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Research Article

THE EFFECT OF WORKING MEMORY TRAINING ON WORKING MEMORY AND BEHAVIORAL SYMPTOMS IN STUDENTS WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER

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ABSTRACT
Attention deficit hyperactivity disorder (ADHD) is one of the most common neuro-developmental disorders of childhood. The current study sought to investigate the effect of working memory instruction on executive functions and academic performance of students with attention deficit hyperactivity disorder. The population studied was comprised of students with ADHD with the age ranging from 7 to 9 years old in Babol, Iran in 2013-14. 58 students with ADHD, whose IQ was above 85, were placed into two groups of experimental and control group; each containing 29 subjects. ADHD diagnosis was made based on SNAP-IV Teacher and Parent Rating Scale and clinical interviews. The experimental group received twenty one 45-minute training sessions of cognitive-remediation therapy with each running for 2 sessions per week. Before and after the treatment, ADHD symptoms were recognized by the parents using SNAP-IV scale. The children in both groups were put to the Listening Span Test (LST). The gathered data were analyzed employing a multivariate analysis of covariance (MANCOVA). The mean scores of ADHD hyperactivity symptoms were 16.93 and 13.55 in the experimental and control group, respectively. However, it went up to 10.12 and 13.33 by the end of the trial; that was significantly lower in the experimental group than the control group. The mean score of working memory in the experimental group was 7.72 (before treatment) and 18.51 (after treatment) while in control group it was 8.37 (before treatment) and 9.32 (after treatment). Multivariate analysis of covariance showed that the experimental group improved significantly more than the control group.

Keywords: *Attention Deficit Hyperactivity Disorder (ADHD), Working Memory, Executive Functions, Academic Achievement*

INTRODUCTION
Attention deficit hyperactivity disorder (ADHD) is a neuro-developmental disorder of childhood that often persists through adolescence and potentially into adulthood and contributes to various problems in the person's social, academic, family or work life. America Psychiatric Association (2000) divided this disorder into three different subtypes as predominantly inattentive type, predominantly hyperactive type and combined type. Prevalence of ADHD diagnosis in children is estimated to be approximately 3 to 7%. The male-to-female ratio for ADHD is nearly 2:1 to 9:1 indicating that males outnumber females (Centers for Disease Control and Prevention, 2007).
The primary characteristics of ADHD include difficulties concentrating, poor sustained attention, distractibility, impulse control, poor planning and organizational skills and restlessness (Barkley, 2006). Studies conducted in the areas of behavioral, genetic, neuropsychological and neurometabolic phenotype along with structural and functional brain imaging studies all consider ADHD to be neuropsychological in origin; especially frontal and prefrontal lobe and insufficient executive functioning were approved to play a role in this disorder (Barkley, 1997, 2000, 2005, 2006; Rapport *et al.*, 2008; Nigg, 2006; Welsh and Pennington, 2008). Executive function is used as an umbrella term to cover several cognitive processes work in the service of behavior and actions. Although there is no consensus among researchers regarding the components of executive functioning, the three components of inhibition, working memory and planning are the main components of executive functioning that almost all researchers agree on (Eskios,

2004; Welsh and Pennington, 1998; Pennington and Ozonoff, 1996; Lezak, Howieson and Loring, 2004; Lezak and Lowring, 2004; Denckla, 2007; Barkley, 1997, 2006; Nigg, 2006). Working memory is one of the components of executive functioning. This component can provide temporary storage and manipulation of information in the brain (Rapport, 2009). The function of this component is essential for the facilitation and accurate performance of other components of executive functioning. In fact, proper functioning of the working memory provides concentration, sustained attention, response inhibition and also inhibition of inappropriate impulses. The association between working memory deficit and ADH disorder has been approved by Barkley and Rapport et al (hadi, 2009; Barkley *et al.,* 2008; Chan *et al.*, 2008). Moreover, results of a large body of researches endorse this association (Klingber, Westerberg & Klimgberg, 2002). The fact is that children with ADHD demonstrate a whole lot of problems in memory and recalling tasks than other children (Mealer, 1996). Barkley (1996) reported that pediatric patients with attention deficit disorder display deficits in their working memory; as a result, the child's resilience will be affected to the point that these children cannot easily adapt themselves to their environment compared to other children.

In recent years, cognitive deficits in children with ADHD have been the focus of an increasing attention and considerably a large number of investigations have been carried out on this matter. Major areas noted in these studies include impaired executive functions and working memory. Neurocognitive executive functions are important structures that play a major role in guiding and controlling one's behavior. Changes in executive functioning are driven by increasing age and during the processes of developmental change and help the child gradually perform more difficult and complex tasks. Impairment in executive functions can have substantial and deleterious consequences on social, academic and emotional performance of the child (Alizadeh, 2006). According to the models of executive function, the ability to respond to an obvious and predominant event results in a delayed response during which people would be able to bear in mind the mental representation of that event. As this ability increases by developmental growth, it forms a basis for the working memory (Barkley and Mash, 2005). The importance of this model for recognizing the relationship between inattention and lack of inhibition in ADHD is that it assumes an important role in maintaining the willingness to work (planning). These programs help create and conduct complex chains of purposeful activities over some period of time. This model predicts that the deficit in inhibition leads to a deficit in the continuity of working memory, as a result; it causes memory loss in people involved with this disorder (mainly inattention subtype) (Barkley and Mash, 2005). Therefore, impairment in working memory creates a weakness in information storage and retrieval and also a lack of necessary ability in effective and efficient processing of learning activities and social skills. Many studies have implied that there are a high number of students in classroom settings with working memory problems who are at the risk of poor academic achievement so that the working memory deficits would not wiped out without early intervention and the decline in academic achievement continues to exist (Nia, 2012). Alloway (2009) asserted that it is essential not only to provide such students with individual and group education programs, but also to enhance their ability to recall and manage information i.e. working memory. Thus, it seems that working memory underpins the academic performance of such students and interventional programs result in less stable changes of their learning; accordingly, the working memory should be reinforced in order to observe improvement in learning.

In a similar vein, many studies were undertaken to explore the effect of working memory instruction on the improvement of ADHD symptoms. For instance, Klingberg *et al.*, (2002) studied working memory training in children with attention deficit hyperactivity disorder. The results of his study denoted that memory capacity can be developed by memory training. Moreover, Milton (2010) indicated the impact of computerized working memory training on cognitive flexibility and working memory. In like manner, Alloway *et al.,* (2010) found out that working memory training not only improve the working memory itself but also results in the academic achievement of students with ADHD. A large number of studies also endorsed that the working memory capacity could be enhanced by training (Denn, 2008; Olesen *et al.*, 2004). Furthermore, Alloway *et al.,* (2006) approved an association between learning and the behavior of working memory. In general, it could be recapitulated that training in working memory can

function as a therapeutic intervention in patients with low working memory capacity which is identified as a limiting factor in their academic performance (Klingberg, 2010). According to the aforementioned discussion, various effective techniques have been proposed to date to train working memory and to reduce hyperactivity symptoms in children with ADHD. Hence, achieving the most effective treatment led the researchers to embark on this memory and to explore the impact of working memory training on executive and academic performance of students with ADHD.

In other words, so far no studies have been conducted taking into account the effect of working memory training on the improvement of behavioral symptoms and working memory in children with attention deficit hyperactivity disorder in Babol County, Iran. To this end, the present study attempted to first assess the memory span of children with this disorder using LST (Listening Span Test) and then provide them with treatment and training through cognitive-remediation therapy. This study aimed to address the following question:

- Does working memory training through cognitive-remediation therapy have any significant impact on the improvement of behavioral symptoms and working memory of children with attention deficit hyperactivity disorder?

MATERIALS AND METHODS

Statistical Population

The population under study consisted of 80 female and male students suspected of ADHD. They were introduced to the study by their schools. They were 7 to 9-year-old pupils majoring in primary school (first to third grade) in 2013-2014 academic years.

Statistical Sample and Sampling Method

Of the population mentioned above, 58 students were randomly selected and assigned into two groups of experimental and control group, each containing 29 subjects. The same test was administered for both groups.

Procedure

At the initial stage, the children with suspected ADHD were put to the test of SNAP- IV for the early detection of ADHD as well as Wechsler Intelligence test (short form). Children whose SNAP scores fell above 18.5, with the approval of a child and adolescent psychiatrist, were diagnosed with ADHD. Students who scored above 85 in Wechsler intelligence test were included in the study while those students having an IQ score below 85 along with depression; conduct disorder and physical disability were excluded from further investigations. Finally, 58 of the children diagnosed with ADHD were randomly placed in two experimental and control groups, each containing 29 subjects. Then, in order to assess the students' executive functions, both groups were tested by academic performance tests (math, reading, and writing) as well as working memory test (LST). The experimental group, in groups of three, received twenty one 45-minute sessions of cognitive-remediation therapy with each running for 2 sessions per week while the control group received no treatment. After two months and a half training session, the experimental and control group were again tested by LST and their parents completed SNAP-IV questionnaire. In the end, the mean changes of dependant variables were analyzed using a multivariate analysis of variance (MANCOVA).

Instruments

SNAP-IV: It was first developed by Swanson, Nolan and Pelham in 1980. This test, which is comprised of 18 questions, has a single form to be completed by parents and teachers. The first nine questions are related to the detection of ADHA-I and the second nine questions deal with the detection of ADHD-PI. The total items are also used to detect ADHD-C. The Cronbach's alpha coefficient was reported 0.94, 0.90 and 0.79 for subtypes (Swanson et al, 2005; Bussing *et al.*, 2008). In Iran, Sadrosadat *et al.*, (2007) reported a reliability of 0.90 using Cronbach's alpha and 0.76 using split-half method. It is a 4-point Likert scale ranging from never, rarely, sometimes too often. According to the rating scale, never is given the minimum value of zero, on the other hand, often receives the highest value of three. Therefore, the other choices fall within these two values: rarely = 1 and sometimes = 2. The symptom severity cut score

is obtained by summing the scores of items 1 to 9 and 10 to 18. In order to choose the sample and detect the effect of the independent variable or the variable rate of ADHD symptoms, screening cut-off score and symptom severity score (SS score) were used, respectively.

Clinical Interviews: They were used for definitive diagnosis of attention deficit / hyperactivity disorder; in such a way that after the initial diagnosis, a psychiatrist made the final diagnosis using ADHD symptoms questionnaire based on DSM-IV.

Short Form of the Wechsler Intelligence Scale for Children-Revised (Wisc-R): The participants in this study were screened based on IQ test score using WISC-R scale (the ternary form of words, information and completion) which was standardized by Shahim (1994) in Iran. The reliability coefficient of the ternary form was reported 0.92 and the coefficient for classification agreement of the ternary short form and the complete form was estimated 59% (Shahim, 1994).

Listening Span Test (Lst): Listening Span Test (LST) is one of the complex working memory tests; answering to which is more difficult than answering to simple working memory tests as Wechsler Digit Span Test.

Simple working memory tests are also called short-term memory tests because the respondents are asked to recall the numbers or letters which they have been told to a few seconds before while in complex working memory tests the respondents are asked not only to recall the materials (numbers, letters or words) from memory but also they need to engage in their processing in order to achieve the correct answer. It is for this reason that complex working memory tests are regarded as the true working memory tests. Since the test is administered orally, it is also applicable for preschoolers. However, due to functional limitations of pre-school children, working memory tests applicable to this age are very few. The test was translated from the original language into Farsi by Dr. Nazifi for the first time in Iran and was adapted to Iranian culture.

This test was developed in 1994 by Tompkinz et al and is comprised of 59 statements. First the test taker is told that he is going to be read to some sentences and he needs to tell if the sentence is true or false as well as remembering the last word of the tester's sentence. Then, he has to recall and say out all the words he remembers in order. For the first time two sentences are read followed by more sentences. Each sentence is read for the child and he tries to keep it in mind and repeats the last part of the sentence. This test is used for children with the age ranging from 6 to 12.

The correlation between this test and word span is estimated 0.504. The validity of the test in forward recall, backward recall and recall is 0.86, 0.79 and 0.93, respectively (Lehman & Tampkinz, 1998). In the current study the reliability of LST was 0.60 employing test-retest methods. The validity of this test with Cohen's effect size for the difference between ADHD group and normal group was 1.065 which was significant at <0.05.

Implementation of Training Sessions

The experimental group consisted of children with ADHD who had 21 forty five-minute working memory training sessions for almost 3 months. The experimental group was provided with training sessions in groups of three with the help of two masters in psychology of exceptional children who were experienced and qualified in Special Education. A majority of training sessions were held in the form of games and the content of working memory training was retrieved from Mahmoudpour (2012) and Tabriz (2012). Working memory exercises were arranged from easy to difficult aiming at working memory enhancement, attention sustainability and inhibition and they were all designed and planed under the supervision of a master in Psychology of Exceptional Children. The participants in the control group did not receive any treatment.

***The content of training sessions is summarized as follows*:**

Objective: Throwing the ball into a basket ring or loop (to be counted)

Different types of games for improving memory and attention sustainability and inhibition:

- Sit down/ stand up (direct opposite), playing through obstacles, running and passing while avoiding obstacles (obstacle racing), sculpture game, rainbow game
- Passing through the maze

- *Eye To Eye Game:* The child puts his hand in the tester's hands while looking into her eyes. The tester asks a question and as long as she has not pressed the child's hand, he is not supposed to answer the question. The game is pursued as a two-player game or in various other forms.
- *Picture Game (Visual Attention):* Look and Say, to watch images of children and then to recognize them, spotting games.
- *Enhancing Visual Memory:* Hidden object games (hiding objects and identifying them), recalling a pre-seen object, mimicking movements based on models and patterns.
- *Enhancing Auditory Memory:* Training in doing activities such as maintaining an order, following an order, bearing in mind some numbers or simple words.
- *Executing Orders:* Multiple instructions are simultaneously given to the child and the child is supposed to follow and comply with those instructions.
- *Taking Orders in a Direct or Inverse Manner:* Students should follow orders sequentially from first to last, and then take the new ones from last to first.
- *Recognition Memory:* Some pictures (cards) from animals, fruits and objects are shown to the child and the child should recognize them after a few seconds.
- *Recalling Memory:* Some short stories are read to the child for a few minutes (3 minutes max.) and the child has to retell the story.

Descriptive and Inferential Statistical Analysis

The following are brief descriptions of the mean and the standard deviation of the control and experimental group proceeded with covariance analysis of the group differences. Table 1 demonstrates the mean and the standard deviation of the groups in the working memory pretest (LST test). According to this table, the mean score of the experimental group was increased after the treatment. Taking into account that the homogeneity of variances (variances approximately equal across sample groups) and normality of the distribution of all the scores within each group are met, running an ANCOVA was legitimized.

Table 1: Mean and standard deviation scores of the experimental and control groups on working memory pre- and posttest (LST test)

Variables	Groups	N	Pretest		Posttest	
			Mean	SD	Mean	SD
Working memory span	Control	29	8.37	8.58	9.32	7.55
	Experimental	29	7.72	6.64	18.51	11.15
	Total	29	8.05	7.61	13.92	10.51
Working memory span (orderly)	Control	29	1	1.28	1.05	1.27
	Experimental	29	1.17	1.22	2.31	0.66
Working memory span (disorderly)	Control	29	1.44	1.72	1.79	1.42
	Experimental	29	0.448	1.05	2.17	3.22

Table 2: Summary of the results of ANCOVA run on the mean difference of the two groups on LST (working memory span)

Variable	Mean square	F	Significance	Chi Square	Leuven test	
					F	Sig
Working memory span	714.780	11.484	0.001	0.175	17.373	0.000

Table 2 demonstrates that the mean difference of the two groups on LST was significant (p=0.001). According to this result and by taking into account the mean of the pretest, it could be stated that the treatment led to a significant difference between control and experimental group meaning that the desired improvement occurred in the working memory of students with ADHD; the effect of which was 0.175. Meanwhile, MANCOVA assumptions as BoxM (F=4.323 and Boxm=13.491) with p=0.005 indicate that the assumption of the equality of variance and covariance matrix are not met. In order to analyze the separated effects, univariate ANOVA was adopted. The assumption of the equality of variances using Leuven test (p=0.000) was satisfied.

Table 3: Multivariate analysis of variance test for a linear combination of pre- and posttest

Effect		Value	F	Hypothesis df	Error df	Sig
Working memory	Pillai's Trace	0.197	6.493	2.000	53.000	0.003
	Wilks' Lambda	0.802	6.493	2.000	53.000	0.003
	Hotelling's trace	0.245	6.493	2.000	53.000	0.003
	Roy's Largest Root	0.245	6.493	2.000	53.000	0.003

According to table 3 and Pillai's value with F=6.493, the effect of group membership on a linear combination of the variables came out to be significant at p=0.003.

Table 4: Mean and standard deviation of behavioral symptoms of experimental and control groups according to SNAP-IV results at pre- and posttest stage

Variables	Groups	N	Pretest		Posttest	
			Mean	SD	Mean	SD
ADD (attention deficit subtype)	Control	29	13.27	2.85	13.78	2.46
	Experimental	29	14.93	5.54	13.55	6.12
	Total	58	14.10	4.44	13.66	4.62
HD (hyperactivity subtype)	Control	29	13.55	4.16	13.33	4.17
	Experimental	29	16.93	24.6	10.12	4.45
	Total	58	15.24	5.52	12.71	4.32
ADHD (combined subtype)	Control	29	26.82	6.26	26.94	5.88
	Experimental	29	31.89	9.90	26.10	10.85
	Total	58	29.36	8.60	26.52	8.66

Table 5: Summary of the results of ANCOVA run on the mean difference of the two groups on SNAP-IV

Variable	Mean square	F	Significance	Chi Square	Leuven test	
					F	Sig
Inattention subtype	33.538	2.758	0.103	0.049	7.999	0.006
Hyperactivity/Impulsivity subtype	140.035	13.211	0.001	0.200	2.095	0.153
Combined subtype	258.628	6.292	0.015	0.106	8.700	0.005

Table 5 above demonstrates that the mean difference between the two groups in attention deficit subtype (ADD) was not significant (p=0.103, effect size=0.49). In other words, the treatment was not effective in the improvement of attention deficit performance of students with ADHD. Moreover, the mean difference in the two groups with respect to hyperactivity (HD) subtype with p=0.001 indicates a significant difference meaning that the treatment was effective in the improvement of hyperactivity disorder of students with ADHD (effect size=0.200). Regarding the mean difference of the combined type, results

revealed a significant difference (p=0.015). Therefore, it could be concluded that the treatment was effective in the improvement of ADHD.

Furthermore, the assumption of MANCOVA as BoxM (BoxM=82.531 and F=12.95) with p=0.000 indicates that the assumptions of the equality of variance and covariance matrix are not met. In order to examine the separated effect, univariate ANCOVA was employed. The assumption of the equality of variances in attention deficit subtype using Leuven test (p=0.000) was satisfied. In hyperactivity/ impulsivity subtype, the assumption of the equality of variances using Leuven test (p=0.153) was also met. Moreover, Leuven test (p=0.005) in combined subtype indicates that the assumption of the equality of variances is in place.

Table 6: Multivariate analysis of variance for a linear combination of pre- and posttest

Effect		Value	F	Hypothesis df	Error df	Sig
Behavioral symptoms	Pillai's Trace	0.204	4.348	3.000	51.000	0.008
	Wilks' Lambda	0.796	4.348	3.000	51.000	0.008
	Hotelling's trace	0.256	4.348	3.000	51.000	0.008
	Roy's Largest Root	0.256	4.348	3.000	51.000	0.008

According to table 6 and Pillai's value with F=4.348, the effect of group membership on a linear combination of the variables came out to be significant at p=0.008.

Discussion and Conclusion

The current study aimed to investigate the effect of working memory training on executive functioning (working memory) of students with ADHD. According to the executive functional patterns of Mash and Barkley (2005) and Pennington and Ozonoff (1996), children with executive functioning impairment are involved with developmental disorders. With regard to the memory functions, Barkley believes that this functional pattern assumes an important role for working memory in maintaining the willingness to plan; since this disturbed working memory, which could lead to amnesia, is a guideline for creating and conducting complex chains of purposeful activities over time**.**

Given the effects of working memory training, it could be concluded that working memory is one of the most important components of executive functioning that is impaired in children with ADHD. The working memory has an important role to play in developing academic, behavioral and social problems in children with ADHD. To the extent that Barkley (1997) asserts impairment in working memory of children with ADHD results in hyperactivity behaviors. In like manner, Rapport *et al.,* (2001) endorses that the major impairment in attention deficit hyperactivity disorder happens in working memory. Kornoldi *et al.,* (2001), similarly, points out deficits in children with ADHD hinder the ability to process and stop irrelevant information; thus, working memory influences behavioral inhibition. Impairment in working memory not only results in irregular and chaotic behaviors but also leads the attention to be paid to irrelevant stimulants in the environment. Therefore, working memory instruction could provide a suitable opportunity for the proper functioning of executive actions as well as improved academic and behavioral performance of students; and thereby prevent the impulsive and hyperactive behaviors. Likewise, Elson *et al.,* (2004), Alloway *et al.,* (2006) and Spengler *et al.,* (1997) investigated working memory in children with ADHD and concluded that working memory training can increase the capacity of working memory.

The results of the current study also added to the existing literature by approving that working memory training and enhancing in students with attention deficit disorder could improve the effectiveness of their

working memory. In line with this, Milton (2010) and Klingber and Fernel (2005) found out that computerized working memory training has a significant impact on working memory of children and adolescents with attention-deficit / hyperactivity disorder. Studying working memory of children with ADHD, Ghamari givi *et al.,* (2011) and Baba Pour et al (2010) revealed that working memory training has a positive effect on the improvement of working memory skills and response inhibition in children with attention deficit. Moreover, the findings of the present study is consistent with the findings reported by Zelazo *et al.,* (2003), Sawnson and Sachezli (2001), Valeria and Sidman (2006) and Saheban *et al.,* (2010) on the effect of executive functioning instruction as working memory on the reduction of hyperactivity and attention deficit symptoms.

An important point about working memory is that each student has an equal opportunity to learn and, unlike intelligence, it does not have any association with parental educational level, social and economical status or financial background. This means that children, regardless of their background or situational impacts, got an equal chance to actualize their potentials. In the present paper, the majority of pedagogical activities focused on those activities that sharpen and develop children's neurological skills leading to the improvement of executive functioning and academic performance. To this end, due to the specific weaknesses of students with ADHD in their executive functioning, including (working memory), it is recommended that the course of treatment be spent on these functions with an emphasis on strengthening and expanding those activities that result in the development of students' neurological ties.

The present study like any other faces a limitation which should be taken into account in future investigations – i.e. the effect of training sessions were not examined in the long run due to time constraints of the researchers. In addition, the researchers could not control the type and dose of medications children with ADHD took; especially children placed in the experimental group did not take their drugs regularly. Therefore, the researchers might not be able to generalize the findings beyond the sample.

The findings suggest that in-service training programs of primary school teachers include in themselves training on working memory and its components, the importance of this kind of memory in learning especially in attention accuracy and enhancement and ways of strengthening this memory. Furthermore, running the aforementioned training program and studying its effectiveness in other groups of children with special needs, especially children with autism who has impairment in this component of their working memory could be fruitful.

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