

Effectiveness of Neuro-feedback on Mathematics Disorder

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Abstract

Background and Purpose: Because of the importance of treatment of learning disorders, this study was conducted to evaluate the treatment of mathematics disorder as one of the learning disabilities by using neurofeedback.

Method: In this study, 28 third grade-primary school children were selected by psychiatric interview, academic records and third grade mathematic test result. One group (N=14) received neurofeedback treatment and on the other group (N=14) non-real neurofeedback treatment (sham or placebo) was conducted. Neurofeedback treatment was performed based on enhancement of beta/theta ratio in CZ region. Each child received 20 sessions of neurofeedback therapy for 10-12 weeks. Each session lasted 30 minutes. The mathematics test was done three times: before neurofeedback treatment, after the 20th session, and after a year as a follow up.

Results: The two groups were matched for age, education, sex and degree of intelligence and severity of mathematics disorder. The comparison between real and sham groups showed that the effect of real neurofeedback therapy was significant versus sham group ($P < 0.05$). A significant increase was seen in consecutive math results in experimental group compared with sham group ($P < 0.01$). The difference trend was linear ($P < 0.05$). The difference between pre-test and post-test was significant only in males and not significant in females.

Conclusion: In group with real neurofeedback therapy, mathematics performance was improved significantly. This neurofeedback effect was also seen after a one-year follow up ($P < 0.01$). In separate evaluation between boys and girls, the significant effect was only seen in boys.

Keywords: Neurofeedback; Learning disabilities (dyscalculia); Theta waves; Beta waves

Introduction

It is believed that learning disorders are the result of changes in brain function. These problems may be in auditory function, memory processing, difficulties in understanding and remembering words, in express or comprehension of verbal or written language, in forming letters or mathematical concepts. Research suggests that individuals with attention deficit have lots of slow brain wave activity. Enhancement of Beta and beta/theta ratio may improve attention-deficit cognitive disturbances associated with ADD, ADHD and LD [1].

Learning disabilities in children with brain mapping show one or several of the following cues: Sharp and focal slow waves in one or more brain regions such as the occipital lobe, wernike area, Broca area and sensory-motor area. Studies on the effects of neurofeedback on learning disabilities especially mathematics disorders are limited, but confirmation of Neurofeedback for ADHD by the FDA has been approved.

Beta waves are essential for attention. Beta reduced activity and increased alpha in these patients can lead to learning problems. Different parts of brain can communicate with each other to understand complexities of the outside world and perform properly. Cutting and maintaining these communications can lead to accurate processing of information. In children with learning disabilities, communications between two or more brain regions are not well established. High and low levels of Coherence in EEG in two or more brain regions, does not let the brain process data properly. Patients with learning disability may suffer from reduced or increased level of coherence states or both in their EEG. Jacob's study in 2006 on two children with learning disabilities using neurofeedback treatment showed that neurofeedback

is a successful treatment for this disease [2]. Fernandez in 2007 showed that neurofeedback is an effective treatment for children with learning disabilities, with a high abnormal ratio of alpha/theta [3].

Becerra in Follow up study performed on children with learning disorders showed that neurofeedback is an effective treatment for a long period [4]. A study conducted by Hanslmayr et al. [5] showed that increased alpha by using neurofeedback improved cognitive performance.

Methods

The purpose of this project was to determine the effectiveness of neurofeedback in the treatment of children with mathematics disorder in third grade of school. In this study, 28 third grade primary school children diagnosed to have mathematics disorder through psychiatric interview, according to DSM -V criteria, as well as school records. All subjects did not suffer from any neurological or any psychiatric disorders other than learning disabilities in a structured clinical interview. They had IQ scores of at least 70 based on Wechsler test and all patients had normal EEG. None of the patients used any kind of medicine. Before onset of treatment, parents were asked to complete the informed consent form. For all the kids, mathematics disorder

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diagnosis test were done and then randomly assigned in two groups. They did not differ according to the variables such as age, sex, IQ scores and severity of mathematics disorder.

The subjects were randomly enrolled into two groups. One group (N=14) have undergone neurofeedback treatment and the other group (N=14) undergone non-real neurofeedback treatment (sham or placebo). In sham group someone else's neurofeedback were played for the subjects. The subjects were taken for mathematic test immediately after 20 sessions of treatment, as well as one year after the completion of treatment.

Neurofeedback treatment program is based on registration system PROCOMP 2 matches. Neurofeedback EEG signals obtained for the ratio of Beta/theta in CZ area to the left ear. In the first session, a threshold was chosen. Threshold was set every three minutes. During subsequent meetings, the last mean threshold was used as the new threshold. Every child received 20 sessions of neurofeedback therapy over 10-12 weeks and each session lasted 30 minutes.

Both groups were the same except that in sham (placebo) group, the recorded neurofeedback video of another person was displayed for the subjects. Data was analyzed by covariance and t-test using SPSS software (20th version).

Results

T-test showed that means difference between the two groups in pre-mathematic test was not significant ($t=1.171, p=0.260$). The differences between the two groups in IQ test ($F=2.064, P=0.805$), and age ($t=0.478, p=0.637$) according to t-test and sex ($p=0.592$) and education ($p=0.559$) according to Chi-square test were not significant as well. Therefore the two groups were similar in terms of IQ, age, education, sex and severity of dyscalculia. One-way analysis of covariance was used to compare the control and experimental groups.

The results (Table 1) showed that the effect of intervention ($F=9.736, sig=0.012$) was statistically significant in the experimental group ($P<0.05$). The difference ($F=5.714, sig=0.035$) in the effect of intervention between the two groups was also statistically significant ($P<0.05$). To evaluate the efficacy of three times measurements (pre-test, post-test, and follow-up) analysis of variance was used (Table 2). The result shows that intervention in experimental group ($F=7.490, sig=0.003$) was statistically significant in three times measurement and their effect ($F=8.226, sig=0.018$) was linear ($P<0.05$). The effect in males and females were separately compared between the two groups by using t-test. The result shows that the effect was significant just in boys ($t=3.203, sig=0.011$) and not in girls ($t=1.120, sig=0.388$).

Discussion

This study investigated the efficacy of neurofeedback on mathematic disorder and showed significant differences between the two groups: those who had undergone real neurofeedback therapy and those who

Effect of Intervention	F	Sig.
In experimental group	9.736	0.012
Difference between the two groups	5.714	0.035

Table 1: Comparison of intervention effect within and between the 2 groups

Intervention effect	F	Sig.
Among three times measurement	7.490	.003

Table 2: Comparison of intervention effect among pre-test, post-test and follow-up test.

had undergone sham or fake neurofeedback therapy (placebo group) ($P<0.05$). Neurofeedback improves mathematic performance in experimental group and it shows that efficacy of treatment remains high even one year after treatment ($P<0.01$). The effectiveness was significant in boys but not significant in females. It was shown in this study that the effectiveness of neurofeedback was compatible with the study of Jacob in 2006 [2]. Becerra in a follow-up study which was performed on children with learning disabilities showed that neurofeedback is an effective treatment for learning disorders and have beneficial effects not only immediately after neurofeedback therapy, but in a longer period overall. The patients had a reduction in symptoms of learning disabilities that is consistent with the results of this study. In the field of cognition, Hanslmayr et al. [5] performed a study in which cognitive performance improved by enhancing alpha wave, whereas in this study beta waves were enhanced.

Hashemian et al. [6] in a study of twelve children with learning difficulties (spelling disorder) in two experimental and control groups that received 15 sessions of 30-45 minute neurofeedback therapy, three times per week to increase the ratio of alpha to theta as Butler's protocol resulted in 67% improvement. As spelling disorder is one of the learning disorders therefore it was compatible with this study. Parastar et al. [7] studied EEG in 6 girls and 10 boys with learning difficulties (writing disorder) by Welch method. The result showed signals in the brain in writing state are more complex and more irregular in frequencies than in relaxation state. This study emphasizes the importance of the use of neurofeedback in the treatment of learning difficulties as well.

Conclusion

Neurofeedback improves mathematic performance in boys and it shows that efficacy of treatment remains high even one year after treatment.

Limitations

Due to the lack of similar studies, comparison was not possible.

Suggestions

Other researches on effectiveness of neurofeedback in children with mathematic disorder must be done with placing electrodes on other regions of the scalp. Other protocols such as the strengthening of Beta/Theta or Alfa/Theta must be evaluated as well.

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Implications for Educators

- Psychiatrists can consider neurofeedback as one way of treating mathematic disorder.
- Neurofeedback therapist can use Alfa enhancement for mathematic disorder.
- Neurofeedback therapist can use other region or with other protocol for treatment of mathematic disorder.

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