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Comparison of the Efficiency of Cognitive Rehabilitation, Intervention based on the Barclay Model, and Neurofeedback on Improving Executive Functions, Performance, and Attitude towards Reading in Children with Dyslexia

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Abstract

Background: *Dyslexia affects the brain's capacity to receive, store, and respond to information, and it is necessary to apply timely and appropriate treatment measures to prevent or improve students' problems. This study aimed to investigate and compare the effectiveness of techniques for brain rehabilitation, intervention based on Barclay's model, and neurofeedback on improving executive Functions, reading performance, and attitude towards reading in children with dyslexia.*

Methods: *This study falls under semi-experimental research with a pretest-posttest design and a control group. The statistical population included all 8-12-year-old students with dyslexia in Shahood city during 2023, alongside their parents and teachers. Out of these, 60 students were chosen through purposive sampling and randomly assigned to four groups (one control group and three experimental groups). Data collection tools comprised the Behavioral Rating Inventory of Executive Function (BRIEF), the Official Reading and Dyslexia Test (NAMA), and the Attitude Test by McKenna and Kerr (1990). The data were subjected to a multivariate analysis of covariance using SPSS26 software.*

Results: *According to the obtained results, two methods of intervention based on the Barclay model and cognitive rehabilitation were effective in improving the reading performance of children with dyslexia, but the intervention based on the Barclay model was more effective than other methods for improving their reading performance; Because the timely strengthening of children's reading skills by parents who spend a long time with their children will be highly effective in improving the learnability of this group. Therefore, from a practical point of view, it can be considered essential and basic skills needed by dyslexic students in the early stages and lower levels of education to have better preventive results.*

Conclusions: *According to the results, proper planning should be done to identify children with problems and take appropriate action to prevent problems in them.*

Keywords: Cognitive rehabilitation, Intervention based on Barclay model, Neurofeedback, Executive Functions, Reading performance, Attitude towards reading, Dyslexia.
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Introduction

Dyslexia, which is not caused by external factors such as poor education or cognitive problems, is a learning disability characterized by severe and persistent reading difficulties. Indeed, if learners with dyslexia don't have particular reading comprehension issues, their destitute decoding abilities can prevent them from making an adjusted representation of the content and, in turn, may adversely influence their reading comprehension[1]. Dyslexia is a neurological disorder that causes weakness in understanding and reading. Dyslexics have difficulty understanding the phonemes of languages, so they show less ability to connect letters to form words and sentences[2]. Dyslexia is characterized by persistent and severe difficulty reading words and/or poor spelling. These problems can have negative effects on academic progress. In addition, dyslexia is associated with internalizing problems such as depression and anxiety[3].

Researches consider weakness in executive Functions[4], weakness in reading performance[5], and attitude towards reading[6] as the most obvious characteristics of children with dyslexia. Executive Functions are a set of cognitive processes needed to choose and monitor behavior which helps achieve the objectives. Many studies reported that students with learning disabilities, especially dyslexia, seem to have impaired executive functioning and have difficulty in executing daily and school-related activities[7]. The presence of failure in the executive Functions of children with reading disorder points out that these children have a hard time focusing on the important areas of the task, inhibiting and inhibiting responses irrelevant to the task, maintaining acquired information from the environment, and as a result, they cannot delay the achievement of the reinforce and do homework and daily activities in a task-oriented manner[8]. The problems of executive Functions in children with dyslexia have been well documented. A small body of laboratory-based research reports that dyslexic children have difficulty planning with higher-order cognitive ability. In addition, the problems of executive Functions also influence dyslexic children in their daily life[9].

Studies have shown that reading ability has a close relationship with executive Functions that are damaged in dyslexic children[10]. As people attain adulthood, a better stage of studying talent is connected to more possibilities for employment, improved bodily well-being, and decreased incidence of intellectual fitness disorders. These positive life outcomes highlight the importance of understanding reading development[11]. Dyslexia is putting children at risk for poor reading comprehension, and wider academic difficulties. Dyslexia makes it difficult for children to read and spell words that are not explained by general intellectual disability or lack of formal reading instruction[12].

The findings of these studies show the effectiveness of this method in improving the mathematical performance of students with learning disabilities[13], improving the working memory and verbal fluency of dyslexic students, improving the attention and memory of those with mathematical learning disabilities and dyslexia, and improving children's cognitive deficits. in primary and secondary schools[14,15]. In this regard, Wiest, Wang, Bacon, Rosales, and Wiest (2020) investigated the applicability of computer-based cognitive training on working memory in a school environment. The pre-test and post-test differences showed that auditory working memory ability improved only for those who received the training program. These results provide initial support for improving working memory through the efficient use of Computer Based Cognitive Training in school environments[16]. Also, Anjum et al (2019) conducted a research regarding the effect of cognitive rehabilitation therapy on working memory, event memory, and attention in people with dyslexia. The results indicated that cognitive rehabilitation therapy effects improved working, event, and attention memory in people with dyslexia[17]. In confirmation of these studies, Ekewerk, Efe, Kilich and Bomin (2018) also conducted a study regarding the effect of cognitive rehabilitation treatment on executive Functions and daily tasks of dyslexic children. The results showed that cognitive rehabilitation treatment for children with dyslexia significantly affects visual attention, cognitive skills, executive Functions, and daily tasks in a positive direction[18].

The cognitive and academic performance of children with dyslexia appears to be improved by neurofeedback therapy. Brain training with neurofeedback has been shown for years to be a nonpharmacological method that is effective in improving multiple functions of the brain[19,20]. Neurofeedback is a type of biofeedback, which measures brain activity and provides this information to allow individuals to regulate their continuous cerebral oscillations to achieve certain behavioral and physiological outcomes. Neurofeedback stimulates important features of neural activity. It turns them into visual, auditory, or tactile feedback, rewards the desired patterns, and inhibits unwanted patterns in brain activity to initiate a training process. Neurofeedback training can increase brain plasticity through a reinforcement learning process. Flexibility caused by neurofeedback can compensate for neurological deficits and cognitive disabilities[21,22].

In Barclay's theoretical model, these four defects are related to defects in the system of executive functions. According to Barclay, the result of the performance of the executive function system and the behavioral inhibition system is self-regulation capability, which by forming this capability, behavior is controlled over time and allows a person to predict and control what happens in the environment[23]. Yousefi, et al compared the effectiveness of executive Functions training and intervention based on the Barclay model on the reading performance and academic self-concept of students with dyslexia. The results showed that the intervention based on executive Functions and the Barkley intervention method has a significant effect on the reading performance score and self-concept of students with dyslexia in general[24].

Considering the high prevalence of dyslexia and its consequences, it is necessary to compare different educational methods used for children; so that the most appropriate and efficient method can be identified according to the educational system of the country. Although some studies have investigated the effectiveness of cognitive rehabilitation training programs, intervention based on the Barclay model and neurofeedback on the problems of children with dyslexia; however, regarding the comparison of the mentioned interventions on the dependent variables in the present study, many research gaps make more studies necessary. Finally, the results of this research can provide a suitable therapeutic framework to improve executive Functions, performance and attitude toward reading in dyslexic students, and help pave the way for further research in this field. Also, the results of this research can be linked to previous similar studies and lead to the formulation of a comprehensive therapeutic theory for children with dyslexia. Special schools for learning disorders, counseling core of education departments, and also specialists in counseling centers for children and adolescents with special needs can benefit from the results of this research. Therefore, the purpose of this research is to investigate and compare the effectiveness of cognitive rehabilitation methods, intervention based on the Barclay model, and neurofeedback on improving executive Functions, reading performance, and attitude towards reading in children with dyslexia.

Materials and Methods

The present research method is applied in terms of research nature and in terms of the amount of manipulation of independent variables by the researcher, it is in the category of experimental research. This is because at the beginning the sample people were selected purposefully and then they were randomly replaced in three test groups and one control group. The research plan is pre-test-post-test with the reference group. Its diagram is shown in (Figure 1).

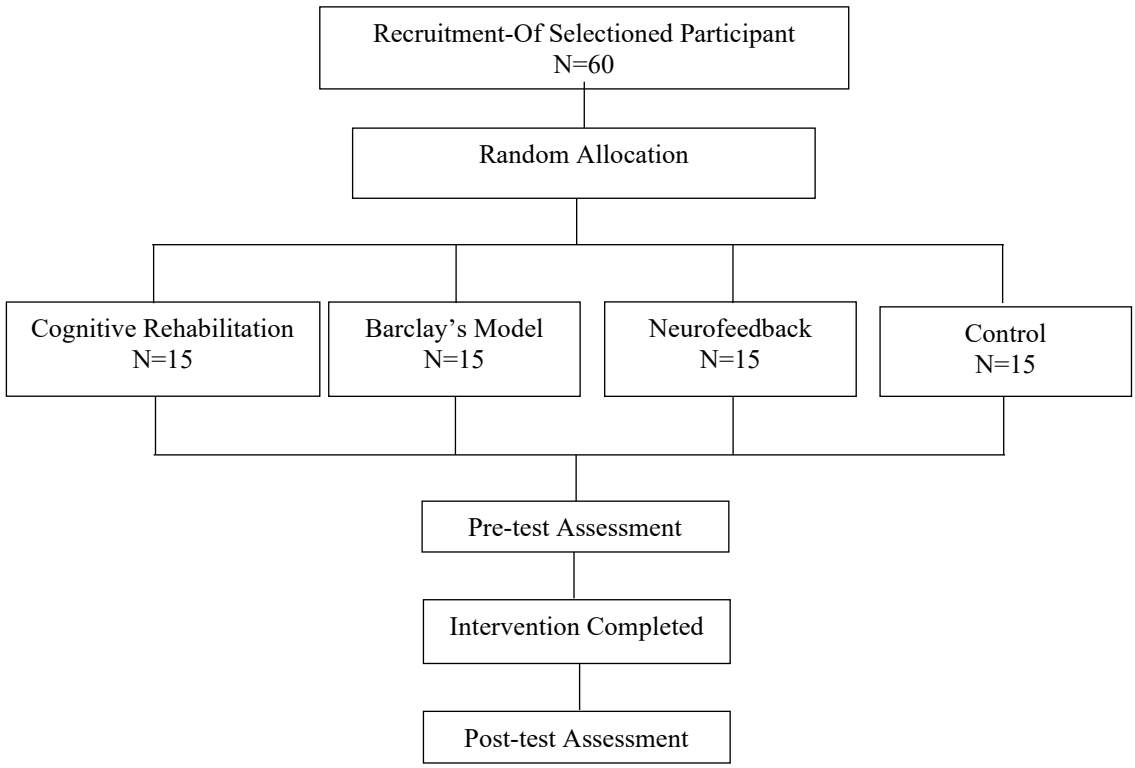

Figure 1. Diagram of the pre-test-post-test plan with control group

This research consists of 4 groups of subjects, all four groups have been measured twice. The first measurement was performed with a pre-test and the second measurement was performed with a post-test. Intervention programs of cognitive rehabilitation, intervention based on Barclay's model, and neurofeedback were implemented as independent variables in three experimental groups, but the control group did not receive any intervention. The variables of executive Functions, performance, and reading attitude were also the dependent variables of this research.

The statistical population of this research included all 8-12-year-old male and female students with dyslexia who were referred to learning disabilities centers in Shahroud city in 2023, and 60 male and female students were selected in the following way. First, the necessary permits were obtained from the university after the approval of the proposal. Then by referring to the Shahroud Department of Education, the necessary permits were obtained for the implementation and introduction to learning disorders centers. In the next stage, two centers were selected from among learning disorder centers in Shahroud. It should be noted that the sample size is based on the formula presented by Tabaknik and Fidel (2014), and Palant (2020) for experimental designs[25]. According to this formula, the sample size in each group should not be less than 15 people. After visiting the two selected centers, the sample people were selected according to the inclusion and exclusion criteria.

The inclusion criteria included the written consent of parents and students with dyslexia to participate in the research; obtaining the necessary cut-off score in the executive action behavioral rating questionnaire (BRIEF), the official reading and dyslexia test (NEMA), and the reading attitude scale for all four groups; dyslexia diagnosis based on official reading and dyslexia test (Nema); age range (8 to 12 years); absence of neurodevelopmental disorder or other simultaneous psychological disorders such as attention-deficit / hyperactivity disorder, and physical-motor problems. The exclusion criteria included receiving cognitive training and rehabilitation intervention based on the Barclay model or biofeedback at least one year before the implementation of the study; non-participation in intervention sessions (absence of more than 2 sessions) or refusal to continue treatment and participation in research, and taking psychiatric drugs for all four groups.

The tools used in order to acquire data included the following questionnaires. Questionnaire (list) for the behavioral rating of executive Functions (short form): This questionnaire is the best checklist for measuring and screening executive Functions in elementary school children, which Gerard, Gioia, Petr, Isujuith, Steven, Guy, and Kenworthy compiled it in 2000, and it has two forms, teacher and parent, with 86 items. In the present research, the trainer form was used. The time required to complete this questionnaire is 10 to 15 minutes, and the teacher should mark the option of never=1, sometimes=2, and always=3 in response to the options related to the child. In

this questionnaire, getting a high score means less executive Functions and getting a low score means more executive Functions. This questionnaire is designed for the behavioral interpretation of the executive Functions of children aged 5 to 18 years and it measures 8 areas of executive Functions: inhibition (14 items), attention transfer (11 items), emotional control (10 items), initiation (8 items), working memory (11 items), planning (15 items), material organization (8 items) and control (9 items). The results of these eight domain indicators are summarized in two overlapping indicators: behavior regulation skills (inhibition, attention transfer and emotional control), and metacognitive skills (planning, organizing materials, monitoring, working memory, and initiation). The creators of the reliability scale for this questionnaire, which is used for clinical samples in the teacher form and has a score of 82/98, have reported their findings in the research of Abdolmohammadi et al.and the test-retest reliability coefficient of the subscales of the behavioral rating test of executive Functions in the inhibition component was 0.90, transfer Attention 0.81, emotional control 0.91, initiation 0.80, working memory 0.71, planning 0.81, material organization 0.79, control 0.78, behavior regulation index 0.90, metacognition index 87 0.0, and the overall score of executive Functions was reported as 0.89. The internal consistency coefficient for this questionnaire was reported as 0.87 to 0.94, which indicates the high internal consistency of all subscales of the questionnaire.

Official Reading and Dyslexia Test (Nama): In the present study, this test was used to identify children with dyslexia and also measure reading performance variables. This test was created by Kermi-Nouri and Moradi (2007) and was standardized on 1614 students (770 boys and 844 girls) in five grades in Sanandaj, Tehran, and Tabriz. After collecting the data and performing statistical operations for each grade in each city, raw grades and standard grades were calculated. This test consists of ten sub-scales where the subject gets one mark for each correct answer and the total score of the test is calculated from the sum of the sub-scales. This test is performed individually and according to its cut-off point (157), a student whose score is 157 or less is recognized as a dyslexic student. In the research of Karminuri and Moradi (2007), the sub-tests of this scale and its Cronbach's alpha coefficients are reported as follows: The word reading test includes three lists of 40 words and at the level of words (such as lead and fox) With Cronbach's alpha of 0.98, words like (table and bus) with Cronbach's alpha of 0.99 and words like (water and jelly) with Cronbach's alpha of 0.91; Non-word reading test including 40 words (such as Sora, Dalibal, Sharke) with Cronbach's alpha 0.85; The word comprehension test consists of 30 questions in which the student chooses one of the four options as the correct answer (such as fare means? A: price, B: lend, C: loan, D: profit) with Cronbach's alpha 0.65. The text comprehension test includes ten sub-tests (common text for the second and third grades and two specific texts for each grade). The number of words in the texts is 320 and 340 words, and 8 questions with 4 options are considered for each text (text question example: Where did the dragonfly live?). The third basic text of form A and B respectively with Cronbach's alpha 0.61 and 0.62; The rhyme test consists of 20 rhyming words, and the subject finds the rhyming word and the target word, and Cronbach's alpha was calculated as 0.88. The picture naming test includes two versions, A and B, and each version has 20 shapes that the student remembers the look and name of each shape, and Cronbach's alpha was calculated as 0.75. The sound elimination test consists of 30 words, which the subject says each word after removing the desired sound, and its Cronbach's alpha is 0.78. The letter sign test includes three letters (A, R, N) that the subject remembers the number of words that start with these letters, and Cronbach's alpha was reported as 0.66. The word sign test includes 6 words (boy's name, girl's name, fruit name, kitchen utensils, body parts, and colors) that the subject remembers the number of words related to each category, and its alpha is reported as 0.75. Also, Hosseini, Moradi, et al reported the validity of this scale as 62.03 with the help of factor analysis[27].

Reading attitude test: In the present study, the reading attitude scale of McKenna and Kear, compiled in 1990, was used. This questionnaire has 20 items that describe the attitude toward academic reading and the attitude towards recreational reading. The respondent should read each item and determine the degree of conformity of his opinion based on the Likert scale which is set in a visual form using the image of the animated character Garfield. The response range is set from one (very sad) to four (very happy). Recreational attitude towards reading means reading in free time and outside the school environment. The academic subscale also measures reading in the school environment. This subscale includes long reading in class, reading workbooks, assignments, and school books. The entertainment attitude subscale has ten items, for example, "How do you feel when you read a new book?". The academic subscale also has ten items such as "In Farsi class, how do you feel when you have to read from a book?" A separate score is calculated for each answer in each of the subscales. Accordingly, the range of individual scores in each subscale will be from ten to forty. The creators of this scale reported its reliability for the subscale of attitude towards recreational reading as 0.78, the subscale of attitude towards academic reading as 0.83 and Cronbach's alpha as 0.80 for the whole scale. Also, the structural validity study showed that the two subscales of the reading attitude test are distinguishable and prominent. Hossein Chari et al also calculated the reliability of this test using Cronbach's alpha method for the whole scale of 0.88. Also, the construct validity of this scale was reported as acceptable and high in their research[28].

In the current research, three methods of cognitive rehabilitation intervention, intervention based on the Barclay model, and neurofeedback have been used. The intervention methods are described as follows: A cognitive rehabilitation software was developed in 2019 to train working memory. It was created under the guidance of psychology professors from Ferdowsi University of Mashhad, in collaboration with the Sinai Research Institute of Behavioral-Cognitive Sciences. The development was based on existing theories and modeled after the software RoboMemo, with adaptations for Iranian culture. Its content validity has been confirmed. This software provides exercises in three parts of auditory, visual, and spatial memory separately by using numbers, letters, and shapes. The degree of difficulty in each assignment is from one to nine, and the user can choose the degree of difficulty he wants and start practicing

from that degree of difficulty; But after starting the training, the degree of difficulty increases automatically and provides the possibility of using the maximum memory capacity for more training and increasing the memory level. The level of difficulty of the exercises is designed in such a way that with the progress of the subjects' skills, the assignments become progressively more difficult. On the left side of the page bar, the score bar provides the user with the number of points earned as feedback from the exercise, and for each correct attempt, 20 points are added to him. Also, 10 points will be deducted for each error attempt, and if you get 100 points, the difficulty level of the exercise will increase by one degree[29]. This software affects the student's working memory ability by using the method of positive reinforcement as well as repetition and practice and sensory stimulation of hearing and vision. The student will gradually learn how to use his senses and mental space to retain more letters and numbers in his mind. In this study, cognitive rehabilitation was provided to the first experimental group through working memory training software, during 11 sessions of 60 minutes once a week. The summary of the meetings is described in Table 1.

Table 1. Summary of cognitive rehabilitation training sessions

Meetings	Objectives and contents of meetings
First	Introducing and establishing a cordial relationship with students, introducing students to the computer, teaching them how to work with the mouse, and explaining the different parts of the software
Second	Reinforcement of forward visual memory is done up to six numbers and letters, the tasks are the same as the second session, only the number of numbers and letters seen is up to six
Third	Reinforcement of forward visual memory is done up to six numbers and letters, the tasks are the same as the second session, only the number of numbers and letters seen is up to six
Fourth	Strengthening the reverse visual memory up to three numbers and letters is done in such a way that the student sees a letter or number on the screen and after the number or letter seen disappears or remembers, from among nine previously seen letters or numbers selects the student does this exercise up to three numbers and letters in reverse
Fifth	Reinforcement of reverse visual memory is done up to six numbers and letters. The assignments are the same as the fourth session, only the number of numbers and letters seen is up to six numbers or letters
Sixth	Strengthening the forward auditory memory up to three numbers and letters is done in such a way that the student hears a letter or number on the screen and after it disappears by memorizing the number or letter heard from the nine houses, letter or number previously heard. The student does this exercise up to three numbers and letters forward
Seventh	Reinforcement of forward auditory memory is done up to six numbers and letters. The assignments are the same as the sixth session, only the number of numbers and letters heard will be up to six
Eighth	Reinforcement of reverse auditory memory is done up to three numbers and letters in such a way that students hear a letter or number from the computer and after the sound stops, remembering the heard number or letter, among the nine houses, the letter or number that has already been heard chooses the student will do this exercise up to three numbers and letters in reverse
Ninth	Reinforcement of reverse auditory memory up to six numbers and letters, do the homework as in the eighth session and only the number of numbers and letters heard will be up to six numbers or letters
Tenth	Consolidation of forward visual and auditory memory in such a way that first the student sees a letter or number in a part of the screen, then he must remember the correct position of the observed letter or number among the nine houses. Next, the student hears one or a number in a part of the screen, then he must remember the correct place of the observed letter or number among the nine houses. The subject of this exercise remembers up to six numbers or letters in a forward manner. Visual and auditory memory stabilization will be done with the purpose of reverse recall of the location of seen and heard numbers and letters
Eleventh	Consolidation of reverse visual and auditory memory of assignments, similar to the 10th session, with the difference that the student must remember the location of numbers and letters seen and heard in reverse

Intervention based on the Barclay model: In this research, the intervention based on the Barclay model is cognitive-behavioral management training for parents, which is based on training the interaction of parents and children, and its purpose is to teach behavioral methods to manage the environment and organize it in the direction curbing children's problems, changing the parents' perception of the situation, is the best way to deal with the situation and improve their skills and abilities to improve and correct the child's behavior. In this study, parent education was based on the educational model

proposed by Barkley (1987), and the parents of the participants of the second experimental group were trained using special education packages for each session[30]. Instructions and tasks were specified and taught to the mothers of the participants of the second experiment group during 10 one-hour sessions. A summary of Barclay's intervention programs is reported in Table 2.

Table 2. Summary of intervention model sessions based on the Barclay model

Meetings	The title of the steps	Content
First	Why do children misbehave?	This session is dedicated to training parents in these areas: full explanation and familiarization with attention-deficit/hyperactivity disorder (symptoms, etiology, treatment, etc.), the causes of child misbehavior, how these factors interact, and how parents can recognize these causes. Start in their children and families
Second	Paying attention	This session aims to educate parents in the field of eliminating ineffective or even harmful attention, while increasing more effective forms of attention to the child's behavior and appreciating its dedication
Third	Increase compliance and independent play	These skills are specifically directed towards increasing child compliance. Also, at this stage, trainings are given on how parents should pay attention to children when they are not bothering their parents while they are working
Fourth	Token and rewarding	Now the therapist asks the parents to implement a very effective motivational program. In this program, a variety of rewards and incentives that are easily available at home are used to increase the child's compliance with commands, rules, and daily tasks of the basics of social behavior at home
Fifth	Exclusion and other disciplinary methods	Parents are trained on how to use the token method described in the previous step as a form of punishment or fine (that is, in the token program, punishments are determined for inappropriate behavior).
Sixth	Generalization of exclusion to other misdemeanors	As soon as the parents have used the exclusion technique effectively, they will be allowed to use it for one or two other children's misbehavior. In situations where they have encountered problems using this method, most of the time of this meeting is dedicated to unraveling the problems by implementing exclusion and correcting them
Seventh	Predicting the problems of managing children in public places	At this stage, parents are taught to use slightly modified versions of child misbehavior management techniques in public places such as stores, restaurants, etc. Education includes a method known as thinking aloud
Eighth	Controlling the improvement of school performance (preparing a daily school behavior report table)	This session is to discuss the child's behavior at school and parents are taught to use the daily behavior report table at school and the token method at home
Ninth	Fix future problems	Parents are now briefly trained on how to use these procedures to solve other behavioral problems that the child does not currently have
Tenth	Empowerment session and supplementary meetings	Parents are asked to return one month later for a rehabilitation session to evaluate their adherence to treatment methods if the situation requires it, plans are made to gradually remove the token method at home, and parents are helped to resolve any problems they are facing

Neurofeedback intervention method: The goal of this program is to gradually learn to increase the amplitude of beta waves and decrease theta waves in the electroencephalogram. The remarkable thing is the gradualness of the training process, which requires multiple sessions between 30 and 40 sessions. The training program will be such that in the beginning, the C3 beta band (15-18 Hz) will be used as an increasing band and theta and beta bands as decreasing bands, and in the second half of the treatment, lower beta bands will be used instead of the beta band. 12-15 Hz was used as the gain band. The enhancement of the low beta band (12-15 Hz) in the right hemisphere and the increase of the C3 beta frequency range (15-18 Hz) are often used in the sensory-motor band: C3, C4, CZ. Since body movements and muscle signals (electroencephalogram artifacts) may also cause artificial brain waves, to ensure that these muscle signals are not accounted for, theta (4 to 8 Hz) and long beta (20 Hz) frequency bands are used. Up to 30 Hz) were used as stop bands. As a result of the time, the person was given a point if he was able to increase the

beta wave (15-18 Hz) or low beta (12-15 Hz) above the determined threshold and decrease theta wave (4-7) for 0.5 seconds. Hz) and keep a high beta (20-30 Hz) below the threshold. This score will be given to the subject visually (selected on the game screen), score (recorded on the computer screen), and audio, and this process will continue until the end of each session. Regarding the connection of the electrodes to the head, it is done under the international 10-20 system, so that in the first half of the treatment, the main electrode is connected to the C3 location, and two electrodes are connected to the ears, and in the second half of the treatment, the main electrode is connected to the C4 location and Two electrodes are connected to the ears.

The method of conducting the research was as follows: after the approval of the thesis proposal, obtaining the code of ethics and receiving the letter of introduction from the research vice-chancellor of the university, referred to the Department of Exceptional Education and Research in Shahroud and obtained the necessary permits to conduct the research. Next, four learning disability centers were selected and referred to, and the students who had a case there and received a definitive diagnosis of dyslexia were selected based on the inclusion criteria. After providing a preliminary explanation about the purpose of the research and attracting the participation of the subjects and reassuring the subjects and their parents about the confidentiality of the information, obtaining written consent from the parents and students, the researcher's commitment that the interventions after the completion of the research on A control group are also conducted, and the results of the research are presented to all three experimental groups and the control group, the sample people are randomly divided into four groups (15 children in the cognitive rehabilitation group, 15 children's parents in the model-based intervention group) Barkley, 15 children were placed in the neurotic group and 15 children in the control group). At this stage, the questionnaires were implemented as a pre-test. Then, in the cognitive rehabilitation node, education was provided to children with dyslexia using working memory software during 11 sessions of 60 minutes. In the case of the intervention group based on the Barclay model, trainings were provided to the parents of these children in 10 sessions of 60 minutes, and in the neurofeedback intervention group, the subjects received 30 sessions of 45 minutes of neurofeedback. While the control group was on the waiting list and did not receive any treatment. Then a post-test was performed for all 4 groups. The subject was asked to answer the questions honestly. The performance was individual and there was no time limit for answering. The research implementation process was carried out from March 2022 to the beginning of 2023 and data were collected. It should be noted that for the implementation of the intervention sessions, the researcher has completed the necessary training courses and conducted them together with the neurofeedback trainer and the learning disorders trainer at the center. Considering that in the present study, the main goal is to compare the effectiveness of cognitive rehabilitation interventions, the intervention based on the Barclay model, and neurofeedback in children with dyslexia. Therefore, to analyze the data and answer the research hypotheses, descriptive statistics methods such as the mean and standard deviation, as well as the Shapiro-Wilks coefficient, were used to check the normality of the data and at the inferential level, while respecting the assumptions, univariate and multivariate covariance analysis and Bonferroni's post-hoc test were used with the SPSS26 software.

Results

In this research, 60 students with dyslexia in Shahroud city were examined in four groups: cognitive rehabilitation (15 people), intervention based on the Barclay model (15 people), neurofeedback (15 people), and control (15 people). The average age of children with dyslexia in the cognitive rehabilitation group (9.00±1.46) years, general burden group (9.13±1.59) years, neurofeedback group (8.86±1.45) years, and controls (8.93±1.53) years. Based on the results of analysis of variance, no significant difference was observed (P-value=0.968, F=0.09). Descriptive findings include the mean and standard deviation of scores of executive Functions, reading performance and attitude towards reading of subjects, which are presented in Table 3.

Table 3. Mean and standard deviation of descriptive indices of the research variables and its components by the four studied groups

Variable	Level	Cognitive rehabilitation		Barkley		Neurofeedback		Control group	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Executive Functions	Pre-test	206.60	7.99	210.73	9.35	208.13	7.96	212.93	10.18
	Post-test	169.46	14.54	189.40	5.39	187.86	10.21	214.20	12.73
Behavior regulation skills	Pre-test	85.06	4.96	88.06	4.71	88.26	3.03	89.66	5.62
	Post-test	70.00	7.28	79.20	3.29	79.26	5.40	90.20	6.29
Metacognitive skills	Pre-test	121.53	5.82	122.66	6.07	119.86	5.75	123.26	5.48
	Post-test	99.46	8.12	110.20	3.25	108.60	5.19	124.00	7.23
Reading performance	Pre-test	137.73	36.01	135.40	35.37	124.13	27.46	128.86	36.54
	Post-test	156.80	36.75	158.26	32.01	131.86	29.29	126.80	34.41
Visual-phonological processing ability	Pre-test	60.93	19.61	58.86	19.48	53.00	15.02	53.73	18.51
	Post-test	69.00	17.74	69.26	17.83	55.80	15.46	53.86	18.44
Ability to speed and accuracy of cognitive processing	Pre-test	76.80	16.69	76.53	16.18	71.13	13.20	75.13	18.95
	Post-test	87.80	20.31	89.00	17.39	76.06	16.32	72.93	17.79
Attitude towards reading	Pre-test	46.80	4.79	42.06	4.94	47.26	3.99	43.60	9.61
	Post-test	59.20	5.84	62.20	5.32	63.20	3.29	45.00	7.34
Reading outside of school	Pre-test	23.66	3.19	21.80	3.48	24.13	2.99	21.86	5.40
	Post-test	29.20	3.36	31.20	3.62	32.40	1.91	22.46	4.82
Reading at school	Pre-test	23.13	2.94	20.26	2.21	23.13	2.44	21.73	4.65
	Post-test	30.00	3.60	31.00	2.42	30.80	2.95	22.53	3.83

According to Table 3, the average scores of the research variables of their components in the groups of cognitive rehabilitation training, intervention based on the Barclay model, and neurofeedback have changed in the post-test stage compared to the pre-test stage.

These changes confirm that in the training groups, the post-test scores of the participants in the variable of executive Functions and its components have decreased. Also, the average scores of the variables of performance and attitude towards reading and its components in the training groups have increased in the post-test stage compared to the pre-test stage.

To check the effectiveness of the interventions carried out in the post-test phase, univariate covariance analysis and multivariate covariance analysis were used, considering the pre-test variables as covariance variables. In this section, the results of the single variable covariance analysis test for the total score of the variables of executive Functions, performance, and attitude towards reading and the multivariate covariance analysis test for the components of executive Functions, performance, and attitude towards reading were presented. Then in the next part, research hypotheses were proposed and these hypotheses were answered using pairwise comparisons of groups with the lmatrix command. Before presenting the results of univariate covariance analysis and multivariate covariance analysis, assumptions of normality of data distribution, homogeneity of variances, homogeneity of the covariance matrix, homogeneity of the slope of the regression line, Bartlett's test of sphericity, absence of outlier data and the non-collinearity of the dependent variables have been confirmed.

The results of single-variable covariance analysis to investigate the differences between the training and control groups in executive Functions, performance, and attitude towards reading in the post-test stage are reported in Table 4.

Table 4. The results of single-variable covariance analysis to investigate the differences between the training and control groups in the research variables in the post-test stage

Variable	Source	Sum of squares	Degrees of freedom	Mean square	F statistic	P-value	Effect size	Test power
Executive Functions	Corrected model	15703.449	4	3925.862	32.829	<0.001	0.662	1
	Pre-test	524.182	1	524.182	4.383	0.041		
	Group	12859.329	3	4286.443	35.844	<0.001		
	Error	6577.284	55	119.587				
Reading performance	Corrected model	61072.648	4	15268.162	64.996	<0.001	0.328	0.993
	Pre-test	48935.381	1	48935.381	208.315	<0.001		
	Group	6305.934	3	2101.978	8.948	<0.001		
	Error	12920.085	55	234.911				
Attitude towards reading	Corrected model	3446.284	4	861.571	30.728	<0.001	0.662	1
	Pre-test	241.084	1	241.084	8.598	0.005		
	Group	3024.186	3	062.1008	35.953	<0.001		
	Error	1542.116	55	28.038				

The results of univariate covariance analysis Table 5 showed that considering the pre-test scores as a covariate (auxiliary) variable, the effect of the group on executive Functions in children with dyslexia was significant at the 0.001 level (P-value=0.001 and F=35.844), so there was a significant difference between the four studied groups in terms of improvement of executive Functions in children with dyslexia.

Also, the effect size of η^2=0.662 was obtained, which shows that 66.2% of the individual differences in executive Functions of children with dyslexia are due to differences in group membership (the effect of training). Also, the statistical power of 1 indicated the adequacy of the sample size and acceptable statistical accuracy for this conclusion. Therefore, there was a significant difference between the groups of cognitive rehabilitation, intervention based on Barclay's model, neurofeedback, and evidence in terms of improvement of executive Functions in the post-test phase by adjusting the pre-test scores. The results of univariate covariance analysis Table 4, showed that considering the pre-test scores as a covariate (auxiliary) variable, the effect of the group on reading performance in children with dyslexia was significant (P-value=0.001 and F=3.55, 8.948), so there was a significant difference between the four studied groups in terms of improving reading performance in children with dyslexia

Also, the effect size of η^2=0.328 was obtained, which shows that 32.8% of the individual differences in the reading performance of children with dyslexia were due to the difference in group membership (the effect of training). Also, the statistical power of 1 indicated the adequacy of the sample size and acceptable statistical accuracy for this conclusion. Therefore, there was a significant difference between the groups of cognitive rehabilitation, intervention based on Barclay's model, neurofeedback, and evidence in terms of improving reading performance in the post-test phase by adjusting the pre-test scores. The results of univariate covariance analysis Table 4, showed that considering the pre-test scores as a covariate (auxiliary) variable, the effect of the group on the attitude towards reading in children with dyslexia was significant at the level of 0.001 (P-value=0.001 and F=35/953), so there was a significant difference between the four studied groups in terms of improving the attitude towards reading in children with dyslexia. Also, the effect size of

η^2=0.662 was obtained, which shows that 66.2% of the individual differences in the attitude towards reading of children with dyslexia is due to the difference in group membership (the effect of training). Also, the statistical power of 1 indicated the adequacy of the sample size and acceptable statistical accuracy for this conclusion. Therefore, there was a significant difference between the groups of cognitive rehabilitation, intervention based on Barclay's model, neurofeedback, and evidence in terms of improving the attitude towards reading in the post-test phase by adjusting the pre-test scores.

The results of multivariate covariance analysis for the components of executive Functions, performance, and attitude towards reading in the post-test stage are reported in Tables 5 and 6.

Table 5. The results of the multivariate covariance analysis test for the research components among the groups in the post-test stage

Variable	Exams	Amount	Degrees of freedom	Error degree of freedom	F statistic	P-value	η2	Test power
Executive Functions	Pillai's Trace	0.668	6	108	9.019	<0.001	0.334	1
	Wilks' Lambda	0.342	6	106	12.529	<0.001	0.415	1
	Hotelling's Trace	1.892	6	104	16.400	<0.001	0.486	1
	Roy's Largest Root	1.877	3	54	33.783	<0.001	0.659	1
Reading performance	Pillai's Trace	0.346	6	108	3.765	0.002	0.173	0.955
	Wilks' Lambda	0.658	6	106	4.109	<0.001	0.189	0.970
	Hotelling's Trace	0.513	6	104	4.445	<0.001	0.204	0.980
	Roy's Largest Root	0.500	3	54	9.001	<0.001	0.333	0.993
Attitude towards reading	Pillai's Trace	0.710	6	108	9.911	<0.001	0.355	1
	Wilks' Lambda	0.324	6	106	13.376	<0.001	0.431	1
	Hotelling's Trace	1.982	6	104	17.180	<0.001	0.498	1
	Roy's Largest Root	1.928	3	54	34.699	<0.001	0.658	1

The results of Table 6 show that the effect of the group on the composition of the components of executive Functions in children with dyslexia in the post-test phase was significant based on Wilks's lambda effect (F(6,106)=12.529, P-value=0.001, η^2=0.415). Therefore, it can be stated that there was a significant difference between the groups of cognitive rehabilitation, intervention based on Barclay's model, neurofeedback, and control in terms of the adjusted scores of executive Functions components in the post-test stage, and it indicates that 41.5% of the difference observed in the average components of executive Functions was related to the effect of the trainings. The results of Table 6 show that the effect of the group on the composition of reading performance components in children with dyslexia in the post-test phase was significant based on Wilks's lambda effect (F(6,106)=4.109, P-value=0.001, η^2=0.189); Therefore, it can be stated that there was a significant difference between the groups of cognitive rehabilitation, intervention based on Barclay's model, neurofeedback and control in terms of the adjusted scores of reading performance components in the post-test stage, and it indicates that 18.9 % of difference observed in the average reading performance components was related to the effect of the trainings. The results of Table 6 show that the effect of the group on the composition of the components of the attitude towards reading in children with dyslexia in the post-test stage was significant based on Wilks's lambda effect (F(6,106)=13.376, P-value=0.001, η^2=0.431). Therefore, it can be stated that there was a significant difference between the groups of cognitive rehabilitation, intervention based on the Barclay model, neurofeedback, and control in terms of the adjusted scores of the components of attitude toward reading in the post-test stage, and it indicates that 43.1% of difference observed in the average components of attitude towards reading was related to the effect of the trainings.

To check which groups of cognitive rehabilitation, intervention based on Barclay's model, neurofeedback and evidence differ in which of the components of executive Functions, performance and attitude towards reading, the results of one-way analysis of covariance are reported in Table 6.

Table 6. The results of one-way covariance analysis related to the inter-group difference of research components in the post-test stage

Variable	component	Source	Sum of squares	Degrees of freedom	Mean square	F statistic	P-value	Eta squared
Executive Functions	Behavior regulation skills	Between groups	2264.351	3	754.784	24.600	<0.001	0.577
		Error	1656.849	54	30.682			
	Metacognitive skills	Between groups	3727.077	3	1242.359	32.840	<0.001	0.646
		Error	2042.827	54	37.830			
Reading performance	Visual-phonological processing ability	between groups	1194.819	3	398.273	6.219	<0.001	0.257
		Error	3458.442	54	64.045			
	Ability to speed and accuracy of	Between	2071.370	3	690.457	6.050	<0.001	0.252

	cognitive processing	groups						
		Error	6162.986	54	114.129			
	Reading outside of school	Between groups	751.153	3	250.384	25.00	<0.001	0.581
Attitude towards reading		Error	540.825	54	10.015			
	Reading at school	Between groups	717.631	3	239.210	23.598	<0.001	0.567
		Error	547.384	54	10.137			

The results of Table 6 showed that by considering the pre-test scores as a covariate (auxiliary) variable, the use of cognitive rehabilitation training, intervention based on the Barclay model, and neural feedback in children with dyslexia led to differences There is a significant difference between the experimental and control groups in the components of behavior regulation skills and metacognition skills in the executive Functions variable (P-value=0.05). The effect rate for behavior regulation skills was 55.7% and metacognition skills was 64.6%.

The findings presented in Table 6 indicate that, when pre-test scores are accounted for as a covariate, the application of cognitive rehabilitation training, Barclay model-based intervention, and neural feedback in children with dyslexia results in significant differences. Specifically, there is a notable distinction between the experimental and control groups concerning the elements of visual-phonological processing capabilities, as well as the speed and precision of cognitive processing within the variable of reading performance (P-value=0.01). The impact rate for visual-phonological processing ability was 25.7% and cognitive processing speed and accuracy ability was 25.2%. The results of Table 6 showed that by considering the pre-test scores as a covariate (auxiliary) variable, the use of cognitive rehabilitation training, intervention based on the Barclay model and neural feedback in children with dyslexia led to a difference There is a significant difference between the experimental and control groups in the components of reading outside the school and reading inside the school in the variable of attitude towards reading (P-value=0.01). The effect rate for reading outside the school was 58.1% and reading inside the school was 56.7%.

To investigate the difference between cognitive rehabilitation training, intervention based on the Barclay model, neural feedback in executive Functions, reading performance and attitude towards reading in Table 7, the results of pairwise comparison of the average adjusted scores of the study groups in the post-test stage has been reported.

Table 7. Examining the differences between two groups in executive Functions, reading performance and attitude towards reading

Variable	Group	Adjusted mean	Mean difference	Standard error	Effect size	P-value
Executive Functions	Cognitive rehabilitation training	170.495	-42.562*	4.126	0.659	<0.001
	Control	213.057				
Behavior regulation skills	Cognitive rehabilitation training	71.115	-18.320*	2.152	0.573	<0.001
	Control	89.434				
Metacognitive skills	Cognitive rehabilitation training	100.112	- 23.266*	2.390	0.637	<0.001
	Control	123.377				
Read performance	Cognitive rehabilitation training	151.417	22.302	5.622	0.222	0.001
	Control	129.115				
Visual-phonological processing ability	Cognitive rehabilitation training	65.471	9.338*	3.054	0.148	0.021
	Control	56.133				
Ability to speed and accuracy of cognitive processing	Cognitive rehabilitation training	86.378	14.021*	4.077	0.180	0.007
	Control	72.356				
Attitude towards reading	Cognitive rehabilitation training	58.580	13.137*	1.967	0.448	<0.001
	Control	45.443				
Reading outside of school	Cognitive rehabilitation training	58.580	13.137*	1.967	0.448	<0.001
	Control	45.443				
Reading at school	Cognitive rehabilitation training	28.998	6.071*	1.176	0.331	<0.001
	Control	22.927				
Executive Functions	Intervention training based on the Barclay model	189.011	- 24.046*	009.4	0.395	<0.001
	Control	213.057				
Behavior regulation skills	Intervention training based on the Barclay model	79.088	10.346*	2.039	0.323	<0.001
	Control	89.434				
Metacognitive skills	Intervention training based on the Barclay model	110.018	13.360*	2.264	0.392	<0.001
	Control	123.377				
Read performance	Intervention training based on the Barclay model	151.910	29.795*	5.610	0.278	<0.001
	Control	129.115				

Visual-phonological processing ability	Intervention training based on the Barclay model	67.385	11.252*	2.983	0.209	0.002
	Control	56.133				
Ability to speed and accuracy of cognitive processing	Intervention training based on the Barclay model	87.606	15.249*	3.982	0.214	0.002
	Control	72.356				
Attitude towards reading	Intervention training based on the Barclay model	63.152	17.709*	1.941	0.602	<0.001
	Control	45.443				
Reading outside of school	Intervention training based on the Barclay model	31.392	8.465*	1.177	0.489	<0.001
	Control	22.927				
Reading at school	Intervention training based on the Barclay model	31.499	8.862*	1.184	0.509	<0.001
	Control	22.637				
Executive Functions	Neurofeedback training	188.370	-24.688	4.070	0.401	<0.001
	Control	213.057				
Behavior regulation skills	Neurofeedback training	79.029	- 10.405*	2.069	0.319	<0.001
	Control	89.434				
Metacognitive skills	Neurofeedback training	108.760	-14.618*	2.297	0.428	<0.001
	Control	123.377				
Read performance	Neurofeedback training	138.291	9.176	5.604	0.046	0.643
	Control	129.115				
Visual-phonological processing ability	Neurofeedback training	58.945				
	Control	56.133				
Visual-phonological processing ability	Neurofeedback training	58.945	2.813	2.985	0.016	1
	Control	56.133				
Ability to speed and accuracy of cognitive processing	Neurofeedback training	79.460	7.104	3.985	0.056	0.481
	Control	72.356				
Attitude towards reading	Neurofeedback training	62.425	16.982*	1.978	0.573	<0.001
	Control	45.443				
Reading outside of school	Neurofeedback training	31.951	9.024*	1.183	0.519	<0.001
	Control	22.927				
Reading at school	Neurofeedback training	30.496	7.859*	1.190	0.447	<0.001
	Control	22.637				

*** P-value<0.005**

The results of Table 7 showed that there is a significant difference between the adjusted average of the cognitive rehabilitation training group with evidence in the post-test stage in the variable of executive Functions, reading performance and attitude towards reading, and its components at the level of 0.001. So their adjusted average in the cognitive rehabilitation training group in the post-test stage was significantly lower than the average of the control group. Therefore, cognitive rehabilitation training, intervention based on Barclay's model, and neural feedback were effective in improving executive Functions, reading performance, and attitude towards reading in children with dyslexia.

To investigate the difference between cognitive rehabilitation methods, intervention based on Barclay's model and neural feedback in executive Functions and its components, in table 8, the results of pairwise comparison of the average adjusted scores of the study groups are reported in the post-test stage.

Table 8. Comparing the average of test groups in the post-test stage in executive Functions

Variable	Group		Mean difference	Standard error	Effect size	P-value
Executive Functions	Cognitive rehabilitation	Intervention based on the Barclay model	-18.516*	4.05	0.275	<0.001
		Neurofeedback	-17.874*	4.001	0.266	<0.001
	Intervention based on the Barclay model	Neurofeedback	0.642	4.016	0.000	1
Behavior regulation skills	Cognitive rehabilitation	Intervention based on the Barclay model	-7.974*	2.079	0.214	0.002
		Neurofeedback	-7.915*	2.142	0.202	0.003
	Intervention based on the Barclay model	Neurofeedback	0.059	2.065	0.000	1
Metacognitive skills	Cognitive rehabilitation	Intervention based on the Barclay model	-9.906*	2.308	0.254	<0.001
		Neurofeedback	-8.648*	2.378	0.197	0.004

	Intervention based on the Barclay model	Neurofeedback	1.258	2.293	0.006	1

*** P-value<0.001**

The results of Table 8 showed that there was a significant difference between the adjusted average of the cognitive rehabilitation training group with the intervention based on the Barclay model and neural feedback in the post-test stage in the variable of executive Functions and its components; So that the adjusted average of the executive Functions and its components in the cognitive rehabilitation training group in the post-test phase was significantly lower than the average of the intervention groups based on the Barclay model and neural feedback. However, there was no significant difference between the adjusted average of the two intervention groups based on the Barclay model and neural feedback in the post-test stage in the variable of executive Functions and its components. Therefore, cognitive rehabilitation training has been more effective in improving the executive Functions of children with dyslexia compared to intervention training based on Barclay's model and neurofeedback. To investigate the difference between cognitive rehabilitation methods, intervention based on Barclay's model, and neural feedback in reading performance and its components, in Table 9, the results of the pairwise comparison of the average adjusted scores of the study groups are reported in the post-test stage.

Table 9. The results of the average comparison of test groups in the post-test stage in reading performance

Variable	Group		Mean difference	Standard error	Effect size	P-value
Read performance	Cognitive rehabilitation	Intervention based on the Barclay model	-3.49	5.598	0.007	1
		Neurofeedback	13.126	5.656	0.089	0.144
	Intervention based on the Barclay model	Neurofeedback	16.619*	5.637	0.136	0.028
Visual-phonological processing ability	Cognitive rehabilitation	Intervention based on the Barclay model	-1.914	2.936	0.008	1
		Neurofeedback	6.525	2.964	0.082	0.192
	Intervention based on the Barclay model	Neurofeedback	8.440*	2.944	0.132	0.035
Ability to speed and accuracy of cognitive processing	Cognitive rehabilitation	Intervention based on the Barclay model	-1.228	3.920	0.002	1
		Neurofeedback	6.917	3.957	0.054	0.517
	Intervention based on the Barclay model	Neurofeedback	8.145	3.930	0.074	0.258

*** P-value<0.001**

The results of Table 9 showed that there was a significant difference between the adjusted average of the intervention group based on Barclay's model with neurofeedback in the post-test stage in the variable of reading performance and visual-phonological processing ability; So that the adjusted mean of reading performance and visual-phonological processing ability in the intervention group based on the Barclay model in the post-test phase was significantly higher than the mean of the neurofeedback group. However, there was no significant difference between the adjusted average of the cognitive rehabilitation training group with intervention based on the Barclay model and neural feedback in the post-test stage in the variable of reading performance and its components. Therefore, the intervention based on the Barclay model has been more effective in improving the reading performance of children with dyslexia compared to neurofeedback. Also, the effectiveness of the cognitive rehabilitation training group with intervention based on Barclay's model and neural feedback has been equal in improving the reading performance of children with dyslexia.

In order to investigate the difference between cognitive rehabilitation methods, intervention based on the Barclay model and neurofeedback in the attitude towards reading and its components, in Table 10, the results of the pairwise comparison of the average adjusted scores of the study groups are reported in the post-test stage.

Table 10. The results of the average comparison of test groups in the post-test stage in the attitude towards reading

Variable	Group		Mean difference	Standard error	Effect size	P-value
Attitude towards	Cognitive rehabilitation	Intervention based on the Barclay	-4.573	2.007	0.086	0.159

reading		model				
		Neurofeedback	-3.845	1.934	0.067	0.311
	Intervention based on the Barclay model	Neurofeedback	0.728	2.021	0.002	1
Reading outside of school	Cognitive rehabilitation	Intervention based on the Barclay model	-2.394	1.216	0.067	0.324
		Neurofeedback	-2.953	1.157	0.108	0.081
	Intervention based on the Barclay model	Neurofeedback	-0.559	1.217	0.004	1
Reading in school	Cognitive rehabilitation	Intervention based on the Barclay model	-1.797	1.223	0.038	0.885
		Neurofeedback	-0.794	1.164	0.009	1
	Intervention based on the Barclay model	Neurofeedback	1.003	1.224	0.012	1

The results of Table 10 showed that there was no significant difference between the adjusted average of cognitive rehabilitation training groups, intervention based on the Barclay model and neurofeedback in the post-test stage in the variable of attitude towards reading and its components; In other words, there has been the same effectiveness between cognitive rehabilitation training groups, intervention based on Barclay's model and neurofeedback in improving the attitude towards reading and its components in children with dyslexia.

Discussion

This research sought to investigate and compare the effectiveness of cognitive rehabilitation methods, intervention based on Barclay's model, and neurofeedback on improving executive Functions, reading performance, and attitude toward reading in children with dyslexia. In this regard, the results of the data analysis showed that there was a significant difference between the adjusted average of the cognitive rehabilitation training group with intervention based on the Barclay model and neurofeedback in the post-test stage in the variable of executive Functions and its components; So that the adjusted average of the executive Functions and its components in the cognitive rehabilitation training group in the post-test stage was significantly higher than the average of the intervention groups based on Barclay model and neural feedback. However, there was no significant difference between the adjusted average of the two intervention groups based on the Barclay model and neurofeedback in the post-test stage in the variable of executive Functions and its components. Therefore, cognitive rehabilitation training has been more effective in improving the executive Functions of children with dyslexia compared to intervention training based on Barclay's model and neurofeedback. This finding was inconsistent with the results of the Azizi et al., study[4]; because these studies showed higher scores of executive Functions in cognitive rehabilitation compared to the neurotic group. Also, in a research, Vosoughifard et al. (2012) showed that neurofeedback improves children's executive Functions, but adding rehabilitation makes the effects of biofeedback more visible[31]. Azizi et al[4] believe that there is no significant difference between the effect of cognitive rehabilitation training and neurofeedback on the executive action of students with a specific learning disorder[1]. However, no research was found regarding the comparison of these methods with the intervention based on the Barclay model.

In explaining the greater effectiveness of cognitive rehabilitation compared to neurofeedback and intervention based on Barclay's model, it seems necessary to point out that cognitive rehabilitation, with the growth and expansion of neural pathways and the construction of new pathways, leads to the creation of stable structural and chemical changes in students' executive Functions suffering from a specific learning disorder, such as an increase in neurotrophic factor derived from the brain[4]. As a result, cognitive rehabilitation with appropriate and frequent stimulation of the brain areas of Kajkar in specific learning disorders can create stable changes in those areas because such changes occur in the structure of brain neurons and will remain constant[32]. In addition, in the present study, the presentation of cognitive rehabilitation programs was designed in a hierarchical form from easy to difficult, and the successful completion of relatively easy games in the early stages of the research made the child have higher self-esteem and self-regulation, and the level of attention in the future He kept the process of the game and tried to improve it. Therefore, in the conditions of the test, while improving attention, it improved executive action. It also seems that cognitive rehabilitation is more effective than intervention based on Barclay's model and neurofeedback in brain areas related to executive Functions (especially prefrontal)[(33)]; Because cognitive rehabilitation by strengthening perception, alertness, memory, concentration, and attention practically improves executive Functions, which is more than the changes resulting from neural feedback (through training to stimulate spontaneous activities through conditioning) or parent training through intervention. Based on the Barclay model, it is done faster. Therefore, the greater effect of cognitive rehabilitation than neurofeedback and intervention based on the Barclay model on executive Functions of dyslexic children can be justified by this means. Also, the results of the data analysis of the present study showed that there was a significant difference between the adjusted average of the intervention group based on Barclay's model with neural feedback in the post-test stage in the variable of reading performance and visual-phonological processing ability; So that the adjusted mean of reading performance variable and visual-phonological processing ability in the intervention group based on the Barclay model in the post-test phase was significantly higher than the mean of

the neurofeedback group. However, there was no significant difference between the adjusted average of the cognitive rehabilitation training group with intervention based on the Barclay model and neural feedback in the post-test stage in the variable of reading performance and its components; Therefore, the intervention based on the Barclay model has been more effective in improving the reading performance of children with dyslexia compared to neurofeedback. Also, the effectiveness of the cognitive rehabilitation training group with intervention based on Barclay's model and neural feedback has been equal in improving the reading performance of children with dyslexia. In this regard, Akbari et al. also showed in a research that the effect of cognitive rehabilitation on improving reading performance, reading non-words, understanding text, removing sounds, rhymes, and non-words, understanding words, marking letters, marking words, and naming pictures is significantly more than nervous feedback[34], but concerning the comparison of the intervention methods of the present study with the intervention based on Barclay's model on children's reading performance, no alignment was found.

Regarding the greater effectiveness of the intervention based on Barclay's model compared to neurofeedback, it can be stated that, the lack of sufficient skills in self-monitoring and self-regulation is evident in children with dyslexia, which can be caused by brain or educational defects[35]. In this way, the timely strengthening of these skills in children by parents who spend a long time with their children will be highly effective in improving the teachability of this group. On the other hand, the greater effect of cognitive rehabilitation intervention on reading performance compared to neural feedback can be attributed to the combination of several factors, such as greater ability to activate related neural networks in the brain, high power in inhibiting previous activity, and adaptation to new conditions when performing activities successfully Education justified[36]. Also, the use of computer-aided educational techniques can improve students' reading and understanding of concepts[37]. The unique features of computer-based education such as waiting time, immediate feedback, and multimedia presentation can help enrich children's education. The fact that the student is actively involved in computer-aided education and has some control over the learning situation increases his motivation to stay on task. With this method, compared to neural feedback, students show a strong desire to repeat a learning task. Therefore, the greater effectiveness of intervention based on Barclay's model and cognitive rehabilitation on reading performance compared to neural feedback is not far from expected.

Finally, the results of the data analysis showed that there was no significant difference between the adjusted average of cognitive rehabilitation training groups, intervention based on the Barclay model, and neural feedback in the post-test stage in the variable of attitude towards reading and its components. In other words, there has been the same effectiveness between cognitive rehabilitation training groups, intervention based on Barclay's model, and neural feedback in improving the attitude towards reading and its components in children with dyslexia. In line with this finding, no research was found, but in explaining the lack of difference between these intervention methods, it can be pointed out that the neurofeedback method is based on the evolved mind-body relationship and emphasizes the ability of the mind to change, restore and heal itself and the attitude in a natural way. In this method, the intervention of biofeedback leads to a change in attitude towards reading by affecting the function of the frontal and prefrontal lobes. Also, the accompaniment and participation of parents in the child's learning in the intervention based on the Barclay model cause the child's enthusiasm for learning; Because in this case, the child is not on one side and the parents are not on the other side, and the parents work together with the child towards his progress. In addition, computer-based cognitive rehabilitation programs make students with learning disabilities recognize their mistakes, and providing immediate reinforcements after providing the correct answer and providing incentives to help compensate for the weakened self-esteem of these students seems very valuable. Therefore, it can be said that all three therapeutic interventions have a high power in improving the attitude toward reading, and for this reason, the difference between the three interventions in this study is not significant.

The existence of limitations in any research is inevitable, which should be taken into account in the generalization and interpretation of findings. This study was limited to the age group of 8 to 12 years. Since children of different ages are in different stages in terms of brain characteristics and the effect of cognitive rehabilitation, neurofeedback, and intervention based on the Barclay model may have different results on different age groups, caution should be observed in generalizing the results. Due to operational problems in determining the sample, random selection was not possible and only random placement was done. The study of gender differences among the participants in this research was not done, which may have a statistical difference due to the studied variables and cultural conditions. The research findings suggest that the intervention programs evaluated in this study are crucial for imparting fundamental skills to dyslexic students at the initial stages and lower educational levels. These programs should be considered for their potential to yield improved preventative outcomes. It is also recommended that the intervention strategies employed in this research be integrated into the educational programs for students with other psychological conditions, such as autism spectrum disorder and developmental delays. It is suggested that in the intervention based on Barclay's model, a longer process for more practice and institutionalization of skills in parents should be considered. Considering the cost-effectiveness, importance and harmlessness of the intervention methods used in the present study, it is suggested to hold workshops for dyslexic students and their families to teach these skills.

Ethical Considerations

This article is a part of the doctoral thesis of Shahrood Islamic Azad University, which was approved by the code of ethics IR.IAU.SHAHROOD.REC.1401.009 in the university.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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