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Attention to Eyes and Mouth in High-Functioning Children with Autism

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In the present study, we used a probe-detection task to compare attentional allocation to the eyes versus mouth regions of the face in high-functioning boys with autism relative to normal control boys matched for chronological age and IQs. We found that with upright faces, children from both groups attended more to the eyes region than to the mouth region, and to the same extent. This pattern of behavior was observed for not only initial orientation of attention, but also when enough time was provided for attention to be disengaged from its initial locus. The present findings suggest that atypical face processing in autism does not result from abnormal attentional allocation to the different face parts.

KEY WORDS: Autism; attention; face processing; probe detection; eyes; dot probe.

Autism is characterized, among other things, by impairments in reciprocal social interaction and communication. A key element in this deficit is marked impairment in the use of eye-to-eye gaze and facial expressions to regulate social interaction (APA, 2000). Furthermore, a significant portion of the difficulties in interpersonal communication of individuals with autism may be attributed to atypical face processing, as the ability to extract meaningful information from the cues provided by other people's faces is crucial to normative social functioning and development (Baron-Cohen, 1995; Joseph & Tanaka, 2003).

The ability of people to recognize faces and to quickly and accurately infer emotional states from facial expressions led many researchers to argue that virtually all adults are experts in face processing (Diamond & Carey, 1986; Tanaka & Gauthier, 1997). This expertise in face processing relies on the tendency of infants and young children to preferentially attend to faces (Goren, Sarty, & Wu, 1975; Johnson & Morton, 1991) and is thought to develop through repeated experience with faces in the environment (Gauthier & Nelson, 2001; Nelson, 2001).

Abnormalities in both face recognition and identification of facial expressions in individuals with autism are widely documented (see, for a review, Schultz, 2005). One interpretation of these findings is that persons with autism fail to develop expertise for faces because of inadequate attention to faces across development. A more refined suggestion is that individuals with autism might atypically attend to elements in faces that fail to provide the most salient social cues. For example, Baron-Cohen and colleagues (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997; Baron-Cohen, Wheelwright, & Jolliffe, 1997) showed that typically developing persons orient to the eyes for information regarding the mental states of others, whereas people with autism have significant difficulty extracting complex emotional states from the eyes. In the same vein, Ristic

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et al. (2005) showed that while both typically developing individuals and individuals with autism used eye gaze as a cue when it was spatially predictive of subsequent targets, typically developing individuals do so even when eye gaze had no predictive value, whereas individuals with autism did not. These findings demonstrate that eyes appear to be special for typically developing individuals because of their social significance, whereas for persons with autism eye gaze is attended only when it is explicitly task relevant.

The special significance of eyes processing deficits in individuals with autism has been debated recently due to inconsistent findings emanating from eye-tracking studies of the actual patterns of looking at faces in individuals with autism. Klin, Jones, Schultz, Volkmar, and Cohen (2002) assessed the visual scan pattern of high-functioning adolescents and adults with autism and of typically developing controls matched for age and verbal IQ while watching films of naturalistic social situations. They found that typically developing participants visually fixated on the actors' eyes approximately twice as much time as did participants with autism, whereas individuals with autism looked significantly longer at the mouth region. Similar finding were reported in studies using still photographs of faces. Dalton *et al*. (2005) found that high-functioning adolescent males with autism spent significantly less time per trial fixating on the eyes than did typically developing adolescents, and that the groups did not differ in amount of time spent fixating on the mouth region or the face in general. Pelphrey *et al*. (2002) reported that high-functioning adults with autism viewed non-feature areas of faces significantly more often and core feature areas of the faces (i.e., eyes, nose, and mouth) significantly less often than did typically developing adults. The difference between the two groups was particularly salient for the eyes region. In contrast to the above findings, van der Geest, Kemner, Verbaten, and van Engeland (2002) found no differences in gaze behavior between high-functioning children with autism and typically developing children viewing upright faces with or without an emotional expression. In addition, children from both groups made most of their first fixations on the eyes region, and made significantly fewer fixations on the mouth region.

One explanation for the discrepancy in findings mentioned above was offered by Volkmar, Lord, Bailey, Schultz, and Klin (2004) who suggested that individuals with autism may display the same behavior as typical participants when engaged in experimental tasks that are not embedded within a natural social context. They further speculated that judging static faces might not require the proficiency and automaticity required for fast processing of dynamic faces in natural environments. While this idea may be consistent with the findings of van der Geest *et al*. (2002) of more normative face-scanning patterns of static face stimuli in individuals with autism, it is clearly inconsistent with the findings of differences between individuals with autism and typical controls in visual scan-paths of photographs of faces (Dalton *et al*., 2005; Pelphrey *et al*., 2002).

In addition, while free viewing of a naturalistic movie may provide a powerful tool for the study of behavior under ecological conditions, it also involves a myriad of cognitive processes (e.g., allocation of attention, feature processing, integration of perceptual information with contextual cues) that may affect the viewing patterns at different stages of the experimental procedure. Consequently, similarities and differences between autistic and typical participants at specific stages of processing may be obscured. Thus, although the combination of eye-tracking methodology and naturalistic stimuli may possess the ability to surface general differences in visual-scan patterns between participants with and without autism, the use of more controlled face stimuli presented in the context of well-studied cognitive-behavioral tasks may assist in the study of similarities and differences between the groups in specific face processing stages.

In the present study, we focus on potential differences between children with and without autism in initial attentional allocation upon presentation of facial stimuli. We used a probe-detection task to compare attentional allocation to the eyes versus mouth regions of the face in high-functioning boys with autism relative to typical control boys matched for chronological age and full scale IQs. On half of the experimental trials, a small dot probe was briefly superimposed near the eyes or near the mouth of a face photograph. On the remaining half, there was no probe. Participants were required to respond as fast as possible when detecting a probe. Based on the attention literature (Navon & Margalit, 1983; Posner, Snyder, & Davidson, 1980), response latencies on dot-probe tasks are held to provide a ''snapshot'' of the distribution of participants' attention, with faster responses to probes presented in attended relative to unattended locations.

Among typically developing children, we expected faster reaction times for probes appearing in the eyes region relative to the mouth region. Finding a different pattern of attentional allocation in children with autism (i.e., faster reaction times to the mouth region or no difference between the two conditions) would suggest that autism is associated with abnormal orientation of attention in face processing. This type of deficit may translate into a tendency to spend less viewing time in the eyes region, and would be consistent with Klin *et al.*'s (2002) results. In contrast, finding that children with autism display the same pattern of attentional allocation as typically developing children would indicate that atypical face processing in autism does not result from abnormal attentional allocation to the different face parts. Such finding would be in line with van der Geest *et al.*'s (2002) results that both children with and without autism make their first fixations to the eyes region, and would suggest that the abnormal face-viewing pattern observed in autism may reflect avoidance of the eyes region at later, perhaps more controlled, stages of processing.

METHOD

Participants

The participants were 12 boys with autism (mean age = 10.17 years, SD = 1.67) and 12 normally developing boys matched for age (mean age = 10.19 years, SD = 1.74) and full-scale IQ scores as measured by the WISC-III (M = 96.17, SD = 11.35 for the children with autism and M = 102.50, SD = 10.27 for the typically developing children). All participants with autism met diagnostic criteria of the *Autism Diagnostic Interview – Revised* (ADI-R, Lord, Rutter, & Le Couteur, 1994) and the *Autism Diagnostic Observation Schedule* (ADOS, Lord *et al.*, 2000), as well as DSM-IV diagnosis of autism. Control participants were screened for behavior problems based on maternal reports on the *Child Behavior Checklist* (Achenbach, 1991). All children had normal or corrected to normal eyesight.

Probe-Detection Task

Apparatus

The stimuli displays were generated by an Intel Pentium 4 computer attached to a 15″ TFT monitor, using 1024×768 resolution graphics mode. Responses were collected via the computer keyboard. Viewing distance was set at 50 cm using a chinrest.

Stimuli

The face stimuli used in the study were 16 chromatic pictures of faces (8 females, 8 males) displaying a neutral emotion expression, and taken from the JAC-Neuf set (Matsumoto & Ekman, 1988). Faces were presented either upright or inverted. The use of inverted faces was designed to control for possible effects of automatic allocation of attention to the top or bottom areas of the screen, regardless of the actual locations of the eyes or mouth of the presented face. The target probe, a black circle 2 mm in diameter, could appear either just below the mouth ("mouth" condition), or slightly above the eyes line of the face stimulus ("eyes" condition). Target probes appeared at an equal distance from the center of the face in the eyes and in the mouth conditions. The center of the face was measured as the mid point between the nasion and the center of the mouth of each face stimulus (see Figure 1 for an example of face and target probe locations).

Procedure

Each trial began with a white fixation cross presented at the center of the computer screen for 1000 ms, followed by a centrally presented face stimulus. On half of the trials, the target probe was superimposed on the face for 50 ms after a face-to-probe stimulus-onset asynchrony (SOA) of either 200 or 400 ms. The face-to-probe SOA was manipulated in order to examine the time course of attentional

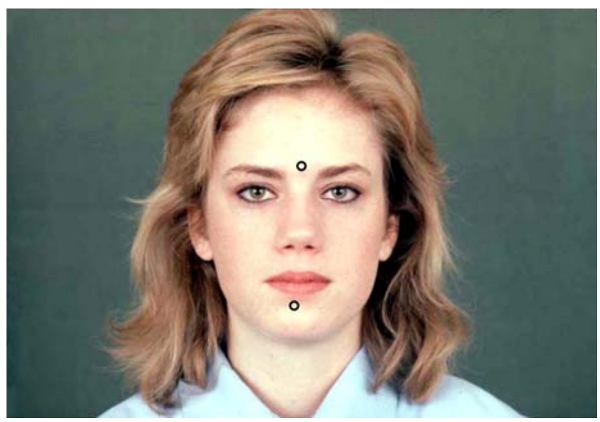

Fig. 1. An example of a face stimulus with superimposed target-probes. Note that in the actual experiment only one probe was presented in each trial. (From the the JAC-Neuf set; © Matsumoto & Ekman, 1988. Reprinted with permission.)

allocation and to test the possibility that initial attentional allocation to the eyes region might be followed by avoidance of the eyes region. After the probe offset, the face remained on the screen until response or after 1500 ms had elapsed. The probe-absent trials (50% of the trials) were identical to probe-present trials except that no probe appeared. Thus, on such trials, the face appeared for either 1750 or 1950 ms.

The experiment included 4 blocks of 40 trials each, two blocks of upright faces and two blocks of inverted faces. Each of the 16 possible faces was presented five times upright and five times inverted. The order of block presentations was counterbalanced across the two groups. The participants were allowed a break after each block. They were instructed to respond to the probe onset as fast as possible while avoiding making errors (i.e., responding in the no probe trials). The experiment began with the experimenter aligning the participant's eyes with the center of the screen. Then, participants were guided through a standard step-by-step practice protocol and proceeded to the experimental phase only after they had successfully completed a preset amount of practice trials. Four extra face stimuli, not used in the actual experiment, were used as practice items. To reduce the likelihood that participants would gradually focus their attention exclusively on the two possible regions of probe presentation, participants were told that they should also memorize the presented faces, because their memory of the faces would be tested at the end of the task. A short memory test, randomly presenting eight of the faces used in the experiment and eight new faces, was conducted at the end of the experiment.

RESULTS

Preliminary Analyses and Data Preparation

Analysis of response accuracy revealed that all children responded with acceptable accuracy levels of both detecting the probes and refraining from button pressing in no-probe trials. The typically developing children were more accurate in detecting the dot probes (90% accuracy) than children with autism (84% accuracy), $t(22) = 2.19$, $p < 0.05$. Analysis of the memory task data indicate that children from both groups were indeed attending to the faces and memorized them with equal levels of accuracy, 72% correct for the children with autism, and 75% correct for the typically developing children, $t(22) = 0.49$, $p = 0.63$.

In the RT analyses, error trials as well as probe-absent trials were removed. In addition, RTs for each subject were sorted into cells according to conditions of probe location, face orientation, and face-to-probe SOA, and RTs exceeding the mean of a specific cell by more than 2 standard deviations were trimmed. We also trimmed responses faster than 150 ms after probe onset. These procedures led to the removal of fewer than 1% of all observations.

Analysis of RT Data

Table I provides mean RTs and standard deviations to probe detection at the eyes or mouth regions of upright and inverted faces at face-to-probe SOAs of 200 and 400 ms by group. To assess the patterns of attention deployment of children with autism and typically developing children we computed a repeated measures multivariate analysis of variance (MANOVA) on reaction times with probe location (eyes vs. mouth), face orientation (upright vs. inverted), and face-to-probe SOA (200 vs. 400 ms) as within-subject variables, and group (autism vs. control) as a between subjects variable. None of the main effects nor the interactions involving the group variable were significant, indicating that the children with autism and the typically developing children did not differ in their patterns of attentional allocation to the eyes versus mouth regions within the face. A significant face orientation by face-to-probe SOA interaction was found, $F(1, 23) = 8.74$, $p < 0.01$. With upright

Table I. Mean RTs (in ms) and Standard Deviations (in Parentheses) to Probe Detection at the Eyes or Mouth Regions of Upright and Inverted Faces at Face-to-Probe SOAs of 200 and 400 ms by Group

	Autism ($n = 12$)				Control ($n = 12$)			
	Upright faces		Inverted faces		Upright faces		Inverted faces	
SOA	200 ms	400 ms	200 ms	400 ms	200 ms	400 ms	200 ms	400 ms
Eyes	369 (80)	357 (74)	432 (114)	421 (104)	422 (130)	452 (156)	465 (137)	537 (219)
Mouth	472 (124)	434 (118)	404 (83)	421 (78)	527 (159)	485 (130)	465 (117)	460 (122)

faces, RTs were slower when the probe appeared shortly after face onset (200-ms face-to-probe SOA trials), than when it appeared at a longer SOA (400-ms face-to-probe SOA trials), whereas the reverse pattern was observed for probe targets superimposed on inverted faces. More importantly, a significant face orientation by probe location interaction was found, $F(1, 23) = 28.86$, $p < 0.0001$ (see Figure 2). RTs were faster when target probes were presented near the eyes than near the mouth for upright faces, $t(23) = 3.13$, $p < 0.005$, indicating an attentional bias toward the eyes relative to the mouth with upright faces in both children with autism and in typically developing children. No such bias was found for inverted face presentations.

DISCUSSION

In the present study, we compared the pattern of attentional allocation to eyes and mouth in high-functioning boys with autism and typically developing children when viewing static faces. Our most significant finding is that in all conditions, the two groups displayed a similar pattern of attention allocation.

We found that with upright faces, the children from both groups attended more to the eyes region than to the mouth region, and to the same extent. Moreover, this pattern of behavior was observed both for initial orientation of attention (with face-to-probe SOA of 200 ms) and when enough time was provided for attention to be disengaged from its initial locus (with face-to-probe SOA of 400 ms). This pattern was not obtained with inverted faces, as probe detection was equally fast in both groups, regardless of whether the probe appeared near the eyes or near the mouth. This finding indicates that the pattern of results observed with upright faces cannot be attributed exclusively to a potential bias towards the top of the screen, because faster probe detection would have been expected for probes appearing near the mouth region in inverted faces. The null result in the inverted-face condition might reveal that the attentional bias towards the eyes was present in both conditions of face orientation but was masked by a bias for the top of the screen in the inverted-face condition. Alternatively, both groups might have processed the inverted-face stimuli as non-facial stimuli and thus showed no attentional preference for either the eyes or mouth regions. Differential processing of upright versus inverted faces is taken to reflect normal configural processing (e.g., Langdell, 1978; Yin, 1969). The present finding is consistent with Teunisse and de Gelder (2003) and Lahaie *et al.* (2005) who reported normal inversion effects among high-functioning adolescents and adults with autism.

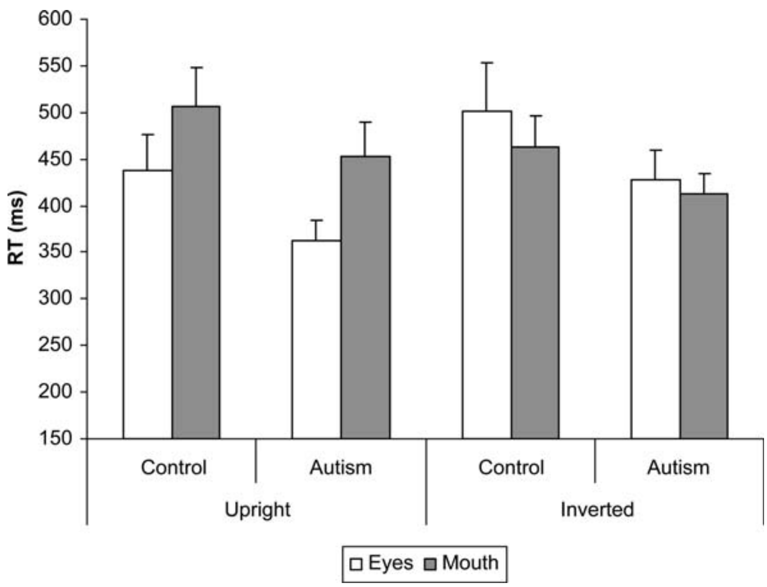

Fig. 2. Mean RTs (ms) and standard errors for target-probes presented near the eyes and mouth regions of upright and inverted faces by group.

The present findings suggest that atypical face processing in autism is not a result of abnormal attentional allocation to different parts of the face and are consistent with van der Geest *et al.*'s (2002) report that both children with and without autism make their first fixations to the eyes region when viewing static faces. Klin *et al.* (2002) suggested that abnormal viewing behavior in autism might become apparent only with the more complex, moving stimuli typically involved in naturalistic social situations. Accordingly, one might argue that the use of static faces in our study may have precluded the detection of abnormal attentional allocation in autism. Yet, the fact that other authors (Dalton *et al.*, 2005; Pelphrey *et al.*, 2002) replicated Klin *et al.*'s eye-tracking findings with static stimuli argues against this possibility.

The pattern of attentional allocation in the present study was not modulated by face-to-probe SOA. This finding indicates that individuals with autism, as well as typically developing persons, make an initial attentional shift to the eyes region, and do not show a tendency to disengage quickly from this region, at least not within 400 ms from stimulus presentation. Thus, the abnormal viewing behavior found by Klin *et al.* (2002) and others (Dalton *et al.*, 2005; Pelphrey *et al.*, 2002) might reflect avoidance of or lack of interest in the eyes region at later, perhaps more controlled, stages of processing. This possibility is also consistent with the findings by Ristic *et al.* (2005) showing that individuals with autism use gaze direction as a cue for shifting attention only when gaze direction has high predictive value, whereas typically developing persons do so irrespective of task demands (see also Vlamings, Stauder, van Son, & Mottron, 2005). Thus, individuals with autism initially orient to the eyes of others, but may quickly lose interest if these fail to provide salient and consistent predictions regarding the immediate environment.

One possible limitation of the present study is that we used only faces displaying neutral expressions. It has been suggested that abnormal face processing in autism is particularly related to social and emotional threat cues in faces, and may thus be especially salient when viewing faces with emotion expressions (e.g., Dalton *et al.*, 2005; Schultz, 2005). A probe detection study using stimuli including faces with emotion expressions could resolve this issue.

In conclusion, the findings from the present study suggest that the reduced looking times in the eyes region reported in individuals with autism (Dalton *et al.*, 2005; Klin *et al.*, 2002; Pelphrey *et al.*, 2002; but see van der Geest *et al.*, 2002) may not result from differences in the pattern of early attentional allocation to eyes, which we found to be normal in high-functioning children with autism. It will be important to replicate the present findings with larger samples, different ages of participants, and individuals with autism who are not high functioning, as well as seek converging evidence from different attentional tasks.

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