Do faces capture the attention of individuals with Williams syndrome or Autism? Evidence from tracking eye movements

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Abstract

The neuro-developmental disorders of Williams syndrome (WS) and autism can reveal key components of social cognition. Eye-tracking techniques were applied in two tasks exploring attention to pictures containing faces. Images were i) scrambled pictures containing faces or ii) pictures of scenes with embedded faces. Compared to individuals who were developing typically, participants with WS and autism showed atypicalities of gaze behaviour. Individuals with WS showed prolonged face gaze across tasks, relating to the typical WS social phenotype. Participants with autism exhibited reduced face gaze, linking to a lack of interest in socially relevant information. The findings are interpreted in terms of wider issues regarding socio-cognition and attention mechanisms.

Keywords: Williams syndrome, Autism, face perception, social cognition

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Due to its social and evolutionary importance the human face not only captures but summons our visual attention. For typically developing individuals a face captures attention above and beyond other aspects of the environment (Theeuwes & van der Stigchel, 2006; Ro, Russell, & Lavie, 2001; Vuilleumier, 2002; Cerf, Harel, Einhauser, & Koch, 2008). It has been proposed that faces may be discriminated 'pre-attentively' (Theeuwes & van der Stigchel, 2006) and therefore once a face is detected, focal attention is automatically directed towards that face. The detection of a face occurs in a manner different to that used for the processing of other objects, for example less time is taken to detect an image of a face than a visually matched alternative (e.g. a scrambled or inverted face; Purcell & Stewart, 1986). It has therefore been proposed that faces are detected and processed early in the visual system (Lewis & Edmunds, 2003), although some researchers do not agree that they 'pop out' in comparison to other non-face objects (e.g. Brown, Huey, & Findlay, 1997; Palermo & Rhodes, 2003). The way that faces capture, or do not capture, attention may occur differently for individuals with disorders of development that impact upon face perception, social functioning and social cognition. For these groups, the seemingly natural drive to view faces and detect subtle communicative signals from them may be disturbed. Individuals with the neuro-developmental disorders of autism and Williams syndrome can provide examples of the disruption to typical face-capture and face-viewing. However, as illustrated by these two groups when studied together, the effect of disorders of development upon face viewing can be very different.

Williams syndrome (WS) is a genetic disorder with a prevalence of approximately 1 in 20,000 (Morris & Mervis, 1999) that is characterised by a dissociation of higher cognitive functions (verbal versus nonverbal information processing) as well as a distinct social phenotype (cf. Bellugi et al., 2000). Whilst individuals with autism are typically characterised by social withdrawal and a lack of desire to engage in social interactions (Frith, 1989; DSM IV, APA 1994), individuals with WS are associated with a drive *towards* social engagement, often labelled as 'hyper-sociability' (Jones et al., 2000) or a 'pro-social compulsion' (Frigerio et al., 2006). They show a desire to interact with people whether they are familiar or unfamiliar to them (Doyle et al., 2004), as well as a propensity to hold prolonged face gaze during social interactions (Mervis et al., 2003) and interview conditions (Doherty-Sneddon, Riby, Calderwood, & Ainsworth, submitted). People with WS are often described as empathetic and sociable (Gosch & Pankau, 1997) although the way they interpret socially relevant facial cues of emotion, and encode faces for identity, does not appear typical (e.g. Karmiloff-Smith et al., 2004; Riby, Doherty-Sneddon & Bruce, 2008a). Eye-tracking evidence illustrates atypicalities of gaze behaviour towards the faces of human actors (Riby & Hancock, 2008; Riby & Hancock, submitted), corroborating evidence of prolonged face gaze (Mervis et al., 2003; Doherty-Sneddon et al., submitted). It is likely that the way individuals with WS attend to socially relevant information is directly related to their socio-cognitive skills. At present however, the underlying mechanisms involved in prolonged face gaze remain somewhat unclear with suggestions of i) frontal lobe inhibition deficits playing an important role in attention shifting

(Porter et al., 2007) and ii) amygdala dysfunction being central to the emotional significance of faces and sociability in WS (Jawaid, Schmolck, & Schulz, 2008). These proposals are not mutually exclusive.

It is well recognised that individuals with autism exhibit atypicalities of visual perception (Dakin & Frith, 2005) and shifting visual attention (e.g. Burack, 1994) to many different types of information, however this is particularly apparent when dealing with social stimuli such as faces (Bird, Catmur, Silani, Frith, & Frith, 2006). Individuals with autism exhibit grossly abnormal gaze behaviour when viewing face information, whether the face appears in isolation (Dalton et al., 2005), within a social scene picture (Riby & Hancock, 2008) or movie extract (Klin et al., 2002; Speer et al., 2007, Riby & Hancock, submitted). Research consistently reports a lack of spontaneous gaze fixation towards the eyes (Dalton et al., 2005; Pelphrey et al., 2002; Klin et al., 2002; Riby & Hancock, 2008) which is likely to be implicated in failures to interpret information from that region; evident as deficits in following gaze cues (Swettenham et al., 1998) or interpreting mental states (Baron-Cohen, 1995). However when cued, attention may be allocated to faces in a more 'typical' manner (Bar-Haim, Shulman, Lamy & Reuveni, 2006) and when drawings of faces are used atypicalities of gaze behaviour are dramatically reduced in comparison to the use of photographs (van der Geest, Kemner, Verbaten & van Engeland,2002b; but see Riby & Hancock, submitted). When directly compared, individuals with autism show many more problems processing information from faces than those with WS (Riby, Doherty-Sneddon, & Bruce, 2008b).

The visual perception system of individuals with autism has been studied in detail and as described above research shows that typically salient items (e.g. faces) do not attract attention. However, it may not just be the detection of appropriate targets that differs for individuals with autism. Fletcher-Watson, Leekam, Turner and Moxon (2006) suggest that individuals who are high-functioning on the autistic spectrum show a typical attention selection strategy but this is combined with difficulty switching or disengaging attention. In much the same way as evidence proposing attention switching atypicalites in WS (e.g. Cornish, Scerif, & Karmiloff-Smith, 2007; Scerif, Cornish, Wilding, Driver, & Karmiloff-Smith, 2004; Brown et al., 2003) it is likely that individuals with autism have difficulty with this aspect of visual attention (e.g. Landry & Bryson, 2004). It has been proposed that shifting attention between objects and people is particularly difficult for individuals with autism (Swettenham et al., 1998) and this could be crucial for attending to socially relevant information (e.g. faces) when presented within an image that also contains non-social objects.

Tager-Flusberg, Plesa Skwerer and Joseph (2006) emphasise the valuable contribution of studying WS and autism in tandem for furthering our understanding of social neuroscience. Previous research has not only studied the face perception abilities of these groups in direct comparison to each other (Riby, Doherty-Sneddon, & Bruce, 2008b), but has also included these groups in the same eye-tracking studies for understanding gaze behaviour (Riby & Hancock, 2008; Riby & Hancock, submitted). Boraston and Blakemore (2007) note the value of eye-tracking techniques for understanding social difficulties associated with autism, and the same can be said for WS. When attending to still pictures of social scenes containing people in natural interactions, individuals with WS and autism both show atypicalities of gaze behaviour, though in opposite directions. Detecting a face within the scene is a crucial step in attending to the information portrayed by that face, such as communicative facial signals. The face-capture effect becomes particularly important here and directing attention to the relevant scene region is a central issue. It could be proposed that attentional mechanisms are pivotal to the gaze behaviour of individuals with WS and autism. The current study involves two tasks that require participants to look at a range of pictures whilst having their gaze behaviour monitored. The tasks involve scenes with embedded faces (Task 1) and scrambled pictures of a person in a scene (Task 2). The analyses focus on the nature of ‘face capture’ in these two different types of image and investigate the typicality of gaze behaviour for individuals with WS and autism.

Due to the social relevance of faces and their importance for engaging and directing visual attention (Theeuwes & van der Stigchel, 2006) we expect faces embedded in scenes (Task 1) and faces shown in scrambled pictures (Task 2) to capture the attention of typically developing participants. Previous research has illustrated that inconsistent objects ‘pop out’ and attract attention (Loftus & Mackworth, 1978) and therefore when using socially important cues such as faces we expect this pop out to occur in dramatic fashion. We are particularly interested in any atypicalities of attention to faces shown by participants with WS and autism. Specifically, we predict that individuals with WS will spend more time than is typical viewing faces across tasks, whilst individuals with autism will spend less time than is typical viewing faces.

Method

Participants

Eighteen participants with Williams syndrome were recruited via the Williams syndrome Foundation to participate in various eye-tracking tasks. All participants were diagnosed phenotypically by clinicians and 14 had their diagnosis confirmed with positive FISH testing[1]. All participants with WS had normal or correct-to-normal vision and none suffered from strabismus. Four individuals had to be removed due to eye-tracking calibration or recording difficulties, thus the final sample consisted of 14 participants with WS between the age 8 years 9 months and 28 years 0 months (mean 15 years 2 months; positive FISH testing 12/14). The sample comprised 10 males and 4 females.

Participants with WS were individually matched to a typically developing individual of comparable nonverbal ability (NV) due to the nature of the experimental task. All participants in this group had normal or correct-to-normal vision. Typically developing participants were recruited from local schools and pre-schools. Teachers of children in the comparison groups completed the Strengths and Difficulties Questionnaire (Goodman, 2001) to ensure the absence of problems in the areas of emotions, conduct, hyperactivity, peer relationships or pro-social behaviour. All typically developing participants scored within the ‘normal’ behaviour range (total difficulties scores between 0-11). The nonverbal ability group was matched using scores on the Ravens Coloured Progressive Matrices task (RCPM; Raven, Court, & Raven, 1990; max score 36). The group with WS scored between 8 and 21 (mean 14) and the comparison group scored between 8 and 20 (mean 13, difference between groups p=.82).

Twenty-six participants with autism were recruited through special educational needs units attached to mainstream schools and specialised schools and all had normal or correct-to-normal vision. All participants had previously been diagnosed by clinicians and satisfied the diagnostic criteria for autism according to the DSM-IV (APA, 1994). When completed by teachers, the Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Rocher Renner, 1988) classified 15 children as mild-moderately autistic and 11 as severely autistic. No participant scored outside the autistic range (scoring 32 to 54). Due to task compliance difficulties 2 participants were removed from the sample (both scored as 'severely autistic' on the CARS) and the final sample comprised 24 individuals aged 6 years 6 months to 17 years 2 months (mean 12 years 4 months; 18 male, 6 female). Participants with autism were individually matched to a typically developing individual of comparable nonverbal ability. Using the RCPM, the group with autism scored between 8 and 20 (mean 12) and the typically developing group scored between 7 and 20 (mean 13, between groups p=.63). Informed consent and ethical approval were received prior to research involvement.

Materials and Design

For each task participants' gaze behaviour was recorded using a Tobii 1750 eye-tracking screen run via the Tobii Studio package. The eye-tracker was interfaced and controlled via a Dell Latitude D820 computer. The eye-tracking system is completely non-invasive, with little indication that eye movements are being tracked and no need to artificially constrain head or body movements. The system tracks both eyes, to a rated accuracy of 0.5 degrees, sampled at 50Hz. The eye-tracker was calibrated for each participant using a 9-point calibration of each eye, whereby each participant followed the location of a blue bouncing ball around the screen. The system was moved to the testing location of each individual.

For *Task 1* where participants viewed images of natural scenes (Figure 1a) colour photographs were taken using a Nikon CoolPix 4100 digital camera. Adobe Photoshop was subsequently used to convert the images to greyscale. Each image was standardised to 640 by 480 pixels with a total of 20 different images being used. Example scenes included a harbour with boats, views from a skyscraper, mountains behind as village and waves crashing onto a beach. Half the images were then manipulated to add an 'incongruent' object (a small face) to them. The term 'incongruent' refers to the fact that the item is inserted in the image in a manner in which it would not typically occur (see Underwood & Foulsham, 2005). This is made clearer in Figure 1a. The location of the embedded face was dispersed around the image (e.g. not all appearing on the left, right or in the centre). The face had previously been edited from a different picture and appeared in greyscale, with each scene containing a face of a different identity and faces looking in various different directions (e.g. not directly ahead at the viewer; for an example see Figure 1a). Due to the nature of the different scene stimuli and the faces being used, the size of the embedded faces was not standardised and varied across scenes, the size of embedded faces ranged from 54 x 64 pixels to 65 x 71 pixels.

Participants viewed each scene for 5 seconds with the order of presentation randomised across the 20 images. Half the images contained the hidden embedded face whilst half contained no face. Each image was separated by a 1 second blank screen. The participant was instructed to 'look at each picture for as long as it remains on screen'. For later analyses areas of interest (AOI) were designated to regions of each image containing an embedded face. AOI were designated to the 'face' region and the 'whole' scene. The 'face' AOI was defined using the

Tobii Studio AOI tool to follow the outline of the hidden face. The 'whole' scene AOI was defined using the Tobii Studio AOI tool to draw a rectangle encompassing the whole image.

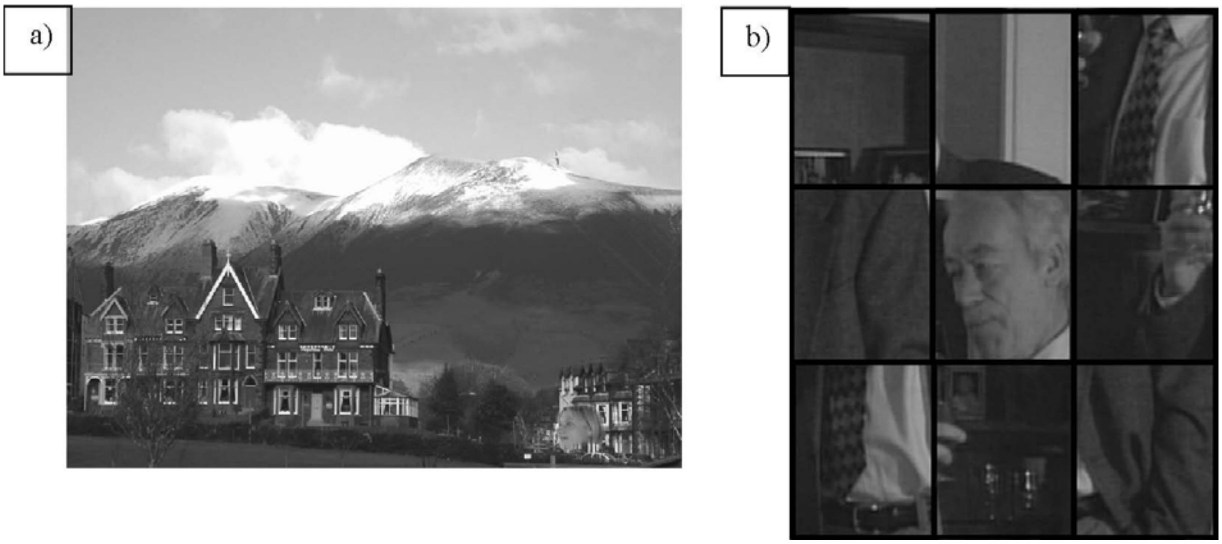

Figure 1. Task examples from a) scenes with embedded faces and b) scrambled pictures.

For *Task 2*, where participants viewed scrambled images, the stimuli were modified versions of those previously used in a face search task with typical adults by Lewis and Edmunds (2005). For the current purposes 9 scrambled scenes (see Figure 1b) were used and modified to show the face of the characters appearing once in each of nine possible location squares (e.g. each square seen in Figure 1b). An additional 9 scenes with faces omitted (created by Lewis & Edmunds, 2005) were used as a 'no face' condition. Due to the nature of the stimuli (see Figure 1b) each face was the same size across trials, as it was contained in one of the 9 equally-sized squares. Each face square measured 180 x 230 pixels. The scrambled pictures showed characters in a range of situations and were created to identify the unique attention capturing aspect of faces (Lewis & Edmunds, 2005). Our participants were questioned after the session to determine whether they recognised any of the people in the pictures; none did.

Participants viewed each scene for 5 seconds with the order of presentation randomised across the 18 images. Half the images contained a character's face whilst half contained no face. Each image measured 289 by 360 pixels in size. Participants viewed all 18 images in a random order with each trial separated by a 1 second blank screen. The participant was instructed to 'look at each picture for as long as it remains on screen'. For later analyses relevant AOI were designated to the pictures. AOI were selected for the 'face' region and the 'whole' scene. The 'face' AOI was designated using the Tobii Studio AOI tool to outline the square containing a face. The 'whole' scene AOI was defined using the Tobii Studio AOI tool to draw a rectangle encompassing the whole picture.

Procedure

Participants completed these tasks during research utilising a number of different eye-tracking assessments. The whole session lasted approximately 15 minutes. The participant was tested in their own home or at school in a quiet setting. At commencement, the participant was seated approximately 50 centimetres from the eye-tracking screen with the experimenter sitting beside them to control the computer but not interfere with viewing behaviour. They would see different types of pictures during the session and calibrating the eye-tracker was completed first. If the calibration process failed or the participant was unable to comply with task demands they were removed from the study (3 participants with autism, 4 participants with WS as detailed in the participants section). Following calibration, the order of eye-tracking tasks was counterbalanced across participants. At task completion the participant was debriefed.

Results

The gaze behaviour of participants in the autism and WS groups was compared with that of their respective comparison groups; the autism and WS groups cannot be directly compared due to differing ages and abilities and we were specifically interested in exploring the typicality of gaze behaviours associated with the groups. The AOIs previously designated to each image were utilised to identify where the participant was looking when viewing the pictures. The analyses focused on fixation length within AOI and time to first fixation within the face AOI across participant groups. Correlation analyses explored the relationship between chronological age, nonverbal ability, and where appropriate level of functioning on the autistic spectrum, in relation to gaze behaviour towards faces. We specifically focused on the relationship between face gaze length and these measures of participant characteristics as face gaze length has previously been used as the outcome measure of previous research (e.g. Klin et al., 2002b; Speer et al., 2007). Some caution is warranted due to relatively small sample sizes used for the correlation analyses.

Task 1: Detecting an embedded face

Autism.

Two participants with autism did not fixate on any of the hidden faces and therefore the data reported here focus on the performance of the remaining 22 participants with autism and their matched comparisons of typically developing individuals[2]. Overall, participants were able to view each image on screen for 5 seconds and the amount of time spent fixating on the whole scene did not vary between groups (p=.29; autism 4300msec, sd 386msec; TD 4872msec, sd 792msec) therefore the analyses reported here are not related to any differences in overall viewing time or attention to the stimuli as a whole.

Investigating the time taken to fixate upon the hidden face revealed a significant difference between participants with and without autism (t(21)=5.93, p<.001), with those in the autism group (mean 2724msec, sd 609msec) taking significantly longer to locate the face than those in the typically developing group (mean 1553msec, sd 532msec). Once the face had been detected, participants with autism spent significantly less time fixating on it than individuals without autism (t(23)=4.31, $p<.001$; mean autism 681msec, sd 110msec; mean TD 1362msec, sd 858msec). In those scenes where a face fixation occurred it is possible to identify the average length of the fixation (dividing the time spent viewing the face by the number of fixations made to that face) for each participant. This revealed that participants with autism made significantly shorter face fixations than individuals who were developing typically (t(21)=3.97, $p<.01$). Whilst the average face fixation lasted 512msec (sd 221msec) for participants in the autism group, the average face fixation for participants without autism was 1231msec (sd 321msec). See Figure 2 for the group 'hotspots' of fixation points.

For participants with autism, Pearson correlation analyses investigated the relationship between participants characteristics (chronological age, nonverbal ability, level of functioning) in relation to the amount of time spent fixating on the face region. There was a significant negative correlation between amount of time spent fixating on the face and level of functioning on the autistic spectrum according to the CARS (r=-.80, $p<.001$). The higher the score on the CARS (greater the severity of autism) the less time participants spent fixating on the embedded face. Face gaze length was not significantly correlated with chronological age (p=.49) or nonverbal ability (p=.73). For typically developing participants there was no significant relationship between face gaze length and chronological age (p=.51) or nonverbal ability (p=.48). Across the ten face trials, the relationship between face area in pixels (due to variations between trials) and fixation length revealed no significant relationship for participants with autism (p=.62) or typically developing participants (p=.32). Participants did not fixate upon larger faces for longer than smaller faces.

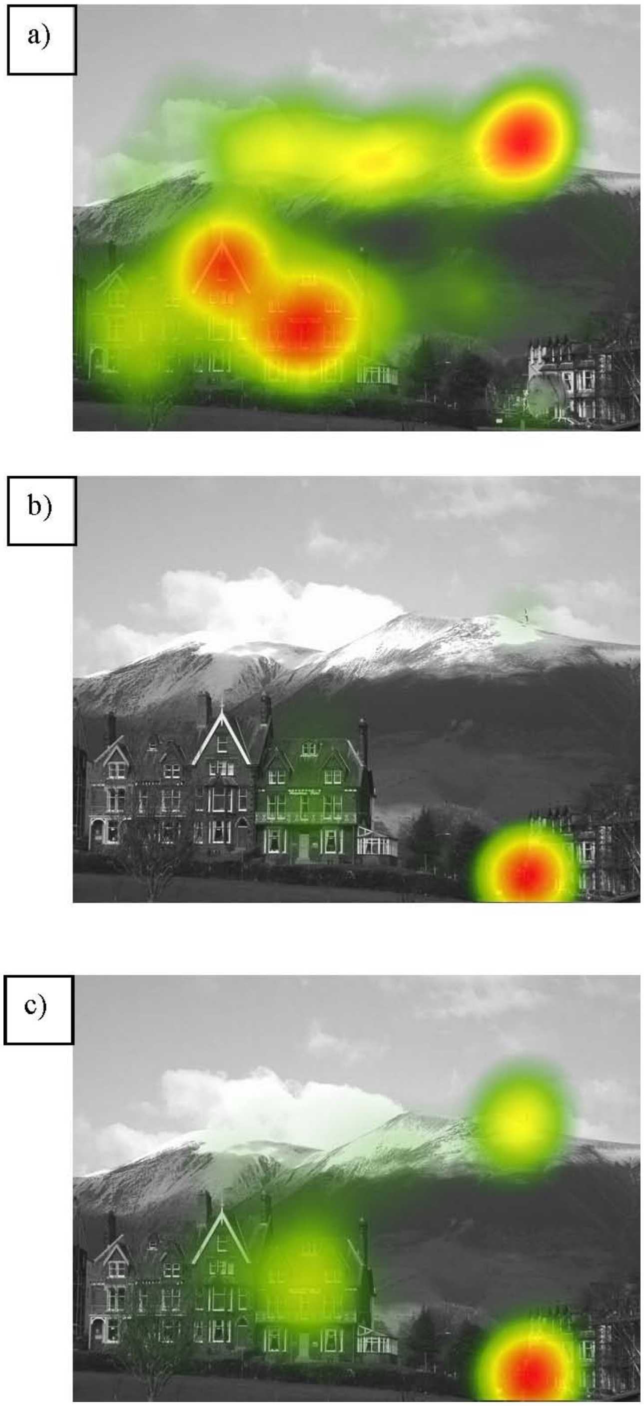

Figure 2. 'Hotspot' data to summarise the fixation patterns of participants a) with autism b) with WS c) developing typically. This trial is taken from Task 1 (see bottom right corner for face region) and hotspots represent the duration of fixation; the 'redder' the hotspot the longer the fixation.

Williams syndrome.

There was no difference between groups in the amount of time (max. 5seconds) spent viewing the scenes as individuals with WS showed a mean viewing time of 4662msec (sd 934msec) compared to 4430msec (sd 716msec) for typically developing participants (p=.18).

The time taken for participants to detect and fixate upon the hidden face showed no difference between participants with WS and those who were developing typically (p=.17, WS 1673msec, sd 328msec; TD 1344msec, 723msec). However, once the face had been located the gaze behaviour of the groups began to differ. Individuals with WS fixated upon the embedded faces for longer than participants who were developing typically (t(13)=7.72, p<.001; WS 2591msec, sd 911msec; TD 1070msec sd 591msec). When this prolonged face gaze occurred there was also a significant difference between groups in the average length of each face fixation. Individuals with WS exhibited significantly longer fixations when viewing faces, compared to participants without WS (t(13)=4.96, p<.001, WS 2073msec, sd 311msec; TD 1011msec, sd 527msec). It appears therefore that when fixating upon faces in the embedded scenes, individuals with WS exhibit atypicalities of gaze behaviour. See Figure 2 for the 'hotspots' of fixations for participants with WS.

Pearson correlation analyses investigated the relationship between participants characteristics for individuals with WS (chronological age, nonverbal ability) and the amount of time spent fixating on the face region. There was no significant correlation between chronological age and face gaze (p=.41), or nonverbal ability and face gaze (p=.63). This was mirrored for typically developing participants (chronological age p=.69; nonverbal ability p=.47). Across face trials, there was no significant relationship between face area in pixels and fixation length for participants with WS (p=.39) or typically developing participants (p=.51).

Task 2: Detecting a face in a scrambled picture

Autism.

The data reported here refer to 23 participants in each group due to additional recording difficulties for one participant with autism. Of the 5 seconds available to view each image the group with autism spent on average 4464msec (sd 822msec) looking at the pictures whilst the group of typically developing participants spent on average 4561msec (sd 912msec). There was no significant difference between groups in overall viewing duration (p=.63). See Figure 3 for an example scanpath.

On average participants with autism attended to the face square on 6.78 trials compared to 8.43 trials for participants without autism (max. 9 trials). Therefore the group with autism attended to the face square on significantly fewer trials than the group without autism (t(22)=3.69, p<.01). When a face fixation did occur, the time taken to make a first fixation on the square containing the face differed significantly between groups. Participants with autism took significantly longer to make this fixation than individuals who were developing typically (t(22)=6.18, p<.001; autism 2011msec, sd 588msec; TD 762msec, sd 114msec). As well as taking longer to fixate on the face square, individuals with autism spent significantly less time attending to the face (t(22)=7.28, p<.001). Participants with autism spent an average of 591msec (sd 211msec) attending to the face square, whilst those without autism spent an average of 1392msec (sd 722msec) viewing the same squares. When participants with autism made a face fixation, on average the length of the fixation was 345msec (sd 207msec) compared to 464msec (sd 265msec) for participants who were developing typically, a significant difference ($t(22)=3.16$, $p<.05$).

For participants with autism, Pearson correlation analyses investigated the relationship between participant characteristics (chronological age, nonverbal ability, level of functioning) and the amount of time spent fixating on the face square. There was a significant negative correlation between chronological CARS score and face gaze length ($r=-.59$, $p<.01$) meaning that participants who were higher functioning spent more time fixating upon the face square. There were no other significant correlations (chronological age p=.25; nonverbal ability p=.23). For typically developing participant neither chronological age, nor nonverbal ability were significantly correlated with the length of face gaze (chronological age p=.48, nonverbal ability p=.31).

Williams syndrome.

On average participants with WS viewed the image for 4694msec (sd 1011msec) compared to 4532msec (1558msec) for individuals without WS. There was no significant difference in overall viewing time for these images ($p=.37$). See Figure 3 for an example scanpath.

There was no difference in the number of trials on which participants with and without WS attended to face squares ($p=.15$; WS mean 8.92 trials, TD 8.36 trials; max. 9 trials). When face fixations occurred there was no difference between groups in the time taken to make an initial fixation on the face square ($p=.43$; WS 1133msec, sd 623msec; TD 1011msec, sd 821msec). However, once the face was fixated, participants with WS spent significantly longer viewing the face square ($t(13)=18.11$, $p<.001$; WS 3200 msec, sd 775msec; TD 1282msec, 823msec). There was also a difference in the average length of the face fixations, with prolonged fixations for participants with WS (803msec, sd 322msec) compared to those without WS (414msec, sd 166msec; $t(13)=4.45$, $p<.01$).

For participants with WS there was no significant correlation between chronological age and the length of gaze fixation to the face square (p=.51) or nonverbal ability and face gaze length (p=.24). For typically developing participants the same pattern was evident (chronological age p=.51; nonverbal ability p=.30).

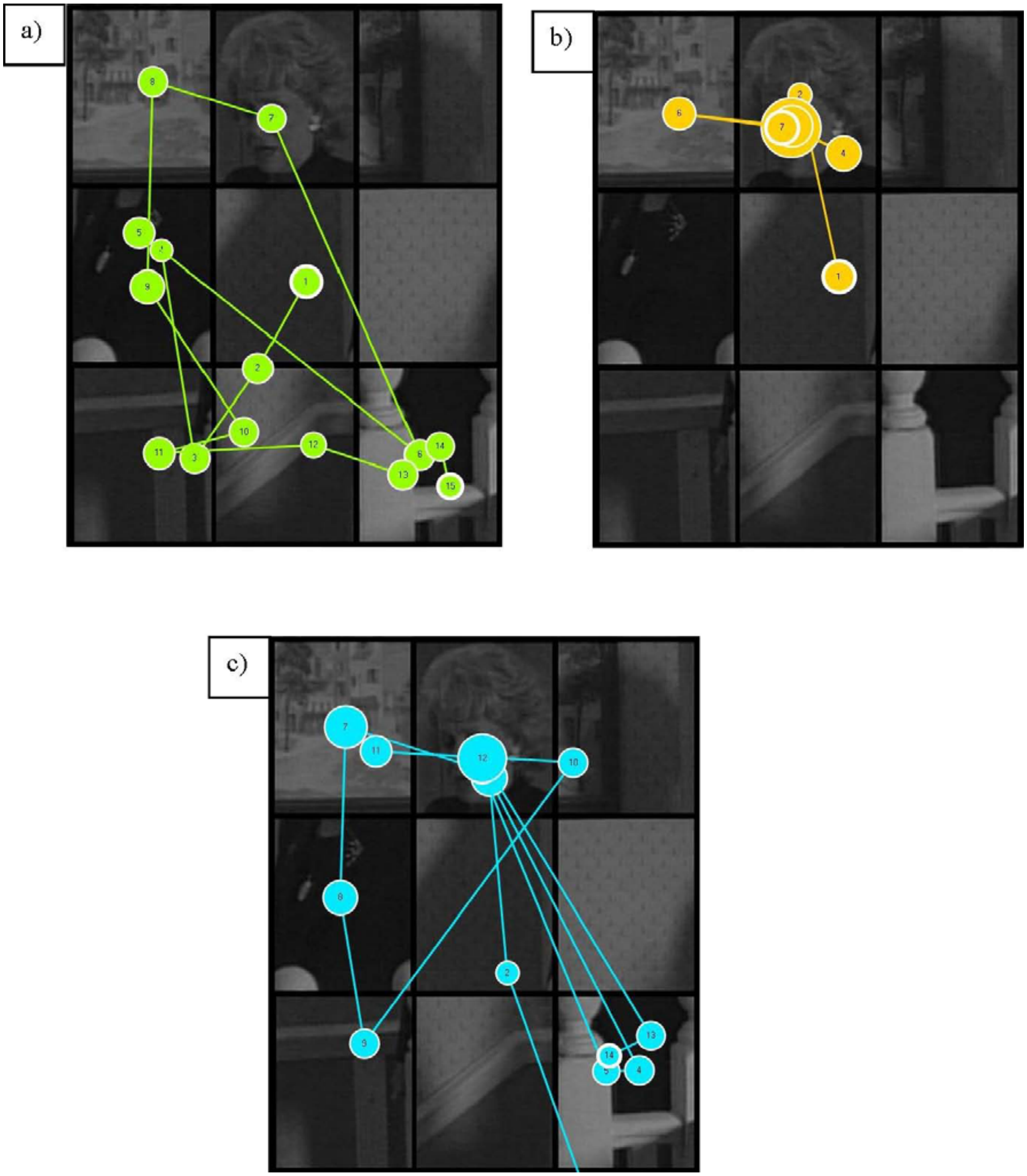

Figure 3. Example scanpaths for one participant with a) autism b) Williams syndrome and c) who is developing typically for Task 2.

Discussion

The current results emphasise the nature of face-capture for individuals with WS and autism in comparison with those who are developing typically. Due to the attention capturing effect of faces in our everyday environment (Theeuwes & van der Stigchel, 2006; Lewis & Edmunds,

2005) it was hypothesised that typically developing participants would detect and fixate upon faces shown in the two tasks. Indeed, typically developing participants did detect and fixate towards the faces in both tasks and data from the participants who were developing typically provide support for the notion that faces capture attention. However, we were particularly interested in gaze behaviour of individuals with WS and autism, two neuro-developmental disorders associated with atypicalities of social behaviour, face perception and gaze behaviour (e.g. Brock, Einav & Riby, 2008; Riby & Hancock, 2008; Klin et al., 2002). Across the tasks used here individuals with both WS and autism exhibited atypicalities of gaze behaviour and the way that faces captured and held visual attention. Explicitly, individuals with autism showed dramatically less face gaze with shorter face fixations, whilst individuals with WS exhibited prolonged face fixations and face gaze across tasks. We noted in the results section that our WS and autism groups could not be directly compared: thus if both had shown reduced face-viewing, it would not be possible to say which disorder of development has the greater effect upon face gaze. However, the difference is in opposite directions, with each differing significantly from their matched comparison groups, so it is safe to say that there is a difference in the way that faces do, or do not, capture attention between the two groups. The fact that overall attention to the stimuli did not differ between groups, but face gaze length did differ, means that attention to the scene background and the distribution of gaze throughout the whole stimuli differed for individuals who were developing typically and those with autism and WS. A natural tendency towards increased or decreased face gaze and the atypical allocation of attention, will have a large impact upon access to social cues during development and subsequently will impact upon the learning of appropriate social behaviours and socio-communicative abilities.

The current research provides further evidence for the suggestion that faces do not capture the attention of individuals with autism in a typical manner, mirroring eye-tracking evidence from tasks involving social scenes containing people (e.g. Riby & Hancock, 2008) and movie extracts (Klin et al., 2002b; Speer et al., 2007; Riby & Hancock, submitted). Differences between the current study and previous reports of 'typical' face scanning in autism are likely to be created by task instruction differences (e.g. Bar-Haim et al., 2006) and the use of real people (rather than drawings; van der Geest et al., 2002b). The results do not corroborate behavioural evidence of Fletcher-Watson, Leekam, Findlay and Stanton (2008) who found that individuals with high functioning autism showed typical allocation of attention in a social scene change blindness task. It could be proposed that eye-tracking techniques are of benefit here for identifying subtle atypicalities in the allocation of attention that are not captured by behavioural tasks. Additionally participant characteristics are important as individuals in the research by Fletcher-Watson and colleagues were 'high functioning' on the autism spectrum and those participating the current research were relatively less able. The significant negative correlation between the length of face gaze and score on the CARS (level of functioning on the autistic spectrum) emphasises that individuals who are relatively more able demonstrate increased face gaze compared to those who are relatively less able. This finding corroborates previous evidence from studies of face gaze (e.g. Klin et al., 2002b; Speer et al., 2007; Riby & Hancock, submitted) and explorations of face perception abilities in relation to level of functioning (Riby et al., 2008b). This finding is also likely to be implicated in the differences between the current findings and those of Fletcher-Watson and colleagues. Methodological procedures and participant characteristics are therefore particularly important when comparing across tasks.

If individuals with autism spend less time than is typical viewing faces from an early age it is likely that they will have less opportunity to perfect skills of social communication that are derived from face signals. If the current results extend to earlier in infancy and early childhood the implications for development (particularly related to social cognition) will be widespread. For the ages studied here there was no significant relationship between chronological age and face gaze in the current sample, implying that the pattern evident in the current results is likely to remain constant (in so far as we can tell from the age range tested). The fact that Task 1 (using embedded faces) showed that the 'incongruent' face item did not capture the attention of individuals with autism implies that this group show a range of atypicalities of visual attention and perception, not only face-specific behaviour but more generally in the way that they attend to pictures. The inclusion of an additional non-face task that probes the same issues as these face tasks would be particularly useful here. Typically developing individuals have been shown to fixate upon 'incongruent' objects in a scene picture as they capture attention (e.g. Loftus & Mackworth, 1978). However individuals with autism do not exhibit this facet of performance in the current task, differing from those who are developing typically and participants with WS. This difference between groups is particularly important as it emphasises that the effect is autism-specific, rather than an aspect of the stimuli in use. It has previously been proposed that individuals with autism engage in different attention and perception mechanisms when viewing a variety of different types of visual stimuli (Behrmann, Thomas & Humphreys, 2006) and indeed the current results suggest that atypical attention mechanisms may be guiding behaviour in this task exploring attention to faces. Previous research has emphasised a link between task difficulty and gaze behaviour, in that difficult tasks rely on longer fixations (e.g. Pollatsek, Rayner, & Balota, 1986; Jacobs, 1986; Hooge & Erkelens, 1996), however individuals with autism show shorter fixations to faces than is typical. We propose that this is unlikely to be evidence of greater proficiency interpreting face information and more likely to be related to a level of disinterest or inattention for individuals with autism. Further work is required to explore the relationship between fixation length and processing difficulty for this population.

A very different story is evident for participants with WS, for whom faces capture attention in a typical manner. Note that, such differences as there are between the WS group and their matched comparisons are in the direction of the WS group being slower to find the face in both studies. There is therefore no evidence here of enhanced face-finding in the WS group. However, once a face has captured the attention of an individual with WS atypicalities of gaze behaviour occur; evidenced by prolonged face fixations as well as exaggerated face gaze. Evidence that individuals with WS spend longer than typical looking at faces provides empirical support to observational evidence (Mervis et al., 2003), interview evidence (Doherty-Sneddon et al., submitted) as well as eye-tracking tasks (Riby & Hancock, 2008; Riby & Hancock, submitted). The length of face fixations needs to be explored further, with greater emphasis on the attention mechanisms being employed by individuals with WS. With previous research linking differences of fixation length to task complexity and difficulty (e.g. Pollatsek et al., 1986; Jacobs, 1986; Hooge & Erkelens, 1996) future research must explore the relationship between fixation length and the ability to decipher information from faces in more detail.

Research concerning attention mechanisms used by individuals with WS has emphasised that toddlers with the disorder show atypicalities of attention disengagement using a range of stimuli (e.g. Cornish, et al., 2007; Scerif, et al., 2004; Brown et al., 2003). Porter et al. (2007) suggest that individuals with WS exhibit deficits of frontal lobe inhibition with an inability to inhibit socially salient information. The current results suggest that the way that faces capture the attention of individuals with WS is typical, and support the notion that it is attention disengagement difficulties that are central to the prolonged face gaze shown by individuals with WS (e.g. Mervis et al., 2003). In both tasks there was a lack of scene scanning (evident by reduced time spent fixating on non-face regions of scenes) by individuals with WS (see Figure 2b) suggesting that once the face was fixated upon, individuals with the disorder did not disengage from this to view other aspects of the picture (Figure 3b). Further research regarding attention mechanisms (for face and non-face stimuli) is required to understand whether attention to wider aspects of socially relevant information is atypical in WS.

The performance of participants who are developing typically is also of interest for the present research. As noted, typically developing individuals have previously been shown to fixate upon ‘incongruent’ objects in a scene picture (e.g. Loftus & Mackworth, 1978). Indeed the children who participated in the current study replicate this finding by detecting and fixating upon the incongruent faces (Task 1). However in both tasks it is unlikely that the evidence supports the notion that faces ‘pop out’ or that they are processed pre-attentively due to the time to first face fixation. For Task 1 it took typically developing participants on average over 1000msec to fixate upon the faces, suggesting that they are not processed pre-attentively but that attention is directed to this region in a systematic manner (see Palermo & Rhodes, 2007). Therefore for the participants tested here faces did capture attention across tasks but further research is warranted to understand the role of attention allocation in this process.

In summary, the current study emphasises that individuals with WS and autism exhibit atypicalities of face-capture and attention to face information when it is presented in a range of stimuli. Eye-tracking evidence suggests that faces are not viewed in a typical manner and gaze behaviour differs from that shown by individuals who are developing typically. The use of eye-tracking techniques alongside behavioural tasks would be particularly beneficial in identifying the link between attending to socially relevant information and utilising this information during social interactions for individuals with both WS and autism.

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Footnote

1. Note that no participants received a negative FISH test. When the two participants who were diagnosed phenotypically, but not genetically, were removed from the analysis there was no change in the reported results pattern.

2. It is not ideal to remove these participants from the analysis; however, taking an alternative approach and inserting the maximum time allowed to view each image (5000msec) for each trial would skew the data and exaggerate group differences reported here, whilst rendering the interpretation less meaningful.