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Impact of Behavioral Aspects of Autism on Cognitive Abilities in Children with Autism Spectrum Disorder

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Abstract**—**Cognitive symptoms and behavioral symptoms may, in fact, overlap and be related to the level of the general cognitive function. We have measured the behavioral aspects of autism and its correlation to the cognitive ability in 30 children with ASD. We used a neuropsychological Battery CANTAB eclipse to evaluate the ASD children's cognitive ability. Individuals with ASD and challenging behaviors showed significant correlation between some cognitive abilities and Motor aspects. Based on these findings, we can conclude that the motor behavioral problems in autism affect specific cognitive abilities in ASDs such as comprehension, learning, reversal, acquisition, attention set shifting, and speed of reaction to one stimulus. Future researches should also focus on the relationship between motor stereotypes and other subtypes of repetitive behaviors, such as verbal stereotypes, ritual routine adherence, and the use of different types of CANTAB tests.

Keywords**—**Autism, Cognitive ability, Motor Behavior, and Neuropsychological battery.

I. Introduction

THERE is a general agreement on the diagnoses of the syndrome of autism based on the behavioral symptoms people with autism exhibit.

Restricted and repetitive behaviors (RRBs) represent the third core criterion for a diagnosis of Autistic Disorder (AD) in the DSM-IV-TR [1], [2]. RRBs are present in children and adults with Autism Spectrum Disorder (ASD) at higher rates than in any other developmental disability [4]-[10].

Among the different subtypes of RRBs, motor stereotypes are defined as patterned, repetitive, and purposeless movements (e.g., hand flapping, finger flicking, rocking). A recent review of the assessment and treatment of motor stereotypic behaviors in children with autism and other pervasive developmental disabilities found that 25 unique categories of stereotypes have been identified in the literature [11]. In ASD, stereotypy, hyperactivity, irritability, and lethargy behaviors have not only been associated with the severity of ASD diagnosis [2], but also with deficits in the executive functions (EF) [15]. EF is defined as a higher order cognitive processes that includes planning, initiating and inhibiting actions, and selecting relevant sensory information from one's surroundings and general cognitive flexibility [3]. The Pre-Frontal Cortex (PFC) and frontal-basal ganglia circuits have been identified as the core brain substrates associated with EF [7].

On the other hand, the language deficits are products of some other primary impairments [16].

The hypothesis tested in the present study was that behavioral problems that children with ASD exhibit, will interfere with the cognitive process and result in a cognitive impairment. The present prospective, controlled trial, evaluated how specific behavioral problems such as irritability, lethargy, hyperactivity, stereotypy, and inappropriate speech will effect on memory, attention, and visual comprehension.

II. Materials and Method

A. Participants

30 ASDs children (aged 6 to 11 years old) participated in this study. Participants were diagnosed by a child psychologist as having ASD based on DSM-IV criteria.

The Autism Diagnostic Observation Schedule (ADOS) and Childhood Autism Rating Scale (CARS) were also administered to confirm the diagnosis. Then, the psychologist took the Aberrant Behavior checklist (ABC) and (CANTAB) eclipse measures. All participants had an IQ mean of 62 based on Stanford Binet 4 (SB4). Inclusion criteria were: 1) diagnosis of autism, and2) 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—ModuleI (ADOS-I) [17], 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. Autism Diagnostic Observation (ADOS):

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 diagnosis of autism or ASD is established based on the cut-off values in the communication domain, the social domain, and the sum of the two.

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2. Childhood Autism Rating Scale (CARS):

It 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).

3. Aberrant Behavioral Checklist (ABC):

It is a 58 item questionnaire that assesses communication, reciprocal social interaction, play, and stereotyped behaviors [19]. It is used to evaluate the effects of therapeutic interventions and is scored from 0 ("not at all a problem") to 3 ("problem is severe in degree"). The ABC is widely and successfully used in clinical trials of autistic individuals [18]. The (ABC) is a scale of non-adaptable behaviors created to scan and indicate the probability of autistic diagnosis. ABC consists of five sub scales which are: irritability, lethargy, stereotypy, hyperactivity, and inappropriate speech.

4. 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 large 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, attention set formation, and shifting and flexibility of attention. This test is primarily sensitive to changes in 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 and color - filled shapes.

The 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, and then, in 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 certain part that is with regard to when stimulus will occur by having a variable interval between the trial, 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.

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.

5. The Stanford Binet 4 (SB4):

It was administered to evaluate participants with intellectual abilities.

C. Procedure

The participants were first interviewed by a child psychologist and diagnosed as having Autism Spectrum Disorder based on DSM-IV criteria. Next, they were evaluated using the Autism Diagnostic Observation Schedule (ADOS) and Childhood Autism Rating Scale (CARS) to confirm the diagnosis of autism, and were then examined using the (ABC) and the (CANTAB) neuropsychological tests: Big/little circle (BLC), Motor screening (MOT), Intra/Extra dimensional set shift (IED), Simple Reaction Time (SRT), and Spatial recognition memory (SRM).

III. Statistical Analysis

The Dependent Samples T test was used to compare the correlation between the groups in terms of different variables across the (30) participants. In this research, all statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS), version 22.

IV. Result

The mean age of children with ASDs was (mean=8.66, SD=2.33), while the IQ was (mean=62.16, SD =12.07). (Table I). There were no significant differences within the group in terms of the ABC's subscale irritability-Big/Little Circle (BLC) percent correct (P=0.06), irritability-Motor (MOT)

(P=0.13), irritability-Simple Reaction Time (SRT) Mean Correct Latency (P=0.48), Maximum Correct Latency (P=0.2), SD Correct (P=0.13), Percent Correct (P= 0.95), Irritability-Intra/Extra Set Shift (IED), Total Error 1 (P=0.73), Total Error 2 (P=0.16), irritability-Spatial Memory (SRM) Percent Correct (P=0.43). (Table II).

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

SUBJECT	ASDs with sensory problem		ASDs without sensory problems	
	Mean	SD	mean	SD
Age	7	2.41	4.46	1.6
IQ	82.57	13.4	79.07	9.6

With regards to lethargy, there were significant differences within the group in terms of ABC's subscale lethargy and Big Little Circle (BLC) percent correct (P=0.00), not to lethargy - Motor (MOT) (P=0.5), lethargy - Simple Reaction Time (SRT), Mean Correct Latency (P=0.21), Maximum Correct Latency (P=0.36), SD Correct (P=0.06), Percent Correct (P=0.15), lethargy-Intra/Extra Set Shift (IED), Total Error 1 (P=0.92), Total Error 2 (P=0.05), Lethargy-Spatial Memory (SRM), Percent Correct (P=0.32). (Table III).

In terms of hyperactivity, there were significant differences within the group in terms of ABC's subscale hyperactivity and Big Little Circle (BLC) percent correct (P=0.06), hyperactivity-Motor (MOT) (P=0.65), hyperactivity-Simple Reaction Time (SRT) Mean Correct Latency (P=0.21), Maximum Correct Latency (P=0.00), SD Correct (P=0.22), and Percent Correct (P= 0.15), hyperactivity-Intra/Extra Set Shift (IED) Total Error 1 (P=0.01), Total Error 2 (P=0.34), hyperactivity-Spatial Memory (SRM) Percent Correct (P=0.97). (Table IV).

In regards to stereotypy, there were significant differences within the group in terms of ABC's subscale stereotypy and Big Little Circle (BLC) percent correct (P=0.53), stereotypy-Motor (MOT) (P=0.01), stereotypy-Simple Reaction Time (SRT) Mean Correct Latency (P=0.22), Maximum Correct Latency (P=0.72), SD Correct (P=0.53), Percent Correct (P=0.57), stereotypy-Intra/Extra Set Shift (IED) Total Error 1 (P=0.31), Total Error 2 (P=0.13), stereotypy-Spatial Memory (SRM) Percent Correct (P=0.11). (Table V).

In regards to inappropriate speech, there were significant differences within the groups in terms of ABC's subscale inappropriate speech and Big Little Circle (BLC) percent correct (P=0.93), Motor stereotypy (MOT) (P=0.03), stereotypy-Simple Reaction Time (SRT)Mean Correct Latency (P=0.16), Maximum Correct Latency (P=0.29), SD Correct (P=0.84), Percent Correct (P=0.96), inappropriate speech-Intra/Extra Set Shift (IED) Total Error 1 (P=0.51), Total Error 2 (p=0.74) inappropriate speech-Spatial Memory (SRM) Percent Correct (p=0.82). (Table VI).

TABLE II
CORRELATION BETWEEN ABC SUBSCALE IRRITABILITY AND CANTAB TESTS

Correlation between Irritability and CANTAB tests	**mean**	**SD**	**correlation**	**p-value**
Irritability-Big/Little Circle Percent Correct	14.38	25.47	0.34	0.06
Irritability-Motor (MOT)	81.76	10.21	0.29	0.13
Irritability-Simple Reaction Time (SRT)				
Mean Correct Latency	412.5	511.85	0.13	0.48
Maximum Correct Latency	80.01	9.88	0.24	0.2
SD Correct	532.83	231.59	0.28	0.13
Percent Correct	16.57	32.94	0.01	0.95
Irritability-Intra/Extra Set Shift (IED)				
Total Error 1	46.4	23.83	0.06	0.73
Total Error 2	21.93	76.04	0.26	0.16
Irritability-Spatial Memory (SRM)				
Percent Correct	37.67	13.82	0.15	0.42

TABLE III
CORRELATION BETWEEN ABC SUBSCALE LETHARGY AND CANTAB TESTS

Correlation between Inappropriate Speech and CANTAB tests	**Mean**	**SD**	**Correlation**	**p-value**
Big/Little circle(BLC)				
Percent correct	13.88	30.89	0.6	0
Motor (MOT)	80.87	14.48	0.13	0.5
Simple Reaction Time (SRT)				
mean correct latency	413	513.94	0.23	0.21
maximum correct latency	79.51	14.12	0.17	0.36
S.D correct	533.33	229.81	0.34	0.06
Percent correct	16.07	37.63	0.27	0.15
Intra / Extra set shift (IED)				
total errors 1	45.9	26.21	0.02	0.92
total errors 2	22.43	74.12	0.36	0.05
Spatial memory (SRM)				
Percent correct	31.17	15.01	0.19	0.32

TABLE IV
CORRELATION BETWEEN ABC SUBSCALE HYPERACTIVITY AND CANTAB TESTS

Correlation between hyperactivity and CANTAB tests	**Mean**	**SD**	**Correlation**	**p-value**
Big/Little Circle (BLC)				
Percent correct	15.15	29.4	0.34	0.06
Motor (MOT)	82.23	15.96	0.09	0.65
Simple Reaction Time (SRT)				
mean correct latency	411.73	514.15	0.22	0.23
maximum correct latency	80.77	15.4	0.32	0.08
S.D correct	532.06	227.28	0.47	0
Percent correct	17.33	37.99	0.23	0.22
Intra / Extra set shift (IED)				
total errors 1	47.17	32.27	0.44	0.01
total errors 2	21.17	76.77	0.18	0.34
spatial memory (SRM)				
Percent correct	38.43	17.51	0.01	0.97

TABLE V
CORRELATION BETWEEN ABC SUBSCALE STEREOTYPY AND CANTAB TESTS

Correlation between Stereotypy and CANTAB tests	Mean	SD	Correlation	p-value
Big/Little Circle (BLC)				
Percent correct	4.42	26.27	0.12	0.53
Motor (MOT)				
	72.87	14.37	0.48	0.01
Simple Reaction Time (SRT)				
mean correct latency	422.46	507.31	0.23	0.22
maximum correct latency	70.04	14.51	0.07	0.72
S.D correct	542.8	232.96	0.12	0.53
Percent correct	6.6	32.85	0.11	0.57
Intra / Extra set shift (IED)				
total errors 1	36.43	24.17	0.19	0.31
total errors 2	31.9	75.25	0.28	0.13
Spatial memory (SRM)				
Percent correct	27.7	18.61	0.29	0.11

TABLE VI
CORRELATION BETWEEN ABC SUBSCALE INAPPROPRIATE SPEECH AND CANTAB TESTS

Correlation between Inappropriate Speech and CANTAB tests	Mean	SD	Correlation	p-value
Big/Little circle (BLC)				
Percent correct	16.28	26.49	0.02	0.93
Motor (MOT)				
	83.08	17.29	0.4	0.03
Simple Reaction Time (SRT)				
mean correct latency	410.6	515.08	0.26	0.16
maximum correct latency	81.91	16.68	0.2	0.29
S.D correct	530.93	235.44	0.04	0.84
Percent correct	18.47	35.36	0.01	0.96
Intra / Extra set shift (IED)				
total errors 1	48.3	29.5	0.12	0.51
total errors 2	20.03	78.76	0.06	0.74
Spatial memory (SRM)				
Percent correct	39.57	18.97	0.04	0.82

V. DISCUSSION

This study was designed to evaluate the relationship between challenging behaviors and cognitive ability in autism children. The findings are consistent with our hypothesis; behavioral problems that children with ASD exhibit will interfere with the cognitive process and result in a cognitive impairment.

Five computerized cognitive tests, consisting of memory, attention, and visual discrimination patterns, were used in this research. A significant correlation was found between Lethargy and Big/Little circle (BLC), Lethargy and Intra/Extra set shift (IED). This means that lethargy in autism has influence on comprehension, learning, reversal, acquisition, and attention set shifting. A significant correlation was also found between Hyperactivity, Simple Reaction Time (SRT), and Intra/Extra set shift (IED).This means that the hyperactivity affects the ASDs' speed of response to a single stimulus and attention shifting.

With regards to stereotypy and Motor (MOT), there was a significant correlation between both of them which means that this stereotypy influences their visual, movement and comprehensive ability.

There was also a significant correlation between Inappropriate Speech and Motor (MOT). This lead to a conclusion, that the stereotypy and motor difficulties in autism affect their comprehension and their appropriate speech abilities.

Our results align with past studies that have indicated links between autistic behaviors and cognitive abilities in children with ASD [12], [13], but stand in contrast to studies which have found no links to specific ASD symptom clusters [6]-[8].

One reason for the discrepancies among results may lie on the conceptualization of repetitive behaviors, rituals, and stereotypy, in addition to the Cognitive Tests.

Based on these findings we can conclude that the behavioral problems in autism affect specific cognitive abilities in ASDs' comprehension, learning, reversal, acquisition, attention set shifting, and speed of reaction to one stimulus.

Future researches should also focus on the relationship between motor stereotypes and other subtypes of repetitive behaviors, such as verbal stereotypes, ritual and routine adherence, and the use of different types of CANTAB tests.

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