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Scan Path Differences and Similarities During Emotion Perception in those With and Without Autism Spectrum Disorders

M. D. Rutherford · Ashley M. Towns

Abstract Typical adults use predictable scan patterns while observing faces. Some research suggests that people with autism spectrum disorders (ASD) instead attend to eyes less, and perhaps to the mouth more. The current experiment was designed as a direct measure of scan paths that people with and without ASD use when identifying simple and complex emotions. Participants saw photos of emotions and chose emotion labels. Scan paths were measured via infrared corneal reflectance. Both groups looked significantly longer at eyes than mouth, and neither overall looking time at eyes nor first fixations distinguished the groups. These results are contrary to suggestions that those with ASD attend preferentially to the mouth and avoid the eyes. Furthermore, there was no interaction between group and area of the face: the ratio of attention between eyes and mouth did not differ between the ASD and control groups. However, those with ASD looked at the eyes less than the control group when viewing complex emotions.

Keywords Emotion perception · Face perception · Scan path · Eye tracking

M. D. Rutherford (✉) · A. M. Towns
Department of Psychology, Neuroscience and Behaviour, McMaster University, 1280 Main Street West, Hamilton, ON, Canada L8S 4K1
e-mail: rutherm@mcmaster.ca

Introduction

When looking at a face, typical adults attend to the features of the face (Caldara et al. 2005): the eyes primarily and the mouth secondarily (Davies et al. 1977; Fraser et al. 1990; Haig 1985, 1986; Sergent 1984; Tanaka and Farah 1993). Similarly, when asked to discriminate the identity of a face (Barton et al. 2001; Rutherford et al. 2007a) or the gender of a face (Schyns et al. 2002), people use primarily the information around the eyes although some studies find important configural processing that includes the eyes and mouth region during identity perception (Schyns et al. 2002).

Some classic research sought to locate where on the face one makes use of information when processing visual displays of emotional facial expressions. Dunlap proposed that the bottom half of the face, or the mouth region, was used primarily when observers were engaged in emotion perception (Dunlap 1927). By cutting photographs of emotional facial expressions through a horizontal midline, and re-pairing the face halves, Dunlap determined that when observers looked at various facial expressions and were asked to tell what emotion they saw, they relied most at the information in the bottom half of the face. The participants' task was to determine what the original emotions were from a list of proposed emotion terms and then to decide whether the composite is more like one original or the other. The lower halves of the composites were more likely to determine the judged expression than the upper half (Dunlap 1927). Hanawalt later suggested that different specific facial features were most important for identifying different specific emotions (Hanawalt 1944). According to him, the mouth is most informative for a happy emotional expression (perhaps explaining Dunlap's study, which involved many "pleased" expressions) and that for fear and surprise, the eyes were most informative.

More recent and precise work on this question has been done by Boucher and Ekman who divided the face into three primary components that were important for recognizing the emotion displayed by a certain facial expression. The upper component consisted of the eyebrows and forehead, the middle component consisted of the eyes and cheekbones and the lower component consisted of the nose, mouth and chin (Boucher and Ekman 1975). Like Hanawalt, they found that each emotion required a different configuration of the three key components in order to be identified (Boucher and Ekman 1975). Sullivan and Kirkpatrick later found that children looking at schematic faces portraying each of Ekman's six basic emotions (Ekman and Friesen 1971) were consistent, within emotion, in which area of the face they looked toward most. The primary focus was consistently on the mouth for happiness, sadness, surprise and disgust, and on the eyebrows for anger and fear (Sullivan and Kirkpatrick 1996). Even more recently, and more precisely, Schyns and colleagues introduced the "bubbles" technique to measure where on the image subjects were finding useful information. They reported that people use primarily the eyes for gender discrimination, the mouth for emotion discrimination, and configural information including the eyes and the mouth for identity determination (Schyns et al. 2002).

Face Processing in Autism Spectrum Disorders

Autism spectrum disorders are pervasive developmental disorders which are characterized by deficits in social interaction, delays and deviance in communication, and repetitive behaviors, rituals and interests (American Psychiatric Association 1994). Past research regarding face processing among those with autism spectrum disorders (ASD) has yielded strikingly varied results. Some studies report deficits in all types of face processing (Gepner et al. 1996), in face recognition (Boucher and Lewis 1992; Braverman et al. 1989; Klin et al. 1999; Tantam et al. 1989; de Gelder et al. 1991) and the identification of emotional facial expressions (Pelphrey et al. 2002; Celani et al. 1999; Hobson et al. 1988; Hobson 1986) while others have not found the expected differences in face discrimination (Nishimura et al. 2007; Rutherford et al. 2007) or emotion perception (Loveland et al. 1997; Ozonoff et al. 1990; Buitelaar et al. 1999). Other research has focused on processing strategies and has found evidence that those with autism use different strategies when identifying emotional facial expressions (Rutherford and McIntosh 2007; Teunisse and de Gelder 2001, 2003). Specifically, Rutherford and McIntosh found that people with ASD were more tolerant of exaggeration in facial expression, consistent with the idea that they might be using a rule-based

emotion perception strategy. In contrast, a control group was less likely to accept exaggerated facial expressions as good examples, preferring the average facial expressions. This pattern in the control group is consistent with a template matching strategy, according to these authors (Rutherford and McIntosh 2007). In addition, recent research suggests that sub-groups of individuals with autism can be defined based on performance on face-processing tasks (Rutherford et al. 2007).

Group Differences in the Use of the Eyes and Mouth for Face Processing

Although typical adults will attend primarily to the eyes, some studies have demonstrated that those with ASD do not attend primarily to the eyes (Klin et al. 2002; Pelphrey et al. 2002; Baron-Cohen et al. 1997) and some have suggested that those with ASD attend preferentially to the mouth (Klin et al. 2002; Langdell 1978; Joseph and Tanaka 2003). Indeed, some have proposed that those with ASD may be expert at processing information around the mouth (Joseph and Tanaka 2003; Langdell 1978). Langdell tested children in a face recognition task and found that children with ASD were better than controls at recognizing faces when only the mouth region was visible (Langdell 1978). Joseph and Tanaka (2003) found that children with ASD were better than typically developing children at recognizing a mouth alone when it was learned in the context of a whole face, suggesting that the children with autism placed unusual significance on the mouth region (Joseph and Tanaka 2003).

Recently, Spezio and colleagues have used the "bubbles" technique to find evidence that those with ASD fixate less on the eyes region and the mouth region, and are more likely to saccade away from the eyes when information is presented there, compared to matched controls (Spezio et al. 2007b). This group also used the "bubbles" technique to show that during emotion judgment, those with ASD rely more on the mouth region than matched controls do, and used eyetracking to show that those with ASD looked more at the mouth and looked less at the right eye compared to matched controls (Spezio et al. 2007a). In contrast, recent work by Rutherford and colleagues has found no evidence of preferential use of information around the mouth when those with ASD process faces (Nishimura et al. 2007; Rutherford et al. 2007). The current study is designed as a direct measure of where those with and without ASD look at a face when perceiving a simple or complex facial expression of emotion. Other researchers have previously used eye-tracking to approach the question of where on the face subjects with ASD look in emotion perception (Pelphrey et al. 2002), but the current study is

unique in including simple and complex emotions, and includes more than twice as many participants as previously reported.

The eyes may be particularly important for understanding complex mental states (Baron-Cohen et al. 1995; Baron-Cohen and Cross 1992). Baron-Cohen and colleagues (1997) tested which areas of the face are important for emotion perception as the complexity of the emotion varied. They presented images of just the eyes, just the mouth, or the whole face to participants who were asked to choose an emotion label to describe the face. A set of simple emotions and a set of complex emotions were presented to both an ASD group and a control group. They found that for complex emotions, seeing just the eyes is as informative as seeing the whole face for the typically developed population. In contrast, the ASD group was not as able to use information from the eyes region of the face to correctly identify complex emotions.

It is possible that individuals with ASD perceive complex emotions differently as a result of the fact that simple emotions are more likely to be explicitly discussed, for example in the social skills training that high functioning adults with autism are likely to be exposed to (Silver and Oakes 2001; Howlin et al. 1999; Hadwin et al. 1996). We are interested in expanding on Baron-Cohen et al.'s findings and testing how the use of eye and mouth information might change as complexity increases by using eye tracking technology to measure where on each face our participants look during emotion perception. For this reason we have designed an experiment using the same stimuli that Baron-Cohen and colleagues (1997) used.

Research Using Eye Tracker Technology to Compare Groups

With respect to the question of where on the face those with ASD look during emotion perception, there have been mixed reports. Pelphrey and colleagues compared five adults with autism to five adults without autism and found strikingly different scan paths between groups when participants looked at emotional facial expressions. Specifically, those with autism spent less time looking at features, and spent less time looking at the eyes. Their scan paths were described as "disorganized" and the control group's as "strategic." The group with autism was also less accurate in identifying emotions (Pelphrey et al. 2002). Similarly, Klin and colleagues found reduced fixation on the eyes region in a group of 15 adults with autism, compared to a matched control group, and found that within the autism group those with higher social functioning were more likely to fixate on the eyes (Klin et al. 2002).

In contrast to this evidence of disordered visual processing, when van der Geest and colleagues compared 17 ten-year-old children with autism to 17 typically developing ten-year-olds, they found no evidence of different fixation patterns between groups in processing upright faces. Both groups looked more at features than at non-features, and more at the eyes than the mouth. This was true across the emotions tested: happy, angry, surprised and neutral (van der Geest et al. 2002).

Current Study

The current study is designed to directly test the differences between scan paths of those with and without ASD when either a simple or a complex emotional facial expression is displayed, and participants are asked to identify the emotion presented. The current study is designed to test whether those with ASD look at the eyes less than control observers, whether they look at the mouth region of the face more than the eyes region, and whether there are different looking patterns given simple and complex emotions. The current study uses eye tracking technology which measures infrared corneal reflectance in order to directly measure the scan path of our observers, so that we can determine what features or areas of the face participants foveate in order to discriminate emotional facial expressions.

Methods

Participants

There were 22 volunteers. There were 11 participants with ASD (all male, average age of 25 years, 8 months, range 19–38 years) and 11 control participants matched for sex, age, IQ and education (all male, average age of 25 years, 7 months, range 19–50 years, see Table 1 for IQ and age information). The 11 ASD participants were high functioning adult males who had previously received clinical diagnoses of autism or Asperger Syndrome before entering the study. One of the authors (MDR) confirmed their diagnoses via the Autism Diagnostic Observation Schedule (ADOS-G) (Lord et al. 2000). They were free from other known medical conditions. Participants in the control group were recruited from the community (rather than on a university campus) through newspaper advertisements. All had IQ scores in the normal range in order to be sure that all participants in both groups would comprehend the instructions of the study. Participants were compensated for their time with 15 dollars.

Table 1 Chronological age and WAIS IQ scores for the ASD and control groups

	ASD ($n = 11$)	Control group ($n = 11$)	t
Age	25.8 (6.09)	25.7 (8.87)	$t(20) = 0.387$
	19–38	19–50	n.s.
Verbal IQ	97.1 (18.28)	101.1 (11.77)	$t(20) = 0.039$
	65–134	86–127	n.s.
Performance IQ	86.7 (12.12)	99.3 (15.03)	$t(20) = -1.522$
	67–109	68–117	n.s.
Full Scale IQ	91.8 (14.07)	101.1 (12.40)	$t(20) = -0.893$
	75–121	81–125	n.s.
Year of Education (post-kindergarten)	12.64 (1.12)	12.09 (1.58)	$t(20) = .92$
	12–15	9–16	n.s.

Apparatus

Stimuli were presented on an NEC monitor 46 cm with a resolution of 1024 by 768 and a refresh rate of 85 Hz. Responses were made using a keyboard. The experiment was created using E-Prime Version 1.1.

Eye movements were tracked using the Eye-Trac 6000 ASL, which was controlled by an HP Intel Pentium M laptop and connected to a Sanyo auxiliary video display where the eye could be viewed by the experimenter while data was recorded. The eye-tracking camera was placed 76 cm from the participant and directly in front of the monitor. This camera focused on one eye (the right eye was used for each participant) and used light from the pupil and a corneal reflection, obtained using infrared light, to follow the participants' gaze. A chin rest was used to stabilize the participant's head in order for the eye tracker to maintain its image of the eye and properly record the participants' scan path. The use of a chin rest also maintained the standard distance (96.5 cm) from each participant to the monitor where stimuli were displayed.

Stimuli

The stimuli used for the experiment included photographs adapted from Baron-Cohen et al. (1997). The images were cut and pasted from Adobe Acrobat 7.0 into Microsoft Paint where they were sized and prepared for use in the E-Prime Version 1.1 software. There were 20 images of a female face portraying different emotions. There were ten images in total of seven different simple emotions (happy (2), surprise (2), angry (2), and one each of afraid, disgust, sadness and distress) and ten images in total of nine different complex emotions (scheming, thoughtful, flirting, admiring, quizzical, bored, interesting (2), guilty and arrogant). The images were 20 cm in width by 27 cm in height. An example of a simple emotion and a complex emotion are shown in Fig. 1.

Fig. 1 (a) An example of a simple emotion, afraid and (b) an example of a complex emotion, arrogant. Face photos from Baron-Cohen et al. (1997)

During the experiment each image was presented twice, for a total of 40 trials. The images were preceded and followed by a pair of emotion words, one of which correctly described the face. The words appeared centered on the screen, were 1.5 cm high and written in black courier font. Word pairs were fixed, with the words presented in a different left-right order each time the image appeared. Within each group of words and images all were either simple emotions or complex emotions.

Procedure

Participants were seated in a room in front of a computer screen and the eye-tracking camera. Participants were asked to adjust the chin rest to the most comfortable height. The lights were turned off so the room was dark with the exception to the light from the computer monitor. Next the experimenter located the participant's right eye on the Sanyo auxiliary eye-tracking monitors. The eye-tracker was then calibrated in order to follow the participant's eye

movements. The accuracy of the eye tracking calibration was similar in the two groups.

Participants were given verbal instructions by the experimenter while being presented with the same instructions visually on the monitor. Participants were told that they would see a word pair, an emotional facial expression, and the same word pair again. The participants were asked to choose one of the two emotion words, and indicate which side of the screen the word appeared on using the keyboard.

Participants began the experiment by pressing the spacebar on the keyboard. The pair of emotion words was presented initially for 1500 milliseconds, then the target image (the face expressing the emotion) was presented for 2500 milliseconds and then the emotion words were displayed again until a response was made (see Fig. 2). There was no feedback, but an asterisk appeared in the center of the screen to indicate that a response had been recorded.

Results

This experiment was designed to test whether those with ASD, relative to a control group, fixate the eyes region or mouth region of an emotional facial expression preferentially, when shown a facial expression and explicitly instructed to identify an emotion. We were also interested in the effect of the complexity of the emotion on these comparisons. Figures 3 and 4 show some representative scan paths for the group with and without ASD, respectively.
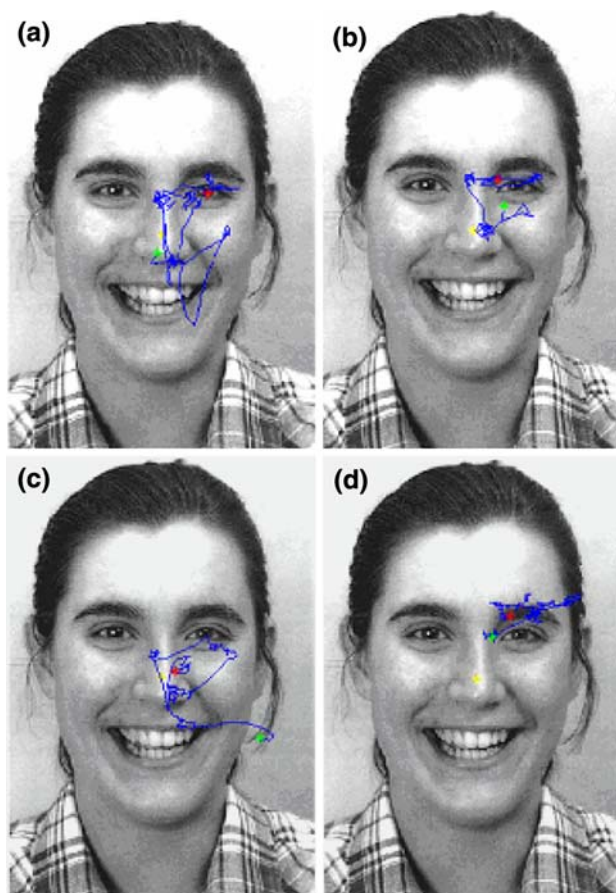

Fig. 3 Scan paths for a happy facial expression for four different control subjects. Face photos from Baron-Cohen et al. (1997)

Fig. 2 Progression of images presented to participants during each of the 40 trials during the experiment. The word choices were presented for 1500 ms, the emotional facial expression was displayed for 2500 ms, and the word pair was presented again until the participant responded. The emotion displayed here is disgust. Face photo from Baron-Cohen et al. (1997)
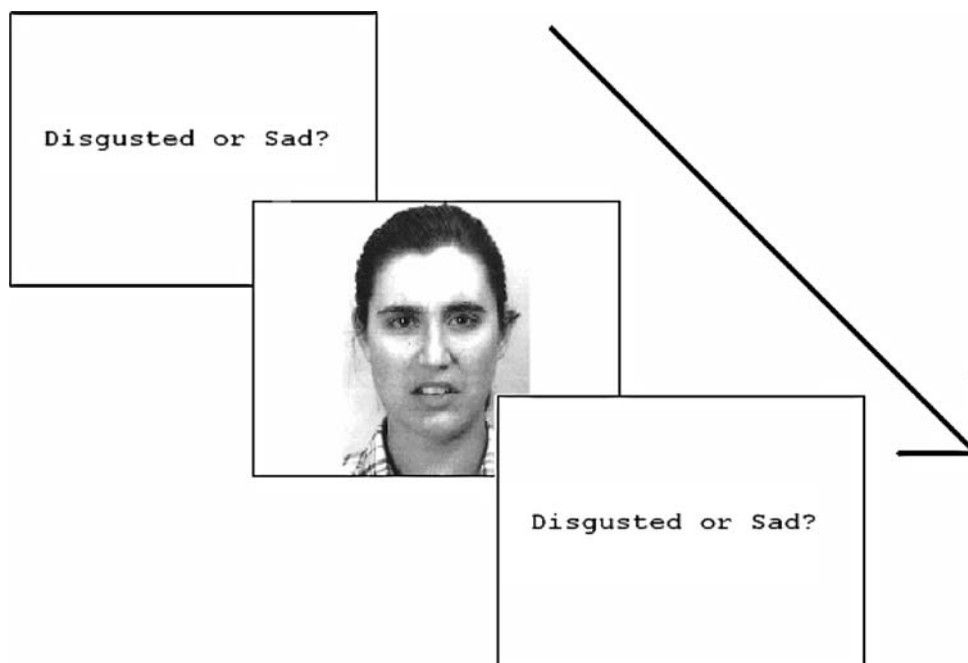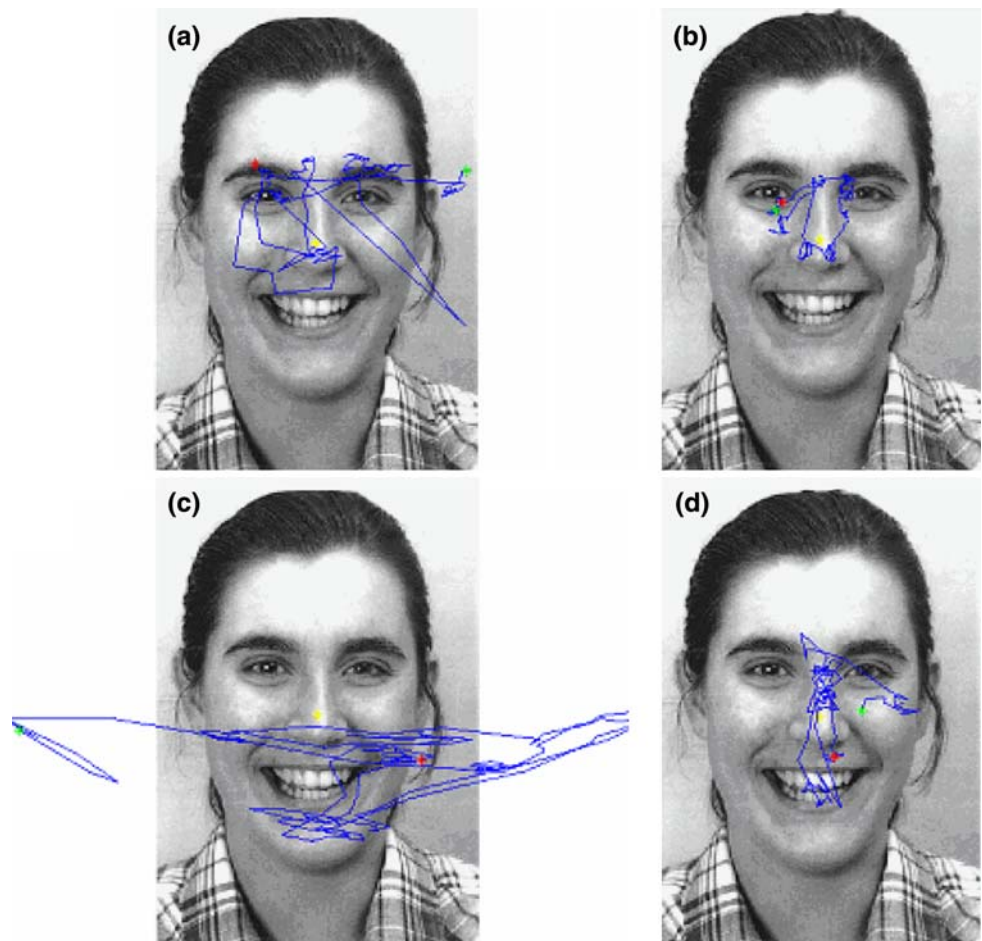
Fig. 4 Scan paths for a happy facial expression from four subjects with ASD. Face photos from Baron-Cohen et al. (1997)

First we analyzed whether off-screen looking time was comparable between groups. For each subject, we totaled the amount of time, across trials, for which the subjects eye direction was not being recorded by the eyetracker. This time included the time the subject was looking away from the computer as well as any time the subject had his eyes closed. Off-screen looking time was quite low and essentially the same between the two groups (ASD ($M = 108$ ms, SD = 142 ms; Typical ($M = 100$ ms, $SD = 128$ ms; $t(20) = .130$, n.s.). We then tested whether the two groups differed in accuracy, the average accuracy was not significantly different (ASD ($M = 82.0\%$, $SD = 12.8\%$); typical ($M = 88.0\%$, $SD = 6.0\%$; $t(20) = -1.53$, n.s.). Note, however, that the means have the expected relationship, and the chance of a type II error is substantial. A power analysis reveals that with sample sizes of 61 in each group, this effect size would be expected to become significant (Faul et al. 2007). Reaction times in the ASD population ($M = 1551$ ms, $SD = 919$ ms) were similar to that in the control group ($M = 1274$ ms, $SD = 587$ ms; $t(20) = 0.84$, n.s.). Again, the means are in the expected direction, and a power analysis reveals that given a sample

size of 178 in each group, a difference of this size would be expected to become significant (Faul et al. 2007). There was no significant interaction between diagnosis and complexity in our measure of accuracy ($F(1,20) = .14$, n.s.): Those with ASD got 83% and 82% of simple and complex emotions correct respectively, and controls got 87% and 88% of simple and complex emotions correct respectively.

Is There a Difference in How the Groups Use the Eyes and Mouth?

First, we considered first fixations. The eyes and mouth regions of interest (ROIs) include the entire area within the box in Fig. 5. This includes the contours of the specific features as well as a small area around these features. For clarity, we will henceforth refer to the regions illustrated in Fig. 5 as the "eyes ROI" and the "mouth ROI." For each subject, we counted the number of trials for which their first fixation was in the eye ROI, in the mouth ROI, or neither. For each group, considered separately, participants were far more likely to look in the eyes ROI during the first fixation than the mouth ROI. For the ASD group, subject
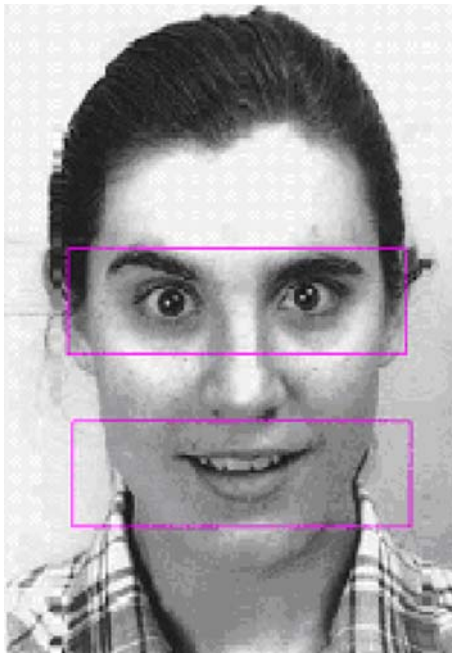
Fig. 5 Two regions of interest were used in the analysis of features. One region of interest captures the eyes and surrounding muscles, and the other captures the mouth and surrounding muscles. The amount of time participants spent looking at each region of interest were compared. Face photo from Baron-Cohen et al. (1997)
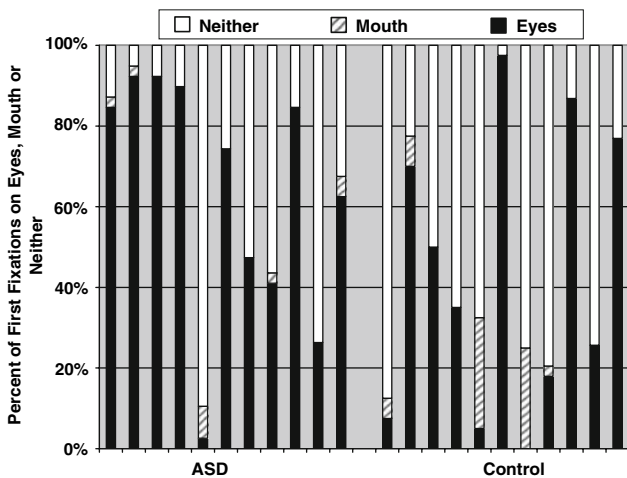

Fig. 6 The first fixation for each subject. Each bar represents one individual, and the colors represent how often their first fixation was in the eyes ROI, the mouth ROI or neither. The ASD subjects are on the left, and the control on the right
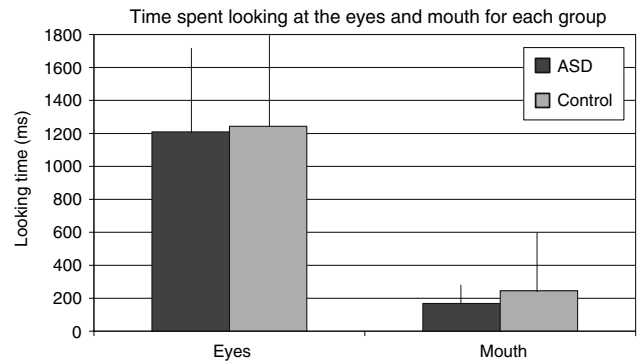

Fig. 7 There was a significant main effect for feature: both groups looked more at the eyes than at the mouth while looking at emotional facial expressions
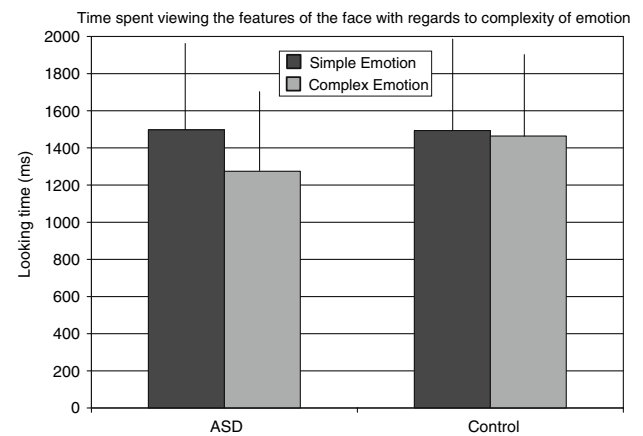

Fig. 8 There was a significant interaction in looking time between complexity and diagnosis
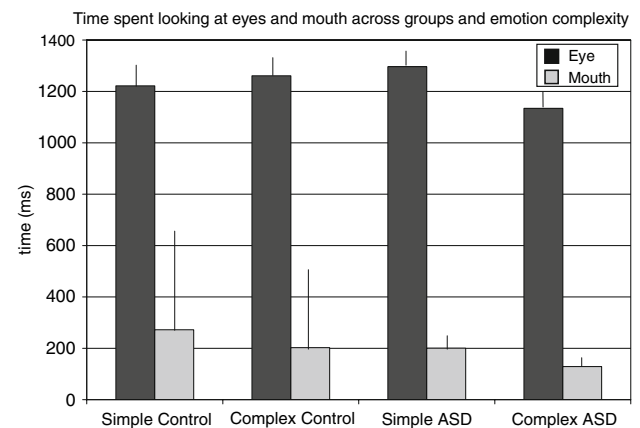
Fig. 9 The interaction between diagnosis, feature and complexity approached significance

looked at the eyes first on an average of 25.3 trials (out of 40), and at the mouth first on an average of .73 trials ($t(10) = 6.32$, $p < .001$) and for the Control group, subjects looked at the eyes first on an average of 17.36 trails and at the mouth first on an average of 2.45 trials ($t(10) = 2.96$, $p = .01$). There seemed to be an unexpected tendency for subjects with ASD to have a greater

preference for eyes over mouth compared to the Control group, but that interaction was not significant ($F(1,20) = 2.29$, $p = .14$). There was a remarkable amount of between individual differences but relative within individual stability. Figure 6 illustrated this

phenomenon. In the figure, each bar represents one individual, and the colors represent how often their first fixation was in the eyes ROI, the mouth ROI or neither.

In a repeated measures ANOVA we tested the effects of feature (using the eyes and mouth region of interest which is illustrated in Fig. 5), diagnosis and complexity. Looking time data in the following analyses includes only the time the subjects spend looking at the screen (that is, excluding blinking time and time spent looking off screen). There were no main effects of diagnosis. There was a strong main effect of feature ($F(1,20) = 36.4$, $p < .001$) with participants looking more at the eyes ($M = 1227$ ms, $SD = 558$ ms) than the mouth ($M = 207$ ms, $SD = 292$ ms). Critically, the expected feature by group interaction was not significant, nor did it approach significance, as illustrated in Fig. 7. There was a significant interaction between complexity and diagnosis ($F(1,20) = 5.62$, $p = .028$) as control participants spent more time looking at the features (eyes ROI and mouth ROI combined) of the complex emotions, and ASD participants spent less time looking at the features of complex emotions, as illustrated in Fig. 8. No other interactions were significant, but it is worth mentioning that the diagnosis by complexity by feature interaction approached significance, despite the relatively weak power of the 3 way analysis ($F(1,20) = 3.95$, $p = .06$). This interaction is illustrated in Fig. 9. Although complexity reduced the amount of time spent looking within the mouth ROI for both groups, an increase in complexity lead to an increase in looking within the eyes ROI for the control group, but a decrease in time spent looking within the eyes ROI for the ASD group.

Other questions focus specifically on the group with ASD. We wanted to know whether those with ASD looked more at the eyes than any other part of the face, whether they looked more at the mouth than any other part of the face, and whether there was a correlation between the attention to eyes and IQ.

Do Those With Autism Look at the Eyes Preferentially?

Participants with ASD spent about the same amount of time looking within the eyes ROI ($M = 1215$ ms, $SD = 545$ ms) compared to all of the rest of the face combined ($M = 1193$ ms, $SD = 600$ ms) ($t(10) = .05$, n.s.). For comparison, the control group looked at the eyes ROI ($M = 1243$ ms, $SD = 607$ ms) about the same amount of time as at all of the rest of the face combined ($M = 1215$ ms, $SD = 572$ ms) ($t(10) = .08$, n.s.) as well. Participants with ASD spend significantly less time looking at the mouth ROI ($M = 168$ ms, $SD = 154$ ms) compared to the rest of the face ($M = 2235$ ms, $SD = 252$ ms) ($t(10) = 19.21$, $p < .001$).

Does the Use of Eyes Relate to IQ in Those With Autism?

Within the ASD group, there was a moderate correlation between time spent looking within the eyes ROI and verbal IQ that approaches significance ($r = .41$, $p = .06$). The correlations between time spent looking within the eyes ROI and performance IQ ($r = .20$) and full scale IQ ($r = .35$) do not approach significance. The correlation between the time spent looking at the mouth and verbal IQ ($r = -.24$), performance IQ ($r = -.11$) and full scale IQ ($r = -.21$) did not approach significance.

Discussion and Conclusions

In this investigation, we were interested in whether there would be differences between a group with ASD and a control group in the use of visual information around the eyes, in the use of visual information around the mouth, and in perceptual strategies used when viewing simple versus complex emotions. In addition, we wanted to know whether there were patterned individual differences within the ASD group.

One of the more remarkable findings in this study is the lack of an overall significant difference in looking time at eyes and mouth based on diagnosis. The ASD group did not look less at the eyes overall, and did not look more at the mouth overall, compared to the control group. These results are surprising in light of some research findings and predictions (Pelphrey et al. 2002; Baron-Cohen et al. 1997). Pelphrey and colleagues found that between their 5 participants with autism and 5 controls, there was a remarkable differences in scan paths, including a much reduced amount of time looking at features among those with autism (Pelphrey et al. 2002). In contrast, van der Geest and colleagues (2002) found no evidence for group differences in facial scanning pattern when comparing a group of children with autism to a group without. This latter group concluded that any abnormality in scanning behavior in response to naturalistic scenes cannot be explained by the presence of faces. Our overall results concur with this later conclusion, at least with regard to the perception of simple emotions.

Another striking finding is within the ASD group itself. Although individuals with autism looked as much at the eyes ROI as at the rest of the image combined, they spent only a small fraction of that amount of time looking within the mouth ROI. In addition, first fixations were much more likely to be in the eyes ROI than in the mouth ROI for this group. This is consistent with recent evidence that given a very brief exposure time participants with autism are not

better able to discriminate small changes in the mouth region compared to the eyes region (Rutherford et al. 2007a), consistent with the idea that participants with ASD attend first to the eyes, not the mouth. These findings, as well and the nearly significant interaction between first fixation and diagnosis, seem inconsistent with suggestions that those with autism attend to the eyes substantially less than matched controls (Pelphrey et al. 2002; Klin et al. 2002), or that they preferentially attend to the mouth (Joseph and Tanaka 2003; Langdell 1978; Klin et al. 2002). However, one should be cautious in directly comparing past studies of this type, since differences in experimental conditions may sometimes be hard to ascertain. Even subtle differences may affect subjects' performance. For instance, it might be interesting to include cueing in future studies. Would cuing subjects to look at the eyes reduce the cognitive load and cause people to process information around the eyes more effectively? If so, would this benefit those with autism more strongly that those without?

Our results are inconsistent with the results of Pelphrey and colleagues (2002), as we did not find reduced looking at features among those with autism, except for trials involving complex emotions. There were some difference in methodology between the current study and that of Pelphrey et al. Their group of five men with autism had unusually high verbal IQs, averaging 117, and lower performance IQs, averaging 86.5, which is an unusual cognitive profile among those with ASD. In addition their control group was not matched on IQ and had a relatively high level of education, most having completed their undergraduate and some graduate study. Another important difference between that study and the current study is that the current study included both simple and complex emotions, not just Ekman's six basic emotions.

However, it is interesting and important to notice that in the current study, those with autism did look less at the eyes while viewing complex emotions. Put simply, those with autism "preferred" to examine the mouth region, as if the more complex the target, the simpler the source of information must be. For the complex emotions, our findings are consistent with the suggestion in the literature that those with autism look less at the eyes than control groups. Therefore, it may be possible that this group difference, when seen, is driven by the processing of more complex emotions or more subtle social information. Notice that this results is consistent with the finding of Baron-Cohen and colleagues, who found that those with autism were able to use the eyes to identify simple emotions, but not complex emotions: the ASD group was not able to make use of information in the eyes region to correctly identify complex emotions (Baron-Cohen et al. 1997). Together these results suggest that there is a difference in processing

simple and complex emotions for those with autism, that they may be less able to perceive complex emotions using the eyes region, and that they are effective at using other strategies to gather the information that is available, and can ultimately identify the emotion.

The ANOVA revealed an interaction between complexity and the looking strategy of the participants. We found an interaction between complexity and diagnosis, and in the control group, participants spent more time looking at the features (eyes ROI and mouth ROI combined) of complex emotions compared to those of simple emotions. Baron-Cohen and colleagues emphasize the role of eyes in conveying Theory of Mind information. Their study taken together with the current results suggest that there is a great deal of information available in the eyes region in the display of complex emotions, and control participants tend to take advantage of this by looking toward the eyes. Our finding is consistent with either or both of the ideas that (1) there is more information in the features, drawing the participants' attention and (2) the display is more difficult to identify, requiring more attention in order to complete the task.

Our ASD participants showed the opposite pattern: they looked slightly longer at the simple emotions compared to the complex emotions. This finding could be a result of familiarity. The simple emotions may be more familiar, being more likely to be explicitly discussed in social skills training and therefore more accessible to the participant (Silver et al. 2001; Howlin et al. 1999; Hadwin et al. 1996). (It is also possible that simple emotions are more frequently discussed in social skills training because they are easier for those with ASD to learn, an effect, rather than a cause of the improved performance in this group. Future research may shed light on this distinction.) If the complex emotion has less meaning, it may not hold the participants' interest for as long. Note, however, that accuracy in the identification of complex facial expressions was not impaired for our participants with ASD. The strategy those with autism use may be featural for simple emotions: examining the mouth may be sufficient to perceive happiness, or examining the eyes may be sufficient to perceive anger. One difference between this study and that of Pelphrey and colleagues' is the inclusion of complex emotions for some of the trials. This might influence results. It is possible that while those in the control group were able to extract information from the eyes region in all trials, those with autism were unable to make use of this information for the complex trials. If this were true, they would have to look elsewhere on the face.

There has been some suggestion that those with autism process visual stimuli, including faces, less globally, with more reliance on features (Hobson et al. 1988; Joseph et al. 2003; Langdell 1978), compared to typical observers,

consistent with the weak central coherence model of autism (Happé and Frith 2006; Plaisted et al. 2003). However, even the weak central coherence account allows for changes of strategies across situation. The use of global complexity may vary such that the complex emotions are more demanding in terms of information processing, thus encouraging a more featural processing strategy for those with autism. Indeed, subtle changes in the stimuli and experimental design may encourage a shift in strategy that we need to be aware of when interpreting results or comparing experiments.

It is possible that in order to identify complex facial expressions, those with ASD may be using alternative strategies. It seems odd that those with ASD would successfully identify emotions in less time than the matched control group, but it is at least possible that by-passing brain areas that involve emotion processing and using a memorize heuristic could lead to quicker identification. If this is the case, one testable implication would be that although the emotion has been accurately verbally labeled, deeper understanding, conceptual implications and physiological reactions do not follow.

The current study contributes little to the on-going discussion of whether there is an autism specific deficit in emotion perception, as the small ASD inferiority in performance did not reach significance. More interesting is the fact that there was no interaction between diagnosis and complexity of emotion in our accuracy measure. One might have expected those with autism to perform more poorly on more complex emotions. Apparently whatever strategy the ASD group is using to decode the complex emotions is nearly as accurate as that being used to decode simple emotions.

Caution should be used when trying to generalize these findings, since all of the stimuli in this experiment relied on one model. For this reason, subjects did not see more than one individual nor more than one sex. We used these stimuli because we wanted to pursue research Baron-Cohen and colleagues had previously done (Baron-Cohen et al. 1997). Nonetheless, future research might find differences in looking time between male and female models, or even differences in the use of features given different models. Similarly, future research might examine the effect of attractiveness of the model on looking time.

This study considers only the perception and processing of static images. Past research using eye tracking has examined the scan paths of those with autism while watching commercially available fictional videos (Klin et al. 2002). In future, it would be interesting to examine the response to a range of systematically developed stimuli. One could take a film developed for this purpose, display to one group a series of static images, to another group the dynamic film clip with no sound, and to a third group the audio and video together, to see if this affected the fixation

pattern. It is possible that people with and without ASD would employ different strategies as a result of the amount of complexity and information available. Simpler, more efficient strategies may be used by those with autism as the complexity of information increases, while control viewers may be able to decode the complexity and make use of the increasing information.

Correlations between time spent looking at features and IQ did not reach significance, but trends were consistently positive with respect to looking within the eyes ROI, and consistently negative with respect to looking at the mouth, more strongly so for verbal IQ than for performance IQ. This may be consistent with the idea that more severe disability leads to more atypical scan patterns when interpreting facial expressions. Conversely, it is also consistent with the idea that more atypical scan paths lead to more severe disability. Because this is weak evidence for this association, this possible phenomenon and its explanation would be worth exploring in the future.

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