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Neuropsychological characteristics and theory of mind in ADHD and normal students

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Abstract

Introduction: Comprehensive neuropsychological assessment considers symptoms in an individual, based on the understanding of structure and function of the brain, and can lead to a better understanding of the symptoms, and eventually more effective treatment recommendations. The aim of this research was to study and compare the neuropsychological character and theory of mind as well as the correlation between them in ADHD and normal children.

Materials and Methods: This was a casual-comparative study. 25 ADHD children were selected through convenience sampling and 25 normal children were selected through cluster sampling. Finally, the Connors Neuropsychological Inventory and Theory of Mind Test were applied to assess the participants. The data were analyzed through multivariate, t test, and Pearson correlation.

Results: Our findings showed that there is a significant difference between these two groups in terms of the theory of mind and the three subscales of the neuropsychological inventory (attention problem (P=0.001), executive function (P=0.0001), and reading function (P=0.027). ADHD children had lower efficiency than normal children did in theory of mind (P=0.009) and the three subscales of the neuropsychological inventory. However, there was no correlation between neuropsychological characteristics and theory of mind in ADHD and normal children.

Conclusion: It can be concluded that neuropsychological tests can be used as a complement to behavioral tests for diagnostic assessment of ADHD children. In addition, it was observed that ADHD children require rehabilitations program focused on academic performance, attention problems, and reading performance, as well as theory of mind. Hence, the necessary measures should be taken for these children.

Keywords: Attention deficit hyperactive disorder, Neuropsychologic, Theory of mind

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Introduction

Attention deficit hyperactivity disorder (ADHD), a neuro-developmental disorder, is characterized by three main features including attention deficit, hyperactivity and impulsivity, which it affects on 3 to 7 percent of children (1). Some of the evidence declares that the physical abnormalities are the reason to prevalence of the attention deficit-hyperactivity behavior (2,3), As a result, the disorder is conceptualized as Neurodevelopment disorder (4-8).

Partial damage to the brain, which has mentioned as the cause of hyperactivity, is not recognizable because of the fallibility of neurological tests (9). The studies based on Neuroimaging have raised the conflict between the sub-cortical and thalamo-cortical processes in frontal networks. In recent decades, influenced by these findings, the neuropsychological pattern related to attention deficit hyperactivity disorder (ADHD) was proposed by neuropsychology. The cognitive deficits, exclusive damage in attention and executive function are the main hypothesis proposed in the scope of this disorder. The children suffering ADHD gain the lower scores and exhibit a weaker performance in multiple tasks such as vigilance, sustained attention and motor inhibition, executive function, verbal learning and memory (10-15). It is reported that the deficit pattern is similar to the findings obtained from the frontal damaged individual and it has considered as the basis of the frontal cortex damage hypothesis or ADHD (10,16).

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Diagnostic criteria, which are based on behavioral symptoms, cannot sufficiently describe the nature of some childhood disorders such as ADHD. In some cases, these children exhibit the severe destruction in operating function as well as deficits in motor control and emotional regulation. The comprehensive neuropsychological assessment, which considers the available symptoms in individuals and is based on the understanding the structure and function of the brain, is led to greater understanding of the symptoms, and eventually, more effective treatment recommendations (17). In addition, the available findings about the different functional and structural development of ADHD children's brain indicates that several nervous systems are involved in cognitive and motor disorders as well as the emotional-behavioral symptoms of the ADHD children. Thus, if the comprehensive neuropsychological assessment does not implement, some important condition, that there is simultaneously in ADHD children, may not be assessed (17). The new findings support the use of neuropsychological tests for the differential diagnosis between ADHD and normal individuals. Although, the controversial findings have observed in studies conducted on the normal and ADHD individuals (13). For example, previous studies have reported that there is no difference among the normal and ADHD individual in case of neuropsychological variable of visual attention (18). Therefore, these studies show the importance of neuropsychological tests to assess and clarify the strengths and weaknesses of the attention in individual, especially the recognition, and ultimately to identify the ADHD individuals. Furthermore, the studies suggest that the neuropsychological test to diagnose the ADHD in individual is more important than the use of the only measurement of individual based on the evaluation tools such as DSM criteria (19, 20). In addition, it is possible that the deficit in executive function and neurological problems of ADHD children such as attention and memory be due to the deficit of their theory of mind (21). Theory of mind, or the ability to ascribe the mental states to oneself and other, is considered as an outstanding achievement in human development. Theory of mind allows us to consider the thoughts and feelings of others beyond our own first-person perspective. Also, this feature allows us to prepare for participation in complex social interactions, yet convenient (22). Previous studies have indicated that ADHD children are lower than normal children in theory of mind are (23-28).

However, the development of theory of mind is initiated by rudimentary skills including attention, the use of mental condition and pretend play in the early stages of children's life. The recent studies have suggested a close link between executive functions and theory of mind. The researchers claim that the carrying out the task of theory of mind significantly requires the executive functions (9,23,29-31). The results imply that there is the fundamental involvement of executive functions in the development of theory of mind. This view is consistent with the findings of other researchers (22,24).

Generally, ADHD and the disorders associated with ADHD lead to difficulty of the definition, assessment and treatment of this disorder. Therefore, it is important to consider the wide range of factors and conditions that cause the inattention, hyperactivity, impulsivity (32). In addition, there are some contradictions in the neuropsychological features of the ADHD individual. Thus, this study is necessary to detect the disorder in school-age children, considering the neuropsychological features and theory of mind of the ADHD children compared with normal children. Hence, the aim of this study was to evaluate the neuropsychological features and theory of mind in children with ADHD compared with normal children. In addition, this study was to clarify whether the neurological problems are related to the theory of mind of ADHD children.

Materials and Methods

This study, based on its purpose and application, is a casual-comparative, which is one of the descriptive (non-experimental) research methods. The statistical population of this study had been consisted of the normal and hyperactive boys of Eslamshahr city. The research was conducted with the permission of the Administration of Education of Eslamshahr city.

The sample of ADHD children was selected from available ADHD boys (age group of 7-12 year old) in the Razi Counseling Center of Eslamshahr. All of the test subjects have expressed their contest towards the participation in the test. It has also emphasized that the information will be confidential. The CSI4 test (parent's form) was implemented to complete the diagnosis of ADHD in children who were previously diagnosed as the hyperactive by a psychiatrist. Finally, a number of 37 children have selected as the initial samples. The inclusion criteria of the subjects in this study were the normal intelligence range obtained through the Stanford-Binet intelligence test that was conducted

on 37 hyperactive children. A number of seven individual had average intelligence lesser than 90 and they excluded from the study due to this problem. Finally, the children with IQ range of 90-120 were included in this study. Of other exclusion criteria, in addition to IQ 90, was the presence of the symptoms of autism as well as other associated disorders, i.e., anxiety, depression and epilepsy and seizure problems. The observation of the child and parents' interview indicated that two children had the autism symptoms, therefore they has excluded from the study. There were no epilepsy symptoms in 37 selected children but three of them had anxiety disorders. Eventually, 25 boys in the age group of 7-12 years old were included into the study. In order to assess the associated disorders (autism, anxiety and depression), CSI4 questionnaire was used. The children were referred to a psychiatrist for the implementation of the EEG to measure the symptoms of children with epilepsy and seizure in addition to background checks and interviews with parents and family of the child.

A list of boys' ordinary schools at the elementary level at Eslamshahr city were provided to achieve the groups of children that can provide suitable statistical analysis, i.e., age and gender appropriate to the requirements of this study. Then, the boy's school of Shohdayeh 17 Shahrivar was selected by the cluster sampling. After achieving the permission to attend and research in that school, the list of students, who had not notable disorder based on the verification of school counselor, was given and we randomly selected 25 students to participate in the study. The questionnaire of ADHD and associated disorders in this group was implemented based on CSI4 test (the parent form). According the results of this questionnaire, the number of 2 children had the anxiety symptoms and one of children had the depression symptoms. These three children were excluded from study, three other normal students were randomly replaced, and CSI4 test were performed. Since the teachers and academic and administrative staff confirmed that these students have good learning situation, the Intelligence Test was not conducted. The results indicated that there was no disorder in these students. Finally, the studied students along with their parents responded to the questions of neurological questionnaire and theory of mind tests.

Research instruments

In this study, four tests were utilized that include:

- *Theory of Mind Test (TOM TEST):* The main form of theory of mind test has been designed in order to assess the theory of mind in normal children and children with pervasive developmental disorders at the ages of 5 to 12 years. It provides the information about the extent of social perception, sensitivity and insight of children. In addition, it clarifies the rate and degree to which the children are able to accept the feelings and thoughts of others (33). The reliability of the test by Cronbach's alpha was obtained to be 0.92, 0.84, 0.86 and 0.85 for the total scale, first scale, second scale and third scale, respectively (33).

Qmrany et al. created some changes in this test. They reduced the number of questions of the test from 72 to 38 and used the Persian name instead of the foreign names. Then, they measured the validity and reliability of the test on a number of normal and educable mental retarded (mild) students at Shiraz. The content validity method, simultaneous validity and correlation of subscale with total score were used to evaluate the validity of the test. Simultaneous validity was estimated to be 89% through the correlation of test with the Dollhouse task, which it was significant at the level of 0.01. The correlation coefficient of the subtests with the total scores was significant in all case and it was in range of 0.92 to 0.98. Test-retest reliability was between 70% and 96% and the entire coefficient was significant at the level of 0.01. Internal stability of the test (using Cronbach's alpha) for the whole test and each of subtests was calculated to be 86%, 72%, 80% and 81%, respectively.

This test has designed based on a multi-dimensional and evolutionary perspective of the theory of mind (33) and it is able to assess the greater range of age groups and more sophisticated and complex levels of theory of mind rather than the older tests such as dollhouse task, boxes of Smartiz, etc. The main form of the test consists of 78 questions and 3 subtests, which are as follows:

- First subscale: Preliminary theory of mind, i.e., the first level of theory of mind or recognition of emotions and pretend, consisting of 20 questions.
- Second subscale: Initial statements of an actual theory of mind, i.e., the second level of theory of mind or initial false belief and understanding of false belief, consisting of 13 questions.
- Third subscale: Advanced concepts of theory of mind, i.e, the third level of theory of mind or secondary false belief and understanding of joke, consisting of five questions.

Participants can receive scores between 0 and 20 in first subtest; scores between 0 and 13 in second

subscale; scores between 0 and 5 in the third subscale; and scores between 0 and 38 in the total score. The sum of the scores obtained from above three subscales gives an overall score for theory of mind. Higher scores indicate that the child has achieved a higher level of theory of mind (33).

- *Connors Neuropsychological Inventory (Parents Form):* Connors designed this test to assess the neuro-cognitive problems with children in age range of 5-12 years. This test assesses the problems of attention, sensory-motor function, language, executive functions, memory, learning and cognition in four spectrums (unobserved to severe). Jadidi and Abedi have translated and standardized this questionnaire and they have obtained its validity using the factor analysis method. They have reported that this tool has appropriate validity. The reliability of this tool using Cronbach's Alpha has reported to be 0.72. The reliability of subscales was also determined using Cronbach's Alpha and it was observed that the reliability of various variables including executive function, attention, sensory-motor function, language and memory & learning was 0.71, 0.74, 0.78, 0.69 and 0.79, respectively (35).

- *The Stanford-Binet Intelligence Test:* AFrooz and Kamkari developed the fifth Edition of Stanford-Binet in 2008. It is utilized to test IQ for the age range of 2-90 years old and it can be used in the areas of identification, diagnosis and placement of individuals in special education programs. The profile has concentrated to identify the detailed performance of the individuals in the 10 subtests with emphasis on two verbal and non-verbal areas, which it is consisted of 10 subtests according to 5-intelligence factor. These 10 subtests in verbal and nonverbal scale include fluid reasoning, knowledge, quantitative reasoning, visual-spatial processing and working memory. In addition, the correlation between the two areas of non-verbal and verbal obtained to be between 0.94 and 0.97. The validity coefficients of this test were extracting to be between 0.84 and 0.89 among the 10 subscales this intelligence test. The coefficients calculated for the tool represents that the tool has high credit for subtest and combined scores (36). In Iran, The validity of this test along with Wechsler for the verbal IQ, non-verbal IQ, and general IQ was 0.58, 0.59 and 0.66, respectively (37).

- *Child Symptom Inventory-4 (CSI4):* The last edition of this questionnaire has two forms for parents and teachers that it shows its suitable effectiveness compared to other measures and practices. Furthermore, the diagnostic criteria of this test are Diagnostic and Statistical Manual (DSM) of Mental Disorders criteria and its terms and phrases are the simple and understandable. Two have designed for scoring methods for Child Symptom Inventory: Scoring methods based on cut off point screening and the scoring method based on the severity of symptoms. In the screening method, the method of scoring is obtained by sum of the number of phrases that which are responded by the options "sometimes" or "often". If the answer of the questions of the test were the "never" or "rarely", the "zero" is given to reply to those questions, while the score of "1" is given to the answers of "sometimes" or "more often". In scoring by severity of symptoms method, the options of "never", "rarely", "sometimes", "more often" is scored with the codes of "0", "1", "2" and "3", respectively and the sum of the obtained scores give the symptom severity. Sprafkin and Gadow et al. (2001) have investigated the reliability and validity of the Child Symptom Inventory (CSI_4) questionnaire. The results of this study have showed that there was satisfactory internal consistency reliability, test-retest reliability as well as stability during a period of 4 years. The CSI-4 scale had convergent validity with the Child Behavior Checklist (CBCL) and children diagnostic interview. In addition, the CSI-4 scale had had divergent validity with parents modified form (DICA-P) (38). Ismaili & Alipour obtained the reliability and validity of this test for children at Tehran at 2002. The validity of this test for abnormalities was achieved as follows: ADHD 60%, ADHD predominantly inattentive type (ADHD-PI) 0.53%, predominantly hyperactive-impulsive type 0.69%, Only hyperactivity 0.70, depression 0.56, Anxiety 0.62, autism 0.58 (39).

Results

The statistical analysis results showed that 11 years old children have the highest frequency in this study. Generally, the mean age of the study was 9.26 years. In addition, the 11-year-old children had the highest frequency in the normal group of children in that the mean age of the normal group was 9.73 years and its variance is equal with 3.21. The standard deviation of this group is 1.79. Among the ADHD group, 11-year-old children had also the highest frequency. The mean of age and its variance are 8.8 and 4.45, respectively. The standard deviation (SD) of this group was calculated to be 2.11.

Table1 shows the descriptive scores of hyperactive and normal children in neurological variables.

Table 1. Mean and SD of the subscales of Connors test among subjects

	Subscales	Status	Mean	SD
1	Attention Problems	Normal	16.8	10.15
		Hyperactive	29.06	8.15
2	Sensori-motor Function	Normal	1.86	3.06
		Hyperactive	5.53	14.40
3	Language Functions	Normal	3.2	5.28
		Hyperactive	5.6	5.81
4	Learning and Memory Function	Normal	7.13	9.47
		Hyperactive	14.06	11.84
5	Executive Functions	Normal	6.86	6.55
		Hyperactive	18.86	9.63
6	Ability and Speed of Cognitive Processing	Normal	3.4	4.67
		Hyperactive	6.33	6.27
7	Visual and Spatial Performance	Normal	1.26	2.15
		Hyperactive	2.66	3.06
8	Academic Performance (Reading)	Normal	4.33	6.22
		Hyperactive	10.93	9.01
9	Academic Performance (Writing)	Normal	9.2	8.87
		Hyperactive	13.8	15.21
10	Academic Performance(Math)	Normal	5.2	7.07
		Hyperactive	5.66	5.97

The Multivariate analysis of variance (MANOVA) test was used to compare the differences between the scores of ADHD and normal individual obtained from the subscales of Connors neuropsychological test and the results were represented following table (Table 2).

Table 2. Differences between hyperactive and normal groups of children in neuropsychological variables

Variables	Degrees of freedom (df)	Mean of square	F ratio	Significance level	Efficiency coefficient
Attention Problems	1	1128.533	13.303	0.001	0.322
Sensorimotor Function	1	100.833	0.93	0.343	0.032
Language Functions	1	43.200	1.4	0.247	0.048
Learning and Memory Function	1	360.533	3.136	0.087	0.101
Executive Functions	1	1080	15.904	0.0001	0.362
Ability and Speed of Cognitive Processing	1	64.533	2.109	0.158	0.070
Visual and Spatial Performance	1	14.7	2.097	0.159	0.070
Academic Performance (Reading)	1	326.7	5.444	0.027	0.163
Academic Performance (Writing)	1	158.7	1.023	0.321	0.035
Academic Performance (Math)	1	1.633	0.038	0.847	0.001

Multivariate analysis (MANOVA) was used to show the difference between the normal and ADHD groups of students; Wilks's Lambda with significant level of 0.0001 represents the difference between normal and ADHD children in neuropsychological features.

As can be seen in Table 2, ADHD children had more problems in three subscale of children's Connors neuropsychological test including “attention problems”, “executive functions” and “academic performance in reading" than normal children.

In the theory of mind test, the mean of normal children (SD=3.08) was obtained to be 30.6 while it was 25.53 for the ADHD children (SD=6.03). In order to understand the significant differences between the two groups of children in test of theory of mind, the independent t-test was used and the results indicated that there is significant difference between two groups for the theory of mind test (t=2.77, df=28 and significant level=0.009). Based on this result, the group of ADHD children has lower score in theory of mind than normal children.

In addition, the Pearson correlation test was applied to measure the correlation level of the Connors neuropsychological tests and theory of mind for both of normal and ADHD children. The results showed that the correlation between theory of mind and the scores obtained from Connors neuropsychological test for normal children is as r=-0.338, p=0.228, there was no significant correlation at the level of 0.05. The measurement of correlation between theory of mind and the scores obtained from Connors neuropsychological test was also conducted for ADHD children and the results was r= -0.105, p= 0.701; there was no significant correlation at the level of 0.05

Discussion

This study aimed to evaluate the neurological characteristics and theory of mind in ADHD and normal children at the age of 7-12 years. The results indicate that the ADHD children were significantly different from normal children solely in the scale of attention, executive functions and reading among the 10 neurological subscales; it means that they had lower performance in these three scales. The results of the study are in accordance with results of some other researchers. They believe that the ADHD and healthy individual have statistically significant difference in one or several tests of executive functions. Approximately, 80 percent of ADHD children have deficits, in at least one of the components of executive function (10-14). Also, Perner et al. express that ADHD children has not good performance in activities that are often required to selective attention and executive skills, as well as sustained attention and executive skills, or both (15).

As mentioned in the results, hyperactive children are also weak in reading performance, in addition to attention and executive functions, than normal children. The researchers introduce the attention as important factor for reading ability, which their expression can be a proper justification to the mentioned result. It has also reported that the attention is important to convert the print into speech. Therefore, the "attention" is necessary for fluent reading (29). Some researchers concluded that deficits of attention is caused the problems in a person's reading (15, 19,20). Gatica has stated that there is a relationship between the maintenance of attention and reading without the loud. People with good maintenance of attention have faster reading ability than those with medium and low maintenance. Therefore, the high ability to maintenance the attention is leading to the successful reading comprehension (21). Thus, in present study, because the hyperactive children received a low score on attention variable, they had low scores in reading.

In the next part of this research, theory of mind were compared between ADHD and normal children and the results showed that ADHD children have lower scores on theory of mind compared to normal children. The results of present study are confirmed by the previous studies (24-30).

Hughes and Ensor have been studied the theory of mind among the primary school children with the behavioral problems; In a sample of 130 children, it was found that deficits in theory of mind task is a strong predictor of behavior problems such as conduct disorder, oppositional defiant disorder and hyperactivity (20). Walker has been used the false belief and showed that the theory of mind, after controlling for age, can significantly predicted aggression and disruptive behavior in boys (32). Buitelaar et al. reported that ADHD children in the false belief are considerably lower than the normal children are (26).

Some researcher proposed that theory of mind explains to parents the reason of externalizing behavioral problems and understanding the mental states and considering the opinions of others their child (40). In addition, some theoreticians purpose that failure in identification of emotions is observed in children with externalizing problems (41).

Theoreticians of cognitive models believe that various cognition such as beliefs, attributions and expectations of yourself and others behavior are very important in determination of feelings and behavior; and individual, who have distorted, inaccurate and inconsistent cognition about themselves, others and their environment event, exhibit problematic behavior and feelings. Aggressive children are also in trouble in front of peers and it is leading to show lesser empathy in interaction with peers; and consequently, they will rejected by their peer that it has significant relationship with deficits of the of the theory of mind task (42).

Of other results of the present study is that there is no relationship among the neurological characteristics and theory of mind in both ADHD and normal children. Although, the studies, the recently published papers about the relationship between executive function and theory of mind, have suggested a close link between executive functions and theory of mind. The researchers claim that the task of theory of mind is significantly required to executive functions (9).

It is believed that their findings are statistically shown the significant relationship between inhibitory control and task of theory of mind. These findings highlight the fundamental involvement of executive functions in the development of theory of mind. This view is consistent with the findings of other researchers (30, 31). The studies show their relationship between executive function in preschool, which are externalized behavior (attention, memory, behavioral inhibition, control or impulsivity, self-regulation) and ideas of theory of mind or emotions, emotion of their theory of mind (29).

Of the limitations of this study was the use of only one gender i.e. boys; thus, it is suggested that the future studies conducted on both girls and boys and the neuropsychological features to be investigate and compared among both genders. Another limitation is the use of only one tool to measure neuropsychological features. It is recommended that other tools be used to assess the neuropsychological features of these types of children in future studies. This test was only conducted in Eslamshahr and children of this area, which it can be considered as another limitation of this study. The next limitation can be relatively small sample size, which it is due to low availability of these children in centers. Since the results of this study showed the poor performance of ADHD children in educational performance of reading, attention and executive functions, and, since the results are consistent with other studies conducted in other countries; therefore, it is suggested that these three components be applied in training and rehabilitation of ADHD children. Furthermore, it is recommended that the questionnaires and the neuropsychological

diagnostic tool be used to comprehensively assess and detect the hyperactive children in addition to interviews and observation methods,. It is also recommended that the study be conducted for other childhood psychiatric disorders and for children with special needs such as learning disorders, autism, and mental retardation. Another suggestion is that this study be tested through other neuropsychological questionnaires as well as other psychiatric tools, which measure the neuropsychological features. In addition, this study can be carried out separately or comparatively in various groups of the ADHD children (inattentive type, hyperactive type, composition type). Finally, it is recommended that this study be performed with higher sample size and in other regions.

Conclusion

It can be concluded that neuropsychological tests can be used as a complement to behavioral tests for diagnostic assessment of ADHD children. In addition, it was observed that ADHD children require rehabilitations program focused on academic performance, attention problems, and reading performance, as well as theory of mind. Hence, the necessary measures should be taken for these children.

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