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REMEMBRANCE CAPACITY IN CHILDREN AND ADOLESCENTS WITH AUTISM

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ABSTRACT

Objective: Remembrance capacity in children and adolescents ages 5–19 with autism (n = 50) and typically developing controls (n = 36) was assessed using a clinical assessment battery, the Test of Memory and Learning (TOMAL).
Method: Participant groups were statistically comparable in age, nonverbal IQ, handedness, and head circumference, and were administered the TOMAL.
Results: Test performance on the TOMAL demonstrated broad differences in remembrance capacity in the autism group, across multiple task formats, including verbal and nonverbal, immediate and delayed, attention and concentration, sequential recall, free recall, associative recall, and multiple-trial learning memory. All index and nearly all subtest differences remained significant even after comparing a subset of the autism group (n = 36) and controls that were matched for verbal IQ (p >.05). However, retention of previously remembered information after a delay was similar in autism and controls.
Conclusions: These findings indicate that performance on measures of episodic remembrance is broadly reduced in autism, and support the conclusion that information encoding and organization, possibly due to inefficient cognitive processing strategies, rather than storage and retrieval, are the primary factors that limit memory performance in autism.

INTRODUCTION

Even though remembrance impairments have been reported in autism, an autism-specific profile of dysfunctional memory has not been established (Minshew and Williams, 2007), but several theories have been proposed to explain the heterogeneity of cognitive impairments observed in autism. Most fall under the proposition that higher-level cognitive functions that require organization or strategy such as memory are affected, while more basic perceptual processes are left intact or even enhanced in some individuals with autism (Jeste, Friedman, and Urion, 2009; Mottron, Dawson, Soulières, Hubert, and Burack, 2006). For example, Ben Shalom (2009) has recently suggested a 3-tiered model of cognitive functioning in autism, consisting of basic, integrative, and higher-order or "logical" levels of processing. Within a memory framework, the autism condition thus spares, or relatively spares, low-level perceptual and procedural information processing, while disabling the consolidation of higher-level or event-related information (i.e., episodic or autobiographical memory). Higher-level memory for context-independent facts (i.e., semantic memory), however, is thought to be either not affected or minimally affected and used to compensate for the lack of integrative episodic memory among high-functioning individuals. Similarly, others have suggested that the semantic or visual complexity and volume of information to be processed, integrated, and retained are key factors that define memory performance deficits in autism (Williams, Goldstein, and Minshew, 2006a, 2006b). Recent studies of memory in autism have focused on individual profiles from broadband neuropsychological batteries, which assess episodic memory functions through a variety of stimuli and task requirements, incorporating visual, verbal, list learning, associative, and working memory paradigms. Minshew and Goldstein (2001) administered a mixed clinical and experimental memory battery, investigating effects of stimulus complexity on memory performance among high-functioning adolescents and young adults with autism matched on verbal and performance IQ. They found that the autism group often performed equal to controls on verbal or

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visual tasks with low processing load. When evaluated using tasks with similar content but increased stimulus complexity, however, memory deficits relative to controls became increasingly apparent in the autism group. More recent studies of autism have reported on remembrance capacity in childhood, using standardized, commercially available test batteries. Lajiness-O'Neill et al. (2005) reported results using the Test of Memory and Learning (TOMAL; Reynolds and Bigler, 1994), which was administered to a size-limited sample of children with high-functioning autism (HFA). Participants were characterized by mean verbal reasoning scores in the borderline range, with performance IQ in the high average range. Analyses of memory scores indicated functioning in the low average range on composite TOMAL measures of overall, verbal, nonverbal, and delayed recall memory. In a separate study, Williams, Goldstein and Minshew (2006b) reported on memory functioning in childhood autism among a relatively large sample, in which HFA and controls were matched on both verbal and performance IQ. Using the Wide Range Assessment of Memory and Learning (WRAML, Sheslow and Adams, 1990), they found evidence for reduced memory performance across verbal and visual domains compared to the control sample, matched in intellectual ability. Consistent with prior research on the effects of stimulus complexity on memory performance, Williams and colleagues found that HFA and controls performed similarly on perceptually simple tasks, while complex task performance discriminated between the groups.

MATERIALS AND METHODS

Subjects and Assessment

Autism and comparison subjects were recruited over a 10-year period (1998–2008) predominantly from community sources, including, and special schools, and from physiotherapy/ occupational therapy clinic. After complete description of the study to subjects and parents, written informed consent was obtained. The subjects in this study are a subset of participants in a longitudinal investigation of late brain development from 3 years of age through early adulthood. The subset for this investigation was selected from the larger sample based on age within the reference norms of the TOMAL, having complete, high quality TOMAL data from the time of initial assessment, and closeness of matching on age, PIQ, handedness, and head circumference. In all cases only the TOMAL data from the first assessment was used to insure the aspect of novelty was consistent across all subjects.

Subject groups: All subjects were males, 5–19 years of age, and had nonverbal ability standard scores greater than 85. All subjects also underwent brain MRI studies, but those findings will not be discussed in detail, other than to mention that all imaging was interpreted clinically to be within normal limits and no subject had a major developmental abnormality of the brain. Potential sex differences in memory were not examined because only male subjects are included in the longitudinal study and this investigation. Idiopathic autism sample. Autism was rigorously diagnosed. The subject's mother was interviewed using the Autism Diagnostic Interview–Revised (ADI-R; Lord, Rutter, and Le Couteur, 1994), a semi-structured, investigator-based interview with good reliability and validity. All autism subjects were also directly assessed using the Autism Diagnostic Observation Schedule–Generic (ADOS-G; Lord et al.; 2000), which is a semi-structured play and interview session designed to elicit social, communication, and stereotyped repetitive behaviors characteristic of autism.

Control sample: To test for autism-related differences in memory and other neurocognitive performance variables, a comparison sample was composed of typically developing individuals. Control subjects had no developmental, neurological, or clinical history for major psychiatric disorders. Control subjects likewise completed an assessment with the ADOS-G and were rigorously assessed for autism spectrum disorders to ensure none met criteria.

IQ: Verbal skills are often diminished in autism, as DSM–IV standards require the presence of a qualitative impairment in communication (Rapin, 1999). In addition, there can be wide splits between verbal and performance IQ in autism (Deutsch and Joseph, 2003). For these reasons, a PIQ $\geq$85 was designated as the inclusion factor for level of intelligence in this study, with verbal intellectual level free to vary. Verbal IQ (VIQ) and nonverbal IQ (NVIQ) were selected as dimensional variables in the autism and control samples to be used descriptively.

Remembrance/Memory: Remembrance was assessed using the TOMAL (Reynolds and Bigler, 1994). The TOMAL samples various domains of memory in children and adolescents, ages 5 years 0 months through 19 years 11 months, 30 days. The TOMAL is composed of a core battery of 10 subtests, including five verbal and five non-verbal subtests, as well as supplementary subtests (three verbal, one nonverbal). Four TOMAL subtests assess retrieval both immediately upon stimulus presentation and following a 30-min filled delay. Among the 10 core subtests, Memory for Stories involves immediate and delayed free recall of short verbal narratives; Word Selective Reminding is a verbal list-learning task that includes a delayed free recall condition; Object Recall requires immediate verbal recall of paired verbal-visual stimuli; Digits Forward involves repetition of a number series; and Paired Recall involves learning verbal paired associates.

In Facial Memory arrays of pictured faces are presented which must be recognized and selected among distractors immediately and following a delay; Visual Selective Reminding is a test of spatial learning with a delayed recall condition; Abstract Visual Memory involves immediate recognition and discrimination of abstract geometric figures; in Visual Sequential Memory a set of abstract figures must be recalled sequentially; and Memory for Location is a spatial recall task. Supplementary subtests consist of three additional auditory span and working memory tasks, Digits Backward, Letters Forward, Letters Backward, and Manual Imitation, which involves serial repetition of basic hand gestures. The TOMAL has been shown to have high reliability using standard methods for estimating the internal consistency of the subtests and composites (Reynolds and Bigler, 1994). The TOMAL assesses declarative memory for novel information

that was encountered within a specific context. Thus, in the present study these results are broadly described as measures of episodic memory functioning.

Statistical analysis

Given the descriptive nature of this investigation, group means were calculated and compared for autism and control subjects, using independent samples **t** tests whose **p** values have not been adjusted for multiplicity. TOMAL composite, index, and subtest scores were compared. Immediate and delayed percent recall was also assessed for tasks with a delayed recall component.

RESULTS

Sample characteristics

Table 1 summarizes the demographic, IQ, head circumference, and handedness characteristics of the samples.

There were no differences in handedness with the sample predominantly right-handed, and head circumference did not differ between the two groups. The aggregate verbal IQ scores were significantly lower in the autism group, but group differences did not reach significance for nonverbal IQ scores ($p > .05$).

Test of Memory and Learning

Results for TOMAL composite, index, and subtest scores are reported in Table 2. Cohen's **d** values serve as an estimate of effect size. Group comparisons for the TOMAL measures were significant for Composite, Verbal, and Delayed memory indexes, for all supplemental indexes, and for all 18 subtests ($p < .05$), as depicted in Table 2. Effect sizes for TOMAL subtests were large, with the exception of a spatial recall task (Memory for Location), sequential motor imitation (Manual Imitation), and word list recall after a 30-min delay (Word Selective Reminding Delayed). These subtest comparisons were associated with moderate effect sizes. Large group effects were found for all TOMAL index scores.

Table 1. Participant Demographic

Variable	Autism		Control		
	n=50		n=36		
	Mean	(SD)	Mean	(SD)	*p*
Age (TOMAL)	11.61	(4.29)	12.34	(4.23)	.42
VIQ	99.75	(22.38)	112.27	(13.26)	<.01
NVIQ	108.31	(13.36)	114.52	(15.87)	.05
Edinburg Handedness Index	65.01	(52.62)	59.56	(44.96)	.65
Head circumference (cm)	54.77	(2.37)	54.55	(2.31)	.69

VIQ= Verbal IQ; NVIQ= Non-verbal IQ; TOMAL= Test of Memory & Learning

Table 2. Result of Test of Memory & Learning

	Autism		Typical Control				
	(n=50)		(n=36)				
	Mean	(SD)	Mean	(SD)	*b*	*p*	*d*
Composite Memory Index	87.0	13.23	106.94	8.57	8.31	<.001	1.76
Verbal Memory Index	83.98	15.66	104.58	10.64	7.17	<.001	1.52
Memory for Stories	7.74	3.12	11.56	2.96	5.71	<.001	1.26
Word Selective Reminding	8.26	4.29	11.56	2.18	4.66	<.001	0.93
Object Recall	6.49	3.51	9.44	2.26	4.71	<.001	0.98
Digits Forward	6.69	3.03	9.14	3.13	3.63	<.001	0.81
Paired Call	9.48	3.11	11.72	2.15	3.71	<.001	0.83
Letter Forward	6.50	2.90	8.97	3.05	3.68	<.001	0.84
Digits Backward	8.16	1.89	10.34	2.41	4.55	<.001	1.04
Letter Backward	7.73	2.98	10.23	2.37	4.05	<.001	.93
Non-Verbal Memory Index	90.51	13.47	108.22	11.35	6.35	<.001	1.42
Facial Memory	7.27	2.52	10.39	3.13	5.10	<.001	1.13
Visual Selective Reminding	7.71	3.37	9.81	2.53	3.13	<.002	0.70
Abstract Visual Memory	9.90	2.75	13.03	2.55	5.35	<.001	1.19
Visual Sequential Memory	8.63	2.39	11.42	2.85	4.87	<.001	1.09
Memory for Location	9.42	3.89	11.61	3.65	2.63	0.010	0.59
Manual Imitation	10.82	3.05	12.14	2.76	2.00	0.049	0.46
Delayed Recall Index	88.60	11.49	102.57	7.79	6.21	<.001	1.40
Memory for Stories Delayed	7.10	3.08	11.29	3.14	6.08	<.001	1.36
Facial Memory Delayed	7.69	2.78	9.86	2.20	3.82	<001	0.86
Word Selective Reminding	9.42	2.52	10.46	1.50	2.35	0.021	0.49
Visual Selective Reminding	8.80	2.63	10.24	1.46	3.43	0.001	0.71
Supplemental Index Score							
Attention/Concentration Index	85.89	12.79	101.40	15.22	4.92	<.001	1.13
Sequential Recall Index	87.66	13.16	102.89	14.18	4.94	<.001	1.13
Free Recall Index	88.60	14.71	107.50	12.02	6.27	<.001	1.41
Associative Recall Index	91.38	15.64	110.00	13.20	5.77	<.001	1.29
Learning Index	86.38	17.50	104.33	8.26	6.24	<.001	1.27

Table 3. Participant Demographic (VIQ and NVIQ-Matched)

Variable	Autism subset (n=36)		Control(n=36)		
	Mean	(SD)	Mean	(SD)	*p*
Age (TOMAL)	12.35	4.12	12.35	4.24	0.99
VIQ	110.64	15.60	112.28	13.27	0.63
NVIQ	108.39	12.88	114.53	15.88	0.08
Edinburg Handedness Index	66.91	52.19	59.57	44.97	0.59
Head circumference (cm)	55.32	2.23	54.56	2.32	0.20

Table 4. TOMAL (VIQ and NVIQ-Matched)

	Autism (n=36)		Typical Control (n=36)				
	Mean	(SD)	Mean	(SD)	*t*	*p*	*d*
Composite Memory Index	91.38	10.07	106.94	8.57	6.98	<.001	1.69
Verbal Memory Index	89.97	11.16	104.58	10.64	5.61	<.001	1.36
Memory for Stories	8.67	2.89	11.56	2.96	4.19	<.001	1.00
Word Selective Reminding	9.33	3.55	11.56	2.18	3.20	.002	0.77
Object Recall	7.69	2.99	9.44	2.26	2.80	.007	0.67
Digits Forward	6.80	3.10	9.14	3.13	3.16	.002	0.76
Paired Call	10.53	2.02	11.72	2.15	2.39	.020	0.58
Letter Forward	7.09	2.97	8.97	3.05	2.55	.013	0.63
Digits Backward	8.53	1.65	10.34	2.41	3.62	.001	0.88
Letter Backward	8.31	2.58	10.23	2.37	3.17	.002	0.79
Non-Verbal Memory Index	93.26	12.71	108.22	11.35	5.20	<.001	1.26
Facial Memory	7.72	2.36	10.39	3.13	4.08	<.001	0.98
Visual Selective Reminding	7.94	3.10	9.81	2.53	2.78	.007	0.67
Abstract Visual Memory	10.31	2.51	13.03	2.55	4.52	<.001	1.09
Visual Sequential Memory	8.91	2.43	11.42	2.85	3.95	<.001	0.96
Memory for Location	10.00	3.79	11.61	3.65	1.81	.074	0.44
Manual Imitation	10.97	2.72	12.14	2.76	1.75	.084	0.44
Delayed Recall Index	91.62	10.29	102.57	7.79	5.00	<.001	1.22
Memory for Stories Delayed	8.03	2.81	11.29	3.14	4.57	<.001	1.11
Facial Memory Delayed	7.91	2.48	9.86	2.20	3.47	.001	0.84
Word Selective Reminding	9.85	2.13	10.46	1.50	1.36	.180	0.33
Visual Selective Reminding	9.14	2.34	10.24	1.46	2.33	.023	0.57
Supplemental Index Score							
Attention/Concentration Index	88.59	11.29	101.40	15.22	3.88	<.001	0.96
Sequential Recall Index	89.91	12.76	102.89	14.18	3.93	<.001	0.97
Free Recall Index	93.06	12.35	107.50	12.02	4.96	<.001	1.04
Associative Recall Index	97.35	11.44	110.00	13.20	4.27	<.001	1.04
Learning Index	92.41	12.75	104.33	8.26	4.61	<.001	1.13

Indicates p values is less than 0.05

Table 5. TOMAL Immediate vs. Delayed Memory: Subtest Comparisons

	Memory for Stories			Memory for faces		
	% Retained			Scaled Score		
	n	% Retain SD	t (p)	n	Immediate delays SD	t (p)
Autism	40	77% (36%)		48	0.42 (3.31)	0.87(.39)
Control	35	86% (17%)	-1.46(.15)	35	0.46 (2.50)	-1.08 (.39)
	Word Selective Reminding			Visual Selective Reminding		
	% Retained			% Retained		
	n	% Retain SD	t (p)	n	% Retain SD	t (p)
Autism	40	78% (37%)		35	86% (25%)	
Control	29	88% (18%)	-1.39 (.17)	29	92% (19%)	-1.02 (.31)

Verbal IQ-matched subset: Characteristics and analysis

Table 3 summarizes the demographic, IQ, head circumference, and handedness characteristics of a subset of the autism group matched on verbal IQ. All IQ comparisons were non-significant (p >.05). Results for TOMAL composite, index, and subtest scores are reported in Table 4. Group comparisons remained significant (p <.05) for the TOMAL Composite and all index scores. Likewise, all subtest comparisons remained significant, except for Memory for Location, Manual Imitation, and the delayed recall portion of Word Selective Reminding.

Immediate versus delayed remembrance

As shown in Table 5 immediate and delayed recall was not significantly different for the autism or control group. Retention percentage values were calculated to reflect the extent of participants' delayed memory for previously recalled story elements (Memory for Stories), words from a list-learning task (Word Selective Reminding), and dot locations from a spatial learning task (Visual Selective Reminding). For the selective reminding tasks, immediate memory was defined by the number of items recalled on the final of eight learning

trials. Retention percentage values should be sensitive to meaningful differences between immediate and delayed memory performance. Thus, to prevent the occurrence of extreme retention scores arising from trivial discrepancies between immediate and delayed recall (e.g., recalling one story unit initially and then subsequently two story units would indicate 200% retention), the scores of individuals with very low initial recall were excluded from this analysis (i.e., <10 story units initially recalled on Memory for Stories, less than four words recalled on the final learning trial of Word Selective Reminding, or less than 4 dots recalled on the final learning trial of Visual Selective Reminding). Results are presented in Table 5. No group differences were observed in percentage of story units, words, or dot locations successfully recalled both before and after a delay. Delayed retention was also examined for the Facial Memory subtest. Retention percentages were not used in this analysis because the number of faces to be identified during the immediate and delayed stages of Facial Memory was not equal (max. immediate raw score = 41; max. delayed raw score = 15). Instead, age-adjusted scaled scores for immediate and delayed Facial Memory were subjected to paired-sample **t** tests. Neither the autism nor control group exhibited a significant difference between immediate and delayed facial recognition.

Memory in autism with low versus high VIQ

All autism subjects had at a minimum an average range nonverbal IQ. Because VIQ was not a selection criterion for this study, those autism subjects with low VIQ scores could be compared to autism subjects with higher VIQ. In the current autism sample those with a VIQ standard score below 85 consisted of a subgroup of 14 individuals we classified a "low verbal ability" or LVA (mean VIQ = 71.8, SD = 8.0) subgroup. These individuals were matched for nonverbal functioning to a high verbal ability autism group (HVA) and typically developing controls, such that there were no group differences in nonverbal IQ, $F(2, 83) = 1.91$, $p = .16$. Global reductions in memory were observed in the LVA subgroup, (Verbal Index = 69.4, SD = 15.8; Nonverbal Index = 83.3, SD = 13.2) relative to the HVA subgroup (Verbal Index = 110.6, SD = 15.6, $p < .001$; Nonverbal Index = 108.4, SD = 12.9, $p = .02$). Among the combined autism group, there was a significant association between VIQ and verbal episodic memory ($r = .65$; $p < .001$) but not nonverbal memory ($r = .19$, $p = .19$). The verbal memory – VIQ association was also significant among typically developing controls (Verbal Index – VIQ, Pearson $r = .52$, $p = .001$). A nonverbal memory – VIQ association approached statistical significance ($p > .0125$) after Bonferroni correction ($r = .37$, $p = .03$).

DISCUSSION

The objectives of this descriptive study were to provide summary findings on a battery of clinical memory measures from the Test of Memory and Learning in children and adolescents with autism. By definition subjects with autism have "impairments in communication"—this criterion alone is associated with a broad spectrum of cognitive profiles and deficits (Happe, Ronald, and Plomin, 2006; Munson, Dawson, et al., 2008; Munson, Faja, Meltzoff, Abbott, and Dawson, 2008). In the current study only autism subjects with nonverbal intellectual abilities ≥85 were included, but verbal intellectual abilities were free to vary. Indeed, in this autism sample although the mean VIQ was average, it was almost a standard deviation below the control sample and likewise, reflected considerably more variability in the range of verbal abilities. Variability in cognitive performance represents a common finding in autism (Towgood, Meuwese, Gilbert, Turner, and Burgess, 2009). Clearly, the reduced overall level of verbal intellectual functioning in autism creates natural differences in cognitive abilities between the autism and control subjects in this investigation. Increased variability in verbal and semantic functions also clouds group comparisons, where some children with autism may have frank deficits and others no impairment, all within the same grouping. Although verbal abilities were reduced and more variable within the autism group, their overall levels of verbal and nonverbal intellectual functions were nonetheless in the average to above average range. Turning to the other TOMAL index memory and subtest scores when statistically compared to the control sample, overall memory performance in autism reflected reduced ability across all aspects of memory. Large between-groups effect sizes were found for all composite scores and for a majority of subtests. Even for the memory tasks where autism subjects performed more closely to controls, including Memory for Location, memory span for imitating simple hand positions sequences (Manual Imitation), and word list selective reminding (Word Selective Reminding-delayed condition only), moderate effect sizes were present. Given the exploratory nature of this study and to facilitate comparison of present results to previous research, statistical controls for multiple comparisons were not employed. However, the robustness of observed effects across TOMAL scores suggests that most of these differences would survive correction.

Comparing autism performance to the national normative standard for the TOMAL, only Object Recall and Digits Forward were performed below the average range. The autism group in this study performed best on the Manual Imitation task, a non-language sequential recall test using simple hand gestures, where performance by the subjects with autism was exactly at the norm for the TOMAL standardization sample. This type of recall is consistent with previous findings suggesting that basic serial recall may be intact in autism (Bennetto, Pennington, and Rogers, 1996; cf. Bowler and Gaigg, 2008; Williams, 2006a). Other TOMAL subtests with scaled scores ≥9.0 included Paired Recall, Abstract Visual Memory, Memory for Location and Word selective Reminding. Likewise, delayed recall was not significantly different from immediate recall in either the autism or control group, indicating no abnormal decay in retained information. In that delayed recall was not disproportionately degraded in the autism subjects compared to their immediate recall implies intact retrieval once the information has been processed. These findings are in line with previous research (Minshew and Goldstein, 1993;Williams et al., 2006b), further supporting the proposition that recall for adequately encoded information is intact in autism. Overall, the current finding that memory in autism is not disproportionately affected by a delay corresponds with previous research (Lajiness-O'Neill et al., 2005; Williams et al., 2006a) that suggests that initial information encoding and organization, rather than storage and retrieval, are the primary memory deficits in autism. Likewise,

since the majority of TOMAL memory measures were performed within the average range suggests basic cognitive functions in autism associated with memory processing may be adequate, but somewhat inefficient resulting in reduced performance when compared to within Group IQ measures or the control sample. Some have postulated that the child with autism is challenged by the complexity of a stimulus to be processed resulting in a "part-oriented strategy" that is simply less efficient, disrupting memory processing and ability level (Bertone, Mottron, Jelenic, and Faubert, 2005; Tsatsanis et al., 2011). While the use of clinical and nationally standardized memory measures constitutes a strength in the present study, in that a broadband assessment of memory functioning using a conformed set of tasks was possible, such an approach does not allow for systematic test modifications that can elucidate cognitive processes and mnemonic strategies.

The current findings document reduced memory performance but without more experimental methods, do not provide an explanatory mechanism why reduced memory performance occurs in autism. Nonetheless, some qualitative speculations about the data from the present study can be made. For example, some of the largest between group effect sizes were exhibited on tests requiring recall of contextually organized information (Memory for Stories, Facial Memory and Abstract Visual Memory). Experimental investigations of cognitive style in autism have suggested that affected individuals are less likely to make spontaneous use of relational information to enhance memorization and recall (Bowler, Gaigg, and Gardiner, 2010). Thus, as the information load increases, as in a story content or array of faces, the use of relational information may become more essential to effective memory performance. In addition to limitations already mentioned, several limitations are apparent in this research. Although the TOMAL is standardized from ages 5 to 19, which encompassed the age ranges of the current sample, a host of developmental issues may influence memory performance that simply cannot be addressed by this type of cross-sectional design (Shing et al., 2010). Autism is a clinical diagnosis with no proven diagnostic biomarker. However, tremendous strides are being achieved in terms of genetic markers which may define certain aspects of the disorder. For example, recently loci on chromosomes 10 and 16 have been identified that relate to the common profile of lowered VIQ to NVIQ that often characterizes an autism sample (Chapman et al., 2010), including the one in this investigation. If a cognitive biomarker is proven to be present in autism, this could prove to be an exceptional method to study memory differences in autism.

Conclusion

Findings indicate that episodic remembrance capacity is broadly reduced in autism. Since retention following a 30-min delay was not disproportionately affected in autism indicating adequate retrieval of information, reduced episodic and declarative memory in autism may be most affected by deficits in information encoding and organization, possibly due to inefficient cognitive processing strategies rather than storage and retrieval as the primary factors that limit memory performance in autism.

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