

Audio-Visual Entrainment Program as a Treatment
for Behavior Disorders in a School Setting

Michael Joyce M.A.

Heart of the Lakes Elementary

St. Henry's Area School

Dave Siever C.E.T.

Comptronic Devices Limited

Running Head: Audio-Visual Entrainment and Behavior Disorders

Abstract

Introduction

It has been suggested that the behavioral manifestations of attention deficit hyperactivity disorder (ADHD) are secondary to neurological abnormalities and are characterized as low brain wave disorders. Brainwave activity in ADHD is shown to be higher in theta and reduced in beta. ADHD. Children produce higher amounts of theta (5-7 Hz) and less beta (13 - 21 Hz) brain wave activity than normals. Many researchers are testing the therapeutic effectiveness of Audio-Visual Entrainment (AVE) as a treatment for a variety of low arousal brain disorders. AVE is the repetitive and intermittent presentation of light and sound. AVE affects electroencephalographic (EEG) output in that brain wave output can be suppressed or enhanced at specific frequencies.

Procedure

Thirty-four elementary students from two different schools were given AVE over the course of seven weeks. Participants were given the Test of Variables of Attention (TOVA) before and after participation. A second group of eight participants were in a special reading (SPALDING) class. All the students in this class received the Standardized Test for the Assessment of Reading (STAR) and compared with a control (n=12).

Results

Overall, inattention, impulsivity and variability as rated by the TOVA improved significantly. The eight students from the SPALDING reading program who received AVE improved their reading scores more than their classmates who served as controls. The results included normalization as recorded on the TOVA, substantial improvements

in reading as recorded on the STAR and improvements in general behavior as expressed by teachers and parents.

Discussion

As the data suggests, AVE was a useful experience for the participants. The results met or exceeded our expectations. Most of the students had noticeable improvements as confirmed by teachers and parents.

Key words: audio-visual entrainment (AVE), audio-visual stimulation (AVS), attention deficit disorder (ADD), learning difficulties (LD), tests of variables of attention (TOVA), academic performance.

Audio-Visual Entrainment Program as a Treatment
for Behavior Disorders in a School Setting

It has been suggested that the behavioral manifestations of attention deficit hyperactivity disorder (ADHD) are secondary to neurological abnormalities (Zametkin et al. 1990; Zametkin et al. 1993; Mann, Lubar, Zimmerman, Miller, & Muenchen, 1992). Electroencephalographic (EEG) recordings reveal that ADHD children produce more theta (4 - 7 Hz) brainwave activity in the frontal and central cortical regions of the brain than normals (Mann, Lubar, Zimmerman, Miller, & Muenchen, 1992). This brainwave pattern is usually associated with drowsiness and low arousal. ADHD children also produce less beta 1 (13 - 21 Hz) brainwave activity than normals (Mann, Lubar, Zimmerman, Miller, & Muenchen, 1992). Dominant beta brainwave activity is associated with higher levels of arousal. These abnormalities in levels of theta and beta activity have been interpreted as evidence supporting the theory that ADHD is a disorder of low levels of arousal. Studies using positron emissions tomography confirm that ADHD is also characterized by reduced cerebral blood flow and lower levels of a glucose metabolism (Zametkin et al. 1990; Zametkin et al., 1993). To compensate for this under arousal, stimulant medication is often prescribed as a treatment for ADHD, and appears to have a calming affect on children that otherwise cannot focus or remain still (Zentall, 1975).

Changing the cerebral electrical activity associated with ADHD have improved ADHD children's symptoms (Lubar 1991; Utter 1996; Russel 1997). As an alternative treatment approach to ADHD, neurofeedback has been used as a means to increasing cerebral activity (Lubar 1991; Lubar and Shouse, 1977; Lubar & Deering, 1981; Lubar & Lubar, 1984; Tansey 1990). Differential neurofeedback in which ADHD children train

with beta (15 - 19 Hz) on site C3 and train with SMR (12 - 15 Hz) on site C4 based on the 10 - 20 electrode placement standard (Othmer 1998), has been becoming increasingly popular in recent years.

Many researchers are testing the therapeutic effectiveness of Audio-Visual Entrainment (AVE) as a treatment for a variety of low arousal brain disorders. AVE is the repetitive and intermittent presentation of light and sound. AVE affects electroencephalographic (EEG) output (Toman 1940; Walter 1956; Barlow 1960; Inouye, Sumitsuji, and Matsumoto, 1979; Kinney, et.al. 1972; Nogawa, Katayama, Tabata, Ohshio and Kawahara 1976; Lesser et.al. 1986, Frederick, et. Al. 1999). It purports to alter perception and consciousness (Glicksohn, 1986; Richardson and McAndrew, 1990; Freedman and Marks, 1965). AVE has been used to improve grade-point average in college students (Budzynski 1999). AVE can induce relaxation (Manns, et.al. 1981; Thomas and Siever 1989; Brauchli 1993; Morse and Chow 1993; hypnotic states (Kroger and Schneider 1959; Sadove 1963, Lewerenz 1963; Margolis 1966) and dissociation (Leonard, Telch and Harrington 1997; Leonard and Telch, 1998). AVE has been used to reduce chronic pain (Boersma and Gagnon 1992), to treat migraine headache (Anderson 1989) and to treat depression (Kumano et.al. 1996). AVE has produced significant reductions in anxiety (Leonard and Telch, 1998). AVE has been used as a treatment for low-arousal brain disorders such as pre-menstrual syndrome (PMS) (Noton 1996), chronic fatigue syndrome (Trudeau 1999), fibromyalgia (Berg and Siever 2000) and seasonal affective disorder (Berg and Siever 2000). Low arousal brain disorders are disorders that can be characterized by abnormal EEG patterns. ADHD is one of these disorders (Noton 1996; Carter and Russell 1993). It has been suggested that many clinicians are using AVE informally for ADHD with anecdotal reports of successful treatment, but with few published results (Noton 1996). Carter and Russell (1993)

conducted a pilot study using AVE to treat learning and behavioral disorders. The results were improvements in IQ scores and behavior. Russell (1997) states that AVE achieves the same results as EEG biofeedback but at less cost and in less time.

The purpose of these studies was to expand on the ADHD research of Carter and Russell, and to further determine the effectiveness of AVE treatment in reducing the symptoms associated with learning disorders such as impaired reading. Improvements in pre- and post-scores on a continuous performance task (TOVA) and on a standardized reading test (STAR) were expected.

Method

Participants

Thirty-four elementary students (13 females) participated in the studies. The mean age of the participants was 9.30 ± 1.55 years. Fourteen students (7 females) were from a Catholic school in the same rural community. All of the Catholic school students participated in the ADHD part of the study. Twenty students (6 females) were from a public school. All twenty students were on the SPALDING reading program. Eight (four girls) of the twenty students in the SPALDING reading program with the poorest marks were selected for the treatment group and the remaining twelve students in the class (two girls) served as controls. The pre-post TOVA data from the treatment were also used in the ADHD study along with the parochial students. Students with a history of distractability and of distracting others were selected. The selection criterion was teacher referral at the public school and parent referral at the parochial school. None of the students had a history of epilepsy or seizure. Two students from the parochial school had no academic or attention problems. These two students were interested in increasing their already adequate academic performance.

Specific diagnoses are as follows: no diagnosis by a medical physician, but a history of distractability and misbehavior, 12; unspecified learning disorder, 10; suspected ADHD, 8; physician diagnosed ADHD, 6; emotional/behavior disorder, 2; and one each of anxiety, allergies, fetal alcohol syndrome, and suspected depression. The sample size doesn't match the number of diagnoses because many students had multiple diagnoses.

Apparatus

The AVE device used was the DAVID *Paradise XL* (manufactured by Comptronic Devices Limited, Edmonton, Alberta, Canada). The eyeglasses for the

DAVID *Paradise XL* are field independent, in that they are able to independently stimulate the individual left and right visual fields of each eye if selected. In this study, independent field stimulation was chosen. The parameters of the stimulation “session” was as shown in Figure 1.

Insert Figure 1 about here.

The frequency and intensity may be programmed to stimulate the left and right fields of vision independently. The DAVID *Paradise XL* was attached to a multi-user amplifier which enabled 10 students to participate simultaneously. Each student had his/her own station which consisted of a set of headphones and an eyeset. The students could control both the audio volume and the light intensity. The students preferred brighter intensities between approximately 400 and 600 lux (full spectrum) measured approximately 0.3 inches from the eyeset screen (approximating their average eye distance from the screen).

Because photic induced seizures involving those aged from 5 - 24 years of 1/4000 has been reported by Newmark and Penry (1979) and Jeavons, Bishop and Harding (1986), care must be taken when delivering photic stimulation to children. Physiological photic stimulators generally used to induce seizures employ a Xenon strobe light that reaches maximum brightness within 50 micro-seconds at intensities of 10,000-300,000 lux. Carterette and Symmes (1952) first reported that red-flicker provoked an increased photo-convulsive response (PCR) relative to other wavelengths. Since then, this finding has been reported by Bickford (1953); Marshall (1953); Pantelakis (1962); Kojima (1963); Brausch and Ferguson (1965); Harley (1967); Takahashi and Tsukahara (1972a, 1973). It has also been reported by Carterette and Symmes (1952); Brausch and

Ferguson (1965); Buskirk (1952); Marshall et al (1953); Bickford (1954); Asano and Umezaki (1965); Maruyama (1968); Takahashi and Tsukahara (1972b) and Harley (1967) that red-removing eyeglasses or contact lenses afforded clinical relief to patients with photogenic epilepsy. Kasteleijn-Nolst Trenite (1989) found that in 100 PCR participants, 81 showed sensitivity with eyes closed while 66 were sensitive with their eyes opened. Harding and Jeavons (1994) found that peak PCR sensitivity occurs from 15 - 20 flashes per second. Takahashi and Tsukahara (1976) measured IPS induced PCRs under controlled lighting conditions. They observed that PCRs were most frequently induced with red light stimulation from 15 - 20 Hz and that it was superior in producing PCRs than stroboscopic (white) light. In all 14 cases generalized PCRs of sharp and wave and spike and wave complex were induced. They also found that 20 cd/m² were inhibited by blue light of 1.9 cd/m². All of these studies used a brief, intense flash pulse. Ruuskanen-Uoti (1994) reported on a person who developed seizures while using a "light and sound" machine utilizing square wave stimulation delivered by red light emitting diodes (LEDs).

Brief, intense flashes produce harmonic activity in the brain, Van der Tweel and Verduyn (1965) whereas sine wave stimulation produces a sine-like response (insignificant harmonic activity). Van der Tweel and Verduyn (1965), Townsend (1973), Donker (1978) and Regan (1965) all agree that sine-wave modulated light eliminates the problem of light intensity from a Xenon strobe increasing with frequency and the harmonics generated within the neo-cortex at frequency multiples much higher than the fundamental at times. It has been our observations that square wave LED flashing at 7 Hz can produce strong harmonics between 20 and 40 Hz. Of these sine wave stimulation studies, the concern of inducing seizures is completely omitted from the studies. In the

raw EEGs shown in the studies, there are no signs of epileptiform activity nor any discussion about it.

To address the concerns of eliciting a photic induced seizure, the eyesets used had a slowed turn-on and -off time of about 15 msec. The light emitted from the eyesets was white light produced by incandescent bulbs over which was a translucent plastic sheet that was tinted a light blue.

The students were given pulsing isochronic tones at a frequency of 170 Hz., through a set of headphones. The students could control the volume of the sounds heard through the headphones from “off” to approximately to 70 db at their own station, using an auditory C-weighting measurement. All of the students preferred a sound volume in the range of 60 to 70 db. The students could not control the program or “session” which they were presented.

Procedure

Before treatment began, the participants were administered the Test of Variables of Attention (TOVA) (Greenburg 1987, Lark 1996). The TOVA is a Continuous Performance Test used to measure impulsivity and inattention. The TOVA is used as an assessment tool in the treatment of attentional disorders (Lubar and Smartwood 1995). It has been shown to be very reliable in long term test-retest reliability (Llorente in press). The eight participants in the reading class were also administered the Standardized Test for the Assessment of Reading (STAR). The STAR is a computer-adaptive, norm-referenced reading test. All pre-assessments were completed within ten days prior to the onset of the AVE sessions.

The AVE sessions took place on school days for a one-month-and-three-week period beginning on September 29, 1997. The public school had sessions with 10

students at 8:20 A.M. and another 10 students at 12:20 P.M. The parochial school had sessions at 1:30 P.M. with 8 students, and at 2:15 P.M. with another 6 students. There were a total of 35 sessions provided. The students experienced a range from 28 to 33 sessions with a mean of 31 sessions. No students dropped out of the study. The sessions were provided in a quiet, dimly lit room. Before each day's session, each student consumed a glass of water. Each student got into a comfortable reclining position on a mat for the AVE session. When the eyesets and headphones were in position, the session would begin.

It was soon found necessary to provide modified audio entrainment by providing an auditory stimulus in addition to that of the AVE device in order to engage some of the students. It was decided to use environmental sounds and instrumental music. These tapes were believed to capture the students' attention. An EEG evaluation to determine if the tapes affected brainwave activity was not done. Four tapes matching these criteria were selected. The environmental sounds included birds, crickets, and rain. The instrumental music used strings and percussion, and could be described as background music. None of these tapes was marketed for relaxation or other purposes. A single tape was randomly selected for each day's session. All students received stimulation from these tapes.

A total of 38 AVE sessions were offered. The first eight sessions were twenty minutes long, and consisted of a low alpha (7 to 9 Hz) protocol. These protocols are generally used to induce relaxation. As discussed previously, children with ADHD have EEG patterns dominated by theta. Therefore it would seem counter intuitive to induce a similar EEG pattern in ADHD children. However, regardless of the diagnoses, many students experience anxiety for various reasons and may not know how to consciously relax. It was deemed necessary to have the students relax with this stimulation to help

enhance the effectiveness of the second protocol. After the initial mu protocol, the participants began the remaining sessions of a 22-minute SMR-beta program (see Figure 1). The frequencies selected were based on Carter and Russell's work (1993) and on Othmer's neurofeedback protocols for treating ADD.

Results

Pre- and post- average results were calculated for the entire group of students. Table 1 lists the pre- and post-treatment group standard score means on the TOVA scale's inattention, impulsivity, reaction time, and variability. Standard deviation and significance are also presented based on the statistical ANOVA procedures described in the TOVA manual.

Insert Table 1 about here

Pre- and post- TOVA results were calculated separately for the catholic school students and the public school students. The public school students' pre-AVE TOVA scores were higher than the catholic school students' pre-AVE scores. The post AVE scores were similar for both. Two separate groups' TOVA scores for attention, impulsivity, reaction time and variability are presented in Tables 2 and 3.

Insert Table 2 about here

Of the 14 catholic students, three students had pre-AVE TOVA results that were invalid due to extremely deviant results. These students' scores were more than 3 standard deviations below the norm before AVE. After AVE all were within normal range. The mean data on these students is presented in Table 3.

Insert Table 3 about here

Four of the twenty students from the public school had invalid pre- and post-TOVA scores. These were due to excessive commission errors or anticipatory results to which the TOVA will automatically not process the results. These students' data were not included for the group analysis.

There were twelve students in the special reading class who did not participate in the AVE program. These students did complete the STAR and their STAR results were compared to the results of the students who participated in the AVE program. Results are presented in Figures 2 through 5.

Grade equivalent (Figure 2) ranges from 0.0 to 13.0+ and represents a student's reading level relative to a norming sample. Instructional reading level (Figure 3) is the level at which the student can comprehend written material with assistance, at 80% proficiency. Normal curve equivalents (Figure 4) are similar to percentile ranks, but are based on an equal interval scale. Comparisons of these measures between pre and post treatment are shown in Figure 5.

Insert Figure 2 About Here

Insert Figure 3 About
Here _____

Insert Figure 4 About Here

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Insert Figure 5 About Here

After the eight alpha (7.8 Hz) sessions nearly all of the students had demonstrated some semblance of deep relaxation as evidenced by their rhythmic and generally deeper diaphragmatic breathing. In addition, there were teacher and parent reports of students being more mellow, centred, focussed and “easier going.” Most of the students concurred with these impressions by reporting that they experienced more relaxation with each daily session.

The anecdotal reports at the end of the alpha-beta protocol were positive and encouraging. There were reports of shy and anxious students “coming out of their shell,” and actively engaging and participating in classroom activities. In general, students also gained assertiveness and began “showing a personality,” whereas previously they were generally passive and not responsive. There were also anecdotal reports of improvements in spelling, reading, fluency, self-esteem, and happiness.

Two students have reduced their dosage of Ritalin by 40 mg each. Their dosages were reduced to 5 mg., twice per day and 10 mg., twice per day. Parents and teachers report that these two children are doing “fantastic.” Other students on the program who were candidates for medication are no longer candidates for medication.

Discussion

As the data suggests, AVE was a useful experience for the participants. The results met or exceeded our expectations. Most of the students had noticeable improvements as confirmed by teachers and parents. Participants whose scores were discrepant consistently did not “get into” the sessions. They were occasionally agitated but reported that they enjoyed the experience. It was felt that these students could have benefited further with more alpha/theta sessions, or with a combination of neurofeedback and AVE.

The participants in the reading program were only a portion of the class. All remaining students were in the elementary K-4 (n=512) participating in the self-esteem class at the same time daily. This set up had provided us with a control situation. The non-AVE students were given comparable therapeutic attention to the AVE students and the AVE students improved more than their peers. AVE seemed to be a better concurrent treatment than a self-esteem program for the reading program.

Several conclusions can be made. AVE proved to be an effective tool for treating learning disabilities of the type described and as a treatment for behavior disorders. This investigation suggests new possibilities for hemisphere specific stimulation. It appears to follow the model implemented by Othmer, Kaiser and Sterman where left hemisphere beta and right hemisphere SMR neurofeedback training are used successfully. This inquiry has also provided a replicable, cost-effective model which school systems can adopt.

There are several good reasons AVE technology should be available in school settings: most communities or parents that need neuro-technologies such as AVE or neurofeedback the most, can afford it the least; travel time is minimized; immediate and ongoing feedback and random on-site observations are more easily obtained; and medication intakes can be reduced.

One of the most exciting implications is that a whole host of seemingly unrelated disorders may all be dysregulation of arousal, which may be defined as an over-activation or under-activation of the sympathetic or parasympathetic systems. Arousal dysregulation disorders may include depression, anxiety, phobias, panic, dysthymia, obsessive compulsive disorder, post-traumatic stress disorder, hypertension, closed head injury, narcolepsy, alcoholism, Tourette's Syndrome, and ADHD (Othmer, in press). All these disorders may be traced to proxysmal events in the brain spikes, slow brainwaves, irregularities, seizures and brain storms of greater or lesser magnitude (Othmer, in press). As Othmer (in press) states, "These disorders can be significantly modified by altering and bringing more order or coherence to brainwave activity and giving individuals more power of self-regulation of brain states through the use of AVE and/or EEG feedback techniques."

The authors speculate that AVE and neurofeedback may work in part not by affecting specific frequencies, but by breaking up rigidities and increasing the brain's functional flexibility. Flexibility may be defined as the ability to move quickly between various coherent brain states and frequencies; between alert and diffuse attention, or between rest and reaction. Mental flexibility is the hallmark of good mental health and peak performance. AVE may be seen as exercising the brain, making it more capable of responding to presented stimuli and taking advantage of presented stimuli.

It appears that in many cases, children referred for ADHD or LD are students experiencing ongoing anxiety and tension that interfere in all aspects of their life. It has been the senior author's experience that once this anxiety is addressed with either AVE or EEG biofeedback, the symptoms that warranted the referral for diagnosis are diminished or eliminated. Mis-diagnoses cannot be ruled out either.

Though appearing cost-effective as compared to neuro-therapy, AVE will certainly not solve all behavior or learning issues in a school setting. Schools often make the assumption that their students are free of stress, family problems, are properly nourished, properly hydrated, and are free of allergies. This is not always the case.

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Table 1

Mean TOVA Standard Scores for Total Group^a

| Scale | Pre-Score | Post-Score | Difference |
|---------------|-----------|------------|------------|
| Inattention | 80 | 100 | 20** |
| Impulsivity | 88 | 109 | 21* |
| Reaction Time | 80 | 94 | 14 |

Audio-Visual Entrainment

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| | | | |
|-------------|----|-----|------|
| Variability | 80 | 103 | 23** |
|-------------|----|-----|------|

n=34 *p<.05 **p=.01

Table 2

Mean TOVA Standard Scores for the Public Schools Group^a

| Sub-Scale | Pre | Post | Difference |
|---------------|-----|------|------------|
| Inattention | 92 | 102 | 10 |
| Impulsivity | 99 | 112 | 13 |
| Reaction Time | 85 | 93 | 8 |
| Variability | 87 | 102 | 15* |

n=20 *p=.05

Table 3

Mean TOVA Standard Scores for the Catholic School Group^a

| Sub-Scale | Pre | Post | Difference |
|---------------|-----|------|------------|
| Inattention | 57 | 95 | 38** |
| Impulsivity | 73 | 107 | 34** |
| Reaction Time | 68 | 94 | 26* |
| Variability | 68 | 103 | 35** |

n=14 *p<.01 **p<.001

Figure Caption

Figure 1 Left and right hemisphere flash rate for the experiment specific AVE session.

Figure Caption

Figure 2 Grade equivalence as measure by the STAR comparing the AVE group from the non-AVE group.

Figure Caption

Figure 3 Percentile rank on the STAR compared between the AVE group and the non-AVE group.

Figure Caption

Figure 4 Normal curve equivalents on the STAR comparing the AVE and non-AVE groups.

Figure Caption

Figure 5 Pre- and Post-AVE STAR Results Comparing the AVE and the non-AVE Groups.