

Changes in attention span, activity, and levels of 5-HIAA in hyperactive children receiving EMG feedback

by Paul Edwin Moes

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Psychology
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Abstract:
Four hyperactive children were given electromyographic ("muscle") biofeedback in a single case design study. All four of the children were able to reduce muscle tension levels as measured by the EMG machine. Two of the children were able to significantly increase attention span and two showed increases in levels of 5-hydroxyindole acetic acid (a metabolite of serotonin) in the urine. None of the subjects showed changes in overall activity levels as measured in this study. The findings suggest, then, that EMG feedback is an effective tool in improving one aspect of their behavior in at least some hyperactive children. Findings concerning biochemical correlates and its clinical implications are also discussed.

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ABSTRACT

Four hyperactive children were given electromyographic ("muscle") biofeedback in a single case design study. All four of the children were able to reduce muscle tension levels as measured by the EMG machine. Two of the children were able to significantly increase attention span and two showed increases in levels of 5-hydroxyindole acetic acid (a metabolite of serotonin) in the urine. None of the subjects showed changes in overall activity levels as measured in this study. The findings suggest, then, that EMG feedback is an effective tool in improving one aspect of their behavior in at least some hyperactive children. Findings concerning biochemical correlates and its clinical implications are also discussed.

INTRODUCTION

Prevalance and diagnosis of hyperactivity. It has been estimated that the "hyperactive child syndrome" (Cantwell, 1975) is present in 4 percent of grade school age children (Millichap, 1968). In a study of the grade school population of a school system in Illinois, Werry and Quay (1971) identified 2.5 percent of the population as exhibiting the "symptoms" of hyperkinesis (i.e. always on the go). However, these estimates of prevalence are somewhat unsure since identification of this syndrome can vary a great deal depending on the criteria being used at the time. When discussing prevalence of minimally brain dysfunctioned children, which includes hyperactive children, Wender (1971) points out that "its prevalence is, among other variables, a function of one's demands for diagnostic precision" (p. 59).

Wender, as well as other writers, have discussed the possibility that hyperactivity is not the result of one single element, but rather may be an outward symptom that can result from various underlying causes. In reviewing the literature of the hyperkinetic syndrome it is seen that much of the research in this area has focused on finding some element or cause that is common to all hyperkinetic (or in the more broad outlook, minimally brain dysfunctioned) children. However, even in studies that have shown statistical differences between normal controls and groups of hyperkinetic children, there are almost always some in the experimental group that show normal or near normal values

for the variables being studied. Also, in many studies that are unable to show differences between the control and treatment groups, it can often be explained as due to the fact that some individuals in the treatment groups responded negatively to the treatment producing a null effect. Therefore, to better understand this syndrome, it is important to understand the various behavioral and physiological aspects that correlate with a given subgroup or individual in the general category of hyperkinesis. As S. Ambrosino (1975) states concerning minimal brain dysfunction (MBD), "MBD is a heterogenous phenomenon cutting across the whole nosological spectrum" (p. 73).

For this reason, rather than demanding a diagnostic precision that includes a variety of symptoms, it was decided that it would be best to look at each subject individually and to see if some of those characteristics that are shown by hyperactive children can be reduced in that individual. The term hyperactivity, then, will refer to the clinical signs of hyperkinesis, restlessness, distractability, lack of self-control, short attention span, and a generally excessive, socially inappropriate, motor activity (Renshaw, 1974; Laufer & Denhoff, 1957). The behavioral aspects of attention span, motor activity, and self control will be concentrated on most heavily.

Non-behavioral components of hyperactivity. Several non-behavioral aspects of hyperactivity have also been studied. Two

examples of these are EEG factors and levels of various neurotransmitters. Both have been thought to reveal either a basic cause or an indirect correlate that results from a more basic problem (Brase & Loh, 1975; Satterfield, et al., 1973; Satterfield & Cantwell, 1974; Wender, 1971). For example, decreased power in the alpha range of a group of hyperactive children was thought by Shetty (1971) to reveal a "disorder of inhibitory mechanisms in the central nervous system" (p. 476). In another example, Brace & Loh (1975), and Bhagavan, et al. (1975) show evidence in support of the idea that decreased levels of 5-hydroxytryptamine (also called serotonin) is a possible cause of minimal brain dysfunction (including hyperkinesis). However, it should be remembered that while these components have been shown to be correlated, this does not necessarily reveal a cause and effect relationship. Also, even if studies show a statistical difference for a given variable, there still could be a great deal of variation within the experimental group.

5-Hydroxyindole acetic acid (5-HIAA), a metabolite of serotonin, vanillylmandelic acid (VMA), and other urinary monoamine metabolites of various neurotransmitters in children with MBD were examined by Wender, et al. (1975). They were unable to reveal any differences between MBD children and controls as to the levels of the metabolites. They also showed that treatment with effective doses of d-amphetamine increased levels of epinephrin and metanephrine in the urine. None

of the others showed an increase. However, as stated previously, research involving a group of children can often mask the individual variation among the children. For example, some who may have been more hyperactive, may also have had lower levels. Another problem with this research is that only a small sample was used for comparison. Therefore, even though values obtained were suggestive of the hypothesis (that hyperactive children have lower values for the neurotransmitters), the N's for the groups were too small to obtain a significant difference.

It is generally assumed, then, by most workers that amphetamines, which was used effectively in hyperactive children, work by causing changes in levels of certain neurotransmitters (Satterfield, 1971). Three other studies suggest that levels of serotonin (and 5-HIAA) may be related to variables other than the administration of amphetamines. Bhagavan, et al. (1975) found that oral administration of phridoxine hydrochloride (Vitamin B_6) resulted in an appreciable increase in the serotonin content of hyperactive children who had shown significantly lower levels of blood serotonin as compared to controls. However, this study did not include any analysis of behavioral changes that might have occured. Greenberg and Coleman (1975 and 1976) have shown that an effective drug response may be predicted by the level of whole blood serotonin present before administration of the drug. A study by Coleman (1971) suggests that serotonin levels may be correlated with

social or behavioral conditions. When two extremely hyperactive children, whose serotonin levels were well below the norm, were cared for at a clinical research center, their serotonin levels increased dramatically as well as their attention span and general clinical picture. Unfortunately, it was not mentioned what type of care was given at the research center. Also, to be able to quantify more clearly the changes that have occured it would be necessary to use a more objective type of behavior modifier. It should be noted at this point that while these last three studies suggest that serotonin is at a below normal level in hyperactive children, one study by Rapoport, et al. (1974) revealed no difference in platelet serotonin between groups of hyperactive and normal children. However, Yuwiler, et al. (1970) states that this method of platelet evaluation often produces inconsistencies.

EMG applied to hyperactivity. To further study this problem, it seems reasonable to use as a more quantifiable behavior modifier, some form of biofeedback regulation that would alter a certain behavior and then allow examination of physiological changes as well as other behavioral aspects that occur in conjunction with the behavioral change. Electromyographic feedback training has been shown to increase general skeletal muscle relaxation (Budzynski, 1977). EMG feedback has been applied to hyperactive children with mixed success. T. Anderson (1975) showed that hyperactive children could learn to "relax" with EMG feedback as measured by the biofeedback instrument. However, this was not

shown to carry over to classroom behavior as shown by a behavior check list. It is possible that this was too broad of an application for only a small amount of biofeedback training. And, again, could be confounded by the fact that some may have reacted negatively to the treatment. Braud, et al. (1975), using a single subject design, was able to reduce tension both immediately after and between EMG training in a 6½ year old hyperactive child. Parent observation of the child also revealed that overall behavior had improved due to the EMG training. A more comprehensive study done by Braud in 1978 was quite dramatic in showing that EMG feedback could be very helpful in improving a variety of symptoms in hyperactive children. When comparing a group of diagnosed hyperactive children (N=15) to a group of non-hyperactive children (N=15) it was found that "the hyperactive children possessed significantly higher ($p<.002$) muscular tension levels and, in addition, presented more behavioral problems and had lower test scores" (p. 69). Then when two experimental groups of hyperactive children received biofeedback or progressive relaxation, a significant reduction of tension as measured by the EMG machine was revealed. Along with the reduction of tension there was a corresponding improvement of behavior as measured by a parental behavioral rating scale as well as improvement on both a "digit span subtest" and a "coding subtest". While the biofeedback group was better at reducing tension levels there was no difference in the amount of improvement in behavior between the groups.

However, both groups were significantly better in all areas than the hyperactive control group. It should also be noted that there was no difference within any of the groups between medicated and nonmedicated subjects as to their tension levels through the study; it was shown that nonmedicated subjects showed significantly greater improvement on behavior as measured by a combined behavioral rating scale.

Relationship of parameters. EMG feedback is shown, then, to affect behavioral aspects of individuals including hyperactive children. Evidence that it can also alter other nonbehavioral variables such as general or specific bodily systems is put forth by Stoyva (1977) and Budzynski (1969). Stoyva sites examples of research that reveals that GSR and heart rate changes are smaller for subjects who have received EMG training and are exposed to a stressor than are control subjects who are exposed to the stressor alone. Budzynski has shown that cortical changes occur with EMG training which is demonstrated by a lessened ability to discriminate paired flashes of light--a sign of decreased cortical arousal (Venables & Wing, 1962). Sittenfeld, Budzynski and Stoyva (1976) have shown that muscle relaxation training is a useful prelude to the induction of EEG theta rythms, a drowsy condition. Because serotonin is directly involved with various "transmissions" in the nervous system (Patton, et al., 1976), alteration of general arousal should alter total body serotonin levels.

Since blood serotonin levels may possibly be altered by a

reduction of hyperactive behavior (Coleman, 1971), EMG feedback would seem to serve very well as a quantifiable behavior change method that would allow for a more exact analysis of the relationship between the two parameters. However, an EMG analysis would only correlate tension with the level of blood serotonin (or 5-HIAA in the urine), and would not reveal the changes in other behaviors such as attention span and gross motor activity. To further examine this relationship a further test must be included that measures attention span and motor activity.

Therefore, since EMG feedback has been shown to decrease tension and improve overall behavior of hyperactive children, it is hypothesized that successful EMG feedback will reduce the activity level, and increase the attention span of hyperactive children as measured by the technique of Hutt, et al. (1963), (see methods section). Furthermore, in relation to this improved behavior, as well as decreased muscle tension (as measured by the EMG machine), there should be corresponding changes in the level of serotonin in the blood as reflected by 5-HIAA urine concentration. 5-HIAA levels, then, are expected to rise to a more "normal" level.

METHOD

Subjects

Four children participated in the study. Their ages ranged from 8.1 years to 11.5 years (mean age of 9.6 years). There was one female ("subject A") and three male ("subjects B, C, and D"). All subjects

had been diagnosed as hyperactive by at least one physician who was familiar with the etiology of hyperactivity. Three of the subjects had also undergone extensive testing at a large medical center in either Salt Lake City or Denver. All three exhibited very slight and nonspecific EEG abnormalities; two of these showed definite visual or visual-motor problems along with some facial "twitching". Two of the subjects were adopted.

Some special assistance had been or was being given in the school to all four children. However, none were in special education, nor had they been classified as "learning disabled". An attempt was made to keep medication dosages constant throughout the study. Medications and treatments were as follows: subject A, 15 mg of Rittalin (methylphenidate) in the morning and afternoon; subject B, 37.5 mg of Cylert (which was discontinued on the 8th day) and was put on 5 mg of Dexedrine (dextroamphetamine) per day on the 12th day (which was increased to 10 mg per day on the 16th day of the experiment); subject C was not put on any medication, and was being treated with a low sugar diet; subject D, 15 mg of Dexidrine per day.

Apparatus

For the EMG feedback training and EMG monitoring an Autogen 1700 electromyographic feedback analyzer was used. Muscle electrical activity is measured in integral average microvolts, i.e., the area under the curve of the EMG waveform. This is a significantly more

accurate indicator of overall muscle tone than peak-to-peak EMG measurement. The bandpass selector was set at 100-200 Hz. This bandpass allows for good artifact rejection and exhibits especially good signal-to-noise ratio, permitting the monitoring of very low microvolt levels. During training sessions, the feedback consisted of a tone which pulsates at a steady rate while the pitch varies in logarithmic proportion to the EMG level. The tone rises in pitch as the EMG level increases and falls in pitch as the EMG level decreases. An audio feedback threshold was set at the average value that was obtained during baseline. When activated, the feedback threshold determines the maximum absolute level of EMG activity required for any of the audio feedback signals to be present.

EMG activity from the Autogen 1700 was relayed to an Autogen 5600 data aquisition center. This instrument allows for instantaneous and continuous readings of average EMG amplitude. Each 30 seconds a cumulative average value is given; at the end of 20 minutes a total average and standard deviation is given.

Procedure

For this study an ABAB single case design was employed as described by Hersen and Barlow (1977). Prior to the beginning of the procedure all of the parents and children were interviewed and familiarized with the experiment. Each child was brought through the whole sequence of events and each procedure was explained in detail.

Instructions were repeated at the beginning of each week.

EMG procedure. Beginning on Monday, at a designated time each day after school, each child participated in a week (five days) of baseline sessions with no feedback (see figure 2). The following week (after a weekend break) consisted of EMG with feedback. The EMG electrodes were attached to the forehead over the frontalis muscles. Relaxation of this muscle group had been shown to affect total relaxation and decreased cortical arousal (Budzynski, 1977). Each child was instructed to "reduce muscle tension by keeping the tone on" (i.e. below threshold). They were also told that relaxing their whole body and sitting very still would assist in keeping the tone on. In the next two weeks the same procedure was repeated.

Activity level analysis. The method used to measure attention span and activity level has been described by Hutt, Hutt, and Ounsted (1963). This method was shown to be useful in objectively measuring activity level and attention span. This procedure involved placing the child in a small room (10x8), with a "grid" of 12 squares marked on the floor, for five minutes. This was done just prior to the EMG session so that any carry over from the preceding day's treatment could be ascertained. The room was unfurnished except for three "toys" that were placed in different parts of the room. The toys included a box of dominoes (square ten), a small puzzle of the United States (square eight), and a large blackboard which was situated opposite the one-way

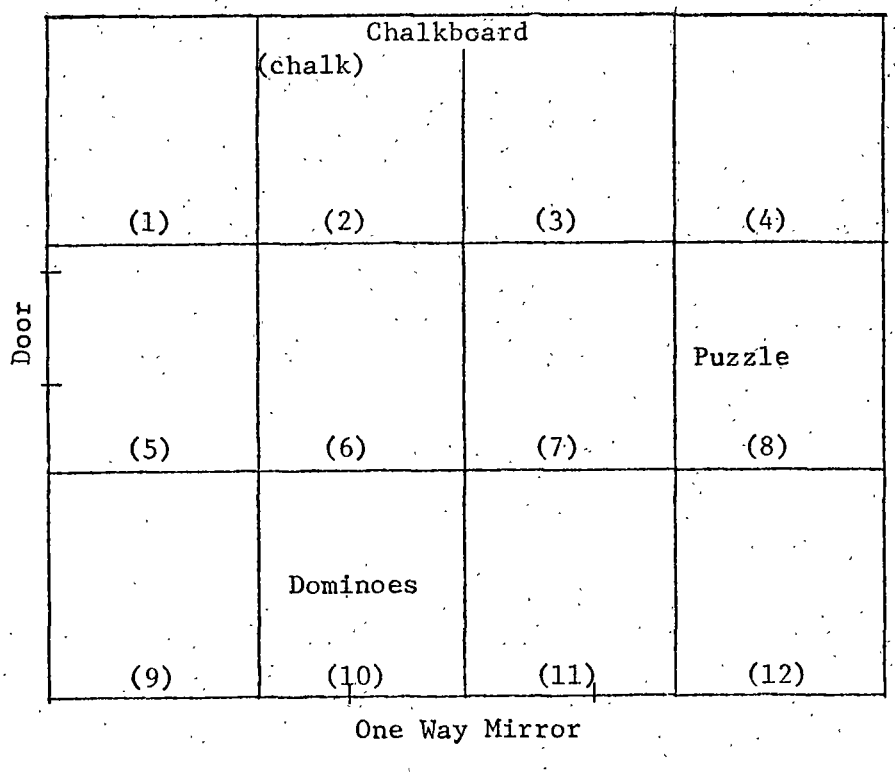
mirror (see figure 1). By watching through the one-way mirror, it was observed which square the child was in and a verbal note was made on a tape recorder as to each square that the child "visited". Also, a short phrase was used to describe the onset of various actions and directions of gaze. After the session, the tape was played back and a measurement was made as to the number of "new attentions" (as described by Hutt, et al.), as well as the number of squares visited. The onset and end of all attention spans were recorded and the time for each span calculated. From this an "average attention span" was calculated for each session.

Urine analysis for 5-HIAA. Beginning three days prior to the first day of the session and lasting throughout the experiment, all subjects were placed on a low serotonin diet (including precurser substances). At the end of each session a urine sample was obtained. A small amount of urine (.5 ml.) was "preserved" with 1 ml. of sulfuric acid immediately afterward, and was placed in the refrigerator overnight. The following day a quantitative test was run according to the procedure described by Natelson (1971) to determine the amount of 5-HIAA in the urine.

RESULTS

Values obtained on all variables: EMG muscle tension (microvolts), levels of 5-HIAA in the urine (mg/100 ml), average attention span (seconds), and number of squares visited ("squares") were plotted for

Figure 1: Diagram of Activity Observation Room



each subject (Figures 2-5). Also, values obtained for each individual are shown in Tables 1-4. Inspection of the means for combined baseline versus combined feedback treatments reveals that all four subjects showed changes in the direction of the hypothesis for EMG tension and 5-HIAA levels. Three of the subjects showed changes in the direction of the hypothesis in average attention span, and two subjects for the number of squares visited during a five minute period.

The Wilcoxon matched-pairs signed-ranks test (Siegel, 1956) was used to compare between baseline and feedback sessions. This test is a nonparametric test which is not dependent on the assumption of serial independency. All four subjects attained significant reduction ($p<.025$) of tension during feedback sessions. Subjects A and B showed significant increases ($p<.01$) of 5-HIAA levels in their urine during the two weeks of feedback sessions. Average attention span increased significantly for subjects A and D ($p<.01$ and $p<.025$ respectively), while none of the subjects showed a significant reduction of the numbers of squares that were visited.

To examine the relationship of the variables, correlation tests between each variable, for each individual, were conducted (Tables 1-4). Of the six correlations examined, four of the comparisons reached significance in at least one child. Significant correlations were not reached between EMG and average attention span, or 5-HIAA and number of squares, in any of the children. All four subjects

Figure 2: Levels of Variables for Subject A

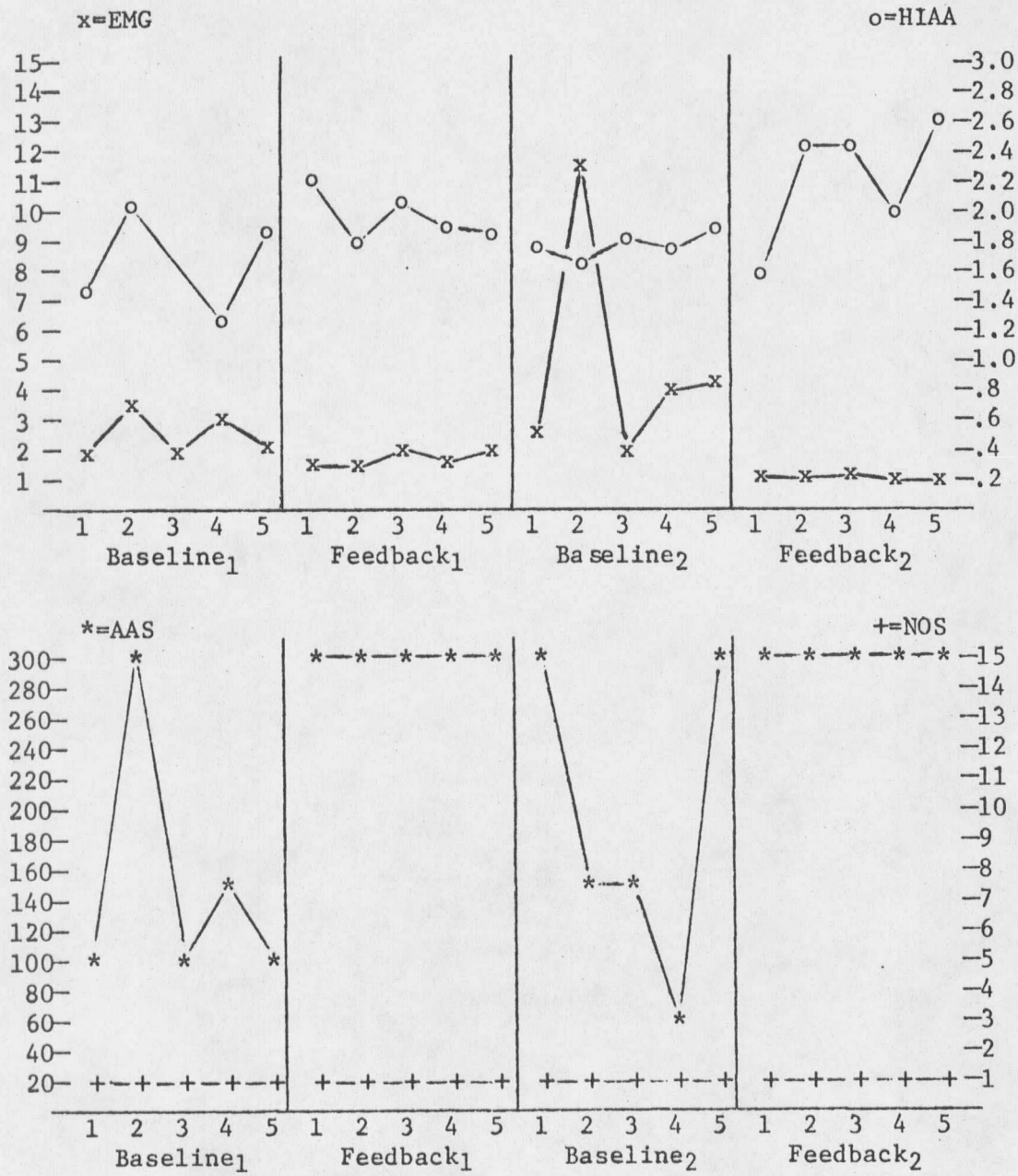


Table 1

Values for all Variables Obtained from Subject A

		Mon.	Tue.	Wed.	Thu.	Fri.	$\bar{X}$	$\bar{X}_B$	$\bar{X}_F$
EMG	B_1	1.968	3.687	2.015	3.162	2.246	2.616		
	F_1	1.827	1.140	1.618	1.344	1.624	1.511	3.834	1.380
	B_2	2.753	11.74	2.046	4.237	4.481	5.051	$p<.025$	
	F_2	1.304	1.252	1.353	1.236	1.094	1.248		
HIAA	B_1	1.48	2.05	-	1.29	1.89	1.68		
	F_1	2.23	1.82	2.09	1.91	1.86	1.98	1.74	2.12
	B_2	1.79	1.67	1.84	1.77	1.91	1.80	$p<.01$	
	F_2	1.60	2.46	2.46	2.15	2.63	2.26		
AAS	B_1	100	300	100	150	100	150		
	F_1	300	300	300	300	300	300	171	300
	B_2	300	150	150	60	300	192	$p<.01$	
	F_2	300	300	300	300	300	300		
NOS	B_1	1	1	1	1	1	1		
	F_1	1	1	1	1	1	1	1	1
	B_2	1	1	1	1	1	1		
	F_2	1	1	1	1	1	1		

Correlated Variables	r	p-value
EMG/HIAA	-.3352	
EMG/AAS	-.3453	
EMG/NOS	-	
HIAA/AAS	.5463	$p<.02$
HIAA/NOS	-	
AAS/NOS	-	

(Abbreviations and units are as follows: EMG=Electromyograph (microvolts); HIAA=5-HIAA (mg/100ml); AAS=Average attention span (seconds); NOS=Number of squares (squares); B=Baseline; F=Feedback.)

Figure 3: Levels of Variables for Subject B

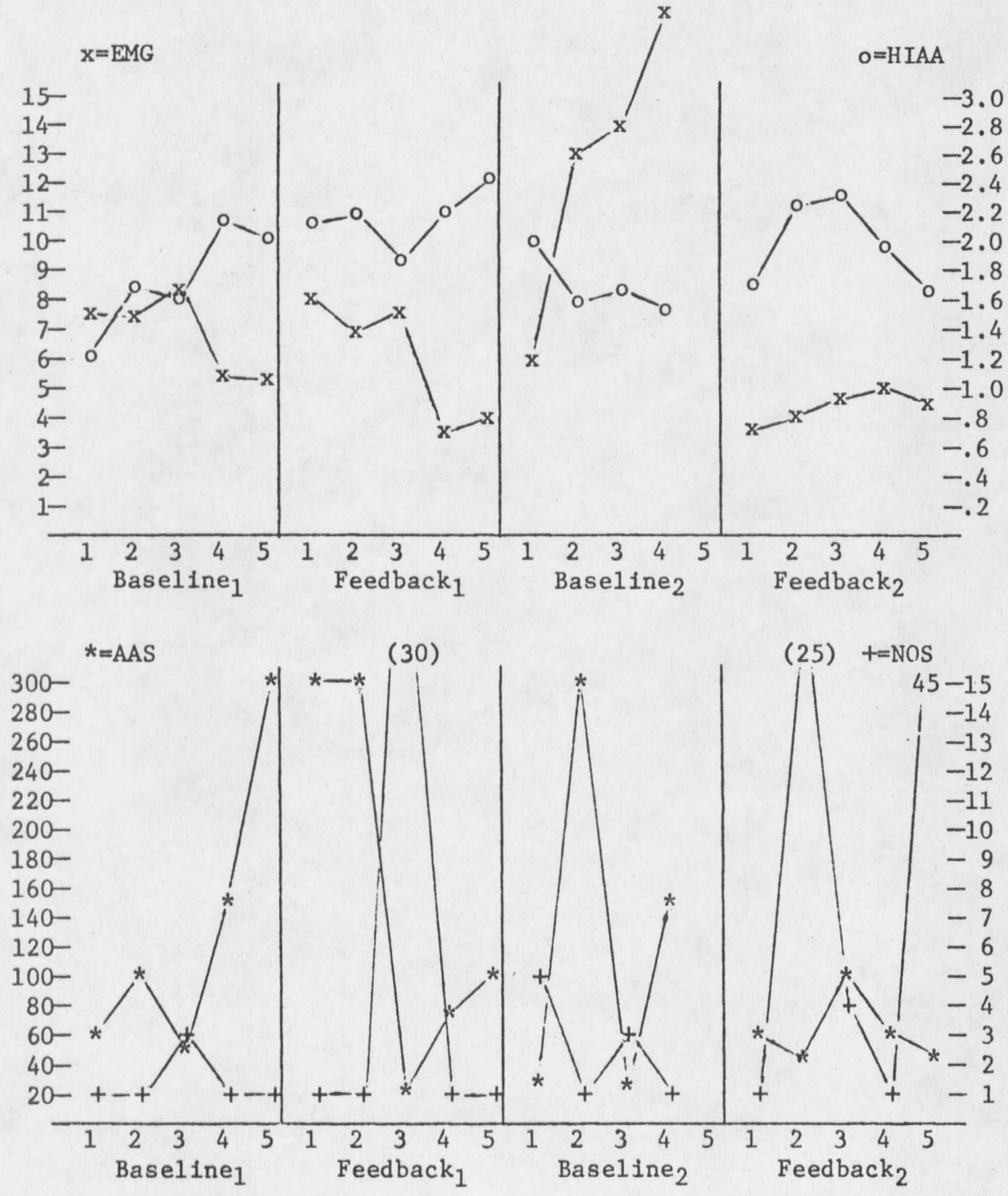


Table 2

Values for all Variables Obtained from Subject B

		Mon.	Tue.	Wed.	Thu.	Fri.	$\bar{X}$	$\bar{X}_B$	$\bar{X}_F$
EMG	B_1	7.636	7.490	8.436	5.530	5.425	6.900		
	F_1	8.054	6.990	7.760	3.677	4.084	6.113	9.855	1.380
	B_2	6.031	13.17	14.04	18.01	-	12.81	$p<.005$	
	F_2	3.660	4.190	4.891	5.066	4.592	4.480		
HIAA	B_1	1.24	1.70	1.63	2.15	2.06	1.76		
	F_1	2.15	2.20	1.88	2.22	2.44	2.18	1.74	2.09
	B_2	2.01	1.60	1.67	1.56	-	1.71	$p<.01$	
	F_2	1.72	2.27	2.34	1.98	1.67	2.00		
AAS	B_1	60	100	50	150	300	132		
	F_1	300	300	21.4	75	100	159.3	129	11[illegible]
	B_2	27.3	300	24.9	150	-	125.6		
	F_2	60	42.9	100	60	42.9	61.2		
NOS	B_1	1	1	3	1	1	1.4		
	F_1	1	1	30	1	1	6.8	2.0	11.0
	B_2	5	1	3	1	-	2.5		
	F_2	1	25	4	1	45	15.2		

Correlated Variables	r	p-value
EMG/HIAA	-.5490	$p<.02$
EMG/AAS	-.2058	
EMG/NOS	.2049	
HIAA/AAS	.1828	
HIAA/NOS	-.0455	
AAS/NOS	-.3828	

(Abbreviations: see Table 1.)

Figure 4: Levels of Variables for Subject C

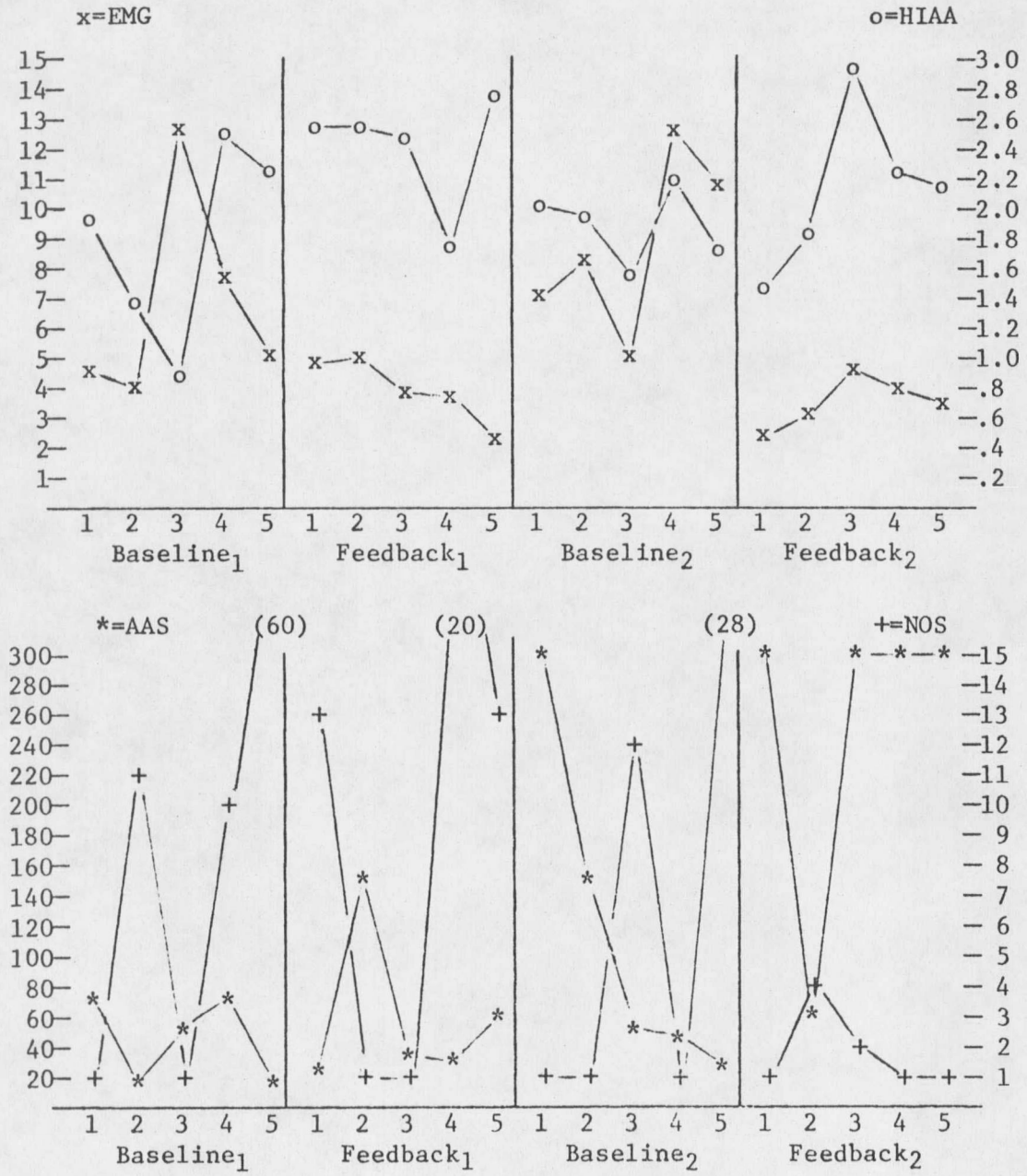


Table 3

Values for all Variables Obtained from Subject C

		Mon.	Tue.	Wed.	Thu.	Fri.	$\bar{X}$	$\bar{X}_B$	$\bar{X}_F$
EMG	B_1	4.765	4.169	12.84	7.648	5.183	6.921		
	F_1	4.932	5.020	3.960	3.740	2.419	4.017	7.903	3.853
	B_2	7.046	8.430	5.288	12.71	10.95	8.885	$p<.01$	
	F_2	2.500	3.426	4.813	4.118	3.581	3.688		
HIAA	B_1	1.96	1.36	0.89	2.51	2.27	1.80		
	F_1	2.54	2.54	2.46	1.77	2.75	2.41	1.84	2.27
	B_2	2.03	1.94	1.58	2.20	1.72	1.89		
	F_2	1.48	1.82	2.95	2.27	2.15	2.13		
AAS	B_1	75	19	50	75	17	47		
	F_1	21	150	38	30	60	60	81	156
	B_2	300	150	50	43	28	114		
	F_2	300	60	300	300	300	252		
NOS	B_1	1	11	1	10	60	60		
	F_1	13	1	1	20	13	9.6	12.6	5.7
	B_2	1	1	12	1	28	8.6		
	F_2	1	4	2	1	1	1.8		

Correlated Variables	r	p-value
EMG/HIAA	-.3108	
EMG/AAS	-.2538	
EMG/NOS	.0159	
HIAA/AAS	.0237	
AAS/NOS	-.4593	$p<.05$

(Abbreviations: see Table 1.)

Figure 5: Levels of Variables for Subject D

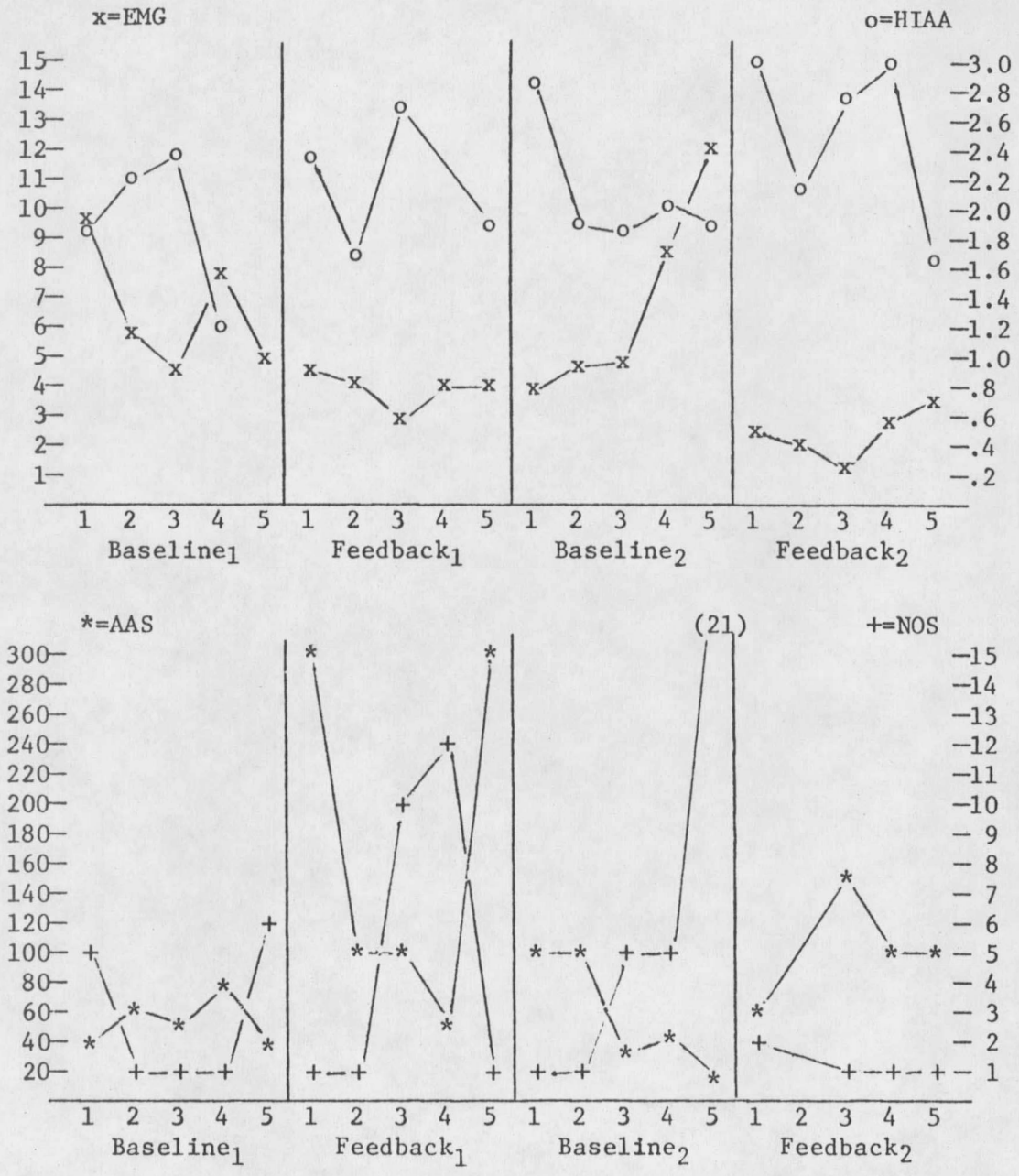


Table 4

Values for all Variables Obtained from Subject D

		Mon.	Tue.	Wed.	Thu.	Fri.	$\bar{X}$	$\bar{X}_B$	$\bar{X}_F$
EMG	B_1	9.636	5.869	4.587	7.763	5.011	6.573		
	F_1	4.699	4.281	2.994	4.186	4.294	4.091	6.740	3.315
	B_2	4.004	4.720	4.888	8.655	12.27	6.900	$p < .005$	
	F_2	2.555	2.239	1.433	2.956	3.509	2.538		
HIAA	B_1	1.87	2.22	2.39	1.22	-	1.93		
	F_1	2.37	1.70	2.70	-	1.91	2.17	2.03	2.36
	B_2	2.88	1.92	1.87	2.06	1.91	2.13		
	F_2	3.11	2.15	2.74	3.04	1.67	2.54		
AAS	B_1	37.8	60	50	75	38	52		
	F_1	300	100	100	50	300	170	55	136
	B_2	100	100	30	42.9	14.3	57	$p < .025$	
	F_2	60	-	150	100	100	102		
NOS	B_1	5	1	1	1	6	2.8		
	F_1	1	1	10	12	1	5	4.7	3.2
	B_2	1	1	5	5	21	6.6		
	F_2	2	-	1	1	1	1.3		

Correlated Variables	r	p-value
EMG/HIAA	-.5197	$p < .05$
EMG/AAS	-.3724	
EMG/NOS	.5492	$p < .02$
HIAA/AAS	.0878	
HIAA/NOS	-.0912	
AAS/NOS	-.4096	$p < .05$

(Abbreviations: see Table 1.)

achieved significant correlations for at least one pair of variables.

To facilitate comparison between subjects and to observe the effects of each week of treatment, the average values for each week have been compiled in Table 5. Also the average for each week across all subjects is shown. Although this deviates from a single subject analysis, it allows for a comparison between individual changes with group changes. Tables 6 and 7 show significant levels of differences between baseline and feedback, and of correlations between variables for all subjects taken together. Correlations were obtained by pairing the average value of each week of each subject for a given variable with another variable of the same week and subject.

DISCUSSION

The results of this study support the idea that EMG biofeedback could be useful in at least some individuals in increasing attention span and decreasing muscle tension. There has also been support shown for the idea that physiological correlates to hyperactivity may be present. Although there were variations in the results among the subjects, significant change was shown for all subjects in at least one variable. Also, all the variables of muscle tension, 5-HIAA levels, and average attention span were shown to "improve" with the therapy that was applied in at least one of the subjects. This suggests that a certain percentage of the population of hyperactive children may show similar kinds of results if an exhaustive study were to be

Table 5

Means of each Phase for all Variables

Across all Subjects

SUBJECTS:		A	B	C	D	$\overline{X}$
EMG	B_1	2.616	6.900	6.921	6.573	5.753
	F_1	1.506	6.113	4.417	4.091	4.032
	B_2	5.051	12.81	8.885	6.907	8.413
	F_2	1.248	4.480	3.688	2.538	2.989
	$\overline{X}$	2.605	7.576	5.978	5.027	5.297
HIAA	B_1	1.68	1.76	1.80	1.92	1.79
	F_1	1.98	2.18	2.41	2.17	2.19
	B_2	1.80	1.71	1.89	2.13	1.88
	F_2	2.26	2.00	2.13	2.54	2.23
	$\overline{X}$	1.93	1.91	2.06	2.19	2.02
AAS	B_1	150	132	47	52	95
	F_1	300	159	48	170	169
	B_2	192	126	114	57	122
	F_2	300	61	252	103	179
	$\overline{X}$	236	120	115	96	142
NOS	B_1	1	1.3	16.6	2.5	5.4
	F_1	1	6.8	9.8	5	5.7
	B_2	1	2.5	8.6	6.6	4.7
	F_2	1	15.2	1.8	1.25	4.8
	$\overline{X}$	1	6.5	9.2	3.8	5.2

(Abbreviations: see Table 1.)

Table 6

Confidence Levels of the Wilcoxon Matched-Pairs Signed-Ranks Test of differences between Treatments for all Variables and across all Subjects

	EMG	HIAA	AAS	NOS
$\bar{X}_B$	7.083*	1.84	109	5.1
$\bar{X}_F$	3.511	2.21	174	5.3
	$p<.005$	$p<.005$	$p<.025$	

*Values represent the means for total baseline or total feedback sessions of all subjects.

Table 7

Correlations and Confidence Levels between Variables for all Subjects (N=16)

Correlated Variables	r	p-value
EMG/HIAA	-.4799	
EMG/AAS	-.4936	
EMG/NOS	.2388	
HIAA/AAS	.0408	
HIAA/NOS	-.0080	
AAS/NOS	-.6079	$p<.02$

conducted.

As for the variations among the subjects, and some negative results, it may be that there are basic differences in "physical make up" or differences in the original cause of the problem. For instance, age and sex may contribute to individual differences (Silverman and Metz, 1973). Subject A was the oldest and the only girl, which may reflect one reason for a slightly greater success as compared to the other subjects. Also, changes in medication during the study such as in subject B may have caused a disruption of the results.

Correlational findings supported the expectation that behavioral changes would be related to a particular physiological change, namely 5-HIAA. This was shown by the correlation between muscle tension and 5-HIAA in two of the subjects. One difficulty in the interpretation of these results is that while the graphs of some variables seem to show an inverse or direct relationship with several of the variables, each individual pair of variables used for calculation did not always appear to show the relationship. This could be due to the fact that some changes did not often occur until the following day or days.

The "number-of-squares-visited" variable did not seem to be that sensitive in evaluating gross motor behavior in any of the subjects. One problem may be that the subjects were much older than the children that were used by Hutt, et al. (1963) in developing the technique. It may be that another more sensitive test could show changes in gross

motor activity.

Trend Analysis

A word should be said at this point about some of the trends that occured during both baseline and feedback periods. Herson and Barlow (1977) have argued that trends during baseline in the direction expected during treatment phases can severely limit any conclusions that are drawn from the treatment affects. Although most baseline phases were free from this type of confound, there were some exceptions. However, these trends seem not to be present in the second baseline or feedback phases and in fact, show dramatic changes in the direction suggested. Therefore, while some baseline trends do exist; it is felt that they have not negated the overall findings.

Clinical Application of EMG Feedback

EMG feedback would appear, then, to be very useful for reducing muscle tension and increasing attention span. However, the drawback of such a therapy would of course be that the child would have to come in to a lab or clinic to maintain its effect (Braud, 1975). However, it appears that EMG training is more objective and somewhat faster in establishing change as was shown in the Braud study. Therefore, a well balanced program of relaxation therapy at home and EMG feedback once or twice a week could well be very useful in both teaching self-control and possibly affecting the nervous system in a way that would

allow for "carry-over" of the treatment.

Also, to further strengthen the effect it would seem appropriate to use stronger reinforcement to promote reduction of tension. All of the subjects in this experiment expressed, at one time or another, boredom with the study. Although they were eager to help themselves, they would seem to lose sight of the goal and had to be encouraged from time to time. If tangible rewards such as toys or candy could be issued along the way it would allow for a greater incentive and therefore, better results.

Concluding Remarks

This study has shown that of four hyperactive children, all four were able to reduce muscle tension with EMG biofeedback. Two of these children showed significant increases in attention span and two in the daily urine levels of 5-HIAA. None of the children reduced overall activity level as it was measured in this experiment. These findings suggest that EMG biofeedback may be effective in improving some symptoms, but it may very well alter more basic neurological functioning which can further promote the growth of the child.

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