I chose to insert it in my list.

		<i>nose</i>	['nas]	[na'zi]	[na'zu]
		<i>boat</i>	['barka]	[bar'kina]	[bar'kuna]
q.	a_a	<i>sausage</i>	[sa'lam]	[sala'mi]	[sala'mu]
		<i>horse</i>	[ka'al]	[kaa'li]	[kaa'lu]
		<i>potato</i>	[pa'tata]	[pata'tina]	[pata'tuna]
		<i>pheasant</i>	[fa'za]	[faza'ni]	[faza'nu]
r.	i	<i>fig</i>	['fik]	[fi'gi]	[fi'gu]
		<i>finger</i>	['dit]	[di'ti]	[di'tu]
s.	u	<i>wolf</i>	['luf]	[lu'fi]	[lu'fu]
		<i>flour</i>	['fjur]	[fjuri'li]	[fjuri'lu]
t.	y	<i>mule</i>	['myl]	[my'li]	[my'lu]
u.	o_a	<i>necklace</i>	[ko'lana]	[kola'nina]	[kola'nuna]
		<i>fountain</i>	[fon'tana]	[fonta'nina]	[fonta'nuna]
		<i>orange</i>	[porto'gal]	[portoga'li]	[portoga'lu]
w.	ø_a	<i>snail</i>	[lø'maga]	[løma'gina]	[løma'guna]
x.	y_a	<i>spoon</i>	[ky'dza]	[kydza'ni]	[kydza'nu]
y.	i_i	<i>dress</i>	[vis'tit]	[visti'di]	[visti'du]
z.	u_i	<i>bottle</i>	[bu'ti'la]	[buti'lina]	[buti'luna]
z. ¹	u_u	<i>doctor</i>	[du'tur]	[dutu'ri]	[dutu'ru]

The data collected and reported in (44) show that RVH is active, regular and symmetric in Bresciano, as it is in the varieties of the plains spoken in the south.

This confirms the observation made by Sanga (1979): the dialect spoken in the plains south of Brescia shares most of its properties with the dialect spoken in the city center. This fact is also reflected in the application of RVH, which is symmetrical in Brescia as it is in Cigole and Pavone (cf. Dalpedri 2013 and Sanga 1979).

Front non-round mid vowels raise to [i], regardless of the relative height of the original vowel. Both [-ATR] /ε/ and [+ATR] /e/ undergo raising in the same way (cf. tokens in 44a and 44b). Similarly, both back round mid vowels have the same outcome: /ɔ/ and /o/ both raise to [u] (cf. 44c. and 44d.).

The front round vowel /ø/ behaves somewhat erratically, sometimes raising to [y] and sometimes to [u] (cf. 44e.). The behavior of raised [ø] in EL raising harmony is treated in detail in section §7.7.

When multiple mid vowels are in a sequence the process applies iteratively, first to the rightmost vowel and then to the leftmost (cf. tokens in sections 44f-o.).

Epenthetic vowels of the kind discussed in (10a) do not interact with harmony, and are absent from harmonized forms (cf. 44b¹).

The low vowel /a/ does not raise (cf. 44p), and blocks raising for preceding mid vowels (cf. 44u. and 44w.). High vowels are unaffected by the process (cf. 44y-z).

No particular effects due to specific syllabic context have been detected: mid vowels raise whether in open or in closed syllables, as shown by the tokens in (44h):

[pærsek] 'peach' → [pirsigi] 'peach DIM'

[pætən] 'comb' → [pitini] 'combDIM'.

While the process has been tested only for nouns, and only using the diminutive and augmentative suffixes, the presence of raised forms in both the dictionary of Cigole (Sanga 1979: 356) and the analysis of Dalpedri (2013) indicates that the process is active in other morphological contexts, such as verbal paradigms. E.g. ['pɛrdɛr] 'to lose.' ['pɪr'dit] 'lost'.

The diminutive and augmentative suffixes proved to be good triggers for the process, but some problems made the computation of veritable harmonic and disharmonic tokens rather complex.

First, not all speakers recognized all the images submitted. In some cases they did not find the word, or did not recognize the object shown to them. When this was the case, I carried on with the task, without insisting on them producing the desired base form. In particular, older speakers had a hard time recognizing all images, and became fatigued after a while. In some cases, I interrupted the task halfway, since the speaker interviewed started to be tired, or unwilling to continue further with the exercise¹⁴⁰.

In general, it appears that the augmentative form tends to be less productive than the diminutive form in Bresciano, especially for male speakers. Cresci (2014: 137) made the same observation discussing raising in the Camuno dialect: speakers generally produced diminutive forms with ease, but they often struggled in the production of augmentatives. Some of the speakers interviewed tended to use periphrasis or different lexemes instead of attaching the augmentative suffix /-u/ to a nominal root. The most extreme example of this fact is the speaker VM, who produced only 10 regular augmentatives, and answered to all other questions regarding augmentatives using periphrastic forms such as [el kor'tɛl 'grɔs] 'the big knife' instead of [kurti'lu] or using alternative lexical items such as [ganassa] instead of [dintu].

Another frequent issue encountered concerns the effect of Italian on Bresciano. On many occasions, speakers gave an Italian word as an answer instead of the expected dialectal cognate.

Let us take the case of the tokens for artichoke [artitʃɔk] and nun [mɔnega] as an example. Speakers often answered with the Italian forms [kartʃɔfo] and [swɔra], and were not able (or not willing) to give the dialectal form. On many occasions, the exercise was carried on, and the diminutive and augmentative forms were produced. For example, speaker PS produced the following form:

[kart'ʃofo] 'artichoke' → [kartʃu'fi] [kartʃu'fu]

In this case, raising regularly applied, even though the form submitted does not correspond to the expected one. Italianisms were thus considered alongside pure dialectal forms in the count of harmonic and non-harmonic tokens.

Another issue that made the analysis of data more complex is the frequent application of different suffixes as the diminutive or the augmentative. An alternative form for the diminutive is [-'ɛt], and an alternative augmentative suffix is the suffix [-'ɔt]. When those forms are used instead of the more frequent [-'i] and [-'u], the process of harmony is not triggered, and therefore raising does not apply. Examples are provided below:

[nɛdra] 'duck' [nedrɔt] 'duck AUG'

[barka] 'boat' [barkɛtɔ] 'boat DIM'

Often the two alternative suffixes [-'ɛt] and [-'ɔt] are used as infixes between the base form and the regular suffix. When used as infixes they lack a proper meaning, and just co-occur with the regular diminutive/augmentative suffix. Cases in point are forms such as [nidru'ti] < /nɛdr-ɔt-i/ 'duck DIM', given by speaker AT, or [bursitɪnɔ] < /bɔrs-ɛt-ɪnɔ/ 'bag DIM', given by speaker RA.

¹⁴⁰ Cases in point were the speakers MB and LB2. This is the reason why they produced fewer tokens than the other participants.

Vowels in the infixes participate in the harmonic process, if mid, and block it if low. Thus mid vowels of additional suffixes raise, and allow harmony to pass through them, while low vowels block the process.

Other infixes that can intervene between a root and the regular suffix are two additional diminutives, [-ɛl] and [-øɫ], and a pejorative suffix [-as] which often appeared as an infix between the root and the regular augmentative or diminutive suffix. Consider the following examples produced by speaker PS.

/fjur-ɛl-i/ → [fjuri'li] 'flower DIM'

/pɛs-øɫ-i/ → [pisu'li] 'fish DIM'

/pret-as-i/ → [preta'si] 'priest DIM'

Cases where an infix influenced the outcome of the process have been taken into account.

III.7.2.2. *Discussing the results*

The series of tables under (45) report the number and percentages of application of VH for each speaker interviewed in Brescia.

The goal of these tables is to identify the degree of activity of the raising process, and whether there are phonological contexts in which disharmony appears frequently (i.e. contexts where harmony often fails to apply).

While filling the tables, I considered only words where harmony could apply, and ignored all the cases in which harmony could not. This means that many tokens collected were not considered on this occasion. In particular, the following kinds of tokens were not taken into account in the compilation of the tables:

- a. Words without a mid-vowel in the root (mainly distractors, or unexpected base forms that lacked a mid/vowel in the root).
- b. Words where a low vowel intervening between the trigger and the targets blocks the process (e.g. words where the pejorative infix –as blocked the application of VH to preceding mid vowels);
- c. Words in which an alternative suffix was applied (i.e. diminutives and augmentatives where the expected suffixes [-i] and [-u] were not produced).

Instead, I counted all the tokens where the root lacks a mid-vowel, but in which an infix that can be raised is inserted.

In sum, all tokens that could potentially host a harmonic process in Bresciano are listed in the column named *Relevant tokens*. From this total, the number of disharmonic words (i.e. tokens in which harmony could, but failed to apply) must be subtracted so to obtain the degree of applicability of RVH in Bresciano.

A relevant issue in the application of VH concerns the nature of disharmonic sequences. In §1 the different patterns of Camuno and Bergamasco were briefly presented (more on each of those harmonies in sections §7.3 and §7.4 respectively). There, harmony behaves as asymmetrical. In Camuno [e/ɛ] systematically fails to undergo harmony when followed by /u/, while in Bergamasco [e, ɛ] is never raised by any high vowel. While in Bresciano harmony is expected to apply in all of those contexts, it would be interesting to see whether disharmonies tend to appear more frequently when front non-round vowels are involved, especially when /u/ triggers the process.

The last table of the list under (45) condenses all the relevant tokens from all speakers, and acts as a summary for the data collection. For each table, the nature of the target (or of the sequence of targets) is indicated in the first column. I chose to group together [+ATR] and [-ATR] mid-vowels, since they behave alike in the context of RVH, as noted above in §7.2.1. Capital letters indicate the nature of mid vowels that can undergo raising: 'E' indicates non-rounded front mid-vowels, 'O' stands for rounded

back mid-vowels and ‘Ø’ indicates front rounded mid vowels. Disharmonies are divided according to the nature of the disharmonic sequence recorded. Since RVH in Brescia is expected to raise all mid vowels followed by a high stressed vowel (or by a high vowel that has been affected itself by raising), I considered as disharmonic each sequence of vowels whereby a mid-vowel is followed by a potential trigger. Disharmonic sequences are once again divided by the nature of the vowels involved: the column ‘E-i’ corresponds to the context of ‘E’ followed by a high vowel [i], which is expected to trigger raising. The column ‘E-u’, instead corresponds to the contexts in which ‘E’ is followed by [u], and it is not raised. Similarly, ‘O-i’ corresponds to the cases in which a ‘O’ fails to be raised by a following [i], and ‘O-u’ to the cases in which ‘O’ fails to raise when followed by [u] etc...

As noted in §7.1 above, /y/ never appears as a raising trigger. It can however display the behavior of a trigger when a raised /ø/ follows a mid-vowel, since the process is local and iterative. However, since the outcome of /ø/ varies between [u] and [y], I chose to consider sequences that involve [y] together with those involving [u]. In other words, a disharmonic sequence of the kind “E-y” like [persy’ti] ‘ham DIM’ is counted in the column of disharmonies of the type ‘E-u’.

(45) Specific results of the data collection carried out in Brescia

RA: 80 years old, female speaker.

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	126	115	11	2	6	1	0	1	1
		91.3%	8.7%	1.6%	4.7%	0.8%		0.8%	0.8%
E	48	43	5	2	3				
		89.6%	10.4%	4.2%	6.2%				
O	25	24	1			1	0		
		96%	4%			4%			
Ø	7	5	2					1	1
		71.4%	28.6%					14.3%	14.3%
E-E	12	11	1	0	1				
		91.7%	8.3%		8.3%				
E-O	4	3	1	0	1	0	0		
		75%	25%		25%				
E-Ø	2	1	1	0	1			0	0
		50%	50%		50%				
O-E	22	22	0	0	0	0	0		
		100%							
O-O	1	1	0			0	0		
		100%							
Ø-E	5	5	0	0	0			0	0
		100%							

AA: 91 years old, male speaker

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	117	96	21	10	5	1	4	0	1
		82.1%	17.9%	8.5%	4.3%	0.8%	3.4%		0.8%
E	36	32	4	3	1				
		88.9%	11.1%	8.3%	2.7%				
O	33	28	5			1	4		
		84.8%	15.2%			3.1%	12.1%		
Ø	10	9	1					0	1
		90%	10%					0	10%
E-E	8	3	5	5	0				
		37.5%	62.5%	62.5%					
E-O	6	4	2	0	2	0	0		
		66.7%	33.3%		33.3%				
E-Ø	1	1	0	0	0			0	0
		100%							
O-E	17	17	0	0	0	0	0		
		100%							
O-O	2	2	0			0	0		
		100%							
Ø-E	4	0	4	2	2			0	0
			100%	50%	50%				

AT: 78 years old, female speaker

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	126	84	42	13	14	10	4	0	1
		66.7%	33.3%	10.3%	11.1%	7.9%	3.1		0.1%
E	40	25	15	7	8				
		62%	37.5%	17.5%	20%				
O	26	17	9			6	3		
		65.4%	34.6%			23.1%	11.5%		
Ø	8	8	0					0	0
		100%							
E-E	12	4	8	5	3				
		33.3%	66.7%	41.7%	25%				
E-O	8	6	2	0	0	1	1		
		75%	25%			12.5%	12.5%		
E-Ø	4	1	3	0	2			0	1
		25%	75%		50%				25%
O-E	20	17	3	0	0	3	0		
		85%	15%			15%			
O-O	2	2	0			0	0		
		100%							

Ø-E	6	4	2	1	1			0	0
		66.7%	33.3%	16.6%	16.6%				

LB1: 81 years old, female speaker

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	144	121	23	7	13	3			
		84.1%	15.9%	4.9%	9%	2%	0	0	1*
E	56	51	5	1	4				
		91%	8.9%	1.7%	7.1%				
O	28	28	0			0	0		
		100%							
Ø	7	7	0					0	0
		100%							
E-E	12	6	6	5	1				
		50%	50%	41.7%	8.3%				
E-O	8	1	7	0	4	3	0		
		12.5%	87.5%		50%	37.5%			
E-Ø	4	2	2	0	2			0	0
		50%	50%		50%				
O-E	23	23	0	0	0	0	0		
		100%							
O-O	2	2	0			0	0		
		100%							
Ø-E	4	1	3	1	2			0	0
		25%	75%	25%	50%				
Ø-Ø	1	0	0					0	1* ¹⁴¹

MB: 76 years old, female speaker¹⁴².

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	40	35	5	2	2	1			
		87.5%	12.5%	5%	5%	2.5%	0	0	0
E	18	17	1	0	1				
		94.4%	5.6%		5.6%				
O	11	10	1			1	0		
		90.1%	9.9%			9.9%			

¹⁴¹ LB1 speaker suggested the base form [køkømer], confusing the image for zucchini with a cucumber. Nonetheless, this form turns out to be rather interesting. The diminutive and augmentative forms given by that speaker for this word were respectively [køkymeri] and [kykymiru]. The diminutive actually displays two disharmonies and an unexpected raising. While [ε] fails to undergo harmony, the preceding ø raises to y and is then unable to raise preceding ø.

¹⁴² The speaker MB had some difficulties in understanding the task, and due to personal affairs had to leave before she could finish the interview. That is the reason why the number of answer provided were rather low, if compared with the answers of other speakers.

Ø	2	2	0					0	0
		100%							
E-E	4	2	2	2	0				
		50%	50%	50%					
E-O	1	0	1	0	1	0	0		
			100%		100%				
E-Ø	0	0	0	0	0			0	0
O-E	3	3	0	0	0	0	0		
		100%							
Ø-E	1	1	0	0	0			0	0
		100%							

PS¹⁴³ 75 years old, male speaker

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	137	126	11	2	6	2	1	0	0
		92%	8%	1.5%	4.4%	1.5%	0.6%		
E	54	50	4	2	2				
		92.6%	7.4%	3.7%	3.7%				
O	32	30	2			1	1		
		93.75%	6.25%			31.25%	31.25%		
Ø	9	9	0					0	0
		100%							
E-E	14	14	0	0	0				
		100%							
E-O	1	0	1	0	0	1	0		
			100%			100%			
E-Ø	4	2	2	0	2			0	0
		50%	50%		50%				
O-E	19	19	0	0	0	0	0		
		100%							
O-O	2	2	0			0	0		
		100%							
Ø-E	2	0	2	0	2			0	0
			100%		100%				

¹⁴³ Disharmonies produced by this speaker are always produced in the same lexical contexts: i.e. the same root in the diminutive and augmentative forms fails to raise. [kike'rina] [kike'runa], [swə'rina] [swə'runa], [nɛb'jina] [nɛb'juna], [persy'ti] [persu'tu] ... This may suggest a lexical effect on the disharmonic behavior, particular to this speaker. An additional fact about those disharmonies: some of them are produced starting from Italian bases. The expected word for 'nun' in Bresciano is ['mɔnɛga], and the one for 'fog' is ['gɛba]. This speaker produced the Italian-based words ['swɔra] and ['nɛbia], and did not raise the mid vowels in those cases.

VR: 79 years old, female speaker

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	∅-i	∅-u
TOT	106	102	4	1	3	0	0	0	0
		96.2%	3.8%	0.95%	2.85%				
E	32	30	2	1	1				
		93.75%	6.25%	3.12%	3.12%				
O	22	22	0			0	0		
		100%							
∅	7	7	0					0	0
		100%							
E-E	10	10	0	0	0				
		100%							
E-O	8	8	0	0	0	0	0		
		100%							
E-∅	5	4	1	0	1			0	0
		80%	20%		20%				
O-E	15	15	0	0	0	0	0		
		100%							
O-O	2	2	0			0	0		
		100%							
∅-E	5	4	1	0	1			0	0
		80%	20%		20%				

LB2: 81 years old, male speaker

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	∅-i	∅-u
TOT	46	45	1	0	1	0	0	0	0
		97.8%	2.2%		2.2%				
E	20	20	0						
		100%							
O	10	10	0			0	0		
		100%							
∅	1	1	0					0	0
		100%							
E-E	6	6	0	0	0				
		100%							
E-O	2	2	0	0	0	0	0		
		100%							
E-∅	0	0	0	0	0			0	0
O-E	6	6	0	0	0	0	0		
		100%							
∅-E	1	0	1	0	1			0	0
			100%		100%				

AA2: 83 years old, female speaker

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	137	133	4	0	3	1	0	0	0
		97.1%	2.9%		2.2%	0.7%			
E	45	43	2	0	2				
		95.5%	4.5%		4.5%				
O	27	27	0			0	0		
		100%							
Ø	10	10	0					0	0
		100%							
E-E	15	15	0	0	0				
		100%							
E-O	10	10	0	0	0	0	0		
		100%							
E-Ø	2	2	0	0	0			0	0
		100%							
O-E	20	18	2	0	1	1	0		
		90%	10%		5%	5%			
O-O	2	2	0			0	0		
		100%							
Ø-E	6	6	0	0	0			0	0
		100%							

AI: 82 years old, female speaker

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	114	110	4	1	2	1	0	0	0
		96.5%	3.5%	0.85%	1.75%	0.85%			
E	43	41	2	1	1				
		95.3%	4.7%	2.35%	2.35%				
O	28	28	0			0	0		
		100%							
Ø	6	6	0					0	0
		100%							
E-E	9	9	0	0	0				
		10%							
E-O	6	5	1	0	0	1	0		
		83.3%	16.7%			16.7%			
E-Ø	2	2	0	0	0			0	0
		100%							
O-E	16	16	0	0	0	0	0		
		16%							
O-O	1	1	0			0	0		
		100%							

Ø-E	3	2	1	0	1			0	0
		66.7%	33.3%		33.3%				

VM: 85 years old, male speaker

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	66	66 100%	0	0	0	0	0	0	0
E	23	23 100%	0	0	0				
O	14	14 100%	0			0	0		
Ø	5	5 100%	0					0	0
E-E	6	6 100%	0	0	0				
E-O	1	1 100%	0	0	0	0	0		
E-Ø	1	1 100%	0	0	0			0	0
O-E	12	12 100%	0	0	0	0	0		
O-O	1	1 100%	0			0	0		
Ø-E	3	3 100%	0	0	0			0	0

Complete analysis

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	1159	1033 89.1%	126 10.9%	38 3.3%	55 4.7%	20 1.7%	9 0.7%	1 0.3%	3 0.9%
E	415	375 90.4%	40 9.6%	15 3.6%	25 6%				
O	256	238 92.9%	18 7.1%			10 3.9%	8 3.2%		
Ø	72	69 95.8%	3 4.2%					1 1.4%	2 2.8%
E-E	108	86 79.6%	22 20.4%	19 17.6%	5 4.6%				
E-O	55	40 72.7%	15 27.3%	0	8 14.5%	6 10.9%	1 1.8%		
E-Ø	25	16 64%	9 36%	0	8 32%			0	1 4%
O-E	173	168	5	0	1	4	0		

		97.1%	2.9%		0.6%	2.3%			
O-O	15	15	0			0	0		
		100%							
Ø-E	40	26	14	4	10			0	0
		65%	35%	10%	15%				

The set of tables in (45) confirms the rather high frequency of the process of raising harmony in Bresciano. Most mid vowels raise whenever they precede a stressed high vowel, and the process generally behaves as iterative, affecting all vowels of the word one at a time. The process affects all mid-vowels, and in general, all high vowels are valid triggers for the harmonic raising¹⁴⁴.

Some differences in the productivity of the process can be observed between different speakers. The most striking example is the speaker AT, who applied raising only 66.7 % of the time. This rather low percentage of application lowers the general percentage of the application of VH in Bresciano to 89.1%. Most speakers applied raising around 85 to 95% of the time (cf. the tables for the specifics of each speaker). Some speakers applied the process with few to no exceptions (e.g. LB2: 97.8%; VM: 100%).

Exceptions to raising (i.e. disharmonic sequences) appear to be relatively more common when the front non-rounded /e/ is involved. In general, the analysis of disharmonic tokens suggests that front non-round vowels are more prone to ignore the raising effects of VH than round vowels, especially when followed by a rounded high vowel. Disharmonic sequences of the ‘E-u’ type are the most common, both in absolute and relative terms, (almost 5% of relevant tokens exhibit a disharmony of this kind, and 43% of all disharmonic sequences belong to the E-u group). The number of disharmonies is even more striking when considering the sequence of targets e-o. When /e/ or /ɛ/ are followed by a raised /o/ or a raised /ø/, raising applied only 80% of the time¹⁴⁵.

Disharmonic sequences of the ‘E-i’ kind are relatively rarer, but especially frequent when two front non-round mid-vowels are in sequence, i.e. when the targets belongs to the ‘E-E’ group in the tables. In this sort of case, raising applies to the first target, but not to the second. Consider the following examples

(speaker AA): [persek] ‘peach’ → *[persigi] ‘peach DIM’

(speaker AT). [servɛl] ‘brain’ → [servili] ‘brain DIM’

The “harmonic wave” affects the first mid vowel it encounters, but does not reach the second one, which remains unaffected.

Exceptions are extremely frequent for certain lexical roots among different speakers. Those roots are [per'søt] ‘ham’, [ˈpegora] ‘sheep’, [lø'zɛrta] ‘lizard’, [bitʃer] ‘glass’, and [kikera] ‘teacup’, which often fail to undergo harmony (cf. the Appendix for the specifics).

This may suggest that tokens of this kind are lexically exceptional. However, each one of those tokens was raised by at least one speaker during the task. Other frequent cases of disharmonies are those that may be derived from the Italian origin of certain words, as discussed in note 38 while discussing the results of the speaker PS. It is possible that some dialectal forms fail to raise due to the effect of a closely related Italian form, but at the same time there are frequent cases of base forms borrowed from Italian that undergo raising according to the harmonic rule.

¹⁴⁴ The role of /y/ and raised /ø/ as valid triggers for raising in EL varieties is discussed in more detail in §7.7.

¹⁴⁵ The sum of relevant tokens in the groups ‘E-O’ (55 tokens) and ‘E-ø’ (25 tokens) is 80. The number of disharmonic sequences for this group is 16.

Besides the cases discussed here, there are some words that appear to be lexically disharmonic. Some of them are reported in the vocabulary proposed by Sanga (1979). Some examples are [peru] ‘fork’ * [piru]; [peeru] ‘bellpepper’ *[piiru]; [dervit] ‘opened’ *[dirvit].

Overall, we can conclude that the process of raising harmony is attested and active in Bresciano, and that disharmonies, while present, are a small minority. The phonological process is regular and symmetric. The overwhelming majority of cases clearly show that all mid vowels raise when they precede a stressed high vowel, or an unstressed raised vowel. Disharmonies are relatively more common when they concern front non-rounded vowels, which appear to be less prone to undergoing harmony than round mid-vowels (cf. §VI.5.3 for an hypothesis on why this may happen). This fact is especially striking, considering the asymmetric and parasitic behavior of other EL harmonies, where in those same contexts harmony does not apply by rule.

III.7.3 Raising VH in Bergamo and neighboring areas

The discussion of the harmonic pattern of Bergamasco will be shorter than the one proposed for the dialect of Brescia. This is because no research specifically dedicated to vowel harmony has been carried out in the area where Bergamasco is spoken. All the data reported here derive from the collection of essays *Il dialetto di Bergamo e le sue Valli*, published by Sanga in 1987. This collection of texts analyzes all the minor varieties spoken in the administrative province of Bergamo, including the urban dialect.

Sanga (1987: 45) describes the harmonic pattern of Bergamasco as a “double pattern” that involves both raising and lowering.

According to his analysis, the height of pre-tonic vowels (except for [a]) depends on the degree of height of the following stressed vowel: if the stressed vowel is high ([i], [u], [y]), all pre-tonic vowels surface as high. If the stressed vowel is mid, all pre-tonic vowels surface as mid.

This means that the underlying nature of vowels in pre-tonic position is undetermined, and that the height degree of the stressed vowels triggers harmony, so that underlying high vowels surface as mid when followed by a stressed mid-vowel, and as high when followed by a stressed high vowel.

This analysis does not appear to stand up to scrutiny. High vowels in pre-tonic position, in Sanga’s proposal, should be expected only as the result of RVH. However, high vowels appear in pre-tonic position even when the stressed vowel is mid or low.

In those occurrences, no case of active lowering is reported in any source. No clear alternations are given as examples to check whether lowering is an active phenomenon in Bergamo, and no form suggests the presence of any kind of lowering.

In my opinion, then, RVH in Bergamasco has the same application that we described for Bresciano, with a notable difference in the selection of targets. Round vowels raise in the harmonic contexts, while front unround mid vowels do not behave as targets, but instead as blockers.

We have already noted in §5.2 that high vowels are indeed present in unstressed pre-tonic positions in the dialect of Bergamo, even in contexts in which the stressed vowel is not high. Furthermore, in the literature on the dialect of Bergamo there is no trace of an active process of lowering.

On the basis of the data reported (cf. Sanga 1987: 46ff and Mora 1960: 23) I identified some cases in which pre-tonic mid-rounded vowels are raised when followed by a high vowel. Additional examples are taken from Zanetti (2004), who wrote a grammar of Bergamasco. I listed in (46) a series of words that display the diachronic effects of harmonic raising: where a mid vowel is expected (due to the general evolution of vowels in Bergamasco discussed in §5.2) a high vowel is present, probably due to the effects of raising triggered by a following stressed high vowel.

(46) Root internal harmony: mid-vowels do not appear if followed by a stressed high vowel

DOCT ^o RE(M)	[du'tur]	*[dotur]	'doctor'
F ^o RT ^u NA	[fyr'tyna]	*[fortyna]	'luck'
AMOR ^o SUS	[mu'rus]	*[morus]	'lover'
F ^o RM ⁱ CA(M)	[fyr'miga]	*[formiga]	'ant'
ÖL ⁱ V ^a (M)	[y'lia]	*[olia]	'olive'

More relevant are the cases of alternation that are reported in the sources treating the dialect of Bergamo. In (47) I list the words I found in these sources that demonstrate the presence of an active process of raising. All of them involve raising of a round mid vowel followed by a stressed high vowel. Crucially, no cases of raised /e/ are reported.

(47) Harmonic alternations in Bergamasco

<i>Base form</i>		<i>Harmonized forms</i>		
[ˈgodʒa]	'needle'	[gu'dʒi]	'needle DIM.'	
[me 'core]	'I run'	[oter cu'ri]	'you PL run'	
[me 'dorme]	'I sleep'	[me dur'mie]	'I was	
[øtʃ]	'eye'	[y'dʒi]	[y'dʒu]	'eye
[ˈdona]	'woman'	[du'ni]	[du'nu]	'woman
[ˈfomna]	'woman'	[fum'ni]	[fum'nu]	'woman
[ˈtond]	'round'	[tun'di]	'rod'	

In (48), instead, I list all the words reported in the sources that display a sequence composed by front non-rounded vowel followed by a high vowel. The existence of words of this kind shows on one hand the asymmetry of the harmony of Bergamasco (i.e. raising affects only round mid vowels) and on the other the absence of an active lowering pattern.

(48) Lack of raising of non-rounded vowels

<i>Disharmonic words</i>		<i>Correspondent items in Bresciano</i>
[forment'u]	'buckwheat'	[furmin'tu]
[ne'ut]	'nephew'	[ni'ut]
[løzer'tu]	'lyzard'	[lyzir'tu]
[fe'nil]	'barn'	[fi'nil]
[ve'di]	'you PL see'	
[pole'dri]	'foal DIM'	[puli'dri]
[tʃare'gi]	'poached egg'	[tʃari'gi]
[le'u]	'lion'	[li'u]
[ves'tit]	'dress'	[vis'tit]
[vesti'di]	'dress DIM'	[visti'di]
[le'sit]	'read'	[li'sit]
[pade'li]	'pan DIM'	[padi'li]
[pade'lu]	'pan AUG'	[padi'lu]

[ale'gru]	<i>'happy AUG'</i>	
[oter kre'di]	<i>'you PL believe'</i>	

To sum up, Sanga does not report any case of active lowering, nor any case in which an expected high vowel surfaces as mid. Sanga suggests that only mid vowels should be expected in unstressed position, and that high vowels in pre-tonic position are found when VH applies (i.e. only when followed by high vowels). However, we observe forms in which high vowels are present in an unstressed position and are followed by a mid or low vowel: [mi'ola] 'marrow'; [mi'ser] 'father in law'; [despi'rat] 'desperate'; [dispia'ser] 'displeasure'.

In light of these data, we can say that both high and mid vowels occur in pre-tonic position, as they do in other eastern Lombard varieties. The alternations that can be gathered in the literature suggest that round mid vowels are raised when followed by stressed high vowels, while non-round vowels are unaffected by the process. Similarly, the low vowel /a/ is not subject to raising.

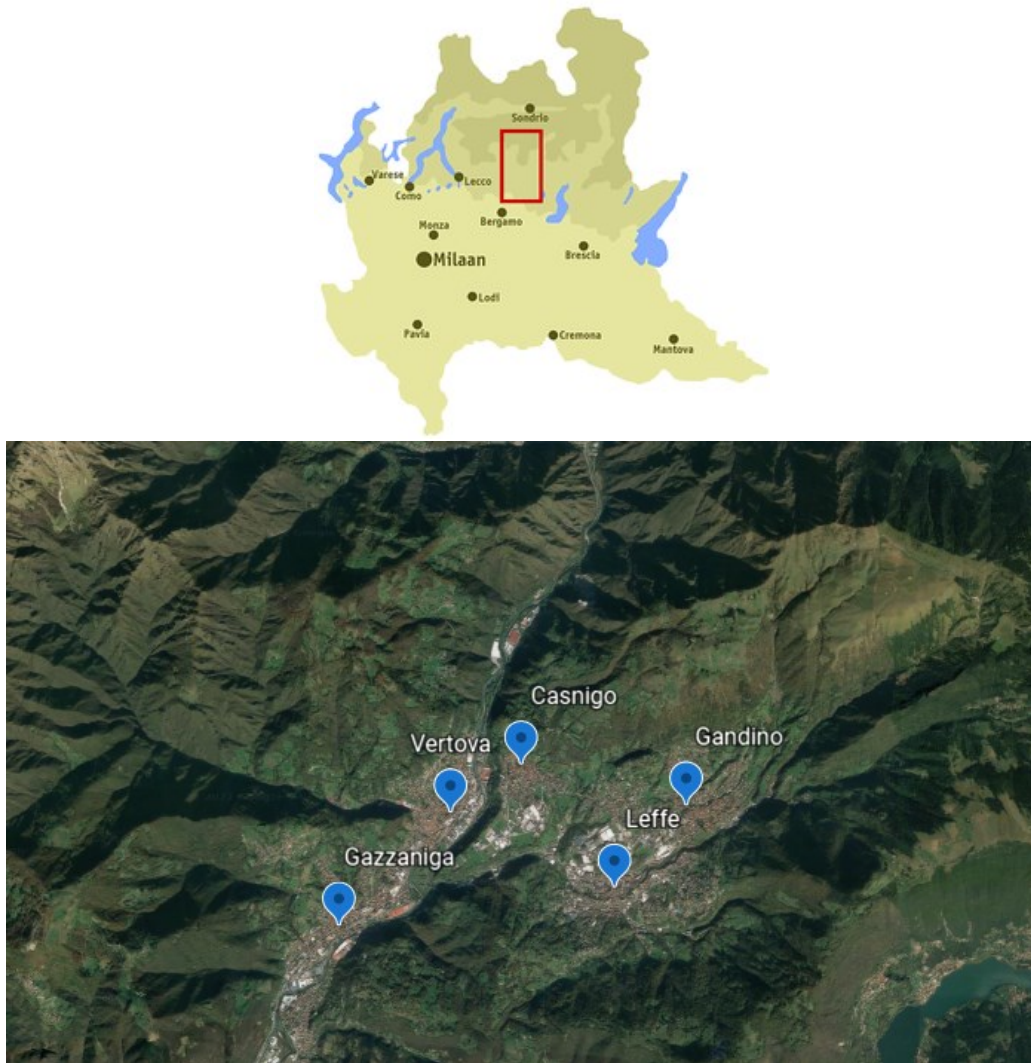
On the basis of the alternations shown in (47), and on the lack of alternations in (48), the process of Bergamasco raising can be defined as an asymmetric raising harmony with a limitation in the selection of targets. A condition forces targets to be rounded vowels /o, ø/ thereby excluding the low vowel /a/ and the non-rounded mid vowels /e/ and /ɛ/ from the set of eligible targets.

Other varieties spoken in the province of Bergamo display different patterns. In particular, dialects of Valle Cavallina and Valle Imagna (cf. §5.4)¹⁴⁶, within the borders of the administrative province of Bergamo, display a harmonic pattern that largely resembles that of Brescia, with both round and unround mid-vowels raising when followed by high vowels (cf. Bonfadini 1987). This distribution may suggest the fact that the process of RVH that is common in EL dialects started as a symmetrical process, and that the asymmetric pattern found in Bergamo is a development of a symmetric harmony that resembles the one discussed for Bresciano.

Something more can be said about the dialects spoken in Valle Seriana and Valle Gandino, which were briefly introduced in §5.4.1. In this area, dialects display a peculiar harmonic pattern that differs from the ones discussed above. All the discussions carried out in this section are based on data published in Agazzi and Bernini in Sanga (1987). The map under (49) reports the position of specific villages within the valley. Valle Gandino is a tributary valley of the larger Seriana Valley. Data reported in Agazzi (1987) and Bernini (1987) concerns the mid part of Valle Seriana and Gandino Valley.

¹⁴⁶ Valle Imagna (§5.4.3) is located in the western portion of the administrative province of Bergamo. The fact that in dialects of this area RVH behaves similarly to Bresciano suggests either a common origin for the two patterns (i.e. EL dialects had a symmetric pattern, and later Bergamo developed an asymmetric harmony) or an independent evolution of two identical processes. Further and more detailed studies of those varieties are necessary to make a hypothesis about the development of RVH.

(49) Mid Valle Seriana and Valle Gandino Valley



Five points of analysis were considered between the mid portion of Valle Seriana and Valle Gandino. Here, two raising harmonies and a lowering harmony have been reported.

The lower part of Valle Gandino and the area of the Mid Valle Seriana (Gazzaniga and Vertova) display a pattern of harmonization similar to the one discussed for Bergamo. Here harmony applies regularly when the target is round, but does not apply to the non-rounded vowel [e], so forms as [kode'gi] 'kind of sausage', [pode'ti] 'pruning knife DIM', [pre'su] 'prison', are grammatical in this area.

In Leffe, Casnigo, and Gandino, harmony appears as symmetrical, like the RVH pattern discussed for Brescia. Raised forms reported in Bernini (1987) are [kudi'gi] 'kind of sausage', [pudi'ti] 'pruning knife DIM', [pris'u] 'prison', [fri'gu] 'strawberry'.

Finally, only for what concerns the villages of Leffe and Casnigo, Bernini (1987) also report a process of lowering triggered by the low vowel /a/, which targets all preceding unstressed vowels. Here are reported forms where a process of lowering seems to have applied. In (50) the forms reported in Bernini (1987) are confronted with forms attested in Bergamasco, where lowering is not attested.

(50) Lowering harmony in Lefte and Casnigo (Valle Gandino)

/a/ lowers preceding high vowels		Correspondent items in Bergamasco
[kø'rat]	'priest'	[ky'rat]
[pe'ka]	'to beat'	[pi'ka]
[sem'patek],	'nice, funny'	[sim'patek]
[be'tfer],	'glass'	[bi'tfer]
[møle'ner].	'miller'	[myli'ner]

III.7.4 Raising Vowel Harmony in Camuno

In §1 the process of RVH of Camuno was briefly introduced as being parasitic. All mid vowels are subject to vowel harmony, but depending on the vowel that triggers the process, the set of vowels affected varies. When stressed /i/ is the triggering vowel, all preceding mid vowels raise. When the trigger vowel is /u/ instead, only round vowels undergo harmony. This means that when [e] precedes a stressed [u], harmony does not apply. The process is iterative and regressive, meaning that raised vowels behave as valid triggers for preceding mid-vowels. Notice however that even though the process may be initially triggered by a stressed /i/, if a mid vowel /o/ is affected by the process and raises to [u], a preceding /e/ would not raise, since the parasitic condition is not met.

The table in (51) shows the observations resulting from the research presented in Cresci (2014) and expanded upon in Cresci (2015).

What is interesting about the harmony of Camuno is the double behavior of the vowels [e] and [u]. Unstressed mid vowel [e] acts as a target when stressed [i] follows (cf. 51a). It acts as a blocker when a following stressed vowel is [u] (cf. 51i-k). Stressed [u] acts as a trigger when preceding vowels are round (cf. 51f-h), but instead acts as a blocker vowel when preceding vowel is [e]. The mid vowel /o/ raises when followed by both /i/ and /u/ (as expected). The result of raising is [u], which in turn behaves as a blocker for the preceding mid vowel /e/ (i.e. does not allow the harmonic property to spread towards it). In this sense, /o/ and /ø/ act as harmonic blockers for what concerns preceding /e/. They undergo and iterate the process if they follow a rounded mid-vowel, but they are unable to iterate harmony further if preceded by /e/.

(51) Results of the data collection described in Cresci (2014: 136) and Cresci (2015: 52)

	Targets	Stimulus	Base form	Diminutive	Augmentative
a.	e	<i>tooth</i>	[ˈdet]	[dinˈti]	[denˈtu]
		<i>church</i>	[ˈtʃezɔ]	[tʃiˈzinɔ]	[tʃeˈzunɔ]
b.	ε ¹⁴⁷	<i>toilet</i>	[ˈtʃɛho]	[tʃiˈhi]	[ˈtʃɛˈhu]
		<i>bed</i>	[let]	[liˈti]	[leˈtu]
c.	ε...ε	<i>comb</i>	[ˈpɛten]	[pitiˈni]	[peteˈnu]

¹⁴⁷ In the augmentative form the lexical mid-low vowel /ε/ surface as [e]. This is not due to a process of raising triggered by the following stressed /u/ of the augmentative, but follows from the fact that stressed mid-low vowels reduce to mid-high in unstressed open syllables, as discussed in 10e.

		<i>brain</i>	[hɛr'vɛl]	[hirvi'li]	[hɛrve'lu]
d.	e...ɛ	<i>cap</i>	[be'rɛt] ¹⁴⁸	[biri'ti]	[bere'tu]
		<i>Stephen</i>	['htɛfɛn]	[htifi'ni]	[htefe'nu]
e.	e...e	<i>loom</i>	[te'ler]	[tili'ri]	[tele'ru]
		<i>mountain trail</i>	[hen'tɛr]	[hinti'ri]	[hente'ru]
f.	ɔ	<i>cow-pie</i>	['hɔtɔ]	[hu'tinɔ]	[hu'tunɔ]
g.	o	<i>nail</i>	['tʃot]	[tʃu'di]	[tʃu'du]
		<i>knot</i>	['grop]	[gru'pi]	[gru'pu]
h.	o...o	<i>tomato</i>	[pon'dor]	[pundu'ri]	[pundu'ru]
i.	o...ɛ	<i>mouse</i>	[ho'rek]	[huri'gi]	[hore'gu]
		<i>umbrella</i>	[om'bɾɛlɔ]	[umbri'linɔ]	[ombre'luna]
j.	o...e	<i>hen-house</i>	[po'ler]	[puli'ri]	[pole'ru]
		<i>coin</i>	[mo'nedɔ]	[muni'dinɔ]	[mone'dunɔ]
k.	ɔ...e	<i>nun</i>	['mɔnegɔ]	[muni'ginɔ]	[mɔne'gunɔ]
l.	e...o	<i>hare</i>	['legor]	[legu'rinɔ]	[legu'runɔ]
m.	ø	<i>fire</i>	['fɔk]	[fɔga'ti/foga'ti]	[fɔga'tu/foga'tu]
		<i>eye</i>	['ɔtʃ]	[øʒa'ti/øʒa'ti]	[øʒa'tu/øʒa'tu]
n.	i...a...ø	<i>apron</i>	[biga'rɔl]	[bigaru'li]	[bigaru'lu]
o.	ɛ...ø	<i>sheet</i>	[lɛn'høl]	[lɛnhy'li/lɛnhu'li]	[lɛnhu'lu]
p.	a	<i>basket</i>	[ka'apɔ]	[kaa'ninɔ]	[kaa'nunɔ]
		<i>chair</i>	['hkaɔ]	[hka'ninɔ]	[hka'nunɔ]
q.	o...a	<i>fountain</i>	[fon'tanɔ]	[fonta'ninɔ]	[fonta'nunɔ]
		<i>necklace/yoke</i>	[ko'lanɔ]	[kola'ninɔ]	[kola'nunɔ]

Camuno displays the harmonic pattern that characterizes a partially parasitic harmony (cf. §I.5.4.1). Round vowels undergo harmony in all valid contexts (cf. 51f-m), while non-round mid vowels require a front non-round vowel to activate the process. When /u/ is a trigger, non-round vowels behave as blockers, impeding the propagation of harmony to preceding mid vowels. As in all other EL dialects considered, /a/ is neutral to the process and behaves as a blocker (cf. 51n, 51p and 51q).

A peculiarity of raising in Camuno is the fact that the asymmetry in this case involves the round/non-round dimension. In the conclusion of the previous chapter (§II.3.6), it was noted how the asymmetric limitation involving the selection of targets in raising harmonies tends to cut the set of potential targets on the high/low axis. Especially in Bantu and Romance examples, whenever a harmonic process displays an asymmetry, it affects only mid-high vowels, or mid-low vowels. Partial exceptions to this observation are the peculiar (and problematic) metaphonies of Apricena and of Veroli, as well as the total parasitic

¹⁴⁸ Data reported in Cresci (2014: 136) and Cresci (2015: 52) have two different forms for two words: [be'rɛt] (2014), [be'rɛt] (2015) 'cap'; [hen'tɛr] (2014), [hen'tɛr] (2015) 'mountain trail'. For table (44) I followed the choices made in the more recent work, Cresci (2015). In addition, there are occasions in which the nature of the pre-tonic non-rounded mid-vowel is different between the two works. I always report the form taken from Cresci (2015).

pattern of Chechen (all those cases are treated in chapter II). Camuno offers a clearer and more complete pattern of asymmetry based on the round/non-round dimension than those presented in chapter II.

Finally, the generalization proposed by Maiden (1991) regarding metaphony, discussed in §II.3.3.5.2, can be extended to all other cases of asymmetries regarding the selection of the trigger: /i/ is a better trigger for raising than back or non-round high vowels. This fact is particularly evident in Camuno, where /i/ triggers raising for all preceding mid vowels while [u] does so only for preceding rounded mid vowels.

III.7.5 Data collection in Valle Camonica: Sonico-Rino and Agnone-Erbanno

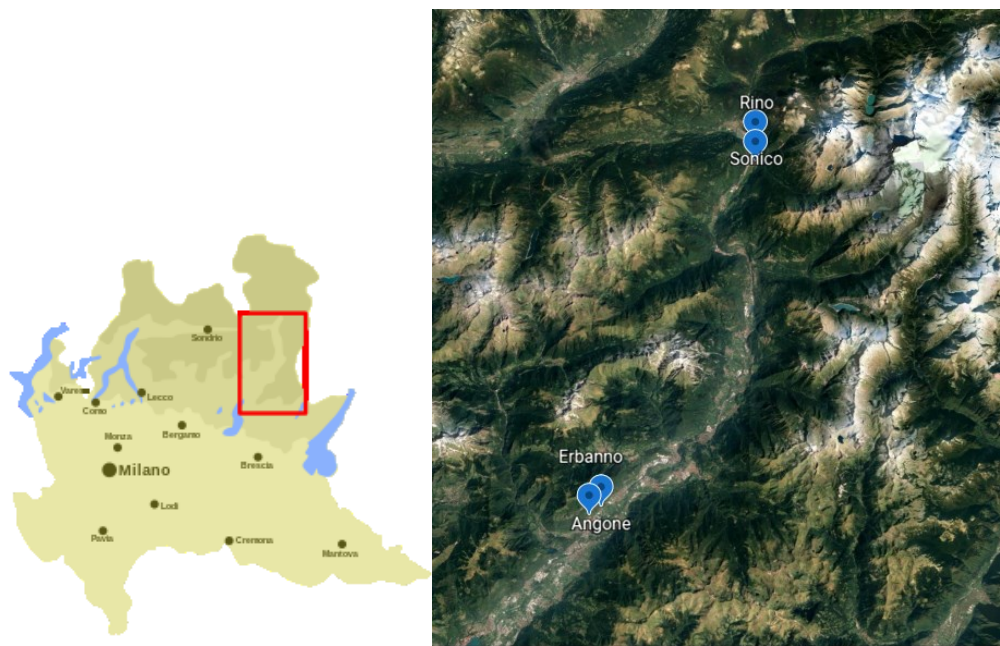
In order to confirm the behavior of the raising process in Camuno, I carried out a small fieldwork project in the area of Valle Camonica between July and September 2021, in two different areas of the valley. Four speakers were interviewed in the communal area of Sonico (in the village of Rino, center-north side of the valley). Three other speakers were interviewed in the vicinity of Darfo-Boario Terme (Erbanno and Agnone), in the southern part of the valley. The position of the villages is shown in the map under (52).

I conducted the same elicitation task discussed in §7.2, expecting roughly the same kind of base forms, and a relevant difference in the number of disharmonic sequences of the type ‘E-u’.

I noted that within the area of Valle Camonica the dialect is spoken more frequently than in Brescia, and it was therefore easier to find competent speakers. Still, all selected speakers are aged between 65 and 93. As in Brescia, the younger speakers I contacted were not confident in their use of the dialect, and preferred not to be interviewed. They asserted that Camuno was not their mother language (parents preferred to speak in Italian with their children, who learned the dialect either from their grandparents or from other speakers as a second language). All speakers I selected were born and raised in the same area where the data collection was carried out. All of them learned Camuno as their first language, and learned Italian as a second language, usually during schooling.

The dialects spoken in the two areas I was able to analyze display some small differences. Recall from §6 that Camuno is not a unitary definition for a single dialect. The valley can be divided roughly into two parts (Cresci 2014: 27), where two slightly different varieties of Camuno are spoken. Data collected in Erbanno and Agnone belongs to the Lower Camuno part, while data collected in Rino belongs to the Upper Camuno part. In addition, the dialect spoken in Rino, Sonico and Garda lacks the feature of debuccalization/weakening, which is frequent in EL dialects and typical of most of the valley (Cresci 2014: 134). Nonetheless, both varieties exhibited the same behavior as far as concerns the RVH process.

(52) Fieldwork in Valle Camonica: point of data collection



The first fieldwork site is situated in the locality of Rino, which is itself on the outskirts of a slightly bigger village called Sonico. Four speakers were interviewed, three females and one male. One of the female speakers originally comes from the nearby village of Garda, even though she lived in Rino in the house of her husband for more than 70 years. The male speaker comes from the village of Sonico. My informants claim that there are notable differences between the varieties of Garda, Sonico and Rino. From what I could hear, the differences are extremely small, and mostly regard the choice of lexical items. In any case, they do not affect the mechanism of RVH.

The second fieldwork-site is situated in the outskirts of Darfo-Boario Terme, which is the biggest center of the lower part of the valley. Speakers interviewed were from Erbanno (two male speakers) and Agnone (one female speaker).

The results of the fieldwork are shown in (53). In the table are presented the most common answers given by the speakers during the fieldwork. Speakers from both areas generally gave the same answers, with the only difference being the presence (in speakers from Erbanno and Agnone) or the absence (in speakers from Sonico and Rino) of the debuccalization/fronting feature of Camuno. In the table, I chose to report forms without debuccalization, since four out of seven participants did not have this feature in their dialect. For the full list of answers given by each speaker, cf. the Appendix.

(53) Results of the fieldwork carried out in Valle Camonica

	<i>Targets</i>	<i>Stimulus</i>	<i>Base form</i>	<i>Diminutive</i>	<i>Augmentative</i>
a.	e	<i>church</i>	[tʃeʒa]	[tʃiʒina]	[tʃeʒuna]
		<i>cup</i>	[kikera]	[kikirina]	[kikeruna]
		<i>saw</i>	[razega]	[razi'gi]	[razi'gu]
		<i>glass shard</i>	[vedre]	[vi'dri]	[vi'dru]

		<i>glass</i>	[bi'tʃer]	[bitʃi'ri]	[bitʃe'ru]
		<i>rock</i>	['kɔrna]	[kurnina]	[kurnuna]
		<i>priest</i>	['pret]	[preta'si]	[preta'su]
		<i>pear</i>	['peer]	[pi'ri]	[pee'ru]
		<i>candle</i>	[kan'dela]	[kandi'lina]	[kande'luna]
b.	ε	<i>bed</i>	[let]	[li'ti]	[le'tu]
		<i>duck</i>	['nɛdra]	[ni'dri]	[ne'dru]
		<i>sock</i>	[kal'set]	[kalsi'ti]	[kalse'tu]
		<i>pan</i>	[pa'dɛla]	[padi'li]	[pade'lu]
		<i>ring bell</i>	[kampa'nɛl]	[kampani'li]	[kampane'lu]
		<i>dustpan</i>	[pa'lɛta]	[pali'tina]	[pale'tuna]
		<i>little owl</i>	[si'ɛta]	[sii'tina]	[sietuna]
		<i>tooth</i>	['det]	[din'ti]	[den'tu]
		<i>chariot</i>	[ka'ret]	[kari'ti]	[kare'tu]
		<i>brother</i>	[fra'dɛl]	[fradi'li]	[frade'lu]
		<i>fish</i>	['pɛs]	[pesu'ti]	[pesu'tu]
		<i>cherry</i>	[sa'rɛrdʒa]	[sarir'dʒina]	[sarɛr'dʒuna]
		<i>fog</i>	['nɛbjɑ]	[nebju'lina]	[ne'bjuna]
		<i>brick</i>	[kwa'drɛl]	[kwadri'li]	[kwadre'lu]
		<i>toilet</i>	['tʃɛso]	[tʃi'si]	[tʃɛ'su]
		<i>ham</i>	[pɛr'syt]	[persy'ti]	[persy'tu]
b. ¹	ε (epenthetic)	<i>book</i>	['libɛr]	[lib'ri]	[lib'ru]
		<i>donkey</i>	['azɛn]	[az'ni]	[az'nu]
c.	o	<i>apple</i>	['pom]	[pu'mi]	[pu'mu]
		<i>nail</i>	['tʃot]	[tʃu'di]	[tʃu'du]
		<i>goose</i>	['oka]	[u'kina]	[u'kuna]
		<i>mushroom</i>	['fɔns]	[fun'zi]	[fun'zu]
		<i>mouth</i>	['bɔka]	[bu'kina]	[bu'kuna]
		<i>bag</i>	['bɔrsa]	[bur'sina]	[bur'suna]
		<i>fly</i>	['moska]	[mus'ki]	[mus'ku]
		<i>door</i>	['pɔrta]	[pur'tina]	[pur'tu]
		<i>lady</i>	['fɔmna]	[fum'nina]	[fum'nuna]
		<i>knot</i>	['grɔp]	[gru'pi]	[gru'pu]
		<i>devil</i>	['dʒaɔl]	[dʒau'li]	[dʒau'lu]
		<i>wood</i>	['bɔra]	[buri'li]	borelu
		<i>strawberry</i>	['frɔla]	[fru'lina]	[fru'luna]
d.	ɔ	<i>artichoke</i>	[arti'tʃɔk]	[artitʃu'ki]	[artitʃu'ku]

		<i>dumpling</i>	[ˈnɒk]	[ɲuˈki]	[ɲuˈku]
		<i>belly</i>	[ˈbɒdʒɑ]	[buˈdʒina]	[buˈdʒuna]
		<i>plum</i>	[ˈbrɒɲɑ]	[bruˈɲina]	[bruˈɲuna]
		<i>crow</i>	[ˈkɔrf]	[kurˈvi]	[kurˈvu]
		<i>blind man</i>	[ˈɔrp]	[ɔrbaˈtʃi]	[ɔrbaˈtʃu]
e.	ø	<i>apron</i>	[bigaˈrøɫ]	[bigaruˈli]	[bigaruˈlu]
		<i>funnel</i>	[turtaˈrøɫ]	[turtaruˈli]	[turtaruˈlu]
		<i>eye</i>	[ˈøtʃ]	[yˈtʃi]	[yˈtʃu]
		<i>egg</i>	[ˈøf]	[øaˈti]	[øaˈtu]
f.	e_e	<i>mountain trail</i>	[sɛnˈter]	[sintiˈri]	[sɛnteˈru]
g.	e_ɛ	<i>cap</i>	[beˈrɛt]	[biriˈti]	[bereˈtu]
		<i>calf</i>	[veˈdɛɫ]	[vidiˈli]	[vedeˈlu]
		<i>brain</i>	[serˈvɛɫ]	[sirviˈli]	[serveˈlu]
h.	ɛ_ɛ	<i>comb</i>	[ˈpɛtɛn]	[pitiˈni]	[peteˈnu]
		<i>peach</i>	[ˈpɛrsɛk]	[pɪrsiˈgi]	[pɛrsɛˈgu]
i.	e_o	<i>hare</i>	[ˈlegɔr]	[leguˈrina]	[leguˈruna]
		<i>sheep</i>	[ˈpɛgɔrɑ]	[pɛguˈrina]	[pɛguˈruna]
j.	ɛ_o	<i>pendulum clock</i>	[ˈpɛndɔɫ]	[pɛnduˈli]	[pɛnduˈlu]
k.	ɛ_ø	<i>sheet</i>	[lɛnˈsøɫ]	[lɛnsuˈli]	[lɛnsuˈlu]
l.	o_e_(ɛ)	<i>foal</i>	[poˈledɛr]	[puliˈdri]	[poleˈdru]
m.	o_ɛ	<i>bird</i>	[oˈzɛɫ]	[uziˈli]	[ozeˈlu]
		<i>ear</i>	[oˈrɛtʃɑ]	[uriˈtʃina]	[oreˈtʃuna]
		<i>sister</i>	[soˈrɛɫɑ]	[suriˈlina]	[soreˈluna]
		<i>umbrella</i>	[omˈbrɛɫɑ]	[umbriˈli]	[ombreˈlu]
		<i>knife</i>	[korˈtɛɫ]	[kurtiˈli]	[korteˈlu]
		<i>pig</i>	[porˈsɛɫ]	[pursiˈli]	[porseˈlu]
		<i>mouse</i>	[ˈsores]	[suriˈsi]	[soreˈsu]
		<i>horn</i>	[ˈkɔrɛn]	[kurˈni]	[kurˈnu]
		<i>pruning knife</i>	[poˈdɛt]	[pudiˈti]	[podeˈtu]
n.	o_o	<i>tomato</i>	[ponˈdɔr]	[punduˈri]	[punduˈru]
o.	ø_ɛ	<i>lizard</i>	[lyˈzɛrda]	[lyzirˈdina]	[lyzerˈdu]
		<i>zucchini</i>	[syˈkɛɫ]	[sykiˈli]	[sykiˈlu]
p.	a.	<i>dog</i>	[ˈkɑɲøɫ]	[kaˈɲuli]	[kaˈɲulu]
		<i>hand</i>	[ˈma]	[maˈnina]	[maˈnuna]
		<i>chair</i>	[ˈskɑɲɑ]	[skaˈɲi]	[skaˈɲu]
		<i>tree</i>	[ˈpʲanta]	[pʲanˈtina]	[pʲanˈtuna]
		<i>cow</i>	[ˈaka]	[aˈkina]	[aˈkuna]

		<i>trousers</i>	['brage]	[bra'gine]	[bra'gune]
		<i>mustaches</i>	['bafi]	[bafi'ti]	[ba'fu]
		<i>cat</i>	['gat]	[ga'ti]	[ga'tu]
		<i>goat</i>	['kavra]	[kav'ri]	[kav'ru]
		<i>bread</i>	['pa]	[pa'ni]	[pa'nu]
		<i>key</i>	['tʃaf]	[tʃai'tina]	[tʃai'tuna]
		<i>cock</i>	['gal]	[gali'ti]	[gali'tu]
		<i>leg</i>	['gamba]	[gam'bina]	[gam'buna]
		<i>nose</i>	['nas]	[na'zi]	[na'zu]
		<i>boat</i>	['barka]	[bar'kina]	[bar'kuna]
q.	a_a	<i>sausage</i>	[sa'lam]	[sala'mi]	[sala'mu]
		<i>horse</i>	[ka'al]	[kaa'li]	[kaa'lu]
		<i>potato</i>	[pa'tata]	[pata'tina]	[pata'tuna]
		<i>pheasant</i>	[fa'za]	[faza'ni]	[faza'nu]
r.	i	<i>fig</i>	['fik]	[fi'gi]	[fi'gu]
		<i>finger</i>	['dit]	[di'ti]	[di'tu]
s.	u	<i>wolf</i>	['luf]	[lu'fi]	[lu'fu]
		<i>flower</i>	['fjur]	[fjuri'li]	[fjuri'lu]
t.	y	<i>mule</i>	['myl]	[my'li]	[my'lu]
		<i>ingernail</i>	['yndʒa]	[yn'dʒina]	[yn'dʒuna]
u.	o_a	<i>necklace</i>	[ko'lana]	[kola'nina]	[kola'nuna]
		<i>fountain</i>	[fon'tana]	[fonta'nina]	[fonta'nuna]
		<i>orange</i>	[porto'gal]	[portoga'li]	[portoga'lu]
w.	ø_a	<i>snail</i>	[ly'maga]	[lyma'gina]	[lyma'guna]
x.	y_a	<i>spoon</i>	[ky'dʒa]	[kydʒa'ni]	[kydʒa'nu]
y.	i_i	<i>dress</i>	[vis'tit]	[visti'di]	[visti'du]
z.	u_i	<i>bottle</i>	[bu'tiʎa]	[buti'ʎina]	[buti'ʎuna]
		<i>rabbit</i>	[ku'nitʃ]	[kuni'tʃi]	[kuni'tʃu]
z ^a .	u_u	<i>doctor</i>	[du'tur]	[dutu'ri]	[dutu'ru]

The results of the collection confirmed the behavior of RVH in Camuno already noted by Cresci. All mid vowels are affected by raising when followed by stressed /i/, while only round vowels were affected by raising when followed by stressed /u/. In other words, the vowel sequence E-u (which was avoided in Brescia, for the most part), is the norm in Camuno.

Some speakers (namely DM, LLB, LR, PG) had the tendency of producing round mid vowels in pre-tonic position as high vowels, even when harmony was not expected. This resulted in a handful of words where raising applied in unexpected contexts. I report them in the table (54) below. Those cases of 'unexpected raising' (or more probably of vowel reduction, cf. the discussion below about the results of the speaker LR) have not been counted as 'relevant'.

(54) Unexpected high vowels in pre-tonic position in diminutive and augmentative forms

<i>Speakers</i>	<i>Base form</i>	<i>Diminutive</i>	<i>Augmentative</i>	
DM	['øf]	[ua'ti]	[oa'tu]	'egg'
LLB	['køɾən]	[kurna'zi]	[kurna'zu]	'horn'
	[om'brɛla]	[umbri'li]	[umbre'lu]	'umbrella'
	['sores]	[suri'si]	[sure'su]	'mouse'
LR	['øtʃ]	[ydʒa'ti]	[ydʒa'tu]	'eye'
	['øf]	[ua'ti]	[ua'tu]	'egg'
PG	['øtʃ]	[ydʒa'ti]	[ydʒa'tu]	'eye'
	['køɾən]	[kurna'zi]	[kurna'zu]	'horn'

In the set of tables under (55) are reported the number and percentages of application of VH for each speaker interviewed. The tables follow the same rules I laid out and discussed in §7.2.2: only “relevant tokens” (i.e. where harmony could apply, whether it does or not) are considered. The disharmonic sequence ‘E-u’, whose frequency is the most relevant difference compared to the process of Brescia, is noted in the tables below alongside the other disharmonic sequences. The last table summarizes the results.

(55) Specific results of the fieldwork carried out in Valle Camonica

CM. 84 years old, female speaker from Rino

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	126	69	57	5	48	1	3	0	0
		54.7%	45.2%	3.9%	38.1%	7.9%	2.4%		
E	55	21	34	5	29				
		38.2%	61.8%	9.1%	52.7%				
O	33	29	4			1	3		
		87.9%	12.1			3%	9.1%		
Ø	8	8	0					0	0
		100%							
E-E	7	3	4	0	4				
		42.8%	57.2%		57.2%				
E-O	5	0	5	0	5	0	0		
			100%		100%				
E-Ø	2	0	2	0	2			0	0
			100%		100%				
O-E	15	7	8	0	8	0	0		
		46.7%	53.3%		53.3%				
O-O	1	1	0			0	0		
		100%							

GF. 93 years old, female speaker from Garda

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	80	46	34	2	32	0	0	0	0
		57.5%	42.5%	2.5%	40%				
E	36	14	22	2	20				
		38.9%	61.1%	5.6%	55.6%				
O	18	18	0			0	0		
		100%							
Ø	2	2	0					0	0
		100%							
E-E	7	4	3	0	3				
		57.1%	42.8%		42.8%				
E-O	4	0	4	0	4	0	0		
			100%		100%				
E-Ø	0	0	0	0	0			0	0
O-E	13	7	5	0	5	0	0		
		53.8%	38.4%		38.4%				

DM 75 years old, female speaker from Rino

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	127	77	50	3	47	0	0	0	0
		60.6%	39.4%	2.4%	37%				
E	49	18	31	2	29				
		36.7%	63.3%	4.1%	59.2%				
O	37	37	0			0	0		
		100%							
Ø	7	7	0					0	0
		100%							
E-E	10	4	6	1	5				
		40%	60%	10	50%				
E-O	4	0	4	0	4	0	0		
E-Ø	2	0	2	0	2			0	0
			100%		100%				
O-E	15	8	7	0	7	0	0		
		53.3%	46.7%		46.7%				
O-O	3	3	0			0	0		
		100%							

LLB 76 years old, male speaker from Sonico

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	123	76	47	2	45	0	0	0	0
E	52	21	31	2	29				
O	37	37	0			0	0		
Ø	6	6 100%	0					0	0
E-E	8	4 50%	4 50%	0	4 50%				
E-O	4	0	4 100%	0	4	0	0		
E-Ø	2	0	2	0	2			0	0
O-E	12	6	6	0	6	0	0		
O-O	2	2 100%	0			0	0		

GR, 70 years old, male speaker from Erbanno

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	84	54 64.3%	30 35.7%	1 1.2%	28 33.3%	1 1.2%	0	0	0
E	34	19 55.9%	15 44.1%	0	15 44.1%				
O	22	21 95.5%	1 5.5%			1 5.5%	0		
Ø	3	3 100%	0					0	0
E-E	8	4 50%	4 50%	1 12.5%	3 37.5%				
E-O	7	0	7 100%	0	7 100%	0	0		
E-Ø	1	0	1 100%	0	1 100%			0	0
O-E	6	4 66.7%	2 33.3%	0	2 33.3%	0	0		
O-O	3	3 100%	0			0	0		

LR, 73 years old, male speaker from Erbanno

Speaker LR realized the vowel [u] unstressed in contexts where an unstressed [o] was expected, differently from other speakers of the valley I interviewed. For example, the word for ‘sister’, that other speakers produced as [ho'relə], was instead produced as [hu'relə], with a high vowel [u] instead of the expected [o]. This happened in all tokens he produced: no occurrence of unstressed [o] was detected for this speaker¹⁴⁹. This clearly makes observing raising more complex for mid rounded vowels. Alternations such as [pom] [pu'mi] [pu'mu] can be considered as the result of two different process. Either it is a case of application of the raising vowel harmony, or it can be considered a case of vowel reduction that targets vowels that pass from a stressed to an unstressed position. Vowel reduction in EL dialects, as far as my observation and my research suggested, was limited to [-ATR] mid-vowels in stressed open syllable that became [+ATR] in unstressed position. While discussing the nature of vowels in Cigole, Sanga (1979) noted that the pronunciation of unstressed pre-tonic [e] and [o] is rather high (Sanga 1979: 23), to the point that ‘they can be sometimes be pronounced as [i]/[u]’. The [u]s in the tokens produced by LR may just be an extremely high-frequency phonetic realization of an underlying /o/.

Regarding the analysis of the tokens of this specific speaker, I operated in the following fashion: when in a given base form an unstressed /o/ was pronounced as [u], I treated it as an underlying /u/ (e.g. [hurek] [hurigi] [huregu]: the only vowel that participates in the harmonic process is /ε/). When a stressed /o/ raised to [u] (e.g. [tʃot] ‘nail’ [tʃu'di] ‘nail DIM’ [tʃu'du] ‘nail AUG’) I counted it as a case of raising caused by harmony, since an alternation is actually recorded.

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	100	49	51	6	44	1	0	0	0
		49%	51%	6%	44%	1%			
E	56	24	32	2	30				
		42.8%	57.2%	3.6%	53.6%				
O	23	22	1			1	0		
		95.7%	4.3%			4.3%			
Ø	1	1	0					0	0
		100%							
E-E	8	1	7	4	3				
		12.5%	87.5%	50%	37.5%				
E-O	4	0	4	0	4	0	0		
			100%		100%				
E-Ø	2	0	2	0	2			0	0
			100%		100%				
O-E	4	0	4	0	4	0	0		
			100%		100%				
O-O	2	1	1		1 ¹⁵⁰	0	0		

¹⁴⁹ The only exceptions are the sporadic [o]s in final position, which are considered to be a masculine suffix derived from modern Italian. In addition, he produced unstressed pretonic [o] in the token [pon'dor] ‘tomato’.

¹⁵⁰ The diminutive of the base form [pon'dor] ‘tomato’ was the regular [punduri], with raising of both mid vowels of the root. The augmentative form this speaker gave was [ponde'ru], with the substitution of [o] in the root by [e]. This bizarre insertion of [e] in the root affects the application of VH, and this is the reason a disharmonic sequence of the type ‘E-u’ turns

		100%			50%				
--	--	------	--	--	-----	--	--	--	--

PG 91 years, female speaker from Agnone.

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	113	60	53	6	47	0	0	0	0
		53%	46.9%	5.3%	41.6%				
E	66	29	37	2	35				
		43.9%	56.1%	3%	53.1				
O	25	25	0			0	0		
		100%							
Ø	3	3	0					0	0
		100%							
E-E	8	0	8	4	4				
			100%	50%	50%				
E-O	5	1 ¹⁵¹	4	0	4	0	0		
		20%	80%		80%				
E-Ø	2	0	2	0	2			0	0
			100%		100%				
O-E	2	0	2	0	2	0	0		
			100%		100%				
O-O	2	2	0			0	0		
		100%							

Complete analysis:

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	753	431	322	25	291	3	3	0	0
E	348	146	202	15	187				
		41.9%	58.1%	4.3%	53.7%				
O	195	189	6			3	3		
		96.9%	3.1%			1.55%	1.55%		
Ø	30	30	0					0	0
		100%							
E-E	56	20	36	10	26				
		35.7%	64.3%	17.8%	46.5%				
E-O	33	1 ¹⁵²	32	0		0	0		
		3.3%	96.7%						

up on this occasion.

¹⁵¹ Speaker PG exceptionally raised one pre-tonic /e/ followed by /u/. Given the base form [legor], her diminutive was [ligursi], with the unexpected raising of /e/. This is the only case I encountered in which the parasitic nature of VH in Camuno was not respected, and a pre-tonic /e/ raised when followed by the trigger /u/.

¹⁵² Cf. note 150.

E-Ø	11	0	11	0	11			0	0
			100%		100%				
O-E	67	32	35	0	35	0	0		
		47.8%	52.2%		52.2%				
O-O	13	12	1		1	0	0		
		92.3%	7.7%		7.7%				

The raising process that is active in Camuno clearly displays a different behavior than the one discussed for Bresciano in §7.2. The harmonic rule of Camuno does not forbid sequences of the type E-u, which are extremely frequent. Raising applies regularly to round mid vowels (with only a handful of exceptions), and rather frequently to front non-round mid vowels when /i/ triggers the process. In this last case, the percentages of disharmonies detected (i.e. disharmonies of the type E-i) does not deviate much from the one discussed for Brescia in §7.2.2. None of the unstressed /e/ followed by a rounded high vowel underwent raising, with a single bizarre exception (discussed in note 150).

III.7.6 Summary: micro-variation in the harmonic patterns of Eastern Lombardy

III.7.6.1. The three main harmonic patterns of EL

The three major varieties of eastern Lombardy individuated in §3.3, Bresciano, Bergamasco and Camuno, display three different patterns of raising caused by vowel harmony. The process exhibited by Bresciano has a symmetrical pattern: harmony applies in all contexts. Bergamasco shows a harmony that does not apply to the non-round front vowels, while Camuno shows a parasitic harmonic pattern. Raising in EL always applies iteratively, with targets of raising behaving as triggers for preceding targets in all three varieties reported.

a /o/ raises to [u] when followed by /i/ and /u/ (and /y/) in Bresciano, Bergamasco and Camuno. The mid-low round vowel /ɔ/ is never expected in unstressed position. When a stressed /ɔ/ becomes unstressed, it reduces to [o] (cf. §4.3 and §5.3).

b /ø/ raises to [u] or [y] when followed by /i/ and /u/ (and /y/) in Bresciano, Bergamasco and Camuno.

c /e/ and /ɛ/ raise to [i] when followed by /i/, /u/ (and /y/) in Bresciano, they are not affected by raising in Bergamasco, while in Camuno they undergo raising only if /i/ is the trigger.

Front non-round vowels [e] and [ɛ], when unstressed, are in complementary distribution in all the three varieties of EL considered. [e] appears in unstressed open syllables, while [ɛ] appears in unstressed closed syllables. Their outcome for raising is always [i] no matter what the original vowel was. The most obvious analysis for this state of affairs is to consider the two realizations of (pre-tonic) [e] and [ɛ] to be allophones of a single underlying /e/, which raises to [i] when subject to harmony. We can thus conclude that only mid-high vowels are present in pre-tonic position, and since all outcomes of raising are high vowels, RVH in EL can be considered a case of complete raising harmony in the sense proposed by Parkinson (1996: 113): all outcomes of raising share the same degree of height. In Camuno, where /e/ undergoes harmony only when /i/ is the trigger, it may appear that a /ɛ/ in the base form becomes [e] when followed by /u/. This is not a case of scalar raising triggered by /u/, however. On all occasions where this happens, the syllabic context changes, resulting in an open syllable which hosts only mid-high vowels. Consider, as an example, the token [be'ret] 'cap'. The augmentative form of this token in Camuno, where harmony is parasitic on rounding, is [bere'tu]. This is not a case of scalar raising (in the

sense discussed in §II.2) but a case of vowel reduction due to the passage of a mid-low vowel from a stressed position to an unstressed open syllable.

The mechanisms of RVH in the three varieties of EL considered in this chapter are summarized in (56). Data for the examples come from Bresciano (data collection discussed in §7.2), Bergamasco (Sanga 1987, Zanetti 2004), Camuno (Cresci 2014, Cresci 2015, data collection discussed in §7.5). The peculiar patterns of the Gandino valley treated in §7.3 are not considered here: all data reported come from Bernini (1987: 153-311), and it appears that raising behaves like in Bergamo in the lower part of the valley, and like in Bresciano in the highest part. The double raising/lowering pattern of the central valley, while interesting, does not exhibit any difference in the raising mechanisms discussed for other EL varieties.

(56) Summary of the three harmonic patterns discussed in this chapter

<i>Trigger:</i> -i	<u>e</u>	<u>o</u>	<u>ø</u>	<u>e...e</u>	<u>e...o</u>	<u>e...ø</u>	<u>o...e</u>	<u>o...o</u>	<u>o...ø</u>	<u>ø...e</u>
<i>Brescia</i> <i>no</i>	i	u	y/u	i...i	i...u	i...y	u...i	u...u	u...y	y...i
	[din'ti]	[tʃu'di]	[fy'gi]	[vidi'li]	[ligu'ri]	[linsy'li]	[kuni'tʃi]	[pundu'ri]	[puzy'li]	[syki'li]
<i>Bergam</i> <i>asco</i>	e	u	y/u	e...e	e...u	e...y	o...e	u...u	u...y	ø...e
	[fe'nil]	[ku'ri]	[y'tʃi]		[legu'ri]		[pole'dri]			
<i>Camuno</i>	i	u	y/u	i...i	e...u	i...y	u...i	u...u	u...y	y...i
	[tʃi'zino]	[tʃu'du]	[fy'gi]	[piti'ni]	[legu'ri]	[lenhy'li]	[huri'gi]	[pundu'ri]	[puzy'li]	
<i>Trigger:</i> -u	<u>e</u>	<u>o</u>	<u>ø</u>	<u>e...e</u>	<u>e...o</u>	<u>e...ø</u>	<u>o...e</u>	<u>o...o</u>	<u>o...ø</u>	<u>ø...e</u>
<i>Brescia</i> <i>no</i>	i	u	y/u	i...i	i...u	i...y	u...i	u...u	u...y	y...i
	[din'tu]	[tʃu'du]	[y'tʃu]	[sirvi'li]	[ligu'ru]	[linsy'lu]	[suri'gu]	[pundu'ru]		[syki'lu]
<i>Bergam</i> <i>asco</i>	e	u	y/u	e...e	e...u	e...y	o...e	u...u	u...y	ø...e
	[pre'su]	[dun'nu]	[y'tʃu]							[løzer'tu]
<i>Camuno</i>	e	u	y/u	e...e	e...u	e...y	o...e	u...u	u...y	ø...e
	[tʃe'zuno]	[tʃu'du]	[y'tʃu]	[serve'lu]	[legu'ru]	[lenhy'lu]	[hore'gu]	[pundu'ru]		

III.7.7 Outcome of mid-round vowel ø subject to raising

In both the fieldwork carried out by Cresci (2015) and in my own in Brescia and Valle Camonica, the expected outcome for the vowel [ø] in all raising contexts is [y], but often the outcome of [ø] is back round [u] instead. Tables in (38) and (46) certify that /y/ generally behaves as /u/ in raising contexts,

meaning that it does not trigger raising of preceding non round mid-vowels in the parasitic harmony of Camuno. Noting the double behavior of \emptyset , Cresci (2014) carried out a data collection focused on the outcome of front rounded $[\emptyset]$ in raising contexts. In Camuno the vowel \emptyset is expected to occur only in stressed position (cf. §6.2) while in Bresciano and Bergamasco, \emptyset is expected both in stressed and unstressed position.

Among Cresci’s data set, only four tokens displayed the vowel \emptyset in the base form: $[\text{f}\emptyset\text{k}]$ ‘fire’, $[\text{\textcircled{e}}\text{t}\text{ʃ}]$ ‘eye’, $[\text{b}\text{i}\text{g}\text{a}\text{r}\emptyset\text{l}]$ ‘apron’, and $[\text{l}\text{e}\text{n}\text{h}\emptyset\text{l}]$ ‘bedsheet’. The table in (57) recalls the results from her initial fieldwork, which we have seen previously in (51).

(57) Tokens containing the target $/\emptyset/$ in Cresci’s data set

\emptyset	<i>fire</i>	$[\text{'f}\emptyset\text{k}]$	$[\text{f}\emptyset\text{g}\text{a}'\text{ti}/\text{f}\emptyset\text{g}\text{a}'\text{ti}]$	$[\text{f}\emptyset\text{g}\text{a}'\text{tu}/\text{f}\emptyset\text{g}\text{a}'\text{tu}]$
	<i>eye</i>	$[\text{'\textcircled{e}}\text{t}\text{ʃ}]$	$[\text{\textcircled{e}}\text{z}\text{a}'\text{ti}/\text{\textcircled{e}}\text{z}\text{a}'\text{ti}]$	$[\text{\textcircled{e}}\text{z}\text{a}'\text{tu}/\text{\textcircled{e}}\text{z}\text{a}'\text{tu}]$
$\text{i}\dots\text{a}\dots\emptyset$	<i>apron</i>	$[\text{b}\text{i}\text{g}\text{a}'\text{r}\emptyset\text{l}]$	$[\text{b}\text{i}\text{g}\text{a}\text{r}\text{u}'\text{li}]$	$[\text{b}\text{i}\text{g}\text{a}\text{r}\text{u}'\text{lu}]$
$\text{\textcircled{e}}\dots\emptyset$	<i>sheet</i>	$[\text{l}\text{e}\text{n}'\text{h}\emptyset\text{l}]$	$[\text{l}\text{e}\text{n}\text{h}\text{y}'\text{li}/\text{l}\text{e}\text{n}\text{h}\text{u}'\text{li}]$	$[\text{l}\text{e}\text{n}\text{h}\text{u}'\text{lu}]$

Cresci (2015: 54) discusses the details of the answers given by the speakers she interviewed. She noted that only a handful of speakers from the upper side of the valley did not interpose the suffix –at/–as between the roots $[\text{f}\emptyset\text{k}]$ and $[\text{\textcircled{e}}\text{t}\text{ʃ}]$ and the augmentative or diminutive stressed suffix. This means that most of her speakers did not raise $/\emptyset/$ because of the effect of an intervening low vowel $/\text{a}/$, that blocks the process of raising for preceding vowels.

In addition, both her and her collaborator’s intuitions of native speakers of Camuno suggested that forms such as $[\text{f}\emptyset\text{g}\text{a}'\text{ti}]$ ‘fire DIM’, $[\text{f}\emptyset\text{g}\text{a}'\text{tu}]$ ‘fire AUG’ and $[\text{\textcircled{e}}\text{d}\text{z}\text{a}'\text{ti}]$ ‘eye DIM’ $[\text{\textcircled{e}}\text{d}\text{z}\text{a}'\text{tu}]$ ‘eye AUG’ were possible alternatives to the forms $[\text{f}\emptyset\text{g}\text{a}'\text{ti}]-[\text{f}\emptyset\text{g}\text{a}'\text{tu}]$, $[\text{\textcircled{e}}\text{d}\text{z}\text{a}'\text{ti}]-[\text{\textcircled{e}}\text{d}\text{z}\text{a}'\text{tu}]$. This means that \emptyset can appear in unstressed position in Camuno (contrary to her expectations, going into the fieldwork), but also that this form can alternate more or less freely with $/\text{o}/$.

Another issue involving the behavior of $/\emptyset/$ in raising contexts concerns the raised forms $[\text{b}\text{i}\text{g}\text{a}\text{r}\text{u}'\text{li}]$ ‘apron DIM’ and $[\text{l}\text{e}\text{n}\text{h}\text{u}'\text{li}]-[\text{l}\text{e}\text{n}\text{h}\text{y}'\text{li}]$ ‘bedsheet DIM’. Both of them are present in Cresci’s data collection, and both of them are grammatical. However, there is a difference in the treatment of the sound sequence $/\emptyset\text{l}/$ in the two tokens.

Some speakers treated it as an intervening suffix between the base and the augmentative or diminutive suffix, for what concerns the base $[\text{b}\text{i}\text{g}\text{a}\text{r}\emptyset\text{l}]$ ‘apron’. Hence, Cresci collected forms such as $[\text{b}\text{i}\text{g}\text{a}'\text{ri}]$ ‘apron DIM’ and $[\text{b}\text{i}\text{g}\text{a}'\text{ru}]$ ‘apron DIM’ (where the sequence $/\emptyset\text{l}/$ is treated as a suffix, and eliminated in the augmentative or diminutive form). The same happened in a handful of cases during my fieldwork (e.g the speakers VM, MB and LB1 in Brescia, and speaker LLB in Rino produced the diminutive form $[\text{b}\text{i}\text{g}\text{a}\text{r}\text{i}]$ starting from the base $[\text{b}\text{i}\text{g}\text{a}\text{r}\emptyset\text{l}]$). This never happened for the base form $[\text{l}\text{e}\text{n}\text{h}\emptyset\text{l}]$ ‘bedsheet’: only forms such as $[\text{l}\text{e}\text{n}\text{h}\text{u}\text{l}\text{i}]-[\text{l}\text{e}\text{n}\text{h}\text{y}\text{l}\text{i}]$ were collected by Cresci, while forms like $*[\text{l}\text{e}\text{n}\text{h}\text{i}]$ $*[\text{l}\text{e}\text{n}\text{h}\text{u}]$ are not accepted.

These facts raise two additional questions. What determines the pattern of $/\emptyset/$ and $[\text{u}]$ alternation, versus the $/\emptyset/$ and $[\text{y}]$ alternation? What determines the pattern of $/\emptyset/$ and $[\text{o}]$ alternation versus the $/\emptyset/$ and $[\emptyset]$ alternation? Cresci organized further field research with the intention of answering these questions.

Her goal was to see whether the alternation between the raised forms $[\text{y}]$ and $[\text{u}]$ for the target $/\emptyset/$ was systematic or random. She hypothesized that $/\emptyset/$ alternating with $[\text{u}]$ was not a pure phonological process,

but instead a morpho-phonological one, i.e. a process that specifically applies to /ø/ when the vowel belongs to the suffix /-øɫ/. In this case, [-'øɫ] and [-ul] would be two allomorphs of the same morpheme /-'øɫ/, with [-ul] occurring in the environment of a following high stressed vowel.

She tested her hypothesis observing harmony in the following morpho-syntactic contexts:

- 1) The suffix /-'øɫ/ (58a-g),
- 2) Verbs ending in ['øɫ] (58h-j),
- 3) Verbs ending in /'ø/ followed by a segment different from /l/ (58k-l);

In addition, she tested four different phonological environments

- 4) [ø] in base-final syllables before /l/ (58m-p)
- 5) [ø] in base-initial syllables before /l/ (58q),
- 6) [ø] in base-final syllables before a consonant different from /l/ (58r-t),
- 7) [ø] in base-initial syllables before a consonant different from /l/ (58u-w).

The conclusions of her fieldwork are reported in (58), where the collected forms are reported as well as the percentages of application of raising and the percentages of raising to [u] and raising to [y] of each kind of token observed.

(58) Possible outcomes of raised /ø/ in Cresci's dataset (cf. Cresci 2015: 56ff)

Morphological context:			Base form	Diminutive	Imperfective	Outcome of ø raising		Raising
1) Diminutive suffix -øɫ	a.	<i>bib</i>	baa'røɫ	baaru'liɔ		[u] 100%	[y] 0%	100%
	b.	<i>apron</i>	biga'røɫ	bigaru'li				
	c.	<i>food-cabinet</i>	mohka'røɫ	mohkaru'li nɔ				
	d.	<i>hankerchief</i>	fa'høɫ	fahu'li				
	e.	<i>armful</i>	bra'høɫ	brahu'li				
	f.	<i>balcony</i>	pø'zøɫ	puzu'li				
	g.	<i>funnel</i>	torta'røɫ	tortaru'li				
2) Verbs ending in øɫ#	h.	<i>it hurts</i>	'døɫ		du'liɔ - dy'liɔ	[u] 95.5%	[y] 4.5%	100%
	i.	<i>s/he/it wants</i>	'vøɫ		vu'liɔ - vy'liɔ			
	j.	<i>s/he/it can</i>	'pøɫ		pu'liɔ - py'liɔ			
3) Verbs ending in ø + a consonant different from /l/.	k.	<i>s/he/it moves</i>	'møf		mu'io - my'io	[u] 46.4%	[y] 53.6%	100%
	l.	<i>it rains</i>	'pjøf		pju'io/pjy'io			
Phonological context:			Base form	Diminutive	Outcome of ø raising		Raising	
4) Base Final	m .	<i>orchard</i>	'brøɫ	bru'li - bry'li	[u] 91.5%	[y] 8.5%	100%	

syllable before /l/ ø/#	n.	<i>bean</i>	fa'zøɫ	fazu'li - fazy'li			
	o.	<i>bedsheet</i>	lən'høɫ	lənhu'li - lənhy'li			
	p.	<i>hazelnut</i>	ni'høɫɔ	nihu'liɔ - nihy'liɔ			
5) Base initial syllable before /l/	q.	<i>home spool</i>	hpo'letɔ - hpø'letɔ	hpuli'tino - hpyli'tino	[u] 50%	[y] 50%	100%
6) Base final syllable before other sound	r.	<i>louse</i>	pi'øtʃ	piu'tʃi - piy'tʃi	[u] 35.5%	[y] 57.7%	93.2%
	s.	<i>cross-eyed</i>	hka'løtʃ	hkalu'tʃi - hkaly'tʃi			
	t.	<i>knee</i>	zi'nøtʃ	zinu'tʃi - ziny'tʃi			
7) Base initial syllable before other sound	u.	<i>heart</i>	'kør	kuri'zi - kyri'zi	[u] 14.3%	[y] 85.7%	100%
	x.	<i>wheel</i>	'rødɔ	rudi'liɔ - rydi'liɔ			
	w.	<i>rose</i>	'røzɔ	ruzi'liɔ - ryzi'liɔ			

She concludes that /ø/ raises to [u] without exception in the suffix /-øɫ/, while elsewhere, it raises either to [u] or [y], with [u] being more frequent in base-final syllables before /l/, and [y] elsewhere. The special status of this suffix /-øɫ/ may affect the way raising applies in other contexts, since a following /l/ seems to prefer [u] as a raised variant, even when the sequence /øɫ/ is not part of the diminutive suffix.

For what is worth, the observations I made during my data collections coincide with insights of Cresci even for Bresciano. I did not carry out specific fieldwork to check the outcome of raised /ø/, as she did, but I observed the raised outcomes of the raised forms containing a front round vowel in the root. I report the results from Brescia in (59).

(59) Tokens containing the target \emptyset in my data set on Bresciano

<i>apron</i>	[biga'røɫ]	[bigaru'li]	[bigaru'lu]
<i>funnel</i>	[tyrta'røɫ]	[tyrtaru'li]	[tyrtaru'lu]
<i>finger nail</i>	['øndʒa]	[yn'dʒina]	[yn'dʒuna]
<i>strawberry</i>	[ma'øla]	[may'lina] - [maulina]	[may'luna]
<i>eye</i>	['øtʃ]	[y'tʃi]	[y'tʃu]
<i>egg</i>	['øf]	[øfa'zi] - [yfi]	[øfa'zu] - [yfu]
<i>sheet</i>	[lɛn'søɫ]	[linsu'li]	[linsu'lu]
<i>ham</i>	[pɛr'søt]	[pɛrsu'ti] - [pɛrsyti]	[pɛrsu'tu] - [pɛrsytu]

As noted by Cresci, whenever the sequence /øɫ/ could be considered a suffix (even when it is not, as in [biga'røɫ] ‘apron’ and [tyrta'røɫ] ‘funnel’) the only observed outcome of /ø/ raising is [u]. Otherwise, there is alternation between [y] and [u]. We can conclude that both [u] and [y] are valid raised alternants for the front rounded mid-vowel /ø/, and that their behavior in the raising process (i.e. their capacity or incapacity to raise preceding mid vowels) coincides in both Bresciano and Camuno. With this I mean that in Bresciano, [y] raises all preceding mid-vowels, both round and non-round, while in Camuno it patterns with [u] in raising round vowels, but fails in raising preceding non-round mid vowels. Proof for this behavior of /y/ comes from the reported form [lɛnhy'li], which co-exists with the form [lɛnhu'li] in Camuno, in Cresci (2015), as well as for static forms such as [pɛr'hyt] ‘ham’, *[pɛr'thyt] and its preferred diminutive alternant [pɛrhy'ti] ‘ham DIM’ *[pɛrhy'ti].

The morphological nature of the vowel can affect the chosen raised alternant, since all occurrences of the diminutive morpheme /-øɫ/ raise to [u] without exception. This effect, while defining the nature of the outcome of raising, does not affect the harmonic process *per se*, which applies to all occurrences of the mid vowel [ø].

III.7.8 Asymmetries in EL: a peculiar asymmetry in the RVH domain

The kind of asymmetries found in EL complete and enrich the typology of Raising Vowel Harmony proposed in the survey given in §II.3. Namely, two asymmetries have been described in which the selection of targets (Bergamasco) and the selection of triggers and targets (Camuno) are limited. Bergamasco is a case in which raising applies only to rounded vowels. Camuno displays a more interesting pattern, a case of partially parasitic RVH.

A peculiarity of EL varieties that strikes the eye, when compared with other asymmetric RVH reported in the survey presented in the previous chapter, is the fact that the condition on the selection of targets is structured around the round/unround axis. Generally, when only a subset of targets undergoes raising, it is either the group of mid-high vowels (as in the metaphony of the dialect of Grado, §II.3.3.5.1) or the set of mid-low vowels (as in Tsonga, §II.3.1.3.8) that undergoes harmony. In Eastern Lombard dialects, instead, harmony may have only the set of round vowels as targets, as in Bergamo, or strictly limit the contexts in which non-round vowels can undergo harmony, as in Camuno). Concerning the limitation on the selection of triggers, which in EL dialects involves only RVH of Camuno, the generalization noted by Maiden (1991) and discussed in §II.3.3.5.2 still holds: raising triggered by /u/ presupposes raising triggered by /i/. The table in (60) summarizes the harmonic patterns encountered in the chapter.

(60) Raising Harmony in Eastern Lombard dialects

<i>Dialect</i>	<i>Directionality</i>	<i>Raising mechanism</i>	<i>Morphological effects on raising</i>	<i>Asymmetries</i>
<i>Raising in Bresciano</i>	Regressive	Complete	None detected	None detected. /a/ behaves as a blocker
<i>Raising in Bergamasco</i>	Regressive	Complete	None detected	Only front non-rounded mid vowels are subject to raising: The process has a condition on the selection of targets
<i>Raising in Gandino and neighboring villages</i>	Regressive	Complete	None detected	Lower portion of the Gandino valley: Harmony behaves as in Bergamo
				Leffe and Casnigo: Raising harmony affects all pre-tonic mid vowels + there are traces of a lowering harmony absent in other varieties
				Upper portion of the valley: raising harmony affects all pre-tonic mid vowels
<i>Raising in Camuno</i>	Regressive	Complete	None detected	Harmony is parasitic. The process applies to all mid vowels if the trigger is front high vowel /i/. Otherwise, only round mid vowels are affected by raising.

As shown in the summary table in (60), RVH in Eastern Lombard is rather homogeneous in the general mechanism of raising. Raising is invariably regressive, it applies as complete harmony (consider the fact

that only mid-high vowels are expected in pre-tonic position, and when unstressed [ɛ] is present, it has been considered an allophone of /e/ (cf. §7.1), and does not exhibit evident traces of morphologization¹⁵³. The only effect morphology plays in the process concerns the choice of the raised alternant of the front round vowel /ø/, as discussed in §III.7.7. Harmony applies in all morphological contexts in which a stressed high vowel is preceded by an underlying mid vowel. Regarding the asymmetries, instead, it appears that each variety has its own set of conditions. Notice that both the asymmetries of Bergamasco and Camuno involve a limitation in the selection of targets that makes non-rounded vowels less likely to undergo raising.

III.8 Conclusions

The description of the raising harmonies of eastern Lombardy concludes the data-centered part of this thesis. The typology of raising harmonies that I could document is now complete and can be considered in its entirety. At the general considerations proposed at the conclusion of chapter II, we can add some new insights derived from the description of Eastern Lombard raising harmonies.

Some general properties of raising as a phonological process are once again found in the data proposed in this chapter. Raising harmony in Lombard dialects is invariably regressive, as in the vast majority of cases considered in the survey given in §II.3, it treats low vowels as neutral and /i/ as the most effective trigger. As in all other cases in which there was an asymmetry in the selection of the trigger, /i/ is not limited in its raising power, and is allowed to affect all preceding targets. Still, raising in Eastern Lombard dialects displays some exceptional features that differentiate them from the rest of the raising harmonies treated in the previous chapter. The first interesting peculiarity concerns the asymmetric patterns reported. Both in Bergamasco and Camuno, the selection of targets and triggers concerns the unrounded-rounded dimension, and not the high-low dimension of the vocalic spectrum, as it was the norm in asymmetries treated in the previous chapter.

An aspect that will come to be extremely relevant in the following chapter is the fact that the three varieties of EL are very similar to each other. Not only are they for the most part mutually intelligible, but they also practically share the same vowel system and the same rules of vowel reduction. Nonetheless, the harmonies they exhibit are notably different.

The following chapter treats the theoretical approach proposed in the literature to analyze the three main problems identified in chapter II: scalarity, morphological activation and, in particular, asymmetry. As we shall see in the following chapter, the most problematic aspect in the analysis of asymmetries is the behavior of vowels in parasitic harmonies. While Raising harmonies display many different asymmetric patterns, Camuno offers the best example of a parasitic harmony involving raising. For this reason, the case of Camuno will serve as the main touchstone for the various approaches explored in chapter IV.

¹⁵³ With this, I mean that there is not a morpheme or a set of morphemes where VH applies in a different manner. For example, there is no morpheme with an unstressed mid vowel that regularly fails to undergo harmony in Bresciano, nor a morpheme containing front unround /e/ that is systematically affected by raising in Bergamasco while all other occurrences of /e/ fail to do so. The tools of phonology are enough to identify all the actors of the raising harmonies of Eastern Lombardy.

Chapter IV. Substance-based analyses of raising harmonies

IV.1 Formalizing the harmony: the roles of representation and computation

A complete theory of phonology must be composed of two ontologically distinct aspects: a theory of phonological representation, which deals with representational objects (such as segments, features, nodes, syllables, morae, etc.) and a theory of phonological computation that deals with rules, constraints etc. (Anderson 1985/2021).

The goal of this chapter is to test the limits of the approaches proposed in the literature to the analysis of vowel harmony, and to define the necessary ingredients (on both the computational and the representational sides) of a complete theory of Raising Vowel Harmonies. In the conclusion of chapter II, three problematic aspects of RVH were identified:

- Raising applies in different ways: scalar and complete (plus diphthongization and fronting in some Italian metaphonies).
- Harmonies display asymmetries of various kinds, and raising harmonies display almost all recorded asymmetries (cf. 127 in §II.3.6).
- The triggers and targets of VH are sometimes selected on a morphological basis, and not on a phonological one. The problem is not the fact that morphology interferes with phonology: phonological processes often can become morphologized (cf. §V.2.4), and apply only in specific morphological contexts. It is not surprising to find traces of morphologization in raising harmonies. The issue is that in some of the patterns discussed in §II.3.3.4.5, morphology is so relevant that some authors have raised the issue whether metaphony should be considered as a phonological process or as something entirely different (Loporcaro 2011, Maiden 1991, Calabrese 2016, Pöchtrager & Kaye 2014).

Within the present chapter various proposals are discussed; each of them deals with one or more of those issues. All the proposals presented in this chapter do not subscribe to the program of Substance Free Phonology (argued for by Hale & Reiss 2008, Blaho, 2008, Odden 2022, Chabot 2021, Dresner 2014, Iosad 2017, just to cite a few), which is presented and argued for in the next chapter.

In section §2 is discussed the scalar behavior of RVH, and the way phonological representation must adapt to account for complete raising and scalar raising. Sections from §3, §4, §5 and §6 discuss various phonological theories that deal with asymmetries in vowel harmonies. Many of them resort to the notion of underspecification (Archangeli 1988, Steriade 1995, cf. §3.1), especially Contrastive Underspecification (Dresher 2009, Hall 2007, cf. §3.1). It will be noted how some asymmetries are hard to account for on these bases, and how the current approaches to phonology are often not equipped to represent parasitic harmonies in an insightful way, or if they are, they struggle with the scalar nature of many RVH. Section §7 deals with those metaphonies where morphology seems to take over, and that led some to assume metaphony (and other similar phenomena) should not be considered as proper phonological processes.

Harmonic processes pose a problem for theories that represent the phonological level of representation as solely linear. We have established in §I.2 that vowel harmonies influence segments at a distance, usually ignoring intervening consonants, and have effect over multiple segments in a domain. A multilinear approach is thus generally applied to harmonic processes: the consensus over the

formalization of a harmony is that it should be considered as spreading of the harmonic feature from a dominant vowel to the other vowels of the word. This is usually formalized applying the general structure of Autosegmental Phonology (henceforth AP, Goldsmith 1976, Clements 1985). Notice, however, that this is not the only way to formalize a harmonic process. Various different approaches have been proposed in the literature, and each one of them may have different strategies to answer the three issues listed above.

Most of the considerations discussed in this chapter involve the representational side of phonological theory. This does not mean that only representation matters in the formalization of VH, but just that scholars have mainly looked for solutions to the problems that regard harmonic processes using representational, and not computational strategies. In other words, they tinkered with phonological primes and their relations, more than with the principles that rule their interactions. In (1) is presented a brief overview of the computational approaches proposed in the literature for the analysis of VH. The table in (1) is not supposed to give a fully-fledged description of every theoretical account that deals with VH, but simply to introduce them and give a brief description.

(1) Approaches to VH formalization:

	<i>Approach</i>	<i>Main representatives</i>	<i>Representational assumptions necessary</i>	<i>How VH is formalized</i>
a.	Autosegmental Phonology	- Clements (1985)	- Presence of different tiers of analysis. - Feature Geometry - Underspecification.	Spreading of primes from a segment to another through the insertion of an association line.
b.	Licensing	- Charette & Göksel (1994, 1996) - Kaye (2000). - Van der Hulst (2016, 2018) - Walker (2005)	- Phonological primes (unary or binary)	The presence of a given prime in the dominant vowel (trigger) allows the presence of a prime of the same kind in a recessive vowel (target)
c.	Search & Copy	- Nevins (2010) - Samuels (2009) - Mahillot & Reiss (2007) - Sandstedt (2018)	- Underspecification	A target underspecified for a feature value searches in a given direction for a feature that can fill its representation.
d.	Feature Percolation	- Halle & Vergnaud (1981)	- Tiers of analysis comprised of syllables, feet and moras.	Primes percolate from triggers to targets following the syllabic structure.
e.	SPE-rules	- Chomsky & Halle (1968)	- Binary features	Given x as the harmonic prime and y as the target of the operation, $y \rightarrow x / C0x$.

f.	Constraints	<ul style="list-style-type: none"> - Optimality Theory - Calabrese (1995) - Charette & Göksel (1994, 1996) - Kaye (2000) 	<ul style="list-style-type: none"> - Phonological primes (unary or binary) 	<p>Constraints of well formedness are hierarchically ordered. A restriction concerning the vowels that can appear in a given position is present (and relevant in the constraint hierarchy) in any language with an active VH.</p>
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The table in (1) is largely based on Samuels (2009), to which I refer for a more precise description of each of those approaches. In the pages that follow, I will comment on analyses that consider VH as an instance of spreading (1a), as the result of a Search & Copy operation (1c), as the result of a relation of licensing (1b) and as the result of the interaction of Constraints (1f). SPE-rules are perfectly able to formalize the effects of the harmonic process, but the proposals presented in this chapter employ different (and more recent) approaches to phonological computation. The analysis of VH as feature percolation (1e) fell out of favor, and thus it is not frequently used in recent literature.

IV.2 Incremental features/primes: a representational strategy to account for scalar raising

IV.2.1 Scalar and complete raising are two different formal processes

The definition of a raising process as complete or scalar depends on the vowel system of the language in which the raising process applies. Let us start by considering the case of a language with a vowel system composed of five vowels, structured around three levels of height. The process of raising affects mostly mid-vowels, while low vowels tend to be unaffected¹⁵⁴. If this is the case, the distinction between complete and scalar raising is generally irrelevant.

In (2), (3) and (4) are described cases of raising harmonies in languages with 5-vowel systems. In those languages, the low vowel /a/ behaves as neutral and does not interact with raising. In Tudanca (Hualde 1989, in 2) and Pasiego (Hualde 1989, in 3) the definition of raising as scalar or complete does not matter, since the only structural modification is the change from mid-high vowels to high vowels. In Zulu (shown in 4), instead, the process applies in such a way that the result of raising is not part of the underlying vowel system of the language, and the process applies as scalar.

Tudanca Montañes (cf. §II.3.2.2.1) is a dialect of European Spanish spoken in the northern region of Cantabria. Each one of the vowels may surface in two forms, the centralized form and the non-centralized form. Centralization depends on a harmonic process that does not interfere with the raising process. In the relevant literature (Hualde 1989, Penny 2009) centralized vowels are reported using the capital letters. In Tudanca, stressed high vowels /i/ and /u/ trigger raising forcing pre-tonic mid vowels to surface as high.

¹⁵⁴ This does not mean that low vowels are never subject to raising, but in the vast majority of languages that exhibit a raising process, low vowels are not affected, while mid vowels are, as discussed at length in the survey in §II.3.

(2) Raising in languages with a 5-vowel system: Raising in Tudanca Montañas (Hualde 1989)

a. Tudanca vowel system

	<i>Front</i>	<i>Back</i>
<i>High</i>	i-I	u-U
<i>Mid</i>	e-E	o-O
<i>Low</i>	a-A	

b. Raising in Tudanca Montañas

<i>Non-raised forms</i>		<i>Raised forms</i>	
'θera	'wax'	θi'rija	'match'
'seka	'dryness'	si'kura	'thirst'
mo'ler	'to grind'	mu'ljenda	'grinding'
'hOrnU	'oven'	hur'nija	'stove'

Similarly, in Pasiego Montañas (which shares the vowel system and the centralizing process with Tudanca) final vowels raise preceding vowels. Here, however, the triggers are unstressed final vowels which raise preceding stressed mid vowels, much like in most Italian metaphonies (cf. §II.3.2.2.2).

(3) Raising in languages with a five-vowel system: the case of Pasiego Montañas (Hualde 1989).

a. Pasiego vowel system

	Front	Back
High	i-I	u-U
Mid	e-E	o-O
Low	a-A	

b. Raising in Pasiego Montañas

<i>M. sing. Countable</i>	<i>M.s Uncountable</i>	
kIsU	keso	'cheese'
nwIstrU	nwestro	'our'
flUxU	floxo	'limp'
gUrdU	gordo	'thick'
<i>M. sing. countable</i>	<i>M. plural</i>	
prImIrU	primeros	'first'
bIθjUsU	biθjosos	'vicious'
rApUsU	raposos	'fox'
nUbUsU	nubosos	'cloudy'

In both Tudanca and Pasiego Montañas raising applies as complete, since the raised outcome of the process matches the height of the trigger. Having only three levels of height, mid vowels (which are mid-high in both varieties) automatically raise to high vowels.

The case of Zulu, treated in (4), differs slightly from the ones treated in (2) and (3). Mid vowels in Zulu surface as mid-low in all contexts, except for when VH applies, i.e., when a high vowel follows a mid-vowel. In this case, mid vowels surface as mid-high: they have a timbre phonetically different from

ε,ɔ, but are allophones of these vowels. Here, the height of the outcome of the process does not match with the height of the triggers, and thus scalar raising applies. Processes such as this, whereby the outcomes of raising have a height that is not matched by any vowel of the underlying vowel system, were referenced in §II.3.1.3 as allophonic raising processes.

(4) Raising in languages with a 5-vowel system: allophonic raising in Zulu

a. Zulu vowel system

	Front	Back
Height 1	i	u
Height 2	ε	ɔ
Height 3	a	

b. Raising in Zulu

phɛk-a	'cook (verb)'	urn-phɛk-i	'cook (noun)'
ngɛn-a/ɲɛn-a	'enter'	ngen-is-a	'bring in'
ɔn-a	'sin'	is-on-i	'sinner' '
bɔn-a	'see'	bon-is-a	'show'

c. Multiple vowel sequences

phelelisa	'make complete'
izikelemu	'worms'
fɔkosi	'little bush'
ɛlovu	'a place name'
ɛmɔjeni	'in the air'

A way to analyze harmony in Zulu is to consider it as a case of ATR harmony, assuming that mid vowels are marked as [-ATR] in their underlying representation, and high vowels are marked as [+ATR]. This would end up with the outcome of the process and the triggers of the process sharing the same feature [+ATR]. Recall from the discussion in §II.2.1 that the feature [±ATR] may not be a good candidate to be considered as the active feature in the harmonic processes of Bantu languages. In addition, the non-iterative nature of harmony in Zulu (exemplified in 4c) ensures that mid-high vowels, resulting from raising, are unable to affect preceding mid-low vowels (which would be expected if the process involved the feature [±ATR]).

Leaving aside, for the time being, the issues of ATR as a height feature in Zulu, we can end up with a regular harmony, that can be formalized as the spreading of the feature [+ATR] from the triggers to the targets. From a formal standpoint, then, raising harmonies in five-vowel systems do not pose a strong problem for the standard representational tools of phonology, if only mid vowels are involved in the process.

The distinction between complete and scalar raising becomes relevant when vowels of three or more levels of height undergo harmony. This may happen if low vowels participate in harmony in five-vowel systems (i.e., systems where /a/ participates in raising, such as in Lena Bable, cf. table (5) below and §II.3.2.2.3), or in languages with vowel systems where height is structured around more than 3 degrees (e.g., Sotho, §II.3.1.3.4).

(5) Raising in a five-vowel system where all vowels participate in harmony: raising in Lena Bable (Hualde 1989)

a. *Lena vowel system*

	Front	Back
High	i	u
Mid	e	o
Low	a	

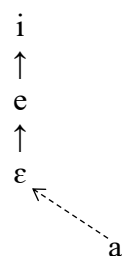
b. *Raising in Lena*

<i>Masculine Singular</i>	<i>Masculine Plural</i>	<i>Feminine singular</i>	
'getu	'gatos	'gata	'cat'
ben'tenu	ben'tanos	ben'tana	'window'
tsa'mergu	tsa'margos	tsa'marga	'muddy lake'
'ninu	'nenos	'nena	'child'
kor'diru	kor'deros	kor'dera	'lamb'
kal'diru	kal'deros	kal'dera	'pot'
'tsubu	'tsobos	'tsoba	'wolf'
'kufu	'kojos	'koja	'cripple'

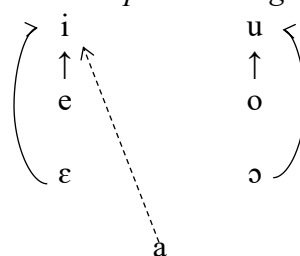
When the vowel system is structured around multiple levels of height, the distinction between complete and scalar raising becomes a central property of the process at hand¹⁵⁵: in a complete raising harmony the outcome of the process always matches the height of the trigger, regardless of the height of the target. Scalar harmonies have a different outcome depending on the height of the target. Low and mid-low vowels raise to mid-high, while mid-high vowels raise to high.

(6) Complete raising vs. Scalar/Gradient raising in a seven-vowel system¹⁵⁶

a. *Scalar raising*



b. *Complete raising*



This double behavior appears to be a peculiarity that belongs uniquely to Vowel Harmonies that involve height, and it is absent in other harmonic processes. In §II.2 the property of scalarity has been

¹⁵⁵ Notice that raising harmony in Eastern Lombard dialects, treated in §III.7, cannot be defined as either complete or scalar. While the vowel system of EL dialects contains multiple height degrees for mid vowels, the process of raising targets solely pre-tonic vowels, where the distinction between mid-low and mid-high vowels is eliminated.

¹⁵⁶ Scalar and complete raising of /a/ is represented with a dotted arrow because is typologically rarer than raising of mid-vowels. In most occasions /a/ behaves as neutral.

connected with the way height-related features correlate with phonetics. The phonetic property of vowel height corresponds to multiple phonological primes; hence, the process can involve a single prime or multiple primes. Note that other processes involving vowels never display the scalar behavior found in raising, as discussed in §II.2 and in more detail in Lindau (1978: 547). The issues that derive from this peculiarity of raising patterns are further discussed in the next section.

IV.2.2 Issues in the representation of scalar raising

Assuming a representation of vowel height based on $[\pm\text{high}]$, $[\pm\text{ATR}]$ and $[\pm\text{low}]$, and an SPE-like computation based on rules, requires an analysis that splits the process of raising into two processes. The first process affects $[-\text{ATR}]$ mid vowels and is triggered by $[\text{+high}, \text{+ATR}]$ vowels, and the second one turns $[\text{+ATR}]$ mid vowels from $[-\text{high}]$ to $[\text{+high}]$. As previously noted in §II.2.1, the use of the ATR feature in height-related processes stems from the fact that a prime that relates to the tongue root position is already a theoretical necessity, since there are various languages that display tongue root harmonies. Its use as a way to distinguish between degrees of height is nowadays common in the literature, but it is not without its problems. The label “ATR” for the prime that must distinguish between tense and lax vowels is not phonetically precise (cf. Ladefoged and Maddieson 1996: 304). Furthermore, this analysis assumes the existence of two different processes, one that involves height and targets mid-high vowels and an asymmetric process that involves the ATR prime which targets mid-low vowels. This second process displays an asymmetry in the definition of triggers, since $[\text{+ATR}]$ mid-high vowels almost never trigger the process of raising for preceding mid-low vowels. Consider the case of Servigliano metaphony, previously treated in §II.3.3.1 as an example:

(7) Formalization of scalar raising using standard binary features and SPE-like rules

a. Metaphonic scalar raising in Servigliano ($/\varepsilon/ \rightarrow [e]$; $/e/ \rightarrow [i]$; $/\text{o}/ \rightarrow [o]$; $/\text{o}/ \rightarrow [u]$ / $_C\text{o}/i,u/$)

'metto	'I put'	'mitti	'you put'
'sposa	'wife'	'spusu	'husband'
'pettene	'comb'	'pettini	'combs'
'predoko	'I preach'	'prediki	'you preach'
'moʃa	'depressed F.'	'moʃu	'depressed M.'

b. SPE-like rules for scalar metaphonic raising in Servigliano

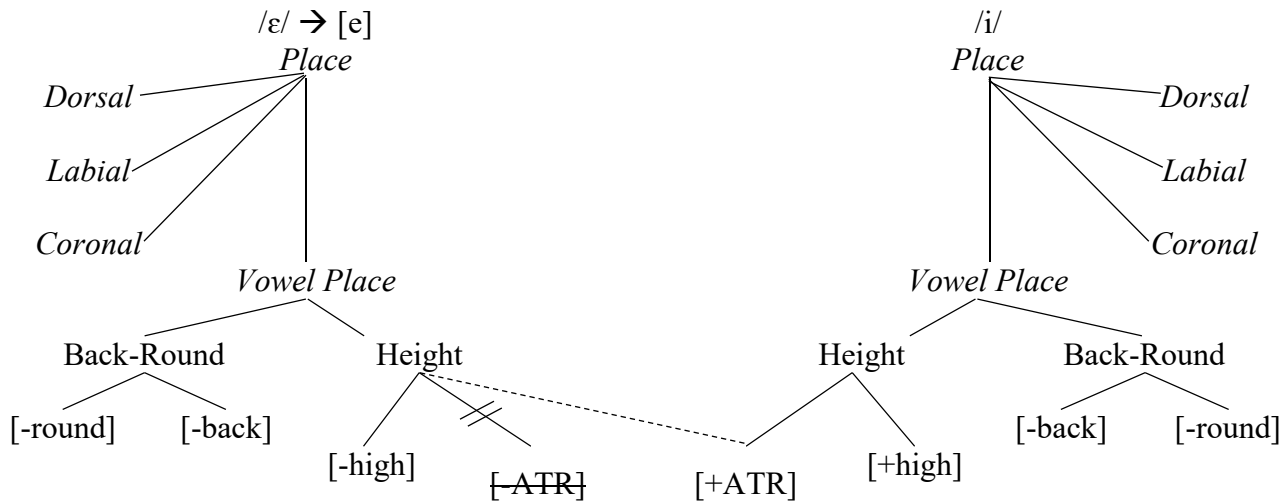
- Rule1: $[-\text{ATR}][-\text{low}] \rightarrow [\text{+ATR}]/_C\text{o}[\text{+high}][\text{+ATR}]$ accounts for $/\varepsilon,\text{o}/ \rightarrow [e,o]/_C\text{o}/i,u/$
- Rule2: $[\text{+ATR}][-\text{high}] \rightarrow [\text{+high}]/_C\text{o}[\text{+high}][\text{+ATR}]$ accounts for $/e,\text{o}/ \rightarrow [i,u]/_C\text{o}/i,u/$

Rule 1 affects only mid-low vowels in roots, and turns them into mid-high vowels, so that $['\text{moʃa}]$ results in $['\text{moʃu}]$ when the final suffix changes from the feminine $[-a/]$ to the masculine $[-u/]$. Rule 2 affects mid-high vowels in roots, and turns them into high. Take the token $['\text{metto}]$ ‘I put’ as an example: it becomes $['\text{mitti}]$ ‘you put’ when the 2nd person suffix $[-i/]$ substitutes the 1st person suffix $[-o/]$. The contexts of application for the two rules coincide, while the target and the structural modification varies according to the target vowels.

This issue is not unique to SPE. The same happens assuming an Autosegmental approach to phonological representation based on Clements (1985) or the feature geometry proposed in Odden (1991:

264¹⁵⁷). Within an Autosegmental approach, a scalar process cannot be captured assuming the propagation of the feature specification for vowel height from the trigger to the target, since the trigger and the outcome of the process may end up having a different height. Once again, the only solution is to assume two different processes happening in the same context, and not a single phonological process. Under (8) is represented a mid-low vowel /ε/ being raised to [e] by a high vowel /i/. The association between the prime [-ATR] and the node Height is severed (shown in 8 as a barred line), while the [+ATR] prime is associated in its place (shown in 8 as a dotted line connecting [+ATR] to the Height node of /ε/).

(8) Scalar raising as feature spreading assuming Odden’s (1991) feature geometry



Notice that the same process would not apply if the triggering vowel were a mid-high vowel: only high vowels act as valid triggers in Servigliano, as in most scalar raising harmonies. However, the [±ATR] feature that is linked to the mid-low vowel is present also in mid-high vowels, and should therefore spread in the same fashion, were it a symmetric process. Assuming a representation of height based around the primes [±high] and [±ATR], we also inherit the problems related to the representation of this asymmetry.

Different scholars came up with representational theories that are able to account for scalar harmonies so that only one phonological process applies. They also manage to rule out raising caused by mid-high vowels. In this section, I will cover the works of Schane (1984), Clements (1991) and Parkinson (1996). All of them represented the property of vowel height in a way that is more consistent with the behaviors of scalar harmonies and the observations made in §II.2. All of those scholars structured their theories of representation around two core ideas:

1. Vowel height is a unique phonological category, and thus it should be represented by a single phonological prime: there is only *one* prime that relates to vowel height. This means that the representation of height is uniform: ATR and ATR-related primes are no longer part of the definition of

¹⁵⁷ The general model of Odden (1991) is preferred to other feature geometries (such as the main model of Feature Geometry proposed in Clements & Hume 1995) because it groups together the three features that we assumed to be related to vowel height in §II.2 under the node “Height”. The argument is applicable to all other feature geometries that do not group height features together: the two processes that are involved in scalar raising harmonies are different, and are not reducible to a single assimilation.

height. In addition, the features [high] and [low] are dropped in favor of a single feature that indicates either relative height or relative lowness.

2. Primes that relate to height are incremental, meaning that they can occur multiple times in the same phonological representation of a segment. The process can involve spreading of a single prime or of multiple occurrences of the same prime. In all the approaches discussed below, height primes are structured around some sort of hierarchic relation.

In the following pages, the specific proposals are explained in detail. Schane’s (1984) model of Particle Phonology is covered in §2.3, Clements’ (1991) Hierarchical model in §2.4 and Parkinson’s (1996) Incremental Constriction Model in §2.5.

IV.2.3 Schane's (1984) model of representation: Particle Phonology

The representational model proposed by Schane radically departs from the standard approaches of representation based on binary features organized in a feature geometry of Autosegments. Schane (1984) developed his model of vowel representation in a search for a better way to represent diphthongs (Schane 1984: 129). Nonetheless, his observation proved to be insightful also for harmonic processes involving height. He envisioned a system of vowel representation based on unary privative primes, which he called Particles, that can be combined to form more complex vowels or diphthongs. This system is extremely similar to the representational strategies developed within the framework of Dependency Phonology (DP, Anderson & Ewen 1987) and Government Phonology (GP, Kaye, Lowenstamm & Vergnaud 1985), where three vocalic primes (that are pronounced, when in isolation, as [i], [u] and [a]) act as the basic building blocks of all vowels. Schane’s model envisions various operations that affect segments, acting over the three vowel particles. Particles can be added, removed or differently distributed within a compound. Some of the operations proposed in Schane (1984: 134) are shown in (9). Particles are represented as letters between parenthesis in the column Underlying Representation.

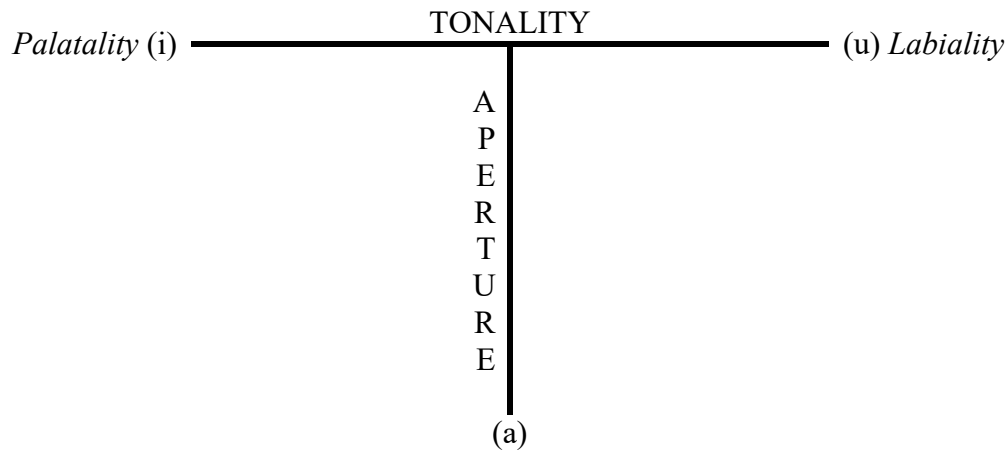
(9) Possible operations in Particle Phonology, adapted from (Schane 1984: 134)

<i>Operation</i>	<i>Surface representation</i>	<i>Underlying representation</i>
<i>Fusion of particles</i>	[ai] > [e]	(a),(i) > (ai)
	[au] > [o]	(a),(u) > (au)
	[ae] > [E]	(a),(ai) > (aa)
<i>Fission of particles</i>	[y] > [iu]	(iu) > (i),(u)
	[e:] > [ei]	(ai i) > (ai),(i)
<i>Cloning of (a) particle from one segment to the other</i>	[u] > [y] / __ [i]	(u) > (iu) / __ (i)
	[i] > [e] / __ [a]	(i) > (ai) / __ (a)
<i>Removal of (a) particle from a compound</i>	[e] > [i]	(ai) > (i)
	[o] > [u]	(au) > (u)

Differences in height among vowels are represented using multiple iterations of the particle (a). The lower a vowel is, the more (a)-particles it will contain. Consider that, much like Elements in Backley (2011), a representation correlates to the vowel system of the language in analysis. The interpretation of particles (and particle compounds) is somewhat language specific (cf. §V.4.3 Scheer 2014: 265) Still,

the relation between a particle and its phonetic form remains fixed, and it works similarly to what we briefly discussed in §1.2.3.

(10) Elementary particles and their phonetic correlates (Schane 1984: 131)



The particle (a) is the only one that relates to vowel height, and it correlates with lowness, similarly to the element |A| in more recent accounts based on elements (Backley 2011, Backley 2012). As a consequence, any process of raising must be formalized as loss of the particle (a) through the operation of decay, in Schane’s terms, which corresponds to the last operation shown in (9). This representational model is assumed also by Maiden (1991: 136) who argues that Schane’s model is perfectly suited to represent metaphonic raising. The unary nature of particles and the fact that they can be stacked are features that allow for a linear representation of scalar raising as *a-demotion*.

Various authors dealing with raising in unary theories have then expanded upon the modeling of raising as a-demotion (cf. Tamarit et al. 2016). The advantage of this proposal is the representation of a scalar raising as a uniform process. Rather than being the result of two different operations, raising is represented as a unitary phenomenon, by which one particle (a) is lost. A mid-low vowel (which Schane assumes to be composed of two low particles, i.e. /ε/= {iaa}), loses one of them, resulting in a mid-high vowel (i.e. /e/= {ia}). Mid-high vowels, ones that have only one single occurrence of the particle (a), raise to high through loss of that same particle. Raising harmony is thus considered as a very different process than other harmonies: while fronting, rounding and lowering harmonies are analyzed as spreading of melodic material (i.e., elements/particles/features spread from the trigger to the targets¹⁵⁸), raising must be represented through another operation that delinks (a) particles.

Notice that the property of particles of being privative is not sufficient for the representation of scalar raising as a single operation. The possibility to stack multiple occurrences of the same prime is a necessary property of a representational model that aims to formalize scalar raising as the result of a single operation. In other words, primes that relate to vowel height need to be *incremental* so that the passage from mid-low vowels to mid-high vowels and the passage from mid-high to high vowels can be

¹⁵⁸ In Shane’s (1984) terms, non-height related harmonies would be represented as fissions (cf. 9).

formalized as the loss of a single phonological prime. From here on out, I will refer to primes that can be stacked one upon the other as incremental primes, borrowing this term from Parkinson (1996: 12).

Within Schane’s model, raising can be represented as a single operation of delinking of a particle (a). This comes with the drawback of differentiating raising from other harmonic processes, which are instead represented as spreading of a particle from the trigger to the targets. Consider that this drawback is shared with all unary approaches, since all of them assume the basic elements of vowels to be akin to the three elements |I|,|U| and |A|¹⁵⁹ (Backley 2012: 67). The element |A| and the particle (a) loosely correspond to the traditional feature [±low], and it is the only prime related to vowel height that can be manipulated in computation.

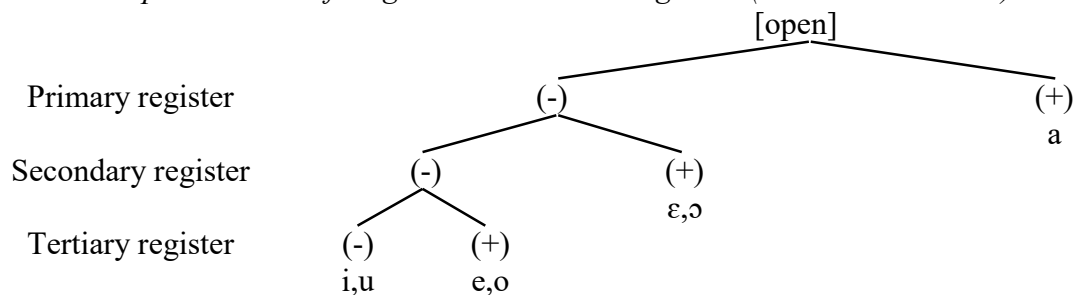
IV.2.4 Clements’ (1991) hierarchical model of representation of vowel height

The goal of Clements (1991) is to represent the various height assimilations present in Bantu languages, which are processes that involve both raising and lowering. Many of the patterns he covers are treated in §II.3.1.

Facing languages that reference multiple vowel heights, and wanting a model that is able to represent all of them in a way that is consistent throughout languages, he integrates some insights from Schane (1984), which we have discussed above, and the basic mechanisms of Autosegmental phonology. In Clements (1991) the Feature Geometry employed is extremely similar to the feature geometry proposed in Clements (1985: 244). What varies is simply the section that involves Vowel Height. Since, as discussed in §II.2 vowel height is a uniform phonetic dimension, Clements (1991: 39) represents it using a single feature named [±open], instead of using the more common combination of the features [±high] and [±ATR]. The feature [±open] is viewed as an abstract phonological space that can be divided into various registers, as in (11a). The various registers of [open] are inserted in the larger multi-tiered model of segmental representation proposed by Sagey (1986) or Clements (1985) under the newly introduced node aperture, as shown in the graph under (11b).

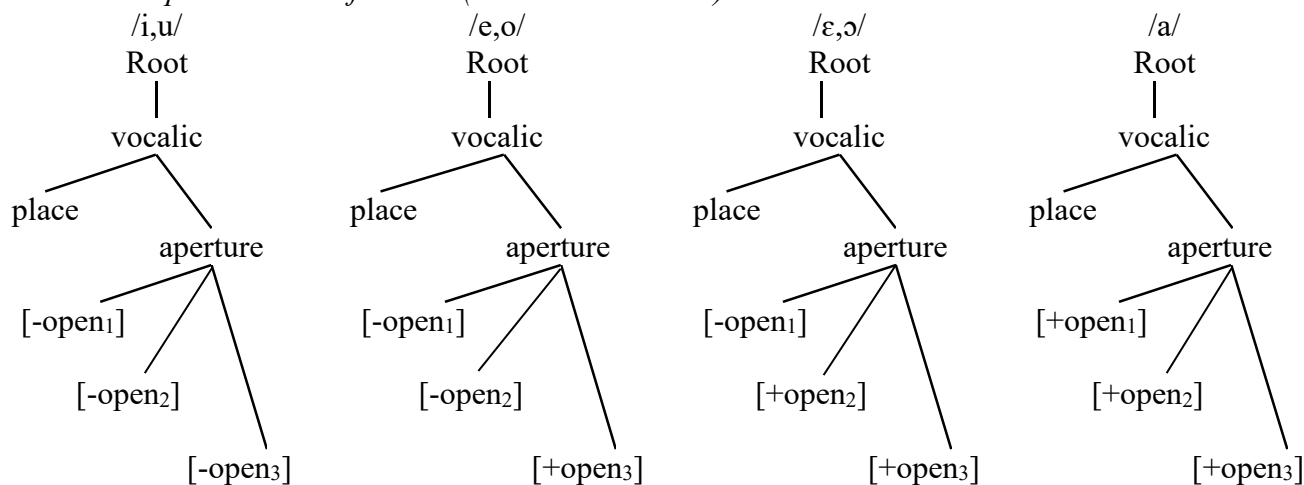
(11) Hierarchical model of vowel height based around registers of openness

a. Representation of height as incremental registers (Clements 1991: 39)



¹⁵⁹ Van der Hulst (2018) built a model of representation based on unary primes that hosts an element that corresponds to the feature [high], and uses it as an advantage in the representation of raising harmonies. His model is presented in detail in section §6 alongside with its potentialities and its issues.

b. Representation of vowels (Clements 1991: 43)



The number of ‘splits’ (or registers) of the prime [open] can be language-dependent (Clements 1991: 62). In a language such as Arabic, which has a 2-height vowel system /i,u,a/, only one register is necessary: /i/ and /u/ are [-open], /a/ is [+open]. Each register can be subdivided, so that a language with a more complex vowel system has a more complex system of registers. In theory, there is no limit to the number of registers a language can have, but according to Clements, the *de-facto* upper limit must be a 5-height system (Clements 1991: 39, 67).

The assumption of a single feature that can be subdivided into multiple layers allows for a process of scalar raising in a language with three degrees of height to be represented as an operation that modifies the secondary and tertiary register of the feature [open]. The feature [open] is arrayed on several autosegmental tiers, ranked according to the register, and linked directly to an aperture node, which in turn links to the vocalic node. The graphs in (11) represent just the portion of the internal structure of vowels that concerns height.

In Clements’ view, Natural Classes are defined by identical feature specifications along any tier. This allows this model to create groupings of natural classes along any level of the height structure. All non-low vowels are thus a natural class identified by the occurrence of [-open₁] in the primary register. Tense vowels {i,e,o,u} can be referenced with the [-open₂] in the secondary register, mid-vowels {e,o,ε,ɔ} share the [+open₃]. Those three features do not have a different phonetic interpretation. Even though vowel height displays this phonological complexity, the complex of structure under the aperture node is interpreted as a single phonetic property: height.

As Clements himself notices (Clements 1991: 40f), the presence of a feature of any lower register in a vowel activates all the higher registers. This means that a vowel cannot be characterized by the feature specification [+open₂] unless it also has a specification for [±open₁] etc. Consider the case of scalar raising in Nzebi, covered by Clements (1991: 47) and described earlier in §II.3.1.3.1.

(12) Nzebi vowel system and raising pattern

a. Nzebi vowel system

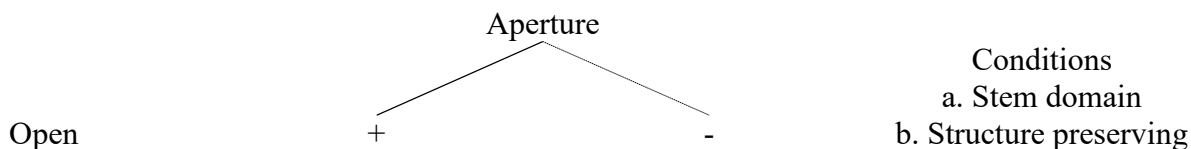
	Front	Central	Back
Height-1	i		u
Height-2	e	ə	o
Height-3	ɛ		ɔ
Height-4		a	

b. Harmonic alternation in Nzebi

Base Form	Yotized form	
betə	biti	'carry'
bexə	bixi	'foretell'
βoomə	βuumi	'breathe'
kolən	kulini	'go down'
sɛbə	sebi	'laugh'
βɛɛdə	βeedi	'give'
suɛmə	suemi	'hide'
tɔɔdə	toodi	'arrive'
mɔnə	moni	'see'
salə	seli	'work'
baadə	bæedi	'be'

The underlying representation of the vowels of Nzebi corresponds to the graphs proposed in (11b). High vowels /i/ and /u/ are identified by three [-open] features, mid-high vowels have two [-open] features and a [+open] feature and mid-low vowels have one [-open] feature and two [+open] features. Notice that Clements assumes the vowel [ə] to be a phonetically reduced form of /a/, and thus underlyingly formed by three [+open] features (Clements 1991: 47). This vowel does not participate in raising. Harmony is triggered by final /i/. The harmonic rule is formalized by Clements (1991: 48) as shown in (13). The rule formulated in (13) means that a sequence [+open]-[-open] is resolved by inserting an association line that connects to the [-open] feature from the following triggering vowel (represented in 13 as a dotted line).

(13) Nzebi Vowel Raising in Clements' (1991) terms



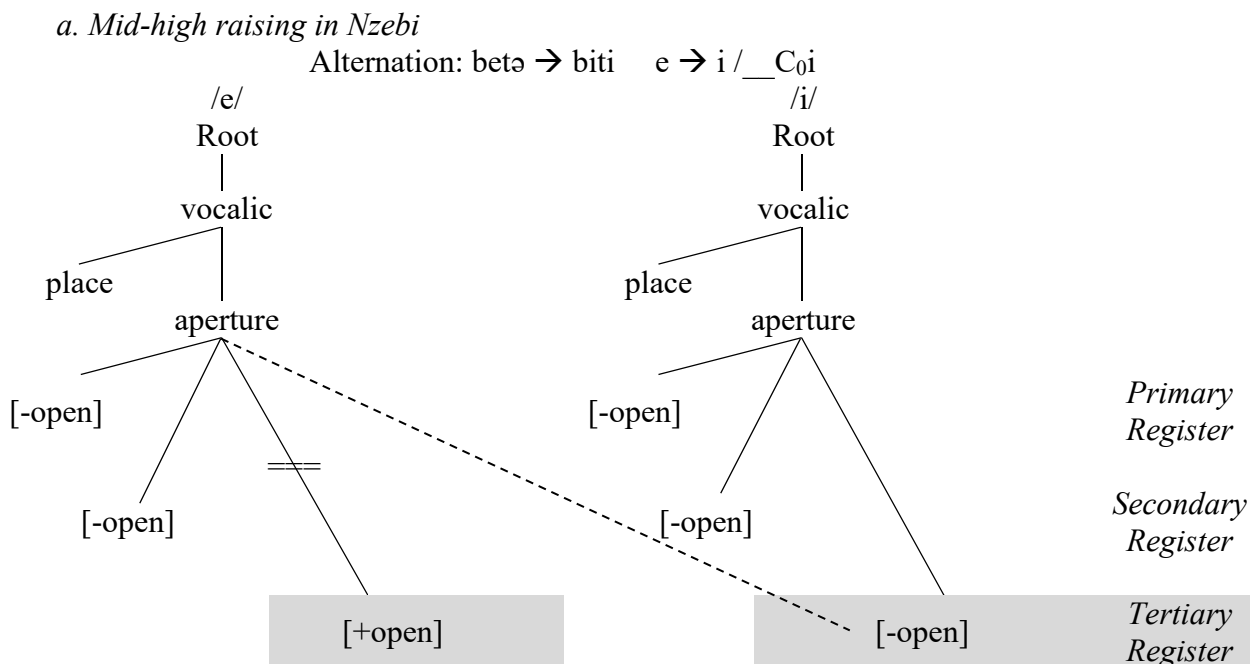
Notice that no restriction is posed on the tier on which the sequence [+open] [-open] must occur, meaning that the rule can apply freely to all sequences of the type [+open] [-open], regardless of their tier. Thus, all vowels undergo harmony. For mid-low vowels, the target sequence [+open, -open] lies on the second tier, while for mid-high vowels it is on the third, etc. The harmonic rule can apply in both

contexts without violating the structure-preserving condition posed in (13b): all vowels undergo harmony.

The rule formalization in (13) would predict that all mid vowels may trigger the raising process, but recall from §II.3.1.3.1 that mid vowels do not occur in V_2 position. The assumption made by Clements that schwa is underlyingly /a/ is key, in this case. If it was considered a mid-vowel with a [-open] feature in any tier, the context for harmony would result in the application of the process.

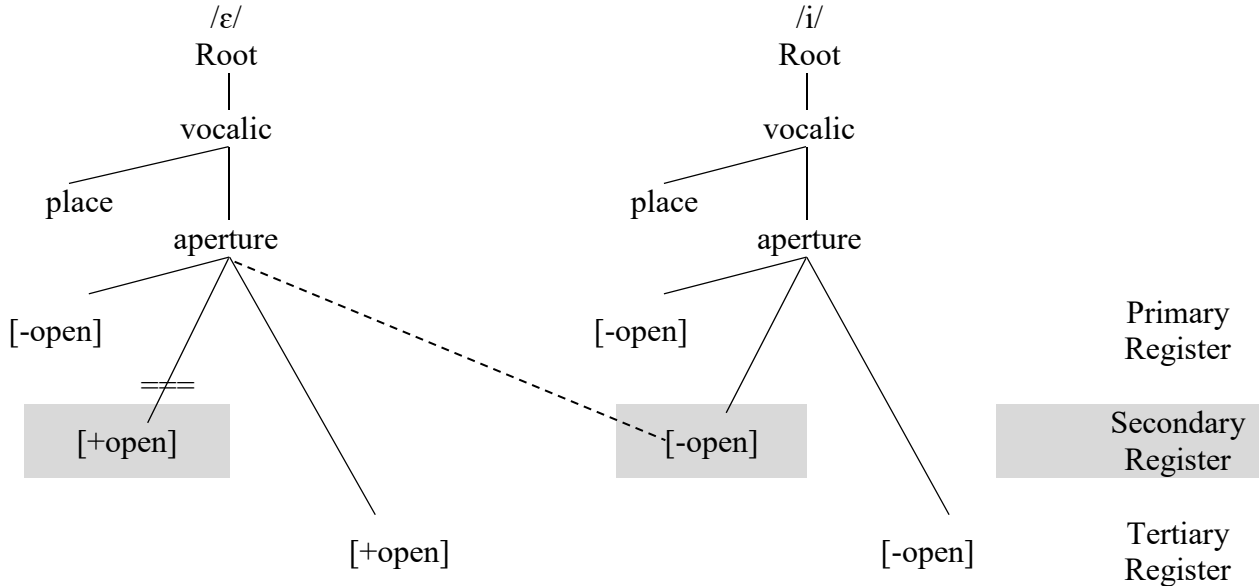
Another issue concerns the tier of application. In Nzebi, the process applies to all tiers, and in sequences of the kind /ε/ - /i/ or /a/ - /i/ the rule could apply in the second or in the third tier. Consider the three examples in (14). In the example in (14a), there is only one tier where the process could apply, so the fact that the rule can apply to any tier creates no problems of interpretation. In (14b) and (14c), however, there are two sequences where the rule could apply. The condition in (13b), which forces the process to produce a structure that is already present in the language, rules out the application of the process in the third tier for (14b) and in the second and third for (14c). Without the condition in (13b) the rule of raising exemplified in (13) could apply in multiple contexts. In all the examples, the tier in which the rule of raising applies is marked in gray.

(14) Scalar raising in Nzebi: raising of mid-high, mid-low and low vowels followed by /i/



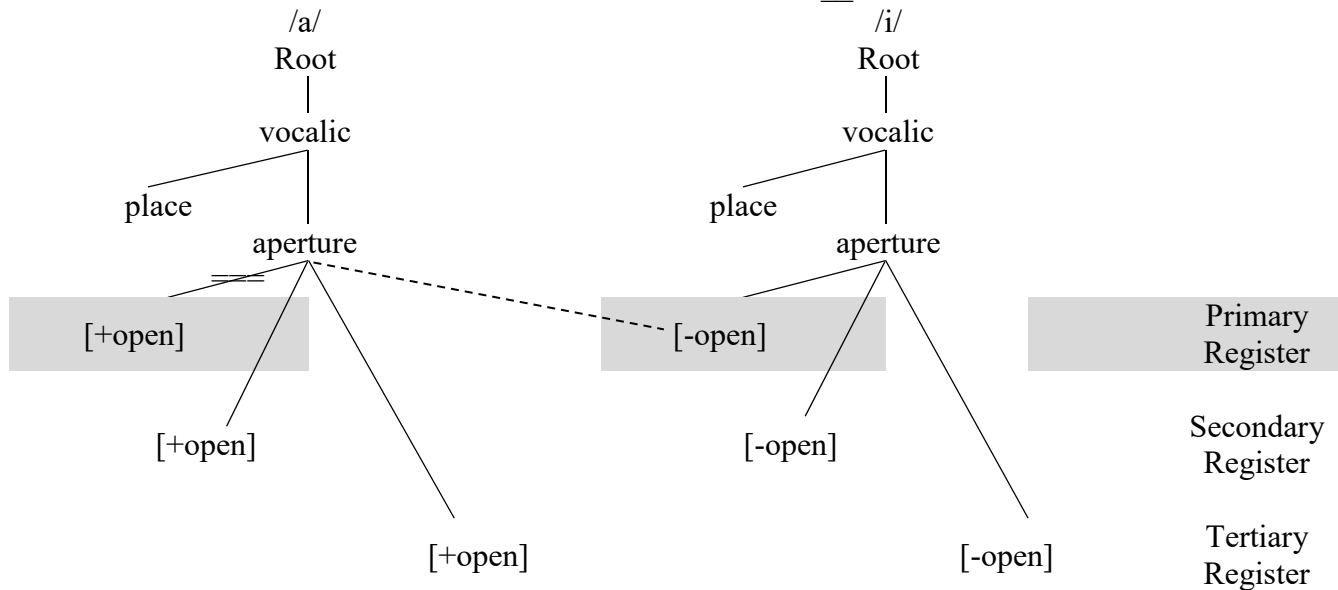
b. *Mid-low raising in Nzebi*

Alternation: $\text{s}\epsilon\text{b}\epsilon \rightarrow \text{sebi}$ $\epsilon \rightarrow e / _C\text{oi}$



c. *Low raising in Nzebi*

Alternation: $\text{sal}\epsilon \rightarrow \text{s}\epsilon\text{li}$ $a \rightarrow \epsilon / _C\text{oi}$



The properties of his model allow for an analysis of scalar and complete raising as the same process, i.e., spreading of some occurrences of the feature [-open]. The model proposed by Clements proves that the concept of incremental features, theorized in models based around unary features, can be easily transported into the realm of standard AP, which assumes binary features¹⁶⁰.

A model based on binary incremental features is able to represent both cases of scalar raising and scalar lowering. Clements' model is, in various aspects, a binary rendition of Schane's model. Vowel height is structured around multiple occurrences of a single prime, whose phonetic correlate is linked to

¹⁶⁰ Salting (1998) offers a slightly modified version of the representational model given in Clements (1991).

low vowels (the lower the vowel, the higher the number of [+open] it has). The binary nature of Clements' model allows it to represent both raising and lowering as the association of one (or multiple) occurrences of [\pm open] from one segment to another. In the final representation of Feature Geometry in Clements & Hume (1995: §3.4.5) the insights introduced in Clements (1991) are inserted in the Unified Feature Theory.

IV.2.5 Parkinson's (1996) model of phonological representation: the Incremental Constriction Model

Parkinson (1996) proposed in his doctoral thesis an effective representational model of vowel height, the Incremental Constriction Model, alongside a large data set composed of many height-related phenomena. Parkinson avoids the use of the feature ATR as a height-related feature, and uses only the unary feature [closed], which can occur multiple times in the same segmental representation. Each contrast in the height continuum is characterized by an occurrence of the unary prime [closed], similarly to the models of Schane and Clements discussed above.

As in Schane's account, the height-related prime proposed by Parkinson is unary, but while Schane's (a) particle has a correlation with low vowels (as [+open] in Clements 1991), the unary prime [closed] proposed in the Incremental Constriction Model correlates with high vowels: the more occurrences of [close] a vowel has, the higher it is.

The number of instances of [closed] that are active in a language is determined by the number of vowel heights that are distinctive. Low vowels are universally specified for no occurrences of [closed], i.e., they possess an empty Height node. The lowest non-low vowels in a language are specified for a single occurrence of [closed]. Each successively higher vowel is specified for an additional occurrence of this feature. The highest vowel in a system (i.e. the vowel or group of vowels specified for the highest number of occurrences of [closed] in the language at hand), have a specific notation, [closed]_{max}, that allows languages to refer to the highest vowels in their inventories.

In most of the cases covered in previous chapters, only the highest vowels of the system are able to trigger raising, while vowels that are relatively higher than the target (such as mid-high vowels for mid-low targets) are unable to do so. This property is common (and almost exceptionless) in raising harmonies. Only the raising harmony of Sotho-Tswana languages exhibits raising caused (also) by vowels that are not the highest in their vowel system.

For example, in Italian metaphonies, where only the highest vowels of the set are valid triggers for VH, the triggers of harmony have a special formal status, [closed]_{max}. The highest height is the only height to which a language may refer directly. This means that a parameter may allow languages to refer only to the height of the highest vowel of the system (e.g. [closed]_{max}: /i,u/), but not the immediately lower vowel (e.g. *[closed]_{max-1}: /e,o/).

To these vowels, e.g., [i u], the language assigns the [closed]_{max} status (Parkinson 1996: 14). The output of assimilation may then be compared to [i u] to determine whether that output is specified for an equal number of occurrences of [closed] as are the [closed]_{max} vowels. In the Incremental Constriction Model, a partial height assimilation involves a single instance of [closed], which corresponds to a single step or increment along the height continuum.

(15) Representation of vowel height in Parkinson (1996: 16)

a. *Vowel height in Arabic*: {i,u,a}

/a/
Height

$[closed]_{max}$
/i,u/
Height
|
[closed]

b. *Vowel height in Servigliano*: {i,u,e,o,ε,ɔ,a}

/a/
Height

/ε,ɔ/
Height
|
[closed]

/e,o/
Height
|
[closed]
|
[closed]

$[closed]_{max}$
/i,u/
Height
|
[closed]
|
[closed]
|
[closed]

c. *Vowel height in SeSotho*: {i,u,i,u,e,o,ε,ɔ,a}

/a/
Height

/ε,ɔ/
Height
|
[closed]

/e,o/
Height
|
[closed]
|
[closed]

/i,u/
Height
|
[closed]
|
[closed]
|
[closed]

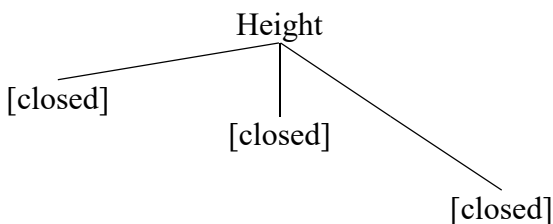
$[closed]_{max}$
/i,u/
Height
|
[closed]
|
[closed]
|
[closed]
|
[closed]

The structures in (15), in which each occurrence of [closed] depends on another and each occurrence of the prime is the same, suggest that assimilation for [closed] can only work in two ways: either the whole height node spreads (and we have complete assimilation of height) or raising applies spreading only one occurrence of [closed]. Since there is no system of registers that allows us to refer to a certain height, we cannot have the spreading of a certain [closed] feature in the continuum. In other words, the different occurrences of [closed] are not defined in isolation.

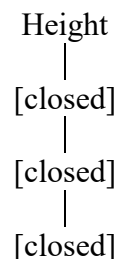
Consider the two structures in (16). The first one resembles the one chosen by Clements (1991) and above. Parkinson calls it a cascading structure. The second one corresponds to the one proposed by the Incremental Constriction Model.

(16) Cascading structure vs. scalar structure in Parkinson (1996:19)

a. Cascading structure



b. Scalar structure



The structure in (16a) is arranged around different registers: a model of height such as this one allows for the reference of a specific height in isolation.

The second one, instead, does not give any specific position to the various occurrences of [closed], but orders them hierarchically. Assuming this structure allows phonology to refer only to the lowest vowel in the system (the one without any occurrence of the [closed] prime), or to the highest, which is specified as [closed]_{max}.

Data gathered and discussed by Parkinson (1996) reveal that the additional power of the structure in (16a) is not necessary. Scalar raising does not affect the prime [closed] at a specific height, but instead applies as assimilation of a single occurrence of [closed] from a higher segment to a lower one, regardless of its degree of height.

An important difference between Parkinson's model and those discussed in previous sections is that it allows the formalization of scalar raising harmonies, but it is not able to represent scalar lowering harmonies. This follows from the fact that [closed] correlates with high vowels, and not (as the particle 'a' or the binary feature [\pm open]) to low vowels.

Recall from §2.1 that one of the main drawbacks in the analysis of raising patterns faced by unary approaches is the fact that the element |A| (or the particle 'a') does not correlate with height, but with lowness, and so processes of raising had to be formalized as cases of a-demotion. Clements' model employs the binary feature [open], and thus can represent both raising and lowering as spreading. In the case of lowering, [+open] spreads, in the case of raising [-open] spreads.

Parkinson (1996) uses a unary prime to represent vowel height, but avoids the issue of other unary theories employing [closed], which refers to height, and thus he is able to represent raising as spreading of melodic material, as happens with other harmonies. The structure in (16b) actually obtains more than that. One may assume that, similarly to other unary theories, Parkinson's model suffers from the same issue noted above regarding lowering harmonies: while Element theory (Backley 2011) and Particle theory (Schane 1984) cannot represent harmonies as spreading, Parkinson's model cannot represent harmonies that result in lowering.

However, this is not the case. A central observation made in Parkinson (1996: 21) is that only raising harmonies are actually scalar. Other VH involving height do not behave as partial/scalar, but only as complete harmonies. In Parkinson's model, complete harmonies are formalized as spreading of the whole height node from one segment to the other, which results in the target vowel assuming the same degree of height of the trigger. The process of complete height harmony is formalized in the same way, regardless of the raising or lowering nature of the harmony. On the other hand, spreading of a single occurrence of [closed], which results in partial raising, is predicted to be possible only for raising

harmonies. The different formalizations of scalar height harmony (which can only result in partial raising of the target) and of complete height harmony (which can be both complete raising or lowering) are exemplified in (17) and (18) respectively. In (17) scalar raising in Lena Bable is formalized as the spreading of an occurrence of the prime [closed] from the trigger to the target. In (18) Lowering is formalized as the spreading of the whole Height node from the trigger to the target.

(17) Scalar raising in Lena Bable

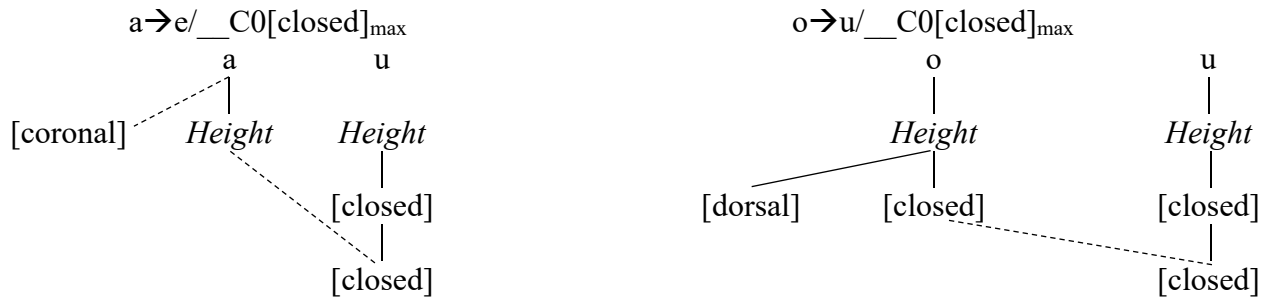
a. Representation of height for vowels in Lena Bable

i	u	e	o	a
[closed]	[closed]	[closed]	[closed]	
[closed]	[closed]			

b. Height alternations in Lena Bable

<i>Masculine plural</i>	<i>Masculine singular</i>	
'gatos	'getu	/a/→[e] ¹⁶¹
'nenos	'ninu	/e/→[i]
'bona	'bunu	/o/→[u]

c. Scalar raising in Lena Bable



(18) Lowering harmony in Kikuria¹⁶² Parkinson (1996: 117)

a. Representation of height for vowels in Kikuria

i	u	e	o	ɛ	ɔ	a
[closed]		[closed]		[closed]		
[closed]		[closed]				
[closed]						

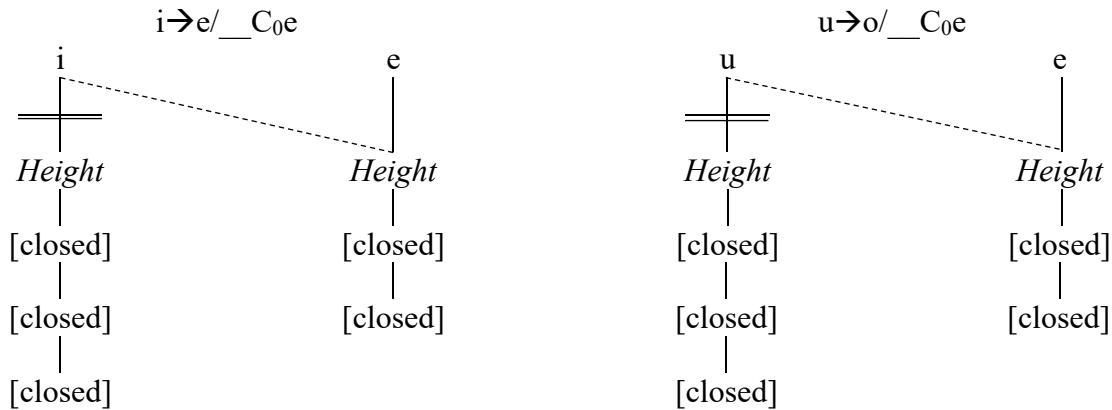
¹⁶¹ According to Parkinson (1996: 22) the vowel /a/, which is specified for no features, surfaces as a mid-vowel when it acquires an occurrence of [closed], and assumes the default place, [coronal] (Hume 1994).

¹⁶² Kikuria also exhibits raising harmony that behaves scalarly, cf. §II.3.1.9. Like many other Bantu languages, Kikuria exhibits lowering harmony (cf. §II.3.1.2), and it is this process that is exemplified in (18). As I did in the entirety of the second chapter, I am leaving aside tones, which do not interfere with the height harmonies active in Bantu languages.

b. Height alternations in Kikuria

ugu-siik-a	'to close'	ogo-seek-era	'to close for'
uku-ruug-a	'to cook'	oko-rog-era	'to cook for'

c. Lowering in Kikuria



The prediction made by Parkinson appears to be true. There is no process of lowering that applies in a scalar way appearing in the record. A possible counterexample to this generalization is harmonic lowering in Mbunda (Sandstedt 2018: 10), a Bantu language that displays a progressive lowering harmony that is parasitic on rounding. In Mbunda the low vowel /a/ (which is generally neutral in processes of lowering in Bantu languages) behaves as harmonic, and is a viable trigger for the lowering of the following high vowel /i/ in the applicative suffix. In the examples from Mbunda in (19) below, the low vowel /a/ acts as a trigger for lowering harmony. In the examples under (19) a low vowel in the root lowers the applicative suffix /-il/ to [el], and the reversive extension /-ul/ to [ol].

- (19) Mbunda progressive lowering, where /a/ behaves as a trigger for lowering of the applicative suffix /-il/

<i>Targets</i>	<i>Applicative /-il/</i>			
<i>High</i>	lum-il-a	'cultivate'	tung-il-a	'build'
<i>Mid</i>	nen-el-a	'bring'	oc-el-a	'roast'
<i>Low</i>	kwat-el-a		'hold'	
	Reversive extension ¹⁶³ /-ul/			
<i>High</i>	zit-ul-a	'untie'	kup-ul-a	'bail out'
<i>Mid</i>	tek-ul-a	'draw water'	tomb-ol-a	'uproot'
<i>Low</i>	nang-ul-a		'warn'	

Harmony in Mbunda is parasitic on rounding. Rounded vowels do not harmonize with non-rounded triggers, and thus maintain their underlying nature, as shown with the example [tek-ul-a] 'draw water' or [nang-ul-a] 'warn'.

¹⁶³ The reversive extension indicates that the subject undoes the action – e.g. [-zit-ul-] 'untie' in comparison to [-zit-] 'tie'. Sandstedt (2018:10) reports that the productivity of this extension is in doubt. Regardless, the behavior of the extension within the harmonic process of Mbunda is predictable.

The parasitic nature of this process certifies that this is a case of lowering harmony, where underlying high vowels /i/ and /u/ in suffixes lower when preceded by lower vowels in the root (when the condition is met).

Notice that when /a/ triggers the lowering process, it does not cause the target to become a low vowel, but instead it turns the high vowel /i/ into a mid-vowel. In a process of complete raising, the outcome of harmony matches the degree of height of the trigger. In the process of lowering triggered by /a/, the outcome of harmony is not a low vowel [a], but a mid-vowel [e]. Isn't it a case of scalar lowering, which Parkinson assumes to be absent from the record?

If we apply the Incremental Constriction Model to the case of Mbunda, we can simply assume that /a/ and /e/ share the same height degree, which means they share the same occurrences of the prime [closed]. Lowering harmonies are supposed to spread their entire Height node, not only a single occurrence of [closed] (cf. Parkinson 1996: 2), and if /a/ was lower than /e/ we should expect a lower outcome when /a/ acts as the trigger of the harmonic process. The representation of vowel height in Parkinson's model is rather free: there is no fixed number of occurrences of [closed] for a given sound. The number of [closed] that the highest vowels can have is defined on a language-specific basis, and the same goes for low vowels. Nothing prevents us from assuming that mid and low vowels in Mbunda share the same height degree.

Therefore, even though at a first glance lowering in Mbunda may appear as a counterexample to the generalization proposed in Parkinson (1996: 21) this process can be easily represented using the Incremental Constriction Model.

What Parkinson model actually predicts is the absence of cases in which a high vowel lowers to a mid-vowel, and a mid-vowel lowers to a low vowel. If a phonological process turned high vowels into mid-high vowels and mid-high vowels into mid-low vowels, it would be hard not to consider it a case of scalar lowering. However, processes of this kind seem to be absent from the record.

To conclude, Parkinson's way to represent vowel height combines both the Autosegmental structure proposed by Clements, and the unary approach pioneered by Schane (1984). Parkinson's model correctly predicts the behavior of raising scalar harmonies (i.e. only higher vowels trigger raising for a single occurrence of high), and rule out the existence of scalar lowering harmonies. The case of Mbunda in (19), while not perfectly adapting to the label of Complete harmony given in Parkinson (1996: 34), does not behave as a scalar lowering harmony that has a different effect on different targets.

IV.2.6. Incremental features

The representational models presented in section §2 are all rather similar. All of them presuppose a model of vowel height based on incremental features that can be stacked one upon the other, de facto forcing a non-binary representation of vowel height. In addition, all of them prefer a unitary representation of height, and discard the "economic" use of the feature ATR as a phonological prime related to vowel height. In other words, while in general explanations and traditional accounts ATR assumes both the role of a tongue-root feature and of a height-related feature, which is economical in terms of the number of features used¹⁶⁴, scholars that deal with height-related processes tend to avoid this confusion, and choose to represent vowel height without employing [\pm ATR]. Other scholars (Goad

¹⁶⁴ With this, I mean that everyone had to assume the existence of an ATR feature. Fusing together the old "tense" and "lax" definition to the new [\pm ATR] reduced the number of innate features necessary for a theory of phonological representation.

1993, Salting 1998) subscribe to the same core strategies discussed above, and propose models that are extremely similar to the ones already presented in this section¹⁶⁵.

The treatment of vowel height as a property that refers to multiple features, namely [high], [low] and [ATR], requires the formulation of multiple rules in the same contexts, and fails to capture scalar raising phenomena as a unitary process. The various accounts proposed in this section aim to represent vowel height as a uniform property, structured around a single prime.

Many authors have argued that articulatory-based features do not optimally define vowel height from a phonetic standpoint, since such a description of height is inconsistent with production (Ladefoged 1964, Lindau 1975, among others). As already discussed in §II.2.1, they argue that differences in vowel height do not actually correspond to specific positions in the tongue root. Acoustically based primes, which correlate directly with the frequency of the first formant F1, have been proposed at various times as alternatives to articulatory-based features (cf. Ladefoged 1964, Heffner 1964, Lindau 1975). Vowel height is argued to be best described in terms of a vowel’s first formant frequency, where low vowels have a relatively higher F1 while high vowels have a lower F1 (Ladefoged 1971: 67ff).

Another central issue that concerns the representation of height in phonology is the fact, observed by Heffner (1964) and Disner (1983), that different languages do not make the distinctions between different heights at the same point in the vowel-height continuum. To account for this, all the proposals listed in the present section are more interested in the identification of the correct language-specific representation of the height continuum than on the clear-cut boundary between vowels of different heights. The consequence is that the underlying representation of the same vowel in different languages can actually be extremely different, since it is language specific.

The common representational strategy for height that is employed by the approaches discussed in this section is to assume the existence of a single prime related to height, which can occur multiple times in a featural specification. Crucially, the number of the possible occurrences of the height prime is language specific (a point discussed explicitly in both Clements 1991: 65 and Parkinson 1996: 17) and can be assessed only on the basis of the number of contrasts in the height dimension that are phonologically relevant in a language. In other words, the actual number of occurrences of the height prime depends on the vowel system of the language under scrutiny, and it is not a universal property of the segment. The difference between those three representational approaches boils down to the nature of the phonological prime that represents vowel height: in other words, is it unary or binary? What is its correlation with phonetics? Under (20) the main differences between the three models discussed in this section are schematized.

(20) Different height primes in representational models based on incremental primes.

<i>Height prime</i>	<i>Binary</i>	<i>Unary</i>
<i>Related to low vowels (high F1- more open oral cavity)</i>	Clements (1991)	Schane (1984)
<i>Related to high vowels (low F1- more constricted oral cavity)</i>		Parkinson (1996)

¹⁶⁵ The proposal of Salting (1998) can actually be considered as an addendum to Clements’ (1991) model presented in §2.4. Salting argues that Clements’ model is not suited to capture non-scalar harmonies like raising in Lhasa Tibetan (Salting 1998: 394) He proposes an alternative organization of the open features, suggesting that languages can assume a different configuration of features depending on the behavior of their VH.

Among the three “incremental” options, the one proposed by Parkinson ensures a better coverage of the survey proposed in §II.3. Scalar raising requires incremental features to be represented as a unitary phenomenon, and the assumption of a height-related unary prime (and not of a prime that relates to low vowels) predicts that only raising harmonies and not lowering harmonies exist, as appears from the data explored in chapter II and chapter III.

All three proposals share a fundamental issue, which I argue is common to all representational theories of phonology in some form. The unique properties of vowel height require representational theories to give it some special status. Standard feature theories based on binary features consider vowel height as correlating with multiple primes, to the cost of losing the capacity to capture raising as a single process. On the other hand, theories (be they unary or binary) that give vowel height a unitary representation based on a single feature are forced to give the property of ‘incrementality’ to height-related primes. The problem in this case is that a specific prime assumes properties that differ from those of other primes¹⁶⁶.

IV.3 Underspecification and asymmetric harmonies

IV.3.1 Introduction and overview

Asymmetries are one of the most problematic aspects in the analysis of harmonic patterns in general, and they often come up in raising processes as well. In §I.4.2.5 was discussed how in numerous cases vowels that lack a harmonic counterpart in the vowel system tend to behave as neutral. The way a vowel system is structured may affect the way vowel harmony applies. This tendency, while not always correct (Ozburn 2019), has directed the research on asymmetric VH for decades.

The correlation between phonological activity and vowel system has been successfully exploited by various approaches that use underspecification as a tool to predict which segments will take part in a given process and which ones will not (Archangeli 1988, Steriade 1995, Dresher 2009). The core idea of Underspecification in phonology is that phonological segments do not need a specification for all the primes present in UG. Predictable distinctive features and/or feature specifications are effectively redundant information, and can be omitted from the underlying representation of a segment. Since they are absent from the underlying representation, they are also not expected to participate in phonological computation. In a later stage, after the application of phonological rules, the missing primes are added to the surface representation so that a complete segment can be produced.

Given a universal set of articulatory features, which is the standard assumption since Chomsky & Halle (1968), some redundancy relations between primes hold in any language system. Their phonetic (articulatory) correlates may require opposite movement, or their combined articulation may be impossible. Consider a low vowel /a/. If this vowel is specified as [+low], we can predict that it must also be specified as [-high]. Underspecification theories hold that the specification for [-high] can be omitted in the representation of /a/, which will then behave as neutral in any process regarding the feature [±high]. If we consider the typological record on both raising and lowering harmonies, this appears to often be the case. In the majority of height-related harmonies /a/ acts as a neutral vowel.

Some redundancies resulting in predictable features may also depend on language-specific factors, and may be related to the phonemic system of a language. This was observed in §I.4.2.5, while describing

¹⁶⁶ Pöchtrager (2006) came up with a model of representation that may partially answer to this state of affair, giving to the prime related to vowel height in Element Theory the status of structural object, and not that of melodic object. In his model the familiar |A| of element theory is substituted with structure, which relates to length.

the harmonies of Finnish and Tangale. In both languages, the specification for the harmonic feature was not necessary to identify the vowels that behaved as neutral.

Since a predictable feature is redundant, phonology may not consider it in derivation. This property of the vowel system is matched in phonological processing by the neutral behavior of the vowel that lacks a specification. This same idea has been around since the conception of distinctive features: in structuralist quarters, features represent only systemic oppositions necessary to distinguish each phoneme from the others. Here, the idea of language-specific Underspecification gives formal substance to the observation made above: asymmetries in the inventory bear some relevance in harmonic processes. This means that the typology of vowel behavior relates to the internal structure of phonological segments. Triggers behave as such because they contain the harmonic feature, targets need specification (they search for a specification for the harmonic feature) while neutral vowels are underspecified and need no specification for the harmonic feature.

In her survey of formal representations of VH, Samuels (2009: 3) notices that Underspecification is a theoretic tool applied by most (if not all) approaches that analyze harmonic systems. The term Underspecification has been used in phonology for a long time, and can assume different meanings depending on the framework assumed. I report here on a brief overview of the two main “flavors” that Underspecification can have.

1) Radical Underspecification (Archangeli and Pulleyblank 1989, Steriade 1995) assumes primes to be binary features, and considers one feature value as marked (and therefore present in the underlying representation of segments), while the other value is filled in after rules apply. Central to this approach is the proposal that for each feature one value is specified in the lexical representation of words, i.e., it is the value that is phonologically active. The other value, on this view, is filled in by a default rule at later stages or at the end of phonological derivation. This default value, then, becomes active late in the derivation (when “called upon” by a phonological rule) or is completely passive¹⁶⁷.

2) Contrastive Underspecification, originally proposed by Steriade (1987) in a different form and then developed in Hall (2007) and Dresher (2009), offers a similar option. The core mechanism does not change: there is a marked and an unmarked value for each binary feature, but instead of limiting itself to the redundant features, this approach considers as unspecified also all the features that do not play a role in differentiating two segments within a phonological system. It builds on the idea that non-contrastive features are inactive in phonology, an idea referred to as the Contrastivist Hypothesis. Only contrastive features are thus specified in the underlying form and can take part in derivation (i.e., be part of a phonological rule).

Contrastive Underspecification has at its core the idea that the phonological operations carried out during derivation and the shape of the phonemic inventory are strictly related. Contrastive Underspecification and related approaches turned out to be extremely successful in the prediction of asymmetries in vowel harmonies (as shown in §3.2 below), and as a consequence turns up frequently as the reason why harmony behaves as asymmetric in some contexts.

In this chapter, three approaches that apply (with different intents and with different scopes) the idea of contrastive underspecification to solve the problems posed by asymmetries are presented. In §3 the core theory advanced by Elan Dresher and his collaborators is presented and discussed: Modified

¹⁶⁷ Consider that the idea of Privativity can be loosely defined as a more radical view of Radical Underspecification, that instead of adding redundant and unmarked features “at a later stage”, simply gets rid of them.

Contrastive Specification (MCS) theory. In §4 I present the main tenets of Nevins' approach to VH. His approach does not hinge on the concepts of underspecification as MCS does, but it still applies some insights related to underspecification. It also tackles some asymmetries that MCS appears to be unable to cover, and proposes a view of VH that differs greatly from the other approaches presented thus far¹⁶⁸. Section §5 describes the work of Charette & Göksel (1996), that correlates phonological processing and vowel systems through Licensing Constraints. Section §6 covers the approach proposed by van der Hulst (2018). When discussing each proposal, I will assume the representational theory employed by the author, i.e., if an author assumes a process to involve the feature [+ATR] I will maintain their assumption in the discussion, even though I argued for a representation of vowel height that does not comprise the feature ATR. As a matter of fact, the possibility to combine the insights about asymmetries explored in the following sections of the chapters and the insights about scalarity discussed in §2 above will be a relevant part in the evaluation of the models.

IV.3.2 Dresher's Modified Contrastive Specification

IV.3.2.1. Workings of MCS

Elan Dresher and his collaborators in Toronto developed a theory, called Modified Contrastive Specification, of which an important piece is the Contrastivist Hypothesis, briefly introduced above and developed under (21)

(21) Contrastivist Hypothesis (Hall 2007: 20)

The phonological component of a language L operates only on those features that are necessary to distinguish the phonemes of L from one another.

In other words, the Contrastivist Hypothesis considers as phonologically active only the features that have a contrastive role in the language, i.e., those features that distinguish a segment from another. As a corollary of the Contrastivist Hypothesis, we also deduce a corollary, shown in (22).

(22) Corollary to the Contrastivist Hypothesis

If a feature is phonologically active, then it must be contrastive.

In the context of VH, the behavior of a vowel in a process should derive from its role in the contrastive definition of the vowel. As explained at length in Dresher (2009), the main role of features is to define the segments of phonology, distinguishing each one of them from the others. The set of contrastive features and the assignation of those features to each segment is obtained through the application of the Successive Division Algorithm (henceforth referred as SDA), a procedure that divides the set of segments of a given language assigning contrastive features at each division up until the whole phonemic inventory has been defined. The SDA procedure is presented in (23).

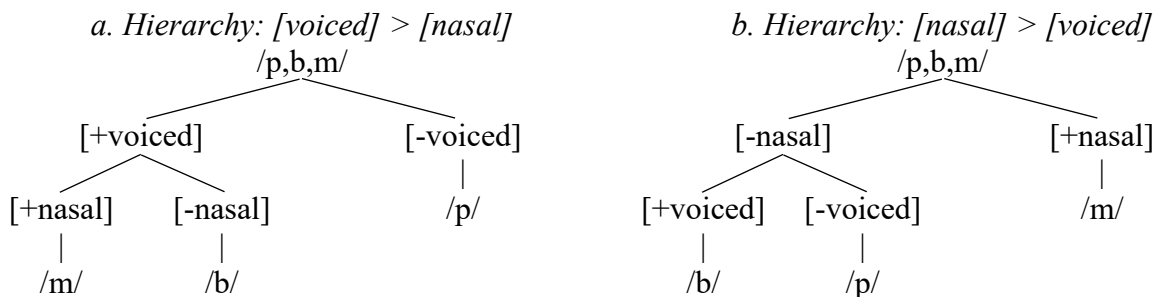
¹⁶⁸ The main difference between his approach and the others explored here is the fact that he assumes VH to be formalized as a Search & Copy operation, and is not fundamentally interested in phonological representation, while other approaches are more interested in the representational side of phonology, and less on the computational one. Still, as noticed above in the introduction of the chapter, both aspects have their relevance, and even if this thesis mostly deals with representation in phonology, the discussion of computational solutions to the problems of raising harmonies is relevant.

(23) The SDA procedure:

1. The set S of the segments of a given language is treated as if it contained N allophones of the same phoneme.
2. If S contains more than one segment, a feature is selected, and the set divided in 2: on one side are put those segments that contains the positive value of the feature, on the other those which don't.
3. The operation 2 is repeated until each subset contains only one segment.

The order in which features are selected for the operation number 2 in (23) is language-specific, and creates a specific contrastive hierarchy. Languages that share the same inventory may thus have different contrastive hierarchies, and different feature compositions for the same segments. As an example of this property, consider the two different graphs in (24a) and (24b), obtained by the application of the SDA given the three consonants /p, b, m/ (Dresher 2009: 15).

(24) Application of SDA on the set of segments {/p/, /b/, /m/}



The two sets of segments coincide, but their feature specification differs greatly. In (24a) /p/ is specified as [-voiced], while in (24b) it is specified as [-nasal],[-voiced]. This difference follows from the different feature hierarchies posed for the two systems. The hierarchy for (24a) is [voiced] > [nasal], the one for (24b) is [nasal] > [voiced].

IV.3.2.2 Patterns covered

The proposal advanced by Dresher does not intend to cover all possible kinds of asymmetries (Dresher 2009: 175), since targets may be restricted from participating in VH because of other properties besides their contrastive status (Archangeli and Pulleyblank 2007: 374). Still, the model proposed by Dresher has the potential to cover many asymmetric patterns. The MCS model exploits the SDA to generate different hierarchies for identical vowel systems, and manages to specify neutral vowels (or entire classes of vowels) by excluding the harmonic feature from the set of primes that define them. This way neutral vowels are ignored during the harmonic process, since they lack the harmonic feature (hence cannot behave as triggers) and do not require to be specified for the harmonic feature in order to be interpreted.

Let us take as an example the case of Halh Mongolian (Svantesson et al. 2008). Recall from §1.5.3 that in Halh Mongolian, there are two vowel harmonies active simultaneously. RTR harmony (which propagates the [+RTR] feature and which is symmetrical) and labial harmony, which is asymmetrical. Only mid and low vowels, which share the feature [-high], behave as triggers and targets of labial harmony. High rounded vowels, which are phonetically produced by protruding lips (i.e., are

phonetically round vowels), do not behave as triggers for labial harmony; that is, they do not propagate the [+round] feature to other vowels. Non-high vowels are subject to rounding only through the effect of other non-high vowels. Tables in (25) describe the situation of Halh Mongolian.

In (25a) the vowel system of Halh Mongolian is reported. (25b) displays tongue-root symmetric harmony and labial asymmetric harmony in suffixes. The direct past suffix alternates between three forms [-lʒa][-lʒe][-lʒo], which depend on the tongue root specification and the roundness of preceding vowels. The causative and the potential suffixes alternate between a RTR and an ATR variant. (25c) exemplifies the interplay between tongue root harmony and labial asymmetric harmony. A high rounded vowel that intervenes between a rounded [-high] trigger and a potential target behaves as a blocker. (25d) shows that the high non-rounded vowel /i/ behaves as transparent for both the tongue-root harmony and the labial harmony, allowing the harmonic features to pass through it.

(25) Harmonic patterns of Halh Mongolian (Svantesson et al. 2008: 47, cf. also §I.5.3).

a. Halh Mongolian vowel system

	[-RTR]		[+RTR]	
	[-round]	[+round]	[-round]	[+round]
[+high]	i	u		ʊ
[-high]	e	o	a	ɔ

b. Suffixes harmonize

Direct past /-lʒE/	Causative /-Ulʒ/	Potential /-xUic ^h /	
it-lʒa	it-ulʒ	it-xuic ^h	'eat'
uc-lʒe	uc-ulʒ	uc-xuic ^h	'see'
ʊʊɾf-lʒa	ʊʊɾf-ʊʒ	ʊʊɾf-xʊic ^h	'evaporate'
xeelʒ-lʒe	xeelʒ-ulʒ	xeelʒ-xuic ^h	'decorate'
og-lʒo	og-ulʒ	og-xuic ^h	'give'
ɔr-lʒɔ	ɔr-ʊʒ	ɔr-xʊic ^h	'enter'
saat ^h -lʒa	saat ^h -ʊʒ	saat ^h -xʊic ^h	'be delayed'

c. Multiple vowel sequences: Causative-Direct past

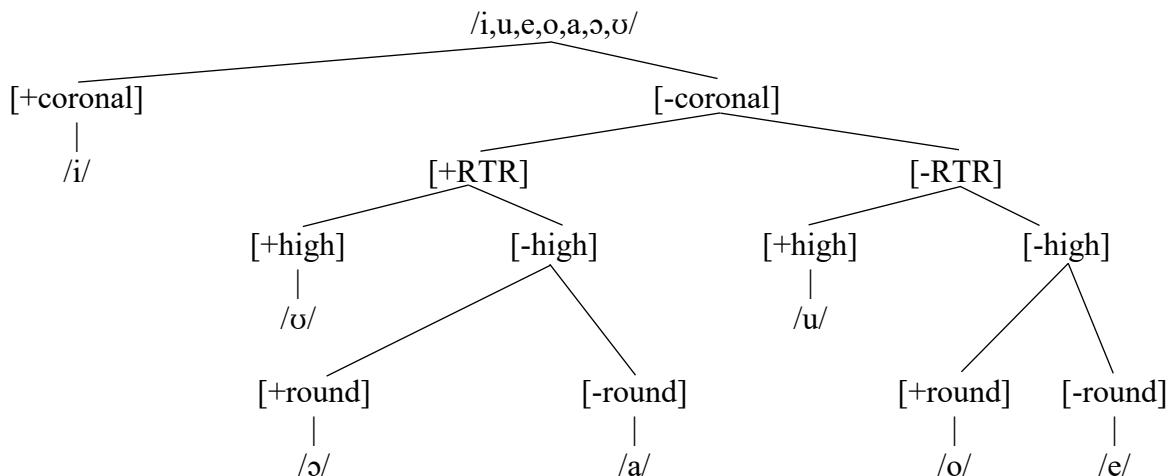
it-ulʒ-lʒe	*it-ulʒ-lʒo	'eat'
uc-ulʒ-lʒe	*uc-ulʒ-lʒo	'see'
ʊʊɾf-ʊʒ-lʒa	*ʊʊɾf-ʊʒ-lʒɔ	'evaporate'
xeelʒ-ulʒ-lʒe	*xeelʒ-ulʒ-lʒo	'decorate'
og-ulʒ-lʒe	*og-ulʒ-lʒo	'give'
ɔr-ʊʒ-lʒa	*ɔr-ʊʒ-lʒɔ	'enter'
saat ^h -ʊʒ-lʒa	*saat ^h -ʊʒ-lʒɔ	'be delayed'

d. /i/ behaves as transparent for tongue-root harmony and labial harmony

t ^h axʲi-lʒa	'to be bent'
gʊwtʲ ^h i-lʒa	'to be hollow'
ɔʒʲi-lʒɔ	'squint'

To sum up, only vowels that are non-high and rounded trigger labial harmony, and only non-high vowels are affected by it. High rounded vowels cannot, and they behave as blockers. The high non-rounded vowel /i/ behaves as transparent. It does not undergo rounding, but it allows the process to reach following targets. The application of SDA using the right contrastive hierarchy makes it possible to identify contrasting features in Halh, and therefore to match the behavior of each vowel. For this language the hierarchy is [coronal] > [RTR] > [high] > [round]. The graph under (26) represents the outcome of the SDA.

(26) Application of SDA in Halh Mongolian (from Dresher 2009:183)



The specification of each vowel correlates with its behavior in processing. The high non-rounded vowel /i/ is transparent for both harmonies because it is unspecified for both [±RTR] and [±round]. Since it does not need specification for any of the two features, it is ignored by the harmonic process. High rounded vowels /u/ and /ʊ/ are not specified for the feature [±round], and thus they behave as neutral with regard to labial harmony. They do not trigger the process because they lack the feature [round] in their underlying form. The fact that these segments are phonetically rounded is irrelevant for the phonological derivation. Non-contrastive properties of the segment are filled in at a later stage. The phonetic property of roundness of [u] and [ʊ] and the ATRness of /i/ are not part of their underlying representation. In other words, there is a set of universal features, but the specification of those features for a given vowel in a given system is not at all universal. According to MCS, the specification of the features depend on the contrastive hierarchy, which is language specific. As a consequence, we may encounter identical (or almost identical) vowel systems that show different behaviors in phonological computation.

This line of reasoning is a re-proposition of structuralist thinking in generative phonology (cf. Dresher 2009: 37, Scheer 2010). The operation done by Dresher and his collaborators practically makes explicit a practice that “most phonologists adopt only implicitly: not all features in a language’s feature-matrix are of equal importance to the phonology of a language” (Nevins 2015: 1). In various writings, other asymmetric harmonies are explained through the application of the MCS model: Dresher (2009) treats cases of ATR and labial harmony in Classical Manchu (Tungusic) and Nez Perce (Peutian, spoken in the Pacific northwest of the U.S.). In addition, Dresher & Nevins (2017) treat the case of Oroqen (Tungusic, spoken in northeastern China) harmony resolving its asymmetries through the application of SDA. The

way Dresher manages to solve those asymmetries is formally consistent. A subset of vowels (which behave as neutral) is positioned in the SDA graph in such a way that it can be contrastively defined (i.e., having a unique set of contrastive features) without the use of the harmonic feature.

IV.3.2.3 Patterns resisting MCS

While MCS is often successful in analyzing asymmetric patterns in Vowel harmonies, there are various cases that cannot be easily covered exploiting SDA. Consider the case of Basque Vowel harmony treated in §II.3.5.3. In Basque, harmony has a limitation in the selection of targets. Only the low vowel /a/ undergoes harmony, while mid vowels remain unaffected. Harmony turns /a/ into [e], modifying the feature [-low] and [+ATR]. (27a) displays the vowel system of Basque, while in (27b) are reported alternations in some suffixes that contain /a/. Each one of them alternates between a mid-high and a low variant, depending on the vowels that precede it. When /i/ or /u/ precede the low vowel /a/ in the suffix, /a/ raises to [e].

(27) Raising harmony in Basque: only low vowels undergo raising

a. Basque vowel system

	<i>Front</i>	<i>Back</i>
<i>High</i>	i	u
<i>Mid</i>	e	o
<i>Low</i>	a	

a. Root internal raising

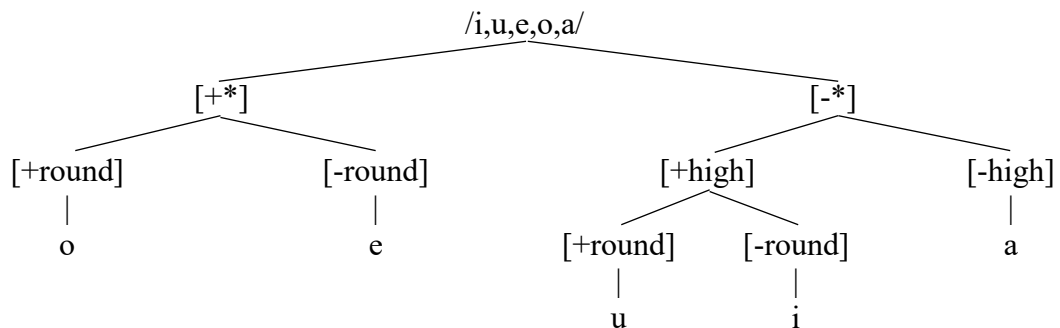
<i>Standard Basque</i>	<i>Baztan Basque</i>		
fabrika	fabrike		'factory'
muga	muge		'limit'
ikaratu	ikeratu		'frighten'
irabazi	idebazi		'to earn'
belaunikatu	belauniketu		'to kneel'
ikatz	iketz		'coal'
kirats	kirets		'stench'
ikasi	ikesi		'to learn'
izan	izen		'to be'
bihar	bier		'tomorrow'
usain	usein		'smell'
hura	ure		'that'
urtarril	urterril		'January'
urte	urte	*urti	'year'
izen	izen	*izin	'name'
izerdi	izerdi	*izirdi	'sweat'
bide	bide	*bidi	'path'

b. Alternations in derivational morphemes

i. Raising in the diminutive suffix /ska/			
afari-xke	little dinner	larra-xka	'little prairie'
mendi-xke	'little mountain'		
ii. Raising in the suffix /lari/ (profession)			
tratu-leri	'dealer'	eske-lari	'beggar'
iii. Raising in the adverbial suffix /ka/			
aldiz-ke	'by turns'	laster-ka	'quickly'
iv. Raising in the suffix /tsa/-[tza] (activity)			
lagun-tze	'help'	arran-tza	'fishing'
v. Raising in /-la/ (that)			
dugu-le	'that we have'	dire-la	'that they are'
vi. Raising in /ta/ (past participle)			
itzuli-te	'turned'	etzan-ta	'lied'
vi. Raising in the singular article /-a/			
itzuli-e	'the turned'	erran-a	'the said' (what has been said)

Notice that Basque has a limitation in the selection of targets. This means that various vowels behave as neutral in the harmonies of those languages. Only the low vowel /a/ undergoes raising, while other mid-vowels remain unaffected. To capture the pattern at hand, we would expect SDA to isolate the vowels that do not alternate and to label them as unspecified for the harmonic feature. However, the strategy applied earlier to capture the behavior of non-alternating vowels does not work for Basque. In fact, in order to capture the patterns at hand, vowels would need to be divided in the way shown under (28).

(28) SDA graph for Basque vowel system in light of the harmonic pattern. Only /a/ undergoes raising.



Contrastive hierarchy: [*] > [high] > [round]

A graph that is able to account for the asymmetry of Basque is formally possible, but there is no feature traditionally assigned to vowels that can be posed in the position marked with * in the graph in

(28). The only eligible target for raising is /a/, which cannot be specified for [-high] and isolated from other [-high] vowels using a standard set of features such as those proposed in Chomsky & Halle (1968), or in Clements & Hume (1995).

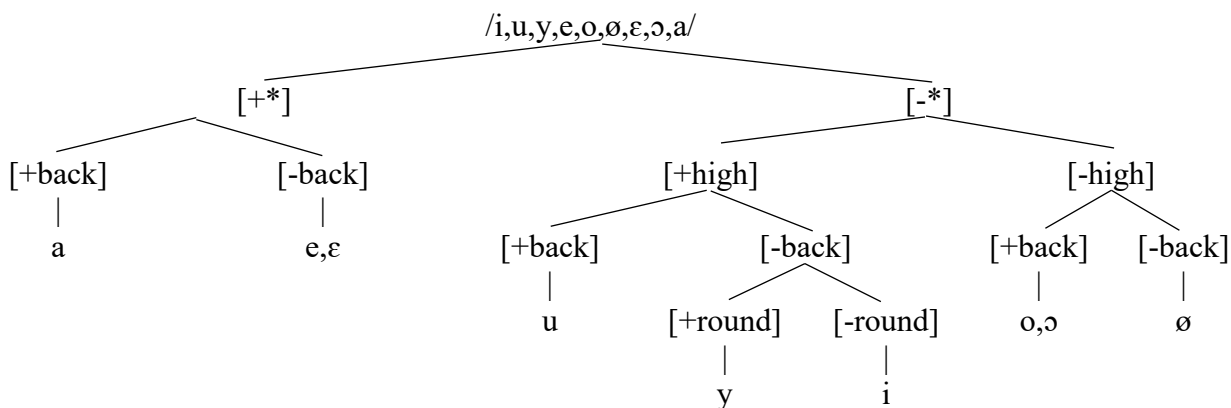
Another problematic case is the one of Bergamasco, treated in §III.7.3. Here /a/ and /e/ behave as neutral, while /o/ behaves as a viable target for the process of raising. The division of vowels that is needed to produce this pattern is shown under (29b).

(29) SDA for the Bergamasco vowel system¹⁶⁹. Only [+round] vowels undergo raising.

a. Height alternations in Bergamasco

Rounded vowels	[ˈgodʒa]	‘needle’	[guˈdʒi]	‘needle DIM’
	[me ˈcore]	‘I run’	[oter cuˈri]	‘you run PL’
	[øtʃ]	‘eye’	[yˈdʒi]	‘eye DIM’
Non-rounded vowels	[poledər]	‘foal’	[poleˈdri]	‘foal DIM’
	[me ˈlese]	‘I read’	[leˈsit]	‘read’

b. SDA graph for Bergamasco



Contrastive hierarchy: [*] > [high] > [back] > [round].

Once again, the graph is formally valid, but there is no feature in any standard set that is able to stand in the place of * under (29).

The problem is thus not specifically with the SDA procedure, but with the set of features employed. If there were a feature able to group /a/ and /e/ in Bergamasco (or /e/ and /o/ in Basque), the MCS model could cover the asymmetric patterns discussed.

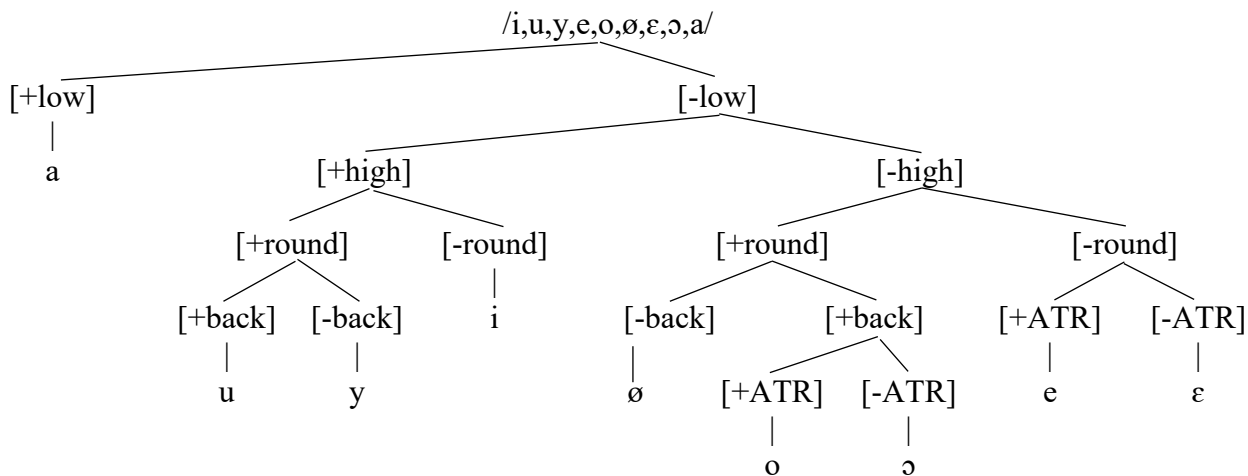
IV.3.2.4 Parasitic VH: a formal limit for MCS

In chapter III three major harmonic patterns in Eastern Lombard dialects are presented. Is MCS and more generally contrast-based approaches to asymmetric harmonies able to account for the three asymmetries? As noticed in §3.1, one of the major properties of MCS is to be able to assign different feature specifications to vowel systems that are identical on the surface. This is a promising property for what concerns Eastern Lombard dialects. Their vowel systems are practically identical (cf. §III.3.1), but

¹⁶⁹ In the graph in (29b) I grouped together tense and lax mid vowels. The reason for the grouping follows from §III.5.3.

the process of vowel harmony applies with great differences in the three varieties considered. Recall that Bresciano applies symmetrically, with only /a/ behaving as neutral. The graph in (30) perfectly accounts for this behavior.

(30) Application of the SDA for Bresciano



For what concerns Bergamasco, in (29) it was shown that the SDA can capture its asymmetries, but that there is no feature that can describe the first division of the graph.

Camuno presents an entirely different problem. In parasitic harmonies like the raising harmony of Camuno, some vowels have a different behavior depending on the context. Recall from §III.7.4 that /u/ behaves as a trigger for rounded mid vowels and as neutral for /e/, which in turn is a valid target for raising caused by /i/, but is neutral when /u/ initiates harmony. If this behavior were to be captured by the contrastive role of features in combination with the Contrastivist Hypothesis, we should expect the following:

(31) Feature specification for /e/ and /u/ in Camuno.

/e/	Targeted by VH when /i/ triggers the process	Specified for [-high]	The feature [±high] is contrastive for /e/
	Neutral when /u/ triggers the process	Non specified for [±high]	The feature [±high] is non-contrastive for /e/
/u/	Valid trigger for /o,ø/ raising.	Specified for [+high]	The feature [±high] is contrastive for /u/
	Neutral when preceded by /e/.	Non specified for [±high]	The feature [±high] is non-contrastive for /u/

Both /u/ and /e/ require a specification for the harmonic feature [±high]: /e/ as a target must be [-high] since it is raised by /i/, and /u/ as a trigger needs to be [+high] since it triggers /o/ and /ø/ raising. At the same time, though, both vowels are neutral and thus need to lack any specification for [high]. This is a contradiction in terms, since the contrastive status of features cannot be switched on or off depending on context.

Thus, there is no possible SDA graph describing the double behavior of triggers and targets: the asymmetry cannot be reduced to contrast. Something else is at play in this situation. I argue that this is true more generally for all Parasitic harmonies, as defined in §1.5.4.1. While the genuine property of parasitic harmonies is to show different behavior depending on the trigger and the target, MCS can only derive VH behavior from a fixed property of features. The SDA cannot explain parasitic asymmetries.

IV.3.2.5 Conflicting evidence from processing requiring different SDA graphs in a given language

As noted in §3.2.2, the core notions on which the MCS approach is built are the SDA procedure on one side and the Contrastivist Hypothesis on the other. SDA selects a subset of contrastive primes, and to assign to each segment its contrastive specification. The Contrastivist Hypothesis postulates that those and only those features that are contrastive can be active in phonological derivation. In the previous paragraph, we focused on the limits of the SDA in defining certain classes of neutral segments as unspecified for the harmonic prime. Another aspect challenging the MCS theory is the empirical question whether the Contrastivist Hypothesis is correct. This issue is not specifically a problem for the coverage of VH typology, but rather a general issue for the MCS model. Are really only contrastive primes those that can play a role in phonological computation?

Recall from §3.2.1 that the Contrastivist Hypothesis states that only contrastive features can be active in Phonology. If the hypothesis is correct, it follows from the corollary that all active features are contrastive. This principle can be assumed to be absolute, meaning that it follows a strict formulation of the CH, or relative, assuming it follows a weak formulation of the CH. The two formulations of the Contrastivist Hypothesis are presented in (32) below.

(32) The Contrastivist Hypothesis: strong & weak formulation

- a. *Strong formulation:* The phonological component of a language L operates only on those features which are necessary to distinguish the phonemes of L from one another.
- b. *Weak formulation:* The phonological component of a language L *may* operate only on those features which are necessary to distinguish the phonemes of L from one another.

Nevins (2010) raises the issue of conflicting evidence from processing in a given language, which appears to require different SDA graphs. He calls it the “Oops I need that” problem, illustrated by the case of the tongue-root harmony of Standard and Ife Yoruba (Niger-Congo, spoken in Nigeria, Benin, and a number of other west African countries). Those two dialects of Yoruba have been the ground for a back and forth between Nevins and Dresher. The issues opened by the discussion of those varieties of Yoruba are discussed first in Nevins (2010), in Dresher (2013) and finally in Nevins (2015). Here I will present the case made in Nevins (2015), where the final argument is made.

Standard and Ife Yoruba are two different dialects of Yoruba, where a tongue-root harmony is active (Dresher 2013: 142). The only indication of harmony in Yoruba is that vowels found in lexical items have a restricted distribution. Monosyllabic words in Yoruba can host any of the seven vowels found in the vowel system (33a) with the exception of /u/, which evolved into /i/ at the beginning of the word (Przedziecki 2005: 75). Words in which multiple vowels appear are limited in the nature of the sequence they can host. Vowel harmony in Yoruba forces mid-vowels to harmonize within roots so that they share the same specification for the tongue-root feature, which in the analysis proposed in Dresher (2013) and

Nevins (2015) is [RTR]. In other words, VH forces mid-vowels to harmonize for the feature [RTR] of vowels in final position. The process is regressive: final vowels affect preceding mid-vowels.

VH applies differently in the two dialects of Yoruba under scrutiny. In Standard Yoruba, high vowels disallow harmony to affect precedent mid vowels (they behave as blockers). In Ife Yoruba, the high vowels /i,u/ behave as transparent, remaining unaffected but allowing harmony to affect preceding mid-vowels. In both cases, the low vowel does not seem to participate in the process. In (33) the tongue-root harmony of Ife Yoruba (33b) and Standard Yoruba (33c) are exemplified.

- (33) Tongue Root harmony in Standard and Ife Yoruba (Nevins 2010: 104, Drescher 2013, Nevins 2015, Archangeli & Pulleyblank 1989, Akinlabi 1993).

a. Yoruba vowel system (both varieties display the same one)

	Front	Back
High	i	u
Mid-high	e	o
Mid-low	ɛ	ɔ
Low		a

b. Harmonic roots in Ife Yoruba

Tongue Root Harmony in Ife Yoruba		Tongue root harmony skips high vowels, which are transparent.
ètè	'lip'	
ègɛ'	'cassava'	
ɛfɔ'	'vegetable'	
ekpo	'oil'	
ɔrú'kɔ	'name'	
ɛlùbɔ'	'yam flour'	
ɛwúɛ'	'goat'	
ɔdíde	'parrot'	
òtító'	'truth'	

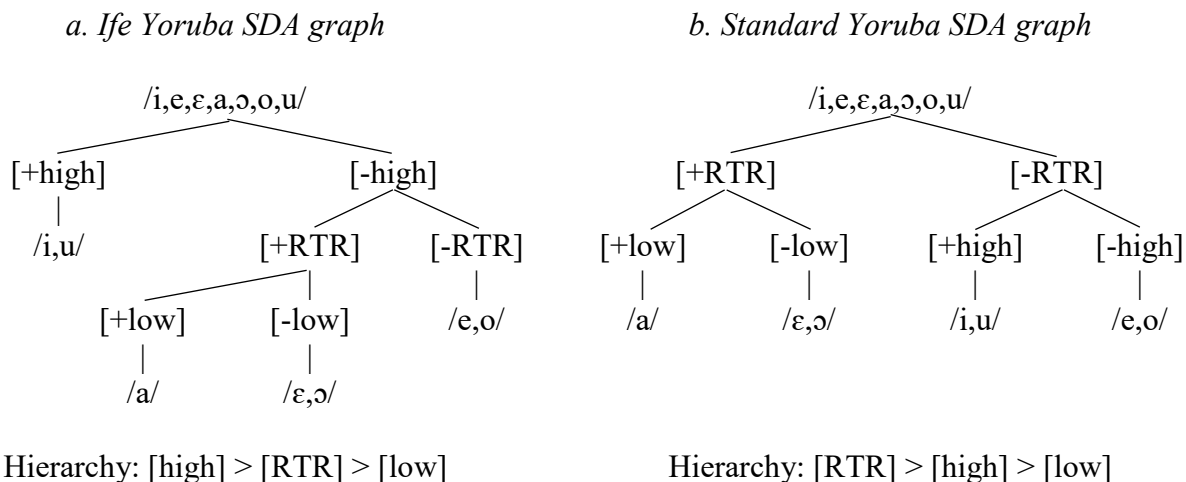
c. Harmonic roots in Standard Yoruba

Tongue Root Harmony in Standard Yoruba		High vowels affect preceding mid-vowels
ètè	'lip'	
ɛjɛ	'blood'	
ɛdɔ	'liver'	
ekpo	'oil'	
ɔrú'kɔ	'name'	
ɛlùbɔ'	'yam flour'	
ewúɛ'	'goat'	
odíde	'parrot'	
òtító'	'truth'	

Drescher (2013) argues that a different contrastive hierarchy, which matches the behavior of vowels in the VH, characterizes Ife Yoruba and Standard Yoruba. The contrastive hierarchy of Ife Yoruba is such that /i,u/ are underspecified for [±RTR], the hierarchy of Standard Yoruba instead specify them as [-RTR]. In other words, Drescher (2013) treats this case by creating two different SDA graphs for the two

dialects starting from the same vowel system. In Ife Yoruba vowels that behave as transparent in VH are excluded from the section of the graph that regards the RTR feature. This leaves them underspecified, meaning that RTR is not contrastive for either /i/ or /u/ in Ife Yoruba and hence they are not allowed to participate in the harmonic process.

(34) Ife and Standard Yoruba SDA graphs according to Dresher (2013: 149).



The graphs in (34) account for the behavior of high vowels for both varieties of Yoruba. They are unspecified for [±RTR], and thus neutral, in Ife Yoruba; they are specified as [-RTR], and thus harmonic, in Standard Yoruba.

However, Nevins argues that within the phonology of Yoruba there is evidence that other groupings are necessary. Two processes are active in both Standard and Ife Yoruba that require high vowels and mid vowels to be specified for [±high]. Akinlabi (1993: 144) describes a process of /r/ deletion (exemplified in 35), that applies when /r/ occurs either between two identical vowels (sequence V_1rV_1) or between any two vowels, one of which is [+high] (sequence V_1rV_2 , V_1 is high| V_2 is high)

(35) /r/ deletion in Yoruba

	<i>Underlying form</i>	<i>Surface form after /r/ deletion</i>	
<i>/r/ occurs between two identical vowels: sequence V_1rV_1</i>	gbègìrì	gbègì	'bean flower roup'
	wèrèpè	wèpè	'nettle'
	àkèré	àkèé	'edible frog'
	èrèkè	èkè	'cheek'
	kòkòró'	kòkò	'key'
<i>/r/ occurs between two different vowels. One of them is high: sequence V_1rV_2 (V_1 is high V_2 is high)</i>	Ìkirè	ìkiè	'city name'
	adire	adiè	chicken
	dàrukò	dàúkò	'to name'
	àburò	àbuò	'younger sibling'

This process of /r/ deletion feeds a process of progressive vowel assimilation. This process involves all vowels in phrases (high, mid and low), but within lexical items, high vowels are prevented from triggering the process.

This process makes so that when a sequence of vowels V_1V_2 appears, V_2 vowels assume all the feature specifications of the preceding vowel. Consequently, a sequence V_1V_2 becomes V_1V_1 . When two vowels are in contact within a lexical item, this process of assimilation is triggered only by mid vowels and low vowels. Lexical items that are affected by vowel assimilation are reported in (36).

(36) Vowel assimilation in Yoruba within lexical items (Akinlabi 1993: 144)

òrìṣà	òòṣà		'god'
orìkì	ookì		'(praise) name'
òrùkà	òòkà		'ring'
dàrukò	dàákò		'to name'
ìkirè	ikiè	*ikìì	'city name'
òmìrán	òmìáń	*òmììn	'giant'
àwùré	àwúé	*àwúú	'medicinal charm'

In light of this fact, Akinlabi (1993) has to refer to the class of [-high] vowels, which has to comprehend /a/ together with mid vowels¹⁷⁰. In Nevins' account, the existence of this progressive assimilation disproves the SDA graphs proposed in Drescher (2013): the SDA graph Drescher proposes for Standard Yoruba fails to assign the [-high] feature to the class of non-high vowels, which is active in both varieties of Yoruba.

The SDA graph for Ife Yoruba, in (34a), assigns the feature [-high] to all mid vowels and to the low vowel /a/. The SDA graph for Standard Yoruba in (34b) assigns [-high] only to mid-high vowels, leaving mid-low vowels and the low vowels without a specification for this feature. However, the class of non-high vowels requires a feature specification for [-high] in both varieties of Yoruba. The fact that non-high vowels behave as an active class in Yoruba is used in Nevins (2015) as an argument to discard the strong formulation of the CH in favor of the weak formulation (Nevins 2015: 13)¹⁷¹.

IV.3.2.6 Dealing with metaphonies

Drescher (2009: 190) suggests that contrastive feature assignation can be restricted to specific positions. In other words, contrast (and hence contrastive hierarchies) may be evaluated separately for each domain or relevant position, if certain conditions are met. Those conditions are the following:

- a. Segments that occur in one contrastive domain must not have an alternant in other domains. Let us assume that we are treating the end of a word as a contrastive domain: given an inflected and a non-

¹⁷⁰ Data on this process of assimilation are reported in Akinlabi (1993). None of the examples reported in the article show a lexical item with the sequence V_1V_2 so that V_1 is a mid-low vowel. Assimilation caused by mid-low vowels is shown in phrasal contexts, where all vowels are supposed to trigger assimilation. The assumption made in Akinlabi (1993:151) that it is necessary to "refer to the class of non-high vowels" may not refer to all non-high vowels. Besides this, it remains true that the low vowel /a/ and mid-high vowels /e,o/ pattern together, and thus, were the strong formulation of the CH true, should share a contrastive feature.

¹⁷¹ A similar argument is also made in Nevins (2010: 81). The asymmetric pattern of Finnish backness harmony suggests that /i/ and /e/ lack a specification for the feature [back]. However, /i/ triggers a process of assibilation that requires it to have the feature [+back].

inflected form of a word (say, ‘ride’ and ‘riding’), we cannot give the final consonant in [raid] and the medial one in [rairiŋ] different specification, since there is a single morpheme for ‘ride’. This condition disallows treating the tapped alternant of final /d/ in [raid] as a separate morpheme.

- b. A contrastive domain must correspond to a category that exists independently in the grammar. Contrastive domains cannot be arbitrary, i.e., there cannot be defined domains such as “the set of consonants that could precede the sequence –ed” (Dresher 2009: 191).

As an argument for the existence of different contrastive domains in a language, Dyck (1995) and Dresher (2009: 191) discuss the case of metaphony in Iberian and Italian varieties, which is of course an extremely relevant case for our discourse. They argue that the contrastive role of features may be evaluated in different ways in stems and in suffixes. In other words, vowels in roots may have a different feature specification than vowels in suffixes. This would explain why only final vowels, and not post-tonic non-final vowels, cf. §II.3.3.4.7, trigger metaphony in many Italian dialects.

To demonstrate the prominent role of contrast in final position, Dyck (1995) proposes a generalization regarding metaphonies in Iberian and Italian varieties, expressed in (37) (cf. Dresher 2009: 192).

- (37) Generalization about metaphonic triggers:

Desinential¹⁷² high vowels can trigger metaphony only if they contrast with a mid-vowel in the same place.

Recall that in many romance dialects (especially in Italian dialects, cf. §II.3.3.1) not all vowels are accepted in final position. Dyck’s generalization aims to predict which vowels may trigger metaphony in which dialect. In particular, this generalization allows us to predict whether a high vowel will behave as a metaphonic trigger or not: a high vowel that does not contrast with a mid-vowel in final/desinential position will not behave as a trigger.

If both /i/ and /u/ contrast with mid vowels in final position, they both behave as metaphonic triggers. This is what we see in the symmetric metaphony of Servigliano (cf. §II.3.3.3.1), where all five vowels appear in final position.

If only four vowels contrast in final position, say /e,o,a,u/ in a given dialect, the generalization predicts that only /u/ (which can contrast with /o/ in final position) will trigger metaphony, while /i/ will not. This is what is observed about the dialect in Northern Asturia (Lena Bable) and Cantabria (Tudanca and Pasiego Montañas). In those Iberian dialects, /u/ and /o/ contrast in final position, while the contrast between /i/ and /e/ is only marginal. The generalization in (37) ensures that only final /u/ triggers raising¹⁷³.

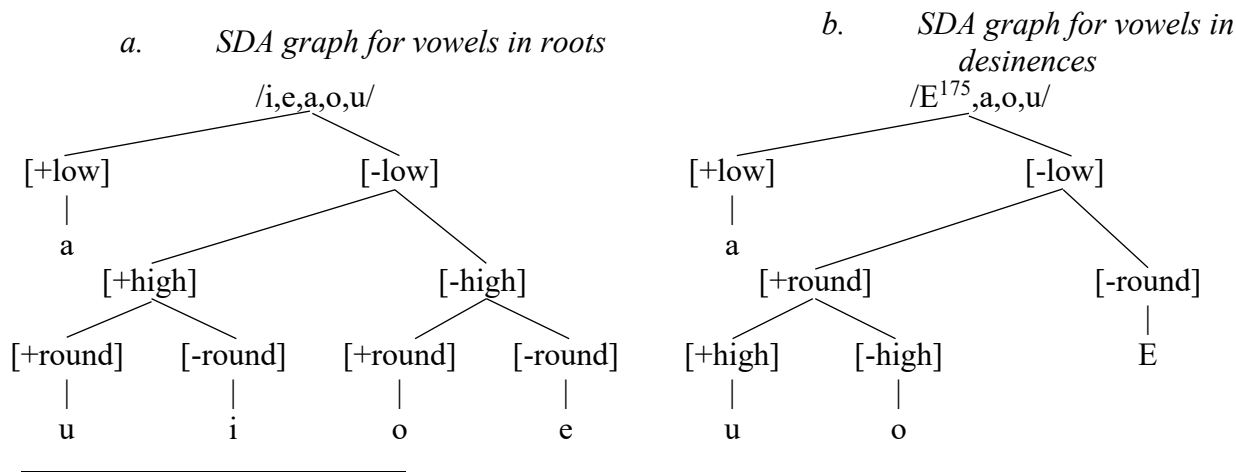
According to the generalization proposed in (37), if a variety has a system of contrasts structured around three vowels in final position (say, only the cardinal vowels /i,a,u/ contrast in final position), neither /i/ nor /u/ will trigger metaphony because they do not contrast with mid vowels. This observation is matched by the fact that metaphony fails to apply in many Italian varieties where the restructuring of

¹⁷²Dyck (1995) and Frigeni (2003) utilize the term ‘desinential’ to refer to the morphological extensions of lexical bases. Besides the citation in (37) I used the term ‘suffixal’ throughout the discussion.

¹⁷³ According to Dyck (1995: 73), in central and eastern Asturian Spanish dialects final underlying /e/ often surfaces as a phonetic high vowel [i]. Data provided in Hualde (1989) and reported in §II.3.2.2.3 do not host [i] in final position, and [e] is the only front vowel expected in the desinential triggering position. As we noticed in §II.3.2.2.3 residual underlying final /i/ in demonstratives seems to have a raising effect on preceding stressed mid vowels.

the vowel system resulted in a ‘Sicilian’ vowel system (cf. §II.3.3.1). While metaphony is a pervasive feature of southern Italy, it is noticeably rarer where only three vowels alternate in final position. In §II.3.3.4.2 were shown some cases of metaphony from Italian varieties that belong to the group of extreme southern dialects (namely the dialect of Modica and that of Ragusa), where only the cardinal vowels surface in final position. However, in those varieties metaphony is never surface-true: even though only the three cardinal vowels surface, only the /i/s and the /u/s that were underlyingly high could trigger the process, while those that derived from historical mid-vowels, while *phonetically* high, have no raising power. Consider that the generalization in (37) concerns only suffixal vowels. If we consider the complete vowel systems of Iberian and Italian varieties, height is always contrastive, in that there is no Romance variety without mid vowels. The generalization in (37) claims that the contrast between mid and high vowels must be relevant in final position, i.e. only at the end of the word. In other words, the contrastive hierarchy that concerns only the final portion of the word has a role in the generalization, the one that concerns the rest of the word (the root) does not count. This means that vowels in suffixes and vowels in roots may follow a different hierarchy. The contrastive hierarchy that concerns roots, where all high vowels are contrastive (at least in stressed position), does not give any information about the nature of metaphonic triggers. The contrastive hierarchy that concerns the final position of the word, instead, is central. If the metaphonic feature is not contrastive in this hierarchy for a high vowel, that vowel will not behave as a trigger for metaphony, regardless of its phonetical height, and regardless of the role of the same feature in other domains. Dyck (1995) treats the case of Ibero-Romance varieties as an example¹⁷⁴. In some varieties of northern Spain, as already noted above, the high vowel /i/ does not alternate meaningfully with a mid-vowel. The high vowel /u/, however, does so. Both /i/ and /u/ alternate with mid vowels in roots. In (38) two SDA graphs for Pasiego Montañas are proposed. The one in (38a) shows the contrastive hierarchy that is relevant in roots, while the one in (38b) shows the hierarchy that is relevant in desinences.

(38) Two different SDA graphs for the Iberian variety of Pasiego



¹⁷⁴ Dyck (1995) does not use the SDA graph in her dissertation, but works using the notion of Contrastive hierarchy. Here, for the sake of coherence, I apply the SDA graph to the Pasiego dialect. The argument works the same: for what concerns suffixes, the feature [±high] is not contrastive for the vowel /i/, which, according to Dyck, does not behave as a trigger for metaphony in Pasiego.

¹⁷⁵ Dyck uses capital letters to refer to underlying contrastive vowels. In this case, the letter E identifies the couple of vowels /i-e/, whose contrast is severely reduced in Iberian varieties such as the one under scrutiny.

Two hierarchies produce different prime specifications for vowels in different contexts. The graph in (38b) assigns features to vowels in desinences. In this graph, only /u/ receives the [+high] feature, and thus may behave as a valid trigger for the raising harmony of Pasiego Montañés, if we assume the generalization proposed in (37). In §II.3.2.2.2, while discussing the specific case of Pasiego, it was proposed that the lack of tokens where /i/ acts as a trigger for raising has more to do with the evolution of Spanish dialects that with phonological contrast. /i/ does not appear in suffixes that may act as a trigger for raising. Dyck (1995: 33) argues that the traces of raising caused by etymological *i found in Pasiego Montañés are not enough to consider the process symmetrical, and that the underlying vowel system of Pasiego actually lacks /i/ in final position. That is to say, /i/ is part of the vowel system in roots, while it is not in the vowel system of desinences, which Dyck assumes to be entirely different. However, I argue that lack of /i/ in final position simply makes it impossible to observe alternations caused by final /i/, and that this absence of /i/ does not require the assumption of two different vowel systems for roots and desinences in Pasiego Montañés.

In the survey in §II.3, I treated as asymmetric those harmonies where a vowel that appears in the system does not participate in the process, and I chose not to consider asymmetric cases in which a vowel simply does not appear in the harmonic domain.

Asymmetric behaviors in VH must be accounted for, while symmetric patterns simply require the identification of the prime shared by triggers and required by targets. I would consider the harmonic process of Pasiego Montañés as asymmetric if there was proof that a final /i/ does not trigger raising for the stressed vowel. However, as Dyck herself notices, there are no cases of final /i/, only remnants of it. Whenever a *i is reconstructed in the phonology, vowels in the root follow the harmonic rule, and surface as if they were raised. Dyck argues that those forms are not proof of /i/ being an active trigger of metaphony. I agree with this statement. However, I do not agree with the necessity to explain why /i/ does not behave as a trigger in Pasiego. Simply, I assume that the simplest form of VH is the symmetric one, and that height alternation caused by /i/ never appears because /i/ is absent from suffixal morphemes, and thus cannot be a trigger for a regressive harmony. For this reason, I treated the metaphony of Pasiego as a symmetric harmony.

There are other cases in which the restructuring of the vowel system in final position may have affected how metaphony applies. In §II.3.3.1 the various vowel systems of Italian dialects were discussed. It was noted that in northern Italian dialects, apocope of the final vowel may have caused the loss of metaphony in most northern dialects. In addition, recall the case of extreme southern varieties, where only the three cardinal vowels [i] [a] and [u] surface in unstressed (and final) position. In dialects of this kind, metaphony is less frequent than in dialects where more vowels are permitted in final position. This fact is in line with the generalization proposed by Dyck (1995). In dialects where high and mid-vowels do not contrast in final position (i.e., varieties where vowel height is not contrastive relevant in final position) metaphony does not apply.

Dresher (2009: 193) expands on the idea of having different hierarchies in different domains within the same language, and shows the case of metaphonic raising in Campidanese Sardinian (Frigeni 2003). Frigeni (2003) argues for a domain split in the assignment of contrastive features to vowels along the lines of Dyck's analysis of Pasiego's metaphony. In other words, vowels in roots and vowels in suffixes have a different feature specification due to the application of two distinct SDA.

In stressed position seven different vowels may surface in Campidanese Sardinian: [a, e, ε, i, o, ɔ, u]. In suffixal position only three vowels may surface [a, i, u]. The analysis proposed by Frigeni (2003)

considers five underlying vowels for both the vowel system of the root and the vowel system of the suffix. (39) shows the different vowel systems as presented in Dresher (2009: 195).

(39) Underlying vowel system of Campidanese Sardinian in stem and Suffixal vowels

<i>a. Stem vowels in Campidanese Sardinian</i>		<i>b. Suffixal vowels in Campidanese Sardinian</i>	
i	u	i	u
e*	o*		
ɛ	ɔ	ɛ	ɔ
a		a	

Mid-high vowels in the stem occur only when an underlying high vowel in the suffix triggers metaphony, while in all other occurrences only mid-low vowels are observed. In other words, they surface as the result of an allophonic raising. For this reason they are marked with an asterisk in the table in (39a): they are not phonemic. In desinences, only high and low vowels surface, but Frigeni claims that mid vowels /ɛ/ and /ɔ/ are still phonemic (39b). The two underlying systems, then, are considered identical.

Metaphonic raising is triggered only by originally high vowels (i.e., vowels that derive from high vowels in Common Romance), suggesting that the underlying vowel system still differentiates between mid and high vowels, albeit both of them surface as high. The behavior of vowels in Campidanese Sardinian suggests that the vowel system of stem vowels and of suffixal vowels is the same, at least in its underlying form. Though the two inventories represented in (39) look identical, Frigeni (2003) argues that their contrastive specification differs.

The structural modification caused by metaphony in Campidanese Sardinian turns underlying mid-low vowels to mid-high. For this reason, Frigeni assumes that the harmonic feature in Campidanese metaphony is the binary feature [\pm ATR], and not [\pm high]. Frigeni (2003) demonstrates that if vowels in roots and in suffixes shared the same contrastive hierarchy (and thus the same feature specification), the underlying form of a raised mid vowel would perfectly match the underlying form of the trigger. In other words, the process of metaphony would be expected to apply in a complete way. Consider the alternations in (40): mid-high vowels surface only in metaphonic contexts, and only in stressed vowels within stems (Frigeni 2003: 71).

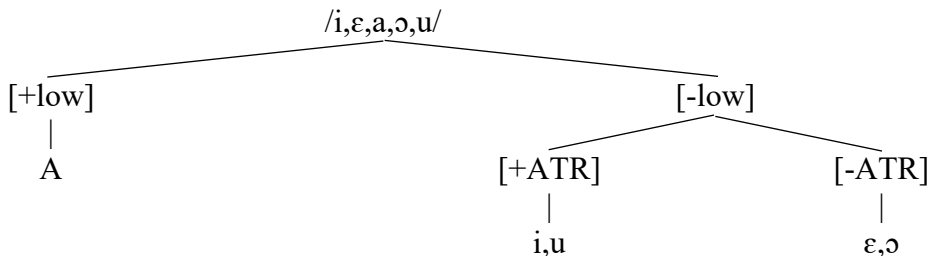
(40) Distribution of mid vowels in Campidanese Sardinian

<i>Class I adj. Masculine singular</i>	<i>Class I adj. Feminine singular</i>	
niɛɖ:u	niɛɖ:a	'black'
lentu	lenta	'slow'
veru	vera	'true'
nou	nou	'new'
sou	sɔβa	'lonely'
mot:u	mot:a	'dead'

Frigeni assumes that the process involves spreading of the feature [+ATR] from high vowels in suffixes to stressed mid-vowels in roots. If both vowel systems in (39) shared the same feature specification, high vowels should be [+ATR], due to the corollary to the Contrastivist Hypothesis: if a

feature is active, it must be contrastive. SDA would apply to the vowel system of Campidanese Sardinian as shown in (41)

(41) Spreading of [+ATR] caused by metaphony in Campidanese Sardinian (Frigeni 2003: 82)



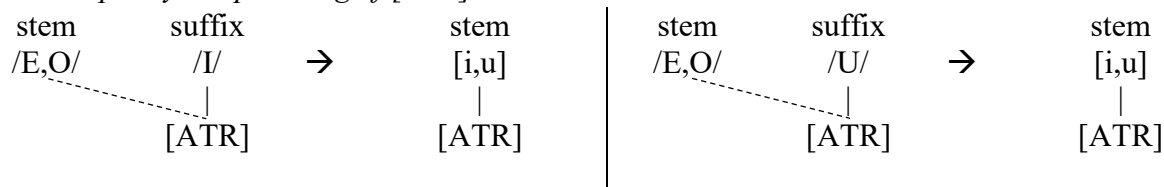
If we assume the feature specification obtained in (41), the outcome of metaphony (which Frigeni assumes to be spreading of [+ATR]) would share the exact same underlying representation of high vowels. They should thus surface as high vowels, if spreading applied as expected. Consider the example in (42) taken from Frigeni (2003: 82).

(42) Metaphony in Campidanese as [ATR] spreading (Frigeni 2003: 82)

a. *Vowel system of Campidanese Sardinian. Only positive properties of primes are assumed to be relevant (cf. §I.2.4).*

I	U	[ATR]
E	O	
A		[LOW]

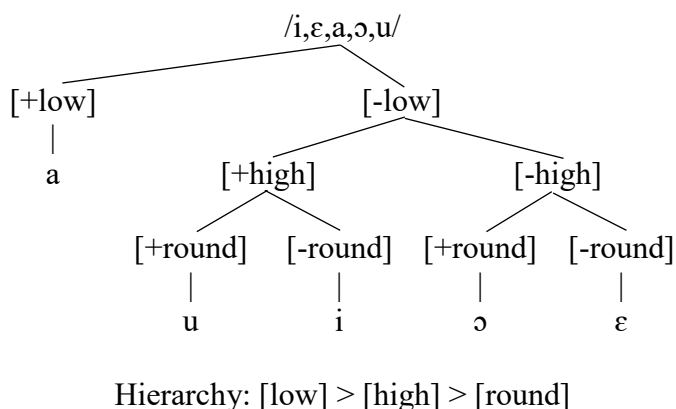
b. *Metaphony as spreading of [ATR]*



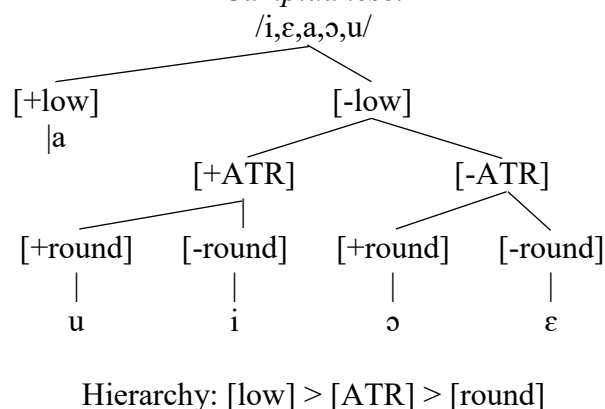
However, alternations in (40) show that the process applies scalarly, in an allophonic manner, meaning that the result of the process does not match the height of the trigger, and also that the outcome of metaphony is a vowel that is absent from the set of underlying vowels. To solve this problem, Frigeni assumes two different contrastive hierarchies for the two domains. The hierarchies (and the graphs they generate through the SDA) are shown in (43). (43a) shows the SDA graph for vowels in roots while (43b) shows the SDA graph for vowels in desinences (Dresher 2009: 196, Frigeni 2003:81).

(43) Application of SDA for the two vowel systems in Campidanese Sardinian

a. SDA for the stem vowel system of Campidanese.



b. SDA for the suffixal vowel system of Campidanese.



The two different feature specifications ensure that metaphonic triggers are [+ATR], and that the outcome of the process are [-high], [+ATR] vowels, i.e., mid-high vowels such as [e] and [o].

(44) Representation of triggers, targets and outcome of raising in Campidanese Sardinian.

<i>suffixal triggers</i>	[-low]	[+ATR]	[±round]	/i,u/
<i>targets in the root</i>	[-low]	[-high]	[±round]	/ε,ɔ/
<i>outcome of metaphony</i>	[-low]	[-high], [+ATR]	[±round]	[e,o]

Noticeably, this explanation does not require the underlying form of targets to be specified for the harmonic feature in order to be treated as targets for VH (as argued above in §3.2). This expansion of Drescher’s theory considers relevant only the “positive” active feature (cf. §1.2.4), but lacks a way to recognize in a representational manner the targets of vowel harmony.

Notice that the MCS theory generally utilizes the language-specific contrastive hierarchy obtained through the application of SDA as a way to recognize triggers, targets and neutral vowels. Targets require a specification for the harmonic feature, triggers have the harmonic feature, and neutral vowels lack a specification for the harmonic feature. The SDA served as an explanation for why certain vowels fail to participate in VH. However, once we assume the presence of different contrastive hierarchies for different domains within the same language, we lose the advantage given by the application of SDA.

Consider the behavior of the low vowel /a/ in Campidanese. Metaphony in this variety, as many raising harmonies encountered in the survey in chapter II, has a limitation in the selection of targets. The low vowel /a/ does not undergo raising, and remains unaffected by the process. In other words, it is neutral.

In previous analyses structured around the contrastive feature hierarchy, SDA was the tool used to justify the behavior of neutral vowels. If we assume the contrastive hierarchy under (43a), the behavior of /a/ would be matched by the SDA graph because the division of the set that involves the feature [low] branches out *before* the [±ATR] and [±high] features are assigned. Therefore, /a/ lacks a specification for [±high] and [±ATR], and does not require one, since it is already contrastively defined (i.e., contains enough contrastive features that can identify it). The neutral behavior of /a/ is justified by the fact that its only contrastive feature is [+low]. Mid vowels would require a specification for [±high], therefore

undergo metaphony, and assume the specification of the high vowel, which (having [+high]) behaves as the trigger of the process.

Once two different SDA graphs for the vowel system of Campidanese Sardinian are assumed (one for roots and one for desinences), the connection between targets and specification is lost.

All vowels in roots are contrastively specified: the features [±high], [±low] and [±round] are enough to build the SDA graph. The feature [±ATR] does not play any role in the contrastive hierarchy under (43a), and should therefore be considered as inactive in phonology, if we assume the Contrastivist Hypothesis. However, desinential vowels have a different contrastive specification, the one under (43b). There, [±ATR] is contrastive, and can thus be active.

In this view, all vowels in stressed position may assume the [+ATR] feature from the metaphonic triggers. None of them contains that feature, and none of them needs it, so there is no specific difference between /a/, /i/ and /ε/ in roots. Why are only /ε/ and /ɔ/, then, affected by metaphony? Why does /a/ behave as neutral? Dresher (2009: 196) suggests that this behavior may be due to the fact that [+low] and [+ATR] are incompatible in this language. However, this incompatibility should then be explained in some other way.

Simply put, I think that we cannot have the cake and eat it too. If we subscribe to the MCS approach and assume that contrast is context-dependent (i.e., that we can have different contrastive hierarchies for different domains), we lose the explanation of asymmetry based on contrast.

Dresher (2009: 196) considers Dyck's generalization under (37) as a proof in support of the Contrastivist Hypothesis. This generalization aims to connect the asymmetry in the selection of triggers of certain metaphonies (i.e., why in Iberian varieties /u/ is the only valid trigger) to the contrastive role of the active trigger. Regardless of my doubts on the specific case of Pasiego discussed in Dyck (1995: 33), I see the value of the generalization in (37). However, the separation between the SDA of suffixal vowels and root vowels makes it so the SDA graph cannot be used as a way to explain asymmetric harmonic patterns, which is the reason we turned to the MCS theory in the first place.

IV.3.2.7 Combining the MCS theory with unary and incremental primes

A last question that is relevant in considering the workings of the MCS theory in the context of raising vowel harmonies regards scalar harmonies and incremental primes discussed in §2.

It was noticed in §2.6 how incremental features are supposed to be unary in Schane's (1984) and Parkinson's (1996) approaches, and how a unary representation, combined with Parkinson's model, captures the typology of raising and lowering harmonies better than one based on binary features. While Dresher (2009) works with binary features, Dresher (2014b) claims that the MCS approach can also work with unary primes.

Employing unary primes has a formal consequence on the way SDA applies, though: one segment in the phonology of any language must lack any specifications, in other words it is contrastively null.

Recall that the three operation that form the SDA are the following, repeated under (45).

(45) The SDA procedure:

1. The set S of the phonological segments of a given language is treated as if it contained N allophones of the same phoneme.
2. If S contains more than one segment, a feature is selected, and the set divided in 2: on one side are put those segments that contains the positive value of the feature, on the other those which don't.
3. The operation 2 is repeated until each subset contains only one segment.

Assuming the rules of SDA and unary features, we have to rephrase the second operation in (45). Instead of choosing a feature and grouping all the segments that have a specification for that feature on either the plus or the minus branch of it, we have to consider that all branching nodes have on one side a prime and on the other side nothing. The second operation of SDA can thus be rewritten as in (46).

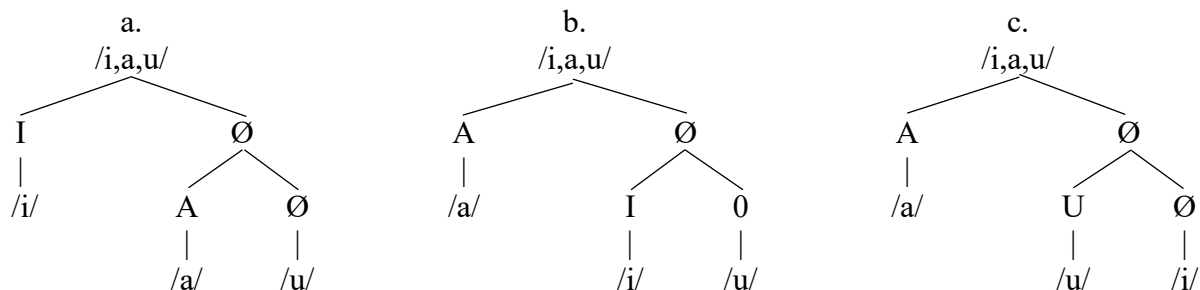
(46) The second operation of the SDA rephrased to accommodate the use of unary primes:

If S contains more than one segment, a unary prime is selected and the set is divided in two subsets: on one side are put those segments that contain it, on the other those which do not.

Binary branching applies to all nodes of the SDA graph, and stops only when all segments have been contrastively defined. All the operations of division will result in a full branch and an empty one. Therefore, for every SDA graph, there will always be a segment whose contrastive definition corresponds to the sum of all the empty branches. This means that in all systems, the application of SDA with unary primes predicts that one segment is empty, and thus cannot be the trigger of any assimilation-like process, since it does not contain any prime it can spread.

This property of SDA is shown in (47), where are reported three examples of SDA applying to a simple three-vowel system comprised of the vowels {i,u,a}. Each graph is obtained applying the SDA with a slightly different contrastive hierarchy. Notice that in each graph one of the three vowels contains no prime. This follows directly from the way branching works once unary primes are used instead of binary primes.

(47) Application of SDA using unary primes (Dresher 2014b: 4)

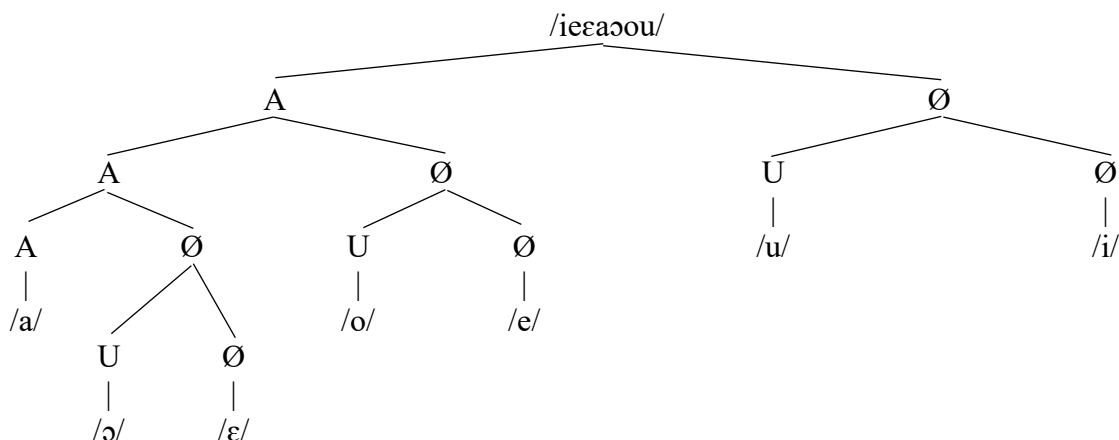


To conclude, the MCS model can be modified so that unary elements can be used instead of binary features. The main consequence of this shift is that one segment in the graph is required to be melodically empty, i.e., to lack any prime at the end of the SDA.

Now it remains to be settled whether MCS can accommodate incremental primes, so that we can profit from the insights discussed in §2. First, we have to assess whether SDA can work with incremental primes at all, and then we should consider whether the graphs resulting from the application of SDA can identify neutral and active vowels in harmonic patterns.

In (48) is shown an SDA graph obtained applying Schane's (1984) model of representation. Here three unary primes can be selected: |A|, |U|, and |I|¹⁷⁶. I will use the Italian dialect of Servigliano as an example. Here metaphony applies scalarly to all mid-vowels, and both /i/ and /u/ are valid triggers for the process.

(48) Servigliano SDA graph obtained using Schane's particles.



As shown in (48) the SDA graph can indeed operate with multiple occurrences of the same prime. In the graph there are three occurrences of the unary prime |A|. The first branching divides the set between vowels without any occurrence of the prime |A| (/i,u/) and vowels that have at least one occurrence of |A| (/a,e,ε,ɔ,o/). This subset is further divided in two, and the prime selected for the division is still the height-related prime |A|. This second branching distinguishes mid-high vowels on one side and mid-low/low vowels on the other. At this stage of the SDA application, then, it is established that high vowels have no |A|, mid-high vowels have one occurrence of |A| and mid-low vowels have at least two occurrences of |A|. The last division that involves contrast for vowel height sees on one side mid-low vowels and low vowels: mid-low vowels have two occurrences of |A| while low vowels have three. SDA, then, has distinguished the following subsets of vowels: high vowels, mid-high vowels, mid-low vowels and low vowels. The height degree of vowels in Servigliano is schematized under (49).

¹⁷⁶ While Schane (1984) uses small letters to identify primes in his model, I use here the more common capital letters. This way, I avoid confusion with the actual segments.

(49) Representation of vowels in Servigliano

	Primes assigned by SDA	vowels
High vowels		i,u
Mid-high vowels	A	e,o
Mid-low vowels	A A	ɛ,ɔ
Low vowels	A A A	a

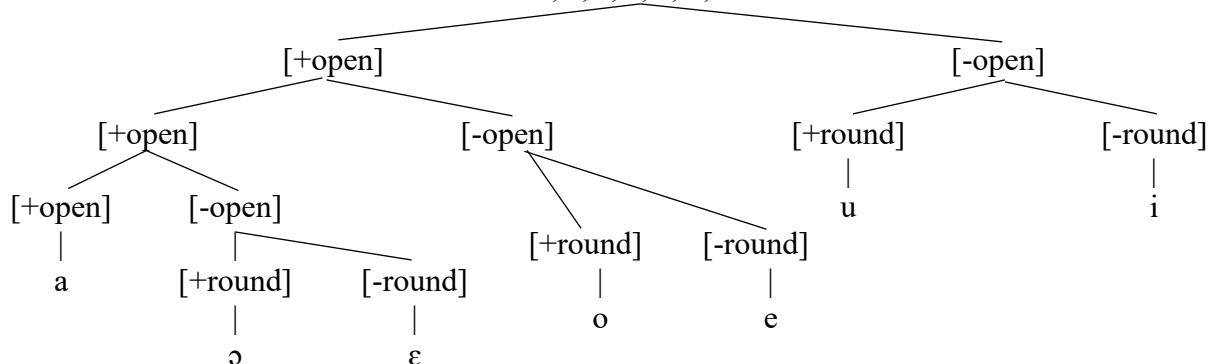
SDA has not finished its job yet. It further splits all subsets that contain more than one segment. Therefore, all individuated subsets (with the exception of the set of low vowels) must be divided again. In this case, the SDA selects the prime [U] to divide between front and back vowels. An equally valid alternative would be to use [I] for each distinction. Consider that since we are assuming multiple occurrences of [A] can appear in the same segment, SDA must check multiple times whether a segment contains [A]. Here [A] was selected by SDA as the prime of the division for a total of three times.

We can conclude that the MCS model can still work even when using a set of primes that are unary and incremental, and that SDA is still a valid way to define the contrastive role of primes for each segment.

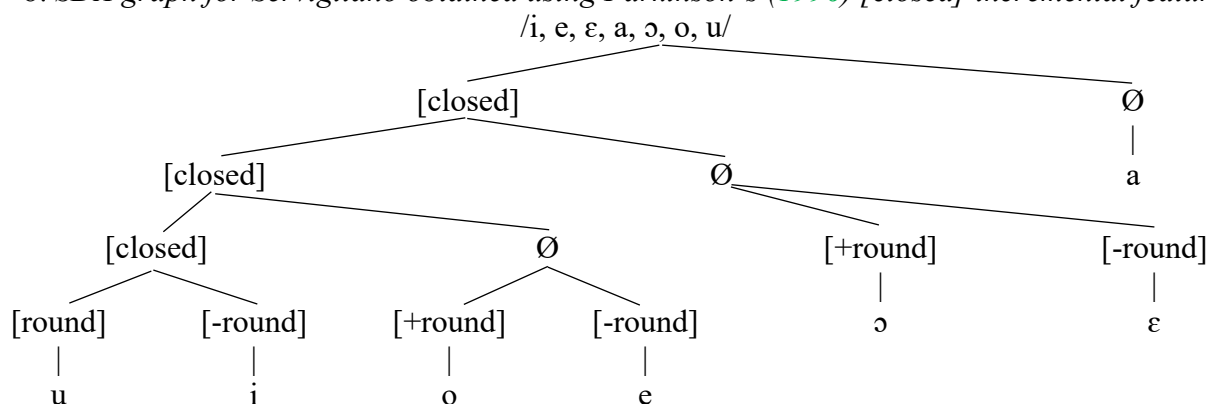
A similar graph can be built using the height-related prime proposed by Clements (1991) and by Parkinson (1996). Consider the graphs shown in (50). (50a) is obtained by applying the SDA to the vowel system of Servigliano using the primes proposed by Clements (1991). It corresponds to/matches with the graph in (48): low vowel /a/ has three occurrences of the height related feature [+open], while mid-low vowels are [+open, +open, -open], mid-high vowels are [+open,-open] and high vowels are [-open]. (50b), instead, is obtained using the unary prime [closed] proposed in Parkinson (1996). Compared with the graphs in (48) and (50a), it appears as flipped over: here high vowels have multiple occurrences of the [closed] prime, while lower vowels have fewer. This simply follows from the fact that the incremental prime proposed in Parkinson’s model relates to relative height and not to “lowness”.

(50) SDA graphs obtained using incremental models

a. SDA graph for Servigliano obtained using Clements’ (1991) [\pm open] incremental feature /i, e, ɛ, a, ɔ, o, u/



b. SDA graph for Servigliano obtained using Parkinson's (1996) [closed] incremental feature



We can safely say that SDA can work with incremental primes, both unary and binary. Nothing disallows SDA from reapplying binary branching for the same prime multiple times.

Now it remains to be assessed whether graphs like the ones in (48) and (50) are able to capture the asymmetric behavior of certain raising harmonies. In §3.2.4 it was noted that parasitic harmonies cannot be formally accounted for using the SDA and innate primes. I will therefore concentrate on kinds of asymmetries that can actually be dealt with by the MCS model. First, I will take the case of Servigliano, which has the most regular pattern of metaphony among Italian dialects.

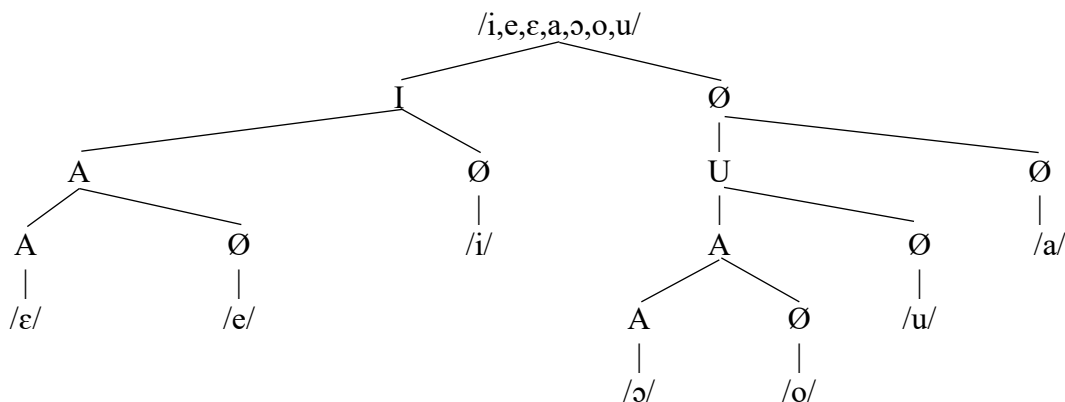
Recall that in Servigliano metaphony applies to all mid-vowels and does not apply to low vowels. The graphs in (48) and (50) are valid SDA graphs, but do not reflect the neutral behavior of /a/ in the raising process active in the variety.

Normally, MCS is able to justify the neutral behavior of a vowel in a harmonic process considering it as not specified for the harmonic feature. If SDA is able to identify the neutral vowel with contrastive primes that are not those involved in the harmonic process, the vowel will behave as neutral, because it lacks the primes involved in harmony. In the case of Bresciano discussed in §3.2.4, where /a/ behaves as neutral, the first division involved the binary feature $[\pm\text{low}]$. On one side only /a/ was identified as $[\text{+low}]$, while all other vowels (which participated in VH) were $[\text{-low}]$. The fact that /a/ does not participate in the VH of Bresciano is then accounted for because the $[\text{high}]$ feature, which we identified as the harmonic feature, is not contrastive for /a/. Since in MCS only contrastive primes can be active (cf. 22) and $[\pm\text{high}]$ does not have a contrastive role in defining /a/, /a/ will simply ignore the harmonic process that involves the feature $[\pm\text{high}]$.

Theoretically, the same can be done for Servigliano. If /a/ can be defined without referring to its height, SDA would justify its behavior as a neutral vowel. However, in all three proposals that use incremental features discussed in §.2, the prime $[\text{low}]$ is substituted by other representational items.

Consider the graphs in (51), where an alternative SDA graph for Servigliano, made using Shane's particle theory, is shown. In this case, the contrastive hierarchy puts the particles |I| and |U| first and leaves |A| as the last one. /a/ is the null segment that does not contain any prime, high vowels contain only |I| or |U|, mid-high vowels contain one occurrence of |A| and mid-low vowels two.

(51) SDA graph for Servigliano obtained using Shane’s (1984) incremental primes



In this case, the low vowel is isolated from the rest of the segments, and lacks any prime related to height. However, the low vowel /a/ ends up having the same degree of height of high vowels, which is none.

The problem with this analysis has to do with the a-demotion problem discussed earlier in §2.3. In particle phonology (as well as in most other theories based on unary primes) raising is formalized as “a-demotion”, and not as spreading. In this case, mid-high vowels lose one occurrence of |A|, resulting in high vowels, and mid-low vowels lose one occurrence of |A| resulting in mid-high vowels, as expected. However, what we lack is a way to identify the triggers of the raising process. There is no prime shared by the triggers /i/ and /u/ that can justify their behavior as triggers for metaphony. In this case, the option of considering the lack of |A| as the trigger has the additional problem of also identifying /a/ as a trigger, which instead behaves as neutral. The primes assigned by SDA to segments in Servigliano are shown in (52) below.

(52) Triggers and targets of metaphony in Servigliano

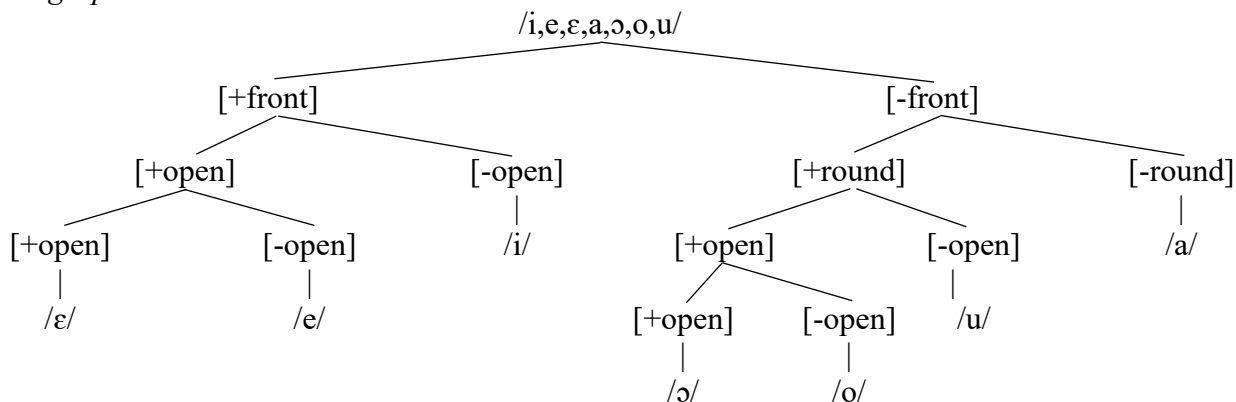
<i>Set of triggers: lack A </i>		<i>Set of targets: contain A </i>		<i>A-demotion:</i>
<i>i</i>	<i>I</i>	<i>e</i>	<i>IA</i>	<i>IA → I</i>
<i>u</i>	<i>U</i>	<i>ε</i>	<i>IAA</i>	<i>IAA → IA</i>
<i>a</i>	<i>Ø</i>	<i>o</i>	<i>UA</i>	<i>UA → U</i>
		<i>ɔ</i>	<i>UAA</i>	<i>UAA → UA</i>

If lack of |A| in high vowels were the triggering cause for raising, /a/ should be part of the set of triggers, since both high and low vowels, given the graph in (51) lack the particle |A|.

If instead of Schane’s particles we employ Clements’ model of representation, we end up with a graph such as the one presented in (53).

(53) SDA graph for Servigliano obtained using Clements' (1991) incremental primes

a. SDA graph



b. Featural representation of vowels in Servigliano in light of the SDA graph

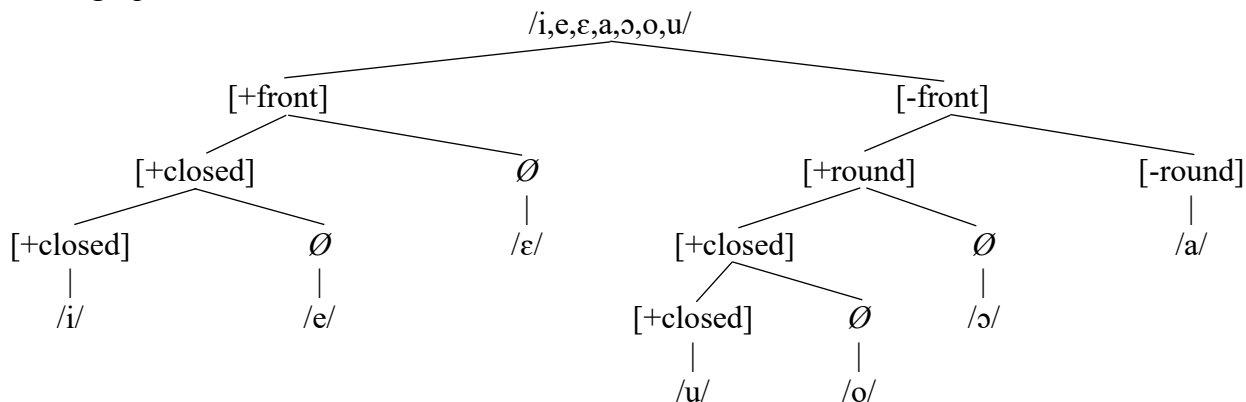
i	[+front] [-open]
u	[-front] [+round] [-open]
e	[+front] [+open] [-open]
o	[-front] [+round] [+open] [-open]
ε	[+front] [+open] [+open]
ɔ	[-front] [+round] [+open] [+open]
a	[-front], [-round]

The graph in (53) manages to define /a/ without recurring to the height-related prime $[\pm\text{open}]$, which instead appears in all other vowels. Thus, vowels that participate in VH are those that have the $[\pm\text{open}]$ feature, triggers are those with [-open] and targets are all the vowels with at least one occurrence of [+open].

If we were to use the primes proposed in Parkinson (1996) we would end up with a graph like the one in (54).

(54) SDA graph for Servigliano obtained using Parkinson's (1996) incremental primes

a. SDA graph



b. Featural specification of vowels in Servigliano in light of the SDA graph

i	[+front] [closed] [closed]
u	[-front] [+round] [closed] [closed]
e	[+front] [closed]
o	[-front] [+round] [closed]
ɛ	[+front]
ɔ	[-front] [+round]
a	[-front], [-round]

In this case, the neutral vowel /a/ is defined as [-front] and [-round], However, since the model proposed by Parkinson hosts both binary features and the unary iterative prime [closed], the SDA ends up assigning two vowels the same set of primes. In this case, the mid-low vowel /ɔ/ and /a/ are both identified as [-front] [-round].

This follows from the fact that after the binary primes [+front] and [round] were selected by SDA, the prime that guides all following divisions is the unary prime [closed].

To sum up, while the SDA algorithm may work with incremental primes, the set of primes chosen has crucial consequences on whether the SDA graph can capture the neutral behavior of vowels in harmonic processes.

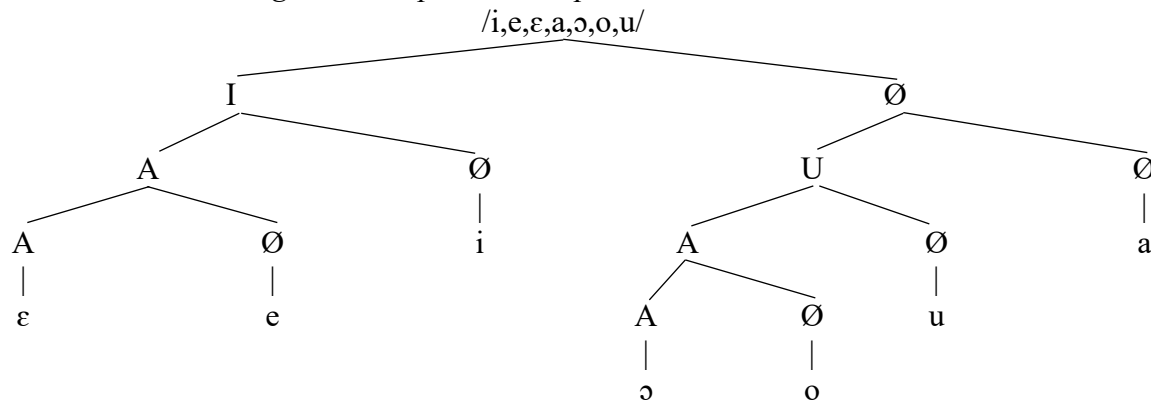
Besides neutral vowels, SDA graphs are supposed to identify asymmetries. Let us take as an example the case of metaphony in the dialect of Teramo. In this dialect, metaphony applies to all vowels (including /a/), but it is triggered only by final underlying /i/, and not by underlying /u/. For the time being, I ignore the process of progressive raising discussed in §II.3.4.3, and try to build an SDA graph able to identify /u/ as a neutral high vowel in metaphony, i.e., as a non-valid trigger.

As in the case above, the neutral /u/ should be defined by SDA without using height-related primes. In other words, since /u/ acts as neutral for metaphony in this variety, it should be defined by SDA using primes that are not involved in the process of metaphony, namely height primes.

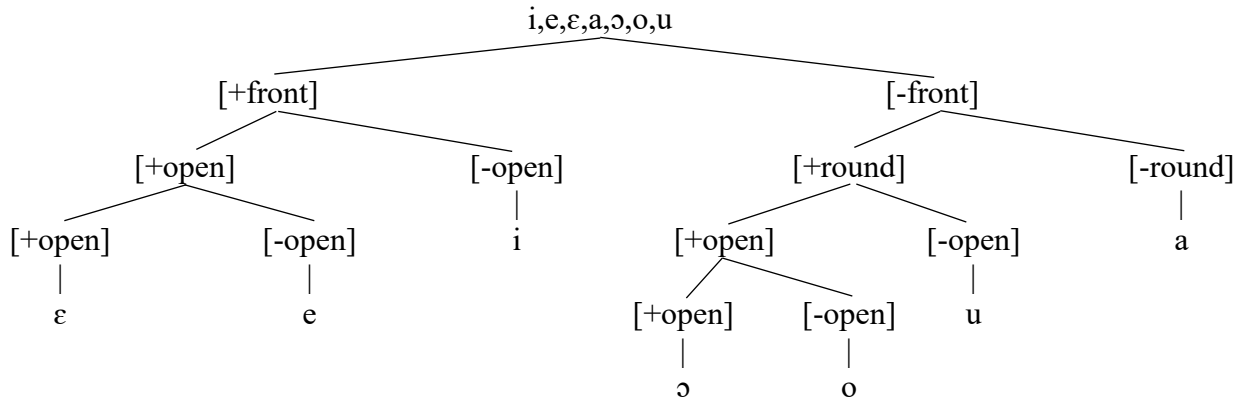
In (55) three SDA graphs obtained applying the algorithm to the vowel system of the dialect of Teramo are shown. (55a) is obtained using Shane’s particle mode, (55b) using Clements’ model and (55c) using Parkinson’s model.

(55) Incremental primes in SDA graphs: capturing the asymmetry of Teramo metaphony

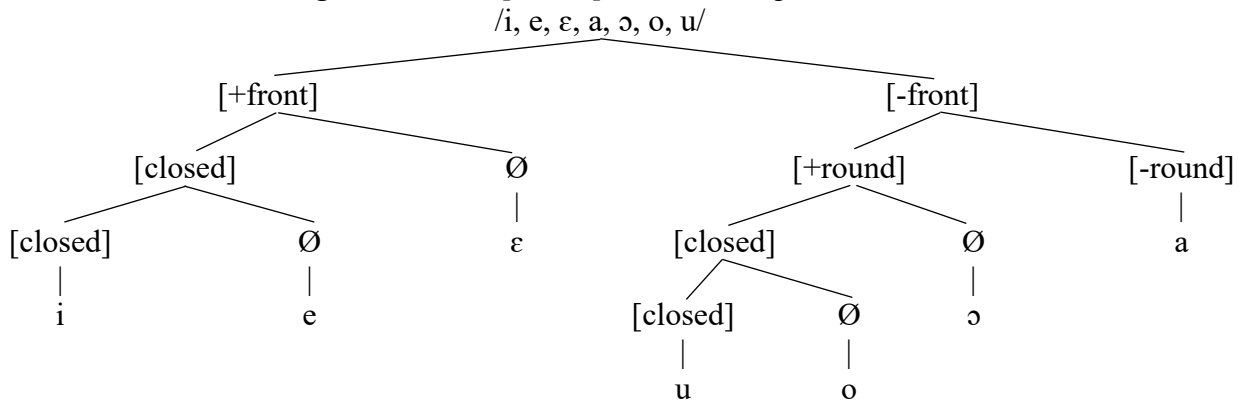
a. SDA obtained using Shane’s particles as primes



b. SDA obtained using Clements' [\pm open] incremental prime



c. SDA obtained using Parkinson's [closed] incremental prime



The graph in (55a) uses the particles of Schane's model, and while it manages to identify /u/ without using height-related primes, it suffers from the same problem discussed above. /u/ has no height related particles, exactly as /i/, which in turn behaves as a trigger for metaphony. The issue here is in the impossibility of defining high vowels as metaphonic triggers.

If we are to use the other incremental options described in §2, as done in (55b) and (55c), we cannot end up with a graph that identifies /u/ without using height-related primes. Therefore, it is not possible to capture the neutral behavior of /u/ in this variety using SDA.

In conclusion, while the MCS model can indeed work with both unary and binary primes and can operate using incremental primes, it cannot identify neutral vowels in raising harmonies, which was the main reason we turned to MCS in the first place. This is not a problem that relates directly to the nature of the SDA, as it was the case for Parasitic harmonies discussed in §3.2.4, but rather a consequence of the set of primes that we are using.

IV.3.2.8 Concluding remarks

MCS offers a valuable answer to many asymmetric processes. The model takes a common practice, already shared by most phonologists, to its logical consequences, and proves itself to work with many labial and tongue root processes. However, it appears that it is more suited to represent harmonies that do not involve vowel height. The main problem encountered with most asymmetries does not lie in the formalization of the SDA graph, but in the set of primes employed. Neither binary articulatory features nor the unary features commonly used in Element Theory (Backley 2011) can be successfully applied to

the MCS architecture in order to predict the asymmetries of raising VH described in the survey in §II.3, and while the core mechanisms of MCS can work with incremental primes, they suffer from the same weaknesses discussed above. Another central issue with MCS is its genuine inability to represent Parasitic patterns.

IV.4 Nevins and the parametrization of the search operation

Nevins (2010) describes in detail the main points of his theory of VH formalization. He is one of the main advocates of a formalization of VH as a Search & Copy operation (cf 1). The main tenets of Nevins' approach to VH are discussed below. His proposal is completely based on the computational side of phonology and results in a model that is able to formalize any possible asymmetry. On the other hand, the extreme power of Nevins' rule formulations ends up simply restating the descriptive situation in a way that appears to be tautological. The formal properties of the Search & Copy operation, which are discussed below, do not appear to be formally limited.

IV.4.1 The formalization of VH as a 'Search and Copy' operation

VH is envisioned as an invariant Search procedure, according to which a value-seeking element initiates a search for the feature it needs, stops as soon as it finds the closest element bearing the relevant feature, and copies the value of that feature to itself (Nevins 2010: 26). This approach involves underspecification: the value-seeking element is an underspecified vowel, which needs a feature specification for the harmonic feature in order to be interpreted. It is the target vowel that initiates the harmonic operation through the operation *Search*. Nevins himself draws numerous parallels between the search operation and the agree operation of syntax, by which it is programmatically inspired (Nevins 2010: 25). The search operation attempts to find the closest source of valuation in a given direction (δ) (Nevins 2010:26). When the search operation fails, due to the effect of neutral vowels or to an asymmetric requirement, targets implement a "default" value of the feature.

IV.4.2 Everything that is relevant in a VH is specified in the harmony statement

The operation of search briefly introduced above may be restricted to certain values of features. This means that in a process of VH, when a restriction parameter is present, not all vowels participate in the process.

Nevins, following Calabrese (1995), suggests three possible ways to parametrize the search operation. Search may evaluate all values of the harmonic feature, only the contrastive values or only the marked values. In all cases, the requirement limits the search domain to a subset of the possible harmonic features. In other words, Nevins incorporates the insights of something like the MCS theory in his model, without fully subscribing to the Contrastivist Hypothesis. When discussing the issues of MCS regarding the "Oops I need that" problem (cf. §.3.2.5), Nevins (2015) argues that the issue with MCS is not in the observation that contrastivity matters, but that it *must* matter. Thus, in Nevins' view, the contrastive role of features may or may not bear on computation.

Consider the case of Finnish treated in Nevins (2010: 69). Recall from §I.4.2.3 that in Finnish front vowels /i/ and /e/, while phonetically front, are non-contrastive for [\pm back], and are hence considered unable to affect following vowels in the process of backness-harmony. In (56) are reported both the Finnish vowel system and a series of harmonic alternations. In the examples provided, front vowels /i/ and /e/ do not participate in harmony and are ignored by the process. (56c) provides the formalization of the Search operation in Finnish.

(56) Backness harmony in Finnish

a. Finnish vowel system

	Front		Back	
High	i	y		u
Mid	e	ö		o
Low	ä		a	

b. Harmonic alternations in Finnish

Stem	Partitive	Possessive	
kylä	kylä-ä	kylä-ni	'village'
täti	täti-ä	täti-ni	'aunt'
isä	isä-ä	isä-ni	'father'
nalle	nalle-a	nalle-ni	'bear'
melu	melu-a	melu-ni	'noise'
talo	talo-a	talo-ni	'house'
keli	keli-ä	keli-ni	'whether'

c. Harmonic rule in Finnish:

Back-Harmonize: δ = left, F = [contrastive; \pm back]

The rule in (56c), written using the notation proposed in Nevins (2010), reads as follows:

An underspecified segment searches for a feature F [\pm back] of a segment to its left. Within the definition of the feature that must be searched, a requirement is added, one that states that only contrastive features can be copied. If there is no contrastive donor, the default value (-back) is inserted.

In sum, within the rule we can insert additional requirements that limit the search to only a subgroup of potential donors. In this case, the operation involves only the contrastive feature [\pm back]. Since in front vowels [+back] is present but not contrastive, it is ignored by the Search & Copy operation. The requirement added to the rule ensures that in this context only contrastive values of [\pm back] can participate in the harmonic process.

Notice that Nevins never suggests that contrastivity has to have a role in the harmonic process, nor that the contrastive role of a feature indicates its activity in the language. In other words, he does not assume /i/ to lack a specification for the feature [\pm back]. In fact, Nevins (2010: 80) shows that /i/ actually needs a specification for [-back] in Finnish due to a different phonological process (cf. Nevins 2010: 80): /i/ acts as a trigger for a process of assibilation that turns /t/ in [s] before /i/. Some alternations caused by assibilation are shown in (57)

(57) Assibilation in Finnish: /t/ → [s]/ __ [+high] [-back].

/halut-a/	[hausi]
'want INF'	'want past'

If we were to analyze the harmony of Finnish using the MCS model, we would fall into the “Oops I need that” problem: we would assume /i/ to be unspecified for [back] due to its neutral behavior in VH, but we would need it to be specified as [-back] for this other process.

In practice, Nevins subscribes to a weak formulation of the Contrastivist Hypothesis (cf. 32b): phonological computation may be limited to the contrastive nature of primes, but it does not have to be. By inserting a requirement in the rule formulation, he manages to profit from the generalization about contrastivity without risking most of the problems linked to the Contrastivist Hypothesis.

The contrastive role of features is not the only requirement that a harmonic rule can host. In fact, VH can be confined in such a way that only the marked value of a given feature is relevant in a harmonic process. A vowel harmony rule may be formulated so as to allow copying from either value of the harmonic feature (e.g., either value of [low] in a two-height system can be searched and copied) or from the marked value alone (e.g., [low] alone), but never from the unmarked value alone (e.g., [-low] alone) (Nevins 2010: 90). This observation is central in the analysis of height-related harmonies. Recall from §I.3.2.4 that in all height-related harmonies, only one of the two feature values (either [+high] or [-high]) is relevant.

The possibility to parametrize the search operation, limiting its domain, is supposed to cover many asymmetries. The reference to contrastivity allows Nevins' model to account for all asymmetries covered by the MCS model. Assuming a context-sensitive markedness allows him to cover VH with a limitation in the selection of targets and triggers, as in the case of Grado (cf. §II.3.3.5.1) and Kikuria (cf. §II.3.1.3.9), or VH with a limitation in the selection of triggers, as in the case of metaphonic raising in the dialect of Teramo. All these additional instructions can be added to a harmonic rule through a conditional requirement (Nevins 2010: 121).

Those requirements limit the application of the operation to specific contexts, so that the target will initiate the search, but if it encounters a specific vowel that has the searched feature value but does not fulfill the requirement, the operation ends with a failure. For example, consider the metaphony of Teramo. Here, only final underlying front-high vowels trigger metaphony, while underlying back-high vowels do not. In other words, a target initiating the search must know not to copy the feature from an underlying /u/ but to do so from an underlying /i/. Consider the tables under (60) where the metaphonic alternations of the dialect of Teramo are reported. Recall that in Teramo non-high vowels undergo raising triggered by only underlying /i/, which corresponds to the plural suffix. The underlying form of the masculine singular, which in many dialects is /u/ and is a valid trigger for metaphony, in Teramo does not trigger metaphony. The asymmetry is accounted for by adding a requirement to the rule (signaled after the capital R in the rule formulation).

(58) Asymmetric metaphony in Teramo: Maiden (1991: 163)

a. Alternations caused by metaphony in the dialect of Teramo

	<i>Singular</i>	<i>Plural</i>	
M	'kænə	'kinə	'dog'
M	'asənə	'isənə	'donkey'
F	'asənə	'asənə / 'isənə!	
M	'bellə	'billə	'beautiful'
F	'bellə	'bellə / billə!	
M	'mæsə	'misə	'month'
M	'pələ	'pilə	'hair'
M	'nərə	'nirə	'black'
F	'nərə	'nərə / 'nirə!	
M	'bənə	'bunə	'good'
F	'bənə	'bənə / 'bunə!	

b. Harmonic rule for metaphony in Teramo

Mid vowels harmonize: δ = right, F[+high & R: = -back]

The rule in (58b) reads as follow: mid vowels initiate search in the right direction. Copy the feature [+high] only from [-back] vowels. This strategy accounts for limitation in the selection of the trigger. The operation, in fact, will consider only the subset of potential triggers that satisfy the requirement.

Consider the case of harmonies with a limitation in the selection of targets such as Basque, where only low vowels raise. A condition such as the one proposed in (59) may be posited:

(59) Basque: R Only [+low] vowels can initiate *Search*

The requirement posed in (59) is actually not a limitation on the way the search operation works, but on the fact that the operation can be initiated or not. In other words, now instead of limiting the copy operation, we are defining the set of vowels that can undergo harmony, hence those vowels that will start the searching.

To my knowledge, Nevins does not treat asymmetries of this kind. His preference for a target-initiated process for the analysis of VH allows him to assume that not all vowels might “want” to undergo harmony. He presents as examples (and as arguments to assume VH as a target-centric operation) vowels of morphemes that fail to undergo harmony (§I.4.2.1). For example, the Turkish plural morpheme /ler-lar/ initiates the search for a specification for [\pm back], while the nominalizing morpheme /-gen/ does not (Nevins 2010: 61). Notice that in both Basque and Bergamasco the target is root-internal, so a limitation caused by a “non-harmonizing root” is harder to parametrize. However, I argue that the requirement in (59) follows the same spirit of the morpheme-based selection of targets, but it is also relevant to notice that it has a different status from the other requirements considered in (57) and (58). The requirement in (59) does not parametrize the search operation, but acts externally to the operation, allowing it to start or not.

IV.4.3 Nevins' account of parasitic harmonies

Nevins (2010) is one of the few analysts that tackles, from a theoretical perspective, parasitic patterns. Consider his analysis of parasitic lowering in Kisa (JE.32, Bantu spoken in Kenya). Here, as in most Bantu languages, the high round vowel /u/ lowers to [o] only if preceded by a round mid-vowel /o/. This is the pattern of lowering defined in §II.3.1.2 as Canonical Bantu lowering. In (60), the Applicative suffix /-il/ can copy any value of the feature [\pm high] from preceding vowels in roots, while the reversative suffix /-ul/ copies the value of the feature [\pm high] only if the source is [+round]. Data reported in (60) are taken from Hyman (1999: 238).

(60) Canonical lowering harmony in Kisa

<i>Applicative forms</i>		<i>Reversative forms</i>	
tsom-el-a	'pierce'	tsom-ol-a	'pull out'
rek-el-a	'set trap'	rek-ul-a	'spring trap'
β is-il-a	'hide'	β is-ul-a	'reveal'
fu:ng-il-a	'lock'	fu:ng-ul-a	'unlock'
β a:mb-il-a	'spread out'	β a:mb-ul-a	'spread apart'

As we have discussed above, the search & copy operation can be limited by additional requirements. In order to account for parasitism, Nevins (2010: 131) proposes an identity condition, in the form of a requirement in the rule formulation, that limits the application of VH. The process is then split in two different operations of search, initiated by different morphemes. The two operations are formalized as in (61).

(61) Two operations account for parasitism in Kisa lowering harmony

Kisa applicative suffix must: Height-Harmonize: δ = left, F=[\pm high]

Kisa reversative suffix must: Height-Harmonize: δ = left, F = [\pm high & R: +round]

The two rules initiate two different search operations. The applicative suffix /-il/ may search for any specification of [high], while the reversative suffix /-ul/ can copy the specification only from [+round] vowels. If the operation cannot be done (i.e., if the requirement is not fulfilled), /-ul/ assumes the default value [+high].

In (62) I apply the same logic to the case of Camuno (§III.7.4), where [-round] mid-vowels in the root raise only if the final stressed vowel is also [-round].

(62) Analysis of Camuno parasitic harmony based on Nevins' (2010) proposal

a. Height alternations in Camuno

<i>Base form</i>	<i>Diminutive</i>	<i>Augmentative</i>	
[ˈdet]	[dinˈti]	[denˈtu]	‘tooth’
[lɛt]	[liˈti]	[leˈtu]	‘bed’
[ˈpetɛn]	[pitiˈni]	[peteˈnu]	‘comb’
[ˈtʃot]	[tʃuˈdi]	[tʃuˈdu]	‘nail’
[ˈgrop]	[gruˈpi]	[gruˈpu]	‘knot’
[ponˈdor]	[punduˈri]	[punduˈru]	‘tomato’
[hoˈrɛk]	[huriˈgi]	[horeˈgu]	‘mouse’
[poˈlɛr]	[puliˈri]	[poleˈru]	‘hen-house’
[bigaˈrɔl]	[bigaruˈli]	[bigaruˈlu]	‘apron’
[ˈlegor]	[leguˈrina]	[leguˈruna]	‘hare’

b. Harmonic rule for raising in Camuno

Camuno [+round] pre-tonic vowels must: Height-Harmonize: δ=right, F=[±high]

Camuno [-round] pre-tonic vowels must: Height-Harmonize: δ=right, F=[±high & R: -round]

Like Nevins, I have posed two different operations for the application of VH in Camuno. The process decomposes into two operations that search for the same feature value (namely [+high]) but splits the set of targets in two: one process (the symmetric one) is initiated by [+round] vowels, the other asymmetric one is initiated by front mid-vowels. The example of Camuno differs from the one Nevins proposed for Kisa lowering in a central property, though. Harmony in Kisa is represented as a process where a morphological suffix requires a specific feature value. Since Camuno is, as most raising harmonies, of the dominant type, the target that initiates search is in the root, and thus not part of a suffixal morpheme. The search operation should be initiated differently by vowels that differ phonologically, i.e. rounded mid-vowels /o/ and /ø/ initiate a search operation for [+high] that is not limited by any requirement, while /e/ initiates a search with the requirement reported in the formulation under (62b) [R: -round]. The formalization obtained this way does not explain why the process applies the way it does, but simply restates the descriptive situation in a way that appears to be tautological: /e/ accepts only /i/ as trigger, while /o/ accepts all high vowels because Search initiated by /e/ requires [-round] vowels as triggers.

The same observation could be made about the general strategy employed by Nevins: whenever a process has an additional requirement for its application, the formulation for the Search & Copy operation can be modified by an additional requirement that modifies the way the operation applies. The problem is that it appears that there is no formal limit to the kinds of requirements that can be added. A theory such as this one, while surely able to represent asymmetric harmonies and even parasitic harmonies, does not do anything more than re-state the empirical facts.

This theory suffers from many criticisms that were advanced against the SPE-theory of phonology proposed by Chomsky & Halle. A theory that is able to formalize everything and its contrary runs the risk of limiting its predictive power.

IV.4.4 Conclusions

All in all, Nevins’ model is powerful enough to represent various kinds of asymmetries, including parasitic harmonies. In Nevins’ model, harmony is initiated by a vowel that lacks a specification for a feature. As such, Nevins’ model is built to work (and could not operate without) assuming binary primes. This may become a relevant issue when considering the fact that raising applies in two different ways: scalar raising and complete raising. In §2, the employment of incremental features was proposed as a way to represent scalar and complete raising without having to employ additional primes such as [±ATR]. Among the three representational options discussed, only the one proposed by Clements could be integrated into Nevins’ Search & Copy formalization, because both Parkinson’s proposal and Schane’s proposal employ unary primes to represent vowel height.

A scalar process could be envisioned as a search & copy operation whereby a mid-vowel seeks for a [-open] feature from neighboring vowels. Vowels of different relative height would copy one occurrence of the [-open] feature from a donor. Recall that in Clements’ account the feature [±open] is arrayed on several autosegmental tiers, ranked according to the register (primary, secondary, tertiary etc...), and that the process applies in different tiers depending on the height of the target.

A process of scalar raising such as the metaphony of Servigliano may be formalized using Nevins’ technology assuming that mid-vowels search for a [-open] prime in neighboring vowels, so that mid-low vowels end up as mid-high, and mid-high as high vowels. This strategy replicates the analysis proposed in Clements (1991: 58).

(63a) shows some alternations caused by metaphony in Servigliano. (63b) displays the harmonic rule formulated as a search and copy operation in Nevins’ terms. The rule in (63b) reads as “search for a [-open] feature specification only in the third register”. The outcomes of this rule are shown in (63c).

(63) Representing scalar raising as a Search & Copy operation

a. Metaphonic alternations in Servigliano

'metto	' <i>I put</i> '	'mitti	' <i>you put</i> '
'pesa	' <i>it weighs</i> '	'pisu	' <i>weight (noun)</i> '
'poce	' <i>fly</i> '	'puci	' <i>flies</i> '
'spōsa	' <i>wife</i> '	'sposu	' <i>husband</i> '
mo'desta	' <i>modest F.</i> '	mo'destu	' <i>modest M.</i> '
'pettene	' <i>comb</i> '	'pettini	' <i>combs</i> '
'predoko	' <i>I preach</i> '	'prediki ¹⁷⁷	' <i>you preach</i> '
'mōre	' <i>he dies</i> '	'mori	' <i>you die</i> '
'mōfa	' <i>depressed F.</i> '	'mofu	' <i>depressed M.</i> '

b. Harmonic rule for scalar raising in Servigliano

Mid vowels harmonize: δ = right, F[-open & R: only in the third register]

¹⁷⁷ In Servigliano is active a regressive copy-harmony that affects post-tonic vowels much like the copy harmony of Umbertide presented in §I.3.2.5. This process is discussed in more detail in §VI.6.

c. Outcome of the harmonic rule

Target		Outcome	
ε	[-open1]	e	[-open1]
	[+open2]		[+open2]
	[+open3]		[-open3]
ɔ	[-open1]	o	[-open1]
	[+open2]		[+open2]
	[+open3]		[-open3]
e	[-open1]	i	[-open1]
	[-open2]		[-open2]
	[+open3]		[-open3]
o	[-open1]	u	[-open1]
	[-open2]		[-open2]
	[+open3]		[-open3]

The table under (63c) shows that mid-low vowels would result in mid-high vowels, which have two occurrences of the [-open] feature and one of the [+open] one. Notice, however, that a raised mid-low vowel and a lexical mid-high vowel, assuming the rule formulation in (63b), would have a different featural specification. A mid-high vowel [e] resulting from ε-raising has the following featural specification, for what concerns height: [-open1, +open2, -open3]. A lexical /e/, which is itself a target of raising, has a slightly different featural representation: [-open1, -open2, +open3].

The requirement R in the rule formulation in (63b) prevents mid-high vowels from behaving as triggers for mid-low vowel raising. All the occurrences of the feature [±open] have the same nature and the same phonetic correlate. The numbering is just a way to represent the fact that those features occur in ordered positions that are hierarchically structured. In fact, Clements' theory requires an autosegmental structure in order to make sense. The various occurrences of [±open] are different not because they are substantially different, but because they are posed on a different register. The externalization of target [e] and trigger [e] coincides exactly because the phonetic implementation of the features does not vary between [open] on the first, the second or the third register.

On the other hand, as Samuels (2009) rightfully notes, models based on a Search & Copy formalization of VH are in direct competition with representational strategies such as autosegmental phonology. The inherent goal of a formalization of the harmonic rule as a search & Copy operation is to flatten phonology, and to avoid the need for additional ordered structure. A rule formalization of this kind, in fact, allows for a representation of VH as a local process. All segments are “checked” by the initiator (the target) and the process stops once the right feature is found or when the default feature is assumed by the vowel that initiated/s the search. Autosegmental Phonology was the main strategy to allow the rule of a VH to affect only vowels, and ignore intervening consonants. In this view, combining Clements' inherently autosegmental representation of height and Nevins' inherently flat rule formulation is counterintuitive.

The two approaches aim towards different goals. The structural complexity of Clements' model is a necessity for a theory of phonological representation that uses incremental features, but hardly combines with a way of formalizing rules that actively tries to reduce the necessity of additional structure. The Search & Copy formalization of VH is formally able to represent processes of scalar raising using incremental features, but the dependency structures that allow for the representation of raising as a unitary

phenomenon do not combine well with the Search & Copy operation that actively tries to simplify representation and boost the power of computation.

IV.5 Harmony as licensing of preceding or following primes

IV.5.1 Licensing Constraints

As reported in table (1) in the introduction of this chapter, there are approaches that represent VH not as spreading of melodic material in an Autosegmental fashion, nor as a Search & Copy operation like Nevins (2010). In GP quarters, some argued for a formalization of the harmonic process as Licensing.

Licensing (Ito 1986) is a term that indicates the procedure by which some phonological element is permitted to occur in some position by the presence of some other element elsewhere. Licensing occurs often in the literature involving Government Phonology and associated approaches, where it is used as an operation that enhances segmental expression as opposed to government, that inhibits segmental expression. A governed nucleus is not pronounced, while a licensed one is.

Charette & Göksel (1994, 1996) propose an analysis of Turkish harmonic patterns as a function of licensing constraints. No language expresses the full range of elemental combinations, so Licensing Constraints (henceforth LC) were assumed to define which primes are allowed to co-exist within the representation of a single segment and which are not.

In GP, phonological expressions (i.e., the internal structure of segments, cf. Harris 1994, Kaye 2000, Charette & Göksel 1994) are composed of elements, which can have the role of Heads or of Operators (Kaye 1990, Backley 2011). The head of a phonological expression licenses its operators (Kaye 2000: 252).

The table under (64) summarizes the full combinatorial possibilities of the three vocalic elements, |I|, |U| and |A|. The table is taken from Kaye (2000: 253), though the symbols used refer to Backley (2011). Headed elements are underlined, while operators do not have any marking.

(64) Possible elemental compositions assuming the three vocalic elements |I|, |U|, |A|

<u>A</u>	A <u>I</u>	A <u>I</u> <u>U</u>	A	A <u>I</u> <u>U</u>
<u>I</u>	A <u>U</u>	A <u>I</u> <u>I</u>	I	∅
<u>U</u>	I <u>A</u>	I <u>U</u> <u>A</u>	U	
	I <u>U</u>		A <u>I</u>	
	U <u>A</u>		A <u>U</u>	
	U <u>I</u>		I <u>U</u>	

LCs limit the number of combinatorial possibilities of elements and define the inventories of languages. Consider for example a seven-vowel system $S: \{i, e, \varepsilon, a, \text{ɔ}, o, u\}$, as the one that defines the possible vowels of Italian and various Bantu languages. 19 of the 26 combinatorial possibilities are thus to be ruled out. The LCs that define the vowel system S are proposed under (65).

(65) How LCs limit the combinatorial possibilities of elements

a. LCs that define a seven-vowel system / i, e, ε, a, ɔ, o, u/

LC1: All expressions are headed

LC2: I and U may not combine

b. Combinatorial possibilities of elements

<u>A</u>	<u>AI</u>	<u>AIU</u>	<u>A</u>	<u>AIU</u>
<u>I</u>	<u>AU</u>	<u>AUI</u>	<u>I</u>	<u>∅</u>
<u>U</u>	<u>IA</u>	<u>IUA</u>	<u>U</u>	
	<u>IU</u>		<u>AI</u>	
	<u>UA</u>		<u>AU</u>	
	<u>UI</u>		<u>IU</u>	

The two LCs under (65a) rule out all headless expressions and all remaining cases in which elements |I| and |U| co-occur.

The proposal advanced in Charette & Göksel (1994, 1996) is that the same LCs that define the vowel system of Turkish can also explain its harmonic patterns. From a theoretical standpoint, this means that the same principles that define the vowel system also influence phonological processing. This is the same goal of the MCS theory discussed above in §3.2, where the SDA defines at once the phonological system (defining the internal composition of segments) and affects computation through the Contrastivist Hypothesis. Similarly, LCs aim at killing two birds with one stone: limit the combinations of elements and at the same time explain the phonological alternations caused by labial and backness harmony in Turkish.

Their LC-based analysis of a complex harmonic pattern is summarized in §5.2 and §5.3. In §5.4 I will try to utilize the same strategy to formalize the asymmetries encountered in the description of raising harmonies, and check whether this system is powerful enough to account for all possible asymmetries individuated in the first chapter.

IV.5.2 Turkish harmonic patterns can be described employing Licensing Constraints

Since the main role of LCs is to limit the possible elemental composition of a phonological expression, the definition of the LCs active in a given language usually starts with the vowel system of the language. Recall from §I.3.2.1 that Turkish has the following vowel system:

(66) Turkish vowel system (Kabak 2011)¹⁷⁸.

	<i>Front</i>		<i>Back</i>	
	<i>non-Round</i>	<i>Round</i>	<i>non-Round</i>	<i>Round</i>
<i>High</i>	i	y	ɯ	u
<i>non-High</i>	e	ø	ɑ	o

According to Charette & Göksel (1996), the only vowel of Turkish that is not the result of any licensing constraint is the vowel /ɯ/, which corresponds to an empty nucleus.

All other vowels derive from the application of the three LCs shown in (67) (Charette & Göksel 1996: 7).

¹⁷⁸ In §I.3.2.1 I reported the vowel system of Turkish according to Kabak (2011), and I reprise it here. Notice that Charette & Göksel utilize the symbols ü for [y], ö for [ø], a for [ɑ] and ı for [ɯ].

(67) Licensing Constraints of Turkish

LC1: Operators must be licensed.

LC2: |A| is not a licenser.

LC3: |U| must be head.

The first constraint disallows expressions lacking a head (recall that heads license operators, Kaye: 2000: 253), and thus vowels composed of a single non-headed element. The simple vowels, i.e., those composed of only one element, are thus headed by definition. The first four vowels defined are thus [i]: |I|, [u]: |U|, [ɑ]: |A|, and [ø]: |∅|.

Other vowels are defined by the other two LCs. Since |A| does not license operators (as per the second LC), it never assumes the role of head when combined with other primes. The expressions in which |A| occurs with another element are expressed as |AU|:[o] and |IA|:[e]. Lastly, the third constraint ensures that in complex representations where both |I| and |U| occur, |U| will take the role of head. Thus, the last vowels of Turkish [y] and [ø] are structured as |UI| and |UIA| respectively. The complete set of vowels in Turkish is thus the one shown in (68), according to Charette & Göksel (1996: 8).

(68) The phonological expressions correspondent to the Turkish vowel system.

	<i>Front</i>				<i>Back</i>			
	<i>non-Round</i>		<i>Round</i>		<i>non-Round</i>		<i>Round</i>	
<i>High</i>	i	I	y	UI	u	∅	u	U
<i>non-High</i>	e	IA	ø	UIA	ɑ	A	o	UA

In preceding sections, while discussing the difference between mid-high and mid-low vowels in Element Theory, the notion of head was used merely as a representational tool to distinguish between tense and lax vowels. However, in the contexts of LCs, heads assume another role, which is not representational, but computational. Heads are objects that may license other elements.

Regarding the harmonic processes of Turkish, recall the discussions in §1.3.2.1: Turkish exhibits a symmetric backness harmony and an asymmetric rounding harmony, whereby only high vowels are affected by the process. Both harmonies and their interactions are reported in the tables in (69).

(69a) reports alternations in the plural /lar-ler/ and in the genitive /un-in/ suffixes caused by backness harmony. Suffixes surface as [-back] when preceded by a [-back] root. (69b) and (69c) report alternations in the same suffixes caused by both backness and labial harmony. Labial/rounding harmony is asymmetric in Turkish, in that it does not target non-high vowels. The plural suffix, which contains a non-high vowel, ignores labial harmony while undergoing backness harmony. The genitive and the imperative suffixes (both structured as /-un/), harmonize for both backness and roundness.

(69) Alternation caused by Turkish vowel harmonies

a. Turkish backness harmony

<i>Nom sg. (Root)</i>	<i>Nom pl.</i>	<i>Gen sg.</i>	<i>Gen pl.</i>	
ip	ip – ler	ip – in	ip - ler – in	'rope'
kuuz	kuuz – lar	kuuz - un	kuuz - lar - un	'girl'
sap	sap – lar	sap - un	sap - lar - un	'stalk'
jyz	jyz –ler	jyz – in	jyz -ler – in	'face'
son	son – lar	son - un	son - lar - un	'end'

b. Turkish labial harmony (Clements & Sezer 1982: 216)

<i>Root</i>	<i>Plural</i>		
jyz	jyz-ler	*jyz-lør	'face'
kjøj	kjøj-ler	*kjøj-lør	'village'
pul	pul-lar	*pul-lor	'stamp'
son	son-lar	*son-lor	'end'
<i>Root</i>	<i>Genitive</i>		
jyz	jyz-yn		'face'
kjøj	kjøj-yn		'village'
pul	pul-un		'stamp'
son	son-un		'end'

c. Interplay between Turkish backness and labial harmonies (Charette & Göksel 1996: 10)

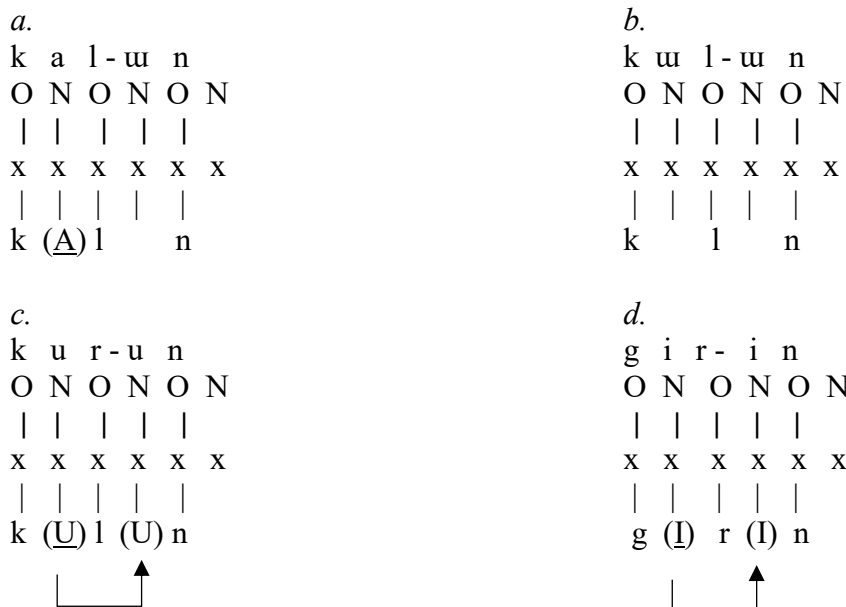
<i>Stem</i>	<i>Imperative /un/</i>	
kal	kalun	'remain'
kuus	kuusun	'reduce'
gir	girin	'enter'
kes	kesin	'cut'
kur	kurun	'establish'
sor	sorun	'ask'
gyl	gylun	'laugh'
gør	gørün	'see'

The three constraints listed in (67) not only define the vowel system of Turkish, but also account for the two harmonic patterns that are active in Turkish. In GP terms, Harmony involves the spreading of an element from a licenser nucleus to a nucleus that is licensed. This spreading is an instantiation of element-licensing, whereby the presence of an element in the governing nucleus allows the presence of an element of the same nature in the governed nucleus. In other words, an element licenses a copy of itself in another nucleus. The elements involved in the harmonic processes active in Turkish are the front element [I] and the rounded element [U].

Under (70) licensing of [I] and [U] in suffixes is signaled with an arrow from the licenser to the position of the licensee. Recall that Turkish harmonies are both root-controlled, so vowels in roots license elements in suffixal positions. In (70a) and (70b) suffixes do not receive any [I] or [U], since they are

absent in the vowels of the root. Notice that in (70b) the vowel [u] is empty. In (70c) and (70d), instead, |I| and |U| license their copies in suffixes. The examples come from Charette & Göksel (1996: 11).

(70) Harmony in Turkish: headed I and U license a copy of themselves in another nucleus

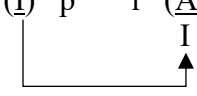


Backness harmony is symmetric in Turkish: a copy of the element |I| can be licensed in all contexts. This happens because the LCs of Turkish do not limit in any way the possibilities of |I| to license. Rounding harmony is asymmetric, though: |U| can spread only if the target is high. In the following paragraph, this property is connected with the LC3, which prevents |U| from being an operator.

Another observation, which is not as trivial as it may seem, is that |A| does not spread. At the base of LC computation lies the idea that elements can combine freely. Therefore, if elements are free to license their copies in other positions, we should expect |A| to act as a licenser. The fact that |A| does not spread like the other elements follows from the LC2, that states that |A| is not a licenser.

|I| and |U| are, instead, free to license Elements either in their own segment (i.e., they can be heads of an expression) or in other nuclei. In this formalization of VH, the licensed element takes part in the elemental composition of the governed vowel, which receives a new element. This newly added element is licensed by the element that allowed it to spawn, and not by the head of the elemental composition. In (71a) the original structure of the plural suffix is /lar/, with a headed |A| in the nucleus. In (71b), an operator |I| is licensed by the preceding |I| in the vowel of the root. Licensing is represented with the arrow connecting the licenser to its licensed copy.

(71) |I| in the root license |I| in the plural suffix /-lar-ler/

a. kuuz-lar 'girls'	b. ip-ler 'ropes'
k u z - l a r	i p - l e r
O N O N O N O	O N O N O N O
x x x x x x	x x x x x
k () z l (A) r	(I) p l (A) r
	

Note that the harmonized suffix vowel, [e]: |A|, is distinct from lexical /e/, which is |I|A|. The LC "A is not a licenser" is not violated, though, since the element I in the suffix is not licensed by the headed |A| present in the nucleus of the suffix, but by the |I| of the harmony trigger. As will be discussed regarding the spreading of |U|, in Turkish headedness cannot be switched, so if |A| was the head of the expression before the spreading of |I|, it will remain the head after the spreading of I. In sum, there are two phonological objects that correspond to the phonetical [e]. This issue of whether it is possible for multiple items in phonology to enjoy the same phonetic implementation is discussed at length in §V.4.3.

Regarding the spreading of |U|, the asymmetric behavior of Turkish is captured considering the LC that states |U| must be head. |U| is free to spread in all contexts, but the fact that it has to be head (as per the third LC introduced in 67) disallows its appearance in a phonological expression as an operator. The LC3 forces the newly added |U| in a harmonized suffix to assume the role of head, but expressions that contain another head disallow this change of headedness. According to Charette & Göksel (1996: 13) "head switching" (i.e., the change of the head of an expression) is not allowed in Turkish. Therefore, rounding harmony can apply only to tokens that lack a head. Or, viewed from the other side, a headed expression cannot receive |U|, because |U| must be the head of the phonological expression, and heads cannot be switched in Turkish.

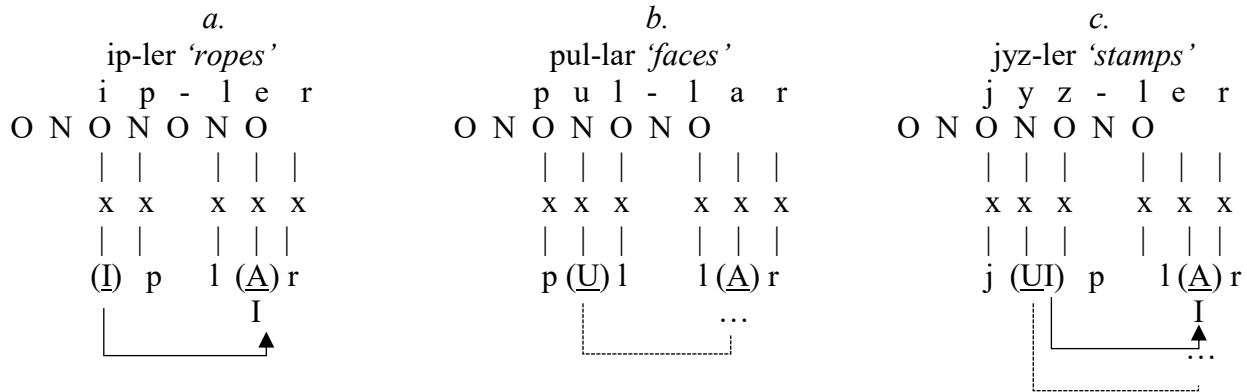
In Turkish, all alternating suffixes are underspecified for backness and roundness, and assume the roundness and backness of the dominant vowel in the root. This means that suffixes that harmonize in Turkish may be either empty or contain the element |A|. As per the LCs under (67), this element |A| must appear as headed |A|, because headless expressions are ruled out in Turkish. What this means is that |U| is free to spread in headless empty nuclei, where it can assume the role of head, and cannot spread in nuclei where headed |A| is present, because it would be forced to assume the role of operator within an elemental composition (which is ruled out by the LC3 in 67).

The different behavior of the elements |I| and |U| in Turkish backness and labial harmony is exemplified in (72). Both elements spread towards the plural suffix /-lar/ from the root. The low vowel in the plural suffix contains headed |A|. Front unrounded vowels, which contain |I|, can spread the element |I| to the plural suffix, as shown in (72a). In (72b) is exemplified the case of back rounded vowels, which cannot spread |U|, since |U| is required to be the head of a phonological expression, but there is already a head in the suffix and head-switching is forbidden.

The case of front rounded vowels is exemplified in (72c). They contain both harmonic elements |I| and |U|, and thus, in theory, can spread both elements. |I| spreads without any issue to all suffixes, but |U| cannot spread to the plural suffix because it cannot assume the role of head, as requested by the LC3.

Licensing of a copied element is shown with an arrow. Failings in licensing are shown with a dotted line from the element in the root to the position in the suffix where its copy cannot be hosted.

(72) Licensing of |I| and |U| in the plural suffix



IV.5.3 Formalizing backness and rounding harmonies in different Turkic languages

Charette & Göksel (1996: 14) consider that the operation of head-switching is a possible phonological operation, and that there are languages that make use of it. Yakut and Kazakh (treated previously in §I.5.4.1.1) are Turkic languages that display both backness and labial harmony, and also exhibit an extremely similar vowel system to that of Turkish.

In Yakut, labial harmony is partially parasitic for height: non-high vowels harmonize for rounding only if the trigger is also non-high. Consider the alternations under (73b), where high vowels are affected by rounding triggered by all preceding rounded vowels, while non-high vowels require a non-high trigger for rounding to apply. In (73b) the plural suffix becomes round only if preceded by a non-high vowel (as in the 3rd person plural of the present tense, [kør-øɭ-lør]) but not if it is preceded by a high vowel, as in the 3rd person plural of the preterit [kør-dy-ler], *[kør-dy-lør].

(73) Harmonic fronting and rounding in Yakut (Sezer & Wetzels 1986; Sandstedt 2018: 78)

a. Yakut vowel system

	Front				Back			
	Non-Round		Round		Non-round		Round	
High	i	I	y	UI	ɨ		u	U
Non-high	e	IA	ø	UIA	a	A	o	UA

b. Harmonic alternations in Yakut

<i>Root</i>	<i>3 p. present</i>	<i>3.pres. Plural</i>		
kel	kel-el	kel-el-ler		'come'
kør	kør-øl	kør-øl-lør		'see'
bar	bar-al	bar-al-lar		'go'
olor	olor-ol	olor-ol-lor		'dwell'
<i>Root</i>	<i>3 p. preterit</i>	<i>3 pret. Plural</i>		
kel	kel-li	kel-li-ler		'come'
kør	kør-dy	kør-dy-ler	*kør-dy-lør	'see'
bar	bar-du	bar-du-lar		'go'
olor	olor-du	olor-du-lar	*olor-du-lor	'dwell'

In Kazakh, labial harmony is restricted only in contexts where both trigger and targets are front (i.e., in contexts where backness harmony applies) and it only applies to high vowels, meaning that non-high vowels are unaffected by rounding, as exemplified under (74). In (74b), front-rounded vowels in roots always affect following suffixes in both roundness and backness (i.e., both |I| and |U| spread without limitations, if the vowel in the root is front and rounded.). Back rounded vowels, instead, affect only high vowels, while non-high vowels remain unaffected, as shown in the second section of the table in (74b).

(74) Harmonic fronting and rounding in Kazakh (Korn 1969:101)

a. Kazakh vowel system

	<i>Front</i>				<i>Back</i>			
	<i>Non-Round</i>		<i>Round</i>		<i>Non-round</i>		<i>Round</i>	
<i>High</i>	i	I	y	UI	ɨ		u	U
<i>Non-high</i>	e	IA	ø	UIA	a	A	o	UA

b. Harmonic alternations in Kazakh

<i>Front vowels in the root</i>	<i>Roots</i>	<i>Suffixes</i>		
	yj	dø		'house LOC'
	køl	dø		'lake LOC'
	yj	dy		'house ACC'
<i>Back vowels in the root</i>	køl	dy		'lake ACC'
	kul	da	*kul-do	'at the servant'
	son	dan	*son-don	'rubble ACC'
	kul	du		'servant ACC'
	koj	du		'sheep ACC'

Charette & Göksel (1996) treat both Yakut and Kazakh as if they had the same LCs of Turkish. Since they share the same vowel system, the static properties of the system are common to all three languages. The three Licensing Constraints of Turkish, Yakut and Kazakh are repeated under (75).

(75) Licensing Constraints of Turkish, Yakut and Kazakh

LC1: Operators must be licensed.

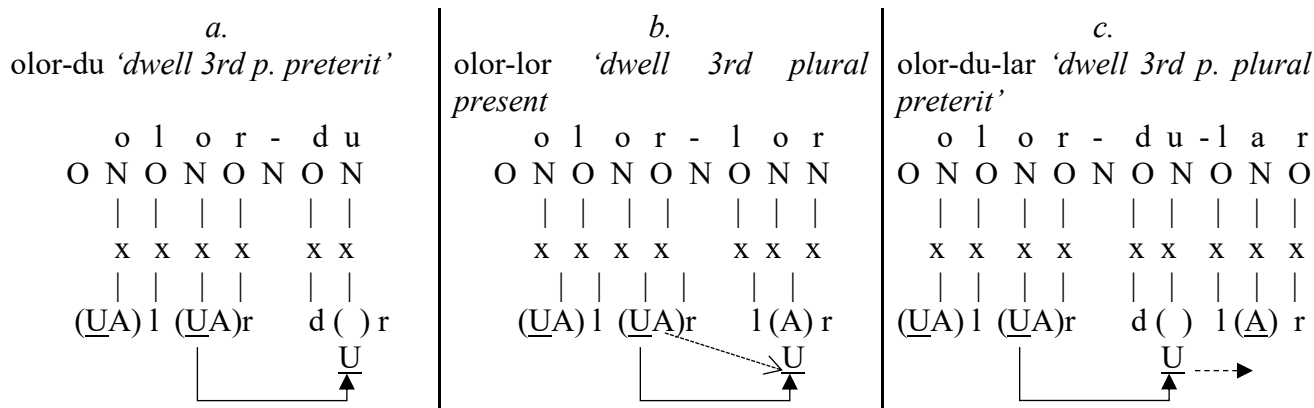
LC2: A is not a licenser.

LC3: U must be head.

So, the three languages at hand share the same set of Licensing Constraints. However, labial harmony applies in different ways in the three languages. The differences in the harmonic process revolve around the fact that in both Yakut and Kazakh head-switching is licensed on specific occasions. In Yakut licensing of |U| is allowed in empty expressions and in expressions containing headed A only if |A| is also present in the licenser. This is formalized assuming that the |A| element in the trigger licenses head-switching. If |A| is present in the trigger, head-switching is allowed, and thus |U| can freely spread in nuclei that contain headed |A|.

Under (76a) |U| spreads freely to an empty position in the suffix. (76b) exemplifies the case in which |U| spreads thanks to the |A|, which licenses head-switching. This licensing is shown as a dotted arrow from the licenser to the headed expression. The element |A| in the licenser allows head-switching to apply, therefore permitting licensing of |U| in the suffix. In (76c), |U| cannot spread to the plural suffix because the high vowel in the preterit suffix (which lacks A) does not license head-switching.

(76) Headed |A| allows head-switching



Spreading of |U| to an expression containing headed |A| is ruled out in Turkish by the fact that head-switching is forbidden. Head-switching is allowed in Yakut by the headed |A| in the root. When headed |A| is absent, as in (76c), labial harmony does not apply.

In Kazakh, instead, licensing of |U| is allowed only if |I| is present in the licenser. In Kazakh, then, the element that licenses head-switching is not |A|, but |I|. If |I| is present in the root, it allows head-switching, so that U is free to spread without limitations. If |I| is absent, it cannot allow head-switching, so |U| does not spread because it would appear as operator in the suffix, which violates the LC3 “U must be head”.

In sum, asymmetries in harmonic patterns can be captured by the use of Licensing Constraints, which affect both the vowel system and the possibilities of primes to spread. The parametric operation of head-switching can be allowed parametrically in specific contexts.

IV.5.4 Raising harmonies and Licensing Constraints

Unary elements are traditionally used in theories that value the economy of the formal system, as noted in Bafle (2015: 14). The rather small number of melodic primes is considered an advantage, because it reduces the possible number of elemental compositions, and thus of possible segments. The downside of having such few primes is that not all sound properties can be represented in phonology by their own feature or element. Height is represented as the absence of |A|, which, by definition, cannot be referenced in a unary system. Recall from §2 that unary theories describe raising harmonies as processes of A-demotion, i.e., as processes whereby the element |A| is weakened or demoted in some way or another. Licensing Constraints work as explanations for harmonies because they formalize the harmonic process as a phenomenon whereby elements spread from a licensor to a licensee. Raising harmonies cannot be represented as a process of spreading, if we apply the primes of Element Theory. Raising can be implemented in ET in two different ways, presented in (77).

(77) Representing raising in ET

Mid-low raising: $\varepsilon \rightarrow e$	AI \rightarrow <u>I</u> A	Headless becomes headed
Mid-high raising: $e \rightarrow i$	<u>I</u> A \rightarrow <u>I</u>	A is removed from the expression.

The literature about LC managed to produce some interesting analyses of raising harmonies using a different kind of LC called Head-Licensing (henceforth H-Licensing). Kaye (1993) introduced this operation as a way to capture tongue-root harmonies. GP employs Element Theory, which in its standard form lacks a way to refer to ATRness¹⁷⁹. The most common strategy to represent it was the concept of head: headed expressions are tense (+ATR) while headless expressions are lax (-ATR). Harmonies that involve the tongue-root position are thus formalized as processes in which a headed expression licenses a head in a dependent nucleus, which then agrees in headedness and thus in +ATRness. H-Licensing is a formal principle which explains the distribution of headed ('ATR') expressions in nuclei in a domain, building on the notion that headed expressions may only be accommodated in H-licensed nuclei (Cobb 1997: 89).

In Turkish, where no Tongue-root harmony is active, the distribution of heads in phonological expressions follows from the language-specific LCs. In other languages, as we shall see below, the distribution of heads in phonological expressions depends on the mechanism of H-Licensing.

Since ET lacks an element that groups together high vowels, the mechanism of H-licensing is the only way high vowels that contain either |I| or |U| (assuming they are headed) can influence in the same way phonological expressions in other nuclei. Cobb (1997) covers various harmonies that we have treated as height related in previous chapters, and manages to explain both raising of mid-low vowels to mid-high as well as raising of mid-high vowels to high (which requires A-demotion) as a consequence of H-licensing.

In the following pages, I will summarize some of the proposals and analyses presented in Cobb (1997), with the goal to consider the effectiveness of LCs as a theoretical tool to represent RVH.

¹⁷⁹ Recall from §1.3.2.3 that some early version of ET accepted an element related to tongue root position (Kaye, Lowenstamm & Vergnaud 1985). It was dropped unanimously in later works, and it is generally absent in recent versions of ET. In this section I am assuming the most commonly used version of ET, which is the one presented in Backley (2011).

The case of Zulu exemplifies the mechanism of H-licensing in a context of raising harmony where mid-low vowels surface as mid-high if followed by a high vowel. As shown in (78b), mid-low vowels in roots surface as mid-high when followed by a high vowel in suffixes. Recall from §II.3.1.3.3 that the harmony of Zulu is allophonic, since the distribution of mid-high vowels derive (almost¹⁸⁰) solely from the process of raising triggered by preceding high vowels.

(78) Zulu vowel system and harmonic pattern

a. Zulu vowel system

	Front		Back		
Height 1	i	I	u	U	
Raised H2	(e)	IA	(o)	UA	*non phonemic
Height 2	ε	AI	ɔ	AU	
Height 3	a		A		

b. Harmonic (allophonic) raising in Zulu

phək-a	'cook (verb)'	urn-phek-i	'cook (noun)'
ngen-a/ŋen-a	'enter'	ngen-is-a	'bring in'
ɔn-a	'sin'	is-on-i	'sinner'
bɔn-a	'see'	bon-is-a	'show'
bɔn-a	'see'	si-bon-il-ε	'we saw'
khə:mmb-a	'point'	si-khommb-il-ε	'we pointed'

Cobb (1997) assumes that harmony in Zulu is caused by H-licensing, and therefore assumes that the high vowels are the only headed expressions of Zulu. This ensures that only high vowels /i/ and /u/ are able to trigger H-licensing.

The LCs of Zulu, then, must rule out all headed expressions except for headed |I|:/i/ and |U|:/u/. Cobb argues that headedness of /i/ and /u/ is not derived from Licensing Constraints, but is instead due to the fact that |I| and |U| are Natural Lexical Heads¹⁸¹ (Cobb 1997: 128). This status grants I and U the possibility to surface as heads when they are in isolation, without having to resort to a LC. The status of Natural Lexical Heads implies certain properties: if they can be heads in an expression, they will be. Secondly, Natural Lexical Heads do not co-occur in the same expression in a language. Employing the notion of Natural Lexical Head, Cobb (1997: 129) introduces the Licensing Constraints of Zulu, which define both its vowel system and its harmonic pattern. The LCs active in Zulu are reported in (79).

¹⁸⁰ Following Doko (1926) and Harris (1987), Cobb notices that mid-high vowels surface in Zulu also when preceding the so-called “syllabic nasals” /m/ and /n/, and also in “long vowels” that appear in certain morphemes. For example, consider the morphemes [nee/nε] ‘and’ and [noo/nɔ] ‘or’ whose vowels can appear as short lax or as a long tense. For the general treatment of the harmony of Zulu, this detail does not matter.

¹⁸¹ Cobb (1997: 129) herself denounces the ad-hocness of the concept of Natural Lexical Heads. However, she argues, the introduction of this concept allows Element Theory to identify high vowels as a natural class, referencing their heads, and disallowing unnatural classes such as /i,a/ or /u,a/.

(79) The LCs active in Zulu

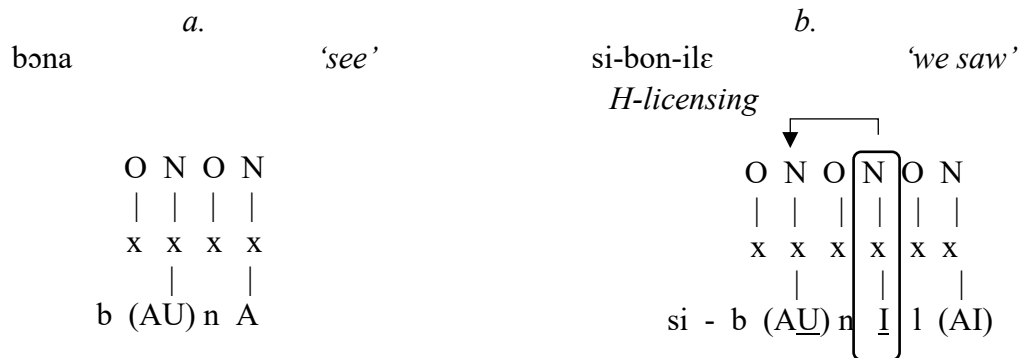
LC1: A cannot be a head

LC2: Natural Lexical Heads license no operators

LC3: I and U don't appear in the same expression: *|UI|

The first LC is recoverable from the behavior of |A| in neither undergoing nor triggering the harmony process. The second constraint serves to ensure that any complex expression is headless. |I| and |U|, which are Natural Lexical Heads, are prohibited from being heads of an elemental compound, i.e., an expression comprised of I/U and A is headless in Zulu. Once those assumptions are in place, the process of scalar allophonic raising of Zulu can be formalized as in (80). The arrow in (80b) indicates H-licensing: a headed element allows another element to assume the role of head within an elemental compound. Here the Natural Lexical Heads |I| and |U| allow preceding vowels to assume the role of heads. Since the first LC disallows headed A, only headless |I| and |U| can assume the role of heads in mid-vowels. This results in raising of mid-low vowels to mid-high.

(80) Application of the LCs of Zulu



Notice that the second LC of Zulu does not disallow headed |I| and |U| to co-occur with other elements, if H-licensing applies. The LC2 (79) ensures that |IA| and |UA| are not part of the vowel system of Zulu. The same expression can surface as the result of H-licensing, which is what happens when headed expression follows a headless one.

As exemplified in (80) above, the mechanism of H-licensing can represent the passage from a lax to a tense vowel, which is part of raising harmonies, but a process that raises mid-vowels to high-vowels requires a different formalization based on A-demotion. In Lena Bable, which has a five-vowel system, mid-high vowels raise to high and the low vowel /a/ raises to [e] when followed by a high vowel.

(81) Lena bable vowel system and harmonic pattern

a. Vowel system of Lena Bable

	<i>Front</i>	<i>Back</i>
High	i	u
Mid	e	o
Low	a	

b. Harmonic alternations in Lena Bable

<i>Masculine Singular</i>	<i>Masculine Plural</i>	<i>Feminine singular</i>	
'getu	'gatos	'gata	'cat'
tsa'mergu	tsa'margos	tsa'marga	'muddy lake'
'ninu	'nenos	'nena	'child'
kor'diru	kor'deros	kor'dera	'lamb'
kal'diru	kal'deros	kal'dera	'pot'
'tsubu	'tsobos	'tsoba	'wolf'

Cobb (1997: 157) assumes that A-demotion follows from a parameter, the Complexity Condition (Harris 1990: 273), which requires a simplification of an elemental compound if it is deemed too complex. Complexity is expressed in terms of the number of primes present in the expression (e.g., |UIA| is more complex than |UA| which is more complex than |A|) as well as in terms of headedness (|UIA| is more complex than |UIA|, |UA| is more complex than |UA|, |A| is more complex than |A|).

Languages implement the Complexity Condition in a language-specific manner, meaning that a language may accept a complex expression, while another one may not accept it. If the outcome of a phonological process is a compound of elements that exceed the complexity allowed in the language, the compound is simplified via the elimination of an element or via the elimination of the head. The alternations of Lena are explained by referring to three different phonological phenomena: Licensing Constraints, H-licensing and the effects caused by the Complexity Condition. The analysis given in Cobb (1997: 178) is provided below.

Lena has a five-vowel system. Stressed mid vowels followed by a high vowel raise to high, while the low vowel /a/ raises to [e] say where we see that in the tables. The LCs that are active in Lena are similar to those that are active in Zulu, and are shown in (82).

(82) Licensing Constraints active for Lena Bable

A cannot be a head

Natural Lexical Heads license no operators

I and U don't appear in the same expression: *|UI|

The same elemental compounds |UA| and |IA| of Zulu, which were implemented phonetically as /ɔ/ and /ɛ/ respectively, in this case surface as [o] and [e]. As noticed above (and discussed in more detail in §V.4.3.3), ET does not rule out the possibility that identical compounds of elements are implemented in different ways, which is what happens in Zulu and Lena Bable. While discussing the analysis of Charette

& Göksel of Turkish we also discussed the fact that two different elemental compounds (namely |IA| and |IA|) are implemented in the same way.

The harmonic process of Lena is caused by H-Licensing, whereby headed expressions license the head of non-headed expressions. For this reason, high vowels are represented as headed, exploiting the notion of Natural Lexical Heads. H-licensing creates complex headed expressions, which are ruled out in Lena by a Complexity Condition, and hence simplified. In this case, the simplification takes the form of A-demotion. The interplay between H-licensing and A-demotion is exemplified in (83). The Complexity Condition under (83a) rules out complex compounds, while H-licensing creates compounds that are composed of two elements and are headed (83b).

The result of this operation does not conform to the complexity condition, and is thus simplified through A-demotion (83c). The result is a headed segment with just one element.

(83) Mid-high raising in Lena caused by H-licensing and the Complexity condition

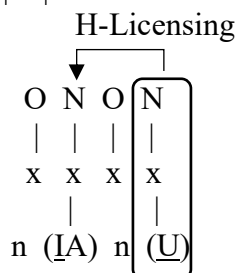
a. Complexity condition:

Expressions cannot be headed and contain two elements.

b. H-licensing:

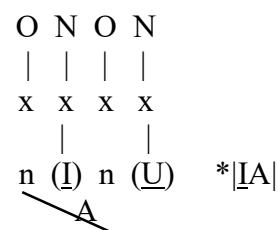
/nenu/ → [ninu]

H-Licensing: |IA| becomes headed → |IA|



c. A demotion:

The complexity condition requires |IA| to simplify. A-demotion applies

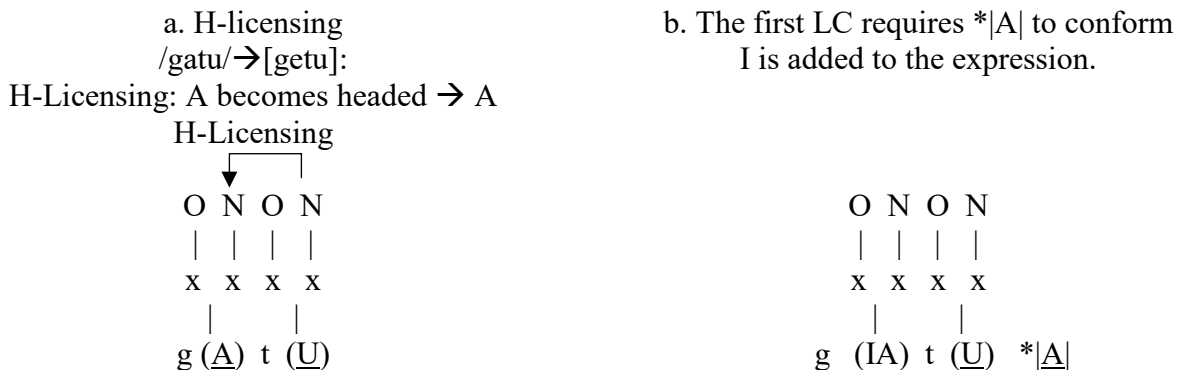


H-licensing creates the environment for A-demotion to apply because the headed phonological expressions |IA| and |UA| do not comply with the complexity condition under (83a).

In Lena, the low vowel /a/ also undergoes raising when followed by high vowels, and when it does it surfaces as mid-high [e]. The operation of H-licensing applied to the low vowel /a/ = |A| would result in a headed |A|, which does conform to the complexity condition in (83a), but violates the first LC1, that states that |A| cannot be head. As a consequence, the elemental composition of headed |A| is resolved in conformity to both the complexity condition and the LC1 with the addition of |I|, resulting in |IA|¹⁸². This analysis, discussed in Cobb (1997: 181), is exemplified in (84).

¹⁸² In reading Cobb's (1997) analysis, I found odd the fact that the LC "A cannot be a head" serves to treat /a/ as neutral in Zulu, while in Lena it does not. I refer to Cobb (1997) for a more in-depth analysis on this matter.

(84) H-licensing and the resolution of the complexity condition in Lena Bable



The interplay between H-licensing and the Complexity Condition can represent the raising of a mid-vowel to a high vowel. Notice that in both the case of Zulu and Lena, the licensing constraints themselves did not affect the application of VH, which is triggered by the H-licensing mechanism. Still, to my knowledge, no scholar that employed LCs as a phonological tool ever analyzed a case of raising that involves a more complex pattern of raising. Many if not most of the cases covered in §II.3 exhibit a seven-vowel system, and a scalar raising mechanism that produced mid-high vowels from mid-low vowels and high vowels from mid-high vowels.

I will try to apply the insights of Charette & Göksel (1996), Kaye (2000) and Cobb (1997) to a case of Italian metaphony such as the one of Servigliano, where scalar raising involves more than one height level. The vowel system of Servigliano (which has been analyzed many times by now) is composed of seven vowels, and is structured around four height levels. Mid-vowels all undergo raising, which applies in a scalar fashion. I will consider the process of Servigliano Metaphony as an instantiation of H-licensing. High vowels are thus required to be the only headed expressions, since they are the only triggers for metaphony. I will consider both vowels as Natural Lexical Heads, similarly to what Cobb proposed for both Zulu and Lena.

The low vowel /a/, which is unaffected by the process and does not trigger it, is bound to be headless, so it corresponds to |A|. The representation of mid-vowels is more problematic.

All four mid-vowels should comprehend two elements each, |IA| and |UA|. The difference between mid-high and mid-low vowels should be marked by mid-high vowels being headed, and mid-low vowels being headless. This is however at odds with an analysis of raising as caused by H-Licensing, because it would require mid-high vowels to behave as triggers for metaphony in Servigliano. The issue is shown graphically in (85), where elemental compounds are correlated with the vowels of Servigliano.

(85) The vowel system of Servigliano: mid-low and mid-high vowels cannot be distinguished by headedness

	<i>Front</i>		<i>Back</i>	
<i>High</i>	i	<u>I</u>	u	<u>U</u>
<i>Mid-high</i>	e	* <u>IA</u>	o	* <u>UA</u>
<i>Mid-low</i>	ɛ	IA	ɔ	UA
<i>Low</i>	a		A	

The problem is more representational than computational in nature. LCs are able to account for one-step raising, as well as complete raising (if we assume that Complexity Conditions may force A-demotion). The problem, in the case of Servigliano and in the case of all raising harmonies that involve raising of both mid-low and mid-high vowels, is due to the representational tangle derived from the double nature of heads in GP.

Heads are the only phonological object that can distinguish between mid-high and mid-low vowels, given a vowel system such as the one of Servigliano, but at the same time, they are the trigger of the only computational operation that can cause raising, i.e., H-licensing.

Hence, I argue that a system based on LCs and H-Licensing cannot formalize raising in systems with contrastive mid-low and mid-high vowels, since they can only be distinguished by headedness.

The economic advantage of having only a handful of elements turns out to be once again a problematic issue in the treatment of raising harmonies in theories that employ unary elements but do not allow multiple occurrences of the same element. In addition, I would like to address the fact that bringing back the old “ATR” element |ɤ|, employed in (Kaye, Lowenstamm & Vergnaud 1985) would not work either, since now we would fall back to the issues encountered in §2: a single phonological context triggers two different processes: A-demotion and spreading of |ɤ|.

IV.5.5 Applying LC to Camuno parasitic harmony

The example of Yakut and Kazakh given in Charette & Göksel (1996) shows that a system of phonological computation based on LC can formalize parasitic harmonies. The same strategy can be used to represent Camuno parasitic harmony, as explained below.

The vowel system of Camuno is comprised of nine vowels, {i,y,u,e,ø,o,ɛ,ɔ,a}. For the sake of the argument, I will leave aside mid-low vowels from the analysis. In Camuno both mid-low and mid-high vowels are distinctive, but due to the specific nature of the Eastern Lombard vowel system (cf. §III.2) we can consider the process as only affecting mid-high vowels. I will therefore assume the same expression for mid-low and mid-high vowels.

The high vowels /i/, /u/ and /y/ can trigger raising, so, assuming that H-Licensing triggers raising, only those three vowels can be headed. For the sake of simplicity, I leave aside the high rounded front vowel /y/, which I will treat separately later. /i/ and /u/ are Natural Lexical Heads, as they were in Zulu and Lena.

The low vowel /a/ always behaves as neutral, and thus I assume that a LC requires |A| to never be headed: as in the case of Zulu this could prevent H-Licensing to apply to /a/≠|A|. Mid vowels are headless, and become headed when H-licensing applies. We can assume the following Licensing Constraints for Camuno, reported in (86a), that generate the elemental representations shown in (86b).

(86) Vowel system and Licensing Constraints active in Camuno

a. Licensing Constraints active in Camuno

LC1: A cannot be a head

LC2: Natural Lexical Heads license no operators

b. *Vowel system of Camuno*

i	<u>I</u>	y	UI	u	<u>U</u>
e,ε	IA	ø	UIA	o,ɔ	UA
a			A		

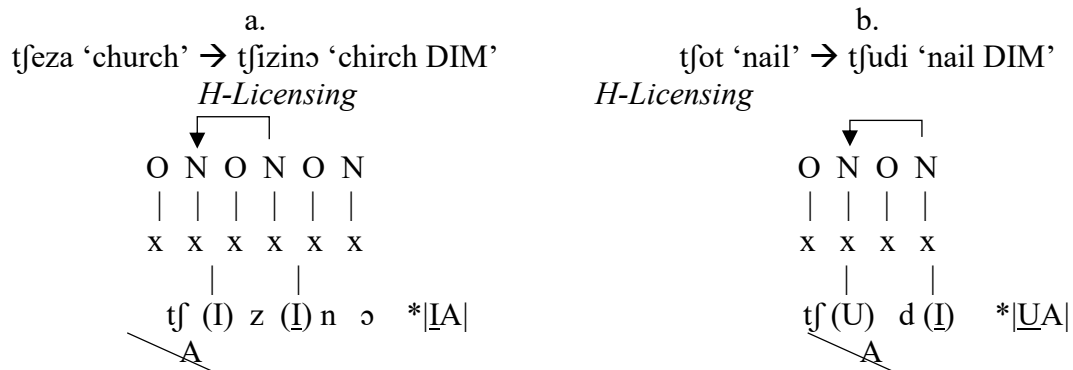
High vowels trigger H-Licensing, which targets mid-vowels making them headed. At this point, similarly to what has been proposed for Lena in §5.4, A-demotion should apply as the consequence of a Complexity Condition. In Lena, nuclei could not contain complex headed vowels. Camuno would require a similar condition that rules out outcomes such as |IA| or |UA|. I propose for Camuno the complexity condition under (87).

(87) Complexity condition of Camuno

Expressions cannot be headed and contain multiple elements.

Raising in Camuno, then, applies as the consequence of H-Licensing, which creates the illicit expressions |IA| and |UA| which are then simplified to follow the complexity condition under (87). Examples under (88a) and (88b) show the interplay between H-Licensing and the Complexity Condition in causing raising in Camuno.

(88) Raising in Camuno formalized as H-Licensing



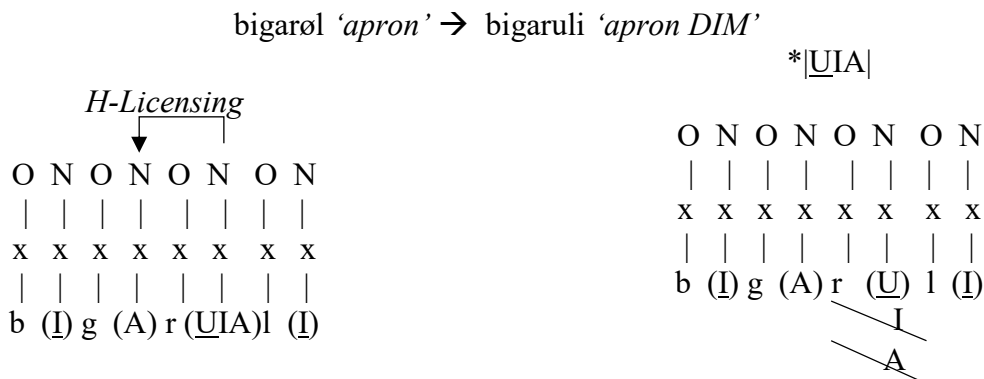
Front rounded vowels are problematic if we consider the interplay between H-Licensing and the complexity condition.

The Complexity condition stated in (87) rules out complex headed expressions, which rule out *|IA| and *|UA|, but should also rule out the phonological expression of front rounded vowels /y/, which assuming a standard view of ET, should be headed (as a valid trigger for raising) and complex, since it contains both |I| and |U|.

As discussed in the previous chapter, /y/ does not appear in any productive morpheme of Camuno (nor in any other Eastern Lombard dialect), which makes it hard to assess whether it acts as a harmonic trigger for preceding vowels. In §III.7.7 is also discussed the fact that often front rounded mid-vowel /ø/ raise to /u/ when affected by raising. It was shown that both [u] and [y] are valid outcomes for /ø/ raising, with the form [u] being more frequent in specific morphological contexts. For the sake of the argument, I assume that [u] is the preferred outcome for raised /ø/, and leave aside the outcomes in which /ø/ actually surface as [y] when raised.

Under this assumption, then, we can analyze Camuno raising as not triggered by /y/ (which hardly ever surfaces as a valid trigger), and make use of the complexity condition in (87) to explain why often front rounded /ø/ raises to [u] and not to /y/. The complexity condition would require that two primes are delinked from the representation |UIA|, which results in |U|. This is exemplified under (89).

(89) /ø/ raising applying the complexity condition: /ø/ raise to [u].



The main feature of Camuno VH is its partial parasitic behavior: rounded vowels are affected by all high triggers, while non-rounded vowels raise only if /i/ triggers harmony. Charette & Göksel (1996) treat the labial harmony of Yakut, which exhibit a parasitic pattern of the same type of Camuno, as licensing of |U|. In their analysis, parasitism follows from the fact that |U| is prevented from appearing as headless by a Licensing Constraint, and head-switching is licensed by headed |A| in the trigger.

The analysis of Camuno cannot follow the same route. First of all, there is no spreading in Camuno, if we assume that raising is formalized as A-demotion caused by H-licensing. What happens instead is that |I| and |U| assume the role of heads in mid-vowels, and then the element |A| is discarded so the resulted compound conforms to the Complexity Condition in (87). To account for Camuno partial parasitism, we have to assume that one of the two operations involved (H-licensing or A-demotion) is contingent upon the presence of another element in the trigger and in the target.

A possible analysis may be to assume that the requirement expressed by the Complexity Condition is satisfied in different manners depending on the elements that appear in triggers and targets.

I assume that Camuno has an additional Licensing Constraint, shown in (90).

(90) Licensing Constraints of Camuno

LC1: A can't be head

LC2: Natural Lexical Heads license no operators

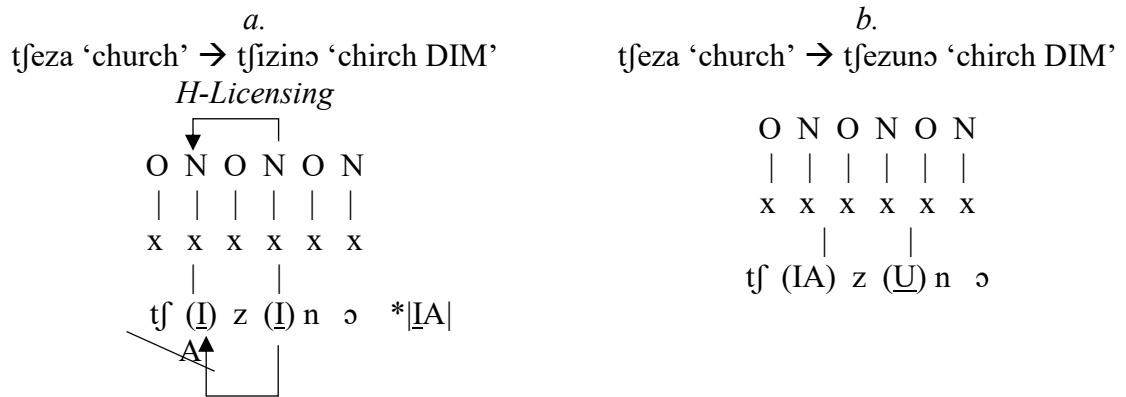
LC3: I must be licensed

The newly added LC3 does not affect the vowel system of Camuno: the notion of Natural Lexical Heads plus the Licensing Constraints shown in (86) already account for all the vowels of Camuno (except for mid-low vowels). The LC3 introduced here requires all occurrences of headed |I| which are not Natural Lexical Heads to be licensed by a headed |I|.

All mid vowels undergo H-licensing, and result in a headed expression. For a front non-rounded vowel |IA|, only |I| can become headed because of the LC1, which prevents |A| from assuming the role of head

in Camuno. The LC3, then, requires a headed $|\underline{I}|$ in the trigger to license it. When $/i/ = |\underline{I}|$ is the trigger, headed $|\underline{I}|$ in the outcome is licensed by headed $|\underline{I}|$ in the trigger. This is shown under (91a): licensing is expressed as an arrow from the licenser to the licensee. When $/u/$ triggers raising, however, $|\underline{U}|$ is headed, and thus headed $|\underline{I}|$ in the newly raised mid vowel is not licensed. The process, then, fails to apply, as shown in (91b).

(91) Formalizing parasitism in Camuno using Licensing Constraints



As it turns out, the mechanism of H-licensing, when combined with the notion of the Complexity Condition, can formalize the problematic parasitic harmony of Camuno. Licensing constraints are a valid way to formalize asymmetric harmonic patterns. They manage to correlate the form of static vowel systems to the behavior of vowels in harmonic processes, and they allow for valid explanations of parasitic patterns such as the one of Yakut and Camuno. They fall short, however, in their possibility to represent scalar raising harmonies in systems where mid-low and mid-high vowels are contrastive.

IV.6 the Radical CV approach to harmonic asymmetry

A different phonological model that subscribes to the unary approach and considers harmony as the result of a licensing operation is the one proposed by van der Hulst in various works (van der Hulst 2018, 2016), and extensively developed in van der Hulst (2018), Radical CV Phonology (RcvP). I will divide the description of the RcvP model into two parts. Section §6.1 covers the representational side of the model, while section §6.2 treats the computational side. Sections §6.3 and §6.5 apply the RcvP model to raising harmonies.

IV.6.1 Phonological representation in Radical CV Phonology

As van der Hulst (2014) notices, Radical CV Phonology is an approach that builds on the insights of Dependency Phonology (Anderson & Jones 1974, Anderson & Ewen 1987) and Government Phonology (Kaye Lowenstamm & Vergnaud 1985, Harris & Lindsay 1996). The explicit foundations of his model are the following:

- Phonological primes are unary elements
- Elements combine entering into dependency relations (Head-dependent)
- There is just one set of elements that can occur in both vowels and consonants
- Elements are grouped into units he calls “gestures” or “class nodes”.

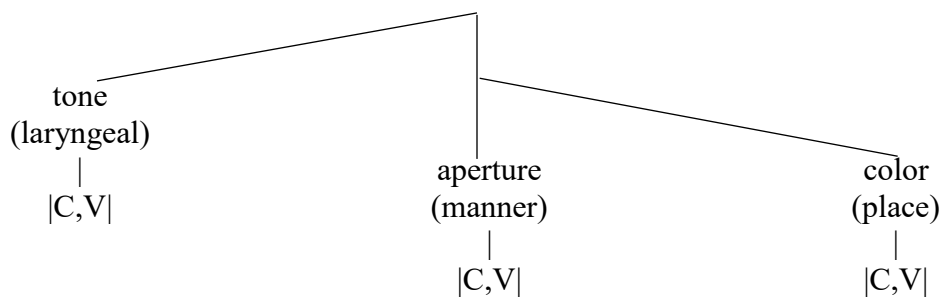
Of course, not all those assumptions are shared by all scholars that subscribed to the DP and GP frameworks. Most notably, GP does not refer to groupings of elements into units, and as we have seen

in §5.4, the behavior and function of a head is rather complex, and not a unitary notion in GP quarters (cf. Backley 2011, Backley 2012, Kaye 1990, Charette & Göksel 1996).

Nonetheless, the influence of DP and GP in RcvP is evident. The choice of a unitary set of unary elements and the prominent role of dependency relations between primes have deep roots in the literature concerning DP and GP since the eighties. RcvP recognizes a different kind of elements from the two approaches cited, and applies the head-dependent relation between them in a more rigid fashion. In van der Hulst’s view, all phonological expressions form a dependency structure, and the elements comprised in this structure cannot be in a relation of mutual dependency. In other words, there is always a head within an elemental composition (van der Hulst 2014: 15, 2018: 52).

The class nodes the author refers to are akin to the nodes of Feature Geometry (Clements 1985, Clements & Hume 1995) and group together couples of elements. The name of Radical CV Phonology derives from the fact that the only two elements that are necessary in the system envisioned by van der Hulst are the “consonantal-oriented” C and the “vowel-oriented” V. Depending on their place in the segmental structure (van der Hulst 2018: 53), those two elements correlate with different phonetic properties. The basic representational structure of RcvP, as developed in van der Hulst (2014: 16; 2018: 53) is reported in (92).

(92) Basic representational structure of RcvP

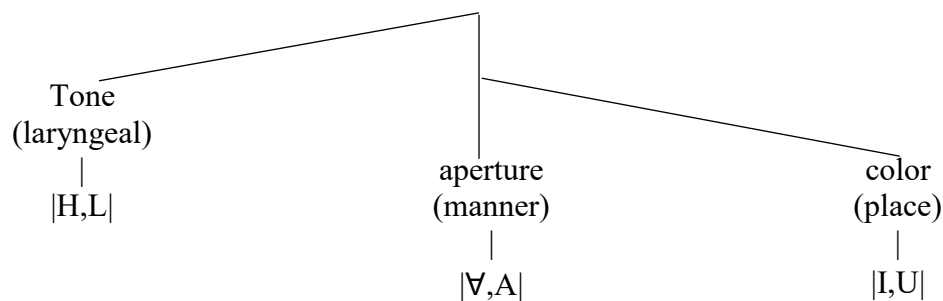


<i> V-elements </i>	<i> C-elements </i>
Place: V = labiality	Place: C = palatality
Manner: V = openness	Manner: C = closure
Laryngeal: V = Low tone, voicing	Laryngeal: C = High tone, voicelessness

For the ease of the reader, van der Hulst uses the elements developed in the DP/GP literature during the explanation, so that the reference to the element |Place: V| is referred to as |U|, since they both correlate with labiality, |Manner: V| is referred to as |A|, since they both correlate with openness etc... The Elemental geometry reported in the graph in (92) can thus be re-written as in (93) with elements grouped in “antagonistic pairs” (van der Hulst 2018: 56). The necessity for an antagonistic pair follows directly from the Opponent Principle, a principle of categorization rooted in categorical perception proposed by the author, which creates categories that are perceptually as distinct as possible¹⁸³.

¹⁸³ The basic structure can divide further, always hosting the two elements C and V in each node. A more complex structure is the one in van der Hulst (2018: 242), where binary branching applies twice more to show the presence of other elements. Those additional primes play little to no role in the analysis concerning VH, so I will not treat them here.

(93) Translation of the basic structure in (92) with commonly used unary elements.



A major difference between the standard set of unary elements given in Backley (2011) and the set of elements used in RcvP is the presence of a prime that directly relates to “closure”, which is a major indicator of vowel height¹⁸⁴.

This move allows for a formalization of raising as licensing (cf. §6.2) of the unary prime ∇. In simpler terms, a process involving raising ends up with the target having the prime ∇. This unifies all the harmonic processes under a single formal analysis: instead of having backness, roundness and lowering harmonies formalized as spreading of an element and raising harmonies as loss of an element, this model can treat raising as a case of spreading, and not resort to the mechanism of A-demotion. The insertion of a high element to the set established in more standardized unary theories is consistent with the logic of the antagonistic pairs, since A lacked an opposite element that could appear in vowels, in sets proposed by Backley (2011) or Kaye, Lowenstamm & Vergnaud (1985). However, it is in sharp contradiction with the economic advantage of unary theories. Since other unary theories are able to formalize raising processes (as we have seen in §2), the addition of ∇ to the set of elements is not a desideratum of these approaches. (94) shows the phonological identity of vowels according to van der Hulst (2018: 66).

(94) Underlying representation of Vowels in RcvP.

	<u>I</u>	<u>I</u> <u>U</u>	<i>Placeless</i>	<u>U</u> <u>I</u>	<u>U</u>
∇ ¹⁸⁵	i/I	y/Y	ɨ - ʉ	ɯ	u/ʊ
∇A	e	ø	ə	ɵ	o
A∇	ɛ	œ	ʌ	ɛ	ɔ
A	æ	ɶ	a	ɑ	ɒ

Different vowel systems are defined by a set of universal constraints, which can be either active or inactive in a given language. Those constraints have the sole purpose to define which vowels can appear in a given language and which cannot, and do not affect phonological processing. For the complete list of constraints, see van der Hulst (2018: 68).

¹⁸⁴ The standard set of unary elements discussed in Kaye (2000) and Backley (2011) has an element that correlates with occlusion/burst of energy, [ʔ], which is absent in RcvP.

¹⁸⁵ The distinction between ATR and RTR high vowels requires an additional element, which follows from ulterior branching of the graph under (93). For more on further elements in RcvP cf. van der Hulst (2018: 65).

An issue that is more relevant in this context is the way van der Hulst obtains a minimal representation for each vowel. In other words, the strategy applied is to specify the vowel systems minimally in terms of elements, so that each vowel has a distinct underlying representation.

The principle guiding the reduction to minimal representation appears to be contrastive underspecification (cf. §3.1). In fact, RcvP employs the SDA algorithm (Dresher 2009, Hall 2007), presented earlier in §3.2.1. The crucial difference between the application of the Successive Division Algorithm in RcvP and in the MCS approach is the fact that van der Hulst assumes the ranking of elements (i.e., the hierarchy of primes that guide the binary branching of the algorithm) to be universal. Recall that within the MCS approach, the SDA can produce different feature specifications for the same vowels in different languages due to the fact that contrastive hierarchies are language specific. The universal ranking assumed by van der Hulst is shown in (95).

(95) Universal Ranking of elements in RcvP

$$Av > Uv > Ic / Vc$$

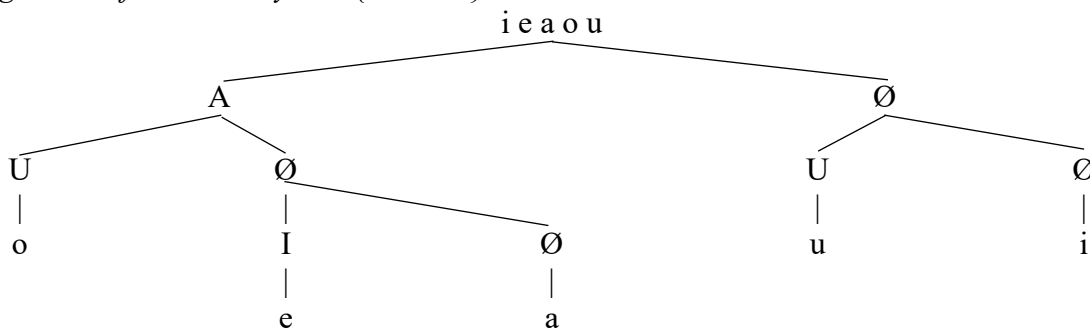
According to Van der Hulst (2018: 75), the position of the dependent elements I and V is freer than the other elements on the hierarchy. This means that while the position of the elements A and U is fixed, cross-linguistic variation concerning the position of I and V in the hierarchy is possible.

According to van der Hulst (2018: 77), only contrastive elements in the representation are active in phonology. In other words, he subscribes to the Contrastivist Hypothesis¹⁸⁶. However, given the fixed nature of the hierarchy in (95), the SDA graph does not serve the same purpose as it does in the MCS theory.

Here the fixed ranking of elements will produce the same graph for identical vowel systems, with the only leeway being the position of the elements |I| and |V|. Under (96), the ranking shown in (95) produces two SDA graphs given a five-vowel system, shown in (96a), and a seven-vowel system, shown in (96b).

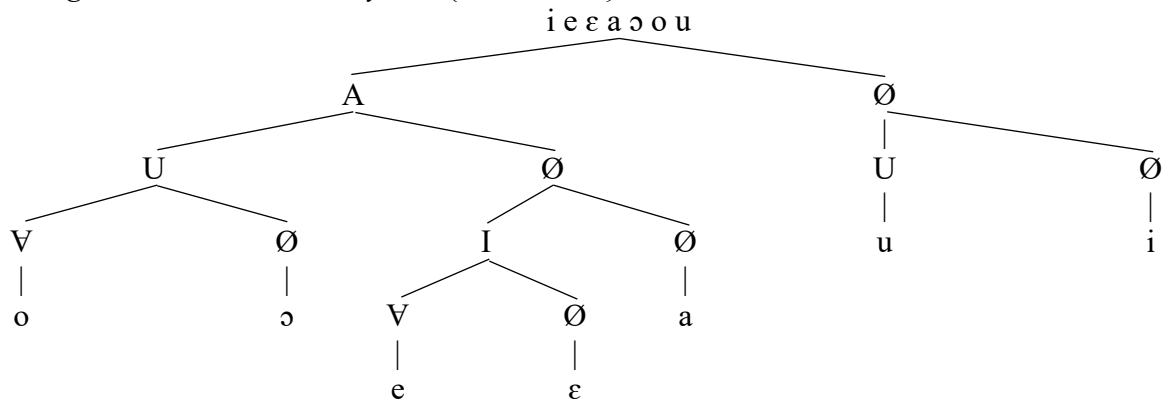
(96) Application of the SDA using the universal ranking: $Av > Uv > Ic / Vc$

a. SDA given the five-vowel system {i,e,a,o,u}



¹⁸⁶ Van der Hulst (2018: 77) argues that unnecessary non-contrastive primes, filled in after phonological computation takes place, may be relevant to post-lexical phonological processes.

b. SDA given the seven-vowel system $\{i, e, \varepsilon, a, \text{ɔ}, o, u\}$



Notice that, differently from what we have discussed in §3.2.1, here the SDA cannot capture the behavior of neutral vowels in languages with similar systems and different harmonic patterns. Given two languages with a five-vowel system, the SDA will assign the primes as in (96a) regardless of the behavior of vowels in that language. The key idea supported by proponents of the MCS theory is the fact that the contrastive hierarchy of primes is language specific. Here the ranking is fixed, which means that identical vowel systems receive the same elemental specification.

IV.6.2 Phonological computation in RcvP

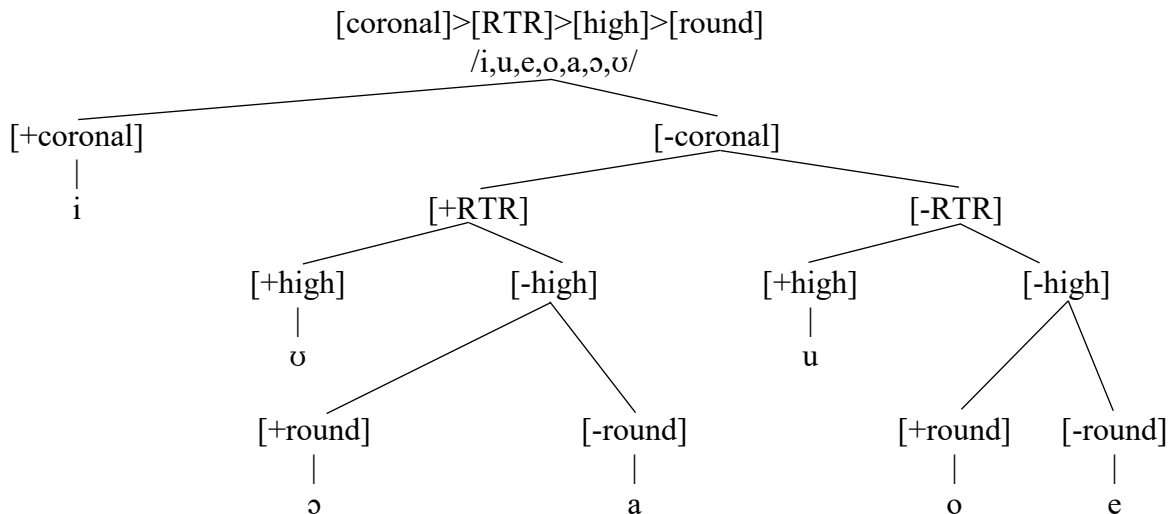
Now that the representational side of the RcvP model has been briefly described, let us consider the computational aspects of this approach. When a vowel is involved in a harmonic alternation, in other words when it is subject to VH, it contains a variable element, signaled in the representation of the vowel between parenthesis. This element, while present in the underlying representation, is not phonetically interpreted unless a non-variable element of the same kind licenses it locally (i.e. the licenser must be in a neighboring nucleus)¹⁸⁷.

Consider the example from Turkish harmony treated under (97) (van der Hulst 2014: 19). The plural suffix /lar-ler/ and the genitive suffix /un-in/ all contain a variable element |I|, which is shown between parenthesis in the table below. A preceding |I| in the dominant vowel can license it, allowing its phonetic interpretation. The symbol (>>) indicates licensing, so a sequence such as “I >> (I)” should be read as “the lexical element |I| licenses the variable element (I)”, allowing for its phonetic interpretation.

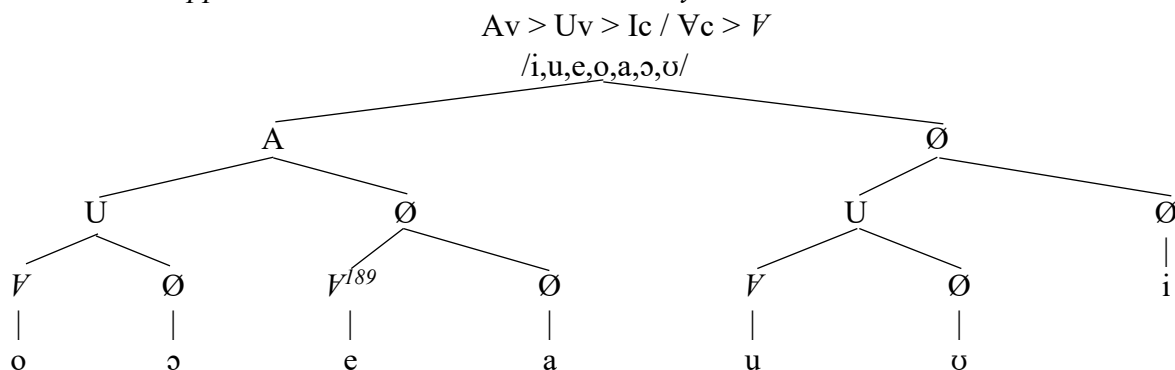
¹⁸⁷ As Van der Hulst himself reports, this locality is not necessarily at the syllabic level, but can involve neighboring feet, or different syllabic formations.

(100) Different applications of the SDA for the vowel system of Halh Mongolian

a. SDA application in MCS: language-specific hierarchy



b. SDA application in RcvP: universal hierarchy



To explain asymmetries, RcvP introduces the notion of Bridge Licensing. Bridge licensing in RcvP terms is a specific form of licensing that applies when two vowels share an element.

Licensing generally applies locally at the syllabic level, meaning the licenser and the licensee must belong to neighboring syllables. The harmonic trigger affects neighboring vowels while vowels that are further away from it are affected by harmony only if the intervening vowel harmonizes as well.

Bridge licensing works as an alternative notion of locality. Instead of calculating locality on the syllabic level, locality may depend on one elemental tier. Simply put, a nucleus can be considered close enough to receive licensing of its variable elements if two lexical elements “build a bridge” between

¹⁸⁹ In Halh Mongolian front vs. back vowels do not form a harmonic pair. There is however an active process of tongue root harmony. In van der Hulst (2018:142) the minimal specification of vowels of Halh Mongolian assigns the tongue root element |ʮ| to front-mid [e]. The application of SDA given the fixed hierarchy would require the front element |I| to distinguish between /e/ and /a/. Under (100b) I reported the SDA following the fixed hierarchy which assigns the rounded element |U| to all rounded vowels, and I presume that the leeway in the position of |I| and |ʮ| in the fixed hierarchy allows for the tongue root element |ʮ| to precede |I| in the hierarchy.

them. In Halh Mongolian (as exemplified under 101a below) the element |A| forms a bridge that allow licensing of variable (U) in the rightmost suffix through a nucleus that does not contain |U|.

In Halh Mongolian the vowel in the root and the vowel in the rightmost suffix are treated as local neighbors because they both contain |A|, and thus the element |A| in the leftmost vowel and the element |A| in the rightmost suffix form some sort of a bridge where licensing of (U) can apply. In (101a), where the bridge is in place, the intervening /i/ is invisible for licensing, and thus behaves as transparent. In (101b), the licensing relation between the initial |U| in the root and the variable (U) in the rightmost suffix is blocked on account of an intervening |U| specification. The process is blocked because there is no licensing relation between this intervening |U| and the variable (U) in the suffix, because these nuclei do not share a |A| element.

(101) Labial harmony in Halh Mongolian in van der Hulst (2018: 142)

a.	mɔ	ri	-tɔi	‘horse COM ¹⁹⁰ ’
	A	----- A		A-bridge: /i/ is
	U	>>	(U)	skipped
b.	ɔr	-ɔ:l	-a:d	‘enter CAUS PERF’
	A	----- A		A-bridge: ɔ blocks
	U	U	(U)	licensing

The notion of Bridge Licensing requires the analysis of Halh Mongolian to be somewhat parasitic, i.e. the propagation of the harmonic wave depends on the presence of another prime. Using the unary primes introduced above and the notion of licensing as intended in RcvP, the process of labial harmony in Halh Mongolian can be treated as a case in which the variable (U) present in mid and low vowels is licensed following the locality established in the |A| tier.

In sum, variable (U) is licensed by |U| in triggers, but this licensing can apply only in contexts where a A-bridge is built, i.e. where the trigger and the target share the element |A|. /i/, which here is considered an empty nucleus, behaves as transparent because no element blocks the licensing of the variable (U). High rounded vowels, which contain |U| are prohibited from licensing variable (U) because they do not “build” the A-bridge. This explains why in Halh Mongolian /i/ behaves as transparent, high rounded vowels /u/ and /ɔ/ behave as blockers albeit containing |U|, and why only non-high vowels participate in labial harmony. Examples of the transparent behavior of /i/ with respect to labial harmony in Halh Mongolian are reported under (102). The /i/ in the accusative suffix /-ig/, intervening between the root and the reflexive suffix, does not participate in harmony, but it allows both labial and tongue-root harmonies to propagate from the root towards the rightmost suffix.

¹⁹⁰ COM=comitative

(102) Transparent behavior of /i/ in Halh Mongolian harmonies

piir-e	'brush REFL'	piir-ig-e	'brush ACC REFL'
suulǰ-e	'tail REFL'	suulǰ-ig-e	'tail ACC REFL'
teelǰ-e	'grown REFL'	teelǰ-ig-e	'grown ACC REFL'
poor-o	'tail REFL'	poor-ig-o	'tail ACC REFL'
moor-a	'cat REFL'	moor-ig-a	'cat ACC REFL'
c ^h aas-a	'paper REFL'	c ^h aas-ig-a	'paper ACC REFL'

In sum, harmonies with opaque vowels can be explained as harmonic patterns where the phonetic interpretation of a specific bundle of elements is impossible (as in Akan, where $*|AV|$ prevented variable (V) to be licensed). Asymmetric harmonies are harmonic patterns in which licensing applies only if a bridge between nuclei is built.

In the following sections I will discuss the specific consequences of the application of RcvP to raising harmonies, with a focus on the case of metaphonies, which van der Hulst (2018) tackles directly, and on the problem posed by partial parasitic harmonies such as Camuno.

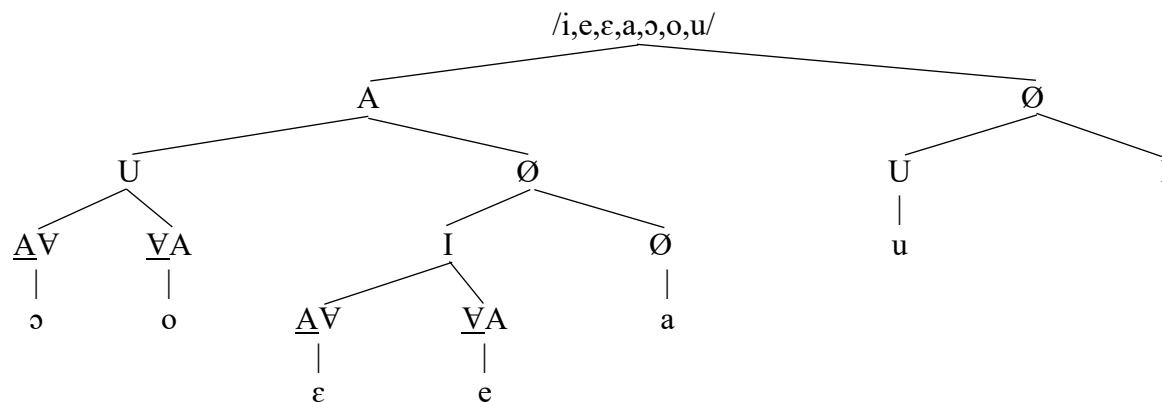
IV.6.3 Metaphony in Radical CV Phonology

In his work, van der Hulst covers many harmonies that involve vowel height (he collectively calls this group of harmonies aperture harmonies). He chooses to group them together in the discussion, but the element of geometry given in (93) allows him to formalize them all using the same strategy: lateral licensing of an element. Following this logic, licensing of a variable (A) would correspond to a lowering harmony, licensing of (V) corresponds to raising and licensing of the secondary prime (Vc) corresponds to a tongue root harmony. Van der Hulst (2018: §6) covers various raising and lowering patterns in Bantu and Romance languages throughout the sixth chapter of his book. I would like to analyze in detail his treatment of metaphony in Italian dialects, in particular the case of Servigliano, and discuss the consequences of his theoretical assumptions for the processes covered in §II.3.

Introducing his analysis, van der Hulst (2018) recalls the works of Casali, who analyzed in detail the seven-vowel systems of Bantu languages, and suggests two different ways to formalize the seven-vowel system of Servigliano. To put it simply, there are two ways to conceive a seven-vowel system based on two degrees of height. The difference between higher and lower vowels revolves either around ATRness or around height. In §2.6 we discussed how a representational model of height based on incremental primes can dodge this issue, but since van der Hulst's formalization of VH hinges strongly on his representational model, which does not recognize incremental primes such as particles, it is worth following him in this discussion without considering the solution proposed above. In Servigliano, stressed mid-low vowels raise to mid-high and mid-high vowels raise to high when followed by a final high vowel.

Van der Hulst (2018: 282) analyzes the vowel system of Servigliano as structured around height, and discards a previous analysis which considers metaphony as a case of tongue-root harmony (cf. van der Hulst 2018: 281). Raising is formalized as licensing of a variable element (V). The representation of vowels in Servigliano follows the application of SDA shown in (103)

(103) Minimal representation for the vowel system of Servigliano (van der Hulst 2018: 282)

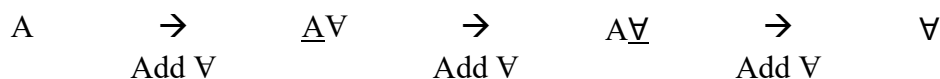


The distinction between mid and high vowels is based around the presence/absence of the $|\mathbf{V}|$ prime, while the distinction between mid-high and mid-low vowels revolves around the headedness of $|\mathbf{A}|$, with mid-low vowels having the element $|\mathbf{A}|$ as head. In mid-high vowels, instead, it is the prime $|\mathbf{V}|$ that is headed. Van der Hulst develops an analysis of metaphony that considers $|\mathbf{V}|$ as the active element, which also directly refers to the role of stress. Van der Hulst recovers from Walker’s (2011) analysis of metaphony the idea that raising is actually the result of the fact that vowels in unstressed position weaken, and thus are in need of licensing from the stressed vowel.

Weakening of vowels in unstressed position is formalized as the passage from a lexical $|\mathbf{V}|$ to a variable (V), which needs to be licensed. Therefore, for variable (V) to be licensed in unstressed vowels, $|\mathbf{V}|$ must strengthen in the stressed vowel. This strengthening is formalized as copying. When a mid-vowel is in stressed position, an $|\mathbf{V}|$ element is added to it, allowing it to license following variable (V).

This operation can, according to the author, be considered as a case of attraction of the element $|\mathbf{V}|$ from the final unstressed position to the stressed one. The element $|\mathbf{V}|$ present in the final high vowel moves to the stressed position, where it is copied from the unstressed position and leaves a trace formalized as a variable element (V). Once the $|\mathbf{V}|$ element is copied in the stressed vowel, this additional element must be integrated into the elemental expression. Thus, a second operation, called *resolution* (Van der Hulst 2018: 284), applies. The addition of $|\mathbf{V}|$ can have different effects on the stressed vowel, depending on the internal composition of the vowel that receives this additional $|\mathbf{V}|$. The possible mechanisms triggered by the resolution operation are schematized in (104).

(104) Different ways to apply resolution



Add V to A →	$\underline{\mathbf{A}}; \mathbf{V}$	Low becomes mid-low	
Add V to $\underline{\mathbf{A}}; \mathbf{V} \rightarrow$	A; $\underline{\mathbf{V}}$	Mid-low becomes mid-high	Loss of $ \underline{\mathbf{A}} $ headness
Add V to A; $\mathbf{V} \rightarrow$	\mathbf{V}	Mid-high becomes high	Loss of $ \mathbf{A} $, i.e. A-demotion.

The ways in which this operation is formalized turn out to correspond to the possible processes of raising encountered in metaphonic processes. Mid-high vowels surface as high, because |V| “pushes” away the non-headed |A| from the expression. Mid-low vowels turn out as mid-high because |V| is added to the elemental composition, and as a result headed |A| loses its role of head. Low vowels generally do not accept the intrusion of |V|, and that is why in most cases metaphony only applies to mid vowels, and not to low vowels. The mechanism of metaphony according to Van der Hulst’s analysis is exemplified under (105) below. In (105a) the element |V| is weakened in the unstressed vowels, while it is copied in stressed vowels. In (105b) copying of |V| applies to a mid-low vowel, where the headed element |A| loses its role of head. In (105c) copying of |V| applies to a mid-high vowel, where it pushes out the operator |A| resulting in a high vowel.

(105) RcvP analysis of metaphony in Servigliano

<p><i>a. Weakening of unstressed vowels: V becomes variable in the final unstressed high vowel.</i></p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 2px 10px;">/m</td> <td style="padding: 2px 10px;">ɔ</td> <td style="padding: 2px 10px;">f:</td> <td style="padding: 2px 10px;">i/</td> </tr> <tr> <td></td> <td style="text-align: center;"><u>A</u></td> <td></td> <td></td> </tr> <tr> <td></td> <td style="text-align: center;">V</td> <td></td> <td style="text-align: center;">(V)</td> </tr> <tr> <td></td> <td style="text-align: center;">U</td> <td></td> <td style="text-align: center;">I</td> </tr> </table>	/m	ɔ	f:	i/		<u>A</u>				V		(V)		U		I	<p><i>b. V is added to a mid-low vowel: V assumes the role of head</i></p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 2px 10px;">[m</td> <td style="padding: 2px 10px;">o</td> <td style="padding: 2px 10px;">f:</td> <td style="padding: 2px 10px;">i]</td> </tr> <tr> <td></td> <td style="text-align: center;">A</td> <td></td> <td></td> </tr> <tr> <td></td> <td style="text-align: center;">V</td> <td style="text-align: center;">>></td> <td style="text-align: center;">(V)</td> </tr> <tr> <td></td> <td style="text-align: center;">U</td> <td></td> <td style="text-align: center;">I</td> </tr> </table>	[m	o	f:	i]		A				V	>>	(V)		U		I	<p><i>c. V is added to a mid-high vowel: A is discarded</i></p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 2px 10px;">[m</td> <td style="padding: 2px 10px;">i</td> <td style="padding: 2px 10px;">t</td> <td style="padding: 2px 10px;">t</td> <td style="padding: 2px 10px;">i]</td> </tr> <tr> <td></td> <td style="text-align: center;">A</td> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td style="text-align: center;">V</td> <td style="text-align: center;">>></td> <td></td> <td style="text-align: center;">(V)</td> </tr> <tr> <td></td> <td style="text-align: center;">I</td> <td></td> <td></td> <td style="text-align: center;">I</td> </tr> </table>	[m	i	t	t	i]		A					V	>>		(V)		I			I
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Van der Hulst also notices that the probability of |V| to be successfully copied in the elemental composition of stressed vowels depends on the preponderance of the element |A|.

The more prominent the role of |A| in an expression, the harder it is for |V| to be copied in the stressed vowel. Therefore, /a/ {A} will receive with more difficulty an additional |V|, while mid-vowels may receive it more easily. This fact reflects the generalization proposed by Maiden (1991: §6.2.3) and discussed in §II.3.3.5.2: metaphony applies more frequently to mid-high vowels, often to mid-low vowels and rarely to low vowels. Furthermore, metaphony does not apply to mid-low vowels if it does not apply to mid-high vowels, and it does not apply to low vowels if it does not apply to mid-low vowels¹⁹¹.

Van der Hulst also suggests that a different implementation of raising in metaphony (which generally occurs as diphthongization in southern dialects; cf. §II.3.3.3.2) results from a different resolution strategy: the added |V| element does not fuse, but it gets its own realization as a glide.

The main advantage of this analysis, according to the author, lies in the lack of reference to |A| in the discussion. While all other element-based theories are forced to assume raising as some sort of A-demotion process, RcvP can account for it as a raising process based around the |V| element.

IV.6.4 Van der Hulst's analysis of Metaphony: discussion

Van der Hulst's analysis faces a number of issues. The need for unstressed high vowels to receive lateral licensing is said to derive from a weakening in unstressed position, formalized as |V|→(V). However, no |V| was present in the composition of high vowels in the first place, assuming the application

¹⁹¹ Van der Hulst does not tackle cases in which /a/ does undergo raising, surfacing as [ɛ]. He notices that this can happen, but suggests that this raising is not actually phonological, but due to a low level co-articulatory effect (van der Hulst 2018: 287).

of SDA as in (103). It is present in mid-vowels, where it seems to be derived by a non-coherent application of the SDA algorithm: instead of adding a binary branching based on the presence vs. absence of a prime, the last branching revolves around the headedness of $|\underline{A}|$.

In addition, I believe that the strategy of resolution presented in (104) actually results in a similar application of the A-demotion strategies introduced in §2. Let us resume the explanation of metaphonic raising given by van der Hulst (2018). Raising in metaphonics is assumed to be the result of the strengthening of $|\mathbb{V}|$ in stressed vowels, which is necessary because, conversely, $|\mathbb{V}|$ weakens in unstressed vowels. Weakening of $|\mathbb{V}|$ is shown as the passage from present/fixed to variable (i.e. a lexical $|\mathbb{V}|$ becomes a variable (\mathbb{V})), while strengthening of $|\mathbb{V}|$ in stressed vowels corresponds to copying of $|\mathbb{V}|$. This copied $|\mathbb{V}|$ has then the role of licenser for following variable (\mathbb{V})s. The presence of $|\mathbb{V}|$ in the stressed vowel depends also on the application of the resolution operation, which may take different forms according to the presence of the $|A|$ element (cf. 105). The resolution strategies applied to mid-vowels correspond exactly to the strategies of A-demotion. $|A|$ loses its prominent role in mid-low vowels and delinks in mid-high vowels. I argue that a model that simply accounts for raising as A-demotion is more streamlined and simpler than the treatment of raising given in RcvP terms. In some sense, the analysis of RcvP employs A-demotion without mentioning it.

Another issue with the analysis of Servigliano comes from the fact that the neutral behavior of /a/ in Servigliano is assumed to derive from the fact that headed $|\underline{A}|$ and operator $|\mathbb{V}|$ are incompatible. This would require a constraint on the phonetic implementation of a sequence such as $*|\underline{A}\mathbb{V}|$. However, this is not what happens in Servigliano, since the expression $|\underline{A}\mathbb{V}|$ corresponds to the mid-low vowel /ε/. Another reason for the neutral behavior of stressed /a/ in metaphony should be found.

One of the main selling points of RcvP is that it can represent raising harmonies as licensing processes similar to all other harmonic processes. However, the fact that it still has to rely on the notion of A-demotion in scalar processes such as Servigliano metaphony proves that the presence of a high-related prime is not sufficient to solve the various issues discussed in §2. Once again, it would be optimal to integrate incremental features into the RcvP framework. Unfortunately, I believe that the specific mechanisms of the Licensing Operation as it is assumed in RcvP cannot be combined with incremental features. Besides the obvious issue of having to change a tight representational theory (why must $|\mathbb{V}|$ occur multiple times? Why only it? Where do we put the various instances of $|\mathbb{V}|$ in the fixed hierarchy that builds the SDA graphs in 103?), it would be necessary to modify the licensing operation to act in a different manner when dealing with the prime $|\mathbb{V}|$.

Let us assume for a moment that scalar raising in Servigliano can be represented using the primes proposed by van der Hulst with the difference that $|\mathbb{V}|$ can occur multiple times. The vowel system of Servigliano would thus look like under (106).

(106) Servigliano vowel system in RcvP assuming incremental features¹⁹²

i	IVV	u	UVV
e	IV(V)	o	UV(V)
ɛ	I(V)	ɔ	U(V)
a	A		

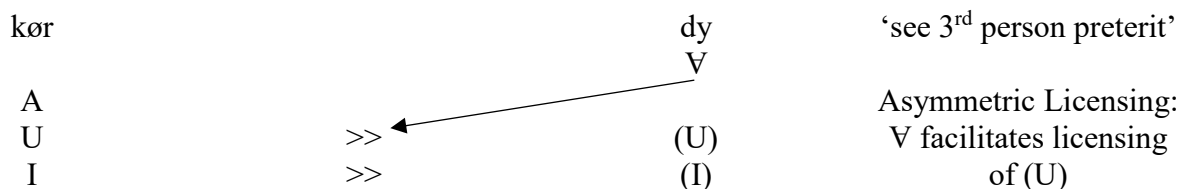
Which one of the two |V|s present in high vowels would license raising? Why don't /e/ and /o/ act as licensers, since they contain a fixed (i.e. non-variable) |V|? This same issue was raised earlier for approaches that employ [±ATR] as a way to distinguish between mid-high and mid-low vowels. The various copies of |V| would need to be numbered, and then raising should refer to the numbered instances of |V|. This, however, is formally equivalent to adding other different elements to the set.

IV.6.5 Representing partial Parasitism with RcvP: the notion of Asymmetric Licensing

As discussed in §6.3, van der Hulst (2018) introduced the notion of Bridge-Licensing to account for asymmetries such the one of Halh Mongolian. Moskal (2018) analyzes in detail various Turkic, Mongolic and Tungusic languages, and applies the main assumptions of RcvP to give a unitary description of the various harmonies. Facing the various harmonic patterns of Turkic languages, the tools given by the RcvP approach fail to describe all the harmonic patterns.

To account for problematic asymmetries, Moskal (2018: 710) introduces the notion of Asymmetric Licensing (henceforth AL). In sum, an element other than the licenser can help the operation of licensing to apply. In the case of Yakut treated in Moskal (2018: 710), high vowels are preferred targets for labial harmony, since they can undergo rounding given all triggers. This is formalized through an Asymmetric Licensing from the high element |V|, which facilitates the licensing operation. Asymmetric Licensing in Yakut harmony is exemplified under (107): the lexical element |V| permits the licensing of variable (U) (shown with the arrow pointing towards the representation of licensing). Non-high vowels, instead, require an A-bridge (recall from the previous section the notion of bridge-licensing) to allow variable (U) to be licensed. The interplay between AL and bridge-licensing is explored later.

(107) Asymmetric Licensing: the presence of an element facilitates licensing



The positing of this ulterior operation appears unexpected, and Moskal (2018: 712) herself recognizes it as a weak spot for the theory. It is however a theoretical necessity, once patterns such as the one of Yakut are considered.

The case of raising in Camuno, which turned out to be rather problematic for various approaches so far, can be formalized in RcvP using both the notion of Bridge licensing and the notion of Asymmetric

¹⁹² I leave aside the minimal representation of segments, which would be another issue in the combining of incremental features with RcvP representational assumptions.

licensing. First, consider the underlying representation of vowels in Camuno if we are to apply the assumptions discussed in §6.1. The representation of the Camuno vowel system within the RcvP framework is shown in (108).

(108) Camuno vowel system¹⁹³ in RcvP terms

i	I∇	y	IU∇	u	U∇
e/ɛ	I(∇)	ø	IU(∇)	o/ɔ	U(∇)
a	A				

High vowels trigger raising of mid vowels. This means that mid vowels have a variable (∇) element, while high vowels have a fixed |∇|, which license preceding occurrences of (∇) in unstressed vowels. While /o/ always raises, /e/ raises only when /i/ acts as a trigger. We can imagine the existence of an instantiation of Asymmetric Licensing, whereby |U| in the target facilitates the licensing of (∇). This would be a complementary operation to the one described in (107) for Yakut, where it is the high element that facilitates the licensing of variable (∇).

At the same time, to account for /u/ and /y/ not being valid triggers for unrounded vowels, we should assume the presence of an I-bridge that allows /i/ to raise preceding /e/. Since |U| is present in rounded mid-vowels, it would allow all vowels with |∇| to act as triggers, while non-rounded mid-vowels require a Bridge to have the variable (∇) licensed.

In (109) below, asymmetric licensing allows |U| in the target to facilitate licensing of variable (∇). This is shown with an arrow connecting |U| in the target to the licensing operation. When non-rounded vowels are targeted, a Bridge-Licensing, signaled as a dotted line between two occurrences of the element |I| in triggers and targets, is required to account for the fact that /e/ raises if affected by /i/. (109a) exemplifies the case in which Bridge Licensing allows |∇| in /i/ to license (∇) in /e/. (109b) shows how Asymmetric Licensing allows |∇| to license (∇). In (109c) both bridge Licensing and Asymmetric Licensing play a role in allowing raising of mid vowels. (109d) and (109f) show cases where raising does not apply because the Bridge Licensing is not ‘built’ between the trigger and the target.

(109) Partial parasitic harmony in Camuno: an RcvP analysis

a.				b.				c.					
'let → li'ti				'tʃot → tʃu'di				ho'rek → huri'gi					
l	i	t	i	tʃ	u	d	i	h	u	r	i	g	i
	I	-----	I		U		I		U		I	-----	I
	(∇)	<<	∇		(∇)	<<	∇		(∇)	<<	(∇)	<<	∇
<i>Bridge Licensing allows ∇ to license (∇)</i>				<i>Asymmetric Licensing allows ∇ to license (∇)</i>				<i>Bridge Licensing and Asymmetric Licensing interplay</i>					

¹⁹³ For the reasons explained in §III.7.2.2. I have simplified the vowel system of Camuno, so that mid-high and mid-low vowels share the same underlying representation. The difference between mid-low and mid-high vowels in this case would probably be captured in terms of the tongue root element ∇.

<i>d.</i>	<i>e.</i>	<i>f.</i>
'let → le'tu l e t - u l e t u I----- / U (∇) <<< ∇ <i>Bridge Licensing does not apply: ∇ cannot license (∇)</i>	'tʃot → tʃu'du u d - i tʃ u d u U → << U (∇) << ∇ <i>Asymmetric Licensing allows ∇ to license (∇)</i>	ho'rek → hore'gu h o r e g - u h o r e g u U I----- / U (∇) << (∇) <<< ∇ <i>Bridge Licensing does not apply: ∇ cannot license (∇)</i>

This analysis manages to describe most of the alternations described in §III.7.4. An issue that persists concerns the behavior of /y/ as a non-valid trigger for non-rounded vowels. In §III.7.7 we determined that the raised outcome of /ø/ as well as lexical /y/s are not valid triggers for preceding non-rounded mid-vowels in Camuno. However, since /y/ should contain |I| it should also be able to license variable (∇) through the bridge.

All in all, RcvP has developed solutions that manage to describe the behavior of parasitic harmonies as licensing of variable elements. Leaving aside the issue with front rounded /y/, the combined use of Bridge Licensing and Asymmetric Licensing allow for a descriptive analysis of the Camuno harmonic pattern.

IV.7 Problematic metaphonies: the role of morphology

In the course of the typological survey proposed in §II.3, the vast majority of raising harmonies discussed turned out to be regressive, meaning that the trigger follows the target in the phonological string. The head of the harmonic domain is often the vowel of a suffix, which raises vowels in roots.

Throughout the survey, at various points, the context of application of raising appeared to depend on both phonological and morphological information. Phonological processes are often subject to morphological conditionings, and apply only in specific morphological contexts; therefore, it is not surprising to find cases of morphologization in raising harmonies. However, some of the patterns discussed in §II.3.3.4.5 regarding metaphonies display some properties that led authors to raise the issue of whether metaphony should be considered as a phonological process, as a case of allophony of the root or something entirely different.

In this section, I focus on morphologically conditioned metaphonies. Metaphony belongs to the group of dominant harmonies in which it is the vowel of a suffix that behaves as the trigger for the vowel of the root. It means that alternations are evident in inflectional paradigms, when the vowel of particular inflectional suffixes becomes the head of the harmonic domain. In this sense, metaphony has always been a shared interest between phonologists and morphologists. As discussed in §II.3.3.5 metaphonic alternations are frequent both in nominal and verbal paradigms.

A first interference of morphology in metaphony can be found in those dialects where the vowel system developed in a way that hampered the presence of high vowels in final position. This is the case of most southern varieties, where unstressed vowels (including unstressed final vowels that trigger metaphony) reduced to [ə]. In northern Italy, apocope of final vowels caused total loss of synchronic alternations controlled by metaphony. In some varieties the evolution of the vowel system that turned final mid-vowels into high vowels created more contexts for the application of metaphony. However, more often than not, when a restructuring of the surface vowel system made metaphony opaque, the

process still applies as if the vowels had not changed. That is, the trigger is not phonetically defined anymore, but by certain morphological contexts, as discussed at length in §II.3.3.4.5.

In many dialects, then, metaphony remains the sole phonological result of a morphological alternation. In other words, metaphony applies opaquely. This fact led many scholars to consider metaphony as a morphologically related process altogether, and not a phonological process. Depending on the kind of metaphony at hand, different strategies are applied to represent this state of affairs.

In this section, two possible solutions to opaque metaphony are presented: counterbleeding rule ordering and floating prime-based representations. What ties those approaches together is the fact that both of them try to avoid reference to morphological categories, and in order to account for metaphony they are proposing an abstract phonological solution.

IV.7.1 Extrinsic rule ordering: two rules apply in a counterbleeding order

Consider the dialect of Arpino (§II.3.3.3.2), where the process applies regularly even though the context of application is not visible in the surface form. All final vowels (with the exception of the low vowel /a/) surface as ə, but some of them activate metaphony, while some do not.

The table under (110) reports some alternations in adjectives. The stressed vowel in the root surfaces as high (or diphthongized) in adjectives conjugated in the masculine singular, and plural forms. Otherwise, it surfaces as a mid-vowel. Data from this variety are derived from Calabrese (1995: 17 and references; and Parodi 1982).

(110) Diphthongizing metaphony in Arpino (southern Lazio)

	<i>Singular</i>	<i>Plural</i>	
<i>M</i>	'sulə	'sulə	'alone'
<i>F</i>	'sola	'solə	
<i>M</i>	'nirə	'nirə	'black'
<i>F</i>	'nera	'nerə	
<i>M</i>	'bwonə	'bwonə	'good'
<i>F</i>	'bɔna	'bɔnə	
<i>M</i>	'vjekkjə	'vjekkjə	'old'
<i>F</i>	'vɛkkja	'vɛkkjə	

An option to represent the process in purely phonological terms is to consider the final vowel as underlyingly high in metaphonic contexts. This corresponds to the diachronic identity of inflectional suffixes: the masculine singular suffix derives from a Latin *u, while the masculine plural from *i. The phonological shape of the singular and plural masculine suffixes is /-u/ and /-i/ respectively, and they surface as [ə] only because they are subject to another phonological process of reduction. Simply put, the diachronic process of vowel reduction is still synchronically present in the dialect of Arpino. In this view, the alternation presented in (110), [nerə]/[nirə], may be the result of two different ordered phonological rules, shown in (111).

(111) Ordered rules result in opaque metaphony in Arpino

Rule 1: Metaphony triggered by underlying unstressed final /i/: [-high]→[+high]/_C0[+high].

Rule 2: Vowel reduction of unstressed vowels, which in Autosegmental terms can be formalized as delinking of the whole Place node.

Metaphonies of this kind have often been considered an argument in support to rule ordering (Mascarò 2011). Let us consider the case of Arpino treated in (110), where all final vowels surface as [ə]. The two rules are Metaphony (rule 1) and vowel reduction (rule 2). Those two processes are extrinsically ordered: vowel reduction necessarily applies after the metaphonic process. The two rules apply in a counter-bleeding order (Goldsmith Riggle Yu 2011: 41), meaning that the second rule that applies hides the context of application of the first rule. Rule 1 causes raising of the stressed vowel (which does not reduce), Rule 2 affects unstressed vowels (including the trigger of the process, a final high vowel) reducing them to [ə], thus hiding the original context of application.

The same explanation works for cases in which the restructuring of the vocalic system yielded only [i,u,a] (cf. §II.3.3.4.2) or [e,o,a] (cf. §II.3.3.4.1) as possible final unstressed vowels. Those cases are exemplified in (112) and (113) respectively. In (112a), the ordered rules active in Mormanno (northern Calabria, Lausberg area, Savoia 2015: 255) are given. Here all final vowels raise to high, but only etymological high vowels are valid triggers for raising metaphony. In (113) is exemplified the case of Sonnino (province of Latina, southern Lazio. Savoia 2015: 249f), where final high vowels lowered to mid-high. In both dialects the underlying identity of vowels can be reconstructed from the behavior of original high vowels as triggers of metaphony.

(112) Opaque metaphony in the dialect of Mormanno

a. Ordered rules: metaphony precedes final-vowel raising

Rule1: /ε,ɔ/→[e,o]/_C0 /i,u/¹⁹⁴

Rule2: Final vowel raising: /e,o/→[i,u]/_#

b. Metaphonic alternations in nouns and adjectives in Mormanno

	<i>Singular</i>	<i>Plural</i>	
<i>M</i>	'veccu	'vecci	'old'
<i>F</i>	'vɛcca	'vɛcci	
<i>M</i>	'novu	'novi	'new'
<i>F</i>	'nɔva	'nɔvi	
<i>M</i>	'lettu	'letti	'bed'
<i>F</i>	'rɔta	'rɔti	'wheel'
<i>M</i>	'occu	'occi	'eye'
<i>F</i>	'sɛddʒa	'sɛddʒi	'chair'

¹⁹⁴ Recall that in the Lausberg Area, between the administrative regions of Basilicata and Calabria, dialects display a vowel system where mid-low vowels appear in all contexts except for the metaphonetic one. In other words, only mid-low vowels are treated as underlying, while mid-high vowels appear as the result of raising caused by metaphony.

(113) Opaque metaphony in the dialect of Sonnino

a. Ordered rules: metaphony precedes final vowel lowering

Rule1: Metaphony: /e,o/ → [i,u] / __ C0 /i,u/ ; /ε,ɔ/ → [e,o] / __ C0 /i,u/.

Rule2: Final vowel lowering: /i,u/ → [e,o] / __ #

b. Metaphonic alternations in adjectival inflections in Sonnino

Adjectives:	Singular	Plural	
<i>M</i>	'nɪro	'nɪre	'black'
<i>F</i>	'nɛro	'nɛre	
<i>M</i>	'nɔvo	'nɔve	'new'
<i>F</i>	'nɔva	'nɔve	
<i>M</i>	'vɛcco	'vɛcce	'old'
<i>F</i>	'vɛcca	'vɛcce	

The same strategy can be applied to cases in which all final vowels are lost, namely for metaphonies of alpine dialects, such as the fronting metaphony of Cevio (cf. table 72 in §II.3.3.4.4) or the case of Lugo (Romagna, treated below 114). Here the original final vowel is lost, but the metaphonic process is still running, and the triggering context appears to be the singular and plural in nominal paradigms. Instead of having a rule of vowel reduction, the dialect of Lugo thus has a rule of apocope that applies after metaphony.

(114) Opaque Metaphony in the dialect of Lugo

a. Ordered rules: metaphony precedes apocope

Rule1: Metaphony: /e,o/ → [i,u] / __ C0 /i,u/ ; /ε,ɔ/ → [e,o] / __ C0 /i,u/.

Rule 2: Apocope: V → 0 / __ #

b. Metaphonic alternations in nouns and adjectives in the dialect of Lugo

	Singular	Plural	
<i>M</i>	'spos	'spus	'groom'
<i>F</i>	'spoza	'spoz(i)	'bride'
<i>M</i>	'ner	'nir	'black'
<i>F</i>	'nera	'ner(i)	
<i>M</i>	'mo ^a rt	'murt	'dead'
<i>F</i>	'mo ^a rta	'mo ^a rt(i)	
<i>M</i>	'bɛl	'bɛ ^a l	'beautiful'
<i>F</i>	'bɛla	'bɛl(i)	

In all three examples proposed in (112), (113) and (114) the height degree of the final vowel is not immediately evident, but is reconstructed from its phonological behavior.

IV.7.2 Floating features

In the (not so) recent history of phonology, extrinsically ordered rules started to fall out of fashion with the rise of Autosegmental Phonology (Odden 2011: §2.4), and were later abandoned by many with the rise of OT. One of the general goals of Autosegmental Phonology is to reduce the phonological process to a consequence of well-formedness conditions (Odden 2011: 19). This is the same core idea that later animated the development of constraint based/OT phonology. Giving phonological computation the power to have an indefinite number of rules allows for analyses of synchronic processes that replicate the diachronic evolution of a language in the mind of a speaker (cf. Loporcaro 2011: 189). Analyses based on this assumption make extensive (sometimes excessive) use of this property.

An alternative analysis is the one discussed in Mascarò (2016), and briefly reported here. Triggers may not be regular phonological segments, but instead feature affixes. The idea is that a morpheme can be represented in phonology simply as a floating feature, features that are not assigned to a position in the string. In other words, the phonological exponence of a morpheme may not be a fully-fledged segment, but it can be just some phonologic material detached from the autosegmental skeleton. The existence of such phonological objects follows from the basic concepts underlying Autosegmental Phonology, and is the same idea that makes underspecified segments common in AP and cognate approaches (Odden 2011).

Melodic material can thus be either attached to the skeleton, and be interpreted or present in the underlying form, but not interpreted by phonetics. In this case, this melodic material is detached from the skeleton and appears as floating material. To exemplify what it means, consider the case of the metaphony of Calvello discussed in Mascarò (2016). In Calvello metaphony seems to be affected by some morphological conditioning. Final vowels are reduced, as is common in dialects of southern Italy. In nouns, metaphony applies only to plural masculine nouns (the plural suffix derives from Latin *i), and it does not apply to masculine singular nouns (the plural suffix derives from *u). In adjectives, the situation is different. The process applies in both the singular and the plural masculine, as shown in the table under (115).

(115) Opaque metaphony in the dialect of Calvello (Basilicata; Gioscio 1985)

		<i>Singular</i>	<i>Plural</i>	
<i>Class I Nouns</i>	<i>M</i>	'vɔskə	'vwoɔskə	'forest'
	<i>M</i>	'sorətʃə	'surətʃə	'mouse'
	<i>M</i>	'rettə	'rittə	'chestnut cupule'
	<i>F</i>	'pɔrtə	'pɔrtə	'door'
	<i>F</i>	'perə	'perə	'pear'
<i>Class II Nouns</i>	<i>M</i>	'rendə	'rjendə	'tooth'
	<i>M</i>	'mesə	'misə	'month'
	<i>M</i>	nə'potə	nə'putə	'nephew'
<i>Class I Adjectives</i>		<i>Singular</i>	<i>Plural</i>	
	<i>M</i>	a'pjertə	a'pjertə	'open'
	<i>F</i>	a'pertə	a'pertə	
	<i>M</i>	'swottə	'swottə	'flat'
	<i>F</i>	'sottə	'sottə	

	<i>M</i>	'cinə	'cinə	<i>'full'</i>
	<i>F</i>	'cenə	'cenə	
	<i>M</i>	'sulə	'sulə	<i>'alone'</i>
	<i>F</i>	'solə	'solə	
<i>Verbs: Present tense</i>	<i>I sing.</i>	'serrə		<i>'I reap'</i>
	<i>II sing.</i>	'sjerrə		<i>'you reap'</i>
	<i>III sing.</i>	'serrə		<i>'s/he reaps'</i>
	<i>I sing.</i>	'monnə		<i>'I peel'</i>
	<i>II sing.</i>	'munnə		<i>'you peel'</i>
	<i>III sing.</i>	'monnə		<i>'s/he peels'</i>

Here metaphony displays what seems to be different behaviors in different morphological classes. In nouns, the process is active in masculine plurals only, meaning that the suffix for masculine singular does not trigger metaphony, while the masculine plural suffix does. An analyst may be simply tempted to assume the process to be asymmetric: front high vowels trigger the process while back rounded high vowels cannot. However, metaphony applies in this fashion only in nouns. In adjectives, metaphony applies in both the masculine singular and plural, i.e., both /i/ and /u/ act as valid triggers for raising.

The process thus appears asymmetric, not on a phonological basis, but on a morphological one. This is rather unexpected, since the evolutionary paths of nominal and adjectival desinences for the singular masculine are supposed to be the same. They both derive from the Latin Accusative applied to nouns of the second declinations and adjectives of the first class, which is –UM. In verbs, the process applies in the second person singular of the present indicative.

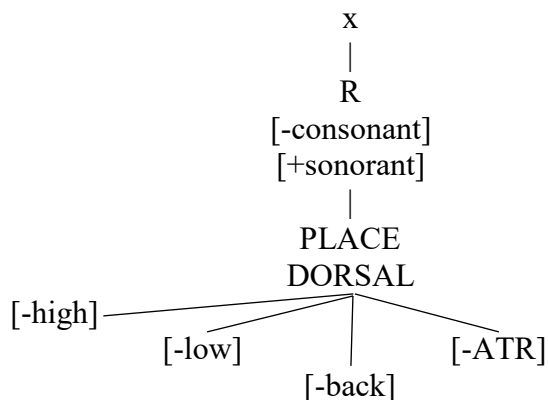
According to Mascarò (2016) the internal structure of the metaphonic suffixes (i.e., the plural masculine in nouns, the singular and plural masculine suffix in adjectives, the 2nd person singular in verbs) does not need to be a different underlying segment altogether. They may have a specific internal structure, composed of some melodic objects attached to the skeleton (which are interpreted as the segment [ə]) and some supplemental floating material, which is not associated with any node nor skeletal position. The phonological representation of morphemes in Calvello in Mascarò's (2016: 264) analysis is reported under (116). (117) reports the autosegmental representation of a metaphonic trigger: features attached to the structure correspond to /ə/, but two additional floating features, [+high] and [+ATR], are present, and are responsible for metaphonic raising in Calvello.

(116) Phonological shape of morphemes stored in the lexicon

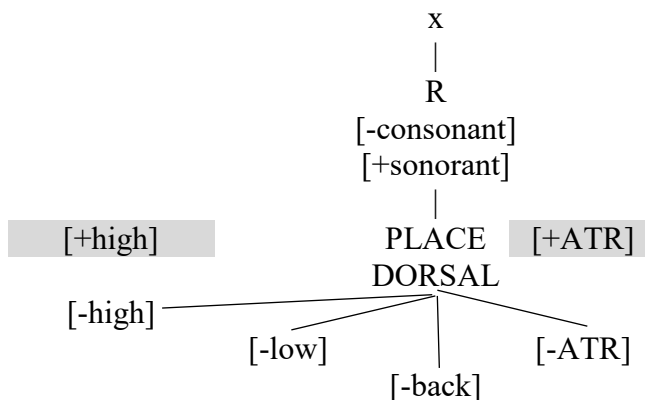
<i>Nouns</i>	<i>Morphemes</i>	<i>Underlying representation</i>
	Masc. Sing.	ə
	Masc. Plur.	ə, [+high], [+ATR]
	Femm. Sing.	ə
	Femm. Plur.	ə
<i>Adjectives</i>	<i>Morphemes</i>	<i>Underlying representation</i>
	Masc. Sing.	ə, [+high], [+ATR]
	Masc. Plur.	ə, [+high], [+ATR]
	Femm. Sing.	ə
	Femm. Plur.	ə
<i>Verbs</i>	<i>Morphemes</i>	<i>Underlying representation</i>
	I sing. pres. Ind.	ə
	II sing. Pres. Ind.	ə, [+high], [+ATR]
	III sing. Pres. Ind.	ə

(117) Underlying representations of suffixal vowels in Calvello (only the dorsal place node is shown)

a. Underlying representation /ə/



b. Underlying representation /ə/, [+high, +ATR]



In Calvello, suffixes can have different underlying representations (the one in 117a or the one in 117b), but they are still pronounced in the same way because only the items attached to the skeletal position are interpreted, while the rest is not. In (117b) the [+high] and the [+ATR] features (marked in gray in the table) are not attached to the skeletal tier, and thus are not pronounced. They are however present in the underlying representation, and thus are able to trigger metaphony.

In other varieties, suffixes can also be composed exclusively of floating features. Consider the case of Lugo metaphony, reported in (114), where apocope of all final vowels made metaphony opaque. There, instead of posing a synchronic rule of apocope, AP allows for an analysis that considers masculine and plural suffixes as only floating [+high], [+ATR], able to trigger the metaphonic process. Here no phonological feature is attached to the skeletal position, which means that the suffix is not pronounced, but it contains melodic material that is detached from the skeleton.

Consider that this idea can be easily translated into an approach that accepts incremental height features instead of the classical [\pm high] and [\pm ATR], and it works also in unary approaches, assuming we can identify a triggering prime for metaphony. In the examples I maintained the representational objects used in the source material, but I believe the fact that this concept can have a wide application to be noteworthy, as it is not restricted to one specific representational model. The only necessary assumption for this explanation to work is the idea of phonological segments as structured objects, an idea popularized by AP and nowadays common to most phonologist. More importantly, this strategy maintains the modular properties of generative phonology (cf. §V.2). The phonological representation of underlying forms of morphemes based on floating features allows for a purely phonological analysis of what seems a morphological interference. This implies assuming a more abstract structure (sometimes radically different) for final unstressed vowels that the one that is observable at the surface level.

IV.7.3 Morphophonology-based explanations of metaphony

Both the proposals advanced in §7.1 and §7.2 have been criticized for their abstractness. Extrinsic rule ordering runs the risk of building a copycat of the diachronic changes in synchrony (Loporcaro 2011: 190) and later innovation in phonological theory moved away from ordered rules in favor of parallel constraints (OT). The approach of applying floating features is maybe less problematic from a theoretical standpoint, but not all occurrences of opaque metaphony can be represented this way. In the following paragraph are reported some cases of metaphony that I argue cannot be explained with an analysis based on floating features.

Consider metaphony in the dialect of Cervara, discussed earlier in §II.3.3.4.5 and §II.3.4.2. Here is active the process Maiden (1991) defined as hypermetaphony, which is a case of complete raising of mid-low vowels. What is special about Cervara is the fact that hypermetaphony is limited to verbs, while in nouns and adjectives metaphony applies as a common scalar raising harmony. Under (118) alternations from Cervara are reported where stressed underlying mid-low vowels in nouns and adjectives surface as mid-high when followed by a final high vowel in the inflectional ending. Notice that final unstressed [-o] that marks the masculine singular in both nouns and adjectives is treated as a valid metaphonic trigger (i.e., is treated as an underlying /u/).

(118) Morphologically conditioned hypermetaphony in Cervara

		<i>Singular</i>	<i>Plural</i>	
	<i>Class I Adjectives</i>	<i>M</i>	'b:eλλo	'b:eλλi
<i>F</i>		'b:ella	'b:elle	
<i>M</i>		'b:ono	'b:oni	'good'
<i>F</i>		'b:ona	'b:one	
<i>Verbs: Present tense</i>	<i>I sing.</i>	'korro		'I run'
	<i>II sing.</i>	'kurri		'you run'
	<i>III sing.</i>	'korre		'he runs'
	<i>III plur.</i>	'kurru		'they run'
	<i>I sing.</i>	'vedo		'I see'
	<i>II sing.</i>	'vidi		'you see'
	<i>III sing.</i>	'vede		'he sees'
	<i>III plur.</i>	'vidu		'they see'

<i>I sing.</i>	'kɔλλo	' <i>I pick</i> '
<i>II sing.</i>	'kuλλi	' <i>you pick</i> '
<i>III sing.</i>	'kɔλλe	' <i>he picks</i> '
<i>III plur.</i>	'kuλλu	' <i>they pick</i> '
<i>I sing.</i>	'meto	' <i>I reap</i> '
<i>II sing.</i>	'miti	' <i>you reap</i> '
<i>III sing.</i>	'mete	' <i>he reaps</i> '
<i>III plur.</i>	'mitu	' <i>they reap</i> '

The issue in this case concerns the difference in the process of raising that affects mid-low vowels. From a phonological standpoint, triggering contexts for mid-low raising are identical in verbal and nominal paradigms. Final /i/ and /u/ share the same height specification (regardless of the model of representation chosen), since they behave as valid triggers for raising in both morphological contexts.

The analyses proposed in the previous section, based on floating features, hinge on the idea that final vowels, even if they were externalized as non-high vowels, are endowed with the harmonic primes, which could thus propagate to the targets. In Cervara, however, final vowels are all already high. They all have the triggering primes, which if we assume a standard feature geometry are [+high] and [+ATR]. Notice, however, that the issue persists regardless of the model of phonological representation that we assume. Even if we choose to adopt an element-based representation or an incremental model of representation, alternation in Cervara ensures that both the nominal and the verbal suffixes share the same phonological form, that of high vowels, since metaphony is active in both contexts.

For an analysis based on floating primes, we should define which primes are added. The active primes in hypermetaphony, however, are the same that are active for metaphony, those that concern height: [+high] and [+ATR]. If we discard the representational model of feature geometry and propose a model based on incremental primes the situation does not change very much

To account for alternations in Cervara, I argue that we have to consider the issue on the side of phonological processing, not on the side of representation. There is no melodic material that could be added to the suffixal vowels that could account for the difference in application between verbs and nouns/adjectives. Since they are both valid triggers for metaphony, they are high vowels, i.e., they both contain a [+high] feature. What happens in Cervara is that two different processes apply in two different morphological contexts, which the theory of representation based on innate primes cannot but treat as identical from a phonological standpoint. The rules presented in (119) must be active in the dialect of Cervara.

(119) Metaphonic rules in Cervara

a. Metaphonic rules I

$[-\text{high}, +\text{ATR}] \rightarrow [+high]/_C0 [+high], [\text{Noun}, \text{masculine}]$

$[-\text{high}, -\text{ATR}] \rightarrow [+ATR]/_C0 [\text{Noun}, \text{masculine}]$

b. Metaphonic rule II

$[-\text{high}] \rightarrow [+high]/_C0 [+high], [\text{Verb}, \text{II sing}, \text{II plur.}]$

(119a) accounts for scalar raising in nouns and adjectives, while (119b) for complete raising in verbs.

Another case that I argue cannot be completely formalized assuming floating primes is the aforementioned case of Mormanno, discussed in the previous section. Opposite to hypermetaphony in Cervara, where the process displays a different degree of activation in verbal and nominal paradigms, here only nouns and adjectives display metaphonic alternation, while final high vowels in verbs (whether etymologically high or not) never trigger metaphony. In (120) below, stressed mid vowels surface as raised when etymological /u/ and /i/s are in final unstressed position.

(120) Morphologically conditioned metaphony in the dialect of Mormanno

<i>Class I Adjectives</i>		<i>Singular</i>	<i>Plural</i>			
	<i>M</i>	'veccu	'vecci	<i>old</i>	VETULUS	
	<i>F</i>	'vecca	'vecci			
	<i>M</i>	'novu	'novi	<i>new</i>	NOVUS	
<i>F</i>	'nova	'novi				
<i>Class I Nouns</i>		<i>Singular</i>	<i>Plural</i>			
	<i>M</i>	'lettu	'letti	<i>bed</i>	LECTUM	
	<i>F</i>	'rōta	'rōti	<i>wheel</i>	ROTAM	
	<i>M</i>	'occu	'occi	<i>eye</i>	OCULUS	
	<i>F</i>	'sēddʒa	'sēddʒi	<i>chair</i>	*SEDIULA	
<i>Verbs: Present tense</i>		<i>I sing.</i>	<i>II sing.</i>	<i>III sing.</i>	<i>III plur.</i>	
		'kreðu	'kreðisi	'kreði	kre'dinu	<i>Believe</i>
		'veŋgu	'venisi	'veni	ve'ninu	<i>Come</i>
		'dōrmu	'dōrmisi	'dōrmi	dōr'minu	<i>Sleep</i>

An account based on floating primes may assign the triggering primes only to nominal and adjectival masculine suffixes, while all other final vowels lack the triggering primes.

A problem with this analysis, however, lies in the fact that all non-low final vowels surface as high in Mormanno, suggesting that in all vowels the primes that are responsible for raising are linked to the skeletal position and thus phonetically interpreted. In the examples under (115) and (116) only the suffixes that triggered metaphony contained the primes of high vowels. Here all vowels (except for /a/) surface as high, so they should share with valid metaphonic triggers the primes that trigger metaphony (in AP [+high, +ATR], in the incremental model of Parkinson [closed]max, etc...). The theories of phonological representation presented so far lack a way to distinguish between high vowels that trigger metaphony and those that do not. In addition, both vowels share the same phonetic interpretation.

This case is more easily formalized using ordered rules as we did in §7.1. First underlying high vowels trigger metaphony, later mid-vowels raise to high, rendering metaphony opaque.

Under this assumption, then, high vowels are in final position in the underlying representation of adjectives and nouns, while final vowels in verbs are mid-vowels. This derives from the fact that metaphony never applies in verbs in Mormanno, even in contexts where */i/ is etymological. If final [i]s in verbs were underlyingly high, they would count as valid triggers for metaphony. The phonological behavior of high vowels in verbs coincides with that of underlying mid-vowels that raise according to the second rule under (119). Therefore, we should assume that etymological high vowels in verbal suffixes underwent a process of lowering, which made them underlyingly mid. Then, the general process of raising of final mid-vowels raises them so they surface as high.

The issue with this analysis is that it requires the positing of a diachronic evolution of final high vowels that affected high vowels only in verbs, and not in nouns or adjectives. At a certain point in history a rule such as the one under (121) should have been active in Mormanno: this rule lowers to mid-vowels in final position in verbs.

(121) Scrambling morphological and phonological items in rule formulation

a. Final vowel lowering in verbal suffixes

[+high] → [-high] / _# [in verbs]

If rules such as this one are possible, another possible analysis is to assume an active rule of metaphony that is limited in nouns and adjectives, such as the one under (122)

(122) Scrambling morphological and phonological items in rule formulation

b. Metaphonic rule in Mormanno

[+high] [-ATR] → [-high] [+ATR] / __C0V, [noun, masculine]

Rules of the kind proposed under (121) and (122) are Morphological Rules or morphophonological rules (Dressler 1985). Rules of this kind correspond to morphologically conditioned phonological processes, or processes that apply only within specific lexemes. On a formal standpoint, they are rules where the context of application is not defined on phonological terms (there are no phonological items, or not only phonological items after the “/”) but on morpho-syntactic terms. In sum, representations that belong to morpho-syntax and phonology coexist in morpho-phonological rules.

Generally, rule formulations that mix phonological and morpho-syntactic representation are avoided. Bermúdez-Otero (2012: 77), following Baudouin de Courtenay (1895[1972]) and Martinet (1965), proposes that a phonological constraint¹⁹⁵ may not refer to syntactic, morphological, or lexical information. In addition, the general theory about the architecture of the faculty of language considers phonology and morpho-syntax as different cognitive realms that operate over different (and not permutable) representations¹⁹⁶.

An alternative analysis for those kinds of alternations that do not use morphophonological rules is to assume that metaphony is not a phonological process at all, but instead the result of root-suppletion. Suppletion is a phenomenon by which different items in a single paradigm are expressed by a totally or partially different morpheme which has little or no phonological connection with the base form. For example, the two forms “go” and “went” are not considered as derived from the same lexical base, but they are assumed to be two lexical morphemes for the same verb selected in different contexts. Similarly in Italian the alternation [vado] ‘I go’ [andate] ‘you go pl’ is explained as the selection of a different lexical root /vad-/ /and-/. Even though the two forms belong to the same verbal paradigm, they are not derived from one another, i.e., there is no phonological process in Italian that turns one of the two forms

¹⁹⁵ The same argument is valid for phonological rules, it just happens that Bermúdez-Otero (2012) utilizes a theory of phonological computation based on constraints.

¹⁹⁶ This issue is expanded in the following chapter, §V.2.

into the other. Instead, the lexical root of the verb ‘to go’ has two phonological forms which are chosen in different contexts.

Assuming that metaphony is a case of root-suppletion implies that for each alternating root there are two allomorphs: one that is selected in non-metaphonic contexts and one selected in metaphonic contexts. This reduces metaphony from a phonological process to a lexical issue. There is no process going on in the grammar: speakers select one root in specific morphological contexts and the other one in the remaining contexts. This means that in the lexicon two different underlying forms are stored for each lexical item that could undergo metaphony, and depending on the context one of the two forms is selected. Metaphony, then, is not a phonological process, but just an epiphenomenon caused by the selection of a different root. The metaphony of Mormanno would thus be explained with the presence in the lexicon of two forms for each noun and adjective that contains a mid-vowel. The form with the high vowel is selected when a masculine suffix follows, otherwise the form with the mid vowel is selected. To my knowledge, this position is not held by any scholar dealing with metaphony, but is a possible explanation for the alternation observed.

Calabrese (2016) presents the case of metaphony in the dialect of Altamura (Apulia, cf. Loporcaro 1988) which exhibits a pattern similar to the one of Cervara. Here metaphony always applies as complete raising, but alternations appear to be guided more by the morphological nature of the trigger than by its role of high vowel. He shows that an abstract analysis based on floating primes is problematic, and argues also against the analysis of metaphony as a case of root suppletion. He instead supports a morphophonological analysis, where phonological and morphological representations coexist within a single rule (Calabrese 2016: 122). Maiden (1991: 216) also subscribes to a morphophonological analysis of metaphony: metaphony, in his terms, is the result of the interplay between phonological and morphological conditioning. Loporcaro (2011) argues that some metaphonies present a problematic challenge for abstract theories, and thus discards options based on floating primes and analyses based on extrinsic rule ordering. In his article, the position of Natural Phonology (Donegan & Stampe 1979) is sustained, which excludes “unmotivated” (i.e. unnatural) and morphologically motivated alternations from the set of possible phonological rules. This would exclude metaphonies such as the one of Cervara and Morcone from phonology, but it is unclear what option is proposed instead. Loporcaro (2011) simply observes the problematic aspects of some metaphonic alternations, and argues against abstract analysis. A similar position is held by Pöchtrager & Kaye (2014), who argue that metaphonies are not valid phonological processes. The authors adhere to the non-arbitrariness condition (Kaye et al. 1990: 195; Pöchtrager 2006: 20) according to which there must be a causal relation between a phonological process and its context of application. In their proposal, metaphony as a process is not phonological in kind, but they do not propose an alternative.

IV.8 Conclusions: raising harmonies require a new theory of phonological representation

In this chapter the three main issues of RVH were considered, and possible solutions were tested. The different effects of raising, complete and scalar, revealed that a different theory of phonological representation, one that allows for the existence of incremental primes, is better suited for dealing with scalar raising. It remains to be explained why only vowel height should receive this special treatment, and what consequences the adherence to an incremental model causes for a theory of phonological computation.

Asymmetries and their formalization were the central topic of most of the chapter. Various proposals were presented and tested. It appears that parasitic harmonies are difficult to formalize, and that a theory

based solely on contrastive underspecification cannot explain the double behavior of vowels in partial parasitic processes. Approaches based around licensing (Licensing Constraints, RcvP) and the linear proposal of Nevins (2010), while formally able to represent parasitic patterns, required specific addenda to their theory of computation, and were not able to combine effortlessly with an incremental theory of representation, nor to represent scalar raising harmonies in a straightforward way.

Lastly, the issue of morphologically conditioned processes was tackled in §7. Many raising harmonies in Bantu languages apply in specific morphological contexts, and the same happened in Romance, especially Italian metaphonies. The specific requirements of two patterns described led some to assume that metaphony is not a proper phonological process.

I argue that a comprehensive theory of RVH, one that can account for both scalar harmonies as well as asymmetric patterns, requires a revolution in the way phonological representation is envisioned.

Besides the issue of scalar/complete raising (which already suggests that some modification of the representation of vowel height is required), it was noticed at multiple times during the chapter that many issues were directly linked with the set of primes employed, more than with the theoretical framework analyzed.

In the following chapters I will present a possible solution to the problematic aspects of raising harmonies, which I believe can be solved assuming a different theory of phonological representation, one that is not based on innate fixed features, but on learned emergent primes.

Chapter V. Radical Substance Free Phonology: Primes are learned and have an arbitrary phonetic correlate

V.1 Setting the stage. Natural and unnatural phonologies

In the previous chapter, various theoretical frameworks were introduced with the goal of finding one that could formalize the problematic patterns of RVH that were identified at the end of §II.3.6: different kinds of raising (scalar and complete), asymmetries, and also morphological conditionings. The established diagnostic was that theories based on incremental primes capture the behavior of scalar-raising harmonies but cannot formalize the behavior of asymmetric harmonies, whereas theories constructed to explain asymmetries in harmonic patterns frequently struggle to represent the property of vowel height in a way that accounts for scalar-raising.

The analyses discussed in chapter IV are extremely different from one another, both in terms of representational accounts and in terms of how phonological processing is formalized. One property is shared by all of them, however: they all assume a fixed relation between phonological primes and phonetic properties. The theories considered may have employed unary or binary primes that were articulatory or acoustic in kind, but all of them assumed that phonological primes had a fixed correlation with phonetics; the relationship between phonological primes and their phonetic correlate is assumed to be universal and innate. The alternative option, which is discussed later in this chapter, is that the correlation between phonological primes and phonetics is absent at the initial state and is learned during acquisition. Primes of this kind are learned themselves, alongside their correlation with phonetics (Emergent Primes, Mielke 2008, Dresher 2014).

The assumption that primes and their correlation with phonetics are fixed, which, as we shall see, has deep roots in the history of phonology as a discipline, implies that raising must be formalized in a certain way. Raising is formalized as a change in the value of the features [-high] and/or [-ATR] in binary theories, while A-demotion is used in unary theories. One notable exception is van der Hulst (2018), who introduces an extra element to the set of primes that should capture raising harmonies as licensing of a high element. Given an alternation, once the underlying and the surface forms are identified, the job of the various proposals explored in chapter IV was to figure out a way to turn a specific representation (that of mid or low vowels) into another representation, that of a high vowel (or a mid-high vowel, in scalar raising processes). In this sense, primes inform computation: the process of raising is defined computationally as the one that turns a mid-vowel into a high one.

In this chapter is presented an alternative view, a theory of phonology that requires phonological primes to be abstract categories without necessarily a universal and innate correlation with phonetics. Both primes and their correlation with phonetic properties are learned during acquisition. This means that learners build their own system of phonological representations, which may not be cross-linguistically consistent. As a consequence, the processes of raising may also not be formalized in the same way cross-linguistically (as we shall see in chapter VI).

It is argued that some of the observations made during the previous chapters as well as other (both theoretical and empirical) facts suggest that primes are emergent: they do not have any phonetic correlate at the initial state of acquisition but rather acquire one in the acquisition process based on environmental information. This issue ties in with substance-free phonology, where primes have no phonetic identity in the phonology but are only related to phonetic correlates upon transduction, i.e., the mapping to phonetics.

The present chapter thus discusses the opportunity of running phonology based on emergent and substance-free primes. This paves the way for an analysis of RVH that can account for both scalar and asymmetric patterns, as we shall discuss in chapter VI.

In §1.1, the regular approach to phonological representation is discussed: phonological primes are infused with phonetic properties at birth, and phonological processing has to work with fixed classes of segments individuated by universal primes. §1.2 challenges the notion that phonetics defines phonology based on so-called crazy rules, i.e., those that make no phonetic sense. It is then argued in §1.3 that some of the processes encountered in the survey in §II.3 are actually crazy processes in their own right, and that asymmetries and some crazy rules are problematic for phonological theories in a similar way: they both require us to rethink the concept of Natural Class.

Substance Free Phonology (henceforth SFP), a phonological framework that bans phonetics from phonology, currently develops in two directions: one holding that the set of primes and their phonetic correlates are innate (§3) and one that assumes emergent primes (§4). The core difference between the two approaches to SFP lies in the properties of the Phonetics-to-Phonology Interface (PPI), which are explored in §4.3 and §4.4.

V.1.1 Phonology is Natural

Phonetics and phonetic-oriented observations have had an important role in phonology since the very beginnings of the study of phonological patterns. The fact that there is a natural relation between underlying segments and their phonetic surface form is often assumed as a basic tenet of phonological theory. Moreover, it is widely assumed that most of what concerns phonology and phonological phenomena can be explained through articulatory or perceptual factors (Hamann 2011: 206, Blevins 2004, Ohala 1993).

It is doubtless that the two realms of phonetics and phonology are in strict correlation since they both deal with speech sounds, albeit in different contexts. Phonetics deals with the physical and gradient nature of sounds, while phonology investigates sound patterns, and meaningful alternations between sounds. It is not by chance that most phonological labels make direct reference to phonetic properties. Both phonological primes (features and elements) and processes (nasalization, raising, lowering, fronting, *etc...*) are referenced through phonetic terminology.

This state of affairs may end up mixing the domains of inquiry of phonetics and phonology¹⁹⁷. In fact, sometimes, this common vocabulary ends up scrambling the two domains. Consider the process of vowel harmony: as discussed in §I.2.1, VH belongs to the broader family of processes known as assimilations, whereby a segment assumes a prime from a neighboring segment. The correspondent phonetic process is coarticulation, which in Hammarberg (1976: 357), is defined as “a process whereby the properties of

¹⁹⁷ Indeed, some argue that phonetics and phonology are not two distinct subjects, but one unique domain of inquiry, cf. Flemming (2001)

a segment are altered due to the influences exerted on it by neighboring segments.” The definitions of assimilation and coarticulation are extremely close, to the point that some authors use them as if they were the same thing (Ohala 1993).

However, the central role of phonetics in phonology goes far beyond the use of terminology. The influence of phonetics on phonology affects both the representational and the computational sides of many phonological theories. Phonetic information is at the core of most phonological theories of representation in that phonological primes (features, elements, particles and the like) are based on phonetic properties. In virtually all phonological theories, features are defined as having direct correlates in articulation, acoustics or audition (see Botma et al. 2011, Jakobson, Fant & Halle 1952) In (SPE 1968: 400), Chomsky and Halle advocate for some sort of intrinsic phonetic content within phonological features. This view strongly influenced subsequent theories of phonological representation to the point that the fact that phonological categories are infused with phonetic properties became more or less the default assumption. In SPE-style feature matrices and in geometric and autosegmental approaches (Clements 1985, Clements & Hume 1995), phonological categories derive from articulation, while in most unary approaches (e.g. Backley 2011, Harris & Lindsay 1996, Schane 1984, van der Hulst 2018) they derive from acoustics. Some theories may mix the articulatory and acoustic nature of phonological primes, but it is generally assumed that phonological primes are endowed with intrinsic phonetic properties, either acoustic or articulatory.

Phonetic factors may also affect phonological processing and rule formalization. Since the inception of phonology, most scholars have shared the idea that phonological alternations derive directly from phonetic phenomena, and that physical or physiological properties can be integrated into a grammar system through grammaticalization (more specifically, in our case, through phonologization). This marks the first step in the life cycle of a phonological process (cf. §2.4). This idea has been around since the dawn of phonology as a discipline (cf. Passy 1891, Baudouin de Courtenay 1895[1972]) and is still considered a shared knowledge among phonologists. For more on the issue, cf. Bach & Harms (1972); Hyman (1975); Kenstowicz & Kisseberth (1977); Blevins (2004); Bermúdez-Otero (2007, 2015); Bermúdez-Otero & Trousdale (2012); Scheer (2015).

If taken one step further, the idea that phonological processes evolved from phonetic phenomena may lead us to assume that phonological processes are subject to the same real-world laws that affect phonetics. This means that physiological/physical constraints have a direct effect on phonological processing, allowing some and disallowing other processes. In other words, a phonological process that does not look plausible from a phonetic standpoint is not natural (i.e. it does not make phonetic sense). This is the opinion of various approaches to phonology, such as Natural Phonology (Donegan & Stampe 1979) or Phonetically Grounded Phonology (Archangeli & Pulleyblank 1994, Hayes et al. 2004). Analyses where physiological/physical constraints have a role in phonological computation has also been proposed within OT (McCarthy 2002; deLacy 2006). A brief excursus on those approaches is proposed below.

Anderson (1985 [2021]: §15.4ff), while reviewing developments in phonology after the publication of SPE, discusses how some approaches tried to solve the “overly formal” nature of phonological analyses provided in SPE by inserting phonetic-based considerations within the theory of phonology.

One theoretical approach in which the role of naturalness is central is Natural Phonology. The program of Natural Phonology, mainly developed in Stampe (1973) and Donegan & Stampe (1979), is based on the hypothesis that “sound patterns of languages in their development in each individual, as well as in their evolution over the centuries, are governed by forces implicit in human vocalization and perception”

(Donegan & Stampe 1979: 126). That is, phonological processes are directly caused and affected by phonetics (i.e. articulatory ease, acoustic and perceptual factors etc...). Naturalness becomes part of the competence of speakers, in that they are born with an innate knowledge of what is natural (Stampe 1973:2). For example, the phonological process of final devoicing derives from the knowledge available to speakers that voiced stops in word-final position pose specific articulatory problems, and so should be replaced by voiceless counterparts, which do not pose the same problems. Therefore, processes are explained by phonetic factors and are accounted for phonologically by assuming that naturalness is part of the competence of speakers.

Grounded Phonology is another approach that puts naturalness at the core of its theory. The goal set by Archangeli and Pulleyblank (1994: 3) is “to provide an explicit characterization of the full range of attested representations and rules, but at the same time should be incapable of characterizing many of the imaginable patterns that are not attested in natural language.” Grounded Phonology is an offshoot of Autosegmental Phonology and Feature Geometry. Segments are composed of features in a hierarchical system of association, defined as paths. Those associations must be phonetically motivated. Association between features is regulated by a set of formal conditions that impose naturalness: the Grounding Conditions, which are derived from the “interaction of the phonetics with phonology” (Archangeli & Pulleyblank 1994: 9). Grounding conditions ensure the generation of well-formed structures on the surface. For example, a path that violates the Grounding Hypothesis (e.g. [+nasal],[–voice]) is deemed ill-formed in the grammar by a grounding condition. Simply put, grounding conditions determine what kinds of segments occur in natural languages. Grounding conditions also affect phonological processing: Since all paths must be phonetically grounded, when a path is the target or source of a rule, the rule will in turn be phonetically grounded. For example, assuming that rules can insert or delete features or entire paths, they cannot insert [–voice] to a path with [+nasal], because this would contravene the aforementioned grounding condition, resulting in an ill-formed association.

References to naturalness are also common within the theoretical framework of OT (McCarthy & Prince 1994; Prince & Smolensky 1993). OT is a theory of phonological computation that employs constraints instead of rules (see Odden 2011 and Uffmann 2010 for discussion of constraints and how they differ from rules). In a constraint-based theory of phonology, computation is motivated by a series of constraints that impose well-formedness conditions on phonological objects: ill-formed structures are banned from reaching the surface form. Phonology is structured around a generative component (GEN), which produces a set of underlying candidates (i.e. phonological representations) and an evaluation component (EVAL), which comprises a set of innate and universal constraints. Among those generated by GEN, EVAL selects the optimal candidate, which corresponds to the surface form.

There are two kinds of constraints, faithfulness constraints and markedness constraints. Faithfulness constraints operate to maintain underlying forms, penalizing divergent outcomes. Markedness constraints modify underlying forms, penalizing “marked” structures. The interplay between faithfulness and markedness constraints, as well as their ranking, explains variation. Constraints are assumed to be innate and universal (i.e. part of phonological competence), but their ranking is language specific. For example, the interplay between a faithfulness constraint and a markedness constraint against final voiced consonants gives rise to the variation among languages with or without final devoicing as an active phonological process. In German and Catalan the markedness constraint against final voiced consonant is ranked higher than the faithfulness constraint (those languages exhibit final devoicing), in English and Spanish, where the faithfulness constraint is ranked higher than the markedness constraint, final vowels do not devoice.

Constraints within EVAL are often phonetically grounded. The correlation between phonetics and markedness constraints is particularly evident in the program of Phonetically Based Phonology (Hayes, Kirchner & Steriade 2004). In this framework, markedness constraints are the grammaticalizations of articulatory and perceptual constraints on production and perception. The constraints that form the core of phonological computation have a phonetic origin. Languages are as they are because they are shaped by articulation and perception, reflected within grammar as phonetically grounded markedness constraints¹⁹⁸.

All three accounts briefly presented here share the same core strategy to ensure that the operations carried out during phonological computation reflect naturalness. In Blaho's (2008) words, "These models blur the distinction between phonetics and phonology, in that they claim that phonological processes are (directly or indirectly) the result of articulatory and perceptual factors. They posit that *articulatory and acoustic knowledge is encoded in phonology* in the form of teleological constraints requiring the optimization of phonological representations according to the requirements of speech perception or production." (Blaho 2008: 1, italic added).

The fact that a phonological process is formally natural ends up being a useful strategy to tell apart possible and impossible phonological rules. In other words, the fact that phonology is assumed to be natural became a useful touchstone for the adequacy of phonological theories (Chabot 2021:51). Within such a view, a theory that generates natural phonological rules is better than a theory that generates unnatural, implausible rules. It is also a way to tell apart phonological and non-phonological processes. If an alternation does not conform to naturalness it is not phonological, and thus has to be treated in some other way: as a morpho-phonological process, as a case of allomorphy *etc...* (cf. §IV.7.3). Chabot (2021:81) offers a summary of the way unnatural processes are treated in theories where naturalness is encoded in the grammar.

Phonetics may bear influence over phonology also in that phonologically active classes share a phonetic property: phonological categories, formalized as primes, individuate groups of segments that participate (either as triggers or as targets) in the same phonological processes, the Natural Classes. If, as we have discussed, phonological categories derive from phonetics, it follows that the segments that participate in a phonological process should share a phonetic property. Therefore, a phonological process may be considered unnatural not only because it does not correlate with a phonetic phenomenon, but also if it affects (or it is triggered) by a class of segments that does not coincide with a Natural Class.

Lastly, the influence of phonetic phenomena in phonology connects to the typological consideration that certain phonological patterns are frequent in languages of different families, while others are rarer, or totally absent from the record. In general, typological frequency correlates strictly with articulatory biases: processes that are probable on an articulatory standpoint are generally more frequent, and processes that are not articulatory plausible are less frequent (Ohala 1972, Blevins 2004, Maddieson 2009).

The correlation between natural processes and typological frequency has an explicit role in theories that utilize the notion of markedness (such as OT, McCarthy & Prince 1994; Prince & Smolensky 1993, or Calabrese 2005). The notion of markedness was first used in the Prague School¹⁹⁹ and was later

¹⁹⁸ Notice that the phonetic grounding of markedness constraints is not a necessary property of OT. Bermudez-Otero, Bojars, Boersma, Hyman (2001) Iosad (2017) apply forms of OT that allow for more formal and not phonetically-grounded markedness constraints.

¹⁹⁹ For Trubetzkoy, markedness is language particular, unlike in SPE and in later approaches.

employed in Chomsky & Halle (1968:400ff.) to ensure a strict relation between phonological formality and the realm of phonetics. In SPE terms, markedness was an intrinsic value assigned to both segmental representations and rules, which measured relative complexity. The more complex a segment (or a rule) is, the more marked, and thus less probable, it is. Theories that employ some formalized version of markedness claim that processes are well behaved (and typologically frequent) if they follow from articulatory or acoustic phenomena, they are suspicious if they do not.

In sum, phonology is often assumed to depend on phonetics on the basis of the following observations:

- Phonological representation is based on phonetics. Phonological categories depend on natural (phonetic) properties; phonological primes have intrinsic phonetic properties.
- Phonological processes operate over natural classes, which are in turn identified by phonetic categories.
- Phonological processes are subject to articulatory or acoustic constraints, so that phonological processes are required to be phonetically plausible (i.e. natural).
- The typology of phonological processes reflects articulatory biases: a phonological process that is articulatory improbable is suspicious.

Some of those assumptions can be found even in approaches that aim at highlighting sharply the distance between phonetics and phonology. Consider the case of Government Phonology, which, as we shall see in §4.3, actually anticipates some insights of the opposite view, and directly advocates for “the absence of any level of phonological structure that could be called phonetic.” (Kaye 2005: 283).

One of the main objectives of GP is to formalize a theory of phonological processing that is non-arbitrary, in that phonological computation follows from principled reasons, and (crucially) not from phonetics. However, Kaye et al. (1990: 195) and Pöchtrager (2006: 20) advocate for the non-arbitrariness condition, according to which processes, which in GP apply whenever the triggering conditions are met, must be “plausible”. Simply put, there must be a causal relation between a phonological process and its context of application. This idea of plausibility is directly linked to phonetic naturalness: a process whereby, say, nasalization is triggered by a non-nasal consonant would not be considered a phonological process (Chabot 2021: 79). Similarly, processes that are not regular in their application, (or that may exhibit morphological conditionings cf. §IV.7) cannot be considered phonological. In sum, even within a theory such as GP, which aims at getting rid of phonetics from the phonology, some may subscribe to the idea that phonology must be natural in some way, and select what a possible phonological process is on the basis of its adherence to naturalness.

To sum up, phonologists often resort to phonetic-based observation to inform their phonological analysis. Phonological processes are supposed to comply with some requirements, which generally involve the concept of naturalness. Some lines of research have gone so far towards this idea as to suggest that phonology can (and perhaps should) be reduced to functional explanations in articulatory or perceptual phonetics, as argued by Hayes & Steriade (2004: 7).

V.1.2 Phonology is not natural. Phonological processes can be sane or they can be crazy

V.1.2.1. Introduction

The idea that phonology should be reduced to functional explanations based on articulation or perception has been debated for quite a while. Anderson (1981), arguing against Natural Phonology, shows that while many phonological processes may be “tantalizingly close to some sort of phonetic explanation; but on the other, we find that when we try to pin them down in such terms, they have

evidently been transformed into something which is no longer merely functional phonetics” (Anderson 1981: 509).

Many phonological processes may have a functional explanation, but there are some that appear as unnatural. Chabot (2021: 139) calls this the ‘Anderson’s Paradox’: most processes on the empirical record can be characterized by alternations with parallel functional descriptions, but many cannot. Chabot (2021) presents a long survey of processes that are inconsistent with the assumption entertained in the previous paragraph, i.e. that phonetics has a strong influence on phonological computation. Processes of this kind are known in the literature as Crazy Rules (Bach & Harms 1972, Chabot 2021). A rule is considered crazy when it does not make sense phonetically, when it involves classes of segments that are deemed unnatural, or when the process described by the rule does not relate to any phonetic phenomenon.

The unnaturalness, or the craziness, of those processes can manifest itself in different manners (Chabot 2021: 296 ff.): through a crazy class of inputs, through a crazy class of triggers, through a crazy structural change (input - output) and through a crazy relationship between the change effected and structural description. In the following subsections, the various kinds of crazy rules are exemplified using data discussed in Chabot (2021) and in Mielke (2008), who each provide a large corpus of phonetically unnatural processes.

V.1.2.2. Crazy rule of the 1st type: a process affects an unnatural class of segments

An example of craziness in the selection of targets comes from Lakota (Teton Dakota) Chabot (2021: 87). Here, the unrelated segments /p/ and /l/ both result in a nasal consonant [m] and [n] when followed by a nasal vowel. In the alternation presented in (1) /p/ and /k/ voice to [b] and [g] respectively when preceding /l/ in consonant clusters. A process of apophony turns /a/ into the nasal vowel /ĩ/, which turns preceding /l/ into [n], and /p/²⁰⁰ (which voices to [b] in the example below) into [m]. Only /l/ and [b] derived from /p/ are subject to nasalization, while other consonants and approximants are not, as shown in the second section of the table.

(1) Nasalization in Lakota (Chabot 2021: 87; Shawn 1980: 99)

ya	‘he goes’	yĩ-kta	‘he will go’
la	‘you go’	nĩ-kta	‘you will go’
/pla/ → [bla]	‘I go’	mnĩ-kta	‘I will go’
/kla/ → [gla]	‘he goes home’	gnĩ-kta	‘he will go home’
p ^h ĩ-kta		‘tip’	
kĩsko		‘as large as that’	
ptĩha		‘last fall’	

The process is a case of nasalization caused by nasal vowels, which is not phonetically crazy by itself. What is crazy in this rule is the selection of the targets. /p/ and /l/ are not identified by a common feature that selects them and excludes all other consonants. I refer to Chabot (2021: 87) for a more in-depth discussion of this process.

²⁰⁰ p-nasalization applies iff /p/ precedes /l/. When /p/ precedes nasal vowels without an /l/ intervening nasalization does not apply. Still, it is noteworthy that no other stop nasalizes when followed by /ĩ/, while /p/, albeit in a narrow context, does: only /l/ and /p/ undergo nasalization and are therefore an active class of segments affected by a phonological process.

V.1.2.3. Crazy rule of the 2nd type: a process is triggered by an unnatural class of segments

The ruki-rule of Sanskrit is a famous example of a crazy rule of the second type. This rule describes a synchronic phonological process in Sanskrit (Zwicky 1970), by which /s/ is realized as [ʂ] when preceding /r u k i/. The synchronic status of the rule in Sanskrit is supported by data shown in (2), derived from Zwicky (1970). The realization of the locative plural suffix changes depending on the segments that precedes it. In (2a) it is shown how it alternates between [su], after roots ending with non-ruki segments, and [ʂu] after /r u k i/. (2b) reports verbal roots where the [ʂ] surfaces after /ruki/, while [s] does in other contexts.

(2) The ruki rule in Sanskrit (adapted from Zwicky 1970: 549)

a. Synchronic alternations following the ruki-rule in Sanskrit

Root	Locative plural	
ja:	ja:-su	'progeny'
marut	marut-su	'wind'
ap	ap-su	'water'
agni	agni-ʂu	'fire'
eatru	eatru-ʂu	'enemy'
va:c	va:k-ʂu	'voice'
swasr	swasr-ʂu	'sister'
ka.ma	ka:mai-ʂu	'love'

b. Distribution of retroflex [ʂ] and dental [s] in verbal roots

tsar-	'creep up on'
psa-	'devour'
b ^h arts-	'revile'
vas-	'clothe'
b ^h a:s-	'shine'
tras-	'be terrified'
kas-	'open'
hras-	'shorten'
kʂud ^h -	'crush'
kʂam-	'endure'
akʂ-	'attain'
dwiʂ-	'hate'
d ^h rʂ-	'dare'
kuʂ-	'tear'
hraiʂ-	'nigh'
b ^h u:ʂ-	'adorn'

The class of segments that triggers the process is not identified by an evident articulatory property²⁰¹, and there is no prime in the commonly used feature theories that may identify /r,u,k,i/ and exclude other segments in Sanskrit²⁰².

The structural modification operated by the rule does not appear fully crazy: Hamann (2003: 83) provides examples of retroflexion caused by rhotics, back vowels and velar consonants in various unrelated languages. Retroflexion caused by those segments appears to have articulatory and perceptual motivation (cf. Hamann 2003: 87ff.). That /i/ also behaves as a trigger for retroflexion, however, is rather rare. Hamann (2003: 103) shows that front vowels generally avoid retroflexion, usually undergoing lowering or retraction if preceded by a retroflex. In addition, front vowels often trigger de-retroflexion (Hamann 2003: 95), further suggesting that front vowels and retroflexion do not combine well. The production of retroflex consonants requires a flat tongue middle and retracted tongue back, while a front vowel requires an articulatory configuration that is almost opposite: high tongue body and fronted tongue back. /i/ behaving as trigger for retroflexion in Sanskrit is thus unnatural. The /ruki/ rule exemplifies, then, also a case of crazy rule of the 4th type (treated in isolation in §1.2.5), where the contexts of application of a rule and the structural change caused by the rule are not related.

Another example of a crazy rule of the 2nd kind is the case of place assimilation of nasals in River-West Tarangan (Aru language spoken in the Maluku islands, eastern Indonesia).

In River West Tarangan (Nivens 1992: 219, Mielke 2008: 121) /m/ undergoes place assimilation to a following /t̪ g s j/, but to no other segments. The consonantal segments of River West Tarangan are shown in (3a), where the active class of place assimilation is highlighted. Examples of /m/ assimilation are provided in (3b).

(3) River West Tarangan phonology (Nivens 1992: 219; Mielke 2008: 121)

a. Consonants in River West Tarangan

	t̪			k
b		d		g
ϕ		s		
m		n		ŋ
		r		
		l		
			j	

²⁰¹ Venneman 1974 suggests that the /r u k i / class may be identified by an acoustic property, since segments of the /r, u, k, i/ class lower the frequency of energy in a following [s].

²⁰² Zwicky (1970) proposes a class based on features introduced in Jakobson, Fant & Halle (1952) identified using Greek letter variants, [α consonantal, α compact]. This use of Greek letter variables, however, does not conform with their use in Chomsky & Halle (1968). In their original use Greek letter variables indicate feature value relations across segments in the use proposed by Zwicky (1970) they indicate either [+consonantal, +compact] or [-consonantal, -compact].

b. Place assimilation of /m/ in River West Tarangan²⁰³

<i>/m/ assimilates before / t̥ g s j/</i>			<i>/m/ fails to assimilate in other contexts</i>		
/bimtem/	[bintém]	'DUP small'	/jerkimkam/	[jerkimkam]	'DUP NF dislike'
/jergingum/	[jergingum]	DUP NF rub'	/dimdumdi/	[dimdumdi]	'DUP six PL
/simsimə/	[sinsimə]	'ant (sp)'	/nimnam/	[nimnam]	'berry (sp)'
/ɸaɸamjɛmnə/	[ɸaɸanjɛmnə]	'overcast 3s'			
/simsimər/	[simsimər]	'DUP east'			

Given the consonant inventory of River West Tarangan, there is no combination of features under any of Jakobson et al. (1952), SPE, or Unified Feature Theory (Clement & Hume 1995) that could encode the set /t̥ g s j/ as a phonological natural class. In the two examples discussed, craziness resides in the selection of triggers, which do not form a natural class.

V.1.2.4 Crazy rule of the 3rd type: the process has an unnatural structural change

Below is treated the case of palatalization in Yawalapiti (Chabot 2021: 97, de Carvalho 2017), an Arawak language spoken in Brazil. Here the set of consonants /p t k m/ in word-final position palatalizes when preceded by a morpheme that ends in /i/. Palatalization triggered by a front high vowel /i/ appears as a rather common and natural phonological process. What is remarkable is the alternation between the underlying form /p/ and the apical trill form [r], exemplified in (4). The craziness of this process concerns the relation between the input and the output of the process, i.e. the structural modification does not make phonetic sense, given the properties of triggers and targets. The target segments and their surface forms are as in (4a), alternations are shown in (4b). Alternations are triggered by second-person nominal markers, which end in /i/²⁰⁴.

(4) Palatalization in Yawalapiti (Chabot 2021: 97)

<i>a. Input and output of palatalization</i>		<i>b. Alternations caused by palatalization</i>		
<i>Input</i>	<i>Output</i>			
p	r	1sg	nu-puti	'thigh'
		2sg	hi-ruti	
		1pl	a-puti	
		2pl	i-ruti	
		3pl	i-puti-pa	
t	ts	1sg	nu-tapaka	'cheek'
		2sg	hi-tsapaka	
k	tʃ	1sg	nu-kuʃu	'head'
		2sg	hi-tʃuʃu	
m	ɲ	1sg	nu-munujati	'forehead'

²⁰³The underlying forms reported in the table under (3b) are actually an intermediate stage occurring after separate processes affected the reduplicant, altering vowel quality and deleting certain vowels and glides.

²⁰⁴The third-person plural marker also ends in [i], but does not trigger palatalization. This suggests that the process became morphologized.

V.1.2.5 Crazy rules of the 4th type: the contexts of application and the structural change are not related

As an example, consider raising in Ikoma (cf. §II.3.1.3.12). Low and mid vowels have the effect of raising preceding mid-vowels in prefixes. The process appears crazy because there is no relation between the context of activation (mid-vowels followed by mid-low and low vowels) and the structural modification, i.e. raising.

The process exemplified in (5) is not the only height alternation active in Ikoma, which exhibits various processes of raising and lowering that makes it hard to assess the behavior of vowels in suffixes and roots. Prefixes, however, are only subject to the process of regressive raising: vowels in noun-class prefixes of Ikoma alternate depending on the height degree of the vowels in the root. Under (5) is shown that the endings of the noun-class prefixes alternate between a mid-high and a high vowel. The mid-high vowel is selected when vowels in roots are mid-high or high, the high vowel is selected when vowels in the root are mid-low or low. The process does not behave as iterative.

(5) Raising caused by mid and low vowels in Ikoma class prefixes (Higgins 2012: 138)

Class 7 prefix /eke/	eke-mira	'mucus'	eki hæno	'fever'
	eye-γiro	'thing'	eki reŋge	'foot'
	eke-mero	'throat'	eyi kɔmbɛ	'shoulder blade'
	eye-tfuri	'chick'	eyi tɔɔke	'banana'
	eye-hoore	'skull'	eyi sare	'twin'
	eye-kundi	'fist'	eyi yambo	'language'
Class 1 prefix /omo/	omo-remi	'farmer'	omu sɛsɛ	'sleave'
	omo-sino	'widow'	omu γaβo	'medicine man'
Class 3 prefix /omo/	omo-γondo	'farm'	omu hɛtɔ	'trap'
Class 4 prefix /eme/	eme-γondo	'farms'	emi hɛtɔ	'traps'
Class 7 prefix /eye/	eye-tumbe	'chair'	eyi sɛntʃɔ	'cup'
Class 8 prefix /eβe/	eβe-tumbe	'chairs'	eβi jana	'kid'
Class 11 prefix /oro/	oro-siri	'rope'	oru hɛmbɛ	'horn'
Class 14 prefix /oβo/	oβo-rere	'bed'	oβu rɛɛsa	'beard'
Class 19 prefix /ehe/	ehe-tumbe	'small chairs'	ehi tɔɔti	'small bracelets'
Class 20 prefix /oyo/	oyo-tumbe	'large chair'	oyu jɔ	'large gourd'
	oyo-siri	'large rope'	oyu γaate	'large bread'

Higgins assumes that vowels in Ikoma's prefixes are underlyingly mid-high. This is consistent with the general evolution of class prefixes in Bantu languages (cf. Odden 2015: 3). The process of raising appears to be crazy in that mid-low and low vowels act as triggers for raising, while mid-high and high vowels are preceded by a mid-vowel. An alternative analysis may be to assume that vowels in prefixes

are underlyingly high, and that mid-high vowels are the result of regressive lowering. This would solve the issue of assuming that mid-low and low vowels are valid triggers for raising. However, such an analysis still ends up with a crazy rule, since this hypothetical process of lowering would be triggered by high and mid-high vowels. In §II.3.1.3.12 it is discussed why this process cannot be considered a case of dissimilation, which leads us to assume that the process is one of crazy assimilation. Either low vowels trigger raising or high vowels trigger lowering. In any case, the relation between the structural modification and the context of application is unnatural.

V.1.2.6. Summary

Processes of this kind challenge directly the notion that phonological computation is conditioned by phonetic properties, since they are phonetically unnatural.

Rules of the 3rd type should be ruled out because the structural modification caused by the rule cannot be related to any phonetic natural phenomenon. In a similar manner, rules of the 4th type fail to adhere to the non-arbitrariness condition (cf. §1.1), and should therefore be ruled out in a theory where rules are expected to be natural. In rules of the 1st and 2nd type the craziness is not so much in the process itself, but instead in the class of segments involved in the process. The set of segments involved in the rules in (1), (2) and (3), either as triggers or as targets, does not coincide with any natural class individuated by a common feature or by some phonetic property (of which regular features are the reflection).

Mielke (2008) proposes a long survey of processes where unnatural classes of segments participate in phonological rules: they are crazy rules of the 1st and 2nd kind. Mielke (2008) argues that the notion of natural class is not adapt at capturing all groups of segments participating in processing, and thus introduces the terms unnatural class and phonologically active class.

Mielke argues that phonological systems of the world's languages refer to phonetically unnatural classes more often than phonologists have previously thought. Mielke identifies 6077 phonologically active classes in 628 language varieties. 1498 of the 6077 classes cannot be identified as natural classes by the most influential feature theories: the one proposed in Jakobson, Fant & Halle (1952), the one of the Sound Pattern of English (Chomsky & Halle 1968), and the more recent Unified Feature Theory (Clements & Hume 1995).

Some have shed doubts about the validity of certain analyses discussed in Mielke (2008). Hall (2010) and Uffmann (2019) manage to reanalyze certain crazy classes proposed in Mielke as natural classes, or to explain the phonological behavior of a series of unrelated segments in some other ways. Uffmann (2019), for example, demonstrates that a process of nasalization in Evenki, which in Mielke (2008: 120) analysis affects the unnatural class /v, g, s/, does not qualify as a crazy rule. The set of targets defined as unnatural by Mielke is reanalyzed as /v, ɣ, s/, which Uffmann (2019) identifies as a natural class in Evenki. Some crazy classes identified by Mielke in his book may not all be crazy after all. However, within the various processes discussed in Mielke (2008) there are cases that cannot be made natural by reanalysis. The point made by Mileke cannot be so easily dismissed: there are phonological processes that operate over unexpected and unnatural classes of segments, which most (or all) set of primes fail to identify.

From this point forward, I will use the term 'active class' to identify a set of segments that undergoes or triggers a phonological process, whether such class is phonetically natural or not. I will reserve the term Natural Class to identify a set of segments characterized by a specific phonetic property. A theory of phonology that assumes that primes correlate with a fixed phonetic property takes for granted the fact that the two concepts of active phonological class and natural class coincide. Crazy processes of the 1st

and 2nd kind, however, challenge this assumption. The classes of segments that participate are active classes but not natural classes.

V.1.3 Asymmetry is craziness: the notion of Natural Class must be rethought

The reason for discussing crazy rules in the previous section is that I believe that some of the problematic asymmetric patterns discussed in §II.3 and §III.7 (especially parasitic harmonies), may be considered as phonological processes that affect only a subset of a natural class. In other words, I argue that asymmetries in VH can be viewed as cases of crazy rules. Asymmetric harmonies may be considered as processes that affect (or are triggered) by a subclass of segments that exclude some of the expected triggers or targets.

The phonological process involved in asymmetric and parasitic harmonies is not crazy per-se. Raising harmony normally applies as a phonetically natural process that turns a non-high vowel into a high one (or a mid-low vowel into a mid-high one in scalar raising). Similarly, labial harmonies, where asymmetries are frequent (Kaun 2004), do not display a phonetically crazy behavior. A non-rounded vowel turns to round because of a neighboring rounded vowel. The relation between the input and the output (or the output of the process and the triggering context) is perfectly natural in most raising harmonies, including asymmetric and parasitic processes. The issue with asymmetries in general is that some of the expected triggers and targets do not behave as such. Given the structural change operated by harmony, the class of active segments we expect is different from the one we see.

Consider the case of Bergamasco, exemplified in (6) below, where raising applies asymmetrically only to rounded mid-vowels and not to non-rounded mid-vowels. Raising is triggered by all high vowels, but only a subset of the expected targets (namely only rounded vowels) are raised.

(6) Asymmetric raising in Bergamasco

<i>Rounded vowels</i>	[ˈɡodʒa]	‘needle’	[ɡuˈdʒi]	‘needle DIM’
	[me ˈcore]	‘I run’	[oter cuˈri]	‘you run PL’
	[øtʃ]	‘eye’	[yˈdʒi]	‘eye DIM’
<i>Non-rounded vowels</i>	[poleder]	‘foal’	[poleˈdri]	‘foal DIM’
	[me ˈlese]	‘I read’	[leˈsit]	‘read’
<i>Expected triggers</i>	<i>Expected targets</i>		<i>Actual triggers</i>	<i>Actual targets</i>
/i, u, y/	/e, ε, o, ɔ, ø/		/i, u, y/	/o, ɔ, ø/

The set of targets of raising does not coincide with the set of expected targets. A natural process of raising would equally affect all mid vowels, as happens in Bresciano (cf. §III.7.2), not only the rounded ones.

A similar case can be made about processes where only a subset of the expected triggers behave as such. In (7) the case of Veroli (treated in §II.3.3.5.1) is exemplified. Here /u/ behaves as a valid trigger only for mid-high vowels, but does not behave as a trigger for mid-low raising. A natural process of raising would involve all high vowels as triggers in all contexts, while in Veroli /u/ does not behave as a trigger for mid-low raising.

(7) Raising in Veroli asymmetry in the selection of triggers

a. Raising of mid-high vowels in Veroli

	<i>Singular</i>	<i>Plural</i>	
<i>F</i>	'veduva	'veduve	<i>widow</i>
<i>M</i>	'viduvu		<i>widower</i>
<i>F</i>	'pera		<i>pear</i>
<i>M</i>	'piru		
<i>F</i>	'freske		<i>chill</i>
<i>M</i>	'frisku		
<i>M</i>	'mesu	'misi	<i>month</i>
<i>M</i>	pa'iesu ²⁰⁵	pa'isi	<i>village</i>
<i>M</i>	'prete	'preti	<i>priest</i>
<i>F</i>	'serpe	'serpi	<i>snake</i>
<i>Expected triggers</i>	<i>Expected targets</i>	<i>Actual triggers</i>	<i>Actual targets</i>
/i, u/	/e, o/	/i, u/	/e, o/

b. Raising of mid-low vowels in Veroli

	<i>Singular</i>	<i>Plural</i>	
<i>F</i>	'lenta	'lente	<i>slow</i>
<i>M</i>	'lentu	'lenti	
<i>F</i>	'vekkja	'vekkje	<i>old</i>
<i>M</i>	'vekkju		
<i>M</i>	'okkju	'okki	<i>eye</i>
<i>M</i>	'kørnu	'korni	<i>horn</i>
<i>Expected triggers</i>	<i>Expected targets</i>	<i>Actual triggers</i>	<i>Actual targets</i>
/i, u/	/ε, o/	/i/	/ε, o/

As discussed in the previous section, the notion of natural class needs to be complemented with the notion of active unnatural class to explain crazy rules of the 1st and 2nd type. The fact that /e/ does not behave as a target for raising in Bergamasco, or that /u/ does not behave as an optimal trigger for metaphony in Veroli, seems to instantiate this pattern.

I thus propose to consider asymmetric harmonies as crazy processes that do not select as triggers or targets a full class of expected triggers or targets, but only a subset of that class.

In Bergamasco, for example, the set of triggers and the set of targets can be easily identified as natural classes. High vowels trigger raising harmony and rounded mid-vowels are affected by raising. It remains unexplained why the mid-vowel /e/ is excluded by the set of targets. The structural modification executed by the harmonic process would naturally include all mid-vowels, not only the rounded ones. The process

²⁰⁵ In two of the examples proposed, namely [mesu] and [paiesu], final [u] does not correspond to the original Latin –UM, which does behave as a valid trigger for raising of mid-high vowels in forms as [viduvu] and [piru] shown in the upper part of table (7).

at hand does not concern directly rounding, but vowel height. The exclusion of /e/ from the set of targets is suspicious.

The issue is more easily defined by looking at a non-harmonic process of assimilation, where asymmetries are rarer (but not completely absent). Consider as an example voicing of /s/ in Italian. /s/ surfaces as voiced [z] whenever followed by a voiced consonant. Some examples are provided in (8).

(8) Voicing of /s/ in Italian: a symmetrical and “sane” phonological process

	<i>Base form</i>		<i>Derived form</i>	
<i>/s/ followed by a voiceless stop surfaces as [s]</i>	[pa:tria]	'homeland'	[espa'trja:to]	'expatriate'
	[pe:lo]	'hair'	[spelak'kja:to]	'maggy, shabby'
	[tempera'tu:ra]	'temperature'	[stempe'ra:re]	'temper'
	[tap:o]	'cap, cork'	[stap'pa:re]	'uncork'
	[kri'te:rjo]	'criterion'	[skrite'rja:to]	'senseless'
	[konklu'sjo:ne]	'conclusion'	[skonklusio'na:to]	'incoherent'
<i>/s/ followed by a voiceless stop surfaces as [z]</i>	[battere]	'to beat'	[zbat:ere]	'to flap/ slam'
	[bef:a]	'mockery'	[zbef:ed'dza:re]	'to mock'
	[dente]	'thooth'	[zden'ta:to]	'thoothless'
	[doltʃe]	'sweet'	[zdoltʃi'na:to]	'sappy, sentimental'
	[gijn:o]	'grin'	[zgijn:at'tsa:re]	'to sneer'
	[gom:a]	'gum, tire'	[zgom'ma:re]	'to take off, to do donuts'

The process in (8) appears perfectly natural. If, however, the process applied only when /s/ is followed by /b, g/ but not when followed by /d/, (i.e. if instead of [zdentato] and [zdoltʃi'na:to] the forms *[sdentato] and *[sdoltʃi'na:to] were produced) it would be a rather suspicious process because one voiced consonant, /d/, is excluded by the set of triggers.

Notice that it is not impossible to identify /b, g/ as a natural class, given the right theory of primes. For example, the acoustic-based features proposed in Jakobson, Fant & Halle (1952) may identify them as [+grave]. Similarly, Element Theory may use the prime [U], present in both bilabial and velar consonants (cf. Backley 2011: 79ff.) as a way to identify /b,g/ as the class of targets. Nonetheless, the process would still be unnatural because it involves voicing, and /d/ is a voiced consonant.

Consider the case of Gwari (Hyman and Magaji 1970). In this language, labial and velar consonants are optionally labialized before back rounded vowels, but, Mielke claims, labiovelars are not (Hyman and Magaji 1970: 13, Mielke 2008: 125).

In SPE, labiovelars are anterior velars, sharing [+back, +high] with velars and [+anterior] with bilabials. In Feature Geometry approaches, labiovelars possess both the features [Labial] and [Dorsal]. That labial and velar may pattern together in a process of labialization is not surprising from a phonetic perspective. In Jakobson Fant & Halle (1952) they share a prime [grave], which also has a role in defining rounded vowels. It is at least unexpected that labiovelars fail to pattern with labials and velars in Gwari. Some data from Gwari, taken from Mielke (2008: 125), are provided in (9).

(9) Gwari labialization: /p, b, k, g/, but not /k̠p, g̠b/, are optionally labialized before back rounded vowels

[g ^w ò]	[gò]	‘to receive’
[g ^w ō]	[gō]	‘to grind’
[zuk ^w ô]	[zukô]	‘hoe’
[knūb ^w à]	[knūbà]	‘ear’
[gnīk ^w ó]	[gnīkó]	‘market’
[túk ^w ó]	[túkó]	‘head’
[àp ^w ò]	[àpò]	‘twin’
*[g̠b ^w ògnu]	[g̠bògnu]	‘squirrel’

Labial and velars can be identified as a natural class, and they can be defined as targets of a process of labialization. It is unexpected that the class of targets for labialization does not involve labiovelars.

I argue that the same issue is present in asymmetric harmonies, and it is exactly the reason why asymmetries require an explanation. All subsets of vowels that participate in the asymmetric harmonies discussed in this thesis can be identified as a natural class by the primes assumed by most theories. It still requires an explanation why some segments that belong to a class do not participate in a process that may involve them.

Various proposals have been advanced, many of which are discussed in the previous chapter, to explain why a specific subset of triggers or targets behave as neutral in asymmetric harmonies. Many accounts of asymmetry revolve around the idea that vowels that are unspecified for the harmonic prime behave as neutral in harmonic patterns. There were, however, the issue of certain cases (in §IV.3.2.3 the examples of Bergamasco and Basque were discussed) where it is unclear how to identify the set of vowels unspecified for the harmonic prime, and of course there is the issue of parasitic harmonies, where the set of triggers and targets varies depending on the context. Various other proposal have been discussed in the previous chapter which requires to modify the mechanisms of phonological computation or representation to explain why only some of the vowels belonging to a class participate in Vowel Harmony. Notions as Bridge Licensing, Asymmetric Licensing (§IV.6.5), head-switching (§IV.5.3) or additional requirements (§IV.4.1) served exactly this purpose.

The proposal advanced here is that asymmetric harmonies display some degree of craziness. The set of triggers or the set of targets of a process does not coincide with the expected class of active segments, given the structural modification specified by the rule. Some asymmetries can be explained by a series of theoretical assumptions, as discussed in the previous chapter. For example, Halh Mongolian is explained by assuming that only contrastive primes are phonologically active, and that [+round] does not have a contrastive role for high vowels in Halh Mongolian. However, it was also discussed how none of the theories discussed in the previous chapter manages to explain all asymmetries satisfactorily, or if it can, struggles with the scalar nature of numerous raising harmonies.

The proposal advanced here is to treat asymmetric harmonies as processes whereby the active classes involved in the process either as triggers or targets do not correspond to the expected classes.

We may define as a crazy rule of the 5th kind those that select only a subclass of the expected triggers or targets. Consider, alongside Bergamasco discussed above, the case of Basque harmony. Here only the low vowel /a/ behaves as a target for raising, while all other vowels which are commonly specified as [-high] do not participate in harmony. Alongside Bergamasco, Basque may be a case of a crazy rule of the kind 5a: it selects a subclass of the expected targets, namely the low vowel /a/, but none of the other mid-vowels present in the language /e,o/. Under (10) raising in Basque is exemplified (cf. §II.3.5.3).

(10) Crazy rule of the type 5a: only a subclass of the expected targets is affected by the process

a. Root internal raising in Baztan Basque

<i>Standard Basque</i>	<i>Baztan Basque</i>		
fabrika	fabrike		'factory'
ikasi	ikesi		'to learn'
izan	izen		'to be'
bihar	bier		'tomorrow'
usain	usein		'smell'
hura	ure		'that'
urtarril	urterril		'January'
urte	urte	*urti	'year'
izen	izen	*izin	'name'
izerdi	izerdi	*izirdi	'sweat'
bide	bide	*bidi	'path'

b. Alternations in derivational morphemes

<i>i. Raising in the diminutive suffix /ska/</i>			
afari-xke	<i>little dinner</i>	larra-xka	'little prairie'
mendi-xke	<i>'little mountain'</i>		
<i>ii. Raising in the suffix /lari/ (profession)</i>			
tratu-leri	'dealer'	eske-lari	'beggar'
<i>iii. Raising in the adverbial suffix /ka/</i>			
aldiz-ke	'by turns'	laster-ka	'quickly'
<i>iv. Raising in the suffix /tʰsa/-[tʰza] (activity)</i>			
lagun-tze	'help'	arran-tza	'fishing'
<i>v. Raising in /-la/ (that)</i>			
dugu-le	'that we have'	dire-la	'that they are'
<i>vi. Raising in /ta/ (past participle)</i>			
itzuli-te	'turned'	etzan-ta	'lied'
<i>Expected triggers</i>	<i>Expected targets</i>	<i>Actual triggers</i>	<i>Actual targets</i>
/i, u/	/a, e, o/	/i, u/	/a/

Veroli may be an example of the type 5b. Here only /i/ (and not /u/) behaves as a valid trigger for raising mid-low vowels. Other examples may be those discussed in §II.3.3.5.1 concerning metaphony in Grado or Lugo, where only underlying /i/ triggers raising, while underlying /u/ does not. An additional example, which surprisingly does not involve harmonization, is the case of labialization in Karata (Pasquereau 2018: 2), a Nakh-Daghestanian language spoken in western Daghestan, in the Caucasus, where only high rounded vowels trigger labialization of preceding consonants, while non-high rounded vowels do not. In the examples shown in (11), consonants labialize only when following a high rounded vowel /u/, while they do not labialize when following a non-high rounded vowel /o/.

(11) Crazy rule of the type 5b: only a subset of the expected triggers behaves as such

	<i>Underlying form</i>	<i>Surface form</i>	
<i>Labialization of stem-consonant</i>	/j-utʃ~aɫ°a/	[jitʃ ^w ãŋɫ°a]	'bathe'
	/j-utʃ°ã-aɫ°a/	[jitʃ ^w ã:ŋɫ°a]	'open'
	/j-uɫ°~aɫ°a/	[jiɫ° ^w ãŋɫ°a]	'share'
<i>Stem consonant is not labialized</i>	/j-oχã-aɫ°a/	[jeχã:ŋɫ°a]	'thrust'
	/j-oʔ~aɫ°a/	[jeʔãŋɫ°a]	'go'
	/j- oɫ°-aɫ°a/	[jeɫ°aɫ°a]	'warm up'
<i>Expected triggers</i>	<i>Expected targets</i>	<i>Actual triggers</i>	<i>Actual targets</i>
/o, u/	C	/u/	C

Parasitic harmonies offer other cases where expectations about the selection of triggers and targets are not met, and may be considered as a group that is in between 5a and 5b. The set of triggers and targets changes depending on the context.

In Camuno, repeated in (12), high vowels do behave as an active class when rounded vowels are affected, while only the subgroup of high vowels containing /i/ is active when /e/ is the target. The natural class of high vowels is active in its entirety only in a subset of cases, namely when rounded vowels are subject to raising.

(12) Crazy rule of the type 5a-b: only a subset of the expected triggers/targets behaves as such in a specific context

<i>Base form</i>	<i>Diminutive</i>	<i>Augmentative</i>	
['det]	[din'ti]	[den'tu]	'tooth'
['tʃezɔ]	[tʃi'zinɔ]	[tʃe'zunɔ]	'church'
[let]	[li'ti]	[le'tu]	'bed'
['pɛtɛn]	[piti'ni]	[pete'nu]	'comb'
['tʃot]	[tʃu'di]	[tʃu'du]	'nail'
['grop]	[gru'pi]	[gru'pu]	'knot'
[pon'dɔr]	[pundu'ri]	[pundu'ru]	'tomato'
[biga'rɔl]	[bigaru'li]	[bigaru'lu]	'apron'
[len'hɔl]	[lenhy'li/lenhu'li]	[lenhu'lu]	'sheet'
[fon'tanɔ]	[fonta'ninɔ]	[fonta'nunɔ]	'fountain'
<i>Expected triggers</i>	<i>Expected targets</i>	<i>Actual triggers</i>	<i>Actual targets</i>
/i, u, y/	/e, ε, o, ɔ, ø/	/i, u, y/	/o, ɔ, ø/
		/i/	/e, ε/

It is evident that the active classes in a parasitic harmonic pattern such as that of Camuno do not coincide with the natural classes expected to participate in a raising process: high vowels as triggers, mid vowels as targets. In Camuno, the active class of segments changes depending on the context. It is therefore impossible to select a fixed, immutable, class of segments that acts as an active natural class in a parasitic harmony.

The 5th class of crazy rules, added here, comprises processes (mostly harmonies, but cf. 11) where the class of active segments expected given the structural change caused by the rule is not the one observed.

Processes of the type 5a select only a subset of targets, 5b only a subset of triggers. Parasitic harmonies belong to both groups, 5a and 5b, in that they select a subset of triggers and a subset of targets, which behave differently with regards to harmony in different contexts.

The detachment of the two concepts of active class and natural class gives rise to the question: are the concepts of Natural class and of Active class both necessary in a phonological theory?

I argue, agreeing with Mielke (2008: 5), that the notion of natural class has to be discarded, and that only the notion of active class should matter. Natural classes are only natural because in most processes the active class of segments share a phonetic property. This does not make naturalness a defining property of an active class, which can be extremely unnatural. Natural classes are in fact just a partial subset of phonologically active classes. In Mielke's (2008: 5) terms, "natural classes are a special case of idiosyncratic historical residues, i.e. they are the [active classes] which most transparently reflect their phonetic origins and which therefore occur most frequently [...]".

If only the notion of active class matters, then asymmetries cease to be problematic patterns. Symmetric harmonies are processes where harmony applies over the expected classes, asymmetric processes simply operate over active classes of segments, which may not correspond to the expected natural class.

When the notion of natural class is discarded in favor of the notion of active class, all harmonies end up being the same kind of process. A set of triggers affects a set of targets, and those sets may or may not coincide with the expected natural classes. If they do, the process will appear as symmetric, if they do not they will appear as asymmetric.

To sum up, I argue that the asymmetric behavior of harmonic processes (here defined as crazy rules of the 5th type), and the issue encountered in processes where segments that are not part of the same natural classes behave alike (crazy rules of the 1st and 2nd type), share the same problematic aspect and the same possible solution. Both kinds of processes require a theory of phonological representation that is able to refer to non-universal classes of segments²⁰⁶.

In the examples discussed in §1.2.2 and §1.2.3 processes are considered crazy because phonology lacks a category able to group together a class of segments as a natural class. In asymmetric harmonies, instead, phonology may fail to identify specific subgroups of segments within the larger class of expected triggers or targets. When considered alongside crazy rules, I believe that asymmetric harmonies are an additional clue that we should envision a theory of phonological representation that allows us to select sets of segments more freely. Phonological processes often operate over classes of segments that may be unexpected or unnatural.

My opinion is that phonological computation should be able to operate over arbitrary sets of segments, even if they do not share a specific phonetic property or if the set excludes one or more segments of a natural class. I support a theory of phonological representation based on learned and purely symbolic phonological primes without a fixed correlation with phonetic properties. In sum, features are not innate and universal categories, but they emerge during acquisition (Mielke 2008: 81).

Such a theory allows for the selection of unnatural classes of segments as active phonological classes, without the need to group together segments that share a phonetic property. I argue, agreeing with Mielke (2008: 9), Dresher (2014: 166ff.), Boersma & Hamann (2008: 226) that the selection of active classes

²⁰⁶ This ties in with the discussion in §IV.8: the way high vowels are traditionally represented makes it hard (or impossible) to represent asymmetries alongside scalar and complete raising harmonies.

should be driven by phonological patterns. Segments that pattern together must share a prime not because they belong to a universal natural class, but just for the fact that they participate in the same phonological process.

This is the main tenet of Emergent Feature theory, pioneered by Mielke (2008) and now a key component of many approaches that are part of SFP theory. During learning, speakers assign to segments the phonological primes that are necessary for the computation of the process they are exposed to. Primes should follow from processing, not the other way around. As a consequence, the specific representation of a speech sound is not universal, but language specific.

Crazy processes and asymmetric harmonies are, in my opinion, good empirical reasons to imagine such a theory of phonology. There are, however, other theoretical arguments in support of this position about the theory of phonological representation, discussed in the following section.

V.2 The role of Phonology within the broader architecture of language

V.2.1 Modularity and the properties of cognitive modules

Generative Linguistics is a branch of cognitive science in the sense that it envisions language as a phenomenon that occurs in the human brain (Jackendoff 1997: 2). The objective of Generative Linguistics is not to define what the various rules of different grammars are, but what cognitive tools humans share so that they can develop grammar as a competence. In other words, Generative Linguistics aims to find the limits of the faculty of humans to develop and produce grammars and languages.

The Chomskyan view, which is followed in this thesis, is that speakers acquire their language on the basis of linguistic structures that are biologically innate and part of the human mind and simply require exposure to language, not teaching, to acquire language. Furthermore, these structures are argued to be universal, applying to all languages at all times. That is, human brains are built with a dedicated architecture for the acquisition and use of language, and that this architecture gives a set of constraints for organizing language, which allow children to acquire a language in a surprisingly short amount of time (Anderson 2008; Chomsky 1980; Jackendoff 2002; Pinker 1994: 22).

This innate and universal part of the brain is Universal Grammar (UG, Chomsky 1986: 25 Jackendoff 2002: 68). This is the initial state of the faculty of language, shared by all human beings. Starting from the UG, humans exposed to speech acquire language positing a set of symbols and a set of functions that manipulate those symbols. That is, they build for themselves a generative grammar that can create an unlimited set of sentences out of a finite list of items (Chomsky 2005: 11, Volenec & Reiss 2020: 11).

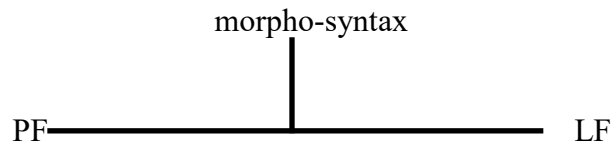
The Language Faculty is assumed to work as an independent part of the human mind and to be made of specialized sub-units of mind that carry out specific cognitive tasks: cognitive modules (Curtiss 2013, Fodor 1983).

In the view of Fodor (1983), any cognitive process which is independent and distinct from central processes²⁰⁷ is known as a cognitive module. A module is a specialized functional unit which accomplishes a specific task. For example, the act of vision appears to be composed by different computational operations: one operation dedicated to color-recognition, one for motion, one for face-recognition et cetera. (Marr 1982, Stevens 2012). Different computations operate independently, that is, in a modular fashion.

²⁰⁷ In Fodor (1983), central systems perform higher cognitive functions: moral and social judgements, problem solving, decision making. The modular mechanism only concerns lower cognitive functions such as vision, audition etc.

In language production, the Inverted T model (Chomsky 1965: 15) represented in (13) envisions morpho-syntax as an engine that concatenates elements drawn from long term memory (the lexicon), and gives the output of its operations to two distinct modules, PF (phonetic/phonological form) and the LF (logical form), which respectively determine how the output of morpho-syntax is pronounced, and what meaning it has.

(13) The architecture of language: the Inverted T model



Each component of the Inverted T is an independent module. Thus, syntax, phonology and semantics each have a correspondent cognitive module endowed with the same general properties that identify a Fodorian Module (Chabot 2021: 32, Fodor 1983, Iosad 2017: 6). Among them, the notions of Domain Specificity and Inaccessibility/Encapsulation deserve a specific explanation for their relevance in the discussion that follows.

Coltheart (1999) argues that Domain Specificity is the defining property of a cognitive module. Domain specificity means that the computation that a cognitive module performs operates over items that are not encountered in other modules. Each module works with a specific kind of cognitive representation, and each system of representation, here referred to as cognitive vocabulary, is specific to the module.

This implies that the modules of the inverted T operate only on linguistic information. Stimuli of different nature (visual, tactile, emotional etc...) do not interfere in the operation carried out in linguistic perception and production. Speakers can produce and parse grammatical sentences regardless of what they are seeing, feeling or touching. At a smaller scale, phonology operates only on phonological vocabulary, as morpho-syntax operates only over morpho-syntactic primes and semantics only on semantic information. That is, phonology deals with primes (features, element), syllabic positions, tones... which are specific of the domain of phonology.

For what concerns our interests, this means that phonology, being a cognitive module, requires that phonological computation only operates over phonological categories.

If phonetics, phonology and morphology are indeed different modules, it follows that a domain-specific phonology cannot operate on formant values, on articulatory positions, or on morpho-syntactic features. All of those objects may be relevant for other aspects of language, but cannot directly be parsed by the phonology module. Domain specificity, then, ensures that modules operate over specific kinds of representation.

Modules, however, do communicate with each other, just not directly. They do so through a cognitive interface, which translates representations encoded in a specific vocabulary into representations of different vocabularies. This translation is a consequence of domain specificity: since different modules speak mutually unintelligible idioms, intermodular communication must rely on translation of items from one vocabulary into another (Scheer 2014: 257). Morpho-syntactic and phonetic information which is of relevance in phonology is translated (or transduced) into the realm of phonology through an interface.

V.2.2 The role of the interface between cognitive modules

The interface is the connecting device that allow communication between cognitive modules. In practice, an interface correlates information pertaining to a cognitive module to information that pertains to a different cognitive module, acting as a translator between vocabularies.

The operation of translation between vocabularies (here called transduction) displays some properties that are different from the operation of computation carried on within cognitive modules. Transduction is not a computation like the one that happens within a cognitive module (Reiss 2007: 51, Scheer 2011: 293, Scheer 2014: 259) but it is done through a lexical access. Like in a dictionary, each item of the input vocabulary is matched with an item of the output vocabulary.

Consider as an example the mechanism of Spell-Out, the operation that converts morpho-syntactic information into phonological material (e.g., Marantz 1997, Embick 2010). Spell-out converts portions of the hierarchical morpho-syntactic structure into phonological material. The morpho-syntactic structure that corresponds to the past tense in English is transduced in phonology as /-ed/. The relation between the morpho-syntactic information [past tense] and the phonological representation /-ed/ is stored in long-term memory, and is arbitrary: there is no reason why, say, -ed, rather than -s, -et or -a realizes past tense in English. The arbitrariness of the relation between items at the interface derives from the fact that items from the two sides of the interface are coded in different vocabularies. This notion has an obvious precedence in the arbitrariness of the sign (Saussure 1916) and is undisputed for what concerns the Morpho-syntax to Phonology interface (hereafter MPI). The interface between modules works as a list of transductional instructions that correlate items of different representations: there is nothing within the phonological form /dog/ that makes it a better phonological exponent of the syntactic features [Noun, +animated,-human ...] than, say, /kane/ (Italian), /gǒu/ (Chinese), /køpek/ (Turkish) or /kão/ (Portuguese). The same point is discussed in Scheer (2019: 107).

This conversion is not a computational operation, i.e. there is no algorithm that modifies representation in one or the other vocabulary. This is a key difference between the transductional operation happening at the interface between modules (at least, at the MPI) and the computation happening within modules. The interface acts as a list of instruction for translation. The item X in the vocabulary of morpho-syntax (syntactic features and categories, DP, VP...) is transduced into the item Y in the vocabulary of phonology (segments, primes, syllables...). In sum, transduction is an operation of mapping between two different representational forms.

Computational operations, which are those carried on within the modules, work instead as mappings between two representation of the same kind. This mapping is not stored in long-term memory, but follows from an algorithm.

I will exemplify the difference using the raising harmony of Eastern Lombard dialects. A transductional instruction occurring at the interface between morpho-syntax and phonology may take the form displayed under (14). The relation between items from one side of the interface to the other is indicated by the symbol ‘↔’ which indicates a list-based relationship. To one item in morpho-syntax correspond an item in phonology and vice versa.

(14) Example of the mechanism of transduction: the morpho-syntax/phonology interface

<i>Morpho-syntactic items</i>		<i>Phonological items</i>
[root]	↔	/tʃez-/
[feminine singular]	↔	/-a/
[diminutive feminine]	↔	/-'in/
[augmentative feminine]	↔	/-'un/

A computation, such as the example of phonological computation proposed in (15), transforms an input (phonological representation) into an output (also phonological representation) through an algorithm. The mapping between the two forms is shown using the arrow ‘→’, which indicates that an algorithmic operation is carried out on the input, that turns out as the output. So, in an Eastern Lombard variety where RVH is active (as Bresciano, for instance), an underlying form is modified by phonological processing as exemplified below

(15) Example of phonological computation

<i>Phonological items</i>		<i>Phonological items</i>
/tʃez-in-a/	→	/tʃizina/
/tʃez-un-a/	→	/tʃizuna/

Computation within the phonological module is what throughout this thesis has been referenced as phonological processing or phonological computation. In (15) vowel harmony is the phenomenon that causes a phonological representation to change, and passes from /tʃezina/ (the underlying form, the input) to [tʃizina] (the surface form, the output) to comply with the rule of harmony that is active in Eastern Lombard varieties. The difference between the two operations is that transduction is lexical in kind, it relies on a list of transductional instructions learned and stored in long term memory. Computation is algorithmic, it transforms an input into an output (made of the same kind of representation, or of the same “modular vocabulary”) through an algorithm.

Not everyone agrees about the inherent difference between computation and transduction. For example, Jackendoff (2002: 223ff.) considers intermodular communication to be computational in kind. The architecture of the mind envisioned by Jackendoff comprises, alongside a central system (inferential processors in Jackendoff’s terms) and domain specific modules (integrative processors), also interface processors, which are modules that act as interfaces. Those computational interfaces are, in Jackendoff’s own terms, bi-domain specific, in that they have access to some information of the two domains of the modules they connect. Scheer (2020: 196) argues that bi-domain specificity is incompatible with modularity, and “simply puts in words a contradiction in terms”. He also argues that bi-domain specificity defies the purpose of interfaces acting as translators between modules: if modules were able to process two different types of vocabulary, there would be no need for specific translation devices in the first place.

To sum up, the process of transduction is non-computational in nature, and simply translates some kind of cognitive representation into a different kind of representation. Computation, on the other hand, converts a representation into another representation of the same kind. Transduction happens at the interface, computation happens within a module (cf. Hale & Reiss 2008: 109 for a summary).

Under those assumptions, we may think of modular interfaces as lists of transductional instructions that map items coded in one specific vocabulary onto items coded in another vocabulary.

Phonology, like any other module, communicates with other modules through interfaces. The most relevant operation of transduction that involve phonology are those that correlate phonology through morpho-syntax and through phonetics. Notice, however, that phonology probably interacts (through other interfaces) with other, non-eminently linguistic, modules (e.g. it may interact with vision, which would explain the McGurk effect, McGurk & MacDonald 1976). The interface that connects phonology with morpho-syntax has been briefly presented above: the output of morpho-syntax (syntactic trees) is interpreted as sequences of sounds. This implies that morpho-syntactic categories are mapped onto phonological representations. There is thus a Morphosyntax-to-Phonology Interface (MPI), which transduces morpho-syntactic into phonological categories.

Another interface connects phonology with phonetics (Phonology-to-phonetics, PPI) and relates phonological representation to articulatory instruction and/or acoustic properties that can be produced and picked up by the sensory-motor system.

Interfaces allow information concerning a module to pass onto another one. Different modules deal with different symbolic units. For example, phonology deals with primes (features, elements) or syllabic structure, prosodic structure etc. while morpho-syntax deals with categories such as “noun”, “verb”, DP etc. The vocabulary used and manipulated by the phonological module is self-contained within phonology, and thus cannot be used by different modules, and vice-versa. This means that morpho-syntactic information such as “2nd person”, “plural” “masculine” is not relevant in phonology by itself. Their phonological exponent (their “morph”, in structuralist terms) is made of phonological material (features, x-slots, association lines etc.), which, as discussed above, is arbitrarily associated to morphemes through a lexical access (Vocabulary Insertion). Phonology operates over phonological entities: x-slots, features, syllables, prosodic units, but cannot operate over morpho-syntactic entities such as “2nd person”, DP, “plural” etc.

If morpho-syntactic information is relevant to phonological computation (e.g. a process applies only to a certain morphological category, such as the processes discussed in §IV.7), it is not because the cognitive module of phonology has access to morphological information: this would be a violation of domain specificity. Instead, morphological information is translated into the “phonological language” (made of features, segments, syllables etc.), and only then can it be manipulated by the rules of phonological computation²⁰⁸. Interfaces are the only means of communication between modules, and correlate arbitrarily items that pertain to different domain-specific vocabularies. The instructions that correlate phonological forms to morpho-syntactic and semantic forms are stored in the Lexicon as a lexical item. There is little to no doubt that the correlations forming lexical items are arbitrary and learned by each speaker, and thus that the interface between those modules forms during acquisition. Simply put, the instructions that form the MPI are learned and not part of the Universal Grammar.

Scheer (2014: 258) argues that all intermodular relationships should have the same architectural properties. This means that the PPI should also correlate arbitrarily phonological and phonetic items. Phonetics deals with the physical properties of sounds, which are not discrete nor symbolic, but tied to the external world (Hamann 2011, Ladefoged 2005). On the other hand, phonology deals with symbolic

²⁰⁸ This assumption is in sharp contradiction with the proposals that analyze metaphony as morphophonology explored in §IV.7.3. In §VI.7 an alternative view that treats metaphonic alternations as purely phonological is given.

and discrete units, (primes, x-slots, prosodic constituents). It appears, then, that a mechanism of translation between the two realms is necessary.

Besides the theoretical argument for a modular phonology separated from phonetics, there are also experimental reasons to believe phonology and phonetics must be treated as separate entities. Infants are able to distinguish speech sounds belonging to all human languages in the first months of language acquisition. At a later stage, they start focusing their perception only to the sound of their mother tongue. The most accepted interpretation of this fact is that young infants still have not acquired the complete phonology of their language, and hence rely purely on phonetic cues to distinguish linguistic sounds. Older speakers, with a fully developed phonology, focus only on distinction that are relevant in their language. Studies on early word perception (Blaho 2008 cites Werker et al. 2002; Pater et al. 2004; Fikkert 2007; Fikkert et al. 2006) found that children able to distinguish different sounds in non-phonological contexts are unable to do so in phonological contexts, suggesting that two different modules (a phonetic one and a phonological one) operate on speech as their input.

As we have discussed in §1.1, however, in most theoretic approaches phonological categories follow from phonetic categories, implying that, differently from the MPI, the PPI is universal and not arbitrary. Consider the prime [+round]: its phonetic (articulatory) correlate is assumed to be lip-protrusion. In no language is the relation between [+round] and the articulatory gesture of lip-protrusion different. The correlation between phonological primes and their phonetic exponent is assumed, by most, to be fixed and innate. This means that the MPI is learned and arbitrary, while the PPI is not. Transduction at the MPI (spell-out) matches morpho-syntactic structure with phonological items in an arbitrary fashion, transduction at the PPI, instead, is generally assumed to be ‘fixed’, i.e. non arbitrary. The correlation between phonological and phonetic items is universal and given at birth. This is the complete opposite of the view shared by most scholars about the MPI, where the relation between morpho-syntactic, semantic and phonological items is learned and arbitrary.

As we shall discuss below, this divergence is the core of the discussion between the two main approaches to SFP: the Concordia School approach (Henceforth CSa) argues that phonological primes are universal and innate and have a fixed correlation with phonetics and holds that the PPI is fixed and part of UG. The emergentist approach, here referred to as the Radical Substance Free Phonology approach (RadSFP), subscribes to the idea that primes emerge during acquisition, and that the PPI is learned and arbitrarily relates phonetic to phonological categories.

Before discussing the differences between the two main schools within SFP, in §2.3 are made explicit the consequences of the assumption of a modular theory in phonology, which are shared by all versions of SFP.

V.2.3 From modularity to Substance Free Phonology: avoid substance abuse

As established in the previous paragraph, there is an interface between phonetics and phonology. Phonetic information is translated into symbolic phonological representation in order to be manipulated by the phonological module. It follows that acoustic signals are transduced into phonological objects, during perception, and that the result of the transduction does not contain any trace of the phonetic signal perceived (Reiss 2007: 74). All the properties of sounds that pertain to phonetics (acoustic and articulatory properties) are irrelevant to phonological processing because phonology is a domain-specific module. Phonological representation, then, is neither auditory nor motor: acoustic and articulatory properties pertain to the gradient dimension of phonetics, while phonology deals with discrete symbolic objects. The profound difference between phonological and phonetic units has been part of phonological

theory since Jakobson, Fant & Halle (1952: 11), where a sharp distinction was drawn between distinctive features (abstract phonological entities) and their implementation. That is, features (primes in general) have phonetic (acoustic or articulatory) correlates, and should not have an intrinsic phonetic value.

During the last two decades Hale & Reiss started developing an approach to phonology that puts the modular nature of the architecture of language at the center of the theory, and that there is no phonetics in phonology. This entails that phonology must be purged from everything that makes reference to phonetics. This approach is thus called Substance Free Phonology (Reiss 2007, Hale & Reiss 2008, Reiss 2018), where substance refers to any non-phonological aspect of realization: reference to human anatomy, acoustic properties, perceptibility, salience...

Theories that allow for phonological computation/primes that refer to auditory or articulatory information, but also typological and markedness-based assumptions do what Hale & Reiss (2000; 2008) call Substance Abuse.

As an example of Substance Abuse, Hale & Reiss (2008: 164) refer to positional faithfulness constraints, such as the one proposed in Beckmann's (1997) analysis of Shona harmony. In Shona is active the process discussed in §II.3.1.2 as Canonical Bantu Lowering harmony, where mid-vowels in roots lower following high vowels in suffixes. Harmony is parasitic on rounding in that the front trigger /e/ lowers /i/ to [e], but fails to lower /u/ to [o]. On the other hand, /o/ lowers both /i/ and /u/ to [e] and [o] respectively.

Positional faithfulness constraints are meant to ensure that the first vowel of the root (which in Shona bears stress and defines the height degree of following vowels) is not subject to harmony. Beckman (1997) then proposes the constraints in (16a, b) as members of the universal constraint set in EVAL:

(16) Positional faithfulness constraints introduced in Beckmann (1997)

a. Ident-σ1 (hi): A segment in the root-initial syllable in the output and its correspondent in the input must have identical values for the feature [high].

b. Ident(hi): Correspondent segments in output and input have identical values for the feature [high].

Given a ranking such as |Ident-σ1 (hi)| > |*HIGH| > |Ident(hi)| (where |*HIGH| is a markedness constraint that disallows high vowels), high vowels would be allowed in the first syllable, and may not be allowed in other positions, since |*HIGH| is ranked higher than |Ident(hi)|. Beckman (1997) justifies the introduction of the positional faithfulness constraint referring to numerous psycholinguistic studies that support that word-initial material is more salient than medial or final material.

Hale & Reiss (2008) argue that such a constraint is unnecessary, because the saliency of word-initial material already accounts for the resilience of initial vowels without the need of integrating this fact within phonology via the introduction of a constraint.

They argue that children learning a language may fail to acquire a contrast between mid and high vowels in relatively short, quiet syllables (those that are non-initial and unstressed), but succeed in acquiring this distinction in initial syllables, which are stressed, longer and louder. On the other hand, it is highly implausible that an acquirer would consistently fail to correctly analyze the mid/high contrast in longer, louder (stressed) syllables, yet successfully analyze the contrast in relatively short, quiet syllables.

The existence of positional faithfulness phenomena can be understood as merely reflecting the nature of the learning situation and not a reflection of any grammatical principle. In their opinion "Since effects such as those observed by Beckman already have a coherent extra-grammatical account within

acquisition theory, building positional faithfulness into a theory of universal phonology is a misuse, or abuse, of phonetic substance in theory construction” (Hale & Reiss 2008: 166).

In sum, substance abuse is the practice of encoding phonetic-based explanations for phonological processes within grammar. SFP does not ignore the role of phonetics in phonology, but bans the insertion of the functional explanations in articulatory or perceptual phonetics within phonology, as ways to constraint computation.

The role of phonetics in shaping phonological systems is explored in the following section.

V.2.4 The origin of craziness: the life cycle of a phonological rule

Since the dawn of phonology as a discipline, it has been proposed that phonological processes derive from phonetic phenomena. Badouin de Courtenay (1895) first suggested that some aspects of the synchronic organization of grammars are caused by phonological change, and later scholars expanded upon this core idea (Vennemann 1972, Janda 1987; Bermúdez-Otero 2007; 2015).

Phonological alternations start as phonetic processes due to the intrinsic phonetic variation, which are grammaticalized and later may become subject to morphological conditions, to the point that they may become “lexical oddities” outside of grammatical control.

First phonetic phenomena enter the grammar through phonologization (Hyman 1976): phonetic effects can be enhanced and over time come to play a systematic role in the phonology of a particular language. Intrinsic phonetic variation may produce a non-canonical pronunciation of sounds in a given context. Often this variation follows from phonetic facts about articulation or perception. For example, front vowels are pronounced with the body of the tongue especially advanced, which may modify the way consonants preceding them are pronounced. The variation may be promoted to a grammatical status which means that the phonetic process is phonologized²⁰⁹.

To continue the example proposed above, the co-articulation caused by front vowels on preceding consonants may assume a grammatical status, and enter the grammar as a phonological rule (in this case a palatalization).

The domain of application of a process may shrink over time²¹⁰, to the point that a phonological process may become morphologized (i.e. a rule is reinterpreted as being conditioned by a particular grammatical category). Lastly, it may happen that the domain of application for the process narrowed to the point that alternations concern only a few lexical items. When this happens, a phonological process dies: the relation between alternating forms is reanalyzed as lexical (i.e. there are two lexical forms stored in the lexicon, and their relation is no longer anymore governed by phonology).

During this life-cycle, alternations become less and less regular. They apply in all contexts that satisfy the triggering conditions at the beginning of the life cycle, but adding morphological and/or lexical conditions subtracts more and more items from their influence. Phonological processes that were phonetically plausible (i.e. natural) may undergo modifications and become less plausible (i.e. crazy) as

²⁰⁹ There are currently two competing theories concerning the origin of innovation. Some argue that change happens upon language acquisition, i.e. children may misperceive a phonetic phenomenon as phonological, which become a phonological rule in the grammar of learners. The alternative, proposed by Labov, is that communities may foster a group identity by (among many other means) differentiating the way they speak.

²¹⁰ Bermúdez-Otero proposes a model of the life cycle that accounts for various internal steps, where phonological rules undergo what he calls “domain narrowing”, whereby phonological processes first apply across the board, then only within the word boundary, then within a stem. Morphologization is the final step of this domain narrowing. (Bermúdez-Otero 2015: §2.3).

time passes. This is the insight formulated by Bach and Harms (1972): there are crazy rules, yes, but they are not born crazy – they have become crazy while aging.

All phonological processes are subject to this cycle, the natural as well as the crazy processes. Chabot (2021:161) argues that during phonology, that is as soon as a process is phonologized, different phenomena may give rise to a crazy pattern.

The most common source of craziness is probably unconditioned sound change, where all occurrences of a sound in a language change to another sound. An example may be the alternations due to velar softening in English. Originally, the process of velar softening turned /k/ into [ts] when followed by /i/. /ts/ was substituted by /s/ by a sound change (i.e all instances of /ts/ in English changed into /s/). Alternations, however, were maintained, giving rise to the unnatural alternation /k/ → [s]/_i,

This is how unnatural phonological processes derive from their natural phonetic source. Crazy rules are not born crazy, since they follow from phonetics: they are always natural at birth. However, they may become crazy during aging.

This explains the fact that phonological processes can (and are) mostly connected to phonetics without presupposing an intrusion of phonetics into the cognitive module of phonology. Phonology does not differentiate between natural and crazy processes: phonology is (and must be) equally able to process both.

The correlation between phonological and phonetic processes is not due to an influence of phonetics in the cognitive module of phonology, but to the fact that phonological processes originate from phonetic ones. The life cycle of phonology also explains the way morphologized processes develop. In this view, crazy processes and morphologically conditioned processes follow from the same cause: the aging of a phonological rule.

It follows that phonetically crazy processes and processes with morphological conditions are to be considered just as plausible as any natural phonological process that follows from phonetic-based phenomena and applies in all expected contexts. The naturalness of a phonological process cannot be an evaluation metric to define whether a theory of phonology is adequate or not. Phonology must be able to account for both natural and unnatural processes, since their evolution follows the same path. Crucially, the reason why most processes are indeed natural is not a question that synchronic phonology has to answer. It is just an epiphenomenon of diachronic change.

Phonetics affects the genesis of a phonological process, and this is why we frequently find phonetically natural processes. This does not mean that we should import phonetic information into phonology, or that phonetic-based factors must be encoded within phonology to justify why some processes are natural. It simply means that since phonological patterns emerge from phonetic phenomena, it is more common to find phonological rules that correlate with phonetic processes rather than crazy phonological processes.

This serves as an argument against a possible criticism of SFP: if phonology is devoid of phonetics and phonetic-related aspects, why are the overwhelming majority of processes natural, well-behaved phonological processes? This is because phonetics affects the way phonological processes originate, not the way the phonological module computes them.

A theory of phonology should care about competence, and not about the typological patterns resulted from the interplay of phonetic influence and diachronic evolution of languages. The reason why some processes are more typologically frequent has more to do with phonetics and diachrony than linguistic competence. (Odden 2013b; Reiss 2018: 5, Hale & Reiss 2000: 162). Phonology, then, does not have to justify the absence of certain processes from the record, nor does it have to give a special status to

frequent and more plausible processes. The position held by SFP is that from the viewpoint of phonology there is no inherent difference between a natural and a crazy synchronic phonological process. Phonology must have the tools to account for both kinds of processes, which are assumed to be formally identical. It is not the (un)naturalness of a process that can dictate its phonological status.

A consequence of this position is that SFP is open to (and actually supports) overgeneration (Blaho & Rice 2014), i.e. models of phonology that are able to generate more than the patterns of alternation that are on the empirical record. As Hale & Reiss (2008: 3) put it, a theory of phonology should aim at explaining the phonological competence of humans, not at explaining the specific mechanisms that generate the set of attested languages.

The set of languages within the scope of phonological theory is by definition larger than the set of languages that are attested. Hale and Reiss (2008: 3) define the scope of phonological theory as the set of humanly computable phonologies, which comprehend and exceed the set of attested phonologies (e.g. the phonology of Italian, English, French, Yoruba, Camuno), and also the set of attestable phonologies, which is practically impossible to attest (e.g. the phonology of French spoken in 400 years from now, of Japanese 4.000 years ago, of Old Etruscan *etc.*). Cf. Chabot (2021: 50) for an overview on the subject.

Phonology is ‘a genuinely abstract framework’ (Fudge 1967) which should have as goal the explanation of phonological competence, and not of the attested phonological alternations. The focus of phonology, then is not to assess *why* a phonological process came into being (this must be searched through the lens of diachronic phonology), but *how* humans compute the sound patterns of languages.

V.2.5 Different ways of being Substance-Free

In sum, SFP is a theory of phonology that takes seriously the modular architecture of grammar, and thus disallows for any scrambling in vocabularies within the cognitive module of phonology. No substance is allowed, and no substance-based arguments can affect how phonological computation works. A phonological rule may add or remove primes or modify their values in any way, and the context of application of a rule can be anything and its reverse. Phonological computation is not required to account for typological generalizations, naturalness, markedness or any kind of substance.

On the side of phonological representation, all SFP voices agree that both the MPI and the PPI correlate incommensurable items. Consider the PPI: on one side there are the real-world properties of sounds (phonetics) and on the other there are the symbolic and discrete primes of phonology. A truly substance-free prime is by definition only symbolic, therefore instead of, say, [+round] other symbols could be used (α , β , 2, @, £, ♣ ...).

So much is shared among advocates of SFP. Difference arise when the specific behavior of the PPI and the nature of phonological primes are considered. Currently, two versions of SFP are entertained that both subscribe to the core ideas of SFP but differ in the way they assume the PPI works.

One approach assumes that there is a universal set of primes that is innate and thus provided by UG, and that the phonetic correlate of each prime is fixed (i.e. always the same cross-linguistically) and universal. This position is held at Concordia University (Bale et. al 2014; Bale & Reiss 2018; Hale & Reiss 2008; Hale, Kissock & Reiss 2007; Reiss 2018; Volenec & Reiss 2017; 2020) and will be referenced here as the “Concordia school approach”, or CSa.

The other approach considers phonological primes to be learned categories that have a free and arbitrary relation with phonetic substance. This is referred to here as Radical SFP (RadSFP). Thus, there is no universal or innate set of primes. Any phonetic category may be associated to any melodic prime: there are no cross-linguistically stable or innate associations. This is the position supported by Blaho

(2008), Boersma (1998), Boersma & Hamann (2008), Chabot (2021), Dresher (2014, 2019 partly), Hamann (2011), Iosad (2017), Odden (2022) Samuels et al. (2022) Scheer (2014, 2019, 2022) among others.

The main difference between the two approaches boils down to the treatment of phonological representation. While both sides agree that primes must be devoid of phonetic substance, the Concordia School approach argues that there is a one-to-one fixed connection between Substance Free primes and phonetic substance, and that primes are innate and part of UG. The Radical SFP approach, instead, aims to free the possible relations between phonological and phonetic objects, and define an interface between phonology and phonetics that is truly arbitrary. In this approach, primes are not universal or innate, but rather learned during L1 acquisition.

V.3 The Concordia School approach to Substance Free Phonology: fixed transduction

Proponents of the Concordia school approach were the first to argue that phonological computation is arbitrary, and that its workings are not grounded in functional tendencies. As already explained in §2.4, the motivation for a phonological process must be sought in the diachronic evolution of a phonetic phenomenon, and not in the context of phonological competence. The CSa differ from other SFP approaches in that it treats phonological primes as innate and universal, and assumes that they have a fixed, and not arbitrary, relation with phonetic categories.

Under §3.1 is presented the computational theory employed by the CSa. Section §3.2 discuss the possible classes of segments that can be individuated by CSa, and in the following paragraphs are presented the building blocks of CSa theory of representation: how the PPI works (§3.3) and why primes are innate (§3.4).

V.3.1 The CSa theory of phonological computation: Logical Phonology

The processing component proposed in the latest iteration of the CSa takes the name of Logical Phonology, and is a formal rendition of standard SPE-type phonological rules as set-theoretic operations. In Logical Phonology, phonological features (which are assumed to be binary, innate and universal) individuate sets of segments. A feature [+F] individuates the set of segments that contain [+F]. Segments are viewed as sets of sets: each segment contains the set of features that identify it. For example, the high vowel /i/ is the set of the following features: {[+high], [-round], [+back]}. In turn, each of those features individuate a natural class, i.e. set of segments. [+high] identifies the set of high vowels: {/i/,/u/,/y/,/ɨ/,/ɪ/,/u/..}.

Here the notion of Natural Class is still relevant, since (as we shall discuss in §3.2) segments belonging to an active class are required to share a property. As Volenec & Reiss (2020: 39) put it, Logical Phonology defines possible rules as functions that map sequences characterized by natural classes of segments to other sequences. In Logical Phonology a natural class is a set of segments defined by the general intersection of the segments of the class. For example, given the set of segments S: {/i/,/u/} the natural class that contains them is the general intersection (\cap) between the set of features of /i/ and the set of features of /u/.

(17) Finding a Natural Class in Logical Phonology

/i/: {-BACK, -ROUND, +HIGH}
/u/: {+ROUND, +HIGH, +BACK}

$$\cap \{i, u\} = \cap \{-\text{BACK}, -\text{ROUND}, +\text{HIGH}\}, \{+\text{ROUND}, +\text{HIGH}, +\text{BACK}\} = \{+\text{HIGH}\}.$$

The general intersection between the two sets /i/ and /u/ is thus {+HIGH}. This natural class contains all the segments identified by the feature [+HIGH].

Crucially, since a vowel such as /y/ is also a superset of the generalized intersection $\cap \{I, u\}$ (i.e. the set /y/ contains the same features of the intersection between /i/ and /u/, namely [+HIGH]), it follows that if a language has a rule that refers, to the vowels /i/ and /u/, the rule must apply equally to the vowel /y/ = {+ROUND, +HIGH, -BACK}. It also follows that if in some language a putative process affects /i/ and /u/ but not /y/, then that process cannot correspond to a single phonological rule (Volenec & Reiss 2020: 40).

The definition of phonological active classes that can be described by one single rule depends on the set of features assumed. Given the binary features [\pm BACK], [\pm ROUND] and [\pm HIGH] and the segments /i/, /u/ and /y/, we can identify a class {+HIGH, -ROUND} (which corresponds to /i/), a class {+HIGH, +ROUND} (which corresponds to /u,y/), a class {+HIGH, -BACK} /i,y/, and a class {+HIGH, +BACK}, which corresponds to /u/. With the given features, the class /u,i/ (excluding /y/) cannot be defined²¹¹.

If the class /i,u/ with the exclusion of /y/ were active in a language, the only option would be to assume the presence of two rules, one that involves the class {+HIGH, -ROUND} (i.e. /i/) and the other that involves {+HIGH, +BACK} (i.e. /u/).

Following Bale et al. (2014), proponents of the CSa discarded the traditional arrow that connects the target of a rule to its structural modification in standard SPE-like rule notation, which they replace with the operators of set theory (i.e. intersect \cap , unite \cup , subtract -...). Bale et al. (2014) argue that rules where features are added to the target (feature filling rules) can be rephrased as set unification (\sqcup ²¹²), and rules whereby a feature changes its specification (feature changing rules) are substituted with two operations, a rule of deletion (the feature specification is subtracted from the set) plus a unification. In sum, feature-changing rules are formalized as two subsequent rules, one that makes the set of targets underspecified for a feature value and another one that fills the underspecified segments with a new feature specification. Set Unification is formalized as under (18).

(18) Unification in Bale et al. (2014: 245)

- Unification \sqcup : For any two sets, A and B, the unification of A and B, $A \sqcup B$, is defined iff $A \cup B$ is consistent. When defined, $A \sqcup B = A \cup B$.
- Consistency²¹³: A set of features S is consistent if and only if there is no feature $F_i \in F$ (the universal set of features) such that $[+F_i] \in S$ and $[-F_i] \in S$.

In sum, Unification is the union of two sets provided that the operation does not result in both the positive and negative value of a feature belonging to the united set. Below is exemplified a process of palatalization active in Brazilian Portuguese, whereby coronal consonants /t/ and /d/ surface as [tʃ] and

²¹¹ One way to do the exclusion of /y/ but not /u/ would be this: {[+high, +back] OR [+high, -round, -back]}. This formulation requires to admit a logical operator OR in the identification of a natural class (i.e. the natural class would not be defined only as the intersection between two sets of features).

²¹² The symbol \sqcup indicates unification, which is slightly different from union, indicated by \cup , as shown in (18).

²¹³ Notice that the necessity to posit a condition on consistency follows only from the use of binary features. If unary primes were employed, all sets would be consistent.

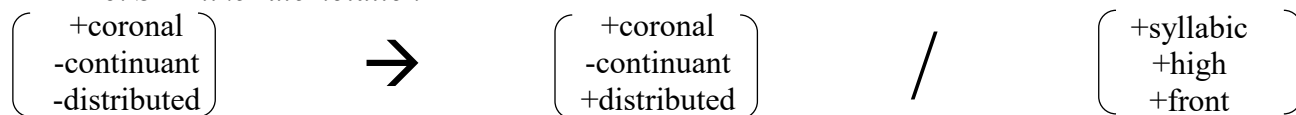
[dz] when followed by /i/. In (19a) are presented some alternations from Brazilian Portuguese. The correspondent rule is reported in (19b) using the SPE notation. Logical Phonology, as proposed in Bale et al. (2014) would re-write it as in (19c).

(19) Formalizing palatalization in Brazilian Portuguese using SPE-like rules and the set-theoretic operation ‘Unification’ (\sqcup)

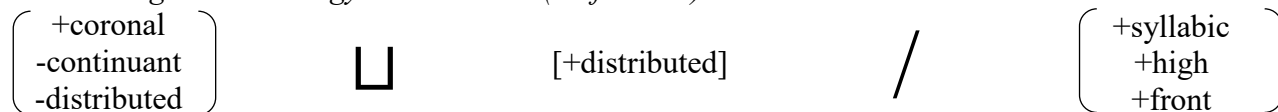
a. Alternations in Brazilian Portuguese

bato	‘I beat’	batʃido	‘beaten’
bater	‘to beat’	mandʒi	‘send IMP’
mandar	‘to send’		
mando	‘I send’		

b. SPE-like rule notation



c. Logical Phonology rule notation (unification)



Notice that the example in (19c) would not work, because it would end up as a segment containing both values of the prime [\pm distributed]. Volenec & Reiss (2020) propose a different operation, Priority Union. They argue that this operation has formal advantages over the operations proposed in Bale & al. (2014), as shown below in (20a). Both the operation of Unification and Priority Union disallow non-existent segments that contain both the positive and the negative value of the same feature. Priority Union is represented formally through the operators \cup_{\downarrow} and \cup_{\uparrow} . The arrow points from what Volenec & Reiss (2020) define as the strict set towards the defeasible set. The strict set is the set that takes priority over the defeasible set in the union operation: if the union between sets ends up being illicit (i.e. containing both the positive and negative value of a feature), the feature value contained in the defeasible set is eliminated, and the feature value contained in the strict set is kept. For example, given the priority union $A [+F, -G] \cup_{\downarrow} B [-F, +H]$, the illicit union between A and B (which contains both the positive and negative value of the feature [$\pm F$]) is solved selecting the value of [$\pm F$] contained in the strict set, which in this case is A. The outcome of the priority union between A and B is therefore $C \{+F, -G, +H\}$. (20a) defines the properties of Priority Union as a set-theoretic operation, while (20b) re-writes the rule of palatalization shown in (19) using priority union.

(20) Definition and property of the set-theoretic operation Priority Union

a. Definition of Priority Union

- For any two sets A and B, their priority union $A \cup_{\downarrow} B$ is the set of valued features that are in A and the set of valued features in B whose opposites are not in A (Volenec & Reiss 2020: 42).

b. Logical Phonology rule notation (Priority union)

$$\left(\begin{array}{l} +\text{coronal} \\ -\text{continuant} \\ -\text{distributed} \end{array} \right) \leftarrow \cup \quad [+ \text{distributed}] \quad / \quad \left(\begin{array}{l} +\text{syllabic} \\ +\text{high} \\ +\text{front} \end{array} \right)$$

Priority union allows for a single formulation for both feature filling and feature changing rules, while unification only accounts for feature filling rules. Consider the case of devoicing in Turkish presented in Bale et al. (2014: 244). Inkelas (1995) analyses Turkish as having a three-way underlying consonant contrast: The segment /d/ is a voiced coronal stop, /t/ is a voiceless coronal stop, and /D/ is a coronal stop with no specification for voicing. /t/ and /d/, which are fully specified, surface as unchanged in codas, while /D/ surfaces as [t] in codas and as /d/ in onsets. Alternations from Turkish are presented in (21a). Instead of phrasing the devoicing rule as in (21b), Bale et al. formalize it using the unification rule in (21c).

(21) Formalization of devoicing in codas in Turkish with set-theoretic operations

a. Devoicing in Turkish (Inkelas 1995: 778f)

	Root	Derived Form	
/t/ {+COR -CONT -SON -VOICE}	at	at-i	'horse acc.'
	at	at-ar	'throw' imperative imperfective
/d/ {+COR -CONT -SON +VOICE}	ad	ad-lar	name PL
	ød	ød-ler	'gall PL'
/D/ {+COR -CONT -SON}	dørt	dørd-u	'four possessive'
		dort-ler	'four PL'

b. Formalization of devoicing in codas with SPE-like rules

$$[\emptyset \text{VOICE}, + \text{CORONAL}, - \text{CONTINUANT}] \rightarrow \{- \text{VOICE}\} / \text{ in Coda}$$

c. Formalization of devoicing in codas in Bale et al. (2014: 244)

$$[+ \text{COR}, - \text{CONT}, - \text{SON}] \sqcup \{- \text{VOICE}\} / \text{ in Coda}$$

The formalization under (21c) makes sure that /d/ and /t/, which are individuated by the set of features {+COR,-CONT,-SON} but also have a specification for [±VOICED], keep their specification for this feature. Recall that the operation 'unification' (\sqcup) applies only if the operation is consistent (cf. 18), which means that it should not result in a segment that contains both the positive and the negative value of a feature. For the underspecified segment /D/, unification inserts the feature [-VOICE], yielding [t]. For the segment /t/, specified for [-VOICE], unification vacuously inserts the feature [-VOICE], yielding [t]. For /d/, specified for [+VOICE], unification does not apply because the condition for consistency is not met, and thus underlying /d/ remains unaffected.

The same can be done using the Priority Union operator \cup introduced in Volenec & Reiss (2020), as shown in (22).

(22) Formalization of final devoicing in Turkish with Priority Union

$$[+ \text{COR} , - \text{CONT} , - \text{SON}] \cup \{- \text{VOICED} \} / \text{ in Coda}$$

The operation “/d/:{+ COR , - CONT , - SON, +VOICE} \cup {- VOICE} / in Coda” does not apply because Priority Unification prioritizes the set of the target (i.e the target is the strict set), hence the [+VOICE] feature contained in the set /d/ takes priority over the negative value of the feature that should be added. The rule “/t/:{+ COR , - CONT , - SON, -VOICE} \cup {- VOICE} / in Coda”, applies vacuously because [-VOICE] is already part of the set of the target. The formulation in (22) then, manages to capture that only the underspecified /D/ undergoes the process: in this case, the target is underspecified for the feature [\pm VOICE], and assumes the negative value [-VOICE].

Given a process such as Turkish devoicing, both the unification approach and the one based on priority union work the same. Unification easily formalizes feature filling processes (i.e. processes that add a feature value [+F]/[-F] to sets of segments that lack a specification for [\pm F]). However, this formulation is not enough to represent feature-changing rules, i.e. processes that turn a segment specified for [+F] or [-F] into a segment specified for [-F] or [+F] respectively.

Let us take a case of final devoicing as it appears in languages such as German, Polish and Russian, assuming that the underlying stops in these languages are fully specified for voicing. Bale et al. (2014) utilize two operations to account for this state of affairs: first, a deletion process eliminates any specification for the feature [\pm F] from the target. Then, another unification operation applies.

In the example under (23) first, the feature specification [+VOICE] is deleted from the set of targets (23a). Then, segments unspecified for [\pm VOICE] assume the feature [-VOICE] (23b).

(23) Devoicing rule split into two operations (Bale et al 2014: 246)

a. *Deletion:*

$$[+\text{CORON} , -\text{CONT}, +\text{VOICE}] - \{+\text{VOICE} \} / \text{ in Coda}$$

b. *Insertion:*

$$[+\text{CORONAL} , -\text{CONTINUANT}] \sqcup \{-\text{VOICE} \} / \text{ in Coda}$$

The approach from Volenec & Reiss (2020), instead, utilizes only the notion of Priority Union. The sole necessary rule for the application of devoicing is shown in (24).

(24) Priority Union accounts for devoicing with a single operation

$$[+\text{COR}, -\text{CONT}] \downarrow \cup \{-\text{VOICE}\} / \text{ in Coda}$$

The rule in (24) is formally identical to the rule in (22) except for one aspect. Here the priority union identifies as the defeasible set the set of targets, and gives to the set of triggers the status of strict set. The negative value of the feature [\pm VOICE] takes precedence, so that eventual occurrences of [+VOICE] in the target are overwritten by [-VOICE]. This means that consonants specified as [+COR,-CONT] receive the [-VOICED].

Logical Phonology can take any set individuated by feature intersection and operate over it using the formal tools of set theory. As far as I am aware, a full list of the possible computational operations that are possible in phonology has not been given. For now, only the priority union operation, which

substitutes the operation of unification (Bale & al. 2014) is discussed in detail in the recent literature, but nothing prevents other operators from being proposed: e.g. a subtraction may remove a feature entirely, resulting in an underspecified surface representation. Crucially, there is no formal limitation to the sets that can appear as targets or triggers. Any natural class may be selected as a target, and any natural class can be determined as a trigger. In this sense, phonological processing has no formal limitation, aside from the ones that derive from the mathematical possibilities of Set Theory.

This means that there is no structural modification that this model is unable to formalize: any class can be mapped onto any other class. Thus, crazy rules of the 3rd and 4th type (cf. §1.2) are permitted by this model of phonological computation, as crazy as they might be.

Logical Phonology has no limitation on what a possible computation is. However, not just anything can be a (natural) class of triggers or targets. Due to the universal phonetic correlates that Logical Phonology implements, some sets of segments cannot be described as a “set of a set of features”. Volenec & Reiss (2020: 28) explicitly say that “if a statement cannot be made in terms of natural classes, then that statement is not a rule”. This dismisses the core argument of Emergent prime theories, which assumes that active classes of segments follow from processes, and not the other way around. In the following section the issue is explored in detail.

V.3.2 CSa identifies some but not all unnatural classes

Logical Phonology can represent crazy structural modifications, i.e. crazy rules of the 3rd and 4th type. Any natural class may be mapped onto any other natural class. What about crazy rules of other types? In §1.2 we defined crazy classes of the 1st and 2nd type as based around unnatural, crazy classes of segments. We also argued that asymmetric harmonies operate over active classes that do not correspond to the expected class. Logical Phonology lacks the representational tools to individuate some unnatural classes or some specific sub-classes, as shown above with the example of high vowels. In the outset of §3.1 it was shown how the class of high vowels /i,u/ could not be identified without also including the segment /y/. In other words, there are classes that can be identified as natural classes and other that cannot. Depending on the set of primes used, some groups of segments in a phonological system can be identified as a natural class, while others cannot. Crucially, CSa does not offer a definitive set of primes, but states that UG provides a set of innate and universal primes (in §3.3 is shown why their correlation with phonetics is also innate and universal), which individuate natural classes.

Regarding the set of features to be employed (and thus the possible classes over which Logical Phonology may operate), Volenec & Reiss (2020: 30) assert that “research on features is not complete, any more than research on genes is complete.” Even the binary status of primes, as well as underspecification (the assumption that features can be valued ‘+’, ‘-’ or be absent from a segmental representation) is open for discussion. The set of primes is not established once and for all, so all the discussions that may be had about the kinds of classes that a rule may affect remain susceptible to variation, depending on the set of primes assumed.

I argue that the kind of classes CSa is able to identify as a Natural Class depends on the features employed. CSa can indeed identify rather crazy classes of sounds, but may fail to identify others. For the sake of the argument, let us take the system of segments of Bresciano (cf. §III.3.2), reported in (25) below.

(25) Phonological segments of Bresciano

Consonants of Bresciano

p b		t d		k g
	f v	s z	ʃ	
			tʃ dʒ	
m		n		ɲ
		l r		
w				j

Vowels of Bresciano

i	y		u
e	ø		o
ɛ			ɔ
		a	

Rules can only reference natural classes, which depend on the set of features employed by the theory. As discussed earlier, CSa does not provide a set of primes, but normally employs features derived from SPE. Given the system above, some phonetically crazy classes could be identified as natural classes. For example, a putative class such as {- SYLLABIC,+VOICED, -LABIAL, -CORONAL} would identify a class of segments which comprises {v,g}. Another possible class that can be referenced by a rule in Logical Phonology may be the rather crazy class {-NASAL, +CONTINUANT, -ROUND, -HIGH}, which would identify {f,v,s,z,ʃ,e,ɛ,a}.

The concept of natural class in CSa has nothing to do with phonetics. Any set intersection may, in principle, be identified, no matter how phonetically unnatural it is. In CSa, Natural Class indicates any class of segments that can be referenced by a rule, i.e. any class of segments that can be identified as the intersection of the set of features. However, not all conceivable sets of segments can be called a natural class.

For example, still assuming the system in (25), a set comprising {k,g,ʃ} and no other consonants could not be the target (or the trigger) of a single phonological rule, unless some feature is added to the set of SPE features. Similarly, the class {i,u} (excluding /y/) cannot be referenced by Logical Phonology as a natural class that participate in a single rule, as discussed above.

The CSa, then, is not unable to identify unnatural classes of segments, but can only identify those unnatural classes that are allowed by the set of features employed (indeed much like old SPE).

The issue concerns processes where unnatural classes that cannot be identified using standard feature sets act as active classes. It is an empirical question whether the active crazy classes of crazy processes of the 1st and 2nd group can actually be represented by what CSa would define as a natural class. However, the possibility to do so varies as the feature theory employed varies.

Let us take as an example the class of triggers of /m/-place assimilation in River West Tarangan (Nivens 1992: 219, Mielke 2008: 121). Recall from (3) that in this language /m/ undergoes place assimilation to a following /t̚ g s j/, but no other segments. Above, this case was presented as a crazy rule of the second type, whereby a process is triggered by an unnatural set of triggers. This specific class cannot be identified by traditional binary features employed in Jakobson et al. (1952), SPE, or Unified Feature Theory (Clement & Hume 1995). I assume that the same goes for CSa, which cannot write a

single rule that selects as triggers the active class /t̥ g s j/. For the sake of the argument, the consonants of River West Tarangan are shown again in (26a), and the alternations in (26b).

(26) River West Tarangan phonology (Nivens 1992: 219; Mielke 2008: 121)

a. Consonants in River West Tarangan.

	t̥			k
b		d		g
ɸ		s		
m		n		ŋ
		r		
		l		
			j	

b. Place assimilation of /m/ in River West Tarangan.

/m/ assimilates before / t̥ g s j/			/m/ fails to assimilate in other contexts		
/bimtem/	[bintém]	'DUP small'	/jerkimkam/	[jerkimkam]	'DUP NF dislike'
/jergingum/	[jergingum]	DUP NF rub'	/dimdumdi/	[dimdumdi]	'DUP six PL
/simsimə/	[sinsimə]	'ant (sp)'	/nimnam/	[nimnam]	'berry (sp)'
/ɸaɸamjəmnə/	[ɸaɸanjəmnə]	'overcast 3s'			
/simsimər/	[simsimər]	'DUP east'			

While the class /t̥ g s j/ cannot be identified as a natural class, CSa can still formalize the state of affairs of River West Tarangan assuming multiple rules²¹⁴, as shown below. Mielke (2008: 122) himself notices that assimilation to /t̥/ is obligatory, while assimilation to /g s j/ seems optional. It remains true that the class /g s j/, with the exclusion of /t̥/, is still an unnatural class. With that being said, if the alternations in (26b) were represented using multiple rules, no generalization is drawn from the observation that the rules affect the same target, or that we are facing a single phonological process. Four different rules would have to be posited, such as those shown in (27).

(27) Rules of /m/ place assimilation formalized in Logical Phonology

- [+NASAL, +LABIAL] ɛ U [+CORONAL]/__ [+CORONAL, +ANTERIOR, -VOICED]
- [+NASAL, +LABIAL] ɛ U [+CORONAL]/__ [+CORONAL, +ANTERIOR, +STRIDENT]
- [+NASAL, +LABIAL] ɛ U [+CORONAL]/__ [+CORONAL, +ANTERIOR, +SONORANT]
- [+NASAL, +LABIAL] ɛ U [+VELAR]/__ [+VELAR, +VOICED]

²¹⁴ Samuels et al. (2022: 16) treat the same issue, and argue that such a solution should not work in CSa. They report from Reiss (2018) that children can only formulate rules that refer to the featural intersection of the segments that participate in the observed alternation (i.e. rules operate only on natural classes). They thus argue that the four-rule analysis is unavailable because it is not a learning strategy provided by UG. They go on and suggest that “in such a scenario the child must have some way to retreat from overgeneralizing and revert to multiple rules. Perhaps, upon realizing that feature intersection would predict the participation of other [+consonantal] segments known not to participate, the child avoids doing so” Samuels et al. (2022: 16).

Logical Phonology has, then, the means to also formalize crazy rules of the 1st and 2nd type. Either the crazy class is identifiable as a natural class, or multiple rules may be posited so that the same process applies in multiple triggering contexts. In theory, however, if a hypothetical feature that has a correlation with some phonetic properties shared by /t̥ g s j / (and not other consonants) were to be found, the process could be easily identified as a natural class. The issue with those rules (which can still be circumvented by positing multiple rules) may also be solved by employing a different set of primes. Until a complete set of primes is selected, this issue remains open.

In §1.3 it was argued that asymmetric and parasitic harmonies may be viewed as crazy processes of the 5th type, where a process applies to (or is triggered by) a class of segments that is unexpected given the structural modification. Only a subset of the expected triggers may trigger a process, or only a subset of the expected targets may undergo the process.

Given that natural classes are formalized as simple subsets of sets, Logical Phonology may easily formalize an asymmetric process of raising as SPE did, simply posing stricter requirements to the set of triggers or targets. Take as an example the case of Bergamasco, where raising does not apply to front mid-vowels (cf. §III.7.3, and also table 6 above). Here, only [+ROUND] vowels are targets of the process, as exemplified in (28).

(28) Bergamasco raising harmony in Logical Phonology

a. Height alternations in Bergamasco

Rounded vowels	[ˈgodʒa]	‘needle’	[guˈdʒi]	‘needle DIM’
	[meˈcore]	‘I run’	[oter cuˈri]	‘you run PL’
	[øtʃ]	‘eye’	[yˈdʒi]	‘eye DIM’
Non-rounded vowels	[poledər]	‘foal’	[poleˈdri]	‘foal DIM’
	[meˈlese]	‘I read’	[leˈsit]	‘read’

b. Formalization of the rule of raising in Bergamasco

$$[+ROUND] \leftarrow \cup [+HIGH] / _ C_0[+HIGH]$$

This rule unites the two sets of features so that all rounded vowels receive the height specification of the following [+high] vowel. Vowels that are already high undergo vacuously this process, while mid-rounded vowels raise. The operator for Priority Union in this case indicates [+HIGH] as the strict set, therefore ensuring that all [-HIGH] specifications will be substituted by [+HIGH] in rounded vowels.

A similar strategy can be applied when the asymmetry is in the set of triggers.

It appears that asymmetric harmonies are easy to represent with the tools of Logical Phonology.

Parasitic harmonies offer a different case, one which I argue can only be formalized by applying two rules to different sets of vowels. Parasitic harmonies do not display a fixed set of targets and triggers, but the set of targets varies depending on the trigger, and vice versa. In Camuno, for example, /e/ raises only if followed by /i/, while rounded mid-vowels raise when followed by any high vowel. The process applies in the same way to rounded and non-rounded vowels (a [+HIGH] feature is added to the set of targets), but there is no way to represent the behavior of rounded triggers to apply the process only to rounded mid-vowels, or to represent the behavior of non-rounded vowels of being targeted only by non-rounded high vowels.

Each rule maps strings of phonological segments (identified as a natural class) to other strings of segments (identified as a natural class). In sum, a rule maps one natural class onto another. The issue

with parasitic harmonies is that they involve not two, but four active classes of segments. There are two classes of targets {e,ε} /{o,ø,ɔ} and two classes of triggers {i}/ {i,u,y}. I argue that Camuno must be represented using two rules because, by definition, a rule maps one set of segments to another set, and here we have four sets, not two.

The two rules that may be posited in Logical Phonology to represent the parasitic harmony of Camuno are shown in (29). (29a) accounts for raising of /e/, which triggers only when a [-ROUND] high vowel follows. (29b), instead, accounts for raising of rounded vowels, which triggers whenever any high vowel follows.

(29) Camuno raising harmony rule in Logical Phonology

a. *Raising of front non-rounded vowels*

[+HIGH,-ROUND] \leftarrow U [+HIGH]/__C₀[+HIGH] [-ROUND]

b. *Raising of rounded vowels*

[+HIGH,+ROUND] \leftarrow U [+HIGH]/__C₀[+HIGH]

This account resembles the one discussed in §IV.4 and proposed by Nevins, whereby two different rules are posited to account for parasitism. Notice that in this case all the classes involved in the process can be identified as natural classes. {+HIGH} vowels trigger raising of {-HIGH+ROUND} vowels, while {+HIGH, -ROUND} vowels (i.e. only /i/) triggers raising of {-HIGH, -ROUND, -LOW} /e,ε/.

The issue is similar to the one discussed for River West Tarangan (and that may be repeated for every unnatural class proposed in Mielke 2008). Logical Phonology has the means to represent both process in phonology as multiple rules. However, it lacks a way to group them in a single statement, even though the process applies in the same manner.

Features are innate, and their relation with phonetics is also innate and universal (as discussed below). Therefore, the way in which the process externalizes (as raising, in Camuno, as place-assimilation in River West Tarangan) informs the way in which phonological processing formalizes it (e.g. as priority union of [+HIGH] in Camuno, as priority union of [+CORONAL] or [+VELAR] in River West Tarangan). The set of features used defines both how the process is formalized and the classes of segments that can be referenced in a single rule. The following issue remains: why does a process that operates in a given way (in the case of Camuno the prime [+HIGH] is added to the set of primes of mid vowels) require two rules to be formalized?

Cases such as River West Tarangan may be reduced to a single rule if a hypothetical feature theory, one that may have a feature able to identify the triggers of /m/ assimilation, is employed. Camuno, instead, requires an analysis based on two operations, even though the structural modification caused by the process is by definition the same, in a theory that employs innate and universal primes (i.e. raising).

In sum, the Concordia School approach proposes a model of phonological computation (Logical Phonology) that is able to map any set identified formally as a natural class to any other set of segments. Rules can only refer to some specific classes, which follow from the set of features employed. Some unnatural classes and parasitic harmonies cannot be represented as a single phonological rule, but require a formalization based on multiple rules.

V.3.3 The Csa theory of the Phonetics-Phonology Interface

Phonological representation, at least on what concerns melodic primes²¹⁵, is based around binary features, which for the CSa are innate, and to have a one-to one non-arbitrary correlation to phonetics. Volenec and Reiss (2017: 272) go as far as to say that "*all recurrent or linguistically relevant differences in pronunciation*" must have a different underlying representation, i.e. different feature specifications.

This is not to say that phonological primes are intrinsically phonetic, as it was suggested in §1.1, but rather that the interface between phonetics and phonology, the correlation between primes and their phonetic exponence, is universal, fixed and innate.

To sum up, phonological processing is limited only by the set theory formalism, and is truly “substance free”, in that considerations about markedness, typology, articulation and audition do not affect it. Phonological representation is, on the other hand, not arbitrary since the relation between phonological and phonetic objects is universal and innate. Features are formally substance free but in practice, they are constrained by the substance they are related to. As Hale & Reiss (2008: 171) put it,

“It is only the treatment of phonological representations within the computation that is arbitrary. Articulatory and acoustic substance are related to the representation we construct, but not within the grammar”

Hale et al. (2007) proposed a first attempt at a SFP-based theory of the interface between phonetics and phonology, which was later developed in Volenec & Reiss (2017, 2020), where is presented a more detailed theory of the production interface.

Hale et al. (2007) argue that phonological representations need to be transduced into two different forms: an articulatory form that can be interpreted by the neuromuscular system associated with speech production, and an acoustic form, which can be interpreted by the system of speech perception. The authors assume that the mechanisms of transduction that regulate production and perception must be different, and therefore a distinct treatment of transduction-for-production and transduction-for-perception is necessary (contra Boersma & Hamann 2008, Hamann 2011, cf. §4.4). Those mechanisms are assumed to be innate and identical in all humans, in other words, they are provided by UG. Since features cannot be learned (as argued in §3.4), their relations with the physical world must also be innate. Some measurable differences in the production of transduced feature matrices is, however, to be expected. These differences may arise from various sources:

- The interplay between the transducers of different features within the same feature matrix as well as co-articulatory effects. In Volenec & Reiss (2017: 25) those phenomena are referred to as Intrasegmental and Intersegmental Coarticulation respectively.
- Physical differences between speakers in the articulators (size and shape of the oral cavity etc...)
- External forces implicated in production (external air pressure)

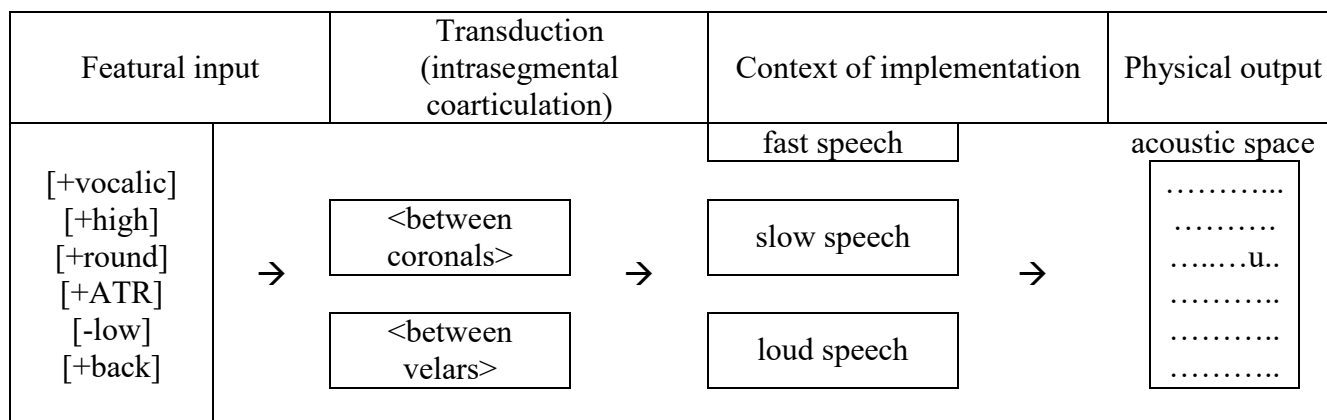
As a result, the transduction for a particular phonological representation will correspond to different physical instantiations anytime a segment is transduced, which nevertheless falls within a well-defined acoustic space.

The authors do not give specifics on the definition of this acoustic space. They choose this definition over the term “target”, which may suggest that a transduction may “miss” (target over- and undershoot).

²¹⁵ Scheer (2022) notices that most of the literature concerning SFP treats melodic processes rather than processes that involve syllabic and structural matters. In his view, this follows from the fact that crazy patterns exist only in the melody, and do not affect higher levels of phonological representation, such as syllables, CV units etc...

They also assume that there may be some overlap between the acoustic spaces of distinct feature bundles, due to performance-based factors such as speech rate and coarticulation. In (30) are schematized the steps of phonetic implementation, i.e the operation of transduction that goes from phonology to phoentics. The input in terms of binary features is sent to the interface, where coarticulation effects may modify the outcome of transduction. The context of implementation can also affect the way a sound is produced. At the end, the result will be within some defined acoustic space.

(30) Transduction and the acoustic space: Hale et al. (2007: 5)



Hale et al. (2007) argue that if the variation of the outcome of transduction falls within this acoustic space, this variation is not related to phonology, and is referred to as micro-variation. All the causes of this micro-variation, in fact, concern the performative aspect of speech, and have nothing to do with competence.

When the outcome of transduction falls outside of the expected acoustic space, instead, this variation is assumed to be related to the phonological representation²¹⁶. This means that any difference in the pronunciation of the same segment cross linguistically, say /i/ in German and /i/ in English, derives from a difference in the feature specification that undergoes transduction.

It is unclear, however, how we could define whether a variation is only a matter of phonetics or if, instead, it is reflected in phonology. In other words, how can we be sure that a variation qualifies as a micro-variation (and is thus not relevant for phonology) or as a phonologically relevant variation?. The crucial notion appears to be that of acoustic space, which is not defined specifically in Hale et al. (2007). What is clear is that variation within this space has been defined as micro-variation, and does not reflect a change in the feature specification of segments. Variation outside of this space is due to phonology, and reflects a difference in feature specification. However, how can we define the exact nature of such acoustic space? Without this knowledge, we cannot be sure whether the German /i/ and the English /i/ fall within the same acoustic space or in different acoustic spaces.

The theory of the PPI of the CSa is further expanded in Volenec & Reiss (2017), in a model of the Phonetics-Phonology Interface the authors call Cognitive Phonetics. Cognitive phonetics is presented as a more complete theory of the interface that deals with production, which maps phonological

²¹⁶ The only exception to this arises if this variation derives from underspecification in the surface form. For an example, consider the case of Marshallese, treated briefly in Hale et al (2007): 10 and at more length in Hale & Kissock (2007).

representations to neuromuscular instructions, which are then interpreted by the sensorimotor system. The transduction related to perception (which, recall, the authors assume must be distinct from the one related to production) has not yet been developed in the same manner.

The mapping between the phonological representation and the neuromuscular instruction consists of two different algorithms that do different things. The first algorithm, the Paradigmatic Transduction Algorithm (PTA) takes features and relates them to a sensomotory instruction which specify the muscles that must be contracted in order to produce the right acoustic effect. The second algorithm, the Syntagmatic Transduction Algorithm (STA), organizes the activities specified by the PTA on a temporal level. Simply put, PTA assigns muscular instructions to features and STA orders those same instructions temporally.

The ordered instructions resulting from this double transduction are then fed to the sensomotory system that actually produces the sound. The two algorithms work considering both the direct translation of specific features into instruction and the interplay between different instructions. Volenec & Reiss (2020: 50) exemplify the case of two surface forms: [luk] and [lok].

The PTA takes a segment, scans its feature composition and determines the required muscular activity for the realization of every feature. In the case of the two rounded vowels in the given forms, the authors concentrate on the interplay between the feature [+round] (shared by both vowels) and [+high] and [-high], which characterize respectively [u] and [o]. The interaction between different features of a segment result in a different transduction for the same feature [+round]. Simply put, PTA accounts for the difference in roundness between the two vowels by assigning a different neuromuscular instruction to a feature depending on the intrasegmental coarticulation, and the interplay between different features within a segment say what the result is: u will be more rounded because co-articulated with +high, and o will be less rounded because of -high.

The STA, instead, extends the neuromuscular instruction related to the [+round] feature (which, due to the PTA, is different in [u] and [o]) to neighboring segments, accounting for coarticulative effects: the pronunciation of [l] in the two sequences differs because PTA assigned to the [+round] feature a slightly different instruction, and this instruction interplays differently with the instructions related to [l].

In the authors' view, Cognitive Phonetics assigns the same neuromuscular schema (the same instructions) to each feature every time that feature is sent to transduction. Notice however, that what is actually pronounced is not precisely correspondent with the outcome of transduction. The output of Cognitive Phonetics is further complicated in the process of externalization by other performance factors. For example, loudness, fatigue, slow or fast enunciation, and many other situational effects may affect the final output. As established in Hale et al. (2007), all those different outcomes are subject to possible micro-variations.

Both PTA and STA are assumed by the authors to be universal properties shared by all humans. In the assumption of the authors, then, the interface between phonetics and phonology will work the same for each speaker of each language.

It remains to be worked out which are the features to which PTA assigns a neuromuscular instruction. In other words, which is the right set of primes of phonology. As we have discussed in §3.2, CSa does not have a definitive answer. Volenec & Reiss (2020: 54) argue that feature specification should be detailed enough to account for all meaningful variation, but also that a set of 30 primes combined with the notion of surface underspecification can produce 206 trillion distinct segments, which are more than enough to encode all possible recurrent articulatory patterns.

Volenec & Reiss (2017: 21) reject any notion of language specific phonetics, i.e. of a possible phonetic computational module that may operate differently for different humans. In their view, the transduction carried out by Cognitive Phonetics (which is crucially not a module but an interface) is the bridge from the symbolic to the physical, relating the substance-free (phonology) to the substance-laden (physiological phonetics) (Volenec & Reiss 2017: 15).

V.3.4 Why features must be innate: the card argument

The Concordia School maintains as the Null Hypothesis the idea that features are given by UG. They strongly disagree with the proposals that phonological primes can be learned because in their view there must be some innate basis for learning: in a computational theory such as phonology, learning can only take the form of a novel configuration of primitives already available. Simply put, a category cannot be learned from nothing or, as Hale & Reiss (2008: 38) put it, “*Ya gotta start with something*”.

This position is explained through an example, the Card Argument, first presented in Hale & Reiss (2003: 219ff) and re-proposed in Hale & Reiss (2008: 31ff), which exemplifies how a generative grammar that lacks an initial set of primes cannot parse meaningful information.

In the explanation below I will refer to cards by indicating the number (or the symbol) of the card (A,2,3,4,5,6,7,8,9,10,J,Q,K) and the suit (♥♦♣♠) between pipes. Therefore, for example |2♠| represents the 2 of spades and |Q♥| represents the queen of hearts etc...

Hale & Reiss (2003; 2008) explore various Card-UGs, each with a different set of primes and operators. A sentence (or in this toy example a card from a standard deck) is grammatical with respect to a grammar G if and only it satisfies the conditions imposed by G. Card UG defines what can be parsed as linguistically meaningful, G defines what is grammatical.

Their argument goes as follows: without a rich representational inventory already available within UG, speakers would not be able to parse linguistically meaningful sounds. In the first example they propose, Card-UG1 contains the primitives # (which corresponds to any number on a card from 2 to 10) the suits (♥♦♣♠) and the operator |AND| (i.e. two items can co-occur).

A first Card-grammar G1 is characterized as G1=[#]. G1 treats as grammatical all cards containing a number. |2♦|, |8♠| and |5♣| are all grammatical, while cards like |Q♦| or |J♣| are ungrammatical. This is because queen and jack are not numbers, and G1 considers as grammatical only cards with numbers. In (31) below are reported some examples of grammatical and ungrammatical cards for G1, as well as the way cards are represented within G1. The way they are represented (their underlying representation, if you will) strictly depends on the content of UG, and it is not affected by the Card Grammar G1. Cards such as |5♦| and |9♦| will receive the same representation (which is put between slashes in the table) /#♦/, where the symbol # represents any card number. |Q♥| is ungrammatical, and receives the representation /♥/. The symbol for queen “Q” is absent from UG, so it cannot be parsed.

(31) G1 given Card-UG1 in Hale & Reiss (2008) card argument

Card-UG1 = # AND ♥♦♣♠		G1 = #	
Cards:	Grammatical / Ungrammatical	Representation	
3♣	Grammatical	/#♣/	
6♦	Grammatical	/#♦/	
K♠	Ungrammatical	/♠/	
10♣	Grammatical	/#♣/	
Q♥	Ungrammatical	/♥/	

Notice that given the content of Card-UG1, different cards, such as $|3\clubsuit|$ and $|10\clubsuit|$ in the example, receive the same representation: $/\#\clubsuit/$. In the card-metaphor, their specific number, which is absent from Card-UG1, is not parsed.

A grammar G_2 (under 32), given the same Card Universal Grammar UG1, is characterized as $G_2 = \# \text{ AND } \diamond$. G_2 treats as grammatical only items that have a number and the suit of diamonds. Within such a grammar, $|9\diamond|$ $|5\diamond|$ and $|2\diamond|$ are grammatical, while $|8\heartsuit|$ and $|5\spadesuit|$ are ungrammatical. As it was the case for Card-G1, cards containing pictures and non-numbers are ungrammatical.

(32) G_2 given Card-UG1 in Hale & Reiss (2008) card argument

Card-UG1 = # AND $\heartsuit\clubsuit\spadesuit$		G2 = # AND \diamond	
<i>Cards:</i>	<i>Grammatical / Ungrammatical</i>	<i>Representation</i>	
$ 3\clubsuit $	Ungrammatical	$/\#\clubsuit/$	
$ 6\diamond $	Grammatical	$/\#\diamond/$	
$ K\spadesuit $	Ungrammatical	$/\spadesuit/$	
$ 10\clubsuit $	Ungrammatical	$/\#\clubsuit/$	
$ Q\heartsuit $	Ungrammatical	$/\heartsuit/$	

A third grammar $G_3 = \spadesuit$ will treat as grammatical all cards within the suit of spades. $|K\spadesuit|$ and $|7\spadesuit|$ are both grammatical while $|J\clubsuit|$ and $|8\heartsuit|$ are ungrammatical.

(33) G_3 given Card-UG1 in Hale & Reiss (2008) card argument

Card-UG1 = # AND $\heartsuit\clubsuit\spadesuit$		G3 = \spadesuit	
<i>Cards:</i>	<i>Grammatical / Ungrammatical</i>	<i>Representation</i>	
$ 3\clubsuit $	Ungrammatical	$/\#\clubsuit/$	
$ 6\diamond $	Ungrammatical	$/\#\diamond/$	
$ K\spadesuit $	Grammatical	$/\spadesuit/$	
$ 7\spadesuit $	Grammatical	$/\#\spadesuit/$	
$ Q\heartsuit $	Ungrammatical	$/\heartsuit/$	

Lastly, consider a fourth grammar G_4 (34), which has no internal requirements so that $G_4 = 0$. All cards in the standard deck would be considered grammatical, except for something like a joker card, or a tarot (Hale & Reiss 2008: 33).

(34) G_4 given Card-UG1 in Hale & Reiss (2008) card argument

Card-UG1 = # AND $\heartsuit\clubsuit\spadesuit$		G4 = 0	
<i>Cards:</i>	<i>Grammatical / Ungrammatical</i>	<i>Representation</i>	
$ 3\clubsuit $	Grammatical	$/\#\clubsuit/$	
$ 6\diamond $	Grammatical	$/\#\diamond/$	
$ K\spadesuit $	Grammatical	$/\spadesuit/$	
$ 7\spadesuit $	Grammatical	$/\#\spadesuit/$	
$ Q\heartsuit $	Grammatical	$/\heartsuit/$	

In all the examples proposed, the representation of cards does not change: this is because the Card-UG was assumed to be the same for all different grammars. UG defines what speakers can parse as linguistically meaningful and how it is parsed, i.e. the representation that any item receives.

All four grammars G1, G2, G3 and G4 are possible grammars given Card-UG1. Some hypothetical grammars such as F1=PICTURECARD (i.e. a grammar that accepts only cards with a figure, like a queen, a jack or a king); F2=#OR♣ and F3=6AND♥♦♣♠ are not possible, because the Card-UG1 does not provide primes for pictures, it does not provide the logical operator OR nor the specific numbers 1 to 10. Items with those characteristics would never be parsed, and could not receive a representation. Out of metaphor, this means that UG and the primitives it contains define what a possible grammar is as well as the form that items receive within grammar. A grammar that refers to primitives that are absent from UG is impossible, given those premises. Given UG1, only eight objects can exist, and thus only grammars referring to those objects can exist. Those objects are: [#♠, #♦, #♥, #♣, ♣, ♦, ♥, ♠].

Hale & Reiss (2008: 35) then exemplify other Card-UGs and other grammars, to show what happens if a Card-UG has an extremely rich or an extremely poor inventory. In Hale & Reiss (2008: 35) two additional UGs are proposed to the reader. One has a particularly rich set of primitives and operators, while the other has an impoverished inventory of features. The argument is exemplified in the table under (35). Examples under (35a) receive a complex representation, and allow for various different grammars. This follows from the fact that Card-UG2 contains all the units that are necessary to represent cards as different grammatical objects. Under (35b), instead, is shown the result of the impoverished Card-UG3=♦, where only cards with the suit of diamonds can be parsed, and receive all the same representation.

(35) Possible and impossible grammars with a rich and an impoverished UG

a. Possible grammars given Card-UG2=1,2,3,4,5,6,7,8,9,10, J,Q,K AND, ♥♦♣♠

Card-UG2 = 1,2,3,4,5,6,7,8,9,10, J,Q,K AND, ♥♦♣♠		G5 =J,Q,K AND ♥,♦	
<i>Cards:</i>	<i>Grammatical / Ungrammatical</i>	<i>Representation</i>	
3♣	Ungrammatical	/3♣/	
6♦	Ungrammatical	/6♦/	
K♠	Ungrammatical	/K♠/	
7♠	Ungrammatical	/7♠/	
Q♥	Grammatical	/Q♥/	
Card-UG2 = 1,2,3,4,5,6,7,8,9,10, J,Q,K AND, ♥♦♣♠		G6 =♥♦♣♠	
<i>Cards:</i>	<i>Grammatical / Ungrammatical</i>	<i>Representation</i>	
3♣	Ungrammatical	/3♣/	
6♦	Grammatical	/6♦/	
K♠	Grammatical	/K♠/	
7♠	Ungrammatical	/7♠/	
Q♥	Grammatical	/Q♥/	
Card-UG2 = 1,2,3,4,5,6,7,8,9,10, J,Q,K AND, ♥♦♣♠		G7 =♦	
<i>Cards:</i>	<i>Grammatical / Ungrammatical</i>	<i>Representation</i>	
3♣	Ungrammatical	/3♣/	

6♦	Grammatical	/6♦/
K♠	Ungrammatical	/K♠/
7♠	Ungrammatical	/7♠/
Q♥	Ungrammatical	/Q♥/

b. Possible and impossible grammars given Card-UG3=♦

Card-UG3 =♦		G5 =,Q,K AND ♥,♦	
<i>Cards:</i>	<i>Grammatical / Ungrammatical</i>	<i>Representation</i>	
3♣	Impossible grammar	---	
6♦		/♦/	
K♠		---	
7♠		---	
Q♥		---	
Card-UG3 =♦		G6 =♥♦♣♠	
<i>Cards:</i>	<i>Grammatical / Ungrammatical</i>	<i>Representation</i>	
3♣	Impossible grammar	---	
6♦		/♦/	
K♠		---	
7♠		---	
Q♥		---	
Card-UG3 =♦		G7 =♦	
<i>Cards:</i>	<i>Grammatical / Ungrammatical</i>	<i>Representation</i>	
3♣	Ungrammatical	---	
6♦	Grammatical	/♦/	
K♠	Ungrammatical	---	
7♠	Ungrammatical	---	
Q♥	Ungrammatical	---	

Card-UG2 allows for various different grammars, while Card-UG3 only allows for one, grammar G7. The point the authors want to make is that unless UG has a rich representational inventory, all the physical inputs receive the same representation or are not parsed at all. If children have to learn that |J♠| and |J♥| are distinct objects, a UG is required that provides all necessary representational tools to parse the two entities as different. An impoverished UG, for example a hypothetical UG that lacks the representational primes to distinguish between voiced and voiceless consonants, would end up with learners not being able to differentiate between similar speech sounds such as [b] and [p].

Hale & Reiss (2008: 36) also argue that without a rich enough UG, speakers would not be able to parse meaningful sounds as being linguistic. Given a hypothetical Card-UG4={0}, i.e. a Universal Grammar devoid of any representational item, nothing could be parsed, and a playing card would receive the same (empty) representation as, say, a bus ticket or any other piece of paper. Out of metaphor, they argue, “*ya gotta start with something*”, otherwise speakers would not only be unable to tell apart meaningful linguistic sounds, but also speech sounds from any other linguistically meaningless sound.

Speakers, then, must have a system of phonological representation built into UG that is rich enough so it can tell them what is language and what is not, as well as any meaningful differences between language sounds. They conclude that children must have innate access to the set of phonological features used in all of the languages of the world (Hale & Reiss 2008: 38). As we shall discuss in following

sections, the reasoning for the Card Argument relies on the premise that primes have a fixed relation with phonetics that cannot be learned by speakers.

V.3.5 Summary

To sum up, the Concordia School approach to Substance Free Phonology has an extremely powerful computational side, with the only limits imposed on phonological computation being the formal limits of set theory. While proponents of the Concordia School approach have only described the operation of priority union, other operations between sets may be carried on by phonology. It is phonological computation that is truly substance-free, and devoid of any reference to substance (markedness, typological factors, phonetic naturalness etc...).

In regards to representation, the Concordia School approach does not have a fully-fledged theory. They argue that features are innate, that they cannot be learned and that their correlation with phonetics is universally fixed and innate. Their theory of the phonetics-phonology interface, which for what concerns the production side takes the name of Cognitive Phonetics, considers transduction as a mapping between features and neuromuscular instructions. They also argue that there is no language-specific phonetics, and that all recurrent variation in the transduction is related to the feature specification (i.e. must be accounted for phonologically).

CSa manages to identify some crazy classes, but not all of them, and, are thus unable to represent some phonological processes as one single rule. The case of the River West Tarangan class of triggers for /m/ place assimilation is discussed, because it involves a class of triggers that cannot be identified as an intersection of SPE-like primes (and thus as a natural class according to CSa). If a different set of primes is employed maybe the class of triggers for /m/ assimilation in River West Tarangan may be identified as a natural class.

The asymmetric harmonies discussed above were represented using a single rule. The set of targets of Bergamasco can be easily defined as a natural class of rounded mid-vowels, and since in SFP phonological computation does not care about phonetic naturalness, it is futile to understand why a process involving raising does not concern all mid-vowels but only a subset of them. It should be noted, however, that a hypothetical harmonic process where /i/ and /u/ behave as an active class but /y/ does not participate in harmony would be impossible to represent using one single rule. In the survey concerning raising harmonies provided in §II.3 no such case has been discussed.

Parasitic harmonies were represented using two rules. All the classes of segments active in the parasitic harmony of Camuno were identified as natural classes (high vowels trigger raising of rounded mid vowels, non-rounded high vowels trigger raising for non-rounded mid-vowels), but the fact that the process applies to different targets in different contexts makes it impossible to formalize as one single rule. This follows from the fact that a rule acts as an algorithm that maps segments of one class to segments of another (via a modification of their featural representation). Camuno RVH involves not two classes, but four classes.

V.4 Radical SFP

Outside of the CSa, various SFP approaches were developed by authors agreeing that phonological primes and their association to phonetic correlates are not innate and universal, but instead are learned by speakers, i.e. emergent, and thus language specific. This position is the core assumption of Radical SFP approaches, which support two ideas that are explicitly discarded by the CSa approach.

- phonetic arbitrariness: the interface between phonetics and phonology is not fixed but arbitrary: there is no fixed relation between a prime and its phonetic exponent.
- Primes are learned through exposure to phonological alternation that informs learners on how to build their phonological representational system.

Proponents of this approach are Blaho (2008: 23) Boersma (1998: 461ff) Boersma & Hamann (2008), Chabot (2021) Drescher (2014), Iosad (2017), Mielke (2008), Odden (2013, 2022), Scheer (2022).

In §4.1 some proposals on how primes may be learned are presented. Two options, the one proposed in Drescher (2014) and the one advanced in Odden (2022) are only hinted at, since the comparison between the two models of prime emergence is covered in detail in the following chapter. §4.2 presents a counter argument to the Card Argument discussed in §3.4. It is shown that the argument is valid only under some specific assumptions, namely that primes have a fixed relation with phonetics that cannot be learned.

Section §4.3 describes phonetic arbitrariness and its consequence for the PPI. Section §4.4 discuss some properties of the PPI.

V.4.1 Innate features are not necessary: phonological categories can be constructed by learners

In §3.4, we discussed the Card Argument, which supports the assumption that phonological primes are stored in UG. The core issue individuated in the Card Argument was the fact that without a fully-fledged set of primes, learners would not be able to parse speech sounds and distinguish them.

Samuels et al. (2022: 5) agree with the idea presented in Hale & Reiss (2008) that there are some representational primes all humans share, but argue that those initial primitives are not exclusively phonological and maybe not even exclusively human. What has to be present in UG for phonological theory to work are not fully-fledged phonological primes but simply the formal concept of a phonological prime and the syntax of features and the phonological computations over which they operate. The human capability to categorize allows speakers to create categories of sounds by perceiving speech.

Proponents of RadSFP do not disagree with the nativist premise. They agree that "ya gotta start with something" and that the mind of a learner is not a blank slate. The difference with CSa is that they do not assume primes to be part of the "something" provided by UG. RadSFP does not deny UG, but argues that primes and their correlation with phonetics are not given at birth but learned during acquisition.

The idea is that learners are able to build categories of sounds. Samuels et al. (2022: §3) provide an overview of different approaches to prime learning.

Primes may be learned starting from the signal, i.e., from acoustic cues. Some authors provided accounts of prime learning based on phonetics only, and proposed models of learning where acoustic information is used to posit categories of sounds. Samuels et al. (2022: §3) list various proposals, where the authors seem agnostic regarding whether the categories learned concern phonology or phonetics. Among the proposals they explore, they cite Cui (2020), who proposed a model of prime learning where learners acquire phonological categories through creating subsequent divisions in the acoustic space whenever they need to represent a lexical contrast.

The child starts off with no phonological contrasts, i.e. all phonological segments receive the same empty representation. Then, when the learner finds evidence that two of the items in their lexicon have distinct referents, they pick the most salient cue that distinguishes the two tokens and turn that cue into a phonological prime. In this approach, the lexicon is a key player in prime learning. When encountering a minimal pair, learners posit a new category as a way to encode the difference between the two items. This representational system, which now individuates two categories, is restructured whenever a new minimal pair cannot be distinguished without positing a new prime. Whenever the child encounters a

lexical distinction not representable by their current feature system, they create a new prime defined by the most salient acoustic cue, i.e., the two tokens that form a minimal pair. This process continues until the child has enough primes to represent every lexical contrast in the language. In Cui's (2020) approach to prime learning, phonetically salient acoustic cues individuate categories that are necessary to distinguish contrastive sounds. Those cues assume the role of primes. This model closely resembles the operation of the Successive Division Algorithm presented in §IV.3.2.1 and has strong similarities to the account of prime emergence proposed in Drescher (2014), which is covered in the following chapter. The main difference is that in Cui (2020) primes are necessarily related to phonetic substance, while in Drescher's account they may not be. Within Cui's account, primes are not universal since they emerge from contrast, but once they emerge, they have a fixed correlation with the acoustic cues.

Lin & Mielke (2008) arrive at the same conclusion. They argue that using an inductive approach to feature learning is a valid alternative to innate feature theory. In their view, feature induction is part of a clustering problem²¹⁷, in which learners discover a hierarchy of natural classes. The inductive approach they introduce relies only on the phonetic distribution of sounds within the target language. The clustering (i.e. the definition of categories based on the distribution of sounds) partitions segments in ways that are similar to the partitions proposed by innate feature theories. They also argue for a difference between place features (learned by using articulatory input) and manner features (learned from acoustic input). In extreme synthesis, the hierarchical organization of binary splits that are the result of clustering is reminiscent of Feature Geometry hierarchies but is derived by a model of unsupervised learning. As the authors themselves argue in Lin & Mielke (2008: 253), "The fact that phonetic dimensions which are frequently exploited by phonological patterns can be learned from phonetic data alone suggests that these dimensions do not need to be defined in Universal Grammar."

There are reasons, however, to believe that phonological knowledge must have a role in prime learning. This entails that the capability to create categories of phonetically distinct sounds is not enough, and that learners build their systems by observing alternations (i.e., phonological processing). A phonetic-based approach to prime learning will necessarily only posit the existence of primes related to a phonetic property, which means that they are only able to learn primes that individuate natural classes. We know, however, that segments pattern together in languages even when they do not coincide with a natural class. Crazy rules of the 1st and 2nd kind are phonological processes whereby computation operates on active but unnatural classes. Theories of prime learning based solely on phonetics are unable to posit unnatural classes since a category that is crazy should be absent from the phonetic source by definition. This fact indicates that phonological computation may have an influence on the learning mechanism. That is, phonetics and phonology are both factors of prime emergence.

There are two options with regards to the division of labor between phonetics and phonology in prime learning. The first assumes that phonetics and phonology affect prime learning simultaneously; the second assumes that first learners identify phonetic categories that correspond to the sounds of their language and then assign to those (phonetic) categories phonological representations.

²¹⁷ Clustering could be defined as the process of organizing objects into groups whose members are related or similar in some way. A cluster is a group of items that are similar to one another and dissimilar to those that belong to other clusters. The goal of clustering is to find the internal grouping in a collection of unlabeled data. For what concerns the learning of phonological categories, clustering can be considered as the identification of phonetic properties of sounds that are similar enough to be treated as a category.

Beguš (2020), for example, managed to train a neural network to distinguish between aspirated and unaspirated stops in English in an allophonic context using unsupervised raw data. He suggests that phonetic and phonological learning may happen at the same time with a single mechanism (the Generative Adversarial Network), and is considered by the author to be a better proposal than models that require already simplified ‘toy’ data to work, which assume that phonetic learning has already taken place and is independent of phonology and vice versa.

Dillon et al. (2013) also propose that phonetics and phonological factors co-occur when learning the different phonemes of each language. They first show how a statistical model that learns phonological categories as perceptual clustering (i.e. using only phonetic information) has some inherent problems in the kinds of categories they identify. They simulate statistical learning of sound categories using data from Inuktitut, which has three underlying vowels /i/, /u/, /a/ but six allophones for those phonemes, namely [i], [e], [u], [o], [a], [ɑ]. [i, u, a] appear in most contexts, while [e, o, ɑ] appear after uvular consonants. They employ statistical cluster analysis tools (Mixture of Gaussian, MOG; cf. Dillon & al. 2013: 11) on a corpus of vowels collected by phoneticians. The categories individuated do not seem to match those expected. For example, the groupings individuated would identify a front and a back allophone of /u/ instead of a higher and a lower one.

Dillon et al. argue that if learning of phonological categories worked in a two-stage fashion where first phonetic categories are learned before phonological categories, in the hypothetical second stage of learning, learners should identify a higher and a lower variant of /u/, but the first stage did not give them such a distribution.

They, therefore, argue for a model where phonetic and phonological factors work simultaneously: learners acquire their categories using both distributive and procedural information. In sum, phonetic information and knowledge about phonological processing should operate simultaneously to inform the learner about the phonological categories he has to learn.

In subsequent statistical experiments, they simulate learning of sound categories treating tokens in the context of a uvular (i.e., those that have undergone the process of vowel-retraction) and tokens in other contexts in different manners (Dillon et al. 2013: §5.2). In this way, the categories learned match more closely the right results.

The different treatment of vowels occurring in the context of a uvular consonant, however, implies that learners should know when they are perceiving a token that undergoes a process, but it is unclear how this knowledge is available to learners before they develop some kind of phonetic knowledge. How can learners know when a token occurs before a uvular before they even define what a uvular is? Additionally, Dillon et al. (2013) discuss how phonological categories may be learned but never address the issue of prime learning. They remain agnostic about whether features are innate or not, and if not, how they would be acquired and assigned to categories.

Besides those issues, it also remains to be defined whether single-stage proposals of prime learning work for phonological systems where a crazy phonological category is needed. Both the proposal of Beguš (2020) and that of Dillon et al. (2013) were proposed in contexts where an allophonic rule applies, and it remains to be tested whether they would work also for a crazy rule.

Samuels et al. (2022: 22) suggest that a more detailed answer to the issue of feature learning may come from a combination of phonetic and phonological-based models of prime learning. As they notice, a common property among phonetic-based approaches seems to be that phonological patterns can overrule the phonetics. On the other hand, they also point out that most approaches to phonological acquisition assume segmental (phonemic) encoding of speech as their input (cf. Odden 2022: 16; the

issue is treated also in Dillon et al. 2013). That is, theories of prime learning based solely on phonology start with an already established system of non-distinctive sounds and assign distinctive primes to those sounds. This entails a process of learning based on a two-stage mechanism. Children first learn the phonetic sounds of their language, and later assign them a phonological representation based on distinctive primes.

This is the proposal discussed in Samuels et al. (2022: 22) concerning the division of labor between phonetics and phonology in the building of a phonological system. Phonetics guides the learning of segmental sounds, i.e. the definition of the speech sounds that appear in a language. Phonology groups together the sounds that belong to the same category (allophones of a phoneme, in structuralist terms) and assigns to each phoneme a prime-based representation. Samuels et al. (2022) suggest that models in which phonological processing affects prime learning may be on the right track, but they represent a stage after which the child has already used a phonetic strategy to arrive at a set of phones (i.e. a set of phonetic categories that correspond to the sound of the language). A two-step approach may explain how and why phonology is able to overwrite phonetic categories creating groups of segments that are not related to each other phonetically or sets of segments that exclude a phonetically similar segment.

In the following chapter, which presents my proposal, the first stage of learning is not treated. It is explored only how, given a set of sounds without a phonological representation, learners may define such representations and assign them to those sounds: two models that deal with prime learning are presented and compared. The first one is proposed in Dresher (2014), and treats contrast and phonological computation as both equally relevant factors in prime emergence. The second one, advanced in Odden (2022), treats phonological computation as the main factor of prime emergence, while contrast matters less. Both models represent a stage after which the child has already used a phonetic strategy to arrive at a set of phonetic categories that require a phonological representation.

In sum, there are different possible ways in which learners may acquire phonological primes and their phonetic correlates. Either by phonetics only (Cui 2020, Lin & Mielke 2008), by a combination of phonological and phonetic knowledge in a single stage approach (Dillon et al. 2013, Beguš 2020), or by a two-stage approach with a strict division of labor between phonetics and phonology. First learners arrive at a stable enough system of phones (first stage of learning, guided by phonetics); then they group phones into categories and assign them a phonological representation based on emergent primes (second stage, guided by phonological alternations), as suggested in Samuels et al. (2022: 22).

The notion of innate primes is unnecessary in all of the approaches briefly presented here. Only the ability to create categories (be they substance-free or substance-laden) is a necessary assumption. In sum, as Samuels et al. (2022: 6) put it, the concept of prime and a syntax that allows one to operate over those primes is what is needed in the UG for the cognitive component of phonology to do its job. On the other hand, innate primes are not a necessary part of UG. If primes are not universal and innate, their relationship to phonetics cannot be universal and innate either.

V.4.2 Contra the Card Argument: the Revised Card Argument

That primes are actually learnable, given a non-universal and non-innate set of features and phonetic correlates, is demonstrated in Odden (2022: 9) where a rebuttal to the Card Argument of Hale & Reiss is presented. The argument provided in Hale & Reiss (2003, 2008) and presented in §.3.4, says that without a well-defined system of primes already in place, it would be impossible to parse distinct objects and give them a distinct representation.

Odden (2022) argues that a modular architecture of language and a truly arbitrary interface (i.e. one in which the mappings between phonetic and phonological items are language specific and are not required to be fixed correlations) between modules permits the learning of new phonological categories without having to assume the existence of a fully-fledged system of primes already in place.

In §2.3 we defined a modular interface as a list of transductional instructions mapping items coded in one vocabulary into items coded in another vocabulary. The PPI works in the same way: it may be viewed as a list of instruction that map phonetic categories onto phonological categories. Proponents of the CSa assume that the transductional instructions are innate and universal, and that they cannot be learned. Odden (2022: 7), instead, argues that learners can infer instructions, and later correct their assumption about those instructions, i.e. they can recognize different forms and assign a different representation to them by observing phonological computation.

He argues that the Card Argument depends on a premise “that is not self-evidently true”. The Card Argument only works assuming that the interface between phonetics and phonology is fixed, and “that phonological prime assignments arise deterministically from an unlearned direct interface between the auditory system and the phonological component.” (Odden 2022: 7). In simpler terms, the Card Argument works only if we assume that the transductional instructions that form the PPI are fixed, and that they cannot be learned. That primes cannot be learned, then, follows only from the fact that the transductional instructions cannot be learned. That the PPI is composed by fixed and universal instructions and that primes cannot be learned, are not two independent arguments, but one follows from the assumption of the other: primes cannot be learned if the interface is fixed, i.e. if learning consists in matching the auditory input with a pre-established set of items that have pre-established phonetic properties. Given the alternative (i.e. the interface is learned by speakers) phonological categories can indeed be learned.

In perception, a first interface of sort transduces any sound that enters the human body into a pressure wave in the cochlea. This interface is not cognitive yet but works mechanically. This pressure wave causes neuronal excitation, which forms the first cognitive representation of a sound (both linguistic and non-linguistic). For CSa this is the only interface that exists between the real world and phonology, for what concerns perception. Odden (2022), instead, assumes that other interfaces may intervene between this first representation and the one manipulated by the phonological module.

For Hale et al. (2007) and Volenec & Reiss (2017), Cognitive Phonetics assigns the same neuromuscular schema (the same instructions) to each feature every time that feature is sent to transduction, and the interface accounts for the coarticulation effects (cf. §3.3). In Odden’s view, instead, there can be multiple intervening modules between the phonological representation that is the output of phonological computation (the Surface Form) and the neuronal excitation patterns that relate to neuromuscular movements (in production) and pressure waves on the cochlea (in perception). In sum, there may be more interfaces between phonology and the physical world).

Odden’s argument describes how a series of stimuli are parsed by subsequent interfaces during perception. Odden assumes a number of modules acting upon perception, which are described below. As a stimulus passes through this series of modules, at each transition it is subject to symbol-to-symbol translations, each one of them carried on at a different interface. From this, Odden (2022) borrows the idea of a Card Grammar from Reiss (treated in §3.4) in order to demonstrate that representations can be distinguished even without a ready-made set of primes, given an arbitrary interface where primes do not have an innate and universal correlation with phonetics.

He argues that information becomes impoverished as it climbs within more embedded modules of grammar through multiple interfaces. A learner can make sense of which information is not meaningful and decide on a language-specific basis what is relevant for his own grammar. Let us assume that the following set of playing cards is presented to a subject.

(36) The Revised Card Argument: parsing “jack of clubs”

A: [*J♣*], B: [*J♣*], C: [*♣J*], D: [*J♣*], E: [*J♣*]

All the cards under (36) are the jack of clubs, but they differ in some properties (dimension, font, order, italic-boldness...). Out of metaphor, they are different stimuli. Those stimuli are subsequently parsed by different interfaces into different representations. The first transduction, which mirrors the one that turns cochlear waves into neuronal excitation, creates the representations under (37) within the first module encountered in perception, here named Mo1. Odden treats this first interface (which is somewhat mechanical) as universal, and that the mapping between the items and the first module is constant among speakers.

(37) The interface between the cards and the first module, Mo1

	<i>Stimuli</i>	<i>Representation within Mo1</i>
A	[<i>J♣</i>]	[Mo1 <i>J♣</i>]
B	[<i>J♣</i>]	[Mo1 <i>J♣</i>]
C	[<i>♣J</i>]	[Mo1 <i>♣J</i>]
D	[<i>J♣</i>]	[Mo1 <i>J♣</i>]
E	[<i>J♣</i>]	[Mo1 <i>J♣</i>]

The representation [Mo1 *J♣*] corresponds to two different stimuli, namely B and E. In sum, two different items are mapped onto the same category in the first module, Mo1. One property of the play card E (namely its size) is not parsed as relevant by the interface. The other properties of E are similar enough to those of B so the first interface parses them as the same item. An alternative view is to assume that the play card |E| cannot be parsed due to its size. This would mean that an item is lost in transduction. This would be analogous to the loss of information in an acoustic signal above or below certain frequencies (for example, humans are unable to hear a bat cry since their frequencies are too high). Either way, after the computation within the first module Mo1 is performed, the output of Mo1 passes through another interface and the representations within Mo1 are sent to the following module, Mo2.

Transduction between Mo1 and Mo2 is treated as if the instructions that make up the interface are innate (as in Hale et al. 2007). In this second interface, the typeface difference between stimuli is lost in the Mod1 to Mod2 interface. This means that Mo2 lacks the prime to parse typeface differences. The second cognitive representation will therefore correspond to the one in (38), where the representation corresponding to the stimuli B, E and D receive the same representation in Mo2, namely [Mo2 J: *♣*]

(38) The interface between Mo1 and Mo2

	<i>Representation within Mo1</i>	<i>Representation within Mo2</i>
A	[Mo1 <i>J♣</i>]	[Mo2 <i>J♣</i>]
B,E	[Mo1 <i>J♣</i>]	[Mo2 <i>J♣</i>]
C	[Mo1 <i>♣J</i>]	[Mo2 <i>♣J</i>]
D	[Mo1 <i>J♣</i>]	[Mo2 <i>J♣</i>]

As further modules parse the items, the number of representations reduces. Items can either be discarded as irrelevant or be grouped with other representations (i.e. the differences between items may be considered negligible by the interface). This depends on the nature of the properties that are parsed, and follows from a fixed PPI as the one argued for by the CSa (§3.3). If the instructions that form interfaces are fixed and innate, the number of representations, given the set of inputs under (36) can be either the same as the number of the inputs or lower, if some information is not parsed, as in the examples under (37) and (38).

In Odden’s (2022: 9) argument, the interface between the second and the third module (Mo2 and Mo3 respectively) is arbitrary and not fixed. The mapping between objects belonging to the module Mo2 and objects of the module Mo3 is not provided by UG, but instead built by learners as a series of hypotheses. A learner may assign a representation within the third module to objects of the second one, and, for example, define the italic/boldface distinction as not relevant. The items in Mo2, then, receive the following mapping to Mo3 at the interface:

(39) The interface between Mo2 and Mo3: first hypothesis

	<i>Representation within Mo2</i>	<i>Representation within Mo3</i>
A	[Mo2 <i>J♣</i>]	[Mo3 <i>J♣</i>]
B,E,D	[Mo2 <i>J♣</i>]	[Mo3 <i>J♣</i>]
C	[Mo2 <i>♣J</i>]	[Mo3 <i>♣J</i>]

Learners assign the same representation in Mo3 to [Mo2 *J♣*] and [Mo2 *J♣*]. They hypothesize that the difference between regular and italic jack of clubs is not relevant, and thus assign the same representation to items that differ only for this property.

Later, as new data become available, hypotheses may be confirmed, or they may be subject to correction when the hypothesis is contradicted by known facts.

A learner that assigned the representation under (39) to the items in Mo2 may notice that some processing going on within Mo3 treats differently some occurrences of the item [Mo3 *J♣*]. Let us assume that [Mo3 *J♣*] undergoes a process only when it corresponds to [Mo2 *J♣*]: the result of the transduction of the italic [Mo2 *J♣*] and the result of the transduction of the regular [Mo2 *J♣*] exhibit different behavior in processing. However, both of them are represented as [Mo3 *J♣*] in Mo3. Observing processing, learners may change their hypotheses on the mapping between Mo2 and Mo3, and derive that [Mo2 *J♣*] has a distinct representation in Mo3. Under the assumption that primes are fixed and given by UG, the distinction between the two objects within Mo3 has to be encoded in terms of those primes. There must be a prime that relates to italic/boldface in Mo3, and if there is not, the difference between the two forms is irretrievably lost. If instead the interface between modules is learned, the difference between the two

forms is still retrievable in Mo2. The learner overwrites the hypothesis in (39), and a different mapping (the one under 40) is learned.

(40) The interface between Mo2 and Mo3: new hypothesis

	<i>Representation within Mo2</i>	<i>Representation within Mo3</i>
A	[Mo2 J♣]	[Mo3 J♣]
B,E,D	[Mo2 J♣]	[Mo3 J♣]
C	[Mo2 ♣J]	[Mo3 ♣J]

In (39) three items in Mo2 were transduced as two items in Mo3: [Mo2 J♣] and [Mo2 J♣] were both transduced as [Mo3 J♣]. In (40), once the learner realizes that the italic property of [Mo2 J♣] is still relevant in Mo3 computation, [Mo2 J♣] and [Mo2 J♣] receive two different representations: [Mo3 J♣] and [Mo3 J♣]

Odden (2022: 10) says that “Although computation within Mo3 is limited to the primitives of Mo3, learning about the interface from Mo2 to Mo3 is not an operation in Mo3. The mind, which is still learning the rules, still has access to information that was erroneously discarded. The key to solving the Card Grammar problem is that the phonological component of a grammar does not learn, the mind learns about the phonological component”.

The card argument discussed in §3.4 was presented by Hale & Reiss (2003, 2008) as a reformulation of the Subset Principle in learning theory. This principle says that whenever there are two competing grammars generating languages of which one is a proper subset of the other, the learning strategy of the child is to select the less inclusive one (Dell 1981: 34). In Hale and Reiss’ (2008) opinion, the Subset Principle applied to phonology implies that, if tasked with learning a system structured around seven vowels (e.g. S1: {/i, ɪ, ε, a, ɔ, ʊ, u/}), children would first learn a simplified version of this system structured around fewer vowels (e.g. S2: {/i, u, a/}). A system such as S2 is a proper subset of S1. While learning, if the representations are not fixed and innately given by UG, learners will posit a system such as S2 before developing the final system S1. However, Hale and Reiss (2008: 40) argue that a learner with only three distinctions say /i/ /u/ and /a/, would parse [ɪ] as either as /i/ or would not be able to parse it. Given the Card Grammar argument, it would be impossible to correct the hypothesis that a language only has the vowels [i a u] to the hypothesis that the language has [ɪ ɪ ε a ɔ ʊ u]. They thus argue that learners must already be able to represent the whole S1 system from the start; otherwise, they would not be able to learn it, if they started from S2. Hale & Reiss, argue for a full set of distinctions available at the initial stage, which is then shrunk through exposure (as proposed in Stampe 1972). They also argue that expanding a set is impossible.

The Revised Card Argument, instead, supports the idea that it is not necessary to have the distinction between vowels encoded in terms of phonological primes from the start. If objects are indeed different and behave as different in computation, the interface can be restructured in order to account for the learning of different categories previously unavailable.

This means that the assumption of an interface that can be learned (i.e. is not universal) and that can be modified during acquisition allows learners to hypothesize for themselves different representations, which may be confirmed or disproved by exposure to phonological data. What is actually universal among learners is the fact that segments are categorized as sets of primes that undergo or trigger a phonological process, i.e. the notion of an active class formalized through phonological primes.

More detailed discussion about how primes are learned is provided in the final chapter, where two approaches to phonological learning are compared. The first one (supported in Dresher 2014 and Sandstedt 2018) argues that the driving forces of prime learning are contrast and processing, and that the Contrastivist Hypothesis (cf. §IV.3.2.1) has a role in prime learning. The second one, developed in this PhD and based on Odden’s (2022) proposal, argues that there is a hierarchy between the two factors: phonological processing informs learners of the primes that account for their phonological system, and then, if needed, contrast kicks in and finishes the job. In sum, the former approach assumes that all primes learned will have a contrastive role, while primes in the latter may or may not be contrastive.

V.4.3 A truly arbitrary interface between phonetics and phonology

V.4.3.1 Definition

To assert that the PPI is truly arbitrary means that the mappings between phonetic and phonological items are language-specific and correlate arbitrarily phonetic and phonological items. This property of the interface between phonetics and phonology is known as phonetic arbitrariness (Scheer 2019: 107ff.).

Since phonetics and phonology are incommensurable domains, the correlation between items on one side of the PPI to the other is necessarily arbitrary. As Ladefoged (1980: 493) puts it,

“[...] the necessary and sufficient set of articulatory parameters required for characterizing linguistic contrasts is not identical with the set of features required for characterizing phonological patterns. A similar point can be made by reference to the acoustic parameters of speech.”

Phonetic arbitrariness is the key property of the PPI according to RadSFP. The correlation between phonological items and phonetic categories is arbitrary exactly as the correlation between morpho-syntactic categories and their phonological representation.

V.4.3.2 Phonology-phonetics mismatches

Mismatches of phonological and phonetic categories are a common pattern in language (Hamann 2011, 2014). A known example of this is the case of rhotics. Chabot (2019) argues that rhotics form a cohesive and recognizable phonological active class, but they can be implemented phonetically (i.e. they can be transduced) in such a variety of ways that it is impossible to pinpoint a single phonetic property shared by all “rhotics”. Rhotics exhibit a cross-linguistically stable behavior in that they may occupy the syllabic position of the secondary element in branching onsets or codas and function as sonorants regardless of their phonetic realization (Chabot 2019: 11). The range of phonetic variation in the realization of rhotics is strikingly varied.

The realization of rhotics spans almost all possible places of articulation and most manners (although usually not obstruent). A rhotic may appear as alveolar (trill [r], fricative trill [r̥], flap [ɾ], approximant [ɹ]); retroflex (approximant [ɻ], flap[ɻ]), velar approximant [ɣ] (it alternates with voiceless [x] in Brazilian Portuguese); uvular trill [R], pharyngeal (fricative [ʕ] in some varieties of German); labiodental [ɸ] (in some regional varieties of English and Italian), bilabial [β]²¹⁸. According to Ladefoged and Maddieson (1996: 225), “The overall unity of the group seems to rest mostly on the historical connections between

²¹⁸ Cf. Chabot (2019: 11) for a discussion on the phonetic realization of /r/ in Polish. He argues that /r/ is realized as a post-alveolar fricative [ʒ]/[ʒ̥] (agreeing in voicing with preceding obstruents) when preceding some morphemes. Chabot argues that there is at least a diachronic relationship between the rhotic phoneme and [ʒ]/[ʒ̥]; and that the synchronic behavior of those realization matches that of a rhotic. He thus argues that in Polish [ʒ]/[ʒ̥] qualify as phonological rhotics.

these subgroups, and on the choice of the letter ‘r’ to represent them all”. One well-defined phonological category lacks a single phonetic exponent.

Another surprising example of phonology-phonetics mismatch concerns the fronting of long /u/ in South-East British English (Harrington et al. 2008, Uffmann 2019, Scheer 2014). In South-East British English, vowels are currently shifting. Among various restructurings of the system, back/high vowels are fronting and unrounding, to the point that (at least for some speakers) the underlying back high long vowel /u:/ is pronounced as long [i:]: /bu:t/ → [biit] ‘boot’. The process of hiatus resolution is, however, unaffected by the sound change, suggesting that underlying /uu/ is still /uu/. A phonetically non-rounded front vowel [i:] corresponding to underlying /u:/ continues to trigger the insertion of [w] in hiatus, thereby attesting that a phonological /u:/ (able to trigger [w] insertion) is phonetically implemented as [i:]: ‘do it’ is pronounced as [di: w it], with glide insertion (Uffmann 2010, Scheer 2014).

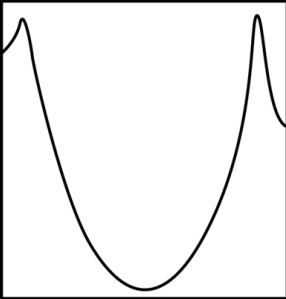
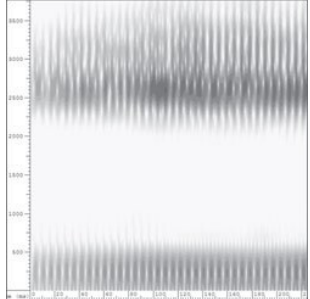
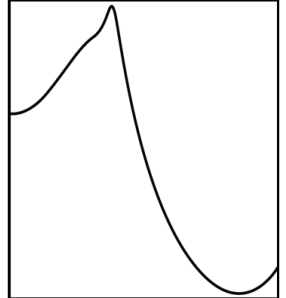
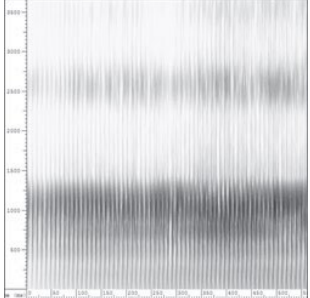
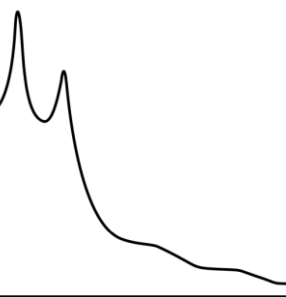
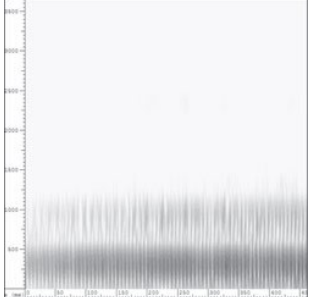
In sum, cases where phonetic and phonological categories fail to match exist, and are actually more frequent than one may assume.

This observation concerns both the various theories of phonological representation that commit substance abuse and the SFP theory of PPI proposed by CSa. Both of them assume that speakers can retrieve phonological representations directly from the acoustic signal. But if a phonological category is not matched in phonetics, what does the listener retrieve?

V.4.3.3 Phonetic arbitrariness

Consider for a moment how the interface between phonetics and phonology works in a theory that has fixed phonetic correlates. Many theories may assert that phonological primes have an intrinsic phonetic content. Even if this has been the default assumption since SPE, not many theories have actually defined in detail what the phonetic content of primes is supposed to be. A theory that tackles the issue explicitly is Element Theory, (Backley 2011). In Element Theory the three vocalic Elements |I|, |A| and |U| have a specific acoustic correlate that can be retrieved from the source. The three elements and their phonetic correlate are reported in the table under (41).

(41) Vocalic elements and their phonetic content (Backley 2011: 22)

Element	Acoustic value	Spectral pattern	Spectrogram
I	Two energy peaks (500 Hz-2,5kHz) with an intervening dip.		
A	Energy in the lower central part of the spectrum (at around 1 kHz), with a drop in energy on either side.		
U	Concentration of energy at lower frequencies. Energy peaks at around 0–1 kHz and then drops.		

The |I| element correlates with a spectral pattern characterized by two energy peaks with an intervening dip (with the first at about 500 Hz and second one at about 2.5 kHz). The |U| element correlates with a spectral pattern showing concentration of energy at lower frequencies. The element |A| correlates with a mass of energy in the central portion of the spectral pattern, followed by a drop of energy at frequencies higher than 1kHz.

In such a theory, where the phonetic correlate of a prime is redundantly specified in phonology and in phonetics, the interface is unnecessary. Phonological objects already have an acoustic content that could be picked up by a listener (Backley, 2011: 5).

Similarly, the PPI proposed by the CSa gives a fixed correlation between a phonological prime and an acoustic and an articulatory form. Even though the perceptual side of the PPI has not been given a specific description, we can assume that whenever a sound enters a specific “acoustic space” (cf. §3.3) it directly relates to a phonological prime. In sum, both the CSa and ET (which here serves as a placeholder for all substance-based theories of phonological representation) are both able to retrieve phonological information from the physical source. This follows from their shared property of having a fixed (that is innate and universal) list of correlates between primes and phonetic substance. ET is explicit in what the acoustic correlates of its elements are, while CSa does not provide a set of primes, and therefore a set of specific phonetic correlates for those primes.

The Radical SFP theory of PPI, instead, states that primes and the mapping between phonetic and phonological representations are not universal: both primes and their phonetic correlates emerge upon acquisition based on environmental information alone. That is, their relationship is not marshalled by any cognitive property or UG, but is truly arbitrary. A child at the initial stage can implement any relationship and its reverse. While developing language, children learn the mapping between phonological and phonetic categories, which is thus language-specific.

As a consequence, there is no way to retrieve the information that, say, a speech sound [p] in a given language contains the prime [+labial], or any other prime for that matter. Phonetically identical [p]'s in different languages do not allow to determine any phonological property from their phonetics.

For Radical SFP only phonological patterns can reveal what the content of a phonological segment is in terms of primes. In other words, only phonological alternations and contrast are a reliable source of information regarding the phonological representation of a segment. This position actually predates SFP, and was formalized as the Phonological Epistemological Principle (Kaye 2005: 283) in GP quarters. The principle states that only phonological behavior can inform about the internal composition of a segment. Phonetic properties of sound are irrelevant.

This means that the only good reason for positing the existence of a class of phonologically active segments (in traditional terms, a natural class) is its activity in phonological processing. The class of high vowels deserves to be called a class not because high vowels share some phonetic properties (low F1) but because they pattern together as triggers in various raising processes.

Scheer (2014: 265; 2019: 110) maintains that all phonological theories should account for some “slack” in the way they relate phonetics to phonological representations in order to account for mismatches in the PPI. That some slack is necessary is evident not only from the frequent mismatches (cf. the examples given above, as well as Haman 2014), but also from the trivial observation that the same segment may receive a different phonetic implementation in different languages. Languages that are supposed to have the same underlying vowel system may give a different phonetic interpretation to the same segments. For example, Spanish /e/ and Zulu /e/ receive different phonetic implementations, which are [e] and [ɛ] respectively (Backley 2011: 19).

Some variation is also to be expected between speakers of the same language or even between single realizations produced by the same speaker. Crucially, the CSa assumes that the mapping between phonological and phonetic items is tightly fixed, and thus is forced to assume that all variation beyond a certain threshold must be encoded phonologically, and thus requires a different phonological representation. No slack due to the PPI is allowed for the CSa.

Other theories with universal features and phonetic correlates, instead, have found ways to allow for some slack in their mapping between phonetic and phonological items. This may be construed as a precedent to the idea of an arbitrary interface between phonetics and phonology.

As an example of this tendency, consider the Modified Contrastive Specification theory (MCS, Dresher 2009, Hall 2007), discussed at length in §IV.3.2. The core idea of the theory is that the phonological properties that are active in phonology do not have to correspond with the acoustic or articulatory properties of the sound, but are instead related to contrast. In §IV.3.2.2 while discussing the harmony of Halh Mongolian, it was noticed how a segment like /u/, which is produced as a rounded vowel [u], does not pattern with other round vowels, and therefore, within the MCS approach, should not share that feature with vowels that actually display that property. In the case of Mongolian that meant that /u/, which is pronounced as a rounded vowel, does not have to display a [+rounded] feature in its representation. In §IV.26) the role of contrast was exploited to account for asymmetric harmonies, and

resulted in a segment whose phonological (active) properties did not coincide with the acoustic/articulatory features of the sound produced.

The MCS approach cannot be considered a theory of phonology that subscribes to phonetic arbitrariness (at least not in the form described in §IV.3.2, but cf. Dresher 2014), since all the features that were not relevant in phonological computation (the non-contrastive primes) were added at a later stage, so that the transduction between phonological and phonetic items could take place (cf. Dresher 2009). However, it is open to the idea that the underlying identity of a phonological segment cannot be predicted by the way its surface form is pronounced. As discussed at more length in §VI.4, the MCS can be developed in a substance-free direction (cf. Hall 2014, Dresher 2014).

Another theory that often flirted with an unfixed relation between phonetic and phonological properties is Element Theory (Backley 2011), where despite claiming a fixed correlation between phonological primes and acoustic patterns, some slack in the definition of a natural classes is encouraged. This slack, however, has never been fully formalized: how far can we go? Is it possible for an underlying /u/ to map onto a phonetic [i] sound? In this aspect, ET finds itself in a somewhat incoherent spot.

On one side, the theory asserts that primes have an intrinsic phonetic component, so that acoustic data contains meaningful phonological information. On the other, the relation between bundles of elements and speech sounds allows for some slack, and permits multiple segments to be pronounced in the same way. ET, as developed in Backley (2011), is part of the larger theoretical framework of GP, which as discussed above subscribes to the Phonological Epistemological Principle.

If all this is considered together, ET ends up asserting on one side that primes have an intrinsic phonetic correlate, which can be overwritten by the necessities that arise from phonological processing. This is not that far from what is proposed in RadSFP, and closely resembles what is discussed in §4.1 (following Samuels et al. 2022).

To sum up, the position of RadSFP is that not only primes and phonological processing are arbitrary, but also that the mapping between phonetic and phonological representations is. The various proposals about the PPI presented in this section are schematized in (42).

(42) Properties of the PPI in different approaches

	<i>Primes are arbitrary labels</i>	<i>Arbitrary computation</i>	<i>Arbitrary mapping</i>	<i>Phonological information can be retrieved from acoustics</i>
<i>ET/GP</i>	No	No, computation must adhere to the Non-Arbitrariness condition (Kaye et al. 1990: 195; Pöchtrager 2006: 20)	No, but some slack is allowed	Yes
<i>MCS</i>	No (Dresher 2009), Yes (Dresher 2014)	Not defined: the Contrastivist Hypothesis defines which primes can have a role in computation, but computation itself is not affected by non-phonological considerations.	No in Dresher (2009), yes in Dresher (2014, to be discussed in §VI.4)	Contrastive primes have a fixed correlation with phonetics. Acoustics does not reveal which primes have a contrastive role and which do not
<i>CSa</i>	Yes	Yes	No	Yes
<i>RadSFP</i>	Yes	Yes	Yes	No

V.4.4. Properties of the PPI in Radical Substance Free Phonology

There are still various properties of the PPI as envisioned by RadSFP that need to be discussed before delving into the way such an interface affects the analysis of raising harmonies. Those properties are explored in the following sections:

- Is there a cognitive module after the PPI? In other words, is the output of PPI (the phonetic representation) ready to be implemented by the sensory-motor system or are there other cognitive operations carried out before the production is handed over to physiology? In §4.2 we have discussed how the Revised Card Argument implied that there are intervening modules between the phonological one and the externalization. Under §4.4 some arguments in favor the existence of a phonetic module, Language-Specific Phonetics, are explored.
- What are the properties of the phonetic representation phonological items are transduced to? Up until now, we have treated the issue of the interface without discussing what is on the other side. If a cognitive phonetic module exists, what kind of representations does it manipulate? This issue is explored in §4.4.1
- What kind of phonological material is sent to the interface to be transduced? Two options are available: single primes are transduced into phonetic properties or segments (i.e. bundles of primes) are transduced into sounds. In §4.4.2 is entertained the option that segments, rather than primes, are the items transduced by the PPI.

V.4.4 There is a cognitive module after PPI

Phonetics has been long considered as lying outside of the realm of grammar, but something that is ‘physical’ and ‘automatic’ (Halle 1983). This view is more or less shared also by Volenec & Reiss (2017: 14), who argue that the Cognitive Phonetics²¹⁹ interface acts as a bridge between phonology (within grammar) and physiological phonetics (outside of grammar). They specifically argue that there is no such thing as language-specific phonetics, i.e. there are no language-specific phonetic rules that affect the way a phonological item is externalized: externalization is universal and happens mechanically once the outcome of the PPI is fed to the neuromuscular system.

However, the phonetic literature shows that speakers do have some phonetic knowledge which is specific to their language (Kingston & Diehl 1994). In a modular architecture this means that there is a phonetic cognitive module that deals with gradient phonetic representations. The literature shows that the phonetic behavior of speakers cannot be fully predicted by physical and physiological constraints on articulation but is indeed influenced by some language-specific phonetic rules (i.e. a phonetic computation). Kingston (2019: 389) says that “speakers and listeners have learned a phonetic grammar along with their phonological grammar in the course of acquiring competence in their language”.

As Kingston & Diehl (1994: 423) put it, “constraints [that] determine what a speaker (or listener) can do but not what they must do; that is, the constraints limit phonetic behavior rather than predicting it”.

They show as an example of this phonetic knowledge the case of voicing. Voicing has an effect on depressing F0: the F0 of a vowel neighboring a voiced stop is lower than that of a vowel that neighbors a voiceless stop. Kingston & Diehl argue that this lowering is not an automatic physiological process, but is instead a controlled one. In English the difference between phonologically voiced and voiceless obstruents varies greatly depending on their position in the string. In (43) I report the table showing the way the contrast between voiced and voiceless obstruents is realized phonetically depending on their contexts (Kingston & Diehl 1994: 427).

(43) Phonetic realization of voiced and voiceless stops in English

	<i>Voiced</i>	<i>Voiceless</i>
<i>Utterance initial or pretonic</i>	short lag VOT	long lag VOT
	F1 lower	F1 higher
	F0 lower	F0 higher
	weaker burst	stronger burst
<i>Intervocalic or post-tonic</i>	closure voicing	no closure voicing
	shorter closure	longer closure
	longer preceding vowel	shorter preceding vowel
	F1 lower	F1 higher
	F0 lower	F0 higher
<i>Utterance final and postvocalic</i>	longer preceding vowel	shorter preceding vowel
	closure voicing possible	no closure voicing
	shorter closure	longer closure
	F1 lower	F1 higher

²¹⁹ Despite its name, there is no cognitive module of phonetics in the CSa. Cognitive Phonetics is the name Volenec & Reiss (2017) give to their Phonetics-Phonology Interface charged with production.

What is shown in (43) is a partial description of phonetic variants of English stops contrasting for voicing; the differences in F1 and F0 occur at the edges of adjacent vowels. F0 is uniformly depressed next to voiced stops, regardless of how the [\pm voice] contrast is otherwise realized. F0-lowering is one of the many ways voicing is externalized phonetically. If phonetics followed from an automatism (i.e. was not at all controlled by speakers), we would expect that a phonetically voiced stop will always lower the F0 of a following vowel. However, it appears that F0 lowering correlates consistently with phonological voicing, not with phonetic voicing. In English, for example, phonetically voiceless unaspirated stops realize the voiced member of a voicing contrast (phonetic [p] is the voiced counterpart of voiceless [p^h]). In French, instead, phonetically voiced unaspirated stops realize the voiced member of the voicing contrast: [b] contrast with [p] (Kingston & Diehl 1994: 432ff).

Regardless of the way the voicing contrast is realized, F0 lowering applies in the same way. In English (where phonetically voiceless unaspirated obstruents are phonologically voiced) and in French (where phonetically voiced obstruents are phonologically voiced), vowels neighboring the [+voiced] obstruent have a lowered F0 (Kingston & Diehl 1994: 435). Lowering of F0 is employed as a way to encode the voiced-voiceless contrast even when other cues for voicing, such as vocal fold vibrations, are not employed. This suggests that F0 is used independently as a cue for voicing, and it is not an automatic effect of voicing caused by physiology.

Additional evidence that F0 lowering is not an automatic consequence of stops' glottal articulation comes from Tamil. Here, non-geminate stops are predictably voiced but geminate stops are voiceless. In other words, length is encoded phonetically as voicing: long consonants are realized as voiceless and short ones as voiced. F0 will only vary with the presence of voicing in stops that contrast for [voice], and not for all voiced consonants; i.e. consonants that are voiced as a consequence of being singletons do not affect F0 of following vowels.

To conclude, F0 lowering is a cue for voicing that is not automatically applied in all contexts of voicing, but only in contexts where voicing is phonologically relevant. F0 lowering is not the consequence of an automatic physiological phonetic implementation, but it is a cue for phonological voicing controlled by speakers, and is used differently in different languages to enhance the distinctive role of voicing.

Another example of a language-specific phonetic rule concerns the way aspirated and unaspirated consonants are externalized in different languages (Cho & Ladefoged 1999). It appears that languages assign different VOT²²⁰ values to aspirated and unaspirated consonants. Cho & Ladefoged (1999) observed that while languages consistently encode laryngeal contrast between voiced, voiceless and aspirated consonants, the VOT value assigned to each of those categories varies greatly from language to language.

Such variation in the selection of a VOT value suggests that different languages select a different phonetic correlate for the prime responsible to differentiate between aspirated and unaspirated consonants. Cho and Ladefoged argue that the selection of a VOT value for aspirated/unaspirated consonants follows a language-specific phonetic rule.

²²⁰ Voice Onset Time corresponds to the time that passes between the abrupt release of air in the pronunciation of a stop consonant and the start of the vibration of the vocal folds. VOT is smaller for voiceless unaspirated consonants, it is longer for voiceless aspirated consonants and it is close to zero or negative for voiced consonants (i.e. the vibration starts before the release of air).

Another argument showing that there is computation after the PPI comes from the fact that the ratio between the duration of long and short vowels varies greatly cross-linguistically (cf, Odden 2022: 15). Vowel duration is affected by the presence of voiced consonants: vowels are longer if they precede voiced consonants and shorter if they precede voiceless consonants. However, the ratio between the duration of vowels that precede voiceless and voiced consonants can vary greatly from language to language. The length of a vowel preceding a voiceless consonant is only 79% of the length of a vowel preceding a voiced consonant in English, while in Polish the length of a vowel preceding a voiceless consonant is 99% of the length of a vowel following a voiced consonant (Cohn 1998: 26).

Additionally, in languages where both vowel and consonant length are contrastive, the ratio between contrasting long vs. short vowels and consonants is not consistent cross-linguistically. In Logoori a short vowel is 52% of the length of a long vowel, while in Finnish, a short vowel is 45% of a long vowel (Odden 2022: 16). In sum, length is implemented differently in different languages, further suggesting that phonetic implementation is not automatic, but is instead (at least partially) under the control of the speaker.

Those facts hint that some phonetic properties are implemented in different manners in different languages, meaning that they are not under the control of a universal phonetics marshalled only by physiology. Speakers have at least some control over the phonetic implementation of phonological categories, which varies depending on the language they have acquired (cf. Cho 2011: 346-49). Additional and more specific arguments for a language-specific cognitive module of phonetics can be found in Keating (1985), Kingston and Diehl (1994), Cohn (1998), Cho & Ladefoged (1999) and Kingston (2019).

In sum, even if more studies are necessary on the subject, we can assume that there is a cognitive module responsible for some phonetic computation after the PPI has transduced the phonological material into a phonetic representation (Odden 2022: 12).

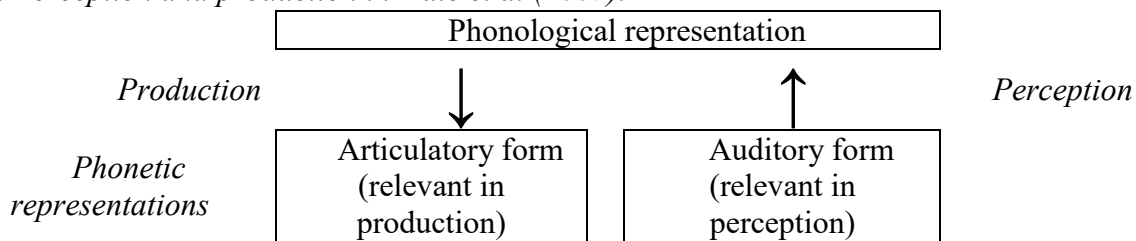
V.4.4.1 What is the phonetic representation made of?

Phonetic representation comes in at least two forms: auditory representation and articulatory representation (Boersma & Hamann 2008: 226ff). For the CSa each phonological prime has a fixed correlation with those two forms, and Volenec & Reiss (2020) explore the ways phonology is transduced into an articulatory representation, defined as a series of neuromuscular instructions.

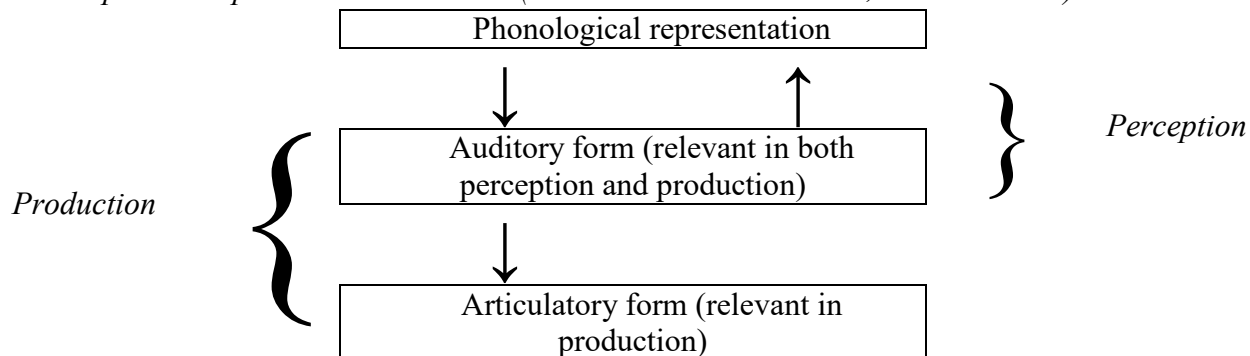
Boersma & Hamann (2008) and Hamann (2011) argue for a PPI that maps phonological items to an auditory form, which in turn, in speech production, is translated into an articulatory form. The core idea of the BiPhon (Bidirectional Phonology and Phonetics) model proposed by the authors is that the same interface between phonetics and phonology governs both perception (i.e. phonetics to phonology) and production (phonology to phonetics). That is, there is only one PPI that works in the same way in production and in perception, since the acoustic form is a stage shared by both the process of speech production and perception. This view is consistent with the idea of a cognitive module of phonetics, which has the role of defining the articulatory implementation of the auditory form received from the PPI. The models in Hale et al (2007) and Boersma & Hamann (2008) are schematized under (44).

(44) Relating phonetic representations: double translation and subsequent translation

a. Perception and production in Hale et al (2007).



b. Perception and production in BiPhon (Boersma & Hamann 2008, Hamann 2011).



During perception, the listener receives an acoustic form that can be transduced into a phonological representation, while in production a further step is required. The acoustic form is the cognitive representation treated by the cognitive module of Language-Specific Phonetics. The articulatory form, instead, is treated by Universal Phonetics, which is not cognitive in kind, but is physiological and lies outside of grammar, exactly as the interface proposed by the CSA in §3.3.

The Language-Specific Phonetic module (LSP) receives a specific acoustic form from the PPI and determines an acoustic target that the following module has the task of producing. The Universal Phonetic module receives the output of the LSP and produces a neuromuscular instruction that can be picked up by the sensory-motor system.

The line between phonetics and phonology is traditionally drawn between the discrete and the continuous nature of the two kinds of representations. Phonological representations are discrete, while phonetic ones are gradient. Notice, however, that the PPI correlates a phonological category to a specific auditory form, expressed in BiPhon as a value on the ERB scale (Equivalent Rectangular Bandwidth, Boersma and Hamann 2008: 229). The LSP module creates relevant variation: given a discrete ERB value, which correlates to a phonological segment in PPI, LSP computation produces ERB values with slight variation around the ERB value received from the PPI (target undershoot, overshoot). Thus, gradience is introduced at the level of the LSP, which produces variable acoustic targets for articulatory implementation, carried out by the Universal Phonetic module. In perception, the LSP receives an ERB value that it has to map onto the specific ERB value correlating with a phonological representation in the PPI.

Below I adopt the view of BiPhon regarding the PPI. That is, there is only one PPI which correlates phonological items to an auditory form, and the interface has a role in both perception and production. Perception takes the auditory form and correlates it to phonological items through the interface, production requires an additional interface within the realm of phonetics; that turns the auditory

representation into sensory-motor instructions. Articulatory/Universal phonetics, which deals with sensorymotor instructions, is responsible for phonetic variation that occurs in all languages: coarticulation, aerodynamics *etc.*...

V.4.4.2 Segments, not primes, are transduced

An issue that also needs to be discussed concerns the question of exactly which phonological item is transduced to the phonetic module. In both substance-laden theories and in CSa, phonological primes have a direct correlation with phonetic properties. There are reasons to believe, though, that it is the whole segment, comprised of one or more phonological primes, that is mapped onto a phonetic representation and vice-versa.

An argument for assuming that it is the segment, and not a single prime, that is transduced into a phonetic representation is the mere existence of crazy classes of segments that are active in phonological processing. In §1.3 we discussed how crazy rules of the 1st and 2nd kind require reference to unnatural classes. Below, I set out to show that if primes were directly transduced into acoustic representations, truly crazy classes could not be formalized.

Consider the case of River West Tarangan (Nivens 1992: 219, Mielke 2008: 121), treated above in §1.2.3 and §3.2. Recall that /m/ undergoes place assimilation to a following /t̪ g s j/, but no other segments. The consonantal segments of River West Tarangan are shown again in (45a), where the active class of place assimilators is highlighted. Examples of /m/ assimilation are provided in (45b).

(45) River West Tarangan phonology (Nivens 1992: 219; Mielke 2008: 121)

a. Consonants in River West Tarangan.

	t̪			k
b		d		g
ɸ		s		
m		n		ŋ
		r		
		l		
			j	

b. Place assimilation of /m/ in River West Tarangan.

<i>/m/ assimilates before / t̪ g s j/</i>			<i>/m/ fails to assimilate in other contexts</i>		
/bimtem/	[bintém]	'DUP small'	/jerkimkam/	[jerkimkam]	'DUP NF dislike'
/jergimgum/	[jergingum]	DUP NF rub'	/dimdumdi/	[dimdumdi]	'DUP six PL
/simsimə/	[sinsimə]	'ant (sp)'	/nimnam/	[nimnam]	'berry (sp)'
/ɸaɸamjɛmnə/	[ɸaɸanjɛmnə]	'overcast 3s'			
/simsimət/	[simsimət]	'DUP east'			

As discussed above in §1.2.3, there is no combination of features under any of Jakobson et al. (1952), SPE, or Unified Feature Theory (Clement & Hume 1995) that could describe the set /t̪ g s j/ as a phonological natural class, distinct from all other consonants. In traditional substance-laden theories, this process would be problematic, and we should come up with a phonetic property shared by all segments

of the active class. In §3.2 is discussed how CSa may represent the process using multiple rules, but is unable to represent the class of triggers of this process as a natural class.

In a Radical SFP approach, where primes are learned, all unnatural classes are permitted. We thus assume that there is a symbolic phonological prime $|\alpha|$ that is shared by all segments of the active class which comprises $/t̥ g s j/$. As we shall explore in more detail in the following chapter, I assume that children construct this prime given the evidence from the alternations they perceive. For RadSFP, then, the class of triggers of River West Tarangan is a valid phonological active class, individuated by a phonological prime.

For the sake of argument, let us assume that the anterior consonants of River West Tarangan form another active class $|\beta|$. Other primes are added to each segment of the class to ensure that all of them are distinguished. A hypothetical prime representation could be the one shown in (46). I assume unary primes, which are formally simpler, over binary primes (Odden 2022: 4). In §VI.2 the choice of unary over binary primes is further explored, but for the discussion at hand the difference between unary and binary primes is negligible.

(46) Prime specification of consonants in River West Tarangan

Segment	Active class: β	Active class: α (trigger place assimilation)	Additional prime (purely contrastive)
$/t̥/$	β	α	$\delta\dots$
$/g/$		α	$\gamma\dots$
$/s/$	β	α	$\mu\dots$
$/j/$	β	α	$\pi\dots$
$/d/$	β		$\varphi\dots$
$/l/$			$\psi\dots$

Now, let us assume that primes are directly transduced in the interface: if this were the case, all the various primes assumed would be correlated arbitrarily to an auditory representation. An auditory representation consists of noises, pitches, spectra, silences, transitions, and durations, which assuming the BiPhon proposal (Boersma & Hamann 2008) come down to a single ERB value, and as such can be externalized, once translated into an articulatory form. Crucially, it is also retrievable from the acoustic source, meaning that human ears and human cognition should be able to recognize the correlate to each prime and parse a specific acoustic property, which transduces to $|\beta|$, $|\alpha|$ or $|\gamma|$ etc....

That the prime $|\beta|$ may have a phonetic correlate is not surprising. Anterior consonants are recognized as a natural class by various representational theories (SPE, Clements & Hume 1995...), and thus it is uncontroversial that there is a phonetic property that listeners can retrieve from the signal that informs them of the presence of an active class that shares this property.

It would be harder to make such a claim for the prime $|\alpha|$. Is there an acoustic (or articulatory, if we do not subscribe to the BiPhon proposal discussed in §4.4) property shared by $/t̥ g s j/$ that does not appear in any other consonant $/\phi, b, m, d, n, r, l, k, \eta/$?

Phoneticians may suggest an option, but such a question should be repeated for any unnatural class reported in Mielke (2008). There surely will be cases in which such a property could be found: consider the case of raising in Tswana (cf. §II.3.1.3.5).

Mielke suggests that raising of mid-low vowels in Tswana is triggered by high vowels but also by nasals and sibilant consonants. Mielke argue that this class is crazy, in that it is impossible to group

together the set of segments /m, n, ŋ, ɲ, ts^h, tʃ^h, ts', tʃ', s, ʃ/ using any of the primes proposed in standard representational theories. However, as Mielke (2008: 128) himself notices, there are acoustic similarities between nasals and sibilants that may be a plausible phonetic exponent of a hypothetical class |α| : {/ m, n, ŋ, ɲ, ts^h, tʃ^h, ts', tʃ', s, ʃ/}. Could such a property be found for all crazy classes?

This is, at the end of the day, an empirical question. If all unnatural classes can receive a plausible phonetic correlate, then a PPI where single primes are transduced is conceivable. This requires a thorough analysis of all crazy rules of the 1st and 2nd type and of their respective phonological systems. A prime-based PPI, one that transduces single primes, should be able to relate a specific phonetic property, one that could be picked up from the signal, to all active classes of phonology. This means that any active class of segments, however crazy, must actually share a phonetic property that is absent from all other segments in the language.

This is not plausible or likely to be true. Therefore, I do not further entertain a prime-based PPI and instead consider an alternative view, where segments are sent to the PPI to be transduced. That is, segments, i.e. bundles of primes, are the items that receive a transduction in the PPI. The crazy class found in River West Tarangan, for example, may be individuated by a prime that does not need to have a phonetic correlate. The instruction for transduction of the segments active in place assimilation of /m/ are proposed under (47). Instead of single primes, groups of primes are collectively transduced. In the table the phonetic correlate of segments is put between square brackets. In the traditional notation, square brackets indicate the surface form resulting from phonological processing. In a modular view, the input and the output of the phonological module are both phonological forms, just observed before and after computation. Here I give to square brackets the role of identifying the phonetic category.

(47) Prime specification and phonetic correlate of segments belonging to the crazy class found in River West Tarangan

Segment (phonological representation in terms of unary primes)	Active class: β	Active class: α (trigger place assimilation)	Additional prime (purely contrastive)	Phonetic correlate.
/t̥/: {β, α, δ}	β	α	δ...	[t̥]
/g/: {α, γ}		α	γ...	[g]
/s/: {β, α, μ}	β	α	μ...	[s]
/j/: {β, α, π}	β	α	π...	[j]

I assume that the interface between phonetics and phonology maps phonological segments to phonetic acoustic forms, which are later the object of phonetic computation and then externalized. In this theory primes have the role they have always had since their inception (Jakobson, Fant & Halle 1952): ensure that segments are contrastively defined and account for phonological processing individuating active classes. They are not, however, what is spelled-out.

Scheer (2022: 36) proposes a different view for why segments and not primes are transduced in the PPI: in his model phonological primes belong to different modules which interface together with phonetics. In such a model it is the sum of primes that specify a segment that are transduced.

Below I sum up three key characteristics of the PPI that are consistent with the project of RadSFP, and that are assumed in the analysis of RVH presented in the following chapter:

- PPI correlates two cognitive modules: the phonological module, where phonological computation is carried out, and the phonetic module where language-specific phonetic rules apply.
- Phonological items are transduced into acoustic forms. The mapping between phonetic and phonological objects works in the same manner in both production and perception.
- The input of the PPI are phonological segments, i.e. bundles of features that are transduced as such into an auditory form. Segments receive a transduction, not single primes, which are symbolic items that live only within the cognitive module of phonology.

V.4.5 A consequence of arbitrariness of the PPI: multiple phonological items map onto the same phonetic exponent.

Now that the main properties of the PPI have been established, we can discuss its main feature: arbitrariness in the mapping between phonological and phonetic items. The fact that it is arbitrary is not only a consequence of the assumption that primes are actually learned categories, but also predicts some phenomena that a non-arbitrary interface would have a hard time accounting for. We can imagine the PPI as a list of associations of items, which allow for the translation of phonological material into an acoustic representation and vice versa. Upon acquisition, children learn those associations as part of their grammar say that this is called a spell-out instruction. Under (48) a hypothetical interface for a toy language is proposed.

(48) Toy example of a PPI

<i>Phonology</i>		<i>Phonetics</i>
{αβ}	↔	[a]
{αδ}	↔	[e]
{βπ}	↔	[u]
{γδ}	↔	[i]
{δπ}	↔	[i]

The use of the symbol “↔” that correlates phonological to phonetic items signifies that the correlation works both ways, since the association between representations of different kinds is meant to work in both perception and production. Additionally, recall the discussion from §2.2 on the difference between the double pointed arrow ‘↔’ and arrow ‘→’. The first one indicates correspondence between items of different cognitive domains, the second one indicates the application of an algorithmic operation.

Notice that a truly arbitrary interface does not only allow for mismatches (Hamann 2011, 2014), but also for multiple-to-one associations between phonological and phonetic forms, i.e. for multiple phonological items that map onto a single phonetic representation. This means that the same sound may actually correspond to different phonological objects, which behave differently during phonological computation. In the toy example under (48), the two sets of primes {γδ} and {δπ} both map onto [i]²²¹.

²²¹ It is an open question whether the opposite is also true, i.e. whether a single phonological item may be correlated to two different phonetic exponents. Allophones in free variation may be the reflection of such mappings, but more research is needed to assess this claim.

This property of the PPI is encountered empirically in a number of languages, among which Inuit, where there is reason to believe that a single phonetic exponent corresponds to two different phonological segments. Compton & Drescher (2011) report that Proto-Eskimo had four vowels, */i, ə, a, u/, which survive in the Yupik branch of Eskimo. In the Inuit branch, dialects display a three-vowel system /i,u,a/ (only one dialect still has contrastive [ə] on the surface). However, some Inuit dialects show palatalization after surface [i] corresponding to original */i/, but not after surface [i] corresponding to */ə/. Compton & Drescher (2011) analyze this situation assuming that in dialects of Inuit that display palatalization, there are two underlying objects that are externalized as [i]: /i/, which triggers palatalization, and /ə/, which does not. The diachronic change in these dialects then did not concern the vowel system or any phonological property, but rather its spell-out: the former mapping $\text{ə} \leftrightarrow \text{ə}$ became $\text{ə} \leftrightarrow \text{i}$. This is exactly what is expected if multiple phonological objects can be transduced into the same phonetic representation.

Gussmann (2007) makes a similar case for Polish, where three underlying objects are pronounced [ɛ]. As in Inuit, only one of them behaves as a valid trigger for palatalization, while the two others exhibit different phonological behavior (Gussmann 2007: 56).

In sum, a truly arbitrary PPI makes use of the Phonological Epistemological Principle presented in Kaye (2005: 283) up to its most radical conclusions. The phonetic properties of a phonological item play no role in identifying its phonological properties. Only phonological processing can show the true identity of a segment. The notion of multiple phonological items mapping onto the same phonetic category will be exploited in chapter VI to account for various problematic aspects of RVH.

V.4.6 Representing height with substance-free primes

The assumption of a truly arbitrary interface between phonetics and phonology and the idea of a Substance Free computation in the phonological component have significant consequences for the issue presented in previous chapters regarding raising harmonies.

First, since substance cannot inform phonological processing, the discussion about the definition of raising vs. tongue root harmony entertained in §II.2.1 loses its relevance within phonology. Recall that in §II.2.1 a heuristic was introduced to distinguish between tongue root harmonies and height related harmony. A harmony was considered a Tongue root-harmony if vowels of different heights are affected or trigger it. Harmonies where higher vowels affect lower vowels (or lower vowels affect higher vowels) were defined as height harmony. The issue derived from the assumption that [±high],[±low] and [±ATR] were the innate primes involved in raising, and thus a diagnostic to distinguish between processes that deal *only* with [ATR] (tongue-root harmonies) and those that deal *also* with [ATR] (height-harmonies) was necessary.

In Radical SFP the issue is non-existent. Each language has its own system of sounds and of primes that identify classes of sounds. The way a process is externalized (raising, lowering, labialization *etc...*) does not concern computation. How processes that were traditionally described as assimilation are formalized in a RadSFP framework is explored in §VI.3.

The distinction between tongue-root and height harmonies remains relevant in the phonetic analysis of a process, but a Radical SFP has no way of “knowing” that a process involves a modification in the position of the tongue, in the protrusion of the lips, in fronting, in nasalization, et cetera. Phonology formalize processes as mappings from one arbitrary string of bundles of primes to another. Their phonetic aspect matters only after the transduction made in PPI. Whether an alternation involves raising or a modification on the position of the tongue root is now a question that is relevant only outside of

phonology. Still, the study of this group of processes may shed light on properties of phonological competence, as shown in chapter VI.

Also, the issue discussed in §II.2, concerning the special status of vowel height, now appears in a different light: in Radical SFP the answer is to be sought outside of phonology. While discussing the property of vowel height, it was noticed that that vowel systems are structured around multiple levels of height and only around two degrees of roundness or backness (Lindau 1978: 547). An explanation of why only height had this property was needed, and to account for this state of affairs, incremental theories of representation were introduced in §IV.2. Once the representation of segments is freed by an arbitrary interface, it does not matter anymore how many height degrees are present in any given language. Or rather, as before: the question is not to be sought in phonology.

In §II.3.1.3.5 the interesting system of height distinctions in Sotho/Tswana languages was discussed. In Sotho-Tswana languages and some neighboring varieties (i.e Phuthi, cf. §II.3.1.3.6), five degrees of height have phonological relevance. Under (49a) two renditions of the vowel system of Sotho-Tswana languages are shown. Notice that they are structured around five phonemic degrees of height, plus an allophonic one (i.e. Raised Height-2 vowels only occur in the language as the result of raising of Height-2 vowels). Regardless of the disagreement on the graphical rendition of the vowels, in both Sotho and Tswana is active a process of raising by which Height-4 vowels /ɛ, ɔ/ raise by one degree, surfacing as [e, o], when followed by Height-2 vowels /i/-/u/ and Height-1 vowels /i/-/u/. Alternations are shown in (49b) and (49c).

(49) Raising harmony in Sotho-Tswana languages

a. Parkinson (1996) and Khabayane (1991) renditions of the vowel system of Sotho-Tswana languages

	<i>Parkinson (1996)</i>		<i>Khabayane (1991)</i>		
<i>Height 1</i>	i̇	u̇	i	u	
<i>Raised H2</i>	i	u	ɛ̇	ɔ̇	*non phonemic
<i>Height 2</i>	ɪ	ʊ	e	o	
<i>Height 3</i>	e	o	ɛ̣	ɔ̣	
<i>Height 4</i>	ɛ	ɔ	ɛ	ɔ	
<i>Height 5</i>	a		a		

b. Raising of Height-4 vowels in Sotho

Target vowels	Roots		Alternations caused by Height-1 and Height-2 vowels		
			P 96	K 91	
ε	fɛl-a	'come to an end'	fel-ɿsa	fɛl-is-a	'finish'
	rɛm-a	'chop down'	rem-ɿle	rɛm-il-e	'have chopped down'
	mɛm-a	'invite'	mem-ɿs-a	mɛm-is-a	'cause to invite'
	bɛtl-a	'sharpen'	betl-ɿw-e	bɛtl-uw-ɛ	'has been sharpened'
ε	ɛp-a	'dig'	ep-oll-a	ɛp-oll-a	'dig out'
	qɛk-a	'entice'	qek-ɿloh-a	qɛk-oloh-a	'avoid'
	ɛm-a	'stand'	em ɿ	ɛm e	'standing'
ɔ	bɔn a	'see'	sɿ bon ɿ	se bɔn i	'thing that sees'
	rɔk a	'praise'	sɿ rok ɿ	se rɔk i	'poet'
			rok ɿl e	rɔk il e	'praised'
bɔl a	'rot'	sɿ bod ɿ	se bɔd u	'rotten thing'	
ɔ	pɔt a	'go round'	pot ɿ	pɔt e	'not go around'
	kɔb a	'bend'	kob ɿll a	kɔb oll a	'unbend'

c. Raising of Height-2 vowels in Sotho

Target vowels	Roots			Alternations caused by Height-1 vowels		
	P 96	K 91		P 96	K 91	
i/e	lim-a	lem-a	'cultivate'	mulimɿ	moɓemi	'cultivator'
	bil-a	bel-a	'boil'	bid ɿle	bɛd il e	'boiled'
				bid ɿs a	bɛd is a	'cause to boil'
lif-a	lef-a	'pay'	lif ɿw e	lɛf uw ɛ	'has been paid'	
o/o	tsum-a	tsum-a	'hunt'	si tsum ɿ	si tsɔm i	'hunter'
	nɔk-a	nok-a	'season'	nukɿwe	nɔkuwɛ	'has been seasoned'

In (50) it is shown how the fixed primes of substance-laden theories may have a hard time representing vowels in Sotho Tswana. It was noticed in §II.3.1.3.5 that standard theories that employ innate features such as [high],[low] and [ATR] are unable to identify enough height degrees. If we assume the analysis of Sotho-Tswana languages of Parkinson (1996), we are unable to define phonologically super-high vowels (Height-1 vowels in 49a); if instead we assume the analysis of Sotho-Tswana vowels proposed in Khabayane (1991), we may have a hard time defining Height-3 and Raised Height-2 vowels.

(50) Feature assignation to the vowels of Sotho-Tswana languages

	<i>Parkinson (1996)</i>			<i>Khabayane (1991)</i>		
<i>Height 1</i>	ị	ụ	?	i	u	[+high][+ATR]
<i>Raised H2</i>	i	u	[+high][+ATR]	ẹ	ọ	?
<i>Height 2</i>	ɪ	ʊ	[+high][-ATR]	e	o	[-high][+ATR]
<i>Height 3</i>	e	o	[-high][+ATR]	ɛ	ɔ	?
<i>Height 4</i>	ɛ	ɔ	[-high][-ATR]	ɛ	ɔ	[-high][-ATR]
<i>Height 5</i>	a		[-high][+low][-ATR]	a		[-high][+low][-ATR]

Assuming RadSFP, a vowel system such as the one under (50) can be easily represented. The system is comprised of 11 vowels, so 11 different prime configurations (each one with its mapping to phonetics) are present in Sotho-Tswana languages. Notice that it is not necessary that all vowels have a prime related to height. It is just necessary that the prime configurations are different. The vowels that raise and the vowels that result from raising will have a similar representation, so that a rule can modify it.

Let us assume that raising is formalized as the addition of a prime, and that no other phonological process applies in Sotho-Tswana languages. Valid triggers for raising of mid-low vowels are /ɪ, i, u, ʊ/, while /ɪ, ʊ/ raise to [i, u] when followed by a super-high vowel /ị, ụ/. The triggers contain the harmonic prime, which is passed onto preceding targets. Under these assumptions, the vowel system in (50a) is represented as under (51). For the sake of the example, I assume the surface system corresponds to the one reported in Parkinson (1996). The process, which for now is expressed informally, targets $|\pi|$ adding $|\beta|$, and $|\delta|$ adding $|\alpha|$.

(51) Vowel system of Sotho/Tswana languages with substance-free primes

a. Raising of Height 2 vowels: add $|\alpha|$ to $|\delta|$.

[ɪm-a] → [mulimɪ]

b. Raising of Height 4 vowels: add $|\beta|$ to $|\pi|$.

[fɛl-a] → [fel-ɪsa]

[ɛm-a] → [em-ɪ]

c. Prime-based specification of vowels in Sotho using substance-free primes

<i>Height 1</i>	ị	↔	$ \alpha\beta $	ụ	↔	$ \gamma\alpha\beta $
<i>Raised H2</i>	i	↔	$ \delta\alpha\beta $	u	↔	$ \delta\gamma\alpha\beta $
<i>Height 2</i>	ɪ	↔	$ \delta\beta $	ʊ	↔	$ \delta\gamma\beta $
<i>Height 3</i>	e	↔	$ \pi\beta $	o	↔	$ \pi\gamma\beta $
<i>Height 4</i>	ɛ	↔	$ \pi $	ɔ	↔	$ \pi\gamma $
<i>Height 5</i>	a	↔	$ \varphi $			

The substance free primes indicated in Greek letters do not have a specific correlate, as discussed in §4.4.2. The configuration of primes reflects the behavior of the vowels in the process of harmony. Triggers have the harmonic primes $|\alpha|$ and $|\beta|$, while the targets (individuated by π, δ) receive the harmonic

primes. More complete examples of how a vowel system can be represented will be given once the issue of rule formalization is tackled in §VI.3.

Recall that in §IV.2 it was discussed how different languages make the distinctions between different heights at different levels along the vowel/height continuum (Disner 1983). Under the CSa approach to the PPI, we expect that UG is endowed with primes that relate to the specific height of Sotho and Tswana super-high vowels, which appear to be useless in all languages with a smaller number of height-based alternations. An arbitrary PPI, instead, permits us to give different phonological representations to the various height degrees, without assuming that all languages require having at their disposal inert primes that may not distinguish speech sounds.

V.5 Conclusion

In this chapter some theoretical and some empirical facts were presented that support the proposal advanced by RadSFP. Phonological processing is not necessarily natural, and the classes of segments that participate in phonological processes may not be natural classes. It was argued that a theory that subscribes to the Substance Free program is better suited to account for asymmetric harmonies, which have been defined as similar to crazy rules of the 1st and 2nd type: processes that select an unnatural set of segments as either triggers or targets of a phonological rule. The two main approaches to SFP have then been discussed, alongside their core difference: the universal and innate vs. language-specific and emergent character of primes. For the CSa all humans share an innate set of binary features which have a fixed correlation with phonetics.

The assumption in RadSFP instead is that primes are learned based on environmental information, and that phonological categories have an arbitrary relation with phonetics. The properties of a PPI consistent with the Radical SFP approach have been discussed.

The last chapter of this thesis applies the insights explored in this chapter to raising harmonies. First, the specific theories of phonological representation and computation supported here are developed. In particular, some assumptions concerning the formalization of processing are introduced and justified. Then, two opposing theories of prime learning are confronted, with the goal of defining which one of them better accounts for parasitic harmonies. In addition, the issue of scalar raising harmonies as well as the issue of morphologically conditioned processes is discussed, showing that a Radical SFP is able to capture all the problematic aspects of RVH.

Chapter VI. Running a Radical Substance Free Phonology: the task of learning phonological primes

VI.1 Introduction

Chapter V discussed the idea (introduced in Mielke 2008) that primes are not innate objects given by UG, but rather categories that speakers learn based on environmental information, i.e. under the pressure of the phonological system (contrastive sounds must have different representations) and phonological processing (groups of segments that pattern together in triggering or undergoing a process share a prime).

It remains to be seen how primes are effectively learned. In §V.4.1, the double-step model argued for Samuels et al (2022) was discussed. First children recognize the sounds of their language (i.e. they learn the phonetic side of the PPI, the phones of their languages in structuralist terms), and at a later stage they learn which of these phones are phonemes, i.e. the phonological form that is transduced into phones. Learning the phonological representation of phones means learning a series of transductional instructions that map one phonological item made of primes to a phonetic correlate and vice versa. The factors that induce prime emergence are two: contrast and phonological processing, i.e. alternations. This is the position held in this thesis: the core part of this last chapter is to identify how phonological representations are assigned to language phones, which I assume are already known by learners.

This chapter's main goal is to compare two theories of prime emergence, which differ in the way they divide the labor of contrast and processing in the learning phase. The first one, proposed in Dresher (2014) and developed in Sandstedt (2018), considers contrast and the contrastive role of primes as a central force guiding prime emergence alongside processing. The second one, put forth by Odden (2022), considers phonological computation as the main evidence of prime learning, while contrast has a minor role. The two options are presented in §4 and §5 respectively, and tested using data provided in chapter II and chapter III.

Before the comparison between theories of prime emergence, it is useful to zoom out on the broader picture regarding phonological representation and phonological computation. Without an established theory of representation and computation, it is difficult to compare theories of prime emergence. Therefore, section §2 summarizes the theory of phonological representation introduced in §V.4, where only primes were discussed, and considers the role of structural items (syllable structure *etc...*) in a RadSFP framework. Section §3 sketches the theory of phonological computation that will be used in the rest of the chapter, paving the road for the comparison between competing models of prime learning.

Since both accounts considered assume that alternations are a relevant source of information for prime learning, phonological computation must be defined beforehand.

Section §4.1 introduces Dresher's (2014) framework, and shows that parasitic harmonies call for a refinement of its workings, which are provided in Sandstedt (2018) §4.2. It is shown how this theory of prime learning accounts for asymmetric and parasitic harmonies.

Section §5 introduces the alternative option entertained by Odden (2022) and shows how this theory accounts for asymmetries and parasitism. Section §6 discusses the way both models of prime emergence deal with scalar raising harmonies. It is argued that the method of prime learning proposed in Odden (2022) is able to account for asymmetric, parasitic and scalar raising. By contrast, the one based on

Sandstedt (2018), while perfectly adapted to account for asymmetric and parasitic harmonies, encounters issues when facing scalar raising. Section §7 proposes an analysis of morphologically conditioned metaphonies discussed in §IV.7.3. Section §8 closes the chapter and the thesis, suggesting possible directions for the research within the scope of RadSFP.

VI.2 Structure vs. melody in phonology

In section §V.4 it was argued that the primes of phonology are substance-free units, that they do not come as a set that is innate and universal, that they do not have innate and universal phonetic correlates, and that segments have a language-specific phonetic correlate.

One issue that has not been covered in §V.4 concerns the unary/binary nature of phonological primes. While CSa assumes primes to be binary, Odden (2022) argues that unary primes are simpler items, and thus preferred as the basic building block of phonological representation. In Odden's terms, a theory of phonology based on unary primes is formally simpler, because it posits one concept – the prime – whereas binary theories require three concepts – “value”, “attribute”, and “feature” (the latter being the conjunction of value and attribute). The choice of unary over binary primes is not without consequences. As we shall see in §3, the kind of prime chosen directly affects the kind of formal processes that are possible. In the discussions that follow unary primes are used; if binary primes were chosen instead, a theory of phonological computation that manipulates them should be put in place, which may differ in the kinds of operation it may implement.

Phonological representation, however, is not limited to primes and their relations. It also features items above the skeleton: syllables, onset, nuclei, codas, rhymes, morae, feet...

Scheer (2019, 2022) observes that since SFP has appeared some 25 years ago, no attention was paid to structural items that occur at and above the skeleton (which, for the sake of exposition, below I refer to as "phonological structure"). Scheer (2022: 2) argues that there is a specific reason for why scholars committed to SFP have hardly ever looked into phonological structure. SFP was born as a reaction to approaches that import phonetic substance into phonology. Scrambling phonetics and phonology (i.e. committing substance abuse) must be avoided, for two reasons. First, substance abuse repeats the phonetic explanations of phonological processes twice, once in phonetics and another time in phonology. In addition, the avoidance of substance abuse follows from the modular architecture of language, assuming that phonetics and phonology are two different modules.

The structural side of phonology remained untouched by the renovation brought by SFP because in phonological structure there are no phonetic properties to expunge, no “substance to abuse”. Onsets, rhymes, stress, prosodic words, metrical grids, timing units or whatever other item may occur at and above the skeleton²²² do not have any phonetic substance to be stripped away because they do not correlate with any phonetic/substantive property²²³. Structural items are themselves a projection of

²²² The list of prosodic/structural items that are represented above the skeleton may vary from one approach to the other. Still, since AP, the insight holds true: prosodic items are not represented using primes, but through structural items that do not have a phonetic correlate.

²²³ Tones, which in AP approaches are represented above the skeleton, have a phonetic correlate: pitch. The behavior of tonal phenomena was one of the first observations that led to autosegmentalism in phonology (Goldsmith 1976, Hyman 2011). They, then, may not be subject to the same treatment as other super-skeletal structure because they have a phonetic correlate. Scheer (2022: 19) argues that tone display a behavior between that of melody and structure.

primes, that is to say the result of a computation based on primes. This is why they lack a phonetic correlate.

Structural items may have an effect on the phonetic realization of segments (they are involved in positional processes cf. §3.1 below), but they lack phonetic properties themselves. Lacking a phonetic property means that structural items are not directly parsed by the PPI. In §V.4.4 the PPI was envisioned as a list of transductional instructions, whereby a list of phonological items (bundles of primes, cf. §V.4.4.2) map onto a phonetic representation. Melodic items (i.e. segments, bundles of primes) are part of this list, while structural objects are not (Scheer 2022: 5).

Structural items (syllables, onsets, codas, rhymes, nuclei...) have no inherent phonetic realization: there is no perceivable sound or sound property retrievable from the speech source that may be used by hearers as a cue that informs them about the boundaries between syllables, or about the onset vs. coda nature of a consonant (there are such cases of course, but they are not systematic). On the other hand, even if primes do not have a universally defined correlation with phonetics, a perceivable acoustic cue informs listeners about the segments they are hearing: [a] correlates with |αβ|, [i] with |γδ|...

In sum, a full autosegmental representation is comprised of items that have a phonetic correlation, primes, and also of items that do not have one. The dichotomy between prime-based representation (traditionally referred as segmental information or melody) and phonological structure is exemplified in the table (1) below. The difference between what is above the skeleton (structure) and what is below the skeleton (melody) lies in the fact that melody is transduced, while structure is not. This segregation between structural and melodic phonology is actually reflected in that crazy processes appear to be only ever melodically crazy, as we shall see in §3.1. The skeletal tier is the common ground between the two domains: structural and melodic items may interact only through the skeleton.

(1) Autosegmental representation: structure and melody are segregated

			<i>Syllabic/Prosodic tier: items at this level of representation are not transduced</i>
x	x	x	
			<i>Skeletal tier</i>
x	x	x	
α	β	δ	<i>Melodic tier: items at this level of representation are transduced</i>
β	γ	δ	

VI.3 Sketching a theory of phonological computation

In §V.4.1 the idea was discussed that prime learning is influenced by two factors, contrast and phonological computation. That is, the fact that segments are defined by the primes they are made of, as

well as the role of primes as definers of active classes in processing are the cues that help learners to discover the set of primes of their language, and to assign primes to individual phones²²⁴.

Among proponents of RadSFP (Samuels et al. 2022: 5; Odden 2022: 11) it is undisputed that the learner is innately provided with the notion of phonological prime and the basic mechanisms of processing. Even though their Card Argument has been dismissed in §V.4.2, the basic observation made in Hale & Reiss (2008: 38) remains: learning requires some basic prior knowledge. Some fixed facts are necessary as an innate basis for prime learning. The existence of primes (but, contra the CSa, not the list of primes or their phonetic correlates) and phonological computation are cases in point. Thus, Odden (2022: 3) argues that “[a] child does not learn from scratch what it means to be ‘a rule in the grammar’, the child knows that. What the child does need to learn is what the rules of a particular grammar are”. If learners use phonological alternations as cues to build their system of phonological primes, they must have a formal notion of phonological processes.

The goal of the present section is to define a bare theory of phonological computation, at least for what concerns harmonic processes. Section §3.1 defines the scope of the proposal, i.e. the kind of processes that involve a change in the prime specification of segments (melodic and positional processes), while sections §3.2 and §3.3 define the ways in which a phonological process involving primes can be formalized. Keep in mind that everything that is proposed in this section is theory-independent, meaning that what is mentioned might be applied to a variety of individual theories, including rule-based or constraint-based approaches.

VI.3.1 Melodic, positional and structural processes

Given the distinction between melody and structure discussed in the previous section and shown under (1), three kinds of phonological processes can be defined. Processes that are caused by melody and affect melody (purely melodic processes), processes that are caused by structure and affect structure (structural processes) and processes that are caused by structure and affect melody (positional processes). There are no processes that are caused by melody and that affect structure (Scheer 2019a: 131).

Given a general template of a phonological alternation, $A \rightarrow B/C$, harmonies and other melodic processes identify all three objects as melodic items, while positional processes have melodic items only in A and B, while C is a position defined by relations between structural items. Structural processes concern only structural items, and do not modify the internal composition of a prime. In this case, A, B and C are all structural items. This is shown in (2).

²²⁴ Recall that in §V.4.1 was argued that the acquisition of phonological processes goes in two steps: first phonetic cues identify the relevant phones of the language, then contrastivity and computation help the learner to create a phonological representation of those sounds based on primes.

(2) Melodic vs. Structural vs. Positional processes

Melodic processes	A→B/C	A	B	C
		melodic items	melodic items	melodic context
Positional processes	A→B/C	A	B	C
		melodic items	melodic items	structural context
Structural processes	A→B/C	A	B	C
		structural items	structural items	structural context

Under (3) are reported some purely melodic processes discussed throughout this thesis. In processes of this kind, the trigger, the structural modification and the target are all identified melodically, through a prime or eventually by a group of primes. Processes like assimilations (palatalizations, labializations, harmonies²²⁵, etc...) and dissimilations belong to this group.

(3) Examples of purely melodic processes: palatalization, labialization, harmony (crazy patterns).

Language	Alternations	Targets	Outcomes	Triggers
<i>Palatalization in Yawalapiti (cf. §V.1.2.4)</i>	p→r/i____ t→ts/i____ k→tʃ/i____ m→ɲ/i____	p, t, k, m	r, ts, tʃ, ɲ	i
<i>Backness harmony in Turkish (cf. §I.3.2.1)</i>	ʊ→i/i,y,e,ø C ₀ ____ u→y/i,y,e,ø C ₀ ____ ɑ→e/i,y,e,ø C ₀ ____ o→ø/i,y,e,ø C ₀ ____	ʊ, u, ɑ, o	i, y, e, ø	i, y, e, ø
<i>Raising parasitic harmony in Camuno</i>	e→i/____C ₀ i o→u/____C ₀ i,u,y ø→y/____C ₀ i,u,y	e, o, ø	i, u, y	i, u, y

Under (4) are exemplified some structural processes that do not affect the prime-based representation of segments (they do not modify the phonetic realization of segments), but affect their association with structure. They may lengthen a segment associating it with multiple timing units (4a); they may shorten a segment disallowing its association with multiple slots (4b); they may allow or disallow the pronunciation of a segment like in epenthesis (4c). None of the processes modifies the prime-based specification of a segment. Instead it modifies the structure around it. Lengthenings and shortenings affect length, (which is not a melodic property, cf. §I.3), while epenthesis inserts a vowel in what would be an illicit context (in 4c consonantal clusters composed by an obstruent and a sonorant at the end of the word).

²²⁵ Vowel harmony (which was a key phenomenon in the development of Autosegmental theory) propagates melodic material to all vowels of a domain, but (usually, cf. Rose & Walker 2011) does not jump intervening vowels, while it ignores intervening consonants. Indeed, if a vowel is ignored (i.e. behave as transparent) phonologists require an explanation for why they do so. If in palatalizations the melodic process applies at immediate proximity, in vowel harmony the process applies at a relative proximity (the rule applies to neighboring nuclei, not to neighboring segments).

(4) Structural processes such as lengthening, shortening, epenthesis.

a. Consonant lengthening in Tuscan dialects (*raddoppiamento fonosintattico*²²⁶ cf. Ledgeway 2016: 214)

Alternation C → CC		Triggering context Sandhi, when preceded by a stressed vowel or a specific monosyllable.	
['kase]	'houses'	[tre k'kase]	'three houses'
[fi'rentse]	'Florence'	[a ffi'rentse]	'to Florence'
['fumi]	'smoke 2 SG'	[perke f'fumi]?	'why smoke 2 SG?'
['tutto]	'everything'	[dɔ t'tutto]	'I give everything'

b. Closed Syllable Shortening (Scheer 2004: 166)

Alternation VV → V		Triggering context: closed syllable		
	Open syllable	Closed syllable C.CV	Closed syllable C#	
Turkish ²²⁷	NOM SG	Possessive	NOM PL	'curiosity'
	meraak-u	merak-tan	merak	
Czech	NOM SG	Diminutive	GEN PL	'cow'
	kraav-a	krav-ka	krav	
Classical Arabic	1 SG	2SG fem.	Imperative	'to say'
	?a-quul-u	ta-qul-na	qul!	

c. Epenthesis in Eastern Lombard dialects

Alternation Ø → ε		Triggering context: CC#		
['furen]	'oven'	[for'ner]	'baker'	*[furn]
['azen]	'donkey'	[az'ni]	donkey DIM	*[azn]
['neger]	'black M.'	['negra]	'black F.'	*[negr]

There are also processes that are caused by structure and that affect the way segments are realized, as those reported under (5). Processes of this kind are those that modify the prime-based representation of segments, but are not triggered by melodic items that precede or follow the target. Instead, they are conditioned by the position occupied by the target of the structural change. Processes of this kind are usually referenced in the literature as Lenitions and Fortitions (Ségéral & Sheer 2008: 131ff; Szigetvári 2008: 104ff). (5a) displays a process of consonant weakening typical of Tuscan dialects (*gorgia toscana*, Bafile 1997; Marotta 2008; Ledgeway 2016: 212), whereby intervocalic consonants (both word-internally and in sandhi) become fricatives. (5b) displays a case of vowel reduction, which applies when a vowel passes from stressed to unstressed position. The example comes, once again, from Eastern Lombard dialects, where mid-low vowels become mid-high when they become unstressed.

²²⁶ This process is active in standard Italian, in most Tuscan dialect, in Romanesco, in Corsican, and in dialects of northern Sardinia (Sassari-Gallura), Ledgeway (2016: 214). The contexts where this process apply are lexically sensitive. Consonants in initial position are doubled when preceded by oxitones and by a closed class of monosyllables (e.g. /a/ 'to', /da/ 'from, by', /e/ 'and', /o/ 'or', /ma/ 'but', /ke/ 'that').

²²⁷ Data reported in Scheer (2004: 166) and derived from Kaye (1990: 302) has been rewritten to follow the vowel system of Turkish proposed in §1.3.2.1).

(5) Alternations caused by position

a. *Gorgia Toscana (consonantal weakening in Tuscan dialects)*

<i>Alternations : Stops → Fricatives</i>		<i>Triggering context: V V</i>	
['pasta]	'pasta'	[la 'ɸasta]	'the pasta'
['tela]	'canvas'	[la 'θela]	'the canvas'
['kasa]	'house'	[la 'hasa]	'the house'
['barka]	'boat'	[la 'βarka]	'the boat'
['denti]	'teeth'	[i 'ðenti]	'the teeth'
['gatta]	'she-cat'	[la 'ɣatta]	'the she-cat'

b. *Vowel reduction in Bresciano*

<i>Alternation: Mid-low → Mid-high</i>		<i>Triggering context: unstressed position</i>	
Mid-low vowels in stressed position		Unstressed position	
['sek]	'dry'	[se'kat]	'dried'
['ɔrp]	'blind'	[orba'ti]	'blind DIM.'
['nɛdra]	'duck'	[ned'rɔt]	'duckling'

In the discussion that follows, only melodic and positional processes are treated. Since they modify the internal composition of segments, it means that they may affect the segments or the association lines between segments and timing units, and thus be used as clues during prime learning. Structural processes, instead, do not directly modify the internal composition of segments, and therefore are not relevant in the definition of melodic primes.

The processes we are mostly interested in are vowel harmonies, which I argue are purely melodic processes (as already suggested in §1.3). There are harmonies that involve melodic properties (roundness, backness, height, nasality ...), but there are no harmonies that involve structural properties of vowels (length, for example).

Recall that in §2 the domain of phonological representation was divided in two. On one side primes enjoy a transduction in the PPI. On the other, structural items are not transduced. Scheer (2022: 9) argues that this segregation correlates with that fact that only processes involving melody appear to be crazy. He notices that all crazy patterns reported in the literature are melodic processes, while positional and structural processes display a cross-linguistic consistent behavior.

Melodic primes are purely symbolic items without a fixed relation to phonetic properties. The computation that involves primes is necessarily arbitrary. As argued in §V.2.4, it does not make sense to distinguish between natural and unnatural melodic processes, and therefore there is no way to distinguish between a licit and an illicit melodic alternation: a 'natural' palatalization as $k \rightarrow tʃ/ _i$ is not more of a phonological process than a crazy one such as $p \rightarrow r/ _i$.

Processes involving phonological structure seem to have a different status from those that involve melody. Scheer (2022: 9) observes that structural processes are absent from the record of crazy rules.

A crazy process is a process that does not make phonetic sense. Crazyiness (i.e. the distance from the naturalness of an alternation) is a consequence of the arbitrary relation between phonological items and phonetic correlates in the PPI. Melodic processes modify the primes of a segment before it undergoes transduction in the PPI. Let us assume that a melodic process turns $|\alpha|$ into $|\alpha\beta|$ and that $|\alpha|$ is transduced

into phonetics as [p] and $|\alpha\beta|$ as [r]²²⁸. This melodic process appears crazy because of the way the outcome of the process is interpreted by the PPI.

A structural process, as we defined it, does not modify the internal prime-based representation of segments, but only their association with structure. A structural process may associate a segment $|\gamma\delta|$ to two timing units in an open syllable, resulting in lengthening. This structural process does not affect the primes of the segment: $|\gamma\delta|$ remains $|\gamma\delta|$, it simply sounds longer because it is associated with two timing units. If structural items were language specific (as we suppose primes to be), we would expect to find languages where they behave in different manners. An open syllable may shorten consonants, instead of lengthening them. Such cases appear to be totally absent from the record, though.

This suggests that structural items are meaningful objects that have the same status in all languages. In other words, unlike primes, they are good candidates to be considered innate and universal, and not learned categories. On the contrary, primes such as $|\alpha|$, $|\beta|$ and $|\gamma|$ are learned (and thus language specific) items, posited by learners to account for contrast and the alternations perceived (as shown in sections 4 to 6).

Computation involving meaningless items (i.e. primes) is necessarily arbitrary, as we shall see in § 3.2, and possibly crazy. Computation involving meaningful items (i.e. structure) cannot be arbitrary, otherwise we would come across structural processes that are crazy (Scheer 2022: 8). In sum, arbitrary computation applies to the domain of phonology that involves melody (i.e. below the skeleton) while faithful, non-arbitrary computation applies in the domain of phonology that involves structure (Scheer 2022: 11ff). Positional processes affect the primes (i.e. the melody), but their context of application is defined through the structure. Scheer (2022: 23) argues that positional processes are the result of structural computation that defines whether a skeletal position is strong or weak. Computation applying above the skeleton does not affect melodic items below the skeleton, but can affect the skeleton itself, which we defined as something to which both melody and structure have access²²⁹.

The theory of computation that is proposed below covers only processes that modify the prime-based representation of segments (i.e. may turn $|\alpha|$ into $|\alpha\beta|$ or into $|\gamma|$ or into $|\delta|$ etc...). In sum, it treats melodic processes and the side of positional processes that affects melody, i.e. what happens in a weak position or in a strong position. The theory proposed does not cover how a position is defined as weak or strong.

VI.3.2 Melodic processes

Within the SFP framework, phonological computation is not limited by any functional, phonetic or typological bias. Phonological processing simply turns a phonological representation into another phonological representation. Melodic processes manipulate substance-free primes, which are by definition empty labels without substance. Since phonological primes and phonetics have no innate and universal correlation there is no way to distinguish between licit and illicit melodic processes. Melodic processes may, in principle, map any representation onto any other representation (Volenec & Reiss 2020: 24; Scheer 2022: 7).

²²⁸ From this point forward, I will use Greek letters to identify substance-free primes. They are reported in the text between pipes, so as $|\alpha|$ or $|\gamma\beta|$.

²²⁹ Scheer (2022: 11ff) argues that an arbitrary computation and a non-arbitrary one cannot coexist in the same cognitive module. From this reason, he argues for a segregation of phonology between multiple modules: one that deals with Place-melodic primes, one that deals with Laryngeal-melodic primes, and one that deals with sonority primes. Only the last one projects structure. Cf. Scheer (2022) for a discussion of those matters.

However, phonological processes apply within phonological systems, and one of the key assumptions defended in §V.4.1 is that computation directly affects the phonological system by being a factor of prime learning. The alternations perceived by learners inform them about the internal prime-specification of segments. If phonological alternations are treated as valuable information in prime learning, the child must know how a process is formalized. Even if phonological computation involving melodic primes may turn any representation into any other, the child must know how to relate the items that participate in a phonological alternation.

Let us assume that children perceive that in their target language [k] (recall from §V.4.1 that children have access to the set of sounds of their language, but those sounds are still without a phonological representation) turns into [tʃ] when followed by [i]. Children must have knowledge on how the prime-based representation of /k/ modifies to become that of [tʃ], and how the presence of /i/ affects this change. If this is not the case, alternations could not be a source of information utilized in prime learning. That is, children must know beforehand, at the initial state, how a phonological rule works and how it can relate the prime-based representation of the segments involved in the alternations they perceive.

Assuming that primes are unary, there are three possible basic operations²³⁰: addition, subtraction or substitution of primes. If binary primes were assumed, another possible operation would be one that inverts the value of a prime from [+α] to [-α] and vice versa. In the discussion that follows, I use unary primes, as discussed above in §2. Once the context of application is considered, there are nine possible ways a melodic process may be formalized, which are presented in (6). In the formulations that follow, the arrow has the same role it had in SPE-like rules. At the left of the arrow is shown the target, at its right is shown the operation that applies to the target in the context, which is defined at the right of the slash. Each operation reads as: the target X undergoes the operation (Y) in the context /Z.

(6) Possible formalizations of melodic processes

<i>Add</i>		<i>Subtract</i>		<i>Substitute</i>	
a.	$\alpha \rightarrow (\alpha + \beta) / \underline{\alpha}$	d.	$\alpha\beta \rightarrow (\alpha\beta - \beta) / \underline{\alpha}$	g.	$\alpha \rightarrow (\alpha - \beta) / \underline{\alpha}$
b.	$\alpha \rightarrow (\alpha + \beta) / \underline{\beta}$	e.	$\alpha\beta \rightarrow (\alpha\beta - \beta) / \underline{\beta}$	h.	$\alpha \rightarrow (\alpha - \beta) / \underline{\beta}$
c.	$\alpha \rightarrow (\alpha + \beta) / \underline{\gamma}$	f.	$\alpha\beta \rightarrow (\alpha\beta - \beta) / \underline{\gamma}$	i.	$\alpha \rightarrow (\alpha - \beta) / \underline{\gamma}$

The table in (6) reads as follows:

(6a): Add |β| to a segment with |α| in proximity of |α|: when two adjacent segments share a prime |α|, add |β| to one of them.

(6b): Add |β| to a segment with |α| in proximity of |β|: when a segment with α is adjacent to a segment with |β|, add |β| to |α|.

(6c): Add |β| to a segment with |α| in proximity of |γ|: when a segment with α is adjacent to a segment with |γ|, add |β| to |α|.

(6d): Subtract |β| from a segment with |αβ| in proximity of |α|: if two adjacent segments contain |α|, subtract |β| from |αβ|.

²³⁰ Notice that each of those operations may apply as the result of a phonological rule or as a result of a constraint that disallow certain representations. I remain agnostic about the formal nature of phonological operations (i.e. whether they follow from rules or from constraints).

(6e): Subtract $|\beta|$ from a segment with $|\alpha\beta|$ in proximity of $|\beta|$: if two adjacent segments contain $|\beta|$, subtract $|\beta|$ from $|\alpha\beta|$.

(6f): Subtract $|\beta|$ from a segment with $|\alpha\beta|$ in proximity of $|\gamma|$: if a segment containing $|\beta|$ is adjacent to a segment containing $|\gamma|$, subtract $|\beta|$ to $|\alpha\beta|$.

(6g): $|\alpha|$ turns into $|\beta|$ in proximity of $|\alpha|$: if two adjacent segments are specified for $|\alpha|$, in one of them $|\alpha|$ is substituted by $|\beta|$.

(6h): $|\alpha|$ turns into $|\beta|$ in proximity of $|\beta|$: if a segment specified for $|\alpha|$ is adjacent to one specified for $|\beta|$, $|\beta|$ substitutes $|\alpha|$.

(6i): $|\alpha|$ turns into $|\beta|$ in proximity of $|\gamma|$: if a segment specified for $|\alpha|$ is adjacent to one specified for $|\gamma|$, $|\beta|$ substitutes $|\alpha|$.

Of course, multiple primes may be manipulated at the same time, as we shall discuss below in §5.2.

Notice that all formal operations described in (6) may apply in all directions. Some melodic processes affect segments that precede a trigger, while others affect segments that follow a trigger. Some harmonies may even apply in both directions, affecting segments that precede and that follow the trigger. Another issue that is relevant, especially when considering harmonies, is the fact that a process may consider only consonants or only vowels. Vowel Harmonies only affect vowels and are generally insensitive to intervening consonants. I assume that melodic computation has access to the information about the role of segments as vowels or consonants, so that a process may apply only to vowels appearing in adjacent syllables ignoring intervening consonants. For this reason Scheer (2022 : 34) argues that the skeleton identifies positions as vocalic and consonantic. In sum, the skeleton is identified as a sequence of C and V positions. Harmony only affects segments in V positions.

Given the arbitrary nature of melodic processes, any of the formalizations under (6) may be the correct one for any alternation. Let us take an alternation out of context, say $/k/ \rightarrow [tʃ]/_i$. Any of the formalizations under (6) may be a valid one, but the assumption of one formalization over the other implies a different relation between the terms involved in the alternation. During acquisition, learners perceive the alternation, and assign primes to the three segments (or classes of segments) involved. The table in (7) reports the internal composition of the three segments involved in the alternation $/k/ \rightarrow [tʃ]/_i$. Depending on the formalization assumed, the prime-based representation of the segments involved in the process varies. Greek letters indicate the substance-free primes posited by learners. Notice that other primes are necessary besides those involved in the process, namely $|\delta|$, for the three segments $/k/$, $/tʃ/$ and $/i/$ to be distinguished in certain contexts. Given the formulations in (7a) and (7d), an additional prime $|\delta|$ is necessary to ensure that the three segments are distinct.

(7) Alternations inform learning: possible rule formalizations give different information

Process formalization		Hypothesis on the prime-based content of segments:		
		/k/	/tʃ/	/i/
a.	$\alpha \rightarrow (\alpha + \beta) / \underline{\alpha}$	α	$\alpha\beta$	$\alpha\delta$
b.	$\alpha \rightarrow (\alpha + \beta) / \underline{\beta}$	α	$\alpha\beta$	β
c.	$\alpha \rightarrow (\alpha + \beta) / \underline{\gamma}$	α	$\alpha\beta$	γ
d.	$\alpha\beta \rightarrow (\alpha\beta - \beta) / \underline{\alpha}$	$\alpha\beta$	α	$\alpha\delta$
e.	$\alpha\beta \rightarrow (\alpha\beta - \beta) / \underline{\beta}$	$\alpha\beta$	α	β
f.	$\alpha\beta \rightarrow (\alpha\beta - \beta) / \underline{\gamma}$	$\alpha\beta$	α	γ
g.	$\alpha \rightarrow (\alpha \rightarrow \beta) / \underline{\alpha}$	α	β	$\alpha\delta$
h.	$\alpha \rightarrow (\alpha \rightarrow \beta) / \underline{\beta}$	α	β	$\beta\delta$
i.	$\alpha \rightarrow (\alpha \rightarrow \beta) / \underline{\gamma}$	α	β	γ

The goal of this section is to define which of the nine formalizations proposed in (6) are the ones that actually take place in phonological computation. During acquisition, learners recognize alternations (this assumption is necessary if computation has a role in learning), and the templates in (6) are the ways learners may relate the items concerned by the alternation perceived, so that they may use the alternation pattern as a clue for learning primes. For example, let us assume that the rule template for the alternation /k/ → [tʃ]/_i/ is the one in (7a): $\alpha \rightarrow (\alpha + \beta) / \underline{\alpha}$. Once the alternation is recognized, children learn that /k/ contains a prime |α|, which /k/ shares with the outcome and the trigger of the process. They also learn that /tʃ/ contains the prime |β|. If instead the rule template is the one in (7b), children learn that target and outcome of the process share |α|, and that outcome and trigger share |β|. In sum, depending on the template assumed, learners acquire different information about the prime specification of the segments involved in the alternation.

We have established that children know how to relate the three phonological items involved in a phonological alternation. How can we, as analysts, arrive at that same knowledge? Recall that, since primes are substance-free labels, any of the formulations in (6) is a viable option: melodic computation is (and has to be) arbitrary, since it involves purely symbolic items (Scheer 2022: 7).

A first way to limit the number of possible operations within melodic computation can be derived from Occam’s Razor. The theory of phonological computation should avoid positing multiple entities (in this case basic operations) if fewer entities can explain the same patterns. In other words, the theory of computation sketched in (6) posits three possible operations: “add”, “subtract” and “substitute”. (8) shows that the same patterns can be formalized using only two operations, namely addition and subtraction of primes. In practice, we can reduce the number of operations our computation can operate at the cost of representing substitutions with two rules²³¹. This is shown in (8). (8a) represents the formalization of substitution as the application of addition and removal, while (8b) re-proposes the table in (7), and shows that the same primes would be assigned to the three elements of the alternation if the operation substitution is eliminated. In sum, a theory of computation only capable of adding and removing items from a phonological representation is also capable of formalizing also substitutions.

²³¹ This operation is inspired by the deconstruction of the arrow in rule notation discussed in Bale et al. (2014: 242ff).

(8) Formalization of melodic processes assuming only two operations: addition and subtraction

a. The operation “substitute” can be rewritten as the combination of addition and subtraction

<i>Add</i>	<i>Subtract</i>	<i>Add-Subtract</i>
$\alpha \rightarrow (\alpha + \beta) / \underline{\alpha}$	$\alpha\beta \rightarrow (\alpha\beta - \beta) / \underline{\alpha}$	$\alpha \rightarrow [(\alpha + \beta) - \alpha] / \underline{\alpha}$
$\alpha \rightarrow (\alpha + \beta) / \underline{\beta}$	$\alpha\beta \rightarrow (\alpha\beta - \beta) / \underline{\beta}$	$\alpha \rightarrow [(\alpha + \beta) - \alpha] / \underline{\beta}$
$\alpha \rightarrow (\alpha + \beta) / \underline{\gamma}$	$\alpha\beta \rightarrow (\alpha\beta - \beta) / \underline{\gamma}$	$\alpha \rightarrow [(\alpha + \beta) - \alpha] / \underline{\gamma}$

b. Prime assignation given the alternation /k/ → [tʃ] / /i/.

<i>Process formalization</i>		<i>Hypothesis on the prime-based content of segments:</i>		
		/k/	/tʃ/	/i/
a.	$\alpha \rightarrow (\alpha + \beta) / \underline{\alpha}$	α	$\alpha\beta$	$\alpha\delta$
b.	$\alpha \rightarrow (\alpha + \beta) / \underline{\beta}$	α	$\alpha\beta$	β
c.	$\alpha \rightarrow (\alpha + \beta) / \underline{\gamma}$	α	$\alpha\beta$	γ
d.	$\alpha\beta \rightarrow (\alpha\beta - \beta) / \underline{\alpha}$	$\alpha\beta$	α	$\alpha\delta$
e.	$\alpha\beta \rightarrow (\alpha\beta - \beta) / \underline{\beta}$	$\alpha\beta$	α	β
f.	$\alpha\beta \rightarrow (\alpha\beta - \beta) / \underline{\gamma}$	$\alpha\beta$	α	γ
g.	$\alpha \rightarrow [(\alpha + \beta) - \alpha] / \underline{\alpha}$	α	β	$\alpha\delta$
h.	$\alpha \rightarrow [(\alpha + \beta) - \alpha] / \underline{\beta}$	α	β	$\beta\delta$
i.	$\alpha \rightarrow [(\alpha + \beta) - \alpha] / \underline{\gamma}$	α	β	γ

A theory of computation that allows for the addition and subtraction of primes is capable of formalizing the same kinds of phenomena as one that also allows for substitution. I will therefore assume the simplest theory of computation, the one that only allows for addition and subtraction of primes, but not for substitution of primes as a different operation. Therefore, the number of fundamental operations shrinks from nine to six. This does not mean that a “double operation” comprised of addition and subtraction is not a possible phonological process. It simply means that, given the alternative, a learner would assume a single, simpler operation is responsible for the alternation perceived, unless additional data requires the application of multiple processes. The table under (9) summarizes the six possible basic operations of melodic computation.

(9) Reduced set of possible melodic processes: add and subtract are the only operations necessary

<i>Add</i>		<i>Subtract</i>	
a.	$\alpha \rightarrow (\alpha + \beta) / \underline{\alpha}$	d.	$\alpha\beta \rightarrow (\alpha\beta - \beta) / \underline{\alpha}$
b.	$\alpha \rightarrow (\alpha + \beta) / \underline{\beta}$	e.	$\alpha\beta \rightarrow (\alpha\beta - \beta) / \underline{\beta}$
c.	$\alpha \rightarrow (\alpha + \beta) / \underline{\gamma}$	f.	$\alpha\beta \rightarrow (\alpha\beta - \beta) / \underline{\gamma}$

VI.3.2.1 Formalizing iterative harmonies

Now let us look at some examples taken from the first part of this thesis. As it turns out, the specific nature of Vowel Harmony is quite useful in the definition of a plausible theory of melodic computation. Vowel Harmony tends to affect all vowels within a domain (cf. §I.2.1), and to display an iterative behavior. In simpler terms, a harmonic process generally turns a target into a valid trigger that reiterates the process for other targets.

The discussion below proves that of the formulations shown in (9), the only one that works is (9b), the formulation that adds $|\beta|$ to a segment with $|\alpha|$ in proximity of $|\beta|$. I exemplify the reasoning using the raising harmony of Bresciano (cf. §III.7.1). Under (10), alternations caused by the harmonic process are presented. RVH raises mid vowels to high, and behaves as iterative: the outcome of raising behaves as a valid trigger for preceding vowels.

(10) Harmonic alternations in Bresciano

<i>Base form</i>	<i>Diminutive</i>	<i>Augmentative</i>	
[ˈtʃeza]	[tʃiˈzina]	[tʃiˈzuna]	‘church’
[paˈdɛla]	[padiˈli]	[padiˈlu]	‘pan’
[ˈtʃot]	[tʃuˈdi]	[tʃuˈdu]	‘nail’
[ˈnɔk]	[nuˈki]	[nuˈku]	‘dumpling’
[ˈøndʒa]	[ynˈdʒina]	[ynˈdʒuna]	‘fingernail’
[senˈter]	[sintiˈri]	[sintiˈru]	‘mountain trail’
[ˈpɛrsek]	[pirsiˈgi]	[pirsiˈgu]	‘peach’
[ˈlegor]	[liguˈrina]	[liguˈruna]	‘hare’
[ˈpegora]	[piguˈrina]	[piguˈruna]	‘sheep’
[lɛnˈsɔl]	[linsuˈli]	[linsuˈlu]	‘sheet’
[koˈnetʃ]	[kuniˈtʃi]	[kuniˈtʃu]	‘rabbit’
[soˈrɛk]	[suriˈgi]	[suriˈgu]	‘mouse’

Perceiving the alternations under (10), children learning Bresciano may assume different formalizations for the process at hand. Alternations individuate a set of targets (mid vowels) and a set of triggers (high vowels). Depending on the formalization assumed, the internal composition of vowels involved in raising varies as shown under (11). For the time being, the prime specification of mid-low vowels is left aside, since they are targeted by a positional process that turns them into mid-high in an unstressed open syllable (cf. §III.4.3). The mechanism of this positional process is explored later in §3.3.

In (11) the Greek letters $|\delta|$ and $|\pi|$ are used as primes assigned to segments only to distinguish them. In the example, front rounded vowels are identified by the prime $|\delta|$, back rounded vowels by the prime $|\pi|$. Those primes are solely contrastive and do not have any role in the process at hand.

The prime assignment to segments derived from the analysis of raising in Bresciano is discussed at length below the table.

(11) Formalization of Raising harmony in Bresciano

<i>Harmonic alternations in Bresciano</i>									
$e \rightarrow i / _ _ u, y, i$	$\varepsilon \rightarrow i / _ _ u, y, i$	$o \rightarrow u / _ _ u, y, i$	$\circ \rightarrow u / _ _ u, y, i$	$\emptyset \rightarrow y / _ _ u, y, i$					
<i>Prime assignment</i>									
<i>Process formalization</i>	/i/	[i]	/y/	[y]	/u/	[u]	/e/	/o/	/ø/
a. $\alpha \rightarrow (\alpha + \beta) / _ _ \alpha$	$\alpha\beta$		$\alpha\beta\delta$		$\alpha\beta\pi$		α	$\alpha\pi$	$\alpha\delta$
b. $\alpha \rightarrow (\alpha + \beta) / _ _ \beta$	$\alpha\beta$		$\alpha\beta\delta$		$\alpha\beta\pi$		α	$\alpha\pi$	$\alpha\delta$
c. $\alpha \rightarrow (\alpha + \beta) / _ _ \gamma$	γ	$\alpha\beta$	$\gamma\delta$	$\alpha\beta\delta$	$\gamma\pi$	$\alpha\beta\pi$	α	$\alpha\pi$	$\alpha\delta$
d. $\alpha\beta \rightarrow (\alpha - \beta) / _ _ \alpha$	α		$\alpha\delta$		$\alpha\pi$		$\alpha\beta$	$\alpha\beta\pi$	$\alpha\beta\delta$
e. $\alpha\beta \rightarrow (\alpha - \beta) / _ _ \beta$	β	α	$\beta\delta$	$\alpha\delta$	$\beta\pi$	$\alpha\pi$	$\alpha\beta$	$\alpha\beta\pi$	$\alpha\beta\delta$
f. $\alpha\beta \rightarrow (\alpha - \beta) / _ _ \gamma$	γ	α	$\gamma\delta$	$\alpha\delta$	$\gamma\pi$	$\alpha\pi$	$\alpha\beta$	$\alpha\beta\pi$	$\alpha\beta\delta$

Some of the formalizations in (11) don't work. The formalizations in (11a) and (11d), for example, would imply that mid vowels are valid triggers for harmony, since they contain the prime $|\alpha|$. Since mid vowels do not trigger the process, (11a) and (11d) cannot be the correct formalization for RVH in Bresciano.

Notice that the formalizations in (11c), (11e) and (11f) assign two different representations to high vowels. In the table those double results have been divided between a column that indicates the representation of triggers (between bars) and a column that indicates the representation of the outcome of the process of raising, shown between square brackets. This means that triggers and outcomes of raising, while sharing the same phonetic implementation, are not the same phonological objects. This is not unexpected, and is a possibility given by the arbitrary PPI, as discussed in §V.4.5. However, the behavior of iterative harmony in Bresciano ensures that the result of the process must also be a valid trigger. (11c, e, f) all give to the outcome of raising a prime-based representation that lacks the triggering prime. However, we know from the iterative behavior of harmony that raised segments do behave as triggers, so the formalizations that result in a different segment than a valid trigger must be discarded. On this basis we can ignore the formalizations in (11c), (11e) and (11f).

The only option remaining is (11b), which also correctly manages to formalize the process. Vowels that undergo raising receive a prime from high vowels, $|\beta|$, which makes them valid triggers for raising. Notice that in (11b) all vowels are specified for $|\alpha|$. This ensures that the outcome of raising and the triggers of raising actually share the same prime-specification.

In sum, given an iterative harmony, we can conclude that the operation carried out in computation adds to the targets a prime of the trigger, which in turns makes the outcome of the process itself a valid trigger.

The vowel system of Bresciano is almost completely identified only by observing a single process. The two primes that are not active in the alternation, in this case $|\pi|$ and $|\delta|$, are the only ones that do not follow from the observation of harmonic alternations. This shows that by observing one single pattern of alternations (that caused by raising harmony in Bresciano) children can converge to a single rule-formalization, excluding the other five possible options.

VI.3.2.2 Formalizing non-iterative harmonies

The issue becomes more problematic once we consider a process that is non-iterative. Let us take a simple case, that of Zulu, presented in §II.3.1.3.3 and repeated under (12) for convenience. Here mid vowels (only mid-low vowels are phonemic in Zulu) raise to mid-high. The outcome of the process does not trigger the raising of preceding mid-vowels, as exemplified in the second section of the table, where sequences of potential triggers are shown. In this case, raising affects only the vowel closer to the trigger, and does not propagate harmony further.

(12) Harmonic alternations in Zulu

<i>Height alternations in Zulu</i>			
phək-a	'cook (verb)'	um-phek-i	'cook (noun)'
ɲɛn-a	'enter'	ɲen-is-a	'bring in'
ɔn-a	'sin'	is-on-i	'sinner'
bɔn-a	'see'	bon-is-a	'show'
bɔn-a	'see'	si-bon-il-ε	'we saw'
le:l-ɔ	'that'	le:l-i	'this'
ε:d-a	'finish'	si-ed-il-ε	'we finished'
khɔ:mmb-a	'point'	si-khommb-il-ε	'we pointed'
<i>Multiple vowel sequences</i>			
phelelisa		'make complete'	
izikelemu		'worms'	
fɔkosi		'little bush'	
εlovu		'a place name'	
εmɔjeni		'in the air'	

Mid-low vowels surface as mid-high if followed by a high vowel. Assuming the formalizations discussed in (9), learners would assign the following primes to the segments involved in the process, shown in (13). Rounded vowels have an additional prime |δ|, which serves only a contrastive role.

(13) Formalizing raising harmony in Zulu

<i>Harmonic alternations in Zulu</i>							
$\epsilon \rightarrow e/ _i, u$				$\text{ɔ} \rightarrow \text{o}/ _i, u$			
<i>Prime assignment</i>							
<i>Process formalization</i>	/i/	/u/	/e/	/ɛ/	/o/	/ɔ/	
a. $\alpha \rightarrow (\alpha + \beta) / _ \alpha _$	α	αδ	αβ	α	αβδ	αδ	
b. $\alpha \rightarrow (\alpha + \beta) / _ \beta _$	β	βδ	αβ	α	αβδ	αδ	
c. $\alpha \rightarrow (\alpha + \beta) / _ \gamma _$	γ	γδ	αβ	α	αβδ	αδ	
d. $\alpha\beta \rightarrow (\alpha - \beta) / _ \alpha _$	α	αδ	α	αβ	αδ	αβδ	
e. $\alpha\beta \rightarrow (\alpha - \beta) / _ \beta _$	β	βδ	α	αβ	αδ	αβδ	
f. $\alpha\beta \rightarrow (\alpha - \beta) / _ \gamma _$	γ	γδ	α	αβ	αδ	αβδ	

Formulation (13a) would require raising to apply when mid-vowels are followed by any other mid vowel, since they all contain |α|. This is not what happens, so the formulation in (13a) is discarded. Formulation (13b) is also discarded, because, as shown above, it would mean that the process at hand is

iterative. Forms such as [phelelisa] or [fɔkosi] ensure that the outcome of raising in Zulu does not behave as valid triggers for preceding mid-low vowels. In the same fashion, (13d) and (13e) are false, because they would treat mid-low vowels as triggers for raising. Two viable options remain: (13c) and (13f). Both of them are viable ways to formalize the harmonic pattern of Zulu.

In (13c), high vowels (identified by the prime $|\gamma|$) raise a mid-low vowel $|\alpha|$ adding the prime $|\beta|$. The outcome of the process does not contain the triggering prime $|\gamma|$, and thus is unable to propagate harmony further. In (13f), instead, high vowels (identified by $|\gamma|$), force mid-low vowels, which are identified by $|\alpha\beta|$ to lose the prime $|\beta|$, resulting in a mid-high vowel. Once again, the outcome of the process does not contain $|\gamma|$, which is the triggering prime. Those formalizations, among the six options, are the only ones that can formalize non-iterative raising in Zulu.

Without any additional information concerning the phonological behavior of vowels in Zulu, it becomes impossible for learners to choose between the two options.

Learners may just assume one of the two formulations at random, and resort to other additional knowledge available in the language to discern whether their hypothesis was the right one. For example, let us assume that a different process in Zulu affects only mid-high vowels which are the outcome of raising: $/e,o/ \rightarrow a/_a$.

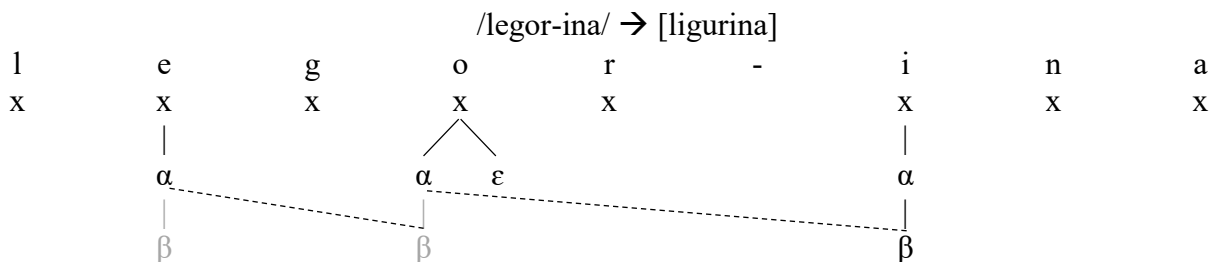
If such a process existed, learners who assumed the formulation in (13f) would be proven wrong. $/e/$ and $/o/$ contain the same primes of $/\varepsilon/$ and $/\vartheta/$ minus the one subtracted by the alternation exemplified in (13f). If a process affects only $/e/$ and $/o/$, those two vowels must share a prime that distinguishes them from $/\varepsilon/$ and $/\vartheta/$, which are unaffected. Knowledge of this different process may then help learners to discern which formulation for the harmony is the right one. However, it is not assured that for every process of this kind a similar solution is offered. In Zulu, for example, there is no process that affects only raised mid vowels.

However, there is a formal distinction between the two formalizations that might help us decide which one should be used. A difference between (13c) and (13f) is that the latter operates over representational items that are already present in the targets (beta is subtracted), while the former requires phonology to make reference to a prime which is absent from the representations of both triggers and targets.

The formalization of the iterative Bresciano VH shown in (14) and the formalization of Zulu non-iterative harmony based on (13f), i.e. the subtraction of a prime, is shown in (15). Neither requires us to add a prime that is absent from the target or the trigger. It manipulates primes that are present in the representation to begin with, and does not require computation to conjure a prime out of nowhere. By contrast, the formalization in (16) based on (13c) requires reference to a prime that is absent from the prime specification of both triggers and targets.

Thus under (14) is represented the iterative harmony of Bresciano. In the example shown, the rounded mid vowel $/o/$ receives the prime $|\beta|$ from $/i/$ in the diminutive suffix, and becomes a valid trigger for raising of the preceding mid-vowel $/e/$. Linking is shown as a dotted line connecting the target prime $|\alpha|$ to the trigger prime $|\beta|$. That $/o/$ (which raises to $/u/$) has received the harmonic prime is shown in gray in the graph below. Now, raised $/o/$ (which became $[u]$) can be a valid trigger for preceding $/e/$, which raises to $/i/$.

(14) Formalization of raising in Bresciano: $\alpha+\beta/_\beta$



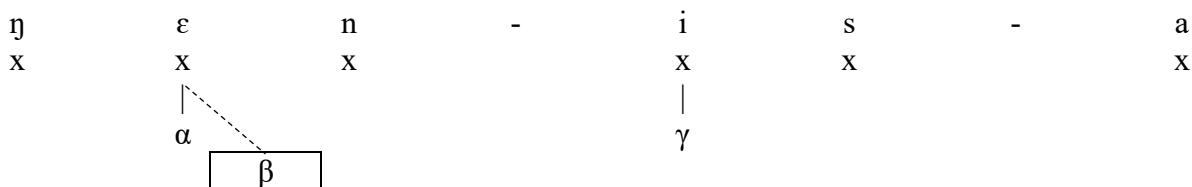
(15) Formalizes the raising harmony of Zulu as a case of delinking, i.e. it instantiates (13f): $\alpha\beta\rightarrow(\alpha\beta-)_\gamma$. Mid-low vowels (specified as $|\alpha\beta|$) lose the prime $|\beta|$ when they are followed by a high vowel, specified for $|\gamma|$.

(15) Formalization of raising in Zulu: $\alpha\beta\rightarrow(\alpha\beta-)_\gamma$



The graph in (16) formalizes the same alternation of (15), but this time assumes the operation under (13c): $\alpha\rightarrow(\alpha+\beta-)_\gamma$. The process is formalized as the addition of $|\beta|$, which is otherwise absent from the representation of the vowels involved in the process: $|\alpha|$ (which identifies mid-low vowels) receives beta when followed by a high vowel, specified for $|\gamma|$. In the graph under (16), the prime $|\beta|$ appears ex nihilo in the context of the rule, and is absent if the rule does not apply.

(16) Formalization of raising in Zulu: $\alpha\rightarrow(\alpha+\beta-)_\gamma$



The two formalizations under (15) and (16) are, in theory, equally viable. The formalization under (16), however, appears to be more complex. The operations in (14) and (15) were implemented as the addition or subtraction of a single item: one association line is added in (14), a prime is removed in (15). In (16), instead, two objects are added: a new prime, in this case $|\beta|$, is added and is linked to the mid-low vowel that contains $|\alpha|$ through an association line.

In (17) I propose a working hypothesis aimed at limiting the number of possible operations within the phonological computation concerning melodic processes: the No Ex Nihilo Hypothesis, (henceforth NEN).

(17) No Ex Nihilo Hypothesis:

Phonological computation cannot manipulate primes that are absent from the representation of the target and the trigger.

If the NEN is assumed, phonological computation cannot refer to primes that appear ex nihilo, but can only manipulate those that are already present in the representation of the segments involved in the process. If the hypothesis holds true, phonological computation can only manipulate primes that are present, through propagation (spreading of a prime from a segment to another) or through the suppression of a prime in a given context. The former operation is known as assimilation, the latter as dissimilation. And more generally, the linking and delinking of primes exhaust computation in an Autosegmental environment (Harris 1994: 13).

The NEN disallows formalizations that require learners to posit more primes than those that serve to identify the trigger and the target of a phonological process. The segment that undergoes a melodic process may either receive a prime from the trigger or lose one of its primes. To go back to the non-iterative harmony of Zulu, the NEN rules out the formulation in (13c) and allows only (13f).

In a sense, the NEN is just a way to reinvent the wheel: it ensures that the same operations that were applicable in Autosegmental Phonology are still viable in a framework that uses emergent primes instead of innate and universal features and feature geometries, ruling out operations that were not considered possible in standard Autosegmental Phonology (cf. Clements & Hume 1995: 10ff., Harris 1994: 13).

The NEN may also be viewed as a re-proposition of the Non-Arbitrariness Condition advanced in the GP literature (cf. §V.1.1). The Non-Arbitrariness Condition demands that there be a direct relationship between a phonological process and the environment in which it takes place (Pöchtrager 2006: 20, Kaye et al. 1990: 194f). This condition was introduced as a way to dismiss SPE-like rules, and prefer an Autosegmental formalization of processes. It was also used as a way to correlate the plausibility of a process to phonetic naturalness (cf. §V.1.1 and Chabot 2021: 79). This effect of the Non-Arbitrariness condition is of course to be avoided in a RadSFP theory.

The choice of the formulation under (15) over the one in (16) for the harmony of Zulu does not follow from a direct observation of phonological patterns. The NEN is proposed as a way to limit the computational power of the phonological component.

Given the arbitrary nature of melodic primes, the limits of phonological computation can only be tested by observing phonological patterns. The iterative nature of most harmonic processes ensures that the operation of addition formalized in (14) can be carried out by phonology. In the absence of a principled way to decide which of the two formalizations in (15) or (16) is correct, a hypothesis must be formulated: either $\alpha+\beta/_\gamma$ is true (against the NEN) or $\alpha\beta-\beta/_\gamma$ (faithful to the NEN) is the correct option. The NEN is a working hypothesis that in the case of non-iterative harmonies may help discern between possible and equally valid formulations.

Following the theory of melodic computation presented in this section, I propose that harmonic processes are formalized as spreading of a prime from the trigger to the targets (which accounts for iterative harmonies) or as the subtraction of a prime from the target in a given context (which accounts for non-iterative harmonies). The NEN disallows melodic processes to reference primes that are otherwise absent from the representation of triggers and targets of the process, or in simpler terms, it rules out the addition of a prime out of nowhere.

Notice that the NEN does not disallow epenthesis. Epenthesis has been identified as a structural process, so it does not directly manipulate primes. It inserts in a position an epenthetic vowel, which does

not come from out of the blue, but is selected from the lexicon. The NEN only disallows the reference to primes that are absent from the context in which the process takes place, but allows the reference to lexical items.

Another option is to accept that different speakers of the same language may have different grammars. For what concerns raising in Zulu, some speaker may use the formalization in (13c) and other speakers may use the formalization in (13f). In the absence of other alternations that allow us analysts to decide between the two options, learners may just use one of the two at random. This would result in different speakers having slightly different grammars (Isac & Reiss 2008: 13).

In sum there are different options. The first one assumes that learners do not need to decide between equally valid formulations, and may therefore have different grammars. The second one assumes that there are restrictions on learning, like the NEN introduced in (17), that force learners into a uniform grammar: in this case one that disallows computation to add primes ex nihilo.

A point in favor of the second option is that it allows us to repurpose the advancements of Autosegmental theory in a RadSFP environment: computation involving melodic items may be limited to linking and delinking. In fact, the assumption of the NEN limits the six possibilities discussed in (9) to four, allowing a simpler and more limited theory of computation. This is shown in the table (18) below. (18a) does not comply with the NEN: the addition of a prime $|\beta|$ in the context of $|\alpha|$ would require computation to refer to a prime that is absent from the representation of both the trigger $|\alpha|$ and the target $|\alpha|$. Similarly, (18c) would be an impossible operation assuming the NEN: the prime $|\beta|$ should be added to $|\alpha|$ in the context of $|\gamma|$, requiring computation to refer to a prime that is absent from both the trigger and the target.

(18) Possible melodic operations

<i>Add</i>		<i>Subtract</i>	
a.	$\alpha \rightarrow (\alpha + \beta) / \underline{\alpha}$	d.	$\alpha\beta \rightarrow (\alpha - \beta) / \underline{\alpha}$
b.	$\alpha \rightarrow (\alpha + \beta) / \underline{\beta}$	e.	$\alpha\beta \rightarrow (\alpha - \beta) / \underline{\beta}$
c.	$\alpha \rightarrow (\alpha + \beta) / \underline{\gamma}$	f.	$\alpha\beta \rightarrow (\alpha - \beta) / \underline{\gamma}$

VI.3.3 Positional processes

Since they are only tangential to the goals of this thesis, the computational theory behind positional processes is just sketched here.

Positional processes are those that modify the prime specification of a segment that appears in a given structurally defined position. Recall that positional processes are assumed to live in-between structural and melodic phonology, in the sense described in §3.1. Computation concerning structural items defines the relative strength of a timing unit, which is then able to sustain or not the primes attached to it. How a position is defined as weak or strong is a matter that concerns a theory of structure, which is not treated here. For a discussion on this subject, cf. Harris (1994: 194ff), Carvalho (2008) and Ségéral & Scheer (2008a).

In section §3.1 some positional processes were discussed, whereby consonants pass from stops to fricatives in intervocalic position and vowels may change when passing from a stressed to an unstressed position. In both cases, the context of application for a positional process is not defined by melody, but by structure. The table reported in (19) formalizes the possible options of formalization of positional processes. Given a strong position (S) or a weak position (W), which are not defined melodically, primes

may be added or subtracted. Recall that we have defined addition and removal as the basic computational operations that affect melody.

(19) Possible positional processes

<i>Add</i>		<i>Subtract</i>	
a	$\alpha \rightarrow (\alpha + \beta) / S$	c.	$\alpha \rightarrow (\alpha \beta - \beta) / S$
b	$\alpha \rightarrow (\alpha + \beta) / W$	d.	$\alpha \rightarrow (\alpha \beta - \beta) / W$

The four operations in (23) read as follows:

(19a): Add $|\beta|$ to $|\alpha|$ in a strong position.

(19b): Add $|\beta|$ to $|\alpha|$ in a weak position.

(19c): Subtract $|\beta|$ from $|\alpha\beta|$ in a strong position.

(19d): Subtract $|\beta|$ from $|\alpha\beta|$ in a weak position.

According to Harris (1990: 270) and Ségéral & Scheer (2008), weak positions are those time slots that may not be able to sustain melodic material associated to them (i.e. are prone to lose melodic primes). That is, loss of melodic material in weak positions corresponds to the operation formalized in (19d), and corresponds to the very definition of lenition in Government Phonology introduced by Harris (1990): primes may be lost in weak positions (lenition = loss of primes)

Strong positions are those where melodic material can be added (as in 19a). The behavior of strong and weak positions, which derives from cross-linguistically stable factors, should be the same cross-linguistically. Therefore, a weak position cannot receive additional primes (19b is ruled out) and a strong position should not lose primes in a positional process, which rules out (19c). The working hypothesis introduced above, the NEN, seems to rule out the option (19a). Both (19a) and (19b) require us to refer to a prime that is absent from the representation of targets and triggers.

The formalization in (19a) corresponds to the process of fortition, where a segment acquires primes in a strong position (Carvalho et al. 2008, Scheer & Ségéral 2008a: 139). Fortitions can still function without invalidating the NEN if we assume that the prime that is added to the segment in strong position is present in the representation but not necessarily linked to it. In other words, fortitions may be processes in which a floating prime is linked to the segment that undergoes the process²³².

Now we have defined our general theory of computation. Primes may spread from one segment to another or may be removed in a melodic or a positional context. The assumption of NEN ensures that computation cannot conjure primes, and thus can only manipulate those that are present in the representation to begin with.

VI.3.4 The ingredients of a phonological theory

In the previous chapter, it was argued that the goal of phonological theory is to identify the properties of the phonological competence of humans. Phonological computation is assumed to take place in a

²³² Rennison (1998: 233) proposes an analysis of contour segments that makes use of floating primes that are not lexically part of the segment, but are either available to melody or acquired from elsewhere in the phonological context. A similar analysis may be proposed for fortitions: primes that are attached to the segment undergoing fortition are present in the representation but floating.

cognitive Fodorian module whose job is to compute: modules turn one representation into another representation of the same kind. A theory of phonology thus has two sides, representations and computation, which cannot be observed independently, especially, I argue, in a RadSFP framework.

A theory of phonology must define the properties of representations as well as the property of the computation carried on by the module on those representations. The relation between the two realms of inquiry makes it so that changing the theory of representation affects the theory of computation and vice versa. Up until now, the proposal of RadSFP has directly affected phonological representation, and only indirectly the issue of phonological computation. RadSFP assumes phonological primes to be learned emergent categories that are substance free, in the sense that they do not have an innate and universal correlation with phonetics. Infusing phonological representations with real-world properties is the job of the interface, which correlates representations pertaining to phonology and representation pertaining to phonetics.

In §V.4.2 it was suggested that primes emerge due to the influence of two factors: contrast and alternations. Contrast requires the representations of different segments to be different, alternations allow learners to infer classes of segments that share some representational properties (i.e. classes of segments that behave alike share a prime).

The fact that alternations inform prime emergence, however, means that the way a process is computed affects the way learning works. A theory of prime emergence cannot be exempt from the influence of computation because computation itself affects the learning of primes. The goal of learning primes is to assign a phonological representation to phones, observing the phonological system and the alternations that occur. Without some assumptions about phonological representation and phonological computation, a theory of learning primes is blind. Sections §2 and §3 had the goal of defining a minimal theory of representation and a minimal theory of computation in a theoretical landscape that does not employ substance-laden features, but substance-free primes. It is clear that a phonological theory that has primes such as [+high] and [-ATR] will be radically different from one that has abstract and language-specific categories such as $|\alpha|$ and $|\beta|$.

It should always be kept in mind, however, that changing one assumption about representation or computation may result in a vastly different theory of prime emergence/ prime learning. In the sections that follow, when not differently suggested by the authors of the proposals, I will assume the theory of computation sketched here, and maintain the assumptions made about phonological representation proposed in the first part of the chapter: primes are unary learned entities, and only concern melody.

The following sections describe two theories of prime-emergence, one employed by Dresher (2014) and developed in Sandstedt (2018) the other proposed in Odden (2022), and explain how they handle learning in systems that exhibit asymmetric and parasitic harmonies, as well as scalar and complete raising. It is shown that while both theories share many assumptions (namely that contrast and computation affect the way primes are learned), they differ in the way they can represent both asymmetric harmonies and scalar/complete raising patterns. Sections 4 to 6 compare the two theories, and show that a theory of prime-emergence that does not require primes to have a contrastive role (i.e. to have a role in distinguishing different segments) is formally simpler and, in general, better suited to account for raising harmonies.

VI.4 Prime learning: contrast and computation inform learning

VI.4.1 Dresher's (2014) model of prime learning: contrast and alternations allow for the emergence of contrastive primes.

VI.4.1.1 The basic assumptions of MCS in a RadSFP framework

First, I present the theory of prime learning that appeared in Dresher (2014) and was later developed in Iosad (2017) and Sandstedt (2018). This theory is based on the Contrastivist Hypothesis (CH), discussed earlier in §IV.3.2.1 and reported under (20a) in its strong formulation (cf. §IV.3.2.5), together with its corollary under (20b).

(20) Contrastivist Hypothesis (Hall 2007)

a. Contrastivist Hypothesis

The phonological component of a language L operates only on those primes which are necessary to distinguish the phonemes of L from one another.

b. Corollary of the Contrastivist Hypothesis

If a prime is phonologically active, then it must be contrastive.

In a RadSFP environment, the CH and its corollary hold that contrast is the main factor of prime learning: the goal of learners is to arrive at a set of features that account for the contrasts in the lexical inventory (the phonemes) of their language. The connection between feature contrast and feature activity imposed by the Contrastivist Hypothesis constrains the number of features that can be posited for a given phonological inventory.

Dresher (2014: 172) argues that primes are learned through a sequence of division of the set of phones: this is the SDA (Successive Division Algorithm). As we have established in §V.4.1, learners can perceive and distinguish sounds, even though they have not yet assigned a phonological representation to any of them. Dresher assumes that contrastive primes are determined in order, and shows how this mechanism works based on an example from Classical Manchu, which has the following vowel system: /i, u, ʊ, ə, a, ɔ/. At the initial stage of prime learning, learners treat those phones as if they were one phoneme /X/. At some point, the learner discovers a contrast between a [low] vowel /A/ and a non-low vowel /I/, and these primes are associated to the phones in question. Then the non-low vowels split into a [coronal] vowel /i/ and a non-coronal vowel /U/. Further, the low vowels split into a [labial] vowel /ɔ/ and a non-labial vowel /A/. [labial] has no role for non-low vowels, where [coronal] has already divided /i/ and /U/. Finally, [ATR] makes the final set of contrasts. [ATR] cannot apply to the [coronal] vowel which is already uniquely specified, nor can it apply to the unique [labial] vowel /ɔ/. The division is applied to /A/ and /U/, which are divided into /ə/, /a/ and /u/, /ʊ/ respectively. At this point there are no further contrasts to find, and the hierarchy is complete. The prime-based specification for the vowels of Classical Manchu, thus, is as shown in (21), taken from Dresher (2014: 172).

(21) Classical Manchu vowels: contrastive prime representation

/i/	/u/	/o/	/ə/	/a/	/ɔ/
<i>non-low</i>	<i>non-low</i>	<i>non-low</i>	[low]	[low]	[low]
[coronal]	<i>non-coronal</i>	<i>non-coronal</i>	<i>non-coronal</i>	<i>non-coronal</i>	[labial]
	[ATR]	<i>non-ATR</i>	[ATR]	<i>non-ATR</i>	

The mechanism of prime learning described in Dresher (2014: 172) follows the same steps of the Successive Division Algorithm, which was discussed in §IV.3.2.1. In the substance-based framework where it was developed, the SDA was a way to identify the contrastive role of primes. Given a prime hierarchy and a set of distinct phonemes, the SDA assigned to each phoneme all and only those primes needed to identify the contrasts of the language. Different languages may share similar systems on the surface, but differ in processing due a different feature hierarchy built by the SDA.

In an emergentist environment, where primes have no universal correlation with phonetics, the SDA is not solely the operation that assigns contrastive primes to segments, but also takes on the task of identifying primes in the learning process. That is, the set of primes is given in Dresher (2014), while it is not in a RadSFP framework, and thus needs to be discovered. The SDA presented in §IV.3.2.1 may be adapted to the RadSFP environment as under (22), where its role in prime emergence is defined. The instruction in (22b) is the one that changes. Instead of selecting a prime from a given set, SDA creates an arbitrary prime and divides the set in two.

(22) Adapted SDA procedure

- a. The set S of the phones of a given language is treated as if it contained N allophones of the same phoneme.
- b. If S contains more than one segment and evidence shows that two items are contrastive, a prime is posited, and the set is divided in two: on one side are put those segments that contains the prime, on the other those which do not.
- c. This operation in (22b) is repeated until each subset contains only 1 segment.

The SDA takes the set of sounds of a language as an input and produces a prime specification for all of them as an output. (22c) ensures that the operation ends when all phonemes are distinguished. This means that only primes that serve a contrastive role can emerge.

In his example from Classical Manchu, Dresher (2014) employs binary features, as a default instead of unary primes. Still, as discussed in §IV.3.2.7, unary primes are not incompatible with the SDA nor with the Contrastivist Hypothesis, and thus a theory that employs unary primes instead of binary features may still be viewed as a variation of his proposal (Dresher 2014: 167). If unary primes were used, only the primes between brackets are to be considered, while negative values (those in italic in 21) would be absent.

Dresher (2014: 167) assumes that learners make use of their real-world knowledge to categorize segments on the basis of acoustic or articulatory properties²³³. This would explain why phonological

²³³ Dresher (2014: 167) notices that the same strategy may be employed to learn primes for sign language. One advantage of emergent theories is the fact that phonological primes involved in different modalities of language may emerge in the same way. This point is discussed and developed in Samuels et al. (2022: 9ff).

representations appear similar from language to language: primes do not have a phonetic content, but they derive from phonetic properties. Aside from contrast, Drescher (2014: 177) holds that patterns of phonological activity are also used by learners to assign primes. This means that phonetics may have a role in prime learning, but phonetic naturalness does not impede the learning of unnatural classes, which may be suggested by processing.

On the pages below I amend the theory proposed in Drescher (2014) to match it with the assumptions presented at the beginning of the chapter. I treat primes as substance-free unary labels that lack any correlation with phonetics. Note that the theory of phonological computation sketched in §3 hinges on phonological primes being unary, otherwise other operations than those discussed may be possible. That the SDA works also with unary primes has been discussed in §IV.3.2.7.

Contrast is, in Drescher's (2019) opinion, the reason why primes emerge in the first place, and why learners do not simply posit segment-level representations. Primes emerge because learners have to arrive at a set of hierarchically ordered features that distinguish between all the phonemes of their language. The approach proposed in Drescher (2009, 2014) stems from Jakobson (1941), who first argued that stages of acquisition could be represented as contrastive feature hierarchies. Learning of primes based on the SDA procedure relies on children being able to discriminate sounds for which they have no phonological representation, in line with the position argued for in §V.4.1. The perceptual system is thus responsible for the first portion of the acquisition of phonology, which identifies the sounds of the language that are candidates for phonemic status. Such a notion of segments, present in the mind of child before phonological representations, is not part of grammar according to Drescher (2014: 173).

VI.4.1.2 The role of alternations in the mechanism of prime learning proposed in Drescher (2014)

The previous section has shown the role of contrast in prime emergence. Now it remains to be explored how phonological computation bears on the procedure of prime learning. Recall from §IV.3.2 that different SDA graphs yield different predictions about the behavior of segments in a language. In §IV.3.2.2, while discussing the MCS approach in a substance-based environment, computation formed the main diagnostic to determine which one of a number of contrast-compatible SDA graphs was the correct one. Given the asymmetric harmony of Halh Mongolian (Svantesson et al. 2008: 47), the graph in (24) reflects the behavior of high rounded vowels, which are unable to trigger rounding even though they are phonetically rounded, as shown by the alternations reported in (23). (23a) displays tongue-root symmetric harmony and labial asymmetric harmony in suffixes. The direct past suffix alternates between three forms [-lʒa][-lʒe][-lʒo], which depend on the tongue root specification and the roundness of preceding vowels. In the causative and the potential, suffixes alternate between a RTR and an ATR variant. (23b) exemplifies the interplay between tongue root harmony and labial asymmetric harmony. A high rounded vowel that intervenes between a rounded [-high] trigger and a potential target behaves as a blocker. (23c) shows that the high non-rounded vowel /i/ behaves as transparent for both the tongue-root harmony and the labial harmony, allowing the harmonic features to pass through. The behavior of vowels in the harmonic patterns of Halh Mongolian are accounted for by the SDA graph in (24).

(23) Harmonic alternations in Halh Mongolian (Sventesson et al. 2008: 47)

a. Suffixes harmonize

Direct past /-lʒE/	Causative /-Uʒ/	Potential /-xUic ^h /	
it-lʒa	it-uʒ	it-xuic ^h	‘eat’
uc-lʒe	uc-uʒ	uc-xuic ^h	‘see’
ʊʊɾf-lʒa	ʊʊɾf-ʊʒ	ʊʊɾf-xʊic ^h	‘evaporate’
xeelʒ-lʒe	xeelʒ-uʒ	xeelʒ-xuic ^h	‘decorate’
og-lʒo	og-uʒ	og-xuic ^h	‘give’
ɔr-lʒɔ	ɔr-ʊʒ	ɔr-xʊic ^h	‘enter’
saat ^h -lʒa	saat ^h -ʊʒ	saat ^h -xʊic ^h	‘be delayed’

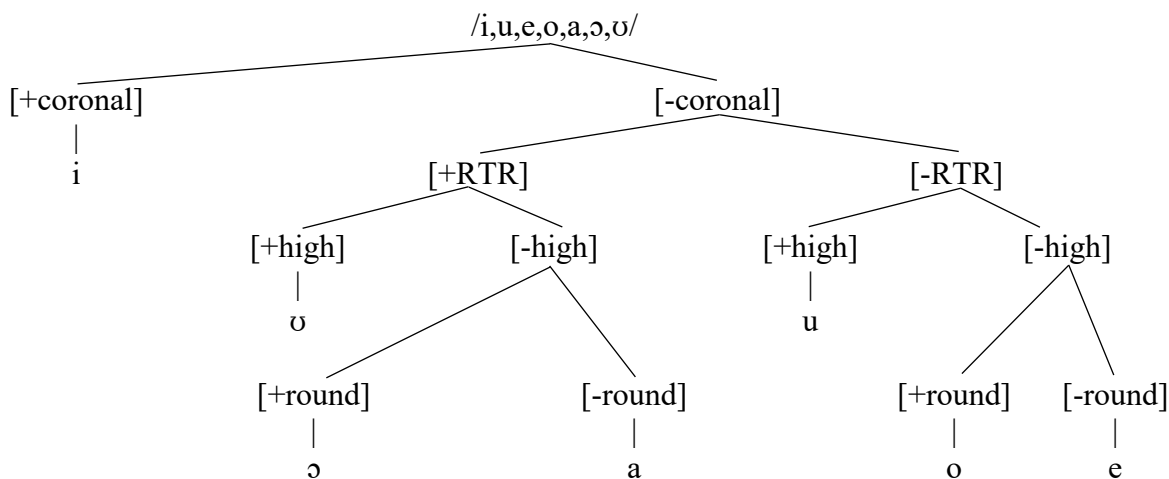
b. Multiple vowel sequences: Causative-Direct past

it-uʒ-lʒe	*it-uʒ-lʒo	‘eat’
uc-uʒ-lʒe	*uc-uʒ-lʒo	‘see’
ʊʊɾf-ʊʒ-lʒa	*ʊʊɾf-ʊʒ-lʒo	‘evaporate’
xeelʒ-uʒ-lʒe	*xeelʒ-uʒ-lʒo	‘decorate’
og-uʒ-lʒe	*og-uʒ-lʒo	‘give’
ɔr-ʊʒ-lʒa	*ɔr-ʊʒ-lʒo	‘enter’
saat ^h -ʊʒ-lʒa	*saat ^h -ʊʒ-lʒo	‘be delayed’

c. /i/ behaves as transparent for Tongue Root harmony and Labial Harmony

t ^h axʲi-lʒa	‘to be bent’
gowtʲ ^h i-lʒa	‘to be hollow’
ɔʒʲi-lʒo	‘squint’

(24) SDA reflecting the behavior of high rounded vowels in Halh Mongolian rounding harmony and ATR harmony



The SDA in (24) assigns the feature [+round] only to non-high vowels, so that /u/ and /ʊ/, which are transduced as rounded vowels, are not treated as such in phonology, i.e. they do not participate in labial harmony. In addition, the graph in (24) does not assign any specification for [±RTR] or [±round], which account for the fact that /i/ behaves as neutral for both harmonies.

Now, let us discuss how this approach may work in a framework where primes are truly substance-free. Using empty labels such as $|\alpha|$ and $|\beta|$ as primes changes slightly the relevance of the contrastive hierarchy. How can a hierarchy such as $\alpha > \beta > \gamma > \delta$ be considered different from one such as $\alpha > \gamma > \phi > \pi$? In the building of a Substance-free SDA graph, the hierarchy itself is not relevant *per se*, since the primes have no phonetic value. What is relevant is the sequence of sets that are divided by each iteration of the operation of division performed by the SDA, and this depends on the phonetic correlates of phonological segments. Learners not only learn the phonological prime composition, they also learn the phonetic correlates of these primes. There is no SDA division without having established a phonetic correlate, i.e. without having identified phones that have a contrastive function. The role of the hierarchy and how it interplays with phonological computation is shown below.

Consider the toy example proposed. This toy grammar has a vowel system composed of three vowels /i,u,a/. In this grammar a process of rounding is active, whose specific details are discussed below the table shown in (25). Given the extremely restricted number of segments considered, only a handful of SDA graphs can be generated. The whole array of possibilities is presented in (25) below. All the graphs have the same hierarchy, $\alpha > \beta$. The set of segments each division identifies, however, changes as well as the prime assignation for each vowel. That is, there are twelve logically possible graphs given contrast: six where the first division is $\alpha - \emptyset$, six where the reverse order $\emptyset - \alpha$ is put to use. Notice that the contrastive hierarchy of primes results in an extremely varied prime assignation. Each one of the graphs below assigns different primes to different segments.

(25) Application of the SDA in a substance-free environment

<p><i>a.</i></p>	<p><i>b.</i></p>	<p><i>c.</i></p>
<p><i>d.</i></p>	<p><i>e.</i></p>	<p><i>f.</i></p>
<p><i>g.</i></p>	<p><i>h.</i></p>	<p><i>i.</i></p>
<p><i>j.</i></p>	<p><i>k.</i></p>	<p><i>l.</i></p>

Each SDA graph assigns a different prime specification to the three vowels /i/ /u/ and /a/. To see how computation may affect the SDA procedure, consider that in this toy grammar, a process of rounding turns /i/ into [u] when followed by /u/. Rounded /i/s behave, once they undergo the process, as valid triggers for rounding. We can imagine this process as an iterative rounding harmony. From the

assumptions presented in §3.2, the process is formalized as spreading of a prime from /u/ to /i/. This means that /u/ must have an active prime that defines it as the trigger of the operation. As a consequence, all graphs that fail to assign a prime to /u/ must be discarded. This means that (25a), (25e), (25i) and (25j) cannot be the right graph. All of them fail to assign a prime to /u/²³⁴.

This process of rounding has only one trigger, /u/. This means that any graph that assigns only one prime to /u/ and the same prime to another segment would fail to capture the behavior of vowels in the process, because it would predict that two vowels behave as triggers. (25k) and (25g) both assign one prime to /u/, $|\alpha|$, and the same prime to another vowel: (25g) assigns $|\alpha|$ to /i/ and (25k) to /a/. This would predict that multiple vowels, and not only /u/, could behave as triggers for rounding. Therefore, (25g) and (25k) cannot be the right graph.

Another issue that allows the learner to disambiguate is that the result of prime addition must be a segment of the language, i.e. one of the segments that appears in the SDA graph. Spreading of a prime of /u/ to /i/ would result in impossible segments, if the graphs under (25c) and (25f) were assumed. This is because they assign a prime to /u/ and another to /i/. Spreading would result in a segment specified as $|\alpha\beta|$, which is absent from the language²³⁵.

Finally, consider the graph in (25l). Here /u/ is specified as $|\alpha\beta|$. Spreading a prime to /i/, which in (25l) is empty, would result in /i/ receiving either $|\alpha|$ or $|\beta|$. In the first case rounding would turn /i/ into /a/, since they would share the same phonological representation, in the other it would create a segment, $|\beta|$, which is absent from the language.

Thus three candidate graphs, (25b), (25d) and (25h), remain as viable options given both contrast and processing in the language. Additional facts about the language may help define which one is the right one. What is relevant here is the fact that the process of rounding of /i/ offers valuable information about the prime specification of vowels, and allows us to discard hypothetical hierarchies that may arise in the mind of learners.

In sum, the SDA in its new role of a prime-generating algorithm defines the representation of segments so that only contrastive primes can be generated. Contrast imposes limitations on phonological computation in that it can only manipulate contrastive primes. Computation affects prime learning because alternations perceived during acquisition inform learners about which, among the possible SDA graphs they could build, is the correct one.

Let us now apply the logic of the toy example to the vowel system of the EL dialect of Brescia (cf. §III.4), which exhibits two phonological processes involving vowels, vowel reduction and symmetric raising harmony. Children learning Bresciano have the following data at their disposal, repeated under (26) from §III.7.1.

²³⁴ The fact that one segment remains unspecified is a consequence of the choice of unary instead of binary primes, as shown in §IV.3.2.7. If binary primes were used, /u/ in the graphs (25a), (25e), (25i) and (25j) would be specified only with negative properties.

²³⁵ Recall from §V.4.5 that it is possible that different segments receive the same phonetic interpretation in the PPI. Therefore, it is theoretically possible that two segments that correlate with [u] are present in the toy language of the example. If additional processes in the language require the presence of another different segment, the SDA would have to be re-run with four vowels, two of which are pronounced as /u/, but with different prime specifications. This option would be assumed if there were additional proof that $|\alpha\beta|$ is present in the language (e.g. a process that affects specifically the /u/ resulting from the process); in this example this option is discarded.

(26) Data at the disposal of learners of Bresciano:

a. *Vowels of Bresciano:*

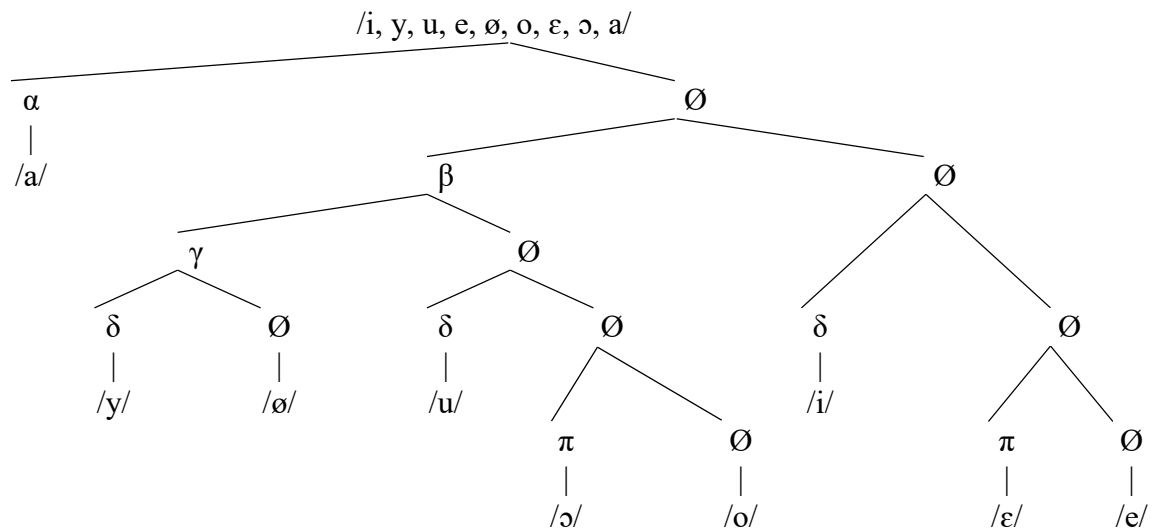
/i, y, u, e, ø, o, ε, ɔ, a/

b. *Active alternations concerning vowels in Bresciano:*

Vowel reduction											
/ε/ → [e]/Unstressed			/ɔ/ → [o]/Unstressed								
['sek]		'dry'		['ɔrp]		'blind'					
[se'kat]		'dried'		[orba'ti]		'blind DIM'					
Vowel harmony											
/e,ε/ → [i]/ C _{oi,u,y}		/o,ɔ/ → [u]/ C _{oi,u,y}		/ø/ → [y]/ C _{oi,u,y}							
[t'feza]		'church'		[t'fot]		'nail'		[t'øndʒa]		'fingernail'	
[t'fi'zina]		'church DIM'		[t'fu'di]		'nail DIM'		[yn'dʒina]		'fingernailDIM'	
[t'fi'zuna]		'church AUG'		[t'fu'du]		'nail AUG'		[yn'dʒuna]		'fingernailAUG'	

Assuming the theory of computation discussed in §3.3, the process of vowel reduction is formalized as subtraction of primes, and thus SDA must generate a graph where the pairs /ε/,/e/ and /ɔ/,/o/ respectively contrast with respect to one prime. Raising, which applies iteratively, must be formalized as spreading of an active prime, which is shared by all high vowels, to all mid vowels. The low vowel /a/ does not participate in harmony and behaves as a blocker. The graph under (27) is consistent with both information from contrast and processing.

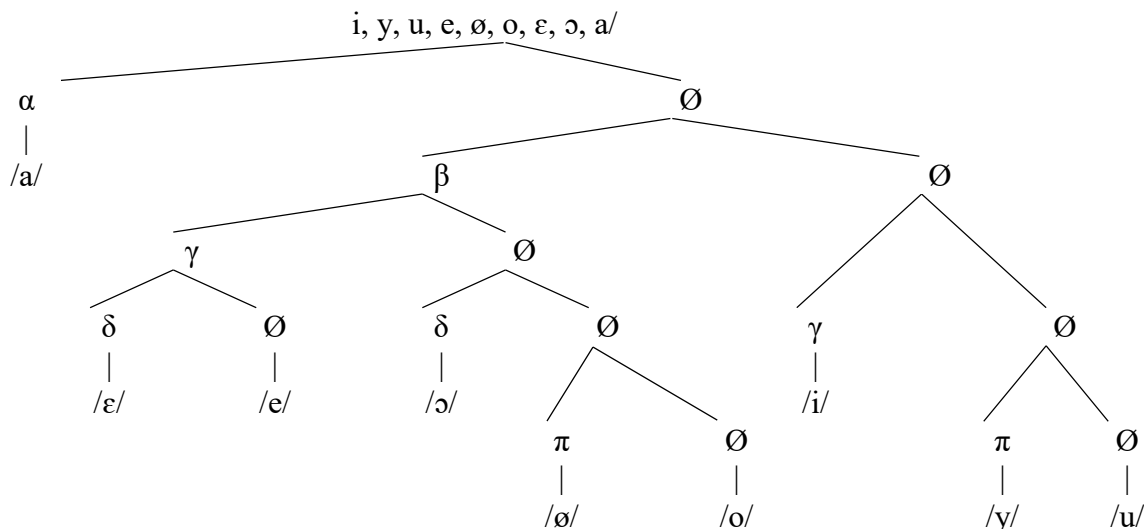
(27) Prime assignment based on the SDA for the vowel system of Bresciano. Option #1



The prime $|\pi|$ individuates vowels that undergo the process of vowel reduction. The prime $|\delta|$ individuates high vowels, while the rest of the primes under (27) (α, β, γ) have a merely contrastive role. Crucially, the SDA does not provide a prime that defines all and only the targets of raising harmony: $\varepsilon, o, \epsilon, e$ do not share any prime. However, the process can be formalized as applying to all vowels, so that any vowel that can receive the prime $|\delta|$ actually receives it: delta is added to $\varepsilon, o, \epsilon, e$ and, vacuoulsy, to i, u, y . The low vowel /a/ behaves as a blocker because the language does not contain a segment specified as $|\alpha\delta|$. If we were using binary primes instead of unary primes, the set of targets would be identified by the negative value of the harmonic prime, in this case a hypothetical $|\neg\delta|$.

An alternative SDA graph for Bresciano may look like the one under (28). As the one under (27), it manages to assign a contrastive specification to all nine vowels of Bresciano.

(28) Prime assignment based on the SDA for the vowel system of Bresciano: Option #2



The SDA under (28) assigns a prime $|\beta|$ to all mid vowels. However, it fails to identify high vowels, and therefore does not reflect their role as an active class of triggers of VH. This is how computation informs prime learning: the SDA must divide sets of segments and assign primes in a way that reflects the alternation perceived. A graph like the one in (28) does not reflect the alternations presented in (26b), and would therefore be discarded in favor of the SDA graph in (27).

Dresher’s model of prime learning, de facto, puts phonological contrast as the main mechanism behind prime learning (which works through the SDA). Computation has the role of selecting the right SDA graph among the possible ones.

Within such a framework, it is worth noticing how the role of the Contrastivist Hypothesis changes from a substance-based framework (like the MCS theory, where substance-laden binary features are employed) to a substance-free one, which employs substance-free unary primes.

The Contrastivist Hypothesis imposes a strong correlation between phonological activity and contrastivity. Dresher (2014: 167) defines the activity of a prime adapting a formulation from Clements (2001: 77): “A feature can be said to be active if it plays a role in the phonological computation; that is, if it is required for the expression of phonological regularities in a language, including both static phonotactic patterns and patterns of alternation”. In sum, if a prime is relevant in a phonological process, it is defined as active.

Given the corollary to the Contrastivist Hypothesis discussed in (20b), which states that an active prime must be contrastive, we derive the heuristic for discovering contrastive features (Dresher (2014: 167): look for phonologically active features, and hypothesize that they are contrastive in those segments in which they are active.

Under this view, the Contrastivist Hypothesis and its corollary would be falsified if a prime was active in processing while not being contrastive for a segment. This would mean that a prime that has a role in processing is not necessary to distinguish it from other segments of the language. We may thus

define as a non-contrastive prime each prime that has a role in computation but that has no contrastive function. The contrastive function of primes can be defined by the appearance of the same prime in the SDA graph. The SDA defines only contrastive primes by definition, since it stops once a segment has received a representation that differs from that of other segments.

VI.4.1.3 Learning asymmetric patterns through the SDA procedure

In section §IV.3.2.2 the SDA was employed as a strategy to explain the behavior of neutral vowels in asymmetric harmonies. The case of Halh Mongolian briefly mentioned in the previous section shows how the SDA may fulfill this role: segments that behave as neutral are not assigned the harmonic prime, and therefore they do not participate in harmony. The algorithm was able to account for various processes, but given the set of innate features employed, some asymmetric harmonies remained problematic. In section §IV.3.2.3 the case of Basque and Bergamasco raising harmonies were treated. The graphs obtained using substance-based binary primes in the fourth chapter are re-proposed in (29) and (30) below. The SDA was able to generate a graph that was formally able to account for the two asymmetries. The problem was in the absence of a prime in the given set that could be put in the position marked with * in the graphs. The issue, then, was not in the SDA itself, but in the set of phonological primes used. Under (29) are reported alternations in Baztan Basque, where the low vowel /a/ (but no other vowels) undergoes raising. (29a) reports some root-internal raisings, that become evident confronting the Baztan variety of Basque with the standard variety. (29b) shows some alternations in derivational morphemes of Baztan Basque: /a/ alternates with [e] when preceded by a high vowel. No other vowel does so. (29c) reports the SDA graph proposed in §IV.3.2.3.

(29) Asymmetric raising harmonies in Basque: MCS analysis

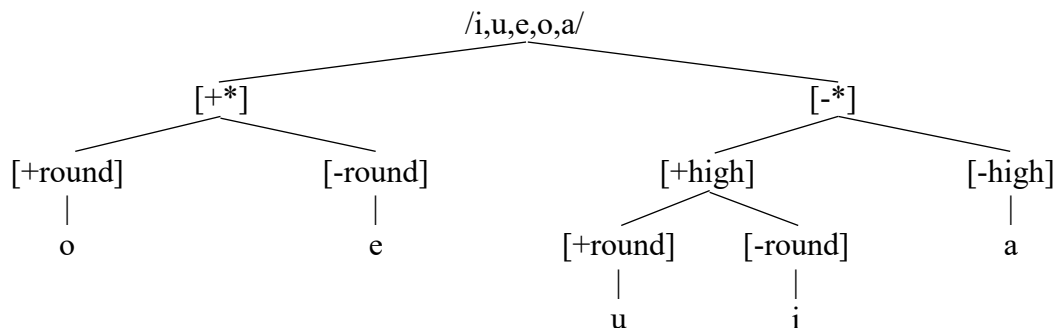
a. Root internal raising

<i>Standard Basque</i>	<i>Baztan Basque</i>		
fabrika	fabrike		'factory'
muga	muge		'limit'
ikaratu	ikeratu		'frightem'
irabazi	idebazi		'to earn'
belaunikatu	belauniketu		'to kneel'
ikatz	iketx		'coal'
kirats	kirets		'stench'
ikasi	ikesi		'to learn'
izan	izen		'to be'
bihar	bier		'tomorrow'
usain	usein		'smell'
hura	ure		'that'
urtarril	urterril		'January'
urte	urte	*urti	'year'
izen	izen	*izin	'name'
izerdi	izerdi	*izirdi	'sweat'
bide	bide	*bidi	'path'

b. Alternations in derivational morphemes

i. Raising in the diminutive suffix /ska/			
afari-xke	little dinner	larra-xka	'little prairie'
mendi-xke	'little mountain'		
ii. Raising in the suffix /lari/ (profession)			
tratu-leri	'dealer'	eske-lari	'beggar'
iii. Raising in the adverbial suffix /ka/			
aldiz-ke	'by turns'	laster-ka	'quickly'
iv. Raising in the suffix /tsa/-[tza] (activity)			
lagun-tze	'help'	arran-tza	'fishing'
v. Raising in /-la/ (that)			
dugu-le	'that we have'	dire-la	'that they are'
vi. Raising in /ta/ (past participle)			
itzuli-te	'turned'	etzan-ta	'lied'
vi. Raising in the singlual article /-a/			
itzuli-e	'the turned'	erran-a	'the said' (what has been said)

c. SDA graph for Baztan Basque vowel system in light of the harmonic pattern: Only /a/ undergoes raising



Contrastive hierarchy: [*] > [high] > [round]

The graph in (29c), where binary features were employed, is formally correct, but there are no primes in the most common standard sets that may be put in the position containing the asterisk in the graph. The same issue is discussed in §IV.3.2.3.

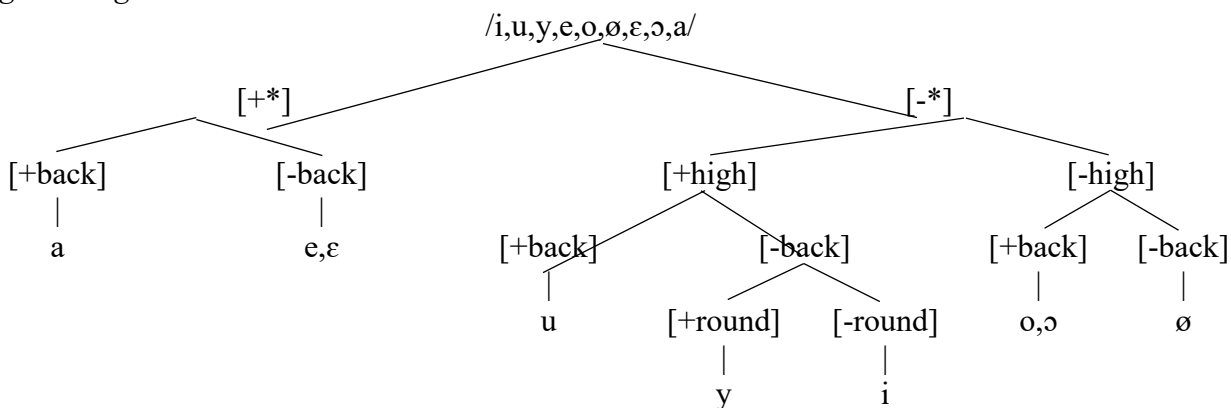
Under (30) the same is done for Bergamasco. (30a) reports height alternations caused by raising in Bergamasco. Recall that in this EL dialect only rounded vowels undergo raising, while front non-rounded vowels remain unaffected. Rounded vowels (in the first part of the table in 30a) raise when followed by a stressed high vowel. Non-rounded vowels, instead, do not undergo harmony. (30b) Reports the SDA graph proposed in §IV.3.2.3.

(30) Asymmetric raising harmonies in Bergamasco: MCS analysis

a. Harmonic alternations in Bergamasco

Rounded vowels	[ˈgodʒa]	‘needle’	[guˈdʒi]	‘needle DIM’
	[meˈcore]	‘I run’	[oter cuˈri]	‘you run PL’
	[øtʃ]	‘eye’	[yˈdʒi]	‘eye DIM’
Non-rounded vowels	[poleder]	‘foal’	[poleˈdri]	‘foal DIM’
	[meˈlese]	‘I read’	[leˈsit]	‘read’

b. SDA graph for Bergamasco vowel system in light of the harmonic pattern: /a/ and /e/ do not undergo raising

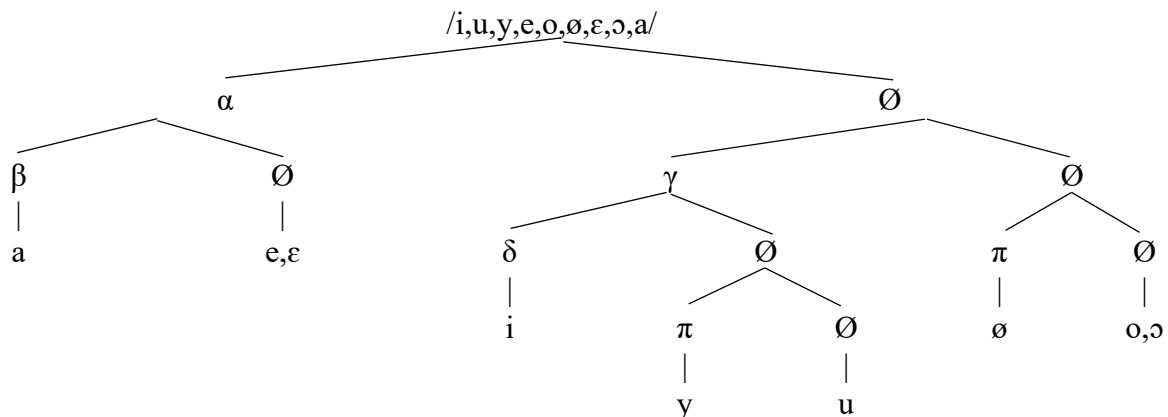


Once again, a graph able to explain the behavior of vowels in Bergamasco can be made; however, traditional feature theories lack a feature that may be posited in the graph instead of the asterisk.

In a RadSFP framework, the issue of the two asymmetries treated above is solved. Since primes are learned and are not substance-based, the SDA graphs proposed can be rewritten. The graph under (31) largely resembles the one in (30b), concerning Bergamasco, but substitutes the substance-full features employed in the previous version with arbitrary substance-free labels. In Bergamasco, where raising applies iteratively, the process is considered as spreading of the prime $|\gamma|$. Front mid-vowels /e/ and /ε/, are specified for $|\alpha|$ and, as /a/, cannot receive γ because it would give rise to an illicit segment $|\alpha\gamma|$ ²³⁶.

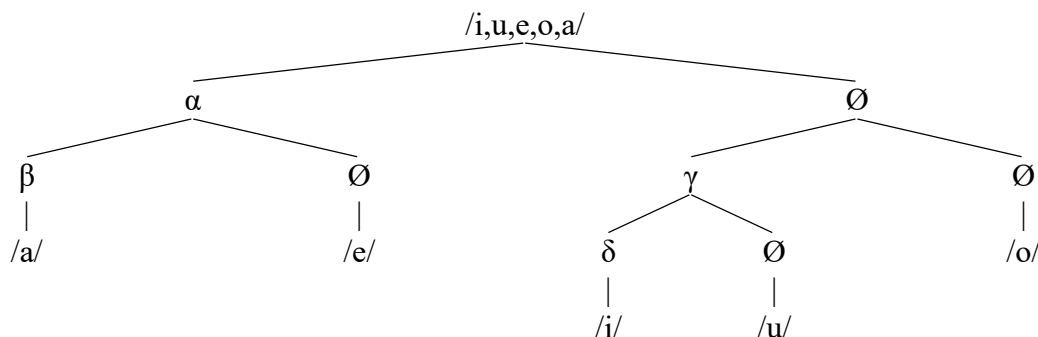
²³⁶ In (31) mid-high and mid-low vowels are not distinguished by the SDA only for reason of exposition. The algorithm would continue and assign a prime to mid-low vowels, which undergo vowel reduction.

(31) Prime assignment based on the SDA for the vowel system of Bergamasco



The case of Basque is slightly different. Basque does not apply iteratively, in that /e/, which is the result of /a/ raising, does not trigger raising of following low vowels. Learners would thus consider this process as a case of subtraction of a prime (cf. §3.2.2). Therefore the SDA graph should assign two primes to /a/, so that when it loses a prime its prime specification coincides with the specification of /e/. The graph under (32) manages to arrive at a correct prime assignment.

(32) Prime assignment based on the SDA for the vowel system of Basque



Assuming the SDA graph in (32), the low vowel /a/ would lose the prime |β| when preceded by a vowel specified for |γ|.

In sum, the theory of prime learning based on the SDA allows for the emergence of asymmetric harmonies. Employing emergent-learned primes instead of substance-based primes allows also for the formalization of asymmetric harmonies that, as shown in §IV.3.2.3 cannot be done by the original MCS.

VI.4.1.4 The problem of formalizing parasitic harmonies using the SDA

It was shown in §IV.3.2.4 that parasitic harmonies are problematic for the MCS approach: the SDA was not able to describe the double behavior of triggers and targets in parasitic harmonies, which behave in certain contexts as active, and in others as neutral vowels. The goal of this section is to find out whether the assumption of a different theory of phonological representation, one that employs emergent substance free primes rather than a fixed set of substance-laden features, solves the issue.

Recall the vowel harmony of Camuno (cf. §III.7.4) where /u/ triggers raising of rounded mid vowels, while /i/ triggers raising for both rounded and non-rounded vowels. The process applies iteratively, thus is formalized as spreading of a harmonic prime. Some harmonic alternation caused by the stress-bearing diminutive suffix /-i,nɔ/ and the augmentative suffix /-u,unɔ/ are shown in (33).

(33) Harmonic alternations in Camuno

<i>Base form</i>	<i>Diminutive</i>	<i>Augmentative</i>	
[ˈdet]	[dinˈti]	[dɛnˈtu]	‘tooth’
[ˈtʃezɔ]	[tʃiˈzinɔ]	[tʃeˈzunɔ]	‘church’
[let]	[liˈti]	[leˈtu]	‘bed’
[ˈpɛtɛn]	[pitiˈni]	[peteˈnu]	‘comb’
[ˈtʃot]	[tʃuˈdi]	[tʃuˈdu]	‘nail’
[ˈgrop]	[gruˈpi]	[gruˈpu]	‘knot’
[ponˈdor]	[punduˈri]	[punduˈru]	‘tomato’
[bigaˈrɔl]	[bigaruˈli]	[bigaruˈlu]	‘apron’
[lɛnˈhɔl]	[lɛnhyˈli/lɛnhuˈli]	[lɛnhuˈlu]	‘sheet’
[fonˈtanɔ]	[fontaˈninɔ]	[fontaˈnunɔ]	‘fountain’

Given this pattern, what kind of information is available to a learner of Camuno? As for Bresciano under (26), I assume that children recognize the vowel system and perceive the alternations caused by harmony as well as those caused by vowel reduction, which applies in the same contexts for Bresciano, Bergamasco and Camuno. I also assume that the harmonic process, which is iterative, would be formalized as spreading of a prime, while the vowel reduction process would be formalized as delinking. It remains to define which primes are linked to targets in this case.

Given the alternations in (33) I argue that children facing the harmonic alternations of Camuno are led to suppose the existence of two different processes of vowel raising, one that targets rounded mid vowels and the other that targets non-rounded mid vowels. In a substance-free environment, the fact that various alternations appear as phonetic raising of mid-vowels does not mean that they have the same cause in phonology. What phonology is about is the alternation, not the phonetic aspect of it. Normally, a process affects a class of targets and is caused by a class of triggers. As we have discussed in §V.3.2, in Camuno there are two classes of targets and two classes of triggers, if we look strictly at their phonological behavior.

High vowels behave as a class of triggers for a process affecting rounded mid-vowels, which surface as high. This individuates a class of targets (mid-rounded vowels) and a class of triggers (high vowels). /i/ (and only /i/) behaves as trigger for raising of non-rounded vowels.

This alternation suggests to learners the presence of a second class of vowels: one which is formed by only one segment, /i/, the other composed by those vowels that raise only if followed by /i/, i.e. non-rounded /e,ɛ/.

That both alternations appear as raising processes is not relevant information for phonology. What is relevant, instead, is that raising of rounded vowels and raising of non-rounded vowels apply in different melodic contexts. Rounded vowels raise when followed by any stressed high vowel, non-rounded vowels raise only if followed by stressed /i/.

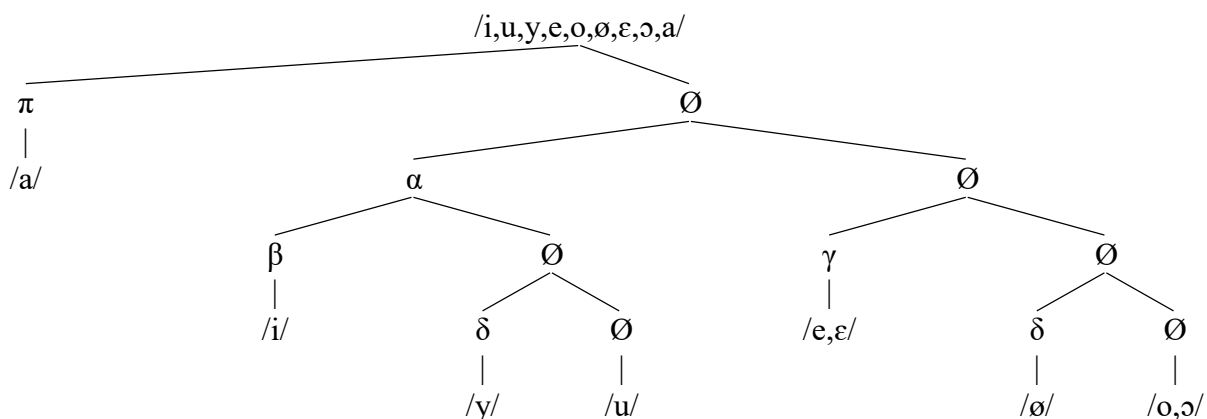
Learners would thus identify an active class of high vowels, comprised of /i/, /u/ and /y/, which behave as triggers for one process of raising that affects rounded vowels, and another class of triggers,

one that is composed only by the high vowel /i/. The identification of active classes corresponds to the assignation of a prime. Therefore, all high vowels must be identified by a prime, say $|\alpha|$, which spreads only to rounded vowels. The high vowel /i/, which triggers the raising of all mid vowels, must be specified for another prime $|\beta|$.

Assuming this prime assignation, two processes of raising are thus active in Camuno, one spreading $|\alpha|$ to rounded vowels, the other spreading $|\beta|$ to non-rounded vowels. With this information available, learners should be able to build an SDA graph that correctly assigns active primes to all the segments involved. The Contrastivist Hypothesis requires both harmonic primes $|\alpha|$ and $|\beta|$, whose activity in phonological processing is the whole point of the pattern, to be contrastive. If they are not, this may mean that the SDA cannot be the source of prime learning, since it can only generate contrastive primes.

I argue that the Camuno VH, even if treated with substance free primes, cannot be analyzed following MCS. Not because of the SDA, but because of the Contrastivist Hypothesis, which requires all primes to be contrastive. The graph under (34) manages to assign two contrastive primes $|\alpha|$ and $|\beta|$ to /i/, which should spread to rounded and non-rounded mid-vowels respectively. However, the graph fails to explain the harmonic pattern, as argued below.

(34) Prime assignation based on the SDA for the vowel system of Camuno: version1



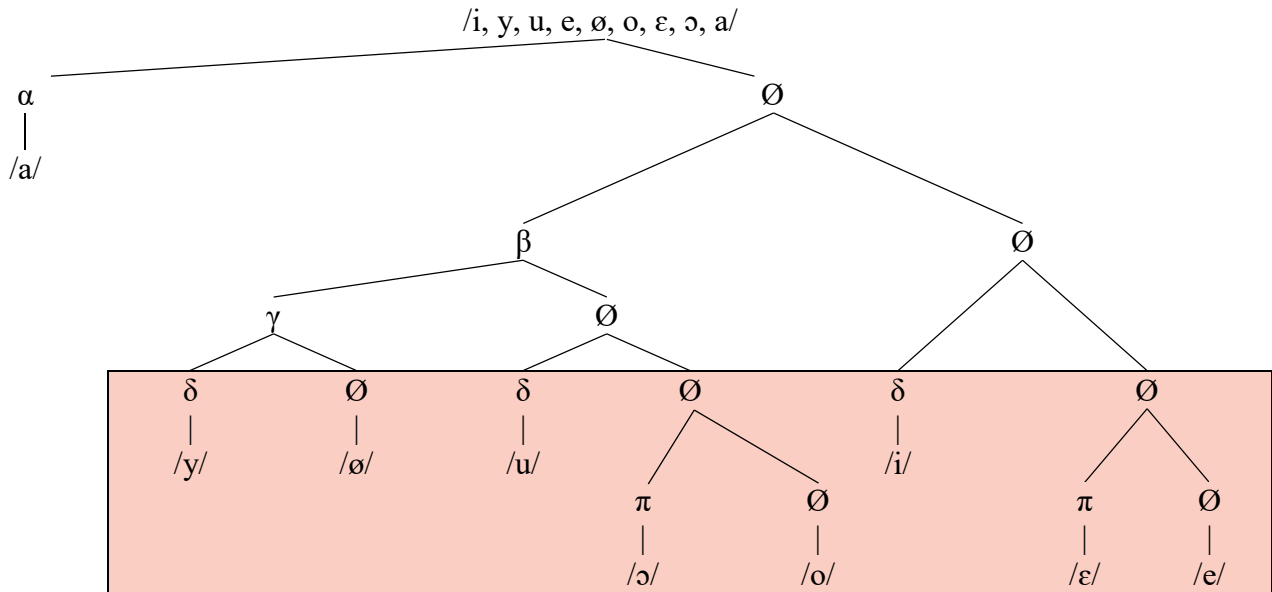
The graph under (34) correctly assigns a common $|\alpha|$ prime to all high vowels and another prime $|\beta|$ only to /i/. This ensures that the class of vowels that raise rounded mid vowels is identified by the prime $|\alpha|$, and that the class of vowels that raise non-rounded vowels, which only comprises /i/, is identified by $|\beta|$. The problem with this graph is that it does not identify the right set of targets.

To see that, recall that while discussing the raising patterns of other EL in the previous sections, the class of target vowels was not identified by a prime. Potential targets were treated as such for being under the scope of the division concerning the harmonic prime. In other words, the position of segments within the SDA graph affects which primes may be assumed by which segment. Consider the two SDA graphs built for the variety of Bresciano and Bergamasco in (27) and (31) respectively, which are recalled in (35). The scope of the harmonic process is isolated and highlighted in the graph. Only vowels within the highlighted area participate in harmony, either as triggers or as targets. Vowels outside the highlighted area are those that behave as neutral. In Bresciano, where the process is symmetric, only /a/ behaves as neutral, and thus is the only vowel outside the scope of Harmony (as

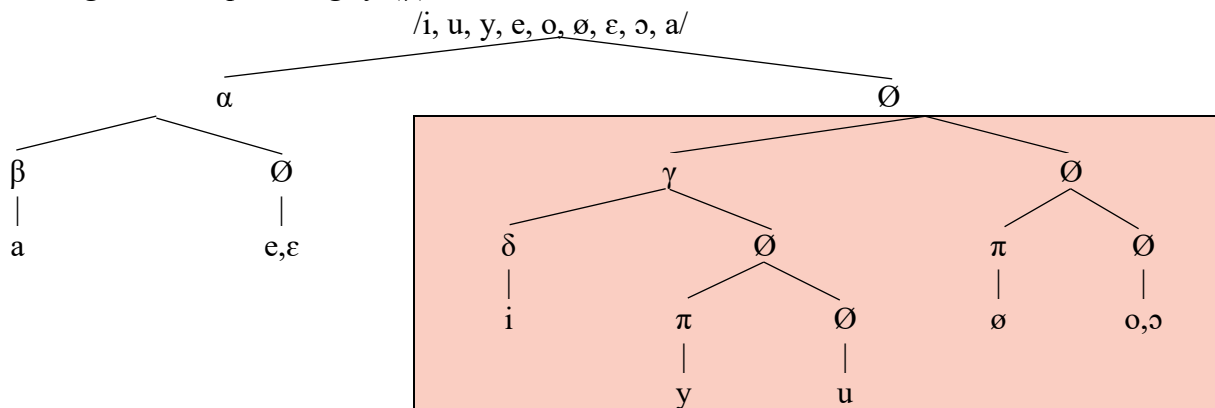
shown in (35a). In Bergamasco both /e/ and /a/ behave as neutral, as shown in (35b), where both /e/ and /a/ are isolated from other vowels, which instead participate in harmony.

(35) Identifying the scope of a harmonic process. Vowels within the highlighted area participate in harmony, those outside do not

a. *VH in Bresciano: spreading of $|\delta|$*



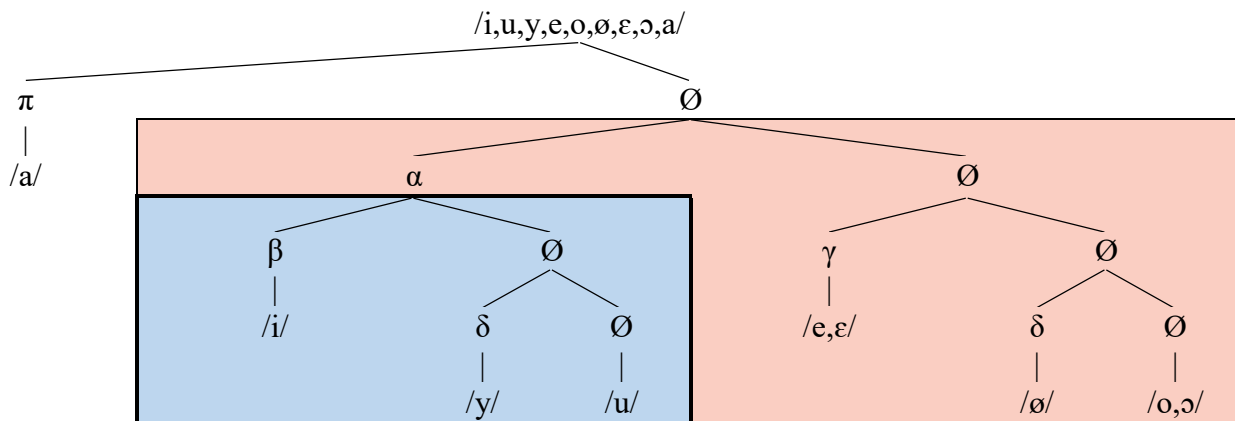
b. *VH in Bergamasco: spreading of $|\gamma|$*



The scope of harmony is defined by the scope of the contrast for the harmonic prime. Vowels for which the harmonic prime is contrastive participate in harmony, those for which it is not contrastive behave as neutral. The graph proposed for Camuno in (34) fails to identify the correct set of targets. The set of vowels active in the process of $|\alpha|$ spreading, i.e. the set of vowels for which the branching between $|\alpha|$ and non- $|\alpha|$ vowels is relevant, comprises also non-rounded mid-vowels, which are not affected by this process. This is shown in graphically (36). The set of vowels contained within the scope of the $|\alpha|$ -contrast (shown in red) contains both rounded and non-rounded mid-vowels. However, given the alternations of Camuno, only non-rounded vowels should be affected by $|\alpha|$ spreading. A second issue concerns the scope of the $|\beta|$ -contrast. Non-rounded mid vowels should be affected by spreading of $|\beta|$, and therefore we expect them to be within the scope of the $|\beta|$ -contrast (shown in blue

under 36). However, they are not. The scope of the $|\beta|$ contrast is contained within the scope of the $|\alpha|$ contrast.

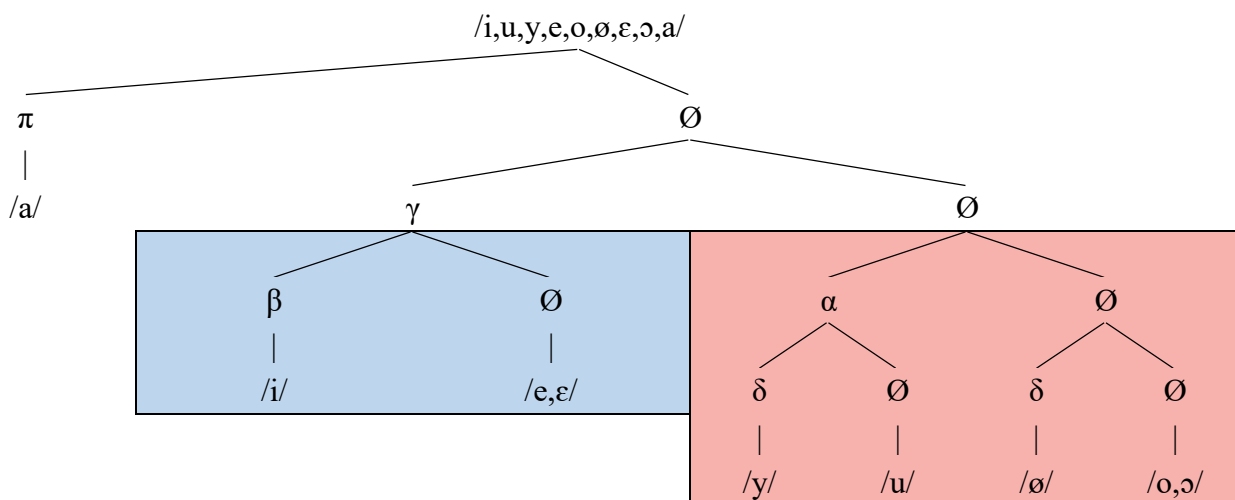
(36) Prime assignment based on the SDA for the vowel system of Camuno: version1. Targets are not identified correctly.



Given the situation, one may argue that non-rounded vowels fail to raise when followed by $|\alpha|$ because the language lacks a segment specified as $|\alpha\gamma|$. The same argument would rule out the spreading of $|\beta|$ to non-rounded mid vowels, because $|\beta\gamma|$ is also an illicit segment in Camuno.

The graph under (37) attempts to build a second SDA graph for Camuno. This time the set of targets is correctly positioned below the harmonic prime in the graph. Rounded mid-vowels are positioned within the scope of the $|\beta|$ contrast (i.e in the red area), meaning that they can receive $|\alpha|$ from a trigger with $|\alpha|$. Non-rounded mid vowels are positioned within the scope of the contrast for $|\beta|$ (shown in blue in the graph), meaning that they could receive it from a following trigger containing $|\beta|$. The issue that the graph under (37) faces, though, is that now it cannot assign both harmonic primes $|\alpha|$ and $|\beta|$ to the trigger /i/, which behaves as trigger for both harmonies.

(37) Prime assignment based on the SDA for the vowel system of Camuno: version2



Given the theory of computation proposed in §3, the SDA is not able to generate a graph that captures the behavior of triggers and targets in a partially parasitic harmony such as the one of Camuno. This does not mean that the contrastive theory of prime emergence is to be rejected completely. In fact, starting from the assumptions proposed in Dresher (2014), Sandstedt (2018) develops a model of prime learning that follows the Contrastivist Hypothesis and that is specifically aimed at explaining partially parasitic harmonies using contrastive emergent primes. Sandstedt's model discussed in the following section makes different assumptions regarding both representation and computation with respect to those argued for in this thesis, but manages to account for both asymmetric and partially parasitic harmonies.

VI.4.2 Sandstedt's (2018) model of prime emergence

VI.4.2.1 Primes emerge as hierarchically ordered micro-cues

Sandstedt's (2018) thesis looks directly at the issue of parasitic harmonies, and sets as its goal the formalization of processes that in §I.5.4.1 were defined as partially parasitic harmonies. He treats processes from Old Norwegian and various Bantu languages, which (as discussed in §II.3.1.2) often display a parasitic harmony involving lowering of high vowels in suffixes. Following his ambition, parasitic harmonies such as Camuno are described in a way that is not only a restatement of the facts. Sandstedt (2018) aims at a model that explains why parasitic patterns behave the way they do. He relies on emergent monovalent features organized in a contrastive hierarchy on the SDA graph.

The theory of prime-emergence proposed in Sandstedt (2018) has some core differences with the one discussed in the previous section about Dresher's model of prime emergence.

First, the SDA is not the algorithm that generates phonological primes, but it is just a step in the operation of the building of the phonological system. Prime-emergence follows another route.

Sandstedt (2018: 37) adapts some insights from Westergaard's (2009, 2013, 2014) model of micro-cues, a theory interested in syntactic learning. In synthesis, this model assumes that children are endowed with a UG that is rich enough to allow them to parse the input they are exposed to. They then posit micro-cues, small pieces of abstract syntactic structure, which become part of their knowledge of a specific language. Imported into phonology, this proposal may be summarized as follows. Children are able to recognize sounds from early on (as argued in §V.4.1 and Dresher 2014: 173) and they discriminate phones for which they have no phonological representations using their innate perceptual system. From contrasts in salient phonetic properties, lexical meaning, and phonological behavior, learners posit representational items or restrictions that form the basic building blocks of phonological systems. Those items and restrictions posited by learners are called micro-cues.

So, children first learn micro-cues, without referencing the SDA. Those micro-cues may take different forms. They can either be unary primes or co-occurrence restrictions / requirements. This means that learners are expected to learn both primes and some restrictions that involve them.

Take the case of two sounds [y] and [i] that contrast in a given language. Learners perceive different sounds, but still have to assign them a phonological representation. Learners posit as a micro-cue the prime $|\alpha|$ to ensure contrastivity between the two objects (say, /y[α]/, /i[\emptyset]/). Now learners have assigned a first phonological representation to the two sounds perceived as [y] and [i]. Primes can be posited also to account for a perceived alternation. Let us assume that /y/ and /i/ behave as triggers of an assimilation. Learners will posit another prime $|\beta|$ as a micro-cue, which is shared by /y/ and /i/. This is actually the same mechanism of learning that was explored in the outset of the chapter.

Interestingly, though, micro-cues can also appear as co-occurrence restrictions or co-occurrence requirements, and not only as primes. For example, let us assume that a third segment /a/ does not undergo assimilation triggered by /y/ and /i/. Assuming that assimilation spreads primes, learners may posit a micro-cue $|\gamma|$, which identifies /a/, and also a micro-cue in the form of a co-occurrence restriction, $|\ast\gamma\beta|$, which disallows $|\beta|$ from co-occurring with $|\gamma|$. In sum, co-occurrence restrictions inform prime emergence in addition to contrast and phonological activity. Thus Sandstedt (2018: 42) says “[t]he sum of these micro-cues – that is, the set of features and permitted/obligatory feature combinations – define the language’s permitted segment inventory. This is the second novelty of Sandstedt’s model: children do not learn only primes, but also some restrictions that affect their possible combinations.

Sandstedt subscribes to a modified version of the Contrastivist Hypothesis discussed in (20a), which he calls the Correlate Contrastivist Hypothesis, reported under (38).

(38) Correlate Contrastivist Hypothesis (CCH):

The phonemes of a language L are equal to the sum of features and feature co-occurrence restrictions which are minimally necessary for the expression of phonological regularities in L

The CCH holds that the phonemic inventory is defined by the set of active phonological features and feature co-occurrence restrictions required to express a language’s phonological regularities. In sum, only the necessary primes and prime co-occurrence restrictions are posited by learners during acquisition. Prime specifications are supposed to be maximally parsimonious, which means that only contrastive primes (those that are necessary to identify a segment) are posited. Simply put, this model assumes the corollary to the Contrastivist Hypothesis: all active primes must be contrastive.

The SDA is how the contrastive role of primes is ensured. The SDA thus has a new role on this view of prime emergence. It takes micro-cues as an input and returns a contrastively specified segment inventory as an output. Sandstedt (2018) follows Iosad's (2017: 40) view in assuming that the SDA assigns feature specifications as well as feature geometric nodes. In this approach, nodes have mainly two functions (Sandstedt 2018: 44): they indicate contrastivity for a feature, and they define locality domains in Autosegmental Phonology fashion. A segment which bears the prime node $A[_]$ is guaranteed to be visible to a process which spreads $|\alpha|$ and vice versa a segment that lacks the $A[_]$ node cannot be involved in a process of $|\alpha|$ spreading. A prime $|\alpha|$ can only appear within a node $A[_]$, and can only spread to segments that have the node $A[_]$.

The presence of nodes marks the third main difference between Sandstedt’s model and the one proposed by Drescher.

In sum, primes are learned as micro-cues together with co-occurrence restrictions or co-occurrence stipulations. They are ordered and fed to the SDA, which produces a fully fledged segmental inventory.

Under (39) is provided an example.

In a given language with a five-vowel system /a,e,i,o,u/, a process of raising is triggered by high vowels and targets mid-vowels. This suggests to learners that there must be a prime $|\beta|$ that distinguishes high vowels from mid-vowels. The low vowel /a/ must also be defined for some property, say $|\alpha|$, and its neutral behavior in the process of raising informs learners that $|\alpha|$ and $|\beta|$ do not combine. So, the co-occurrence restriction $\ast|\alpha\beta|$ is posited. The pattern of alternation, which turns /e/ into [i] and /o/ into [u] suggests that /e, i/ and /o, u/ must be distinct. A prime $|\gamma|$ is posited, which distinguishes /o, u/ from /e, i/.

The three primes $|\alpha| |\beta| |\gamma|$ and the co-occurrence restriction $\ast|\alpha\beta|$ are the micro-cues. They are ordered as shown in (39a) The set of ordered micro-cues is fed to the SDA, which assigns primes and nodes to

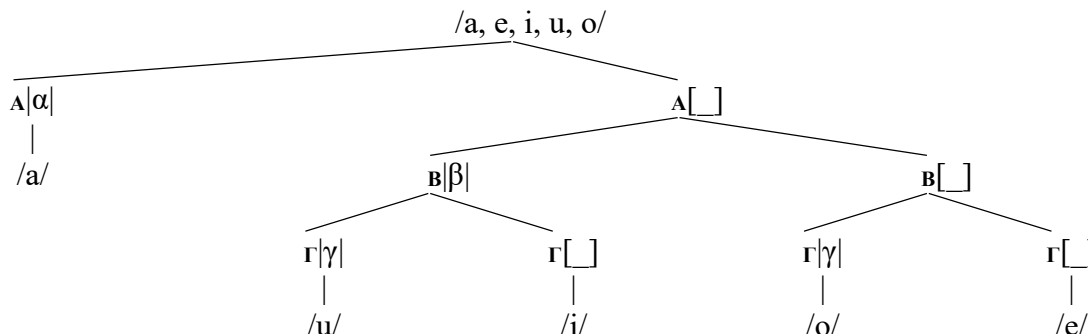
the segments. The graph in (39b) is the graphic rendition of the micro-cue hierarchy under (39a). The internal structures of segments of this toy language is shown in (39c), and it reflects the branchings operated by the SDA.

(39) Toy example that applies Sandstedt’s (2018) model of phonological representation

a. *Micro-cues ordered hierarchically*

$|\alpha|; *|\alpha\beta| > |\beta|; > |\gamma|$

b. *Application of the SDA given the hierarchy above*



c. *Internal structure of segments, assuming the SDA graph above*

/a/	/u/	/i/	/o/	/e/
A α	A[]	A[]	A[]	A[]
	B β	B β	B[]	B[]
	r γ	r[]	r γ	r[]

The theory of prime learning proposed in Sandstedt (2018) has some properties in common with the one advanced in Dresher (2014) as well as some sharp differences. Both models subscribe to a Contrastivist Hypothesis, which in an emergentist environment boils down to its corollary: all active primes have a contrastive role. Both models subscribe to the emergentist view, but both Dresher and Sandstedt employ labels for primes that seem substance-laden. Their models, however, works also with substance-free labels such as $|\alpha|$, $|\beta|$ etc.

Both models employ the SDA, albeit in different ways. In Dresher’s model it is the way primes are posited and assigned to segments, in Sandstedt’s model it is a way to ensure that primes have a contrastive role and also an algorithm that defines the internal structure of segments through the insertion of nodes.

One issue with this model concerns the status of co-occurrence restrictions. Sandstedt (2018) treats co-occurrence restrictions as if they were representational items, learned as “micro-cues” during acquisition, and taking part in the hierarchy of micro-cues that is fed to the SDA. However, they reflect

a computational requirement, and do not take part in the representation of segments as normal unary primes do. So, are they representational items or computational statements²³⁷?

A second issue concerns the role of the SDA. In its original iteration (Dresher 2009), the SDA is conceived as a property of the language, which applies once and defines the segmental inventory assigning primes to segments. Similarly, in Dresher (2014) the SDA is the mechanism that make primes emerge and that assigns them to segments. Here, instead, it is a step in prime-learning, which takes already defined primes, assigns them to segments and is reflected in the internal structure of segments through the hierarchy of nodes. This means that the SDA also has both a role in the definition of the inventory and a role in phonological representation: the SDA graph is replicated within segments as a feature geometry.

Let us take the segment /i/ as structured in (39c). It does not only contain the prime $|\beta|$, but also an empty node $\Lambda[\]$ and an empty node $r[\]$. Those notions are irrelevant for the representation of /i/, which could be just defined as the segment containing $|\beta|$, but inform about the presence of other segments in the language, where those empty nodes are filled. This information comes from the application of the SDA, which upon learning divided the set of segments between those that contain $|\alpha|$ and those that do not, and later between segments that contain $|\gamma|$ and those that do not. This information is reported in all segments of the language, meaning that learners, besides having to apply the SDA to assign primes and nodes to segments, also have to learn its hierarchy and store it within each segment of the language.

VI.4.2.2 Representing Vowel Harmonies

Sandstedt (2018) does not present a fully-fledged theory of phonological computation. He provides, however, some assumptions about the way harmonic processes are formalized. In practice, he treats harmony as a process whereby a target with an empty node may receive a prime from a segment with a full node. Simply put, in a language where harmony is active, a segment with $\Lambda[\]$ may receive the prime $|\alpha|$ from a segment with $\Lambda[\alpha]$. This corresponds to the operation of addition discussed in §3.2.1. It is unclear, however, if harmonies may incarnate in other ways (as subtraction, of primes, for example, as argued in §3.2.2 regarding non-iterative harmonies).

Crucially, the assumption of an additional representational item, the node, affects the way harmony applies. The node limits the possible processes of spreading to those contexts where an empty node is present. In sum, it identifies the targets of a harmonic process as those that have an empty harmonic node. Spreading does not apply to segments that lack the empty node. A first notion assumed in Sandstedt (2018) concerning computation is, then, that primes may spread from a full node to an empty node, but cannot spread to position without the relevant empty node, or to other filled nodes.

In the context of asymmetric harmonies, it also means that a vowel that lacks the harmonic node behaves as neutral in the harmonic pattern.

Notice that Sandstedt's representational framework provides two different ways to account for the lack of participation in a harmonic process. Either a micro-cue disallows the co-occurrence of two primes, or a segment lacks the node for the harmonic prime because it is fully specified before the harmonic prime spreads. Recall from §I.4.2.2 that there are two kinds of neutral vowels in harmonic processes.

²³⁷ Co-occurrence restrictions closely resemble the Licensing Constraints (LC) treated in §IV.5, which were meant to define both the inventory of a language as well as its computation. However, LCs were overtly computational statements, and, while affecting it, they did not take part in the representation of segments.

Transparent vowels are those that ignore harmony and allow the process to continue once the “harmonic wave” passes them. Opaque vowels or blockers are those that do not participate in VH and that disallow the harmony to affect ulterior vowels.

The different behavior of transparent and opaque vowels in VH is reflected in the SDA graph. Transparent vowels are those that lack the harmonic node altogether while blockers have the node, but are prevented from harmonizing because of a co-occurrence restriction. Sandstedt (2018: 59) discusses extensively the case of two varieties of Yoruba (previously discussed in §IV.3.2.5), which respectively have transparent and opaque vowels. In both varieties of Yoruba a regressive tongue-root harmony is active. Mid-low vowels affect preceding mid-vowels turning them mid-low. The process ignores high vowels in Ife Yoruba (40b), but is blocked by high vowels in Standard Yoruba (40c), which disallow harmony to apply past them. Thus, the difference in the two varieties is that in Ife Yoruba high vowels behave as transparent, while in Standard Yoruba they behave as blockers.

(40) Tongue Root harmony in Standard and Ife Yoruba (Nevins 2010: 104)

d. Yoruba vowel system (both varieties display the same one)

	Front	Back
High	i	u
Mid-high	e	o
Mid-low	ɛ	ɔ
Low		a

e. Harmonic roots in Ife Yoruba

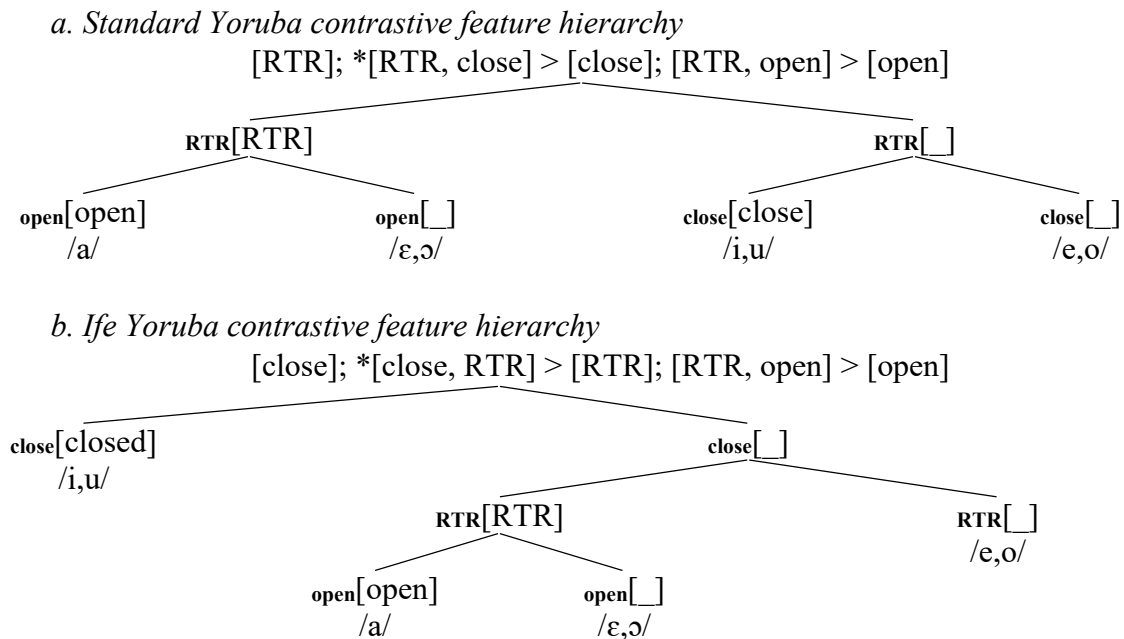
Tongue Root Harmony in Ife Yoruba		Tongue root harmony skips high vowels in Ife Yoruba
[ètè]	‘lip’	
[ègɛ]	‘cassava’	
[ɛfɔ]	‘vegetable’	
[ekpo]	‘oil’	
[oru’kɔ]	‘name’	
[ɛlùbɔ]	‘yam flour’	
[eúré]	‘goat’	
[ɔdíðɛ]	‘parrot’	
[òtító]	‘truth’	

f. Harmonic roots in Standard Yoruba

Tongue Root Harmony in Standard Yoruba		High vowels block harmony in Standard Yoruba
[ètè]	‘lip’	
[ɛjɛ]	‘blood’	
[ɛdɔ]	‘liver’	
[ekpo]	‘oil’	
[oru’kɔ]	‘name’	
[èlùbɔ]	‘yam flour’	
[ewúré]	‘goat’	
[odíðɛ]	‘parrot’	
[òtító]	‘truth’	

Sandstedt (2018: 59) argues for two different hierarchies using the same primes, which appear under (41). Sandstedt uses substance-laden primes in his graphs, but in fact they are assumed to be learned substance-free primes, the label being merely a notational aid. The graphs could as well implement arbitrary primes such as $|\alpha|$, $|\beta|$, $|\gamma|$, as done elsewhere in this chapter. The choice of using seemingly substance-based primes derives only from the desire to maintain a formal coherence with the source material. Primes are reported within brackets, which are specified by nodes. For example, a retracted vowel has the specification $\text{RTR}[\text{RTR}]$.

(41) Standard and Ife Yoruba contrastive feature hierarchies

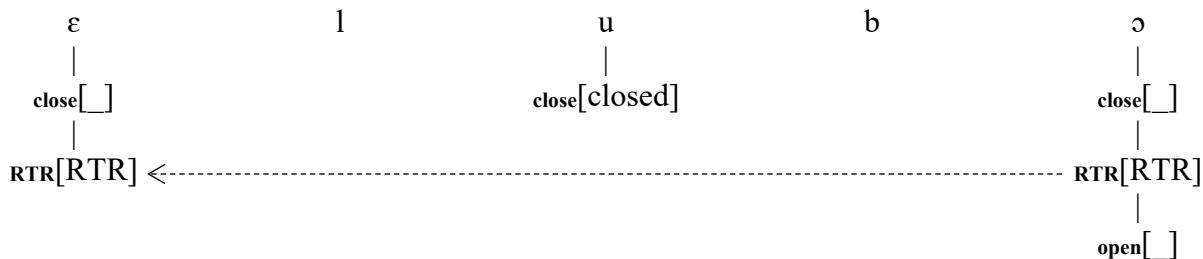


Consider first the graph in (41b) that presents the contrastive hierarchy of Ife Yoruba. In this variety high vowels /i/ and /u/ behave as transparent. The behavior of /i/ and /u/ as transparent is accounted for by the position of the node $\text{close}[\text{close}]$, which makes sure that the contrast involving RTR and non-RTR vowels does not concern them. Conversely, in Standard Yoruba (41a) the node close is positioned below the RTR node, therefore making RTR a contrastive prime for /i/ and /u/. The co-occurrence restriction $[\text{*RTR,close}]$ ensures that segments such as [i] or [u], specified for [RTR, close] are impossible in Yoruba. The position of the nodes in the SDA defines the role of segments in the harmonic process.

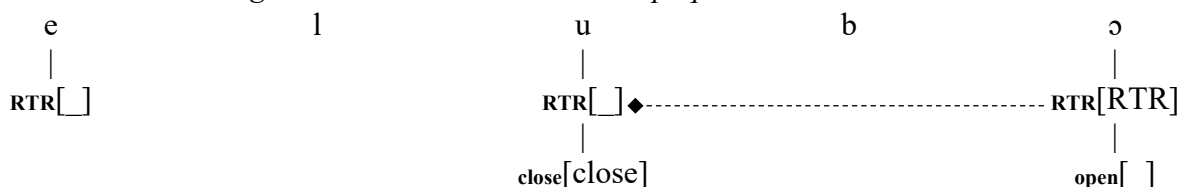
The behavior of high vowels in Yoruba harmony is exemplified in (42). (42a) shows that high vowels are transparent in Ife Yoruba: spreading of the RTR prime does not concern them because they lack the $\text{RTR}[\]$ node altogether. (42b) shows the case of Standard Yoruba, where high vowels are prevented from receiving the RTR prime by the co-occurrence restriction $[\text{*RTR,close}]$, and behave as blockers. Their internal structure contains the empty node $\text{RTR}[\]$, but due to the co-occurrence restriction that disallows [RTR] to co-occur with [closed], the prime RTR cannot be assumed. In the tables, spreading of RTR is shown with a dotted arrow from the trigger to the target.

(42) Different representation of transparent and opaque vowels²³⁸

a. *Ife Yoruba: high vowels behave as transparent*



b. *Standard Yoruba: high vowels behave as blockers/opaque vowels*



To sum up, vowels are specified as hierarchically ordered nodes, which can be filled or empty. The hierarchy of nodes is defined by the SDA, which itself follows from the hierarchy of micro-cues. The behavior of vowels in harmony reflects their internal structure. Vowels with a harmonic prime behave as triggers and spread the harmonic prime. Vowels with a harmonic empty node may still participate in harmony as targets, and if they receive the prime propagate the harmony to other vowels. They may not receive it if a co-occurrence restriction disallows the co-occurrence of the harmonic prime and of another prime: in the example in (42b), the restriction *[RTR, close] impedes spreading of [RTR] from final /ɔ/ to /u/. If harmony is impeded (as in 44b), the process is blocked. Vowels without the harmonic node altogether simply ignore the harmony, and behave as transparent vowels.

The case of Standard and Ife Yoruba exemplify the role of the ternary opposition introduced by the notion of node, which reflects the possible behaviors of vowels in a harmonic process. This is shown in the table under (43) below. Assuming that the process of harmony spreads the prime |α|, the behavior of vowels is defined by their internal structure

(43) The role of ternary opposition in harmonic processes.

<i>Full node</i>	A[α]	trigger
<i>Empty node</i>	A[]	target
<i>Full node, co-occurrence restriction</i>	A[], *[αβ]	blocker (assuming that the vowel contains β).
<i>No node</i>		transparent

²³⁸ In the tables under (42), tones are not reported.

VI.4.2.3 Sandstedt's (2018) proposal: all harmonies are parasitic

VI.4.2.3.1. Full nodes above the harmonic node affect the application of harmony

Since Sandstedt's model uses the SDA, asymmetric harmonies are accounted for by the same strategy discussed in §4.1.2. If only a subset of the expected targets undergoes harmony, the SDA assigns an empty harmonic node only to that subset. If only a subset of the expected triggers behaves as such, then only the true triggers receive a full harmonic node. In this aspect, this proposal is identical to the one discussed in §4.1. However, as was mentioned at the outset of §4.1.4, the model proposed in Sandstedt (2018) aims to explain parasitic harmonies, rather than merely describing them.

Sandstedt (2018: 77) argues that all harmonies, both parasitic and non-parasitic, are limited in how they can affect targets. We have established that targets are valid recipients for the harmonic prime because they have an empty node in their internal structure. A segment may receive the harmonic prime $|\alpha|$ if it has an empty node $\mathbf{A}[_]$ ready to host it. The proposal advanced in Sandstedt (2018: 75) is that “asymmetries reflect a universal limitation on harmony processes; namely, harmonization is limited by harmony-recipient subsegmental feature specifications”. In other words, not all targets are equal. Some targets accept the prime from all possible triggers, some are picky, and accept it only in certain contexts.

Sandstedt's idea is that the internal structure of segments affects the way harmony applies. The number and position of full nodes involved in the specification of a segment are a factor in spreading of the harmonic prime, and may, if the conditions are met, halt harmony.

Targets that have a full node above the empty node that is supposed to receive the harmonic prime set stricter limits on which kind of vowel can donate the harmonic prime.

In a regular target the harmonic empty node is not dominated by any full node. In a picky target, the harmonic empty node is dominated by another full node, and thus accepts the harmonic primes only from triggers that contain that same full node. Parasitism, in Sandstedt's terms, can thus be derived from the SDA graph. Targets that contain a full node above the harmonic one that needs to be filled set stricter parameters on donors (i.e they are picky), targets that do not have a full node above the harmonic node that needs to be filled, will select any trigger as a donor.

Specifically, Sandstedt (2018: 77) argues that all VH are actually parasitic “insofar as harmony is limited by harmony-recipient broader-scope feature specifications” (Sandstedt 2018: 77). What we call parasitic harmony is a harmony in which targets with the empty harmonic node, say “ $\mathbf{A}[_]$ ”, plus some other full node above it set limits on prime-donors (i.e triggers). If a vowel has the empty node $\mathbf{A}[_]$ dominated by a full node $\mathbf{B}[\beta]$, this vowel will accept the harmonic prime $|\alpha|$ only from donors that share with it the full node $\mathbf{B}[\beta]$.

To see how this works, we first look at a toy example, then at an actual Bantu language analyzed by Sandstedt, and finally apply the mechanism to the three harmonic patterns of Eastern Lombard varieties.

VI.4.2.3.2. Canonical lowering in Bantu

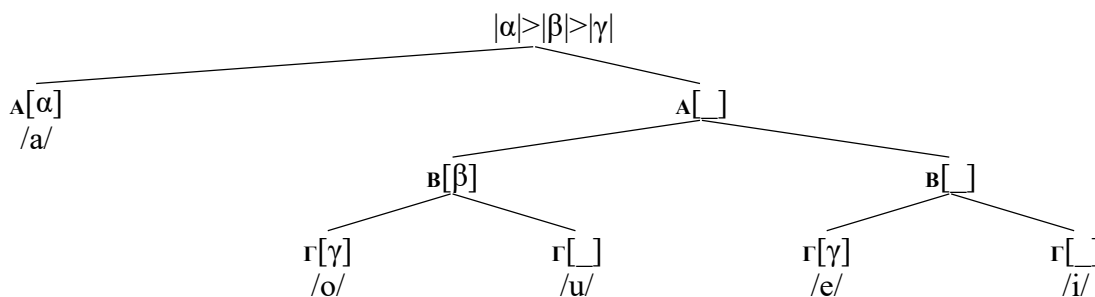
Consider the SDA graph under (44a), and assume that the prime $|\gamma|$ is harmonic in a progressive lowering harmony. Vowel harmony spreads $|\gamma|$ from segments with $\mathbf{r}[\gamma]$ to following segments with $\mathbf{r}[_]$. Both high vowels /i/ and /u/ have the empty node $\mathbf{r}[_]$, but they exhibit a different behavior. /i/, which has the empty node $\mathbf{r}[_]$ dominated only by empty nodes, will receive the harmonic prime from

all donors with the full node $r[\gamma]$. /u/, which has the empty node $r[_]$ dominated by a full node $B[_]$, will accept as donor only /o/, which has itself the full node $B[_]$ above the harmonic node $r[_]$.

(44a) reports the contrastive specification for the toy example, (44b) formalizes harmony of $|\gamma|$, and shows how /i/ behaves as a better recipient for $|\gamma|$ than /u/ does. /i/ accepts $|\gamma|$ from both /o/ and /e/, while /u/ accepts it only from /o/. The full $B[\beta]$ node above the harmonic empty node in /u/ checks whether the donor qualifies as valid, i.e. if they share the $B[\beta]$ prime. If they do (shown with ☺ in the table), the process applies, and $|\gamma|$ is free to spread to the empty node $r[_]$. If they do not (shown with ☹ in the table) the process does not apply.

(44) Formalizing parasitism: harmony is limited by the internal structure of segments

a. Toy grammar contrastive prime hierarchy



b. Harmony of $|\gamma|$ in Toy grammar: $r[_]$ receive $|\gamma|$ from preceding $r[\gamma]$ vowels

/u/ → [o]/o__		/i/ → [e]/o__	
/o/	/u/ → o	/o/	/i/ → e
A[]	A[]	A[]	A[]
B[β]	☺	B[β]	B[]
r[γ]	----->	r[γ]	----->
/u/ → [u]/e__		/i/ → [e]/e__	
/e/	/u/	/e/	/i/ → e
A[]	A[]	A[]	A[]
B[]	☹	B[]	B[]
r[γ]	-----◆	r[γ]	----->

$r[_]$ appears under both empty and full $B[\beta]$ nodes. The full node $B[\beta]$ influences the application of $|\gamma|$ spreading to $r[_]$. The segments with the empty $r[_]$ node search for the prime $|\gamma|$ from a valid trigger. Segments that contain no other prime than the one they would receive are non-selective harmony recipients. That is, the segment /i/, which is specified as $[B[_], r[_]]$ is the ideal target for harmony: it is a potential recipient of the harmonic prime $|\gamma|$ because it has an empty $r[_]$ node, and it does not contain any prime at all. Since its nodes are all empty, it can receive the harmonic prime $|\gamma|$

from both /e/:[**B**[],r[γ]] and /o/:[**B**[β],r[γ]]. On the other hand, the segment /u/, which is specified as [**B**[β],r[]] is picky, and only accepts the harmonic prime from donors that have the full node **B**[β]: this is the case of /o/ [**B**[β],r[γ]] , but not of /e/ [**B**[],r[γ]].

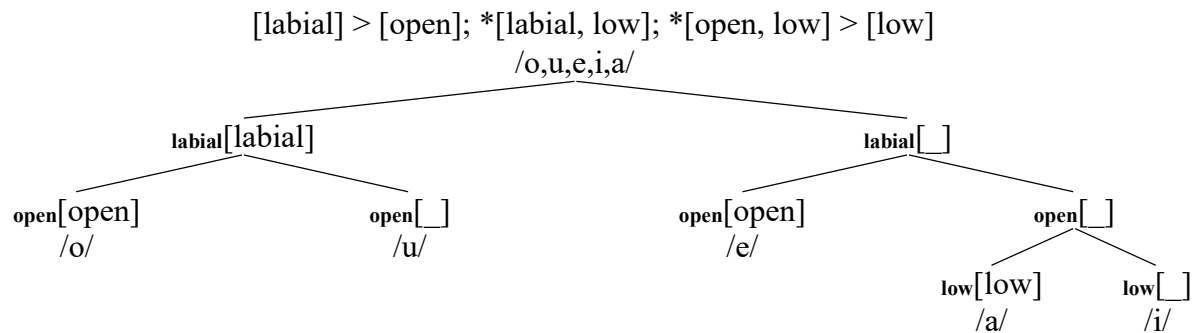
The contrastive hierarchy in (44a) is very similar to the one in (45) which is representative for canonical lowering harmony in Bantu languages with a five-vowel system (cf. §II.3.1.2). Sandstedt assumes the graph under (45) to be representative for numerous Bantu languages such as Chewa (N.31²³⁹). These languages display a lowering harmony triggered by mid vowels which targets high vowels. The harmony is parasitic on rounding, in that high rounded vowels undergo lowering only if preceded by rounded mid-vowels, but not if the trigger of harmony is a front unrounded /e/. In addition, /a/ may behave as a blocker, as in Chewa under (45).

(45) Chewa lowering harmony, parasitic on rounding

a. Height alternations in Chewa (Sandstedt 2018: 71)

/i/ alternates with [e] in the applicative suffix /-il/			
phík-il-a	'cook'	túm-il-a	'send'
tsék-el-a	'close'	gón-él-á	'sleep'
/u/ alternates with [o] in the reversive suffix /-ul/			
pítíks-ul-a	'overturn'	fúnth-ul-a	'loosen'
tsék-ul-a	'open'	wónj-ol-a	'spring a trap'
* tsék-ol-a			

b. Chewa contrastive feature hierarchy (Sandstedt 2018: 192)



Harmony spreads the prime [open] to open[] segments. /i/, which has the empty node open[] dominated only by empty nodes, accepts the harmonic prime from all valid triggers. /u/, on the contrary, is picky because has its open[] node dominated by the full node labial[labial]: it only accepts spreading from /o/. Finally, /a/ is prevented from participating in harmony by the micro-cue *[open,low].

The strategy employed by Sandstedt (2018) to account for asymmetric and parasitic harmonies imposes a strong limitation on the computational side of phonology, while it boosts the assumptions (and the role) of phonological representation. Computation involving harmony is limited to spreading

²³⁹ The abbreviations in brackets indicate the Guthrie codes proposed in Maho (2009), which individuate Bantu languages in the literature.

of a prime, and representation, made more complex with the introduction of the notion of nodes, indicates the contexts in which the process can take place.

VI.4.2.3.3. Eastern Lombard dialects

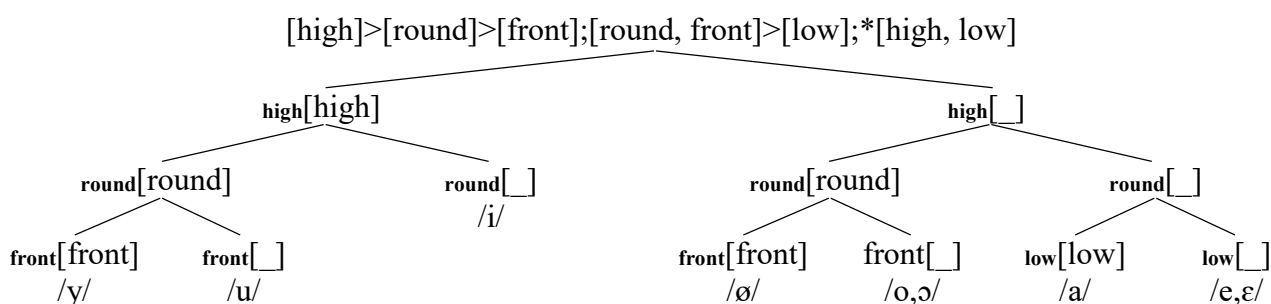
Recall that the three varieties of EL treated in chapter III, Bresciano, Bergamasco and Camuno, display the same surface vowel system, and they all exhibit raising harmony, with slightly different patterns, though. Bresciano has a symmetric harmony, with all mid vowels raising when followed by a high vowel. In Bergamasco VH is asymmetric, in that only rounded mid vowels are targeted by harmony. Camuno displays a parasitic pattern. Rounded vowels raise when followed by any high vowel, while non-rounded vowels /e,ε/ raise only if followed by /i/.

The present section shows how these three patterns may be analyzed in Sandstedt's system.

Let us start with Bresciano. Here, all vowels participate in VH except for /a/, which is a blocker. Here again, I borrow from Sandstedt (2018) the labels used to indicate primes and nodes, but recall that labelled primes are just placeholders for alphas and betas in RadSFP.

The SDA under (46) captures the behavior of vowels in Bresciano. The harmonic node sits high up in the graph, ensuring that no higher node interferes with it. Raising of /a/ is prevented by the co-occurrence restriction *[high, low], high vowels are specified for high[high] and mid vowels as high[].

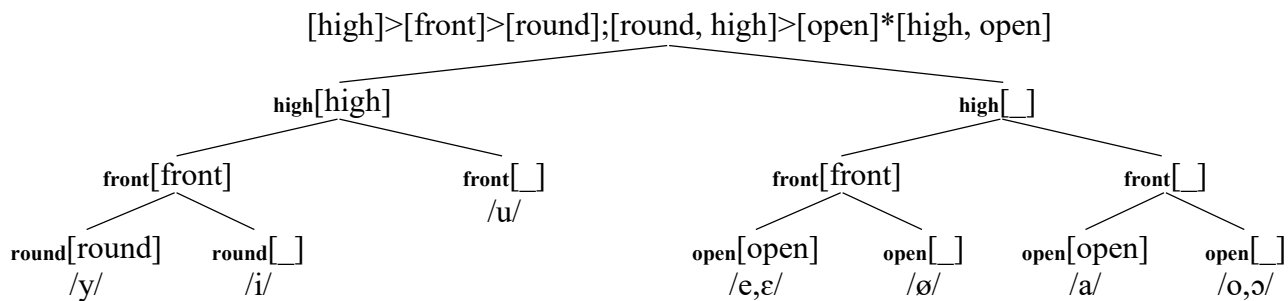
(46) Bresciano contrastive feature hierarchy following Sandstedt's (2018) model of prime learning



The harmonic prime [high] propagates from high to mid vowels without being halted, because no full node dominates the high[] node in any of the targets. The low vowel /a/ cannot receive the prime [high] due to the co-occurrence restriction *[high, low], and thus behaves as a blocker.

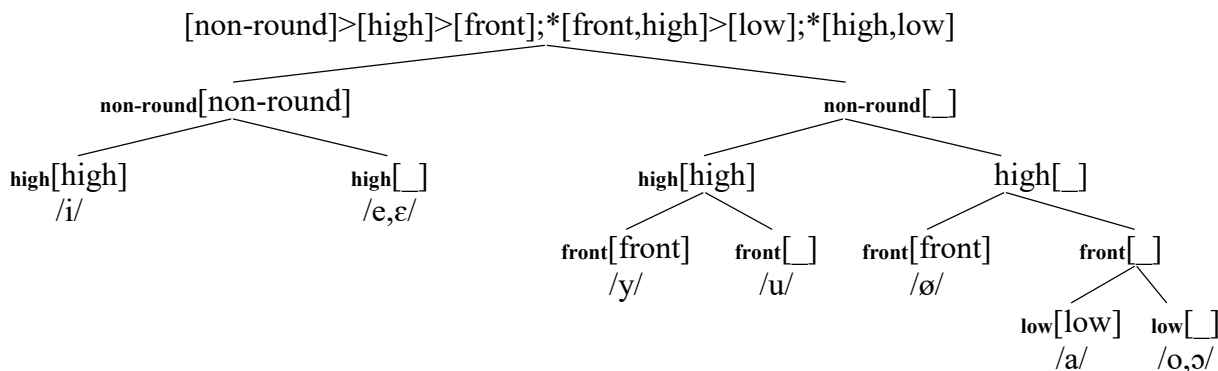
Let us now turn to Bergamasco. The SDA graph under (47) is designed to capture the behavior of vowels in this dialect. Here non-rounded vowels behave as blockers, and do not harmonize. Only rounded mid-vowels are valid targets for raising harmony. The graphs in (47) and (46) share the same kind of primes and similar co-occurrence restrictions. In the hierarchy under (47), the prime [front] is positioned higher than the prime [round]. Crucially, round mid-vowels are not specified as [round], but are empty. As structurally simpler segments, they are better recipients for [high] than other vowels. Non-rounded vowels and /a/ are prevented from harmonizing by the same co-occurrence restriction discussed above: *[high,open].

(47) Bergamasco contrastive feature hierarchy following Sandstedt's (2018) model of prime learning



Camuno exhibits parasitic raising. /e/ receives the harmonic prime [high] only from /i/, while rounded mid vowels receive it from all high vowels, regardless of their roundness. To capture the behavior of vowels in Camuno, the SDA graph must isolate front non-rounded vowels, and only then distinguish between high and non-high vowels. In sum, the SDA must use a prime such as [non-round], so that /e/ will behave as the picky recipient, as shown in the graph under (48).

(48) Camuno contrastive specification hierarchy following Sandstedt's (2018) model of prime learning



In sum, what changes between the three dialects is the behavior of /e/ as a recipient for the harmonic prime [high]. It is a valid target in Bresciano, a blocker in Bergamasco and a picky target in Camuno. Table (49) shows the varying behavior of /e/ in harmonic contexts in the three varieties.

(49a) shows that /e/ behaves as target for both /i/ and /u/ in Bresciano. (49b) exemplifies the behavior of /e/ as blocker in Bergamasco and (49c) its behavior of target and blocker in Camuno, depending on the vowel that propagates the [high] prime.

(49) Behavior of /e/ in different Eastern Lombard varieties

a. Harmony in Bresciano

/e/→[i]/ C _{0i}		/e/→[i]/ C _{0u}	
/e/→[i]	/i/	/e/→[i]	/u/
high[high]	high[high]	high[high]	high[high]
round[]	round[]	round[]	round[round]
low[]		low[]	front[]

b. Harmony in Bergamasco

/e/→[e]/ C _{0i}		/e/→[e]/ C _{0u}	
/e/	/i/	/e/	/u/
high[]	high[high]	high[]	high[]
front[front]	front[front]	front[front]	front[]
open[open]	round[round]	open[open]	

c. Harmony in Camuno

/e/→[i]/ C _{0i}		/e/→[e]/ C _{0u}	
/e/→[i]	/i/	/e/	/u/
n.round[nonround]	n.round[nonround]	n.round[nonround]	n.round[]
high[]	high[high]	high[]	high[high]
			front[]

VI.4.2.4 Conclusion

To sum up, the representational model of prime learning proposed in Sandstedt (2018), based on learned primes and the Contrastivist Hypothesis, is able to represent all kinds of asymmetries found in RVH. Not only asymmetries that limit the selection of triggers or targets, but also parasitic harmonies. In order to do so, Sandstedt (2018) sets up a complex theory of representations, one where primes come in hierarchically ordered nodes, instead of a simpler theory of melodic representation where only primes exist.

This model shares some assumptions with the one proposed in Dresher (2014). Contrast and alternations are relevant factors in prime learning. Primes are required to be contrastive (as per the Contrastivist Hypothesis). However, it develops the model proposed in Dresher (2014) adding some new properties:

- i. Primes are learned alongside co-occurrence restriction, requirements that force or impede the co-occurrence of primes in a segmental representation, without the influence of the SDA.
- ii. Nodes are introduced in the internal representation of segments. They reflect the hierarchy of the SDA and introduce ternary oppositions. Segments may have a full node, an empty node or no node at all. This reflects the behavior of vowels in harmonies, as shown in §4.2.2.
- iii. Prime learning and the assignation of primes to segments is composed by two operations. First micro-cues are learned, and then they are fed to the SDA, which produces complete segmental representations.

In order to account for parasitic harmonies, Sandstedt's (2018) model introduces the notion of nodes, and builds on the new idea that harmony reflects a universal limitation: the SDA hierarchy affects harmony in that nodes above the potential recipient of the harmonic prime impact spreading: if there are only empty nodes, spreading occurs without condition, but in case there are filled nodes dominating the potential recipient, only vowels that share the same filled nodes can spread the harmonic prime.

Recall from §4.1.4 that the model of prime learning that assumes the Contrastivist Hypothesis without additional mechanisms is unable to account for parasitic harmonies. Sandstedt's model is thus one candidate for amending this situation.

VI.5 The alternative view: alternations, not contrast, are the main factors of prime learning

VI.5.1 Odden (2022): processing over contrast

Odden (2022) offers an explicit account of how a substance-free phonology with no UG-endowed feature set or phonetic correlations could work. Differently from the models developed in Drescher (2014) and Sandstedt (2018), where contrast and alternations are equally relevant sources of information regarding prime emergence, the main factor of prime-learning for Odden (2022) is phonological processing.

Learners know how two representations may correlate (cf. §3) which means that they are endowed with knowledge about phonological computation. By observing alternations in the language they perceive, they form hypotheses on the prime-based representation of the segments without recurring to knowledge referring to phonetic substance. Primes are assigned to segments such that the set of primes used by rules is as simple as possible, and the set of primes is minimal. In Odden (2022), alternations (i.e. computation) inform feature acquisition first, while contrast may become relevant only when all active features are in place. He obtains a system in which all active features (features that may appear in a rule) emerge first, while purely contrastive features (non-active features that serve only the purpose of distinguishing different segments) emerge if needed at a later stage²⁴⁰ (Odden 2022: 41).

Odden does not pose any contrastive limitation on emergence of primes. In other terms, he proposes a less restrictive theory of learning, one where both contrastive and non-contrastive primes may co-exist: he does not subscribe to the Contrastivist Hypothesis. A non-contrastive prime is a prime that is not necessarily needed to account for the differentiation between segments. While the objective is to have a minimal set of primes, computation may require more primes than those that are necessary to ensure

²⁴⁰ Recall, however, that by the assumptions introduced in §V.4.1 children have at their disposal the set of distinctive sounds of their language, i.e. they know the phones of their language. Only on the basis of this knowledge they can perceive alternations, that they use as clues for learning primes.

contrast between segments. In Odden’s account of prime learning, then, primes are tailor-made for the rule they take part in (they primarily individuate active classes), their contrastive role matters less.

The issue regarding the Contrastivist Hypothesis set aside, the ingredients of prime learning are the same in Odden's and Drescher's / Sandstedt's approach: processing and contrast. The difference lies in the primacy in the acquisitional road given to either: while contrast is primary in Drescher’s and Sandstedt’s models, computation has a logical precedence over contrast for Odden. First alternations inform the learner about active features and then, if needed, contrast kicks in and ensures that all segments are distinguished. That the two systems are not incompatible has been argued for in Chabot (2021: 227).

The basic mechanism of prime learning proposed in Odden (2022) is summarized as this: “when a class of segments functions together, that is because they have a shared grammatical property. The task of feature acquisition is finding the simplest system of properties that accounts for those cases of grammatical functioning-together that can be observed in the primary linguistic data.” (Odden 2022: 22).

Odden (2022: 6) does not present (nor considers this to be necessary) a fully-fledged theory of phonological computation. He assumes that processes are the result of phonological rules (but also argues that his argument for prime learning may work also assuming constraints, as in Blaho 2008), and assumes that a rule is limited to the insertion or deletion of a single dominance relation or node in an autosegmental representation. That is, a rule can insert or delete an association line, or a segment, feature, or other phonological constituent.

The theory of computation sketched in §3 imposes stricter parameters on how a rule may be formalized. Primes may spread from one segment to another (which corresponds to an association line being added to the representation), or primes may be suppressed. The only specific difference concerns the possibility of adding primes ex nihilo, which is an operation that is not explicitly ruled out in Odden’s article.

A good half of the article that presents the theory of prime emergence proposed by Odden (2022) demonstrates how prime learning works in the Bantu language Kerewe (JE.24). By observing phonological alternations, learners posit primes that correspond to active phonological classes and arrive at a minimal specification based on unary primes for all the segment of Kerewe. In this particular case, processing furnishes enough information to specify most of the system of Kerewe.

The case of Kerewe serves as an example on how learners may assign to each segment of their language a single prime specification starting from alternations active in the language. Together with the Revised Card Argument, the example of Kerewe serves as a proof of concept for Odden's (2022) learning mechanism. Primes can be learned (contra the Card Argument) and alternations alone may inform prime learning such that the result covers all contrasts and processes of the language. Odden does not contend, though, that contrast never plays a role in prime learning. It kicks in when evidence from processing is not sufficient to represent all distinctions.

Instead of presenting the whole system of Kerewe, I will report the mechanism of prime learning proposed in Odden using the toy grammar he presents in (Odden 2022: 20), summarized under (50).

(50) Toy grammar proposed in Odden (2022: 20)

a. Sounds of the toy language

/p t k m n ŋ i a u/

b. Alternations perceived by learners

1) stops nasalize when followed by nasal consonants	$p \rightarrow m / _ m$	$t \rightarrow n / _ m$	$k \rightarrow \eta / _ m$
	$p \rightarrow m / _ n$	$t \rightarrow n / _ n$	$k \rightarrow \eta / _ n$
	$p \rightarrow m / _ \eta$	$t \rightarrow n / _ \eta$	$k \rightarrow \eta / _ \eta$
2) /i/ surfaces as [u] when preceded by {p, k, m, η}	$i \rightarrow u / p _ _$		
	$i \rightarrow u / k _ _$		
	$i \rightarrow u / m _ _$		
	$i \rightarrow u / \eta _ _$		
3) /i/ surfaces as [a] when followed by {k, η}	$i \rightarrow a / _ k$		
	$i \rightarrow a / _ \eta$		

In response to the set of alternations under (50b), learners would posit a prime $|\alpha|$, which identifies stops, and a prime $|\beta|$ which identifies nasals. /i/ rounding suggests that /u/ shares with the set of triggers a prime $|\gamma|$, and /i/ lowering to [a] suggests that /a/ shares a prime $|\delta|$ with /k/ and /η/. /i/ thus receives a specification $|\pi|$ that allows for the rules to go into effect, such as $\pi \rightarrow \delta / \delta$ or $\pi \rightarrow \gamma / \gamma$. The whole phonological system thus receives the specifications under (51).

(51) Prime specification given the alternations of the toy-language

/p/	/t/	/k/	/m/	/n/	/η/	/a/	/u/	/i/
α	α	α	β	β	β			
γ		γ	γ		γ		γ	
		δ			δ	δ		
								π

As was mentioned in §3.4, the theory of computation employed may radically change the outcome of prime learning. Odden (2022), in his toy example, considers each alternation under (50) as a case of substitution of primes: phonological computation turns one prime into another. Given this theory of computation, learners would build the system under (51).

Using the more restrictive theory of computation proposed above, the various processes reported under (50) do not take the form of substitutions, but rather are analyzed as additions. If this is the case, then stops and nasals share a prime $|\alpha|$, and nasals share a prime $|\beta|$. The first rule adds $|\beta|$ to $|\alpha|$ in the context $_|\beta|$, which makes it so oral stops become nasals. This is shown in (52a)

The second process, exemplified in (52b) rounds /i/, identified as $|\pi|$ when it follows /p,k,m,η/. Those four consonants have a prime $|\gamma|$ in common, and if the process formalizes as addition, /u/ also contains the same prime $|\gamma|$. The third process is triggered by /k, η/, which share a prime $|\delta|$. This primes added to /i/ results in /a/, as shown in (52c).

Those notions are enough to assign a full prime specification to the segments of the toy language. Under (52) each process and the information it gives to prime emergence is exemplified.

(52) Prime specification given the alternations of the toy-language

a. stops nasalize when followed by nasal consonants

$p \rightarrow m/ _ m$			$t \rightarrow n/ _ m$			$k \rightarrow \eta/ _ m$		
$p \rightarrow m/ _ n$			$t \rightarrow n/ _ n$			$k \rightarrow \eta/ _ n$		
$p \rightarrow m/ _ \eta$			$t \rightarrow n/ _ \eta$			$k \rightarrow \eta/ _ \eta$		
$\alpha \rightarrow (\alpha + \beta) / _ \beta$								
/p/	/t/	/k/	/m/	/n/	/η/	/a/	/u/	/i/
α	α	α	α β	α β	α β			

b. /i/ surfaces as [u] when preceded by {p, k, m, η}

$i \rightarrow u/ p _ _$								
$i \rightarrow u/ k _ _$								
$i \rightarrow u/ m _ _$								
$i \rightarrow u/ \eta _ _$								
$\pi \rightarrow (\pi + \gamma) / \gamma _ _$								
/p/	/t/	/k/	/m/	/n/	/η/	/a/	/u/	/i/
α	α	α	α β	α β	α β			
γ		γ	γ		γ		γ π	π

c. /i/ surfaces as [a] when followed by {k, η}

$i \rightarrow a/ _ k$								
$i \rightarrow a/ _ \eta$								
/p/	/t/	/k/	/m/	/n/	/η/	/a/	/u/	/i/
α	α	α	α β	α β	α β			
γ		γ δ	γ		γ δ	δ π	γ π	π

The final table in (52c) assigns a greater number of primes to some segments, if compared to the table in (51). Notice that all vowels share the prime $|\pi|$, and that nasals and stops share the prime $|\alpha|$, while in (50) $|\pi|$ specifies only /i/, and $|\alpha|$ only stops.

As discussed in §3.4, the assumptions made regarding phonological computation greatly affect the outcome of prime learning. The theory of computation presented in this chapter assumes as basic operations only addition and subtraction of primes, and considers the operation “substitute” to be composed of two operations, addition and subtraction. In sum, the theory of computation presented in §3 uses a smaller number of operations (addition and subtraction vs. addition, subtraction, substitution), but ends up with a more complex structure of prime-informed representations. Here as elsewhere in phonology and linguistics, there is a trade-off between computation and representation: the labour not done on one side will appear on the other side.

In the pages that follow, I assume the theory of computation defended in §3. Primes or association lines are added or subtracted, and substitution (if necessary) is a two-step operation involving addition and subtraction.

VI.5.2 Learning harmony: symmetric, asymmetric and parasitic patterns in EL dialects

Let us now see how Odden's (2022) model of prime learning fares in Eastern Lombard varieties. We have seen in how the theories of prime emergence that subscribe to the CH manage to account for the three varieties, now let us see how Odden's (2022) system accounts for the three systems.

VI.5.2.1. Vowel reduction common to the three dialects

Recall that Bresciano, Bergamasco and Camuno share virtually the same sound system, especially in what concerns vowels, and in all three varieties is active a process of vowel reduction that turns mid-low vowels into mid-high vowels and a process of raising harmony. The main difference between the three varieties is in the behavior of vowels in raising harmony. Recall that Bresciano displays a symmetric harmony, Bergamasco an asymmetric one (where /e/ never raises) and Camuno a parasitic one, where /e/ raises only if followed by non-rounded high vowels.

The assumption made in Odden (2022) is that children exposed to different phonological processes will assign a different prime specification to the same set of segments. In EL dialects there are two active alternation patterns. The first one applies in the same way to all EL varieties, and turns stressed mid-low vowels into mid-high in unstressed position. It is therefore a positional process, which is formalized as the suppression of a prime from mid-low vowels when they appear in unstressed position. From this alternation, learners assign a prime to mid-low vowels (alpha under 53b) which is lost when passing from stressed to unstressed position. This property is common to all three EL varieties, so they all pose the same prime specification for mid-low vowels, as shown in (53).

(53) Prime specification in EL varieties

a. Alternations caused by vowel reduction

$\varepsilon \rightarrow e$ /Unstressed		$\varrho \rightarrow o$ /Unstressed	
[sɛk]	'dry'	['ɔrp]	'blind'
[se'kat]	'dried'	[orba'ti]	'blind DIM'

b. Prime specification in EL dialects

/a/	/e/	/ɛ/ α	/o/	/ɔ/ α	/ø/	/i/	/u/	/y/
-----	-----	----------	-----	----------	-----	-----	-----	-----

Besides the fact that mid-low vowels share a prime, learners gain knowledge of the fact that the result of vowel reduction corresponds to that of mid-high vowels. Therefore, any prime assigned to mid-high vowels would also be automatically assigned to mid-low vowels.

VI.5.2.2. Symmetric harmony in Bresciano

The different alternations caused by harmony give rise to three different learning paths in the three languages. Let us start by considering Bresciano. A child exposed to Bresciano, where the process is symmetric, will consider mid vowels /e, o, ε, ρ, ø/ as a natural class of vowels that undergoes raising.

VH suggests the emergence of a prime $|\beta|$ common to all these vowels, which identifies the set of targets. On the other hand, /i/, /u/ and /y/ are part of the active class of vowels that raises mid vowels. They too will thus receive a common prime, $|\gamma|$. Since raising is iterative, learners will assume that harmony spreads a prime from triggers to targets. In addition, learners would notice the relation between pairs of triggers and targets. Raised /e/ and lexical /i/ share the same phonetic interpretation and are thus led to assume that they also share the same phonological representation. The same can be said about raised /o/ and /u/ as well as raised /ø/ and /y/. High vowels would thus be assumed to be akin to mid-vowels plus an additional prime $|\gamma|$. Under (54) are schematized the primes assigned to each vowel that participates in Bresciano symmetric harmony. All mid vowels receive the prime $|\beta|$. High vowels receive the prime $|\gamma|$, and also the prime $|\beta|$, which reflects the fact that raised mid vowels correspond to high vowels.

(54) Prime specification in Bresciano: harmonic alternations inform prime learning

a. Alternations caused by vowel harmony

e,ε→i/ Coi,u,y		o,ɔ→u/ Coi,u,y		ø→y/ Coi,u,y	
[tʃeza]	'church'	[tʃot]	'nail'	[ʃøndʒa]	'fingernail'
[tʃi'zina]	'church'	[tʃu'di]	'nail DIM'	[ʃyn'dʒina]	'fingernailDIM'
[tʃi'zuna]	'church'	[tʃu'du]	'nail'	[ʃyn'dʒuna]	'fingernailAUG'

b. Prime specification

/a/	/e/	/ε/	/o/	/ɔ/	/ø/	/i/	/u/	/y/
	β	α β	β	α β	β	β γ	β γ	β γ

Bresciano does not have active processes that concern vowels besides vowel reduction and vowel harmony. Given that the processing-based evidence does not distinguish all contrastive vowels, contrast is used for additional prime specification, to ensure that all vowels are contrastively specified. Knowledge about alternations already established relations between trigger and targets, so children may assume that /ø, y/ might share a prime, as well as /o, ɔ, u/. Two contrastive (but inert) primes are added. $|\delta|$ is shared by back rounded vowels, $|\pi|$ by front rounded vowels²⁴¹. Consider the finalized system under (55).

²⁴¹ I am leaving aside the behavior of raised front rounded vowels, which often raise to [u] and not to [y]. Recall from §.III.7.7 that this process appears to have some ties with morphology, a topic that is covered in §.7. I assume that if this fact is due to phonology, the representation of vowels may vary. All rounded vowels (both front and back) may share the prime $|\delta|$, and front rounded vowels may have the additional prime $|\pi|$. /ø/ raising to [u] may suggest that, besides raising, another process applies that removes the prime $|\pi|$ from raised /ø/, which surfaces as [u].

(55) Complete prime specification in Bresciano

/a/	/e/	/ɛ/	/o/	/ɔ/	/ø/	/i/	/u/	/y/
	β	α β	β	α β	β	β γ	β γ δ	β γ
			δ	δ	π			π

/a/, which does not participate in any alternation, does not receive any specification (nothing prevents an empty prime specification to be transduced²⁴²). Thus, all vowels of Bresciano have a contrastive prime-based specification, and the alternations perceived are accounted for formally.

VI.5.2.3. *Asymmetric harmony in Bergamasco*

Now consider Bergamasco. A child exposed to Bergamasco treats the vowels /o, ɔ, ø/ as part of the natural class of vowels which undergoes raising (and which contain the prime β). Non-rounded mid vowels /e, ɛ/ are not considered part of this class because they do not undergo raising, and receive thus a specification based on different primes. The set of triggers (i.e. high vowels) is identified by the prime |γ|, which spreads to vowels with |β|. The table in (56) shows the prime specification of vowels in Bergamasco, once the alternations caused by VH are considered. Purely contrastive (and thus inactive) primes, such as |δ| and |π| are added, so that all vowels are contrastively specified. Notice that in this case the purely contrastive prime |δ| is added to non-rounded vowels, since they do not participate in the harmonic process. The same prime is added to /i/, even though speakers of Bergamasco have no phonological clue that /e, ɛ/ and /i/ should be related, as speakers of Bresciano do. However, high vowels still require a specification, and using the same prime |δ| is formally equal to add a different contrastive prime to /i/, with the advantage that the system does not have to posit another prime.

(56) Prime specification in Bergamasco. Harmonic alternations inform prime learning

a. *Alternations caused by vowel harmony*

o,ɔ,ø→u,y/ __Coi,u,y		e,ɛ→e,ɛ/ __Coi,u,y	
['godʒa]	'needle'	[poledɛr]	'foal'
[gu'dʒi]	'needle DIM'	[pole'dri]	'foal DIM'
[øtʃ]	'eye'	[me 'lese]	'I read'
[y'dʒi]	'eye DIM'	[le'sit]	'read'

²⁴² Empty segments are allowed to be transduced. In ET, for example, an empty nucleus correlates with [ɨ] (Bacley 2011: 31).

b. Prime specification in Bergamasco

/a/	/e/	/ε/	/o/	/ɔ/	/ø/	/i/	/u/	/y/
		α	β	α β	β	β γ δ	β γ	β γ
	δ	δ			π			π

VI.5.2.4 Parasitic harmony in Camuno

A child exposed to Camuno perceives two different VH patterns. The first raises rounded vowels /o, ɔ, ø/ (identified by the emergent prime β) and is triggered by all high vowels /i/, /y/, and /u/, identified by the prime |γ|. The second process raises non-rounded vowels to high. The targets of this process are specified by the prime |δ| and the trigger, only /i/, by the prime |π|.

In Camuno, therefore, the speaker assumes the presence of two processes: there are two classes of triggers (γ and π) and two classes of targets, β and δ. Camuno does not have the same rule twice, but two different harmonic rules, which involve two different harmonic primes. The fact that both processes surface as involving raising is irrelevant. This issue was discussed in §4.1.4, while discussing the model proposed by Dresher (2014), and is briefly summarized here for convenience.

Given the alternations caused by raising harmony, children learning Camuno are led to suppose the existence of two different processes of vowel raising, one that targets rounded mid vowels and the other that targets non-rounded mid vowels. Normally, a process affects a class of targets and is caused by a single class of triggers and affects a single class of targets, but in Camuno there are two classes of targets and two classes of triggers, if we look strictly at their phonological behavior. High vowels behave as a class of triggers for a process affecting rounded mid-vowels, which surface as high. This individuates a class of targets (mid-rounded vowels) and a class of triggers (high vowels). /i/ (and only /i/) behaves as trigger for raising of non-rounded vowels. This alternation suggests to learners the presence of a second class of vowels: one which is formed by only one segment, /i/, the other composed by those vowels that raise only if followed by /i/, i.e. non-rounded /e, ε/. Raising of rounded vowels and raising of non-rounded vowels apply in different melodic contexts. Rounded vowels raise when followed by any stressed high vowel, non-rounded vowels raise only if followed by stressed /i/. Learners of Camuno would thus posit the prime-specifications under (57) for the vowels in their language. As before, learners realize that mid-vowels raising results in vowels that have the same phonetic interpretation as high vowels. They thus assume that /i, e, ε/ all share a prime |δ|, while front rounded vowels /ø, y/ share the prime |μ|.

(57) Prime specification in Camuno. Harmonic alternations inform prime learning

a. Alternations caused by vowel harmony

/e, ε/ → [i]/ __ C ₀ i		o, ɔ, ø → u, y/ __ C ₀ i, u, y	
['det]	'tooth'	['tʃot]	'nail'
[din'ti]	'toothDIM'	[tʃu'di]	'nail DIM'
[den'tu]	'toothAUG'	[tʃu'du]	'nail AUG'

b. Prime specification

/a/	/e/	/ε/	/o/	/ɔ/	/ø/	/i/	/u/	/y/
		α	β	α β	β		β	β
	δ	δ			μ	γ δ π	γ	γ μ

The table in (57b) is not yet complete. The behavior of vowels in Camuno has some additional information available to learners: the process is iterative, and the outcome of /e/ raising behaves as a valid trigger for preceding rounded vowels. Consider the examples reported in (58). The outcome of /e/ raising acts as a trigger for all preceding mid vowels, and not only for preceding non-rounded vowels.

(58) Iterative raising in Camuno

Base form	Diminutive	Augmentative	
[ˈpɛtɛn]	[ˈpitiˈni]	[ˈpeteˈnu]	‘comb’
[ponˈdɔr]	[ˈpunduˈri]	[ˈpunduˈru]	‘tomato’
[ˈbigaˈrøɫ]	[ˈbigaruˈli]	[ˈbigaruˈlu]	‘apron’
[ˈlɛnˈhøɫ]	[ˈlɛnhyˈli/lɛnɦuˈli]	[ˈlɛnɦuˈlu]	‘sheet’
[ˈhɔrɛk]	[ˈɦurigi]	[ˈhɔregu]	‘mouse’

The iterative nature of harmony ensures that the process is analyzed as spreading of melodic material. The harmonic processes should thus be formalized as under (59).

(59) Formalization of raising processes in Camuno

a. Raising of rounded vowels:

$$\beta \rightarrow (\beta + \gamma) / _ _ C_0 \gamma$$

b. Raising of non-rounded vowels:

$$\delta \rightarrow (\delta + \pi) / _ _ C_0 \pi$$

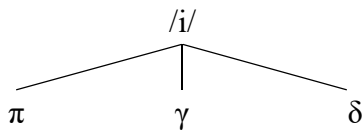
The formalizations under (59) does not completely capture the iterative behavior of harmony. What is relevant is that raised /e/, which under this assumption would receive the harmonic prime $|\pi|$ from the trigger /i/, behaves as a trigger for preceding rounded vowels, suggesting that it also receives the prime $|\gamma|$. That is, the process that raises /e/ operates on two primes at the same time.

This can be formalized only using the representational items introduced in section §2: primes and association lines.

Up until now, segments have been treated as amorphous bundles of primes. It is possible that segments have an internal structure. Assuming that segments are structures, phonological primes can be either unordered (as in the example in 60a) or in a dependency relation, as in (60b). The process at hand can be analyzed by putting the two harmonic primes, $|\pi|$ and $|\gamma|$, in a dependency relation within the segment /i/. The prime $|\pi|$ dominates the prime $|\gamma|$.

(60) Internal structure of /i/

a. /i/ where primes are not related



b. /i/ where primes are hierarchically related



Given (60b), the process of raising can be formalized as spreading, both when it involves raising of rounded vowels and when it involves raising of non-rounded vowels. Consider the examples under (61), where the trigger /i/ raises a preceding /e/, which in turn becomes a valid trigger for the raising of /o/. Spreading of primes is shown by a dotted association line. Raising is shown by adding the harmonic primes (in gray in the table) to targets that undergo the process. In (61c) the non-rounded vowel /e/ receives the prime $|\pi|$ from the trigger /i/, due to the rule in (61b). Alongside $|\pi|$, raised /e/ receives also the prime $|\gamma|$ because the dependency relation between $|\pi|$ and $|\gamma|$ entails that once $|\pi|$ spreads, also $|\gamma|$ does so. As a consequence, raised /e/ is a valid trigger for the rule in (61a), which raises rounded vowels when they are followed by a segment with $|\gamma|$.

(61) Formalization of the iterative parasitic harmony of Camuno

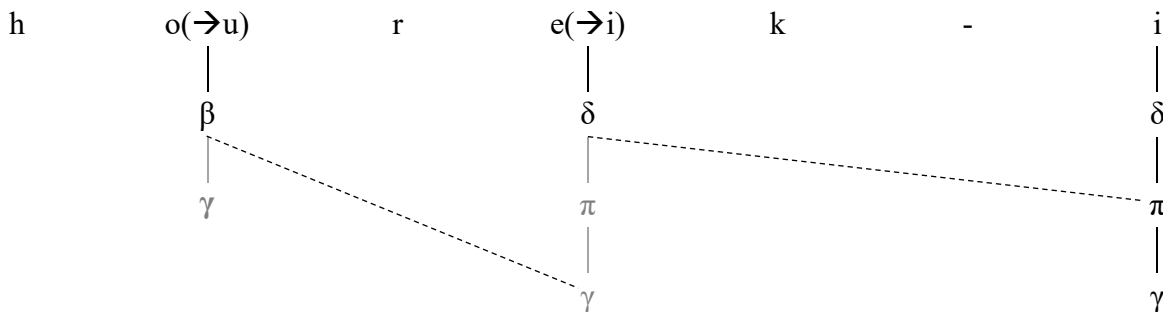
a. Raising of rounded vowels:

$$\beta \rightarrow (\beta + \gamma) / _ _ C_0 \gamma$$

b. Raising of non-rounded vowels:

$$\delta \rightarrow (\delta + \pi) / _ _ C_0 \pi$$

c. Iterative harmony. Spreading of $|\pi|$ entails spreading of $|\gamma|$.



It is the behavior of vowels in the language that informs learners about the relation between primes: that $|\gamma|$ is hierarchically ordered below $|\pi|$ in /i/ formalizes the relation between the two primes, and the fact that spreading of $|\pi|$ entails spreading of $|\gamma|$. That $|\pi|$ and $|\gamma|$ are hierarchically ordered does not follow from any general assumption, but is assumed by learners who perceive the pattern of alternation of Camuno. The representation of vowels of Camuno, then, corresponds to the one under (62). The primes assigned to each prime correspond to the ones already shown in (57), but now primes are structured

within a geometry. When processing does not inform about dependency relations between primes, I assume that they are unordered.

(62) Prime specification in Camuno: harmonic alternations inform prime learning

/a/	/e/ δ	/ε/ / α δ	/o/ β	/ɔ/ / β α	/ø/ / β μ	/i/ δ π γ	/u/ β γ	/y/ / β μ γ
-----	---------------	--------------	---------------	--------------	--------------	-----------------------------------	-------------------------	------------------------

The complete specification of vowels is thus derived. Interestingly, the internal structure of segments for Camuno derived in the present section based on processing share some similarities with the one resulting from the application of Sandstedt’s approach. In both cases primes are structured in a hierarchical relation. The difference is that the application of Odden’s model derives the relations between primes directly from the observation of alternations, and does not require the SDA and the addition of the representational item ‘node’.

Another key difference is that this model does not assign a special status to parasitism. In the two processes under (60), the relation between the harmonic primes are learned only on the basis of the alternation, without assuming that they are caused by the same trigger. The model proposed in Sandstedt (2018) instead considers parasitism the consequence of a specific property of phonological computation: the contrastive hierarchy derived from the application of the SDA affects the way primes spread.

Lastly, notice that the prime $|\pi|$, which is a key component in the analysis of parasitic raising, does not have a contrastive role. In other words, it is not necessary to distinguish $/i/$ from the rest of the vowels of the system. If $/i/$ were composed only by $|\delta\gamma|$, it would still be distinguished from all the other vowels of the system. Processing informs us about the fact that $/i/$ contains both $|\pi|$ and $|\gamma|$. However, as demonstrated in §4.1.4, they cannot both have a contrastive role for $/i/$.

Recall that the corollary to the Contrastivist Hypothesis says that all active vowels must be contrastive. Camuno, however, requires the positing of primes that are active but not contrastive, such as $|\pi|$. This case falsifies the Contrastivist Hypothesis and its corollary: the parasitic harmony of Camuno requires an active but non-contrastive prime to be analyzed.

VI.5.3 Comparing the two models: is there a phonetic explanation for parasitism?

Sandstedt's model discussed in §4.2 interprets parasitism as a consequence of the contrastive hierarchy, formalized in the SDA graph. That is, parasitism derives from the position of the harmonic prime in the SDA graph: the presence of a full node above the empty node that needs to be filled may halt harmony. The analysis proposed in §5.2 based on Odden (2022), instead, grants no specific status to parasitism: given a parasitic harmony, learners simply assign primes according to the alternations perceived. In §V.2.4 it was argued that the goal of phonology should be to explain how humans compute the sound patterns of languages, and not why a specific phonological process applies the way it does. The answers to this kind of questions are to be sought in phonetics and in the diachronic development of phonological patterns. Simply put, phonology does not have to explain how parasitic

harmonies develop. If there is a phonetic reason for parasitism (that is, if there are phonetic tendencies that lead to the possible emergence of this pattern) there is no need to assume that there is a universal requirement to account for parasitic harmonies.

As it turns out, there is some evidence that parasitism may derive from the phonetic properties of vowels involved in harmony. Kaun (2004) discusses the typology of rounding harmonies cross-linguistically. As discussed in §1.5.4.1.1, labial harmonies often display asymmetries, including parasitic patterns. Kaun (2004) provides an explanation for asymmetries in labial harmonies based around the articulatory and perceptive nature of harmony²⁴³.

Among other properties, Kaun (2004: 2) notices that cross-height rounding is typologically rare: rounding harmony applies more commonly between vowels of the same height. She provides an explanation for this fact based on the articulatory properties of rounded vowels. High rounded vowels are cross-linguistically and systematically more rounded than vowels of other height. The articulatory factors that identify round vowels (small horizontal opening, small vertical opening and lip protrusion, cf. Linker 1982: 102) are more prominent in high vowels than in non-high vowels.

Cross-height rounding is avoided because of a general principle that Kaun (2004: 11) labels Gestural Uniformity: “A harmony span including vowels mismatched for height would necessarily involve re-adjustments in lip aperture and lip width. The avoidance of cross-height harmony can thus be construed as the avoidance of this kind of articulatory re-adjustments”. In simpler terms, harmonizations that involve too many articulatory re-adjustments are dispreferred.

Cresci (2014: 157; 2015: 70) argues that the same principle may explain parasitism in Camuno raising harmony. High rounded vowels fail to raise preceding non-rounded mid vowels because “in a harmony span including vowels mismatched for rounding this would imply an articulatory cost in terms of a re-adjustment in lip rounding, aperture and width” (Cresci 2015: 70). The distance between /u/ and /e/ is so pronounced that a harmonization between the two vowels is too costly in terms of articulatory re-adjustments. The co-articulation between /u/ and /e/, then, is not grammaticalized as harmony, while co-articulation between /u/ and /o/ is. One may ask why Camuno did not develop the opposite kind of parasitism, i.e. why /i/ is able to raise preceding /o/. This follows from the difference in roundness of high and non-high rounded vowels. High rounded vowels are more rounded than non-high vowels (Linker 1982). The articulatory distance between /i/ and /o/, then, is not as great as the one between /e/ and /u/, thus the height co-articulation between /i/ and /o/ is grammaticalized as harmony.

Interestingly, all cases of partial parasitism that I am aware of involve the lack of harmonization between non-rounded mid vowels and back rounded high vowels. We see that in labial harmonies of the Turkic family, as well as in Bantu lowering harmonies, which frequently exhibit parasitism. In that case, it is /u/ that does not lower unless the trigger is rounded. /o/ can lower all high vowels (both /i/ and /u/), while /e/ can only lower /i/.

Partial parasitism may therefore have an articulatory reason to emerge. Co-articulation between vowels that are too different may require too many adjustments and thus fail to grammaticalize. The parasitic patterns discussed here may thus have a plausible phonetic origin, in which case there is no

²⁴³ After having identified the phonetic factors to be discussed, Kaun (2004: 15) imports them into phonology in the guise of OT-style constraints. In a SFP theory, the phonetic explanation for a phonological process is enough. If parasitism and asymmetries have a phonetic origin, it means that speakers grammaticalized an asymmetric harmony. As discussed in §V.2.4, phonology should not care about why a process behaves the way it does, but should care about the tools necessary to formalize the patterns encountered.

necessity to seek a phonological reason for parasitism, as Sandstedt does. Once again, phonology may not explain why a process behaves the way it does, it simply needs to be equipped with the tools to formalize it.

The formalization of parasitic raising obtained following Odden's model of prime emergence is, in my opinion, a simpler one when compared to the one based on Sandstedt (2018) discussed in §4.2.3. The assumptions of the former are the following:

- Primes emerge from perceived alternations
- Rules may add or subtract primes already present in the representation of triggers and targets
- Perceived alternations inform speakers about the internal structure of segments (i.e if dependency relations are needed)

In this analysis there is no need to refer to additional assumptions regarding representation or computation to account for parasitism. The same assumptions are necessary for the analysis based on Sandstedt's (2018) model. In addition, this analysis requires the assumption that phonological primes are hosted in nodes, though, and that a universal limitation halts harmony in specific contexts: targets with a specific structure are picky.

On this basis, I argue that the prime-learning theory presented in Odden (2022), which considers phonological alternations the main factor, is a better choice. It manages to formalize asymmetries and parasitic harmonies, and is more in line with the SFP line of research: phonological processes do not require a phonological explanation. The reasons for the properties of patterns lie outside of phonology. If there is reason to believe that parasitic harmonies appear for phonetic reasons, it is unnecessary to insert in our phonological theory a reason for why parasitism appears in harmonic patterns.

A central difference between the two analyses that makes the one based on Sandstedt (2018) particularly tempting is the fact that it manages to represent parasitic harmonies with a single rule, one that spreads the [high] prime, rather than having to resort to two rules, as is the case of the Odden-based analysis in §5.2. The Sandstedt-based analysis is thus more complex on the representational side than the Odden-based approach, since it employs an additional phonological item, the node, but it reduces the number of rules necessary to describe a parasitic harmony.

The following section considers another issue that may be able to tell which theory of prime learning better suits the analysis of raising harmony: scalar vs. complete raising (cf. §IV.2.1).

VI. 6 Scalar and complete raising

Raising may apply in different ways in different varieties. Most raising patterns apply in scalar fashion, with mid-low vowels raising to mid-high and mid-high vowels raising to high. Some raising harmonies display complete raising, with both mid-low vowels and mid-high vowels raising to high.

Consider the alternations caused by metaphony in Servigliano (cf. §II.3.3.3.1 Nibert 1998, Camilli 1929). Here stressed mid-high vowels raise to high when followed by a high vowel in final position, and stressed mid-low vowels raise to mid-high. In sum, Servigliano metaphony behaves as a scalar raising harmony. In addition, post-tonic unstressed vowels participate in a vowel copy harmony (cf. §I.3.2.5): they take on the complete prime specification of the final vowel. Finally, pre-tonic unstressed vowels also undergo raising.

Mid-vowels (which here are only mid-high due to a process of vowel reduction that turns unstressed mid-low vowels into mid-high vowels) raise to high when followed by a high vowel in stressed position. Data for Servigliano are repeated under (63). The pattern of pre-tonic raising corresponds to

the ones discussed in §II.3.4.1 for other dialects spoken in roughly the same area: Amandola, Monte Giberto and Amelia (Savoia 2015: 284).

(63) Servigliano height alternations

a. Metaphonic raising: stressed mid vowels undergo scalar raising

'metto	'I put'	'mitti	'you put'
'pesa	'it weighs'	'pisu	'weight (noun)'
'poce	'fly'	'puci	'flies'
'spōsa	'wife'	'sposu	'husband'
mo'desta	'modest F.'	mo'destu	'modest M.'
'pette	'comb'	'pettini	'combs'
'predoko	'I preach'	'prediki	'you preach'
'mōre	'he dies'	'mori	'you die'
'mōfa	'depressed F.'	'mofu	'depressed M.'

b. Process of vowel copying affecting unstressed post tonic vowels

'predoko	I preach	'prediki	you preach	'predaka	he preaches
'persaka	peach	'persiki	peach trees	'persuku	peach tree
bir'kōkana	apricot		bir'kokunu	apricot tree	
'mettatfala	put it (F.SG) there		'mittutfulu	put it (M.SG) there	
mettetfele	put them (F.PL) there		mittitfili	put them (M.PL) there	

Given the process of vowel copying shown in (63b), the metaphony at hand may be considered iterative: final vowels affect eventual unstressed post-tonic vowels that may intervene between the final vowel and the stressed one, and propagate the harmonic wave.

Mid-low vowels cannot occur in unstressed position, thus allowing us to assess the scalar nature of raising in Servigliano only through metaphony, which affects stressed vowels. Under (64) are shown alternations involving vowel reduction in Servigliano. Mid-low vowels surface as mid-high when they pass from stressed to unstressed position, much like in Eastern Lombard dialects.

(64) Vowel reduction in Servigliano: mid-low vowels surface as mid-high when unstressed

a. /ɛ/ reduces to [e]

'stene	'he spreads/hangs the laundry'	sten'nete	'you PL spread/hang the laundry'
'vengo	'I come'	ve'nete	'you come PL'
'spello	'I skin'	spel'la	'to skin'

b. /ɔ/ reduces to [o]

'dōmo	'I sleep'	dor'mete	'you sleep PL'
'mōro	'I die'	mo'rete	'you die PL'
'skōdo	'I forget'	skor'da	'to forget'

Pre-tonic vowels undergo raising if followed by stressed high vowels. Raised mid-high vowels behave as valid triggers for raising of preceding unstressed mid-vowels, meaning that metaphony feeds the process of pre-tonic raising. All mid-vowels undergo raising in this context, as shown in (65), but

notice that mid-low vowels never surface as such in pre-tonic context, due to the process of vowel reduction exemplified in (64). Thus, in sum, mid-low vowels undergoing vowel reduction become valid targets for pre-tonic vowel raising, which turns mid-high vowels (all mid-vowels in pre-tonic position are mid-high) into high vowels.

(65) Pre-tonic raising: high vowels in stressed position raise preceding mid vowels

a. Pre-tonic /e/ raise to [i]

kre'denno	'believing'	kri'di	'to believe'
le'gete	'you tie PL'	li'gimo	'we tie'
stomme'kosa	'nauseating F.SG'	stummi'kusu	'nauseating M.SG'

b. Pre-tonic /ɛ/ (reduced to [e]) raise to [i]

'stenne	'he spreads/hangs the laundry'	sten'nete	'you PL spread/hang the laundry'	stin'ni	'to spread/hang the laundry'
'vɛŋgo	'I come'	ve'nete	'you come PL'	vi'ni	'to come'

c. Pre-tonic /o/ raise to [u]

kommon'e'ka	'to communicate'	kummuni'kimu	'we communicate'
nfor'kete	'you PL mount'	nfur'kimu	'we mount'

d. Pre-tonic /ɔ/ (reduced to [o]) raise to [u]

'dɔrmo	'I sleep'	dor'mete	'you sleep PL'	dur'mimu	'we sleep'
mɔro	'I die'	mo'rete	'you die PL'	mu'ri	'to die'
bbe'sɔŋa	'need F.SG'	bbeso'ŋa	'to need'	bbisu'ŋimu	'we need'

In sum, final vowels and stressed vowels behave as triggers for raising. Final vowels trigger vowel-copy for preceding unstressed post-tonic vowels and trigger metaphony (i.e. scalar raising) of mid-vowels in stressed position. High vowels in stressed position, both lexical and raised metaphonically, raise preceding mid-vowels.

VI.6.1 Representing scalar raising in Sandstedt's model

First, let us observe the way Sandstedt's (2018) model of prime emergence accounts for harmonies that apply as scalar raising like the one of Servigliano.

A central issue to be discussed concerns the way scalar harmony is formalized. Since we are working in a RadSFP environment, the fact that the process surfaces as raising is not a valid argument to assume a priori that it involves the spreading of a prime. There are multiple ways the process could be formalized, especially considering that Sandstedt (2018) does not provide an explicit theory of rules or constraints. There are thus different options for the treatment of scalar raising, considered separately in the following subsections.

The four options treated are the following:

1. Raising applies as a single process of spreading of the prime [high].
2. Raising applies as a single process of spreading. This analysis assumes that two additional vowels exist in Servigliano, which are the result of spreading of [high] to mid-low vowels.

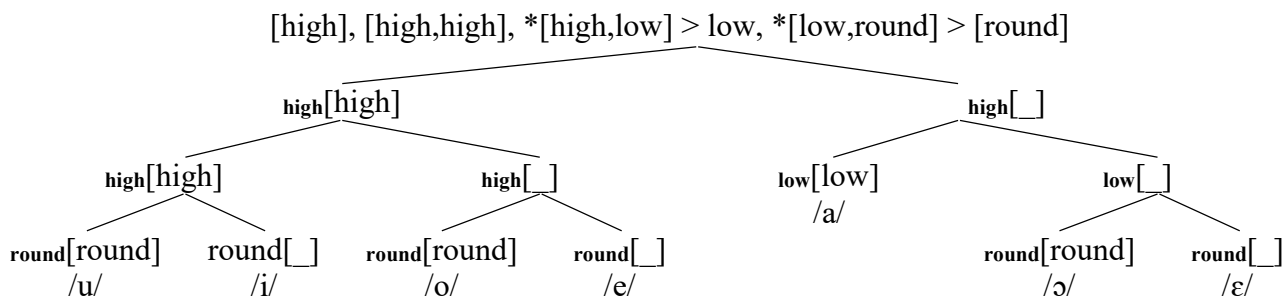
3. Raising applies as two processes of spreading. One spreads [high], the other spreads [close]. This analysis assumes that four additional vowels exist in Servigliano, which share their phonetic implementation with mid and high vowels.

4. Raising applies as spreading of [high] from high vowels to mid-high vowels, and as subtraction of the prime [RTR] from mid-low vowels which become mid-high vowels.

VI.6.1.1 Option #1: one single process of spreading

The first option considers scalar raising as the result of a single process of spreading. The graph under (66) represents this option. If raising of both mid-low and mid-high vowels is the result of a single phonological process, the same harmonic prime must spread from /i/ and /u/ to both mid vowels. Two iterations of the same prime $\text{high}[\text{high}]^{244}$ occur in the SDA graph. Mid-low vowels contain one empty $\text{high}[\]$. Mid-high vowels have one full node and one empty H-node. High vowels have two full $\text{high}[\text{high}]$ nodes.

(66) Servigliano contrastive prime hierarchy: first option



The graph proposed in (66) treats scalar raising as spreading of the prime [high] from high to mid vowels. Recall that the hierarchy of nodes in the SDA is reflected in the internal structure of segments: the graph in (66) treats the property of height as proposed in incremental models, explored in detail in §IV.2 (Schane 1984, Clements 1991, Parkinson 1996). That is, high vowels have two [high] primes under (66), mid-high vowels only one and mid-low vowels none. When [high] spreading from /i,u/ is received by ɔ,ɛ they become e,o, and when it adds to e,o, they become high i,u. Recall from §IV.3.2.7 that incremental primes can be integrated into an SDA graph.

The low vowel /a/ behaves as neutral in Servigliano. This means that there is a co-occurrence restriction preventing [low] from co-occurring with [high].

I argue that the graph in (66) leads to a wrong analysis of raising in Servigliano. The SDA graph reported in (66) assigns a full $\text{high}[\text{high}]$ node to mid-high vowels, thereby treating them as possible triggers for mid-low raising. However, this is not what happens: mid-high vowels do not behave as triggers for raising of stressed mid-low vowels, as shown in (63) and (64). The graph under (66) is therefore discarded.

²⁴⁴ Recall that the primes used are considered emergent and not substance-based. The use of a prime such as [high] instead of a label such as |ψ| serves only the purpose to uniform the analysis proposed here with those proposed in the source material (Sandstedt 2018).

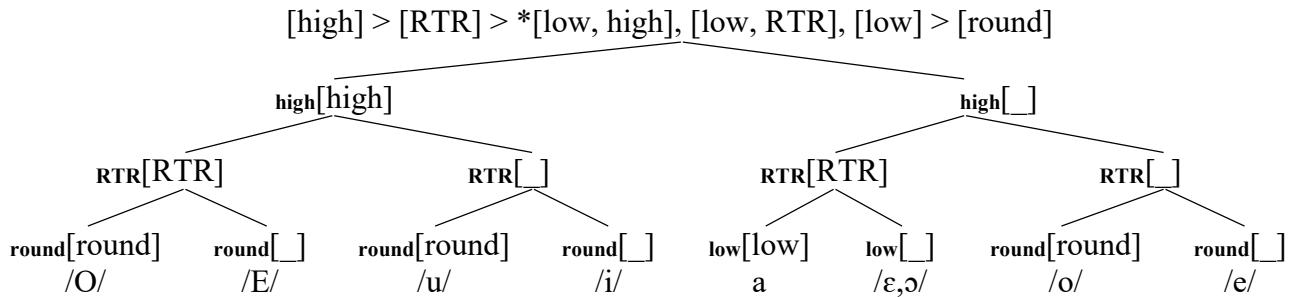
VI.6.1.2 Option #2: spreading of high and two additional non-contrastive vowels

A second analysis of scalar raising which may be consistent with Sandstedt's (2018) model considers raising as spreading of the prime **high**[high], which spreads from high vowels to both mid-low and mid-high. Mid-low vowels are specified for the prime **RTR**[RTR]. The SDA graph resulting from the hierarchy under (67a) gives a prime specification to two additional segments, reported in the graph as /E/ and /O/ respectively. Those two segments would appear only as the result of raising of mid-low vowels.

In sum, the second option consists in assuming that Servigliano vowel system is composed of nine vowels, not seven, and that two of those vowels only occur as the result of mid-low raising. Those segments, which have a contrastive specification and a unique phonological identity, share the same phonetic interpretation as /o,e/, that is [o,e]: as argued in §V.4.5, two different phonological items map onto the same phonetic representation, as shown in (67b).

(67) Servigliano contrastive prime hierarchy: second option

a. SDA graph for Servigliano



b. List of transductional instructions given the segments derived from the SDA

Phonology			Phonetics
Segment	prime specification		
/i/	[high]	↔	[i]
/u/	[high,round]	↔	[u]
/E/	[high, RTR]	↔	[e]
/O/	[high, RTR, round]	↔	[o]
/a/	[RTR, low]	↔	[a]
/ε/	[RTR]	↔	[ε]
/ɔ/	[RTR, round]	↔	[ɔ]
/o/	[round]	↔	[o]
/e/	∅	↔	[e]

Under this assumption, raising applies in the same way to both mid-low and mid-high vowels: they both receive the same harmonic prime [high] from high vowels. Mid-low vowels, which are specified as [RTR], receive the prime [high], and become [RTR, high]. This results in the specification of the added vowels /E/ and /O/. They only appear in the language as the result of mid-low raising. Mid-high vowels receive the [high] prime, and thus become high vowels.

Those vowels do not involve primes that are not needed to represent other vowels, i.e. no additional non-contrastive prime is added to account for the existence of those two vowels.

However, recall that in Servigliano pre-tonic mid-vowels also raise when followed by a stressed lexical high vowel. The result of mid-low raising receives the harmonic prime and should therefore behave as a valid trigger for preceding unstressed mid vowels. Forms such as [mo'desta], [mo'destu] *[mu'destu] show that raised mid-low vowels do not act as triggers, though, and thus do not contain the harmonic prime. On the contrary, raised mid-high vowels behave as valid triggers, as shown in alternations such as [stomme'kosa]‘nauseating F.SG’, [stummi'kusu]‘nauseating M.SG’. Raising of mid-low vowels cannot come from the same process of spreading that raises mid-high vowels.

The fact that raised mid-low vowels do not behave as triggers for preceding mid-high vowels ensures that they do not contain the same harmonic prime that is passed to mid-high vowels, when they undergo raising. Something different must be happening and thus the SDA under (67) cannot be correct. This argument rules out any scenario with a single harmonic prime. This means that this argument is an additional proof that the first option is to be discarded.

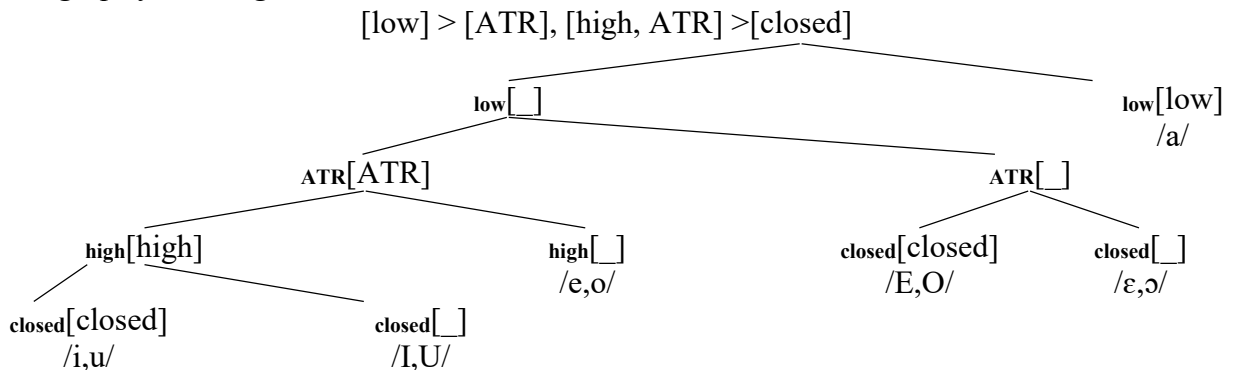
VI. 6.1.3 Option #3: two processes and 4 additional non-contrastive vowels

The third option treats metaphony as composed by two different harmonic processes. High vowels contain two different harmonic primes, *high*[high] and *close*[close], which spread to mid-low and mid-high vowels, respectively. Thus [high] spreads to mid-high vowels, while [close] spreads to mid-low vowels. Notice that on this option the outcome of either mid-low and mid-high raising does not correspond to the mid-high and high vowels that appear in the lexicon. This third analysis, then, requires the assumption of eleven different vowels in the system of Servigliano, four of which share the same phonetic interpretation. The four vowels in question (which result from metaphonic raising) have a specific prime-content, but a phonetic interpretation that corresponds to those of lexical mid-high and high vowels.

The graph under (68a) represents this situation: it assigns a contrastive specification to eleven vowels, four of which appear in the language only as the result of raising. (68b) exhibits the transductional instructions that map those segments to their phonetic interpretation. In this analysis there are two segments pronounced as [i], two segments pronounced as [u], two segments pronounced as [e] and two segments pronounced as [o].

(68) Servigliano contrastive prime hierarchy: third option

a. SDA graph for Servigliano



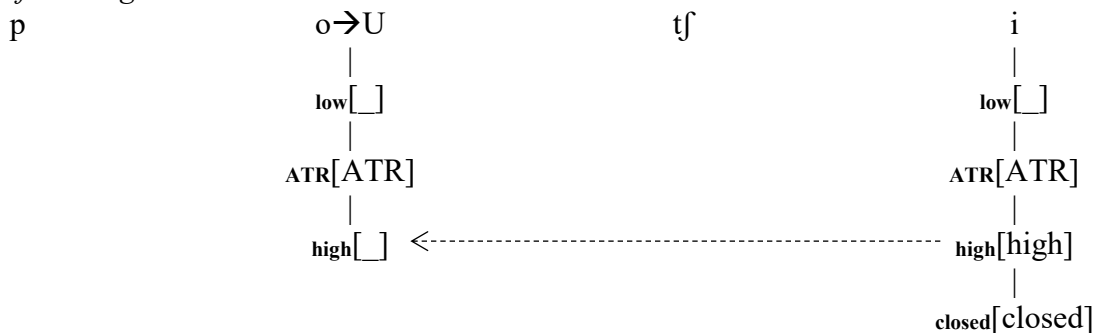
b. List of transductional instruction given the segments derived from the SDA

Phonology			Phonetics
Segment	prime specification		
/i,u/	[ATR,high, closed]	↔	[i], [u]
/I,U/	[ATR, high]	↔	[i], [u]
/e,o/	[ATR]	↔	[e], [o]
/a/	[low]	↔	[a]
/E,O/	[closed]	↔	[e], [o]
/ε,ɔ/	∅	↔	[ε], [ɔ]

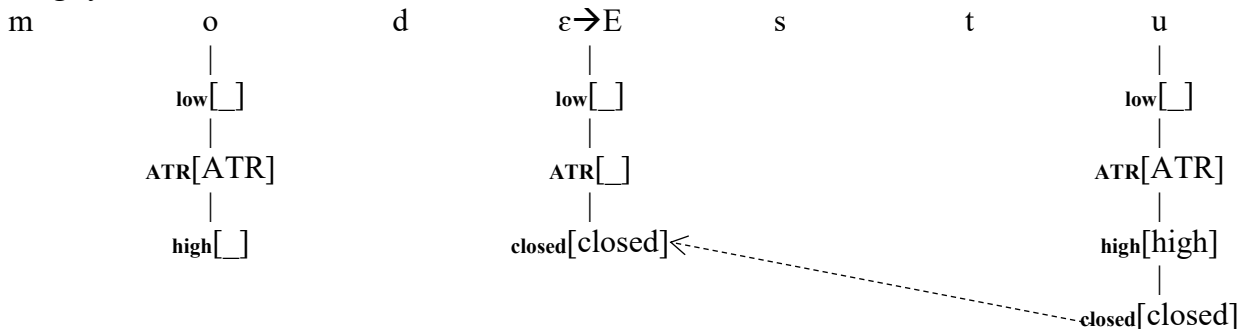
This third option, while quite abstract, manages to account for the alternations of Servigliano. Mid-low vowels receive the [closed] prime from high vowels and result in /E,O/ (which transduce to [e], and [o] respectively). The result of mid-low raising lacks the [high] prime, thereby making it an invalid trigger for pre-tonic raising. Mid-high vowels receive the [high] prime from high vowels, and result in /I,U/, which share with high vowels the [high] prime, but lack the [closed] prime. Since in the language there are no pre-tonic mid-low vowels, it is impossible to assess the role of /I,U/ as triggers for mid-low raising. The process is symmetric. Triggers share with mid-high vowels the filled $\text{ATR}[\text{ATR}]$ node, so there is no trace of parasitism. Mid-low vowels, which have no filled node above the harmonic node $\text{closed}[\]$ behave as targets in all contexts. The formalization of scalar raising in Servigliano is presented in (69). (69a) shows raising of mid-high vowels, formalized as spreading of [high], while (69b) shows raising of mid-low vowels, formalized as spreading of [closed]. Preceding the raised mid-low vowel under (69b) is a mid-high vowel /o/, which does not receive the prime [closed] because it lacks the node $\text{closed}[\]$.

(69) Scalar raising in Servigliano

a. Raising of mid-high vowels



b. Raising of mid-low vowels



This analysis of scalar raising takes advantage of the properties of the PPI discussed in §V.4.5. That the process appears as a case of raising is not truly a fact about phonology, but an information about the transductional instructions that make up the interface. The result of mid-low raising must share the phonetic implementation (not necessarily the phonological representation) of mid-high vowels. The downside of this analysis is its abstractness. It requires the positing of four segments that do not participate in any other process of the language. They are proposed solely to account for scalar raising.

Notice, however, that the prime [closed] has a contrastive role only if we assume the presence of the segments /I/ and /U/. Otherwise, it has no contrastive role for /i/ and /u/, which would be contrastively defined even without it. The prime [closed], then, may be violating the Contrastivist Hypothesis.

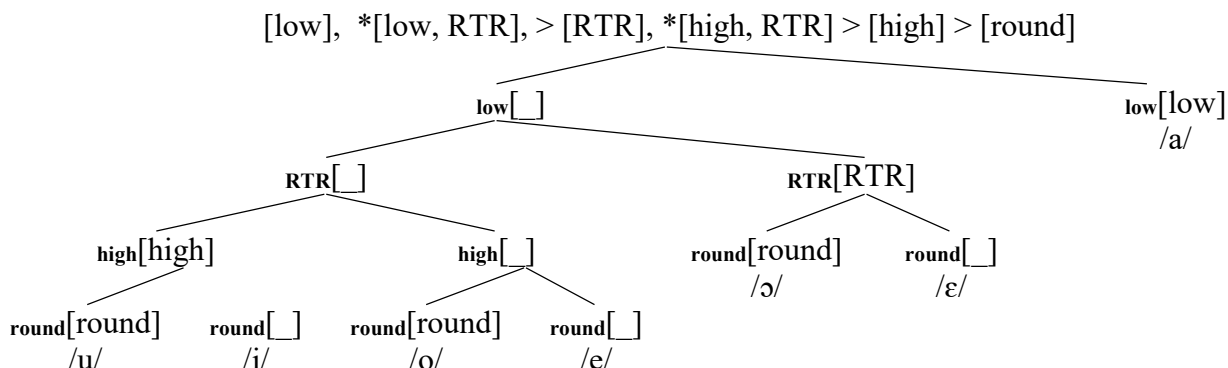
VI.6.1.4 Option #4: raising applies as spreading and as subtraction

One option that has not yet been considered is to treat scalar raising as composed of two fundamentally different operations. As discussed above, raising of mid-high vowels results in segments that are able to propagate harmony backwards (i.e. raising of mid-high vowels is iterative), while raising of mid-low vowels results in vowels that do not trigger raising of preceding vowels (i.e. raising of mid-low vowels is non-iterative). We may apply the insights proposed in §3, and argue that raising of mid-high vowels is a case of spreading while raising of mid-low vowels is a case of subtraction of a prime.

If height alternations are formalized as spreading (only to mid-high) and prime subtraction (only to mid-low), the SDA graph should identify as targets of harmony only mid-high vowels, while mid-low vowels should not be identified as such. In practice, assuming that [high] is the harmonic prime, mid-high vowels should have an empty `high[_]` node, while mid-low vowels should not.

Recall also, that mid-low vowels undergo vowel reduction in unstressed position, meaning that they should lose a prime in unstressed position and assume the prime specification of mid-high vowels. If this process is taken into account, we should arrive at an SDA graph whereby mid-low vowels have the same prime specification as mid-high vowels plus a prime (which is lost in both unstressed position and as a consequence of raising). The graph under (70) manages to do so. Mid-low vowels are specified as [RTR], and they are divided from ATR in the first division operated by the SDA. The processes of vowel reduction and raising affects them in the same way: removal of RTR. Raising affecting mid-high vowels, instead, applies as spreading of [high]. Only mid-high vowels have the empty node `high[_]`, so they are the only targets for spreading.

(70) Servigliano contrastive prime hierarchy: fourth option



The harmonic prime [high] spreads from /i/ and /u/ to mid-high vowels, which raise to high and become valid triggers for pre-tonic raising. Mid-low vowels, instead, do not receive the [high] prime, but another process applies, one that removes their [RTR] prime, which means that they end up being specified for the same primes as mid-high vowels.

A central issue with this analysis concerns the way vowel reduction and metaphony interplay in the dialect of Servigliano. Under (71) I recall data that show how mid-low vowels (left column under 71) which undergo vowel reduction in pre-tonic unstressed position (middle column) are raised in pre-tonic position if the following stressed vowel is a valid trigger (right column).

(71) Reduced mid-low vowels behave as targets for pre-tonic raising

a. Pre-tonic /ɛ/ (reduced to [e]) raise to [i]

Stressed /ɛ/		Pre-tonic /ɛ/ reduces to e		Pre-tonic reduced /ɛ/ → e raise to [i]	
'stenne	'he spreads/hangs the laundry'	sten'nete	'you PL spread/hang the laundry'	stin'ni	'to spread/hang the laundry'
'vɛŋgo	'I come'	ve'nete	'you come PL'	vi'ni	'to come'

b. Pre-tonic /ɔ/ (reduced to [o]) raise to [u]

Stressed /ɔ/		Pre-tonic /ɔ/ reduces to e		Pre-tonic reduced /ɔ/ → o raise to [u]	
'dɔrmo	'I sleep'	dor'mete	'you sleep PL'	dur'mimu	'we sleep'
mɔro	'I die'	mo'rete	'you die PL'	mu'ri	'to die'
bbe'sɔŋa	'need F.SG'	bbeso'ŋa	'to need'	bbisu'ŋimu	'we need'

Alternations in (71), previously shown in (65), demonstrate that mid-low vowels must have an empty $\text{high}[_]$ node, so that when they undergo vowel reduction, becoming mid-high vowels, they can actually receive the harmonic prime. If they did, however, they should behave as targets for spreading of [high], which they do not. These facts are fatal for this fourth option.

VI.6.1.5. Conclusion

Given the discussion above, it appears that Sandstedt's (2018) model is unable to analyze the height alternations of Servigliano. Notice that this does not mean automatically that Sandstedt's (2018) account of prime learning is unable to formalize scalar raising harmonies as such. If only metaphony applied in Servigliano, options #2 and #3 would work. What makes the pattern inaccessible is the behavior of raised mid-high vowels as triggers for pre-tonic raising, and the fact that mid-low vowels do not behave as such.

In sum, Sandstedt's model of prime emergence and prime structuring is able to represent asymmetric harmonies and especially parasitic harmonies using only one rule. When confronted with scalar raising harmonies, however, it needs to implement "abstract" segments, i.e. segments which exist only for harmonic reasons and have no contrastive import. In some cases (cf. §6.1.3), the primes needed for the implementation of these vowels do not serve any distinctive purpose and therefore violate the CH.

The abstract character of these non-contrastive segments may be debated when comparing analysis involving them with others that do not need to resort to them.

VI.6.2 Scalar harmony assuming Odden's (2022) model of prime learning

VI.6.2.1. Servigliano

Now let us turn to Odden's model of prime emergence, and see how it manages scalar raising in Servigliano. Under the assumption that computation guides learning, a scalar process would be perceived by a learner through the alternations shown in (72).

(72) Height alternations perceived by learners of the dialect of Servigliano

/e/ → [i]/ C _{0i,u}		/o/ → [u]/ C _{0i,u}	
'metto	'I put'	'sposa	'wife'
'mitti	'you put'	'sposu	'husband'
kre'denno	'believing'	kommone'ka	'to communicate'
kri'di	'to believe'	kummuni'kimu	'we communicate'
/ɛ/ → [e]/ C _{0i,u}		/ɔ/ → [o]/ C _{0i,u}	
'predoko	'I preach'	'mɔʃa	'depressed F.'
'prediki	'you preach'	'moʃu	'depressed M.'
mo'desta	'modest F'		
mo'destu	'modest M'		

The context of application for the alternations under (72) is the same. Mid-vowels are assigned the prime |α|, since they are part of the set of targets for raising, while high vowels are recognized as an active class of triggers, and assigned a prime |β|.

The system of alternations of Servigliano also informs learners about the fact that mid-low and mid-high vowels are respectively the target and the outcome of a process of vowel reduction. This process is positional in kind, and therefore, following the discussion in §3.3, formalized as subtraction of primes.

(73) Alternations caused by vowel reduction

ɛ → e/Unstressed		ɔ → o/Unstressed	
'stenne	'he spreads'	'mɔro	'I die'
sten'nete	'you spread PL'	mo'rete	'you die PL'

For now, we have identified a set of targets |α|, the set of triggers |β| and a set of vowels undergoing reduction |γ|. The process of prime emergence, at this point, has assigned the following primes, shown in (74)

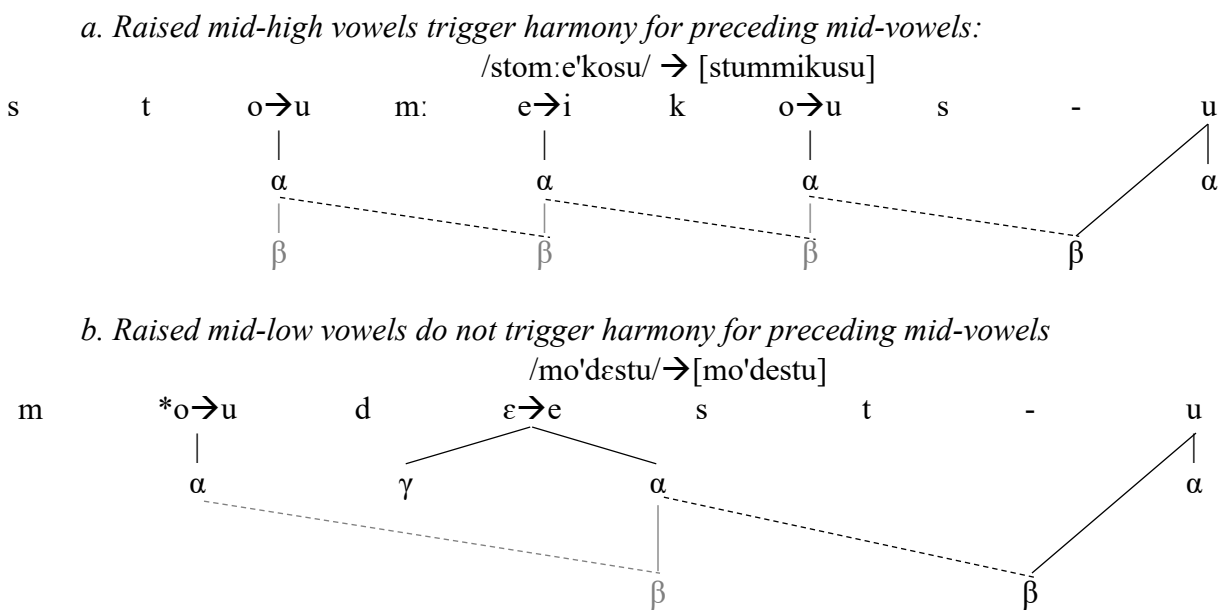
(74) Prime assignment following raising and vowel reduction

/a/	/e/ α	/ɛ/ α	/o/ α	/ɔ/ α	/i/ β	/u/ β
		γ		γ		

It is still to be defined how harmonic raising is formalized. Mid-high vowels undergoing raising become valid triggers for raising of preceding mid vowels. This suggests an iterative treatment of raising, one which spreads the harmonic prime $|\beta|$ to segments specified for $|\alpha|$. The outcomes of mid-high raising have the same behavior as high vowels in the harmonic process: they trigger raising of preceding vowels. They also share the same phonetic interpretation. Learners would, thus, assume that the outcome of $|\beta|$ spreading to mid-high vowels corresponds to the prime specification of high vowels. This means that high vowels are also specified for $|\alpha|$.

For what concerns mid-low vowels, however, the process does not behave as iterative. Raised mid-low vowels result in mid-high vowels, which are not valid triggers for raising. The behavior of raised mid-low vowels is that of harmonic blockers. Regardless of the phonetic nature of the outcome of mid-low raising, if the process involves spreading of the prime $|\beta|$, we should come across forms such as *[mudestu], while in fact the correct form is [modestu]. As shown below in (75), the analysis of raising as spreading of $|\beta|$ to $|\alpha|$ predicts that both raised mid-low vowels and raised mid-high vowels should trigger raising of preceding mid-vowels.

(75) Raised mid-high vowels propagate harmony backwards, raised mid-low vowels do not

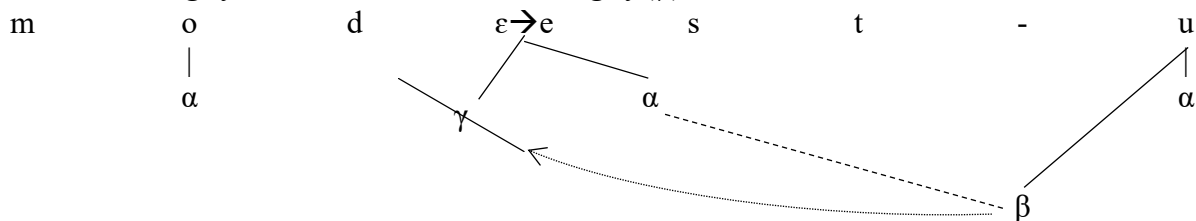


The alternative analysis is to treat raising of mid-low vowels as a case of prime subtraction. This would allow the analysis of mid-low raising and vowel reduction as the same process, avoiding positing additional segments, as we were forced to do in §6.1.3. A rule like $\alpha\gamma \rightarrow (\alpha\gamma - \gamma) / _ C_0\beta$ is allowed by the theory of computation proposed in section 3.

Scalar raising, then, is split in two operations, as shown in (76a): the harmonic prime $|\beta|$ is added to mid-high vowels, and the prime $|\gamma|$ is subtracted from mid-low vowels. (76b) shows the example from (75b) under this new analysis. The arrow connecting $|\beta|$ to the suppressed prime is meant to show that it is the presence of $|\beta|$ that triggers vowel reduction.

(76) Formalizing scalar raising: two processes apply in the same context

- a. *Scalar raising: active processes in Servigliano*
- $\alpha + \beta / _ C_0 \beta$
 - $\alpha \gamma - \gamma / _ C_0 \beta$
- b. *Raising of mid-low vowels as delinking of $|\gamma|$*



The formalizations in (76a), however, still assumes that mid-low and mid-high vowels should receive the harmonic prime $|\beta|$ from high vowels, as represented in the table with the insertion of the association line. In fact, both mid-low and mid-high vowels share the $|\alpha|$ prime, which identifies targets of $|\beta|$ -spreading. Some additional assumptions must thus be put in place to account for the case of Servigliano.

In the analysis of Camuno, learners were assumed to be able to posit hypotheses about the internal structure of segments. In that case, the behavior of non-rounded mid vowels suggested that they received, alongside the prime $|\pi|$ an additional prime $|\gamma|$, which was relevant in the process of raising targeting rounded vowels. The internal structure of segments was adapted accordingly: primes $|\pi|$ and $|\gamma|$ are structured hierarchically, so that spreading of $|\pi|$ also entails spreading of $|\gamma|$.

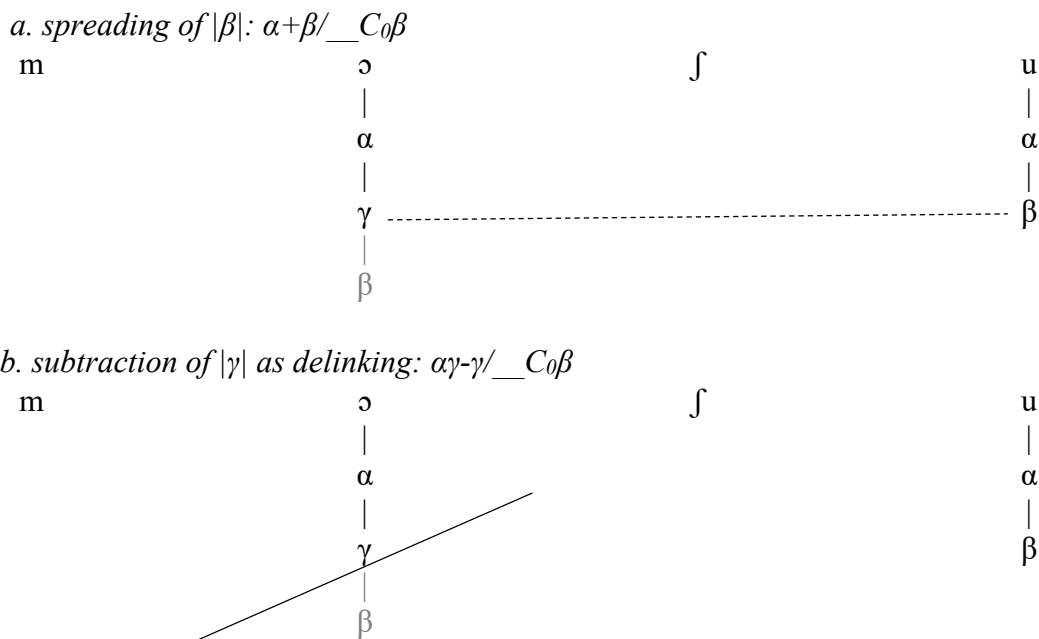
Here a similar representational strategy may describe the scalar behavior of metaphony. We defined mid-low vowels as having two primes, namely $|\alpha|$ and $|\gamma|$. $|\alpha|$ specifies them as targets of raising, $|\gamma|$ as targets of vowel reduction. Scalar raising may be explained supposing that the internal structure of mid-low vowels is structured as shown in (77).

(77) Internal structure of mid-low vowels: $|\alpha|$ dominates $|\gamma|$



Segments which contain $|\alpha|$ receive $|\beta|$. This prime enters in the internal structure of mid-low vowels under the two primes $|\alpha|$ and $|\gamma|$, as shown in (78a). This way, the two rules presented in (76a) apply regularly to all mid-vowels involved. All mid vowels receive the prime $|\beta|$, and mid-low vowels lose the prime $|\gamma|$, but alongside it, they also lose $|\beta|$, which is positioned below it in the internal structure of the segment. This follows the rule that a segment loses the prime that is the target of subtraction, plus all other primes dominated by the target prime.

(78) Scalar raising in Servigliano: spreading of $|\beta|$ and delinking of $|\gamma|$



Notice that this analysis requires processes to apply in order: $|\beta|$ spreads, and only then vowel reduction, which delinks $|\gamma|$, applies. This hypothesis imagines that segments have an internal structure, i.e. that primes within a segment may enjoy hierarchical relations. This is similar to what is proposed in the model of Sandstedt (2018). What differs is that the segmental structure proposed in Sandstedt (2018) derives from the SDA, while the one proposed here is learned directly from alternations.

All mid-vowels receive the prime $|\beta|$, including mid-low vowels, which immediately lose it due to the process that delinks $|\gamma|$ and all primes positioned under it in the segmental structure.

The complete prime specification for the vowel system of Servigliano is shown in (79). Rounded vowels are specified with an additional prime, $|\delta|$, which has no role in computation. It simply ensures that rounded and non-rounded vowels are contrastively specified. This addition is minimal, and ensures that raised rounded vowels surface as rounded high vowels. It is not, however, an active prime in computation. (79a) displays the prime assignment, (79b) shows the internal structure of segments.

(79) Prime specification of vowels in Servigliano

a. Prime assignment

/a/	/e/	/ɛ/	/o/	/ɔ/	/i/	/u/
	α	α γ	α δ	α γ δ	α β	α β δ

b. Segmental structure

/a/	/e/	/ɛ/	/o/	/ɔ/	/i/	/u/
	 α	 α γ	α δ	α δ γ	 α β	α δ β

VI.6.2.2. Complete raising: metaphony in Foggia

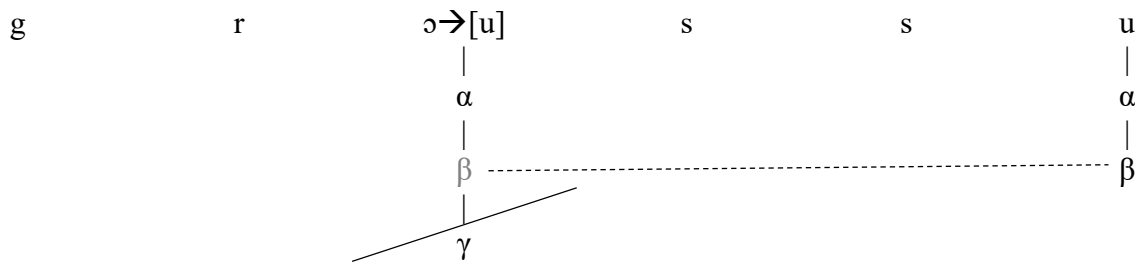
In contexts where complete raising applies, I assume that learners implement a reversed hierarchy. This is exactly what happens in complete raising harmonies, such as the one active in Foggia, discussed in §II.3.3.3.3 and recalled in (80).

(80) Metaphonic raising in Foggia: all mid vowels surface as high in metaphonic contexts

	<i>Singular</i>	<i>Plural</i>	
<i>M</i>	mu ^h ffu		'soft'
<i>F</i>	mo ^h ffa		
<i>M</i>	kj ^h inu		'full'
<i>F</i>	kj ^h ena		
<i>M</i>	gr ^h ussu		'big'
<i>F</i>	gr ^h ossa		
<i>M</i>	pe ^h te	pi ^h ti	'foot'

Let us assume, for the sake of the argument, that the two dialects share the same prime specification shown in (79a). The two varieties differ in the way primes are structured within the segments. Scalar raising in Servigliano suggests that $|\gamma|$ dominates $|\beta|$, while in the dialect of Foggia the order is reversed. The prime $|\gamma|$ that is delinked by the same rule, is positioned below the harmonic prime received, $|\beta|$, so that complete raising applies. All mid vowels receive $|\beta|$ and mid-low vowels lose $|\gamma|$. (81) shows the two processes, spreading of $|\beta|$ and suppression of $|\gamma|$, applying to mid-low vowels.

(81) Formal representation of complete raising in the dialect of Foggia



VI. 6.3. Summary

The formalization of scalar raising obtained by applying the prime-emergence model proposed in Odden (2022) displays some clear advantages with respect to the one discussed in §6.1.3 following Sandstedt's model. First, it manages to avoid the positing of additional segments in the language. Second, it considers both vowel reduction and raising of mid-low vowels as the same phonological process.

VI.7. Morphologically conditioned metaphonies

VI.7.1. Data and problem

The last issue to be discussed concerns morphologically conditioned harmonies of the kind discussed in §IV.7.3: metaphonic raising in the dialect of Cervara and Mormanno . Given the assumption that

primes are innate and that they enjoy a universal correlation with phonetics, the processes of Cervara and Mormanno appeared to be impossible to account for. Neither an analysis based on ordered rules or floating features, which were applied in other similar cases, work for those two specific patterns.

Maintaining the assumptions that primes are universal and enjoy a consistent cross-linguistic correlation with phonetics, the only option that remained for the analysis of Cervara and Mormanno metaphony was to analyze them as cases of root-suppletion or as morpho-phonological rules. The first option requires us to assume that for each alternating root there are two lexical forms: one that is selected in non-metaphonic contexts and one selected in metaphonic contexts. The treatment of the process as a morpho-phonological rule, instead, violates domain specificity (cf. §V.2.1), since it would require that a computational process operate over both morpho-syntactic and phonological representations.

The issue with the specific varieties of Cervara and Mormanno revolved around the fact that these languages have multiple items surfacing as /i/ and /u/ that display a different phonological behavior depending on the morphological status of the suffix they appear in. In Cervara, for example, metaphony applies in all expected contexts, but final /i/ belonging to a verbal suffix triggers complete raising, while in nominal contexts scalar raising applies. Examples are provided in (82).

(82) Metaphonic alternations in Cervara (cf. §II.3.3.4.5, §IV.7.3)

a. Metaphony apply as scalar raising in nominal paradigms

	<i>Singular</i>	<i>Plural</i>	
<i>M</i>	'b:ελλο	'b:ελλι	'beautiful'
<i>F</i>	'b:εlla	'b:elle	
<i>M</i>	'b:ono	'b:oni	'good'
<i>F</i>	'b:ona	'b:one	

b. Metaphony apply as complete raising in verbal paradigms

<i>I sing.</i>	'korro	<i>I run</i>
<i>II sing.</i>	'kurri	<i>you run</i>
<i>III sing.</i>	'korre	<i>He/she/it runs</i>
<i>III plur.</i>	'kurru	<i>They run</i>
<i>I sing.</i>	'vedo	<i>I see</i>
<i>II sing.</i>	'vidi	<i>You see</i>
<i>III sing.</i>	'vede	<i>He/she/it sees</i>
<i>III plur.</i>	'vidu	<i>They see</i>
<i>I sing.</i>	'kɔλλο	<i>I pick</i>
<i>II sing.</i>	'kuλλι	<i>You pick</i>
<i>III sing.</i>	'kɔλλε	<i>He/she/it picks</i>
<i>III plur.</i>	'kuλλυ	<i>They pick</i>
<i>I sing.</i>	'meto	<i>I reap</i>
<i>II sing.</i>	'miti	<i>You reap</i>
<i>III sing.</i>	'mete	<i>He/she/it reaps</i>
<i>III plur.</i>	'mitu	<i>They reap</i>

c. Pre-tonic mid vowels raise when followed by high vowels in stressed position: Metaphony feeds pre-tonic raising

ne'pote	'nephew'	ni'puti	'nephew'
frel'lenka	'vulva (vulg.)'	fril'linku	'penis (vulg.)'
ko'lore	'color'	ku'luri	'colors'
sot'tʃede	'it happens'	sut'tʃidi	'you happen'

In Mormanno (§II.3.3.4.5; §IV.7.3), only high vowels belonging to nominal suffixes act as valid triggers for raising. Harmonic raising applies only in nouns and adjectives, and not in verbs, as exemplified under (83). Additionally, only /i/ that derive from etymological high vowels are valid triggers for raising. In the examples under (83a), feminine plural suffixes (derived from *e) do not trigger raising, regardless of their phonetic implementation.

(83) Metaphonic alternations in Mormanno

a. Metaphony applies in nominal paradigms

	<i>Singular</i>	<i>Plural</i>	
<i>M</i>	'veccu	'vecci	'old'
<i>F</i>	'vecca	'vecci	
<i>M</i>	'novu	'novi	'new'
<i>F</i>	'nɔva	'nɔvi	

b. Metaphony does not apply in verbal paradigms

	<i>I sing.</i>	<i>II sing.</i>	<i>III sing.</i>	<i>III plur.</i>	
<i>Verbs: Present tense</i>	'kreðu	'kreðisi	'kreði	'kreðinu	'believe'
	'venqu	'venisi	'veni	'veninu	'come'
	'dormu	'dormisi	'dormi	'dorminu	'sleep'

VI.7.2. Analysis in a RadSFP environment

VI.7.2.1. Mormano

Let us now consider how the metaphonic alternations under (82) and (83) might work in a RadSFP framework. Recall from §V.4.5 that the PPI allows for mismatches in the mappings between phonological and phonetic items. Inuit (Compton & Drescher 2011) and Polish (Gussmann 2007) were cited as cases in which multiple phonological items map onto the same phonetic exponent. In Inuit, for example, two different phonological items are interpreted as phonetically identical by the PPI. Similarly, I argue that in both Mormano and Cervara there are multiple segments, with a different phonological behavior, that surface as high vowels. Processing suggests to learners that segments that display a different behavior have a different representation, regardless of the way they are externalized.

Let us treat first the case of Mormanno, where metaphony applies only in nouns and adjectives, but not in verbs.

In Mormanno (Northern Calabria, in the Lausberg Area, cf. §II.3.3.4.5), etymological mid-vowels raised to high in final position. The system of contrasts for final vowels is [i, a, u]. Metaphony applies only when the high vowel on the surface corresponds to an etymological high vowel. However, metaphony also fails to apply in a context where surface [i] corresponds to etymological /i/: in the second

person of verbs in the present tense. The table under (84) reports nominal and verbal suffixes, all containing high vowels. It is shown when final high vowels correspond to an etymological high vowel and when they do not. Normally, high vowels that correspond to etymological high vowels are valid metaphonic triggers. The marker for the second person singular in the present tense exhibits surface [i] which corresponds to etymological /i/, but does not behave as a valid trigger for metaphony.

(84) Metaphonic and non-metaphonic morphemes with high vowels

<i>Nominal morpheme</i>		<i>Etymological origin</i>	<i>Status as metaphonic trigger</i>				
<i>Feminine plural marker in adjectives and nouns of Class I²⁴⁵</i>	-i	*e	Does not trigger metaphony	'seddʒa	'chair'	'seddʒi	'chairs'
				'vɛcca	'old F.S.'	'vɛcci	'old F.P.'
				'rɔta	'wheel'	'rɔti	'wheels'
<i>Masculine singular marker in adjectives and nouns of Class I</i>	-u	*u	Triggers metaphony	'vɛcca	'old F.S.'	'veccu	'old M.S.'
				'nɔva	'new F.S.'	'novu	'new M.S.'
				lettu			'bed'
<i>Masculine plural marker in adj and nouns of Class I</i>	-i	*i	Triggers metaphony	'vɛcci	'old F.P.'	'vecci	'old M.P.'
				'nɔvi	'new F.P.'	'novi	'old M.P.'
				occi			'eyes'
<i>Masculine singular marker in adjectives and nouns of Class II</i>	-i	*e	Does not trigger metaphony	'kɔri	'heart'	*'kori	
				'sɔli	'sun'	*'soli	
<i>Verbal morpheme</i>		<i>Etymological origin</i>	<i>Status as metaphonic trigger</i>				
<i>1st person singular</i>	-u	*o	Does not trigger metaphony	'krɛðu	*krɛðu	'I believe'	
				'vɛŋgu	*vɛŋgu	'I come'	
				'dɔrmu	*dɔrmu	'I sleep'	

²⁴⁵ Cf. §II.3.3.4 for a discussion of the classification of nominal classes in Italian dialects.

<i>2nd person singular</i>	-i	*i	Does not trigger metaphony	'kreðisi	*kreðisi	'you believe'
				'venisi	*venisi	'you come'
				'dormisi	*dormisi	'you sleep'
<i>3rd person singular</i>	-i	*e	Does not trigger metaphony	'kreði	*kreði	'he believes'
				'veni	*veni	'he comes'
				'dormi	*dormi	'he sleeps'
<i>3rd person plural</i>	-inu	*unt	Does not trigger metaphony	'kreðinu	*kreðinu	'they believe'
				'veninu	*veninu	'they come'
				'dorminu	*dorminu	'they sleep'

RadSFP allows an analysis where final [i] in verbs receives a different representation from final [i] in nominal paradigms. Learners would perceive metaphonic alternations in nouns and adjectives and not in verbs, and would thus posit the existence of two different segments, one that contains the harmonic prime that spreads to preceding vowels and the other that does not.

Under (85) is provided the prime specification of vowels in the dialect of Mormanno. Metaphonic alternations in nouns and adjectives provide clues to learners that mid-high vowels alternate with high vowels and that mid-low vowels alternate with mid-high vowels. Learners would thus posit a prime specification for mid and high vowels similar to the one presented for Servigliano in section §6.2. In addition, learners would also notice that there are two other segments in the language that happen to occur in verbal morphemes, whose behavior in phonology is that of neutral vowels. They do not trigger harmony, and thus receive a prime specification that simply follows from contrast. Those two vowels receive the same phonetic implementation as high vowels, as shown in (85b). The PPI correlates the phonetic exponents [i] and [u] to the segments /I/ and /U/ respectively. Those segments have a different phonological behavior from that of high vowels /i/ and /u/, but they share the same pronunciation.

Finally, (85c) repeats the rules of metaphony from Servigliano, which also apply in Mormanno. Vowels with |α| raise when followed by vowels with |β|: mid-high vowels undergo a process of spreading, which result in them gaining the prime |β|, mid-low vowels undergo a process of |γ| delinking. /a/, /I/ and /U/ do not participate in the harmonic process.

(85) Prime specification of vowels in Mormanno

a. Prime specification of vowels

/a/	/e/	/ε/	/o/	/ɔ/	/i/	/u/	/I/	/U/
	α	α	α	α	α	α		
					β	β		
		γ	γ			δ		
			δ	δ				
							μ	π

b. Phonetic implementation at the PPI

Phonology			Phonetics
Segment	Prime specification		
/i/	$\alpha\beta$	\leftrightarrow	[i]
/I/	μ	\leftrightarrow	[i]
/u/	$\alpha\beta\delta$	\leftrightarrow	[u]
/U/	π	\leftrightarrow	[u]
/e/	α	\leftrightarrow	[e]
/ε/	$\alpha\gamma$	\leftrightarrow	[ε]
/o/	$\alpha\delta$	\leftrightarrow	[o]
/ɔ/	$\alpha\gamma\delta$	\leftrightarrow	[ɔ]
/a/	\emptyset	\leftrightarrow	[a]

c. Scalar raising: active processes in Mormanno

- $\alpha \rightarrow (\alpha + \beta) / _ C_0 \beta$
- $\alpha\gamma \rightarrow (\alpha\gamma - \gamma) / _ C_0 \beta$

The analysis proposed here does not require reference to morphological information. The morphosyntactic opposition between nominal suffixes (able to trigger metaphony) and verbal suffixes (unable to trigger metaphony) is represented only through phonological items. The vowels involved in the two suffixes have a different phonological representation and thus a different phonological behavior. This proposal is in line with the goal set by Newell & Ulfsbjörninn (2021): morphologically conditioned phonological processes can be formalized as purely phonological processes without resorting to explanations that require morphophonological rules.

Phonological terms are used to encode the differences between morphological objects that serve as metaphony triggers in a way that is consistent with domain specificity. This means that the distinction between verbal and nominal suffixes as metaphonic triggers is a difference between phonological representations rather than a difference in information available to morphology. The marker for masculine plural nouns and adjectives is /-i/, whereas the marker for the second person singular in the present tense is /-I/ (phonetically realized as [i]).

Notice that there are other morphemes that surface as [i] and that do not trigger metaphony. The feminine plural, which derives from etymological *e, is such a case.

One could speculate that the speaker began to treat the marker for the second person singular as an underlying /e/, instead of a different item /I/, and that a process of vowel reduction in final position turned all mid-vowels at the end of the word into high vowels. For example, the marker for the third person singular surfaces as [i] while deriving from an etymological *e. This still necessitates that a specific phonological process applied only in a certain morphological context: the final vowel of the verbal suffix /i/ lowered to [e] and was then grammaticalized as /e/, but this process applied only in verbs, and not to nouns and adjectives. This option has been already discussed in §IV.7.3, where it is shown that it would require the application of a morphophonological rule.

Even if this were the case, it would still need to be explained how speakers of Mormanno's dialect might come to understand that just a small subset of surface [i]s at the end of words serve as metaphonic triggers. There is no situation in which final surface [i] that corresponds to etymological *e alternates with mid-vowels, according to data proposed in Savoia (2015: 255f). Children learning the dialect of Mormanno have no access to the etymological origin of vowels, and only morpho-syntactic

information allows for the distinction between the surface [i] of a masculine plural noun and the [i] of a feminine plural noun, or of a verb.

A RadSFP framework allows us to represent the phonological process of metaphony in Mormanno from the children's point of view. Segments that cause metaphony will receive a phonological representation that reflects this fact since processes provide information about the internal representation of segments. To account for metaphony, it is not necessary to refer to morpho-syntactic information. Any theoretical framework that permits numerous phonological components to share the same phonetic interpretation can use this approach. This means that ET and the MCS theory, which allow for some 'slack' in the way they relate phonetics to phonological representations, can represent the case of Mormanno in the same way. In the terminology presented in this thesis, this indicates that two phonological items are mapped onto the same phonetic form.

VI.7.2.2. Cervara

A similar analysis is proposed for raising in Cervara. In this context, all high vowels cause raising; nevertheless, high vowels in verbal suffixes cause full raising, whereas high vowels in nominal suffixes cause scalar raising. This pattern, illustrated in IV.7.3, had a problem in that substance-based theory had to give the same properties to the two sets of vowels that cause metaphony. That is, the /i/ that appears on verbs and the /i/ that appears in nouns and adjectives both share the primes [+high] and [+ATR] when analyzed in a framework where feature specification derives from the phonetic quality of sounds. They both act as triggers for raising, as well. Metaphony applies in all contexts, but it operates differently with nouns and verbs.

First, I argue that learners of Cervara would notice the double behavior of mid-low vowels in the raising pattern at hand. That is, mid-low vowels display a different behavior in verbs, undergoing complete raising in metaphonic contexts instead of undergoing scalar raising, as happens in nouns and adjectives. RadSFP has at its disposal the possibility of positing multiple phonological segments which may map onto the same phonetic representation.

There are two options: either the language has two sets of mid-low vowels, which differ in the way they undergo raising, or the language has two sets of high vowels, which differ in the way they trigger raising. I tend to prefer an analysis that posits the existence of two distinct underlying triggers. This way, the additional segments (here defined as /I/ and /U/) would appear only in verbal suffixes, which is a closed class of lexical items. /I,U/ are vowels that trigger complete raising, while /i,u/ are vowels that trigger scalar raising. Under (86) is proposed a list of the suffixes that have /I/U/ and suffixes that have /i/ /u/, assuming this analysis.

(86) Metaphonic triggers in Cervara

<i>Phonological representation and phonetic implementation of metaphonic triggers in Cervara</i>			
<i>Nominal morphemes</i>			
<i>Masculine singular marker in adjectives and nouns of Class I</i>	[-u]	/u/	Trigger for scalar raising
<i>Masculine plural marker in adj and nouns of Class I</i>	[-i]	/i/	Trigger for scalar raising
<i>Verbal morphemes</i>			
<i>2nd person singular</i>	[-i]	/I/	Trigger for complete raising
<i>3rd person plural</i>	[-u]	/U/	Trigger for complete raising

A learner exposed to the dialect of Cervara perceives a series of alternations, shown under (87). (87a) shows metaphony triggered by nominal suffixes, which raise mid-low vowels to mid-high (i.e. it applies as scalar raising). (87b) shows metaphony triggered by verbal suffixes, which applies as complete raising.

(87) Alternations perceived by learners of the dialect of Cervara

a. Metaphony triggered by nominal suffixes

<i>/e/ → [i]/ C_{oi,u}</i>		<i>/o/ → [u]/ C_{oi,u}</i>	
frel'lenka	'vulva (vulg.)'	ne'pote	'nephew'
fril'linku	'penis (vulg.)'	ni'puti	'nephew'
		'kolema	'full F'
		'kulimu	'full M'
<i>ε → [e]/ C_{oi,u}</i>		<i>ɔ → [o]/ C_{oi,u}</i>	
'b:elle	'beautiful F PL'	'b:one	'good F PL'
'b:eλλi	'beautiful M PL'	'b:oni	'good M PL'

b. Metaphony triggered by verbal suffixes

<i>/e/ → [i]/ C_{oI,U}</i>		<i>/o/ → [u]/ C_{oI,U}</i>	
'vedo	'I see'	'korro	'I run'
'vidi	'you see'	'kurri	'you run'
'vede	'he sees'	'korre	'he runs'
'vidu	'they see'	'kurru	'they run'
<i>ε → [i]/ C_{oI,U}</i>		<i>ɔ → [u]/ C_{oI,U}</i>	
'meto	'I reap'	'kɔλλo	'I pick'
'miti	'you reap'	'kuλλi	'you pick'
'mete	'he reaps'	'kɔλλe	'he picks'
'mitu	'they reap'	'kuλλu	'they pick'

All mid-vowels, which are targeted by raising, are specified for a prime $|\alpha|$, which identifies targets. Also, all high vowels (both /i,u/ and /I,U/) behave as triggers for raising, and are thus specified for $|\beta|$.

The dialect of Cervara, as the dialect of Servigliano, displays pre-tonic raising of mid-vowels (cf. §II.3.4.2, cf. also 82) and never exhibits mid-low vowels in pre-tonic position (Merlo 1922: 30ff). We can thus borrow most of the prime specification from Servigliano. Mid-low vowels never occur in unstressed position, thus have a prime $|\gamma|$ that is delinked when they are unstressed. Mid-vowels share the prime $|\alpha|$, which identifies them as targets of raising, and high vowels have the prime $|\beta|$, which identifies them as triggers. The complete prime specification of vowels in Cervara is provided in (88), and is identical to that of Servigliano, except, of course, for the specification of /I,U/, which for now share the same specification as high vowels /i/ and /u/.

(88) Prime specification of vowels in Cervara (incomplete)

/a/	/e/ α	/ε/ α γ	/o/ α δ	/ɔ/ α γ δ	/i/ α β	/u/ α β δ	/I/ α β	/U/ α β δ
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The internal specification of /I/ and /U/ must be somehow different from that of /i/ and /u/ because they display a different phonological behavior. I argue that the difference between /i,u/ and /I,U/ is in the presence of an additional $|\beta|$ prime in the specification of /I,U/. In practice, this proposal recycles the insights presented in §IV.2.6 concerning incremental theories. Segments may contain multiple instantiations of the same prime.

I assume that the same rules discussed for Servigliano apply also in Cervara. So, mid vowels (identified by the prime $|\alpha|$) receive the prime $|\beta|$ from high vowels that follow them. Mid-low vowels also lose the prime $|\gamma|$ in the same context (and also when passing from stressed to unstressed). In simpler terms, metaphony applies exactly as in Servigliano, when it is triggered by /i/ and /u/. This is shown under (89). (89a) repeats the rules of metaphonic scalar raising that apply also in Servigliano. They are exemplified under (89b) and (89c)

(89) Scalar metaphony in Cervara applies exactly as in Servigliano.

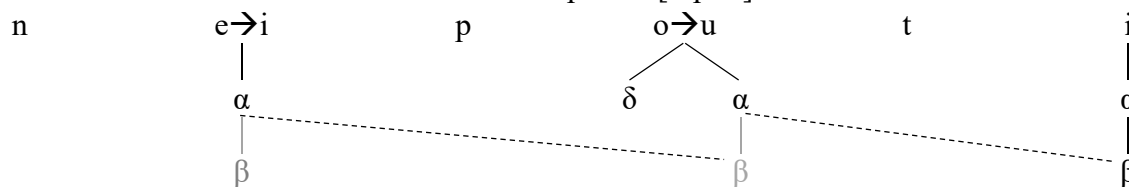
a. Metaphonic rules

$$\alpha \rightarrow (\alpha + \beta) / _ _ C_0 \beta$$

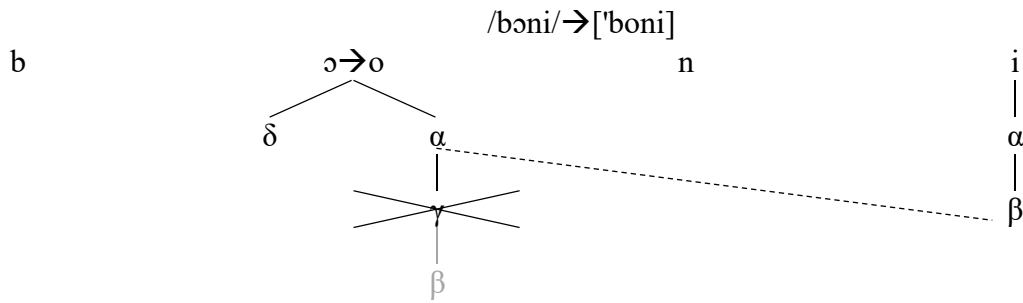
$$\alpha \gamma \rightarrow (\alpha \gamma - \gamma) / _ _ C_0 \beta$$

b. Raised mid-high vowels raise to high, and become valid triggers for preceding mid-vowels

$$/nepoti/ \rightarrow [niputi]$$



c. Raised mid-low vowels raise to mid-high vowels

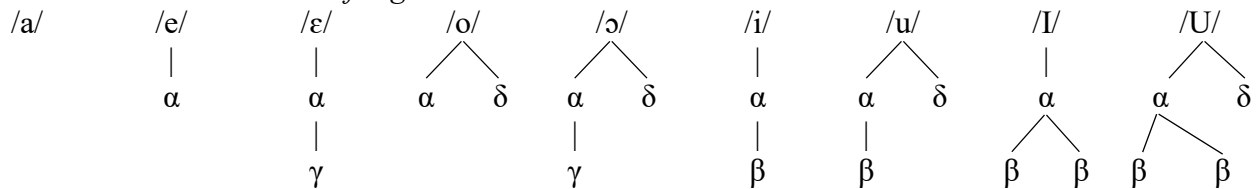


High vowels triggering scalar raising (nominal suffixes) spread $|\beta|$ to all mid vowels, and delinking of $|\gamma|$ applies and it entails delinking of $|\beta|$, which is positioned below $|\gamma|$.

High vowels triggering complete raising (i.e. verbal suffixes) display the same behavior, but apply $|\beta|$ spreading twice to mid-low vowels. Once $|\gamma|$ -delinking has taken place, mid-low vowels end up having the same representation of mid-high vowels. The second $|\beta|$ is therefore added to $|\alpha|$, resulting in a high vowel. The internal representation of segments of Cervara is proposed in (90a) Notice that /I/ and /U/ have two primes $|\beta|$, so that the rule of addition presented in (89a), $\alpha \rightarrow (\alpha + \beta) / _ C_0 \beta$, can apply twice. (90b) displays the application of scalar raising, which would end up with mid-low vowels turning to mid-high, (90c) displays the application of complete raising whereby mid-high vowels resulting from the first application of the two rules presented in (89a) again undergoes the rule that adds $|\beta|$.

(90) Complete and scalar raising in the dialect of Cervara

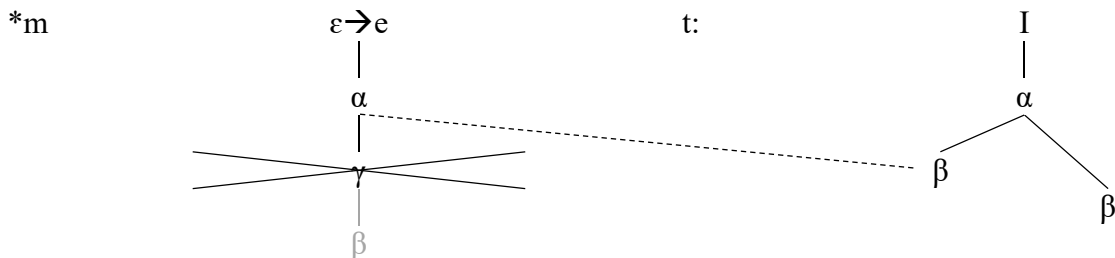
a. Internal structure of segments



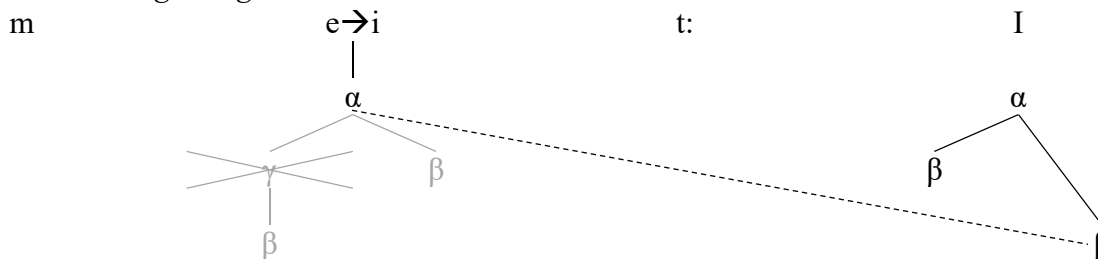
b. The metaphonic rules apply: mid-low vowels raise to mid-high

$$\alpha \rightarrow (\alpha + \beta) / _ C_0 \beta$$

$$\alpha \gamma \rightarrow (\alpha \gamma - \gamma) / _ C_0 \beta$$



c. Complete raising applies: the mid-high vowel resulted from (b) undergoes again the process, raising to high



VI.7.2.3. Conclusion

The properties of the PPI discussed in §V.4.5 allow for learners to posit the existence of multiple phonological items, which permits the treatment of the metaphonies of Cervara and Mormanno as purely phonological processes. As discussed in §V.2.2 interfaces between modules operate arbitrary mappings among the representations of the two domains. The analyses explored in §IV.7.3, based on innate fixed primes and that assumed a fixed PPI, was unable to treat as different phonological entities that act as a trigger for complete raising and a trigger for scalar raising, even if they exhibit a different phonological behavior. The issue was evident in the case of Cervara: high vowels in nouns and in verbs behave as triggers for metaphony, and thus (given innate primes) have to be specified for [+high], in a theory of representation where innate primes correlate with phonetics. The analyses proposed here frees phonology from the limitations of a universal set of primes and from the assumption that those primes have a fixed relation with phonetics. In doing so, we gain access to an analysis of Cervara raising that does not require us to scramble morphological and phonological domains in a morpho-phonological rule, nor to posit that all lexical items have multiple allomorphs.

VI.8 Conclusions and further research

VI.8.1. Three EL dialects and their analysis

Raising harmonies display a vast array of different patterns. They may apply as scalar or complete harmonies; they often display asymmetries of various kinds among which is a specific pattern, parasitic harmony, like in Camuno. Processes that involve raising vary in the set of triggers that may affect vowels, in the set of targets, and also in the way the process applies. It was shown in chapter IV that regular approaches are in trouble when facing these patterns, one recurrent obstacle being the fact that primes have a universal and innate phonetic correlate.

The case of Eastern Lombard dialects is emblematic. The three varieties at hand are extremely similar, to the point of being mutually intelligible. They also share the same vowel system, and most of the same phonological patterns. Regardless of all other similarities, those dialects each display a different harmonic pattern and speakers learn three different grammars.

There is some evidence that asymmetries and parasitic patterns have a phonetic cause (see §5.3): co-articulation is less advantageous in certain contexts, and thus may be limited between high rounded vowels and non-rounded mid-vowels.

I argue that this phonetic factor is ignored in Bresciano; it informs learners that /e/ is not a valid target for raising in Bergamasco; it is imported into the grammar as a parasitic pattern in Camuno. As is generally the case, phonological theory must be one that allows different grammars to be learned, not

one that duplicates phonetic causes in the phonology: in our case, there is no phonological reason for parasitism.

RadSFP maintains that primes are learned, not innate, and that they do not have a universal correlation with phonetics. In this chapter, two theories of prime learning were compared. The mechanism of prime emergence argued by Dresher (2014) fails to capture the behavior of parasitic harmonies without the developments proposed in Sandstedt (2018), which is able to account for asymmetric harmonies, but not for scalar processes. The mechanism of prime emergence proposed in Odden (2022), instead, manages to formalize asymmetric patterns as well as scalar and complete raising harmonies, and may therefore be seen as having an advantage as a theory of prime learning, at least for what concerns raising harmonies.

The peculiar properties of Raising Vowel Harmonies require a theory of prime learning that allows for non-contrastive primes to emerge, and where alternations are the primary source of information about the representation of segments.

VI.8.2. Prime learning: is contrast or processing the primary evidence?

In the course of the chapter, two models concerning prime emergence have been considered. The first one, proposed in Dresher (2014) and developed in Sandstedt (2018) to account for parasitic harmonies, hypothesizes that contrast is a central factor in prime learning, alongside alternations. Both approaches subscribe to the Contrastivist Hypothesis, and use the SDA in their theory of emergence. The one based on Odden (2022), instead, gives a logical precedence to alternations over contrast in prime emergence. In both cases, the discussion concerns the learning of primes, and not of the sound categories that are linguistically relevant for children.

The two models of prime learning share many assumptions. Odden (2022), Dresher (2014) and Sandstedt (2018) all agree that primes emerge, that there is no innate and universal set of primes, that primes have no innate or universal phonetic correlates, and that they emerge as a consequence of contrast and alternations perceived during acquisition.

The proposal advanced in Dresher (2014), unless developed in the direction proposed in Sandstedt (2018), cannot formalize parasitic harmonies. Given our assumptions about computation, the process would be considered as a double process of spreading, which would inform learners about the existence of a prime that is not contrastive, as discussed in §4.1.4. This means that an active prime is not contrastive, which contradicts the Contrastivist Hypothesis. Sandstedt (2018) introduces the notion of node, the idea that SDA is not the algorithm that generates primes but only a step in the building of a system, and the idea that segments reflect the internal structure built by the SDA. It also makes some additional assumptions concerning the way harmony is computed (empty nodes receive harmonic primes from donors, the selection of donors follows from the generalization that spreading may be halted by “picky” recipients). The result is a sound theory of asymmetric harmonies, which manages to account for symmetric, asymmetric and parasitic harmonies alike. The system shows some issues when facing scalar raising harmonies, though, as was shown in §6.1.

Odden (2022) does not subscribe to the Contrastivist Hypothesis, and considers contrast only a marginal factor in prime learning. What matters are alternations, which are the primary source of information about prime specification. Odden’s (2022) model of prime emergence, coupled with the assumptions about computation discussed in §3, results in a model where both raising harmonies and parasitic harmonies may be accounted for. Alternations inform learners about the set of triggers and targets of a phonological process. They may also inform them about the internal structuring of segments, which reflects the alternations perceived. Learners exposed to Camuno learn that the two harmonic

primes are hierarchically ordered, and that spreading of one of them entails spreading of the other. Learners exposed to the Servigliano dialect learn that the prime received by spreading is positioned below the prime that is delinked. It also allows for a formalization of morphologically conditioned metaphonies, which were problematic if analyzed with approaches based on substance-laden primes and that considered the interface between phonetics and phonology as innate and universal.

In the model of prime emergence proposed by Odden (2022: 41) contrast is still a relevant factor in learning, in that it ensures that segments have a distinct phonological representation. It may also have a direct role in prime learning, when phonological processing does not give enough information to distinguish between segments. In all the cases discussed in the chapter, rounded and non-rounded vowels were distinguished by primes that had no role in phonological computation.

The Contrastivist Hypothesis, which in a RadSFP framework disallows the emergence of active primes that do not have a contrastive role, is falsified by the parasitic harmony of Camuno, where two active primes must be posited, but only one of them is enough to contrastively identify /i/ from other vowels.

VI.8.3 Externalization, spreading and delinking

Phonological computation does not care about the way a phonological process externalizes. The only information available to learners are those provided by alternations. Mid-vowels raise (and thus are a phonological class), high vowels cause the raising (and are thus a phonological class as well), mid-low vowels and mid-high vowels raise in different ways (which informs learners about the structural difference between mid-high and mid-low vowels). It is our theory of computation, proposed in §3, that defines the possible ways in which children assign primes. An iterative process receives the formalization of spreading, a non-iterative harmony receives a formalization that corresponds to delinking. The phonological representation, both in prime assignation and in the way primes are structured within the segment, is derived from the alternations that children perceive.

A crucial insight is that the way the process behaves phonetically does not affect in any way the phonological formalization of the process. In §3.2.2 the process of Zulu raising was formalized as the subtraction of an element in a given context. This choice followed from the NEN as well as from the observation that the process does not iterate. The same formalization was used in section §6 to account for scalar raising in Servigliano and in other varieties. Since raised mid-low vowels do not behave as valid triggers, the process of raising that affects them is treated as subtraction of a prime. This, however, does not mean that all instances where mid-low vowels raise to mid-high must be formalized as subtraction of a prime. Consider raising of mid-low vowels in Kikuria, discussed in §II.3.1.3.9. Some alternations involving raising of mid-low vowels in Kikuria are recalled in (91): here raised mid-vowels behave as valid triggers for preceding mid-vowels, i.e. Kikuria raising is iterative. Notice that the outcome of a mid-low vowel is, exactly as in Zulu, a mid-high vowel. The process of Kikuria raising, however, must be formalized as spreading of a prime, because unlike in Zulu spreading is iterative.

(91) Raising of mid-low vowels in Kikuria

erem-ya	'make swim!'	εrεm-a	'swim'
uku-eegek-ya	'to prop up'	ukw-εεgek-a	'to be propped up'
oyok-ya	'make greedy!'	oyək-a	'be greedy'
ok-ooyok-ya	'to make greedy'	ok-ooyoka	'to be greedy'
orok-ya	'verify!'	oroka	'come out!'

The examples under (91) show that raising of mid-low vowels, triggered by the causative suffix, propagates to all mid-vowels of the word in Kikuria. Targets of raising behave as triggers for preceding mid-vowels, which means, after §3.2.1, that this process is formalized as spreading of a prime. This means that the same surface alternation, say /ε/→[e]/__i/, receives different phonological analyses in different systems depending on the phonological behavior displayed. In Zulu, the process does not behave as iterative and thus is formalized as subtraction of a prime, in Kikuria it is iterative, and therefore mid-low raising in Kikuria qualifies as addition of primes. The physical implementation of the phonological process does not say anything about the way it is computed nor represented in the phonological component.

VI.8.4 A theory of prime-emergence requires a theory of representation and a theory of computation

That primes can be learned is, by itself, an empty statement. Primes and other phonological items only exist within a system of phonological rules and representations. Hypotheses about prime learning are meaningless without a theory of phonology that addresses the issues of what kind of representations are learned and what kind of operations are possible over those representations.

In this chapter, both a theory of representation and a theory of computation have been proposed and defended. The following sections summarize the proposals made in the outset of the chapter.

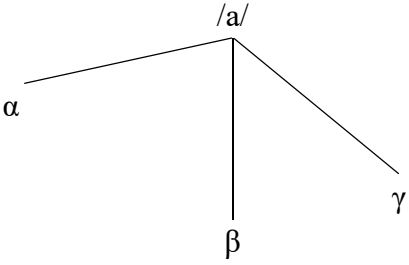

VI.8.4.1 Phonological representation

For what concerns the melodic side of phonology, the proposal is that there is just one kind of item that exist: the prime. Following Odden's reasoning, primes are here supposed to be unary (cf. Odden 2022: 3; as well as §2). This property of primes has great consequences for the theory of computation proposed, since the possible operations involving melodic items vary depending on the properties of primes. We argued that two basic operations, addition or subtraction of primes, are enough to exhaust the possible list of processes. This, however, follows from the unary nature of primes: if binary primes were employed, other operations may be possible. For example, processing may modify the value of the binary prime, turning a prime [+A] into [-A].

The analyses of raising harmonies discussed in this chapter hold that segments display an internal structure, where primes may enjoy different relations. The parasitism of Camuno was analyzed as a process whereby two primes are spread at the same time, and in scalar raising two primes are subtracted simultaneously.

Here only two kinds of intra-segmental relation have been proposed: primes may be unordered (as in 92a) or hierarchically ordered, as in (92b).

(92) Internal structure of a segment /a/: $|\alpha\beta\gamma|$

<i>a. Primes are unordered</i>	<i>b. Primes are hierarchically ordered</i>
	

It was shown in which way this distinction contributes to the analysis of Camuno and other patterns (Servigliano, Foggia), but no assumption is made that this is the only representational tool that exists. I leave it an open question whether other relations between primes need to be made operational.

Notice that those representations correspond exactly to the possible relation between primes in a traditional feature geometry (Clement & Hume 1995), and when primes are affected by a process, they behave exactly as they did in traditional autosegmental approaches. For instance, if a process adds a prime $|\alpha|$ from /a/ represented in (92b) to another segment, the process spreads the prime $|\alpha|$ as well as all other primes that are hierarchically ordered beneath it. A process that delinks $|\beta|$ in the representation proposed in (92b) affects also the prime $|\gamma|$, which is hierarchically ordered beneath $|\beta|$. A prime geometry can exist, and is a useful tool in representing phonological processes and segments, even in an emergentist environment that employs substance-free primes with an arbitrary correlation with phonetics.

VI.8.4.2 Phonological computation

This thesis does not defend a fully-fledged theory of phonological computation, but rather introduces some building bricks that ought to be consistent with RadSFP.

First and foremost, the theory of computation introduced concerns only melody (i.e. the part of phonology below the skeleton). Processes that affect or involve structural items at or above the skeleton are not treated here.

The analyses proposed in this chapter assumed that phonological computation can manipulate primes in two ways. It can add primes through spreading from a neighboring segment, or it can remove a prime in a melodic or positional context (through subtraction). Whether other operations are necessary is an open question.

As discussed above, the possible operations correspond exactly to those that were possible in an Autosegmental environment: linking/spreading corresponds to an addition of primes, delinking to the removal of a prime.

Another aspect of phonological computation that should be further developed concerns the contexts in which multiple processes are equally viable formalizations for a perceived alternation. Iterative harmonies were formalized as addition of primes due to the fact that a harmonized vowel behaves as a harmonic trigger. Non-iterative harmonies were formalized as suppression of a prime because of the NEN (cf. 17). However, what about a simple vowel-to-consonant assimilation, say a palatalization? Either a segment receives a prime from a neighboring one (as in traditional Autosegmental approaches)

or a segment loses a prime. The theory proposed here suggests that both operations are viable. Which one applies? Alternatively, is there another kind of process that may apply in the same context?

What this thesis demonstrates, I hope, is that a theory of phonology based on a set of innate primes that enjoy universal phonetic correlates is unfit to account for raising harmonies, and that a phonology where primes are learned alongside their correlation with phonetics is a valid alternative. Phonological analyses are still possible, and can still provide insight about the behavior of segments in phonological systems, even in an environment where emergent substance-free primes are used.

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Appendix

In this appendix are reported the results of the fieldwork carried out in Eastern Lombardy between December 2018 and August 2021. The appendix recalls the tables previously shown in §III.45 and §III.55 and shows the answers that speakers gave during the elicitation task. Tokens are shown in the order they were produced by speakers. Where [x]s are shown in the table, it means that the participant was shown the image and was not able to answer or refused to do so. Cases of disharmony are highlighted. Forms reported in red correspond to disharmonies of the type E-i (an unrounded mid-vowel is followed by /i/ and does not raise). Forms in green correspond to disharmonies of the type E-u (an unrounded mid-vowel is followed by /u/ or /y/ and does not raise), yellow indicates disharmonies of the type O-i/Ø-i and orange indicates disharmonies of the type O-u/Ø-u. The same colors are used for speakers of Bresciano (where sequences E-u are ungrammatical) and for speakers of Camuno (where sequences E-u are grammatical). Few occasions where /e/ behaves as transparent and not as a blocker in Camuno (the issue is discussed in chapter III) are highlighted in blue.

RA: 80 years old, female speaker of Bresciano

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	126	115	11	2	6	1	0	1	1
		91.3%	8.7%	1.6%	4.7%	0.8%		0.8%	0.8%
E	48	43	5	2	3				
		89.6%	10.4%	4.2%	6.2%				
O	25	24	1			1	0		
		96%	4%			4%			
Ø	7	5	2					1	1
		71.4%	28.6%					14.3%	14.3%
E-E	12	11	1	0	1				
		91.7%	8.3%		8.3%				
E-O	4	3	1	0	1	0	0		
		75%	25%		25%				
E-Ø	2	1	1	0	1			0	0
		50%	50%		50%				
O-E	22	22	0	0	0	0	0		
		100%							
O-O	1	1	0			0	0		
		100%							
Ø-E	5	5	0	0	0			0	0

ENG	Bresciano	DIM	AUG
<i>dog</i>	'ka	ka'ni	ka'nu
<i>tooth</i>	'dent	din'ti	den'tu
<i>artichoke</i>	kar'tʃɔfo	kartʃu'fi	kartʃu'fu
<i>hand</i>	'ma	ma'nina	ma'nuna
<i>glass</i>	'vedre	vedra'si	vedra'su
<i>sausage</i>	sa'lam	sala'mi	sala'mu

ENG	Bresciano	DIM	AUG
<i>mountain trail</i>	sen'ter	sinti'ri	sente'ru
<i>cup</i>	skø'dɛla	skydi'lina	skydi'luna
<i>duck</i>	'nedra	ni'dri	ne'drɔt
<i>chair</i>	'skapɔ	skapi'lina	skapi'luna
<i>hat</i>	bɛ'ret	biri'ti	biri'tu
<i>sock</i>	kal'set	kalsi'ti	kalsi'tu

ENG	Bresciano	DIM	AUG
<i>apron</i>	biga'rəl	bigaru'li	bigaru'lu
<i>rabbit</i>	ko'netʃ	kuni'tʃi	kuni'tʃu
<i>pan</i>	pa'dɛla	padi'lina	padi'luna
<i>horse</i>	ka'al	kaa'li	kaa'lu
<i>saw</i>	'rasega	rase'gɔta	rasega 'grɔsa
<i>apple</i>	'pom	pumi'li	pumi'lu
<i>church</i>	'tʃeza	tʃi'zina	tʃi'zuna
<i>book</i>	'liber	libri'si	x
<i>hare</i>	'legor	x	x
<i>stainbeck</i>	'bek	be'ki	be'ku
<i>fig</i>	'fik	x	x
<i>bell</i>	kampa'nɛl a	kampani'lin a	kampani'lun a
<i>calf</i>	ve'del	vidi'li	vidi'lu
<i>nail</i>	'tʃot	tʃudi'li	tʃu'du
<i>potato</i>	pa'tata	pata'tina	pata'tuna
<i>dustpan</i>	pa'leta	pali'tina	pali'tuna
<i>goose</i>	'oka	u'kina	o'kɔta
<i>belly</i>	'pansa	pan'sina	pan'suna
<i>owl</i>	si'ɛta	x	x
<i>tree</i>	'pjanta	pjan'tina	pjan'tuna
<i>tree</i>	'alber	albe'ri	albe'ru
<i>candle</i>	kan'dɛla	kandi'lina	kande'lɔta
<i>mushroom</i>	'fons	fun'zi	fun'zu
<i>boletus edulis</i>	legor'sɛla	ligursi'lina	legorse'lɔta
<i>cow</i>	'aka	a'kina	a'kɔta
<i>bed</i>	'let	li'ti	li'tu
<i>pig</i>	'si	sina'tɛl	sina'tu
<i>pig</i>	ma'jal	maja'li	maja'lu
<i>pig</i>	por'sɛl	pursi'li	pursi'lu
<i>snail</i>	lɔ'maga	x	x
<i>trousers</i>	'brage	bra'gine	bra'gune
<i>mouth</i>	'boka	bu'kina	bo'kasa
<i>funnel</i>	turta'rəl	turtaru'li	x
<i>mustaches</i>	'bafi	ba'fetʃ	ba'fu
<i>glass</i>	bi'tʃer	bitʃi'ri	bitʃi'ru
<i>fog*</i>	'gɛba	x	x
<i>house</i>	'kaza	kazi'lina	kazi'luna
<i>rock</i>	'preda	pri'dina	x
<i>cat</i>	'gat	ga'ti	ga'tu

ENG	Bresciano	DIM	AUG
<i>bag</i>	'borsa	bursi'tina	bursi'tuna
<i>priest</i>	'pret	preta'si	preta'su
<i>bat</i>	gri'napola	gri'napo'lina	x
<i>fly</i>	'moska	mus'ki	mus'ku
<i>tshirt</i>	ma'ina	mai'tina	mai'tuna
<i>boy</i>	'naro ja'rɛl	ɲari'li	x
<i>eye</i>	'ɔtʃ	y'tʃi	x
<i>dress</i>	vis'tit	visti'di	visti'du
<i>horn</i>	'koren	korna'tʃi	x
<i>goat</i>	'kavra	kav'rina	x
<i>sheep</i>	'pekora	piku'rina	piku'runa
<i>toilet</i>	x	x	x
<i>bread</i>	'pa	pa'ni	x
<i>pendulum clock</i>	'pendol	pendu'li	x
<i>key</i>	'tʃaf	tʃai'tina	tʃai'tuna
<i>cock</i>	'gal	gali'li	gali'lu
<i>donkey</i>	'azen	az'ni	az'nu
<i>nun</i>	'swɔra	muni'gina	swo'rɔta
<i>bird</i>	o'zɛl	uzi'li	uzi'lu
<i>egg</i>	'ɔf	ɔfa'zi	ɔfa'zu
<i>comb</i>	'peten	piti'ni	piti'nu
<i>lyzard</i>	lɔ'zertola	lyzir'tina	lyzir'tuna
<i>wolf</i>	'lupo	x	x
<i>skinny</i>	'mager	magru'li	magru'lu
<i>door</i>	'porta	pur'tina	pur'tu
<i>leg</i>	'gamba	x	gam'buna
<i>charriot</i>	ka'ret	kari'ti	kari'tu
<i>ear</i>	o'retʃ	uri'tʃina	uri'tʃuna
<i>brother</i>	fre'dɛl	fradi'li	
<i>rat</i>	so'rek	suri'gi	suri'gu
<i>brick</i>	kwa'drɛl	kwadri'li	kwadre'lɔt
<i>butter*</i>	x	x	x
<i>flour</i>	'fjur	fjuri'li	fjuri'lu
<i>tomato</i>	pon'dor	pundu'ri	x
<i>lady</i>	'fonna	x	fun'nuna
<i>orange</i>	porto'gal	portoga'li	x
<i>sister</i>	so'rɛla	suri'lina	x
<i>brain</i>	ser'vel	sirvi'li	sirvi'lu
<i>coffin</i>	'bara	bari'lina	x
<i>foal</i>	pu'leder	puli'dri	puli'dru
<i>nose</i>	'nas	nazi'li	nazi'lu
<i>knot</i>	'grop	grupi'ti	grupi'tu

ENG	Bresciano	DIM	AUG
<i>bottle</i>	'bɔsa	busi'tina	busi'tuna
<i>zucchini</i>	sø'kɛl	suki'li	x
<i>devil</i>	'djaol	djau'li	djau'lu
<i>doctor</i>	du'tur	dutu'ri	x
<i>sheet</i>	lɛn'søl	linsu'li	x
<i>plum</i>	'brɔɲa	bru'ɲi	x
<i>crow</i>	'kɔrf	x	x
<i>boat</i>	'barka	bar'keta	bar'ku
<i>ham</i>	pɛr'søt	pɛrsy'ti	x
<i>peach</i>	'pɛsek	pirsi'gi	pirsi'gu
<i>pruning knife</i>	ron'kaja	ronka'i	ronka'ju
<i>pruning knife</i>	po'det	pudi'ti	x
<i>pot</i>	pɛ'ɲata	pɛɲa'tina	pɛɲa'tuna
<i>fish</i>	'pɛs	pifju'li	pifju'lu
<i>cherry</i>	sa'reza	sari'sina	sari'suna

ENG	Bresciano	DIM	AUG
<i>spoon</i>	ky'dʒa	kydʒa'ni	kudʒa'nu
<i>salad</i>		x	x
<i>umbrella</i>	om'bɾɛla	umbri'li	umbri'lu
<i>phaesant</i>	fa'za	faza'net	faza'nu
<i>old man</i>	'vɛtʃo	vɛtʃa'si	vɛtʃa'su
<i>nail</i>	'øndʒa	øndʒina	øndʒuna
<i>mouse</i>	so'rek	suri'gi	sorga'tu
<i>pear</i>	'pɛr	piru'li	piru'lu
<i>finger</i>	'dit	x	x
<i>pine tree</i>	pa'gɛr	pagi'ri	pagi'ru
<i>dumpling</i>	'ɲɔk	ɲo'kɛt	x
<i>necklace</i>	ko'lana	kola'nina	kola'nuna
<i>knife</i>	kor'tɛl	kurti'li	kurti'lu
<i>fountain</i>	fon'tana	fonta'nina	x
<i>strawberry</i>	ma'øla	mau'lina	maø'lot
<i>mule</i>	'myl	x	x

AA: 91 years old, male speaker of Bresciano

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	117	96	21	10	5	1	4	0	1
		82.1%	17.9%	8.5%	4.3%	0.8%	3.4%		0.8%
E	36	32	4	3	1				
		88.9%	11.1%	8.3%	2.7%				
O	33	28	5			1	4		
		84.8%	15.2%			3.1%	12.1%		
Ø	10	9	1					0	1
		90%	10%						10%
E-E	8	3	5	5	0				
		37.5%	62.5%	62.5%					
E-O	6	4	2	0	2	0	0		
		66.7%	33.3%		33.3%				
E-Ø	1	1	0	0	0			0	0
		100%							
O-E	17	17	0	0	0	0	0		
		100%							
O-O	2	2	0			0	0		
		100%							
Ø-E	4	0	4	2	2			0	0
			100%	50%	50%				

ENG	Bresciano	DIM	AUG
<i>mountain trail</i>	sen'ter	sente'ri	x
<i>cup</i>	x	ta'sina	ta'suna
<i>duck</i>	'nedra	ne'dri	ni'dru
<i>chair</i>	'skapa	ska'ji	x
<i>hat</i>	ka'pel	kapi'li	kapi'lu
<i>sock</i>	kal'set	kalsi'ti	kalsi'tu
<i>apron</i>	biga'røl	bigaru'li	x
<i>blind</i>	x	x	x
<i>rabbit</i>	ko'netʃ	kuni'tʃi	kuni'tʃu
<i>pan</i>	pa'dela	padi'lina	padi'luna
<i>horse</i>	ka'al	kaa'li	kaa'lu
<i>saw</i>	'sega	se'get	x
<i>apple</i>	'pom	pumi'li	pumi'lu
<i>church</i>	'tʃesa	tʃizu'lina	tʃi'zuna
<i>wood</i>	'lep	x	x
<i>book</i>	'liber	libri'ti	li'bru
<i>hare</i>	le'gor	ligur'si	ligu'ru
<i>stainbeck</i>	'bek	x	x
<i>fig</i>	'fik	figi'ti	x
<i>bell</i>	kampa'nel	kampani'li	x
<i>calf</i>	ve'del	vidi'li	x
<i>nail</i>	'tʃot	tʃudi'li	tʃudi'lu
<i>potato</i>	pa'tata	pata'tina	pata'tuna
<i>dustpan</i>	pa'leta	x	x
<i>goose</i>	'oka	u'ki	o'kuna
<i>belly</i>	'pansa	pan'sina	pan'suna
<i>owl</i>	x	x	x
<i>tree</i>	'pjanta	x	pjantu
<i>candle</i>	kan'dela	kandi'li	kandi'lu
<i>mushroom</i>	'fons	fun'zi	fun'zu
<i>cow</i>	'aka	x	x
<i>bed</i>	'let	le'ti	li'tu
<i>pig</i>	por'sel	maja'li	maja'lu
<i>pig</i>	por'sel	pursi'li	x
<i>snail</i>	lø'maga	luma'gi	luma'gu
<i>trousers</i>	'brage	x	x
<i>mouth</i>	'boka	bu'ki	buki'tu
<i>funnel</i>	turta'røl	turtaru'li	x
<i>mustaches</i>	'bafi	barbi'ti	x
<i>glass</i>	bi'tʃer	bitʃe'ri	bitʃe'ru
<i>house</i>	'ka	kazi'ti	ka'zu
<i>rock</i>	'prede	pridi'li	pri'du

ENG	Bresciano	DIM	AUG
<i>cat</i>	'gat	ga'ti	ga'tu
<i>bag</i>	bor'seta	bur'si	bur'suna
<i>priest</i>	'pret	pri'ti	pri'tu
<i>bat</i>	gri'napole	gri'napu'li	x
<i>fly</i>	'moska	mus'ki	mus'ku
<i>tshirt</i>	ma'ina	ma'i	ma'ju
<i>boy</i>	'naro	pari'li	pari'lu
<i>eye</i>	'øʃ	u'tʃi	u'tʃu
<i>dress</i>	vis'tit	visti'di	x
<i>horn</i>	ku'ræn	kurna'tʃi	kura'tʃu
<i>goat</i>	'kavra	ka'vri	ka'vru
<i>sheep</i>	'pegora	api'li	api'lu
<i>bread</i>	'pa	pa'ni	pa'nu
<i>slices of bread</i>	'fete	fi'tine	fi'tune
<i>pendol clock</i>	'pendola	pindu'li	pindu'lu
<i>key</i>	'tʃaf	tʃai'zi	tʃai'tu
<i>cock</i>	'gal	gali'ti	gali'tu
<i>donkey</i>	'azen	az'ni	x
<i>nun</i>	'swœra	swo'rine	swœ'runa
<i>bird</i>	'paser	x	x
<i>egg</i>	'øf	y'vi	o'vu
<i>comb</i>	'petæn	piti'ni	peti'nu
<i>lyzard</i>	lø'zertola	løzer'ti	løzer'tu
<i>wolf</i>	'luf	x	x
<i>skinny</i>	'mager	ma'gri	ma'gru
<i>door</i>	'porta	purtun'si	pur'tu
<i>leg</i>	'gamba	gam'bina	gam'bu
<i>charriot</i>	ka'ret	kara'ti	kara'tu
<i>ear</i>	o'retʃa	uri'tʃi	uri'tʃu
<i>brother</i>	fra'del	fradi'li	x
<i>rat</i>	'sorga	suri'gi	suri'gu
<i>brick</i>	kwa'drel	kwadri'li	x
<i>flour</i>	'fjur	fjuri'li	fjuri'lu
<i>tomato</i>	pon'dor	pundu'ri	pundu'ru
<i>lady</i>	'fonna	fun'ni	fun'nu
<i>orange</i>	porto'gal	purtoga'li	x
<i>sister</i>	so'rela	x	x
<i>brain</i>	ser'vel	sirvi'li	servi'lu
<i>coffin</i>	'kasa del 'mort	x	x
<i>foal</i>	po'leder	puli'dri	puli'dru

ENG	Bresciano	DIM	AUG
<i>nose</i>	‘nas	na’zi	na’zu
<i>knot</i>	‘grop	gru’pi	gru’pu
<i>bottle</i>	bu’tiʎa	buti’ʎi	buti’ʎu
<i>zucchini</i>	kø’kømer	kukøme’ri	kokome’ru
<i>meat roll</i>		mombu’li	x
<i>devil</i>	‘djaol	djau’li	djao’lu
<i>doctor</i>	du’tur	dutu’ri	dutu’ru
<i>sheet</i>	len’søl	linsu’li	linsu’lu
<i>plum</i>	‘brøpe	x	x
<i>crow</i>	‘kørf	kur’vi	kur’vu
<i>boat</i>	‘barka	bar’ki	barki’tu
<i>ham</i>	pør’søt	x	x
<i>peach</i>	‘persek	persi’gi	persi’gu
<i>pruning knife</i>	‘ronkola	runki’ti	run’ku
<i>pruning knife</i>	po’det	pudi’ti	purki’tu
<i>pot</i>	pi’jata	pipa’ti	pipa’tu
<i>pan</i>	pa’dela	padi’li	padi’lu

ENG	Bresciano	DIM	AUG
<i>fish</i>	‘pēs	piʎi’ti	piʎi’tu
<i>cherry</i>	sa’resa	sari’zi	x
<i>spoon</i>	ky’dzat	kydza’ni	kydza’nu
<i>salad</i>	ver’dyra	x	x
<i>umbrella</i>	om’breʎa	umbri’li	umbri’lu
<i>phaesant</i>	fa’za	x	uzi’lu
<i>old man</i>	‘vetʃ	vetʃu’li	x
<i>finger nail</i>	‘øndʒa	un’dʒi	un’dʒu
<i>mouse</i>	so’rek	suri’gi	suri’gu
<i>pear</i>	pe’er	peru’li	x
<i>finger</i>	‘dit	x	di’tu
<i>pine tree</i>	‘pi	pi’ni	pi’nu
<i>dumplings</i>	‘ʒøk	ʒuki’ti	ʒuki’tu
<i>necklace</i>	ko’lana	kola’nina	x
<i>knife</i>	kor’tel	kurti’li	kurti’lu
<i>fountain</i>	fon’tana	fonta’ni	fonta’nu
<i>strawberry</i>	ma’øʎa	mau’li	mau’lu
<i>mule</i>	‘myl	myla’ti	x

AT: 78 years old, female speaker of Bresciano

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	126	84	42	13	14	10	4	0	1
		66.7%	33.3%	10.3%	11.1%	7.9%	3.1%		0.1%
E	40	25	15	7	8				
		62%	37.5%	17.5%	20%				
O	26	17	9			6	3		
		65.4%	34.6%			23.1%	11.5%		
Ø	8	8	0					0	0
		100%							
E-E	12	4	8	5	3				
		33.3%	66.7%	41.7%	25%				
E-O	8	6	2	0	0	1	1		
		75%	25%			12.5%	12.5%		
E-Ø	4	1	3	0	2			0	1
		25%	75%		50%				25%
O-E	20	17	3	0	0	3	0		
		85%	15%			15%			
O-O	2	2	0			0	0		
		100%							
Ø-E	6	4	2	1	1			0	0
		66.7%	33.3%	16.6%	16.6%				

ENG	Bresciano	DIM	AUG
<i>dog</i>	'ka	ka'ni	ka'ņu
<i>tooth</i>	'det	den'ti	din'tu
<i>artichoke</i>	arti'tʃɔk	artitʃu'ki	arti'tʃu
<i>hand</i>	'ma	ma'nina	ma'nuna
<i>glass</i>	'veder	x	x
<i>sausage</i>	sa'lam	sala'mi	sala'mu
<i>mountain trail</i>	sen'ter	sente'ri	sente'ru
<i>cup</i>	skø'dela	skydi'lina	skydi'luna
<i>duck</i>	ne'drɔt	nidru'ti	nidru'tu
<i>chair</i>	'skapɔ	x	x
<i>hat</i>	be'ret	beri'ti	bere'tu
<i>sock</i>	kal'set	kalsi'ti	kalse'tu
<i>apron</i>	bega'rəl	begaru'li	x
<i>rabbit</i>	ko'netʃ	kuni'tʃi	kuni'tʃu
<i>pan</i>	pa'dela	padi'lina	x
<i>horse</i>	ka'al	kaa'li	kaa'lu
<i>saw</i>	'sega	se'gina	se'guna
<i>apple</i>	'pom	pumu'li	pumi'lu
<i>church</i>	'tʃeza	tʃezu'lina	tʃe'zuna
<i>wood</i>	'lep	lepun'si	li'ņu
<i>book</i>	li'ber	libri'ti	libru'tu
<i>hare</i>	'legor	ligu'rina	ligu'runa
<i>stainbeck</i>	ka'vru	x	x
<i>fig</i>	'fik	fi'ki	fi'ku
<i>bell</i>	kampa'nel	kampani'li	kampani'lu
<i>calf</i>	ve'del	vidi'li	vidi'lu
<i>nail</i>	'tʃot	tʃodi'li	tʃodi'lu
<i>potato</i>	pa'tata	x	x
<i>dustpan</i>	pa'leta	pali'tina	pali'tuna
<i>goose</i>	'oka	u'kina	u'kuna
<i>belly</i>	'pansa	panse'tina	pansi'tuna
<i>owl</i>	sa'eta	sae'tina	sae'tuna
<i>tree</i>	'pjanta	pjanti'lina	pjan'tuna
<i>candle</i>	kan'dela	kandi'lina	kandi'luna
<i>mushroom</i>	'fons	funzi'ti	fun'zu
<i>cow</i>	'aka	a'kina	a'kuna
<i>bed</i>	'let	li'ti	li'tu
<i>pig</i>	por'sel	pursi'li	pursi'lu
<i>snail</i>	lø'maga	løma'gina	løma'gota
<i>trousers</i>	'brage	bra'gine	bra'gune
<i>mouth</i>	'boka	bu'kina	bu'kuna

ENG	Bresciano	DIM	AUG
<i>funnel</i>	torta'rəl	turtaru'li	torta'ru
<i>mustaches</i>	ba'fi	bafi'ti	bafi'tu
<i>glass</i>	bi'tʃer	bitʃe'ri	bitʃe'ru
<i>fog*</i>	'nebja	nibju'lina	ni'bju
<i>house</i>	'kaza	ka'zi	ka'zuna
<i>rock</i>	'preda	pridu'lina	pre'duna
<i>cat</i>	'gat	ga'ti	ga'tu
<i>bag</i>	'borsa	bor'sina	bor'suna
<i>priest</i>	'pret	preta'si	preta'su
<i>bat</i>	x	x	x
<i>fly</i>	'moska	mus'ki	mos'ku
<i>tshirt</i>	'maja	ma'ina	maj'una
<i>boy</i>	'stʃa	stʃati'li	x
<i>eye</i>	'øtʃ	u'tʃi	otʃa'u
<i>dress</i>	vis'tit	visti'di	visti'du
<i>horn</i>	'korɛn	x	x
<i>goat</i>	'kavra	ka'vri	ka'vru
<i>sheep</i>	'pegore	pigo'rina	pego'runa
<i>toilet</i>	x	x	x
<i>bread</i>	'pa	pa'ni	pa'nɔt
<i>pendulum clock</i>	x	x	x
<i>key</i>	'tʃaf	tʃa'ina	x
<i>cock</i>	'gal	gali'ti	x
<i>donkey</i>	'azen	azi'ni	azi'nɔt
<i>nun</i>	'swɔra	swɔ'rina	swɔ'runa
<i>bird</i>	o'zel	uzi'li	x
<i>egg</i>	'øf	ui'ti	x
<i>comb</i>	'peten	piti'ni	peti'nu
<i>lyzard</i>	lø'zerta	lozer'tina	lozer'tuna
<i>wolf</i>	'lupo	x	x
<i>skinny</i>	'mager	ma'gri	ma'grɔt
<i>door</i>	'porta	porti'lina	pur'tu
<i>leg</i>	'gamba	gam'bina	gam'buna
<i>charriot</i>	ka'ret	kari'ti	kari'tu
<i>ear</i>	o'retʃa	ori'tʃina	uri'tʃu
<i>brother</i>	fra'del	fradi'li	fradi'lu
<i>rat</i>	so'rek	suri'gi	sur'guna
<i>brick</i>	kwa'drɛl	kwa'dri	kwadri'lu
<i>flour</i>	'fjur	fjuri'li	fju'ru
<i>tomato</i>	pon'dor	pundu'ri	pundu'ru
<i>lady</i>	'sjura	sju'rina	sju'runa

ENG	Bresciano	DIM	AUG
<i>orange</i>	porto'gal	portoga'li	portoga'lu
<i>sister</i>	so'rela	suri'lina	suri'luna
<i>brain</i>	ser'vel	servi'li	servi'lu
<i>foal</i>	po'leder	puli'dri	puli'dru
<i>nose</i>	'nas	na'zi	na'zu
<i>knot</i>	'grop	grupi'li	grupi'lu
<i>bottle</i>	bu'tilja	x	butilju
<i>zucchini</i>	zø'kel	syki'li	syki'lu
<i>pig-roll</i>	mombo'li	mombi'li	x
<i>devil</i>	'djaol	djau'li	djau'lu
<i>doctor</i>	du'tur	dutu'ri	dutu'ru
<i>sheet</i>	len'søl	linsu'li	lenso'lu
<i>plum</i>	'brøna	bro'jina	bro'jota
<i>crow</i>	x	x	x
<i>boat</i>	'barka	barke'tina	barke'tuna
<i>ham</i>	per'søt	persu'ti	persu'tu
<i>peach</i>	'persek	pirsi'gi	perse'gu
<i>lazy</i>	x	x	x
<i>priuning knife</i>	po'det	pudi'ti	pudi'tu

ENG	Bresciano	DIM	AUG
<i>pot</i>	pi'jata	pija'tina	pija'tuna
<i>fish</i>	'pes	pisu'li	pi'su
<i>cherry</i>	'kalem	kala'mi	x
<i>spoon</i>	ky'tja	kytja'ni	kutja'nu
<i>salad</i>	insa'lata	sala'tina	insala'tuna
<i>umbrella</i>	om'brëla	ombri'lina	ombri'lu
<i>phaesant</i>	fa'za	x	x
<i>old man</i>	'vetfo	vetja'si	vetja'søt
<i>nail</i>	'ondza	un'dzina	un'dzuna
<i>mouse</i>	so'rek	suri'gi	sur'guna
<i>pear</i>	pe'er	piru'li	piru'lu
<i>finger</i>	'dit	miju'li	x
<i>pine tree</i>	'pi	pi'ni	x
<i>dumplings</i>	'jøk	jukiti	x
<i>necklace</i>	ko'lana	kolan'ina	kolan'una
<i>knife</i>	kol'tel	kulti'li	kulti'lu
<i>fountain</i>	fon'tana	fonta'nina	fonta'nuna
<i>strawberry</i>	ma'øla	mau'lina	x
<i>mule</i>	x	x	x

LBI: 81 years old, female speaker of Bresciano

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	144	121	23	7	13	3	0	0	1
		84.1%	15.9%	4.9%	9%	2%			
E	56	51	5	1	4				
		91%	8.9%	1.7%	7.1%				
O	28	28	0			0	0		
		100%							
Ø	7	7	0					0	0
		100%							
E-E	12	6	6	5	1				
		50%	50%	41.7%	8.3%				
E-O	8	1	7	0	4	3	0		
		12.5%	87.5%		50%	37.5%			
E-Ø	4	2	2	0	2			0	0
		50%	50%		50%				
O-E	23	23	0	0	0	0	0		
		100%							
O-O	2	2	0			0	0		
		100%							
Ø-E	4	1	3	1	2			0	0
		25%	75%	25%	50%				

Ø-Ø	1	0	0					0	1
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ENG	Bresciano	DIM	AUG
<i>dog</i>	'ka	ka'ni	ka'nu
<i>tooth</i>	'dent	din'ti	din'tu
<i>artichoke</i>	kar'tʃɔf	kartʃu'fi artitʃu'ki	kartʃu'fu artitʃu'ku
<i>hand</i>	'ma	ma'nina	ma'nuna
<i>glass</i>	'vedre	vi'dri	vi'dru
<i>sausage</i>	sa'lam	sala'mi	sala'mu
<i>mountain trail</i>	sen'ter	sintiru'li	sintiru'lu
<i>cup</i>	'kikera	kike'rina	kike'runa
<i>duck</i>	'nedra	ni'drina	ni'druna
<i>chair</i>	'skapa	skapi'lina	skapi'luna
<i>hat</i>	be'ret	biri'ti	biri'tu
<i>sock</i>	kal'set	kalsi'ti	kalse'tu
<i>flour*</i>	x	x	x
<i>apron</i>	biga'rəl	biga'ri	biga'ru
<i>blind</i>	'sgwers	sgwir'si	sgwir'su
<i>rabbit</i>	ko'netʃ	kuni'tʃi	kuni'tʃu
<i>pan</i>	pa'dɛla	padil'ina	padi'luna
<i>horse</i>	ka'al	kaa'li	kaa'lu
<i>saw</i>	'ranzɔ	ran'zina	x
<i>apple</i>	'pom	pumi'li	pumi'lu
<i>church</i>	'tʃeza	tʃezu'lina	tʃe'zuna
<i>wood</i>	'leɲa	bastun'si	bastun'su
<i>book</i>	'liber	libri'ti	libru'tu
<i>hare</i>	le'gor	ligur'sina	legur'su
<i>stainbeck</i>	'bek	bi'ki	bi'ku
<i>fig</i>	'fik	fi'ki	fi'ku
<i>bell</i>	kampa'nɛl	kampani'li	kampani'lu
<i>calf</i>	ve'dɛl	vidi'li	vidi'lu
<i>nail</i>	'tʃot	tʃudi'li	tʃudi'lu
<i>potato</i>	pa'tata	x	x
<i>dustpan</i>	pa'leta	pali'tina	pali'tuna
<i>goose</i>	'oka	u'kina	u'kuna
<i>belly</i>	'pansa	pan'sina	pan'suna
<i>owl</i>	x	x	x
<i>tree</i>	'pjanta	pjan'tina	pjan'tuna
<i>candle</i>	kan'dɛla	kandi'lina	kandi'lu
<i>mushroom</i>	'fons	funzi	fun'zu
	legor'sɛla	legursi'lina	legursi'luna

ENG	Bresciano	DIM	AUG
<i>cow</i>	'aka	a'kina	a'kuna
<i>bed</i>	'let	li'ti	li'tu
<i>pig</i>	'si	pursi'li	pursi'lu
<i>snail</i>	lɔ'maga	lɔma'gina	lɔma'guna
<i>trousers</i>	'brage	bra'gine	bra'gune
<i>mouth</i>	'boka	bu'kina	bu'kuna
<i>funnel</i>	turta'rəl	turtaru'li	turta'ru
<i>mustaches</i>	x	x	x
<i>glass</i>	bi'tʃer	bitʃi'ri	bitʃi'ru
<i>fog*</i>	'neɟa	ni'bina	ni'bu
<i>house</i>	'baita	bai'tina	bai'tuna
<i>rock</i>	'preda	pri'dina	pri'duna
<i>cat</i>	'gat	ga'ti	ga'tu
<i>bag</i>	'borsa	bur'sina	bor'suna
<i>priest</i>	'pret	pri'ti	pri'tu
<i>bat</i>	x	pipistri'li	pipistri'lu
<i>fly</i>	mus'ku	mus'ki	mus'ku
<i>tshirt</i>	'maia	ma'jeta	x
<i>boy</i>	'ɲaro	ɲari'li	ɲari'lu
<i>eye</i>	'ɔtʃ	y'tʃi	u'tʃu
<i>dress</i>	vis'tit	visti'di	visti'du
<i>horn</i>	'koren	korna'tʃi	korna'tʃu
<i>goat</i>	'kavra	kav'rina	kav'runa
<i>sheep</i>	'pegore	peko'rina	peko'rona
<i>toilet</i>	'tʃeso	tʃi'si	tʃi'su
<i>bread</i>	'pa	pa'ni	pa'nu
<i>pendulum clock</i>	'pendol	pendo'li	pendu'lu
<i>key</i>	'tʃaf	tʃa'ina	tʃa'una
<i>cock</i>	'gal	gali'ti	gali'tu
<i>donkey</i>	'azen	azi'ni	azi'nu
<i>nun</i>	'mɔnegɔ	muni'gina	muni'guna
<i>bird</i>	o'zel	uzi'li	uzi'lu
<i>egg</i>	'ɔf	ɔfa'si	x
<i>comb</i>	'peten	peti'ni	peti'nu
<i>lyzard</i>	lɔ'zɛrta	lɔzertu'lina	lɔzertu'luna
<i>wolf</i>	'lupo	x	x
<i>skinny</i>	'mager	ma'gri	ma'gru
<i>door</i>	'porta	pur'tina	pur'tuna
<i>leg</i>	'gamba	gam'bina	gam'buna

ENG	Bresciano	DIM	AUG
<i>charriot</i>	ka'ret	kari'ti	kari'tu
<i>ear</i>	o'retʃa	uri'tʃi	uri'tʃu
<i>brother</i>	fra'del	fradi'li	fradi'lu
<i>rat</i>	so'rek	suri'gi	suri'gu
<i>brick</i>	kwa'drel	kwadri'li	kwadri'lu
<i>flour</i>	'fjur	fjuri'li	fjuri'lu
<i>tomato</i>	pon'dor	pundu'ri	pundu'ru
<i>lady</i>	'fonna	fun'nina	fun'nuna
<i>orange</i>	porto'gal	purtuga'li	purtuga'lu
<i>sister</i>	so'rela	suri'lina	suri'luna
<i>brain</i>	ser'vel	servi'li	servi'lu
<i>coffin</i>	x	x	x
<i>foal</i>	po'leder	puli'dri	x
<i>nose</i>	'nas	na'zi	na'zu
<i>knot</i>	'grop	grupi'ti	grupi'tu
<i>bottle</i>	bu'tilja	buti'ʎina	buti'ʎuna
<i>zucchini</i>	kø'kømer	køkym'eri	kykymi'ru
<i>meat rolls</i>		x	x
<i>devil</i>	djaol	djau'li	djau'lu
<i>doctor</i>	du'tur	dutu'ri	dutu'ru
<i>sheet</i>	bø'gada	linsu'li	lensu'lu
<i>plum</i>	'brøpa	bru'ʎi	bru'ʎu
<i>crow</i>	'korf	kur'vi	kur'vu

ENG	Bresciano	DIM	AUG
<i>boat</i>	'barka	bark'itina	barki'tuna
<i>ham</i>	per'søt	persu'ti	persu'tu
<i>peach</i>	'persek	persi'gi	persi'gu
<i>lazy</i>	x	x	x
<i>pruning knife</i>	po'det	pudi'ti	pudi'tu
<i>pan</i>	pi'nata	piɲa'tina	piɲa'tuna
<i>fish</i>	'pes	x	x
<i>cherry</i>	sa'resa	sari'zina	sari'zuna
<i>spoon</i>	'kydʒa	kydʒa'ni	kydʒa'nu
<i>salad</i>	ver'dyra	verdy'rina	verdy'runa
<i>umbrella</i>	om'bræla	umbri'li	umbri'lu
<i>phaesant</i>	fa'za	faza'ni	faza'nu
<i>old man</i>	'vetfo	vi'tʃi	vi'tʃu
<i>nail</i>	'øndʒa	yn'dʒina	yn'dʒuna
<i>mouse</i>	so'rek	suri'gi	sur'guna
<i>pear</i>	'peer	pero'li	pero'las
<i>finger</i>	'dit	miju'li	x
<i>pine tree</i>	'pi	pi'ni	pi'nu
<i>dumplings</i>	'ɲøk	ɲuki'ti	ɲuki'tu
<i>necklace</i>	ko'lana	kola'nina	kola'nuna
<i>knife</i>	kor'tel	kurti'li	kurti'lu
<i>fountain</i>	fon'tana	fonta'nina	fonta'nuna
<i>strawberry</i>	ma'øla	mau'lina	mau'luna
<i>mule</i>	'myl	myla'ti	myla'tu

MB: 76 years old, female speaker of Bresciano

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	40	35	5	2	2	1	0	0	0
		87.5%	12.5%	5%	5%	2.5%			
E	18	17	1	0	1				
		94.4%	5.6%		5.6%				
O	11	10	1			1	0		
		90.1%	9.9%			9.9%			
Ø	2	2	0					0	0
		100%							
E-E	4	2	2	2	0				
		50%	50%	50%					
E-O	1	0	1	0	1	0	0		
			100%		100%				
E-Ø	0	0	0	0	0			0	0

O-E	3	3 100%	0	0	0	0	0		
Ø-E	1	1 100%	0	0	0			0	0

ENG	Bresciano	DIM	AUG
<i>dog</i>	'ka	kapu'li	ka'ņas
<i>tooth</i>	'dent	din'ti	ga'nasa
<i>artichoke</i>	kar'tʃəfo	kartʃu'fi	x
<i>hand</i>	'ma	ma'nina	ma'nasa
<i>glass</i>	'vedre	skeza	x
<i>sausage</i>	sa'lam	sala'mi	sala'mu
<i>mountain trail</i>	x	sinti'ri	x
<i>cup</i>	'tasa	ta'sina	sko'dela
<i>duck</i>	'nɛdra	ni'dri	ne'drɔt
<i>chair</i>	'skapa	ska'pɛla	pul'truna
<i>hat</i>	be'ret	biri'ti	x
<i>sock</i>	kal'set	kalsi'ti	kalsi'tu
<i>flour*</i>	x	x	x
<i>apron</i>	biga'rɔl	biga'ri	x
<i>blind</i>	x	x	x
<i>rabbit</i>	ko'netʃ	kuni'tʃi	x
<i>pan</i>	pa'dela	padi'lina	padi'lu
<i>horse</i>	ka'al	pu'leder	kaa'lu
<i>saw</i>	'rasega	rasi'gi	ranse'got
<i>apple</i>	'pom	pumi'li	x
<i>church</i>	'tʃeza	tʃi'zina	kate'dral
<i>wood</i>	'lep	x	x
<i>book</i>	x	libri'ti	li'bru
<i>hare</i>	'lepre	x	x
<i>stainbeck</i>	x	x	x
<i>fig</i>	'fik	fi'gi	x
<i>bell</i>	kampa'nɛla	kampa'nina	x
<i>calf</i>	ve'dɛl	x	manza
<i>nail</i>	'tʃot	tʃu'di	x
<i>potato</i>	pa'tata	pata'tina	pata'tuna
<i>dustpan</i>	pa'lɛta	pali'tina	pali'tuna
<i>goose</i>	'oka	u'kina	x
<i>belly</i>	'bɔdʒa 'pansa	pan'sina	bu'dʒu
<i>owl</i>	ku'ku	kuku'ni	x
<i>tree</i>	'pjanta	pjan'tina	albero
<i>candle</i>	kan'dela	kandi'lina	kandelu

ENG	Bresciano	DIM	AUG
<i>mushroom</i>	'fons	fun'si	fons grɔs
<i>cow</i>	'aka	a'kina	a'kuna
<i>bed</i>	'let	li'ti	x
<i>pig</i>	'si	sina'ti	si
<i>snail</i>	lɔ'maga	lɔma'gi	x
<i>trousers</i>	'brage	bra'gine	bra'gɔte
<i>mouth</i>	'boka	bu'kina	bu'kuna
<i>funnel</i>	turta'rɔl	x	x
<i>mustaches</i>	ba'fu	x	x
<i>glass</i>	bi'tʃer	bitʃi'ri	x
<i>fog</i>	'geba	x	ni'bju
<i>house</i>	'kaza	ka'zina	x
<i>rock</i>	'preda	pri'dina	mas
<i>cat</i>	'gat	ga'ti	ga'tu
<i>bag</i>	'borsa	bor'sina	x
<i>priest</i>	'pret	preta'si	preta'su
<i>bat</i>	x	x	x
<i>fly</i>	'moska	mus'ki	mus'ku
<i>tshirt</i>	'maja	ma'ina	x
<i>boy</i>	'ɲaro	ɲari'li	x
<i>eye</i>	'ɔtʃ	y'tʃi	x
<i>dress</i>	vis'tit	visti'di	x
<i>horn</i>	x	x	x
<i>goat</i>	'kavra	ka'preta	ka'vrɛna
<i>sheep</i>	'pegore	pegu'rina	x
<i>toilet</i>	x	x	x
<i>bread</i>	'feta de 'pa	fi'tina de pa'nino	pa'nu
<i>pendulum clock</i>	oro'loj a 'pendol	x	
<i>key</i>	'tʃaf	x	x
<i>cock</i>	'gal	gali'ti	gali'tu
<i>donkey</i>	'azen	az'ni	myl
<i>nun</i>	'swɔra	x	x
<i>bird</i>	o'zɛl	uzi'li	uzi'lu
<i>egg</i>	'ɔf	ɔfa'si	y'vu
<i>comb</i>	'peten	peti'ni	peti'nu
<i>lyzard</i>	lɔ'zɛrta	lyzir'tina	x

PS 75 years old, male speaker of Bresciano

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	137	126	11	2	6	2	1	0	0
		92%	8%	1.5%	4.4%	1.5%	0.6%		
E	54	50	4	2	2				
		92.6%	7.4%	3.7%	3.7%				
O	32	30	2			1	1		
		93.75%	6.25%			31.25%	31.25%		
Ø	9	9	0					0	0
		100%							
E-E	14	14	0	0	0				
		100%							
E-O	1	0	1	0	0	1	0		
			100%			100%			
E-Ø	4	2	2	0	2			0	0
		50%	50%		50%				
O-E	19	19	0	0	0	0	0		
		100%							
O-O	2	2	0			0	0		
		100%							
Ø-E	2	0	2	0	2			0	0
			100%		100%				

ENG	Bresciano	DIM	AUG
<i>dog</i>	'ka	ka'ni	ka'nu
<i>tooth</i>	'dent	din'ti	din'tu
<i>artichoke</i>	kar'tʃɔf	kartʃu'fi	kartʃu'fu
<i>hand</i>	'ma	ma'nina	ma'nuna
<i>glass</i>	'veder	vi'dri	vi'dru
<i>sausage</i>	sa'lam	sala'mi	sala'mu
<i>mountain trail</i>	sen'ter	sinti'ri	sinti'ru
<i>cup</i>	'kikera	kike'rina	kike'runa
<i>duck</i>	'nedra	ni'dri	ni'dru
<i>chair</i>	'skapa	ska'ni	ska'nu
<i>hat</i>	be'ret	biri'ti	biri'tu
<i>sock</i>	kal'set	kalsi'ti	kalsi'tu
<i>apron</i>	biga'rəl	bigaru'li	bigaru'lu
<i>blind</i>	'tʃek	tʃi'ki	tʃi'ku
<i>rabbit</i>	ko'netʃ	kuni'tʃi	kuni'tʃu
<i>pan</i>	pa'dela	padi'li	padi'lu
<i>horse</i>	ka'al	kaa'li	kaa'lu
<i>saw</i>	'rasega	rasi'gina	rasi'gu
<i>apple</i>	'pom	pu'mi	pu'mu
<i>church</i>	'tʃeza	tʃizu'lina	tʃi'zuna
<i>wood</i>	'tronk	trunki'ti	trunki'tu

ENG	Bresciano	DIM	AUG
<i>book</i>	'liber	libri'ti	libru'tu
<i>hare</i>	'legor	x	lego'rat
<i>stainbeck</i>	'bek	x	x
<i>fig</i>	'fik	fi'ki	fi'ku
<i>bell</i>	kampa'nel	kampani'li	kampani'lu
<i>calf</i>	ve'del	vidi'li	vidi'lu
<i>nail</i>	'tʃot	tʃudi'li	tʃudi'lu
<i>potato</i>	pa'tata	pata'ti	pata'tu
<i>dustpan</i>	pa'leta	pali'tina	pali'tuna
<i>goose</i>	'oka	u'kina	u'ku
<i>belly</i>	'pansa	pansi'ti	bu'dzu
<i>owl</i>	si'eta	sii'tina	sii'tuna
<i>tree</i>	'pjanta	pjan'tina	pjan'tu
<i>candle</i>	kan'dela	kandi'lina	kandi'lu
<i>mushroom</i>	'fons	fun'zi	fun'zu
<i>cow</i>	'aka	a'kina	a'kuna
<i>bed</i>	'let	li'ti	li'tu
<i>pig</i>	por'sel	pursi'li	pursi'lu
<i>snail</i>	lø'maga	løma'gi	løma'got
<i>trousers</i>	'brage	bra'gine	bra'gu
<i>mouth</i>	'boka	bu'kina	bo'kasa

ENG	Bresciano	DIM	AUG
<i>funnel</i>	turta'röl	tyrtary'li	x
<i>mustaches</i>	'baffi	bafi'ti	bafi'tu
<i>glass</i>	bi'tfer	bitfi'ri	bitfi'ru
<i>fog*</i>	'nəbja	nə'bjina	nə'bjuna
<i>house</i>	'kaza	ka'zina	ka'zuna
<i>rock</i>	'preda	pri'dina	pri'duna
<i>cat</i>	'gat	ga'ti	ga'tu
<i>bag</i>	'borsa	bur'sina	bur'suna
<i>priest</i>	'pret	pri'ti	pri'tu
<i>bat</i>	x	x	x
<i>fly</i>	'moska	mus'ki	mus'kuna
<i>tshirt</i>	ma'ina	x	x
<i>boy</i>	ɲa'rel	ɲari'li	ɲari'lu
<i>eye</i>	'ətʃ	y'tʃi	y'tʃu
<i>dress</i>	vis'tit	visti'di	visti'du
<i>horn</i>	'koren	korna'si	korna'su
<i>goat</i>	'kavra	ka'vrina	ka'vru
<i>sheep</i>	'peora	peo'rina	x
<i>toilet</i>	gabi'ner	x	x
<i>bread</i>	'pa	pa'ni	pa'nu
<i>pendulum clock</i>	oro'lɔj	x	x
<i>key</i>	'tʃaf	tʃa'ina	tʃa'una
<i>cock</i>	'gal	gali'ti	gali'lu
<i>donkey</i>	'azen	az'ni	az'nu
<i>nun</i>	'swəra	swə'rina	swə'runa
<i>bird</i>	o'zəl	uzi'li	uzi'lu
<i>egg</i>	'əf	u'vi	u'vu
<i>comb</i>	'pəten	piti'ni	piti'nu
<i>lyzard</i>	løzerta	lyzertu'li	løzertu'lu
<i>wolf</i>	'lupo	x	x
<i>skinny</i>	'mager	magri'ti	magri'tu
<i>door</i>	'porta	pur'tina	pur'tu
<i>leg</i>	'gamba	gambi'tina	gambi'tu
<i>charriot</i>	ka'reta	kari'tina	kari'tuna
<i>ear</i>	o'retfa	uri'tʃina	uri'tʃuna
<i>brother</i>	fra'del	fradi'li	fradi'lu
<i>rat</i>	so'rek	suri'gi	sorga
<i>brick</i>	kwa'drəl	kwadri'li	kwadri'lu
<i>butter*</i>	x	x	x
<i>flour</i>	'fjur	fjuri'li	fjuri'lu
<i>tomato</i>	pon'dor	pundu'ri	pundu'ru

ENG	Bresciano	DIM	AUG
<i>lady</i>	'fonna	fun'nina	fun'nuna
<i>orange</i>	porto'gal	portoga'li	portoga'lu
<i>sister</i>	so'rela	suri'lina	suri'luna
<i>brain</i>	ser'vel	sirvi'li	sirvi'lu
<i>coffin</i>	x	x	x
<i>foal</i>	po'leder	puli'dri	puli'druna
<i>nose</i>	'nas	nazi'li	pee'ru
<i>knot</i>	'grop	grupiti	grupi'tu
<i>bottle</i>	bu'tilja	buti'kina	buti'ku
<i>zucchini</i>	sy'ki	syki'ti	x
<i>meat rolls</i>	x	x	x
<i>devil</i>	'djaol	djau'li	djau'lu
<i>doctor</i>	du'tur	dutu'ri	dutu'ru
<i>sheet</i>	lən'səl	linsu'li	linsu'lu
<i>plum</i>	'brɔɲa	bru'ɲi	bru'ɲu
<i>crow</i>	'kɔrf	x	x
<i>boat</i>	'barka	barki'ti	bar'ku
<i>ham</i>	per'sət	persyti	persu'tu
<i>peach</i>	'persek	pirsi'ki	pirsi'ku
<i>lazy</i>	x	x	x
<i>pruning knife</i>	x	x	x
<i>pan</i>	x	x	x
<i>fish</i>	'pes	pisi'ti	pisi'tu
<i>cherry</i>	sa'reza	sari'zina	sari'zuna
<i>spoon</i>	ky'dʒa	kydʒa'ni	x
<i>salad</i>	ver'dyra	x	x
<i>umbrella</i>	om'brɛla	umbri'li	umbri'lu
<i>phaesant</i>	fa'za	faza'ni	faza'nu
<i>old man</i>	'vetʃo	vetʃa'si	vetʃa'su
<i>nail</i>	'øndʒa	yn'dʒina	yn'dʒuna
<i>mouse</i>	so'rek	suri'gi	suri'gu
<i>pear</i>	'peer	pi'ri	pi'ru
<i>finger</i>	'dit	x	di'tu
<i>pine tree</i>	pa'ger	pagi'ri	pagi'ru
<i>dumplings</i>	'ɲɔk	ɲuki'ti	ɲuki'tu
<i>necklace</i>	ko'lanə	kola'nina	kola'nuna
<i>knife</i>	kor'təl	kurti'li	kurti'lu
<i>fountain</i>	fon'tana	fonta'nina	fonta'nuna
<i>strawberry</i>	ma'əla	x	x
<i>mule</i>	'myl	x	x
<i>black</i>	'neger	nigri'ti	nigri'tu

VR: 79 years old, female speaker of Bresciano

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	106	102	4	1	3	0	0	0	0
		96.2%	3.8%	0.95%	2.85%				
E	32	30	2	1	1				
		93.75%	6.25%	3.12%	3.12%				
O	22	22	0			0	0		
		100%							
Ø	7	7	0					0	0
		100%							
E-E	10	10	0	0	0				
		100%							
E-O	8	8	0	0	0	0	0		
		100%							
E-Ø	5	4	1	0	1			0	0
		80%	20%		20%				
O-E	15	15	0	0	0	0	0		
		10%							
O-O	2	2	0			0	0		
		10%							
Ø-E	5	4	1	0	1			0	0
		80%	20%		20%				

ENG	Bresciano	DIM	AUG
<i>dog</i>	'ka	ka'ni	ka'ju
<i>tooth</i>	'dent	din'ti	din'tu
<i>artichoke</i>	arti'tʃək	x	x
<i>hand</i>	'ma	ma'nina	ma'nuna
<i>glass</i>	'vedre	x	x
<i>sausage</i>	sa'lam	sala'mi	sala'mu
<i>mountain trail</i>	sen'ter	sinti'ri	x
<i>cup</i>	skø'dela	skydi'lina	x
<i>duck</i>	nē'drət	nidru'ti	nidru'tu
<i>chair</i>	'skapa	skapi'lina	ska'ju
<i>hat</i>	be'ret	biri'ti	biri'tu
<i>sock</i>	kal'set	kalsi'ti	kalsi'tu
<i>apron</i>	biga'rəl	bigaru'li	bigaru'lu
<i>blind</i>	'ørp	x	x
<i>rabbit</i>	ko'netʃ	kuni'tʃi	kuni'tʃu
<i>pan</i>	pa'dela	padi'li	padi'lu
<i>horse</i>	ka'al	kaa'li	kaa'lu
<i>saw</i>	'rasega	x	x
<i>apple</i>	'pom	pumi'li	pu'mu
<i>church</i>	'tʃeza	tʃi'zina	tʃi'zuna
<i>wood</i>	x	x	x

ENG	Bresciano	DIM	AUG
<i>book</i>	'liber	libri'ti	libru'tu
<i>hare</i>	'legor	ligu'ri	ligu'ru
<i>stainbeck</i>	ka'vru	ka'vri	ka'vru
<i>fig</i>	'fik	x	x
<i>bell</i>	kampa'nel	kampani'li	kampani'lu
<i>calf</i>	manzu'li	vidi'li	x
<i>nail</i>	'tʃot	tʃudi'li	tʃudi'lu
<i>potato</i>	pa'tata	pata'tina	pata'tuna
<i>dustpan</i>	pa'leta	pali'tina	pali'tuna
<i>goose</i>	'oka	u'kina	u'kuna
<i>belly</i>	'pansa	pan'sina	pan'suna
<i>owl</i>	x	x	x
<i>tree</i>	'pjanta	pjan'tina	pjan'tuna
<i>candle</i>	kan'dela	kandi'lina	kandi'luna
<i>mushroom</i>	'fons	fun'zi	x
<i>cow</i>	x	x	x
<i>bed</i>	'let	li'ti	li'tu
<i>pig</i>	'si	sina'ti	sina'tu
<i>snail</i>	lø'maga	løma'gi	løma'gu
<i>trousers</i>	'brage	bra'gine	bra'gune
<i>mouth</i>	'boka	bu'kina	bu'kuna

ENG	Bresciano	DIM	AUG
<i>funnel</i>	turta'rəl	turtaru'li	turtaru'lu
<i>mustaches</i>	x	x	x
<i>glass</i>	bi'tfer	bitfe'ri	bitfe'ru
<i>fog</i>	'nebja	nibju'lina	ni'bjū
<i>house</i>	x	x	x
<i>rock</i>	'preda	pri'dina	pri'duna
<i>cat</i>	'gat	ga'ti	ga'tu
<i>bag</i>	'borsa	bur'sina	bor'suna
<i>priest</i>	'pret	preta'si	preta'su
<i>bat</i>	x	x	x
<i>fly</i>	'moska	mus'kina	mus'kuna
<i>tshirt</i>	'maia	ma'ina	ma'juna
<i>boy</i>	'ɲaro	ɲa'ri	ɲa'ru
<i>eye</i>	'øtʃ	y'tʃi	u'tʃu
<i>dress</i>	vis'tit	visti'di	visti'du
<i>horn</i>	'koren	korna'tʃi	korna'tʃu
<i>goat</i>	'kavra	ka'vrina	ka'vruna
<i>sheep</i>	'pegore	pigu'rina	pigu'runa
<i>toilet</i>	x	x	x
<i>bread</i>	'pa	pa'ni	pa'nu
<i>pendulum clock</i>	'pendol	pindu'li	pindu'lu
<i>key</i>	'tʃaf	tʃai'zina	tʃai'zuna
<i>cock</i>	'gal	gali'li	gali'lu
<i>donkey</i>	'azen	azi'ni	azi'nu
<i>nun</i>	'monega	x	x
<i>bird</i>	pasa'ri	uzi'li	uzi'lu
<i>egg</i>	'øf	øfa'zi	øfa'zu
<i>comb</i>	'peten	pitini	pitinu
<i>lyzard</i>	lø'zerta	lyzir'tina	luzer'tu
<i>wolf</i>	'lupo	x	x
<i>skinny</i>	'mager	ma'gri	x
<i>door</i>	'porta	pur'tina	pur'tuna
<i>leg</i>	'gamba	gam'bina	gam'bu
<i>charriot</i>	ka'ret	kari'ti	kara'tu
<i>ear</i>	o'retʃa	uri'tʃina	uri'tʃuna
<i>brother</i>	fra'del	fradi'li	fradi'lu
<i>rat</i>	so'rek	suri'gi	suri'gu

ENG	Bresciano	DIM	AUG
<i>brick</i>	kwa'drel	x	x
<i>flour</i>	'fjur	fjuri'li	x
<i>tomato</i>	pon'dor	pundu'ri	pundu'ru
<i>lady</i>	'fonna	fun'nina	x
<i>orange</i>	porto'gal	portoga'li	portoga'lu
<i>sister</i>	so'rela	suri'lina	sori'luna
<i>brain</i>	ser'vel	sirvi'li	sirvi'lu
<i>foal</i>	po'ledər	x	x
<i>nose</i>	'nas	na'zi	x
<i>knot</i>	'grop	grupi'ti	grupi'tu
<i>bottle</i>	bu'tilja	x	x
<i>zucchini</i>	sø'kel	syki'li	syki'lu
<i>devil</i>	'djaol	djau'li	djau'lu
<i>doctor</i>	du'tur	dutu'ri	dutu'ru
<i>sheet</i>	lən'søl	linsu'li	linsu'lu
<i>plum</i>	'brɔɲa	bru'ɲi	x
<i>crow</i>	'kɔrf	x	x
<i>boat</i>	'barka	bar'keta	x
<i>ham</i>	per'søt	persy'ti	x
<i>peach</i>	'persek	pirsi'gi	pirsi'gu
<i>pruning knife</i>	'ronkola	ronka'i	
<i>pot</i>	pi'jata	pija'tina	pija'tuna
<i>fish</i>	'pes	pesa'ti	x
<i>cherry</i>	sa'reza	sari'zina	sari'zuna
<i>spoon</i>	ky'dza	kydza'ni	kydza'nu
<i>salad</i>	x	x	x
<i>umbrella</i>	om'brel	umbri'li	umbri'lu
<i>phaesant</i>	fa'sa	faza'ni	faza'nøt
<i>old man</i>	'vetʃo	vetʃa'si	x
<i>nail</i>	'øndza	x	x
<i>mouse</i>	so'rek	suri'gi	x
<i>pear</i>	'peer	piru'li	x
<i>finger</i>	'dit	x	x
<i>pine tree</i>	'pi	x	x
<i>dumplings</i>	'ɲøk	ɲuki'ti	ɲuki'tu
<i>necklace</i>	ko'lana	kolanina	kola'nuna
<i>knife</i>	kor'tel	kurti'li	kurtilu
<i>fountain</i>	fon'tana	fonta'nina	x
<i>strawberry</i>	ma'øla	mau'lina	x
<i>mule</i>	'myl	x	x

LB2: 81 years old, male speaker

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	46	45	1	0	1	0	0	0	0
		97.8%	2.2%		2.2%				
E	20	20	0						
		100%							
O	10	10	0			0	0		
		100%							
Ø	1	1	0					0	0
		100%							
E-E	6	6	0	0	0				
		100%							
E-O	2	2	0	0	0	0	0		
		100%							
E-Ø	0	0	0	0	0			0	0
O-E	6	6	0	0	0	0	0		
		100%							
Ø-E	1	0	1	0	1			0	0
		100%			100%				

ENG	Bresciano	DIM	AUG
<i>dog</i>	'ka	ka'net	ka'ɲu
<i>tooth</i>	'dent	din'ti	din'tu
<i>artichoke</i>	x	x	x
<i>hand</i>	'ma	ma'nina	ma'nuna
<i>glass</i>	'vedre	vi'dri	x
<i>sausage</i>	sa'lam	sala'mi	sala'mu
<i>mountain trail</i>	sen'ter	sinti'ri	sinti'ru
<i>cup</i>	ta'sina	x	x
<i>duck</i>	'nedra	ni'dri	ne'drɔt
<i>chair</i>	'skapa	ska'ɲel	ska'ɲu
<i>hat</i>	ka'pel	kapi'li	kapi'lu
<i>sock</i>	kal'set	kalsi'ti	kalsi'tu
<i>apron</i>	biga'rɔl	biga'rɔl	x
<i>blind</i>	'ɔrp	x	x
<i>rabbit</i>	ko'netʃ	kuni'tʃi	ko'netʃa
<i>pan</i>	pa'dela	padi'li	padi'lu
<i>horse</i>	ka'al	kaa'li	kaa'lu
<i>saw</i>	'rasega	rasi'gi	x
<i>apple</i>	'pom	pumi'li	x
<i>church</i>	'tʃeza	tʃi'zina	tʃi'zuna
<i>wood</i>	x	x	x
<i>book</i>	'liber	li'bret	li'bru

ENG	Bresciano	DIM	AUG
<i>hare</i>	'legor	ligu'ri	ligu'ru
<i>stainbeck</i>	'bek	x	x
<i>fig</i>	'fik	x	x
<i>bell</i>	kampa'nel	kampani'li	kam'pana
<i>calf</i>	manzu'li	vidi'li	x
<i>nail</i>	'tʃot	tʃu'di	tʃu'du
<i>potato</i>	pa'tata	pata'ti	pata'tu
<i>dustpan</i>	pa'leta	pali'ti	x
<i>goose</i>	'oka	u'ki	u'ku
<i>belly</i>	'pansa	x	x
<i>owl</i>	si'eta	x	x
<i>tree</i>	'pjanta	pjan'tina	pjan'tu
<i>candle</i>	kan'dela	x	x
<i>mushroom</i>	'fons	x	x
<i>cow</i>	x	x	x
<i>bed</i>	'let	x	x
<i>pig</i>	'si	sina'ti	sina'tu
<i>snail</i>	lø'maga	løma'gi	løma'gu
<i>trousers</i>	'brage	bra'gine	bra'gune
<i>mouth</i>	'boka	x	x
<i>funnel</i>	turta'rɔl	turtaru'li	x
<i>mustaches</i>	x	x	x
<i>glass</i>	bi'tʃer	bitʃi'ri	x

ENG	Bresciano	DIM	AUG
<i>fog</i>	'nebja	x	ni'bju
<i>house</i>	x	x	x
<i>rock</i>	x	x	x
<i>cat</i>	x	x	x
<i>bag</i>	x	x	x
<i>priest</i>	x	x	x
<i>bat</i>	x	x	x
<i>fly</i>	x	x	x
<i>tshirt</i>	x	x	x
<i>boy</i>	x	x	x
<i>eye</i>	x	x	x
<i>dress</i>	x	x	xx
<i>horn</i>	x	x	x
<i>goat</i>	x	x	x
<i>sheep</i>	x	x	x
<i>toilet</i>	x	x	x
<i>bread</i>	x	x	x
<i>pendulum clock</i>	x	x	x
<i>key</i>	x	x	x
<i>cock</i>	x	x	x
<i>donkey</i>	x	x	x
<i>nun</i>	x	x	
<i>bird</i>	x	x	x
<i>egg</i>	x	x	x
<i>comb</i>	x	x	x
<i>lyzard</i>	lø'zerta	x	luzer'tu
<i>wolf</i>	'lupo	x	x
<i>skinny</i>	x	x	x
<i>door</i>	'porta	x	pur'tu
<i>leg</i>	'gamba	gam'bina	gam'bu
<i>charriot</i>	ka'ret	kara'ti	x
<i>ear</i>	o'retʃa	x	uri'tʃuna
<i>brother</i>	fra'del	fradi'li	fradi'lu
<i>rat</i>	so'rek	suri'gi	x
<i>brick</i>	kwa'drel	x	x
<i>flour</i>	'fjur	fjuri'li	x
<i>tomato</i>	x		

ENG	Bresciano	DIM	AUG
<i>lady</i>	'fonna	fun'nina	x
<i>orange</i>	x	x	x
<i>sister</i>	x	x	x
<i>brain</i>	ser'vel	sirvi'li	x
<i>foal</i>	po'leder	puli'dri	x
<i>nose</i>	x	x	x
<i>knot</i>	'grop	gru'pi	x
<i>bottle</i>	x	x	x
<i>zucchini</i>	x	x	x
<i>devil</i>	x	x	x
<i>doctor</i>	x	x	x
<i>sheet</i>	x		
<i>plum</i>	'brɔna	bru'ni	x
<i>crow</i>	'korf	kur'vi	x
<i>boat</i>	'barka	barki'ti	x
<i>ham</i>	x	x	x
<i>peach</i>	x	x	x
<i>pruning knife</i>	'ronkola	ronka'i	
<i>pendulum clock</i>	x	x	x
<i>fish</i>	'pes	pisu'li	x
<i>cherry</i>	x	x	x
<i>spoon</i>	ky'dza	kydza'ni	kydza'nu
<i>salad</i>	x	x	x
<i>umbrella</i>	x	x	x
<i>phaesant</i>	x	x	x
<i>old man</i>	x	x	x
<i>nail</i>	x	x	x
<i>mouse</i>	x	x	x
<i>pear</i>	x	x	x
<i>finger</i>	x	x	x
<i>pine tree</i>	x	x	x
<i>dumplings</i>	x	x	x
<i>necklace</i>	x	x	x
<i>knife</i>	x	kurti'li	kurti'lu
<i>fountain</i>	x	x	x
<i>strawberry</i>	x	x	x
<i>mule</i>	x	x	x

AA2: 83 years old, female speaker of Bresciano

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	137	133	4	0	3	1	0	0	0
		97.1%	2.9%		2.2%	0.7%			
E	45	43	2	0	2				
		95.5%	4.5%		4.5%				
O	27	27	0			0	0		
		100%							
Ø	10	10	0					0	0
		100%							
E-E	15	15	0	0	0				
		100%							
E-O	10	10	0	0	0	0	0		
		100%							
E-Ø	2	2	0	0	0			0	0
		100%							
O-E	20	18	2	0	1	1	0		
		90%	10%		5%	5%			
O-O	2	2	0			0	0		
		100%							
Ø-E	6	6	0	0	0			0	0
		100%							

ENG	Bresciano	DIM	AUG
<i>dog</i>	'ka	ka'ni	ka'pu
<i>tooth</i>	'dent	din'ti	din'tu
<i>artichoke</i>	arti'tʃək	artitʃu'ki	x
<i>hand</i>	'ma	ma'nina	ma'nuna
<i>glass</i>	'vedre	vi'dri	vi'dru
<i>sausage</i>	sa'lam	sala'mi	sala'mu
<i>mountain trail</i>	sen'ter	sinti'ri	sinti'ru
<i>cup</i>	skø'dela	skydi'lina	skydi'luna
<i>duck</i>	'nedra	ni'drina	ni'druna
<i>chair</i>	'skapa	ska'pina	ska'puna
<i>hat</i>	be'ret	biri'ti	biri'tu
<i>sock</i>	kal'set	kalsi'ti	kalsi'tu
<i>apron</i>	biga'røl	bigaru'li	bigaru'lu
<i>blind</i>	'ørp	ur'pi	ur'pu
<i>rabbit</i>	ko'netʃ	kuni'tʃi	kuni'tʃu
<i>pan</i>	pa'dela	padi'lina	padi'luna
<i>horse</i>	ka'al	kaa'li	kaa'lu
<i>saw</i>	'sega	si'gi	si'gu
<i>apple</i>	'pom	pumi'li	pumi'lu
<i>church</i>	'tʃeza	tʃi'zina	tʃi'zuna

ENG	Bresciano	DIM	AUG
<i>wood</i>	'lep	li'ni	li'pu
<i>book</i>	'liber	libri'ti	libru'tu
<i>hare</i>	'legor	ligu'ri	ligu'ru
<i>stainbeck</i>	x	x	x
<i>fig</i>	'fik	fi'gi	fi'gu
<i>bell</i>	kampa'nel	kampani'li	kampani'lu
<i>calf</i>	e'del	vidi'li	x
<i>nail</i>	'tʃot	tʃudi'lina	tʃudi'luna
<i>potato</i>	pa'tata	pata'ti	pata'tu
<i>dustpan</i>	pa'leta	pali'tina	pali'tuna
<i>goose</i>	'oka	u'kina	u'kuna
<i>belly</i>	'pansa	pan'sina	pan'suna
<i>owl</i>	si'eta	sii'tina	sii'tuna
<i>tree</i>	'pjanta	pjan'tina	pjan'tu
<i>candle</i>	kan'dela	kandi'lina	kandi'luna
<i>mushroom</i>	'fons	fun'zi	fun'zu
<i>cow</i>	'aka	a'kina	a'kuna
<i>bed</i>	'let	li'ti	li'tu
<i>pig</i>	'si	x	x
<i>snail</i>	lø'maga	løma'gina	løma'guna

ENG	Bresciano	DIM	AUG
<i>trousers</i>	'brage	bra'gine	bra'gu
<i>mouth</i>	'boka	bu'kina	bo'kasa
<i>funnel</i>	turta'røl	tyrtary'li	turtaru'lu
<i>mustaches</i>	'baffi	ba'fi	ba'fu
<i>glass</i>	bi'tfer	bitfi'ri	bitfi'ru
<i>fog</i>	'gɛba	gi'bina	gi'buna
<i>house</i>	'kaza	ka'zina	ka'zuna
<i>rock</i>	'preda	pri'dina	pri'du
<i>cat</i>	'mitfo	mi'tfi	mi'tfu
<i>bag</i>	'borsa	bur'sina	bur'suna
<i>priest</i>	'pret	pri'ti	pre'tu
<i>bat</i>	gri'napola	x	x
<i>fly</i>	'moska	mus'ki	mus'ku
<i>tshirt</i>	ma'jeta	ma'ina	ma'juna
<i>boy</i>	ja'rɛl	ja'ru'li	x
<i>eye</i>	'øtʃ	u'tfi	u'tfu
<i>dress</i>	vis'tit	visti'di	visti'du
<i>horn</i>	'koren	korna'zi	korna'zu
<i>goat</i>	'kavra	ka'vrina	ka'vruna
<i>sheep</i>	'peora	pigu'rina	pigu'runa
<i>toilet</i>	x	x	x
<i>bread</i>	'pa	pa'ni	pa'nu
<i>pendulum clock</i>	oro'løj	pindu'li	pindu'lu
<i>key</i>	'tʃaf	tʃa'ina	tʃa'una
<i>cock</i>	'gal	ga'li	ga'lu
<i>donkey</i>	'azɛn	az'ni	az'nu
<i>nun</i>	'mɔnɛga	muni'gina	muni'guna
<i>bird</i>	o'zɛl	uzi'li	uzi'lu
<i>egg</i>	'øf	x	x
<i>comb</i>	'pɛten	piti'ni	piti'nu
<i>lyzard</i>	ly'zɛrta	lyzir'tina	lyzir'tu
<i>wolf</i>	'luf	lu'fi	lu'fu
<i>skinny</i>	'mager	ma'gri	ma'gru
<i>door</i>	'porta	pur'tina	pur'tuna
<i>leg</i>	'gamba	gam'bina	gam'buna
<i>charriot</i>	ka'reta	kari'tina	kari'tuna
<i>ear</i>	o'rɛtʃa	uri'tʃina	uri'tʃuna
<i>brother</i>	fra'dɛl	fradi'li	x
<i>rat</i>	so'rɛk	suri'gi	sori'gu
<i>brick</i>	kwa'drɛl	kwadri'li	kwadri'lu
<i>butter</i>	bo'tɛr	buti'ri	buti'ru
<i>flour</i>	'tʃur	fjuri'li	fjuri'lu

ENG	Bresciano	DIM	AUG
<i>tomato</i>	pon'dor	pundu'ri	pundu'ru
<i>lady</i>	'fonna	fun'ni	fun'nu
<i>orange</i>	x	x	x
<i>sister</i>	so'rɛla	suri'lina	suri'luna
<i>brain</i>	ser'vɛl	sirvi'li	sirvi'lu
<i>coffin</i>	'kasa del 'mort	x	x
<i>foal</i>	po'leder	puli'dri	x
<i>nose</i>	'nas	nazi'li	na'zu
<i>knot</i>	'grop	grupi'ti	grupi'tu
<i>bottle</i>	bu'tilja	buti'kina	buti'kina
<i>zucchini</i>	sø'kɛl	syki'li	syki'lu
<i>devil</i>	'djaol	djau'li	djau'lu
<i>doctor</i>	du'tur	dutu'ri	dutu'ru
<i>sheet</i>	lɛn'søl	linsu'li	linsu'lu
<i>plum</i>	'brɔpɛ	bru'pine	bru'pune
<i>crow</i>	x	x	x
<i>boat</i>	'barka	bar'kina	bar'kuna
<i>ham</i>	per'søt	pirsy'ti	persu'tu
<i>peach</i>	'pɛrɛk	pirsi'ki	pirsi'ku
<i>lazy</i>	x	x	x
<i>pruning knife</i>	po'dɛt	pudi'ti	pudi'tu
<i>pan</i>	pi'nata	pina'tina	pina'tuna
<i>fish</i>	'pɛs	pisi'ti	pisi'tu
<i>cherry</i>	sa'rɛs	sari'zina	sari'zuna
<i>spoon</i>	ky'dʒa	kydʒa'ni	kydʒa'nu
<i>salad</i>	vɛr'dyɾa	x	x
<i>umbrella</i>	om'brɛla	umbre'lina	umbri'luna
<i>phaesant</i>	fa'za	faza'ni	faza'nu
<i>old man</i>	'vɛtʃo	vɛtʃa'si	vɛtʃa'su
<i>nail</i>	'ɔndʒa	yn'dʒina	yn'dʒuna
<i>mouse</i>	so'rɛk	suri'gi	x
<i>pear</i>	'pɛr	piru'li	piru'lu
<i>finger</i>	'dit	di'di	x
<i>pine tree</i>	'pi	pi'ni	pi'nu
<i>dumplings</i>	'ɲɔk	ɲuki'ti	ɲuki'tu
<i>necklace</i>	ko'lana	kola'nina	kola'nuna
<i>knife</i>	kor'tɛl	kurti'li	kurti'lu
<i>fountain</i>	fon'tana	fonta'nina	fonta'nuna
<i>strawberry</i>	ma'øla	may'li	may'lu
<i>mule</i>	'myl	my'li	my'lu
<i>black</i>	'nɛgɛr	ni'gri	ni'gru

AI: 82 years old, female speaker of Bresciano

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	114	110	4	1	2	1	0	0	0
		96.5%	3.5%	0.85%	1.75%	0.85%			
E	43	41	2	1	1				
		95.3%	4.7%	2.35%	2.35%				
O	28	28	0			0	0		
		100%							
Ø	6	6	0					0	0
		100%							
E-E	9	9	0	0	0				
		10%							
E-O	6	5	1	0	0	1	0		
		83.3%	16.7%			16.7%			
E-Ø	2	2	0	0	0			0	0
		100%							
O-E	16	16	0	0	0	0	0		
		16%							
O-O	1	1	0			0	0		
		100%							
Ø-E	3	2	1	0	1			0	0

ENG	BS	DIM	AUG
<i>dog</i>	'ka	kapu'li	ka'ju
<i>tooth</i>	'dent	din'ti	din'tu
<i>artichoke</i>	kar'tʃɔf	kartʃu'fi	kartʃu'fu
<i>hand</i>	'ma	ma'nina	ma'nuna
<i>glass</i>	'vedre	vi'dri	x
<i>sausage</i>	sa'lam	sala'mi	sala'mu
<i>mountain trail</i>	sen'ter	sinti'ri	sinti'ru
<i>cup</i>	'tasa	ta'sina	skø'dela
<i>duck</i>	'nedra	ni'dri	ne'drɔt
<i>chair</i>	'skapa	skapi'lina	ska'ju
<i>hat</i>	ka'pel	kapi'li	kapi'lu
<i>sock</i>	kal'set	kalsi'ti	kalsi'tu
<i>apron</i>	biga'rɔl	bigaru'li	grem'bjal
<i>blind</i>	'ɔrp	urbi'zi	x
<i>rabbit</i>	ko'netʃ	kuni'tʃi	kuni'tʃu
<i>pan</i>	pa'dela	padi'li	padi'luna
<i>horse</i>	ka'al	kaa'li	kaa'lu
<i>saw</i>	'sega	se'get	si'gu
<i>apple</i>	'pom	pumi'li	pu'mu

ENG	Bresciano	DIM	AUG
<i>church</i>	'tʃeza	tʃizu'lina	tʃi'zu
<i>wood</i>	'lepa	x	x
<i>book</i>	'liber	li'bri	li'bru
<i>hare</i>	'legor	ligu'ri	ligu'ru
<i>stainbeck</i>	'bek	x	x
<i>fig</i>	'fik	x	x
<i>bell</i>	kampa'nel	kampani'li	kam'pana
<i>calf</i>	e'del	vidi'li	x
<i>nail</i>	'tʃot	tʃudi'li	tʃot'grɔs
<i>potato</i>	pa'tata	pata'ti	pata'tu
<i>dustpan</i>	pa'leta	pali'tina	pali'tuna
<i>goose</i>	'oka	u'kina	u'kuna
<i>belly</i>	'bɔdʒa	bu'dʒina	bu'dʒuna
<i>owl</i>	'gufo	gu'fi	x
<i>tree</i>	'pjanta	pjan'tina	pjan'tu
<i>candle</i>	kan'dela	kandi'lina	kandi'luna
<i>mushroom</i>	'fons	fun'zi	fun'zu
<i>cow</i>	'aka	a'kina	a'kuna
<i>bed</i>	'let	li'ti	li'tu

ENG	Bresciano	DIM	AUG
<i>pig</i>	'si	si'ni	si 'grəs
<i>snail</i>	lø'maga	løma'gina	løma'guna
<i>trousers</i>	'brage	bra'gine	bra'gu
<i>mouth</i>	'boka	bu'kina	bu'kuna
<i>funnel</i>	turta'røl	turtaru'li	tørtar'røl 'grəs
<i>mustaches</i>	bar'bis	x	x
<i>glass</i>	bi'tfer	bitfe'ri	bitfe'ru
<i>fog</i>	'nəbja	nibju'lina	ni'bju
<i>house</i>	'kaza	ka'zina	ka'zuna
<i>rock</i>	'preda	pridu'lina	pri'du
<i>cat</i>	'gat	'gat	ga'tu
<i>bag</i>	'borsa	bur'si	bur'su
<i>priest</i>	'pret	pri'ti	pri'tu
<i>bat</i>	gri'napola	gri'napu'lina	gri'napu'lu
<i>fly</i>	'moska	mus'kina	mus'ku
<i>tshirt</i>	ma'jeta	ma'ina	ma'ju
<i>boy</i>	ɲa'rəl	ɲari'li	x
<i>eye</i>	'øtʃ	y'tʃi	y'tʃu
<i>dress</i>	vis'tit	visti'di	visti'du
<i>horn</i>	'koren	korna'tʃi	kurna'tʃu
<i>goat</i>	'kavra	ka'vrina	ka'vrana
<i>sheep</i>	'peora	peko'rina	piku'rana
<i>toilet</i>	'tʃeso	x	x
<i>bread</i>	'pa	pa'ni	pa'nu
<i>pruning knife</i>	'pendola	pindu'lina	pindu'luna
<i>key</i>	'tʃaf	tʃai'zina	tʃai'zuna
<i>cock</i>	'gal	ga'li	ga'lu
<i>donkey</i>	'azen	az'ni	azi'nu
<i>nun</i>	'monega	muni'gina	muni'guna
<i>bird</i>	o'zəl	uzi'li	uzi'lu
<i>egg</i>	'øf	x	x
<i>comb</i>	'peten	piti'ni	petina
<i>lyzard</i>	ly'zerta	lyzir'tina	lyzer'tu
<i>wolf</i>	'luf	x	x
<i>skinny</i>	'mager	magru'li	x
<i>door</i>	'porta	pur'tina	pu'rtu
<i>leg</i>	'gamba	gam'bina	gam'bu
<i>charriot</i>	ka'ret	kari'ti	ka'rata
<i>ear</i>	o'retʃa	uri'tʃina	uri'tʃuna
<i>brother</i>	fra'del	fradi'li	fradi'lu

ENG	Bresciano	DIM	AUG
<i>rat</i>	so'rek	suri'gi	suri'guna
<i>brick</i>	kwa'drəl	kwadri'li	x
<i>flour</i>	'fjur	fjuri'li	fjuri'lu
<i>tomato</i>	pon'dor	pundu'ri	pondor 'grəs
<i>lady</i>	'fonna	fun'nina	fun'nuna
<i>orange</i>	porto'gal	x	x
<i>sister</i>	so'rela	suri'lina	x
<i>brain</i>	ser'vel	sirvi'li	sirvi'lu
<i>foal</i>	po'leder	puli'dri	x
<i>nose</i>	'nas	na'zi	na'zu
<i>knot</i>	'grop	grupi'ti	x
<i>bottle</i>	bu'tilja	buti'kina	buti'ku
<i>zucchini</i>	sø'kəl	syki'li	x
<i>devil</i>	'djaol	djau'li	djau'lu
<i>doctor</i>	du'tur	dutu'ri	x
<i>sheet</i>	len'søl	linsu'li	x
<i>plum</i>	'brøɲe	bru'ɲine	x
<i>crow</i>	'kørf	kur'vi	x
<i>boat</i>	'barka	bar'kina	bar'kuna
<i>ham</i>	per'søt	pirsy'ti	x
<i>peach</i>	'persek	pirsi'ki	x
<i>pruning knife</i>	po'det	pudi'ti	pudi'tu
<i>pan</i>	pi'ɲata	piɲa'tina	piɲa'tuna
<i>fish</i>	'pəs	pisu'li	x
<i>cherry</i>	sa'reza	sari'zina	sari'zuna
<i>spoon</i>	ky'dʒa	kydʒa'ni	kydʒa'nu
<i>salad</i>	ver'dyra	x	x
<i>umbrella</i>	om'brəla	umbri'li	umbri'lu
<i>phaesant</i>	fa'za	faza'ni	x
<i>old man</i>	'vətʃ	vetʃa'si	x
<i>nail</i>	'øndʒa	yn'dʒina	yn'dʒuna
<i>pear</i>	'peer	pi'ri	x
<i>finger</i>	'dit	di'di	di'du
<i>pine tree</i>	'pi	pi'ni	pi'nu
<i>dumplings</i>	'ɲøk	ɲuki'ti	x
<i>necklace</i>	ko'lana	kola'nina	kola'nuna
<i>knife</i>	kor'təl	kurti'li	kurti'lu
<i>fountain</i>	fon'tana	fonta'ni	fonta'nuna
<i>strawberry</i>	ma'øla	x	x
<i>mule</i>	'myl	my'li	x
<i>black</i>	'negər	ni'gri	negra'tʃu

VM: 85 years old, male speaker of Bresciano

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	66	66	0	0	0	0	0	0	0
		100%							
E	23	23	0	0	0				
		100%							
O	14	14	0			0	0		
		100%							
Ø	5	5	0					0	0
		100%							
E-E	6	6	0	0	0				
		100%							
E-O	1	1	0	0	0	0	0		
		100%							
E-Ø	1	1	0	0	0			0	0
		100%							
O-E	12	12	0	0	0	0	0		
		100%							
O-O	1	1	0			0	0		
		100%							
Ø-E	3	3	0	0	0			0	0

ENG	Bresciano	DIM	AUG
<i>dog</i>	'ka	ka'ni	x
<i>tooth</i>	'dent	din'ti	ga'nasa
<i>artichoke</i>	kar'tʃɔfo	x	x
<i>hand</i>	'ma	ma'nina	ma 'grɔsa
<i>glass</i>	'veder	vi'dri	x
<i>sausage</i>	sa'lam	sala'mi	sala'mu
<i>mountain trail</i>	sen'ter	sinti'ri	x
<i>cup</i>	'tasa	ta'sina	skø'dela
<i>duck</i>	'nedra	ni'drina	ne'drɔt
<i>chair</i>	'skapa	ska'nina	ska'nu
<i>hat</i>	ka'pel	kapi'li	ka'pela
<i>sock</i>	kal'set	kalsi'ti	kalsi'tu
<i>apron</i>	biga'røl	biga'ri	biga'røla
<i>blind</i>	'ɔrp	x	x
<i>rabbit</i>	ko'netʃ	kuni'tʃi	ko'netʃa
<i>pan</i>	pa'dela	padi'lina	x
<i>horse</i>	ka'al	kaa'li	x
<i>saw</i>	se'get	x	rasega
<i>apple</i>	'pom	po'mela	x
<i>church</i>	'tʃeza	ka'pela	kate'dral
<i>wood</i>	'tronki	x	x
<i>book</i>	'liber	lib'ret	x

ENG	Bresciano	DIM	AUG
<i>hare</i>	'legor	ligu'ri	x
<i>stainbeck</i>	'bek	x	x
<i>fig</i>	'fik	x	x
<i>bell</i>	kampa'nel	kampani'li	kam'pana
<i>calf</i>	e'del	vidi'li	x
<i>nail</i>	'tʃot	tʃudi'li	x
<i>potato</i>	pa'tata	pata'ti	x
<i>dustpan</i>	pa'leta	pali'tina	x
<i>goose</i>	'oka	u'kina	x
<i>belly</i>	'bɔdʒa	bu'dʒina	bu'dʒuna
<i>owl</i>	si'eta	x	x
<i>tree</i>	'pjanta	pjan'tina	x
<i>candle</i>	kan'dela	kandi'lina	x
<i>mushroom</i>	'fons	fun'zi	x
<i>cow</i>	'aka	x	x
<i>bed</i>	'let	li'ti	x
<i>pig</i>	'si	sina'ti	ver
<i>snail</i>	lø'maga	løma'gina	løma'gɔt
<i>trousers</i>	'brage	bra'gine	x
<i>mouth</i>	'boka	bu'kina	bo'kasa
<i>funnel</i>	turta'røl	turtaru'li	x
<i>mustaches</i>	'baffi	bafi'ti	mus'tas

ENG	Bresciano	DIM	AUG
<i>glass</i>	bi'tʃer	bitʃi'ri	ka'rafa
<i>fog</i>	'nebja	nibu'lina	ni'bju
<i>house</i>	'kaza	ka'zina	ka'zota
<i>rock</i>	'preda	ba'löt	mas
<i>cat</i>	'gat	ga'ti	x
<i>bag</i>	'borsa	bor'seta	bur'su
<i>priest</i>	'pret	preta'si	x
<i>bat</i>	gri'napola	grinapu'lina	x
<i>fly</i>	'moska	mus'kina	mus'ku
<i>tshirt</i>	'maja	ma'ina	x
<i>boy</i>	ɲa'rɛl	ɲari'li	ɲare'löt
<i>eye</i>	'øtʃ	u'tʃi	x
<i>dress</i>	vis'tit	visti'di	visti'du
<i>horn</i>	'koren	korna'zi	x
<i>goat</i>	'kavra	ka'vrina	bek
<i>sheep</i>	'pera	pi'rina	x
<i>toilet</i>	'tʃeso	x	x
<i>bread</i>	'pa	x	x
<i>pendulum clock</i>	'pendola	x	x
<i>key</i>	'tʃaf	x	x
<i>cock</i>	'gal	ga'lɛl	x
<i>donkey</i>	'azen	az'ni	az'nu
<i>nun</i>	'monega	muni'gina	x
<i>bird</i>	o'zɛl	uzi'li	x
<i>egg</i>	'øf	øfa'zi	x
<i>comb</i>	'peten	piti'ni	x
<i>lyzard</i>	lø'zerta	lyzir'tina	lyzir'tuna
<i>wolf</i>	'lupo	x	x
<i>skinny</i>	'mager	magru'lina	x
<i>door</i>	'porta	pur'tu	
<i>leg</i>	'gamba	gam'bina	gam'buna
<i>charriot</i>	ka'reta	kari'ti	x
<i>ear</i>	ore'tʃa	uri'tʃina	uri'tʃuna
<i>brother</i>	fra'del	fradi'li	x
<i>rat</i>	so'rek	suri'gi	tu'pu
<i>brick</i>	kwa'drɛl	kwadri'li	x
<i>flour</i>	'fjur	fjuri'li	x
<i>tomato</i>	pon'dor	pundu'ri	x
<i>lady</i>	'fonna	fun'nina	fun'nuna

ENG	Bresciano	DIM	AUG
<i>orange</i>	porto'gal	x	x
<i>sister</i>	so'rela	suri'lina	x
<i>brain</i>	ser'vɛl	sirvi'li	x
<i>coffin</i>	'kasa del 'mort	x	x
<i>foal</i>	po'leder	puli'dri	x
<i>nose</i>	'nas	na'zi	na'zu
<i>knot</i>	'grop	x	x
<i>bottle</i>	bu'tilja	buti'kina	but'i'kina
<i>zucchini</i>	sø'kɛl	syki'li	x
<i>devil</i>	'djaol	djau'li	x
<i>doctor</i>	du'tur	dutu'ri	x
<i>sheet</i>	lɛn'søɫ	linsu'li	x
<i>plum</i>	'brøɲe	bru'ɲi	x
<i>crow</i>	'kørf	x	x
<i>boat</i>	'barka	bar'kina	bar'kuna
<i>ham</i>	per'søt	x	x
<i>peach</i>	'pɛrsek	pirsi'gi	x
<i>lazy</i>	x	x	x
<i>pruning knife</i>	po'dɛt	pudi'ti	x
<i>pan</i>	pi'ɲata	piɲa'tina	x
<i>fish</i>	'pɛs	pisi'ti	x
<i>cherry</i>	sa'resa	x	x
<i>spoon</i>	ky'dza	kydza'ni	x
<i>salad</i>	vir'dyre	virdy'rine	x
<i>umbrella</i>	om'brela	x	x
<i>phaesant</i>	fa'za	faza'ni	fa'zana
<i>old man</i>	'vɛtʃo	x	x
<i>nail</i>	'øndza	yn'dzina	yn'dzuna
<i>mouse</i>	so'rek	suri'gi	x
<i>pear</i>	'peer	x	x
<i>finger</i>	'dit	di'di	x
<i>pine tree</i>	pa'ger	pagi'ri	x
<i>dumplings</i>	'ɲøk	x	x
<i>necklace</i>	ko'lana	kola'nina	kola'nuna
<i>knife</i>	kor'tɛl	kurti'li	x
<i>fountain</i>	fon'tana	fonta'nina	fonta'nuna
<i>strawberry</i>	ma'øla	may'lina	x
<i>mule</i>	'myl	my'li	my'lu
<i>black</i>	'neger	ni'gri	negra'tʃu

CM. 84 years old, female speaker of Camuno from Rino

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	126	69	57	5	48	1	3	0	0
		54.7%	45.2%	3.9%	38.1%	7.9%	2.4%		
E	55	21	34	5	29				
		38.2%	61.8%	9.1%	52.7%				
O	33	29	4			1	3		
		87.9%	12.1			3%	9.1%		
Ø	8	8	0					0	0
		100%							
E-E	7	3	4	0	4				
		42.8%	57.2%		57.2%				
E-O	5	0	5	0	5	0	0		
			100%		100%				
E-Ø	2	0	2	0	2			0	0
			100%		100%				
O-E	15	7	8	0	8	0	0		
		46.7%	53.3%		53.3%				
O-O	1	1	0			0	0		
		100%							

ENG	Camuno	DIM	AUG
<i>dog</i>	ka'nɔl	kapu'li	kapu'lu
<i>tooth</i>	'det	din'ti	dɛn'tu
<i>artichoke</i>	kar'tʃɔfo	kartʃɔfu'li	kartʃɔfu'lu
<i>hand</i>	'ma	ma'nina	ma'nuna
<i>glass</i>	'veder	edru'li	x
<i>sausage</i>	sa'lam	sala'mi	sala'mu
<i>mountain trail</i>	'senter	senteru'li	sente'ras
<i>cup</i>	'tasa	ta'sina	ta'suna
<i>duck</i>	na'drɔta	ni'dri	x
<i>chair</i>	'skapa	ska'nina	ska'nuna
<i>hat</i>	ka'pel	kapi'li	kape'lu
<i>sock</i>	'kalsa	kal'si	kalse'tu
<i>apron</i>	biga'rɔl	bigaru'li	bigaru'lu
<i>blind</i>	'ɔrp	orba'tʃi	x
<i>rabbit</i>	ku'nitʃ	kuni'tʃi	kuni'tʃu
<i>pan</i>	pa'dela	padi'lina	pade'luna
<i>horse</i>	ka'al	kaa'li	kaa'lu
<i>saw</i>	'rasega	rasi'gina	rase'gu
<i>apple</i>	'pom	pu'mi	pu'mu
<i>church</i>	'tʃeza	tʃi'zina	tʃe'zuna
<i>wood</i>	'bora	boradi'li	borade'lu

ENG	Camuno	DIM	AUG
<i>book</i>	'liber	libri'ti	libre'tu
<i>hare</i>	'legor	legur'sina	legu'runa
<i>stainbeck</i>	x	x	x
<i>fig</i>	'fik	x	fi'kos
<i>bell</i>	kampa'nɛl	kampani'li	kampane'lu
<i>calf</i>	ve'dɛl	vidi'li	vede'lu
<i>nail</i>	'tʃot	tʃu'di	tʃu'du
<i>potato</i>	pa'tata	pata'ti	pata'tu
<i>dustpan</i>	x	x	x
<i>goose</i>	'oka	u'ki	o'kasa
<i>belly</i>	'bɔdʒa	bu'dʒina	bu'dʒuna
<i>owl</i>	si'eta	sie'tina	sie'tuna
<i>tree</i>	'pjanta	pjian'tina	pjan'tuna
<i>candle</i>	kan'dela	kandi'lina	kande'luna
<i>mushroom</i>	'fons	fun'si	fun'su
<i>boletus edulis</i>	x	x	x
<i>cow</i>	'aka	a'kina	a'kuna
<i>bed</i>	'let	li'ti	le'tu
<i>pig</i>	por'sɛl	pursi'li	porse'lu
<i>pig</i>	x	x	x
<i>snail</i>	ly'maga	lyma'gina	lyma'guna

ENG	Camuno	DIM	AUG
<i>trousers</i>	'brage	bra'gine	bra'gune
<i>mouth</i>	'boka	bu'kina	bu'kuna
<i>funnel</i>	pidri'øl	pidriu'li	pidriu'lu
<i>mustaches</i>	'bafi	ba'fi	ba'fu
<i>glass</i>	bi'tfer	bitferu'li	bitferu'lu
<i>fog</i>	'geba	ge'bina	ge'buna
<i>house</i>	'ka	ka'zina	ka'zuna
<i>rock</i>	'korna	kurnu'lina	x
<i>cat</i>	'gat	ga'ti	ga'tu
<i>bag</i>	'borrsa	bursi'li	bur'su
<i>priest</i>	'pret	pre'ti	pre'tu
<i>bat</i>	pipis'trel	x	x
<i>fly</i>	'moska	mus'kina	mus'kuna
<i>tshirt</i>	x	x	x
<i>boy</i>	ja'rel	ja'ri'li	'zuen
<i>eye</i>	'øtʃ	u'tʃi	u'tʃu
<i>dress</i>	vis'tit	visti'di	visti'du
<i>horn</i>	'koren	korna'dʒi	korna'dʒu
<i>goat</i>	'kavra	kavri'ti	kavre'tu
<i>sheep</i>	'peora	x	peu'runa
<i>lamb</i>	x	aji'li	x
<i>toilet</i>	'tʃeso	tʃi'si	tʃe'su
<i>bread</i>	'pa	x	x
<i>slices of bread</i>	'feta	fi'tina	fe'tuna
<i>pendulum clock</i>	ro'loj a 'pendolo	pendu'li	pendu'lu
<i>key</i>	'tʃaf	tʃai'tina	tʃae'tuna
<i>cock</i>	'gal	gali'ti	gale'tu
<i>donkey</i>	'azen	az'ni	az'nu
<i>nun</i>	'monega	muni'gina	mone'guna
<i>bird</i>	u'zel	uzi'li	uze'lu
<i>egg</i>	'øf	x	u'vu
<i>comb</i>	'peten	piti'ni	pete'nu
<i>lyzard</i>	ly'zertola	lu'zertola	lusertu'lu
<i>wolf</i>	'luf	lu'fi	lu'fu
<i>skinny</i>	x	x	x
<i>door</i>	'porta	pur'tina	pur'tuna
<i>leg</i>	'gamba	gam'bina	gam'buna
<i>charriot</i>	ka'ret	kari'ti	kare'tu
<i>ear</i>	o'redʒa	uri'gina	ore'dʒu

ENG	Camuno	DIM	AUG
<i>brother</i>	so'rela	suri'lina	sore'luna
<i>rat</i>	'sores	suri'si	sore'su
<i>brick</i>	kwa'drel	kwadri'li	kwadre'lu
<i>butter</i>	bo'ter	x	x
<i>flour</i>	'fjur	fjuri'li	fjore'lu
<i>tomato</i>	pon'dør	pundu'ri	ponderu'lu
<i>lady</i>	'fomna	fum'nina	fum'nuna
<i>orange</i>	li'mu	limun'si	x
<i>sister</i>	fra'del	fradi'li	frade'lu
<i>brain</i>	ser'vel	sirvi'li de ga'lina	serve'lu
<i>coffin</i>	x	x	x
<i>foal</i>	kaa'li	x	x
<i>nose</i>	'nas	na'zi	na'zu
<i>knot</i>	'grop	gru'pi	gru'pu
<i>bottle</i>	bu'tiʎa	buti'xi	boti'ʎu
<i>zucchini</i>	sy'ki	sy'ki	su'ku
<i>cucumber</i>	x	x	x
<i>meat roll</i>	x	x	x
<i>devil</i>	'djaol	djau'li	djau'lu
<i>doctor</i>	du'tur	dutu'ri	dutu'ru
<i>sheet</i>	len'søl	lensu'li	lensu'lu
<i>plum</i>	'broje	bru'ni	bru'ju
<i>crow</i>	'korf	kor'vi	kor'vu
<i>boat</i>	'barka	bar'kina	bar'kuna
<i>ham</i>	per'syt	persy'ti	persu'tu
<i>peach</i>	x	x	x
<i>pruning knife</i>	x	x	x
<i>pruning knife</i>	po'deta	pudi'ti	pode'tu
<i>pot</i>	pa'dela	padi'lina	pade'luna
<i>fish</i>	'pes	pesu'li	pesu'lu
<i>cherry</i>	sa'rerdʒa	sarir'dʒi	sarer'dʒu
<i>spoon</i>	ku'dʒa	kudʒa'ni	kudʒa'nu
<i>salad</i>	x	x	x
<i>umbrella</i>	om'brela	umbri'li	ombre'lu
<i>phaesant</i>	x	x	x
<i>old man</i>	'vetʃ	ve'tʃino	ve'tʃu
<i>nail</i>	'yndʒa	yn'dʒina	yn'dʒuna
<i>mouse</i>	'sores	suri'si	sore'su
<i>pear</i>	'pera	pe'rina	pe'runa

ENG	Camuno	DIM	AUG
<i>finger</i>	'dit	di'ti	di'tu
<i>pine tree</i>	x	x	x
<i>dumpling</i>	'ɲək	ɲu'ki	ɲu'ku
<i>necklace</i>	ko'lana	kola'nina	kola'nuna

ENG	Camuno	DIM	AUG
<i>knife</i>	kor'tel	kurti'li	korte'lu
<i>fountain</i>	fon'tana	fonta'nina	fonta'nuna
<i>strawberry</i>	'frola	fru'lina	fru'luna
<i>mule</i>	'myl	my'li	my'lu
<i>black</i>	x	x	x

GF. 93 years old, female speaker of Camuno from Garda

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	80	46	34	2	32	0	0	0	0
		57.5%	42.5%	2.5%	40%				
E	36	14	22	2	20				
		38.9%	61.1%	5.6%	55.6%				
O	18	18	0			0	0		
		100%							
Ø	2	2	0					0	0
		100%							
E-E	7	4	3	0	3				
		57.1%	42.8%		42.8%				
E-O	4	0	4	0	4	0	0		
			100%		100%				
E-Ø	0	0	0	0	0			0	0
O-E	13	7	5	0	5	0	0		
		53.8%	38.4%		38.4%				

ENG	Camuno	DIM	AUG
<i>dog</i>	ka'ɲəl	kaɲu'li	ka'ɲəl
<i>tooth</i>	'det	din'ti	den'tu
<i>artichoke</i>	kar'tʃɔfo	kartʃu'fi	kar'tʃɔf 'gros
<i>hand</i>	'ma	ma'nina	ma'nuna
<i>glass</i>	x	x	x
<i>sausage</i>	sa'lam	sal'sisa	sa'lam
<i>mountain trail</i>	sen'ter	sinti'ri	sente'ru
<i>cup</i>	'tasa	ta'sina	sky'dela
<i>duck</i>	x	x	
<i>chair</i>	'skana	ska'ɲina	ska'ɲu
<i>hat</i>	ka'pəl	kapi'li	kape'lu
<i>sock</i>	kal'si	kal'si	'kalsa
<i>apron</i>	biga'rəl	bigaru'li	x
<i>blind</i>	'ɔrp	x	x

ENG	Camuno	DIM	AUG
<i>rabbit</i>	ku'nitʃ	kuni'tʃi	ku'nitʃ 'gros
<i>pan</i>	pa'dela	padi'li	pade'luna
<i>horse</i>	ka'al	x	kaa'lu
<i>saw</i>	se'get	sigi'ti	rase'gu
<i>apple</i>	'pom	pu'mi	'pom 'gros
<i>church</i>	'tʃeza	tʃezu'lina	x
<i>wood</i>	x	x	x
<i>book</i>	'liber	x	libru
<i>hare</i>	'legor	legu'ri	'legor 'grosa
<i>stainbeck</i>	'bək	bi'ki	be'ku
<i>fig</i>	'fik	'fik pitʃi'ni	'fik 'gros
<i>bell</i>	kampa'nəl	kampani'li	kampa'nu
<i>calf</i>	ve'dəl	vidi'li	'aka
<i>nail</i>	'tʃot	tʃu'di	'tʃot 'gros

ENG	Camuno	DIM	AUG
<i>potato</i>	pa'tata	pata'ti	pa'tata 'grosa
<i>dustpan</i>	pa'leta	pali'tina	pale'tu
<i>goose</i>	'oka	u'ki	'oka 'grosa
<i>belly</i>	'bødza	bu'dzi	bu'dzu
<i>owl</i>	si'eta	sie'tina	x
<i>tree</i>	'pjanta	pjan'tina	pjan'tu
<i>candle</i>	kan'dela	kande'lina	kande'lu
<i>mushroom</i>	'fonk	fun'gi	kape'lu
<i>boletus edulis</i>	x	x	x
<i>cow</i>	'aka	ve'del	x
<i>bed</i>	'let	li'ti	le'tu
<i>pig</i>	por'sel	pursi'li	purse'lu
<i>pig</i>	x	x	x
<i>snail</i>	ly'maga	lyma'gi	lyma'gu
<i>trousers</i>	'brage	bra'gi	bra'gu
<i>mouth</i>	'boka	'boka pitʃi'nina	bo'kaɲa
<i>funnel</i>	pidri'øl	pidri'øl pitʃi'ni	'pidriol 'gros
<i>mustaches</i>	'bafi	x	x
<i>glass</i>	bi'tfer	bitʃi'ri	ka'rafa
<i>fog</i>	'nebja	nebu'li	'nebja 'fitta
<i>house</i>	'ka	kazi'tina	kaze'tu
<i>rock</i>	'korne	kur'ni	kurnelu'
<i>cat</i>	'gat	'gati	ga'tu
<i>bag</i>	'borsa	bur'si	bur'suna
<i>priest</i>	'pret	preta'si	preta'su
<i>bat</i>	pipis'trello	pipis'trello pitʃi'ni	x
<i>fly</i>	'moska	mus'ki	mus'ku
<i>tshirt</i>	x	x	x
<i>boy</i>	'pi	'pi pitʃi'ni	ma'tel
<i>eye</i>	øtʃ	x	'øtʃ 'grant
<i>dress</i>	vis'tit	vis'tit pitʃi'ni	x
<i>horn</i>	'køɾen	kur'ni	kur'nu
<i>goat</i>	'kavra	bu'di	x
<i>sheep</i>	'pevra	x	pevruna granda
<i>lamb</i>	a'ɲel	ɲi'li	x
<i>toilet</i>	'tʃeso	tʃesuli	tʃeso grant
<i>bread</i>	'pa	pa'ni	pa'nu

ENG	Camuno	DIM	AUG
<i>slices of bread</i>	x	x	x
<i>pendulum clock</i>	re'loj a 'dondolo	pendu'li	pendu'lu
<i>key</i>	tʃaf	tʃaf pitʃinina	tʃaf 'grosa
<i>cock</i>	'gal	gali'ti	'gal 'gros
<i>donkey</i>	'azen	az'ni	'azen 'gros
<i>nun</i>	'swøra	x	x
<i>bird</i>	o'zel	uzi'li	uze'lu
<i>egg</i>	'øf	øa'ti	'øf 'gros
<i>comb</i>	'petena	piti'ni	pete'nu
<i>lyzard</i>	ly'zerda	lyzerda pitʃinina	lyzertu
<i>wolf</i>	'luf	lupo pitʃi'ni	x
<i>skinny</i>	x	x	x
<i>door</i>	'porta	pur'tina	pur'tu
<i>leg</i>	'gamba	gam'bi	gam'bu
<i>charriot</i>	ka'ret	kari'ti	kare'tu
<i>ear</i>	o'redza	uri'dzina	o'redze 'grose
<i>brother</i>	fra'del	ɲari'li	x
<i>rat</i>	'soɾes	suri'si	pante'gana
<i>brick</i>	kwa'drei	kwadri'li	kwadre'lu
<i>butter</i>	x	x	x
<i>flour</i>	'fjur	fjuri'ti	'fjur 'grant
<i>tomato</i>	x	x	x
<i>lady</i>	'fomna	ɲa'rela	x
<i>orange</i>	porto'gal	purtuga'li	purtoga'lu
<i>sister</i>	so'rela	suri'lina	zue'nota
<i>brain</i>	x	x	x
<i>coffin</i>	x	x	x
<i>foal</i>	x	puli'dri	ka'al
<i>nose</i>	'nas	'nas pitʃi'ni	na'zu
<i>knot</i>	'grop	'grop pitʃi'ni	'grop 'gros
<i>bottle</i>	bo'tiɭa	buti'ɭi	buti'ɭu
<i>zucchini</i>	x	x	x
<i>cucumber</i>	x	x	x
<i>meat roll</i>	x	x	x
<i>devil</i>	x	x	x
<i>doctor</i>	du'tur	dutu'ri	du'tur 'grant
<i>sheet</i>	x	x	x
<i>plum</i>	'broɲa	bru'ɲi	'broɲa 'grosa

ENG	Camuno	DIM	AUG
<i>crow</i>	'kɔrf	uzi'li	'kɔrf 'gros
<i>boat</i>	'barka	bar'ki	bar'ku
<i>ham</i>	pro'ʃut	pro'ʃut pitʃi'ni	x
<i>peach</i>	x	x	x
<i>pruning knife</i>	po'deta	pudi'ti	pode'tu
<i>pruning knife</i>	x	x	x
<i>pot</i>	pi'nata	pina'ti	pina'tu
<i>fish</i>	'pes	pesu'li pitʃi'ni	'pes 'gros
<i>cherry</i>	sa'rerɔza	sarir'dʒi	x
<i>spoon</i>	ky'dʒa	kydʒa'ni	kudʒa'nu
<i>salad</i>	x	x	x
<i>umbrella</i>	om'brɛla	umbri'li	ombre'lu

ENG	Camuno	DIM	AUG
<i>phaesant</i>	x	x	x
<i>old man</i>	x	x	x
<i>nail</i>	'yndʒa	yn'dʒi	'umdʒa' grosa
<i>mouse</i>	'sores	suri'si	sore'su
<i>pear</i>	'per	peru'li	pe'ru
<i>finger</i>	'dit	ditu'li	di'tu
<i>pine tree</i>	pa'ger	pagi'tri	page'ru
<i>dumpling</i>	'ɲok	ɲu'ki	ɲu'ku
<i>necklace</i>	x	x	x
<i>knife</i>	kor'tel	kurti'li	korte'lu
<i>fountain</i>	x	x	x
<i>strawberry</i>	'frola	fruli'ti	'frola 'grosa
<i>mule</i>	x	x	x
<i>black</i>	x	x	x

DM 75 years old, female speaker of Camuno from Rino

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	127	77	50	3	47	0	0	0	0
		60.6%	39.4%	2.4%	37%				
E	49	18	31	2	29				
		36.7%	63.3%	4.1%	59.2%				
O	37	37	0			0	0		
		100%							
Ø	7	7	0					0	0
		100%							
E-E	10	4	6	1	5				
		40%	60%	10	50%				
E-O	4	0	4	0	4	0	0		
E-Ø	2	0	2	0	2			0	0
			100%		100%				
O-E	15	8	7	0	7	0	0		
		53.3%	46.7%		46.7%				
O-O	3	3	0			0	0		
		100%							

ENG	Camuno	DIM	AUG
<i>dog</i>	ka'ɲɔla	kapu'li	kapu'lu
<i>tooth</i>	'det	din'ti	den'tu
<i>artichoke</i>	kar'tʃɔfo	kartʃu'fi	kartʃu'fu

ENG	Camuno	DIM	AUG
<i>hand</i>	'ma	ma'nina	ma'nuna
<i>glass</i>	'vedre	vi'dri	ve'dru
<i>sausage</i>	sa'lam	sala'mi	sala'mu

ENG	Camuno	DIM	AUG
<i>mountain trail</i>	sen'ter	sinti'ri	sente'ru
<i>cup</i>	'kikera	kike'rina	kike'runa
<i>duck</i>	'anedra	x	x
<i>chair</i>	'skapa	ska'nina	ska'nuna
<i>hat</i>	ka'pəl	kapi'li	kape'lu
<i>sock</i>	'kalsa	kal'si	kalse'tu
<i>apron</i>	biga'rəl	bigaru'li	bigaru'lu
<i>blind</i>	'ərɸ	ur'bi	ur'bu
<i>rabbit</i>	ku'nitʃ	kuni'tʃi	kuni'tʃu
<i>pan</i>	pa'dela	padi'lina	pade'luna
<i>horse</i>	ka'al	kaa'li	kaa'lu
<i>saw</i>	'rasega	rasi'gi	rase'gu
<i>apple</i>	'pom	pu'mi	pu'mu
<i>church</i>	'tʃeza	tʃi'zina	tʃe'zuna
<i>wood</i>	'sək	su'ki	su'ku
<i>book</i>	'liber	libri'ti	lib'ru
<i>hare</i>	'leor	leu'ri	leu'runa
<i>stainbeck</i>	'bək	bi'ki	bə'ku
<i>fig</i>	'fik	fi'ki	fi'ku
<i>bell</i>	kampa'nəl	kampani'li	kampane'lu
<i>calf</i>	ve'dəl	bi'zi	man'dəl
<i>nail</i>	'tʃot	tʃu'di	tʃu'du
<i>potato</i>	pa'tata	pata'ti	pata'tuna
<i>dustpan</i>	pa'leta	pali'tina	pale'tuna
<i>goose</i>	'oka	u'kina	u'kuna
<i>belly</i>	'pansa	pan'sina	pan'suna
<i>owl</i>	si'eta	sii'tina	x
<i>tree</i>	'pjanta	pjan'tina	pjan'tuna
<i>candle</i>	kan'dela	kandi'lina	kande'luna
<i>mushroom</i>	'fonk	fun'gi	fun'gu
<i>boletus edulis</i>	x	x	x
<i>cow</i>	'aka	a'kina	a'kuna
<i>bed</i>	'let	li'ti	lə'tu
<i>pig</i>	por'sel	pursi'li	purse'lu
<i>pig</i>	x	x	x
<i>snail</i>	ly'maga	lyma'gina	lyma'guna
<i>trousers</i>	'brage	bra'gine	bra'gune
<i>mouth</i>	'boka	bu'kina	bu'kuna
<i>funnel</i>	pidri'əl	pidriu'li	pidriu'lu

ENG	Camuno	DIM	AUG
<i>mustaches</i>	'bafi	bafi'ti	ba'fu
<i>glass</i>	bi'tʃer	bitʃe'ri	bitʃe'ru
<i>fog</i>	'nebja	nebju'lina	ne'bjuna
<i>house</i>	'ka	kazi'tina	ka'zuna
<i>rock</i>	'korna	kur'nina	kur'nu
<i>cat</i>	'gat	ga'ti	ga'tu
<i>bag</i>	'borsa	bur'sina	bur'suna
<i>priest</i>	'pret	preta'si	preta'su
<i>bat</i>	pipis'trello	x	x
<i>fly</i>	'moska	mus'kina	mus'kuna
<i>tshirt</i>	x	x	x
<i>boy</i>	ɲa'rel	'pi	zue'nət
<i>eye</i>	'ətʃ	ydʒa'ti	ydʒa'tu
<i>dress</i>	vis'tit	visti'ti	visti'du
<i>horn</i>	'køren	kur'ni	kur'nu
<i>goat</i>	'kavra	kav'rina	kav'runa
<i>sheep</i>	'peora	peu'rina	peu'runa
<i>lamb</i>	x	x	x
<i>toilet</i>	'tʃeso	tʃi'si	tʃe'su
<i>bread</i>	'pa	paju'ki	paju'ku
<i>slices of bread</i>	x	x	x
<i>pendulum clock</i>	ro'loj	urulu'dzi	x
<i>key</i>	'tʃaf	tʃa'ina	'tʃaf'granda
<i>cock</i>	'gal	gali'ti	ga'lu
<i>donkey</i>	'azen	az'ni	az'nu
<i>nun</i>	'monega	muni'gina	mone'guna
<i>bird</i>	u'zəl	uzi'li	uze'lu
<i>egg</i>	'əf	ua'ti	oa'tu
<i>comb</i>	'peten	piti'ni	pete'nu
<i>lyzard</i>	ly'zerda	lyzerdu'lina	lyzer'du
<i>wolf</i>	'luf	lu'fi	'luf'grant
<i>skinny</i>	x	x	x
<i>door</i>	'pɔrta	pur'tina	pur'tu
<i>leg</i>	'gamba	gam'bina	gam'buna
<i>charriot</i>	ka'ret	kari'ti	kare'tu
<i>ear</i>	u'redʒa	uri'dʒina	ure'dʒu
<i>brother</i>	fra'del	fradi'li	frade'lu
<i>rat</i>	'sores	suri'si	sure'su
<i>brick</i>	kwa'drel	kwadri'li	kwadre'lu

ENG	Camuno	DIM	AUG
<i>butter</i>	bo'ter	buti'ri	x
<i>flour</i>	'fjur	fjuri'li	fjure'lu
<i>tomato</i>	pon'dor	pundu'ri	pundu'ru
<i>lady</i>	'fomna	fomna'sina	fum'nuna
<i>orange</i>	porto'gal	portoga'li	portoga'lu
<i>sister</i>	so'rela	suri'lina	sore'luna
<i>brain</i>	ser'vel	sirvi'li	serve'lu
<i>coffin</i>	x	x	x
<i>foal</i>	x	puli'dri	x
<i>nose</i>	'nas	na'zi	na'zu
<i>knot</i>	'grop	gru'pi	gru'pu
<i>bottle</i>	bo'seta	busi'tina	bose'tuna
<i>zucchini</i>	sy'ki	sy'kel	sy'kel 'grant
<i>cucumber</i>	x	x	x
<i>meat roll</i>	x	x	x
<i>devil</i>	'djaol	djau'li	djau'lu
<i>doctor</i>	du'tur	dutu'ri	dutu'ru
<i>sheet</i>	len'sol	lensu'li	lensu'lu
<i>plum</i>	'brope	bru'ni	bru'nu
<i>crow</i>	'korf	kur'vi	kur'vu
<i>boat</i>	bar'keta	barki'tina	bar'kuna
<i>ham</i>	per'syt	persy'ti	persu'tu
<i>peach</i>	'persek	pirsi'gi	perse'gu

ENG	Camuno	DIM	AUG
<i>pruning knife</i>	po'deta	pudi'ti	pude'tu
<i>pruning knife</i>	x	x	x
<i>pot</i>	pi'nata	pina'tina	pina'tu
<i>fish</i>	'pes	pesu'li	pesu'lu
<i>cherry</i>	se'resdza	seres'dzina	seres'dzuna
<i>spoon</i>	ky'dza	kydza'ni	kydza'nu
<i>salad</i>	er'dyre	x	x
<i>umbrella</i>	om'brel	umbri'li	ombre'lu
<i>phaesant</i>	fa'dza	fadza'ni	fadza'nu
<i>old man</i>	'etf	vedza'si	vedza'su
<i>nail</i>	'yndza	yn'dzina	yn'dzuna
<i>mouse</i>	'sores	suri'si	sore'su
<i>pear</i>	'per	peru'li	peru'lu
<i>finger</i>	'dit	di'ti	di'tu
<i>pine tree</i>	pa'ger	pagi'ri	page'ru
<i>dumpling</i>	'nok	nu'ki'ti	nu'ku
<i>necklace</i>	ko'lana	kola'nina	kola'nuna
<i>knife</i>	kor'tel	kurti'li	korte'lu
<i>fountain</i>	pon'tana	funta'ni	fonta'nu
<i>strawberry</i>	'fraola	frau'li	frau'lu
<i>mule</i>	'myl	my'li	my'lu
<i>black</i>	x	x	x

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LLB 76 years old, male speaker of Camuno from Sonico

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	123	76	47	2	45	0	0	0	0
E	52	21	31	2	29				
O	37	37	0			0	0		
Ø	6	6 100%	0					0	0
E-E	8	4 50%	4 50%	0	4 50%				
E-O	4	0	4 100%	0	4	0	0		
E-Ø	2	0	2	0	2			0	0

O-E	12	6	6	0	6	0	0		
O-O	2	2	0			0	0		
		100%							

ENG	Camuno	DIM	AUG
<i>dog</i>	ka'jøl	kapu'li	kapu'lu
<i>tooth</i>	'det	din'ti	den'tu
<i>artichoke</i>	kar'tʃɔfo	kartʃu'fi	kartʃu'fu
<i>hand</i>	'ma	ma'nina	ma'nona
<i>glass</i>	x	x	x
<i>sausage</i>	sa'lam	sala'mi	sala'mu
<i>mountain trail</i>	sen'ter	senteru'li	myla'tera
<i>cup</i>	sky'dela	ta'sina	sy'pera
<i>duck</i>	'anedra	ani'dri	ane'druna
<i>chair</i>	'skapa	ska'ni	ska'puna
<i>hat</i>	ba'ret	bari'ti	bare'tu
<i>sock</i>	kal'si	kal'si	kalse'tu
<i>apron</i>	biga'røl	bigaru'li	bigaru'lu
<i>blind</i>	'ørp	ur'bi	x
<i>rabbit</i>	ku'nitʃ	kuni'tʃi	kuni'tʃu
<i>pan</i>	pa'dela	padi'li	pade'lu
<i>horse</i>	ka'al	kaa'li	kaa'lu
<i>saw</i>	'rasega	rais'gi	rase'gu
<i>apple</i>	'pom	pu'mi	pu'mi
<i>church</i>	'tʃeza	tʃi'zina	tʃe'zu
<i>wood*</i>	'bora	bo'rel	'gran 'bora
<i>book</i>	'liber	libri'ti	libre'tu
<i>hare</i>	'legor	legora'ti	legora'tu
<i>stainbeck</i>	'bek	be'ki	be'ku
<i>fig</i>	'fik	fi'ki	fi'ku
<i>bell</i>	kampa'nel	kampani'li	ba'tøk
<i>calf</i>	ve'del	vedi'li	vede'lu
<i>nail</i>	'tʃot	tʃu'di	tʃu'du
<i>potato</i>	pa'tata	pata'ti	pata'tu
<i>dustpan</i>	pa'leta	pali'tina	pale'tuna
<i>goose</i>	'oka	u'ki	u'ku
<i>belly</i>	'bødʒa	bu'dʒi	bu'dʒu
<i>owl</i>	si'eta	sii'ti	sie'tu
<i>tree</i>	'pjan̩ta	pjan'tina	pjan'tuna
<i>candle</i>	kan'dela	kandi'li	kande'lu

ENG	Camuno	DIM	AUG
<i>mushroom</i>	'fonk	fun'zi	fun'gu
<i>boletus edulis</i>	'frer	fre'ri	x
<i>cow</i>	'aka	a'kina	a'kuna
<i>bed</i>	'let	li'ti	le'tu
<i>pig</i>	por'sel	pursi'li	porse'lu
<i>pig</i>	x	x	x
<i>snail</i>	ly'maga	lyma'gi	lyma'gu
<i>trousers</i>	'brage	bra'gine	bra'gu
<i>mouth</i>	'boka	bu'kina	bu'kuna
<i>funnel</i>	pidri'øl	pidriu'li	pidriu'lu
<i>mustaches</i>	'bafi	x	ba'fu
<i>glass</i>	bi'tʃer	bitʃi'ri	bitʃe'ru
<i>fog</i>	'nebj̥a	nebj̥u'lina	ne'bju
<i>house</i>	'ka	ka'zina	ka'zuna
<i>rock</i>	'pløk	pluki'ti	pluki'tu
<i>cat</i>	'gat	ga'ti	ga'tu
<i>bag</i>	'borsa	bur'sina	bur'su
<i>priest</i>	'pret	preta'si	pre'tu
<i>bat</i>	gre'napola	griɲapu'lin a	griɲapu'lun a
<i>fly</i>	'moska	mus'ki	mus'ku
<i>tshirt</i>	x	x	x
<i>boy</i>	'pi	'pi	x
<i>eye</i>	'øtʃ	y'dʒi	ydʒa'tu
<i>dress</i>	vis'tit	visti'di	visti'du
<i>horn</i>	'køren	kurna'zi	kurna'zu
<i>goat</i>	'kavra	ka'vri	ka'vru
<i>sheep</i>	'pegore	pegu'ri	pegu'ru
<i>lamb</i>	a'nel	ani'li	x
<i>toilet</i>	'tʃeso	tʃi'si	tʃe'su
<i>bread</i>	'pa	pa'ni	pa'nu
<i>slices of bread</i>	'feta	fi'tina	fe'tuna
<i>pendulum clock</i>	'pendola	re'lui	relu'ju
<i>key</i>	'tʃaf	tʃai'tina	tʃae'tuna
<i>cock</i>	'gal	gali'ti	gale'tu

ENG	Camuno	DIM	AUG
<i>donkey</i>	'azen	az'ni	az'nu
<i>nun</i>	'mɔnɛga	muni'gina	mone'guna
<i>bird</i>	u'zɛl	uzi'li	uze'lu
<i>egg</i>	'ɔf	ɔa'ti	ɔa'tu
<i>comb</i>	'pɛtɛt	piti'ni	pete'nu
<i>lyzard</i>	ly'zɛrda	lyzir'di	lyzer'du
<i>wolf</i>	'luf	lufi'ti	x
<i>door</i>	'ys	ysa'ti	ysa'tu
<i>leg</i>	'gamba	gam'bina	gam'buna
<i>charriot</i>	ka'ret	kari'ti	kare'tu
<i>ear</i>	o'rɛdʒa	uri'dʒina	uri'dʒuna
<i>brother</i>	fra'dɛl	fradi'li	frade'lu
<i>rat</i>	'sores	suri'si	sure'su
<i>brick</i>	kwa'drɛl	kwadri'li	kwadre'lu
<i>flour</i>	'fjɜr	fjuri'li	fjure'lu
<i>tomato</i>	pon'dɔr	pundu'ri	pundu'ru
<i>lady</i>	'fɔmna	fum'ni	fum'nu
<i>orange</i>	portu'gal	purtuga'li	purtuga'lu
<i>sister</i>	so'rela	suri'lina	sore'luna
<i>brain</i>	ser'vel	sirvi'li	serve'lu
<i>coffin</i>	x	x	x
<i>foal</i>	kaa'li	puli'dri	kaa'lu
<i>nose</i>	'nas	na'zi	na'zu
<i>knot</i>	'grop	gru'pi	gru'pu
<i>bottle</i>	bu'tiʎa	buti'ʎi	buti'ʎu
<i>zucchini</i>	sy'ki	syki'ti	sy'ki 'grant
<i>cucumber</i>	x	x	x
<i>meat roll</i>	x	x	x
<i>devil</i>	'djaol	djau'li	djau'lu

ENG	Camuno	DIM	AUG
<i>doctor</i>	du'tur	dutu'ri	dutu'ru
<i>sheet</i>	lɛn'sɔl	lɛnsu'li	lɛnsu'lu
<i>plum</i>	'brɔɲɛ	bru'ɲi	bru'ɲu
<i>crow</i>	'kɔrf	kur'vi	kur'vu
<i>boat</i>	'barka	bar'ki	bar'ku
<i>ham</i>	pɛr'syt	persy'ti	persy'tu
<i>peach</i>	'pɛsek	pirsi'gi	perse'gu
<i>pruning knife</i>	ram'pɛla	rampi'li	rampe'lu
<i>pruning knife</i>	po'dɛt	pudi'ti	pode'tu
<i>pot</i>	pi'ɲata	piɲa'ti	piɲa'tu
<i>fish</i>	'pɛs	pɛsa'ti	pɛsa'tu
<i>cherry</i>	sa'rɛrdʒa	sarir'dʒi	sarer'dʒu
<i>spoon</i>	ky'dʒa	kydʒa'ni	kydʒa'nu
<i>salad</i>	ɛr'dyɾa	verdy'rina	x
<i>umbrella</i>	om'bɛla	umbri'li	umbɛr'lu
<i>phaesant</i>	fa'za	faza'ni	faza'nu
<i>old man</i>	'vɛtʃɔ	vedʒa'si	vedʒa'su
<i>nail</i>	'yndʒa	yn'dʒi	yn'dʒu
<i>mouse</i>	'sores	suri'zi	sore'zu
<i>pear</i>	pɛr	pɛra'ti	pɛra'tu
<i>finger</i>	'dit	di'ti	di'tu
<i>pine tree</i>	pa'gɛr	pagi'ri	page'ru
<i>dumpling</i>	'ɲɔk	ɲuki'ti	ɲoke'tu
<i>necklace</i>	ko'lana	kula'ni	kulanu
<i>knife</i>	kor'tɛl	kurti'li	korte'lu
<i>fountain</i>	fon'tana	fonta'ni	fonta'nu
<i>strawberry</i>	'fragola	fragu'li	fragu'lu
<i>mule</i>	'myl	myla'ti	myla'tu
<i>black</i>	x	x	x

GR, 70 years old, male speaker of Camuno from Erbanno

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	84	54	30	1	28	1	0	0	0
		64.3%	35.7%	1.2%	33.3%	1.2%			
E	34	19	15	0	15				
		55.9%	44.1%		44.1%				
O	22	21	1			1	0		
		95.5%	5.5%			5.5%			
Ø	3	3	0					0	0
		100%							
E-E	8	4	4	1	3				
		50%	50%	12.5%	37.5%				
E-O	7	0	7	0	7	0	0		
			100%		100%				
E-Ø	1	0	1	0	1			0	0
			100%		100%				
O-E	6	4	2	0	2	0	0		
		66.7%	33.3%		33.3%				
O-O	3	3	0			0	0		

ENG	Camuno	DIM	AUG
<i>dog</i>	'ka	kaɲu'li	ka'ɲah
<i>tooth</i>	gana'hal	x	x
<i>artichoke</i>	arti'tʃək	artitʃuki'li	x
<i>hand</i>	'ma	ma'nina	ma'naha
<i>glass</i>	'edre	'hkədʒa	tu'kel de 'edre 'grant
<i>sausage</i>	x	hala'mi	hala'mu
<i>mountain trail</i>	hen'ter	hinti'ri	hente'ru
<i>cup</i>	hkø'dela	hkydi'lina	hkude'luna
<i>duck</i>	'nedra	ni'dri	ne'drət
<i>chair</i>	'hkaɲa	hka'ɲi	'hkaɲa
<i>hat</i>	bə'ret	biri'ti	bə'ret
<i>sock</i>	kalhe'ri	kalhi'ti	kalhe'tu
<i>apron</i>	biga'rəl	bigaru'li	biga'rəl
<i>blind</i>	'ørp	urba'hi	urba'ha
<i>rabbit</i>	ku'niʃ	kuni'tʃi	kuni'tʃu
<i>pan</i>	pa'dela	padi'li	pade'lu
<i>horse</i>	ka'al	kaa'li	kaa'lu
<i>saw</i>	'radega	radi'gina	rade'gu
<i>apple</i>	'pom	pu'mi	poma'hu
<i>church</i>	'tʃeða	tʃedu'lina	'dom
<i>wood</i>	'bora	ka'itʃ	x

ENG	Camuno	DIM	AUG
<i>book</i>	'liber	libri'ti	li'brafi
<i>hare</i>	'legər	legur'hi	legur'hu
<i>stainbeck</i>	'bək	beka'ri	beka'ru
<i>fig</i>	'fik	fi'ki	x
<i>bell</i>	kampa'nəl	kampani'li	kampa'nah
<i>calf</i>	man'dəl	mandu'li	a'kuna
<i>nail</i>	'tʃot	tʃu'di	tʃu'du
<i>potato</i>	pa'tata	pata'tina	pata'tuna
<i>dustpan</i>	pa'leta	pali'tina	pa'leta
<i>goose</i>	'oka	u'ki	x
<i>belly</i>	'bədʒa	bu'dʒi	bu'dʒu
<i>owl</i>	si'eta	x	x
<i>tree</i>	'pjanta	pjan'ti	pjan'tuna
<i>candle</i>	kan'dela	kandi'li	tu'ribol
<i>mushroom</i>	'fons	'fonh	fonha'tu
<i>boletus edulis</i>	'frer	x	x
<i>cow</i>	'aka	man'dəl	'aka
<i>bed</i>	'let	li'ti	
<i>pig</i>	por'hel	purhi'li	x
<i>pig</i>	x	x	x
<i>snail</i>	ly'maga	lyma'gi	lyma'guna
<i>trousers</i>	'brage	bra'gine	bra'gahe

ENG	Camuno	DIM	AUG
<i>mouth</i>	'boka	bu'kina	bo'kaha
<i>funnel</i>	turta'rəl	turtaru'li	x
<i>mustaches</i>	muh'tah	muhta'hi	muhta'hu
<i>glass</i>	bi'tfer	bitfi'ri	bitfe'ru
<i>fog</i>	'nɛbja	nɛbju'lina	x
<i>house</i>	'ka	kadi'lina	ka'lah
<i>rock</i>	ba'lət	balu'ti	'korna
<i>cat</i>	'gat	ga'ti	ga'tu
<i>bag</i>	'borha	bur'hina	va'liha
<i>priest</i>	'pret	preta'hi	preta'hu
<i>bat</i>	i'gorgola	x	x
<i>fly</i>	'moska	muh'ki	muh'ku
<i>tshirt</i>	x	x	x
<i>boy</i>	'kət	'pi	'botfa
<i>eye</i>	'ətʃ	ydʒa'ti	udʒa'ti
<i>dress</i>	is'tina	x	x
<i>horn</i>	'koren	korna'hi	x
<i>goat</i>	'kavra	kav'rina	kav'runa
<i>sheep</i>	'pegora	pegu'ri	pegu'ru
<i>lamb</i>	pegu'ri	x	x
<i>toilet</i>	'tʃɛho	tʃi'hi	tʃɛ'hu
<i>bread</i>	'pa	papu'ki	papu'ku
<i>slices of bread</i>	x	x	x
<i>pendulum clock</i>	oro'loj	urulu'i	x
<i>key</i>	'tʃaf	tʃai'dina	x
<i>cock</i>	x	x	x
<i>donkey</i>	'aden	ad'ni	ad'nu
<i>nun</i>	'mɔnega	x	x
<i>bird</i>	od'ɛl	udi'li	
<i>egg</i>	'oʃ	x	x
<i>comb</i>	'peten	peti'ni	x
<i>lyzard</i>	ly'derdola	lyderdu'lina	lyderdu'luna
<i>wolf</i>	'luf	x	x
<i>skinny</i>	x	x	x
<i>door</i>	'pɔrta	purti'lina	pur'tu
<i>leg</i>	'gamba	gam'bina	gam'bu
<i>charriot</i>	ka'ret	kari'ti	bre'gada
<i>ear</i>	o'redʒa	uri'dʒina	far'fɔja
<i>brother</i>	fra'dɛl	fradi'li	frade'lu

ENG	Camuno	DIM	AUG
<i>rat</i>	ho'rek	huri'gi	'patega
<i>brick</i>	kwa'drɛl	x	x
<i>butter</i>	x	x	x
<i>flour</i>	'tʃur	fjuri'li	fjure'lu
<i>tomato</i>	pon'dor	pundu'ri	pundu'ru
<i>lady</i>	'sjura	sju'rina	sju'raha
<i>orange</i>	porto'gal	aran'tʃi	x
<i>sister</i>	so'rela	suri'lina	sure'luna
<i>brain</i>	her'ver	hirvi'li	herve'lu
<i>coffin</i>	x	x	x
<i>foal</i>	kaa'li	x	x
<i>nose</i>	'nah	na'di	ka'nipa
<i>knot</i>	'grop	gru'pi	x
<i>bottle</i>	bu'tiʎa	buti'ʎi	buti'ʎu
<i>zucchini</i>	x	kykili	'huki'lu
<i>cucumber</i>	x	x	x
<i>meat roll</i>	x	x	x
<i>devil</i>	'djaol	djau'li	djau'lu
<i>doctor</i>	du'tur	dutu'ri	dutu'ru
<i>sheet</i>	lɛn'həl	lenhu'li	x
<i>plum</i>	'brɔna	bru'ni	bru'nu
<i>crow</i>	'kɔrf	korva'ti	kor'vah
<i>boat</i>	'barka	bar'ki	bar'ku
<i>ham</i>	pɛr'hyt	perhy'ti	perhu'tu
<i>peach</i>	'pɛrhek	pirhi'gi	x
<i>pruning knife</i>	po'dɛta	pudi'ti	po'dɛta
<i>pruning knife</i>	x	x	x
<i>pot</i>	pa'dɛla	pali'di	pale'du
<i>fish</i>	'pɛh	pehu'li	pehu'lu
<i>cherry</i>	ha'reda	hari'dina	hare'duna
<i>spoon</i>	ky'dʒa	kydʒa'ni	x
<i>salad</i>	x	x	x
<i>umbrella</i>	om'bɛrɛl	umbri'li	ombre'lu
<i>phaesant</i>	fa'dʒano	fadʒa'ni	fadʒa'nu
<i>old man</i>	'vɛtʃ	vɛtʃa'hi	vɛtʃa'hu
<i>nail</i>	'yndʒa	yndʒi'tina	x
<i>mouse</i>	ho'rek	huri'gi	'patega
<i>pear</i>	'pɛr	pera'ti	x
<i>finger</i>	'dit	ditu'li	ditu'lu

ENG	Camuno	DIM	AUG
<i>pine tree</i>	pa'ger	pagi'ri	page'ru
<i>dumpling</i>	'ɲək	ɲu'ki	ɲu'ku
<i>necklace</i>	ko'lana	kola'nin	ko'lana
<i>knife</i>	kor'tel	kurti'li	korte'lu

ENG	Camuno	DIM	AUG
<i>fountain</i>	fon'tana	fonta'ni	fonta'nu
<i>strawberry</i>	'fragola	frago'lina	x
<i>mule</i>	'myl	x	x
<i>black</i>	'neger	negra'hi	negra'hu

LR, 73 years old, male speaker of Camuno from Erbanno

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	100	49	51	6	44	1	0	0	0
		49%	51%	6%	44%	1%	0	0	0
E	56	24	32	2	30				
		42.8%	57.2%	3.6%	53.6%				
O	23	22	1			1	0		
		95.7%	4.3%			4.3%			
Ø	1	1	0					0	0
		100%							
E-E	8	1	7	4	3				
		12.5%	87.5%	50%	37.5%				
E-O	4	0	4	0	4	0	0		
			100%		100%				
E-Ø	2	0	2	0	2			0	0
			100%		100%				
O-E	4	0	4	0	4	0	0		
			100%		100%				
O-O	2	1	1		1	0	0		
		100%			50%				

ENG	Camuno	DIM	AUG
<i>dog</i>	'ka	kaɲu'li	x
<i>tooth</i>	'det	din'ti	den'tu
<i>artichoke</i>	arti'tʃək	x	x
<i>hand</i>	'ma	ma'nina	ma'nuna
<i>glass</i>	'edre	verdu'li	nvedri'ada
<i>sausage</i>	ha'lam	hala'mi	hala'mu
<i>mountain trail</i>	hin'ter	hinteru'li	vi'a
<i>cup</i>	'kikera	kike'rina	hky'dela
<i>duck</i>	'nɛdra	ni'dri	nɛ'dru
<i>chair</i>	'hkaɲa	hka'ɲina	hka'ɲu
<i>hat</i>	ka'pel	kapi'li	kape'lu
<i>sock</i>	kal'hɛt	kalhi'ti	kalhe'tu
<i>apron</i>	biga'rɔla	biga'ri	biga'rɔl

ENG	Camuno	DIM	AUG
<i>blind</i>	'ɔrp	urba'tʃi	urba'tʃu
<i>rabbit</i>	ku'niʃ'	kuni'tʃi	kuni'tʃu
<i>pan</i>	pa'dela	padi'lina	pade'luna
<i>horse</i>	ka'al	pu'leder	kaa'lu
<i>saw</i>	'raðega	raði'gina	parti'dur
<i>apple</i>	'pom	pu'mi	pu'mu
<i>church</i>	'tʃeða	tʃeðu'lina	tʃe'ðuna
<i>wood</i>	bu'rɛl	buri'li	bure'lu
<i>book</i>	'liber	li'bɛt	li'bru
<i>hare</i>	'legor	legur'hi	legur'hot
<i>stainbeck</i>	'bek	beka'ri	beka'ru
<i>fig</i>	'fik	x	x
<i>bell</i>	kampa'nɛl	kampani'li	kampa'nu
<i>calf</i>	ve'dɛl	vedi'li	'aka

ENG	Camuno	DIM	AUG
<i>nail</i>	'tʃot	tʃu'di	tʃu'du
<i>potato</i>	pa'tata	pata'tina	pata'tu
<i>dustpan</i>	pa'leta	pal'iti	pale'tu
<i>goose</i>	'oka	u'kina	'ok
<i>belly</i>	'bɔdʒa	bu'dʒina	bu'dʒu
<i>owl</i>	x	x	x
<i>tree</i>	'pjanta	pjan'tina	pjan'tu
<i>candle</i>	kan'dela	kandi'lina	'tʃero
<i>mushroom</i>	'fons	funsa'ti	funsa'tu
<i>boletus edulis</i>	'frer	frerar'ti	frerar'tu
<i>cow</i>	'aka	x	x
<i>bed</i>	'let	li'ti	x
<i>pig</i>	pur'hɛl	purhi'li	x
<i>snail</i>	ly'maga	lyma'gi	lyma'gu
<i>trousers</i>	'brage	bra'ginɛ	pa'tole
<i>mouth</i>	'boka	bu'kina	bo'kaha
<i>funnel</i>	turta'rɔl	turtaru'li	x
<i>mustaches</i>	muh'tatʃ	muhta'tʃi	ba'fu
<i>glass</i>	bi'tʃer	bitʃe'ri	bitʃe'ru
<i>fog*</i>	'nebbja	nɛbju'lina	nɛ'bju
<i>house</i>	'ka	kaði'lina	pa'lah
<i>rock</i>	ba'lɔtʃ	balu'ti	balu'tu
<i>cat</i>	'gat	ga'ti	ga'tu
<i>bag</i>	'borha	bur'hina	vali'ha
<i>priest</i>	'pret	preta'hi	preta'hu
<i>bat</i>	gri'napola	gri'napolin α	
<i>fly</i>	'mohka	muh'ki	muh'ku
<i>boy</i>	x	x	x
<i>eye</i>	'ɔtʃ	ydʒa'ti	ydʒa'tu
<i>dress</i>	ih'tina	ih'tina	x
<i>horn</i>	'koren	kurna'zi	'kɔrno
<i>goat</i>	'kavra	kavri'ti	kav'ru
<i>sheep</i>	'pegora	pegu'ri	be'hɔt
<i>lamb</i>	pegu'ri		
<i>toilet</i>	'tʃɛho	x	
<i>bread</i>	'pa	papu'ki	pa'pɔka
<i>slices of bread</i>	'fete	fi'tine	x
<i>pendulum clock</i>	'pendol	pendu'li	pendu'lu

ENG	Camuno	DIM	AUG
<i>key</i>	'tʃaf	tʃai'tina	tʃae'tu
<i>cock</i>	'gal	gali'ti	gale'tu
<i>donkey</i>	'aðɛn	ah'ni	ah'nu
<i>nun</i>	'mɔnega	muni'gina	mone'guna
<i>bird</i>	u'ðɛl	uzi'li	uðe'lu
<i>egg</i>	'ɔf	ua'ti	ua'tu
<i>comb</i>	'petɛn	peti'ni	pete'nu
<i>lyzard</i>	lu'ðerda	luðerdu'lin α	luðer'du
<i>wolf</i>	'luf	x	x
<i>skinny</i>	x	x	x
<i>door</i>	'porta	purti'lina	pur'tu
<i>leg</i>	'gamba	gam'bina	gam'bu
<i>charriot</i>	ka'ret	x	x
<i>ear</i>	u'rɛdʒa	uri'dʒina	far'fole
<i>brother</i>	fre'dɛl	fredi'li	fre'dɛl
<i>rat</i>	hu'relk	huri'gi	hure'gu
<i>brick</i>	kwa'drɛl	kwadri'li	kwadre'lu
<i>butter</i>	x	x	x
<i>flour</i>	'fjur	fjuri'li	fjure'tu
<i>tomato</i>	pon'dɔr	pundu'ri	punde'ru
<i>lady</i>	'fonna	fumna'hin α	fumna'huna
<i>orange</i>	purto'gal	x	x
<i>sister</i>	hu'rela	huri'lina	hu'rela
<i>brain</i>	hɛr'vel	hirvi'li	hɛrve'lu
<i>coffin</i>	x	x	x
<i>foal</i>	pu'leder	x	x
<i>nose</i>	'nah	na'ði	ka'nipa
<i>knot</i>	'grop	gru'pi	gru'pu
<i>bottle</i>	bu'tiʎa	buti'ʎina	buti'ʎu
<i>zucchini</i>	hy'kɛl	hyki'li	hyke'lu
<i>cucumber</i>	x	x	x
<i>meat roll</i>	x	x	x
<i>devil</i>	'djaol	djau'li	djau'lu
<i>doctor</i>	du'tur	dutu'ri	dutu'ru
<i>sheet</i>	lɛn'hɔl	lenhu'li	lenhu'lu
<i>plum</i>	'brɔpa	bru'pi	x
<i>crow</i>	'kɔrf	kurva'ti	kurva'tu
<i>boat</i>	'barka	bar'kina	bar'ku
<i>ham</i>	pɛr'hyt	pɛhy'ti	pɛrhy'tu

ENG	Camuno	DIM	AUG
<i>peach</i>	'perhek	perhi'gi	perhe'gu
<i>pruning knife</i>	pu'deta	pudi'tina	pude'tu
<i>pot</i>	pa'dela	padi'lina	pade'lu
<i>fish</i>	'peh	pehu'li	pehu'lu
<i>cherry</i>	ha'reða	hari'ðina	hare'ðu
<i>spoon</i>	ky'dza	kudza'ni	kydza'nu
<i>salad</i>	x	x	x
<i>umbrella</i>	um'bræla	umbri'li	umbre'lu
<i>phaesant</i>	fa'dzano		x
<i>old man</i>	'vetʃo	x	x

ENG	Camuno	DIM	AUG
<i>nail</i>	'ondza	un'dzina	un'dzu
<i>mouse</i>	hu'rek	huri'gi	hure'got
<i>pear</i>	'per	peru'li	x
<i>finger</i>	'dit	ditu'li	ditu'lu
<i>pine tree</i>	pa'ger	pagi'ri	page'ru
<i>dumpling</i>	'ɲok	ɲu'ki	x
<i>necklace</i>	ku'landa	kula'nina	kula'nuna
<i>knife</i>	kur'tel	kurti'li	kurte'lu
<i>fountain</i>	fon'tana	funta'ni	funta'nu
<i>strawberry</i>	'frola	fru'li	x
<i>mule</i>	'myl	x	x

PG 91 years, female speaker of Camuno from Agnone

Relevant tokens		Harmonies	Disharmonies	Disharmonic sequences					
				E-i	E-u	O-i	O-u	Ø-i	Ø-u
TOT	113	60	53	6	47	0	0	0	0
		53%	46.9%	5.3%	41.6%				
E	66	29	37	2	35				
		43.9%	56.1%	3%	53.1				
O	25	25	0			0	0		
		100%							
Ø	3	3	0					0	0
		100%							
E-E	8	0	8	4	4				
			100%	50%	50%				
E-O	5	1	4	0	4	0	0		
		20%	80%		80%				
E-Ø	2	0	2	0	2			0	0
			100%		100%				
O-E	2	0	2	0	2	0	0		
			100%		100%				
O-O	2	2	0			0	0		
		100%							

ENG	Camuno	DIM	AUG
<i>dog</i>	'ka	kaɲu'li	ka'ɲu
<i>tooth</i>	'det	din'ti	den'tu
<i>artichoke</i>	arti'tʃok	artitʃu'ki	x
<i>hand</i>	'ma	ma'nina	ma'nuna
<i>glass</i>	'vedre	vedra'hi	ve'dru
<i>sausage</i>	ha'lam	hala'mi	hala'mu
<i>mountain trail</i>	hin'ter	hinte'ri	hinte'ru
<i>cup</i>	'kikera	kike'rina	kike'ru

ENG	Camuno	DIM	AUG
<i>duck</i>	'nedra	ni'dri	ne'drət
<i>chair</i>	'hkaɲa	hka'ɲina	hka'ɲot
<i>hat</i>	ka'pel	kapi'li	kape'lu
<i>sock</i>	kal'het	kahli'ti	kalhe'tu
<i>apron</i>	biga'rəl	biga'ri	x
<i>blind</i>	'ørp	urba'hi	x
<i>rabbit</i>	ku'nitʃ	kuni'tʃi	kuni'tʃu
<i>pan</i>	pa'dela	padi'lina	pade'lu

ENG	Camuno	DIM	AUG
<i>horse</i>	ka'al	kaa'li	kaa'lu
<i>saw</i>	rðe'gət	raði'gi	rade'gu
<i>apple</i>	'pom	pu'mi	pu'mu
<i>church</i>	'tʃeða	tʃedu'lina	tʃe'du
<i>wood</i>	x	x	x
<i>book</i>	'liber	libri'ti	li'bru
<i>hare</i>	'legor	ligur'hi	legur'hu
<i>stainbeck</i>	'bək	beka'hi	ka'vru
<i>fig</i>	'fik	fiku'li	fi'ku
<i>bell</i>	kampa'nel	kampani'li	kampane'lu
<i>calf</i>	ve'dəl	vedi'li	x
<i>nail</i>	x	x	x
<i>potato</i>	pa'tata	pata'ti	pata'tu
<i>dustpan</i>	pa'leta	pali'tina	pale'tu
<i>goose</i>	'ok	u'ki	u'ku
<i>belly</i>	'bədʒa	bu'dʒet	bu'dʒu
<i>owl</i>	hi'eta	x	x
<i>tree</i>	'pjanta	pjan'tina	pjan'tu
<i>candle</i>	kan'dela	kandi'lina	kande'lu
<i>mushroom</i>	'fons	fonsa'ti	fonsa'tu
<i>cow</i>	'aka	ve'dəl	x
<i>bed</i>	'let	li'ti	le'tu
<i>pig</i>	pur'həl	purhi'li	purhe'lu
<i>snail</i>	ly'maga	lyma'gi	lyma'gu
<i>trousers</i>	'brage	bra'gine	bra'gu
<i>mouth</i>	'boka	bu'kina	bu'ku
<i>funnel</i>	turta'rəl	turtaru'li	turtaru'lu
<i>mustaches</i>	'bafi	bafi'ti	bafe'tu
<i>glass</i>	bi'tʃer	bitʃe'ri	bitʃe'ru
<i>fog</i>	'nebjə	x	x
<i>house</i>	'ka	kaði'lina	kaðe'lu
<i>rock</i>	ba'lət	balu'ti	balu'tu
<i>cat</i>	'gat	ga'ti	ga'tu
<i>bag</i>	bor'hina	bur'hina	bur'hu
<i>priest</i>	'pret	preta'hi	preta'hu
<i>bat</i>	griɲapola	griɲapuli	x
<i>fly</i>	mohka	muhki	muhku
<i>boy</i>	pi	pitʃini	zuenət
<i>eye</i>	ətʃ	ydʒati	ydʒatu
<i>dress</i>	vistit	vistidi	x

ENG	Camuno	DIM	AUG
<i>horn</i>	'koren	kurna'zi	kurna'zu
<i>goat</i>	'kavra	kavri'ti	kavre'tu
<i>sheep</i>	'pegora	pegu'ri	pegu'ru
<i>lamb</i>	a'ɲel	aɲi'li	x
<i>bread</i>	'pa	pa'ni	pa'ɲoka
<i>slices of bread</i>	'fete	fi'tine	fe'tuna
<i>pendulum clock</i>	re'loi	relu'i	x
<i>key</i>	'tʃaf	tʃai'ðina	tʃaedu
<i>cock</i>	'gal	gali'ti	ga'lu
<i>donkey</i>	'aðɛn	að'ni	ah'nu
<i>nun</i>	'mɔnega	muni'gina	mune'guna
<i>bird</i>	u'ðel	udi'li	ude'lu
<i>egg</i>	'øf	ua'ti	ua'tu
<i>comb</i>	'peten	peti'ni	pete'nu
<i>lyzard</i>	ly'ðerda	lyðir'di	lyðer'du
<i>wolf</i>	'luf	x	x
<i>skinny</i>	x	x	x
<i>door</i>	'porta	pur'tina	pur'tu
<i>leg</i>	'gamba	gam'bina	gam'bu
<i>charriot</i>	ka'ret	kari'ti	kare'tu
<i>ear</i>	u'redʒa	uri'dʒina	ure'dʒu
<i>brother</i>	fre'del	fridi'li	frede'lu
<i>rat</i>	hu'rek	huri'gi	hure'gu
<i>brick</i>	kwa'drel	kwadri'li	kwadre'lu
<i>butter</i>	x	x	x
<i>flour</i>	'fjur	fjuri'ti	fjure'tu
<i>tomato</i>	pon'dor	pundu'ri	pundu'ru
<i>lady</i>	'fonna	fumna'hina	fumna'huna
<i>orange</i>	purtu'gal	purtuga'li	purtuga'lu
<i>sister</i>	hu'rela	huri'lina	hure'luna
<i>brain</i>	her'vela	hervi'lina	herve'lu
<i>coffin</i>	x	x	x
<i>foal</i>	pu'leder	puli'dri	pule'dru
<i>nose</i>	'nah	na'ði	na'ðu
<i>knot</i>	'grop	gru'pi	gru'pu
<i>bottle</i>	bu'tiʎa	buti'ʎi	buti'ʎu
<i>zucchini</i>	hy'kel	hyki'li	hyke'lu
<i>cucumber</i>	x	x	x
<i>meat roll</i>	x	x	x

ENG	Camuno	DIM	AUG
<i>devil</i>	'djaol	djau'li	djau'lu
<i>doctor</i>	du'tur	dutu'ri	dutu'ru
<i>sheet</i>	len'hөл	lenhu'li	lenhu'lu
<i>plum</i>	'brəpe	bru'ni	bru'nu
<i>crow</i>	'kərf	kurva'ti	kurva'tu
<i>boat</i>	'barka	bar'ki	bar'ku
<i>ham</i>	pər'hyt	x	x
<i>peach</i>	'pəhək	perhi'gi	perhe'gu
<i>pruning knife</i>	pu'deta	pudi'ti	pude'tu
<i>pot</i>	x	x	
<i>fish</i>	'pəh	pehu'li	pehu'lu
<i>cherry</i>	ha'reða	hari'ði	hare'ðu
<i>spoon</i>	ky'dza	kydza'ni	kydza'nu

ENG	Camuno	DIM	AUG
<i>salad</i>	x	x	x
<i>umbrella</i>	um'brəla	umbri'li	umbre'lu
<i>old man</i>	'vətfo	x	x
<i>nail</i>	'yndza	yn'dzina	yn'dzuna
<i>mouse</i>	hu'rek	huri'gi	hure'gu
<i>pear</i>	'peer	peru'li	pera'tu
<i>finger</i>	'dit	ditu'li	ditu'lu
<i>pine tree</i>	pa'ger	pagi'ri	page'ru
<i>dumpling</i>	'nək	ɲu'ki	ɲu'ku
<i>necklace</i>	ku'lana	kula'nina	kula'nu
<i>knife</i>	kur'tel	kurti'li	kurte'lu
<i>fountain</i>	fon'tana	fonta'nina	fonta'nuna
<i>strawberry</i>	'frola	x	x
<i>mule</i>	'myl	myla'di	myla'du
<i>black</i>	x	x	x