Binaural-Beat Induced Theta EEG Activity and Hypnotic Susceptibility

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May 1997

ABSTRACT

Six participants varying in degree of hypnotizability (two lows, two mediums, and two highs) were exposed to three sessions of a binaural-beat sound stimulation protocol designed to enhance theta brainwave activity. The Stanford Hypnotic Susceptibility Scale, Form C (SHSS:C) was used for pre and post-stimulus measures of hypnotic susceptibility. Time-series analysis was used to evaluate anterior theta activity in response to binaural-beat sound stimulation over baseline and stimulus sessions. A protocol designed to increase anterior theta activity resulted in a significant increase in theta measures (% activity) between pre-stimulus baseline and stimulus observations for five of six participants. Hypnotic susceptibility levels remained stable in the high-susceptible group, and increased moderately in the low and medium susceptible groups.

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INTRODUCTION

Differential individual response to hypnosis, has, captured the attention of hypnosis practitioners and researchers since the time of Mesmer, in the late 18th century. Despite the long recognized importance of individual variation in hypnotizability, efforts to modify or increase individual hypnotic susceptibility have proven to be problematic and controversial.

Part of the difficulty in addressing the nature of hypnotizability has been the lack of consensus regarding the basic phenomena of hypnosis. The central issue has been whether observed hypnotic responses are due to an altered stated of consciousness or merely the product of psychosocial factors.

Considering hypnosis as either an altered state or as a purely psychosocial phenomenon served to provide two opposing factions into which most theories of hypnosis could be grouped. Contemporary hypnosis researchers tend to hold less extreme positions, realizing the benefit of a perspective which is comprised of the strengths of both the special-process (i.e., altered state of consciousness) and the social-psychological theoretical domains.

Theoretical Perspectives of Hypnosis

The 1960's witnessed the advent of standardized hypnotic susceptibility measurements. Reliable standardized instruments have been developed for use with groups and individuals. Early work with the electroencephalogram (EEG) designed to identify hypnotic susceptibility also began around this time. More recent EEG / hypnosis research has focused on electrocortical correlates of both the state of, and differential individual response to, hypnosis. The concept of a reliable electrocortical correlate of hypnotic susceptibility draws attention to the recent applications of neurofeedback therapy, which has employed a number of protocols designed for individual brainwave modification. Recent advances in the application of binaural-beat technology and the associated EEG frequency following response, which can be either relaxing or stimulating, have demonstrated efficacy of brainwave modification in areas such as enriched learning, improved sleep, and relaxation (Atwater, 1997). In consideration of recent EEG / hypnosis research along with the recently demonstrated efficacy of EEG neurofeedback training research and the binaural-beat technology applications, it would seem that the lingering question of hypnotizability modification can now be addressed by utilizing brainwave modification within a systematic protocol.

As mentioned earlier, it has often been the case in the past to view the field of hypnosis as being dominated, theoretically, by two opposing camps; the special-process and the social-psychological. In general, the special-process view holds that hypnosis induces a unique state of consciousness; whereas, the social-psychological view maintains that hypnosis is not a distinct physiological state.

Popular authors of the post-Mesmeric period (i.e., mid 19th century), such as James Braid, proposed psychophysiological and sometimes neurophysiological explanations for the hypnotic phenomenon (Sabourin, 1982). In fact, Braid adopted the term "neuro-hypnology" to describe the phenomenon and is credited as the originator of the term "hypnosis" (Bates, 1994, p. 27). The work of other English physicians, such as John Elliotson and James Esdaile, on surgical anesthesia and clinical pain relief in the mid-19th century (Soskis, 1986), are indicative of the psychophysiological zeitgeist of hypnosis in that time. This physiologically-oriented perspective is reflected in Hilgard's neodissociation model (Hilgard, 1986), which suggests that hypnosis involves the activation of hierarchically arranged subsystems of cognitive control. This dissociation of consciousness is clearly manifested in the realm of hypnotically induced analgesia. Hilgard's conception of a "hidden observer" (Hilgard, 1973) as a dissociated part of consciousness, a part that is always aware of nonexperienced pain and can be communicative with the therapist, is exemplified in his description of a hypnotically analgesic individual whose hand and arm were immersed in circulating ice water as follows:

> All the while that she was insisting verbally that she felt no pain in hypnotic analgesia, the dissociated part of herself was reporting through automatic writing that she felt the pain just as in the normal nonhypnotic state. (p. 398)

In Hilgard's model, the hidden observer is the communication of the above described subsystem not available to consciousness during hypnosis. It is reasonable to assume, considering hypnosis research with pain control, that such a dissociative effect of cognitive functioning (i.e., cortical inhibition) would have, as a substrate, some neuropsychophysiological correlate.

Often the social-psychological or social-learning position sees hypnotic behaviors as other complex social behaviors, the result of such factors as ability, attitude, belief, expectancy, attribution, and interpretation of the situation (Krisch & Lynn, 1995). The influence of such variables as learning history and environmental influences are described by Barber (1969). In this influential discourse, Barber presents a framework in which hypnotic responding is related to antecedent stimuli, such as expectations, motivation, definition of the situation, and the experimenter-subject relationship. Diamond (1989) proposed a variation of the social-psychological view which emphasized the cognitive functions associated with the experience of hypnosis, as described in the following:

> It may be most fruitful to think of hypnotizability as a set of cognitive skills rather than a stable trait. Thus, it is conceivable that the so called "insusceptibe" or refractory S [subject] is 'simply less adept at creating, implementing, or utilizing the requisite cognitive skills in hypnotic test situations. Similarly, what makes for a highly responsive or "virtuoso" S may well be precisely the ability or skill to generate those cognitive processes within the context of a unique relationship with a hypnotist. (p. 382)

According to the social-psychological paradigm, an individual's response to hypnosis is related to a disposition toward hypnosis, expectations, and the use of more effective cognitive strategies, not because the individual pos-

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sesses a certain level of hypnotic ability. An important implication of the social psychological or social-learning theory is that an individual's level of hypnotizability can be modified and thus enhanced with systematic strategies to accommodate for individual deficiencies. These two positions can no longer be perceived as a dichotomy, but more accurately as overlapping areas in a Venn diagram. It is not difficult for one to recognize the role of both individual characteristics (i.e., differential neurological activity) and contextual variables (i.e., psychosocial constructs) in measuring and determining the hypnotic response. In other words, the hypnotic response can be viewed as a product of a trance-like state of altered consciousness, which is itself moderated by psychosocial factors such as social influence, personal abilities, and possibly the effects of modification strategies. Such a perspective allows for a more complete investigation of the nature of hypnotic susceptibility by taking into account the relevant issues within each position.

Importance of Individual Differences

In the middle 1960's the focus on hypnotic research was dominated by a trait, or individual difference, approach. The use of standardized hypnotic susceptibility measurements became common. Most practitioners today tend to view hypnotic susceptibility as a relatively stable characteristic that varies across individuals. This view, and the realization of individual variability in the ability to experience hypnosis, are not new ideas, as Mesmer long ago emphasized the individual's receptivity to hypnotic process (Laurence & Perry, 1988). Braid, an English physician during the 19th century, described the remarkable differences of different individuals in the degree of susceptibility to the hypnotic experience (Waite, 1960). The importance of within-individual variability in hypnotic susceptibility is also found in Braid's comments that individuals are affected differently, and that even the same individual could react differently at different times to hypnosis (Waite, 1960). Differential responses to hypnosis were recognized by Freud in his attempts to determine which patients would be the most responsive to hypnotic training. Freud, like others at this time, was unable to identify reliable correlates of hypnotizability. Freud's frustration is reflected in his observation that "We can never tell in advance whether it *VAII* be possible to hypnotize a patient or not, and the only way m have of discovering is by the attempt itself' (Freud, 1966, p. 106). This view is reflected in the methodology of current standardized scales of hypnotizability which use direct measures of hypnotic responses to determine level of hypnotizability.

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Differential treatment outcome, associated with individual differences in the way individuals respond to hypnosis, has been observed by practitioners for centuries. Hypnotic susceptibility may also be a relevant factor in the practice of health psychology / behavioral medicine. Bowers (1979) suggested that hypnotic ability is important in the healing or improvement of various somatic disorders. He has also provided evidence that therapeutic outcomes with psychosomatic disorders "re correlated with hypnotic susceptibility, even Men hypnotic procedures were not employed (Bowers, 1982). Significant relationships have been found between hypnotizability and the reduction of chronic pain, chronic facial pain, headaches, and skin disorders (e.g., warts, chronic urticaria, and atopic eczema) with hypnotic techniques (Brown, 1992). Support for the interaction of negative emotions and hypnotic ability as a mediator of symptoms and disease has also been provided by recent research (Wickramasekera, 1979,1994; Wickramasekera, Pope, & Kolm, 1996). A recent article by Ruzyla-Smith, Barabasz, Barabasz & Warner (1995), measuring the effects of hypnosis on the immune response, found significant increases in B-cells and helper T-cells only for the highly hypnotizable participants in the study. This report not only suggests that hypnosis can modify the activity of components of the immune system, but also highlights the importance of individual variability in response to hypnosis.

In terms of modification of hypnotizability, initial hypnotic susceptibility level may be a factor in the resulting degree of modification. In a paper discussing the issue of hypnotizability modification, Perry (1977) presented a number of studies employing a range of less susceptible individuals for modification training. Overall, the attempts to modify hypnotizability were unsuccessful in these studies. Perry suggested that successful modification tends to be more common in medium susceptible individuals. It may be that the medium susceptible individual, having already demonstrated a certain degree of hypnotic ability, possesses the underlying cognitive framework essential to the hypnotic experience. This line of reasoning could explain the differential responses of low susceptible and medium susceptible individuals to hypnotizability modification training. The high susceptible individual could also prove to be less responsive to modification strategies compared to the medium susceptible individual, as a potential exists for a ceiling effect with the high susceptible individual.

Standardized Measures of Hypnotic Susceptibility

The long observed differences in individual response to hypnosis eventually led to the development of the first viable measures of hypnotizability, the Stanford Hypnotic Susceptibility Scale, Forms A and B (SHSS:A and SHSS:B) by Weitzenhoffer and Hilgard (1959). The introduction of the Stanford Hypnotic Susceptibility Scale, Form C (SHSS:C) by Weitzenhoffer and Hilgard (1962) represented an improved version of the two earlier forms; it was comprised of a greater proportion of more difficult cognitive items. The SHSS:C is still the prevalent measure of hypnotic susceptibility in current use and is often the criterion by which other measures of hypnotizability are evaluated (Perry, Nadon, & Button, 1992). This instrument is essentially an ascending scale which begins with relatively easy hypnotic induction procedures and progressively moves to more difficult trance challenges.

A recent study by Kurtz & Strube (1996), comparing a number of hypnotic measures, described the SHSS:C as the gold standard of susceptibility tests. This study also addressed the idea of using multiple measures of hypnotic susceptibility in order to improve predictive power over using a single administered test. Kurtz & Strube (1996) concluded that the use of multiple measures of susceptibility was not warranted, and that the "rational" choice for a single measure of hypnotic susceptibility would be the SHSS:C.

Research with the EEG and Hypnotic Susceptibility

Brainwaves are the far-field electrical wave patterns set up by neurochemical activity in the living brain. The electroencephalograph (EEG) is an instrument which can measure this activity and determine its strength (higher or lower amplitude) and speed (high or low frequency). Scientists have characterized brainwaves into four broad categories: (a) beta, brainwaves above 13 cycles per second (or hertz), indicative of active consciousness; (b) alpha, a slower brainwave ranging from 8 to l2 hertz, characteristic of a relaxed conscious state of awareness; (c) theta, the next slower waves ranging from 4 to 8 hertz, often associated with dreamlike imagery and deep relaxation; (d) delta, the slowest waves from 0 to 4 hertz which can predominate during dreamless sleep.

The majority of early research with hypnosis shared a common goal: the development of a methodology to determine if, and when, an individual is hypnotized. The majority of early EEG research with hypnosis focused on the state of hypnosis, often attempting to distinguish the state of hypnosis from the state of sleep (Sabourin, 1982). Weitzenhoffer's 1953 review of studies utilizing the EEG with hypnosis concluded that hypnosis is perhaps more akin to light sleep than either deep sleep or the waking state.

A shift occurred in the late 1960's as researchers began investigating possible electrocortical correlates of hypnotic susceptibility using the EEG. The predominant focus in hypnosis research from this time forward was on individual differences rather that the hypnotic state per se. Much of the early research focused on alpha wave indices of hypnotic susceptibility. A review by Dumas (1977) found that no alpha-hypnotizability correlation existed in the general population. Additionally, a recent critical review by Perlini & Spanos (1991) offered little support for an alpha-hypnotizability relationship. Other early studies found greater resting theta wave activity with highly susceptible individuals (Galbraith, London, Leibovitz, Cooper & Hart, 1970; Tebecis, Provins, Farnbach & Pentony, 1975; Akpinar, Ulett, and ltil, 1971). Overall, the comparison of early EEG research proves difficult given the aggregate of technologies and methodologies employed over a span of time characterized by extreme variance in technological development.

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Recent studies have reexamined the relationship between EEG measures and hypnotic susceptibility based on rigorous subject screening and control, along with enhanced recording and analytic techniques. Sabourin, Cutcomb, Crawford, and Pribram (1990) found highly hypnotizable subjects to generate substantially more mean theta power than did low hypnotizable subjects in frontal, central, and occipital derivations during resting non-hypnotic baseline, with largest differences observed in the frontal (F3, F4) locations. According to a review by Crawford and Gruzeiler (1992), theta activity, which is strongly and positively related to hypnotic susceptibility, is the most consistent EEG correlate of hypnotic susceptibility. The results of a recent study by Graffin, Ray & Lundy (1995) indicate that highly hypnotizable subjects demonstrate significantly more theta activity in frontal (F3, F4) and temporal (T3, T4) areas in comparison to low hypnotizable subjects at baseline measures. The studies by Sabourin et al. (1990) and Graffin et al. (1995) are alike in that each employed fast Fourier transformation (FFT) and power spectral analysis of monopolar EEG derivations, which allows for the examination of activity within each component frequency of each EEG epoch.

The position which is most supported in the contemporary literature is a consistent pattern of EEG activity which can differentiate individuals according to standardized hypnotic susceptibility scores. It is suggested that high-susceptible individuals produce more anterior theta activity as compared to low-susceptible individuals. This baseline individual difference is an important neuropsychophysiological indicator of hypnotizability and could prove to be a more stable individual difference measure than standard psychometric measures (Graffin et al., 1995).

<u>Theta Waves and Perceptual Variations</u>

The relationship between theta activity and selective attentional processes lends further support to a coexistent relationship with hypnotizability. The concepts of Class I and Class 11 inhibition have been presented by Vogel, Broverman, & Klaiber (1968). Class I inhibition is described as being correlated with a general inactivity or drowsiness, whereas Class 11 inhibition is related to more efficient and selective attentional processes. The Class 11 concept of slow wave activity is described by Vogel et al. (1968) as "a selective inactivation of particular responses so that a continuing excitatory state becomes directed or patterned (p. 172)". Sabourin et al. (1990) suggested that the theta activity observed in highly hypnotizable subjects reflects involvement in greater absorptive attentional skills. As in the Sabourin et al. (1990) study, Graffin et al. (1995) provide suggestions regarding the selective attentional component of theta: " high hypnotiizables either possess, or can manifest, a heightened state of attentional readiness and concentration of attention" (p. 128). The relationship between greater attentional readiness and frontal theta has also been suggested in psychophysiological studies (Bruneau et al., 1993; Ishihara & Yoshii, 1972; Mizuki et al., 1980). Another possible supportive line of research involves the examination of psychological absorption and hypnotizability relationships. Studies have found absorption to be consistently correlated with hypnotizability (Glisky, Tataryn, Tobias, Kihlstrom, & McConkey, 1991; Nadon, Hoyt, Register, & Kihlstrom, 1991; Tellegen & Atkinson, 1974). In a review of psychological correlates of theta, Schacter (1977) described the relationship between the hypnagogic state and the presence of low voltage theta activity. Green & Green (1977) described the theta state as that of reverie and hypnogogic imagery. They employed theta neurofeedback training to induce quietness of body, emotions, and mind, and to build a bridge between the conscious and unconscious. In describing theta EEG brainwave biofeedback, the Life Sciences Institute of Mind-Body Health (1995) associated increased theta activity with "states of reverie that have been known to creative people of all time" (p. 4).

Considering these findings related to theta activity, a relationship between individual levels of hypnotizability, selective inhibition, hypnogogic reverie, and theta activity is more easily understood. Relatively high theta activity may be indicative of a characteristic brainwave pattern which reflects an underlying cognitive mechanism that relates to a type of selective inhibition and hypnogogic imagery.

<u>Research with Neurofeedback Training</u>

Neurofeedback training works on the brain's ability to produce certain brainwaves the way exercise works to strengthen muscles. EEG biofeedback instruments show the kinds of brainwaves an individual is producing, making it possible for that individual to learn to manipulate the observed brainwaves.

Demonstrated individual success acquiring the ability to self-regulate characteristic brainwave patterns is evident in the neurofeedback literature. Various protocols have been employed by many practitioners to enhance both relaxation (an increase in production of slow waves, such as theta, and a decreased production of fast beta waves) and mental activity (a decrease production of excessive slow wave, such as delta and lower frequency theta; with an increase in the production of 'fast" beta waves). An impressive number of recent studies have demonstrated the efficacy of brainwave neurofeedback training. The work by Peniston and others with individuals with alcohol abuse issues (Peniston & Kulkosky, 1989, 1990, 1991; Saxby and Peniston, 1995) has provided remarkable results. Peniston has shown 13 month follow-up relapse rates of 20% (compared to 80% using conventional medical training), significant reductions in Beck Depression Inventory scores, and decreased levels of beta-endorphin in subjects treated with Alpha-Theta brainwave training. The area of attention deficit hyperactivity disorder (ADHD) has received strong attention from neurofeedback researchers (Barabasz & Barabasz, 1995; Lubar, 1991; Rossiter & Vaque, 1995). Lubar's work has provided strong support for the effectiveness of a protocol designed for Beta-training (16-20 Hz) and Theta inhibition (4-8Hz), with 80% of 250 treated children showing grade point average improvements of 1.5 levels (range 0-3.5) (Lubar, 1991). Objective assessments of the efficacy of neurofeedback training for ADHD have shown significant improvements on the Test of Variables of Attention (T.O.V.A.) scales and Wechsler Intelligence Scale for Children-Revised (WISC-R) IQ scores with subjects who demonstrated significant decreases in theta activity across sessions (Lubar, Swaamod, Swartwood, & O'Donnell, 1995). Additional studies with post-traumatic stress disorder (PTSD) with Vietnam veterans (Peniston, 1990; Peniston & Kulkosky, 1991; Peniston, Marrinan & Deming, 1993) have provided unprecedented results with a condition often very resistant to training with other interventions.

The work by Ochs (1994) with the use of light and sound feedback of EEG frequencies, EEG disentrainment feedback (EDF), is also promising in terms of modification of EEG patterns. However, unlike traditional EEG biofeedback, with Dr. Ochs' device there is no need for the individual to be consciously involved in the process. The visual and auditory stimuli respond to and match the individual's brainwaves and these stimuli are in turn generated by the overall frequency of the individual's brainwaves. The aptitude of this system is the capacity for the clinician to alter the feedback frequencies upward or downward, in effect, providing flexibility into a "set" or "characteristic" brainwave pattern.

The flexibility of individual neurofeedback training is evident in the various approaches designed to intensify certain types of EEG activity either by itself, or to intensify certain types of EEG activity and decrease other types of EEG activity occurring at the same time. Overall, the relatively high number of recent neurofeedback training studies with consistent positive results strongly demonstrate the changes in cognitive and behavioral variables resulting from the alteration of individual brainwave patterns.

Research with Binaural-Beat Sound Stimulation

Binaural-beat stimulation is an important element of a patented auditory guidance system developed by Robert A. Monroe. In fact, Robert Monroe has been granted several patents for applications of psychophysical entrainment via sound patterns in (Atwater, 1997). In the patented process referred to as Hemi-Sync®, individuals are exposed to factors including breathing exercises, guided relaxation, visualizations, and binaural beats. Extensive research within the Monroe Institute of Applied Sciences, which has documented physiological changes associated with Hemi-Sync use, along with consistent reports of thousands of Hemi-Sync users, appears to support the theory that the Hemi-Sync process encourages directed neuropsychophysiological variations (Atwater, 1997).

The underlying premise of the Hemi-Sync process is not unlike that adopted by many EEG neurofeedback therapists, that an individuals' predominant state of consciousness can be reflected as a homeostatic pattern of brain

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activity (i.e., an individual differential bandwidth activity within the EEG spectrum) and can often be resistant to variation. Atwater (1997) reported that practitioners of the Hemi-Sync process have observed a state of hypnagogia or experiences of a kind of mind-awake/body asleep state associated with entrainment of the brain to lower frequencies (delta and theta) and with slightly higher-frequency entrainment associated with hyper suggestive states of consciousness (high theta and low alpha). In line with current EEG research relating to ADHD (see Lubar,1991), Hemi-Sync researchers have noted deep relaxation with entrainment of the brain to lower frequencies and increased mental activity and alertness with higher frequency entrainment. The Monroe Institute has been refining binaural-beat technology for over thirty years and has developed a variety of applications including enriched learning, improved sleep, relaxation, wellness, and expanded mind-consciousness states (Atwater, 1997).

Binaural beat stimulation can be further understood by considering how we detect sound sources in daily life. Incoming frequencies or sounds can be detected by each ear as the wave curves around the skull by detraction. The brain perceives this differential input as being "out of phase", and this waveform phase difference allows for accurate location of sounds. Stated simply, less noise is heard by one ear, and more by the other. The capacity of the brain to detect a waveform phase difference also enables it to perceive binaural beats (Atwater, 1997). The presentation of waveform phase differences (different frequencies), which normally is associated with directional information, can produce a different phenomenon when heard with stereo headphones or speakers. The result of presenting phase differences in this manner is a perceptual integration of the signals; the sensation of a third "beat" frequency (Atwater, 1997). This perception of the binaural-beat is at a frequency that is the difference between the two auditory inputs.

Binaural beats can easily be heard at the low frequencies (<30 Hz) that are characteristic of the EEG spectrum (Austere, 1973). This perception of the binaural-beat is associated with an EEG frequency following response (FFR). This phenomenon is described by Atwater (1997) as EEG activity which corresponds to the fundamental frequency of the stimulus, such as binaural-beat stimulation.

The sensation of auditory binaural beating occurs when two coherent sounds of nearly similar frequencies are presented one to each ear with stereo headphones or speakers. Originating in the brainstem's superior olivary nucleus, the site of contralateral integration of auditory input (Oster, 1973), the audio sensation of binaural beating is neurologically conveyed to the reticular formation (Swann, Bosanko, Cohen, Midgley & Seed, 1982) and the cortex where it can be observed as a frequency-following response with EEG equipment. The word reticular means 'net-like' and the neural reticular formation itself is a large, net-like diffuse area of the brainstem (Anch, et al. 1988). The RAS regulates cortical EEG (Swann et al. 1988) and controls arousal, attention, and awareness - the elements of consciousness itself (Tice & Steinberg, 1989; Empson, 1986). How we interpret, respond, and react to information (internal stimuli, feelings, attitudes, and beliefs as well as external sensory stimuli) is managed by the brain's reticular formation stimulating the thalamus and cortex, and controlling attentiveness and level of arousal (Empson, 1986). Binaural beats can influence ongoing brainwave states by providing information to the brain's reticular activating system (RAS). If internal stimuli, feelings, attitudes, beliefs, and external sensory stimuli are not in conflict with this information, the RAS will alter brainwave states to match the binaural-beat provocation.

A recent study by Foster (1991) was conducted in an effort to determine the effects of alpha-frequency binaural-beat stimulation combined with alpha neurofeedback on alpha-frequency brainwave production. Foster found that the combination of binaural-beat stimulation and alpha neurofeedback produced significantly higher alpha production than that of neurofeedback alone, but that the group which received only binaural-beat stimulation, produced significantly higher alpha production than either group. In a review of three studies directed towards the effects of Hemi-Sync tapes on electrocortical activity, Sadigh (1994) reported increased brainwave activity in the desired direction after virtually minutes of exposure to the Hemi-Sync signals.

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Research to date, therefore, has suggested that the use of the binaural-beat sound applications can contribute to the establishment of prescribed variation in individual psychophysiological homeostatic patterns (brainwave patterns), which can precipitate alterations in cognitive processes. The relationship between individual patterns of cognitive variables and characteristic brainwave patterns affords not only a methodology for change, but also an objective unit for measure of change.

Purpose of the Present Study

The present study was an effort to develop, and to test the efficacy of, techniques designed to increase anterior theta activity and susceptibility to hypnosis as measured by currently employed standardized instruments. Contemporary hypnosis / EEG research studies have found individual electrocortical differences (anterior theta activity) to be reliable predictors of hypnotic susceptibility. Clinicians and researchers within the field of neurofeedback training have also demonstrated the efficacy of prescribed changes in individual EEG patterns and behavioral variables, with a number of medical and psychological disorders. Practitioners and researchers utilizing the binaural-beat technology developed by the Monroe Institute have produced impressive changes in individual EEG patterns. Given the strong support of brainwave modification, and the efficacy of the binaural-beat sound patterns to modify brainwave patterns, it is logical and advantageous to make use of a binaural-beat sound based protocol. Since theta activity is positively related to individual level of hypnotic susceptibility, it follows that the employment of a protocol designed to increase frontal theta activity could also mediate an increase in hypnotic susceptibility. It was proposed that a binaural beat protocol designed to increase anterior theta activity will result in a significant increase in theta measure (% activity), and a related increase in hypnotic susceptibility, as measured by standardized instruments. In consideration of the previous association between hypnotic susceptibility and anterior theta activity, the potential exists for differential increases in theta activity relative to hypnotizability group. The examination of potential differential changes in theta activity relative to initial level of hypnotizability could provide further data supporting the association of theta activity and hypnotic susceptibility.

Research Hypotheses

Hypothesis l. Increases in hypnotic susceptibility, after exposure to binaural-beat sound stimulation protocol, will be observed for all participants from pre to post-measures. The Significant Change Index (SCI) was used to evaluate change between pre and post SHSS:C scores. Graphing was used to provide visual interpretation of individual level of hypnotizability.

Hypothesis 2. Theta activity will increase in all individuals as a result of the binaural beat sound stimulation protocol. The C Statistic was performed on the time series of theta measures across baseline and stimulus sessions for each individual.

Hypothesis 3. Increases in theta activity after exposure to binaural-beat sound stimulation protocol YAII be of greatest significance in individuals in the medium-hypnotizable group. The C Statistic was performed on the time series of theta measures across baseline and stimulus sessions for each individual.

Hypothesis 4. Increases in theta activity after exposure to binaural-beat sound stimulation protocol will be of least significance in individuals in the low hypnotizable groups. The C Statistic was performed on the time series of theta measures across baseline and stimulus sessions for each individual.

METHOD

Participants

Six participants were selected from a pool of Northern Arizona University (NAU) undergraduates who were administered the Stanford Hypnotic Susceptibility Scale, Form C (SHSS:C, Weitzenhoffer & Hilgard, 1962). The six participants were grouped according to varying degrees of hypnotizability (two lows, two mediums, and

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two highs) for participation in the stimulus sessions. The variations in hypnotic susceptibility within each group were minimal, assuring the participants were relatively homogeneous in terms of initial hypnotic susceptibility measures. To reduce the risk of attrition during this study, participants were paid $40.00 each for participation in the study.

Instrument

Stanford Hypnotic Susceptibility Scale, Form C (SHSS:C). Each participant's score on the SHSS:C served as a baseline measure of hypnotic susceptibility. Also, after completion of the three stimulus sessions, raw scores were obtained on the SHSS:C for each participant a second time. The raw scores obtained in this post4reatment evaluation provided an index of each participants' hypnotic susceptibility level after exposure to the binaural-beat stimulus protocol. The following general hypnotizability level designation and raw-score ranges are used with the SHSS:C: (a) low hypnotizable (0-4), (b) medium hypnotizable (5-7), (c) high hypnotizable (8-10), and (d) very-high hypnotizable (1 1-12).

The Kuder-Richardson total scale reliability index, which provides a measure of the degree of consistency of participants' responses, was reported by E. R. Hilgard (1965) as .85, with retest reliability coefficients ranging from .60 to .77 over the range of twelve items on the SHSS: C.

Apparatus

EEG-Recording. The NRS-2D (Lexicor Medical Technology, Inc.) is a miniaturized two channel Electroencephalograph (EEG) system. The device is approximately one inch tall, three inches wide, and six inches long and is connected directly to a 486 computer via the parallel port. It has a built in impedance meter and operates with both BIOLEX (BLX) neurotherapy software and NeuroLex (NLX) EEG acquisition software. The BLX and NLX systems comprise an array of tools including an audio/visual display system, graphing and reporting features, fast Fourier transformation and spectral analysis of complex wave forms, as well as conventional EEG recordings. An artifact inhibit feature stops all recording v,/hen the artifact (e.g., eye movement or other muscle signals) exceeds the selected artifact inhibit amplitude threshold. The computerized system was used to measure participants' theta activity for each 2-second epoch. In the EEG data analysis, fast Fourier transformation was performed, and a power spectrum calculated, for each epoch.

Binaural-Beat Sound Tapes. The audio cassette tapes used in this study were produced by the Monroe Institute specifically for this study. Both a control tape and experimental tape were used in this study. The binaural beats provided in the experimental tape are unique in that they were designed to be complex brain-wave-like patterns rather than simple sine waves. The right-left differences in stereo audio signals on these tapes were assembled in a sequence to produce a dynamic wave pattern (brain-wave-like) as compared to a static, uniform sine wave pattern. Specifically, the experimental tape used in this experiment was produced with a binaural-beat pattern that represents a theta brainwave pattern of high hypnotic susceptibility. The Monroe Institute provided objective data verifying the binaural-beat components imbedded in the experimental tape, both in wave form and frequency spectra formats.

The experimental tape was produced with pink sound and theta binaural beats imbedded in carrier tones. The control tape was produced with pink sound and tones without binaural beats.

Procedures

General. For all participants, informed consent forms were provided. All participants mere debriefed at the completion of the study. All participants, at each stage of the study, were treated according to the ethical guidelines of the American Psychological Association.

Participant EEG Setup. During all sessions earlobes and the forehead electrode sites were cleaned with Ten-20 Abrasive EEG Prep Gel to decrease skin resistance prior to attaching EEG electrodes. Ten-20 EEG conductive

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paste was used as a conduction medium to fill the cups of silver-chloride electrodes. One monopolar EEG derivation was used, located according to the 10-20 system (Jasper, 1958) at FZ; the references were linked ears (R1, R2).

Participant Binaural-Beat Audio Setup. During all sessions participants wore headphones, providing audio input of pink sound and tones (baseline) or pink sound and theta binaural beats imbedded in carrier tones (stimulus).

Multiple Baseline EEG Recordings. The length of pre-stimulus session baseline for participants within each category of hypnotizability varied as follows: the duration of baseline recordings for Participant #1 was 5 minutes, Participant #2 was 10 minutes. For each category of hypnotizability, the two participants were exposed to a baseline session of either 5 or 10 minutes, and three 20 minute stimulus sessions. This procedure allowed participants to be exposed to the same stimulus sessions under "time-lagged" conditions. This approach is the foundation of the Multiple Baseline single-subject experimental design, which allows for examination of changes in stimulus sessions relative to the varied baseline periods.

Theta Measures. EEG measures of percent theta activity at frontal (FZ) placement were recorded during all sessions. Data were recorded at each 2second epoch during EEG recording. These data support trend analysis over time of baseline and stimulus sessions.

Hypnotizability Measures. Pre-stimulus data for level of hypnotizability (SHSS:C scores) were collected for each participant during the selection process. Post-stimulus sessions data for level of hypnotizability (SHSS:C scores) were collected following each participant's last stimulus session.

Baseline Session. During this session participants were given information regarding-. (a) general understanding of theta binaural-beat sound stimulation and (b) the purpose/protocol of stimulus sessions. Prior to recording of EEG data, the experimenter instructed participants to close their eyes and to take two to three minutes to allow themselves to become relaxed. The experimenter instructed the participant to visualize herself as relaxed and comfortable and still, to experience a feeling of inner quietness. This procedure was used to allow the participant's brainwave activity to stabilize prior to baseline recordings.

Binaural-Beat Stimulus sessions. The duration of each session was 20 minutes. Prior to recording of EEG data, the participants were allowed 2-3 minutes for stabilization of brainwave activity as previously described in the baseline session procedures. Prior to exiting the room, the experimenter started the cassette tape, the EEG recording function, and turned off the overhead light, leaving a single table lamp as a source of illumination in the room. The stimulus session was preset to terminate at 20 minutes. Each participant completed three sessions over a period of one week.

Interviews. Following each stimulation session, each participant was asked about her experience. This free-flow interview was used to assess the participants' subjective experience of listening to the binaural-beat sound stimulation, and to test for adverse effects or reactions on the part of each participant.

Schedule of Sessions. The four sessions (1 baseline and 3 stimulus) were completed for each participant in two meetings within a five day period. During the initial meeting, the participants completed the first two stimulus sessions in addition to the baseline session. The sessions were scheduled in this manner to reduce participant response cost and to decrease participant attrition. Participants were allowed to take breaks of approximately 1 0 minutes between each session. The second meeting took place on the second day following the initial meeting. During this second meeting the participants completed the third stimulus session.

Data Analysis

Data were analyzed in order to evaluate changes in theta activity across sessions and changes in hypnotizability levels from pre-stimulus to post-stimulus scale administrations (SHSS:C).

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The EEG data of each 2-second epoch during the baseline sessions were averaged to yield 10 data points for the 5-minute baseline recording and 20 data points for the 1 0-minute baseline recording. The EEG data for each stimulus session was averaged to yield 25 data points for each 20-minute recording.

In an effort to determine if the pretest to posttest change hypnotizability scores on the SHSS:C exceeded that which would be expected on the basis of measurement error, the Significant Change Index (SCI) as suggested by Christensen & Mendoza (1 986) was used. Descriptive techniques (graphical representations) were used to indicate the change in hypnotizability from pre to post-measures.

The C statistic was used to analyze the series of theta activity data across baseline and stimulus sessions. This approach was used to determine if a statistically significant difference existed between baseline and stimulus session observations of theta activity.

When comparing baseline and stimulus sessions observations, the C statistic provides information about changes in the level and direction between the two time series. In the determination of statistical significance of an obtained C value, a Z value is obtained from the ratio of the C value to its standard error of the mean. Graphical representations of the time series of theta activity measures were used to allow confirmation of the statistical findings by visual inspection of the data.

RESULTS

Participant Characteristics

The six participants in this study were female, ranging in age from 19 to 32. In order to facilitate association of each participant with relevant data, the following labels will be used in reference to the participants by hypnotizability group (LOW, MED, HIGH) and by duration of baseline (1 = 5-minute baseline, 2 = 1 0-minute baseline). The three participants (one from each hypnotizability group) with 5-minute baselines are referred to as LOW1, MED1 and HIGH1, the three participants (one from each hypnotizability group) V,/ith 10 minute baselines are referred to as LOW2, MED2, and HIGH2. The majority of participants reported having no previous experience with relaxation-oriented experiences such as hypnosis, meditation, or formal relaxation training.

Test of Hypotheses

Hypothesis 1. *Increases in hypnotic susceptibility, after exposure to binaural-beat sound stimulation protocol, will be observed for all participants from pre to post-measures.* Both participants in the low-susceptibility group (LOW1, LOW2) increased by a raw score of 1 from pre to post-measures. Both of the participants in the medium-susceptibility group (MED1, MED2) increased to the raw score of 8. MED1 increased from a raw score of 6 to a raw score of 8, MED2 increased from a raw score of 7 to a raw score of 8. No changes in raw score values were observed with the participants in the high-susceptibility group (HIGH1, HIGH2) between pre and post-measures. A calculation of the Significant Change Index (SCI) [used to assess pretest to posttest SHSS:C scores considering the standard error of the difference (S_D) between the two test scores: SCI value > 1.65 denotes significance at p<.05] for each participant in the low and medium susceptibility groups revealed the following values: LOW1 - SCI = 1.96, S_D =.51, p< .05; LOW2 - SCI = 1.96, S_D = .51, p< .05, MED1 - SCI = 3.92, S_D = .51, p< .05, MED2 - SCI = 1.96, S_D =.51, p<.05. According to these calculations, a change of .84 or greater in raw-score value was required to establish a significantly different change in hypnotic susceptibility. Therefore, these data suggest that this hypothesis was supported in participants LOW1, LOW2, MED1, and MED2.

Hypothesis 2. *Theta activity will increase in all individuals as a result of the binaural-beat sound protocol.* Evaluation of intersession theta activity relative to baseline theta activity first required an analysis of baseline data to assure stability for subsequent comparison. In the examination of baseline trends of theta activity, the C statistic was calculated for each participant. LOW1 demonstrated no significant trend during the 5-minute baseline session (C = .18**,** n=10, p>.05). LOW2 demonstrated a significant downward trend during the 10-minute baseline session (C =.75, n=20, p<.05). MED1 demonstrated no significant trend during the 5-minute baseline session (C -.20, n=10, p>.05). MED2 demonstrated no significant trend during the 10-minute baseline session (C =.32, n=20, p>.05). HIGH1 demonstrated no significant trend during the 5-minute baseline session (C = -.28, n=10, p>.05). HIGH2 demonstrated no significant trend during the 10-minute baseline session (C = -.07, n=20, p>.05).

In five of six participants, the baseline time series of theta activity data did not show a constant direction or trend, and indicated no departure from random variation. One participant (LOW1) demonstrated a significant downward trend. Therefore, the baseline data for all six participants provided adequate support for subsequent comparisons.

In the examination of trends in theta activity across baseline and the three binaural-beat stimulation sessions, the C statistic was calculated for each participant. LOW1 demonstrated a significant upward trend (C = .36, n=85, p<.01). LOW2 demonstrated a significant upward trend (C =.35, n=95, p<.01). MED1 demonstrated a significant downward trend (C =.74, n=85, p<.01). MED2 demonstrated a significant upward trend (C = .88, n=95, p<.01). HIGH1 demonstrated a significant upward trend (C =.70, n=85, p<.01). HIGH2 demonstrated a significant upward trend (C =.77, n=95, p<.01).

Thus, in five of six participants significant upward intersession trends in theta activity were observed. This significant intersession activity in relation to nonsignificant baseline activity provides support for this hypothesis in five of six participants.

Hypothesis 3. *Increases in theta activity will be of greatest significance in the participants in the medium-hypnotizable group.* An examination of the derived C statistic values for each hypnotic susceptibility group provided data regarding the relative significance of theta activity increases between groups. Mean C values for each susceptibility group (LOW, MED, HIGH) were calculated. The mean value for the medium-hypnotizable group does not include MED1, as this participant demonstrated a decrease in theta activity across stimulus sessions. Therefore, comparing the mean C value for the low and the high susceptible groups with the single C value for the medium susceptibility group which increased, the following values were obtained: LOW (M =.36), MED (M =.88), HIGH (M =.74). This analysis indicates a supportive trend in the data, but without inclusion of participant MED1, it does not provide support for this hypothesis.

Hypothesis 4. *Increases in theta activity will be of least significance in the participants in the low-hypnotizable group.* An examination of the derived C statistic values for each hypnotic susceptibility group provided data regarding the relative significance of theta activity increases between groups. Mean C values for each group of susceptibility (LOW, MED, HIGH) were calculated. The mean value for the medium-hypnotizable group does not include MED1, as this participant demonstrated a decrease in theta activity across stimulus sessions. The mean C values for each group of susceptibility are as follows: LOW (M =.36), MED (M = .88), HIGH (M = .74). Therefore, these data suggest support for this hypothesis.

DISCUSSION

Hypothesis l.

Increases in hypnotic susceptibility, after exposure to binaural-beat sound stimulation protocol, will be observed for all participants from pre to postmeasures. As mentioned earlier, the participants who demonstrated a significant increase in hypnotic susceptibility were Participants LOW1, LOW2, MEDI, and MED2. The participants in the high-hypnotizable group did not change in the measure of hypnotic susceptibility. Graphical analysis allowed for a simplified examination of the changes in hypnotizability levels from the pre to post binaural-beat stimulation administrations.

Inasmuch as no decreases in demonstrated raw-score values were observed across the six participants, these data suggest support of previous data indicating the relatively stable nature of hypnotic ability over time (Perry, Nadon & Button, 1992).

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As previously mentioned, a potential ceiling effect may be present in the SHSS:C. The items on the SHSS:C are presented in a progressively greater difficulty. Data reported by Perry, Nadon & Button (1992) showed that 68% of the normative sample passed the first four items, and only 16% passed the last four items. The items begin relatively easy and become progressively more difficult and therefore are rank-ordered and do not meet interval level requirements. Thus, to accurately interpret of the findings of this study, the progressive organization of the SHSS:C items must be taken into consideration. The obtained changes in the medium-susceptible group may be more meaningful than observed changes in the low-susceptible group, as a change of 1 raw-score point would be a more difficult task in the medium-susceptible group than would a change of 1 raw-score point in the low-susceptible group. This indicates that the application of the Significant Change Index may not reveal the true significance of changes in hypnotic susceptibility with the SHSS:C. The organization of the SHSS:C is also an important factor in the ceiling-effect phenomena observed in the two participants in the high-susceptible group.

<u>Low-Hypnotizable Group</u>. The two participants in the low-hypnotizable group demonstrated modest increases in SHSS:C raw score values. Both participants LOW1 and LOW2 increased 1 raw-score value from 2 to 3. As previously suggested, the lack of initial hypnotic ability in less hypnotizable individuals often leads to unsuccessful attempts at modification of hypnotizability with this population. Although both participants in this group demonstrated only a single point increase in raw-score values on the SHSS:C, a positive increase suggests that modification of hypnotizability % with less susceptible individuals using binaural-beat stimulation can lead to positive results.

<u>Medium-Hypnotizable Group</u>. Considering the previously mentioned hierarchy of difficulty with the SHSS:C, it may be said that the two participants in the medium-hypnotizable group demonstrated the greatest increase in SHSS:C raw score values. Both participants MED1 and MED2 changed in general hypnotizability level from medium to high, with raw-scores of 6 to 8 and 7 to 8, respectively. These data also suggest support for Perry's (1977) findings, in which successful modification of hypnotizability was most common in medium hypnotizable subjects.

These individuals appear to possess a certain essential cognitive framework or a predisposition which provides for a variety of hypnotic experiences, as demonstrated on the SHSS:C.

In relation to the effects of binaural-beat sound stimulation on hypnotic susceptibility, these data reveal mixed conclusions. An interesting point is that Participant MED1 demonstrated the largest increase in hypnotic susceptibility and also a significant decrease in theta activity in response to the binaural-beat sound stimulation. In contrast, Participant MED2 demonstrated the most significant increase in theta activity in response to the binaural-beat sound stimulation. Therefore, these data indicate that theta activity is not the only contributing factor in hypnotic susceptibility, suggest that modification of hypnotizability with medium susceptible individuals using binaural-beat stimulation can be effective, and highlight the importance of individual variation. These data can provide a meaningful direction for researchers and practitioners of hypnosis interested in increasing hypnotic susceptibility.

<u>High-Hypnotizable Group</u>. The two participants in the high-hypnotizable group demonstrated no change in SHSS:C raw-score values. The possibility exists for a ceiling-effect with individuals scoring at the upper end of the SHSS:C scale. Both participants HIGH1 and HIGH2 had the same pre and post raw-scores, 9 and 10, respectively. The items or skills an individual must demonstrate to increase in raw score above 9 are cognitive items of greater difficulty including, negative and positive hallucination tasks. This potential ceiling-effect is also evident in Hilgard's (1965) report on relative item difficulty within the SHSS:C, in which only nine percent of participants in the normative base passed the positive and negative hallucination tasks. These data suggest that those who are high in hypnotizability, in terms of the SHSS:C, may be less responsive to binaural-beat stimulation relative to individuals who demonstrate less hypnotic ability. Perhaps there is a ceiling effect on an individual's ability to produce theta as well.

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Hypothesis 2.

Theta activity will increase in all individuals as a result of the binaural-beat sound protocol This hypothesis was supported in data from five of six participants, each showing an upward intersession trend in theta activity across stimulus periods. The subject in the medium hypnotizable group with the 5-minute baseline (MED1) demonstrated a downward intersession trend in theta activity across stimulus periods. The theta activity of Participant MED1 changed significantly in session-3. No significant change or trend in theta activity was observed for this participant prior to session-3. These data indicate that some confounding factor(s) may have been in effect during the session-3 stimulation/recording period of participant MED1.

In a post-hoc analysis of intersession theta activity, the C statistic was calculated for the five participants who demonstrated a significant increase in theta activity over the three binaural-beat stimulation periods. This analysis was employed to determine which of the three binaural-beat stimulation sessions produced the most significant increase in theta activity relative to the baseline measures. For all five participants, the data from the third stimulation session (session-3) produced C values of the highest significance relative to baseline. These third session C values follow. LOW1 ($C = .49$, $n=35$, $p<.01$), LOW2 ($C = .67$, $n=45$, $p<.01$), MED2 ($C = .89$, $n=45$, $p<.01$), HIGH1 ($C = .62$, $n=35$, $p<.01$**,** HIGH2 ($C = .83$, $n=45$, $p<.01$. These data suggest that continued exposure to binaural-beat stimulation could have an incremental positive effect on theta activity, and that in this study the most significant incremental effect was observed in the third stimulus session.

In a post-hoc analysis of intersession theta activity, the C statistic was calculated for all six participants using the combination of data from session-1 and session-2 relative to data from the baseline session. This comparison was done to further evaluate the initial effects of the binaural-beat sound stimulation. The following C values were revealed: LOW1 ($C = .36$, $n=60$, $p<.01$), LOW2 (C .30, $n=70$, $p<.01$), MED1 (C .11, $n=60$, $p>.05$), MED2 ($C = .74$, $n=70$, $p< .01$), HIGH1 ($C = .18$, $n=60$, $p>.05$), HIGH2 ($C = .36$, $n=70$, $p<.01$). These data suggest that the binaural-beat stimulation effected an initial change (increase) in four of the six participants (LOW1, LOW2, MED2, AND HIGH2).

The two participants who did not demonstrate a significant increase in theta activity during the two initial sessions were MED1 and HIGH1. As mentioned earlier, Participant MED1 demonstrated a significant downward intersession trend across all three sessions, most obvious in session-3. The explanation of this anomalous response is uncertain, but as described in the introductory section on binaural-beat sound stimulation, a number of factors influence the EEG frequency-following response. Factors of primary interest in relation to theta activity are internal feelings, attitudes, beliefs, and overall mood-state. As theta is related to an overall relaxed state, any negative affect related to these factors could adversely affect theta production. Participant HIGH1 also demonstrated the most significant response in session-3. Participant HIGHI reported previous experience with head injury and EEG measurements. This experience involved an automobile accident in which the participant was knocked unconscious some ten years previous. Reported results of EEG at that time indicated an "abnormal" pattern during the sleep state. The relationship of possible brainwave abnormalities to measured theta activity in response to binaural-beat stimulation is not known. However, there is the possibility that the theta response of participant HIGH1 was affected by this head injury.

An additional post-hoc analysis was utilized to provide a precise evaluation of the immediate effect of the binaural-beat sound stimulation within the framework of the Multiple Baseline design. In this analysis, within each susceptibility group, the 1 0-minute baseline recording periods of Participant LOW2, MED2, and HIGH2 were compared to the 5-minute baseline recording periods appended with 5-minutes of the first stimulus session of Participants LOW1, MED1, and HIGH1. As previously stated, the participants within each susceptibility group assigned 10-minute and 5-minute baseline recording periods all demonstrated no significant upward trends in theta activity during baseline recordings. An examination of the initial five-minute stimulation period following the baseline period for the participants assigned the 5-minute baseline % within each susceptibility group

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revealed the following C values; LOW1 (C =.72, n=16, p<.05), MED1 (C =.27, n=16, p>.05), HIGH1 (C = .25, n=16, p>.05). The corresponding Z values for each C value stated above follow. LOW1 (Z = 2.99); MED1 (Z = 1.12); HIGH1 (Z = 1.02). Participant LOW1 demonstrated a significant upward trend during the initial 5-minute stimulus period, and participants MED1 and HIGH1 did not demonstrate a significant trend during the initial 5-minute stimulus period. As mentioned earlier, participants MED1 and HIGH1 did not demonstrate a significant increase in theta activity during the two initial sessions. In contrast, participant LOW1 demonstrated a significant increase in theta activity during all three stimulus sessions. These data highlight the power of individual differences in relation to theta brainwave activity. The observation that the initial recording of stimulus data seemed predictive of a differential theta activity response over time may be particularly important is this analysis. It may be that the significance of an initial theta activity response to binaural-beat sound stimulation is positively related to the significance of the theta activity response over time.

<u>Hypothesis 3.</u>

Increases in theta activity will be of greatest significance in the participants in the medium-hypnotizable group. The obtained unequal number of participants in each group, due to the exclusion of participant MED1 (this participant demonstrated a decrease in theta activity across stimulus sessions), presents difficulties in providing support for this hypothesis.

Participant MED2 demonstrated the highest significant overall increase in theta activity across the baseline and stimulus sessions primarily manifested in session-2 and session-3. Further support for this hypothesis is also indicated in the previously mentioned post-hoc analyses of (a) session-1 and session-2 combined relative to baseline, and (b) session-3 comparison to baseline. In both analyses, participant MED2 demonstrated the highest significant overall increase in theta activity.

<u>Hypothesis 4.</u>

Increases in theta activity will be of least significance in the participants in the low-hypnotizable group, The observed unequal number of participants in each group, due to the exclusion of participant MED1 (this participant demonstrated a decrease in theta activity across stimulus sessions), also presents difficulties in providing support for this hypothesis. Even with this consideration, the observation that both participants LOW1 and LOW2 demonstrated the least significant overall increase in theta activity across the baseline and stimulus sessions suggests support for this hypothesis.

<u>Conclusions</u>

The findings of this study provide support for the efficacy of the binaural-beat sound stimulation process, pioneered by the Monroe Institute, in effecting an increase in theta brainwave activity. As mentioned earlier, the baseline and stimulus tapes differed only in the presence or absence of the binaural-beat stimulation (i.e., both contained pink sound and tones). Each participant demonstrated no significant upward trend in baseline recordings of theta activity. Thus, the observed trends in theta activity following introduction of the binaural-beat sounds allows one to state, with a good deal of certainty, that it is the effect of the binaural-beat sounds and not merely the passage of time, the measurement operation, or some other independent event that effected the observed increases in theta activity. During the post-session interviews, no descriptions of unpleasant experiences were reported, Individual reports of each stimulation session varied from profoundly insightful to pleasant and relaxing.

The single-subject experimental design used in this study allowed for examination of the effects of binaural beat stimulation on individual theta activity over time. With single-subject methodology there is no need to compromise the effects of stimulation on different subjects by averaging across groups as is done with group designs.

The data in this study relative to hypnotizability suggest support for the stability of hypnotic susceptibility over time and suggest support for previous data showing differential response to modification of hypnotizability relative to initial susceptibility level. This support is evident in the fact that no participant decreased in hypnotic susceptibility over time and in the differential participant responses across general hypnotic susceptibility levels. Surprisingly, the most significant increase in hypnotic susceptibility was observed in the participant with the most significant decrease in theta activity in response to the binaural-beat sound stimulation. Even though the significance of the decrease in theta activity for this participant was explained entirely by third session recordings, it is difficult to draw conclusions regarding the relationship of theta activity to hypnotic susceptibility when reviewing the findings of this study. Overall, this study indicates that theta activity is related to, but cannot uniquely explain, the variation in hypnotic susceptibility.

Limitations. Although the single-subject experimental design used in this study provided a direct examination of individual responses over time, the design of this study is not without inherent limitations. For example, as the participants in this study are not representative of the general population, it would be difficult to generalize the findings of this study, even to a similar group of females. It is worth noting, however, that the issue of external validity, which often essentially relates to possible inconsistencies in the data due to small sample sizes, is tempered somewhat in this study by the adequate number of recorded data points within each subject.

The demographic data were collected post-hoc, and thus prevented the homogeneous selection of subjects based on such variables as previous experience with EEG recordings or head-injury. Also, data collected in intersession interviews was not recorded for further analysis. This is unfortunate, as information regarding the subjective experience of binaural-beat stimulation is meaningful not only in and of itself but could have provided data relating to the differential participant theta activity in response to binaural-beat sound stimulation observed in this study.

Future Research.

In future related research with the use of binaural-beat stimulation, the time of exposure could be increased. An increase in exposure time could provide important data relating to modification of theta brainwave activity and hypnotic susceptibility. This could be easily accomplished by using a home-practice protocol, not unlike home-practice relaxation training commonly used in behavioral medicine settings with disorders such as migraine headaches. This type procedure would allow for extended stimulation periods in a true applied setting. Another possible line of research could involve the use of binaural-beat stimulation within background music during hypnotic procedures in an effort to increase participant response to hypnotic susceptibility evaluation measures. The use of "background support" via binaural-beat sound stimulation could also prove a valuable asset to clinical practitioners as well. Data from this study may also provide a foundation for subsequent group comparison designs directed toward the generalization of stimulation effects across larger groups of individuals.

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