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ABSTRACT

A series of studies examined the effects of biofeedback and relaxation on performance of learning disabled (LD) students. In study 1, 114 LD students received a randomly assigned treatment combination twice a week for 6 weeks. Four individual treatment components included electromyographic biofeedback monitoring, handwriting practice, prerecorded relaxation tapes, and homework. Results of pre- and post-test scores on a battery of tests revealed that biofeedback training and listening to relaxation tapes, especially in combination, appeared to enhance general attention level and verbal facility. In a second study, it was found that teachers can deliver a relaxation program within the school and obtain significant improvement in the basic academic skills of their learning disabled students. A final study field-tested a self-contained instructional training package for use by teachers of learning disabled students. The studies suggested that trained clinicians were able to bring about greater gains in academic performance than were teachers who had little clinical training, especially with the complex biofeedback instruments. (CL)

Final Report

Project No. 443CH00207
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APPLICATION OF BIOFEEDBACK RELAXATION PROCEDURES TO HANDICAPPED CHILDREN: FINAL REPORT

John L. Carter, Ph.D.

University of Houston--Clear Lake

Houston, Texas

January 10, 1984

The research reported herein was performed pursuant to a grant with the Bureau of Education for the Handicapped, U.S. Department of Education. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

U.S. DEPARTMENT OF
EDUCATION

Bureau of Education for the Handicapped
National Center for Educational Research and Development

Final Report

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Application of Biofeedback/Relaxation
Procedures to Handicapped Children: Final Report

Approximately 20 percent of all children perform very poorly in school. The most serious manifestations are difficulty in learning to read and spell, trouble with basic arithmetic, and problems with written expression. The effects of this learning failure have long been known to be cumulative and pervasive. Hammar (1967) reported that 67 percent of underachievers were learning disabled. Similarly, Harrower (1955) earlier found that over 75 percent of juvenile delinquents were poor readers, the most common academic symptom of learning disability.

The psychological effects of chronic school failure are readily observed. Poor academic performance generates criticism which results in the development of a poor self-concept; this in time lowers interest and motivation and works to increase anxiety and tension. McMillan (1969) found that poor learners tend to perceive even neutral events as failures which lowers the sense of self-worth.

Attending school daily while performing poorly is a source of considerable stress which even further limits school performance. The basic theory behind these investigations is that learning is most effective and academic performance of poor achievers is increased when the learner is physically relaxed and mentally attentive to the material being presented. The investigations reported here strongly support this theory.

Chronically poor school performance by the child results in his experiencing an "emergency" or "fight or flight" reaction, a characteristic pattern of internal arousal which occurs when the child is faced

with the threat of another failure.

If either running or fighting is inappropriate or impossible for a child then there is no way for this heightened level of arousal to dissipate except over time. If the threat or stress persists then a chronically high and fluctuating internal activity level will be maintained. Sheer (1977) has shown that learning disabled children show much more autonomic lability and inability to focus attention than do normal controls.

Biofeedback training has been developed as a means of teaching adults individual control over their physiological responses. Exploratory work, using small numbers of children, suggests that children can also learn such control.

The specific training procedures presented here were developed in a pilot investigation (Carter and Russell 1978) with four learning disabled boys. Since initial results indicated significant gains in reading, spelling and handwriting legibility for a small sample it was decided to maintain the same experimental procedures for more controlled investigations.

The data collected from the original pilot work with approximately 200 children strongly suggested that a combination of the following procedures was effective in assisting learning disabled children to relax and, hence, to cope more effectively in school:

- Electromyographic biofeedback (EMG) training
- Listening to prerecorded relaxation audio cassette tapes
- Supervised handwriting practice, and
- Home practice consisting of listening to the prerecorded relaxation tapes and practicing handwriting

Figure 1 presents the experimental schema followed in the investigations conducted and reported here. First, we wished to determine which of the treatments or combinations listed in Figure 1 would bring about the best results.

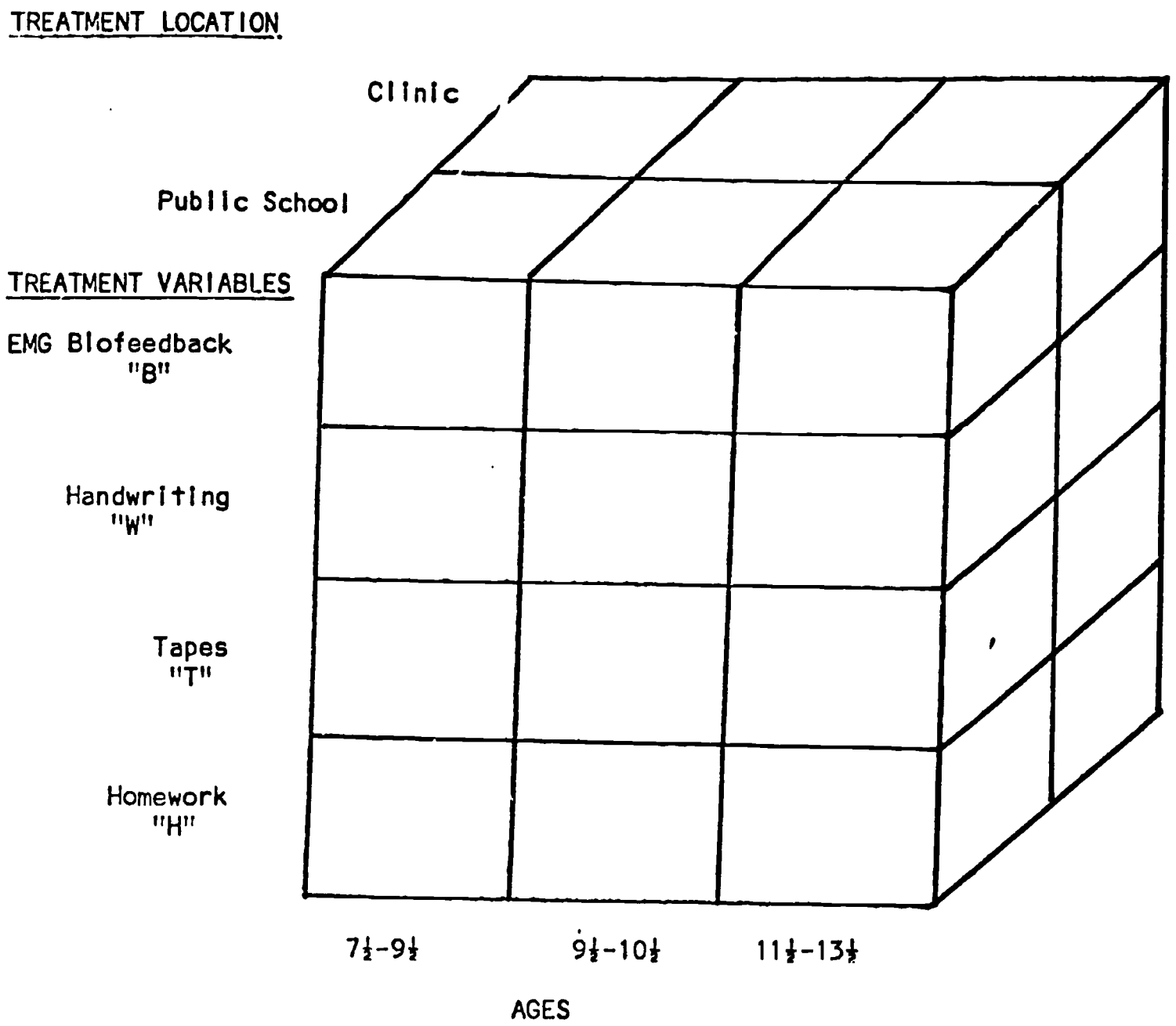

FIGURE 1: EXPERIMENTAL SCHEMA

We also wanted to determine the effects of age and sex on the outcome. The intent was to replicate the relaxation procedures within a carefully developed experimental model and perhaps to broaden their application.

With this in mind the four treatment procedures were incorporated so that every possible combination could be evaluated in terms of test gains. Following is a list of the treatment combinations:

B & W	W & T	B, W & T	W, T & H
B & T	W & H	B, W & H	B, W, T & H
B & H	T & H	B, T & H	

Note: B = EMG Biofeedback

W = Handwriting

H = Home practice

T = Listening to Relaxation Tapes

Subjects were selected from three age ranges, 7½-9½, 9½-11½, 11½-13½, and were randomly assigned to one of the eleven treatment groups by age. Because an insufficient number of male learning disabled children were available in the cooperating schools, learning disabled girls were also selected for inclusion. Sex, then, also became a predictor variable. Finally, due to the number of subjects and IQ range, it was decided to dichotomize the pretest IQ range at the median. Scores above the median were labeled Hi IQ and those below the median were labeled Lo IQ. This procedure added another predictor variable.

Learning disabled children, boys and girls, were selected from special education programs in cooperating area schools, they had met the Texas Education Agency criteria for inclusion. These criteria are:

1. Lack of achievement in one or more of the following areas: oral expression, listening comprehension, written expression,

basic reading skills, reading comprehension, mathematics calculation, mathematics reas[illegible]ng, or spelling.

2. A severe discrepancy b[illegible] intellectual ability and academic achievement where the achievement is at least one standard deviation below intellectual functioning.

All subjects were then administered the following battery of tests and procedures for dependent measures:

Slosson Intelligence Test (SIT)

Peabody Individual Achievement Test (PIAT)

Gray Oral Reading Test (GORT)

Bender Motor Gestalt Test using Koppitz scoring (BENDER)

Simple Auditory Memory (AUDMEM)

Penmanship Evaluation (PENMAN)

These are essentially the same dependent measures used in the pilot investigations. All testing was conducted one week immediately prior to initiation of treatment and one week immediately following the cessation of treatment. All testing was done "blind" by advanced psychology students.

Each student received his randomly assigned treatment combination two times a week for six weeks. The four individual treatment components were operationally defined as follows:

1. EMG Biofeedback Monitoring (B): Subjects were taken individually to the treatment room and seated in a comfortable chair. Electrodes were attached over the flexor muscles of the preferred writing forearm. An auditory tone synchronized to a visual guage indicating muscular tension was present,

audible and visible to the child. The child was instructed to lower the tone by relaxing the arm muscles and received immediate auditory and visual feedback. In addition, an integrator displayed the mean EMG level each two minutes. The child was asked to see if he could have each subsequent reading lower than the previous one. This training procedure lasted 20 minutes.

2. Handwriting Practice (W): The children were given handwriting practice for 20 minutes two times a week. The same practice sheets developed for the pilot investigations were used.
3. F recorded Relaxation Tapes (T): Each child was taken individually to a treatment room with dimmed lights. He was seated in a comfortable chair with the experimenter to the side and slightly behind. Then a prerecorded bodily relaxation tape exercise was played by the examiner and the child was given help and encouragement by the examiner in following directions. This continued for approximately 20 minutes.
4. Homework (H): A series of prerecorded, 20 minute audio tapes were given to each subject. The child was asked to listen to and follow the directions on the tape two times each week and then complete two handwriting exercise pages after listening to the tape.

Results and Discussion

There were 11 treatment combinations and three age ranges. Four children were randomly placed in each treatment by age cell, making for a total of 132 subjects. Eighteen subjects were lost due to attrition. This made for a total of 114 subjects.

The criteria or dependent measures were:

Slosson Intelligence Test (SIT)

Peabody Individual Achievement Test (PIAT)

Mathematics (Math)

Reading Recognition (Read Rec)

Reading Comprehension (Read Comp)

Spelling (Spell)

General Information (Info)

Total Score (Total)

Gray Oral Reading Test (GORT)

Bender Visual Motor Gestalt (BENDER)

Auditory Memory Test (AUDMEM)

Penmanship Evaluation (PENMAN)

The above pre and posttreatment scores were organized and coded along with the independent or predictor variables of biofeedback (B), tapes (T), writing practice (W), home practice (H), age, sex and IQ. When possible, as with the SIT and PIAT tests, standard scores were used. Grade scores were used with the GORT, and the number of errors determined by the Koppitz (1963) method was used with the Bender. The AUDMEM score was determined by the number of word sequences immediately recalled by the child when presented orally by the examiner. The PENMAN score was determined by a noninvolved teacher who rated general legibility and overall quality on a five-point scale from 1, very poor, to 5, very good. This method was developed during the pilot investigations.

Since improvement was to be expected on the dependent criterion

measures, pretest scores were subtracted from the posttest. This yielded a gain or difference score. The pre, post and difference scores for all dependent measures for the entire group are presented in Table 1. This pretest defines the sample used. All achievement measures were lower than the ability measure, SIT. As would be expected, variability on all measures but the Bender increased following treatment. That of the Bender decreased because there were fewer errors on the posttest than on the pretest.

Table 1 About Here

Table 2 presents a Pearson-Product moment correlation matrix of all variables, predictor/treatment and dependent/criterion. Note the significant correlation between the biofeedback treatment and nine of the eleven dependent measures. Only decrease in Bender errors and Penmanship improvement are not significantly related to the biofeedback treatment. Also, handwriting practice only resulted in improvement in Penmanship.

Table 2 About Here

Although not significant, Home Practice shows a low order negative relationship with six of the eleven criterion measures. The same can

be said of Age which also shows a significant relationship with decrease in Bender errors. That is to be expected. Sex F, being female and learning disabled, shows a low order, nonsignificant negative relationship with nine of the eleven criterion measures. This, too, is expected. Girls tended to score higher, though not significantly, than boys on most measures of achievement, coordination and memory. Also, as expected, gains in achievement measures, excluding Penmanship, tended to show high interrelationships, and IQ gain on the SIT was significantly related to gains in Total Achievement, Memory, Math, Spelling and Information, but not to Bender errors or Penmanship improvement. This, too, tallies with experience. Of importance, improvement in Penmanship was also significantly related to Spelling improvement and, of course, Handwriting practice. Writing practice appears to make children more alert to word configurations.

Following the evaluation of the intercorrelation matrix, a stepwise multiple regression analysis was conducted. In this case the multiple predictions were from the predictor variables (Bio, Tapes, Writing, Age, Sex F, Hi IQ) to the dependent or criterion measures. The stepwise analysis was cumulative. For each dependent variable the highest multiple correlation (R) is displayed first, the second highest second, etc. Table 3 presents a summary of this data.

Table 3 About Here

In considering the SIT, there was a significant gain in IQ (F=35.092) and a significant (R) with Biofeedback. Adding the next strongest (R),

Writing, did not significantly increase the correlation from Bio alone (Rho-.284). No other predictors add significantly to Biofeedback in predicting gain in SIT score.

With Math the situation is slightly altered. The multiple correlation of .3493 between Biofeedback and Math improvement is significantly greater than 0 (p=.026); however, the addition of listening to the tapes significantly improves the prediction (Rho=.010). Adding other predictor variables results in no further improvement in prediction of gains.

Only Biofeedback treatment predicted the significant gains in Reading Recognition while listening to the relaxation tapes was the best predictor of gains in Reading Comprehension. The addition of Biofeedback significantly added to the Tapes in predicting Reading Comprehension. Biofeedback and Tapes, in that order, significantly predicted the increased information score.

The total PIAT gains score is most interesting. Biofeedback significantly predicted the gain and Tapes and Handwriting practice each, in that order, add significantly to the prediction. Only Biofeedback significantly predicts the significant improvement on the GORT, and no predictor successfully predicted improvement on the Bender. Auditory Memory and Penmanship improvement each had two significant predictors. Biofeedback and Writing Practice enhanced Auditory Memory in that order. The reverse, Writing Practice and Biofeedback significantly improved Penmanship.

It should be noted that significant improvements were demonstrated on all dependent/criterion measures as indicated by the significant F values. The specific treatment/predictor combinations, however, did vary somewhat.

The following briefly summarizes the significant predictor variables to the dependent/criterion measures:

SIT:	Bio., Writ., Tapes, Sex, IQ
Math:	Bio., Tapes, Writ., Sex, IQ
Read Rec:	Bio., Sex, Tapes, IQ, Writ.
Read Comp:	Tapes, Bio., Sex, Writ., IQ
Spell:	Bio., Tapes, Writ., Sex, IQ
Info:	Bio., Sex, Tapes, Writ., IQ
Total:	Bio., Tapes, Writ., IQ, Sex
GORT:	Bio., Tapes, Writ., Sex, IQ
Bender:	Writ., Sex, Bio., Tapes, IQ
Audmem:	Bio., Writ., IQ, Tapes, Sex
Penman:	Writ., Bio., Sex, Tapes, IQ

For each criterion measure the predictors are listed in descending order or magnitude. If the first predictor is significantly greater than zero, it is underlined. If each succeeding predictor adds significantly to that predictive value, it is also underlined.

From this array it can be seen that the Biofeedback treatment was the most significant predictor for eight of the eleven criterion gains variables and added significantly to two other predictors. Decreasing number of errors on the Bender was the only criterion measure to which Biofeedback treatment did not contribute significantly. However, no other predictor variable significantly predicted decrease in Bender errors.

Listening to prerecorded relaxation tapes was the best predictor of gains in Reading Comprehension and Biofeedback training significantly enhanced the predictability. The Tape was the significant additional

predictor for three other criterion variables, Math, Spelling and Total Achievement on the PIAT. Either Biofeedback or Tapes was a significant predictor or additional predictor for all criterion measures but the Bender which had no significant predictors.

IQ, Age, and Sex were not significant predictors or contributors to any of the criterion measures while Handwriting Practice was the most significant predictor of Penmanship gains and added significantly to Biofeedback to predict increased Auditory Memory. Lastly, but importantly, controlled handwriting practice was the best indicator of improvement in Penmanship. Biofeedback did, however, significantly add to this improvement.

In general, Biofeedback training and listening to relaxation tapes, especially in combination, appeared to enhance general attention level and verbal facility. These results are quite consistent with those obtained in the pilot study. Biofeedback and relaxation training for learning disabled children appears to permit better access to both current and previously learned academic and cognitive information. Learning and recall appear to be most effective when the learner is physically relaxed and mentally attentive to the material being presented. The biofeedback relaxation procedures seem to counteract the internal stress encountered by learning disabled children by giving them more direct control over the fight--flight response. This, in turn, appears to result in greater attending and recall. Consequently, there is an increased ability to cope academically.

Follow-up Results

At this point an important issue is raised. To what extent would

these experimental gains be maintained over time? Attempting to answer this question was an important feature of the second year of this project. A random 50 percent sample of the first year subjects was obtained representing two groups: 1) those subjects receiving any combination of Biofeedback or Tape relaxation training, and 2) those subjects not receiving Biofeedback or Tape training. In all, 56 experimental children were located and administered the same dependent tests as administered originally.

The children were administered the follow-up test battery between nine and 10 months after their treatment. The data were analyzed by using "t" tests for repeated measures.

Table 4 presents a summary of the results of the follow-up for subjects who received Biofeedback, Tape, or a combination of the two as treatment. For each dependent measure the mean pretest, posttest and follow-up test is presented along with the probability of each change. There is also a brief concluding statement concerning the long range effect of the treatment for each dependent measure.

Table 4 About Here

On all dependent measures but one, Information, there were significant gains ($p. < .01$) between pre and posttest. This is slightly different from the results presented originally because group composition is different.

The probability of the change between posttest and follow-up is

also presented. Of the 11 subtests, three continued to show improvement 10 months after either Biofeedback or Tape training. Six measures held level over time and only one, Reading Comprehension, showed a significant decrease in the 10 months between posttest and follow-up test times. No change was observed between either test period for Information.

In summary, the long range positive effects of the Biofeedback and/or Tape treatment were maintained or continued to improve on nine of the 10 dependent measures which originally showed significant improvement. And importantly, the original significant gains in oral reading, spelling, and handwriting continued to improve over time.

Table 5 presents a summary of the test data for 26 subjects who did not receive Biofeedback or Tape treatment. Only one gain, Handwriting, was observed between pre and posttreatment and no significant changes were obtained on any of the dependent measures between posttest and follow-up. Of course, no significant decreases were noted either.

Table 5 About Here

The contrast between the two groups is impressive. Those subjects who received the most viable experimental treatments, Biofeedback and Tapes showed significant immediate improvement on 10 of 11 dependent measures, and these were maintained or improved over time. Children who did not receive these treatments showed improvement on only one of the eleven variables initially, and their follow-up scores tended to decrease slightly, if not sifnificantly.

A second investigation was undertaken to determine the degree to which the treatments, EMG Biofeedback and Tapes, could be administered by teachers in their school setting. Also, possible placebo or attention effects of treatment was to be determined as well as comparing effects of treatment conducted in the public school setting with that obtained in the clinical setting of the university Diagnostic Education Center.

With these objectives in mind, 90 learning disabled children (as defined in the first year of this project) were chosen from the area cooperating schools. Once selected for the investigation pool of subjects, they were randomly placed into one of the five following groups, four public schools and one clinical setting:

1. Biofeedback: 18 experimental subjects received EMG frontalis biofeedback
2. Tapes: 21 subjects listened to prerecorded relaxation tapes
3. Placebo/games: 16 subjects received equal attention playing educational games, such as Phonics Bingo. This was to control for the possible effects of attention and/or motivational set to learn.
4. Control/no treatment: 17 subjects only identified and administered the pre and posttreatment test battery
5. Center: 18 subjects received relaxation training in the university Diagnostic Education Center by experienced graduate students. This group was used to compare the effects of training in the schools by school personnel with the results obtained in the more clinically oriented university center.

The intention was to have 18 children in each group but attrition and

"slippage" slightly altered the number in three of the groups.

All subjects were administered the following tests one week preceding and one week after treatment:

Slosson Intelligence Test	Bender Visual Motor Gestalt
Wide Range Achievement Test	Simple Auditory Memory
Gray Oral Reading Test	Handwriting Evaluation

The Tennessee Self-Concept Test was scheduled but many teachers pleaded time constraints. Accordingly, that test was discarded as a dependent measure. All handwriting evaluation was done by two fourth-grade teachers. Pre and posttreatment samples were coded and randomly assigned to the two teachers to evaluate. Finally, all testing was conducted by graduate education and psychology students who were unaware of the nature of the investigation and group placement of the children.

Each of the public school subjects received his randomly assigned treatment three days a week for six weeks. The four public school treatment groups were treated as follows:

1. Biofeedback--Subjects were taken individually to the training room and seated in a bean-bag chair. Lights were dimmed. Electrodes were attached to the flexor muscles of his preferred writing arm. An auditory tone synchronized to indicate muscular tension was heard. The child was instructed to lower the volume and pitch of the tone by relaxing the arm muscles. Immediate and continuous auditory feedback was present. An integrator displayed the mean EMG muscle tension level each two minutes. The child was asked to see if he could get each subsequent reading lower than the previous one. This lasted 20 minutes.

2. Tapes--Small groups--three to five children were taken to the training room with dimmed lights. They were seated in the bean-bag chair with the teacher to the side and slightly behind. The prerecorded audio cassette relaxation exercises were played and the child asked to follow the directions. Each was assisted as necessary. This continued for 20 minutes.
3. Placebo/Games--Small groups of three to five children were taken to the training room and seated around a table with the teacher. They then selected what to play from an array of educational reading and spelling games, such as Language Lotto. The children and teacher then played the games for 20 minutes.
4. Control--These subjects were only identified and received the pre and posttest battery.

Project graduate students and the director trained the teachers in the procedures and continually monitored and assisted the teachers throughout their delivery of the programs.

Nine cooperating teachers in three area school districts volunteered to receive the training and then to deliver the treatment to learning disabled children. In order to counteract possible teacher effects, each teacher worked with children in two treatment groups. For example, one teacher trained some children in Biofeedback and some in the Tape group. Another teacher worked with children representing the Games and Tape or Biofeedback group. The treatment groups remained small, ranging from three to five children receiving Games or Tape Treatment. Biofeedback training was conducted individually.

Training the teachers in biofeedback procedures proved to be very difficult and time consuming. The teachers were trained individually

and in groups of three for over 20 hours by experienced graduate assistants. As a group, the teachers never became comfortable with the EMG instrument. They tended to focus undue attention on the instrument rather than on the children. The teachers, however, had no difficulty in learning the procedure with the relaxation tapes or educational games.

Table 6 summarizes the results of training of all groups. For each dependent measure, the mean pretest, posttest and difference scores are presented for each experimental group. The probability of attaining those changes utilizing "t" tests for repeated measures is also presented. The first four treatment groups listed were trained in the schools by the cooperating teachers. These are listed in order of number of significant gains attained.

Table 6 About Here

Children who were supervised in listening to the relaxation tapes by the teacher trainer showed significant gains ($p. < .01$) on all eight dependent measures. In contrast, those children who received EMG biofeedback training made significant ($p. < .01$) gains on only three of the eight measures. It should be noted that three other measures approached significance, Reading ($p. = .057$), Spelling ($p. = .062$), and Handwriting legibility ($p. = 081$). Teachers were more effective in obtaining gains using relaxation tapes than when they were utilizing biofeedback.

The placebo group that played educational games also made significant gains, but only at the .05 level of confidence. Both measures of reading increased significantly ($p. < .05$) and spelling approached significance ($p. = .068$). This is not unexpected as all games involved practice with reading or spelling skills.

Finally, the control group children showed significant improvement only on the WRAT reading test ($p. < .05$).

It is concluded that teachers can deliver the relaxation program within the school setting and obtain statistically and practically significant improvement in the basic academic skills of their learning disabled children. Further, the teachers were more adept at learning to use prerecorded relaxation tape procedures than they were in learning to use the EMG biofeedback instruments. It is felt that assisting children to listen to cassette tapes is more consistent with the teachers' training, experience, and role than is using the complex biofeedback instruments currently available.

The final objective at this point was to compare results made in the schools with those made in the more clinically oriented setting of the university Diagnostic Center. It should be noted that the three university graduate assistants each had over one years supervised biofeedback treatment experience. Also, in addition to 20 minutes of EMG biofeedback training, the experimental group children listened to the same prerecorded relaxation cassette tapes at home three times per week. They received the training in groups of six.

A comparison was made between the relaxation tape group of children in the schools and the university group children. The Tape

group was selected for the comparative group because they made the most significant gains of any of the groups of school children. A one-way analysis of variance was computed between the two groups utilizing difference scores. On five of the dependent measures, SIT, Reading, GORT, Memory, and Writing the Center group gained significantly ($p. < .01$) over the school Tape group. Spelling also showed significant ($p. < .05$) gains by the university group. No differences were found between gains in the two groups on Arithmetic or Bender decrease in errors. The school Tape group did not improve more than the University Center group on any dependent measure.

It is our conclusion from the data that more clinically based treatment by experienced personnel is the most effective way to produce positive change in academic skills of learning disabled children. However, significant changes can be brought about in students by teachers trained in the delivery of prerecorded relaxation training; the magnitude of change is just not as great as those obtained by well-trained and experienced clinicians.

The primary objective of the third and final year of this project was to field test a self-contained instructional training package to be used in the schools by teachers with learning disabled children. Since it had been determined that teachers had difficulty learning to use the biofeedback equipment and that they were able to obtain significant improvement with their children while using the relaxation tapes, it was decided to field test a training package using the tapes as the vehicle for relaxation.

Accordingly, the six prerecorded relaxation exercise tapes

developed by the experimenter prior to this investigation and used during the earlier phases of this investigation were used in the preplanned sequence. Also, a handwriting improvement handbook was assembled. Handwriting exercises previously developed by the investigator were used and coordinated with the cassette tapes. Included in the handbook was an instructional manual for the teachers. The manual included a brief theoretical overview and rationale of the program along with specific instructions on how to use the program on a session-by-session basis. Twelve training sessions and an informal progress evaluation form were included. The kit was designed to be self-contained, requiring little supervision of the teachers.

During the fall of 1982 the six coordinators selected 10 to 12 teachers each to use the program with their identified learning disabled children. Following a briefing by the project director each coordinator in turn oriented the teachers. The coordinators were responsible for arranging for the appropriate pre and posttesting of the children and collecting the data. All data were then forwarded to the project director for analysis.

Each cooperating teacher was responsible for using the program with 6 to 10 children. The original intention was for them to use the program for 30 minutes three times per week for 10 weeks, but individual scheduling difficulties rendered this impossible. Consequently, the teachers varied considerably in the number of times they used the program. Some worked with the program twice a week for 8, 10, or twelve weeks, while others worked three times per week for 6, 8, or 10 weeks. An attempt was made by the project director to keep track of these scheduling variances for

analysis, but this proved impossible. Most of the time that information was not available.

This unexpected variability in scheduling resulted in strengthening the project. The original intention was for teachers to be able to obtain a kit, read the instructions, and put the program to use with their children within the constraints of their own schedules and unique teaching styles. That is exactly what they did.

The group of children labeled "clinical" were not diagnosed as having an exceptionality or disability other than in handwriting. These children were referred by teachers or parents for assistance in developing more adequate handwriting skills.

In all, 82 teachers from 24 different schools representing 10 districts in four states participated in this study. The schools represented a diversity of locales: rural, small town, urban, and suburban. A total of 801 school children used the relaxation/handwriting improvement kit. The teachers used the kit with the special education children in their classes; 650 learning disabled and 79 emotionally disturbed children comprised this sample. It is assumed that all children met the state criteria for admission to their respective special education programs.

During the week prior to receiving the program the children were administered the following tests:

Slosson Intelligence Test	Bender Gestalt Test
Wide Range Achievement Test	Simple Auditory Memory Test
Gray Oral Reading Test	Handwriting Sample

The children were posttested the week following the termination of the program. Behavior ratings of the children by the parents and teachers

were also requested, but too few were returned for analysis.

The area coordinator arranged for all testing to be done by examiners uninformed as to the nature of the project. When all pre and post assessments were completed and scored they were forwarded to the project director for analysis.

Tables 7 and 8 present a summary of the pre, post and gains scores made by each group on all dependent measures. As a group the 650 learning disabled children showed very significant gains ($p. < .000$) on all dependent measures. These gains ranged from over five points IQ, approximately one-half year gain on both reading tests, and a third of a year and one-fourth of a year gain in spelling and arithmetic respectively. Using the Koppitz (1963) scoring system, errors on the Bender Gestalt decreased by over 1.5 points and auditory memory increased four units. Handwriting also showed improvement on the five-point legibility scale.

Table 7 About Here

The 79 emotionally disturbed children were more than two and a half years older than the other groups. All of the emotionally disturbed children were in secondary level programs whereas other groups represented elementary and secondary age children. Except for spelling, the emotionally disturbed children showed very significant gains ($p. < .01$) on all dependent measures. Spelling improvement was significant at the .05 level of confidence. The emotionally disturbed children made their most dramatic improvement on measures of auditory memory and arithmetic.

Both are measures of concentration or focused attention.

Table 8 About Here

Children who were not diagnosed as having an identifiable disability but who had difficulty with written expression received their relaxation training by more experienced clinicians. These children were referred primarily because of their handwriting disability. Encouragingly, they made their most dramatic gains on the measure of writing legibility. Of the three groups, pretest showed the "clinically trained" group to be lowest in handwriting. At posttest they were the highest. The "clinical" group not only showed the highest mean IQ at pretest, they also made the greatest gains on IQ. Interestingly, the "clinical" group also showed no gains beyond chance in arithmetic although the teacher trained groups made significant improvement ($p. < .01$). All other measures showed very significant gains ($p. < .01$).

When magnitude is considered, the "clinical" group made the greatest gains on five of the eight dependent measures while the emotionally disturbed made the most improvement on two of the eight. The learning disabled group was first on one of the eight. This preponderance of gains made by the clinical group is especially important since they showed no deficits on the pretest measures of achievement, reading, spelling and arithmetic. Although younger, they scored a year or more above the children who were learning disabled or emotionally disturbed. These children were initially most deficient

in handwriting legibility, the very area of achievement in which they made the most gains.

These results are consistent with those obtained during the second year of this project. It was clearly demonstrated that the relaxation tape program used by teachers with learning disabled children enhanced and improved the children's academic skills. Table 9 compares the gains made by the 18 learning disabled children receiving relaxation training during the third year of the project. The results are remarkably similar. Both groups made highly significant gains ($p. < .01$) on all dependent measures. Even the magnitude of the gains are essentially the same.

Table 9 About Here

In addition, a local school district asked to use the relaxation kit with a small number of underachieving gifted children. The request was granted with the condition that the same pre and posttest data be obtained. This was agreed to but only sporadically carried out with 12 identified "underachieving gifted" children. The definitions of "underachievement" and "gifted" were not detailed, and data were not consistently obtained. Consequently, the results were not statistically analyzed. Nevertheless, the scores which were obtained were very encouraging. Improvement was observed on the measures of achievement, reading, spelling and arithmetic as well as in auditory memory. Slosson IQ, Bender and handwriting showed no change, but these variables were very adequate at the beginning of treatment.

Summary

The investigations reported here indicate that academic performance of learning disabled children can be markedly enhanced through a program of systematic relaxation training. Significant improvements following such training were obtained in verbal IQ, reading, spelling, arithmetic computation, auditory memory, eye-hand coordination and written expression. Relaxation training in the form of EMG biofeedback and listening to prerecorded audio relaxation tapes were used to enhance these abilities in learning disabled children of all ages.

Trained clinicians were able to bring about greater gains than were teachers who had little clinical training. The greatest changes were effected by experienced clinicians using a combination of EMG biofeedback and prerecorded relaxation tapes.

Although there were individual variations, teachers as a group were able to bring about greater positive changes in their learning disabled children when using prerecorded relaxation tapes than when using the complex biofeedback equipment. Teaching children to learn to relax by listening to the tapes is more consistent with the teachers' training and experience than is using biofeedback instruments.

It is concluded from these investigations that the clinically based biofeedback treatment by experienced personnel is the most effective way to produce positive change in academic skills of learning disabled children. Unfortunately the cost of equipment and trained personnel make such treatment far more expensive than the use of prerecorded relaxation tapes by teachers. The implication for cost effectiveness is that the teachers might work with the majority of

children in small groups with the tapes. The children who do not respond or who respond only minimally could then be referred for more intensive individualized treatment by trained and experienced personnel.

In order to determine if the gains were stable over time, a follow-up evaluation was made 10 months after the original relaxation training. The learning disabled children who received the relaxation tape or EMG biofeedback training either maintained or continued to improve on nine of the 10 dependent measures. Children who did not receive either treatment showed no improvement over time except in handwriting. Apparently, once the children learned to control their internal level of arousal their attention and memory improved and they could cope more adequately with school learning tasks.

The data also indicate that the placebo or attentional effects upon the results were minimal. The learning disabled children who played educational games rather than receiving relaxation training (either tape or biofeedback) showed gains only slightly greater than the control group.

Finally, it was demonstrated that a packaged kit composed of prerecorded relaxation tapes and a handwriting workbook with instructions could be used effectively by teachers with their learning disabled children. The improvements in cognitive, achievement, and psychomotor abilities were of such a magnitude as to be of practical importance in the classroom as well as being highly significant statistically. It is important to note that these results were obtained by 650 learning disabled children and 82 teachers in 24 different schools.

This relaxation package was also used with 79 secondary age

emotionally disturbed children. They made significant gains on all dependent measures and their most dramatic improvements were on measures of auditory memory and arithmetic computation. Both are measures of focused attention.

A group of children who presented no identifiable handicap other than difficulty with written expression also showed significant improvement when trained by experienced clinicians.

The program was also used with a small group of underachieving gifted elementary children. Although not analyzed statistically, the results were encouraging. Improvement was observed on measures of reading, spelling, and arithmetic. In an earlier study, Carter (1974) demonstrated that a similar program was effective in increasing attention and academic test scores of educable mentally retarded adolescents.

These results clearly indicate the viability of both EMG biofeedback and prerecorded tape relaxation training for improving academic functioning of learning disabled children. The tape relaxation training can be done by teachers with minimal orientation and the positive results are maintained over time. Application of these procedures appears to be appropriate for a variety of handicapped children including learning disabled, educable mentally retarded, emotionally disturbed and nondiagnosed children with academic learning problems.

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Table 1: Mean and Standard Deviations of Pre and Posttest of all Criterion Measures.

	Mean			Standard Deviation		
	Pre	Post	Dif	Pre	Post	Dif
Slosson IQ	86.121	91.667	5.546	10.157	11.958	1.801
Peabody (PIAT)						
Math	81.773	86.576	4.803	9.641	10.796	1.155
Read Rec.	80.864	85.349	4.485	11.868	12.218	.350
Read Comp.	81.424	87.612	6.188	12.079	13.264	1.185
Spell.	79.667	83.939	4.272	8.995	10.750	1.755
Info.	86.091	89.788	3.697	10.489	11.675	1.186
Total	79.636	85.106	5.470	9.344	10.669	1.325
Gray Oral Reading	2.414	2.994	.530	1.501	1.688	.187
Bender	7.197	4.167	-3.030	3.799	2.582	-1.217
AudMem	13.288	17.909	4.621	3.181	5.380	2.199
Penman	1.833	2.288	.455	.669	.799	.130
C.A.	10.12					

Table 2: Intercorrelation Matrix of all Variables

	Predictors						Dependent/Criterion										
	Bio	Write	Tape	Home	Age	Sex (F)	SIT	Math	Read R.	Read C.	Spell	Info.	Total	Gray	Bender	Aud Mem	Penman
Biofeed	1.00	-002	-002	-091	-085	-072	599***	349**	496***	331**	524***	454***	602***	526***	-098	629***	219
Writing		1.00	079	040	-016	-182	107	114	114	053	132	-004	208	110	-143	241	522*
Tapes			1.00	023	005	085	096	310*	180	397**	281*	-030	348**	141	-076	061	060
Home				1.00	-004	-027	-233	032	081	-038	-055	070	096	113	-020	-068	-024
Age					1.00	-198	-129	-175	-149	-042	077	-155	-014	020	306*	115	062
Sex (F)						1.00	031	-144	152	-169	-136	-131	-068	-112	-110	-056	-088
SIT							1.00	425***	215	216	291*	334**	467***	468***	166	534***	195
Math								1.00	266*	418***	359**	274*	610***	465***	-321*	364**	107
Read Rec.									1.00	311*	311*	391**	590***	350**	-058	451***	093
Read Comp.										1.00	342**	137	605***	411***	-084	251*	245
Spell											1.00	247	602***	410***	048	413***	252*
Infor.												1.00	577***	418***	052	301*	019
Total													1.00	584***	-151	460***	193
Gray														1.00	-173	535***	227
Bender															1.00	-238	-134
Aud Mem																1.00	434*
Penman																	1.00

Note: r sig. for 100 df
*.05 = .250
**.01 = .325
***.001 = .408

Table 3 Summary of Data Analysis;

Multiple Regression and Tests of Significance

		R (cumulative)	B	F	Rho p. (cumulative)
SIT					
	Bio	.5992	7.2983	35.092	.000*
	Writ	.6088	1.5534	1.594	.284
	Tapes	.6161	1.2678	1.076	.291
	Sex F	.6243	-1.1084	.735	.615
	Hi IQ	.6258	-.5224	.181	.673
	(Constant		-1.0434)		
Math					
	Bio	.3493	3.6184	8.198	.026*
	Tapes	.4671	3.5555	8.049	.159
	Writ	.4876	1.3968	1.225	.212
	Sex F	.4963	-1.0731	.654	.587
	Hi IQ	.4985	.5318	.178	.676
	(Constant		.3351)		
Read Rec					
	Bio	.4963	4.6961	26.162	.008*
	Sex F	.5308	1.8073	3.517	.084
	Tapes	.5560	1.6930	3.458	.122
	Hi IQ	.5767	-1.2668	1.918	.149
	Writ	.5970	1.6353	2.218	.142
	(Constant		-.5547)		

Table 3 Continued:

	(cumulative)	B	F	Rho p. (cumulative)
Read Comp				
Tapes	.3973	4.9491	15.333	.011*
Bio	.5175	3.8806	9.269	.005**
Sex F	.5477	-2.1160	2.502	.097
Writ	.5504	.5915	.216	.616
Hi IQ	.5553	-.8719	.478	.500
(Constant		4.7625)		
Spelling				
Bio.	.5239	5.4899	23.131	.003*
Tapes	.5950	3.2454	8.221	.037*
Writ	.6150	1.5848	1.933	.125
Sex F	.6227	-1.1290	.888	.664
Hi IQ	.6263	.7618	.449	.511
(Constant		-1.4699)		
Information				
Bio	.4543	5.5235	15.483	.026
Sex F	.4650	-1.3317	.769	.616
Tapes	.4654	-.2784	.038	.842
Writ	.4660	-.2976	.046	.830
(Constant		2.6213)		

Table 3 Continued:

	(cumulative)	B	F	Rho p. (cumulative)
Total PIAT				
Bio	.6048	4.6307	45.676	.000*
Tapes	.6985	2.8544	17.649	.001*
Writ	.7377	1.8073	6.977	.010*
Hi IQ	.7379	-.1199	.031	.857
Sex F	.7380	-.1101	.023	.873
(Constant		.3033)		
Gray Read				
Bio	.5265	.5170	21.244	.007*
Tapes	.5453	.1535	1.904	.184
Writ	.5589	.1182	1.113	.249
Sex F	.5628	-.7088	.362	.538
Hi IQ	.5658	.6107	.299	.591
(Constant		.6982)		
Bender				
Writ	.1429	-.9948	1.912	.538
Sex F	.1987	-.8506	1.263	.268
Bio	.2264	-.6091	.758	.613
Tapes	.2392	-.4417	.387	.541
Hi IQ				
(Constant		-.6878)		

Table 3 Continued:

	(cumulative)	B	F	Rho p. (cumulative)
Aud Mem				
Bio	.6288	5.7359	39.259	.001
Writ	.6739	2.4648	7.270	.015**
Hi IQ	.6805	.8407	.850	.312*
Tapes	.6842	.6539	.519	.541
Sex F	.6849	.3158	.108	.742
(Constant		-2.2488)		
Penman				
Writ	.5216	1.0256	24.939	.004*
Bio	.5662	.4218	4.458	.040*
Sex F	.5667	.3443	.023	.820
Tapes	.5655	.1944	.920	.657
Hi IQ				
(Constant		-.5705)		

Note:

F sig @ .05 =

F sig @ .01 =

* significant at either level

**significant improvement @ .05 level

Table 4: Summary of Follow-Up Results of Subjects Receiving Biofeedback and/or Relaxation Tape Treatment

n=56

Dependent Measures	Pre-Test	(p.)	Posttest	(p.)	Follow-Up	Conclude
Slosson Intelligence Test	88.43	(<.01)	95.50	(.48)	93.42	Gains held level over time
Peabody Individual Achievement Test						
Math	83.19	(<.01)	88.88	(.912)	88.81	Gains held level over time
Read Recog.	83.11	(<.01)	87.04	(.437)	86.54	Gains held level over time
Read. Comp	84.92	(<.01)	91.62	(.016)	89.42	Gains dropped over time but is still sig. greater than original pretest
Spelling	81.38	(<.01)	86.19	(.285)	87.08	Gains continue to occur over time
Information	91.04	(.838)	91.88	(.687)	91.54	No significant effects
Total	82.08	(<.01)	87.92	(.134)	86.58	Gains held level over time
Gray Oral Reading	2.37	(<.01)	2.84	(<.01)	3.38	Gains continue to improve over time significantly
Bender (Koppitz)	7.88	(<.01)	4.73	(.400)	4.27	Gains held level over time
Auditory Memory	13.58	(<.01)	17.81	(.847)	17.92	Gains held level over time
Handwriting	1.96	(<.01)	2.46	(<.01)	2.81	Gains continue to improve significantly over time

Table 5: Summary of Follow-Up Results of Subjects Not Receiving Biofeedback and/or Relaxation Tapes n=26

Dependent Measures	Pre-Test	(p.)	Posttest	(p.)	Follow-Up
Slosson Intelligence Test	91.3	(.53)	91.7	(.47)	92.6
Peabody Individual Achievement Test					
Math	82.6	(.44)	83.4	(.49)	82.2
Read Rec.	85.3	(.37)	84.7	(.63)	85.9
Read. Comp.	93.3	(.91)	96.4	(.13)	93.8
Spelling	80.7	(.60)	81.1	(.35)	80.4
Information	84.5	(.25)	86.1	(.41)	85.8
Total	83.0	(.43)	84.3	(.72)	82.2
Gray Oral Reading	3.9	(.11)	4.1	(.16)	4.3
Bender errors	6.3	(.09)	5.6	(.42)	6.1
Auditory Memory	16.7	(.28)	15.3	(.74)	16.1
Handwriting	2.1	(.04)*	2.3	(.39)	2.4

N=26

Table 6: Summary of Means, Differences and Probabilities for All Treatment Groups on all Dependent Test Measures

TREATMENT n=90	SIT	WRAT Read	WRAT Spell	WRAT Arith	GORT	Memory	Bender	Writing Legibility	C.A.
Relaxation Tapes n=21									
Pre-test	80.38	76.95	75.43	78.57	1.93	13.29	6.19	2.32	10.75
Posttest	84.09	80.67	78.71	80.81	2.31	15.57	4.48	2.84	
Difference	3.71	3.72	3.28	2.24	.38	2.28	-1.71	.52	
p.	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	
EMG Biofeedback n=18									
Pre-test	91.83	83.22	87.44	83.22	2.75	15.56	5.61	2.19	10.89
Posttest	94.06	86.33	90.56	84.67	3.28	17.50	4.11	2.51	
Difference	2.23	3.11	3.12	1.45	.53	1.94	-1.50	.32	
p.	.154ns	.057ns	.062ns	.358ns	<.01	<.01	<.01	.081ns	
Educational Games n=16									
Pre-test	92.25	81.69	82.56	84.50	2.55	14.48	5.06	2.29	10.64
Posttest	93.81	84.13	85.38	86.56	2.86	15.89	3.98	2.47	
Difference	1.56	2.44	2.82	2.06	.31	1.41	-1.08	.18	
p.	.178ns	<.05	.068ns	.144ns	<.05	.187ns	<.05	.239ns	
Control n=17									
Pre-test	87.82	75.24	78.82	79.76	2.13	14.47	4.59	2.24	10.40
Posttest	87.76	77.41	76.88	81.29	2.25	15.65	4.06	2.46	
Difference	-.06	2.17	-1.94	1.53	.12	1.18	-.53	.22	
p.	.962ns	<.05	.961ns	.175ns	.051ns	.330ns	.332ns	.187ns	
University Center n=18									
Pre-test	89.94	81.28	81.83	84.39	2.51	13.39	6.44	2.18	10.91
Posttest	96.39	88.00	86.89	85.44	3.12	18.67	4.67	3.24	
Difference	6.45	6.72	5.06	1.05	.61	5.28	-1.77	1.06	
p.	<.01	<.01	<.01	.283ns	<.01	<.01	<.01	<.01	

Legend
SIT: Slosson Intelligence Test
WRAT: Wide Range Achievement Test
GORT: Gray Oral Reading Test
Bender: Koppitz scoring of Bender Gestalt Test
CA: Chronological age at pre-test

Table 7 = Means and Standard Deviations of Pretests, Posttests, and Gains for all Treatment Groups

Dependent Measures	C. A. (Pretest)		Slosson IQ		Wide Range Achievement Test: Read		Wide Range Achievement Test: Spell		Wide Range Achievement Test: Arith		Gray Reading		Bender		Auditory Memory		Hand-writing	
	X	S.D	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D.	X	S.D
Learning Disabled n=650	135.83	23.41																
Pretest	11 yrs. 4 mos.		85.73	14.27	3.83	1.58	3.52	1.51	3.62	1.26	2.97	1.82	4.26	2.74	16.59	5.65	1.66	.64
Posttest			90.84	15.54	4.29	1.79	3.89	1.67	3.87	1.37	3.62	2.13	2.73	1.95	20.60	6.72	2.13	.79
Gains			5.11**		.46**		.37**		.25**		.65**		-1.53**		4.01**		.47**	
Emotionally Disturbed n=79	166.74	21.74																
Pretest	13 yrs. 11 mos.		86.90	13.19	4.37	1.47	3.65	1.66	3.83	1.23	3.69	1.39	2.65	2.04	23.05	9.67	1.65	.75
Posttest			89.69	12.19	4.83	1.51	3.91	1.40	4.21	1.25	4.31	1.43	1.59	1.57	28.97	10.06	2.22	.75
Gains			2.79**		.46**		.26*		.38**		.62**		-1.06		5.92**		.57**	
Clinical Setting n=72	134.13	31.91																
Pretest	11 yrs. 2 mos.		101.20	16.99	5.47	2.11	4.65	1.94	4.56	1.87	4.49	3.19	3.16	2.33	19.52	6.37	1.42	.52
Posttest			107.00	18.57	5.91	2.13	5.12	1.79	4.72	1.87	5.28	3.24	2.13	1.77	23.88	6.15	2.75	.45
Gains			5.80**		.44**		.47**		.16 n.s.		.79**		-1.03**		4.36**		1.33**	
Composite (above) n=801	138.59	25.94																
Pretest	11 yrs. 6 mos.		86.23	15.45	4.05	1.70	3.66	1.61	3.74	1.36	3.17	1.98	4.01	2.69	17.45	6.49	1.65	.6
Posttest			91.19	16.57	4.51	1.87	4.03	1.69	3.99	1.44	3.83	2.24	2.57	1.93	21.67	7.48	2.16	.7
Gains			4.96**		.46**		.37**		.25**		.66**		-1.44*		4.22**		.51**	

Note: ** $p < .001$ *$P < .05$

Table 8 = Mean gain, standard deviation of gain, "t" value, and p. of dependent measures

	Slosson IQ	Wide Range Achievement Read	Spell	Arith	Gray Oral	Bender	Auditory Memory	Hand-writing
Learning Disabled								
n=650								
Gains	5.11	.46	.37	.25	.65	-1.53	4.01	.47
S.D. of Gains	9.91	.51	.53	.47	.76	1.91	4.47	.87
"t" value	9.30	16.13	12.50	9.80	15.31	14.39	16.08	9.27
2-tail probability	.000	.000	.000	.000	.000	.000	.000	.000
Emotionally Disturbed								
n=79								
Gain	2.79	.46	.26	.38	.62	-1.06	5.92	.57
S.D. of Gains	5.56	.67	.69	.63	.42	1.39	5.85	.93
"t" value	3.14	4.21	2.35	3.76	9.24	4.50	6.24	3.72
2-tail probability	.003	.000	.024	.001	.000	.000	.000	.001
Clinical Setting								
n=72								
Gain	5.80	.44	.47	.16	.79	1.03	4.36	1.33
S.D. of Gain	8.04	.87	.90	1.12	1.59	1.45	6.31	.49
"t" value	4.27	3.25	3.44	.94	2.91	4.03	3.97	9.38
2-tail probability	.000	.002	.001	.354	.006	.000	.000	.000

Table 9: Mean Gains of Learning Disabled Children In Four Treatment Groups

	Current Experimental	Earlier Experimental	Placebo Control	No-Treatment Control
C. A.	11.33	10.75	10.64	
Slosson IQ	5.11**	3.71**	1.56	1.06
Reading	.46**	.41**	.27*	.22*
Spelling	.37**	.32**	.19	.15
Arithmetic	.25**	.24**	.16	.21
Gray	.65**	.38**	.31*	.12
Bender	-1.53**	1.71**	-1.08*	-.53
Aud Mem	4.01**	2.28**	1.41	1.18
Handwriting	.47**	.52**	.18	.22
N=Teachers	71	9	4	4
Children	650	18	18	18

* $p. < .05$
** $p. < .01$

50