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The Effectiveness of Working Memory Training on Reading Difficulties among Students with Reading Disorder

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Abstract

The present study aimed at investigating the effectiveness of working memory training on reading difficulties of students with reading disorder. The method of this study was experimental with a pretest-posttest design and a control group. The statistical population consisted of all elementary school children with reading disorder, who had attended counseling centers of Tehran Education Department in the spring of 2017. Then, these students were randomly assigned to two groups of 15 (one control group and one experimental group) and the intervention program of working memory training was performed on the experimental groups over a period of 10 sessions, with each session lasting for half an hour. Both Simple Random Sampling and Convenience Sampling methods were applied. To measure reading difficulties, WISC- R (3rd edition) and Reading and Dyslexia Test (NEMA) were used. The obtained data were analyzed using the statistical method "Covariance Analysis". The results of Covariance Analysis showed that working memory training intervention is effective on all sub-components of Reading and Dyslexia Test ($p < 0.01$), with its greatest impact being on picture naming, sound elimination and category mark. Accordingly, it was concluded that the experimental group`s interventions based on working memory training, as a useful intervention method, can be effective on reducing reading difficulties of students with learning disorder, and can be applied as a complementary exercise to reduce reading difficulties among this group of students.

***Keywords*:** Learning Disorder, Reading Disorder, Working Memory

Introduction

Learning disorder refers to a single structure or disorder which is associated with deficiencies in the advancement of academic skills; this disorder has a heterogeneous nature which is reflected in academic patterns, information processing strengths and weaknesses as well as in the main classification system as academic disorders of certain areas including reading disorder or math disorder (Casey, 2012), and has characteristics such as difficulty in learning and listening function, speaking, reading, writing and calculation. These disorders begin in pre-school age and continue until adulthood (Abolghasemi, Ahadi, Narimani, & Abbasi, 2013). Learning disability is a neurological disorder and it is attributed to children with natural IQ (Intelligence Quotient) who have difficulties in one or more academic skills such as reading, writing, pronunciation, and reasoning. It is among common disorders (Azarnoosh, Amoopour & Nojabi, 2012; Buelow, Cooper & Okdie, 2015; Mogasale, Patil, Mogasale & Patil, 2011). Studies (Afrooz, Bakhshi, Ghobari Bonab, Hassanzadeh, & Pirzadi, 2012; Aldenkamp, Hendriksen, Hurks & Peijinenborg, 2015; Davari & Sharifi, 2008; Lotfabadi, 2003) suggest that the main problem in learning disability and academic failure (dropout) of children who are at risk of learning disability is related to reading skills and about 80% of students with learning disabilities have difficulty in

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reading. Disorder in memory functions (including impairment in short-term memory and working memory, and slight impairment in code-switching and cognitive and metacognitive strategies) is another important feature of children with learning disabilities (Asli Azad & Zaghian, Tofighi, 2016; Bosman, Walda, Weerdenburg & Wijnants, 2014).

Learning disorder, as British Dyslexia Association defines, is a combination of abilities and problems that affect the learning process in one or more areas such as reading, writing and spelling (Casey, 2012). This disorder may include other areas such as short-term memory, processing speed, and spoken language sequence; and in order to be placed under the category of reading disorder, child`s reading performance must be lower than expected in terms of age, education and intelligence. This disorder greatly impedes academic achievement or daily activities that need and is considered one of the most common disorders among elementary school students (Reid, 2016). According to some experts, dyslexia is the main cause of student failure in schools and strongly affects students' sense of adequacy, competence, self-concept and self-esteem. In addition, it could lead to behavioral disorder, anxiety and lack of motivation (Boochan, 2009). Dyslexic children make multiple mistakes while reading. These mistakes are identified by deleting, adding or reversing the words. Such children have difficulty distinguishing between letters in terms of shape and size, especially letters that are only different in terms of orientation and length of lines, and their reading speed is low and often with minimal understanding (Sadock & Sadock, 2003); so that continuation of these negative effects on the child increases the risk of developing disorders such as communication disorders, depression, and oppositional behavioral disorders, and such children are more likely (about 40%) to leave school and in the future they are at risk of social problems (Sadock & Sadock, 2003).

Reading disability is due to the lack of regular growth of the nervous system. Through some activities and practices, these steps can be re-organized and the severity of the disorders can be reduced (Dela Cato, 1998, quoted from Babapour Kheiroddin, Khanjani, Kazemi & Pour Abbas Wafa, 1394). Children who have difficulty acquiring adequate skills and get much lower ability in reading than expected and their reading age is two years or more behind their calendar age are called 'dyslexic' (Wajuihan, 2011). In this disorder (dyslexia), the transfer to the left hemisphere is carried out earlier than the due time or basically, from the beginning, the left hemisphere has played a crucial role in reading words. As a result of this disorder, normal procedure of word recognition and then turning it into sound and meaning are not followed, resulting in major mistakes (such as mistakes associated with omissions, reversals and displacement of letters and syllables in a word) by dyslexic children. Bakker calls this type reading disorder 'L- Type or Linguistic Type' (Naderi & Seif Naraqi, 2014). Excessive reliance of these children on the left hemisphere leads to high speed in reading and because such children do not benefit from the right hemisphere strategies, they are not mindful of the perceptual feature of the text, so they make fundamental mistakes (such as eliminations and additions, displacement of letters and syllables) in reading (Bakker & Robertson, 2006; Jansen & Kaltner, 2014) and thus, they read quickly and inaccurately. Spoken language defects constitute a large part of the problems of children with learning disabilities. Many believe that problems faced by children with spoken language learning disabilities are closely associated with other academic disabilities (Azizinejad, 2015).

Various factors have been investigated about the causes of reading disorder, including working memory and the impact it has on this disorder, which has significantly been the focus of many studies in recent years; in fact, recent studies have emphasized the association between working memory capacity and reading disability and showed that dyslexic children have problems in their working memory, which is related to the inability to read and write. Studies (such as Anderson, Baddeley, & Eysenck, 2009; Arjmandnia,2012; Kartini & Susan, 2013; Lotfi, Rostami , Salehi Azar & Shokouhi Yekta (2014); Papalia, 2013; Pumferey (2004); Sachese-Lee & Sowanson, 2008) indicate the impact of working memory on dyslexia. The results of the studies conducted by Shaw, Grayson and Lewis (2005); Antonson et al. (2005); and Milton (2010) suggested that training based on working memory increases learning capacity and affects the cognitive flexibility, and as a result, it can lead to the improvement of learning disorder. Working memory training has an effective role in managing children`s behavioral problems. These programs are applicable at home and school either individually or in groups (Carlson, Mauphin & Pharm, 2011) and have multiple benefits, especially if used in group situations (Power, 2012). Many of the solutions of this children`s training, taking into account the child`s behavioral antecedents and consequences, along with implementation of home assignments would lead to the improvement of interactions with parents and other children (Kazdin, 1997). In this regard, review of the literature related to this area revealed that attention & working memory

training improves cognitive action of normal people, and this improvement is observable in both the assignment used and not used in training.

Although, previous studies have investigated the effect of cognitive training on the psychological variable or on the improvement of academic performance, children with learning disability spectrum were neglected in these studies. Accordingly, considering the existing literature, the researcher sought to answer the following question:

- How does cognitive training affect working memory and information processing speed in children with reading learning disability? And
- How are verbal working memory capacity, visual-spatial working memory, processing speed and finally the student`s academic performance affected by this training?

Therefore, given that psychiatric treatments mostly include drugs (and sometimes with associated complications), the present study was conducted with the aim of investigating the effectiveness of working memory training (strengthening) on reading difficulties of dyslexic children.

Method

Participants

In the present study, 30 people were present in both the experimental and control groups. As regards the experimental group, most participants aged 9 and least ones aged between 7 and 11 (13.3% each). And as for the control group, most participants aged 9 and least ones aged between 8 and 11. Moreover, both boys and girls participated in the study.

Instruments

A. WISC- R (fourth edition):

WISC-R was applied to measure the students' intelligence. Wechsler Intelligence Scale was developed by David Wechsler (1949) in order to measure the children`s intelligence. It contains 12 sub-scales: 6 verbal sub-scales and 6 non-verbal sub-scales. Verbal scale includes general knowledge, numerical memory (digit span), vocabulary treasure, calculation, comprehension and similarities, while non-verbal scale includes picture completion, picture adjustment, attachment of fragments, designing with cubes, code-switching and mazes. Verbal scales examine verbal comprehension, and practical scales examine visual-spatial abilities. Through Split-half method, the reported validity of this test was 0.97 for overall IQ, 0.97 for verbal IQ, and 0.97 for practical IQ (Marnat, 2005). This scale was revised in 1995 and was standardized for measuring the intelligence of children between 6 and 12 years of age, and from then on it was named as "WISC-R" (Shahim, 1995). Through Split-half method, the reported validity of this test was 0.94, 0.90 and 0.96 for overall intelligence, verbal intelligence and non-verbal intelligence, respectively. Additionally, as reported, the correlation of the test with academic achievement and retest was 0.88 and 0.85, respectively (Asghari, Ghanaei Chaman Abad & Kalani, 2014).

B. Reading and Dyslexia Test:

To measure the students` reading disorder, Reading and Dyslexia Test (NEMA) standardized by Karami Noori and Moradi (2008) for students with dyslexia in three cities including Tehran, Sanandaj and Tabriz was used. This test consists of 10 subtests. To validate this test, a pilot (preliminary) study was conducted on 100 students (100 Persian-speaking students from Tehran, 100 Kurdish-speaking students from Sanandaj and 100 Turkish-speaking students from Tabriz). Following the analysis of the pilot study data, the necessary modifications were made and so the final version of the test was prepared. The test was performed on 1614 students including 770 male and 844 female students (in five grades in Tehran, Sanandaj and Tabriz). After collecting data and performing the required statistical operations in each city, raw scores and norm scores were calculated. Dyslexia test was performed individually and with the following specifications and subtests:

1. Word Reading Subtest: words with high, moderate and low frequency
2. Word Chain Subtest
3. Rhyme Subtest
4. Picture Naming Subtest
5. Text Comprehension Subtest
6. Word Comprehension Subtest
7. Sound Elimination Subtest
8. Non- or Quasi-Word Subtest
9. Letter Mark Subtest
10. Subtest of Categories

First subtest has a maximum score of 40, second, 53, third, 20, fourth, 40, fifth, 24, sixth, 30, seventh, 30, eighth, 30, ninth, 43 and tenth, 90.The participant in each subtest received 1 score for each correct answer. In the end, the scores of each sub-test were calculated individually and the sum was considered as reading score, with full score being 380. Scores below 190 indicated reading disorder in students.

In a study by Karami Noori and Moradi, Cronbach's alpha coefficient of reading was 0.98, while it was 0.97 in dual coding mode. Cronbach's alpha coefficients of rhyme subtest were 0.93 and 0.66 in sextuple and dual coding, respectively. Cronbach's

alpha coefficients of picture naming subtest for quad and dual modes of coding (form A) were 0.93 and 0.86, respectively. And Cronbach's alpha coefficients for quad and dual modes (form B) were 0.97 and 0.90, respectively. Text comprehension subtest consists of two subtests. Cronbach's alpha coefficients for sextuple and dual modes of coding were 0.72 and 0.87, respectively. Cronbach's alpha coefficients of sound elimination subtest were 0.96 and 0.96 for quad and dual modes, respectively. And finally, Cronbach's alpha coefficients for non- and quasi-words subtest were 0.98 and 0.98 for quad and dual modes of coding, respectively.

Face validity was also checked in the present study. Face validity is a kind of content validity of a test which is typically determined by individuals specialized in the study subject matter. Further, reliability of the research instrument was determined through Cronbach's alpha coefficient by using SPSS v.21. To do so, a pilot study was carried out on 20 students with dyslexia, and then using the data obtained from this test, the measured reliability for tenfold subtests including word reading, word chain, rhyme, picture naming, comprehension, sound elimination, non- or quasi-words reading, letter mark and categories was 0.88, 0.90, 0.78, 0.91, 0.86, 0.89, 0.92, 0.86, 0.79 and 0.85, respectively, and it was confirmed.

C. Content of Working Memory Training Sessions:

Considering the theoretical basis of the intervention program, appropriate training content was designed and ready for implementation by using the books "Working Memory Improvement" and "How to strengthen our Child's Learning Ability with Working Memory Training?" The topics of the training sessions are as follows:

Table 1

Content of Working Memory Training Sessions (Visual and Auditory)

Getting familiar and establishing proper communication with the group members, explaining the rules of the group for the children, providing session programs and their schedules, sharing training objectives with members of the group, introducing the concept of memory and working memory with childish literature
Visual Memory Training: Practicing with word cards, numbers and shapes Visual Memory Training: Practicing of remembering objects
Auditory Memory Training: Reading words, numbers and names of pictures Auditory Memory Training: Listening to the set of words and finding rhyming words Visual Memory Training: Practicing with visual cards Visual Memory Training: Practicing with word, number and geometric shape cards
Auditory Memory Training: Reading words, numbers and names of pictures Auditory Memory Training: Listening to the set of words and finding rhyming words and practicing associative words
Visual Memory Training: Practicing by displacing the word card with the card of the letters forming the word Visual Memory Training: Practicing by displacing the word card with the same word card without points
Auditory Memory Training: Practicing by reading words and eliminating some letters of words, and asking the child to fill the eliminated letters Auditory Memory Training: Practicing by reading words and then asking the child to find those words
Visual Memory Training: Practicing by remembering the sequences of colored abacuses and asking the child to find them Visual Memory Training: Practicing with letter sound cards and asking the child to find similar letters
Auditory Memory Training: Reading three letters for the child to find words beginning with those letters Auditory Memory Training: Recognizing the first and last sounds of words, and practicing the order of numbers
Visual Memory Training: Practicing with visual cards and finding the sounds of the words Performing Post-Test

Procedure

In this research, a quasi-experimental design including pre-test/post-test with a control group was applied. The statistical population of the study included all elementary school students with reading disorder, who had attended counseling centers of Tehran Education Department in the spring of 2017. The sampling method was as follows: After obtaining the necessary permissions regarding this research from the relevant centers, five counseling centers were asked to provide a list of students with reading disabilities to the researcher. First of all, Tehran was divided into five

geographical areas: North, South, East, West and Center. From among counseling centers in each of these areas, a counseling center was randomly selected, and from each counseling center, a number of students were randomly selected. Using random placement, a total of 30 students were assigned into two groups, namely experimental and control groups.

To win the trust of the parents of the subjects, prior to the start of the sessions, the research objectives were described and also the researcher ensured the parents that all content provided in the training sessions and the results of the questionnaires would be kept confidential and would not be shared with any person or organization, and that the results would be presented collectively without mentioning the students' names. After making the necessary arrangements, training sessions were held at 'Aftabgardan Counseling Center' in which the experimental group received working memory training intervention in 10 sessions, with each session lasting for 2 hours, while the control group did not receive any intervention. After the end of the training sessions, both the experimental and control groups were post-tested, and during the training stages, all moral considerations were taken into account. The criteria for entering the research included being in the age range of 7-11 years, having an IQ between 90 and 110 in Wechsler Intelligence Scale for Children-Revised (WISC-R), diagnosing reading disorder with reading and dyslexia test, having visual and hearing health based on the students` Record Assessment Plan. And exclusion criteria included discontinuation of cooperation, absence in more than one session during research or suffering from other physical and psychological diseases.

For data analysis, the collected data were analyzed using SPSS 21 computer software. To analyze the obtained data, Covariance Analysis test was used after examining its assumptions.

Findings

As mentioned before, 30 people were present in both the experimental and control groups. As regards the experimental group, most participants aged 9 (33.3%) and least ones aged between 7 and 11 (13.3% each). And as for the control group, most participants aged 9 (33.3%) and least ones aged between 8 and 11 (13.3% each). Moreover, in terms of gender, the experimental group consisted of 40.0% boys and 60.0% girls, while in the control group, 46.7% were boys and 53.3% were girls. In terms of grade, most participants in the experimental group (33.3%) were in the third grade and least ones (13.3%) were in the first and fifth grades. As for the control group, most participants (33.3%) were in the third grade and the least ones (13.3%) were in the second and fifth grade. Also, both the experimental and control groups were evaluated in terms of IQ. The mean and standard deviation in the experimental group were 98.6 and 5.0, respectively, while in the control group, the mean and standard deviation were respectively 99.6 and 6.2.Below, descriptive statistics related to the components of reading test in the experimental and control groups are presented separately in pre-test and post-test stages.

Table 2.
Descriptive Statistics of the Components of Reading and Dyslexia Test (NEMA) in the Control group

Components	Descriptive Statistics		Descriptive Statistics		Post-Test
	Number	Mean	Standard Deviation	Mean	Standard Deviation
Reading Words	15	9/66	2/19	15/20	3/16
Word Chain	15	11/86	2/13	17/00	2/00
Rhyme	15	9/40	1/80	15/86	2/13
Picture Naming	15	25/66	2/60	31/93	2/31
Text Comprehension	15	12/86	1/30	18/40	1/45
Word Comprehension	15	15/66	1/44	21/33	2/66
Sound Elimination	15	8/73	3/08	15/26	2/96
Reading Non- or Quasi- Words	15	15/66	2/55	20/46	2/32
Letter mark	15	9/40	1/24	15/46	2/41
Category Mark	15	35/73	2/28	43/73	2/49
Total	15	154/66	15/97	214/66	13/99

According to the above table, the highest mean of pre-test in the experimental group is reported for category mark component (mean = 35.73) and the lowest mean is reported sound elimination component

(mean = 8.73). Also, the highest mean of post-test in the experimental group is reported category mark component (mean = 43.73) and the lowest mean is reported for word reading component (mean = 15.20). As seen, total mean of components in pre- and post-tests in the experimental group was 154.66 and 214.66, respectively.

Table 3.
Descriptive Statistics of the Components of Reading and Dyslexia Test (NEMA) in the Control Group

Components	Descriptive Statistics		Descriptive Statistics		Post-Test
	Number	Mean	Standard Deviation	Mean	Standard Deviation
Reading Words	15	9/06	1/33	10/00	1/81
Word Chain	15	11/66	2/02	12/66	2/69
Rhyme	15	9/06	1/75	9/73	1/79
Picture Naming	15	25/46	2/50	29/06	2/31
Text Comprehension	15	12/66	1/39	13/40	1/63
Word Comprehension	15	15/60	1/40	16/00	1/64
Sound Elimination	15	9/33	3/39	10/06	2/98
Reading Non- or Quasi- Words	15	16/33	2/22	16/40	2/52
Letter mark	15	8/93	1/38	9/13	1/59
Category Mark	15	35/93	2/68	36/66	2/46
Total	15	154/04	17/62	16/013	16/89

As seen in Table 3, the highest mean of pre-test in the control group is reported for category mark component (mean = 35.93) and the lowest mean is reported for letter mark component (mean = 8.93). Also, the highest mean of post-test in the control group is reported for category mark component (36.66) and the lowest mean is reported for letter mark (mean = 9.13). As seen, total mean of components in pre- and post-tests in the control group was 154.06 and 160.13, respectively. Overall, as descriptive findings show, mean scores of dyslexia test components in the control group students has had little increase in the post-test stage as compared to pre-test stage, which can be due to the effects of pre-test. Covariance analysis was used to analyze the main problem of the research. Prior to using the parametric test of covariance analysis, Shapiro-Wilk and Leven`s tests were applied in order to comply with its assumptions including normal distribution of scores, regression gradient homogeneity and variance homogeneity. The results are presented in the following tables.

Table 4.
Results of Shapiro-Wilk Test for Examining Normal Distribution of Scores in Groups

Degrees	Statistic Level	Freedom	Significance Degrees	Statistic Level	Freedom	Significance
Pre-Test	0.092	45	0.20	0.961	45	0.12
Post-Test	0.081	45	0.20	0.958	45	0.10

As seen in the above table, Shapiro-Wilk test was performed to examine normal distribution of the research variables. The results indicate that when all the variables become insignificant, the distribution of the research variables will be normal ($p<0.05$).

Table 5.
The Results of Leven`s Test: Assumption of the Equality of Variances of the Two Groups in Post-Test Stage

(F) Value	Df2	Df1	Significance Level
3.12	2	42	0.054

The result of Levene`s test for examining the assumption of homogeneity of variances shows that the significance level in (F) is greater than 0.05 (P≥0.05), therefore the assumption of the homogeneity of variances is established. Based on Leven`s test and its insignificance for all the variables, the condition of the equality of intergroup variances has been met. Thus, performing covariance analysis test is acceptable.

Table 6.
Assumption of Homogeneity of Examining the Regression Gradient

Change Sources	Sum of Squares	Degrees of Freedom	Mean Squares	(F) Value	Significance Level
Pre-Test Group*	293.43	2	149.71	2.68	0.081
Error Value	2134.91	39	54.74		
Total	159839.0	45			

Given the result of the calculated F value which is 2.68 with freedom degrees 2 and 32, the significance level is greater than 0.05 (P≥ 0.05). Therefore, it can be safely asserted that the homogeneity assumption of regression gradient is established.

Table 7.
The Results of Covariance Analysis Significance Test in the Experimental and Control Groups

Trace	Value	F-value	Degrees of Freedom	Error Degree of Freedom	Significance Level	Eta
Pillai`s Trace	0.97	31.21a	10	9	0.000*	0.97
Wilks` Lambda						
Hotelling`s Trace						
Roy`s Largest Root						

As seen in Table 7, the value of Wilks` Lambda is 0.02 which is at 0.01 significance level (p< 0.01). The smaller the value of Wilks` Lambda indicates that there is a significant difference between the two groups. Further, the observed Hotelling and Roy`s largest root values suggest that there is a significant difference between the experimental group and control group in terms of the linear composition of the dependent variable. In other words, significance of Pillai, Wilks and Hotelling tests indicates that, at least in one component of reading and dyslexia post-test (NEMA), there is a significant difference between the two groups of working memory improvement, namely the experimental and control groups.

Eta-squared (η2) shows that the difference between the two groups is in total significant in terms of dependent variables, and the value of this difference based on Wilks` Lambda test is related to the difference between the two groups due to the interaction of the dependent variable.

Table 8.
A Comparison of Reading and Dyslexia Test (NEMA) in the two Groups (Experimental and control) with Pre-Test Effect Control

Change Eta Sources	Components	Sum of Squares	Degrees of Freedom	Mean Squares	F- Value Level	Significance
0.75	Word Reading	129.35	1	129.35	54.99	0.000**
0.75	Word Chain	108.39	1	108.39	56.04	0.000**
0.82	Rhyme	201.90	1	201.90	85.42	0.000**
0.88	Picture Naming					
Group	Text Comprehension					
	Word Comprehension					
	Sound Elimination	172.52	1	172.52	134.93	0.000**
	Non-Word Reading					
	Letter Mark					
	Category Mark					

As seen in the above table, considering the pre-test scores as covariates (auxiliary variables), working memory improvement intervention leads to a significant difference between the experimental and control groups ($p< 0.01$). The effect of working memory improvement intervention on each sub-component of reading disorder is as follows: Word reading (0.75), word chain (0.75), rhyme (0.82), picture naming (0.88), text comprehension (0.75), elimination of sounds (0.84), non- and quasi-word reading (0.69), letter mark (0.80), and category mark (0.80). These results show that working memory improvement intervention has great effect on all sub-components of reading and dyslexia test (NEMA), with the highest impact being on the components of picture naming, sound elimination and category mark; in other words, intervention has significantly improved reading disorder components in post-test of the experimental group.

Discussion and Conclusion

The results of the present study showed that intervention on the basis of working memory training reduces reading difficulties of students with learning disorder. These findings are consistent with those obtained by Hamidi and Fayyazbakhsh (2016) who showed that working memory training is effective on the improvement of reading skill of students with dyslexia. They are also in line with a study by Holmes, Gathercole and Dunning (2009) who found that working memory training improves reading skill of dyslexic students. This is because the results of the present studies also showed that working memory training reduces reading difficulties and thus, improving the performance of reading and mathematics disorder among elementary school students. To explain the above findings, we can say that one of the patterns accounting for poor reading is working memory (Narimani & Soleimani, 2013). Active dynamism is a prerequisite for learning everything, including reading, writing and mathematics, and it appears that processes of memory system and mental stores of children with reading disorder have problems (Kasaeian et al., 2013). All writing steps require working memory, therefore, active memory defects are considered as one of the etiological factors in learning disabilities (Ghaedi & Hemati Alamdarloo, 2015).

In addition, as compared to the previous research, the present study results are consistent with findings of Mo`azami-e-Goodarzi, Farrokhi, Goodarzi, and Nazari (2016); Zare and Amini (2016); Khanzadeh, Azadimanesh, Mohammadi, Ahmadi and Sadeqi (2016); Karimi and Askari (2013); Abedi and Aqababaei (2011); Papalia (2013); Saches-Lee & Swanson (2008); Zach & Thomas (2012); Zare and Lotfi (2015); Nevo & Breznitz (2011); and Holmes et al. (2009) who found in their studies that brain activity associated with working memory will increase after training, and also its performance will be better. According to the finding of this study and aligned studies, one can say that reading disorder is a component that can affect all levels of learning in students. Working memory training intervention as an efficient intervention that is selected by the present study can help reduce learning and reading difficulties.

Findings of the present study, like recent studies, emphasized the relationship between working memory capacity and reading disability and showed that children with reading disorder have difficulties in their working memory which are associated with reading and writing disability. Children must have a series of skills to master reading performance. These skills, like working memory, are acquired from experience, training and learning. Normal children do this automatically, while children with reading disorder face difficulties in these skills when learning and thus they should be trained in this regard. Due to the fact that these children have difficulties in their working memory, training this memory can reduce reading difficulties, leading to the improvement of reading performance in students with reading difficulties. Lack of full cooperation of the Education Department for obtaining permission and access to subjects, failure to follow up by parents and the geographical and cultural differences were among the main constraints of this study. Given the findings of the present study, it is suggested that in future studies the effectiveness of this intervention on a larger sample size and in students with mathematics disorder and spelling disorder be investigated and eclectic methods of intervention be applied.

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