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Cranial Electrotherapy Stimulation in the Treatment of Stress Related Cognitive Dysfunction With an Eighteen Month Follow-up

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An earlier clinical study in which cranial electrotherapy stimulation (CES) was used to treat attention deficit disorder (ADD), concluded that "CES is an effective non-drug alternative in a cognitive rehabilitation model for treating attention-to-task deficit (Wilson & Childs, 1988)." The authors had used a CES device that stimulated at 100pps, with a stimulation amplitude limited to 1 mAmp. Their study sample was small, limited to four subjects, and their research design did not enable them to determine whether or not the positive results found would hold up over time. We decided to replicate that study with a larger patient sample. In addition we wanted to clinically examine the relative effectiveness of three widely different CES stimulators that were then available on the market. And finally, we wanted to follow up our results over an 18 month period to see if any positive results would carry over to that period of time.

Method

Over an eight month period we admitted to the study 23 consecutive children and adults who entered our outpatient psychiatric facility presenting with the stress related symptoms of anxiety and/or depression, and in addition complained of 1) difficulty in focusing when attempting cognitive tasks, 2) difficulty in "connecting" when initially focused on a cognitive task, and 3) once connected, having difficulty remaining on task or tracking it. After complete description of the study to the subjects, written informed consent was obtained by the subjects or the parent or guardian, if the subject was a minor.

We are aware of the wide ranging diagnostic groups of ADD patients discussed in the literature (Shaywitz, Fletcher & Shaywitz, 1997; Waschbusch, Kipp & Pelham, 1998) and decided not to study ADD as such, but the specific cognitive dysfunction of persons with the ADD like symptoms noted above. The three cognitive functions noted above comprised our *a priori* definition of ADD like cognitive dysfunction for this study, since that was the definition used in the study we were replicating. All were medically examined and screened for these three areas of dysfunction by the staff psychiatrist prior to being added to the study.

All patients were tested on the IPAT Depression Scale, the STAI State and Trait Anxiety Scales, and either the full WISC-R (children) or WAIS-R I.Q. (adults) test, depending on their age. Testing took place prior to CES treatment, following CES treatment, and 18 months following treatment.

Three CES devices were used. The CES Labs device, which was similar to that used in the study being replicated, promised 100 biphasic, modified square wave pulses per second with stimulation intensity limited to 1.5 mAmp on a 20% duty cycle. The Alpha-Stim CS device promised 0.5 modified square wave biphasic pulses per second on a 100% duty cycle with amplitude limited to 0.6 mAmp. The Liss Stimulator promised 15,000 modified square wave biphasic pulses per second with embedded pulse rates of 500 and 15 pulses per second. It promised a 75% duty cycle with amplitude limited to 4.0 mAmp.

Subjects

There were nine males and 14 females in our study sample. Their average age was 30.96 (s.d.=15.68) with a range of nine to 56 years. They were all Caucasian with an average education level of 10.56 years. In addition to the ADD like symptoms given above, 61% were diagnosed as suffering from generalized anxiety disorder, 45% were diagnosed with depression, and 17% with dysthymia. The percentages add up to more than 100% because many patients presented with a combination of symptoms. All but four of the subjects were medication free throughout the study. Two were taking methylphenidate 5mg. bid, one was taking fluoxetine hydrochloride each morning, and one was on an undetermined dosage of alprazolam. They were asked not to alter their medication schedule during the study.

Procedure

Following pretesting on the psychological measures, subjects were randomly assigned to one of the three CES devices employed in the study and inserviced by a clinician regarding the device and its proper use. Minors were accompanied by their parent or guardian during the inservice session. The subjects were asked to stimulate themselves with their CES device for 45 minutes daily for three weeks and to return to the clinic three times per week during the three weeks so that clinical staff could monitor their progress and check their compliance. Following the three weeks, they were post tested on the original psychological measures.

Eighteen months following the end of the original treatment period the subjects were called back in for follow-up testing on the original psychological measures.

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Results Immediately Following the Study

All subjects reported using their assigned CES device daily as instructed. They all completed the testing except for one patient who inadvertently failed to complete the back page of the initial STAI test, and it was discarded from the study. All tests of significance used two tailed distributions.

In analyzing relative effectiveness of the different devices it was found that in the process of random assignment, seven subjects each were treated with the Alpha Stim-CS and CES labs device, while nine were treated with the Liss Stimulator. When obtained means and standard deviations were t-tested, no differences in results were found between the three devices, so all scores were combined for subsequent testing. Table 1 shows the testing results pre and post study for all subjects combined.

Table 1.
Changes on test scores by the combined group.

Test	Mean	s.d.	dr	t score	p value
IPAT Depression					
Pre test	19.38	8.44			
Post test	13.19	7.00	20	4.07	.001
State Anxiety					
Pre test	39.95	11.78			
Post test	29.76	6.99	20	4.87	.001
Trait Anxiety					
Pre test	43.90	11.31			
Post test	32.19	7.50	19	6.14	.001
Full Scale I.Q.					
Pre test	103.2	13.70			
Post test	117.6	14.28	22	15.18	.001
Verbal I.Q.					
Pre test	99.38	13.20			
Post test	107.50	14.13	22	5.94	.001
Performance IQ					
Pre test	107.4	15.05			
Post test	126.6	14.20	22	10.89	.001

N=21 for mood tests (two younger children were not tested, one additional subject did not complete the pre test trait anxiety scale). N=23 for I.Q. scores which were obtained on the WISC-R or WAIS-R. s.d.=standard deviation of scores from the mean, df=degrees of freedom, p value=the two tailed probability that the groups have not changed between pre and post testing.

It can be seen that all scores changed significantly, in a positive direction, indicating less depression, and less state and trait anxiety. The I.Q. measures improved also. The Verbal I.Q. increased an average of 8.12 points, the Performance I.Q. increased and average of 19.2 point and the Full Scale I.Q. increased and average of 14.4 points.

Earlier studies have shown that there is a gain in I.Q. scores from the practice effect when subjects are tested over small time frames. There are published norms showing this practice effect for subjects averaging 30 years of age, who obtained an initial average Full Scale I.Q. score of 102. When they were retested between two and seven weeks later, their average Full Scale score had increased to 105.3, presumably from the practice effect (4, 5). Our subjects were retested within that time frame and went from an average Full Scale score of 103.2 to a retested score of 117.6. As can be seen in Figure 1, this is more than four times the increase that would be expected from practice effect alone, and since the standard error of the means for the two published groups and our treatment group were 1.66, 1.70, and 2.98 respectively, this gain could be only attributed to treatment effect.

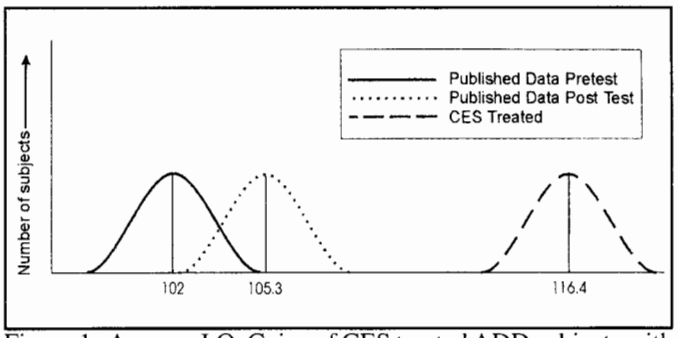

Figure 1. Average I.Q. Gains of CES treated ADD subjects with an average 6 week test-retest period equated and compared with published practice effect gains following 2 to 7 week test-retest period.

Table 2 shows pre and post test scores on the individual subsets of the WAIS-R or WIS-R where it can be inferred from several of the scores on the Verbal I.Q. subsets (the first six subtests) that the increased verbal scores are due less to increased length of memory (Digit Span), than to a better quality of cognitive responding (Vocabulary, Arithmetic, Comprehension, Similarities). The gains on the Performance I.Q. subset (the remaining five subtests), are likely due to both better comprehen-

sion and quicker response times on the first four, and perhaps improved memory skills and/or quicker response time on the last (Digit Symbol/Coding).

Table 2.
WISC-R and WAIS-R subtest scores for the combined group, N=23.

Test	Mean	s.d.	df	t score	p value
Verbal Subset					
Information					
Pre test	9.19	2.06			
Post test	9.76	2.68	22	1.83	n.s.
Digit Span					
Pre test	10.38	2.40			
Post test	10.33	2.50	22	0.13	n.s.
Vocabulary					
Pre test	10.29	3.33			
Post test	11.62	3.20	22	3.92	.001
Arithmetic					
Pre test	9.14	2.20			
Post test	10.48	2.60	22	2.53	.05
Comprehension					
Pre test	9.43	3.50			
Post test	11.90	2.93	22	4.07	.001
Similarities					
Pre test	9.10	2.60			
Post test	10.57	3.25	22	2.92	.01
Performance Subset:					
Picture Completion					
Pre test	10.67	2.06			
Post test	12.76	2.66	22	4.58	.001
Picture Arrangement					
Pre test	10.67	2.42			
Post test	12.52	2.79	22	3.38	.001
Block Design					
Pre test	10.62	2.38			
Post test	13.14	2.33	22	4.45	.001
Object Assembly					
Pre test	9.81	2.04			
Post test	14.00	1.76	22	10.63	.001
Digit Symbol (coding)					
Pre test	9.43	2.38			
Post test	11.19	3.08	22	4.32	.001

s.d.=standard deviation of scores from the mean, df=degrees of freedom, p value=the two-tailed probability that the groups have not changed.

Clinicians are sensitive to the relative numbers of patients who are likely to respond to a new treatment in their clinic, and we found that 18 (86%) of our subjects who were tested improved on depression, 18 (86%) improved on state anxiety and 18 (90%) improved on trait anxiety in the three weeks of treatment. In addition 100% had an increase in their full scale I.Q. score, 22 (96%) increased their verbal I.Q. score, and 100% improved their performance I.Q. score.

Clinically, all subjects reported that they were much better at locking onto cognitive tasks and tracking them than they were before the CES treatment. Several of the Adult subjects reported that they felt "mentally normal" for the first time in their lives. Empirically, improvements in cognitive dysfunction were inferred from the I.Q. test performances.

Results on 18 month follow up

A year and a half after the study was completed we contacted subjects from the study and requested that they return for follow up testing. Eighteen of the original 23 complied. The other five had moved out of state or had been transferred by their employers to different locations in the state and were not available at the dates and times when retesting took place.

A goodness of fit of the follow up group was analyzed, comparing the original scores of the subjects who returned for follow up, with the original scores of the entire earlier group. As shown in table 3, two-tailed t-tests of these means found no significant differences between the initial test scores of the original group and the initial test scores of those who returned for follow up testing. It was concluded that the follow up group was representative of the original sample.

Table 3.
Goodness of fit comparison of the test scores of the 23 subjects in the original group with those of the 18 subjects in the follow up sample.

Test	Originial Group Mean	Follow Up Group Mean	F[1]	p value
Depression (IPAT)				
Pre test	19.38	17.37	1.00	ns
Post test	13.19	10.78	1.45	ns
State Anxiety				
Pre test	39.95	37.19	1.35	ns
Post test	29.76	27.62	1.15	ns
Trait Anxiety				
Pre test	43.90	42.75	1.05	ns
Post test	32.19	29.31	1.32	ns
Full Scale I.Q.				
Pre test	103.2	102.6	1.18	ns
Post test	117.6	116.6	1.08	ns
Verbal I.Q.				
Pre test	99.4	98.7	1.12	ns
Post test	107.50	105.5	1.09	ns
Performance IQ				
Pre test	107.4	107.1	1.03	ns
Post test	126.6	127.2	1.08	ns

[1]The N's were 23 and 18 respectively with an overall df=22 in the numerator and 17 in the denominator on the F test of variances.

The anxiety and depression results are given on figure 2. The scores were converted to percentile scores on outpatient psy-

chiatric norms, so that while our patient sample scored above the 50th percentile on all three stress measures prior to the study, with the trait anxiety score toping off at the 80th percentile, all of the scores were well below the 50th percentile, both immediately following the study and at 18 months post study. None of the scoring changes between post study and follow up testing were found to be significant.

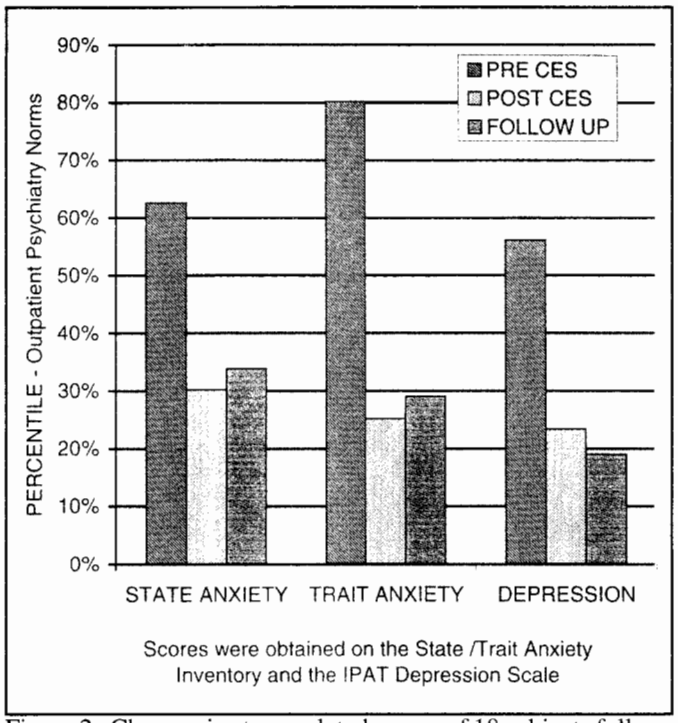

Figure 2. Changes in stress related scores of 18 subjects following 3 weeks of CES treatment and at 18 month follow up.

Figure 3 shows the I.Q scores from the beginning of the study through the follow up testing. It can be seen that the initial Full Scale I.Q. increase held up over the 18 month period while there was a slight but significant (t=2.37, df=17, p>0.05) rise in the Verbal I.Q. score and a similar slight, but significant (t=3.75, df=17, p>.01) decrease in the Performance I.Q.

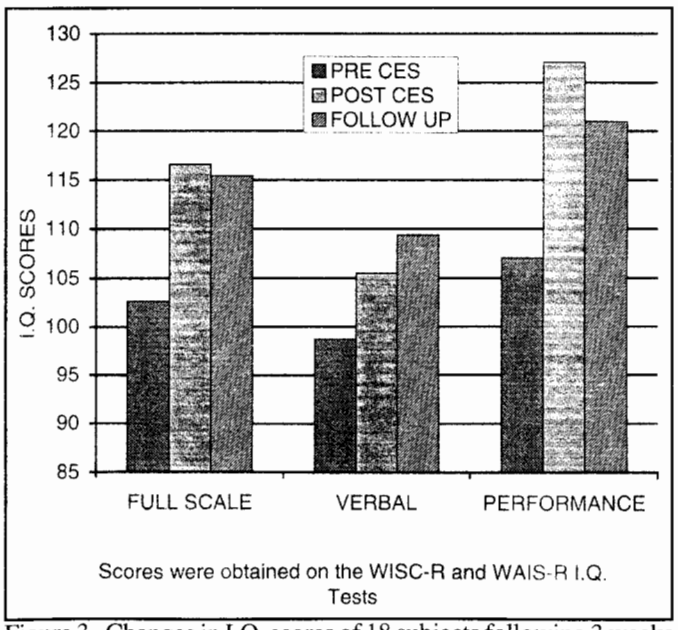

Figure 3. Changes in I.Q. scores of 18 subjects following 3 weeks of CES treatment and at 18 month follow up.

Discussion

While ADD like cognitive dysfunction is often thought of as a developmental disorder of childhood and early adolescence, many adults also manifest the same or similar cognitive difficulties (Biederman, 1998), with one study estimating that as many as one third of ADD children still suffer from ADD as adults (Krause, Krause & Trott, 1998). Other studies have found that ADD is often comorbid with anxiety or depression (Pliszka, 1998; Hornig, 1998). Spielberger (1975) cited experimental findings that indicated that while some anxiety can be helpful to learning, high levels are detrimental to the learning process, and Hamilton (1975) hypothesized that high levels of afferent signals reaching the brain's cognitive processing system in anxious persons block or limit the availability of the brain's information processing apparatus from accepting and/or reacting to incoming information from externally presented task relevant information.

Earlier studies have shown CES to be effective in reducing anxiety and depression in clinical populations of addicted persons (Smith & O'Neill, 1975; Schmitt, Capo & Boyd, 1986), and subsequent studies showed CES treatment to be associated with an increase in cognitive functioning in similar clinical populations (Schmitt et al, 1986; Smith & Day, 1977; Smith, 1982; Schmitt, Capo, Frazier & Boren, 1984). A study involving an entirely different clinical group found CES treatment associated with significant improvement in anxiety and depression accompanied by significant gains in cognitive functioning in closed head injured patients (Smith, Tiberi & Marshall, 1994).

While this study was not designed to elucidate the mechanism of action of CES, one of the ADD studies of comorbidity cited above implicated Dopamine in bipolar disorder and serotonin and norepinephrine in depression and anxiety disorders. Also implicated was the possibility of self-medication for dopamine dysfunction related to substance abuse (Hornig, 1998). Another study of the mechanism of action of methylphenidate in ADD patients concluded that its mechanism of action was to increase the synaptic concentration of dopamine (Volkow, Want, Fowler, Gatley, Logan, Ding, Hitzemann & Pappas, 1998). Earlier animal studies of the mechanism of action of CES concluded that CES brought back into homeostasis the acetylcholine-dopamine system when it had been experimentally thrown out of balance (Pozos, Strack, White & Richardson, 1971; Pozos, Richardson & Kaplan, 1971), and a double blind study of methadone withdrawal in heroin addicts found that CES aborted withdrawal symptoms in that group. The report concluded that CES apparently increased the available amount of β-endorphins to a level where they regained homeostatic balance with norepinephrine at the locus ceruleus (Gold, Pottash, Sternbach, Barbaban & Anmnitto, 1982).

As far as which CES device is superior in the treatment of patients with ADD like cognitive dysfunction, additional studies may shed further light on this, but from the present study design it appears that the brain may be relatively insensitive to pulse rates, pulse intensities, duty cycles, and so forth. These patients responded to three widely differing types of CES stimulation in altering their mental and emotional functioning, and the initial

results of all three held up over an 18 month follow up period. The present study gives strong support for the clinical use of CES in treating stress related cognitive dysfunction as defined herein, in both children and adults.

REFERENCES

Biederman, J. (1998). A 55-year-old man with attention-deficit/hyperactivity disorder (clinical conference). *JAMA, 280*, 1086-1092.

Gold, M.S., Pottash, A.L.C., Stembach, H., Barbaban, J. & Anmnitto, W. (1982). *Anti-withdrawal effects of alpha methyl dopa and cranial electrotherapy*. Paper presented at Society for Neuroscience 12th Annual Meeting.

Hamilton V. (1975). Socialization anxiety and information processing: A capacity model of anxiety-induced performance deficits. In I.G. Sarason, C.D. & Spielberger (Eds.) *Stress and Anxiety Vol 2*. New York: John Wiley & Sons.

Hornig M. (1998). Addressing comorbidity in adults with attention-deficit/hyperactivity disorder. *Journal of Clinical Psychiarty, 59*, 69-75.

Krause, K.H., Krause, J. & Trott, G.E. (1998). Hyperkinetic syndrome (attention-deficit/hyperactivity disorder) in adulthood. *Nervenarzt, 69*, 543-556.

Pliszka, S.R. (1998). Comorbidity of attention-deficit/hyperactivity disorder with psychiatric disorder: An overview. *Journal of Clinical Psychiatry, 59*, 50-58.

Pozos, R.S., Richardson, A.W. & Kaplan, H.M. (1971). Electroanesthesia: A proposed physiologic mechanism. In D.V. Reynolds & A. Sjoberg (Eds.) Neuroelectric Research. Springfield: Charles Thomas.

Pozos, R.S., Strack, L.E., White, R.K. & Richardson, A.W. (1971). Electrosleep versus electroconvulsive therapy. In D.V. Reynolds & A. Sjoberg (Eds.) *Neuroelectric Research*. Springfield: Charles Thomas.

Schmitt, R., Capo, T. & Boyd, E. (1986). Cranial electrotherapy stimulation as a treatment for anxiety in chemically dependent persons. *Alcoholism: Clinical and Experimental Research, 10*, 158-160.

Schmitt, R., Capo, T., Frazier, H. & Boren, D. (1984). Cranial electrotherapy stimulation treatment of cognitive brain dysfunction in chemical dependence. *Journal of Clinical Psychiatry, 45*, 60-63.

Shaywitz, B.A., Fletcher, J.M. & Shaywitz, S.E. (1997). Attention-deficit/hyperactivity disorder. *Advances in Pediatrics, 44*, 331-67.

Smith, R.B. (1982). Confirming evidence of an effective treatment for brain dysfunction in alcoholic patients. *Journal of Nervous and Mental Disorder, 170*, 275-278.

Smith, R.B. & Day, E. (1977). The effects of cerebral electrotherapy on short-term memory impairment in alcoholic patients. *International Journal of Addiction, 12*, 575-582.

Smith, R.B. & O'Neill, L. (1975). Electrosleep in the management of alcoholism. *Biological Psychiatry, 10*, 675-680.

Smith, R.B., Tiberi, A. & Marshall, J. (1994). The use of cranial electrotherapy stimulation in the treatment of closed-head-injured patients. *Brain Injury, 8*, 357-361.

Spielberger, C.D. (1975). Anxiety; state-trait process. In C.D. Spielberger & I.G. Sarason (Eds.) *Stress and Anxiety Vol. 1*. New York: John Wiley & Sons.

Volkow, N.D., Wang, G.J., Fowler, J.S., Gatley, S.J., Logan, J., Ding, Y.S., Hitzemann, R. & Pappas, N. (1998). Dop amine transporter occupancies in the human brain induced by therapeutic doses of oral methylphenidate. *American Journal of Psychiatry, 155*, 1325-1331.

Waschbusch, D.A., Kipp, H.L. & Pelham, W.E. Jr. (1998). Generalization of behavioral and and psychostimulant treatment of attention-deficit/hyperactivity disorder (ADHD): Discussion and examples. *Behavior Researc and Therapy, 36*, 675-694.

Wechsler, D. (1981). Statistical properties of the scale, in Manual for the *Wechsler Adult Intelligence Scale-Revised*. New York: Psychological Corporation.

Wechlser, D. (1984). Manual for the *Wechsler Intelligence Scale for Children-Revised*. New York: Psychological Corporation.

Wilson, L.F. & Childs, A. (1988). Cranial electrotherapy stimulation for attention-to-task deficit; a case study. *Medical Electronics, 12*, 93-99.

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