Impaired memory for faces and social scenes in autism: clinical implications of memory dysfunction

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Abstract

A clinical memory test, the Wechsler Memory Scale-III (WMS-III), was used to study the auditory and visual memory of 29 high-functioning adults with autism and 34 group-matched normal controls. The individuals with autism performed as well as the controls on immediate and delayed memory for word pairs and stories and on a verbal working memory task. The autism group was impaired on immediate and delayed recall of faces and of family scenes and had impaired spatial working memory. The integrity of verbal working memory and impaired spatial working memory is consistent with the findings of other studies and may reflect the greater computational demands of the spatial task. Most importantly, the deficits in memory for faces and common social scenes, complex visual/spatial stimuli, demonstrate the contribution of memory dysfunction in autism to deficits in real life function.

Keywords: Autism; Memory; Information processing

High-functioning individuals with autism are generally described as having strengths in rote or echoic memory, short-term memory, and associative memory skills (Bennetto, Pennington, & Rogers, 1996; Hermelin & O’Connor, 1970; Lincoln, Dickstein, Courchesne, Elmasian, & Tallal, 1992; Minshew & Goldstein, 1993, 1998; Rumsey & Hamburger, 1988). However, memory is a multifaceted phenomenon and individuals with autism may have strengths in one or more facets of memory, while other aspects may be impaired and adversely impact learning and adaptive function. A recent study has shown that the complexity of the material and its
organizational structure are two dimensions that negatively affect memory and learning in individuals with autism (Minshew & Goldstein, 2001). In that study, individuals with autism did progressively worse than controls as the complexity of the stimulus material was increased. Memory dysfunction appeared to be related to the failure to self-initiate organizational strategies or to use the organization inherent to the stimulus to promote memory, a conclusion supported by other investigations (Ameli, Courchesne, Lincoln, Kaufman, & Grillon, 1988; Bennetto et al., 1996; Minshew & Goldstein, 1993). The adverse impact of increasing information complexity on memory in autism reflects the greater need for organizational strategies as the complexity of the stimulus increases.

The ability to recognize and create organizational structure is an important aspect of the process of memory. Baddeley (1998) noted that a central feature of human learning is that it is dependent upon organization. This organization involves three different levels: (a) the existent organization provided by the individual’s long-term memory store; (b) the organization inherent in the material to be learned; and (c) the organization that is created between the existent and inherent organizational structures when the material is stored in long-term memory. A dynamic memory system requires that a learner extract salient information from all the information presented and construct an organizational structure that will enhance later retrieval of the learned information. The presence of an organizational or categorical structure or pattern in “to be remembered” information is positively related to the ability of the learner to store and retrieve the information (Bower, Clark, Lesgold, & Winzenz, 1969; Broadbent, Cooper, & Broadbent, 1978; Tulving & Pearlston, 1966). While simple information may be recalled verbatim, complex information requires the memory system to extract an explicit or implicit structure or pattern of information to enhance retrieval and recall (Baddeley, 1998).

A memory impairment due to poor use of organizational strategies, whether self-initiated or inherent in the material, appears to be universal in autism. Its expression is severity dependent, requiring increasingly challenging tasks to reveal the deficit at higher general levels of ability. Mentally retarded children with autism have been found to perform as well as matched controls on free recall of semantically unrelated word lists but significantly less well on related word lists, because the memory of controls improved with semantic content while that of the children with autism did not (Hermelin & O’Connor, 1970). The children with autism also did not use regrouping or sentence organization strategies to facilitate recall of lists of words, even when word order deliberately facilitated this strategy. High functioning children and adults with autism have been shown to extract word categories or patterns when learning word lists, but they do not use them as well as controls, resulting in a subtle inefficiency of memory and learning for word lists (Bennetto et al., 1996; Frith, 1970; Minshew & Goldstein, 1993, 2001; Tager-Flusberg, 1991). High functioning children and adults have considerable difficulty with memory for complex grammatical sentences and stories, which involve a higher level of semantic organization than word lists (Minshew & Goldstein, 2001). This same pattern of increasing difficulty with increasing semantic structure was also reported by Fein et al. (1996) in mildly retarded children with autism who had the least trouble recalling digits, more difficulty with sentences, and the greatest difficulty with stories.

The effect of the complexity of the material on memory in autism has also been reported with respect to visual stimuli. High functioning adults with autism have shown deficits on immediate and delayed recall of complex designs such as the Rey-Osterrieth Complex Figure (Minshew
and did progressively more poorly than controls on a stylus maze task as the complexity of the maze was increased (Minshew & Goldstein, 2001). Ameli et al. (1988) found that high functioning individuals with autism performed significantly worse than matched normal controls on visual recognition memory for complex meaningless shapes (nonsense forms). However, they did as well as controls on meaningful shapes, suggesting that while they were able to make use of the structure inherent in meaningful shapes, they could not create an organizational structure to help them recall the meaningless shapes.

The task other than the Rey-Osterrieth Complex Figure commonly used in neuropsychology to assess memory for complex visual material is recall of faces. Several studies have found that children with autism have an impaired memory for previously viewed faces as compared to mental age and nonverbal mental age matched controls (Boucher & Lewis, 1992; de Gelder, Vroomen, & van Der Heide, 1991; Klin et al., 1999; McPartland & Pangiotides, 2001). Gepner, de Gelder, and de Schonen (1996) reported that children with autism had poor immediate memory for unknown faces and performed better on remembering what shoes they had seen than what faces they had seen. Plaisted (2000) has proposed that faces are difficult for children with autism not simply because they are faces, or social information, but because they are complex information. She argues that “faces belong to a category of complex stimuli with spatial configurations and that the deficit in autism lies at the level of processing complex spatial configurations” (Plaisted, 2000, p. 244). This deficit in face recognition and the previously described impairments in memory share a reliance on rapid automatic concept, strategy or prototype formation required for dealing with complex information.

One study has assessed the impact of memory dysfunction in autism on real life function. Boucher (1981) observed that children with autism recalled significantly less than matched controls about activities they participated in recently even with contextual cues. Boucher (1981) concluded that children with autism encoded less information from complex stimuli, such as ongoing events. She proposed that this memory deficit would have an adverse impact on social interactions because of the complexity of the stimuli involved.

The purpose of the present study was to use a standard clinical instrument, the Wechsler Memory Scale-III (WMS-III; Wechsler, 1997b), to examine memory in non-retarded individuals with autism. This test assesses learning, memory, and working memory in immediate and delayed conditions in both the auditory and visual modalities. There is also a range of stimulus complexity, although there are no simple visual memory tasks. A major advantage of this instrument is that many types of stimuli are assessed in the same participants (whereas most prior studies have reported on just one type of stimuli, like words or faces) and several of the subtests have direct relevance to everyday life.

1. Method

1.1. Participants

The participants in this study were 29 individuals with autism (26 males and 3 females) and 34 normal control individuals (30 males and 4 females) between the ages of 16 and 53 years.
Table 1
Demographic and psychometric data for individuals with autism and control groups

<table>
<thead>
<tr>
<th></th>
<th>Autism (n = 29)</th>
<th>Control (n = 34)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>S.D.</td>
</tr>
<tr>
<td>Age</td>
<td>28.72</td>
<td>10.44</td>
</tr>
<tr>
<td>SES a</td>
<td>4.11b</td>
<td>1.70</td>
</tr>
<tr>
<td>Years of education</td>
<td>13.11</td>
<td>2.31</td>
</tr>
<tr>
<td>Verbal IQ</td>
<td>108.76</td>
<td>14.85</td>
</tr>
<tr>
<td>Performance IQ</td>
<td>100.76</td>
<td>13.85</td>
</tr>
<tr>
<td>Full scale IQ</td>
<td>105.86</td>
<td>14.19</td>
</tr>
<tr>
<td>Female (%)</td>
<td>10.3</td>
<td>11.8</td>
</tr>
</tbody>
</table>

a Hollingshead-Redlich Scale.
b These values reflect middle-class status (e.g., administrative personnel, small business owners).

All had Verbal and Full Scale Wechsler IQ scores above 80. Demographic characteristics are provided in Table 1. The two groups did not differ significantly with respect to age, Verbal or Full Scale IQ score, gender, race or SES. Each group had one member who was African American. This study was approved by the University of Pittsburgh Medical Center Institutional Review Board and written informed consent was obtained from participants or their guardians.

Participants with autism had no identifiable etiology for their autism such as tuberous sclerosis or fragile-X syndrome. All participants with autism communicated in grammatically correct complete sentences and were able to cooperate with testing. Screening tests to determine eligibility of the participants with autism with respect to cognitive abilities included the Wechsler Adult Intelligence Scale-III (Wechsler, 1997a) and the Kaufman Test of Educational Achievement (K-TEA; Kaufman & Kaufman, 1985). The diagnosis of autism was provided by the agreement of the results from two structured instruments, the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 1989) and the Autism Diagnostic Interview (ADI and ADI-Revised; Le Couteur et al., 1989; Lord, Rutter, & Le Couteur, 1994) administered by two separate individuals and was also confirmed by expert clinical opinion. Subjects with autism were also required to be in good medical health, free of seizures and have a negative history of traumatic brain injury.

All the cases in this study had delayed and disordered language development and met ADI and ADOS criteria for autism. They also met the DSM-IV criteria for Autistic Disorder and did not meet criteria for Asperger’s Disorder. While this group of participants did not include individuals with Asperger’s, it should be noted that research comparing those diagnosed with High Functioning Autism and Asperger’s Disorder has generally concluded that there are no distinctions between the two that are not explainable by IQ differences and the tendency in the community to use the diagnostic label of Asperger’s in higher IQ cases (Miller & Ozonoff, 2000). The relatively small number of female subjects in the sample is consistent with the lower prevalence of autism in females relative to males. Preliminary analysis of the data indicated no significant differences between males and females on any of the WMS-III scores with the exception of the Spatial Span subtest on which males did better. Male and female subjects were therefore combined for the data analysis.
Controls were volunteers from the community who met preset inclusion and exclusion criteria. Potential controls were screened by completion of a questionnaire on demographic information and family and personal history. They were also observed during psychometric testing for evidence of social, communication, or other abnormality. Controls were required to be in good physical health, free of regular medication usage, and have good peer relationships, based on report and staff observations during testing. Controls were excluded if they had a history of neuropsychiatric disorder, learning disability or brain insult at or after birth, or a positive history in first degree relatives of developmental cognitive disorders, affective or anxiety disorder, or autism in first or second degree relatives. Controls were recruited from neighborhoods with socioeconomic status similar to that of the families of origin of the participants with autism.

1.2. Procedure

Several trained technicians administered the WMS-III. The WMS-III is a revision of the Wechsler Memory Scale-Revised and is an individually administered instrument designed to function as part of a neuropsychological test battery. The WMS-III is comprised of 10 subtests: Logical Memory I and II, Verbal Paired Associates I and II, Faces I and II, Family Pictures I and II, Letter-Number Sequencing, and Spatial Span. In each case, subtest II is a delayed recall version of subtest I and is administered approximately 30 min after subtest I. Due to the nature of the disorder of autism, it was not possible to blind the technicians to participant group membership.

On the Logical Memory I subtest of the WMS-III, the participant listens to two different one episode stories (A & B) with a large number of details as they are read aloud by the examiner, and is immediately asked to retell the story from memory. Points are awarded for each designated story unit and each thematic unit. In the delayed recall task, the participant is asked to retell both of the stories from memory.

The Verbal Paired Associates I subtest consists of the presentation of a list of eight pairs of unrelated words. The participant is then given the first word of the pair and asked to recall the second word for four trials. The delayed recall consists of a single trial of the word pairs.

For the Faces I subtest the participant is shown 24 photographs of faces one at a time. The participant is then shown 48 faces one by one and asked to respond “yes” or “no” to indicate whether or not they had seen the face in the earlier presentation.

In the Family Pictures I subtest the participant views four different scenes of four family members engaged in a common activity (such as buying clothing). After viewing all four scenes, the participant is shown a card divided into four quadrants, given the name of the scene, and asked to recall it, indicating where each family member was located in the original picture and what that family member was doing.

For the Letter-Number Sequencing subtest the participant is read strings of letters and numbers one at a time ranging in length from 2 to 8 items and asked to first give the numbers in ascending order and then the letters in alphabetical order. At the initiation of the Spatial Span subtest, the participant is presented with a board with 10 solid-color blocks in fixed locations. The examiner then touches the blocks in predetermined sequences two to nine blocks in length. The participant is asked to tap the blocks in the demonstrated sequence either forward or backward.
2. Results

For all of the analyses, the raw scores were converted to scaled scores based on the participant’s age using normative information provided in the WMS-III manual. The means and standard deviations for the individual subtest scaled scores from the WMS-III are presented in Table 2.

Except as indicated, repeated measures ANOVA were performed to compare the performances of the participants with autism and the control group, to compare the within group performance for the two trials of the subtest and to determine the trials × group interactive effects. The results of all statistical comparisons are summarized in Table 3.

Table 2
Means and standard deviations for the primary subtest scaled scores from the WMS-III

<table>
<thead>
<tr>
<th>Subtest</th>
<th>Autism M</th>
<th>Autism S.D.</th>
<th>Control M</th>
<th>Control S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logical Memory I</td>
<td>11.41</td>
<td>2.99</td>
<td>11.85</td>
<td>2.18</td>
</tr>
<tr>
<td>Logical Memory II</td>
<td>11.59</td>
<td>3.54</td>
<td>12.24</td>
<td>2.18</td>
</tr>
<tr>
<td>Verbal Paired Associates I</td>
<td>10.24</td>
<td>2.71</td>
<td>10.38</td>
<td>2.99</td>
</tr>
<tr>
<td>Verbal Paired Associates II</td>
<td>10.72</td>
<td>2.53</td>
<td>10.53</td>
<td>2.63</td>
</tr>
<tr>
<td>Faces I</td>
<td>8.00</td>
<td>2.73</td>
<td>10.12</td>
<td>2.99</td>
</tr>
<tr>
<td>Faces II</td>
<td>7.97</td>
<td>2.46</td>
<td>10.94</td>
<td>3.36</td>
</tr>
<tr>
<td>Family Pictures I</td>
<td>7.66</td>
<td>3.03</td>
<td>11.85</td>
<td>2.70</td>
</tr>
<tr>
<td>Family Pictures II</td>
<td>7.28</td>
<td>3.02</td>
<td>11.85</td>
<td>2.79</td>
</tr>
<tr>
<td>Letter-Number Sequencing</td>
<td>10.86</td>
<td>3.07</td>
<td>11.38</td>
<td>2.24</td>
</tr>
<tr>
<td>Spatial Span</td>
<td>8.24</td>
<td>3.42</td>
<td>11.79</td>
<td>2.14</td>
</tr>
</tbody>
</table>

Table 3
Results of statistical analyses

<table>
<thead>
<tr>
<th>Subtest</th>
<th>Group t</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Letter-Number Sequencing</td>
<td>-.78</td>
<td>.44</td>
<td></td>
</tr>
<tr>
<td>Spatial Span a</td>
<td>15.77</td>
<td>&lt;.001</td>
<td></td>
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</table>

Repeated measures ANOVA results

<table>
<thead>
<tr>
<th>Subtest</th>
<th>Group F</th>
<th>p</th>
<th>φ²</th>
<th>Within F</th>
<th>p</th>
<th>φ²</th>
<th>Interaction F</th>
<th>p</th>
<th>φ²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logical Memory I and II</td>
<td>.68</td>
<td>.41</td>
<td>.01</td>
<td>1.75</td>
<td>.19</td>
<td>.03</td>
<td>.25</td>
<td>.62</td>
<td>.00</td>
</tr>
<tr>
<td>Verbal Paired Associates I and II</td>
<td>.01</td>
<td>.91</td>
<td>.00</td>
<td>.72</td>
<td>.40</td>
<td>.01</td>
<td>.07</td>
<td>.80</td>
<td>.00</td>
</tr>
<tr>
<td>Face Recognition I and II</td>
<td>13.41</td>
<td>.001</td>
<td>.18</td>
<td>2.46</td>
<td>.12</td>
<td>.04</td>
<td>2.91</td>
<td>.09</td>
<td>.05</td>
</tr>
<tr>
<td>Family Pictures I and II</td>
<td>37.53</td>
<td>&lt;.001</td>
<td>.38</td>
<td>2.34</td>
<td>.13</td>
<td>.04</td>
<td>2.34</td>
<td>.13</td>
<td>.04</td>
</tr>
</tbody>
</table>

Note. φ² = effect size.

a Performance IQ used as a covariate.
The within and between group performances on trials 1 (immediate recall) and 2 (delayed recall) of the Logical Memory subtest, in which the respondent is asked to recall details and the thematic units of two auditorily presented stories, were compared. There was no main effect for group, no trial effect and no trials × group interaction (see Table 3). In addition to a total score for this subtest, the WMS-III provides separate scores for the recall of details and for the verbal mention of the main thematic units of each of the stories. A comparison of the scores for the immediate and delayed recall of details for Story A yielded no significant difference in performance between the participants with autism and the control group, $F(1, 61) = .29, P = .59$. Both groups recalled more details at time 1 than time 2, $F(1, 61) = 46.36, P > .001$, but no interaction between group and task was found, $F(1, 61) = .49, P = .49$. A comparison of recall of details for Story B, the immediate retelling of Story B, and the delayed retelling of Story B yielded similar results. No significant between, $F(1, 61) = .68, P = .41$, or within, $F(1, 61) = .60, P = .44$, group differences were revealed when the scores for thematic units for Logical Memory I and II were compared. The WMS-III provides for the calculation of a percent retention score based on the performance of the individual on the Logical Memory II subtest. A $t$-test comparing the difference between the two participant groups on this measure did not yield a significant difference, $t(61) = -1.42, P = .16$.

Similar results were obtained using the scaled scores for immediate and delayed recall of the Verbal Paired Associates subtests. No main effect for group or for performance from trial 1 to trial 2 was obtained. No interaction effect occurred for trials × group.

Results of an independent sample $t$-test comparing the performance of the two groups on the Letter-Number Sequencing subtest yielded no significant group difference.

For the Faces subtest, a significant main effect between groups was observed. There was no significant difference in the performance of either group from trial 1 (immediate recall) to trial 2 (delayed recall). The trials × group interaction was also not significant. The participants with autism performed more poorly than the controls on both the first and second administration of the Faces Recognition subtest but their performance in the delayed condition was not significantly changed from their immediate recall.

A comparison of the performance of the autism and control groups on the two trials of the Family Pictures subtest yielded a significant main effect for group with the controls out-performing the group with autism. No significant difference was obtained on the within group performance of the participants from trial 1 (immediate recall) to trial 2 (delayed recall) and there was no trials × group interaction. Thus, as with the Faces subtest, the autism group performed more poorly than the controls on immediate and delayed recall of the Family Pictures but their performance in the delayed condition was not significantly changed from their immediate recall. Because the Faces, Family Pictures and Spatial Span subtests involve visual memory, analyses were repeated using Performance IQ as a covariate. This procedure did not alter the significance level of group differences for any of these subtests. Group differences for Faces, Family Pictures, and Spatial Span remained significant following controlling for level of intelligence on the WAIS-III performance IQ scale. All significant between group differences were at the <.001 level, suggesting that chance significance was not a consideration in determining the results.
3. Discussion

This study of memory in non-retarded adults with autism using a clinical memory test, the Wechsler Memory Scale-III, revealed no deficits in immediate or delayed memory for word pairs or stories. There was also no evidence of a deficit in verbal working memory. The autism group was impaired on immediate and delayed recall of faces and of family scenes, but there was no worsening under the delayed condition. They also had impaired spatial memory. Thus, no deficits were found in verbal memory in this group of non-retarded adults with autism, but deficits were present in all aspects of visual memory tested.

The absence of difficulty with paired associate learning in this autism group is consistent with a previous study reporting intact performance of another group of non-retarded adolescents and adults with autism on three-word short-term memory and paired associate learning procedures (Minshew & Goldstein, 2001). Paired associate learning places little to no demand on organizational strategies and thus is dependent on rote memory strategies that have been demonstrated to be intact in autism by many studies.

A deficit was anticipated but not found on immediate or delayed recall of stories. Rumsey and Hamburger (1988) also found no difficulty in recall of the Wechsler Memory Scale (WMS) stories by their 10 adults with autism. The negative findings for the current group of participants are in contrast to the impaired performance on the same Anna Thompson story (WMS-R) by another group of non-retarded individuals with autism (Minshew & Goldstein, 2001). Differences between the two studies reporting negative results and the study that found impaired story recall could be related to several factors. The autism and control groups in the present study and in that of Rumsey and Hamburger (1988) had Full Scale and Verbal IQ scores 14 points higher than the study reporting deficient story recall; therefore, the lack of difficulty of the present subjects in recalling the WMS-III stories may be because these brief stories were not sufficiently challenging for individuals with autism and average IQ, and thus did not reveal a memory problem. Both the present study and the Rumsey and Hamburger study were confined to adults whereas the study reporting impairment (Minshew & Goldstein, 2001) included adolescents and adults. It could be that deficits in story recall are present in non-retarded children and adolescents with autism but that brain maturation results in sufficient acquisition of conceptual abilities such that these brief stories are no longer sufficiently challenging. A third possibility is that the changes in the scoring system between the WMS-R and WMS-III resulted in more credit for details in the latest version. However, the most likely explanation is the 14-point IQ advantage of the two groups who did not demonstrate deficits on story recall.

Verbal working memory was also assessed in this study and no deficits were found in the autism group. Although one initial study reported a deficit in verbal working memory in non-retarded children with autism (Bennetto et al., 1996), a second study did not (Russell, Jarrold, & Henry, 1996). The importance of the status of verbal working memory in autism is related to the executive dysfunction-frontal systems theory, which, until a few years ago, was a leading model for autism (Pennington et al., 1997). Recent findings that have challenged this theory include lack of evidence of group differences in performance on executive function tasks by preschoolers with autism (Dawson et al., 2002; Griffith, Pennington, Wehner, & Rogers, 1999) and the lack of universality of executive function impairments (Liss et al., 2001). The executive dysfunction theory predicts deficits in verbal working memory (Pennington et al.,
In contrast to the integrity of verbal working memory, a deficit was found in spatial working memory. It could be argued that the autism group did more poorly than the controls because their mean Performance IQ score was 10 points lower than the controls’ and Spatial Span is highly correlated with Performance IQ. However, controlling for performance IQ did not remove the statistically significant difference between the performance of the participants with autism and the controls. This finding suggests that the scores were the result of an underlying factor and not simply a function of the lower IQ scores.

This deficit in spatial working memory is consistent with the findings of other studies with the exception of Ozonoff and Strayer (2001) who documented intactness of working memory in autism. A nonverbal selective reminding task similar to the test used in this study revealed a deficit in spatial working memory in a previous group of non-retarded adults with autism (Minshew, Goldstein, & Siegel, 1997). A classic test of spatial working memory is the oculomotor delayed response task in which participants move their eyes to the location where a light briefly appears after varying delays (Goldman-Rakic, 1996). However, in a study using this task with non-mentally retarded participants with autism, Minshew, Luna, & Sweeney (1999) found that the task was failed not because the autism participants forgot where the target was, but because the accuracy of their responses was reduced. This result suggested that it was not working memory per se that was the problem. Rather, the calculation or processing demands required by the brain to arrive at the precise location exceeded the capacity of the subjects with autism. The spatial working memory task from the WMS-III is similarly demanding on processing resources due to its lack of structure. Thus, in the case of autism, an apparent spatial working memory deficit may not be the result of impaired working memory but of inability to perform the complex information processing typically associated with spatial working memory tasks.

This consideration could lead to the conclusion that memory is not the cognitive domain responsible for the poor performances obtained by individuals with autism. Rather, an apparent deficiency in memory could be due to deficits in visuoperceptual or spatial reasoning. While the WMS-III does not directly assess these skills, the participants in this study were also assessed with a larger neuropsychological battery that included assessments of these areas. The performance of the individuals with autism were in the average range and did not significantly differ from that of the controls on the Picture Completion, $t(61) = -1.50, P = .14$, Block Design, $t(61) = -.90, P = .37$, or Object Assembly, $t(56) = -1.28, P = .21$, subtests from the WAIS-III (Wechsler, 1997a). A reduced sample (16 autism and 14 control participants) also received the Benton Judgment of Line Orientation Test (Benton, Hamsher, Varney, & Spreen, 1983) on which the autism group obtained a mean score in the average range ($M = 25.69$, S.D. = 5.06). The difference from the controls was nonsignificant ($t = 1.10, P > .05$). These findings indicate the presence of intact skills in these areas. A finding of intact visuoperceptual skills is consistent with previous reports in the literature on autism (O’Riordan & Plaisted, 2001; Shah & Frith, 1993).

The differential performance on the verbal and the visual memory subtests may be related to the nature of the tasks within each of these domains rather than a domain specific event. The visual memory subtests may be inherently more difficult than the verbal memory sub-
tests. Thus, the autism group may have performed poorly on these subtests simply because of difficulty with more difficult tasks. However, in other published studies we have demonstrated that, while individuals with autism do have difficulty with more complex tasks, it is not the result of a generalized deficit (Minshew et al., 1997). We have shown that individuals with autism have differential deficits so that it is difficult to predict the level of complexity at which their responses will begin to break down (Minshew et al., 1997; Minshew, Meyer, & Goldstein, 2002). One consistency in the performance of high functioning individuals with autism appears to be a positive response to an inherent organizational structure (Minshew & Goldstein, 2001). This factor appears to be a greater influence on their level of performance than the level of task demands. Thus, prior research indicates that the performance of the individuals with autism is not interpretable as the result of a generalized deficit in which they have more difficulty simply because the task itself is a more difficult one (Minshew et al., 1997).

The reason for the dissociation in the status of verbal and spatial working memory in autism is unknown but certainly consistent across measures and subject groups. It could be that the lack of an intrinsic structure to many spatial working memory tasks makes those tasks more demanding. The language element in verbal working memory tests may provide sufficient scaffolding or structure to make such tasks less demanding than spatial working memory tasks. In addition, the semantic content of the typical test of verbal working memory is very simple, as in the Letter-Number Sequencing subtest of the WMS-III. Recall on this task uses highly familiar alphabetic and numeric order. If the processing demand of the task is increased, as occurs with comprehension of complex grammatical sentences, deficits in verbal working memory become apparent in non-retarded subjects with autism not because of reduced working memory capacity but because of increased information processing demands (Minshew & Goldstein, 2001).

The WMS-III also revealed deficits in memory for faces in the autism group consistent with previously reported results (Blair, Frith, Smith, Abell, & Cipoletti, 2002; Boucher and Lewis, 1992; de Gelder et al., 1991; Gepner et al., 1996; Klin et al., 1999; McPartland & Panagiotides, 2001). Together these studies demonstrate that deficits in face memory are present across the autism severity spectrum and also that they persist across the life span. As noted, Plaisted (2000) has proposed that the difficulty with recall of faces may be because they are complex spatial configurations. Others have emphasized instead the neural basis of face processing proposing that the deficit is related to a dysfunction in superior temporal sulcus associated with recognition memory for moving objects (Blair et al., 2002). Some studies have focused on the fusiform gyrus which, until recently, was considered to be specialized for face recognition (Kanwisher, McDermott, & Chun, 1997). Consistent with this idea, two studies of individuals with autism reported reduced activation in the fusiform area and/or increased activation in aberrant areas such as the frontal cortex, primary visual cortex, cerebellum, and right inferior temporal gyri suggesting that the fusiform area did not develop its normal specialization for faces (Pierce, Muller, Ambrose, Allen, & Courchesne, 2001; Schultz et al., 2000).

Any argument that face memory problems in individuals with autism are related to the complexity of the stimulus must also address the previously reported finding that individuals with autism do not demonstrate difficulty with memory for stimuli that some would argue are as complex as faces, such as buildings (Boucher & Lewis, 1992). Although both buildings
and faces can be seen as complex stimuli, there is evidence that these stimuli are processed differently (Levy, Hasson, Avidan, Hendler, & Malach, 2001). An emerging theory about the face recognition system proposes that it is a complex pattern recognition system based on configural representations or template prototypes while manufactured objects, such as buildings, are based on a different type of recognition process (Kanwisher & Moscovitch, 2000). Difficulty with prototype formation would thus disrupt the face recognition system while the recognition system for buildings remains intact in autism.

The group with autism also had significant difficulty with memory for everyday family scenes. The Family Pictures subtests measure memory skills that are needed for encoding of actual events, the recall of the actors, their locations, and their ongoing activities. The impaired performance of the autism group on these subtests is consistent with the results of Boucher (1981), who reported that children with autism recalled significantly less about recently experienced events than language-matched peers. She proposed that their difficulty related to the complexity and amount of stimuli, which was further accentuated by their dynamic quality. In the Family Pictures subtests, a sequence of four pictures is presented, and the subject is asked to identify the location and activity of each character in one of these pictures. Successful performance on this test requires the capacity to rapidly and automatically identify the theme of the picture, recognize the activities as subordinate details, encode each activity spatially, and associate the correct character with each action. The pictures are therefore quite complex in terms of the amount of information contained in them. The procedure resembles the demands of real life, though still falling very far short of the amount and rapidity of presentation of stimuli in everyday life.

Difficulty on the Family Pictures subtests could be the result of an inability to rapidly and automatically identify the thematic organization of the pictures to facilitate recall of the details of the pictured action. In addition to the complexity of the pictures, this task also involves facial recognition and spatial memory. However, the recognition of the characters is based not on faces alone as much as on hair cues, clothing and other stylized features of elderly persons or children, and the spatial demands are at a gross level rather than the fine discriminations that are typically required on tests of spatial working memory. Thus, these factors likely contributed little to impaired memory on this task.

Another issue involving the visual stimuli is the social nature of faces and scenes depicting social interaction. It could be argued that the stimuli were difficult for the individuals with autism not because of their complexity but because they involve social perception. Certainly an essential part of the social deficit in autism is making inferences about the perspective, intentions, and motives of others. However, the Family Pictures subtest of the WMS-III does not have a theory of mind component. The required tasks are to recall previously viewed pictures and to tell who was doing what in which part of the picture. Certainly prior social knowledge of people and events would allow the individual to bring that knowledge to assist in the task. However, the individuals with autism also had difficulty on the spatial working memory task that has no social component. Since they did poorly on both social and nonsocial stimuli, we would propose that it is the complexity of the stimuli rather than their social component that is the important factor.

A final interesting finding is that the memory of the autism group did not decay with delayed recall for either verbal or visual material. This finding is consistent with those
reported by Minshew and Goldstein (2001) in another cohort and by Rumsey and Hamburger (1990). If the subjects with autism successfully encoded the material for immediate recall, the material was still available for recall 30 min later. Generally retention of information is dependent on the depth of encoding, which relates to the use of structure and organization in memory acquisition and storage. It would be reasonable therefore to expect that if use of structure and organization is deficient, that memory in autism would be characterized by relatively rapid forgetting. In contrast, verbal individuals with autism are renowned for the capacity to remember minutiae indefinitely. One possible explanation is that there are two somehow reciprocal features of the memory problem in autism—one is the reduced use of structure and the second is enhanced retention of encoded trivial details. The lack of decay suggests that the abnormality both in reduced encoding and enhanced retention is at the level of encoding.

With improved understanding of the neurobiology of autism, the alteration in the neural circuitry responsible for these phenomena may become apparent. Conceptualizations of the neurobiology of autism are rapidly evolving with emerging data. As proposed above, impairments in spatial working memory, memory for faces and memory for social situations are interpreted to represent difficulty with managing complex information. In the case of spatial working memory as opposed to verbal working memory, the difficulty appears to be related to the computational challenge imposed by the task in the absence of environmental cues. With regard to face recognition, the impairment is likely related to the difficulty in forming prototypes necessary to handle this type of complex information. Efficiency in dealing with social scenes also requires the identification of themes or organizing strategies. The common cognitive theme of these deficits is dependence on concept formation, a complex information processing ability.

Emerging evidence suggests that the neural basis for the information processing abnormality in autism involves the localized circuitry of neocortex and its intra- and inter-hemispheric connections, i.e., the U fiber, association and commissural pathways. These hypotheses about the brain abnormality are supported by reports of two brain abnormalities in autism. Recent imaging studies have found an early transient accelerated growth of the brain in autism that resulted in an increase in total brain volume that “normalized” in late childhood as a result of brain volume changes in children with autism and brain growth in normal children (Aylward, Minshew, Field, Sparks, & Singh, 2002; Courchesne et al., 2001). The increase in total brain volume involved both cerebral gray and white matter volumes. Most recently, a neuropathologic study of several areas of neocortex has found bilateral abnormalities in minicolumnar composition and organization (Casanova, Buxhoeveden, Switala, & Roy, 2002). The minicolumns were small, more densely packed horizontally, and more widely dispersed vertically. Interestingly, an increase in minicolumns would result in an increase in white matter to accommodate the increase in connections required for the columns to be connected. The demonstration of abnormalities in the cerebral cortex of the brain in autism is a milestone. The neuropathology up until now has been remarkable for the paucity of findings. The studies have been few, narrow in their focus, at the cellular level of examination, and remarkable for the absence of abnormalities in the cortex that would more logically account for the deficits in higher order cognitive functions. Considerable research needs to be done to explore these hypotheses further.
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