

# A Comparison of the Effectiveness of Neurofeedback (NFB) Training Method and Fernald's Multisensory Approach on Dictation Performance among Students Suffering from Dictation Disorder (Dysgraphia)

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## Abstract

**Introduction:** Dysgraphia (disorder in dictation, disorder of written expression) is considered as one of common disorders among students, where there are different methods on how to cope with and treat it. The present study aimed to compare the effectiveness of Neurofeedback (NFB) Training Method and Fernald's multi-sensory approach on students' dictation disorder in Rafsanjan city in 2015.

**Methods:** Twenty six students (age 7-11 years), suffering from dysgraphia, were selected using convenience sampling method from those who referred to Rafsanjan's Javaneh Consultation Center and randomly divided into two groups, neurofeedback and Fernald. Initially, we conducted a dictation test (pretest) and Raven's Progressive Matrices. The students that their dictations score were 50/100 or lower enrolled to study. In the NFB group, we applied 15 sessions of neurofeedback training in areas C3 and C4 to strengthen the SMR waves, whereas the second group received 15 sessions of training using Fernald's multi-sensory approach. Then, both groups were participated in a dictation test at the end of their training processes. Finally, data analyzed by using independent and paired t-test and Cohen's effect size.

**Results:** The mean score of dictation in NFB and Fernald groups were  $34.2 \pm 3.87$  and  $32.9 \pm 4.66$  respectively. The difference was not significance ( $P=0.043$ ). The mean scores of dictation in posttest in NFB and Fernald groups were higher than pretest. The difference was significance ( $P < 0.001$ ). However, neurofeedback method showed a much more significant influence in mitigating this disorder as compared to Fernald approach.

**Conclusions:** The results of our study indicated that each of both Fernald and neurofeedback training methods can be used to improve dictation performance among students suffered from dictation disorder, where depending upon students' circumstances and parents' choice, the process of selecting an appropriate method out of these methods can be proceeded.

## INTRODUCTION

There are numerous factors that can lead to failures in different areas of life. These factors can contribute to special, detrimental corollaries for the scholastic achievement of students such as decreased self-confidence, and as a result, such factors may underlie many mental and behavioral disorders and even may increase the likelihood of showing psychosomatic symptoms and eventually may encompass physical symptoms. One of such factors is subsumed as the child's risk of learning disor-

ders. Learning disorders are divided into three groups: reading disorder, writing disorder, and mathematics disorder; any of these disorders also have subdivisions [1]. Children with learning disabilities usually are diagnosed when their progress in individually administered tests in areas such as reading, mathematics, or written expression is fundamentally less than what normally expected from them in terms of their age, educational background, and measured intelligence [2]. Dictation

(saying words aloud to be typed, written down, or recorded on tape) action is a difficult task for children because it is an objective and subjective performance. For the same reason, written language is followed by listening, speaking and reading in the hierarchy of language abilities, and therefore, any problems in other areas such as listening, speaking and reading, can have a negative impact on learning written language [3]. According to Lerner [4], writing process is complex and depends on different skills and abilities and requires a correct understanding of the symbolic pattern embodied in writing process. Writing skill is associated with eye movement and coordination of related movements. It also requires eye-hand movement coordination, arm control, hand and finger muscles [5]. To treat dictation disorder, treatments are provided in various ways. One of these common methods is called as Grace Fernald's method. Fernald's method is consisted of visual, auditory, kinesthetic, and tactile (VAKT) rudiments. Fernald's multi-sensory approach can help people with learning disabilities to be able to use different senses and strengthen them, in an effort to be more successful in their learning activities. The aim of this multisensory approach is to provide new words for reading and spelling by using widespread method of visual, auditory, kinesthetic, and tactile. As a new teaching method, neurofeedback is the result of science-technology marriage that has so far showed a very promising trend in the treatment of a number of disorders, especially disorders related to children's cognitive system. Neurofeedback is a useful tool for improving cognitive processes and includes the process of conditioning brain waves activities through which people learn to voluntarily control their brainwaves and improve their memory performance [6]. Neurofeedback is also looking for helping people to train themselves about how to normalize their brain reactions to stimulus [7]. Findings of Fathollahpoor et al. showed that subjects in neurofeedback group had some significant improvements in their general intelligence, verbal, and practical scores, but these improvements were not seen in the Fernald's group [8]. The results of the one study conducted by Heydari et al showed that the experimental intervention based on Fernald's multi-sensory approach and Kephart's perceptual-motor method, for both experimental groups, as compared with the control group had a significant effect in reducing dictation disorder [9]. Moreover, other studies showed that Neurofeedback (NFB) Training Method and Fernald's Multisensory Approach also had positive effect on dictation progress and this progress was maintained in the two-month and three-month follow-up. In addition, the best results have been reported when a combined approach to treatment is used and students who were trained by Fernald's multisensory approach showed a much better performance in comparison to those received neurofeedback treatment [10]. According to the above statements, the present study aimed to compare the effectiveness of Neurofeedback (NFB) Training Method and Fernald's Multisensory Instructional Approach on dictation performance of students suffered from dictation disorder. The results of these studies help to psychologists, teachers and parents for choosing the better and cost benefit ways to help students or offspring for improve writing skills.

## METHODS

The present study can be categorized in the realm of quasi-experimental studies. The independent variables included neu-

rofeedback training method and Fernald's multi-sensory approach while the dependent variable was the level of progress in the dictation task. The statistical population consisted of students with dysgraphia in Rafsanjan city, who were visiting Javaneh Consulting Center under the supervision of Behzisti (Welfare) Organization, in 2015. We used Convenience sampling method to select and interview 26 students with dysgraphia, which were referred to the clinic at the time of the study. The Fernald or NFB methods are long term methods (at least 10-15 sessions). Therefore, the study was impossible on a large number of cases. In the following, students were requested to take dictation test with 100 words based on the current Persian literature book that was prepared by their teachers. Based on the following writing rules, students were categorized in four groups: if students' writing included 90-100 words correctly, they were placed in the first group (Excellent, without any writing disorder); the second group included students that wrote 50-89 words correctly (Good); if students had only 25-50 words correctly in their dictation tasks, they were placed in dictation disorder group (Weak,); and finally, if students' correct number of words of writing included less than 25 percent of all words, they were among students with Learning disability (very weak) which showed a poor performance in relation to their ages. Because of the aim of our study, we selected students who were in dictation disorder group. Test-retest reliability is a measure of reliability obtained by administering the same test twice over a period of time to a group of individuals. The scores from Time 1 and Time 2 can then be correlated in order to evaluate the test for stability over time. In Aghababaei study that used same Checklist for Identifying Students with Spelling Learning Disability, Content validity of the Checklist was confirmed by five expert psychologists and psychiatrists and Retest reliability coefficient was also obtained as 0.89 [11]. Test-retest reliability of the Checklist for evaluation of dictation performance in this study was 0.76. The Raven's Progressive Matrices (for Children (color) that is used to measure the intelligence of children age 5-11 years) was performed using the software. Criteria for inclusion was to having DSM-IV-IR diagnostic criteria to be recognized as dysgraphia, writing dictation test score 25-50, lack of Ritalin consumption, ages 8- 10 years (Second, third and fourth grade of school) and score higher than 85 on the Raven's Progressive Matrices (RPM) Test. Students with family problems such as divorce, addicted or Imprisoned parents, students with ADHD, Oppositional defiant disorder (ODD), Obsessive-compulsive disorder (OCD) and students with sensory-motor problems were excluded from further analysis. Based on parental consent, students were assigned to two groups of Fernald's multi-sensory approach and NFB training method. After dictation disorder was established, two methods of Fernald and neurofeedback were explained to parents.

## Ethical Considerations

The NFB is generally recognized as a safe intervention for improving electroneurological flexibility but some people report side effects (Fatigue, Depression, Dizziness, Headaches, Head pressure, Low energy, Muscle tension, Social anxiety, Tiredness). Before starting intervention, we explained about possible side effects. Written informed consent was obtained parents.

## Neurofeedback Group

In this study we used treatment protocol of increased alpha and theta reduction in the CZ area and increased SMR (Sensory Motor Rhythm) and theta repression in areas C<sub>3</sub> and C<sub>4</sub>. The procedure for planning the length of treatment was, first, 15 sessions every other day until the tenth session, two sessions per week until the twelfth session, one session per week until the fourteenth session as well as one session, just one month after the last session. Neurofeedback was conducted using original Canadian dual-channel device, Procomp II software.

## Fernald's Treatment Protocol

First session: Meet with students and analyze family status; second session: write a word on A<sub>4</sub> paper and read aloud by researchers, then after seeing and hearing by students, they were asked to move their fingers on the word, then write the word in the air (air writing), and finally write the word on the tray of sand to further strengthen their sense of touch; third session: the words on the sandpaper were cut by the researcher; in this session, a more number of words was given to the students and, in addition to writing words on the sand tray, they were given a chance to attach words on the sandpaper together and then touch words on it with their hands and read them aloud; fifth and sixth sessions: continue practice conducted in fourth session with other different words; seventh session: students should apply learned words from these three sessions to create their own story; eighth session: words easier than their last scholastic year were given to the students to write on the sand tray in an effort to increase their motivation; the ninth to the thirteenth sessions: these sessions are the same as fourteenth session, within which words that students had trouble in the dictation test were presented to them to write on the sand tray, while it may also help learning to be occurred at the same time; then a few simple words were given to them to increase their motivation; fifteenth session: summing up the sessions, recalling all the words learned during these sessions and writing those words on the sand tray. Finally, from both groups, dictation test was conducted with a hundred different words at the

opening session and obtained data using SPSS version 16 and independent t-test were analyzed. To collect data, we used dictation test and Raven's Progressive Matrices. Validity of the test questions using faculty opinions was determined and Cronbach's alpha was calculated to assess the reliability of questions presented in the test. To analyze the information gathered, the techniques of descriptive statistics including frequency tables, and inferential statistics such as mean, standard deviation, independent and paired t-test and Cohen's effect size were used. The SPSS software was applied to accomplish these statistical analyses.

## RESULTS

Mean age of students examined was  $8.25 \pm 0.75$  years and their mean IQ scores ( $103.73 \pm 6.65$ ) were in the range of 95-118. Values for skewness and kurtosis of IQ and dictation scores, in the pre-test stage, were in the range of  $\pm 2$ , showing the normality of the data. Also, a significant level higher than 0.05 in the Shapiro-Wilk Test was found which provide further evidence for normal distribution of the data used in our study. Mean dictation scores between the two groups (neurofeedback and Fernald) in the pre-test stage were compared using independent t-test. Mean dictation scores in the neurofeedback and Fernald groups in pre-test were  $34.2 \pm 3.87$  and  $32.9 \pm 4.66$  respectively. The mean difference between the two groups was not significant ( $P = 0.43$ ). Moreover, mean IQ scores were compared between the two groups in the pre-test stage. This difference was not significant as well ( $P = 0.39$ ) (Table 1).

Paired t-test was used to compare the mean dictation scores for the pre- and post-test stages. In the neurofeedback group, the mean dictation score was  $34.2 \pm 3.87$  in the pre-test stage, while this score was  $48.15 \pm 8.91$  in the post-test stage. Results showed that in the neurofeedback group, mean post-test dictation scores were significantly higher than those scores found in the pre-test stage ( $P < 0.001$ ). The result showed that the students in the Fernald group improved their dictation scores. Paired t-test found a highly significant difference between the conditions at pretest and posttest ( $P < 0.001$ ) (Table 2).

**Table 1:** Mean Score of Dictation and IQ of Two Groups (Pretest)

Variable and Group	Mean $\pm$ SD	Levene's P value	T test P value
<b>Dictation</b>		P = 0.8	P = 0.43
Neurofeedback	$34.2 \pm 3.87$		
Fernald	$32.9 \pm 4.66$		
<b>IQ</b>		P = 0.36	P = 0.39
Neurofeedback	$102.7 \pm 7.3$		
Fernald	$105 \pm 6.3$		

**Table 2:** Mean Scores of Dictation in Two Groups

Group and Stage	Mean $\pm$ SD	T	df	P value
<b>Neurofeedback</b>		-7.22	12	P < 0.001
Pretest	$34.2 \pm 3.87$			
Posttest	$48.15 \pm 8.91$			
<b>Fernald</b>		-8.01	12	P < 0.001
Pretest	$32.88 \pm 4.66$			
posttest	$47.46 \pm 11.03$			

Variable and Group	Mean $\pm$ SD	Levene's P value	T test p value
<b>Dictation (posttest)</b>		0.28	0.86
<b>Neurofeedback</b>	48.15 $\pm$ 8.91		
<b>Fernald</b>	47.46 $\pm$ 11.03		

Group	Pretest	Posttest	Cohen's d	Effect- size r
	Mean $\pm$ SD	Mean $\pm$ SD		
<b>Neurofeedback</b>	3.87 $\pm$ 34.2	48.15 $\pm$ 8.9	-2.03	-0.71
<b>Fernald</b>	32.88 $\pm$ 4.66	47.76 $\pm$ 11.03	-1.76	-0.66

In the post-test stage, the mean dictation scores of the two groups were compared. Results of independent t-test showed that mean dictation scores were not significantly different between neurofeedback and Fernald groups ( $P = 0.86$ ) (Table 3). Using Cohen's effect size, the difference between the means of two groups was compared. Findings from Cohen's effect size indicated that changes in scores were occurred in a much wider range in the neurofeedback group (Table 4).

## DISCUSSION

Our results showed that Fernald's multisensory approach was an effective method in improving dictation performance of students suffered from dictation disorder. This finding is concurred with Hassannia [12], Haghtalab [13], Delpasand [14], Heidari [9], Mansurnejad [15] and Taghvaei [16] which showed the effectiveness of Fernald's multisensory approach on mitigating the symptoms of dictation disorder. Moreover, other studies have provided evidence for Fernald's multi-sensory approach effectiveness in areas such as the development of reading and comprehension skills among dyslexic students [17-19], and improved bilingual children's reading performance with reading disabilities [20]. Multi-sensory methods aim to correct the problems that students may confront in their educational process by using a combination of student's sensory systems. Teaching by Multi-sensory method, because takes hearing, seeing, correct spelling and tracking of the finger into account at the same time, not only will improve student's problems in dictation task, but also will prevent these problems to be not further exacerbated or be recurred and set the area for effective learning. Multi-sensory methods can facilitate child's nerve stimulation, so these methods are reflected as one of the most efficient ways to solve the problems of students who are considered disordered in writing tasks [13]. Our results also showed that neurofeedback training method effectively enhanced student's dictation performance with dictation disability. This finding was in accord with Walker [21]. Neurofeedback training method also plays an important role in mitigating Dyslexia disorder [22-25] and improving short-term memory [26]. There are several factors that affect how successfully student may deal with dictation task. One of these important factors is long-term memory. Recent studies have shown that neurofeedback training method is an effective intervention in improving decreased levels of student's memory struggled with dictation disorder [6, 9, 27-37]. To justify this finding, since one part of the protocol used in our study was increased SMR in the CZ area, this proto-

col can simultaneously affect three parts of sensory-motor, motor and cingulate. Sensory-motor cortex is bordered by parietal and frontal lobes. Given the widespread effects of sensorimotor cortex, the reason for why the early pioneers in the field of neuropsychological treatment has begun their training process throughout sensorimotor cortex, is understandable. In addition, Ratey [38] stated that sensory-motor cortex is involved in the processes that help cerebral cortex performance through encoding physical and cognitive tasks. This researcher adds: "The brain circuitry for ordering, sequencing and scheduling a mental act is the same circuitry involved in ordering, sequencing and scheduling a physical act"; that is the sensorimotor cortex has a shared function in leading both processes of physical and mental. Most of activity of this cortex is devoted to sensorimotor functions rather than just the role of leading processes involved in brain. Therefore, patients that have difficulty in understanding the logical sequence of cognitive tasks can take advantage of neurofeedback training method focused on the sensorimotor cortex of the left hemisphere ( $C_3$ ). In our study, the SMR waves in regions  $C_3$  and  $C_4$  were also strengthened. As stated before, neurofeedback training in the sensorimotor cortex of the left hemisphere ( $C_3$ ) can help patients to better understand the logical sequence of cognitive tasks, while this training in the sensorimotor cortex of the right hemisphere ( $C_4$ ) will lead to invoked emotions, excitement or feeling of being calmness. This training at the mid-point or CZ also facilitates a mixed response. As highlighted before, neurofeedback training in the CZ can simultaneously affect three cortexes of sensorimotor, motor, and cingulate. In cingulate cortex, systems that are associated with feeling and emotion, attention, and working memory, have close interaction with each other in an effort to constitute the energy source required for external actions (moves) and internal practices (reasoning, thinking) [39]. This issue also can be looked at from another angle. Increased SMR in the CZ area will help to activate neuronal circuit involved in working memory. Previous studies have shown that working memory is based on a neuronal circuit, emanating from the interaction between attention control system located in the prefrontal cortex and sensory data storage in posterior communication cortex [40]. Herman and others have also shown that during the cognitive task of working memory, an increase in the 10-14 band coherence can be seen between frontal and posterior areas [27]. Therefore, in general, it can be said that with an increase in the SMR wave in the CZ area, some improvements in working memory will be seen. Also, one other part of the protocol

used in this study was to suppress theta; in other words, our findings showed neurofeedback training had positive effects on individual's mental functioning and cognitive processing; this finding is congruent with findings of Hans and Mayer [41], Oh [42] and McDonald [43]. Moreover, neurofeedback therapy helped students to develop skills required for reading comprehension, while students treated by Fernald's multisensory approach showed better indicators of written expression; however a combination therapy that integrated both groups (Fernald and neurofeedback), could have significant effect on both variables mentioned above in each isolated group [10].

Overall, our results showed that both neurofeedback and Fernald's multi-sensory approaches have a significantly positive effect on long-term memory in students with dictation disorder. In this regard, findings of Cohen's effect size indicated that neurofeedback training method had a more effect than Fernald's multi-sensory approach. Very few studies have compared the effectiveness of neurofeedback therapy against other teaching or treatment methods. Pahlavanyan et al. demonstrated that the effectiveness of neurofeedback along with neuro-cognitive rehabilitation was more effective than neurofeedback per se in mitigating the symptoms of children with ADHD [44]. Sharifi et al. showed that when occupational therapy is incorporated with neurofeedback training method, their combined effects were much more significant on stroke patients' memory than those patients only treated by occupational therapy [45].

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## AUTHORS' CONTRIBUTIONS

All authors contributed to this project and article equally. All authors read and approved the final manuscript.

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## CONFLICT OF INTERESTS

None declared.

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