

Association of Sensory Processing and Cognitive Deficits in Children with Autism Spectrum Disorders – Pioneer Study in Saudi Arabia

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Abstract—The association between sensory problems and cognitive abilities has been studied in individuals with Autism Spectrum Disorders (ASDs). In this study, we used a Neuropsychological Test to evaluate memory and attention in ASDs children with sensory problems compared to the ASDs children without sensory problems. Four visual memory tests of Cambridge Neuropsychological Test Automated Battery (CANTAB) including Big/little circle (BLC), Simple Reaction Time (SRT) Intra /Extra dimensional set shift (IED), Spatial recognition memory (SRM), were administered to 14 ASDs children with sensory problems compared to 13 ASDs without sensory problems aged 3 to 12 with IQ of above 70. ASDs individuals with sensory problems performed worse than the ASDs group without sensory problems on comprehension, learning, reversal and simple reaction time tasks, and no significant difference between the two groups was recorded in terms of the visual memory and visual comprehension tasks. The findings of this study suggest that ASDs children with sensory problems are facing deficits in learning, comprehension, reversal, and speed of response to a stimulus.

Keywords—Visual memory, Attention, Autism Spectrum Disorders (ASDs).

I. INTRODUCTION

AUTISM Spectrum Disorders (ASDs) are characterized by abnormalities in social interaction, verbal and non-verbal communications and having repetitive and stereotyped behaviors [1]-[3].

In fact quite a large percentage of children with ASD (78 to 90%) have sensory processing problems [6], [7] which are as hyper- and/or hyposensitivity [4]-[8] such problems have an impact on the child's development and the ability to perform activities of Daily living such as storing and utilizing information.

Sensory and attention issues are most likely both real and primary. In some cases, one may help cause the other [2]. But researchers suspect that they are usually related only through similar neurobiology developmental causes. Both attention and sensory problems may have developmental consequences that help create the full autistic syndrome. In order to avoid

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sensory information over load, autistic people acquire voluntary and involuntary strategies and compensations, such as mono-processing. When they focus their attention to one single channel, or so-called 'tunnel perception', and when they concentrate on a detail instead of a whole. They have very narrowly focused attention. Autistic individuals often compare this attention pattern with having 'a mind like a flash light', 'a laser pointer', or 'a laser beam' that highlights only a single dot (an area of high focus) that they see very clearly while everything around is grey and fuzzy. Murray [11] refers to this phenomenon in monotropism as 'attention tunneling'.

Regarding the memory [2], many people with autism do not remember verbally but while remembering they actually see, hear, feel, smell or taste the items (in their mind). The thought about something produces real experiences they had when encountering this thing or event for the first time. They store their visual, auditory, olfactory, gustatory and tactile memories, which are very real. For instance, the thought of textures they hate might cause goose bumps and chills and a general sense of unease would follow Wiley [12]. Some autistic people, while having excellent memory, have problems with recognition memory. Autistic memory is often described as associative memory (or 'serial memory') [13]. It differs from 'ordinary' (verbal memory) is the way it unfolds: verbal memory is linear, associative memory is non-linear, multi-dimensional, sort of 'spatial', and can be triggered by sensory stimuli, such as smells, certain colors or patterns, touch, physical movement, and combination of sounds or words; storing memory would be an obstacle in the way of children who have sensory deficits in processing information.

Since to our best knowledge no study has ever used Neuropsychological Test Automated Battery, and no studies have been conducted in Saudi Arabia to measure this association between sensory and cognitive ability. Therefore, the purpose of this study was to establish whether there is a relationship between sensory processing problems and a number of cognitive problems such as memory and attention in children with ASD. We expected that children with sensory processing problems would have more cognitive problems than those without such problems.

II. MATERIALS AND METHOD

A. Participants

14 ASDs with sensory deficits (aged 3 to 12 years old) were compared with 13 age matched ASDs without sensory deficits.

Participants with ASDs were diagnosed by a child psychologist based on DSM-IV criteria. The Autism Diagnostic Observation Scale (ADOS) and Childhood Autism Rating Scale (CARS) were also administered to confirm the diagnosis in addition to the short sensory profile (SSP) to point out children who have sensory problems. All participants had IQ above 70 based on Stanford Binet 4 (SB4) see (Table I). Inclusion criteria were: 1. Diagnosis of autism, 2. An absence of a known co-morbid medical condition (such as tuberous sclerosis). Autism diagnosis was based upon meeting all of the following criteria: 1. past clinical diagnosis of autism, 2. current clinical diagnosis as determined by the psychologist on the research team, 3. exceeding autism cut off on the Autism Diagnostic Observation Schedule—Module I, 4. exceeding the autism cut off on the Childhood Autism Rating Scale (CARS), and 5. meeting APA criteria for autism as specified in DSM-IV.

B. Measures

All participants were rediagnosed in the Autism Research and Treatment Center ARTC. The medical history and observational scales that were used are:

1. Diagnose of Autism

Autism Diagnostic Observation: The ADOS is a standardized, semi structured observation of communication, social interaction, and repetitive behaviors of individuals with possible autism spectrum disorder. Items are scored from 0 (Not abnormal) to 2 or 3 (most abnormal), and a diagnoses of autism or ASD is established cut-off values in the communication domain, the social domain, and the sum of the two.

Childhood Autism Rating Scale (CARS): rates the child from 1 to 4 in each of the 15 areas (relating to people, emotional response, imitation, body use, object use, listening response, visual response, verbal communication, nonverbal communication, activity level, level of intellectual response, adaptation to change, touch and smell response, general impression.

2. Measure of Memory and Attention

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

Big/Little Circle (BLC): BLC is a simple test of attention; this is a visual discrimination, comprehension test, in this test the subject is presented with series of pairs of circles; one large and one small. The subject is instructed first to touch the small circle and then, after 20 trials, to touch the larger circle for a further 20 trials.

Intra/Extra Dimensional set shift (IED): Intra/Extra dimensional set shift is a test of rule acquisition and reversal. It features: Visual discrimination and attention set formation and, maintenance, shifting and flexibility of attention. This test is primarily sensitive to changes to the fronto-striatal areas of the brain.

Two artificial dimensions are used in the test: Color-filled shapes and white lines. Simple stimuli are made up of just one of these dimensions, whereas compound stimuli are made up of both, namely white lines over lying color - filled shapes.

Subject progresses through the test by satisfying a set criterion of learning at each stage (6 consecutive correct responses). If at any stage the subject fails to reach this criterion after 50 trials, the test terminates. The test starts with block 1, the presentation of two simple color-filled shapes. The subject must learn which of the stimuli is correct by touching it, and continue until the criterion is reached. In block 2, the contingencies are reversed, so that now the previously incorrect stimulus is correct. In block 3, the second dimension is then introduced initially lying adjacent to and then, for block 4, overlapping.

Simple Reaction Time (SRT): SRT is an attention test to measure simple reaction time through delivery of a known stimulus to a known location to elicit a known response. The only certainty that is with regard to when stimulus will occur, by having a variable interval between the trial and response and the onset of stimulus for the next trial.

Spatial Recognition Memory (SRM): It is a memory test of spatial recognition memory in a forced - choice paradigm. This test is primarily sensitive to dysfunction in frontal lobe, and relatively insensitive to temporal lobe damage.

A white square is shown on the screen in various locations. In the presentation phase, a white square is shown on the screen in five different locations. Each appearance of a square marks a location on the screen which the subject must later remember. In the recognition phase, the square reappears in the same five locations as in the presentation phase but in reverse order. On each appearance, it is paired with an identical distracter square in a location not used in the presentation phase. The subject must touch the square in the location that has appeared before whilst ignoring the distracter which is one block. This block is repeated three more times; each time with five new locations.

The test is scored using four indices: a) Mean correct latency, b) Maximum correct latency, c) S.D. correct latency and, d) Total corrects.

The Stanford Binet 4 (SB4) was administered to evaluate participants with intellectual abilities.

3. Measure of Sensory Processing Problems

Sensory problems have been measured in both groups using a sensory measuring scale (Short Sensory Profile).

Short Sensory Profile (SSP): The SSP is a standardized questionnaire [9]. It permits clinicians and researchers to quickly identify children with sensory processing problems [10]. The 38 items of the (SSP) are extracted from the long version of the sensory profile (SP,125 items)based on factor analyses and correlation studies from two samples of 117 and 1037 children with variety of problems [10] The (SSP) consists of seven sections 1) tactile sensitivity (7 items), 2) taste/smell sensitivity (4 items), 3) movement sensitivity (3 items), 4) under responsive seek sensation (7 items), 5) auditory filtering (6 items), 6) low energy /weak (6 items), and

7) visual /auditory sensitivity (5 items). The SSP classification system includes: typical performance (range from 190-155), probable difference (range from 154-142), and definite system (range from 141-38).

There were significant differences between the two groups in terms of the SSP sections tactile sensitivity ($t=5.554$, $p=0.01$), taste/smell sensitivity ($t=5.562$, $p=0.01$), movement sensitivity ($t=6.33$, $p=0.01$), under responsive seek sensation ($t=4.925$, $p=0.001$), auditory filtering ($t=5.562$, $p=0.001$), low energy/weak ($t=3.11$, $p=0.001$), but no significant differences between the two groups in terms of visual/auditory sensitivity ($t=2.978$, $p=0.18$), and there was a significant term between the two groups in terms of total score on the SSP ($t=6.88$, $p=0.01$) (Table II).

C. Procedure

The participants were firstly interviewed by a child psychologist and diagnosed as having Autism Spectrum Disorders based on DSM-IV criteria. Next, they were evaluated using the Autism Diagnostic observation Scale (ADOS) and Childhood Autism Rating Scale (CARS) scores to confirm the diagnosis. The short sensory profile SSP was filled out by one of the research team. Then the participants were examined using neuropsychological tests.

III. STATISTICAL ANALYSIS

Independent Samples T test was used to compare the two groups in terms of different variables. In this research, all statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS), version 22.

IV. RESULT

The mean age ASDs with sensory problems was 7 (SD = 2.41) while the mean age of control group was 4.46 (SD = 1.61), (p value = 0.38). There was no significant difference between the two groups in terms of age. With regards to IQ, there were no significant differences between the two groups ($P=0.15$). In regards to sensory profile, there were significant differences between two groups ($P=0.01$).

In regards to Big/Little Circle (BLC), the individuals with ASDs and without sensory problems had better performance on this task compared to ASDs with sensory problem group (Table III). There were significant differences between the two groups on the "percent of correct" score ($t=5.562$, $p=0.03$). In the Simple Reaction Time (SRT), no significant differences were found between the two groups on "mean correct latency" ($t=3.864$, $p=0.8$) or on "S.D correct" ($t=2.393$, $p=0.64$), but significant differences were found between the two groups on "maximum correct latency" ($t=1.036$, $p=0.02$) and on "percent correct" ($t=3.834$, $p=0.001$). In terms of Intra /Extra dimensional set shift (IED), no significant differences were found between the two groups on "total errors 1" ($t=3.788$, $p=0.08$) or on "total errors 2" ($t=2.74$, $p=0.15$). With regards to Spatial Recognition Memory (SRM) task, no significant differences were found between.

TABLE I
DEMOGRAPHIC VARIABLES IN CHILDREN WITH SENSORY PROBLEMS
COMPARED TO ASDS WITHOUT SENSORY PROBLEMS

SUBJECT	ASDs with sensory problem		ASDs without sensory problems		t	p value
	mean	SD	mean	SD		
age	7	2.41	4.46	1.6	3.18	0.38
IQ	82.57	13.4	79.07	9.6	0.78	0.15

TABLE II
DEMOGRAPHIC SENSORY DIFFERENCES BETWEEN TWO ASD GROUPS

short sensory profile	ASDs with sensory problems		ASDs without sensory problems		t	P-value
	mean	SD	mean	SD		
tactile sensitivity	29.71	5.16	15.84	7.65	5.554	0.01
taste /smell sensitivity	20	1.12	12.61	4.97	5.562	0.01
movement sensitivity	14.42	0.51	8.69	3.35	6.334	0.01
Under responsive /seek sensation	31.71	2.97	24.76	4.28	4.925	0.01
auditory filtering	20	1.12	12.61	4.975	5.562	0.01
low energy/weak	30	5.14	27.69	2.78	3.11	0.001
visual / auditory sensitivity	22.71	1.54	20.23	2.68	2.978	0.18
total	170	12.19	122	23.06	6.88	0.01

TABLE III
RESULTS OF COGNITIVE TESTS IN ASDS WITH SENSORY PROBLEM COMPARED
WITH ASDS WITHOUT SENSORY PROBLEM GROUP

cantab visual memory tests	ASD with sensory problem		ASDs without sensory problem		T	P-value
	Mean	SD	mean	SD		
Big/Little circle BLC						
Percent correct	80.85	13.52	55.53	9.62	5.562	0.03
Simple Reaction Time SRT						
mean correct latency	461.67	258.15	90.42	239.68	3.864	0.8
maximum correct latency	112.53	279.38	28.25	91.86	1.036	0.02
S.D correct	395.13	206.59	623.51	285.82	2.393	0.64
Percent correct	79.53	16.68	43.5	30.42	3.834	0.001
Intra / Extra set shift (IED)						
total errors 1	38.85	11.04	20.46	14.11	3.788	0.08
total errors 2	88.85	57.36	157	71.48	2.74	0.15
spatial memory (SRM)						
Percent correct	52.85	5.44	46.92	6.3	2.623	0.55

V. DISCUSSION

Some researchers study the association between cognitive abilities and sensory problems in children with autism spectrum disorders (ASDs) having sensory problems, but their experiments were mostly based on investigating this association using different tests than ours, the current study was designed to evaluate the association between attention, memory, and sensory problems using computerized neuropsychological battery to evaluate (ASDs) children with sensory problems.

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

We found that ASDs with sensory problems had worse performances on Big / Little Circle (BLC) compared to ASDs without sensory problems. This means that these individuals have problems in comprehension, learning, and reversal of information. It was also found that ASDs with sensory problems' group had significantly a lower performance on Simple Reaction Time SRT which means that ASDs with sensory problems have difficulties with speed of response to a single stimulus.

In regards to memory, no significant differences were found between the two groups on Spatial Recognition Memory (SRM), and no significant differences were found between the two groups in terms of attention set shifting.

These findings are consistent with the results of some other studies like. They found that ASDs individuals with sensory problems have poorer performances and a simple delay in attention.

The findings of this study suggest that ASDs children with sensory problems are facing deficits in learning, comprehension, reversal of information, and speed of response to a stimulus. This hypothesis should be reevaluated in larger samples using different tasks.

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REFERENCES

- [1] First MB, Frances A, Pincus HA. DSM-IV-TR: Handbook of differential diagnosis. United States of America: American Psychiatric Publishing; 2002.
- [2] Olga Bogdashina, Sensory Perceptual Issues in Autism and Asperger Syndrome. 1st edition. London, UK: Jessica Kingsley Publisher.
- [3] Howlin P. Autism and asperger syndrome. 2th ed. United States of America: Routledge; 2005.
- [4] S.J. Rogers, S. Hepburn, and E. Wehner, "parent reports of sensory symptoms in toddlers with autism and those with other developmental disorders," *Journal of Autism and Developmental disorders*, vol.33, no.6, pp.631-642, 2003.
- [5] R.L. Watling, J. Deitz, and O. White, "comparison of sensory profile scores of young children with and without autism spectrum disorders," *American Journal of Occupational Therapy*, vol. 55, no.4, pp.416-423, 2001.
- [6] S.R. Leekam, C. Nieto, S.J. Libby, L. Wing, and J. Gould, "Describing the sensory abnormalities of children and adults with autism," *Journal of Autism and Developmental Disorders*, vol. 37, no. 5, pp.416-423, 2001.
- [7] G.T. Baranek, F.J. David, M.D. Poe, W.L. Stone, and L.R. Watson, "Sensory experiences questionnaire: discriminating sensory features in young children with autism, developmental delays, and typical developmental," *Journal of Child Psychology and psychiatry and Allied Disciplines*, vol. 47, no.6, pp.591-601, 2006.
- [8] S.D. Mayes and S.L. Calhoun, "Symptoms of autism in young children and correspondence with the DSM," *Infants and Young Children*, vol. 12,no. 2, pp. 90-97, 1999
- [9] W. Dunn, *The Sensory Profile Manual*, The Psychological Corporation, San Antonio, Tex. USA, 1999.
- [10] D. N. McIntosh, L. J. Miller, V. Shyru, and R. J. Hagerman, "Sensory-modulation disruption, electrodermal responses, and functional behaviors," *Developmental Medicine and Child Neurology*, vol. 41, no. 9, pp. 608-615, 1999.
- [11] Lynne Murray, "The Impact of Postnatal Depression on Infant Development", *Journal of Child Psychology and Psychiatry*, vol. 33, no. 3, pp. 543-561, 1992.
- [12] Wiley, *International Journal of Systematic Theology*, 1999.
- [13] Diane I. Williams, "the profile of memory function in children with autism" *Journal of neuropsychology*, 2007.