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Emotional recognition ability among children with
high-functioning autism spectrum disorder

(高機能自閉症スペクトラム児の情動認知特性)

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Emotional recognition ability among children with high-functioning autism spectrum disorder

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Individuals with autism spectrum disorder have difficulties recognizing emotional information, especially from facial expressions. The present study investigated facial expression recognition ability among 17 children with high-functioning autism spectrum disorder and 26 typically developing children. Three facial expression tasks were used: the Eyes Task, the Morphed Faces Task, and the Movie Stills Task with and without faces. Children were asked to adapt emotional words for stimuli (eye stimuli and emotional scenes) or rate emotional intensity from facial expressions. Results showed that children with high-functioning autism spectrum disorder had difficulties perceiving subtle fear, complex emotions, and using contextual information appropriately in the absence of faces. These findings suggest that difficulty in recognizing emotional information from not only facial expressions but also contextual cues could provide a basis for understanding to social deficits among children with high-functioning autism spectrum disorder.

自閉症スペクトラム(ASD)者は感情的情報、特に表情の認知に困難があることがこれまでに指摘されている。本研究では、高機能 ASD 児 17 名および定型発達児 26 名を対象に、3 つの表情認知課題(the Eyes Task, the Morphed Faces Task, the Movie Stills Task)を実施した。参加児童は、刺激(目、感情シーン)に最も当てはまる感情語の回答、表情から読み取れる感情強度の評価を要求された。その結果、高機能 ASD 児は定型発達児と比較して、曖昧な恐怖表情、より複雑な感情の認知が困難であることが示された。加えて、顔情報の有無にかかわらず、文脈的/感情的場面を適切に判断することが難しく、高機能 ASD 児の社会性の障害の背景には、表情だけでなく表情以外の感情的情報の認知困難さも関連している可能性が示唆された。

Keywords: autism spectrum disorder, facial expression, emotion recognition

Introduction

In everyday life, people generally infer others' feelings and behave accordingly based on these assessments. It is necessary to appropriately understand others' emotions in order to maintain harmonious interpersonal relationships. Facial expressions are considered an obvious cue containing a wealth of information regarding human emotions. Therefore, it is essential that we are able to adequately recognize facial expressions as a way to infer others' emotions.

Autism spectrum disorder (ASD) is characterized by three major symptoms: impairments concerning social interactions, communication, and restricted or repetitive interests and behaviors (American Psychiatric Association, 2000). Golan and Baron-Cohen (2006) suggest that one factor associated with social dysfunction among individuals with ASD is a difficulty in understanding others' emotions due in part to impairment in interpreting facial expressions. However, this deficit is not always observed: although some studies show evidence of an impairment or abnormality in emotion recognition in individuals with ASD (e.g., Celani, Battacchi, & Arcidiacono, 1999; Davies, Bishop, Manstead, & Tantam, 1994; Hobson, 1986; Lindner & Rosén, 2006), others show that individuals with ASD and typically developing (TD) groups have equal abilities (e.g., Baron-Cohen, Wheelwright, & Jolliffe, 1997; Capps, Yirmiya, & Sigman, 1992;

Castelli, 2005; Homer & Rutherford, 2008). Several perspectives could explain this inconsistency. First, there could be differences in intellectual levels among individuals with ASD. The intended clinical participants in previous studies showing deficits in emotion recognition among individuals with ASD include both low and high functioning ASD participants, whereas studies targeting only high-functioning ASD participants fail to find observe differences between ASD and TD participants. This indicates that performance on emotional facial expression tasks is likely influenced by intellectual abilities (Dyck, Piek, Hay, Smith, & Hallmayer, 2006; Hobson, 1986).

In spite of intact behavioral performance when reading facial expressions, recent studies focusing on high-functioning ASD participants have reported abnormal brain activity in emotion-processing circuitry (Akechi, Senju, Kikuchi, Tojo, Osanai, & Hasegawa, 2010; Corbett, Carmean, Ravizza, Wendelken, Henry, Carter, & Rivera, 2009; Piggot, Kwon, Mobbs, Blasey, Lotspeich, Menon, Bookheimer, & Reiss, 2004; Wong, Fung, Chua, & McAlonan, 2008). Wong et al. (2008) also found that event-related potential responses (P1, N170, and P2) among children with high-functioning ASD were significantly weaker or lower than were those of TD peers when identifying emotions from facial expression stimuli. These findings suggest that children with ASD might use compensatory analytical strategies to process facial emotions. Another neuroimaging study

outlined a mechanism for a potential compensatory strategy among high-functioning individuals with ASD. This study suggested that individuals with ASD rely on a feature-based strategy related to object perception when reading facial expressions (Schultz, Gauthier, Klin, Fulbright, Anderson, Volkmar, Skudlarski, Lacadie, Cohen, & Gore, 2000). While Schultz and colleagues suggest that this serves as a potential compensatory strategy, most individuals with ASD still exhibit difficulty in interpreting others' emotions in everyday life. Thus, when investigating deficits in recognizing facial expressions among high functioning ASD individuals, stimuli should be carefully selected (such as using more life-like faces).

The type of stimuli presented to participants might also influence performance during emotion recognition tasks. For instance, several studies failing to observe impairment in recognizing facial expression among high-functioning individuals with ASD have utilized obvious displays of basic emotions. In contrast, studies revealing difficulties in recognizing facial expressions among children with high-functioning ASD have employed tasks involving complex emotions (Baron-Cohen, Wheelwright, Spong, Scahill, & Lawson, 2001; Capps, et al., 1992). Basic emotions (happy, surprised, sad, angry, fearful, and disgust) are seen as fairly universal (Ekman & Friesen, 1971) and are typically recognized correctly without the need to attribute the intent of the person

providing the display. However, more complex emotions (i.e., guilt, envy, and shame) involve attributing intention to the individual providing the display, and such displays are not universal but culturally dependent (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001). Moreover, studies employing tasks involving subtle facial expressions (Bal, Harden, Lamb, Van Hecke, Denver, & Porges, 2010; Greimel, Schulte-Rüther, Kircher, Kamp-Becker, Remschmidt, Fink, Herpertz-Dahlmann, & Konrad, 2010; Lindner & Rosén, 2006) and social scenes containing facial expressions and other emotional cues (Golan, Baron-Cohen, & Golan, 2008) report that high-functioning ASD individuals are less accurate in identifying emotions than are their TD peers. These findings indicate that children with high-functioning ASD have more difficulty reading emotions from naturalistic facial expressions that convey complex or subtle emotions (as well as expressions in context from visual scenes) as compared to basic emotions. Additionally, it appears that individuals with ASD have difficulty applying compensatory strategies when recognizing more complex emotional stimuli. Thus, addressing the deficits in emotion recognition of individuals with ASD should start with assessing challenges in detecting emotion from naturalistic, real-world scenarios.

Facial expression tasks require a wide range of social cognitive abilities (Baez, Rattazzi, Gonzalez-Gadea, Torralva, Vigliecca, Decety, Manes, & Ibanez,

2012). For example, the Eyes Task, which assesses the detection of complex emotions, is related to Theory of Mind abilities (Baron-Cohen et al., 1997); the Morphed Faces Task, which requires ability to discriminate subtle emotions, is related to amygdala function (Adolphs & Tranel, 2004); and tasks using emotional scenes are related to the integration of visual context information (Wright, Clarke, N., Jordan, Young, Clarke, Miles, Nation, Clarke, P., & Williams, 2008). Therefore, it is useful to combine several tasks related to these functions in order to better understand overall deficits in recognizing others' emotions among children with high-functioning ASD. Nevertheless, few studies have used a battery of facial recognition tasks. One study examining the emotional recognition abilities of individuals with high-functioning ASD, using an emotional recognition battery, reported that high-functioning adolescents with ASD showed inferior performance to that of a control group (Losh, Adolphs, Poe, Couture, Penn, Baranek, & Piven, 2009). This study employed tasks that required judging complex emotions (the Eyes Task; Baron-Cohen, Wheelwright, Spong, et al. 2001), rating subtle facial expressions (the Morphed Faces Task; Adolphs & Tranel, 2004), and recognizing emotional scenes that contained faces and other emotional information (the Movie Stills Task with and without faces; Adolphs & Tranel, 2003). These tasks were chosen because stimuli were nearer to natural facial expressions and were associated with activation in brain

regions crucial to emotional recognition (Couture, Penn, Losh, Adolphs, Hurley, & Piven, 2010). For instance, impaired performance on the Eyes Task has been associated with decreased amygdala, medial prefrontal cortex, and superior temporal gyrus activation (Baron-Cohen, Ring, Wheelwright, Bullmore, Brammer, Simmons, & Williams, 1999). Furthermore, amygdala activity is related to performance on the Morphed Faces Task (Adolphs & Tranel, 2004), as well as performance on the Movie Stills Task (Adolphs & Tranel, 2003). Losh et al. (2009) showed that adolescents with high-functioning ASD show overall deficits in emotion recognition. According to other studies, emotion recognition abilities continue to develop throughout childhood and adolescence (Herba & Phillips, 2004; Thomas, De Bellis, Graham, & LaBar, 2007). O'Connor, Hamm, and Kirk (2005) reported no differences in emotion recognition ability for basic emotions between high-functioning ASD and TD children; however, there were significant differences among ASD and TD adults. The authors suggested that the differences in results between children and adults might be due to generally incomplete development in neuronal generators among children. This developmental hypothesis only seems to be relevant for basic facial expressions and has not been tested for complex or subtle emotional contexts. Therefore, the current study investigated whether children with high-functioning ASD show difficulties in reading more realistic facial expressions using the

same tasks as Losh et al. (2009).

The current study investigated whether children with high-functioning ASD are impaired in performing emotional facial recognition tasks in the same manner as adults with high-functioning ASD. Specifically, the current study attempted to more comprehensively capture emotion recognition impairment across a diverse set of recognition tasks.

Methods

Participants

The present study included a high-functioning ASD group of 17 children (14 boys and 3 girls) aged 8–12 years (mean, 9.4 ± 1.3) recruited from Osaka University Hospital. Children were diagnosed according to criteria outlined in the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR; American Psychiatric Association, 2000). Intellectual Quotient (IQ) among children with high-functioning ASD was assessed using the Wechsler Intelligence Scale for Children, 3rd Edition (WISC-III; Wechsler, 1991); all children had IQs greater than 75. One child with ASD was assessed using the Kaufman Assessment Battery for Children.

The TD group included 26 children (16 boys and 10 girls), aged 8–12 years (mean age, 9.8 ± 1.3 years), who were recruited from the general community.

All children in the TD group were enrolled in regular classes at local elementary schools, and none reported any history of neurological or mental illness. The TD group was screened for ASD using the Autism Screening Questionnaire (ASQ), which was completed by parents; none of the TD children scored above the ASD cut-off of 13. The TD group had significantly lower ASQ scores compared with the high-functioning ASD group ($t(18.84) = 5.89, p < .01$). Participants' demographic characteristics are presented in Table 1.

All children and parents were given explanations regarding the intent and purpose of the present study, including a description of the experimental tasks. Informed consent was obtained from participants and a written informed consent form was obtained by the parents. The Institutional Review Board of Osaka University Hospital approved this study.

Table 1

Procedure

The current study employed three tasks (the Eyes Task, the Morphed Faces Task, and the Movie Stills Task) used in previous study (Losh et al., 2009) to investigate emotional recognition abilities. All tasks were presented on a 15.6-in. laptop computer with a resolution of 1366 × 768 pixels. Stimulus size for the Eyes Task was 826 × 699 pixels, and it was 812 × 560 pixels for the Morphed Faces and Movie Stills Tasks. All tasks were performed using Microsoft Visual

Studio 2008 Professional software.

All participants were assessed in a quiet room in a comfortable environment. Participants were seated in front of a computer screen at a distance of roughly 40cm. High-functioning ASD and TD children received the same instructions, which were illustrated by an example for each task. The researcher explained emotion word meanings until participants fully understood the tasks when there was a question from the participants. There was no response time limit for any task. Stimuli were presented on the screen until the participant responded; the next stimulus was presented after the participant pressed the “Next” button, which was presented on the right side of the display. All stimuli were presented only once. Task order was counterbalanced across participants.

Facial expression tasks

1. *The Eyes Task*: The Eyes Task assesses the ability to read others’ mental states (Baron-Cohen, Wheelwright, Spong, et al., 2001). This task requires participants to recognize complex emotions. Participants are presented with only the eye region of a face and are asked to choose the best word (among four alternatives) that best describes what the person is thinking or feeling. All words convey complex emotions (i.e., jealous, panicked, arrogant, and hateful). Twenty-eight images were presented during this task. The number of correct answers was used as the dependent measure.

2. *The Morphed Faces Task*: The Morphed Faces Task assesses the ability to identify emotions from faint facial expressions generated by morphing a neutral facial expression into progressively prototypical expressions of happiness, sadness, and fear (Losh et al., 2009). This task consists of 18 photographs containing 3 neutral and 5 emotional faces (happy, sad, and fearful). The emotional faces were chosen from 19 linear morphs that each had different intensity of morphing (Adolphs & Tranel, 2004). Furthermore, we followed Losh et al.'s (2009) procedure by classifying stimuli as "high" or "low": two "high" stimuli, classified according to higher morph intensities (more similar to the presented emotional faces); and two "low" stimuli, classified according to lower morph intensities (more similar to the neutral faces for each emotion). All children were asked to judge the intensity of how happy, sad, or fearful each face looked on a scale from 1 (not at all, opposite to the presented feeling) to 10 (strong presented feeling). Scoring was calculated by the difference between ratings given to the emotional faces and the mean rating of the three neutral faces for each participant and each emotion.

3. *The Movie Stills Task with and without faces*: The Movie Stills Task with and without faces measures one's reliance on facial information to identify the emotional content of complex scenes. This task consists of 16 photographs depicting contextual scenes with obvious emotional content (Adolphs & Tranel,

2003). First, children were shown 16 photographs with the faces covered (without face condition), and then they were shown the photographs with the faces present (with face condition). In a preliminary study using a Japanese reference group (Eto & Sakai, 2012)¹, 14 stimuli were classified into five emotion categories (happy, sad, surprised, angry, and fearful), and two stimuli were not classified into any emotion category. Therefore, for the present study, 14 scenes were used as stimuli, consisting of two scenes each for happy and fearful, three each for angry and surprised, and four scenes for sad. Children were asked to choose among seven words (happy, sad, fearful, surprised, angry, disgusted, or neutral) to describe the way the people were feeling. Performance was converted into an accuracy score based on data from a reference group. For instance, if 50% of reference participants answered “angry,” 40% answered “happy,” and 10% answered “fearful,” participants answering “angry” received a score of 1.0, those answering “happy” received a score of 0.8, and those answering “fearful” received a score of 0.2. Accuracy scores were summed for both with face and without face conditions, and then averaged separately for each emotion.

Intellectual ability scale

Some studies suggest that the performance of children with ASD on facial expression tasks is more dependent on their intellectual ability than is that of TD

children (Dyck et al., 2006; Hobson, 1986). Therefore, it is possible that the IQ of children with ASD would influence their performance on the experimental tasks. In particular, verbal comprehension and visual perception might be related since our tasks also require understanding emotional words and perceiving visual stimuli as cues to judge an emotion. To examine this association for children with high-functioning ASD, correlations between task performance and WISC- III IQ scores (Full-scale IQ, verbal IQ, and performance IQ), as well associations with specific performance indices (Verbal Comprehension: VC, Perceptual Organization: PO), were calculated. VC reflects the overall ability to understand language, and PO is an index of the ability to integrate visual information.

Statistical analyses

Statistical analyses were carried out using IBM SPSS Statistics version 20.0 (International Business Machines Corp.).

In the present study, there were more girls in the TD group ($n = 10$) than in the ASD group ($n = 3$). Therefore, we assessed the effects of gender on our main results. However, no gender differences emerged in terms of task performance in the TD group². Thus, data was collapsed across gender for all analyses.

For the Eyes Task, a *t*-test analysis was conducted between groups. For the

Morphed Faces Task, rating scores were calculated by comparing the mean differences relative to neutral face norms. Therefore, in order to assess potential differences between high-functioning ASD and TD children's neutral norm scores, a *t*-test analysis was conducted between groups. Results showed that there were no significant differences between groups in terms of mean ratings for neutral faces (happy: $t(41) = -.59$, $p = .56$; sad: $t(41) = -.34$, $p = .74$; fearful: $t(41) = 1.1$, $p = .28$). Thus, we were confident that any differences in terms of emotional face ratings would not be due to different neutral comparisons for the two groups. Therefore, a mixed-model analysis of variance (ANOVA) was conducted with emotion (happy, sad, and fearful) and intensity (high and low) as within-group factors and group (high-functioning ASD and TD) as the between-group factor. For the Movie Stills Task with and without faces, a mixed-model ANOVA was conducted with emotion (happy, surprised, sad, angry, and fearful) and face information (with face and without face) as the within-group factors and group as the between-group factor. Furthermore, Pearson's correlation coefficients were calculated for performance on each task and WISC-III scores (Full-scale IQ, verbal IQ, performance IQ, VC, and PO) to assess relationships between visual perception ability and emotion recognition performance among children with high-functioning ASD.

Results

Task Performance

Task performance among the high-functioning ASD and TD groups is shown in Table 2.

Table 2

For the Eyes Task, significant group differences emerged ($t(26.27) = -3.24, p < .01$) (Figure 1). The TD group was more accurate than was the high-functioning ASD group.

Figure 1

Results for the Morphed Faces Task are shown in Figure 2. There was a significant main effect of emotion ($F(2, 82) = 4.15, p < .05$) and emotional intensity ($F(1, 41) = 51.35, p < .01$). Both groups showed higher scores for “high” stimuli than for “low” stimuli. All children were able to discriminate the “low” emotion face from the “high” emotion face for each emotion type. In contrast, there was no significant main effect of group, but the interaction between group and emotion was marginally significant ($F(2, 82) = 2.58, p = .08$). In order to describe the characteristics for emotion recognition among children with high-functioning ASD in detail, we further probed this marginally significant interaction via a simple main effects analysis. Children with high-functioning ASD had lower ratings for fearful faces than did TD children ($p < .05$); however,

there were no group differences for happy and sad faces (Figure 2). In order to confirm whether children with high-functioning ASD are able to discriminate “high” from “low” stimuli, we conducted supplemental analysis on the high-functioning ASD group. A separate repeated-measures ANOVA with emotion and intensity as within-group factors was conducted. Results revealed significant main effects of emotion and intensity ($F(2, 50) = 9.69, p < .01$; $F(1, 25) = 51.47, p < .01$, respectively), as well as a significant interaction ($F(2, 50) = 3.58, p < .05$). Post hoc analyses revealed that children with high-functioning ASD showed higher rating scores for “high” stimuli than for “low” stimuli regardless of emotion type ($p < .01$).

Figure 2

The results of the Movie Stills Task with and without faces are presented in Figure 3. There was a significant main effect of group ($F(1, 41) = 9.19, p < .01$), emotion ($F(4, 164) = 21.89, p < .01$), and face information ($F(1, 41) = 44.04, p < .01$). However, there were no significant interactions. Both the high-functioning ASD and TD groups performed better when the task included faces than when it did not include faces. However, the performance of the high-functioning ASD group was significantly worse compared to the TD group, in both the with and without faces conditions.

Figure 3

Relationships between task performance and WISC-III scores in ASD

Correlations between task performance and WISC-III scores are shown in Table 3. No significant correlations were found between task performance and full-scale IQ, verbal IQ, performance IQ, or the VC index. However, there was a significant positive correlation between performance on the Movie Stills Task with faces and PO score ($r = .62, p < .05$).

Table 3

Discussion

The present study attempted to comprehensively capture impairment with recognizing facial expressions among children with high-functioning ASD. We found that children with high-functioning ASD have deficits in recognizing complex emotions and subtle fearful faces. In contextual scenes, these children also have difficulty judging emotions, regardless of whether facial information is present. Furthermore, it was only the case that when scenes included faces, task performance was related to the ability to integrate visual information for children with high-functioning ASD.

For the Eyes Task, which measured the ability to identify complex emotions displayed only in the eye region of faces, children with high-functioning ASD performed less proficiently than TD children did. This finding shows there is

already a salient difference in the ability to identify others' state of mind between children with high-functioning ASD and TD children aged 8–12 years. This result is consistent with previous studies using the Eyes Task (Baron-Cohen, Wheelwright, Spong, et al., 2001; Brent, Rios, Happé, & Charman, 2004; Kaland, Callesen, Møller-Nielsen, Mortensen, & Smith, 2008). The Eyes Task is related to Theory of Mind ability, and Baron-Cohen (1989) argued that disability in this domain is the core impairment among individuals with high-functioning ASD. Our result also supported this hypothesis.

On the Morphed Faces Task, which measures the ability to discriminate emotional intensity from a facial expression (happy, sad, and fearful), children with high-functioning ASD provided higher scores for “high” stimuli than for “low” stimuli. This result suggests that these children were able to discriminate the “low” emotional face from the “high” emotional face. However, for fearful faces, their ratings for “high” stimuli were similar to those of the TD children for “low” fear faces, as shown in Figure 2. Though there was only a marginally significant group difference, we found that children with high-functioning ASD tend to have difficulty in recognizing fearful faces. This finding indicates that although children with high-functioning ASD are able to discriminate low and high intensity for certain emotions, this discrimination is less refined when reading fearful faces. Previous studies investigating adolescents and adults with

high-functioning ASD have reported deficits in recognizing specific emotions (e.g., fear). The tasks used included obvious facial expression stimuli (Ashwin, Baron-Cohen, Wheelwright, O’Riordan, & Bullmore, 2007; Howard, Cowell, Boucher, Broks, Mayes, Farrant, & Roberts, 2000) that were similar to the “high” stimuli, and less obvious facial expressions, such as morphed facial stimuli (Humphreys, Minshew, Leonard, & Behrmann, 2007) that were similar to the “low” stimuli used the present study. Our results suggest that these deficits emerge in younger children as well.

The Movie Stills Task required participants to integrate visuospatial emotional information that contained contextual cues, such as body language, as well as facial information. There were differences between high-functioning ASD and TD children in both conditions with and without faces. Similarly, high-functioning ASD adolescents have difficulties encoding and integrating emotional information with and without faces during the Movie Stills Task (Couture et al., 2010; Losh et al., 2009). However, we found that accuracy scores did improve when facial expressions were added to the scene for children with high-functioning ASD. This shows that these children are capable of using facial information to aid their emotion recognition ability. Thus, while children with high-functioning ASD can judge basic facial expressions appropriately, they have difficulty reading contextual information other than faces to detect

emotional tone. Previous studies have shown that individuals with ASD experience abnormal perceptual processing known as “Weak Central Coherence” (Frith, 1989). This theory posits that ASD is characterized by impairment in the integration of environmental information. In other words, individuals with ASD fail to coherently process the main themes of a particular context. Although individuals with ASD are proficient in processing the details of complex visual stimuli, they demonstrate deficits in integrating these details into a coherent whole (Sasson, 2006). The Movie Stills Task also requires participants to integrate contextual cues, and participants are challenged to use their abilities related to processing holistic properties in emotional scenes. Therefore, it can be concluded that children with high-functioning ASD are not as capable of decoding and integrating these non-facial cues when evaluating emotional scenes.

Regarding relationships between task performance and intellectual abilities, IQ subscales and the VC index had no significant correlation with performance on any task. These results suggest that our tasks were not dependent on overall or verbal intellectual abilities. However, a significant correlation was observed between the Movie Stills Task with faces and the PO index. Stimuli from the Movie Stills Task were clear emotional scenes; therefore, these scenes contained obvious facial expressions. This indicated that these children used

their visual integration abilities when decoding obvious emotional facial expressions. However, ASD children likely do not effectively use integration when decoding complex emotions, subtle facial expressions, and contextual cues other than faces. Previous studies reported that high-functioning ASD participants have difficulty with holistic face processing (López, Donnelly, Hadwin, & Leekam, 2004); however, little is known how and what kind of ability is necessary for children with high-functioning ASD to recognize visual contextual cues other than faces in emotional contexts. Future investigation regarding the process of recognizing contextual cues among high-functioning ASD individuals is needed.

In combining the results from these three tasks, characteristics of emotion recognition among children with high-functioning ASD can be described as follows. First, children with high-functioning ASD are able to recognize basic emotions from facial expressions, although their threshold for detecting fearful emotions might be higher than for TD children. Second, ASD children have difficulty in judging complex emotions. Third, they also have difficulty in judging basic emotions when required to integrate contextual information. These results suggest that children with high-functioning ASD are able to recognize others' emotion partially, although they have difficulties in reading complex emotions, and are poor in integrating emotional and contextual information. These

irregularities in strength and difficulty might lead to children with high-functioning ASD misunderstanding others' traits in daily life.

Furthermore, performance on these three tasks is related to hypotheses predicting ASD impairment such as impairment in Theory of Mind ability or Weak Central Coherence. These tasks are associated with amygdala function based on evidence from previous studies (Adolphs & Tranel, 2003, 2004; Baron-Cohen, Wheelwright, Spong, et al., 2001). Waterhouse, Fein, and Modahl (1996) proposed the amygdala dysfunction hypothesis in ASD; that is, ASD individuals might suffer from amygdala dysfunction, which in turn relates to deficits in processing emotion and motivated behavior (Baron-Cohen, Ring, Bullmore, Wheelwright, Ashwin, & Williams, 2000). Our findings partially support these hypotheses. However, we did not measure actual difficulties in social interaction among children with high-functioning ASD. Therefore, the present study cannot specifically speak to the relationships between emotion recognition impairments and difficulties with social interaction in daily life. These relationships need to be investigated in future studies.

Our study did have a few limitations. First, our sample size was relatively small, and we did not have proper homoscedasticity in the Eyes Task. Second, whereas Herba and Phillips (2004) reported that the ability to recognize emotions among TD individuals is acquired through childhood and adolescence,

another study suggested that abilities for recognizing most basic emotions mature by around age 10 (Durand, Galla, Seigneure, Robichon, & Baudouin, 2007). As the present study recruited children aged 8–12 years, and due to the limited number of participants, we were unable to divide our participants into smaller groups to investigate potential differences within this age range. Third, we measured IQ scores in only the high-functioning ASD group. Therefore, it is unclear whether there is an association between task performance and IQ for TD children in our study. Finally, although our participants were Japanese, we adapted stimuli from photographs depicting individuals from Western cultures because it is theorized that such facial expressions are universal. However, some participants in our study reported that these facial expressions seemed a bit strange. Therefore, we need to consider using culturally appropriate stimuli to better capture facial recognition abilities in this participant sample.

In spite of these limitations, our tasks were able to capture aspects of emotion recognition dysfunction among children with high-functioning ASD. Moreover, our findings support the notion that difficulties in recognizing emotions among children with high-functioning ASD are perhaps partially related to amygdala dysfunction, impairment in Theory of Mind ability, and Weak Central Coherence. In addition, these results suggest that it is possible for children with high-functioning ASD to use abilities related to integrating

visual information when recognizing obvious facial expressions. However, further studies are needed in order to provide evidence for these suggestions.

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References

- Adolphs, R., & Tranel, D. (2003). Amygdala damage impairs emotion recognition from scenes only when they contain facial expressions. *Neuropsychologia*, 41, 1281–1289.
- Adolphs, R., & Tranel, D., (2004). Impaired judgments of sadness but not happiness following bilateral amygdala damage. *Journal of Cognitive Neuroscience*, 16, 453–462.
- Akechi, H., Senju, A., Kikuchi, Y., Tojo, Y., Osanai, H., & Hasegawa, T. (2010). The effect of gaze direction on the processing of facial expressions in children with autism spectrum disorder: an ERP study. *Neuropsychologia*, 48, 2841–2851.
- American Psychiatric Association (2000). Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR), Washington, DC: American Psychiatric Association.
- Ashwin, C., Baron-Cohen, S., Wheelwright, S., O’Riordan, M., & Bullmore, E. T. (2007). Differential activation of the amygdala and the ‘social brain’ during fearful face-processing in Asperger Syndrome. *Neuropsychologia*, 45, 2–14.
- Baez, S., Rattazzi, A., Gonzalez-Gadea, M. L., Torralva, T., Vigliecca, N. S., Decety, J., Manes, F., & Ibanez, A. (2012). Integrating intention and context: assessing social cognition in adults with Asperger syndrome. *Frontiers in Human Neuroscience*, 6, 302.
- Bal, E., Harden, E., Lamb, D., Van Hecke, A. V., Denver, J. W., & Porges, S. W. (2010). Emotion recognition in children with autism spectrum disorders: relations to eye gaze and autonomic state. *Journal of Autism and Developmental Disorders*, 40, 358–370.
- Baron-Cohen, S. (1989). The autistic child’s theory of mind: A case of specific developmental delay. *Journal of Child Psychology and Psychiatry*, 30, 285-297.
- Baron-Cohen, S., Ring, H., Bullmore, E., Wheelwright, S., Ashwin, C., & Williams, S. C. R. (2000). The amygdala theory of autism. *Neuroscience & Biobehavioral Reviews*, 24, 355–364.

- Baron-Cohen, S., Ring, H., Wheelwright, S., Bullmore, E., Brammer, M., Simmons, A., & Williams, S. C. R. (1999). Social intelligence in the normal and autistic brain: an fMRI study. *European Journal of Neuroscience*, 11, 1891–1998.
- Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The “Reading the Mind in the Eyes” Test revised version: a study with normal adults, and adults with Asperger syndrome or high-functioning autism. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, 42, 241–251.
- Baron-Cohen, S., Wheelwright, S., & Jolliffe, T. (1997). Is there a "language of the eyes"? evidence from normal adults, and adults with autism or Asperger syndrome. *Visual Cognition*, 4, 311–331.
- Baron-Cohen, S., Wheelwright, S., Spong, A., Scahill, V., & Lawson, J., (2001). Are intuitive physics and intuitive psychology independent? A test with children with Asperger Syndrome. *Journal of Developmental and Learning Disorders*, 5, 47–78.
- Brent, E., Rios, P., Happé, F., & Charman, T. (2004). Performance of children with autism spectrum disorder on advanced theory of mind tasks. *Autism: The International Journal of Research and Practice*, 8, 283–299.
- Capps, L., Yirmiya, N., Sigman, M. (1992). Understanding of simple and complex emotions in non-retarded children with autism. *Journal of Child Psychology and Psychiatry*, 33, 1169–1182.
- Castelli, F. (2005). Understanding emotions from standardized facial expressions in autism and normal development. *Autism : The International Journal of Research and Practice*, 9, 428–449.
- Celani, G., Battacchi, M. W., & Arcidiacono, L. (1999). The understanding of the emotional meaning of facial expressions in people with autism. *Journal of Autism and Developmental Disorders*, 29, 57–66.
- Corbett, B. Carmean, V., Ravizza, S., Wendelken, C., Henry, M. L., Carter, C., & Rivera, S. M. (2009). A functional and structural study of emotion and face processing in children with autism. *Psychiatry Research*, 173, 196–205.
- Couture, S. M., Penn, D. L., Losh, M., Adolphs, R., Hurley, R., & Piven, J.

- (2010). Comparison of social cognitive functioning in schizophrenia and high functioning autism: more convergence than divergence. *Psychological Medicine*, 40, 569–579.
- Davies, S., Bishop, D., Manstead, A. S. R., & Tantam, D. (1994). Face perception in children with autism and Asperger's syndrome. *Journal of Child Psychology and Psychiatry*, 35, 1033–1057.
- Durand, K., Gallay, M., Seigneuric, A., Robichon, F., & Baudouin, J. Y. (2007). The development of facial emotion recognition: The role of configural information. *Journal of Experimental Child Psychology*, 97, 14–27.
- Dyck, M. J., Piek, J. P., Hay, D., Smith, L., & Hallmayer, J. (2006). Are abilities abnormally interdependent in children with autism? *Journal of Clinical Child and Adolescent Psychology*, 35, 20–33.
- Ekman, P., & Friesen, W. (1971). Constants across cultures in the face and emotion. *Journal of Personality and Social Psychology*, 17, 124–129.
- Eto, M., Sakai, S. (2012). Correlation between social awareness and autism-like characteristics in adults. *The 23rd Annual Meeting for the Japan Society of Developmental Psychology*, 688.
- Frith, U. (1989). *Autism: Explaining the enigma*. Oxford, UK: Blackwell.
- Golan, O., & Baron-Cohen, S. (2006). Systemizing empathy: teaching adults with Asperger syndrome or high-functioning autism to recognize complex emotions using interactive multimedia. *Development and Psychopathology*, 18, 591–617.
- Golan, O., Baron-Cohen, S., & Golan, Y. (2008). The “Reading the Mind in Films” Task [child version]: complex emotion and mental state recognition in children with and without autism spectrum conditions. *Journal of Autism and Developmental Disorders*, 38, 1534–1541.
- Greimel, E., Schulte-Rüther, M., Kircher, T., Kamp-Becker, I., Remschmidt, H., Fink, G. R., Herpertz-Dahlmann, B., & Konrad, K. (2010). Neural mechanisms of empathy in adolescents with autism spectrum disorder and their fathers. *NeuroImage*, 49, 1055–1065.
- Herba, C., & Phillips, M. (2004). Annotation: development of facial expression recognition from childhood to adolescence: behavioural and neurological

- perspectives. *Journal of Child Psychology and Psychiatry*, 45, 1185–1198.
- Hobson, R. P. (1986). The autistic child's appraisal of expressions of emotion. *Journal of Child Psychology and Psychiatry*, 27, 321–342.
- Homer, M., & Rutherford, M. D. (2008). Individuals with autism can categorize facial expressions. *Child Neuropsychology*, 14, 419–437.
- Howard, M. A., Cowell, P. E., Boucher, J., Broks, P., Mayes, A., Farrant, A., & Roberts, N. (2000). Convergent neuroanatomical and behavioural evidence of an amygdala hypothesis of autism. *Neuroreport*, 11, 2931–2935.
- Humphreys, K., Minshew, N., Leonard, G. L., & Behrmann, M. (2007). A fine-grained analysis of facial expression processing in high-functioning adults with autism. *Neuropsychologia*, 45, 685–695.
- Kaland, N., Callesen, K., Møller-Nielsen, A., Mortensen, E. L., & Smith, L. (2008). Performance of children and adolescents with Asperger syndrome or high-functioning autism on advanced theory of mind tasks. *Journal of Autism and Developmental Disorders*, 38, 1112–1123.
- Lindner, J. L., & Rosén, L. A. (2006). Decoding of emotion through facial expression, prosody and verbal content in children and adolescents with Asperger's syndrome. *Journal of Autism and Developmental Disorders*, 36, 769–777.
- López, B., Donnelly, N., Hadwin, J., & Leekam, S. (2004). Face processing in high-functioning adolescents with autism: evidence for weak central coherence. *Visual Cognition*, 11, 673–688.
- Losh, M., Adolphs, A., Poe, M. D., Couture, S., Penn, D., Baranek, G. T., & Piven J. (2009). Neuropsychological profile of autism and the broad autism phenotype. *Archives of General Psychiatry*, 66, 518–526.
- O'Connor, K., Hamm, J. P., & Kirk, I. J. (2005). The neurophysiological correlates of face processing in adults and children with Asperger's syndrome. *Brain and Cognition*, 59, 82–95.
- Piggot, J., Kwon, H., Mobbs, D., Blasey, C., Lotspeich, L., Menon, V., Bookheimer, S. Y., & Reiss, A. L. (2004). Emotional attribution in high-functioning individuals with autistic spectrum disorder: a functional

- imaging study. *Journal of the American Academy of Child and Adolescent Psychiatry*, 43, 473–480.
- Sasson, N. J. (2006). The development of face processing in autism. *Journal of Autism and Developmental Disorders*, 36, 381–394.
- Schultz, R. T., Gauthier, I., Klin, A., Fulbright, R. K., Anderson, A. W., Volkmar, F., Skudlarski, P., Lacadie, C., Cohen, D. J., & Gore, J. C. (2000). Abnormal ventral temporal cortical activity during face discrimination among individuals with autism and Asperger syndrome. *Archives of General Psychiatry*, 57, 331–340.
- Thomas, L., De Bellis, M. D., Graham, R., & LaBar, K. S. (2007). Development of emotional facial recognition in late childhood and adolescence. *Developmental Science*, 10, 547–558.
- Waterhouse, L., Fein, D., & Modahl, C. (1996). Neurofunctional mechanisms in autism. *Psychological Review*, 103, 457–489.
- Wechsler, D. (1991). Wechsler Intelligence Scale for Children (3rd ed.). San Antonio, TX: Psychological Corporation.
- Wong, T. K. W., Fung, P. C. W., Chua, S. E., & McAlonan, G. M. (2008). Abnormal spatiotemporal processing of emotional facial expressions in childhood autism: dipole source analysis of event-related potentials. *The European Journal of Neuroscience*, 28, 407–416.
- Wright, B., Clarke, N., Jordan, J., Young, A. W., Clarke, P., Miles, J., Nation, K., Clarke, L., & Williams, C. (2008). Emotion recognition in faces and the use of visual context in young people with high-functioning autism spectrum disorders. *Autism : The International Journal of Research and Practice*, 12, 607–626.

<Note>

1. In our pilot study, we examined facial expression task performance among a normal adult sample. All participants were 20 years of age or older ($N = 69$, mean age = 23.8 ± 2.7 years old).
2. In order to assess the influence of gender in our study, we conducted a *t*-test analysis between boys and girls for TD children on the Eyes Task. There were no differences between groups ($t(24) = 1.62, p = .66$). On the Morphed Faces Task, we conducted a mix-model ANOVA, with emotion and intensity as within-group factors and gender as a between-group factor (girls, boys). Results showed no significant effect of gender ($F(1,24) = .33, p = .57$). For the Movie Stills Task with and without faces, a mixed-model ANOVA was conducted with emotion and face information as the within-group factors and gender as the between-group factor. There was also no significant main effect of gender in this analysis ($F(1,24) = .02, p = .90$).

Table 1. Demographic Characteristics

Characteristics	ASD	TD	
N	17	26	
Male/Female	14/3	16/10	
age	9.4 (1.3)	9.8 (1.3)	
ASQ	14.6 (7.8)	3.1 (2.8)	*
WISC-III			
Full-scale IQ	97.4 (12.2)	-	
Verbal IQ	100.1 (14.7)	-	
Performance IQ	95.2 (14.6)	-	
Verbal Comprehension	102.9 (17.4)	-	
Perceptual Organization	93.0 (12.1)	-	

Note : All WISC-III scores was averaged across 16 high-functioning ASD participants.

* $p < .01$

Table 2. Study measures

	ASD (N = 17)		Control (N = 26)	
	Mean	(SD)	Mean	(SD)
The Eyes Task	11.88	(5.18)	16.58	(3.65)
The Morphed Faces Task				
Happy Low	1.11	(2.40)	0.96	(1.32)
Happy High	3.23	(2.37)	3.63	(1.84)
Sad Low	1.20	(2.14)	1.60	(2.10)
Sad High	2.61	(2.25)	3.13	(2.27)
Fearful Low	1.59	(1.63)	2.81	(1.97)
Fearful High	2.85	(2.60)	4.74	(2.29)
The Movie Stills Task				
Without Face	7.16	(1.58)	8.35	(1.73)
happy	0.51	(0.25)	0.66	(0.36)
surprised	0.34	(0.19)	0.38	(0.18)
sad	0.62	(0.24)	0.62	(0.29)
angry	0.43	(0.18)	0.56	(0.22)
fearful	0.36	(0.22)	0.50	(0.20)
With Face	8.98	(2.49)	10.33	(1.35)
happy	0.88	(0.28)	1.00	(0.00)
surprised	0.50	(0.26)	0.59	(0.25)
sad	0.59	(0.21)	0.69	(0.23)
angry	0.52	(0.27)	0.54	(0.22)
fearful	0.46	(0.27)	0.60	(0.23)

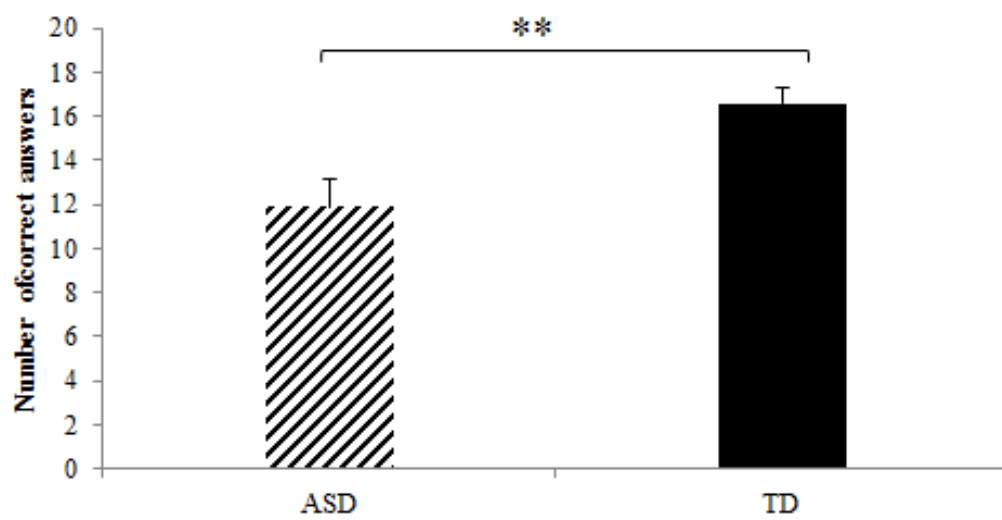


Figure 1. Number of correct answers on the Eyes Task

**** $p < .01$**

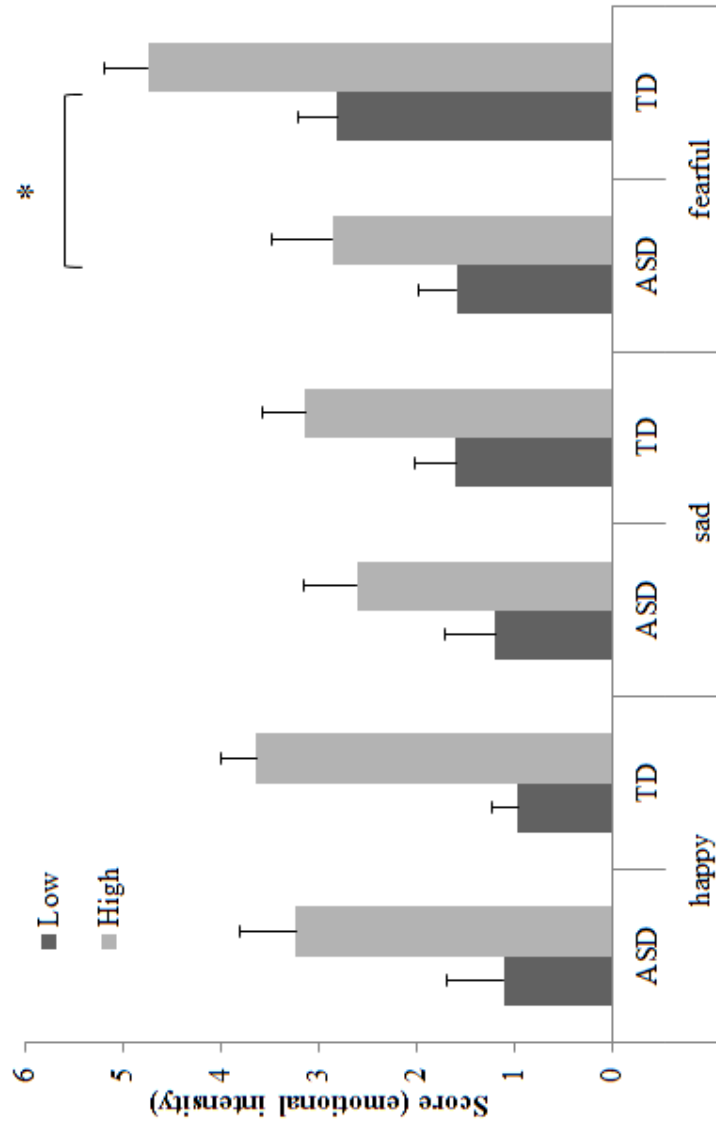


Figure 2. Intensity scores for the Morphed Faces Task

* $p < .05$

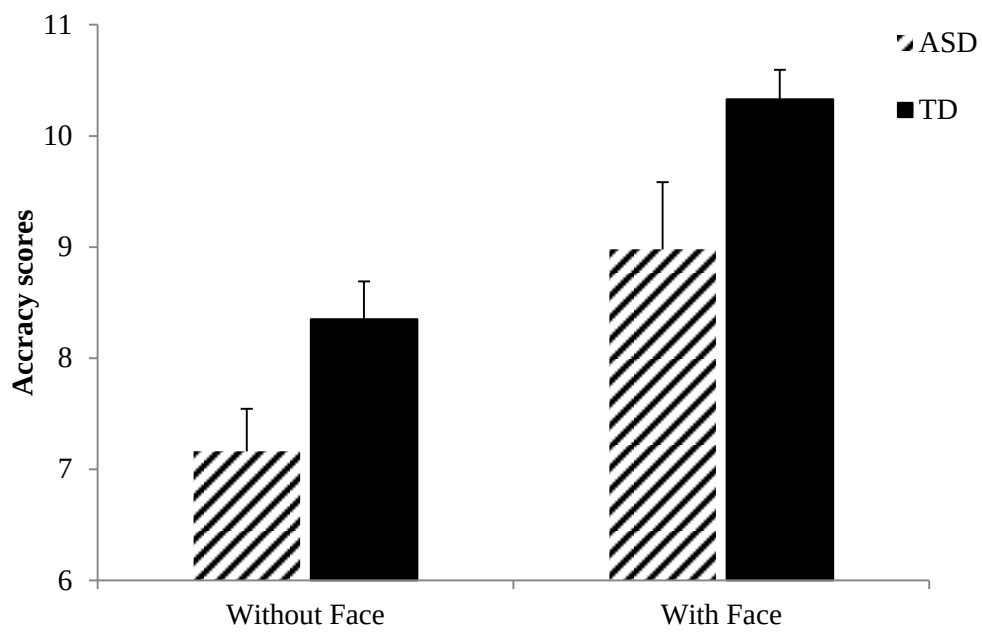


Figure 3. Accuracy scores on the Movie Stills Task

Table 3. Correlations between task performance and WISC-III scores

	the Eyes Task	the Morphed Faces Task		the Movie Stills Task	
		Low	High	Without face	With face
Full-scale IQ	.04	-.25	.07	.18	.43
Verbal IQ	.25	-.15	.23	.13	.16
Performance IQ	-.23	-.26	-.16	.11	.48
Verbal Comprehension	.07	-.24	.27	.06	.22
Perceptual Organization	-.16	-.13	-.01	.15	.62 *

* $p < .05$