EFFECT OF MUSIC BY MOZART AND SOUNDS CLAIMING TO CONTAIN BETA-FREQUENCY ENHANCING AUDIO SIGNALS ON BACKWARD DIGIT SPAN RECALL

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To the Graduate Council:

I am submitting a thesis written by Bryan Pickett entitled "Effect of Music by Mozart and Sounds Claiming to Contain Beta-Frequency Enhancing Audio Signals on Backward Digit Span Recall." I have examined the final copy of this thesis and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science with a major in Experimental\Research Psychology.

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Dedication

This thesis is dedicated to my parents who have always been behind me and who have pushed me to do my best in all that I do. This thesis is also dedicated to my beautiful wife of four years, Shannon, and our precious child Taylor Rayne for without them in my life; all my accomplishments would feel empty.

Abstract

Neurofeedback is the process of monitoring and manipulating brainwaves. In 1976, Lubar and Shouse used neurofeedback to treat a child with Attention Deficit\ Hyperactivity Disorder (ADHD). The most typical method for treating ADHD is to increase beta waves (14+ Hz), which are linked with increased focus and attention and to decrease theta waves (4-8 Hz), which are linked to daydreaming states. Recently this principle of increasing focus and attention through increasing beta waves has been used in audio technology that claims to increase beta waves through sound. The idea that sound or music can increase a person's attention, and thus cognitive abilities, is not new. In 1993, Rauscher, Shaw, and Ky reported that listening to Mozart resulted in higher participants' scores in their mean spatial reasoning as compared to silence and listening to progressive relaxation tapes. Since then, there have been conflicting results on the veracity of this "Mozart Effect." In this study, 87 participants were randomly assigned to one of three treatment conditions: listening to Mozart, the control group (silence), or listening to a CD that claims to contain beta-frequency enhancing audio signals. Each participant was tested individually. Participants completed a consent form, a pretest backward digit span task, a pretest state anxiety form, listened to 15 minutes of the independent variable, completed a posttest anxiety form, completed the posttest backward digit span task, and completed a demographic data form before being debriefed. Results were analyzed using a repeated measures 2 X 3 ANOVA. The results indicate that participants in all three treatment groups showed a practice effect; however, there was no difference between groups on the backward digit span task as a result of the treatment condition. Those participants who listened to the beta-frequency enhancing CD had significantly higher posttest state anxiety scores ($p < .05$) compared to the Mozart group and the control group who both had significantly lower posttest state anxiety scores ($p < .05$). There was no correlation between backward digit span performance and state anxiety. Other interesting correlations were found between variables on the demographic data form (e.g., participants self-report of attention, mood, music training, self-report of liking the independent variable, etc.). Listening to Mozart or to the proclaimed beta-frequency enhancing CD did not increase performance on the backward digit span task in this study. Strengths and limitations as well as considerations for future research are also discussed.

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Overview

Since the advent of EEG (electroencephalograph) biofeedback technology, many clinicians and researchers have explored the wide variety of clinical indications for which efficacy has been observed directly, or claimed by others. This thesis will specifically explore the indication of use of EEG technology to treat Attention Deficit/Hyperactivity Disorder (ADHD); and to see if this ability has the capability of extending to assisting individuals without ADHD to perform better in their cognitive functioning. Additionally, there has been conflicting reports on the "Mozart Effect", or proposed effect that listening to music by Mozart will help individuals score significantly higher on a spatial-temporal task as compared to listening to relaxation, silence, or a story. Although this effect has been reported in the general press, some researchers have not been able to reproduce this effect casting some doubt on the generalizability of the effect. This thesis will thus explore prior studies on the Mozart Effect. After exploring EEG biofeedback technology and the Mozart Effect, this thesis will continue to describe the study conducted by this author to compare the effect of EEG biofeedback technology and listening to music by Mozart as compared to a control group, silence, on a spatial-temporal task, measured by performance on backward digit span recall.

Introduction and Literature Review

One purpose of psychology is enabling or assisting people to fulfill their maximum potential in life. Psychologists have devoted their efforts into helping individuals who are challenged either physically, mentally, emotionally or otherwise, to function more effectively in society. This is a very noble endeavor; however, the knowledge gleaned from science should be used to benefit any individual, whether disabled or not. For example, is it possible that a method used to help individuals with Attention Deficit/Hyperactivity Disorder (ADHD) and Learning Disabilities (LD), can also be used to improve learning in individuals without such disabilities? The specific method to which this paper refers is electroencephalogram (EEG) neurofeedback, which is used to monitor and then alter the users' brain waves to a desired frequency and amplitude pattern. This thesis will give a brief introduction to EEG biofeedback and the process of biofeedback and brainwaves. I will discuss and define neurofeedback, the process and outcomes of neurofeedback, common methods used, and present one theory on how neurofeedback works. Then, I will discuss how neurofeedback may affect unimpaired individuals, the "Mozart Effect," and beta wave enhancement through music. Following this, I will briefly introduce some theories of how anxiety may affect test performance and specifically how state anxiety may correlate with performance on the backward digit span task. Finally, I will discuss the purposes, hypotheses, and proposed methodology of the present study.

EEG and Brain Waves

EEG, or electroencephalogram, is the measurement of electrical energy generated by the brain. In other words, the technician records the electrical impulses in the brain, through wires that are attached to the scalp. This electrical energy is naturally produced by the brain during the firing of neurons. When a neuron fires, a transmission of electrical messages is sent to other neurons. Neurons do so by acting as a type of electrical switch. This switch, or action potential, changes the voltage of a neuron from -65 millivolts to +55 millivolts in milliseconds (Scott, 1995). This process of firing is the very basis of existence, as the brain requires that neurons constantly fire, sending electrical impulses from one to another.

Neurofeedback, or EEG, is a process by which this electrical activity can be recorded, by placing electrodes on the scalp. The electrodes send the brain-wave impulses to an oscillograph, a machine which amplifies and records the activity (Comer, 1995). The recorded activity is the EEG waveforms which are the "summated synaptic potentials generated by the pyramidal cells of the cerebral cortex" (Handout from Stevens, 2000, p. 27). It is possible to record this activity for individual neurons (through inserting an electrode), specific regions of the brain, or for the whole brain itself. However, neurofeedback practitioners are usually more interested in the activity measured in particular regions of the brain, rather than in single neurons and/or in the whole brain. This is partly due to the their focus upon less invasive methods of assessing brain states as well as due to localization of functions within the brain.

Scientists call these electrical impulses brain waves because the aforementioned change in voltage is recorded on the oscillograph in what could best be described as a wave-like motion. These brainwaves, and the corresponding recordings, can either be slow (oscillations at .5 cycles per second (cps) or hertz (Hz)), fast (oscillations of 40+ cps), or any range in between (Brain Wave Functions, 2000). A cycle would be how long it takes for the wave to travel from the trough of one wave to the trough of the next wave.

There are five categories of these brainwaves, ranging from the most activity to the least activity (Brain Wave Functions, 2000). The highest category of brain waves is gamma, which ranges in frequency above 35 Hz. There is some evidence of association between gamma waves and peak performance states. When the brain is aroused and engaged in mental activities, it generates beta waves. Beta waves have relatively low amplitudes and are the second fastest of the five brainwaves, conservatively ranging from 13-35 Hz. Beta waves are characteristic of a strongly engaged mind. The next brainwave category, by order of frequency, is alpha, which are slower than beta and higher in amplitude. Their frequency ranges from 8-12 Hz. Whereas beta waves typically indicates arousal, alpha represents non-arousal; for example, the individual may have just completed a task and is resting, or is in a meditative state. The next category of brainwaves is the theta brainwave, which have an even greater amplitude and slower frequency, between 4-7 Hz. This brainwave tends to occur when the individual is drowsy or daydreaming. The final category is the delta brainwave, which has a greater amplitude and the slowest frequency of the four, below 4 Hz. This state is often characteristic of an individual who is asleep and is dreaming or not dreaming. (See Appendix A for a short summary of brain waves, their related frequencies and behavior, and examples of their EEG readouts).

An underlying assumption within neuropsychology is that the brain waves grossly correspond to our behavior and consciousness. For example, if the brain is in the delta brain wave state, then that person is generally assumed to be asleep. Therefore, the function of measuring brain waves is to gain normative data on the functioning of an individual. By knowing what brain waves are and the corresponding state and behavior of the individual, scientists gain a better understanding of the human brain. It is believed that one can measure the brain waves of one individual and compare them to the brain wave patterns of other individuals. If the EEG reveals an abnormal brain wave pattern, otherwise known as dysrhythmia, then clinicians might suspect that the brain is not operating as it should due to a problem, such as a lesion or a tumor (Comer, 1995). Armed with this knowledge the clinician can then use more sophisticated techniques to determine the nature of the problem so that a remedy may be found. For example, the different types and causes of epileptic seizures are correlated with certain recognizable focal or diffuse brain wave abnormalities, such as spikes. Treatment with anticonvulsant drugs or neurosurgical removal of brain scars often depends on the data furnished by an EEG (Handout from Stevens, 2000).

EEG Neurofeedback

However, the benefits of EEG need not stop at merely the diagnostic level with external interventions necessary, such as surgery and medicine. EEG can also be used to enable internal interventions to remedy directly any problems that exist in the functioning of brain waves. This is the process known as biofeedback. One definition of biofeedback is "the technique of using equipment (usually electronic) to reveal to human beings some of their internal physiological events, normal and abnormal, in the form of visual and auditory signals in order to teach them to manipulate these otherwise involuntary or unfelt events by manipulating and displayed signals" (Basmajian, 1979, p. 1; as cited in Schwartz, 1995). This process of biofeedback can refer to any internal physiological event, even those thought to be involuntary including heart rate, skin temperature and brain waves.

The specific process of monitoring and manipulating brain waves is known as neurofeedback. Essentially, an EEG machine measures and records brain wave activity;

then, when a specific brain wave occurs the individual is notified, via a visual or auditory signal. By focusing on increasing the occurrence of these signals, an individual learns to modify his/her brain wave to the specific pattern desired.

Neurofeedback and Attention Deficit\Hyperactivity Disorder (ADHD)

Kennerly (2000) states that in the1960s, EEG neurofeedback was primarily used to control stress. Since then, technology and interests have slowly expanded researchers' understanding of brainwave patterns. Hutchinson (1994) reports that "associations were found between specific patterns of brain wave activity and pathological, normal, and optimal cognitive performance/states" (as cited in Kennerly, 2000, p. 4). He continues by stating that biofeedback researchers utilized this information to train participants who have frequency patterns associated with various disorders to alter their brain wave patterns to match those associated with normally functioning individuals (as cited by Kennerly, 2000). For instance, researchers now use EEG neurofeedback in the treatment of ADHD.

Attention Deficit\Hyperactivity Disorder or ADHD is recognized as a pervasive disorder that affects between 5-10 percent of school age children, and it is believed that approximately seventy percent of these children never outgrow the disorder (Linden, Habib, & Radojevic, 1993). Lubar, Swartwood, Swartwood, and O'Donnell (1995) state that it is clear "that the primary symptoms of Attention Deficit/Hyperactivity Disorder – inattentiveness, impulsiveness, and hyperactivity as well as their various manifestations – are really secondary outcomes resulting from an underlying neurological disorder" (p. 84). The neurological basis of ADHD may be a decrease in arousal, decreased noradrenergic activity, an increase in theta activity (slow 4-8 Hz) in frontal and central cortical regions, as well as decreased glucose metabolism in frontal cortical and subcortical regions. An excerpt from The Attending Physician states that ADD is a biologic, heritable disorder. If one parent has ADD, then current estimates suggest a 30% chance of having a child with ADD (handout from Stevens, 2000). Similarly, an excerpt from The ADD Book states that the genetic component far outweighs the environmental component with ADD. Environment influences how severe and persistent ADD traits will be but does not produce them (handout from Stevens, 2000). The Attending Physician confirms that it is not caused by poor parenting, not the product of family chaos, not the result of food coloring or preservatives, and not caused by sugar or yeast. Abarbanel (1995) adds that attentional disorders impose a great burden on the individual, disrupts family functioning, and their "effects discourage and demoralize a significant percentage of its sufferers too often leading them away from productive activity and into antisocial lifestyles, drug abuse, and crime" (p. 15). He continues to state the combination of increased beta activity and decreased theta activity associates directly with states of increased stillness, attentiveness, decreased drowsiness, and other cognitive disturbances associated with theta activity. In fact, the higher frequency beta has been correlated with focussed attention in a number of species. (For other facts on ADHD, the reader is referred to Appendix B).

ADHD is often managed pharmacologically with perhaps the most frequent drug of choice being Ritalin. However, Ritalin only lasts for 3 to 4 hours and has numerous side effects such as insomnia, loss of appetite, and depression. As soon as the medication wears off, full-blown symptoms of ADHD reappear (Alhambra, Fowler, & Alhambra, 1995). Barkley (1990) states that 70 – 80% of children with ADHD respond favorably to psychostimulants compared to 35% that improve that with placebos (as cited in Rossiter & La Vaque, 2000). Unfortunately, noncompliance with taking medications is a major limitation of the effectiveness of medicine to combat ADHD. Long-term compliance is typically poor; therefore, the 60 – 70% of individuals who continue to experience significant ADHD symptoms through adolescence suffer emotionally, socially, academically, and vocationally (Rossiter & La Vaque, 2000). Therefore, psychologists are constantly seeking a better treatment, one with long-term results and minimal or no side effects.

In 1976, Lubar and Shouse used EEG biofeedback to treat a child with ADHD (as cited in Boyd and Campbell, 1998). Since then, other studies have been done showing the effectiveness of treating ADHD using neurofeedback in clinical settings (Alhambra, Fowler, & Alhambra, 1995; Lubar, Swartwood, Swartwood, & O'Donnell, 1995) as well as in the school setting (Boyd & Campbell, 1998). The most typical method for treating ADHD through neurofeedback is to enhance the amount of beta activity (14+ Hz) while inhibiting theta activity (4-8 Hz) (Lubar, Swartwood, Swartwood, & O'Donnell, 1995). It is desirable to decrease theta activity because it is most commonly associated with the hypnagogic, hypnopompic states (before and after sleep) as well as daydreaming and deeply relaxing states (Neurosync, 1998). Conversely, beta waves "are associated with focused attention towards external stimuli, alert mental activity, normal waking consciousness, and active thought processes" (Neurosync, 1998). Therefore, increasing beta waves and decreasing theta waves should help the individual to become more focused and alert, a desirable result considering ADHD individuals have problems with inattentiveness and impulsiveness which not only lead to behavioral problems but also interfere with their ability to learn and complete work in school.

Neurofeedback has many more applications than just treating individuals with ADHD and Learning Disabilities. "This technique has been found to be a rapid and effective intervention for many severe and resistant pathologies including, 'depression, sleep disorders, seizures, chronic fatigue, headaches, mood swings, anxiety' (Hutchison, 1994, p. 361), alcoholism, (Peniston & Kulkosky, 1989), addiction, . . ., epilepsy, post-traumatic stress, paralysis and cognitive impairment as a result of a stroke or head injury (Ochs, 1993)" (Kennerly, 2000, p. 4). In a clinical study, Othmer, Othmer & Marks (1991) found that beta training in fifteen participants (ages 6-16 who were diagnosed with ADHD, LD or both) over a period of several months produced an average IQ increase of 23 points and, in cases where the starting IQ value was lower than 100, the average IQ increase was 33 points. This study also found dramatic improvements in visual retention and auditory memory and the subjects showed major gains in reading and arithmetic. The authors state that any practice effect affecting the dependent variable is negligible as IQ testing was performed at least six months apart as the WISC-R criterion states. Additionally, significant gains were found in areas where long-term memory could not have been a factor, such as the digit span task.

Tansey (1984) conducted another study to examine the effects of EEG biofeedback on learning disabled children. All participants showed an increase in their full-scale IQ scores of at least one standard deviation (15 points). He also found that "those subjects, with either a significant (> 15 points, $p < .01$) verbal greater than performance or performance greater than verbal IQ score discrepancy, exhibited no less than a 60% greater increase in the lower of the two IQ scores" (p. 173). Unfortunately, he did not utilize a control group and only had six subjects in his study.

However, another study by Linden, Habib, and Radojevic (1999) randomly assigned participants, ages 5 to 15, who were diagnosed with ADD, ADHD, or LD (N = 18) to two groups. The treatment group received 40 sessions of EEG biofeedback while the waiting list, control group, received no treatment. None of the participants in either condition received psychotherapy or pharmacological treatment during their participation in the study. The authors found a significant mean increase in the Composite IQ of nine points in the experimental group as compared to the control group. Furthermore, they also found that participants in the experimental group diagnosed as Learning Disabled (LD) had an average IQ increase of 20 points. However, the number of LD participants was not large enough to reach statistical significance. The authors conclude by stating that their study utilized better controls than previous studies, such as: a control group, consistent bandpasses of EEG biofeedback, the same length of treatment for participants, reliable multiple dependent measures to assess improvement, as well as a large enough sample size to have adequate power. The author also admits that further research utilizing double-blind placebo designs and larger sample sizes are needed to support and replicate these findings.

Another study cited by Kennerly (2000), performed by Hutchison (1994), found that in a one-year follow-up study, the trainees showed major improvements in self-esteem and concentration and significant improvements in such areas as handwriting, school grades, sleep, irritability, organization, hyperactivity, verbal expression, and headaches, all of which appeared permanent. It is important to note that all of these positive benefits occurred after multiple beta training sessions spanning several weeks if not months and not after just a single session.

The argument has arisen about whether or not the placebo effect could really be the cause of these specific effects and not attributable to EEG biofeedback training. However, Othmer, Othmer, and Kaiser (2000) state that the placebo effect is not the explanation for the efficacy claimed in these EEG studies for nine reasons. First, statistical evidence from these studies heavily favor EEG training as the mechanism of change. Second, the effects of the training are highly specific to electrode placement and to training frequency band. Third, training protocols exist which can commonly elicit effects opposite those desired. Fourth, the effects of training with one protocol can be reversed with another. Fifth, the effect of the training is cumulative, rather than fading with time, as is common with placebos. If EEG biofeedback were to be explained in terms of placebo phenomenon, it would be the first time that placebos are dose-dependent (i.e., cumulative). Sixth, training effects are in line with research from neuropsychology regarding localization of function. Seventh, populations can be moved to levels of performance which exceed those of native populations. Eighth, the effects of the training often lie outside of the range of expectations for spontaneous recovery or placebo effects, not only with respect to the magnitude of changes elicited but also with respect to the consistency with which they are produced, and the time-scale over which they occur. Finally, EEG biofeedback was discovered in connection with animal research. It may be assumed that the test animals were not subject to the placebo effect. Additionally, the researcher (Sterman, 1976) was blind to the effect, since the discovery was by way of serendipitous connection to an unrelated experiment.

Various Methods of EEG Training

Several different methods for EEG training have emerged. The most traditional type, as discussed previously, is to utilize an EEG biofeedback machine, which records the electrical activity of the trainee and displays it via auditory or visual means. The trainees then observe their brain activity and learn to control it to gain the desired amplitude and pattern. However, the application of this method is often unfeasible. As Kennerly (2000) states, "it is hard to imagine a classroom where all twenty students are seated with electrodes on their heads and a biofeedback therapist attending to each of them . . . EEG biofeedback equipment can cost between $4,000 and $20,000 (Hutchison, 1994) per machine. Furthermore, EEG biofeedback requires the one on one attention of highly trained personnel" (p. 8). Therefore, several people are developing or have developed various alternatives to achieve the same result.

One method developed is Cranial Electrical Stimulation (CES), a technique that introduces the desirable frequencies by low level electrical currents applied to the cranium. Another less invasive procedure is the use of Binaural-Beat Audio Signals (BBS's). Binaural beats occur when two pure tones of different pitch and nearly similar frequencies (less than 1500 Hz) are presented separately to each ear of the trainee (Atwater, 1999). The brain synthesizes the two tones into a single tone, which is felt by the trainees as originating from the center of their heads. This process produces a phenomenon known as hemispheric synchronization, where the electrical activity of the two hemispheres of the brain unite into a single pattern which has an overall frequency of the difference between the two original tones. Morris (1991) states that "if the individual listens to a tone with the frequency of 440 Hz in one ear and another tone of 444 Hz in the other ear, a binaural beat of 4 Hz will be produced" (as cited in Guilfoyle & Carbone, 1997, p. 1). However, none of the studies using this technology that I reviewed indicate if there is a specific formula to present to the participant to result in any particular brain wave state, possibly due to attempts to trademark the technology utilized in their studies.

Neurofeedback and Unimpaired Individuals

It has been established that neurofeedback is an emerging method which can be effective in the treatment of many health and mental problems. However, it is possible that these methods may also be used to enhance the performance of unimpaired individuals. There are now materials available on the market which claim that they can enhance mental well-being and self-esteem, improve attention, increase memory, improve academic performance, and produce states of intense relaxation and reverie. (See Appendix C for an example). Is there any scientific basis for believing that the principles of neurofeedback can be applied to unimpaired individuals to enhance their potential?

A recent study (Rasey, Lubar, McIntyre, Zofuto, & Abbott, 1996) was designed to determine whether the EEG biofeedback techniques that are so effective in improving attentional processing in individuals with ADHD will have similar benefits for normal subjects. In this study, participants who were diagnosed as free of any neurological or attention deficit disorder and who had never received prior EEG biofeedback were pre-tested on the Wechsler Adult Intelligence Scale- Revised (WAIS-R), on the Intermediate Visual and Auditory Attention (IVA) tests, and an Autogen A620 Neurofeedback Assessment. Participants then underwent an average of 20 EEG neurofeedback sessions to increase beta activity while decreasing theta activity. For the purposes of this study, the authors differentiated the participants as either Learners or Non-Learners based upon changes in the parameters of EEG testing, such as participants exhibiting negative theta/beta ratio correlations and positive correlations in the percentage of EEG beta. Following treatment, participants were re-evaluated on the pretest measures and the results between those classified as Learners and Non-Learners were compared. The Learners achieved Full Attention Quotient (FAQ) deviation scores of 2.2 and 3.73 as compared to the FAQ scores of -.93 and .13 for the Non-Learners on the IVA. There was no significant change between these two groups on the pretest or posttest on the WAIS-R. Rasey, Lubar, McIntyre, Zoffuto, and Abbott (1996) state that the results suggest that some normal young adults can learn to increase EEG activity that is typically associated with improved attention. While it is an interesting study, there are several inherent problems. One problem is in the number of participants used for the study. The authors originally recruited seven subjects, which is a small number. Through the course of the study, three of the seven subjects dropped out of the study. The final sample size of four is inadequate to provide a good, generalizable study. Another problem with this study, somewhat related to the meager sample size, is the fact that the authors did not incorporate a control group. This makes it difficult to accept that the results of the study are due to treatment alone. Similar problems abound in the data analysis and in the interpretations of the results, undermining the overall validity of the results. For example, the authors state that a "possible explanation for why Non-Learners were unable to perform as well as Learners may have to do with the relatively low number (mean = 20) of EEG biofeedback sessions all participants received" (p. 5). If all participants received a nearly equal number of sessions, then the relatively low number of sessions itself can not be a differentiating variable between the two groups. Although the theoretical ideas behind the study seem valid, the execution of the study falls short of its goal. Therefore, another study should be done to examine the effectiveness of EEG neurofeedback in unimpaired individuals.

Another study by Edrington (1984) tested the effects of "cognitive learning enhancement tapes" on college students taking an Introductory Psychology course. These tapes were based on binaural beat technology. There were two separate sections for the same course. One section was randomly assigned the enhancement tapes to listen to during class while the other section did not listen to anything. Six tests were administered over the course of the semester and on all of the tests, except the first one, the experimental group scored on average approximately ten points higher on each of the tests (as cited in Guilfoyle & Carbone, 1997).

Mozart Effect

The idea that music can effect changes in the brain is not a new idea. Ancient cultures and religions have long used music in life and ceremonies, sometimes with the aid of drugs or dancing, to achieve a change in consciousness. More recently, Rauscher, Shaw, and Ky (1993) reported that 12 undergraduates displayed significantly higher ($p < .002$) mean spatial reasoning scores of 8 or 9 IQ points on portions of the Stanford-Binet Intelligence Scale (4th ed.) after listening to 10 min. of Mozart's Sonata for Two Pianos in D Major, K448 than did the other 24 undergraduates who were in either a silence condition or a condition listening to a progressive relaxation tape. However, these results were gained through a posttest only study, which leaves open the possibility of other factors or pre-existing differences between the groups as the reason for these results.

Further studies have shown that music lessons improved spatial-temporal reasoning in preschool children (Rauscher, Shaw, Levine, Wright, Dennis, & Newcomb, 1997). Rauscher and Shaw's (1998) theory on how listening to Mozart can affect spatial-temporal tasks is known as the 'trion' theory. The trion model is based upon the Hebbian learning principle that neural firing patterns can be strengthened through small modifications to their connectivity strengths. Music enhances the performance of more complex spatial tasks, or spatial-temporal tasks. It does so by exciting the cortical firing patterns used in spatial temporal reasoning. This excitation via music primes the neural pathways temporarily (approximately 10 minutes in the Mozart Effect) which facilitates the subsequent cortical firing patterns necessary for spatial-temporal processes.

Hetland (2000) cites two recent articles, Rideout and Laubach (1996) and Sarnthein, von Stein, Rappelsberger, Petsche, Rauscher, and Shaw (1997), which utilized brain imaging to show that music and spatial-temporal tasks activate proximinal brain regions. The Rideout and Laubach (1996) study was designed for two purposes. First, the authors attempted to replicate the improved spatial performance following exposure to music in adults and secondly, to examine any EEG correlates of changes in performance after listening to music. This study was able to replicate the Mozart Effect, but to a lesser extent, which the authors attribute to employing only four subjects in their study. The authors also found several interesting correlations that were reliable between changes in EEG characteristics and changes in performance on the spatial task, the paper folding and cutting task. These correlations include the association between improved performance and lowered theta frequency in the left temporal region and increased average power in the $beta_1$ range, seen in the left temporal, right temporal, and left frontal regions. The authors conclude that in general, "a lower $alpha_2$ frequency and a higher $beta_1$ frequency were associated with greater improvement on the spatial task", which is similar to the treatment protocol of beta wave enhancement through EEG biofeedback (p. 431). Despite these interesting correlations, I am unaware of anyone conducting a study to determine if any consistent EEG changes are caused by listening to Mozart vs. "non-enhancing" music or silence conditions used in the Mozart studies. As Hetland (2000) states, "the properties of music that enhance spatial tasks have not yet been explicitly specified" (p. 136). Some researchers have proposed that "complex" music or music possessing symmetry activates the right hemisphere; others propose that any stimulus the person likes enhances spatial performance; while still others propose that the rhythmic elements in the music are responsible (Hetland, 2000). Is it possible that certain music capable of positively affecting an individual's EEG pattern towards a more attentive and focused mental state could be the underlying cause of the Mozart Effect? Perhaps the current study can provide adequate data to see if further studies into this possibility should be conducted.

Since the Rauscher, Shaw, and Ky study in 1993, there have been numerous studies performed on this effect known as the "Mozart Effect" with some supporting and some not supporting this research (e.g. Newman, Rosenbach, Burns, Latimer, Matocha, & Vogt, 1995; Rideout, Doughtery, & Wernert, 1998, Steele, Ball, & Runk, 1997; Steele, Brown, & Stoecker, 1999; Steele et al. 1999). Rauscher and Shaw (1998) state that these varied results are due to researchers' diverse choices of dependent measures, which do not adequately measure spatial-temporal tasks. Perhaps the most vocal critic of the Mozart Effect is Steele, who has attempted to replicate the Mozart Effect in several studies (Steele, Ball, & Runk, 1997; Steele, Brown, & Stoecker, 1999; Steele et al. 1999). Steele, Ball and Runk first attempted to replicate the effect using the backward digit span as the dependent variable. The authors chose this task because it incorporates both spatial and temporal transformations; however, they were unsuccessful. Rauscher and Shaw replied that the backward digit span is not an appropriate task as it is "often not included in subclasses of spatial ability" (p. 837). Accordingly, Steele, Brown and Stoecker (1999) and Steele et al. (1999) tried to replicate the Mozart Effect following recommendations from Rauscher and Shaw and even tried to replicate the original Rauscher, Shaw, and Ky study without success. Steele et al. (1999) conclude that the sonata had no effect on performance and that a "requiem may therefore be in order" (p. 827). Rauscher (1999) replied that Steele et al. found no Mozart Effect in three differently designed studies since not one design replicated the original reports. Rauscher concludes that the Mozart Effect can not be found under all laboratory conditions but several studies outside of her lab have successfully replicated it. "Because some people cannot get bread to rise does not negate the existence of a 'yeast effect'" (Rauscher, 1999, p. 828).

A recent meta-analysis was performed by Hetland (2000) to determine if the Mozart Effect does exist. In this article, the author discusses several competing theories other than Rauscher and Shaw's (1998) trion model concerning why the Mozart Effect might exist. One such hypothesis is arousal, "according to which music listening produces an optimal level of adrenaline in the brain and thus elevates performance on cognitive tasks compared to performance following silence" (p. 106). However, the author points out that if arousal is the explanatory mechanism, then all forms of cognitive tasks should be facilitated, which have not been substantiated in studies. Two other hypotheses contend that either a strong positive mood or a preference for the selection is the facilitating mechanism. Yet, the author again contends that either hypothesis naturally leads back to the increased arousal hypothesis, which has not been substantiated. Clearly, more work needs to be done to resolve the questions raised by conflicting results and competing theories.

To help do so, Hetland (2000) identified a total of 26 studies reporting 36 independent experiments, both published and non-published. Her criterion for inclusion into the meta-analysis was strict; for example, only studies of normal human subjects were accepted, studies had to contain at least one condition where subjects listened to approximately eight to fifteen minutes, under laboratory conditions, any musical stimulus predicted to enhance spatial performance, studies also had to contain one or more conditions of equal duration predicted not to enhance spatial performance, studies had to include one or more outcome measures on performance on spatial tasks, studies had to provide the necessary statistics to compute an effect size, and studies had to control for practice effects. After analysis, Hetland concludes that there is a Mozart Effect which is limited "to a specific type of spatial task that requires mental rotations in the absence of a physical model. It is a moderate effect [mean r = .24], and it is robust" (p. 136). However, the enhancing effect is not limited to Mozart's music and the properties of music that enhance spatial tasks have not been explicitly specified; therefore, she can not be certain, yet, of why the effect occurs. One possibility is that labs affiliated with Rauscher and Rideout, which have been successful in replicating the effect, emphasize that participants attend to the music. Hetland finds nothing "to suggest that their results are in any way inflated or suspect" (2000, p. 135). A second possibility is that those studies of higher quality (e.g., had equivalent subject groups, reduced experimenter expectancy effect, and ensured that participants were naïve as to the purpose of the experiment) produced higher effect sizes ($p < .0001$). Additionally, Hetland notes that several "experiments included in my analysis here have small effects in the predicted direction (e.g. Steele et al., "Failure to Confirm the Rauscher and Shaw Description", and the . . . study reported in Steele et al., "Prelude or Requiem, UWO Experiment") but have previously been referred to as failures to replicate because they did not achieve significance levels of $p < .05$" (p. 141). She attributes this problem to the low power of a small sample.

A final point that Hetland makes is that the effect of arousal, mood, and preference still need to be explored. As pointed out above, researchers are currently working to resolve the questions raised by the conflicting findings and competing theories, e.g., trion model, arousal hypothesis, mood hypothesis, and preference hypothesis. "Are arousal, mood, and preference synonymous, causing some other factor (e.g., attention) to enhance performance on spatial tasks? Or are factors somehow linked in a causal chain (e.g., preferred stimuli are enjoyed more, leading to positive mood, which in turn heightens arousal, which then heightens attention, ultimately resulting in improved task performance)?" (Hetland, 2000, p. 107). Both Hetland, and Rauscher and Shaw (1998) admit that more work needs to be done in this area before practical applications can be derived. For this reason, as will be discussed later, additional questions were asked of the participants regarding their attention, mood, preference for the independent variable, etc.

Beta Wave Enhancement through Music

Although the veracity of the Mozart Effect is still debated, many studies have shown that music has the potential to elicit changes in the brainwave pattern of the listener (Altenmueller, Gruhn, Parlitz, & Kahrs, 1997; Ogata, 1995; Petsche, Lindner, Rappelsberger, & Gruber, 1988; Walker, 1977).

One such technique, as discussed earlier, is the use of specially formulated sounds or music (BBS's or Binaural Beat Audio Signals), which have the ability to change brain wave patterns. An example of this is a new CD called Focused Attention, developed by Emily Stevens and John Cayhill, which they claim uses specially formulated sounds to create specific brain waves. They have not conducted any studies or rigorous testing to support their claim, choosing instead to rely on the personal testimony of users as well as scientific theory. Unfortunately, they are unwilling to provide the exact process by which their CD creates these specific brain waves pending a patent, except to say that they are blending several techniques, including BBS's. This CD contains two tracks called Focus and Super Attention. John Cayhill (personal communication, April 20, 2000) states that the Focus track produces a beta state in the listener's brain while the Super Attention track induces an even higher frequency of beta in the listener's brain. He has designed these tracks specifically for the purpose of creating a state of increased attention in the listener, which should positively affect their performance on cognitive tasks. The following is written on the inside cover of the CDs being sold by Stevens and Cayhill:

> Focused Attention is specifically designed for individuals with attentional deficits and for individuals who want to improve their attention. This CD is designed to enhance and improve attention while the person engages in an activity while utilizing the Neurosound® technology.

This CD utilizes Beta frequencies from QEEG brainmapping research that are associated with concentration to entrain the brain during concentration tasks. This is the only CD of its kind which uses identified Beta frequencies from research on patients with Attention Deficit Disorder and places it into highly advanced sound technology to help develop and enhance an individual's concentration. Neurosound® technology has been clinically utilized to improve concentration with Attention Deficit Disorder patients showing significant improvements in their EEG brainwave response patterns during concentration tasks.... Neurosound® technology is based on over 7 years of research and the treatment of hundreds of patients. QEEG neurometric brainmapping has identified key frequencies associated with different brain states and disorders. By using scientific data and current technology brain frequencies can be placed in sound ort music to enhance brain performance . . . **Track 1: Focus** This track supports concentration needed on day-to-day tasks such as homework, studying, paying bills, balancing checkbooks and basic work activity . . .**Track 2: Superfocus** This track supports concentration needed for projects, studying for tests, writing papers, and tasks associated with immediate deadlines that require intense focus and concentration.

In fact, the reasoning for two tracks is that Super Attention should create a higher beta state than Focus so it should positively affect the listener's attention even more than Focus. This CD is only one of many that Stevens and Cayhill either have produced or will be producing to enable the listener to enter into several different useful brain wave patterns (J. Cayhill, personal communication, April 20, 2000). At this point, I feel that I should notify the reader that I am not endorsed by Stevens or Cayhill or associated with either in any capacity that interferes with this study being a fair and objectively scientific investigation.

<u>Theories of Test Anxiety</u>

The dependent variable chosen for this experiment is the backward digit span task. Later in the Methods section, I shall discuss my reasons for this decision. In this current section, the possible confounding effects of anxiety on test performance shall be explored. This will be followed by a discussion of the possible correlation between anxiety and the backward digit span task. Turner (1996) gives an excellent overview of the theories of test anxiety. In the early 1950's, researchers became interested in test anxiety partly in response to the popular claim made by students that they knew the material but "froze" on the tests due to anxiety leading to poor test performance. Turner states that various literature reviews and meta-analyses (e.g. Eysenck, 1982; Hembree, 1988; Sarason, 1986; Seipp, 1991) confirm that the vast majority of research indicates the existence of a negative relationship between anxiety and test performance. As Turner explains, Spence (1958) incorporated anxiety as an important component in his theoretical construct as motivation. Spence described an "inverted-U" shaped function in which moderate levels of anxiety were necessary for optimum performance, and too much or too little anxiety inhibited performance. Further exploration into the complexities of the construct of anxiety led to the division of state and trait anxiety, which will be further explicated in the next section. An alternative theory differentiates anxiety into worry and emotionality components. The worry component refers to the cognitive manifestations of anxiety, such as expectation of failure. The emotionality component refers to unpleasant feelings or tension. Research in this area (Deffenbacher, 1978; Deffenbacher & Dietz, 1978; Morris, Davis, & Hutchings, 1981; Sarason, 1984; Tryon, 1980) indicates that the negative effects on anxiety are attributable to worry rather than to emotionality (as cited in Turner, 1996). Other researchers have continued to explore the multi-faceted concept of anxiety in an attempt to adequately explain why anxiety negatively affects performance. (For a detailed discussion on this topic, I refer the reader to Turner, 1996). In summary, Turner agrees with the conclusions of Eysenck and Calvo (1992) who state that "(a) state anxiety is generally associated with poor processing efficiency under test conditions, as high anxiety individuals use more processing resources than low-anxiety individuals; (b) the effects of state anxiety on performance effectiveness depend on (1) the availability and utilization of additional resources and (2) the demands of the task on working memory" (1996, p. 27). Digit span tasks involve the major components of the working memory and should be adversely affected by high levels of anxiety.

Anxiety and the Backward Digit Span

Matarazzo (1972) states that the digit span task, both forwards and backwards, has been widely used in intelligence scales partly due to the fact that it is easy to administer, easy to use, and specific as to the type of ability it measures. This task is an excellent indicator of short-term memory. Low scores on the digit span task "when not associated with organic defect, can be due to anxiety or inattention" (p. 204). However, Matarazzo continues to explain that psychologists have found contradictory results concerning the relationship of anxiety to intelligence test performance. It was out of these contradictory indications that the "distinction between the effect on intellectual functioning of transient, situational (state) anxiety versus a type of more chronic, psychiatric, enduring anxiety called trait anxiety" was introduced (p. 443). Since then, according to Matarazzo, several studies (Siegman, 1956b; Siegman, 1956a; Matarazzo, 1955; Goodstein & Farber, 1957; and Jackson & Bloomberg, 1958) have all failed to show a correlation between trait anxiety and Wechsler subtests, including the digit span task.

However, several studies have found a negative correlation between digit span performance and state, or temporary, anxiety. Firetto and Davey (1971) performed a study replicating two previous studies: Walker, Sannito, and Firetto (1970) and Walker and Spence (1964). Their study utilized the same procedure of randomly assigning students to either a control group or an experimental group. The control group received the usual digit span instructions while the experimental group was told that their questionable performance on class tests would hopefully be clarified by a 'brief intelligence test', the digit span task. After completing the task, all subjects reported how they felt. Those who reported being anxious, uneasy, worried, or something equivalent were classified as possessing anxiety. The other subjects were classified as anxiety absent. As in the previous two studies, those who possessed anxiety had significantly lower digit span scores than those who reported no anxiety ($p < .02$). Turner (1996) cites the subsequent research of McGraw and Mallory, 1981; and Idzikowski and Boddeley, 1987 who also found a main effect of state anxiety on digit span performance supporting the hypothesized negative relationship of state anxiety on digit span scores.

Yet, "several investigators (Guertin, 1954; Craddick & Grossman, 1962; and Pyke & Agnew, 1963) also utilized situational stress conditions [as in the Walker et al. studies and Firetto and Davey, 1971], such as bland instructions, or gazing at the subject directly in the eye during his performance, or threat of electric shock, and failed to show a decrement in digit span" (Matarazzo, 1972, p. 448). In fact, Matarazzo cites a study by Sherman and Blatt (1968) where subjects experienced a failure experience, a success experience, or a control experience. After the experiences, subjects completed the digit span task. The authors found that the failure experience, increasing state anxiety, significantly enhanced performance on the digit span task. Steyeart and Snyder (1985) studied the effect of seating arrangement on anxiety and digit span scores. They concluded that the state anxiety variable did not significantly affect digit span scores. Turner (1996) concludes, "while there is some empirical support for a negative relationship between anxiety and digit span performance, the evidence remains limited" (p. 31). In her own study, Turner found no significant relationship between the anxiety measure used in her study and the digits backward scores.

Despite Turner's (1996) suggestion that the inverted-U shaped function associated with Spence's Drive Theory does not correctly represent the relationship between test anxiety and performance; I feel that it is an accurate model of how state anxiety affects performance (partly due to personal experience). However, I also believe, after reading the research on anxiety, that the inverted-U shaped function is also dependent on the individual differences between each person. The higher level of anxiety needed by one individual to perform optimally might be too much anxiety for another person. Unfortunately, this current study does not have the resources available to determine each individual's optimum anxiety level to better examine the fullest extent to which anxiety might contribute to their performance on the backward digit span. However, measures of anxiety will be added to determine if anxiety does confound with the backward digit span task.

<u>Hypotheses and Purpose</u>

The purpose of this study is to evaluate whether or not a CD designed through the principles of neurofeedback can positively affect participants' performance on cognitive tasks, as measured by backward digit span recall, as compared to Mozart and silence.

There are three hypotheses in this study. Hypothesis one is that the track Super Attention from Cayhill and Stevens' CD, Focused Attention, will positively affect digit span recall compared to either Mozart or silence. Hypothesis two is that Mozart will positively affect performance on digit span recall as compared to silence. Another way of stating this is that individuals listening to Super Attention will score higher on the digit span posttest than individuals who listen to Mozart, who in turn will score higher than individuals who are in the control (silence) condition. The third hypothesis is that state anxiety will have some effect on the digit span scores. State anxiety will be associated with digit span scores in an inverted-U shaped function, as described by Spence, such that individuals who score very low or very high on state anxiety will not do as well on the digit span task as individuals who fall within the midrange in anxiety scores.

Method

Participants

The participants in this study consisted of 87 volunteer undergraduate students from the University of Tennessee in Chattanooga. The participants consisted of 27 males and 60 females. In age, 40 were 18 years old; 23 were 19 years old; 9 were 20 years old; 12 participants ranged in age from 21 to 27; and 3 participants were ages 42-64; with the mean age equal to 20.24. Thirty-one participants had no music training, 31 participants had less than 5 years of music training, 16 participants had 5 to 10 years of training, and 3 participants had more than 10 years in music training. Sixty-three participants were college freshmen, 9 were sophomores, 4 were juniors, 8 were seniors, and three participants were unclear as to what their school standing was. Only three participants stated that they had been diagnosed or treated for ADHD, and 9 participants recorded their responses in the reverse order that they were supposed to. As seen in the Results section, neither of these latter two categories affected any of the data analysis so their data was retained for all analyses. Volunteers were offered extra credit in their Psychology 101 classes in exchange for their participation.

Power Analysis

A power analysis was performed to determine the number of participants needed for this study. None of the original research gave information by which to determine effect size or power used. However, Hetland (2000) conducted a meta-analysis on the Mozart Effect and, as discussed earlier, she critiqued several studies for not employing enough power. Although a small effect in the predicted direction occurred, those studies did not have enough power to achieve statistical significance. In her meta-analysis, she calculated the effect sizes for all experiments separately and combined using r. She found a mean effect size of $r = .24$, with the 95% confidence interval ranging from $r = .14$ to $r = .35$. Additional tests showed that these results could be generalized to any new experiments on this research question. In addition, I felt that a moderate effect size was sufficient to explore the effects of the beta enhancing CD. Therefore, I chose $r = .30$ as my desired effect size, which is considered medium. This ensures that any difference found will not only be statistically significant but practically significant as well. I also chose .8 as my desired power to detect any difference, which is considered large. I was then able to use these numbers in a standard power table (Rosenthal & Rosnow, 1991, p. 452, table 19.3) to determine that the total N for significance at the .05 level two-tailed should be 85. Additionally, Hetland (2000) reported that the average number of participants per experiment for 36 experiments was 69. However, I attempted to recruit more participants than this to allow for fall-out and to increase power even more.

Measures

This study utilized backward digit span performance as the dependent measure. As mentioned earlier in the section entitled Beta Wave Enhancement through Music, an appropriate task for replication of the Mozart Effect is one that incorporates both spatial and temporal transformations (Rauscher, Shaw, & Ky, 1995). For this reason, Steele, Ball, and Runk (1997) chose the backward digit span task as their dependent measure. The backward digit span task requires that the participant listens to a string of digits and then reproduces the string in reverse order from memory. The authors report that theoretically "the backward digit task is of interest as a spatial reasoning task because it requires rotation or transformation of the sequence (Carroll, 1993; Das, Kirby, & Jarman, 1979). Empirically, performance scores on this task correlate strongly with scores on memory for designs (Schofield & Ashman, 1986), performance with Raven's Progressive Matrices (Banken, 1985), and is a good predictor of performance with the Rod and Frame task (Haller, 1981)" (p. 1180). However, they were unable to replicate the Mozart effect utilizing this dependent variable and were subsequently critiqued by Rauscher and Shaw (1998) for choosing an incorrect dependent variable. However, it is my contention that this task qualifies as spatial-temporal as defined by Rauscher and Shaw (1998) who define a spatial-temporal task as "the ability to transform mental images [rotate a sequence of numbers] in the absence of a physical model [from memory]" (p. 836). Hetland (2000) noted that the backward digit span does stretch the definition of the construct of a spatial task and sensitivity analysis temporarily removing that study did not change the mean effect size computed in her meta-analysis. Additionally, only one study was performed using this dependent variable (Steele, Ball, & Runk, 1997) who have been unable to replicate using any dependent variable, partly due to low power. If Hetland's (2000) analysis is correct that lab affiliation may play an important role in finding an effect, then it makes sense that someone other than Steele et al. should attempt to replicate the Mozart Effect using the backward digit span task to either confirm or disprove their initial results. Additionally, Othmer, Othmer, and Marks (1991) found that beta enhancing neurofeedback has the potential to significantly enhance performance on the digit span task.

However, as discussed earlier, state anxiety has the potential to correlate negatively with digit span scores. Therefore, I also utilized a pre- and posttest measure of state anxiety, namely the State-Trait Anxiety Inventory ("Self-Evaluation Questionnaire") by Spielberger, Gorsuch, and Lushene, to determine how much state anxiety does confound with the digit span task.

Independent Variable

There were three different conditions, each lasting 15 minutes, used in this study. In the first condition, participants listened to a recording of a blank track (silence). In the second condition, participants listened to Mozart - Sonata for Two Pianos in D Major (Allegro con spirito and Allegro molto). In the third condition, participants listened to one of the two tracks from the Focus Attention CD, Super Attention.

Apparatus

The CDs were played using a Sony ® CD Radio Cassette-Corder (Mega Bass) system, model type CFD-758. One important note about using this model CD player is that the system has the capability to play the CD in several different sound modes, which emphasizes certain sounds over others. It is important for anyone replicating this study, or anyone using a CD player with a similar function, that the sound mode is set to "no indication", which allows for all the ranges of sound to play as they normally would on a regular CD player. Playing this CD using a noise reduction system may cause the CD player to reduce the beta enhancing frequencies imbedded in the music; thereby, reducing the CD's effectiveness. The headphones used were Jensen ® stereo headphones, model type JF 20.

Procedure

All participants were tested individually. First, participants were asked to read and sign a consent form explaining the directions. They received a copy of the consent form. (See Appendix D for a copy of the Consent Form used). Then they listened to a randomly assigned CD. The CDs were blindly numbered prior to all testing to ensure that the researcher was unaware of the stimulus recorded on each. Each CD repeated the instructions and informed the participant of the following procedure:

> In this experiment, you will first hear three sets of digits. Each set will contain nine digits each. After each set you will be given 30 seconds to record those digits in reverse order starting from your left and proceeding to your right. After the third set you will then complete a short self-evaluation questionnaire. Then you will listen to 15 minutes of either music, silence, or sounds. Following this, you will then be asked to complete the short self-evaluation questionnaire again. Finally, you will be asked to listen to three more sets of digits to record in reverse order. If you have any questions or did not understand these directions then

please raise your hand and the experimenter will answer your questions. Now you will hear the first set of digits. Wait until you hear the request to record your answers before doing so.

Participants then heard a set of nine digits read at a digit every two seconds. After the digit string was read, they were then prompted to record their answers during a 30-second interval. This procedure was repeated for two more sets of digits. After this, they were instructed to fill out the self-evaluation questionnaire (State Anxiety Form) during the following 5 minutes. Then the CD continued to state that they would now hear 15 minutes of music, silence, or sounds. After 15 minutes, the CD told the participants that they had five more minutes to re-complete another self-evaluation questionnaire. Then they were instructed to listen to three more sets of digits to recall in reverse order and the digit sets were read in a similar fashion to the previous three sets. Afterwards, the CD informed the participants to raise their hands to signal that they were finished. Participants were then asked to fill out a form consisting of normal demographic data and other information, such as musical training, mood, attention, etc. with the promise that test results and any data gathered would be confidential. (A copy of the Demographic Data Form is included in Appendix E). Following completion of testing, subjects were debriefed and offered a number to contact to find the results of the study. Results will be analyzed using a repeated measures 2 X 3 ANOVA to determine if there are any differences between the mean scores of the three conditions as well as to determine any differences in pretest/posttest scores.

Pilot Study

I performed a small pilot study utilizing the same dependent and independent measures as listed above. I enlisted the help of 15 volunteers to be participants in this study (five for each group). However, I did not utilize the measure of state anxiety and the independent variable played for 24 minutes. I decided to modify the study to play the independent variable for only 15 minutes since this is an average time used in Mozart studies. (The data from the pilot study can be seen in Appendix F).

The preliminary results seemed to indicate no practice effects between the pretest and posttest. However, the starting means of all three groups were very different, perhaps due to the small sample size. This difference in the starting values for each group made it difficult to see if the differences in posttest scores were due to the variability of each group or to the effects of the CDs. The results also indicated a negative effect on test scores as a result of listening to the beta-enhancing CD contrary to the hypothesis. Both the control condition and the Mozart condition indicated little change between the pretest and posttest scores. This could have been due to a variety of factors including anxiety, interests, participant bias, and a small sample size (all of which are dealt with in the current study). Based upon the information gained from the pilot study, I was able to modify the procedure and methodology of the current study to help strengthen any conclusions drawn. For example, during the pilot study, I tried testing while watching subjects the whole time or only a part of the time. Although it may add some anxiety to the participants, I felt it was necessary to monitor the participants during the entire testing time to minimize the possibility of cheating. Secondly, I had to modify the instructions both on the CDs and on the Answer Recording Forms to clarify that answers must be recorded in reverse order and in a readable manner. Thirdly, I was able to determine that additional questions needed to be added to the demographic data for post hoc analysis, such as whether or not they liked the CD they listened to, since several expressed a dislike of the Beta CD possibly affecting their posttest scores. Most importantly, I was made aware of the fact that anxiety may confound with performance on the backward digit span task, as mentioned earlier, and was therefore able to incorporate a measure of state anxiety into the study. Despite the preliminary results to the contrary, I maintained my original hypotheses for the current study. Namely, that those participants who listen to the beta-enhancing CD will have higher scores on the digit span task than those participants who listen to Mozart, who in turn will score higher than those participants in the control group (silence). However, I also added a hypothesis based upon the recent understanding that state anxiety may affect participants' scores on the digit span task. Hypothesis three is that anxiety will have some effect on the digit span scores. State anxiety will be associated with digit span scores in an inverted-U shaped function, as described by Spence, such that individuals who score very low or very high on state anxiety will not do as well on the digit span task as individuals who fall within the midrange in anxiety scores. Overall, I feel that this study will produce good results from which to properly analyze the effectiveness of the beta-enhancing CD as compared to Mozart and silence.

Results

<u>Effect of Independent Variables on Backward Digit Span</u>

Table 1 shows the mean number of correct digit span recall in the pretest and posttest for participants in each treatment group (Mozart, Beta CD, and Silence). Pretest and posttest scores were homogeneous and normally distributed. A one-way analysis of variance carried out on the pretest scores showed that there were no differences between the three groups before exposure to the experimental treatment ($F_{2, 86} = 1.558$).

Table 1

Number of correct digit span recall (Maximum is 27)

Condition	n	Pretest		Posttest	
		M	SD	M	SD
Mozart	29	16.24	5.19	18.52	5.44
Silence	29	16.48	5.00	17.59	4.72
Beta CD	29	14.45	4.13	16.24	4.80
Total	87	15.72	4.83	17.45	5.02

The main research interest concerned whether or not any changes on the backward digit span recall task were attributable to the different experimental treatments. Therefore, a 2 X 3 analysis of variance with repeated measures on the pre-/post factor was performed to assess the presence of main effects and interactions. The results indicated no main effects across treatment groups ($F_{2,84} = 1.819$). No significant treatment effect was found. This is further confirmed by a one-way analysis of variance carried out on the posttest scores in Table 1. The analysis indicated that there were no differences between the three groups after exposure to the experimental treatment ($F_{2, 86} = 1.522$). There was, however, a main effect on the within-subjects repeated measures ($F_{1, 84} = 12.755$, $p = .001$) indicating that there was a practice effect which was not different across treatment groups (interaction $F_{2, 86} = .497$). It should be noted that all pretest and posttest means were in the midrange, thus indicating that floor or ceiling effects did not limit the possibility of demonstrating improvement or decrease in scores after experimental treatment.

Effect of Independent Variables on State Anxiety

As mentioned earlier, another research concern is to investigate whether or not state anxiety affects digit span recall thereby confounding with the experimental condition. Therefore, a measure of state anxiety was added to the study as a dependent variable. Table 2 shows the mean state anxiety scores in the pretest and posttest for participants in each treatment group (Mozart, Silence, and Beta CD) with higher scores indicating more anxiety.

Table 2

State Anxiety Score (Minimum is 20 and Maximum is 80)

Condition	n	Pretest		Posttest	
		M	SD	M	SD
Mozart	29	52.31	13.32	41.24	12.95
Silence	29	48.86	11.28	44.59	16.29
Beta CD	29	50.90	10.46	56.21	14.13
Total	87	50.69	11.70	47.34	15.74

Pretest and posttest scores were homogeneous and normally distributed. Anxiety scores ranged between 26 to 80 for the Mozart CD, 23 to 80 for Silence, and 31 to 68 for the Beta CD on the pretest. Posttest anxiety scores ranged from 20 to 80 for the Mozart CD, 20 to 75 for Silence, and 23 to 80 for the Beta CD. Thus, the ranges in this study encompassed the total range of the test; thereby, allowing for a fuller evaluation of the results. The means, standard deviations, and the ranges closely approximated the normative data for this measure, although they were slightly higher possibly due to the fact that the testing occurred towards the end of the semester when papers were due and final exams were approaching; thereby, raising participants' overall state anxiety.

A one-way analysis of variance carried out on the pretest scores showed that there were no differences between the three groups before exposure to the experimental treatment ($F_{2, 86} = .631$). In order to compare the effect of the three treatment conditions on state anxiety, a 2 X 3 analysis of variance with repeated measures on the pre-/post factor was performed to assess the presence of main effects and interactions. The results indicated a main effect across treatment groups ($F_{2,84} = 3.293$, $p < .05$). There was a difference in the three groups in anxiety due to the different treatments. Additionally, a one-way analysis of variance carried out on the posttest scores also indicated differences between the three groups after exposure to the experimental treatment ($F_{2, 84} = 8.483$, $p < .001$). Paired samples T-tests confirmed that state anxiety was significantly decreased in both the control condition ($t = 2.132$, $p < .05$) and the Mozart condition ($t = 4.464$, $p < .001$), but was significantly increased in the Beta CD condition ($t = -2.196$, $p < .05$). Additional post hoc analysis reveal that the Mozart and control conditions are homogeneous and different from the Beta CD group. There was also a main effect on the within-subjects repeated measures ($F_{1, 84} = 6.287$, $p < .05$) indicating that there was a change in pre- and posttest scores which was different across treatment groups (interaction $F_{2, 86} = 12.686$, $p < .001$).

Anxiety as a Confounding Variable

Since state anxiety was significantly affected as a result of the different experimental treatments, additional analysis needed to be performed to investigate whether state anxiety confounded with performance on the backward digit span task. Results indicated that there was not a significant correlation between the change in digit span and change in anxiety ($r = -.048$). These two variables indicated a change as either positive or negative. Therefore, an additional correlation was performed between these two variables while accounting only for the magnitude of change and not direction. The correlation between the raw change in digit span and the raw change in anxiety scores was also non-significant ($r = -.035$). Further evidence for the lack of relationship between digit span performance and state anxiety was provided by the non-significant correlations between change in digit span and change in anxiety within each group (Beta CD, $r = -.113$; Control, $r = .071$; and Mozart, $r= -.070$).

There were, however, two significant correlations between digit span performance and anxiety. The starting digit span scores were correlated with the posttest state anxiety scores ($r = -.268$, $p < .05$). This means that participants who recalled more digits in the pretest were more likely to have reduced posttest state anxiety. Additionally, pretest state anxiety scores correlated with participants' change in digit span performance ($r = .262$, $p < .05$) indicating that participants with higher pretest anxiety tended to increase their posttest digit span recall more so than participants with low pretest anxiety. Therefore, the data was also divided into two categories based upon whether the pretest anxiety scores were above (high-anxiety group) or below (low-anxiety group) the mean. The correlation between high or low anxiety and change in digit span performance was found to be non-significant within all three groups (Beta CD, $r = .33$; Control, $r =.334$; Mozart, $r = -.059$). Therefore, a majority of the results indicates a lack of relationship between digit span performance and state anxiety.

Other Significant Results – CD

In coding the data, participants who listened to the Beta CD were given a label of 1, those in the control group were labeled as 2, and those who listened to Mozart were labeled as 3. Several interesting correlations were found as a result of this order of coding. For instance, results show that participants who listened to Mozart had lower posttest state anxiety ($r = -.391, p < .001$), had a greater reduction in state anxiety ($r = -.477, p < .001$), felt the CD helped them more on the digit span task ($r = .446, p < .001$), reported that they listen to music while studying ($r = .289, p < .01$), and liked the CD ($r = .665, p < .001$) more than those in the control condition who in turn were higher on these variables than those who listened to the Beta CD. Additionally, those who listened to Mozart reported being more attentive during the study than those in the control condition who were more attentive than those participants who listened to the Beta CD ($r = .218, p < .05$).

Digit Span Scores

Both pretest and posttest performance on the digit span were negatively correlated with age ($r = -.256, p < .05$; and $r = -.237, p < .05$, respectively) indicating that younger participants recalled more digits than older participants. However, there was no significant correlation between age and change in digit span performance indicating that each group performed equally well within their age group on both pre- and posttest. Males also performed significantly better on the digit span posttest than females ($r = -.233, p < .05$). Finally, posttest digit span scores were significantly correlated with participants' opinions on the effect of the CD on their digit span performance ($r = .279$, p

$< .05$). Thus, those who performed better on the posttest felt that the CD helped them more than those who performed worse on the posttest did.

State Anxiety

Pretest state anxiety scores were negatively correlated with age ($r = -.222, p < .05$) and mood ($r = -.459, p < .001$). Thus younger participants and those who had a more negative mood (by self-report) exhibited higher pretest state anxiety. Posttest state anxiety scores were negatively correlated with participants' belief that the CD they listened to helped their posttest digit span performance ($r = -.407, p < .001$), with self-reported attention ($r = -.296, p < .01$), mood ($r = -.468, p < .001$), and whether participants liked the independent variable ($r = -.398, p < .001$). Thus, those with lower posttest anxiety scores believed that the CD helped their posttest digit span performance, were more attentive during the study, had a more positive mood, and liked the CD that they listened to. Interestingly, those who reported that they listened to music while studying also had significantly lower posttest anxiety scores ($r = -.245, p < .05$).

Other Variables

Gender did not significantly correlate with any other variable except posttest digit span scores as noted previously. In addition to correlations already mentioned above, age was positively correlated with school year ($r = .549, p < .001$), whether or not the participant listened to music while they studied ($r = .333, p < .01$), as well as with attentiveness ($r = .231, p < .05$), and mood ($r = .258, p < .05$). Thus, older participants are farther along in their education, listen to music while they study, were more attentive during the study, and were in better moods than younger participants.

Years of music training was positively correlated with whether participants listen to music while studying ($r = .228$, $p < .05$), but was not significantly correlated with any other variable.

Participants who reported liking the CD were positively correlated with school year ($r = .246$, $p < .05$), reporting that the CD helped them on their posttest digit span performance ($r = .530$, $p < .001$), and reporting that they listen to music when they study ($r = .338$, $p < .01$). Attentiveness was positively correlated with mood ($r = .392$, $p < .001$) and whether respondents liked the independent variable they listened to ($r = .292$, $p < .01$) as well as reports that the CD improved their performance on the posttest digit span task ($r = .233$, $p < .05$).

Finally, there were two other variables that did not correlate with any other variable except for each other. These variables were whether or not participants had ever been diagnosed or treated for ADHD ($n = 3$) and whether or not they recorded the digits in the wrong order, i.e., in the order the digits were read instead of in reverse order ($n = 9$). Since neither variable correlated with any other variable, their data was left in for all analyses. Interestingly, these two variables were significantly correlated with each other ($r = .350$, $p = .001$); however, there are not enough cases to make a valid generalization from this data.

Discussion

Present results indicate that exposure for 15 minutes to a recording of either the Mozart Sonata for Two Pianos in D Major (k448) or to 15 minutes of a CD specially designed to enhance beta waves was not followed by an enhancement in performance on a backward digit span recall task as compared to a control group. Thus these results do not support Rauscher et al.'s (1993) theory of a Mozart Effect nor do they support the theory that enhancing beta waves can help facilitate human performance on cognitive tasks in individuals without ADHD or Learning Disabilities. Additionally, there was no difference between listening to Mozart and the control condition on state anxiety. Results indicated that listening to the beta enhancing CD significantly increased state anxiety as compared to both Mozart and the control group. However, the effect of the independent variable on state anxiety did not have any direct effect on backward digit span performance in this study. Thus, state anxiety did not confound with digit span performance but was intricately connected with the treatment conditions, such that Mozart and silence both reduced state anxiety while the Beta CD increased state anxiety in this study. Therefore, the data does not permit the rejection of the null hypotheses in favor of any of the three research hypotheses proposed in this study.

However, there are other variables utilized in this study which require further attention. As can be seen in the correlations discussed above, there is a complex weave of interactions between anxiety, mood, age, attentiveness, CD, etc. The interplay of these variables could be responsible for the lack of effect on digit span across treatment groups. For instance, the results indicated that participants who listened to Mozart were more attentive than those in the control group who in turn were more attentive than those participants who were in the Beta CD group. Therefore, it is possible that no effect was found in the latter group simply because this group lost interest in the experiment because they did not like the sounds that they heard. (In fact, many of the participants expressed such sentiments at the conclusion of their testing session). It is interesting to note that these participants still experienced an increase in their posttest digit span scores despite the fact that their dislike of the Beta CD caused them to quit paying as much attention as other groups and despite the fact that they felt as if listening to this particular CD actually hurt their posttest digit span recall performance. Additionally, age was correlated with digit span scores as well as with mood and attentiveness. Perhaps using younger college students negatively affected results partly due to their lower level of attention and more negative moods as compared with older participants. Thus, careful consideration should be given to these variables in future studies to investigate the true nature of their impact.

Strength and Limitations

Perhaps the biggest limitation of this study is the fact that the resources were not available to truly investigate whether or not the CD, Focused Attention, is capable of enhancing beta waves in the listener. To prove this claim, another study needs to be performed to establish base state brain wave patterns in two groups. Then one group would listen to the Focused Attention CD while the other group is in a control (silence) condition. Results from brainwave mapping could then indicate if the group listening to the Focused Attention CD had a higher number or higher frequency of beta waves as compared to the control group. Until such a study is performed, the conclusion drawn from the study can only state that listening to the Focused Attention CD does not enhance performance on the backward digit span task, not that enhancing beta waves has no effect on digit span performance.

A second limitation is that brain-wave training is more effective over several training sessions as discussed earlier. Thus a lack of treatment effect may only indicate that not enough brain wave entrainment had occurred as a result of listening to this CD for only 15 minutes to provide an optimum effect on digit span performance. To counteract this limitation, another study could be performed in a similar fashion to the present study with the addition of several other testing sessions, over a period of several months, after listening to the Focused Attention CD each time.

A third limitation is that the resources were not available to utilize two or more dependent measures of visual-spatial tasks to further explore if the inconsistencies of results in prior studies were really due to differences in the dependent measures utilized. Therefore, another study could follow similar procedures to the ones employed in this study except that more groups could be added to test these experimental conditions on other spatial-temporal tasks that typically display a higher consistency of being affected by listening to Mozart.

A final limitation is that the current design of the study made it impossible to continue playing the Focused Attention CD while participants were completing the posttest measures. There is some evidence that increasing beta waves in an individual may lead to a higher state of arousal or anxiety (Handouts from Stevens, 2000). Thus beta waves may have been enhanced through this experimental treatment; however, the inability to focus their increased attention onto a concrete task may have caused the anxiety to increase more so than it should for optimal operating conditions, indirectly affecting their digit span performance via lack of attentiveness, negative moods, a dislike of the CD they heard, and the thought that the CD actually was detrimental to their performance. Therefore, further exploration into this complex interplay of variables in future studies is warranted.

There are also several strengths in this study. First, it is the only study to replicate Steele, Ball, and Runk's (1997) study in the use of the backward digit span as a dependent measure in a study on the Mozart effect. This study confirmed the results of Steele et al that performance on the backward digit span task is not enhanced after exposure to music by Mozart. Another strength lies in the analysis of other data gathered from the demographic data form. These results indicate that enhancement of digit span performance is not correlated with state anxiety, gender, age, years of musical training, school year, participants opinion of whether the independent variable affected their digit span performance, whether or not participants' listen to music while they study, their self-reported level of attentiveness, self-reported mood, whether or not participants liked the independent variable, or whether participants had been treated or diagnosed as ADHD. Although this study found no evidence for the Mozart Effect; the lack of correlation between change in digit span performance and any of the variables listed above indicate that the Mozart Effect, if it exists, appears unrelated to mood attentiveness, preference for the stimulus, musical training, etc.

Future Research

It would be beneficial to conduct a study to determine what effect the Focused Attention CD has on brain waves to verify that it does indeed enhance beta waves in the listener as it claims. It would also be interesting to compare this with brain wave states of individuals who listen to Mozart as compared to a control group. As mentioned earlier, the exact mechanism by which Mozart may enhance performance is not clear. Thus, the effect of listening to Mozart on brain waves, if any, needs to be further explored. Given that brain-wave training is more beneficial over a long period of time, it would also be prudent to so a longitudinal study of the effect of beta-wave enhancement on a variety of tasks requiring mental concentration. Another study could address the concern over dependent variables used in Mozart studies by using two or more such variables in the same study, especially by a laboratory that is comprised of scientists who have found a Mozart Effect or comprised of a mixture of scientist who both have and have not replicated the Mozart Effect to explore possible laboratory effects, as Hetland (2000) suggests. Finally, further studies could be performed to further explore and either confirm disprove the results of this study, especially as it pertains to the lack of relationship between change in digit span performance or any dependent variable used; and mood, arousal, musical training, etc. This study found no relationship; however, attentiveness might affect performance or another task; thereby, resulting in a Mozart Effect through these variables contrary to the results found in this study.

<u>Summary</u>

No significant differences in backward digit span performances among treatment conditions were found. Although there was significant difference among treatment conditions in state anxiety, there are no indications in this study that state anxiety affected backward digit span performance. Therefore, this study concludes that listening to Mozart or the Focused Attention CD is not followed by an enhancement on a visual-spatial task, as measured by performance on the backward digit span task.

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Appendix – A

BRAIN WAVE FREQUENCIES/BRAIN STATES

GAMMA 35 Hz+ - SOME EVIDENCE OF ASSOCIATION WITH PEAK PERFORMANCE STATES

HIGH BETA 18-35 Hz - HIGH CORRELATION WITH ANXIETY, WHEN DOMINANT

MID BETA 15-18 Hz - ACTIVE, EXTERNAL ATTENTION

SMR BETA 12-15 Hz - RELAXED, EXTERNAL ATTENTION

ALPHA BETA 8-12 Hz - VERY RELAXED, PASSIVE ATTENTION

THETA 4-7 Hz - DEEPLY RELAXED, INWARDLY FOCUSED

DELTA 0.5-3 Hz - SLEEP

Appendix – A (cont.)

Electroencephalograph Examples

EEG and States of Arousal

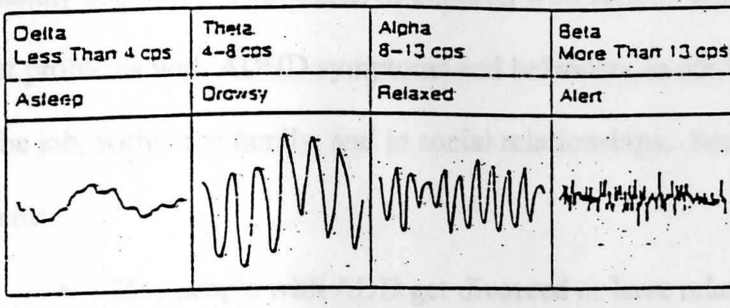
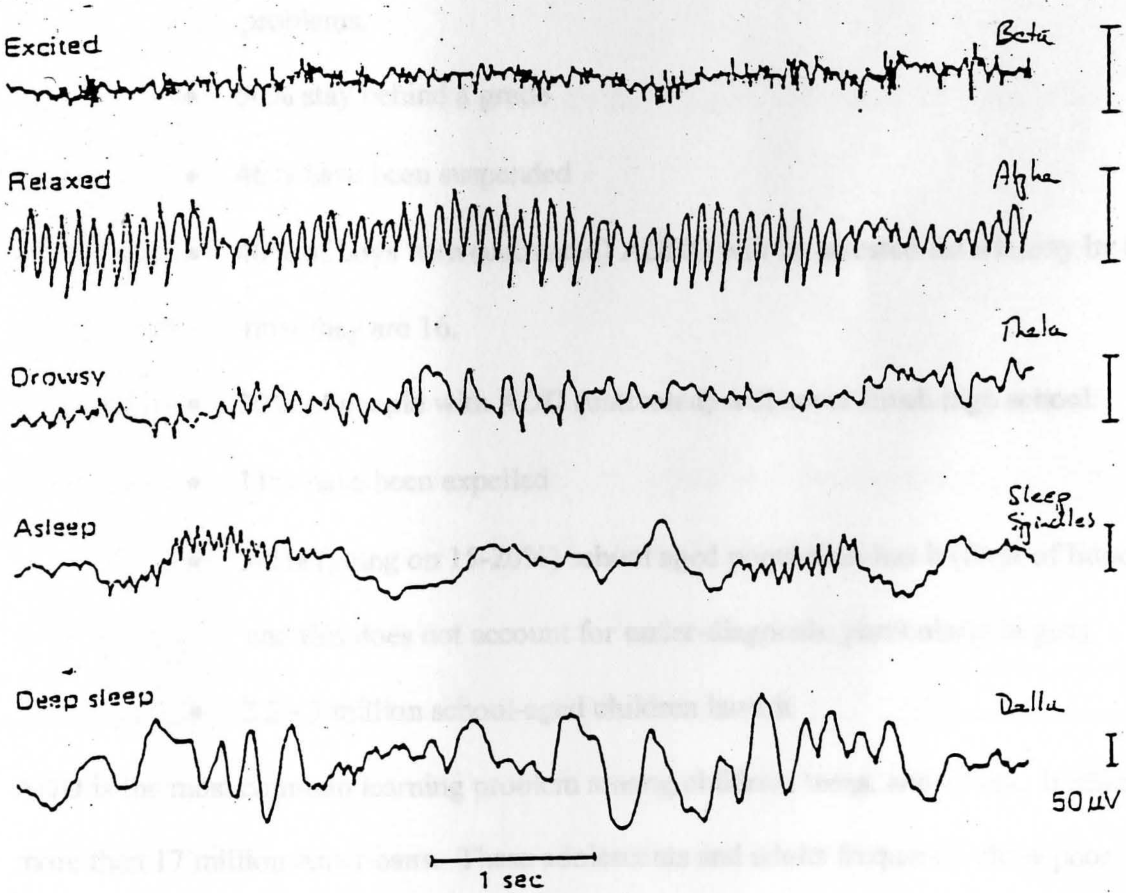


FIGURE 6–5 An Illustration of Four Rhythms Commonly Seen in the EEG.



Appendix B

ADHD (Attention Deficit Hyperactivity Disorder) Facts

ADHD is one of the largest - or certainly most readily identifiable population. ADHD usually persists throughout a person's lifetime. It is NOT limited to children. Approximately one-half to two~thirds of children with ADHD will continue to have significant problems with ADHD symptoms and behaviors as adults, which impacts their lives on the job, within the family, and in social relationships. Some statistics indicate the problems:

- 75% people with ADD get divorced or have relationship problems
- 52% of people with (untreated) ADD will have drug or alcohol problems.
- 50% stay behind a grade
- 46% have been suspended
- 40% of boys with (untreated) ADHD will be arrested for a felony by the time they are 16.
- 30% of people with ADD (untreated) will never finish high school.
- 11% have been expelled
- 3-5% (going on 15-20%) school aged population has it (Dept of Educ.) and this does not account for under-diagnosis, particularly in girls.
- 2.5 - 3 million school-aged children have it

ADD is the most common learning problem among children, teens, and adults. It affects more than 17 million Americans. These adolescents and adults frequently show poor academic performance, poor self-image, and problems with peer relationships.

Appendix B – (cont.)

ADHD Facts

• Around two million school-aged children in the United States (at least 5 percent) are thought to have ADD or ADHD.

• Boys diagnosed with ADHD outnumber girls about 3:1, but in ADD without hyperactivity - the overall incidence is similar in both genders. In the younger years, however, both ADD and ADHD are diagnosed more frequently in males. By adulthood, there is gender equality in these diagnoses.

• The genetic component far outweighs the environmental component, with ADD Environment influences how severe and persistent the inherited ADD traits will be but does not produce them.

• One large study found that 25 percent of the first~degree relatives of children with ADHD had the problem.

• If one identical twin has ADD, there is an 8O~ to 90-percent chance that the other twin will also have ADD.

• ADD is most often suspected or diagnosed after school entry, at around six or seven years of age. Children with the ADD style may be fine in a play-based program, but they have trouble once they have to sit and work independently in first or second grade.

• The diagnosis of ADD is not based on laboratory tests. It is based on observations made by parents, teachers, and ADD professionals.

• Children usually do not grow out of ADD, though there is less hyperactivity after puberty Unrecognized and unmanaged, people with ADD are at risk for developing debilitating social and academic problems.

• If unrecognized and untreated, children with ADD have a high (30 to 50 percent) chance of school difficulties; this may mean special education placement, repeating a grade, dropping out, or being expelled.

• If unrecognized and unmanaged, 20 to 30 percent of these children may have problems with the law.

• Children diagnosed with ADD should never be treated with drugs only. They require additional management techniques to improve their behavior and learning skills.

In 1995, 1.5 million children in the United States (2.8 percent of schoolchildren) age five to eighteen years were being treated with Ritalin. From 1990 to 1995, the number of children on ADD drugs tripled in the United States. In Canada between 1990 and 1995, the use of Ritalin increased three to four times according to a 19% publication by Health Canada.

A survey of the driving records of people with an ADD diagnosis showed that they got more speeding tickets and had four times as many accidents in which someone was injured. However, when their knowledge of driving was compared to a control group, there was no difference.

• Divorce is twice as common in families where a child has ADD.

• In 1990, in a monthly survey of 2,400 practicing physicians, there were two million patient visits associated with the diagnosis of ADD. By 1994, this number had increased to 4.7 million. Approximately 90 percent of these patient visits resulted in a prescription for drug therapy.

• If managed, most children with ADD can be taught to use their differences to their advantage. They show creative accomplishments and are a credit to themselves

Appendix C

Example of Proclaimed Neurofeedback Technology on the Market

SuperMind Unleashes Mind Power! wysiwyg://mainpage.69/http://altered-states.net/zygon/super.htm

Plug your brain into this powerful mind machine to zap stress, boost mental powers, and trip your mind into virtual reality-like fantasies. Plus, get NZ $ 100 worth of free Moodscapes!

I put on my space age shades, plugged in the "Thunderstorm" soundtrack, and programmed the SuperMind computer for a heavy-duty Theta session. As I punched the start button, I was reminded of NASA's billion-dollar virtual reality machines. Of course, the SuperMind isn't virtual reality. No. It's more like electronic Zen.

Trip to Theta Land

After only a few moments, I was sucked into a deep trance. Weird colors and patterns were created on the insides of my closed eyelids. I could hear the rumblings of a tremendous electrical storm brewing in the distance. I was pulled deeper and deeper into the eye of the storm. Suddenly, I felt an incredible endorphin rush stream into my brain. I was launching into Theta-land. Big time.

Using pulses of sequenced light emitted from the glasses and computer generated sound frequencies, the SuperMind synchronizes your brainwave patterns, driving your brain into an altered state of consciousness.

Based on hard scientific evidence that associates states of consciousness with dominant brainwave activity, this machine coaxes your brain into an Alpha/Theta pattern (brainwaves in the 4-lOHz range), which is associated with deep meditation and mental imagery. The result is greater control over your mental states. Increased intuition. Creativity. And I enhanced well-being. And because it's computer controlled you can experiment with, thousands of different frequency combinations to induce optimal mental states. Or you can choose from 10 preset programs designed to produce specific states of consciousness-ranging from sleep and meditation to extreme alertness -all at the push of a button.

The size of a pocket calculator, it's so portable I take it with me on business trips to beat jet lag. A 20-minute session before landing gives me the equivalent of 8-hours sleep and helps reset my biological clock.

Brain Tune-Up
Training your brain to generate theta activity for even a few minutes each day has enormous benefits, including boosting the immune system, enhancing creativity, triggering peak experiences, along with increasing feelings of psychological well-being For a little black box to do all that to your brain in 20 minutes is amazing enough, but it's only part of the story. Because this machine can also be used to accelerate learning and modify negative, self-defeating behavior.

Automatic Hypnosis
Let's say you wanted to quit smoking, enhance your self-esteem, lose weight, or just play a better game of golf. By plugging into the SuperMind you can induce a hypnotic trance in a matter of seconds. Then, while your subconscious is primed for psychological programming, you play prerecorded behavioral mindscripts, and these new success patterns become transferred onto your brain.

I'll include a special report that teaches you exactly how to create your own behavioral mindscripts on everything from success conditioning and weight control to enhancing sexual performance. Or if you wish, use Zygon's prerecorded library of MindWare tapes. Whichever method you choose, you'll possess an extremely flexible and powerful tool for improving your life.

Speed Learning
Plus, you can use this machine for speed learning. In a University of California study, a group of 20 students learned 1,800 words of Bulgarian in 120 hours while using Theta stimulation programs. In about 1/3 of normal time they spoke and wrote the new language. As an additional bonus I'll be sending you a special report on how to set up your own speed learning system to learn foreign languages and new material at lightning-fast speed.

NZ $ 100 Worth of Moodscapes
And if you order your SuperMindT now you'll receive a third special bonus-FREE. Four unique MindWare3! soundtrack, called Moodscapes, enhance your SuperMind experience. You simply connect a stereo player to the SuperMindT unit using the patch cord provided. While the SuperMind alters your mind-state, the Moodscape soundtrack transports your consciousness into a beautiful and unique aural landscape. Your mind will create an intense array of mental images. The combination is truly mind blowing.

NZ $ 100 WORTH OF MIND-ALTERING "MOODSCAPES" FREE
A powerful new form of mind expansion" is how one researcher describes the experience. Another calls it "Electronic LSD." Mood-scapes are "software" (or MindWare as we call it) experiences, that enhance your SuperMind sessions. They transport your consciousness on a powerful meditative journey. Your Moodscapes library includes 4 separate aural landscapes. Each soundtrack uses a special combination of environmental sound effects and musical textures designed to stimulate vivid sensory responses in the brain. Each is a unique experience that seems to change every time you listen to it.

NZ $ 100 Worth Of Mind-Altering Moodscapes" FREE

Thunderstorm (NZ $ 25 value)

A storm is coming. You hear the thunder. Lighting strikes and rain begins to fall. You feel safe but charged by the powerful forces of nature.

Appendix D - Informed Consent Form

This consent form is intended to inform you of your rights as a participant in scientific study. By signing this consent form you agree to participate in a study entitled "The Effect of Sounds on Test Taking Ability." The purpose of this study is to assess how various sounds or music affects the performance of college students on their test taking ability. If you choose to participate in the study, your involvement will take no more than 1 hour of your time. First, we will ask you to listen to three sets of digits and after each set you will record them in reverse order. Next, you will complete a short self-evaluation questionnaire. Then, we will ask you to listen to a CD through headphones for approximately 24 minutes. After listening to the CD for 24 minutes, you will then re-complete the short self-evaluation questionnaire. Next, you will be asked to listen to three more sets of digits and record them in reverse order. There are no foreseeable risks or benefits from your participation, because this is simply an assessment study and not a treatment study. Finally, you will be asked to complete a simple demographic form.

Your participation is completely voluntary and you will be free to refuse or stop at any time without penalty. Your grades or class standing will not be affected in any way if you decide to stop. All information will be number coded and strictly confidential. Your identity, demographics, or score will not be revealed without your consent.

Do you have any questions?

If you have any questions later, please feel free to contact me.

Bryan Pickett   Pager: 550-7321

Please read the following statement, and, if you agree to participate, please sign below.

I understand that any information about me obtained from this research will be kept strictly confidential.

Signature______________________________ Date____________________

Investigator____________________________ Date____________________

Please place your initials here acknowledging that you received a copy of this consent form. ________

Thank you for your cooperation.

Appendix E - Demographic Information Form

1. Are you male ____ or female _____.
2. What is your age ________.
3. Have you ever been diagnosed, treated, or taken any medications for Attention Deficit Disorder. ________.
4. Have you had any training or schooling with music or musical instruments? If yes, please specify amount of schooling and/or what instrument you play.____
5. What was your highest level of education completed? _______________.
6. Did you feel that listening to this CD helped or hurt your performance on the digit span task afterwards? ____________________________________.
7. Do you commonly listen to music to help you study or do you need silence.

   ____.
8. What is your field of study? ______________________________.
9. How attentive were you during this study?

Not at all	Somewhat	Moderately	Very Attentive
1	2	3	4

10. How was your general mood today?

Very Bad	Slightly Bad	Slightly Good	Very Good
1	2	3	4

11. How did you like the CD selection that you heard?

Extremely Disliked	Moderately Disliked	Didn't Care	Moderately Liked	Extremely Liked
1	2	3	4	5

Appendix F – Pilot Study Data

The following table is a summary of the data I obtained from the pilot study conducted.

Data from Pilot Study

Number of correct digit span recall (Maximum is 27)

Condition	n	Pretest		Posttest	
		M	SD	M	SD
Mozart	5	19.6	4.21	19.8	5.06
Silence	5	16.2	2.39	16.4	2.88
Beta CD	5	14.6	5.59	12.0	5.09
Total	15	16.8	4.51	16.0	5.30

Vita

Bryan Michael Pickett was born in Charleston, South Carolina on May 13, 1975. He attended several elementary schools and middle schools due to moves with his military family. He graduated in the top five percent of his class from Socastee High School, Socastee, S.C. in May 1993. The following August, he entered the College of Charleston, Charleston, S.C. where he received a B.A. in Philosophy and a B.A. in Religious Studies in May 1997. He completed requirements for his B.S. in Psychology from College of Charleston in Dec. 1998. In January 1999, he enrolled in The University of Tennessee at Chattanooga and in May 2001 received the degree of Master of Science in Research Psychology.

He is planning to join the Air Force as an officer, conduct more research, and to continue his education to the fulfillment of a Ph.D. degree.