American Journal of Clinical Hypnosis
43:1, July 2000

Binaural-Beat Induced Theta EEG Activity and Hypnotic Susceptibility

Brian Brady
Larry Stevens
Northern Arizona University

Six participants varying in degree of hypnotizability (2 lows, 2 mediums, and 2 highs) were exposed to 3 20-minute 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. A time-series analysis was utilized to evaluate anterior theta activity in response to binaural-beat sound stimulation over baseline and stimulus sessions. The protocol designed to increase anterior theta activity resulted in a significant increase in percent theta for 5 of 6 participants. Hypnotic susceptibility levels remained stable in the high-susceptible group and increased significantly in the low and medium-susceptible groups.

Differential individual response to hypnosis has captured the attention of hypnosis practitioners and researchers since the time of Mesmer in the late 18th century. This notion is reflected in the early writings of Mesmer (Laurence & Perry, 1988), Braid (Waite, 1960), and Freud (Freud, 1966) and argues for uniqueness in individual receptivity to hypnosis and relative consistency in hypnotizability within an individual across time. Despite the long-recognized importance of individual variation in hypnotizability, efforts to modify or to increase individual hypnotic susceptibility have proven to be problematic and controversial. Consequently, most practitioners today tend to view hypnotic susceptibility as a relatively stable characteristic that varies across individuals.

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), comprised of a greater proportion of more difficult cognitive items, represented an improved version of the two earlier forms. This instrument is essentially an ascending scale which begins with relatively easy hypnotic induction procedures and progressively moves to more difficult trance challenges. The SHSS:C

This study was conducted as part of a Master of Arts thesis by the first author under the supervision of the second author. Parts of this study were presented by the second author at the 42nd Annual Scientific Meeting and Workshops on Clinical Hypnosis of the American Society of Clinical Hypnosis held in Baltimore, MD, Febrbruary 25-29, 2000. Address correspondence to and request reprints from:
Larry C. Stevens
Department of Psychology
NAU Box 15106
Nothern Arizona University
Flagstaff AZ 86011
Larry.Stevens@nau.edu

continues to be the dominant measure of hypnotic susceptibility and the "gold standard" by which other measures of hypnotizability are evaluated (Kurtz & Strube, 1996; Perry, Nadon, & Button, 1992).

Hypnotic susceptibility is of more than academic or heuristic interest, as susceptibility may be an important factor in the maintenance of health and the prevention and treatment of disease. Bowers (1979) has suggested that hypnotic ability is important in the healing or improvement of various somatic disorders, providing evidence that therapeutic outcomes with psychosomatic disorders are often correlated with hypnotic susceptibility, even when hypnotic procedures are 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) using 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). Ruzyla-Smith, Barabasz, Barabasz and 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 and others not only suggest that hypnosis can modify the activity of components of the immune system, but also highlight the importance of individual variability in response to hypnosis.

With regard to modification of hypnotizability, initial hypnotic susceptibility level may be a factor in the resulting degree of modification. Perry (1977) presented a number of studies employing a range of less susceptible individuals for modification training and, in general, found attempts to modify hypnotizability unsuccessful. However, 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. Additionally, because of a potential ceiling effect with high susceptible individuals, this latter group could also prove to be less responsive to modification strategies compared to the medium susceptible individual.

Perry's original conclusions regarding the stability of individual hypnotic susceptibility across time have been challenged, however, by other researchers. Bowers (1976) reviewed a number of methodologies shown to affect hypnotic susceptibility, including sensory deprivation, biofeedback, psychotomimetic drugs, hypnotic training, personal growth, and natural developmental changes. For example, Barabasz (1982) more than doubled hypnotic susceptibility after prolonged sensory restriction. And following Diamond's (1977) argument for an attitude and skills training approach as an effective way to increase susceptibility, Gorassini and Spanos (1986, 1999) developed the Carleton Skills Training Program and demonstrated that, even with low hypnotizables, directed efforts to secure their cooperation, to elicit role playing of suggested responses, and to promote the construal of presented situations according to suggested stories can produce significant and usually quite large increases in hypnotic susceptibility. It now seems quite clear from this longstanding body of research that individual hypnotic susceptibility can be significantly altered.

Hypnotic Susceptibility and Brainwaves

Early hypnosis and brainwave research focused on alpha (8-12 hertz) brainwave indices of hypnotic susceptibility because of the association of these waveforms with relaxed, meditative, and trance-like states of awareness. This commonsensical relationship notwithstanding, reviews by Dumas (1977) and Perlini & Spanos (1991) found essentially

no alpha-hypnotizability correlation in the general population, even though Dumas' results have been rather convincingly refuted by Barabasz (1983). Early studies also found greater resting theta (4-8 hertz) wave activity with highly susceptible individuals (Akpinar, Ulett, and Itil, 1971; Galbraith, London, Leibovitz, Cooper & Hart, 1970; Tebecis, Provins, Farnbach & Pentony, 1975); however, the comparisons of these earlier EEG studies have proven difficult due to technological and methodological differences.

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 high hypnotizable subjects to generate substantially more mean theta power, in the 4.0 to 7.75 Hz. range, than low hypnotizable subjects during a resting non-hypnotic baseline, with largest differences observed in frontal (F3, F4) locations. The results of a more recent study by Graffin, Ray and Lundy (1995) indicated that highly hypnotizable subjects demonstrate significantly more theta activity (3.91-8.00 Hz.) in frontal (F3, F4) and temporal (T3, T4) areas in comparison to low hypnotizable subjects at baseline measures. According to Crawford and colleagues (Crawford, 1990; Crawford & Gruzeiler, 1992), theta activity, and perhaps more specifically high theta or theta2 in the 5.5 to 7.5 Hz range, not only is strongly and positively related to hypnotic susceptibility, but is the most consistent EEG correlate of hypnotic susceptibility. DePascalis and collaborators (DePascalis & Ray, 1998; DePascalis, Ray, Tranquillo, & Amico, 1998; DePascalis, 1999) have supported these findings of higher, generally frontal, theta power for high versus low hypnotizables, although conflicting results have been obtained (DePascalis, 1999). Additionally, these researchers have explored the contributions to hypnotizability and to hypnosis of a waveband within high beta, the 40-Hz. frequency, theoretically representing "focused arousal" (Sheer, 1976). Although some studies have found the 40-Hz. EEG rhythm to discriminate high and low hypnotizables (Sheer, 1976; DePascalis, 1999), others have indicated the 40-Hz. rhythm as a possible marker of "sensory suggestibility" rather than hypnotic susceptibility per se (DePascalis, Ray, Tranquillo, & Amico, 1998).

Therefore, the position most strongly supported in the contemporary literature is that a consistent pattern of EEG activity (anterior theta waveforms) can be identified which can differentiate individuals on standardized hypnotic susceptibility measures. This baseline individual difference is an important neuro-psychophysiological indicator of hypnotizability and could prove to be a more stable individual difference measure than standard psychometric measures (Graffin, et al., 1995). Furthermore, relatively high theta activity may reflect an underlying cognitive mechanism that relates to a type of selective inhibition of particular cognitive functions (Vogel, Broverman, & Klaiber, 1968), to a focusing of attention onto specific processes (Graffin, et al., 1995; Sabourin, et al., 1990), and to facilitated hypnogogic imagery (Green & Green, 1977; Schacter, 1977). The manipulation of theta brainwave patterns for the improvement of disease status, through such techniques as neurofeedback, is a growing arena of research and clinical practice (Lubar, 1991; Lubar, Swartwood, Swartwood, & O'Donnell, 1995; Ochs, 1994; Peniston, 1990; Peniston & Kulkosky, 1989, 1990, 1991; Peniston, Marrinan, Deming, & Kulkosky, 1993; Saxby & Penniston, 1995).

Manipulation of Brainwave Patterns by Binaural-Beat Sound Stimulation

Binaural-beat stimulation is a critical component of a recently developed brainwave manipulation process which includes breathing exercises, guided relaxation, visualizations, and binaural beats (Atwater, 1995). The phenomenon of a binaural beat occurs when two slightly different waveforms are presented in stereophonic earphones to each ear, with the perception of a third "beat" frequency occurring as the difference between the two auditory

inputs (Atwater, 1995; Oster, 1973). The subjective effect of listening to binaural beats may be relaxing or stimulating, depending on the binaural beat frequencies utilized (Owens & Atwater, 1995). Atwater (1995) has reported that practitioners of this process have observed a state of hypnogogia 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).

Foster (1991) examined the effects of alpha-frequency binaural-beat stimulation combined with alpha neurofeedback on alpha-frequency brainwave production. Results of this study suggested 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 of the effects of binaural beat training on electrocortical activity, Sadigh and Kozicky (1994) reported increased brainwave activity in the desired direction after minutes of exposure to the binaural signals. Recent studies by Atwater (1996) and by Lane, Kasian, Owens, and Marsh (1998) have provided, respectively, evidence of a frequency-following response to a 7 Hertz (theta) binaural beat and direct effects of binaural beats on psychomotor performance and mood.

Research to date, therefore, has suggested that the use of the binaural-beat sound applications can facilitate prescribed variations in individual psychophysiological brainwave patterns, which can then precipitate alterations in cognitive processes. The relationships between these individual patterns of cognitive variation and characteristic brainwave patterns afford not only a methodology for change, but also an objective unit for measurement of change. If theta entraining binaural beats can be utilized to increase theta brainwave production, and if heightened theta activity is characteristic of increased hypnotic susceptibility, then individuals who experience binaural-beat stimulation should also manifest increases in hypnotizability. Such increases in hypnotizability may also be a function of original level of hypnotizability, with medium hypnotizable individuals showing the most dramatic increases. The present study was an effort to test the efficacy of this relatively new methodology designed to increase anterior theta activity and, therefore, susceptibility to hypnosis.

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). Participants were female and ranged in age from 19 to 32 years. The six participants were stratified according to varying degrees of hypnotizability (two lows, two mediums, and two highs) for participation in the stimulus sessions. The variations in hypnotic susceptibility within each group were minimal, assuring that the participants were relatively homogeneous in terms of initial hypnotic susceptibility measures. The following labels were used to reference participants by hypnotizability group (LOW, MED, HIGH) and by duration of baseline (1 = 5-minute baseline, 2 = 10-minute baseline).

Participants reported having had no previous experience with relaxation-oriented experiences such as hypnosis, meditation, or formal relaxation training. All were free of tobacco or drug use and reported only minimal alcohol use (2 times/month or less). To reduce the risk

of attrition, participants were paid for participation in the study.

Instrument

Stanford Hypnotic Susceptibility Scale, Form C (SHSS:C) Each participant's score on the SHSS:C, obtained during a pre-screening process, served as a baseline measure of hypnotic susceptibility. After completion of the third training session, raw scores were obtained on the SHSS:C for each participant a second time. The raw scores obtained in this post-treatment evaluation provided an index of each participant's hypnotic susceptibility level after exposure to the binaural-beat stimulus protocol. The following general hypnotizability level designation and raw-score ranges were 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 (11-12).

Apparatus

EEG-Recording The NRS-2D (Lexicor Medical Technology, Inc., Boulder, Colorado) Electroencephalograph (EEG) was used to measure participants' 4.0-8.0 Hz. theta activity over baseline and stimulus phases. The NRS-2D records EEG data from 2 channels at a sampling rate of 128 Hz. across 2-second epochs at a frequency resolution of 0.5 Hz. Low pass and high pass filters are set at 32 Hz. and 0.5 Hz respectively, with notch filtering factory definable at 60/50 Hz. A built-in impedance meter allows convenient measurement of electrode impedances, with valid results obtained for impedances as high as 20K ohms; for the present study, electrode impedances were held at 10K ohms or less. An artifact inhibit feature stops all recording when the artifact (e.g., eye movement or other muscle signals) exceeds the selected artifact inhibit amplitude threshold. The NRS-2D was supported by a 486DX-2 PC operating with BIOLEX (BLX) neuro-therapy EEG acquisition software, comprising 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. For the EEG data analysis, Fast Fourier Transformation (FFT) was performed and a power spectrum was calculated for each 2-second epoch and integrated across baseline and treatment sessions.

Binaural-Beat Sound Tapes Binaural beats were presented on audio cassette tapes produced by the Monroe Institute (Atwater, 1996) specifically for this study. Both a control tape and an experimental tape were used. The experimental tape was produced with a complex theta brainwave binaural-beat pattern imbedded in carrier tones and pink sound. In order to encourage listener vigilance, carrier tones were changed periodically according to the following sequence: 0-3 minutes, C-Major-7^{th} (292 Hz., 330 Hz., 392 Hz., 466 Hz.); 3-6 minutes, C-Major (292 Hz., 330 Hz., 392 Hz., 523 Hz.); 6-10 minutes, G-Major (196 Hz., 247 Hz., 294 Hz., 392 Hz.); 10-15 minutes, D-Minor (294 Hz., 349 Hz., 440 Hz.); 15-20 minutes, C-Major (292 Hz., 330 Hz., 392 Hz., 523 Hz.). The theta effect for the experimental tape was generated by continuously varying a 7 Hz. left-right frequency difference by plus or minus 1.5 Hz. over a period of 4 seconds; the theta stimulus thus cycled from 5.5 Hz. to 8.5 Hz. and back to 5.5 Hz. over a period of 4 seconds. The control tape was produced with pink sound and the same tones as the experimental tape but without binaural beats, so that the control and experimental tapes were perceptually indistinguishable. Participants were blind as to presentation of control or experimental tapes. During all sessions, participants wore headphones providing either the control tape recording (during baseline) or experimental tape recording (during stimulus presentation).

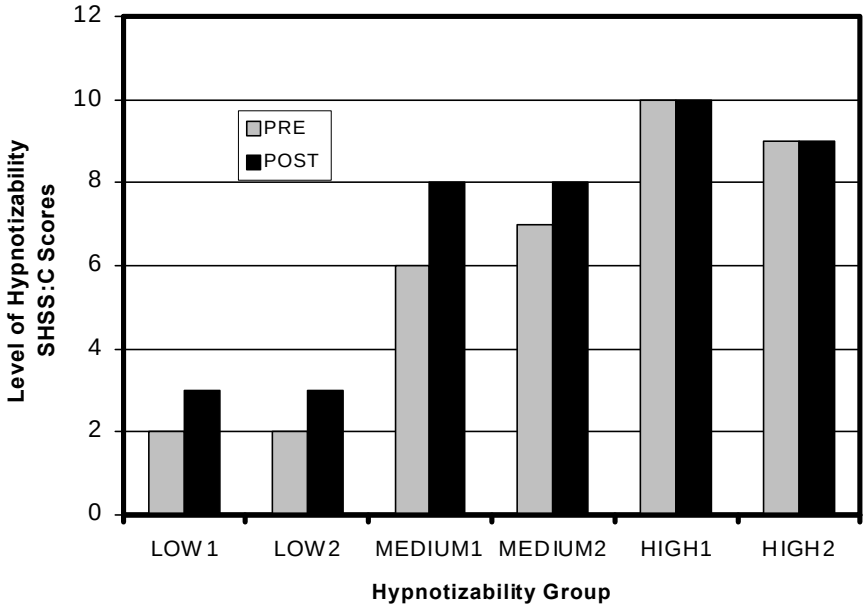
Procedures

Participant EEG Setup During all sessions, earlobes and 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 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[1], 30% of the nasion-inion distance along the longitudinal midline; the references were linked ears, with forehead (Fp) ground.

Multiple Baseline EEG Recordings The length of pre-stimulus session baselines for participants within each category of hypnotizability varied as follows: the duration of baseline recordings for Participant #1 was 5 minutes; Participant #2 baseline was 10 minutes. Each participant was then exposed to a 20-minute stimulus session across three separate training sessions over a period of one week. This procedure allowed participants to experience the same stimulus duration 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. EEG measures of percent theta activity at frontal (FZ) placement were recorded during all sessions.

Prior to baseline recording, all participants were given identical information regarding: (a) general understanding of theta binaural-beat sound stimulation; and (b) the general purpose of stimulus sessions; thus expectancies and demand characteristics were identical across all subjects. In order to allow stabilization of brainwave activity prior to both baseline and

Figure 1: Participant hypnotic susceptibility (scores on SHSS:C) from pre- to post-treatment by hypnotizability group.



[1]A single monopolar site was used in this study because of data recording limitations of the NRS-2D Biolex software. Although the NRS-2D records and reports EEG data averages across a session for two channels, epoch-by-epoch data are only available for analysis on one channel. As F3 and F4 sites have been reported in research to be sensitive to theta frequency changes, a single site between F3 and F4, FZ, was identified for the present study

stimulus recordings, the experimenter instructed participants to close their eyes and to take two to three minutes to allow themselves to become relaxed, to visualize herself as relaxed, comfortable, and still, and to experience a feeling of inner quietness; no formal hypnotic induction occurred. The 5- or 10-minute baseline or 20-minute stimulus session recordings then followed.

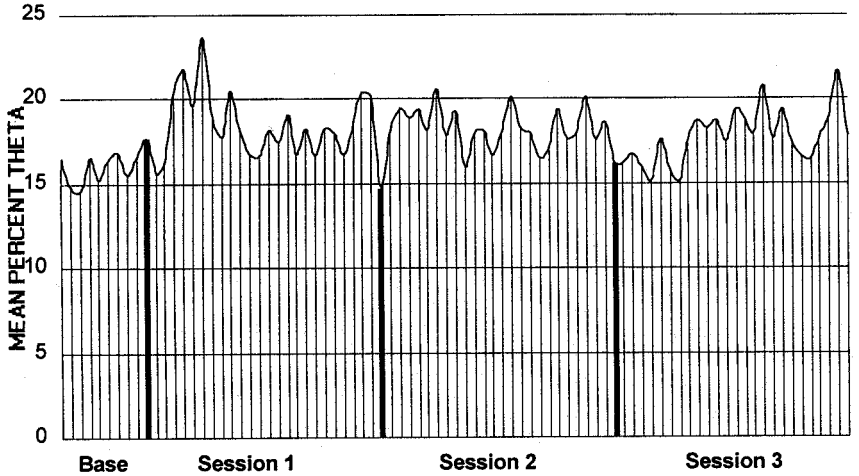
Interviews At the completion of each stimulation session, each participant was asked about her experience. This free-flow "interview" was used to assess the participants' subjective experience of listening to the binaural-beat sound stimulation and to test for possible adverse reactions.

Data Analysis

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 10-minute baseline recording. The EEG data for each stimulus session were averaged to yield 25 data points for each 20-minute recording. The C statistic (Krishef, 1991) 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. For ease of explication and to determine statistical significance, C statistics were converted to Z scores; additionally, data were graphed for visual presentation of results.

In an effort to determine if the pretest to posttest change in hypnotizability scores on the SHSS:C exceeded that which would be expected on the basis of measurement error, the Significant Change Index (SCI)[2], as suggested by Christensen and Mendoza (1986), was

Figure 2: Mean percent theta activity over baseline and three stimulus sessions for Participant LOW1.



[2] The SCI was used to assess SHSS:C score changes over treatment utilizing the standard error of the difference (S_D) between the two test scores: *SCI* value > 1.65 denotes significance at $p<.05$.

Figure 3: Mean percent theta activity over baseline and three stimulus sessions for Participant LOW2.

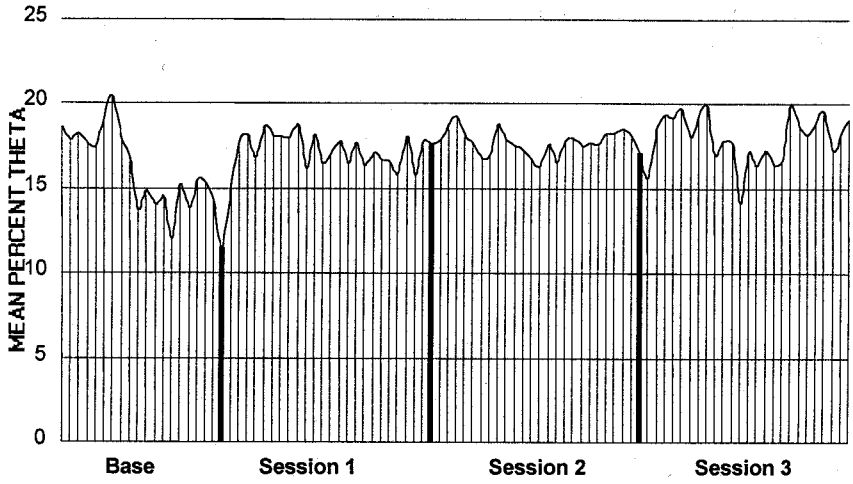


Figure 4: Mean percent theta activity over baseline and three stimulus sessions for Participant MED1.

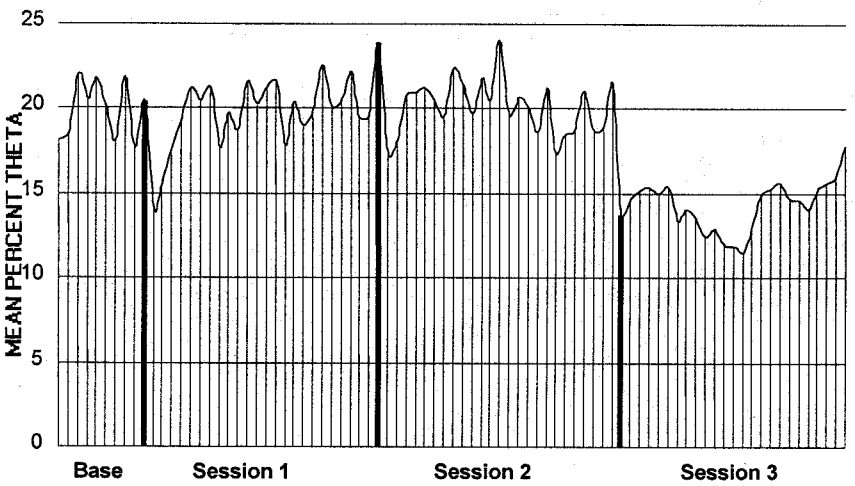


Figure 5: Mean percent theta activity over baseline and three stimulus sessions for Participant MED2.

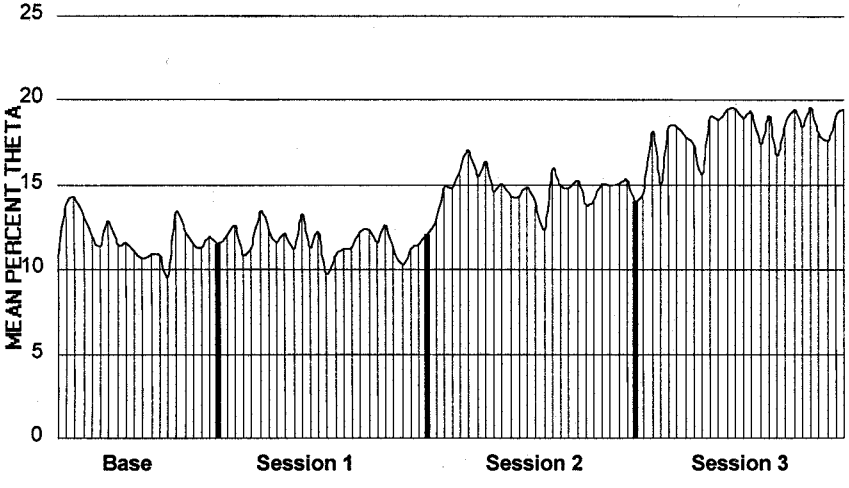


Figure 6: Mean percent theta activity over baseline and three stimulus sessions for Participant HIGH1.

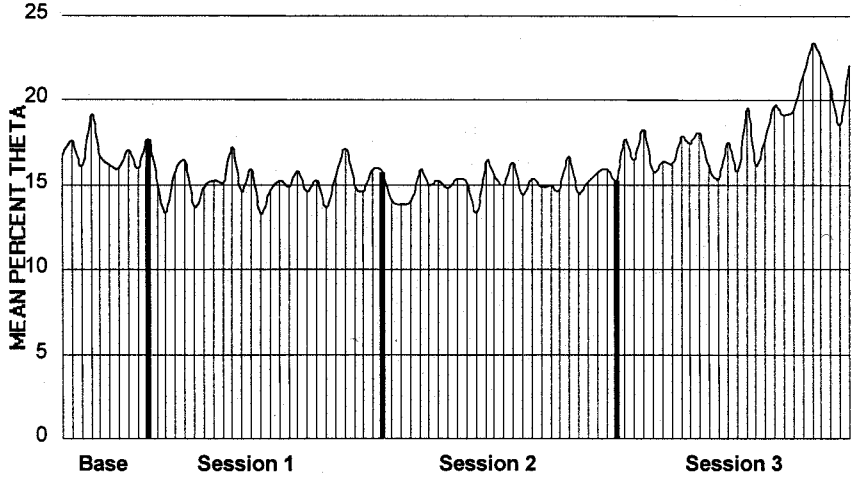
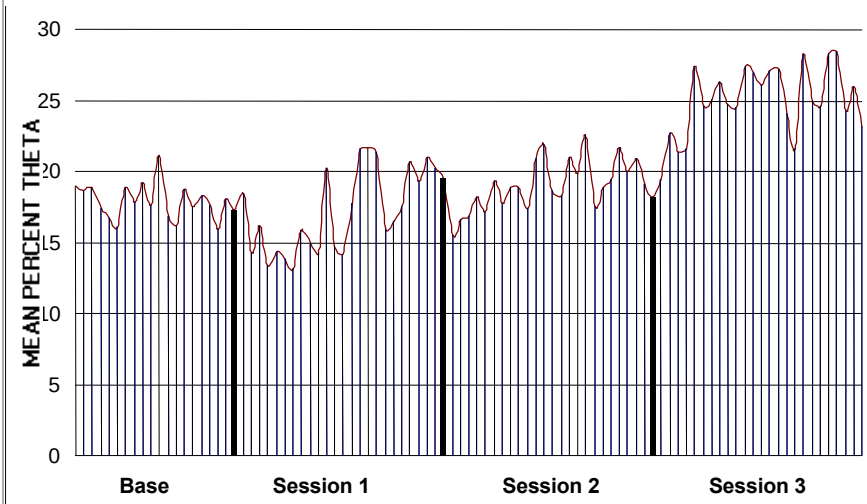


Figure 7: Mean percent theta activity over baseline and three stimulus sessions for Participant HIGH2.



used. Descriptive techniques (graphical representations) were also used to indicate the change in hypnotizability from pre- to post-measures.

Results

Hypothesis 1: Following exposure to binaural-beat sound stimulation, increases in hypnotic susceptibility will be observed for all participants from pre- to post-treatment.

Graphical representations of the changes in participant hypnotic susceptibility (scores on the SHSS:C) from pre- to post-treatment are presented in Figure 1. Both participants in the low-susceptibility group (LOW1, LOW2) increased by a raw score of 1. 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 for the participants in the high-susceptibility group (HIGH1, HIGH2). Calculation of the Significant Change Index (SCI)[2] 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 - $SCI = 1.96$, $S_D = .51$, $p < .05$. These data suggest that low and medium hypnotizable participants in this study did significantly increase hypnotizability scores after exposure to binaural-beat stimulation.

Hypothesis 2: Theta activity will increase in all individuals following binaural-beat stimulation.

Evaluation of intersession theta activity relative to baseline theta activity first required an analysis of baseline data to assure stability of measures by calculation of the C statistic for each participant (Krishef, 1991). Participants LOW1 (C = .18, n = 10, $p > .05$; see Figure 2), MED1 (C = -.20, n = 10, $p > .05$; see Figure 4), MED2 (C = .32, n = 20, $p > .05$; see

Table 1: Intersession theta Z values for each participant.

	S1	S2	S3
LOW1	**2.97****	**2.74****	**3.08****
LOW2	**3.87****	**4.10****	**4.17****
MED1✦	**1.41**	**0.10**	**4.96****
MED2	**1.24**	**4.71****	**5.54****
HIGH1	**1.36**	**1.63**	**3.87****
HIGH2	**3.10****	**2.01***	**5.20****

S1=baseline compared to session1
S2=baseline compared to session2
S3=baseline compared to session3

✦ this participant demonstrated a significant downward trend
* $p < .05$
** $p < .01$

Figure 5), HIGH1 (C = -.28, n = 10, $p > .05$; see Figure 6), and HIGH2 (C = -.07, n = 20, $p > .05$; see Figure 7) demonstrated no significant baseline trends; participant LOW2 (C = .75, n = 20, $p < .05$; see Figure 3) did show a significant downward trend during baseline. Therefore, in five of six participants, the baseline theta time series analysis revealed a stable baseline, suitable for subsequent comparisons. One participant demonstrated a significant downward trend, but as this trend was in the opposite direction from that hypothesized, their data were included in subsequent analyses.

For the examination of trends in theta activity across baseline and the three binaural-beat stimulation sessions, the C statistic was calculated across the entire time series for each participant (Krishef, 1991). Participants LOW1 (C = .36, n = 85, $p <$. 01; see Figure 2), LOW2 (C = .35, n = 95, $p < .01$; see Figure 3), MED2 (C = .88, n = 95, $p < .01$; see Figure 5), HIGH1 (C = .70, n = 85, $p < .01$; see Figure 6), and HIGH2 (C = .77, n = 95, $p < .01$; see Figure 7) demonstrated significant upward trends with binaural-beat stimulation; participant MED1 showed a significant downward trend with treatment (C = .74, n = 85, $p < .01$; see Figure 4). Thus, in five of six participants significant upward intersession trends in theta activity were observed with binaural-beat stimulation.

Hypothesis 3: Increases in theta activity will be of greatest magnitude for the participants in the medium-hypnotizable group and of least magnitude for 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 magnitude of theta activity increases among 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_C = .36, MED M_C = .88, HIGH M_C = .74. This analysis suggests a supportive trend in the data for the medium hypnotizable group; however, without inclusion of participant MED1, the results are difficult to interpret. Referring to the mean C values for each susceptibility group reported above, the data do indicate lower C values for the low hypnotizable group.

Discussion

The results of this study provide preliminary support for the efficacy of a unique approach to increasing hypnotic susceptibility and theta brainwave activity. As the baseline and stimulus conditions differed only in the presence or absence of the binaural-beat stimulation and as each participant demonstrated no significant upward trends in theta activity until the stimulus conditions, the observed trends in theta activity following binaural-beat sound stimulation suggest that binaural-beat stimulation can increase theta activity. Furthermore, participants generally increased hypnotic susceptibility coincident with these increases in theta activity and consistent with predicted changes. During the post-session interviews, no descriptions of unpleasant experiences were reported, with individual reports of each stimulation session varying from "profoundly insightful" to "pleasant and relaxing".

Results also suggest support for the stability of hypnotic susceptibility over time and support for a 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 (See Figure 1).

Although the present study provided for no traditional placebo control group to control for expectancy or demand characteristics, the multiple baseline design, with variable-length baselines, with pink noise plus carrier tones without binaural beats during baselines, and with participants blind to binaural-beat presentation, allowed for demonstration of a binaural-beat theta entrainment effect only during the binaural-beat stimulus-presentation phase of the study with expectancies held stable across all participants. This effect was most apparent for participant LOW1 who showed a remarkable theta increase with onset of binaural-beat stimulation, in comparison with her paired-companion, LOW2, who showed decreased theta during the same phase of study without binaural beats on the control tape.

One observation from this study, which rendered this type of design less dramatic than was anticipated, was the finding of a more gradual acquisition of binaural-beat induced theta entrainment. Thus for four of the participants, LOW2, MED2, HIGH1, and HIGH2, the theta-entrainment effect was gradual and progressive over the three training sessions. In a post-hoc analysis of intersession theta activity, the C statistic was calculated for each participant comparing theta for each stimulus session with baseline theta; these C statistics were then converted into Z-scores for ease of explication. Results of this analysis are presented in Table 1. 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 those participants who showed an increase in theta with training, the data from the third stimulation session produced *C* values of the highest magnitude relative to baseline. These data suggest that continued exposure to binaural-beat stimulation could have an incremental effect on theta activity and that continued training might have produced even greater changes in theta activity as well as in susceptibility.

As noted earlier, the phenomenon of a ceiling effect may explain the lack of an hypnotic

susceptibility change for the high group. Data reported by Perry, Nadon, and Button (1992) showed that 68% of their normative sample passed the first four items, but that only 16% passed the last four items. 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 9% of participants in the normative base passed the positive and negative hallucination tasks. The items on the SHSS:C therefore begin relatively easy and become inconsistently more difficult; they are consequently rank-ordered and do not meet interval level requirements. Thus, to accurately interpret the findings of this study, the progressive organization of the SHSS:C items must be taken into consideration at least on a qualitative basis. The obtained changes in the medium-susceptible group may therefore be more meaningful, and more clinically significant, than observed changes in the low-susceptible group, as a change of one raw-score point would be a more difficult task in the medium-susceptible group than would a change of one raw-score for the low-susceptibles. Consequently, the application of the Significant Change Index, which does not take into consideration this ordinal nature of SHSS:C items, may underestimate the true "clinical" significance of changes in hypnotic susceptibility in this study. (Furthermore, the observed ceiling effect with the SHSS:C may extend to the ability to produce theta as well.) Nonetheless, the results of this study support 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.

With regard to the effects of binaural-beat sound stimulation on hypnotic susceptibility, these data reveal mixed results. An interesting finding was that Participant MED1 demonstrated the largest increase in hypnotic susceptibility but also a significant decrease in theta activity following binaural-beat sound stimulation. In contrast, Participant MED2 demonstrated the largest increase in theta activity but a smaller increase in susceptibility. These data indicate that theta activity may not directly or purely contribute to hypnotic susceptibility, although it is important to note that in this study theta was not differentiated into theta1 or theta2, perhaps diluting important effects of high frequency theta (Crawford, 1990). However, they do suggest a modification of hypnotizability with medium susceptible individuals using binaural-beat stimulation and they highlight the importance of individual variation. Certainly replicated studies with larger groups of individuals differing in susceptibility should clarify this relationship.

In future research with the use of binaural-beat stimulation, the duration of exposure should be increased. An increase in exposure time could provide important clarification of incremental and potential ceiling effects of binaural-beat stimulation on both theta production and hypnotic susceptibility. Such a design modification 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 of procedure would allow for extended stimulation periods in a true applied setting. Another research or clinical application could be the use of binaural-beat stimulation within background music during hypnotic procedures, in an effort to further increase participant hypnotic susceptibility.

References

Akpinar, S., Ulett, G. A., & Itil, T. M. (1971). Hypnotizability predicted by computer

analyzed EEG pattern. *Biological Psychiatry, 3*, 387-392.

Atwater, F. H. (1995). The Monroe Institute's Hemi-Sync Process [On-line]. Available: http://www.monroeinstitute.org/research /hemi-sync-atwater.html.

Atwater, F. H. (1996). *Binaural beats and the frequency-following response: A pilot study.* Unpublished manuscript.

Barabasz, A. F. (1982). Restricted environmental stimulation and the enhancement of hypnotizability: Pain, EEG alpha, skin conductance and temperature responses. *The International Journal of Clinical and Experimental Hypnosis, 30*(2), 147-166.

Barabasz, A. F. (1983). EEG alpha-hypnotizability correlations are not simple covariates of subject self-selection. *Biological Psychology, 17*, 169-172.

Bowers, K. S. (1976). *Hypnosis for the Seriously Curious.* Belmont, California: Wadsworth Publishing Company, Inc.

Bowers, K. S. (1979). Hypnosis and healing. *Australian Journal of Clinical and Experimental Hypnosis, 7*(3), 261-277.

Bowers, K. S. (1982). The relevance of hypnosis for cognitive-behavioral therapy. *Clinical Psychology Review, 2*(1), 67-78.

Brown, D. P. (1992). Clinical hypnosis research since 1986. In E. Fromm & M. Nash (Eds.), *Contemporary Hypnosis Research* (pp. 427-486). New York: Guilford Press.

Christensen, L. & Mendoza, J. (1986). A method of assessing change in a single subject: An alteration of the RC index. *Behavior Therapy, 17*, 305-308.

Crawford, H. J. (1990). Cognitive and psychophysiological correlates of hypnotic responsiveness and hypnosis. In M. L. Fass & D. P. Brown (Eds.), *Creative mastery in hypnosis and hypnoanalysis: A festschrift for Erika Fromm* (pp. 47-54). New York: Plenum Press,

Crawford, H., & Gruzelier, J. (1992). A midstream view of the neuro-psychophysiology of hypnosis: Recent research and future direction. In E. Fromm & M. Nash (Eds.), *Contemporary Hypnosis Research* (pp. 227-266). New York: Guilford Press.

DePascalis, V. (1999). Psychophysiological correlates of hypnosis and hypnotic susceptibility. *The International Journal of Clinical and Experimental Hypnosis, 47*(2), 117-143.

DePascalis, V. & Ray, W. J. (1998). Effects of memory load on event-related patterns of 40-Hz EEG during cognitive and motor tasks. *International Journal of Psychophysiology, 28*, 301-315.

DePascalis, V., Ray, W. J., Tranquillo, I., & Amico, D. D. (1998). EEG activity and heart rate during recall of emotional events in hypnosis: Relationships with hypnotizability and suggestibility. *International Journal of Psychophysiology, 29*, 255-275.

Diamond, M. J. (1977). Hypnotizability is modifiable: An alternative approach. *The International Journal of Clinical and Experimental Hypnosis, 25*(3), 147-166.

Dumas, R. A. (1977). EEG alpha-hypnotizability correlations: A review. *Psychophysiology, 14*, 431-438.

Foster, D.S. (1991). EEG and subjective correlates of alpha-frequency binaural-beat stimulation combined with alpha biofeedback [On-line]. Available: http://www.monroeinstitute.org/research/alpha-binaural-beat.html.

Freud, S. (1966). Hypnosis. In J. Strachery (Ed. and Trans.), *The standard edition of the complete psychological works of Sigmund Freud* (Vol. 1, pp. 103-114).

Galbraith, G. C., London, P., Leibovitz, M. P., Cooper, L. M., & Hart, J. T. (1970). EEG and hypnotic susceptibility. *Journal of Comparative and Physiological Psychology, 72*, 125-131.

Gorassini, D. R. & Spanos, N. P. (1986). A social-cognitive skills approach to the successful modification of hypnotic susceptibility. *Journal of Personality and Social Psychology, 50*(5), 1004-1012.

Gorassini, D. R. & Spanos, N. P. (1999). The Carleton skills training program for modifying hypnotic suggestibility: Original version and variations. In I. Kirsch, A. Capafons, E. Cardena-Buelna, & S. Amigo (Eds.), *Clinical hypnosis and self-regulation* (pp. 141-177). Washington, D. C.: American Psychological Association.

Graffin, N. F., Ray, W. J., Lundy, R. (1995). EEG concomitants of hypnosis and hypnotic susceptibility. *Journal of Abnormal Psychology, 104*(1), 123-131.

Green, E. & Green, A. (1977). *Beyond biofeedback*. New York: Delacorte Press.

Hilgard, E. R. (1965). *Hypnotic susceptibility*. New York: Harcourt, Brace & World.

Jasper, H.H. (1958). Report of the committee on methods of clinical examination in electroencephalography. *Electroencephalography and Clinical Neurophysiology, 10*, 370-375.

Krishef, C. H. (1991). *Fundamental approaches to single subjects design and analysis*. Malabar, Florida: Krieger Publishing Company.

Kurtz, R. M. & Strube, M. J. (1996). Mulitple Susceptibility Testing: Is it Helpful? *American Journal of Clinical Hypnosis, 38*(3), 172-184.

Lane, J.D., Kasian, S.J., Owens, J.E., & Marsh, G.R. (1998). Binaural auditory beats affect vigilance performance and mood. *Physiology and Behavior, 63*(2), 249-252.

Laurence, J. & Perry, C. (1988). *Hypnosis, will, and memory: A psycho-legal history*. New York: Guilford Press.

Lubar, J. F. (1991). Discourse on the development of EEG diagnostics and biofeedback for attention-deficit/hyperactivity disorders. *Biofeedback and Self-Regulation, 10*(8), 201-225.

Lubar, J. F., Swartwood, M. O., Swartwood, J. N., & O'Donnell, P. H. (1995). Evaluation of the effectiveness of EEG neurofeedback training for ADHD in a clinical setting as measured by changes in T.O.V.A. scores, behavioral ratings, and WISC-R performance. *Biofeedback and Self-Regulation, 20*(1), 83-99.

Ochs, L. (1994). New lights on lights, sounds, and the brain. *The Journal of Mind Technology, 11*, 48-52.

Owens, J. E. & Atwater, F. H. (1995). EEG correlates of an induced altered state of

consciousness; “mind awake/body asleep”. Manuscript submitted for publication.

Oster, G. (1973). Auditory beats in the brain. *Scientific American, 229*, 94-102.

Peniston, E. G. (1990). EEG brainwave training as a bio-behavior intervention for Vietnam combat-related PTSD. *The Medical Psychotherapist, 6*(2).

Peniston, E. G. & Kulkosky, P. J. (1989). Alpha-theta brainwave training and beta-endorphin levels in alcoholics. *Alcoholism: Clinical and Experimental Research, 13*, 271-279.

Peniston, E. G. & Kulkosky, P. J. (1990). Alcoholic personality and alpha-theta brainwave training. *Medical Psychotherapy: An International Journal, 3*, 37-55.

Peniston, E. G. & Kulkosky (1991). Alpha-theta brainwave neuro-feedback for Vietnam veterans with combat related post-traumatic stress disorder. *Medical Psychotherapy: An International Journal, 4*, 1-14.

Peniston, E. G., Marrinan, D. A., Deming, W. A. & Kulkosky, P. J. (1993). EEG alpha-theta brainwave synchronization in Vietnam theater veterans with combat-related post-traumatic stress disorder with alcohol abuse. *Advances in Medical Psychotherapy: An International Journal, 6*, 37-50.

Perlini, A. H. & Spanos, N. P. (1991). EEG alpha methodologies and hypnotizability: A critical review. *Psychophysiology, 28*(5), 511-530.

Perry, C. (1977). Is hypnotizabilty modifiable? *The International Journal of Clinical and Experimental Hypnosis, 25*(3), 125-146.

Perry, C., Nadon, R., & Button, J. (1992). The measurement of hypnotic ability. In E. Fromm & M. Nash (Eds.), *Contemporary hypnosis research* (pp. 227-266). New York: Guilford Press.

Ruzyla-Smith, P., Barabasz, A., Barabasz, M. & Warner, D. (1995). Effects of hypnosis on the immune response: B-cells, T-cells, helper and suppressor cells. *American Journal of Clinical Hypnosis, 38*(2), 71-79.

Sabourin, M. E., Cutcomb, S. D., Crawford, H.J., & Pribram, K. (1990). EEG correlates of hypnotic susceptibility and hypnotic trance: Spectral analysis and coherence. *International Journal of Psychophysiology, 10*, 125-142.

Sadigh, M.R. & Kozicky, P.W. (1994). The effects of Hemi-Sync on electrocortical activity: A review of three empirical studies [On-line]. Available: http://www.monroeinstitute.org/research/effects-of-hemi-sync-on-electrocortical-activity.html.

Saxby, E. & Peniston, E. G. (1995). Alpha-theta brainwave neuro-feedback training: An effective training for male and female alcoholics with depressive symptoms. *Journal of Clinical Psychology, 51*(5), 685-693.

Schacter, D. L. (1977). EEG theta waves and psychological phenomena: A review and analysis. *Biological Psychology, 5*, 47-82.

Sheer, D. F. (1976). Focused arousal and 40 Hz EEG. In M. Knights & D. J. Bakker (Eds.), *The neuropsychology of learning disorders* (pp. 71-83). Baltimore: University Park Press.

Tebecis, A. K., Provins, K. A., Farnbach, R. W., & Pentony, P. (1975). Hypnosis and the

EEG: A quantitative investigation. *Journal of Nervous and Mental Disease, 161*, 1-17.

Vogel, W., Broverman, D. M., & Klaiber (1968). EEG and mental abilities. *Electroencephalography and Clinical Neurophysiology, 24*, 166-175.

Waite, A. E.. (1960). *Braid on hypnotism: The beginnings of modern hypnosis*. New York: Julian. (Rev. ed. of Neurohypnology, by J. Braid, 1843).

Weitzenhoffer, A. M. & Hilgard, E. R. (1959). *Stanford Hypnotic Susceptibility Scale, Forms A and B.* Consulting Psychologists Press: Palo Alto, CA.

Weitzenhoffer, A. M. & Hilgard, E. R. (1962). *Stanford Hypnotic Susceptibility Scale, Form C.* Consulting Psychologists Press: Palo Alto, CA.

Wickramasekera, I. (1979). *A model of the patient at high risk for chronic stress related disorders: Do beliefs have biological consequences?* Paper presented at the Annual Convention of the Biofeedback Society of America, San Diego, CA.

Wickramasekera, I. (1994). Psychophysiological and clinical implications of the coincidence of high hypnotic ability and high neuroticism during threat perception in somatization disorders. *American Journal of Clinical Hypnosis, 37*(1), 22-33.

Wickramasekera, I. , Pope, A. T., & Kolm, P. (1996). On the interaction of hypnotizability and negative affect in chronic pain: Implications for the somatization of trauma. *Journal of Nervous and Mental Disease, 184*(10), 628-635.