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155 Hypnosis, Neural Basis

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1. The Domain of Hypnosis

Modern conceptions of hypnosis can be traced directly to the work of Franz Anton Mesmer, a Viennese physician working in Paris just prior to the French Revolution. Within 30 years of Mesmer's work, most of the basic hypnotic phenomena from amnesia to pain control to hallucinations had been reported (see Ellenberger 1970). James Braid, a Scottish surgeon, coined the term hypnosis in the 1840s. Nowadays, hypnosis refers to the acceptance of a social role, usually involving deep relaxation, and engagement in fantasy. During hypnosis a lowering of critical judgement permits a wide range of behavioral, cognitive, and affective responses to suggestion (see, for example, Orne 1970). This article addresses the question of whether response to hypnosis can be related to specific neural mechanisms or events.

During the last two hundred years, a variety of exaggerated and mistaken claims have been made for hypnosis. Claims have ranged from enhanced psychic abilities to past life regression to revived memories of alien abduction. In the past, such claims have resulted in periods of scientific disrepute for hypnosis. Nevertheless, during this century fine scientists (e.g., Hull, Hilgard, Orne, Barber, Sarbin and their students) have been drawn to study hypnosis (see Sheehan & Perry 1976). As well as elucidating the domain of hypnosis, their careful investigations have increased understanding of the potential pitfalls that appear in experimentation with human research participants (see Orne 1959, 1970).

An observer, watching a demonstration of hypnosis with a highly hypnotizable research participant, sees a series of simple verbal suggestions that result in relatively spectacular alterations of behavior, thought, emotion, and perception. For example, the hypnotized burn patient lies quietly and reports no pain, seemingly relaxing while his dressings are changed, a highly painful procedure (Hilgard & Hilgard 1975). The laboratory research participant asked to re-experience the distant past seems to become childlike, entirely captured by the delusion that it is many years earlier. Asked to hallucinate the absence of an obstacle between where the participant sits and some other place, the participant claims to see nothing in the intervening space. But when asked to walk to that place (and thus, through the obstacle whose absence is being hallucinated), the participant walks around the obstacle without seeming to notice doing so. Asked to look back and see that there is nothing there, there is easy agreement with no seeming sense that walking around the obstacle has just contradicted this statement. Asked to forget all that has happened until a pencil is tapped twice, the participant will later "awaken" with amnesia that is (almost always) temporary and reversible.

Thus, in response to brief verbal suggestions, the hypnotized individual seems to see, hear, feel, smell, and taste in apparent contradiction to the stimuli actually present (see Orne & Hammer 1974). Memory, the sense of volition, mood, and even awareness of self may be altered. With appropriate suggestions, such effects may be extended into the posthypnotic period.

Hypnotic phenomena are easy to elicit and robust. A graduate student, given two or three hours training and a standardized script, such as one of the *Stanford Hypnotic Susceptibility Scales*, can elicit all the major hypnotic phenomena in a psychology laboratory (Weitzenhoffer & Hilgard 1959, 1962; see also Shor and E. Orne 1962). There they can be studied under controlled conditions. Note that for all practical purposes, hypnotic suggestions are likely to be carried out only in settings seen as culturally appropriate. These include therapeutic, classroom, entertainment, research, and forensic settings (Orne 1970).

2. Problems with seeking psychophysiological concomitants of hypnosis

People commonly speak of being “hypnotized” or in a hypnotic “trance.” The underlying assumption is that hypnosis is a distinct, altered state of consciousness. Most early theorizing (and much current clinical thought) about the hypnotic state employed circular reasoning that goes something like this - Q: Why do you say that person is hypnotized? A: Because she is responding to hypnotic suggestions. Q: Why does she respond to hypnotic suggestions? A: Because she is hypnotized.

As Orne (1959) showed us, the hypnotized participant acts as shared cultural expectations suggest. In fact, the deeply relaxed hypnotic participant lying or sitting quietly while listening attentively to the hypnotist’s voice manifests only one of many forms hypnosis has assumed. For example, in the late 18th century, Mesmer’s Parisian patients sometimes had pseudo-epileptic seizures during hypnosis. In the late 19th century, Charcot’s Parisian patients demonstrated first catalepsy, then lethargy and finally somnambulism (but generally did not have seizures) when deeply hypnotized. At the same time in the south of France, Bernheim’s hypnotized patients simply restfully reclined (see Ellenberger 1970). Most modern research participants and patients sit quietly and look very relaxed during hypnosis, although they may also be hypnotized with an “active-alert” induction, involving, for example, pedaling a stationary bicycle vigorously (see Banyai & Hilgard 1976).

Obviously, peripheral neural activity during these varying hypnotic activities differs widely, reflecting the activity, not hypnosis. Nor has there been any evidence of brain activity unique to hypnosis *per se*. Nor is there evidence of specific brain activity that accompanies the entire hypnotic experience. After fifty years of modern research, the lack of evidence for any unique psychophysiological marker of a hypnotic trance state is one of the factors that have led researchers to largely abandon the concept of a hypnotic trance as a causal explanation for response to hypnotic suggestions (see Kirsch & Lynn 1995).

Concepts such as response expectancies, role involvement, self-delusion, and cognitive abilities are currently used to explain hypnotic responses. This does not mean that hypnotizing people does not have specifiable effects or that the experiences of highly hypnotizable subjects are consciously faked or otherwise theoretically unimportant. Rather, hypnotic effects result from making suggestions to willing participants of differing abilities and from the expectations and cognitive models that a hypnotic induction engenders both for the hypnotist and the participant (see Sheehan & Perry 1976).

At present, it is clear that the ability to respond to hypnotic suggestions lies largely in the subject (and not in the skill of the hypnotist as was previously held). Reports of being hypnotized or in a trance are seen as reflecting a subjective experience that is one of the many effects of cognitive and emotional set, social and historical setting, and suggestion (see Kirsch & Lynn 1995). And while all subjective experiences must have some neurophysiological substrate, Psychology as a field of study has not reached the point where many can be pinpointed. Nonetheless, if phrased properly, reasonable questions about the psychophysiologic concomitants of hypnosis can be asked.

3. Psychophysiological differences in response to hypnotic induction?

A discussion of the neural basis of hypnosis may be phrased in terms of answers to three questions. First, are there measurable differences in brain activity in response to hypnotic induction among those who subsequently respond strongly to hypnosis in comparison to those who do not? Second, when measured outside hypnosis, are there overall psychophysiologic differences between participants who usually respond to hypnotic suggestions for major changes in perception, memory, and/or cognition and those who do not? Third, are there patterns of brain activity associated with response (vs. lack of response) to specific hypnotic suggestions? While there are interrelated issues among these three questions, it is probably least confusing to look at these questions sequentially.

First, does hypnotic induction result in measurably different neural patterns among those who subsequently respond to the more spectacular hypnotic suggestions (those calling for hallucinatory or major cognitive changes) and those who do not? The evidence, while mixed, favors a tentative "Yes, but for reasons that render the difference unimportant." Brain function studies are divided between those that find highly hypnotizable, well lateralized, right handed research participants shifting to greater relative right hemisphere activation after hypnotic induction and studies that find no differences. The lack of consistent findings may be methodological: studies finding differences tend to use ratio measures that are meant to be sensitive to small differences (see, for example, LaBriola, Karlin & Goldstein 1987). Studies that do not find differences after induction tend to look at absolute values of measures of brain activation, a less sensitive measure (Graffin, Ray & Lundy 1995). So there is some evidence that successful induction of hypnosis often involves a "shift to the right" a finding in line with task performance measures of the effects of induction.

Why is this unimportant? Activation changes in response to induction are relatively small and disappear once other suggestions are made or tasks required. Relative hemispheric activation, with or without hypnosis, depends on the mental task participants are asked to perform. So the "shift to the right" that has been sometimes emerges seemingly reflects a response specific to the "task" of induction. And that response might well change were a different type of induction used (see Crawford & Gruzelier 1992).

4. Psychophysiological differences between highly hypnotizable participants and their less hypnotizable counterparts?

Many studies distinguish between highly hypnotizable subjects and their less hypnotizable peers. Most modern scales of hypnotic responsiveness comprise standardized, relaxation oriented inductions followed by five to twelve hypnotic suggestions that are each scored pass/fail based on an objective criterion. Entire hypnotic scales are often administered by tape recorder and both experimenter scored individual formats and self-scored group formats are available. Total score, the measure of each participant's <u>hypnotizability</u>, is simply number of suggestions passed (see Kihlstrom 1985).

All social scientists use Pearson's reliability coefficient, a coefficient that varies from +1.00 (relative scores on two measures are identical) to 0.00 (no linear relationship between two sets of scores) to –1.00 (relative scores are identical in size but opposite in sign). Hilgard and his colleagues have found that test-retest reliability of hypnotizability scales usually averages about +.90 over periods of one week and about +.70 over periods from 10 to 25 years (Piccione, Hilgard & Zimbardo 1989). These data indicate that hypnotizability is a highly stable difference among individuals. Among personality traits, the reliability of hypnotizability measurement is equaled or exceeded only by multi-task measures of intelligence.

Hypnotizability is not easily modifiable and governs the large majority of the variance in most experimental studies of hypnotic phenomena. Moreover, what has come to be called "hypnotizability" is observable in response to suggested alterations in perception, memory, and/or cognition with or without formal hypnosis (see Kihlstrom 1985).

There are two fairly well established psychophysiologic correlates of hypnotizability. First, highly hypnotizable research participants (highs) show higher levels of resting theta activity than their less hypnotizable counterparts. Spontaneous EEG activity may be viewed as constituted of wave forms of different frequencies (delta - 0 to 3 Hz, theta - 4 to 7 Hz, alpha - 8 to13 Hz, beta - 14 to 30 Hz). Waking EEG records are largely made up of alpha and beta activity, with a small percentage of theta activity. When measured during rest, this small proportion of theta activity is slightly higher among the more highly hypnotizable participants, especially in recordings from the more anterior brain regions. While no convincing explanations for this phenomenon have yet been advanced, the notion that the theta differences between highly hypnotizable participants and their less hypnotizable counterparts are related to attentional abilities is the most popular hypothesis (see Graffin, Ray & Lundy 1995, Sabourin, Cutcomb, Crawford & Pribram 1990).

Second, if a variety of other factors are controlled (e.g., task difficulty, familial history of right handedness), well lateralized, right handed research participants will show greater relative left cerebral hemispheric activation during verbal and mathematical tasks and greater right hemisphere activation during mental imagery. This pattern of task specific hemispheric asymmetry is seen more clearly among highly hypnotizable participants than among their less hypnotizable counterparts. Highs show greater relative left cerebral hemisphere activation during verbal and mathematical tasks than do less hypnotizable participants. Similarly, highs show greater relative right hemisphere activation during imagery than do low or moderately hypnotizable participants. (The inclusion of moderately hypnotizable subjects provides some control for compliance. Moderates show the same level of compliance to behavioral suggestions as the highs, but are largely unresponsive to hallucinatory suggestions.) These findings have been interpreted as showing greater cognitive flexibility for highs and are in line with some findings in studies using task performance measures (see Crawford & Gruzelier 1992).

5. Psychophysiological correlates of response to specific hypnotic suggestions?

The third question is whether psychophysiologic differences can be found between those responding to specific hypnotic suggestions and those who fail to respond. This question can be asked in respect to hypnotic phenomena of central interest to experimental psychologists (e.g., hypnotic hallucinations), clinicians (e.g., healing of skin and immune system related disorders), or both (e.g., hypnotic analgesia).

Until the recent advent of functional magnetic resonance imaging (fMRI), activity in the normal waking human brain has been studied, for the most part, using measures of spontaneous and evoked electrical activity in the brain. Researchers usually utilize one of three electroencephalographic (EEG) technologies in which brain activity is recorded from the surface of the skull using standardized electrode placements. Obtaining EEG signals is similar to making an electrocardiogram except that EEG signals are measured in microvolts rather than millivolts signals studied with an EKG. (Since much greater amplification is required, EEG recording requires great care in avoiding electrical, movement, and other artifacts.)

Once having obtained an artifact free EEG signal, researchers digitize and transform it. Most frequently they use signal processing, mathematical (Fourier) transformations to determine the proportion of time in which alpha, beta, and theta activity occur. Alternatively, one may integrate the total area under the curve of an EEG record and compare total area at various sites in the brain during different tasks. In both methods one examines the signals from many recording periods (usually of 1 second to 10 minute duration) over minutes or hours of total recording time (see Karlin et al. 1980, Perlini & Spanos 1991, Sabourin et al. 1990). Almost all the research underlying the conclusions in the earlier sections of this essay has used one of these two techniques.

A third EEG procedure involves the presentation of brief, repeated auditory, visual, or tactile stimuli to elicit acute changes in electrical brain activity called event-related evoked potentials. Evoked potentials can be seen when the spontaneous EEG, used as data in the first two methods, is mathematically removed and only short term changes in EEG signals remain. The precise shape of evoked potentials differs in relationship to a variety of factors including the duration, intensity, predictability, meaning, and sensory modality of the stimulus. However, when such factors are controlled, one expects a sequence of alternating positive and negative potentials during the second or so after stimulus presentation.

Several studies seemingly indicate that hypnotic suggestions to hallucinate alter evoked potentials among highly hypnotizable participants in ways consistent with their reported hallucinatory experiences. In these studies, highly hypnotizable participants who claim to experience either a particular hallucination or amnesia are compared to less hypnotizable counterparts who do not report similar experiences. Across visual and auditory stimuli and across experiments, highly hypnotizable participants seem to show augmented or faster positive evoked potentials and/or decreased or delayed negative potentials when asked to hallucinate the presence of stimuli that are not there. Again consistent with suggested hallucinations, when asked to hallucinate the absence of stimuli that are present, highly hypnotizable subjects show decreased or delayed positive evoked potentials, and/or augmented or faster negative evoked potentials compared to their less hypnotizable counterparts. Parallel findings to those found in negative hallucinations have emerged after amnesia instructions. In sum, highly hypnotizable participants show brain activity consistent with their reports of hypnotic hallucinations (see Crawford, in press).

Perhaps because it is the most clinically relevant negative hallucination, the effects of hypnotic analgesia instructions, instructions to not experience pain when exposed to a painful stimulus, has been studied with a variety of measures of brain activity. These have included fMRI, cerebral blood flow using 133-xenon, SPECT, and integrated EEG. Such studies confirm the pattern seen in the evoked potential studies: instructions to experience analgesia leads to measurable changes in brain function indicating central amelioration of the painful stimuli among highly hypnotizable participants, but not in lows or moderates (see Crawford in press, Karlin, Morgan & Goldstein 1980).

It is also noteworthy that other studies indicate that hypnotic analgesia is not mediated by endogenous opiate systems (Hilgard & Hilgard 1975).

As to immune system and skin disorders, the positive data remain largely anecdotal. There is a long history of treating skin disorders with hypnosis. (For example, hypnosis is still treatment of choice for warts that do not respond to conventional treatment.) Similarly, asthma may be treated with hypnosis (although there is some evidence that hypnotic effects are limited to relaxation of the upper airways, rather than changes at the level of the lung where oxygen exchange occurs). Finally, there have been a number of studies on the ability of suggestion and imagery to directly alter immune responding. However, findings have been mixed and no clear conclusions can yet be drawn other than that large, robust effects seem unlikely (see Rhue, Lynn & Kirsch 1993).

7. Conclusions

Hypnotic responses remain intriguing, somewhat spectacular effects produced by simple verbal suggestion. During the last 50 years, careful rigorous work has been done to elucidate underlying mechanisms and any psychophysiologic concomitants of these phenomena. Inducing hypnosis *per se* has no clear physiologic effects. However, when compared to their less hypnotizable counterparts, highly hypnotizable subjects show slightly higher levels of theta activity during rest and greater task consistent asymmetry on strongly lateralized cognitive tasks. This is consistent with the notion that highs are capable of more flexible attention than are their less hypnotizable counterparts. Moreover, when successfully engaged in positive and negative hallucinations, including hypnotic analgesia and amnesia, highly hypnotizable subjects show cortical activity consistent with their reported subjective experiences across a number of measures of brain function.

Cross references in this encyclopedia: See also Electroencephalography; Event-related evoked potentials; Amnesia, transient and psychogenic.

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