Neurofeedback for Elementary Students with Identified Learning Problems

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ABSTRACT. *Introduction*. The goal of this research was to ascertain whether basic reading, reading comprehension, the reading composite, and IQ scores could be improved using neurofeedback. Pre-test and post-test reading and cognitive assessments were administered to sixth, seventh and eighth graders identified as having learning problems. Control and experimental groups were chosen at random. With the exception of three students, every student in the control and experimental group had previously been diagnosed with Specific Learning Disabilities or as Other Health Impaired according to State and Federal guidelines for special education services. The three students were medically diagnosed as having ADHD and were on a 504 Accommodation Plan.

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Method. The research began in late August 2001 with securing administrative and parental permissions. Student participation began during the last week in September and lasted through the last week in April. A day was set aside to administer QEEGs (also called "brain maps") to the students in the experimental group. Protocols were developed by following the brain maps and by using clinical judgment after staffing the students with their teachers on a regular basis; their psychoeducational evaluations were also used to plan the protocols. Following the statistics on the biofeedback machines also influenced protocol decisions. Neurofeedback training was provided to the participants of the experimental group only. Both the experimental group and the control group had their Individualized Educational Plans (IEP) or 504 Plans plus their general curriculum plans. Neurofeedback training lasted approximately 30 to 45 minutes within each one-hour time block. The sessions were conducted weekly for the seven-month period. Some students received more sessions than others because of absences, field trips, testing and other natural rhythms of home and school life. The average number of sessions per student was 28.

Results. Neurofeedback was more effective in improving scores on reading tests than no neurofeedback training. There were significant interactions between neurofeedback and time on basic reading. Wilks' lambda (Λ) = .69, $F(1, 23) = 10.32$, $p < .01$, on reading comprehension, $\Lambda = .75$, $F(1, 23) = 7.62$, $p = .01$, and on reading composite scores, $\Lambda = .65$, $F(1, 23) = 12.59$, $p < .01$.

Neurofeedback training was more effective in improving both the Verbal and Full Scale IQ scores than no neurofeedback training. There was a significant interaction between neurofeedback and time on Verbal IQ, $\Lambda = .62$, $F(1, 21) = 12.71$, $p < .01$, and on Full Scale IQ, $\Lambda = .56$, $F(1, 21) = 16.50$, $p < .01$. However, there was not a significant interaction between neurofeedback and time on Performance IQ, $\Lambda = .87$, $F(1, 21) = 3.00$, $p = .10$.

Discussion. The results support the hypothesis that biofeedback training is effective in improving reading quotients. Limitations of the study and ideas for further research are presented. Neurofeedback may be an effective supplement to special education in improving IQ and reading performance.

KEYWORDS. Neurofeedback, EEG biofeedback, learning problems, reading scores, IQ scores, school psychology

INTRODUCTION

Most of the work of a school psychologist is to accurately diagnose children who have learning and/or behavioral problems in order to see whether they are eligible for special education. Psychologists make their recommendations for eligibility in the most effective and efficient manner possible. Accurately diagnosing students impacts many things (e.g., the self-concept of the student, the type of support a student will receive and parental/community perceptions of what a school is supposed to be doing).

Special education has used over $350 billion dollars in Federal money over a twenty-year period. Many special education programs have lacked rigorous scrutiny and research to ascertain whether they have been effective or not. Nonetheless, most of them continue to be funded year after year. Moreover, school psychologists are aware that re-evaluation data often indicates that cognitive functioning frequently decreases in the re-evaluation process, especially six years after the initial evaluation.

The physical sciences have gone through technological evolutions, if not revolutions, in their ability to diagnose illnesses by directly viewing organs, genes and brain functioning. School psychological assessment, however, is almost entirely dependent upon psychometric instruments. Of course, some advocates of statistical procedures justify the use of psychometric tests because they consider that the powers of their mathematical formulas are capable of overcoming the limitations of not being able to observe brain functioning directly.

School psychologists and neurofeedback professionals now have a way to directly observe brain functioning in educational settings through quantitative electroencephalogram and EEG biofeedback (neurofeedback). The capability of quantitative electroencephalogram (QEEG) and EEG biofeedback has the potential to transform school psychology into a whole different profession–from 'test and place' to 'train and heal.'

Neurofeedback is a method that permits the student to pay attention to his or her own brain activity, and then change it if he or she desires, and to eventually control it. The student is provided immediate feedback on what his or her brain activity is like at any given moment through the use of high-speed computers that provide both auditory and visual feedback.

Neurofeedback is an operant conditioning mode of intervention based on the QEEG variables. Brain wave patterns are transmitted via electrodes (sensitive sensors) placed upon discrete sites on the scalp. These electrodes are then connected to a computer. Subsequently, the brain waves respond to the reward-inhibit information provided by the software. The more successful the student is with the computer programs, the more control the student gains in changing his or her brain wave patterns.

Neurofeedback equipment can both track an individual's raw EEG patterns and track how those patterns change. Raw EEG patterns can be collected and compared to validated norms for "normal students" and other children who have been diagnosed with various disabilities. The result is a brain map (also called a QEEG). The brain map then serves as a guide for the trainer because it indicates where to place electrodes on the scalp and how to attempt to normalize brain wave patterns.

Review of the Literature

Neurofeedback has been documented to improve IQ scores (Othmer, Othmer, & Marks, 1992; Tansey, 1991; Othmer, Othmer, & Kaiser, 1999; Linden, Habib, & Radojevic, 1996). Neurofeedback has been said to go beyond supportive psychotherapy because it helps children with learning disabilities reverse dysfunctional neurological and/or psychological processes (Tansey, 1991).

Othmer et al. (1999) reviewed neurofeedback work with learning disabilities from 1984 to May 1998. They concluded, ". . . functional imaging and EEG-biofeedback may yield near-term breakthroughs in the remediation of various specific learning disabilities that have been relatively intractable to date." Boyd and Campbell (1998) reported that five of their six subjects improved from the pre-test to the post-test in their combined WISC-III Digit Span, TOVA Inattention and TOVA Impulsivity scores that suggested improvement of ADHD. They quoted Othmer and Othmer (1999), who demonstrated that the effects of SMR training could have long lasting effects. The successful work of Lubar and Lubar (1984) and Lubar (1991) have encouraged many practitioners to use neurofeedback with ADHD students.

Othmer et al. (1992) reported: "Significant improvements in cognitive skills, academic performance and behavior are found, and confirmed in follow up. Average improvement in WISC-R Full Scale IQ was 23 points." Rossiter and La Vaque (1995) reported that a treatment program using neurofeedback was a major component in the reduction of both cognitive and behavioral symptoms of ADHD after 20 treatment sessions completed over a period of four to seven weeks as compared to a like group being treated with stimulants only. Subjects who had neurofeedback training and drug treatment maintained gains over those using drugs alone. They concluded that neurofeedback might even be the treatment of choice when medication is ineffective or only partially effective, has unacceptable side effects or where compliance with taking medication is low. Kaiser (1997) demonstrated the efficacy of neurofeedback in treating attentional deficits in adults using an outcome study. The study was even more impressive because the subjects involved in the research had already undergone numerous prior treatments including stimulant medication with little or no success-some for over 20 to 30 years. This reached back into elementary school years. Joyce and Siever (2000) speculated that neurofeedback might work because it breaks up neurological rigidities and it increases the brain's functional flexibility.

Finally, of great interest to a school psychologist is the use of neurofeedback for children with autism. An example of this is the article by Jarusiewicz (2002). In this article it was shown that neurofeedback training resulted in a 26% average reduction in rated autistic symptoms using the Autism Treatment Evaluation Checklist (Rimland & Edelson, n.d.) compared to 3% for a control group. Jarusiewicz concluded that using neurofeedback with autistic children could help them improve cognitive functioning and reading proficiency.

It must be admitted, however, that most neurofeedback research has been done without of control groups, and most especially, without the use of a double blind design. This study employed a control and experimental group.

The purpose of this study was to ascertain whether or not neurofeedback training would enhance basic reading, reading comprehension and reading composite scores, as well as verbal, performance and full scale IQ scores versus a control group in a public school setting for children identified as having learning disabilities. Students in the study were from the sixth, seventh and eighth grade special education program. Every student was diagnosed according to State and Federal special education guidelines as having Specific Learning Disabilities or as Other Health Impaired with the exception of three students who were referred to the psychologist with a 504 Accommodation Plan due to complications surrounding a medical diagnosis of ADHD.

The Peoria District considered a significant difference between achievement and potential to be academic standard scores that were one standard deviation from the estimation of cognitive potential. The school psychologist randomly assigned subjects to experimental and control groups for this study.

METHOD

Participant Characteristics

Students had a one one-hour neurofeedback session each week from September 2001 to the end of April 2002. Rarely did a student have two sessions per week. On occasion a student, a teacher or a parent would request an extra session. However, no one had any more than two one-hour sessions a week. The sessions were scheduled as one-hour blocks of time. By the time the student arrived at the office and was prepared to use the equipment, the student received no more than forty-five minutes of treatment time per session. Field days, field trips, standardized testing, sickness and other factors resulted in some missed appointments. Integration of the training sessions into the normal school schedule was achieved without significant conflict, insuring that this study could be easily replicated. The average number of sessions each student received was twenty-eight.

The original experimental group had seventeen students who were randomly selected to participate in this study. Twelve subjects, whose parents agreed to participate, actually finished the project. All students in the experimental group had an Individualized Educational Plan (IEP) or a 504 Behavioral Contract, plus their general curriculum and the experimental variable: the neurofeedback. Two students in the experimental group with a behavioral contract for ADHD did not have previous psychoeducational evaluations on record with requisite IQs documented and one did have this information available. All other students had previous psychoeducational evaluations on record along with requisite cognitive and academic assessments in place. This left only 10 students (M_{age} = 11.27 years, *SD* = 2.00) for the IQ comparisons. These students received no other interventions, at home or at school, other than their IEP or behavioral plans, the neurofeedback and the general curriculum. Two students in the experimental group and three in the control group were using stimulant medication. No effort was made to control for this variable.

Originally, the control group had seventeen students chosen. One student was jailed just as the study started; another was removed from the school and placed in a self-contained program for the mildly mentally retarded and one student moved out of district. The remaining fourteen students (M_{age} = 13.14 years, *SD* = .77) had their IEP plus their general curriculums. All the students in the control group had resource support (pull-out) with the exception of one student who was on a monitor schedule within a mainstream environment. (A monitor program is a system that requires a special education teacher to visit the regular classroom to supervise how a special education student is doing rather than pulling the student out of the classroom for support in a separate setting.)

The study was initiated in August 2001 after securing administrative and parental permissions. Student participation began during the last week in September of 2001. A day was scheduled for the quantitative electroencephalogram (QEEG; brain mapping). After the results of the QEEG evaluation were secured, student participation began with the use of the Lexicor NRS-2D machine. The BrainMaster Type 2E Module machine and its software were put into place during the first week in January. The students were then free to choose which machine they wanted to use. There was no control for this choice. Protocols were chosen by following the QEEG map and by using clinical judgments in conjunction with the equipments' statistics, consultation with teachers as well as parents and the psychoeducational evaluations.

A neurofeedback practitioner in the community volunteered to do the QEEG evaluations for the school using the Lexicor system. He did this on a pro bono basis. He dedicated one day for doing those evaluations. Every student in the experimental group had a QEEG done with the exception of three students who were absent that day. For the nine students who had a QEEG done, the brain maps were used as a protocol guide. The school psychologist

chose the locations using the QEEG data and information obtained from the student and the teacher about how the week was going for that particular student.

For the three students who never received a QEEG, protocols were developed based upon the clinical decisions made by the psychologist and upon information gained from teachers and/or parents concerning the student's behavior for the week. The description of the student in the psychoeducational evaluation was also taken into consideration. Data was also studied from previous and current sessions.

The training goals in all cases were directed to reduce any brain wave pattern considered by the psychologist to interfere with focus and concentration. Regrettably, brain maps were not done as a post project assessment because of the lack of funds and time. Impedance levels were monitored for 5 K ohms for the Lexicor instrument; the BrainMaster machine was self-monitoring inasmuch as the machine indicated when the impedance levels were workable or not.

QEEGs were obtained using Lexicor Medical Technology, Inc. recording equipment (NRS-24). The sampling rate was set to 128 to allow for examination of up to the 32 Hz range with a 60 Hz notch filter. In the system employed in this study, filtering is accomplished in the software. The signals passed are between .5 and 32 Hz (3 dB points). The signals which pass are then subjected to a Fast Fourier Transform (FT) using Cosine-tapered windows, which output spectral magnitude in microvolts as a function of frequency. The bandwidths were divided according to the following divisions: Delta: .00-3.5 Hz, Theta: 4-7.5 Hz, Alpha: 8-12.5 Hz, Beta: 13-31.5 Hz. This equipment provides for the collection of data in the standard 10-20 system (ear linked references) format of EEG collection. Impedances below 5 K ohms, and within 1.5 K of each other, were obtained on all locations. Gain was set to 32000 and the high pass filter was set to off. The earlobes and forehead were prepped with rubbing alcohol and Nu-Prep. An Electro-cap with the requisite 24 leads was employed and spaces filled with Electro-gel. The data was visually analyzed and marked for deletion when artifact was evident.

The school psychologist administered all the post academic and IQ testing. He was also the psychologist who did more than half of the students' previous psychoeducational evaluations used for this study. Other district psychologists produced the remainder of the evaluation data used for pre-test analysis.

Instruments

The previous psychoeducational evaluation results were used as pre-test data. These evaluations used the Wechsler Intelligence Scale for Children–Third Edition (WISC-III; 1991) for the cognitive (IQ) assessment. For a post-cognitive assessment, the Wechsler Abbreviated Scale of Intelligence (WASI; 1999) was used. This instrument was chosen because of its high correlation (.8) to the WISC-III. There was not time to give the WISC-III as a post-test measure. Moreover, sometimes the WISC- III could not be given because it had been administered within the last six months. The WASI had items mostly different from the WISC-III subtest counterparts that reduced the possibility of any practice effect.

The Wechsler Individual Achievement Test (WIAT; 1992) was used as both the pre- and post-test academic assessment instrument for all students with the exception of one student; this student had the Woodcock-Johnson Tests of Achievement-Revised used as a pre-test because it was used in his psychoeducational evaluation. This student was eliminated from the statistical analysis for the academic results. It was interesting to note that his reading scores increased in post-test scores in all areas. Nevertheless, his scores were not factored into the statistical analysis. The WIAT was still used as the post assessment instrument for this student as well. The same academic post-test was given to all students.

Data Analysis

The effectiveness of two levels of student neurofeedback exposure was evaluated: neurofeedback (experimental group), and no neurofeedback (control group) on reading and intelligence tests. It was also an assessment of the effectiveness of the special education program at the school for the sixth, seventh and eighth graders.

The reading test data consisted of basic reading, reading comprehension, and composite scores. The intelligence data consisted of verbal IQ, performance IQ, and full-scale IQ scores. To evaluate the effect of neurofeedback exposure on each of the reading and intelligence scores, two-way between and within subjects' analyses of variance were conducted. The between-subjects factor was neurofeedback with two levels (neurofeedback and control). The within-subjects factor was time with two levels (pre-test and post-test). For each of the analyses, the time main effect and Neurofeedback × Time interaction effect were tested using the multivariate criterion of Wilks' lambda (Λ).

RESULTS

Basic Reading

A two-way between and within subjects ANOVA was conducted to evaluate the effect of neurofeedback (neurofeedback and comparison) and time (pre-test and post-test) on the dependent variable: basic reading. The means and standard deviations for the basic reading scores are reported in Table 1. The time main effect was not significant. Wilks' lambda (Λ) = 1.00, $F(1, 23) = .07$, $p = .79$, partial $\eta^2 = .00$. However, the Neurofeedback × Time interaction effect was significant. $\Lambda = .69$, $F(1, 23) = 10.32$, $p < .01$, partial $\eta^2 = .31$. The significant interaction supports the hypothesis that neurofeedback is more effective than no neurofeedback.

Two paired-sample t-tests were computed to assess mean basic reading score differences between the pre-test and the post-test. We controlled for family wise error rate across these tests using Holm's sequential Bonferroni approach. The results indicated that within the neurofeedback group, the mean basic reading post-test score was significantly greater than the mean basic reading pre-test score, $t(10) = 2.91$, $p = .02$. However, within the control group, the mean basic reading score was not significantly different between the pre-test and the post-test, $t(13) = -2.20$, $p = .05$.

Reading Comprehension

A two-way between and within subjects ANOVA was conducted to evaluate the effect of neurofeedback (neurofeedback and control) and time (pre-test and post-test) on the dependent variable: reading comprehension. The means and standard deviations for the reading comprehension scores are reported in Table 1. The time main effect was not significant. $\Lambda = .98$, $F(1, 23) = .48$, $p = .49$, partial $\eta^2 = .02$. However, the Neurofeedback × Time interaction effect was significant. $\Lambda = .75$, $F(1, 23) = 7.62$, $p = .01$, partial $\eta^2 = 25$. The significant interaction supports the hypothesis that neurofeedback is more effective than no neurofeedback.

Two paired-sample t-tests were computed to assess reading comprehension mean differences between the pre-test and the post-test. Family wise error rate between these tests was controlled using Holm's sequential Bonferroni approach. Within the neurofeedback group, the mean reading comprehension post-test score was significantly greater than the mean pre-test score $t(10) = 2.63$, $p = .025$. However, within the control group the mean reading comprehension score was not significantly different between the pre-test and the post-test, $t(13) = -1.44$, $p = .17$.

Reading Composite

A two-way between and within subjects ANOVA was conducted to evaluate the effect of neurofeedback (neurofeedback and comparison) and time (pre-test and post-test) on the dependent variable: composite reading. The means and standard deviations for the composite reading scores are reported in Table 1. The time main effect was not significant. $\Lambda = 1.00$, $F(1, 23) = .02$, $p = .90$, partial $\eta^2 = 00$. However, the Neurofeedback × Time interaction effect was significant. $\Lambda = .65$, $F(1, 23) = 12.59$, $p < .01$, partial $\eta^2 = .35$. The significant interaction supports the hypothesis that neurofeedback is more effective than no exposure.

TABLE 1. Means and Standard Deviations of Basic Reading, Reading Comprehension, and Composite Reading as a Function of Neurofeedback and Time

Neurofeedback	Time: Pre-test M	Pre-test SD	Post-test M	Post-test SD
Basic Reading				
Experimental (n = 11)	84.09	11.37	88.82	11.50
Control (n = 14)	87.00	11.58	81.43	15.32
Reading Comprehension				
Experimental (n = 11)	83.45	7.71	89.91	11.95
Control (n = 14)	88.36	16.95	84.50	14.99
Composite Reading				
Experimental (n = 11)	81.09	11.48	86.45	12.59
Control (n = 14)	86.43	13.72	81.43	15.38

Two paired-sample t-tests were computed to assess reading composite mean differences between the pre-test and the post-test. We controlled for family wise error rate between these tests using Holm's sequential Bonferroni approach. Within the neurofeedback group, the mean reading composite pre-test score was significantly lower than the mean reading composite post-test score, $t(10) = 2.37$, $p = .04$. Within the control group the mean reading composite post-test score was significantly lower than the reading composite pre-test score, $t(13) = -2.66$, $p = .02$.

Verbal IQ

A two-way between and within subjects ANOVA was conducted to evaluate the effect of neurofeedback (neurofeedback and control) and time (pre-test and post-test) on the dependent variable: Verbal IQ. The means and standard deviations for the verbal IQ scores are reported in Table 2. The time main effect was significant. $\Lambda = .74$, $F(1, 21) = 7.49$, $p = .01$, partial $\eta^2 = .26$. Additionally, the Neurofeedback × Time interaction effect was also significant. $\Lambda = .62$, $F(1, 21) = 12.71$, $p < .01$, partial $\eta^2 = .38$. The significant interaction supports the hypothesis that the neurofeedback group is more effective than the control group.

Two paired-sample t-tests were computed to assess verbal IQ score mean differences between the pre-test and the post-test. We controlled for family wise error rate across these tests using Holm's sequential Bonferroni approach. The results indicated that within the neurofeedback group, the mean verbal IQ post-test score was significantly greater than the mean verbal IQ pre-test score, $t(8) = 3.04$, $p = .02$. However, within the control group, the mean verbal IQ score was not significantly different between the pre-test and the post-test, $t(13) = -.91$, $p = .38$.

TABLE 2. Means and Standard Deviations of Verbal IQ, Performance IQ, and Full IQ as a Function of Neurofeedback and Time

Neurofeedback	Time: Pre-test M	Pre-test SD	Post-test M	Post-test SD
Verbal IQ				
Experimental (n = 9)	82.00	16.45	92.33	20.95
Control (n = 14)	78.57	11.82	77.21	14.06
Performance IQ				
Experimental (n = 9)	87.33	19.29	89.22	15.21
Control (n = 14)	81.86	16.36	78.57	14.18
Full IQ				
Experimental (n = 9)	82.89	18.54	89.78	18.55
Control (n = 14)	75.79	14.83	72.71	15.41

Performance IQ

A two-way between and within subjects ANOVA was conducted to evaluate the effect of neurofeedback (neurofeedback and control) and time (pre-test and post-test) on the dependent variable: performance IQ. The means and standard deviations for the performance IQ scores are reported in Table 2. The time main effect was not significant. $\Lambda = .99$, $F(1, 21) = .22$, $p = .65$, partial $\eta^2 = .01$. Similarly, the Neurofeedback × Time interaction effect was not significant. $\Lambda = .87$, $F(1, 21) = 3.00$, $p = .10$, partial $\eta^2 = .13$. This result does not support the hypothesis that EEG biofeedback is more effective than the control group. Since there were no significant effects, follow up analyses were not conducted.

Full Scale IQ

A two-way between and within subjects ANOVA was conducted to evaluate the effect of neurofeedback (neurofeedback and control) and time (pre-test and post-test) on the dependent variable: full-scale IQ. The means and standard deviations for the full-scale IQ scores are reported in Table 2. The time main effect was not significant. $\Lambda = .90$, $F(1, 21) = 2.42$, $p = .13$, partial $\eta^2 = .10$. However, the Neurofeedback × Time interaction effect was significant. $\Lambda = .56$, $F(1, 21) = 16.50$, $p < .01$, partial $\eta^2 = .44$. The significant interaction supports the hypothesis that neurofeedback training is more effective than no training.

Two paired-sample *t*-tests were computed to assess full-scale IQ score mean differences between the pre-test and the post-test. We controlled for family wise error rate between these tests using Holm's sequential Bonferroni approach. Within the neurofeedback group, the mean full scale IQ post-test score was significantly greater than the mean full scale IQ pre-test score $t(8) = 2.75$, $p = .025$. However, within the control group, the mean full scale IQ post-test score was significantly lower than the mean full scale IQ pre-test, $t(13) = -2.68$, $p = .02$.

DISCUSSION

The purpose of this study was to determine whether neurofeedback would be able to improve reading measures and intelligence quotients for children identified as having learning disability problems. The test results supported the hypothesis that neurofeedback training is more effective in improving reading quotients than no neurofeedback training. The three reading quotients (Basic Reading, Reading Comprehension, and Reading Composite) increased for the experimental group but not for the control group. There were no other interventions occurring in the resource room to increase reading scores other than the usual curriculum. No attempts were made to improve IQ scores in the special education program.

However, not all of the intelligence quotients improved significantly with neurofeedback training. Neurofeedback training was not significantly effective in improving Performance IQ scores. Nonetheless, the results did demonstrate that neurofeedback training was significantly more effective in improving both the Verbal and Full Scale IQ than no neurofeedback training. It may appear that the Verbal IQ increase accounted for all the full-scale upward change in the Full Scale IQ. But this would not be the complete picture. The Performance IQ of the control group deceased but not significantly in the post-test. This, combined with the significant increase of Verbal IQ scoring in the experimental group, accounted for the significant change in the Full Scale IQ results.

The important aspect of this study was to place before future researchers the implication that some of our present special education approaches may actually contribute to lowering cognitive functioning. Perhaps this study will encourage more research into the matter.

Limitations

This study could have been more helpful if added effort had been made to measure whether or not improvement on post-assessment standardized tests could also be linked to behavioral and/or academic improvement in the classroom. For example, students reported several improvements such as attitude toward school, cooperation with their teachers, and the willingness to do and complete homework assignments. However, no efforts were made to measure these improvements.

This study took a school's sixth, seventh and eight grade students ($M_{age} = 12.5$ years) who were identified as having learning disabilities. Three younger students ($M_{age} = 8.2$ years), from grades first, fourth and fifth, who were referred from other schools were added to the study. In hindsight, it would have been preferable to accept only students in the same age group and more students from other schools for this research study so that inferences could be made to similar special education populations.

A lottery procedure was used to assign students to either the control or experimental group. It would have been better to use a computer to produce the randomization of the samples or to use a published table of random numbers. In this way, other researchers could replicate a verifiable method.

The control group scored significantly lower in the basic reading, reading comprehension, reading composite, Verbal IQ and Full Scale IQ post-tests than the pre-tests. The students' scores in the control group did not merely remain flat; they tended to decrease. Why? The answer is not clear. The fact that these students did not have the one-on-one supervision with an adult using exciting new technology could have influenced the data in some manner.

In future studies it is recommended that a placebo group be incorporated into such a study. Moreover, the decrease in scores could have been due to what was occurring (or what was not occurring) in the resource room or in the general curriculum (e.g., such as the distraction of students acting out or the teacher's methodology). As mentioned above, it was regrettable that QEEGs were not done as a post-study assessment. Therefore, no comparisons can be made between pre-study and post study brain maps.

Implications

Care was taken that every duty of the school psychologist would be fulfilled while this project was in progress. No special permissions were sought or granted to postpone or be excused from the normal routine and duties of a school psychologist. The purpose was to illustrate that if the results would support the use of neurofeedback in a school setting, then most psychologists trained in neurofeedback would be able to incorporate it into their school psychological practice.

The focus of this study was strictly upon reading and IQ scores. However, several individuals reported important improvements in other areas such as mathematics, attitude or written expression. For example, one student reported, "I am reading and writing better. I just like school better and I am having more fun." Another student said, "My math is easier. I like to study now." These variables can be explored in future quantitative studies.

Neurofeedback may be an effective supplement to special education. It may be an even more effective method for improving IQ and reading performance than some of our present special education programs. However, further research is necessary to explore this issue as well.

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