# Automatic facial responses to briefly presented emotional stimuli in autism spectrum disorder

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## ABSTRACT

Emotion processing, including automatic facial mimicry, plays an important role in social reciprocity. Disruptions in these processes have implications for individuals with impaired social functioning, such as autism spectrum disorders (ASDs). Past research has demonstrated that ASDs are impaired in the recognition of briefly presented emotions and display atypical mimicry of emotions presented for protracted duration. Mimicry (electromyography; EMG) of briefly presented emotions was investigated in adults with ASDs. Concurrent measures of skin conductance and cardiac responses were used as markers of orientation and stimulus detection, respectively. A backward masking task was employed whereby the emotional face (happy, angry) was presented for 30 ms followed by a neutral face "mask". An implicit comparison task required rapid gender identification. The ASD group failed to differentiate by valence in their EMG (zygomaticus, corrugator) and demonstrated atypical pre- and post-stimulus arousal. These findings may provide a potential mechanism for marked deficits in social reciprocity.

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## 1. Introduction

Individuals with autism spectrum disorders (ASDs; including autism and Asperger's Syndrome)[1] display marked impairments in social interaction (poor social-emotional reciprocity, deficits in the use of non-verbal communication such as eye-gaze and facial expression) and the presence of repetitive and stereotyped behaviours (APA, 2000, 2013). Consistent with diagnostic criteria of marked deficits in reciprocal social interaction, individuals with ASDs generally have impaired emotion processing and recognition. Studies have shown that low-functioning children display deficits in the recognition of basic facial emotional expressions (Celani, Battacchi, & Arcidiacono, 1999; Gross, 2004), whereas high-functioning individuals with ASDs appear impaired in the recognition of complex (e.g., sincerity, pride and embarrassment; Capps, Yirmiya, & Sigman, 1992; Golan, Baron-Cohen, Hill, & Rutherford, 2007) but not basic emotions (Adolphs, Sears, & Piven, 2001; Boucher, Lewis, & Collis, 2000; Capps et al., 1992; Grossman, Klin, Carter, & Volkmar, 2000; Loveland et al., 1997). As a result, it has been suggested that emotional responsivity and recognition

in ASDs increases with cognitive ability (Dissanayake, Sigman, & Kasari, 1996; Rutherford & McIntosh, 2007). In order to diminish the confound of cognitive ability, emotional stimuli may be presented briefly, thereby shifting the load from higher-level intellectual functioning to more automatic processing abilities. Using a backward masking paradigm, whereby participants are exposed to brief displays that are rapidly masked, or simply rapidly presenting the emotional face without a mask, two recent studies demonstrated that high-functioning children (Hall, West, & Szatmari, 2007) and young adults (Clark, Winkielman, & McIntosh, 2008) with ASDs continue to be impaired in the recognition of basic emotional stimuli (fear/neutral backward masking (33 ms) and happy/angry rapid presentation (30 ms), respectively. Importantly, these deficits were specific to emotion recognition, as recognition of facial identity, age, and gender remained intact (Celani et al., 1999; Clark et al., 2008).

This finding is intriguing and prompts further enquiry as to the basic processes involved in recognising and processing emotional stimuli, in particular, automatic orientation to and mimicry of emotional expressions. Mimicry, including rapid, automatic facial responses to facial emotions and affective scenes, may be conceptualised as a marker of emotional processing and affective response to the environment (Cacioppo, Petty, Losch, & Kim, 1986; Dimberg & Thunberg, 1998; Winkielman & Cacioppo, 2001). It is present at an early age, such that typically developing infants actively seek and mimic the facial expressions of their mothers (Haviland & Lelwica, 1987), and use this information to regulate their responses to ambiguous environmental stimuli (Smith, McHugo, & Kappas, 1996). Similarly, automatic facial mimicry

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[1] The recently released *DSM-5* has removed the distinction between autism and Asperger's, instead referring to severity and functioning (APA, 2013). Thus, for the purpose of this study, individuals with no clinically significant delay in language and an IQ within the normal range will be referred to as high-functioning individuals with ASDs.

is not purely a motor mirroring of environmental stimuli, but reciprocally interacts with emotional state, thus providing important emotional feedback information (Moody, McIntosh, Mann, & Weisser, 2007). Furthermore, mimicry facilitates emotion recognition, whilst preventing or blocking mimicry impairs emotion processing (Neidenthal, Brauer, Halberstadt, & Innes-Ker, 2001; Oberman, Winkielman, & Ramachandran, 2007). Impaired mimicry may therefore have negative effects for social reciprocity (see Hatfield, Cacioppo, & Rapson, 1994 for review). This has important implications for individuals with known impairments in social functioning, such as autism spectrum disorders (ASDs).

Mimicry is typically investigated using automatic facial muscle responses (as measured by electromyography; EMG). For example, the *corrugator supercilii* (frown) muscle is generally increased in response to angry faces and other negative stimuli, whereas the *zygomaticus major* (smile) muscle is generally increased in response to happy faces/positive stimuli (e.g., Cacioppo et al., 1986; Dimberg, 1982; Lang, Greenwald, Bradley, & Hamm, 1993; McDonald et al., 2011). These responses occur even when the emotional stimuli are presented very briefly (30 ms; Dimberg, Thunberg, & Elmehed, 2000). A handful of studies have shown that high-functioning children (Beall, Moody, McIntosh, Hepburn, & Reed, 2008), adolescents and adults (McIntosh, Reichmann-Decker, Winkielman, & Wilbarger, 2006) with ASDs, and adults with ASD traits (Hermans, van Wingen, Bos, Putman, & van Honk, 2009), display atypical (delayed or absent) spontaneous/automatic mimicry of passively viewed facial emotional (happy and angry) expressions presented for protracted duration (3–8 s), whilst their voluntary mimicry (production of expression when instructed) remains intact. Whilst this research implies that the early automatic aspects of emotion recognition are impaired in ASDs, the use of protracted exposure times makes it difficult to draw definite conclusions regarding this. Only one study to date has investigated automatic mimicry of briefly (25 ms) presented emotional expressions in a small sample (*n* = 13) of children with ASDs (Oberman, Winkielman, & Ramachandran, 2009). Consistent with previous research on protracted presentation of emotional stimuli, this study found that high-functioning children with ASDs were delayed in their mimicry response (Oberman et al., 2009). Interestingly, they found no deficits in the *amplitude* of their mimicry responses. This may have been due to the explicit instructions to label the emotional expression, which would have alerted their attention to the emotional content of the stimuli and potentially primed the mimicry system. Furthermore, in comparison tasks, longer presentation time (75 ms and 1000 ms) reduced but did not entirely remove the delay in mimicry response in the children with ASDs (Oberman et al., 2009).

Taken together, these studies demonstrate atypical automatic facial mimicry (EMG) of both protracted and briefly presented emotional stimuli in individuals with ASDs. Despite this impaired affective responsivity, these individuals demonstrate intact ability to recognise facial identity, age, and gender, as well as basic emotions. One potential explanation for these conflicting findings is a lack of motivational engagement in ASDs, which is proposed to result in reduced attention to social stimuli such as faces, voices, and hand gestures (Dawson, Webb, & McPartland, 2005). Similarly, it has been suggested that ASDs may be associated with a disruption in the allocation of emotional significance to facial stimuli (Pinkham, Hopfinger, Pelphrey, Piven, & Penn, 2008). Indeed, recent studies have shown that individuals with ASDs will only show spontaneous mimicry when the task sufficiently engages them in emotion processing (Magnée, de Gelder, van Engeland, & Kemner, 2007; Mathersul, McDonald, & Rushby, 2013a; Oberman et al., 2009). Current conceptualisations of this social motivation hypothesis propose that deficits in ASDs occur not just at the basic behavioural level, but also encompass social orienting/attention and social maintaining (Chevallier, Kohls, Troiani,

Brodkin, & Schultz, 2012). The majority of support for this comes from eye tracking or visual fixation studies that demonstrate impaired orienting and attention to socially-relevant stimuli such as eyes or people in pictures and movies of social interactions (e.g., Dalton et al., 2005; Klin, Jones, Schultz, Volkmar, & Cohen, 2002; Pelphrey et al., 2002). If this is indeed an accurate representation of this hypothesis, then autonomic measures (e.g., heart rate, skin conductance) provide a potential method of further investigating these processes.

Classic notions of orienting propose a combination of behavioural and physiological changes (e.g., heart rate (HR), electrodermal activity (skin conductance), respiration rate, pupillary dilation) in response to novel or significant environmental stimuli, including socially-relevant stimuli (e.g., Sokolov, 1960, 1963). However, extensive work over the past three decades suggests that skin conductance responses (SCRs) are the only true physiological marker of this orienting response (OR) in that they are elicited by novel stimuli, are modulated by stimulus intensity, and habituate with stimulus repetition (i.e., the Preliminary Process Theory (PPT); see Barry, 1981, 1996, 2006, 2009). As such, they may be seen to reflect allocation of attention/engagement or (emotional) significance to stimuli over time (e.g., Barry, 1990; Barry & Sokolov, 1993; Maltzman, 1977; Maltzman & Boyd, 1984; Rushby & Barry, 2007, 2009; Sokolov, 1990). In contrast, evoked cardiac deceleration (ECD) typically occurs as an initial response to stimulus presentation, regardless of novelty, intensity (magnitude) or repetition, and is suggested to reflect early stimulus registration or detection (see Barry, 1981, 1996, 2006, 2009). Similarly, ECD has been proposed to reflect continued attention to, and interest in, a stimulus (e.g., Graham & Clifton, 1966; Turpin, 1983). Slower, longer lasting changes in arousal are reflected in skin conductance levels (SCLs), which have the potential to influence task-dependent SCRs (e.g., Barry, 2004; Barry & Sokolov, 1993; Rushby & Barry, 2007). SCL typically increases (sensitisation) to novel stimuli then rapidly decreases (habituation) with stimulus repetition (Barry, 2004; Groves & Thompson, 1970; Rushby & Barry, 2007; VaezMousavi, Barry, Rushby, & Clarke, 2007).

Socially-relevant information (including facial emotional expressions) is particularly salient to humans, and as such, typically elicits an OR and influences autonomic responses generally (Levenson, Ekman, & Friesen, 1990). Past research generally suggests that autonomic responses are disrupted in individuals with ASDs (Bal et al., 2010; Bölte, Feineis-Matthews, & Poustka, 2008; Corona, Dissanayake, Arbelle, Wellington, & Sigman, 1998; Hubert, Wicker, Monfardini, & Deruelle, 2009; Jansen et al., 2006; Joseph, Ehrman, McNally, & Keehn, 2008; Mathersul et al., 2013a; Mathersul, McDonald, & Rushby, 2013b; Van Hecke et al., 2009), although this is not always the case (e.g., Ben Shalom et al., 2006). Importantly though, one recent study demonstrated (through the use of SCL and SCR) disruptions in the allocation of attention and (emotional) significance to socially-relevant stimuli (neutral faces) in ASDs, whilst stimulus registration/detection (ECD) remained intact (Mathersul, McDonald, & Rushby, 2013c). Concurrent autonomic measures therefore provide an important means of investigating allocation of attention and emotional significance to social stimuli (including emotional faces) in ASDs, and may help to explain why automatic mimicry to emotional stimuli is disrupted whilst processing of non-emotional features of faces is not.

Thus, the aim of the present study was to investigate automatic facial mimicry (EMG responses) to briefly presented facial emotional stimuli in high-functioning individuals with ASDs. Building and extending on past research, particularly the study by Oberman et al. (2009), the present study investigated 30 adults with ASDs compared to 31 demographically matched, developmentally unremarkable adults, when viewing angry versus happy facial emotional expressions. Specifically, the present study employed two