BIO-ACOUSTICAL UTILIZATION DEVICE (BAUD)-ASSISTED NEUROTHERAPY FOR ATTENTION DEFICIT HYPERACTIVITY DISORDER (ADHD)**

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ABSTRACT

A small acoustical instrument was used in self-regulation therapy to assist patients in altering brain wave function and altering emotional and functional capabilities relating to symptoms of ADHD. Twenty six participants, age 14-65 years old, were trained to alter brain wave function using the sonic stimulation device. They were administered pre- and post-therapy tests of emotional self-assessment, auditory memory, spatial reproduction, and arithmetic proficiency. The therapy process consisted of a single session whereby participants were taught to and were successful to increase their LoBeta brain signals. Participants were also able to remember significantly more details from a 26-bit story. Participants improved in spatial reproduction, and arithmetic abilities. These data demonstrated the benefits of sonic stimulation-assisted therapy in four areas related to symptoms of ADHD. The small sample size of the wait group and lack of sophisticated methodology does suggest a continued examination of the sonic stimulation model for ADHD.

Introduction

The use of neurotherapy in the form of EEG output to help a person learn how to affect his or her brain frequencies has been documented for many years. Lubar and others ("Chabot, et al., 1996", "Cunningham & Murphy, 1981", "Linden, et al. 1996", "Lubar, 1983, 1997, 2003", "Lubar, et al., 1995") have researched this method and concluded that it has substantial impact for for the management of Attention Deficit/ Hyperactive Disorder (ADHD). The theory underlying ADHD symptomotology is that there is a heightened intensity and unbalanced frequency in the prefrontal cortex particularly in the theta wave range (4-7 Hz.) (Lubar,1997). This alteration in the theta wave range is associated with high imagery and dream-like consciousness, which matches subjective accounts given by individuals with ADHD Cunningham & Murphy, 1981). They have a very difficult time breaking off this dream-like state related to high dominance of theta range when they are required to become more problem-solving, which is related to the Beta (greater than 16 Hz) and LoBeta (12 – 15 Hz) frequencies. There is also a pattern of high delta (0.5 to 4 Hz), which is indicative of sleep states.

The primary limitation for neurotherapy and other self-regulation approaches is the length of time it takes to learn these subtle controls, usually 20-50 sessions (Linden et al. 1996). There are several logistical reasons for the long delay. The client cannot take the equipment home for daily training or for use in specific circumstances, such as school or work. There are also limitations as to the number of training sessions allowed before the costs become prohibitive. Moreover, frustration levels can become overwhelming, especially for those suffering from ADHD and having limited concentration and memory.

For these and other logistical issues, the Bioaccoustical Utilization Device (BAUD) was invented by G. Frank Lawlis, Ph.D. and T. Frank Lawlis, B.S. and consequently exempted by the

FDA as a relaxation device. The BAUD technology is based on the principle of brain entrainment using acoustical tones. The research on acoustical influence of brain waves was documented with the pioneering research of Melinda Maxfield (1994), Frederick, et al. (1999), Leeds (2001) and Pratt et al. (1995). The most common entrainments for commercial uses seem to be based in the lower frequencies of alpha to enhance theta output from the brain, and produce an emotional sense of relaxation and pain reduction (Maxfield, 1994).

The BAUD engineering technology utilizes a different sound wave frequency in a square wave pattern for each ear in frequencies are from 39 to 362 Hz, and the difference between the two have a range from 0 to 20 hz.. The subject has control of volumes and level of frequency of each ear by turning the knob indicating the function. The interference between the two frequencies will form a third tone which we observed to be the most sensitive for the person's reactions. This observation might explain how various sources of the brain are known to overlap and create an integral energy pattern for multiple-level coordination of several functions.

The advantage of using BAUD in neurotherapy is due to increased control and more convenient logistics for the client. In supervised sessions, the client is instructed to increase or decrease the acoustical feedback in accordance with the desired frequency, offering feedback to his or her manipulation of the machine. This quite different than using an auditory feedback signal from a EEG device in that the tone is only a signal of change. The EEG device is used as collaboration that the BAUD signal is producing the brain wave desired. For example, if the desired output is increased LoBeta or SMR (as for ADD), the client can quickly learn that listening to the acoustical stimulation can significantly influence that frequency. In our experience, the client can usually learn to manage his or her brain frequencies to a noticeable degree within five minutes. The resultant emotional and functional experience can increase

motivation and training facility. Moreover, once that experience is obtained, the client can take the BAUD to various arenas to experiment with specific challenges. The BAUD is approximately the size of a cell phone and light in weight, enhancing its use in practical setting.

The purpose of this study was to investigate the efficacy of the BAUD in management of ADHD symptoms, such as concentration, memory and spatial orientation. Specifically, it was hypothesized that BAUD-assisted neurotherapy would:

1. Enhance the ability to increase LoBeta and Beta frequencies and maintain that control in specific personal arenas of emotional life.
2. Increase recall of details of a 26bit story.
3. Increase performance on math problems.
4. Increase the ability to complete a spatial reproduction task.
5. Improve emotional states.

Procedure

Participants

Twenty-six participants agreed to take part in the study. The participants (14-65 years old, 15 males, 11 females, 100% Caucasian), were drawn from a private practice office in Dallas, Texas. All were initially diagnosed with ADHD by a licensed psychiatrist and were in counseling or psychotherapy. The primary diagnosis was ADHD, although other comorbipities could be assumed. Many were long-term sufferers and all were on one or more medications (Ritalin 50%, Concerta 30%, Strattera 10%, Adderall 10%, Zoloft 40%, Celexia 40%).

Procedure

The study consisted of two sessions for BAUD-assisted neurotherapy and consistent with all subjects. The environment was quiet and similar to a typical clinical practitioner's

surrounding.

Before therapy, the participants were given a pre-test consisting of four elements. First, they completetd an locally devised emotional self-assessment test using subjective units of emotional well-being (See Figure 1). Next, in a test of auditory memory, participants were read the following 26-bit story and asked to remember as many details as possible. A bit is one information element and the stories were purposively designed to have 26 elements of relevant information. The 26 information bits were compared to the ones the subject identified from memory.

Jerry was a very curious boy and liked to go to the movies. He usually went to them on Saturdays, but today he skipped school and went to see a movie called "Claws" on Friday. The movie was about this kid that turned into an ape and scared everyone, especially his girlfriend, Jean. He did not like the movie much, and he got into a lot of trouble because he missed school. He was grounded at home, and he had to go to detention room for a week after school. He thought a lot about his actions and decided that movies are not that good to cause this much trouble. His girlfriend was also mad at him and dumped him because he had such bad judgment. His favorite subjects in school were mathematics and biology, and he hated history and English. He never skipped school again, but he got another girlfriend named Lorri.

Next, participants were asked to draw and replicate the figure shown in Figure 2. The drawings were scored in five dimensions: a) Disconnections (the number of times the lines were not connected or misplaced, b) Distortions (the number of distortions), c) Omissions (the number of omissions in the drawings, d) Number of errors, and e) Scale (graded on a scale from 0 to 2 where 0 = in correct scale, 1 = some minor change, and 2 = a major distortion). Finally, participants were asked to complete as many of the following arithmetic problems as possible in

4 minutes:

242	25	361	1204	23	152
199	51	983	5545	85	339
564	98	765	7823	69	342
+457	+ 87	+ 129	+ 4578	+ 15	+ 239
245	414	2504	231	13	45
X34	X25	X345	X98	X9	X7
87564	2101	7612	1412	23456	5342
- 73588	-1998	- 6574	-1209	- 8765	- 976

Neurotherapy procedure

Each person was connected to a Brainmaster EEG monitor, using one channel. Two brain locations were used – the fz and cz. The rationale for using these positions were based on the literature and the expectations of optimal results from an experiential basis. The subject participated in a practice session after reliability and validity readings were obtained. After a ten-minute practice session, subjects were introduced to the BAUD and were asked to attempt to control the LoBeta frequency. The criteria for whether or not the subject had significant control was based on the "game" of crickets in which the subject would gain scores if he or she kept a cylinder full of green color, indicating increased LoBeta signals. Consistently "winning the game" with 100 points was an indication of success that the client had attained significant control for this dimension. All 26 participants reached the criteria within 20 minutes and expressed satisfaction for this achievement.

Post-testing

The participants were asked to repeat the emotional states rating form and drawings (Figures 2). They were administered a parallel form of the story (shown below) and asked to recall as many details as possible.

Judy was a very serious young girl and loved to read books about mysteries. She usually went to the library on Saturdays and read books from noon to about 3:00 o'clock, and returned home to do her normal errands. But she got involved with a story about a girl who worked with the police to solve crimes and didn't leave the library until it closed at 5:00. She got in trouble at home and had to clean the house and garage the next weekend, which caused her to miss her usual reading time. She had a boyfriend but he was not interested in reading, so he did not understand why she was upset. She was upset but realized that she needed to pay more attention to her schedule and never was late again.

They were also administered a parallel form of the arithmetic test (shown below).

241	24	362	1201	22	151
199	51	983	5545	85	339
564	98	765	7823	69	342
+457	+ 87	+ 129	+ 4578	+ 15	+ 239
246	413	2502	231	11	43
X34	X25	X345	X98	X9	X7
87569	2109	7615	1419	23465	5347
- 73588	-1998	- 6574	-1209	- 8765	- 976

It should be noted that both the math and stories were administered to a different group of 20 random employees at a medical center in a counter-balanced design of sequencing for reliability determination. The group descriptions were as follows:

Sex types: 12 females 8 males

Age range: 21-63 (mean 40.35)

Education: Mode 12 (8) Range 12-18

The reliability for the math exercise was 0.88. The mean for scores for the respective tests were 8.25 and 9.10 with the individual results being extremely close to exact scores. The reliability for

the story memory exercise was 0.75 with means of 6.6 and 6.9, relating the high level of agreements.

Control group

Six subjects were used as a waiting control group in which the pre-test and post-test were administered with ten minutes separation (no therapy). These scores were analyzed for practice affects.

Statistical analyses. Means and standard deviations were calculated for both Cz and Fz locations for all brain wave patterns and are presented for illustration only. Comparison between pre- and post-test values was performed using a Chi-square analysis.

Results

Brain frequency changes.

Although the individual wave patterns did not meet parametric assumptions for computations, the means and standard deviations are presented in Table 1. Data for the Cz and Fz locations are presented for their respective Delta, Theta, Alpha, LoBeta and Beta amplitudes. It should be noted that the baseline patterns are similar to the typical ADHD patterns in the literature (Linden et al. 1996). Chi-square analysis of these data demonstrated the expected ascension trends of LoBeta and Beta after BAUD therapy (Table 2).

Next, various combinations of waveform patterns were analyzed because they represented patterns associated with success after treatment for ADHD. It was assumed that if an individual were attaining control of concentration abilities, the delta and beta frequencies would come closer together, making their differences less. Therefore the pre- and post-treatment differences were compared. Also, the differences between theta and LoBeta were calculated and the pre- and post-treatment differences compared (Table 3). The results demonstrate that both

values were significantly different for the Fz placement.

Emotional states

The pre- and post-treatment values for each of the ten emotional ratings were compared (Table 4). There was a ceiling effect for the positive emotions, making statistical significance clinically irrelevant. Significant reductions occurred for distraction and stress (Table 4), the two ingredients in ADHD, as well as for anger. There were no clinical changes in the pre-post emotional states in the Wait-Control group based on the experience of attention or expectations (Table 5).

Auditory memory

Each of the participants was read a short story in order to determine whether BAUD-assisted neurotherapy altered auditory memory. The number of bits of information remembered was recorded for pre- and post-therapy. The subjects receiving the BAUD therapy remembered significantly more bits of information post-therapy compared with pre-therapy (13.2 ± 4.0 vs 8.1 ± 2.8; $t = 6.80$, $p = 0.000$). In contrast, the number of bits of information remembered by the wait control group did not differ pre- and post-wait (XX ± XX vs 8.0 ± 4.3; $t=0.73$, $p=0.55$).

Spatial organization

Spatial organization was assessed through the ability to reproduce two drawings. Despite performances that were not that abnormal in the pre-test, the therapy group demonstrated significant improvements in four of the five dimensions, and a trend for significant improvement in the fifth dimension (Table 6). The wait-control group also demonstrated improvement in the Distortion dimension.

Number functions

Data on the number of problems attempted and the number of problems correct are

presented in Table 7. The therapy group attempted significantly more problems and got more problems correct during the post-therapy trial compared with the pre-therapy trial. No such improvement was seen in the wait-control group.

Discussion

The limitations to interpreting results from these findings should be made cautiously. The entire study for the subjects was short, only two sessions, and a number of alternative explanations are very viable than the ones discussed. The statistical application lacked the sophisticated of parametric tests. The Placebo Effect could certainly be considered with the special attention and free use of a device. The emotional charge produced by having control for a major problem would be very powerful for motivation in the secondary assessments. Mainly, the effects would have been predicted from neurotherapy as described in various protocols (Linden, et al. 1996.)

These data could have demonstrated the benefits of BAUD-assisted therapy in four areas: emotional state, increased recall of a 26-bit story, increased performance on an arithmetic test, and improved spatial reproduction. It cold be assumed that all these areas have a single function, possibly need for control over inattention or perhaps boredom. In addition, BAUD therapy may have demonstrated the potential to overcome time limitations found in other self-regulation approaches. In the current study, patients were able to exert significant control of brain-wave function after one training session of approximately 20 minutes.

The initial session with the device yielded promising results. There was quick learning and control of brain wave function with the assistance of the device. The more remarkable response was in the other brain frequencies as they moved toward a state of more constructive cognitive capacity, as related to the SMR ranges.

The results on emotional states were interesting in that the variables that were most improved were the areas of concern in ADHD, i.e., distractions and stress. Perhaps the other emotional ratings could be used as control variables in future studies when small samples have to be used. and variables can be used as target control as compared to those that are not predicted to change.

The results of the functional tests were impressive. Improvements in auditory memory, spatial organization, and arithmetic performances were significant, even after taking into account of the error rate for testing these variables by modifying acceptable the levels for accepting the experimental hypotheses.. The ability to perform arithmetic tasks is especially difficult for individuals with ADHD primarily because of the demand for tedious detail. Many simply will not attempt such a task because of the discomfort facing them and the strong demand for accuracy. In this study, many individuals did not attempt all the arithmetic problems, and one individual attempted only one problem pre-therapy and two problems post-therapy.

Follow up

Although this study was based on a brief administration, each individual was asked for a life goal that could be assessed within three weeks, such as making better grades or being successful in a task. However, no subject took the challenge and was dismissed as possible interference to the goals of the psychotherapist. Each participant took the BAUD device home and practiced on a daily basis as documented. 33 percent terminated the use of medication for their ADHD symptoms, and the remaining reduced medication significantly, as reported to their physician.

References

Chabot, R. J., Merkin, H., Wood, I. M., Davenport, T. L., & Serfontein, G. (1996). Sensitivity and specificity of QEEG in children with attention deficit or specific developmental learning disorders. *Clinical Electroencephalography*, 27(1), 26-34

Cunningham, M., & Murphy, P. (1981). The effects of bilateral EEG biofeedback on verbal, visuospatial and creative skills in LD male adolescents. *Journal of Learning Disabilities*, 14(4), 204-208.

Frederick, J. A., Lubar, J. F., Rasey, H. W., Brim, S. A., & Blackburn, J. (1999). Effects of 18.5 Hz. auditory and visual stimulation on EEG amplitude at the vertex. *Journal of Neurotherapy*, 3(3), 23-27.

Leeds, J. (2001) *Psychoacoustics: The Power of Sound*, Healing Arts: Rochester, Vt.

Linden, M., Habib, T., & Radojevic, V. (1996). A controlled study of the effects of EEG biofeedback on the cognition and behavior of children with attention deficit disorders and learning disabilities. *Biofeedback and Self Regulation*, 21(1), 35-49.

Lubar, J. F. (1983). *Physiological Basis of Behavior*, Collegiate Publishing Company, San Diego, California.

Lubar, J. F., Swartwood, M. O., Swartwood, J. N., & O'Donnell, P. (1995). Evaluation of the effectiveness of EEG neurofeedback training for ADHD in a clinical setting as measured by changes in T.O.V.A. scores, behavioral ratings, and WISC-R performance. *Biofeedback and Self-Regulation*, 20, 83-99.

Lubar, J. F. (1997). Neurobiological Foundation for Neurofeedback Treatment of Attention Deficit Hyperactivity Disorder (ADHD/HD). *Biofeedback*, 25, 4-5, 18-19.

Lubar, J. F. (Ed.) (2003). *Quantitative Electroencephalographic Analysis (QEEG) Databases for Neurotherapy: Description, Validation, and Application*. New York: The Haworth Medical Press

Pratt, R. R., Abel, H., Skidmore, J. (1995). The effects of neurofeedback training with background music on EEG patterns of ADD and ADHD children. *International Journal of Arts Medicine*, 4(1), 24-31.

Maxfielf, M., (1994) The Journey of the Drum, *ReVision*, Vol. 16, pp. 157-63

Table 1. Brain wave amplitudes.

Location/Wave	Baseline		post-BAUD	
	Mean	S.D.	Mean	S.D.
Cz Delta	10.67	3.32	11.21	3.44
Cz Theta	15.68	5.03	16.11	4.99
Cz Alpha	12.09	4.98	11.58	4.57
Cz LoBeta (SMR)	5.78	1.71	11.64	2.16
Cz Beta	7.48	2.48	6.67	2.84
Fz Delta	10.93	3.93	10.93	3.93
Fz Theta	16.63	5.20	15.42	3.79
Fz Alpha	10.27	4.16	10.79	2.89
Fz LoBeta (SMR)	4.92	1.68	5.30	1.73
Fz Beta	6.57	2.50	6.92	2.23

Table 2. Non-parametric analysis of pre- and post-treatment brain frequency trends

Location	Delta	Theta	Alpha	LoBeta	Beta
Cz Baseline					
Ascensions/Dissensions	13/13	14/12	12/14	10/16	11/15
Cz BAUD*					
Ascensions/Dissensions	3/23	6/20	13/13	26/0	22/4
Fz Baseline					
Ascensions/Dissensions	14/12	15/11	15/11	12/14	11/15
Fz BAUD†					
Ascensions/Dissensions	9/17	9/17	12/14	26/0	23/3

*$Chi^2 = 1048$, $p \leq .0000$, baseline vs BAUD; †$Chi^2 = 721$, $p \leq .0000$, baseline vs BAUD.

Table 3. Wave form comparisons.

	Mean	S.D.	T-Value	p
Cz				
Delta - Beta	-1.35	7.80	-0.88	0.19
Theta - LoBeta	-0.57	3.27	-0.47	0.32
Fz				
Delta - Beta	1.47	4.48	1.67	0.05*
Theta - LoBeta	-1.60	4.23	-1.92	0.03*

*$p \leq 0.05$, pre- vs post-treatment. Values represent the pre-post change in difference values for each wave pair.

Table 4. Comparison of pre- and post-treatment emotional ratings.

	Pre-treatment		Post-treatment			
	Mean	S.D.	Mean	S.D.	t	p
Depressed	3.23	2.26	2.80	2.11	1.21	0.12
Weakness	2.96	2.00	2.69	1.69	0.65	0.26
Distracted	5.23	2.74	2.65	1.38	4.40	0.00*
Anger	2.92	2.39	1.80	1.05	2.49	0.01*
Stress	4.61	2.48	2.69	1.62	4.08	0.00*
Happy	5.38	2.33	5.55	2.49	0.26	0.40
Excited	4.95	2.73	5.73	2.50	-1.57	0.13
Strong	5.19	2.32	5.46	2.37	-0.61	0.55
Smart	5.27	2.27	5.88	2.42	-1.30	0.20
Energy	4.69	2.36	5.65	2.31	-1.64	0.11

*$p \leq 0.05$

Table 5. Comparison of pre- and post-treatment emotional ratings for the Wait-Control group (n=7).

	Pre		Post	
	Mean	S.D.	Mean	S.D.
Depressed	3.23	2.26	2.00	2.11
Weakness	2.96	2.00	4.00	2.00
Distracted	5.23	2.74	5.00	3.02
Anger	2.92	2.39	2.00	2.70
Stress	4.61	2.48	3.85	2.26
Happy	5.38	2.33	4.57	2.37
Excited	4.95	2.73	4.72	3.14
Strong	5.19	2.32	4.28	2.43
Smart	5.27	2.27	4.57	2.22
Energy	4.69	2.36	3.42	1.81

Table 6. Spatial organization results.

	Pre		Post			
	Mean	S.D.	Mean	S.D.	t	p
Disconnections						
Wait-control			2.57	1.81	0.001	0.999
Therapy	3.11	1.75	1.88	1.27	2.96	0.003*
Distortions						
Wait-control			1.71	1.25	3.16	0.025*
Therapy	2.30	1.37	1.00	0.75	5.44	0.000*
Omissions						
Wait-control			0	0	1.58	0.175
Therapy	0.35	0.68	0.11	0.32	1.54	0.065
Number of errors						
Wait-control			3.14	2.19	1.00	0.363
Therapy	3.89	2.03	1.78	0.99	6.34	0.000*
Scale						
Wait-control			1.28	0.76	1.00	0.363
Therapy	1.42	0.58	0.42	0.58	8.06	0.000*

*$p \leq 0.05$, pre vs post.

Table 7. Arithmetic test results.

	Pre		Post			
	Mean	S.D.	Mean	S.D.	t	p
Number of problems attempted						
Wait-control			10.7	2.7	0.17	0.87
Therapy	10.7	3.8	15.0	3.9	7.4	0.00*
Number of problems correct						
Wait-control			6.8	3.5	0.38	0.72
Therapy	7.2	4.3	11.8	3.8	5.89	0.00*

*$p \leq 0.05$, pre vs post.

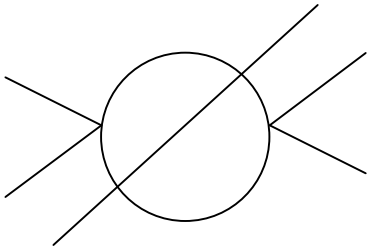
Figure 1 Brief Assessment of Moods

On the scales below, please rate how you are feeling now on a scale of 1 (no symptoms or signs) to 10 (very high signs and symptoms).

	No Sign			Some			Definite			Very Much
	1	2	3	4	5	6	7	8	9	10
1. I feel depressed today.	1	2	3	4	5	6	7	8	9	10
2. I feel weak today.	1	2	3	4	5	6	7	8	9	10
3. I feel distracted today.	1	2	3	4	5	6	7	8	9	10
4. I feel angry today.	1	2	3	4	5	6	7	8	9	10
5. I feel stressed today.	1	2	3	4	5	6	7	8	9	10
6. I feel happy today.	1	2	3	4	5	6	7	8	9	10
7. I feel positive and excited today.	1	2	3	4	5	6	7	8	9	10
8. I feel strong today.	1	2	3	4	5	6	7	8	9	10
9. I feel smart today.	1	2	3	4	5	6	7	8	9	10
10. I feel energetic today.	1	2	3	4	5	6	7	8	9	10

Figure Two Drawings

Drawing One:



Drawing Two: