Title	Common and unique impairments in facial-expression recognition in pervasive developmental disorder-not otherwise specified and Asperger's disorder
Author(s)	Uono, Shota; Sato, Wataru; Toichi, Motomi
Citation	Research in Autism Spectrum Disorders (2013), 7(2): 361-368
Issue Date	2013-02
URL	http://hdl.handle.net/2433/189088
Right	© 2014 Elsevier Ltd.
Type	Journal Article
Textversion	author

Research in Autism Spectrum Disorders, 7, 2, 361-368.

DOI: 10.1016/j.rasd.2012.10.007

Common and unique impairments in facial-expression recognition in pervasive developmental disorder-not otherwise specified and Asperger's disorder

Shota Uono[1], Wataru Sato[2], and Motomi Toichi[1]

1 Graduate School of Human Health Science, Faculty of Medicine, Kyoto University, Shogoin Kawahara-cho, Sakyo-ku, Kyoto 606-8507, Japan.

2 The Hakubi Project, Primate Research Institute, Kyoto University, Inuyama, Aichi 484-8506, Japan.

Correspondence concerning this article should be addressed to Shota Uono, Graduate School of Human Health Science, Faculty of Medicine, Kyoto University, Shogoin Kawahara-cho, Sakyo-ku, Kyoto 606-8507, Japan.

Tel: +81 75 751 3965; Fax: +81 75 751 3965;

E-mail: uonoshota1982@gmail.com

Research in Autism Spectrum Disorders, 7, 2, 361-368.

Abstract

This study was designed to identify specific difficulties and associated features related to the problems with social interaction experienced by individuals with pervasive developmental disorder-not otherwise specified (PDD-NOS) using an emotion-recognition task. We compared individuals with PDD-NOS or Asperger's disorder (ASP) and typically developing individuals in terms of their ability to recognize facial expressions conveying the six basic emotions. Individuals with PDD-NOS and ASP were worse at recognizing fearful faces than were controls. Individuals with PDD-NOS were less accurate in recognizing disgusted faces than were those with ASP. The results suggest that PDD subtypes are characterized by shared and unique impairments in the ability to recognize facial expressions. Furthermore, the ability to recognize fearful but not disgusted expressions was negatively correlated with the severity of social dysfunction in PDD-NOS and ASP. The results suggest that impaired recognition of fearful and disgusted faces may reflect the severity of social dysfunction across PDD subtypes and the specific problems associated with PDD-NOS, respectively. Characteristics associated with different levels of symptom severity in PDD-NOS are discussed in terms of similarities with brain damage and other psychiatric disorders.

Research in Autism Spectrum Disorders, 7, 2, 361-368.

Keywords: Asperger's disorder; Facial expression recognition; Pervasive developmental disorder; Pervasive developmental disorder-not otherwise specified

Correspondence: uonoshota1982@gmail.com

Research in Autism Spectrum Disorders, 7, 2, 361-368.

Common and unique impairments in facial-expression recognition in pervasive developmental disorder-not otherwise specified and Asperger's disorder

Pervasive developmental disorder (PDD) is characterized by qualitative impairments in social interaction and communication as well as repetitive and stereotyped behavior. PDD includes autistic disorder (AD), Asperger's disorder (ASP), and pervasive developmental disorder-not otherwise specified (PDD-NOS) (American Psychiatric Association [APA], 2000). However, previous studies have placed too much emphasis on the investigation of AD and ASP (Volkmar & Lord, 1998) even though epidemiological studies have shown that PDD-NOS is the most common disorder of those included in PDD (Baird et al., 2006). Individuals with PDD-NOS do notmeet the full criteria for PDD but show severe and pervasive impairments in the skills involved in reciprocal social interactions or verbal and nonverbal communication or engage in stereotyped behavior, interests, and activities (APA, 2000). Although these individuals experience clinically significant problems with social interaction and frequently suffer from secondary problems (de Bruin, Ferdinand, Meester, de Nijs, & Verheij, 2007; Gadow, DeVincent, Pomeroy, & Azizian, 2004), the characteristics associated with different levels of PDD-NOS symptom severity remain unknown. Furthermore, under the

newly developed criteria of DSM-5, which adopts a unified diagnosis for autism spectrum disorder (ASD), some individuals with PDD-NOS may not be diagnosed with ASD and may not receive appropriate support (Gibbs, Aldridge, Chandler, Witzlsperger, & Smith, 2012; McPartland, Reichow, & Volkmar, 2012). Thus, we need to clarify the characteristics associated with symptom severity in PDD-NOS.

Several recent studies have investigated the severity of symptoms related to impaired social interaction in PDD-NOS using standard diagnostic tools. Walker et al. (2004) demonstrated that individuals with PDD-NOS showed milder autistic symptoms and relatively poor daily living skills. Mandy, Charman, Gilmour, and Skuse (2011) found that individuals with PDD-NOS had impairments in social interaction that were comparable to those associated with other PDD subtypes, but that they exhibited fewer repetitive and stereotyped behaviors. Although these studies provide abundant evidence about the characteristics of PDD-NOS, the question of whether PDD-NOS is just a less severe variant of AD and ASP remains unanswered. Given that individuals with PDD-NOS are likely to have co-morbid psychiatric disorders (de Bruin et al., 2007; Gadow et al., 2004) that relate to impaired social cognition, it is possible that those with this condition have specific intrinsic impairments. This study was designed to

identify specific difficulties and associated features related to the problems with social interaction experienced by individuals with PDD-NOS who have no comorbid psychiatric disorders.

Extensive research on the ability to recognize the emotions depicted on another's face [see Harms, Martin, and Wallace (2010) for a review] has been conducted to elucidate the cause of poor social interaction in PDD because difficulty with the perception and expression of emotions has been suggested as contributing to failure in establishing interpersonal relationships (Hobson, 1993). A number of studies asked participants to select the verbal label that best described the emotion shown in photographs of emotional faces. The same method has also been used with individuals suffering from psychiatric disorders (e.g., Douglas & Porter, 2010; Sprengelmeyer et al., 1996) and brain damage (e.g., Adolphs, Tranel, Damasio, & Damasio, 1994; Calder, Keane, Manes, Antoun, & Young, 2000). These studies revealed some strong correlations between impaired recognition of specific emotions and structural and/or functional abnormalities in specific brain regions such as the amygdala and the insula (e.g., Adolphs et al., 1994; Sprengelmeyer et al., 2011). Several functional MRI studies have shown that these brain regions are involved in social and emotional functions [see Adolphs (2010) and Lamm and Singer (2010) for

reviews]. Thus, this method offers a number of advantages to efforts to infer the underlying psychological and neural mechanisms of the clinical manifestations of PDD-NOS.

The extant literature suggests that individuals with AD or ASP experience specific impairments in the ability to recognize fearful facial expressions (Adolphs, Sears, & Piven, 2001; Ashwin, Chapman, Colle, & Baron-Cohen, 2006; Corden, Chilvers, & Skuse, 2008; Howard et al., 2000; Humphreys, Minshew, Leonard, & Behrmann, 2007; Pelphrey et al., 2002; Uono, Sato, & Toichi, 2011). Several studies have also reported that the ability to recognize fearful expressions was negatively correlated with the severity of social and emotional dysfunction in individuals with ASP (Humphreys et al., 2007; Uono et al., 2011) and typically developing individuals (Corden, Critchley, Skuse, & Dolan, 2006). These findings have been viewed as clues to the psychological and neural mechanisms of social dysfunction in PDD because difficulties with the recognition of fearful faces have been linked to damage to the amygdala (Adolphs et al., 1994; Sato et al., 2002), which is involved in various social behaviors [see Baron-Cohen et al. (2000) for a review].

In contrast to AD and ASP, only a few studies have investigated the ability to recognize facial emotions in PDD-NOS (Buitelaar, Van Der Wees,

Swaab-Barneveld, & Van Der Gaag, 1999; Kessels, Spee, & Hendriks, 2010; Serra, Jackson, van Geert, & Minderaa, 1998; Uono et al., 2011). Several studies found no impairment in individuals with PDD-NOS (Buitelaar et al., 1999; Serra et al., 1998). However, this may be because these studies did not analyze group differences for each category of emotion. Two recent studies demonstrated impaired emotion recognition in PDD-NOS. Uono et al. (2011) suggested that individuals with ASP and PDD-NOS are worse than typically developing controls at recognizing fearful faces, although participants' demographic characteristics, such as age and IQ, were not sufficiently matched across subtypes. The study conducted by Kessels et al. (2010), in which most participants were diagnosed with PDD-NOS, showed impaired recognition of fearful and disgusted faces. However, it remains unknown whether that result is specific to PDD-NOS because the study did not compare emotion recognition among PDD subtypes. Thus, questions about the pattern of impaired facial expression recognition in individuals with PDD-NOS remain unanswered.

To investigate this issue, we examined the recognition of facial expressions conveying the six basic emotions in individuals with PDD-NOS. Our participants with PDD-NOS had pathologies that were milder than ASP,

and they had no comorbid psychiatric conditions. Thus, we compared those with PDD-NOS, those with ASP, and typically developing individuals with respect to the ability to recognize emotions. Based on the evidence described above, we hypothesized that individuals with PDD-NOS and ASP would exhibit impaired recognition of fearful faces compared with typically developing individuals. Furthermore, we explored whether individuals with PDD-NOS were impaired in recognizing specific emotional facial expressions (e.g., disgust; Kessels et al., 2010). To elucidate the factors that contribute to impaired recognition of facial expressions, we also investigated the relationship between this specific ability and the more general ability to perceive faces. Furthermore, we tested the relationship between impaired facial expression recognition and severity of social dysfunction in individuals with PDD-NOS and ASP. On the basis of previous studies (Corden et al., 2006; Uono et al., 2011), we predicted that the ability to recognize fearful expressions would be negatively correlated with the severity of social dysfunction in individuals with PDD-NOS and ASP.

Methods

Participants

The sample consisted of 54 Japanese individuals: 18 typically developing controls (CON), 18 with ASP, and 18 with PDDNOS. Table 1 summarizes the participants' demographic characteristics. The three groups (CON, ASP, and PDD-NOS) were matched for chronological age [mean ± SD years, CON: 18.8 ±3.6, ASP: 18.6 ± 6.5, PDD-NOS: 19.8 ± 4.7; one-way analysis of variance (ANOVA), $F(2,51) = 0.31$, $p > 0.10$] and sex (CON: four females and 14 males; ASP: three females and 15 males; PDD-NOS: six females and 12 males; Fisher's exact test, $p > 0.10$). The verbal and performance IQs of clinical groups were measured using the Japanese versions of the Wechsler Adult Intelligence Scale (WAIS) and Wechsler Intelligence Scale for Children (WISC). We found non-significant differences in the IQs of the ASP and PDD-NOS groups [mean ± SD verbal IQ, ASP: 108.3± 11.9, PDD-NOS: 103.1 ± 17.7, $t(34) = 1.04$, $p > 0.10$; mean ± SD performance IQ, ASP: 101.9 ± 13.9, PDD-NOS: 98.2 ± 11.3, $t(34) = 0.88$, $p > 0.10$; mean ± SD full-scale IQ, ASP: 106.0 ± 11.9, PDD-NOS: 101.0 ± 14.1, $t(34) = 1.15$, $p > 0.10$]. All participants had normal or corrected-to-normal visual acuity.

Participants were diagnosed with either ASP or PDD-NOS at the time of the present study using the DSM-IV-TR (APA, 2000). PDD-NOS includes heterogeneous subgroups of PDD with varying degrees of

qualitative social impairments. The present study used subgroups that did not satisfy the criteria for ASP in that: (1) they had similar impairments in qualitative social interaction in the absence of apparently restricted interests and stereotyped behaviors, or (2) their impairments in qualitative social interaction were milder than those observed in individuals with ASP. The diagnostic criteria met by each participant are shown in Supplementary Table 1. The PDD-NOS group had a milder pathology regarding repetitive behavior and restricted interests than did those with ASP, and no one in this group met the diagnostic criteria for ‘‘atypical autism’’ (ICD-10; World Health Organization, 1992). The final diagnoses were made by child psychiatrists based on exhaustive interviews with each participant (a total of 5–6 hours), advice of clinical psychologists, information from each participant’s parents or teachers, and childhood clinical records, when available. Each diagnostic criterion was checked in the diagnostic interviews. Additionally, to corroborate the diagnoses, several detailed questions, drawn from a standardized diagnostic interview (Lord, Rutter, & Le Couteur, 1994), were asked. The participants were referred from a variety of sources, and we found no systematic bias in referral sources. All participants were free of neurological or psychiatric problems other than PDD, and none of the participants was taking any medication. All

participants aged 18 years and older and the parents of all participants aged younger than 18 years provided written informed consent for participation in this study, which was approved by the local ethics committee.

Based on interviews with participants and their parents and the direct observation of participants in the interview, the severity of symptoms experienced by individuals with PDD was assessed using the Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Renner, 1986), which was administered by psychiatrists. The CARS has been shown to be an effective tool for diagnosing autism in adolescents, adults, and children (Mesibov, Schopler, Schaffer, & Michal, 1989). The CARS includes 14 items assessing autism-related behaviors and one item rating general impressions of autistic symptoms. Each item is rated on a scale from 1 to 4. A higher rating indicates more severe impairment. Total scores ranged from 15 to 60. We found non-significant differences in the CARS scores of the ASP (mean $\pm$ SD = 21.9 $\pm$ 3.0) and PDD-NOS (mean $\pm$ SD = 21.3 $\pm$ 3.0) groups ($t(34) = 0.65$, $p > 0.10$). Although their average CARS scores were below the cut-off score (27) for a diagnosis of autistic disorder (see Mesibov et al., 1989), the CARS scores obtained by the ASP ($t(52) = 0.33$, $p > 0.10$) and PDD-NOS ($t(52) = 0.94$, $p > 0.10$) groups were comparable to those obtained by Japanese individuals with ASP in a previous study (mean

± SD = 22.22 ± 3.57) (Koyama, Tachimori, Osada, Takeda, & Kurita, 2007). These data indicate that the symptoms of individuals in the two clinical groups were severe enough to allow for the diagnosis.

****

Insert Table 1 here

****

Stimuli and Procedures

Expression Recognition Task.

A total of 48 photographs of facial expressions depicting six basic emotions (anger, disgust, fear, happiness, sadness, and surprise) were used as stimuli. Half of these pictures were of Caucasian models, and the other half were pictures of Japanese models. These pictures were chosen from standardized photograph sets (Ekman & Friesen, 1976; Matsumoto & Ekman, 1988). A label-matching paradigm previously used by Sato et al. (2002) was employed to assess participants' recognition of emotional facial expressions. Pictures of people whose faces expressed various emotions were individually presented on the monitor in a random order. Verbal labels identifying the six basic emotions were presented next to each photograph. Participants were asked to select the label that best described the emotion shown in each photograph. They were instructed to carefully consider all

six alternatives before responding. No time limits were set, and no feedback was provided about performance. Participants viewed each emotional expression eight times, resulting in a total of 48 trials for each participant. Prior to the experiment, we established that all participants understood the meaning of the emotional label and the task instructions, and participants engaged in two training trials to become familiar with the procedure. After ensuring that participants understood the task requirements, the experimental trials were initiated.

Face-recognition Task.

The shortened version (13 items) of the Benton Facial Recognition Test (Benton, Sivan, Hamsher, Varney, & Spreen, 1994) was administered. This test assesses perceptual factors and reflects basic visual face-processing mechanisms (e.g., Bentin, Deouell, & Soroker, 1999). Caucasian models were used for all face stimuli. Participants were required to match a target face with either one or up to three pictures of the same person (with different orientation and lighting) presented in an array of six faces. No time limits were set, and no feedback was provided regarding performance.

Apparatus

The events were controlled by SuperLab Pro 2.0 (Cedrus, San Pedero, CA) implemented on a Windows computer (HP xw4300 Workstation,

Hewlett-Packard, Palo Alto, CA). Stimuli were presented on a 19-inch CRT monitor (HM704UC, Iiyama, Tokyo; screen resolution 1024 × 768 pixels; refresh rate 100 Hz).

Data Analysis

The ANOVAs, follow-up tests, and correlation analyses were conducted using SPSS 10.0J (SPSS, Tokyo, Japan). Data on the accuracy of responses to the expression-recognition task were subjected to a 2 (group) × 6 (facial emotion) repeated measures ANOVA. Because preliminary analyses showed that participants' sex and stimulus type (Caucasian or Japanese) had no significant effects related to group, these factors were omitted from subsequent analyses. Probability values were evaluated with the Huynh–Feldt adjustments for degrees of freedom. Significant interactions were followed up with simple effects analyses (cf. Kirk, 1995) and multiple comparisons using Ryan's method. When interactions were significant, the main effects were not subjected to follow-up analyses or interpretation.

The total numbers of correct responses to the face-perception task were analyzed using a one-way ANOVA with group as the factor and multiple comparisons using Ryan's method.

The CARS (Schopler et al., 1986) was used to assess the level of

social dysfunction in individuals with ASD. Although factors in the CARS are structured, studies have been inconsistent with regard to which items should be included in the social-functioning construct (DiLalla & Rogers, 1994; Magyar & Pandolfi, 2007; Stella, Mundy, & Tuchman, 1999). Therefore, we selected the following CARS items that were classified as elements of the social-functioning construct in all previous studies (cf. Magyar & Pandolfi, 2007): ‘‘imitation,’’ ‘‘nonverbal communication,’’ ‘‘relationship to people,’’ ‘‘verbal communication,’’ and ‘‘visual response.’’ We averaged the scores on these items to obtain the social-dysfunction scale.

To analyze relationships among expression recognition, face perception, and CARS scores, Pearson’s product–moment correlations between combinations of these variables were calculated for each group. The significance of correlation coefficients was evaluated using t-tests (one-tailed). We excluded outliers by calculating the Mahalanobis distance for each case (probability of group membership <0.05). On the basis of the ANOVA results for facial expression recognition, the results for the fearful- and disgusted-expression tasks were used as the measure of facial expression recognition.

Results

Expression-recognition Task

The ANOVA for the percentages of accurate responses (see Fig. 1 and Table 2) revealed a significant interaction between group × facial emotion [$F(10,255) = 2.60$, $p < 0.05$]. Additionally, the main effects of group and facial emotion were also significant [$F(2,51) = 3.53$, $p < 0.05$; $F(5,255) = 105.21$, $p < 0.05$].

Follow-up simple-effect analyses of the interaction revealed that the simple main effects of group were significant for fearful [$F(2,306) = 7.95$, $p < 0.05$] and disgusted [$F(2,306) = 6.02$, $p < 0.05$] facial expressions. No significant simple main effects of group were observed for other facial emotions ($p > 0.10$). Multiple comparisons showed that the recognition accuracy of the ASP [$t(306) = 2.44$, $p < 0.05$] and PDD-NOS [$t(306) = 3.95$, $p < 0.05$] groups was worse than that of the control in response to fearful facial expressions. The recognition accuracy of the PDD-NOS group was worse than that of the control [$t(306) = 3.25$, $p < 0.05$] and the ASP [$t(306) = 2.67$, $p < 0.05$] groups in response to disgusted facial expressions.

****
Insert Figure 1 and Table 2 here
****

Face-recognition Task

A one-way ANOVA for responses to the Benton Facial Recognition Task revealed a significant main effect of group [$F(2,51) = 3.71$, $p < 0.05$]. Follow-up analyses showed that the ASP and PDD-NOS groups were less accurate than was the CON group [ASP vs. CON: $t(51) = 2.54$, $p < 0.05$; PDD-NOS vs. CON: $t(51) = 2.13$, $p < 0.05$]. All participants in all three groups obtained scores above the threshold for impaired face perception (i.e., 18/27; Benton et al., 1994).

Associations of facial expression recognition with face perception and social dysfunction

The correlation between recognition of fearful expressions and face-perception performance was not significant in any of the three groups [CON: $r = 0.36$; ASP: $r = 0.08$; PDD-NOS: $r = 0.29$, $p > 0.10$]. The correlation between fearful expression recognition and social dysfunction was significant in both the ASP [$r = -0.59$, $p < 0.05$] and PDD-NOS [$r = -0.42$, $p < 0.05$] groups, indicating that individuals with ASP and those with PDD-NOS who demonstrated worse recognition of fearful expressions had more severe symptoms in social domains. The correlation between recognition of disgusted expressions and face perception was significant

only in typically developing individuals [CON: $r = 0.47$, $p < 0.05$; ASP: $r = 0.35$, $p > 0.10$; PDD-NOS: $r = 0.30$, $p > 0.10$]. The correlation between recognition of disgusted expressions and social dysfunction was not significant in either the ASP [$r = -0.21$, $p > 0.10$] or PDDNOS [$r = -0.30$, $p > 0.10$] group.

Discussion

The present study revealed that individuals with ASP and PDD-NOS were, in general, less accurate in recognizing fearful facial expressions than were typically developing controls. Consistent with our data, recent studies have found impairments in the recognition of facial expressions, particularly those depicting fear, among individuals with AD and ASP (Ashwin et al., 2006; Corden et al., 2008; Howard et al., 2000; Humphreys et al., 2007; Pelphrey et al., 2002). These findings suggest the impaired fearful-face recognition is common across PDD subtypes.

Researchers have investigated whether a specific pattern of symptoms can be detected in PDD-NOS because individuals with this disorder show diverse clinical features. However, evidence indicating that impaired fearful-face recognition is common across PDD subtypes may contributet understanding the common psychological and neural mechanisms associated

with social dysfunction in PDD subtypes. Difficulties with the recognition of fearful faces have been linked to dysfunction in the amygdala (Adolphs et al., 1994; Sato et al., 2002), which is involved in various social behaviors [see Baron-Cohen et al. (2000) for a review]. The present results also revealed that impaired recognition of fearful expressions was related to social dysfunction in individuals with ASP and PDD-NOS. In the context of these findings, shared impairment in fearful-face recognition suggests that the characteristics of impairments in social interaction as well as their underlying pathological features (e.g., involvement of the amygdala) do not differ between individuals with ASP and those with PDD-NOS.

More importantly, individuals with PDD-NOS were less accurate in recognizing disgusted facial expressions than were typically developing individuals. Previous studies have also reported impairment in the recognition of disgusted faces among individuals with PDD (Ashwin et al., 2006; Law Smith, Montagne, Perrett, Gill, & Gallagher, 2010). Furthermore, although participants with PDD-NOS had milder pathologies than did those with ASP, the current data suggest that individuals with PDD-NOS are worse at recognizing disgusted facial expressions than are those with ASP. Consistent with this result, a recent study in which most participants were diagnosed with PDD-NOS demonstrated a specific impairment in the

recognition of fearful and disgusted faces (Kessels et al., 2010). In the present study, general intellectual abilities did not account for differences between those with ASP and those with PDD-NOS in the recognition of disgusted faces because IQs did not differ between groups. The results revealed that individuals with different subtypes of PDD show different patterns of impaired recognition of facial expressions.

Impaired recognition of disgusted faces may illuminate the nature of the clinical manifestations of individuals with PDDNOS. Given that the impairment in disgusted-face recognition was not correlated with social dysfunction, impairment in the ability to recognize disgusted faces suggests a concomitant impairment specific to PDD-NOS. It has been reported that individuals with Parkinson's disease (e.g., Sprengelmeyer et al., 2003; Suzuki, Hoshino, Shigemasu, & Kawamura, 2006) and Huntington's disease (e.g., Sprengelmeyer et al., 1996; Wang, Hoosain, Yang, Meng, & Wang, 2003) show a specific impairment in disgusted-face recognition. Both of these disorders are characterized by dysfunctions in involuntary motor movements and underlying pathological changes in the basal ganglia. The results of a lesion study also suggest that a lesion in the basal ganglia produces impairment in the ability to recognize disgusted faces (Calder et al., 2000). These findings suggest a link among impairment in disgusted-

face recognition, motor deficits, and structural and functional abnormality of the basal ganglia. In fact, motor deficits are not uncommon among individuals with PDD (Green et al., 2009; Hilton et al., 2007; see Matson, Matson, and Beighley (2011) for a review). It is possible that the impairment in disgusted-face recognition in PDD-NOS reflects the existence of more severe motor deficits and functional abnormalities in the basal ganglia than are present in other PDD subtypes. However, very few studies have investigated differences in motor deficits between subtypes and specifically between ASP and PDD-NOS (cf. Mandy et al., 2011). Future studies should investigate the relationships among impaired recognition of disgusted faces, motor deficits, and underlying brain abnormalities in each subtype.

Another line of research suggests that maladaptive affective states produce impaired recognition of specific facial expressions. For example, recent studies have demonstrated that patients with major depression have a specific impairment in the ability to recognize disgusted faces (Douglas & Porter, 2010; Sprengelmeyer et al., 2011). Gerhards (1998) also found that patients with psychosomatic gastrointestinal disorders have difficulty with the recognition of disgusted faces. These findings suggest that impairment in the ability to recognize disgusted faces in individuals with PDD-NOS

reflects a vulnerability to affective problems, although participants in the present study did not have co-morbid affective disorders. Individuals with PDD-NOS may tend to have secondary problems such as depression because individuals with PDD-NOS are harder to detect due to their milder autistic symptoms compared with those with other PDD subtypes (cf. Mazurek & Kanne, 2010).

Our results showed that individuals with ASP and PDD-NOS were impaired in their ability to perceive faces. These results are consistent with some previous findings on ASP and PDD-NOS (e.g., Barton et al., 2004; Serra et al., 2003; Wallace, Coleman, & Bailey, 2008). However, performance on the face-perception task was not significantly correlated with ability to recognize fearful and disgusted faces among those with ASP and PDD-NOS. We found no differences between those with ASP and those with PDD-NOS in face perception. This result suggests that the general ability for face perception does not completely account for the impairment in the ability to recognize fearful and disgusted faces shown by individuals with ASP and PDD-NOS.

Our data may clarify several qualitative differences between PDD subtypes. A recent study suggested that the distinction between subtypes based on the DSM-IV may not be stable across sites even when the same

diagnostic tool is used (e.g., Lord et al., 2012) and that the conceptualization of the disorder in the field is moving toward a unified ASD diagnosis (DSM-5). On the other hand, consistent with the present study, other studies have suggested that subgroups differ with regard to behavioral, cognitive, and neurobiological factors (e.g., Karand, 2011; Koyama & Kurita, 2008). Thus, it remains an open question whether individuals in each PDD subgroup are uniquely impaired. More empirical evidence regarding this issue is needed. The current study showed that individuals with PDD-NOS are additionally impaired in their ability to recognize disgusted faces, which may relate to motor impairments and affective vulnerabilities. These findings suggest that distinctions among subtypes are helpful for characterizing symptom severity and for tailoring appropriate interventions to the needs of each subgroup.

It should be noted that this study has some limitations. First, we investigated the ability to recognize emotions only in individuals with ASP and PDD-NOS because we could easily match the intellectual abilities of clinical groups. However, further studies are needed to investigate whether individuals with PDD-NOS are similar to or different from individuals with AD with respect to impairments in the ability to recognize facial expressions. Second, we cannot draw definite conclusions about the cause

of impaired disgusted-face recognition in PDD-NOS because we have no additional information about all the potential factors involved in impaired facial-expression recognition. Additional research is needed to explore the relationship between this impairment and the clinical manifestations specific to PDD-NOS. These data may prove helpful in attempts at disambiguating specific problems associated with PDD-NOS.

Conclusion

The present study examined the recognition of facial expressions conveying the six basic emotions by individuals with PDD-NOS. Individuals with ASP and PDD-NOS were worse at recognizing fearful faces than were typically developing individuals. Individuals with PDD-NOS were less accurate in recognizing disgusted faces than were those with ASP. The results suggest that the subtypes of PDD are characterized by both shared and unique impairments in the ability to recognize facial expressions. Furthermore, impairment in the ability to recognize fearful but not disgusted expressions was related to social dysfunction in those with ASP and PDD-NOS. The results suggest that impairment in the ability to recognize fearful and disgusted faces may reflect the severity of the social dysfunction across PDD subtypes and the specific problems associated with

Research in Autism Spectrum Disorders, 7, 2, 361-368.

PDD-NOS, respectively.

Research in Autism Spectrum Disorders, 7, 2, 361-368.

Role of the funding source

This study was supported by a Grant-in-Aid for JSPS Fellows (08J07939; 11J05000), the JSPS Funding Program for Next Generation World-Leading Researchers (LZ008), the Organization for Promoting Developmental Disorder Research, and the Benesse Corporation. The funding sources had no involvement in the study design; the collection, analysis, and interpretation of the data; the writing of the report; or the decision to submit the article for publication.

Acknowledgements

We would like to thank Dr. Sayaka Yoshimura for recruiting participants, Yukari Ise for technical support, and Tokika Kurita for helpful advice on the early version of the manuscript. We are grateful to both the volunteer study participants and their parents.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.rasd.2012.10.007.

References

Adolphs, R. (2010). What does the amygdala contribute to social cognition? *Annals of the New York Academy of Sciences, 1191*, 42–61.

Adolphs, R., Sears, L., & Piven, J. (2001). Abnormal processing of social information from faces in autism. *Journal of Cognitive Neuroscience, 13*, 232–240.

Adolphs, R., Tranel, D., Damasio, H., & Damasio, A. (1994). Impaired recognition of emotion in facial expressions following bilateral damage to the human amygdala. *Nature, 372*, 669–672.

American Psychiatric Association. (2000). *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR).* Washington, DC: Author.

Ashwin, C., Chapman, E., Colle, L., & Baron-Cohen, S. (2006). Impaired recognition of negative basic emotions in autism: A test of the amygdala theory. *Social Neuroscience, 1*, 349–363.

Baird, G., Simonoff, E., Pickles, A., Chandler, S., Loucas, T., Meldrum, D., et al. (2006). Prevalence of disorders of the autism spectrum in a population cohort of children in South Thames: The Special Needs and Autism Project (SNAP). *Lancet, 368*, 210–215.

Baron-Cohen, S., Ring, H., Bullmore, E. T., Wheelwright, S., Ashwin, C., & Williams, S. C. (2000). The amygdala theory of autism. *Neuroscience and Biobehavioral Reviews, 24*, 355–364.

Barton, J. J. S., Cherkasova, M. V., Hefter, R., Cox, T. A., O'Connor, M., & Manoach, D. S. (2004). Are patients with social developmental disorders prosopagnosic? Perceptual heterogeneity in the Asperger and socio-emotional processing disorders. *Brain, 127*,

1706–1716.

Bentin, S., Deouell, L. Y., & Soroker, N. (1999). Selective visual streaming in face recognition: Evidence fromdevelopmental prosopagnosia. *Neuroreport, 10*, 823–827.

Benton, A. L., Sivan, A. B., Hamsher, K., Varney, N. R., & Spreen, O. (1994). *Contributions to neuropsychological assessment.* New York, NY: Oxford University Press.

Buitelaar, J. K., Van Der Wees, M., Swaab-Barneveld, H., & Van Der Gaag, R. J. (1999). Theory of mind and emotion-recognition functioning in autistic spectrum disorders and in psychiatric control and normal children. *Development and Psychopathology, 11*, 39–58.

Calder, A. J., Keane, J., Manes, F., Antoun, N., & Young, A. W. (2000). Impaired recognition and experience of disgust following brain injury. *Nature Neuroscience, 3*, 1077–1078.

Corden, B., Chilvers, R., & Skuse, D. (2008). Avoidance of emotionally arousing stimuli predicts social-perceptual impairment in Asperger's syndrome. *Neuropsychologia, 46*, 137–147.

Corden, B., Critchley, H. D., Skuse, D., & Dolan, R. J. (2006). Fear recognition ability predicts differences in social cognitive and neural functioning in men. *Journal of Cognitive Neuroscience, 18*, 889–897.

de Bruin, E. I., Ferdinand, R. F., Meester, S., de Nijs, P. F. A., & Verheij, F. (2007). High rates of psychiatric co-morbidity in PDD-NOS. *Journal of Autism and Developmental Disorders, 37*, 877–886.

Research in Autism Spectrum Disorders, 7, 2, 361-368.

DiLalla, D. L., & Rogers, S. J. (1994). Domains of the Childhood Autism Rating Scale: Relevance for diagnosis and treatment. *Journal of Autism and Developmental Disorders, 24*, 115–128.

Douglas, K. M., & Porter, R. J. (2010). Recognition of disgusted facial expressions in severe depression. *British Journal of Psychiatry, 197*, 156–157.

Ekman, P., & Friesen, W. V. (1976). *Pictures of facial affect.* Palo Alto, CA: Consulting Psychologists Press.

Gadow, K. D., DeVincent, C. J., Pomeroy, J., & Azizian, A. (2004). Psychiatric symptoms in preschool children with PDD and clinic and comparison samples. *Journal of Autism and Developmental Disorders, 34*, 379–393.

Gerhards, F. (1998). Decoding of facially expressed emotions in patients with psychosomatic gastrointestinal disorders. *Behavior Modification, 22*, 184–191.

Gibbs, V., Aldridge, F., Chandler, F., Witzlsperger, E., & Smith, K. (2012). Brief report: An exploratory study comparing diagnostic outcomes for autism spectrum disorders under DSM-IV-TR with the proposed DSM-5 revision. *Journal of Autism and Developmental Disorders, 42*, 1750–1756.

Green, D., Charman, T., Pickles, A., Chandler, S., Loucas, T., Simonoff, E., et al. (2009). Impairment in movement skills of children with autistic spectrum disorders. *Developmental Medicine and Child Neurology, 51*, 311–316.

Harms, M. B., Martin, A., & Wallace, G. L. (2010). Facial emotion recognition in autism spectrum disorders: A review of behavioral and neuroimaging studies. *Neuropsychology Review, 20*, 290–322.

Research in Autism Spectrum Disorders, 7, 2, 361-368.

Hilton, C., Wente, L., LaVesser, P., Ito, M., Reed, C., & Herzberg, G. (2007). Relationship between motor skill impairment and severity in children with Asperger syndrome. *Research in Autism Spectrum Disorders, 1*, 339–349.

Hobson, R. P. (1993). *Autism and the development of mind.* Hove, UK: Lawrence Erlbaum Associates Ltd.

Howard, M. A., Cowell, P. E., Boucher, J., Broks, P., Mayes, A., Farrant, A., et al. (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.

Karand, N. (2011). Brief report: Should Asperger syndrome be excluded from the forthcoming DSM-V? *Research in Autism Spectrum Disorders, 5*, 984–989.

Kessels, R. P. C., Spee, P., & Hendriks, A. W. (2010). Perception of dynamic facial emotional expressions in adolescents with autism spectrum disorders (ASD). *Translational Neuroscience, 1*, 228–232.

Kirk, R. E. (1995). *Experimental design: Procedures for the behavioral sciences (3rd ed.)*. Pacific Grove, CA: Brooks/Cole.

Koyama, T., & Kurita, H. (2008). Cognitive profile difference between normally intelligent children with Asperger's disorder and those with pervasive developmental disorder not otherwise specified. *Psychiatry and Clinical Neurosciences, 62*, 691–696.

Koyama, T., Tachimori, H., Osada, H., Takeda, T., & Kurita, H. (2007). Cognitive and

symptom profiles in Asperger's syndrome and high-functioning autism. *Psychiatry and Clinical Neurosciences, 61*, 99–104.

Lamm, C., & Singer, T. (2010). The role of anterior insular cortex in social emotions. *Brain Structure and Function, 214*, 579–591.

Law Smith, M. J., Montagne, B., Perrett, M. G., Gill, M., & Gallagher, L. (2010). Detecting subtle facial emotion recognition deficits in high-functioning autism using dynamic stimuli of varying intensities. *Neuropsychologia, 48*, 2777–2781.

Lord, C., Petkova, E., Hus, V., Gan, W., Lu, F., Martin, D. M., et al. (2012). A multisite study of the clinical diagnosis of different autism spectrum disorders. *Archives of General Psychiatry, 69*, 306–313.

Lord, C., Rutter, M., & Le Couteur, A. (1994). Autism Diagnostic Interview—Revised: A revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *Journal of Autism and Developmental Disorders, 24*, 659–685.

Mandy, W., Charman, T., Gilmour, J., & Skuse, D. (2011). Toward specifying pervasive developmental disorder-not otherwise specified. *Autism Research, 4,* 121–131.

Magyar, C. I., & Pandolfi, V. (2007). Factor structure evaluation of the Childhood Autism Rating Scale. *Journal of Autism and Developmental Disorders, 37*, 1787–1794.

Matson, M. L., Matson, J. L., & Beighley, J. S. (2011). Comorbidity of physical and motor problems in children with autism. *Research in Developmental Disabilities, 32*, 2304–2308.

Matsumoto, D., & Ekman, P. (1988). *Japanese and Caucasian facial expressions of*

emotion. San Francisco, CA: Intercultural and Emotion Research Laboratory, Department of Psychology, San Francisco State University.

Mazurek, M. O., & Kanne, S. M. (2010). Friendship and internalizing symptoms among children and adolescents with ASD. *Journal of Autism and Developmental Disorders, 40*, 1512–1520.

McPartland, J. C., Reichow, B., & Volkmar, F. R. (2012). Sensitivity and specificity of proposed DSM-5 diagnostic criteria for autism spectrum disorder. *Journal of the American Academy of Child and Adolescent Psychiatry, 51*, 368–383.

Mesibov, G. B., Schopler, E., Schaffer, B., & Michal, N. (1989). Use of the Childhood Autism Rating Scale with autistic adolescents and adults. *Journal of the American Academy of Childhood Adolescent Psychiatry, 28*, 538–541.

Pelphrey, K. A., Sasson, N. J., Reznick, J. S., Paul, G., Goldman, B. D., & Piven, J. (2002). Visual scanning of faces in autism. *Journal of Autism and Developmental Disorders, 32*, 249–261.

Sato, W., Kubota, Y., Okada, T., Murai, T., Yoshikawa, S., & Sengoku, A. (2002). Seeing happy emotion in fearful and angry faces: Qualitative analysis of the facial expression recognition in a bilateral amygdala damaged patient. *Cortex, 38*, 727–742.

Schopler, R., Reichler, R. J., & Renner, B. R. (1986). *The Childhood Autism Rating Scale (CARS) for diagnostic screening and classification of autism*. New York: Irvington.

Serra, M., Althaus, M., de Sonneville, L. M. J., Stant, A. D., Jackson, A. E., & Minderaa, R. B. (2003). Face recognition in children with a pervasive developmental disorder not otherwise specified. *Journal of Autism and Developmental Disorders, 33*, 303–317.

Research in Autism Spectrum Disorders, 7, 2, 361-368.

Serra, M., Jackson, A. E., van Geert, P. L., & Minderaa, R. B. (1998). Brief report: interpretation of facial expressions, postures and gestures in children with a pervasive developmental disorder not otherwise specified. *Journal of Autism and Developmental Disorders, 28*, 257–263.

Sprengelmeyer, R., Steele, J. D., Mwangi, B., Kumar, P., Christmas, D., Milders, M., et al. (2011). The insular cortex and the neuroanatomy of major depression. *Journal of Affective Disorders, 133*, 120–127.

Sprengelmeyer, R., Young, A. W., Calder, A. J., Karnat, A., Lange, H., Ho¨mberg, V., et al. (1996). Loss of disgust. Perception of faces and emotions in Huntington's disease. *Brain, 119*, 1647–1665.

Sprengelmeyer, R., Young, A. W., Mahn, K., Schroeder, U., Woitalla, D., Bu¨ ttner, T., et al. (2003). Facial expression recognition in people with medicated and unmedicated Parkinson's disease. *Neuropsychologia, 41*, 1047–1057.

Stella, J., Mundy, P., & Tuchman, R. (1999). Social and nonsocial factors in the Childhood Autism Rating Scale. *Journal of Autism and Developmental Disorders, 29*, 307–317.

Suzuki, A., Hoshino, T., Shigemasu, K., & Kawamura, M. (2006). Disgust-specific impairment of facial expression recognition in Parkinson's disease. *Brain, 129*, 707–717.

Uono, S., Sato, W., & Toichi, M. (2011). The specific impairment of fearful expression recognition and its atypical development in pervasive developmental disorder. *Social Neuroscience, 6*, 452–463.

Volkmar, F. R., & Lord, C. (1998). Diagnosis and definition of autism and other pervasive

developmental disorders. In F. R. Volkmar (Ed.), *Autism and pervasive developmental disorders* (pp. 1–31). Cambridge: Cambridge University Press.

Walker, D. R., Thompson, A., Zwaigenbaum, L., Goldberg, J., Bryson, S. E., Mahoney, W. J., et al. (2004). Specifying PDD-NOS: A comparison of PDD-NOS, Asperger syndrome, and autism. *Journal of the American Academy of Child and Adolescent Psychiatry, 43*, 172–180.

Wallace, S., Coleman, M., & Bailey, A. (2008). Face and object processing in autism spectrum disorders. *Autism Research, 1*, 43–51.

Wang, K., Hoosain, R., Yang, R. M., Meng, Y., & Wang, C. Q. (2003). Impairment of recognition of disgust in Chinese with Huntington's or Wilson's disease. *Neuropsychologia, 41*, 527–537.

World Health Organization. (1992). *The ICD-10 classification of mental and behavioural disorders.* Geneva, Switzerland: Author.

Research in Autism Spectrum Disorders, 7, 2, 361-368.

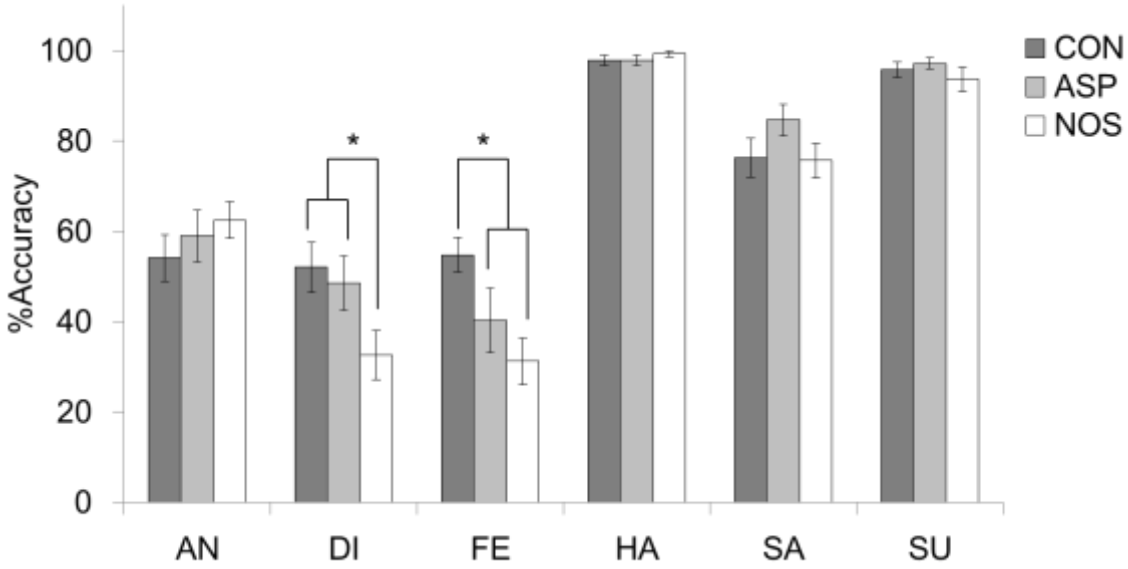
Figure Captions

Figure 1. Mean (with SE) percentages of accurate responses to facial-expression tasks in typically developing controls (CON), individuals with Asperger's disorder (ASP), and individuals with pervasive developmental disorder-not otherwise specified (NOS). An asterisk indicates a significant difference between groups ($p < 0.05$). AN = anger; DI = disgust; FE = fear; HA = happiness; SA = sadness; SU = surprise.

Research in Autism Spectrum Disorders, 7, 2, 361-368.

Figure 1.

top



Research in Autism Spectrum Disorders, 7, 2, 361-368.

Table 1. Demographic characteristics of the three groups

	CON (*N* = 18)	ASP (*N* = 18)	NOS (*N* = 18)	*p*-value
Male : Female	14 : 4	15 : 3	12 : 6	0.62
	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	
Age	18.8 (3.6)	18.6 (6.5)	19.8 (4.7)	0.73
Verbal IQ	-	108.3 (11.9)	103.1 (17.7)	0.31
Performance IQ	-	101.9 (13.9)	98.2 (11.3)	0.39
Full-scale IQ	-	106.0 (11.9)	101.0 (14.1)	0.26
CARS	-	21.9 (3.0)	21.3 (3.0)	0.53

CON = control; ASP = Asperger's disorder; NOS = pervasive developmental disorder-not otherwise specified

Table 2. Mean (*SE*) scores on the face-perception task and mean (with *SE*) percentages of accurate responses on the emotion-recognition task

		Benton	Emotion Recognition						
Group			AN	DI	FE	HA	SA	SU	ALL
CON	Mean	24.1	54.2	52.1	54.9	97.9	76.4	95.8	71.9
	(*SE*)	(0.3)	(5.2)	(5.5)	(3.8)	(1.1)	(4.3)	(1.8)	(1.6)
ASP	Mean	22.3	59.0	48.6	40.3	97.9	84.7	97.2	71.3
	(*SE*)	(0.5)	(5.7)	(6.0)	(7.1)	(1.1)	(3.4)	(1.3)	(1.9)
NOS	Mean	22.6	62.5	32.6	31.3	99.3	75.7	93.8	65.9
	(*SE*)	(0.6)	(4.0)	(5.4)	(5.2)	(0.7)	(3.8)	(2.7)	(1.8)

CON = control; ASP = Asperger's disorder; NOS = pervasive developmental disorder-not otherwise specified
AN = anger; DI = disgust, FE = fear, HA = happy, SA = sad, SU = surprise, ALL = the mean of all conditions

Research in Autism Spectrum Disorders, 7, 2, 361-368.

Supplementary Table 1. The diagnostic criteria met in each participant.

ASP									PDD-NOS								
	(I) Social interaction				(II) RRBs					(I) Social interaction				(II) RRBs			
Participants	A	B	C	D	A	B	C	D	Participants	A	B	C	D	A	B	C	D
1	±	+	+	±	+	±	−	−	1	±	±	+	±	+	−	−	−
2	±	+	±	+	+	+	−	−	2	±	+	±	±	+	−	−	−
3	±	+	−	+	+	+	−	−	3	±	±	+	±	±	−	−	−
4	+	+	−	±	+	±	−	−	4	±	+	±	±	±	−	−	−
5	+	+	+	±	+	+	−	−	5	±	+	−	+	±	−	−	−
6	±	+	±	+	+	−	−	−	6	±	±	±	±	±	+	−	−
7	±	±	+	+	+	−	−	−	7	−	−	±	+	±	−	−	−
8	+	+	±	±	±	+	−	−	8	+	±	±	±	+	±	−	−
9	+	±	+	±	+	−	−	−	9	±	±	−	±	+	−	−	−
10	±	+	±	+	+	+	−	−	10	+	−	±	+	−	±	−	−
11	+	±	−	+	+	+	−	−	11	+	±	±	+	±	±	−	−
12	+	+	±	+	+	−	−	−	12	±	±	±	−	±	+	−	−
13	±	+	±	+	+	−	−	−	13	+	±	±	±	+	−	−	−
14	+	+	±	±	+	−	−	−	14	−	+	±	−	±	−	−	−
15	+	+	+	±	±	+	−	−	15	−	+	−	−	−	−	−	−
16	±	+	+	±	±	+	−	−	16	+	±	±	±	−	±	−	−
17	+	+	−	±	±	+	−	−	17	+	+	+	+	±	±	−	−
18	+	+	+	+	+	±	−	−	18	±	±	−	+	±	±	−	−

+, clinical; ±, sub-clinical; −, normal; RRBs, restricted and repetitive behaviors and interests

ASP, Asperger's disorder; PDD-NOS, pervesive developmental disorder not-otherwise specified