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Hernán Anlló

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Université Sorbonne Paris Cité – Université Paris Diderot

École Normale Supérieure – Paris Sciences et Lettres

Brain and Consciousness Team – Laboratoire de Sciences Cognitives et
Psycholinguistique (UMR 8554)

École Doctorale Frontières du Vivant (ED474) – Centre de Recherche
Interdisciplinaire

Hypnosis through the lens of attention

Hernán ANLLÓ

THÈSE DOCTORALE

Sciences Cognitives

Dirigée par Jérôme SACKUR

Présentée et soutenue publiquement à l'École Normale Supérieure, le 25/09/2017

Jury:

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Hypnosis through the lens of attention

Hernán ANLLÓ

DOCTORAL THESIS

Cognitive Science

Advisor: Jérôme SACKUR

To be presented and defended publicly at the École Normale Supérieure on the
25/09/2017

Jury:

Maria Augustinova, Professeure.-HDR, Université Rouen-Normandie	President
Devin Terhune, Lecturer, University of London	Reviewer 1
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Tristan Bekinschtein, Researcher, Cambridge U.	Member
Jérôme Sackur, Directeur d'Études, EHESS/ENS/Polytechnique	Director

Title: Hypnosis through the lens of attention

Abstract: We posit that a clearer outline of the interaction between hypnotic suggestion and attention would help establishing the precise point in the perceptual timeline at which hypnosis effects intervene, how exactly do they modulate cognitive control, and to what extent is hypnotic responding dependent on attentional resources. In order to tend to these experimental questions, we developed three research projects: (1) the normative data on our French translation for the Harvard Group Scale of Hypnotic Susceptibility, (2) an evaluation of the effects of posthypnotic suggestion on visuospatial attention, and (3) an evaluation on the capability of hypnotic suggestion to modulate the automatic attention allocation granted by the anger-saliency effect. The results from our first study allowed us to reliably score the hypnotic susceptibility of over 500 participants for the studies that ensued. Results from our second study indicated that for highly susceptible participants, posthypnotic suggestion successfully disrupted the early attentional mechanisms necessary for the fostering of priming, as well as late subjective visual awareness judgments. Our third study revealed that, through hypnotic suggestion, highly susceptible participants were able to deflect automatic attention allocation towards targets' task-irrelevant angry features through strategic decoupling of cognitive control, but only when attentional resources were not coopted by competing processes.

Keywords: Hypnosis – Attention – Consciousness – Cognitive Control – Psychophysics – Hypnotic susceptibility – Suggestion – Emotion

Titre : L'Hypnose à travers l'attention

Résumé : Nous proposons qu'un aperçu plus clair de l'interaction entre la suggestion hypnotique et l'attention aiderait à établir le point précis du chronogramme perceptif auquel les effets de l'hypnose interviennent, comment modulent-ils exactement le contrôle cognitif et dans quelle mesure la réponse hypnotique dépend-elle des ressources attentionnelles. Afin de répondre à ces questions expérimentales, nous avons développé trois projets de recherche: (1) les données normatives sur notre traduction en français pour l'Échelle de Susceptibilité Hypnotique de Groupe Harvard, (2) une évaluation des effets de la suggestion posthypnotique sur l'attention visuo-spatiale et (3) une évaluation sur la capacité de la suggestion hypnotique de moduler l'allocation automatique de l'attention accordée par le Anger Superiority Effect. Les résultats de notre première étude nous ont permis de noter avec fiabilité la susceptibilité hypnotique de plus de 500 participants pour les études qui ont suivi. Les résultats de notre deuxième étude indiquent que, pour les participants hautement susceptibles, la suggestion posthypnotique a perturbé avec succès les mécanismes d'attention précoce nécessaires à la stimulation de l'amorçage, ainsi que des jugements de visibilité subjectifs tardifs. Notre troisième étude a révélé que, grâce à une suggestion hypnotique, les participants hautement hypnotisables ont pu empêcher l'allocation automatique de l'attention vers des expressions de colère par un découplage stratégique du contrôle cognitif, mais seulement lorsque les ressources attentionnelles n'avaient pas été cooptées par des processus concurrents.

Mots clefs : Hypnose – Attention – Conscience – Control Cognitif – Psychophysique – Susceptibilité Hypnotique – Suggestion – Emotion

Résumé substantiel : Nous avons présenté les données normatives sur notre traduction en français pour l'Échelle de susceptibilité hypnotique du groupe Harvard (formulaire A) et nous l'avons comparé avec succès à d'autres validations de ce genre. Le développement et la validation de l'échelle française de Harvard ont été une étape nécessaire dans la poursuite de nos objectifs de recherche; c'est avec cette version française de l'échelle que nous avons évalué la susceptibilité hypnotique du pool de plus de 500 participants que nous avons convoqué plus tard pour nos autres expériences. En outre, nous avons abordé un problème généralement négligé dans les études de validation des normes d'hypnotisabilité: l'impact de la volonté sur le succès comportemental des suggestions et donc sur les scores d'hypnotisabilité. Étant donné qu'il s'agissait d'une étude de validation, nous nous sommes basés sur les outils statistiques traditionnels habituellement implémentés dans les études concernant les normes d'hypnotisabilité, mais nous avons également capitalisé sur la sortie de l'échelle de volonté de Kihlstrom pour produire un ensemble supplémentaire de taux d'hypnotisation, plus sensible à la volontarité. L'échelle de volonté de Kihlstrom interroge les participants sur une échelle de 1 à 5 quant à combien leurs réponses sont-elles été adoptées volontairement, et combien sont-elles arrivées "d'eux-mêmes". Étant donné que la perte de l'agence qui correspond à l'exécution d'une action proposée est considérée comme le trait caractéristique de l'hypnose (Kihlstrom, 2008), nous considérons qu'il est primordial d'inclure les jugements subjectifs comme étant plus qu'un simple indice

subsidaire. En outre, en utilisant des valeurs ajustées selon leur valeur de volonté, nous avons considérablement réduit les surestimations d'hypnotisation.

À l'issue de ces travaux, nous avons décidé d'élargir la recherche sur la suggestion posthypnotique et l'attention spatiale, en accordant une attention particulière à l'interaction entre la négligence visuelle hypnotique et la réduction de la résolution d'attention périphérique. Bien que l'attention et la conscience ne soient pas la même chose, et l'attribution de la première ne prévoit pas l'émergence de cette dernière (Hsieh et al., 2011), l'attention joue un rôle fondamental dans la transmission de l'information qui atteint la conscience (Cohen et Al., 2012). En raison de ce fait, la réduction de l'attention spatiale périphérique a souvent été détournée pour favoriser l'amorçage subliminal à travers le masquage et l'encombrement de la stimulation périphérique rapide (Del Cul et al., 2006, 2007, 2009; Reuter et al., 2007). Ici, nous avons présenté notre travail sur les effets de la suggestion posthypnotique sur l'attention visuo-spatiale, au niveau du traitement visuel automatique et de la prise de conscience visuelle subjective. Notre question expérimentale était double. Tout d'abord, en termes de recherche sur l'hypnose intrinsèque, nous voulions établir dans quelle mesure l'attention visuo-spatiale conditionnait les effets de la réponse hypnotique et la façon dont la suggestion posthypnotique pouvait efficacement orienter l'allocation de l'attention endogène. Deuxièmement, en ce qui concerne la recherche instrumentale, nous nous demandions si une telle suggestion suffirait à dissuader la perception subjective et objective des cibles hypnotisées sans surveillance en remplacement de l'encombrement physique ou du masquage, à différents niveaux d'énergie stimulante. Principalement, une réponse affirmative à cette dernière question impliquerait que la suggestion posthypnotique pourrait moduler avec succès le seuil d'accès à la conscience. Nous avons testé notre hypothèse grâce à une suggestion posthypnotique basée sur le syndrome de Balint, dans laquelle nous avons suggéré aux participants de négliger leur espace visuel périphérique. Nous avons ensuite testé les participants à sensibilité hypnotique haute et basse sur la détection et la discrimination des cibles affichées dans cette espace rendu sans surveillance par l'hypnose. Les participants hautement hypnotisables ont signalé une diminution subjective de la visibilité sur ces cibles périphériques (par opposition aux résistants à l'hypnose). Cependant, leur performance a également mis en évidence l'absence d'effets d'amorçage sémantique au nom des amorces sans surveillance. Cette absence de traitement inconscient suggère que l'hypnose ne semble pas être un outil approprié pour transformer simplement un stimulus supraliminal en subliminal. Plutôt que de prévenir physiquement les stimuli de devenir visibles en les forçant sous le seuil d'accès à la conscience, les modifications perceptuelles et cognitives hypnotiques étaient plus un équilibre entre les suggestions, les attentes et les instructions de tâches qui ont causé sur les individus hautement hypnotisables la formation des stratégies cognitives de haut niveau en privilégiant la réduction de conflit.

Sur le troisième et dernier travail de cette thèse, nous avons testé la capacité des suggestions hypnotiques de moduler l'allocation automatique de l'attention accordée par le Anger Superiority effect (Yao et al., 2013). Nous l'avons fait en testant les participants à une susceptibilité hypnotique faible, moyenne et élevée dans le cadre d'un paradigme de clignotement attentionnel (Attentional Blink) utilisant des visages en colère et neutres comme stimuli. Notamment, nous avons combiné ce paradigme avec une suggestion hypnotique d'engourdissement émotionnel, ce qui nous a permis d'évaluer dans quelle mesure la suggestion hypnotique pouvait annuler l'influence automatique que le Anger Superiority effect avait sur le Attentional Blink,

et son impact sur la performance des tâches. Avoir exécuté une telle modulation dans le contexte d'un RSVP nous a permis d'utiliser le clignotement comme une forme d'étiquette temporelle sur le traitement des stimuli, ce qui à son tour nous a permis de regarder l'influence de la résolution temporelle de l'attention sur la dynamique de l'hypnose. Nous avons également incorporé un groupe témoin, qui a effectué la tâche dans des conditions égales de motivation, mais sans aucune suggestion (hypnotique ou autre) et sans induction hypnotique. Nos résultats ont confirmé que notre suggestion hypnotique pour l'engourdissement émotionnel entravait les modulations que le Anger Superiority effect exerçait sur le Attentional Blink, et atténuait la capture d'attention différentielle exercée par les visages irréguliers (par rapport aux visages neutres). Cependant, nos résultats suggèrent que, bien que la modulation émotionnelle elle-même dépendait de la suggestion hypnotique et de l'hypnotisabilité des participants, la perturbation réelle du lien entre le Anger Superiority et le Attentional Blink résultait de l'impact général de l'hypnose sur la charge cognitive, et les changements qu'elle favorisait sur l'ensemble du task set attentionnel.

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Summary

In the present work, we posit that a clearer outline of the interaction between hypnotic suggestion and attention would help establishing the precise point in the perceptual timeline at which hypnosis effects intervene, how exactly do they modulate cognitive control, and to what extent is hypnotic responding dependent on attentional resources. In order to tend to these experimental questions, we developed three research projects: (1) the normative data on our French translation for the Harvard Group Scale of Hypnotic Susceptibility, (2) an evaluation of the effects of posthypnotic suggestion on visuospatial attention, and (3) an evaluation on the capability of hypnotic suggestion to modulate the automatic attention allocation granted by the anger-saliency effect. The results from our first study allowed us to reliably score the hypnotic susceptibility of over 500 participants for the studies that ensued. Results from our second study indicated that for highly susceptible participants, posthypnotic suggestion successfully disrupted the early attentional mechanisms necessary for the fostering of priming, as well as late subjective visual awareness judgments. Our third study revealed that, through hypnotic suggestion, highly susceptible participants were able to deflect automatic attention allocation towards targets' task-irrelevant angry features through strategic decoupling of cognitive control, but only when attentional resources were not coopted by competing processes. Pooled together, our findings support the ideas that hypnosis enacts its effects through cognitive control, that these can disrupt both early and late attentional mechanisms in distinct manners, and that the availability of attentional resources determines the range of action of hypnotic induction and suggestion.

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1. Introduction

1.1 Hypnosis: an art of the state (*An informal preface*)

Since its birth about two centuries ago, the term “hypnosis” continues to be shrouded in mystery in the eyes of the general public. Even at this day and age, its evocation alone suffices for stimulating imaginations, as if the “hypnotist” actually withheld a mystic, dangerous key to the subconscious mind. The enticing, literary promise of absolute power over someone, nicely seasoned with some dirty access to her innermost fantasies, has fueled countless novels, comic books and movies, in spite of being little more than an overblown misconception (Raz, 2011). So much so that, as anyone who has tackled the subject experimentally knows, participants and students alike often show up to hypnosis labs displaying an emotional cocktail of curiosity, fascination, utter disbelief and sheer fear. Unfortunately, the troubling cloud of misinformation surrounding the topic is still nourished every day by the ever-growing troupe of “street hypnotists” and “hypnosis performers” who continuously dazzle unsuspecting bystanders and eager audiences with their “powers”. YouTube offers an undying and somewhat entertaining testimony of these “hypnotic” mishaps: mostly, calculated combinations of deception, people-handling skills and careful camera editing.

It is important to understand that this double identity as research field and pop-culture phenomenon puts hypnosis in a unique position. Indeed, while its unscientific counterpart continues to develop a life of its own, the clinical and scientific study of hypnosis is in perfectly good health and steadily growing. Hypnosis has constituted a serious research topic at least since Hull’s first scientific publication on the matter in

1933. Several reputed authors have acknowledged it as an inherently relevant part of the broader field of consciousness research (Landry, 2014), and as a rich tool for studying “the intersections of cognitive control, sense of agency, metacognition, and germane functions” (Terhune *et al.*, 2017).

Perhaps because of its particularly charged and ambivalent reputation, hypnosis research is still met at times with a sizable dose of veiled skepticism by a sector of the scientific community. This, however, is only natural at this genetic stage: we are but now starting to really understand hypnosis’ inner mechanisms. Only now, after the cognitive revolution left us with outstanding developments in [neuro]cognitive science, can we begin to comprehend the utter social, cognitive and neuroscientific complexity of the hypnotic phenomenon. Luckily, as we continue to strive towards answering the topic’s central and larger questions in a replicable manner, we see the scientific community gradually becoming more accepting.

Clinically, hypnosis is also progressing, and becoming an increasingly tested therapeutic tool (Barabasz & Watkins, 2005; Stewart, 2005; Elkins, 2017; Terhune *et al.*, 2017). The fact that a small part of the hypnosis clinical community would still appeal to pseudo-scientific practices in an official capacity is a problem indeed (see the program of the “Paris 2015 World Congress of Hypnosis” for an example), but one that exceeds the field itself. Some medical doctors will always be tempted to overplay their hands and give “quantic hypnosis” a go, yet such a practice is hardly any different from other questionable professional choices in need of swift rebuttal (as is, for instance, the use of homeopathy). Their utilization pertains to a generalized rigor problem in medicine, and for this the field of hypnosis should not be faulted.

Despite the aforementioned encumbrances, in all, the role of the hypnosis researcher remains the same as that of every other researcher anywhere: to keep moving forward responsibly, through the spread of her findings. Hypnosis research has an appeal that transcends its inherent cognitive, neural and therapeutic questions; its properties render it a potentially unique tool for instrumental research in a variety of fields including psychopathology (Woody & Szechtman, 2011) and cognitive science/neuroscience (Oakley & Halligan, 2013). May this thesis contribute to the realization of this potential.

1.2 What *is* hypnosis?

The history of hypnosis can be quite fascinating. A true exploration of its beginnings would set us in the early years of psychological healing and animal magnetism (Laurence & Perry, 1988; Crabtree, 1988; 1993). The coining of the term has been attributed to the Scottish surgeon James Braid, who developed the concept of “neuro-hypnotism” after witnessing the “healing trance” of Charles Lafontaine’s “magnetic demonstrations” in 1841 (Braid, 1843). Beyond the term itself, among Braid’s greatest contributions to the field we count the notion of separating the hypnotic “trance” from any form of pseudo-ritual “magnetization”, his efforts for validating “hypnotism” as medical practice, and the idea that all hypnosis is actually an act of self-modulation (“auto-hypnotism”, as he called it) and not the result of “powers” stemming from an external individual (Braid, 1843).

The applied therapeutic effects of hypnosis continue to be of great interest to the scientific and medical communities; so has its phenomenology transcended the vagueness of the “healing trance”. The deconstruction of hypnosis through the lens of modern research has revealed a complex interaction between the careful

modulation of attentional resources (Raz, 2011; McLeod, 2011; Terhune *et al.*, 2017), dissociative and unconscious behaviors (Dienes & Perner, 2007; Woody & Sadler, 2008), hypnotic and non-hypnotic suggestibility, response expectation, and socio-cognitive variables such as motivation and perceived authority (Lynn *et al.*, 2015). Whether each and every one of these elements is necessary or sufficient for hypnosis to take place, or even if the latter composes a distinctly altered state of consciousness or not, remains a matter of debate.

The main interest of this doctoral thesis lies on furthering our understanding on the role that attention plays within the mechanisms of hypnotic response. To date, the latter remains rather unclear: some argue that attentional absorption constitutes a fundamental, necessary part of the hypnotic process (Rainville & Price, 2003; Raz, 2011; Lifshitz *et al.*, 2012), while others consider attention simply as a mechanism subservient to other more important socio-cognitive variables such as expectation, motivation and social context (Sheehan & McConkey, 1982; Council, Kirsch, & Grant, 1996; Lynn *et al.*, 2015b). In particular, authors such as Raz and his team go as far as referring to hypnosis straightforwardly as a form of “atypical attention” (Lifshitz *et al.*, 2012), a claim largely based on their experimental work on how hypnosis could de-automatize attention allocation (Raz, Kirsch, Pollard & Nitkin-Kaner, 2006). Nonetheless, most modern hypnosis research pieces agree on portraying the effect of hypnotic suggestion on perception and behavior in terms of cognitive control (see section 1.4). At the stage of consolidating perceptual information, hypnotic suggestion would work as a potent top-down control mechanism, ultimately leading to favoring hypnotically suggested perceptual traits (“rogue representations”, produced endogenously) over default representational content and external bottom-up sensory input (Brown & Oakley, 2004).

Given the tight link between hypnotic responding, attention allocation, top-down bias and cognitive control (Terhune *et al.*, 2017), we propose that expanding the existing research on hypnotic attention constitutes an inescapable echelon for the better understanding of hypnosis, but also of the general mechanisms of attention and cognitive control. Furthermore, hypnosis could be of particular relevance for consciousness research, as a potentially promising mechanism for warranting subliminal and pre-conscious processing solely through attentional modulation (Landry *et al.*, 2014).

As particularly salient issues, we identified the need for addressing hypnotic response in relation to specific forms of attention (experimentally contrasting the role of hypnosis across different attentional limitations) and hypnosis' alleged capability to “de-automatize” attention allocation. We have done so through two experimental pieces. The first one (section 2.2) added to the incipient work on whether hypnotic suggestion could modulate visuospatial attention (Priftis *et al.*, 2011). We evaluated in particular the level at which hypnotic attentional modulation intervened: if its effects were limited to late subjective awareness judgments or if they also encompassed early automatic attention. The second one (section 2.3) tested the hypnotic modulation of automatic attention allocation through a hypnotic manipulation of the anger-saliency effect (Jong *et al.*, 2007; Jong *et al.*, 2009; Yao *et al.*, 2013a; Yao *et al.*, 2014). Importantly, this second experiment was performed within the context of a face-based attentional blink paradigm, in order to evaluate how the setup's signature competition for attentional resources (Raymond, Shapiro & Arnell 1992; 1995) affected the bounds of hypnotic response.

1.3 Fundamentals of hypnosis

When understood as a practice, outlining hypnosis' fundamental principles becomes simple. In its core, hypnosis can be seen as the process through which an agent (e.g., a researcher, a clinician, a tape-recorder) delivers a suggestion (e.g., negative or positive, motor or cognitive) to an actor (e.g., the participant of a research protocol, a patient). Hypnotic suggestions differ from simple instructions because (1) the socio-cultural context in which they are delivered is specifically conceived to render the actor more permeable to suggestion (*i.e.*, more willing to comply) (Lynn & Sherman, 2000), (2) they usually are preceded by an induction protocol intended to produce experiential and/or motivational changes also aimed towards enhancing the actor's permeability (Woody & Sadler, 2016), (3) the response they intend to elicit is involuntary in nature (e.g., "the word 'scissors' will leave your mind, and you won't be able to remember it, no matter how hard you try") (Bowers, 1981). Refer to Figure 1 for an outline of a standard hypnosis protocol.

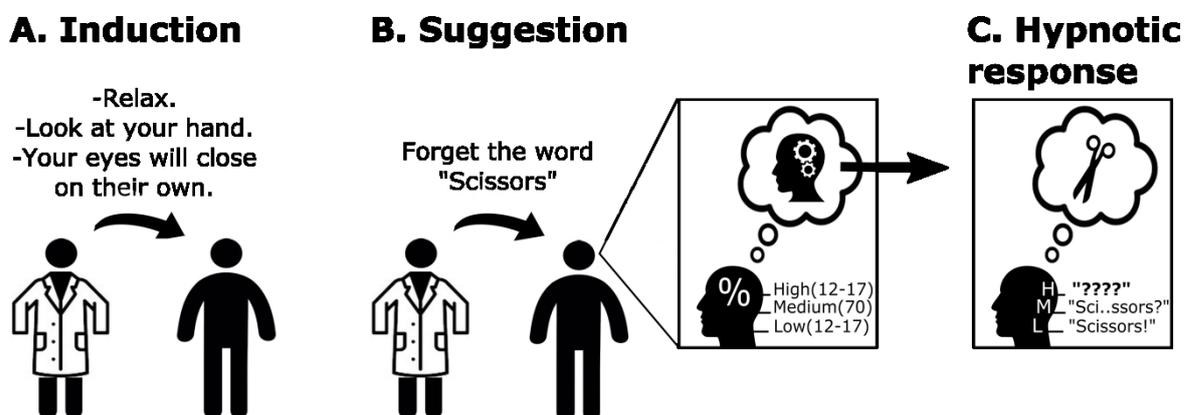


Figure 1: A. Induction phase. The hypnosis practitioner proposes diverse strategies to increase the patient/participant's attentional focus and motivation to engage in the process, while at the same time

modulating her awareness. Induction is typically ended on a suggestion. **B. Suggestion(s) phase.** The practitioner then proposes the patient/participant to “give into” or “act upon” the content of a concise suggestion: typically a change in the way she perceives her environment, her own mind-states and/or the deployment of her cognitive resources. Her permeability to suggestion will be mediated by her level of hypnotic susceptibility (High, between 12-17% of the population; Medium, 70%; Low 12-17%) **C. Hypnotic Response.** The participant/patient complies, and her actions and/or experiential changes reflect the effect of the suggestion. The quality of her response will depend on the difficulty of the suggestion and her level of hypnotic susceptibility.

Although the intervention of an external agent is frequent, it is not mandatory. Every process of hypnosis is in fact an act of self-hypnosis, since it is *the receiver of the suggestion* who employs her own cognitive skill to generate all of the suggested experiential changes (Kihlstrom, 2008). Whether a suggestion is delivered by an external operator, by a recording or by the subject herself, hypnotic susceptibility (the individual ability to enact a hypnotic suggestion) constitutes the main predicting variable of hypnotic responding.

1.3. 1 Hypnotic induction and suggestions

As outlined above, the prototypical hypnosis session begins with the administration of a hypnotic induction. Inductions generally consist of proposing the execution of a series of cognitive and behavioral patterns that will ultimately foster attentional absorption, relaxation and a modified awareness of the self and the environment (Price & Rainville, 2003; Brown, 2001). As clinical hypnosis progressively increased its number of therapeutic targets, practitioners developed a plethora of different induction techniques. Most common induction strategies usually include some form of eye fixation, breathing and relaxation techniques, and the evocation of mental

imagery. Over the years, several different induction procedures have been contrasted across the relevance of their components. Relaxation has indeed been found to have a general positive effect on susceptibility (Batty *et al.*, 2006), but tonic inductions stimulating physical activity have also led to the successful execution of hypnotic suggestions (Banyai & Hillgard, 1976; Malott 1984; Miller, Barabasz & Barabasz, 1991), which discarded relaxation as a *necessary* component for induction. Similar findings have shown that as long as expectations for the outcome of the procedure were matched, no conclusive differences were found between directive (“*Your arm is heavy*”) and non-directive (“*Your arm might start getting heavier*”) styles of delivery (Lynn, Neufeld & Maré, 1993). And while proof exists that face-to-face inductions can yield slightly better results than recordings (Johnson & Wiese, 1979), the latter have also been implemented with ample success (Lynn, Neufeld & Maré, 1993). This variability, together with the replication of some hypnosis landmark studies in the absence of hypnotic induction (Raz *et al.*, 2006), have brought some social-cognitive theorists to propose that inductions are only important inasmuch as they set a participant’s mood for the hypnotic experience, boosting her expectations and motivation. In all, despite its general role as a facilitator, a final word on hypnotic induction’s relevance, its form and interaction with individual cognitive profiles would demand furthering the study of its components (Terhune & Cardeña, 2016).

Some authors consider hypnotic induction itself as particular form of hypnotic suggestion, crafted specifically for targeting the experiential and behavioral phenomena that launch the hypnotic process (Nash, 2005). The malleable content of hypnotic suggestion is at once its greatest asset and its biggest source of complexity: through employing the correct wording, it is virtually possible to propose the inhibition/facilitation of all sorts of motor, sensory, cognitive or affective responses.

Table 1 resumes various examples of hypnotic suggestion according to their type, and the function they target. Naturally, the capability of targeting a sensory modality does not guarantee the elicitation of an according response; uncovering precisely which psychological functions are sensitive to hypnotic suggestion, and to what extent, constitutes a present challenge in the field.

TYPE	FUNCTION			
	Motor	Perceptual	Cognitive	Affective
Inhibition	Arm paralysis (Roelofs, 2002)	Analgesia (Facco, 2011)	Agnosia (Barnier, 2010)	Numbing (Bryant, 2001)
Facilitation	Arm levitation (Cardeña, 2012)	Color hallucination (Kallio, 2016)	Age regression (Nash, 1985)	Posthypnotic happiness (Gaunitz, 1975)

Table 1: Examples of hypnotic suggestions (Type across Function). Hypnotic/posthypnotic suggestions can have the effect of either inhibiting or facilitating a vast array of motor, perceptual, cognitive, and affective experiences. Examples are provided for both cases at every level, together with studies evaluating their implementation and phenomenology.

Several pivotal studies have provided us with valuable information regarding hypnotic responding, its limits and more importantly, its authenticity (see for reviews: Oakley and Halligan, 2013; Landry, 2014; Connors, 2015; Terhune, 2017). Facilitatory motor suggestions seem to trigger truly passive motor responses in highly susceptible individuals, closer in brain qualitative activation to alien control than to voluntary responses (Haggard *et al.*, 2004; Walsh, Oakley, Halligan, Mehta, & Deeley, 2015). Inhibitory motor suggestions successfully induce paralysis, and do so by setting off qualitatively distinct neurophysiological patterns compared to voluntary inhibition and simulated paralysis (Cojan *et al.*, 2009). Facilitatory perceptual suggestions can

effectively trigger hallucinatory content for susceptible individuals (Woody & Szechtman, 2011), enforcing low-level perceptual changes. In this line, compelling studies have shown that altered color perception suggestions could reliably produce changes in color-processing regions of the brain (V4, fusiform gyri), different from the changes stemming from purposefully imagining the corresponding alterations (Kosslyn et al., 2000; McGeown et al., 2012).

Research aimed towards finding the general neural correlates of hypnosis' universal mechanisms has also shown great progress. Jiang *et al.* (2016) have mapped the correlates of the focused attention, enhanced somatic/emotional control, and lack of self-consciousness that characterize hypnosis, onto patterns of neural activity largely consistent with previous findings, concerning mainly the involvement of the dorsolateral prefrontal cortex (DLPFC) and the anterior cingulate cortex (ACC) (Rainville & Price, 2003; Raz, Fan & Posner, 2006; Dienes & Hutton, 2013; Landry *et al.*, 2015; Landry *et al.*, 2017). Their findings have found 1) reduced activity in the dACC, 2) increased functional connectivity between the dorsolateral prefrontal cortex (DLPFC) and the insula in the Salience Network, and 3) reduced connectivity between the Executive Control Network (DLPFC) and the Default-Mode Network (PCC). At the neurophysiological level, Jensen *et al.* (2015) have proposed that the changes detected in theta oscillations during hypnosis were acting as facilitators of hypnotic responding, and further speculated that suggestion-dependent phase-locked theta–gamma oscillations could point to a link between fast thalamo-amygdaline networks and hierarchical cortical circuits.

While commendable advancements have been accomplished so far, it is important to note that the field has evolved through targeting a vast amount of sometimes-distant psychological mechanisms simultaneously and in isolation, and this has led to an

inevitable lack of systematicity (Terhune et al., 2017). Because of this spread, findings concerning the neural and behavioral correlates of hypnotic suggestion are frequently anchored around the particulars of their experimental paradigms and targeted modalities (Terhune et al., 2017). In order to tend to this matter, current hypnosis research has started revisiting the existing literature through meta-analyses and inter-study contrasts. We consider that future venues should continue with this tendency, and additionally focus on developing cross-modal hypnosis setups.

1.3.2 Hypnotic susceptibility

Hypnotic susceptibility is the coefficient that codes the individual variability comprised in the response to hypnotic suggestion (Laurence, Beaulieu-Prévost & du Chéné, 2008). It is typically measured through either collective or individual behavioral scales, which generally consist of the administration of a hypnotic induction followed by a representative array of motor and cognitive suggestions, in order of ascending difficulty (Woody, 1997). The participants who undergo these scales are evaluated objectively (*i.e.*, “did the participant produce the expected behavioral response to the hypnotic suggestion?”) and subjectively (*i.e.*, “did the participant report that the behavior was a result of the suggestion?”). Suggestions are scored on a pass/fail basis, and hence a hypnotizability score is produced. Several different scales for the measurement of hypnotic susceptibility exist (see Balthazard, 1993 for examples), but the most widely implemented still are the Harvard Group Scale for Hypnotic Susceptibility, Form A (HGSHS, Shor & Orne, 1962) and the Stanford Hypnotic Susceptibility Scales, Forms A & B (SHSS, Weitzenhoffer & Hilgard, 1959). The validation of the Harvard norms in over twenty countries (Carvalho, 2013; Anlló *et al.*, 2017) have shown that irrespective of language and culture, response to hypnotic suggestion tends to be normally distributed, with a 70% of the population displaying

intermediate susceptibility, 12-17% very low susceptibility, and the remaining 12-17% very high susceptibility (Laurence, Beaulieu-Prévost & du Chéné, 2008).

Hypnotizability is generally regarded as a trait that remains largely stable through adulthood (Piccione, Hilgard, & Zimbardo, 1989). Sustained psychological training and strategic increases in motivation can have a moderate, temporary impact on susceptibility scores (Gorassini & Spanos, 1986; Gorassini, 2004), and so can certain pharmacological components (Bryant *et al.*, 2011). Twin studies suggest that hypnotizability could be a hereditary trait, but genetic studies on hypnotic susceptibility so far can only be deemed as preliminary (Morgan 1973; Morgan, Johnson, & Hilgard, 1974; Lichtenberg *et al.* 2004; Rominger *et al.*, 2014).

Hypnotic susceptibility is the basis of hypnosis research, but measuring it can be very resource-intensive given the large amounts of people that need to be screened in advance in order to build powerful sample sizes for the three groups. Additionally, studies based exclusively on high and low groups risk being burdened by issues concerning the research on extreme populations (Preacher *et al.*, 2005) and need therefore to be examined with care. Although most studies designs only contrast high and low populations, a better strategy for the generalization of hypnosis findings seems to be to include medium susceptibility participants as controls, considering how they represent a statistically more accurate proxy for the general population. In particular, since it is possible that low hypnotizability populations may, in fact, not be “impervious to hypnosis”, but rather simply be reacting differently to it (Orne *et al.* 1996).

1.3.3 Clinical hypnosis: a validated therapeutic tool

Hypnosis has proved to be a surprisingly powerful tool for a wide variety of health practitioners (Barabasz & Watkins, 2005; Elkins, 2017). It is most effective when implemented as a therapeutic complement to an already established psychological treatment or medical procedure, but in some particular cases it can yield positive results when utilized as stand-alone therapy. Clinical hypnosis exploits the patient's capability of altering her perception and actions upon suggestion, by proposing specific experiential or behavioral changes aligned with a given treatment's therapeutic goals (Elkins, 2017). Hypnosis has been successfully implemented by different schools of psychotherapy since its beginnings. While the most widespread approach in the psychotherapeutic community was Milton Erickson's method of indirect hypnotic suggestion and brief intervention (Erickson, Rossi & Rossi, 1976), hypnosis has also been integrated to psychoanalysis and ego-state therapy (Mott, 1982; Brown and Fromm, 1986), cognitive and behavioral therapy (Elkins, Johnson & Fisher, 2012; Fine, 2012) and mindfulness-based cognitive therapy (Lynn *et al.* 2012). Interestingly, hypnosis is of great use for re-orienting attention away from aversive stimuli, which has warranted it a particularly popular place in acute, chronic and perioperative pain management therapies (Patterson & Jensen 2003; Patterson *et al.* 2006; Patterson 2010).

One of the main advantages of this approach lies on its virtual universality. Unlike the case of experimental hypnosis, suggestions posed in the framework of a treatment are generally easy to follow and don't demand a particularly high susceptibility (*e.g.*, relaxation, searching for positive memories, evoking mental imagery). Their success relies preferentially on the patient's motivation (Barber, 1980).

Clinical hypnosis' versatility stems from the ample variety of themes that hypnotic suggestion can comprise. Suggestions can be of great use for proposing and reinforcing new and better adaptive behavioral patterns (e.g., to diminish compulsory acting), thinking patterns (e.g., to counteract depressive ruminations) and emotional response (e.g., to induce calmness and relaxation in the wake of traumatic events) (Barabasz, Olness, Boland & Kahn, 2010). Therapists and medical doctors commonly customize their inductions and suggestions strategically around each patient, attuning them to their resources, and to the particular challenges their diagnosis may impose. Generally, suggestions focus on enhancing confidence, positive remembrance, self-trust, empathy, well-being, relaxation and pleasantness, in order to 1) allow the patient to evoke these feelings in times of need, through auto-hypnosis and posthypnotic suggestion, 2) protect her from the affective value of past traumatic events, and foster their re-appreciation, 3) increase her resilience for facing future events (Elkins, 2017).

Certainly, it is hard to know exactly how the elements composing therapeutic hypnosis interact with each other and result in a positive clinical outcome, since not enough clinical studies have picked these components apart. Likewise, the gold standard of randomized, double-blind, controlled trials is particularly challenging to apply in hypnosis psychotherapy, since the positive effects of cooperation and rapport between patient and therapist are often a needed part of the process (Stewart, 2005). However, existing clinical trials and meta-analyses of hypnotic interventions offer promising evidence for the use of hypnosis as treatment of a variety of conditions. To conclude this incise, we present a table (Table 2) compiling an array of relevant studies, clinical trials and meta-analyses conducted to date, which evaluate the applicability and efficacy of hypnosis on an ample spectrum of

treatments. The majority of the studies there presented were scouted from reviews by Stewart (2005), Wark (2008) and Terhune *et al.* (2017).

Pain (general) (Montgomery, DuHamel, & Redd, 2000)	Moderate to large hypnoanalgesic effect.
Acute pain (adult) (Patterson & Jensen, 2003)	Hypnosis has a reliable and significant impact on acute procedural pain and chronic pain.
Acute pain (children) (Zeltzer & LaBaron, 1982)	Hypnosis works better than distraction for bone marrow aspiration pain.
Chronic pain (Adachi <i>et al.</i> 2014)	Moderate treatment benefit over standard care, superior effects than other psychological interventions.
Cancer pain (Syrjala, Cummings & Donaldson, 1992; NIH Technology Assessment Panel, 1996)	Hypnosis reduces cancer pain.
Obstetrics pain (Jenkins & Prichard, 1933)	Hypnosis shortens labor and reduces analgesic use.
Neuropathic pain (Spiegel & Albert, 1983)	Hypnotic pain alleviation persists after administration of naloxone.
Surgical pain (adults) (Tefikow <i>et al.</i> , 2013)	Positive treatment effects on emotional distress, pain, medication consumption, physiological parameters, recovery, and surgical procedure time.
Surgical pain (children) (Lambert, 1996)	Guided-imagery hypnosis reduces pain and hospital time vs. control (no hypnosis).
Distress during surgery (Lang <i>et al.</i> , 2006)	Hypnosis reduces anxiety and pain during surgery better than control.
Surgical outcome (Montgomery <i>et al.</i> , 2002)	Hypnosis treatment groups had better clinical outcomes than the majority of patients in control groups.
Irritable bowel syndrome (Schaefer <i>et al.</i> , 2014)	Hypnosis was superior to control for symptom relief and in reducing global gastrointestinal score.
Anorexia (Baker & Nash, 1987)	Staged treatment with hypnosis better than same treatment without hypnosis.
Bulimia (Griffiths <i>et al.</i> , 1996)	Hypnosis equal to CBT, and better than wait list control.
Obesity & weight-loss (Kirsch, 1996)	Hypnosis+CBT patients show greater improvement over time than controls.
Vomit during chemotherapy (Richardson <i>et al.</i> , 2007)	Hypnosis is at least as valuable as CBT for anticipatory and chemotherapy-induced vomiting in children.
Surgical outcome (Montgomery <i>et al.</i> , 2002)	Hypnosis treatment groups had better clinical outcomes than the majority of patients in control groups.

Hypertension (Friedman, 1977;1978)	Hypnosis produced a decrease in blood pressure compared with the control group. At a six-month follow-up, the hypnosis group had mean decreases of 13.3 mm Hg systolic and 8.5 mm Hg diastolic below their baseline blood pressures.
Refractory fibromyalgia (Haanen <i>et al.</i> , 1991)	Patients who were randomly assigned to receive hypnosis obtained significant improvement compared with those assigned randomly to physical therapy alone.
Hemophilia (LaBaw, 1992)	Patients assigned to receive hypnosis had a decreased need for transfusions compared with controls(no hypnosis).
Depression (Shih <i>et al.</i> , 2009)	Hypnosis improved symptoms of depression; promising nonpharmacological intervention for depression.
Psychosomatic disorders (Flammer & Alladin, 2007)	Hypnotherapy is highly effective in treatment of psychosomatic disorders
Disorders treatable with CBT. (Kirsch, 1995)	Patients treated with Hypnosis+CBT show greater improvement than a majority of those treated with CBT alone.

Table 2. A sample of hypnosis clinical studies, trials and meta-analyses. The table presents an array of publications evaluating the applicability and efficacy of hypnosis on different ailments, and serves as an example of the wide variety of clinical hypnosis implementations. (*DISORDER: target ailment. RESULT: a brief summary of the results. CBT: cognitive-behavioral therapy. In red: meta-analyses. In blue: studies, reviews and clinical trials.*)

1.3.4 Debates around consolidating a theoretical definition

The theoretical definition of hypnosis is bound to change as research continues to advance and shed light on its procedural, behavioral and neurocognitive building-blocks. Unlike sleep, which has clear behavioral and neurophysiological markers, the heterogeneity of hypnotic response and lack of definitive universal neural correlates make hypnosis much harder to delimitate. At multiple occasions (Elkins, Barabasz, Council, & Spiegel, 2015; Green, Barabasz, Barrett, & Montgomery, 2005; Kirsch, 1994), the Division 30 of the American Psychological Association has appointed a Hypnosis Definition Committee (HDC), in charge of revising and updating the existing

definitions of hypnosis and its key components (*i.e.*, “hypnosis”, “hypnotic induction”, “hypnotizability”, “hypnotherapy”). Although it is now considered by some as an outdated starting point, the simplest and most popular proposal was perhaps that of Kihlstrom (1985), on which Kirsch’s (1994) official definition was based: a *procedure* during which a health professional or researcher suggests that a patient or subject experience changes in sensations, perceptions, thoughts or behavior.

Unsurprisingly, each official revision of the “hypnosis” concept has sprung considerable debate (Lynn *et al.*, 2015; Yapko, 2015), to the point of dividing at times the hypnosis community. The main conductive thread across the last twenty years of this experimental-epistemic controversy has been the dispute between state-theorists, who attribute the term “hypnosis” to a particular *state* of consciousness, and social-cognitive-theorist, who propose the term “hypnosis” should rather describe the sum of social and cognitive variables that compose the context in which hypnotic response is produced.

State-theorists consider that hypnosis constitutes in its own right an altered state of consciousness, characterized by a particularly focused attention, reduced peripheral awareness, and an enhanced capacity for response to suggestion (Elkins *et al.* 2015). Like any other state-theory of consciousness, they postulate that hypnosis is identifiable through its own neural markers (Lynn *et al.*, 2015), even if so far hypnosis’ neuroscientific research still faces the challenge of conclusively pinpointing a universal neural correlate of hypnotic responding (Landry & Raz, 2015; Landry *et al.*, 2017; Terhune 2017). The state-theory umbrella also includes dissociative theories, which focus on the typical loss of agency produced by hypnosis (namely, the reported certainty that suggested behaviors are taking place “on their own” or “without the conscious initiation of the actor”---Bowers, 1981; Weitzenhoffer, 1980).

This “dissociation” between volition and action is interpreted as a temporary loss of familiar associative processes (Bell et al. 2011), either at the level of the subjects’ experiencing of a behavior (Hilgard, 1991) or at the level of the underlying mechanisms controlling such behavior (Woody & Bowers, 1994). Social-cognitive-theorists, for their part, propose that the necessity for an altered attentional/dissociative state to arise in order for someone to become more permeable to suggestion or manifest a hypnotic response is not only superfluous, but most importantly, lacking of experimental evidence (Sheehan & McConkey, 1982; Kirsch & Lynn, 1998; Yapko, 2015). They propose that hypnotic behavior can well be observed outside of any so-called altered state, and rather be explained in terms of engagement with suggestion, affect, relational factors, rapport, motivation and expectation, and in particular, without the actual need for attentional focus or dissociative processes (Sheehan & McConkey, 1982; Barber, 2000; Lynn *et al.*, 2011; Lynn et al., 2015a).

Although for quite some time the debates around the phenomenology of hypnosis were conceived as a radical opposition between these two sides, other theories have found their way between the two. The Cold Control theory (Dienes & Perner, 2007; Dienes & Hutton, 2013) attributes the emergence of hypnotic responding to a metacognitive distortion (Terhune, 2012). Following to some extent Rosenthal’s High Order Thoughts theory of consciousness (Rosenthal, 2005), it proposes that 1) if awareness of an action or state comes from the “executive monitor module” in charge of building a high-order representation of said action, 2) hypnosis’ hallmark trait, the loss of the agency that corresponds to performing a suggested action, should be the result of an induced decoupling of executive monitoring. Namely, Cold Control proposes that hypnotic responding constitutes an example of executive control in the

absence of conscious awareness. Ultimately, Cold Control is compatible with both state-theories and social-cognitive theories: its emphasis on executive function brings it in line with Hilgard's neo-dissociation theory (Hilgard, 1974), and with socio-cognitive approaches such as Spanos' and Lynn's (Dienes & Perner, 2007). The former understands the decoupling experience as the conduit for actual unconscious action resulting from an altered state; the latter, as an experiential report that while honest, comes from involuntary confabulation at the personal level, namely, as the use of intentions without the awareness of having those intentions.

The fact that Cold Control could accommodate to either of the classical approaches is not accidental. Its best strength is its *focus on hypnotic responding*. It renders it concrete inasmuch as it allows for proposing predictions that can be readily testable at behavioral and neuroscientific levels (Terhune, 2012; Dienes & Hutton, 2013). Crucially, any modern cognitive/metacognitive procedural theory of hypnosis is bound to share this advantage, as its bases would stand on observing response to suggestion rather than on spontaneous experiences or diffuse state accounts. Hypnotic responding theories occupy a pivotal position in the definition debate, possibly even the potential of closing it for good. As said by Terhune (2014),

"[In a procedural definition] hypnosis consists of a set of procedures including a hypnotic induction, intended to modify suggestibility, followed by the administration of one or more suggestions, intended to measure hypnotic suggestibility, modulate a particular psychological phenomenon, or treat a specific symptom. This definition is neutral with regard to competing definitions of hypnosis, in particular state and non-state positions, to the requirements of an induction, as well as to the core element(s) of hypnosis. It also avoids confusions regarding whether

someone was or was not hypnotized or whether or not someone has the ability to be hypnotized (these questions become meaningless)”.

In all, much effort has been made over the last twenty years to reach a consensual definition of hypnosis, but it is likely that the relevance of such consensus could have been overestimated (Yapko, 2015). As the procedural approach to hypnosis continues to gain support, researchers across the board seem to be shifting their focus from uncovering what hypnosis exactly *is* towards revealing *what hypnosis can do*. Importantly, according a heavier importance to the instrumentalization of hypnosis could constitute a step forward towards a better integration between the hypnosis field and broader fields within cognitive science and neuroscience, for their mutual theoretical and methodological benefit.

1.4 Hypnosis, top-down control and the role of attention

A procedural approach to hypnosis, then, requires focusing primarily on what hypnosis can *do* and *how* it is that it does what it does. As already discussed (section 1.3.1), hypnotic suggestion harbors the capacity of transversally influencing motor control, perception, cognition and affective systems (Woody & Sadler, 2008). Processing a hypnotic suggestion is by no means different from processing any other portion of regular speech; rather, the particular character of hypnotic suggestion hails from the mental work that takes place if the receptor complies. Regardless of its wording, every hypnotic suggestion consists of a series of instructions aimed at eliciting a certain endogenous mental representation, conveying directly or indirectly the idea that said representation is an actual depiction of the listener's reality, independently of conflicting sensory information.

It is a well-established fact that human rich and dynamic representations of reality consist not only of passively-processed bottom-up sensory information, but also of binding, accurate guesses and inferences made rapidly and unconsciously (Cavanagh, 2001). These top-down influences, which intervene at multiple levels of processing, stem from the prior world-knowledge a person has, and her expectations regarding each particular experience (Cavanagh, 2001). Crucially, it has been shown that when purposefully managed, these top-down influences can drastically shape perception (Carrasco 2004; Hansen *et al.*, 2006; Balci *et al.*, 2006, 2010; Rahman *et al.*, 2008). Under this light, hypnosis is definable as nothing more than a particularly powerful technique for the maximization of the top-down influences' role in the building of a perceptual experience. Instead of accessing her particular set of personal priors normally triggered by the present sensory information, the highly susceptible individual relies on this proposed hypnotic mental representation and the expectations created by it, allowing it to drive the consolidation of the percept and its commission to memory. Namely, while a simple instruction would not suffice to see the color red as blue, in the eyes of a highly hypnotizable individual, a hypnotic suggestion enunciating just that would suffice for eliciting a color hallucination (Koivisto *et al.*, 2013; Kallio & Koivisto, 2016). A review of the existing literature (Terhune *et al.*, 2017) points out that nearly all state-theorists, social-cognitive theorists and dissociation-theorists tend to agree that hypnotic action relies primarily on cognitive control and a top-down distortion of perception or executive monitoring. Neuroimaging research has so far contributed to this conclusion by implicating the dorsolateral prefrontal and anterior cingulate cortices, as well as parietal networks typically involved in top-down regulation, as recurrent participants of multimodal hypnotic responding (Landry *et al.*, 2015; Jiang *et al.*, 2016).

1.4.1 Hypnosis mechanisms and attentional dimensions

As hypnosis research continues to close on down on the main components of hypnotic responding, still a non-negligible share of disagreement persists in terms of the specific mechanisms involved, and further exploration is direly needed. As a token of example, faced to a hypnotic suggestion such as “You cannot read anymore, the words on the screen appear as senseless gibberish to you”, most highly hypnotizable participants would indeed report an inability to read (Raz, Kirsch, Pollard, & Nitkin-Kaner, 2006). A weak interpretation of hypnotic action would consider this experiential report as driven by the unconscious implementation of a cognitive strategy to avoid reading, retrospectively judged as an inability to read. By a strong interpretation, however, this inability to read would imply either the de-automatization of the attentional allocation that mediates the process of reading, the fostering of unconscious reading (*i. e.* reading without awareness), or a full-fledged visual hallucination.

Each of the above interpretations implicates radically different cognitive mechanisms, and it is only through further decomposing hypnotic responding that one can eventually prevail. In facing such endeavor, redoubling the efforts invested in understanding the role that attention plays in both hypnotic responding and the phenomenology of hypnosis is crucial. In particular, one of the main claims about hypnosis’ research utility relies on its capability of enforcing top-down attentional control beyond the limits of standard self-managed cognitive control, affecting and orienting both exogenous and endogenous attention (McLeod, 2011). Since attention allocation is the primary gateway through which stimuli reach awareness, even at the level of their most basic perceptual primitives, a better understanding of how exactly attentional mechanisms interact with hypnotic induction, hypnotic suggestion and

hypnotizability, would allow us at least to better define the limits of hypnosis' range of action and utility for cognitive research, and crucially, to shed light on how hypnosis affects perception, and in a larger scale, consciousness. First and foremost, because attention plays a fundamental role in the selection and maximization processes fostered by top-down cognitive control (Cohen *et al.*, 1990, 2004; Mackie *et al.*, 2013). Remarkably, a sizable amount of studies point to overlaps between the neural mechanisms concerning attention allocation and those relative to hypnotic suggestion (Raz, 2005; Lifshitz, 2012). Second, the limits of how much can hypnosis tamper with attentional resources are yet unclear. A paradigmatic example of this instance can be found in the claim that hypnotic suggestion can act through de-automatizing attention allocation (Raz, Fan & Posner, 2005; Raz, Kirsch, Pollard, & Nitkin-Kaner, 2006), which has to date been contested (Augustinova & Ferrand; 2012) and demands further study. Third, no studies to date have explicitly contrasted the effects of any one given hypnotic suggestion on all different types of attention. Fourth, the exact point of the cognitive timeline at which hypnosis intervenes it is still uncertain (Terhune, 2017); since attention intervenes both early (at the level of stimulus identification) and late (once perception is complete) (Luck & Ford, 1998), a better understanding of the interaction between hypnosis and attention could potentially shed a definitive light on this matter. Finally, since models of consciousness such as the Global Neuronal Workspace consider attention to play a key role in allowing stimuli into awareness (Dehaene, Changeux, Naccache, Sackur & Sergent, 2006), uncovering to what extent can hypnosis constrain or expand attention selectively and at precise points in time would constitute a fundamental step in the process of proving whether hypnotic suggestion can foster true unconscious action.

While targeting all of the above within the scope of a single doctoral thesis would prove too ambitious, the present work does aspire to further advance the current knowledge on how exactly consciousness, attention and hypnotic responding interact. To that end, the following sections will provide a brief account on the spatial and temporal dimensions of attention, top-down control, and the studies that we have tailored to address some of the aforementioned issues.

1.4.2 The argument of hypnotic attention de-automatization, and the path it clears.

To date, hypnotic attention research has mainly focused on selective attention, and it has been particularly oriented towards hypnosis' capability of moderating cognitive conflict (Raz, Fan, & Posner, 2005). Often built seeking the hypnotic enhancement of performance, this type of studies carry out experimental paradigms known for eliciting reliable cognitive conflict together with a hypnotic suggestion destined to minimizing it (Raz, Kirsch, Pollard, & Nitkin-Kaner, 2006). One of the most referenced and replicated instances of this approach has been the modulation of the Stroop effect: by “disabling” their ability to read through an alexia suggestion, highly susceptible participants become significantly better at managing the semantic incongruence created between the color of the target word and its meaning (typically a different color). This conflict-modulation explanation of hypnotic suggestion moderatory effects is further supported by the recurrent ACC involvement in hypnotic responding (Raz *et al.*, 2005; Landry *et al.* 2015; Jiang *et al.* 2016). The fact that the latter consists of a de-activation, hints towards a reduction of cognitive control, or maybe even its strategic decoupling, rather than an attentional enhancement of any kind. The findings on neurophysiological correlates of hypnotic conflict modulation are not numerous, but the existing evidence so far also points to a reduction or dissipation of

early conflict monitoring markers (Raz, Kirsch, Pollard, & Nitkin-Kaner, 2006; Terhune *et al.*, 2010).

One of the strongest claims that derived from the aforementioned studies was the alleged de-automatization of attention allocation. In the particular case of the Stroop effect minimization (Raz, Fan & Posner, 2005), this interpretation relied on the idea that accomplishing the obtained results implied both the fracture of the automaticity that supports the reading process, and the virtually immediate and compulsory nature of the semantic processing of words (MacLeod *et al.*, 1991; Neely, 1991). Interestingly, follow-up studies by some of the same authors successfully replicated this effect beyond posthypnotic responding, *i. e.* through suggestion alone (Raz, Kirsch, Pollard, & Nitkin-Kaner, 2006), which led to sustain that for highly suggestible individuals, suggestion alone sufficed for attention de-automatization.

Since then, however, a revealing study by Augustinova & Ferrand (2012) has brought all of these hypotheses into question (if not discarded them entirely). In order to evaluate the validity of the Stroop-originated de-automatization claims, Augustinova *et al.* assembled highly suggestible individuals who completed both standard and semantically based Stroop tasks, either with or without a suggestion to construe the words as meaningless symbols. By showing that suggestion substantially reduced standard Stroop interference, Augustinova replicated Raz *et al.*'s (2006) results, but also found significant semantically-based Stroop effects of similar magnitudes in all suggestion conditions. The dire importance of such results rests on the fact that the suggestion for construing words as meaningless symbols did not modulate semantic activation at all, as assessed by the semantically based Stroop effect, which in turn indicated that suggestion acted rather by reducing the non-semantic task-relevant response competition inherent to the Stroop task. In sum, contrary to Raz *et al.*'s

claim, suggestion most likely 1) did not de-automatize reading, 2) conserved semantic processing, and rather 3) influenced response competition (Augustinova & Ferrand, 2012).

Importantly, the fact that both simple suggestion and posthypnotic suggestion would satisfactorily reduce the Stroop conflict, but not necessarily through installing the de-automatization of attention allocation, does not invalidate the hypothesized intervention of attention in hypnotic responding. Attention is integral to early perceptual mechanisms and the selection processes of cognitive control (Chun *et al.*, 2011), and even if hypnosis does not foster its de-automatization, it could still interact with it in a number of different ways. As previously mentioned (section 1.3.3), hypnotic attentional modulation and diversion both play a central role in virtually all of hypnosis steadily tested therapeutic implementations. Furthermore, when considered together, Augustinova *et al.* (2012) and Raz *et al.* (2006) would seem to show a robust piece of evidence for unconscious reading, namely, reading and executing the corresponding semantic processing task in absence of awareness, despite high stimuli energy.

In conclusion, the relation between attention and hypnosis still needs to be carefully scrutinized. We need to better understand the limits of hypnotic attentional modulation, namely, to what extent hypnotic attentional changes are dependent on hypnotic susceptibility and how exactly it is that attention can be redirected, dissipated or enhanced through hypnotic and posthypnotic suggestion. This will require that we elucidate the exact psychological points of the perceptual experience where hypnosis has an impact and whether they pertain to early, late, internal or external attentional processes. Only then will it be possible to estimate the integral role of attention in hypnosis processes as a whole; as either a fundamental part of

general hypnotic responding and hypnotically altered cognitive control, or rather as an element whose modulation would be limited to specific tasks and suggestions.

1.4.3 A topical taxonomy of attention.

Attention can be understood in its most basic form as a psychological evolutionary feature. It is the mind's strategic solution for handling the exposure to a virtually unlimited stream of external stimulation, while under the constraint of a limited amount of cognitive resources. It can be defined as the ensemble of mechanism by which some primary (or salient) stimuli are selected and preferentially processed, at the expense of other less important (or less available) elements from our perceptual space (Posner, 1990; Pashler, 1998; Petersen & Posner, 2012; Chun, Golomb & Turk-Browne, 2011; Carrasco, 2011). As a selection system, it is responsible for understanding the differences between stimuli, and biasing competition in favor of target objects and expected events (Desimone & Duncan, 1995). As an amplifying system, attention guarantees the preferential processing of a target's features, and even modulates the experiential qualities of the resulting percept (Carrasco, 2004). As a system of alert, it administers its own facilitatory traits over the long term in order to preemptively foster the conditions for their optimal implementation in the face of task-relevant warning signals or spontaneous stimulus onset (Leber *et al.*, 2008; Leber, 2010). Importantly, the aforementioned functions influence every stage of the cognitive hierarchy, rendering attention naturally ubiquitous: it pervades low-level multimodal sensory processing, percept consolidation, commission to memory, memory retrieval, consciousness access and cognitive control. It arbitrates stimuli perception across all sensory modalities, throughout early and late processing

stages, in relation to their location in space and their relative position in the perceptual timeline (Chun, Golomb & Turk-Browne, 2011).

1.4.3.1 Spatial attention.

Spatial attention enables the preferential attribution of cognitive resources to relevant locations. Because of the richness of our visual environment, it plays a fundamental role in efficacious visual perception. Of course, proprioceptive and auditory stimulation both convoke the intervention of spatial attention as well, but visual perception is particularly dependent on it because of the limited scope of foveal acuity. Much like directing a spotlight (Cave & Bichot, 1999), spatial attention maximizes saccades towards task-relevant and inherently-attractive emplacements in order to process the information they harbor with the best possible resolution (*i. e.* foveal resolution). This particular control over saccadic movements is typically referred to as *overt attention*, and has evolved to the extent that the neural networks attributed to visual attention and ocular motion partially overlap (Corbetta *et al.*, 1998). Despite the preeminent role of saccades, however, spatial attention functions are not limited to orienting eye movements. Numerous studies have shown that when an individual is properly cued, attentional resources can also be distributed within her visual space *covertly*, *i.e.* without the need of directing saccades, as a strategy to compensate for peripheral lower resolution (Jonides & Yantis, 1988; Yantis *et al.*, 2002; Mulckhuysse & Theeuwes, 2010). Overt and covert attention shifts appear to share the same cortical structure, including activations in the precentral sulcus, intraparietal sulcus, and lateral occipital cortex (Beauchamp, Petit, Ellmore, Ingelholm & Haxby, 2001). The main difference between them extends to the particular neural

activity respectively involved in ocular motion (Beauchamp, Petit, Ellmore, Ingeholm & Haxby, 2001) and ocular motor suppression (Kulke, Atkinson & Braddick, 2016). In terms of oscillatory activity, spatial attention generally increases the synchrony between the posterior parietal cortex and the medial temporal area (Saalmann et al., 2002).

Cueing plays a fundamental role in both covert and overt spatial attention, as a trigger mechanism: exogenous cues can attract attention to their location because of how their physical properties appeal to sensory interphases preferentially (e.g., a flashing stimulus, a red dot), while endogenous cues can do so in a goal-directed fashion, as the result of top-down control (e.g., an arrow pointing to a certain location, an instruction to voluntarily attend to a certain space when a certain event happens, Macaluso & Doricchi, 2013). The facilitatory effects of cues vary depending on their nature and on their position relative to the target in the perceptual timeframe, but are broadly the same. However, stimulus-driven and goal-directed attention allocation operate at different timeframes, and through different cognitive and neural mechanisms: the robust differences and dissociation between them has led to the proposal of considering bottom-up and top-down attentions as completely different attentional components (Connor et al, 2004; Pinto et al., 2013). Bottom-up cueing is optimal at 70-150 ms before target presentation, which reveals an attentional component that consists of a transient, involuntary effect that facilitates simple immediate processing. This is a faster, different component from the slower, dilated attentional component that results from goal-oriented attention (Chun, Golomb & Turk-Browne, 2011). Furthermore, the neural activity related to target location manifest first in the prefrontal cortex for top-down oriented attention, but it does so in the parietal cortices for bottom-up cued shifts (Corbetta et al. 2008). Their oscillatory

activity also differs homologously, as frontal and parietal areas prioritize low-frequency synchronization for top-down shifts, and high-frequency synchronization for bottom-up cued shifts (Buschman & Miller, 2007).

Interestingly, the resource amplification granted by spatial attention comes not only as a result of location selection, but also location inhibition (Klein, 2000). When attention is diverted away from one location to the next across the duration of a task or a succession of tasks, the previously attended locations become temporally inhibited as a mean for facilitating attentional switching. This phenomenon is usually referred to as “inhibition of return” (Klein, 2000). Naturally, precise switching also depends on the inhibition of task-irrelevant locations that may be harboring distractors, which can be particularly challenging, if not impossible, when said distractors contain alerting features (*e.g.*, if they move) or task-relevant features (*e.g.*, red numbers among black numbers, in a red letters among black numbers detection task, Folk *et al.*, 1992; Folk *et al.*, 2002). Evidence shows that orienting and re-orienting attention towards key locations premeditatedly appears to recruit different brain networks than doing so spontaneously. The former involves the intraparietal sulcus, superior frontal and superior temporal cortex (Yantis *et al.*, 2002), while the latter depends fundamentally on the right tempoparietal junction (Corbetta *et al.*, 2008).

Despite its complexity, spatial attention’s capacity for selective improvement of processing is limited by its own resolution. The more densely-packed a given space is, the harder it becomes to single out a target among its distractors (Intriligator & Cavanagh, 2001). This is particularly true regarding the parafoveal and extrafoveal spaces, where attentional resolution drops together with visual acuity, but at a much higher rate, making stimuli ensembles much harder to disaggregate not only the

closer they are bound together but also the further they appear from the foveal space. Importantly, spatial attention resolution is not subserved by primary visual cortex, as attentionally-neglected stimulation still produce orientation-specific visual after-effects (He *et al.*, 1996).

The potential interactions between hypnosis and proper spatial attention have but began to be explored. Regarding hypnosis onset and its phenomenology, most theories of hypnosis agree that modulating the attentional focus on the perceptual environment constitutes a fundamental step for fostering hypnotic response (sections 1.2; 1.3.1), and several traditional induction techniques call for the participant to shut her eyes and successively displace her attentional focus around the room or around her body (Erickson, Rossi & Rossi, 1976). Furthermore, it is possible that the overlap between the brain regions controlling ocular motion and spatial attention could provide grounds for the claim that gaze-fixation and eye-rolling facilitate the induction of hypnotic responses (Spiegel & Spiegel, 2004).

The effects of hypnotic suggestion over spatial attention have also been probed only on a preliminarily basis. Only a handful of studies to date have actually explored how hypnotic suggestion could modulate spatial attention, even less so in relation to vision and awareness. Through a “hemispacial neglect” hypnotic suggestion, Oakley and Halligan (2009) managed to reproduce the symptoms of the hemineglect syndrome on a single “hypnosis virtuoso” participant, but did not test for any kind of unconscious processing on the hypnotically neglected visual field as is customary with this type of patients, leaving little information behind regarding how exactly encoding and attention allocation acted in the neglected space. Priftis *et al.* (2011) developed Oakley and Halligan’s idea further, and implemented a “neglect posthypnotic suggestion” on a number of participants highly susceptible to hypnosis,

suggesting that the participants' visuospatial attention would become locked onto only one side of their visual space. The utilization of a posthypnotic suggestion in this particular case is important, since this kind of suggestion allows participants to get "back to their senses" before engaging on the target task, preventing contaminations from relaxation or demand characteristics. While under the effect of posthypnotic suggestion, participants were asked to fixate their gaze on the center of the screen and then perform a simple detection task at both sides of fixation. While very far from actual blindness or total lack of awareness, Priftis *et al.*'s participants did show significantly slower response times for the identification of the "neglected" stimuli.

In the present thesis, we attempted to further our knowledge on the interactions between hypnotic responding and visuospatial attention beyond these limitations, through an adapted version of the consciousness-threshold detection paradigms (Del Cul *et al.*, 2006, 2007, 2009; Reuter *et al.*, 2007). These paradigms would typically consist of a blank screen; while fixating on its center, participants would be required to detect or discriminate peripheral targets; almost always, peripheral targets would be masked. Like so, such paradigms are attuned to test for task performance, priming effects and both objective and subjective visibility in the periphery (Del Cul *et al.*, 2006, 2007, 2009; Reuter *et al.*, 2007). We emulated these experimental setups, but replaced masking and other forms of physically diminishing stimulus energy by our posthypnotic suggestion: a hypnotic instruction to not attend the periphery, inspired on the "tunnel vision" effect from the Balint Syndrome (Edgette & Edgette, 1995).

1.4.3.2 Temporal attention.

Temporal attention manages the distribution of cognitive resources across the stimuli presentation timeline. Its role is similar to that of spatial attention inasmuch as it also optimizes processing face to reduced resolution (temporal, rather than spatial) and efficiently switches from one (temporal) locus to the other (Potter, 1975; Thorpe *et al.* 1996). Despite their closeness, temporal attention constitutes its own dissociable mechanism; its effects are additive to those of spatial attention (Doherty *et al.*; 2005), and the two do not interfere with each other when evoked simultaneously (Correa & Nobre, 2008). Target-search tasks in rapid serial visual presentation settings have shown that temporal attention grants a fully conscious sampling rate of 10 Hz for single complex image detection (Thorpe *et al.* 1996), although constraints become much stronger and resolution plummets when participants are asked to report or memorize two or more targets (Raymond, Shapiro & Arnell 1992; Chun & Potter, 1995).

One of the best researched experimental paradigms for probing temporal attention resolution and the effects that temporal attention deprivation can have on target detection and discrimination is the Attentional Blink (AB, Raymond, Shapiro & Arnell 1992). The AB paradigm intersperses two targets (T1, T2) within a series of distractor stimuli, and rapidly displays them in succession at the same location. Typically, when the time lag between T1 and T2 is short enough, the attentional resources invested in detecting and acting upon T1 fail to be diverted in time to T2, causing an attentional “blink” that can impact negatively on the performance of T2-related tasks, performed at the end of the Rapid Serial Visual Presentation (RSVP). This deficit has been confirmed to be attentional in nature, since it disappears when T1 is absent, or when cueing allows participants to ignore it. As pointed out by Anderson (2005), the AB

paradigm reflects how attentional limitations during encoding restrict perceptual awareness (Raymond, Shapiro & Arnell 1995; Jiang & Chun, 2001). Even though the AB is of post-sensory locus and does not accurately portray the degradation of early sensory processing (Luck, Vogel, Shapiro, 1996), it still demonstrates that perceptual encoding depends on a funnel-like, immediate consolidation process mediating the entry of perceptual information into working memory (Vogel, Luck & Shapiro, 1998). Much like with items neglected as a result of spatial attention deficit, neuroimaging and priming studies have shown that missed T2s, while unreportable, can be processed up to their semantic identity (Luck *et al.* 1996, Marois *et al.* 2004).

The phenomenon of temporal attention resolution limiting perceptual awareness has been subjected to different interpretations. Traditionally, it has been suggested that encoding a target amongst distractors constitutes a serial task, namely, that only one target can be singled out and committed to memory a time. In this view, a first, rapid attentional component warrants target identification, which in turn gives rise to a second, slower encoding phase that depletes the systems' attentional resources; any other supplementary targets arriving within the same processing window may go as far as having their features integrated into a representation with sense, but would escape the higher-order operations that grant conscious awareness (Chun & Potter, 1995; Jolicoeur, 1999). A more recent view, however, proposes that temporal attention privileges T1 treatment by inhibiting the re-engagement of attention for future targets, in a phenomenon similar to that of spatial inhibition (Di Lollo *et al.*, 2005; Olivers & Meeter, 2008). This new idea is appealing for several reasons; not only does it bring spatial and temporal attention closer together, but it also provides an explanation to phenomena intestine to the AB. For instance, if the blink were a result of resource depletion, we would expect it to remain immutable as long as there

is T1 processing; yet implementing strategic cueing favoring T2 or tampering with T2's emotional salience can successfully attenuate its effects (Nieuwenstein *et al.*, 2005). Additionally, the Lag 1 Sparing effect¹ has shown that in most AB settings, attentional focus can expand to encode T1 and T2 with the same efficacy as long as both are equally strong and happen contiguously (*i. e.*, at lag 1); an event more consistent with the inhibition hypothesis than with the more rigid alternative of single-target resource depletion (Hommel & Akyürek, 2005; Akyürek & Hommel, 2005; Di Lollo *et al.*, 2005).

Hypnosis research regarding time has been to date mostly focused on the subjective aspects of time perception while under the effects of hypnotic suggestion, and have only touched upon temporal attention marginally, as the levels of attention or expectancy are known to modulate subjective time even though objective time is constant (Martin *et al.*, 2016). To our knowledge, no real efforts have been pursued to date to combine hypnotic suggestion with the AB paradigm, or more specifically, with elements that could attenuate or enhance the blink. We propose that pursuing this line of research would constitute an opportunity to see how hypnosis interacts with temporal attention at the earlier and later levels of perception, and how exactly hypnotic induction and suggestion are modulated by the lack or inhibition of attentional resources that the AB fosters.

¹ The “Lag 1 sparing” is a widespread (albeit not universal) phenomenon by which T2s with a lag of 1 are exempted of the attentional interference exerted by the blink. Several different explanations as to why this occurs have been proposed (Raymond, Shapiro & Arnell, 1992). Some consider that temporal attention resolution is high enough for subsequently allocating attention to a T2 that is immediately contiguous to a T1, while others propose that due to the closeness between targets, T1 and T2 are targeted and perceived as part of the same perceptual instance (Chun *et al.*, 2011).

1.5 Hypnosis, a matter of attention. (*The contributions of this thesis*)

1.5.1 French norms for the Harvard group scale of hypnotic susceptibility

(Form A)

We have presented the normative data on our French translation for the Harvard Group Scale of Hypnotic Susceptibility (Form A), and successfully compared it to other validations of its kind. The development and validation of the French Harvard Scale was a necessary step in the pursuit of our research goals; it was with this French version of the scale that we screened for suggestibility the pool of over 500 participants that we later convoked for our other experiments. Furthermore, we tackled an issue typically neglected in hypnotizability norms validation studies: the impact of volition on the behavioral success of suggestions, and hence in hypnotizability scores. This being a validation study, we committed to the traditional statistical tools that hypnotizability norms habitually implement, but we also capitalized on the Kihlstrom's Involuntariness Scale output to produce an additional set of hypnotizability rates, more sensitive to voluntariness. Kihlstrom's Involuntariness Scale questions participants on a scale of 1 to 5 as to how much were their responses to suggestions voluntarily enacted, and how much did they happen "on their own". Since the loss of the agency that corresponds to performing a suggested action is considered hypnosis' hallmark trait (Kihlstrom, 2008), we deemed of the utmost importance to include the subjective judgments as something more than a simple subsidiary index. Besides, using values adjusted for involuntariness we significantly reduced hypnotizability overestimations.

1.5.2 Hypnosis enhances attentional modulation of visual awareness.

Following some of the experimental key venues that we outlined in the introduction, in the present work we decided to expand the research on posthypnotic suggestion and spatial attention, paying particular attention to the interaction between hypnotic visual attentional neglect and reduced peripheral attentional resolution. While attention and conscious awareness are not the same thing, and the allocation of the former does not mandate the emergence of the latter (Hsieh *et al.*, 2011), attention does play a fundamental role in gating the information that reaches awareness (Cohen *et al.*, 2012). Capitalizing on this fact, reduced peripheral spatial attention has often been hijacked for fostering subliminal priming through the masking and crowding of rapid peripheral stimulation (Del Cul *et al.*, 2006, 2007, 2009; Reuter *et al.*, 2007). Here, we presented our work on the effects of posthypnotic suggestion over visuospatial attention, at the levels of both automatic visual processing and subjective visual awareness. Our experimental question was twofold. First, in terms of intrinsic hypnosis research, we wanted to establish the extent to which visuospatial attention conditioned the effects of hypnotic responding, and how efficiently could posthypnotic suggestion orient endogenous attention allocation. Second, in terms of instrumental research, we wondered if such a suggestion would suffice to deter subjective and objective perception of the hypnotically unattended targets as a replacement of physical crowding or masking, at different levels of stimulus energy. Crucially, an affirmative answer to the latter question would imply that posthypnotic suggestion could successfully modulate the threshold of access to consciousness. We put our hypothesis to the test through a posthypnotic suggestion based on the Balint Syndrome, coined to create a hypnotically unattended peripheral space. We then tested High and Low susceptibility participants on the detection and

discrimination of targets displayed at the hypnotically unattended space. Highs reported a subjective visibility decrease on peripheral targets (as opposed to Lows). However their performance on also evidenced an absence of semantic priming effects on behalf of hypnotically unattended primes. This absence of unconscious treatment suggested that hypnosis did not seem like a suitable tool for simply turning a given supraliminal stimulus into a subliminal one. Rather than physically preventing stimuli from becoming visible by forcing them below the threshold of access to consciousness, hypnotic perceptual and cognitive alterations were more of a balance between suggestion, expectation and task instructions that led the highly hypnotizable individuals to integrate the three in the form of high-order strategies that privilege conflict reduction.

1.5.3 Hypnosis hampers emotion-driven automatic attention allocation through cognitive control

On the third and final work of this thesis, we tested the capability of hypnotic suggestion to modulate the automatic attention allocation granted by the anger-superiority effect (Yao *et al.*, 2013). We did so by testing participants of low, medium and high hypnotic susceptibility in the framework of an attentional blink paradigm that used angry and neutral faces as stimuli. But most importantly, we combined this paradigm with an emotional numbing hypnotic suggestion (Bryant & Mallard, 2002; Bryant, 2005; Bryant & Kapur, 2006) aimed at desensitizing participants to the menacing value of angry expressions. This allowed us to study the automatic attention allocation evoked by the Anger Superiority and its effect as a modulator of the blink, at incrementally different levels of temporal attention. Crucially, it also allowed us to evaluate the extent to which the hypnotic suggestion managed to undo the influence that the Anger Superiority effect had on the blink, and on task

performance altogether. The fact that we executed such modulation within the context of an RSVP allowed us to use the blink as a form of temporal tag on stimulus processing, thus getting a hold of the influence of temporal resolution on the dynamics of hypnosis. We also incorporated a control group, who performed the task in equal conditions of motivation, but without any suggestion (hypnotic or otherwise) and without hypnotic induction. Our results confirmed that our hypnotic suggestion for emotional numbing hampered the modulations that the Anger Superiority effect exerted over the Attentional Blink, and attenuated the differential attentional capture exerted by angry over neutral faces, in a manner coherent with participant hypnotizability and suggestion content, by enforcing changes in cognitive control. However, our results suggest that while the modulation of Anger Superiority itself did depend on the hypnotic suggestion and participants' hypnotizability, the actual disruption of the link between Anger Superiority and the Attentional Blink was a result of hypnosis' general impact on cognitive load, and the changes it fostered on the attentional task set, regardless of hypnotizability.

2. Experimental Studies

2.1 French norms for the Harvard group scale of hypnotic susceptibility (Form

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2.1.1.1 Highlights

*We present the normative data on the Harvard French translation, and compare it to other validations of its kind.

*We tackle an issue typically neglected in hypnotizability norm validation studies: the impact of volition on the behavioral success of suggestions, and hence in hypnotizability scores.

*We use the Involuntariness Scale output to produce an additional set of hypnotizability rates, more “sensitive” to voluntariness.

2.1.1.2 Keywords

Hypnosis; Hypnotic susceptibility; HGSHS:A; Involuntariness

2.1.2 Paper.

2.1.2.1. Abstract: The authors present the French norms for the Harvard Group Scale of Hypnotic Susceptibility, Form A (HGSHS:A). They administered an adapted translation of Shor and Orne's original text (1962) to a group of 126 paid volunteers. Participants also rated their own responses following our translation of Kihlstrom's Scale of Involuntariness (2006). Item pass rates, score distributions, and reliability were calculated and compared with several other reference samples. Analyses show that the present French norms are congruous with the reference samples. Interestingly, the passing rate for some items drops significantly if "entirely voluntary" responses (as identified by Kihlstrom's scale) are scored as "fail." Copies of the translated scales and response booklet are available online.

2.1.2.2 INTRODUCTION

Several recent reviews have pointed out the potential of hypnotic suggestion as a tool for cognitive research (Cardena, 2014; Egner & Raz, 2007; Kihlstrom, 2013, 2014; Landry, Appourchaux, & Raz, 2014; Oakley & Halligan, 2013). Suggestions can temporarily alter perception in a controlled fashion, producing effects that range from perceptual degradation to eliciting hallucination (see Oakley & Halligan, 2013, for a review). Their degree of effectiveness, however, is mediated by each subject's individual level of hypnotizability (Kihlstrom, 2013; Oakley & Halligan, 2013). Hence, determining hypnotic responsiveness constitutes a fundamental echelon in hypnosis research. The standard for categorizing hypnotizability is the Stanford Hypnotic Susceptibility Scale, Form C (SHSS:C; Weitzenhoffer & Hilgard, 1962). This

individual test exposes the subject to a variety of suggestions and then rates them on a “pass/fail” basis. A general score is computed, based on the objective behavioral response of the participant.

It has already been repeatedly shown across the normalization of this same protocol and others like it (see, for instance, Laurence & Perry, 1982; McConkey, Barnier, Maccallum, & Bishop, 1996; Shor & Orne, 1962) that only a small amount of the population presents the trait of very high hypnotizability. Screening through sizable groups is the only way of assuring a large enough sample of individuals capable of responding to very demanding hypnotic suggestions. Therefore, when designing suggestion-based protocols, the Stanford scale can be too resource intensive.

To address this issue, Shor and Orne created the Harvard Group Scale of Hypnotic Susceptibility, Form A (HGSHS:A; 1962), which presents several advantages over the SHSS:C: it does not call for any props, it can be administered virtually anywhere, and it offers reliable and efficient individual ratings for large groups on one single screening. Whether employed on its own or as a prescreening test for the SHSS:C, the HGSHS:A has been to date the tool of choice in dozens of studies for assessing individual differences in hypnotizability (Benham, Smith, & Nash, 2002; Carvalho, 2013). Much like its predecessor, the Harvard scale presents three parts. First, an introduction phase aimed to reassure the subjects and to demystify hypnosis. Second, an induction phase carefully designed to increase relaxation and mental absorption. Finally, a suggestion phase presenting 12 suggestions with known differences in difficulty.

A crucial issue, typically neglected in hypnotizability norm validation studies, is the impact of volition on the behavioral success of suggestion and, hence, in

hypnotizability scores. As was pointed out by Cunningham and Ramos (2012, p. 417), on its own, the HGSHS:A fails to assess whether successful responses to the suggestions are due to a “classic (*i.e.*, involuntary and automatic) suggestion effect” (Bowers, 1981; Weitzenhoffer, 1980), or if the suggested behavior simply stems from the active and willing participation of the subjects. Dissociative models of hypnosis (Bowers, 1992; Hilgard, 1977) and dissociative cognitive approaches to hypnosis (Dienes & Perner, 2007) crucially associate hypnotic suggestion with an alteration of selfhood and agency that manifests itself as an apparent dilution of volition and adequate executive monitoring (Rainville & Price, 2003). Hence, in order to take into account this demand and offer an additional measure of hypnotizability, we decided to also present our participants with Kihlstrom’s Scale of Involuntariness (2006, as adapted to be used with the HGSHS: A) and used it to produce an additional set of hypnotizability rates. The Kihlstrom scale assesses, for every participant, whether his or her response to each suggestion was “voluntary” or “involuntary” (*i.e.*, autonomously generated). For the purpose of generating this additional set of corrected results, suggestions that were marked as successful in the HGSHS:A but later acknowledged as fully voluntary were discarded and treated as failed (*i.e.*, not “passed”) items.

We present data on the French translation of the HGSHS:A and Kihlstrom’s complementary Scale of Involuntariness (2006) and compare it to other validations of its kind: the American normative data (for being the original study), the Australian sample (for being by far the largest), and, notably, with the Canadian normative data obtained by Laurence and Perry in 1982 (the only other sample in French). It should be noted that, while the aforementioned study also implied a French translation,

important dialectal and cultural differences between France and Canada, the 40-year gap between studies and, crucially, as disclaimed by the authors themselves, the wide linguistic heterogeneity of their original sample are reason enough to elaborate and validate a set of norms suited to the French population. Finally, a comparison to the German, Spanish, and Portuguese norms was added in order to further compare the norms to other romance and nonromance European samples. It should also be noted that all results stemming from the implementation of this protocol and others like it can only be interpreted as final in the context of cognitive research. Strict ecological and deontological differences exist between hypnosis in research and hypnosis in the clinical environment, and the interplay between the two has been occasionally considered but still needs to be carefully studied (Perry, Gelfand, & Marcovitch, 1979). A low score in hypnotic susceptibility from the Harvard group scale will not necessarily translate to an impossibility to undergo a hypnosis-based medical or psychological treatment (J. Barber, 1980).

2.1.2.3 METHOD

2.1.2.3.1 Participants

Participation was voluntary in exchange for 12.5 € for a 1-hour-and-40-minute session. Participants were all contacted by e-mail and were recruited through official laboratory recruitment channels. They were told that they would take part of a group experiment to evaluate their response to hypnotic suggestion but were warned since first contact that all levels of susceptibility were relevant for the present study and that their response, if any, to the procedure had no impact on their monetary compensation. It was also clearly stated that the authors did not have any

expectation about their performance. The whole experiment took place over 12 sessions in the year 2014, in a room conditioned specifically for the experiment and in groups that varied from 5 to 20 people.

A total of 126 native-French speakers aged between 18 and 35 (95 female) attended the sessions and followed the entire process until completion of the response booklets. As many as five booklets were discarded for lack of compliance with the terms of the instructed task (three incomplete, two improperly filled), leaving a total of 121 for subsequent analysis. Six other participants were rejected (N = 115) after manifesting improper behavior during the task (*i.e.*, falling asleep, talking, or refusing to participate).

2.1.2.3.2 Materials

The HGSHS:A was translated by the first and third authors, both fluent in English and French, and later moderately modified by the first and second authors so that the delivery of all 12 suggestions would accommodate to a slightly less directive paradigm of hypnosis (Erickson, Rossi, & Rossi, 1976; Lankton & Lankton, 1983; Yapko, 1983), while still remaining true to its original structure and content. Such modifications comprised the elimination of most references to hypnosis as “sleep” (except those in which the term sleep is used merely with a comparative value), the insertion of additional dubitative adverbs (*i.e.*, “your eyes are now tightly shut, maybe”), positive reinforcement in key positions (*i.e.*, “your breath becomes deeper and deeper, yes, very good”), and the replacement or elimination of certain lexemes that could be interpreted as affectively negative (*i.e.*, “These suggestions will not bother you” was replaced by “You will be ok with these suggestions”). Importantly, the structure of the script and of each suggestion were left untouched. In order to

check the quality of the resulting translation and to make sure that the introduced changes would not alter the actual meaning of the text or its pace in any fundamental way, a bilingual French-English linguist independent to the study first translated our rendering of the scale back into English and then compared it to Shor and Orne's text, reaching the conclusion that the translation was consistent with the original.

2.1.2.3.3 Procedure

Participants were first presented with a written consent, which they had to sign to be able to remain in the room for the session (no participants left the room). Then, the instructions prescribed in the original HGSHS were followed to the letter (Shor & Orne, 1962). Subjects received a translated version of the original response booklet and were told not to interact with it until so told except to write their personal information on the cover. The second author, an MD and hypnotherapist, presented an explanation aimed toward demystifying the practice of hypnosis, addressing some of the most common questions on the subject and correcting some common misconceptions nurtured by folk hypnosis, fiction, and the media. He then would seamlessly proceed to start the experiment by reading the script. The first author would also stay in the room to monitor the participants. By the session's end, participants were guided through the completion of the response booklet in accordance with Shor and Orne's original indications. Once all booklets were collected, participants were encouraged to ask questions and discuss their experience with the authors.

2.1.2.3.4 Scoring, Correction for Involuntariness, and Outliers

Just like with the original, a single point was assigned if the suggestion was carried out successfully. The amnesia suggestion was reverse scored, namely a point was

assigned only if the participant recalled three items or less before the signal to lift the amnesia and two or more additional items immediately afterwards (Kihlstrom & Register, 1984). Points were added together to establish a score over 12.

All booklets were scored by the first author. Then, a random sample of 45 booklets plus the five incomplete booklets were mixed together and given to an independent scorer with no ties to the project. All rejected booklets were rejected again, and only two booklets were rated differently, by one point (the amnesia suggestion). These differences did not imply a change of category in any of the involved subjects. To quantify the impact of involuntariness on the sample spread, we utilized Kihlstrom's complementary Scale of Involuntariness (2006) to elaborate an additional "corrected" version of the sample. In this extra version, all suggestions ranked as "I did not respond at all during this time" or "My response was mostly voluntary" were marked as failed, regardless of the objective response section input. We provide separate analysis and present the results for both the corrected and uncorrected versions of the French sample in the results section.

2.1.2.4 RESULTS

2.1.2.4.1 Gender Differences

Given the large size difference of male and female participants (91 female, 24 male), a permutation test with 1000 permutations was used to calculate the significance of the difference between mean hypnotizability of gender groups. No significant difference was found for mean hypnotizability across genders in the sample for either the corrected ($p = .55$) or uncorrected ($p = .48$) datasets. Hence, all data were pooled together.

2.1.2.4.2 Mean Total Scores and Distribution

All analyses comprised the entire remaining sample of 115 participants. As shown in Table 1, mean scores and sample distribution were calculated twice, on the raw data and after applying the correction for involuntariness. Following the same criterion as in Laurence and Perry (1982), we separated the participants into four categories depending on their level of suggestibility: high (scores between 10–12), medium high (7–9), medium low (3–6), and low (0–2). For the uncorrected data, 31% of participants were ranked in the “high” category, 44% in the “medium high,” 22% in “medium low,” and 3% in the “low” category. For the corrected sample, which took into account the voluntariness of the response, 15% of the subjects were considered as high, 37% as medium high, 38% as medium low, and 10% as low. This difference between samples portrays a shift toward higher levels of hypnotizability in the uncorrected scores.

Table 1
Score Distribution for the Corrected and Uncorrected Instances of the French Sample

Total Score	Uncorrected			Corrected		
	No. of Cases	%	Cumulative %	No. of Cases	%	Cumulative %
0	0	0	0	3	2.6	2.6
1	0	0	0	4	3.5	6.1
2	4	3.5	3.5	5	4.3	10.4
3	4	3.5	7	15	13	23.4
4	6	5.2	12.2	7	6.1	29.5
5	4	3.5	15.7	11	9.6	39.1
6	11	9.6	25.3	11	9.6	48.7
7	12	10.4	35.7	8	7	55.7
8	13	11.3	46.9	17	14.8	70.5
9	25	21.7	68.6	17	14.8	85.3
10	21	18.3	86.9	11	9.6	94.9
11	12	10.4	97.3	5	4.3	99.2
12	3	2.6	100	1	0.8	100
High (10–12)	36	31	31	17	15	15
Medium-High (7–9)	50	44	75	42	37	52
Medium-Low (3–6)	25	22	97	44	38	90
Low (0–2)	4	3	100	12	10	100

In order to assess the significance of such differences, we proceeded to compare the spread of the score across participants before and after the correction, as well as individual success rates for every suggestion, sample means, and standard deviations (SD). Figure 1a presents all item pass rates and means. Success rate is higher across items for the uncorrected sample and so is the sample mean. As shown in Figure 1b, a repeated-measures analysis of variance (ANOVA) test points to a significant main effect of correction for the difference between the samples, $F(1, 114) = 98.87, p < .0001$. When scouting each suggestion individually, a logistic regression shows (after correction for multiple comparison) a value of $p < .01$ for the difference between samples in the “Finger interlocking” suggestion and, crucially, $p < .0001$ for the “Posthypnotic Suggestion.”

Values of both the corrected and uncorrected sample means (6.35 and 8) are in the range of the reference samples (United States: 7.39; Canada: 5.38; Australia: 5.45; Germany: 6.51; Spain: 7.13; Portugal:

6.73) with the values for the uncorrected sample ranking on the higher end of the group.

2.1.2.4.3 Item Difficulty

Table 2 shows the item pass rates, means, and standard deviations for the corrected French sample and the reference samples. The highest pass rates for the French sample were found in Item 1 (head falling), Item 3 (hand lowering), and Item 7 (hand moving), all in the range of the reference samples. In particular, these three items are also the three highest-ranked items in the U.S. original sample obtained by Shor and Orne. One item (the fly hallucination, 18% and 14% for the uncorrected and corrected samples, respectively) was ranked substantially lower than the reference samples but

was still congruous with several other samples that have pointed out this item as particularly hard to pass, such as the Portuguese (fly hallucination: 12%), Swedish (14%), and Polish (12%) samples (Carvalho, 2013).

2.1.2.4.4 Reliability

Table 3 displays the impact across samples of each item against the total scale (point-biserial coefficients of correlation between each suggestion and the sum of all other suggestions) and the total scale reliability (Kuder-Richardson coefficient of reliability; Hoyt, 1941). The magnitude of the correlation coefficients for the French Sample (corrected: .8; uncorrected: .7) are comparable to the Australian (.76), Canadian (.84), American (.8), Spanish (.68), German (.62), and Portuguese (.63) samples.

Figure 1
Impact of involuntariness on individual suggestions and overall hypnotizability scores.

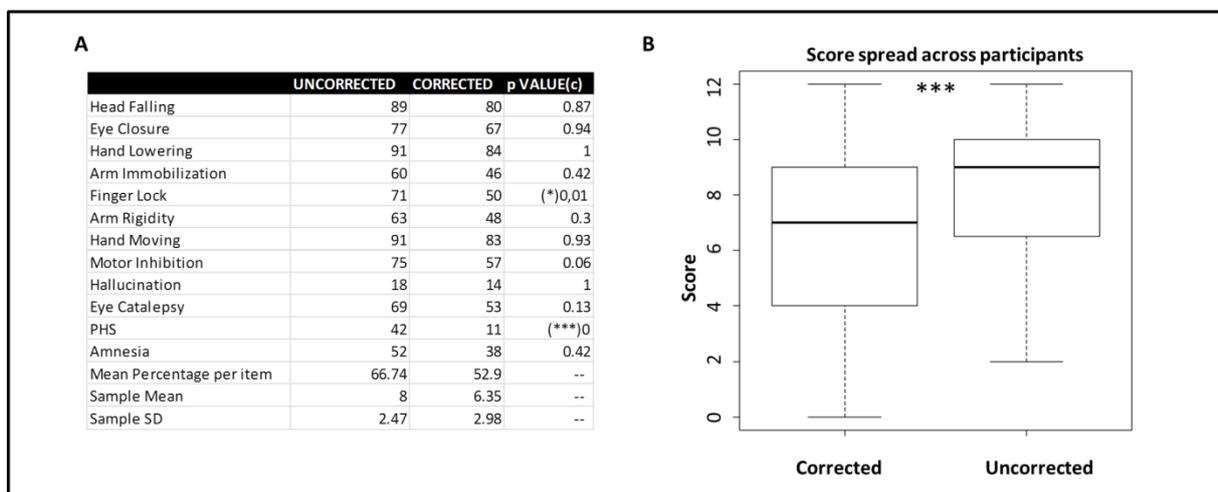


Figure 1. Impact of involuntariness on individual suggestions and overall hypnotizability scores. **A.**

Item Pass Rates (%), means, and standard deviations for the corrected and uncorrected French Samples. After correction for multiple comparison (*12), logistic regression shows $p < .01$ for the difference in the “Finger interlocking” suggestion and, crucially, $p < .0001$ for the “Posthypnotic Suggestion.” (PHS: Posthypnotic Suggestion; SD: standard deviation; (c): corrected for multiple comparison). **B.** Scores spread across participants. Repeated-measures ANOVA for the difference shows $F(1,114) = 98.87, p < .0001$.

Table 2
Item Pass Rates, Means, and Standard Deviations for the French and Reference Samples

	FRAu (115)	FRAc (115)	USA (132)	AUS (1944)	CAN (535)	GER (374)	SPA (220)	PRT (313)
Head Falling	89	80	86	61	65	73	73	58
Eye Closure	77	67	74	57	63	73	64	60
Hand Lowering	91	84	89	71	66	83	60	68
Arm Immobilization	60	46	48	36	47	52	58	57
Finger Lock	71	50	67	53	50	57	67	75
Arm Rigidity	63	48	57	41	47	52	69	65
Hand Moving	91	83	86	71	64	74	79	67
Motor Inhibition	75	57	50	42	43	49	74	51
Hallucination	18	14	56	25	36	47	29	12
Eye Catalepsy	69	53	56	38	36	47	59	46
PHS	42	11	36	17	15	31	29	44
Amnesia	52	38	48	33	19	36	52	72
Mean Percentage per Item	66.74	52.9	61.3	45	44.8	56.1	59.4	56.3
Sample Mean	8	6.35	7.39	5.45	5.38	6.51	7.13	6.73
Sample SD	2.47	2.98	3.04	2.95	3.28	2.43	2.61	2.51

Note. FRAu: French sample, uncorrected; FRAc: French sample, corrected; AUS: Australia; CAN: Canada; GER: Germany; SPA: Spain; PRT: Portugal; PHS: Posthypnotic Suggestion; SD: standard deviation.

Table 3
Item-Scale Correlation and Total Scale Reliability for the Corrected French and Reference Samples

	FRAu (115)	FRAc (115)	USA (132)	AUS (1944)	CAN(535)	GER(374)	SPA(220)	PRT(313)
Head Falling	.27	.37	.34	.39	.44	.21	.3	.29
Eye Closure	.29	.45	.3	.39	.51	.06	.27	.28
Hand Lowering	.25	.42	.48	.25	.44	.25	.09	.28
Arm	.34	.39	.66	.36	.53	.33	.38	.31
Finger Lock	.66	.66	.86	.59	.71	.42	.52	.34
Arm Rigidity	.41	.5	.89	.55	.7	.42	.51	.43
Hand Moving	.38	.4	.44	.42	.6	.18	.22	.35
Motor Inhibition	.84	.7	.78	.51	.65	.38	.4	.43
Hallucination	.4	.39	.48	.34	.53	.23	.31	.1
Eye Catalepsy	.7	.45	.74	.53	.75	.47	.46	.45
PHS	.05	.36	.46	.18	.47	.14	.11	.03
Amnesia	.31	.36	.39	.18	.65	.09	.18	.02
----- Kuder-Richardson total scale reliability	.7	.8	.8	.76	.84	.62	.68	.63

Note: FRAu: French sample, uncorrected; FRAc: French sample, corrected; AUS: Australia; CAN: Canada; GER: Germany; SPA: Spain; PRT: Portugal; PHS: Posthypnotic Suggestion.

2.1.2.5 DISCUSSION

We have presented and analyzed the data for our French translation of the HGSHS:A and Kihlstrom's Scale of Involuntariness. Comparisons with the reference samples indicate that our normative data are congruous with the preexisting results. Interestingly enough, this statement holds true for both before and after correcting with Kihlstrom's scale of voluntariness, albeit with some differences that deserve our attention.

We can enumerate a number of factors that could have led to this state of affairs: First, we may have inflated demand characteristics or social expectation effects. Even when participants were told that their susceptibility to suggestion was of no consequence for their involvement in future experiments and that the experimenters were neutral with respect to the level of hypnotizability of each participant, the fact that the scale was administered by a trained professional instead of a recording could have had an impact on subjects' criteria and could lead them to attribute expectations to the experimenters nonetheless. Furthermore, while indeed some studies have pointed out a lack of any significant differences between recorded hypnosis and live suggestion (T. Barber & Smith, 1964), no study was ever performed comparing the difference between recordings and live suggestion while at the same time assessing voluntary versus automatic (or "dissociated") responses.

Second, the mild changes targeting the directive modus of the original scale could have played a part, although we believe that this is not probable. Research as to whether less-directive hypnosis is indeed more effective, or different, than earlier more directive approaches is contradictory and unclear. Mostly, though, it declares that there are no significant differences between both methods (for a detailed review

on this matter, see Lynn, Neufeld, & Maré, 1993). The changes in the present version aspired simply to offer the French-speaking community a modern translation that, while staying true to the directive nature of the original, would be more consonant with the clinical practice. It should be noted that the goal of this work was not to produce a new scale: Other purely indirect scales such as the Alman-Wexler Indirect Hypnotic Susceptibility Scale (AWIHSS) were already produced to this end (Pratt, Wood, & Alman, 1984). Rather, it was aimed to adapt the use of Shor and Orne's existing scale to the dominant contemporary style of induction procedure in the French-speaking community.

Finally, it could be that none of the aforementioned factors on one's own, but rather an interaction between them, is responsible for the differences we found. It should be noted though that the corrected data fit the reference criteria even better than that of the uncorrected sample. The popularity of hypnosis is high in French society: It could be the case that the participants of this study were very motivated to pass as many suggestions as possible, even when instructed to "simply let go and let things happen spontaneously." If indeed this was the case, then our correction was a useful tool to eliminate such contamination. A larger study applying this correction on different samples and countries should be conducted to generalize its beneficial effects on raw data. Yet, we advise that if a strict "classic (involuntary, autonomous)" effect is to be sought, then the implementation of our correction can prove of use to successfully avoid false positives, particularly for posthypnotic suggestions of a motor nature.

In all, the data we have reported indicate that the French norms concur with those of the three selected reference samples. Beyond the differences that we outline, it can be seen that the progression in item difficulty and biserial correlations, as well as the internal scale consistency, are in line with data from the other norms. Taken together,

these elements validate the viability of our French translation of the HGSHS: A and the Involuntariness Scale as tools for acquiring initial ratings of hypnotizability and further advance hypnosis research in the francophone scientific and clinical hypnosis community.

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2.2 Posthypnotic redirection of visuospatial attention hampers semantic priming and subjective visibility.

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2.2.1.1 Highlights

* We developed a novel paradigm for testing the precise influence of posthypnotic suggestion over spatial visual attention at increasingly different levels of stimulus energy.

* Our posthypnotic suggestion for peripheral visual inattention hampered subjective visibility of highly hypnotizable participants and dissipated priming effects stemming from peripheral primes.

* Highly susceptible participants showed reduced subjective visibility of targets affected by the suggestion, but even more so when receiving a hypnotic induction as complement to the suggestion.

2.2.1.2 Keywords

Hypnosis; Hypnotic Induction; Posthypnotic Suggestion; Visuospatial Attention; Subjective visibility; Semantic Priming.

2.2.2 Paper

2.2.2.1. ABSTRACT

To test the specific effects of hypnosis on the attentional components of visual perception, we developed a posthypnotic suggestion for peripheral visual inattention inspired on the “tunnel vision” symptom of the Balint Syndrome. We constructed a dual-target visibility and discrimination paradigm, in which single-digit numerical targets were placed both on the hypnotically affected peripheral space and on the remaining undisturbed central area. Our design allowed us to test the effects of our manipulation on subjective visibility of hypnotically affected targets and over priming between affected and spared targets. Results showed that participants highly susceptible to hypnosis presented decreased subjective peripheral visibility, and were unaffected by the priming effects triggered by hypnotically unattended primes. We conclude that while hypnotic manipulation of visuospatial attention can successfully produce experiential changes, it does in addition block subliminal and preconscious perception. Thus we conclude that its effects on visibility result from cognitive control strategies that deem unattended secondary information as task-irrelevant and discard it untreated.

2.2.2.2 INTRODUCTION

Much has been written about the promising venues of hypnosis as a tool for cognitive research (Oakley and Halligan, 2009, 2013; Raz, 2011). In particular, recent reviews have proposed that hypnotic negative and positive hallucinations would be a valuable asset for the study of consciousness (Landry, 2014; Kihlstrom, 2014). The rationale behind such affirmation stems mainly from the theoretical claim that

hypnosis can alter percept consolidation by fostering a downplay of bottom-up perceptual information while simultaneously privileging the integration of endogenously-generated features (Brown & Oakley, 2004; Terhune *et al.*, 2017). It has been argued that this top-down dismissal of perceptual information could potentially replace the physical modulation of stimulus energy, customarily used in the fostering of preconscious and subliminal perception. It may thus constitute an alternative for the study of unconscious perception, one without the hindrances of physically degraded stimulation (Landry, 2014).

However, the exact psychological mechanisms by which hypnosis enacts this top-down control remain a matter of debate (Terhune *et al.*, 2017). In recent years, some authors have proposed that hypnotic responding could be understood as the result of a particular instance of altered attention— more specifically, a form of top-down-driven “selective inattention” (Lifshitz *et al.*, 2012; McLeod, 2011; Raz 2005, 2011; Terhune *et al.*, 2017). This notion originated from the seminal work of Raz *et al.*, in which the experimenters used a hypnotic alexia suggestion to successfully hamper the Stroop effect (Raz, Fan & Posner, 2005), and concluded that the obtained results implied a detour of the otherwise automatic attention allocation that supports both the reading process and the semantic processing of words (MacLeod *et al.*, 1991; Neely, 1991).

While the aforementioned work sprung new venues of research pertaining the effects of hypnosis over automatic attention allocation and the conciliation of cognitive conflict (Raz, Kirsch, Pollard, & Nitkin-Kaner, 2006; Terhune *et al.*, 2010, Augustinova & Ferrand, 2012), a finer-grained study of the effects of hypnotic suggestion, induction and hypnotizability over the entire spectrum of cognitive mechanisms that compose attention remains direly needed. We have to date little

knowledge as to how the concrete temporal and spatial dynamics of attention unravel during hypnotic responding, and the limits of how much (or how little) hypnosis can tamper with attentional resources are yet unclear (Terhune *et al.*, 2017).

Since models of consciousness such as the Global Neuronal Workspace consider attention to play a key role in allowing stimuli into awareness (Dehaene, Changeux, Naccache, Sackur & Sergent, 2006), uncovering to what extent can hypnosis constrain or expand attention selectively and at precise points in time would constitute a fundamental step in the process of proving whether hypnotic suggestion can render stimuli unconscious. In this vein, the present work has specifically targeted visuospatial attention through posthypnotic suggestion, with the purpose of hampering subjective visibility and probing the extent to which hypnotically unattended information could be processed.

Crowding experiments have shown that spatial attention's capacity for selective improvement of processing is limited by its own resolution. The more densely-packed a given space is, the harder it becomes to single out a target among its distractors (Intriligator & Cavanagh, 2001). This is particularly true regarding the parafoveal and extrafoveal spaces, where attentional resolution drops as targets stray away, but at a much higher rate, making stimuli ensembles much harder to disaggregate not only the closer they are bound together but also the further they are displayed from the foveal space. Importantly, spatial attention resolution is not determined in the primary visual cortex, as stimuli that are below the threshold of consciousness because of attentional manipulations still produce orientation-specific visual after-effects (He *et al.*, 1996). Taking advantage of this fact, a number of experiments have been developed around peripheral attentional constraints, and how the latter could modulate awareness and task performance. These paradigms would

typically consist of a blank screen; while fixating on its center, participants would be required to detect or discriminate peripheral targets; almost always, peripheral targets would be masked. Like so, such paradigms are attuned to test for task performance, priming effects and both objective and subjective visibility in the periphery (Del Cul *et al.*, 2006, 2007, 2009; Reuter *et al.*, 2007). In the present work, we have emulated these experimental setups, but replaced masking and other forms of physically diminishing stimulus energy by our posthypnotic suggestion: a hypnotic instruction to not attend the periphery, inspired on the “tunnel vision” effect from the Balint Syndrome (Edgette & Edgette, 1995). While of course our posthypnotic suggestion is not intended to exactly reproduce the pathology, pathology-inspired suggestions for the study of hypnotic visual attention are not unprecedented (Oakley and Halligan Supplementary Methods, 2009; Priftis *et al.* 2011).

Only a handful of studies to date have actually explored the workings of hypnotic inattention and its specificity when applied to visual awareness and subjective visibility². Through a “hemispacial neglect-inspired” hypnotic suggestion, Oakley and Halligan (2009) have managed to reproduce the symptoms of the hemineglect syndrome on a single “hypnosis virtuoso” participant, but did not test for any kind of unconscious processing on the hypnotically neglected visual field (an ideal confirmatory measure, as it has already been shown that neglected spaces

² Efforts pursued to elicit full “hypnotic blindness” through suggestion (Bryant & McConkey 1989a, 1989b, 1990) deserve a mention. Despite producing what highly-hypnotizable subjects reported as the incapacity to see full-energy stimulation, and the clear potential such cognitive distortion could represent for the study of conscious awareness (Bryant & McConkey 1989b), by large the existing studies have not targeted spatial attention specifically as we did. Furthermore, participants have rarely been asked to perform a task upon the blinded target, and while in some occasions objective measurements were taken (*e. g.*, response times), the evaluation of the blindness itself has been mostly based on non controlled subjective reports, and susceptible to be explained by demand characteristics (Mallard & Bryant, 2001, 2006).

elicit different levels of unconscious processing; see Sackur et al., 2008). Priftis *et al.* (2011) developed Oakley and Halligan's idea further, and implemented a "visual neglect hypnotic suggestion" on a number of participants highly susceptible to hypnosis, by explicitly demanding them to direct their visuospatial attention to only one side of their visual space. By having the participants perform a simple detection task while under posthypnotic effects, their results pointed out the neglecting of stimuli in the opposite side of the attended space: while very far from actual blindness or total lack of awareness, Priftis *et al.*'s participants did show significantly slower response times for the neglected stimuli. Oakley and Halligan's study was clinically inspired and hence evaluated subjective visual awareness through phenomenological tests. On the other hand, Priftis *et al.* work did not directly test visual awareness, but used response time as a proxy. Finally, none of these two studies tested the impact of the dampening of subjective awareness by means of hypnosis on higher cognitive processes, such as semantic categorization. Furthermore, they did not differentiate between the effects of induction and suggestion as distinct components of hypnosis. This differentiation, crucial for the correct understanding of hypnotic response and addressed by only a handful of studies, is fundamental inasmuch as existing evidence for the role of induction in suggestion-specific effects is preliminary at best (Terhune, 2016).

The present work constituted an effort to add to our knowledge regarding how exactly posthypnotic suggestion, when aimed towards diminishing visuospatial attention, altered perception, information processing and performance. As mentioned before, we did not implement any form of physical masking, as means to evaluate how the posthypnotic suggestion, on its own, diminished subjective visibility and affected the treatment of peripheral targets displayed "outside of the tunnel" for highly

hypnotizable participants (as opposed to low susceptibility ones). Yet, we displayed peripheral targets at five different fixed durations (0, 16, 33, 67 and 85 ms) to probe for their visibility at various levels of stimulus energy. Finally, instead of utilizing a central fixation cross, we instructed participants to fixate their gaze on a central elliptic placeholder that was periodically occupied with a central target. These last targets, “inside of the tunnel”, were meant to be spared by the posthypnotic suggestion, and thus served as controls to test whether hypnosis gave rise to any unspecific cognitive or behavioral effects. The core of this experiment was designed along the lines of classical hypnotic manipulations, *i. e.* a contrast between groups of high and low hypnotic susceptibility. However, as an additional measure, we have proceeded to recruit a second group of highly susceptible participants and had them perform the experiment under the effect of the same suggestion, but in the absence of hypnotic induction. We then contrasted both highly susceptible groups with the intention of singling out the particular contributions of hypnotic induction to their hypnotic responding. The decision of focusing on highly hypnotizable participants alone for this manipulation stemmed from two particular reasons. Firstly, because of the nature of hypnotizability measurements: hypnotizability scoring attributes the lowest grades to individuals who show little to no response in the face of several different types of hypnotic suggestion already within the context of an hypnotic induction (Shor and Orne, 1962; Anllo, Becchio and Sackur, 2017). Hence, we deemed it unlikely that low hypnotizability participants would provide us with a richer, contrastable hypnotic response *in the absence of induction*. Secondly, because of highly susceptible individuals’ responsiveness: indeed, one of the main reasons why the relevance of hypnotic induction has been put into question has been the existence of experiments in which highly susceptible participants have reacted to

suggestion in the absence of induction (see Terhune *et al.*, 2016 for a review; see Raz, Kirsch, Pollard, & Nitkin-Kaner, 2006, Augustinova and Ferrand, 2012 as examples). Consequently, we decided to perform this additional step in order to establish what, if any, where the palpable differences elicited by hypnotic induction in highly susceptible participants, whose response has already been shown to be potentially independent of the latter, and more linked to susceptibility.

2.2.2.3 MATERIALS & PROCEDURES

2.2.2.3.1 Stimuli, Trials & Blocks

Each stimulus consisted of a single black digit (2, 4, 7 and 9) of 0.8° of size on a uniform gray background (24.6 cd/m^2). Stimuli were displayed in dark gray (18.4 cd/m^2) when presented as the central target, and in lighter gray (21.4 cd/m^2) when presented as peripheral targets, yielding respective Weber contrasts of -0.25 and -0.13 . A central elliptical hollow placeholder ($2^\circ \times 1.8^\circ$) was displayed in black. Four dot-shaped gray pointers were set in each quadrant at a distance of 4° from fixation, at the positions of potential peripheral targets³. All stimulation was prepared and displayed with the Psychophysics Toolbox for Matlab (Brainard, 1997; Pelli, 1997; Kleiner et al, 2007).

All trials presented an identical structure (see Figure 1), consisting of a peripheral target of variable duration (0, 16, 33, 67 and 84 ms) presented at either

³ The value of gray utilized for peripheral stimuli and pointers derived of a pilot study featuring the same task as on the third block of the main study, but at multiple contrasts and durations. We used the method of constant stimuli to determine that peripheral targets of -0.13 contrast would yield mean 71% accuracy across participants for the categorization task with a target duration of 67 ms. For further detail, refer to Figure A of the Supplementary Methods.

one of the four pointers, immediately followed by a central target of fixed duration (50 ms) displayed at the center of the central ellipse. Immediately after stimuli presentation, the central ellipse flickered briefly to indicate that a response was expected. The trials were split into four blocks of 140 stimuli, with stimuli identity, duration and position fully balanced within blocks. The task changed from block to block: in Block OC (Objective Central task), participants had to perform a discrimination task assessing if the Central Target was either greater or smaller than 5, by pressing the L or the M key on a standard AZERTY French keyboard with their right hand (reabeled for clarity). This block was conceived to test any possible priming elicited by the peripheral stimulus, as well as to test if hypnosis had any unintended effects on either accuracy or response times for the hypnotically “spared” targets. In Block SP (Subjective Peripheral task), participants were asked to evaluate the visibility of the Peripheral Targets through a perceptual awareness scale (PAS, Ramsøy and Overgaard, 2004) ranging from 1 to 4, using their left hand on the Q, S, D and F keys (reabeled for clarity). As with standard traditional PAS scales, “1” represented no experience of visibility, “2” a brief non-specific glimpse, “3” an almost clear experience of visibility and “4” full visibility. This block was designed for evaluating peripheral subjective visibility, as a means for testing whether perceptual changes followed the content of the hypnotic suggestion. In Block OP (Objective Peripheral task), participants had to perform the discrimination task on the Peripheral Targets, with their right hand. The rationale behind this task was to test if highly susceptible participants were able to execute the task in a condition of reduced subjective visual awareness. Finally, in block OCSP (Objective Central task, Subjective Peripheral tasks), participants had to perform the discrimination task on the Central Target, and immediately afterwards, the Subjective Visibility task on the

Peripheral Targets. This block combined central discrimination with peripheral visibility, in order to check for congruency effects between peripheral and central targets when both were task-relevant and attended. Additionally, this block was designed to test if by paying attention at the same time to peripheral targets (which are affected by the posthypnotic suggestion) and central targets (spared by the posthypnotic suggestion), we would observe any hypnotic spillover effects over the central task.

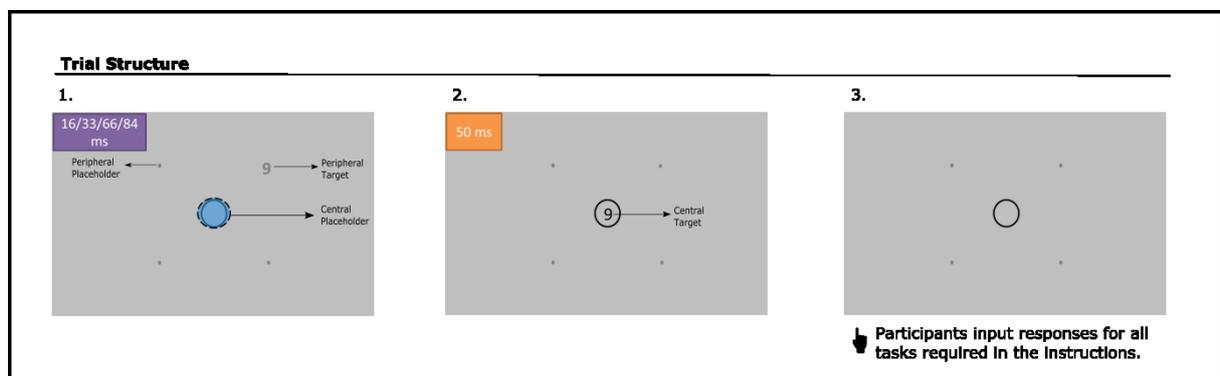


Fig. 1: Graphical outline of the trial structure. All trials presented an identical structure, consisting of a Peripheral Target of variable duration (16, 33, 67 and 84 ms) presented at either one of the four pointers set around the center of the screen, immediately followed by a Central Target of fixed duration (50 ms) displayed inside of the central ellipse. Only the task changed across blocks. Block order was balanced across participants.

2.2.2.3.2 Participants

Participation was voluntary, in exchange of 15 € for a one hour and thirty minute session. Participants were all contacted by e-mail and recruited by a research assistant independent to the study, from a database of volunteers previously screened with the French Norms of the HGSHS:A (Shor and Orne, 1962; Anlló, Becchio and Sackur, 2017). Participants intervening in the main experiment (High vs.

Low hypnotic susceptibility) were told that they would take part of an experiment that would include their response to hypnotic suggestion, and warned since first contact that all levels of susceptibility were equally relevant, equally important and equally desirable for the experimenters. In the case of participants recruited for the No Induction control group, no mention of hypnosis was made at all at during the procedure or at any point of the recruitment process.

On testing session 1, a total of 24 right handed, native French speakers aged between 18 and 35 (mean 25.9, 16 female) participated in the main contrast (high vs. low hypnotic susceptibility): 12 participants highly susceptible to hypnosis (Harvard score 8-12), 12 of low susceptibility (score 0-4). Participants were called and tested in a random order, as to prevent the hypnosis practitioner from knowing their hypnotic susceptibility scores in advance.

On testing session 2, an additional 20 right-handed, native French speakers (mean age 23.5, 12 female) of all hypnotizability scores were recruited for preparing the No Induction control group. Participants were tested in a random order, as means of preventing the hypnosis practitioner from knowing about their hypnotic susceptibility. Amongst these participants, the 7 who presented high hypnotic susceptibility were retained in the No Induction group, and the rest were discarded.

All participants signed a written consent allowing for the anonymous exploitation of the data they produced. The experiment was conducted in agreement with the Declaration of Helsinki (2008) and approved by the Ethics Committee of the Université Paris Descartes (Paris 5).

2.2.2.3.3 Hypnotic Induction & Suggestion

The hypnotic induction consisted of a shortened variation of the gaze-fixation induction from the French Norms for the Harvard Group Scale of Hypnotic Susceptibility (Shor and Orne, 1962; Anlló *et al.*, 2017). The posthypnotic suggestion that ensued was based on the symptomatology of the Balint Syndrome (see Supplementary Methods for the full induction and suggestion procedures), and expressed in terms of attention, attention direction and attentional modulation. The intended effect of this hypnotic procedure was to produce a visually unattended space outside of the central elliptical placeholder, ideally rendering “negligible” any stimuli present outside of this area. The first author, who is a licensed clinical hypnosis practitioner, constructed and administered both the induction and the suggestion blinded to participant’s hypnotizability scores.

The suggestion for the No Induction control group was as similar as possible to the one implemented with hypnotized participants, as to elicit similar degrees of motivation and instruction, but without any hypnotic references. This suggestion was also administered by the first author, who was again blind to the hypnotizability of the participants until after the post-test interview. See Supplementary Methods for the full induction and suggestion procedures

2.2.2.3.4 Procedure

Participants sat in a dim-lit, soundproof test booth, equipped with a headset, a calibrated standard LCD screen, a chinrest fixed at 60 cm from the screen, at a height that assured that the participants’ resting gaze fell at the center of the screen.

A standard keyboard for inputting responses was provided. Participants underwent then a Training phase consisting of a short version of each of the four blocks (25 trials per block). Crucially, after explaining the specific instructions for the blocks, participants were warned that at any given trial peripheral targets could be displayed “fast enough to seem completely absent”, but that a response was mandatory even if they felt like they were guessing. Participants were instructed to keep their gaze fixated on the center of the ellipse at all times, even when expected to perform a task on Peripheral Targets. Those who could not reach at least 90% accuracy on the OC task and 70% accuracy in the OP task, for durations of 67 and 84 ms, were to be discarded (none were). Participants were instructed to respond as fast as possible at all moments of the test, but never at the sake of their precision. Upon completion of the training phase, participants were then set to undergo the hypnotic induction and posthypnotic suggestion, or simply the suggestion, depending on the testing session. In order to trigger the posthypnotic suggestion into effect, the suggestion script stated that “as you return your head to the chinrest and fixate your gaze at the center of the ellipse, immediately your attention will focus on the inside of the ellipse and whatever happens inside of it, to the extent of rendering whatever may happen outside of it completely negligible, even invisible”. After suggestion delivery, the experimenter performed the scripted partial de-induction process, asked the participants to wear the designated audio headset, and left the room. Through the audio headset, participants were instructed by a recorded voice, clearly different from the experimenter’s, to adopt the position and place their head on the chinrest (as the experimenter verified through an obscured side window). Once in position, the recording announced the beginning of the experiment, explained the main tasks again and introduced each block as it came by repeating its instructions. Participants

had to acknowledge proper understanding of the recorded instructions by pressing the “H” key for the block to start, or could choose to listen to the instructions again by pressing the “J” key (both relabeled for clarity). After the experiment, participants were de-induced and told to regain their normal awareness, and then debriefed and casually asked to be honest about their hypnotic experience. None of them expressed any faking or “forcing” of the suggestion effects either.

2.2.2.4 RESULTS

2.2.2.4.1 Statistical analyses

We performed data analysis using *R* (R Core Team, 2014). Response times and accuracy were modeled by implementing (generalized) linear mixed models, with a random intercept per participant (*lme4*, Bates 2015). We compared models including as regressors Hypnosis Group Type (levels: High, Low), Peripheral Target Duration (levels: 0, 16, 33, 67, 84 ms), Congruency between Targets (levels: Congruous (both stimuli below or above 5), Incongruous), Hypnotizability Score (levels: 1 to 12) and Block Type (levels: OC, SP, OP, OCSP). Model selection was performed through likelihood ratio tests (Pinheiro & Bates, 2000; Bolker et al., 2009). For each analysis, we report below the effects based on the best model, selected according to these criteria. ANOVA tables were computed through Analysis of Deviance (Type II Wald χ^2 test), and post-hoc pairwise comparisons through Tukey contrasts of least-squares means (0.95 CI) (*car* and *lsmeans* *R* packages, Fox and Weisberg 2011 and Lenth 2016 respectively). For each analysis, the full list of tested models with their respective Bayesian Information Criterion (BIC) is provided as supplementary material in table ST 1. For the contrast consisting of comparing highly susceptible

participants who underwent a hypnotic induction vs. those who did not, we produced new models in which we conserved the same model structure as before, but 1) we introduced an Induction factor (Induction, No Induction), and 2) removed the Hypnosis Group Type factor as regressor.

2.2.2.4.2 Subjective visibility in the periphery diminishes for High participants

Subjective visibility was measured through the implementation of a PAS ranging from 1 to 4, both in a single-task (block SP) and double-task framework (block OCSP). As displayed in Figure 2, subjective visibility increased as a function of Hypnosis Group Type (low susceptibility > high susceptibility) and Peripheral Target duration. These results fell within expectation, as they showed that the hampering effects of the posthypnotic suggestion were modulated coherently by hypnotizability. We tested the statistical significance of these effects by means of a regression with factors of Congruency, Peripheral Target Duration and Hypnosis Group Type, over pooled SP and OCSP blocks, since the preferred model lacked the Block factor.

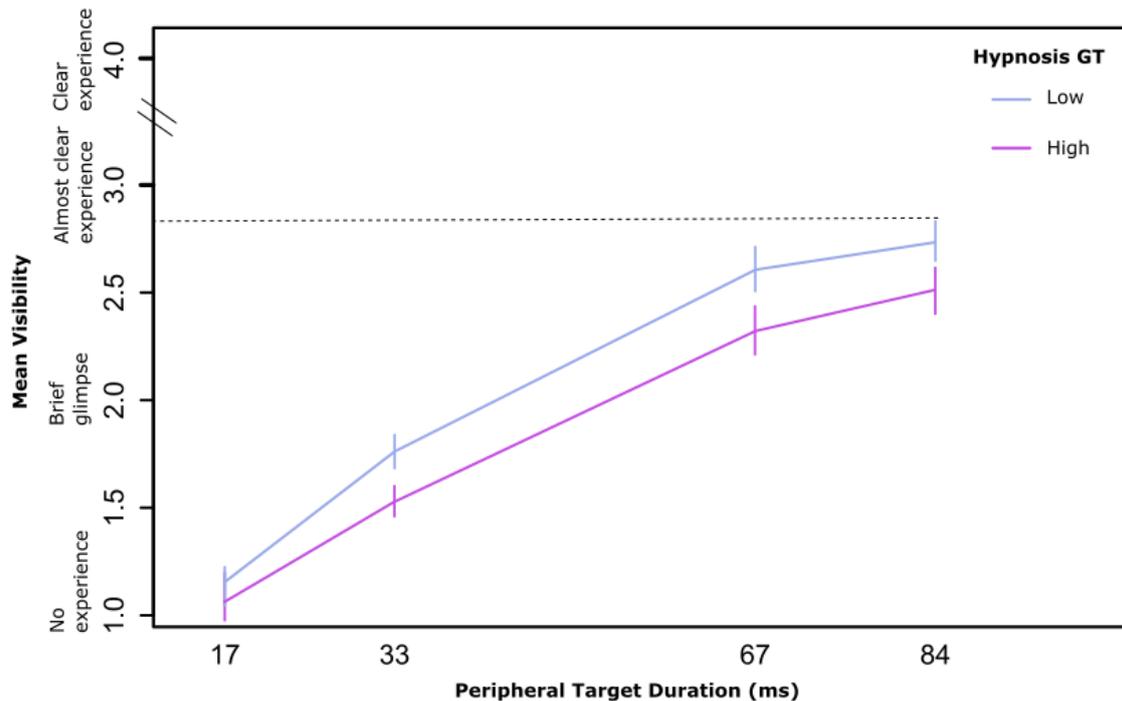


Fig. 2: Visibility rating task. A. Subjective visibility (PAS scale) for all Peripheral Target durations, across all groups of participants. Visibility increased as a function of Hypnosis Group Type and Peripheral target duration. We verified a significant interaction between Peripheral Target duration ($p < 0.05$). SE bars calculated over grand mean minus participant mean, Morey-corrected.

Analysis of Deviance full results (Type II Wald χ^2 test) are in Table 1. Analyses reflected significant main effects of Peripheral Target Duration ($\chi^2=2904$, $DF=3$, $p<0.0001$) and Congruency ($\chi^2=6$, $DF=1$, $p<0.05$), which translated into global visibility increases associated to the rise in stimulus energy and to the incongruence regarding the backward central prime, respectively. There was no main effect of hypnosis ($p>XXX$), but crucially, results also indicated a significant interaction between Hypnosis x Peripheral Target Duration ($\chi^2=8$, $DF=3$, $p<0.05$), pointing to the fact that, for highly susceptible participants, the post-hypnotic suggestion of

peripheral inattention hampered subjective visibility more when stimulus energy was high.

	χ^2	Df	Pr(> χ^2)
Visibility			
Hypnosis GT	0.9	1	0.3
Peripheral Duration	2904	3	<0.0001
Congruency	6	1	<0.05
Hypnosis GT x Peripheral Duration	8	3	<0.05
Hypnosis GT x Congruency	0.3	1	0.6
Peripheral Duration x Congruency	2.7	3	0.4
Hypnosis GT x Pdur x Congruency	2	3	0.6

Table 1: Detection of peripheral targets. Analysis of Deviance (Type II Wald χ^2 test) for the model comprising Congruency, Peripheral Target Duration and Hypnosis Group Type as regressors over visibility. Visibility scores are expressed in PAS units (considered as a continuous variable).

The data collected from the No Induction testing session allowed us to evaluate the impact of hypnotic induction for highly susceptible participants at this particular task.

As displayed in Figure 3, subjective visibility decreased as a function of Induction implementation (No Induction > Induction) and Peripheral Target duration.

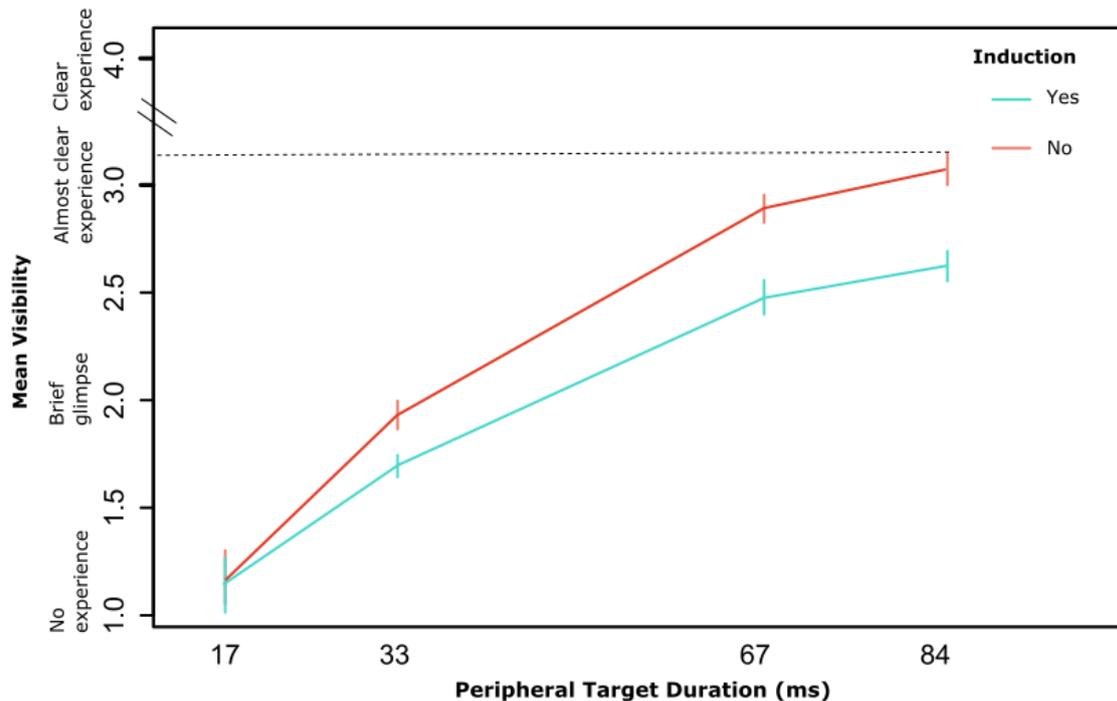


Fig. 3: Visibility rating task. A. Subjective visibility (PAS scale) for all Peripheral Target durations, for highly susceptible participants with and without a hypnotic induction, respectively. Visibility increased as a function of adding an Induction, and as a function of Peripheral Target duration. A significant reduction in visibility was present in Induction participants relative to No Induction participants ($p < 0.0001$). SE bars calculated over grand mean minus participant mean, Morey-corrected.

We tested the statistical significance of these effects by means of a regression with factors of Congruency, Peripheral Target Duration and Induction implementation, over pooled SP and OCSP blocks as with the original dataset. Analysis of Deviance full results (Type II Wald χ^2 test) can be found in Table 2. Analyses reflected significant main effects of Peripheral Target Duration ($\chi^2=3099$, $DF=3$, $p<0.0001$), Induction ($\chi^2=5$, $DF=1$, $p<0.05$) and a significant interaction between Induction implementation x Peripheral Target Duration ($\chi^2=117$, $DF=3$, $p<0.0001$). Overall,

these findings point to the fact that the introduction of a hypnotic induction further hampered subjective visibility, even more so for high energy stimuli.

	χ^2	Df	Pr(> χ^2)
Visibility			
Induction	5	1	<0.05
Peripheral Duration	3099	3	<0.0001
Congruency	4	1	0.06
Induction x Peripheral Duration	117	3	<0.0001
Induction x Congruency	0.03	1	0.9
Peripheral Duration x Congruency	5	3	0.2
Induction x Pdur x Congruency	3	3	0.5

Table 2: Detection of peripheral targets. Analysis of Deviance (Type II Wald χ^2 test) for the model comprising Congruency, Peripheral Target Duration and Induction implementation as regressors over visibility. Visibility scores are expressed in PAS units (considered as a continuous variable).

2.2.2.4.3 Central discrimination task: suggestion impairs priming effects stemming from the periphery for High participants

The question remained whether hypnotic inattention was only active at the subjective level or whether it impaired cognitive processing of the stimulus. To answer this question, we turned to the investigation of priming effect between the peripheral and central stimuli: Because of trial structure, Peripheral Targets worked as primes for the Central Target in blocks OC and OCSP. As shown in Figure 4, accuracy for the Low group was significantly lower for incongruous trials, but remained unaffected by congruency for the High group, suggesting that highly susceptible individuals were impervious to priming effects stemming from the hypnotically unattended targets. .

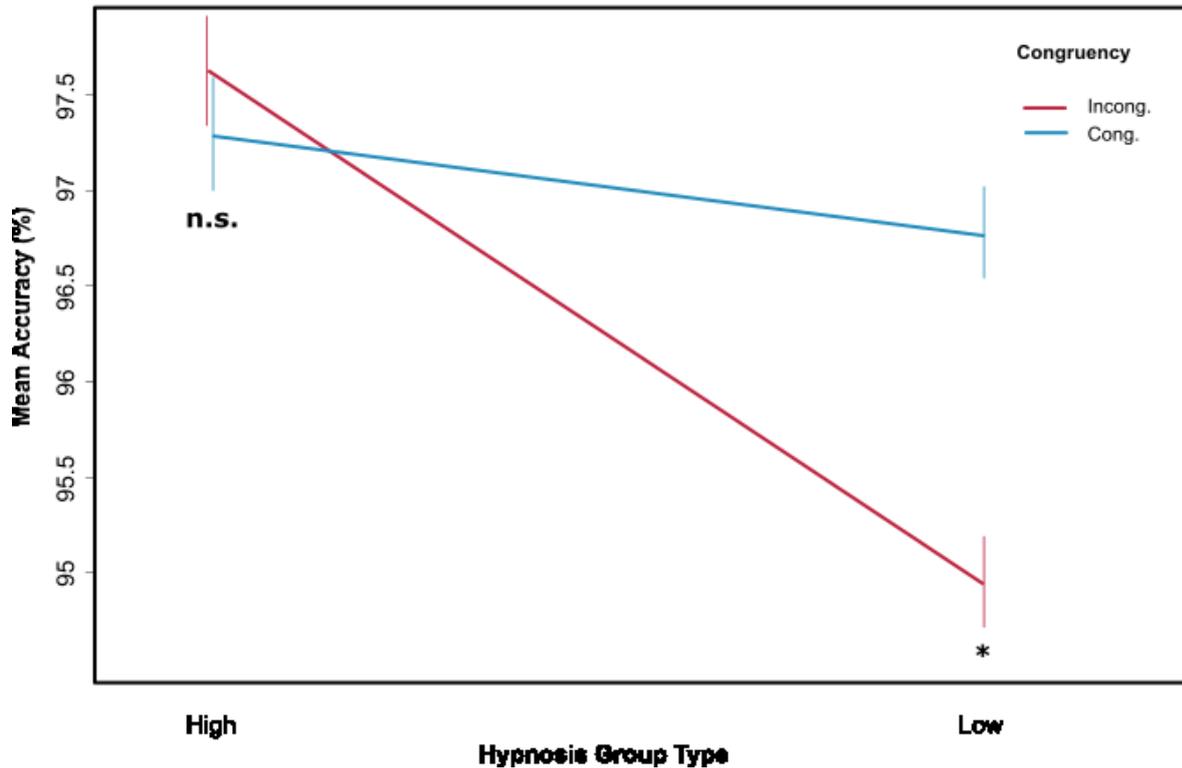


Fig. 4: Central discrimination task. Accuracy scores (percentage correct) for congruent and incongruent trials, across groups of participants. Accuracy for the Low group decreased for incongruous trials, but remained unaffected for the other group ($p < 0.01$). SE bars calculated over grand mean minus participant mean, Morey-corrected.

We tested the statistical significance of this effect by means of a binomial regression on accuracy with factors of Congruency and Hypnosis Group Type, over pooled OC and OCSP blocks. Analysis of Deviance full results (Type II Wald χ^2 test) are in Table 3. Results reflected an interaction of Hypnosis Group Type x Congruency, $\chi^2=3$, $DF=2$, $p < 0.05$. For further verification, we repeated the analysis utilizing raw hypnotizability scores of all participants as a regressor, rather than the Group Type factor, and replicated the result, i. e. difference in performance for incongruous and congruous trials increased in direct relation to hypnotizability (Congruence x Individual Hypnotizability Score, $\chi^2=7.64$, $DF=1$, $p < 0.01$; Tukey pairwise Congruency

contrasts for Hypnosis Group Type, Low and High: High, Estimate = 0.14, SE=0.25, $p > 0.08$; Low, Estimate = -0.5, SE=0.2, $p < 0.05$). It should be noted that no other main effects or interactions between hypnosis and performance were found at any point of the analysis in either the selected or the discarded models (all $p_s > .08$), which strengthens the claim of hypnotic specificity, as it suggests that the central stimuli were indeed spared by the suggestion. Thus, when processing the central stimulus highly hypnotizable individuals seem to be shielded from the influence of the peripheral stimulus, contrary to low hypnotizable individuals.

	χ^2	Df	Pr(> χ^2)
Accuracy			
Hypnosis GT		1	0.3
Congruency		2	0.1
Hypnosis GT x Congruency		3	<0.05

Table 3: Central discrimination task. Analysis of Deviance (Type II Wald χ^2 test) for the model comprising Congruency, Peripheral Target Duration and Hypnosis Group Type as regressors over accuracy. Hypnosis GT: Hypnosis Group Type.

As shown in Table 4, a binomial regression on accuracy with factors of Congruency and Induction implementation did not reflect any interactions or main effects. When considered together with the results from the previous contrast (Highs vs Lows), the fact that hypnotic induction would have no effect of its own over congruency-related effects suggests that the shielding from the peripheral target depends on suggestion and hypnotic susceptibility alone. Additionally, the lack of impact of hypnotic induction on the accuracy of the central discrimination task implied that the general relaxation suggestions and mental imagery evoked by the induction procedure did not have any non-specific effects over the task that they were intended to spare.

	χ^2	Df	Pr(> χ^2)
Accuracy			
Induction	0.04	1	0.8
Congruency	1	1	0.4
Induction x Congruency	0.03	1	0.9

Table 4: Central discrimination task. Analysis of Deviance (Type II Wald χ^2 test) for the model comprising Congruency, Peripheral Target Duration and Induction implementation as regressors over accuracy.

2.2.2.4.4 Peripheral discrimination task: posthypnotic suggestion did not impair priming effects stemming from central primes

Block OP was designed to provide evidence on whether highly susceptible participants would be able to execute the discrimination task on the peripheral, hypnotically unattended targets, on par with low susceptibility participants. Indeed, while highly hypnotizable individuals seem to respond to the attentional suggestion on subjective visibility, still, they might be able to perform the task at a low level. This is all the more plausible since the suggestion that we administered did not hint towards any impairment of the cognitive mechanisms necessary to perform the objective categorization task. In addition, because of trial structure, Central Targets worked as backward primes for the Peripheral Target task, allowing us to probe for contaminating effects from these hypnotically-spared central primes. Results displayed in Figure 5 show that all participants were able to perform the task at a high level, but that, critically, performance was worse for incongruous trials for all hypnotizabilities, albeit much more so for Low susceptibility participants. The fact that both High and Low participants were influenced by the contaminant effect of the

backward central primes was consistent with the specificity of the suggestion, which had only targeted the peripheral targets.

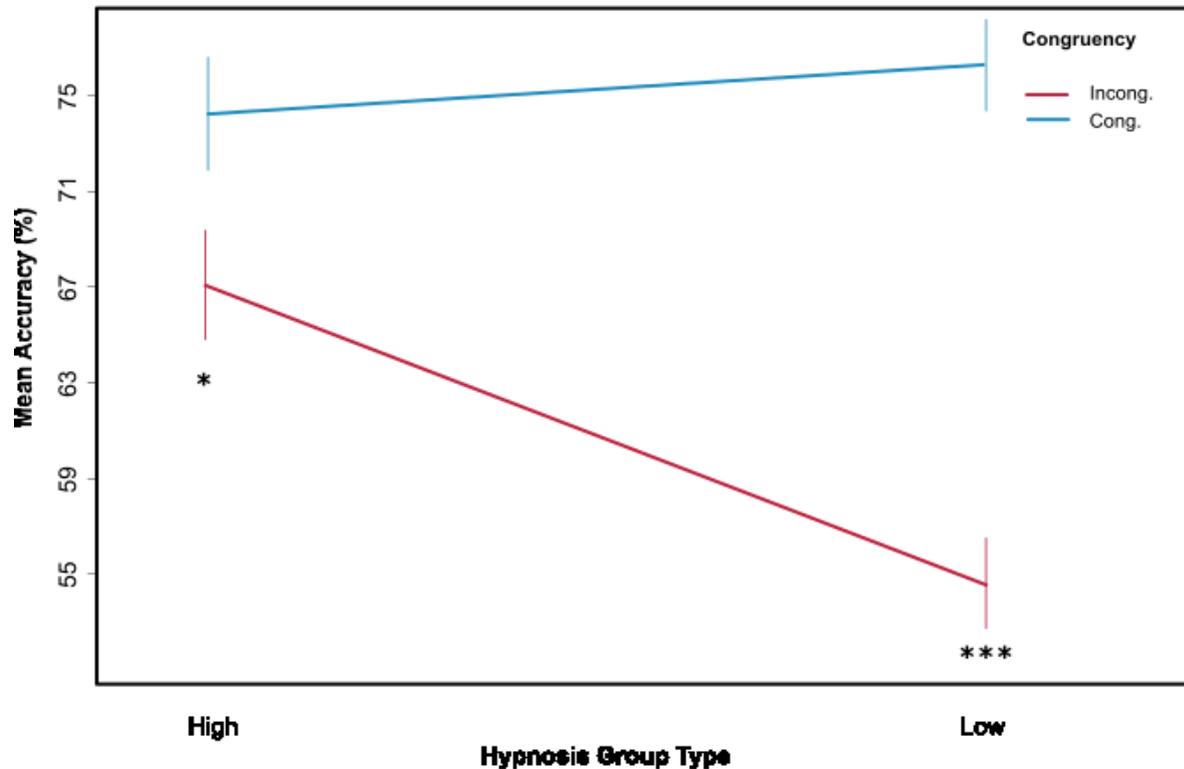


Fig. 5: Peripheral discrimination task. Accuracy scores (percentage correct) for all collapsed Peripheral Target durations, across both groups of participants. Results showed a significant Interaction between Hypnosis x Congruency ($p < 0.0001$). SE bars calculated over grand mean minus participant mean, Morey-corrected.

We tested these effects with a model with Peripheral Target Duration, Congruency and Hypnosis Group Type as regressors for accuracy. Analysis of Deviance full results (Type II Wald χ^2 test) are in Table 5. Analyses revealed main effects of Congruency ($\chi^2=71$, $DF=1$, $p < 0.0001$) and Peripheral Target Duration ($\chi^2=150$, $DF=3$, $p < 0.0001$), which translated into better accuracy scores for congruent trials and longer target durations. Crucially, the model confirmed the aforementioned interaction between Hypnosis x Congruency ($\chi^2=18$, $DF=1$, $p < 0.0001$; Tukey pairwise

Congruency contrasts for Hypnosis Group Type, Low and High: High, Estimate = -0.4, SE=0.1, $p < 0.05$; Low, Estimate = -1.1, SE=0.13, $p < 0.0001$).

	χ^2	Df	Pr(> χ^2)
Accuracy			
Hypnosis GT	2	1	0.2
Peripheral Duration	150	3	<0.0001
Congruency	71	1	<0.0001
Hypnosis GT x Peripheral Duration	3	3	0.3
Hypnosis GT x Congruency	18	1	<0.0001
Peripheral Duration x Congruency	1	3	0.8
Hypnosis GT x Pdur x Congruency	3	3	0.4

Table 5: Peripheral discrimination task. Analysis of Deviance (Type II Wald χ^2 test) for the model comprising Congruency, Peripheral Target Duration and Hypnosis Group Type as regressors over accuracy. Hypnosis GT: Hypnosis Group Type; Pdur: Peripheral Target Duration.

Once again, Table 6 shows that a binomial regression on accuracy with factors of Congruency, Peripheral Target Duration and Induction implementation did not reflect any interactions or main effect coming from the induction procedure. These results are not surprising: the periphery-center target relationship also was but permeable only to the suggestion effects. These results further confirm that hypnotic induction had no influence of its own over congruency-related effects, in either direction.

	χ^2	Df	Pr(> χ^2)
Accuracy			
Induction	0.3	1	0.6
Peripheral Duration	205	3	<0.0001
Congruency	0.7	1	0.4
Induction x Peripheral Duration	6	3	0.1
Induction x Congruency	1.3	1	0.25
Peripheral Duration x Congruency	1	3	0.8
Induction x Pdur x Congruency	1.8	3	0.6

Table 6: Peripheral discrimination task. Analysis of Deviance (Type II Wald χ^2 test) for the model comprising Congruency, Peripheral Target Duration and Induction implementation as regressors over accuracy. Hypnosis GT: Hypnosis Group Type; Pdur: Peripheral Target Duration.

2.2.2.5 DISCUSSION

We administered a posthypnotic suggestion for selective inattention to High and Low hypnotic susceptibility participants, inspired by the “tunnel vision” symptom of the Balint Syndrome. We set out to evaluate how the creation of an “unattended visual space” would successfully degrade subjective visibility and modulate information treatment at different levels of stimulus energy and hypnotizability. We did so through a single / double-task design, which asked for visibility judgments and target discrimination, and placed targets in the center of the visual field, outside the influence of the suggestion, and closer to its periphery, within the influence of the suggestion. This allowed us to both evaluate the efficacy and specificity of the posthypnotic suggestion, as well as its interference with any priming or congruency effects between peripheral and central targets. Additionally, we utilized the same paradigm, and set out to observe the same phenomena, but in connection to the specific influence of hypnotic induction on highly susceptible participants.

Our main findings are threefold. First, the contrast between high and low susceptibility participants showed that our standard posthypnotic suggestion could hamper Highs’ subjective visibility (when compared to Lows’). This was particularly relevant, as it confirmed that the suggestion had successfully fostered the intended effects on subjective experience. Furthermore, this difference in subjective visibility could be interpreted in terms of a difference in awareness: reportability and cognitive

accessibility are regarded in many preponderant theories of consciousness as an index of awareness (Kouider, 2009 Kouider, de Gardelle, Sackur and Dupoux, 2010). As for the nature of this visibility modulation, the presence of an interaction between hypnotizability and stimulus energy would suggest that hypnosis altered subjective visibility on a belated fashion, as part of a later, control-related process. Namely, since immediate basic perceptual processing was common to all peripheral targets, particularly beyond 33 ms, the sustained increase in the effect of the posthypnotic suggestion had to hinge on the increase of stimulus energy. In other words, we can posit that the more a target was likely to be seen, the more the posthypnotic suggestion obscured the awareness of it for highly susceptible participants. This interaction constituted as well a favorable argument against attributing the reported effects solely to expectations, or demand characteristics. Namely, if the Low hypnotizability group had approached the task with the expectation of responding to show a conserved full visibility, these participants would have likely overestimated visibility for lower stimulus energy targets. Conversely, if the High hypnotizability group had approached the task with the opposite expectation, their visibility would have likely plateaued instead of rising together with stimulus energy. Finally, both the thesis for a late, control-related effect and the argument against demand characteristics, were strengthened by the fact that our results showed hypnotic induction to extend this diminishment of visibility *also* in relation to stimulus energy.

Second, results have shown that highly hypnotizable participants remained impervious to the influence of incongruent primes in the periphery for the central discrimination task, while the low hypnotic susceptibility group did not. These results expanded our understanding of the specific information treatment fostered by hypnotic inattention, particularly in connection to the question of whether utilizing

hypnosis as a device would warrant subliminal or preconscious processing (Landry, 2014). The reported reduced subjective awareness of peripheral primes manifested by the High group would have been promising in this precise sense if it had also elicited any unconscious stimulus treatment, comparable to that of subliminal or pre-attentive stimulation (e.g. strong priming effects stemming from the hypnotically-affected periphery for highly susceptible participants, paired with across-the-board reduced subjective visibility). Yet, current results showed that, at least within the context of this paradigm, highly susceptible participants discarded hypnotically unattended peripheral information and did not use it, preventing it from influencing the central target task. While these results may discourage the idea of implementing hypnotic suggestions as a replacement for physical stimuli suppression techniques such as masking, they do however contribute to the literature questioning the automaticity of priming effects and the latter's susceptibility to cognitive control (Kunde, 2003; Kiefer, Kiesel, Kunde & Hoffman, 2006; Kiesel, Kunde, Pohl & Hoffman, 2005; Kunde, Kiesel & Hoffman, 2003; Adams & Zovko, 2012). While classical theories of automaticity assume that automatic processes elicited by unconscious stimuli are autonomous and independent of higher-level cognitive influences, the aforementioned findings bring forward evidence that unconscious visual processing is automatic only in the sense that it is initiated without deliberate intention, but susceptible to attentional top-down control and only elicited if the cognitive system is "configured accordingly" (Adams & Zovko, 2012). Attentional influences on subliminal priming depend not only on attentional resources, but can also be modulated through stimulus expectations, intentions and task sets (Adams & Zovko, 2012). We suggest that posthypnotic-induced inattention attenuated unconscious priming processes stemming from the periphery for highly susceptible

individuals as a result of a late, high-order manipulation, likely originated at the level of cognitive control, resulting from the highly susceptible participants' effort to enact the content of the suggestion. Namely, rather than producing a perceptual lack of vision, the posthypnotic suggestion led highly susceptible participants to actively (albeit not purposefully) execute the task of "not seeing" through a lesser consideration and a subsequent dismissal of the peripheral information. Results from the induction contrast reinforced this idea: the fact that performance and priming effects were sensitive to hypnotic susceptibility but not to induction could point to the fact that, for highly hypnotizable individuals, direct suggestion is sufficient, and probably bears the same weight as task instructions when it comes to top-down designation of relevant information and its unconscious processing. This idea could also explain why hypnotic induction failed to have an influence over performance, but did alter the posthypnotic effects over subjective visibility. Designating the relevance of peripheral stimuli can be conceived as a binary judgment (either relevant or irrelevant) whose decision can be biased sufficiently through suggestion alone (before even starting the task). Visibility, on the other hand, was a gradual judgment to be established *in situ* (during each trial) amidst the contradiction between the suggestion instructional content and variable physical energy, a setup more frail and likely more vulnerable to be biased by the cumulative motivational and phenomenal changes warranted by induction.

Third, results have shown that when probed for an objective peripheral task, both High and Low participants were able to perform the task despite the suggestion, and that they were vulnerable to backward contaminating information from the central stimulus. This finding is of relevance (1) because it confirmed the specificity of the posthypnotic suggestion, as the suggestion did not prescribe any restrictive effects

for the central targets, and (2) because the extent to which High and Low participants were under the contaminating influence of the central stimulus was different. The fact that the performance differences between congruent and incongruent trials were smaller for highly susceptible participants was consistent with the growing body of literature identifying highly susceptible participants as better at reducing cognitive conflict (Raz *et al*, 2005, Raz *et al*, 2006; see Terhune *et al.*, 2017 for a review). Indeed, by being able to better reconcile the contradictory/incongruent influence of the central stimulus over the peripheral target information, highly susceptible participants outperformed Low ones on incongruent trials. A third point of importance to consider was the fact that (3) Highs managed to perform on par with Low participants for congruent trials altogether, despite simultaneously reporting lesser visibility for the subjective visibility task. A weak interpretation of these results would imply that the suggestion managed to reduce subjective visibility, but not enough to have a real impact over objective performance. A stronger interpretation would imply that since the task was of the forced-choice variety, Highs' performance in the face of reduced awareness was supplemented by the unaware treatment of the "hypnotically less-attended" peripheral targets. Post-session interviews tended to support the second view, with highly susceptible participants invariably reporting the impression of seeing "next-to-nothing" in the periphery, and manifesting little to no confidence regarding their performance over peripheral targets.

In all, these findings provide a consistent picture of the effects of hypnotic inattention as a tool for hampering subjective visibility and cognitive processing in a top-down fashion. In particular, they have allowed us to identify and separate the late mechanisms by which posthypnotic induction and suggestion hampered visual awareness and reduced cognitive conflict. One first mechanism, susceptible to the

influence of hypnotic induction and dependent on hypnotizability, that intervened belatedly into reshaping the subjective awareness of affected stimuli, and was all the more present the higher the stimulus energy was. And one second top-down mechanism, impervious to induction, dependent on the instructional content of suggestion, similar (if not homologous) to task-instructions set, that mediated the attribution of relevance to certain segments of the visual space for particular tasks in a way that was congruous with both the suggested hypnotic effects and the task demands. Crucially, this last mechanism did not render stimuli unconscious, but rather affected them through the top-down preemptive decision of not according them any unconscious processing (Adams & Zovko, 2012). This same results attest to the cognitive flexibility of highly susceptible participants, at both handling incongruent semantic information and the conflict elicited between suggestion (e.g. “ignore the target”) and task instructions (e.g. “perform a task over the target”), by always privileging performance.

Finally, it should be mentioned that our results could arguably limit the possibilities of implementing hypnosis as a classic subliminal masking tool, as purported by some theoretical reviews in the field (Landry, 2014; Kihlstrom, 2014). Rather than physically preventing stimuli from becoming visible by forcing them below the threshold of access to consciousness, hypnotic perceptual and cognitive alterations respond to a delicate balance between suggestion, expectation and task instructions, leading the highly hypnotizable individual to integrate the three in the form of high-order strategies that privilege conflict reduction. Hypnosis does not seem like a suitable tool for simply turning a given supraliminal stimulus into a subliminal one. The more susceptible individuals may be, the more they may be able to flexibly adapt to suggestion and task instructions, giving rise to effects phenomenologically similar to

traditional masking, but that may not guarantee the unconscious treatment of the hypnotically-affected information. However, our results do (1) constitute a first step in the study of perception in diminished awareness as warranted by hypnosis, (2) bring forward new information pertaining how hypnotic components interact with the specific dimension of spatial attention, and (3) further our understanding regarding the hypnotizability-dependent top-down control that posthypnotic suggestion exerts over unattended information. Since previous EEG studies have already established that hypnosis and suggestion can modulate early ERP components associated to automatic target detection and classification for certain susceptible individuals (Raz, 2005; Terhune, 2010), and the paradigm we devised has been inspired by other paradigms built for imaging research, we hope that our present results would trigger further imaging advances on the path of our findings. This could improve our understanding of hypnotic responding, the role of induction, and bring a final word, one beyond self-reported experience, on whether highly susceptible participants are capable of addressing hypnotically-unattended targets unconsciously.

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2.2.2.8 REFERENCES

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2.2.2.9 SUPPLEMENTARY MATERIALS

2.2.2.9.1 Annex A: Additional Plots & Model Comparisons

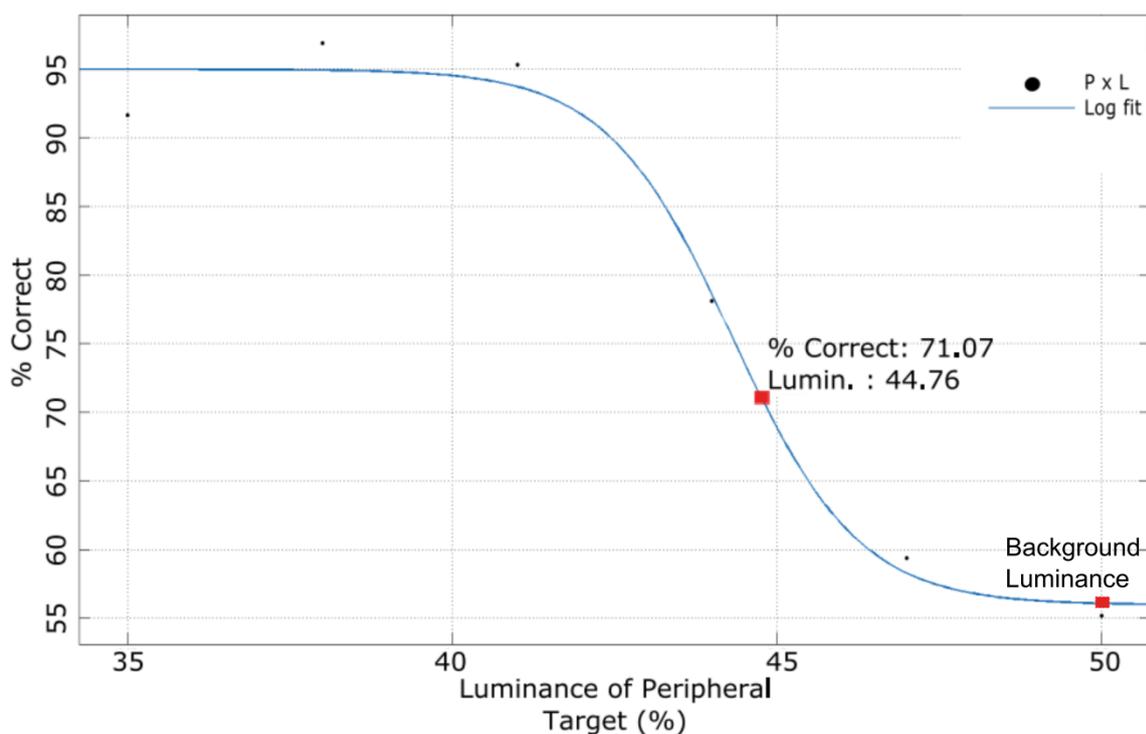


Figure A. Psychophysical curve fitted for the establishment of the Peripheral Target luminance value.

We performed a visual inspection of the results of a first pilot study, in which 6 subjects performed the task of Block 3 at fixed a luminance value (gray 60% CMYK scale) at 9 randomized display durations (0, 16, 33, 50, 67, 84, 100, 130, 150, ms). We established 67 ms to be the first stable supraliminal duration after the performance raise of the sigmoidal psychophysical curve. We then did a second pilot study with a separate group of 8 participants, in which we fixated the duration of the Peripheral Target to 67 ms, and tested performance for 4 different luminance levels (35%, 40%, 45% and 50% gray CMYK scale). A logistic fit of the resulting data

allowed us to estimate a value of gray 44.76% on the CMYK scale for a predicted performance of 71% for durations of 67 ms.

Table ST 1

Peripheral visibility task					
VISIBILITY	DF	BIC	χ^2	DF	p
~ Hypnosis GT X Congruency X PT Duration X Block Type + ϵ	34	13097	22	16	n.s.
~ Hypnosis GT X Congruency X PT Duration + ϵ	18	12982	2318	12	<0.0001
~ Hypnosis GT X Congruency + ϵ	6	15197	—	—	—
Central discrimination task					
ACCURACY					
~ Hypnosis GT X Congruency X PT Duration X Block Type + ϵ	33	1598	44	16	<0.001
~ Hypnosis GT X Congruency X PT Duration + ϵ	17	1505	14	12	n.s.
~ Hypnosis GT X Congruency + ϵ	5	1416	—	—	—
Peripheral discrimination task					
ACCURACY					
~ Hypnosis GT X Congruency X PT Duration + ϵ	17	3179	167	12	<0.0001
~ Hypnosis GT X Congruency + ϵ	5	3251	—	—	—

Table ST 1: Full list of tested models. Selection between different models was performed through likelihood ratio tests and by computing for each model an approximation of its Bayesian Information Criterion (BIC). We selected the models with the lowest BIC, indicated in red. For each analysis, the last line of the table host the simplest model, which was taken as reference.

Labels for regressors: Hypnosis GT: Hypnosis Group Type; PT duration: Peripheral Target Duration; n.s.: non-significant.

2.2.2.9.2 Annex B: Annex B: Hypnotic Induction and Suggestion (Hypnotic “Balint Syndrome” inattention suggestion, based on the Harvard induction)

Participant handling

Participants were greeted by the first author, who was also responsible for the hypnosis procedure. The first author remained uninformed of the hypnotic susceptibility of the participants until after the test, when the moment came for a post-test interview. Responses to participants’ questions and the interactions with them were scripted as much as possible, and discussions about the participants’ experience at the HGSHS: A screening avoided until after the test. Before starting the procedure, participants were informed again that their response, if any, to the procedure had no impact on their monetary compensation. It was also clearly stated to participants from testing session 1 that the experimenters did not expect them to express any particular degree of susceptibility to hypnotic suggestion, but that faking a response to the hypnotic procedure would be “pretty evident to any trained hypnotizer” and, while it would not impact their payment, it would lead to the experimenters having to discard the collected data and that “that would be a shame”. After signing the written consent, participants proceeded to start with the training phase, after which they received the hypnotic induction.

Induction

Stage 1

(Merci d'être venu, et merci de travailler avec nous.) Vous avez jusqu'à présent bien travaillé durant la première partie de cet expérience, et maintenant il est temps de passer à la partie suivante. Oui, comme vous pouvez probablement l'imaginer maintenant, nous allons commencer avec l'induction hypnotique. C'est une procédure que vous connaissez bien maintenant. Vous connaissez l'effet que ça porte sur votre esprit et sur votre corps, car pendant le test de l'échelle dont vous avez déjà participé vous avez bien ressenti la transe hypnotique. Tout ce qu'on va faire maintenant c'est simplement de rentrer dans cet état que vous connaissez déjà, qui vous est familier. Nous allons à nouveau le revivre avec toutes les sensations plaisantes qui en font partie. C'est bien pour vous maintenant de commencer à vous souvenir de cette occasion durant laquelle vous avez été hypnotisé chez nous, alors que vous vous préparez pour cette expérience. Très bien. Permettez-vous de commencer à tout revivre maintenant alors que nous nous préparons à commencer. Excellent.

[(Thank you for coming, and for working with us.) You have up until now worked very well during the first part of this experiment, and now it's time to move on to the next stage. Yes, as you may probably imagine, we shall now start a hypnotic induction. This is a procedure that you now know well. You know the effect it has on your mind and body, since during the screening test you have already participated of you already felt quite well the hypnotic process. All we will be doing now is simply going back into this state you already know, that you are familiar with. We will re-live it, together with all the fine sensations that come with it. It's ok for you now to start

remembering that time in which you were hypnotized with us, while you're getting ready for this experience. That's great. Allow yourself to start re-living the whole thing while we get ready to start. Excellent.]

Je veux que vous vous adossiez confortablement et que vous reposiez vos mains sur vos genoux. C'est ça. Reposez vos mains sur vos genoux. S'il vous plaît, regardez maintenant vos mains et choisissez un point sur l'un d'entre elles. Le point que vous choisissez n'est pas important, choisissez tout simplement un point sur lequel vous vous concentrer. S'il vous plaît, regardez directement ce point pendant que vous suivez ma voix, et concentrez-vous sur les instructions que je suis sur le point de vous donner. Elles vont vous aider à vous relaxer et à progressivement atteindre un état d'hypnose. Peu importe le point que vous choisissez, choisissez simplement un point sur lequel se concentrer. Je vais faire référence à ce point que vous avez choisi comme «cible ». C'est parfait . . . mains relaxées . . . regardez directement la cible. Je suis sur le point de vous donner quelques instructions qui vous aideront à vous relaxer et à rentrer graduellement dans un état d'hypnose. Simplement relaxez-vous et mettez-vous à l'aise. Je veux que vous regardiez constamment la cible et pendant que vous gardez vos yeux sur elle, écoutez ce que je dis. Votre capacité à être hypnotisé dépend en partie de votre volonté à coopérer, et en partie de votre capacité à vous concentrer sur la cible et sur mes mots. Vous avez déjà démontré que vous étiez coopératif en venant ici aujourd'hui, et avec votre coopération je peux vous aider à être hypnotisé. Vous ne pouvez être hypnotisé que si vous le voulez, je suppose que vous le voulez et que vous faites au mieux pour coopérer en vous concentrant sur la cible et en écoutant mes mots, en laissant arriver les sensations nouvelles qui vont se produire. Simplement laissez-le arriver. Et si vous faites très attention à ce que je vous dis, et que vous pensez à ce

que je vous demande de penser, vous allez facilement ressentir ce que c'est qu'être hypnotisé. Comme vous le savez maintenant, l'hypnose est un phénomène naturel. Il est probable que vous allez commencer à vous souvenir de la ou les expériences hypnotiques précédentes... la manière dont vous les avez ressentie, la manière dont vous les ressentez... Ça c'est bien, vous pouvez vous permettre de tout ressentir à nouveau. Revivez-tout cela en suivant mes instructions. Relaxez-vous, tout simplement. Soyez confortable. Gardez vos yeux sur la cible. Regardez-la aussi constamment que vous le pouvez. Si vos yeux s'en écartent, ce n'est pas important . . . faites juste revenir vos yeux sur la cible. **En fait, vous allez découvrir que vous devenez de plus en plus capable de fixer vos yeux sur la cible au point qu'ils deviennent complètement immobiles, que vous regardez la cible et que la cible, et rien d'autre. Très très bien.** Après un moment, vous allez peut être trouver que la cible devient floue, ou peut-être qu'elle bouge, ou encore qu'elle change de couleur. Ce n'est pas important. **Ça n'a pas d'effet sur votre capacité extraordinaire de fixer votre attention et votre regarde sur la cible, au point que tout ce qui se trouve à côté de la cible deviens peut être flou ou même invisible. Ceci est tout à fait normal, et même utile car ce qui se passe autour de la cible n'a aucun intérêt pour vous.** Si vous somnolez un petit peu, ça aussi c'est normal. Peu importe ce qui se passe, laissez-le se passer, et continuez à fixer la cible pendant un moment. Il viendra un moment, ou vos yeux seront tellement fatigués, ils seront tellement lourds, que vous ne serez plus capable de continuer à les garder ouverts, et ils se fermeront, peut-être de manière involontaire. Quand cela arrivera, laissez-le se produire. Très très bien.

[I would like you to lie comfortably on your chair and to rest your hands on your lap. That's it. Lay your hands on your lap. Please, look down to your hands now and pick

a spot upon which to concentrate. Whatever spot you may choose is not important, simply choose a spot on either one of your hands and concentrate on it. Please, look straight at the spot while you follow my voice, and concentrate on the instructions that I'm about to give you. They will help you to relax and to progressively achieve a state of hypnosis. It doesn't matter which spot you choose, just choose a spot to concentrate on. I shall now address that spot you have selected as "the target". That's perfect... Hands relaxed... look directly at the target. I'm about to give you some instructions that will help you relax and gradually achieve a state of hypnosis. Simply relax and get comfortable. I would like you to keep looking at the target, and while you keep your eyes on it, listen to what I have to say. Your ability to be hypnotized depends partially of your will to cooperate, and partly of your ability to concentrate on the target and on my words. You have already shown that you were willing to cooperate by coming here today, and with your cooperation I can help you become hypnotized. You cannot be hypnotized unless you want it, and I suppose that you want it and that you are doing your best to collaborate with us and to concentrate on the target and on my words, to welcome all of the new sensations that may soon take place. Just let them take place. And if you really pay attention to what I am saying, and you think about what I'm asking you to think about, you will easily feel what being hypnotized is like. As you now know, hypnosis is a natural phenomenon. It is likely that you may start remembering any or all of your previous hypnotic experiences... the way they felt, what it feels like right now... That's ok, you can allow yourself to feel all this all over again. You can re-live the experience while you listen to my instructions. Relax completely. Be comfortable. Keep your eyes on the target. Look at it as constantly as you can. If your eyes stray away from it, it's ok... just bring them back on the target. **You will actually start to notice that you**

become more and more capable of fixating your eyes on the target, to the point of rendering them completely still, of looking at the target and nothing but the target. Very good! After a little while, you may find that the target becomes blurry, or that it moves, even... or that it changes color. This is ok. **It has no effect on your extraordinary capacity to fixate your attention and your gaze upon the target, to the point that anything around and outside of the target becomes maybe blurry or totally invisible. This is perfectly normal, and even useful to you, as nothing outside the target is of any interest to you at the moment.** If you feel slightly tired, this is normal too. Whatever may happen, just let it happen, and keep looking at the target. The moment will come in which your eyes will be so tired, so heavy, that you may become unable to keep them open, and they will close, maybe by themselves. When this happens, and it will, just let it happen. Very good, that's perfect.]

Vous allez découvrir que vous pouvez porter votre attention sur votre corps en lui permettant de trouver le confort tout en se relaxant. Maintenant, relaxez tous les muscles de votre corps. Relaxez les muscles de vos jambes. . . Relaxez les muscles de vos pieds. . . Relaxez les muscles de vos bras. . . Relaxez les muscles de vos mains . . . de vos doigts . . . relaxez les muscles de votre cou, de votre poitrine . . . relaxez tous les muscles de votre corps. Relaxez-vous de plus en plus, de plus en plus. Relaxez-vous complètement. Relaxez-vous complètement. Relaxez-vous complètement. Très très bien.

Votre vision devient floue, vos paupières clignent et vos yeux sont peut-être déjà fermés. Très très bien. Il est très agréable de fermer vos yeux, de vous relaxer complètement, et d'écouter, ma voix qui vous parle. Vos yeux sont fermés maintenant, et s'ils ne le sont pas, ils devraient bientôt se fermer d'eux-mêmes. Mais il n'est pas nécessaire de continuer à les forcer. Même si vos yeux ne se sont pas

fermés complètement pour l'instant, vous vous êtes bien concentré sur la cible, et vous êtes confortable.

[You will realize that you can direct your attention towards your own body, allowing it to find a deeper comfort as it relaxes. Now, relax all the muscles in your body. Relax the muscles of your legs... Relax the muscles of your feet... Relax the muscles of your arms... Relax the muscles of your hands... of your fingers... relax the muscles of your neck, of your chest... relax every muscle of your body. Relax more and more, more and more. Relax completely. Relax completely. Relax completely. Very good.

Your vision becomes blurry, your eyes blink and are maybe already closed. Very good. It is quite pleasant to close your eyes, to relax completely, and to listen to my voice talking to you. Your eyes are now closed, and if they aren't, they should close by themselves soon enough. But it's not necessary to continue to force them. Even if your eyes aren't completely closed right now, you are very well concentrated on the target, and you are comfortable.]

Stage 2

Vous êtes maintenant confortablement relaxé, et vous allez vous relaxer encore plus. Et encore plus. Vos yeux sont maintenant fermés. Vous allez garder vos yeux fermés, jusqu'à ce que je vous dise de vous éveiller. . . . Vous vous sentez confortable. Continuez simplement à écouter ma voix. Faites très attention à elle. Gardez vos pensées sur ce que je dis, écoutez simplement. Vous allez devenir beaucoup plus confortable. Bientôt vous serez toujours confortable, mais vous continuerez à m'écouter. Vous ne vous éveillerez pas avant que je vous le dise. Je vais maintenant commencer à compter. À chaque chiffre, vous allez évoluer vers ce

confort profond. Un état dans lequel vous serez capable de faire tout sorte de choses que je vous demanderez de faire. Un—vous allez vers cette état profonde. . . deux—de plus en plus profonde et confortable. . . trois—quatre—de plus en plus, de plus en plus confortable. . . cinq—six—sept--vous glissez agréablement dans cette état... Ne faites attention qu'à ma voix, et portez votre attention sur les éléments auxquelles je vous demanderai de faire attention. Je voudrais que vous continuez à faire attention à ma voix et aux choses que je vous dis. . . huit—neuf—dix—onze—douze—De plus en plus d'attention, toujours profondément confortable—treize—quatorze—quinze—même si vous êtes profondément confortable vous pouvez clairement m'entendre. Vous allez toujours m'entendre, peu importe à quel niveau de profondeur vous sentez que vous êtes arrivé . . . seize—dix-sept—dix-huit—profondément, agréablement confortable, tonique mais confortable. Vous allez ressentir beaucoup des sensations que je vais vous demander de ressentir. . . Dix-neuf, Vingt. Profondément confortable! Vous allez ressentir ce que je vais maintenant décrire.

[You are now comfortably relaxed, and you will relax even more. And even more. Your eyes are now closed. You shall keep them that way, up until I tell you come out of it... You are feeling comfortable. Just continue listening to my voice. Pay very good attention to it. Keep whatever you may think about what I'm saying to yourself, and just listen. You will get even more comfortable. Soon you'll be even more comfortable but yet you shall continue to listen to me. You will not come out of it before I tell you so. I will now start counting. At each number, you will continue to evolve towards this profound comfort. A state in which you will be fully capable of doing all sort of things I shall ask you to do. One- you move forward towards this profound state... two- more and more comfortable... three- four- more and more, more and more comfortable... five- six- seven- you glide gently into this state... Pay attention to my voice and

nothing else, and to the elements I ask you to pay attention to. I would like you to continue to pay attention to my voice and to the things I say... eight- nine- ten- eleven- twelve, More and more attention, always deeply comfortable... thirteen- fourteen- fifteen- even if you're deeply comfortable you can listen to me clearly. You will continue to listen to me, regardless of the level of depth you feel you have achieved... sixteen- seventeen- eighteen- deeply, nicely comfortable, aware but comfortable. You will feel plenty of sensations that I will ask you to feel... nineteen- twenty. Deeply comfortable! You will now feel what I'm about to describe.]

Poshypnotic suggestion and de-induction:

Stage 1

Comme vous le savez très bien, vous êtes ici aujourd'hui pour participer à une expérience. Suivre les instructions en fait va vous aider à rester dans l'état de transe. Vous devez savoir qu'un individu peut parfaitement ouvrir ses yeux et s'engager dans toutes sortes de tâches, en continuant toujours à vivre profondément les effets de sa transe hypnotique. En fait, en suivant les instructions, vous trouverez, que vous le réalisiez ou non, que l'effet des suggestions donnés pendant l'hypnose devient encore plus consolidé. Plus vous travaillez, plus vous suivez mes instructions, plus vous appréciez l'expérience plaisante de la transe. Et ça c'est très bien.

Vous avez devant vous, comme vous le savez déjà, un clavier et un écran. Sur l'écran vous allez vérifier que pendant la tâche que nous allons vous demander de faire bientôt il y a des images, des lettres et chiffres, qui s'affichent dans l'écran. Aussi, notamment, comme je vous ai montré déjà, une ellipse qui s'affiche au centre même de l'écran. Quelque chose de très intéressant va se passer avec cette ellipse.

Au moment de commencer la tâche, vous allez suivre mes instructions et fixer votre attention et votre regarde sur l'ellipse. Et vous allez le faire tellement, que vos yeux vont rester immobiles sur cette ellipse. Vos yeux vont rester immobiles sur cette ellipse et votre attention va se concentrer exclusivement sur cette ellipse et son contenu. Au point qu'il n'y a rien autour de cette ellipse, tout autour de l'ellipse est invisible : il n'y a rien autour de l'ellipse, et même si quelqu'un voudrait afficher quelque chose sur l'écran autour de l'ellipse vous allez l'ignorer au point de ne pas le voir. Oui. Pendant que vous regardez l'écran vous allez voir exclusivement l'ellipse et son contenu. Et ça serait très bien pour vous. Sans doute vous allez percevoir l'écran différemment de comment vous le percevez d'habitude, et ça c'est très bien. Que vous vous souvenez des instructions que je viens de vous donner ou vous les oubliez, ou que vous les ressentez de manière consciente... peu importe, car l'effet va se passer quand même grâce à votre travail active et inconsciente. Plus vous regardez l'écran, plus cet effet devient fort et consolidé. Plus votre attention et vos préférences se concentrent exclusivement sur l'ellipse du centre et son contenu.

[As you know all too well, you are here today to participate in an experiment. Following the instructions will actually help you stay in a trance state. You must know that a person can perfectly open her eyes and engage on all sorts of tasks, while still experiencing the profound effects of her hypnotic trance. Actually, following the task instructions, whether you realize it or not, will consolidate the effects of any suggestion given to you. The more you work, the more you follow my instructions, the more you experience the pleasant experience that is the trance. And that's great.

You have now in front of you, as you already know, a keyboard and a screen. On the screen you will see that during the task that we will ask you to complete some images will show up, letters and numbers... they will all appear on the screen. Also, as I have already shown you, an ellipse lays in the very center of the screen. Something very interesting is about to happen with this ellipse.

As you start the task, you will follow my instructions and fixate your attention and your gaze on the ellipse. And you'll do this so much so, that your eyes will stand motionless on the center of this ellipse. They will stay motionless on this ellipse, and your attention will concentrate exclusively on the ellipse and its contents. To the extent that there's nothing outside and around this ellipse, everything outside of it is invisible: there's nothing around the ellipse, and even if anyone tries to display something outside of the ellipse you will ignore it to the point of not seeing it. Yes. While you look at the screen you will focus exclusively on the ellipse and its contents. And that will be just perfect for all of us. Surely you will perceive the screen differently from how you normally perceive it, and that's also very good. Whether you'll remember these instructions I have just mentioned or you'll just forget them, or that you'll keep them in your mind unconsciously... it's of no consequence, since the effect will be there anyhow due to your active and unconscious work. The more you look at the screen, the more this effect becomes strong and consolidated. The more your attention and your preferences concentrate exclusively on the central ellipse and its contents.]

Stage 2

*Demeurez profondément détendu et faites bien attention à ce que je vais vous dire maintenant. Dans un instant, je vais commencer à compter à rebours de 20 jusqu'à 1. Vous allez graduellement vous éveiller, mais pendant la plupart du temps où je vais compter, vous allez encore demeurer dans l'état où vous êtes maintenant. Au moment où je dirai cinq, vous allez ouvrir vos yeux, mais vous ne serez pas complètement éveillé. **DÈS QUE VOUS VOUS RETROUVEREZ DEVANT L'ECRAN ça va se faire de soi-même : il n'y a rien autour de cette ellipse, tout autour de l'ellipse est « très invisible ».** Lorsque je dirai un, vous allez être complètement vigilant, dans votre état normal d'éveil, et **DÈS QUE VOUS VOUS RETROUVEREZ DEVANT L'ECRAN, ça va s'installer : il n'y a rien autour de cette ellipse, tout autour de l'ellipse est « très invisible ».***

[Remain deeply relaxed and pay attention to what I'm about to tell you now. In a moment, I'll start counting backwards from 20 to 1. You will gradually come out of it, but for the most of this countdown, you will still remain in the state you are now. When I say five, you will open your eyes, but you will not be fully out of it. **AS SOON AS YOU FIND YOURSELF IN FRONT OF THE SCREEN, it will happen on its own: there's nothing around the ellipse, everything around the ellipse is "very much invisible".** As I say one, you will be completely vigilant, out of it, in your normal wake state, and **AS SOON AS YOU FIND YOURSELF IN FRONT OF THE SCREEN, it will happen on its own: there's nothing around the ellipse, everything around the ellipse is "very much invisible".**]

Stage 3

Je vais maintenant commencer à compter à rebours en partant de vingt, et à cinq, pas avant pas après, vous allez ouvrir vos yeux, mais vous ne serez pas

*complètement éveillé avant que je dise un, vers **le vide... à l'extérieur de l'ellipse...***
. Je vais maintenant commencer à compter à rebours en partant de vingt, et à cinq,
pas avant, vous allez ouvrir vos yeux, mais vous ne serez pas complètement éveillé
avant que je dise un. À un, vous serez éveillé... Prêt, maintenant (lentement et après
plus rapidement vers la fin) : 20-19-18-17-16-15-14-13-12-11-10-la moitié-9-8-7-6-5-
4-3-2-1. Éveillez-vous ! Complètement éveillé ! Confortable et tonique. Très très bien.

[I will now start to count backwards starting from twenty, and on five, not before, not afterwards, you will open your eyes, but you will not be completely out of it until I say one, towards the void outside of the ellipse... I will now start counting starting from 20, and on five, you will open your eyes, but you will not be completely out of it before I say one. On one you will be fully out of it.... Ready, go (slowly and progressively faster towards the end) 20-19-18-17-16-15-14-13-12-11-10-la moitié-9-8-7-6-5-4-3-2-1. Fully out of it! In your normal wake state! Comfortable and performant. Very very good.]

Suggestion (without induction)

Stage 1

Vous avez devant vous, comme vous le savez déjà, un clavier et un écran.
Sur l'écran vous allez vérifier que pendant la tâche que nous allons vous demander
de faire bientôt il y a des images, des lettres et chiffres, qui s'affichent dans l'écran.
Aussi, notamment, comme je vous ai montré déjà, une ellipse qui s'affiche au centre

même de l'écran. Nous allons vous suggerer quelque chose de particulier par rapport a cette ellipse.

Au moment de commencer la tâche, je voudrais bien que vous fixiez votre attention et votre regarde sur l'ellipse. Et si possible je voudrais que vous puissiez le faire au point que vos yeux restent immobiles sur cette ellipse. Vos yeux vont rester immobiles sur cette ellipse et votre attention va se concentrer exclusivement sur cette ellipse et son contenu. Au point que vous pourriez avoir l'impresion de qu'il n'y a rien autour de cette ellipse, et de que tout autour de l'ellipse est invisible : il n'y a rien autour de l'ellipse, et même si quelqu'un voudrait afficher quelque chose sur l'écran autour de l'ellipse vous allez l'ignorer au point de ne pas le voir. Oui. Pendant que vous regardez l'écran vous allez voir exclusivement l'ellipse et son contenu. Et ça serait très bien pour vous. Sans doute vous allez percevoir l'écran différemment de comment vous le percevez d'habitude, mais ça serait très bien. Ce n'est pas nécessaire de beaucoup réfléchir aux instructions que je viens de vous donner ou les ressentir constamment de manière consciente... Naturellement vous trouverez que regarder l'écran va bien vous aider pour que votre attention soit fortement située sur l'ellipse. Plus votre attention et vos préférences se concentrent exclusivement sur l'ellipse du centre et son contenu.

[You have now in front of you, as you already know, a keyboard and a screen. On the screen you will see that during the task that we will ask you to complete some images will show up, letters and numbers... they will all appear on the screen. Also, as I have already shown you, an ellipse lays in the very center of the screen. I am about to suggest that you adopt a particular stance regarding this ellipse, one that you may find intriguing.

As you start the task, I would like you to follow my instructions and fixate your attention and your gaze on the ellipse. I'd like you to do this so much so, that your eyes may feel motionlessly posed on the center of this ellipse. Let them stay motionless on this ellipse, and your attention will concentrate exclusively on the ellipse and its contents. To the extent that at times it may seem like there's nothing outside and around this ellipse, as if everything outside of it were invisible: there's nothing around the ellipse, and even if anyone tries to display something outside of the ellipse you might find yourself ignoring it to the point of not seeing it. Yes. While you look at the screen you will focus exclusively on the ellipse and its contents. And that will be ok. Surely you will perceive the screen differently from how you normally perceive it, and that's also very good. You don't need to keep consciously thinking about these instructions I have just mentioned. You may find that the more you look at the screen, the easier it gets for this effect to become stronger and consolidated. And your attention and your preferences may concentrate exclusively on the central ellipse and its contents.]

2.3 Hypnosis hampers emotion-driven automatic attention allocation through cognitive control.

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2.3.1.1 Highlights

* We developed an Attentional Blink paradigm with angry and neutral faces as targets, for testing the precise influence of hypnosis over automatic emotional processing, at different levels of temporal attention resolution.

* Our hypnotic suggestion for emotional numbing hampered the modulations that the Anger Superiority effect exerted over the Attentional Blink, and attenuated the differential attentional capture exerted by angry over neutral faces.

* The hypnotic process attenuated the Anger Superiority effect in a manner coherent with participant hypnotizability and suggestion content, by enforcing changes in cognitive control. However, the disruption of the link between Anger Superiority and

the Attentional Blink was a result of hypnosis' general impact on cognitive load, and the changes it fostered on the attentional task set regardless of hypnotizability.

2.3.1.2 Keywords

Hypnosis; Attentional Blink; Temporal Attention; Anger Superiority; Emotional Numbing; Automatic Processing; Task Set; Cognitive Control.

2.3.2 Paper

2.3.2.1. ABSTRACT

To understand how hypnosis interfered with automatic stimulus processing, we composed an “angry vs neutral” face-based Attentional Blink paradigm that enhanced the blink selectively by capitalizing on the Anger Superiority effect (AS), and then targeted the resulting automatic attentional enhancement warranted by the targets' emotional saliency through a hypnotic emotional-numbing suggestion. By hypnotically suggesting distance and emotional detachment from the angry faces' menacing and affective traits, we successfully hampered the modulations that the AS exerted over the blink and attenuated the AS influence on task performance. Crucially, the effects relative to the hypnotic suggestion were systematically dependent on participants' hypnotizability scores. Further analysis through the implementation of a drift-diffusion decision model led us to conclude that these hypnosis-related fluctuations depicted an optimization process signed by a decrease in decisional bounds that was inversely correlated with hypnotizability. In all, our results show that hypnosis can attenuate the differences elicited by automatic emotional attention through its effects on cognitive control.

2.3.2.2 INTRODUCTION

Temporal attention manages the distribution of cognitive resources across the stimuli presentation timeline. Its role is similar to that of spatial attention inasmuch as it also optimizes processing in the face of reduced resolution (temporal, rather than spatial) and efficiently switches from one (temporal) locus to the other (Potter, 1975; Thorpe et al. 1996). One of the most researched experimental paradigms for probing temporal attention resolution and the effects that temporal attention deprivation can have on target detection and discrimination is the Attentional Blink (AB) (Raymond, Shapiro & Arnell 1992). The AB paradigm intersperses two targets (T1, T2) within a series of distractor stimuli, and rapidly displays them in succession at the same location. Typically, when the time lag between T1 and T2 is short enough, the attentional resources invested in detecting and acting upon T1 fail to be diverted in time to T2, causing an attentional “blink” that can impact negatively on the performance of post-series T2-related tasks. As pointed out by Anderson (2005), the AB paradigm reflects how attentional limitations during encoding restrict perceptual awareness (Raymond, Shapiro & Arnell 1995; Jiang & Chun, 2001). Even though the AB is of post-sensory locus and does not accurately portray the degradation of early sensory processing (Luck, Vogel, Shapiro, 1996), it still demonstrates that perceptual encoding depends on a funnel-like, immediate consolidation process mediating the entry of perceptual information into working memory (Vogel, Luck & Shapiro, 1998).

Factors other than lag, such as target traits that evoke arousal and attract attention exogenously or endogenously, may also influence the AB, by either disrupting it or enhancing it (Olivers & Nieuwenhuis, 2006; Arend, Johnston & Shapiro, 2006). Many

studies have taken advantage of this phenomenon to study the link between temporal attention and emotion perception (Stein *et al.*, 2009). In particular, AB paradigms that employ angry or menacing faces as target stimuli have shown that the Anger Superiority effect (AS, *i. e.* the preferential processing of angry faces among crowds or series of other faces, Hansen & Hansen, 1988) could enhance the blink selectively (Jong, Koster & Martens, 2010). If an angry face (as opposed to neutral or happy faces) was presented as T1, then the additional attentional capture fostered by the AS would further difficult the allocation of attentional resources on T2 (Jong, Koster & Martens, 2010; Maratos, Mog & Bradley, 2008). Furthermore, repeated implementations of emotional AB paradigms have suggested that the affective impact of T1 features on temporal attention was automatic in nature, and did not require stimuli to be attended, let alone reported (Arnell, Killman, & Fijavz, 2007; Barnard, Ramponi, Batty, & Mackintosh, 2005; Most, Chun, Widders, & Zald, 2005; Most, Smith, Cooter, Levy, & Zald, 2007; Smith, Most, Newsome, & Zald, 2006).

Crucially, the arousal and affectively negative values elicited by disturbing and menacing stimuli have also been shown to be sensitive to top-down hypnotic modulation (Bryant & Mallard, 2002; Bryant, 2005). The “emotional numbing” hypnotic suggestion, first developed and implemented by Bryant *et al.*, successfully changed participants’ affective response to negative stimuli. While still perfectly capable of categorizing target distressing stimuli as troubling, hypnotized subjects reported to feel no emotional disturbance, menacing sensation or particular concern when exposed to stimulation, and displayed attenuated behavioral and EMG responses compared to controls (Bryant & Kapur, 2006). Since the Anger Superiority effect relies on affective appreciation (Öhman, 2002), it is reasonable to infer that an “emotional numbing” suggestion applied to an “angry face vs neutral face” AB

paradigm would impede or at least attenuate anger preferential processing, in turn modifying or attenuating this automatic attentional capture mechanism.

Implementing a hypnotic emotional numbing suggestion along the aforementioned lines would prove beneficial for both the study of the emotional AB and hypnosis. First, the successful implementation of a hypnotic procedure capable of altering the perceptual dynamics of the emotional AB could clarify the role of top-down control in emotional processing. Second, successfully modulating the AS effect and its impact over the blink through hypnotic suggestion would allow us to study the exact way in which hypnosis and temporal attention interact. Research regarding hypnosis and time has been to date mostly focused on the subjective aspects of time perception while under the effects of hypnotic suggestion, and have only touched upon temporal attention marginally, only in connection to the fact that attention and expectancy modulate subjective time (Martin *et al.*, 2016). To our knowledge, no real efforts have been made to date to combine hypnotic suggestion with the emotional AB paradigm. Pursuing this line of research would constitute an opportunity to see how hypnosis interacts with temporal attention, at the earlier and later levels of perceptual processing, and in turn appreciate how exactly the hypnotic procedure is modulated by the constrain of attentional resources that the AB fosters. Finally, the hypnotic modulation of a phenomenon largely conceived as fast, implicit and automatic could mean a valuable contribution to the argument as to whether hypnotic suggestion can achieve attention de-automatization, and influence in a controlled manner functions otherwise beyond the limits of conscious control (Raz *et al.*, 2006; Augustiova & Ferrand, 2012; Terhune *et al.*, 2010).

In order to address these interests, we composed an “angry vs neutral” face-based AB paradigm that both selectively enhanced and hampered the blink’s effects by

capitalizing on the AS, and then targeted these affective attentional modulations through a hypnotic emotional-numbing suggestion. Through this manipulation, we expected firstly to replicate the AB, predicting that the blink would affect performance for the task on T2 as a function of the latter's proximity to T1. Second, we expected angry T1 faces to accentuate this blink-related performance drop, and angry T2 faces to dampen it. Primarily, we expected that by hypnotically suggesting distance and emotional detachment from the angry faces' menacing and affective traits, we would successfully hamper the modulations that the AS exerted over the blink, and attenuate altogether the AS influence on task performance. Finally, that since both T1 and T2 had an equally task-irrelevant emotional value, we hypothesized that any differential effects of the hypnotic suggestion over the two would be attributable to the structural attentional and processing discrepancies fostered by the AB.

2.3.2.3 MATERIALS & PROCEDURES

2.3.2.3.1 Stimuli

The experiment consisted of a Rapid Serial Visual Presentation Paradigm (RSPV) designed to produce an Attentional Blink (AB). The RSVP was built with three types of stimuli: neutral and angry faces (targets), and composite faces (distractors). In order to produce these stimuli, first, we selected all available male, neutral-looking and angry-looking faces from the Cohn-Kanade (Kanade, Cohn & Tian, 2000; Lucey *et al.*, 2010), AR Face (Martinez and Benavente, 1998), ADFES (van der Schalk *et al.*, 2011), NimStim (Tottenham *et al.* 2009), Chicago Face (Ma *et al.*, 2015) and RaFD (Lagner *et al.*, 2010) databases as raw materials. All images were cropped and resized to 228 by 240 pixels. Faces were then converted to grayscale and manually

cropped again to a 2.5° major radius oval (using the tip of the nose as center). The resulting oval-shaped faces were sorted out by two independent scorers, in order to select those that better represented anger and neutrality. Faces that were not considered “angry enough” or “neutral enough” by both scorers were discarded. A total of 40 angry and 40 neutral faces were selected as stimuli.

We then used the SHINE Matlab Toolbox (Willenbockel *et al.*, 2010) to match mean luminance and contrast (*i. e.* the standard deviation of the luminance distributions) of all selected faces to a template. Said template was the composite face that resulted from averaging all pixel values for all 40 Angry and 40 Neutral Faces combined. Background luminance was set at the nominal 122 value of gray (24.6 cd/m^2). Then, in order to develop the composite faces stimuli in the same range of luminance, we combined all of the already matched neutral and angry faces into a single pool and used them as raw materials: each composite face was the result of averaging 25 faces selected at random from the pool. We produced 40 composite faces. Mean luminance of the stimuli was $18,49 \text{ cd/m}^2$ ($SD=2,21$) for the Neutral Faces, $18,97 \text{ cd/m}^2$ ($SD=1,95$) for the Angry Faces and $17,81 \text{ cd/m}^2$ ($SD=1,48$) for the Composite Faces. Mean Michelson contrast was $0,77$ ($SD=0,01$) for both Neutral and Angry Faces, and $0,76$ ($SD=0,03$) for the Composite Faces.

2.3.2.3.2 Trials

Each trial of the paradigm consisted of a RSVP stream of 16 stimuli displayed over a gray background (24.6 cd/m^2), at the center of the screen, for a duration of 116.7 ms

each. Additionally, a blank gray frame of 16 ms would appear between stimuli to accentuate inter-stimuli separation and avoid face-merging. We designated angry and neutral faces as targets, and composite faces as distractors. All faces were tilted by 12° either clockwise (CW) or counterclockwise (CCW). In each stream of stimuli, Target 1 (T1) would appear in either the third, fourth or fifth position. The delay of apparition (lag) of Target 2 (T2) in the stream was set in relation to T1 position (e.g. a lag of 3 meant that T1 was followed by two subsequent distractors before the apparition of T2). We selected a total of six lags: 1, 2, 3, 5, 8 and 10. Additionally, we presented control trials in which only T2 would appear, with its position calculated relative to a composite distractor face in the position of T1. In the case of these control trials, the composite filler face would too be either the third, fourth or fifth stimulus of the stream. The composite faces and their tilting direction were randomly selected. The targets' positions (lag), tilts (CW, CCW) and manifested emotions (anger, neutrality) were counterbalanced across trials. The main experiment consisted of a total of 600 trials, of which 120 were controls. Of the remaining 480 trials, 96 corresponded to lags 1, 2 and 3, and 64 to Lags 5, 8 and 10. These were counterbalanced for all possible target combinations (angry and neutral T1s and T2s) and inclination combinations (CW-CCW, CW-CW, CCW-CCW, CCW-CW). Control trials were counterbalanced as well. By the end of each trial, two symbolic successive cues were displayed to prompt for speeded responses. Figure 1 presents a graphical outline of the paradigm's trials.

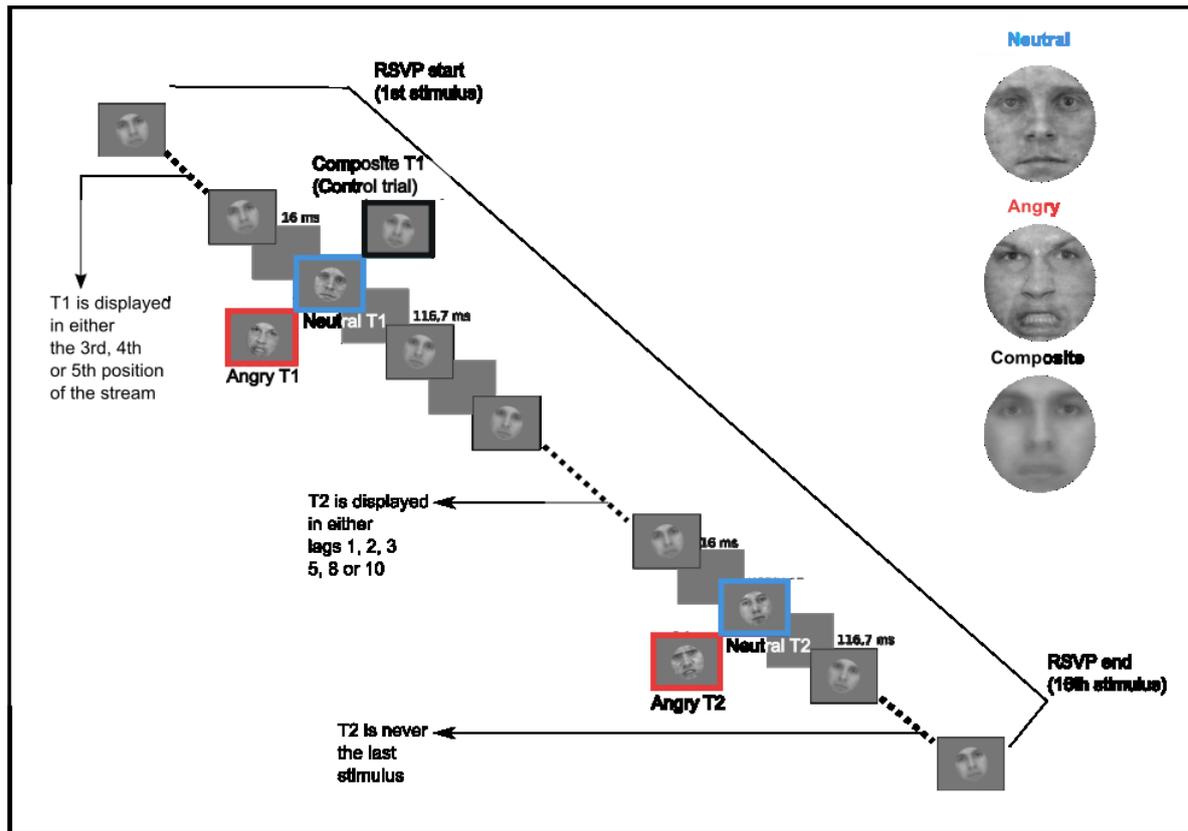


Figure 1: Face-based Attentional Blink paradigm. The paradigm consisted on the RSVP of 16 faces, for a duration of 116,7 ms each. Angry and neutral faces were selected as targets, and composite faces as fillers. All faces were tilted by 12° either clockwise (CW) or counterclockwise (CCW). In each stream of stimuli, Target 1 (T1) would appear in either the third, fourth or fifth position. The delay of apparition (lag) of target 2 (T2) in the stream was set in relation to T1. We selected a total of six lags: 1, 2, 3, 5, 8 and 10. Additionally, we presented control trials in which only T2 would appear, with its position calculated relative to a composite filler face in the position of T1. All trials were counterbalanced for all possible target combinations (angry and neutral T1s and T2s) and inclination combinations.

2.3.2.3.3 Participants

Participation was voluntary, in exchange of 15 € for a one hour and thirty minutes session. Participants were all contacted by e-mail and recruited by an independent research assistant, from a database of volunteers who had been previously screened with the French Norms of the HGSHS:A (Shor and Orne, 1962; Anllo, Becchio & Sackur, 2017). A total of 65 right-handed, native French speakers aged between 18 and 35 (mean 24.6, 38 female) attended the sessions. 47 participants were tested under hypnotic suggestion (Hypnotized Group), and 18 were tested without any sort of suggestion or hypnotic induction (Not Hypnotized Group). Interactions with all participants were scripted in order to ensure equal conditions of motivation for both groups. The Hypnosis Group was composed by 15 participants highly susceptible to hypnosis (Harvard score 9-12), 18 of medium susceptibility (score 5-8) and 14 of low susceptibility (score 0-4). The No Hypnosis Group was composed by 5 highly susceptible participants, 6 of medium susceptibility and 7 of low susceptibility. No mention whatsoever to hypnosis was made during the recruiting.

Participants from the Hypnosis Group were tested blindly, without the hypnosis practitioner knowing their level of hypnotizability at the time of explaining the task instructions or administering the hypnosis procedure. They were told that they would be taking part of an experiment that would include their response to hypnotic suggestion, and warned that all levels of susceptibility and hypnotic responding were relevant for the study. They were informed that their response, if any, to the procedure had no impact on their monetary compensation. It was also clearly stated that the authors did not have any particular expectation about their performance or hypnotic response. Participants on the No Hypnosis Group were also tested blindly,

but did not receive any information whatsoever regarding the connection between the test and hypnosis. The mention of hypnosis and hypnotic susceptibility were explicitly avoided at all times throughout the testing of this group.

All participants signed a written consent allowing for the anonymous exploitation of the data they produced. The experiment was conducted in agreement with the Declaration of Helsinki (2008) and approved by the Ethics Committee of the Université Paris Descartes (Paris 5).

2.3.2.3.4 Hypnotic Induction

The hypnotic induction was as a variation of the Elman induction (Elman, 1984), and the “emotional numbing” suggestion was based on Bryant’s emotional numbing suggestion, suggesting distance and emotional detachment from all targets’ menacing and negative affective traits (Bryant & Mallard, 2002; Bryant, 2005). The intended effect of this induction was to maximally attenuate the affective differences between the emotional content of faces, and minimize any feelings of menace the latter could inspire. It should be noted that facial traits such as expressions of anger and menace were mentioned explicitly during the administration of the suggestion. However, because of how the procedure was structured, participants ignored that during the task they were about to perform the target faces were to sport different emotions. Induction and suggestion were both crafted by the first author, who is a licensed clinical hypnosis practitioner. A detailed account of the induction and the suggestion can be found in the Appendix 2 of the Supplementary Methods. Participants who did not undergo a hypnosis procedure received no mention whatsoever regarding the faces’ expressions, anger or menace.

2.3.2.3.5 Procedure

Participants were greeted by the first author, who was also responsible for the hypnosis procedure. The first author remained uninformed of the hypnotic susceptibility of the participants until after the test, when the moment came for a post-test interview. Responses to participants' questions and the interactions with them were scripted as much as possible, and discussions about the participants' experience at the HGSHS:A screening were avoided until after the test. After signing the written consent, participants sat in a dim-lit sound-proof test booth in front of a standard LCD screen, and were provided with a standard AZERTY French keyboard to input their responses. Participants underwent first a Pre-Training phase in which they were asked to learn the difference between target and composite faces, and between CW and CCW inclinations. Participants who could not reach at least an 80% accuracy in both tasks were discarded (none were). Then, participants underwent a Training phase in which they were presented with an RSVP identical to the one described on the *Trials* incise, but with two crucial modifications: 1) Targets were only Neutral Faces, 2) the initial stimuli duration was four times longer (466,8 ms), and it decreased by a fourth every twenty trials, until matching the target duration intended for the main task (116,7 ms). Immediately after each stream of stimuli, participants were presented with two subsequent response cues, and asked to perform the following two tasks in sequence, as fast as possible: 1) At the first response cue, report the tilt of the *last target face they had seen*, and 2) at the second response cue, report *how many target faces* had appeared in the stream. This secondary task was added to ensure that participants would pay attention to Target 1, and sustain it throughout the entire RSVP stream. Response cues were symbolic, distinct, and

appeared immediately after the last face of the stream. For the first task, participants responded by using their left hand, pressing the letters “A” and “Z” of the French keyboard (reabeled CCW and CW, respectively). For the second, they used their right hand to indicate the amount of faces (either 1 or 2) on the numeric pad of the keyboard. Participants who did not reach an overall 80% accuracy rate on the Training set (100 trials) had to do it again, to a maximum of three times. Participants who did not reach an overall 80% accuracy rate after three tries were discarded (none were). Immediately after this phase, the first author delivered the hypnotic induction and administered the “emotional numbing” suggestion. Once the suggestion had been delivered, he instructed the participants to get ready for the Main Phase, in which they would have to execute the same two tasks as before, as fast and as accurately as possible, while under the effect of the suggestion. The experimenter then left the room. Trials were distributed in six blocks of 100 trials each, separated by a 3 minute pause. During the pause, the experimenter reinforced the hypnotic suggestion (see Supplementary Methods for the complete hypnosis procedure). Participants of the No Hypnosis group did not receive any kind of induction procedure or suggestion, but were instructed to use the pauses to close their eyes, relax, and hone their concentration in order to perform to the best of their abilities.

2.3.2.3.6 Post-testing

Participants in the Hypnosis Group then underwent a short debriefing interview, consisting of the following questions: 1) What is your general impression of this experiment? 2) Do you think you were hypnotized? 3) Do you think that hypnosis had an effect on the task? 4) What would you say was the hypothesis behind this experiment? 5) Would you say that hypnosis helped you with any of the tasks, and

particularly with the inclination task? 6) Did you spot any differences in expression between the faces? 7) Would you say that hypnosis changed the way you perceived these differences, or your reaction to them? Answers to these questions were written down informally and used to detect any anomalous or unwanted behaviors elicited by poor understanding of the suggestion, or by convoluted expectations regarding the hypnosis procedure (e.g., “*Hypnosis made me fall asleep completely*” or “*Hypnosis changed the way I controlled my hands*”). Participants who were to report any such behavior would be discarded (none were). Also, participants who would correctly identify the experiment’s hypotheses, state them and declare to had used them as a strategy while resolving the task were to be discarded (none were).

2.3.2.4 RESULTS

2.3.2.4.1 Statistical analyses

We performed data analysis using *R* (R Core Team, 2008). Response times and accuracy were modeled by implementing (generalized) linear mixed models, with a random intercept per participant (*lme4*, Bates 2015). We chose a hierarchical modeling approach in order to account for individual differences and for imbalances in sample sizes across factors and levels (Agresti, 2002; Jaeger, 2008). We first developed a Main Model including as regressors whether participants had been hypnotized (“Hypnotized”, levels: Yes, No), their hypnotizability (“Hypnotizability”, levels: High, Medium, Low), the emotional value of Target 1 (“T1”, levels: Angry, Neutral), the one of T2 (“T2”, levels: Angry, Neutral), and the lag category (“Lag Category”, levels: Early [lags 1, 2, 3], Late [lags 5, 8, 10]). Our rationale for splitting the multiple lags into a single two-level factor was that both our pilot data and the literature on face-based attentional blink paradigms reflected that no “Lag 1 sparing”

effects were to be expected (Jong et al., 2007; Jong et al., 2010). With the purpose of testing for the presence of AB, we also produced a version of the model that included single-target control trials, and used the number of targets per trial as a regressor (“Targets”, levels: 1, 2). The statistical significance for the fixed effects was determined through likelihood ratio tests (Pinheiro & Bates, 2000; Bolker *et al.*, 2008). To facilitate the interpretation of the resulting significant multiple interactions in a hypothesis-driven fashion, we then created smaller models by unfolding the main model across the levels of the Hypnotized factor (Hypnosis Model, No Hypnosis Model). Ratcliff’s (1978) diffusion model parameters were estimated through the maximum likelihood method, using the *fast-dm* software (Voss *et al.*, 2004); the resulting v , a and t_0 parameters were then modeled through mixed models, utilizing the same regressors, a random intercept per participant and the same modeling procedure.

For each analysis, we reported below the effects based on the best model selected according to these criteria. ANOVA tables were computed through Analysis of Deviance (Type II Wald χ^2 test), and post-hoc pairwise comparisons through Tukey contrasts of least-squares means, setting a 0.95 CI (*car* and *lsmeans R* packages, Fox and Weisberg 2011 and Lenth 2016 respectively). All models complete for accuracy, response time and diffusion model parameters can be found in full in the Appendix 1 of the Supplementary Methods.

2.3.2.4.2 Anger superiority successfully modulates the Attentional Blink

We started our analyses by observing the accuracy scores for the face-orientation task, as means to evaluate performance differences that would confirm the presence

of an Attentional Blink (AB) and a potential interference from an Anger Superiority effect (AS). First, we found that independently of whether participants had been hypnotized or not, and irrespective of their hypnotic susceptibility, their performance was consistently higher for trials in the Late lag category, in consonance with an AB effect (Lag Category main effect for the Main Model: $\chi^2=483$, $DF=1$, $p<0.0001$). The presence of the AB was further confirmed when we contrasted task performance between late lag trials and early single-target control trials (*i. e.*, just one target, displayed within the Early lag range), and found no difference (Lag Category x Targets interaction for the Main Model: $\chi^2=21$, $DF=1$, $p<0.0001$; Tukey contrast for late double-target trials vs early single-target trials: estimate=-0.02, SE=0.04, $p=1$). After establishing the presence of a blink effect, we then confirmed that for non-hypnotized participants, the blink's impact on performance was modulated by AS, meaning that the attentional benefits warranted by the AS effect favored the processing of anger-expressing targets when disturbed by the blink, in detriment of neutral targets (Lag Category x T1 x Hypnotized for the Main Model: $\chi^2=3.5$, $DF=1$, $p=0.06$; Lag Category x T1 for the No Hypnosis Model: $\chi^2=6$, $DF=1$, $p<0.05$; Lag Category x T1 for the Hypnosis Model: $\chi^2=0.2$, $DF=1$, $p=0.7$). As displayed in Figure 2, the AS effect worked both as an enhancer and a moderator of the blink, depending on whether it affected T1 or T2. Figure 2.A shows how anger valence successfully reinforced the strain exerted by T1 over the already blink-constrained attentional resources for the task on T2, leading to a decrease in accuracy coherent with the AS effect (Lag Category x T1 for the No Hypnosis Model: $\chi^2=6$, $DF=1$, $p<0.05$; Tukey contrast for early lags, Angry T1 vs Neutral T1, estimate= -0.25, SE=0.06, $p < 0.001$). Conversely, Figure 2.B shows an attenuation of the blink's detrimental effect on performance, specific to T2's anger value (Lag Category x T2 for the No Hypnosis

Model: $\chi^2=4$, $DF=1$, $p<0.05$; Tukey contrast for early lags, Angry T2 vs Neutral T2, estimate=0.24, $SE=0.06$, $p < 0.001$). It should be noted that both of these interactions between lag category and emotional valence were independent from participant's hypnotizability.

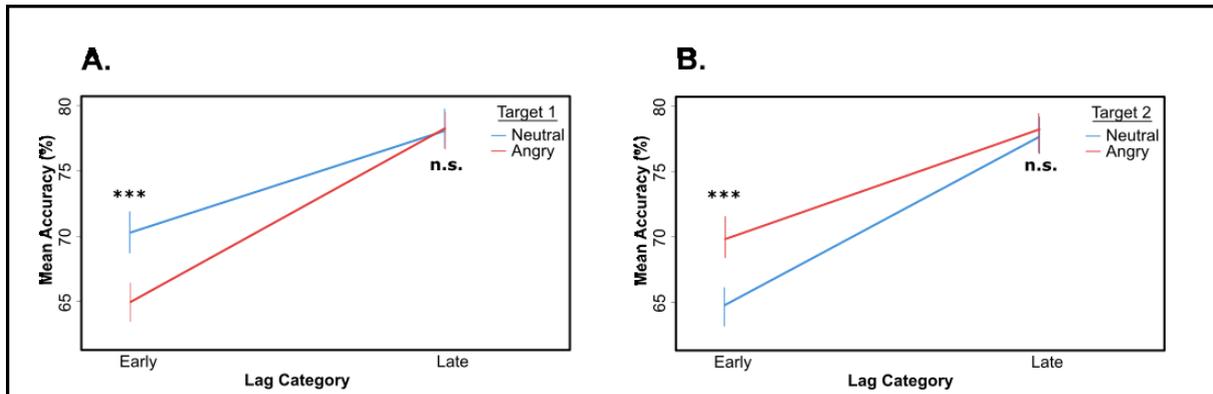


Figure 2: Attentional Blink hampers accuracy, but is modulated by the Anger Superiority effect.

Non-hypnotized participants exhibited a worsened performance for the inclination task on T2 in blink-affected trials ($p<0.0001$). **A. The impact of the AB's attentional constrains, as enhanced by the Anger Superiority effect.** Accuracy scores were significantly lower in Early lag trials when T1 displayed anger ($p<0.001$). **B. The impact of the AB's attentional constrains, as attenuated by the Anger Superiority effect.** Accuracy scores were significantly higher in Early lag trials when T2 displayed anger ($p<0.001$). SE bars calculated over grand mean minus participant mean, Morey-corrected.

2.3.2.4.3 Hypnosis disrupts the AS – AB relationship beyond hypnotic susceptibility

Following to the confirmation of the AB and AS effects, we proceeded to analyze their permeability to the effects of the hypnotic emotional numbing procedure, in relation to hypnotizability. Figure 3 outlines what was previously stated in the above section, namely, that the hypnotic procedure significantly hampered the automatic attentional leverage that AS bestowed upon T1 processing independently of hypnotizability, by extension altering the relationship between AS and AB (Lag Category x T1 x

Hypnotized for the Main Model: $\chi^2=3.5$, $DF=1$, $p=0.06$; Lag Category x T1 for the No Hypnosis Model: $\chi^2=6$, $DF=1$, $p<0.05$; Lag Category x T1 for the Hypnosis Model: $\chi^2=0.2$, $DF=1$, $p=0.7$).

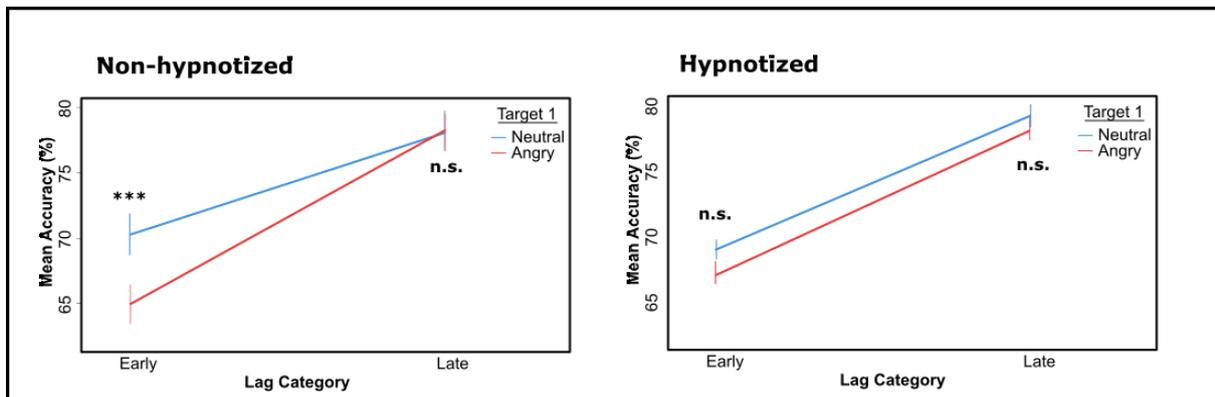


Figure 3: The Anger Superiority effect does not modulate the AB's effect on performance for hypnotized participants. For hypnotized participants, the hypnotic-numbing procedure mitigates the AS effect over T1 processing, as seen by the disappearance of its impact over the blink. SE bars calculated over grand mean minus participant mean, Morey-corrected.

2.3.2.4.4 Hypnosis modulation of the AS effect is dependent on hypnotizability

While the effects over T1 processing were independent of hypnotizability, our results also showed hypnotizability-dependent interferences of the hypnotic suggestion over T2 processing independent of the AB for hypnotized participants (T2 x Hypnotized x Hypnotizability for the Main Model: $\chi^2=12$, $DF=2$, $p<0.01$). Furthermore, as seen in Figure 4, hypnosis modulated T2's accuracy in the direction predicted by the suggestion content, namely, performance differences between angry and neutral T2s where maximal for Low participants, and decreased with hypnotizability (High<Medium<Low) (T2 x Hypnotizability for the Hypnosis Model: $\chi^2=8$, $DF=2$, $p<0.05$). Namely, while angry targets fostered an increase in accuracy, this effect was modulated by participant hypnotizability, and as predicted, the influence of

emotional traits was maximal for Low susceptibility participants (Tukey contrast Angry vs Neutral T2, Low: estimate=0.35, SE=0.05, $p < 0.0001$, Medium: estimate=0.18, SE=0.05, $p < 0.001$, High: estimate=0.14, SE=0.05, $p > 0.05$).

Interestingly, hypnosis and hypnotizability interacted with T2's emotional value not only as modulators of the task's accuracy, but also in the temporal domain, affecting response times. As seen in Figure 4, while they did not follow such pattern for non-hypnotized participants, hypnotized ones exhibited an decrease in response time correlated with hypnotizability (High<Medium<Low) (T2 x Hypnotized for the Main Model: $\chi^2=6$, DF=1, $p<0.05$; Hypnotizability main effect for the Hypnosis Model: $\chi^2=9$, DF=2, $p<0.01$).

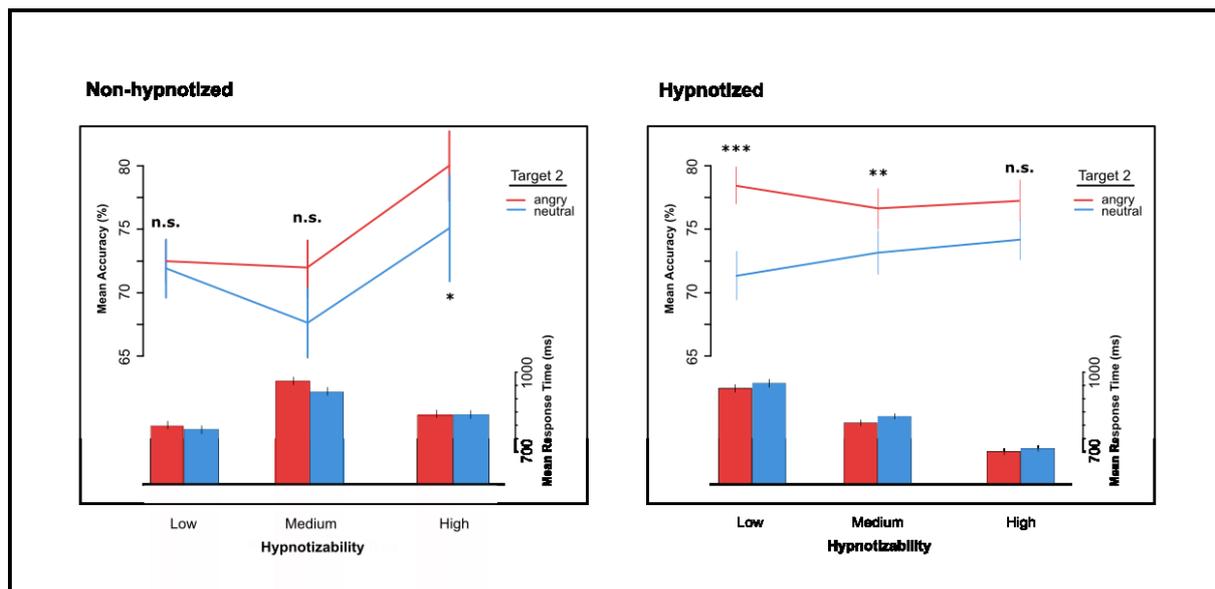


Figure 4: Accuracy and Response Times for the face-orientation task over T2, as a function of T2's emotional value and participant's hypnotizability. For non-hypnotized participants (left) hypnotizability held no effect, neither over response times nor accuracy. However, hypnotized participants (right) exhibited a response conditioned by hypnotizability both at the level of accuracy differences. Improved accuracy as granted by AS was attenuated as a function of hypnotizability (Low:

$p < 0.0001$, Medium: $p < 0.01$, High: n.s.), and times decreased globally as hypnotizability increased (main, $p < 0.01$). SE bars calculated over grand mean minus participant mean, Morey-corrected.

2.3.2.4.5 AS and AB interfere with information accumulation; hypnosis interferes through cognitive control

In order to better interpret the meaning of the uneven effect that hypnosis simultaneously held over accuracy and response times, we implemented a drift-diffusion decision model (Voss et al., 2004) to analyze response time distributions through sequential sampling for correct and incorrect trials. The model has three main parameters: a is the threshold for decision, and thus an indicator of the speed-accuracy trade-off. Lower a corresponds to a more liberal response strategy. The drift rate v is the rate of information accumulation, and thus essentially equivalent to the d' in signal detection theory. The non decision time constant t_0 represents all other psychological and physiological durations not pertaining to the decision at hand, including encoding and execution. Of these three parameters, only a was susceptible to interactions with the Hypnotizability factor, and only for hypnotized participants (Hypnotizability x Hypnotized for the Main Model: $\chi^2=10$, $DF=2$, $p < 0.01$; Hypnotizability main effect for the Hypnosis Model: $\chi^2=13$, $DF=2$, $p < 0.01$; Hypnotizability main effect for the No Hypnosis Model: $\chi^2=3$, $DF=2$, $p > 0.08$). As shown in Figure 5, mean a decreased with the increase in hypnotizability, pointing to a direct correlation between hypnotizability and lower decisional thresholds, typically associated to cognitive control. Highly hypnotizable participants under hypnosis were thus more liberal in their response, as they had lower threshold and needed less accumulated information to trigger their response. It is important to note that this

greater liberality was not accompanied by a decrease in accuracy; hence, in a sense it can be said that highly hypnotizable participants under hypnosis achieve perform closer to optimality than other participants.

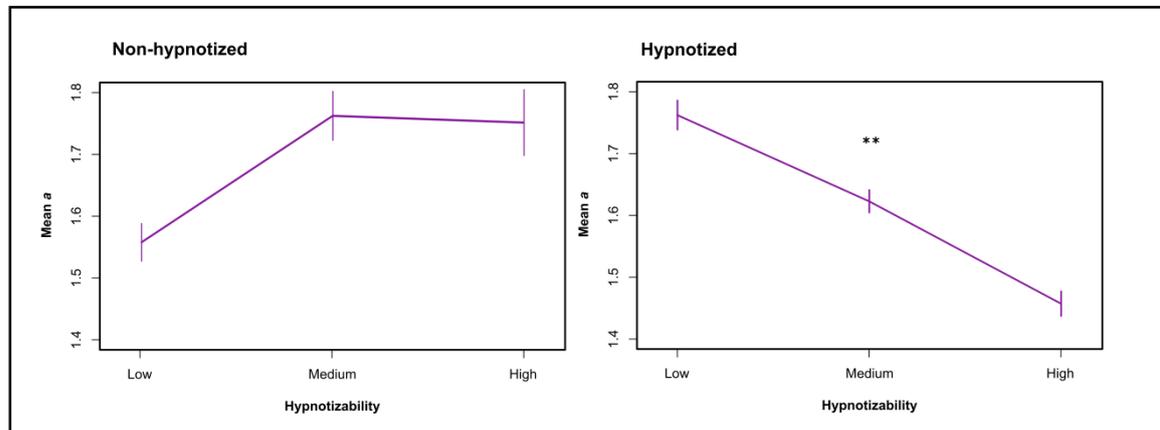


Figure 5: Evolution of response bounds in a drift diffusion model across hypnotizability. For non-hypnotized participants (left), we registered no effects or interactions in terms of response bounds and hypnotizability. Hypnotized participants (right), on the other hand, exhibited a diminishment in a inversely correlated to hypnotizability (High<Medium<Low) ($p<0.01$). SE bars calculated over grand mean minus participant mean, Morey-corrected.

Otherwise, hypnosis did not seem to affect the rate of accumulation of evidence (drift rate v) in terms of hypnotizability, but did hold a global effect over non-hypnotized participant's v corresponding to the accuracy limitations registered as a result of the AB and the AS effect. The constraining effects of the blink diminished information accumulation on T2 globally, for all blink-affected trials, mediated by the modulation of the AS effect. Figure 6 shows how for the drift rate both rose (6.B) and fell (6.A) coherently with T1 and T2's anger valence, mirroring the enhancing and the hampering of the blink, respectively (Lag Category x Target 1 interaction for the No Hypnosis Model: $\chi^2=16$, $DF=1$, $p<0.05$, Tukey contrast for early lags, Angry T1 vs Neutral T1, estimate= -0.18, $SE=0.05$, $p < 0.01$; Lag Category x Target 2 interaction

for the No Hypnosis Model: $\chi^2=4$, $DF=1$, $p<0.05$), Tukey contrast for early lags, estimate= 0.17, $SE=0.05$, $p < 0.01$).

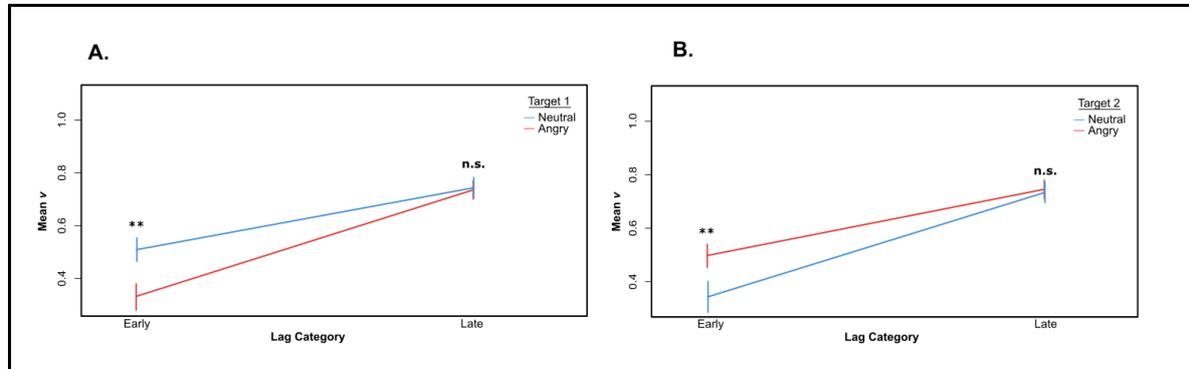


Figure 6: Effects of the AB and AS over evidence accumulation. 6.A The drift rate (v) for evidence accumulation on T2 fell further on blink-affected trials as a consequence of the anger valence of T1 ($p<0.01$). **6.B** Conversely, the drift rate on T2 rose for blink-affected trials as a consequence of the anger valence of T2 ($p<0.01$). SE bars calculated over grand mean minus participant mean, Morey-corrected.

2.3.2.5 DISCUSSION

The present work was developed to address two different questions in tandem. The first was to determine if an automatic, immediate, affective-driven enhancement of stimulus processing could be modulated through hypnotic suggestion. The rationale behind this query was to evaluate whether a robust, low-level feature of face-processing, consensually considered as automatic and involuntary (Öhman, 2002; Jong & Martens, 2009), could be defused or at least attenuated through hypnotic suggestion. The second question was to evaluate how, if at all, such modulation depended on temporal attention and immediate processing. In particular, several

authors consider hypnosis straightforwardly as a form of “atypical attention” (Lifshitz *et al.*, 2012), a claim largely based on the experimental work on how hypnosis could de-automatize attention allocation (Raz, Kirsch, Pollard & Nitkin-Kaner, 2006); should this claim hold, constrains in attentional resources would necessarily entail constrains in hypnotic responding.

We tackled these questions by composing an “angry vs neutral” face-based Attentional Blink (AB) paradigm that both selectively enhanced (for angry T1) and hampered (for angry T2) the blink’s effects by capitalizing on the Anger Superiority effect (AS), and then targeting these affective attentional modulations through a hypnotic emotional-numbing suggestion. The rationale behind this paradigm’s pertinence rested on several predictions. First, that the AB would decrease performance for the task on T2 as a function of the latter’s proximity to T1. Second, that because of the AS, angry T1 faces would accentuate this blink-related performance drop, and angry T2 faces would dampen it. Third, that by hypnotically suggesting distance and emotional detachment from the angry faces’ menacing traits, we would successfully hamper the modulations that the AS exerted over the blink, and attenuate altogether the AS influence on task performance. Finally, that since both T1 and T2 had an equally task-irrelevant emotional value, any differential effects of the hypnotic suggestion over the two would be traceable to the attentional and processing discrepancies fostered by the AB.

Our results confirmed all of the aforementioned predictions concerning the expected effects of the AB and the mediation of AS (see Introduction & Fig. 2, Fig. 3). Furthermore, they provided us with valuable evidence regarding the functioning of hypnotic emotional numbing at dissimilar points of temporal attention dynamics. Indeed, while the hypnosis procedure spared the AB entirely, it affected the AS

modulations on the blink differently for T1 and T2, globally obstructing the effect for the former, and modulating it in a hypnotizability-dependent manner for the latter. Traditionally, the phenomenon of hypnosis eliciting an even response (different from control) at all levels of hypnotic susceptibility, is either explained in terms of the easiness of the suggestion (e.g. clinical suggestions for relaxation appear to work for all patients, independently of hypnotic susceptibility), or as a global non-specific effect of the procedure (e.g. the mental absorption and increased concentration triggered by the prototypical induction process, for a review, see Terhune *et al.*, 2017). However, we consider that none of these explanations suffices to clarify the differences in the hypnotic influence over T1 (global) and T2 (hypnotizability-dependent). The first of these explanations seems unlikely; precedent utilizations of emotional-numbing suggestions have so far elicited hypnotizability-dependent responses (Bryant *et al.*, 2002; Bryant, 2005), and even more importantly, we did register such responses for the treatment of T2. The second alternative could provide us with a partial, albeit insufficient, explanation. Some theoretical models propose that hypnosis' inherent relaxation fosters a reduction in ascending cholinergic activity to the thalamus (Rainville *et al.*, 1999; Price *et al.*, 2002). These physiological changes could feasibly interfere with activity in the right pulvinar of the thalamus, a visual structure associated to the kind of pre-cortical processing fostered by AS (Öhman, 2002). Furthermore, the DLPFC, identified as one of the most critically implicated regions for a variety of hypnotic responses (Dienes *et al.*, 2007; Dienes *et al.*, 2013), has also been linked to the top-down imposition and sustainability of attentional task sets according to their emotional significance (Compton *et al.*, 2003). However, if these general influences were enough to defuse the AS on their own

right, we would not have found hypnotizability-dependent fluctuations in either accuracy or response times relative to T2's emotional valence.

We posit that the key in interpreting this differential hypnotic effect lies in the different attentional constraints that our AB paradigm imposed over each target. As previously stated, participants had to engage in two different tasks: screening every stimulus to count the targets amongst them (T1 and T2), and indicating the inclination orientation for the last perceived target (*i. e.* the main task over T2). Hence, the temporal attention consecrated for the extended processing of T1 was much scarcer than that of T2; namely, after spotting T1, participants had to count it as one target, evaluate its inclination (in case this was a single target trial), commit the information to memory and then immediately switch their focus towards the subsequent stimulus. Additionally, given the higher proportion of double target trials throughout the experiment, participants developed a strong implicit motivation for remaining alert to the arrival of a second target. In contrast, despite being affected by the blink, T2's extended processing was much less attentionally-encumbered and memory-intensive, as T2 appraisal led directly to response preparation.

Fundamentally, our results show that this difference in extended processing encumbrance between T1 and T2 interacted with the hypnosis procedure. The emotional modulation of the blink can be understood not only as a preference for attracting attentional resources that benefitted angry T1 faces, but also as a *facilitation* of T1 processing thanks to angry faces *requiring less attention* (Anderson, 2005). Now, a crucial difference between hypnotized and non-hypnotized participants was their explicit awareness of the targets' emotional value and potential menace. Although the emotional value of the targets was task-irrelevant for both groups, non-hypnotized participants did not receive any warnings or mentions regarding face

content. Hypnotized participants' attention, on the other hand, was preferentially oriented towards targets' facial expression through repeated allusions to it in the content of the suggestion (See Appendix 2 of the Supplementary Methods for a detailed script of the suggestion). We propose that the instructional content of the suggestion, together with the general components of the hypnotic procedure, increased the attentional task set and augmented the cognitive load for T1 processing, for all hypnotized participants irrespective of their hypnotizability. As pointed out by Stein *et al.* (2009), studies that increased the attentional load on T1 or included it on the task set usually showed no impact of T1's emotional value over the blink (Jong *et al.*, 2007; Arend & Botella, 2002; Stein, 2010). On the contrary, studies that allowed for the implicit processing of T1 did show an impact of the latter's emotional valence over the blink (Most *et al.*, 2005; Smith *et al.*, 2006; Most *et al.*, 2007). Hence, we posit that non-hypnotized participants from our study processed the emotional saliency of T1 implicitly and preemptively, as an automatic consequence of AS, and this in turn modulated T1's saliency on the RSVP, ultimately modulating the blink. But for hypnotized participants, despite T1's emotional valence, the increased cognitive load exceeded the little-available temporal attention, and blocked the differential processing relying on emotional saliency. Put together these findings indicate that the hypnotic procedure was capable of driving the cognitive load for T1 processing to change for all participants, independently of their hypnotizability, hence inducing a de-automatization not necessarily linked to hypnotic numbing *per se*, but rather to task set and attentional resources. This is a finding is informative beyond emotional processing: it shows the impact of the attentional demands that come with hypnotic process, and hints that suggested instruction may

be in competition with task-instruction information, even without the explicit will of the participant and beyond hypnotizability.

Unlike T1, the extended processing of T2 and the posterior processing leading to response preparation were less temporally-encumbered. Figure 4 details the effects of the interactions between hypnosis, hypnotizability and T2's emotional value, for both accuracy and response times. Performance was globally better for angry T2 targets, and the interaction between T2's emotional valence and hypnotizability was not significant for non-hypnotized participants. In particular, non-hypnotized Low participants did not manifest any accuracy differences for angry and neutral T2 targets ($p=1$). However, amongst hypnotized participants, T2's emotional valence did interact with the hypnotic procedure, and Low participants who did receive the suggestion manifested a maximal accuracy difference between angry and neutral T2 targets. For all hypnotized participants, evaluating the target facial expression became a part of the task set, but the lack of constraints in extended processing and response preparation allowed them to also *respond to the hypnotic suggestion*, and downplay the differences in attention between angry and neutral T2s as a function of their hypnotic susceptibility. Non-hypnotized Low participants did not consciously evaluate T2s emotional value as a part of the task, which expectedly minimized the impact of T2s emotional valence on task performance. On the contrary, hypnotized Lows' attention was driven towards the targets' emotional valence as a result of suggestion influence over the task set, and because of their inability to actually enact the suggestion, the difference in accuracy between angry and neutral T2s increased for them. Medium and High participants, on the other hand, managed to increasingly avoid the explicit attention allocation towards facial emotional features out of successfully enacting the hypnotic suggestion, diminishing the accuracy advantages

fostered by T2's emotional value. These differences between hypnotized and non-hypnotized participants further reinforce the interpretation of a top-down task-set update independent of hypnotizability which, when not occluded by temporal attention constraints, was met by a hypnotic response coherent with hypnotizability and suggestion demands.

Together with T2-dependent accuracy fluctuations, we observed a fall in response times for hypnotized participants inversely correlated with hypnotizability that did not have a negative impact on accuracy. Said results suggested that the success in avoiding faces' emotional saliency amounted to a less resource-intensive task. The resulting interactions between the hypnosis procedure, hypnotizability and the parameters of our drift diffusion models allowed us better understand the relationship between accuracy and response times fluctuations, as well as to pinpoint the cognitive mechanisms by which AS modulated the AB, and by which hypnosis affected performance. Of the three main parameters of the model (a being the threshold for decision separation, v the information accumulation drift rate and t_0 the non-decisional time constant representing encoding and execution), only a was susceptible to interactions with the Hypnotizability factor for hypnotized participants. The setting of the response bounds defines the liberality of the participant, namely, how much information will she decide to accumulate before casting an answer (Voss *et al.*, 2004). On its own, liberality is typically associated with a fall in accuracy, as accumulating less information usually renders participants more error-prone. Yet, liberality fluctuations that do not harm performance, but do in turn successfully improve response times, can be considered adjustments associated to optimality, and the exercise of cognitive control (Bogacz *et al.*, 2006). We posit that for the present work, the optimality increase associated with hypnotizability stemmed from a

strategic disengagement of cognitive control that immunized highly susceptible participants to the full treatment of salient emotional features of T1 and T2. We consider the converse alternative unlikely, *i. e.* a stronger engagement of cognitive control to warrant the active suppression of emotional features, since this would have rendered the task more resource-intensive and time costly for highly hypnotizable participants. Furthermore, trait suppression would have also entailed changes in signal accumulation, but we did not register any modulations of the drift rate, v , that were dependent on hypnotizability. The fact that the drift rate, which, again, corresponds to the sensitivity (d') in signal detection theory, would only change as a function of whether participants had been hypnotized or not, strongly favors the idea that the attentional load of the hypnosis procedure ultimately interfered with the low-level automatic perceptual advantages of AS.

In conclusion, hypnosis successfully attenuated the AS effect and hampered its influence over the blink, but acted differently as the availability of attentional resources changed. Faced with the attentional and temporal constraints of T1 that our task imposed, hypnosis successfully fostered the de-automatization of the Anger Superiority effect, but did so through cognitive overload and changes in the attentional task set rather than through hypnotic susceptibility. In this particular sense, hypnosis was no different from a variety of other existing experimental manipulations that influence cognitive load and end extinguishing T1's emotional facilitation (Stein, 2010). In contrast, the undisturbed extended processing of T2 allowed for hypnosis late effects to come into play, and accuracy differences between angry and neutral targets were attenuated through a hypnotizability-dependent manipulation of cognitive control, which ultimately led to the strategic dismissal of task-irrelevant emotional features, and favored optimality.

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2.3.2.9 Supplementary Materials

2.3.2.9.1 Appendix 1 – Full statistical models and supplementary results

In red squares, the effects and interactions relevant to the hypotheses of our study, for the Hypnosis Model and No Hypnosis Model.

All participants (N=65)							
~ Target1 X Target2 X Lag Category X Hypnotized X Hypnotizability + ε							
a	χ^2	DF	Pr(> χ^2)	v	χ^2	DF	Pr(> χ^2)
Lag Category	161	1	<0.0001	Lag Category	280	1	<0.0001
Target 1	0.4	1	0.5	Target 1	9	1	<0.01
Target 2	1.2	1	0.3	Target 2	28	1	<0.0001
Hypnotizability	6	2	<0.05	Hypnotizability	4	2	0.1
Hypnotized	0.7	1	0.4	Hypnotized	3	1	0.1
Lag Category x Target 1	0.01	1	0.9	Lag Category x Target 1	2	1	0.1
Lag Category x Target 2	1.3	1	0.3	Lag Category x Target 2	4	1	<0.05
Target 1 x Target 2	0	1	1	Target 1 x Target 2	4	1	<0.05
Lag Category x Hypnotizability	3	2	0.3	Lag Category x Hypnotizability	4	2	0.2
Target 1 x Hypnotizability	2	2	0.3	Target 1 x Hypnotizability	0.4	2	0.8
Target 2 x Hypnotizability	0.6	2	0.7	Target 2 x Hypnotizability	0.2	2	0.9
Lag Category x Hypnotized	4	1	<0.05	Lag Category x Hypnotized	3	1	0.07
Target 1 x Hypnotized	1.6	1	0.2	Target 1 x Hypnotized	0.4	1	0.5
Target 2 x Hypnotized	2	1	0.1	Target 2 x Hypnotized	1	1	0.3
Hypnotizability x Hypnotized	10	2	<0.01	Hypnotizability x Hypnotized	2	2	0.3
Lag C x T1 x T2	0	1	1	Lag C x T1 x T2	1	1	0.3
Lag C x T1 x Hypnotizability	2	2	0.4	Lag C x T1 x Hypnotizability	2	2	0.5
Lag C x T2 x Hypnotizability	3	2	0.2	Lag C x T2 x Hypnotizability	0.3	2	0.9
T1 x T2 x Hypnotizability	3	2	0.2	T1 x T2 x Hypnotizability	0.3	2	0.9
Lag C x T1 x Hypnotized	2	1	0.1	Lag C x T1 x Hypnotized	2	1	0.2
Lag C x T2 x Hypnotized	0.3	1	0.6	Lag C x T2 x Hypnotized	0.4	1	0.5
T1 x T2 x Hypnotized	0.2	1	0.7	T1 x T2 x Hypnotized	0.1	1	0.7
Lag C x Hyptzd x Hypnotizability	14	2	<0.01	Lag C x Hyptzd x Hypnotizability	8	2	<0.05
T1 x Hyptzd x Hypnotizability	0	2	1	T1 x Hyptzd x Hypnotizability	0.5	2	0.8
T2 x Hyptzd x Hypnotizability	2.4	2	0.3	T2 x Hyptzd x Hypnotizability	3	2	0.2
Lag C x T1 x T2 x Hypnotizability	0.2	2	0.9	Lag C x T1 x T2 x Hypnotizability	1	2	0.6
Lag C x T1 x T2 x Hypnotized	0.04	1	0.8	Lag C x T1 x T2 x Hypnotized	0.4	1	0.5
Lag C x T1 x Hyptzd x Hyptzblty	3	2	0.2	Lag C x T1 x Hyptzd x Hyptzblty	0.3	2	0.9
Lag C x T2 x Hyptzd x Hyptzblty	1.2	2	0.5	Lag C x T2 x Hyptzd x Hyptzblty	1	2	0.5
T1 x T2 x Hyptzd x Hyptzblty	0.5	2	0.8	T1 x T2 x Hyptzd x Hyptzblty	0.3	2	0.8
Lag C x T1 x T2 X Hyptzd x Hyptzblty	3.4	2	0.2	Lag C x T1 x T2 X Hyptzd x Hyptzblty	1	2	0.6
t0	χ^2	DF	Pr(> χ^2)				
Lag Category	48	1	<0.0001				
Target 1	0.9	1	0.3				
Target 2	5	1	<0.05				
Hypnotizability	1	2	0.7				
Hypnotized	2	1	0.2				
Lag Category x Target 1	0.3	1	0.6				
Lag Category x Target 2	1	1	0.2				
Target 1 x Target 2	0.2	1	0.6				
Lag Category x Hypnotizability	13	2	<0.01				
Target 1 x Hypnotizability	1	2	0.5				
Target 2 x Hypnotizability	4	2	0.2				
Lag Category x Hypnotized	0.1	1	0.7				
Target 1 x Hypnotized	0.2	1	0.6				
Target 2 x Hypnotized	0.4	1	0.5				
Hypnotizability x Hypnotized	0.2	2	0.9				
Lag C x T1 x T2	0.01	1	0.9				
Lag C x T1 x Hypnotizability	0.7	2	0.7				
Lag C x T2 x Hypnotizability	1.6	2	0.5				
T1 x T2 x Hypnotizability	3	2	0.2				
Lag C x T1 x Hypnotized	2	1	0.1				
Lag C x T2 x Hypnotized	3	1	0.08				
T1 x T2 x Hypnotized	0.5	1	0.5				
Lag C x Hyptzd x Hypnotizability	3	2	0.2				
T1 x Hyptzd x Hypnotizability	0.3	2	0.9				
T2 x Hyptzd x Hypnotizability	3	2	0.2				
Lag C x T1 x T2 x Hypnotizability	0.6	2	0.7				
Lag C x T1 x T2 x Hypnotized	0.2	1	0.7				
Lag C x T1 x Hyptzd x Hyptzblty	4	2	0.1				
Lag C x T2 x Hyptzd x Hyptzblty	1	2	0.6				
T1 x T2 x Hyptzd x Hyptzblty	1	2	0.6				
Lag C x T1 x T2 X Hyptzd x Hyptzblty	3	2	0.2				

Table SM 2. Full array of effects and interactions over α , ν and t_0 (DM parameters) for the Main Model. ANOVA tables were computed through Analysis of Deviance (Type II Wald χ^2 test). In pink, statistically significant effects and interactions. In dotted red squares, the effects and interactions related to the hypotheses of our study.

With Hypnosis (N=47)				Without Hypnosis (N=18)			
~ Target1 X Target2 X Lag Category X Hypnotizability + ϵ				~ Target1 X Target2 X Lag Category X Hypnotizability + ϵ			
α	χ^2	DF	Pr(> χ^2)	α	χ^2	DF	Pr(> χ^2)
Lag Category	103	1	<0.0001	Lag Category	57	1	<0.0001
Target 1	1	1	0.2	Target 1	0.3	1	0.6
Target 2	0.02	1	0.9	Target 2	3	1	0.08
Hypnotizability	13	2	<0.01	Hypnotizability	4	2	0.2
Lag Category x Target 1	0.5	1	0.5	Lag Category x Target 1	1.3	1	0.2
Lag Category x Target 2	2	1	0.2	Lag Category x Target 2	0	1	1
Target 1 x Target 2	0.1	1	0.8	Target 1 x Target 2	0.2	1	0.6
Lag Category x Hypnotizability	4	2	0.2	Lag Category x Hypnotizability	11	2	<0.01
Target 1 x Hypnotizability	2	2	0.3	Target 1 x Hypnotizability	0.4	2	0.8
Target 2 x Hypnotizability	1	2	0.7	Target 2 x Hypnotizability	2	2	0.4
Lag Category x T1 x T2	0	1	0.9	Lag Category x T1 x T2	0	1	1
Lag Category x T1 x Hypnotizability	0	2	1	Lag Category x T1 x Hypnotizability	4	2	0.1
Lag Category x T2 x Hypnotizability	4	2	0.1	Lag Category x T2 x Hypnotizability	0.5	2	0.8
T1 x T2 x Hypnotizability	1	2	0.5	T1 x T2 x Hypnotizability	2	2	0.4
Lag C x T1 x T2 x Hypnotizability	1	2	0.5	Lag C x T1 x T2 x Hypnotizability	2	2	0.4
ν	χ^2	DF	p	ν	χ^2	DF	p
Lag Category	207	1	<0.0001	Lag Category	79	1	<0.0001
Target 1	4	1	<0.05	Target 1	7	1	<0.01
Target 2	23	1	<0.0001	Target 2	5	1	<0.05
Hypnotizability	4	2	0.1	Hypnotizability	3	2	0.3
Lag Category x Target 1	0.4	1	0.5	Lag Category x Target 1	6	1	<0.05
Lag Category x Target 2	2	1	0.2	Lag Category x Target 2	4	1	<0.05
Target 1 x Target 2	3	1	0.07	Target 1 x Target 2	1	1	0.3
Lag Category x Hypnotizability	0	2	1	Lag Category x Hypnotizability	17	2	<0.001
Target 1 x Hypnotizability	0.7	2	0.7	Target 1 x Hypnotizability	0.1	2	0.9
Target 2 x Hypnotizability	2	2	0.4	Target 2 x Hypnotizability	2	2	0.3
Lag Category x T1 x T2	0.3	1	0.6	Lag Category x T1 x T2	2	1	0.2
Lag Category x T1 x Hypnotizability	1	2	0.5	Lag Category x T1 x Hypnotizability	0.6	2	0.8
Lag Category x T2 x Hypnotizability	0.2	2	0.9	Lag Category x T2 x Hypnotizability	2	2	0.4
T1 x T2 x Hypnotizability	0.2	2	0.9	T1 x T2 x Hypnotizability	0.7	2	0.7
Lag C x T1 x T2 x Hypnotizability	1	2	0.5	Lag C x T1 x T2 x Hypnotizability	0.7	2	0.7
t_0	χ^2	DF	Pr(> χ^2)	t_0	χ^2	DF	Pr(> χ^2)
Lag Category	35	1	<0.0001	Lag Category	12	1	<0.0001
Target 1	0.3	1	0.6	Target 1	0.7	1	0.4
Target 2	2	1	0.2	Target 2	3	1	0.06
Hypnotizability	0.2	2	0.9	Hypnotizability	1	2	0.6
Lag Category x Target 1	2	1	0.2	Lag Category x Target 1	1	1	0.3
Lag Category x Target 2	4	1	0.05	Lag Category x Target 2	1	1	0.4
Target 1 x Target 2	0.6	1	0.4	Target 1 x Target 2	0.1	1	0.7
Lag Category x Hypnotizability	14	2	<0.001	Lag Category x Hypnotizability	2	2	0.4
Target 1 x Hypnotizability	1	2	0.5	Target 1 x Hypnotizability	0.5	2	0.8
Target 2 x Hypnotizability	1	2	0.7	Target 2 x Hypnotizability	6	2	<0.05
Lag Category x T1 x T2	0.1	1	0.7	Lag Category x T1 x T2	0.1	1	0.7
Lag Category x T1 x Hypnotizability	0.2	2	0.9	Lag Category x T1 x Hypnotizability	5	2	0.1
Lag Category x T2 x Hypnotizability	2	2	0.3	Lag Category x T2 x Hypnotizability	0	2	1
T1 x T2 x Hypnotizability	1	2	0.6	T1 x T2 x Hypnotizability	4	2	0.2
Lag C x T1 x T2 x Hypnotizability	1	2	0.5	Lag C x T1 x T2 x Hypnotizability	3	2	0.2

Table SM 3. Full array of effects and interactions over α , ν and t_0 (DM parameters) for the Hypnosis Model (left) and the No Hypnosis Model (right). ANOVA tables were computed through Analysis of Deviance (Type II Wald χ^2 test). In pink, statistically

significant effects and interactions. In red squares, the effects and interactions relevant to the hypotheses of our study, for the Hypnosis Model and No Hypnosis Model.

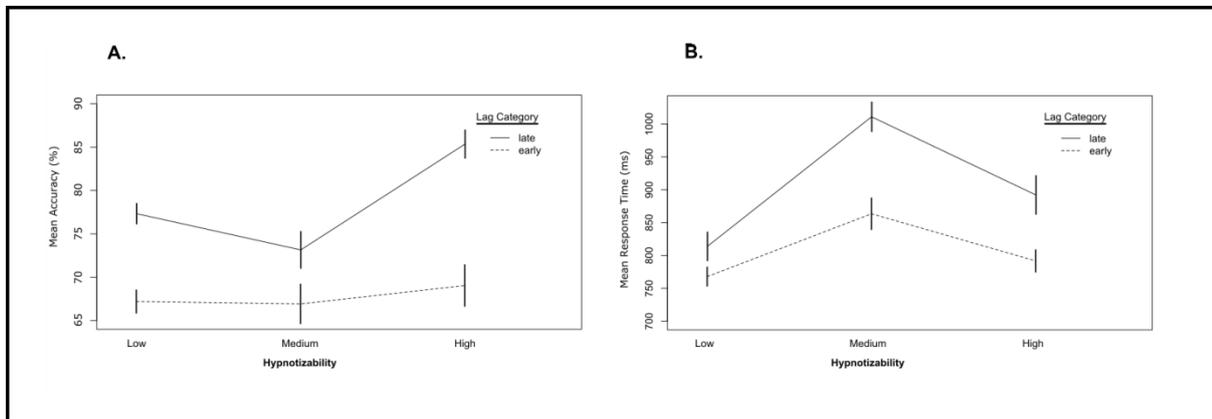


Figure SM 1. Hypnotizability-specific fluctuations of accuracy and response times, for non-hypnotized participants. **A.** Interaction between Lag Category and Hypnotizability, over accuracy: $\chi^2=23$, $DF=2$, $p<0.0001$. As is expectable, all participants perform better on the T2 task in later lag trials. Yet, this difference is maximal for highly susceptible participants. **B.** Interaction between Lag Category and Hypnotizability, over response times: $\chi^2=15$, $DF=2$, $p<0.001$. Participants take longer to answer for late-lag trials, which could be trivially explained by the fact that later lags start being processed closer to the end of the trial and the response cues. Yet, while a contrast for the difference between early and late lag trials reveals no significant changes for High and Low participants, it does show that intermediate susceptibility participants take significantly longer to execute their response. SE bars calculated over grand mean minus participant mean, Morey-corrected.

2.3.2.9.2 Appendix 2 – Hypnotic induction and suggestion

1st Induction (based on the Elman induction)**Stage 1**

Participant is asked to sit comfortably and relax. She's then asked to slow her breathing and consciously take control of it. She's asked to make it deep, regular and refreshing. The operator, sitting by her side, then tells her that during the procedure that he will be engaging on some forms of mild physical contact and demonstrates

“Donc, Il se trouve que pendant l’activation de la procédure hypnotique je vais peut-être vous toucher gentiment ici [touches wrist], ici [touches shoulder] et ici [touches forehead] avec votre permission. C’est très bien. ” [So then, it so just happens that during the launching of the hypnotic procedure I may touch you here [touches wrist], here [touches shoulder] and here [touches forehead], with your permission of course. That's perfect.]

The operator brings his right hand close to the participant's face, vertically, keeping it at approximately 10 cm from her forehead, and asks her to fixate her gaze on the top of his middle finger. It is crucial that the participant forces herself to look up in order to be able to maintain visual contact with the aforementioned target. The participant is then told to concentrate as much as possible on the operator's fingertip, and she's instructed to breathe increasingly deeper and slower. She's then told to get ready to experience a “descending wave” of relaxation from the head to the tip of her toes, which will come the moment she closes her eyes. The operator then takes a brief moment to describe this pleasant sensation, in order to give the participant's eyes enough time to get tired and strained.

Stage 2

The operator gets ready to enact the interactive relaxation procedure

“Maintenant, je vais rapprocher ma main de vos yeux de façon descendante. Il serait bien si vous permettez à votre corps de se relaxer en fermant vos yeux en même temps. Les fermer en suivant le mouvement de ma main. Très bien. [approaches hand towards eyes in a descending fashion, almost like closing them, but without touching them] Vous allez ressentir sans doute comment ils se ferment, et la détente de vos muscles oculaires... elle se propage d'elle-même vers tous les muscles de votre corps. Très bien. Comme une vague qui descend jusqu'au bout de vos orteils. Ressentez cette sensation très agréable.” [Now, I shall bring my hand close to your eyes in a descending fashion. It would be great if you'd allow your body to be completely relaxed as you close your eyes... As you close them following the movement of my hand. That's great [approaches hand towards eyes in a descending fashion, almost like closing them, but without touching them]. You will certainly feel how they close, and your eyes' muscles relaxation... propagates all the way down to the tip of your toes. Indulge in this pleasant sensation...]

Now, the operator will hold his hand horizontally, over the participant's closed eyes. The operator should try to block her potential visual field as much as possible. The operator will then explain that even though the participant's eyes feel quite heavy and tight-shut, he will be asking her to make the effort of opening them. Even if it may come as a very hard thing to do. Once the participant manages to open her eyes, she'll see that the operator's hand is blocking her view. The operator should not make any mention of this fact. She will simply congratulate the participant on being able to open her eyes, and with a descending fashion of his palm he will tell her to close them again, following the movement. The

operator will then inform that with each closing motion, the hypnotic process becomes more solid, and so does the relaxation. This will be done 6 (six) times.

Stage 3

Then, the operator will grab the participant gently by the wrist and lift her arm. The arm should feel like a limp rag. The operator will then tell the participant that he's going to let the arm fall, and that it is very possible that she may feel like her arm is somewhat independent from her body. Once the arm falls, the participant will be told that the activation of the trance shall increase five-fold. This will be done once per arm.

Stage 4

The participant is then asked to try to count backwards from a hundred to one in a very precise way

“Très bien. Maintenant, pour installer la tranche active de manière complète et totale, vous allez compter à rebours depuis cent. Mais vous allez le faire en suivant mes instructions. Vous allez essayer de prononcer chaque chiffre de manière douce mais audible, et vous allez vous en servir vous-même de ce compte pour faire le travail d'activer le processus. Écoutez-moi bien, je veux que vous poussez les chiffres dehors votre esprit, dehors votre conscience. Pour chaque chiffre que vous allez mentionner, vous allez avancer plus vers cette état, et l'expansion du processus va pousser les chiffres dehors votre esprit. Peut-être que vous allez visualiser comment elles s'évanouissent, ou vous allez les oublier tout de suite... Mais dans tous les cas vous

finirez par devenir incapable de continuer le compte à rebours, car les chiffres ne seront plus là, tout simplement. Et ça c'est très bien. Commencez, s'il vous plaît."

[Excellent. Now, in order to install this state in a complete and absolute fashion, you will count backwards, starting at one hundred. But you will do it following my instructions. You will try to pronounce each number ever so gently but yet audibly, and you will use this count to work towards the consolidation of the process. Listen to me very carefully please, I want you to push each number you pronounce outside your mind, outside your consciousness. For every number you will mention, you will advance further into this state, and the expansion of the state itself will push the numbers outside of your mind. Maybe you'll see them disappearing, or you'll just forget them immediately... But no matter what you'll end up becoming incapable of finishing the count, because the numbers will no longer be there. And that's fine. Start, please.]

At every step, whenever the participant manages to count, the operator will insist gently on the increasing relaxation and departure of the numbers. Soon enough, the participant should become unable to count. At this point we consider that the induction is complete. If for whatever reason, a sensitive participant manages to count beyond 80 (which is quite rare) then the operator can choose between going back to Stage 3 or dropping the participant.

Main Suggestion

This main suggestion is oriented towards the goal of the Attentional Blink experiment.

“Maintenant vous allez ressentir plusieurs choses que je vais vous décrire. Vous allez ressentir comment avec cet état d’hypnose que vous avez réussi sans doute à installer et vérifier à travers cette espèce d’amnésie que vous venez de mettre en place, une grande sensation de sécurité s’installe dans votre tête, dans votre corps, dans votre esprit Cette sécurité, cette protection, elle est totale. Prenez s’il vous plaît un petit moment pour vraiment l’apprécier, la ressentir. Et pendant que vous serez dans la cabine de tests cette agréable sensation de sécurité sera avec vous de manière permanente. C’est presque comme si vous regardiez tout ce qui se passe sur l’écran et dans la salle comme derrière un verre protecteur, complètement détaché, au secours, comme depuis très très loin. Derrière une barrière de protection... Profitez vraiment de cette sécurité totale qui va vous aider à vous concentrer sur la tâche, qui va vous aider à regarder toutes les images toutes les visages en sécurité, détaché, concentrée sur la tâche. Tout ici est également inoffensif, en arrière-plan, et ça c’est très bien car comme ça vous pouvez vous détacher de tout et juste faire la tâche et ne pas vous concentrer sur autres aspects de cette cabine, de ces images. Bientôt je vais partir et dès que vous serez prête vous pourrez ouvrir vos yeux et commencer l’expérience, toujours en profitant de cette sécurité très agréable et de cet état. Dans les pauses je vais revenir vous voir pour vous aider à vous reposer et vous relaxer... et c’est très possible, même presque inévitable, que le fait d’entendre encore ma voix vous aide aussi à vous relaxer et récupérer si besoin ou encore ancrer cet état de sécurité totale et ses effets. [Now you will feel several things that I will describe to you. You will now feel how this state of hypnosis that you have certainly managed to develop and verify through this sort of amnesia that you have just enacted, comes along with a strong sense of security, strongly present in your head, in your body, in your mind. This security, this protection, it is absolute. Take if you may a moment to really appreciate how palpable this feeling is. While you’ll be in this booth, you’ll feel this

very pleasant feeling of safety, permanently. It's as if you looked at everything that happened in here through a protective glass... like while being completely detached, in total safety, as if you looked from afar. Behind a protective barrier... Take your time to enjoy of this absolute safety that will help you concentrate on the task, that will help you look at every image at every face in perfect safety, detached, in perfectly concentrated on the task. Everything here is equally inoffensive, almost like background noise, and that's awesome because it will help you detach from everything and just do the task, without concentrating in any other aspect of this booth, or this images. Soon I shall leave, and as soon as you are ready you can open your eyes and start with the experiment, always while enjoying of this nice security and of this state. During the pauses I shall come back to see you and help you relax... and it is quite possible, almost inevitable, that the sound of my voice may also help you relax and recover if needed or maybe even further anchor this absolute safety and its effects.]

Suggestion Reinforcement

At every pause, the experimenter reinforced the suggestion as follows:

Très bien. Vous avez très bien travaillé jusqu'à présent. Vous allez ressentir comment avec cet état d'hypnose que vous avez réussi sans doute à installer et vérifier à travers cette espèce d'amnésie que vous venez de mettre en place, une grande sensation de sécurité s'installe dans votre tête, dans votre corps, dans votre esprit Cette sécurité, cette protection, elle est totale. Prenez s'il vous plaît un petit moment pour vraiment l'apprécier, la ressentir. Et pendant que vous serez dans la cabine de tests cette agréable sensation de sécurité sera avec vous de manière permanente. C'est presque comme si vous regardiez tout ce qui se passe sur l'écran et dans la salle comme derrière un verre protecteur, complètement détaché,

au secours, comme depuis très très loin. Derrière une barrière de protection... Profitez vraiment de cette sécurité totale qui va vous aider à vous concentrer sur la tâche, qui va vous aider à regarder toutes les images toutes les visages en sécurité, détaché, concentrée sur la tâche. . [Great, you have worked splendidly so far. You will now feel how this state of hypnosis that you have certainly managed to develop and verify through this sort of amnesia that you have just enacted, comes along with a strong sense of security, strongly present in your head, in your body, in your mind. This security, this protection, it is absolute. Take if you may a moment to really appreciate how palpable this feeling is. While you'll be in this booth, you'll feel this very pleasant feeling of safety, permanently. It's as if you looked at everything that happened in here through a protective glass... like while being completely detached, in total safety, as if you looked from afar. Behind a protective barrier... Take your time to enjoy of this absolute safety that will help you concentrate on the task, that will help you look at every image at every face in perfect safety, detached, in perfectly concentrated on the task.]

3. Summary Discussion & Conclusions

3.1 Summary

Through the three pieces of original research that we have presented on this thesis manuscript, we attempted to expand on our knowledge regarding how exactly and by which mechanisms hypnosis modulated low-level and high-level perception. Most of our work was founded on the theoretical and methodological premise of exploring and differentially exploiting the interactions between hypnosis and the temporal and spatial domains of attention, in a systematic and quantifiable fashion. The rationale behind this choice did not stem from a desire to align ourselves with the timeless debate, still reverberating through the hypnosis community, of whether attentional modulations constitute an inescapable component of hypnotic responding. Rather, we saw in attention a measurable cognitive construct, that could help us pinpoint and separate between high-order and low-level hypnotic effects, since attention allocation both warrants privileges in the processing of basic perceptual primitives and intervenes in the selection and execution of top-down cognitive control strategies (Cohen *et al.*, 1990, 2004; Mackie *et al.*, 2013). In the present work, then, we have strived to develop a clearer understanding on how hypnosis modulated attentional resources, and conversely, how attentional mechanisms conditioned hypnotic responding.

The unavoidable first step of our research program consisted of adapting and validating the French Norms for the Harvard Group Scale of Hypnotic Susceptibility. Our version of the scale, together with the added measuring and analysis methods that we implemented, gave us the means to calculate the traditional scores of

hypnotic susceptibility, but also to obtain a clear insight on how participant's own metacognitive judgments regarding involuntariness drastically altered hypnotizability measurements. When objective scores were corrected to match participants' own appreciations on their level of involuntariness, hypnotic susceptibility scores for medium and highly hypnotizable participants dropped, but the actual internal consistency of the scale improved. This served as an indicator that new, more precise measurements for quantifying hypnotic susceptibility are currently a dire need in the field of hypnosis. To prevent this issue from adding noise in our own experiments, we opted for expanding the use of the subjectivity-corrected measurements to all hypnotizability scorings and recruitments. This seminal step was crucial for the proper development of the rest of our work, as it allowed us to increase the precision with which we categorized and sorted the pool of over 500 paid volunteers from where we would eventually recruit the participants to all of our pilot studies and experiments.

Our research approach consisted of dissecting attention across its two main domains, time and space, and studying their relationship with hypnosis separately. For each attentional domain, we developed a specific hypnotic procedure and adapted a specific psychophysical paradigm that would allow us to quantify and manipulate stimulus energy, processing stages, and attentional capacity.

The first of the studies in this line consisted of an evaluation of the effects of posthypnotic suggestion over visuospatial attention. We found that hypnotically-induced spatial inattention hampered subjective visibility and cognitive processing in a predominantly top-down fashion. In particular, we identified and separated the late mechanisms by which posthypnotic induction and suggestion hampered visual awareness and reduced cognitive conflict. One first mechanism, susceptible to the

influence of hypnotic induction and dependent on hypnotizability, intervened belatedly into reshaping the subjective awareness of affected stimuli, and was all the more present the higher stimulus energy was. The second top-down mechanism, impervious to induction, was dependent on the instructional content of suggestion, similar (if not homologous) to task-instructions sets. It mediated the attribution of relevance to certain segments of the visual space for particular tasks, in a way that was congruous with both the suggested hypnotic effects and the task demands. This last mechanism interfered with priming stemming from hypnotically-affected primes, through what we identified as a top-down preemptive decision of not according them any unconscious processing (Adams & Zovko, 2012).

Our third study found relatively similar results on the temporal domain. We aimed at clarifying if the automatic low-level emotional enhancements of stimulus processing were sensitive to hypnotic suggestion, at different time points in the dynamics of temporal attention. The rationale behind this query was first to evaluate whether a robust, low-level feature of face processing, consensually considered as automatic and involuntary (Öhman, 2002; Jong & Martens, 2009), could be defused or at least attenuated through hypnotic suggestion. Second, if said modulation would be constrained by the availability of attentional resources. We therefore selected the anger superiority effect (AS), whereby angry faces are preferentially processed compared to happy or neutral faces. Our results showed that hypnosis successfully attenuated the AS effect and hampered its influence over the blink, but that its general influence over performance changed depending on the availability of attentional resources. For targets that were temporally-constrained at the level of late and extended processing (T1), the hypnotic procedure de-automatized implicit emotional enhancements through cognitive overload and changes in the attentional

task set prescribed in the content of the suggestion (Stein *et al.*, 2009; Stein *et al.*, 2010). In contrast, for targets in which the temporal restriction was axed on early stimulus processing (T2), we found that undisturbed extended processing allowed for hypnosis late effects to come into play. For these targets in particular, the accuracy differences between angry and neutral targets were hypnotizability-dependent. We traced back this effects to a cognitive control manipulation, which we ultimately interpreted as the strategic dismissal of task-irrelevant emotional features, in favor of avoid conflict and achieving optimality.

3.2 Towards a cognitive two-step model of hypnotic responding

Despite the differences in attentional modalities, when put together our results appeared to uncover some of the common mechanisms behind basic hypnotic responding. In both experiments, the effect of hypnotic suggestion over performance worked through top-down control; more precisely, through the impact that suggestion had over the task attentional set. Indeed, our posthypnotically-induced spatial inattention experiment showed that while certain hypnotic components such as hypnotic induction had a strong effect over late subjective markers (such as visual awareness), low-level automatic processing could only be altered a priori and indirectly, through the kind of broad, goal-oriented high-order control usually attributed to cognitive strategy. The lack of semantic priming stemming from the hypnotically unattended targets strengthened this idea: rather than having a direct incidence on sensory processing (as physical masking does), the posthypnotic suggestion fostered the strategic dismissal of the perceptual information.

Our data on the hypnotic emotional numbing experiment pointed to the same phenomenon. Previous studies had shown that the interaction between the anger superiority effect (AS) and the attentional blink (AB) was known to disappear when participants were asked to treat T1's emotional information explicitly (e.g., Jong *et al.*, 2007). In paradigms such as the one we implemented, where emotion was task-irrelevant, the key to the AS modulation effect over the AB was that the processing of the faces' emotional value remained implicit (Most *et al.*, 2005; Most *et al.*, 2007; Smith *et al.*, 2006). While the non-hypnotized participants from our study manifested dire modulations of the AS effect over the AB, this was not the case for hypnotized participants, who independently of hypnotic susceptibility had all incorporated the faces' emotional valence as a part of their attentional task set. From this we cannot help but to conclude that hypnotic suggestions carry a fair amount of task-relevance, independently of hypnotic susceptibility, and that their impact on the attentional task set is at least in the same order of magnitude than that of task instructions.

Based on these convergent findings, we could infer that although they differ from actual task instructions, hypnotic suggestions are processed as having an equivalent cognitive value in terms of attentional task sets. With this fact in mind, we could posit a rudimental cognitive model of hypnotic responding as a two-stage process. On the first stage, the suggestion would actualize the task set, provoking attention to be driven towards the hypnotically targeted components. We posit that this would happen independently of what the actual instruction may consist of, independently of how much it could conflict with the preexisting representational set or the original task instructions, and independently of hypnotic susceptibility. The additional attentional load this would produce would explain why on our hypnotic emotional numbing experiment, hypnosis disarmed the AS modulation over the blink, and furthermore, it

would explain why the performance difference between angry and neutral T2 targets for Low participants was larger in the Hypnotized group (as contrasted against the Lows from the non-hypnotized group). It could also explain why, when probed on a task other than peripheral visibility over hypnotically affected targets, High participants from the posthypnotic inattention experiment showed such high performances, despite their subjective visibility scores.

During the second stage, with a variable degree of involuntariness, participants would attempt to manage this new updated task set, which would often hold a contradiction between suggestion content and the original attentional set. Those participants we commonly identify as highly susceptible individuals would be able to privilege the suggested new task set components, and avoid contradiction by updating their cognitive strategy and disengaging from resource-intensive conflict monitoring. After all, our findings point to a drop in cognitive load directly correlated to hypnotizability, manifested through a drop in response times and decision bounds. Conversely, those identified as Low susceptibility participants would respond by developing the strategy of trying to ignore the newer components of the attentional task set, and their performance would exhibit maximum signs of conflict. Our data also reflects this cognitive effort through data on bounds and response times.

Although the evidence available may not be enough to go beyond simple speculation, we posit that the conception of such a model would sport several advantages worth of consideration. To begin with, such a conception would be compatible with most main recent neuroscientific findings on hypnotic responding. The latter have proposed that hypnosis often entails the recurrent desynchronization of the Anterior Cingulate Cortex and structures related to conflict mediation (Egner *et al.*, 2005; Jiang *et al.*, 2016). The hypo activation of the Dorsolateral Prefrontal

Cortex, also related to hypnotic responding, would appear to point towards a hypnotic deactivation of cognitive control rather than its enhancement (Dienes *et al.*, 2007; Dienes *et al.*, 2013; Raz *et al.*, 2005; Terhune *et al.*, 2010; Terhune *et al.*, 2017). Such a model would be compatible as well with the original concept of hypnotic susceptibility as proneness for harmonizing cognitive conflict through cognitive control detachment (Egner *et al.*, 2005). Finally, from this model's standing point, we could go as far as to hypothesize that the contributions of hypnotic traditional inductions are limited to their motivational and attentional absorption effects. Additionally, this model would explain why in a vast array of contexts hypnotic susceptibility can predict the susceptibility to regular suggestions.

3.3 A proposal on future research venues on hypnosis and attention

To date, little to no attention has been paid to the interactions between hypnosis and the concretely different components of attention, mostly because the existing corpus of experimental work regarding the matter has generally targeted attentional components in bulk. We propose that future hypnosis research should contrast the effects of hypnosis on endogenous and exogenous cueing, and at a larger scale, on stimulus-driven and goal-directed attention in general. It would be of great interest to see if hypnosis can either suppress or enhance the inhibitory effects of spatial attention, and modulate crowding or masking effects. Although some preliminary points have been made regarding hypnosis' capability of altering visual acuity through attention (Raz *et al.*, 2004), further experimental research is direly required in order to evaluate if hypnotic hallucinations behave the same when invoked over stimuli displayed inside foveal, parafoveal and extrafoveal spaces. Understanding

how spatial attention acuity conditions hypnotic responding and hypnotic susceptibility, namely, answering the question of whether hypnotic phenomena are possible in the absence of attention, would constitute a crucial step in the phenomenal characterization of hypnosis, and would clarify the boundaries of its practical applications.

Aside from selecting and modulating the sensory processes involving the environment, attention plays a crucial role in the regulation of internal mental processes through cognitive control (Cohen *et al.*, 1990, 2004). As argued by Chun & *et al.* (2011), the capacity limitations constraining the repertoire that can be contained in working memory, the number of decision-making alternatives and the amount of responses that can be produced at a given time require the intervention of attention as an arbitrating mechanism. Internal attention encompasses all selection mechanisms, including cognitive control, that operate over biasing the competition between cognitive representations at all of the aforementioned stages. Cognitive control in particular constitutes a bridge between “internal and external attention” (Chun *et al.*, 2011): through the top-down enforcement of priors, executive networks in prefrontal and posterior parietal cortices bias the selection competition (Desimone & Duncan, 1995; Buschman & Miller, 2007) through the establishment of task rules that will filter perceptual information and map it onto motor responses. Only afterwards, external selection without prefrontal interference occurs (Rossi *et al.*, 2007). It is possible that some of hypnosis’ most impressive effects (*e.g.* visual hallucinations) could be explained at least partially by this internal control feature. We know that attention can alter a percept appearance through increasing the strength of its attended features (Carrasco *et al.*, 2004), but top-down executive control also imposes perceptual filtering based on memory (Hansen *et al.*, 2006) context

(Rahman *et al.*, 2008) and motivation (Balcetis, 2006). It would be in the best interest of the field of hypnosis to isolate every one of these features and evaluate how and to what extent can hypnotic suggestion impact internal attention, in order to better understand in a more precise fashion *how* does hypnosis modulate cognitive control, if through attention or otherwise.

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