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# Detecting subtle facial emotion recognition deficits in high-functioning Autism using dynamic stimuli of varying intensities

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ABSTRACT

Autism Spectrum Disorders (ASD) are characterised by social and communication impairment, yet evidence for deficits in the ability to recognise facial expressions of basic emotions is conflicting. Many studies reporting no deficits have used stimuli that may be too simple (with associated ceiling effects), for example, 100% 'full-blown' expressions. In order to investigate subtle deficits in facial emotion recognition, 21 adolescent males with high-functioning Austism Spectrum Disorders (ASD) and 16 age and IQ matched typically developing control males completed a new sensitive test of facial emotion recognition which uses dynamic stimuli of varying intensities of expressions of the six basic emotions (Emotion Recognition Test; Montagne et al., 2007). Participants with ASD were found to be less accurate at processing the basic emotional expressions of disgust, anger and surprise; disgust recognition was most impaired – at 100% intensity and lower levels, whereas recognition of surprise and anger were intact at 100% but impaired at lower levels of intensity.



## 1. Introduction

Autism Spectrum Disorders (ASD) are common neurodevelopmental disorders of childhood and present with abnormalities in social interaction, communication and restrictive and repetitive behaviours. The earliest accounts of high-functioning ASD by Asperger (1944), noted prominent social abnormalities, including difficulties in social interactions and abnormal use of eye gaze. Modern theorists consider the primary aspect of ASD is the lack of the normal drive to socially interact with others (e.g. Baron-Cohen, 1995; Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998; Grelotti, Gauthier, & Schultz, 2002). This reduced drive may be responsible for impairments in emotion perception and understanding (Hobson, 1993).

Facial expressions of emotion are the foundations of social interaction, as they convey vital non-verbal cues for inferences about the motivations and intentions of others (Darwin, 1872). Six basic universal emotions have been identified: happiness, sadness, fear, anger, disgust and surprise (e.g. Ekman, 1992; Ekman & Friesen, 1971). Opinion is divided as to whether individuals with ASD are impaired at processing basic emotional expressions, with much evidence to suggest that they are (e.g. Bolte & Poustka, 2003; Celani, Battacchi, & Arcidiacono, 1999; Davies, Bishop, Manstead, & Tantam, 1994; Hobson, 1986a, 1986b; Tantum, Monaghan, Nicholson, & Stirling, 1989). However, numerous other studies fail to find such impairment (e.g. Baron-Cohen, Jolliffe, Martimore, & Robertson, 1997; Castelli, 2005; Grossman, Klin, Carter, & Volkmar, 2000; Ogai et al., 2003; Ozonoff, Pennington, & Rogers, 1990; Prior, Dahlstrom, & Squires, 1990). These findings confuse the current understanding of emotion recognition in ASD (Frith, 2003).

Much of the research that has failed to find impaired processing of basic emotional expressions employed very simplistic stimuli i.e. 'full blown' or '100% expression' stimuli (Baron-Cohen et al., 1997; Grossman et al., 2000; Ogai et al., 2003; Ozonoff et al., 1990; Prior et al., 1990) which may also have produced ceiling effects. Recent evidence suggests that individuals with ASD perceive 'exaggerated' emotional facial expressions as being more realistic and representative of real life emotions (Rutherford & McIntosh, 2007). It is therefore possible that difficulties processing basic emotional expressions in individuals with ASD are often not detected in experiments employing 'full blown' stimuli. If singular facial emotion stimuli are presented at more moderate intensities, individuals with ASD may find them more difficult to recognise. This forms the rationale for the current study. The only study to investigate using different intensities of stimuli in participants with ASD (Humphreys et al., 2007) has used expressions of *mixed* intensities (e.g. 70% fear mixed with 30% anger – which still equates to a 100% expression).

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An innovative test, the Emotion Recognition Task (ERT) (Montagne, Kessels, De Haan, & Perrett, 2007) was used in the current study to measure differing intensities of singular emotion expressions ranging from 20% to 100%, rather than just the 100% expressions employed in most previous research. This is a computerised task using dynamic stimuli of differing intensities of the six basic facial expressions, which affords more sensitivity to subtle deficits in facial emotion processing. The dynamic nature of the stimuli also adds ecological validity to the task, compared with tasks using static images. On each trial, participants watch a 'video' clip of the expression morphing from a neutral expression to an emotion displayed at variable intensities from 20% to 100%. Participants have to match the expression to one of the six emotion labels displayed on screen. The ERT has demonstrated subtle deficits in clinical and non-clinical groups (e.g. Montagne, Kessels, Frigerio, De Haan, & Perrett, 2005; Montagne, Kessels, Wester, & De Haan, 2006; Montagne, Vanhonk, et al., 2005). The current study is unique in that it will test recognition of facial expressions of various intensities in adolescents with ASD. We predicted that the participants with ASD would show poorer performance on the ERT than typically developing controls (matched for age and IQ). As some studies have shown no deficits on full-blown stimuli (i.e. 100%), it might be expected that there may be no difference between groups on the 100% stimuli, but that deficits will be apparent in the ASD group on the subtle stimuli (i.e. the lower intensities).

## 2. Methods

### 2.1. Participants

#### 2.1.1. Clinical sample

The clinical sample consisted of 21 males aged 12–19 years old (mean age = 15.33, SD = 2.20) with a psychiatrist's diagnosis of High-functioning Autism (HFA) or Asperger's syndrome according to the DSM-IV diagnostic criteria. This diagnosis was confirmed by administering the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000) and the Autism Diagnostic Interview-Revised (ADI-R; Rutter, Le Couteur, & Lord, 2003); all cases met ADI criteria and ADOS criteria for Autism Spectrum Disorder and had a performance IQ > 80, measured by the Leiter International Performance Scale-Revised (Royd & Miller, 1997) (mean IQ = 100.67, SD = 12.216, range = 83–129). Participants scored within the age-appropriate norms on the measure of verbal ability using the Peabody Picture Vocabulary Test—Third Edition (PPVT-III; Dunn & Dunn, 1981) (Mean standard PPVT score = 107.71, SD = 15.81, range = 78–132). Participants outwith the age normed values were excluded to avoid the effect of deficits in receptive language on results shown.

#### 2.1.2. Control group

16 typically developing males aged 12–18 years old (mean age = 14.75, SD = 2.08) were recruited from local secondary schools. The Child Behaviour Checklist (CBCL), 6–18 years (Achenbach & Rescorla, 2001) was used to screen for psychiatric disorder. Control participants scored below the clinical ranges on all of the DSM normed criteria. Controls IQ were > 80 on IQ using the Leiter-R (Mean IQ = 100.56, SD = 11.69, range = 80–124). Control PPVT scores were within the normed averages (mean standard PPVT score = 107.36, SD = 11.99, range = 77–127).

### 2.2. Emotion Recognition Task (Montagne et al., 2007)

The Emotion Recognition Task (ERT) is a computer-generated program showing 'video clips' of varying intensities of facial expressions of emotion. Stimuli was developed using algorithms (Benson & Perrett, 1991) which created intermediate morphed images between a neutral face (0% emotion) and a full-blown expression (100% emotion). Stimuli for this test were based on colour pictures from actors mimicking emotional expressions and a neutral face. There were four actors (two male and two female) who each posed six emotions (anger, disgust, fear, happiness, sadness, and surprise). These images were used to construct video clips that incrementally increase the degree of expression by 10% steps from 20% to 100% (i.e. nine video clips for each actor) nine video clips were constructed for each of the six emotions by increasing the number of morphed images presented in succession. For full details of the methods of creation of the ERT and results of piloting the task, see Montagne et al. (2007).

The presentation procedure consisted of four practice trials followed by the actual task. The practice trials consisted of four video clips of neutral to 100% expressions. For the task, participants saw, in a random order, the 24 video clips running from neutral to 20% expression (6 emotional expressions by all 4 actors), followed by the 24 clips from neutral to 30%, and continued in blocks of increments of 10% until they reached the final sequence of clips in which the neutral face changed into a full-blown expression (100%). After each trial, a forced choice between one of six emotional expression labels displayed on the screen was required. There was no time restriction for each trial; and after the clip is played the static image of the final intensity remains on screen until the forced choice is made. The total task takes approximately 20 min.

### 2.3. Design

The study used a mixed-factor design, one between subjects factor (group) with two levels (ASD group vs. controls), and two within-subjects factors; facial emotion type – with six levels (anger, disgust, fear, happy, sad, surprise); and intensity of emotion – three levels (the nine intensity levels were combined into three intensity levels; low intensity 20–40%; medium intensity 50–70%; high intensity 80–100%). Results were analysed using a mixed 3-way ANOVA.

### 2.4. Procedure

Ethical approval was granted by the HSE Linn Dara Child and Adolescent Psychiatry written informed consents were obtained from all participants and their parents (where under 18 years old).

Subjects were recruited through the Autism Genetics Program of the Neuropsychiatric Genetics Research Group, Trinity College Dublin. Controls were recruited from local secondary schools in Dublin. Diagnostic and cognitive assessments (as outlined above) and the ERT were conducted either in the school or home environment.

## 3. Results

### 3.1. Confounding variables

There was no significant differences between the subjects and controls in age [$t_{35} = -0.82$, $p = 0.42$], IQ [$t_{35} = -0.03$, $p = 0.98$], or PPVT standard scores [$t_{33} = -0.07$, $p = 0.94$].

Within the control group ($n = 16$), there was no correlation (Spearman's rank) between total recognition accuracy on facial emotion and IQ (all $r = .001$, $p = .99$), PPVT standard score ($r = -.36$, $p = .10$), or age ($r = .379$, $p = .15$). Within the ASD group ($n = 21$), there was no correlation between total facial emotion accuracy and IQ ($r = .278$, $p = .223$) or PPVT standard score ($r = .345$, $p = .126$), but there was a significant positive correlation between total facial emotion accuracy and age ($r = .525$, $p = .014$) and this was due to a highly significant positive correlation between total disgust accuracy and age ($r = .594$, $p = .005$); with accuracy improving at older ages.

### 3.2. way ANCOVA (Group × Emotion × Intensity) controlling for age

The nine intensity levels (20–100%) were combined into three levels to increase the amount of trials in each level of intensity; low (20% + 30% + 40%), medium (50% + 60% + 70%), and high (80% + 90% + 100%).

#### 3.2.1. Main effects

Overall, there was a main effect of group [$F_{1,34} = 11.40$, $p = .002$]; children with ASD were less accurate than controls [mean total correct trials: ASD = 113.76, SD = 19.23; controls = 129.31, SD = 14.19].

There were significant main effects of age [$F_{1,34} = 10.61$, $p = .003$] and emotion [$F_{5,170} = 6.10$, $p < .0005$]. Bonferroni corrected post hoc pairwise comparisons revealed happy was identified more accurately than the rest (all $p < .005$), and fear less accurately than the rest (all $p < .033$) (see Fig. 1). There was no main effect of intensity [$F_{2,68} = .53$, $p = .59$].

#### 3.2.2. Interaction effects

A highly significant interaction between emotion and group was observed [$F_{5,170} = 5.37$, $p = .0005$]. This interaction was a result of participants with ASD performing significantly worse than controls on anger [$F_{1,35} = 4.90$, $p = .034$], disgust [$F_{1,35} = 11.53$, $p = .002$]