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THE EFFECTS OF PERFORMANCE ENHANCEMENT TRAINING ON ATTENTION, EMOTION, AND PERSONALITY STYLES

by

DMITRY BURSHTEYN

A dissertation submitted to the Graduate Faculty in Psychology

in partial fulfillment for the degree of Doctor of Philosophy,

The City University of New York

2000

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This manuscript has been read and accepted for the Graduate Faculty in Psychology in satisfaction of the dissertation requirement for the degree of the Doctor of Philosophy.

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Abstract

THE EFFECTS OF PERFORMANCE ENHANCEMENT TRAINING ON ATTENTION, EMOTION, AND PERSONALITY STYLES

by

Dmitry Burshteyn

Advisor: Professor Ching-tse Lee

The purpose of this study was to investigate the effects of performance enhancement alpha-increase training on human attention, brainwave patterns, personality styles, positive affect, self-esteem, and life-satisfaction. Three experiments were conducted to investigate the aforementioned issues. The results of the first experiment indicated that training resulted in statistically significant improvement on measures of reaction time, $F\ (1,9) = 34.99, p < .0001$,and reaction time variability, $F(1,18) = 10.46, p < .005$, for the experimental group. The second experiment indicated that in addition to an increase in alpha in the posterior region of the brain, (Pz), $F(1,7) = 72.84, p <. 001$, the training also produced a simultaneous increase in alpha (8-13 Hz) in the anterior region of the brain, (F4), $F(1,14) = 17.62, p < .001$. The third experiment resulted in statistically significant changes in personality styles measures of thinking, $F(1,9) = 15.007, p < .004$, and modifying, $F(1,9) = 10.852, p < .009$, as well as in measures of life satisfaction, $F(1,9) = 22.157, p < .001$, positive affect $F(1,9) = 28.43, p < .001$, and self-esteem, $F(1,9) = 29.79, p < .001$.

DEDICATION AND ACKNOWLEDGEMENTS

My deepest gratitude to everyone who provided support, encouragement, expertise, wisdom, and friendship along the way. This work is yours as much as it is mine.

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INTRODUCTION

Theories of Attention

At the end of the nineteenth century, William James noted that every person "knows what attention is." In his view, attention is "taking possession of the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thoughts." James observed that attention implies "withdrawal from one thing in order to deal effectively with others" (James, 1970). John R. Anderson (1995) believed that attention is essentially a process that involves the allocation of processing resources among ongoing cognitive events. Robert J. Sternberg (1999) defined attention as a process that links the limited amount of mentally manipulated conscious information with the colossal amount of information available through the senses, stored memories, and other cognitive processes.

According to Sternberg, attention plays a pivotal role in our cognition. It enables us to monitor our interaction with the environment, maintaining our awareness of how well we are adapting to the situation in which we find ourselves, and linking our past memories and present sensations to give us a sense of continuity of experience. Therefore, attention may serve as a basis for personal identity, controlling and planning for our future actions.

An individual focuses her attention by "dimming the lights" on the majority of stimuli, both internal and external. These may include outside sources of noise, along with internal "noise" such as thoughts, memories, and emotions (Sternberg, 1999). Mihaly Csikszentmihalyi (1990) considers attention as a medium that makes events occur in consciousness, and suggests that it would be helpful to think of attention as psychic or mental energy.

An enormous amount of research has been conducted in the field of psychology since William James first addressed the issue of attention. Many fascinating discoveries have been made in the past 13 decades. Yet, as we now move into a new millenium, no single definition of attention is accepted as universal. Despite this lack of consensus, most of the experts in the field agree on several general statements concerning the properties of attention.

Most scientists agree that attention involves both preconscious and conscious processing. It is usually referred to as an automatic process when it requires no conscious control, and as a controlled process when conscious control is required (Schneider & Shiffrin, 1977). Csikszentmihalyi (1990) notes that conscious attention is the function without which no qualitative learning of a new skill can take place. Since the objective of this paper is to emphasize the importance of conscious self-regulation of attention leading to an increase in attentional capabilities, we shall focus on the conscious control of attentional processes. There are three major areas of research investigating conscious attention. These are selective attention, divided attention, and signal detection. Alertness, arousal, and vigilance have also been accepted as being factors influencing attention.

Early in the experimental investigation of attention several landmark studies were carried out investigating selective attention from the signal blocking or signal attenuation perspective. Experimental results suggested the existence of some sort of information bottleneck with a built-in filter, allowing only some of the selected information to pass through (Broadbent, 1958; Morray, 1959; Triesman, 1960, 1964a, 1964b; Deutch & Deutch, 1963). There has been some disagreement among the aforementioned researchers as to the exact location of the filter in the attentional system, as well as the qualitative and quantitative properties of information that can pass through the barrier.

Broadbent (1958) suggested the existence of an attentional filter that allows only one particular stream of information to reach the level of perceptual processing. His model, however, was later criticized for not allowing for any possibility of parallel processing. Moray (1959) suggested that more than one stream of information can be attended to simultaneously. Consequently, although an individual needs to focus on one informational stream to analyze its meaning effectively, some information from the second stream will still be available provided it has sufficient salience. Triesman (1960, 1964a, 1964b) indicated that an attenuation filter, rather than a selective filter operates between the sensory register and perceptual processing stages. Deutch and Deutch (1963) suggested that the location of Triesman's filter must be modified, and the filter should be placed between the perceptual processing stage and the short-term memory stage. Niesser (1967) was able to unify most of the filter approaches. He suggested that automatic processes operate early on in processing, occur in parallel, and are able to detect physical properties of the stimuli. Controlled attentive processes occur later, both serially and in parallel, and involve extracting meaning and forming mental representations of the information.

Feldman et al. (1994) supported the notion of considering an information bottleneck as inherent in the individual's psychological structure. According to them, there is a limited number of information units an individual can process at a time. They hypothesized that the estimated duration of each "attentional unit" is about 1/18 of a second. Thus, a person can become aware of 90 to 162 bits of information in the space of a second, with an average capacity of 126 bits. Therefore, a person can process 7, 560 bits of information per minute. In a lifetime of 70 years with a waking day of 16 hours this amounts to 185, 000,000,000 bits of information. Considering that it takes 40, 000 bits of information per second to succeed in speech comprehension, our "maximal level of attentional experience" is not that large. Although encoding strategies allow us to optimize the use of our resources, the knowledge of this upper limit should give us an idea of how valuable it can be to improve the usefulness of every single bit of information. We can enhance the quality of learning experiences by optimizing our attentional capabilities.

Thus, most researchers agree that we have some sort of a limit to the amount of information we can focus our limited cognitive processing resources on at a given time. The analysis of the psychological phenomenon of attention, when applied appropriately, presents us with the possibility of further maximizing effective use of our resources. The latest models of attention have emphasized the importance of the allocation of limited processing resources, rather than information filtering and blocking, in looking at the process of divided attention as a method of resource utilization method in information processing (Kahneman, 1973; Wickens, 1980).

Kahneman (1973) favored a perspective emphasizing the importance of allocation of limited processing resources, initially considering these resources to be undifferentiated with regard to the modality in which a task was performed (Kahneman, 1973). However, he later modified his position when Wickens (1980) introduced the concept of modality to the field. Wickens discovered that when the attentional system performs more than one task at the same time, performance is affected to a larger extent when those tasks are performed in the same modality. This finding gave rise to a multiple-resource theory whereby Wickens (1980) also identified three different pools of processing resources, as compared to Kahneman's one common pool. These are early vs. late processing, auditory vs. visual processing, and verbal vs. spatial processing (Wickens, 1980).

The signal detection function of attention has been mainly investigated in connection with vigilance and arousal (Neiss, 1988). Vigilance is essential for detection of a signal and responding to the detected information as quickly as possible. It is therefore fundamental to the individual's ability to maintain sustained attention for an extended period of time. According to Sternberg (1999), vigilance is a person's ability to attend to a field of stimulation over a prolonged period of time, in which the person seeks to detect the appearance of a particular target stimulus of interest. Fisk and Schneider (1981) discovered that the performance of individuals on a variety of tasks varies as a function of sustained vigilance. Sternberg (1999) noted that training may help to increase performance, but only in tasks requiring sustained vigilance. Vigilance was also found to be a key factor in signal detection and in the process of visual search. Individuals use this type of attention for the detection of target signals when they have been prompted to take speedy actions when such target stimuli appear. According to Eysenck and Byrne (1992), a degree of alertness and arousal is also an important factor influencing attention: being tired or drowsy limits attention. They also indicated that both trait-based anxiety and situation related anxiety affect attention.

According to Kahneman (1973), the allocation of attentional resources is determined by the overall level of arousal or state of alertness. Kahneman's attentional model suggests that high levels of arousal can interfere with performance. This assumption is consistent with the Yerkes-Dodson (1908) law, which indicates that performance is best at an intermediate level of arousal. This intermediate level of arousal allows an individual to reach an optimal capacity for a particular task. Kahneman also suggested that the level of arousal depends on the complexity of the task. Individuals are less aroused when performing an easy task and more aroused when performing a more difficult one.

Kahneman (1973) was the first researcher to incorporate individuals' ability to control and direct their mental resources into the attentional theory. He suggested that individuals are not just passive filtering mechanisms. Instead, they play an important role in attention by choosing which stimulus to focus on, and directing their mental efforts toward reaching their goal. His model specifies two important aspects of attention. The first indicates that arousal affects our attentional capability, and the second provides the mechanism of allocation of the processing resources through the means of mental effort. He called this an allocation policy, which is affected by an individual's dispositions or voluntary attention. Therefore, controlled attention, according to Kahneman, is an interaction of alertness and mental effort. His model also predicts that individuals pay more attention to things they are more interested in. This implies that by affecting levels of arousal, alertness, and vigilance, it is possible to affect attentional processes (Kahneman, 1973).

In addition to the aforementioned landmark studies, current investigations of Attention Deficit Disorder (ADD) have contributed to our deeper theoretical understanding of attention. According to Barkley (1997) there are three primary diagnostic symptoms for ADD. These are poor sustained attention, impulsiveness, and hyperactivity. Some of the neuropsychological functions that have been implicated as key elements in ADD are arousal, self-regulation, and working memory (Barkley, 1997). Douglas (1972, 1980) implicated the key roles of sustained attention and impulse control in this disorder. As a disorder, ADD presents a major impairment in self-regulation, resulting in a number of dysfunctions that have been mentioned as extremely important in the etiology of this disorder. These include deficient modulation of arousal to meet situational demands, difficulties with impulse control, poor investment and maintenance of effort, and a strong inclination to seek immediate reinforcement. It has been suggested that hyperactivity arises from the inability to maintain an ultimate level of arousal, resulting in hyperactive stimulation seeking behavior (Zentall, 1985).

Neurophysiology of Attention

One of the objectives of this paper is to investigate the neurophysiological foundation of the networks that regulate attentional processes. According to Posner and Raichle (1994), Posner and Dehaene (1994) and Mesulam (1981) there are six major areas of the brain that combine to form several attentional networks and systems. These are the reticular formation, the superior colliculus, the thalamus, the singulate cortex, the parietal lobes and the frontal lobes. The reticular formation is a brain center implicated in the processes of alertness and arousal. The superior colliculus directs attention to various locations and objects. The pulvinar area of the thalamus is considered to be the brain's relay station, and plays an important role in selective attention. Attentional and emotional information is integrated by the singulate cortex. The parietal lobes oversee the allocation of processing resources to a particular stimulus, and the frontal lobes allocate attentional resources toward a selected motor response (Posner et al., 1994; Mesulam, 1981).

Posner and Raichle (1994) described a structural-functional continuum that plays an important role in supporting the signal detection function of attention. A major problem of attention, according to them, is maintaining a sustained state of alertness. To be successful on tasks that require fast responding to a target with a high degree of accuracy a subject needs to maintain an alert state of mind. These authors implicated several areas of the brain responsible for maintaining this relaxed and alert state, and suggested that they are part of a network. They named this network the Vigilance Network of Attention, and described its role in maintaining an optimal level of arousal. The right frontal lobe, along with the parietal lobe, the pulvinar, and the colliculus, are all parts of this network. They emphasized the importance of a dual feedback system between the parietal lobe and the anterior singulate cortex: as activation in the right parietal lobe rises, activation in the anterior singulate nucleus is inhibited. Posner and Raichle (1994) also noted that the reverse activation of these regions always produces very high levels of arousal. They hypothesized that several physiological reactions take place in the body and in the brain to sustain this state. Specifically, the heart rate slows while blood flow to certain areas of the brain is increased, and electrical activity (EEG) recorded from the scalp is reduced (Posner & Raichle, 1994).

In signal-detection tasks, when one needs to suspend attention while waiting for the signal, it is important not to carry out any mental operations. An increase in alpha wave EEG amplitude in subjects' parietal regions while they report being relaxed and alert points toward alpha's importance in achieving an optimal level of arousal (Kamiya, 1969; Green, 1991; Parks, 1995, 1996; Norris et al., 1998). Sterman (1994) related this generation of electrical potentials to the influence on the thalamus of three integrative activities in the neurons of brain: vigilance, sensorimotor integration, and cognitive integration. The vigilance system involves both diffuse networks and specific centers in the brainstem and their ascending influence on thalamic, subcortical and cortical centers. Sterman (1996) related the generation of sensory-motor, alpha, and theta EEG rhythms to the presence or absence of input from these systems influencing the thalamic oscillatory generators. When vigilance is withdrawn (as in states of inattentive drowsiness), slow wave EEG activity begins to spread throughout the human brain.

In her research based on patients with unilateral lesions of the parietal lobes, Martha Farah (1994) discovered that attention involves an interaction between diverse areas of the brain. Posner and Raichle (1994) also indicated that attentional processes are neither controlled by one particular part of the brain nor by the entire brain. They proposed several additional attentional networks and systems, and indicated that a complex interaction of these networks regulates an individual's attention. The Vigilance Network therefore interacts with a number of different attentional networks, and thus, by affecting the Vigilance Network of Attention, one can influence other networks.

Posner and Dehaene (1994) proposed a total of three networks and two systems of attention. They distinguished between frontal and posterior attentional systems. Their posterior system deals with the movement of the focus of attention in space, while the function of their anterior area makes it possible for people to sustain attention on particular objects despite the presence of other stimuli in the environment. The frontal system is active when performing tasks requiring planning and selecting an action, and on tasks requiring attention to the meaning of words. The posterior system involves the parietal lobes of the cortex, the pulvinar, and several areas of the midbrain related to eye movements. This system becomes activated on tasks requiring visuospatial attention. According to Banich (1997), the parietal lobes serve to integrate information related to an individual's internal state with information from the external sensory world. It acts to release attention from its current focus and signals movement of the spotlight of attention from its current location to another cue or a different area of the present cue. The thalamus selects the contents of the attended area and emphasizes those contents so they are given priority in processing by anterior areas that detect targets and generate responses (Posner & Dehaene, 1994).

Posner and Raichle (1994) described the importance of their Vigilance Network of Attention, and hypothesized a neurophysiological connection between areas of the network and the locus coereleus, where norepinephrine is produced. It has well-developed anatomical connections with the parietal lobe, pulvinar, and superior colliculus—all parts of the visual attention system. They suggested that a relationship exists between the vigilance system and awareness, and that vigilance serves to maintain attention to input information (Posner & Raichle, 1994).

Attention and EEG

Changes in alertness and vigilance have been associated with changes in the electrical activity of the brain measured by EEG (Niedermyer &DaSilva, 1982; Duffy et al, 1989; Naatanen, 1992; Sams, 1996; Posner & Raichle, 1994; Posner & Dehaene, 1994). Other methods of studying attentional processes have become available since the advent of the EEG. Specifically, changes in blood flow to a particular area measured by Positron Emission Tomography (PET) scans, regional cerebral blood flow (rCBF) as measured by rCBF scans, magnetic resonance imaging (MRI), and oxygen concentration by functional MRI (fMRI) have been used to assess the neurophysiological correlates of attention.

In the opinion of the author of this paper, the EEG still remains the best way to investigate attentional properties in research and clinical settings. The EEG accurately describes communication between different areas of the brain and can be used to record the brain's electrical activity in real time. It has excellent temporal resolution in comparison with invasive PET scans and noisy procedures with poor temporal resolution such as the MRI.

PET scans and MRI can best be applied to show the localization of a particular function in the brain while EEG techniques can best be used to show the temporal sequence of information processing within that anatomy. PET and other imaging methods utilizing blood flow provide little information about the sequence of rapidly occurring mental operations because while a signal crosses a synapse in only a millisecond, it takes from several hundred milliseconds to several seconds for neuronal activity to change the blood supply. In order to perform successful research in the area of attention it is advantageous to know when the connections are first activated, in what order, and for how long. The EEG technique allows us to accomplish all of the above, and provides a much more sensitive record of the chronology of responses (Naatanen 1988; Posner & Raichle, 1994; Martin, 1998; Banich, 1997).

Current theories suggest that there are two known sources contributing to the production of EEG signals. One is located in the thalamus and is referred to as the thalamic pacemaker (Dempsey & Morison, 1942; Sterman, 1996). The second major source has cortical origins (Duffy, 1989; Thatcher et al., 1994). Dempsey and Morison (1942) were the first to identify thalamic nuclei as pacemaker regions for the EEG. According to Sterman (1996), the repetitive waves that can be recorded from the surface of the scalp are summated synaptic potentials generated by the pyramidal cells in the cerebral cortex. These potentials are the responses of the cortical cells to rhythmic discharges from the thalamic nuclei. During activation, inputs from the reticular formation produce rhythmic discharges in the thalamic nuclei and desynchronize cortical potentials.

Duffy (1989), Posner and Raichle (1994), Martin (1998), Niedermier and DaSilva (1989), Sams (1996), and Lubar (1997) have all suggested that EEG patterns are correlated with levels of alertness. These levels range from coma to hyperactivity, and include sleep, drowsiness and alertness. Sterman's (1994, 1995) work provides a direct correlation between specific EEG rhythms and the attentional processes involved in motionless vigilance. More specifically, the broad range of event related potential (ERP) studies illustrate that specific components of perceptual and attentional processes can be reproducibly correlated with specific EEG waveforms (Hillyard, 1985, 1987).

Risto Naatanen (1988a, 1988b, 1990, 1992) from the University of Helsinki conducted robust research in the area of EEG Evoked Potentials and attention, focusing on investigating the relationship between event related brain potentials (ERP) and attention. He studied exogenous and endogenous ERP components in auditory and visual attentional processes, and used the EEG to investigate the exact locations of the neuronal generators involved in attention. He thus attempted to bridge the gap between the theoretical concept of allocation of processing resources and its structural implementation in actual neural networks. Naatanen (1992) found a specific brainwave pattern that appeared in an individual brainwave recording when the test stimulus presented to the individual differed from the standard stimulus. He called this brainwave pattern a mismatch negativity (MMN) pattern. He also discovered a particular EEG pattern corresponding to the effect of arousal. According to his research, arousal is usually associated with an increase in the N1 component of the ERP. Exogenous EEG components are not only the products of external sensory stimuli but are also influenced by a wide range of internal organismic factors. Exogenous components, however, are relatively stable while endogenous components are more variable. He indicated that early ERPs reflect neural activity related to the detection of the stimulus location (about 100 ms), while ERPs of 200 msec and longer reflect stimulus feature integration and object identification. P300—a positive deflection wave occurring with a latency of 300 msec after stimulus presentation—has been known to change in amplitude corresponding to various cognitive loads. The higher the cognitive load the smaller is the amplitude of the P300. Naatanen was able to distinguish the underlying brain stem responses as auditory cortex deflections. The auditory cortex was implicated in the production of the N1 component. Alertness and arousal tend to enhance the N1 component most of the time, and it was found to be higher on tasks with better performance. (Naatanen, 1988a, 1988b, 1990, 1992).

Brainwaves and Signal Detection

One of the limitations of EEG-ERP research is its primary focus on automatic unconscious processing. Furthermore, while areas of selective and divided attention have been thoroughly investigated, the area of signal detection has not been given enough focus.

Since the mid-1970s more research has been conducted on the topic of signal detection utilizing quantitative aspects of the EEG and states of attention. Sterman et al. (1992, 1994, 1995, 1996), and Lubar et al.(1970, 1976) investigated various EEG frequencies and their corresponding attentional states within the individual. High percentages of slow brainwave frequencies such as delta (0-4 Hz) and theta (4-7 Hz) are associated with drowsy states and sleep spindles, while faster frequencies (16-32 Hz) are associated with hypervigilance (Lubar, 1997).

In 1978 Stoyva and Kamiya proposed that amplitude increases within alpha EEG frequencies (8-13 Hz) are strongly associated with a relaxed and alert state. This relaxed and alert state has been implicated as essential for optimal attentiveness (Kahneman, 1973; Posner & Raichle,1994). Ray and Cole (1985) also suggested that alpha EEG activity reflects the level of attentional demand. A number of studies reported that changes in alpha wave amplitude and percentage led to better performance on tasks requiring attention to the environment, while an increase in slow theta activity or high beta activity led to performance deterioration. Beatty et al. (1973) demonstrated that a decrease in vigilance is associated with an increase in slow theta wave activity on the EEG. They reported that an operant increase in slow wave activity leads to deterioration in performance on a continuous performance radar monitoring task, while an operant decrease in slow wave performance leads to a decrease in numbers of errors committed. This has been correlated with an increase in vigilance. They also demonstrated that an individual's reaction time (RT), measured by the Test of Variables of Attention (TOVA), correlates with the amplitude of theta. The higher the amplitude of theta, the higher were the reaction times to the stimuli (Beatty et al., 1973).

Sterman et al. (1992) indicated that high-workload tremendously suppresses alpha activity leading to early exhaustion in most people. O'Hanlon and Kelly (1993) investigated the vigilance of poorer and better drivers as defined by the frequency of lane drifting. They correlated self-assessment scores of alertness and fatigue with driving performance, and found extremely low vigilance as reflected by behavioral indications in drivers, such as slouching over the wheel, resting elbows on the wheel, and staring at the road without interest or reaction to traffic changes. The power of slow-wave activity increased as the session progressed, and the number of errors increased as participants shifted to the theta state. They found a consistent relationship between an increase in percentage of theta waves, which in high proportion is associated with sleepiness, and an increase in driving errors (O'Hanlon & Kelly, 1993). According to Sterman (1996), suppression of slower frequencies translates into the ability to sustain attention better. Training that focuses on the suppression of these frequencies, therefore, may reduce drowsiness and even facilitate mental capabilities.

Several studies indicate that alpha seems to be the ultimate state for sustained attention tasks. Crawford et al. (1995) found that subjects who produced higher alpha amplitudes performed better on a sustained attention task. This finding pointed toward the importance of an increase in alpha percentage and a consequent decrease in the proportion of other waves, such as theta, in order to sustain attention. According to Sterman (1994), pilots who were able to maintain their alpha level during flight simulation were more accurate in their tasks than pilots whose alpha level decreased during flight simulation.

In 1984, Hartfield et al. noted that left hemisphere shifts in alpha were noted in peak performance of archers, gunners, and basketball players. He discovered a burst of alpha waves in the left hemisphere of an expert shooter just before the sharpshooter pulled a trigger (Hartfield, 1984). Crews (1989) found changes in left hemispheric alpha to be related to improved performance in golfers. To be successful in the tasks investigated in the studies described above, an individual must be skilled in components related to attention such as concentration, impulse control, reaction time and accuracy.

Alpha-increase Training and Attention

These research studies stimulated interest in the effects of operant alpha-increase training on attention and performance enhancement in increasing alertness and vigilance and improving attention on tasks requiring signal detection. Joe Kamiya (1969) was the first researcher to attempt to train subjects to increase the level of alpha activity with operant conditioning. Kamiya initially asked subjects to tell him at the sound of a tone whether their brain waves were in an alpha state or a non-alpha state, and he found that participants could successfully make this discrimination. In their 1970 article, Nowles and Kamiya indicated that participants could establish operant control of alpha brain waves, specifically increasing and decreasing alpha activity. This finding clearly demonstrated the possibility of voluntary control of alpha rhythms. Participants in this study also reported general relaxation and overall pleasant sensations as a result of the generation of alpha rhythms. Hardt and Kamiya (1978) suggested that high anxiety subjects, whose brains were usually geared toward fast activity, showed a decrease in anxiety in high anxiety settings as a result of alpha training.

According to Parks (1996), alpha-increase training offers instrumental and methodological aids to learning a set of skills that emphasize the interaction of mental, emotional, and physiological processes. Self-regulation training strategies are introduced by teaching sensorial awareness of physiological processes that usually occur without conscious awareness. Such training procedures have been reported to encourage internal exploration, which is believed to have the potential to lead to conscious awareness of normally unconscious mental, emotional, and physiological processes. From a theoretical perspective, conscious awareness of psychophysiological processes provides an opportunity for the individual to coordinate these processes. Such mind-body coordination skills might provide useful tools in an effort to promote the harmonious integration of conscious and unconscious processes. It has been suggested that with the use of alpha-increase training strategies individuals can learn to modify their attentional states by learning to modify their EEG frequencies and amplitude (Parks, 1996).

Alpha-increase training, as described by Green et al. (1991), has been associated with an experiential state of calm and deep relaxation. Landers (1991) monitored the brain wave patterns of students as they learned archery and found that the brain wave patterns displayed during shooting changed as the archers' skills improved. At the end of alpha training, beginning archers showed left hemispheric alpha bursts prior to releasing the arrow. This alpha pattern was also found in experienced archers as they released the arrow. In 1978, Kamiya discovered that subjects in a high state-anxiety group experienced a reduced state of anxiety after having benefited from alpha training. Watson, Herder, and Passini (1978) conducted an 18-month follow-up study on subjects who received alpha training and found that improvements on a variety of tests, including state and trait anxiety scores, remained the same 18 months after the training. Overall, this study demonstrated the possibility of long-lasting effects of an alpha training program.

Norris et al. (1998) conducted a case study that clearly demonstrated the positive effects of alpha-increase Performance Enhancement Training on some variables of attention, specifically, reaction time and reaction time variability. Their results strongly support the results of Watson et al.'s (1978) study, indicating not only changes in alpha wave amplitude and frequency as a function of changes in attentional demands, but also changes in variables of attention as a result of alpha amplitude increase. Their data suggested that an increase in alpha amplitude enhances individuals' performance on tasks measuring attentional variables as they improve their ability to sustain attention.

Andrew Abarbanel (1995) suggested that the neurophysiological mechanism underlying alpha-increase during neurofeedback training involves the individual learning to exercise neuromodulatory control over the neural circuitry mediating the attentional process, thus triggering a short-term change in synaptic efficacy. He implicated long-term potentiation (LTP) as playing an important role in the consolidation of an optimal state of the attentional system because of its long-term synaptic influence. During neurofeedback training sensory and proprioceptive input initiates feedback regulation of the motor circuits. Over time, practice consolidates attentional capacity by mediating neuronal plasticity (Abarbanel, 1995).

In their 1998 article, Hoptman and Davidson investigated baseline EEG asymmetries and performance on neuropsychological tasks. They discovered that asymmetries in EEG alpha activity were correlated with performance levels on several tasks. They also discovered that asymmetries over anterior scalp regions are possibly independent from those in posterior regions.

Attention and Emotion

A large number of studies suggest strong connections between processes of attention and emotion. Heilman et al. (1985) described two neurological pathways connecting the cortical, limbic and hippocampal regions implicated in attention and emotion. Sensory transmission occurs as a result of input from the reticular activating system, via the thalamus, to primary sensory areas. The nucleus reticularis in the thalamus can inhibit thalamocortical flow from specific thalamic nuclei. Cortical arousal occurs, on the other hand, as a result of sensory input reaching the cortex directly from the reticular formation. This leads to a flow of information to the limbic system, prefrontal cortex, superior temporal cortex, pertinent cortical sensory reception areas, and sensory association areas, as well as the nucleus reticularis in the thalamus (Heilman, Watson, & Valenstein, 1985). Sterman (1994) emphasized the role of the brainstem-thalamic-cortical system in attentional processes. Thalamic centers involved in attentional processes can induce LTP in the hippocampus (Doyere et al., 1990). Furthermore, hippocampal and other limbic centers can neuromodulate centers in the brainstem that are responsible for alertness and arousal (Derryberry & Tucker, 1990). Ascending brainstem modulation of thalamic and limbic centers affect switches between different EEG states via dopaminergic and noradrenergic centers mediating attentional states (Abarbanel, 1995). These findings suggest that the function of several centers in the limbic system should be incorporated into current attentional theories.

In addition, Abarbanel (1995) suggested that disturbances of attention and concentration always involve disturbances in limbic functioning. Depression and mania, for instance, both involve difficulties with attention and memory, a function mediated through limbic centers. In addition, several animal studies reveal that hippocampal lesions produce symptoms similar to ADD in humans, include hyperactivity, distractibility, and obsessions with certain activities (Pribram & McGuinness, 1992; Crowne & Riddell, 1969).

Josesph E. LeDoux (1986, 1994) presented evidence demonstrating the importance of projections from sensory neurons in the neocortex and the thalamus to the limbic system. He looked at emotion as the information processing function of the nervous system and suggested the possibility that sensory messages to the subcortical forebrain are transmitted directly from thalamic nuclei, without first being relayed through the neocortex. This transmission occurs in parallel to the classical sensory projection system, transmitting input through thalamic relay nuclei to neocortical sensory receiving areas, and from there to cortical association circuits and subcortical regions of the forebrain.

Consistent with these findings, similar areas have been implicated as areas of EEG origin and as parts of attentional networks (Niedermyer & DaSilva, 1982; Duffy et al. 1989; Naatanen, 1992; Sams, 1996; Posner & Raichle, 1994; Posner & Dehaene.1994).

The series of experiments to be reported here is intended to show that alpha-increase Performance Enhancement Training (PET) provides a powerful approach to mediating attentional and emotional functions of the brain. The changes in electrophysiological properties of the brain produced by alpha (8-13 Hz) training lead to improvements in sustained attention. These changes lead to changes in emotional function and result in increases in positive affect, life satisfaction and self-esteem. The training also affects modifying and thinking-feeling personality styles.

In summary, the major purpose of this investigation was, first, to show that PET improves human attention. The changes in attention were measured by the Test of Variables of Attention (TOVA), for four attentional variables: reaction time, reaction time variability, errors of omission, and errors of commission. Second, global and local electrophysiological changes in the brain produced by the training were investigated. Quantitative elelectroencephalographic evaluation (QEEG) was conducted for nineteen locations on the scalp. This evaluation focused on anterior and posterior attentional networks, and anterior areas involved in affective processing and executive functions. The observed changes are thought to be related to the underlying neurophysiology of attentional and emotional networks.

Positive Affect and Personality Styles

Finally, strong neurophysiological connections between brain areas responsible for attention and emotion, and reports of training effects on participants' affective states and subjective well-being, prompted us to conduct a third experiment investigating possible changes in individual affective processes. The instruments used for measuring changes in subjects' affective processes were the Positive Affect Scale (PAS), and the Life Satisfaction Inventory (LSI) (Martinez-Pons, 1999). In addition, it was hypothesized that modification of affective characteristics would lead to new interactions between the individual and his/her environment, potentially resulting in new behavioral patterns and personality styles. In particular, changes in personality styles on the emotionally related thinking and modifying scales, as well as measurements of life satisfaction, were of interest. In addition, participants' introspective reports obtained during the pilot project indicated that this type of self-regulatory training results in increases in subjects' self-esteem. The differentiation between changes resulting from cognitive factors and those resulting from neurophysiological changes were specifically investigated.

EXPERIMENT 1

The purpose of my first experiment was to investigate the effects of Performance Enhancement Training on participants' sustained attention. It was hypothesized that participants would improve on tasks measuring number of commission errors committed, number of omission errors committed, reaction time, and reaction time variability.

Method

Participants. Twenty healthy college students participated in this study as volunteers. They had no previous history of EEG biofeedback training. Participants were randomly assigned to either the experimental group that received Performance Enhancement Training or to the control group that was not given training of any kind. There were ten students in each condition.

Materials. The experiment was conducted in the Biofeedback and Behavioral Medicine Laboratory at Brooklyn College. The Performance Enhancement Training was conducted using the Lexicor POD-2 Mental Conditioning System. A POD-2 performance optimization device was used for the brainwave training. POD-2 is a two-channel EEG unit capable of simultaneously recording two EEG inputs from any one or two locations on the human scalp. It is a real-time digital acquisition device capable of raw-data acquisition and power spectrum measurement.

The pre- and post-TOVA continuous performance test was used to assess variables of attention. The TOVA is an objective, standardized, and highly accurate continuous performance test used to assess attention (Greenberg & Waldman, 1993). It is a non-verbal test that requires no left-right discrimination or sequencing, and has no appreciable practice effects. It is an individually administered computerized test developed to assess attention in both normal and clinical populations. It can be used in conjunction with other information gathering tools or diagnostic tests in neuropsychological or psychological evaluations. During TOVA, a participant performs a visual discrimination task. The stimuli are two easily discriminated geometric shapes. During the test one of the two stimuli is randomly presented in the center of the computer screen for 100 msec. The participant is instructed to respond as quickly as possible without sacrificing accuracy as soon as he detects the stimulus. The new stimulus is presented every two seconds and the participant is presented with 324 targets and 324 nontargets during 21.5 minutes. The TOVA measures variables of attentional processes in four areas: reaction speed, reaction speed variability, errors of omission, and errors of commission. The raw scores obtained on TOVA are compared with population means for the participant's age and sex, and then transformed linearly into standard scores with a mean 100 and a standard deviation to 15. Higher numerical values are assigned to scores indicating better performance: fewer omission errors, fewer commission errors, faster reaction times, and lower reaction time variability.

Procedure. The TOVA standardized attention test was administered to both the experimental (n = 10) and the control (n = 10) groups, with Performance Enhancement Training administered to all experimental group participants. The test software automatically recorded the subject's responses, non-responses, and reaction times, and then calculated standardized transformed scores. All of the subject's responses and non-responses were recorded and categorized for all of the variables throughout the test.

Each participant in the experimental and control group was told about the effects of alpha training on relaxation and was administered the TOVA test twice. The first test was given one day prior to the beginning of the first session of alpha-increase training and the second test was administered a day after the conclusion of the twenty-third alpha-increase session. Each participant in the control group was given a pre- and post- TOVA evaluation within the 11-week study period. No training of any kind was administered to this group during this period. The experimental group participants were trained to increase alpha wave amplitude within the 8-13 Hz frequency band. The PET employed one electroencephalographic channel, thus requiring input from one sensor at one location on the subject's head. The resulting output was then amplified and fed back to the participant as both auditory and visual stimuli.

Each experimental group participant was given 23 alpha-increase sessions for a period of 11 weeks. Each session was conducted for a period of 30 minutes. Before the beginning of each session a five-minute baseline reading was recorded. The individual threshold for each session was established according to the outcome of the five-minute baseline. The threshold was set at 85 per cent of alpha baseline value. Feedback was contingent upon the presence of Alpha (8-13 Hz) activity. The Standard International (10-20) Electrode Placement System was used to determine electrode placement. Based on this system four electrodes were placed at the following locations: (1) one at Mid-Parietal (PZ), (2) one at Frontal (ground (G)), (3) one at right earlobe for reference, (4) one at left ear lobe for reference. Each participant in the experimental group received both auditory and visual feedback. When the threshold level was surpassed, the participant was presented with a bell-sound as an auditory reward and blue bar graph as a visual reward. Upon completion of the training each participant was asked to demonstrate his or her ability to increase the level of alpha waves upon request, thus demonstrating his/her ability to increase the level of alpha waves at will.

Results

A two-way analysis of variance (ANOVA) for repeated measures was utilized for this 2×2 factorial design. The simple effects and possible interactions for the experimental and the control group on pre- and post-tests were analyzed for each variable measured by TOVA. The four variables of interest were: omission errors (misses), commission errors (false alarms), reaction speed (RS), and reaction speed variability (RSV). The raw scores were transformed into standard scores for each variable, and higher numerical values were assigned to scores indicating better performance. The means and standard deviations for the commission errors, omission errors, and reaction speed variables are presented in Tables 1, 2, and 3. The means and standard deviation for the reaction speed variability measure are presented in Table 4, p. 26.

Table 1

Standardized transformed scores for omission errors committed by 10 experimental and 10 control group participants on pre and post TOVA

Group	Pretest		Posttest	
	Mean	SD	Mean	SD
Experimental	105.50	3.63	106.60	3.78
Control	105.20	6.18	105.60	4.55

Note. Higher scores indicate fewer errors committed

Table 2

Standardized transformed scores for commission errors committed by 10 experimental and 10 control group participants on pre- and post-TOVA

Group	Pretest		Posttest	
	Mean	SD	Mean	SD
Experimental	103.20	13.34	109.00	9.23
Control	104.7	8.70	107.9	10.81

Note. Higher scores indicate fewer errors committed

Table 3

Standardized transformed scores for reaction speed shown by 10 experimental and 10 control group participants on pre- and post-TOVA

Group	Pretest		Posttest	
	Mean	SD	Mean	SD
Experimental	115.90	11.85	131.2	5.98
Control	126.10	7.95	123.4	9.03

Note. Higher scores indicate faster reaction times

Table 4

Standardized transformed scores for reaction speed variability collected from 10 experimental and 10 control group participants on pre and post TOVA

Group	Pretest		Posttest	
	Mean	SD	Mean	SD
Experimental	104.80	11.70	124.10	11.50
Control	113.70	11.03	113.80	12.66

Note. Higher scores indicate less variability

The analysis of variance yielded the following results for the reaction speed: Group×Prepost interaction yielded an $F(1,18) = 36.72, p < .0001$. The simple effects were then calculated on this measure. For the experimental group, an $F(1,9) = 34.99, p < .0001$, was obtained indicating statistically significant improvement for this group on the reaction speed measure. Calculations of the simple effect for the control group generated an $F(1,9) = 3.415, p < .098$, indicating no statistically significant difference between pre- and post-tests for the reaction speed variable (see Figure 1).

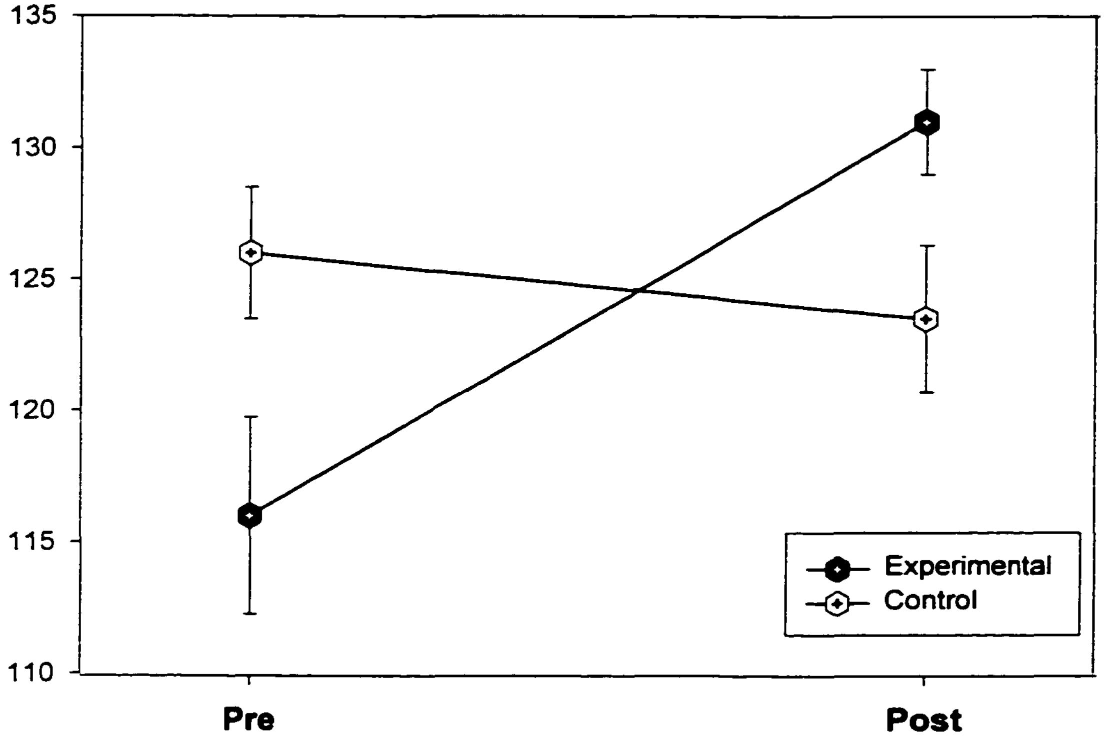

Figure 1. Transformed reaction time scores collected from 10 experimental and 10 control group participants on Test of Variables of Attention. Higher scores indicate faster reaction times.

The statistically significant Group×Prepost interaction was also observed on the measure of reaction speed variability, with $F(1,18) = 10.46, p < .005$. The simple effect for the experimental group yielded an $F(1,9) = 11.58, p < .0001$, indicating statistically significant improvement on the reaction time variability measure. The obtained $F(1,9) = .003, p < .956$, for the control group's reaction speed variability measure was not statistically significant (see Figure 2).

The analysis of variance generated no statistically significant results for the Group×Prepost interaction or the Prepost main effect on measures of commission and omission errors.As anticipated, a statistically significant increase in alpha (8-13 Hz) amplitude was observed for the experimental group t (205) = 56.05, $p < .0001$ (see

Figure 3).

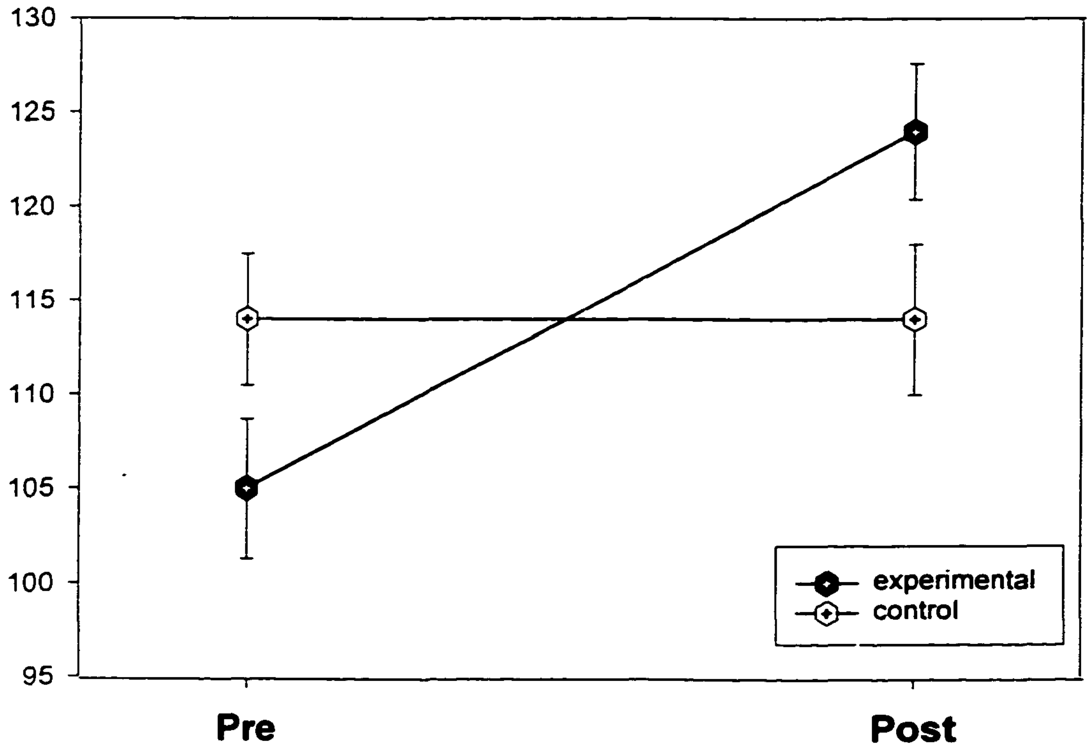

Figure 2. Reaction Speed Variability transformed scores collected from 10 experimental and 10 control group participants. Higher scores indicate less variability.

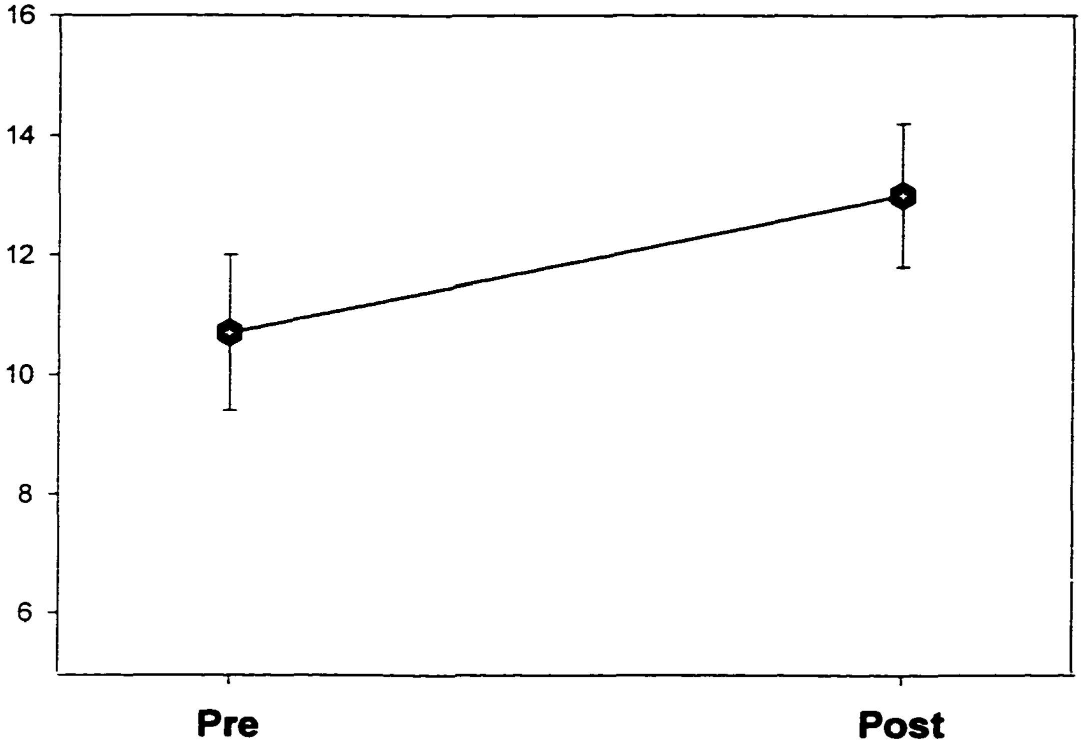

Figure 3. Alpha (8-13 Hz) wave amplitude mean scores (μV) collected from 10 experimental group participants before and after each of the 23 training session

Discussion

The results of our study support our hypothesis regarding two out of the four variables of attention investigated in this experiment. Statistically significant improvement for the experimental group on reaction time and reaction time variability measures, along with no improvement for the control group suggest the effectiveness of Performance Enhancement Training for improving these two variables of attention.

Reaction time and reaction time variability decreased for the experimental group, indicating that this type of training may produce improvement in many aspects of attentional functioning, such as vigilance, and should also result in increased performance on signal detection tasks. Although no statistically significant improvement on variables measuring accuracy (omission and commission errors) was obtained, this result could be attributed to the limitations of the TOVA test. Its sensitivity to accuracy appears to be limited, specifically for the normal college population that commit an insufficient number of errors on this type of task to permit adequate evaluation.

The results of this study are consistent with the outcome of Joe Kamiya's (1969) work. All experimental group subjects in this study established operant control of alpha brain waves and were able to demonstrate their ability to increase alpha amplitude on the experimenter's or his assistant's command. Similar to Kamiya's subjects, nine of our subjects also reported being more focused and involved in their daily tasks outside of the experimental situation. This is an interesting finding due to the fact that subjects were never told that this experiment measured variables of attention.

Our results strongly support the results of Watson et al.'s (1978) study, indicating not only changes in alpha wave amplitude and frequency as a function of changes in attentional demands, but also changes in variables of attention as a result of alpha amplitude increase. Our data suggest that an increase in alpha amplitude enhances individuals' performance on tasks measuring attentional variables by improving their ability to sustain attention.

The increase in alpha wave amplitude observed during Performance Enhancement Training may have been associated with a mechanism that allows the individual to reduce unneeded external stimulation and permits more efficient processing of internal cognitive tasks, thus improving reaction time and reaction time variability. The mechanism possibly involves a more efficient allocation of the processing resources by the parietal lobes and is consistent with the finding that the parietal lobes allocate processing resources to a particular stimulus (Posner et al., 1994). The training possibly activates a double feedback system between the parietal lobes and the anterior singulate nucleus: an activation in the parietal region leads to an inhibition of the anterior singulate nucleus (Posner & Raichle, 1994), resulting in a relaxed but alert state. This finding is consistent with Banich's (1997) findings suggesting that the parietal lobes serve to integrate information related to an individual's internal state with information from the external sensory world. The internal state of the newly-trained individual allows him or her to process new sensory input more efficiently.

These findings led us to a further investigation of the effects of Performance Enhancement Training on brain functioning. In particular, we were interested in whether cortical centers that are part of the anterior attentional system play a more direct role in executive functions and in emotional information processing. The inclusion of another control group given an alternative type of brain wave training would have helped us to achieve better control of our experimental situation. However, previous pilot projects yielded high dropout rates for control group subjects.

EXPERIMENT 2

The investigation of the effects produced by this type of alpha-increase training on the functioning of anterior and posterior regions of the brain is essential to a better understanding of the identity of the neuronal networks which training influences. As such, the Performance Enhancement Training was conducted with another group of participants who underwent quantitative EEG evaluations both before and after the training. This was done to further examine the changes in alpha wave amplitude in both the frontal and posterior regions. We anticipated that these evaluations would allow us to get a better global neurophysiological picture of the training's influence on the attentional and emotional properties mediated by the anterior and posterior areas of the brain. We hypothesized that the training would produce changes in the posterior (training site) region, and would also influence frontal regions involved in executive functions and processing of affective information.

Method

Participants. Sixteen undergraduate Brooklyn College students participated in this experiment as volunteers. They had no previous history of EEG biofeedback training. Participants were randomly assigned to either the experimental group that received Performance Enhancement Training or to the control group that was given narrow band alpha training (12.5-13 Hz). There were ten students in each condition

Materials. The Neurosearch 24 (NRS-24), 24 channel digital EEG/EP acquisition and analysis system was used in this experiment. The NRS-24 has nineteen EEG channels, and it provides real-time raw data acquisition, power spectrum measurement, topographic mapping, and quantitative analysis. The Standard International (10-20) Electrode Placement System was used to determine electrode placement. Based on this system, twenty-one electrodes were placed at the following locations: (1) nineteen on the scalp, (2) one at ground/scalp (G), (3) one each on the left and (4) right ear lobes for reference. The Performance Enhancement Training was conducted using the Lexicor POD-2 Mental Conditioning System. POD-2 is a two-channel EEG unit capable of simultaneous recording of two EEG inputs from any one or two locations on the human scalp. It is a real-time digital acquisition device capable of raw-data acquisition and power spectrum measurement.

Procedure. Sixteen participants were randomly assigned to two groups of eight participants each. Participants in the experimental group took part in twelve sessions of Performance Enhancement Training, while participants in the control group received twelve thirty-minute sessions of narrow band alpha frequency training (12.5-13 Hz). This more challenging training made it difficult for the control group participants to learn the desired contingency in twelve-session period.

Before the beginning of each session a five-minute baseline reading was recorded. The individual threshold for each session was established according to the outcome of the five-minute baseline. The threshold was set at 85 per cent of alpha baseline value for the experimental group, and at 60 per cent for the control group. Feedback was contingent upon the presence of alpha (8-13 Hz) activity. Each participant in the experimental group received both auditory and visual feedback. When the threshold level was surpassed, the participant was presented with a bell-sound as an auditory reward and blue bar graph as a visual reward. Upon completion of the training each participant was asked to demonstrate his or her ability to increase the level of alpha waves on request, thus demonstrating his/her ability to increase the level of alpha waves at will.

Results

A two-way analysis of variance (ANOVA) for repeated measures had been used for this 2×2 factorial design. The simple effects and possible interactions for the experimental and the control group on pre- and post-tests were investigated for each of the five sites measured by a Quantitative EEG evaluation. The five variables of interest included two anterior areas (F3, F4), and three posterior areas (PZ-the training site, and O1, O2). The raw data for each of the five variables are included in Appendix A. The means and standard deviations for the anterior areas are presented in Tables 5 and Table 6 .The means and standard deviation for the posterior areas are presented in Table 7, Table 8, p. 36, and Table 9, p. 36. Mean alpha amplitude scores obtained before and after each training session are presented in Table 10, p. 37.

Table 5

Alpha (8-13 Hz) amplitude scores (µV) obtained by QEEG evaluation from PZ electrode site from the experimental (n=8) and control (n=8) group participants on pre and post QEEG evaluations

Group	Pretest		Posttest	
	Mean	SD	Mean	SD
Experimental	9.56	2.98	12.58	3.71
Control	9.50	1.15	10.04	1.51

Table 6

Alpha (8-13 Hz) amplitude scores (μV) obtained by QEEG evaluation from F4 electrode site from the experimental (n=8) and control (n=8) group participants on pre and post QEEG evaluations

Group	Pretest		Posttest	
	Mean	SD	Mean	SD
Experimental	8.86	2.38	11.50	2.48
Control	8.86	1.42	9.48	1.74

Table 7

Alpha (8-13 Hz) amplitude scores (μV) obtained by QEEG evaluation from F3 electrode site from the experimental (n=8) and control (n=8) group participants on pre and post QEEG evaluations

Group	Pretest		Posttest	
	Mean	SD	Mean	SD
Experimental	10.01	3.72	11.84	6.51
Control	9.31	4.05	10.10	4.53

Table 8

Alpha (8-13 Hz) amplitude scores (μV) obtained by QEEG evaluation from O1 electrode site from the experimental (n=8) and control (n=8) group participants on pre and post QEEG evaluations

Group	Pretest		Posttest	
	Mean	SD	Mean	SD
Experimental	11.31	4.57	11.96	3.36
Control	9.09	1.59	10.03	1.99

Table 9

Alpha (8-13 Hz) amplitude scores (μV) obtained by QEEG evaluation from O2 electrode site from the experimental (n=8) and control (n=8) group participants on pre and post QEEG evaluations

Group	Pretest		Posttest	
	Mean	SD	Mean	SD
Experimental	12.05	5.50	12.96	4.05
Control	9.56	1.57	10.41	1.97

Table 10

Mean alpha (8-13 Hz) amplitude scores (μV) obtained from the experimental (n=8) and control (n=8) group participants before and after each training session

Group	Pretest		Posttest	
	Mean	SD	Mean	SD
Experimental	10.31	1.74	10.76	2.01
Control	10.44	1.64	10.58	1.90

The analysis of variance yielded the following results for alpha (8-13 Hz) wave amplitude (μV) for the Pz electrode site: Group×Prepost interaction yielded an $F(1,14) = 33.60$, $p < .001$. The pre-post simple effects were then calculated on this measure. For the experimental group, $F(1,7) = 72.84$, $p < .001$, which indicates a statistically significant increase for this group on the alpha amplitude measure. Calculations of the simple effect for the control group generated an $F(1,7) = 4.93$, $p < .062$, indicating no statistically significant difference between pre- and post- tests on the alpha amplitude measure (see Figure 4).

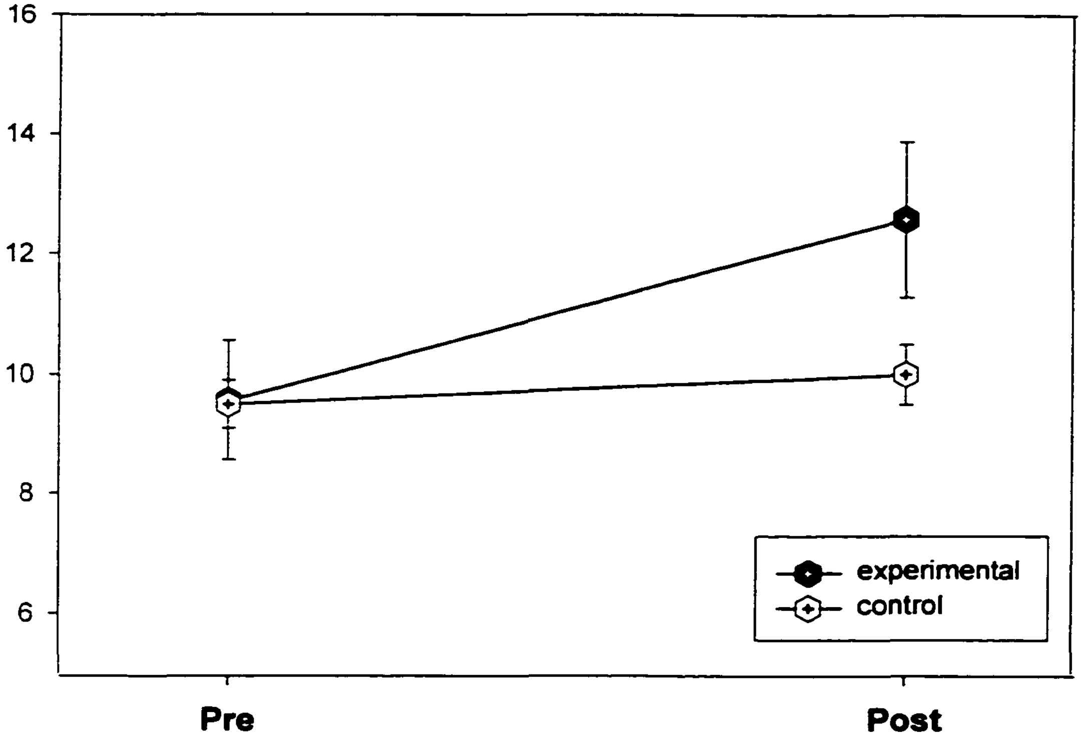

Figure 4. Alpha amplitude scores (µV) for Pz electrode site collected from 8 experimental and 8 control group participants on Quantitative EEG Evaluation measure.

The statistically significant Group×Prepost interaction was observed on the alpha amplitude measure for the F4 electrode site with $F(1,14) = 17.62, p <. 001$. The simple effect for the experimental group yielded an $F(1,7) = 84.71, p < .0001$, indicating a statistically significant increase for the experimental group on the alpha amplitude measure. A non statistically significant $F(1,7) = 2.66, p <. 148$, was obtained for the control group's alpha amplitude measure at this site (see Figure 5).

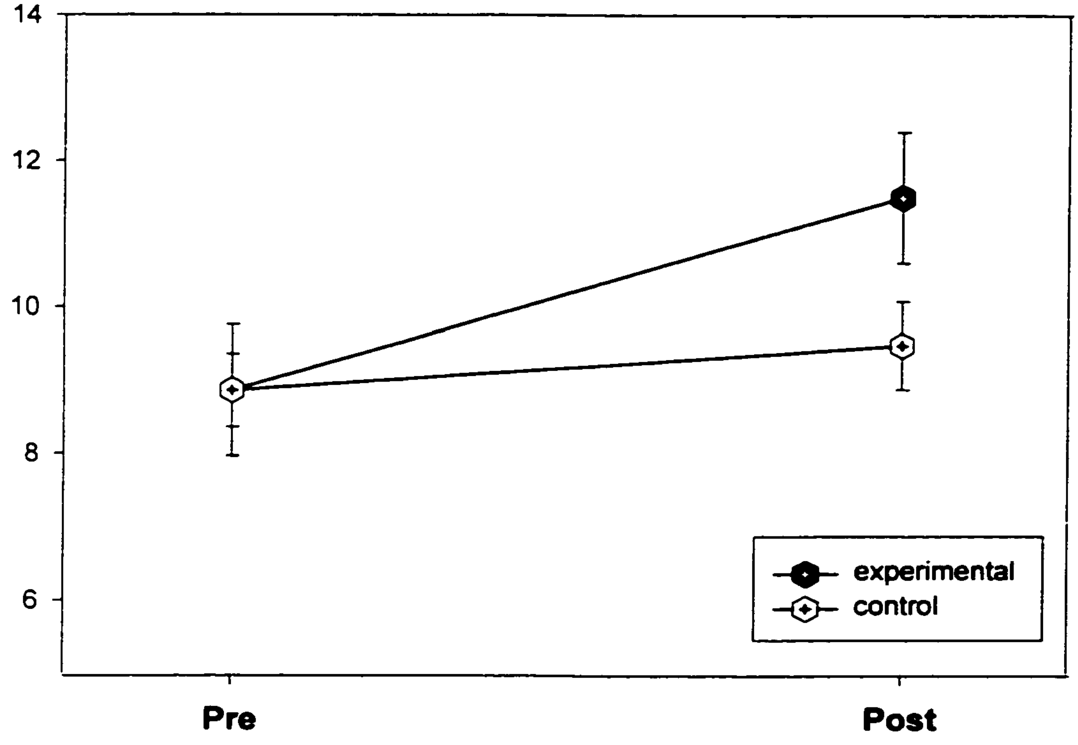

Figure 5. Alpha amplitude scores (μV) for F4 electrode site collected from 8 experimental and 8 control group participants on Quantitative EEG Evaluation measure.

The analysis of variance generated no statistically significant results for the Group×Prepost interaction ($F(1,14) = .837, p < .38$, for the F3 site; $F(1,14) = .118, p < .73$, for the O1 site; $F(1,14) = .003, p < .954$, for the O2 site) or for the Prepost main effect on alpha amplitude measures for any of three sites (See Figure 6, Figure 7, p. 41, and Figure 8, p. 42).

The Group×Prepost interaction yielded a statistically significant $F(1,196) = 7.388$, $p < .007$, for the alpha wave measure before and after each of the twelve training sessions. The simple effect for the experimental group was statistically significant, $F(1,95) = 12.86, p < .001$, while the simple effect for the control group, $F(1,95) = .59, p < .809$, was not (see Figure 9, p. 43).

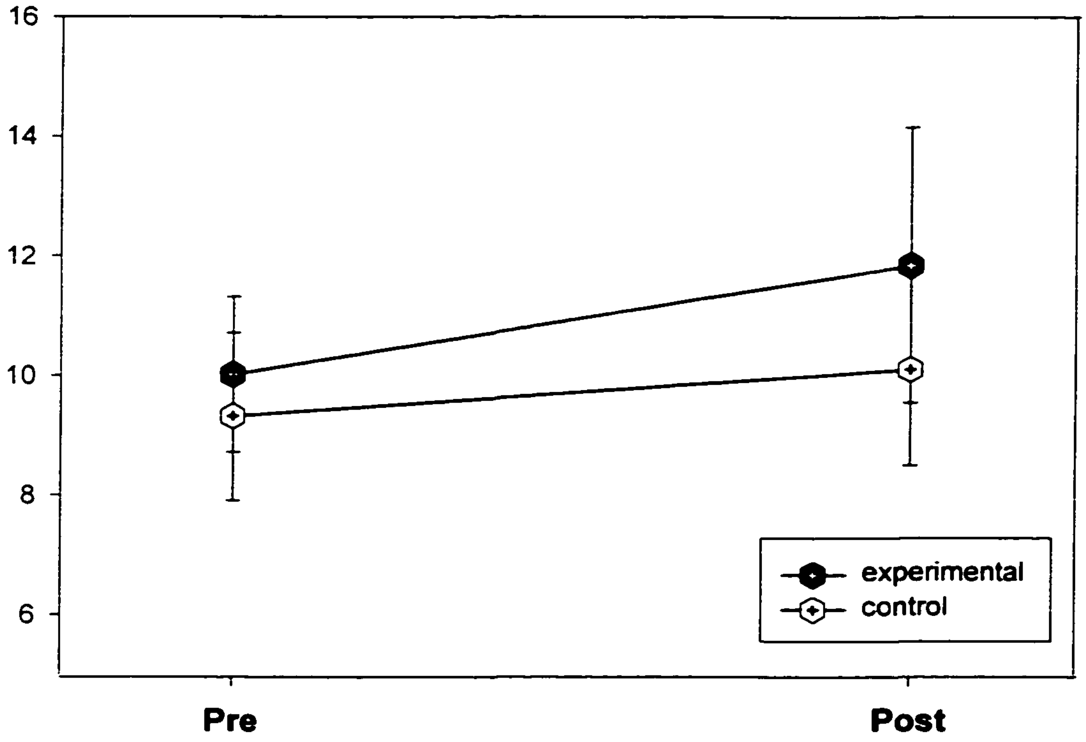

Figure 6. Alpha amplitude scores (μV) for F3 electrode site collected from 8 experimental and 8 control group participants on Quantitative EEG Evaluation measure.

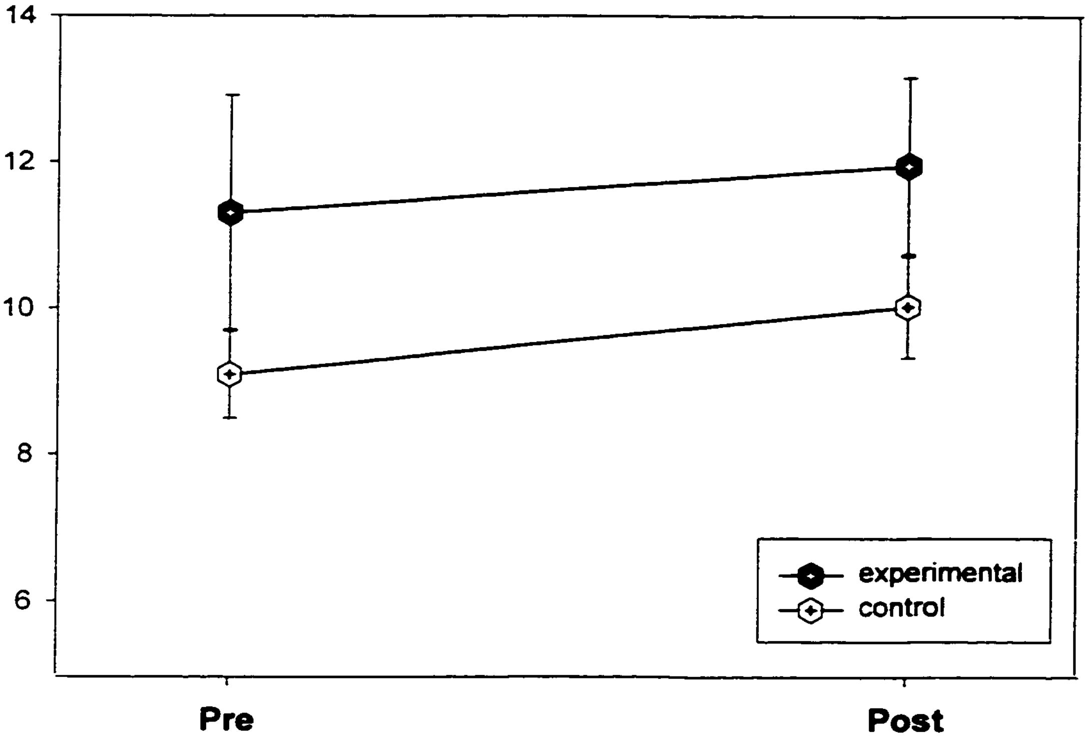

Figure 7. Alpha amplitude scores (μV) for O1 electrode site collected from 8 experimental and 8 control group participants on Quantitative EEG Evaluation measure.

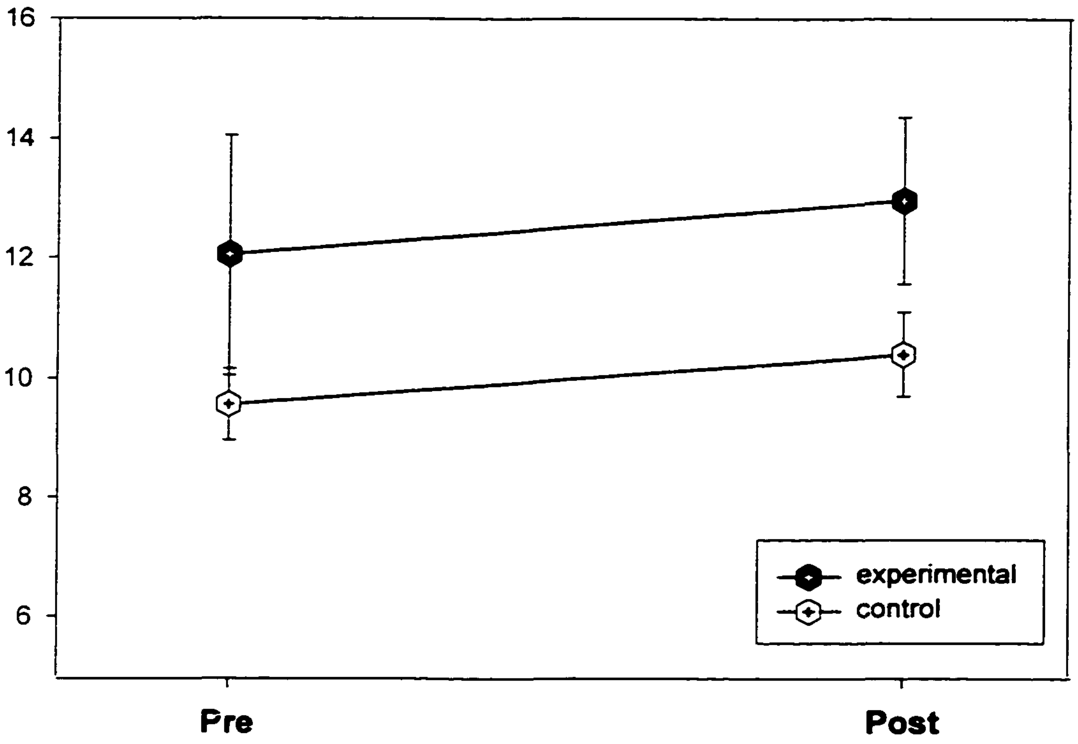

Figure 8. Alpha amplitude scores (μV) for O2 electrode site collected from 8 experimental and 8 control group participants on Quantitative EEG Evaluation measure

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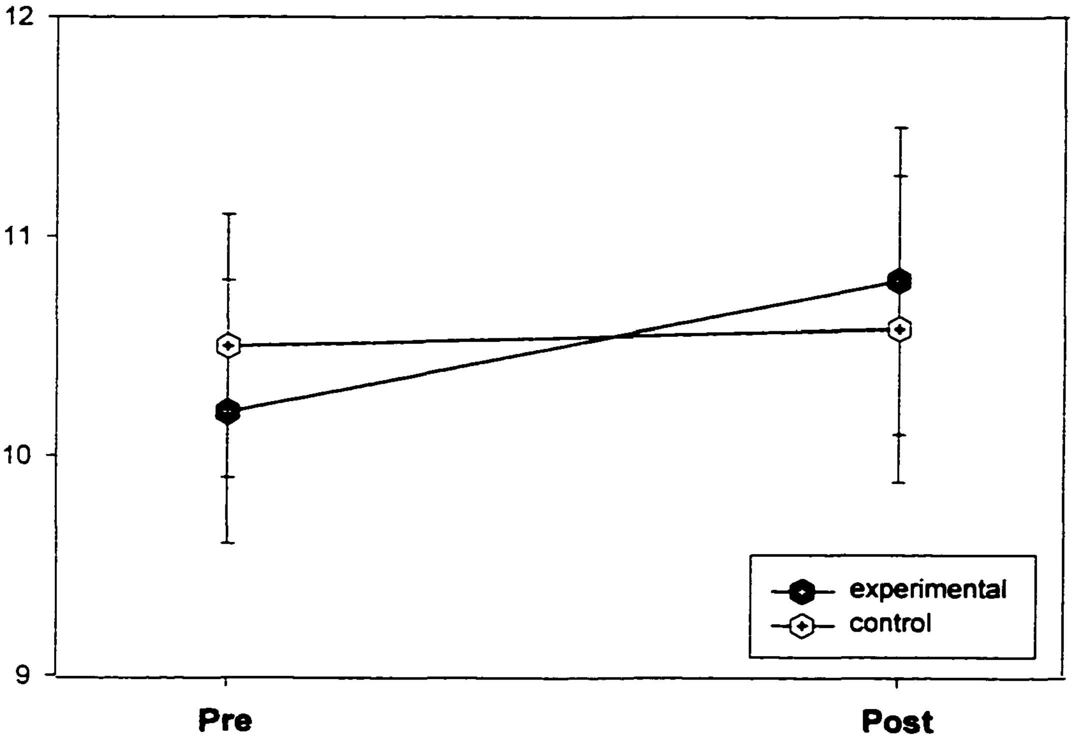

Figure 9. Mean alpha amplitude scores (μV) collected from 8 experimental and 8 control group participants before and after each of the twelve training sessions

Discussion

The results of this experiment support two major conclusions consistent with our experimental hypotheses. One of the findings indicates a significant increase in alpha amplitude at PZ, the training electrode site, in measurements obtained from the experimental group, while no statistically significant changes were observed for the control group. Thus, training resulted in mediation of the anterior attentional system where the parietal lobes integrate information related to the individual's internal state with information from the external sensory world (Banich, 1997). The parietal lobes interact with the thalamus, which enhances certain elements of the attended stimulus so that it is given processing priority by the anterior areas (Posner & Duhaene, 1994). As a parallel mechanism, the training may affect the Vigilance Network of Attention, which has well-developed anatomical connections with the parietal lobes and locus coereleus, the site where norepinephrine is synthesized. The training influences the locus coereleus to produce norepinephrine at rates sufficient for an optimal level of alertness (Posner & Raichle, 1994) and enables motionless vigilance (Sterman, 1994; Sterman, 1995). In addition, an increase in alpha amplitude was observed at the F4 electrode site in the experimental group, while no statistically significant changes were observed for the control group. This finding suggests that in addition to the effects of training on the posterior attentional system, alpha activation also spreads to the anterior attentional system (Posner & Dehaene, 1994). Therefore, in addition to an improvement in sustained attention, and in the ability to deal with distractions from other stimuli in the environment, one could expect an improvement on tasks requiring planning and selecting an action—executive functions mediated by the frontal lobes. Furthermore, increases in alpha at F4 are shown to take place on tasks eliciting positive affect (Baehr et al., 1999).

Therefore, it can be hypothesized that the increases in alpha in the frontal regions are also produced by the mediation of limbic functioning elicited by the training. In the final debriefing interview, seven experimental group subjects reported that they noticed changes in themselves, and stated that they perceived themselves as being calmer than before the training. Some of them also reported being less emotional. Further self-reports included statements indicating that the participants felt less worried, more focused, more in touch with their feelings and emotions, more thoughtful, less impulsive, more positive in their feelings about themselves, and more satisfied with their lives. These reports led us to a further investigation of the effects of training on human emotions and personality styles related to positive changes in affective processing.

EXPERIMENT 3

The neurological connections between the attentional and emotional areas of the brain are so intertwined that it is logical to hypothesize that performance enhancement training will result in changes in affective processing, as well as attentional functioning. The role of emotions is now recognized as essential in the concept of mind. Emotions mediate between our inner mental life and our perceptions of, and interaction with, the world of events, people, and things. The connection between alpha frequency and emotional responses was initially made by Davidson et al. (1984) and Tomarken et al. (1990) who conducted an extensive investigation of alpha wave distribution in the frontal lobes.

According to Tomarken et al. (1990) alpha EEG asymmetry in the frontal regions can predict affective responses to emotion elicitors, with more alpha appearing in the right frontal region. Resting alpha power asymmetry in the frontal regions indicated differences between positive and negative affect. Davidson (1984) suggested that changes in EEG are associated with changes in both affect and personality. In their 1992 article describing psychometric properties of resting anterior EEG asymmetry, Tomarken et al. (1992) suggested that the alpha frequency band possesses sufficient psychometric properties, such as test-retest reliability and internal consistency, to become a measure for assessment of individual emotional differences. Davidson (1994) made a distinction between emotions, moods, and affective styles. Emotions, according to him, arise in situations where adaptive actions are required. Autonomic activity typically accompanies emotion and supports the action that coincides with that emotion. The primary function of moods, on the other hand, is to modulate or bias cognition. Mood states serve as primary mechanisms for altering information-processing priorities, and shift modes of information processing. Mood will accentuate the accessibility of some cognitive contents and semantic networks, and attenuate the accessibility of others. For example, individuals with depressed mood have increased accessibility to sad memories and decreased accessibility to happy memories.

Another important distinction between moods and emotions is the nature of the antecedent events that elicit them. Emotions appear to be precipitated by events that are perceived as occurring quickly and without warning, while moods may be more likely to follow events that are perceived as occurring over a slower time course. Moods are produced as an accumulation of emotions over time. Moods and emotions constantly interact. Emotions can elicit particular moods and moods can alter the probability that particular emotions will be triggered.

Affective style refers to the entire domain of individual differences in personality. Such differences are conceptualized as trait-like constructs that are consistent over time. Certain personality traits reflect affective style as long as they are associated with systematic differences in affective reactivity (Laresen & Ketelaar, 1991). Affective style also emphasizes differences in the intensity and temporal parameters of behavioral regulation, expression of arousal, and emotionality, and the way these individual differences influence intrapersonal and interpersonal processes. Temperament is treated as a set of dispositional properties of traits.

Based on the aforementioned theoretical and empirical accounts, we hypothesized that over the course of training, an individual will be able to change his/her emotional patterns. It was anticipated that the initial change would lead to a more balanced emotional state, eventually resulting in the ability to maintain this state longer. Increased ability to prolong this emotional state should lead to a gradual change in the interaction between the individual and the environment, and result in different behavioral-emotional outcomes. We believe that this will further lead to changes in behavioral patterns or changes in personality styles. These changes can be evaluated by positive affect and personality measures. In addition to the aforementioned characteristics, multiple pilot projects yielded data indicating that participants reported feeling better about themselves, and experienced improved satisfaction with the their lives. This led us to investigate the effect of the training on self-esteem and life satisfaction. It was hypothesized that increases in self-esteem reflect both the experience of successful self-regulatory training and changes in neurophysiological functioning.

Method

Participants. Twenty undergraduate Brooklyn College students participated in this experiment as volunteers. They had no previous history of EEG biofeedback training. Participants were randomly assigned to either the experimental group that received Performance Enhancement Training or to the control group that was given narrow band (12.5-13 Hz) training. There were ten students in each condition.

Materials. The Performance Enhancement Training was conducted using the Lexicor POD-2 Mental Conditioning System. The POD-2 is a two-channel EEG unit capable of simultaneous recording of two EEG inputs from any one or two locations on the human scalp. It is a real-time digital acquisition device capable of raw-data acquisition and power spectrum measurement.

Millon's Inventory of Personality Styles (MIPS) was used to assess personality styles. The MIPS was constructed by Millon (1997), and is a 180-item, true/false questionnaire designed to measure personality styles of normally functioning adults between the ages of 18 and 65. The MIPS consists of 24 scales grouped into 12 pairs with each pair containing two juxtaposed scales. The twelve scale-pairs are organized into three major areas: Motivational Aims, Cognitive Modes, and Interpersonal Behaviors. In addition to the twelve pairs of content scales, the MIPS contains 3 validity indicators: Positive Impression, Negative Impression, and Consistency. MIPS sample questions are included in Appendix G.

Three pairs of scales from the Motivating-Aims category assess the person's orientation toward obtaining reinforcement from the environment. The first pair of scales examines the extent to which the respondent's behavior is basically motivated by obtaining positive reinforcement (Enhancing) or avoiding negative stimulation (Preserving) from the world. The second pair assesses the extent to which the individual's activities reflect a Modifying or Accommodating approach toward the world. The third pair of scales focuses on the source of reinforcement, assessing the extent to which the person is primarily motivated by Individuating (referring to self) or Nurturing (referring to others) aims. Four pairs of scales from the Cognitive-Modes area examine styles of information processing. The first two pairs in this area, Extraversing or Intraversing, and Sensing or Intuiting, assess information-gathering strategies. The second two pairs, Thinking or Feeling, and Systematizing or Innovating, assess different styles of processing information once it has been gathered. In addition, five pairs of scales from the Interpersonal-Behaviors area asses the extent to which the person's style of relating to others is generally Retiring or Outgoing, Hesitating or Asserting, Dissenting or Conforming, Yielding or Controlling, and Complaining or Agreeing. The MIPS scales have a rich theoretical foundation in a model of personality that is deeply rooted in biosocial and evolutionary theory. The MIPS is a valid and highly reliable measure (Millon, 1994). The median split-half reliability for the MIPS scales is $r = .82$ in the adult sample ($N = 1{,}000$), and $r = .80$ in the college sample ($N = 1{,}600$).

Fleming and Courtney's (1984) Self-Rating Scale was used to evaluate individual's self-esteem. This scale is an outgrowth of their hierarchical faceted model of self-esteem that measures five self-esteem dimensions. These include: self-regard, social confidence, school abilities, and physical abilities, all of which load on a single general factor. It is a thirty-six item scale that has high internal consistency ($\alpha = .92$) and high test-retest reliability ($r = .92$) with correlations for every factor significant beyond the .001 level (see Appendix D).

A life satisfaction questionnaire and positive affect scale were adapted from Martinez-Pons (1999). The life satisfaction questionnaire is a twenty-item instrument that seeks information about general life satisfaction. The Likert-type responses allow a participant to indicate how much he/she agrees with a number of statements (see Appendix F). The internal consistency of this measure is $\alpha(108) = .75$. Positive affect scale is a sixteen-item questionnaire that measures individual's positive affect. The internal consistency and of this scale is $\alpha(116) = .87$. Positive affect scale is included in Appendix E.

Procedure. Twenty participants were randomly assigned to two groups having ten participants each. The experimental group was administered twelve sessions of Performance Enhancement Training. Each participant in the control group received twelve thirty- minute sessions of narrow band alpha frequency training (12.5-13 Hz), making it difficult for them to learn the desired contingency in a twelve-session period. Before the beginning of each session, a five-minute baseline reading was recorded. The individual threshold for each session was established according to the outcome of the five-minute baseline. The threshold was set at 85 percent of alpha baseline value for the experimental group and at 60 percent for the control group. Feedback was contingent upon the presence of alpha (8-13 Hz) activity. The Standard International (10-20) Electrode Placement System was used to determine electrode placement. Based on this system, four electrodes were placed at the following locations: (1) one at Mid-Parietal (PZ), (2) one at Frontal (ground (G)), (3) one on the right earlobe for reference, (4) one on the left ear lobe for reference. Each participant in the experimental group received both auditory and visual feedback. When the threshold level was surpassed, the participant was presented with a bell-sound as an auditory reward and blue bar graph as a visual reward. Upon completion of the training each participant was asked to demonstrate his or her ability to increase the level of alpha waves upon request, thus demonstrating his/her ability to increase the level of alpha waves at will.

Results

A two-way analysis of variance (ANOVA) for repeated measures had been implemented for this 2×2 factorial design. The possible interactions and simple effects for the experimental and the control group on pre- and post-tests were analyzed for the thinking, feeling, and modifying scales of the MIPS. The means and standard deviations for each of the three measures are presented in Tables 11, 12, and Table 13, p. 52.

Table 11

Thinking Scale scores reported by 10 experimental and 10 control group participants on pre and post MIPS

Group	Pretest		Posttest	
	Mean	SD	Mean	SD
Experimental	16.20	7.84	23.60	9.68
Control	14.40	4.77	14.40	7.87

Table 12

Feeling Scale scores reported by 10 experimental and 10 control group participants on pre and post MIPS

Group	Pretest		Posttest	
	Mean	SD	Mean	SD
Experimental	33.60	12.28	37.40	9.98
Control	28.50	9.29	29.90	9.26

Table 13

Modifying Scale scores reported by 10 experimental and 10 control group participants on pre and post MIPS

Group	Pretest		Posttest	
	Mean	SD	Mean	SD
Experimental	28.50	12.28	37.40	9.98
Control	29.40	9.29	29.90	9.26

The statistically significant Group×Prepost interaction was obtained for alpha (8-13 Hz) wave amplitude measured before and after each training sessions, an $F(1,238) = 15.669$, $p < .0001$. The simple effects were then calculated for this measure. For the experimental group, an $F(1,119) = 31.568$, $p < .001$ was obtained, indicating a statistically significant increase for this group on the alpha amplitude measure. Calculations of the simple effect for the control group generated an $F(1,119) = .885$, $p < .349$, indicating no statistically significant difference between pre- and post- tests for this measure (see Table 14 and Figure 10).

Table 14

Mean alpha amplitude scores (µV) collected before and after each training session from 10 experimental and 10 control group participants

Group	Pretest		Posttest	
	Mean	SD	Mean	SD
Experimental	11.00	2.59	11.96	3.10
Control	10.64	3.71	10.76	3.72

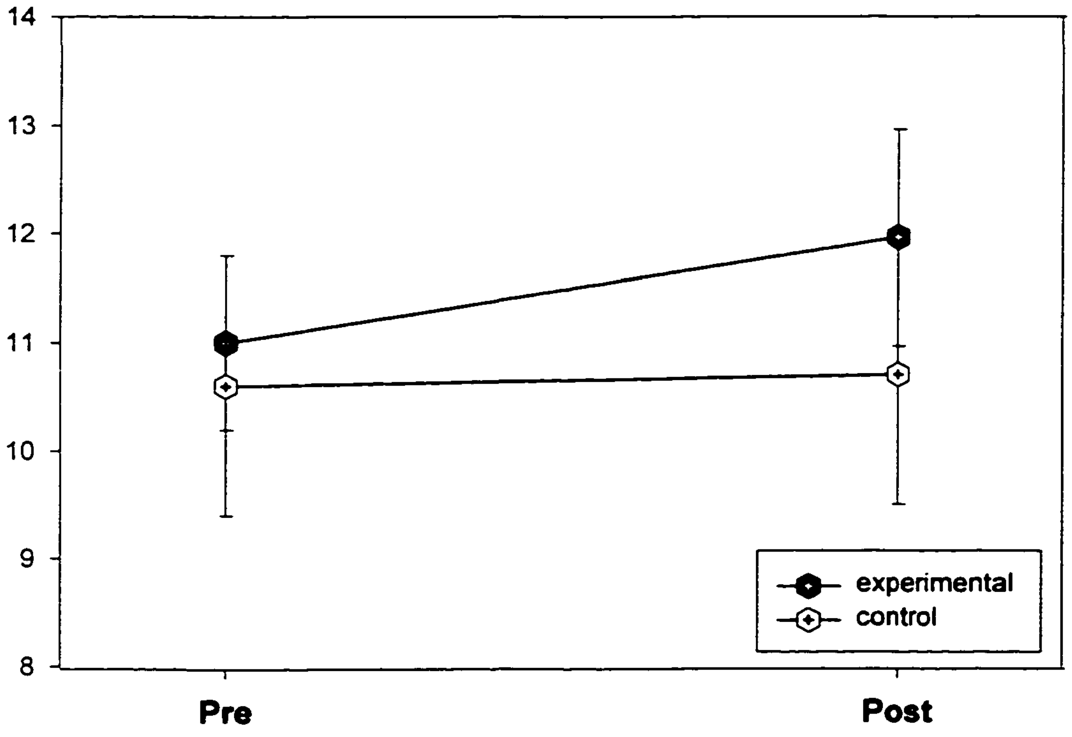

Figure 10. Mean alpha (8-13 Hz) amplitude scores (µV) collected before and after each training session from 10 experimental and 10 control group participants.

The analysis of variance yielded the following results for the Thinking variable: the Group×Prepost interaction yielded an $F(1,18) = 8.61, p < .009$. The simple effects were then calculated on this measure. For the experimental group, an $F(1,9) = 15.007, p < .004$ was obtained, indicating a statistically significant increase for this group on the thinking style measure. Calculations of the simple effects for the control group generated an $F(1,9) = 0, p = 1.00$, indicating no statistically significant difference between pre- and post- tests for this measure (see Figure 11).

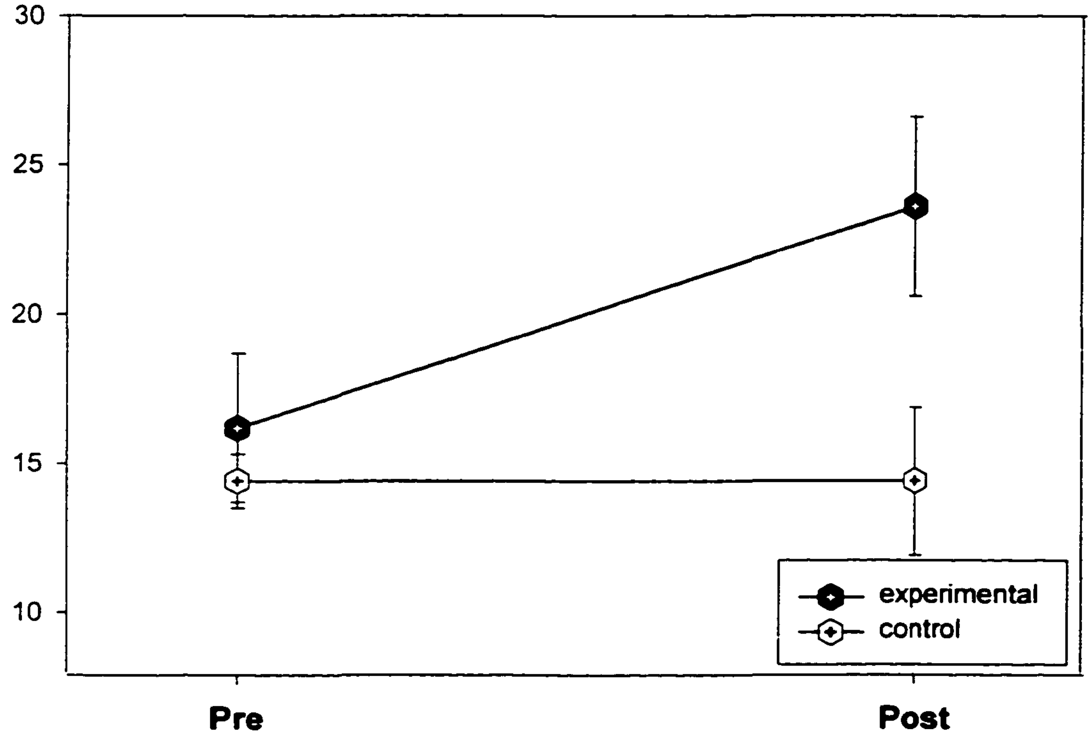

Figure 11. Thinking Scale scores reported by 10 experimental and 10 control group participants on pre- and post-MIPS

No statistically significant Group×Prepost interaction was observed on the feeling style measure, with $F(1,18) = 1.593, p < .223$ (see Figure 12). The analysis of variance generated the following results for the modifying variable: the Group×Prepost interaction yielded an $F(1,18) = 8.211, p < .01$. The pre-post simple effects were then calculated for this measure. For the experimental group, an $F(1,9) = 10.852, p < .009$ was obtained, indicating a statistically significant increase for this group on the modifying style measure. Calculations of the simple effect for the control group generated an $F(1,9) = .193, p < .671$, indicating no statistically significant difference between pre- and post-tests for this measure (see Figure 13). The raw data for the thinking, feeling, and modifying measures are presented in Appendix C.

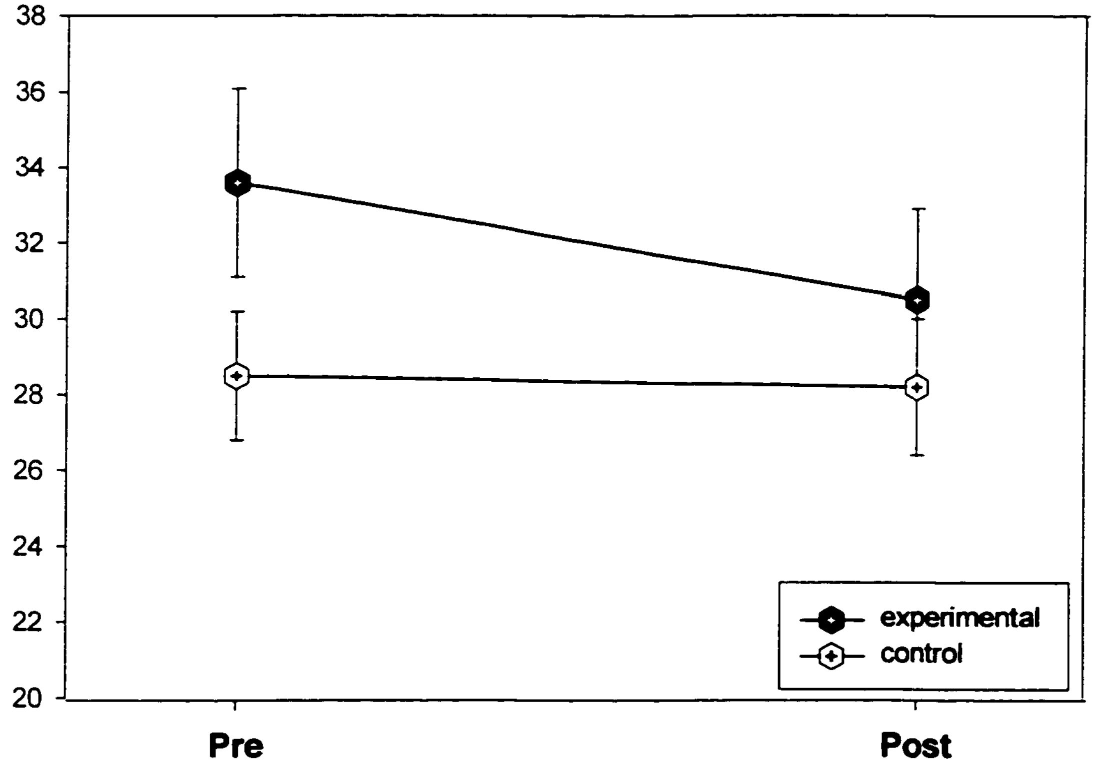

Figure 12. Feeling Scale scores reported by 10 experimental and 10 control group participants on pre- and post-MIPS

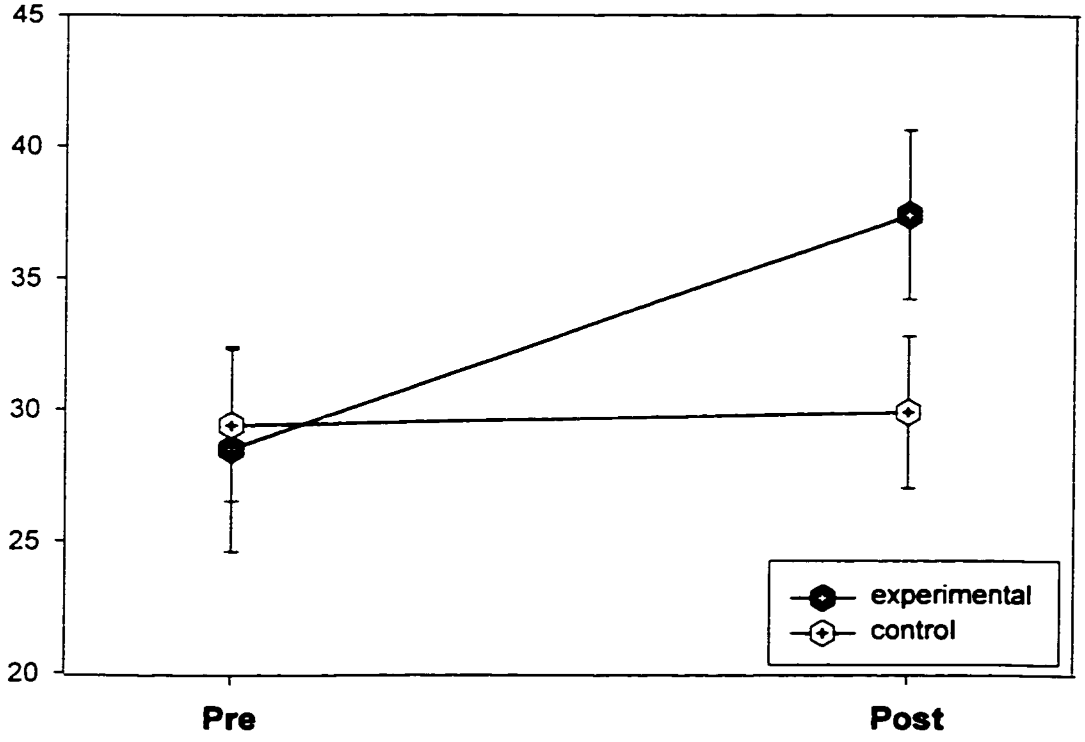

Figure 13. Modifying Scale scores reported by 10 experimental and 10 control group participants on pre- and post-MIPS

The interactions and simple effects were analyzed for positive affect (PAS), self-esteem(SE), and life satisfaction (LS) measures for both experimental and control groups at pre- and post-testing. The means and standard deviations for PAS and SE measures are presented in Table15 and Table16. The means and standard deviations for the LS measure are presented in Table 17, p. 58.

Table 15

Life Satisfaction (LS) scores reported by 10 experimental and 10 control group participants on pre and post tests

Group	Pretest		Posttest	
	Mean	SD	Mean	SD
Experimental	112.50	8.68	117.80	8.26
Control	115.20	7.44	116.70	6.89

Table 16

Positive Affect (PA) scores reported by 10 experimental and 10 control group participants on pre and post tests

Group	Pretest		Posttest	
	Mean	SD	Mean	SD
Experimental	70.80	9.53	76.0	9.85
Control	70.40	10.40	71.5	11.59

Table 17

Self-esteem scores reported by 10 experimental and 10 control group participants on pre and post tests

Group	Pretest		Posttest	
	Mean	SD	Mean	SD
Experimental	177.20	14.75	184.20	15.19
Control	174.10	15.01	176.90	16.27

The analysis of variance generated the following results for the LS variable: The Group×Prepost interaction yielded an $F(1,18) = 8.194, p < .01$. The pre-post simple effects were then calculated for this measure. For the experimental group, an $F(1,9) = 22.157, p < .001$ was obtained, indicating statistically significant improvement for this group. Calculations of the simple effect for the control group yielded an $F(1,9) = 4.551, p < .062$, indicating no statistically significant difference between pre- and post-tests (see Figure 14).

The statistically significant Group×Prepost interaction was also observed on the PA measure, with $F(1,18) = 6.343, p < .02$. The pre-post simple effect for the experimental group yielded an $F(1,9) = 28.43, p < .001$, indicating statistically significant improvement. No improvement, $F(1,9) = .712, p < .421$ was seen on the control group's positive affect measure (see Figure 15, p. 60).

The analysis of variance generated the following results for the self-esteem variable: the Group×Prepost interaction resulted in an $F(1,18) = 6.68, p < .019$. The pre-post simple effects were then calculated for this measure. For the experimental group, an $F(1,9) = 29.79, p < .001$ was obtained, indicating statistically significant improvement for this group. Calculations of the simple effect for the control group generated an $F(1,9) = 7.875, p < .02$, also indicating statistically a significant difference between pre- and post-tests for this measure (see Figure 16, p. 61). The raw data for SE, PA, and LS variables are presented in Appendix C.

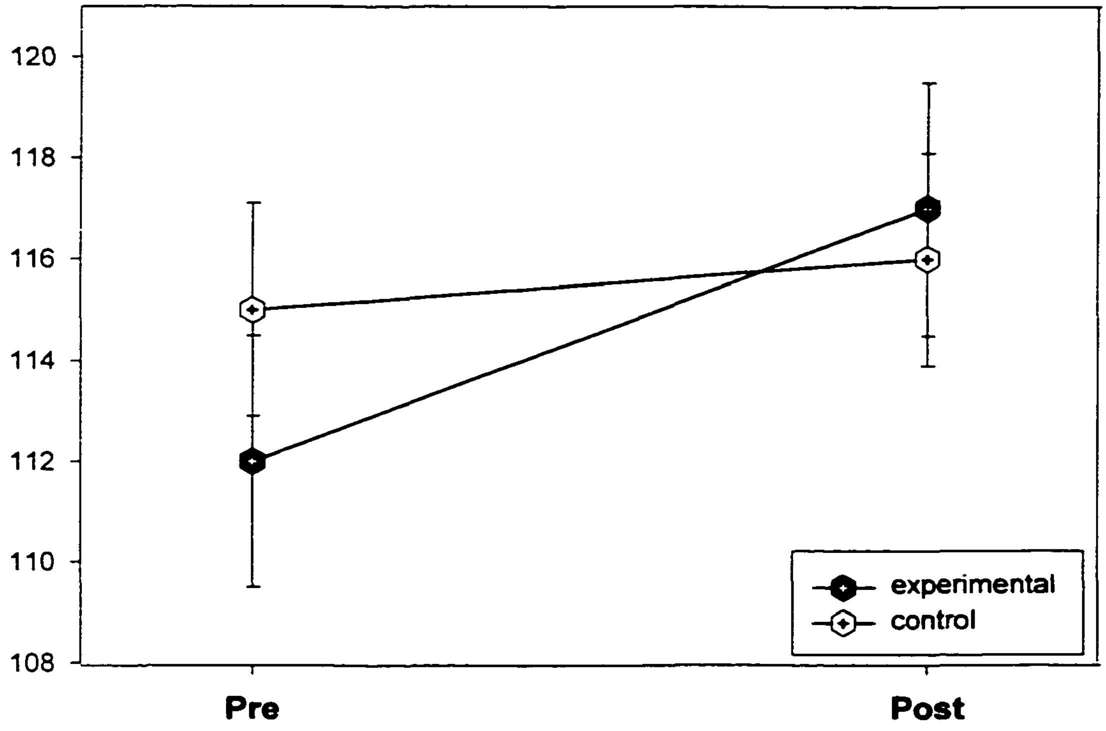

Figure 14. Life-satisfaction scores reported by 10 experimental and 10 control group participants on pre- and post-LS measure

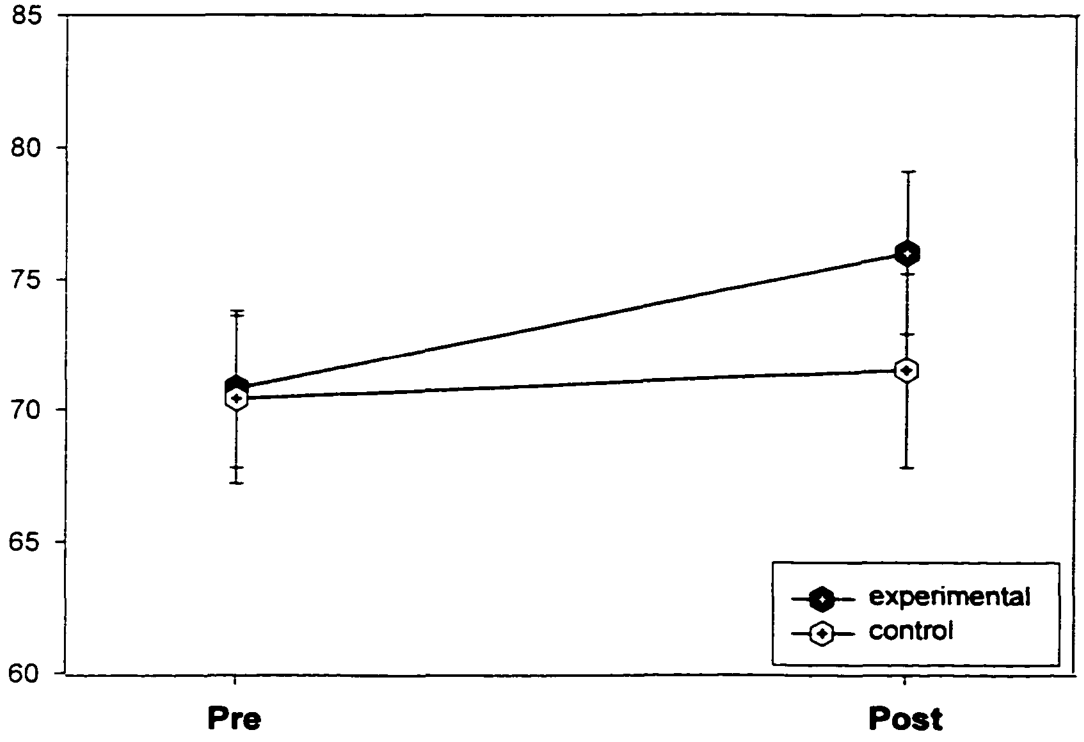

Figure 15. Positive affect scores reported by 10 experimental and 10 control group participants on pre- and post-PA measure

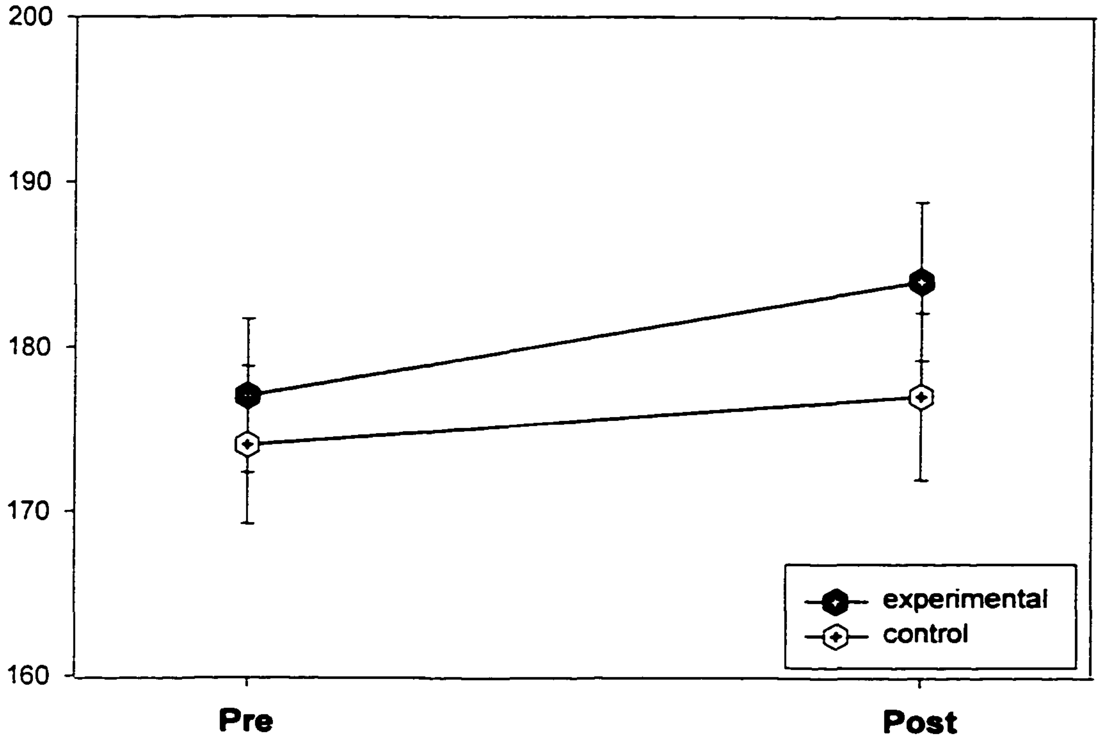

Figure 16. Self-esteem scores reported by 10 experimental and 10 control group participants on pre- and post- measures of SE

Discussion

Although we strongly believe that personality is partially influenced by genetic make-up, it is also apparent that both the individual's internal and external environment can play a role in shaping and re-shaping certain traits. Many researchers believe that people are born with certain dispositions or temperaments that influence their emotional nature. However, temperaments, depending on one's life experiences, develop into personality traits. Buss and Plomin (1984) identified three temperamental dispositions: emotionality, activity, and sociability. Our results suggest that emotionality can be modified with the appropriate techniques.

The statistically significant increase in measures of thinking style for experimental group participants suggests that they acquired more effective cognitive control over their emotional processes. The fact that their feeling styles scores did not significantly decrease suggests that these subjects did not just suppress their emotions, but were able to use their cognitive modalities to separate the affect when desired.

The changes in modifying scale scores should also not be surprising. Zinser et al. (1999) investigated changes in EEG as a function of approach motivation, and discovered an asymmetry of EEG activity across the frontal region of the two hemispheres. In their study, a measure that involved two locations, F3 and F4, and was sensitive to increases in alpha, has been used as an index to approach motivations.

Henriques and Davidson (1991) proposed that differences in frontal activation may be related to the rapidity with which subjects recover from an emotionally evocative event. They indicated that depressed subjects had more alpha in the left frontal regions of the brain and more interhemispheric asymmetry than normal controls. Tomarken et al. (1992) related individual differences in anterior brain asymmetry and fundamental dimensions of emotions. They discovered that the presence of faster beta frequencies, or a lack of alpha in the right frontal regions was related to negative affect. In 1992, Sobotka et al. investigated the mechanism underlying anterior EEG changes in response to reward and punishment. They reported that punishment was associated with lower levels of alpha in the right anterior and temporal regions. Davidson (1992) proposed a theoretical account of the role of hemispheric asymmetry in approach and withdrawal behavior. He delineated the importance of the frontal and temporal regions of both hemispheres. In Wheeler et al. (1993), right frontal beta was associated with greater negative affect when 90 undergraduate students were presented with film clips having positive or negative emotional contents.

Our results support the finding that self-esteem increases as a result of physiological mediation during alpha-increase training. However, the fact that self-esteem also increased in the control group participants suggests that this finding can also be explained by individuals' motivation to achieve a self-regulatory process, and their belief that they are in the process of mastering a skill. At the same time, it is plausible that the control group has begun to learn a narrow-band alpha contingency during the training and that the newly acquired skill resulted in their awareness of new-found attentional and emotional states resulting in increased self-esteem.

The statistically significant results obtained on affective measures support Davidson's (1984) theoretical approach to emotional processes. The participants gradually learn to change their emotional states during training, and as training progresses, it results in more long-term changes in the duration of the emotional states, and leads to more positive affect. This improved mood translates into new learned interactions between the individual and the surrounding environment, and results in new affective or personality styles, and an increase in overall life-satisfaction.

It also appears that, as a result of the training, participants not only report being calmer and more relaxed (Kamiya, 1969), but also indicate higher positive affect. According to David Watson (1988), individuals experiencing low levels of negative affect would describe themselves as calm and relaxed, while conversely, persons experiencing high negative affect typically would report various negative mood states, including feelings of nervousness, dissatisfaction, discouragement, and irritability. His initial formulation might suggest that someone who is experiencing high levels of negative affect must necessarily be experiencing low levels of positive affect. This is true in a limited sense, in that individuals experiencing very high levels of negative affect usually report low levels of positive affect. However, individuals experiencing low negative affect (calm and relaxed) are not necessarily feeling happy or enthusiastic, in fact, they may fall anywhere on the continuum ranging from low to high PA (Watson, 1988). However, this does not seem to be the case with this alpha increase training. It seems that as a result of practice our participants felt both low negative affect and high positive affect. Isen (1987) found that positive moods facilitate cognitive flexibility, result in more creative responses and more remote associations, and increase the perception of relatedness among conditions. Apparently these processes lead to newly formed emotional-behavioral patterns. The results of our study clearly indicate that training can modify consistent, long-term individual differences in affective experience and/or emotional traits.

GENERAL DISCUSSION

This paper presented a set of findings that should shed some light on the electroneurophysiological processes instrumental in the efficacy of alpha-increase training. There seem to be several possible explanations for this phenomenon. One possible mechanism is that in the process of training, an individual learns to exert neuromodulatory control over the neural networks mediating attentional and emotional processes, and as training progresses, long term potentiation consolidates an optimization of these processes.

Abarbanel (1995) suggested that during the training the system is modulated in the attractor state, a stable point of equilibrium for the system. As a result, other functionally related states will also settle into configuration. As a person continues to practice the skill, sensory and proprioreceptive input initiates feedback regulations of the circuits involved, and practice automatizes this process. Thalamocortical neurons, reticular nucleus neurons, and interneurons are all involved in this process in several distinct modes. They may act as relay cells that depolarize to input volleys and transmit ascending sensory input, and as oscillatory cells that fire in a collective rhythm. The resting potentials are determined by neuromodulation from the brain stem centers. Neuromodulation provides either depolarizing or hyperpolarizing influences to the thalamic neurons by adjusting thalamic membrane permeability to ion flow. The training mediates the interaction between the reticular neurons and the thalamacortical neurons involved in the generation of alpha rhythm. The training, therefore, may mediate attentional and emotional processes through both neuromodulation and long-term potentiation. The subject learns to consolidate his capacity to regulate state changes, resulting in improved attention and newly acquired limbic control, which leads to emotional self-regulation. This suggests that training efficacy can be explained by both an increased capacity for self-regulation on a cognitive integration level, and entrainment of the neural centers in the brain to provide new modulatory mechanisms supporting those states.

Joe Kamiya (personal communication) characterized the state of high alpha amplitude as being similar to a car's idling in neutral, ready to be shifted into gear. In this state an individual does not engage in any specific motor or cognitive process. However, one is normally very far from this state, since there always seems to be some sort of neuronal noise occurring in the system. At times, an individual engages in random motor or cognitive activity without being aware of it. Performance Enhancement Training possibly assists in minimizing this random neuronal activity, and as a result provides an "unobstructed" modality for stimulus detection, optimizing transmission and producing improvements on tasks measuring reaction time. An increase in alpha amplitude may represent a process analogous to an automobile's tune up, which optimizes the engine's performance. The outcome of our study finally allows us to go one step further in characterizing the precise role of alpha EEG frequency in mediating corresponding attentional and emotional states.

Sergeant (1995) used a combination of arousal, activation and effort to explain successful self-regulation and goal-directed functions. According to him, an optimal level of arousal along with emotional stability is required for self-regulation and goal-directed persistence. He suggested that the foremost executive process, among all executive functions, is self-regulatory behavior. One such self-regulatory behavior is the inhibition of responding, known as impulse control. This function is essential to successful performance on signal detection tasks, and varies as a function of vigilance. The control of impulse permits a delay in making the decision to respond that can be used for further self-directed, executive actions. Those actions affect the decision to respond and control the responses these executive functions generate. The successful regulation of these functions leads to deferred gratification, resistance to temptation and behavioral inhibition.

According to Barkley (1997) one of the consequences of successful impulse control and response delay is the separation of affect. Bronowski (1976) indicated that there are tremendous benefits to emotional regulation by self-directed executive functions. He demonstrated the importance of acquiring self-regulation of affect. Included in this component is also the self-generation of drive, or motivational and arousal states, that support the execution of goal-directed actions and persistence in working toward a goal. Barkley (1997) defined separation of affect as the ability to separate the emotional valence from the content of the response to an event. This involves self-regulation of emotion apart from motor behavior, and it allows an individual to generate neutral responses despite emotionally provocative events that may elicit highly charged feelings within the individual. These findings shed more light on the underlying reason for improved affective functions reported by our participants upon the completion of alpha-increase training.

Levenson (1988) suggested that one of the most important functions of emotions is to create an optimal physiological condition to support a particular behavior. Considering that the factors affecting this condition include the central, somatic, and autonomic nervous systems, each with a number of important subsystems, and considering the importance of rapidity of responses, the ability of emotion to influence the activity of the diverse systems has profound implications for our capacity to adapt and survive.

According to Bower (1992), the persistence of emotional arousal and its slow decay leads to a continuous recycling of events viewed as belonging to the emotional reaction. According to him, this evolutionary mechanism was created to produce a better memory of a threatening event. At the present time, however, this process may no longer be advantageous in every threatening situation. It is true that emotion is an indicator of the role that evolution has played in shaping its current function. From an evolutionary perspective, emotions have evolved in their adaptive value in dealing with fundamental life tasks. Emotions prompt us in a direction, that in the course of evolution led to better solutions in recurring circumstances relevant to our goals.

Tooby and Cosmides (1990) emphasized the crucial role of evolution in understanding our emotions today, telling us that emotions impose "on the present world an interpretative landscape derived from the covariant structure of the past." Emotions deal with recurrent adaptive situations. Under certain circumstances, the interval between a stimulus and an emotional response can be extraordinarily short, so that an emotional appraisal mechanism must be capable of operating with great speed. Because emotions can occur with a very rapid onset, through automatic appraisal with little awareness, and with involuntary changes in expression and physiological arousal, we often experience emotions as happening to us, not as chosen by us.

At the same time, results of our study indicate that emotions are subject to successful self-regulation. This implies that the underlying neurophysiology that reflects millions of years of evolutionary processes allows us to use alternative neurological pathways (LeDeux, 1987) to acquire better self-regulatory control of our emotions.

In today's world, threatening stimuli often elicit immediate, stereotyped behavioral and visceral defense responses that lead to problems rather than solutions. The tendency of this fear-related stimuli to lead to behavioral and visceral reactions is easily explained by the intimate connectivity of the amygdala with brainstem systems involved in the control of preprogrammed, species-typical behaviors and associated autonomic and endocrine reactions (LeDoux et al., 1987; LeDoux, 1989). This propensity is supported by the amygdala's connections with those brainstem motor areas involved in impulsive stereotypical responses. At the same time, most high-level associative areas of the cortex have connections with the motor control system in the neocortex and basal ganglia that are involved in voluntary motor control. The amygdala's connection with basal ganglia may allow the amygdala to contribute, along with cortical cognitive systems, to instrumental voluntary emotional behavior responses that are emitted in an effort to cope with the involuntary emotional reactions elicited by emotional stimuli. Arousal is a concept that plays a major role in the theory of emotion. Le Deux believes that in addition to reticular activating system, the amygdala plays an important role in the mechanism of arousal as it contributes to the coding of stimulus significance. The amygdala detects emotional significance and contributes to the triggering of brainstem arousal functions. There is a strong connection between the amygdala and the neurocortex. Therefore, the amygdala can influence cortical processes, and it is possible that cortical processes can affect the amygdala. That is to say, emotional processing can influence cognitive processing, and vice versa. Since the projections span all the way from the primary sensory cortex, through to the highest and more complex association fields, the possibilities for emotional modulation of cognition are enormous. The possibilities are further amplified if the amygdala also projects to brainstem and forebrain cholinergic systems, each of which can play an important role in cortical arousal and vigilance. The so-called unspecific arousal that accompanies emotional activation must be due to significance of the stimulus. The amygdala can thus influence cognitive processing directly, by way of back-projection to the cortex, and indirectly, by the pathway of nonspecific brainstem systems.

Today, people are dealing with different types of threats. Most of them, however, are not life and death situations, and most do not require a mere fight or flight response. The ability to maintain a moderate level of arousal during an emotionally arousing situation may allow individual to achieve better outcomes, which may be advantageous. Prolonged arousal, however, may lead to health hazards, and to the formation of maladjusted responses to any potentially emotionally arousing situation. Far too often, emotions short circuit cognitive processes that would yield a better situational outcome for an individual. Evolution has provided humans with cognitive powers, which provide possibilities of action and inaction for responding to environmental challenges. Emotion should be a means toward efficient adaptation. Only when the threat to internal-well being is the strongest, should the more primitive emotional system gain the upper hand. There are indeed still rare situations, when action is more appropriate than deliberation, and when responding is more appropriate than considering. In situations when hesitation could have more direct consequences, emotions function to set aside cognitive processing that is too cumbersome, obsessive, and likely to be inconclusive (Lazarus et al., 1984).

Emotional responses are normal and adaptive as long as there is a recovery of emotional equilibrium within a reasonable time limit. Although there is nothing unhealthy about activation of the autonomic nervous system, there are negative consequences when autonomic arousal is sustained and chronic, and exceeds metabolic demand. Under numerous stressful situations that occur daily, when recovery is impeded, the response becomes dysfunctional because it does not serve any of the adaptive functions described above. In addition, the emotional event becomes a priority for working memory, and begins to divert limited attentional resources from items that might be more important for successful resolution of a conflict. Emotions soak up processing resources, and alter an individual's perception of a situation, often preventing processing an event in its entirety. These distractions will not lead to optimal learning and performance, or to optimal conflict resolution. As Bowers (1992) stated, anxious and depressed people are notoriously poor learners because their working memory is preoccupied with upsetting ruminations, and attentional resources are diverted to the rumination process.

According to Lazarus and Folkman (1984), we often become too emotional, feeling threatened and in need of self-protection. This makes us constrained, inhibited, and defensive, resulting in holding back, and leads us further away from optimal cognitive functioning. On the other hand, Davidson (1994) suggested that an individual who has dispositions toward positive affect presents a primed approach system and should likely be resilient in the face of stress. The outcome of our study indicated that the dispositions toward positive affect can be trained.

Theodore Millon (1982), a theorist concerned about personality in relationship to stress and health, summarized major approaches to personality and developed a measure that summarizes the person's style of defending against anxiety, resolving interpersonal stress, and dealing with psychological conflicts. One of the main aspects of Millon's views on personality is related to the individual's emotional and thinking styles which are influenced by arousal levels. The fact that the outcome of our study indicated a possibility of modifying certain aspects of personality by modifying arousal levels should not be surprising considering that some personality researchers (Eysenck, 1981; Millon, 1982) suggested that certain levels of arousal are associated with certain personality traits. Eysenck argued that extraverts and introverts differed in their physiological make up. He suggested that extraverts and introverts differ in the levels of cerebral cortex arousal. Extraverts seek highly arousing social behavior because their level of arousal is below threshold while introverts are above optimal arousal level. It appears that change in level of arousal can in fact produce a shift in trait. Emotional processing can be extremely rapid, receiving inputs from very early stages of perceptual processing. It may also result after extensive cognitive processing has occurred, or in response to the semantic labels attached to an event. The outputs of emotional processes include changes in the individual's alertness, direction of attention, and somatic, autonomic, and endocrine processes—all subject to self-regulatory modification.

Effortful control has also been noted as an important dimension of personality variability because attentional processes serve regulatory functions over the emotions and their expression. Effortful control is also important because it allows the individual to act in directions counter to those indicated by immediate cues of reward and punishment (Rothbart, 1994).

According to Rothbart (1994) there are three major dimensions to personality: positive affect, negative affect, and fear in addition to individual difference in attention and activity. Negative emotional traits include feelings of negative engagement, stress, worry, and resentment. They have also been related to measures of negative affectivity in mood, and the tendency to endorse items like distressed, fearful, hostile, and nervous rather than calm and relaxed. The results of our study suggest that alpha-increase training assists individuals in self-regulating their affective states, resulting in them having low negative affect (being calm and relaxed) and, at the same time, exhibiting high levels of positive affect. Of course, moods lie somewhere in between acute emotions and personality changes. Moods transcend contexts while acute emotions are usually provoked by particular events. People reporting increases in positive affect as a result of the training are able to transcend context better. When people feel good about themselves, they are less likely to respond to or interpret an event as emotionally loaded or stressful. In addition, they probably cope better in situations when stress occurs. These newly developed changes in their self-regulatory abilities provide more positive feedback about their day-to-day functioning and probably lead to further increases in self-esteem.

According to Levinson (1988), positive emotions are associated with the state of autonomic quiescence, and their primary function might be to undo the autonomic activation produced by negative emotions. They restore the organism to its pre-arousal state in a more efficient and rapid manner than would be the case if the negative emotions were allowed to run their natural course. Performance Enhancement Training teaches individuals to acquire self-regulatory control—a concept that implies the ability to respond in the way one wants, whether it entails the inhibition or expression of a response. The self-regulation training of alpha brainwave frequency leads to improved attention and better emotional-self regulation that in turn leads to higher self-esteem, life satisfaction, more positive affect, and some personality changes.

Fuster (1989) argued that the proficiency of working memory is dependent on impulse and interference control. According to him, working memory represents a location where goals and intentions to act are retained and action plans are formulated and used to guide the performance of the goal-directed responses. The delay in responding, during which the cross-temporal behavioral structures are being formed and retained, is a critical time that requires protection from a variety of sources of interference that can affect the individual's planning abilities. Traces of information still held in working memory from the formation of immediately previous behavioral structures can also interfere with these processes, and this retention of previous motor plans past their time of execution and term can lead to persistence in responding and the inability to terminate them.

Drive and motivation appear to be part of the same psychoneurophysiological system that governs emotion, so that the capacity to self-regulate attention may also initiate the capacity to self-regulate emotion and motivation. Lang (1995) argued that the array of human emotions can be reduced to a two-dimensional model, of which one dimension is motivation (reinforcement or punishment) and the other is level of arousal. Thus the ability to self-regulate and even to induce emotional states as needed in the service of goal directed behavior also may involve the ability to regulate and induce motivation, drive, and arousal states in support of such behavior.

It is also conceivable that individuals may learn to self-regulate arousal levels for the purposes of goal accomplishment, which can affect self-regulation of emotion, and self-regulation of drive and motivational states. Therefore, people are capable of creating more positive emotional and motivational states in themselves when angered, frustrated, disappointed, anxious or bored by learning to manipulate the internal states that correlate with such emotions.

Self-directed rules permit individuals to persist in responding under conditions of very low levels of immediate reinforcement, or even in the absence of reward, as well as during extensive delays in the consequences for responding. These self-regulated actions serve to create a shift in the control of behavior, from control exclusively by the external environment to control by internally represented information.

Barkley (1997) noted that functions that originate within the executive brain areas can affect sensory-perceptual, linguistic, learning and memory, in addition to the attentional and emotional systems. Children with ADD are more influenced by context and less influenced by internally represented information, and they are also more influenced by immediate events and their consequences than by those more distant in time. Children with ADD, for example, are less likely to alter their subsequent responding when they make an error. Numerous studies demonstrate that children with ADHD produce greater errors of commission on continuous performance tasks, indicating problems with sustained attention and impulse control (Barkley, 1991, 1994).

Ellis (1987) suggested that emotional or affective states such as stress, anxiety, depression, and arousal strongly impact cognitive processes such as memory and cognition. People with attentional disorders show greater emotional reactivity to emotionally charged immediate events, less capacity to induce and regulate emotional, drive, motivational, or arousal states in the service of goal-directed behavior and a greater dependence on external sources affecting drive, motivation, and arousal that are within the immediate context.

Impulse control has been shown to be important for developing self-regulation of emotion and motivation (Garber & Dodge, 1991; Kopp, 1982). Clinical data suggest that impulse control problems are associated with disorders of drive and motivation, emotional hyperactivity, irritability, low frustration tolerance and loss of emotional self-control. Poor behavioral inhibition may lead to secondary deficiencies in working memory, and research suggests that measures of impulse control are significantly and positively correlated with measures of working memory (Lee, Vaughn, & Kopp, 1983). The most important issue in emotional development is an issue of impulse control. According to Izard, emotional development consists of the processes whereby the emotions system achieves an increasingly complex matrix of functional links with the other subsystems of the individual—the physiological/drive, perceptual, cognitive, and action systems. Conceived in this way, emotional development is facilitated and constrained by development within each of the organismic subsystems. Emotional development is a cornerstone of personality development, the coordination of all the subsystems for the purpose of interpersonal and person-environment transactions.

Development that leads to harmonious interactions of all the subsystems provides the basis for effective coping, creative behavior, and physiological and psychological well-being. (Seeman, 1989).

People store material in memory on the basis of its affective tone. The good mood is a cue that increases the probability of positive thoughts, so the person feeling good will evaluate others more favorably and will be more ready to offer assistance. People with attentional deficits are less likely to recall and hold in mind information about the past for the formulation of a plan in the future. Working memory has often been assessed in neuropsychological research with repetition of digit spans and mental arithmetic. The children with ADD appear to be less proficient in mental arithmetic (Ackerman, Anhalt, & Dykman, 1986), and show more difficulties with repetition of digit spans and memory for spatial location (Barkley, Murphy, & Kwasnik, 1996). Measures of working memory, such as delayed spatial memory, mental arithmetic, digit span, and reproduction of hand movement sequences have been found to correlate with measures of sustained attention and behavior inhibition (Barkley, 1997).

Levy and Hobbes (1989) found that a measure of vigilance loaded on the same factor as a measure of working memory, and these factors distinguish individuals with ADD from a normal population. Livanov (1940) has made the association between the relationship of alpha rhythm to processes of memory and perception. Maltseva and Masloboev (1997) found that alpha wave frequency was positively correlated with memory performance as indicated by memory span tests.

The connection between attention, learning, and memory processes was proposed by Andersen and Andersson (1968). They suggested that spontaneous spindles initiated in the thalamus and interacting with the ones initiated in the cortex are essential for learning processes. They indicated that the repeated activation of cortical neurons in each spindle renders more permanent any changes that occur at cortical synapses during the acquisition of recent sensory data.

The aforementioned studies suggest a powerful link between attention, impulse control, working memory and emotion. Consequently, by affecting any one of these links, the functioning of others can be mediated. The robust effects of alpha-increase training on human attention, emotion, and behavioral control can be results of this multifaceted mediation. Alpha-increase training enables the individual to develop the psychophysiological control and self-regulation of processes occurring in these areas.

EEG self-regulation has also been beneficial in addressing attention deficit disorder (ADD). According to Shouse and Lubar (1976), individuals with ADD show significant elevation of slower EEG frequencies and their attention improves as these slower EEG frequencies disappear. Thus it seems reasonable to conclude that alpha-increase training appears to produce in an individual a state of mind correlated with an optimal level of arousal leading to the enhancement of sustained attention. This state has been found beneficial for self-regulation of the individual's behavior. At the end of the study some of the experimental group participants reported doing better on exams, being more relaxed and happier, and feeling more confident. Since our training also resulted in increased self-regulatory function, we would anticipate that it would lead to a better coping strategies and lead to a better health and overall life satisfaction. We also noted that our participants reported an enhanced awareness of their emotional states and began to realize what situations lead to increase stress, and also how to manage some of these moods and emotions.

For years, emotions have been known to affect individuals' attention, memory and behavior. As Neiss (1988) pointed out, optimal performance probably results from a state in which tension is low and intensity is high. Indeed, a hallmark of outstanding musicians, dancers, and athletes is their ability to maintain high intensity and remain loose. Many others are unable to do this, instead experiencing a debilitating degree of anxiety in connection with important motor performances or avoiding them altogether.

Recent ADD, Performance Enhancement, and neurofeedback studies suggest that as individuals improve attention they often report improvement in many emotional skills. These emotional skills include self-awareness: identifying, expressing, and managing feelings and actions. These skills then make it possible to learn to make better emotional decisions by first controlling the impulse to act, then identifying alternative actions and their consequences before acting. This often leads to improvement in some interpersonal skills, such as reading social and emotional cues, listening, being able to resist negative influences, taking others' perspective, and understanding what behavior is acceptable in a situation. The aforementioned factors have been found to be crucial in the development of emotional intelligence (Goleman, 1995).

Martinez-Pons (1997-1998) proposed a model of emotional intelligence in which he identified at least three distinct processes including attending to one's moods and emotions, clarifying them, and regulating them. He discovered that the emotional intelligence measure was positively correlated with life satisfaction and goal orientation and negatively correlated with depression symptomatology. This mechanism needs further investigation but the implications are that participants improve in managing their moods and emotions, not only decreasing negative affect but increasing positive affect. Participants also reported being more sensitive to their moods and emotions—a key factor in emotional intelligence (Salovey and Meyer, 1989). It appears that performance enhancement training affects more than one factor involved in the concept of emotional intelligence by modifying emotional neurophysiology.

Leont'ev (1994) indicated the key importance of the development of voluntary attention in an individual. He mentioned that researchers have noted that the ability or inability to direct one's attention is an essential determination of the success or failure of any practical operation. Thus, self-regulation of attention is essential for the development of higher cognitive abilities. Voluntary regulation of behavior, specifically attention, has been the way for a human species to develop higher cognitive abilities. Therefore, I suspect that development of this form of attention should lead to a further development of the connection between the environment and social world and should be advantageous to our species. Leont'ev (1994) described Pavlovian conditioning as the simplest form of activity that regulates behavior referred to in psychology as involuntary "primary attention, [which] is wholly conditioned by external stimuli and their direct bearing on the particular state of the organism." The term "voluntary attention" expresses the nature of higher forms of behavior regulation "with two specific signs: first, its outward independence of direct factors, and secondly, the presence of effort" (Leont'ev, 1994).

The self-regulation of attention, therefore, presumes a two-fold change: a change in the direction of behavior and an increase in the duration of the act. The degree of self-regulation of attention determines the degree of one's cognitive development.

Cskzentmihalyi (1993) implicated the role of attentional processes as a key to talent development and postulated the importance of autotelic experiences for self-regulation. He characterized the state of enjoying an activity as flow, and in order to reach and maintain this state a person needs to find new challenges in order to avoid boredom, and to perfect new skills in order to avoid anxiety.

According to Berk and Winsler (1995), one of the factors leading to successful learning and development is being in Vigotsky's Zone Of Proximal Development. They suggested that the balance of challenges and skills is never a static process. One cannot do the same thing at the same level of proficiency for a long time unless one continues to enjoy it. We believe, that by learning to self-regulate their attention people can learn to reach a state of flow, leading to the enjoyable sustained effort.

According to Csikszentmihalyi (1990), the most critical task in human development is to learn to create a self-regulatory state of flow, making it possible to maximize the quality of both personal and social life. Once, the attentional state of flow is achieved, certain personal qualities develop that contribute to the realization of talent. Feldman et al. (1994) suggested that while a person has no control over some of his or her genetically determined and special skills, there are traits where the individual's own efforts can make a significant difference. He emphasized the primary importance of the development of appropriate attentional structures, habits of concentration, and personality and motivational patterns (Feldman et al., 1994).

Csikszentmihalyi et al. (1993) suggested that both Roger's "fully functioning person" and Maslow's "self-actualized individual" have complex cognitive styles and exhibit personality traits indicative of mastering self-regulation of attention. Csikszentmihalyi et al. (1993) discovered that talented students exhibited relatively higher levels of concentration than their peers when involved in class work, studying, reading, and playing games. He suggested that optimal attention lies in the individual's ability to self-regulate different types of attention. Possibly alpha-increase training allows students to reach this optimal attentional flexibility by developing sensitivity to different levels of concentration.

It seems that information enters our consciousness either because we intend to focus attention on it or as a result of automatic attentional processes based on biological or social instructions. It is attention that selects the relevant bits of information from the potential millions of bits available, and it takes attention to retrieve the appropriate references from memory, to evaluate the event, and then to choose the right action. Unfortunately only very few people learn to use this processes efficiently, while others neglect their potential development. The trait of a person who is in control of his or her life is the ability to focus attention at will, to maintain it for as long as possible, and not be affected by distractions. The development of these skills usually leads to a productive life.

Each person allocates his or her limited attentional resources either by focusing it intentionally like a beam of energy or by diffusing it. Csikszentmihalyi (1993) suggested that the names we use to describe personality traits—such as extrovert, high achiever, or paranoid—refer to the specific patterns people have used to structure their attention. Attention can be invested in countless ways, ways that can make individual experience fulfilling or distressing.

Csikszentmihalyi (1990, 1993) likened attention to a form of energy that varies as function of work and effort. This energy is used to do work, and without it no effort can materialize and no work can be accomplished. All human experience varies as a funcion of attentional energy investment— memories, thoughts, and feelings are created as a function of attentional investment. The most important factor, however, is that this most powerful attentional mechanism is under our conscious control. The proper use of it can assist our development and its misuse can destroy us. Attention, therefore, appears to be the most important tool in the task of improving the quality of experience (Csikszentmihalyi, 1990, 1993).

The investigation of physiological, neurological, psychological, and behavioral aspects of attention demonstrates that complex systems are involved in the mediation of the attentional processes. A complex interaction seems to exist between the attentional and emotional systems of the human organism. Acquiring conscious control of these attentional processes may lead to certain benefits for the individual. Training to achieve the self-regulation of arousal levels can lead to optimal states of alertness and vigilance and significantly enhance performance.

An individual can learn to become conscious of the relaxed and alert state of mind corresponding to high alpha levels through alpha-increase training, and by learning how to enter and exit this state at will so that he or she can learn to regulate levels of arousal, increase attentional capacity and sustain attention longer. This self-regulation of attention may lead to improved impulse control, enhanced cognitive development, greater emotional balance, and greater attentional capacity resulting in better memory. Self-regulation of attention may also lead to enhanced self-awareness resulting in improvement of interpersonal skills and higher emotional intelligence. Thus, alpha-increase training not only helps individuals achieve a better control over their lives, it also appears to enhances their abilities to reach a state of flow and improve the general quality of their conscious experience.

Although several different networks of attention have already been identified, more needs to be learned about their precise communication. Also, more needs to be learned about global electrophysiological changes in the entire brain during the process of alpha-increase training as well as the nature and scope of its long-term effects.

The aforementioned issues represent potentially rewarding topics for further investigation in the areas of cognitive neuroscience, health psychology, educational psychology, clinical psychology, and personality.

APPENDIX A

Alpha (8-13 Hz) amplitude scores obtained by QEEG evaluation from Pz, F3, F4, O1, and O2 electrode sites from the experimental (n=8) and control (n=8) group participants before and after QEEG evaluations

Table 18

Alpha (8-13 Hz) amplitude scores obtained by QEEG evaluation from Pz, F3, F4, O1, and O2 electrode sites from the experimental group (n=8) participants before and after QEEG evaluations

Participant	Location	QEEG Alpha Before	QEEG Alpha After
1.00	F3	11.00	14.10
1.00	O1	13.30	14.80
1.00	F4	12.70	15.10
1.00	O2	15.30	15.70
1.00	PZ	12.20	15.10
2.00	F3	6.50	7.20
2.00	O1	7.10	8.20
2.00	F4	7.50	9.40
2.00	O2	6.50	8.70
2.00	PZ	6.90	8.60
3.00	F3	6.30	7.10
3.00	O1	6.10	8.10
3.00	F4	7.20	8.70
3.00	O2	6.70	8.70

(table continues)

Table 18 (continued)

Participant	Location	QEEG Alpha	
		Before	After
3.00	PZ	6.90	9.90
4.00	F3	7.90	8.30
4.00	O1	12.30	13.70
4.00	F4	6.30	9.90
4.00	O2	12.50	16.30
4.00	PZ	7.20	10.30
5.00	F3	9.80	10.80
5.00	O1	10.80	10.80
5.00	F4	8.10	11.80
5.00	O2	10.20	11.90
5.00	PZ	9.40	11.80
6.00	F3	8.90	7.90
6.00	O1	7.60	8.80
6.00	F4	7.40	9.60
6.00	O2	6.60	8.40
6.00	PZ	7.10	9.80

(table continues)

Table 18 (continued)

Participant	Location	QEEG Alpha	
		Before	After
7.00	O1	20.20	16.10
7.00	F4	9.60	12.90
7.00	O2	20.70	15.40
7.00	PZ	13.10	16.30
8.00	F3	17.80	26.60
8.00	O1	13.10	15.20
8.00	F4	12.10	14.60
8.00	O2	17.90	18.60
8.00	PZ	13.70	18.90

Table 19

Alpha (8-13 Hz) amplitude scores obtained by QEEG evaluation from Pz, F3, F4, O1, and O2 electrode sites from the control group (n=8) participants before and after QEEG evaluations

Participant	Location	QEEG Alpha	
		Before	After
1.00	F3	7.90	7.80
1.00	O1	11.20	10.90
1.00	F4	8.10	8.30
1.00	O2	12.10	12.40
1.00	PZ	11.10	11.60
2.00	F3	9.30	10.10
2.00	O1	7.50	9.50
2.00	F4	9.80	9.90
2.00	O2	8.50	10.90
2.00	PZ	10.80	10.90
3.00	F3	6.50	5.30
3.00	O1	7.20	6.50
3.00	F4	7.20	6.30
3.00	O2	7.80	6.70

(table continues)

Table 19 (continued)

Participant	Location	QEEG Alpha	
		Before	After
3.00	PZ	7.60	7.10
4.00	F3	8.10	9.10
4.00	O1	7.70	7.70
4.00	F4	11.80	11.60
4.00	O2	7.60	8.40
4.00	PZ	8.40	8.60
5.00	F3	8.90	10.70
5.00	O1	9.60	12.30
5.00	F4	9.20	11.10
5.00	O2	10.10	12.30
5.00	PZ	9.80	10.40
6.00	F3	7.20	7.80
6.00	O1	11.20	10.90
6.00	F4	8.10	8.30
6.00	O2	10.90	10.10
6.00	PZ	9.30	9.70
7.00	F3	19.10	20.50

(table continues)

Table 19 (continued)

Participant	Location	QEEG Alpha	
		Before	After
7.00	O1	9.60	11.20
7.00	F4	8.50	10.30
7.00	O2	10.30	11.60
7.00	PZ	9.80	11.20
8.00	F3	7.50	9.50
8.00	O1	8.70	11.30
8.00	F4	8.20	10.10
8.00	O2	9.20	10.90
8.00	PZ	9.20	10.80

APPENDIX B

Life satisfaction, positive affect and self-esteem scores obtained from 10 experimental and 10 control group participants before and after twelve sessions of performance enhancement training

Table 20

Life satisfaction, positive affect and self-esteem scores obtained from 10 experimental group participants before and after twelve sessions of performance enhancement training

Participant	Life Satisfaction		Positive Affect		Self-Esteem	
	Before	After	Before	After	Before	After
1	110.00	115.00	71.00	79.00	72.00	178.00
2	107.00	114.00	63.00	71.00	204.00	211.00
3	120.00	125.00	74.00	82.00	179.00	186.00
4	115.00	118.00	69.00	74.00	168.00	169.00
5	103.00	113.00	49.00	53.00	173.00	189.00
6	132.00	134.00	78.00	81.00	162.00	173.00
7	115.00	121.00	81.00	81.00	157.00	162.00
8	107.00	106.00	69.00	70.00	198.00	204.00
9	112.00	123.00	81.00	89.00	183.00	190.00
10	104.00	109.00	73.00	80.00	176.00	180.00

Table 21

Life satisfaction, positive affect and self-esteem scores obtained from 10 control group participants before and after twelve sessions of performance enhancement training

Participant	Life Satisfaction		Positive Affect		Self-Esteem	
	Before	After	Before	After	Before	After
1	109.00	112.00	65.00	69.00	201.00	206.00
2	123.00	120.00	86.00	88.00	183.00	185.00
3	115.00	116.00	78.00	82.00	154.00	156.00
4	101.00	102.00	53.00	56.00	172.00	176.00
5	118.00	117.00	67.00	58.00	168.00	171.00
6	125.00	127.00	62.00	66.00	190.00	196.00
7	113.00	117.00	71.00	74.00	157.00	154.00
8	115.00	119.00	64.00	62.00	161.00	167.00
9	123.00	124.00	85.00	88.00	182.00	180.00
10	110.00	113.00	73.00	72.00	173.00	178.00

APPENDIX C

MIPS scores obtained from 10 experimental group participants before and after twelve sessions of performance enhancement training

Table 22

MIPS scores obtained from 10 experimental group participants before and after twelve sessions of performance enhancement training

Participant	Thinking Scale		Feeling Scale		Modifying Scale	
	Before	After	Before	After	Before	After
1	19.00	20.00	18.00	22.00	29.00	27.00
2	22.00	20.00	27.00	34.00	26.00	30.00
3	11.00	14.00	25.00	22.00	20.00	16.00
4	16.00	9.00	33.00	38.00	42.00	42.00
5	9.00	7.00	35.00	33.00	36.00	35.00
6	13.00	8.00	32.00	33.00	39.00	34.00
7	10.00	6.00	23.00	27.00	12.00	16.00
8	21.00	31.00	33.00	25.00	35.00	40.00
9	12.00	18.00	31.00	23.00	23.00	23.00
10	11.00	11.00	28.00	25.00	32.00	36.00

Table 23

MIPS scores obtained from 10 control group participants before and after twelve sessions of performance enhancement training

Participant	Thinking Scale		Feeling Scale		Modifying Scale	
	Before	After	Before	After	Before	After
1	31.00	41.00	19.00	16.00	16.00	22.00
2	3.00	16.00	37.00	32.00	9.00	30.00
3	13.00	19.00	30.00	26.00	16.00	30.00
4	14.00	17.00	44.00	44.00	41.00	48.00
5	23.00	27.00	25.00	24.00	40.00	47.00
6	9.00	10.00	33.00	35.00	29.00	25.00
7	21.00	29.00	30.00	33.00	29.00	42.00
8	14.00	16.00	35.00	30.00	45.00	48.00
9	14.00	35.00	43.00	30.00	23.00	45.00
10	20.00	26.00	40.00	35.00	37.00	37.00

APPENDIX D

Self-esteem Questionnaire

Thirty-six items were adapted from Fleming and Courtney's hierarchical facet model. The subjects were asked to respond to the following questions on a 7-point Likert scale, where the answers ranged form "none of the time" to "most of the time."

1. How often do you feel inferior to most of the people you know?
2. Do you ever think that you are a worthless individual?
3. How confident do you feel that someday the people you know will look up to you and respect you?
4. Do you ever feel so discouraged with yourself that you wonder whether you are a worthwhile person?
5. How often do you dislike yourself?
6. In general, how confident do you feel about your abilities?
7. How often do you have the feeling that there is nothing you can do well?
8. How much do you worry about how well you get along with other people?
9. How often do you worry about criticisms that might be made of your work by your teacher or employer?
10. Do you ever feel afraid or anxious when you are going into a room by yourself where other people are already gathered and are talking?
11. How often do you feel self-conscious?
12. How much do you worry about whether other people will regard you as a success or failure in your job or in school?
13. When in a group of people, do you have trouble thinking of the right things to talk about?
14. When you make an embarrassing mistake or have done something that makes you look foolish, how long does it take you to get over it?
15. Do you often feel uncomfortable meeting new people?

16. How often do you worry about whether other people like to be with you?

17. How often are you troubled with shyness?

18. When you think that some of the people you meet might have an unfavorable opinion of you, how concerned or worried do you feel about it?

19. How often do you feel worried or bothered about what other people think about you?

20. When you have to read an essay and understand it for a class assignment, how worried or concerned do you feel about it?

21. When you have to write an argument to convince your teacher who may disagree with your ideas, how concerned or worried do you feel about it?

22. How often do you have trouble expressing your ideas when you try to put them into writing as an assignment?

23. How often do you have trouble understanding things you read for a class assignment?

24. How often do you imagine that you have less scholastic ability than your classmates?

25. In turning in a major assignment such as a term paper, how often do you feel you did an excellent job on it?

26. Compared with classmates, how often do you feel you must study more than they do to get the same grade?

27. Have you felt ashamed of your physique or figure?

28. Do you often feel that most of your friends and peers are more physically attractive than yourself?

29. Do you often wish or fantasize that you were better looking?

30. Have you been concerned or worried about your ability to attract members of opposite sex?

31. How confident are you that others see you as being physically appealing?

32. Have you ever thought of yourself as physically uncoordinated?

33. Have you felt inferior to most other people in athletic ability?

34. When involved in sports requiring physical coordination, are you often concerned that you will not do well?

35. Have you thought that you lacked the ability to be a good dancer or do well at recreational activities involving coordination?

36. When trying to do well at a sport and you know other people are watching, how rattled or frustrated do you get?

APPENDIX E

Positive Affect Scale

The participants were asked to rate how often they feel each affective state listed on a 6-point Likert scale, with answers ranging from never to always:

1. competent
2. ashamed
3. happy
4. optimistic
5. guilty
6. proud
7. dirty
8. serene
9. in charge of my own life
10. panicky
11. in control of things
12. healthy
13. irritable
14. confident
15. secure
16. energetic

APPENDIX F

Life Satisfaction Questionnaire

Participants rated their agreement with each of the following statements on a 7-point scale, where 1=completely disagree, and 7=completely agree.

1. I am satisfied with my life.
2. Life has not been good to me
3. I am better off than a lot of people I know
4. Life is not worth living
5. I am always making plans for the future
6. I am always exploring new aspects of the world around me
7. I have serious problems for which there seem to be no solution
8. Those who know me appreciate what I have done with my life.
9. I do not have a sense of fulfillment about my life
10. I am proud to be what I am
11. It is a blessing to be alive
12. I have done a lot of good for the people around me
13. I don't seem to be able to enjoy life.
14. I have not made a lot of the opportunities given to me
15. I have a lot to look forward to in life
16. I am worse off than a lot of people around me
17. I find life exciting
18. I feel ashamed of myself
19. People like being around me
20. Life is nothing but a vale of tears

APPENDIX G

MIPS Sample Questions

The participants were asked to respond "yes" or "no" to each of the following items:

Modifying Scale

1. I spend a lot of time and effort to see that life works out well for me
2. Most of the time I am actively involved in arranging events in my life
3. I decide my priorities and then take firm action to achieve them
4. I quickly size up the situation and then act to make them turn out the way I want
5. I look for opportunities that are exciting and new to me

Thinking Scale

1. I am always cool and objective when dealing with others
2. I can ignore personal and emotional matters in my work
3. I think ahead and then actively follow through
4. I am impersonal and objective when I try to solve the problem
5. I prefer to make decisions on my own

Feeling Scale

1. My heart seems to rule my head
2. I often feel that my life goes from bad to worse
3. I often feel on the edge, waiting for something to go wrong
4. Lots of small things upset me
5. My heart seems to rule my head

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