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HYPNOTIZABILITY AND SENSORIMOTOR GATING: A Dopaminergic Mechanism of Hypnosis

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Abstract: Dopaminergic mechanisms have been theorized to influence hypnotizability and sensorimotor gating. In this study, the authors investigated an association between sensorimotor gating, as measured by prepulse inhibition (PPI), and hypnotizability, as assessed by the Stanford Hypnotic Susceptibility Scale, Form C (SHSS:C). They found an inverse correlation between the SSHS:C and PPI. This finding, which replicates an earlier study, provides further evidence for a dopaminergic basis for hypnotizability and suggests additional avenues for research, including a method for possibly enhancing hypnotizability through pharmacological interventions.

Hypnotizability is a complex behavioral phenomenon with biological, cognitive, and social components (Lichtenberg, Bachner-Melman, Ebstein, & Crawford, 2004). Attempts to consistently correlate hypnotizability with other physiological, cognitive, or personality measures have usually produced inconsistent results.

Prepulse inhibition (PPI) is a technique for assessing sensorimotor gating (Braff, Geyer, & Swerdlow, 2001). A subject hears via earphones...
a “prepulse,” which is a brief noise at a decibel level that would not cause him or her to blink. A second stronger stimulus, the “pulse,” is sufficiently loud to produce blinking. However, when the prepulse is presented immediately before the pulse, with the interval between the two stimuli too brief to be consciously perceived, the test subject will be less likely to blink. That is to say, even though the subject is unaware of the prepulse, it serves to inhibit the subsequent startle reaction upon hearing the pulse. The degree to which the prepulse inhibits the blink response following the pulse is the PPI and is presumed to reflect the efficiency of the sensorimotor gating system. Human and animal studies suggest that increased dopaminergic tone may be correlated with reduced prepulse inhibition (Bitsios, Giakoumaki, & Frangou, 2005; Lind, Arnfred, Hemmingsen, & Hansen, 2004; Powell et al., 2003; Swerdlow et al., 2006; Zhang, Forkstam, Engel, & Svensson, 2000).

We recently reported an inverse correlation between PPI and hypnotizability (Lichtenberg, Even-Or, Levin, Brin, & Heresco-Levy, 2007). Our finding is in line with a growing body of evidence suggesting that increased hypnotizability reflects increased central dopaminergic activity. Cerebrospinal fluid levels of homovanillic acid, a dopamine metabolite, were found to be higher in high hypnotizables (Spiegel & King, 1992). By now, three genetic association studies have suggested a positive correlation between the polymorphism producing lower levels of the enzyme catechol-O-methyltransferase (COMT), which metabolizes dopamine, and hypnotizability (Lichtenberg et al., 2004; Raz, 2005; Szekely et al., 2010).

We sought to extend our 2007 study (Lichtenberg et al., 2007) with a sample of new subjects in an attempt to replicate our finding of reduced prepulse inhibition with high hypnotizables.

**METHOD**

**Subjects**

As part of an ongoing study of neurobiological correlates of personality, 50 subjects, mainly college students were recruited. Of these, 10 subjects failed initial PPI testing (details below) so that we remained with 40 subjects.

Forty subjects aged 17–31 (mean 23.2 ± 3.9), including 16 men and 24 women, were evaluated for hypnotizability and underwent PPI testing. Exclusion criteria were a diagnosable mental disorder, according to Axis I of the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed. [DSM-IV]; American Psychiatric Association, 1994), as determined by a psychiatrist with over 10 years experience, and a history of head injury leading to unconsciousness.
PPI was performed as described in Heresco-Levy et al. (2007). Testing required approximately 20 minutes, during which 82 pulses and prepulses were presented via headphones to the subject. Startle response was measured as the mean of all responses to a 115-decibel stimulus pulse. Prepulse inhibition was computed as the percentage of reduction in amplitude of blink response to a pulse when it was preceded by a prepulse, using the formula:

\[ \text{PPI} = \frac{(A - B)}{A} \times 100, \]

where \( A \) indicates amplitude of blink response in response to single pulses, while \( B \) is amplitude of blink response to pulses preceded by prepulses. We examined blink response to pulses occurring at intervals of 30, 60, and 120 ms after the prepulse (PPI-30, PPI-60, and PPI-120, respectively). Subjects without an adequate baseline blink response of 192.5 \( \mu V \) to the first six pulses were excluded from the study, according to the criteria of Braff, Grillon, and Geyer (1992).

Hypnotizability was assessed using the 12-point Stanford Hypnotic Susceptibility Scale, Form C (SHSS:C; Hilgard 1965), in a validated Hebrew translation (Lichtenberg, Shapira, Kalish, & Abramowitz, 2009).

This study was approved by the Herzog Hospital Institutional Review Board and by the Israel Ministry of Health. We obtained written informed consent from all participants.

*Statistics*

Pearson correlation coefficients were calculated between variables. Each coefficient is presented together with \( p \) value. Additionally to the whole group Pearson correlation we divided the subjects into three hypnotizability–level groups according to their SHSS:C score: low (0–3, \( n = 11 \)), medium (4–8, \( n = 25 \)) and high (8–12, \( n = 4 \)). Group differences in PPI were assessed using repeated-measures multivariate analysis of variance (RM–MANOVA) with prepulse condition (30, 60, and 120 ms) as the within-subject factor and group (low vs. medium vs. high score) as the between-subject factor.

*Results*

Forty individuals underwent hypnotizability and PPI testing. An additional 10 subjects were excluded because they were found to be nonstartlers in reaction to baseline single pulses.

All subjects were evaluated with the SHSS:C. The mean score on the SHSS:C was 5.4 ± 2.6 (for men, 5.5 ± 3.1; for women, 5.3 ± 2.2; the difference was not statistically significant \( [t = .25, p = .8] \)).
We found significant reverse correlations between SHSS:C total score and the PPI for all prepulse-pulse intervals (for PPI-30, $r = -0.445$, $p = 0.004$; for PPI-60, $r = -0.412$, $p = 0.008$; and for PPI-120, $r = -0.510$, $p = 0.001$).

When we divided subjects into low, medium, and high hypnotizability groups, we did not find significant correlations between the groups and PPI testing (PPI Intervals x Hypnotizability level $F = 1.107$, $p = 0.36$).

**Discussion**

In this study, we found a significant inverse correlation between sensorimotor gating, as measured by prepulse inhibition levels, and hypnotizability, as measured by the SHSS:C. This finding held across the three prepulse-pulse time intervals, which we measured at 30, 60, and 120 ms.

This finding is a replication and confirmation of our earlier study (Lichtenberg et al., 2007), yet there are certain differences. In the former study, we obtained a significant inverse correlation between SHSS:C and PPI scores when dividing subjects into groups according to hypnotizability level; in this study, the correlation was not significant. This may be related to the fact that in the present study, we did not specifically seek to recruit high hypnotizables, and indeed only 4 subjects scored 8 or above on the SHSS:C.

Another difference between the two studies is that in the former, the inverse correlation between SHSS:C scores and PPI pertained only for 60 and 120 ms prepulse-pulse intervals, while in the present study we found the correlation for 30 ms intervals as well.

Overall, the basic finding has been replicated. Individuals who are more highly hypnotizable show evidence of poorer sensorimotor gating, as evidenced by reduced inhibition of the startle blink reflex following a pulse primed by a prepulse.

The interval between the prepulse and the pulse is so brief that to the unaided ear it is perceived as a single auditory stimulus. Hence the correlation here does not appear to be a function of some sort of cognitive processing, and is presumably not under conscious control. We may have then, in the PPI, a neurophysiological correlate of hypnotizability.

Reduced sensorimotor gating, as evidenced by reduced PPI, appears to be associated with enhanced dopaminergic tone. For example, PPI is reduced in patients with schizophrenia and may return to normal levels with medication (Swerdlow et al., 2006). Our finding, therefore, is an additional piece of evidence implicating dopaminergic mechanisms in hypnotizability.

Further research, beyond seeking to confirm this finding in other labs and with groups with broader variation in age, might also attempt...
to use dopamine agonists to enhance hypnotizability. Were such an approach proven effective and safe, it might provide a neuropharmacological technique for enhancing hypnotizability.

References


Hypnosefähigkeit und sensorimotorisches Gating - ein dopaminriger Mechanismus der Hypnose


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Hypnotisabilité et synchronisation sensorimotrice: un mécanisme dopaminergique de l’hypnose


Résumé: On a émis l’hypothèque que des mécanismes dopaminergiques influençaient l’hypnotisabilité et la synchronisation sensorimotrice. Dans cette étude, les auteurs ont examiné une association entre la synchronisation sensorimotrice, telle que mesurée par une inhibition prépulsatoire (PPI), et l’hypnotisabilité, évaluée à l’aide de l’échelle de susceptibilité hypnotique de Stanford, formulaire C (SHSS:C). Ils ont découvert une corrélation négative entre la SHSS:C et la PPI. Ces résultats, qui reproduisent ceux d’une étude précédente, fournissent d’autres preuves d’une base dopaminergique à l’hypnotisabilité et proposent de nouveaux parcours de recherche, y compris une méthode pouvant éventuellement hausser le niveau d’hypnotisabilité grâce à des interventions pharmacologiques.

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Hipnotizabilidad y la regulación sensoriomotora: Un mecanismo dopaminérgico de la hipnosis


Resumen: Se ha teorizado que mecanismos dopaminérgicos influencian la habilidad hipnótica y la habilidad para bloquear la transmisión sensoriomotora. En este estudio, los autores investigaron la asociación entre la regulación sensoriomotora, medida a través de la inhibición prepulso (PPI),
y la hipnotizabilidad, evaluada con la Escala Stanford de Susceptibilidad Hipnótica, Forma C (ESSH:C). Encontraron una correlación inversa entre la ESSH:C y PPI. Este hallazgo, que replica los resultados de un estudio anterior, provee mayor evidencia para una base dopaminérgica de la hipnotizabilidad y sugiere líneas de investigación adicionales, incluyendo posiblemente un método para aumentar la hipnotizabilidad a través de intervenciones farmacológicas.

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