A Pilot Investigation of Auditory and Visual Entrainment of Brain Wave Activity in Learning Disabled Boys

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Research demonstrates that individuals can learn to voluntarily alter and control the frequency of their brain wave activity resulting in a normalization of brainwave patterns and improved functioning. A problem is the length and intensity of training time required to bring about these changes. The purpose of this investigation was to determine if regular and sustained auditory and visual stimulation would bring about neurodevelopmental growth as reflected in increasedI Q scores, achievement test scores, and self-control in learning disabled boys. Results suggest significant improvement following this training and that longer training time results in greater improvement.

An innovative and inexpensive procedure that may improve student's school performance and behavior is the focus of this pilot study. Previous studies have shown that auditory or visual stimulation has a powerful effect on the frequency activity of the brain. It has been shown that rhythmic sound waves entering the ears results in a phenomenon called "entrainment" whereby brain waves match and resonate at the same frequency as the stimulating audio frequency. In auditory entrainment, the hemispheres of the brain produce symmetrical brain waves highly similar in frequency, amplitude, phase, and coherence. Entrainment to visual rather than to auditory stimulation occurs when rhythmic lights flashed into a subject's eyes cause the brain wave pattern of the entire cortex to fall into the same frequency as the flickering light.

Electroencephalograph (EEG) studies have demonstrated that significant targeted behavioral changes occur as a result of the challenge and stimulation of intensive EEG training. Other studies suggest that individuals with epilepsy have reduced seizure activity by learning to regulate their brain wave activity (Sterman & Friar, 1972, Lubar, 198 1). Cunningham (198 1) reported increased math and reading scores as well as increased self-control in children following EEG biofeedback training; and Lubar (1985) demonstrated significantly improved academic performance in learning disabled students. Both Carter and Russell (1981, 1992) and Tansey (1984, 1990) investigated the effects of EEG biofeedback training with learning disabled boys and found that the children made significant gains on their IQ scores.

In a related series of investigations, Diamond (1988) has shown that environmental stimulation in rats increased dendritic growth which resulted in improved performance on tasks such as maze learning and memory. Although there is considerable evidence that visual and auditory entrainment is a replicable physical phenomenon, there have been no quantitative studies on the possible effects on behavior and brain functioning of sustained visual and auditory entrainment. The present study focused on the effects of synchronized visual and auditory stimulation on the academic and behavioral functioning of learning disabled boys. Following auditory and visual stimulation entrainment training, it was hypothesized that elementary-aged learning disabled boys would show improvement in these areas: Verbal and nonverbal IQ; reading, spelling, and arithmetic; and self-control behavior as rated by teachers and parents.

Method

Students

An original sample of 20 students (group 1) consisted of learning disabled boys between eight and twelve years of age from a private school. As this original sample of students dwindled to 14 by attrition, 12 other students with learning disabilities (males in the same age group) were located in a public school (group 2). Data for the two groups of students were analyzed separately. All students were right handed, had no history of a seizure condition, and presented no sensory deficits.

Instrumentation

The Audiovisual Stimulator (AVS) consisted of small, red, light emitting diodes (LEDs) which were affixed to the top of each lens of smoke colored glasses. A stereo headset attached to each side of the glasses provided the auditory input. A microchip was programmed to activate and control the tone generator and LEDs. In one ear, a 220 Hertz (Hz) tone was presented, while in the other ear, a 230 or 238 Hz tone was presented. This resulted in entraining brain waves to the different tones at either 10 Hz or 18 Hz. These frequencies were selected for use because Carter and Russell (1981) found that subjects who learned to alter brain wave activity between low (10 Hz) and higher frequencies (18 Hz) improved significantly in IQ and in their scores on tests of achievement. The AVS was preset to operate for a total of 25 minutes in a cycle repeated five times consisting of two minutes at a 10 Hz frequency, one minute at a 0 Hz frequency, and two minutes at an 18 Hz frequency.

The dependent measures were selected because of their wide use and availability. Also, the same tests have been used by the investigators in previous projects. Both validity and reliability were assumed to be adequate for this study. The measures included the Peabody Picture Vocabulary Test (a measure of verbal IQ), the Raven Coloured Progressive Matrices (a measure of non-verbal IQ), the Auditory Sequential Memory subtest of the Illinois Test of Psycholinguistic Abilities, the Wechsler Intelligence Scale for Children-Revised, and the Wide Range Achievement Test-Revised.

Procedure

Each student was administered a group of pretests. In order to minimize experimental bias, all testing was conducted by graduate psychology students "blind" to the experimental design. In addition, teachers and parents were asked to complete the Burk's Behavior Rating Scale on each youth. There was some attrition on this variable, as four parents did not return the pretest or the posttest behavior rating scales; however, all teachers complied. All testing was completed during the week prior to the AVS treatment and during the week immediately following cessation of the AVS treatment.

Systematic AVS treatment was administered in a designated room at school, to groups of four or five experimental students, five days a week for eight weeks (40 treatments). In addition, at home these students used a special relaxation cassette tape developed during a previous study

(40 treatments). The tape had the same pattern of sound stimulation used in AVS. The students in this group received a total of 80 training sessions or 4.5 times as much as the students from the public school. The 12 learning disabled boys from the public school received the AVS treatment three days per week for six weeks (18 treatments). The public school boys did not receive the relaxation home practice training sessions.

In both groups, students got into a comfortable position and put on the headphones and glasses. The trainer simply turned on the AVS and monitored the students during the sessions. The students were encouraged to play table games, such as checkers, or to play with hand-held electronic games during the AVS exercise. Only a minimal intervention by the trainer was required.

Results and Discussion

An analysis of variance test of significance was used for all measures (Bruning & Kintz, 1987). Table I summarizes the results of cognitive changes for the first group of students (N-14). Significant differences were found on four of six variables. The Peabody Picture Vocabulary Test (PPVT), did not show a significant change in IQ, whereas the Raven Coloured Progressive Matrices did show a significant increase in IQ ($p < .05$). Memory, reading, and spelling showed significant improvement ($p < .01$). Although the change in arithmetic score showed improvement, the results were not significant.

Table I

Summary of Cognitive Changes for Group I (N- 14)

	Pretest		Posttest			
	M	S.D.	M	S.D.	F	n
PPVT IQ-	116.00	15.15	120.79	12.79	3.80	NS
Raven IQ'	106.64	17.83	114.57	12.456	.905	<.05
Memory'	26.29	8.28	30.29	9.80	11.030	<.01
Reading"	100.93	10.54	107.21	9.00	39.317	<.01
Spelling	101.71	10.94	108.50	11.07	26.832	<.01
Arithmetic	104.93	10.27	106.29	13.71	.305	NS

[1]Peabody Picture Vocabulary Test (PPVT IQ).
[2]Raven Coloured Progressive Matrices (RAVEN IQ).
[3]llinois Test of Psycholinguistic Abilities, Auditory Sequential Memory subtest. [4]WideRange Achievement Test, Revised (WRAT-R) for Reading, Spelling, and Arithmetic.

Table 2 summarizes results of cognitive changes for the second group of students (N-12). The verbal IQ showed a significant increase, but the performance IQ did not. Of the academic measures, only spelling showed a significant increase ($p < .05$). Although the change in reading and arithmetic scores showed improvement, the results were not significant. It is important to note, however,

that second group of students received only 18 training sessions as compared with the 80 AVS training sessions and relaxation tape sessions received by the first group of students.

Table 2
Summary of WISC-R and WRAT-R for Group 2 (N=12)

	Pretest		Posttest			
	M	S.D.	M	S.D.	F	n
WISC-R						
Verbal IQ	92.50	11.67	98.00	11.66	6.776	<.05
Performance IQ	100.86	10.43	102.63	7.71	.827	NS
Full Scale IQ	96.50	7.63	99.25	9.04	2.123	NS
WRAT-R2						
Reading	85.43	7.26	91.14	9.61	6.308	NS
Spelling	84.86	9.89	92.00	9.62	11.347	<.05
Arithmetic	80.86	7.55	89.14	10.94	3.848	NS

[1]Weschsler Intelligence Scale for Children, Revised (WISC-R).
[2]Wide Range Achievement Test, Revised (WRAT-R).

Table 3 summarizes the changes in the behavior ratings of each child in the first group of students as rated by teacher and parents. There was agreement of improvement on three scales. Both parent and teacher concurred that the students became less dependent and improved their academic attention and interests. Teachers also indicated that the students became less anxious, more self-contained, improved their coordination and intellectual pursuits, and seemed to suffer less and control their anger better. Parents said their children were more compliant (less resistant), felt less persecution, and controlled impulsiveness better. In general, lower scores indicate improvement on this behavior rating scale. Of the 19 scales, 17 showed the desirable decreased scores as rated by parents. According to the teachers, every scale was lower at posttest than at pretest. There was considerable agreement between teachers and parents that the children's behavior improved following treatment with AVS entrainment.

Although the results of this pilot investigation must be viewed cautiously, the data suggests improvement similar to that found in EEG biofeedback studies with children with learning disabilities and attention deficit disorder problems. Carter and Russell (1992) found increases in the lower of the 1Qs (verbal or performance) following hemisphere-specific EEG training. In a like manner, Tansey (1984,1990) has reported significant IQ gains with these kinds of students after intensive EEG training and Cunningham (1981) obtained similar kinds of improvement in reading and increased self-control after EEG biofeedback training.

The AVS training results presented in this pilot study suggest that this may be a simpler and lower-cost alternative to EEG training, apparently producing many of the same effects. This procedure appears to be less threatening and demanding on the students being trained than the

SCALES	Ratings (N=14) Pretest M	Pretest S.D.	Posttest M	Posttest S.D.	F	p	Ratings (N=11) Pretest M	Pretest S.D.	Posttest M	Posttest S.D.	F	p
1 Excessive Self-Blame	8.43	3.02	8.21	2.91	.042	*	9.73	3.44	8.54	1.88	1.677	*
2 Excessive Anxiety	8.50	3.01	6.78	1.66	6.959	<.05	7.72	2.09	6.46	1.56	3.698	*
3 Excessive Withdrawal	8.71	2.50	7.43	2.03	3.915	*	7.09	1.08	7.17	2.92	.009	*
4 Excessive Dependency	9.50	3.78	7.36	1.54	5.658	<.05	8.91	2.02	7.28	1.14	9.643	<.05
5 Poor Ego Strength	11.64	9.43	3.85	2.45	9.662	<.01	11.18	2.86	9.46	2.90	4.813	*
6 Poor Physical Strength	5.93	6.14	.88	1.77	.173	*	5.54	.66	5.36	.64	1.000	*
7 Poor Coordination	7.57	6.28	3.66	2.25	4.944	<.05	6.91	2.19	6.73	2.05	.168	*
8 Poor Intellectuality	12.57	10.21	4.45	2.39	9.092	<.05	11.54	3.23	9.64	2.57	3.973	*
9 Poor Academics	9.29	7.79	4.16	2.73	7.951	<.05	9.82	4.61	7.00	2.66	5.761	<.05
10 Poor Attention	11.43	8.57	4.59	2.97	6.641	<.05	11.18	5.13	8.46	2.61	6.285	<.05
11 Poor Impulse Control	10.50	7.78	5.91	3.29	4.610	*	10.64	8.73	5.69	4.59	17.500	<.01
12 Poor Reality Contact	11.07	10.07	2.68	1.87	1.468	*	9.56	3.19	8.91	2.56	3.595	*
13 Poor Sense of Identity	7.00	6.93	1.90	2.74	.016	*	6.82	1.80	6.36	1.67	.740	*
14 Excessive Suffering	10.71	9.00	3.88	3.93	8.00	<.05	10.27	2.45	9.09	2.31	4.568	*
15 Poor Anger Control	9.29	4.86	2.07	2.01	4.788	<.05	10.36	3.31	8.64	3.65	5.453	*
16 Excessive Sense of Persecution	8.54	7.46	3.69	2.82	1.403	*	8.54	3.20	7.27	2.86	6.806	<.05
17 Excessive Aggressiveness	10.50	8.14	5.07	2.77	3.994	*	9.18	2.76	8.09	2.64	4.865	*
18 Excessive Resistance	8.57	7.57	3.74	2.87	1.717	*	11.27	3.84	9.36	2.81	7.045	<.05
19 Poor Social Conformity	11.86	10.00	4.39	2.73	4.429	*	12.55	4.38	11.09	2.68	5.447	*

*Not significant.

Table 3
Summary of Results for Burk's Behavior Rating Scale

EEG training model where the subject is required to learn how to recognize and produce the desired brainwaves in amplitude and/or frequency. Instead, the AVS entrains the brain wave activity, enabling it to produce the desired brain wave frequencies. This appears to be accomplished quite rapidly. This may significantly shorten the training time required for the child to learn to recognize and bring about an internal state in the brain such as concentration or attention that is characterized by brain wave activity of particular frequencies and amplitudes. More rapid learning may shorten the amount of student and trainer time needed to bring about significant changes in functioning.

The number of AVS treatment sessions used ranged from 40 AVS sessions and 40 special relaxation tape sessions for a total of 80 for the first group down to a total of 18 for the second group. These preliminary results suggest that the degree of significant improvement in functioning is related to the number of treatment sessions. It appears highly possible that increasing the number of treatment sessions would result in more improvement in functioning. Some very important questions to be answered are: Is there a ceiling effect or limit on the amount of increase in brain functioning that is possible? Are there optimal stimulating conditions that will result in the greatest changes in the least amount of time? Will both boys and girls show equal improvement? Finally, to what extent is age a factor? Currently, there are no answers to these and other important questions; further research is indicated.

This preliminary data suggests that use of AVS entrainment to challenge and stimulate the brain appears to result in improved functioning on intelligence tests, achievement tests, and behavior as rated by parents and teachers. The simplicity of use and the low cost of the equipment may make effective treatment for learning disabilities and attention deficit disorders available to many of the children who need it but who would otherwise never receive it.

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