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Spilling the beans: The development of conceptual knowledge about food and its links with food rejection in young children (3-7-years-old)

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LEAD
Laboratoire d'Etude de l'Apprentissage et du Développement

**THESE DE DOCTORAT DE L'ETABLISSEMENT UNIVERSITE BOURGOGNE
FRANCHE-COMTE**

PREPAREE AU CENTRE DE RECHERCHE DE L'INSTITUT PAUL BOCUSE

Ecole doctorale n°554

Ecole doctorale Environnement Sante

Doctorat de Psychologie du développement

Par

Mme Abigail PICKARD

Le développement des connaissances conceptuelles sur les aliments et leurs liens avec les
tendances au rejet des aliments chez les jeunes enfants (3-7 ans)

Thèse présentée et soutenue à Lyon, le 25 octobre 2021

Composition du Jury :

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Titre : Le développement des connaissances conceptuelles sur les aliments et leurs liens avec les tendances au rejet des aliments chez les jeunes enfants (3-7 ans)

Mots clés : développement cognitif, néophobie alimentaire, sélectivité alimentaire, rejets alimentaires, enfants, connaissances conceptuelles.

Une variété alimentaire insuffisante chez les enfants augmente la prévalence des carences nutritionnelles et des problèmes de santé dans de nombreux pays développés (DeCosta et al. 2017). Les mécanismes cognitifs, tels que la catégorisation et les connaissances conceptuelles, jouent un rôle important dans la compréhension et l'acceptation ou le rejet approprié des aliments. L'alimentation se prête à de nombreuses représentations, telles que les groupes taxonomiques (ex. l'agneau est de la viande), les associations thématiques (ex. l'agneau se mange dans une assiette) ou les concepts de scénario (ex. l'agneau se mange au dîner). Ces connaissances permettent une reconnaissance précise, une compréhension et une interaction appropriée lorsque l'enfant est confronté à des aliments dans un contexte particulier. Si les connaissances conceptuelles sont sous-développées, la possibilité de comprendre les stimuli et les situations est réduite. Lorsqu'un enfant est confronté à l'incertitude dans le domaine alimentaire, il est dès lors plus susceptible de rejeter une substance, qu'elle soit comestible ou non. Ce rejet inapproprié est fréquemment observé chez les jeunes enfants, dont le niveau de connaissances conceptuelles dans le domaine alimentaire est encore insuffisant.

Des études antérieures ont montré que les rejets des aliments (néophobie alimentaire et sélectivité alimentaire) sont associés à une connaissance insuffisante des catégories taxonomiques dans le domaine alimentaire (ex. fruits ou légumes). Cependant, les jeunes enfants ont accès à d'autres formes de connaissances conceptuelles pour les aider à interpréter les situations et les objets, comme les catégories de scénario (ex. les aliments du petit déjeuner) ou les associations thématiques (ex. la soupe et la cuillère).

L'objectif principal de ma recherche, qui a débuté en octobre 2018, était d'approfondir les résultats antérieurs en déterminant si les rejets alimentaires sont liés à l'immaturité de structures de connaissance spécifiques (catégories de scénario et thématiques), ou à des connaissances insuffisantes du monde des aliments. La première étape de la recherche a nécessité la détermination de l'âge auquel les enfants acquièrent certains types de connaissances et de catégories dans le domaine alimentaire. La deuxième étape consistait à déterminer comment la disposition à rejeter des aliments influence cette acquisition de connaissances. Quatre études empiriques ont été menées au cours des trois dernières années auprès d'enfants âgés de 3 à 7 ans. Les résultats obtenus ont montré que les jeunes enfants maîtrisent d'abord les concepts fonctionnels et les relations alimentaires thématiques (par exemple, la soupe et la cuillère), puis les scénarios alimentaires (par exemple, les aliments associés avec le petit-déjeuner). Cela indique que les enfants de 3 et 4 ans peuvent déjà s'appuyer sur les associations thématiques dans les situations alimentaires, tandis que les

enfants plus âgés peuvent orienter leurs choix en fonction de scénarios alimentaires normatifs. Comme pour les connaissances taxonomiques, les enfants ayant une connaissance conceptuelle plus faible des relations basées sur les scénarios alimentaires et des relations basées sur les associations thématiques dans le domaine alimentaire présentent des niveaux plus élevés de rejet des aliments. Les études menées dans cette thèse fournissent des preuves convaincantes que l'éducation des enfants sur les règles et les normes conventionnelles dans le domaine alimentaire pourrait être une stratégie efficace pour accroître la familiarité et promouvoir l'acceptation des aliments. Enfin, les résultats de cette recherche m'ont permis de formuler des suggestions adressées aux psychologues du développement et aux professionnels de la santé publique afin de développer des initiatives éducatives pour améliorer la connaissance des enfants en matière d'alimentation et favoriser un régime alimentaire plus diversifié.

Résumé Vulgarisé

Même les jeunes enfants s'appuient sur leurs connaissances existantes des aliments et des situations alimentaires pour identifier, puis accepter ou rejeter un aliment possible. En cas d'incertitude sur une situation alimentaire, ils peuvent rejeter d'autres aliments de manière inappropriée. Les recherches que j'ai menées visaient à déterminer le lien entre les connaissances alimentaires et le rejet des aliments. Les études ont testé les connaissances des enfants sur des situations alimentaires, comme les aliments appropriés à un repas ou les aliments associés. Les résultats ont montré que les enfants présentant des niveaux élevés de rejet des aliments ont une moins bonne connaissance des aliments habituellement consommés ensemble ou des aliments destinés à des repas spécifiques. L'éducation des enfants sur les situations alimentaires pourrait être un moyen bénéfique d'accroître la familiarité des enfants avec la nourriture et, par la suite, de promouvoir l'acceptation des aliments.

Title: Spilling the beans: The development of conceptual knowledge about food and its links with food rejection in young children (3-7-years-old)

Keywords: cognitive development, food neophobia, food pickiness, food rejection, young children, conceptual knowledge

Insufficient dietary variety in children leads to significant nutrient deficiencies and health issues, both in childhood and later life (DeCosta et al., 2017). Cognitive mechanisms, such as categorization and conceptual knowledge, play an important role in understanding and appropriately accepting or rejecting foods (Mura Paroche et al., 2017). The food domain lends itself to many concepts and categories, such as taxonomic (i.e., lamb is meat), thematic (i.e., lamb goes on a plate), or script (i.e., lamb is eaten at dinner). Such knowledge aids accurate recognition, understanding, and appropriate interaction when confronted with foods situated in context. If conceptual knowledge is underdeveloped, the possibility to understand food and eating situations is mired. When faced with such uncertainty in the food domain, children with increased food rejection tendencies are likely to reject a substance, regardless of whether it is edible or not. It thus stands to reason that impoverished conceptual knowledge in the food domain will lead to increased displays of food rejection in children.

Previous evidence demonstrated that food rejections (food neophobia and picky/fussy eating) are associated with impoverished knowledge of taxonomic categories in the food domain (such as the food groups: fruits or vegetables). However, young children have access to other forms of conceptual knowledge to help interpret situations and objects, such as script categories (i.e., breakfast foods) or thematic associates (i.e., soup and spoon). The overarching aim of my research, beginning in October 2018, was to expand upon these previous findings by determining whether food rejection is related to deficits in specific knowledge structures (script and thematic categories), or a global deficit in knowledge of food. The first step of the research required determining at what age children acquire certain types of knowledge and categories in the food domain. The second step was to determine how food rejection influences such knowledge acquisition. Four empirical studies were conducted over the past three years with children between 3 and 7 years old.

My findings show that young children first master functional and co-occurring food relations (i.e., soup and spoon), and later master food scripts (i.e., food to expect at breakfast). This indicates that children as young as 3 and 4 years old may already rely on common co-occurrence to guide their food acceptance in eating situations, while older children may depend on script norms. As with taxonomic knowledge, children with poorer conceptual knowledge of both script and co-occurring relations in the food domain exhibit increased levels of food rejection. The research findings provide compelling evidence that educating children about conceptual knowledge and food norms could be an effective strategy for increasing familiarity and subsequently promoting greater food acceptance. The research concludes by suggesting opportunities for developmental psychologists and public health professionals develop educational initiatives to improve children's knowledge of food and foster increased dietary variety.

Popularized Summary

Even young children rely on their existing knowledge of food and eating situations to identify and then accept or reject a possible food. However, children's knowledge of food is still rapidly developing, and if uncertain about an eating situation, they may inappropriately reject more foods. The research I conducted over the past three years aimed to determine what type of food knowledge children have, and more importantly, how food knowledge is linked with food rejection. The studies tested 3-7-year-olds' knowledge of eating situations, such as meal-appropriate foods or foods commonly paired together. The results showed that children with higher levels of food rejection have poorer knowledge of foods conventionally eaten together, or foods for specific mealtimes. Educating children about foods and eating situations could be a beneficial way to increase children's familiarity with food and subsequently promote food acceptance.

“It was all very well to say, “Drink me,” but the wise little Alice was not going to do that in a hurry. “No, I’ll look first,” she said, “and see whether it’s marked ‘poison’ or not”; for she had read several nice little stories about children who got burnt, and eaten up by wild beasts, and other unpleasant things, all because they would not remember the simple rules their friends had taught them: such as, that a red-hot poker will burn you if you hold it too long; and that, if you cut your finger very deeply with a knife, it usually bleeds; and she had never forgotten that, if you drink much from a bottle marked “poison,” it is almost certain to disagree with you, sooner or later.”

- Lewis Carroll

Institut Paul Bocuse

For Pip,

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General introduction

Decision-making in the food domain is a fundamental process because it is crucial to execute caution when deciding whether to accept or reject the food due to the potential toxicity in certain substances. However, sufficient dietary variety and food availability also require that we do not inappropriately reject potential foods.

Our acceptance of food is not solely guided by the food itself but by the conceptual knowledge we have of food and eating situations. Such representations allow for accurate recognition, understanding, and decision-making when confronted with a potential food source (Ross & Murphy, 1999). From a young age (post-weaning period), children must increasingly make independent decisions when confronted with food. However, young children's mental representations are still relatively underdeveloped (Inhelder & Piaget, 2013; Keil, 1992; Markman, 1989; Gelman, 2003). To understand how children make decisions in the eating arena, it is essential to investigate children's contextual representation of food, and how this guides and shapes early dietary behavior and food acceptance.

Take the example of when, at 8 years old, I ordered mussels for the first time at a restaurant with my family. After taking our order, the waiter appeared and served what appeared to be warm water in a porcelain bowl. I hesitantly picked up my spoon and began to ladle up the 'soup' to try. After a few mouthfuls, my mother witnessed what I was doing and informed me that the bowl of liquid was not for eating, but to wash our fingers, after eating the mussels. Despite being presented with a peculiar and unfamiliar soup that did not conform to my 'expected' representation of soup, I had relied on other knowledge of eating situations to believe that the water was for consumption rather than cleaning. The spatial cues of being served alongside a spoon, the temporal cues of being produced after ordering, and the functional cues of being presented in a bowl, all contributed to my interpretation that I was presented with something to be consumed.

This anecdote may appear rare, but for a child of 3, 4, or even 8 years old, they will be confronted with many unfamiliar foods and food-based situations that they must decide whether to accept or reject. While my mental representation of the eating scenario provoked me to sample the 'soup', such uncertainty or incomprehension may equally have provoked a rejection of the substance served. In other words, children must draw upon their mental representations of food and eating situations to make an informed decision. Incomplete mental representations, such as not knowing that fingers are cleaned after consuming shellfish, may

lead to inaccurate interpretations, provoking both inappropriate rejections and acceptations. Of course, to execute caution in unfamiliar situations and reject a substance is an effective survival mechanism, particularly in terms of ingesting potentially toxic substances. However, if this cautiousness is executed in abundance, it is likely to lead to a significant reduction in potential foods to be accepted (Crane, 2020).

The reliance on existing knowledge to interpret unfamiliar instances of food led early research to hypothesize that a lack of food knowledge incites uncertainty leading to subsequent food rejection (Birch & Marlin, 1982). Following such logic, exposure or familiarity with foods should incite food acceptance. However, this is not the observed case as children who present persistent food rejection tendencies between two and six years old continue to reject familiar fruits and vegetables. Given that children who are exposed to foods continue to display such food rejection, this thesis questions whether it is other forms of knowledge, such as contextual and situational foods that influence children's certainty in eating situations. As evidenced in the above example our interpretation and acceptance of food does not rely solely on knowledge of the food item, but also our knowledge of the contextual cues available in eating situations. Regardless of whether a child recognizes a food or not, the situational cues will heavily influence a children's interpretation of the appropriateness of food in situ. If the child has insufficient associations and contextual knowledge of food situations, this is likely to lead to uncertainty and inappropriate food rejection (Lafraire et al., 2016; Rioux et al., 2016). For example, if a child was commonly served bread in isolation, but on one occasion served bread with butter, insufficient knowledge that bread and butter are a conventional association may provoke feelings of novelty in the child, causing them to reject the pair as a whole, regardless of the child being familiar with bread and butter as individual entities.

Therefore, the overarching aim of this research, beginning in October 2018, was to explore how different forms of context-based knowledge influence food rejection in young children. The research empirically investigates the hypothesis that impoverished contextual knowledge in the food domain drives food rejection.

This thesis cumulates three years of research responding to the research problem: If food knowledge leads to greater food acceptance, why do children still present food rejection tendencies despite familiarity with food?

The thesis concludes by suggesting opportunities for developmental psychologists and public health professionals to better understand children's cognition in the food domain to develop educational initiatives to improve children's dietary variety.

The present Ph.D. project was in collaboration with the Institute Paul Bocuse Research Center (IBPR), the Laboratory for Research on Learning and Development (LEAD), along with the financial support from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement No. 764985. Support was also received from the France-Stanford center for interdisciplinary research, as part of the BEETROOT project in collaboration with Ellen Markman of the Department of Psychology, Stanford.

This doctoral dissertation consists of seven chapters, structured under three sections. Part A comprises three chapters, including reviews of the existing literature, the theoretical framework, and the methodologies. Chapter 1 defines specific types of conceptual knowledge (namely taxonomic, thematic, and script knowledge), as well as explaining the relevance and importance of such knowledge in guiding food decisions. Chapter 2 provides an overview of the developmental literature detailing the acquisition, availability, and use of such knowledge structures in childhood. Chapter 3 explores how impoverished conceptual knowledge may invoke increased food rejection tendencies in young children. The chapter first elaborates on the directionality of said relationship, before providing the existing literature on food knowledge and food rejection. Chapter 4 outlines the proposed methodologies to achieve the respective research aims, detailing the objectives, hypotheses, and data collection tools.

Part B – chapter 5 presents the first study conducted for this research as a written paper in journal format. This chapter explores the relationship that food rejection has with both taxonomic and thematic analogical reasoning and categorization ability in young children.

Part B - chapter 6 presents the second published article, encompassing three consecutive experiments. The compilation of these three studies outlines different interpretations of thematic and script associates and their respective developmental trajectories. The research concludes with findings on food rejection and gaps in conceptual knowledge. The final part of this doctoral dissertation (Part C) provides a discussion and conclusion on the empirical findings and the contribution of this research to understanding food rejection in young children.

Part A – Theoretical Framework

Chapter 1 - Conceptual Knowledge of Food

1. Conceptual Knowledge

Concepts are the mental representation we have of objects (for example, my concept of a banana is of food that is yellow, long, and sweet) and conceptual relations are the principles that govern the interrelations between concepts (i.e., my concept of a banana is related to my concept of chocolate in that they are both foods, but also a common food pairing) (Murphy, 2002; Gelman, 2003). Conceptual knowledge encompasses much of our real-world knowledge and allows us to understand what objects are and what properties things have. Without such mental representations, when we encounter objects, we would be required to investigate and learn about every new exemplar of the same category (Murphy, 2002). This would be a very costly process, so as such we form mental representations that group concepts to make sense of our surroundings. For example, having a concept of what a banana is, based on a previous encounter with an exemplar from the category of bananas, would then allow us to make a quick judgment about the object and its function when we encounter a different exemplar of a banana. One method of grouping concepts is through perceptual similarities, such as grouping a green banana and a zucchini since they share the visual features of color and shape (Gelman & Markman, 1986; see figure 1 from Rioux et al., 2018b). However, with cognitive development and experience, we come to learn that there are often more informative ways of associating concepts, such as knowing that zucchini and eggplant are both vegetables, rather than fruit (Rioux et al., 2018b).



Figure 1 Example of a triad of pictures used in the property generalization task (Rioux et al., 2018b)

Considering the daily encounters humans face with food, sophisticated conceptual knowledge of the food domain is beneficial to quick and appropriate decision-making (Nguyen & Murphy, 2003). However, there are effectively a limitless number of ways to represent food, with

different conceptual categories conducive to inferring different information (Ross & Murphy, 1999; Nguyen & Murphy, 2003). Concerning food, adults have been witnessed to spontaneously categorize eating situations taxonomically (e.g., vegetables; Ross & Murphy, 1999), script-based (e.g., breakfast foods; Ross & Murphy, 1999), thematically (e.g., cereal-bowl; Lin & Murphy, 2001; Murphy, 2002), and even ad hoc or goal-derived (e.g., things to eat in a hurry; Barsalou, 1983, 1991). For brevity, this research examines three forms of grouping foods that have been shown pertinent to people's food perceptions (Ross & Murphy, 1999). However, it is worth noting that children, as well as adults, have access to a compendium of other conceptual structures to represent the world around them.

Sophisticated conceptual knowledge does not only refer to the knowledge of a conceptual relation but also the knowledge that such relations allow. Thus, conceptual knowledge is not solely understanding the relationship or shared features between items of the same category, but also appropriately using the conceptual knowledge to guide behavior. For example, when trying to determine the health-related properties of zucchini it would be more beneficial to refer to the properties shared by other exemplars of vegetables as opposed to perceptual similarity to the banana. This chapter will define the three conceptual relations, as well as their respective importance in food recognition and subsequent food-based decision-making.

1.1. Taxonomic Knowledge

One form of categorization, having received much research focus, is representing objects through their taxonomic associations. Taxonomic categories are a collection of objects that are similar in functional, biological, perceptual properties (Medin & Smith, 1981; Medin & Smith, 1984; Murphy, 2002; Gelman, 2003). The grouping of taxonomic category members is based on a set-inclusion relation, with a basic level of the entity itself (i.e., apple), and the superordinate and subordinate levels in taxonomic categories being more or less inclusive, respectively (Rosch, 1973). Alternatively worded, taxonomic categories classify objects under a hierarchical system in which such objects are differentiated into levels of varying specificity (e.g., fruit, apple, Granny Smith) related by class inclusion (e.g., a Granny Smith is an apple, an apple is a fruit, thus a Granny Smith is a fruit; see E.M. Markman & Callanan, 1983; Murphy & Lassaline, 2013, for reviews).

Taxonomic categorization is critical to making inferences about category members we have less experience or knowledge of (Malt et al., 1995; Murphy & Ross, 1994; Ross & Murphy,

1996). Particularly in the food domain, taxonomic belonging is advantageous for the inference of internal properties (i.e., food provides energy). Basic level categories, such as ‘apples’, provide a wealth of information, such as what an item is likely to look like, taste like, its composition and function (i.e., an apple is round, it provides energy, it has seeds, it is juicy, etc.) (Tversky, 2019). Seminal research by Ross and Murphy (1999) also observed that superordinate levels of categorization (e.g., fruits and vegetables) were salient to adults’ categorization of food. For example, knowing that meat contains proteins, which helps build muscle mass, is helpful when having to select a diet appropriate for a bodybuilder (Ross & Murphy, 1999). The ability to infer biochemical properties and nutrient components using taxonomic category belonging is subsequently key in a domain with heavy consequences for health and lifestyle.

1.2. Thematic Knowledge

While taxonomic categories may be used in cataloging objects and inferring properties, “people also spend a lot of time organizing their experiences by identifying the temporal, functional, or spatial relations that cause entities to form unified wholes, such as looking for chalk near a blackboard or expecting a bill after a meal,” (E.M. Markman, 1981, p. 203). Such categories based on external or complementary associations between objects, events, people, and entities are referred to as thematic categories (Denney, 1972; Denney & Moulton, 1976; Lucariello et al., 1992; Lucariello & Rifkin, 1986; E.M. Markman, 1981, 1989). Given that food is rarely presented in isolation, the food domain lends itself to mental representation structured around thematic categories (Nguyen & Murphy, 2003).

Thematic categories may be spatial (e.g., soup is served with croutons), functional (e.g., soup is served in a bowl), or temporal (e.g., dessert comes after the main course). It is important to note that objects sometimes share several thematic associates concomitantly, for example, the functionally related croutons and soup are also spatially proximate. Some functional food categories may even be bound in their sensory complementarity. Take, for example, a soft-boiled egg and toast soldiers; the toast and egg have a considerable sensory complementarity, but also afford a functional relation. Some thematic associates arise through convention; research on the contextualization of foods found that thematic associates often speak to sensory aspects when selecting the appropriateness of food combinations (Tuorila et al., 1990). Tuorila et al. (1990) found that sandwich components contributed differently to the acceptance (e.g.,

the saltiness of bread was acceptable when the accompanying components, such as cheese, were kept within a normal range. Sensory complementarities may be a type of thematic association, but equally, may simply be a sensory constraint on complementary food pairs.

Hedonic intentions require we enjoy the taste of food, but equally meet nutritional requirements. The contextual information offered by thematic categories may be deemed helpful in knowing what food is appropriate to eat with other foods (i.e., ice cream compliments a wafer cone). For example, potato fries and ketchup have distinctive nutritional profiles, so would not be classified under the same superordinate taxon. However, it would be of value to know that these items have a thematic relationship, thus are likely to taste good together or be culturally accepted as a combination. Being capable of thematically associating appropriate food pairs based on sensory properties, such as salad and dressing, allows both hedonic and nutritional needs to be met. Food research supports the idea that food-food associates, based on sensory properties, guide feelings of familiarity. Studies have even evidenced that creating a thematic association between a familiar food flavor and a novel food was a method to circumvent reluctance to trying new food (Stallberg-White & Rozin, 1999; Pliner, 2008). Such examples demonstrate compelling arguments for why food-related categories based on thematic relations are important in both adults' and children's food acceptance.

In the conceptual development literature, thematic relationships have been treated as an unimportant or naive basis for categorization (Inhelder & Piaget, 2013). However, thematic knowledge is central in similarity judgment, language comprehension, memory processes, and analogy making (Estes et al., 2011). Utensils that serve functional relations with food, such as spoons, forks, and chopsticks, likely guide the understanding that an unfamiliar substance is intended to be consumed (such as my expectation that soup is served in a porcelain bowl). The same is perhaps true for commonly associated foods, such as bread and butter. When presented with bread with an unfamiliar topping, we may draw upon the common thematic associate of bread and butter, to infer that the substance is likely safe to eat. For example, if presented with a novel cereal in a bowl with milk, using thematic concepts such as cereal:bowl and cereal:milk, makes us more likely to accept that the substance is appropriate to eat. In the other direction, we may rely on thematic associates to appropriately reject an incongruent association, such as novel cereal served in a dog bowl and covered in gravy. Markman (1989) pointed out that thematic categories are an important part of social development and acculturation because they

inform us what things go together and at what times, how objects are used in specific events, and what expectations to hold in various situations. Indeed, several studies have acknowledged that thematic relations are important to both adults and children (Smiley & Brown, 1979; E.M. Markman, 1989; Ross & Murphy, 1999).

1.3. Script Knowledge

Somewhere between taxonomic and thematic categories are what literature defines as script categories. Scripts are formed through categorizing objects based on a shared event script or schema representation (Estes et al., 2011). Nguyen and Murphy (2003) state that script categories are formed when “items play the same role in a script,” such as bread or cereal at breakfast (Nguyen & Murphy, 2003, p. 1783). By defining script-related concepts as similar in roles, category members often share internal properties, allowing them to also be categorized at a superordinate taxonomic level. For example, cereal and eggs belonging to the script of ‘breakfast’ may also be categorized at the superordinate level of ‘food’. However, items may equally be deemed belonging to the same script, while sharing relatively few properties allowing taxonomic categorization (for example, cake and balloons belonging to the script of ‘party’). Scripts allow us to make inferences and decisions about objects based on the context, rather than the individual item. For example, when at the dinner table we have a script of things that we would typically see at dinner. If during dinner we are presented with food, such as soup served in a bowl with a spoon, we can add them to our repository of things to expect for dinner. Although we would not be afforded the same information, as the basic level would allow, (i.e., soup is liquid or warm) the script association allows alternative expectations such as expecting food at dinner rather than at a dentist.

Food readily lends itself to different scripts, such as mealtimes, events, and special occasions, and such scripts inform us on the appropriateness of foods. Temporal aspects of food influence individuals' reasoning and food acceptance, such as the characteristic sequence of courses, with studies showing that presenting dessert first makes the dish less palatable (Pliner, 2008). Rodin (1980) showed that a critical determinant of food acceptance was perceived appropriateness in situations, taking cues from certain meals (e.g., breakfast) or special events (e.g., holiday). This notion of context-appropriate foods is already salient in pre-school children, with American children already imposing contextual constraints of certain foods for the breakfast context (Birch et al., 1984). These results were replicated in a recent cross-cultural study,

demonstrating that American 4-year-olds hold more rigid breakfast scripts than their Chinese counterparts (Bian & Markman, 2020). By 7 years old, children were even witnessed to depend upon such script categories to make inferences about which foods were eaten on a novel holiday (Nguyen & Murphy, 2003).

2. Cross-classification

Having sophisticated conceptual knowledge in the food domain is conducive to appropriate food acceptance and decision-making. However, objects rarely fall into a single category, and flexible categorization is beneficial at extracting different information in different situations (Nguyen & Gelman, 2012). Cross-classification is the ability to consider an object as a member of multiple categories or conceptual structures simultaneously (Blaye & Bonthoux, 2001; Blaye et al., 2006; Nguyen & Murphy, 2003).

Food, being highly contextualized, is a domain heavily reliant on cross-classification and different forms of conceptual knowledge (Ross & Murphy, 1999). If hosting guests for a breakfast, it would be conducive to consider the category of breakfast food, to facilitate the selection of appropriate foods to serve. If a non-conventional exemplar of breakfast food was served to American guests, e.g., a lamb chop, the lamb would not be recognized as a typical breakfast food, and potentially lead the guests to reject the food. Alternatively, if the guests are invited for dinner, it would be beneficial to know common thematic associations with lamb, such as mint sauce or mashed potatoes. Serving a food not considered to have a complementary sensory association with lamb, such as chocolate, would appear unfamiliar and possibly even repulsive to individuals. Taxonomic knowledge of food categories is conducive when selecting foods appropriate to individuals' dietary requirements (i.e., serving lamb chops to a vegan or cheese to someone with a dairy intolerance, would ultimately result in rejection). In other words, individuals are required to view the same food as a member of different categories, dependent on the situation and contextual cues.

To the best of our knowledge, food is the only domain in which research has evidenced salient script and taxonomic cross-categorization in both adults and children (Nguyen & Murphy, 2003). Previous research indeed witnessed that adults formed unprompted taxonomic and script categories in a food sorting task. For example, a bagel was categorized both as bread (taxonomic) and as breakfast food (script) (Ross & Murphy, 1999). However, the researchers noted that flexible categorization of food occurred more for script categories than for

taxonomic categories, perhaps due to the overlap these forms of categorization allow (Ross & Murphy, 1999). Taxonomic categories are often mutually exclusive, for example, if filet steak belongs to the meat category one can then reason it is not a fruit. However, objects may be representations of multiple different scripts simultaneously (e.g., sandwiches may be categorized as party food, but equally as picnic food).

3. Conclusion

When presented with a possible food, the most salient sensory properties are often the first to be interpreted (i.e., the pleasantness of the smell, color, texture). However, an object is always situated in context, and it is thus beneficial to draw upon the conceptual cues that inform us of a substance's edibility. Conceptual relations allow for the inference of properties and are conducive to feelings of familiarity when confronted with novel instances of objects or situations (Gelman & Markman, 1986; Aldridge et al., 2009). Several studies have illustrated how food acceptance in adults is guided by conceptual knowledge of thematic, taxonomic, and script representations of food. This chapter illustrated how such taxonomic, script, and thematic concepts are pertinent in food recognition and how they are influential in guiding food recognition and food acceptance.

Chapter 2 - Conceptual Development of Food

1. Conceptual Development

Although conceptual knowledge is crucial to our daily reasoning and understanding of the world, much conceptual knowledge must be acquired through everyday experience (Murphy, 2002; Gelman, 2003; Rakison & Oakes, 2003). Initially, infants attend to immediately salient visual features to recognize objects, such as perceptual similarity based on shared shape or color (Smith & Heise, 1992; Imai et al., 1994; Sloutsky, 2003). However, as children develop and experience the world, they begin to acquire conceptual knowledge and recognize the importance of referring to ‘less evident’ conceptual categories (Markman, 1989; Murphy, 2002; Sloutsky & Fisher, 2004).

Individual factors, including, but not limited to, experience and education, contribute tremendously to a child’s cognitive abilities. From the weaning phase, children face increased exposure to foods and eating situations, and subsequently, their conceptual repertoire in the food domain grows. Concomitant to such learning and experience, children face increased independence in food decision-making. While they must accept food for survival and pleasure, children quickly learn they must also execute caution in an eating context to avoid distaste or even toxicity (Fallon et al., 1984).

To understand how conceptual knowledge influences children’s food recognition and decision-making, it is essential to investigate their capacity to represent and master conceptual relations identified in the previous chapter. This chapter will first provide an overview of the extensive research detailing conceptual development in young children, before examining evidence of conceptual development in the food domain. As previously noted, conceptual knowledge encompasses not only relational knowledge but also the cognitive ability to flexibly draw upon appropriate conceptual knowledge given contextual cues (Nguyen & Gelman, 2012). Therefore, research will also be addressed on children’s ability to flexibly draw upon thematic, script, and taxonomic knowledge in different instantiations.

1.1. Global conceptual development

Within the first six months of life, children initiate the spontaneous categorization of objects in their environment (Mareschal & Quinn, 2001; Rakison & Oakes, 2003). Pioneering work on conceptual development took the stance that young children had immature notions of concepts and their relations (Inhelder & Piaget, 2013). Vygotsky (1962) observed that when asked to

select objects with the same name, preschoolers selected objects based on contiguity or relations "*observed in practical experience, in which collections of complementary things often form a set or a whole*" (Vygotsky, 1962, p. 63). A free-sorting task by Inhelder and Piaget (2013) also observed that 4-year-olds commonly formed groups based on salient properties, such as shared shape or color, and equally through thematic categories (i.e., a carrot and a rabbit). Whereas, seven-year-olds and adults were witnessed to group items based on taxonomic belonging (i.e., a dog and a monkey). From their research, the idea was widely formulated that there is a developmental shift in categorization ability, from figurative collections (i.e., shape) through thematic categories as a more primitive approximation to 'real' categories, and finally, taxonomic categories attained by 7-8 years old (Troadek, 1999; Lin & Murphy, 2001). Both sorting tasks and match-to-sample tasks qualified this conclusion, appearing to demonstrate a shift from thematic categories in early childhood to taxonomic categories by later childhood (Tenney, 1975; Smiley & Brown, 1979; Greenfield & Scott, 1986; Tversky, 1985, Landau et al., 1988; Baldwin, 1992; Jones & Smith, 1993; Imai et al., 1994). Thus, it was assumed that young children had impoverished categorization knowledge and could not appreciate the relatedness of taxonomic kinds or their value.

However, developmental researchers raised doubts about whether the studies witnessed an impoverished conceptual ability or rather a saliency for certain conceptual relations. Relatively minor changes to match-to-sample and free-sorting tasks illustrated that even 3-year-olds possess taxonomic knowledge (Fenson et al., 1989; Bauer & Mandler, 1989). For example, 3-year-olds showed increased taxonomic categorization when the task was framed as "find another one" rather than "find the one that goes with" (Waxman & Namy, 1997). Several other studies also evidenced that young children could identify different conceptual relations with changes in the task design, such as providing novel nouns (Markman & Hutchinson, 1984; Waxman & Hall, 1993), giving superordinate category labels (Waxman & Gelman, 1986), or the spatial configuration of the task (Markman et al., 1981). This evidence was enough to suppose that thematic, script, taxonomic, and even other forms of conceptual organization (including evaluative categories: such as yummy/yucky) may be available from 2-years-old, but preference and task design were lending themselves to the earlier conclusions by developmental scientists.

1.2. Conceptual development of food

Whilst there is a wealth of literature on the conceptual development of natural kinds and artifacts, there is less concerning the food domain (Gelman, 1988 & 2004; Nguyen, 2007; Rioux, 2017). It is important to consider the developmental literature with specific regard to the food domain, as food is often considered a borderline domain, with some foods (e.g., unprocessed vegetables and fruits) treated as natural kinds, while others (e.g., highly processed foods) being considered artifacts (Gelman, 1988; Rumiati & Foroni, 2016; Foroni & Rumiati, 2017).

Through daily exposure and experience, children begin to acquire conceptual knowledge of foods relatively early on (Birch et al., 1984). Consequently, in the early years of life children are limited in their representation and interpretation of foods and are incapable of using salient physical attributes to distinguish food versus non-food (Shutts et al., 2009). A study on 8-9-month-old infants used looking-time to determine whether children held an innate core knowledge of food versus non-food based on perceptual features. A lack of significant difference indicates that children must learn about the relevance of texture, shape, and color of food through experience (Shutts et al., 2009). Macario (1991) then demonstrated that by 2-3-years-old, children could already infer that foods shared the same taste based on color or texture, rather than shape. Furthermore, by three-year-old, children were capable of referring to color, odor, and texture to discriminate foods from non-foods (Lavin & Hall, 2001; Macario, 1991; Santos et al., 2002).

As aforementioned, a great developmental achievement comes when children can refer to conceptual knowledge as oppose to solely perceptual knowledge to guide their understanding (Sloutsky & Fisher, 2004). Brown (2010) found that after 22 months, infants even distinguished between basic level concepts, such as biscuit and fruit as well as superordinate taxonomic categories, such as food versus animals. Similarly, using a sorting task procedure, Bovet et al. (2005) found that 30-month-old children systematically distinguished between toys and foods. More recent research demonstrates that preschoolers (2-5 years old) can already discriminate food versus non-food and even discriminate at the superordinate level of vegetables and fruits (Foinant et al., 2021a; Rioux et al., 2016; Lafraire et al., 2016). Additionally, preschoolers can differentiate healthy and unhealthy foods and even use this categorization to make inferences about the effects of such food on the human body (Nguyen, 2007; Nguyen, 2008). Despite the early ability of such conceptual knowledge of food, studies demonstrate that children's

taxonomic knowledge dramatically improves between 2 and 7 years old (Lafraire et al., 2016; Rioux et al., 2016; Nguyen & Murphy, 2003).

As demonstrated in the early developmental studies, children are particularly partial to script and thematic relations, thus it is apt that children have such conceptual knowledge for food (Inhelder & Piaget, 2013). However, while the developmental shift in taxonomic knowledge has been widely investigated, there are fewer studies empirically investigating alternative conceptual knowledge specifically in the food domain. Meal script appropriateness already appears salient in pre-school children, with ecological studies demonstrating that 3/4-year-old American children already impose contextual constraints of certain foods for specific mealtimes, such as not deeming chicken appropriate for breakfast (Birch et al., 1984; Nguyen & Murphy, 2003; Zeinstra et al., 2007; Nguyen, 2012). Qualitative research, using free sorting and word-association tasks, has been used to establish the basis by which children represent the food domain. Nelson & Nelson (1990) altered the phrasing in a word production task with young children to determine whether they made more script (slot-filler) associates or taxonomic associates. In the taxonomic condition, children were asked to produce as many items as possible in three categories: animals, clothing, and food. In the slot-filler condition, children were asked to name as many items as possible from categories within particular contexts, namely animals found at the Zoo or on a farm; the clothing worn indoors or outdoors; foods eaten for lunch or breakfast. In general, children across all ages produced significantly more associates in the food domain than animals or clothing. More specifically in the food condition, 5-year-olds produced significantly more script foods than taxonomic foods. However, by 8-year-old, this finding was inverted, and children produced significantly more taxonomic food associates (Nelson & Nelson, 1990).

A similar task by Lucariello et al. (1992) employed three sequential studies with preschoolers and elementary school children to explore the saliency of specific taxonomic, thematic, and script relations both within and outside the food domain. A word association task was used in which 4-year-olds and 7-year-olds were asked to give the first word that came to mind when presented with stimuli. The results indicated that 4-year-olds evoked significantly more words relating to functional relations (e.g., ice-cream – eat) and thematic relations (e.g., soup – bowl) (see figure 2; Lucariello et al., 1992). Whereas 7-year-olds produced significantly more script

responses (e.g. oatmeal – pancakes) and taxonomic category responses (such as oatmeal – pizza; both belonging to the superordinate category of ‘food’).

MEAN NUMBER OF RESPONSES ON WORD-ASSOCIATION TASK BY CATEGORY AND AGE (Experiment 2)

RESPONSE CATEGORY	4 YEARS		7 YEARS		t VALUE
	Mean	SD	Mean	SD	
Taxonomic-horizontal:					
Slot-filler category	3.90	(4.61)	8.75	(4.97)	3.20*
Conventional category .....	.30	(.47)	1.80	(1.67)	3.86*
Total horizontal	4.20	(4.91)	10.55	(5.36)	3.91*
Taxonomic-vertical:					
Slot-filler label .....	.05	(.22)	.25	(.91)	.95
Conventional superordinate label .....	.15	(.37)	1.60	(3.66)	1.76
Subordinate .....	.60	(.82)	.60	(.88)	.00
Total vertical .....	.80	(.89)	2.45	(4.33)	1.67
Thematic/schematic:					
Function	8.65	(7.24)	1.55	(2.19)	4.20*
Complementary	4.30	(3.40)	3.00	(3.39)	1.21
Spatial-temporal organizer	2.20	(1.88)	.95	(1.15)	2.54
Total thematic	15.15	(7.47)	5.50	(4.36)	4.99*
Other:					
Feature	2.00	(1.92)	1.40	(2.06)	.95
Idiosyncratic	3.25	(3.34)	6.85	(5.18)	2.61
No answer	1.60	(1.73)	.25	(.72)	3.23*
Total other	6.85	(4.17)	8.50	(5.19)	1.11

* $p < .05$.

Figure 2: Word-association responses from Lucariello et al. (1992)

However, a study using a free sorting task witnessed that 7/8-year-olds showed no taxonomic sorting of fruits and vegetables. Zeinstra et al. (2007) asked children to make groups from images of fruits and vegetables. The youngest group of 4/5-year-olds made groups based on concrete perceptual characteristics, such as shape and color. The 7-8-year-old children showed a lesser, yet still present preference towards grouping items on perceptual similarity, but also made groups on abstract characteristics, such as liking or knowing the fruits and vegetables. Whereas all children at 11 years old deferred to abstract categories such as "liking" or "fruit versus vegetables" or a combination of both (Zeinstra et al. 2007). The discrepancy in the findings with Lucariello et al. (1992) and Nelson & Nelson (1990) is likely because Zeinstra et al. (2007) did not provide labels or conceptual references in their instruction. Studies show that providing even basic level labels (i.e., apple) significantly increases taxonomic responding (Gelman & Markman, 1986; Deak & Bauer, 1996). Taken together, these three studies potentially demonstrate that 4- & 7-year-olds possess knowledge of taxonomic groups, but taxonomic categories of food are not as immediately salient as other forms of categorization.

Such qualitative methods, based on association and sorting, are particularly useful in identifying children's preferences or saliency of certain conceptual relations. Quantitative investigations have used conflict triad tasks to determine children's conceptual preferences, versus non-conflict triads to evaluate children's conceptual knowledge. Nguyen & Murphy (2003) employed a conflicting triad task and indeed witnessed that 4-year-olds showed a significant preference for script associates (i.e., meals) to taxonomic matches (i.e., fruits). However, using a non-conflicting triad task, they also noted that 4-year-olds performed significantly above chance in identifying both script and taxonomic associates of food items (Nguyen & Murphy, 2003). Their follow-up task evidenced that taxonomic and script food knowledge developed equally between four and seven years old (Nguyen & Murphy, 2003). Even more impressively, children from 4-years could cross-classify foods, meaning they can simultaneously subsume a food item under both taxonomic and script categories (Nguyen & Murphy, 2003). The four-year-old children were less accurate than the seven-year-olds, but they still cross-classified the same food-based on taxonomic and script relations. Work by Nguyen (2007) supported these findings, demonstrating that 2-year-olds can classify and cross-classify items into script and taxonomic categories in domains including food, but there are significant developmental improvements between 3 and 4 years (Nguyen, 2007).

Studies in conceptual development outside the food domain have repeatedly evidenced children's preference for thematic relations (Smiley & Brown, 1979). Lucariello et al. (1992) witnessed that 4-year-olds frequently refer to food associations that can be considered thematically related (e.g., soup – bowl). However, few studies empirically investigated children's knowledge of thematic associates in the food domain. One seminal study briefly addressed 3-year-olds possess knowledge of complementary thematic relations (i.e., strawberries and cream, or bread and butter), but 7-year-olds performed significantly better (Thibaut et al., 2016). Identifying children's knowledge of thematic associations was not the researcher's intended aim of the study, and as such, there is ground for investigating children's thematic relations of food more in-depth.

Based on the aforementioned research showing young children's saliency for thematic and script relations it stands to reason that when confronted with food instances, children can refer to such notions to guide acceptance. Previous evidence has broached children's taxonomic ability in the food domain, but little research has empirically investigated how children rely on

thematic and script categories. Given that younger children are potentially more susceptible to such conceptual relations over taxonomic relations it is crucial to investigate thematic and script ability in the food domain.

2. Conceptual Flexibility in the Food Domain

The aforementioned studies indicate that conceptual knowledge in early childhood is indeed pluralistic, in that children have access to multiple conceptual relations. As such, developmental psychologists began to address how and when children draw upon different conceptual relations. As mentioned in chapter 1, sophisticated conceptual understanding is not solely based on recognition of conceptual relations, but also the tacit understanding of when to rely on specific conceptual relations to gather the most relevant information. Appropriately drawing upon conceptual relations draws upon contextual, individual, and developmental factors (Berger & Aguerra, 2010; Blaye et al., 2006; Blaye & Jacques, 2009; Ionescu, 2017). Categorization tasks have demonstrated how cognitive abilities, such as inhibition, cognitive flexibility, and working memory, are correlated with conceptual understanding (Bonthoux & Kalénine, 2007; Lagarrigue & Thibaut, 2020). Throughout early childhood, such cognitive abilities are rapidly developing, as is their conceptual knowledge. Hence, it is important to address at which developmental stage children can subsume foods under certain multiple types of categorization.

Nguyen & Murphy (2003) investigated whether children could assume the appropriate conceptual relation when both a script and taxonomic choice were presented simultaneously. In the so-called biochemical condition, the child was told a food item had a novel ingredient, and they had to determine which other food would contain the same ingredient (i.e., “Pary is an ingredient in grapes. Do you think a strawberry or bread probably also has Pary in it too?”) (Nguyen & Murphy, 2003, p. 1795). In the situational condition, the child was told that a food item was eaten on a novel holiday and asked to select another food that was also eaten on that holiday (e.g., “Cake is eaten on a special holiday called Dax. Do you think ice cream or soup is eaten on Dax too?”) (Nguyen & Murphy, 2003, p. 1795). Impressively, 4-year-old children already appeared to understand using taxonomic categories to make biochemical inferences about food, and script categories to make situational inferences about contexts in which foods are usually eaten (Nguyen & Murphy, 2003; Nguyen, 2012). However, success rates for both

the script and taxonomic-based inference did not reach the performance of adults until 7 years old.

Thibaut et al. (2016) followed up on the findings of Nguyen & Murphy (2003) by examining children's generalizations based on thematic and taxonomic, rather than script and taxonomic relations. The researchers tested whether four, six, and nine-year-olds generalize psychological and biological properties to novel foods using an induction task in which a biological or psychological property was associated with a food item. Children were then asked whether the property would be shared by a thematic or taxonomic-based food associate. For example, the experimenter told children, "See this food. It is a strawberry. It makes Diddl smart. See these other foods here [one thematic associate and one taxonomic associate], which one do you think will also make Diddl smart?" (Thibaut et al., 2016, p. 9). Children across all ages preferred to generalize both properties to the taxonomic associate. This preference was weak at age 4 but established by age 5 and almost always selected by 9-year-olds.

Taken together, the results from this work speak to the fact that children as young as four years old do not rely solely on one form of conceptual knowledge but are flexible in the types of relations they form and use for inductive inferences. However, as with concept acquisition, there remains a steep development in children's conceptual flexibility for taxonomic and script knowledge in the food domain. Furthermore, given that children may rely on other conceptual knowledge, such as complementary foods or functional associates, to guide understanding in eating situations, it is crucial to investigate the flexible use of alternative conceptual knowledge.

3. Conclusion

Research demonstrates that children's knowledge of conceptual relations in the food domain is undergoing rich development in the preschool years. However, there are two important caveats to consider. Firstly, rich conceptual knowledge will be relatively underdeveloped in preschoolers due to insufficient experience with eating situations and instances of food. Secondly, full-fledged conceptual understanding of the food domain stems not only from the knowledge of salient relations but also from the cognitive abilities to recognize that different conceptual relations are required for different situational cues. Developmental research shows that children's relevant cognitive abilities are still undergoing rapid development and are

respectively impoverished compared to adults. However, during early childhood children are becoming more strategic and capable of suppressing salient relations in favor of less obvious, more advantageous ones (White, 1965; Tversky & Teiffer 1976; Flavell & Wellman, 1977). This chapter illustrated the few studies that have begun to investigate such cognitive development in the food domain, but there is still insufficient understanding of how conceptual knowledge affects food choices in young children. The following chapter will investigate how children's knowledge and appropriate use of conceptual relations influence decision-making and potentially lead to inappropriate food rejection.

Chapter 3 - Formulation of how conceptual development is linked to food rejection

1. Food Rejection and Conceptual Knowledge

Chapter 1 illustrated the importance of conceptual knowledge in facilitating our recognition and understanding of our surroundings. Such cognitive accomplishments are essential in the food domain given that ingesting potential food sources can lead to disgust or even toxicity. Furthermore, the earlier chapters stressed the importance of different types of conceptual knowledge about food in guiding food acceptance. Chapter 2 then provided a state of the art about how such conceptual knowledge develops and manifests in children. However, conceptual development in the food domain is not solely determined by age, and it would be remiss to infer that children are homogenous in their conceptual development. One factor linked to conceptual development is food rejection tendencies in young children (Lafraire et al., 2016; Rioux et al., 2016, 2018b, 2018c). The following chapter discusses the theoretical approach grounding this thesis research. Firstly, a definition and brief introduction of children's food rejection tendencies, namely food neophobia and food pickiness, will be provided. The complex relationship between conceptual knowledge and food rejection will be thoroughly considered with reference to the existing literature on food rejection in young children.

1.1. Food Rejection

From the post-weaning period, children become more involved in food-decision making and exert greater selectivity in their consumption of foods (Addessi et al., 2005; Cashdan, 1994; Cooke et al., 2003). Witnessed in concomitance to this increased independence, is a greater level of food rejection in children (Carruth et al., 2004; Levene & Williams, 2017). The two correlated dispositions of food neophobia and food pickiness heavily account for food rejection tendencies in children between 2 and 7-years-old (Carruth et al., 2004; Levene & Williams, 2017).

Food neophobia is the reluctance to eat or even try novel food items, believed to be a protective function to prevent the ingestion of potentially harmful substances (Fallon et al., 1984; Pliner & Hobden 1992; Milton, 1993). Heavily interlinked to food neophobia, yet distinct is picky/fussy eating (Dovey et al., 2008; Rioux et al., 2017). Picky eating is defined as a substantial rejection of familiar food, certain food textures, or a lack of particular foods or food groups, (Birch et al., 1991; Taylor et al., 2015). While food neophobia occurs before the tasting step, food pickiness occurs either before or after the tasting step (Dovey et al., 2008). Food pickiness and food neophobia share many similar traits and because food neophobia is

exclusively the fear of novel foods many researchers consider food neophobia as a sub-trait of food pickiness, being a fear of both familiar and unfamiliar foods (Johnson et al., 2018).

With only 18 percent of children eating five standard portions of fruit and vegetables per day (Conolly et al., 2019), it is imperative to address the factors influencing children's eating behaviors. Dietary variety is of paramount importance not only for physical health but also for forming healthy eating attitudes and behaviors in later life (Maratos & Sharpe, 2018; Evans et al., 2018; Jirout et al., 2019). Food neophobia has been linked to a significant reduction in vegetable consumption, decreased dietary variety, and lower liking for all food groups (Galloway et al., 2003; Dovey et al., 2008). Both food neophobia and food pickiness heavily reduce dietary variety, particularly in fruit and vegetable consumption (Fletcher et al., 2017; Perry et al., 2015). A study showed that children between 2 and 5 years old were twice as likely to be underweight if they were picky eaters (Dubois et al., 2007).

To a certain extent, food rejection tendencies are present in most typically developing children (Moding & Stifter, 2018). Food rejection in early childhood may remain insignificant if the child learns to accept foods later in life. However, problems arise when the child presents extreme food rejection tendencies leading to problematic nutrient deficiencies or enduring problematic eating behaviors later in life (Johnson et al., 2018). Longitudinal research demonstrates that food rejection in childhood increases the prevalence of eating disorders in adulthood (Marchi & Cohen, 1990; Herle et al., 2020; Jezewska-Zychowicz et al., 2021; Knaapila et al., 2015). Thus, effective methods and interventions to foster greater food acceptance in young children are necessary. To create such effective interventions, it is important to underpin the mechanisms involved in children's early acceptance of food. Current methods to foster food acceptance commonly question sensory, taste, and food preferences as explanatory factors. However, these approaches neglect the fact that children develop advantageous cognitive abilities, allowing them to form naive theories and reasoning when making food-based decisions (Shutts et al., 2013; DeJesus et al., 2018).

2. The Cognitive Contribution to Food Rejection

Literature informs us that many factors influence children's acceptance or rejection of food, including genetics, taste preference, and social cues (Lafraire et al., 2016). However, Lafraire et al. (2016) provided new lines of research in their comprehensive review of both

social/environmental and cognitive mechanisms potentially responsible for food rejection. One theme neglected in empirical research is children's food cognition, encompassing how perception, conceptual knowledge, and feelings and emotions influence food-based reasoning (Lafraire et al., 2016).

When confronted with a known food, children and adults can rely on their previous experience and knowledge (i.e., I liked the carrot last week so I will like this carrot) (Aldridge et al., 2009). When slightly suspect or unsure of a food conceptual knowledge and categorization in the food domain play an important role in shaping children's eating behavior (Pliner, 2008; Aldridge et al., 2009, Mura Paroche et al., 2017). The child may hold a representation of a 'typical' carrot with perceptual features such as being orange, long, and thin. If presented with a purple pureed carrot, the dissonance between the child's perceptual representation of a carrot and the instance in front of them will invoke feelings of uncertainty, increasing the likelihood they will reject the food. When individuals fail to recognize a stimulus, increased environmental risk or uncertainty can often induce fear towards novel stimuli (Brown, 2010; Meuthen et al., 2016; Crane et al., 2020). From a biological perspective, when faced with uncertainty, it is safer to err on the side of caution and avoid novel stimuli (Crane et al., 2020). Such reactions are particularly adaptive in the food domain when ingesting an unfamiliar substance may lead to disgust or potential toxicity. Along this line of reasoning, if we fail to represent a carrot as a food item, we are more likely to avoid consuming it. Contrariwise, having a good knowledge of food increases the likelihood that we recognize food and thus reduces our uncertainty.

Therefore, early research proposed that food familiarity fosters food acceptance, and a method to overcome food rejection in young children was through exposure and familiarization with foods (Birch & Marlin, 1982). Several intervention studies stemmed from this theory and food exposure programs became commonplace in trying to tackle food rejections (Nekitsing et al., 2017). However, there are two important caveats to consider for such a proposal. Firstly, despite being somewhat effective at increasing acceptance of the targeted food, the effects of such interventions are somewhat limited. Systematic reviews have shown that the effects of exposure and familiarization programs are fairly small and not enduring over longer periods (Corsini et al., 2013). Secondly, food rejection is the rejection of both familiar and unfamiliar foods as defined through food neophobia and food pickiness dispositions (Dovey et al., 2008; DeJesus et al., 2018). As such, the theory that knowledge of a food fosters food acceptance

falls short in explaining the rejection of known fruits and vegetables. Such reasoning led us to expand the thinking of food knowledge and consider how other forms of conceptual knowledge may guide children's food acceptance. As detailed in chapter 2, even children as young as 2 years old rely on less evident conceptual information to guide their reasoning and interpretation of entities. A child will have certain expectations not solely regarding the look of the food item, but also the context in which the food item is situated (Pliner, 2008). These expectations will draw upon conceptual knowledge such as appropriate scripts and thematic associations of foods. As detailed in chapter 1, even adults are less likely to accept foods if it does not conform to their notions of appropriate scripts and thematic contexts (Rodin, 1980; Birch et al., 1984; Pliner, 2008; McLeod et al., 2020).

The developmental literature of chapter 2 details that children are already interpreting the world through such script and thematic associations. However, the chapter also details how children are yet to acquire the sophisticated conceptual representations adults have. If we have few scripts and thematic associations for food, we are limited in what we consider appropriate or familiar in eating situations. For example, a child with little experience may hold the association that carrots are appropriate at dinnertime or served alongside a beef stew. If the child is then served carrots at lunchtime in the canteen, alongside fish they may feel increased uncertainty for the dissonance between their conceptual representation of carrots and the reality of the carrots in situ. This uncertainty is likely to lead the child to reject the food, despite having the knowledge that the food is in fact carrots.

2.1. Previous links with taxonomic and perceptual knowledge

Seminal studies have indeed determined that impoverished conceptual knowledge based on taxonomic categorization is linked to food rejection in young children (Rioux et al., 2016, 2018b, 2018c). Rioux et al. led a series of works investigating the possible link between conceptual knowledge and food rejection. Their first study, used a picture sorting task in which 79 children, between 2 and 6-years-old, were required to sort foods as either fruits or vegetables (Rioux et al., 2016). As well as witnessing an age-related improvement in fruit and vegetable sorting, task performance was significantly negatively correlated with children's food rejection scores. A subsequent study examined how food neophobia and food pickiness predicted children's category-based inductions (Rioux et al., 2018b). Younger children and food neophobic children were witnessed to rely on perceptual similarities, namely color, to infer

novel properties to foods (Rioux et al., 2018b). For example, children with high levels of neophobia would generalize a property of a green zucchini to a green banana based on color and shape similarity, whereas non-neophobic children would generalize properties based on taxonomic groups (e.g., a green zucchini to an orange carrot). The researchers went on to investigate whether this limited taxonomic reasoning in children with high food rejection tendencies extends to domains other than food (Rioux et al., 2018c). 109 children between 39 and 56 months old, completed a study demonstrating that neophobic children have poorer taxonomic inductive reasoning in both the food and artifact domain compared to non-neophobic children. Taken together these results suggest that children with higher levels of food rejection fail to identify the taxonomic relations at hand, or favor less informative cues (i.e., perceptual similarity) to make property inferences.

Recent evidence supports the theory that children with high levels of food rejection are executing increased caution when determining whether items are edible. Foinant et al. (2021a) demonstrated with a sample of 137 4-6-year-olds, that children with high levels of food rejection displayed a more conservative strategy, in that they incorrectly categorized food items as inedible more than children with lower food rejection. Children with lower food rejection appeared to rely on the transformation of a substance (either sliced or a whole) to determine whether the food was edible or not. Whereas, for the more picky and neophobic children, the level of processing of the substance bared no stance on the child's acceptance (Foinant et al., 2021a). Such differences demonstrate that whilst non-picky, non-neophobic children believe transformation may be a cue for edibility, neophobics, and picky eaters do not operate by the same logic. In a subsequent study, Foinant et al. (2021b) conducted an induction task in which 126 children between 3 and 6 were required to generalize positive or negative health-related properties (i.e., "gives Feppe strength", p. 5) for familiar and unfamiliar foods. In general, regardless of whether the food was presented as sliced or whole, children positively evaluated familiar foods, and negatively regarded unfamiliar foods (Foinant et al., 2021b). Children with high food neophobia scores had an increased likelihood of extending negative properties to all foods regardless of whether they were unfamiliar or familiar, processed or whole. These studies speak to the argument that children with high food rejection tendencies will over execute caution, rejecting conceptual cues to predict information about novel substances.

2.2. Thematic and Script Knowledge

While Rioux et al.'s work informed us of a negative relationship between food rejection and taxonomic knowledge in the food domain, children are guided by many forms of conceptual relations, including both thematic and script associates. Young children are encountering many foods and eating situations for the first time. However, even novel stimuli may be recognized based on conceptual knowledge to guide our interpretation of objects and situations (Murphy, 2003).

For example, if we were unable to recognize a novel instance of blackberry, we may rely on our taxonomic repository of other instances of berries (such as raspberries and blackcurrants) to infer that the unfamiliar food was a fruit and thus safe to eat. However, we also rely on other conceptual structures, such as thematic and script categories, to guide our understanding when confronted with novel or unfamiliar foods (see chapter 1). The food itself is rarely served identically at each instance (i.e., an apple will rarely be cut or arranged in the same formation). Therefore, it is helpful to rely on alternative conceptual knowledge to interpret a stimulus. For example, from a young age, meal scripts inform us that certain times are appropriate for consuming food (e.g., the canteen is a meal script in which food is much more likely to be offered than a forest script). As such, an apple (in a puree form) in the canteen may invoke greater feelings of recognition and subsequent acceptance than an apple (in a natural form) growing in an orchard. Although such thematic associates are often subjective and culturally bound (e.g., peanut butter and jelly in the US), they still appear crucial in determining whether a presented substance is appropriate to consume.

The example above illustrates how when we fail to identify a stimulus in isolation, we can draw upon contextual and associative information to aid our understanding. Cues such as a substance simply being cut have been shown to influence children's reasoning that the substance is edible (Foinant et al., 2021a, 2021b). The fact that children with high food rejection did not refer to the cue of food processing like their non-neophobic counterparts, indicates either that they do not consider such cues as informative, or they miss such cues. Such evidence demonstrates the importance of contextual information in children's food-decision making, such as being served food by a chef rather than a dentist.

As Foinant et al.'s (2021b) research demonstrates, the presentation, rather than the food entity itself, lends itself to children's interpretation of the edibility of substances. The transformation

of foods is one salient cue, but thematic co-occurrence and functionality may also aid food recognition and appropriate acceptance. For example, blackberries served with familiar thematic associates (i.e., placed a bowl with yogurt), help guide our understanding that they are in fact edible. Equally, script knowledge, such as being served in a familiar breakfast setting, provides the potential to understand that we are presented with possible breakfast food, even if we have not mastered the taxonomic category of blackberry. Therefore, this research argues that the fear of novel food, frequently witnessed in children, stems not only from feelings of novelty for the item itself but also from the situation (Crane, 2020). Considering that our interpretation and recognition of situations is heavily guided by thematic and script cues, it is logical that food neophobia is linked with gaps in such conceptual knowledge to appropriately interpret eating situations.

Research into children's understanding of appropriate meal scripts indicates children already have adequate knowledge of what foods should be eaten at certain mealtimes. However, food script knowledge is a double-edged sword. On one hand, representations of food scripts may provide guidance and lead to accepting appropriate exemplars, but on the other hand, food scripts may present as a barrier to dietary variety if they are too rigid. Bian and Markman (2020) demonstrated that American 4-year-olds hold much stronger breakfast scripts than their Chinese counterparts, believing certain foods as inappropriate alternatives for specific meals. In this sense, it may not necessarily be insufficient conceptual knowledge that drives uncertainty and subsequent food rejection, but rigidity or narrowness of conceptual knowledge in children's understanding. Equally, individuals learn that thematic associates guide the recognition of substances to be consumed, such as food served at a table with crockery and utensils, to facilitate the act of eating. For example, soup served in a syringe is incongruent with the typical thematic association of soup being served in a bowl with a spoon, so is likely to invoke greater feelings of uncertainty. If incongruence appears for a child between their perceived notion of a category or concept, they will likely be reluctant to accept that exemplar into such concept. This line of reasoning, led us to hypothesize that food rejection is driven by a global lack of conceptual knowledge, including thematic and script representations, in the food domain.

3. Cyclical Nature

An important caveat to consider is that the influence of food rejection on conceptual development in young children is likely cyclical. Conceptual knowledge is heavily dependent on lived experience and semantic knowledge is acquired through children's interaction with real-world events and objects (Contento, 1981; Chi et al., 1989; Fisher et al., 2015; Gelman & Markman, 1987). Associative learning, observational learning, and familiarization are three developmental processes that support children's knowledge and understanding in the food domain (Birch & Anzman, 2010). Furthermore, conceptual relations are formed when the entities occur sufficiently often in human experience to warrant a stored representation of their association (A. B. Markman & Stilwell, 2001). For example, food-to-mealtime associations form through frequent consumption of food or through the perceived appropriateness of consuming food at a given mealtime (McLeod et al., 2020).

However, certain individual traits, temperaments, and dispositions influence children's conceptual development (Moding & Stifter, 2016). Some researchers propose that food rejections, and neophobia in particular, could be a direct consequence of the specific temperament dimension of approach/withdrawal (Moding & Stifter, 2018). Lafraire and colleagues (2016) also point out that food rejections can be partly explained by personality traits such as tactile defensiveness (i.e., overreactions to the experience of touch, and withdrawal responses to some typically inoffensive tactile stimuli, perceived as offensive). It has been shown that tactile defensive children refuse vegetables to a higher degree than non-tactile defensive ones (Smith et al., 2005). Children who are low in approach tend to show negative affect toward new stimuli and withdraw from them (Rothbart & Bates, 2006). In their longitudinal study, Moding and Stifter (2016) showed that children with low approach tendencies at 18 months had higher levels of food neophobia at 4.5 years of age.

Conceptual development heavily depends on experience, and such personality traits and temperaments may prevent children from gaining experience because they tend to reject learning opportunities (Rioux, 2017). A review of the feeding practices linked to children's food-rejection behavior demonstrated that offering variety through taking children to new restaurants, exposing the child to variety, and offering unfamiliar foods were significantly predictive of greater food acceptance (Pliner, 2008). However, if children exhibit high food neophobia and pickiness behaviors, parents/caregivers may be discouraged from exposing the

child to new foods and eating situations. For example, a child may stay home from the canteen at lunch or take their own food and snacks when visiting relatives on the holidays. Consequently, the learning opportunities of foods and eating situations may be greatly reduced, and the opportunity to learn about conceptual relations is mired. Following this line of thought, it is plausible that food rejection dispositions lead to decreased learning opportunities, resulting in impoverished conceptual knowledge in the food domain. Such impoverished conceptual knowledge hinders children in feeling familiar with eating situations and food, causing them to withdraw from such experiences, thus perpetuating the cycle.

4. Conclusion

Intake of fruits and vegetables is alarmingly low in young children, and dietary variety is problematic in the early years (Carruth et al., 2004; Levene & Williams, 2017). Food neophobia and food pickiness are two of the greatest barriers to food acceptance and dietary variety, but the mechanism underpinning these dispositions remains elusive. One explanatory factor for food rejection in young children that has begun to merit investigation is children's knowledge of food. It is believed that knowledge of certain foods will foster greater food acceptance (Birch & Anzman, 2010). However, children are noted to show a high frequency of food rejection regardless of whether the substance is familiar or unfamiliar.

Given that contextual knowledge of the eating situation rather than solely knowledge of the food guides adults' acceptance of food, this thesis proposes that other conceptual knowledge guides children's increased food rejection tendencies. Children's conceptual knowledge is rapidly developing in early childhood as they require experience to form such representations. Thus, children are more likely to be confronted with eating scenarios and food in situ that leads to increased uncertainty. On one extreme, this uncertainty may lead the child to be incredibly liberal when deciding what substances are edible, even consuming inappropriate substances. On the opposite end of the spectrum, a child may display a sweeping rejection of potential foods. This research invests itself in the latter proposal that poor conceptual understanding and categorization may explain food rejection in young children.

1. Conceptual development of food

The recognition of food and the interpretation of eating situations are particularly sensitive to multiple conceptual relations to guide appropriate behavior (i.e., lamb is an exemplar of dinner food, but also an exemplar of meat). Some studies have examined children's use of conceptual knowledge in the food domain, but with a heavy focus on taxonomic relations (e.g., fruits or foods). To form an accurate representation of how children rely on conceptual knowledge to guide food acceptance, it is crucial to address the development of food knowledge.

1.1. Objectives

The foundational step of the research was to examine children's conceptual ability in the food domain. Developmental research outside of the food domain has determined that thematic, script and taxonomic categories develop greatly in young children. However, to date, there has been no direct comparison of which relations are most salient and relevant to young children concerning eating situations. Empirical evidence will allow future food education and intervention methods to appropriately target the specific conceptual knowledge available to children.

1.2. Hypothesis

The first hypothesis was that script, and thematic knowledge in the food domain will develop significantly between 2 and 7 years old.

1.3. Methodology

The following studies used an analogical categorization task, and conflicting and non-conflicting triad tasks to determine the developmental trajectories for specific thematic and script knowledge in the food domain.

A methodological issue with investigating both thematic and script associates is that they are relatively subjective compared to taxonomic relations (Jouravlev & Ken McRae, 2016). Individuals are likely to converge on the fact that objects belong to certain taxonomic categories, such as clothes and food. However, they may be less likely to converge on the fact that pancakes are a typical breakfast exemplar. Children, as adults, will therefore differ in their thematic and script representations. To overcome such methodological difficulties, we

identified the thematic and script relations that are the most salient and well-established representations (Estes et al., 2011). All four of the subsequent studies conducted pre-tests with both adults and children to establish these salient relations in the population of interest.

2. Conceptual Development and Food Rejection

If conceptual knowledge is underdeveloped, the possibility to understand stimuli and situations is hindered producing increased feelings of uncertainty. When faced with uncertainty in the food domain, a common disposition witnessed in young children is to inappropriately reject food. However, it is not necessarily that a child lacks the knowledge of the food, but potentially a lack of knowledge for the associated concepts accompanying a given instance of food. Thus, we argue that impoverished conceptual knowledge, namely thematic and script representations, in the food domain will lead to increased displays of food rejection in children. To date, solely the negative relationship between taxonomic knowledge and food rejection has been empirically tested. The subsequent research investigates how other conceptual knowledge gaps in the food domain may be linked with greater food rejection tendencies in young children. This is timely research, given that children's knowledge and reasoning about food is of paramount importance in their subsequent acceptance and increased dietary variety (Frazier et al., 2012; Shutts et al., 2013).

2.1. Objectives

The overarching objective of this work was to examine whether the previously reported negative relationship between food rejection and taxonomic knowledge extends to other forms of conceptual knowledge, namely thematic and script knowledge.

2.2. Hypothesis

The second hypothesis was that script and thematic conceptual knowledge in the food domain will be significantly linked with food rejection tendencies.

2.3. Methodology

In parallel to measuring children's conceptual knowledge, children's levels of food rejection were collected using the Child Food Rejection Scale (Rioux et al., 2017). The CFRS includes two subscales: food pickiness (five items, e.g., My child sorts his/her food on the plate) and food neophobia (six items, e.g., My child is suspicious of new foods). Caregivers were asked

to rate their agreement with each item on a 5-point Likert-like scale (strongly disagree, disagree, neither agree nor disagree, agree, strongly agree), according to their child's eating behavior. Total scores could range from 5 to 25 for food pickiness, and from 6 to 30 for neophobia. Higher scores indicate higher levels of pickiness and neophobia. A general child food rejection score was also calculated, combining the scores of both subscales (scores ranging from 11 to 55). Three of the four following studies used the CFRS measure of food neophobia and food pickiness to test the second hypothesis that food rejection is linked to poorer script and thematic performance in the tasks.

Part B – Empirical Research

Chapter 5 - Exploring thematic reasoning in food

This chapter (Part C, chapter 5) presents the first study as a written article in journal format. The study was designed to examine the previously untold relationship between thematic category knowledge and food rejection tendencies in children between 3 and 7-years-old.

A forced-choice analogy task was conducted with children between 85 French children between 37 and 82-months-old. Children were provided with a thematically or taxonomically related pair of foods (i.e., ice cream & cone or apple & banana, respectively), proceeded by a target food with both a thematically and taxonomically related choice. The child then had to refer to the conceptual relation between the example pair to select the analogous associate to pair with the target food. The child's level of food rejection was measured using the Child Food Rejection Scale (CFRS; Rioux et al., 2017).

The results indicate that poor analogical reasoning in the thematic condition is linked with increased levels of food pickiness and food neophobia. The analogical ability for thematic knowledge in the food domain is reduced in children with high levels of food neophobia and pickiness.

Chapter 6 - Delineating thematic and script knowledge

This chapter presents the second published article, which is comprised of three consecutive experiments investigating the development of the specific script and thematic structures in the food domain and their respective links with food rejection. The compilation of these three studies outlines different conceptual structures in the food domain and their respective developmental trajectories. The research also addresses which conceptual structures are related to food rejection tendencies, as well as providing an interpretation of the causal mechanisms explaining this link.

Study 2 used a non-conflicting triad task testing children's knowledge of four subtypes of script and thematic associations (food-food pairs, food-utensil pairs, event scripts, and meal scripts). To examine the developmental trajectories of these four category subtypes, 32 2-5-year-old children living in the United States took part in the initial study. The results revealed that age was a strong predictor of improved conceptual knowledge in the food domain. Post-hoc analyses revealed that functional thematic concepts (food-utensil) were acquired earliest, followed by knowledge of conventional food pairs (food-food) and script representations (event scripts).

Study 3 was a direct replication of study 2 with a larger sample of 129 French children, including the measures of food pickiness and food neophobia. The developmental findings were replicated in the French sample, with meal script categories mastered significantly later than food-utensil, food-food, and event script relations. Neither food neophobia nor food pickiness were significant factors in the models predicting conceptual knowledge.

Study 4 entailed a more demanding task in which potential thematic and script associates were pitted against one another. 72 children between three and seven years old were tasked with selecting the conceptual relation most appropriate to the task demands. In the script condition, children had to select an alternative meal script exemplar as a possible substitute for the target food. Whereas in the thematic condition children had to select the conventional associate to accompany the target food. The final study showed that both age and food neophobia were significant predictors for appropriate conceptual selection.

Title: The development of conceptual knowledge in the food domain and its relation with food rejection dispositions in 3-7-year-old children

Abstract: Previous research established that children with poorer taxonomic knowledge in the food domain display increased levels of food rejection. However, the food domain heavily lends itself to script and thematic conceptual knowledge (i.e., pancakes at breakfast), to which young children already attend. This series of studies investigated the development of conceptual knowledge specifically in the food domain, and the link with food rejection. Study 1 used a non-conflicting triad task testing children's knowledge of four subtypes of script and thematic associations (food-food pairs, food-utensil pairs, event scripts, and meal scripts) with children 3-6 years old living in the United States (18 boys and 14 girls). Study 2 employed the same design along with a measure of food rejection in 3-6-year-olds living in France (67 boys and 62 girls). There was significant conceptual development in both groups, but thematic food concepts are acquired earlier than meal script concepts. Study 3 investigated the link between thematic and script cross-classification and food rejection in 39 girls and 33 boys living in France (4-7 years old). Results demonstrate that children as young as 3 years old are already attending to thematic and script structures to inform food-based decision making. Even more critically, study 3 showed that increased food rejection tendencies are negatively related to script and thematic understanding in the food domain. Such seminal studies illustrate the importance of conceptual knowledge in children's interpretation and acceptance of food, highlighting promising avenues for knowledge-based interventions to foster dietary variety.

Concepts are the mental representation of entities (e.g., a tomato is round, red, and juicy) and conceptual relations are the interrelations between concepts (e.g., a tomato is related to cheese in that they are both foods but also commonly paired together) (Murphy, 2002; Gelman, 2003). There are many prevalent associations when thinking about eating situations because food rarely appears in isolation, is frequently accompanied by other items and foods, and is consumed in certain spatiotemporal contexts (Thibaut et al., 2016). Pioneering studies show that children and adults regularly rely on diverse concepts and categories to organize, store, and retrieve information about eating situations (Ross & Murphy, 1999; Nguyen & Murphy, 2003; Thibaut et al., 2016; Rioux et al., 2016). Adults have been witnessed to spontaneously refer to taxonomic (e.g., vegetables), script-based (e.g., breakfast foods), thematic (e.g., cereal-bowl), and even ad hoc or goal-derived knowledge (e.g., things to eat in a hurry) when confronted with foods (Barsalou, 1983; Ross & Murphy, 1999; Lin & Murphy, 2001). Script relations are formed when items that play the same role in an event or routine, such as foods eaten at breakfast or a birthday party (Lucariello et al., 1992; Nelson, 1993). Thematic relations are complementary or conventional relations between objects, events, people, and other entities that co-occur or interact in space and time (Denney, 1975; Denney & Moulton, 1976; Markman et al., 1981; Markman, 1989). Research demonstrates that such conceptual knowledge influences our food decisions and allows us to form expectations of eating situations (Ross & Murphy, 1999; Bian & Markman, 2020a). For example, although a tomato belongs to the taxonomic category of fruits, we may be less accepting of a tomato prepared in a fruit salad or served as a dessert.

Decades of developmental literature demonstrate that young children are particularly attentive to thematic and script knowledge and spontaneously form collections of items that belong together or form a scene (Denney & Moulton, 1976; Markman et al., 1981; Markman, 1989;

Keil, 1989). Such is true in the eating situations and meal script appropriateness already appears salient in preschool children. 3-4-year-old American children already impose contextual constraints of certain foods for specific mealtimes, such as deeming chicken inappropriate for breakfast (Birch et al., 1984; Nguyen & Murphy, 2003; Zeinstra et al., 2007; Nguyen, 2012; Bian & Markman, 2020b). Recent work has examined children's knowledge of breakfast scripts in four- and five-year-old children living in the United States and China (Bian & Markman, 2020b). Children in the US had more rigid notions of foods that belong in the script of breakfast foods, believing that fewer foods were appropriate at certain mealtimes (Bian & Markman, 2020b). However, it is not until approximately 7-years-old when children refer to script categories to make situational inferences about which foods are eaten at novel holiday scripts (e.g., candy is eaten at the same event as cupcakes) (Nguyen & Murphy, 2003).

Children's judgment about the script associations of foods does not solely rest at the level of the food itself but children also extend that judgment to people eating unconventional food associations (DeJesus et al., 2019). In a task in which 5-year-olds were asked to judge individuals based on what they ate, children evaluated anyone who did not eat conventional foods more negatively than people who ate what they considered to be more typical to eat (DeJesus et al., 2019). Together these findings demonstrate that children are not only attending to conventional thematic and script knowledge to guide food acceptance but also to evaluate others' food choices. In other words, at a relatively young age, children understand that they must follow script and thematic norms to attain social acceptance and peer approval. Consequently, it is crucial in a domain such as food to investigate how children come to acquire and appreciate the more culturally dependent thematic and script relations.

Research shows that even young children have cognitive abilities allowing them to form naive theories and reasoning when making food-based decisions (Shutts et al., 2013; DeJesus et al.,

2018). Therefore, from a public health perspective, it is crucial to address how children's conceptual knowledge guides their acceptance or rejection of foods. There are three main lines of argument for our subsequent investigation into whether food rejection is linked with thematic and script knowledge in the food domain. Firstly, as aforementioned, our expectations and acceptance of food are heavily guided by contextual cues based on existing thematic and script knowledge. Food is much more likely to be accepted if it conforms to our existing notions of thematic and script associations (i.e., cheese served with tomatoes). Secondly, developmental studies show that such thematic and script structures are particularly salient to young children who frequently rely on such conceptual knowledge to interpret their surroundings (e.g., expecting cereal at breakfast). However, the most crucial argument is that thematic and script associations are reliant on experience (Murphy, 2002; Gelman, 2003; Oakes & Madole, 2003). As such, younger children will have a limited conceptual representation of foods including important thematic and script associations (Shutts et al., 2009). Having reduced script and thematic knowledge is problematic as it increases the potential that a young child is presented with foods or eating scenarios that do not align with their conceptual knowledge. When faced with incongruent or unknown eating situations the child is likely to feel uncertain about the acceptability of the food in situ. Alternatively having less conceptual understanding and cognitive ability to draw upon appropriate conceptual relations may lead to a child forming incorrect conclusions (e.g., believing that eggs cannot be eaten at breakfast or with tomatoes). Such uncertainty or incorrect conclusions frequently result in food rejection tendencies, namely food neophobia, and food pickiness, which are commonly witnessed in children aged 2 to 7 years old.

Food neophobia is the reluctance to eat or even try novel food items, believed to be a protective function to prevent the ingestion of potentially harmful substances (Fallon et al., 1984; Rozin

et al., 1985; Milton, 1993). Heavily interlinked to food neophobia yet distinct is picky/fussy eating (Dovey et al., 2008; Rioux et al., 2017). Picky eating is defined as a substantial rejection of familiar food, certain food textures, or a lack of particular foods or food groups, (Birch et al., 1991; Taylor et al., 2015). While many different factors invoke food rejection tendencies in young children, one theory gaining gravitas is the idea that a lack of conceptual knowledge drives uncertainty and ultimately results in food rejection (Pliner, 2008; Lafraire et al., 2016).

In considering what renders a food familiar, it is not solely identification of the food, but also whether the food falls into a known context of consumption or alongside the associated foods or objects. Take for example knowing that eggs can be served at breakfast with toast. If children do not have sufficient knowledge of foods belonging to scripts (i.e., eggs for breakfast) and thematically associated foods (i.e., eggs with toast soldiers), they will be left feeling uncertain about the appropriateness of the food scene. When an item or situation holds a potential risk, it is safer to reject such instances, this is especially true in a domain such as food in which ingesting a novel substance may lead to disgust, illness, or even toxicity (Crane et al., 2020). Therefore, this research argues that a lack of thematic and script knowledge of food is expected to be related to increased food rejection.

However, the relation between food rejection and conceptual development is far from simple because conceptual knowledge is heavily dependent on lived experience (Contento, 1981). Evidence shows that food-to-mealtime scripts (e.g., oatmeal at breakfast) form through frequent consumption of food at a specific mealtime in the past, or through the perceived appropriateness of consuming food at a given mealtime, learned implicitly through social cues rather than explicit food consumption (McLeod et al., 2020). Considering that a common disposition of picky eating and food neophobia is this rejection of food across eating periods and contexts, the opportunity to learn about script and thematic relations is mired, and the cycle

of food rejection is perpetuated. Therefore, it is equally expected that food rejection tendencies hinder children's potential to experience and learn about conceptual knowledge in the food domain. Both directional theories support the idea that poor conceptual knowledge of food will be significantly negatively correlated with increased levels of food rejection in young children.

The three studies presented in this paper focus on the developmental acquisition of thematic and script knowledge of foods and how conceptual development is linked with food rejection tendencies in children between 3 and 7 years old. Study 1 investigated the distinct developmental trajectories of thematic and script knowledge structures in the food domain. Study 2 expanded upon the first study, to investigate whether specific conceptual knowledge is linked to food rejection tendencies. The third and final study investigated thematic and script knowledge in a conflicting triad design that demanded the most appropriate relation in response to the situational demands. All three studies were pre-registered, and the protocols, stimuli, anonymized datasets, and statistical scripts can be accessed at <https://osf.io/bc8fs/>.

Study 1

While research claims that young children show a preference for thematic and script relations the generic terminology does not adequately account for the heterogeneity of the relations that encompass such semantic associations. Thematic relations may be based on common conventions (e.g., soup is served with croutons), functional affordances (e.g., soup is served in a bowl), or even causal relations (e.g., a cow produces milk) (Keil, 1989; Markman, 1989). Equally, some thematic associates arise from convention (i.e., bread is served with butter), while others arise from functional complementarity (i.e., a spoon to eat soup). Script and thematic associations, to that end, are not well-defined and stable entities but heterogeneous in their nature (Barsalou, 2005; Glenberg, 1997). Such heterogeneity could account for potential differences in how and when children come to acquire such conceptual relations. Therefore,

the first study used the food domain to investigate when children were able to accurately attend to and use different types of script and thematic relations. The food domain is a great arena to explore how such heterogeneous features in thematic and script structures influence developmental acquisition because food lends itself simultaneously to these different conceptual relations. Lucariello et al.'s (1992) word association task indicated eight distinct conceptual structures available to children as young as four years old. However, for the conciseness of the research, the following studies examine the four most referenced conceptual relations (Lucariello et al., 1992). The definitions of the four conditions were adapted from Lucariello et al. (1992, p. 996), but interpreted to align with the conceptual relations relevant to food and eating situations. These were:

Event scripts = foods that belong to a spatiotemporal concept denoting a place, time, or event in which the target food typically occurs (e.g., cake-celebration). These associates will be referred to as event scripts.

Food-Food associates = conventional associations, in which two objects form a part-whole (e.g., ice cream-cone) or mere-association (e.g., fish-lemon). These relations will be subsequently referred to as food-food pairs.

Food-utensil associates = Functional associates denoting a characteristic functional association between food and an object (e.g., knife-to-cut bread; spoon-to scoop ice cream). These functional associates will be referred to as food-utensils.

Meal-scripts = Slot-filler concepts of foods that are exemplars of specific meals and can be substituted for one another in a spatiotemporal context (e.g., cereal-toast "breakfast foods"). These associates will be referred to as meal scripts.

The first study applied a match to sample task to determine whether the heterogeneous script and thematic relations outlined above show distinct developmental trajectories. The pre-

registered hypothesis for the first study was that children's knowledge in the food domain would be predicted by condition (type of association) and age. In Lucariello et al.'s (1992) qualitative investigation, both 4 and 7-year-olds evoked script relations when establishing matches in several domains (food, clothing, animals, furniture, tools), but thematic associates remained the most prevalent response in both age groups. Consequently, it was expected that food-food and food-utensil associates would develop earlier than event and meal script concepts in children aged 3-6 years.

Method

Participants

No previous research directly compared the development of the four conceptual relations with linear modeling, so power analysis estimates had to be determined based on the work of Nguyen & Murphy (experiment 1, 2003). Nguyen and Murphy conducted a non-conflicting triad task for meal script knowledge and witnessed a significant effect of age for 4-year-olds, 7-year-olds, and adults. Following their results, a sample of 16 participants in each age group would be needed to obtain a similar effect size to Nguyen & Murphy, with a power of .8 and alpha level of .05. Participants were 16 children aged between 34.5 and 47 months ($M = 42.9$, $SD = 3.9$) (9 male and 7 female) and 16 children aged between 55 and 68 months-old ($M = 61.9$, $SD = 4.3$) (9 male and 7 female). The children were recruited from a preschool affiliated with [hidden for review] and drew from middle to high socioeconomic populations. All legal caregivers provided written consent, and the children provided oral assent. The study received ethical approval from the [hidden for review] and complied with international regulations for research on human subjects.

Design and Materials

Study 1 used a forced-choice triad task, pitting a match against a distractor, with six trials for each of the respective conceptual relations outlined above: (A) event scripts (e.g., cake-celebration), (B) food-food (e.g., wafer cone-ice cream), (C) food-utensils (e.g., soup-spoon), and (D) meal scripts (e.g., bread-cereal). Each child was consecutively tested across all four conditions, and an example triad always preceded each condition to explain the association sought. To determine possible order effects, half of the participants received the trials in one order (condition sequence A-B-C-D), and the remaining half received the trials in the reverse order (condition sequence D-C-B-A) (See Figure 1). To determine whether a child showed a preference for specific stimuli, the distractor for one triad was a correct match for another triad. Post-hoc analyses revealed that there were no triads in which the distractor was the most salient choice.

Figure 3

Design and condition examples for study 1

Condition A: Event Scripts	Condition B: Food-Food
<p data-bbox="352 356 501 383">Target: Cake</p>    <p data-bbox="199 683 422 710">Distractor: Baseball</p> <p data-bbox="486 683 630 710">Match: Party</p>	<p data-bbox="826 356 975 383">Target: Burger</p>    <p data-bbox="678 683 869 710">Distractor: Cereal</p> <p data-bbox="957 683 1101 710">Match: Bread</p>
Condition C: Food-Utensil	Condition D: Meal Scripts
<p data-bbox="320 770 533 797">Target: Watermelon</p>    <p data-bbox="199 1108 438 1135">Distractor: Chopsticks</p> <p data-bbox="486 1108 630 1135">Match: Knife</p>	<p data-bbox="790 770 1029 797">Target: Salad (dinner)</p>    <p data-bbox="678 1108 917 1135">Distractor: Pancakes</p> <p data-bbox="965 1108 1109 1135">Match: Pasta</p>

The stimuli were color photographs featuring foods, food utensils, and objects representing events or scenes. Child-directed literature and research papers studying food categorization in U.S. preschoolers (e.g., Nguyen and Murphy, 2003) were consulted to establish the food associations children were familiar with. Parents of children aged 3-6 years and preschool staff were informally interviewed about children’s experiences and knowledge of particular foods (e.g., “Does your child know what chicken tenders are?”, “Does your child eat peanut butter with jelly?”). The list of the items used in the first study can be found online at <https://osf.io/bc8fs/>.

Procedure

A pilot of the procedure was conducted on five children across the ages of 3 to 6 years old, to establish that the test was comprehensible for young children. The procedure was identical to the intended study, but with the addition of asking the child after each choice why they had selected that item, to determine if any non-intentional associates were salient to the child. The pilot study was appropriate and no changes to the procedure or stimuli set needed to be made.

The preschoolers were tested individually in a quiet area of the school for approximately 10 minutes. The experimenter presented a puppet named Feppe: *“This is Feppe. Feppe comes from a faraway place, so he needs your help. Feppe has many different things to choose from and needs your help to decide which things go together. Can you help Feppe decide?”*

The experimenter showed a picture of the example target item (e.g., popcorn), and subsequently, a picture of an associative match (e.g., a movie ticket representing the movies) and a distractor item (e.g., a Christmas tree representing Christmas) placed on a flat surface in a pre-counter balanced placement. The experimenter then explained: *“Look Feppe has popcorn [experimenter pointing at popcorn picture], and he must choose whether it’s more normal to eat popcorn at the movies [pointing at movies ticket] or at Christmas [pointing at Christmas tree]. Feppe should choose the movies because this is what people eat at the movies. Now it’s your turn to help Feppe choose what food he should eat.”* The child then completed the six subsequent test trials. For condition B (food-food) the question was phrased as *“Would it be more normal for Feppe to eat the burger with the bread or the cereal?”* Condition C (food-utensil) the question was phrased similarly; *“Would it be more normal for Feppe to use the chopsticks or the knife with the watermelon?”* The explanation for the meal script condition deviated slightly, as it needed to be phrased so that the child understood they must choose a possible substitute for a meal, not a complimentary choice. As such, the experimenter asked

“Feppe wanted oatmeal for breakfast, but there was no oatmeal left. Would he have a bagel for breakfast or pizza for breakfast instead?”

In each of the triads, the experimenter labeled the pictures to clarify what the items were. When providing the specific label would bias the child’s response, such as “*cheese grater*” as a match for “*cheese*”, the experimenter provided a generic label for the object, such as “*grater*”. The experimenter repeated the question if a child did not make a clear choice or did not respond. Except for the example trials, the experimenter never provided the child with feedback on the test trials. Once the child had completed the six triads of the condition, they moved onto the subsequent condition after the experimenter said: “*We are now going to look at some different things that go together in a different way*”. The experimenter then demonstrated the example relationship, so the child was informed that the type of association had changed.

Statistical analyses

Data sets for the three studies and the respective scripts are openly available at [hidden for review]. The significance level was set at $p < 0.05$. Age was calculated in months and then coded as a binary variable, with children 34-48 months coded as younger and 54-68 months coded as older.

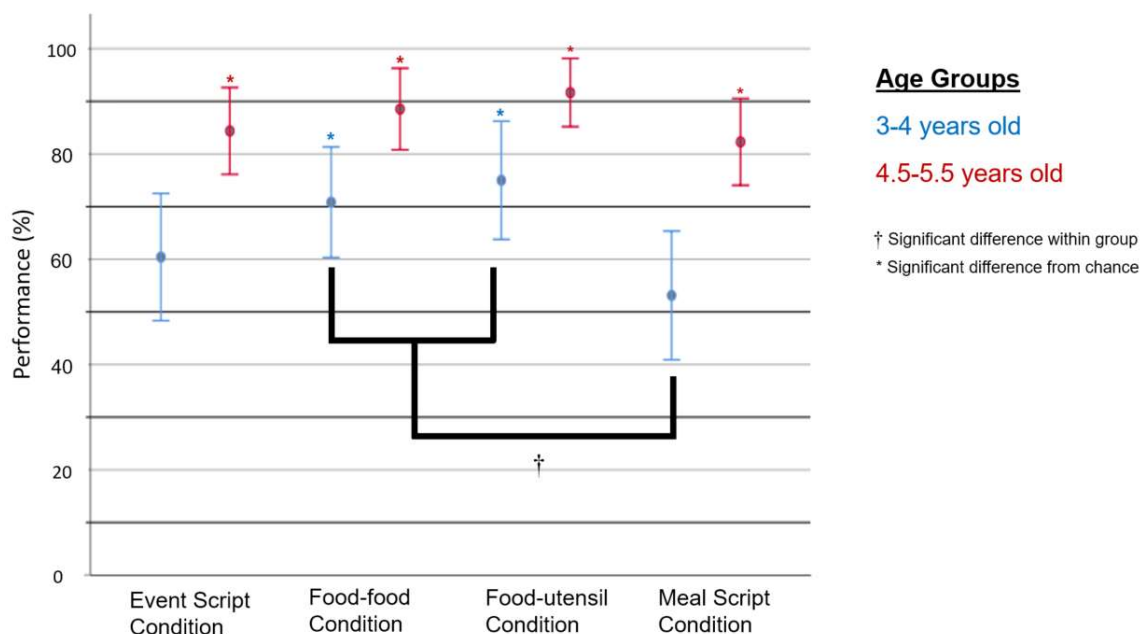
For each trial, a 1 was assigned to children’s selection of the associated choice, and a 0 was assigned to children’s selection of the distractor choice, a composite score was calculated for each condition. Descriptive statistics were run for all variables, and independent samples t-testing was conducted to determine whether the children performed above chance level ($M > 0.50$) in each condition. For hypothesis testing, mixed model regression models were used to determine how age (independent variable) affects conceptual knowledge (dependent variable). Subjects served as a random variable, given that scores across the four conditions were collinear within participants.

Results

The younger children did not differ from chance (50%) in both the event-script and meal-script conditions ($t(15) = 1.838, p = .086$ and $t(15) = .545, p = .594$, respectively). The younger children performed significantly above chance in the food-food and food-utensil conditions ($t(15) = 4.226, p < .001, t(15) = 4.743, p < .001$, respectively). Older children performed significantly above chance in all conditions.

Figure 4

Graph demonstrating mean score comparisons between age groups for each condition



An independent samples t-test was run for each condition to compare the mean performance for the two age groups (see Figure 2). The older children ($n = 16$) scored significantly better than the younger children ($n = 16$), across all conditions and total performance (see Table 1).

Table 1

Mean scores for each condition for younger and older children with t-test comparisons of significant differences between age groups and significant differences from chance.

		34.5-47 months (n = 16)		55-68 months (n = 16)		Comparison of groups <i>t</i> value
Conceptual Type	Relation	Mean	SD	Mean	SD	
	Event scripts	60.4%	(22.7)	84.4%**	(15.5)	-3.491††
	Food-food	70.8%**	(19.7)	90.6%**	(13.6)	-3.307††
	Food-utensils	75%**	(21.1)	90.6%**	(12.1)	-2.57†
	Meal scripts	53.1%	(22.9)	80.2%**	(19.5)	-3.601††
Total Score		64.8%	(15.7)	86.5%	(7.8)	-4.919**

Note. Significantly different to chance at * $p < .05$, ** $p < .01$. Significant difference between age groups at † $p < .05$, †† $p < .01$

Based on the procedure of decreasing the Akaike Information Criterion (AIC; Hu, 2007), the model of best fit included fixed effects of age group and condition, but no random effects or intercepts. The tests of fixed effects show that age ($F=25.602, p < .001$) and condition ($F = 6.269, p = .001$), have a significant effect on a child’s performance in the thematic and script categorization task.

The estimated increase in task performance for the older children compared to the younger children was 0.219 (95% confidence interval = [.130, .307]). Post-hoc analyses of the main effects of condition show that scores differed significantly for the food-food ($\beta = .12, p = .003$) and food-utensil ($\beta = .156, p < .001$) conditions compared to the meal-scripts. Scores for event scripts were not significantly better than scores for meal scripts (see Table 2 for estimates).

Table 2

Estimates of fixed effects predicting performance

Parameter	Std.		t	Sig.	95% Confidence Interval	
	Estimate	Error				
Intercept	.786	.039	20.116	.000	.709	.864
Event Scripts	.047	.040	1.178	.242	-.032	.126
Food-food	.120	.040	3.010	.003	.041	.199
Food-Utensil	.156	.040	3.926	.000	.077	.235

Meal Scripts	0 ^b	0	.	.	.	.
Age = Younger	-.219	.043	-5.060	.000	-.307	-.130
Age = Older	0 ^b	0	.	.	.	.

Note. ^b = reference variable

Discussion

In line with the literature, there was a significant yet steady development for the proficiency of all four conceptual relations from three to six years old (Nguyen & Murphy, 2003). As the first study to directly compare the development of distinct conceptual relations, the results demonstrate that the heterogeneous nature of thematic relations renders them developmentally different. The main effects of condition show that the script and thematic subtypes (meal scripts, food-food, and food-utensils) differ significantly. For children aged between 34-47 months, knowledge for functional relations and food-food relations was significantly better than knowledge for meal script relations. Furthermore, knowledge of meal scripts was at chance level for the younger children. Between 55 and 68 months, there were no significant differences in knowledge across the four conceptual relations tested, demonstrating that children appear to have relatively proficient knowledge of all four forms of conceptual relations in the food domain. One possible interpretation for witnessing that script knowledge developed later than thematic understanding is that given the added complexity of finding a substitute as opposed to an associate, one example was not sufficient to prepare children in the script conditions. However, the trial-by-trial analyses did not indicate that children had greater difficulty on the first trials compared to the later trials. Additionally, there were no effects of starting with the meal script condition compared to beginning with the thematic condition indicating that the task demands did not influence children's performance.

Study 2

While age accounts for a substantial part of the variance in conceptual development in the food domain, the inter-individual differences observed warrant investigation of other explanatory variables. As detailed in the introduction, recent research has shown that food rejection may partly account for differences in conceptual development in the food domain. Having established the developmental trajectories of these distinct conceptual relations, the second study aimed to investigate how food rejection may influence conceptual knowledge.

Previous studies have evidenced that a lack of taxonomic knowledge has been linked to increased food rejection in young children (Rioux et al., 2016 & 2017a). Later research has also shown that increased food rejection is linked to poorer thematic performance in a food analogy task (Pickard et al., 2021). The researchers only investigated food rejection with co-occurring thematic associates. Given that the results from study 1 demonstrate the discriminability of conceptual knowledge acquisition, it begs the question of how such subtypes of conceptual knowledge are linked with food rejection. Study 2 expands upon the developmental inquiry by investigating if food rejection is related to the specific subtypes of conceptual knowledge investigated in study 1. The hypothesis for study 2 was that food rejection negatively predicted conceptual knowledge across all four conceptual relations. An additional aim of study 2 was to replicate study 1 in a different culture to verify whether developmental trajectories of conceptual food knowledge are stable cross-culturally.

Method

Participants

While the effect sizes and results obtained in study 1 were robust, the expected effect sizes of food rejection on conceptual knowledge are much smaller, requiring a more substantial sample size. No mixed model analyses have been conducted on conceptual knowledge and food

rejection in young children, but an analogy task incorporating thematic knowledge and food rejection detected effect sizes of .247 (Pickard et al., 2021). To expect the same effect size, 126 children would be needed to obtain a power of .8 at an alpha level of .05.

Participants were 129 children (67 boys and 62 girls), aged 36.5-72.25 months ($M = 55.72$ months, $SD = 10.35$). The children were recruited from a public preschool in France with low to middle socio-economic backgrounds. Due to national ethical regulations, individual demographic data, including ethnicity and race, was not authorized to be collected. All legal guardians provided written consent, and the children provided oral assent. Both studies 2 and 3 received ethical approval from University Lyon II Independent Review Board and complied with national regulations for research on human subjects.

Materials

Thematic and script associations, particularly in the food domain, are culturally dependent and heavily tied to individual experiences and exposure (Estes et al., 2011). For example, rice may be a perfectly appropriate breakfast meal for Chinese children, but not considered appropriate to U.S. children (Bian & Markman, 2020b).

Thus, the stimuli set from study 1 with the American children were recalibrated to accommodate the food culture most familiar to French children. Child-directed literature, research papers about typically consumed foods in France (e.g., Poquet et al., 2019), and online local school menus were consulted, and parents of children aged 3-6 were interviewed. This resulted in an initial stimuli list ($n = 62$ pairs of food-related associations). In a second phase, this list was used to create an online survey, which was then sent to 40 parents of preschool-aged children living in the same geographical location as where the study was conducted. The parents were asked to indicate their child's knowledge (yes or no) of particular foods, food utensils, typical events, and food combinations (e.g., "Does your child know what noodles

are?’’, ‘‘Does your child know a pancake pan’’, ‘‘Does your child know Easter’’, ‘‘Does your child know that fries go with ketchup?’’). Only the items indicated as well-known by the majority of parents (above 80%) were retained from the list. Once the finalized stimuli images were sourced, a naming test with a sample of six children (age range: 3-5 years) was conducted to verify their knowledge and recognition of the selected stimuli represented on the pictures. Items identified by more than five of the six children were retained, resulting in the final 28 stimuli sets (consult online repository for the complete stimuli set).

Procedure

The procedure of study 2 was identical to study 1; a forced-choice triad task with four conditions testing for knowledge of event scripts, meal scripts, food-food associates, and food-utensils associates.

To measure food rejection tendencies, caregivers of each child filled out the Child Food Rejection Scale (CFRS; Rioux et al., 2017b) prior to the test phase at the school. The CFRS includes two subscales measuring the two main food dispositions, five items for food pickiness (e.g., *My child sorts their food on the plate*) and six items for food neophobia (e.g., *My child is suspicious of new foods*). Caregivers were asked to rate their agreement with each item on a 5-point Likert-like scale (strongly disagree, disagree, neither agree nor disagree, agree, strongly agree), according to their child’s eating behavior. Total scores could range from 5 to 25 for food pickiness, and from 6 to 30 for neophobia. Higher scores indicate higher levels of pickiness and neophobia. A global child food rejection score was calculated, combining the scores of both subscales (scores ranging from 11 to 55).

Statistical analyses

A mixed-effect linear model was performed to explain children’s conceptual knowledge in the food domain (Baayen et al., 2008). The models were constructed by iteratively adding

predictive variables to the null model (M_0 = the intercept and no predictor), using the Akaike Information Criterion (AIC; Hu, 2007) as a basis for model selection. Age and subject were included in all models as a fixed and random effect, respectively. Additional separate models included fixed effects of food pickiness, food neophobia, and global food rejection (CFRS), as well as all possible interaction terms. Due to the collinearity of food pickiness and food neophobia, the subscales were never entered simultaneously into the same models.

Results

Average scores for pickiness, neophobia and CFRS were 18.34 ($SD = 3.93$), 17.13 ($SD = 5.31$), and 35.47 ($SD = 8.48$), respectively. As in previous research, the distribution of food pickiness was negatively skewed and food neophobia was platykurtic (see <https://osf.io/bc8fs/> for data visualization).

Global conceptual knowledge scores ranged from 38% to 100% ($M = 80.65\%$, $SD = 14.93\%$). Scores in each condition ranged from 38-100%; event script ($M = 76.87\%$, $SD = 22.27$), food-food (mean = 84.88%, $SD = 20.76$), food-utensils ($M = 88.24\%$, $SD = 17.23$), and meal script scores ($M = 72.61\%$, $SD = 22.61$).

Although the stimuli set differed across study 1 and study 2, study 2 participants were divided into the two age groups predefined in study 1 to observe the broader developmental effects. There was a significant improvement between the younger children compared to the older children in all four conditions except meal script knowledge (see <https://osf.io/bc8fs/> for data visualization).

Confirmatory Hypotheses Testing

As witnessed in study 1, the model of best fit included fixed effects of age and condition, there were no significant random or interaction effects. The tests of fixed effects show that age ($F = 88.574$, $p < .001$) and condition ($F = 21.736$, $p < .001$) each have a significant effect on a

child’s performance. As witnessed with the U.S. participants, scores for food-food and food-utensil concepts were significantly better than scores for meal scripts within participants ($\beta = .123$, $p < .001$, and $\beta = .156$, $p < .001$, respectively). Scores for event scripts were not significantly better than scores for meal scripts (see Table 3).

Table 3

Estimates of fixed effects predicting performance

Parameter	Estimate	SE	t	Sig.	95% Confidence Interval	
Intercept	.227385	.056337	4.036	.000	.116065	.338706
Event Scripts	.042636	.023510	1.814	.072	-.003883	.089154
Food-Food	.122739	.021195	5.791	.000	.080801	.164677
Food-Utensils	.156331	.021684	7.209	.000	.113425	.199237
Meal Scripts	0 ^b	0	.	.	.	.
AGE	.008950	.000951	9.411	.000	.007068	.010832

Note. ^b = reference variable

Discussion

In conjunction with the results from study 1, study 2 showed that both condition and age were predictive for knowledge of conceptual relations in the food domain. Again, there were significant differences in children’s performance between scripts and thematic associates. Scores for event and meal scripts were significantly lower than scores for food-food and food-utensil associates within participants. This speaks in favor that although the material was recalibrated to a different sample, the design and stimuli sets provide robust cross-cultural findings.

Food pickiness and food neophobia did not improve the fit of the model predicting performance on the food knowledge task. This result seems surprising considering the previous research by (Pickard et al., 2021), who concluded that increased levels of food rejection were linked to poorer thematic knowledge in the food domain. The results of the present experiment call for reinterpreting the results of Pickard et al., (2021), who used an analogical reasoning task in

which the child was required to pick the most appropriate response from a taxonomic or thematic match. Children with higher food rejection were perhaps capable of identifying both thematic and taxonomic relations but could not select the most appropriate in line with the task demands. This line of reasoning suggests that children with higher food rejection can identify common food associates and scripts when there is no strong contender, as shown by the high percentage of correct answers. However, they perhaps cannot contextualize and cross-classify this knowledge appropriately when a more diverse perspective is requested from the task. For example, a child may know that cereal belongs to the category of breakfast food, but they may fail to retrieve this information when required to pick an appropriate substitute for breakfast when presented with a more salient associate, such as milk. For the cognitive system to use categories effectively, such concepts must work in concert at the appropriate moment they are required (Markman & Stilwell, 2001). Food scenarios sometimes call upon script categories, such as finding an appropriate slot-filler or upon thematic categories, like selecting an associated food. Therefore, the final study aimed to disentangle children's knowledge of categories from cross-classification ability in response to task demand.

Study 3

The results from study 2 appear to contradict the findings of Pickard et al. (2021), who witnessed that children with higher food rejection showed poorer knowledge of co-occurring food associates. However, their study pitted taxonomic and thematic associates in an analogy task, which does not allow the conclusion that children failed to identify the thematic relation. Children with increased food rejection may have been biased towards taxonomic relations pitted against thematic relations. Alternatively, the authors note that food rejection may be linked to other abilities, such as analogical reasoning, inhibition of preferred relations, or flexible switching between conditions (Pickard et al., 2021). This limitation and the results of

study 2 present compelling reasons to conduct the subsequent investigation examining the relation between food rejection and children's conceptual understanding when given a more demanding task design.

The final study used a repeated match-to-sample task, this time with two competing options (a meal script match and a food-food match) framed across two scenarios. The first condition required a thematic associate response (requiring a co-occurring associate) and the second condition required a script associate response (requiring an alternative substitute). In other words, children were required to interpret the contextual cues to select the most appropriate choice. Meal scripts and thematic foods were the two conceptual relations retained for the final study, as they showed significantly different development in both studies 1 and 2.

It was determined a priori that, per Rioux et al. (2018) and Pickard et al. (2021), children with higher levels of food rejection would fail to appropriately select the correct conceptual relation in response to the contextual cues. The developmental hypothesis, based on literature and studies 1 and 2, was that age and condition would be a significant predictor of cross-classification. More specifically, children would be better in the thematic condition than in the script condition.

Method

Participants

The previous analogy task incorporating thematic knowledge and food rejection detected effect sizes of .247 (Pickard et al., 2021), which would require 126 children to obtain .80 power at the standard 0.05 alpha error probability. Given the task design for study 3 was less demanding than the analogy task by Pickard et al., a larger effect was expected, requiring a smaller sample size. Children were recruited from a preschool different to study 2, in a middle socioeconomic

area of France. National ethical regulations do not permit the collection of individual demographic data collection.

39 girls and 33 boys aged between 48.95 and 84.04 months old, with a mean age of 66 months (SD = 10.9 months), provided oral assent to participate in the task. 34 children completed the script, followed by the thematic condition, and the remaining 38 children completed the thematic, then the script condition. As in study 2, parents or legal guardians at a preschool in [hidden for review] were informed of the study and provided consent for their child to participate through completing the food rejection measure. Three children did not complete the task, three children failed to understand the script condition of the task, and one child failed the thematic training condition (having scored less than 50% on the script or thematic training trials, respectively). These seven children were not included in any further analyses, as established in the pre-registration of the study.

Materials

The stimuli were color photographs featuring foods presented on a laptop screen. The target food appeared centered at the top of the screen, and the script match, thematic match, and distractor were displayed on the row below in a randomized left to right configuration. The basic label was written below each image, as well as being labeled aloud by the researcher at the beginning of each stimulus set (the complete list of the stimuli sets can be found by visiting <https://osf.io/bc8fs/>).

A pilot of the procedure with the finalized stimuli sets was conducted with 15 adults and 8 children. The pre-test with the adults was used as a baseline measure to establish that all trials had a ubiquitous response across the two framed conditions. There was 100 percent convergence on all trials across both script and thematic framed scenarios, thus all stimuli were retained. The pre-test with the eight children between 4 and 6 years old was to determine

whether the procedure was comprehensible for the children, but sensitive enough to capture individual differences.

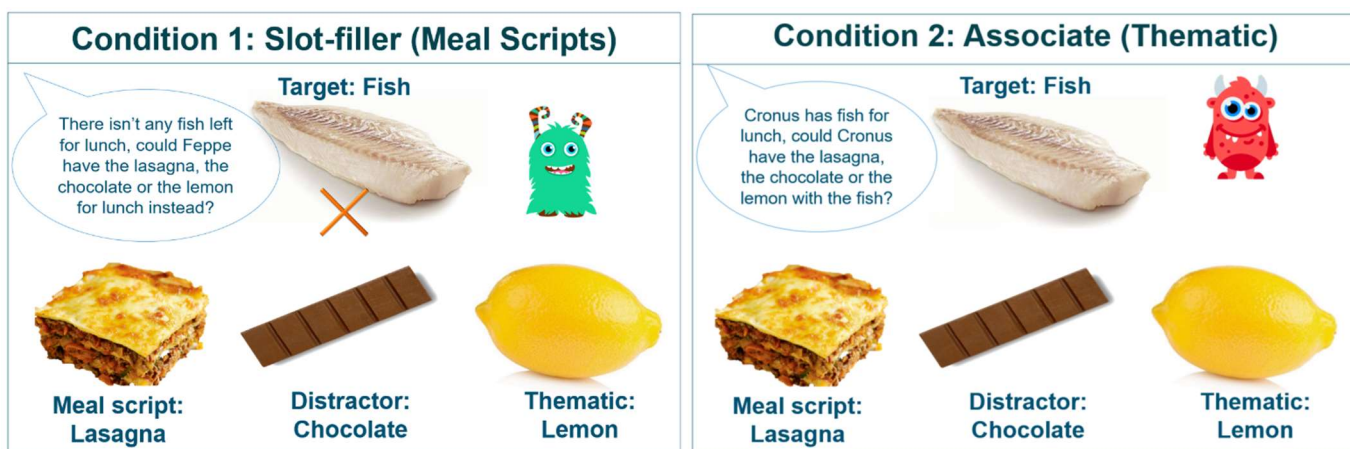
Procedure

The preschoolers were tested individually in a quiet area of the school for approximately 10 minutes. The researchers introduced two novel characters (*Feppe and Cronus*) and explained that they were from a faraway planet. Therefore, they needed the child’s help to understand objects and foods normally found in specific situations.

Children completed 24 test trials in one of two counterbalanced sequences. The script condition was framed that the character had a specific meal, and since there was no more of one food left, he had to select a suitable substitute for that meal script (*“Feppe was having lunch, but there was no fish left, should Feppe have lasagna, chocolate or a lemon for lunch instead?”*). The other condition, requiring a thematic associate, was worded *“Cronus has some fish for lunch, could Cronus have the lasagna, the chocolate, or the lemon with the fish?”* Children had to select between a meal script match, thematic food match, and a distractor (see Figure 3).

Figure 5

Example of the task design for study 3



To calculate contextual understanding in the food task, a score of 0 was assigned if participants selected the divergent choice for each trial (e.g., thematic scenario: script associate OR script scenario: thematic associate). A score of 0 was assigned to a distractor selection. In contrast, a score of 1 was assigned to each trial that the participant selected the corresponding choice (e.g., thematic scenario: thematic choice OR script scenario example: script associate). Scores were then averaged for both thematic and script conditions.

The task included four training trials with non-food stimuli to determine if the child understood the script and thematic scenarios. Testing was suspended for children who failed on more than 3 of the four training trials to identify the convergent match to the condition.

Statistical Analyses

As in the previous studies, a mixed-effects linear regression was performed on the child's score in each condition. The models were constructed by iteratively adding predictive variables to the null model (M_0 = the intercept and no predictor), using the Akaike Information Criterion (AIC; Hu, 2007) as a basis for model selection. Age and subject were included in all models as a fixed and random effect, respectively. Order was included as a fixed effect, as was food pickiness, food neophobia, and global food rejection (CFRS), as well as all possible interaction terms.

Results

Descriptives

Average scores for pickiness, neophobia and CFRS were 17.22 ($SD = 4.54$), 14.63 ($SD = 5.16$), and 29.8 ($SD = 8.69$), respectively. Global performance across all children ranged from 37.5% - 95.8% ($M = 71.3%$, $SD = 14.32$). Scores ranged from 25% - 91.6% ($M = 65.2%$, $SD = 18.8$) in the script condition and 33.3%-91.6% ($M = 70%$, $SD = 14.2$) for the thematic condition.

Confirmatory Hypotheses Testing

Based on the procedure of decreasing the Akaike Information Criterion (AIC; Hu, 2007), the best fitting model contained fixed effects of age, condition, and neophobia, as well as an interaction effect of condition and order (see Table 4 for model reporting). The main effect of age shows an improvement of 0.056 in overall task performance for each unit increase in age. The main effect of the condition demonstrates that children performed significantly worse in the script condition than in the thematic condition ($F = 4.83, p = .031$); between 0.061 and 1.184 less for the script condition compared to the thematic condition. A main effect of neophobia was also witnessed; for every unit increase in food neophobia, there is a decrease in task performance of 0.092.

There was also an interaction effect between condition and order included in the final model. Children who completed the thematic condition followed by the script condition found the script context easier than the children who were asked to complete the script condition first. The estimated increase in script performance for the children who completed the script condition last was 1.46 (95% confidence interval = [.452, 2.468]) (see Table 4).

Table 4

Estimates of fixed effects predicting performance

Parameter	Estimate	Std. Error	t	Sig.	95% Confidence	
					Interval	
Intercept	5.867	1.104559	5.312	.000	3.664	8.071
Condition (script)	-1.176	.406272	-2.896	.005	-1.987	-.366
Neophobia	-.092	.031243	-2.934	.005	-.154	-.029
Age	.056	.014560	3.850	.000	.027	.085
Script condition * thematic→script	1.460	.505394	2.889	.005	.452	2.468
Thematic condition * thematic→script	.336	.362	.930	.356	-.385	1.058

Discussion

The final study investigated children's ability to respond to contextual task demands and select the appropriate conceptual relation when given a conflicting choice between a meal script and thematic associate. As expected, age significantly improved children's performance for the task in both thematic and script conditions. Reiterating the findings of studies 1 and 2, children performed significantly better in the thematic condition than in the script condition. In addition, performance in the script condition was better for the children who had completed the task with the thematic condition first, followed by the script condition. Crucially, food neophobia was determined to reduce the selection of the most appropriate relation for both meal scripts and thematic associates in the food domain. A possible explanation is that children with higher food neophobia levels have decreased inhibitory control to suppress a salient, albeit inappropriate, associate. In other words, highly neophobic children may be aware that one conceptual relation is more appropriate in response to situational demands, but when presented with such items in competition, they are unable to inhibit the immediate saliency or preference for a less appropriate associate. An alternative explanation for both studies 2 and 3, could be that children with higher food neophobia fail to flexibly apply the correct conceptual relation in response to contextual demands. This suggests that a food neophobic child lacks the appropriate interpretation of situational cues and the ability to infer the most appropriate conceptual relation.

General Discussion

The food domain is especially liable to multiple conceptual relations, such as thematic and script-based associates (Ross & Murphy, 1999; Nguyen & Murphy, 2003). Additionally, young children have been found to depend on their notions of script and thematic associates to interpret and interact with their surroundings (Denney & Moulton, 1976; Markman et al.,

1981). However, few studies have addressed children's script and thematic understanding of foods, and none have investigated how thematic and script knowledge influences food acceptance or rejection. The aims of this research were twofold. Firstly, to investigate at what age children have sufficient script and thematic knowledge in the food domain, and secondly to determine whether poorer knowledge of such conceptual relations is linked with food rejection tendencies.

In response to the first line of inquiry, studies 1 and 2 investigated children's knowledge of four distinct thematic and script relations, these were defined as:

Event scripts = foods that belong to a spatiotemporal concept denoting a place, time, or event in which the target food typically occurs (e.g., cake-celebration).

Food-Food associates = conventional associations, in which two objects form a part-whole (e.g., ice cream-cone) or mere-association (e.g., fish-lemon).

Food-utensil associates = Functional associates denoting a characteristic function between food and an object (e.g., knife-to-cut bread; spoon-to scoop ice cream).

Meal-scripts = Slot-filler concepts of foods that are exemplars of specific meals and can be substituted for one another in a spatiotemporal context (e.g., cereal-toast "breakfast foods").

Different developmental trajectories for thematic and script knowledge

Both study 1 and study 2 demonstrate that children's knowledge of thematic and script associations improves significantly between 34 and 55 months. When presented in a non-conflicting triad, by 55 months old, children were selecting the correct relation above chance across all four conditions. This finding supports the developmental research, both within and outside of the food domain, demonstrating that there is rich conceptual development during early childhood (Markman, 1989; Gelman, 2003; Murphy; 2002). Such conceptual development is believed in large part due to experience and education, which broaden "the

features (both conceptual and perceptual) that enable categorization and more sophisticated mental representations of objects, people, and situations” (Oakes & Madole, 2003, p. 143).

In addition to replicating previous developmental work, our research details differences in the developmental acquisition of specific thematic and script relations. The post-hoc analyses reveal that functional thematic associates (food-utensil) are mastered earliest followed by knowledge of conventional food pairs (food-food) and event scripts. Knowledge of slot-filler associates (meal scripts) developed significantly later but still showed a significant developmental improvement. This developmental difference aligns with previous researchers who argued that property differences for specific conceptual relations made functional thematic associates available earlier than slot-filler concepts (scripts) (see Lucariello et al., 1992; Nelson & Nelson, 1990). Thematic associates must satisfy the requirement of complementarity, convention, or functional affordance (Estes et al., 2011). Whereas, finding two appropriate meal script associates (such as oatmeal and pancakes at breakfast) requires inhibiting an initial salient script associate (i.e., the oatmeal) to identify a possible substitute script associate (i.e., the pancakes). The results from the three studies illustrate that the cognitive manipulation needed for identifying script associates may be more cognitively demanding than identifying a thematic associate based on co-occurrence. This interpretation is further supported in the results viewed in our final task in which children performed better in the script condition when they were presented with the thematic condition first. This is possibly due to the child already having eliminated the thematic associate as a potential choice in the first part of the task. This indicates that the thematic associate appears more salient or accessible to younger children, as the children who completed the script condition first did not perform as well.

While there appears to be a shift in preference or accessibility of thematic over script relations, by 5 years old children are attending to both thematic and script relations. Such evidence is ground-breaking in revealing the conceptual knowledge they may be relying on when deciding

to accept or reject a food. It is not until slightly above 5 years old, that children are increasingly attending to meal scripts in guiding food acceptability, as is witnessed from older children and adults (Ross & Murphy, 1999; Bian & Markman, 2020a). Such a finding indicates that early childhood could be a critical period for instilling dietary variety and a diverse range of foods at mealtimes to avoid children forming overly restrictive or rigid notions of thematic and script food knowledge.

Food Neophobia linked to global deficits in conceptual knowledge

Having established young children's developmental acquisition of script and thematic food knowledge, this research ultimately aimed to determine whether lacking such script and thematic knowledge was linked with food rejection. On the one hand, having a very limited repertoire of thematic and script associates is likely to lead to many food instances that the child fails to interpret as appropriate. For example, not knowing that eggs are commonly served for breakfast in certain cultures may lead the child to reject such an instance of eggs for breakfast. On the other hand, having a very rigid script or thematic representations of foods (i.e., only pancakes are an acceptable instance of breakfast food) limits the child's acceptance of other foods that deviate from the child's breakfast script. Therefore, this research hypothesized that food rejection tendencies, namely food pickiness and food neophobia, would be significantly linked with reduced knowledge for thematic and script associations in the food domain.

Somewhat surprisingly, study 2 demonstrated that food rejection was not a significant predictor for conceptual knowledge in any of the four thematic and script relations examined. However, the null findings may have resulted from the simplicity of the task design, pitting the correct associate against an irrelevant distractor. This explanation seems plausible, given that in the more demanding study 3, where a script associate was pitted against a thematic associate, food neophobia was a significant predictor of poorer conceptual understanding. The main effects of

the model demonstrate that higher levels of food neophobia predicted poorer ability to select the most appropriate conceptual relation in the conflicting triad design for both script and thematic associates.

Taken together these results indicate that, rather than a lack of conceptual knowledge leading to increased uncertainty, food rejection may be related to children's appropriate use of conceptual knowledge or limited inhibition for more salient associates. An inability to flexibly refer to appropriate conceptual relations to guide understanding is problematic because food is situated in context and liable to many simultaneous representations (i.e., soup shares functional associates [bowl & spoon], conventional associates [croutons], script associates [dinner], temporal associates [starter]). With so many possible representations available at any one instance, children with increased food neophobia may face difficulty in referring to the most appropriate conceptual relations to guide appropriate acceptance. Not being able to draw upon the most informative conceptual relation is likely to lead to incorrect interpretations or conclusions being formulated.

With cognitive development, children with higher levels of food rejection should eventually be able to reason that different conceptual relations are conducive to concluding different pieces of information (i.e., knowing that foods that are thematically associated may not necessarily share the same taste profiles). The pronounced advances in children's cognitive abilities and improved ability to refer to appropriate conceptual structures may explain why food rejection tendencies show a decrease around 6-7 years old (Dovey et al., 2008). Improved ability to draw inferences and reason using appropriate conceptual relations will thus reduce feelings of uncertainty in food situations.

An important caveat to bear in mind is that the influence of food rejection on conceptual development in young children is far from simple, as it is likely a cyclical process. Conceptual knowledge is heavily dependent on lived experience and acquired through children's

interaction with real-world events and objects (Contento, 1981; Chi et al., 1989; Fisher et al., 2015; Gelman & Markman, 1986). If children present high food neophobia and pickiness behaviors, caregivers may be discouraged from exposing the child to new foods and eating situations. For example, a child may stay home from the canteen at lunch or take their own food and snacks when visiting relatives on the holidays. Consequently, the learning opportunities of foods and eating situations may be greatly reduced, and the opportunity to learn about common conceptual relations is mired. Therefore, a possible explanatory mechanism for food rejection is that the behavior itself leads to decreased learning opportunities, resulting in impoverished conceptual knowledge in the food domain.

Future Research

Our results strongly suggest that knowledge-based interventions appear promising in facilitating children's understanding of food situations and subsequently boosting dietary variety (Gripshover & Markman, 2013; Nguyen et al., 2011). However, current food education places a heavy emphasis on knowledge of nutritional food groups or individual foods and their respective health benefits. Such educational methods may hold limited effectiveness given that children are particularly sensitive to other types of conceptual knowledge. Our research demonstrates that young children draw upon thematic and script knowledge when making conclusions about the acceptability of foods. As such, food education that expands children's food scripts and thematic knowledge could foster increased certainty in the food arena leading to subsequent dietary variety.

Having provided concrete evidence that there is a link between thematic and script understanding and food neophobia, future work must investigate the cause and effect of this relation. Longitudinal or interventional research could indeed determine whether food rejection tendencies lead to poorer conceptual knowledge in the food domain, or whether poorer conceptual knowledge in the food domain leads to food rejecting behaviors. Such approaches

would also be valuable in investigating confounding variables such as socioeconomic status and genetic dispositions that influence the relation witnessed in this research. Studies have witnessed that both socioeconomic status and educational level also appear to modulate the expression of the disposition to reject fruits and vegetables (Flight et al., 2003; Giskes et al., 2002; Lien et al., 2002). Furthermore, as evidenced from the stimuli sets in studies 1 and 2 there is notable cultural diversity in script and thematic concepts in the food domain. It was beyond the remit of this investigation to determine the effects of culture and SES on children's conceptual knowledge in the food domain, but future evidence should consider such potentials.

Conclusion

Previous research of thematic and taxonomic knowledge in the food domain indicates that impoverished conceptual knowledge in young children is linked with greater food rejection tendencies. However, food is a domain susceptible to many conceptual relations and categories across different contexts and situations. These three studies examined the developmental acquisition of distinct thematic and script food relations in children between 2 and 7 years old. The results indicate that knowledge of event and meal scripts develops slightly later than knowledge for thematic associations based on co-occurrence and functional affordance. These findings are fundamental in understanding that at younger ages children may place greater importance on what foods and objects belong together, whereas at an older age child may place more emphasis on what context is appropriate for food.

This research additionally addressed whether food rejection tendencies (food neophobia and food pickiness) are linked with poorer conceptual knowledge of script and thematic associates. Food neophobia and food pickiness were not predictive of children's performance when a thematic or script associate appeared in a non-conflicting triad. However, study 3 demonstrated that food neophobia was predictive of children's performance when a thematic and script associate were competing associates. The results suggest that children with higher levels of

food neophobia have conceptual knowledge in the food domain, but struggle to draw upon the most appropriate conceptual knowledge when making food-based decisions.

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Part C - Discussion

Chapter 7 - Findings & Perspectives

1. Research Findings

Insufficient dietary variety in children leads to significant nutrient deficiencies and health issues in both childhood and later life (DeCosta et al., 2017). Therefore, it is of great societal impact to determine the mechanisms responsible for the increased food rejection tendencies witnessed in young children. The initial departure of this thesis was guided by the previously expressed hypothesis that children are likely to accept foods they know and reject foods they do not know (Birch, 1980; Sullivan & Birch, 1990). This argument is partly defended by the definition of food neophobia being the tendency to avoid or reject foods that appear novel or unfamiliar (Dovey et al., 2008). However, the current literature and interventions aimed at fostering food acceptance in children encouraged us to reexamine this statement. A counterargument to the original claim that food knowledge fosters food acceptance is that children's displays of food rejection encompass both unfamiliar and familiar foods (Dovey et al., 2008; Johnson et al., 2018). For both food neophobic and picky eaters, even after exposing children to fruits and vegetables, rejection of such foods persists. Such arguments threaten the theory that food knowledge fosters food acceptance. However, one possible argument for why food knowledge does not always lead to food acceptance is that the previous notion of food knowledge fostering food acceptance did not account for all types of knowledge in guiding food acceptance.

Developmental psychologists have continuously demonstrated that both adults and children are susceptible to many forms of knowledge to guide their behavior and understanding of the world (Markman, 1989; Keil, 1992; Murphy, 2002; Gelman, 2003). Children as young as two years old interpret objects and their surroundings based on conceptual features, such as script knowledge (i.e., items at a party) or thematic knowledge (i.e., a rabbit and a carrot) (Nelson & Nelson, 1990). Such conceptual knowledge is particularly abundant in the food arena, as we interpret and understand food for the context in which it is situated (e.g., pancakes are considered a breakfast food or a dessert). Such conceptual knowledge, in addition to knowledge of the food itself, guides our recognition and interpretation of the acceptability of the food (Nguyen & Murphy, 2003; Nguyen, 2007). This is true for both children and adults with studies showing that conceptual knowledge of food, namely script and thematic associations, heavily influences whether we choose to consume food (see chapter 1).

Thematic and script knowledge is largely established through experience and as such, there is great conceptual development during early childhood (chapter 2). The importance that food places on contextual information such as script and thematic knowledge leads us to believe that gaps in such knowledge may be responsible for children's increased food rejection tendencies. Therefore, this thesis argues that food knowledge does not solely encompass the knowledge of the food itself, but also the contextual knowledge available from the food being situated in a specific scenario. We argue that children's familiarity and subsequent acceptance of foods is determined by a more encompassing construct of food knowledge. Since such contextual knowledge (i.e., co-occurring foods and meal scripts) guides comprehension, it may not suffice to solely recognize the food at hand, but to be familiar with thematic and script relations that influence food acceptance. Therefore, this research program set out to address the importance of children's contextual knowledge, namely script and thematic knowledge, of food in increasing subsequent acceptance. Such investigation is seminal in informing researchers, policy makers, and caregivers on how knowledge-based interventions can be enriched with broader conceptual knowledge to foster greater food acceptance.

To respond to this research aim, a series of four observational studies were conducted on children between 3 and 7 years old. The first study (chapter 5) confirmed that thematic knowledge was negatively linked with food rejection tendencies. The second and third studies (chapter 6) aimed to distinguish different forms of contextual knowledge in the food domain and when they are available to children. The results showed that **meal script categories are mastered later than food-utensil, food-food, and event script relations**. The final study (chapter 6) used a situation-based task pitting a thematic food associate and a script food associate, to determine which forms of knowledge were most related to food rejection. **Increased levels of food neophobia were significantly predictive for poorer appropriate thematic and script knowledge.**

The present chapter offers an interpretation of these findings concerning our theory that contextual based (thematic and script) knowledge about foods is conducive to food recognition and subsequent acceptance. The chapter culminates in a presentation of potential perspectives and intervention methods to foster greater food acceptance in young children.

2. Conceptual Development in the Food Domain

2.1. Strong thematic and script conceptual development between 2 and 5 years

Our results from study 2 (chapter 6) demonstrate that knowledge of script and thematic associates in the food domain improves significantly between 3 and 5 years of age. This finding was replicated in study 3 with French children, illustrating that age is a strong predictor of improved conceptual knowledge in the food domain.

This finding supports the developmental research, both within and outside of the food domain, demonstrating that there is rich conceptual development during early childhood (E.M. Markman, 1989; Gelman, 2003; Murphy; 2002). Such conceptual development is believed in large part due to experience and education, which broaden “the features (both conceptual and perceptual) that enable categorization and more sophisticated mental representations of objects, people, and situations” (Oakes & Madole, 2003, p. 143). Study 1 strongly supports this argument as **age was positively correlated with food identification and food identification was positively correlated with thematic knowledge**. As children experience food situations, their knowledge of food items and eating situations increases, and subsequently their thematic understanding of food pairings improves. Thus, older children have had invariably more opportunities to be exposed to thematically related food.

By five years of age, children perform significantly above chance across all four conditions, demonstrating that they indeed have access to contextual knowledge when encountering food. Even more compelling, despite performing worse than the older children in all conditions, 3–4-year-olds have access to script and thematic knowledge of food. In all four conditions, the global performance in at least one of the six triads was above the level of chance (see Appendix 4 and 6 for the global percentage of success for each stimulus set). These findings strongly affirm earlier research that the food domain is highly susceptible to many forms of conceptual knowledge and even young children possess such representations. Consequently, children’s interpretation of eating situations is not solely liable to the knowledge of the food item but also the contextual knowledge of thematic and script food associations.

Post-hoc analyses revealed that **functional thematic associates (food-utensil) were mastered earliest followed by knowledge of conventional food pairs (food-food) and event scripts.**

Knowledge of slot-filler associates (meal scripts) developed significantly later but still showed a significant developmental improvement.

Three to four-year-olds were already outperforming chance in the two thematic conditions (functional utensils and co-occurring foods) we employed for studies two and three. The availability of thematic knowledge for young children provides key insight as to how children may reason and make decisions in the food domain. Between three and four years old, thematic associates may be more available than script representations in the food domain and thus bear more weight on a child's interpretation of an eating scenario and subsequent acceptance of potential foods. Our results illustrate that the co-occurrence of foods is potentially an important aspect when children are deciding whether to accept or reject food.

Our results align with earlier investigations using alternative methodologies. Lucariello et al. (1992) explored the saliency of the thematic, script, and taxonomic associates in four and seven-year-olds, with a word association task. In the food domain, 4-year-olds made significantly more references to thematic relations, such as soup and bowl, whereas, the 7-year-old children made significantly more references to slot-filler script associates, (e.g., oatmeal or pancakes at breakfast) and a lesser extent to taxonomic associates (e.g., pizza and food). In our non-conflicting trials children, the youngest children selected the appropriate functional thematic and co-occurring thematic relation above the level of chance. Whereas, in the meal script and event script, the youngest children were only correct at the level of chance. However, by 5 years old, the children were outperforming chance in all four of the conditions, demonstrating a good knowledge of thematic and script associates. In replicating the findings of Lucariello et al. (1992) with an empirical measure, we may conclude that younger children indeed can recognize or recall taxonomic, script, and thematic associates, but there is earlier access to thematic knowledge in the food domain.

In study 4 (chapter 6) we pitted thematic and script associates against one another in a conflicting match design. The significant main effect of condition demonstrates that even the older children performed better in the thematic condition, compared to the script condition. Such results indicate that although young children have access to both thematic and script associates, thematic knowledge appears more salient to preschoolers. In questioning why thematic associations are acquired earlier than script categories, it is crucial to consider the nature of such associations. The material calibration between studies two and three (chapter 6)

demonstrates that meal script categories are the most culturally bound from the four conceptual relations investigated. Only four of the fourteen meal-script associates were retained from the US experiment to the French experiment (soup, pizza, spaghetti [dinner], and cookies [snack]; see Appendix 3 and 5 for the respective stimuli sets). Not only do we see a difference cross-culturally in food scripts, but also there is great heterogeneity across participants, particularly concerning meal scripts. Hence, a mature system of script categorization is a consequence of experiencing and subsequently learning socio-cultural norms (Estes, 2011). Whereas our thematic relations were often functionally related based on complementarity between utensils or foods, rather than cultural convention. For example, bread is a thematic associate of a toaster because the toaster allows the cooking of the bread, or a wafer cone is an associate of ice cream because the former serves as a container for the latter.

An alternative explanation for witnessing that thematic knowledge was more accessible than script knowledge is perhaps due to the structure of thematic and script knowledge. Script associates are based on rules of similarity (e.g., cereal & toast), whereas the thematic associates are based on rules of contiguity (e.g., the co-occurrence of bread and butter) (Schmitterer & Schroeder, 2019). Our thematic condition in tasks 2, 3, and 4 required an associative match to be made, in that the child was required to identify the external relation uniting the two tangible entities (i.e., steak and a pan). For script relations, there was similarly an association, but with the additional process of identifying an object equivalent to the target item. In other words, the children were required to isolate the script relation and then produce an object that shares the same role or representation. The additional level of cognitive processing, in that the association needs to be extracted from a script representation and then extended to another possible exemplar may render the meal script condition more demanding. In the script condition, the child needed to inhibit the simple fact that the choices belong to the overarching category of food and search for the contextual ‘belonging’ of each food to meal script. Whereas, in the non-conflicting task for the thematic conditions it would suffice to have experienced the two foods in a co-occurring scenario.

Although preschoolers show a greater affinity for thematic knowledge of food, our results show that script knowledge is still available to children as young as 3-years-old. This aligns with earlier research demonstrating that younger children already hold ideas about meal script appropriateness, (see chapter 2) evidencing that 3- and 4-year-olds are capable of stating whether foods were appropriate or inappropriate for a specific meal (Birch et al., 1984; Nguyen

& Murphy, 2003). In simpler word-association tasks, 4-year-olds did provide spontaneous meal script representations for breakfast, lunch, and dinner (Lucariello et al., 1992). Such methodologies, although not as cognitively taxing as the task we employed, do demonstrate that younger children (2-5 years) can refer to meal scripts, but lack rich representations of possible meal script exemplars.

Since young children have relatively little experience, their ‘typical’ representations of meal and event scripts involving foods will be fewer. If children hold only a few food exemplars for meal scripts, they are limited in what foods they deem appropriate at that given meal. Having only one or two available associates for a meal script ultimately narrows the child’s perspective that other exemplars are possible. Bian and Markman (2020) found that four and five-year-old children in the United States displayed a more rigid representation of breakfast foods than children in China. This finding was linked to witnessing that children in the American sample were more likely to reject atypical breakfast exemplars than children in China (i.e. lamb chops were not accepted for breakfast). By adulthood, most individuals will have experienced many different dishes served at different mealtimes. Additionally, older children and adults will have improved reasoning abilities to understand that despite food not being a ‘typical’ exemplar of a meal script it is a possible alternative and may be acceptable to eat. For example, when abroad we can reason that sausages may be suitable for breakfast, despite not belonging to *our* concept of ‘breakfast foods’. This level of cognition allows us to try potential deviations from our mental representations after having weighed up other information, such as knowing that different cultures have different diets. However, young children have yet to reach such cognitive achievements in which they can account for information counter to their mental representation (Bonthoux & Kalénine, 2007).

In the meantime, it appears beneficial for young children to continuously be exposed to a large range of different foods at mealtimes, to expand their mental representations of mealtimes, and be willing to accept greater dietary variety. Studies show that menus at home often rotate around the same staple meals, and canteen menus are produced in weekly rotations (Corfe, 2018). However, to ensure that children’s meal scripts do not remain narrow and exclusive to certain meals, it is important to explore a variety of foods from as young as 34 months when our research shows children are already accessing food script representations.

2.2. Appropriate Conceptual Use

Our recognition and understanding of the food domain must draw upon many different conceptual structures at different occasions, from taxonomic food groups to meal scripts to thematic food pairs. Both anecdotal evidence and empirical research demonstrate that adults become flexible in their reliance and use of conceptual knowledge to guide food recognition and appropriate acceptance or rejection in eating situations (Ross & Murphy, 1999). Sometimes our recognition and acceptance of food may be guided by taxonomic understanding, such as knowing that an instantiation of a blackberry belongs to the category of fruit, which falls under the superordinate taxon of food and thus is likely edible. Other times we may rely on script representations such as being served blackberries at a mealtime, as oppose to blackberries found on a hike and potentially toxic. Equally, we may rely on familiar thematic associates such as a blackberry being served with yogurt or in a bowl with a fork to guide feelings of recognition and acceptance.

The final study (chapter 6) further investigated children's ability to switch conceptual strategies based on situational demands. Whilst the developmental trends were not as precipitous as in the simpler non-conflicting tasks (chapter 6), there is still evidence that children's cognitive skills are rapidly improving for referring to appropriate conceptual knowledge to suit the task. **Age was still a significant predictor for appropriate conceptual choice in response to the task demand.** When asked to find an appropriate substitute to replace a portion of food, older children were more capable of drawing upon knowledge of meal scripts. Equally, older children could defer to thematic associates when required to select an appropriate food pairing. "As children become more able to take advantage of the information to them in different contexts, such as comparison and inhibition of alternative possibilities" (Oakes & Madole, 2003). In other words, older children become better at suppressing irrelevant conceptual information to attend to more relevant information (Oakes & Madole, 2003). The older children having the ability to appropriately refer to meal scripts or thematic associates demonstrates this developmental milestone in the eating arena.

3. Food Rejection links with Conceptual Knowledge

3.1. Food rejection is linked with poor conceptual knowledge

As evidenced in our studies, the conceptual development of food is undergoing rapid development between 2 and 7 years old. This is concomitant with the period in which food rejection is at its highest across the lifespan, with prevalence ranging from 13 to 47 percent in children aged 2-6-years-old (Jacobi et al., 2008, Mascola et al., 2010). Based on the concomitance of food rejection tendencies and rapid conceptual development, researchers postulated that displays of food rejection in young children are the behavioral consequence of impoverished food representation (Lafraire et al., 2016; Rioux et al., 2016). The researchers argued that if taxonomic knowledge is insufficient, the ability to recognize food as belonging to food groups is subsequently mired, provoking greater feelings of uncertainty in eating situations (Lafraire et al., 2016). Their seminal studies repeatedly demonstrated that children with a poorer taxonomic understanding display greater levels of food rejection (Rioux et al., 2016, 2018a, 2018b, 2018c). However, children with increased food rejection are frequently witnessed to reject foods they have been exposed to and that they are even able to recognize (Dovey et al., 2008), which falls counter to the claim that increased food rejection is linked to gaps in 'food' knowledge. Explanations for persistent food rejection may indeed lie in other social and environmental factors that influence food rejection tendencies in children. Parental feeding practices, prenatal food experiences, genetics, and socio-economic status are just some of the factors that research has evidenced affecting food rejection tendencies in children (Adessi et al., 2005; Mennella et al., 2001; Lafraire et al., 2016). However, little research has examined the cognitive mechanisms of food rejection, and none has addressed how contextual knowledge of food is linked with food rejection.

As outlined in chapter 1, the eating environment is particularly liable to other conceptual structures (e.g. meal scripts, associated foods, etc.). Studies with adults demonstrate that script and thematic knowledge of eating situations guide adults' acceptance of food (Stallberg-White & Rozin, 1999; Pliner, 2008). Individuals are less willing to accept food that is served at an incongruent mealtime (e.g., chicken for breakfast) or served alongside an incongruent food (ice cream with ketchup) (McLeod et al., 2020). As evidenced in our developmental findings, children already have access to such script and thematic knowledge of food. This demonstrates that when confronted with food, young children are not just attending to the food item, but they

also attend to the contextual knowledge offered by the situation in which the food is experienced. This leads to the question of how contextual knowledge, such as thematic and script knowledge, influences children's food acceptance. The leading objective of this thesis was to determine whether insufficient context-based knowledge provokes increased feelings of uncertainty and subsequent food rejection.

The analogical thematic and taxonomic task (chapter 5) showed that children with increased levels of food rejection show poorer performance for appropriate thematic knowledge of foods commonly paired together (i.e., ice cream and cone). The situational script and thematic task (chapter 6) also evidenced that children with increased levels of food neophobia make fewer correct thematic food associates and meal script matches.

Both studies speak favorably to our argument that it is not solely knowledge of food, but also knowledge of food in situ that guides children's interpretation and acceptance of foods. Children, similar to adults, have access to conceptual knowledge based on thematic and script relations in the food domain. If such contextual knowledge is insufficient, children's feelings of uncertainty in eating situations will be augmented leading to an increased likelihood of food rejection. The children with neophobia had a worse performance for selecting the appropriate co-occurring foods and meal script foods in context. In other words, foods that conventionally share thematic and script associates (such as bread and butter, or pancakes at breakfast, respectively) would be less likely to be represented as such in children with neophobia. Consequently, when faced with such situations, children with food neophobia would fail to recognize the conceptual relation that would normally guide a child to accept that food situation. For example, a neophobic child may not draw a thematic association when presented with bread and butter, despite knowing the two foods individually. Not appreciating the association between the two items may decrease the feelings of familiarity and lead to rejection.

Our results also indicate that the same may be true for understanding script representations and the acceptability of foods at certain mealtimes. Children with food neophobia may not be able to draw upon script knowledge when faced with potential meal substitutes or 'slot fillers'. For example, if a neophobic child holds the restricted view that only cereal is an appropriate breakfast food the child would likely feel increased uncertainty when presented with toast, regardless of the child knowing what the toast is. This uncertainty may lead the child to reject the food.

Such arguments are supported by the findings witnessed in our first study. There was no direct correlation observed between correct food identification and food rejection scores in the **analogical thematic and taxonomic task**. However, there was a direct correlation between poor thematic performance and global food rejection. Taken concomitantly, this demonstrates that children with high levels of food rejection had similar knowledge of the individual foods and could identify them but struggled to identify the thematic associations. These results suggest that food acceptance might not solely be driven by the knowledge about the food itself, but rather the knowledge of the conceptual representations a food falls into and the congruency between such conceptual representation and reality.

3.2. Conceptual Flexibility is linked with Food Rejection

The non-conflicting thematic and script task (study 3, chapter 6) did not witness a direct relation between food rejection tendencies and conceptual knowledge across the four conditions. However, study 4 (chapter 6) employed a more cognitively demanding task in which children had to follow the task demands to infer whether a script or a thematic food associate was most appropriate. This conflicting configuration, requiring flexible conceptual understanding, did show negative correlations with food neophobia. Children with higher levels of food neophobia made fewer appropriate script and thematic associations when required to select either a substitute or a complementary pairing, respectively.

These results indicate that, rather than a lack of conceptual knowledge leading to increased uncertainty, food rejection may be related to children's appropriate use of conceptual knowledge or limited inhibition for more salient associates. As outlined in chapter 1 an inability to flexibly refer to appropriate conceptual relations to guide understanding is problematic because food is situated in context and liable to many simultaneous representations (i.e., soup shares functional associates [bowl & spoon], conventional associates [croutons], script associates [dinner], temporal associates [starter]). With so many possible representations available at any one instance, children with increased food neophobia may face difficulty in referring to the most appropriate conceptual relations to guide appropriate acceptance.

The findings of Rioux et al.'s studies (2016, 2018b, 2018c) support this interpretation. The researchers witnessed that higher food rejection scores were linked to less informative category-based inductions, based on perceptual similarity, as opposed to taxonomic knowledge (Rioux et al., 2018b). In a food induction task, younger children and children with higher levels

of food rejection used perceptual similarity rather than taxonomic relations as a basis to infer novel properties (Rioux et al., 2018b). Whilst children with low food rejection scores referred to category membership when generalizing properties of a given food to another food (e.g. from a green zucchini to an orange carrot), children with high food rejection scores tended to generalize properties based on color similarity (e.g. from a green zucchini to a green banana; Rioux et al., 2018b). The researchers concluded that children with high food rejection referred to perceptual similarities despite taxonomic categories allowing ‘better’ property inference (Rioux et al., 2018b). In other words, the mechanism at hand may be a naïve view of which conceptual representations are most relevant to interpreting the eating situation. With cognitive development, children with higher levels of food rejection should eventually be able to reason that there is greater predictive validity in specific information (such as the taste or the appropriate occasion for foods) using other conceptual structures. The pronounced advances in children’s cognitive abilities and improved ability to refer to appropriate conceptual structures may explain why food rejection tendencies show a decrease around 6-7 years old (Dovey et al., 2008). Improved ability to draw inferences and reason using appropriate conceptual relations will thus reduce feelings of uncertainty in food situations.

3.3. Food Neophobia stronger predictive factor with Conceptual Knowledge

The thematic-taxonomic analogy task (study 1, chapter 5) demonstrated that the **composite score of food pickiness and food neophobia is significantly predictive of poorer thematic reasoning**. Whereas the thematic and script situational task (task 4, chapter 6) found that solely **food neophobia is a significant predictor of worse thematic and script use in the food domain**. Although these two findings seem inconsistent, the subtle nuances between food pickiness and food neophobia have led several previous investigations to similar findings (Rioux et al., 2016, 2018b, 2018c; Foinant et al., 2021a, 2012b). Rioux et al. (2016) reported that taxonomic sorting was negatively linked with global food rejection in a fruit and vegetable discrimination task. Whereas solely food neophobia was predictive of perceptual, rather than taxonomic based inductions (2018b & 2018c). Equally, Foinant et al. (2021a) witnessed that global food rejection was predictive of incorrect categorization of foods as non-foods in their first study. The subsequent study, investigating children’s strategies for generalizing negative and positive properties, found that only food neophobia was predictive of generalizing negative properties to familiar foods (2021b).

Such discrepancies between studies of children’s conceptual knowledge potentially lie in the employed measure of food rejection and the heavy collinearity of food pickiness and food neophobia. All current empirical tasks investigating the link between food rejection and conceptual reasoning in young children have used the Child Food Rejection Scale (CFRS; Rioux et al., 2017) to measure food pickiness and food neophobia. However, an important caveat to consider is the nature of food pickiness and food neophobia. Several empirical and theoretical articles argue strongly that food neophobia and food pickiness are heavily collinear (Raudenbush et al. 1995; Potts & Wardle, 1998; Dovey et al., 2008; Rigal et al. 2012). Researchers also have argued that food neophobia is a sub-feature of food pickiness and that not being willing to try new foods is a necessary disposition in picky eaters (see figure 3; Dovey et al. 2008). Additionally, children who reject a novel food on the first instance will be considered neophobic, but every subsequent rejection of that food, no longer novel, considers the child as a picky eater (Rioux, 2017). Consequently, without extensive observation of children’s eating behaviors, it is unrealistic to be able to accurately distinguish children’s food neophobia versus food pickiness behaviors.

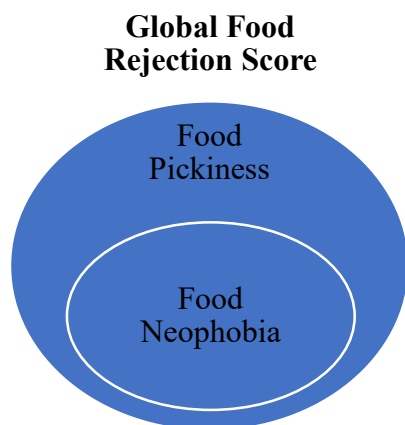


Figure 6: Dovey et al's (2008) proposition of the relationship between food neophobia and food pickiness.

When interpreting whether there is greater support for the initial negative relation between CFRS and thematic reasoning or food neophobia and thematic and script reasoning, there appears greater support for the latter findings. From a theoretical standpoint, it seems more compelling that food neophobia, rather than food pickiness, has a more robust link with poor conceptual knowledge. Neophobia, in general, is a fearful reaction and avoidance of a situation or stimulus because it appears novel (Greenberg & Mettke-Hofmann, 2001; Mettke-Hofmann,

2017). Food neophobia, therefore, is the fear of foods or eating situations that appear novel, contrary to food pickiness that can be related to both novel and familiar instances of food (Dovey et al., 2008; Crane et al., 2020). Reviews on food neophobia postulate that food neophobia is considered an adaptive mechanism, that promotes survival (Greenberg & Mettke-Hofmann, 2001; Cooke et al., 2018; Crane et al., 2020). As food neophobia incites increased feelings of anxiety and physiological response, an outcome not evidenced in food pickiness, when faced with uncertainty neophobic children are likely to present with greater rejection than picky-eaters (Mettke-Hofmann, 2017; Crane et al., 2020). In the case of a neophobic child confronted with novel foods, they are indeed over-executing conservative decision criteria by rejecting foods that are appropriate and will not lead to an unpleasant outcome. As argued throughout this thesis, an eating situation or food is likely to appear novel to a child if their conceptual knowledge to guide recognition is insufficient. Therefore, it is unsurprising that food neophobia has a greater link with gaps in conceptual knowledge than food pickiness.

3.4. Directionality

Although our research argues that poor conceptual knowledge is linked to food rejection, the directionality of our constructs cannot be inferred from the empirical evidence. To return to the rationale in chapter 3, there are arguments that support both hypotheses that food rejection causes poor conceptual knowledge and poor conceptual knowledge causes food rejection.

Food neophobia has been linked to a child's temperament in several studies (Pliner & Loewen, 1997; Bellows et al., 2013; Moding & Stifter, 2016). Negative emotionality, shyness, and a withdrawal approach to novelty have all been linked to higher levels of food neophobia in children (Moding & Stifter, 2016; Rioux, 2017). In addition to temperament, children with a high level of food neophobia were observed to have a lower enjoyment of tactile play (Coulthard & Sahota, 2016; Coulthard & Thakker, 2015). Equally, studies have demonstrated links with food neophobia and increased sensitivity to taste and smell, which may cause aversion to foods (Coulthard & Blissett, 2009; Johnson et al., 2015). For example, if a child was presented with a novel instance of an apple that did not align with the child's expected concept of an apple, there are two possibilities. A child with a more adventurous temperament may decide to take the risk and taste the food. A child with an avoidant/withdrawal temperament would be more likely to err on the side of caution and reject the food. Consequently, uncertainty poses a major problem for children predisposed to neophobic tendencies because they face an increased likelihood of rejecting said stimulus (Crane et al.,

2020). Such adversity to foods indicates that interventional methods to increase food acceptance that focus on sensory and tactile play with fruit and vegetable might have limited scope with children more averse to such methods of exploration. Such interventions may even invoke fearful responses in children with food neophobia, through an associated pressure when around the food that already incites fear.

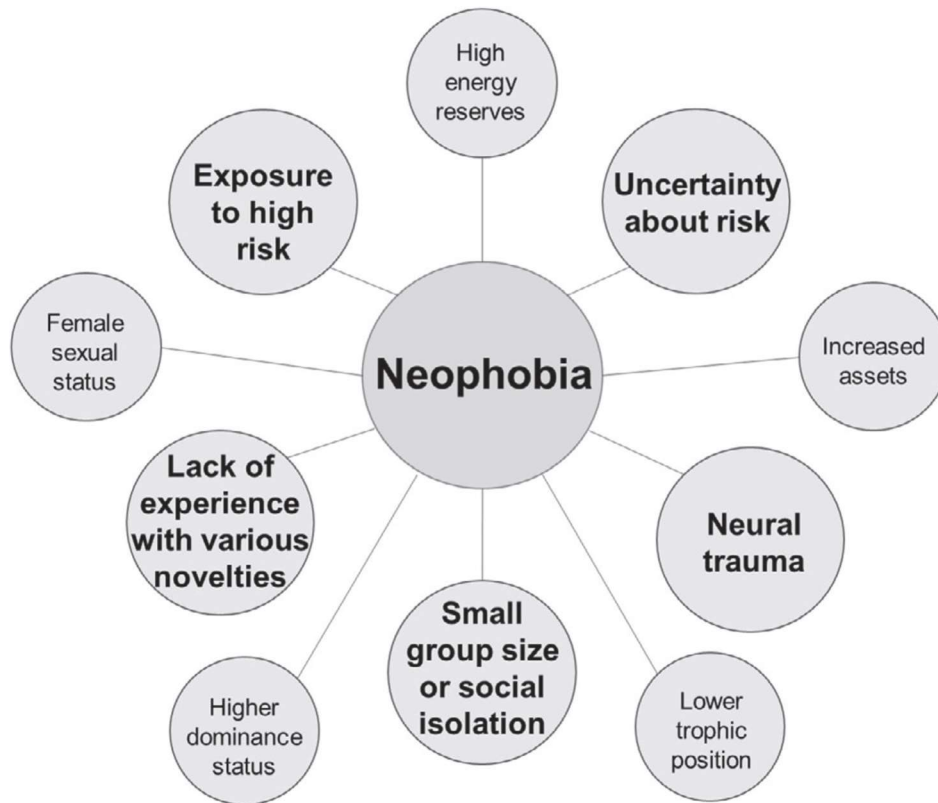


Figure 7: Major factors thought to cause neophobia in organisms from Crane et al. (2020)

Note: larger circles with bold text denote major factors causing neophobia and the smaller circles denote factors that intensify neophobic responses.

However, as evidenced in figure 7, a major factor contributing to neophobic response is a lack of experience with various novelties (Brown & Chivers, 2005; Crane et al., 2020). “Consistent with broader developmental theories related to familiarization learning (Rheingold, 1985) and with the epigenetic framework, individuals learn to like what becomes familiar,” highlighting the critical role of knowledge of foods (Birch & Anzman, 2010, p. 140). Evidence shows that food-to-mealtime associations form through frequent consumption of food at a specific mealtime or through the perceived appropriateness of consuming food at a given mealtime (McLeod et al., 2020). However, parents of neophobic children may be discouraged in presenting and trying different/novel foods with children leading to fewer exposures and

opportunities to learn about food properties and categorization (Dejesus et al., 2018). For example, a child may stay home from the canteen at lunch or take their own food and snacks when visiting relatives on the holidays. Such reactions and withdrawal from novel situations or uncertainty reduce the learning opportunities, which in turn perpetuate feelings of uncertainty. Therefore, food neophobia is likely to be a vicious cycle, in which the uncertainty of eating situations invokes fear causing the child to avoid the food and miss the learning opportunities. A lack of conceptual knowledge creates feelings of uncertainty, leading to greater rejection of food, the increased rejection of foods hinders exposure and education of conceptual information in the food domain, subsequently perpetuating feelings of uncertainty. Following such a proposal would allow interventions to be better tailored to the fearful dispositions of children with neophobia so that the potential learning opportunities are not missed in such populations (Heath et al., 2011).

4. Perspectives

4.1. Interventions to foster dietary variety

With important implications on children's physical and mental wellbeing, it is important to establish effective methods to mitigate the risk of poor dietary variety by encouraging greater food acceptance. Knowledge-based interventions and educational methods appear promising in facilitating children's understanding of food and subsequently boosting dietary variety (Gripshover & Markman, 2013; Nguyen et al., 2011). However, current food education places a heavy emphasis on knowledge of nutritional food groups or individual foods and their respective health benefits. Such educational methods may hold limited effectiveness given that children are particularly sensitive to other types of conceptual knowledge. Our research demonstrates that young children rely on thematic and script knowledge when making food choices. As such, food education expanding children's food scripts and thematic knowledge could foster increased certainty in the food arena leading to subsequent dietary variety.

A literature review by Mura Paroche et al. (2017) described how the developmental learning processes of familiarization, observational learning, associative learning, and categorization shape early eating behavior and food preferences. It is therefore logical that interventions that expose children to foods and eating situations increase feelings of familiarity and have promising potential in reducing food rejection. To foster food acceptance, familiarity and recognition of food are crucial. Several interventions have shown the potential to promote

increased willingness to taste by increasing children's familiarity with food through knowledge-based children's books (Houston-Price et al., 2009a; Owen et al., 2018; Houston-Price et al., 2019). One study compared whether books containing both pictures and information about what food is and where it comes from versus books containing solely pictures were more effective in children's visual preference for the targeted foods (Houston-Price et al., 2009a). No significant difference was witnessed between conditions but the effect on children's preference was more robust in the pictures and information condition. Additionally, an interventional study by Owen et al. (2018) and Houston et al. (2019) used books with color photographs and 'farm to fork' information about how a fruit or vegetable is grown, sold, prepared, and served. Results showed that children in the intervention condition showed an increased willingness to try the targeted vegetables (Owen et al., 2018; Houston et al., 2019).

This indicates that teaching children knowledge of foods is an effective strategy for boosting food acceptance. However, because the focus is on knowledge of the food the success of such interventions may be limited to the particular food in question (Pliner, 2008). As demonstrated in this research, young children attend to script and thematic knowledge when interpreting food and eating situations. However, the issue remains that children's script and thematic knowledge is still undergoing great development, shaped by the experiences they encounter. We strongly believe, based on our evidence, that children's limited knowledge of thematic and script relations is responsible for feelings of uncertainty in less familiar eating scenarios, provoking greater food rejection. Therefore, nutrition education with children should incorporate information and experiences based on the contextual knowledge of food, rather than solely the food itself.

Given that children's understanding of the world is heavily guided by thematic and script associates, food education must consider the global context in which food appears (e.g., what food is likely to be presented with certain tableware or utensils). Improving script and thematic knowledge ultimately enhances the cues and situational information children can process when confronted with a 'novel' food. For example, children's script and thematic associations allow for the inference that something is edible (i.e., being served on a plate with cutlery). Broadening food representations associated with event scripts and meal scripts is strategic in expanding dietary variety, such as explaining to children that other cultures eat different things at breakfast time (such as eggs or baked beans). Scenes and scenarios could be acted out or presented in a

child-friendly manner, showing that certain cues can be useful in making potential inferences (i.e., following dinner we are likely to be served a sweet dessert). Such methods allow increased feelings of familiarity of contexts and situations, rather than individual novel foods. Improving children's conceptual knowledge of food and eating situations has the potential to reduce uncertainty in the food domain and scaffold children's appropriate interpretation of food scenarios. The findings of this research indicate that teaching children not solely about the food but about the thematic and script knowledge surrounding that food may have increased ecological validity in boosting food acceptance.

4.2. *A more global measure of Food Rejection*

Based on the findings of this thesis, it is not solely important for interventional methods to approach knowledge from a broader conceptual view of food situations, but also for food neophobia measures to take a more comprehensive approach. Neophobia is defined as a fearful reaction towards novel stimuli or novel situations" (Mettke-Hofmann, 2017). Evidence indicates that childhood temperament and food neophobia are directly related, with children with high levels of neophobia showing higher levels of withdrawal in response to new stimuli, people, or *situations* (Moding & Stifler, 2016).

A limitation to the CFRS is that it does not consider children's food rejection tendencies in response to situational and contextual factors. Both within and outside of the food domain studies demonstrate that children use script and thematic knowledge to inform their behavior. Yet the items included in the CFRS solely examine children's reactions to the food itself rather than the eating context. It would be favorable to add additional items that question children's behavior in different food settings. For example, "*my child will accept food at one meal, but not when offered the same food at another mealtime,*" or "*my child rejects foods when presented in the canteen that they would normally accept at home*". Such items could capture one important facet of neophobic disposition, which is not the fear of the novel (food) stimulus but the fear of novel (food-related) situations (Crane et al., 2020). Observational studies, in which eating scenarios are replicated and thematic and script associations are manipulated, would be very informative of how contextual information guides children's uncertainty in the food domain. Situational cues could be altered, such as comparing how a child approaches food served in different script contexts (i.e. serving foods at home versus foods serving foods at a friend's house or a party). Alternatively, thematic associations could be manipulated, such as serving a novel food with a child's typical crockery versus serving novel crockery could

provide insight into how reliant the child is on conceptual knowledge to guide familiarity in a real-world environment.

5. Conclusion

Research posits that food familiarity is a significant catalyst to food acceptance in young children, with results showing moderate effects from knowledge-based interventions. However, since the alarming rates of food rejection witnessed in young children target both unfamiliar and familiar foods, the question remains as to why knowledge of food alone does not rectify inappropriate food rejection. The framework grounding this research posits that food knowledge does not solely encompass the knowledge of the food itself, but also the contextual knowledge available from the food being situated in a specific scenario. This research builds on previous evidence demonstrating that a lack of taxonomic knowledge of food incites uncertainty and subsequent rejection (Rioux, 2017).

A review of the existing literature demonstrated that preschoolers have access to many different forms of conceptual knowledge, such as thematic (strawberries and cream), script (cereal and breakfast), taxonomic (apple and fruit), and evaluative (healthy or unhealthy). However, children's use and preference for such conceptual knowledge in their interpretation of eating situations remained unknown. Therefore, the first objective of this research program was to determine the developmental trajectories for different conceptual structures available in the food domain. Two studies tested children's conceptual development across meal scripts (e.g., soup for dinner), event scripts (e.g., cake at a party), thematic associates (e.g., bread and butter), and functional associates (e.g., knife and steak). Results demonstrated that 3-year-old children already have access to functional thematic relations earliest, followed by thematic co-occurrences. Knowledge of meal script associations is mastered later than thematic relations, but by 7 years, children have a good ability to use the relevant conceptual knowledge given the contextual demands. These results demonstrate that even young children are likely to interpret eating situations with regards to their conceptual knowledge of thematic and script food associates.

Considering that young children have access to thematic and script knowledge to guide interpretation of foods situated in context, the main aim of the research turned to clarify whether gaps in such conceptual knowledge are linked with food rejection. The first study used a

thematic and taxonomic food analogy task with children between 3 and 7 years old. The results revealed that children with poorer thematic food reasoning demonstrate higher levels of food rejection. The final study witnessed that poorer knowledge of thematic and script associates was linked with increased food neophobia in children between 4 and 7 years old. These seminal findings are crucial in re-evaluating the earlier claims that food knowledge fosters food acceptance. Our results demonstrate that it is not solely conventional knowledge of food and food groups that inform familiarity and acceptance, but contextual knowledge, such as script and thematic associations that inform whether a food should be accepted. Therefore, knowledge-based interventions to foster food acceptance need to consider all facets of knowledge relevant to the eating arena, rather than a focus on food and health benefits of food groups.

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Appendix 1: Child Food Rejection Scale (CFRS; Rioux et al., 2017)



Etude sur les comportements alimentaires des enfants (de 3 à 7 ans)

Formulaire et autorisation à destination des parents

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Vos réponses sont essentielles pour la suite de notre étude et sachez que les données recueillies sont exclusivement destinées aux travaux du Centre de Recherche et leur confidentialité est garantie.

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Questions préliminaires :

i) **Prénom et nom de l'enfant :**

ii) **Date de naissance :**/...../20...

iii) **Sexe :**

Garçon

Fille

iv) **J'autorise mon enfant à participer à l'étude sur les comportements alimentaires qui se déroulera dans sa maternelle**

Oui

Non

Signatures des **parents**, le cas échéant :

.....

Questionnaire à destination des parents (Cochez la case correspondante) :

	Pas du tout d'accord	Pas d'accord	Ni d'accord ni pas d'accord	D'accord	Tout à fait d'accord
Mon enfant refuse de manger certains aliments à cause de leurs textures	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mon enfant fait le tri dans son assiette	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mon enfant rejette certains aliments après les avoir goûté	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mon enfant peut manger un aliment aujourd'hui et le refuser demain	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mon enfant peut manger certains aliments en grandes quantités et d'autres pas du tout	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

	Pas du tout d'accord	Pas d'accord	Ni d'accord ni pas d'accord	D'accord	Tout à fait d'accord
Mon enfant recherche constamment des aliments familiers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mon enfant se méfie des aliments nouveaux	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mon enfant aime seulement la cuisine qu'il connaît	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mon enfant rejette un nouvel aliment avant même de l'avoir goûté	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mon enfant est angoissé à la vue d'un nouvel aliment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Mon enfant ne goûte pas un nouvel aliment si cet aliment est en contact avec un autre aliment qu'il n'aime pas



Nous vous remercier de votre précieuse collaboration !

Appendix 2: Study 1 Stimuli Set

Training Stimuli Sets	Analogy Pair		Triad		
	A	B	C	D:Taxonomic	D:Thematic
Thematic Ex.1	Notebook	Pencil			
Thematic Ex.2	Bee	Honey			
Taxonomic Ex.1	Dog	Chimpanzee			
Taxonomic Ex.2	Necklace	Ring			
Triad X			Soccer Shoe	Rain Boots	Soccer Ball
Thematic Ex.1	Ice Cream	Wafer Cone			
Thematic Ex.2	Pancakes	Chocolate Sauce			
Taxonomic Ex.1	Banana	Apple			
Taxonomic Ex.2	Sardine	Salmon			
Triad A			Lemon	Cherry	Fish
Triad B			Sausage	Steak	Mashed Potatoes
Triad C			Milk	Camembert	Cereal
Triad D			Spaghetti	Couscous	Bolognaise
Triad E			Chocolate	Sweets	Bread Roll
Triad F			Cheese Dessert	Hard Cheese	Sugar
Triad G			Grated Cheese	Milk	Macaroni
Triad H			Green Beans	Beetroot	Butter
Triad I			Grapefruit	Pear	Sugar
Triad J			Beef Patty	Chicken	Burger Bun
Triad K			Gherkin	Sweetcorn	Pâté
Triad L			Strawberry	Satsuma	Pastry
Triad M			Nuggets	Steak	Ketchup
Triad N			Cheese Slice	Yogurt	Sliced Bread
Triad O			Apple	Gooseberry	Puff Pastry
Triad P			Cheese Spread	Yogurt	Breadsticks

Appendix 3: Study 2 Stimuli Set

Event scripts	Target	Match	Distractor
Example	Cotton Candy (Fair)	Ferris wheel (Fair)	Hiking shoes (Hike)
Event-1	Hot dog (Baseball game)	Baseball glove (Baseball game)	Pine tree (Christmas)
Event-2	Popsicle (Beach)	Sunglasses (Beach)	Movie tickets (Movies)
Event-3	Cake (Birthday)	Party hat (Birthday)	Baseball glove (Baseball game)
Event-4	Popcorn (Movies)	Movie tickets (Movies)	Bunny (Easter)
Event-5	Gingerbread cookie (Christmas)	Pine tree (Christmas)	Party hat (Birthday)
Event-6	Chocolate egg (Easter)	Bunny (Easter)	Sunglasses (Beach)
Food-food associates	Target	Match	Distractor
Example	Burger patty	Burger bun	Cereal
Compl-1	Celery sticks	Hummus	Sprinkles
Compl-2	Pizza	Salami	Cookies
Compl-3	Macaroni's	Grated cheese	Hummus
Compl-4	Milk	Cookies	Peanut butter
Compl-5	Ice cream	Sprinkles	Grated cheese
Compl-6	Jelly	Peanut butter	Salami
Food-utensil associates	Target	Match	Distractor
Example	Soup	Spoon	Chopping board
Object-1	Fried egg	Pan	Cooking knife
Object-2	Noodles	Chopsticks	Rolling pin
Object-3	Bloc of cheese	Cheese grater	Pan
Object-4	Cookie dough	Rolling pin	Toaster
Object-5	Watermelon	Cooking knife	Chopsticks
Object-6	Loaf of bread	Toaster	Cheese grater
Meal scripts	Target	Match	Distractor
Example	Sandwich (Lunch)	Wrap (Lunch)	Toaster pastry (Breakfast)
Meal-1	Bagel (Breakfast)	Pancakes (Breakfast)	Soup (Dinner)
Meal-2	Grapes (Snack)	Cheese (Snack)	Spaghetti (Dinner)
Meal-3	Pizza (Dinner)	Soup (Dinner)	Apple (Snack)
Meal-4	Oatmeal (Breakfast)	Bacon (Breakfast)	Cheese (Snack)
Meal-5	Salad (Dinner)	Spaghetti (Dinner)	Pancakes (Breakfast)
Meal-6	Chocolate chip cookies (Snack)	Apple (Snack)	Bacon (Breakfast)

Appendix 4: Study 2 Performance across Trials

Study 2: US 4 x condition triad results

Triad	Younger		Older	
	Mean	SD	Mean	SD
Event-1	62.50%	50.00%	75.00%	44.72%
Event-2	56.25%	51.23%	75.00%	44.72%
Event-3	81.25%	40.31%	93.75%	25.00%
Event-4	56.25%	51.23%	93.75%	25.00%
Event-5	43.75%	51.23%	87.50%	34.16%
Event-6	62.50%	50.00%	81.25%	40.31%
Condition A	60.42%	49.00%	84.38%	35.65%
Compl-1	56.25%	51.23%	87.50%	34.16%
Compl-2	62.50%	50.00%	87.50%	34.16%
Compl-3	62.50%	50.00%	100.00%	0.00%
Compl-4	68.75%	47.87%	87.50%	34.16%
Compl-5	100.00%	0.00%	100.00%	0.00%
Compl-6	75.00%	44.72%	68.75%	47.87%
Condition B	70.83%	40.64%	88.54%	25.06%
Object-1	75.00%	44.72%	68.75%	47.87%
Object-2	81.25%	40.31%	100.00%	0.00%
Object-3	68.75%	47.87%	100.00%	0.00%
Object-4	68.75%	47.87%	81.25%	40.31%
Object-5	75.00%	44.72%	100.00%	0.00%
Object-6	81.25%	40.31%	100.00%	0.00%
Condition C	75.00%	44.30%	91.67%	14.70%
Meal-1	62.50%	50.00%	100.00%	0.00%
Meal-2	50.00%	51.64%	56.25%	51.23%
Meal-3	43.75%	51.23%	93.75%	25.00%
Meal-4	37.50%	50.00%	81.25%	40.31%
Meal-5	43.75%	51.23%	87.50%	34.16%
Meal-6	81.25%	40.31%	75.00%	44.72%
Meal condition	53.13%	49.07%	82.29%	32.57%
Total	64.84%	45.75%	86.72%	26.99%

Appendix 5: Study 3 Stimuli Set

Condition			
Event-based scripts	Target	Match	Distractor
Example	Cake (Birthday)	Party hat (Birthday)	Ferris wheel (Fair)
Event-1	Chocolate egg (Easter)	Bunny (Easter)	Pine Tree (Christmas)
Event-2	Popsicle (Beach)	Sunglasses (Beach)	Pumpkin basket (Halloween)
Event-3	Popcorn (Movies)	Movie tickets (Movies)	Picnic basket (Picnic)
Event-4	Candy (Halloween)	Pumpkin basket (Halloween)	Bunny (Easter)
Event-5	Sandwich (Picnic)	Picnic basket (Picnic)	Movie tickets (Movies)
Event-6	Chocolates (Christmas)	Pine tree (Christmas)	Sunglasses (Beach)
Food-food associates	Target	Match	Distractor
Example	Beef patty	Burger bun	Rice cake
Compl-1	Wafer cone	Ice cream	Lemon
Compl-2	Chicken Nuggets	Ketchup	Chocolate sauce
Compl-3	Fish	Lemon	Milk
Compl-4	Spaghetti	Bolognaise	Ice cream
Compl-5	Cereal	Milk	Ketchup
Compl-6	Pancakes	Chocolate sauce	Bolognaise
Food-utensil associates	Target	Match	Distractor
Example	Orange juice	Glass	Fork
Object-1	Cheese	Cocktail stick	Spoon
Object-2	Cereal	Bowl	Straw
Object-3	Soup	Ladle	Cocktail stick
Object-4	Baguette	Knife	Bowl
Object-5	Yogurt	Spoon	Ladle
Object-6	Apple juice	Straw	Cocktail stick
Meal-based scripts	Target	Match	Distractor
Example	'Grilled cheese' (Dinner)	Soup (Dinner)	'Chocolate croissant' (Breakfast)
Meal-1	Baguette (Breakfast)	Cereal (Breakfast)	Pizza (Dinner)
Meal-2	Yogurt drink (Snack)	Cookies (Snack)	Croissant (Breakfast)
Meal-3	Quiche (Dinner)	Spaghetti (Dinner)	Cereal (Breakfast)
Meal-4	Sliced bread (Breakfast)	Croissant (Breakfast)	Apple compote (Snack)
Meal-5	Rice salad (Dinner)	Pizza (Dinner)	Cookies (Snack)
Meal-6	Mini cakes (Snack)	Apple compote (Snack)	Spaghetti (Dinner)

Appendix 6: Study 3 Performance across Trials

Study 3: France 4 x condition triad results

	Mean	SD
Event-1	75.19%	43.36%
Event-2	61.24%	48.91%
Event-3	67.44%	47.04%
Event-4	78.29%	41.38%
Event-5	89.15%	31.23%
Event-6	89.92%	30.22%
Event condition	76.87%	40.36%
Compl-1	96.90%	17.40%
Compl-2	82.95%	37.76%
Compl-3	75.19%	43.36%
Compl-4	81.40%	39.07%
Compl-5	79.07%	40.84%
Compl-6	93.80%	24.21%
Complementary condition	84.88%	33.77%
Object-1	64.34%	48.09%
Object-2	91.47%	28.04%
Object-3	93.02%	25.57%
Object-4	89.15%	31.23%
Object-5	97.67%	15.13%
Object-6	93.80%	24.21%
Funtion condition	88.24%	28.71%
Meal-1	61.24%	48.91%
Meal-2	73.64%	44.23%
Meal-3	75.97%	42.89%
Meal-4	65.12%	47.85%
Meal-5	82.17%	38.43%
Meal-6	77.52%	41.91%
Meal condition	72.61%	44.04%
total	80.65%	36.72%

Appendix 7: Study 4 Stimuli Set

Trial	Target	Thematic Match	Script Match (scene)	Distractor
Example 1	Hammer	Nail	Wrench (toolbox)	Hairbrush
Example 2	Glass	Straw	Teacup (breakfast)	Baseball cap
Example 3	Row boat	Oars	Pedal boat (lake)	Football
Example 4	Pencil	Exercise book	Paintbrush (art room)	Spoon
Trial-1	Chicken nuggets	Ketchup	Grilled cheese (lunch)	Chocolate spread
Trial-2	Soup	Croutons	Mayonnaise vegetables (dinner)	Jelly
Trial-3	Baguette	Chocolate spread	Cereal (breakfast)	Rice
Trial-4	Beef burger	Bread bun	Chicken escalope (lunch)	Lemon
Trial-5	Cookies	Milk	Yogurt drink (snack)	Lasagna
Trial-6	Spaghetti	Bolognaise	Quiche (dinner)	Croissant
Trial-7	Ice cream	Cone	Mini-cakes (snack)	Chicken escalope
Trial-8	Cereal	Milk	Danish Pastry (breakfast)	Ketchup
Trial-9	Fish	Lemon	Lasagna (lunch)	Cone
Trial-10	Croissant	Jelly	Chocolate croissant (breakfast)	Grilled cheese
Trial-11	Chocolate	Brioche bread	Apple compote (snack)	Roast chicken
Trial-12	Pizza	Ham	Roast chicken (lunch)	Milk

Appendix 8: Study 4 Performance across Trials

Study 4: Script and thematic cross-classification

	Mean	SD
TH1	75.00%	43.61%
TH2	84.72%	36.23%
TH3	93.06%	25.60%
TH4	45.83%	50.18%
TH5	26.39%	44.38%
TH6	93.06%	25.60%
TH7	95.83%	20.12%
TH8	79.17%	40.90%
TH9	72.22%	45.10%
TH10	65.28%	47.94%
TH11	76.39%	42.77%
TH12	59.72%	49.39%
Thematic Condition total	72.22%	39.32%
SC1	73.61%	44.38%
SC2	63.89%	48.37%
SC3	76.39%	42.77%
SC4	66.67%	47.47%
SC5	62.50%	48.75%
SC6	58.33%	49.65%
SC7	70.83%	45.77%
SC8	87.50%	33.30%
SC	83.33%	37.53%
SC10	80.56%	39.85%
SC11	68.06%	46.95%
SC12	52.78%	50.27%
Script condition total	70.37%	44.59%
Total	71.30%	41.95%