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Memory Awareness in Individuals with Autism

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Abstract

Little is known regarding metacognition in individuals with autism. Specifically, it is unclear how individuals with autism think about their own mental states. The current study assessed memory awareness during a facial recognition task. High-functioning children (*M*=13,1 years, *n*=18) and adults (*M*=27.5 years, *n* =16) with autism matched with typically developing children (*M* =14.3 years, *n* =13) and adults (*M* =26.9 years, *n*=15) were tested. Children with autism demonstrated less accurate memory awareness and less reliable differentiation between their confidence ratings compared to typically developing children. Subtle impairments in memory awareness were also evident in adults with autism. Results indicate that broader metacognitive deficits may exist in individuals with autism, possibly contributing to other known impairments.

Keywords

autism; face recognition; memory awareness; theory of mind; metacognition

Although autism is a developmental disorder characterized by behavioral, communicative and social impairments, the majority of research on autism has focused on deficits within the social domain, including those relating to nonverbal behaviors (e.g., eye-to-eye gaze), the quality and quantity of social relationships, interpersonal sharing, and social or emotional reciprocity. Research on social deficits in individuals with autism burgeoned when children with autism were found to have impaired theory of mind, or an impaired ability to attribute mental states to others (Baron-Cohen, Leslie, & Frith; 1985). Compared to typically developing children, children with autism are significantly delayed in their understanding of false-belief tasks and require a higher verbal mental age in order in order to make successful attributions about another person's mental state (Happé, 1995; Pellicano, 2007). Moreover, individuals with autism continue to have impairments in advanced tests of theory of mind into adulthood (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997). While theory of mind continues to be the focus of much research on autism, little research has examined individuals' with autism understanding of their own mental states, or metacognition.

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Metacognition can broadly be defined as one's general knowledge regarding any aspect of cognitive activity, either within *oneself* or within *others* (Lockl & Schneider, 2007). Under this definition, metacognition includes the knowledge typically described as theory of mind. However, more specifically, metacognition can be divided into two types, metacognitive *knowledge* of cognition and metacognitive *regulation* of cognition (Shraw & Moshman, 1995). Metacognitive knowledge refers to what an individual knows about cognition, including declarative knowledge (e.g., knowledge about oneself as a learner and about factors that influence performance), procedural knowledge (e.g., knowledge about the execution of strategies or procedural skills), and conditional knowledge (e.g., knowledge concerning when and why to apply various cognitive processes). In contrast, metacognitive regulation refers to how one actively uses metacognitive knowledge to influence cognition. Metacognitive regulation includes planning (e.g., the selection of appropriate strategies and allocation of resources), monitoring, (e.g., one's online awareness of comprehension and task performance), and evaluation (e.g., one's assessment of what one knows).

Commenting on the theory of mind literature, Frith (1989) acknowledged that little attention has been given to a child's awareness of self, noting that "there is no reason to distinguish the ability to reflect on other people's mental states and on our own. This reflective ability is self-awareness in the case when we consider our own states of mind. To know that we know and to think about our own thinking are accomplishments that presuppose higher order processing ability," (p. xx). Thus, the theoretical relationship between theory of mind and metacognition highlights the need for further metacognitive research with individuals with autism, as general metacognitive deficits could contribute to impairments in both social and nonsocial learning.

Despite increasing recognition concerning the similarity between theory of mind and metacognition, there is a paucity of research on metacognition in individuals with autism (Farrant, Blades, & Boucher, 1999; Farrant, Boucher, & Blades, 1999). In one study, Farrant, Blades and Boucher (1999) examined recall readiness in children with autism. Recall readiness refers to the ability to monitor learning and judge when information has been sufficiently learned so that it can be later recalled. Children with autism performed worse on the recall readiness task, indicating that they have trouble monitoring and evaluating their own memory. In contrast, another study by Farrant and colleagues (1999) examined several components of metamemory in children with autism, including knowledge about variables that influence memory such as knowledge about memory strategies, and knowledge about another person's memory. Although there were qualitative differences in the types of memory strategies they reported using, children with autism did not differ from typically developing children in their *knowledge* about memory. Thus, the limited research on metacognition in individuals with autism is mixed.

These conflicting findings, however, may reflect a difference between the ability to understand metacognitive knowledge versus the ability to use or regulate metacognitive knowledge. For example, metacognitive knowledge or rules can be taught. For instance, one can be taught to improve memory by using rehearsal or saying things out loud. These static rules require little tailoring to one's individual needs. In contrast, metacognitive regulation requires active tracking of information and is highly specific to the situation, the task demands, and the individual. Thus, while monitoring performance on a test, there is no algorithm to determine how well one is doing, but, rather, estimates of performance might be based on the amount of time spent studying, the testing situation, the material being tested, performance on previous tests, and general feelings of confidence. Thus, while individuals with autism may understand metacognitive knowledge, they may be impaired in their abilities to use or regulate metacognitive information.

A critical aspect of metacognitive awareness is the ability to monitor one's own memory performance. With typically developing children, memory awareness is usually measured by comparing confidence judgments to actual performance. The accuracy of the confidence judgment, or the accuracy of the memory awareness, is indicated by the degree to which reported confidence corresponds with actual performance. In an early study, Berch and Evans (1973) examined the accuracy of confidence judgments of typically developing children. Children as young as 5 years of age were able to use a 4-level confidence rating scale to accurately assess their memory recall. Research has shown that memory awareness accuracy continues to improve with development and, by adulthood, typically developing individuals have highly accurate memory awareness (Allwood, Granhag & Jonsson, 2006; Pressley, Ghatala & Ahmad, 1987; Roebers, Gelhaar & Schneider, 2004; Roebers & Howie, 2003; Roebers, 2002). However, little is known regarding individuals with autism's understanding of their own mental processes (Happé, 1995; Yirmiya et al., 1998). In particular, it is unclear whether impairments in metacognitive monitoring and evaluating, as measured by memory awareness, exist with regard to one's own mental states in individuals with autism.

The Current Study

This study examined memory awareness accuracy in children and adults with autism during a face recognition task. Memory awareness was assessed using confidence judgments as has been previously done with typically developing children (Berch et al., 1973). While memory awareness for faces is generally important for social functioning, it is particularly important for individuals with autism. Ample research suggests that individuals with autism have difficulty processing faces (Hauck, Fein, Maltby, Waterhouse, & Feinstein, 1998; Rouse, Donnelly & Hadwin, 2004) and that this difficulty continues into adulthood (Blair, Frith & Smith, 2002; Molesworth, Bowler, & Hampton, 2005; Rump, Giovannelli, Minshew, & Strauss, 2008;Williams, Goldstein & Minshew, 2005). However it is unknown to what extent individuals with autism are aware of this face recognition deficit. More specifically, are individuals with autism able to monitor their memory on face recognition tests in order to identify faces they remember compared to faces they do not remember?

A benefit of studying memory awareness within face recognition is that it is a task with real life analogs, as one is frequently expected to remember what acquaintances look like. Furthermore, metacognitive impairments within this domain would have substantial repercussions for social interactions. Poor memory awareness for faces may lead to confusing and potentially negative social experiences; whereas, accurate memory awareness of one's impaired ability to recognize faces would allow for compensatory strategies. Thus, while memory awareness is generally important for learning, it has additional implications within the domain of face recognition for individuals with autism.

Method

Participants

Participants included both children and adults. Child participants consisted of 18 high-functioning children with autism and 13 typically developing control children who ranged in age from 9 to 17 years. Adult participants included 16 high-functioning adults with autism and 15 control adults who ranged in age from 18 to 45 years. Control participants in each age group were matched with participants in the autism group on age, full scale IQ, verbal IQ, and performance IQ. Table 1 summarizes the participants' demographic characteristics. For both children and adults, no significant differences existed between the autism group and the control group for any demographic variable.

Participants were recruited through public advertisements. For the autism group, participants' diagnoses were confirmed using the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore, & Risi, 2003) and the Autism Diagnostic Interview-Revised (ADI-R; Rutter, Le Couteur, & Lord, 2003) and clinical opinion. Participants with Asperger's disorder or PDD-NOS were excluded. Control participants were volunteers recruited from the community. Parents of potential control participants completed questionnaires with demographic and family information to determine eligibility. Control participants were required to have a negative family history of first degree relatives with major psychiatric disorders and of first and second degree relatives with autism spectrum disorder. Control participants were also excluded if they had a history of poor school attendance or evidence of a disparity between general level of ability and academic achievement suggesting a learning disability. Additionally, the Wide Range Achievement Test-Fourth Edition (WRAT4; Wilkinson & Robertson, 2006) was administered to all participants to identify participants with a diagnosable learning disability. All participants were healthy, free of seizures, had a negative history of traumatic brain injury, and had an IQ greater than 80 as determined by the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999).

Apparatus

Testing occurred in a quiet room. Each participant sat in front of a 43-cm monitor controlled by a computer and responded using a modified keyboard with large keys (approximately 2.54 cm squares) that is commercially available for young children. During the recognition test, all keys were covered with black felt except for the two response keys labeled "old" and "new". The left and right location of the "old" and "new" labels was counterbalanced.

Stimuli

Stimuli during the learning phase consisted of 24 color photographs of adult female faces. During the memory test, stimuli consisted of 48 color photographs of adult female faces, 24 faces used in the learning phase (old), and 24 faces not used during the learning phase (new). For all stimuli, non-facial cues, (i.e., hair and clothing) were occluded. For both the learning phase and the memory test, stimuli order was randomized.

Procedure

At the initial visit, all participants were administered the WASI and the WRAT4 to determine eligibility. At the second visit, participants were tested on their face recognition and memory awareness. The face recognition task consisted of a learning phase followed by a memory test. Prior to the learning phase, participants were told that they were going to view a presentation of faces and to pay attention because immediately following the presentation their memory for the faces would be tested. Each stimulus in the learning phase was presented for 5 seconds, followed by a black screen for 4 seconds. Following the learning phase, participants were then tested on their recognition of the faces they had just seen. Participants were asked to push the key labeled "old" if they remembered seeing the face in the previous presentation and to push the key labeled "new" if they did not remember seeing the face in the previous presentation. During the memory test, stimuli remained on the screen until participants responded by pressing either the "old" or "new" button. After each memory assessment, participants were also asked to make a confidence judgment. Participants were instructed to say how certain or confident they felt regarding their response using a 3 point Likert scale consisting of "certain," "somewhat certain," and "guessing." For younger participants, an illustrated scale consisting of "sure," "somewhat sure," and "guessing" was used and participants were permitted to either say their response or to point to the corresponding word.

Memory Awareness Accuracy

For each participant, memory awareness accuracy was calculated for each certainty rating (certain, somewhat certain, and guessing) by dividing the number of correct trials for a given certainty level by the overall number of trials a participant reported a given certainty level. Thus, accuracy percentages reflected the percentage of correct recognition trials for each of the participants' certainty response levels. As a result, each participant had 3 measures of memory awareness accuracy: memory awareness accuracy when certain, memory awareness accuracy when somewhat certain, and memory awareness accuracy when guessing. It was expected that memory awareness would be most accurate when participants were certain and least accurate when participants were guessing.

Results

Separate two-way ANOVAs were conducted for child participants and adult participants, with diagnosis (control vs. autism) as a between-subjects variable, certainty (certain vs. somewhat certain vs. guessing) as a within-subjects variable, and memory awareness accuracy as the dependent measure. The preliminary analysis indicated that there was a violation of the assumption of sphericity. As a result, a Huynh-Feldt correction was employed in subsequent analyses.

Memory Awareness in Children

Results indicated a significant main effect of certainty, $F(1.46, 42.42)=18.41$, $p<.001$, suggesting that in general, memory awareness accuracy varied depending on one's certainty level, with increased accuracy reflecting greater certainty. Results did not indicate a significant main effect of diagnosis, $F(1, 29)=.24$, $p>.05$; however, there was a significant Diagnosis X Certainty interaction, $F(1.46, 42.42)=10.36$, $p<.001$ (see Figure 1). Thus, for children with autism, their accuracy was also differentially affected by their certainty level when compared to typically developing children.

Effect of diagnosis on certainty—Separate ANOVAs were conducted for each certainty level. When children reported that they were certain, memory awareness accuracy was significantly greater for typically developing children compared to children with autism [$F(1,29)=16.10$, $p<.01$]. In contrast, when children reported that they were somewhat certain, children in both groups performed similarly [$F(1,29)=.89$, $p>.05$]. Lastly, when children reported that they were guessing, children with autism were more accurate than typically developing children [$F(1,29)= 7.08$, $p<.05$].

Additional analyses were conducted to explore the discriminability among certainty judgments. Šidák-Bonferroni corrections were used to account for multiple comparisons. Paired *t*-tests were conducted to determine if memory awareness accuracy differed significantly between certainty levels. Among typically developing children, memory awareness accuracy when children were certain was significantly different than when they were somewhat certain, and memory awareness accuracy when they were somewhat certain was significantly different than when they were guessing [$t(12)=4.27$, $p<.01$; $t(12)=3.31$, $p<.05$, respectively]. Furthermore, *t*-tests were used to determine whether memory awareness accuracy levels for certain, somewhat certain, and guessing were significantly better than chance (50%). One would expect that if the relationship between memory awareness accuracy and certainty is meaningful, then accuracy levels both when certain and when somewhat certain would be statistically better than chance, whereas, accuracy when guessing would be random and therefore no different than chance. For children in the control condition, memory awareness accuracy was significantly better than chance both when certain and when somewhat certain (see Table 2).

Thus, typically developing children were using all three certainty levels in a meaningful way. These results suggest that each certainty level was both discrete and statistically meaningful for typically developing children.

In contrast, for children with autism, differences in accuracy between certainty levels were not significant. Furthermore, children with autism performed better than chance only when they were certain [$t(17)=4.26$, $p<.01$; see Table 2]. Thus, children with autism, unlike typically developing children, appear to have a rudimentary awareness of their memory, as only accuracy when certain was significantly better than chance. Moreover, these results suggest that children with autism are not able to reliably distinguish between certainty levels.

Memory Awareness in Adults

Within adult participants, the 2-way ANOVA only indicated a significant main effect for certainty, $F(1.58, 45.90)= 28.51$, $p<.001$. Neither the main effect of diagnosis nor the interaction between Diagnosis X Certainty were significant [$F(1,29)=1.03$, $p>.05$; $F(1.58, 45.90)=.92$, $p>.05$, respectively]. Thus, the overall memory awareness of adults with autism was comparable to that of adults in the control condition. Moreover, their accuracy was similarly affected by their certainty level (see Figure 2).

In order to clarify the effects of certainty, paired *t*-tests which employed Šidák-Bonferroni corrections were conducted. For adults in the control group only, memory awareness accuracy was significantly better when certain compared to somewhat certain [$t(14)=3.20$, $p<.05$]. In contrast, memory awareness accuracy was significantly better when somewhat certain compared to guessing for both adults with autism [$t(15)=3.16$, $p<.05$] and adults without autism [$t(14)=5.23$, $p<.01$]. These results suggest that when adult participants in both groups were more certain, their memory awareness accuracy for faces improved; however, the accuracy of adults with autism “certain” judgments was not distinguishable from the accuracy of their “somewhat certain” judgments. In addition, *t*-tests were conducted to examine whether memory awareness accuracy levels were significantly different from chance. As shown in Table 2, accuracy when certain and accuracy when somewhat certain were significantly better than chance for both adults with autism and adults in the control condition. Thus, although the confidence judgments of adults with autism were not associated with unique increases in accuracy for each confidence level, the accuracy of all adult participants was meaningfully moderated by certainty level.

Discussion

The primary objective of the current study was to examine memory awareness in individuals with autism since little research has examined metacognitive processes in this population. It was hypothesized that individuals with autism would have impaired metacognitive abilities with respect of memory awareness. Consistent with this hypothesis, children with autism demonstrated less accurate memory awareness and less reliable differentiation between their confidence ratings compared to typically developing children. For children with autism, memory awareness accuracy did not consistently vary with their stated certainty levels. Furthermore, on face recognition trials in which children with autism were somewhat certain, their memory awareness accuracy was not significantly different from chance. Thus, children with autism appear to have only a very basic awareness of their memory. In contrast, previous research has indicated that typically developing children as young as 5½ years old can reliably assess whether they are certain, somewhat certain or guessing (Berch et al., 1973). The current study provides additional support, as typically developing children’s certainty levels accurately and uniquely reflected their performance on the facial recognition task.

In addition, the current study found evidence for impairments in memory awareness among adults with autism, although the differences between adults with autism and adults without autism were more subtle than the differences found for child participants. Among adults with autism, increasing certainty was associated with increasing accuracy. However, only memory awareness accuracy for "somewhat certain" judgments was distinct from memory awareness accuracy for "guessing" judgments. Unlike adults in the control group, a high degree of certainty was not associated with incremental accuracy compared to a moderate degree of certainty for adults with autism. Thus, adults with autism appear to have a less sensitive awareness of their memory for faces compared to adults without autism.

Together, these results have important implications for how we conceptualize specific impairments, as well as our general understanding of autism. Deficits in memory awareness or metacognitive monitoring and evaluating of faces may contribute to more general deficits in social interactions. While there are many barriers that a child with autism must overcome in order to be successful in social interactions, accurately assessing one's recognition of faces is key. In this study, even when children with autism were certain that they remembered a face or did not remember a face, their accuracy was only 63.6%, a level which is only marginally better than chance. As a result, in everyday social interactions, children with autism may ignore some acquaintances, and conversely, approach strangers as if they know them. Both of these possibilities would have detrimental implications, either by reducing possible social interactions and slighting peers, or by evoking negative responses from strangers. Furthermore, decreased awareness of this impairment in facial recognition makes it unlikely that individuals with autism will spontaneously seek help from others or employ strategies to compensate for this impairment.

While it is unclear whether impaired memory awareness in individuals with autism reflects a general impairment in metacognitive monitoring, additional research is warranted. Since the current study examined memory awareness within the context of facial recognition, it is possible that the observed impairments in memory awareness are specific to facial recognition. However, if general impairments in metacognitive monitoring exist, metacognitive skills may need to be developed before new skills can be incorporated into daily life. For example, even if you develop strategies to increase your memory for faces, you must recognize situations in which you need to use them. Thus, it is important that researchers consider the possibility that individuals with autism may have a general impairment in metacognitive monitoring, especially since accurate metacognitive monitoring and evaluating is critical for both social and nonsocial learning. Moreover, while there is a plethora of research on theory of mind development in autism, a general impairment in metacognitive monitoring could underlie these findings.

Several limitations are important when considering the current results. While this study examined memory awareness in children and adults, the child group included both children and adolescents. As a result, it is not clear whether memory awareness accuracy in individuals with autism improves significantly prior to adulthood. Another limitation of the current study is that memory awareness was examined only within the context of facial recognition. While it is important to understand memory awareness for faces in individuals with autism, it is unclear whether more general impairments in memory awareness exist. Lastly, the 3-point certainty scale may not have provided sufficient precision in order to detect changes in memory awareness accuracy between children and adults in the control condition. Use of more than three choices might have indicated that control adults, in contrast to children, have an even more finely tuned sense of certainty about their memory performance. Thus, future research on memory awareness in individuals with autism is needed to continue to clarify how accuracy changes with development and how the task influences performance.

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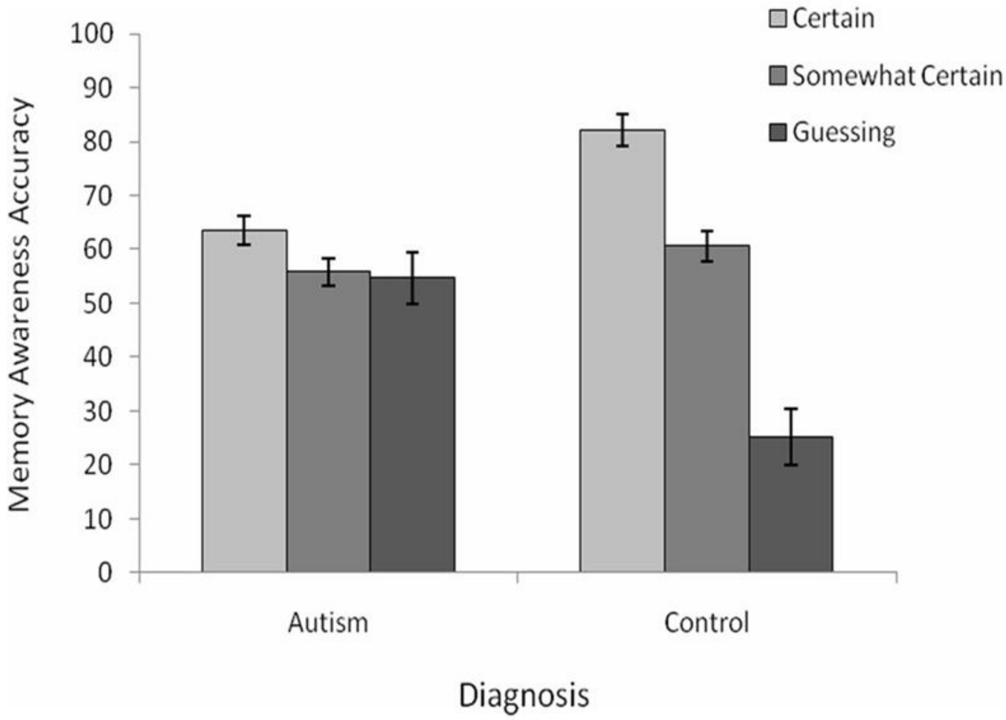

Figure 1.
Effects of certainty level and diagnosis on memory awareness accuracy in children.

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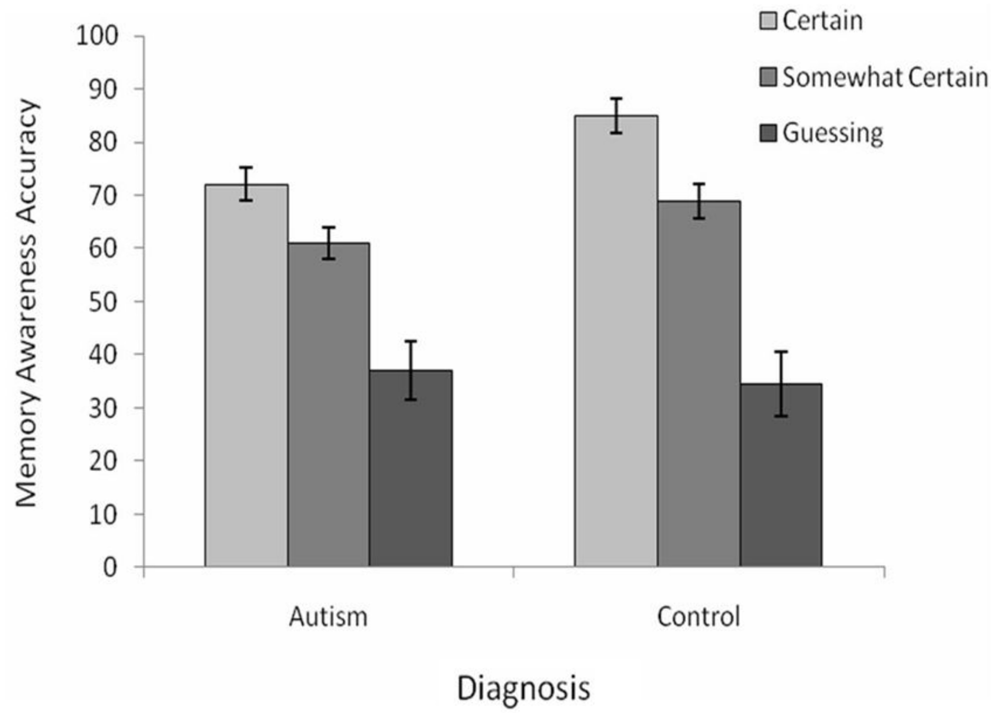

Figure 2.
Effects of certainty level and diagnosis on memory awareness accuracy in adults.

Table 1

Demographic Characteristics of Autism and Control Groups

	Child		**Adults**	
	Controls (*n*=13)	**Autism (*n*=18)**	**Controls (*n*=15)**	**Autism (*n*=16)**
Age	14.3 (1.7)	13.1(2.2)	26.9(7.9.4)	27.5(9.4)
VIQ	106.6(10.1)	105.2(10.4)	106.4(7.8)	100.4(14.1)
PIQ	109.0(7.8)	111.9(10.6)	111.2(9.0)	109.7(13.4)
FSIQ	109.1(9.4)	109.5(8.6)	109.9(8.7)	105.9(12.6)

Note. Values enclosed in parentheses represent standard deviations.

VIQ=Verbal IQ; PIQ=Performance IQ; FSIQ=Full-Scale IQ.

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Table 2

Significance of Mean Memory Awareness Accuracy Compared to Chance

	Child		Adult	
Certainty Level	**Control (n=13)**	**Autism (n=18)**	**Control (n=15)**	**Autism (n=16)**
Certain	82.1%(11.4)**	63.6(13.6)**	85.0%(24.6)**	72.0%(24.5)*
Somewhat	60.6%(14.0)*	55.8%(14.1)	68.9%(15.5)**	61.0%(13.6)*
Guessing	25.2%(32.3)	54.7%(29.1)	34.5%(34.1)	36.8%(31.9)

Note. Values enclosed in parentheses represent standard deviations.

* $p < .05$.

** $p < .01$.