DOI:
10.1016/j.concog.2023.103473

Comparative effects of hypnotic suggestion and imagery instruction on bodily awareness

C. APELIAN[1,2], F. DE VIGNEMONT[1], D.B. TERHUNE[3,4]

1- Institut Jean Nicod, Département d'études cognitives, ENS, EHESS, CNRS, PSL University, UMR 8129, 29 rue d'Ulm 75005 Paris, France.

2- A.R.C.H.E. Research Center, 27 rue de Fontarabie 75020 Paris, France.

3- Department of Psychology, Goldsmiths, University of London, London, UK

4- Department of Psychology, Institute of Psychiatry, Psychology & Neuroscience, King's College London, London, UK

Corresponding author : C.APELIAN, clement.apelian@arche-hypnose.com

ABSTRACT

Bodily awareness is informed by both sensory data and prior knowledge. Although misleading sensory signals have been repeatedly shown to affect bodily awareness, only scant attention has been given to the influence of cognitive variables. Hypnotic suggestion has recently been shown to impact visuospatial and sensorimotor representations of body-part size although the mechanisms subserving this effect are yet to be identified. Mental imagery might play a causal or facilitative role in this effect, as it has been shown to influence body awareness in previous studies. Nonetheless, current views ascribe only an epiphenomenal role to imagery in the implementation of hypnotic suggestions. This study compared the effects of hypnotic suggestion and imagery instruction for influencing the visuospatial and sensorimotor aspects of body-size representation. Both experimental manipulations produced significant increases (elongation) in both representations compared to baseline, although the effects were larger in the hypnotic suggestion condition. The effects of both manipulations were highly correlated across participants, suggesting overlapping mechanisms. Self-reports suggested that the use of voluntary imagery did not significantly contribute to the efficacy of either manipulation. Rather, top-down effects on body representations seem to be partly driven by response expectancies, spontaneous imagery, and hypnotic suggestibility in both conditions. These results are in line with current theories of suggestion and raise fundamental questions regarding the mechanisms driving the influence of cognition on body representations.

Keywords: Hypnosis, imagery, body representations, body image, body schema, suggestion

INTRODUCTION

Although considerable attention has been devoted to the sensory contributions to bodily awareness (Blanke, 2012; Blanke et al., 2015; Vignemont, 2018; Ehrsson, 2020; Salomon et al., 2017), cognitive factors are also known to play a role. Hypnotic suggestion (for an overview see Oakley & Halligan, 2009; Terhune et al., 2017), defined as a suggestion following a hypnotic induction, which is a procedure intended to facilitate response to suggestion (Barnier & Nash, 2008; Green et al., 2005; Terhune & Cardeña, 2016), has been shown to modify various dimensions of self-awareness, including the sense of agency (Deeley et al., 2013; Lush et al., 2017; Polito et al., 2018), the sense of body ownership (Rahmanovic et al., 2012), and mirror self-recognition (Barnier, Cox, et al., 2008). Specific hypnotic suggestions can also be used to induce sex change delusion (Noble & McConkey, 1995), and alterations in body-part size estimation (Apelian et al., 2022), amongst others (Röder et al., 2007; Terhune & Cardeña, 2009; Zeev-Wolf et al., 2016). Hypnosis recruits multiple components, some of which are widely recognized as mundane psychological processes, such as attention, expectancy, imagery, etc. (Barnier et al., 2020; Lynn et al., 2008; Wagstaff, 2004; Woody et al., 2005; Woody & Barnier, 2008). These processes are also thought to play an important role in alterations of conscious experience in everyday life, outside the context of hypnosis (Cardeña & Terhune, 2014). Understanding the mechanisms underlying these phenomena is key to uncovering the determinants of healthy and pathological bodily experiences and offers hope of better prevention and treatments (Oakley & Halligan, 2011; Woody & Szechtman, 2011).

One of the components that seems to be recruited by hypnotic suggestion is mental imagery, which is often experienced following hypnotic inductions (Cardeña et al., 2013; Pekala & Kumar, 2007). Mental imagery should not be confused with supposition imagination (S-imagination), which involves representing that something is the case while it may not be true, for instance S-imagining that COVID-19 did not spread across the world. This does not involve visualizing a healthy world, but simply entertaining a counterfactual thought. It is purely conceptual and has no sensory dimension (Goldman, 2006). By contrast, mental imagery is a type of enactment imagination (E-imagination), which involves a facsimile of a specific state, and in our case, of a sensory state. For instance, while looking at a horse, you can E-imagine it as a unicorn by representing the sensory features of the mythic beast. This does not entail that you believe that the horse has a spiralled horn on its forehead. You simply visualize it without further commitment. It has been shown that visual imagery shares mechanisms with visual perception (Dijkstra et al., 2019) and activates modality-specific cortical networks, including fronto-parietal regions and a well delimited area in the left fusiform gyrus (Spagna et al., 2021). Mental imagery can also encompass other sensory modalities and involves multisensory integration, such as imagining lifting a cup of coffee, while smelling its aroma and feeling the warmth of the brew.

Although mental imagery is often reported after hypnosis, it is unclear whether it is a crucial feature of responsiveness to hypnotic suggestion (Sheehan & Robertson, 1996) or only a mere epiphenomenon (Terhune & Oakley, 2020). It has even been argued that imagery and hypnosis may be orthogonal processes (Kirsch et al., 1987). One study compared conditions in which the use of counter-pain imagery was either prescribed or proscribed during hypnotic analgesia. It was found that responsiveness to the suggestion did not vary across the two conditions, indicating that counter-pain imagery did not contribute to the suggestion effect (Hargadon et al., 1995). Another study analysed participants' goal-directed imagery reports after administration of a hypnotic suggestibility scale and found that voluntary use of imagery was not associated with responsiveness to hypnotic suggestions (Comey & Kirsch, 1999).

However, different hypnotic suggestions might recruit different mechanisms and the results obtained for hypnotic analgesia (Hargadon et al., 1995) might not generalize to all hypnotic suggestions (e.g. Barnier et al., 2021; Woody et al., 2005). Furthermore, one major hurdle to elucidate how hypnotic suggestion relates to imagery is the multidimensionality of both constructs. One dimension of imagery (e.g., vividness) might play a role for a specific dimension of hypnotic experience (e.g., verisimilitude) for a particular suggestion (e.g., motor suggestion), but not for other combinations.

There are thus important uncertainties surrounding the relation between hypnotic suggestion and imagery (Terhune & Oakley, 2020). This article aims at uncovering the recruitment of imagery during hypnotic suggestion and how it relates to changes in experience and behaviour. Here, we define hypnotic suggestion as a procedure, whose most salient consequences are reduced sense of agency (Weitzenhoffer, 1980) and increased verisimilitude of the suggested event (Woody & Szechtman, 2007). Imagery, on the other hand, is defined as a psychological process that can be triggered by participants (i.e., deliberate imagery) or elicited by the context (i.e., spontaneous imagery) (Walton, 1990). Deliberate imagery occurs after conscious intention to engage into an act of imagination whereas spontaneous imagery occurs without conscious intention, possibly triggered by the environment or by other thoughts. For instance, one can try to visualize what one’s living room would look like with the sofa in display in the shop (deliberate imagery). Alternatively, when pressed not to think of a pink elephant, many report intrusive imagery of a pink elephant (spontaneous imagery). This is not something that one decides to do; the imagery is perceived as just happening. This spontaneous phenomenology could be linked to the antecedents of the imagery process (e.g., having a desire to imagine something with a specific property), the process itself (e.g., how easy it was to convoke the mental image), or posterior processes (e.g., how congruent the mental image was with one’s goals). Many of these processes are also key aspects of the theoretical background of hypnosis, for instance fluency (how relatively easy or effortful a process is) is a key component of the discrepancy-attribution theory of hypnotic suggestion (Barnier, Dienes, et al., 2008). Therefore, in this study, we asked participants to rate their imaginative experience regarding deliberate and spontaneous imagery. We assumed that imagery can be reliably reported by participants (e.g., Bowers & Woody, 1996).

Here we focused on the representation of body-part size, assessed at both sensorimotor and visuospatial levels (Apelian et al., 2022). The visuospatial component, the body that one perceives, is usually referred to as "body image", whereas the sensorimotor component, the body one acts with, is generally labelled "body schema" (Vignemont, 2010). Although this distinction raises a number of issues, the evidence shows that information about the body can be encoded in different ways depending on the purpose of the task. What differs then is not the information represented as such, but its format in relation to the function of the representation (Vignemont et al., 2021). The sensorimotor format can be directly exploited by the motor system to guide action, unlike the visuospatial format, which can be used by the perceptual system.

Several studies have shown that body-size perception can be influenced by sensory manipulations, for instance through proprioceptive-tactile illusions (Lackner, 1988), visuo-tactile illusions (Kilteni et al., 2012), and tool use (Cardinali et al., 2009). It has also been shown that participants can incorporate larger hands in the Rubber Hand Illusion (Botvinick & Cohen, 1998; Pavani & Zampini, 2007). Although the latter illusion can be impacted by cognitive factors, it is widely accepted that it relies on multisensory integration (Ehrsson et al., 2022; Slater & Ehrsson, 2022). There are still only a few results showing the modulation of body-size perception exclusively induced by cognitive states (e.g., Gadsby, 2017). It is only recently that hypnotic suggestion has been shown to be effective at modulating both body representations compared to an active placebo and to the classic Lackner illusion (Apelian et al., 2022; Lackner, 1988), but no direct comparison with imagery has been made yet, to our knowledge.

The effect of imagery on basic body representations, such as size of body parts, is still an evolving field. Deficits of body schema are commonly assessed by using motor imagery tasks

(Purcell et al., 2018; Schwoebel et al., 2001, 2002; Schwoebel & Coslett, 2005). Several studies have further found that motor imagery can significantly influence body schema in healthy participants (Baccarini et al., 2014; Jeannerod, 1994; Naito, 1994; Oikawa et al., 2017). One study showed that imagining using a tool had similar effects on movement kinematics as physically using it, and that it sufficed for integrating the tool into the body schema (Baccarini et al., 2014). By contrast to motor imagery, to our knowledge, few studies have used sensory imagery to alter body schema and body image, and those doing so mainly target body satisfaction (e.g., Esplen et al., 2018). It thus remains unclear to what extent sensory imagery modulates body representations at both sensorimotor and visuospatial levels.

In this study, we contrasted the effect of imagery instruction and hypnotic suggestion on body metrics. Both manipulations targeted the perceived size of the left index finger, such that participants were alternatively given the hypnotic suggestion that their finger was growing longer or instructed to imagine their finger growing longer. Responsiveness to the manipulations was assessed with an estimation of finger size to measure body image and a line reaching task to index body schema (Apelian et al., 2022). The central aim of this study was to test to what extent mental imagery modulates body image and body schema and how the magnitude of this effect compares to that of hypnotic suggestion. We also measured expectancies prior to each manipulation and whether participants used imagery voluntarily or experienced spontaneous imagery. We further evaluated whether hypnotic suggestibility and familiarity with hypnosis covaried with these effects as they were both previously found to relate to the effects of hypnotic suggestion on body image and body schema, respectively.

MATERIAL AND METHODS

Participants

The sample size was estimated prior to data acquisition. We expected the difference between hypnotic suggestion and imagery instruction to be relatively small given that the wording of suggestion evokes imagery. Hence, we prespecified an effect size similar to the differential effect of hypnotic and non-hypnotic suggestions (i.e. with or without induction). This effect size was estimated around Cohen's $d=0.28$ based on previous experiments (Braffman & Kirsch, 1999). Using this effect size, a statistical power estimate ($1-\beta$) of .80 and an α-level of .05 with a one-tailed paired-samples t-test and an effect size of 0.28, an *a priori* power analysis run using GPower 3.1 (Faul et al., 2009) yielded a minimum sample size of 81 participants. A total of 82 participants (60 females, 22 males) completed the experiment ($M_{age}=38.4$; $SD=11.6$; range: 22-64 year-old). All were right-handed or ambidextrous according to the *Edinburgh Handedness Inventory* (Oldfield, 1971), $M=4.55$, $SD=0.83$. None reported psychiatric or neurologic disorders nor current use of psychoactive drugs (medical or recreational). All participants had two valid, functional arms, normal or corrected to normal vision, and were fluent French speakers. Participants were recruited *via* two communication networks. One was the RISC (Relais d'Information sur les Sciences de la Cognition; *RISC*-UAR 3332 CNRS), a service advertising experiment opportunities in cognitive science to potential participants. The second one was the first author's personal communication network. The sample was diverse in age, gender, ethnicity and prior knowledge of hypnosis.

Materials

Hypnotic suggestibility. Hypnotic suggestibility was measured using a French translation of the online version of the *Sussex-Waterloo Group Scale of Hypnotizability* (SWASH) (Apelian, 2022; Lush et al., 2018; Palfi et al., 2019). This scale consists of a relaxation-based hypnotic induction followed by ten suggestions for alterations in motor control, cognition, and perception. Following a de-induction, participants self-rated their behavioural and subjective responsiveness to each of the suggestions with dichotomous and 6-point (0-5) Likert scales, respectively. The SWASH was selected because of its similarity to the widely-used *Stanford Hypnotic Susceptibility Scale: Form C* (Weitzenhoffer & Hilgard, 1962). The SWASH usually has good internal consistency for the subjective scale, and this is confirmed in our sample, Cronbach's α=.85 (George & Mallery, 1999). However, the internal consistency of the behavioural scale was poor, α=.62 (Apelian, 2022; Lush et al., 2018; Palfi et al., 2019). Correcting for compliance helped raise internal consistency to an acceptable level, by counting as failed any suggestion with a subjective score of 0 or 1 (implying compliance). In our sample, the corrected behavioural scale was good, α=.70 (George & Mallery, 1999). In this study, "hypnotic suggestibility" refers to the corrected behavioural ratings. We also asked participants to report their familiarity with hypnosis ("Report your familiarity with hypnosis (being hypnotized) or self-hypnosis.") using a Likert scale (0-5) from (0) "I never experienced hypnosis" to (5) "I am acquainted with the experience of hypnosis". Hypnotic suggestibility was normally distributed in our sample according to Shapiro-Wilk test, W=0.96, p=.10, and no significant gender difference was present, $t(53)$=0.85, p=.40. The mean SWASH score, M=3.9 (SD=2.2), represents medium hypnotic suggestibility (Apelian, 2022; Lush et al., 2018). Only 55 participants completed the online SWASH.

Body image. The *finger length perception task*, identical to our previous study (Apelian et al., 2022), was used to measure body image. The task was performed using a graphical user interface (GUI) displaying a picture of the participant's left hand and a slider. This GUI was presented on a laptop (Lenovo ideapad 100S; screen size: 14") situated at 50cm on the right side of the participant at approximately 30° from the facing direction. A picture of the participant's left hand was taken at the start of the experiment against a white backdrop with ambient light (no directional light to prevent hard shadows) from above using a web camera (F/#2.0 ; f: 4.8mm - ∞). The GUI was developed by the first author using python and the

OpenCV library (accessible on demand). The “target” window (Figure 1.c) separating the index finger from the rest of the hand was positioned and sized by the experimenter at the beginning of the experiment, just after the picture of the hand was taken. The participant was instructed to adjust the slider, using a standard mouse, until the picture of their finger matched their perceived length of their finger. Adjusting the slider resized the “target” window laterally, thus shrinking or expanding the represented length of the finger. In each condition, perceived finger length was measured as the mean of two trials, one with the starting position of the slider at the maximum distortion (three times the normal size) and one starting at the minimum distortion (one third of the normal size). This was done to prevent anchoring effects (Furnham & Boo, 2011). Perceptual change was computed as the mean difference of measurements in each condition relative to baseline. In other words, perceptual change corresponds to how long participants perceived their finger elongating, with negative values reflecting perceived contraction.

Body schema. The *line reaching task*, similar to our previous study (Apelian et al., 2022), was used to measure body schema. In this task, the participant’s left arm was hidden in a box on a table (Figure 1.a and 1.b), resting on a sliding platform (drawer mechanism). Four parallel lines {1,2,3,4} with an inter-line distance of 30mm were displayed in the field of view of the participant next to the box, with a number displayed next to each line. In each condition, participants completed nine trials in which they were asked to match their left index fingertip with the position of one of the lines in the following sequence {1,2,3,4,3,2,1,4,1}. This was done by the participant sliding the moving platform inside the box until they felt their fingertip matched the target mark. The lines were only visible to the participants outside the box, so they could not see the position of their left hand. Pointing change was computed as the mean difference between measurements in each condition relative to baseline, with positive values corresponding to undershooting (pointing closer to the body relative to the baseline trial) and negative values corresponding to overshooting (pointing further away from the body relative to the baseline trial).

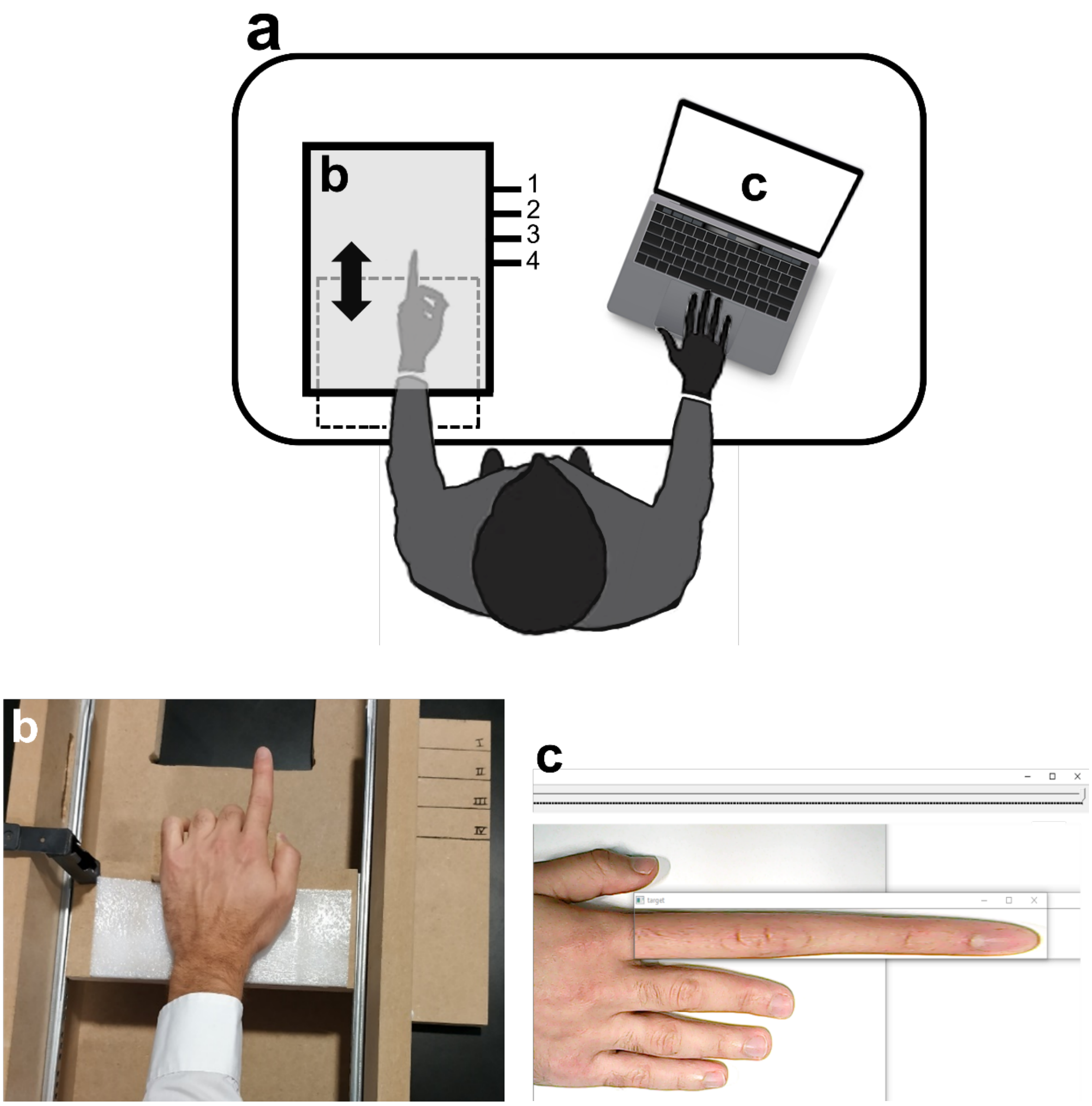

Figure 1: Schematic of the apparatus for measuring body image and body schema. (a) Schematic of the apparatus. The dotted line rectangle in the box represents the moving platform. (b) Interior of the experimental apparatus in the line reaching task. Participants pushed or pulled the platform so that their fingertip match the position of the line specified by the experimenter. The interior of the box is visible for demonstration purposes but in the experiment, a lid covered the apparatus at all times, occluding the participant's hand so that they could not see the inside of the box. (c) Graphical user interface of the finger length perception task in one of the starting

positions (finger extended). Participants used the slider on the top right of the image to change the displayed distortion.

Hypnotic suggestion. The hypnotic suggestion condition was conducted following a script developed for this experiment and contained a short induction, focussed on breathing and being absorbed in bodily sensations, followed by a suggestion to experience the left index finger elongating: “the finger is growing like a branch and extends until it is 10cm longer”. Participants were given 60s to experience the suggestion without further suggestions or cues. This was done to allow for optimal responding, as the perceived effect of the suggestion can take several seconds and often a couple of minutes to peak (see, e.g., McConkey et al., 1999). Afterwards, and before testing, participants were told that they would go through the measurement tasks, eyes open, while remaining hypnotized with their index finger keeping the same size for the whole duration of the measurements. When testing was done, the suggestion was cancelled and a standard de-induction was administered (similar to Bowers, 1993). Participants were then instructed to rub their hands and take a short break.

Imagery instruction. The imagery instruction procedure consisted of a simple instruction matching the suggestion wording without an induction: “imagine that the finger is growing like a branch and extends until it is 10cm longer”. Then participants were left to implement the instruction for 60s (matching the length of the hypnotic suggestion condition). When one minute elapsed, participants were asked to stop whatever they were doing to ascertain that they did not maintain deliberate imagery during measurements. This was done to make sure that participants would not report imagery but rather perceived finger length in the perceptual task. Note that these instructions, while not mentioning the word “imagery” were designed to be understood as such (by non-expert French speakers). Indeed, there is no equivalent for the term in French, and it is foremost a technical term absent from common language (Nanay, 2021). Deliberate imagery report was able to confirm that imagery was indeed recruited in the imagery instruction condition (Mean = 4.5/5; Median = 5).

Response expectancies and imagery reports. Participants rated three statements with Likert scales (1-5) from "strongly disagree" to "strongly agree" in the context of each condition. Prior to each condition, participants rated their response expectancy: "I think I will experience my index finger growing longer". After each condition, they rated their deliberate use of imagery relative to their experience of finger elongation: "I voluntarily used imagery"; and their experience of spontaneous imagery: "Imagery happened spontaneously". These last two questions aimed at assessing the experience of intentionality associated with imagery, as both conditions might elicit a combination of mental images felt as deliberately produced or spontaneously occurring. Note that the last question can be interpreted as assessing the origin of imagery (self vs. the world) or the fluency of imagery (how easy it was to generate). However, there two interpretations are closely related, and reflect source monitoring as suggested by studies on the sense of agency (Chambon & Haggard, 2012) and models of hypnotic suggestion (Barnier, Dienes, et al., 2008).

Procedure

Participants' involvement consisted of two sessions separated by at least one day. The first session involved the administration of a French translation of the online SWASH (Apelian, 2022). In the second session, participants completed the finger length perception and line reaching tasks first at baseline and then in the imagery instruction and hypnotic suggestion conditions in randomized counterbalanced order. In each condition, the finger length perception task always preceded the line reaching task. At the end of the experiment, a question-and-answer period was offered to dissipate any uneasy feelings that might arise due to the unusual experience of hypnosis. Participants were compensated 10€ for their time.

General setup. The experiment was run in a windowless room without any distraction (visual or noise). The apparatus is represented in Figure 1.a and consisted of a desk chair that participants adjusted at the beginning of the experiment; a standard table (height: 73cm); the line reaching task apparatus (see Figure 1.a and 1.b); and a laptop (Figure 1.a and 1.c). Participants sat 5cm from the table. When the moving platform of the reaching task apparatus was at full extension, drawn towards the participant's body, the hand and wrist remained hidden by the lid.

Baseline measurements. After demonstrating the apparatus to the participant, and one practice trial, both tasks (finger length perception task [2 trials] and line reaching task [9 trials]) were completed at baseline. These measurements constituted the reference point from which perceptual change and pointing change were computed for each participant. Note that baseline measurements do not necessarily reflect correct estimates (i.e., no distortion in the perceptual task and on the marks for pointing task), although they are generally closer than what was obtained in the imagery and hypnotic suggestion conditions.

Statistical analyses

No multivariate outliers (>M+3 SDs in 2 conditions) were identified in the dataset. Data were analysed using linear mixed effects models, t-tests (frequentist and Bayesian) and correlation comparisons using R (Version 4.0.3) with the lme4, car and cocor libraries (Bates et al., 2015; Diedenhofen & Musch, 2015), respectively. All other analyses were performed using Python 3 and the scipy library. All data are publicly available on the Open Science Framework (https://osf.io/gy7u9/).

RESULTS

Sample description

The distribution of hypnotic suggestibility in our sample, as indexed by the SWASH, behavioural corrected: M=3.6, SD=2.2 (range: 0-9) was commensurate with our previous French study (Apelian, 2022). There were no significant gender differences for perceptual change in the hypnotic suggestion condition, two-sample two-tailed t-test $t(80)=0.45$, $p=.66$, Hedge's $g=0.08$, or in the imagery instruction condition, $t(80)=-0.13$, $p=.90$, $g=-0.02$. The same held for pointing change, $t(80)=0.49$, $p=.63$, $g=0.09$, $t(80)= 0.54$, $p=.59$, $g=0.10$, respectively. Therefore, we pooled both gender samples for subsequent analyses. Similarly, there was no significant effect of condition order (imagery instruction first or second) on perceptual change, either in the hypnotic suggestion condition, $t(80)=1.52$, $p=.13$, $g=0.24$, or in the imagery instruction condition, $t(80)=0.58$, $p=.56$, $g=0.09$. The same held for pointing change, $t(80)=1.71$, $p=.09$, $g=0.27$, $t(80)=0.81$, $p=.42$, $g=0.13$, respectively. Therefore, we did not consider condition order in our subsequent analyses.

Hypnotic suggestion vs. imagery instruction on finger elongation

Our first analysis contrasted the magnitude of the condition manipulations on perceptual and pointing changes. Figure 2 presents the effect of the two conditions (relative to baseline) on perceptual and pointing changes as well as their difference. Relative to baseline, hypnotic suggestion produced larger perceptual changes, two-tailed paired-sample t-test $t(81)=11.84$, $p<.001$, $g=1.50$, and pointing changes, $t(81)=8.19$, $p<.001$, $g=1.10$. The same was observed for imagery instruction on perceptual changes, $t(81)=8.77$, $p<.001$, $g=1.25$, and pointing changes, $t(81)=5.45$, $p<.001$, $g=0.73$. Furthermore, the effect of hypnotic suggestion was significantly larger than the effect of imagery instruction on perceptual changes, $t(81)=3.41$, $p=.001$, $g=0.32$, and pointing changes, $t(81)=3.60$, $p<.001$, $g=0.31$. These results demonstrate that both manipulations produced significant changes on the finger length perception and line reaching tasks compared to baseline, and that the effect of the hypnotic suggestion was stronger than the effect of imagery instruction on both measurements, although this difference was small in magnitude.

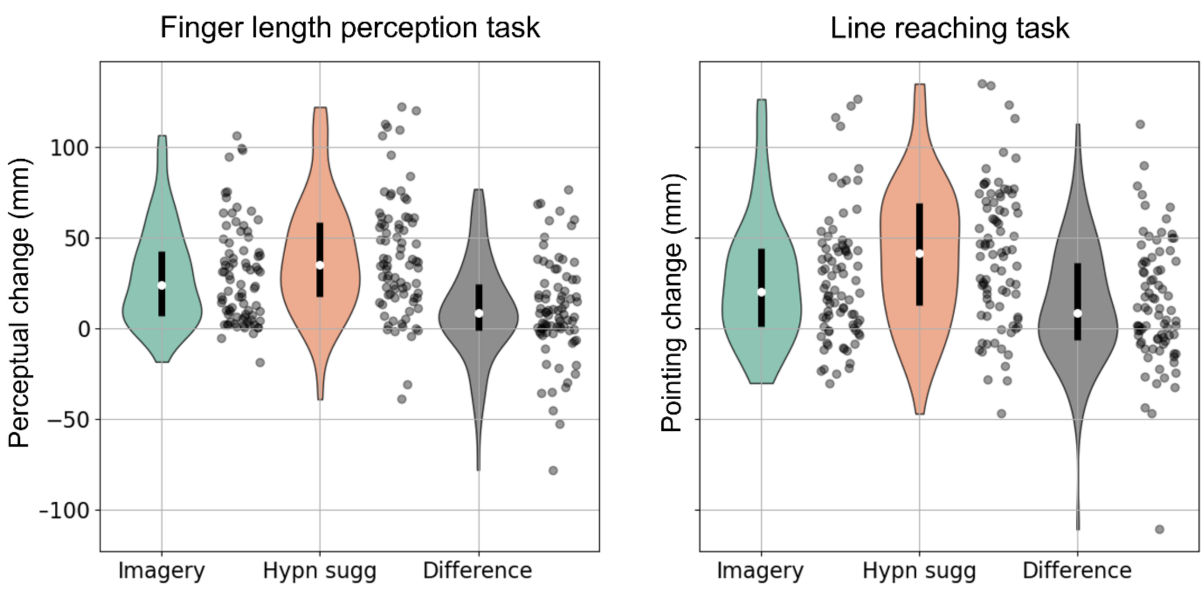

Figure 2: Violin (kernel density estimation) plots and individual mean measurements of perceptual and pointing change (mm) as a function of Condition ($N=82$). Positive values reflect subjective elongation and undershooting respectively in the perceptual task and the line reaching task, whereas negative values reflect subjective contraction and overshooting. Central black lines represent the interquartile range and the white dots the median changes in each condition. Difference = hypnotic suggestion - imagery instruction.

Relation of condition effects with hypnotic suggestibility

First, we examined whether baseline performance on both tasks was *not* significantly correlated with hypnotic suggestibility. This was indeed the case, with $r(53)$=-.14, p=.30 for the perceptual task, and $r(53)$=.07, p=.62 for the line reaching task. This means that further correlations with perceptual change and pointing change were unlikely to be confounded by baseline errors in the task. Our next analyses considered the extent to which the condition effects on finger length representation were related to hypnotic suggestibility. We found that perceptual change in the hypnotic suggestion condition was moderately (positively) correlated with hypnotic suggestibility, r=.37, 95% CI=[.12, .58], p=.005. Similar positive correlations were observed in the hypnotic suggestion condition between pointing change and hypnotic suggestibility, r=.43, 95% CI= [.19, .63], p<.001. However, in the imagery instruction condition perceptual change was not significantly correlated with hypnotic suggestibility, r=.18, 95% CI=[-.09, .43], p=.19. Hypnotic suggestibility was also significantly positively correlated with pointing change in the imagery instruction condition, r=.34, 95% CI=[.08, .55], p=.012. These results indicate that the effect of hypnotic suggestion is positively associated with hypnotic suggestibility, whereas the link between imagery and hypnotic suggestibility is weaker and more uncertain.

In order to incorporate these different effects, hypnotic suggestibility was included in a mixed-effect model alongside the effect of the different conditions with participant as a random effect (global intercept only). Model relevance was assessed with a χ^2 test comparing the basic mixed linear model (perceptual change ~ condition / pointing change ~ condition) against a model where hypnotic suggestibility was included as a covariate. We also allowed for an interaction between hypnotic suggestibility and condition. In the perceptual model, hypnotic suggestibility improved the model, $\chi^2(1,n=56)=9.10$, p=.002, with further improvement when the condition x hypnotic suggestibility interaction was included, $\chi^2(1,n=56)=6.10$, p=.014. The pointing change model improved when we added hypnotic suggestibility, $\chi^2(1,n=56)=11.1$,

p<.001, but it did not improve by allowing for interaction between condition and hypnotic suggestibility, $\chi^2(1,n=56)=1.8$, $p=.18$. Insofar as familiarity with hypnosis predicted pointing change in our previous experiment (Apelian et al., 2022), we also included it as a covariate, which did not improve the perceptual model, $\chi^2(1,n=56)=2.3$, $p=.13$, but did improve the pointing change model, $\chi^2(1,n=56)=4.38$, $p=.036$. The model further improved with the inclusion of the condition x familiarity interaction, $\chi^2(1,n=56)=7.46$, $p=.006$, but no improvement occurred when allowing the interaction between familiarity and hypnotic suggestibility, $\chi^2(1,n=56)=3.27$, $p=.35$. A summary of the best models is presented in Table 1 and Table 2. Taken together, these results suggest that hypnotic suggestibility explains an important part of the variance in both tasks and conditions. The effect of hypnotic suggestibility was still significant after including familiarity with hypnosis. Indeed, the two variables were weakly and non-significantly correlated, $r=.15$, *95% CI*=[-.12, .40], $p=.26$.

Table 1

Best linear mixed effects model of perceptual change (n=56)

Perceptual change ~ Condition * hypnotic suggestibility + (1|Pariticipant)					
Fixed effects	Estimate	*SE*	95% *CI*		*p*
			LL	UL	
Intercept (Imagery instruction)[a]	**17.77**	**6.97**	**4.10**	**31.44**	**.011**
Hypnotic suggestion [a]	-1.17	5.89	-12.72	10.38	.84
Hypnotic suggestibility [b]	2.91	1.67	-0.37	6.19	.082
Hypnotic suggestion x hypnotic suggestibility [b]	**3.51**	**1.41**	**0.74**	**6.28**	**.013**

Notes. CI = confidence interval; LL = lower limit; UL = upper limit. Within subject variance = 492.58; residual variance = 273.43. [a] = estimates in mm; [b] = estimates in mm/scale unit (0-10 scale).

Table 2

Best linear mixed effect model of pointing change (n=56)

Pointing change ~ Condition * familiarity with hypnosis + hypnotic suggestibility + (1|Pariticipant)					
Fixed effects	Estimate	*SE*	95% *CI*		*p*
			LL	UL	
Intercept (Imagery instruction)[a]	-3.62	11.29	-25.74	18.50	.75
Hypnotic suggestion [a]	2.86	5.59	-8.10	13.82	.61
Hypnotic suggestibility [b]	**7.51**	**2.38**	**2.85**	**12.17**	**.002**
Familiarity with hypnosis [c]	1.90	2.68	-3.36	7.16	.48
Hypnotic suggestion x familiarity with hypnosis [c]	**4.78**	**1.72**	**1.40**	**8.16**	**.006**

Notes. CI = confidence interval; LL = lower limit; UL = upper limit. Within subject variance = 1325.9; residual variance = 356.2. [a] = estimates in mm; [b] = estimates in mm/scale unit (0-10 scale); [c] = estimates in mm/scale unit (0-5 scale).

Correlations

Figure 3 presents the correlations between perceptual and pointing changes in hypnotic suggestion and imagery instruction conditions, as well as the correlations of measurements (perceptual and pointing change) across conditions. We found that perceptual and pointing changes were highly correlated in the hypnotic suggestion condition with a similar (yet non-significantly weaker) association in the imagery condition z=-1.45, p=.15 (Figure 3 left). We also report strong positive correlations between task changes in the hypnotic suggestion and imagery conditions (Figure 3 right). Taken together with other results reported above, these correlations highlight the similarities between imagery instruction and hypnotic suggestion in this experiment.

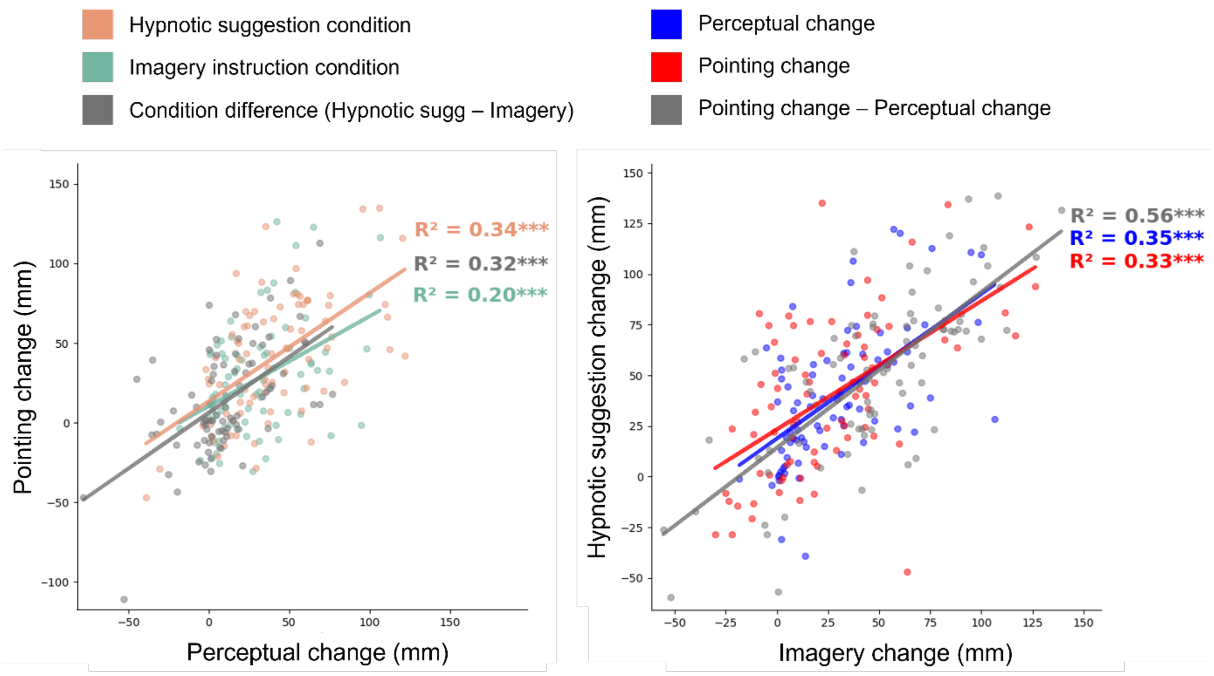

Figure 3: Scatterplots depicting the associations between pointing and perceptual changes as a function of condition (left), and associations of each change across conditions (right) (N=82).

*** p<.001

Relations between response expectancies and condition effects

We next considered the role of expectancies in the modulation of body representation by hypnotic suggestion and imagery instruction. Surprisingly, participants had similar expectancies in the hypnotic suggestion and imagery instruction conditions, B_{10}=0.32 (or odds of 3.14:1 in favour of the null hypothesis of no condition difference). Self-reported response expectancy correlated with the magnitude of perceptual change in both the hypnotic suggestion condition, r=0.39, 95% CI=[.14, .59], p=.003, and the imagery instruction condition, r=0.43, 95% CI=[.19, .62], p<.001; and with the magnitude of pointing change in both the hypnotic suggestion condition, r=0.33, 95% CI=[.07, .54], p=.013, and the imagery instruction condition, r=0.34, 95% CI=[.09, .55], p=.009. As hypnotic suggestibility and response expectancy were significantly correlated across conditions r=0.33, 95% CI=[.11, .52], p=.004, we sought to examine if they predicted unique or overlapping variance of perceptual change. To that end, we computed a linear model of perceptual change including response expectancies and hypnotic suggestibility as covariates. Both were significant predictors in the hypnotic suggestion condition with respectively β=12.23 (0-4 scale), p=.004, for response expectancies and β=4.99 (0-10 scale), p=.014, for hypnotic suggestibility. In the imagery instruction condition, hypnotic suggestibility failed to reach significance β=2.07, p=.23, but response expectancies remained a significant predictor of perceptual change, β=10.57, p=.012. This means that the predictive power of expectancies is not reducible to hypnotic suggestibility. We also tested for interaction between hypnotic suggestibility and response expectancy, but it did not reach significance in either the hypnotic suggestion condition, β=1.01, p=.62, or the imagery instruction condition, β=-0.23, p=.91. We computed similar models of pointing change. In the hypnotic suggestion condition response expectancies remained a significant predictor of pointing change, β=10.44, p=.05, hypnotic suggestibility failed to reaching significance, β=4.92, p=.06, though it was close. No significant interaction was observed, β=1.89, p=.47. In the imagery instruction condition, neither response expectancies or hypnotic suggestibility reached significance, β=9.63, p=.12 and β=2.93, p=.26 respectively. These results indicate that self-reported expectancies are important predictors of both perceptual and pointing changes and that this association is not reducible to hypnotic suggestibility, albeit it is more uncertain for pointing change, especially in the imagery instruction condition.

Relation of deliberate vs. spontaneous imagery during conditions with condition effects

Participants also reported having similar levels of spontaneous imagery in the two condition, B_{10}=0.33 (odd ratio of 3:1 in favour of the null hypothesis), but superior *deliberate* imagery in the imagery instruction compared to the hypnotic suggestion condition, B_{10}=29458 (odds ratio in favour of the alternative hypothesis of different means). Notably, we found no evidence for a significant correlation between deliberate and spontaneous imagery ratings, r=.06, 95% CI=[-.12, .24], BF_{10}=0.14, which suggests that spontaneous and deliberate generation of imagery occur concurrently and are not related. To assess the relations between these reports and perceptual and pointing changes, we performed linear mixed effects models with condition, deliberate and spontaneous imagery reports as covariates and participant as a random effect. For perceptual change, spontaneous imagery predicted a significant portion of the variance, β=5.99 (mm per scale unit; 1-5 Likert scale), 95% CI=[2.46, 9.51], p=.001, but not deliberate imagery, β=-0.99, 95% CI=[-4.60; 2.63], p=.59. For pointing change, the same pattern appeared with β=5.79, 95% CI=[1.14; 10.43], p=.002, and β=1.25, 95% CI=[-3.5; 6], p=.61, respectively. Allowing for an interaction between spontaneous imagery and condition did not significantly improve the perceptual change model, $\chi^2(1,n=56)=5.4$, p=.07, or the pointing change model, $\chi^2(1,n=56)=3.1$, p=.21. These results coherently indicate that spontaneous imagery explains variations in both measurement tasks and conditions whereas deliberate imagery does not.

We further controlled for expectancies and hypnotic suggestibility by including these variables in the model described above (perceptual/pointing change ~ spontaneous imagery + (1|Participant)). Spontaneous imagery remained a significant predictor of perceptual change when expectancies were included in the model, β=4.74, 95% CI=[1.22; 8.25], p=.008, when hypnotic suggestibility was included, β=4.16, 95% CI=[0.50; 7.81], p=.026, or both variables, β=3.70, 95% CI=[0.01; 7.4], p=.050. However, for pointing change, spontaneous imagery failed to reach significance when expectancies were included in the model, β=4.31, 95% CI=[-0.36; 8.98], p=.070, or when hypnotic suggestibility was included, β=3.12, 95% CI=[-1.92; 8.16], p=.23.

Finally, we tested if the sub-group of n=18 participants reporting *no spontaneous imagery* significantly responded to the imagery instruction. This was indeed the case for both perceptual change, $t(17)=3.60$, $g=0.99$, $p<.001$, and pointing change, $t(17)=2.76$, $g=0.80$, $p=.017$. This suggests that spontaneous imagery is not a *necessary* condition for the effect of imagery instruction. Few participants reported no spontaneous imagery in the hypnotic suggestion condition (5), but all but one had both perceptual and pointing changes in the range of several centimetres.

DISCUSSION

This study compared the effects of imagery instruction and hypnotic suggestion on body image and body schema. We reported a significant finger elongation effect of both manipulations on both types of body representation, as indexed by perceptual and pointing changes, with a slight, albeit significantly larger effect of hypnotic suggestion compared to imagery instruction. In addition, we found strong correlations between perceptual and pointing changes (i.e. between modulations of body image and schema representations), which is consistent with our previous research (Apelian et al., 2022), and aligns with models proposing an interaction between body image and body schema (Pitron et al., 2018). Importantly, we also found strong correlations between the effects of hypnotic suggestion and imagery instruction on both perceptual and pointing changes, suggesting overlapping abilities enabling responsiveness to these manipulations. Our results further suggest that hypnotic suggestibility predicts a substantial proportion of the variance in responsiveness to both methods. We sought to determine whether these effects were supported by strategic deliberate use of imagery. Notably, self-reports indicated that deliberate use of imagery *per se* did not seem to drive changes in body representations in any of the conditions. This conclusion is in line with evidence drawn from the literature regarding imagery and other suggested phenomena (Terhune

& Oakley, 2020). We explain these effects in terms of task-relevant expectancies and hypnotic suggestibility and propose that spontaneous mental imagery might play a facilitating role in modulating body image and body schema.

Hypnotic suggestion vs. imagery instruction in the modulation of body representations

Both imagery instruction and hypnotic suggestion significantly altered the two types of body representations with a significantly larger influence of the latter. However, the difference between these effects was small (and not explained by response expectancies), and they were strongly correlated, suggesting overlapping abilities underlying responsiveness to these manipulations. One likely candidate is hypnotic suggestibility (also known as hypnotisability), defined as responsiveness to direct verbal suggestions in the context of hypnosis (Laurence et al., 2008). This trait predicted a sizable amount of the variance in perceptual and pointing changes in both conditions, though it was weaker and less reliable for the imagery instruction condition. Hypnotic suggestibility is a stable trait-like ability, but most efforts in the domain of experimental hypnosis have been allocated to its relation with losses of agency rather than top-down regulation (Laurence et al., 2008; Oakley et al., 2021; Terhune et al., 2017). Therefore, the mechanisms subserving this effect are poorly understood. Additionally, we found that familiarity with hypnosis covaried with the effect of hypnotic suggestion on body schema. This might indicate a subset of attitudes or traits that are recruited by the hypnotic suggestion only to alter the sensorimotor representation. However, it is possible that participants acquainted with hypnosis refrained from using their abilities in the imagery instruction condition. Relatively little is known about the extent to which familiarity with hypnosis modulates responsiveness to hypnotic suggestions, but this result is consistent with previous work demonstrating that it might be an important variable above and beyond hypnotic suggestibility (Apelian et al., 2022).

Overlapping mechanisms for hypnotic suggestion and imagery instruction

The effects of manipulations were strongly correlated regardless of the measurement task, reflecting a similar effect (and arguably similar mechanisms) of hypnotic suggestion and imagery instruction on body image and body schema. Furthermore, this similarity between manipulations is not confounded by response expectancies and spontaneous imagery as these variables did not change significantly across manipulations. Only the use of deliberate imagery was largely higher in the imagery instruction condition compared to the hypnotic suggestion condition as a direct result of the communication style (instructions). Our results are in line with the experimental hypnosis research literature: deliberate imagery is *not* an effective strategy for changing target representations as evidenced by the small amount of variance it explained (Comey & Kirsch, 1999; Hargadon et al., 1995; Kirsch et al., 1987; Terhune & Oakley, 2020). In particular, previous studies show no meaningful correlations between goal-directed imagery and the effect of suggestion on cognition and perception (e.g. Comey & Kirsch, 1999; Hargadon et al., 1995).

One can interpret the underlying mechanism behind both manipulations in terms of Bayesian inference (Clark, 2013; Colombo & Seriès, 2020; Doya et al., 2007). This framework has been recently used to account for hypnotic suggestion (Jamieson, 2016; Lynn et al., 2022; Martin & Pacherie, 2019), placebo effects (Büchel et al., 2014; Ongaro & Kaptchuk, 2019), and body representations (Fang et al., 2019; Samad et al., 2015). According to this account, priors are modelled by a probability distribution reflecting expectations before accessing sensory data (priors), albeit updated over time on the basis of sensory data, with a narrower distribution corresponding to increased certainty (prior precision). Sensory data are modelled in the same way, with a distribution width reflecting noise (uncertainty). On this basis, priors are updated most strongly when sensory data are precise (narrow likelihood distribution), or unlikely (surprising) given prior knowledge; and when prior knowledge is imprecise (i.e. wide prior distribution). Conversely, when sensory signals are noisy (wide likelihood distribution) and/or when prior knowledge benefits from high confidence (narrow prior distribution), updating is reduced.

In our experiment, sensory data were mostly unreliable to determine finger length since participants could not see their finger and did not have tactile inputs. Sensory inputs pertaining to the target finger were present; for instance, the weight of the finger was accessible through muscle spindles, Golgi tendon organs and joint receptors (Tuthill & Azim, 2018). However, even with optimal integration of these sensory inputs (Ernst & Banks, 2002; van Beers et al., 2002), the information remained noisy and less reliable to determine finger length than under normal circumstances (using vision and touch). This amounts to an imprecise likelihood; in turn, we maintain that finger size representations mostly depended on priors. This probability distribution of sizes was shaped by both the remembered actual size of the finger and task relevant expectancies. Hence, the amount of perceptual elongation, according to this framework, was mostly dictated by the ratio of credence between a normal finger model and a longer finger model.

In this view, hypnotic suggestibility can be interpreted as an individual tendency to form strong (or precise) task-relevant priors; and thus, a tendency to respond according to the suggestion. This aligns with a wealth of data highlighting the importance of expectancies in responsiveness to hypnotic suggestions and how it interacts with hypnotic suggestibility (Benham et al., 2006; Lynn et al., 2008). A recent example, outside of the context of hypnosis, is that direct verbal (non-hypnotic) suggestibility was associated with greater response expectancies for placebo hypoalgesia, which mediated greater placebo responding in highly suggestible participants (Parsons et al., 2021). Our data are broadly consistent with the idea that hypnotic suggestibility represents a trait-like ability to form strong priors aligned with experimental expectancies that are subsequently over-weighted, resulting in the experience of aberrant perceptual states.

The small differential effect of hypnotic suggestion and imagery instruction on tasks cannot be explained by the former producing stronger expectancies. Indeed, while previous studies have shown that labelling the procedure “hypnosis” increased responsiveness to suggestions, plausibly through stronger expectancies (Gandhi & Oakley, 2005; Scacchia & De Pascalis, 2020), our data suggest that participants had similar response expectancies in both conditions. One interpretation compatible with the abovementioned framework is that the hypnotic induction was responsible for this small difference on tasks. It has been shown that hypnotic induction has a small but reliable effect on responsiveness to suggestions (Terhune & Cardeña, 2016). This effect is poorly understood, but it is likely to depend in part on raising response expectancies (Kirsch & Braffman, 2001; Terhune & Cardeña, 2016). Nonetheless, our data cannot confirm this theoretically appealing hypothesis, as we measured response expectancies only *before* the induction was performed.

Overall, our data converge with the experimental hypnosis research literature and hint at similar mechanisms for hypnotic suggestion and imagery instruction. One plausible account – but not the only one (e.g. Lynn et al., 2008) – is Bayesian inference, with a major explanatory role of hypnotic suggestibility and response expectancies.

The role of imagery in the modulation of body representation

We hypothesize that the effect of imagery on bodily representations is driven by the sensory properties of imagery, whose source can be misinterpreted as being perceptual. In brief, at some level, the elongated finger is taken to be perceived, and not only imagined. Imagery has a unique role in this cognitive architecture because it straddles perception and cognition.

On the one hand, imaginative content is shaped and influenced by one's beliefs and desires. On the other hand, it shares many of the features of perception, including overlapping neurocognitive processes. As a consequence, the boundary between perception and imagination is permeable. It can go one way, from perception to imagination, as in the Perky effect: what participants imagine is influenced by their visual experiences (Dijkstra et al., 2022; Perky, 1910). It can also go the other way, from imagination to perception, as possibly in many effects of so-called cognitive penetration of perception. For instance, it has been suggested that many effects of expectations on perception, as found in classic studies of colour perception (Bruner et al., 1951) are mediated by imagination (Macpherson, 2012). According to this view, participants spontaneously imagine a yellow banana, which in turn influences the perceived colour of the banana stimulus. The sensory features of the imagined banana and the sensory features of the seen banana are not kept distinct, but rather fused together. By recruiting processing mechanisms that partially overlap with those recruited during perception, visual imagery can directly affect it. It has thus been repeatedly shown that mental imagery can be powerful even for influencing low-level processes (Jeannerod, 1994). Our hypothesis is that imagining the body (voluntarily or spontaneously) shares some mechanisms with those enabling us to perceive the body and that it can thus have effects similar to distorted perception on bodily representations.

The similarity of hypnotic suggestion and imagery instruction might lead some to wrongly assume that a relevant strategy to shape perception (in the context of this experiment) was to voluntarily generate mental images. However, our data suggest otherwise. Deliberate imagery, as indexed by self-reports, was not a significant predictor of perceptual change or pointing change in either condition. Hence, the data show that deliberate imagery does not seem to drive the modulatory effect on body representations, even in the imagery instruction condition. This explains why, despite having substantially more use of deliberate imagery, imagery instruction yielded significantly smaller effects on both tasks. This difference in deliberate imagery is easily understood as a by-product of task expectancies, which is in line with the experimental hypnosis research literature (Comey & Kirsch, 1999; Hargadon et al., 1995; Kirsch et al., 1987; Terhune & Oakley, 2020). In particular, one study showed that when deliberate imagery and response expectancies point towards different responses, experience shifted toward expectancies (Kirsch et al., 1987).

The role of spontaneous imagery in the observed effects was different from that of deliberate imagery. Spontaneous imagery, the unintended emergence of mental images, significantly predicted variations on both tasks. Furthermore, it remained a significant predictor of perceptual change when controlling for response expectancies and hypnotic suggestibility. This suggests that spontaneous imagery is not merely an epiphenomenon resulting from high hypnotic suggestibility, even if such a profile seems to have overall more spontaneous imagery in daily life (Cardeña & Terhune, 2014). It is also noteworthy to mention that a hypnotic induction seems to foster spontaneous imagery in some medium and highly suggestible participants (Cardeña et al., 2013; Pekala & Kumar, 2007), although it was not the case in our experiment (imagery instruction and hypnotic suggestion conditions had similar levels of spontaneous imagery).

The difference between spontaneous and deliberate imagery indicates that mental images *per se* did not *directly* play a direct role in modulating response in our tasks. One compelling explanation is that spontaneous imagery can be mistaken for perception in some cases, and therefore may constitute false (pseudo-)sensory evidence in the model discussed above. Indeed, mental images do not come readily identified as such; rather, when needed *source monitoring* is used to discriminate imagery from perception (Dijkstra et al., 2022). Most of the time in our daily lives this discrimination is achieved easily and robustly, and the two are not confused. However, under some constraints perception can be mistaken for imagery, as with the Perky effect (Dijkstra et al., 2022; Perky, 1910), or mental imagery can be mistaken for perception, as in hallucinations and dreams (Corlett et al., 2014; Dijkstra et al., 2022). Previous research has proposed aberrant source monitoring as an important element of hypnotic responding (Woody & Sadler, 2008). Our hypothesis is thus two-fold: (1) imagination can affect bodily representations because of overlapping mechanisms between imagination and perception and (2) the effect can be inhibited if one is aware of being engaged in imagination, thus avoiding the confusion with perception.

Different factors might foster this second kind of misclassification such as imagery vividness, fluency, contextual constraints, and voluntariness (among others). Imagery vividness is a credible factor for confusing imagery and perception. Indeed, there is a significant overlap between the neurophysiological substrates of perceptual and imaginal processes (Dijkstra et al., 2019) and higher vividness of imagery is correlated to higher activation of brain areas linked to perception (Dijkstra et al., 2017); and it has been associated with responsiveness to hypnotic suggestions (Glisky et al., 1995; Marucci & Meo, 2000; Spanos et al., 1988; Srzich et al., 2016). However, the available evidence indicates that hypnotic suggestion and deliberate imagery have distinct neurophysiological correlates (for a review, see Terhune & Oakley, 2020). Agentive feelings (feeling of deliberately imaging), and lack of it, may also be an important additional source of confusion between imagery and perception, although it has less empirical support (Fazekas, 2021). It is important to note that we are referring here to conscious agentive *feeling*. It is entirely possible that mental images are generated in a strategic, goal-directed, intentional manner, without such feelings. Indeed, many theories of hypnosis rest on the assumption that suggested effects are the result of unconscious intentions (Barnier, Dienes, et al., 2008; Woody & Sadler, 2008).

Nevertheless, an important question remains regarding the dynamic interaction of spontaneous imagery and response expectancies in the modulation of body representations.

Participants in our experiment likely followed the prescribed strategy: progressively perceiving their finger elongating. In this scenario participants first expected small increase in finger size perception. Spontaneous imagery confused with perception might have consolidated expectancies, and acted as a bootstrap leading to higher modulation of body representations. This recursive loop is consistent with the fact that participants reporting no spontaneous imagery could perceive their finger longer, but much smaller than those experiencing spontaneous imagery. It is also in line with the idea that response expectancy adapts throughout events (though only slightly it seems: Benham et al., 2006). It might also be the case that goal directed mental images that are highly unlikely given the current prior are double-checked in order to prevent large mistakes. In any case, the temporal dynamics of spontaneous mental images and expectancies could reveal important features of the hypnotic modulation of body representations and deserves additional research.

Such a recursive model predicts that deficits in spontaneous imagery should lead to a significant, though not complete, reduction in the magnitude of the effect. To test this prediction, one could replicate this study on participants with aphantasia (Keogh & Pearson, 2018). Recent studies suggest that aphantasia results from a deficit of imagery and not simply a lack of awareness of mental images; hence, spontaneous imagery is unlikely to be elicited from aphantasic individuals (Dawes et al., 2020; Wicken et al., 2021). If aphantasic individuals could reach large perceptual elongation despite their lack of spontaneous imagery, then it would falsify the recursive model hypothesis. The case of low hypnotic suggestibility individuals provides some evidence in that direction. Indeed, it seems that these individuals have poor imagery abilities compared to higher levels of hypnotic suggestibility (Sheehan & Robertson, 1996; Sutcliffe et al., 1970). Nonetheless, this hypothesis needs to be properly tested in future experiments.

Overall, the interpretation articulated above is in line with current understanding of hypnosis as driven (in part) by expectancies (Benham et al., 2006; Kirsch, 2001) and hypnotic suggestibility (Woody & Barnier, 2008), as well as by the metacognitive ability of source monitoring (Barnier, Dienes, et al., 2008; Woody & Sadler, 2008). As counterintuitive as it seems, instructing individuals to voluntarily produce mental images of a longer finger does not seem to be the driving mechanism modulating body representations in the imagery instruction condition. Rather, response expectancy and misclassification of imagery as perception, fostered by abilities such as hypnotic suggestibility, seem to be responsible for the effects observed in both the hypnotic suggestion and imagery instruction conditions.

Limitations of the study

We acknowledge some limitations of this study despite the advances discussed above. Expectancies were measured only once, before the manipulations, and therefore, we lack a comprehensive tracking of response expectancies dynamics. In particular, the induction process in the hypnotic suggestion condition may raise expectancies (Lynn et al., 2008). Although repeated measurement of expectancies (e.g., prior to each trial) is experimentally appealing and has been done before (e.g. Benham et al., 2006), this approach may introduce a confound wherein participants feel compelled to respond congruently with their expectations (consistency motivation; Council & Green, 2004), thereby artificially biasing response patterns towards expectations (Woody et al., 1997). This remains a confound in the present experiment whereby participants' self-reported responses to the suggestions might have been artificially constrained by the prior measurement of their expectancies.

Additionally, controlling for participants' imagery ability may help to clarify whether reported effects intersect with heterogeneity in high hypnotic suggestibility. For example, although highly suggestible participants do not tend to reliably display superior imagery, as indexed by self-reported measures or behavioural tasks, than medium suggestible participants (Sheehan, 1996; Terhune & Oakley, 2020), a subset of highly suggestible individuals have been reported to have superior imagery (Terhune et al., 2011; Wallace et al., 1996). Highly suggestible participants also differ considerably in their spontaneous experience of imagery in response to an induction (Finn & McKernan, 2020; Pekala & Kumar, 2007; Terhune & Cardeña, 2010). Nonetheless, it remains a difficult construct to assess as it is understood as composed of multiple components (Cumming & Eaves, 2018; Mizuguchi et al., 2019; Williams et al., 2015). Additionally, context effects might influence the correlation of scales completed in the same context, such as by artificially inflating them due to participants' inclination to perceive a link between the two measured variables (Council et al., 1986; Council & Kirsch, 1996). Therefore, we think that optimal experimental design should ensure that assessments of imagery ability and hypnotic suggestibility are administered in two unrelated contexts (however, see Barnier & McConkey (1999) for an alternative interpretation). As implementing this kind of precaution is time consuming, and it was peripheral to our main question, we did not measure imagery ability in this study.

A final related consideration is that we cannot exclude the possibility that measuring the impact of imagery instruction and hypnotic suggestion on body metrics in the same participants in the same experiment may artificially inflate the correlation between these effects, especially since they were not blind to the condition being tested (Council et al., 1986; Holman et al., 2015). One might also consider that phase one of the experiment, wherein participants were tested for hypnotic suggestibility, might have influenced the results in the main experiment. In particular, the use of hypnosis, the word "imagine" and the fact that several suggestions target the hand in the SWASH might have primed participants. If such an effect were present, we would expect even larger order effects between conditions wherein the imagery instruction should have primed the response to the hypnotic suggestion or *vice versa*. However, no significant order effect was found. It is therefore unlikely that a carryover effect would be present over more than 24h but not clearly present in the interval of a few minutes.

CONCLUSION

Our results show that both hypnotic suggestion and imagery instruction were effective in modulating representations of finger-size (body image and body schema) with only a slightly larger effect of hypnotic suggestion. Moreover, both manipulation effects were highly correlated regardless of the task, suggesting overlapping mechanisms. Self-reported expectancies, spontaneous imagery reports, and hypnotic suggestibility were significant predictors of both manipulation effects. In line with previous research, hypnotic suggestion effects were not associated with deliberate imagery. Perhaps more surprising, the effect of imagery instruction also appeared to not be supported by deliberate imagery, as indexed by self-report. Hence, this study reveals that the mode of presentation of the manipulation, instruction or suggestion, and the presence or absence of induction procedure has only minimal effect on shaping body representations. The main determinants of body metrics modulation in our study are to be found in the inferential process of the individual, biased by expectancies, and helped by hypnotic suggestibility and spontaneous imagery. This study bridges the field of experimental hypnosis, where the influence of top-down factors has important foundations, and the field of study of body representations, where it was lacking, despite strong experimental and theoretical work on the effect of sensory modulation. Future work will have to examine the interplay of both top-down cognitive factors and bottom-up sensory factors on body representations when they are in conflict to better understand their underlying mechanisms.

ACKNOWLEDGEMENTS

Funding

This research was supported by ARCHE formation (scholarship of A.C. and experimental expenses, no grant number), FrontCog (ANR-17-EURE-0017 FrontCog) and PSL (ANR-10-IDEX-0001-02 PSL)

Declaration of interest

Clément Apelian received scholarship from ARCHE formation. Devin Terhune and Frédérique de Vignemont do not declare any conflict of interest.

Approval for human experiments

The whole experiment was approved by the ethical comity of Paris Descartes under the IRB n° 00012020-81 in agreement with the Declaration of Helsinki (2008). Written informed consent was obtained from each participant before the beginning of the study.

CRediT author statement

Clement Apelian : Conceptualization, Methodology, Formal analysis, Investigation, Writing - Original Draft. **Devin Terhune :** Methodology, Writing - Review & Editing. **Frédérique de Vignemont :** Conceptualization, Methodology, Writing - Review & Editing.

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