Research Note:
Viewing it differently: Social scene perception in Williams syndrome and Autism

Deborah M Riby
School of Psychology
Newcastle University

Peter J B Hancock
Department of Psychology
Stirling University

Correspondence: Dr. Deborah M Riby, School of Psychology, Newcastle University, Ridley Building 1, Framlington Place, Newcastle upon Tyne, NE1 7RU, UK
Tel: +44 (0)191 222 6557 Fax: +44 (0)191 222 5622 Email: D.M.Riby@newcastle.ac.uk

Abstract

The genetic disorder Williams syndrome (WS) is associated with a propulsion towards social stimuli and interactions with people. In contrast, the neuro-developmental disorder autism is characterised by social withdrawal and lack of interest in socially relevant information. Using eye-tracking techniques we investigate how individuals with these two neuro-developmental disorders associated with distinct social characteristics view scenes containing people. The way individuals with these disorders view social stimuli may impact upon successful social interactions and communication. Whilst individuals with autism spend less time than is typical viewing people and faces in static pictures of social interactions, the opposite is apparent for those with WS whereby exaggerated fixations are prevalent towards the eyes. The results suggest more attention should be drawn towards understanding the implications of atypical social preferences in WS, in the same way that attention has been drawn to the social deficits associated with autism.

Keywords: Eye-tracking, Williams syndrome, autism, social cognition

1.   Introduction

Autism and Williams syndrome (WS) are neuro-developmental disorders associated with distinct social characteristics. These two disorders present noticeably different phenotypes that when studied together can advance our understanding of numerous aspects of behaviour and cognition (Tager-Flusberg, Plesa Skwerer, & Joseph, 2006). Individuals with the spectral disorder of autism are typically characterised by social withdrawal and isolation (Frith, 1989), whereas those with the rare genetic disorder WS exhibit very different behaviours typified by hyper-sociability (Jones et al., 2000), a 'pro-social' drive (Frigerio et al., 2006) and an inability to inhibit social responses (Porter, Coltheart, & Langdon, 2007). Whilst previous research has used eye-tracking to investigate social attention and preferences of individuals with autism, the current study is the first to involve individuals with WS and investigate the unique profile of social gaze across these two neuro-developmental disorders. Both populations have been linked to atypicalities of the 'social brain' (Johnson, 2005) and the structures involved in processing emotional and socially relevant information (e.g. amygdala structure and functioning, Grelotti, Gauthier & Schultz, 2002; Jawaid, Schmolck, & Schulz, in press). It is likely that there are complex interactions between amygdala abnormalities and social behaviours in these groups that are evident by their divergence of social cognition skills (cf. Tager-Flusberg et al., 2006). Social cognition encompasses wide ranging abilities including interpreting social cues, communication, interactions and social referencing that are sub-served by a complex distributed neural system (e.g. Amodio & Frith, 2006). Here, we use eye tracking techniques to explore how individuals with autism and WS view socially relevant pictures, which may link to reported abnormalities of social brain functions and provide insight into how reported social cognition differences relate to the way individuals direct their attention to socially relevant information.

Using pictures showing people (and specifically faces) within social scenes, research has concluded that individuals with autism exhibit a lack of interest in socially relevant information. They fail to orient towards socially relevant cues such as faces in a way that dissociates them from individuals without autism (Sasson et al., 2007). When watching movies showing an intense or argumentative interaction between characters, individuals with autism look less frequently than typically developing individuals at the eyes of characters and spend significantly more time viewing mouths and bodies as well as non-social objects (Klin, Jones, Schultz, Volkmar, & Cohen, 2002b). These results are consistent with studies using isolated face stimuli, finding that individuals with autism spend significantly less time fixated on the eyes (Dalton et al., 2005; Pelphrey et al., 2002). However, stimulus characteristics play a central role in fixation patterns, with differences between fixations towards drawings, photographs, isolated faces and movie clips (van der Geest, Kemner, Camfferman, Verbaten, & van Engeland., 2002a; Speer, Cook, McMahon, & Clark, 2007) such that reducing ecological validity impacts upon results (see Smilek, Birmingham, Cameron, Bischof, & Kingstone, 2006 in relation to 'cognitive ethology' when discussing the issue of ecological validity in eye-tracking research). In the current paper the term ecological validity refers to how well the stimuli mirror realistic social information. Utilising isolated face images without context, or cartoon drawings of people, is less realistic with respect to natural social information, compared to photographic or movie images of humans engaged in social interactions (see Birmingham, Bischof & Kingstone, 2007). Differences in the nature of stimuli, for example comparing cartoon images versus photographs, or isolated faces versus faces within a social scene, may be particularly important when associating visual fixation patterns with social cognition and understanding. Research using drawings containing two-dimensional, disproportionate representations of people (thus reduced ecological validity) did not show atypical gaze patterns for individuals with autism (van der Geest et al., 2002a). The

data reported here records gaze fixation durations when individuals view photographic images of social scenes containing human actors. A range of social situations will be shown to mirror a range of interactions; for example a family at a dining table, a classroom of children, or a group of friends chatting.

Atypicalities in perceiving natural social information are closely related to the social interaction profiles observed in autism (Joseph & Tager-Flusberg, 2004) and the same association may be evident for the genetic disorder WS. The hyper-social drive evident in WS (e.g. Jones et al., 2000) is manifested in observable characteristics: abnormally high ratings of friendliness for unfamiliar faces (Jones et al., 2000), using unusual parts of unfamiliar faces (internal features) to make judgments regarding identity (Riby, Doherty-Sneddon, & Bruce, 2008a) and prolonged face gaze (Mervis et al., 2003). Recent research has linked such characteristics to frontal lobe dysfunction and the inability to inhibit responses to social information (Porter et al., 2007). Equally, social behaviours may be linked to atypicalities of brain regions associated with social functioning such as the amygdala (e.g. Meyer-Lindenberg et al., 2005; Jawaid et al., in press) and therefore direct comparisons of social behaviours in WS and autism (also associated with atypical amygdala regulation) have been proposed and may advance the study of social neuroscience (Tager-Flusberg et al., 2006). The current paper includes the two neuro-developmental disorders to explore possible differences of social interests and attention.

Boraston and Blakemore (2007) emphasise the strength of eye-tracking for 'closing the gulf' between abilities on cognitive tasks and everyday social skills (p.895). Therefore, with the aim of consolidating our understanding of social scene viewing preferences in these two neuro-developmental disorders that are valuable to unearthing aspects of social cognition (Tager-Flusberg et al., 2006), we presented individuals with autism and WS pictures of social scenes and monitored gaze durations. It was hypothesised that group membership (specifically the presence of a specific neuro-developmental disorder) would be associated with viewing patterns and with this hypothesis in mind, group differences in fixation duration patterns were explored. Based on previous research we propose that individuals with autism will spend less time than is typical viewing actors' faces. Given evidence of difficulties interpreting information from the eye region and using the upper face region (e.g. Langdell, 1978; Riby, Doherty-Sneddon, & Bruce, in press) we also propose that individuals with autism will spend less time than their comparison groups engaged in eye-viewing. Individuals with WS are predicted to spend significantly longer than the comparison groups viewing actors' faces, given evidence of prolonged face gaze (Mervis et al., 2003). It is also proposed that they will engage in prolonged fixation towards the eyes that may link to a relative strength using information from this region compared to other related face skills (e.g. Riby, Doherty-Sneddon & Bruce, 2008b; Riby et al., in press). It is proposed that an interesting dissociation will be apparent between individuals with WS and autism that provides empirical support for evidence of divergent social interests as well as social skills.

2.   Method

2.1   Participants

Eighteen participants with Williams syndrome were recruited via the Williams syndrome Foundation. All participants were diagnosed phenotypically by clinicians and 14 had previously had their diagnosis confirmed with positive FISH testing. Two individuals had to be removed due to eye-tracking calibration difficulties, thus the final sample consisted of 16

participants with WS between the ages 8 years 9 months and 28 years 0 months (mean 17 years 6 months; positive FISH testing 14/16; see Table 1).

Participants with WS were individually matched to a typically developing individual of comparable chronological age (CA) to account for life experience and to another typically developing individual of comparable nonverbal ability (NV). Typically developing participants were recruited from local schools and pre-schools. At the recruitment stage teachers completed the Strengths and Difficulties Questionnaire (Goodman, 2001). This short screening questionnaire requires teachers to score each individual on emotional symptoms, conduct, hyperactivity, peer relationships and pro-social behaviour. All typically developing participants scored within the 'normal' range for the total difficulties score (scoring between 0-11). The chronological age matched group of typically developing children ranged between 8 years 10 months and 28 years 0 months (mean 17 years 6 months; difference between groups on chronological age $p=.98$). The nonverbal ability group was matched using scores on the Ravens Coloured Progressive Matrices task (RCPM; Raven, Court, & Raven, 1990). The group with WS scored between 8 and 24 (mean 16; max score 36) and the typically developing group scored between 8 and 25 (mean 17, difference between groups on RCPM score $p=.78$).

Table 1: Participant demographic data (standard deviation in parenthesis)

Group	N	Gender M:F[1]	CA[2]	RCPM[3]
Autism	20	15:5	13:04 (48m)	13 (4)
CA match	20	14:6	13:03 (48m)	25 (6)
NV match	20	13:7	5:03 (17m)	13 (3)
WS	16	11:5	17:06 (76m)	16 (5)
CA match	16	10:6	17:06 (75m)	29 (4)
NV match	16	11:5	7:06 (48m)	17 (6)

1. Gender ratio is the number of males : number of females in the group
2. CA is shown as years : months (standard deviation in full calendar months)
3. RCPM is shown as the raw score out of 36

Twenty-six participants with autism were recruited through schools (special educational needs units attached to mainstream schools and specialised schools). All participants had previously been diagnosed by clinicians and satisfied the diagnostic criteria for autism according to the DSM-IV (APA, 1994) and when completed by teachers, the Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Rocher Renner, 1988) classified 15 children as mild-moderately autistic and 11 children as severely autistic. No participant scored outside the autistic range when assessed using the CARS (scores ranged 32 to 54). Due to task compliance difficulties and eye-tracking calibration requirements, 6 participants were removed from the sample (1 mild-moderately autistic, 5 severely autistic) and the final sample comprised 20 individuals aged 6 years 4 months to 18 years 4 months (mean 13 years 4 months; see Table 1). Participants with autism were individually matched to two typically developing individuals of i) comparable chronological age and ii) nonverbal ability. The chronological age matched group ranged between 6 years 2 months and 18 years 8 months (mean 13 years 3 months; difference between groups $p=.89$). For nonverbal ability, using the

RCPM, the group with autism scored between 7 and 20 (mean 13) and the typically developing group also scored between 7 and 20 (mean 13, difference between groups *p*=.59). Informed consent and ethical approval were received prior to the research.

2.2   *Materials*

Colour photographs were taken of a range of social settings involving human actors using a Nikon CoolPix 4100 digital camera. The number of characters (up to four) and their position on screen varied across items. Example scenes included a mother and daughter sharing a meal, a group of teenage friends chatting, a bride and groom on their wedding day (see Figure 1) and work colleagues discussing information. In all scenes the actors were engaged in natural activities and were not purposefully directing their attention towards to viewer. They were not engaged in intense or argumentative interactions but showed a range of natural expressions of emotion relevant to the scene. Participants saw 20 scenes containing actors with 5 randomly presented filler scenes containing no actor. All images were standardised to 640 by 480 pixels using Adobe Photoshop CS.

Participants' gaze behaviour was recorded using a Tobii 1750 eye-tracking screen run by ClearView 2.5.1. 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 is portable and was moved to the testing location of each individual. 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.

To investigate fixations to specific regions, areas of interest (AOI) were designated to the face, body and background. To further investigate fixations to the face region AOI were designated to the eyes and mouth. The AOI 'face' was marked using the ClearView AOI 'definition tool' with an oval shape covering the face region with a boundary at the hairline. The 'body' AOI was defined by the outline of the body region (excluding the face), this was marked by following the outline of the character. 'Background' was calculated by marking the outline of the complete picture and measuring fixations to the whole image, then at the point of analysis removing the fixation data directed towards any characters. Finally, areas of interest for the 'eyes' and 'mouth' were defined using the rectangular AOI 'definition tool' to define regions covering eyes or mouth.

2.3   *Procedure*

Participants were tested individually in their home or at school and this study took place within a session containing other eye-tracking tasks. The whole session lasted approximately 15 minutes. Participants were 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. The participant was told they would see different types of pictures during the session and the first eye-tracking task involved calibration of the eye tracker. At this point if the calibration process failed or the participant was unable to comply with task demands they were removed from the study (6 participants with autism, 2 participants with WS and 5 participants who were developing typically). Following calibration, participants viewed the social scene stimuli. They were asked to look at the pictures whilst they were on screen and no further instruction was provided. Images were presented for 5 seconds and

were separated by a white screen for 1 second. At task completion the participant was debriefed.

(a)
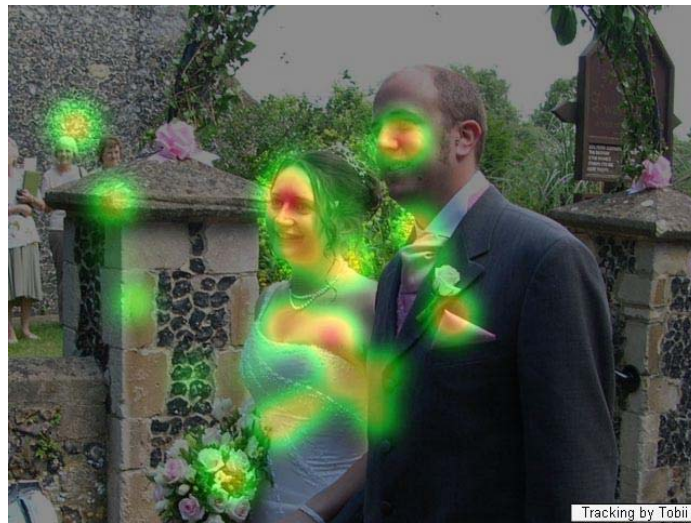
(b)
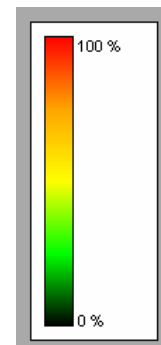
(c)

Figure 1: Fixation duration as a function of group membership. Hotspots represent the relative amount of time spent fixating throughout the scene for each group (a) typically developing children (b) autism (c) WS.

## 3.	Results

There was no overall difference in the time spent viewing the social scenes between participants with WS and their comparison groups ($p=.56$; WS 3176 msec, NV 3224 msec, CA 2811 msec) or participants with autism and their comparisons ($p=.48$; Autism 2848 msec, NV 3205 msec, CA 3094 msec). Therefore the groups engaged in the task for comparable lengths of time. To each area of interest (AOI) the duration of gaze fixation was calculated across participants using ClearView 2.5.1.
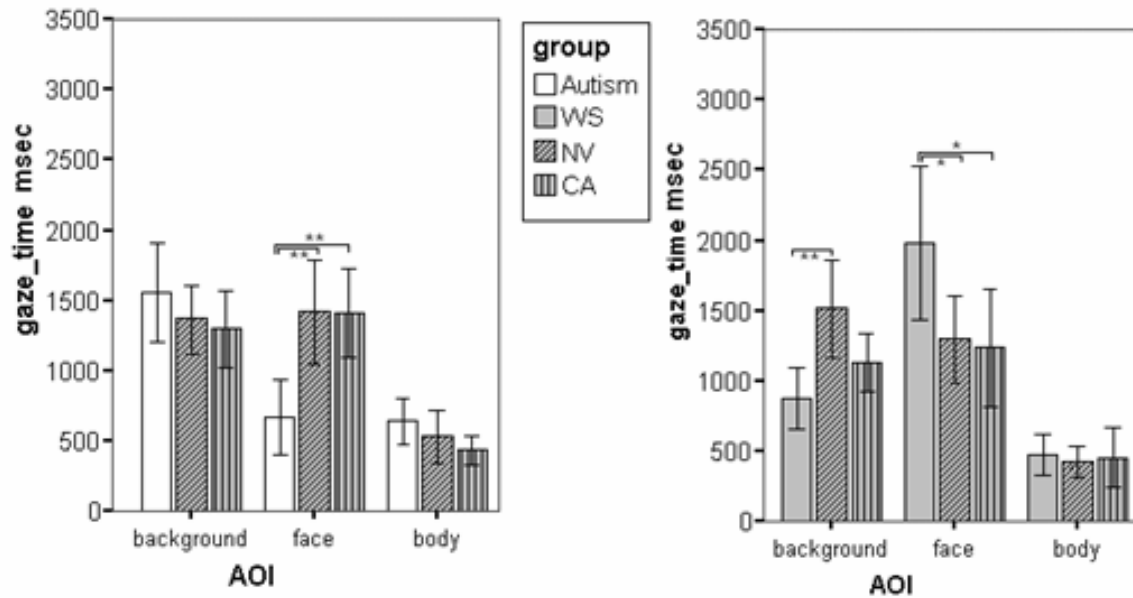

Figure 2: Gaze fixation duration to defined areas of interest as a function of group membership for autism and their matched comparisons (left) and for WS and their comparisons (right). NV: matched for non-verbal ability; CA: chronological age. * indicates $p<.05$ whilst ** indicates $p<.01$.

### 3.1	Williams syndrome

An ANOVA with factors AOI (background, face, body) and Group (WS, NV, CA) was applied to gaze fixation durations. Although there was no effect of Group ($p=.40$) there was an effect of AOI ($F(2,90)=48.27$, $p<.001$) and an interaction between factors ($F(4,90)=7.01$, $p<.001$). Groups did not differ for viewing duration towards actors' bodies ($p=.90$) but did differ for gaze durations to the background ($F(2,47)=6.93$, $p<.01$) and face regions ($F(2,47)=4.15$, $p<.05$). The WS group viewed the face region significantly longer than either comparison group (WS-NV $t(15)=2.58$, $p<.05$; WS-CA $t(15)=2.25$, $p<.05$) but viewed the background less than the NV group ($t(15)=3.38$, $p<.01$) and comparable in duration to the CA group ($p=.15$). See Figures 1 & 2.

The proportion of face gaze directed to the eye and mouth regions was calculated and an ANOVA was conducted with factors Group (WS, NV, CA) and Feature (eye, mouth). There were significant effects of Group ($F(2,45)=6.31$, $p<.01$) and Feature ($F(1,45)=98.20$, $p<.001$) and an interaction between factors ($F(2,45)=5.07$, $p=.01$). Groups differed in the proportion of time spent viewing the eyes ($F(2,47)=6.51$, $p<.01$; WS 0.58, NV 0.38, CA 0.36) but not the mouth ($p=.51$; WS 0.07, NV 0.11, CA 0.09). Group differences viewing the eyes were driven

by prolonged fixations by participants with WS (WS-NV $t(15)=3.08$, $p<.01$, WS-CA $t(15)=4.29$, $p<.01$).

3.2   Autism

An ANOVA with factors AOI (background, face, body) and Group (Autism, NV, CA) was conducted for gaze fixation durations. There was no effect of Group ($p=.48$) but an effect of AOI ($F(2,114)=51.04$, $p<.001$) and an interaction between factors ($F(4,114)=8.22$, $p<.001$). Groups did not differ in time spent viewing the background ($p=.40$) or characters' bodies ($p=.19$) but differed for gaze durations to actor's faces ($F(2,59)=4.14$, $p<.05$). Individuals with autism spent significantly less time than either comparison group viewing actor's faces (A-NV $t(19)=3.34$, $p<.01$, A-CA $t(19)=3.96$, $p<.01$). See Figures 1 & 2.

The proportion of face gaze directed towards the eye and mouth regions was calculated and an ANOVA was conducted with factors Group (Autism, NV, CA) and Feature (eye, mouth). There was an effect of Group ($F(2,57)=14.00$, $p<.001$) and Feature ($F(1,57)=29.78$, $p<.001$) and an interaction between factors ($F(2,57)=3.53$, $p<.05$). Groups did not differ in the proportion of time spent viewing the mouth ($p=.71$; A 0.11, NV 0.12, CA 0.13) but did differ for eye fixations ($F(2,59)=8.04$, $p<.01$; A 0.17, NV 0.40, CA 0.36), whereby individuals with autism spent significantly less time than either comparison group (A-NV $t(19)=4.00$, $p<.01$, A-CA $t(19)=3.29$, $p<.01$).

4.   Discussion

Corroborating previous evidence, individuals with autism exhibited grossly different viewing patterns compared to those without autism. This was also evident for individuals with WS who differed from their matched controls. However, related to divergent social phenotypes, the neuro-developmental disorder groups differed in the way they exhibited their atypicalities. Whilst individuals with autism spent significantly less time than typical viewing actors' faces, those with WS spent significantly longer than typical viewing the same region. The results suggest that subtle dissociations of sociability associated with these neuro-developmental disorders (Brock, Einav & Riby, in press) are supported by viewing preferences when faced with socially relevant information. Any visual preference / attraction of socially important information may be correlated with the ability to subsequently interpret cues of a social nature; for example directly linking to dissociations of socio-cognitive skills and face perception abilities in these groups (Riby et al., 2008b).

Importantly, this study provides the first experimental evidence to support suggestions of prolonged face gaze in WS (e.g. Mervis et al., 2003). The results pattern is further emphasised by the proportion of time spent fixating on communicative facial features; specifically the eyes. Although other facial features (such as the mouth) are central to the expression of communicative signals, the eyes provide access to mental states (Baron-Cohen, 1995) and emotional expressions (Lundqvist, Esteves, & Öhman, 1999). Whilst individuals with autism spent a significantly smaller proportion of time than typical fixating on characters' eyes (17% of face gaze time), those with WS spent significantly longer than typical fixating on the same region (58% of face gaze time). Visual attention to the eyes may be implicated in other divergent abilities in face perception, such as the interpretation of gaze cues and expressions, where individuals with WS are more proficient than those with autism (Riby et al., 2008b). It may also help to explain the striking finding that individuals with WS are better at matching unfamiliar faces from internal features (eyes, nose etc) rather than

external ones (hair, face outline), which is contrary to previous research in unfamiliar face matching (Riby et al., 2008a). Future work might consider exactly where those with WS look when performing unfamiliar face matching, to see what might be learned about how to do it better.

The underlying cause of hyper-sociability in WS remains a matter for debate. Porter et al. (2007) considered three possible explanations: poor control of behaviour, due to frontal lobe anomalies; poor emotion recognition, due to abnormal amygdala function; and heightened salience for social stimuli. Their results supported the frontal lobe hypothesis. Our data could also be seen as consistent with a poor control of behaviour explanation: prolonged eye-contact is often seen as threatening and therefore to be avoided, however individuals with WS may exhibit less control of attention when engaged in social interactions and hence hold face gaze and direct eye contact for extended periods of time. However, further work is required to examine whether such behaviour is truly an aspect of inhibitory control (an inability to direct gaze appropriately), or more closely associated with the understanding of social rules. Tasks involving executive control of attention in both social and non-social settings become important here and recent evidence suggests deficits on executive functioning and working memory tasks that provide support for attentional control problems in WS (Rhodes, Fraser, & Riby, 2008). Work with other populations has also attempted to associate abnormalities of gaze behaviour with inhibitory control in the context of schizophrenia (e.g. Katsanis & Iacono, 1991) and an elderly population (Wong, Cronin-Golomb & Neargarder, 2005). Particularly relevant here is research suggesting that individuals with schizophrenia and those with autism share similar abnormalities of gaze behaviour when assessing the emotional content of social scenes (Sasson et al., 2007). The source of these abnormalities has been linked to another commonly discussed mechanism implicated in social atypicalities; amygdala dysfunction (Sasson et al., 2007). One possible reason for atypicalities of gaze and attention towards socially threatening information in patients with schizophrenia is a lack of inhibitory influence upon the amygdala (Green & Phillips, 2004). Indeed it could be proposed that the complex relationship between the pre-frontal cortex (involved in inhibitory control) and the amygdala is particularly important in neuro-developmental disorders associated with atypicalities of both these structures. If it is possible to detangle the involvement of amygdala dysfunction in WS (Jawaid et al., in press), inhibitory control mechanisms (Porter et al., 2007) and the understanding of social rules in unearthing the nature of gaze atypicalities, such research is of direct importance. The current paper makes some headway in emphasising the exact nature of atypicalities of gaze behaviour in WS but further work must explore the underpinnings of this behaviour.

Relating back to the autism findings, the results support evidence of atypical gaze behaviour that is likely to be implicated in the range of social communication problems reported across the autistic spectrum. When placed within the context of a social scene, faces are viewed for a shorter amount of time, allowing less access to cues provided by the facial features. Although Speer and colleagues (2007) report gaze atypicalities towards only dynamic (movie) stimuli and not static pictures, we find differences even for static pictures. The visual attention of individuals with autism is distributed throughout the scene in an atypical way. The findings support evidence from static pictures of faces both in isolation and within social scenes (Dalton et al, 2005; Pelphrey et al., 2002; Sasson et al., 2007). Again the underpinnings of these observable differences in gaze behaviour remain somewhat complex. Arguments concerning the implication of amygdala as well as inhibitory deficits are widely reported (Sasson et al., 2007) in a similar manner to those arising with regarding to WS. These structures / mechanisms have become candidates for unearthing the nature of social

difficulties and when studied together autism and WS emphasise the important link between these mechanisms and social behaviours (see Tager-Flusberg et al., 2006). Whilst the current study emphasises the nature of gaze behaviour in autism, future research must explore the underlying neural mechanisms involved in these observable behaviours in a similar vein, and preferably alongside, the research exploring the underpinnings of behaviour in WS.

The eye-tracking technique used here provides important markers for atypical sociability and visual attention in two neuro-developmental disorders within one study. The data represent the first reports of atypical social scene viewing in WS and contribute to knowledge of social preferences and interests, showing extreme contrasts with autism. Both autism and WS are associated with atypicalities of the 'social brain' (Johnson, 2005) and here we see how different the implications of atypical development may be on social preferences. The term 'social brain ' is rather broad, encompassing a range of neural structures, but importantly an abundance of research emphasises the central role of the amygdala in social / emotional functioning. We hypothesise that future research will elucidate the nature of amygdala dysfunctions that are implicated in social behaviours and how these present themselves in autism and WS. Identifying the exact nature of any abnormality is critical to dis-entangling the contribution of inhibitory deficit and amygdala dysfunction, which becomes increasingly important when considering WS and autism. Although the current research is limited to emphasising the observable differences between groups, we propose that future research is dedicated to assessing the contributions of inhibitory control and amygdala dysfunction in the diverse social phenotypes presented in WS and autism. Utilising these groups together reveals the possible bi-directionality of social preferences and how atypical brain mechanisms may relate to both social withdrawal and a pro-social drive.

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