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Original Article

The effectiveness of visual perception training in improving the working memory of students with attention-deficit hyperactivity disorder

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Abstract

Attention Deficit/ Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder including a persistent attention-deficit or hyperactivity which happens during the childhood. The purpose of this study was to evaluate the effectiveness of visual perception training in improving the working memory of students with attention-deficit hyperactivity disorder. This was an experimental research with pre-test, post-test and control group. The population of the study consisted of all preschool male children with ADHD enrolled in preschool educational level in Ardabil city, among whom 30 participants were selected using screening method, after completing the structured clinical interview. They were randomly assigned, in equal numbers, into experimental and control groups. The intervention group received visual perception exercises for ten 45-minute sessions. The control group did not receive any intervention. The instruments used in this study were the Revised Wechsler Intelligence Scale for Children (Digit Span) and the Conners' Parent Rating Scale-Revised: Short Form (CPRS-R:S). The data were analyzed using univariate analysis of variance. The results showed that visual perception training was effective in improving the working memory of children with ADHD. Therefore, in addition to other training methods, visual perception can be used to improve the working memory of children with ADHD.

Keywords

ADHD
Visual perception
Working memory

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Introduction

Attention Deficit/Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder that includes a persistent attention-deficit or hyperactivity (Whitbourne & Halgin, 2014), which happens in childhood (Lee & Jung, 2017). There are eighteen symptoms based on Diagnostic and Statistical Manual Disorders fifth edition (DSM-5), of which at least six symptoms need to be observed in (children with) ADHD to help diagnose the disorder. There are a variety of statistics on the prevalence of this disorder, but in DSM5, the prevalence of this disorder was reported to be 5% in children. In Iran, the prevalence of this disorder in children of primary-school age was reported to be 12.5% (Parvaresh, Ziauddini, Erfani, & Shokouhi, 2014). Therefore, a large proportion of schoolchildren suffer from this disorder. It seems that a set of symptoms of ADHD is, at least partly, due to impairment in executive functions (Gibson, Gondoli, Johnson, Steeger, & Dobrzeneski, 2011). The executive

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function is a kind of vast structure that involves a variety of processes, such as attention, working memory, planning flexibility, and setting target behaviors. One of the major impairments in the executive function process of the disorder is the working memory (Beck, Hanson, Puffenberger, Benninger & Benninger, 2010). Deficit in working memory, as a central executive memory, is one of the biggest ADHD-related neurological impairments, which is probably observed in 80% of children with ADHD (kasper, Alderson, & Hadec, 2015). Working memory is a component that allows temporary storage and data manipulation in mind (Raiker, Rapport, Kofler & Sarver, 2012; Hossein Zadeh Maleki, Mashhadi, Soltanifar, & Mohair, 2013). Working memory is a multi-component system that plays an important role in learning, and the component of "workability" of this memory covers the processing of stored internal information (Kavan, 2011; Kofler, Alderson, Raiker, Bolden, & Sarver, 2015). Based on the Baddeley's Model of Working Memory (2000), memory is divided into three components: two storage systems (phonographic orbit and a visual-spatial screen) and a central executor. If children with ADHD are not properly diagnosed and treated, the result will be adolescents and adults with ADHD who are at the risk of poor academic performance, job failure, aggression, problems with interpersonal relationships and other psychological disorders such as alcohol abuse, drug abuse, depression and anxiety (Biederman & Faraone, 2005). Therefore, the need for early diagnosis and treatment of children with ADHD is of significant importance. Drug therapy is the main treatment for this disorder. Stimulants such as methylphenidates and amphetamines are considered the first-line treatment for this disorder (Paykina & Greenhill, 2008). Today, due to the complications and limitations of drug therapy, the tendency toward drug therapies for ADHD is declining and the contribution of non-medical treatments and cognitive interventions is on the rise (Khoushabi, Shamsaei, Jadidi, Nikkhah, & Baste Hosseini, 2013; Miranda & et al., 2013). One of the therapeutic methods is cognitive trainings and interventions (Rapport, Orben, Kofler, & Friedman, 2013; Choko, Kofler & Jert, 2014). There are many reasons for the tendency toward providing cognitive trainings for children with ADHD. First, cognitive trainings target the underlying cognitive deficiencies of ADHD, and they can be used to replace medical treatments for these children (Tajik Parvinchi, Wright-Bahons, & Schachar, 2014).

One of these training methods for children with ADHD is the visual perception training. The Frostig visual perception training program was developed in 1963 to improve visual perception. Visual perception skills were developed by Marianne Frastic (1963), which include a training reinforcement program for improving disability in five main areas of visual perception, such as the ability to have visual-motor integration, recognize the image and background, understand shape stability, distinguish the situation in space and understand spatial relationships (Naderi & Seif Naraghi, 2008). Since there is a great demand for non-pharmacological treatments for ADHD in Iran, such trainings as visual perception can be effective in reducing and modifying the symptoms of this disorder. The study by Garmabi, Adib-Shakibi, Taheri, Movalleli, and Seyed Nouri (2016) shows that visual perception training improves the memory of hearing-impaired children. A study by Ghaffarian and Alizadeh (2014) shows that visual-perceptual exercises are effective in improving the overall performance score, concentration, accuracy, and attention of school children with ADHD.

Moreover, in neuroimaging studies conducted by Holmes, Gathercole, Place, Dunning, Holton, and Elliott (2010), it has been shown that working memory rehabilitation has a significant effect on the neural activity of brain regions associated with working memory and improves their performance. In his study, Milton (2010) demonstrated the impact of computer programs training on improving working memory and cognitive flexibility in children with ADHD and learning disorders. According to previous studies, the overlapping of visual perception skills with cognitive processes such as working memory is obvious (Garmabi Adib-Shakibi, Taheri, Movalleli, & Seyed Nouri, 2016). Due to the importance of the role of working memory in ADHD, and the fact that the demand for non-pharmacological treatments for ADHD has increased significantly among the Iranian people, and no research has ever been done on this topic in Iran, the importance of developing or applying non-pharmacological treatments for ADHD on Iranian samples such as visual perception training that addresses cognitive and behavioral problems led us to conduct a study on the impact of training visual perception skills on working memory of children with ADHD. If proven effective, these activities will be included in the form of a modified program. Therefore, the purpose of this study was to investigate the effect of visual perception training on improving the working memory performance of students with ADHD.

Method

Participants

This was an experimental research with pretest-posttest control group design. In this study, visual perception training and working memory component were considered independent and dependent variables, respectively. The population of this study consisted of all preschool male students with ADHD in Ardabil (approximate estimation based on prevalence: 350 individuals). Convenience sampling was used in this study; however, random assignment was used to select participants in the two experimental and control groups.

The sample included 30 school children with ADHD. The data were analyzed using descriptive statistics such as mean and standard deviation through the SPSS software.

Instrument

The Conners' Parent Rating Scale-Revised: Short Form (CPRS-R: S)

This questionnaire consists of 27 items filled out by mothers and 4 subscales of oppositionalism, cognitive/attention deficit problems, hyperactivity and ADHD index. A benchmark score equal to or greater than 65 usually indicates significant clinical problems in that sub-scale. The age range used in the Conners' scale is 3-17 years. Filling out this questionnaire takes 10-5 minutes. Conners, Erhardt and Sparrow (1999) reported the reliability of this scale as equal to 0.90 and in Iran, its reliability has been reported to be 0.89 (Khoushabi, 2000) and its validity from 0.760 to 0.90 (Shahaeian, Shahim, Bashash, & Yousefi, 2007). The validity of this questionnaire has been reported to be 0.85 by the Institute of Cognitive Sciences (Alizadeh, 2005).

The Wechsler Intelligence Scale for Children – Revised (WISC-R)

This is a test to measure short-term memory by measuring rote memory, the accuracy, and movement of thinking patterns. Direct figures measure rote memory and reverse figures measure the abilities of concentration, patience and flexibility (Marnette, 2011). The reliability of the Wechsler memory subtests has been calculated using the split-half and re-testing method. Average reliability coefficients of split-half conducted through dividing the test questions into two parts of even questions and odd questions for verbal, practical and total IQs were 0.94, 0.90, and 0.96, respectively; and the re-test coefficients of the two age groups of 6.5 to 7.5 and 10.5 to 11.5 years old, were 0.93 and 0.90, respectively (Marnat, 2005). For the validity of the test, the correlation of the test with Stanford-Binet's test (fourth revision) was equal to 0.78, with group-based tests of intelligence was 0.66 and with a Peabody achievement of 0.71 (Marnat, 2005).

Clinical interview: In addition to the Conners' questionnaire, for a more reliable diagnosis and more precise selection of students with ADHD, a clinical interview was conducted based on ADHD diagnostic criteria, derived from the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM) by the researchers.

Intervention method: The visual perception training program used in this study was based on the Marianne Frostig's visual perception training model (1963). The visual perception training program was developed by Marianne Frostig in 1963 to improve visual perception, which includes a training program for improving disability in five main visual perception areas, such as visual-motor integration, recognition of image and its background, understanding of shape stability, distinguishing the situation in the space and understanding the spatial relationships (Naderi & Seif Naraghi, 2008). This training program was taught in ten 45-minute sessions. The sessions were also held intensively, 2 or 3 times a week.

Table1. Summary of visual perception training sessions

Title of the meeting	Explanation
Session 1: Eye and hand coordination	Getting acquainted with students and communicating with them, as well as performing some exercises to strengthen visual-motor integration such as connecting points to each other in the right direction
Session 2: Detect shape from field	Performing some exercises to strengthen the visibility of shapes in their backgrounds. In this exercise, we reinforce the ability of children in discovering the hidden shapes.
Session 3: Sustainability and shape	Providing necessary trainings to enhance the ability of school children to understand the stability of the shapes; that is, to understand and recognize any shape regardless of its size, color, or condition.
Session 4: Visual memory	Providing a fictional image for students and asking them about the image, to examine their attention to details.
Session 5: Visual sequence	In these exercises, students should follow the path of the shapes specified by lines or solve the mazes.
Session 6: Visual completion	Providing some exercises to complete the images and incomplete shapes.
Session 7: Spatial communication	Working with students on spatial relationships through teaching left and right directions, understanding space, and the ability to recognize the state of objects and forms in connection with one another.
Session 8: Similarities	Providing some exercises to recognize similar shapes.
Session 9: Differences	Providing some exercises to recognize different forms or shapes.
Session 10: Shape recognition in space	Providing exercises that make the students (school children) capable of measuring a shape at any particular form in any situation.

Procedure

In this study, after completion of sampling, six pre-schools were selected by visiting the Welfare Organization in Ardabil. After that, by visiting these schools, teachers first identified students suspected of having ADHD based on their behavioral background. Then, the Conners' Parent Rating Scale-Revised: Short Form (CPRS-R: S) was filled out by the parents of these students, and the students with high scores (cut-off point of 65, based on the study conducted by Khoushabi, 2002) were subjected to structured clinical interviews, and screening operation was performed based on the recorded symptoms. Finally, the students with ADHD were identified. Considering the fact that the smallest sample size in an experimental research should include at least 15 participants (Delaware, 2006), 30 participants were selected from among school children with ADHD and then they were randomly and equally assigned into two experimental and control groups. After determining the sample size, in order to observe research ethics, parental consent forms for the participation of school children in the training sessions were first received from the parents of students of the experimental group. Then, a pretest (the Wechsler memory test: digit span) was performed on the experimental group. In the next step, 10 visual perception training sessions were held for students with ADHD. However, the control group did not receive any intervention. After completing the training sessions, two post-tests were performed on the experimental and control groups again.

Results

Table 2. Participants' profile

				PERCENT
PARENT'S EDUCATION	EXPERIMENTAL GROUP	father	Diploma	13.3
			bachelor	60.0
			master	20
			PhD	6/7
		mother	Diploma	26.7
			bachelor	13.3
			master	20.0
			PhD	6.7
	CONTROL GROUP	father	Diploma	13.3
			bachelor	40.0
			master	26.7
			PhD	13.3
		mother	Diploma	20.0
			bachelor	13.3
			master	40.0
			PhD	13.3
Sex	EXPERIMENTAL GROUP		5.5-6	33.3
			6.1-6.5	40.0
			6.6-7	26.7
	CONTROL GROUP		5.5-6	20.0
			6.1-6.5	60.0
			6.6-7	20.0

Table 3. Descriptive indices of working memory scores of the experimental and control groups in pre-test and post-test

variable		Groups	SD	M
Working memory	pretest	experimental	10.14	2.13
		Control	9.74	2.01
	posttest	experimental	12.34	2.23
		Control	10.74	2.22

According to Table 3, the working memory score in pre-test and post-test is 10.14 and 12.34, respectively, which indicates an increase in the working memory score in post-test. The normality assumption was also examined and verified. Before performing the parametric test of analysis of covariance (ANCOVA), the Box's and Levene's tests were performed to observe the pre-assumptions of ANCOVA. Since the Levene's test was insignificant, F (1.19) = (0.31), the equality of variances has been observed.

Table 4. ANCOVA results for the mean working memory scores of pre-test and post-test of the experimental and control groups

variable		SS*	df*	MS*	F	P
Working memory	pretest	55.04	1	55.04	17.71	1.010
	Group	12.95	1	12.95	4.17	0.041

* Abbreviations: SS, sum of squares; MS, mean square; df: Degree of Freedom

According to Table 4, the difference between the pre-test and post-test scores of the working memory of the experimental and control groups is significant (p<.05). Thus, the mean working memory scores of the experimental group is greater than that of the control group (F = 4.17) (p < .05). Therefore, the results indicate the effect of training visual perception skills on improving working memory).

Discussion

The purpose of this study was to investigate the effectiveness of visual perception training in improving the working memory of children with ADHD. ANCOVA results showed that, considering pretest and posttest scores, early interventions based on visual perception training were effective in improving the working memory of children with ADHD. The results of this study are also consistent with the results of the studies conducted by Milton (2010), Garmabi, Adib-Sereshki, Taheri, Movallali & Seyyed Noori (2016), Narimani, Soleymani, Zahed-Babelani, & Abolghasemi (2015), Abdi, Arbani-Dana, Hatami, & Parand (2014), and Tajik Parvinchi, Wright-Bahons, and Schachar (2014). In their study, Garmabi, Adib-Sereshki. Taheri, Movallali and Seyyed Noori (2016) reported that visual perception training improves the working memory of hearing-impaired children. In his study, Milton (2010) demonstrated the impact of computer program training on improving working memory and

cognitive flexibility in children with ADHD and learning disorders. The results of this study are consistent with the results of the study conducted by Tajik Parvinchi, Wright-Bahons, and Schachar (2014). According to their study, cognitive interventions can be effective for children with ADHD. Abdi, Arbani-Dana, Hatami, and Parand (2014) also concluded that cognitive computer games training could improve the working memory, attention, and cognitive flexibility of children with ADHD. In the neuroimaging studies conducted by Holmes, Gathercole, Place, Dunning, and Holton (2010), it has been shown that working memory rehabilitation has a significant effect on the neural activity of the brain regions associated with working memory and improves their performance. These are the results that can be said to be consistent with the results of the present study. To explain the results of the present study, it can be said that, as research evidence suggests, ADHD reduces executive functions and working memory in children (Nejati, Bahrami, Abravan, Robenzade & Motiei, 2013).

Therefore, the role of working memory deficits in ADHD is important (Duarte, Rooney, Atkinson, & Grant, 2012). Neurological studies have shown that patients with ADHD have deficits in their hippocampus (Sterley, Howells, & Russell, 2013), and since hippocampus plays an important role in working memory, one can justify the working memory deficit in these individuals (Melby-Lervåg & Hulme, 2013). In addition, researchers point out the importance of the frontal and parietal lobes in the performance of working memory so that the upper margin labyrinth of the parietal and frontal regions play a role in storing information in working memory tasks (Croesus, Alzinga, Owei, Part, Niedefeld, Sinhon, Boss & Smahel, 2014). The activity of these areas during doing the tasks related to the working memory in people with ADHD is abnormal, and deficits in these brain regions can explain the problems of concentration and inhibition in these individuals (McVay & Kane, 2009). Activity in the 6, 44, 9, and 46 regions of the cerebral cortex also predict the power of working memory (Sa'ed, 2011). The working memory function is related to the frontal-parietal network activity (Chein & Fiz, 2010; Palva, Monto, Kulashekhar & Palva, 2010) so that the working memory functions are related to the frontal lobe, and the storage of the working memory data is related to the parietal region (Sauseng, Griesmayr, Freunberger & Klimesch, 2010; Champod & Petraeus, 2010). Research by brain imaging techniques also indicates the relationship between the frontal lobe and the processing and storage of information in the working memory (Sauseng, Griesmayr, Freunberger & Klimesch, 2010; Kelimesh, 2008). On the other hand, several studies have shown the relationship between visual perception and parietal cortex (Pisella, 2017). Therefore, working memory can be improved by visual perception training through activating the frontal-parietal regions.

In the program based on the training of visual perception skills, it was tried to draw children's attention to the learning of such things as shape and background, shape stability, spatial orientations, and relationships between objects. Because paying attention to and learning these subjects results in better working memory. As the results of the study by Wana, Chianga, Chenb & Wuanga (2017) suggest, the computer-based training program of visual perception is effective in improving the performance of visual perception and increasing cortical activity as presented in the discussed research as well as the current study.

Conclusion

In general, the results of the current study showed that teaching visual perception skills were effective in activating areas involved in working memory and thus improved the working memory. One of the limitations of this study is the small size of the sample, the impossibility of separate examination of ADHD subgroups and the limited sample of male students. Therefore, it is recommended that in future studies, the related psychological neuropsychiatric disorders should be investigated through studying larger population groups and conducting longitudinal studies on the course of this disorder from childhood to adolescence. It is also recommended that visual perception training should be used as a complementary therapeutic approach, combined with other treatments available for children with ADHD. Psychologists, pedagogical educators, people involved in educational and pedagogical affairs, especially teachers, educators and parents, can use the results of this study to improve the working memory of children with ADHD.

Disclosure statement

No potential conflict of interest was reported by the authors.

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