

Visual Memory of Meaningless Shapes in Children and Adolescents with Autism Spectrum Disorders

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Objective: Visual memory is an important cognitive ability, which has been studied in individuals with Autism Spectrum Disorders (ASDs). In such studies meaningful shapes were used more frequently. Since meaningless shapes provide a better assessment of short term visual memory, in this study we used them to evaluate visual memory in children and adolescents with ASDs compared to the normal group .

Methods: Four visual memory tests of Cambridge Neuropsychological Test Automated Battery (CANTAB) including Paired Associates Learning (PAL), Pattern Recognition Memory (PRM), Spatial Recognition Memory (SRM) and Delayed Matching to Sample (DMS) were administered to 15 children and adolescents with ASDs (high functioning autism and Asperger syndrome) and to 15 normal participants aged 8 to 17, with IQ of above 70.

Results: Individuals with ASDs performed worse than the normal group on visual memory tasks. After eliminating IQ as a covariate, no significant difference was observed between the two groups in terms of visual memory performance .

Conclusion: It seems that deficits on visual memory tasks in youths with ASDs could be related to their general intellectual abilities.

Key words: *Visual memory; Meaningless shapes; Autism Spectrum Disorders (ASDs)*

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Autism Spectrum Disorders (ASDs) which include autistic disorder, Asperger syndrome and Pervasive Developmental Disorders not otherwise specified (PPD NOS), are characterized with abnormalities in social interaction, verbal and non-verbal communications and having repetitive and stereotyped behaviors (1-3).

Visual memory is an important cognitive ability involved in encoding, storage and recall of visual information. Using meaningless shapes to study visual short term memory seems to be more appropriate, as it can eliminate unwanted effects of other types of memory as well as semantic and non visual information (4, 5).

It has been found that children with ASDs have different abilities in visual memory compared to normal people. There are some studies reporting no impairment in visual memory of meaningful shapes in this group (6-11), while there are findings indicating some impairments in this area (6, 7, 12, 13). On the other hand, there are experiments showing superiority of spatial visual capability and visual memory of meaningful shapes in individuals with ASDs compared

to normal people (13-16).

Early experiments carried out by Hermelin and O'Connor (1970) and Bryson (1972) showed abnormalities in visual short term memory in autistic children. However, another study done by Prior and Chen (1976) indicated no significant difference in visual short term memory in children with autism compared to children with mental retardation and normal group (6). In an investigation performed by Boucher and Warrington (1976), autistic children were less able to recognize pictures compared to control groups (12). In a later study done by Boucher (1992), autistic children matched on verbal ability with control group showed no impairment in recognizing unknown buildings (9). In her research, Minshew (2001) compared visual memory performance of a matched control group with high functioning autistic children and adolescents using visual memory tests. She found that individuals with autism performed significantly worse than the control group on immediate and delayed recall of a complex geometric figure (7). In another research, Blair (2002) found that autistic individuals had impaired visual recognition memory for living and non-living mobile agents including cats, horses and

motorcycles compared to an age matched normal group. On the other hand, autistic people performed better on recognition memory of immobile objects like unknown buildings and leaves (13). Recently, some studies indicated that children and adults with autism have superiority on visual discrimination and search tasks. O'riordan showed that adults with autism were superior on searching for targets and visual discrimination tasks (14). Most of the studies on visual memory in individuals with ASDs have used meaningful shapes. The only experiment on visual memory of using meaningless shapes was carried out on adults with high functioning autism by Ameli and colleagues. They found that these patients performed worse than the normal group on visual recognition memory of meaningless shapes tasks, but no significant difference was found in visual recognition memory of meaningful shapes of these individuals compared to normal people (8). As meanings of the shapes used for such experiments may influence memory, using meaningless shapes could be more appropriate. Since to our best knowledge no study has ever used meaningless shapes in studies conducted on children with ASDs, we carried out this study to evaluate the ability of children with ASDs in recognition of meaningless visual shapes compared to normal children.

Materials and Method

Participants

Fifteen children and adolescents with ASDs (Asperger and high functioning autism) aged eight to 17 years old were compared with 15 age matched normally developing individuals. Participants with ASDs were diagnosed by a child and adolescent psychiatrist based on DSM-IV criteria (17). The Asperger Syndrome Diagnostic Scale was also administered to confirm the diagnosis. All participants had IQ above 70 based on Raven's Progressive Matrices Test. The normal group was recruited from mainstream schools.

Measures

Visual memory tasks were assessed in all participants using some tests from Cambridge Neuropsychological Test Automated Battery (CANTAB):

1. Paired Associates Learning (PAL): In this test, some boxes are displayed on the screen and opened in a randomized order. One or more of them will contain a pattern. The patterns are then displayed one by one in the middle of the screen. The participant is instructed to touch the box where the pattern was originally located. There are different stages in which the number of patterns increased up to eight. Error occurs when the participant selects a box not containing the target stimulus (18, 19).

2. Pattern Recognition Memory (PRM): This test has two phases. In the first phase, the participant is presented with a series of 12 colored visual patterns for three seconds. The examinee needs to memorize these patterns. In the second phase, 12 paired novel and old patterns are presented in which the participant is

required to choose between a pattern they have already seen and a novel pattern (20).

This test is scored using two indices: a) Mean correct latency; b) Number correct.

3. Spatial Recognition Memory (SRM): This test has also two phases. In the first phase, the participant is presented with a white square which appears at five different locations on the screen. The participant is told to memorize the locations of the square. In the second phase, the participant sees a series of five pairs of squares, one of which is in a place previously seen in the presentation phase. The participant must choose the square which was presented previously (18). This test has two indices for scoring: a) Mean correct latency; b) Number correct.

4. Delayed Matching to Sample (DMS): In this test, one target (a complex visual pattern) and four different patterns are presented in four different time intervals. The four patterns are presented simultaneously or 0, 4, and 12 seconds after target presentation. The participant is instructed to touch the pattern which exactly matches the target (21).

The test is scored using four indices: a) Mean correct latency; b) Total corrects; c) Prob error given correct: this index indicates the probability of error following a correct; d) Prob error given error: in this index, the probability of error is illustrated following a previous error.

The Raven's Progressive Matrices (RPM) test was administered to evaluate participants' intellectual abilities (22).

Asperger Syndrome Diagnostic Scale (ASDS) was used to confirm the Asperger's diagnosis. This scale is a 50-item, "Yes" or "No" questionnaire, designed to identify children and adolescents aged 5 to 18 with Asperger syndrome. These questions cover five different aspects of mental states including cognition, language skills, social interactions, sensorimotor, and maladaptive behaviors (23).

Procedure

The participants were firstly interviewed by a child and adolescent psychiatrist and diagnosed as having Autism Spectrum Disorders based on DSM-IV criteria. Next, they were evaluated using the ASDS to confirm the diagnosis and were then examined using neuropsychological tests.

Statistical analysis

Independent Samples T test was used to compare the two groups in terms of different variables. IQ was considered as covariate and then the two groups were compared again to eliminate the IQ effect. In this research, all statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS), version 14.

Results

The mean age of children and adolescents with ASDs was 12.80 (SD=3.23) while the mean age of control group was 10.53 (SD= 3.04). There was no significant difference between the two groups in terms of age.

With regards to IQ, youths with ASDs had significantly lower IQs compared to normal children and adolescents ($P < 0.01$) (table 1). In regards to Paired Associates Learning Test (PAL), individuals with ASDs had poorer performance on this task compared to normal group (table 2). There was a significant difference between the two groups on "first trial memory score" ($t = 2.092$, $p = 0.046$), "total errors adjusted" ($t = 17.662$, $p = 0.015$) and "total trials adjusted" ($t = 15.794$, $p = 0.013$). While IQ was considered as covariate, none of the PAL variables showed any significant difference between the two groups.

In terms of Pattern Recognition Memory (PRM) and Spatial Recognition Memory (SRM) tests, significant differences were found between the two groups on "number correct" variable in PRM ($t = 6.390$, $p = 0.045$) and SRM ($t = 1.026$, $p = 0.005$) tests. Considering IQ as covariate the differences were eliminated.

With regards to Delayed Matching to Sample (DMS) task, it was found that children with ASDs had worse performance compared to normal youths on DMS task (table 2). Children and adolescents with ASDs had less "total corrects" ($t = 0.786$, $p = 0.002$) and more "prob error given correct" ($t = 0.277$, $p = 0.012$) and "prob error given error" ($t = 13.834$, $p = 0.019$) compared to normal group. By eliminating the IQ effect, no significant difference was found between the two groups in terms of DMS variables.

Discussion

Some studies investigated visual perception and memory in children with autism spectrum disorders (ASDs), but their findings are not consistent. Because these experiments were mostly based on investigating meaningful shapes, the current study was designed to evaluate visual memory using meaningless shapes in children and adolescents with ASDs.

Four computerized visual memory tests based on meaningless patterns were used in this research.

We found that youths with ASDs had poorer performance on

Paired Associate Learning Test which is mediated by temporal lobe compared to normal youths. This means that these individuals are poorer in learning new patterns. It was also found that ASDs group had poorer performance on recognizing meaningless patterns on PRM task, which is sensitive to impairment of temporal lobe.

Youths with ASDs were poorer on visuospatial memory task, which is mediated by frontal lobe (24).

They were also poor in matching the patterns to the sample based on the findings of delayed matching to sample task.

This task is sensitive to impairment of frontal lobes and is assumed to be mediated by temporal lobe (18).

These findings are inconsistent with the results of some other studies which indicated that children and adolescents with ASDs have intact object recognition and visual memory (25, 26) or showed that youths with ASDs had a better ability to recognize objects (27).

Table 1: Demographic variables in children with ASDs and normal group

Subjects	ASDs		Normal		t	p value
	Mean	SD	Mean	SD		
Age	12.80	3.23	10.53	3.04	.373	.058
IQ	99	11.92	113.47	8.29	1.242	.001

Table 2: Results of visual memory tests in children with ASDs compared with normal group without considering the IQ as the covariance

	ASD		Normal		t	p value
	Mean	SD	Mean	SD		
CANTAB visual memory tests						
Paired Associates Learning test (PAL)						
* First trial memory score	10.26	5.59	14	4.08	2.092	.046
* Stages completed (SC)	4.73	.703	5	0	12.033	.164
* SC on first trial	1.93	1.57	2.60	1.05	2.958	.185
* Total errors adjusted	42.86	41.90	12.60	9.84	17.662	.015
* Total trials adjusted	15.93	8.06	9.73	3.28	15.794	.013
Pattern Recognition Memory test (PRM)						
* Mean correct latency	2838.10	1183.24	2629.68	684.43	2.176	.560
* Number correct	18.06	3.95	20.60	2.41	6.390	.045
Spatial Recognition Memory test (SRM)						
* Mean correct latency	3414.70	1727.27	3066.45	1058.96	3.066	.511
* Number correct	10	3.31	13.40	2.72	1.026	.005
Delayed Matching to Sample test (DMS)						
* Mean correct latency	3759.99	1039.03	4323.07	1154.58	.069	.171
* Total corrects	13.46	3.31	17	2.29	.786	.002
* Prob error given correct	.35	.20	.174	.173	.277	.012
* Prob error given error	.25	.27	.05	.103	13.834	.019

This inconsistency may be due to different tasks that were used in our study as compared to the others. The visual memory tasks used in previous studies were mostly based on recognizing objects which may have been particularly interesting to children and adolescents with ASDs, so they could have recognized them easier than otherwise normal developing youths. We used meaningless patterns which might not be as interesting to children with ASDs. Therefore, it can be gathered that the findings of this study could show the visual memory ability of children and adolescents with ASDs with better precision. On the other hand, these findings are consistent with the results of Ameli's study on autistic individuals comparing the meaningful and meaningless pictures (8). They found that individuals with autism have poorer performance on meaningless visual memory patterns whereas they are as good as normal people on meaningful pictures (8). Moreover, when we considered IQ as a covariance, the significant difference disappeared and the visual memory ability in both groups proved to be the same. By eliminating the IQ effect, our findings will be consistent with prior study's results which showed no significant difference between normal youths and ASDs group. This means that this ability may be related to global cognitive ability, which is totally lower in youths with ASDs compared with normal children in the same age group. In fact, children and adolescents with ASDs have deficits in different aspects of cognition including the intellectual ability, visual memory, visuospatial recognition, and executive functioning.

Based on these findings, we can conclude that youths with ASDs have poorer performance on meaningless pattern recognition as well as the visuospatial memory compared to normal age matched children and adolescents .

One limitation of this study was the difference between the two groups in terms of their IQs. Since the intellectual abilities of youths with ASD are mostly lower than their age matched normal group, matching the IQs of the two groups was rather difficult .

The findings of this study suggest that ASDs children and adolescents are not superior in visual memory ability compared to normal youths. This hypothesis should be reevaluated in larger samples using different tasks.

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