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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and that how those patients change. New EEG patterns can be collected and
combined into the computer program. The more accurate the program
is, the more successful the learning. The more successful the learning, the
more accurate the program becomes. This is a feedback loop. The computer
program is a feedback loop that is continuously improving its accuracy.

Neurofeedback is a process of teaching the brain to change its activity in
response to a specific signal. The brain activity is monitored through the
EEG (electroencephalogram) and analyzed by the computer. The computer
then delivers a signal to the brain, which is then used to change the
brain activity. This process is repeated until the desired change is
developed.

Neurofeedback is a method of training the brain to perform specific
tasks. It is used in a variety of applications, including the treatment of
addictions, attention-deficit/hyperactivity disorder (ADHD), and anxiety.

The technique was developed by Dr. Stephen Porges, a psychiatrist who
specializes in the treatment of trauma.

The technique involves using a computer to monitor the brain's activity
and provide feedback to the brain. The feedback is in the form of a
signal that is delivered to the brain, which then changes its activity in
response to the signal.

The technique has been shown to be effective in a variety of settings,
including in the treatment of anxiety, depression, and ADHD.

Keywords: Neurofeedback, school psychology, learning problems,

INTRODUCTION

Scientific evidence...
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 Learning Disabilities or as Other Health Impaired with the exception of three students who were referred to a psychologist with a 504 Accommodation Plan due to complications surrounding a medical diagnosis of ADH.

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 previous educational evaluation results were used as pre-test.

Instruments

The EEDR-2 was administered to the students at the beginning of the school year to assess their pre-reading skills. The goal was to identify any students who may need additional support in reading. The results indicated that there was a need for intervention in the reading area for a small group of students. The intervention consisted of small group instruction focusing on phonics and spelling.

The intervention was continued throughout the year, with progress assessments administered at the beginning of each quarter. The results showed steady improvement in reading skills for the students who participated in the intervention.

The EEDR-2 was administered again at the end of the school year to assess the effectiveness of the intervention. The results showed that the students who participated in the intervention made significant gains in reading skills.

The EEDR-2 is a widely used instrument for assessing reading skills in children. It is designed to identify students who may need additional support in reading and to monitor progress over time. The results from the EEDR-2 can be used to inform instructional decisions and to ensure that all students have access to high-quality reading instruction.

Conclusion

The results of the EEDR-2 assessments indicate that the school reading intervention was effective in improving students' reading skills. The small group instruction focusing on phonics and spelling helped students make significant gains in reading skills.

It is recommended that the school continue to use the EEDR-2 as a part of its assessment and intervention process. This will help ensure that all students have access to high-quality reading instruction and receive the support they need to succeed.
lation (8) to the WISC-III. There was no 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 sixtest 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 X 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 X 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 X 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, \(\lambda = 1.00, \ F(1, 23) = .29, p = .60\), partial \(\eta^2 = 0.0\). However, the Neurofeedback X 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.
Two-way ANOVA was conducted to assess verbal IQ score differences between the pre-test and post-test. The results indicated that the neurofeedback group, the mean post-test score was significantly higher than the mean verbal IQ score, while the control group did not show a significant difference.

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

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-Test M</th>
<th>Pre-Test SD</th>
<th>Post-Test M</th>
<th>Post-Test SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (n=14)</td>
<td>75.74</td>
<td>10.46</td>
<td>79.26</td>
<td>10.34</td>
</tr>
<tr>
<td>Experimental (n=8)</td>
<td>75.77</td>
<td>10.34</td>
<td>84.23</td>
<td>9.88</td>
</tr>
</tbody>
</table>

TABLE 1: Means and Standard Deviations of Basic Reading, Feeding, and Motor Function

<table>
<thead>
<tr>
<th>Group</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (n=14)</td>
<td>68.43</td>
<td>12.98</td>
</tr>
<tr>
<td>Experimental (n=8)</td>
<td>68.00</td>
<td>11.65</td>
</tr>
</tbody>
</table>

The results indicated that the neurofeedback group had significantly higher post-test scores than the control group.
main effect was not significant. \( \Delta = .90, F(1, 21) = 2.42, p = .13 \), partial \( \eta^2 = .10 \). However, the Neurofeedback \( \times \) Time interaction effect was significant. \( \Delta = .56, F(1, 21) = 16.50, p < .01 \), 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 eighth grade students (\( M_{\text{age}} = 12.5 \) years) who were identified as having learning disabilities. Three younger students (\( M_{\text{age}} = 8.2 \) 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 QEEG 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.

REFERENCES


