RELATIONSHIP OF ALPHA-THETA AMPLITUDE CROSSOVER DURING NEUROFEEDBACK TO EMERGENCE OF SPONTANEOUS IMAGERY AND BIOGRAPHICAL MEMORY

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I obtained 182 session graphs from 10 client records from a university-based neurotherapy clinic and from a private practitioner. These graphs were used to examine the relationship of *therapeutic* crossover activity (defined as at least 3 minutes in duration and at least 1µv in amplitude) with and without predetermined amplitude thresholds of beta (15-20Hz) to client reports of imagery and to treatment outcomes. Crosstab analysis revealed that significantly more reports of imagery were observed in the therapeutic crossover with beta condition and that higher amplitudes of slower brainwave activity correlated with progression to deeper states of consciousness. Multi-level modeling revealed a significant interaction between therapeutic crossover activity, higher beta frequency amplitude, and reported salient imagery. Due to small sample size, significance testing was not deemed appropriate. However, observation in change of pre-post scores suggested that individuals who experienced more therapeutic crossover with sufficient beta amplitude conditions had greater improvements on post-test measures (BAI, BDI, BHS, PSQI and MMPI) than those with no or few crossovers. Higher amplitudes of slower brainwave activity correlated with progression to deeper states of consciousness, with delta amplitude positively correlating with transpersonal states.

Reports of imagery and/or biographical memory are much more likely to occur during theta-alpha crossover activity characterized by 3 minutes or more in duration, one microvolt or more in amplitude, and 3.75µv amplitude or more of beta. This defined therapeutic crossover condition does appear to facilitate recall of imagery and memories during alpha-theta neurofeedback and was related to better treatment outcomes.

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This manuscript represents the culmination of a scholarly journey that began early in life for me, in which I embarked on a trajectory of unknown destination. My dissertation marks the end of my academic program, but is only the beginning of future scholarly and professional endeavors. This monumental milestone validates the trust I placed in the process and on the path that has shaped my professional identity.

I would like to first acknowledge my parents, Larry and Cecilia Johnson, who did not impose religious ideology on me, and chose to give me the freedom to make my own decisions about spirituality in my own time, and who continuously supported my academic efforts along the way.

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CHAPTER 1

INTRODUCTION

Alpha-theta brainwave biofeedback (neurofeedback) training is a promising intervention for the treatment of anxiety-based disorders, such as alcoholism and post-traumatic stress disorder (PTSD). Throughout his early research, Dr. Eugene Peniston, developer of this EEG-biofeedback training protocol, identified a theta-over-alpha crossover state that he associated with spontaneous imagery and biographical memories. He believed that this crossover state, which enabled individuals to access and process emotionally-salient material, was important to therapeutic outcomes. Since his initial findings, Peniston's alpha-theta crossover state has been the subject of controversy with discrepant subsequent research findings. This study will attempt to clarify methodological and technical considerations related to clinical phenomena reported during alpha-theta neurofeedback and the relationship of alpha-theta crossovers to clinical outcomes.

The application of alpha-theta brainwave biofeedback (neurofeedback) training to treat a variety of disorders began with research conducted in the 1960s and 1970s. The early pioneers of this training were a small group of individuals who explored self-regulated brain wave activity and its effects on consciousness. This group of researchers included Elmer and Alyce Green (1970, 1977, 1993) Dale Walters (Green, Green & Walters, 1970), and Steven Fahrion (1992, 1995) of the Menninger Institute; as well as Joe Kamiya (1962, 1968, 1969), Barbara Brown (1970, 1974), Lester Fehmi (1978), and Thomas Budzynski (1973). The ground-breaking research of these individuals established the association between electroencephalographic (EEG) changes and changes in states of subjective consciousness. One definition of consciousness, as a subjective experience, may be defined as the monitoring of internal representations (Tassi & Muzet, 2001).

EEG and Brain Activity

An electroencephalograph records the electrical activity along the scalp that is produced by the firing of neurons within the brain. The electrical activity of the human brain was traditionally quantified by electroencephalography into broad aggregate frequency bands that correspond with different states of consciousness (Tansey, Tachiki & Tansey, 1996). These bands (listed from fastest to slowest) include *beta, alpha, theta,* and *delta*. In brief, beta brainwaves are associated with an alert, outward focus of mental concentration; alpha brainwaves are associated with a relaxed, idling state that is disengaged and calm; theta brainwaves are associated with a detached semi-conscious or relaxed state and often correlate with the hypnagogic imagery that occurs between wakefulness and sleep; and delta brainwaves are associated with sleep (Hammond, 2006). To fully appreciate the subjective phenomenology of what occurs in alpha-theta training, it is useful to provide a more in-depth explanation of the frequency bands involved in this training.

Alpha

The origins of lpha/Theta biofeedback training can be traced back to the first known applications of EEG biofeedback in which individuals were trained to identify alpha frequency bursts, and also learned to voluntarily produce the alpha rhythm in the absence of biofeedback (Kamiya, 1962). Alpha is a band of brainwave frequencies comprised of approximately 8-12 hertz (Hz). Hertz (or cycles per second) is a measure of frequency characterized by the number of times a wave cycles in one second. While faster activity is often associated with greater arousal, slower brainwave frequency activity is usually associated with more meditative and subdued states. Subjects trained to produce alpha wave activity identified this (alpha) state with being relaxed and at peace (Kamiya, 1962). Alpha brainwave activity has also been associated with alterations in the perception of time (Wacker, 1996). Loss of the awareness of time and space occurs when one is shifting into a dissociative state of consciousness (Wilson, 1993).

Theta

Theta is a band of brainwave frequencies ranging from approximately 4-8 Hz. Theta is usually associated with liminal states of consciousness often accompanied by hypnagogic (leading to sleep) or hypnapompic (waking from sleep) imagery (Brown, 1974). Hypnagogic imagery was described by Frederick Myers (1903) as being a spontaneous projection of impulses from unconscious sources (Brown, 1974) and has thus been associated with creativity and spontaneous imagery states.

It was these associations with relaxation, creativity and emergent imagery that led some to speculate that alpha-theta training might promote insight and be a useful method for augmenting psychotherapy (Budzynski, 1973). In fact, it was while experiencing hypnagogic imagery during a Menninger EEG biofeedback workshop that Veteran's Administration Psychologist, Eugene Peniston envisioned his successful protocol for treating alcoholism and post-traumatic stress disorder (PTSD) (Green, 1993).

Alpha-Theta Protocol Effectiveness

Alpha-theta neurofeedback training is a form of "deep states" training (Demos, 2005) that has been applied to alcohol abuse (Peniston & Kulkosky, 1989; Peniston & Kulkosky, 1990; Saxby & Peniston, 1995), post-traumatic stress disorder (PTSD) (Peniston & Kulkosky, 1991), and more recently to performance enhancement (Gruzelier & Egner, 2005), and personal growth (Boynton, 2001). There is considerable evidence to support the foundation, uses, and efficacy of Alpha/Theta training. Replication studies have yielded similarly promising findings (Callaway & Bodenhamer-Davis, 2009; Sokhadze, Cannon & Trudeau, 2008). The guidelines for evaluation of clinical efficacy of psychophysiological interventions (LaVaque et al., 2002) are accepted by both International Society of Neurofeedback and Research (ISNR) and Association of Applied Psychophysiology and Biofeedback (AAPB). In addition, they are consistent with American Psychological Association (APA) Division 12 guidelines for defining empirically-validated treatment. According to these guidelines, Alpha-theta training (combined with inpatient rehabilitative treatment for alcoholism), has been classified as Level 3 – probably efficacious, meaning the treatment method has been shown to be effective in "multiple observational studies, clinical studies, wait-list control studies, and within subject and between subject replication studies" (Yucha & Montgomery, 2008; Chambless, 1995; Chambless & Hollon, 1998; Sokhadze, Cannon & Trudeau, 2008). Alpha-theta training can thus be considered an "evidence-informed" treatment in which emerging evidence can be taken into account to inform practice (Bohart, 2005). Hirshberg (2005) noted the benefits of giving weight to the informal knowledge base shared among clinicians to guide the evaluation of new treatment modalities. Current trends towards translational research paradigms suggest the need to examine the utility of emerging research on the neurobiological basis for stress and addiction being generated by advanced neuroimaging technologies.

Neurophysiological Correlates of Addiction and PTSD

The clinical utility and effectiveness of Alpha-Theta training was first demonstrated with military veterans treated for alcoholism. Earlier EEG research showed that the EEG (eyes closed condition) of alcoholics show a deficiency of alpha activity (Pollock, Valavka, Mednick, & Goodwin, 1983) and may be indicative of a predisposition to develop alcoholism. Consumption of alcohol by non-alcoholic individuals has been shown to increase alpha activity (Pollock et al., 1983, Egner, Strawson & Gruzelier, 2002; Ehlers & Shuckit, 1991) and to normalize the EEG (Bauer, 1992).

In addition to decreased alpha activity, chronic alcoholics tend to exhibit more low voltage (amplitude), fast (higher frequency, i.e. beta) activity in their EEGs (Winterer, Kloppel, Heinz, Ziller, Dufeu, Schmidt, & Hermann, 1998; Ehlers and Shuckit, 1990), which has been correlated with over-arousal, tension and anxiety (Ehlers & Shuckit, 1990). A familial history of alcoholism correlates with increased high beta brainwave activity (Winterer et al., 1998; Ehlers and Shuckit, 1990). The state of hyper-arousal many alcoholics experience likely contributes to the craving and relapse associated with the desire to relieve this chronic state of tension (Byers, 1992). Gabriella, Mednick, Volvka, Pollack, Shulsinger & Ith (1982) suggested that "one might speculate that alcohol may be used by the alcoholic to escape from an uncomfortable state associated with fast brain activity" (p. 406). Individuals who are highly susceptible to the stress-alleviating effects of alcohol pose a higher risk for alcoholism. A study by Bauer & Hesselbrock (1992) showed that subjects' heart rate responses to stress attenuated after consumption of alcohol.

These findings in the EEG literature seem to fit well with a theory of alcoholism that is based on cybernetics. The cybernetics theory of alcoholism (Bateson, 1971) proposed that if an alcoholic's sober life somehow drove him to drink, then efforts to help that person maintain sobriety will not likely reduce his alcohol consumption tendencies. The intoxicated state somehow corrects the problem of over-arousal. In fact, maintaining sobriety "at all costs" will sustain the flawed over-aroused state that perpetuated the need to drink in the first place. There is evidence to support this notion. For example, in Peniston's study, the control group (that did not receive alpha-theta training) experienced an increase in levels of stress hormones called beta endorphins, possibly indicating increased stress related to their recent abstinence during hospitalization (Peniston & Kulkosky, 1989). Thus, alcoholism may be a secondary symptom to the primary symptom of central nervous system over-arousal/anxiety marked neurologically by decreased slow frequency and increased high frequency brainwave activity. The aim of alpha-theta training with alcoholics has been to increase slow wave activity via EEG-biofeedback to normalize brain activity by correcting the slow wave activity deficit. Research indicates alpha-theta neurofeedback training may also be an appropriate treatment for alcoholics who are abstinent but still experiencing stress-induced cravings and the fear associated with the risk of relapse (Fahrion, Walters, Coyne, & Allen, 1992).

PTSD

Following Peniston's successful clinical application of using alpha-theta neurofeedback therapy to treat alcoholism, he subsequently applied alpha-theta treatment to post-traumatic stress disorder (PTSD). Quantitative electroencephalographic assessment of combat veterans with PTSD showed decreased alpha activity and increased beta activity (Jokic-Begic & Begic, 2003).

The Peniston Protocol

In his application of alpha-theta brainwave training to alcohol addiction, Peniston developed a protocol in which all subjects in the experimental condition were briefly introduced to the concept of EEG biofeedback training and instructed on how to interpret the auditory feedback sounds. Subjects sat in comfortable recliner chairs with their eyes closed and received eight 30 minute pre-training sessions of temperature biofeedback-assisted autogenic training in which the goal was to increase their hand temperature to 95° Fahrenheit or more, to stimulate the theta EEG state. Subjects also received fifteen 30 minute EEG biofeedback sessions 5 times a week for 28 days. The researcher instructed the subjects to close their eyes, visualize alcohol rejection scenes, imagine increased alpha-theta activity, and visualize the normalization of their emotions and behaviors. They were then instructed to "sink down," keep their mind quiet and alert, and their body calm. The final command given encouraged the client to "do it." The temperature pre-training and visualization script were the added features that separated Peniston's approach from the approach of earlier researchers (Sokhadze, Cannon & Trudeau, 2008)

Peniston's Research

Peniston initially introduced his alpha-theta brainwave training protocol and subsequently measured beta-endorphin (stress hormone) levels with a group of 20 in-patient alcoholic subjects (Peniston & Kulkosky, 1989, 1990) in a Veteran's Administration (VA) Hospital. The results of this study revealed that the 10 alcoholics in the control group who received the standard VA Hospital alcoholism treatment displayed significantly higher levels of beta-endorphins upon treatment completion compared to their pre-treatment levels and/or compared to levels of the experimental brainwave training group or of a non-alcoholic control group. This finding indicates that subjects who receive traditional medical treatment for alcoholism may end up in a state of unrelieved stress once treatment is complete. Peniston's study demonstrated that alpha-theta brainwave training effectively reduced self-rated depression scores (using Beck Depression Inventory) and relapse rates in their 10 experimental alcoholic subjects. Furthermore, significant increases of alpha and theta brainwave amplitudes were quantified in this group. Eight of the 10 were totally abstinent 13 months following completion of treatment, while 8 of the 10 controls had relapsed.

After their initial reports on alcohol addiction, Peniston and Kulkosky (1991) reported the effects of alpha-theta neurofeedback training on Vietnam War veterans who had combat-related post-traumatic stress disorder (PTSD) in addition to substance abuse. All 14 experimental subjects showed a variety of positive changes on post-treatment clinical personality (Minnesota Multiphasic Personality Inventory) (MMPI) measures. All alpha-theta trained subjects who were initially medicated, successfully reduced their medication dosages and only three out of the fifteen alpha-theta treated subjects relapsed. In comparison, only one out of thirteen of the traditional care subjects reduced medication dosage, and all fourteen of the traditional care subjects relapsed within 13 weeks (Peniston and Kulkosky, 1991).

Similarly impressive results have since been achieved in a much larger study with a polysubstance abuse inpatient population (*n* = 121) in which 77% of the experimental group (*n* = 55), who received a combination of beta (15-18 Hz) and SMR (12-14 Hz) brainwave training followed by an alpha-theta protocol, remained abstinent from substance use at 12 months compared to 44% of the control group (*n* = 48) (Scott, Kaiser, Othmer, and Sideroff, 2005). This study approximated Peniston's 80% abstinence rates in his pioneering studies.

Peniston concluded from his initial studies that alpha-theta brainwave neurofeedback training could be effective for treating stress-related disorders, including alcoholism. A follow-up study revealed that veterans who received alpha-theta brainwave neurofeedback training reported a significant reduction in previously recurrent anxiety provoking flashbacks and nightmare activity as well as significant reductions in their need to use psychotropic medications for PTSD-related symptoms (Peniston and Kulkosky, 1991).

Theta-Alpha Amplitude Crossover

The purpose of alpha-theta neurofeedback training is to facilitate a deeply relaxed state that is similar to meditative or other altered states of consciousness, and to reduce central nervous system arousal. As with all forms of biofeedback, these training objectives are achieved via a process of computer-facilitated operant conditioning. The therapist sets thresholds for feedback on selected EEG brainwave measures of the specified alpha and theta frequency bandwidths, and arranges feedback rewards for increased production of these frequencies. In the eyes closed, relaxed state, the EEG shows highly rhythmic alpha waves that subside as drowsiness increases. As alpha activity declines, theta and delta waves become the dominant frequencies. In some cases, theta amplitude may temporarily rise above alpha activity without the aforementioned, concurrent decline in alpha amplitude. Regardless, when theta becomes dominant over the alpha activity, an amplitude *crossover* condition exists that Eugene Peniston (1995) originally termed an *alpha-theta crossover*. However, a more accurate term for this EEG phenomenon would be *theta-alpha crossover*, since theta amplitude rises temporarily over that of the alpha amplitude during this condition. Consequently, for the remainder of this paper, the term *theta-alpha crossover* is used. This crossover correlates with a mind state that is generally unconscious to the individual experiencing it (Egner, Strawson & Gruzelier, 2002). An example of a theta-alpha amplitude crossover in its strictest definition is exemplified as Figure 1.

Spontaneous Imagery and Biographical Memories

Spontaneous imagery and biographical memories have been a subject of interest in research related to both ordinary and non-ordinary states of consciousness. Tinnin (1990) hypothesized that normal states of consciousness occur when dynamic brain processes generate a sense of mental unity. The loss of this sense of mental unity might cause one to experience a dissociated or altered state of consciousness. Altered states of consciousness may be spontaneously occurring (i.e. – hypnagogic states), physically or physiologically induced (i.e., respiratory maneuvers), psychologically induced (i.e., biofeedback), disease induced (i.e., coma), or pharmacologically induced (not reviewed) (Vaitl, 2005). Spontaneous occurrences of altered states of consciousness, such as hypnagogic states, are known to onset along the wake-drowsiness-sleep continuum (Vaitl et al., 2005). During hypnagogic states, 86% of reported occurrences were visual, 8% were acoustic, and other sensory modalities accounted for the remaining 6% (Vaitl, et al., 2005). The average recall rate reported was 35%. Schacter (1976) described the hypnagogic state as a period between wakefulness and sleep in which spontaneous visual, auditory, or acoustic imagery may occur, possibly in conjunction with symbolic material representative of ongoing psychological or physiological processes. Freud (1910) used the term repression to refer to an individual's unconscious efforts (resistance) to prevent the emergence of emotionally painful memories from entering into conscious awareness. Thus, repression involves a disruption in the flow of emotional energy. An abreaction occurs when the continuation of energy is facilitated again. The American Psychiatric Association (1980) defined abreaction as "an emotional release or discharge after recalling a painful experience that has been repressed because it was consciously intolerable. A therapeutic effect sometimes occurs through partial discharge or desensitization of the painful emotions and increased insight" (p. 1). Anxiety provoking imagery is often associated with the memory of a past trauma or aversive situation (Hirsch & Holmes, 2007). Research in the field of cognitive psychology has demonstrated that imagery has a greater impact on negatively valenced events than verbal processing does for the same material (Holmes & Mathews, 2005). Hirsch and Holmes (2007) note that, "as imagery appears to have a special impact on emotion, it would appear to be an important cognitive process to target in therapy" (p. 162). Bluck and Habermas (2000) construed autobiographical memories as memories that have emotional or motivational significance to that person's life. "Improvement in PTSD symptoms was significantly associated with improved retrieval of specific memories" (Sutherland & Bryant, 2007; p. 2915)

Neurophysiological Correlates

The theta-alpha crossover state may be a unique consciousness state that defies classification in traditional categories such as meditation, lucid dreaming, or dreaming. However, in order to examine the possible mechanisms of action that may be involved in the emergence of imagery and/or memory during theta-alpha crossover states, it may prove beneficial to explore the neurophysiological correlates of state change and recall mechanisms along the continuum of alterations of consciousness.

Neurophysiological Correlates of Meditation

Peniston (1999) conceptualized his alpha-theta neurofeedback protocol as "an EEG-based relaxation therapy" (p. 158), which would be similar categorically to other relaxation therapies, including meditation. Early research showed that individuals who could learn to consciously control their brainwaves and produce alpha reported subjective experiences that closely resembled descriptions provided by those who practiced Zen and yoga meditation (Kamiya, 1968). Kamiya also found that experienced Zen meditators learned to self-regulate their alpha brainwave activity more rapidly than non-experienced meditators. It has been suggested that increased alpha brainwave production is related to the ability to access the kinds of phenomena that are associated with altered states of consciousness, which can include a distorted perception of time (Wacker, 1996). However, theta, rather than alpha, has been reported to be the more reliable marker associated with central nervous system de-arousal (Jacobs & Friedman, 2004), as well as the specific change in brainwave spectral activity associated with the practice of meditation (Ivanoski & Malhi, 2007). Ivanoski (2007) reported the finding that "theta activity strongly related to level of experience of meditation" (p. 76). Kamiya (1968) similarly had reported that trains of theta brainwave activity were produced by mystics who had practiced Zen meditation for twenty years or more. While neurophysiological correlates of meditative altered states of consciousness have not yet been firmly established, the main findings implicate increased amplitude activity in both theta and alpha frequency bands, in conjunction with decreased overall frequency (Cahn & Polich, 2006). Other research has shown that meditation increases upper band theta power and lower band alpha power (Takahashi, Murata, Hamada, Omori, Kosaka, Kikuchi, Yoshida & Wada, 2004). As such, it is plausible that a person experienced in meditation may respond more successfully to alpha-theta training compared to someone who is not experienced in meditation. Research has also shown parallels between relaxed states, hypnagogic states, and Stage 1 sleep (Jacobs and Friedman, 2004).

Neurophysiological Correlates of Lucid Dreaming

Alpha-theta neurofeedback training has been compared to lucid dreaming, a dream state in which the dreamer becomes consciously aware that he or she is dreaming, which warrants investigation of the research literature on lucid dreaming and the mechanism for bringing dream activity into conscious awareness. The main distinction that has been found between lucid dreaming and non-lucid dreaming is increased beta (13-19 Hz) activity seen in lucid dreaming in the parietal region with the greatest increase at P3 in the left parietal region (Holzinger, LaBerge, & Levitan, 2006). Taylor (1999) has suggested that the parietal region is a site essential to conscious brain activity, which supported Holzinger et al. findings that increased beta in the parietal region was a physiological correlate of conscious activity (2006). This also supports Maddock's (1999) research implicating the left posterior caudal region of the cingulate cortex located behind the occipital lobe and visual cortex regions of the brain, possibly at the 01 site as a location important to the retrieval of autobiographical memories.

Neurophysiological Correlates of Dream Recall

The theta-alpha state is one that has been characterized as a twilight state (Budzynski, 1973) associated with the hypnagogia that occurs while progressing from wakefulness into Stage 1 sleep. During alpha-theta training, the presence of high amplitude alpha waves gradually decreases, which has been associated with the onset of Stage 1 sleep (Fuller, 2006) and conducive to the emergence of hypnagogic reverie. Alpha-theta training is designed to promote this limenous state bordering wake and sleep that would normally be unconscious to the individual. Since research questions in this proposed study concern both the emergence as well as the retention of imagery and memories, it seems plausible that neurophysiological correlates of memory retrieval and recall from either wake or sleep research could account for the occurrence of imagery/memory emergence and retention resulting from the theta-alpha crossover phenomenon. Since alpha-theta neurofeedback training facilitates the kind of hypnagogic activity that occurs in states bordering on sleep stages, it may be relevant to consider research regarding the neurophysiological mechanisms of dream recall related to various stages along the wake-sleep continuum.

A study on the classification of waking, sleep onset, and deep sleep (Susmakova and Krakovska, 2007) revealed that the best discriminator between a wakeful state and Stage 1 light sleep (the stage associated with alpha-theta hypnagogia) was the power ratio of theta to alpha. The investigation reported that EEG activity in the 2-7 Hz range displayed the highest amplitude during Stage 1 sleep, while alpha activity constituted less than 50% of overall EEG activity in a sleep recording epoch (Susmakova and Krakovska, 2007). Therefore, in distinguishing the sleep/awake state in an EEG record, it is not just what frequency activity is present, but what percentage and ratio of frequency is observed. This supports one hypothesis (of this study) that the amount of theta amplitude increase in the theta-alpha crossover is an important determinant of whether or not imagery or memories will emerge.

Further along the wake-sleep continuum, dreaming has not been found to be specific to any one stage of sleep, and stages that include lower amplitude fast (beta) activity were found to be more likely to contain vivid story-like imagery than stages characterized only by higher amplitude slow (theta and delta) brainwave activity (Williamson, Csima, Galin & Mamelak, 1986). The mental activity, characterized by the presence of beta frequency brainwave activity, was equally likely to occur in any stage of sleep and considered to be a more thought-like function of cortical arousal (Williamson, Csima, Galin & Mamelak 1986). Williamson conducted research in which he used the Dreamlike Fantasy (DF) scale to rate subjects' reports of no recall, thinking, imagery, or dream activity and explored differences in the EEG power spectrum analysis based on the DF level reported in relation to Stage 2, Stage 4, and REM sleep activity. Williamson and colleagues cited Itil (1970), who also associated the superimposition of fast frequency brainwave activity on slower states of activity as representing a functional stage-shift that might explain dream recall. The premise of the functional stage-shift model is that the more closely the EEG pattern in any stage of sleep resembles patterns observed during wakefulness, the more likely one is to recall the mental activity that occurred therein. Williamson's study supported this contention and concluded that higher amplitudes in the beta band were correlated with increased dream recall (Williamson, Csima, Galin & Mamelak, 1984).

Moffett, Hoffman, Wells, Armitage, Pigeau, and Shearer (1981) conducted research on dream recall when subjects were aroused from different stages of sleep. In both REM sleep and Stage 2 sleep, beta activity was correlated with successful recall and longer reports of dream activity. Greater average beta power correlated with better dream quality characterized by enhanced color, vividness, activity, and the number of people and scenes the subject recalled. This was true for high recallers and low recallers. However, differences in beta activity were observed in relation to which hemisphere and in which stage of sleep the beta activity occurred. Low recall of dreams has also been associated with greater endorsement of repression based on Minnesota multiphasic personality inventory (MMPI) responses (Tart, 1962; Williamson, Heckel & Boblitt, 2006).

Relationship of Delta Brainwave Activity to Deeper States of Consciousness

Delta brainwave activity (0-3 Hz) has traditionally been associated with sleep, early infancy stages, and neurological pathology (Alper, 1999). Delta activity also positively correlates with P300 evoked responses to unexpected stimuli as a correlate of cognitive and attentional processes. Research indicates that delta activity may serve to inhibit irrelevant neural activity in order to increase one's attention to internal processing (Harmony, Fernandez, Silva, Bernal, Diaz-Comas, Reyes, Marosi, Rodriguez & Rodriguez, 1996). Alpert (1999) states that "delta in normal awake humans can apparently be a correlate of the process of allocating attention and limiting access of extraneous stimuli during states in which the cortex is processing its own output" (p. 212). There is evidence that the presence of delta brainwave activity might be associated with cognitive processes, which includes abstract reasoning (Alper, 1999). Increased delta amplitude has been associated with peak euphoric experiences (Alper, 1999). Increased amplitude in delta and theta bands has also been associated with transformations in conscious experience that could involve insight, creativity, problem-solving, or mystical experience (Don, 1977). Delta activity also has been demonstrated to occur during transpersonal experiences and transpersonal changes in consciousness (Wilson, 1994; Sagi, 2003). An EEG study revealed a pattern of increased delta, theta and alpha amplitudes among an experienced group of transcendental meditation practitioners during subjectively reported higher states of consciousness during sleep (Mason, 1997).

Alpha-Theta and Beta

Theta-over-alpha amplitude crossover has been associated with a hypnagogic state in which spontaneous imagery as well as the recovery of repressed personal memories may occur (Green, Green, and Walters, 1970) and is thought to represent a state of consciousness in which the individual may access hypnagogic imagery representative of issues in that individual's life.

Peniston noted that over the course of alpha-theta neurofeedback treatment, as the patient learns to increase alpha and theta amplitudes in his EEG, he may eventually access a "window of opportunity," indicated by the specific crossover pattern in the EEG, in which emotionally charged, anxiety-provoking imagery can emerge and be associated with subsequent abreactive and integrative processes. In this newly acquired state of consciousness, some subjects are able to transfer accessed images to a more wakeful state for deliberate processing. Peniston, Marrinan & Deming (1993) noted, "these images, or the memories, can then be retrieved while in a normal beta-alpha state or conscious mode" (p. 39). Peniston et al. (1993) cited Horowitz (1970) who posited that "increased theta *and beta* rhythms reflect a brain process which enables the patient to remember and/or relive the traumatic anxiety provoking event" [and] "further postulated that the healing process (self-awareness) is manifested in high amplitude beta and theta waves in conjunction with the aforementioned cross-over patterns of alpha and theta waves" (emphasis added; p. 46). Peniston believed that this particular combination of frequency bandwidth interactions enabled the patient to harness the necessary cognitive state to process his anxiety-provoking imageries. In a subsequent report of an additional replication study, Saxby & Peniston (1995) also observed that "there were significant increases in the theta *and beta*, but not the alpha wave amplitudes in the abreactive session compared to pre-treatment measures" (emphasis added; p. 45). Dr. Peniston believed that much of the therapeutic benefit of this treatment came from an emergence of significant biographical memories and insights during or following these brainwave crossover experiences. He believed that once evoked, the vivid re-experiencing or re-living of these repressed events via abreactive imagery afforded the individual the opportunity to constructively process and resolve negative psychological and/or physiological symptoms associated with such events. Peniston, Marrinan, & Deming (1993) suggested that the emergence of these abreactive imageries and/or memories should be the target and goal of alpha-theta training. Paradoxically, Peniston later expressed uncertainty as to why the results of alpha-theta training were beneficial (Peniston, 1998).

Theories on Alpha-Theta Effectiveness

Since these first reports of alpha-theta training, experts in the field have debated the nature of its effectiveness (White, 1999; Budzynski, 1973, Brownback and Mason, 1999; Moore, 2000). However, there seems to be some agreement that alpha-theta training addresses elements common to both PTSD and alcohol addiction. For instance, White (1999) suggested that “alpha brain waves (8-13Hz) may be considered a bridge from the external world to the internal world and vice versa. With some addicts and patients previously exposed to major trauma, alpha amplitudes can be low, thereby creating an inflexibility that keeps one from shifting readily between outward and inward states” (p. 344-345). Such patients may avoid or be unable to access internal states and therefore lack self-awareness. In turn, the production of alpha waves seems to facilitate greater theta wave activity, which some think is present any time personal insight occurs (Crane, 1992)

There has also been speculation that state dependent learning and state dependent memory may be involved. This has been hypothesized because the brainwave activity of children under age 6 is predominantly in the 4-8 Hz (theta) range. White (1999) suggested, “The surfacing of memories from early childhood during the alpha-theta brain wave training fits observations of state dependent memory. Because information learned while in one state of consciousness may be more difficult to access when in another state of consciousness” (p. 345).

White also cites Budzynski (1971) conjecturing "that a predominance of theta in the EEG was the ideal state for rescripting or reimprinting the brain (reassociate and reorganize)" (p. 346).

Viewing this crossover state as a "window of opportunity," Houck (1994) noted that when an individual's dominant EEG activity is 7.81 to 7.83 Hz, a mental access opportunity occurs. Tansey, Tansey & Tachiki (1994), who investigated specific [1 Hz wide] brainwave signatures, reported that the brainwave signature specific to memory was the 7 Hz frequency band. And Brownback & Mason (1999), who applied alpha-theta neurofeedback to treatment of women with multiple personality disorder (MPD), conceptualized the brain state resulting from this training as facilitating integration of traumatic memories with minimal risk, due to a lowered state of arousal. Thus, it may be a highly narrow frequency range at the fulcrum of alpha and theta frequencies that enables access to this highly liminal state.

Personality changes reported following alpha-theta neurofeedback training could also be a product of this treatment. Several studies have demonstrated that alpha-theta neurofeedback training can normalize personality measures (Raymond, Varney, Parkinson, & Gruzelier, 2005; Peniston & Kulkosky, 1991; Bodenhamer-Davis & Callaway, 2003; Byers, 1992; Scott, Kaiser, Othmer & Sideroff, 2005). Enhanced mood resulting from decreased drug habits may also contribute to outcomes (Raymond, et al., 2005). Others have speculated that flooding and systematic desensitization are key mechanisms as the client retrieves traumatic memories (Trudeau, 2000).

Alpha-theta neurofeedback training is generally implemented as the participant assumes a relaxed position seated in a reclining chair with his/her eyes closed. An active sensor is placed at occipital sites 01, 02, or parietal site PZ (Figure 4). The EEG biofeedback apparatus is set to produce a reward sound (pleasant tone) when alpha brainwaves (8-12 Hz) exceed a specified threshold. A second, different reward sound is produced when theta brainwave activity (4-7 Hz) exceeds a specified threshold. Usually, after 10 or more training sessions, theta amplitude will begin to exceed the level of alpha amplitude during part of the session, manifesting the theta-over-alpha crossover pattern.

The Crossover Controversy

Following early replications of Pensiton's 1989 and 1991 research reports, controversy arose over whether or not the "alpha-theta crossover" condition was essential to the Peniston protocol's therapeutic effectiveness (Moore, Trudeau, Thuras, Ruben, Stockley & Dimond, 2000). The debate included whether or not the emergence of imagery and emotional memories produced during theta-over-alpha amplitude crossover experiences was a necessary component to a successful treatment outcome.

This debate began with the publication of a study by Moore et al. (2000) who found an inverse relationship between the incidence of theta-alpha crossovers and the occurrence of visual imagery during alpha-theta neurofeedback training. Following their analysis of alpha and theta patterns produced by subjects undergoing the Peniston Protocol, Moore and colleagues reported that self-reported visualizations were less likely to occur during the presence of "alpha-theta crossover" states. They reported that visualizations occurred with greater frequency in sessions where fewer crossovers were present. The researchers concluded that the theta-over-alpha crossover state was not related to retrieval of imagery or emotional memories as Peniston had contended.

Several methodological issues related to this study are important to note, however. Moore et al.'s subjects were trained in randomly assigned groups of 2-6 rather than individually, and it was not clear if the recording technician watching the subjects was a trained therapist. In the context of his research with marijuana subjects, Tart (1969) noted that the presence of other subjects and/or the presence of a technician who did not have a therapeutic relationship with the subjects involved could impact the subjective experience of an altered state of consciousness.

Furthermore, Moore's report of his findings focused on alpha and theta brainwave activity and did not take into account the activity of other frequency bandwidths that may mediate or moderate subjects' abilities to self-report. The relationship of theta-alpha amplitude crossover during neurofeedback to the emergence of spontaneous imagery and biographical memories may be mediated or moderated by the presence of cognitive brainwave activity in the lower beta range.

Closer Analysis of the "Alpha-Theta Crossover" Phenomenon

Another way of viewing the theta-alpha crossover and imagery relationship question is to consider that the presence or absence of a theta-alpha crossover condition during a session may not be the only requisite precondition to imagery recall, but that there may need to be a high enough percentage of cognitive beta present to enable the therapy participant to transfer the experience from unconscious experience to conscious awareness and retrieval of the imagery. This theoretical model supports Peniston's original contention that a parallel increase in beta brainwave amplitude occurring concurrently with a theta amplitude increase is necessary for retrieval of personally relevant imagery or memories during alpha-theta neurofeedback. However, before introducing the potential role of cognitive beta on memory, the role of theta and alpha bandwidth activity in relation to memory will be discussed further.

Theta and Hippocampal Memory

The hippocampus structure of the brain is involved in consolidating emotional experiences into long term memory storage (Tesche & Karhu, 2000). The hippocampus generates theta wave oscillations when in its "on-line" state of functioning (Buzsaki, 2002). Theta oscillations have been strongly correlated with memory functions (Tesche & Karhu, 2000). It has also been suggested that they facilitate the process of long-term potentiation, to promote the formation of long term memories (Cantero, Atienza, Stickgold, Kahana, Madsen, & Kocsis, 2003), and to correlate with successful encoding and retrieval of episodic memory tasks (Tesche & Karhu, 2000). Brief theta bursts recorded in the human hippocampus during REM sleep may support memory consolidation models positing potentiated "off-line" memory consolidation during sleep (Cantero et al., 2003). Cantero et al. speculate that "A possible functional role for the human REM bursts reported here might be the "off-line" reactivation of memory traces within the hippocampus, perhaps priming the memory for replay to the neo-cortex during other sleep stages or in association with other electrophysiological events" (p. 10902).

EEG Correlates of Processing, Memory, and Recall Mechanisms

Neurophysiological Correlates of Waking Memory and Recall

Klimesch, Vogt, and Doppelmayr (2000) have reported on inter-individual differences in how alpha and theta frequency bands reflect memory performance. Their research demonstrated that desynchronized alpha activity in the upper range (10-12 Hz) reflects the encoding and processing of semantic (long term) memory demands, while synchronized theta activity (4-7 Hz) reflects the encoding of new information as a function of working memory (2000). While some researchers have reported on the separate activity of decreasing alpha waves and increasing theta waves during alpha-theta training, studies such as this by Klimesch et al. suggest that it may prove more instructive to consider the combined interaction of alpha and theta frequency bands,

A study on mental imagery (Von Stein and Sarnthein, 2000) revealed that the prominent feature of internal mental processing activity was increased theta and alpha *interactions*, suggesting that low-frequency EEG interactions might characterize top down (mental internal processing) activities (as opposed to bottom up sensory processing via the peripheral nervous system). The authors of this study proposed that higher amplitude alpha activity does not reflect an inactive or "idling" brain state, but rather a state of internal mental activity driven by mental imagery and free-floating associations (Von Stein and Sarnthein, 2000). Thus, alpha and theta frequency interactions may represent different types of internal mental processing activity. However, wave form interactions where theta amplitude only briefly exceeds alpha amplitude may not be sufficient to produce emergent imagery or memories.

Schack, Klimesch, and Sauseng (2005) also reported that "there is evidence that the activation and flow of information across widely distributed brain areas may be reflected or coordinated by phase coupling within and between different frequencies" (p. 106). Their research on memory indicates that while the upper alpha frequency is dominant in memory retention, alpha and theta oscillations both become more prominent during memory retrieval. The findings of this research support the understanding of how a complex interplay between timing, different EEG oscillations, complex brainwave topographical patterns, and widely distributed brain areas and frequencies contribute to the process of working memory. Their contentions support the primary assumption of this proposal that alpha and theta amplitudes should not be examined in isolation for their relevancy to emotional memory and spontaneous imagery retrieval in alpha-theta neurofeedback training, but that the complex interplay of additional EEG spectral activity and components should be addressed. Further investigation of the theta-alpha crossover visualization and memory retrieval phenomenon may necessitate taking a wider view of the ongoing EEG brainwave activity during alpha-theta training, especially the role that information-carrying cognitive beta may play in an individual's ability during the session to become aware of and recall the occurrence of memories that need to be transferred to alert consciousness in order to be used for psychotherapeutic benefit.

Relationship of Beta to Imagery and Memory

In contrast to alpha activity (8-12 Hz), which has been associated with shifting attention away from external stimuli in order to process internal experiences with greater efficiency, beta activity (16-20 Hz) has been associated with emotional and cognitive processes (Ray & Cole, 1985). Changes in the beta rhythm have been found to accompany changes in the alpha rhythm (Carlqvist, Nikulin, Stromberg & Brismar, 2005). Carlqvist et al. investigated the relationship between resting state alpha (7.5-12.5 Hz) and beta (15–25 Hz) frequency oscillations. The strongest correlations of power and synchrony between the two bandwidths were observed in the occipital region of the brain, suggesting that these two bandwidths may be generated by a common mechanism. Visual imagery has been associated with the occipital lobe, which includes visual cortical areas (Fallgatter, Mueller & Strike, 1997). Wrobel (2000) demonstrated that increased power in the beta band also appeared during visual attention in the primary visual cortex, lateral geniculate nucleus (LGN), and in the higher visual areas. Wrobel, who cited Mundy-Castle (1951) and Stein et al. (1993), noted "observations of increased beta activity in subjects habitually using vivid visual imagery as compared to negligible beta activity recorded in subjects with relatively inadequate visual imagery ability" (p. 250). Wrobel subsequently ascribed beta frequency brainwave activity the role of an attention carrier related to visual processes (2000). Wrobel (2000) concluded from his investigations that activity in the beta frequency band reflects a specific attentional state of the visual system that can be activated during increased visual attention demands.

While alpha activity may be characteristic of idle arousal of the visual system, beta activity, as a carrier of visual attention, may function to shift the visual system to an attentional state that subsequently enables perception and integration of visual stimuli via additional processes in the gamma (30-100 Hz) frequency range (Wrobel, 2000). Thus, alpha, beta, and gamma frequency bands related to visual pathways may be conceptualized as having gating functions that can shift processing levels from a state of idle visual system arousal, to a state capable of carrying visual attention, and then finally to a state that can integrate and process. This framework also suggests that each preceeding stage might set the background necessary for the next level of higher functional processing to emerge. This research is consistent with the contention of this proposal that a concatenation of events needs to occur for successful therapeutic processes relevant to Theta-Alpha crossover phenomenon to occur.

Beta frequency brainwave activity might also have a unique connection to brain structures related to imagery and memory. Laufs et al. observed that increased fMRI signal in the retrosplenial cortex (Figure 3, #29) correlated with increased beta-2 (17-23 Hz) power. It has been suggested that when a person is awake but in a resting state, brain activity switches to a default mode in which the highest values of blood flow and metabolic activity occur in the retrosplenial cortex (Laufs, Krakow, Sterzer, Eger, Beyerle, Salek-Haddadi, & Kleinschmidt, 2003). The retrosplenial cortex is a relatively unstudied brain region located caudal to the posterior cingulate cortex and is anatomically positioned to draw on amygdala, parahippocampal and entorhinal cortices known to be associated with emotional and episodic (long-term) memory processes (Maddock, 1999). Activation of the retrosplenial cortex has been associated with the retrieval of episodic autobiographical memories (Maddock, 1999). During autobiographical memory retrieval, the greatest activation has been shown on functional magnetic resonance imaging (fMRI) to occur in the left posterior caudal region of the cingulate cortex (Maddock, 2001). According to the cytoarchitecture of the brain outlined by Brodmann (1903), this brain region appears to be located behind the occipital lobe and visual cortex regions of the brain, possibly at the 01 site as measured by the International 10-20 electrode placement system (Jasper, 1958). Maddock (1999), citing the research of Andreason et al. noted that these researchers suggested "retrosplenial activity might be associated with the spontaneous mentation that occurs when human subjects are not engaged in a focused task. This mentation would typically include the retrieval of emotionally salient mental contents from autobiographical memory and possibly the encoding into memory of these episodes of reflection and thought" (Maddock, 1999) (p. 314). The retrosplenial [and parietal regions], which often show activation during episodic memory recall, were deactivated in a group of Vietnam veterans with PTSD during the experimental condition in which they were exposed to combat sounds intended to induce mental imagery from past personal experience (Liberzon, et al., 1999). This deactivation of the retrosplenial cortex may serve to manage the symptoms of PTSD by limiting access to anxiety-provoking autobiographical memories. The retrosplenial cortex has also been known to be activated by pleasant stimuli as well (Maddock, 1999).

EEG Spectral Band Interaction Pattern

As posited earlier, in order to understand the imagery recall function of the "alpha-theta crossover" phenomenon described by Peniston and others, not only does the interaction of specific frequency band activity need to be considered, but also the complex interaction of the wider collective brainwave frequency band activity. Bastiaansen, Oostenveld, Jensen, and Hagoort (2008) conducted a study in which they investigated EEG oscillatory brain dynamics as subjects engaged in a visual lexical (words related to imagery and colors) task. The researchers of this study found that while alpha power (8-12 Hz) decreased, both theta power (4-7 Hz), and beta (13-18 Hz) increased. This was consistent with Peniston's (1993) findings that during alpha-theta sessions in which subjectively relevant imagery was reported, significant amplitude increases occurred in both theta and beta ranges, but not in alpha. In addition to their other findings, Bastiaansen et al. reported the striking finding that larger theta amplitude increases produced by words with *auditory* semantic properties were observed in the left temporal cortex, while larger theta amplitude increases produced by words with *visual* semantic properties were observed in the occipital cortex, which is the location of choice for alpha-theta training and perhaps necessary to access imagery and visualizations. These topographical power changes were specific to theta power changes, but not found in relation to other frequencies, which would correspond to the clinically observed substantial rise in theta amplitude during therapeutically significant theta-alpha crossovers.

Gating Function of Frequency Bands to Imagery and Memory

An effort was made to gain a better understanding of how spectral QEEG spectral band activity may interact and combine to produce the fertile circumstances necessary for access to imagery and memory. An exploration of the literature led to an emerging hypothetical conceptualization of how each frequency, and combinations of frequencies, may provide "gating functions" to achieve certain ends. Alpha brainwave activity may shift attention inward to a state of visual system arousal (White, 1999). Beta may shift to a state capable of carrying visual attention (Wrobel, 2000). Theta may produce a shift that activates hippocampal processes (Tesche & Karhu, 2000). Delta may shift to internal processing of cortical output and limit extraneous stimuli (Harmony, Fernandez, Silva, Bernal, Diaz-Comas, Reyes, Marosi, Rodriguez & Rodriguez, 1996). And, delta and beta may be a functional stage shift that might account for dream recall (Itil, 1970).

See Table 1 for a summary of this data. It is a contention of this study that certain frequency band combinations (i.e., alpha, theta and beta; or alpha, theta and delta) may facilitate access to different types of imagery experiences.

Categorization of Spontaneous Imagery

While the precise mechanisms of psychotherapeutic action remain unclear, there has been a steady proliferation of practitioners using alpha-theta neurofeedback training because of its effectiveness in treating conditions such as alcohol addiction and PTSD. As stated earlier, many of these practitioners attribute the success of the treatment to the frequently observed emergence of imagery and memories that occurs during theta-over-alpha crossover experiences. The spontaneous emergence of imagery and memories range in depth from light hypnagogic imagery, such as colors, geometric shapes, etc. to much deeper states of consciousness containing more personally relevant material. Previous studies of the theta-alpha crossover state do not provide specific description of the kinds of visual imagery that subjects reported. Moore et al. (2000) noted variability in the nature and complexity of self-reported imagery provided by subjects. A method for categorizing imagery and memories that emerge during alpha-theta neurofeedback would be useful in order to examine the relationship between brain wave configurations and ratios to the level and type of content that emerges in treatment.

Description of Non-Cognitive States of Consciousness:

One cannot assume that everyone experiences the same alterations of consciousness when participating in alpha-theta training; there may be a variety of patterns (Demos, 2005). Thus, it is useful to consider the writings of those who have attempted to define subjective imagery experienced in non-ordinary or non-cognitive states of consciousness. Some of these descriptive cartographies include: realms of human unconscious (Grof, 1976), mapping the regions of consciousness (Ring, 1976), and cartography of consciousness (Crane, 1992). The following levels are an adaptation of the aforementioned constructs by an early neurofeedback research-practitioner (Tansey, 1994).

Category I: Abstract/Aesthetic (Brown, 1974)

Category 1 contains abstract/aesthetic experiences possibly in the range of 10-15 Hz (SMR/Alpha). Category 1 may include visual (intense colors, geometric shapes, after images, optical illusions, animation of visual material, colored spots, exotic scenes, and geometric/abstract designs), acoustic (hypersensitivity to sound, acoustical illusions, and synaesthesia), and emotional experiences (interpretation of the environment as beautiful, comical, or magical).

Category II: Biographical

Category II includes biographical experiences and is possibly associated with brainwave frequencies in the range of 5-10 Hz (alpha/theta). This level includes important memories, emotional problems, and unresolved conflicts from various periods in an individual's life and may include: humiliation/degradation, shocking or frightening events, guilt/moral failure, claustrophobic/suffocating, emotional, deprivation/rejection, and sex as dangerous/disgusting, aggression/violence, endangered survival/health/body integrity, and abandonment/separation.

This stage can also include physical/motor responses that precurse the emergence of Category II: nausea/vomiting, breathing difficulties, cardiovascular complaints, profuse salivation, sweating, diarrhea, pain, stereotyped movement, and mechanical verbal repetition.

Category III: Perinatal (Birth Matrixes) (Grof, 1976)

Category III is probably associated with the same brainwave frequencies as Category II, in the range of 5-10 Hz (alpha/theta). Grof defined four basic perinatal matrices (BPM's):

- BPM I: Intrauterine experiences
- BPM II: Contractions in closed womb (unbearable and never-ending, victim, helpless/hopeless, anxiety of unknown source related to impending doom, separation, meaninglessness.
- BPM III: Propulsion through birth canal (death-rebirth struggle, power struggles, aggressive and sexual energies).
- BPM IV: Release, expulsion into new mode of existence, overcoming hardship, victory.
- BPM I-IV is not linear, but circular

Category IV: Transpersonal (Ring, 1976; Jovanov, 1998)

Category IV is probably associated with brainwave frequencies in the range of 0-4 Hz (delta/theta). Unconscious, expanded beyond ego boundaries, time and space limitations, and consensus reality. Embryonic and fetal development, identification with ancestral, archetypal, past-life, animal/plant, collective/racial, and dual identities, precognition, telepathy, clairvoyance, clairaudience, oneness with all life/creation, out of body experiences, spiritistic or mediumistic experiences/channeling encounters with deceased persons.

These categories of abstract, biographical, perinatal, and transpersonal categorical domains provide a useful framework for examining the relationship between alpha-theta neurofeedback session graph configurations and brainwave frequency ratios with different types of subject reports of imagery and emotional memories. Therefore, more in-depth examination of content in reported subjective experiences during alpha-theta training needs to be done to further add to the discussion regarding the importance of theta-alpha crossover phenomenology in alpha-theta neurofeedback.

Refinement of the Crossover Definition

Given the earlier, simplistic descriptions of crossover phenomenology, it may prove beneficial to formulate a broader conceptualization of the crossover occurrence that recognizes the complex nature of this phenomenon. Basar, Basar-roglu, Karakas & Schurmann (2001) defined complex brain functions as being characterized by several superimposed brainwave oscillations that vary in their degrees of amplitude, duration, and timing. Consistent with this definition, this paper proposes the term *therapeutic crossover* to describe the type of phenomenon Peniston and others have reported occurring during alpha-theta neurofeedback. A therapeutic crossover that is likely to accompany emergent imagery would be distinguished as a theta-over-alpha amplitude crossover that rises at least 1 microvolt or more in amplitude above alpha and remains dominant over alpha amplitude for 3-10 minutes or longer, as well as contain the 15-20 Hz beta superimposed brainwave frequency components (Figure 2). This definition provides quantifiable and observable criteria that may describe the type of crossover that Peniston identified as a significant contributor to therapeutic success in his protocol.

Purpose of the Study

The purpose of this study was to extend the current literature on alpha-theta neurofeedback training. Questions of interest included whether duration of cross-over, amplitude of difference (i.e. – amplitude of theta above alpha), interactions between duration and crossover, time-of-day, session length, and experience with meditation have an effect on imagery/memory, and the precise nature of these relationships. Furthermore, this study focused on clarification of the relationship of theta-alpha crossovers to therapeutic outcomes in alpha-theta neurofeedback. The study was designed to answer the following research questions:

1) What constitutes a therapeutic *theta-alpha crossover*? Is the amount of theta amplitude increase in the theta-to-alpha crossover and its duration important to the emergence of spontaneous imagery and memory?

2) Is a minimum amount of cognitive beta amplitude increase necessary to recall the content of imagery and memories evoked in alpha-theta training after a client returns to an alert state of consciousness?

3) Are there relationships and ratios of specific bandwidths that are relevant to the type of imagery content that emerges?

4) Is there a relationship between delta brainwave activity and category III & IV (deeper/transpersonal) states of consciousness?

5) Are higher quality, *therapeutic*, crossovers (as defined above) related to better overall treatment outcomes?

Hypotheses

Based on prior research, the following hypotheses are proposed:

I. Subjects who displayed therapeutic crossover activity (minimum of 1 microvolt in amplitude and minimum of 3 minutes in duration) will show significantly more occurrences of category II, III, and IV imagery than those who did not.

II. Participant reports of category II, III, and IV imagery will occur only following sessions in which theta-alpha crossovers occurred along with at least a mean amplitude of 3.5 microvolts in 15-20 Hz beta activity.

III. Lower dominant frequency ranges will be associated with deeper states of consciousness with a positive correlation between delta and categories 3 and 4 levels of imagery.

IV. Participants with more therapeutic crossovers will show greater improvement on treatment outcome measures than those with fewer therapeutic crossovers.

CHAPTER 2

METHODS

Subjects

Participants included clients who completed alpha-theta neurofeedback training as part of their overall psychotherapeutic treatment for substance abuse, depression, or post-traumatic stress disorder (PTSD) at the University of North Texas Neurotherapy Lab (NT Lab). The sample of subjects was gender balanced (5 women and 5 men). All were Caucasian ranging from 22 to 58 years of age with a mean age of 41. The mean session length of alpha-theta training was 32.97 minutes. Data for these subjects was collected using 2002-2008 archived records from the NT Lab. Records for additional subjects were obtained from a private neurofeedback practitioner outside the university. A total of 10 client records were found to be suitable for analysis. As a pre-requisite to treatment, clients whose records were used in this study were required to have read and signed an informed consent document that explained treatment requirements and possible side effects or risks of the treatment. Clients also gave written permission for any information gained through this treatment process to be used anonymously for educational or research purposes. While participants were intended to receive 30 alpha-theta training sessions, the actual number of sessions completed varied due to attrition. With the exception of one client who only completed 3 sessions (but did have a significant crossover with accompanying biographical imagery), other clients received treatment that ranged from 11 to 29 sessions. Alpha-theta session graphs (n = 182) were analyzed for crossover characteristics, reports of associated imagery content, and treatment outcomes.

Instrumentation and Protocol

Alpha-theta brainwave training was provided using BrainMaster Atlantis version 3.0 software (n = 8) and Lexicor, Biolex software (n = 2) EEG-biofeedback instrumentation. BrainMaster equipment was set to include a 60Hz notch filter, 256 data sampling rate, 125µv artifact threshold, and peak-to-peak amplitude scale. This equipment was set for theta (5.0-8.0) to be enhanced 30-40% of the time above threshold, and alpha (8.5-11.5) to be enhanced 70-90% of the time above threshold. Lexicor equipment was set for a 60Hz notch filter and for a 128 sampling rate with theta (4-7) enhanced 20-25% of the time and alpha (8-12) enhanced 70-75% of the time. All active electrode placements were at 01 (Figure 4), with left ear (A1) reference sites. The right ear was used for the ground site. These slight variations between equipment and software protocol settings should have had no influence on the kinds of variables of interest in this study since both instruments and protocols reliably enabled subjects to produce increased amplitudes of alpha and theta frequencies. Each client sat with eyes closed in a comfortable recliner chair, received progressive muscle relaxation instructions, behavioral outcome visualization suggestions (e.g., alcohol rejection behaviors), and usually a 30-40 minute brainwave training session. For the most part, this session activity procedure was consistent across all subjects.

Methods

Client alpha-theta neurofeedback session graphs and session report data collected and recorded on BrainMaster or Lexicor EEG-biofeedback equipment was extrapolated into an Excel spreadsheet from archived client data collected at the Neurotherapy Lab or at the private practice of Richard E. Davis, M. S., LPC. These data were then imported into the statistical analysis software program SPSS (Statistical Package for the Social Sciences) for analysis. The variables of interest included client demographic and training information (meditation experience, time of day, length of session); theta-over-alpha crossovers (amplitude and length); mean frequencies and amplitude differences in delta, theta, alpha, beta (15-20 Hz), and high beta bandwidths; and subject reports of imagery and memories documented by therapists in session reports (see appendix).

Statistical Analyses

Chi square tests were performed to address Hypothesis I by evaluating the independence of therapeutic versus non-therapeutic crossovers. A multi-level model design was used to address Hypotheses I through III. This model was chosen for its predictive value and its evaluation of repeated measures, as well as the ability to accurately describe relationships among the variables of interest in this study. Multi-level modeling is a technique that was developed to analyze variables at different levels of hierarchically structured data (Kreft & De Leeuw, 1998) and is a generalization of the linear regression model. The longitudinal structure of the data, with multiple observations per participant, required a two-level model in which the macro level (Level 2) was the individual and the micro level (Level 1) was the observation. A flow chart representing the hierarchical and multi-variable predictive pathway investigated using the multi-level modeling analysis procedure to evaluate the cross-tabulation (directionality) of occurrences of imagery is depicted by Figure 5. Finally, a means comparison analysis was performed to address Hypothesis IV. In this analysis, the number of therapeutic crossovers was the independent variable and treatment outcome measures Beck Anxiety Inventory (BAI), Beck Depression Inventory (BDI), Beck Hopelessness Scale (BHS), Pittsburg Sleep Quality Inventory

(PSQI), and Minnesota Multi-phasic Personality Inventory (MMPI) were the dependent variables.

First conducted were crosstab analyses and chi-square significance tests regarding the category of visual imagery by crossover type with and without beta. Next, additional crosstab analyses was conducted to assess changes extant in the data when only therapeutic events (biological, perinatal, transpersonal) were reported (by the client to the therapist), and whether increases in the mean amplitudes of slower brainwave activity correlated with progression into deeper states of consciousness. For purposes of this study, in cases where clients experienced multiple categories of imagery (25%), the higher category was reported (i.e. – a report of a biographical memory and a transpersonal experience was coded as the latter). However, in 75% of cases, the client reported one category of imagery, which the therapist categorized and documented according to specified criteria (Appendix). Two reviewers reviewed the documentation independent of brainwave data for categorization as well. The two reviewers achieved 100% inter-rater reliability. This occurred approximately five times with only one instance of discrepancy. Third, a series of multi-level models were used to test the whole model on its ability to predict a greater number of reports of imagery in therapeutic crossover with beta conditions and deeper levels when higher amplitudes of delta were present. Since a subject may have experienced differing types of crossovers in the course of treatment, he/she would be categorized according to overall tendency (e.g. – a client who experienced one or two therapeutic crossovers with sufficient beta, but also experienced eight therapeutic crossovers without sufficient beta would be placed in the latter category). Fourth, an analysis of variance (ANOVA) was performed to assess whether treatment outcomes showed greater improvement when therapeutic crossover conditions were present.

CHAPTER 3

RESULTS

Occurrence of Crossover Activity

Crosstab analysis was used to examine crossover activity in which theta brainwave frequency rose in amplitude above alpha brainwave frequency activity. This analysis indicated that 27.9% of the alpha-theta neurofeedback session graphs contained no crossover activity, 34.1% contained non-therapeutic crossover activity, and 37.9% contained therapeutic crossover activity. A follow-up crosstab analysis assessing occurrences of categorical imagery types revealed that no imagery was reported in 67.4% of the sessions; hypnagogic imagery was reported in 14.7%, biographical imagery was reported in 7.1%, perinatal imagery was reported in 2.1%, and transpersonal imagery was reported in 6% ($\chi 2(8, N=182) = 47.42, p < .001$). Table 2 summarizes the reports of imagery according to crossover type in sufficient beta and in insufficient beta conditions.

Relationship of Crossover Activity to Other EEG Frequencies and Categories of Imagery

Since a primary clinical question motivating this research was whether imagery and memories of emotionally salient material are related to occurrence of crossovers in neurofeedback therapy sessions (Peniston, 1995), a thorough analysis was performed on the relationships between crossovers and imagery reports. Since amorphous hypnagogic activity was more frequently observed in sessions with no crossover or non-therapeutic crossover activity, it was determined to focus on reports of biographical, perinatal and transpersonal imagery in sessions where therapeutic crossover activity was observed (Table 3). These three types of potentially personally meaningful imagery were reported 85.7% of the time in the therapeutic crossover condition, with 71.4% of reports conveyed when beta was of sufficient amplitude.

The multi-level model using the hierarchical design illustrated in Figure 5, revealed a significant interaction between therapeutic crossover activity and sufficiency of beta frequency amplitude (F (177,5) = 23.421, $p < .001$), Table 4. Significantly deeper levels of imagery were reported in sessions where higher levels of beta frequency amplitude were observed independent of other variables (F (177,5) = 36.288, $p < .001$). Further, significantly deeper levels of imagery were reported in sessions where a therapeutic crossover occurred (F (177,5) = 21.170, $p < .001$). No significant difference in categories of imagery was observed for higher elevations in delta frequency amplitude independent of the other variables when analyzed in this model. However, because the cutoff utilized to denote elevated delta frequency amplitude was arbitrary based on session observations, an analysis of variance (ANOVA) was performed to explore changes in mean delta amplitude for all categories of imagery. Progression from hypnagogic imagery across the spectrum to deeper states of consciousness was associated with a rise in delta mean amplitude (Table 5). Specifically, delta mean amplitude was significantly higher in states in which transpersonal imagery was reported compared to when biographical or hypnagogic imagery was reported (F (177,5) = 3.429, $p = .011$). Although a consistent rise in delta mean amplitude was observed across categories, the mean amplitude for sessions in which perinatal imagery was reported was not significantly different than other categories.

Relationship of Therapeutic Crossovers to Treatment Outcomes

Treatment outcome measures included the beck anxiety inventory (BAI), beck depression inventory (BDI), beck hopelessness scale (BHS), Pittsburgh sleep quality index (PSQI) and

Minnesota multiphasic personality inventory (MMPI) for eight participants (outcome measures were not available for two participants who terminated treatment prematurely). Due to the small sample size of 8 subjects, a repeated measures analysis of number of crossovers to treatment outcomes yielded no significant differences. Therefore, it was decided to perform a descriptive analysis comparing the therapeutic outcome measures to conditions of no crossover, therapeutic crossover without sufficient beta, and therapeutic crossover with sufficient beta. The highest improvements in therapeutic scores across most treatment measures occurred for clients in the condition of therapeutic crossover with sufficient beta (Table 6 and Figure 6). This group was comprised of 4 subjects who were then separated into high count number of crossovers with sufficient beta versus low count number of crossovers with sufficient beta. The subject in the high count category showed greatest improvements on BAI, BDI, BHS, PSQI and MMPI Scales 1 (hypochondriasis), 2 (depression), 3 (hysteria), and 6 (paranoia) and 7 (psychasthenia) (Table 7 and Figure 7). The 3 subjects subject in the low count category showed the next greatest improvements on BAI, PSQI and MMPI Scales 3 (hysteria), 4 (psychopathic deviance), 7 (psychasthenia) and 8 (schizophrenia) (Table 7 and Figure 7). This latter group reversed on Scale 5 (male/female) and Scale 6 (paranoia).

CHAPTER 4

SUMMARY AND DISCUSSION

This study examined the relationship of the alpha-theta amplitude crossover in alpha-theta neurofeedback therapy to the occurrence of categories of imagery and memories that may contribute to treatment outcomes. Because of differing conclusions on the therapeutic value of the crossover in this treatment among previous researchers, it was first necessary to examine the definition of the alpha-theta crossover, which had previously been defined as a condition in which theta amplitude brainwave activity becomes predominant over alpha amplitude brainwave activity (See Figure 1). This broad definition might explain why some researchers (Moore et al., 2000) found an inverse relationship in which greater numbers of crossovers were associated with fewer reports of imagery. After observing crossover data from 182 client sessions used in this study, it was decided to better operationalize the description of the alpha-theta crossover. This refinement led to the development of the term *therapeutic crossover* that restricted the definition of "crossover" to theta amplitude predominant over alpha measuring 1μv or more in amplitude for 3 minutes or more in duration.

The first hypothesis was that this defined minimum level of crossover activity would result in significantly more client reports of imagery than crossover activity not meeting these criteria. Additionally, crossover data analysis resulted in a decision to exclude "no imagery" and "hypnagogic imagery" categories in favor of those categories more likely to contribute to treatment outcomes, including biographical, perinatal and transpersonal categories of visual experience. Crosstab analysis revealed that the overwhelming majority of reports of imagery in the biographical, perinatal and transpersonal categories occurred in the therapeutic crossover condition. Thus, "alpha-theta crossovers" were re-conceptualized as theta-over-alpha amplitude crossover activity that met these stipulated conditions as a “therapeutic crossover” that was more likely to correlate with access to imagery and memories.

The second hypothesis concerned the relationship of beta (in the range of 15-20Hz activity) and imagery recall. It hypothesized that imagery reports were more likely to follow sessions in which sufficient beta brainwave amplitude (3.5μv or more) occurred to mediate imagery recall. Upon further evaluation of amplitudes ranging from 3.5μv to 4μv, it was discovered that 3.75μv was the most meaningful threshold for predicting reports of imagery. Therefore, this more heuristically-based threshold was used for examining relationships in the data. It was found that the majority of reported imagery (biographical, perinatal and transpersonal) occurred in the therapeutic crossover condition where beta amplitude was at least 3.75μv. Yet a small percentage of reported imagery occurred when beta activity was less than 3.75μv. It could be concluded, therefore, that a client with sufficiently elevated 15-20Hz beta amplitude is more likely to recall and retain imagery and memories than a client with insufficient amplitude in this range. This finding is consistent with clinical observations in which some clients that experience therapeutic crossover activity, but with insufficient beta amplitude, sometimes report limited access to the mental contents of their sessions, evidenced by statements such as, “It seemed like a lot was going on in my mind, but I just can’t recall it.”

The third hypothesis stated that lower frequency amplitude states would correspond with deeper subjective states of consciousness. In other words, a client who achieved higher amplitudes of progressively slower brainwaves (i.e. – alpha » theta » delta) would be more likely to progress along the continuum of hypnagogic to biographical to perinatal/transpersonal states. An analysis of imagery by mean amplitude of each frequency (beta, alpha, theta and delta) indicated that increased amplitude across all frequency bandwidths was associated with transition to deeper states of consciousness. For example, the hypnagogic imagery category was comprised of beta (3.63), alpha (5.87), theta (5.3) and delta (5.93) mean amplitudes. The transpersonal imagery category, at the other side of the spectrum, was comprised of beta (4.52), alpha (8.62), theta (9.75) and delta (9.15) mean amplitudes. It could be concluded that higher amplitude in delta activity was associated with greater access to deeper levels of imagery. Alpha-theta treatment was successful in increasing the amplitude of all frequencies, and imagery type was dependent upon which frequencies were dominant.

These findings indicate that certain spectral activity patterns might be associated with reports of specific imagery categories. Several actual client alpha-theta session graphs illustrate how this might translate to clinical application. An example of a session in which the client reported hypnagogic imagery was characterized by elevated alpha activity (Figure 8). An example of a session in which the client reported biographical imagery was characterized by therapeutic crossover with sufficient beta (Figure 9). An example of a session in which the client reported perinatal imagery was characterized by therapeutic crossover with sufficient beta, marked by higher amplitudes of alpha and theta, and elevated delta amplitude activity (Figure 10) as well. An example of a session in which the client reported transpersonal imagery was characterized by therapeutic crossover with sufficient beta, and highest amplitudes in alpha, theta, and delta activity (Figure 11).

Additionally, alpha-theta session graphs were inspected to see if patterns emerged among fluctuations in different frequency bands, specifically, to see if beta fluctuations occurred concurrently with crossover activity. In the majority of cases (approximately 75%), beta activity did rise concurrently with crossover activity, even when the beta amplitude was insufficient in facilitating recall. Typically, beta would rise (sometimes gradually, sometimes dramatically) towards the end of the session, which was when higher amplitude crossover activity was observed. This observation supports earlier mentioned research in which beta activity superimposed on slower wave activity may explain a stage shift that could account for recall during such a state (Itil, 1970).

The fourth hypothesis stated that more therapeutic crossover activity would be associated with better treatment outcomes. Results showed that therapeutic crossovers with sufficient beta amplitude was associated with the best improvements on post-treatment assessment measures, and the individual who had the most therapeutic crossovers showed the greatest improvements. This finding is consistent with Peniston's earlier contention that emergent emotionally salient imagery should be the target and goal of therapy.

The 3 subjects in the low count of therapeutic crossovers with sufficient beta amplitude condition showed greatest improvement on measures of anxiety (BAI), and on MMPI Scales 2 (Depression), 3 (Hysteria), 4 (Psychopathic Deviance), 7 (Psychasthenia), and 8 (Schizophrenia). One of the subjects in this group showed an increase on Scale 6 (paranoia). While subjects in this condition also showed improvement, scores did not improve to the same extent as the subject who had the highest count of therapeutic crossovers with sufficient beta amplitude. However, the subject with the highest crossover count also presented with higher baseline scores, indicating greater initial pathology. It is possible that this group of 3 subjects with fewer crossovers with sufficient beta had less pathology at baseline, consequently, perhaps less need for personally significant material to emerge and therefore fewer crossovers in treatment. It is also possible that a client may not have fully divulged the contents or fully processed emergent material with the therapist for optimal therapeutic benefit. Overall, it was found that the subject in the highest count of therapeutic crossovers with sufficient beta amplitude (and concomitant reports of imagery and memories) condition experienced better outcomes (greater improvement on pre-to-post treatment measure BAI, BDI, BHS, PSQI and MMPI scores) than each of the other crossover conditions. This subject also reported greater recall of her dreams following treatment, which is of interest to note since this client had the greatest emergence of repressed material and repression has been associated with low dream recall (Tart, 1962).

The 2 subjects in the therapeutic crossovers without sufficient beta condition showed slight improvements, comparable to the 2 subjects in the no crossovers condition, on most measures. One of the subjects in this condition experienced 11 therapeutic crossovers without sufficient beta amplitude and had no reports of imagery or memories, but showed much improvement overall on outcome measures, which was not clearly represented in the treatment outcomes bar graph. A possible explanation for this subject's improvement is that it may not be necessary for emergent emotionally salient material to translate into a normal wakeful state of consciousness for the experience to render therapeutic benefit. It may be enough that this material be manifest for subconscious processing.

Subjects in the no crossover condition also showed an elevation on MMPI Scale 5 (Male/Female) and greatest improvement on MMPI Scale 0 (Social Introversion). The reversal on the MMPI Male/Female scale could indicate a shift away from, or towards a more balanced view of gender role behavior. All 8 subjects also showed increased scores on MMPI 9 (Mania), which may have reflected increased energy following biofeedback.

Conclusions

In general, the results of this study are in agreement with Peniston's earlier (1995) speculation that beta activity is involved in recall of memories/imagery following "alpha-theta" crossover activity in alpha-theta neurofeedback treatment. Because of insufficient data, findings in this study are inconclusive, but tentatively support his belief that crossover activity is a significant factor in the therapeutic effectiveness of this treatment.

Limitations of the Study

The small number of subject and treatment outcome measures was a limitation of this investigation, especially in relation to testing the hypothesized relationship between therapeutic crossovers and alpha-theta treatment outcome measures. Another limitation was the reliance on client subjective reports of imagery experience during treatment sessions. It is possible that some clients may have experienced relevant imagery but not felt comfortable reporting the material to the therapist. Any lack of client willingness to process what emerged also could have affected treatment outcomes.

Recommendations for Future Research

Since the small sample of therapeutic outcome measures acquired in this study permits only tentative conclusions about the role of therapeutic crossover activity, with or without sufficient beta amplitude, in alpha-theta biofeedback treatment, a future study that could replicate this investigation with a larger sample size might better determine if treatment outcome measures are more positively influenced by conscious or subconscious processing of emergent material. The observation that outcome measures improved for some subjects who had no therapeutic crossovers during treatment should be explored further to determine if any variables distinguish those clients from the ones who had therapeutic crossovers. Finally, it would be helpful to further explore the observation that at least one client who had therapeutic crossovers without sufficient beta showed good overall improvement on treatment outcome measures. Replication of these findings could hold important psychotherapeutic implications regarding the role of unconscious versus conscious processing of emotional material.

Table 1

Gating Functions of Frequency Bands

Frequency Band	Measurement in Hz	Corresponding State of Consciousness	Gating Function
Alpha	8-12	Idling state: Internal mental activity driven by mental imagery (White,1999)	Shifts attention inward to a state of visual system arousal
Theta	15-20	Alert, outward focus of mental concentration (Wrobel, 2000)	Shifts to a state capable of carrying visual attention
Beta	4-7	Pre-sleep, hypnagogic (Tesche & Karhu, 2000)	Shift may activate hippocampal processes
Delta	1-3	Sleep, dreaming (Harmony et al. 1996)	Shifts to internal processing of cortical output and limits extraneous stimuli
Delta/Beta	1-3/Beta 2*	Present during greater dream recall (Itil, 1970)	Functional stage shift that might explain dream recall

* Beta 2 reflects a brainwave frequency band rage of approximately 15-20Hz.

Table 2

Category of Visual Imagery by Crossover Type With and Without Beta

	No crossover *n*=51	*Non-therapeutic crossover* *n*=62		*Therapeutic crossover* *n*=69	
		No beta	*Beta*	*No beta*	*Beta*
No imagery	26.3%	12.6%	10.4%	14.3%	3.8%
Hypnagogic imagery	1.6%	4.9%	3.8%	4.4%	2.2%
Biographical imagery	0%	1.1%	1.1%	.5%	4.4%
Perinatal imagery	0%	0%	0%	.5%	1.6%
Transpersonal imagery	0%	0%	0%	1.1%	4.9%

($\chi2(8, N=182) = 47.42, p < .001$)
Note. *N* represents the total number of sessions (182) characterized by no crossover activity (51), Non-therapeutic crossover activity (with or without sufficient beta) (62), or Therapeutic crossover activity (with or without beta) (69). The 5 table columns sum to illustrate 100% of the session graph activity examined.

Table 3

Category of Visual Imagery by Crossover Type With and Without Beta Excluding No Imagery and Hypnagogic Imagery Conditions

	No crossover *n*=0	*Non-therapeutic crossover* *n*=4		*Therapeutic crossover* *n*=24	
		No beta	*Beta*	*No beta*	*Beta*
Biographic imagery	0.0%	7.1%	7.1%	3.6%	28.6%
Perinatal imagery	0.0%	0.0%	0.0%	3.6%	10.7%
Transpersonal imagery	0.0%	0.0%	0.0%	7.1%	32.1%
Total Imagery	0%	7.1%	7.1%	14.3%	71.4%

Note. The five table columns collectively sum to reflect 100% of client reported imagery of salient material while excluding no imagery and hypnagogic imagery categories.

Table 4

Mixed Models Analysis

Source	*df*	*F*	*p*
Crossover	177	3.866	.051
Therapeutic	177	21.170	.001
Beta Rise	177	36.288	.001
Therapeutic Beta Rise	177	23.421	.001

Category of Visual Experience					
Crossover Occurrence	Therapeutic Crossover	Sufficient Beta	*n*	Mean	*SD*
No	Non-therapeutic	No	23	.0870	.28810
		Yes	28	.0357	.18898
		Total	51	.0588	.23764
Yes	Non-therapeutic	No	29	.2069	.41225
		Yes	33	.5455	.71111
		Total	62	.3871	.61016
	Therapeutic	No	28	.3571	.82616
		Yes	41	1.8537	1.55822
		Total	69	1.2464	1.49908
	Total	No	57	.2807	.64792
		Yes	74	1.2703	1.40739
		Total	131	.8397	1.23921
Total	Non-therapeutic	No	52	.1538	.36432
		Yes	61	.3115	.59276
		Total	113	.2389	.50488
	Total	No	80	.2250	.57313
		Yes	102	.9314	1.32201
		Total	182	.6209	1.11455

Note. Mixed Model Analysis showed that crossover occurrence that is therapeutic and has sufficient beta amplitude predicts increased reports of deepening levels of imagery (Mean value change from 0 towards 4 indicates progression from reports of no imagery to reports of hypnagogic, biographical, perinatal and transpersonal categories).

Table 5

Imagery by Mean Amplitudes Measured in Microvolts

	Hypnagogic imagery	Biographic imagery	Perinatal imagery	Transpersonal imagery
Beta	3.63	4.14	4.45	4.52
Alpha	5.87	6.82	10.65	8.62
Theta	5.30	6.91	11.02	9.75
Delta	5.93	6.59	7.92	9.15

Note. Mean amplitudes measured in microvolts are observed to increase from left to right and progress from lighter to deeper states of consciousness as indicated by Crosstabs Analysis. Analysis of Variance (ANOVA) indicated significantly higher mean amplitudes in microvolts of delta as level of imagery increased (F = 3.429, p = .011).

Table 6

Pre and Post BAI, BDI, BHS and PSQI) Outcome Measures by Crossover Type

Measure	Cond.	No Crossover		Crossover No Beta < 3.75		Crossover w/Beta > 3.75	
		M	SD	M	SD	M	SD
BAI (Anxiety)	Pre	8.0	2.8	17.5	6.4	18.8	12.3
	Post	6.0	1.4	3.5	0.7	16.5	6.7
BDI (Depression)	Pre	9.0	5.7	13.5	14.8	10.5	8.4
	Post	2.5	3.5	5.0	0.0	11.3	3.8
BHS (Hopelessness)	Pre	1.5	2.1	4.5	0.7	7.0	2.4
	Post	1.0	1.4	3.5	0.7	4.3	1.7
PSQI (Sleep)	Pre	11.5	2.1	8.0	5.7	7.3	4.2
	Post	9.0	5.7	5.5	4.9	7.8	4.1

Table 7

Pre and Post MMPI Outcome Measures by Crossover Type

Measure	Cond.	No Crossover		Crossover No Beta < 3.75		Crossover w/Beta >3.75	
		M	SD	M	SD	M	SD
Scale 1 (Hysteria)	Pre	62.5	2.1	63.5	17.7	57.0	14.4
	Post	63.5	6.4	52.5	6.4	56.0	15.2
Scale 2 (Depression)	Pre	70.0	2.8	57.5	12.0	63.5	6.9
	Post	61.5	14.8	51.0	15.6	56.5	7.6
Scale 3 (Hypochondriasis)	Pre	67.0	4.2	71.0	2.8	59.5	15.5
	Post	61.5	10.6	55.5	2.1	58.5	9.7
Scale 4 (Deviant)	Pre	72.5	9.2	66.0	11.3	65.8	14.2
	Post	68.5	0.7	62.5	5.3	61.3	7.4
Scale 5 (Male/Female)	Pre	52.5	7.8	58.0	2.8	54.0	10.2
	Post	63.0	1.4	52.0	0.0	56.8	11.4
Scale 6 (Paranoia)	Pre	60.0	1.4	56.5	16.3	60.8	10.3
	Post	52.5	0.7	53.0	11.3	56.5	5.7
Scale 7 (Psychasthenia)	Pre	75.5	4.9	68.0	5.7	65.3	6.5
	Post	69.0	17.0	57.5	9.2	62.0	3.6
Scale 8 (Schizophrenia)	Pre	64.0	7.1	68.5	4.9	68.3	11.0
	Post	63.5	12.0	60.5	7.8	65.0	3.6
Scale 9 (Mania)	Pre	46.0	4.2	51.5	6.4	54.0	10.4
	Post	47.0	8.5	57.5	30.4	54.8	13.4
Scale 0 (Introversion)	Pre	50.0	2.8	56.0	19.8	52.0	9.6
	Post	41.5	7.8	52.0	12.7	51.0	9.5

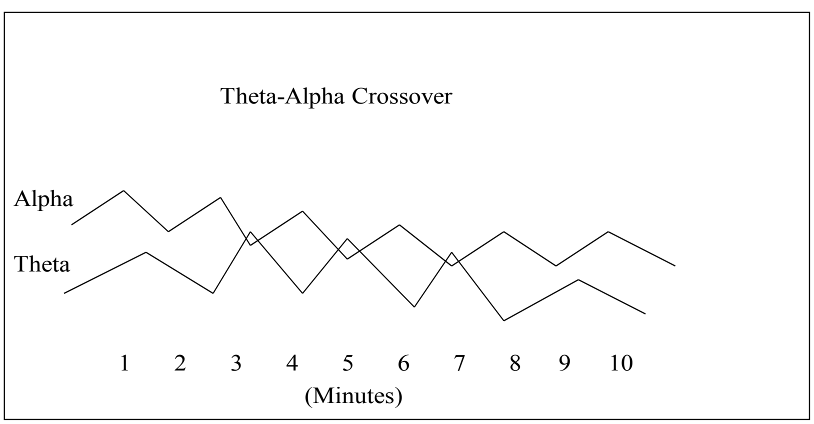

Figure 1. Theta-alpha crossover (broadly defined).

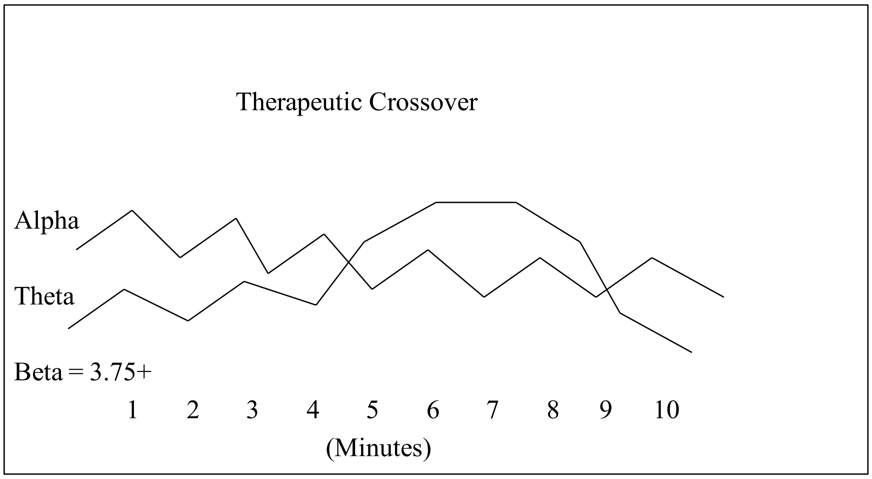

Figure 2. Refinement of the therapeutic crossover definition.

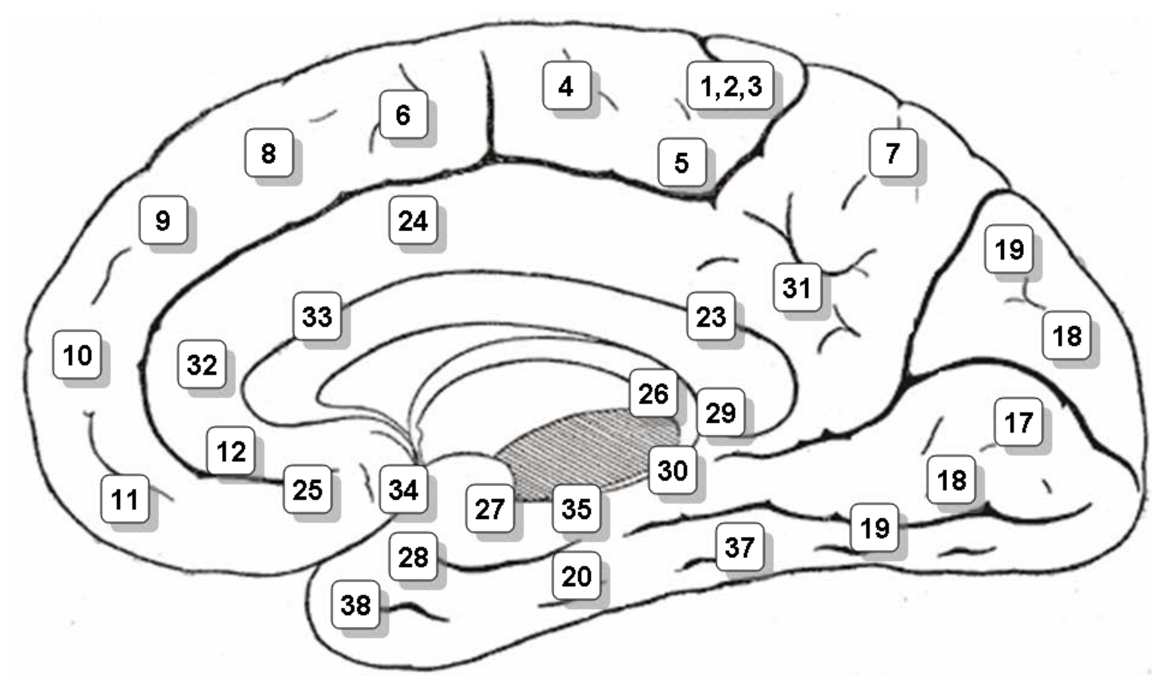

Figure 3. Anatomical location of the retrosplenial cortex. Brodmann located the retrosplenial cortex (29) as being positioned adjacent to the occibital lobe and visual cortical areas.

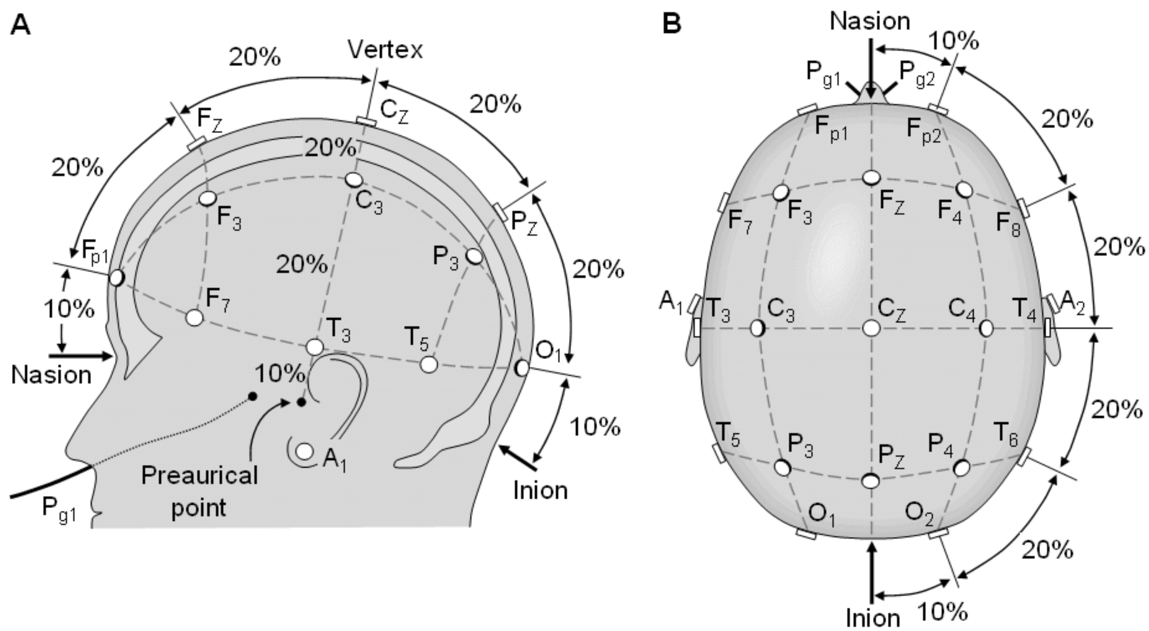

Figure 4. The International 10-20 System of Electrode Placement. Site 01 is located on the left side of the occipital lobe at the back of the head.

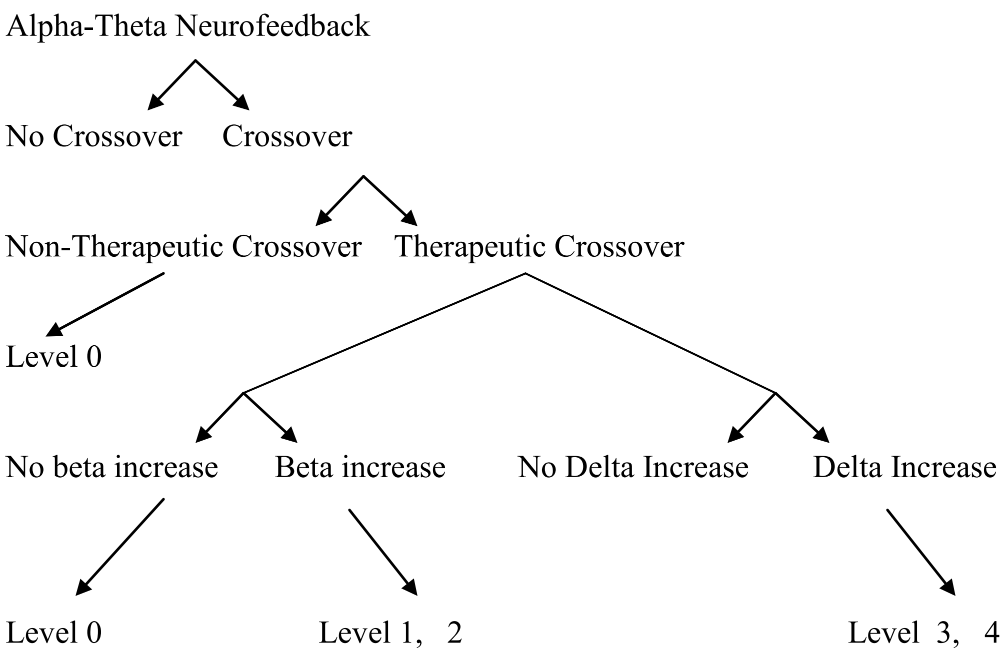

Figure 5. Design of the study; sequence of investigational questions.

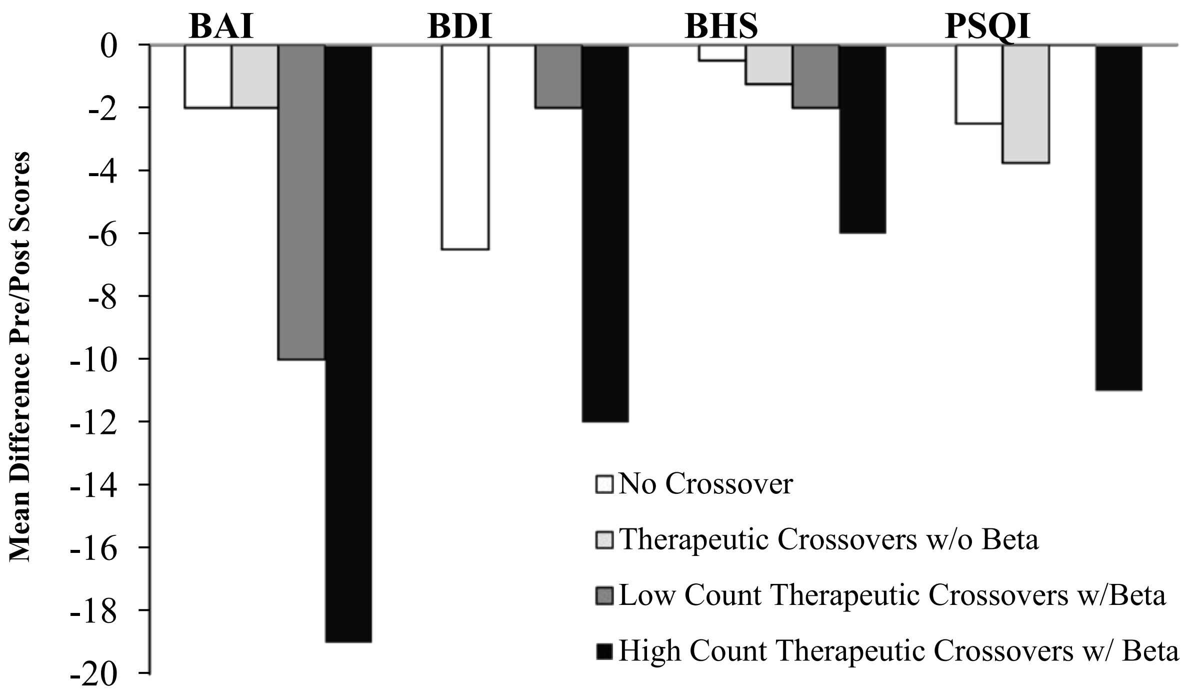

Figure 6. BAI, BDI, BHS and PSQI Outcome measures by crossover type. Mean difference comparison scores of pre- and post-outcome measures on the Beck Anxiety Inventory (BAI), Beck Depression Inventory (BDI), Beck Hopelessness Scale (BHS), and Pittsburg Sleep Quality Inventory (PSQI) for clients with no crossovers (*n*=2), therapeutic crossovers without rise in beta (*n*=4), low count therapeutic crossovers with rise in beta (*n*=1), and high count therapeutic crossovers with rise in beta (*n*=1).

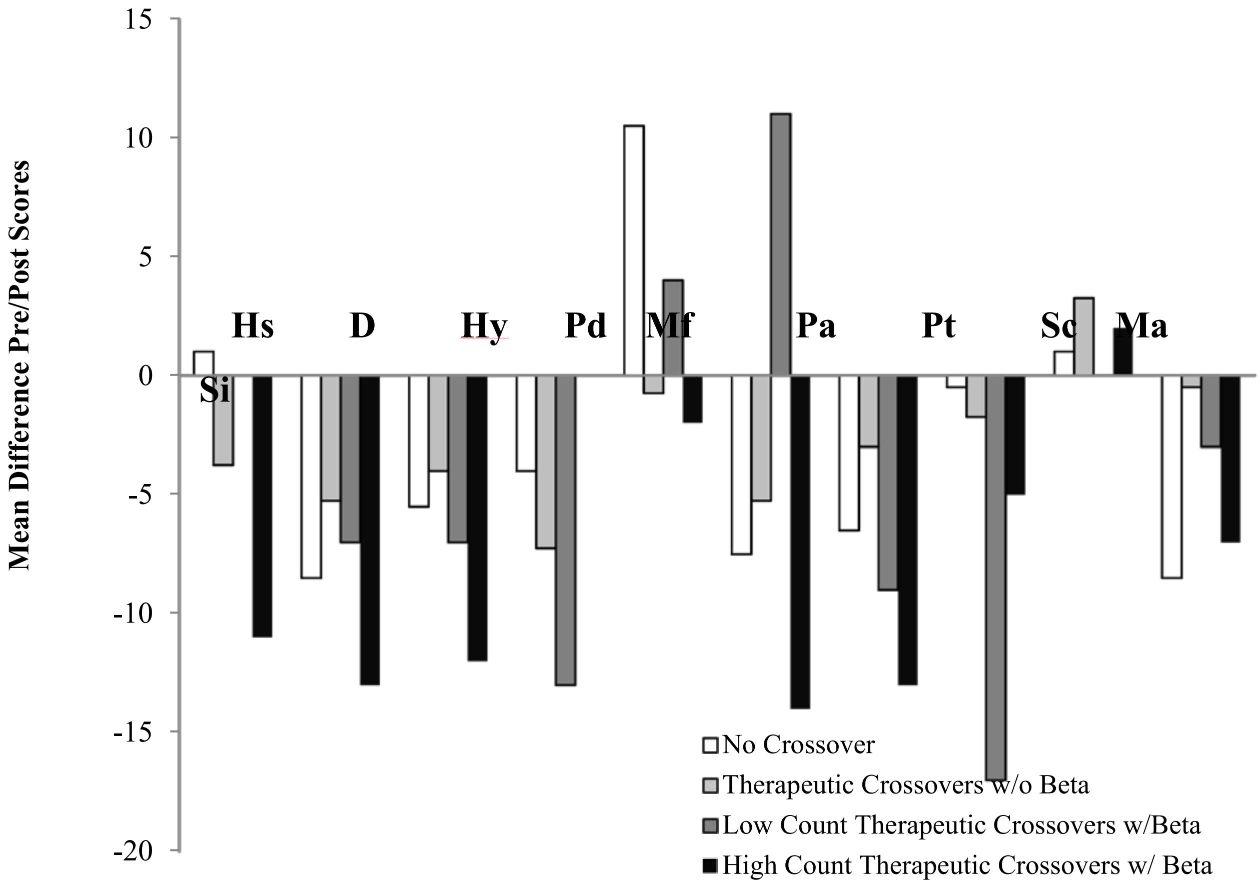

Figure 7. MMPI outcome measures by crossover type . Minnesota Multi-phasic Personality Inventory (MMPI) included Hypochondriasis (Hs), Depression (D), Hysteria (Hy), Psychopathic Deviant (Pd), Male-Female (Mf), Paranoia (Pa), Psychasthenia (Pt), Schizophrenia (Sc), Mania (Ma), and Social Introversion (Si) scales for clients with no crossovers (*n*=2), therapeutic crossovers without sufficient beta (*n*=4), low count therapeutic crossovers with sufficient beta (*n*=1), and high count therapeutic crossovers with rise in beta (*n*=1). Mean difference score change in the negative direction indicates improvement (i.e. – movement away from clinical elevation).

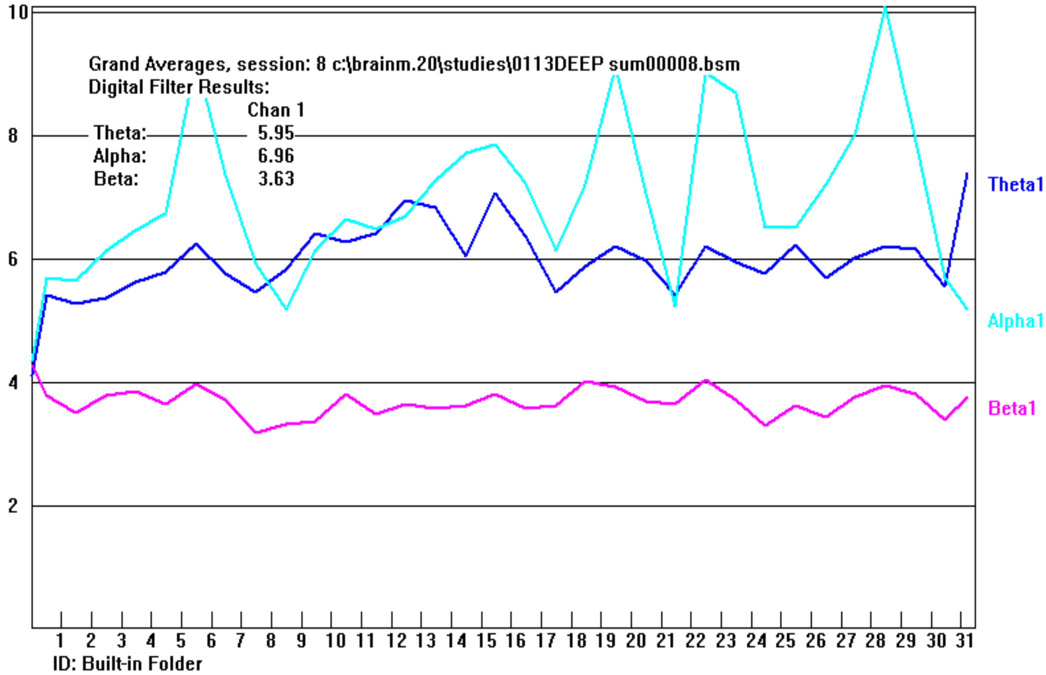

Figure 8. Session exemplifying hypnagogic imagery. Example of a session in which the client reported hypnagogic imagery was characterized primarily by elevated alpha activity.

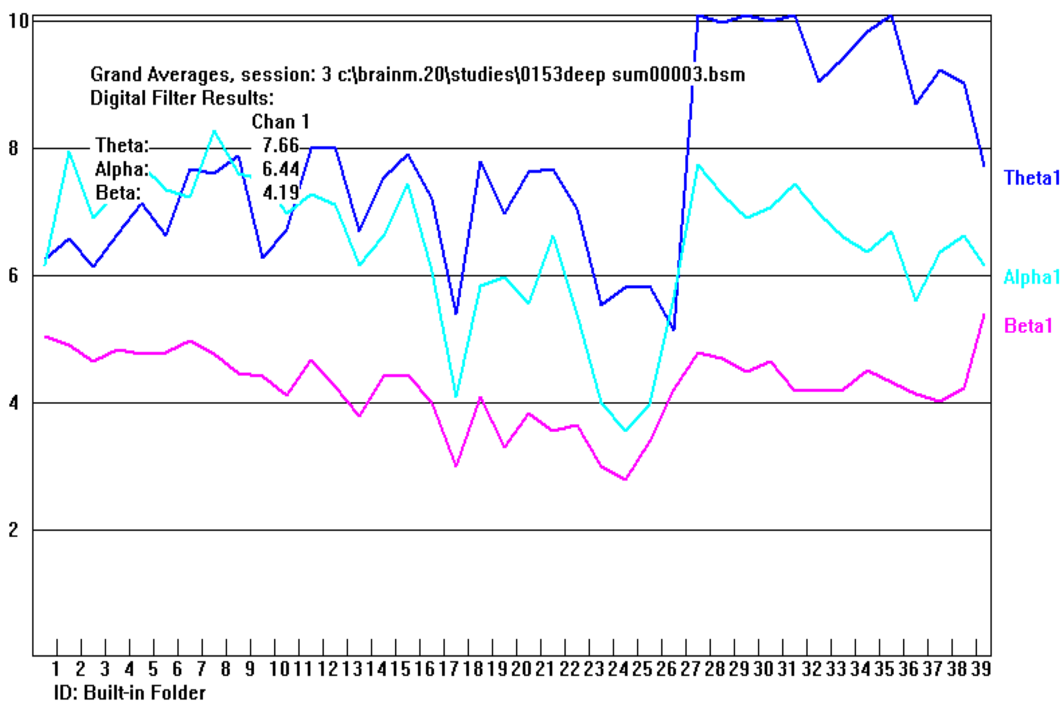

Figure 9. Session exemplifying biographical imagery. Example of a session in which the client reported biographical imagery was characterized primarily by therapeutic crossover with sufficient beta.

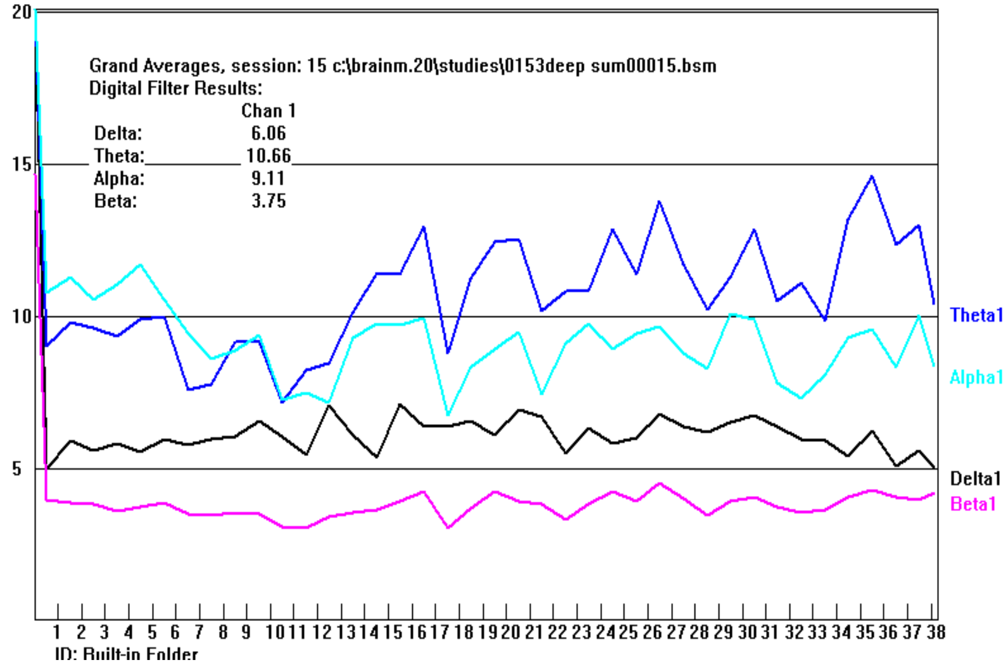

Figure 10. Session exemplifying perinatal imagery. Example of a session in which the client reported perinatal imagery was characterized by therapeutic crossover with sufficient beta, marked by higher amplitudes of alpha and theta, and increasingly elevated delta amplitude activity.

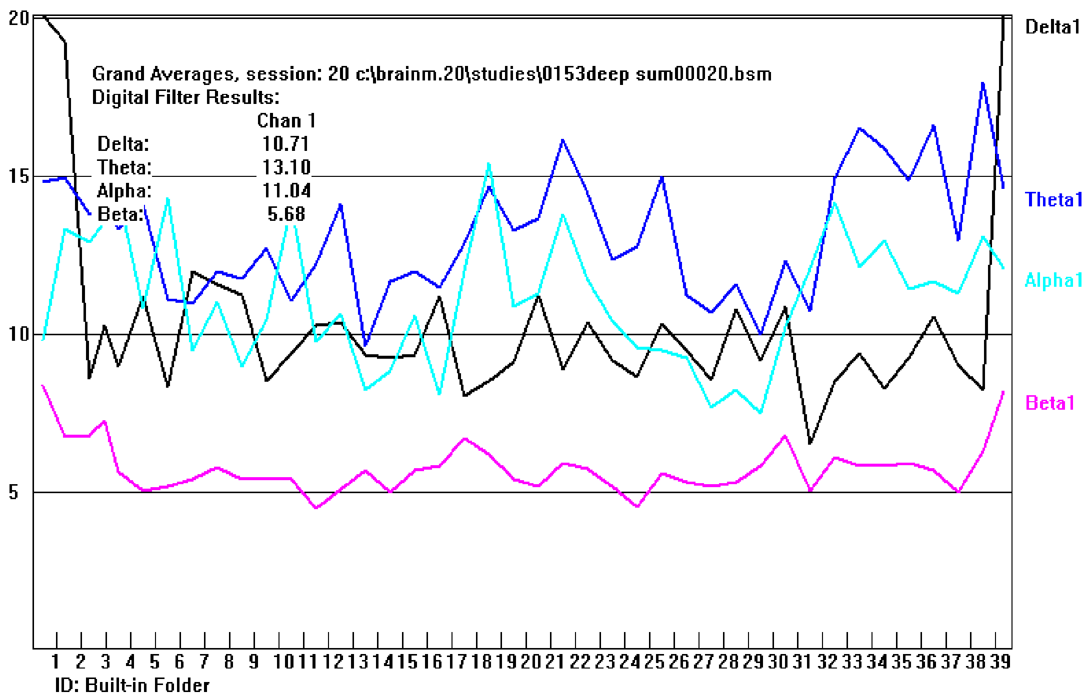

Figure 11. Session exemplifying transpersonal imagery. Example of a session in which the client reported transpersonal imagery was characterized primarily by therapeutic crossover with sufficient beta, and highest amplitudes in alpha, theta, and delta activity.

APPENDIX

ALPHA-THETA CLIENT PROGRESS NOTE FORM

<u>ALPHA-THETA</u> CLIENT PROGRESS NOTES - UNT NEUROLAB

Client #:_________ Therapist: ________________ Session #:_____ Date: ____/____ /09
Time:_______ Room 134: B ☐ C ☐ G ☐ F ☐ Manual Threshold: ☐
Equipment(s): B-master 3.0 ☐; 1☐ Channel; EEG Audio: ☐
HRV ☐ Low ___ % Med___ % High ___ % Coherence; Alpha-Stim ☐ Other:___________
Session Protocol: Site 01 ☐ 02☐ PZ ☐ Theta: 4-7↑ Alpha 8.5-11.5↑ High Beta: 20-30↓

Technical Summary: Include mean and standard deviation changes recorded this session; note changes since last session; calculate percentage time of feedback (pts divided by time X120)

Site(s)	Mean D	Mean T	Mean A	Mean LoB	Mean B	Mean HB	Standard Deviation D	Standard Deviation T	Standard Deviation A	Standard Deviation LoB	Standard Deviation B	Standard Deviation HB	% FB			%

End Thresholds: Delta_____ Theta_____ Alpha_____ Hi Beta_____ lo/Beta ______

End Thresholds: Delta_______ Theta_______ Alpha_______ Hi Beta_______ lo/Beta _______

increased/plateaued ***increased/plateaued***
_______-activity ***decreased*** throughout the session. _______-***decreased*** throughout the session.

increased/plateaued ***increased/plateaued***
_______-activity ***decreased since previous session***. _______-***decreased since previous session***.

Other observations:

Descriptive Summary: Report client's mood, response to various training modalities used in session, behaviors observed, client-counselor interaction, & client self-report including pre-session questionnaire.

Client arrived:	**Dressed:**	**Appeared:**	**Energy level:**	**Mood:**
☐ **On time**	☐ **Nice/formal**	☐ **Well groomed**	☐ **Excessive**	☐ **Happy**
☐ **Few min late**	☐ **Casually**	☐ **Adequate**	☐ **Awake/alert**	☐ **Sad/depressed**
☐ **Very late**	☐ **Disheveled**	☐ **Un-groomed**	☐ **In between**	☐ **Neither**
☐ **Cancelled**	☐ __________	☐ ___________	☐ **Tired/sleepy**	☐ **Irritable**
☐ **No-showed**			☐ **Allergies**	☐ ___________

Descriptive Summary –and/or- Debriefing of Previous Session:

Assessment/Goals/Plans for Next Session:

For Client:	For Therapist:
☐ Next appt scheduled on _____/_____/09	☐ Continue current NF protocols
☐ Continue w/ previous recommendations	☐ Discuss change of NF protocols
☐ Practice HRV/Breathing	☐ Re-map: mid / post
☐ Meditation/relaxation	☐ Additional testing/re-assess/re-evaluate
☐ Journal/expressive writing	☐ Contact collateral source:_____________
☐ In Vivo Activity:____________________	☐ Refer to/for:________________________
☐ Recommended reading:______________	☐ Research:___________________________
☐ CBT Homework:____________________	☐ Bring article/exercise:________________
☐ Other:_____________________________	☐ Other:_____________________________

Debriefing of Current Session:

For Research Purposes:
Crossover: Yes ☐ No ☐; Cognitive Beta↑ Yes ☐ No ☐; Imagery/memories: Yes ☐ No ☐
Level 1 ☐ **Hypnagogic** - colors, shapes, abstract designs, sounds, synaesthesia, environment
Level 2 ☐ **Biographical** – important memories, emotional problems, and unresolved conflicts
Level 3 ☐ **Perinatal** – Intrauterine, womb, birth-related memories/experiences
Level 4 ☐ **Transpersonal** - Identification with ancestral, archetypal, symbolic, past-life, contact w/ deceased, animal/plant, collective/racial, and dual identities, precognition, telepathy, clairvoyance, clairaudience, oneness with all life/creation, out of body & spiritual experiences.

Therapist Signature____________________________

4/20/07 neurolab/forms/clinical/session forms/client progress notes3

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