Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

Eye Contact Perception in High-functioning Adults with Autism Spectrum Disorder

Shota Uono [1, 2], Sayaka Yoshimura [1, 2, 3], Motomi Toichi [2, 3]

[1] Department of Neurodevelopmental Psychiatry, Habilitation and Rehabilitation, Graduate School of Medicine, Kyoto University, Kyoto, Japan.

[2] Organization for the Promotion of Neurodevelopmental Disorder Research, Kyoto, Japan

[3] Faculty of Human Health Science, Graduate School of Medicine, Kyoto University, Kyoto, Japan.

Correspondence concerning this article should be addressed to Shota Uono, Department of Neurodevelopmental Psychiatry, Habilitation and Rehabilitation, Faculty of Human Health Science, Graduate School of Medicine, Kyoto University, 53 Shogoin Kawahara-cho, Sakyo-ku, Kyoto 606-8507, Japan.

Tel: +81- 75-751-3966; Fax: +81-75-751-3966; E-mail: uonoshota1982@gmail.com

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

Acknowledgments: We thank Emi Yokoyama for her help of recruiting participants.

Funding: This study was supported by the Japan Society for the Promotion of Science, Grant-in-Aid for JSPS Fellows (11J0500). The funding sources had no involvement in study design; in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to submit the article for publication.

Author contributions: SU designed and performed the experiments. SY and MT diagnosed and/or evaluated participants. SU analysed the data and wrote first draft of the manuscript. All authors contributed to the revision of the manuscript.

Compliance with ethical standards

Conflict of interest: The authors declare that they have no conflict of interest.

Ethical approval: All procedures performed in this study involving human participants were in accordance with the guidelines of the Declaration of Helsinki 1964 and its later amendments. The experimental procedure was approved by the local ethics committee of Kyoto University Graduate School and Faculty of Medicine.

Informed consent: All participants included in the study provided written informed consent following an explanation of the procedures.

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

Lay Abstract

The detection of a self-directed gaze is often the starting point for social interactions and a person who feels as if they are being watched can prepare to respond to others' actions irrespective of the real gaze direction because the other person may likely be motivated to approach. Although many studies demonstrated that individuals with autism spectrum disorder (ASD) have difficulty discriminating gaze direction, it remains unclear how the perception of self-directed gaze by individuals with ASD differ from that of age-, sex-, and IQ-matched typically developing (TD) individuals. Participants observed faces with various gaze direction and answered whether the person in the photograph was looking at them or not. Individuals with and without ASD were just as likely to perceive subtle averted gazes as self-directed gazes. The frequency of perceiving a self-directed gaze decreased as gaze aversion increased in both groups and, in general, individuals with ASD showed a comparable ability to perceive a self-directed gaze as that of TD individuals. Interestingly, considering face membership of photographs (ingroup or outgroup faces), TD individuals, but not individuals with ASD, were more likely to perceive self-directed gazes from ingroup faces than from outgroup faces. However, individuals with ASD had different affective experiences in response to ingroup and outgroup faces. These results suggest that individuals with ASD did not show an ingroup bias for the perception of a self-directed gaze, and raise a possibility that an atypical emotional experience contributes to the diminished ingroup bias.

Abstract

The present study investigated how the eye contact perception of ingroup and outgroup faces by Japanese adults with high-functioning autism spectrum disorder (ASD)

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

differed from that of age-, sex-, and IQ-matched typically developing (TD) individuals. The ASD and TD individuals were equally likely to perceive subtly averted gazes as self-directed gazes. In both groups, the frequency with which self-directed gazes were perceived decreased as gaze aversion increased. In general, individuals with ASD were equally capable of perceiving a self-directed gaze as TD individuals. However, TD individuals, but not individuals with ASD, were more likely to perceive self-directed gazes from ingroup faces than from outgroup faces. Stimuli ratings revealed that individuals with ASD, but not those with TD, gave higher warmth ratings to ingroup faces with averted gazes and outgroup faces with direct gazes compared to other types of face stimuli, suggesting atypical affective experiences in response to ingroup and outgroup faces in ASD. These results suggest that individuals with ASD did not show an ingroup bias for the perception of a self-directed gaze, and raise the possibility that an atypical emotional experience contributes to the diminished ingroup bias for the perception of a self-directed gaze.

Keywords: Autism spectrum disorder; Eye contact; Emotion; Gaze direction; Ingroup bias; Social anxiety

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

Eye Contact Perception in Adults with High-functioning Autism Spectrum Disorder

Autism spectrum disorder (ASD) is primarily characterized by qualitative impairments in social communication and the presence of repetitive behaviors and restricted interests (American Psychiatric Association [APA], 2013). Another salient feature of ASD is atypical attention to eye gaze (Frazier et al., 2017). Researchers have demonstrated that less attention to (Jones et al., 2008; Klin et al., 2002) and a reduced understanding of eye gaze (Bedford et al., 2012; Elsabbagh et al., 2012) predict social impairments and a later diagnosis of ASD. Eye gaze provides crucial cues for understanding the attentional focus and mental state of others (Baron-Cohen, 1997) as well as maintaining social relationships (Kleinke, 1986). For typically developing (TD) individuals, eye contact enhances several cognitive functions, including joint attention (Senju & Johnson, 2009), which is an indispensable skill for social development (Baron-Cohen, 1997). Thus, research in the field of eye contact perception is theoretically and practically important in terms of understanding and improving the social difficulties associated with ASD.

Many studies have examined whether individuals with ASD can accurately discriminate the gaze directions of others. One procedure to assess this phenomenon involves the simultaneous presentation of two faces with a direct or averted gaze after which the participants are asked to choose the face with the direct gaze. In studies that have used this paradigm, individuals with ASD are poorer at identifying a direct gaze than TD individuals (Gepner et al., 1996; Howard et al., 2000), particularly young participants (Webster & Potter, 2011). Other paradigms require participants to determine the gaze directions (direct [straight], left, and right) of face stimuli, and most

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

of these studies have found that the accuracy of individuals with ASD for recognizing gaze direction is lower than that of TD individuals (Ashwin et al., 2009; Campbell et al., 2006; Lawson et al., 2017; Pellicano et al., 2013; Wallace et al., 2006; Wallace et al., 2010; however, see Kylliäinen & Hietanen, 2004). Furthermore, individuals with ASD are worse at identifying the object and location looked at by face stimuli than TD individuals (Forgeot d'Arc et al., 2016; Pantelis & Kennedy, 2017; Riby & Doherty, 2009; Webster & Potter, 2011). These findings indicate that individuals with ASD have difficulty discriminating gaze direction and further suggest that they have an atypical understanding of the attentional focus and mental state of others during dyadic and triadic interactions.

The tendency to detect a self-directed gaze rather than the ability to discriminate gaze direction might be a more important explanatory factor for the presence of social difficulties in individuals with ASD. Humans are likely to accept considerable deviations from a straight gaze as a self-directed gaze when judging whether another person's gaze is directed at them (Gibson & Pick, 1963; Mareschal et al., 2013). The detection of a self-directed gaze is often the starting point for social interactions and a person who feels as if they are being watched can prepare to respond to others' actions irrespective of the real gaze direction because the other person may likely be motivated to approach. In fact, eye contact during a live interaction elicits electroencephalographic changes that reflect positive affect and approach motivation (Hietanen et al., 2008; Pönkänen et a., 2011) and also enhances self-awareness and the tendency to associate incoming information with the self (i.e., self-referential processing; Hietanen & Hietanen, 2017). Individuals with ASD exhibited reductions in approach-related electrophysiological and autonomic nervous activity in response to a direct gaze

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

(Helminen et al., 2017; Lauttia et al., 2019), and in self-referential processing in an implicit memory task (Toichi et al., 2002; Yoshimura & Toichi, 2014). Thus, these individuals may have a reduced tendency to detect and/or perceive self-directed gazes.

Several studies have investigated the perception of self-directed gaze in individuals with ASD. Vida et al. (2013) presented upright and inverted faces with emotional expressions that had various gaze directions and asked participants to determine whether the face was looking directly at them. Both TD individuals and individuals with ASD exhibited a greater bias to the perception of a self-directed gaze in response to a subtly averted gaze under angry stimulus conditions compared to other emotional face conditions. Additionally, there were no group differences regarding the perception of a self-directed gaze from an upright face, although TD individuals were more likely to perceive a self-directed gaze from an inverted face compared to individuals with ASD. Dratsch et al. (2013) presented a virtual character that moved their averted gaze (15–25°) toward participants (0° or 1–7°) and found that individuals with ASD are more likely to perceive a subtly averted gaze (1–7°) as a self-directed gaze compared to TD individuals. However, Matsuyoshi et al. (2014) found a significant negative correlation between scores on the Autism-Spectrum Quotient (AQ) and the threshold for the looking-at-me response in TD males, which indicates that males with a high AQ score are less likely to perceive an averted gaze as self-directed than those with a low AQ score. These conflicting results suggest that there are many potential factors that can modulate the perception of a self-directed gaze in individuals with ASD.

Studies of TD individuals have revealed several factors that can induce the perception of self-directed gaze. First, observers with high levels of social anxiety tend

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

to perceive averted gazes as self-directed gazes (Chen et al., 2017; Gamer et al., 2011). Individuals with ASD generally exhibit high levels of social anxiety (Bejerot et al., 2014) and are likely to have comorbid social anxiety disorder (Hollocks et al., 2019). Therefore, studies assessing the perception of self-directed gaze by individuals with ASD should consider the possibility that group differences in social anxiety may explain differences in the perception of a self-directed gaze. Second, recent studies have suggested that feelings of membership with face stimuli could affect one's sensitivity to perceiving self-directed gazes. Uono and Hietanen (2015) demonstrated that Finnish, but not Japanese participants had a smaller bias toward judging slightly averted gazes as self-directed gazes when assessing ingroup faces compared to outgroup faces. Collova et al. (2017) observed a greater detection sensitivity for direct gazes from ingroup faces compared to outgroup faces in both Caucasian and Asian participants using a discrimination task for direct and left- and right-averted gazes. Although previous studies have reported a typical ingroup advantage in terms of face recognition and cross-racial face scanning patterns in individuals with ASD (Wilson et al., 2011; Yi et al., 2016; Yi et al., 2015), other studies have reported that these individuals do not show ingroup advantages for face recognition (Chien et al., 2014) or face discrimination (Hadad et al., 2019). Given that individuals with ASD show reduced attention to eye gaze (Frazier et al., 2017), and a less-marked experience-dependent perceptual advantage with respect to the processing of ingroup faces (Hadad et al., 2019), it is reasonable to predict that individuals with ASD do not differentially process the eye gazes of ingroup and outgroup faces.

The present study examined differences in the perception of a self-directed gaze between Japanese adults with ASD and age-, sex-, and IQ-matched TD controls. The

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

participants observed ingroup and outgroup faces with neutral expressions and various gaze directions (0° and 2°, 4°, 6°, 8°, and 10° to the left and right; Figure 1) and were asked to determine whether the face stimuli were looking at them or not. First, this study aimed to determine whether individuals with ASD would be more or less likely to perceive self-directed gazes than TD controls irrespective of social anxiety levels. Second, it was explored whether individuals with or without ASD would show a different bias for the perception of self-directed gazes from ingroup versus outgroup faces. To assess whether individuals with ASD and TD individuals would interpret neutral faces in the same or a different manner, the participants evaluated face stimuli in terms of affect-related dimensions of subjective experience and emotion.

Material and methods

Participants

The participants' demographic information is shown in Table 1. This study included 20 Japanese adults with ASD (5 females and 15 males; age: mean [*M*] = 24.9 years, standard deviation [*SD*] = 4.8 years) who were recruited from people who visited the Faculty of Human Health Science of xxxx University Graduate School of Medicine for consultation. Diagnoses of ASD were based on the criteria of the Diagnostic and Statistical Manual of Mental Disorders, 4th Edition, Text Revision (APA, 2000) and each diagnostic criterion for ASD was carefully assessed during intensive interviews with the participants and their parents by psychiatrists with expertise in neurodevelopmental disorders. The ASD group consisted of 12 individuals with Asperger's disorder (three females and nine males) and eight individuals with pervasive developmental disorders that were not otherwise specified (PDD-NOS; two females and

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

six males). Both diagnoses are also included within the ASD category of the DSM-5 (APA, 2013).

The severity of symptoms in each of the 18 ASD participants was assessed using the Childhood Autism Rating Scale (CARS; Schopler et al., 1986), which consists of 15 items that assess autistic behaviors and general impressions. Each item is assigned a score from 1.0 to 4.0 in increments of 0.5, and a higher score is indicative of more severe symptoms. The total CARS score in the ASD group (M = 24.9, SD = 3.3) in the present study was higher than those reported by previous studies investigating participants with Asperger's disorder or PDD-NOS (Koyama et al., 2007; Uono et al., 2011). The IQ levels of the participants were measured using the Japanese version of the Wechsler Adult Intelligence Scale, third edition. None of the participants with ASD had any intellectual disabilities (full-scale IQ: M = 116.9, SD = 9.7), or neurological or psychiatric problems other than those derived from ASD, nor were receiving any medication during the study period.

The TD group included 31 Japanese adults who were first recruited from among undergraduate and graduate students. The participants in both groups completed the Japanese version of the AQ (Wakabayashi et al., 2006) and the Social Interaction Anxiety Scale (SIAS; Kanai et al., 2004). TD participants with an AQ score above the clinical cut-off (> 32) were excluded from all subsequent analyses (n = 3). Next, the TD participants were matched with the ASD participants, in terms of sex, age and IQ, prior to analyzing their task performance. For both sexes, younger participants and those with higher IQs were excluded. Ultimately, 20 Japanese TD adults were selected for the analysis (five females and 15 males; age: M = 23.2, SD = 2.0; full-scale IQ: 115.9 ± 9.7). The TD group had a significantly lower AQ than the ASD group (ASD: M = 29.6, SD =

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

5.4; TD: $M = 21.8$, $SD = 4.8$; t [38] = 4.83, $p < .001$). There was no significant group difference in age (t [25.6] = 1.47, $p = 0.15$), IQ (t [38] ≤ 0.84, $p \geq .41$), or SIAS score (ASD: $M = 43.2$, $SD = 11.9$; TD: $M = 36.4$, $SD = 12.7$; t [38] = 1.77, $p = .09$).

All procedures were in accordance with the guidelines of the Declaration of Helsinki 1964 and its later amendments. The experimental procedure was approved by the local ethics committee of **** University Graduate School and Faculty of Medicine and, written informed consent was obtained from all participants.

Stimuli

Face photographs of eight Japanese (four females) and eight Finnish (four females) were presented as an ellipse (10.2° width × 13.8° height) and consisted of faces with direct gazes and averted gazes of 2°, 4°, 6°, 8°, and 10° to the left and right (Figure 1); a total of 176 face photographs were used. The face models were asked to keep their facial expressions neutral and to change their gaze direction without making any other movements (e.g., head and body orientation). It was confirmed that the degree of gaze aversion at each gaze angle did not differ with respect to face group. Detailed explanations of stimulus development and properties have been provided in a previous report (Uono & Hietanen, 2015).

Design

The gaze direction judgment task included three factors: group (ASD and TD) as an independent measure, and face group (ingroup [Japanese] and outgroup [Finnish]) and gaze angle (0°, 2°, 4°, 6°, 8°, and 10°) as repeated-measures factors.

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

Apparatus

Stimulus presentation and data acquisition were controlled using Presentation software (Neurobehavioral Systems, Berkeley, CA, USA) running on a Windows computer (Microsoft, Redmond, WA, USA). The face stimuli and rating scales were presented on a 17-inch CRT monitor (Mitsubishi, Tokyo, Japan) with a screen resolution of 1024 × 768 pixels and a refresh rate of 75 Hz. A headrest was used to keep the distance between the monitor and the participant (~ 57 cm) and the eye level constant.

Procedure

Gaze direction judgment task: A white fixation cross on black background was presented at the center of the screen for 500 ms and then a face (10.2° vertical and 13.8° horizontal) with either a direct (0°) or averted gaze (2°, 4°, 6°, 8°, or 10°) appeared for 150 ms. Subsequently, the participants were asked to answer whether the person in the photograph was “looking at me” or “not looking at me” as accurately as possible using two response buttons. The instructions for the assigned buttons for each response remained on the screen until the participant gave a response. The combination of the assigned buttons was counterbalanced across participants. If no response was acquired within 5000 ms, the next trial started. The task consisted of 176 trials separated into two blocks and the trial order was randomized for each participant. The participants completed five practice trials and were familiar with the task procedure prior to testing.

Rating tasks: The participants evaluated ingroup (Japanese) and outgroup (Finnish) faces with direct and averted gazes using a nine-point Likert scale. First, the participants were asked to rate the subjective pleasantness of (1 = very unpleasant; 9 = very

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

pleasant) and their arousal level in response to (1 = very calm; 9 = very aroused) each face stimulus. For faces with an averted gaze, half of the faces (both Japanese and Finnish) had a 10° left-averted gaze, whereas the other half had a 10° right-averted gaze. Second, the participants observed the same face stimuli and evaluated how dominant (1 = submissive; 9 = dominant) and warm (1 = cold; 9 = warm) the person looked. Finally, the participants assessed how intensely the faces with a direct gaze reflected each emotion in the following order: anger, disgust, fear, neutrality, happiness, sadness, and surprise (1 = not at all; 9 = very much). In each trial, a given face and the named scale remained on the screen until a response was provided. The order of presentation the blocks was the same across participants, whereas the order of presentation of the faces was randomized for each rating task.

Data analysis

For the gaze direction judgment task, trials with no response and those with a response prior to the response stage were excluded from the analyses. Consistent with previous studies (Lobmaier et al., 2008; Uono & Hietanen, 2015), the data were collapsed across the left and right gaze directions to calculate the percentages of looking-at-me responses. The percentages of the looking-at-me responses were subjected to a 2 (participant group: ASD and TD) × 2 (face group: ingroup and outgroup) × 6 (gaze angle: 0°, 2°, 4°, 6°, 8°, and 10°) mixed-design analysis of variance (ANOVA).

For the rating tasks of the affect-related dimensions, the average scores for each condition were calculated for each participant and analyzed using a 2 (participant group: ASD and TD) × 2 (face group: ingroup and outgroup) × 2 (gaze direction: direct and

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

averted) mixed-design ANOVA. For the emotion rating task, each participant's average scores were analyzed using a 2 (participant group: ASD and TD) × 2 (face group: ingroup and outgroup) × 7 (emotion type: anger, disgust, fear, neutrality, happiness, sadness, and surprise) mixed-design ANOVA.

When the sphericity assumption was violated, probability values were evaluated with Greenhouse–Geisser adjustments for degrees of freedom, and significant interactions were followed up with using simple effects analyses. Finally, although there were no significant group differences in social anxiety as measured using the SIAS, the scores of the SIAS were entered as a covariate into the ANOVA assessing the gaze direction judgment task and each rating task.

Results

Gaze direction judgment task

The percentages of looking-at-me responses for each condition are shown in Table 2 and Figure 2. An ANOVA revealed a significant main effect of gaze direction (F [5, 190] = 369.47, $p < .001$, $\eta_p^2 = .907$). All pairwise comparisons between each gaze direction condition were significant (t [38] > 4.42, Bonferroni corrected $p < .002$). The results indicated that the proportion of looking-at-me responses gradually decreased as gaze angle increased. There was also a significant main effect of face group (F [1, 38] = 4.16, $p = .048$, $\eta_p^2 = .099$), such that the proportion of looking-at-me responses was higher for ingroup faces than for outgroup faces. However, there was no significant main effect for participant group (F [1, 38] = .019, $p = .892$, $\eta_p^2 = .001$).

Importantly, there was a significant interaction between participant group and face group (F [1, 38] = 4.10, $p = .0499$, $\eta_p^2 = .097$). A follow-up analysis revealed that

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

the TD group gave more looking-at-me responses when presented with ingroup faces than with outgroup faces (F [1, 19] = 11.19, p = .003, η_p^2 = .371), whereas the ASD group gave similar numbers of looking-at-me responses when presented with ingroup and outgroup faces (F [1, 19] = 0.01, p = .993, η_p^2 < .001). There were no significant simple effects of participant group for either ingroup faces (F [1, 38] = 0.71, p = .403, η_p^2 = .018) or outgroup faces (F ([1, 38] = 0.24, p = .625, η_p^2 = .006).

There was also a significant interaction between gaze direction and face group (F [5, 190] = 5.76, p < .001, η_p^2 = .132). A follow-up analysis revealed that ingroup faces induced more looking-at-me responses than outgroup faces when gazes were subtly averted at 2° (F [1, 38] = 13.55, p < .001, η_p^2 = .263) and 4° (F [1, 38] = 9.94, p = .003, η_p^2 = .207).

Rating tasks

The results for the ratings of affect-related dimensions and emotion types are shown in Tables 3 and 4, respectively.

Pleasantness: There were no significant main effects or interactions (F [1, 38] < 0.87, p > .358, η_p^2 < .023).

Arousal: There was a significant main effect of face group (F [1, 38] = 15.41, p < .001, η_p^2 = .289), which indicated that the participants gave higher arousal ratings to outgroup faces than to ingroup faces. There was also a significant main effect of gaze direction (F [1, 38] = 6.75, p = .013, η_p^2 = .151), and a significant interaction between participant group and gaze direction (F [1, 38] = 5.08, p = .030, η_p^2 = .118). A follow-up analysis revealed that the ASD (F [1, 19] = 15.05, p = .001, η_p^2 = .442) but not the TD group (F [1, 19] = 0.05, p = .828, η_p^2 = .003) reported higher arousal ratings for direct gazes

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

compared to averted gazes. There was no significant simple effect of participant group for direct (F [1, 38] = 2.81, p = .102, η_p^2 = .069) or averted gazes (F [1, 38] = 0.01, p = .905, η_p^2 < .001).

Dominance: There were significant main effects of face group (F [1, 38] = 21.29, p < .001, η_p^2 = .358) and gaze direction (F [1, 38] = 7.65, p = .009, η_p^2 = .168), which indicated that the participants gave higher dominance ratings to outgroup faces and direct gazes than to ingroup faces and averted gazes, respectively. There were no other significant main effects or interactions (F [1, 38] < 2.67, p > .110, η_p^2 < .007).

Warmth: There was a significant interaction for the participant group × face group × gaze direction analysis (F [1, 38] = 9.20, p = .004, η_p^2 = .195). A follow-up ANOVA that included face group and gaze direction as factors was conducted for each group. The analysis did not reveal any significant main effects or interactions in the TD group (F [1, 19] < 3.72, p > .069, η_p^2 < .164). In the ASD group, there was a significant interaction between face group and gaze direction (F [1, 19] = 5.88, p = .025, η_p^2 = .236). Although the ASD group was more likely to give higher warmth ratings to ingroup faces with an averted gaze and outgroup faces with a direct gaze than to other face stimuli, the follow-up analyses did not reveal any clear simple effects of face group (F [1, 19] < 2.64, p > .121, η_p^2 < .122) or gaze direction (F [1, 19] < 2.26, p > .149, η_p^2 < .107).

Emotion types: An ANOVA revealed significant main effects of face group (F [1, 38] =5.70, p = .022, η_p^2 = .131) and emotion (F [6, 228] = 28.34, p < .001, η_p^2 = .427), as well as a significant interaction between these two factors (F [6, 228] = 4.16, p < .001, η_p^2 = .099). Follow-up analyses revealed that the participants gave a higher neutral rating to ingroup faces than to outgroup faces (F [1, 38] = 6.55, p = .015, η_p^2 = .147) but

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

higher sadness (F [1, 38] = 4.81, p = .034, η_p^2 = .113) and surprise (F [1, 38] = 10.06, p = .003, η_p^2 = .209) ratings to outgroup faces than to ingroup faces. There were no significant effects involving participant group (F [1, 38] < 3.55, p > .067, η_p^2 < .086).

Effects of social anxiety

Analysis of covariance tests with the SIAS score as a covariate revealed that there were no significant main effects or interactions involving the SIAS score in any analyses (p > .10), which suggests that the group differences in the gaze direction judgement task and the rating tasks could not explained by high social anxiety levels in the ASD group.

Discussion

The present results showed that, in general, individuals with and without ASD perceived self-directed gazes to the same degree. The ASD group did not report higher levels of social anxiety than the TD group. The results did not identify an influence of social anxiety on the perception of self-directed gazes. In both groups, looking-at-me responses were recorded most frequently when true eye contact was made (0°), with the frequency gradually decreasing as the gaze deviation (2–10°) increased. Consistent with previous studies (Dratsch et al., 2013; Vida et al., 2013), the present results suggest that adults with and without ASD perceived considerable gaze deviations as self-directed gazes.

More importantly, the present results indicate that face group differentially affected looking-at-me responses in the ASD and TD groups. Ingroup faces were more likely than outgroup faces to induce the perception of a self-directed gaze in the TD group but not the ASD group. Although some studies have reported a typical ingroup

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

advantage for face recognition and cross-racial face scanning patterns in individuals with ASD (Wilson et al., 2011; Yi et al., 2016; Yi et al., 2015), other studies did not observe an ingroup advantage for face recognition (Chien et al., 2014) or discrimination (Hadad et al., 2019). The present findings indicate that individuals with ASD did not show an ingroup bias for the perception of a self-directed gaze. Because individuals with ASD exhibit atypical social attention, such as lower degrees of attention to faces and gazes (Jones et al., 2008; Klin et al., 2002), the reduced exposure of faces might have prohibited the differentiation of ingroup faces from outgroup faces. However, the perception of gazes by the ASD group in the present study cannot be solely explained by less expertise in processing ingroup faces because the facilitated perception of a self-directed gaze does not indicate a superior ability to discriminate gaze direction. Thus, several potential causes that could have induced the effects of face group on looking-at-me responses in the TD group, but not in the ASD group, will be discussed.

Previous studies have reported that TD individuals exhibit facilitated perception of self-directed gazes under specific conditions. Some studies have demonstrated that the perception of a self-directed gaze is enhanced by facial expressions indicating anger (Ewbank et al., 2009) and happiness (Lobmaier & Perrett, 2011); these expressions signal the motivation of observers to approach when accompanied by a direct gaze (Adams & Kleck, 2003). A study using multisensory stimuli reported that participants accept a wide range of averted gazes as self-directed gazes when self-relevant auditory information (i.e., one's own name) is presented simultaneously (Stoyanova et al., 2010). These findings suggest that information relevant to the self or information that induces self-referential processing may facilitate the perception of a self-directed gaze. Ingroup faces that might resemble one's own face and subsequently evoke an interaction could

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

be more self-relevant than outgroup faces. Individuals with ASD have an atypical sense of self as well as difficulties with self-referential processing (Frith, 2003; Toichi et al., 2002; Yoshimura & Toichi, 2014). Therefore, ingroup faces (i.e., relatively highly self-relevant but not apparent faces) may be more likely to induce the perception of a self-directed gaze relative to outgroup faces in TD individuals but in not individuals with ASD. However, it has been reported that TD and ASD groups are more likely to perceive self-directed gazes on angry faces (Vida et al., 2013), which are threatening and highly self-relevant, than on neutral faces.

There are other possible explanations for the lack of a modulatory effect of face group on the perception of a self-directed gaze in individuals with ASD. Although we did not find a significant group difference in the perception of self-directed gaze under any gaze angle condition, a visual inspection of the present data indicated that individuals with ASD were less likely to perceive a self-directed gaze when gazes were subtly averted (2–4°) than TD individuals, which suggests that the ASD group had a superior ability to discriminate gaze direction (Table 2). Previous studies have shown that individuals with ASD have enhanced perceptual abilities during low-level visual processing (Mottron et al., 2006). Additionally, Matsuyoshi et al. (2014) observed that TD males with a high AQ score were less likely to perceive an averted gaze as a self-directed gaze than those with a low AQ score. In the present study, the TD group, but not the ASD group, was less likely to perceive averted gazes on Japanese faces than on Finnish faces when the faces were subtly averted. In general, Japanese faces have dark irises and, thus, small changes in pupil position may be less visible. As a result, the enhanced visual processing abilities of individuals with ASD might have contributed to

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

the ability to discriminate gaze direction on Japanese faces and might have obscured a small effect from face group membership.

The present results also revealed group differences in the ratings of face stimuli. First, individuals with ASD tended to give higher warmth ratings to ingroup faces with an averted gaze and outgroup faces with a direct gaze than to other types of face stimuli. Positive (happy) faces induce the most significant looking-at-me responses in TD individuals (Lobmaier & Perrett, 2011). One study demonstrated that TD individuals, but not individuals with ASD, showed increased pupillary diameter in response to happy faces with direct gazes versus those with an averted gaze, suggesting a reduced reward value for happy faces in individuals with ASD (Sepeta et al., 2012). However, the higher warmth ratings for outgroup faces with a direct gaze (i.e., subjectively positive faces) and lower warmth ratings for ingroup faces with an averted gaze (i.e., subjectively negative faces) in the present study might have obscured an ingroup bias for the perception of a self-directed gaze in the ASD group. As mentioned above, some studies have demonstrated the effects of face group membership in individuals with ASD; these individuals tend to exhibit a typical ingroup bias for face recognition and cross-racial face scanning patterns (Wilson et al., 2011; Yi et al., 2016; Yi et al., 2015). The warmth rating results in the present study also suggest that individuals with ASD can use facial information relevant to face group membership.

Second, the arousal rating results showed that individuals with ASD, but not TD individuals, experienced more arousal in response to a direct gaze than an averted gaze. This finding is consistent with the increased autonomic response to (Kylliäinen et al., 2012), and avoidance of, direct gaze (Madipakkam et al., 2017) in ASD as well as the lack of enhanced physiological responses following the perception of a direct gaze

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

during non-live interactions in TD individuals (Hietanen et al., 2008; Pönkänen et al., 2011). Although the level of social anxiety was not associated with the perception of a self-directed gaze in the present study, it is possible that high emotional sensitivity to a direct gaze in the ASD group, irrespective of face group, obscured differences in the perception of self-directed gazes between ingroup and outgroup faces.

These two results from the rating tasks in the present study raise the possibility that atypical emotional experiences to faces with a direct gaze might have contributed to the lack of an ingroup bias for the perception of a self-directed gaze in individuals with ASD. However, this interpretation should be treated with caution because the present study did not find associations between gaze direction and ratings of affect-related dimensions in the TD group. Moreover, the study design made it difficult to directly relate ratings to the perception of self-directed gazes, which depends on the difference in stimulus duration between the gaze-direction judgement and rating tasks (150 ms vs. no time limit). A recent review observed that implicit measures produced more consistent results than explicit measures regarding the effects of eye contact (Hietanen, 2018). In addition to assessing the subjective evaluation of faces, parallel physiological recordings could provide insights into the mechanisms underlying the perception of a self-directed gaze.

The present study had other limitations that should be noted. First, the sample size of each group was relatively small, although previous studies used similar sample sizes. No significant effects of participant group in some rating tasks may be attributable to low statistical power. Further studies with large samples will be necessary to reveal factors that contribute to the perception of a self-directed gaze in individuals with ASD. Second, the participant sex ratio was biased towards males

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

because ASD is more prevalent in males than in females (APA, 2013). A previous study that included more TD Japanese adult females than males reported no differences in the perception of a self-directed gaze between ingroup and outgroup faces (Uono & Hietanen, 2015), as with the ASD group in the present study. Recent studies have reported sex differences in social attention and motivation in individuals with ASD (Harrop et al., 2018; Sedgewick et al., 2016). Thus, sex may be a potentially important factor that modulates the perception of a self-directed gaze from ingroup and outgroup faces. Third, the instrument used to assess symptom severity in the present study (i.e., the CARS) is not ideal for high functioning and mild ASD cases. Thus, we did not investigate the relationship between symptom severity and task performance. Given the diversity and varying definitions of ASDs (Constantino & Charman, 2016), a standardized measure of symptom severity, such as the Autism Diagnostic Observation Schedule (Lord et al., 2012), is valuable for comparing the findings of different studies. **In addition, studies are needed to confirm whether our findings can be generalized to the individuals with severe ASD symptoms, because the participants with ASD in the present study had mild symptoms as shown by both CARS and AQ average scores.**

In summary, the present study found that individuals with ASD and TD individuals were just as likely to perceive subtle averted gazes as self-directed gazes. The frequency of perceiving a self-directed gaze decreased as gaze aversion increased in both groups and, in general, individuals with ASD showed a comparable ability to perceive a self-directed gaze as that of TD individuals. Interestingly, compared to outgroup faces, ingroup faces induced more frequent perception of self-directed gazes in the TD group but not in the ASD group. The results indicate that individuals with ASD

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

did not exhibit an ingroup bias for the perception of a self-directed gaze. However, the results of the rating tasks raise the possibility that an atypical emotional experience in response to faces with a direct gaze in the ASD group might have obscured an ingroup bias for the perception of a self-directed gaze.

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

References

Adams, R. B., & Kleck, R. E. (2003). Perceived gaze direction and the processing of facial displays of emotion. *Psychological Science, 14*(6), 644-647. doi:10.1046/j.0956-7976.2003.psci_1479.x

Ashwin, C., Ricciardelli, P., & Baron-Cohen, S. (2009). Positive and negative gaze perception in autism spectrum conditions. *Social Neuroscience, 4*(2), 153-164. doi:10.1080/17470910802337902

American Psychiatric Association (2000). *Diagnostic and statistical manual for mental disorders (DSM-IV-TR)*. Washington, DC: Author.

American Psychiatric Association (2013). *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition*. Arlington, VA: American Psychiatric Association.

Baron-Cohen, S. (1997). *Mindblindness: An essay on autism and theory of mind*. Cambridge, Massachusetts: The MIT Press.

Bedford, R., Elsabbagh, M., Gliga, T., Pickles, A., Senju, A., Charman, T., . . . team, B. (2012). Precursors to social and communication difficulties in infants at-risk for autism: gaze following and attentional engagement. *Journal of Autism and Developmental Disorders, 42*(10), 2208-2218. doi:10.1007/s10803-012-1450-y

Bejerot, S., Eriksson, J. M., & Mortberg, E. (2014). Social anxiety in adult autism spectrum disorder. *Psychiatry Research, 220*(1-2), 705-707. doi:10.1016/j.psychres.2014.08.030

Campbell, P., Lawrence, K., Mandy, W., Mitra, C., Jeyakuma, L., & Skuse, D. (2006). Meanings in motion and faces: Developmental associations between the processing of intention from geometrical animations and gaze detection accuracy. *Development and Psychopathology, 18*, 99-118.

Chen, T., Nummenmaa, L., & Hietanen, J. K. (2017). Eye contact judgment is influenced by perceivers' social anxiety but not by their affective state. *Frontiers in Psychology, 8*, 373. doi:10.3389/fpsyg.2017.00373

Chien, S. H.-L., Wang, L.-H., Chen, C.-C., Chen, T.-Y., & Chen, H.-S. (2014). Autistic children do not exhibit an own-race advantage as compared to typically developing children. *Research in Autism Spectrum Disorders, 8*, 1544-1551. doi:10.1016/j.rasd.2014.08.005

Collova, J. R., Kloth, N., Crookes, K., Burton, N., Chan, C. Y. H., Hsiao, J. H., & Rhodes, G. (2017). A new other-race effect for gaze perception. *Journal of Experimental Psychology: Human Perception and Performance, 43*(11), 1857-1863. doi:10.1037/xhp0000460

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

Constantino, J. N., & Charman, T. (2016). Diagnosis of autism spectrum disorder: reconciling the syndrome, its diverse origins, and variation in expression. *The Lancet Neurology, 15*(3), 279-291.

Dratsch, T., Schwartz, C., Yanev, K., Schilbach, L., Vogeley, K., & Bente, G. (2013). Getting a grip on social gaze: control over others' gaze helps gaze detection in high-functioning autism. *Journal of Autism and Developmental Disorders, 43*(2), 286-300. doi:10.1007/s10803-012-1569-x

Elsabbagh, M., Mercure, E., Hudry, K., Chandler, S., Pasco, G., Charman, T., . . . Team, B. (2012). Infant neural sensitivity to dynamic eye gaze is associated with later emerging autism. *Current Biology, 22*(4), 338-342. doi:10.1016/j.cub.2011.12.056

Ewbank, M. P., Jennings, C., & Calder, A. J. (2009). Why are you angry with me? Facial expressions of threat influence perception of gaze direction. *Journal of Vision, 9*(12), 16 11-17. doi:10.1167/9.12.16

Forgeot d'Arc, B., Delorme, R., Zalla, T., Lefebvre, A., Amsellem, F., Moukawane, S., . . . Ramus, F. (2016). Gaze direction detection in autism spectrum disorder. *Autism*. doi:10.1177/1362361316630880

Frazier, T. W., Strauss, M., Klingemier, E. W., Zetzer, E. E., Hardan, A. Y., Eng, C., & Youngstrom, E. A. (2017). A meta-analysis of gaze differences to social and nonsocial information between individuals with and without autism. *Journal of the American Academy of Child and Adolescent Psychiatry, 56*(7), 546-555. doi:10.1016/j.jaac.2017.05.005

Frith, U. (2003). *Autism: Explaining the enigma*. Oxford: Blackwell.

Gamer, M., Hecht, H., Seipp, N., & Hiller, W. (2011). Who is looking at me? The cone of gaze widens in social phobia. *Cognition and Emotion, 25*(4), 756-764. doi:10.1080/02699931.2010.503117

Gepner, B., de Gelder, B., & de Schonen, S. (1996). Face processing in autistics: Evidence for a generalised deficit? *Child Neuropsychology, 2*(2), 123-139. doi:10.1080/09297049608401357

Gibson, J. J., & Pick, A. D. (1963). Perception of another person's looking behavior. *American Journal of Psychology, 76*(3), 386-394.

Hadad, B. S., Schwartz, S., & Binur, N. (2019). Reduced perceptual specialization in autism: Evidence from the other-race face effect. *Journal of Experimental Psychology: General, 148*(3), 588-594. doi:10.1037/xge0000550

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

Harrop, C., Jones, D., Zheng, S., Nowell, S. W., Boyd, B. A., & Sasson, N. (2018). Sex differences in social attention in autism spectrum disorder. *Autism Research, 11*(9), 1264-1275. doi:10.1002/aur.1997

Helminen, T. M., Leppanen, J. M., Eriksson, K., Luoma, A., Hietanen, J. K., & Kylliainen, A. (2017). Atypical physiological orienting to direct gaze in low-functioning children with autism spectrum disorder. Autism Research, 10(5), 810-820. doi:10.1002/aur.1738

Hietanen, J. K. (2018). Affective eye contact: An integrative review. *Frontiers in Psychology, 9*, 1587. doi:10.3389/fpsyg.2018.01587

Hietanen, J. K., Leppänen, J. M., Peltola, M. J., Linna-Aho, K., & Ruuhiala, H. J. (2008). Seeing direct and averted gaze activates the approach-avoidance motivational brain systems. *Neuropsychologia, 46*(9), 2423-2430. doi:10.1016/j.neuropsychologia.2008.02.029

Hietanen, J. O., & Hietanen, J. K. (2017). Genuine eye contact elicits self-referential processing. *Consciousness and Cognition, 51*, 100-115. doi:10.1016/j.concog.2017.01.019

Hollocks, M. J., Lerh, J. W., Magiati, I., Meiser-Stedman, R., & Brugha, T. S. (2019). Anxiety and depression in adults with autism spectrum disorder: a systematic review and meta-analysis. *Psychological Medicine, 49*(4), 559-572. doi:10.1017/S0033291718002283

Howard, M. A., Cowell, P. E., Boucher, J., Broks, P., Mayes, A., Farrant, A., & Roberts, N. (2000). Convergent neuroanatomical and behavioral evidence of an amygdala hypothesis of autism. *Neuroreport, 11*(13), 2931-2935.

Jones, W., Carr, K., & Klin, A. (2008). Absence of preferential looking to the eyes of approaching adults predicts level of social disability in 2-year-old toddlers with autsim spectrum disorder. *Archive of Genaral Psychiatry, 65*(8), 946-954.

Kanai, Y., Sasagawa, S., Chen, J., Suzuki, S., Shimada, H., & Sakano, Y. (2004). Development and validation of the Japanese version of social phobia scale and social interaction anxiety scale. *Japanese Journal of Psychosomatic Medicine, 44*(11), 841-850.

Kleinke, C. L. (1986). Gaze and eye contact: A research review. *Psychological Bulletin, 100*(1), 78-100.

Klin, A., Jones, W., Schultz, R., Volkmar, F., & Cohen, D. (2002). Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. *Archives of General Psychiatry, 59*, 809-816.

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*(1), 99-104. doi:10.1111/j.1440-1819.2007.01617.x

Kylliäinen, A., & Hietanen, J. K. (2004). Attention orienting by another's gaze direction in children with autism. *Journal of Child Psychology and Psychiatry, 45*(3), 435-444.

Lauttia, J., Helminen, T. M., Leppänen, J. M., Yrttiaho, S., Eriksson, K., Hietanen, J. K., Kylliäinen, A. (2019). Atypical pattern of frontal EEG asymmetry for direct gaze in young children with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 49*(9), 3592-3601

Lawson, R. P., Aylward, J., Roiser, J. P., & Rees, G. (2017). Adaptation of social and non-social cues to direction in adults with autism spectrum disorder and neurotypical adults with autistic traits. *Developmental Cognitive Neuroscience*. doi:10.1016/j.dcn.2017.05.001

Lobmaier, J. S., & Perrett, D. I. (2011). The world smiles at me: self-referential positivity bias when interpreting direction of attention. *Cognition and Emotion, 25*(2), 334-341. doi:10.1080/02699931003794557

Lobmaier, J. S., Tiddeman, B. P., & Perrett, D. I. (2008). Emotional expression modulates perceived gaze direction. *Emotion, 8*(4), 573-577. doi:10.1037/1528-3542.8.4.573

Lord, C., Rutter, M., DiLavore, P. C., Risi, S., Gotham, K., & Bishop, S. L. (2012). *Autism Diagnostic Observation Schedule. 2nd.* Torrance, CA: Western Psychological Services.

Madipakkam, A. R., Rothkirch, M., Dziobek, I., & Sterzer, P. (2017). Unconscious avoidance of eye contact in autism spectrum disorder. *Scientific Reports, 7*(1), 13378. doi: 10.1038/s41598-017-13945-5.

Mareschal, I., Calder, A. J., & Clifford, C. W. (2013). Humans have an expectation that gaze is directed toward them. *Current Biology, 23*(8), 717-721. doi:10.1016/j.cub.2013.03.030

Matsuyoshi, D., Kuraguchi, K., Tanaka, Y., Uchida, S., Ashida, H., & Watanabe, K. (2014). Individual differences in autistic traits predict the perception of direct gaze for males, but not for females. *Molecular Autism, 5*, 12.

Mottron, L., Dawson, M., Soulieres, I., Hubert, B., & Burack, J. (2006). Enhanced perceptual functioning in autism: an update, and eight principles of autistic perception. *Journal of Autism and Developmental Disorders, 36*(1), 27-43. doi:10.1007/s10803-005-0040-7

Pönkänen, L. M., Alhoniemi, A., Leppänen, J. M., & Hietanen, J. K. (2011). Does it make a difference if I have an eye contact with you or with your picture? An ERP study. *Soc Cogn Affect Neurosci, 6*(4), 486-494. doi:10.1093/scan/nsq068

Pantelis, P. C., & Kennedy, D. P. (2017). Deconstructing atypical eye gaze perception in autism spectrum disorder. *Scientific Reports, 7*(1), 14990. doi:10.1038/s41598-017-14919-3

Pellicano, E., Rhodes, G., & Calder, A. J. (2013). Reduced gaze aftereffects are related to difficulties categorising gaze direction in children with autism. *Neuropsychologia, 51*(8), 1504-1509. doi:10.1016/j.neuropsychologia.2013.03.021

Riby, D. M., & Doherty, M. J. (2009). Tracking eye movements proves informative for the study of gaze direction detection in autism. *Research in Autism Spectrum Disorders, 3*(3), 723-733. doi:10.1016/j.rasd.2009.02.001

Schopler, E., Reichler, R. J., & Renner, B. R. (1986). *The Childhood Autism Rating Scale (CARS): For Diagnostic Screening and Classification of Autism*. New York: Irvington.

Sedgewick, F., Hill, V., Yates, R., Pickering, L., & Pellicano, E. (2016). Gender differences in the social motivation and friendship experiences of autistic and non-autistic adolescents. *Journal of Autism and Developmental Disorders, 46*(4), 1297-1306. doi:10.1007/s10803-015-2669-1

Senju, A., & Johnson, M. H. (2009). The eye contact effect: mechanisms and development. *Trends in Cognitive Science, 13*(3), 127-134. doi:10.1016/j.tics.2008.11.009

Sepeta, L., Tsuchiya, N., Davies, M.S., Sigman, M., Bookheimer, S. Y., & Dapretto, M. (2012). Abnormal social reward processing in autism as indexed by pupillary responses to happy faces. *Journal of Neurodevelopmental Disorder 4*, 17. https://doi.org/10.1186/1866-1955-4-17

Stoyanova, R. S., Ewbank, M. P., & Calder, A. J. (2010). "You talkin' to me?" Self-relevant auditory signals influence perception of gaze direction. *Psychological Science, 21*(12), 1765-1769. doi:10.1177/0956797610388812

Toichi, M., Kamio, Y., Okada, T., Sakihama, M., Youngstrom, E. A., Findling, R. L., & Yamamoto, K. (2002). A lack of self-consciousness in autism. *American Journal of Psychiatry, 159*, 1422-1424.

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

Uono, S., & Hietanen, J. K. (2015). Eye contact perception in the west and East: a cross-cultural study. *PLoS One, 10*(2), e0118094. doi:10.1371/journal.pone.0118094

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*(5-6), 452-463. doi:10.1080/17470919.2011.605593

Vida, M. D., Maurer, D., Calder, A. J., Rhodes, G., Walsh, J. A., Pachai, M. V., & Rutherford, M. D. (2013). The influences of face inversion and facial expression on sensitivity to eye contact in high-functioning adults with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 43*(11), 2536-2548. doi:10.1007/s10803-013-1802-2

Wakabayashi, A., Baron-Cohen, S., Wheelwright, S., & Tojo, Y. (2006). The Autism-Spectrum Quotient (AQ) in Japan: A cross-cultural comparison. *Journal of Autism and Developmental Disorders, 36*(2), 263-270. doi:10.1007/s10803-005-0061-2

Wallace, S., Coleman, M., Pascalis, O., & Bailey, A. (2006). A study of impaired judgment of eye-gaze direction and related face-processing deficits in autism spectrum disorders. *Perception, 35*, 1651-1664.

Wallace, S., Sebastian, C., Pellicano, E., Parr, J., & Bailey, A. (2010). Face processing abilities in relatives of individuals with ASD. *Autism Research, 3*(6), 345-349. doi:10.1002/aur.161

Webster, S., & Potter, D. D. (2011). Gaze perception develops atypically in children with autism. *Child Development Research, 2011*, 1-9. doi:10.1155/2011/462389

Wilson, C. E., Palermo, R., Burton, A. M., & Brock, J. (2011). Recognition of own- and other-race faces in autism spectrum disorders. *Quartely Journal of Experimental Psychology (Hove), 64*(10), 1939-1954. doi:10.1080/17470218.2011.603052

Yi, L., Quinn, P. C., Fan, Y., Huang, D., Feng, C., Joseph, L., . . . Lee, K. (2016). Children with Autism Spectrum Disorder scan own-race faces differently from other-race faces. *Journal of Experimental Child Psychology, 141*, 177-186. doi:10.1016/j.jecp.2015.09.011

Yi, L., Quinn, P. C., Feng, C., Li, J., Ding, H., & Lee, K. (2015). Do individuals with autism spectrum disorder process own- and other-race faces differently? *Vision Research, 107*, 124-132. doi:10.1016/j.visres.2014.11.021

Yoshimura, S., & Toichi, M. (2014). A lack of self-consciousness in Asperger's disorder but not in PDDNOS: Implication for the clinical importance of ASD subtypes.

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

Research in Autism Spectrum Disorders, 8(3), 237-243. doi:10.1016/j.rasd.2013.12.005

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

Table 1.

Participant demographic characteristics

	TD	ASD	Statistics	*p*-value	Cohen's *d*
Age (Y)	23.2 (2.0)	24.9 (4.8)	*t* (25.6) = 1.47	.15	.46
Sex	5 F : 15 M	5 F : 15 M	-	-	
Verbal IQ	120.8 (9.7)	120.0 (11.3)	*t* (38) = 0.25	.80	.08
Performance IQ	105.7 (11.6)	109.1 (13.7)	*t* (38) = 0.83	.41	.27
Full-scale IQ	115.9 (9.7)	116.9 (9.7)	*t* (38) = 0.31	.76	.10
SIAS	36.4 (12.5)	43.2 (11.9)	*t* (38) = 1.77	.09	.56
AQ	21.8 (4.8)	29.6 (5.4)	*t* (38) = 4.83	<.001	1.53
CARS	-	24.9 (3.3)	-	-	

Values are provided as means (*SD*).
ASD autism spectrum disorder; *AQ* Autism-Spectrum Quotient; *CARS* Childhood Autism Rating Scale; *IQ* intelligence quotient; *SD* standard deviation; *SIAS* Social Interaction Anxiety Scale; *TD* typically developing individuals.

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

Table 2.

Percentages of looking-at-me responses under each gaze angle condition

	0°	2°	4°	6°	8°	10°
TD						
In-group	92.50 (12.43)	90.00 (9.15)	70.00 (20.03)	38.13 (24.49)	18.44 (21.33)	10.31 (19.37)
Outgroup	88.75 (13.39)	76.88 (17.57)	57.05 (16.49)	35.63 (21.18)	17.19 (21.92)	10.94 (16.46)
ASD						
In-group	88.75 (12.10)	81.38 (13.51)	65.00 (15.62)	37.50 (20.48)	16.15 (12.22)	10.94 (15.56)
Outgroup	86.25 (15.65)	77.01 (15.81)	59.60 (20.53)	41.29 (20.34)	22.32 (18.72)	13.13 (17.55)

Values are provided as means (*SD*).
ASD autism spectrum disorder; *SD* standard deviation; *TD* typically developing individuals.

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

Table 3.
Ratings for the affect-related dimensions

		Pleasantness	Arousal	Dominance	Warmth
TD					
In-group	Direct	4.33 (0.71)	3.93 (0.89)	5.55 (0.99)	4.35 (0.81)
	Averted	4.39 (0.66)	3.89 (1.25)	5.14 (0.94)	4.18 (0.81)
Outgroup	Direct	4.40 (1.03)	4.44 (0.91)	6.11 (0.72)	3.88 (0.91)
	Averted	4.24 (0.86)	4.39 (1.05)	5.80 (1.09)	4.04 (1.06)
ASD					
In-group	Direct	4.34 (0.59)	4.27 (1.21)	5.26 (0.62)	4.38 (0.78)
	Averted	4.39 (0.78)	3.96 (1.26)	4.87 (0.63)	4.58 (0.81)
Outgroup	Direct	4.33 (0.68)	5.08 (1.18)	5.76 (0.60)	4.44 (0.96)
	Averted	4.38 (0.69	4.24 (1.15)	5.53 (0.79)	4.30 (1.07)

Values are provided as means (*SD*).
ASD autism spectrum disorder; *SD* standard deviation; *TD* typically developing individuals.

Autism. 2020;1362361320949721. doi:10.1177/1362361320949721
Accepted version

Table 4

Ratings for the six basic emotions and neutrality

	Anger	Disgust	Fear	Neutrality	Happiness	Sadness	Surprise
TD							
In-group	4.26 (1.34)	4.45 (1.52)	3.01 (1.89)	5.64 (1.59)	2.45 (0.93)	3.24 (2.07)	2.71 (1.67)
Outgroup	4.49 (1.62)	4.63 (1.83)	3.33 (1.83)	4.93 (1.75)	2.56 (1.07)	3.39 (1.84)	3.21 (1.42)
ASD							
In-group	3.72 (1.42)	3.84 (1.27)	2.39 (1.11)	4.41 (1.44)	2.21 (1.32)	2.47 (1.11)	2.38 (1.16)
Outgroup	4.24 (1.38)	3.82 (1.33)	2.61 (1.09)	4.13 (1.32)	2.23 (1.43)	2.89 (1.41)	2.87 (1.76)

Values are provided as means (*SD*).
ASD autism spectrum disorder; *SD* standard deviation; *TD* typically developing individuals.

Figure Legends

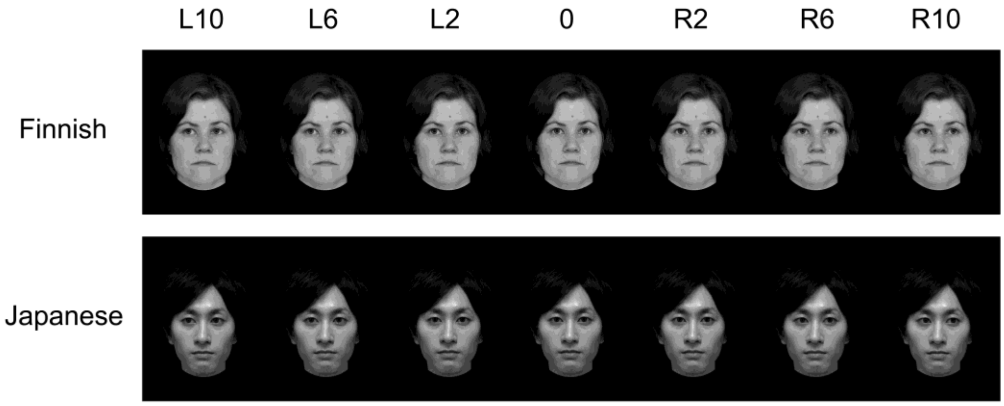

Figure 1. Examples of Finnish (outgroup) and Japanese (in-group) face stimuli with various gaze directions. The figure illustrates a straight gaze (0°) and gazes averted to the left and right by 2°, 6°, and 10°. Although not illustrated, the experiment also included gazes averted by 4° and 8°. Stimuli are reproduced under the terms of the CC-BY (Uono & Hietanen, 2015).

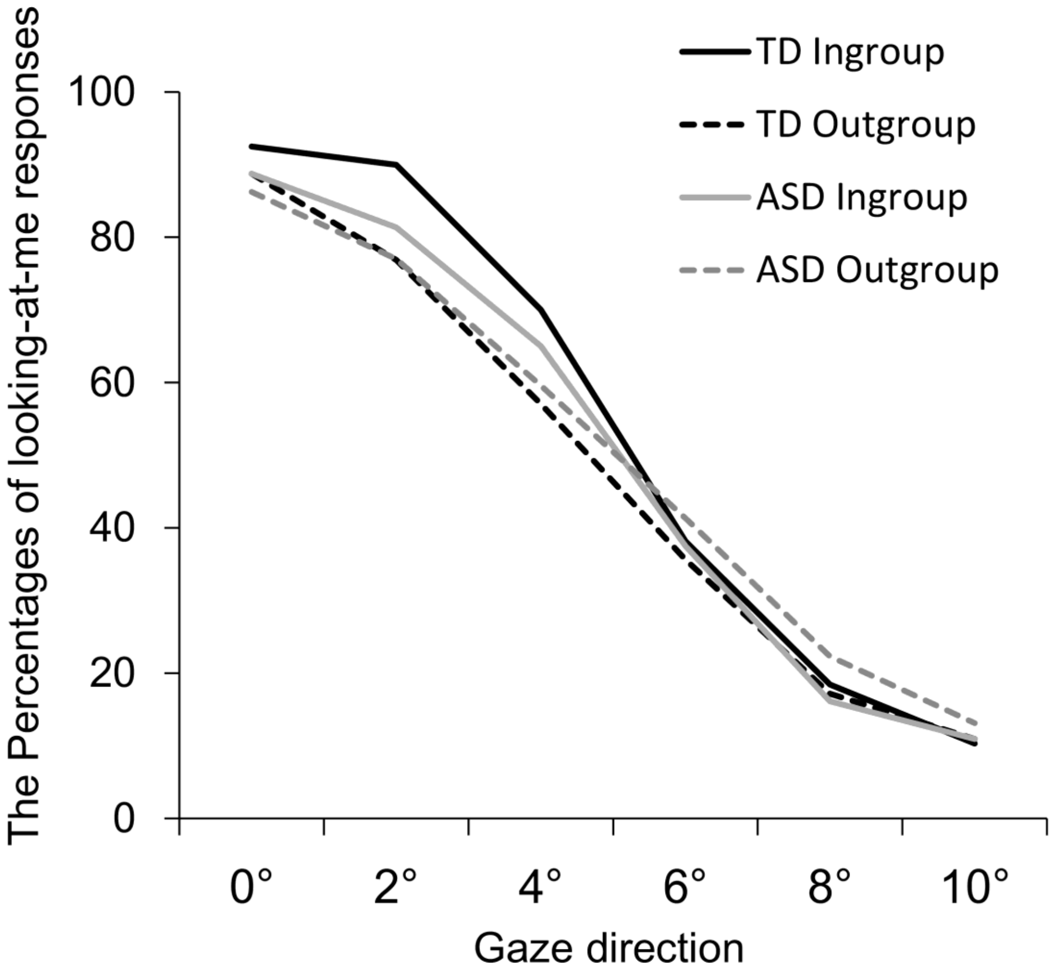

Figure 2. Percentages of looking-at-me responses to in-group and outgroup faces as a function of gaze angle in the TD and ASD groups.