

Comparing Iconic Memory in Children with and without Attention Deficit Hyperactivity Disorder

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Objective: Children with attention deficit hyperactivity disorder (ADHD) do not process most information due to inattention and loss of the opportunity to save and retrieve information. Therefore, these children experience memory impairment. Although visual memory has been previously studied in children with ADHD, iconic memory in these children has been less evaluated. We aimed to study the possibility of iconic memory impairment in children with ADHD, and compare the results with that of children without ADHD.

Methods: The experimental group of this study were 6-9 year-old children who referred to the Imam Hosein Clinic and were diagnosed as having ADHD by a psychiatrist during 2011-2012 (n=30). The subjects were interviewed clinically by a psychologist; and in order to diagnose ADHD, their parents and teachers were asked to complete the child symptom inventory-4 (CSI-4). The comparison group were 6-9 year-old children without ADHD who studied in 1st and 2nd educational district of Yazd (n=30). Subjects' iconic memory was assessed using an iconic memory task. Repeated measure ANOVA was used for data analysis.

Results: Based on the iconic memory test, the mean score of ADHD children was significantly lower than that of children without ADHD ($P < 0.001$). Moreover, the performance of the experimental group differed significantly when the duration of the presentation differed from 50 ms to 100 ms as compared to the control group ($P < 0.001$). The number of correct answers increased in the experimental group as the duration of presentation increased. However, children with ADHD scored less than children without ADHD at 50 ms as well as 100 ms. The means of ADHD children increased as the duration of the presentation increased from 50 ms to 100 ms to 300 ms ($P < 0.001$).

Conclusion: Visual memory is weaker in children with ADHD, and they have weaker performance than normal children in both visual and auditory symbols at presentation durations of 50 and 100 ms. The performance of ADHD children improves as the stimulation time increases

Key words: ADHD, Iconic memory, Iconic memory test, Visual symbols, Auditory symbols

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Attention deficit hyperactivity disorder (ADHD) is a rife neurobehavioral disorder among children and adolescents; ADHD symptoms emerge before preschool and sometimes last until adulthood.

In imaging studies on people with ADHD, impairment is seen in areas of the brain related to this function such as the prefrontal cortex and striatum (1). Other areas of the brain also have some impairment leading to defects in activities that are related to the executive function and the prefrontal cortex. One of these functions is iconic memory which needs a healthy undamaged temporal lobe, amygdale nuclei and hippocampus (2). Moreover, the function of the iconic memory depends on tasks that are primarily related to the parietal lobe (3).

Iconic memory enables the brain to recall an image that is displayed later, and according to research by Sperling & Averbach (1961), it lasts for about 250 ms after the display of an image. Iconic memory is the primary stage of visual memory and consists of two components, visible persistence and informational persistence (4).

Children with ADHD do not process most information because of inattention. They lose the opportunity to save and retrieve information, and therefore experience memory impairment (5). However, it is not clear what parts of the memory are affected by inattention in these children. Because the information is stored in the visual memory for a fraction of a second, the main point may be that such children do not receive input data due to impairment

in their visual memory and as a result do not fully transfer these data to further stages for processing. Most studies on memory in children with ADHD have focused on impairments in verbal or visual-spatial memory (6-13 and 5). Although visual memory has been previously studied in children with ADHD, iconic memory in these children has been less evaluated.

On the other hand, in previous studies, to assess visual memory deficit in children with ADHD patterns of memory with the title delayed matching to the sample were used; (DMS) is a useful test for evaluating short term spatial-visual recognition memory, but is not efficient to assess iconic memory deficit. In order to overcome these shortcomings, this study tried to use a task drawn from the accomplished studies on normal iconic memory to study the possibility of iconic memory impairment in children with ADHD, and to compare the result with that of children without ADHD.

Material and Methods

The subjects of this comparative study were primary and preschool aged children (6-9 year-old) selected from the 1st and 2nd educational district of Yazd, southeast Iran .

For sampling, the list of children with the above conditions was prepared. In the next step, for muster of comparison group, 30 children were selected with a stratified random method; and for muster of experimental group, 30 children who referred to the Imam Hosein Clinic, and were diagnosed as having ADHD by a psychiatrist during 2011-2012 were selected. All of the participants in experimental group were interviewed clinically by a psychologist. Further, in order to diagnose ADHD, and their parents and teachers were asked to complete the child symptom inventory-4 (CSI-4). Children in both groups were matched with respect to age, sex, and school. Children in the comparison group were selected from the same class as the experimental group.

We included all boys and girls with ADHD who had all the three types of this disorder which included mainly inattentive type, mainly hyperactive- impulsive type and combined type in the experimental group. The comparison group consisted of children who did not have any history of psychiatric disorder according to the diagnostic and statistical manual of mental disorders (DSM-IV) axis I and II. We also included children who wore glasses. The exclusion criteria were color blindness, diagnosis of a physical or mental disorder, or drug consumption. Children who had been previously diagnosed with ADHD and were on medication were also excluded from the study because of the drug's effect on their attentiveness and ultimately on their iconic memory.

Child Symptom Inventory

The CSI is a common screening tool for psychiatric disorders; and its items are written based on the diagnostic criteria of DSM-IV. This inventory includes

the symptoms of 21 behavioral and emotional disorders such as ADHD (14). The fourth edition of this inventory (CSI-4), like the previous versions, has a teacher and parent checklist. The parent checklist consists of 112 items including 41 items (group A, B, and C) related to destructive behavior and attention deficit. We only used the items in group A that were related to ADHD. Each item is scored on a 4-point response scale from never to often .

The teacher checklist has 79 items, 35 of which (A, B, and C) are related to destructive behavior and attention deficit disorders. However, we only used items in group A that were related to ADHD. Group A consists of 18 items and is similar in both parent and teacher checklists. The CSI-4 is scored either by criterion-related cut-off scores or by norm-based cut-off scores for determining symptom severity.

In most studies as well as ours, criterion-related cut-off scores are used because of higher reliability and efficiency. In this method, scoring is done by adding the number of items rated as sometimes and often. A score of zero is given to items rated as never and seldom, and one to items rated as sometimes and often (14). The cutoff point score for diagnosing ADHD based on the CSI-4 was 6 for both the mainly attention deficit (questions 1-9) and the mainly hyperactive-impulsive (questions 10-18) types. These scores are summed up for the diagnosis of ADHD (14).

In a study conducted in Iran, the retest reliability of the parent and teacher checklists of the CSI-4 was reported to be 0.90 and 0.96, respectively. Moreover, Kalantari and colleagues (2006) also reported a reliability of 0.91 and 0.85 for the parent and teacher checklists, respectively (14). With respect to face validity, the items of this questionnaire were compiled based on the criteria of CSI-4, whose reliability had been previously assessed by the American Psychiatric Association. Shariatzadeh (2007) assessed the reliability of this inventory using a Cronbach's alpha of 0.92 and a sensitivity of 0.94 (14).

Iconic Memory Task

This test was designed for testing iconic memory and adapted from a test initially introduced by Sperling and Averbach in 1961 for testing iconic memory in healthy individuals.

In this test, a 2×2 matrix is presented to the participants. Since this test has been designed for children, instead of alphabets used in Sperling and Averbach's test (1961), images of an object, which are easily identifiable for 6-9 year-old children, are presented in each box. Twelve images were shown to twenty 6-year-old children, and 4 images that were nearly identifiable by all children were selected for the test, assuming that the images that can be identified by 6-year-olds would also be easily identified by 9-year-olds .

In general, the iconic memory test consists of two blocks each containing 20 test trials and 90 experimental trials. The duration of matrix presentation varied for the 20 test trials. For the experimental trials,

the durations were 50, 100, and 300 ms for the first 30, second 30, and third 30 trials, respectively. We used a Sony Computer (VGNSR Model) for the trials. The size of the whole matrix was 1280×800 pixels and the size of each cell was 320×266 pixels .

In the first block, an empty matrix was presented immediately after each trial. Then, by bringing a random arrow next to each row, the participant was asked to name the objects in that row aloud.

In the second block, after presenting the matrix in each trial, an empty matrix was shown. In order to determine the row in which the participants should name the objects, two different sounds were used (top row: high-pitched sound, bottom row: low-pitched sound). The participants had no prior knowledge about which row would be marked.

Based on Sperling and colleagues' report (1961), the iconic memory test was scored as follows: the number of right answers in the marked row divided by the total number of presentations in that row. Sperling and colleagues (1961) found that healthy individuals had an iconic memory score more than 0.75. In this scoring system the highest score was 1. The number of correct answers in each marked row could also be considered as the iconic memory score. Here, the highest score is equivalent to the number of cells in each row (15). Our test score was equal to the number of right answers in the marked row. Therefore, the highest score would be 2 and the lowest 0.

In order to assess the reliability of this test, it was done twice for 25 children aged 6-9 years (12 girls and 13 boys) with a one-week interval, and the correlation coefficient between the two presentations was calculated. The total reliability of the test was 0.92, with a reliability of 0.88 for the visual section and 0.87 for the auditory section.

The applicability of this test for measuring iconic memory has been previously proven.

Data Analysis

Data were analyzed using SPSS software, version 17. Mean and standard deviations were computed for descriptive data. Since several repeating experimental forms were used for each participant in this study, repeated measure ANOVA was used.

Result

In each group, there were 22 boys and 8 girls. The mean age of the participants in both groups was 7.6 ± 0.99 (range: 6-9) years (table 1). Thirty seven (61.7%) children in both groups were the first child of their family (table 2). Most of the fathers (35%) and mothers (50%) had a diploma or associate degree (table 2.)

The performance of children in both groups differed significantly at the different types of symbols and durations of stimulation (table 3) .

Based on the iconic memory test, the mean score of ADHD children was significantly lower than that of children without ADHD (27.61 ± 1.41 vs. 38.41 ± 1.41 ($P < 0.001$)). Moreover, the performance of the experimental group differed significantly when the duration of the presentation differed from 50 ms to 100 ms as compared with the comparison group ($P < 0.001$). The number of correct answers increased in the experimental group as the duration of presentation increased. However, children with ADHD scored less than children without ADHD at 50 ms (25.36 ± 1.47 vs. 37.46 ± 1.47) as well as 100 ms (29.86 ± 1.45 vs. 39.36 ± 1.45). Therefore, by increasing the duration of stimulation, the performance of the children with ADHD could be improved.

We also found no significant difference in the performance of children with ADHD with respect to the type of symbols (visual or auditory) when we calculated the average duration of presenting the stimulants. The mean±SD scores of visual and auditory symbols were 27.48 ± 1.36 and 27.75 ± 1.67 , respectively ($P < 0.001$). At stimulation duration of 50 ms, the mean±SD scores of visual and auditory symbols were 26.40 ± 1.53 and 24.33 ± 1.85 , respectively. The corresponding figures for stimulation duration of 100 ms were 28.56 ± 1.43 and 31.16 ± 1.74 , respectively .

The duration of presentation had a significant effect on the performance of children with ADHD, regardless of the type of presentation. The mean scores of the children with ADHD increased as the duration of the presentation increased from 50 ms (25.36 ± 1.46) to 100 ms (29.86 ± 1.43) to 300 ms (31.50 ± 1.62) ($P < 0.001$).

We found a non-linear relationship between the two different groups with respect to the number of correct answers at different durations of stimulation. Repeated measure ANOVA was performed in order to determine which type of symbol (visual or auditory) creates this relationship. We found that the group-time interaction existed between auditory symbols (table 5). As the duration of stimulation increased from 50 ms to 100 ms, the number of correct answers had a higher increase in the experimental group compared with the comparison group. However, although the performance of children with ADHD improved at stimulation duration of 300 ms and had a slight increase, the scores of children without ADHD had a considerable increase at the mentioned time .

A linear relationship was found between group and stimulation durations of 50 ms and 100 ms. the two groups differed in the mean scores of auditory symbols at 50 ms and 100 ms ($P < 0.001$).

Table 1: Age distribution in the experimental and comparison groups

Age (years)	Experimental group	Comparison group	Total	Frequency (%)
6	4	4	8	13.3
7	10	10	20	33.3
8	9	9	18	30
9	7	7	14	23.3
Total	30	30	60	100

Table 2: Frequency of some demographic variables in the experimental and comparison groups

Variables	Experimental group	Comparison group	Total	Frequency (%)
Birth order	1	19	18	61.7
	2	9	10	31.7
	3	1	2	5
	4	0	0	0
	5	1	0	1.7
Father's education level	Primary and secondary education	16	0	26.7
	Diploma and associate degree	11	10	35
	Bachelor and master's Degree	3	16	31.7
	Doctorate degree	0	4	6.7
Mother's education level	Primary and secondary education	13	1	23.3
	Diploma and associate degree	14	16	50
	Bachelor and master's Degree	3	11	23.3
	Doctorate degree	0	2	3.3

Table 3: Repeated measure ANOVA for type of symbols and durations of stimulation

Source of variance	Sum of squares	Degrees of freedom	Mean squares	F	Level of significance
Type of symbols	2.01	1	2.01	0.047	Ns
Group×Type of symbols	0.41	1	0.41	0.010	Ns
Error (type of symbols)	2481.56	58	42.78	-	-
Durations of stimulation	614.40	1	614.40	32.302	0.000*
Group× Durations of stimulation	101.40	1	101.40	5.331	0.025*
Error (durations of stimulation)	1103.20	58	19.02	-	-
Type of symbols× Durations of stimulation	163.35	1	163.35	7.600	0.008*
Group×Type of symbols× Durations of stimulation	28.01	1	28.01	1.303	Ns
Error (type of symbols× durations of stimulation)	1246.63	58	21.49	-	-

*(P<0.05)

Table 4: Mean±SD scores of visual and auditory symbols at different durations of stimulation

Group	Type	Duration of stimulation	Mean	SD
ADHD	Visual	50	26.40	1.45
		100	28.56	1.43
		300	31.56	1.62
	Auditory	50	24.33	1.85
		100	31.16	1.76
		300	31.43	1.71
Control	Visual	50	37.90	1.45
		100	38.83	1.43
		300	42.83	1.62
	Auditory	50	37.03	1.85
		100	39.90	1.76
		300	43.70	1.71

*(P<0.001)

Table 5: Mean±SD scores of both groups with respect to group-time interactions in visual and auditory symbols

Symbol	Group	Duration of stimulation (ms)	Mean	SD
Visual	ADHD	50	26.40	1.45
		100	28.56	1.43
		300	31.56	1.62
	Control	50	37.90	1.45
		100	38.83	1.43
		300	42.83	1.62
Auditory	ADHD	50	24.33	1.85
		100	31.16	1.76
		300	31.43	1.71
	Control	50	37.03	1.85
		100	39.90	1.76
		300	43.70	1.71

*(P<0.001)

Discussion

We found that iconic memory (visible and informational persistence) was weaker in ADHD children than children without ADHD. Moreover, the performance of children with ADHD is weaker when the duration of visual and auditory stimulations is shorter. We also found no significant difference in the performance of ADHD children with respect to the type of symbols.

Since iconic memory is a subcategory of the human memory, our findings are consistent with studies showing memory impairment in patients with ADHD. Children with ADHD do not process most information because of inattention (16-21 and 5) or more specifically deficits in temporal resolution of visual attention (22). Therefore, they lose the time to save some information and as a result experience memory deficits. This finding is consistent with some previous studies (23-34 and 7-13).

However, our findings are not consistent with two previous studies. Jonsdottir and colleagues (2004) found that children with ADHD do not show deficits in active memory (35). Sadeh and co-workers (1996) found no significant difference between children with and without ADHD with respect to their visual memory and visual organization (36).

The difference in the iconic memory of children with and without ADHD can show that the iconic memory test could differentiate between the iconic memory of children with and without ADHD. Moreover, age was not an effective differentiating factor between children with and without ADHD. By controlling this factor, we still found a significant difference in the mean scores of the visual memory test between the case and comparison groups. Moreover, the weaker performance of children with ADHD cannot be attributed to their sex or school since the children in both groups were matched with respect to these factors. On the other hand, since all the subjects had 20 test trials before the experimental trials, this weakness cannot be attributed to their lack of knowledge regarding the nature of the test. We also found that visual and informational performance (iconic memory) did not differ between the two groups with respect to both visual and auditory symbols. In contrast, Kataria, Wright Hall, Wong, & Keys (1992) found that children with ADHD have disorders in sensory, short-term, and long-term memory in visual and auditory symbols. They found a more significant difference in auditory symbols making them more susceptible to losing more information in auditory presentations (34). Moreover, Shapiro and co-workers (1993) found that children with ADHD have a weaker performance in tasks that need complex processes at the conscious level, which is inconsistent with our study (13).

We only used visual and auditory symbols and the stimulants that the children identified were only visual. It can be stated that the symbols used in our study are instructions that guide children to the place where they should remember the images. It can be concluded that

presenting short instructions in the form of visual or auditory symbols does not create any difference in the performance of children with ADHD.

As the duration of presentation increased, the performance of children with ADHD significantly improved. Consistently, Young and colleagues (2006) found that as the presentation time becomes shorter and the test harder, children with ADHD experience higher memory impairment (26). In our study, increased test time positively improved the performance of children with ADHD. The scores at 300 ms were significantly higher compared with 50 and 100 ms. Due to inattention, children with ADHD experience more problems when the duration of stimulation is shorter and as time increases their performance improves because they have more time to concentrate.

Children with and without ADHD differed significantly with respect to auditory presentations time of 50 and 100 ms. Children with ADHD had considerable differences in test scores in the two mentioned durations, while children without ADHD did not show a considerable difference at the two different presentation times. This is because at longer presentation time complex auditory processing improves in children with ADHD.

Limitation

The current study had a number of limitations, of which the following worth mentioning. First, in this study two groups were not matched in terms of IQ and children's ability of intelligence was not assessed. Second, only one questionnaire was used to evaluate the diagnostic of ADHD. Third, it would have been useful if the study evaluated other psychiatric disorders such as learning disabilities.

Conclusion

Visual memory is weaker in children with ADHD and these children perform weaker than normal children in both visual and auditory symbols at presentation durations of 50 and 100 ms. The performance of children with ADHD improves as the stimulation time increases.

Our study had some limitations. Therefore, we had to compare our results with studies on other types of memory. Moreover, since the subjects had 20 test trials before the 90 experimental trials, the results may have been affected by learning and repetition.

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