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Diminished sensitivity and specificity at recognising facial emotional expressions of varying intensity underlie emotion-specific recognition deficits in autism spectrum disorders

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ABSTRACT

Background: A plethora of research on facial emotion recognition in autism spectrum disorders (ASD) exists and reported deficits in ASD compared to controls, particularly for negative basic emotions. However, these studies have largely used static high intensity stimuli. The current study investigated facial emotion recognition across three levels of expression intensity from videos, looking at accuracy rates to investigate impairments in facial emotion recognition and error patterns ('confusions') to explore potential underlying factors.

Method: Twelve individuals with ASD (9 M/3F; M(age) = 17.3) and 12 matched controls (9 M/3F; M(age) = 16.9) completed a facial emotion recognition task including 9 emotion categories (anger, disgust, fear, sadness, surprise, happiness, contempt, embarrassment, pride) and neutral, each expressed by 12 encoders at low, intermediate, and high intensity.

Results: A facial emotion recognition deficit was found overall for the ASD group compared to controls, as well as deficits in recognising individual negative emotions at varying expression intensities. Compared to controls, the ASD group showed significantly more, albeit typical, confusions between emotion categories (at high intensity), and significantly more confusions of emotions as 'neutral' (at low intensity).

Conclusions: The facial emotion recognition deficits identified in ASD, particularly for negative emotions, are in line with previous studies using other types of stimuli. Error analysis showed that individuals with ASD had difficulties detecting emotional information in the face (sensitivity) at low intensity, and correctly identifying emotional information (specificity) at high intensity. These results suggest different underlying mechanisms for the facial emotion recognition deficits at low vs high expression intensity.

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1. Introduction

Autism-Spectrum-Disorder (ASD) is defined by repetitive patterns of behaviour and difficulties in communication skills and social functioning, including non-verbal communication (American Psychiatric Association, 2013). Facial expressions of emotion are one form of non-verbal communication, and the ability to infer emotional states from facial expressions has

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been a major research interest in ASD. Literature reviews and meta-analyses have reported deficits in facial emotion recognition in ASD compared to controls (see Gaigg, 2012; Harms, Martin, & Wallace, 2010; Lozier, Vanmeter, & Marsh, 2014; Nuske, Vivanti, & Dissanayake, 2013; Uljarevic & Hamilton, 2013).

While much facial emotion recognition research has used high intensity facial emotional expression stimuli, daily social interactions typically involve subtler displays (Cassidy, Ropar, Mitchell, & Chapman, 2014; Motley & Camden, 1988). Low intensity facial emotional expressions provide less emotional cues to the observer and are harder to recognise than more intense expressions (Wingenbach, Ashwin, & Brosnan, 2016). Only a very limited number of studies have been published including intensity variations of emotional expression in ASD populations. These studies have reported an overall facial emotion recognition deficit in children and adults with ASD compared to controls using both static and video stimuli (Mazefsky & Oswald, 2007; Rump, Giovannelli, Minshew, & Strauss, 2009). However, those studies did not report group comparisons across the different expression intensities. Law Smith, Montagne, Perrett, Gill, and Gallagher (2010) investigated emotion recognition in male adolescents with ASD and controls using morphed dynamic stimuli of low, medium, and high expression intensity of the six basic emotions of anger, disgust, fear, sadness, surprise, happiness (Ekman, 1992). The authors reported that those with ASD performed significantly worse than controls on some emotion categories of low expression intensity (disgust, surprise, anger), medium expression intensity (disgust, anger), and high expression intensity (disgust). These results demonstrate that the level of intensity is important in emotion recognition, and that further research is needed including intensity variations and also a broader range of emotions.

Next to basic emotions, there are complex emotions, typically including a greater cognitive component than basic emotions. Some complex emotions are called self-conscious emotions (e.g. embarrassment), indicating the necessity of self-evaluation and assumptions about how others perceive oneself (Tracy & Robins, 2007), and are thought to regulate social behaviour (Adolphs, 2002). Thus, recognition of these emotions plays a crucial role in social interactions. However, complex emotions are rarely investigated alongside basic emotions in studies on facial emotion recognition in ASD. However, complex emotions are rarely investigated alongside basic emotions in studies on facial emotion recognition in ASD.

Investigation of errors in attributing emotion categories to facial expressions (i.e. confusions) can provide insight into mechanisms underlying facial emotion recognition deficits. Confusions of attributing an emotion to a neutral facial expression (e.g. fear as neutral) provide information regarding the recognition *sensitivity*, i.e. the ability to detect emotional content in the face. Confusions between two emotion categories (e.g. fear as surprise) provide information about the *specificity* of emotion recognition, i.e. the ability to differentiate between facial emotional expressions. Despite their informative nature, few studies have reported results about confusions. Some have reported that individuals with ASD tend to confuse the facial expressions of disgust as anger, and fear as surprise (Humphreys, Minshew, Leonard, & Behrmann, 2007; Jones et al., 2011). However, these specific confusions are also seen in typical individuals (see e.g. Recio et al., 2013). Statistical comparisons of the confusions made by individuals with ASD to controls provide information on whether individuals with ASD make more such confusions than typical individuals. We are aware of only one facial emotion recognition study in ASD that reported statistical comparisons of confusions to controls, which found (based on static stimuli) that individuals with ASD misinterpreted neutral faces as displaying an emotion more often than controls, showed reduced sensitivity, and lowered specificity (Eack, Mazefsky, & Minshew, 2015). Confusion analysis can thus provide valuable information about what is driving the facial emotion recognition deficits in ASD, and could be particularly informative at low and high expression intensity where the emotional information in the face is lowest and highest respectively.

The present study used a recently developed and validated video stimulus set including low, intermediate, and high intensity of basic and complex emotions to compare accuracy rates and confusions for emotion recognition in ASD to controls. It was hypothesised that: (1) individuals with ASD would show an overall deficit in facial emotion recognition compared to controls; (2) recognition of some emotional categories would be influenced differently by the level of expression intensity and emotion valence in ASD, with deficits expected mainly for negative emotions when expressed at lower intensities; and (3) the ASD group would make more confusions than controls with respect to both recognition sensitivity and specificity at low and high expression intensity.

2. Methods

2.1. Participants

The sample consisted of 12 adolescents and young adults with high-functioning ASD (9 M/3F; *M*(age) = 17.3) and 12 age- and sex-matched controls (9 M/3F; *M*(age) = 16.9), with no differences between the groups for mean age (see Table 1). All participants were British and had normal or corrected-to-normal vision. The ASD sample was recruited during an Autism Summer School run at the University of Bath for individuals diagnosed with ASD who were applying to start university. All participants in the ASD group had a diagnosis of ASD by a qualified clinical professional. The ASD diagnosis was confirmed by viewing a copy of their clinical report, which was brought to the Autism Summer School. The gold standard in confirming an ASD diagnosis is the Autism Diagnostic Observation Schedule (ADOS-2; Lord et al., 2012); the current study applied the self-report Autism-Spectrum Quotient (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) and the parent-report Social Communication Questionnaire (SCQ; Rutter, Bailey, & Lord, 2003) (see Table 1). An independent-samples *t*-test showed that the mean AQ score for the ASD group was significantly higher than that for the controls (see Table 1). The mean AQ score of the ASD group was similar to mean AQ scores for large previous ASD samples (Baron-Cohen et al., 2001;

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