Accelerated Learning by College Students Through Audio-Visual Entrainment Technology

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ABSTRACT

This study was designed to determine if audio-visual stimulation **(AVS)** would enhance learning. The subjects of this investigation were college students at SIAST Palliser Campus in Moose Jaw, Saskatchewan, Canada. The method involved the use of a DAVID Paradise XL, a digital audio-visual entrainment device manufactured by Comptronic Devices Ltd. of Edmonton, Canada.

The number of subjects was sixteen, consisting of eight experimental and eight control. The experimental group received 10 treatments of audio-visual stimulation combined with relaxing background music. The control group also received 10 sessions of the same relaxing music but with no AVS stimulation. Each session lasted 15 minutes, and was administered, approximately, once a week. Pre- and post-treatment tests were administered to all subjects, using the Rey Auditory-Verbal Learning Tests (RAVLT) as the dependent variable. Independent ***t*** statistic with a one-tailed test at the 0.10 level revealed a significant difference in the mean pre- and post- scores of the experimental and control groups.

The results suggest that audio-visual stimulation has the potential to enhance learning.

CHAPTER 1: INTRODUCTION

Life-long-learning has become the phenomenon of modern living. The need for continual retraining of the workforce in technologically advanced countries has soared significantly. Modern medicine has made it possible for people to live far beyond the established retirement age of 55 - 65. The result is more and more elderly people may find the need to continue working past the age of 65. The number of children and adults being diagnosed with learning difficulties such as attention deficit disorder (ADD) is increasing dramatically. Techniques that can accelerate learning offer tremendous benefits to modern society.

New Visions School in Minneapolis, USA, has established a neurofeedback training program for its students. The goal of this program was to correct problems in brain function, such as ADD, hyperactivity, depression, and anxiety. Michael Joyce, conductor of the training program at New Visions School, reported, "AVS has shown to be a useful tool in bringing about brainwave modulation, coherence and balance, with significant student gains academically, socially and emotionally" (1997 –1998, p. 27).

Budzynski, T., Jordy, Budzynski, H. and Tang (1999) studied the effects of AVS on academic performance in their preliminary work with "Biolight bio-driven" AVS. The researchers used the AVS equipment to train university students who sought help in overcoming their academic difficulties. The researchers were convinced by the results of the training that AVS had a significant impact on academic performance.

Numerous studies have been conducted on the effects of AVS on the electro-encephalograph (EEG) of healthy people, as well as people who suffer from various ailments such as attention deficit disorder (ADD), migraine, premenstrual syndrome, and insomnia.

In their controlled study of the effect of binaural auditory beats on vigilance performance and mood, Lane, Kasian, Owens, and Marsh (1998) concluded that subjects, when presented with binaural beats in the EEG-beta frequency range, produced a higher performance rate and positive mood than when beats with EEG-theta/delta were presented (p. 6). The results of the researchers led to an interpretation "consistent with earlier studies that suggest apparent EEG changes in response to binaural beat stimulation" (p. 7). The researchers expressed the need for further study into "the phenomenon of binaural auditory beat stimulation and its psychophysiological consequences" (p. 7).

In their study of six healthy volunteers, Sappey-Marinier, Calabrese, Fein, Hugg, Biggins, and Weiner (1992), reported that photic stimulation produced a statistically significant increase in brain lactate. The results of the researchers supported the view that brain pH and the concentrations of brain phosphates are affected by increases in brain functioning. The researchers stated, "these changes may in turn stimulate brain metabolism and increase brain lactate concentrations" (p. 585).

The results from the various studies on AVS provide compelling evidence to support the hypothesis that AVS alters brain function. The purpose of this study was to investigate the effect audio-visual stimulation **(AVS)** has on learning.

CHAPTER2: THE PROBLEM

Purpose of the study

The purpose of the study was to determine if audio-visual stimulation (AVS) has a significant effect on learning.

Research Hypothesis

Students presented with audio-visual stimulation (AVS) will produce a higher increase between pre- and post-scores in Rey Auditory-Verbal Learning Tests (RAVLT) than students without AVS.

De-limitations

Sixteen two-year college students enrolled at SIAST Palliser Campus in Moose Jaw, Saskatchewan, Canada participated in the study. The study, of ten weeks duration, presented AVS to eight of the 16 subjects and compared the mean difference in pre- and post-test scores of RAVLT with that of the other eight subjects without AVS.

Limitations

This study was subject to the following limitations:

1. It has been shown that audio-visual entrainment increases with the number of stimulation sessions. The 10 treatment sessions administered in a10-week period might not provide enough time for effective entrainment.

2. Studies suggest that the degree of entrainment is a function of initial or baseline

amplitudes of constituent EEG waveforms. Since subjects were not screened for susceptibility to the audio-visual treatment stimulus, the variability of susceptibility within subjects could have attenuated treatment effectiveness.

3. The degree of entrainment is also dependent on the *guardian response*, a condition of anxiety engendered by apprehension of a situation. Dissociation produces the *guardian response* in some people. Since audio-visual entrainment (**AVE)** can produce dissociation, it could have elicited a *guardian response* in some subjects.

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Definition of Terms

1. **Audio-Visual Entrainment** (AVE): sound-light (audio-visual) stimulation can be effective only when it produces changes in the brain wave pattern. When the energy of light and sound is transduced by the appropriate receptors of the body into electrical waveforms that represent the frequencies present in the light and sound stimulus, entrainment is achieved. This change in brainwave pattern may be observed with an electro-encephalograph (EEG) machine. The sound and light energy is also converted into chemical energy, and this change in energy can be observed with a positron emission tomography (PET) machine.

2. **Binaural beat**: when two sounds having different frequencies, say 1000 Hz and 1010 Hz, are presented to the brain simultaneously but separately through each ear, for example with the use of stereo headphones, the two hemispheres of the brain process the two sound signals in such a way that the brain is aware of only the sound represented by the difference in the two frequencies. In this example, the brain "hears" a sound that has a frequency of 10 Hz (1010 - 1000). This 10 Hz sound is called a binaural beat.

Significance of the Study

Information technology has drastically altered the way many jobs are performed today. As the technology evolves, it brings about frequent changes in the tools it offers. To survive in today's workplace, it is imperative that workers continually learn in order to keep abreast with changing technologies.

Many orthodox medicines used in the treatment of chronic illnesses produce iatrogenic diseases. With increasing numbers of people being diagnosed with learning difficulties, the incidence of iatrogenic diseases is likely to increase when treatment modality is limited to orthodox medicine such as ritalin and aderall. A number of preliminary studies in the use of AVS for the treatment of learning difficulties such as ADD have proved encouraging. Techniques propitious for learning are highly desirable in modern society.

Chapter 3: REVIEW OF LITERATURE

Introduction

Interest in audio-visual entrainment (AVE) technology has been growing steadily in recent years. Many preliminary research studies in the applications of AVE in such areas as Attention Deficit Disorder (ADD), Premenstrual Syndrome (PMS), alcoholism, and academic performance have shown encouraging results. The literature review will cover the theories, observations, and some research applications of AVE technology.

Brainwaves and States of Consciousness

It has been established that at any given time, whether awake, asleep or comatose, the brain is constantly generating electrical impulses known as brainwaves (Atwater, 1999; Wise, 1995). Brainwaves are characterized by frequency and amplitude. Amplitude is a measure of the magnitude of the voltage of the electrical impulse (measured in micro volts). The frequency, measured in cycles per second (Hertz or Hz), is a measure of how rapidly the electrical impulse changes. Brainwaves are categorized by their frequencies: beta (14 - 40 Hz), alpha (8 -13 Hz), theta (4 - 8 Hz) and delta (1 - 4 Hz).

Beta brainwaves

Beta brainwaves “are associated with active thinking or active attention, focusing on the outside world or solving concrete problems” (Cade & Coxhead, 1979, p. 24). Beta waves are the dominant brainwaves during normal waking states of consciousness. They are fast and of low amplitude. Over-production of high amplitude beta is associated with great anxiety (Hutchison, 1991; Siever, 1999; Wise, 1995).

Alpha brainwaves

Alpha brainwaves of the EEG have been observed during states of relaxation, visualization, daydreaming, and fantasizing (Wise, 1995). Siever (1999) stated that an increased production of alpha brainwaves leads to peaceful feelings, warm body extremities, a sense of well-being, improved sleep, improved academic performance, reduction in anxiety, and improved immune functioning (pp. 14 - 15).

Wise (1995) stressed the point that alpha brainwaves have been erroneously "portrayed as a kind of be-all and end-all of brainwaves" (p. 5). Alpha brainwaves are like a bridge that links the conscious mind to the subconscious mind. The absence of alpha in the EEG, therefore, represents a loss in connection to the subconscious mind (p. 4). Ornstein (1972) echoed the same caution regarding the interpretations of alpha production. In his book, *the Psychology of Consciousness*, Ornstein echoed this caution as follows: "To speak, for instance, of a 'high alpha' state without describing both where (area of cerebral cortex) it is recorded from and the concurrent activity throughout the brain is an incomplete and almost useless statement" (p. 219). Ornstein, however, was of the opinion that an increase in alpha at any specific area of the cerebral cortex seemed to indicate a reduction in information processing. He arrived at this conclusion after he and his colleague David Galin compared the EEG activity of the two hemispheres of the brain while tasks designed to predominantly engage one or the other hemisphere were being performed. They observed that alpha production tended to increase in the hemisphere less involved in the task (p. 219). This observation lends support to correlating alpha production to relaxation, since during relaxation information processing is at its minimum; and it is only during relaxation that the subconscious can be reached by the alpha bridge.

Cade and Coxhead (1979) stated, "the more meditation is practised, the easier it becomes to produce alpha rhythm, and the longer alpha rhythm is maintained, the more often the individual experiences states of higher awareness" (p.103). The ability to "infuse the calm, detached awareness of the alpha state into normal brain activity" is essential to achieving the higher states of consciousness (p. 103). This observation by Cade and Coxhead supports the notion of alpha being the bridge that connects the conscious to the unconscious minds.

Theta brainwaves

Theta brainwaves operate at frequencies ranging from 4 - 8 Hz. They have been observed during dreaming and deep meditation. Wise (1995) reported this of theta waves: "they are particularly strong during so-called peak experiences, spiritual insight, and high-functioning brain states" (p. 7). Davidson, Schwartz, and Shapiro (1983) reported that Pegano and Warrenburg (1982) observed bursts of theta in all subject groups who participated in a relaxation experiment. Davidson et al. also reported that previous works done by other investigators such as Fenwick et al. (1977), and Herbert and Lehmann (1977) support the findings that theta brain waves are associated with meditation or relaxation. Davidson et al. (1983) stated, "This treatment effect suggests that subjects who show theta bursts at all are able to increase the occurrence of this activity by engaging in a deliberate attempt to meditate or relax" (p. 172).

According to Hutchison (1986), Budzynski and others who studied theta waves discovered that subjects in theta state vividly recalled events that had long been forgotten (p. 91). He also cited the work done by Elmer and Alyce Green of the Menninger Foundation that supports Budzynski's findings. Hutchison (1986) wrote, "As a result of their work, the Greens are convinced that the theta state not only is conducive to memory and learning, but is the source of creative thinking" (p. 91).

Delta brainwaves

Delta brainwaves are the slowest of the brainwaves. They range in frequency between 1 - 4 Hz. Delta brainwaves have been observed mostly during deep sleep but may be present along with other brainwaves during normal states of awakeness. Delta brainwaves seem to enable the mind to process information like radar on an instinctive level (Wise, 1995, p. 8).

The high performance mind

Using their patented Mind Mirror Machine, Cade and Coxhead (1979), in their studies of the brainwaves of yogis, healers, and advanced meditators, observed a recurring pattern of brainwaves symmetrically displayed in both hemispheres of the cerebral cortex. This unique pattern of brainwaves, named "the awakened mind" by the researchers, consists of all four brainwaves, beta, alpha, theta, and delta. "The awakened mind is a higher waking state in which continuous self-awareness is maintained in addition to awareness of the external environment" (p. 122). Wise (1995) wrote of the awakened mind, "when the awakened mind …… is experienced even briefly, the sensation is one of focus, clarity, and unity with no extraneous or unnecessary thoughts or distractions" (p.16).

Studies done by other researchers besides Cade and Wise indicate that there are techniques to train the mind to enter, at will, a state of consciousness that is most desirable and beneficial for any given task. The Abstracts of the 1999 Society for Neuronal Regulation (SNR) conference at Myrtle Beach, South Carolina, reported a hypothesis by Sams that states, "optimal performance can occur when the brain has a full repertoire of resonant frequencies, and is capable of efficiently and appropriately shifting these frequencies in different cortical areas to match the task being undertaken" (Sams, 1999, p. 22). This hypothesis bears a strong resemblance to the concept of “the awakened mind” put forth by Cade and Coxhead.

Learning and Brain Chemistry

Neuroscientists are now virtually unanimous in their opinion that the general processes involved in activities that generate such things as learning, memory, intelligence, and thinking are essentially chemical (Hutchison, 1986, p.126). According to Hutchison, this virtual unanimity of opinion is due largely to studies done by Mark Rosenzweig and colleagues on the brains of rats that were raised either in enriched or impoverished environments (p. 127). The studies demonstrated a strong correlation between learning and brain chemistry. “Rats that had received greater stimulation and demonstrated greater learning, memory, intelligence, and ability to process information showed higher levels of the brain chemical acetylcholine esterase (AchE)” (p. 127). Other chemicals or neurotransmitters found to be involved in the process of learning include norepinephrine, glutamate, and serotonin.

Hobson (1994) put forth the theory that consciousness is a “dynamic continuum” controlled by two chemical systems: the aminergic and cholinergic systems. The aminergic system mediates the waking state of consciousness while the cholinergic system mediates the dreaming state. The continuum of consciousness regularly alternates between two extremes: waking and dreaming. When both the aminergic and cholinergic chemical systems are in balance, sleep is deep with no dreams and little or no conscious mental activity. The state of consciousness constantly and gradually fluctuates between the extremes of dreaming and waking. Even at these extremes of consciousness, both chemical systems are active to some extent (pp. 14 - 15).

Hobson’s theory that consciousness is a “dynamic continuum” controlled by two chemical systems that are always present to some degree, depending on the state of consciousness, bears a similarity to the findings of brainwave reseachers. It has been established that at any given time, whether awake, asleep or comatose, the brain is constantly generating electrical impulses known as brainwaves (Atwater, 1999; Wise, 1995).

Photic stimulation and brain chemistry

Past findings through animal and human studies have shown that photic stimulation produced increased cerebral blood flow and glucose metabolism more than oxygen consumption, "suggesting selective activation of anaerobic glycolysis" (Sappey-Marinier et al., 1992, p. 588). To further investigate the effect of photic stimulation on brain chemistry, Sappey-Marinier et al., (1992), used image-guided ^{1}H and ^{31}P magnetic resonance spectroscopy (MRS) to examine changes in lactate and high-energy phosphate concentrations in the human visual cortex. In this study with six normal subjects, the researchers concluded, "these results are consistent with the view that photic stimulation activated brain visual cortex, leading to increased ATPase activity, which stimulated glycolysis more than oxidative pathways" (p.591).

Audio-Visual Entrainment

Audio-visual entrainment (AVE) is the technique of using sound (audio) and light (visual) stimuli to cause the brain to generate electrical signals (brain waves) whose frequencies reflect those of the stimuli. When the stimuli are presented as often as four or more per second, the response is called the frequency following response (FFR). When only light stimuli are used, the technique is called photic stimulation or photic driving. When sound is the source of the stimuli, the technique is called auditory driving; the terms binaural and monaural beat stimulation may also be used.

Auditory driving

In their study of binaural and monaural stimulation effects on human frequency-following responses, Gerken, Moushegian, Stillman and Rupert (1975) concluded, “the frequency-following response approximates a sinusoid, and thus bears a resemblance to the stimulus waveform” (pp. 384 - 385). The researchers concluded also that there are two independent sets of neurons that have the ability to generate a frequency-following response (p. 384). Each set of these neurons, the researchers suggested, is activated by the corresponding left or right ear. The researchers also argued, “the frequency-following response (FFR) is not a microphonic-like response but rather that the individual waves in the FFR are evoked by the collective activity of phase-locked single units” (p. 385).

Sohmer, Pratt and Kinarti (1977), on the other hand, observed that in normal subjects, the frequency-following response “to tone bursts with single onset phases is made up of a short latency cochlear microphonic (CM) potential and a longer latency neural component” (p. 663). In subjects with upper brain-stem lesions, the researchers could not record any neural FFR. The FFR displayed by these subjects were “exclusively a cochlear microphonic potential” (p. 663). In subjects with high-tone hearing loss as a result of acoustic trauma, the researchers were able to detect only neural FFR with a 6-millisecond latency; no CM potential was detected. The researchers were of the opinion that “the pathway of the neural FFR begins in the apical turn of the cochlea” (p. 663). Several studies have demonstrated that sound stimulation (monaural and binaural beats) produces alterations in brain waves (Dobie & Norton, 1980; Neher, 1961; Foster, 1990).

Photic driving

Several researchers have investigated the effects of photic driving on brain waves. Van der Tweel and Verduyn Lunel (1965), in their study of “Human Response to Sinusoidally Modulated Light”, reported that the responses to photic driving “more or less faithfully reflect the input sine wave both in form and amplitude” (pp. 594 - 595). This observation, noted the researchers, was most evident within frequency ranges of 9 to 18 Hz with diffuse light, and above 30 Hz with concentrated light (p. 595).

The work done by Tsuyoshi Inouye, Noboru Sumitsuji, and Kazuo Matsumoto (1980) using alpha wave modulated light (AML) stimulation supports the findings of Van der Tweel et al. Tsuyoshi Inouye et al. (1980) reported that “the alpha frequency during AML stimulation seems to follow the frequency fluctuations of the spontaneous alpha” (p.139). As early as 1940, Toman reported that intermittent light stimulation produced “flicker” potentials that were observed in the EEG of subjects (Toman, 1940, p.51).

Clinical Applications of Audio-Visual Stimulation

The first reported clinical application of brainwave entrainment was that of Janet, a French psychologist, at the Salpetriere Hospital. Using a lantern placed behind a rotating strobe-wheel, Janet produced flickering light to which he exposed patients. He observed a reduction in hysteria and increased relaxation in the patients exposed to the flickering light (Siever, 1997, p. 6.3). In recent years, there has been an increased interest in applying audio-visual entrainment in clinical settings. The following are a few of such preliminary studies:

Attention and Mood

Attention Deficit Disorder (ADD) and Attention Deficit Hyperactivity Disorder (ADHD) have been preliminarily studied with subjects presented with audio-visual stimulation. Results from these studies were encouraging.

Patrick (1995), in a controlled study that tested a 15-session EEG-driven photic stimulation neural training procedure designed to enhance the regulation of brain wave activity and thereby improve cognitive functioning in ADHD children, reported encouraging results (p.1).

Joyce (1997 – 1998) investigated the use of audio-visual stimulation (AVS) of subjects who experienced either ADD, ADHD or learning disability LD) at two elementary schools in Perham, Minnesota, USA. Joyce concluded, "the results warrant serious consideration to utilize AVS as a viable strategy to address reading, attention, learning and general over-all academic, social/emotional growth and development of children" (p. 1).

In his dissertation towards the degree of Doctor of Philosophy in Social Work at the University of Houston, Texas, Micheletti (1999) conducted a controlled study on the use of AVS for the treatment of ADHD children. The study compared the effectiveness of standard treatment for ADHD, that is, ritalin and aderall, AVS, and a combination of AVS/stimulant medication. Micheletti reported that both the AVS and AVS/stimulant combination indicated a significantly greater efficacy than standard treatment (p.1).

Budzynski, T., in an article in the *Voyager XL User Guide* (1993), reported the preliminary work done by Dr. Russell and his colleagues Drs. Carter and Ochs on brain injured and aged individuals. In their exploratory work in which AVS was used with these clients, Dr. Russell and colleagues reported that significant progress was achieved after daily use of AVS for a period of months (Budzynski, T., 1993, p. 1).

Budzynski, T., Jordy, Budzynski, H., Tang and Claypoole (1999) conducted a controlled study to evaluate the effectiveness of AVS with electrodermal response (EDR) biofeedback on academic performance. Subjects were university students who experienced academic problems. The researchers concluded that AVS could enhance academic performance (p. 11).

Other clinical applications of AVS

Noton (1997) of the Forest Institute reported a preliminary study in which photic stimulation was used as a treatment for premenstrual syndrome (PMS) at the Royal Postgraduate Medical School in Hammersmith Hospital, London, U.K. The results indicated a 76% mean reduction in PMS symptoms of all the subjects. Also, more than two-thirds of the subjects showed no further symptoms of PMS (p. 8).

Berg, Seibel, Siever, and Mueller (1999) conducted an unpublished study to evaluate the effectiveness of three treatments for fibromyalgia. The treatments were used in an attempt to improve quality of life of subjects diagnosed with fibromyalgia syndrome (FMS). The three treatments consisted of:(a) AVS, (b) standard and alternative medical methods such as prolotherapy, neural facial therapy, acupuncture and/or osteopathic, and (c) nutritional supplements made up of amino acids, vitamins, minerals and herbs. The researchers concluded that AVS “could be used to treat anxiousness, pain, and fatigue, while other specific treatments could be used to treat other variables” (p. 4).

Anderson (1989) conducted a pilot study to determine the effectiveness of Variable Frequency Photo-Stimulation in the treatment of migraine headache. He concluded, “the reduction in duration of migraine headache was significant within this small group ($p < 0.02$)”

(p. 154).

Peniston and Kulkosky (1989) used brainwave training in a controlled study to treat alcoholism. The researchers concluded that brainwave training, as a treatment of chronic alcoholism, “is a promising alternative to traditional medical treatment of alcoholism” (p. 277).

Summary

Numerous studies have confirmed that photic and auditory stimulation, either with eyes open or closed, produce responses in the brains of most people. Many preliminary clinical applications of AVS indicate promising results. Cade and Coxhead (1979) reported this of flickering lights: when “properly used, such stimulation has a genuinely self-expanding effect, enhancing awareness, arousing creative drive, stimulating memory, and powerfully re-enforcing other out-of-this-world exercises, hypnagogic reverie and meditation” (p. 128).

Interest in audio-visual entrainment (AVE) technology has been growing steadily in recent years. Many preliminary research studies in the applications of AVE in such areas as Attention Deficit Disorder (ADD), Premenstrual Syndrome (PMS), alcoholism, and academic performance, have shown encouraging results.

CHAPTER 4: METHOD

Introduction

Chapter 4 identifies the equipment used, and provides a description of the subjects and their selection procedure. The experimental treatment, the type of data collected, and the statistical analysis used are also described.

Equipment

The Audio-Visual Stimulation (AVS) device used in the study was the DAVID™ Paradise XL manufactured by Comptronics Devices Limited of Edmonton, Alberta, Canada. The DAVID™ Paradise XL simultaneously provides both flashing white full spectrum light that pulses at a specified rate inside an eye-set (Tru-Vu™), and tone pulses through a headphone. The Tru-Vu™ eye-set provides hemispheric specific visual stimulation. With the eye-set, the DAVID™ Paradise XL can be programmed to stimulate the right and left fields of both eyes independently with different frequencies, thereby stimulating the right and left hemispheres of the brain independently.

Subjects

Twenty students enrolled in 2-year college programs at SIAST Palliser Campus in Moose Jaw, Saskatchewan, Canada, were recruited on a volunteer basis for the study. The age of the subjects ranged from 18 to 39, with 22 being the median age. Nine out of the 20 subjects were female. Four of the subjects did not complete the study; no reasons were given.

It was emphasised to potential subjects that people with a history of epilepsy and /or photic epilepsy must not participate in the study.

Permission for students' participation in the experiment was sought from my supervisor, who is SIAST's Dean of Technology. All subjects were required to sign an informed consent document.

Experimental Design

The 20 students were divided into two groups (experimental and control) by the toss of a coin. The experimental group was presented with relaxing music combined with the pre-programmed session 33 (Accelerated Learning) of the DAVID™ Paradise XL. Each session lasted for15 minutes.

The control group was presented with the same relaxing music without AVS for the same duration. Treatment was administered to subjects in an environment conducive to relaxation, ensuring that there was no excessive external noise, and the room was kept at a comfortable temperature.

Although the experiment was designed to provide each subject with one treatment session per week for ten weeks, this was not possible. Table 5-1 shows the dates on which sessions were administered to each subject.

Pre- and post-treatment tests were administered using the Rey Auditory-Verbal Learning Test (RAVLT) as the dependent variable. The test measured memory and recognition.

Both pre- and post-RAVLT tests were administered in accordance with instructions stated in Rey Auditory and Verbal Learning Test Handbook by Michael Schmidt (1996).

Each subject was verbally presented a 15 – word list (list A). This list was for learning, and was presented five times. After each presentation, the subject was asked to recall as many words as could be remembered, and in any order. The number of wrong words recalled was subtracted from the number of correct words.

Next, a second list of 15 words, (list B) was presented, after which the subject was asked to recall as many words from it as could be remembered, and in any order. This formed trial B. Finally, the subject was asked to recall as many words as could be remembered from only list A, and in any order (trial VI). Both trials B and VI were scored as in the previous trials.

The raw score for each memory test was the sum of the scores for trials 1 through V, B, and VI.

For the recognition test, the subject was presented with a 50-word list that was made up of words from lists A and B, in addition to 20 new words. The subject was asked to identify words from only list A. Here again, the number of wrong words identified was subtracted from the number of correct words. Independent ***t*** statistic with a one-tailed test at the 0.10 level was used for hypothesis testing.

CHAPTER 5: RESULTS

The research hypothesis that students presented with audio-visual stimulation (AVS) will produce a higher increase between pre- and post-scores in Rey Auditory-Verbal Learning Tests (RAVLT) than students without AVS, has been demonstrated ($p < 0.10$).

Table 5-1 shows the dates on which the ten treatment sessions were administered to each subject. Fifty percent (50%) of subjects received treatment sessions on a regular weekly basis. The other 50% missed sessions for between one to two weeks. To compensate for missing a week or two, subjects received two or more treatments per week.

TABLE 5-1 Dates on which treatment sessions were administered (N = 16)

Session #	1	2	3	4	5	6	7	8	9	10
C1	09/25	10/02	10/09	10/16	10/25	10/30	11/06	11/13	11/20	11/27
C2	09/23	09/30	10/07	10/16	10/23	10/30	11/06	11/13	11/20	11/27
C3	09/30	10/07	10/15	10/18	10/28	11/04	11/14	11/19	11/21	11/25
C4	09/25	10/02	10/09	10/16	10/23	10/24	10/30	11/06	11/13	11/20
C5	09/24	10/01	10/08	10/15	10/29	11/06	11/12	11/14	11/18	11/21
C6	10/03	10/10	10/17	10/31	11/04	11/21	11/25	12/02	12/03	12/04
C7	10/03	10/10	10/31	11/01	11/08	11/14	11/15	11/20	11/27	11/28
C8	10/07	10/17	10/18	10/24	10/31	11/07	11/21	11/27	11/28	12/04
E1	10/17	10/18	10/25	11/01	11/07	11/14	11/15	11/21	11/22	11/28
E2	10/10	10/17	10/31	11/05	11/06	11/19	11/20	12/04	12/05	12/06
E3	10/07	10/17	10/021	10/28	11/04	11/18	11/20	11/25	11/27	12/02
E4	09/26	10/03	10/17	10/24	10/31	11/07	11/14	11/22	11/26	11/28
E5	09/25	10/02	10/09	10/21	11/01	11/06	11/13	11/15	11/20	12/02
E6	09/24	10/01	10/08	10/22	10/29	11/07	11/12	11/14	11/19	11/28
E7	10/03	10/10	10/17	10/24	10/31	11/07	11/14	11/21	11/28	12/05
E8	09/27	10/11	10/17	10/18	10/23	10/30	11/13	11/15	11/20	12/03

Notes: 1. Dates are given as month and day. The year was 2002

2 C1 represents subject #1 in the control group and E1 represents subject #1 in the experimental group.

RESULTS OF MEMORY TEST

Tables 5-2(a) and 5-2(b) show the results of the pre- and post- memory and recognition tests for the control and experimental groups respectively. Dm, and Dr represent the difference between the post- and pre- test memory and recognition results respectively. SD = standard deviation.

TABLE 5-2(a) Results of pre- and post tests for control group subjects, C1 to C8 (N=8)

	Memory Test			Recognition Test		
Subject	Pre-test	Post-test	Dm	Pre-test	Post-test	Dr
C1	54	63	9	12	11	-1
C2	74	63	-11	13	15	2
C3	68	76	8	14	15	1
C4	73	75	2	15	13	-2
C5	74	73	-1	15	12	-3
C6	81	68	-13	15	15	0
C7	64	73	9	14	15	1
C8	74	81	7	13	15	2
Mean			1.25			0
SD			8.348			1.732

TABLE 5-2(b) Results of pre- and post tests for experimental group subjects, E1 to E8 (N=8)

	Memory Test			Recognition Test		
Subject	Pre-test	Post-test	Dm	Pre-test	Post-test	Dr
E1	75	82	7	12	15	3
E2	72	83	11	15	15	0
E3	66	69	3	12	14	2
E4	82	82	0	15	14	-1
E5	64	67	3	13	15	2
E6	49	71	22	12	13	1
E7	61	76	15	9	13	4
E8	79	79	0	15	14	-1
Mean			7.625			1.25
SD			7.347			1.71

CHAPTER 6: DISCUSSION

The mean change in post- and pre-memory test scores for the experimental group is greater than that for the control group (7.625 and 1.25 respectively). The difference in the mean scores is statistically significant ($p< 0.10$). Likewise, the difference in the mean change in post- and pre-recognition test scores for the experimental group (1.25) and control group (0.0) is statistically significant ($p< 0.10$). These findings support the hypothesis and other studies.

At Heart of the Lakes Elementary and St. Henry's Area School at Perham, Minnesota, Joyce (1997 – 1998) conducted a study to determine the effectiveness of the digital audio-visual integration device (DAVID™) "as an educational strategy for ADD, LD, reading and other arousal disorders that impact focusing, attending, and learning" (p. 7). Joyce reported a significant improvement from pre- to post-TOVA scores in inattention ($p< .05$ slightly $> .01$), impulsivity ($p< .05$ slightly $> .01$), and reaction time (p slightly $>.05$ but $< .10$) (p. 15). Participants ($N = 30$) in this study received daily AVS sessions. The number of sessions received by students ranged from 26 – 35, with a mean of 31 sessions. Each session was of 20-minute duration. Joyce concluded, "the data generated from this investigation suggests that an enjoyable twenty minute AVS session, on a regularly scheduled basis over a period of several months, can make a substantial improvement in a child's school performance" (p. 32).

Another study that demonstrated the effectiveness of audio/visual stimulation (AVS) on academic performance was conducted by Budzynski, T. et al. (1999). This study was designed "to test the possibility that training with the Biolight™, a combined audio/visual stimulation and Endo Dermal Resistance (EDR) feedback device, would result in positive changes in academic performance" (p. 1). A one-tailed *t*-test ($p = 0.004$) suggested that training with the Biolight™ produced significant changes in academic performance (pp. 7 & 8). In their study, Budzynski, T. et al. administered training with the Biolight™ "for 15 minutes for 5 days of the week for 6 weeks" (p. 7). Each experimental subject received a total of 30 training sessions within 6 weeks.

In the two studies cited above, AVS was found to produce a positive effect in academic performance at lower significance levels ($p < 0.05$) than the level found in my study. This difference in significance levels is likely due to the number, duration, and the frequency of treatment sessions. In the two studies cited, each subject received, on the average, 30 daily treatment sessions. This number contrasts sharply with the ten weekly sessions administered in my study.

The theory of AVS entrainment states that the degree of entrainment is dependent on the number of treatment sessions. The $p < 0.10$ level of significance achieved in my study with only ten treatment sessions supports this statement when contrasted with $p < 0.05$ level of significance that resulted with 30 treatment sessions used in the two studies cited.

Also, as mentioned earlier, one limitation of the study is that the 10-week duration of the study might not provide enough time for effective entrainment, since it has been shown that audio-visual entrainment increases with the number of stimulation sessions.

How could audio-visual stimulation (AVS) accelerate learning? Sound and light are forms of energy. Sounds of certain frequencies or wavelengths, such as lullabies, have soothing effects. Lights of different wavelengths produce different effects on people and animals. The bullfighter uses red colour to agitate the animal. The ear and the eye are transducers that transform sound and light energy, respectively, into corresponding electrical impulses, and transmit them to the brain.

It may be argued that audio-visual stimulation produces a training effect on the brain, just as a gymnast, through physical exercise, trains her body to perform complicated manoeuvres. The more the gymnast practices, the better she becomes in performing her manoeuvres. Likewise, the greater the number, and the longer the duration of AVS sessions a subject receives, the easier it would be for the brain to operate at the wavelengths contained in the audio-visual stimulation equipment. By selecting wavelengths conducive to learning, it could be possible to use AVS to help students accelerate their learning.

The implications of this study are enormous. Budzynski, T. et al (1999) stated, “A number of studies have been performed on numerous types of subjects, indicating that photic stimulation achieves the desired changes (in the EEG)” (p. 4). The audio-visual entrainment (AVE) technology used in this study provides a means of changing the EEG to the frequencies selected in the AVE equipment. In this study, EEG frequencies suitable for academic performance were selected. The results of the study seem to support the theory of AVE technology. The applications of AVE technology could be expanded into clinical treatments of many problems such as ADD, ADHD, fibromyalgia, alcoholism, and cognitive deficiency.

For future studies in the application of AVE technology in education, it may be helpful to provide a minimum of 30 daily treatment sessions to increase the degree of entrainment.

It may also be suggested that pre-tests be administered after, rather than prior to, the first treatment session. This may help create, as much as possible, similar conditions for pre- and post-tests for the dependent variable.

CHAPTER 7: SUMMARY AND CONCLUSIONS

The need for continual retraining has never been greater in the history of the workforce in technologically advanced countries. Increasing numbers of children and adults are being diagnosed with learning difficulties such as attention deficit disorder (ADD). Traditional methods used in treating learning difficulties depend on drugs such as ritalin and aderall. The side effects of these drugs include nervousness, insomnia, stomach pain and loss of appetite. Like all amphetamines, these drugs pose a high potential for abuse that could lead to dependence and addiction. Simple and inexpensive techniques that accelerate learning offer tremendous benefits.

The results of the study suggested that students presented with AVS produced a higher increase between pre- and post-scores in the Rey Auditory-Verbal Learning Test than students without AVS ($p < 0.10$). The significance of this result is that AVS does enhance learning.

Students who find it difficult to learn as a result of poor concentration may benefit from the result of this study. A daily twenty-minute session of AVS will afford a student enhanced relaxation, and improved concentration and memory retention.

Daily twenty-minute sessions of AVS could lead to a significantly reduced use of drugs in the treatment of learning difficulties associated with inability to relax, and poor concentration. In conclusion, the purpose of the study was achieved; audio-visual stimulation (AVS) has a significant positive effect on learning.

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APPENDIX A

CLAYTON COLLEGE OF NATURAL HEALTH
2140 - 11TH AVENUE SOUTH- SUITE 305
BIRMINGHAM, ALBAMA 35205-2841

INFORMED CONSENT

Accelerated Learning by College Students Through Audio-Visual Entrainment Technology

Invitation To Participate

You are invited to participate in a research study that will determine whether or not Audio-Visual Stimulation accelerates learning. Your participation in this study is entirely voluntary.

Basis For Subject Selection

You are being asked to participate in this study because you are healthy and between the ages of 19 to 40. You may not participate if you or your family has a history of epilepsy and /or photic epilepsy.

Purpose of the study

The purpose of the study is to determine if audio-visual stimulation (AVS) has a significant effect on learning. A number of preliminary studies have shown that AVS has a beneficial effect on brain wave activity. This study is to determine if AVS has any effect on a student's ability to learn faster.

Explanation of Procedure

You will be asked to come to a quiet room located at SIAST Palliser Campus for a total of ten AVS treatment sessions, each lasting 15 minutes. A treatment will be administered once a week.

You will be given a pre- and post-treatment tests using the Rey Auditory-Verbal Learning Tests (RAVLT) as the measuring instrument. The purpose of the Rey Auditory-Verbal Learning Tests is to assess your verbal learning and memory prior to the AVS treatment, and after.

"The RAVLT is a brief, easily administered pencil and paper measure that assesses immediate memory span, new learning, susceptibility to interference, and recognition memory" **(A compendium of neuropsychological tests (p. 326).**

The AVS treatment session will be conducted as follows using a DAVID Paradise XL audio-visual entrainment device manufactured by Comptronic Devices Ltd. of Edmonton, Alberta:

Wearing comfortable clothing, you will sit in a comfortable chair in a room that is conducive to relaxation. You will wear a headphone through which you may hear music and/or a pulsed tone and heart bit. The volume, pitch and heart rate will be adjusted to your comfort level.

You will also wear and eye-set, (the Omniscreen, manufactured by Comptronic Devices Ltd.). With the omniscreen eye-set on, you may, or may not see flickering lights. The rate of flickering and the intensity of the lights will be adjusted to your comfort level.

Once the sound and light have been adjusted to your comfort level, all you do is sit back, open or close your eyes, and enjoy the session.

Prior to the commencement of each AVS treatment, you will be given a glass of purified water to drink. This is to improve hydration.

WARNING

If at any time during a session, you begin to feel vertigo, nausea, or a sense of mental instability you must discontinue the session.

Potential Risks

It is strongly recommended that you do not participate in the study if any of the following situations applies to you:

1. you are epileptic or photic epileptic.
2. you are taking drugs or using alcohol.
3. you have any form of learning disability

Safety Precautions

The experimenter will:

1. require all subjects to complete a screening questionnaire prior to participation in the study.
2. obtain details of each subject's family doctor to facilitate speedy contact in case of an emergency.
3. arrange to have subject conveyed to hospital by ambulance.

Potential Benefits To Subjects

You will have an opportunity to assess your verbal learning and memory.

Potential Benefits To Society

Society would benefit from the knowledge of the effect of Audio-Visual Entrainment on learning.

Financial Obligations

The treatment sessions will be provided to you free of charge.

Assurance of Confidentiality

Any information obtained from you in regard to this study will remain confidential. Your name will be kept out of any publications of this study, and only grouped data will be reported.

Rights of Research Subjects

As a research subject, your rights have been explained to you. Should you have any addi tional issues concerning the rights of research subjects you may contact the Clayton College of Natural Health Institutional Review Board (IRB), telephone 205-323-8236.

Voluntary Participation and Withdrawal

It is your right to decide not to participate in this study, or to withdraw at any time without any obligation.

Should any information or changes develop during the course of this study that may affect your willingness to continue your participation you will be immediately informed.

Documentation of Informed Consent

It is your voluntary decision whether or not to participate in this research study. Your signature testifies that the content and meaning of the information contained in this consent form have been fully explained to you and that you have voluntarily made the decision to participate, having read and understood the information presented. Your signature also signifies that all your questions regarding your participation in the study have been answered to your satisfaction. If ,at any time during the study, you think of any additional questions, please contact the investigator .

Make sure you receive a copy of the consent form for your records.

______________________________ ______________________________

Signature of Subject Date

My signature as witness certifies that the Subject signed this Consent form in my presence as his/her voluntary act and deed.

______________________________ ______________________________

Signature of Witness Date

In my judgement the Subject is voluntarily and knowingly giving informed consent and possesses the legal capacity to give informed consent to participate in this research study.

______________________________ ______________________________

Signature of Investigator Date

Allan Atsu
Program Head
Instrumentation Programs
SIAST Palliser Campus
306-694-3356

SAMPLE PERMISSION LETTER TO SIAST

Allan E. Atsu
1611 - 11 Avenue N.W.
Moose Jaw, SK., S6H 6M5
Ph: 306-694-3356 (Bus) 306-693-0611 (Res)
E-mail:atsu@siast.sk.ca

January 24, 2002

Arnold Boldt, Dean
Technology Division
SIAST
Palliser Campus
P.O. Box 1420
Moose Jaw, SK, S6H 4R4

Dear Arnold:

I am writing to request permission to conduct a research study that will involve some SIAST students at Palliser Campus in Moose Jaw.

The research study, Accelerated Learning by College Students Through Audio-Visual Entrainment Technology, is in partial fulfillment of the requirements for the Degree of Master of Natural Health at Clayton College in Birmingham, Alabama.

The following sections of the thesis proposal are attached: cover page, table of contents, abstract, introduction, the problem, and informed consent.

I plan on starting the study in February of 2002. My academic advisor is Anne Barnhill. She may be reached by e-mail at: aebarnhill@ccnh.edu

I hope I can count on your assistance and support.

Sincerely,

Allan Atsu
Program Head
Instrumentation Programs
SIAST Palliser Campus
atsu@siast.sk.ca
Ph: 306-694-3356

cc: Anne Barnhill
Claude Naud

APPENDIX B

SCREENING QUESTIONNAIRE

Accelerated Learning by College Students Through Audio-Visual Entrainment Technology

Name of Subject: ____

Family Doctor: ____

Address: ____

Telephone: ____

Please answer the following questions to the best of your ability. Answers to these questions are necessary to minimise the chance of triggering a medical problem during the study.

1. Do you have any serious medical illness? [ ] Yes [ ] No
2. Are you on any medication? [ ] Yes [ ] No
3. Do you have any family history of epilepsy? [ ] Yes [ ] No
4. Do you have a personal history of seizure disorder? [ ] Yes [ ] No
5. Are you taking drugs or using alcohol? [ ] Yes [ ] No
6. Do you have any form of learning disability? [ ] Yes [ ] No

______________________________ ______________________________

Signature of Subject Date