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Brief Communication

Superior fluid intelligence in children with Asperger's disorder

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Abstract

Asperger's disorder is one of autistic spectrum disorders; sharing clinical features with autism, but without developmental delay in language acquisition. There have been some studies of intellectual functioning in autism so far, but very few in Asperger's disorder. In the present study, we investigated abstract reasoning ability, whose form of intelligence has been labeled fluid intelligence in the theory of Cattell [Cattell, R. B. (1963). Theory of fluid and crystallized intelligence: A critical experiment. *Journal of Educational Psychology*, *54*, 1–22.], in children with Asperger's disorder. A test of fluid intelligence, the Raven's Standard Progressive Matrices Test, was administered to 17 children with Asperger's disorder and 17 age-, gender-, and FIQ-matched normal children. The results showed that children with Asperger's disorder outperformed on the test of fluid reasoning than typically developing children. We suggest that individuals with Asperger's disorder have higher fluid reasoning ability than normal individuals, highlighting superior fluid intelligence.

Keywords: General fluid intelligence; Raven's progressive matrices test; Abstract reasoning ability

1. Introduction

Asperger's disorder is a pervasive developmental disorder characterized by impairments in social interaction, with restricted and repetitive patterns of behaviors and interests. This disorder is a subgroup on the autistic spectrum, sharing many clinical features with Autistic Disorder (American Psychiatric Association., 1994), but without clinically significant developmental delays in language acquisition. In Asperger's disorder, basic language skills are intact, although there are delays in nonverbal communication skills and pragmatics (Stein et al., 2004). There has been a report that individuals with Asperger's disorder often have a distinct profile on standard tests of intelligence such as the Wechsler Adult Intelligence Scale (WAIS) and Wechsler Intelligence Scale for Children (WISC), characterized by high verbal IQ and relatively low performance IQ (Klin, Volkmer, Sparrow, Cichetti, & Rourke, 1995).

Some studies have indicated that children with Asperger's disorder have high performances on the Vocabulary and Comprehension verbal subtests of the WISC, while their performances on nonverbal subtests, including Block Design and Object Assembly, are impaired (Ehlers et al., 1997). These findings at first sight suggest that individuals with Asperger's disorder have superior verbal crystallized intelligence, rather than nonverbal fluid intelligence. However, Wechsler-type intelligence scale is not considered as a test of fluid intelligence but rather an example of tests that typically measure skills and knowledge, crystallized intelligence (Gray & Thompson, 2004). General fluid intelligence (gF) is a major dimension of individual differences and refers to reasoning and novel problem-solving ability (Cattell, 1963; Gray & Thompson, 2004). Empirically, fluid intelligence is strongly associated with frontal executive function (Duncan, Burgess, & Emslie, 1995), attentional control and working memory (Conway, Cowan, Bunting, Therriault, & Minkoff, 2002; Gray, Chabris, & Braver, 2003; Kane & Engle, 2002), and the core function of fluid intelligence is the abstract reasoning ability, which has been a component of most formal theories of intelligence (Stern-

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berg, 1985; Thurstone, 1938). On the other hand, general crystallized intelligence is distinct from gF, referring to overlearned skills and static knowledge such as vocabulary, and there is empirical evidence for a distinction between the psychological processes and the neural substrates that subserve fluid reasoning and crystallized knowledge (Cattell, 1963; Duncan et al., 1995). As a test of fluid intelligence, the Raven Progressive Matrices test (Raven, Raven, & Court, 1993) is regarded as one of the best measurements, because it provides an optimal domain-independent measure of the abstract reasoning processes relevant to the management of novel problem-solving goals in working memory (Carpenter, Just, & Shell, 1990; Duncan et al., 2000; Gray & Thompson, 2004; Gray et al., 2003).

In cognitive research with autism, IQ is the most frequent matching variable in use, and Wechsler scales, British Picture Vocabulary Scale (BPVS) and the Raven's Coloured Progressive Matrices test (RCPM) are the frequently used instruments to determine IQ. Mottron (2004) claimed that there is a high probability of overestimating the level of intelligence in percentile vales of BPVS and RCPM score as compared to those of Wechsler scale, recommending a replacement to Wechsler scale as a basis of IQ matching.

Thus, the RCPM is frequently used to assess intelligence in individual with pervasive developmental disorders. However, the RCPM was developed to assess young children (5 to 10 1/2 years), whereas the Raven's Standard Progressive Matrices (RSPM) was developed for use with older children and adults (Raven et al., 1993). The colored backgrounds on which the problems are printed attract attention and make the test spontaneously interesting (Raven et al., 1993), and so the way to solve the problems on the RCPM is closely tied to the perceptual and analytical processes. By contrast, most of the problems on the RSPM are not as closely tied to the perceptual format and require a more abstract characterization in terms of dimensions and attributes (Carpenter et al., 1990). Therefore, the RSPM is widely accepted as a measure of high level analytical reasoning and of fluid intelligence (Carpenter et al., 1990; Dawson, Soulieres, Gernsbacher, & Mottron, 2007).

It is possible to assume that individuals with Asperger's disorder would show low fluid intelligence, as in the case of autistics who showed poor fluid reasoning (Blair, 2006; Pennington & Ozonoff, 1996) and poor performance on the tests of high-level integration or abstraction (Courchesne & Pierce, 2005; Just, Cherkassky, Keller, & Minshew, 2004). However, a recent study by Dawson and colleagues (2007) provided us with empirical evidence that autistic children showed high scores on the test of fluid intelligence using the RSPM. Such an empirical study has never been documented in Asperger's disorder or high-functioning autism. Here, we aimed to examine fluid intelligence in children with Asperger's disorder, using the Raven's Standard Progressive Matrices test (RSPM).

2. Methods

2.1. Participants

Seventeen participants with Asperger's disorder (10 boys and 7 girls, ages 6 to 12 years) were recruited from the outpatient's clinic of one children's hospital and took part in this study. These participants all were found to meet DSM-IV (American Psychiatric Association, 1994) criteria for a diagnosis of Asperger's disorder and were screened for psychiatric disorders through an in-depth clinical investigation performed by two of us (M.K., a psychiatrist and K.I., a child neuropsychologist) at the time of passing a standardized diagnostic instrument. Exclusion criteria included epileptic disorder, severe head trauma, the other neurological illness, or serious medical problems. In particular, those who had attention deficit/hyperactivity disorder, learning disability and developmental dyslexia were excluded from this study. None of them were on medication or showed signs of gross neurological abnormalities at the time of testing.

Although all participants with Asperger's disorder showed clinical symptoms including abnormal social interaction, and restricted and repetitive patterns of behaviors, they could use single words by the age of two years and communicative phrases by the age of three, and had no echolalia, pronoun reversal, nor stereotyped language.

Participants with Asperger's disorder showed a mean full-scale IQ of 96.7 (SD = 15.3) as measured with the Wechsler Intelligence Scale for Children-Third Edition (WISC-III), and their mean verbal IQ (VIQ) (101.7 ± 13.7) was higher than their mean performance IQ (PIQ) (91.5 ± 19.3) [$t(16) = 2.29$, $p < .05$].

Seventeen typically developing children (10 boys and 7 girls) participated in this study as age- and sex matched controls (NC). They were recruited from public primary schools in Tokyo. All participants were initially screened by teachers and were evaluated further by a structured psychiatric interview of two independent child psychiatrists and medical assessment. The exclusion criteria were a history of DSM-IV psychiatric disorders including attention deficit / hyperactivity disorder, learning disability and evidence of any other organic diseases. These control children had a mean FIQ of 99.8 (SD = 9.8) as measured with WISC-III, and their mean verbal IQ (VIQ) (101.3 ± 9.2) did not differ from their mean performance IQ (PIQ) (99.1 ± 10.2) [$t(16) = .96$, $p > .05$]. There were no significant differences on the mean of age and FIQ score between the participants with Asperger's disorder and the control participants ($p > .05$, Table 1.). The parents of each group were mostly from upper middle-class social status. Written informed consent was obtained from all participants and their parents.

2.2. Measures

The Raven's Standard Progressive Matrices test (RSPM) (Raven, Court, & Raven, 1992) was administered

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Table 1
Descriptive characteristics of participants in control (NC) and Asperger's disorder (AD) groups

	Groups	
	NC	AD
N (boys/girls)	17 (10/7)	17 (10/7)
Age (years)	9.5 (2.5)	9.2 (1.9)
WISC-III		
FIQ	99.8 (9.8)	96.7 (15.3)
VIQ	101.3 (9.2)	101.7 (13.7)
PIQ	99.1 (10.2)	91.5 (19.3)*

Data are expressed as group mean and standard deviation in parentheses. WISC-III, Wechsler Intelligence Scale for Children-Third Edition.
* The mean PIQ score was significantly lower than the mean VIQ in AD group ($p < .05$).

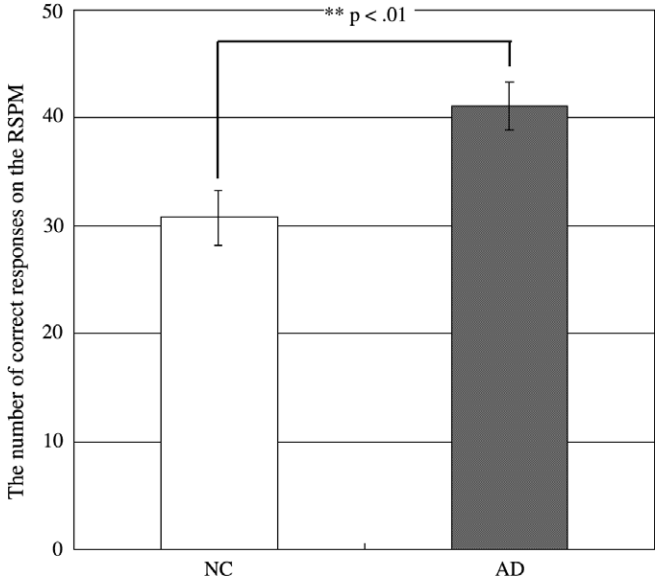

Fig. 1. Mean numbers of correct responses on the RSPM for control (NC) and Asperger's disorder (AD) groups. Open (left) and filled (right) columns represent numbers of correct responses in NC and AD groups, respectively. Vertical bars represent the standard error of the mean.

to the participants. The RSPM comprises 60 problems, divided into five sets (A–E) of increasing difficulty, and the each set begins with easy problems and ends with difficult ones. Each item contains a matrix of geometric design with one cell of the matrix removed, and there are six or eight alternatives given to insert in place of the missing cell, one of which fits correctly.

All participants were tested individually, and the RSPM was administered without time limit.

3. Results

Mean numbers of correct responses on the RSPM in the Asperger's disorder (AD) and normal controls (NC) groups are shown in Fig. 1. The number of matrices correctly solved in both groups were analyzed as a dependent variable, and two-tailed t tests revealed that the AD group (41.1 ± 9.3) made significantly more correct responses than the NC group (30.7 ± 10.3) [$t(32) = -3.08$, $p < .01$, Cohen's $ds = 1.05$].

Furthermore, a two-way ANOVA with groups and gender as variables, revealed significant main effects of groups [$F(1,30) = 8.69$, $p < .01$] and group × gender interaction [$F(1,30) = 17.37$, $p < .01$]. Regarding the boys, the AD group (46.0 ± 2.6) outperformed the NC group (26.0 ± 2.6) [$ds = 2.48$]. On the other hand, the girls in the AD group (34.0 ± 3.0) showed the equivalent number of correct responses to the girls in the NC group (37.4 ± 3.0) [$ds = 0.42$].

There was no significant correlation between the number of correct responses on the RSPM, and FIQ ($r = .24$, $p > .05$), VIQ ($r = .27$, $p > .05$) and PIQ ($r = .16$, $p > .05$) on the WISC-III for all children combined.

4. Discussion

The present study demonstrates that participants with Asperger's disorder made more correct responses on the RSPM than did normal controls. The results of this study suggest that Asperger's disorder involves superior abstract reasoning ability or higher general fluid intelligence. A theoretical account in the literature regarding the processing of the Raven test (Carpenter et al., 1990) proposes that the RSPM involves abstraction and goal management processes. In order to solve the problems on the RSPM, it is necessary to induce rules from the relationship between elements in matrices, and to generate and maintain goals in working memory until a target satisfies a theorem as a whole. As compared to normally developing children, the performance on the RSPM in children with Asperger's disorder was critically different and was significantly better, implying the superiority in fluid intelligence in Asperger's disorder.

Moreover, from clinical case records of children with Asperger's disorder diagnosed by Hans Asperger and his team, it was revealed that some individuals with Asperger's disorder had a special gift for abstract thinking and logical reasoning (Hippler & Klicpera, 2003). Hans Asperger contended, in his original paper, that the traits of this disorder were in fact necessary for high achievement in the arts and sciences (Wing, 2005). Logical reasoning ability is a premise for conducting scientific research, and in fact there have been some outstanding scientists who were the cases of Asperger's disorder (Asperger, 1944; Frith, 2004). Such clinical characteristics could be in correspondence to the superior performance on abstract reasoning problems of the RSPM in the present study.

Recently, an interesting study of autistic intelligence has been published (Dawson et al., 2007). In this study, autistic children showed high scores on the RSPM. However, the percentile score on the RSPM were higher than the percentile scores on the Wechsler scales of intelligence in autistic

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children, while typically developing children did not show such discrepancy. The results of this study suggested that intelligence has been underestimated in autistics. Although this study was conducted to children with autism, and some autistics included IQ score below the average, indicating 'low-functioning' autism (i.e., in the range of mental retardation), our participants included children with Asperger's disorder who had average or high IQ scores. Nevertheless, the results of our study were in line with those of the study by Dawson and colleagues (2007), since Asperger's disorder shares the same clinical features to autism in poor social communication and is considered as one of autistic spectrum disorders (Wing, 1981).

Recent cognitive neuroscience studies showed that analytic reasoning activates the left frontal cortex (Prabhakaran, Smith, Desmond, Glover, & Gabrieli, 1997; Wharton et al., 2000). Moreover, general fluid intelligence reflects the function of a specific neural system, including the lateral frontal cortex as one major part (Duncan et al., 2000; Gray et al., 2003). Thus, the left lateral frontal function may play an important role for fluid reasoning, and our results of superior fluid intelligence in Asperger's disorder may imply the unique involvement in the left frontal lobe functioning. Future research should explore the neural substrates for fluid intelligence in Asperger's disorder.

Although we demonstrated new cognitive characteristics in Asperger's disorder, there are some limitations in our study. The major one is the small number of participants with Asperger's disorder. The results of this study suggested that boys with Asperger's disorder particularly performed better on the RSPM. It might be because that males are better at 'systemizing', that is, 'to predict and to respond to the behavior of nonagentive deterministic systems by analyzing rules that govern such systems' (Baron-Cohen, 2002). Hans Asperger himself even noted that autistic mind is an extreme variant of male intelligence (Asperger, 1944; Frith, 2004; Wing, 2005). However, unfortunately, it would be too early to reason from such a small number of participants. The comparison of boys versus girls in Asperger's disorder with more cases would be of importance and should be carefully examined. Another limitation is the lack of multiple measures of general fluid intelligence in this study. Although we suppose that the RSPM would be a good and convincing enough measure, it would be hard to clearly articulate the types of cognitive processes that the RSPM taps into. Future study is expected to investigate general fluid intelligence with some other cognitive tests in Asperger's disorder. Thirdly, the children participated in this study were diagnosed as Asperger's disorder. This diagnosis was made only for autistic children without relevant delay or deficits in language development. It would be interesting and necessary to compare the performance on the tests of fluid intelligence in Asperger's disorder with high-functioning autism. Finally, what is the most puzzling for us is why persons with Asperger's disorder have such a special abstract reasoning ability? We should explore what cognitive factors associated with Asperger's disorder would contribute to high fluid intelligence in future research.

In conclusion, we demonstrated that individuals with Asperger's disorder are able to perform better on the RSPM than normally developing individuals, and highlights superior abstract reasoning ability and high general fluid intelligence in this disorder. This study provides new insight into the cognitive strengths associated with Asperger's disorder.

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