That Looks Familiar:

Attention allocation to familiar and unfamiliar faces in children with Autism Spectrum Disorder

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Abstract

Introduction: Existing eye-tracking literature has shown that both adults and children with ASD show fewer and slower fixations on faces. Despite this reduced saliency and processing of other faces, recognition of their own face is reported to be more 'typical' in nature. This study uses eye-tracking to explore the typicality of gaze patterns when children with ASD attend their own faces compared to other familiar and unfamiliar faces.

Methods: Eye-tracking methodology was used to explore fixation duration and time taken to fixate on the eye and mouth regions of familiar, unfamiliar and self faces. Twenty-one children with ASD (9-16 years) were compared to typically developing matched groups.

Results: There were no significant differences between children with ASD and typically matched groups for fixation patterns to the eye and mouth areas of all face types (familiar, unfamiliar and self). Correlational analyses showed that attention to the eye area of unfamiliar and self faces was related to socio-communicative ability in children with ASD.

Conclusions: Levels of socio-communicative ability in children with ASD were related to gaze patterns on unfamiliar and self faces, but not familiar faces. This lack of relationship between ability and attention to familiar faces may indicate that children across the autism spectrum are able to fixate these faces in a similar way. The implications for these findings are discussed.

Keywords: social attention, self, familiarity, autism, face perception

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Introduction

Eye-tracking research has shown that individuals functioning on the autism spectrum can take longer to locate faces, and once located spend less time looking at faces when presented either in isolation (Boraston, Corden, Miles, Skuse & Blakemore, 2008; Pelphrey, et al., 2002; Spezio, Adolphs, Hurley & Piven 2007) or within social scenes (Fletcher-Watson, Leekam, Benson, Frank & Findlay, 2009; Freeth, Chapman, Ropar & Mitchell, 2010; Hanley, McPhillips, Mulhern, & Riby, 2013; Klin, Jones, Schultz, Volkmar, & Cohen, 2002; Riby & Hancock 2008, 2009a, 2009b; Speer, Cook, McMahon & Clark, 2007).

The majority of existing eye tracking research is carried out using stimuli such as photographs of unfamiliar persons within unfamiliar settings (e.g. Fletcher-Watson et al., 2009; Riby & Hancock 2008). In comparison to the unfamiliar face attention literature, there is a dearth of research on how familiar faces are attended to be individuals with Autism Spectrum Disorders (ASD). This is an important question because there is evidence from research with typically developing individuals to show qualitative differences in the way familiar versus unfamiliar faces are attended to, and processed (for review see Hole & Bourne, 2010). An eye-tracking study by Heisz and Shore (2008) repeatedly presented faces to a group of adult females (n = 11) until the faces became 'familiar'. They found that scanning patterns changed as a function of familiarity. Fixation count decreased with increased exposure (familiarity) which was proposed to indicate that fewer fixations were needed for processing familiar compared to unfamiliar faces. When faces became more familiar, the few fixations that did occur were mainly allocated to the eye region (a source for important social cues during interactions). These results indicate that individuals who are developing typically, scan faces differently depending on the familiarity of the face and this may also be the case for individuals with autism.

To date, only one eye-tracking study, by Sterling, et al. (2008), has examined how familiar and unfamiliar faces are visually attended to by high functioning adults with ASD (n = 17). Sterling and colleagues reported that adults with ASD fixated for less time on the eye area across all familiar face types compared to their typical counterparts. It was not clear whether varying levels of autism symptomology (even within this high functioning sample), might have influenced gaze behaviour. Examining links between autism symptomology or socio-cognitive profiles and gaze patterns could potentially increase our understanding of both developmental trajectories and compensatory strategies used by individuals with an ASD (Rice, Moriuchi, Jones, & Klin 2012). Indeed, links have already been reported between gaze patterns and individual differences across the autism spectrum (Klin et al., 2002; Norbury, et al., 2009; Riby & Hancock 2009b; Rice, et al., 2012; Speer et al. 2007).

One study, which reported an association between individual differences and eye gaze, was by Speer et al. (2007). They found that in high functioning children and adolescents with ASD (n = 12), eye region fixation and body region fixation was associated with social competence as assessed by the SRS (Social Responsiveness Scale: Constantino & Gruber, 2005). Less time spent fixating on the eye region was associated with less social responsiveness, indicating that social ability was related to how long the eye region was fixated. Another study by Riby and Hancock (2009b) on a group of children (n = 20) with moderate to severe ASD reported a relationship between the child's performance on a visual search task and their level of autistic impairment. The visual search task involved children looking for incongruent faces placed within grey landscape scenes. A higher score on the CARS (indicative of more severe autism; Childhood Autism Rating Scale: Schopler, Reichler

& Renner, 1988), was associated with less time fixating on the embedded faces. Indeed, this relationship between face fixations and individual differences associated with ASD has been reported several times in the literature (e.g. Riby & Hancock, 2008; 2009a; 2009b; Klin, et al. 2002) and is not surprising given recent evidence that even at a non-clinical level autistic traits can be associated with reduced face fixation (e.g. Freeth, Foulsham & Kingstone, 2013).

This evidence shows that it is crucial for eye-tracking research to take into account the effect of individual differences within autism given the heterogeneity that characterises the disorder. By doing this we can further explore the issues that may influence attention to faces across the autism spectrum. The present study therefore aims to replicate and extend Sterling et al.'s study by considering children with ASD and examining the critical issue of how levels of communicative ability and autism severity is associated with eye gaze behaviour when attending to familiar and unfamiliar faces .

Furthermore, the current study will extend the research by Sterling et al. (2008) by presenting the participant's own face within the battery of familiar and unfamiliar stimuli. The rationale for including the participant's own face is twofold: One reason is that there is no face proposed to be more familiar than a person's own face and it has been proposed that our own face captures and demands specialised attention (Tong & Nakayama, 1999). Indeed, it is proposed that all information related to the self, is 'special' and demands preferential processing (Bargh 1982; Turk, et al., 2011; Turk, et al., 2013).

Another reason to include the participant's own face is to explore rudiments of self-concept in populations with ASD. Self-recognition and attending our own face is proposed to be a form of self-concept or self-awareness, which is anchored in social functioning and communicative skills (Butterworth, 1992; Carruthers & Smith, 1996; Lewis, 1995; Lewis &

Ramsay, 2004). Given the difficulties and atypicalities of socio-communicative functioning associated with the autism spectrum, researchers have proposed that an impaired or delayed self-concept may be evident (Frith & Happé, 1994; 1999; Bird, et al. 2010; Fitzgerald, Angstadt, Jelsone, Nathan & Phan, 2006; Lombardo, Chakrabarti, Bullmore, Sadek, and Pasco 2010; Silani, et al. 2008). However, children with autism do show intact self-recognition and meet this milestone at a typical age (i.e. 18 months; Dawson & Mckissick 1984; Neuman & Hill 1978; Spiker & Ricks 1984). Self-recognition was assessed using the rouge task (devised by Gallup 1970). This task involved covertly marking a child's face with a spot of rouge and then presenting them with a mirror. Intact self-recognition was ascribed to any child who touched the rouge upon seeing their reflection. Reports in autism of intact self-recognition coupled with preliminary reports of typical activation of neural networks when viewing their own faces (Uddin et al., 2008) suggests that children with ASD may fixate typically on their own face and warrants further investigation.

It was predicted that:

1) Similar to Sterling et al. (2008) children with ASD will look less at the eye regions for both familiar and unfamiliar faces compared to the children who are typically developing

2) Due to evidence of intact self-recognition in Autism there will be no significant differences in gaze behaviour during own face viewing compared to children who are typically developing.

3) Levels of autism severity (assessed by CARS), socio-communicative ability (assessed by the Social Communication Questionnaire SCQ; Rutter, Bailey, Berument, Lord & Pickles, 2003) and non-verbal ability (assessed by Ravens Coloured Progressive Matrices RCPM; Raven, Court & Raven, 1990) will be related to gaze behaviour

during familiar and unfamiliar face attention but will not be related to own face attention due to reports of intact self-recognition.

Method

Participants

Twenty-one children with ASD were recruited from special units attached to three mainstream schools, and one specialist ASD school (see Table 1). Participants ranged between 9 years 7 months and 16 years 5 months (mean = 13 years 7 months; SD = 2 years 5 months). Verbal ability was assessed using the British Picture Vocabulary Scale (BPVS II; Dunn, Dunn, Whetton, & Burley, 1997) and provided a mean verbal mental age (VA) for the group of 7 years 3 months (ranging from 3 years 7 months to 15 years 2 months). Non-verbal ability (NVA) was assessed by the Raven's Coloured Progressive Matrices (RCPM; Raven, Court & Raven, 1990) giving a mean score of 27 (ranging from 11 to 35; max score possible 36). All children had studied at their respective school for at least two years so they were all familiar with the staff – this was important because images of staff members would act as the familiar face stimuli

[Insert Table 1 here]

Schools reported that all participants had previously been diagnosed by a clinician as being on the autism spectrum. A range of questionnaire measures were completed by teachers to assess levels of functioning. The Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Rocher-Renner, 1988) rated 9 children as mild-moderately autistic and 7 children as severely autistic. The remaining 5 children scored over 90 on the Asperger Syndrome Diagnostic Scale (ASDS; Myles, Bock, & Simpson, 2001). A score over 90 on this scale indicates the presence of Asperger Syndrome. The Social Communication Questionnaire (SCQ; Rutter, Bailey, Berument, Lord & Pickles, 2003) was conducted; with 19 children obtaining a score over 15, (a score of 15 or over implies the presence of ASD or PDD-NOS). The remaining two children showed a score of 13 and 11 which may imply these children have higher socio-communicative ability compared to the other children in the ASD group.

Each child with ASD was individually matched to three children who were typically developing, based on chronological age, verbal ability and non-verbal ability. The three groups of typically developing children were recruited from three mainstream schools.). Chronological age matched group (CA) had a mean chronological age 13 years 6 months. The VA participants were matched to participants with ASD based on verbal ability using the BPVS II and had a mean verbal ability age of 7 years 4 months. The NVA children matched to the children with ASD based on non-verbal ability had a mean RCPM score of 27. Participating schools confirmed that all children recruited as typical controls did not have a previous or present diagnosis of any learning or developmental disorder.

Materials

Two photographic images of one familiar adult male and two images of one familiar adult female were used. Each image was a head and shoulder photograph of a teacher, or care-worker, which was familiar to the child. Two images of one unfamiliar adult male and two images of one unfamiliar adult female were also shown to each child. Unfamiliar faces were those that were familiar to other participants recruited from different schools (therefore, the same face was familiar to one child and unfamiliar to another child). The self-condition consisted of two images of each child participant. Therefore, in summary each participant viewed the same five people twice (n = 10) across the factors of Familiarity (Unfamiliar, Familiar, Self).

All photographic images were taken using a Panasonic camera and edited in Adobe Photoshop CS (Adobe, San Jose, California, USA) to ensure size and pixels were constant. The size of each image was 650 pixels x 488 pixels, (9.17cm x 6.89cm). To explore how children with ASD spontaneously attend these face types within their social environments, the images were not controlled for background, facial expression and luminance.

All images were presented via a Tobii 1750 eye-tracker (Tobii Technology, Stockholm, Sweden), using Tobii studio (Tobii Technology) for the presentation of stimuli and recording eye movements. The eye-tracker was controlled via a Dell Inspiron 6400 (Dell, Round Rock, Texas, USA) laptop. The system was portable and was moved to the testing location of each individual. The system was also completely non-invasive, with no need to constrain the head or body and little indication that eye movements were being tracked. The Tobii 1750 system tracks both eyes to a rated accuracy of 0.5 degrees, sampled at 50 Hz and was calibrated for each participant using a 5-point infant calibration of each eye. For all images, areas of interest (AOIs) for the face, eyes and mouth were defined using tools within Tobii studio to mark regions covering these features (see Figure 1).

After data collection was complete, it was found that the calibration for some individuals was rather inaccurate, because of the size of the infant calibration animation that was used. The error showed up in the recorded gaze on the fixation cross that preceded each photograph, a steady gaze just below the actual cross. A program was written in Matlab (Mathworks, Natick, Massachusetts, USA) which computed the average of the gaze locations while the fixation cross was shown and then subtracted the difference between this average and the true location of the fixation cross from all recorded fixations. The program then computed hits on the AOIs as exported from Clearview.

[*Insert Figure 1 here*]

Procedure

Participants were tested individually at home or at school. They were seated approximately 50 cm from the eye-tracking screen with the experimenter sitting to one side to control the computer but not interfere with viewing behaviour. The participants were told that they would see different types of pictures during the session and the first eye-tracking task involved calibration of the eye-tracker.

For this purpose, the participant followed a bouncing cat around the screen to five locations. Participants were then told 'please look at the pictures while they are on the screen', and no further instruction was provided to explore the spontaneous allocation of attention to these images (replicating the instruction used by Riby & Hancock, 2008). All participants were able to comply with task demands and could be calibrated successfully (no data were removed). The task reported here was presented along with other tasks in a session lasting approximately 10-12 minutes. Each image was presented, in a random order, for 3 seconds and separated with an inter-stimulus central fixation cross for 1 second. Once all the conditions were complete, the experimenter thanked and debriefed the participant.

Analysis

Each individual's data was examined for any atypical gaze measures including not fixating long enough on the face region as a whole (fixation duration <1000ms) or looking too quickly at the eye and mouth AOIs (time taken to fixate <150ms) as the latter would have indicated involuntary eye movements. All individual trials met with these criteria, therefore no data were removed for further analysis.

Results

Visual inspection of histograms showing fixation duration and time taken to first fixate data during the whole image, face, eye and mouth regions show that data were normally distributed and there were no outliers within each group.

Fixation Duration

We first checked whether there were any differences between the groups in task engagement, as indicated by the fixation duration on the whole image. Anova showed no effect of group, $F (3,80) = .295$, $p > .05$, $\eta_p^2 = .011$, (mean ASD 6346ms, CA 7176.ms, VA 6889ms, NVA 6705ms). However, to account for individual variance in overall visual attention, proportional scores (calculated as time spent looking at the eye or mouth region as a proportion of time spent looking at the whole face) were used.

A mixed 4x3x2 ANOVA was conducted with between subject factor of Group (ASD, CA, VA, NVA) and within subject factors of face Familiarity (Familiar, Unfamiliar, Self), and AOI (Eye, Mouth). There was a main effect of AOI, confirming that all participants looked longer at the Eye AOI (m = .40) compared to the Mouth AOI (m = .13), $F (1, 80) = 72.7$, $p < .001$, $\eta_p^2 = .48$. There was also a significant three-way interaction between Group membership, AOI and Familiarity $F (6, 155) = 2.57$, $p < .05$, $\eta_p^2 = .088$ (see Figure 2).

[Insert Figure 2 Here]

To investigate this interaction, the three possible two-way ANOVAs, between Group and AOI, Group and Familiarity, and Familiarity and AOI, were carried out. The first two of these gave no significant interactions (Group and Familiarity F (3, 80) = 0.61, p > .05, η_p^2 = .022; Group and AOI, F (3,80) = 1.90, p > .05, η_p^2 = .066). There was, however, a significant interaction between Familiarity and AOI, F (2, 155) = 3.29, p < .05, η_p^2 = .039.

To identify the source of this interaction, paired samples t-tests were carried out for each AOI (Eye and Mouth). There was a significant difference between Unfamiliar Eye (m = .44) and Self Eye (m = .37), t (83) = 2.40, p <.05, *d* = .26: participants fixated on the Unfamiliar Eye more than the Eye region of their own face. There was no significant difference between Familiar Eye (m = .39) and Unfamiliar Eye t (83) = 1.74, p >.05, *d* = .18, or between Familiar Eye and Self Eye t (83) = 1.42, p >.05, *d* = .09. For the mouth AOI, there was a significant difference between the Familiar Mouth (m = .16) and Unfamiliar Mouth AOI (m = .12) t (83) = 2.49, p <.05, *d* = .30. There was no significant difference between Self Mouth (m = .12) and Familiar Mouth, t (83) = 1.18, p >.05, *d* = .25, or Self Mouth and Unfamiliar Mouth, t (83) = .42, p >.05, *d* = .01, implying that there were no differences in the way children looked at their own mouths compared to the mouths of others.

To further examine the driving factors of the significant three-way interaction observed in the main ANOVA, the eye and mouth AOI data were analysed in separate 3 (Familiarity) x 4 (Group) mixed measures ANOVAs. For the eye AOI, there were no significant effects of Familiarity, F (2, 147) = 1.06, p >.05. η_p^2 = .013, Group, F (3,80) = 1.20, p>.05, η_p^2 = .016, or a significant interaction between Familiarity and Group, F (6, 147) = .500, p >.05, η_p^2 = .008). For the mouth AOI, there was no significant main effect of Familiarity, F (2, 159) = 2.36, p >.05, η_p^2 = .029, or Group, F (3, 80) = .671, p>.05, η_p^2 = .049 but a significant interaction between Group and Familiarity, F (6, 155) = 2.25, p <.05, η_p^2 = .078. To explore this significant interaction, separate one way ANOVAs were carried out for each face type, between groups. There was no significant effect of Group on proportion of gaze time for either Unfamiliar or Familiar Mouth AOIs (all ps >.05), however there was a significant effect of Group on attention to the Self Mouth AOI F (3, 80) = 2.79, p < .05, η_p^2 = .093. Post-hoc bonferroni comparisons showed that the CA group (m = .053) looked significantly less at the self mouth AOI than the VA group (m = .211), p < .05 There were no other group differences (all ps >.05).

Correlational Analyses

Pearson's correlation analysis was applied to investigate the relationship between participant socio-communicative characteristics (SCQ) and autistic symptoms (CARS) and time spent fixating on the eye and mouth regions. Bonferroni correction for multiple correlations (p=.05 / 5 = alpha level for significance of .01) was conducted due to multiple correlations being explored. There were no significant correlations between chronological age, verbal age, non-verbal age, CARS scores and time spent looking at the eye and mouth areas showing that age, level of cognitive ability and autistic impairment were not associated with time spent looking at the eyes and mouth regions across all familiarity categories (all ps >.01). However it was found that level of social functioning (according to the SCQ) was significantly correlated with the proportion of time spent fixating on the eye area of Unfamiliar (r = -.54, p <.01) and Self faces (r = -.65, p < .01), but not Familiar faces (r = -.25, p>.05).

To further explore these possible differences in attention within the ASD group according to levels of social functioning, the children were split into two groups; high social functioning (i.e. lower SCQ scores) and low social functioning (i.e. higher SCQ scores). The higher social functioning group showed significantly longer fixation on the Self eye area (m = .630) compared to the low social functioning group (m = .36) t (19) = 2.26, p <.05, *d* = .98, but there was no difference. for attention to the mouth area (high, m = .105, low, m = .078, t (19)

= .45, p >.05, *d* = .21. This shows that even though the low social functioning group show less attention to the eyes they are not looking longer at the mouth, implying that they are looking more elsewhere within the face.

For unfamiliar faces, a similar pattern was observed: although the difference in fixation proportion to the eye area between the high and low social functioning groups was not formally significant, the effect size was similarly large. For the Unfamiliar eye area, high functioning, m = .60, low m = .45, t (19) = 1.81, p >.05, *d* = .76, for the Unfamiliar mouth area, high, m = .078, low, m = .030, t (19) = 2.00, p > .05, *d* = .88. The implication, therefore, is that for both own and unfamiliar faces, the low social ability group are not looking as much at the salient features of a face (Figure 3 illustrates some typical scan paths).

[Insert Figure 3 here]

There were significant correlations between level of functioning according to the SCQ and how much longer eye areas were fixated on compared to mouth areas on the Unfamiliar (r = -.53, p <.01) and Self (r = -.48, p <.01) faces. Therefore, children with higher social functioning showed a greater difference in looking at the eye area compared to the mouth area. There were no significant correlations observed between level of social functioning (measured on the SCQ) and the difference of time spent fixating on the eye compared to mouth areas on familiar faces (r = -.13, p >.01).

Time Taken to First Fixate

Time to first fixation on AOIs Eyes and Mouth was examined to explore attentional priority to these regions across the familiarity levels,. Using the same mixed ANOVA (Group x AOI x Familiarity). There was no significant main effect of AOI, F (1, 80) = .724, p = .40, η_p^2 = .009. There was no interaction between Group membership, AOIs and the Familiarity conditions F (6, 152) = .744, p = .61, η_p^2 = .027 (see Figure 4) showing that there were no differences in the way groups oriented to the AOIs across the Familiarity levels.

[Insert Figure 4 here]

A significant effect of Familiarity was observed F (2,151) = 7.12, p < .001, η_p^2 = .082. This was found to be driven by attention to the Self faces. All Participants fixated quicker on Self AOIs (m = 496ms) than on Familiar AOIs, (m = 639ms) t (83) = 2.38, p < .05, *d* = .036 or Unfamiliar AOIs (m = 696ms) t (83) = 3.91, p < .001, *d* = .054, showing that the internal features of the Self face captured the children's attention quicker than any other face type. There was no significant difference found between time taken to fixate on Familiar and Unfamilar AOIs, t (83) = .069, p >.05, *d* = .14.

There was also a significant interaction observed between Group and Familiarity on time taken to first fixate F (6, 151) = 2.01, p < .05, η_p^2 = .070. To investigate this, one-way ANOVAs were carried out between Groups (ASD, CA, VA, NVA) for each Familiarity condition (Self, Familiar and Unfamiliar). There was no significant effect of group on time to first fixate on familiar AOIs, F (3, 80) = 2.21, p > .05, η_p^2 = .18 and the Self AOIs, F (3, 80) = .98, p > .05, η_p^2 = .084. Group membership however influenced attention to unfamiliar AOIs F (3, 80) = 3.39, p < .05, η_p^2 = .15. A post-hoc bonferroni comparison found that there was a significant difference between ASD group (m = 354 ms) and NVA group (m = 608 ms), p <.05, showing that the ASD group took significantly less time to fixate on the unfamiliar AOIs compared to the NVA group. No other significant differences were found between groups (all ps >.05).

Correlational Analyses

Pearson's correlations found that there were no significant correlations for time taken to first fixate on the AOIs across familiarity, and chronological age, verbal age, nonverbal age, CARS scores or SCQ scores (all ps >.01). This suggests that level of social functioning or level of autistic impairment is not related to how faces attract attention despite there being a relationship between how long faces maintain this attention and socio-communicative ability.

Summary

The Eye regions were fixated on significantly longer than the Mouth regions by all participants. The analyses further showed a significant three-way interaction between Group, AOI and Familiarity, which was driven by the CA group (the oldest participant group) fixating significantly less on the Self Mouth AOI compared to the VA group (the youngest participant group), indicating that Self faces may be attended to differently by older and younger children. The Unfamiliar Eye AOI was fixated on significantly longer compared to the Self Eye AOI; and Familiar Mouth AOIs were fixated on significantly longer compared to Unfamiliar Mouth AOIs by all participants, suggesting that different gaze strategies are employed by children when attending faces of varying familiarity.

Significant relationships were observed between socio-communicative ability scores (SCQ scores) and fixation duration on the Eye areas of both Unfamiliar and Self faces. Children with ASD who show high social ability looked longer at the Eye regions of Unfamiliar and Self faces compared to those children with low social ability.

Time to first fixation data showed that all children fixated significantly quicker on the Self faces compared to Unfamiliar and Familiar faces, indicating that the internal features of Self faces may capture children's attention quicker than other face types. The analyses revealed a significant interaction between Familiarity and Group, which was driven by the children with

ASD fixating quicker on Unfamiliar AOIs compared to the NVA group, which could imply that children with ASD are able to detect and attend unfamiliar faces quicker.

Discussion

The research presented here highlights the nature of spontaneous attention allocation to faces of varying degrees of familiarity, for individuals functioning across the autism spectrum and those developing typically. The results showed that all children (including the children with ASD) in the current study fixated for longer on the eye areas compared to mouth areas. This makes sense since the eye region is an important source of social information during interactions (i.e. Argyle & Cooke, 1976) and is consistent with previous findings of children with ASD allocating typical visual scanning patterns when looking at isolated static faces (Bar-Haim, Shulman, Lamy, & Reuveni, 2006; de Wit, Falck-Ytter, & von Hofsten, 2008; Rutherford & Towns, 2008).

Across all groups of children, there were no differences in fixation to the Eye AOI for Familiar and Unfamiliar faces. Familiarity did influence how long the Mouth AOI was fixated on by children, since they fixated longer on the Familiar Mouth compared to the Unfamiliar Mouth. This is an interesting finding as attention to the mouth area is an important aid to the interpretation of language and communicative intentions. Further research is required to examine whether different visual scanning patterns are adopted by child groups as they attend faces of varying familiarity and whether these patterns are linked to increased language comprehension or communicative skills.

In contrast to Sterling et al.'s results, which found that adults with ASD fixated the eye area of all face types significantly less compared to typical adults, the current study did not show significant differences between groups in general face scanning. The current results therefore show that children with ASD did not look at the eye and mouth areas of familiar and unfamiliar faces in a different way compared to their typical peers. One possible influential factor for this discrepancy is the different age of participant populations. Sterling et al.'s population involved *adults* with high functioning ASD (unlike the present study which has examined children with ASD). Both participant groups included individuals who were high functioning on the autism spectrum and were presented with isolated faces, therefore differences in results between these two studies cannot be explained by the inclusion of individuals with less autistic impairment or that stimuli depicted varying complexity levels. The results instead could highlight that there may be developmental differences in attention to familiar and unfamiliar faces in populations with ASD. Indeed an initial longitudinal study within a child population implied that the visual scanning of faces change as children with ASD develop (Chawarska & Shic, 2009). By examining eye-gaze longitudinally in ASD, we can draw more accurate inferences about the actual typical or atypical development of gaze behaviour and more adequately represent a developing, changing child/adult population (for a brief review see Kramer, Yesavage, Taylor, & Kupfer, 2000).

A critical component of the current study, with an important contribution to current literature, is the inclusion of Self-images. Children in the current study fixated differently on their own face compared to other faces. Less time was taken to fixate on the internal features of Self-faces compared to Familiar and Unfamiliar faces, indicating that their own face attracted their attention quickest. This is consistent with previous findings, which propose our own face captures, and demands specialised attention (Tong & Nakayama, 1999), similar to all information related to the Self, (Bargh 1982; Turk, van Bussel, Brebner, Toma, Krigolson, & Handy, 2011). All children looked longer at the Unfamiliar Eye region compared to their own Eye region. This longer fixation on the Eye region of Unfamiliar faces may have been caused by the children trying to identify the face.

Despite there being no significant differences in the Self condition between children with ASD and other groups, it was found that the CA group looked less at their own mouth compared to the VA group. A possible explanation is that children in the younger VA group (m = 8y 4m) are less self-conscious than the older CA group (m = 13y 6m). Lewis, Sullivan, Stanger, & Weiss (1989) noted from several studies that as typically developing children grow older they are prone to show more self-conscious behaviours when they perceive their own face. Further work would be needed to establish a link between self-consciousness and such gaze patterns.

The current study aimed to consider the role of autistic impairment and socio-communicative ability on attention allocation to the eye and mouth regions of faces. The communicative abilities reported by the SCQ for the individuals with ASD were correlated with attention to the eye region on unfamiliar and self faces, but not familiar faces. Better social and communication ability was associated with more time spent looking at the eyes (of unfamiliar and self faces). This finding is consistent with previous literature such as Speer *et al.* (2007) who found eye region fixation on unfamiliar faces predicted social ability, as individuals with ASD who showed reduced fixation on the unfamiliar eye showed less social responsiveness. The present study has also shown that socio-communicative ability is related to fixation on self eye area, which may imply that longer attention allocation to the eye region of their own faces is linked to increased self-awareness in high functioning individuals with ASD. Further exploration with the use of self-images is required to explore this possibility and build on this preliminary suggestion.

Interestingly, the relationship between level of social functioning and attention to the eye region was found only for self and unfamiliar faces and not for familiar faces. This suggests that personally familiar faces are attended to similarly across the autism spectrum and that previously reported differences in attention to the eye area of faces between typical groups and groups with ASD may have been influenced by faces being unfamiliar (for example, Klin et al. 2002; Pelphrey et al., 2002; Riby & Hancock 2008; 2009a; 2009b). These correlational findings also have important implications for how children across the autism spectrum interact with familiar persons. If children with ASD (regardless of their level of functioning) are able to attend to important communicative cues presented on a familiar face then they may be able to engage in social interactions with familiar persons more efficiently.

The current study emphasises the effect of socio-communicative ability on the autism spectrum and attention allocation length to the eyes. The issue of participant characteristics, specifically level of social functioning, may explain why there are no differences between groups in the current study and may highlight why there are such discrepancies in the group differences reported in previous eye-tracking studies (Freeth, Foulsham, & Chapman 2011, Riby & Hancock 2009a; 2009b). This is a critical feature to be recognised in all research involving individuals with this spectral developmental disorder. Further research into the exact social or communicative profiles that are mostly related to typical or atypical attention allocation to faces (across different levels of familiarity) remains a challenge for future research within this field.

Possible limitations of this study include using natural images presenting the head and shoulders of familiar, unfamiliar and the children themselves with a background being present. This is similar to how these faces are seen and experienced within the real social environment of children with ASD. Although this is in some ways may be regarded as a strength, (as it provides a more ecologically valid exploration of how children with ASD attend faces of varying familiarity they encounter in their environment), lack of control over aspects of the images such as background and luminance may have affected how the children attended to these images. Researchers may wish to control these variables in future studies to ensure any differences or effects are directly associated with familiarity differences.

Despite these limitations, the current study has made several important contributions to existing literature. The most important contribution is highlighting that level of socio-communicative functioning in children with ASD is associated with how unfamiliar and self eyes are attended to but not familiar eye areas. This may have important implications for the use of unfamiliar and self images within the learning and social environments of children with ASD as well as how these children may attend unfamiliar faces they encounter within real environments. These findings may also indicate that children across the autism spectrum are able to fixate typically on familiar faces potentially allowing appropriate comprehension of familiar facial communicative cues by children with ASD. This information could be utilised to train children with ASD in face perception skills to improve communicative abilities and potentially facilitate future social interactions.

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Figure Captions

Figure 1 An example of how the eye Area of Interest (AOI) and mouth Area of Interest (AOI) were marked out on the faces.

Figure 2 Mean proportion of face fixation time during familiar, unfamiliar and self conditions, Areas of Interest – AOIs, a) eye and b) mouth across groups.

Figure 3 Gaze plots which show an example of a) a child on the autism spectrum with high socio-communicative ability (as indicated by Social Communication Questionnaire - SCQ) and b) a child on the autism spectrum with low socio-communicative ability (as indicated by the SCQ) looking at familiar and unfamiliar faces.

Figure 4 Mean time to first fixation (ms) during familiar, unfamiliar and self conditions, Areas of Interest – AOIs, a) eye and b) mouth across groups.

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