

Effect of computerized cognitive rehabilitation on the visuospatial and problem-solving abilities of the students with a learning disorder in mathematics

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ABSTRACT

The aim of this research was to investigate the effect of cognitive rehabilitation on spatial visual ability and problem solving of students with a learning disorder in mathematics. The research design was quasi-experimental with pretest-posttest, a control group, and a two-month follow-up. From among the fourth grade male students with special disability in mathematics learning in Karaj, we selected 40 people by simple random sampling method and after matching with random substitution, we divided them into experimental (20) and control (20) groups. The subjects in the experimental group received the Software (2018 version) training program of Captain's log Cognitive Rehabilitation individually for 12 sessions of 50 to 60 minutes, while the control group was not provided with this training program. In order to collect data, we used the Tower of London test (TOL), Andre Ray complex image test (ROCF), Wechsler Children's Intelligence Scale - Fifth Edition (WISC-V), and Iranian Mathematical Diagnostic Test (Keymath). We used a Multivariate analysis of covariance statistical test to analyze the data through the 24th version of SPSS software. The results showed that computerized cognitive rehabilitation caused the experimental group to show more visuospatial ability in the post-test and follow-up stages compared to the control group ($p < 0.05$). Also, computerized cognitive rehabilitation caused the experimental group to have less delay, test time, and fewer errors to solve the problem in the post-test and follow-up stages compared to the control group, while the number of solved problems increased ($p < 0.01$).

Keywords

Learning Disorder in Math, Cognitive Rehabilitation, Spatial Visual Ability, Problem Solving Skill

Introduction

One of the most common issues for children in school learning and life skills acquisition is learning disorders. A Learning disorder is a chronic problem with a neurological and developmental basis that usually begins early in development, before school age, and continues into adulthood if left untreated (Bulthé et al, 2019; Perelmutte, McGregor & Gordon, 2017).

The prevalence of special learning disorder is estimated to be between 3.6 and 8.9 and the prevalence of students with low progress in mathematics is estimated to be between 10 and 15% (Iglesias-Sarmiento & Deano, 2016). Children with math deficiency are children who have serious deficiencies in learning math skills from recognizing numbers, mathematical operations, and issues related to spatial perception and problem solving (Ariapooran, Amiri Manesh, Taqvae, and Haghtalab, 2014).

Visuospatial ability is one of the most important cognitive abilities in education, which consists of high-level neurological skills (Possin, 2010). Components of visuospatial ability include mental rotation and the ability to produce a mental representation of a structure as a two- or three-dimensional pattern, as well as a set of sub-processes that

¹. Bulthé, Prinsen, Vanderauwera, Duyck, Daniels, Gillebert, Mantini, Op. de. Beeck & De Smedt

include stimulus coding, information storage in a short-term storage system, and transformation (rotation/change) of stimuli (Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000).

Children with a math disorder have less visuospatial skills than children with normal levels and children with reading or spelling disorders (Lambert & Spinath, 2017). Other studies on neuropsychology have shown that in many of these children the Occipital lobe of the right hemisphere, which plays a major role in the processing of visual information and especially the perception of spatial relationships, is functionally impaired (Goswami, 2008).

There is a relationship between visuospatial skill and problem-solving. In a research on the visuospatial skill and its effects on problem-solving, the findings showed that there is a relationship between achieving higher levels of spatial ability and mathematical performance; the students with high levels of visuospatial abilities use more problem-solving strategies (Buckley, Seery & Canty, 2019).

Problem-solving is the highest form of learning and involves the process by which the learner reaches new learning by combining pre-learned rules (Seidman, Biederman, Monuteaux, Doyle, & Faraone, 2006). The ability to solve a mathematical writing problem is recognized as an essential component of mathematical ability. Researches have shown that writing problem solving is especially difficult for students with a learning disorder (Krawec, 2014). Andersson (2010) reported major weaknesses in problem-solving for students with a mathematics learning disorder in the third and fourth grades of elementary school. Also, these students often use inadequate strategies to solve mathematical problems that cause problems in using both cognitive and metacognitive processes. On the other hand, these students have shortcomings in generalizing and transferring the learned knowledge to new assignments (Strickland, 2010). On the other hand, by presenting easy and difficult tasks and studying the brain while doing homework, Berteletti et al. (2014) concluded that, during solving mathematical problems, the brain needs to change constantly two mechanisms from numerical structure to verbal structure. They found that children with a math disorder were unable to make the transition to the verbal mechanism when solving the problem because they had poor functioning in the mechanism of numerical structure.

Nowadays, based on advances in knowledge about the formability and self-healing capacity of the human brain, there is strong evidence that neuropsychological functions can be sustained and improved through carefully designed cognitive training (O'Connell, R. G., Bellgrove, M. A., Robertson, 2007). According to the principle of brain formability and self-healing, with continuous excitation of less active areas in the brain the computerized cognitive rehabilitation creates stable synaptic changes in them (O'Connell et al., 2007). These programs can adjust the level of difficulty of the task from simple to difficult based on individual differences and create ongoing cognitive challenges for the individual (Gaitán, Garolera, Cerulla, Chico, Rodriguez-Querol & Canela-Soler, 2013).

Numerous empirical evidence has shown the effectiveness of computerized cognitive rehabilitation.

By systematically reviewing computerized cognitive rehabilitation studies on visuospatial problems in post-stroke patients, Svaerke, Niemeijer, Mogensen, and Christensen (2019) concluded that this intervention was the strongest cognitive intervention.

In a study of computer-based cognitive rehabilitation in patients with spatial visuospatial neglect or hemianopia after stroke, Svaerke, Omkvist, Havsteen, and Christensen (2019) showed that computer-based cognitive rehabilitation improves significantly the post-stroke visuospatial symptoms.

By comparing the effectiveness of combination therapy with separate cognitive rehabilitation treatment in patients with visuospatial impairment, Celeste et al. (2016) concluded that, contrary to expectations, no difference in performance was observed between the right hemisphere stroke patients who had combination therapy with cognitive rehabilitation in visuospatial skills, and the other group receiving only cognitive rehabilitation treatment.

In their study on people with brain injury, Barrett and Mozaffar (2014) showed that rehabilitation of visuospatial perception could improve motor performance in people with stroke. Evidence also confirmed the effectiveness of this treatment in solving the problem. Greenberg et al. (2018) studied post-war veterans and found that physical, psychological experiences, and neurological problems in war affect their mental health performance. One of the therapies that improve their mental health is the rehabilitation of Problem-solving. The result of the effectiveness of this treatment has caused motivation and self-confidence in them.

Beyrami and Mohammadi (2015) examined the effect of software-based neuropsychological rehabilitation on improving problem-solving performance in people with reading learning disabilities. They showed that neuropsychological rehabilitation has improved problem-solving performance in people with reading disabilities.

Mohammadi and Afrooz (2020) studied the effect of group cognitive rehabilitation on problem-solving ability in students with attention-deficit / hyperactivity disorder. They showed that group-based cognitive rehabilitation has a significant effect on improving problem-solving ability in these students by strengthening related brain areas.

In the present research, we attempted to introduce a new method of computerized cognitive rehabilitation for improving the cognitive variables in children with a learning disorder in mathematics. Numerous researches have shown that one of the problems of children with various learning disorders is their low motivation to do their homework and learn;

using a computer and teaching the child through a computer can go a long way toward solving this problem. Various educational programs have been developed to improve these functions and their effectiveness has been confirmed in various researches (Owen, 2010). Accordingly, the purpose of this research was to investigate the effect of cognitive rehabilitation on visuospatial ability and problem solving in students with a learning disorder in mathematics.

Research method

The present research is experimental with pre-test-post-test design, a control group and a follow-up period. Its statistical population included all male students in the fourth grade of elementary school who had referred to the Learning Disorders Educational Centers in Karaj in the academic year of 2019-2020. Their math grade in the first semester record required the effort and the scores of monthly classroom tests was two standard deviations below the class average. After performing the Wechsler (Wisc-R) IQ test, the student had a normal IQ and ranged from 90 to 115. Then, in order to investigate the learning disorder, we took the Keymat test from them. The sample of this research was 40 people. We selected them by simple random sampling method and then randomly assigned them to two experimental (20 people) and control (20 people) groups.

In addition to the criteria mentioned in the statistical population section, the inclusion criteria included having a learning disorder in mathematics according to the DSM-5 diagnostic criteria and the Keymat test, the child's presence in the learning disorder center, age range 10 to 12 years, parent, child and teacher's consent. Exclusion criteria also include receiving another concomitant treatment plan, having a disorder other than learning one, being absent for more than 2 sessions, and expressing a reluctance to attend sessions.

Tool

The following questionnaires were used to collect data:

Tower of London Test (TOL): Shallice first invented it (1982). Therefore, the Tower of London test is one of the best tests for evaluating problem-solving and planning. It is used quickly and efficiently with the aim of the least required movements and has 2 steps; each step can be done with three attempts. If the subject succeeds in the first attempt, it receives 3 points and zero Error, in the second attempt, gets 2 points and 1 error, in the third attempt, gets 1 point and 2 errors, and if it fails in all three attempts, it receives 3 error points. The validity of this test was accepted and it was 0.79 (Lezak et al., 2004). This test has good structural validity in measuring the planning and organization of individuals. There was a correlation between the results of this test and the Pertussis maze test and its reliability was 0.41 (Culbertson and Zillmer, 1998; Krikorian et al., 1994).

In this research, using Cronbach's alpha, Spearman-Brown, and Gutmann methods for the whole test, the reliability of this scale was 0.76, 0.64, and 0.66, respectively. In addition, in the present research, the content validity ratio of the test, which was evaluated by 10 specialists of learning disorder educational centers in Karaj, was 0.89 for delay time, 0.92 for testing time, 0.91 for total time, 0.97 for error number and 0.94 for a number of solved problems.

Andre Ray Complex Image Test: This test is used to measure and evaluate spatial perceptual organization as well as visual memory. Ray first invented this test in the 1930s and then Ostrieth developed it (1944), one of Ray's students. This test has 18 perceptual components and is performed in two stages. The first step is to copy a shape. The subject's analysis of the drawing pattern at this stage shows his perceptual activity. The second stage is the stage of production from memory, based on the results of which we can reveal the range and accuracy of visual memory (Bahrami, 2004). The research results of Ahadi and Mirhashemi (2003) show that this test has a validity coefficient of 0.77 in the copy stage and 0.51 in the reminder stage and its validity is 0.624. In research using Wechsler numerical memory subtest, Mirhashemi (1992) has obtained its reliability by 0.62 using the retest method, which indicates acceptable reliability. In this research, using Cronbach's alpha, Spearman-Brown, and Gutmann methods, the reliability of this scale was 0.88, 0.80, and 0.82 for visual perception, 0.81, 0.68, and 0.70 for visual memory, respectively. The total test was 0.89, 0.74, and 0.77. Moreover, in the present research, 10 specialists of learning disorders educational centers in Karaj assessed the content validity of the Andre Rey complex image test. It was 0.89 for visual perception and 0.91 for visual memory.

Wechsler Intelligence Scale for Children - Fifth Edition (WISC-V): It is one of the most complete tests for measuring various IQ scales and a comprehensive clinical tool for assessing the intelligence of children aged 6 to 16 years and 11

months. Its fifth version was introduced in 2014. The fifth edition of the Wechsler Intelligence Scale for Children consists of 10 main subtests, six secondary subtests, and five supplementary subtests. Mousavi Sadati et al. (2019) have adapted and standardized this test on a sample of Iranian children. The validity of the subtests in the retest ranged from 0.65 to 0.95 and the split-half validity coefficients of this test were 0.71 to 0.86.

In this research, we used the fifth edition Wechsler IQ test to determine the IQ and basic cognitive processes in children with a learning disorder in mathematics (sample). The validity of the Wechsler test, fifth edition, was obtained through content validity and predictive validity (0.61 to 0.79) by examining the correlation between Wechsler subtests (WISC-V) (0.56 to 0.84). In addition, we investigated the reliability of this test, in the present research, using Cronbach's alpha, Spearman-Brown, and Guttman halving methods; the reliability coefficients were 0.81, 0.89, and 0.88, respectively.

Keymat Mathematical Test: This test has its use in identifying students with a learning disorder in mathematics.

Conley developed this math test in 1988; it is a reference criterion test with rules for normative interpretation and consists of three sections of basic concepts, operations, and application in terms of subject matter and sequence. Mohammad Ismail and Hooman (2002) standardized nationally this test for 9 to 12-year-old students. The reliability of this test was estimated using Cronbach's alpha method in 5 elementary grades, between 0.80 and 0.86. Its validity was calculated through content validity, discriminant validity, and predictive validity and its simultaneous validity has been between 0.50 and 0.97.

In this research, we have used three methods of Cronbach's alpha, Spearman-Brown, and Guttman split-half to determine the reliability of the Iran Keymat test. Cronbach's alpha coefficients in the subtests ranged from 0.75 to 0.86 and a total 0.89, in the split-half method the reliability coefficients for the subtests ranged from 0.76 to 0.89 and a total 0.90. We calculated the validity of the Iran Keymat test in this research through discriminant validity and predictive validity (prediction of students' mathematical scores by the test) and it was from 0.61 to 0.72.

Captain's log Cognitive Software Program: In this research, we provided visuospatial and problem-solving skills by the exercises of this software. The Brain train company first introduced Captain's log in 2000 in the United States. This training set is for improving advanced cognitive functions and processes. Captain's Log evaluation system can evaluate a person in 9 areas of cognitive functions and suggest a training program according to the individual's situation. In addition to this ability, for each exercise that a person does from the beginning and in the early stages of homework, basic skills are practiced and the person practices different skills based on a specific structure. The tasks become more difficult and the skill level becomes different. Pumacchua, Wong, and Wiest (2017) studied 81 students with an average age of 8 to 12 years who had a working memory deficit. They concluded that the use of Captain's Log cognitive rehabilitation software could improve the working memory (especially visual working memory) of these students.

Procedure

At first, we took the Wechsler IQ test from the clients to diagnose IQ. Then, to adapt the students to the diagnostic criteria for learning disorder in mathematics, we performed the Iran Keymat mathematics test. After obtaining the consent of students and their parents to participate in the research, we randomly divided forty sample subjects, selected by simple random sampling method, into two groups of 20 individuals. The control group did not receive any special intervention or training. The experimental group received 10 sessions of 50 minutes of therapeutic-educational intervention by Captain's log cognitive rehabilitation method. At the end of each training session, we determined homework for parents to do some of the provided exercises.

Table (1) lists the sessions, objectives of each session, and the educational content of the Captain's log Cognitive Rehabilitation Intervention Program (2018 version).

Table 1: Objectives and content of Captain's log Cognitive Rehabilitation Training Program (2018 version)

Sessions	Goal	Exercises
First	Getting acquaintance	Introducing the software and familiarizing the subjects with the software and working with it, performing a pre-test by the program and determining the initial level

Second	(visuospatial ability)	Wht's Next/ Tower Power/ Conceptor
Third	(visuospatial ability)	Counting Critters/ Happy Trails/ Total Recall
Fourth	(visuospatial ability)	Smart Detective/ Eagle Eye / Pop-N-Zap
Fifth	(visuospatial ability)	Hide & Seek/ Remember the Alamo/ Match play
Sixth	(problem-solving)	Conceptor/ Eagle Eye/ Whats Missing
Seventh	(problem-solving)	Pick and Pop/ Figure it out/ Mystery Messages
Eighth	(problem-solving)	Total Recall/ City Lights/ Puzzle Power
Ninth	(problem-solving)	Pick Quick/ Code Cracker/ Total Recall
Tenth	Reviewing sessions & post-test	Summarizing the sessions, holding the post-test, presenting the final progress chart and appreciating and thanking the students and parents

Findings

Table 2 shows the descriptive indicators of visuospatial ability and problem solving in the pre-test, post-test and follow-up stages separately for the experimental and control groups.

Table 2: Descriptive Indicators of Research Variables by Experimental and Control Groups in Three Measurement Stages

Variable		Group	Measurement stage					
			Pre-test		Post-test		Follow-up	
			Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
visuospatial ability	Visual perception	Experiment	28.50	0.89	30.10	1.21	29.70	0.73
		control	30.00	1.12	29.70	1.17	29.90	1.37
	Visual memory	Experiment	15.20	0.41	16.50	0.69	16.55	0.76
		control	15.60	0.88	15.60	0.60	15.40	0.75
problem solving	Delay time	Experiment	242.45	77.99	210.65	71.18	205.00	69.55
		control	275.40	78.97	279.35	78.56	276.15	76.41
	Test time	Experiment	772.85	154.77	106.15	123.14	707.05	121.17
		control	800.70	180.89	808.00	170.07	806.35	171.32
	Total time	Experiment	1015.30	153.54	916.80	140.18	912.05	141.10
		control	1076.10	196.95	1087.35	189.63	1082.50	184.89
	Number of error	Experiment	36.35	10.34	29.05	6.67	29.60	7.48
		control	38.60	9.37	38.75	9.12	38.55	8.54
	Number of solved problems	Experiment	20.35	3.67	24.05	3.62	24.-20	3.38
		control	17.75	3.43	18.45	2.91	18.10	3.40

The results of Table (2) show that after the application of computerized cognitive rehabilitation intervention in students with a special learning disability of the experimental group, the mean scores of perseveration, the time to reach the first model, and the efforts to achieve the first model from among the criteria of delay time, test time, total time and the number of errors from among the problem-solving criteria have been reduced from pre-test to post-test. These changes in the mean scores of the criteria of visuospatial ability and problem-solving skills of students with a special disability of math learning in the experimental group have remained somewhat stable after two months in the follow-up phase. However, the mean scores of the visuospatial and problem-solving ability criteria of students with a special disability of math learning in the control group did not change much from pre-test to post-test and follow-up. Although

these conclusions are inferred without statistical testing, in more detailed subsequent studies, there will be significantly determined the difference in the pre-test, post-test, and follow-up of experimental and control groups.

Before performing the multivariate analysis of covariance test, we used the Kolmogorov-Smirnov test to check the normality of the distribution of scores between the two groups in research variables, the Levin test to examine the homogeneity of variances of research variables in the population, and the MBox test to evaluate the homogeneity of variance-covariance matrices. The results of these tests were not significant ($p < 0.05$). The study of the homogeneity of the regression line slope also supported the insignificance of the interaction of conditions and pre-test ($P < 0.05$). We used Bartlett sphericity test to test the default correlation of covariate variables or pre-tests with each other. With the significance of the KMO index and the value of chi-square calculated for Bartlett sphericity test ($P < 0.05$), we can state that there is no multiple collinearities between the covariate variables and the correlation of the covariates with each other is normal. Therefore, the data did not question the assumptions of using analysis of covariance. So according to the assumptions, we can use the analysis of covariance test.

In order to compare the experimental and control groups and to investigate the effect of cognitive rehabilitation on increasing visuospatial skill in fourth-grade elementary school male students with a special learning disability in mathematics based on posttest scores, after controlling the effect of pre-tests, we performed a multivariate analysis of covariance on the data. Significance level of all multivariate tests for visuospatial ability ($p < 0.01$, $F = 10.66$) and problem solving ($p < 0.01$, $F = 13.67$) was less than 0.01 in the post-test stage with pre-test control. That is the case also about the significance level of all multivariate tests for visuospatial ability ($p < 0.01$, $F = 13.67$) and problem solving ($p < 0.01$, $F = 22.99$) in the follow-up phase with pre-test control (Table 3).

Table 3: Multivariate analysis of covariance on post-test and follow-up scores of visuospatial and problem solving skills of experimental and control groups

Variable	Effect	Test	Post-test			Follow-up		
			Value	F	Effect size	Value	F	Effect size
visuospatial skill	Group	Pillais Trace test	0.38	10.66	0.38	0.44	13.67	0.44
		Lambdai Wilkes	0.62	10.66	0.38	0.56	13.67	0.44
		Hotelling's trace	0.61	10.66	0.38	0.78	13.67	0.44
		Largest root on	0.61	10.66	0.38	0.78	13.67	0.44
Problem solving skill	Group	Pillais Trace test	0.74	21.65	0.74	0.75	22.99	0.75
		Lambdai Wilkes	0.26	21.65	0.74	0.25	22.99	0.75
		Hotelling's effect	2.79	21.65	0.74	2.97	22.99	0.75
		Largest root on	2.79	21.65	0.74	2.97	22.99	0.75

In order to investigate the difference between the experimental and control groups in each of the visuospatial and problem-solving skills, we used the inter-subject effects test, the results of which have been presented in Table 4.

Table 4: Effects among the subjects. Comparing Post-test and follow-up of visuospatial and problem solving skills of groups with pre-test control

Variable		Post-test				Follow-up			
		Total squares	Mean squares	F	Effect size	Total squares	Mean squares	F	Effect size
Visuospatial skill	Visual perception	9.45	9.45	7.99	0.18	0.21	0.21	0.18	0.01

	Visual memory	5.94	5.94	16.25	0.31	9.65	9.65	20.33	0.36
Problem solving	Delay time	12907.99	12907.99	13.95	0.29	13692.21	13692.21	14.71	0.30
	Test time	45116.09	45116.09	17.07	0.33	35801.17	35801.17	9.93	0.23
	Total time	641.67	641.67	49.42	0.59	520.76	520.76	56.84	0.63
	Number of error	118.80	118.80	24.53	0.42	150.25	150.25	30.04	0.47
	Number of solved problems	12907.99	12907.99	13.95	0.29	13692.21	13692.21	14.71	0.30

According to the results presented in Table 4, there is a significant difference between the experimental group and the control group in terms of the post-test of visuospatial and problem-solving skills ($p < 0.01$). Therefore, the null hypothesis is rejected. The research hypothesis is confirmed that computerized cognitive rehabilitation is effective in increasing the visuospatial and problem-solving skills of students with a learning disability in mathematics. In addition, according to the results presented in Table 4, it was found that with pre-test control, there is a significant difference between the experimental group and the control group in terms of the follow-up of visuospatial and problem-solving skills ($p < 0.01$).

Discussion and conclusion

This research aimed to determine the effect of computerized cognitive rehabilitation on increasing visuospatial ability and processing speed of students with a special learning disorder in mathematics. The results obtained from the first part of the research findings showed that computerized cognitive rehabilitation has improved the visuospatial ability of students with special disabilities in mathematical learning in the dimensions of visual perception and visual memory. This finding is generally consistent with the results of research conducted by Svaerke et al (2019), Svaerke et al (2019), Celeste et al. (2016), Barrett and Mozaffar (2014); they showed that computer-based cognitive rehabilitation is effective in visuospatial empowerment of patients with the deficit of perceptual function and visual memory, such as hemianopia, stroke, hyperactivity, and learning disorders. With the development of neural pathways and the construction of new pathways, cognitive rehabilitation leads to sustained structural and chemical changes in the visuospatial perception of students with special math learning disability, such as increased brain-derived neurotrophic factor (BDNF) (Churchill, Galvez, Colcombe, Swain, Kramer, & Greenough, 2002). Consequently, with appropriate and repeated stimulation of dysfunctional brain regions in learning disabilities, cognitive rehabilitation can bring about lasting changes in those regions; because such changes occur in the structure of brain neurons and remain constant (Azami, Moqaddas, Hemmati and Ahmadi, 2013). The tools used in the Captain's log cognitive rehabilitation software are different from the previous time each time the exercises are used. This makes the tools do not cause repetition and practice in students and are not uniform and repetitive for children. The attractive appearance of these games makes the child do these exercises with more excitement and without fatigue, and having a time limit causes the child to make more effort and increase the speed of action in the visuospatial perception of stimuli. It does not take long to complete each task and prevents fatigue (Gaitán et al., 2013).

The results of the second part of the research findings showed that computerized cognitive rehabilitation has improved the problem-solving ability of students with a learning disorder in mathematics. This finding is generally consistent with the results of researches that have shown that computerized programs and cognitive rehabilitation based on continuous practices have improved problem-solving ability (Greenberg et al., 2018; Mohammadi and Afrooz, 2020; Beyrami and Mohammadi, 2018). Rehabilitation can stimulate areas in the brain that are involved in executive action. Given that students with a learning disorder in mathematics experience anterior lobular dysfunction and that this part of the brain is responsible for executive functions of the brain, it is reasonable to expect that working memory will improve through cognitive rehabilitation (Rodríguez-Blanco, Lubrini, Vidal-Mariño, & Ríos-Lago, 2017) and increase problem-solving ability.

According to the brain pathways involved in computerized cognitive tasks (Ciesielski et al., 2006), it seems that, due to the presence of different visual and audio stimuli and by simultaneously involving sensory areas (for processing

sensory inputs), the prefrontal cortex (to process the complexities of the task and choose the appropriate strategy for responding to the task) and finally the motor areas (to give motor feedback), the computerized cognitive rehabilitation involves well the brain areas related to working memory, ie visuospatial ability and problem-solving of students with a learning disorder in math. Involvement and activation of working memory brain areas are especially effective when the task involves an emotional aspect of success (immediate reward) or failure (failure to progress to the next level).

This research was associated with some limitations including the drop in performance due to corona conditions. Some parents did not allow the sessions to continue. The non-nativeness of the Captain's log program, which is not Persian, imposed some restrictions on the implementation process. We suggest other researchers evaluate the effectiveness of this program in more detail and the subcomponents of visuospatial perception and measure the size of the effect. One future task is to examine the visuospatial ability and problem-solving in writing learning disorder.

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