ISSN: 2588-5715; Health Education and Health Promotion. 2020;8(3):125-133

Cognitive Effectiveness of Auditory and Visual Memory on Improving Cognitive Flexibility in Children with Attention-Deficit/Hyperactivity Disorder

ARTICLE INFO

Article Type
Original Research

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How to cite this article
Hamidi F, Rezaei S. Cognitive Effectiveness of Auditory and Visual Memory on Improving Cognitive Flexibility in Children with Attention-Deficit/Hyperactivity Disorder. Health Education and Health Promotion. 2020;8(3):125-133.

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Article History
Received: July 6, 2020
Accepted: August 16, 2020
ePublished: September 20, 2020

ABSTRACT

Aims This study was done to investigate the Effectiveness cognitive effect of visual and auditory memory on improving the cognitive flexibility of children with Attention-Deficit/Hyperactivity Disorder.

Materials & Methods This study was a quasi-experimental one, which was done by the pretest-posttest with the control group. The statistical population of this study was all students with Attention-Deficit/Hyperactivity Disorder in Kermanshah in the academic year of 2018-2019. The sample consisted of 34 people who were selected by randomized sampling and replaced in two equal groups of experimental (17 subjects) and control group (17 subjects). The research tools were: SWAN Questionnaire and Stroop Color-word Test. Data were analyzed using the mean and standard deviation of the Levine test and homogeneity of slope from regression and covariance analysis to study the research hypotheses.

Findings The results of this study showed that the cognitive effect of visual and auditory memory could improve the cognitive flexibility with effect size 0.45 in children with Attention-Deficit/Hyperactivity Disorder at the significant level ($p<0.01$)

Conclusion It can be concluded that cognitive and auditory memory training may enhance certain skills in ADHD children, but more research is required to generalize the positive effects of these programs on the other clinical features of ADHD.

Keywords Cognitive Effect; Photographic Memory; Auditory Memory; Attention-Deficit/Hyperactivity Disorder

CITATION LINKS

[1] Attention-deficit hyperactivity disorder: A ... [2] Attention-deficit/hyperactivity ... [3] Attention, deficit hyperactivity ... [4] Attention-deficit/hyperactivity ... [5] Diagnostic and statistical manual of mental ... [6] The worldwide prevalence of ADHD: A systematic review and ... [7] The descriptive epidemiology of DSM-IV Adult ADHD in the World Health ... [8] Prevalence of attention-deficit/hyperactivity disorder: A systematic ... [9] Inflammatory markers, endothelial function and ... [10] Prevalence of attention deficit hyperactivity disorder among ... [11] Examining the link between hoarding symptoms and cognitive ... [12] Cognitive flexibility in internet addicts: fMRI evidence from difficult ... [13] Demystifying cognitive flexibility: Implications for ... [14] Prefrontal cortical mechanisms underlying individual differences in ... [15] Executive functioning and reading achievement in school: A ... [16] Association of creative achievement with cognitive flexibility by ... [17] Effectiveness of a cognitive training program on cognitive skills and ... [18] Does working memory training work? The promise and ... [19] Training and transfer effects of executive functions in ... [20] Essential Cognitive ... [21] The World Health Organization Adult ADHD ... [22] Assessing the role of attention-deficit/hyperactivity disorder ... [23] Functional alignment with anatomical networks is ... [24] The effectiveness of cognitive rehabilitation education on improving ... [25] The effectiveness of Cognitive Rehabilitation Computer (CRT) ... [26] Working memory training for older adults after ... [27] Cognitive-behavioral therapy for children with ... [28] Comparing Alliance in two cognitive-behavioral ... [29] Working memory and cognitive flexibility-training for ... [30] Psychometric properties of ADHD rating scales among ... [31] Prevalence of attention deficit hyperactivity ... [32] Neuropsychological ... [33] Effects of attention control training on ... [34] The comparison of selective ... [35] The measurement of creativity by ... [36] Effectiveness of attention-shaping training ... [37] Assessment of attention bias in the ... [38] Working memory, attention control, and ... [39] Do programs designed to train working ... [40] The effectiveness of play therapy on visual ... [41] Cognitive training for impaired neural ... [42] The foundations of next-generation attention ...

Introduction

The term attention-deficit/hyperactivity disorder (ADHD) is familiar to most people, especially the parents and teachers. A child who is continually moving, taps with his fingers, shakes his legs, elbows other for no apparent reasons, and jumps around is usually called hyperactive. These children usually have difficulties concentrating their thought on the task at hand for some considerable time [1]. Symptoms of ADHD are still the subject of extensive studies. However, much evidence shows that ADHD is a highly advanced and multifaceted neurologic disorder [2, 3] and considers the abnormalities in various neurotransmitter systems as the symptoms of ADHD [4].

According to DSM-5, the significant symptoms of ADHD are impulsivity, attention deficit, or hyperactivity disorder that should start before 12 years and be observed at least in two various points like kindergarten, school, home, or during evaluation and cognitive examination. DSM-5 has presented 18 symptoms and requires that at least six symptoms of ADHD should be observed to diagnose this disorder in individuals [5].

ADHD is a neurodevelopmental disorder that affects children, adolescents, and adults worldwide [6]. A mean worldwide prevalence of ADHD of ~2.2% overall (range: 0.1–8.1%) has been estimated in children and adolescents (aged <18 years). The mean prevalence of ADHD in adults (aged 18–44 years) from a range of countries in Asia, Europe, the Americas, and the Middle East was reported as ~2.8% overall (range: 0.6–7.3%) [7]. A meta-analysis of 175 research studies worldwide on ADHD prevalence in children aged 18 and under found an overall pooled estimate of 7.2% [7]. The US Census Bureau estimates 1,795,734,009 people were aged 5-19 worldwide in 2013. Thus, 7.2% of this total population is 129 million—a rough estimate of the number of children worldwide who have ADHD [8]. The prevalence of ADHD in Iran was 8.7% and a confidence interval of 95% (6.10-11.23). The highest prevalence rate was in Tehran, and the least amount was related to the study in the Ilam province. According to the results, the prevalence of this disorder in boys is nearly twice compared to girls [9, 10].

Children with ADHD have low cognitive flexibility. Although many studies have been done on this cognitive construct, there is currently no consensus on how it is defined. Generally, the ability to modify cognitive stimuli to adapt to changing environmental stimuli is a critical element in operational definitions of cognitive flexibility [11]. Cognitive flexibility, also called flexibility cognitive, is a method of mental processing, based on which the individual recursively readjusts mental resources [12]. Cognitive flexibility can connect to the readiness used to communicate between the mental processes selectively used to produce appropriate behavioral responses [13]. In other words, cognitive flexibility is a skill and ability that changes appropriate behavior according to environmental conditions [14]. Cognitive flexibility enables an individual to quit an old job efficiently and effectively, rearrange a new response set, and implement this new response on task. Greater cognitive flexibility is associated with favorable outcomes in life, such as better reading ability in childhood [15] and higher creativity [16].

According to the aforementioned, ADHD led to a decrease in cognitive flexibility. This decrease can cause many problems not only for people with ADHD and their families but also for the teacher. Learning classroom activities needs careful attention to the relevant stimuli associated with assigning and ignoring irrelevant stimuli [17]. There are many treatments for children with ADHD, and the present study considers cognitive auditory-visual memory training. According to Morrison and Chein, cognitive training is a useful and effective tool for improving cognitive abilities. The results presented show the effectiveness of cognitive training techniques in enhancing cognitive skills and reducing the symptoms of ADHD. Among them, regular visual and auditory interventions to improve the cognitive abilities of children with ADHD showed significant improvement in working memory, sustained attention, and planning ability [18]. Cognitive training: refers to practice based on the findings of the cognitive sciences that try to improve or enhance executive functions in the form of games [19].

Recent studies have shown that attention can direct memory representations and produce a flexible model of active memory contents [20]. It is a long time that ADHD is the most common psychiatric disorder in children and often persists into adulthood [21]. ADHD is one of the most common chronic developmental disorders, and its three main characteristics are impaired cognitive flexibility, inattention, and lack of patience. People with this disorder show a marked continuation of those defects in adulthood [22]. On the other hand, studying cognitive flexibility in the human brain is essential for understanding the human mind [23]; thus, attention to cognitive flexibility among children with ADHD is of great significance.

Several studies have been done in Iran and abroad on the cognitive effects of auditory and auditory memory. The results of a study conducted in 2018 showed that the cognitive rehabilitation method was sufficient for the mentioned groups and the difference between the effectiveness of auditory memory was significant between the two groups. The rate of improvement in auditory memory of children with learning disorders and hyperactivity was higher than that of the group with learning disorder without hyperactivity [24].

Another study that was done in 2017 showed that CRT was effective in improving working memory and reducing attention deficit in children with ADHD. Using CRT of computerized cognitive rehabilitation can reduce the persistent attention deficit disorder and improve the working memory of children with ADHD [25].

Similar studies have been done outside Iran. Carbone *et al.* concluded that cognitive training could maintain cognitive and emotional functioning and especially spirituality, by targeting memory [26].

A study entitled "Cognitive-Behavioral Therapy for Children with ADHD," Gould *et al.* concluded that neither the diagnosis of ADHD nor its subtypes could predict response rates or remedies for early childhood disorders. After cognitive-behavioral anxiety therapy, children with ADHD showed modest but significant improvements in ADHD [27]. Boyer *et al.* showed that persistence, especially cohesion in therapeutic activities, was significantly higher for structured cognitive-behavioral therapy [28].

Vries examined the effect of working memory training and cognitive flexibility on autistic children. Their results showed the effectiveness of both working memory training and cognitive flexibility training in improving children's symptoms [29].

Moreover, given the effectiveness of cognitive training on children with ADHD and as there have been no comprehensive studies on the effectiveness of cognitive-auditory memory training on cognitive flexibility in children with ADHD, it is necessary to examine the cognitive efficacy of auditory and auditory memory in improving cognitive flexibility in children with ADHD.

Materials and Methods

The present study was a quasi-experimental study with a pretest and posttest with a control group. The pretest and posttest with the control group were shaped by two groups, where each group was measured twice. The first measurement was done with one pretest and the second one with one posttest (Diagram 1).

The sample consisted of 34 people who were selected and substituted by randomized sampling in two groups. Before applying the independent variable (performing cognitive auditory and visual memory training), both groups were measured with the Stroop software pretest, and the results were recorded. After applying the independent variable that included n-back software individually and training sessions on visual and auditory memory reinforcement for the experimental group, both groups were re-examined using the posttest. The training sessions used for children have held one session per week, lasting approximately two months. Then, the measurement was done by a questionnaire. To observe ethical issues at the beginning of the study, by explaining the purpose of the research honestly, informed consent was obtained from the research participants so that the researcher fully maintained the confidentiality of the information. Written parental consent was a criterion for admission to the study, and more than two sessions of absenteeism in receiving education led the subjects to exit.

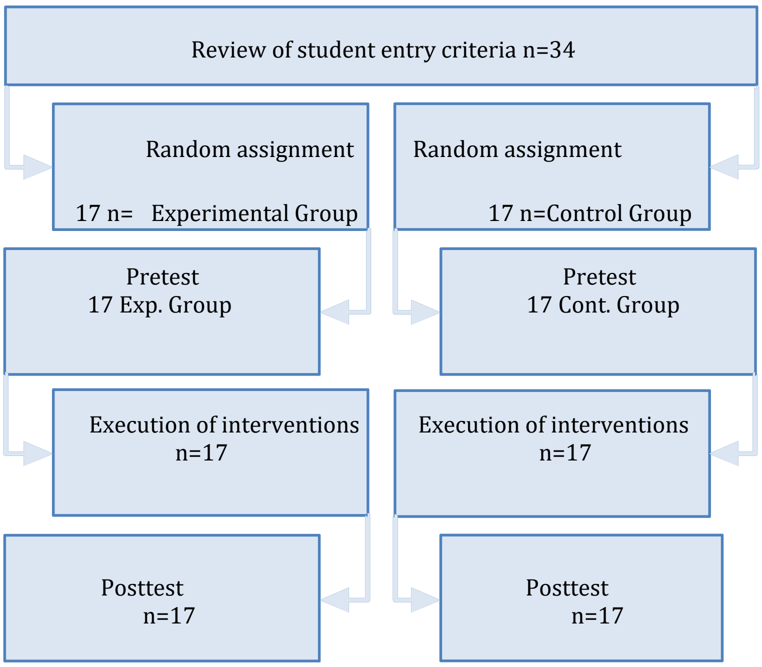

Diagram 1) Consort of clinical trial research

The population of the study was selected from first and second-grade male students with ADHD in Kermanshah, who were studying in the academic year of 2018-2019. Education Counseling Center of the city was attended to identify the subjects. The sample consisted of 34 people who were selected by randomized sampling and replaced in two equal groups of experimental (17 subjects) and control group (17 subjects).

Research tools

SWAN questionnaire: A SWAN questionnaire is used to evaluate ADHD. The reason for selecting this questionnaire is the innovation in providing positive rather than negative expressions. The questionnaire has 18 items, designed based on DSM_IV with two 9-word sections. The nine symptoms of inattention were listed in items 1 to 9 and nine items of hyperactivity in items 10 to 18 by Swanson, Nolan, and Pelham in 1980 to evaluate ADHD in children completed by the child teacher.

In scoring this questionnaire, a 7-point grading is used, with the expected behavior in the middle of the grading range, with zero being assigned to positive behavioral scores and negative scores to lack of behavioral problems or reinforcing child behavior. Diagnosis of the children with ADHD in this questionnaire is based on a 10% high range of the distribution of subjects' scores, and those below this range have no problems. Positive scores (slightly below 1, below-average two, and well below average 3) belong to behavioral issues, and negative scores (slightly above -1, above-average -2, and well above average -3) belong to non-presence of behavioral problems or the strengthening of child's behavioral issues [30].

Cronbach's alpha coefficient and test-retest were used to calculate reliability. Cronbach's alpha coefficient was 0.96 for attention deficits, 0.95 for hyperactivity, and 0.96 for combined impairment, and the test-retest reliability coefficient was calculated for 102 patients (31 boys and 71 girls) after 5-6 weeks. The results were 0.75 for attention deficits, 0.63 for hyperactivity, and 0.74 for combined impairment. Overall, the results of the questionnaire's reliability through two methods showed the necessary and appropriate reliability of the questionnaire.

Shahim *et al.* examined the psychometric properties (validity and reliability) of this questionnaire and reported them as desirable [31]. Swan questionnaire test-retest coefficients after two weeks for the hyperactivity and attention deficit subscales were 0.69 and 0.78, respectively. The internal correlation between the two subscales was 0.90. In the present study, the reliability of the questionnaire with Cronbach's alpha coefficient was 0.88 and 0.79 for the hyperactivity and impulsivity, respectively.

Stroop Color and Word Test (SCWT): SCWT test was used to measure cognitive flexibility in the study. SCWT was first developed by Ridley Stroop in 1935 to measure selective attention and cognitive flexibility. This test, translated into several languages, including Chinese, German, Swedish, and Japanese, and so on, is one of the most important tests researchers have used to measure response inhibition. Indeed, SCWT is not a single test but has been developed for different purposes. The original form of the test has four stages [32], but in the new version, it has three stages, which include color detection, concurrent, and non-interfering attempts, respectively. In the first step, the subject is asked as soon as possible to tell the name of the colors written on a special card (the colors shown are four: blue, green, red, and yellow). The purpose of this step is to practice only knowing the colors and locations of the keys and thus not affecting the result. The second involves reading the color words printed in their color. The reaction time and the number of errors in all three steps are recorded. The difference between reaction time and errors between the trial of the awkward trial phase (stage three) and the concerted trial phase (second stage) is measured as the intrinsic error. This test has been developed and validated by Fadardi & Ziai for Persian-speaking users [33]. Jamehpour has reported the validity of this test in Iran as 0.93 [34]. Golden reported the reliability coefficient for single-item versions as 0.85, 0.82, and 0.73 [35]. Pretest and posttest correlation coefficients were calculated for Stroop software with a one-month interval, which was 0.768 in the correct Stroop response and 0.904 in the Stroop incorrect response [36].

The test scoring is that the time for each stimulus to be displayed on the screen is 2 seconds and the distance between the two stimuli is 0.8 seconds. The amount of inhibition or interference as an index for measuring and evaluating cognitive flexibility and response inhibition is a decrease in the mean duration of response to incongruent stimuli compared to congruent stimuli in seconds, whatever the distance from zero to a low degree of flexibility indicates that this number can never be harmful [36]. This test is as software. The longer mean duration of response to the incongruent stimulus, compared to the incongruent, is an indicator for evaluating the interference. Test validity has been reported through re-testing in the range from 80 to 90% [37]. Moreover, four psychology professors confirmed the content validity of the Persian form of the test. The questionnaire validity was 0.77 in the present study.

N-Back software: N-BAC DUAL exercise is a memory-strengthening exercise first used in a study in 2008. In this computer program, a sequence of audiovisual stimuli in the form of a number and simultaneously a letter of the alphabet is displayed randomly for a few seconds and presented to the subject. The subject must check whether the present stimulus is compatible with the stimulus at the n step before. The subject's assignment is that whenever a previous target image is viewed, press the "A" key and if you hear the previous target, press the "L" key, and in case of seeing and hearing the previous target, press both keys in the keyboard at the same time. If the subject remembers 90% of the goals correctly, the software will automatically increase the difficulty level of the tasks. Thus, the subject has to recall 1, 2, 3 to 12 auditory and visual stimuli, respectively. If the subject responds to less than 50% of the targets, he will automatically return to the previous stage. The second part in this part means that the person has to remember the two stimuli, and the letter n in the n-back shows that the subject must remember several previous steps to decide and respond to the location or sound oneness. This software should be offered to students for two months to be effective in 10 half-hour sessions. In a study, the reliability coefficients in the range from 0.54 and 0.84 show the high reliability of this test. The validity of this test is also highly accepted as a measure of working memory performance [38].

Contents of training sessions

Cognitive auditory-visual memory training was performed individually and in groups of 10 for 60 min sessions individually for each student:

First session: Familiarizing students with friendships, setting goals, explaining the choice and visual and auditory memory, and getting students motivated to get started and motivated a few minutes out of the classroom, replacing a few people and the student finds and report changes in the classroom. Some descriptions are given on n-back software and its implementation by students.

Second session: Techniques for reducing pause time and increasing view field using a card exercises enhance visual and auditory coordination such as connecting dots in the right way through dialogue such as drawing straight lines, angles, and curves while working continuously with n-back software.

Third session: Keeping an eye on the exercises and doing such exercises where we place a limited set of objects and images in front of the child and ask the students to remember their name and order, then close their eyes and then replace some of the tools. We ask him to sort things out by first explaining the numbers and letters, and then the student repeats them upside down, trying to improve the accuracy of n-back software.

Fourth session: Speech-based visual imaging, images (four in each) are presented and shown through the image, then students are asked to repeat them directly and upside down, with several cardboard written on each word where the students are given the words to memorize, then the cards are taken from them, two are kept, and the rest is given to the student to determine the ones removed to continue with n-back software.

Fifth session: We give three words to the students and ask them to say them after all three words and then four and then five words. The numbers were presented verbally and illustrated, and then the student was asked to repeat them directly and inversely while working with n-back software.

Sixth session: One sentence is told to the student, and he is asked to repeat and paint it and pays attention to the details, then two sentences, three sentences, and so on. We repeat this exercise, but this time the student will follow the order of the sentences.

Seventh session: Providing image stories to the student and asking questions about the images to increase the child's attention to detail, tell stories to the child, and ask them about the story to increase their focus and memory.

Eighth session: Providing exercises for the student to remember objects, five objects are placed in front of the child, and a set of instructions the child must follow, a red ball under the desk, a pencil on the desk, etc.

Ninth session: Work with students on spatial relationships using learning directions, understanding space, the ability to recognize objects, and how to interact with each other, including having the child recognize the direction of the sounds, remembering the location of objects, and closing their eyes and asking questions. He is asked about the locations of objects like the pencil on which side of the office.

Tenth session: Using dual training in reading with the help of a teacher and student, preserving children's poems in children's books and drawing their paintings, though not similar

Findings

The purpose of the study was to examine the cognitive effect of auditory and visual memory on improving cognitive flexibility in children with ADHD. The results were presented in three sections: a) descriptive findings, b) findings related to the analysis of covariance analysis hypotheses, and c) findings related to the research hypothesis. Data were analyzed using the mean and standard deviation of the Levine test and homogeneity of slope from regression and covariance analysis to study the research hypotheses.

Table 1 shows the descriptive findings, including mean and standard deviation of the cognitive flexibility in the experimental and control groups in the pretest and posttest stages.

As the results in Table 1 show, the mean scores of pretest and posttest of cognitive flexibility in the experimental group were 101.47 and 63.82 and in the control group, 99.94 and 96.35, respectively.

Before analyzing the data for the hypotheses, they are examined to ensure that the data in this study estimate the underlying assumptions of the covariance analysis. For this purpose, four assumptions of covariance analysis, including linearity, multicollinearity, homogeneity of variances, and homogeneity of regression slopes were examined, respectively. Table 2 shows the results of Levine's test for the equation of variance of the dependent variable error in the experimental and the control groups in the posttest phase.

As the results in Table 2 show, Levine's test on cognitive flexibility (F=2.989; p<0.093) was insignificant, so the posttest error variance of the experimental group and the control group in cognitive flexibility did not differ significantly, and the assumption of homogeneity of variances is confirmed in the posttest.

Table 1) Mean and standard deviation of the variables in experimental and control groups

Variable	Cognitive flexibility	
	Mean	**SD**
Experimental group		
Pre-test	110.471	44.685
Post-test	63.821	38.542
Control group		
Pre-test	99.941	53.720
Post-test	96.353	51.172

Table 2) Levine's test results for equality of variance of the dependent variable

The dependent variable	Cognitive flexibility
Degree of freedom 1	1
Degree of freedom 2	32
F	2.989
Sig.	0.093

While it is assumed that the variables in the analysis of covariance in whole data should show linearity, it should also be considered that the regression lines for each group in the study should be the same. If the regression is heterogeneous, then the analysis of covariance would not be appropriate. The assumption of homogeneity of regression is a critical issue in covariance. It should be explained that in the present study, posttests of cognitive flexibility were considered as dependent variables and their pretest as a covariate. The assumption of homogeneity of slopes will be established when there is equality between the covariate (pretest) and the dependent variable (posttest) at all operating levels (experimental and control groups). What would be considered is a little interaction between dependent and auxiliary variables.

Table 3 shows the results of the homogeneity of the regression slopes between the covariates (pretests) and the dependent (posttests) at the factor levels (experimental group and control group) at the posttest stage.

Table 3) Homogeneous results of regression slopes between the covariate and dependent variable at factor levels in posttest

Statistical index	Cognitive flexibility
The sum of the squares	1132.223
df	1
Mean squares	1132.223
F	3.325
Sig.	0.078

As the results in Table 3 show, the interaction between covariate (cognitive flexibility pretest) and dependent (cognitive flexibility posttest) at the factor levels (experimental group and control group) was not significant (F=3.325; p<0.078). Thus, the assumption of homogeneity of regression in cognitive flexibility pretest and posttest at factor levels are confirmed.

Multivariate analysis of covariance (MANCOVA) was performed to examine the meddling effect of the experiment control on posttest scores by controlling the pretests of the dependent variables. Table 4 shows the results of multivariate analysis of covariance on posttest scores by controlling the dependent variable.

The general hypothesis of cognitive-auditory-visual memory training is effective in improving the cognitive flexibility of children with ADHD.

As the results in Table 4 show, there was a significant difference between the experimental and control groups in terms of the dependent variable - cognitive flexibility - (F=24.191; p<0.001). Thus, the general hypothesis of the study is confirmed. To examine this effect more accurately, one-way covariance analysis (ANCOVA) in the MANCOVA test was performed on dependent variables. Table 5 shows the results of MANOVA in the MANCOVA text for posttest comparison by controlling the pretest of the dependent variables in the experimental and control groups.

As the results in Table 5 show, ANOVA in cognitive flexibility (F=25.298; p<0.001) is significant. To understand how this difference is sufficient, we compare the mean scores of the posttest and the control group in terms of the dependent variable stated. According to the results in the table, the mean cognitive flexibility posttest in the experimental group is 63.82 and in the control group 96.35, indicating that by controlling pretest, the cognitive flexibility of the experimental group in the posttest is significantly different from that of the control group. Thus, the research hypothesis is confirmed.

Table 4) The results of MANCOVA on posttest scores with dependent variable controlled

Effect	Tests	Value	F	Hypothesis df	df error	Sig.	Effect size
Group	Pillai's Trace	0.625	24.191	2	29	0.001	0.625
	Wilks Lambda	0.375					
	Hoteling's Trace	1.668					
	Roy's Largest Root	1.668					

Table 5) The results of MANOVA in MANCOVA text for posttest comparison

Effect	Group value
Dependent variable	Cognitive flexibility
Sum of squares	9560.450
Degree of freedom	1
Mean squares	9560.450
F	25.298
Sig.	0.001
Effect size	0.457

Discussion

The purpose of the study was to examine the cognitive effects of auditory and visual memory in improving cognitive flexibility in children with ADHD. Using the cognitive-auditory-visual effectiveness memory method on cognitive flexibility was done in this study for the first time. This is in line with similar studies. The results are consistent with the researches of Vries , Morrison & Chein, Khanjani *et al.*, Khanzadeh *et al.*, and Carbone *et al.*. Vries examined the effect of working memory training and cognitive flexibility on autistic children. Their results showed the effectiveness of both working memory training and cognitive flexibility training in improving children's symptoms [29]. According to Morrison & Chein, visual and auditory interventions to enhance the cognitive abilities of children with ADHD showed significant improvement in working memory, sustained attention, and planning ability [18]. Cognitive training is based on the findings of the cognitive sciences that try to improve or enhance executive functions in the form of games [19]. Visual memory is a sensory memory that holds the image in the memory for a short time. Auditory memory refers to a form of a system of sensory memory related to auditory reception, which is a system allowing the preservation and manipulation of visual and auditory information, thus enabling one to interact with the environment. The ability to maintain this information is minimal.

Khanjani *et al.* study showed that the cognitive rehabilitation method was significant for the groups mentioned above and the difference between the effectiveness of auditory memory was significant in the two groups. The rate of improvement in auditory memory of children with a learning disorder and ADHD was higher than that of the group with learning disorder but no ADHD [24]. Hossein Khanzadeh *et al.* examined the effect of play therapy on short-term visual memory and cognitive flexibility in children with ADHD [40]. The results of covariance analysis showed that in the posttest, play therapy improved cognitive flexibility and short-term visual memory in children with ADHD. Play therapy, if done correctly, provides children with a tangible and profound experience of skill development, and this practical exercise directly brings about improved cognitive flexibility and short-term visual memory in these children [40]. Carbone *et al.* concluded that cognitive training could maintain cognitive and emotional functioning and especially spirituality, by targeting memory [26]. Boyer *et al.* conducted a study entitled "Comparing and measuring the continuity between two cognitive-behavioral therapies using a randomized controlled trial." Their results showed that continuity, and in particular, cohesion in therapeutic activities, was significantly higher for structured cognitive-behavioral therapy [28].

As ADHD has reported a highly progressive and multifaceted neurological disorder [2, 3] and abnormalities in various neurotransmitter systems have been reported as symptoms of ADHD [4] and given the prevalence of this disorder in children and the irreversible damages it has on the children's personal and academic performance, timely identification and appropriate intervention can have a significant role in preventing its consequences. In recent years, cognitive training has been examined as a potential treatment for ADHD [39]. According to evidence of brain plasticity from contemporary rehabilitation science and advanced neuroscience, cognitive training is based on the assumption that crucial brain networks associated with ADHD can be enhanced, and cognitive processes can reduce symptoms of ADHD and improve performance by targeting neuropsychological disorders [41]. Given the complex nature of ADHD, cognitive training approaches target various functions (e.g., attention control, working memory, and skill control) [42]. In other words, cognitive rehabilitation is a method of restoring lost or damaged cognitive abilities accomplished by exercises and the provision of targeted stimuli that try to enhance one's performance in performing tasks and activities.

As cognitive training is a structured set of therapeutic activities designed to retrain one's memory and other cognitive functions based on evaluating and understanding a patient's brain and behavioral disorders, it can enhance cognitive functions by being involved in symptoms of students with ADHD and help improve these symptoms and thus their cognitive flexibility. Explaining this finding, it can be said that this can affect the visual and auditory function of children. The cause of ADHD is primarily biological or neurodevelopmental. These children may have a mild abnormality in the brain that interferes with their attention, memory, and activity, and distraction is the result of attention deficit hyperactivity disorder. This can affect the visual and auditory function of children. Visual cues are among the capabilities that children need to learn lessons. The use of memory-based visual and auditory games and enhances attention improves the cognitive functions of these children.

Conclusion

According to the results, the cognitive effect of students' visual and auditory memory could improve their cognitive flexibility. It showed training and performing cognitive-auditory-visual memory exercises, besides improving memory and attention control, can be useful in better cognitive flexibility performance. This cognitive ability allows the child to self-evaluate and overcome the obstacles and difficulties they face in life. Hence, by providing cognitive-auditory-visual memory exercises in a developed way, they improve executive functions and increase cognitive flexibility in students with ADHD as these skills are learned through providing the context.

The major limitation of this study was that it is being conducted solely on boys with ADHD, and it would be impossible to generalize the results to girls. Another limitation was related to the relatively short duration of cognitive rehabilitation programs without a follow-up period. Thus, it is suggested that similar studies could be conducted on girls, and the duration of the cognitive rehabilitation program be extended to three months for better generalization of the results.

Acknowledgments: In the end, we would like to extend my deep gratitude and appreciation to Thales Babajani County Education and School Administrators.

Ethical Consideration: All ethical principals were considered in this research. The research was extracted from a clinical trial as an MSc dissertation of educational psychology in Shahid Rajaee Teacher Training University (Ref.no.2577848).

Conflict of interest: The authors declared no conflict of interest.

Authors' contribution: Hamidi F. (First Author), Introduction Writer/Methodologist/Assistant Researcher/ Statistical Analyst/Discussion Writer (50%); Rezaei S. (Second Author), Methodologist/Main Researcher/ Statistical Analyst/Discussion Writer (50%)

Funding/Support: There was no financial support for the present research.

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