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Comparison of different components of executive functions in children with attention-deficit/hyperactivity disorder, children with specific learning disorders, and normal children

Asiyeh Khaledi[1], Hadi Hashemi-Razini[2], Mohammad Hossein Abdollahi[2]

1 Department of General Psychology, Shahr-e Kord Branch, Islamic Azad University, Shahr-e Kord, Iran
2 Department of Psychology, Kharazmi University, Tehran, Iran

Original Article

Abstract

BACKGROUND: The present study was conducted with the aim of examining and comparing different components of executive functions (inhibitory control, cognitive flexibility, working memory, planning) of 3 groups of children with attention-deficit/hyperactivity disorder (ADHD), children with specific learning disorder (LD), and normal children.

METHODS: Statistical society of the study included all 7-12 year-old students of Lordegan City, Iran, in the school year of 2015-2016. To carry out this study, 26 normal children were selected by multistage cluster sampling method and 22 children with ADHD and 18 children with specific LD through convenience sampling method. The causal-comparative method was exploited to perform the study. The tools used included clinical interview, Conners questionnaire, the forms filled in by the teachers of children with ADHD, Stroop Color and Word Test (SCWT), and the Tower of London (TOL), active memory, and Wisconsin cards. The analysis was performed using SPSS software with descriptive and inferential statistics [multivariate analysis of variance (MANOVA)].

RESULTS: The results showed that, children with ADHD and specific learning disability were lower in 3 areas of performance of working memory, planning, and inhibition performance in comparison to the normal group, however there was no significant difference among groups in terms of flexibility performance.

CONCLUSION: In this study, it has been shown that the problems emerging among the exceptional children studied in this study, namely, children with ADHD, and children with learning disabilities, are rooted in their brain functions.

KEYWORDS: Executive Function, Attention Deficit Hyperactivity Disorder, Specific Learning Disorder

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Introduction

Attention deficit/hyperactivity disorder (ADHD) is one of the most common psychological disorders among children and teenagers that is shown by three main signs including chronic problems in controlling attention, excessive action, and impulsivity. Different rates have been reported regarding the prevalence of this disorder. For instance, some researchers declared that ADHD occurs in 3-7% of school children and 5% of adults.[1] Finally, based on Diagnostic and Statistical Manual of Mental Disorders (DSM-5), 5% of children and 5.2% of adults have ADHD, with boys facing this disorder 2 times more than girls and also men facing it 1.6 times more than women.[2]

Students with learning deficits are a huge subgroup of students with special needs. The main sign of students with learning disorder (LD) is loss of concentration and defect in attention and memory.[3]

Based on the reports released by education department of the United States of America

Corresponding Author:
Hadi Hashemi-Razini
Email: hadihashemi@khu.ac.ir

(USA), 4.3% of all registered students in 2003 have LD.[4] LD affects almost all aspects of students' lives and is a long-lasting problem. LD in educational occasion may have outcomes in other aspects. For example, this ability can also affect daily activities as weak memory, weak deduction, and low ability in solving problems is because of the neurobiological problems among individuals. In addition, executive functions, social relationships, and emotional activeness could be influenced by this ability.[5]

Executive function is a general term that refers to mental process, controlling ability of a body, cognition, and excitement to guide the behavior toward the goal.[6]

Dawson and Guare categorized the most important functions into scheduling, organizing, working memory, time management, response inhibition, task initiation, and target-based resistance.[7]

Related processes include inhibitory control, active memory, as well as language and general memory capabilities.[8]

Any defect in the development of executive functions can cause attention deficit disorders, hyperactivity disorder, or disruption in planning for beginning and completing a task, memorizing a task, memory impairment, and LD.[9] One of the problems of children with LDs that attracts the attention of researchers and experts is executive functions and attention. The low performance of children with learning disabilities in executive functions and attention has been reported in numerous studies.[10,11] Executive function and attention have been the center of attention of recent neuropsychological theories regarding children encountering the risk of disability, particularly children with learning deficiency and ADHD. The main purpose in this study was to compare the functioning of active memory and planning among children with ADHD, children with special learning disabilities, and normal children.

Materials and Methods

The present study is structural in terms of purpose and descriptive cross-sectional in terms of data collection method with a comparative causal type. According to research topic, active memory functions and scheduling were regarded as dependent variables and the groups under study as independent variables. The statistical population of the study included all students of elementary schools (7-12 years old) in Lordegan City, Iran, who were studying in the academic year 2015-2016. The number of samples for the study was 66 individuals in three groups consisting of normal cases, cases with ADHD, and cases with LDs with 26, 22, and 18 children, respectively. In order to collect the sample in this study, a specific method was used for each sample group and the convenience sampling method was used to choose samples. Since the study was conducted in a small city, there was no possibility of selecting a large sample group. It should be noted that studies using convenience sampling method will always have general limitations.

Using convenience sampling, 22 children with ADHD and 18 children with learning disabilities were selected by referring to counseling centers and clinics and center for LDs in Lordegan, and these 2 groups were regarded as the statistical sample. In addition, the multistage cluster sampling method was utilized for selecting normal children.

Tower of London (TOL) test: this test is one of the important tools for measuring performance of planning and organizing. The reliability coefficient of this test has been reported to be 0.86 through a re-test, moreover, its validity by means of cross-correlation test between subtest and verbal, practical, and total test has been calculated as 0.78, 0.74, 0.80, respectively.[12]

Working memory index (WMI): this test is one of the subscales of Wechsler Memory Scale

(WMS) (3rd edition) and contains 2 small scales: 1. sequence of numbers and letters which is a vocal task by which working acoustic memory is measured, and 2. spatial area which is a visual task measuring working spatial memory. The first form of WMS has been translated and adjusted in Iran and has been standardized on 1007 individuals with a confidence level of 0.85 on the population living in Tehran in 9 age groups.[13]

To analyze the data, descriptive and inferential statistics were used. The descriptive statistics were employed for reporting central index and mean dispersion and standard deviations (SD) of the study variables. Besides, inferential statistics of multivariate analysis of variance (MANOVA) test and post-hoc Tukey test were exploited for analyzing the study questions. Analyzing the data collected through the study questionnaires was carried out using SPSS statistic software (version 23, IBM Corporation, Armonk, NY, USA).

Results

In this study, 22 children with ADHD, 18 children with learning disabilities, and 26 healthy children participated. The mean ± SD of the age of the participants was 9.01 ± 1.33 years. One-way ANOVA showed no significant difference in age between the three groups ($P < 0.050$, $F = 0.446$). In terms of gender, the groups were peer groups. The MANOVA test was used in order to compare the working memory of children with ADHD and children with specific LDs with normal children. The MANOVA test was primarily performed, which revealed that there were significant differences in memory test subscales for measuring performance of working memory between groups, with the results of MANOVA and post-hoc Tukey tests presented in table 1 for exact examination of the position of the differences. Groups were matched for age and sex. As a result, the effect of age and gender differences was controlled.

According to the results presented in table 1, there was a significant difference between the two groups of normal children and children with ADHD in progressing acoustic memory as the probability value was less than the determined alpha value ($\alpha = 0.05$).

There was no difference in the paired comparison between normal children and children with specific LD. In addition, there was no significant relationship between the two clinical groups of children with specific learning deficiency and children with ADHD. A paired comparison between groups in inverse auditory memory indicated that there was a significant difference between the normal group with children with ADHD and children with specific LDs since the probability value was lower than the determined alpha value. This difference was not observed between the group with ADHD and the group with specific LDs. The same result was obtained for acoustic memory area, so that normal children had a significant difference with children with specific LD and ADHD, however this difference was not observed between the two groups. In visual memory and inverse visual memory area, normal children indicated a better performance compared to the hyperactive children and the probability for paired comparison between these two groups showed a significant difference in accordance with the alpha value determined. Nevertheless, no significant difference was observed between the two groups of normal and specific LD as well as the two groups of ADHD and specific LDs. In progressing visual memory, the normal group had a significant difference with the two groups of ADHD and LDs, however a difference was not observed between the two clinical groups. In order to compare the planning performance, the MANOVA test was performed, and it was revealed that there was a significant difference between groups in subscales of TOL test for measuring planning performance, with the results of MANOVA and post-hoc Tukey tests presented in table 2 for exact examination of the position of the differences.

Table 1. Results of multivariate analysis of variance (MANOVA) test and post-hoc Tukey test along with the scores of the three groups in working memory

Variable	df	MS	F	P	Reference group	Compared group	Mean difference	SE	P
Progressing acoustic					Normal	ADHD	1.53	0.429	0.002
						LD	0.85	0.454	0.153
	2	14.127	6.430	0.003	ADHD	Normal	-1.53	0.429	0.002
						LD	-0.38	0.471	0.329
					LD	Normal	-0.85	0.454	0.153
						ADHD	0.68	0.471	0.329
Inverse acoustic					Normal	ADHD	1.58	0.408	0.001
						LD	0.41	0.439	0.005
	2	17.910	9.038	< 0.001	ADHD	Normal	-1.58	0.408	0.001
						LD	-0.17	0.447	0.926
					LD	Normal	-1.41	0.432	0.005
						ADHD	0.17	0.447	0.926
Acoustic memory area					Normal	ADHD	1.73	0.489	0.002
						LD	1.52	0.518	0.013
	2	21.335	7.477	0.001	ADHD	Normal	-1.73	0.489	0.002
						LD	-0.22	0.537	0.914
					LD	Normal	-1.52	0.518	0.013
						ADHD	0.22	0.537	0.914
Progressing visual					Normal	ADHD	1.12	0.457	0.044
						LD	1.74	0.484	0.002
	2	17.395	6.989	0.002	ADHD	Normal	-1.12	0.457	0.044
						LD	0.62	0.501	0.435
					LD	Normal	-1.74	0.484	0.002
						ADHD	-0.62	0.501	0.435
Inverse visual					Normal	ADHD	1.00	0.311	0.006
						LD	0.23	0.329	0.763
	2	6.344	5.514	0.006	ADHD	Normal	-1.00	0.311	0.006
						LD	-0.77	0.341	0.068
					LD	Normal	-0.23	0.329	0.763
						ADHD	0.77	0.341	0.068
Visual memory area					Normal	ADHD	1.30	0.372	0.002
						LD	0.80	0.394	0.113
	2	10.400	6.311	0.003	ADHD	Normal	-1.30	0.372	0.003
						LD	-0.51	0.408	0.436
					LD	Normal	-0.80	0.394	0.113
						ADHD	0.51	0.408	0.436

df: Degree of freedom; MS: Mean square; SE: Standard error; LD: Learning disorder; ADHD: Attention deficit/hyperactivity disorder

The results of table 2 shows that there was a difference in total results (total score) in TOL test among the three groups. The results of post-hoc Tukey test indicated that there was a significant difference between the normal children group in the TOL test and the two groups of children with ADHD and children with specific LDs, due to the 99% probability amount in paired comparison of normal group with ADHD group and normal group with specific learning deficiency group. Moreover, the results of MANOVA showed that there was a significant difference in the number of errors between the three groups. The results of post-hoc Tukey test showed a significant difference between normal children and children with ADHD, though there was no significant difference between the two groups of normal children and children with specific LD as well as the two groups of ADHD and specific LD.

Table 2. Results of multivariate analysis of variance (MANOVA) test and post-hoc Tukey test along with the scores of the three groups in Tower of London (TOL) test

Variable	df	MS	F	P	Reference group	Compared group	Mean difference	SE	P
Progressing acoustic	2	19371.7	0.446	0.642	Normal	ADHD	-15.42	60.389	0.965
						LD	45.31	63.920	0.759
					ADHD	Normal	15.42	60.389	0.965
						LD	60.73	66.255	0.632
					LD	Normal	-45.31	63.920	0.759
						ADHD	-60.73	66.255	0.632
Inverse acoustic	2	721.30	0.072	0.931	Normal	ADHD	10.91	29.036	0.925
						LD	6.43	30.734	0.977
					ADHD	Normal	-10.91	29.036	0.925
						LD	-4.57	31.856	0.989
					LD	Normal	-6.43	30.734	0.977
						ADHD	4.57	31.856	0.989
Acoustic memory area	2	21050.8	0.955	0.390	Normal	ADHD	-5.12	43.010	0.922
						LD	54.15	45.525	0.464
					ADHD	Normal	5.12	43.010	0.922
						LD	59.27	47.187	0.425
					LD	Normal	-54.15	45.525	0.464
						ADHD	-59.27	47.187	0.425
Progressing visual	2	422.5	3.868	0.026	Normal	ADHD	-8.02	3.028	0.027
						LD	-6.12	3.205	0.145
					ADHD	Normal	8.02	3.028	0.027
						LD	1.91	3.322	0.834
					LD	Normal	6.12	3.205	0.145
						ADHD	-1.91	3.322	0.834
Inverse visual	2	107.9	4.607	0.014	Normal	ADHD	3.19	1.402	0.024
						LD	3.59	1.848	0.048
					ADHD	Normal	-3.79	1.402	0.024
						LD	-0.20	1.538	0.991
					LD	Normal	-3.59	1.484	0.048
						ADHD	0.20	1.538	0.991
Visual memory area	2	107.9	4.607	0.014	Normal	ADHD	3.79	1.402	0.024
						LD	3.59	1.484	0.048
					ADHD	Normal	-3.79	1.402	0.024
						LD	-0.20	1.538	0.991
					LD	Normal	-3.59	1.484	0.048
						ADHD	0.20	1.538	0.991

df: Degree of freedom; MS: Mean square; SE: Standard error; LD: Learning disorder; ADHD: Attention deficit/hyperactivity disorder

Discussion

The objective in the present study was investigating and comparing some executive functions such as working memory and planning in the three groups of normal children, children with ADHD, and children with LDs. The results showed that children with ADHD and with specific LDs had weaker function in working memory and planning compared to the normal children. The results of this study are consistent with the findings of the one carried out by Chiang and Gau[14] as well as Smith-Spark and Fisk[15] regarding differences between children with ADHD and children with LDs. This point can be also explained by neurology. According to the neurologic viewpoint, the functions of attention and working memory involve common areas in brain.[16] Due to this close

relationship, the difference in working memory performance was not unexpected. Considering the relationship between attention and memory, and taking into account that this memory is known as an effective process in controlling and monitoring learning tasks, the defects of children with ADHD and children with special LDs is justifiable.

The results of the studies by Chiang and Gau[14] and McLean and Hitch[17] are consistent with the findings of the present study about the difference between children with ADHD and children who have LDs with normal children. Regarding the explanation and confirmation of this finding, neurological studies have shown that students with ADHD have deficiency in cerebellum and frontal lobes, which play a significant role in excellent cognitive processes such as planning.[18]

The ability of planning and organizing as one of the most important executive actions and excellent brain activities has attracted the attention of different researchers in terms of its role in daily life activities and in coordinating other actions to achieve the goal. In addition, dyslexic children have poorer planning skills in comparison to their regular counterparts, as these functions play a very important role in academic performance and in the functions concerning daily life assignment and time planning ability. As the inability to organize challenging and new assignments is because of the weakness of these children in planning function. Moreover, children with problem in planning may have a poor verbal and mental process and put wrong spaces between words and letters. Therefore, it seems that planning deficiency is relevant to impulsivity in children with ADHD. Because the defect in planning causes inability to identify, follow up, and organize the steps necessary to solve an issue or assignment. Therefore, these children are incapable of pursuing a goal as programmed steps while doing an assignment. Since the comparison of children with specific LD and normal children was not statistically significant, despite the difference in mean values, it is necessary to consider other studies with bigger sample size and considering more precise research controls in order to achieve correct results. The results of this study can be used to study these children so that they are not deprived of proper education. Furthermore, strategies of executive function training can be included in educational programs designed for these children so that they can substantially improve their education through these interventions. In a general overview, it can be concluded that improving the performance of children with ADHD and children with learning disabilities plays an essential role in their development. Therefore, consideration of this factor in the treatment of these children is necessary.

Conclusion

In this study, it has been shown that the problems with the exceptional children studied, namely, children with ADHD and children with learning disabilities, are rooted in their executive functions. Based on the findings of this study, executive functions decrease problems among exceptional children and represent new horizons in clinical interventions, and thus could be used as an effective interventional method. Therefore, it seems that intervention on executive functions is an applicable treatment for children with ADHD, and children with learning disabilities.

Conflict of Interests

Authors have no conflict of interests.

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