



The effectiveness of working memory computer assisted program on executive functions and reading progress of students with reading disability disorder

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ABSTRACT

Objective: In this study we investigated the effectiveness of working memory computer assisted program teaching on improving executive functions and reading performance of students with reading disorder.

Methods: Due to the nature of issue, the semi-experimental method and pretest - posttest with control group was used. The population of present study consisted of 20 boy students' with reading disorder in the third and fourth grade of primary school in the Tehran city .The students were selected by using sampling method and randomly assigned to experimental and control groups.

Subjects consistently were evaluated by performance tests (Rosvold, Mirsky, Sarason, Bransom and Beck 1965), computerized version of London Tower (Morris, Ahmad, Saiyed & Tone, 1993), Stroop Test (Stroop, 1935), Testing Memory of Cornoldi, (Cornoldi, & Vecchia, 1995) and Reading tests (Azizian & Abedi, 2003). Experimental group passed the computer assisted program of working memory (Bokharaeian, 2010) in the 20 session which the duration of each session was 45 minutes.

Results: The results of T-test showed that there is significant difference on post-test in the executive function and reading progress of students with reading disorders .The results also indicated that working memory computer assisted program is effective for improving executive functions and reading progress of students with reading disorder.

Conclusion: Teaching and paying attention to the executive functions as the underlying neuropsychological functions can be expressed as new approach for the treatment of especial learning disorders.

Keywords: executive function, working memory computer assisted program, reading disorder

INTRODUCTION

Most of the educational instructors and cognitive scientists believe that listening and speaking skills are prior to the reading and writing, the extent of learning the listening and speaking skills will prepare the child or person more for reading and writing. These skills are considered as cognitive and social skills and shaping and fundamental improving of them is essential for success in social interaction. Dyslexia is known as the most important factor in school failure. These problems are simplest sign that can predict child failure in the most of educational areas. Dyslexia while occurs which reading skills (e.g., reading comprehension) and general ability to read of person significantly is less than his/her intelligence that we expect of him/her and also it should be notice that other situational and environmental factors don't affect it. About diagnosis of reading disorder and subsequent treatment of it various theories and research has been done (1). Reading inability is usually one of the important areas that face students with more difficulty for learning. Because reading difficulty is associated with most of speech and writing problems, many names for these type of problems has been mentioned that dyslexia is the most common one. In the reading disability a person completely lost the ability to read but in the dyslexia a person doesn't lost his ability completely (2). Almost 80% of students with

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learning disabilities have difficulty to read (3). They have difficulty in learning to decode words and reading comprehension (4).

During the last decade the area of executive function attracts increasing attention to itself. From a neurological point of view, the term is associated with a wide network of prefrontal cortex function and includes a number of cognitive processes such as self-regulation of behavior and improving cognitive and social skills which formed during the period childhood development (5). In a study that conducted by (6) on 21 children age 8 to 11 years old, results showed that students with reading disabilities have more difficulty in executive functions. (7) in their research paid attention to the comparison of the response inhibition of executive function and target tracking of three groups of students with dyslexia and math disorder and normal ones. The results showed that students with math disorder have the greatest weakness in the field of executive functions compare with normal and dyslexia students and also students with reading disorder have lower score in the mentioned function compare with normal students.

Reading disorder is the confusion for identifying similar words, guessing words considering the first and last letters of them, the mirror-reading or inverted words reading, severe problems for spelling words, reluctances for learning to read and difficulty for diagnosing of compound and separated words (8). It is thought that children with learning disorders permanently in one or more of the basic psychological processes have problem (9) which is seen as carelessness, inattention, impaired comprehension, impaired thinking, speaking, reading, writing, spelling and arithmetic (2) and mentioned symptoms happen because of executive function deficit.

MATERIALS AND METHODS

The numbers of 30 students 9 to 11 year old with reading disorder were selected by sampling method from Tehran learning disorder centers in the 2015-2016 school year. Participants were evaluated by reading tests (10) and executive functions of Stroop test (11) continues performance test (12); London Tower (13) and working memory test (14), and then they were taught to families because teaching to the family is important for their cooperation (15). In the present study dependent variable are reading performance and executive functions. According to the research tools, the level of measuring variables are in the interval scale. At present research independent variable is working memory computer assisted teaching program. The research design is semi-experimental because there wasn't possibility for random sampling, so available sampling method was used and both experimental and control group were selected randomly and independent variable is also in the interval scale. In this research statistically for assessing the significances of variables differences in the both experimental and control group, after implementing of teaching program one way T-test variance analyzing was used (16).

After identifying and elimination of students who have more than one disorder because of necessity, cognitive science institute work with us as executor of research for implementing the executive function test and the performance reading test for students with reading disorder and normal students also were evaluated for executive functions. Then group with reading disorder randomly divided into two groups, one group received working memory computer assisted teaching program and the other didn't receive it, in the post test both group were again evaluated for executive functions and reading progress.

After implementing pretest, teaching stage and manipulating independent variables was started individually. For teaching working memory computer assisted program each student for 7 weeks received 20 sessions teaching which the duration of sessions were 30 minutes. After finishing the task reading and executive functions post-test were implemented for each student and the results were ready for analyzing. A month later follow-up test for both group were done. In this research following test were used.

The Test of Identifying Reading Level

This test is designed to assess the ability to read and detect basic early problems. This test consists of a series of subtests in three areas of reading, reading accuracy, comprehension and understanding of phonological knowledge and assesses the abilities of subjects. Coefficient reliability of test by using 1780204 Cronbach's alpha for reading accuracy was 94%, reading comprehension was 51% and for understanding of phonological knowledge was 84% (10). Grading the test for all subtests will do according to the error scores. The test scores have mean of 100 and standard deviation of 15.

Working memory test of Cornoldi (1995)

Working memory is measured by the test which has been designed by Cornoldi and Vecchia. The reliability of the test base on the Cronbach's alpha coefficient has been reported 0.6 (17). In revalidating of test for present research, the coefficient of Cronbach's alpha was 0.78. This test is known as working memory matrix. In this task we used 3*3 matrixes which only the left part of its square (lower part) has red color. The red square is considered as start point. The subjects are asked to watch at matrix carefully then keep its shape in their mind then they are asked to listen examiner command "right, left, up, down" and according to the orders of examiner move the red square in the matrix, at the end the subjects showed the location which red square has been place on it hand after making mind imagination they should be able to point out the location which matrix has been stopped, it be must notice that the path moving of red square as start point happed completely subjectively.

The score of each subjects will calculated according to their success in the each stage. We will consider one score for each success in the stages and they will receive zero if they fail to complete the task and totally examinees will receive 0 to 3 score.

The Computerize London Tower Test

The London Tower test first had been designed by Shallice (1982) in order for assessing planning abilities of patients with frontal lobe injuries. In this test examinees are asked to displace a set of color nuts on the three vertical bars for matching with specific purpose. Morris designed computer software for this test which its nuts are three dimensions (18). The arrangement orders of nuts were shown to examinees in a touchable screen. At any stage of test the arrangement order of upper row was fixed and downer row consisted of nuts that examinees should match according to the upper row. Examinee can displace the nuts by touching screen; at the end the target touching will be feasible. The target situation is variable for nuts but the starting point is fixed. The numbers of test tasks are minimum movement which examinees do for solving the problems (19). Variables are presented following: A) The numbers of movement which is consider as performance standard, the numbers of movement which examinees do for solving problems B) time scheduling, the duration of time for touching the first nut C) the next thinking time, is time interval for selecting the first nut and problem completion which also is used as performance standard (18). The London Tower Test is used for evaluation planning ability and organizing which are sensitive to formal lobe performance (20,21)

Continuous Performance Test

Continuous Performance Test is used for measuring inhibition and attention. This test (12) is existed in different forms. In this test target stimuli is presented on the screen randomly between different stimulus and examinee is asked to push button when the target stimuli appeared. Variable are A) the numbers of commission errors which is index for impulsivity (examinees responses to none target stimulus is considered as error). B) The number of omission which is index for attention (while examinees lost the target, omission target will occurred) C) Reaction time: Is interval time while target is presented and examinee wants to response.

Stroop's Test

The Stroop's Test (1935) is used for measuring attention, displacement ability and inhabitation. Examinees are given three cards; the first one is dot card which is consisted of different dots with green, red, blue, yellow color and examinees are asked to name the colored dots. The second one is word card which is consisted of different words with green, red, blue, yellow color and examinees are asked to name word without considering their colors. The third one is color card which the vocabularies of "green, red, blue and yellow" are printed in different color apart from their names and examinees are asked to name the colors without considering the notions of the words. The errors and the time of answering will be recorded. The time differences which was spent for dot card and colored card is used as difference index. All of these tests have been standardized in the cognitive science institute (22).

Working Memory Computer Assisted Teaching Program

This program has been created in the Aminr kabir University (23) and had been registered in August 2010 with recorded number of 203922. This program is consisted of 20 teaching sessions in the 30 minutes which include visual and audible practices. This program have four teaching tasks (square Four * Four, Fixed and Rotate able, the table of audible numbers, the table of meaningless letters and task of assimilating the syllables). In each part of this teaching program some reinforcements have been considered for students.

Table 1: The results of dependence T-test between the score means of pre-test and post-test score of research variables of London Tower test

variable	The experimental group (n = 10)					A control group (n = 10)			T
	pre	M	SD	Pre	post	Follow	M	SD	
Number of movements									
Level 3	4/82	3/39	3/11	1/43	4/24	4/19	0/78	1/90	
Level 4	10/53	09/8	0/92	1/33	9/65	9/58	0/03 *	1/93	
Level 5	34/12	37/6	1/35	1/19	11/51	10/02	0/17	2/65	
Thinking time									
Level 3	18/91	52/19	0/45	0/56	28/11	29/80	0/71	1/97	
Level 4	31/62	45/31	1/27	1/44	41/27	43/56	0/01 *	2/78	
Level 5	41/17	61/42	2/32	2/92	50/14	42/50	0/59	2/54	
Planning time									
Level 3	6/39	20/0	4/42	23/5	7/09	2/13	0/02 *	3/01	
Level 4	5/61	81/1	3/78	73/3	5/75	1/67	0/03 *	2/61	
Level 5	7/47	91/1	4/15	13/4	7/61	36/0	0/52	3/18	

Table 2: Characteristics of the two groups on the Stroop's test

Mean	The experimental group (n = 10)				The control group (n = 10)					
	Standard deviation	Mean	standard deviation	Error of standard deviation	Pre	Post	Follow up	standard deviation	Errors of standard deviation	
Time	21/43	16/03	17/87	3/65	2/43	19/81	19/78	19/92	4/32	3/92 0/01
errors	1/23	0/14	0/87	0/64	0/50	1/43	1/39	1/32	0/41	0/39 0/01
Time	43/45	23/46	24/91	2/56	1/79	46/28	43/12	42/52	8/29	2/38 0/01
errors	2/32	1/12	1/54	0/67	0/39	2/54	2/19	2/01	0/29	0/17 0/01
Time	51/76	34/45	35/82	3/65	1/91	49/90	46/13	45/57	8/72	1/01
errors	3/53	1/63	1/48	1/23	2/61	3/64	3/51	3/48	0/37	0/49 0/01

This teaching program has been created for school age students from 8 to 14 years old and its validity has been approved with university professors and its reliability was evaluated by Cronbach's alpha which the results showed that its reliability for visual part was 0.78 for audible part was 0.69. This program also has working memory computerized pre-test and post-test which used for identifying the working capacity for examiner.

In the number of movement part at 3 and 5 level of, because the aim of teaching program is to reduce the extra movement so this reduction is natural because the students achieved skills. In the 5 level at the thinking time part the purpose of implementing of program is decreasing the time so this reduction is natural .The number errors commitment in the pre-test and post-test have significant difference. In the London Tower test there are significant differences between two groups for the numbers omission errors. The results on the pre-test and post-test in the two groups show the efficacy of teaching program.

According to **Table 2**, the time used to name the colors of the dot cards compare with word cards and color cards in the students with reading disability significantly is more than control group. $t = 2/23, P < 0/05$. The time of dot cards and color cards in the students with reading disability after practicing with working memory computer assisted were improved, so this difference is statistically significant. The score mean of post-test and follow up have no significant difference so the created changes on post-test stage remained fixed in the follow up stage.

The **Table 2** results showed that this test is used for evaluation of attention ability, inhabitation and flexibility which spent time for naming the color of dot cards compare with word cards and colored cards in students with reading disability significantly is more than control group. The time of dot cards and colored cards in experimental group after practicing with working memory computer assisted program were improved. The score mean of post-test and follow up have no significant difference which it means that created changes on post-test stage remained fixed on the follow up stage.

Table 3: The results of dependence T-test between the score means of follow up and post-test of research variables on continues performance test

Variable	The experimental group (n = 10)				The control group (n = 10)				P t
	M				M				
	Pre-test	Post-test	Follow up	SD	Pre-test	Post -test	Follow up	SD	
number of errors	2/69	1/76	1/91	0/54	2/81	2/62	2/58	0/63	0/56 1/32
Number of omission	1/23	0/29	0/43	0/73	1/43	1/26	1/25	0/50	*0/01 1/41
Time	11/45	8/65	9/02	0/32	10/28	10/91	9/61	0/79	*0/04 2/29

05/0> P*

Table 4: The mean and standard deviation of pre-test, post-test score and following research variables in the working memory test

Variable	The experimental group (n = 10)				The control group (n = 10)				P t
	M				M				
	Pre-test	Post-test	Follow up	SD	Pre-test	Post -test	Follow up	SD	
First command	0/59	0/85	0/81	0/44	0/53	0/71	0/81	0/88	0/56 2/32
Second command	0/233	0/79	0/53	0/63	0/40	0/34	0/21	0/16	*0/01 1/41
Third command	0/55	0/67	0/62	0/42	0/59	0/49	0/32	0/29	*0/03 2/29

05/0> P

Table 5: The results of dependence T-test between the score means of follow up and post-test of research variables on reading test

Variable	The experimental group (n = 10)				The control group (n = 10)				P t
	M				M				
	Pre-test	Post-test	Follow up	SD	Pre-test	Post -test	Follow up	SD	
reading	9/5	11/06	10/01	0/14	8/81	8/62	2/58	0/63	*0/06 1/32
comprehension	6/13	8/19	7/43	0/53	6/43	6/26	1/25	0/50	*0/01 1/41
Phonological knowledge	3/45	5/81	5/02	0/82	3/28	3/91	9/61	0/79	*0/04 2/29

According to **Table 3**, in the continuous performance test, the number of errors commitment in the experimental group is less than the control group so observed difference is not significant but for the number of omission and the time of performance there was significant difference. So working memory teaching program improved inhabitation and attention in the students with reading disability. So the results showed that the score mean of post-test and pre-test have no significant difference.

Table 4 is the comparison of score means of working memory in students with reading disorder before and after the teaching intervention. Working memory teaching program increased working memory of students with reading disability. The comparison of post-test and follow up showed no significant difference so the created changes on post-test remain fixed in the follow up stage.

According to the results reported in **Table 5**. The working memory computer assisted program increase students' ability in the experimental group. Reading, comprehension and phonological knowledge in the students on post-test compare with pre-test significantly is different. The comparison of the mean on the post-test and follow up showed no significant difference which it means that created changes on the post-test remain fixed on follow up stage.

CONCLUSION

In the present study the impact of working memory computer assisted teaching program was investigated on improvement the students reading disability. The results showed that students with reading disability have better performance in organizing, planning, attention and response inhabitation after practicing working memory computer assisted program. Also reading progress of students who practice the program considerably changed compare to those who didn't received the program teaching. The results of this research is in the same path with other researches, in this research 86 participants were evaluated by executive function tests (working memory, planning, inhabitation and organizing) and the results showed that students who have problem on reading disability after receiving this program teaching have better ability for reading. The differences of executive function in students with reading disability and

normal students and efficacy of the program have been approved by a research (24). Reading is defined as extracting the meaning from text. Reading skill is process of understanding the text continually. This process is complicated and depends on the development of two process of recognizing the words and comprehension. Written words are manifesting of speeches and speeches is manifesting of the names and environmental experiences. So the learning of reading ability needs to different knowledge and skills which are related to the lingual and non-lingual cognitive ability (25). These cognitive abilities are those executive functions. The efficacy of working memory for improvement the students' learning disability performance referred to the findings for example For example, the research mentioned (26,27,28). The reading speed of students with reading disability is less than normal students, processing speed is one components of executive functions (29,30). But in the one research different results were acquired in this research students have some deficit on syntax fluency, processing of phonological skill and speed naming but there wasn't significant difference between students with learning disability and normal ones in the syntax fluency (31).

Students with learning disability disorder because of consequent and circular failure in the school have emotional maladaptive behavior. For inverting this circular failure we should reinforce their self-confidence and created for them successful experiences. So we suggested that educational workshop to be held for teachers and experts of learning disorder centers in order they freely discussed about the utility of working memory computer assisted program on improvement reading disorder and the impact of using this tools on reading subjective processes such as executive functions.

REFERENCES

1. Mirmehdi S, Seyfenaraghi M. Comparison of Anchoring Patterns in Dyslexic and Dysgraphic Male Students of Fourth and Fifth Elementary Schools with Normal Students in Tehran City during the 2005-2007 academic year. *Quarterly journal of research in the field of exceptional children*. 2003;3(1):75-92.
2. Berninger VW, Nielsen KH, Abbott RD, et al. Writing problems in developmental dyslexia: under-treated. *Journal of school psychology*. 2008;46(1):1-21. <https://doi.org/10.1016/j.jsp.2006.11.008> PMID:18438452 PMCID:PMC2344144
3. Mayes SD, Calhoun SL. Frequency of reading, Math and writing disability in children with clinical disorders. *Learning and individual Differences*. 2006;16(2):145-57. <https://doi.org/10.1016/j.lindif.2005.07.004>
4. Wallace AJ. Math learning Disorder. Retrieved from health and medical complete database. *Dyslexia and secondary prevention*. 2005.
5. Zelazo PD, Muller U, Marcovitch S, Argitis GR, Sultherland A. the development of Executive Functions in early childhood of Learning Disabilities. 2002;36(3):230-46.
6. Adams JW, Snowling MJ. Executive function and reading impairments in children reported by their teachers as 'hyperactive'. *British Journal of Developmental Psychology*. 2001;19(2):293-306. <https://doi.org/10.1348/026151001166083>
7. Van der sluis S, Dejenge PF, Van der leij A. Inhibition and shifting in children with learning deficits in arithmetic reading of *Experimental Child Psychology*. 2004;87:239-66.
8. Kelly PD. This Issue. *Learning disorders. Pediatric Annals*. 2005;34(4):259-62. <https://doi.org/10.3928/0090-4481-20050401-04>
9. Stoet G, Markey, Handlopez B. developmental medicine and child neurology: How soon will we prevent neurdisability in childhood? From health and medical complete database. 2007;14:45-64.
10. Azizian F, Abedi M. Build and standardize the Reading Level Detection Test. *ISFAHAN Education Organization Research Index*. 2004;5:50-4.
11. Stroop JR. Studies of interference is serial verbal reaction. *Journal of Experimental psychology*. 1935;18:643-662. <https://doi.org/10.1037/h0054651>
12. Rosvold H, Mirsky A, Sarason I, Bransom E, Beck LH. A continues Performance test of Brain damage. *Journal of consulting Psychology*. 1965;20:343-5. <https://doi.org/10.1037/h0043220>
13. Shallice T. Specific Impairments of Planning. *Philosophical transaction of Royal Society of London*. 1982;298:199-209. <https://doi.org/10.1098/rstb.1982.0082>
14. Cornoldi C, Vecchia D. Visuo-Spatial Working Memory Limitations in Low Visuo-Spatial High Verbal Intelligence Children. *Journal of Experimental Child psychology*. 1995;80(1):44-57. <https://doi.org/10.1111/j.1469-7610.1995.tb01350.x>

15. Alavirafiee T, Vaezi M, Taheri R, Marvi E, Khosrorad R. The Effectiveness of Educational Parenting Skills on Mothers' Self-esteem. *Astra Salvensis*; 2018 Supplement 1:25-32.
16. Ferguson C, Takate Yoshio. *Statistical Analysis in Psychology and Education* translation by Ali Delaware and Siamak Naqshbandi. Tehran: Arasbaran Publications; 2006.
17. Kakavand A. Studying and comparing active memory in students with learning disabilities and normal and The Effect of Self-Esteem Techniques on the Level of Understanding and Learning of Children With Reading problems and Normal. Unpublished doctoral dissertation: Allameh Tabatabai University of Tehran. 2002.
18. Morris RG, Ahmed SL, Sted GM, Toone GK. Neural correlates of planning ability: Frontal lobe activation during the Tower of London Test. *Neuropsychology*. 1993;31:1367-78. [https://doi.org/10.1016/0028-3932\(93\)90104-8](https://doi.org/10.1016/0028-3932(93)90104-8)
19. Morris RG, Rushe T, Woodfuffp WR, Murray RM. Problem solving in schizophrenia: A specific deficit in planning ability. *Schizophrenia research*. 1995;14:235-46. [https://doi.org/10.1016/0920-9964\(94\)00044-9](https://doi.org/10.1016/0920-9964(94)00044-9)
20. Owen AM, Downes JJ, Sahakian BJ, et al. Planning and spatial working memory following frontal lobe in man. *Neuropsychologia*. 1990;28:1021-34. [https://doi.org/10.1016/0028-3932\(90\)90137-D](https://doi.org/10.1016/0028-3932(90)90137-D)
21. Pantelis C, Barnes TRE, Nelson HE, et al. Executive function and developmental psychopathology. *Journal of child psychology and psychiatry*. 1996;37:51-87. <https://doi.org/10.1111/j.1469-7610.1996.tb01380.x>
22. Tehranidoost M, Rad goodarzi R, Sepasi M, Alagheband rad J. Disadvantages of executive functions in children with ADHD syndrome. *Journal of Cognitive Sciences*. 2002;1:1-9.
23. Bokharayian B. Educational plan of working memory. Master's thesis. Faculty of biomedical engineering. Amirkabir University of Technology. 2007.
24. Nouchi R, Loang A. Brain Training Game boots Executive Functions, Working memory and processing speed in the young Adults: A Randomized controlled trail. University of Pittsburgh, USA. 2005;2(907):2-15.
25. Vellutino FR, Fletcher JM, Snowling MJ, Scanlon DM. Specific reading disability (dyslexia): What have we learned in the past four decades? *Journal of Child Psychology and Psychiatry*. 2004;45:2-40. <https://doi.org/10.1046/j.0021-9630.2003.00305.x> PMID:14959801
26. Helland T, Asbjornes A. Executive functions in dyslexia *J. neuropsychology*. 2001;15(4):44-56.
27. Brosnan M, Demeter J, Hamill S, Robson K, Cody G. Executive functioning adults and children with Developmental Dyslexia *J. Neuropsychologia*. 2002;40(12):44-55. [https://doi.org/10.1016/S0028-3932\(02\)00046-5](https://doi.org/10.1016/S0028-3932(02)00046-5)
28. Randall M, Michael F. Making working memory work: A computational model of learning in the prefrontal cortex and Basal ganglia. *J of neural computation*. 2006;18(2):283-328. <https://doi.org/10.1162/089976606775093909> PMID:16378516
29. Harty K. Subtypes of reading disabilities: Examining the relationships among measures. University of Pittsburgh. 2003. Available at <http://www.lib.umi.com/dissertations/fullcits31047320>
30. Forst J, Emery M J. Academic interventions for children with dyslexia who have phonological care deficits. 2003. Available at <http://www.kidsourae.com/>
31. Wolf M. The Double Deficit Hypothesis for Developmental Dyslexia. Paper presented at the 44 Annual conference of the orton Dslexia Boston. M.A. 1996.



<http://www.ejgm.co.uk>