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A fine-grained analysis of facial expression processing in high-functioning adults with autism

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Abstract

It is unclear whether individuals with autism are impaired at recognizing basic facial expressions, and whether, if any impairment exists, it applies to expression processing in general, or to certain expressions, in particular. To evaluate these alternatives, we adopted a fine-grained analysis of facial expression processing in autism. Specifically, we used the 'facial expression megamix' paradigm [Young, A. W., Rowland, D., Calder, A. J, Etcoff, N. L., Seth, A., & Perrett, D. I. (1997). Facial expression megamix: Tests of dimensional and category accounts of emotion recognition *Cognition and Emotion, 14*, 39–60] in which adults with autism and a typically developing comparison group performed a six alternative forced-choice response to morphs of all possible combinations of the six basic expressions identified by Ekman [Ekman, P. (1972). Universals and cultural differences in facial expressions of emotion. In J. K. Cole (Ed.), *Nebraska symposium on motivation: vol. 1971*, (pp. 207–283). Lincoln, Nebraska: University of Nebraska Press] (happiness, sadness, disgust, anger, fear and surprise). Clear differences were evident between the two groups, most obviously in the recognition of fear, but also in the recognition of disgust and happiness. A second experiment demonstrated that individuals with autism are able to discriminate between different emotional images and suggests that low-level perceptual difficulties do not underlie the difficulties with emotion recognition.

Keywords: Face processing; Emotion; Developmental disorders

1. Introduction

Autism is a neurodevelopmental condition characterized by impairments in communication and social cognition, and repetitive, stereotyped behaviors. Facial expression processing has been the focus of much attention in the condition (e.g. Adolphs, Sears, & Piven, 2001; Ashwin, Baron-Cohen, Wheelwright, O'Riordan, & Bullmore, in press; Critchley et al., 2000; Davies, Bishop, Manstead, & Tantam, 1994; Teunisse & de Gelder, 1994, 2001). This is for multiple reasons, including the difficulties with face identity processing seen in autism (e.g. Behrmann, Thomas, & Humphreys, 2006) and possible links with theory of mind impairments (Baron-Cohen et al., 1994), with the obvious ramifications for social skills. Surprisingly, however, given the social implications of understanding facial expression, it is still unclear whether individuals with autism are impaired at recognizing basic facial expressions, although they do appear to have problems with more subtle or cognitive expressions such as arrogance or flirtatiousness (e.g. Baron-Cohen, Jolliffe, Martimore, & Robertson, 1997; Kleinman, Marciano, & Ault, 2001). While many studies have revealed difficulties with basic expressions (e.g. Celani, Battachi, & Arcidiacono, 1999; Davies et al., 1994; Hobson, 1986a,b; Hobson, Ouston, & Lee, 1988; Langdell, 1978), others have not (e.g. Adolphs et al., 2001; Baron-Cohen et al., 1997; Grossman, Klin, Carter, & Volkmar, 2000; Ogai et al., 2003; Ozonoff, Pennington, & Rogers, 1990; Prior, Dahlstrom, & Squires, 1990; Spezio, Adolphs, Hurley, & Piven, 2007; Teunisse and de Gelder, 1994; Volkmar, Sparrow, Rende, & Cohen, 1989).

Even if a deficit in facial expression processing exists in autism, it is not evident whether all expressions are implicated and if so, whether this is to an equal extent. Whereas one study reported relative impairments in the recognition of anger and disgust (Ellis & Leafhead, 1996), another found that a group of children with autism were impaired at recognizing surprise, but not happiness or sadness (disgust, fear and anger were not

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tested) (Baron-Cohen, Spitz, & Cross, 1993). Yet other studies report greater difficulties in the recognition of fear than the other five basic expressions although some difficulties with anger were also noted (Howard et al., 2000; Giola & Brosgole, 1988; Pelphrey et al., 2002). Teunisse and de Gelder (2001) found that performance on a morphed continuum between happiness and sadness was at the level of typically developing individuals but that recognition of the other two continua tested (anger–sadness and anger–fear) was impaired.

One reason for the lack of consensus amongst these findings may be that, in high-functioning individuals with autism, impairments in processing basic expressions may be relatively subtle, if present, and not all studies succeed in uncovering the subtle deficits. Additionally, some studies do not contain comparison groups (e.g. Adolphs et al., 2001), not all previous studies have matched appropriately the autism and comparison groups (e.g. Teunisse & de Gelder, 2001), and some of these studies have not measured verbal ability or IQ in their autism group. It is also the case that some studies test facial emotion processing in children (e.g. Davies et al., 1994), while other studies test it in adults (e.g. Adolphs et al., 2001), and it is possible that development might play a role in the discrepant findings. The aim of the present studies was to uncover possible subtle impairments, which may exist in facial expression processing in adults with autism using morphed expressions and a well-matched comparison group. Although a previous study has used morphed expressions to investigate facial expression processing in high-functioning adolescents with autism, only three different morphed continua – anger–sadness, anger–fear and happiness–sadness – were used in a two alternative forced-choice paradigm (Teunisse & de Gelder, 2001). To allow for a full exploration of expression processing and a much more complete test of the questions at issue, we compare the performance of individuals with autism and well-matched controls on a fifteen morphed expression continua and a six alternative, rather than a two alternative, forced choice. We also investigated whether there were relationships between the degree of any impairment and the severity of autism symptoms in the individual and, finally, we consider possible explanations for the pattern of impairment we uncover.

2. Experiment 1

2.1. Method

2.1.1. Participants

Twenty high-functioning individuals with autism and 18 IQ-matched typically developing comparison individuals took part (see Table 1). The diagnosis of autism was established using the Autism Diagnostic Interview-Revised (ADI-R) (Lord, Rutter, & Le Couteur, 1994), the ADOS (social and communication domains; Lord et al., 2000) and expert clinical diagnosis. It was not possible to administer the ADI-R for three participants with autism, for whom no living relatives who could complete the inventory were available. One participant (A13) did not meet the criteria on the ADI-R, but in the expert clinical opinion of the second author (NM), he still merited a diagnosis of autism. Individuals were excluded if they had an associated condition such as fragile-X syndrome or tuberous sclerosis. All participants had normal or corrected-to-normal vision.

The comparison participants were community volunteers matched to the participants with autism approximately on age and IQ, as measured on the Wechsler abbreviated scale of intelligence (WASI^{TM} The Psychological Corporation, 1999) (see Table 1). The mean ages of the groups were: autism 24 years (S.D. 9 years), comparison group 28 years (S.D. 10 years), and the mean IQs were: autism VIQ 102 (S.D. 14) PIQ 105 (S.D. 15) FSIQ 103 (S.D. 15); comparison group VIQ 107 (S.D. 11) PIQ 108 (S.D. 7) FSIQ 109 (S.D. 9). *T*-tests confirmed that there were no significant differences between the two groups on age or any IQ measure (age, $t(36) = 1.15$, $p = 0.26$; VIQ, $t(36) = 1.30$, $p = 0.20$; PIQ, $t(36) = 0.91$, $p = 0.37$, FSIQ, $t(36) = 1.40$, $p = 0.17$).

The Benton facial recognition test (BFRT; Benton, Sivan, Hamsher, Varney, & Spreen, 1994), a standard neuropsychological test of face matching, that involves matching face identity across changes in lighting and viewpoint, was administered to 18/20 of the participants with autism.

Written informed consent was obtained from all participants or their guardians, using procedures approved by the University of Pittsburgh Medical Center Institutional Review Board and by the Carnegie Mellon University Institutional Review Board.

2.1.2. Stimuli and apparatus

Stimuli were taken from the Facial Expressions of Emotion: Stimuli and Test (FEEST) (Young, Perrett, Calder, Sprengelmeyer, & Ekman, 2002) set of morphed facial expressions (see Fig. 1 for an example).

Further details of the stimuli can be found in Young et al. (1997) but, briefly, black and white photographs of face JJ (Ekman & Friesen, 1976) showing happiness, surprise, fear, sadness, disgust and anger, were morphed in all possible pairwise combinations. The proportions of the blend in each continuum were 90:10, 70:30, 50:50, 30:70 and 10:90 (e.g. 90% fear 10% surprise etc for the fear–surprise continuum). Each continuum is labeled by the emotions at each end: fear–surprise is FS and then the proportion of the second emotion is included (FS10 indicates 10% surprise which implies 90% fear. The other expressions are abbreviated as follows: anger, A; disgust, D; happiness, H; sadness, M). The prototype (100%) expressions were not used. Thus, there were 15 different continua, each consisting of five images, i.e. 75 faces in total. Each morphed face measured 11.4 cm horizontally and 14 cm vertically and was viewed from a distance of approximately 0.6 m.

2.1.3. Procedure

The 75 morphed facial expressions were presented one at a time centrally using E-Prime (Psychology Software Tools Inc.) on a Dell laptop screen, in a random order, and stayed visible until response. The task was to decide which prototypical expression the image most resembled. Responses were made using six labeled keys on the keyboard. No feedback was given as to the accuracy of the response. There were seven practice trials, and following this, 11 blocks of 75 test trials. Due to fatigue or failure to cooperate for the duration of the experimental session, two participants with autism completed nine blocks, one completed six blocks and one completed four blocks. For all participants, responses were averaged across all presentations of a particular expression morph. In contrast to the original Young et al. (1997) study, there was no time limit for responding as we anticipated that people with autism would respond more slowly than controls (e.g. Behrmann, Avidan, et al., 2006), and we wished to maximize accuracy. The task took between 25 min and 1 h, depending on the speed of the individual's responses.

2.2. Results

We first discuss correct recognition of the unambiguous expressions (those which contained 90% of a particular expression) and present confusability matrices for these expressions. We then briefly present the correct recognition results for the 70% and 50% expressions and look at all responses for all 75 expression blends together.

2.2.1. Recognition of unambiguous (90%) expressions

For each expression, results were obtained by pooling over all five stimuli containing that 90% expression (e.g. the 'happiness' results are the average of 90% happiness mixed with each of 10% fear, sadness, disgust, surprise and anger). Mean accuracy and mean log reaction times for the group with autism and IQ-matched comparison group are shown in Fig. 2a and b.