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Difficult Turned Easy: Suggestion Renders a Challenging Visual Task Simple

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Abstract

Suggestions can cause some individuals to miss or disregard existing visual stimuli, but can they infuse sensory input with nonexistent information? Although several prominent theories of hypnotic suggestion propose that mental imagery can change our perceptual experience, data to support this stance remain sparse. The present study addressed this lacuna, showing how suggesting the presence of physically absent, yet critical, visual information transforms an otherwise difficult task into an easy one. Here, we show how adult participants who are highly susceptible to hypnotic suggestion successfully hallucinated visual occluders on top of moving objects. Our findings support the idea that, at least in some people, suggestions can add perceptual information to sensory input. This observation adds meaningful weight to theoretical, clinical, and applied aspects of the brain and psychological sciences.

Keywords

suggestion, hypnosis, perception, visual imagery, perceptual integration, open data

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Suggestions can dramatically alter how individuals process perceptual information (e.g., Lifshitz, Aubert Bonn, Fischer, Kashem, & Raz, 2013), including the suppression of visual inputs (Schmidt, Hecht, Naumann, & Miltner, 2017). Conversely, evidence remains ambiguous as to whether suggestions can reliably infuse novel information into the perceptual stream. This ambiguity contrasts with prominent theories that emphasize the ability of hypnosis to generate perceptual experiences and hallucinations (e.g., Kirsch & Braffman, 2001; Martin & Pacherie, 2019; Spiegel, 2003). Findings that support such viewpoints have often come with serious limitations, however, such as reliance on self-reports that are prone to bias and demand characteristics (e.g., Kirsch et al., 2008), reverse inferences from brain imaging (e.g., McGeown et al., 2012), small sample sizes, and anecdotal case-study designs (e.g., Kallio & Koivisto, 2013). Further highlighting these limitations, recent findings have intimated that suggestions induce a response bias for hallucination-prone individuals in noisy perceptual contexts (Alganami, Varese, Wagstaff, & Bentall, 2017). Accordingly, positive hallucinations may correspond to a reinterpretation of the sensory experience rather than to genuine changes in the perceptual content. Research into consciousness deals with a similar conundrum: Reports of awareness may sometimes follow from a response bias (Peters, Lau, & Ro, 2016). Some researchers have attempted to address this particular issue in the context of hypnotic hallucinations by inducing synesthesia-like experiences through posthypnotic suggestions and then validating the effect with a challenging perceptual task (Anderson, Seth,

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Dienes, & Ward, 2014; Cohen Kadosh, Henik, Catena, Walsh, & Fuentes, 2009; Kallio, Koivisto, & Kaakinen, 2017)—so far, however, with mixed results (Schwartzman, Bor, Rothen, & Seth, 2019).

Considering these shortcomings, we here examined whether a suggestion to append novel information to perception can transform a difficult perceptual task into an easy one. Our goal was to provide support for the idea that suggestion can instigate perceptual information endogenously while avoiding the aforementioned limitations. To this end, we relied on occlusion-related perceptual integration of object motion, in which the presence of shape stimuli at the apex of moving lines produces the percept of an occluded figure performing a circular revolution around a central axis (Fig. 1a; Lorenceau & Shiffrar, 1992). Critically, this particular percept vanishes whenever the occluding shape stimuli are removed from the display, making it nearly impossible to see the geometric figure and the direction of the revolution without the occluders. We accordingly examined whether a suggestion to imagine the occluders would allow individuals who exhibit greater sensitivity to suggestions, referred to here for convenience as “highly suggestible individuals,” to experience perceptual integration of the line stimuli and thereby perceive the geometric figure. We compared their performance with that of individuals who showed less sensitivity to suggestion, referred to here for convenience as “less-suggestible individuals,” as well as with several cohorts of control participants who completed the task both online and within our laboratory.

Statement of Relevance

Mounting evidence shows that hypnotic suggestion can regulate various kinds of perceptual experiences, such as pain. Yet most of these findings involve reducing or suppressing an experience. In the present research, we asked a complementary question: Can a hypnotic suggestion enhance or increase perceptual experience? To test this question, we identified young adults who scored especially high or low on a scale of hypnotic suggestibility. We then provided these individuals with the suggestion that they would be able to perceive phantom (i.e., nonexistent) geometric shapes on a computer screen while completing a visuospatial task. Our experimental approach rested on the idea that being able to imagine these geometric shapes on the screen would benefit participants’ performance on this otherwise difficult task. Our results were consistent with this prediction and show that the suggestion improved performance of individuals who scored high on the suggestibility scale while having little effect on those who scored low. These findings imply that individuals susceptible to hypnotic suggestions are capable of creating novel perceptual experiences.

Method

Participants

Drawing from a convenience sample, we prescreened individuals for hypnotic susceptibility from a pool of approximately 500 students in psychology classes at McGill University, using the Harvard Group Scale of Hypnotic Susceptibility, Form A (HGSHS:A; Shor & Orne, 1962). Our final sample consisted of 16 highly suggestible individuals (i.e., HGSHS:A score > 8) and 16 less-suggestible individuals (i.e., HGSHS:A score < 4). We recruited additional participants, not screened for hypnotic suggestibility, who completed the task without occluders present and without receiving hypnotic suggestion—14 completed the task in our laboratory and 186 online. To ascertain possible learning effects, we invited 49 random participants, who completed the task online, to a second session in our laboratory. Two additional samples performed the task with occluders present—that is, 46 participants completed the task online, and 17 completed it in the laboratory. All participants (N = 295; 215 women; mean age = 20.81 years, SD = 2.27) had normal or corrected-to-normal vision and received course credit in exchange for participation. See Figure S1 in the Supplemental Material for a diagram describing the groups and the corresponding experimental conditions.

We had little information regarding the effect size of the experimental suggestion on highly suggestible individuals for this visual task, so we based our sample size for the suggestion conditions on a collection of studies from our own group that similarly investigated the influence of hypnotic suggestion on perception and cognition (for a review, see Lifshitz et al., 2013). We reasoned that a meaningful effect size should be at least comparable with and easily detectable with a sample of the same size. Following this rationale, we pooled data from our previous studies and performed simulations to estimate the minimal sample size required to achieve a power of .8 for the detection of the effect of suggestion in highly suggestible individuals at an α of .05 (see the Supplemental Material for details). This procedure revealed a modest effect size of hypnotic suggestion in highly suggestible individuals (i.e., marginal R^2 for this hierarchical regression model = .14), and 13 highly suggestible individuals were required to attain a power level of .8 for an α of .05. Our sample size aligned with these parameters.

When participants performed the task without occluders during controlled conditions, we aimed to

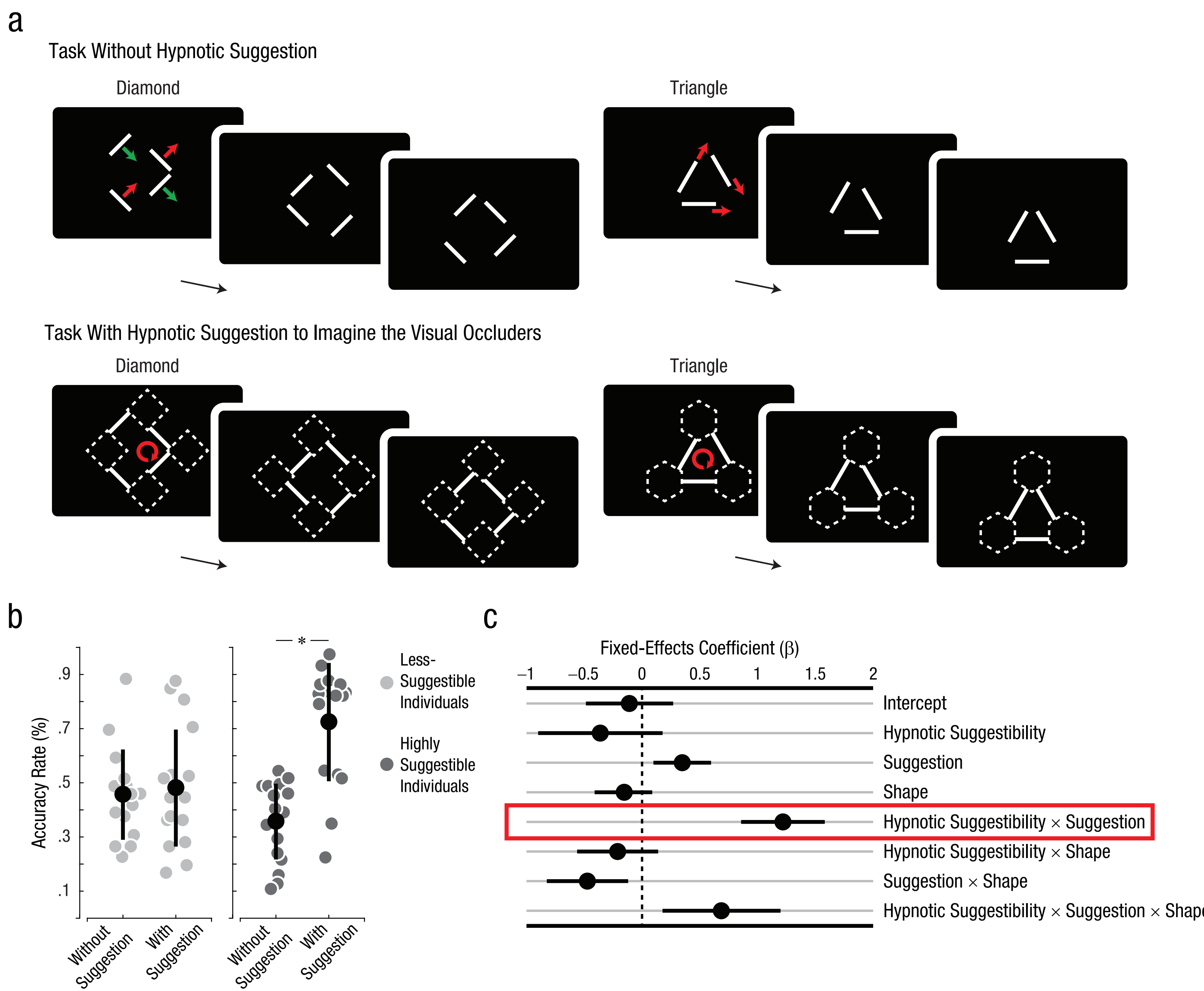

Fig. 1. *(continued on next page)*

Fig. 1. Experimental design, accuracy for the highly suggestible and less-suggestible groups, and model results. The experimental task (a) consisted of four or three moving lines that formed the shape of a diamond, a square, a triangle, or an inverted triangle. Diamonds and squares moved only in a clockwise or counterclockwise fashion, whereas triangles and inverted triangles could move clockwise, counterclockwise, or with a directionless motion (i.e., neither clockwise nor counterclockwise; arrows in the figure indicate the direction of motion). The task was presented without any visual occluders (as shown in the top row), but two groups of participants (highly suggestible and less suggestible) underwent hypnotic suggestion, in which they were instructed to imagine the occluders at the vertices of the moving lines (as indicated by the dashed areas in the bottom row). Participants indicated the direction of the moving shape (i.e., clockwise, counterclockwise, or directionless motion). (Movies of diamond trials with and without occluders are available in the Supplemental Material.) Discrimination accuracy (b) is shown separately for highly suggestible and less-suggestible individuals, with and without suggestion, across shape trials. Black dots represent average accuracy rates, and error bars correspond to bootstrapped 95% confidence intervals. Gray dots represent individual performance. The asterisk indicates a significant difference between suggestion conditions ($p < .05$). Coefficients (c) are shown from the single-trial hierarchical logistic regression model for predicting accuracy. These coefficients are from the best-fitting model following chi-square goodness-of-fit statistics over the deviance and following the Bayesian information criterion. The red rectangle highlights the statistically reliable interaction between hypnotic suggestibility and suggestion.

recruit as many online participants as possible from psychology classes at McGill University. In contrast, the subset of individuals asked to complete the control task in our laboratory was comparable in size with both our highly suggestible and less-suggestible groups. The sample size for participants who completed the task twice merely followed from the limited potency of the learning effects, which we had observed in the preceding pilot experiments. Here, we aimed to have a large-enough sample to assess any potential effect, yet the effect size was quite modest ($d = 0.28$). Last, given that the performance was at ceiling in the presence of occluders, we aimed for a sample size akin to that of the suggestion group to ensure a proper comparison. Both our online and laboratory samples met this criterion. All procedures were approved by the local institutional review board.

Task and procedure

We constructed a Web-based Adobe Flash task and sent e-mail invitations to participants with the URL. We designed the task—which we called "MoTraK"—based on the paradigm of occlusion-related perceptual integration of object motion (Fig. 1a; Lorenceau & Shiffrar, 1992). The task was composed of trials with moving occluded diamonds, squares, triangles, and inverted triangles. The task accordingly involved 72 outlines of each geometric shape in motion—18 trials for diamonds, 18 for squares, 18 for triangles, and 18 for inverted triangles—with vertices occluded by shapes that matched the color of the background. Subsequently, only segments of the geometric outlines were visible (i.e., four straight line segments on diamond and square trials and three straight segments on triangle and inverted-triangle trials). We relied on homogenous colors: uniform gray for the lines (hexadecimal color code [HCC] = 666666; RGB value = 102, 102, 102) and black for the background (HCC = 000000; RGB value = 0, 0, 0), resulting in medium contrast, which creates a low coherence of motion. We rotated the diamond by 45° to create a square stimulus and flipped the triangle to create an inverted-triangle stimulus. We randomly varied the order of these stimuli on the screen across trials to discourage participants from replacing the occluders with physical objects affixed to the screen (e.g., stickers).

A second version of the task contained fully visible occluders in white (HCC = ffffff; RGB value = 255, 255, 255). When participants were sitting approximately 45 cm away from the screen, the width and height of the lines for the diamond and square stimuli approximated 5.7° and 1.3° of visual angle, respectively, and the square occluders measured roughly 6.3°. For the diamond and square stimuli, the length of lines approximated 7.6°, and the pentagon occluders were estimated at 8.8°. All target stimuli were centered, and they rotated in a circle around the fixation point (see Fig. 1).

Throughout the task, the diamonds and squares moved only in a clockwise or counterclockwise fashion, whereas the triangles and inverted triangles could move clockwise, counterclockwise, or with a directionless motion (i.e., neither clockwise nor counterclockwise). Note that the directionless motion could therefore occur only for the upward and inverted triangles. For directionless-motion trials, the shape would move around the fixation point without following a specific trajectory while repeatedly expanding and then shrinking in size. We included the directionless motion for triangles and inverted triangles as catch trials. Participants were aware of these contingencies.

Our Adobe Flash interface recorded the trials and immediately sent the measures to a password-protected MySQL online database. The program recorded responses when participants pressed the "F" key, "J" key, or space bar to indicate counterclockwise, clockwise, and directionless motion, respectively, for triangles and inverted triangles. Participants completed the task in two separate blocks: The first block consisted only of diamond and square trials, and the second block consisted only of triangle and inverted-triangle trials. We opted for this design because we wanted to avoid confusion and ensure that participants considered the response option of directionless motion only during triangle and inverted-triangle trials.

To ensure that participants understood the task well, we included two short training sessions in the preassessment of MoTraK. During the first training session, participants went through consecutive 15-s interactive demonstrations, in which they could make the occluders visible or invisible on a pentagon shape that moved first clockwise, then counterclockwise. Using a pentagon for training prevented exposure to the actual stimuli prior to data collection. Next, participants practiced on a few trials, and they were given feedback stating whether their responses were correct or incorrect. These practice trials consisted of six pentagon trials—three clockwise and three counterclockwise (pseudorandomized). After the practice trials, we informed participants that they would no longer receive feedback. The second training block occurred between the diamond/square and the triangle/inverted-triangle blocks, during which participants viewed a single interactive demonstration of directionless motion on a pentagon. To ascertain comprehension, we included no demonstrations in the postassessment of MoTraK, only three practice trials with feedback. Instructions emphasized both speed and accuracy. The entire task lasted about 15 min.

Procedure for highly suggestible and less-suggestible groups

First, for testing performance without suggestion, we sent all potential participants an e-mail providing them with the URL of the Web page hosting MoTraK and inviting them to complete the task online in a calm environment of their choice. The online consent forms informed participants that they had the right to withdraw from the study at any time and that the data gathered, including response time and accuracy, would be used only for scientific research. We collected demographic information as well as Internet protocol (IP) addresses, which allowed us to identify and exclude participants who completed the task more than once. In addition, MoTraK automatically assigned a random number (a unique completion code) to each participant. This number was required to complete the postassessment. During the first session without suggestion, participants were unaware that this research involved hypnotic suggestion. This strategy minimized the potential influence of holdback effects.

Approximately a week after their online participation, we sent participants an e-mail inviting them to participate in a second session at our laboratory. On arriving at the laboratory, participants were greeted by an experimenter who obtained informed consent and disclosed that participants would receive a hypnotic suggestion. The experimenter then escorted participants to a separate room to meet with one of the authors (A. Raz), a researcher with more than 30 years of experience working with hypnosis and a diplomat of the American Board of Psychological Hypnosis. A. Raz administered a hypnotic induction adapted from the Carleton University Responsiveness to Suggestion Scale (Spanos, Radtke, Hodgins, Stam, & Bertrand, 1983). He then suggested to all participants that they would be able to view the occluders at the vertices of the moving lines while playing MoTraK and that this hallucination would allow them to perform the task quickly and easily. (A script of the suggestion is available in the Supplemental Material.) Induction and suggestion took about 10 min; participants then completed the task. When the task was over, A. Raz administered a standard hypnotic termination. The experimenter then escorted participants out of the room for debriefing. Thus, we tested participants under two conditions: first at baseline without suggestion and then with a specific suggestion to perceive phantom occluders covering the otherwise uncovered corners. Note that A. Raz was blind as to participants' susceptibility to hypnosis.

Procedure for online participants

We provided all participants with the URL for MoTraK and asked them to complete the task online. A written notice in the task asked them to complete it in a calm environment, free from distractions. Participants provided consent by clicking on the "Accept" button following the consent information. We gathered demographic information, student identification numbers, and IP addresses to avoid repeated participation.

Procedure for participants in the laboratory

In the laboratory, the experimenter greeted participants and led them into a quiet room containing a computer. The experimenter sat beside participants to monitor their engagement and ensure that they refrained from utilizing alternative strategies while performing the task (i.e., participants were to remain seated in a stable and appropriate position, looking forward with their eyes open normally and at the target without averting their gaze, at an approximate distance of 45 cm from the screen).

Participants who completed the task twice received an automatically generated e-mail inviting them to participate once again in our study, either online or at our laboratory. The purpose of this invitation was to control for learning effects. Moreover, an additional group of participants completed the task with white occluders present. We expected this experiment to yield ceiling effects across participants, because the percept effortlessly emerges as soon as the occluders become visible.

Analysis

We removed anticipation (response time < 150 ms) and timeout (response time > 3 *SD*s from the mean). Overall, anticipation trials corresponded to less than 1% of total trials, whereas timeout trials represented approximately 1% of total trials. No additional observations were removed from analysis. We gauged overall performance using hierarchical single-trial logistic regression predicting accuracy for each trial (i.e., correct vs. incorrect discrimination). Hypnotic suggestibility (low vs. high), suggestion (with vs. without), shape (squares and diamonds vs. triangles and inverted triangles), and their interactions were included as fixed factors, and the participants were included as random factors. MATLAB (Version R2017B; The MathWorks, Natick, MA) and the *fitglme* function were used to fit all regression models. We opted for the Laplace fitting method and selected the best-fitting model using goodness-of-fit chi-square tests over deviance ($\alpha = .05$) and by evaluating the Bayesian information criterion. Post hoc evaluations were performed using pairwise permutation *t* tests (i.e., 10,000 permutations).

We similarly compared task improvements for highly suggestible individuals with performance from other cohorts in different control conditions. We first compared the performance of highly suggestible individuals before and after receiving the suggestion with the performance of individuals who completed the same task online and in the laboratory. We relied on nonparametric two-tailed permutation tests (i.e., 10,000 permutations) to compare mean accuracy rates.

Our goal was twofold: first, to validate that performance was no different between highly suggestible individuals and a matched-controlled group prior to receiving the suggestion and, second, to demonstrate that the improvement in highly suggestible individuals marked a significant departure from baseline performance following suggestions. One group of participants also performed the task twice, once online and another time in the laboratory, which allowed us to assess learning effects and underline how the improvement seen for highly suggestible individuals related to that of learning. Here, we accordingly contrasted the difference in performance between the first and second session for this control group and the performance with suggestion minus the performance without suggestion for highly suggestible individuals. Last, we compared the performance of highly suggestible individuals with that of individuals who performed the task with occluders present. Again, one sample performed the task online and another in our laboratory. The purpose of this control condition was to accurately gauge performance when participants endogenously hallucinated the occluders compared with performance when the occluders were actually present. In this way, we contrasted how visual imagery measured up against the actual perception of the occluders. Note that we further computed the Jeffrey-Zellner-Siow (JZS) Bayes factor (BF) to evaluate evidence in favor of the null hypothesis using the default Cauchy *r* scaling value of .707 (Rouder, Speckman, Sun, Morey, & Iverson, 2009). Bootstrapped confidence intervals were computed using MATLAB's *Bootfun* algorithm.

Results

Comparison of highly suggestible and less-suggestible groups

The performance of highly suggestible individuals improved significantly, compared with that of less-suggestible individuals, for whom the suggestion made little difference. We tested the efficiency of the hypnotic suggestion to add new perceptual information (i.e., visualizing the occluders) by evaluating accuracy rates across all trials—those involving diamond, square, triangle, and inverted triangle shapes—through hypnotic suggestibility and suggestion conditions (Fig. 1b). Here, we relied on single-trial logistic regression (see Analysis section). Fixed factors were included in a stepwise approach. Our results showed that the best-fitting model included suggestion ($\beta = 0.35$, $SE = 0.127$, 95% CI = [0.1, 0.597]), the Hypnotic Suggestibility × Suggestion interaction ($\beta = 1.22$, $SE = 0.184$, 95% CI = [0.857, 1.58]), the Suggestion × Shape interaction ($\beta = -0.471$, $SE = 0.18$, 95% CI = [−0.824, −0.118]), and the Hypnotic Suggestibility × Suggestion × Shape interaction ($\beta = 0.69$, $SE = 0.26$, 95% CI = [0.18, 1.2]) as reliable predictors (see Fig. 1c, as well as Tables S1 and S2 in the Supplemental Material, for details). Following the Hypnotic Suggestibility × Suggestion interaction, post hoc pairwise permutation tests confirmed limited benefits between conditions with suggestion and without suggestion for less-suggestible individuals ($M = .46$, $SD = .17$ without suggestion; $M = .48$, $SD = .23$ with suggestion), $t(15) = 0.65$, $p = .53$, JZS BF = 3.25, whereas we rejected the null hypothesis for highly suggestible individuals when comparing performance with and without suggestion ($M = .36$, $SD = .15$ with suggestion; $M = .72$, $SD = .22$ without suggestion), $t(15) = 5.14$, $p < .001$, JZS BF = 239.88. These results are therefore consistent with our primary research objective and provide evidence for the hypothesis that the experimental suggestion would change how highly suggestible individuals process perceptual information and subsequently improve their performance. Note that our analyses further confirmed that the Hypnotic Suggestibility × Suggestion interaction was reliable for both square/diamond and triangle/inverted-triangle trials separately (see Tables S3 and S4 in the Supplemental Material). Moreover, we further controlled for conservative strategies and the tendency to indicate motionless direction between highly suggestible and less-suggestible individuals for diamond trials. This analysis showed no difference between both groups.

Less-suggestible individuals served as a control group for highly suggestible individuals because they performed the exact same experiment. However, we wanted to gauge the benefits of suggestions on highly suggestible individuals by comparing additional control conditions. In particular, we looked at baseline performance when participants completed the task online (n = 186) and in our laboratory (n = 14). This way, we could further certify suggestion-related improvements for highly suggestible individuals against a larger sample. We similarly investigated learning effects in a group of individuals (n = 49) who performed the task twice, because highly suggestible individuals also completed the task on two occasions. Last, we also compared highly suggestible individuals who imagined the presence of the occluders with participants who played MoTraK with the occluders physically present (n = 46 online and n = 17 in our laboratory), thereby comparing veridical perception with suggestion-induced visual imagery.

Comparison of highly suggestible individuals with control condition without occluders

We evaluated the performance of highly suggestible individuals across sessions, with and without suggestion, against the performance of the online and laboratory groups who completed the task without occluders (Fig. 2a). Here, we relied on permutation tests over the mean accuracy rate of each group. Without suggestion, highly suggestible individuals performed similarly to both the online (observed mean difference = −.0099; p = .86; d = −0.06; Fig. 2b) and laboratory groups (observed mean difference = −.032; p = .67; d = −0.16; Fig. 2b). Conversely, following suggestion, highly suggestible individuals performed better than the online group (observed mean difference = .35; p < .001; d = 1.67; Fig. 2c) and the laboratory group (observed mean difference = .34; p < .001; d = 1.45; Fig. 2c). Together, both analyses convey that highly suggestible individuals performed similarly to the baseline groups without the suggestion and significantly improved their performance with the suggestion, which further highlights how suggesting the presence of occluded shapes improved performance on an otherwise difficult task.

Comparison of highly suggestible individuals with the control condition for repeated sessions

We also sought to assess learning effects on the task. Here, we aimed to corroborate that the benefits we observed for highly suggestible individuals followed from the suggestion and not from learning. Note that the less-suggestible individuals already provided information to this effect, because they completed the task under the same experimental conditions as the highly suggestible individuals; however, we aimed for further confirmation with a larger sample. A separate group of participants therefore completed the task twice, once online and later in our laboratory (Fig. 3a). We first evaluated evidence of improvement for this control group with a pairwise permutation t test over accuracy across the first and second sessions (M = .33, SD = .22 for the first session; M = .39, SD = .26 for the second session), $t(48)$ = 1.92, p = .06, JZS BF = 1.51. Thus, evidence favored the null hypothesis, showing that this group showed little improvement from the first to the second session. Comparing the perceptual benefits from both the highly suggestible individuals (i.e., performance with suggestion minus performance without suggestion) and this control group (i.e., performance on the second session minus performance on the first) further corroborated the gain conferred by the suggestion, as we observed a greater increase in performance for highly suggestible individuals (observed mean difference = .31, p < .001, d = 1.26; Fig. 3c). These results, therefore, imply that highly suggestible individuals' improvement on the task did not follow from practice effects.

Comparison of highly suggestible individuals with control condition with occluders

Last, we wanted to evaluate how visual imagery of the occluders induced by the suggestion in highly suggestible individuals fared against the actual presence of the occluding stimuli. One group of participants completed the task online and another in the laboratory with occluding stimuli located at the vertices of the moving lines. The presence of the occluding stimuli yielded ceiling effects for discrimination accuracy rates (Fig. 3b). Thus, as one would expect, the comparison between visual imagery and veridical perception of the occluders

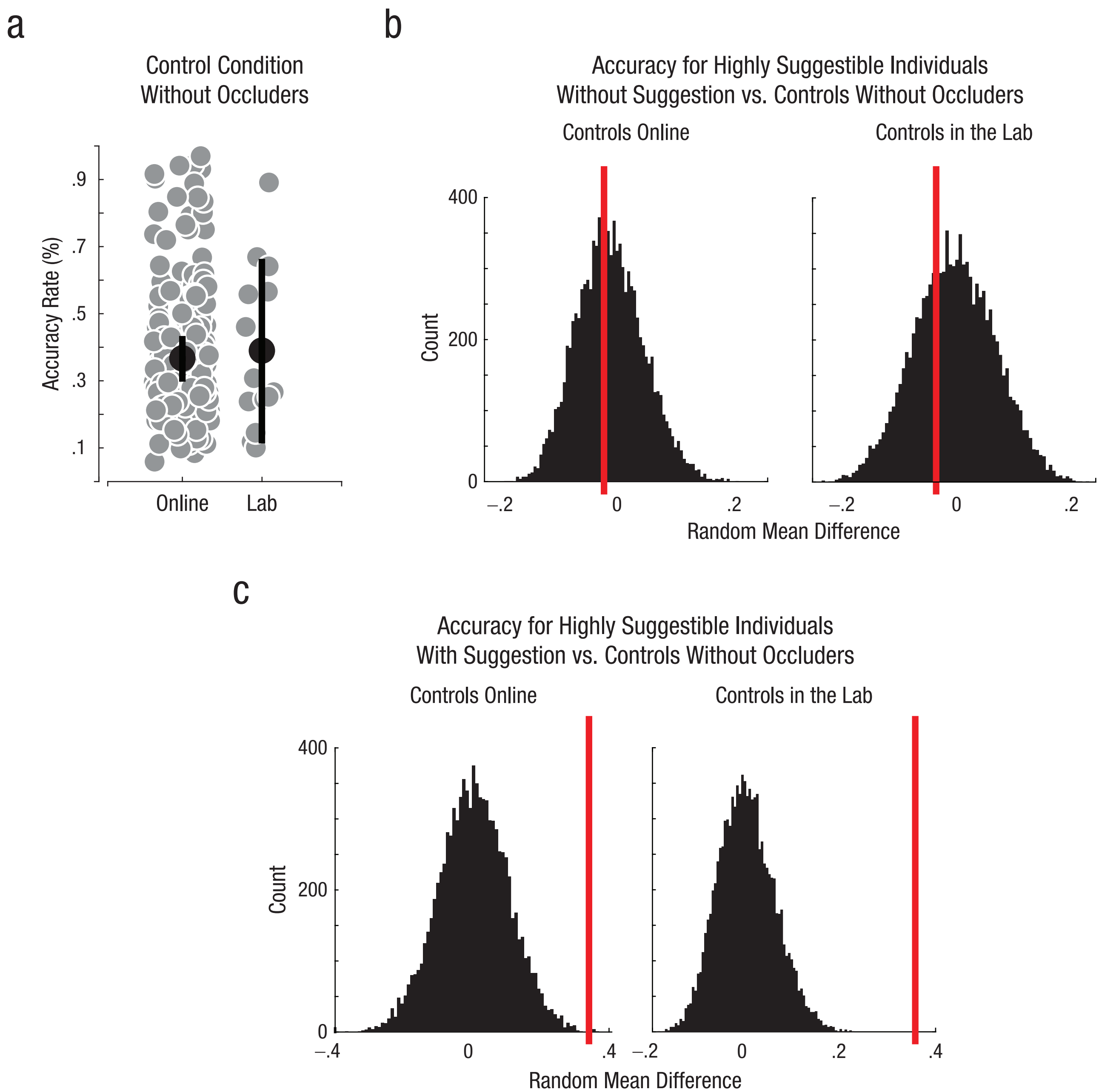

Fig. 2. Performance of highly suggestible individuals who received and did not receive hypnotic suggestion, compared with performance in the baseline control condition. Discrimination accuracy (a) is shown for the baseline control condition in which visual occluders were absent, separately for participants who completed the task online and in the laboratory. Gray dots represent average individual accuracy, black dots represent average group accuracy, and error bars correspond to 95% bootstrapped confidence intervals. Null distributions of random permutations are shown for mean comparisons of accuracy rates between control participants and (b) highly suggestible individuals who did not receive hypnotic suggestion and (c) highly suggestible individuals who received hypnotic suggestion. In (b) and (c), distributions are shown separately for comparisons in which the control group completed the task online and in the laboratory. Red bars indicate observed differences.

revealed that, despite the significant performance improvement of highly suggestible individuals following suggestion, this benefit remained lower than that seen in both groups who completed the task with occluding stimuli in the display (observed mean difference with online group = −.24, $p < .001$, $d = -1.69$; observed mean difference with laboratory group = −.23, $p < .001$, $d = -1.64$; see Fig. 3d). Evidence therefore supports the notion that

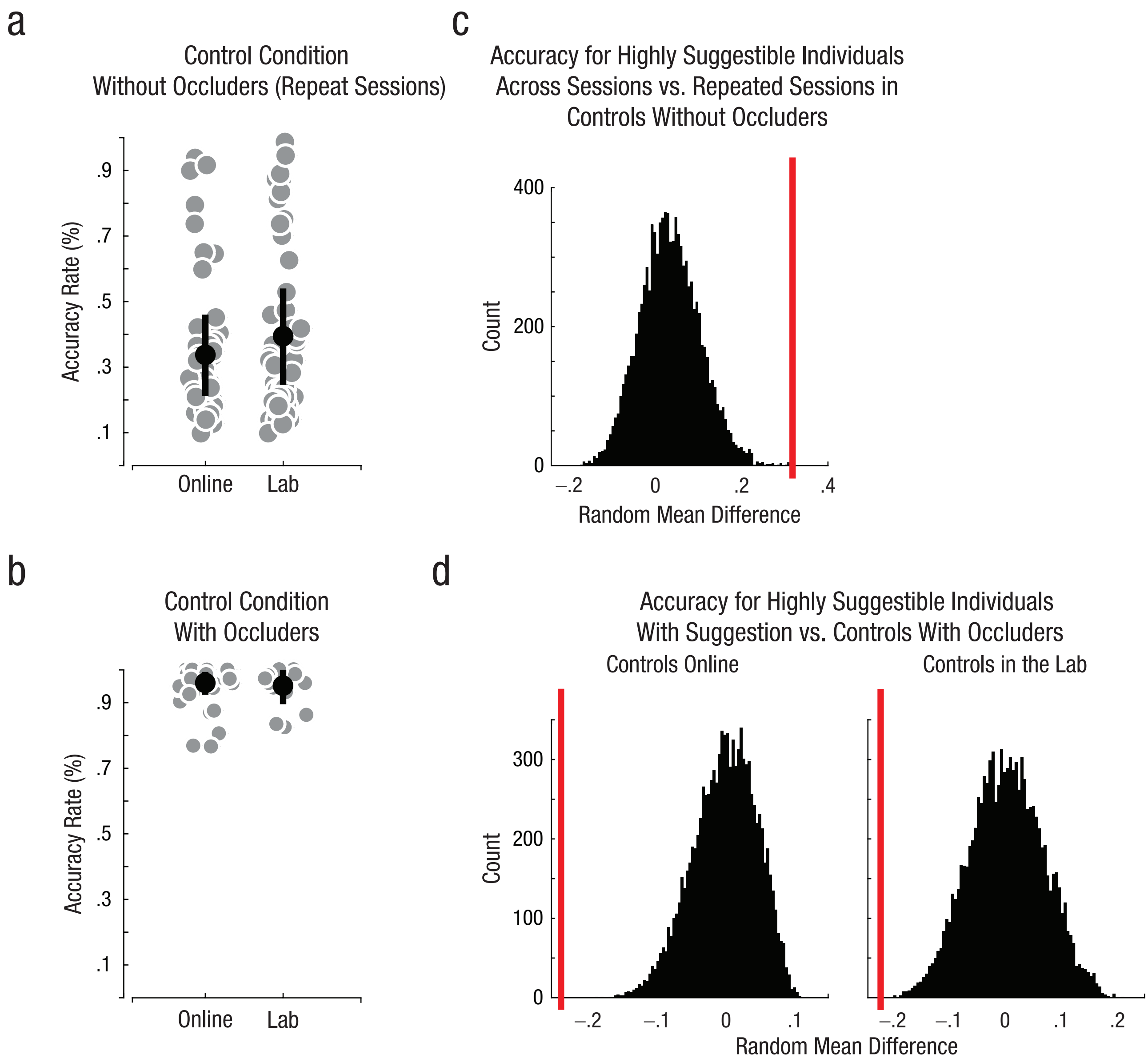

Fig. 3. Performance of highly suggestible individuals who received hypnotic suggestion, compared with performance in the control condition across repeated sessions and when visual occluders were present. Discrimination accuracy is shown for control conditions in which individuals completed the task (a) when visual occluders were absent and (b) when visual occluders were present. Participants who completed the task when occluders were absent did so twice, first online and then in the laboratory, whereas those who completed the task when occluders were present did so only once, either online or in the lab. Gray dots represent average individual accuracy, black dots represent average group accuracy, and error bars correspond to 95% bootstrapped confidence intervals. Null distributions of random permutations are shown for mean comparisons of accuracy rates (c) between highly suggestible individuals across sessions (i.e., performance with suggestion minus performance without suggestion) and control participants who completed the task twice without receiving hypnotic suggestion (performance on the second session minus performance on the first session) and (d) between highly suggestible individuals who received hypnotic suggestion and control participants who completed the task with occluders only once. In (d), distributions are shown separately for comparisons in which the control group completed the task online and in the laboratory. Red bars indicate observed differences.

the suggestion conveyed reliable perceptual benefits, albeit the subjective experience of visualizing the occluders with suggestion remains substantively different from actually seeing them.

Discussion

Here, we showed that a hypnotic suggestion to see nonexistent occluders improves the performance of highly suggestible individuals on a challenging visual task. Our findings intimate that the suggestion afforded highly suggestible individuals with the capacity to experience perceptual integration by conjuring the presence of the occluders via endogenous means. These influences, fueled by a suggestion to add visual information to the perceptual stream, yoked top-down processes driven by expectation and mindset with bottom-up processing mostly driven by sensory inputs. The improvement of highly suggestible relative to less-suggestible individuals, alongside data from multiple control conditions, supports this idea—and yet suggestion-based performance hardly reached that measured when occluders were present. Imagery therefore appears weaker than actual perception.

Although generalization to other perceptual processes goes beyond the present data, our findings complement other reports that document how expectation and cognition can govern stimulus-driven processes (Szechtman, Woody, Bowers, & Nahmias, 1998). Our results accordingly confirm the reliability of this framework to shed light on mental imagery and perceptual hallucinations. However, it remains uncertain whether the current experimental context applies to other forms of atypical perception, such as those observed in clinical disorders. Still, our work paves the way for a more scientific understanding of suggestion to elucidate mind–body phenomena, including the mechanisms underlying the influence of placebos, symbolic thinking, and expectancy.

Transparency

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Author Contributions

A. Raz designed the experiment, collected the data, and performed an initial exploration of the results with help from two students in the lab (see Acknowledgments). M. Landry analyzed the data in depth and wrote a draft of the manuscript. M. Landry, J. Da Silva Castanheira, J. Sackur, and A. Raz wrote the final version of the manuscript and approved it for submission.

Declaration of Conflicting Interests

The author(s) declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

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Open Practices

All data and codes for analyses have been made publicly available via OSF and can be accessed at https://osf.io/25rpx/. The design and analysis plans for the experiment were not preregistered. This article has received the badge for Open Data. More information about the Open Practices badges can be found at http://www.psychologicalscience.org/publications/badges.

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Supplemental Material

Additional supporting information can be found at http://journals.sagepub.com/doi/suppl/10.1177/0956797620954856

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