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Visual search for basic emotional expressions in autism; impaired processing of anger, fear and sadness, but a typical happy face advantage

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ABSTRACT

Facial expression recognition was investigated in 20 males with high functioning autism (HFA) or Asperger syndrome (AS), compared to typically developing individuals matched for chronological age (TD CA group) and verbal and non-verbal ability (TD V/NV group). This was the first study to employ a visual search, "face in the crowd" paradigm with a HFA/AS group, which explored responses to numerous facial expressions using real-face stimuli. Results showed slower response times for processing fear, anger and sad expressions in the HFA/AS group, relative to the TD CA group, but not the TD V/NV group. Reponses to happy, disgust and surprise expressions showed no group differences. Results are discussed with reference to the amygdala theory of autism.
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Autism spectrum disorder (ASD) is a pervasive developmental disorder, affecting approximately 1% of the population (Baird et al., 2006) with a sex distribution ranging from 4:1 to 16:1 male to female. It is characterised by a triad of impairments in language, imagination and social interaction (American Psychiatric Association, 1994). In addition, facial expression processing is atypical in ASD (Annaz, Karmiloff-Smith, Johnson & Thomas, 2009; Baron-Cohen, Wheelwright, Skinner, Martin & Clubley, 2001; Grice et al., 2001; Hobson, 1986a, 1986b). Due to the social significance of facial expressions in communicating the outcome of social interactions, it is thought that impaired face processing skills contribute strongly to the characteristic weaknesses in social interaction observed in ASD. The current paper explores facial expression processing in individuals who fall within the autistic spectrum, namely those with high functioning autism (HFA) or Asperger syndrome (AS).

This study employed a visual search "*face in the crowd*" task design. In this type of design participants are presented with an array of faces and asked to determine whether a target face is present or not. In a pioneering study, Hansen and Hansen (1988) reported that, in the typical population, angry faces are detected more quickly and accurately than happy faces; the anger superiority effect (ASE). This is thought to reflect an evolutionary measure which accelerates the identification of threatening stimuli and is associated with activation of the amygdala (Fox et al., 2000). However, subsequent studies do not consistently replicate the ASE (e.g. Horstmann, 2009; Juth, Lundqvist, Karlsson, & Ohman, 2005; Purcell, Stewart & Skov, 1996), with a number of studies showing a happy face advantage (e.g. Eastwood, Smilek & Merikle, 2003). On reviewing this literature, the ASE is more often reported when the faces employed are schematic faces (e.g. Ashwin, Wheelwright, & Baron-Cohen, 2006; Calvo, Avero, & Lundqvist, 2006; Horstmann, 2009; Juth et al., 2005, exp 1) as opposed to real faces, where a happy face advantage is most often observed (e.g. Calvo & Nummenmaa, 2008; Juth et al., 2005, exp 5). These inconsistencies

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have been explored in relation to the relative input of emotional vs. perceptual comparisons across faces (Frischen, Eastwood & Smilek, 2008; Horstmann, 2009; Juth et al., 2005). For example, the happy face advantage seems to involve an interplay between emotional and perceptual factors. For real-face stimuli the mouth is a perceptually salient feature particularly if it is showing teeth (which introduces a high luminance contrast) (Frischen et al., 2008), whilst the advantage for recognition of positive words and smells demonstrates additional impact on account of emotional salience (see Juth et al., 2005).

Despite the above inconsistencies in response patterns, there is a clear consistency that the visual system is differentially sensitive to emotions, and that visual search is sensitive to differences in emotional expression (see Frischen et al., 2008 for a review). This study employs visual search in order to explore facial expression processing in HFA/AS. Visual search ability is an area of proficiency within ASD (e.g. O'Riordan & Plaisted, 2001), which makes it an appropriate experimental design for capturing atypical patterns of expression recognition performance in our HFA/AS group should they exist.

In light of the link between the detection of threat and the amygdala in the typical population (Fox et al., 2000), facial expression processing is an ideal forum in which to assess the amygdala theory of autism (Baron-Cohen et al., 2000). In reference to impairments in 'social intelligence' observed in ASD, the amygdala theory proposes that the amygdala is one of a number of atypical brain regions in individuals with ASD (Baron-Cohen et al., 2000). In the typical population, amygdala activation is reported for detection of fearful expressions (Ashwin, Baron-Cohen, Wheelwright, O'Riordan & Bullmore, 2007), but has also been reported for other negative or threat related emotions, such as anger and sadness (Adolphs, 1999). Individuals with ASD have been shown to have reduced amygdala volume (Abell et al., 1999) as well as reduced amygdala activation relative to typically developing control participants when asked to judge the valence of fearful or angry faces (Ashwin et al., 2007; Baron-Cohen et al., 2000; Critchley et al., 2000).

Behaviourally, only two studies have explored face expression processing in ASD using visual search. These studies have focused on determining whether individuals with ASD demonstrate an ASE, and so have only employed angry, happy and neutral expressions (Ashwin, Wheelwright, & Baron-Cohen, 2006; Krysko & Rutherford, 2009). Ashwin, Wheelwright, et al. (2006) presented adults with HFA\AS and typically developing adult controls with a matrix of schematic line drawn faces that contained a single target (happy or angry) among neutral faces or the other emotional face. Both groups demonstrated an ASE, and there was some evidence that the HFA/AS group were less efficient than the control group at detecting angry faces (i.e. in their Experiment 2, but not Experiment 3). Krysko and Rutherford (2009) digitally modified real faces such that their stimuli only showed pixels that belonged to eye, eyebrow, mouth, nose and cheek regions. Happy or angry target faces were presented among neutral distracter faces. Results showed poorer overall accuracy for adults with HFA relative to typically developing adults and a comparable ASE for RT and accuracy data in both groups. Although not supported by significant interactions, the authors point out that the ASE was stronger for small than large display sizes (4 vs. 12 distracters) in the HFA group only.

The above two studies, therefore, show limited support for an atypical ASE in ASD. To explore whether this reflected the stimuli employed, the current study employed real-face stimuli without any pixel reduction. This is based on evidence from adults with ASD, for impaired expression processing of real-face stimuli showing negative emotions, on face expression identification tasks (participants identify the expression of a singly presented real-face) (Ashwin, Chapman, Colle & Baron-Cohen, 2006; Boraston, Blakemore, Chilvers & Skuse, 2007; Humphreys, Minshew, Leonard & Behrmann, 2007; Wallace, Coleman & Bailey, 2008). Interestingly, this appears to be a developmental effect as children with ASD do not show an atypical profile of expression recognition on this kind of task (Castelli, 2005; Ozonoff, Pennington & Rogers, 1991).

Whilst previous studies of visual search for facial expressions in ASD have employed just two emotions, happy and angry (Ashwin, Wheelwright, et al., 2006; Krysko & Rutherford, 2009), we used visual search to investigate the speed and accuracy of processing six emotions (happiness, sadness, anger, fear, surprise and disgust) of standardised real-face stimuli developed by Vanger, Hoenlinger and Haken (1998). The study focused on children and adolescents with HFA/AS. As visual search is particularly sensitive to differentiating between facial expressions (Frischen et al., 2008), we argue that this measure provides a stronger possibility of capturing any atypical patterns present in children and adolescents with HFA/AS should they exist. If amygdala dysfunction is a feature of children and adolescents with HFA/AS, we expected to minimally see impaired performance (longer response times and possibly increased error rates) in trials containing the socially threatening targets fear and anger, possibly extending to sadness and disgust, as these are also negative emotions. Any advantage for search for happy faces was not predicted to differentiate across groups. As we used real faces rather than schematic faces, based on the literature on the typical population, we did not necessarily predict an ASE, but predicted that the profile of abilities in the typical control groups would differentiate anger (and possibly all negative emotions) from positive emotions.

1. Method

1.1. Participants

Three groups of right-handed males ($N = 60$) were recruited from local mainstream schools, specialist ASD units and branches of the National Autistic Society. All participants were assessed for verbal ability using the British Picture Vocabulary Scale-second edition (BPVS II; Dunn, Dunn, Whetton & Burley, 1997), and for non-verbal ability using Ravens coloured progressive matrices (RCPM; Raven, Raven, & Court, 1998). The experimental group comprised 20 males, all of whom had been clinically diagnosed with HFA/AS according to DSM-IV criteria, with no co-morbid Axis 1 or 2 disorders. Two typically developing control groups were recruited. The first was individually matched to the HFA/AS group by chronological age (henceforth referred to as TD CA) and the second control group (henceforth referred to as TD V/NV), were

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