Moore, DJ, Reidy, J and Heavey, L

Attentional allocation of autism spectrum disorder individuals: Searching for a Face-in-the-Crowd.

Attentional allocation of ASD individuals: Searching for a Face-in-the-Crowd

David J. Moore, John Reidy and Lisa Heavey

Department of Psychology, Sociology and Politics,

Sheffield Hallam University

Running Header: Attentional allocation of ASD individuals

Abstract

A study is reported which tests the proposition that faces capture the attention of those with Autism Spectrum Disorders (ASD) less than a typical population. A visual search task based on the Face-in-the-Crowd paradigm was used to examine the attentional allocation of ASD adults for faces. Participants were required to search for discrepant target images from within 9-image arrays. Both participants with ASD and control participants demonstrated speeded identification of faces compared to non-face objects. This indicates that when attention is under conscious control both ASD and TD comparison adults show an attentional bias for faces, which contrasts with previous research which found an absence of an attentional bias for faces in ASD. Theoretical implications of this differentiation are discussed.

Keywords: Autism, ASD, Autism Spectrum Disorder, Faces, Attention, Social Cognition, Adults, Bias.

Contact: Email: d.j.moore@ljmu.ac.uk

Introduction

Autism Spectrum Disorder (ASD) is diagnosed based on deficits in social and communication skills as well as repetitive or restricted behavioural routines (APA, 2013). Within the social domain, face processing has been shown to be a specific problem. Individuals with ASD have been shown to have a poorer memory for faces than controls (Hauck, Fein, Maltby, Waterhouse and Feinstein, 1998; Williams, Goldstein and Minshew, 2005), and are less susceptible to the face inversion effect (Langdell, 1978; Hobson, Ouston, and Lee 1988). Overall individuals with ASD appear to be less efficient at processing facial identity, facial expressions of emotion and processing/using the eye gaze of others (for reviews see Behrmann, Thomas and Humphreys, 2006; Sasson, 2006). These studies suggest that those with ASD have not become "experts" in face processing (Grelotti, Gauthier and Schultz, 2002; Grelotti, Klin, Gauthier, Skudlarski, Cohen, Gore et al., 2005) and one possible explanation for this is that individuals with ASD do not attend to faces in the same way as typically developing (TD) individuals. Additionally these deficits persist into adulthood (Schultz et al., 2000).

The above research suggests that individuals with ASD have a deficit in processing face stimuli compared to TD individuals. In typical development it has been noted that faces are a unique class of object that hold specific biological and social significance (Carey, 1992; Grüsser and Landis, 1991). The preference that TD individuals show for social information is observable as early as a few hours old (Goren, Sarty, and Wu, 1975; Johnson and Morton, 1991). Recent research has also indicated that faces capture attention in competition with other stimuli in typical development into adulthood (Ro, Russel and Lavie, 2001; Bindemann, et al, 2007). This suggests that both in early development and in adulthood faces occupy a special place in the attentional system of the TD individual.

Johnson and Morton (1991) proposed a theoretical account to explain the development of face expertise through an attentional model. Johnson and Morton claimed that the findings of attentional bias for face shapes in infancy (Goren, Sarty and Wu, 1975) but the absence of these effects at 2 months (Maurer and Barrera, 1981) suggest a U shaped developmental curve. Johnson and Morton argue that this is best explained not by a single developmental mechanism but by two mechanisms interacting with one another. This is supported by evidence that the visual cortex moves from a subcortical to cortical system early in the child's development (Johnson, 1990a, b). Therefore, the infants' subcortical visual pathways will include basic mechanisms that cause them to orient attention to simple and easily differentiable visual information. This will later give way to more organised and 'top-down' controlled cortical orientation of attention, and this is what is observed in later adult processing. It is possible that in individuals with ASD have a difference in either the biological tendency to attend to faces, or lack the learning to attend to faces. Recent findings from Jones and Klin (2014) suggest that attention to the eyes in children who later develop ASD is the same as in TD infants at 2 months, however this reduces during development, suggesting a learning rather than biological difference.

New cognitive experimental and eye tracking literature is emerging which discusses how social information may be viewed differently by individuals with ASD. When engaging in face processing tasks, research has shown that, compared to a TD comparison group, ASD individuals have reduced fixation on the eye region (Dalton, Nacewicz, Johnstone, Schaefer, Gernsbacher, Goldsmith et al., 2005; Sterling, Dawson, Webb, Murias, Munson, Panagiotides and Aylward, 2009) and other central facial features (Pelphrey, Sasson, Reznick, Paul, Goldman and Piven, 2002). Others have examined attention to the social elements of more complex scenes. Using naturalistic film clips rich in social content, Klin, Jones, Schultz, Volkmar and Cohen (2002) found that individuals with ASD fixated less on the eye regions and more on the mouths and bodies of actors when free-viewing the scenes. Fixations on objects within the scenes were also more frequent for those with ASD than the comparison group. In a subsequent change blindness experiment Kikuchi, Senju, Tojo, Osanai and Hasegawa (2009) showed that this effect was a result of attention rather than a processing difficulty. Similarly, participants with ASD were found to show less face gaze and fixations were shorter for faces when free-viewing natural and scrambled images when compared with a TD comparison group (Riby and Hancock, 2009). However when scenes are simpler, more cartoon like or more relevant to the child with ASD no difference is observed (van der Geest, Kemner, Camferrman, Verbaten and van Engeland, 2002; Boraston and Blakemore, 2007; Gillespie-Smith, Riby, Hancock and Doherty-Sneddon, 2014). Additionally when considering simple attention towards either a person or object Fletcher-Watson, Leekam, Benson, Frank and Findlay (2009) found no difference between individuals with ASD and a TD comparison group. This distinction is made particularly clearly by Speer et al. (2007) who used eye-tracking to examine differences between ASD and control adolescents in attention to faces in isolated and social scenes which could be either static or dynamic. Findings in this study suggested that differences between the groups were selective for reduced attention to eyes and increased attention to bodies in individuals with ASD in the social dynamic scenes. For more detailed reviews see Nation and Penny (2008) and Ames and Fletcher-Watson (2010).

Although eye tracking has revealed potential differences between those with and without ASD’s in terms of social interest, this method is not without problems. While it may seem logical that the direction of a person's eyes are a direct measure of where they are attending, it has been established on a number of occasions that attention can be directed to peripheral locations within the visual field without moving the eyes from the centre of the display (e.g. Posner, 1980). Therefore, eye tracking cannot categorically tell us where in the visual field an individual is attending, only where their eyes are directed. Additionally Bar-Haim, Shulman, Lamy and Reuveni (2006) noted that although eye tracking of natural scenes is an ecologically valid method for examining social attention in ASD, this involves a great array of cognitive processes (attentional capture, feature processing context, etc) which can contribute to any observed effects. This makes it harder to identify which aspects of processing are different in individuals with ASD. To address this Bar-Haim et al. conducted a controlled cognitive-behavioural experiment using the dot probe task to examine for attentional bias differences to eyes and mouths in children with ASD and a TD comparison group. Bar-Haim et al. observed no differences between the two groups and found that both showed a significant bias for attending to the eye region.

Given these limitations of eye tracking others have also considered the use of cognitive behavioural measures of attentional allocation. Ashwin, Wheelwright and Baron-Cohen, (2006) utilised a version of the Face-in-the-Crowd task (originally devised by Hansen and Hansen, 1988) to explore attentional search for faces depicting emotional expressions. This task involved participants being presented with picture arrays of 9 line drawings depicting happy, angry or neutral faces. On some trials all pictures were the same and on others 8 were the same with one odd-one-out. Participants were instructed to indicate if all pictures were the same or if one was different. Ashwin et al. found that angry faces were located faster than happy faces amongst neutral distracters, and that both groups were slower to search through emotional distracters. Although this study suggests that ASD and TD adults both have the same emotional bias, these findings need to be considered with caution due to the use of schematic stimuli resulting in reduced ecological validity. This issue of the use of schematic face stimuli was remedied by Krysko and Rutherford (2009), who used a visual search task to examine for attentional bias for happy and angry faces using cropped photographs of real faces. The findings of this study supported Ashwin et al. and suggested that there are no differences between individuals with ASD and controls in search bias for emotional faces, with both groups showing an attentional bias for angry face stimuli. Neither of these studies can comment on the more general bias for face stimuli compared to non-face stimuli. To examine this issue Moore, Heavey and Reidy, (2012) used a visual dot probe task to examine for attentional bias to neutral face photographs compared to non-social pictures. This study found a significant bias for faces in the TD comparison group but not in ASD participants when participants were consciously aware of the stimuli. Others have also examined how faces may capture attention when they are not the targets in cognitive-behavioural tasks. Langton et al. (2008) asked TD participants to detect the presence or absence of butterfly targets in a visual search task. On 50% of trials an irrelevant face distractor was included. Findings suggested that search for butterfly targets was significantly slower when a face distractor was present compared to when there were no face distractors. Riby, Brown, Jones and Hanley (2012) replicated this study however included a population of children and adolescents with ASD. Unlike control participants individuals with ASD showed no differences in reaction times between trials with face distractors and those without face distractors.

In the present study the Face-in-the-Crowd task was used to examine attention to visual scenes containing social (faces) and non-social stimuli. This adds to the current literature by using a visual search paradigm to examine a pure face bias rather than the bias for emotional faces (i.e. Ashwin et al. 2006; Krysko and Rutherford, 2009). The Face-in-the-Crowd task explores attentional bias by examining the speed at which a discrepant image is detected in a visual display. It is reasoned that if attention is biased towards a preferred class of stimuli then this information should be detected faster in a crowd of non-preferred stimuli, than a non- preferred image within a field of preferred images. Additionally the Face-in-the-Crowd task allows for data to be analysed to examine whether any biases observed are a result of hyper-vigilance for the preferred stimuli or difficulty in disengaging from this preferred stimulus once attention has been engaged (Horstmann, Scharlau and Ansorge, 2006). The aim of the current study was to compare the ability of ASD participants with TD participants to detect social and non-social information using a Face-in-the-Crowd task. It was predicted that participants diagnosed with ASD will show a reduction in the bias for detecting facial stimuli compared to the TD participants.

Method

Participants

Nineteen high functioning adults with ASD (13 male), 17 with a diagnosis of Asperger's Syndrome and 2 with a diagnosis of autism participated in this study. Participants were recruited from support groups, educational establishments, and supported housing schemes. Participants had previously received a diagnosis of autism or Asperger's syndrome from a trained clinician based on DSM-IV criteria (APA, 2000), and symptom severity was assessed using the Autism Quotient (AQ: Baron-Cohen, Wheelwright, Skinner, Martin and Clubley, 2001). AQ scores ranged from 20-47 (Mean 32.47, SD 6.76), 17 participants with ASD had scores on the AQ greater than the threshold of 26 suggested by Woodbury-Smith, Robinson, Wheelwright and Baron-Cohen (2005). The two participants with ASD with AQ scores below this threshold were, however, retained in the study as they had received a rigorous diagnosis by trained professionals and the evidence for these diagnoses was available to the experimenter. Additionally all analyses were conducted with these participants excluded and no changes to the findings were seen. A measure of participants' full-scale IQ was obtained using the Wechsler Abbreviated Scale for Intelligence (WASI; Wechsler, 1999) this revealed that participants with ASD had an FSIQ range of 88-135 (Mean 111.79, SD 13.17).

Additionally, nineteen age, gender and FSIQ matched participants were recruited from a university participant pool, and adverts through local educational establishments. Participants were matched using a stratified group match; which involved splitting ASD participants into three sub groups based on FSIQ. All participants below an FSIQ of 100 made up one group, all those between 100 and 116 (one standard deviation above the standard mean) made up a second group and all those above 116 made up the third. Each sub group was comparable on age and gender. The overall ASD and TD comparison groups were then compared on their age, FSIQ and AQ scores using independent t-tests (for details see Table 1). These showed that the groups differed in terms of AQ scores but not in terms of IQ or age. All participants reported having normal or corrected to normal vision. All participants in the current study had previously participated in another study examining attentional bias published elsewhere (Moore, Heavey and Reidy, 2012).

[Insert Table 1 here]

Materials

A single image (image 7 file N7.JH.1C01) of a Caucasian male face was selected from Ekman and Matsumoto's (1993) Japanese and Caucasian Neutral Faces images (JACNEUF). Additionally, a single picture of one car and one house were obtained from a search of the internet. Images were prepared for presentation by removing any environment and replacing this with a white background. Cars and houses were selected as non-social stimuli as they are similar to faces in complexity, are also familiar in our environment and are also usually only seen in mono-orientation (i.e. houses and cars are similar to faces in that they are usually seen on a single orientation and rarely on their roofs). Additionally cars and houses have been used in a previous report as non-social stimuli in comparison for faces (Moore, Heavey and Reidy, 2012).

The main task in this study was a modified Face-in-the-Crowd task (Hansen and Hansen, 1988). Each participant was presented with displays of 9 pictures (in 3X3 matrices). These displays included either identical pictures, or 8 identical pictures “the crowd” with one discrepant (‘target’) picture (e.g. 8 faces and a car target). The matrices were presented in a random order with participants giving their responses using one key if all pictures were the same and another if there was an odd-one-out (8 pictures the same ‘the crowd’ and one odd-one-out) on a stimulus response box. A total of 90 trials were included in the current task, of which 54 contained a target. The 54 target present trials were made up of 9 presentations of each target (once in each position) within each of the two distracter crowds (i.e. a face was presented once in each of the 9 positions in a crowd of houses and in each of the 9 positions in a crowd of cars). Of the remaining 36 trials these consisted of 12 trials where all 9 stimuli were faces, 12 where all 9 were houses and 12 where all 9 were cars.

Images were displayed in monochrome (256 colour greyscale pallet) on a white background, and were displayed on an Iiyama, 19 inch, Vision Master 1451, CRT Monitor using e-Prime software (Schneider, Eschman and Zuccolotto, 2002). Presentation was controlled by a Viglen Genie desktop computer with a 1.7GHz Pentium 4 processor and 512Mb of RAM Images were 99 X 64 pixels in size and the edge of each image was 64 pixels from the next image (both vertically and horizontally), the outside edges of the displays were 214 pixels from the top and bottom of the screen and 219 from the left and right of the screen. Participants sat approximately 90cm from the screen, and the height of the chair and the height of the screen were altered until the participant reported that the centre of the screen was at eye level.

Procedure

Following ethics committee approval, all ASD participants who responded to advertisements regarding the research were invited to an initial screening session in which the history of their diagnosis, IQ and AQ data were collected. Participants whose IQ was greater than 85 and whose diagnosis could be confirmed were invited to a second test session in which participants completed the Face-in-the-Crowd task. Participants in the TD comparison group were also invited to the same initial screening session where checks were made to ensure they had no previous ASD diagnosis and the AQ was administered and IQ measure conducted. Once this had been undertaken these scores were used to identify if the participant made a good match for the ASD population and if so they were invited back to take part in the Face-in-the-Crowd task.

Participants were told that the experiment involved searching for the odd picture out in a display. They were then told that they would see a cross in the middle of the screen (500ms) which they should use as a fixation and that once this disappeared from the screen it would be replaced by an array of pictures (until response). Participants were instructed to press the ‘different’ key if one of the pictures was different to the others in the display, and the ‘same’ key if all pictures were the same. Participants were asked to respond as quickly and accurately as possible. After any questions were answered participants were told that they would be given 10 practice trials and that they would have to get 100% correct on these before they could advance to the main task. All participants were able to perform this task with minimal practice.

Analysis

Reaction time data were recorded for all experimental trials (practice trials were discarded). For the initial stage of analysis data were screened to exclude all incorrect responses and all reaction times less than 200ms (anticipatory responses; consistent with Mogg et al, 1998). In the ASD group 4.1% of trials were removed whereas in the control group 3.3% of trials were removed, this difference was not significant $F(1,36)=.056$, $p=.814$. There were too few incorrect responses in the current task to allow analysis of this data in relation to the individual variables included in the Face in the Crowd (FITC) task. Individual participant median reaction times were calculated for each condition in the study, consistent with our previous study (Moore, Heavey and Reidy, 2012). Median values were used to reduce the influence of outlying data and of the positive skew often observed within individual participant's responses in reaction time studies (Ratcliff, 1993).

Participant's median reaction time data were subsequently analysed at a group level and were examined for parametric assumptions. Normal distributions were assessed based on skewness values between -2.56 and 2.56 (Clark-Carter, 2004). Data were also examined for outliers (scores greater than three standard deviations above/below the group mean (Stevens, 1996).

To assess whether participants showed a bias for finding faces faster than non faces, target present data were initially entered into a 2 (diagnosis: ASD vs. TD comparison) X 2 (stimuli pair: faces and cars vs. faces and houses) X 2 (face role: face as target vs. face as distracter) mixed design ANOVA. The interpretation of Face-in-the-Crowd data needs to be considered carefully. This is because bias for one particular stimulus category over another may be the result of three separate attentional processes; disengagement from an initial stimulus, switching of attention, and subsequent engagement with a newly attended stimulus (Posner, Walker, Frances, and Rafel, 1984). Therefore it is possible that any attentional bias in the Face-in-the-Crowd task either reflects faster detection of faces in non-social crowds or a slower detection of non-social stimuli within face crowds.

First, the standard interpretation, that attentional bias effects reflect vigilance for test stimuli, was examined. It was reasoned that if participants found, for example, faces among car distracters quicker than houses among car distracters then it could be said that this was a result of an increased vigilance for faces (based on the suggestions of Horstmann, Scharlau and Ansorge, 2006). This was followed by an examination of the role that a difficulty in social disengagement may play in the apparent social bias found in this study. In this instance it was reasoned that if, for example, car targets were found faster among house distracters than cars among face distracters then this would reflect a difficulty in disengaging from the faces in the display (based on the suggestions of Horstmann, Scharlau and Ansorge, 2006).

Results

From the median RT data for each participant overall mean reaction times for the ASD and TD comparison groups were calculated for each condition (See Table 2). As the RT data overall were positively skewed the data were subjected to a Log10 transformation prior to analysis which corrected this skew.

[Insert Table 2 here]

Target present analysis

To assess whether participants showed a bias for finding faces faster than non faces, target present data were initially entered into a 2 (diagnosis: ASD vs. TD comparison) X 2 (stimuli pair: faces and cars vs. faces and houses) X 2 (face role: face as target vs. face as distracter) mixed design ANOVA. This revealed a significant main effect of face role F(1,36) = 7.553, p = .009, $\eta_p^2 = .173$, such that faces were found significantly faster among non-social crowds than non-social targets among face crowds. The effect of face role however did not interact with participant diagnosis F(1,36) = .199, p = .659, $\eta_p^2 = .005$. All other main effects and interactions were found to be non-significant (all F<1, all p>.4). This indicates that both groups showed a bias for finding faces within non-social crowds compared with non-social stimuli in face crowds (See Fig 1 for illustration).

[Fig 1 here]

To examine potential differences in the mechanisms underlying the apparent attentional bias for faces further analyses were conducted. First a test of vigilance was run to explore whether, as targets, faces are found faster than houses or cars when searching for all of these stimuli in non-social arrays. Data were entered into a 2 (diagnosis: ASD vs. TD comparison) X 2 (distracter type: car vs. house) X 2 (target: faces vs. non-social stimuli). This revealed a significant main effect of target F(1,36) = 30.149, p < .0001, $\eta_p^2 = .456$ indicating that faces are found faster than non-social stimuli among different non-social crowds. This effect did not interact with participant diagnosis F(1,36) =. 148, p = .703, $\eta_p^2 = .004$. All other main effects and interactions were non-significant (all F < 2.5 all P > .1). This provides strong evidence for social vigilance in both TD comparison and ASD groups.

Failure to disengage from face stimuli was tested by comparing response times to detecting a non-social target from a crowd of faces when compared to detecting a non-social target from a crowd of different non-social images (e.g. target of car from a crowd of houses). Data were subjected to a 2 (target: cars vs. houses) X 2 (crowd type: face vs. non-social) X 2 (diagnosis: ASD vs. TD comparison) mixed design ANOVA. This revealed a significant main effect of crowd type F(1,36) = 7.006, p = .012, $\eta_p^2 = .163$, indicating that there was a faster response to non-social targets when the distracting crowd was made up of faces than when the crowd was made up of other non-social stimuli. This effect did not interact with participant diagnosis F(1,36) =. 008, p = .930, $\eta_p^2 < .001$. All other main effects and interactions were non-significant (F<3, p>.1). This finding suggests that individuals are faster to search through crowds consisting of faces than non-social stimuli. This suggests that in addition to showing attentional vigilance for faces, once participants have engaged attention, they are also more rapid to disengage attention from the face stimuli compared to non-social stimuli. This is an unexpected finding as the overall attentional bias for faces which was observed would be predicted to result from increased vigilance for face targets (which was observed) and/or difficulty disengaging from face crowds/distracters (for which the opposite was observed).

Target absent analysis

As the target present data on disengagement was counter to what might have been expected, the target absent data were also analysed to further explore this effect (Hansen and Hansen, 1988). Analysis of the target absent data provides and examination of how long it takes a participant to search through a uniform crowd and provides an excellent measure of uncontaminated attentional disengagement. A 2 (diagnosis: ASD vs. TD comparison) X 3 (display: faces vs. cars vs. houses) mixed design ANOVA was conducted. An examination of Mauchly's test of sphericity revealed that this assumption had been violated (p=.001), therefore the Greenhouse-Geisser adjustment is reported. This revealed a significant main effect of display $F(1.51, 54.356)=3.787$, $p=.040$, $\eta_p^2= .095$. This effect was explored further using pairwise comparisons with a Sidak adjustment. None of the effects were found to reach statistical significance, a trend was found towards longer latencies for all face trials than for all house trials ($p=.091$), no differences were found between face and car trials ($p=.209$) or between the car and house trials ($p=.676$). The main effect of diagnosis was non-significant $F(1,36)=.243$, $p=.625$, $\eta_p^2= .007$, as was the interaction $F(1.51, 54.356)=1.414$, $p=.250$, $\eta_p^2= .038$.

Discussion

The purpose of the current study was to examine whether there were differences between individuals with ASD and TD participants in their attention to face stimuli. This was implemented by use of a Face-in-the-Crowd task. The findings of the present study indicate that both TD comparison and ASD groups show an attentional bias for faces. When examining these effects in more detail it was found that both populations showed vigilance for faces when compared to non-social stimuli, indicated by faces being found faster amongst non-social displays than non-social targets amongst conflicting non-social displays. Further examination of the target present trials revealed that participants were quicker to reject displays in which the distracters are faces than when they are non-face distracter displays. This indicates that participants are (1) faster to detect faces than non-social images, as targets and (2) faster to process and disengage from face stimuli, when used as distractors. To further test the effect of disengagement on attentional bias, target absent trials were analysed. These revealed a contrary pattern of findings with face arrays showing the longest response latencies compared to house and car arrays. It is surprising that the same attentional patterns have been found in the current study for ASD and TD participants given the previously published evidence for disengagement difficulties exhibited by ASD (e.g. Landry and Bryson, 2004). Although individuals with ASD have been shown to have a significant impairment in disengagement for non-social stimuli Kikuchi et al. (2011) used a gap overlap task to examine disengagement from faces in children with ASD. Kikuchi et al. found that the presence of a face at the fixation point caused slower task performance in TD participants but not in ASD children. This suggests that TD children are slower to disengage from faces but that individuals with ASD do not find it difficult to disengage from face. The finding from the current study suggests that disengaging from faces is not different in ASD compared to TD further confounding the question of the role of social disengagement in ASD.

The finding that both ASD and TD participants in this study were faster to find non-social targets in face fields than in other non-social fields contradicts the findings of Langton et al. (2008) and Riby et al. (2012). In these two previous studies participants were slower to find a non-face target (a butterfly) when the distractor field included the image of a face. It is possible that the different findings observed in the current study compared to these previous accounts can be explained by the presence of 8 uniform distractors in the current study as compared to one distractor amongst a group in Langton et al and Riby et al.'s studies. It is possible therefore that when one face is used as a distractor that this is more unique and therefore more likely to capture attention. It is also possible that the different findings between this study and others which have explored the role of the face as a distractor is that the face stimuli in the current study were also targets on other trials and this might therefore have reduced uniqueness of the stimuli.

The results of the present study contrast with findings by the research group, using the Visual Dot Probe task (Moore, Heavey and Reidy 2012). In this study, a bias in attention for faces was limited to the TD comparison group with the ASD group showing no bias for faces. It is possible that this discrepancy reflects the different role played by the stimuli in the tasks. In the Visual Dot Probe paradigm, the stimuli (faces, cars and houses) were secondary to the task requirement (to respond to the presence or absence of a dot), and attentional bias reflected the capacity of the stimuli to attract attention from the participant away from the task of responding to the dot. However, in the Face-in-the-Crowd task, the faces are central to the tasks requirements, as they must be searched to identify discrepant images. This raises the possibility that individuals with ASD's do not preferentially attend to faces when it is not necessary to attend to them (i.e. they can be ignored), as revealed by the Visual Dot Probe task. However, once attention has been engaged explicitly and over longer durations (and directed, i.e. through explicit task instructions) these stimuli are processed more speedily/readily than non-face stimuli. It is important to consider the automaticity of these biases in more detail as in everyday social interactions we are required to engage in complex and fast paced social exchanges and a significant predictor of social ability is likely to be the automaticity of social interaction. To further examine the role of automaticity in this relationship studies should consider manipulating the size of the display. In the current study a uniform display of nine images was used, this allows for attentional bias in visual search to be examined, however in Hansen and Hansen (1988) they also introduced 2x2 displays. If attentional bias is automatic then there should be little or no increase in search times for faces in a 3x3 matrix compared to a 2x2 matrix as the face would 'pop-out' however even with an attentional bias for faces if the search time increased then this would represent a serial visual search. These criteria have shown in the context of attentional bias for emotional stimuli that although search is faster and more efficient for angry faces that these do not 'pop out' (Frischen, Eastwood and Smilek, 2008;

Yiend, 2010). Examining the search slopes for face stimuli in ASD and control populations across different set sizes might indicate difference in search efficiency between the groups. This was not included in the current study due to limitations on time with the population and trying to reduce anxiety and fatigue.

Potentially there are other factors that could explain the present findings. It is possible that faces were found faster in the present study by one or both of the groups as a result of some low-level feature of the images (i.e. the greater contrast in tone between the hairline and facial features on the face stimuli), and not a result of the social meaning that the face holds. This seems unlikely as images used as non-social images were matched as well as possible to faces for complexity, are familiar and are also usually only seen in mono-orientation (i.e. houses and cars are similar to faces in that they are usually seen on a single orientation and rarely on their roofs). Although it is possible to gain greater experimental control over stimuli by using schematic line drawings to represent faces, this significantly compromises the ecological validity of the research and introduces a variety of additional problems about what is being measured.

A further explanation for the present findings may lie in the simplicity of the stimuli and task demands. The use of eight identical and one discrepant picture (i.e. eight of the same face and one car) might not have been complex or challenging enough to identify the differences between groups (low task complexity is evidenced by the high accuracy in the task). In a recent study Worsham, Gray, Larson and South (2014) examined the face processing abilities of individuals with ASD using a conflict adaptation task. In this task participants were required to identify the emotion expressed in a face when this was overlaid with a congruent or incongruent emotional label (i.e. a happy face with the word angry' overlaid). Findings suggested that for incongruent trials the ASD group were faster but less accurate at detecting the emotion in the face but no difference on congruent trials. This suggests that for simple tasks, such as in the current study, no differences may be observed, however for more complex tasks deficits in social attention in ASD may be seen. Illustrating this, both van der Geest et al (2002) and the present study used simple static displays as compared to Klin et al (2002) who used more complex dynamic stimuli and found significantly reduced social attention in ASD. This explanation requires further exploration as the findings of Kikuchi et al (2009) suggested that processing difficulty could not explain social inattention in ASD.

Finally, although this study found an absence of differences between the ASD and TD comparison groups in terms of attentional bias to faces, it is important to consider the power of the study to detect differences between the groups. Although a sample size of 19 per group is comparable with other studies in the field of autism research (including Ashwin et al.'s study using the Face-in-the-Crowd task which had 18 participants/condition) this is a statistically small sample to identify group differences. It is therefore possible that with a larger sample these differences may be revealed. It does however have to be acknowledged that the same sample was used in our previous report using the visual dot probe task (Moore, Heavey and Reidy, 2012) and that in this sample significant differences were observed between the ASD and TD comparison populations. Additionally none of the differences between the ASD and TD comparison groups approached significance suggesting that the absence of differences between the ASD and TD comparison groups is meaningful and has not occurred by chance.

In conclusion this study indicates that when consciously engaging with face stimuli in a visual search paradigm, individuals with ASD appear to show the same patterns for detecting face and non-face stimuli as do TD participants. This supports evidence that social inattention might not be universal in individuals with ASD, at least when task complexity is low. Further research is needed to examine under what circumstances attentional bias to faces is observed and under which circumstances this is absent.

References

American Psychiatric Association (2000). *Diagnostic and statistical manual of mental disorders (4^h ed.-TR)*. Washington DC.

American Psychiatric Association (2013). *Diagnostic and statistical manual of mental disorders (5^h ed.)*. Washington DC.

Ames C and Fletcher-Watson S (2010). A review of methods in the study of attention in autism. *Developmental Review.* 30. 52-73.

Ashwin C, Wheelwright S and Baron-Cohen S (2006b). Finding a Face-in-the-Crowd: Testing the anger superiority effect in Asperger Syndrome. *Brain and Cognition.* 61. 78 -95.

Bar-Haim Y, Shulman C, Lamy, D and Reuveni A (2006). Attention to eyes and mouth in high-functioning children with autism. *Journal of Autism and Developmental Disorders, 36,* 131-137

Baron-Cohen S, Wheelwright S, Skinner R, Martin J and Clubley E (2001). The Autism-Spectrum Quotient (AQ): Evidence from Asperger Syndrome/High Functioning Autism, males and females, scientists and mathematicians. *Journal of Autism and Developmental Disorders, 31,* 5–17.

Behrmann M., Thomas C and Humphreys K. (2006). Seeing it differently: visual processing in autism. Trends in Cognitive Sciences, 10(6), 258-264.

Bindemann M, Burton AM, Langton SRH, Schweinberger SR and Doherty MJ (2007). The control of attention to faces. Journal *of Vision, 7*(10):15, 1–8.

Boraston Z and Blakemore SJ (2007). The application of eye-tracking technology in the study of autism. *Journal of Physiology*, *581,* 893-898.

Carey S (1992). Becoming a face expert. *Philosophical Transactions of the Royal Society of London B.* 335. 95-103.

Clark-Carter D (2004). Quantitative Psychological Research: A Student's Handbook (Hove, UK: Psychology Press).

Dalton KM, Nacewicz BM, Johnstone T, Schaefer HS, Gernsbacher MA, Goldsmith HH et al. (2005). Gaze fixation and the neural circuitry of face processing in autism. *Nature Neuroscience, 8*(4), 519-526.

Ekman P and Matsumoto D (1993). *Combined Japanese and Caucasian Facial Expressions of Emotion (JACFEE) and Japanese and Caucasian Neutral Faces(JACNeuF).* [Available: http://www.humintell.com/for-use-in-research/. (1st March 2005).

Fletcher-Watson S, Leekam SA, Benson V, Frank MC and Findlay JM (2009). Eye-movements reveal attention to social information in autistic spectrum disorder. *Neuropsychologia.* 47. 248-257.

Frischen A, Eastwood JD and Smiliek D (2008). Visual search for faces with emotional expressions. *Psychological Bulletin. 134(5).* 662-676.

Gillespie-Smith K, Riby DM, Hancock PJB and Doherty-Sneddon G (2014). Children with autism spectrum disorder (ASD) attend typically to faces and objects presented within their picture communication systems. *Journal of Intellectual Disability Research.* 58(5): 459-470.

Goren CC, Sarty M and Wu PYK (1975). Visual following and pattern discrimination of face like stimuli by newborn infants. *Paediatrics.* 56. 544-549.

Grelotti DJ, Gauthie, I and Schultz RT (2002). Social interest and the development of cortical face specialization: What autism teaches us about face processing. *Developmental Psychobiology, 40*, 213-225.

Grelotti DJ, Klin AJ, Gauthier I, Skudlarski P, Cohen DJ, Gore JC. et al. (2005). fMRI activation of the fusiform gyrus and amygdala to cartoon characters but not to faces in a boy with autism. *Neuropsychologia, 43,* 373-385.

Grüsser OJ and Landis T (1991). *Visual agnosia and other disturbances of visual perception and cognition.* MacMillan. London.

Hansen CH and Hansen RD (1988). Finding the Face-in-the-Crowd: An anger superiority effect. *Journal of Personality and Social Psychology,* 54. 917-924.

Hauck M, Fein D, Maltby N, Waterhouse L and Feinstein C (1998). Memory for faces in children with autism. *Child Neuropsychology.* 4. 187-198.

Hobson RP, Ouston J and Lee A (1988) What's in a face? The case of autism. *British Journal of Psychology.* 79, 441–453.

Horstmann G, Scharlau I and Ansorge U (2006). More efficient rejection of happy than angry face distractors in visual search. Psychonomic Bulletin and Review. 13(6). 1067-1073.

Johnson MH (1990a). Cortical maturation and the development of visual attention in early infancy. *Journal of Cognitive Neuroscience.* 2. 81-95.

Johnson MH (1990b). Cortical maturation and perceptual development. In H. Block and B. Bertenthal (Eds.). *Sensory Motor Organisation and Development in Infancy and Early Childhood.* Dordrecht. Kluver Academic Publishers. pp145-162

Johnson MH and Morton J (1991). *Biology and cognitive development: The case of face recognition.* Oxford, England. Blackwell.

Jones W and Klin A (2014). Attention to eyes is present but in decline in 2–6-month-old infants later diagnosed with autism. *Nature Letters. 504.* 427-431.

Kikuchi Y, Senju A, Tojo Y, Osanai H and Hasegawa T (2009). Faces do not capture special attention in children with autism spectrum disorder: A change blindness study. *Child Development. 80(5).* 1421-1433.

Kikuchi Y, Senju A, Akechi H, Tojo Y, Osanai H and Hasegawa T (2011). Atypical disengagement from faces and its modulation by the control of eye fixation in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, 41(5), 629-645.

Klin A, Jones W, Schultz R, Volkmar F and Cohen D (2002). Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. *Archives of General Psychiatry*, *59*, 809–816.

Krysko KM and Rutherford MD (2009). A threat-detection advantage in those with autism spectrum disorder. *Brain and Cognition. 69.* 472-480.

Landry R and Bryson SE (2004). Impaired disengagement of attention in young children with autism. *Journal of Child Psychology and Psychiatry, 45,* 1115-1122.

Langdell T (1978). Recognition of faces: An approach to the study of autism. *Journal of Child Psychology and Psychiatry*, *19,* 225–238.

Langton SRH, Law AL, Burton AM and Schweinberger SR (2008). Attention capture by faces. *Cognition. 107. 330-342.*

Maurer D and Barrera M (1981). Infants' Perception of Natural and Distorted Arrangements of a Schematic Face. *Child Development.* 52(1). 196-202.

Mogg K, Bradley BP, Hyare H and Lee S (1998). Selective attention to food-related stimuli in hunger: Are attentional biases specific to emotional and psychopathological states, or are they also found in normal drive states? *Behaviour Research and Therapy,* 36, 227-237.

Moore DJ, Heavey L and Reidy J (2012). Attentional processing of faces in ASD: A dot-probe study. *Journal of Autism and Developmental Disorders.* 42: 2038-2045.

Nation K and Penny S (2008). Sensitivity to eye gaze in autism: Is it normal? Is it automatic? Is it social? *Development and Psychopathology.* 20. 79-97.

Pelphrey KA, Sasson NJ, Reznick S, Paul G, Goldman BD and Piven J (2002). Visual scanning of faces in autism. *Journal of Autism and Developmental Disorders, 32*(4), 249-261

Posner MI (1980). Orienting of attention. The VIIth Sir Frederic Bartlett Lecture. *Quarterly Journal of Experimental Psychology.* 32A. 3-25.

Posner MI, Walker JA, Friedrich FJ and Rafal RD (1984). Effects of parietal lobe injury on covert orienting of visual attention. *Journal of Neuroscience.* 4. 1863-1874.

Ratcliff R (1993). Methods for dealing with reaction time outliers. *Psychological Bulletin. 114(3).* 510-532.

Riby DM, Brown PH, Jones N and Hanley M (2012). Faces cause less distraction in autism. *Journal of Autism and Developmental Disorders. 42(4):*634-639.

Riby DM and Hancock PJB (2009). Do faces capture the attention of individuals with Williams syndrome or Autism? Evidence from tracking eye movements. *Journal of Autism and Developmental Disorders*. 39(3):421-431.

Ro T, Russell C and Lavie N (2001). Changes faces: A detection advantage in the flicker paradigm. *Psychological Science, 12*(1), 94-99.

Sasson NJ (2006). The development of face processing in autism. *Journal of Autism and Developmental Disorders, 36*(3), 381-394.

Schneider W, Eschman A and Zuccolotto A (2001). E-Prime User's Guide. Pittsburgh: Psychology Software Tools, Inc.

Schultz RT, Gauthier I, Klin A, Fulbright RK, Anderson AW, Volkmar, Skudlarski P, Lacadie C, Cohen DJ and Gore JC (2000). Abnormal ventral temporal cortical activity during face discriminations among individuals with autism and Asperger syndrome. *Archives of General Psychiatry.* 37. 331-340.

Speer LL, Cook AE, McMahon WM and Clark E (2007). Face processing in children with autism: Effects of stimulus contents and type. *Autism. 11(3).* 265-277.

Sterling L, Dawson G, Webb S, Murias M, Munson J, Panagiotides H and Aylward E (2009). The role of face familiarity in eye tracking of faces by individuals with Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders, 38,* 1666-1675.

Stevens J (1996). Applied multivariate statistics in the social sciences: 3rd edition (New Jersey: LEA).

van der Gees, JN, Kemner C, Camferrman G, Verbaten MN and van Engeland H (2002). Looking at images with human figures: Comparison between autistic and normal children. Journal of Autism and Developmental Disorders, 32(2), 69-75.

Wechsler D (1999). *The Wechsler Abbreviated Scale for Intelligence*. San Antonio,TX: The Psychological Corporation.

Williams D L, Goldstein G and Minshew NJ (2005) Impaired memory for faces and social scenes in autism: clinical implications of memory dysfunction. *Archives of Clinical Neuropsychology*. 20. 1-15.

Woodbury-Smith M, Robinson J and Baron-Cohen S (2005). Screening adults for Asperger syndrome using the AQ: a preliminary study of its diagnostic validity in clinical practice. *Journal of Autism and Developmental Disorders*. 35. 331- 335.

Worsham et al. (2014). Conflict adaptation and congruency sequence effects to social-emotional stimuli in individuals with Autism Spectrum Disorders. Autism. e-pub ahead of print, DOI 10.1177/1362361214553280.

Yiend J (2010). The effects of emotion on attention: A review of attentional processing of emotional information. *Cognition and Emotion. 24(1).*3-47.

Table 1: To show demographic data for ASD and control participants.

	Age	*IQ*	*AQ*
ASD	26.47 (9.50)	111.79 (13.17)	32.47 (6.76)
Control	28.58 (7.31)	112.50 (11.82)	14.89 (6.50)
t-scores	**t(36)=.77, p=.449**	**t(36)=.18, p=.862**	**t(34)=7.50, p<.001**

Table 2: Means & standard deviations for reaction times on the Face-in-the-Crowd task in the ASD and control groups

Target	Distracter	ASD	Control
Face	Face	746.70 (371.53)	673.79 (175.51)
Face	Car	637.13 (139.20)	597.53 (87.94)
Face	House	649.02 (184.70)	580.71 (112.13)
Car	Face	672.25 (201.40)	610.34 (67.69)
Car	Car	677.86 (164.49)	622.61 (103.53)
Car	House	683.68 (193.46)	635.76 (116.39)
House	Face	696.39 (313.50)	629.29 (106.72)
House	Car	725.82 (240.57)	661.45 (121.34)
House	House	635.00 (151.79)	643.53 (140.95)

Figure captions

Figure 1: Illustrating a main effect of face role and the absence of an interaction between face role and diagnosis, 95% Confidence Intervals are shown as error bars