

Mutual eye-gaze facilitates person categorization for typically developing children, but not for children with autism

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Abstract

Previous investigations of gaze processing in autism have demonstrated a pattern of intact and impaired performance. While individuals with autism are capable of discriminating another's gaze, they fail to interpret gaze direction especially within the context of socio-communicative (i.e., mentalistic) interactions. Extending this general line of inquiry, we explored whether typical children and children with autism spectrum disorder (ASD) were influenced by gaze direction in a task that demands a core person-related judgment, namely sex categorization. The results revealed that typically developing school-aged children were faster to classify faces by sex when targets displayed direct rather than averted gaze, or when the eyes were closed. This was not the case, however, for children with ASD whose responses were unaffected by gaze direction. These findings suggest that difficulties in gaze processing in autism extend beyond socio-communicative inferences to include basic person-perception judgments.

Detecting and interpreting another's direction of gaze is pivotal to interpersonal interactions. Mutual eye-gaze, in particular, serves to signal the likely flavor of a social interaction, be it 'nasty' or 'nice', to initiate and regulate social communication, and to provide important information about the mental states of others (Nummenmaa & Calder, 2009). It is perhaps of no surprise, then, that adults are exquisitely sensitive to gaze direction (von Grönau & Anston, 1995), that such sensitivity emerges early in ontogenesis (Farroni, Mansfield, Lai, & Johnson, 2003) and that atypicalities in gaze processing are a defining feature of autism (American Psychiatric Association [APA], 2000), a developmental condition characterized by profound difficulties in social reciprocity and communication.

In typical development, infants appear to be born with a preparedness to respond to gaze cues. Newborns prefer to look at faces with direct than averted gaze (Farroni, Csibra, Simion, & Johnson, 2002) or eyes closed (Bakti, Baron-Cohen, Wheelwright, Connellan, & Ahluwalia, 2000). Three-month-old infants smile less when an adult looks away and resume smiling when the adult re-initiates eye contact (Hains & Muir, 1996), and 4-month-olds rapidly shift their own gaze towards a target only when such shifts are preceded by a period of mutual eye-gaze (Farroni et al., 2003). Recent work has revealed that this early sensitivity to eye-gaze direction, particularly mutual gaze, holds special significance during infant-adult interactions. In one study, Senju and Csibra (2008) examined 6-month-old infants' gaze-following as they observed a person looking toward a toy located on either the left or the right. Infants followed the adult's eye movement only when it was preceded by direct eye-contact, suggesting an early awareness of the ostensive nature of gaze cues. In another study, 9-month-olds observed a face either always looking towards an object or always looking away from it. Infants preferred to look at an adult making object-directed shifts in eye-gaze but, again, only when such shifts were preceded by direct gaze (Senju, Csibra, & Johnson, 2008). Both findings demonstrate an apparent 'eye-contact effect' in which perceived eye-contact influences subsequent processing of another's socio-communicative intentions.

Direct eye-gaze clearly affords advantages for children's developing mentalizing skills (e.g., Baron-Cohen, 1995). Yet research with adults and children suggests that mutual gaze also affords additional benefits. Notably, it shapes more basic aspects of the *person-perception* process. Macrae, Hood,

Milne, Rowe, and Mason (2002) demonstrated that gaze direction moderates the efficiency of person construal. Specifically, adults are faster to judge the sex of a face when the target's eyes are directed straight-ahead than when they are averted or closed. Also, they are more accurate in recognizing faces seen previously if they display direct gaze (Mason, Hood, & Macrae, 2004), a memorial effect that has also been reported in 4-month-old infants (Farroni, Massaccesi, Menon, & Johnson, 2007) and children (Hood, Macrae, Coles-Davies, & Dias, 2003). Mutual gaze therefore not only conveys important mentalistic information about others, but also poses an additional advantage: it facilitates the extraction of core person-relevant knowledge (e.g., sex, identity) from faces.

In autism, deviant patterns of reciprocal eye-gaze are a striking feature (APA, 2000; see Nation & Penny, 2008) and may be one of its earliest (detectable) manifestations (e.g., Baron-Cohen et al., 1996). Children with autism engage less in direct eye-to-eye contact (Sigman, Mundy, Sherman, & Ungerer, 1986), and fixate less on the eyes during spontaneous viewing of faces than typical individuals (e.g., Pelphrey et al., 2002; but see Fletcher-Watson, Leekam, Benson, Frank, & Findlay, 2009). Furthermore, they fail to monitor the target of another person's gaze during joint visual attention (e.g., Leekam, Hunnisett, & Moore, 1998). In gaze-reading tasks, children with autism do not interpret gaze direction as a cue to another's mental state (Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, 1995) and autistic adults show difficulties inferring another's mental state from viewing expressions in the eyes (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997). This failure to understand the 'mentalistic significance of the eyes' is thought to be instrumental in causing autistic children's theory-of-mind difficulties (Baron-Cohen, 1995).

Research has shown, however, that individuals with autism are not completely insensitive to gaze cues. Older and more able children with autism do demonstrate basic knowledge about eyes and seeing (Tan & Harris, 1991). They are also able to accurately discriminate where another person is looking (Leekam, Baron-Cohen, Perrett, Milders, & Brown, 1997; Wallace, Coleman, Pascalis, & Bailey, 2006), and can automatically shift their visual attention in response to gaze cues in a manner similar to typical individuals (see Nation & Penny, 2008, for review).

Overall, these findings suggest that individuals with autism show no specific impairment in the ability to detect and orient automatically to another's gaze direction. Rather, the primary difficulty appears to lie in the ability to extract information from the eyes for specific socio-communicative purposes (Baron-Cohen, 1995; Nation & Penny, 2008). This might suggest that the difficulty with eye-gaze in autism derives from the socio-communicative functions to which eye-gaze relates, functions thought by some to be the core impairment in autism. No study, however, has yet considered whether gaze-processing atypicalities in autism also extend to other potential eye-gaze advantages among the typical population, such as those seen in the more basic features of the person-perception process (Macrae & Bodenhausen, 2000).

In this inquiry we investigated therefore the impact that gaze cues exert on the efficiency of person categorization in both typical development and autism. We anticipated that typical school-age children would display a response-time advantage when faces display direct gaze during a sex categorization task, as is the case for adults (Macrae et al., 2002). We also hypothesized that if one considers gaze atypicalities in autism to be attributable to specific socio-communicative difficulties (e.g., Baron-Cohen, 1995), then such atypicalities should be restricted to mentalistic contexts, and basic person-perception processes should remain unaffected. Accordingly, like their typical counterparts, children with autism should demonstrate facilitated categorical performance when targets displayed direct gaze. If, however, children with autism have more basic difficulties processing gaze cues, such an effect should fail to emerge.

Method

Participants and Design

Descriptive information is provided in Table 1. Twenty-four children with an autism spectrum disorder (ASD) (23 boys; M age = 10 years; 2 months, SD = 1; 9) were recruited in Perth, Western Australia. All children had been diagnosed independently by an experienced clinician using DSM-IV criteria (APA, 2000) and also met either full algorithm criteria on the Autism Diagnostic Interview –

Revised (Lord, Rutter, & Le Couteur, 1994) ($n = 19$) or scored one point below the threshold for autism ($n = 5$) (see Table 1 for scores). Three additional boys with ASD were tested (M age = 8; 2), but were excluded from further analysis due to poor overall task performance ($< 75\%$ correct).

Twenty-four typical children (20 boys; M age = 10; 0, $SD=1$; 8) were recruited from local mainstream schools. No typical child had a history of psychiatric/neurological disorder, or displayed clinically-significant levels of autistic symptomatology, as indexed by the Social Communication Questionnaire (Rutter, Bailey, & Lord, 2003), a screening tool for autism (see Table 1). There were no significant differences between the ASD and typical groups in chronological age, $F(1, 47) = .11, p = .74$, nonverbal reasoning ability, $F(1, 47) = .51, p = .48$, as assessed by Raven's Standard Progressive Matrices (Raven, Court, & Raven, 1992) or receptive-vocabulary ability, $F(1, 47) = 2.63, p = .11$, as measured by the Peabody Picture Vocabulary Test – Third Edition (PPVT-III; Dunn & Dunn, 1997) (see Table 1). All 48 children obtained verbal and nonverbal IQ scores of at least 70, reported normal or corrected vision, and were free of medication.

The experiment had a 2 (group: ASD vs. typical) X 4 (eye-gaze: direct eye-gaze, frontal view vs. direct eye-gaze, 3/4 view vs. averted eye-gaze, frontal view vs. eyes closed, frontal view) mixed design with repeated measures on the second factor.

 Insert Table 1 about here

Materials and Procedure

Stimuli and procedure were similar to Macrae et al. (2002). Stimuli consisted of 48 black-and-white photographs (24 female, 24 male) of faces displaying neutral expressions. Of the 48 targets, 12 displayed direct gaze in frontal view, 12 displayed direct gaze in 3/4 view, 12 displayed averted gaze (6 left, 6 right) in frontal view, and 12 targets had their eyes closed (see Figure 1). Equal numbers of male and female targets were present in each condition.

Insert Figure 1 about here

Children were told that they would see a number of photographs of faces and were asked to identify, as quickly and accurately as possible, the sex of the face ('boy' or 'girl') by making an appropriate key press. Trials consisted of a central fixation cross (2400 ms), a blank screen (30 ms), followed by the target face, which remained onscreen until children made a response, or until 1200 ms had elapsed. Note that the eye-region of each target face fell slightly above the central fixation cross, which did not therefore cue children's attention towards the eyes specifically. This procedural detail allowed us to examine the *spontaneous* effects of eye-gaze direction during children's gender judgments. All 48 trials were presented randomly in center-screen on an Apple Macintosh G3 laptop computer. Accuracy and response times (RTs) were recorded.

Children were tested individually in a quiet room in their school, and were seated approximately 50cm from the computer screen. Their attention towards target stimuli was monitored carefully by the experimenter. Importantly, children were not informed in what way the faces differed (i.e., eye-gaze or head direction) and were never instructed explicitly to attend to the target's eye-gaze. No feedback was given regarding performance. The session lasted approximately 40 minutes, with the PPVT-III administered first, followed by the Raven's Matrices and the sex categorization task.

Results

Accuracy. All children classified faces by sex with at least 75% accuracy. Accuracy data were submitted to a 2 (group) X 4 (eye-gaze) mixed-model analysis of variance (ANOVA). No significant effects emerged. Thus, gaze direction did not modulate the accuracy of person categorization and children with ASD were just as accurate at categorizing faces by sex ($M = 87.8\%$; $SE = .01$) as their typical counterparts ($M = 89.3\%$; $SE = .01$).¹

Response Latencies. Mean categorization latencies on correct trials served as the dependent measure.² Given the presence of outlying responses in the data set, RTs that were slower than 3 *SDs* from the mean were excluded from the analysis (4.5% of data). The data were submitted to a 2 (group) X 4 (eye-gaze) mixed model ANOVA. Although there was no main effect of group, $F < 1$, there was a significant effect of eye-gaze, $F(3, 138) = 3.96, p < .01, \eta_p^2 = .08$, which was qualified by a significant group x eye-gaze interaction, $F(3, 138) = 4.13, p < .01, \eta_p^2 = .08$ (see Figure 2). Subsequent within-group analyses revealed that sex categorization performance in typical children was moderated by gaze direction, $F(3, 69) = 11.08, p < .001, \eta_p^2 = .32$, such that RTs were faster when targets displayed direct gaze compared to averted gaze and eyes closed (*t*-test, all *ps* < .004). In contrast, gaze direction had no effect on task performance in the ASD group, $F(3, 69) = .03, p = .99$. Children with ASD were as fast to categorize faces by sex when the eyes were directed straight-ahead, averted, or closed.

 Insert Figure 2 about here

There were no significant group differences in the speed with which children's judged gender for any eye-gaze condition (all *ps* > .15). Also, individual differences in the effect of eye-gaze direction (computed by subtracting the mean RT for averted/eyes-closed conditions from the mean RT for direct conditions) were unrelated to autistic children's symptom scores on the ADI-R or SCQ.

Discussion

This study sought to determine whether gaze direction modulates a basic person-perception process – sex categorization – for typical children and children with ASD, as it does for typical adults (Macrae et al., 2002). The results were revealing. While direct eye-gaze enhanced the speed of categorical judgments in typical school-age children, it did not facilitate the speed with which children with ASD classified faces by sex. In fact, the sex categorization times of children with ASD were similar across all conditions, indicating that children were unaffected by the gaze direction of the targets.

The lack of an advantage for direct gaze in the ASD group cannot be attributed to difficulties perceiving gender, since children with ASD were just as accurate at categorizing faces as age- and ability-matched comparison children. Nor can these findings be a result of overall slower RTs usually characteristic of this population (e.g., Behrmann et al., 2006), as the RTs across all four eye-gaze conditions for the ASD group were well within the range of RTs of typical children. Moreover, both aspects of the results attest to children's attention and motivation to the task. Also, it is unlikely that results are due to fundamental difficulties discriminating eye-gaze direction since it is well-established that children with autism can accurately make such judgments when deviations in gaze are of the size used in the current study (e.g., Baron-Cohen et al., 1995; Wallace et al., 2006).

Here, children were asked to judge as quickly as possible the gender of faces – a key component of the person-perception process. Since eye-gaze impairments have been argued previously to be rooted in the inability to understand fully the intentional nature of gaze cues, and thus related to their socio-communicative functions (e.g., Baron-Cohen, 1995), we anticipated that gaze direction might affect the efficiency with which children with ASD extract basic person-relevant information from faces. The fact that it did not suggests that gaze processing impairments in autism may extend beyond a primary problem in interpreting eye-gaze in socio-communicative (i.e., mentalistic) contexts. The current findings suggest that children with autism miss out both on crucial aspects of social communication (e.g., joint shared attention) and on the other important advantages mutual gaze affords.

What might be driving children's failure to benefit from direct eye-gaze during the person-construal process? One possibility is that they were not fixating the eye-region of the face. Several reports have demonstrated that individuals with ASD fixate the eyes less than typical individuals during viewing of facial images (e.g., Pelphrey et al., 2002), but this finding is not uncontroversial. Other studies report typical spontaneous attention towards the eyes in autism (e.g., Fletcher-Watson et al., 2009; see Senju & Johnson, *in press*, for discussion), and one study has shown that children with autism made as many fixations to eyes as typical children during a gender identification task (Best, Dundas, & Strauss, 2009).

Although our observation of autistic children's gaze during testing confirmed good inspection, future studies might monitor children's eye movements during task performance to rule out this possibility.

A second possibility is that children with ASD attended less to faces showing direct eye-gaze specifically. Some researchers (e.g., Dalton et al., 2005) propose that individuals with autism actively avoid faces 'looking at me' because direct eye-gaze elicits negative arousal. Reduced attention towards mutual gaze in particular should, in turn, have deleterious effects for subsequent information processing. On this view, then, one should expect that autistic children's gender judgments might be slower for faces showing direct compared to averted gaze or eyes closed. Yet our sample of children with ASD showed *comparable* response times for gender judgments in direct and averted gaze conditions. Our findings parallel those showing similar processing of direct and averted eye-gaze in behavioural (Wallace et al., 2006), eye-tracking (Hernandez et al., 2009) and ERP (Senju et al., 2005) studies, which together speak against the possibility that the current findings are due to hyperarousal to direct eye-gaze in autism.

We suggest instead that eye-gaze does not modulate subsequent person-construal processes for children with ASD. Clearly, someone looking at you can be critically different from someone looking away in many different ways (Mason, Tatkov, & Macrae, 2005). Establishing the meaning conveyed by direct eye-gaze (e.g., attraction, aggression, friendliness) leads to more elaborate encoding of a person's face (identity, expression, sex). Functional imaging studies provide converging evidence that faces with direct eye-gaze warrant deeper encoding: faces displaying direct eye-gaze elicit greater neural activity in 'social brain' areas than averted eye-gaze for numerous different person-perception judgments (see Nummenmaa & Calder, 2009, for review). Indeed, George, Driver, and Dolan (2001) reported that, during performance of a gender discrimination task, eye-gaze direction (regardless of head orientation) modulated the connectivity or temporal 'coupling' between the amygdala and fusiform cortex. Their findings fit with a new proposal suggesting that subcortical structures (including amygdala), together with contextual information modulated by prefrontal cortical regions, modulate activity in key cortical structures of the social-brain network (Senju & Johnson, in press). It is possible therefore that the failure to find evidence of an eye-contact effect in our sample of children with ASD might be attributable to

reduced connectivity between ‘fast-track’ subcortical structures and social brain regions in response to perceived eye contact.

Findings from recent reflexive orienting studies further support the notion that the difficulties in autism might reflect a failure to understand the ‘significance of the eyes’ in this broader sense. Unlike typical individuals whose attentional orienting is more strongly reflexive in response to gaze than non-gaze cues (Friesen, Ristic, & Kingstone, 2004), individuals with autism do not show this preferential sensitivity to gaze (e.g., Senju, Tojo, Dairoku, & Hasegawa, 2004). Ristic et al. (2005) argued that individuals with autism may rely on physical stimulus characteristics (e.g., apparent motion and/or low-level visual analysis) when learning cue-target contingencies, rather than direction of eye-gaze per se, reflecting a lack of appreciation of eye-gaze direction as an inherently social cue. The current findings provide corroborating evidence for this view: while typical children’s gender judgments were affected by irrelevant gaze direction, the responses of autistic children were not, suggesting that mutual eye-gaze does not hold special significance for those with autism.

What is clear from our study is that autistic individuals’ difficulties with eye-gaze go beyond the disadvantages described in previous studies, to encompass more basic features as person perception. Further research should aim to elucidate the precise neurological mechanisms that underlie these broader social disadvantages.

Author Note

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Footnotes

¹This analysis was re-run to include the three children with ASD who obtained very poor sex classification scores: no significant group differences in accuracy emerged, $F(1, 49)=1.42, p=.24$.

²Analyses using median RT as the dependent measure revealed comparable results.

Table 1. *Descriptive statistics for chronological age, nonverbal IQ, verbal IQ, Social Communication Questionnaire (SCQ) scores (Rutter et al., 2003) and subdomain scores on the Autism Diagnostic Interview – Revised (ADI-R; Lord, Rutter, & Le Couteur, 1994).*

Measure	Group					
	ASD (n=24)			Typical (n=24)		
	M	SD	range	M	SD	range
Chronological age (months)	122.29	21.79	96 – 163	120.25	20.58	96 – 168
Nonverbal IQ ^a	100.00	14.29	74 – 131	97.29	11.28	78 – 131
Verbal IQ ^b	96.12	18.03	70 – 129	103.00	10.33	78 – 119
SCQ (out of 39) ^c	24.62	5.87	14 – 36	3.12	2.72	1 – 10
ADI-R scores ^c						
abnormal development (cut-off = 1)	4.00	0.88	3 – 5			
social interaction (cut-off = 10)	17.04	6.29	9 – 28			
communication (cut-off = 8)	13.83	4.34	8 – 22			
repetitive behaviors (cut-off = 3)	6.00	2.57	3 – 12			

Notes: ^a Raven's (Raven's Standard Progressive Matrices (Raven, Court, & Raven, 1992); ^b Peabody Picture Vocabulary Test – Third Edition (PPVT-III; Dunn & Dunn, 1997); ^c Elevated scores reflect increased symptomatology.

Figure Captions

Figure 1. Example of stimuli presented in (a) the direct gaze, frontal view condition, (b) the direct gaze, 3/4 view condition, (c) the averted gaze, frontal view condition, and (d) the eyes closed condition.

Figure 2. Mean reaction times (ms) to categorize faces by sex as a function of group and gaze direction.

Error bars represent ± 1 standard error of the mean.

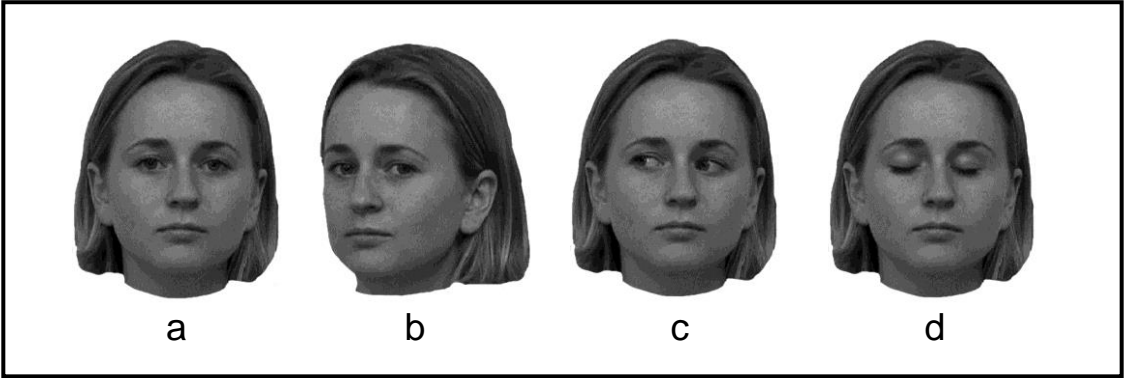


Figure 1.

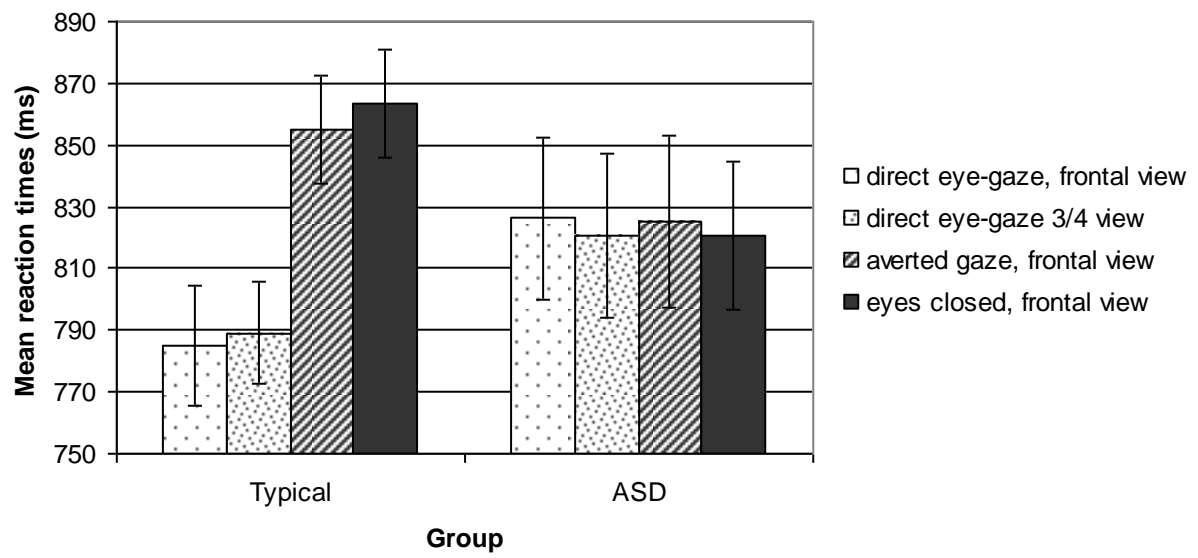


Figure 2.