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Hypnotic Hallucination Alters Evoked Potentials

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Brain electrical potentials evoked by visual stimulation were analyzed to study the neurophysiological mechanism associated with hypnotic hallucination. The visual evoked responses of 6 high- and 6 low-hypnotizable subjects were compared in three hypnotic conditions: stimulus enhancement, stimulus diminution, and stimulus elimination (obstructive hallucination). High-hypnotizable individuals demonstrated significant suppression of the later components of the evoked response (N_2 and P_3) while experiencing obstructive hallucinations, indicating a change in information processing. This effect was significantly greater in the right, as compared to the left, occipital region.

Hypnosis involves intense concentration (Hilgard, 1965; Spiegel & Spiegel, 1978; Van Nuys, 1973) and can, therefore, be a useful tool for exploring the neural mechanisms involved in focused attention. The hypnotic state can be considered one extreme of a continuum in which focus is accomplished at the expense of the range of ambient awareness. In animals, neural controls on input processing have been demonstrated (Lassonde, Ptito, & Pribram, 1981; Spinelli & Pribram, 1966, 1967). The nature of these controls suggests that they operate much as does a zoom lens in providing a trade-off between a wide-angle view (ambience) and resolution (focus; Marg & Adams, 1970; Pribram, 1966, 1967). Individuals vary in hypnotizability, and there is some evidence that in hypnotizable individuals the amplitude of the evoked response (ERP) is diminished in response to hypnotic suggestion that the stimulus is attenuated (Clynes, Kohn, & Lifshitz, 1964; Galbraith, Cooper, & London, 1972; Guerrero-Figueroa & Heath, 1964; Hernandez-Peon & Donoso, 1959; Wilson, 1968), but others have not confirmed this relation (Amadeo & Yanovski, 1975; Andreassi, Balinsky, Gallichio, De Simone, & Mellers, 1976; Beck & Barolin, 1965; Beck, Dustman, & Beier, 1966; Halliday & Mason, 1964; Serafetinides, 1968; Zakrzewski & Szelenberger, 1981). In contrast to these earlier studies, Barabasz and Lonsdale (1983) recently demonstrated significant amplitude increases rather than decreases of the P300 component of olfactory-evoked potentials among high-hypnotizable subjects experiencing anosmia. This is the only study to report such an inverse relation between hypnotic perceptual experience and ERP amplitude.

This study was designed to determine whether the amplitude of the visual evoked potential is reduced during hypnotic hallucination in which the subject is instructed to perceive visual stimuli as diminished in brightness or obstructed from view. The specific effect of hypnosis was tested by comparing the visual evoked responses of extremely high-hypnotizable versus extremely low-hypnotizable subjects asked to perform identical tasks. Using this design, low-hypnotizable subjects are asked to attempt to experience hypnotic hallucination. Differences between high- and low-hypnotizable groups in identical tasks should be attributable to the differences in their hypnotizability. The hypothesis tested was that low-hypnotizable subjects instructed to simulate a hallucination obstructing their view of the monitor should show no alteration in the amplitude of their evoked potentials as compared with other attention conditions, whereas high-hypnotizable subjects were predicted to show a diminution in amplitude of the evoked response in the condition in which they were instructed that they would be un-

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able to see the visual stimulus. Because differences in perception of the stimuli could be expected to influence button-pressing responses to the stimuli, an additional control group was included to assess the effects of motor response on the evoked potential.

Method

Subjects

For the high- and low-hypnotizable portion of the study, 16 right-handed volunteers (9 women and 7 men) between the ages of 18 and 33 (M = 23.0) were recruited on the basis of having scores of 0–3 or 9–12 on the Harvard Group Scale of Hypnotic Susceptibility (HGSHS: Shor & Orne, 1962). They were then administered the Hypnotic Induction Profile (HIP: Spiegel & Spiegel, 1978). Only 12 subjects who were classified as comparably high or low hypnotizable on both scales (2 were not) and who provided reliable scalp recordings (2 others did not because of excessive eye-blink rates) were included in the study. The mean hypnotizability scores for the highs were 9.3 on the HIP (range = 8–10) and 10.3 on the HGSHS (range = 9–12). The mean scores for the lows were 2.8 on the HIP (range = 0–5) and 1.7 on the HGSHS (range = 0–3). The 6 button-pressing control subjects were selected from a similar pool of psychology students. Two others were dropped because of excessive eye blinks. They were not hypnotized during the study, but their mean hypnotizability scores on the HIP was 6.0 (range = 2–10).

Experimental Conditions

The visual evoked potentials of the high- and low-hypnotizable subjects were compared in three hypnotic conditions: (a) *stimulus enhancement*, in which subjects were instructed that one of two colored stimuli would appear unusually bright and interesting; (b) *stimulus diminution*, in which subjects were instructed that the alternate color stimulus would appear drab, dull, and uninteresting; and (c) *obstructive hallucination*, in which subjects were instructed to visualize a cardboard box that blocked viewing of the TV monitor on which the stimuli were presented, making perception of anything on the screen impossible.

All stimuli were colored gratings presented within an 8 cm × 8 cm square area on a color television 1 m in front of the subject. The stimulus series, analogous to the auditory paradigm of Hansen and Hillyard (1980), contained stimuli of two colors: 50% blue vertical gratings and 50% pink horizontal gratings. Each series contained 512 stimuli. For each color, 224 stimuli—which were the standards for evoked-potential recording—were presented for a brief duration (133 ms), and 32 stimuli—which were the targets—for a long duration (399 ms). To assure attention, subjects were asked to press a button with their right hand in response to each target of one designated color. The stimuli of each color were presented in random order with equal probability, with the constraint that one target of each color appeared at least once every 16 stimuli. Presentation rate averaged one stimulus per 1.4 s, with an interstimulus interval ranging from 1.0 to 1.8 s in a rectangular distribution for a total of 12 min per run. The same stimulus series was used for each of the three hypnotic conditions and two control tasks, which were presented to the subjects in counterbalanced order. The specific color to be enhanced or diminished was similarly varied.

Because of the difficulty of the obstructive hallucination task, it was thought that it would be confusing to ask these subjects to be unable to see any stimuli on the one hand, and to button press to certain target stimuli on the other. Thus, they were told to press to any stimulus they happened to see. This meant that all stimuli became potential targets in this condition, raising the possibility that any observed differences might be due to the effect of motor potentials when they pressed, or the absence of any expectation that they would have to press when they did not. A button-pressing/passive-attention control group was therefore added to control for the amount of variance in response that could be accounted for by both of these factors, excluding differences in hypnotic hallucinatory experience. Only results that proved significant beyond those found in this latter control group were attributed to an effect of hypnotic hallucination. The 6 additional behavioral control subjects selected for intermediate hypnotizability were not hypnotized, but were asked to perform two tasks: (a) to press a button after each stimulus presented and (b) to attend passively to the screen without pressing a button to any stimuli. Thus, we had three control conditions: (a) for attentional demands, comparing the performance of high hypnotizables in the obstructive hallucination versus the hypnotic stimulus enhancement condition, (b) for hypnotizability, in comparing the high hypnotizables in the obstructive hallucination condition versus the low hypnotizables in the same condition, and (c) for button-pressing behavior, comparing the performance of the high hypnotizables to that of control subjects in press versus no-press conditions.

The fixation of each subject's eyes on the center of the television screen was monitored continuously using a closed-circuit TV camera placed directly on top of the television set. In only one case did it deviate, when the subject became drowsy. He was aroused and the run resumed.

EEG Measurement

The electroencephalogram (EEG) was recorded from monopolar leads at Fz, Cz, Pz, O_1, and O_2, all referred to linked ears, A1–A2. Electrooculogram (EOG) was recorded as a bipolar channel, using two electrodes located on the lower orbital ridge and on the outer canthus of the right eye. The EEG was amplified 40,000 times and the EOG was amplified 4,000 times, using Tektronix FM-122 AC preamplifiers and AC power amplifiers. The standard preamplifier time constants were modified to yield a system band pass with −3dB down at .08 Hz (time constant = 2.0) and 50 Hz. The EEG was digitized on line at 200 Hz for 55 ms preceding, and 655 ms following, the onset of each stimulus. Five standard ERP components were measured as amplitude maxima and minima within selected latency ranges as follows: P_1 at 65–150 ms, N_1 at P_1–210 ms, P_2 at N_1–300 ms, N_2 at P_2–380 ms, and P_3 at 290–550 ms. The mean wave forms for each subject from each electrode

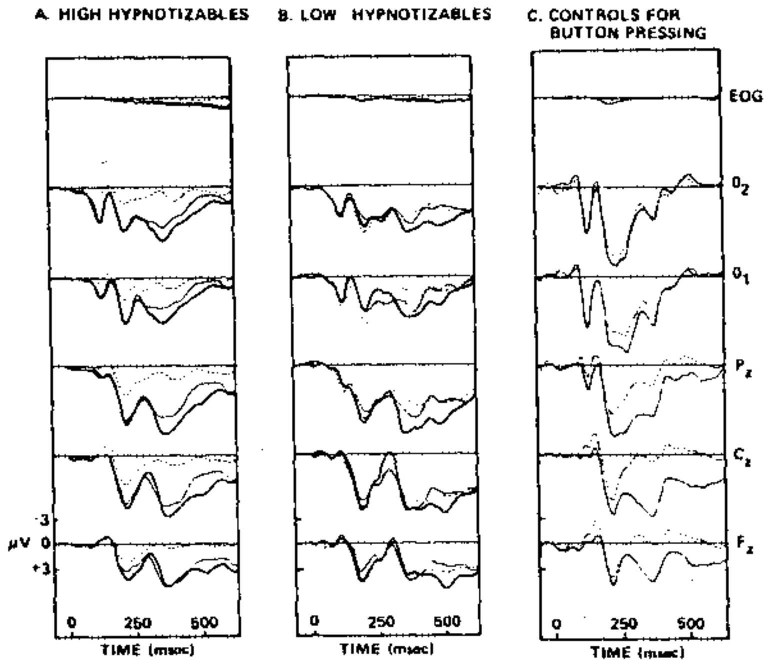

Figure 1. Effect of hypnotic obstructive hallucination on visual evoked potentials. (Visual evoked potentials [VEPs] recorded at leads Fz, Cz, Pz, O_1, and O_2 are expressed as the mean of recordings in each condition from 6 individuals per group yielding approximately 1,800 VEPs per waveform. In A and B, high hypnotizable and low hypnotizable group data shown are VEPs to stimuli observed in the hypnotic enhancement condition [thick solid lines], the hypnotic diminution condition [thin solid lines], and the hypnotic obstructive hallucination condition [dotted lines]. In C, control subjects for button pressing, solid lines are VEPs to stimuli that were all treated as button-pressing targets. Dotted lines are VEPs in a passive attention condition in which all stimuli were treated as standards and required no button pressing.)

were visually inspected to insure that the computer could select an identifiable peak, especially at P_3. In approximately 10% of the cases distributed randomly across groups and conditions, the computer selected either the beginning (290 ms) or the end (550 ms) of the window. In these cases, a latency was selected for amplitude measurement, which was determined by the mean P_3 latency for that group of subjects (high hypnotizables, low hypnotizables, or button-pressing control subjects) at that electrode site. The overall average P_3 latency was greater than 400 ms. The amplitudes at these five standard ERP latency ranges were then utilized as variables for statistical analysis of group by condition effects. An experimentally derived heuristic was used to exclude from data analysis visual evoked potentials (VEPs) that were EOG contaminated. During off-line analysis, the average EOG signal amplitude was computed for each epoch. If the EOG signal deviated for more than 30 μv from the average value for that epoch for more than 45 (of 655) ms, then the VEP for each channel during that epoch was excluded from analysis.

Results

The evoked responses among high hypnotizables in the obstructive hallucination condition are clearly diminished, both in comparison to the other hypnotic conditions experienced by that group and in comparison to those of low-hypnotizable subjects in the analogous condition. The averaged VEPs to standard stimuli for all conditions are shown in Figure 1.

The initial statistical comparison of interest was between high- and low-hypnotizable subjects in the three conditions to which they were exposed: enhancing the brightness of the stimulus, diminishing the brightness of the stimulus, and having an obstructive hallucination blocking the stimulus. As Table 1 indicates, enhance–diminish differences are small and comparable in high- and low-hypnotizable groups, whereas enhance–obstructed view differences are large at all peaks among high-hypnotizable subjects only.

However, because the instructions were different in the obstructive hallucination condition, that is, the subjects were told to treat

Table 1
Difference Between Hypnotic Conditions in VEP Amplitudes

Visual evoked potential peak	Enhance vs. diminish: Hypnotizability High	Enhance vs. diminish: Hypnotizability Low	Enhance vs. obstructed view: Hypnotizability High	Enhance vs. obstructed view: Hypnotizability Low
P_1	0.09	0.19	1.42	0.02
N_1	0.13	0.19	1.26	0.41
P_2	0.43	0.22	3.05	0.12
N_2	0.40	0.55	1.65	0.38
P_3	0.98	0.42	3.28	0.75

Note. Visual evoked potentials (VEPs) were recorded at leads Fz, Cz, Pz, O_1, and O_2. The amplitude difference at each of five VEP peaks between hypnotic conditions is compared among the 6 high- and 6 low-hypnotizable subjects. Numbers are standardized differences in the mean VEP amplitudes in microvolts ($(M_1 - M_2)/\sqrt{s.e._1^2 + s.e._2^2}$) between the hypnotic enhancement and both the hypnotic diminution and hypnotic obstructive hallucination conditions.

all stimuli as targets in this condition, the comparability of these findings in relation to the other two conditions is open to question because of possible contamination by motor potentials when subjects button pressed, or a possible difference in expectancy when they did not; that is, the high hypnotizables could have differentially interpreted their instructions and could have seen the targets, but simply failed to report seeing them. In fact, they pressed to only 5% of the stimuli, whereas the low hypnotizables in the same condition pressed to 96% of the stimuli. This is a behavioral indication that the highs were complying with the hypnotic instruction and is consistent with their reports that they were unable to see the stimulus generated because of a cardboard box blocking it. The low hypnotizables, given identical instructions, reported a failure to see any image strong enough to obstruct their view of the monitor. However, because these hallucination instructions could conceivably have produced a differential expectancy regarding the need to button press, a third group was included that had been instructed in one condition to treat all stimuli as targets and in the other condition to observe them but treat them all as standards, that is, not to button press to any of them. Because the diminished condition was not significantly different from the enhanced condition (see Table 1) and there was no strictly analogous condition for the button-pressing control group, it was decided to drop the diminished condition from subsequent analysis.

Data were then analyzed using a two-way, repeated measures analysis of variance (ANOVA) comparing the VEP difference between the standard stimulus enhancement condition and the obstructive hallucination condition for the high and low hypnotizables, and the analogous button-pressing target response task for the control subjects. Statistically significant differences among the three groups using data from all five leads were obtained at N_1, $F(2, 15) = 4.2$, $p < .05$; P_2, $F(2, 15) = 8.9$, $p < .005$; and P_3, $F(2, 15) = 3.9$, $p < .05$, whereas those at P_1 and N_2 just missed significance ($p < .1$). In all cases, the differences in evoked response between the two conditions were smallest among the low hypnotizables.

Post hoc t tests were performed only when protected by a significant overall ANOVA, and then in order to include as significant only findings in which differences among the high hypnotizables were significantly greater than those found among both the low hypnotizables and the behavioral control subjects. The amplitude differences among the high hypnotizables were not significantly higher than those of the button-pressing control subjects at N_1 or P_2. The high hypnotizables demonstrated a unique suppression of P_3 throughout the cortex in the obstructive hallucination condition. The mean P_3 difference for the high hypnotizables was twice that of these control subjects, $t(10) = 3.5$, $p < .01$, and three times that of the low hypnotizables, $t(10) = 5.3$, $p < .001$. There were no significant Group × Condition VEP latency differences: ANOVA $F(2, 20) = 1.1$ at P_1; 1.2 at N_1; 1.3 at P_2; 2.7 at N_2; and 0.5 at P_3.

Because this was a visual task, the extent of suppression of the evoked response was analyzed separately using data from the occipital leads only. The high-hypnotizable group showed significantly greater suppression at N_2, $F(2, 15) = 6.9$, $p < .01$, and P_3, $F(2, 15) = 5.3$, $p < .025$, than did both other groups confirmed by post hoc t tests.

Table 2
Laterality Differences in Hypnotic Suppression of VEP Amplitude

VEP peak and occipital lead	High hypnotizables *M*	High hypnotizables *SD*	Low hypnotizables *M*	Low hypnotizables *SD*	Controls for button pressing *M*	Controls for button pressing *SD*	F(2, 15)
P_2							
O_1 Left	1.57	0.89	−1.12	0.51	2.29***	0.69	7.9****
O_2 Right	2.98**	0.58	−0.58	0.44	1.04	0.53	
N_2							
O_1 Left	1.72	0.52	0.89	0.55	0.47****	0.39	6.3**
O_2 Right	3.05**	0.61	1.29	0.67	−0.91	0.62	
P_3							
O_1 Left	3.03	0.79	1.19	0.64	1.37****	0.28	7.0****
O_2 Right	4.37*	1.02	1.30	1.02	0.09	0.19	

Note. Significant Group × Lead interactions using O1 (left occipital) and O2 (right occipital) leads were found at P_2, N_2, and P_3. Mean differences in microvolts are shown between hypnotic attention enhancement and obstructive hallucination conditions among the 6 high- and 6 low-hypnotizable subjects, and between button-pressing/no-button-pressing tasks among the 6 control subjects. Data were examined using two-way, repeated measures analysis of variance with post hoc *t* tests. VEP = visual evoked potential.
* $p < .05$. ** $p < .025$. *** $p < .01$. **** $p < .005$.

In view of the data suggesting a relation between hemispheric laterality and hypnotizability, and especially a preferential use of the right hemisphere among high hypnotizables (Bakan, 1969; Bakan & Svorad, 1969; Galin, Selig, & Ellis, 1975; Gur & Gur, 1974; Morgan, MacDonald, & Hilgard, 1974), it was of interest to examine differences in the suppression of response in the left, as compared with the right, occipital region. There were significant Group × Lead interactions at P_2, N_2, and P_3 (see Table 2). Among high hypnotizables, amplitude differences between enhancement and obstructive hallucination conditions were found to be consistently and significantly higher on the right, using post hoc *t* tests: at P_2, $t(10) = 3.28$, $p < .01$; at N_2, $t(10) = 4.03$, $p < .01$; and at P_3, $t(10) = 2.58$, $p < .05$. However, among the lows there was no clear pattern, and among the control subjects amplitude differences comparing the analogous press/no-press conditions were significantly higher on the left.

Discussion

Our results are consistent with the hypothesis that an hypnotic instruction of obstructive hallucination among high-hypnotizable subjects is accompanied by a decrease in the amplitude of the P_3 component of the evoked response throughout the brain, and of the N_2 and P_3 components in the occipital region. This dampening of amplitude is particularly notable among high hypnotizables in the right, as compared with the left, occipital area, suggesting greater inhibition of scalp-recorded response to a visual stimulus in the right hemisphere.

These data show that while experiencing an obstructive hallucination blocking the stimulus, high-hypnotizable subjects demonstrate a change in the information-processing components of the evoked response (Baribeau-Braun, Picton, & Gosselin, 1983), rather than primarily in channel selection, which is reflected more by P_1 and N_1 (Ford, Roth, Dirk, & Kopell, 1978; Hillyard & Picton, 1979). Although there were differences at P_1 and N_1 between high and low hypnotizables, they were not significantly greater than those observed in the press/no-press control group. These observations make it possible to address several alternative explanations for the findings, such as the possibility of differences in nonspecific arousal leading to a differential preparation (Naatanen, 1969), which should be reflected primarily in changes in the early components, as would any differences in pupil size. Drowsiness or inattention in this condition should be associated with an increase, rather than a decrease, in response amplitudes (Schacter, 1976). The possibility that high hypnotizables might have defocused their view of the monitor (Schulman-Galambos, & Galambos, 1978) is made less likely by the fact that defocusing is accompanied by increases in P_1 latency (Sokol & Moskowitz, 1981), whereas there were no P_1 latency differences in the obstructive hallucination condition.

These results may help explain the negative reports (Amadeo & Yanovski, 1975; Andreassi et al., 1976; Beck & Barolin, 1965; Beck, Dustman, & Beier, 1966; Halliday & Mason, 1964; Serafetinides, 1968; Zakrzewski & Szelenberger, 1981), in which attempts were made to have high-hypnotizable subjects diminish the brightness of a stimulus in the hope that the evoked response would mimic that elicited by a stimulus of decreased brightness. Clearly, hypnotizable subjects are performing a different kind of mental work when they block out the view of a stimulus altogether, rather than attend to a stimulus and attempt to decrease its intensity. Diminution of the perceived stimulus requires attention to the stimulus, even if it is for the purpose of diminishing its brightness. It is not surprising that the time-locked evoked response during such effort is more substantial than in the condition in which the subject is instructed to focus on a hallucinated object blocking any perception of the visual stimulus. It is of interest that among the high-hypnotizable subjects our results suggest a continuum of attention from the enhancement condition with the greatest amplitude through diminishing the stimulus with slightly lower amplitudes to the obstructive hallucination, which seemed to reduce markedly cortical response to the stimulus.

Our findings show a difference in the opposite direction from the findings in the recent report of Barabasz and Lonsdale (1983). In their study, negative hallucination instructions in the olfactory system resulted in an increase in P_3 when hypnotized highs instructed to experience anosmia were exposed to both weak and strong odors. In our study in the visual system, high hypnotizables demonstrated suppression of P_3 in the obstructive hallucination condition. Barabasz and Lonsdale proposed, reasonably, that high-hypnotizable subjects in their study may be demonstrating a general increase in cortical arousal. Because the P_3 is associated with information processing (Baribeau-Braun, Picton, & Gosselin, 1983) and is increased when the stimulus is unexpected, intrusive, and defined as task relevant (Hillyard & Picton, 1979), it may be that if the hypnotically instructed anosmia was incomplete, the high-hypnotizable subjects were surprised by any perception of odor, even though they reportedly did experience anosmia. The instructions given their subjects differed in one important respect from those given ours. They were told "You can no longer smell anything at all" (Hilgard, 1965). The subjects in the present study were instructed to visualize a cardboard box blocking the monitor. Thus, the obstructive hallucination in this study was the product of a positive hallucination and may have more fully absorbed the high-hypnotizable subjects' attention in this visual task, whereas the instruction not to smell anything may have left the high hypnotizables more vulnerable to some experience of the stimulus. Although this may represent differences in design or the effect of hypnotic hallucinations on different sensory systems, what may be measured by both studies is the greater flexibility of high hypnotizables in directing attention toward or away from a given perceptual channel.

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