



Autonomic arousal explains social cognitive abilities in high-functioning adults with autism spectrum disorder



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ABSTRACT

Empirical research into behavioural profiles and autonomic responsivity in individuals with autism spectrum disorders (ASDs) is highly variable and inconsistent. Two preliminary studies of children with ASDs suggest that there may be subgroups of ASDs depending on their resting arousal levels, and that these subgroups show different profiles of autonomic responsivity. The aim of the present study was to determine whether (i) adults with high-functioning ASDs may be separated into subgroups according to variation in resting arousal; and (ii) these ASD arousal subgroups differ in their behavioural profiles for basic emotion recognition, judgements of trustworthiness, and cognitive and affective empathy. Thirty high-functioning adults with ASDs and 34 non-clinical controls participated. Resting arousal was determined as the average skin conductance (SCL) across a 2 min resting period. There was a subgroup of ASD adults with significantly lower resting SCL. These individuals demonstrated poorer emotion recognition, tended to judge faces more negatively, and had atypical relationships between SCL and affective empathy. In contrast, low cognitive empathy was a feature of all ASD adults. These findings have important implications for clinical interventions and future studies investigating autonomic functioning in ASDs.

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1. Introduction

Individuals with ASDs (including autism and Asperger's Syndrome)¹ display marked impairments in social interaction such as poor social–emotional reciprocity, deficits in the use of non-verbal communication such as eye-gaze and facial expression and also demonstrate repetitive and stereotyped behaviours (APA, 2000). One potential method of objectively investigating social–emotional reciprocity in these individuals is through physiological markers of the orienting response (OR), such as electrodermal activity (skin conductance). ORs are typically elicited by salient environmental stimuli, particularly socially-relevant information such as faces and affective scenes, and assist in the generation of action and approach within an organism (Barry, 1990). They involve a combination of behavioural and physiological changes, and are affected by the novelty, intensity and significance of the evoking stimulus (Barry, 1990; Rushby et al., 2005). Skin conductance responses (SCRs) may reflect the arousal or intensity of motivationally significant stimuli (Lang, 1995; Lang et al., 1990), as well as the allocation of attention to stimuli over time (e.g., Barry, 1990; Barry and Sokolov, 1993; Maltzman, 1977;

Maltzman and Boyd, 1984; Rushby and Barry, 2007, 2009; Sokolov, 1990).

Past research into phasic, task-dependent ORs (SCRs) in ASDs is inconsistent and appears inconclusive. One study found that ASDs have higher SCRs to socially-relevant stimuli (Kylläinen and Hietanen, 2006) whilst another demonstrated lower SCRs (Hubert et al., 2009). Still other studies have failed to find any differences in SCRs between individuals with ASDs and controls (Ben Shalom et al., 2006; Joseph et al., 2008). In contrast, a series of studies from our own lab have consistently demonstrated that individuals with ASDs have disruptions in SCRs (Mathersul et al., 2013a, 2013b, submitted for publication-a). Differences in experimental design may partly explain these discrepancies in the direction of the effects. For example, SCRs *across face viewing time* for neutral faces failed to habituate for individuals with ASDs (Mathersul et al., 2013b), whereas SCRs *across tasks* to briefly presented emotional faces showed rapid habituation followed by a gradual increase in responses (Mathersul et al., submitted for publication-a). In terms of responses to highly arousing scenes, SCRs were reduced only to affective but not neutral scenes (Mathersul et al., 2013a). Given that the elicitation of an OR (SCRs) to salient information in the environment is directly influenced by baseline arousal levels (both resting and pre-stimulus skin conductance levels (SCLs); Barry and Sokolov, 1993; Sokolov, 1963), it is important to investigate potential differences in baseline arousal. Interestingly, results from our own lab suggest that pre-stimulus SCLs (i.e., slower, more longer lasting changes in arousal related to novel and/or salient stimuli) in individuals with ASDs may

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¹ Proposed changes to diagnostic criteria in the upcoming DSM-5 recommend the removal of the distinction between autism and Asperger's (APA, 2011). In line with these proposed changes to nomenclature, 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 for the purposes of this study.

be either typical (Mathersul et al., 2013b) or atypical (at least initially; Mathersul et al., submitted for publication-a). However, what remains unclear is whether or not resting levels of arousal are typical or atypical in these individuals. This was the first aim of this study.

There is generally a paucity of research into resting arousal levels in ASDs, particularly in recent years. Two studies in the 1980s reported no difference from controls in resting SCL (James and Barry, 1980; Zahn et al., 1987), however, other work suggests that individuals with ASDs may not be homogenous in this regard. One study demonstrated that low-functioning children with ASDs could be separated into subgroups depending on their resting arousal levels (spontaneous fluctuations in SCLs), and these subgroups showed significantly different task-dependent ORs (SCRs) to auditory stimuli (van Engeland, 1984). Similarly, a more recent study of high-functioning children with ASDs again demonstrated separation into subgroups depending on resting arousal levels (SCLs) which showed significantly different SCRs to non-social environmental stimuli (Schoen et al., 2008), although they did not compare to a control group. This issue prompted enquiry into the resting arousal levels of the high-functioning adults who have participated in previous studies from our lab, particularly whether or not the ASD group may be separated into subgroups according to variation in SCLs. This was the second aim of this study.

These two findings in children with ASDs that suggest that variability in resting SCL may contribute to variation in SCRs to salient stimuli are intriguing. They may help explain the extensive inconsistencies in behavioural responses to socially-relevant stimuli in the literature. For example, with regard to basic emotion recognition, some studies have demonstrated deficits (e.g., Ashwin et al., 2006a, 2006b, 2006c; Bal et al., 2010; Corden et al., 2008; Teunisse and de Gelder, 2001; Wallace et al., 2008) whilst others have found no differences between ASDs and controls (Adolphs et al., 2001; Boucher et al., 2000; Capps et al., 1992; Grossman et al., 2000; Loveland et al., 1997). Similarly, some studies suggest that individuals with ASDs rate faces as more trustworthy than controls (Adolphs et al., 2001; Couture et al., 2010), whereas other studies have found no differences (Mathersul et al., 2013b; Pinkham et al., 2008). Finally, whilst impaired empathy is clinically considered a central characteristic of ASDs (Baron-Cohen and Wheelwright, 2004; Baron-Cohen et al., 2001a), empirical research is inconsistent, with some studies demonstrating deficits in both cognitive and affective empathy (Mathersul et al., in press; Shamay-Tsoory et al., 2002), whilst others have shown deficits only in cognitive but not affective empathy (Dziobek et al., 2008; Rogers et al., 2007). A potential explanation for these inconsistencies may be variability in resting arousal levels, given the high degree of variability and heterogeneity across the spectrum of ASDs. Therefore, the third and final aim of this study was to explore the behavioural profile(s) of the different ASD subgroups (as determined by resting SCL).

In summary, the aim of the present study was to investigate (i) whether adults with high-functioning ASDs differ from controls in their resting arousal levels (SCLs); (ii) whether or not the ASD group may be separated into subgroups according to variation in these resting arousal levels; and (iii) whether or not the ASD arousal subgroups differ in their behavioural profiles for basic emotion recognition, judgements of trustworthiness, and cognitive and affective empathy.

2. Methods

2.1. Participants

Thirty high-functioning adults with ASDs and thirty-four non-clinical control individuals were recruited from Sydney and surrounding regions in New South Wales, Australia, via advertisements,

support groups, clinicians, Aspect (Autism Spectrum Australia)² and undergraduate university populations. Individuals were reimbursed for their time or received course credit for participation. Participants gave written informed consent in accordance with the University of New South Wales Human Research Ethics Committee (UNSW HREC).

All individuals in the clinical group met *DSM-IV-TR* (APA, 2000) diagnostic criteria for an ASD, as assessed by experienced clinicians independent of the present study. These clinicians (e.g., clinical psychologists, neuropsychologists, psychiatrists) administered standardised clinical interviews such as the ADI-R (Autism Diagnostic Interview—Revised; Lord et al., 1994) and ADOS-G (Autism Diagnostic Observation Schedule—Generic; Lord et al., 1999), however, the information from these reports was not typically made available to the researchers. As such, the Autism Quotient (AQ; ≥ 32 ; Baron-Cohen et al., 2001b) and/or Ritvo Autism Asperger's Diagnostic Scale (RAADS; ≥ 77 ; Ritvo et al., 2008) were used to support diagnosis. The AQ has been shown to produce good test–retest reliability ($r = .70$) and good internal consistency (Cronbach's $\alpha = .63-.77$; Baron-Cohen et al., 2001b). The RAADS has been shown to produce reliable clinical discrimination (97–100% sensitivity, 100% specificity), high test–retest reliability ($r = .99$), and good internal consistency (Cronbach's $\alpha = .65-.92$; Ritvo et al., 2011, 2008). Exclusion criteria were a self-reported personal history of physical brain injury, neurological or developmental disorder (other than an ASD in the clinical group), psychiatric illness, or any other serious medical condition. In addition, control participants were excluded if they had a score above the recommended clinical cut-off on the AQ and/or RAADS. Three control participants were subsequently excluded. One ASD participant was excluded due to smoking immediately prior to arriving, and the data from an additional ASD participant was lost due to equipment problems. The final sample consisted of 28 high-functioning adults with ASDs (aged 18–73 years; 22 males) and 31 non-clinical control individuals (aged 18–72 years; 24 males) (see Table 1).

2.2. Materials and measures

2.2.1. Wechsler Abbreviated Scale of Intelligence

The Wechsler Abbreviated Scale of Intelligence (WASI) is a brief, standardised measure of general intellectual functioning that demonstrates good reliability and validity (Wechsler, 1999). All participants were administered the two-subtest format, allowing for a measure of full scale IQ (FSIQ).

2.2.2. The Awareness of Social Inference Test (TASIT)

The Awareness of Social Inference Test (TASIT; McDonald et al., 2002) uses video vignettes depicting conversational exchanges to assess basic emotion recognition, as well as the ability to understand more subtle emotions and conversational inferences. Part 1 (The Emotion Evaluation Test) of TASIT assesses the ability to recognise and discriminate six basic emotions (happiness, sadness, anger, fear, surprise, disgust) as well as neutral expressions (overall total score maximum = 28). TASIT has a total playing time of approximately 35 min and an administration viewing time of 60–75 min. Practice items are provided for all parts. The vignettes are presented in a fixed order, randomised between emotion types. TASIT has been shown to have good test–retest reliability ($r = .74-.88$) (McDonald et al., 2006). It is sensitive to clinical conditions and also predictive of real-world function (McDonald et al., 2004).

2.2.3. Interpersonal Reactivity Index (IRI)

The Interpersonal Reactivity Index (IRI; Davis, 1980, 1983) is a 28-item self-report questionnaire designed to assess both cognitive

² Australia's largest not-for-profit provider of services related to ASDs, including access to information, support groups, blogs, research participation and relevant media releases.

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