Journal of Brain Science, March 30, 2013,Vol.40

Research and Report

Visual perception of unstructured figures in patients with autism spectrum disorder: a preliminary study

Tomoko Muramatsu[1] , Hideo Nakatani [2],Mitsuru Kikuchi [3],Toshio Munesue[3]

1.Department of Psychiatry and Neurobiology, Graduate School of Medical Science, Kanazawa University, Kanazawa 9208641, Japan

2.Department of Neuropsychiatry, Kanazawa University Hospital, Kanazawa 9208641, Japan

3.Research Center for Child Mental Development, Kanazawa University, Kanazawa 9208640, Japan

Corresponding Author

Toshio Munesue, M.D., Ph.D.

Telephone number, +81 76 234 4213

Fax number, +81 76 234 4213

E-mail:

munesue@med.kanazawa-u.ac.jp

Abstract

Ambiguous figures, such as the reversible figure of the girl/old women (Boring, 1930), have inspired an enormous amount of research into the domain of visual perception. However, visual perception of unstructured figures, such as stains on walls, which contain no meanings themselves, has not been a main topic of research in healthy subjects or in subjects with autism spectrum disorder (ASD). The aims of this study were to obtain inkblot responses characteristic of subjects with ASD (n = 36), to compare these response to those of healthy subjects (n = 50), and to assess whether these responses had any relevance to ASD traits, as evaluated using standard questionnaires, such as the Autism-spectrum Quotient (AQ) and the Empathy Quotient (EQ). All of the responses of each subject were scored using the Exner Comprehensive Scoring System, which is the standard method for evaluating responses to the Rorschach test. The scores of total responses were not different between the subjects with ASD and healthy subjects. Only the scores for the variable designated FM were significantly lower in ASD subjects compared to healthy subjects, indicating that the subjects perceived animals in motion in their visual perceptions of unstructured figures in inkblots. Furthermore, the FM scores demonstrated a significantly inverse correlation with the AQ scores and were significantly correlated with the EQ scores. Each variable of M indicated a response of humans in motion, with m indicating a response of inanimate in motion, Human indicating total responses concerning humans, and Animal indicating total responses concerning animals; these measurements were not different between the two groups and were not correlated with the scores on the AQ or the EQ. Based on this preliminary study, representations of animals in motion in visual perception may be a subject that could shed light on the biological relevance between unstructured figures and autism traits.

Key words

ambiguous figure, autism phenotype, autism spectrum disorder, illusion, inkblots of the Rorschach, unstructured figure, visual perception

Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental disorder that comprises autistic disorder, Asperger's disorder, and pervasive developmental disorder not otherwise specified as designated in the *Diagnostic and Statistical Manual of Mental Disorders Fourth Edition Text Revision*

(DSM-IV-TR) [1]. Behavioral signs of ASD emerge between 6 and 12 months of age in the form of a decline in social engagement, such as gazing at faces and social smiles [2], [3]. Moreover, the head circumference of subjects with ASD becomes significantly larger than that of normal subjects at 12 to 24 months of age[4], [5]. These results suggest that ASD should be considered a nearly innate, rather than acquired, disease. The etiology of ASD has not yet been clarified. However, genetic components are believed to play important roles in the pathogenesis of ASD; for example, a twin study reported higher rates of concordance in monozygotic twins than in dizygotic twins [6] and a recent transcriptomic analysis reported different gene expression patterns in the brains of subjects with and without ASD [7]. The prevalence of ASD has been proposed to be as high as approximately 1% [8], and no effective treatments for ASD exist, with the exception of those that can alleviate irritability[9] and treat epileptic attacks. Thus,clinical symptoms are most strongly associated with the burdens of caregiver over time [10].

The clinical symptoms of ASD range widely across almost all domains of mental and cognitive function, although social impairments and repetitive patterns of activities represent the core symptoms. For instance, intellectual ability can range from profound impairment to savantism [11]. Epilepsy is a major comorbidity and is recognized in approximately 30% of subjects [12]. The affective and emotional domains can be affected in terms of irritability (e.g., temper tantrums and self-injurious behavior), which caregivers and school teachers regard as unmanageable behavior and results in the pursuit of drug therapy [13]. In the memory domain, ASD subjects can experience suddenly vivid recollections of past personal events, the contents of which are often unpleasant and distressing to them [14]. Moreover, healthy subjects, but not subjects with ASD, show greater memory performance in self-referential processing as compared to semantic processing [15], and this result suggests deficits of self-consciousness in ASD.

The perception domain of mental and cognitive function can also be affected in subjects with ASD. Perception refers to the recognition of all of sensory information for an individual to perceive and understand the environment, whereas sensation refers to sensory information that itself does not include functions of memory, emotion, and thinking that an individual processes after perceiving sensory information. Sensation generally consists of visual, auditory, gustatory, tactile, olfactory, pain, and interoceptive modalities, among others. Hypersensitive or hyposensitive reactions to sensory information often occur in subjects with ASD [16]. For instance, these individuals may dislike specific sounds, such as vacuum cleaners or babies' crying, and cover their ears; in contrast, these individuals may remain entirely unperturbed when a balloon suddenly bursts, even when everyone around them is startled. Furthermore, individuals with ASD may also dress lightly in the middle of winter as if they are insensitive to cold, dislike being touched by other peoples, have deviant food habits dating from infancy, or look embarrassed and offer no replies to questions concerning their physical conditions (as if they are unable to understand the term "physical condition" or perceive the conditions of their bodies). These clinical observations suggest that subjects with ASD can be affected in various domains of sensation and perception.

Of course, affected behaviors in the visual domain can also appear in the daily lives of ASD subjects. For example, they may stare at a whirlpool of water in a washing machine or gaze for a long time at the spinning tire of a miniature car; they may also stare at anything that glitters, such as sunshine filtering through foliage, glass blowing, or the flow of a river. Moreover, they may be absorbed in the process of scanning a carpet of a rice field from one end to the other. It is very interesting not only from a clinical standpoint but also from a research standpoint to examine how ASD subjects perceive their external environments through visual sensations.

Numerous studies have been conducted with regard to vision in ASD [17]. As complete review of visual perception in ASD is far beyond the scope of this article, the clinical characteristics of visual recognition will first be described based on research using neuropsychological methods, which traditionally have been utilized in patients who suffer from strokes or head injuries. Generally, various types of visual recognition, including object identification, figure recognition, color recognition, topographical memory and orientation, and spatial orientation, do not differ between ASD subjects with mental deficiencies and subjects with mental retardation [18]. No gross deficits in visual recognition exist in subjects with ASD. Thus, it is worth considering whether the above-mentioned behavioral symptoms specific to ASD have relevance to cognitive processes in visual perception, which can be evaluated using more elaborate measures.

One of the most consistent results with regard to the visual perception of subjects with ASD is that they have superior abilities in processing fine details, particularly those of local structures [19]. For example, children with ASD were shown to perform better than healthy children in response to a visuo-spatial task called the Embedded Figures Test, which was designed to evaluate the ability to distinguish items from their surrounding contexts [20].

Moreover, ASD subjects were significantly faster than control subjects in conjunctive search tasks, in which target in the form of a letter of the alphabet shared its color with one set and its shape with another set of letter distracters, and the participants were instructed to respond to the presence or absence of the target as quickly as possible [21]. In another study, adults with ASD and healthy adults were tested using figure discrimination tasks with extremely confusing contents, and although control subjects were significantly better able to distinguish familiar from novel figures, ASD subjects distinguished novel figures significantly better than control subjects [22]. It has also been readily noticed that ASD subjects have superior abilities in processing fine details, and they show better performance on the block design task of the Wechsler Intelligence Scale [23].

Figures used to distinguish targets from distractive contexts can be divided into two categories: ambiguous figures and unstructured figures. Ambiguity refers to multiple possible interpretations of a figure [24]. For instance, the reversible figure of the girl/old women (Figure 1) [25] can be recognized as a girl from one viewpoint and as an old woman from another, which characterizes this figure as ambiguous. In contrast, unstructured figures have no significance on their own. As a result, paradoxically, these figures can induce innumerable interpretations. For example, when looking at a cloud in the sky, one person may state that part of the cloud looks like the beak of a pelican, whereas another person would likely make different observation. A cloud is therefore characterized as an unstructured figure.

Previous research has suggested that children with ASD are as likely as control subjects to generate both interpretations of ambiguous figures [26-28]. Interestingly, the ability to reverse an ambiguous figure is correlated with success in theory of mind tasks in normally developing children[29]. The theory of mind is the ability to attribute mental states to oneself and to others, and it has been reported that subjects with ASD cannot initiate and maintain social interaction with others because they do not understand others' abilities to have beliefs, intentions, and desires [30]. The theory of mind hypothesis is regarded as one of the most accepted theories for explaining the pathogenesis of ASD, along with the weak central coherence hypothesis [31]. In research in subjects with ASD, a significant correlation between the ability to represent others' mental states and the ability to reverse an ambiguous figure was suggested in two studies [27], [28] but was not shown in a third study [26].

In contrast, there has been a paucity of research into the perception of unstructured figures in subjects with ASD. Typical examples of unstructured figures would be the inkblots of the Rorschach test, which was developed to assess individual personalities. Although the Rorschach test is a psychological test, the inkblot figures are obviously unstructured, and the process of the subjects verbally expressing what he or she sees in the whole or in parts of an inkblot could represent visual perception.

The aims of this study were, first, to obtain inkblot responses characteristic of subjects with ASD as compared to healthy subjects and, second, to assess whether the variations in responses were correlated with ASD traits, as evaluated using the standard questionnaire. Although this was a preliminary study, authors are unaware of other study investigating the characteristics of visual perception of unstructured figures, such as inkblots, in subjects with ASD.

Methods

Participants

Thirty-six subjects with ASD and 50 healthy subjects were enrolled in this study. ASD was diagnosed based on the DSM-IV-TR, using the Diagnostic Interview for Social and Communication Disorders [32], the Tokyo Autistic Behavior Scale[33], or the Autism Spectrum Screening Questionnaire[34].

The ASD subjects were visiting Kanazawa University Hospital and had previously been evaluated using the Wechsler Intelligence Scale, the Autism-spectrum Quotient (AQ) [35], the Empathy Quotient (EQ) [36], and the Systemizing Quotient (SQ) [37]. Healthy subjects were recruited from among the nurses at Kanazawa University Hospital and students of Kanazawa University, and they did not have schizophrenia or related psychotic disorders, mood disorders, or substance dependence, based on the Structured Clinical Interview for the DSM-IV, Non-patient Edition [38]. Healthy subjects met the inclusion criteria, which consisted of not having a prior history of serious diseases or a family history of psychiatric consultations among first-degree relatives.

All of the participants provided written informed consent after receiving detailed information about this study. The study was approved by the medical ethics committee of Kanazawa University.

Procedure

All of the participants were administered the Rorschach inkblot test according to the regular method. Responses to inkblots were scored using the standard Exner Comprehensive Scoring System.

Healthy subjects entered the answers into categories AQ, EQ, and SQ, and they underwent examination with the Wechsler Intelligence Scale.

Statistical analysis

The Exner Comprehensive Scoring System generates 142 variables to provide a psychological interpretation. These variables can be divided into 12 categories according to the system. Thus, when comparing the variables between ASD subjects and healthy subjects, the significance level was set at 0.0042, bearing in mind multiple comparisons. If the subjects' characteristics (such as gender) were significantly different between the two groups, then an analysis of covariance (ANCOVA) was performed, using the characteristic in question as a covariate. If an ANCOVA could not be conducted, then the relationships between the variables and the covariates were examined. Data analysis was performed using the software package of SPSS Statistics 17.0.

Result

The subject's characteristics were significantly different regarding the variables of gender ratio, full intelligence quotient (IQ), verbal IQ, performance IQ, duration of education, AQ, EQ, and SQ between the ASD subjects and healthy subjects (Table 1).

The numbers of total responses were not different between the two groups. Ten variables, designated as "", "WDo", "FM", "FC", "Sum Color", "FC'", "Lambda", "Pure F%", "FM + m" and "p(positive)" within the Exner Comprehensive Scoring System, were significantly different between the two groups by non-parametric analysis using the Mann-Whitney test (The statistic of each variable was as follows; FQxo, U = 478.0, $P < 0.001$; WDo, U = 502.5, $P < 0.001$; FM, U = 423.5, $P < 0.001$; FC, U = 408.5, $P < 0.001$; Sum Color, U = 526.5, $P = 0.001$; FC', U = 571.5, $P = 0.002$; Lambda, U = 434.5, $P < 0.001$; Pure F%, U = 448.0, $P < 0.001$; FM + m, U = 478.0, $P < 0.001$; p(positive), U = 538.5, $P = 0.001$). However, these differences may have been affected by any of the variables of subject characteristics used covariates. Full IQ was significantly correlated with verbal IQ (Pearson product-moment correlation, r = 0.847, $P < 0.001$), performance IQ (r = 0.842, $P < 0.001$) and education (r = 0.309, $P = 0.004$). Thus, together with gender, only full IQ was regarded as a possible covariate. We sought to perform ANCOVAs to compare each variable between groups, including FQxo, WDo, FM, FC, Sum Color, FC', Lambda, Pure F%, FM + m, and p(positive), with gender and full IQ serving as covariates. However, ANCOVA could not be conducted because the data did not pass tests for the homogeneity of variance assumption and the homogeneity of regression slopes assumption. Therefore, the relationships between the 10 variables and gender or full IQ were examined.

First, we evaluated whether the scores for the 10 variables were significantly different between male and female subjects using the non-parametric Mann-Whitney test, with a significance level of 0.005. Because each variable among FQxo (U = 501.5, $P < 0.001$), WDo (U = 460.0, $P < 0.001$), Lambda (U = 572.0, $P = 0.002$), and Pure F% (U = 586.0, $P = 0.003$) was significantly different between male subjects and female subjects, it was suggested that the significant differences of these four variables between ASD subjects and healthy subjects may have been affected by gender.

Second, we evaluated whether the scores of the 10 variables were correlated with full IQ, using significance level of 0.005. Because there were significant correlations between each variable among FQxo (Spearman's rank correlation, rho = 0.471, $P < 0.001$), WDo (rho = 0.432, $P < 0.001$) and p (positive) (rho = 0.408, $P < 0.001$), and full IQ, it was suggested that the significant differences among these three variables between ASD subjects and healthy subjects may have been affected by full IQ.

As a result, the FM, FC, Sum Color, FC' and FM+m variables remained in the analysis. Next, we sought to take the results of the studies of visually perceived ambiguous figures into consideration in an attempt to obtain the characteristic responses of subjects with ASD as compared to healthy subjects. Because this study noted the shape but not the attributes, each variable among FC, Sum Color and FC' that was scored for responses referring to color was excluded from subsequent considerations. FM+m is represented the sum of the FM and m scores. Because the variable of m indicated responses of inanimate objects in motion and was not different between the two groups (U = 792.0, $P = 0.323$), the variable FM+m was excluded (Figure 2).

Only the variable FM remained in the analysis and was further investigated. According to the Exner Comprehensive Scoring System, the responses for FM indicated that the subjects received animals in motion in the unstructured figures of the inkblots. Subjects with ASD showed responses for FM significantly less often than healthy subjects (Figure 2), whereas the responses for M, which indicated representations of humans in motion, were not different between the two groups. Here, the sums of all of the variables concerning humans among the 142 variables were designated "Human", and the sums of all of the variables concerning animals among the 142 variables were designated "Animal". However, the results indicated that neither variables, Human (U = 818.5, P = 0.718) or Animal (U = 701.5, P = 0.081)), was different between the two groups (Figure 2).

Finally, significantly negative correlations were found between FM scores and AQ scores (rho = -0.364, P = 0.001; Figure 3), and significantly positive correlations were found between FM scores and EQ scores (rho = 0.219, P = 0.045; Figure 4), although SQ scores were not correlated with FM scores (rho = -0.157, P = 0.152)

Discussion

In this study, we administered the inkblots of the Rorschach test to subjects with ASD as unstructured figures to investigate characteristics of visual perception, rather than as a psychological test to evaluate the subjects' personalities. The Rorschach test has been subject to criticisms, such as inter-rater reliability, the validity of the test and so on, although some psychologists continue to use this test to examine personality characteristics and emotional functioning. Although a few studies have been conducted in ASD subjects to obtain psychological results using the routine Rorschach test [39][40], the administration of the test from the viewpoint of vision research represents an alternative strategy that has demonstrated interesting results [41].

The main findings of this study were 1) that the FM scores, but not scores for M, m, Human, or Animal, were found to be significantly lower in subjects with

ASD as compared to healthy subjects and 2) that the FM scores, not but the scores for M, m, Human and Animal, were significantly correlated with the AQ scores and EQ scores. These results show that unstructured figures of inkblots induced different representations only of animals in motion, which may have been produced by any cognitive process related to the pathogenesis of ASD. Although these results cannot be rigorously explained in light of the paucity of research on the visual perception of unstructured figures, there is intriguing relevance to autism traits that merits some discussion.

It is well known that one of the core symptoms of ASD is social impairment, with another core symptom being repetitive behaviors. Social impairment implies difficulties in forming reciprocal relationships with other human, but not with animals. The question of how people with ASD see and feel the existence of animals remains surprisingly understudied, although animal-assisted therapies have been applied as complementary interventions and sessions with dogs or horses have been proposed [42] Animals, as well as humans, are parts of the world.

Moreover, a community is composed of by not only humans but also pets and domestic animals, which comfort, feed, and help people in daily life. Thus, it could be an informative research topic to determine how subjects with ASD perceive the existence and behaviors of animals.AQ can be used as a screening method for ASD [43], although it was developed to measure the degree of autism traits in subjects with normal intelligence, whereas EQ was developed to measure empathy, which plays an essential role in daily social interaction, and has been suggested to be lower in subjects with ASD than in the general population[36].

The significant correlations between representations of animals in motion and autism traits also cannot readily be explained, and the reversal of ambiguous figures but not of unstructured figures requires perceptual alterations. There are significant correlations between spontaneous reversals of ambiguous figures and the theory of mind task in healthy children[29] and in children with ASD[27], and it has been suggested that abilities related to the theory of mind and executive functions are linked in healthy children [44] and in children with ASD [45]. The reversal of ambiguous figures could have relevance to higher-level executive functions, which may be involved in social impairment. In the same way, representation abilities after perceiving unstructured figures may be connected to social cognition based on higher-level cognitive functions.

From the standpoint of psychiatric semiology, pareidolias, which are complex visual illusions involving unstructured forms (e.g., clouds or stains on walls) that are perceived as meaningful objects, have been suggested to be similar in regards to their responses as inkblots, in terms of obvious visual perceptions originating from unstructured visual sensations. Whereas pareidolias imply spontaneous and persistent illusions, inkblot responses are forcedly represented. However, a comprehensive study of pareidolias in patients with Lewy body disease applied the Pareidolia test, in which subjects were instructed to describe, in as much detail as possible, objects shown in pictures that contained animals, plants, or artifacts[46]. Closer inspection of the pictures revealed that both definite objects and unstructured figures (e.g., vague shadows or blurred objects) were photographed. If vague shadows were perceived as ghosts in the Pareidolia test, then the response was evaluated as an illusion, and not as a representation. In this case, the demarcation line between whether it was an illusion or a representation seemed obscure. Interestingly, this study showed that, with regard to the contents of illusory responses on the Pareidolia test, the number of responses regarding animals was more greater than the number of responses regarding humans.

As a future direction of research, it might be fruitful to study how unstructured figures, designed apart from Rorschach inkblots, are visually perceived as compared to ambiguous figures in subjects with ASD. Moreover, it might also be worthwhile to study how visual perception of ambiguous or unstructured figures has relevance to autism traits, as evaluated using theory of mind tasks or AQ and EQ questionnaires. Moreover, these two subjects would be appropriate objectives for neuroimaging studies.

Some limitations of the current study should be noted. First, the subjects' responses to the inkblots were difficult to analyze objectively as reliable variables. However, the Exner Comprehensive Scoring System is systematized for scoring various responses in a standard manner. Second, as none of the authors was authorized to use the Autism Diagnostic Interview-Revised (ADI-R) or the Autism Diagnostic Observation Schedule (ADOS), which are diagnostic tools used worldwide, ASD was diagnosed using other tools. However, the authors believe that the Diagnostic Interview for Social and Communication Disorders could be substituted for the ADI-R or the ADOS.

References

1. American Psychiatric Association.

Diagnostic and Statistical Manual of mental Disorders, Fourth Edition, Text Revision. Washington D.C.: American Psychiatric Association, 2000.

2. Ozonoff S, Iosif AM, Baguio F, et al. A prospective study of the emergence of early behavioral signs of autism. J Am Acad Child Adolesc Psychiatry, 2010; 49 (3): 256-266.

3. Zwaigenbaum L, Bryson S, Rogers T, et al. Behavioral manifestations of autism in the first year of life. Int J Dev Neurosci, 2005; 23 (2-3): 143-152.

4. Courchesne E, Pierce K, Schumann CM, et al. Mapping early brain development in autism. Neuron, 2007; 56 (2): 399-413.

5. Aoki Y, Kasai K, Yamasue H. Age-related change in brain metabolite abnormalities in autism: a meta-analysis of proton magnetic resonance spectroscopy studies. Transl Psychiatry, 2012; 2: e69.

6. Ritvo ER, Freeman BJ, Mason-Brothers A, et al. Concordance for the syndrome of autism in 40 pairs of afflicted twins. Am J Psychiatry, 1985; 142 (1): 74-77.

7. Voineagu I, Wang X, Johnston P, et al. Transcriptomic analysis of autistic brain reveals convergent molecular pathology. Nature, 2011; 474 (7351): 380-384.

8. Fombonne E. Epidemiology of pervasive developmental disorders. Pediatr Res, 2009; 65 (6): 591-598.

9. McCracken JT, McGough J, Shah B, et al. Risperidone in children with autism and serious behavioral problems. N Engl J Med, 2002: 347 (5): 314-321.

10. Lecavalier L, Leone S, Wiltz J. The impact of behaviour problems on caregiver stress in young people with autism spectrum disorders. J Intellect Disabil Res, 2006; 50 (3): 172-183.

11. DeMyer MK, Barton S, Alpern GD, et al. The measured intelligence of autistic children. J Autism Child Schizophr, 1974; 4 (1): 42-60.

12. Tuchman R, Rapin I. Epilepsy in autism. Lancet Neurol, 2002; 1 (6):352-358.

13. Aman MG, McDougle CJ, Scahill L, et al. Medication and parent training in children with pervasive developmental disorders and serious behavior problems: results from a randomized clinical trial. J Am Acad Child Adolesc Psychiatry, 2009; 48 (12): 1143-1154.

14. Sugiyama T. A specific recollection phenomenon seen in autistic patients: the time slip phenomenon in autism. Seishin Shinkeigaku Zasshi, 1994; 96 (4): 281-297. (Japanese).

15. Toichi M, Kamio Y, Okada T, et al. A lack of self-consciousness in autism. Am J Psychiatry, 2002; 159 (8): 1422-1424.

16. Jones RSP, Quigney C, Huws JC. First-hand account of sensory perceptual experiences in autism: a qualitative analysis. J Intellect Dev Disabil, 2003; 28 (2): 112-121.

17. Simmons DR, Robertson AE, McKay LS, et al. Vision in autism spectrum disorders. Vision Res, 2009; 49 (22): 2705-2739.

18. Munesue T. A neuropsychological study on the language of autistic children. J Juzen Med Soc, 1985; 94 (2): 268-288. (Japanese).

19. Dakin S, Frith U. Vagaries of visual perception in autism. Neuron, 2005; 48 (3): 497-507.

20. Shah A, Frith U. An islet of ability in autistic children: a research note. J Child Psychol Psychiatry, 1983; 24 (4): 613-620.

21. Plaisted K, O'Riordan M, Baron-Cohen S. Enhanced visual search for a conjunctive target in autism: a research note. J Child Psychol Psychiatry, 1998; 39 (5): 777-783.

22. Plaisted K, O'Riordan M, Baron-Cohen S. Enhanced discrimination of novel, highly similar stimuli by adults with autism during a perceptual learning task. J Child Psychol

Psychiatry, 1998; 39 (5): 765-775.

23. Shah A, Frith U. Why do autistic individuals show superior performance on the block design task? J Child Psychol Psychiatry, 1993; 34 (8): 1351-1364.

24. Jensen MS, Mathewson KE. Simultaneous perceptions of both interpretations of ambiguous figures. Perception, 2011; 40 (8): 1009-1011.

25. Boring EG. A new ambiguous figure. Am J Psychol, 1930; 42 (2): 444-445.

26. Roper D, Mitchell P, Ackroyd K. Do children with autism find it difficult to offer alternative interpretations to ambiguous figures. Br J Dev Psychol, 2003; 21 (3): 387-395.

27. Sobel DM, Capps LM, Gopnik A. Ambiguous figure perception and theory of mind understanding in children with autistic spectrum disorders. Br J Dev Psychol, 2005; 23 (2): 159-174.

28. Wimmer MC, Doherty MJ. Children with autism's perception and understanding of ambiguous figures: evidence for pictorial metarepresentation, a research note. Br J Dev Psychol, 2010; 28 (3): 627-641.

29. Gopnik A, Rosati A. Duck or rabbit?: reversing ambiguous figures and understanding ambiguous representations. Dev Sci, 2001; 4 (2): 175-183.

30. Baron-Cohen S, Leslie AM, Frith U. Does the autistic child have a "theory of mind"? Cognition, 1985; 21(1): 37-46.

31. Boucher J. Putting theory of mind in its place: psychological explanations of the socio-emotional-communicative impairments in autistic spectrum disorder. Autism, 2012; 16 (3): 226-246.

32. Wing L, Leekam SR, Libby SJ, et al. The Diagnostic Interview for Social and Communication Disorders: background, inter-rater reliability and clinical use. J Child Psychol Psychiatry, 2002; 43 (3): 307-325.

33. Kurita H, Miyake Y. The reliability

and validity of the Tokyo Autistic Behaviour Scale. Jpn J Psychiatry Neurol, 1990; 44 (1): 25-32.

34. Posserud MB, Lundervold AJ, Gillberg C. Autistic features in a total population of 7-9-year-old children assessed by the ASSQ (Autism Spectrum Screening Questionnaire). J Child Psychol Psychiatry, 2006; 47 (2): 167-175.

35. Baron-Cohen S, Wheelwright S, Skinner R, et al. The autism-spectrum quotient (AQ): evidence from Asperger syndrome/high functioning autism, males and females, scientists and mathematicians. J Autism Dev Disord, 2001; 31(1): 5–17.

36. Baron-Cohen S, Wheelwright S. The empathy quotient: an investigation of adults with Asperger syndrome or high functioning autism, and normal sex differences. J Autism Dev Disord, 2004; 34 (2): 163–175.

37. Baron-Cohen S, Richler J, Bisarya D, et al. The systemizing quotient: an investigation of adults with Asperger syndrome or high functioning autism, and normal sex differences. Philos Trans R Soc Lond B Biol Sci, 2003; 358 (1430): 361–374.

38. First M, Spitzer R, Gibbon M, et al. Structured Clinical Interview for DSM-IV Axis I Disorders, Research version, Non-patient Edition (SCID-I/NP). New York: Biometrics Research Dept. New York State Psychiatric Institute, 2002.

39. Bernabei P, Palli FG, Levi G, et al. Disturbance of imagination and symbolization in pervasive developmental disorders: preliminary study utilizing the Rorschach Inkblot Test. Percept Mot Skills, 1999; 89 (3): 917-930.

40. Ghaziuddin M, Leininger L, Tsai L. Thought disorder in Asperger syndrome: comparison with high-functioning autism. J Autism Dev Disord, 1995; 25 (3): 311-317.

41. Blake R, Logothetis NK. Visual competition. Nat Rev Neurosci, 2002; 3 (1): 13-21.

42. Grandgeorge M, Tordjman S, Lazartigues A, et al. Does pet arrival trigger prosocial behaviors in individuals with autism? PLoS One, 2012; 7(8): e41739.

43. Woodbury-Smith MR, Robinson J, Wheelwright S, et al. Screening adults for Asperger Syndrome using the AQ: a preliminary study of its diagnostic validity in clinical practice. J Autism Dev Disord, 2005; 35(3) :331-335.

44. Carlson SM, Moses LJ, Hix HR. The role of inhibitory processes in young children's difficulties with deception and false belief. Child Dev, 1998; 69(3): 672-691.

45. Ozonoff S, McEvoy RE. A longitudinal study of executive function and theory of mind development in autism. Dev Psychopathol, 1994; 6 (3): 415-431.

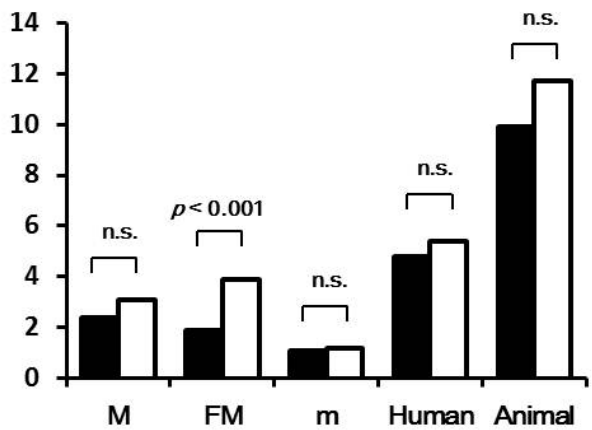
46. Uchiyama M, Nishio Y, Yokoi K, et al.Pareidolias: complex visual illusions in dementia with Lewy bodies. Brain, 2012; 135 (8): 2458-2469.

Figure 1

Example of ambiguous figure.

The girl/old women (Boring [25])

Figure 2



Mean scores of responses regarding human, animal and inanimate.

Black bar and white bar indicate mean scores of responses in subjects with ASD and healthy subjects, respectively. M indicates the scores of responses representing humans in motion. FM indicates the scores of responses representing animals in motion. m indicates the scores of responses representing inanimate objects in motion. Human indicates the sum of the scores of responses concerning human. Animal indicates the sum the scores of responses concerning animals.

Figure 3

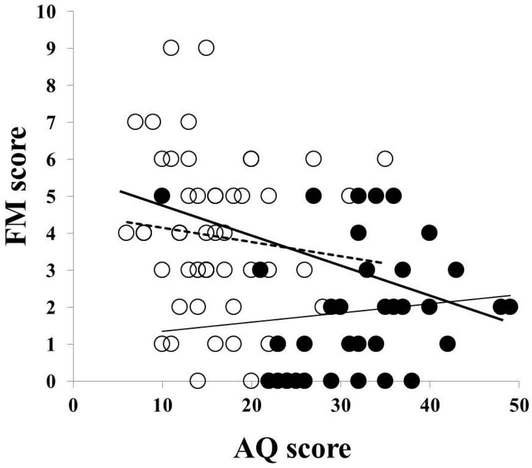


Figure 3. Scatter plots portraying the relationship between AQ scores and FM scores.

Black spots and circles indicate each subject with ASD and control subjects, respectively. Regression lines are drawn through scatter plots of two scores as thin slop in subjects with

Figure 4

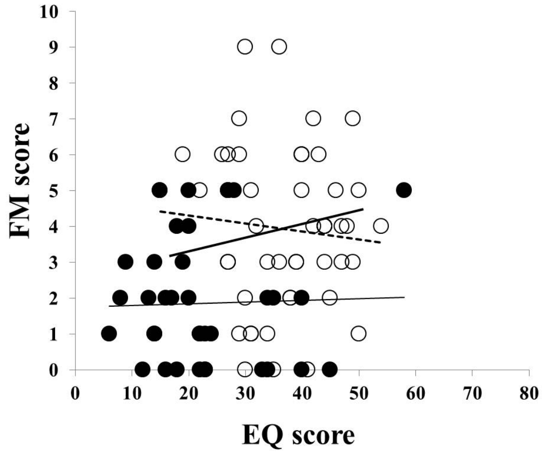


Figure 4. Scatter plots portraying the relationship between EQ scores and FM scores.

Black spots and circles indicate each subject with ASD and control subjects, respectively. Regression lines are drawn through scatter plots of two scores as thin slop in subjects with ASD, dotted slop in healthy subjects, and bold slop in all subjects.

Table 1. Subjects characteristics

	ASD	Control	P
N	36	50	
Age [a]	21.7 [5.0]	22.3 [3.4]	0.494
Gender, male : female	26 : 10	17 : 33	0.001
Full IQ [b]	96.8 [12.7] [c]	106.6 [10.5]	< 0.001
Verbal IQ [b]	101.9 [12.5] [c]	108.1 [10.4]	0.014
Performance IQ	91.1 [15.5] [c]	102.9 [13.4]	< 0.001
Education [a]	11.7 [2.3]	14.4 [2.1]	< 0.001
AQ [b]	31.6 [8.1]	16.2 [6.2]	< 0.001
EQ [b]	22.9 [11.2] [d]	36.7 [9.0] [e]	< 0.001
SQ [b]	24.2 [14.9] [d]	15.7 [10.0]	0.002

ASD, autism spectrum disorder; IQ, intelligence quotient
AQ, Autism-spectrum Quotient; EQ, Empathy Quotient
SQ, Systemizing Quotient
a, means [SD], years
b, means [SD]
c, d, e, The result of one subjects was not obtained.