Direct Current Potentials in Hypnoanalgesia

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Hypnoanalgesia has intrigued and plagued investigators in clinical and experimental hypnosis from the very beginnings of scientific inquiry into the general area of hypnosis. Adequate reviews of the experimental evidence bearing on the validity of the phenomenon have been presented by Weitzenhoffer [12] and Barber.[2] In view of the equivocal results from investigations of hypnoanalgesia and alterations of involuntary physiological correlates of pain, and given the more positive evidence of changes in voluntary function with hypnotic suggestion, Weitzenhoffer has indicated that there is no evidence that the alterations brought about are anything more than functional in nature. Barber, in his development of a theory of pain, has emphasized the role of central psychological, as against peripheral and neurophysiological, factors in the mitigation of discomfort caused by noxious stimuli. He arrives at a formulation in which the salient factor in pain, in terms of discomfort and suffering, is a function of the organism's "readiness to respond" to stimulation. Hypnosis, then, is understood as an interpersonal relationship which can bring about a relative inattention to, and unconcern with, nociceptive stimuli.

The current study is concerned with the more peripheral, and presumably involuntary, manifestations of hypnoanalgesia, as demonstrated in locally determined biophysical correlates, direct current potentials. The findings are compared with the results of local chemical anesthesia which has a direct relationship to peripheral nerve d.c. potential gradients.[5,6,9] Further, inasmuch as occipito-frontal d.c. potentials have been noted to vary with changes in consciousness,[4,7] this study

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TABLE 1.—*Millivolt Changes in Direct Current Potentials*

Subject	Head			Right Arm			Left Arm		
	Waking	Hypnosis	Change	Preanalgesic	Analgesic	Change	Preanalgesic	Analgesic	Change
1	+1.0	+2.0	+1.0	−5.0	0	+5.0	−7.0	−3.0	+4.0
2	+2.0	+5.5	+3.5	−7.5	0	+7.5		a	
3	−5.0	−2.5	+2.5	−14.0	−5.0	+9.0	−5.0	0	+5.0
4	−2.5	+2.5	+5.0	−14.0	−9.0	+5.0	−21.0	−15.0	+6.0
5	0	+3.0	+3.0	−17.0	−5.0	+12.0	−22.0	−10.0	+12.0
6	+5.0	+7.5	+2.5	−6.0	−18.0	−12.0	−16.0	−32.0	−16.0

a Change in positive direction noted but not reported due to questionable electrode contact.

presents for the purpose of comparison, cerebral d.c. gradient changes accompanying hypnosis.

Procedure

Using the standard method of eye fixation with suggestions of relaxation and sleep, 6 clinically normal white male subjects between 22 and 37 years of age were trained as hypnotic subjects. The minimum level of depth was the "light trance" as described in the Davis and Husband scale,[8] to which was added arm levitation and an analgesia which extended from the fingers to the elbow of the right hand. Five of the 6 subjects had less than 3 hours of training time.

Diffused boundary carbon-saline electrodes,[1] providing highly drift-free operation over long periods of time, were placed, by means of rubberized bandages, to determine the cerebral occipitofrontal potential and the bilateral d. c. potential gradients along the brachial plexus and upper extremity nerve trunks. The electrode placements (recording electrode on distal portion of palm of hand, reference electrode over midportion of biceps muscle) followed the rationale elaborated by Becker[3] for a tripartite organization of the living organism's d. c. field pattern rather than the simple cephalocaudal dipole. The subjects reclined on an examining table with wooden arm rests, the head resting on foam rubber pads hollowed out to receive the occipital electrode. Continuous recordings were obtained on an Offner Dynograph Type R recorder with d. c. coupling and an input impedance of 2 megohms.

The subjects were rapidly hypnotized, all having the ability to enter the hypnotic state within a few minutes of a signal. Analgesia of the right arm from the elbow down was induced by simultaneously counting, stroking with a handerchief, and suggestions of numbness, woodenness, lifelessness, and the absence of sensation. The analgesia was maintained until the recording indicated that a stable level of d. c. potential had been achieved. The analgesia was then removed and the subject brought out of hypnosis. To achieve deeper trance, the procedure was repeated after a few minutes. The analgesic arm was tested by pricking with the point of a sharp knife blade. In 2 cases, the subjects were asked, after being brought out of hypnosis, to simulate analgesia in the left arm.

Results

Table 1 presents the amount of change in millivolts for the 3 electrode placements for each subject.* The occipitofrontal changes refer to difference between prehypnotic base-line level and stable hypnotic level prior to suggestions of analgesia. Brief transient changes in head potential, in the negative direction, accompanied the onset of the suggestions of analgesia, but they were never of such a magnitude as to reach the prehypnotic base-line level. Figure 1 shows an example of d.c. potential changes in the occipitofrontal electrodes. Figure 2 demonstrates changes in d.c. potential in both arms during the induction of analgesia.

Table 2 presents the amount of change in millivolts in the arms of 2 of the hypnotic

* For each recording the reported results were adjusted for electrode drift which usually was a fraction of a millivolt.

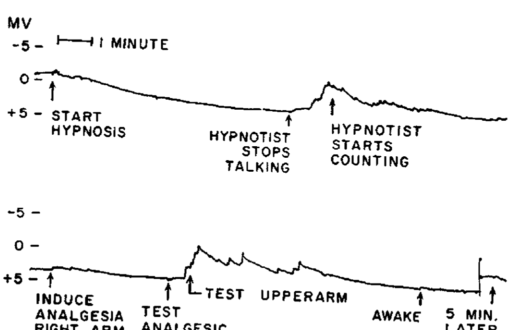

Fig. 1.—Continuous recordings of occipitofrontal d. c. potential during hypnosis. Upper arm test refers to point above elbow line of analgesia on right arm.

TABLE 2.—*Millivolt Changes in Direct Current Potentials with Simulated Analgesia*

Subject	Right Arm			Left Arm		
	Base Line	Suggestion	Change	Base Line	Suggestion	Change
Simulator after hypnosis	— 3.0	— 4.0	— 1.0	— 4.0	— 5.0	— 1.0
Simulator after hypnosis	— 8.0	—10.0	— 2.0	— 8.0	— 8.0	0
Nonhypnotic subject						
Concentration	—18.0	—32.0	—14.0	—22.0	—32.0	—10.0
Muscle tension	—18.0	—24.0	— 6.0	—22.0	—24.0	— 2.0
Simulated analgesia	—20.0	—32.0	—12.0	—22.0	—30.0	— 8.0

subjects when they were brought out of hypnosis and asked to simulate analgesia in the left arm. It also shows the results obtained from a naive nonhypnotic subject who was asked simply to attend to and concentrate upon the sensations in his right hand, to tense his forearm muscles, and then to try

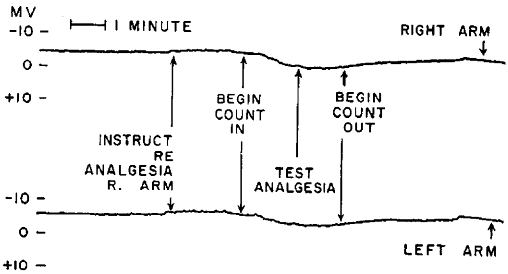

Fig. 2.—Changes in d. c. potentials in arms during hypnoanalgesia.

to experience an analgesia in the right arm comparable to his previous experience of having a limb falling asleep or receiving a procaine hydrochloride (Novocain) injection.

Figure 3 exemplifies the changes in d.c. potential occurring with simulated analgesia in one of the experimental subjects. Figure 4 demonstrates the changes in the nonhypnotic subject.

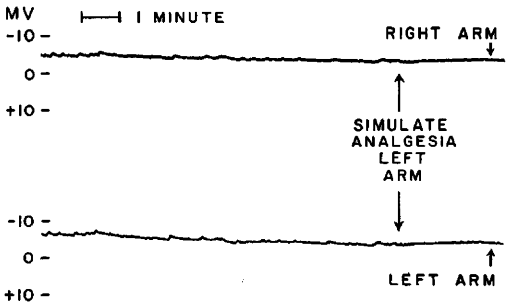

Fig. 3.—Changes in d. c. potentials of arms with simulation of analgesia after hypnosis.

In the cases of simulation and in the nonhypnotic subject, there were no changes in occipitofrontal potentials beyond the small change which occurred with relaxation in every subject during the period of prehypnotic base-line establishment.

Comment

As Table 1 shows, with the induction of hypnosis there is a consistent change in occipitofrontal potential with the frontal electrode going more positive. Ravitz,[10] who has done extensive investigations of d.c. potential correlates of hypnosis, found changes representing either a decrease or increase in potential. However, he apparently did not find any consistency in the direction of change. This may be the result of the difference in electrode placement, for finding no significant results with cephalic bracketing, he used temporal-chest placements. The direction of change of potential (increased positivity frontally) is consistent with findings in states of sleep and general chemical anesthesia in animals and humans,[4,7] although the magnitude of change obtained is less.

The limited range of changes in d.c. potential from 1 to 5 millivolts should be considered

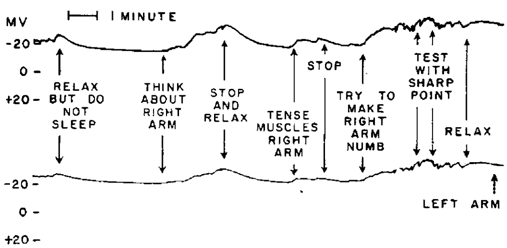

Fig. 4.—Changes in d. c. potentials of arms in nonhypnotic subject.

in the light of the following: (*a*) relatively brief preexperimental hypnotic training in all but one subject, and (*b*) reports, by most subjects, of some discomfort with the occipital electrode. Further investigation is needed to determine whether more careful electrode placement, increased comfort of the subject, and deeper trance states in more intensively trained subjects could increase the change in d.c. potential beyond the maximum of 5 mv. obtained in this study.

Although the present findings cannot delineate with any rigor the nature and extent of involvement of biophysical parameters in the hypnotic state, it would seem most likely that there are consistent measurable bioelectric correlates. Any comprehensive theory of hypnosis would then have to go beyond the purely psychological and encompass within it the alterations in this highly primitive and basic activity of the nervous system. In view of the presence of bioelectric fields in all living organisms, it is possible that the present findings lend some support to those theoretical formulations, as, for example, Schneck's view,[11] in which a phylogenetic psychophysiological variable is the significant basic ingredient in hypnosis.

The findings with regard to the right (analgesic) arm show, with the exception of Subject 6, changes in d.c. potential consistently in a positive direction, i.e., toward the point of zero potential. These alterations are in keeping with observations made of changes in d.c. potential with chemical and traumatically induced anesthesia. Grenell and Burr [9] have demonstrated that local chemical or pressure block of the brachial nerve produced a marked drop in the d.c. potential measured between the hand and the ipsilateral pinna. With these coordinates the hand is negative to the pinna. Becker and Bachman,[7] using electrode placements along the limb axis nerve gradient (reference electrode on upper arm, measuring electrode in palm of hand), have shown similar drops in negativity with procaine or pressure block and also with nerve section in some animal experiments. They noted a crude relationship between the degree of anesthesia and the magnitude of the d.c. potential drop.

As Table 1 reveals, closely parallel changes in d.c. potential in the left arm generally accompanied suggestions of analgesia in the right arm. It is difficult to provide a satisfactory explanation of this phenomenon. In part, this may be due to a generalization of the analgesic experience, for several of the subjects volunteered the information that the numbness suggested seemed to spread beyond the arm involved. Another, and more speculative, explanation is the possibility that the hypnotic subject, in effecting analgesia of an upper extremity, influences in some fashion the entire neural cell mass innervating that limb. In this case the neural mass would be that cellular aggregate at the brachial enlargement of the neural cord which innervates both upper extremities. It is interesting to note, in this connection, that Becker [5] found that brachial plexus nerve sectioning of one limb of the salamander caused a substantial decrease in d.c. field voltage in the contralateral nondenervated limb.

The findings in Subject 6 can best be understood in terms of the records of the hypnotic subjects who simulated analgesia and the nonhypnotic control subject. As seen in Table 2, changes in d.c. potential for these subjects were observed in the arms, but in the opposite direction (increased distal negativity) from those subjects who produced analgesia under hypnosis. The indication, then, is that the hypnotic suggestion of analgesia brings about, or at least is accompanied by, a specific unidirectional change in d.c. potential (decreased distal negativity) which is something more than a manifestation of active attention to, and concern with, a somatic region. When the latter gross function is involved, the distal negativity increases in magnitude. In the case of Subject 6, the findings probably reflect this phenomenon, for he reported that instead of experiencing analgesia, as in preexperimental training, he noted increased sensitivity in his arm.

In general, although this study provides some evidence for the inclusion of d. c. potentials, as peripheral biophysical correlates, among the necessary and sufficient conditions for hypnoanalgesia, it in no way minimizes the role of central psychological and neurophysiological factors in the pain experience. If the d. c. field is conceived of as a primitive and basic data-transmission and control system then it may be possible to find in the results of this study an example of hierarchic control, established with the aid of hypnosis, over a subordinate organic system. As such this could be comprehended within the broader framework of Werner's [13] general developmental theory which describes the essence of all organic development as steadily increasing differentiation and hierarchic integration, the latter function necessarily involving central control over subordinate and otherwise autonomous systems. Although Werner is primarily concerned with the development of mental life, he makes generous and profitable use of biogenetic parallelism in explicating his conceptual framework. He points to the phylogenetic and ontogenetic changes in the central nervous system as a most significant example of such a parallelism. The d. c. field activity of the organism, lending itself to precise measurement, linked as it were to both neurophysiological and psychological functioning, and comprehended within a general developmental law, would then be of considerable heuristic value.

Summary

Cerebral occipitofrontal direct current potentials and bilateral potential gradients along the brachial plexus and upper extremity nerve trunks were recorded from 6 subjects during hypnoanalgesia of the right arm, and from one nonhypnotic subject who successively concentrated upon, tensed, and simulated analgesia in an arm. Two of the hypnotic subjects also simulated analgesia of the left arm in the waking state.

Hypnosis and hypnoanalgesia were accompanied by changes in the d. c. potentials consistently in the positive direction (using measurement correlates as outlined in this paper) demonstrating similarity in direction, though not always in magnitude, to sleep, general and local chemical anesthesia, pressure block, and nerve section. Simulation of analgesia and active focusing of attention on a limb resulted in increased distal negativity of d. c. potential.

The findings point in the direction of inclusion of changes in biophysical correlates, d. c. potentials, among the necessary and sufficient conditions for hypnosis and hypnoanalgesia.

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