Reduced prepulse inhibition is associated with increased hypnotizability

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Abstract

Hypnosis involves the manipulation of conscious attentional discrimination. The prepulse inhibition (PPI) paradigm assesses primary unconscious information processing. We investigated the correlation between hypnotizability and PPI of the startle reflex. Forty-eight healthy subjects were evaluated with the Stanford Hypnotic Susceptibility Scale, Form C (SHSS:C) and acoustic PPI. Subjects were divided into low, medium, and high hypnotizable groups. The low-hypnotizable group showed a significantly higher inhibition of the startle response, at lead intervals 60 ms and 120 ms, than did the medium- and high-hypnotizable groups. We conclude that hypnotizability and PPI may be negatively correlated. These findings lend further support for the role of dopaminergic neurotransmission mechanisms in the determination of hypnotizability levels.

Introduction

Emerging from a long and controversial history as a therapeutic intervention, hypnosis has gained clinical respectability and currently shows evidence of effectiveness for a wide variety of applications in medicine, psychiatry and psychotherapy (Lynn et al., 2000). Hypnotizability, defined here as the ability to enter a hypnotic state, is a complex behavioural phenomenon with biological, cognitive and social components. In the hypnotic state an individual attends to certain stimuli (e.g. the hypnotist’s voice) while disattending others (e.g. distracting thoughts). While the neurobiological substrates of hypnosis have not been unravelled, recent findings indicate that the attentional skills involved in hypnotizability may correlate with central dopaminergic activity (Lichtenberg et al., 2004; Raz et al., 2006).

Prepulse inhibition (PPI) is a technique for assessing primary, unconscious information processing (Braff et al., 2001). In this paradigm, the subject is presented with an auditory stimulus, or prepulse, which would not ordinarily arouse a startle reaction such as blinking. A second, stronger stimulus, the pulse, which without the prior prepulse would be expected to cause blinking, is then presented. The interval between the prepulse and pulse is too brief to be perceived. The degree to which the prepulse inhibits the blink response following the pulse is the PPI. Accordingly, a higher PPI score reflects greater inhibition of the startle response by the prepulse and presumably a more efficient sensory gating system. As with hypnosis, a contribution of dopaminergic mechanisms to the physiology of the PPI phenomenon has been suggested (Swerdlow et al., 2006).

Hypnotizability and PPI have never been evaluated for the same set of individuals. Determining a correlation between these two measures could provide insights into the mechanisms of hypnosis and the biological determinants of high and low hypnotizability. Moreover, such assessments might have practical implications for the enhancement of hypnotic susceptibility.
Methods

Subjects

Healthy volunteers were recruited mostly from a class at Hadassah Medical School whose students had been screened by a group hypnotizability assessment (see below); ten participants were drawn from an earlier hypnosis research project (Lichtenberg et al., 2004). A psychiatrist with more than 10 years of clinical and research experience interviewed the subjects, and using a semi-structured interview determined whether they were receiving or had received in the past psychiatric treatment of any sort and whether they were currently in distress. Individuals diagnosed currently or in the past with psychotic, mood, or anxiety disorders, or with substance abuse, according to DSM-IV criteria (APA, 1994), were not included in the study. Past or current use of antipsychotic, antidepressant, or mood-stabilizing medication also precluded participation in the research. This study was approved by the Herzog Hospital Institutional Review Board and by the Israel Ministry of Health. After complete description of the study to the subjects, written informed consent was obtained.

Hypnotizability testing

Two widely used and validated assessments of hypnotizability were administered by a mental health professional accredited by the Israel Ministry of Health to perform hypnosis.

Harvard Group Scale of Hypnotic Susceptibility, Form A (HGSHS:A) (Shor and Orne, 1962). This is a test of hypnotizability administered to groups, wherein each participant rates his/her own compliance with 12 suggestions (e.g. arm rigidity or eye catalepsy) offered by the hypnotist. Scoring is on a 12-point scale, with each suggested task carried out by the participant constituting a point.

Stanford Hypnotic Susceptibility Scale, Form C (SHSS:C) (Hilgard, 1965). Similarly to the HGSHS:A, the participant is offered 12 tasks, some of them more difficult (e.g. anosmia or negative hallucinations), but testing is done individually, and the hypnotist rates whether the tasks have been carried out or not. Scoring is again on a 12-point scale, with each suggested task that is carried out by the participant constituting a point.

PPI

Testing and data extraction were carried out as in previous studies (Braff et al., 1992; Heresco-Levy et al., 2007). We examined blink response to pulses occurring 30, 60, and 120 ms after the prepulse. PPI was computed as the percentage of reduction of the amplitude over pulse-alone trials [i.e. \( PPI = (A - B) / A \times 100 \), where \( A \) indicates amplitude over pulse-alone trials and \( B \) amplitude over prepulse trials]. Such a procedure is recommended to correct for the influence of individual differences in startle amplitude.

Statistical methodology

Continuous variables are expressed in mean ± S.D. Pearson correlation coefficients were calculated between variables. Each coefficient is presented together with \( p \) value and sample size. Continuous variables were compared with the \( t \) test or ANOVA. PPI data were analysed using a repeated-measures ANOVA model with PROC MIXED in SAS version 9 (SAS Institute, Cary, NC, USA), where PPI values were modelled as the dependent variable and time (30 ms, 60 ms, and 120 ms) and hypnotizability level (low, medium, or high) as covariates. An interaction term for time × hypnotizability level was also entered. All tests were two-tailed and a \( p \) value of \( \leq 0.05 \) was considered statistically significant.

Results

Forty-eight individuals (23 men, 25 women) participated in the project. Mean age was 24.5 ± 6.7 yr (range 21–59 yr). Two subjects were not included in further analysis because they were found to be ‘non-startlers/non-reactive’ (mean pulse-alone amplitude of first block <25 units), according to the criteria of Braff et al. (1992). Three subjects were excluded for technical reasons (the data was irretrievable from the computer). Statistical analyses therefore refer to 43 subjects.

All subjects were evaluated with the SHSS:C; mean score was 6.1 ± 3.3. Thirty-eight were medical students pre-tested with the HGSHS:A; mean score was 6.5 ± 3.3 (range 0–11). Ten subjects who did not undergo the group testing were participants in a previous research project (Lichtenberg et al., 2004).

Correlation between the SHSS:C and HGSHS:A was 0.715 (Pearson correlation, \( p < 0.0001 \)). For all statistical analyses, we used the SHSS:C and not the HGSHS:A because the former is more challenging and therefore more effective in separating high and low hypnotizables. Results for the two hypnotizability tests did not differ significantly (data available upon request).

Pearson correlation coefficients calculated between hypnotizability scores and PPI were not significant.
Prepulse inhibition and hypnotizability

Figure 1. Hypnotizability measured by Stanford Hypnotic Susceptibility Scale, Form C (Hilgard, 1965). Low, 0–3 (); medium, 4–8 (); high, 9–12 (). At 30 ms: no significant difference between low and combined medium-high hypnotizables (ANOVA, p = 0.3953). At 60 ms: statistically significant difference between low and combined medium-high hypnotizables (post-hoc t test, p = 0.0121). At 120 ms: statistically significant difference between low and combined medium-high hypnotizables (post-hoc t test, p = 0.0075).

(for 30 ms: n = 43, r = −0.0138, p = 0.93; for 60 ms: n = 43, r = −0.143, p = 0.359; and for 120 ms: n = 43, r = −0.195, p = 0.299).

Subjects undergoing testing with the SHSS:C are regularly divided into three or even four groups on the basis of their scores (e.g. de Pascalis, 1999; Hilgard, 1965; Lichtenberg et al., in press), reflecting possibly different neurophysiological characteristics which may contribute to varying levels of hypnotizability (Lichtenberg et al., 2004). We divided the subjects into three hypnotizability-level groups as determined by their SHSS:C score: low (0–3; n = 10, six male, mean age 30.7 ± 11.0 yr), medium (4–8; n = 21, nine male, mean age 27.4 ± 3.9 yr) and high (9–12; n = 12, seven male, mean age 26.0 ± 6.9 yr). There were no statistically significant differences between the three hypnotizability groups with respect to age (ANOVA, p = 0.47) or gender (χ² test, p = 0.57). We then compared PPI scores between the three hypnotizability groups with the repeated-measures ANOVA model. We found statistically significant differences between the groups (p = 0.0173) irrespective of time, significant interaction between time and hypnotizability level (p = 0.0475), but in addition found no significant differences between medium and high hypnotizables at any measurement time (post-hoc pairwise t test; at 30 ms, p = 0.29; at 60 ms, p = 0.45; and at 120 ms, p = 0.86). We therefore combined high and medium hypnotizable groups for further statistical analysis. The second model showed similar results as before (p = 0.0139 low vs. medium-high irrespective of time) with a significant interaction between time and hypnotizability (p = 0.0199) indicating that the differences between the groups are not the same over time. At 30-ms intervals between prepulse and pulse, low hypnotizables showed an insignificantly milder decrease than the combined medium- and high-hypnotizable group (post-hoc pairwise t tests, p = 0.40). However, with 60 ms and 120 ms intervals separating the prepulse from the pulse, the low-hypnotizability group showed a significantly higher inhibition of the startle response than did the medium- and high-hypnotizable groups. For PPI at 60 ms, the low hypnotizables averaged 43% inhibition, compared with 19% for the combined groups (post-hoc pairwise t tests, p = 0.012). For PPI at 120 ms, the low hypnotizables averaged 47%, while the combined medium and high group averaged 21% (post-hoc pairwise t tests, p = 0.008). The results are presented in Figure 1.

Discussion

This is the first study to assess the association between hypnotizability and PPI. Our results indicate that individuals scoring lowest on hypnotizability testing, as measured by the SHHS:C, tend to have more efficient sensorimotor gating, as reflected by a reduced startle response following a prepulse stimulus.

While hypnosis is a complex behaviour doubtlessly involving various neurotransmitter systems, we speculate that a possible explanation for this finding may involve the potential role of dopaminergic mechanisms in hypnotizability. Animal and human studies suggest that the sensorimotor gating mechanisms assessed by PPI are sensitive to dopaminergic activity, with reduced dopaminergic tone producing increased inhibition of the response to a startle stimulus primed by a substartle prestimulus (Bitsios et al., 2005; Lind et al., 2004; Powell et al., 2003; Swerdlow et al., 2006; Zhang et al., 2000). Similarly, individuals with lower hypnotizability may also be characterized by reduced dopaminergic activity, as found in CSF (Spiegel and King, 1992), brain imaging (Halligan et al., 2000; Rainville et al., 1997; Szechtman et al., 1998), and genetic polymorphism (Lichtenberg et al., 2004) studies. Our findings suggest that individuals with reduced dopaminergic activity, as evidenced by greater PPI of the startle reflex, may tend to be less hypnotizable.

Individuals with high hypnotizability do not show enhanced sensory gating with reduced PPI, although they may selectively attend and disattend different stimuli (Lichtenberg et al., 2004). PPI measures an automatic, preattentive neurophysiological response and is not mediated by conscious attentional mechanisms. The span of time between the prepulse and the
pulse in this experiment, which ranged from 30 ms to 120 ms, is not sufficient to recruit conscious responses.

Interestingly, the reduced PPI found amongst individuals with higher hypnotizability parallel findings for people with psychotic disorders (Swerdlow et al., 2006). Hypothetically, these two populations may share certain characteristics, such as the ability to experience auditory hallucinations and their underlying mechanisms. Auditory hallucinations in both highly hypnotizable individuals undergoing hypnosis (Szechtman et al., 1998) and in schizophrenia (Allen et al., 2007) correlate with activation of the dopaminergically innervated anterior cingulate cortex. Recent findings confirm a greater incidence of schizophrenia with auditory hallucinations, especially commenting voices and command hallucinations, amongst individuals suffering trauma or abuse in childhood (Read et al., 2005). When trauma is characterized by the appearance of a dissociative state, as for example in acute stress disorder which by definition requires at least three dissociative symptoms (APA, 1994), this process may constitute a potential source of increased hypnotizability (Bryant et al., 2001), predisposing the victim to auditory hallucinations by quasi-hypnotic processes. For individuals upon whom early abuse is inflicted, high hypnotizability may represent a risk factor for the subsequent development of spontaneous auditory hallucinations. While hypnotizability has been investigated in schizophrenia (Frischholz et al., 1992), it has not yet been evaluated specifically for individuals with auditory hallucinations, with or without a history of child abuse.

Further studies are warranted to replicate our findings and to investigate the issues raised here. Although PPI does not vary with age (Ludewig et al., 2003), further studies would do well to include a larger proportion of older subjects than in the present study. Additional issues to be addressed in future studies include the interactions between hypnotizability levels, sensorimotor gating variables, and neurocognitive performance. Furthermore, the hypothesized involvement of dopaminergic mechanisms in hypnosis could be further tested by assessing whether dopaminergic challenge procedures enhance hypnotizability. Such a pharmacological strategy may have practical implications for enhancing the effectiveness of selected hypnotherapeutical procedures.

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Statement of Interest

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References


