PROCESSING CHIMERIC FACES
IN ADOLESCENTS WITH ASPERGER SYNDROME

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Abstract

Persons with Asperger Syndrome (AS) are known to process facial expressions (FE) of emotion differently than typically developing (TD) individuals. Here the differences were examined using chimeric faces. Stimuli (N=91) were either Ekman-Friesen (1976) prototypes of seven basic emotions or composites with left and right halves from different basic emotions. Five AS adolescents and five age-matched TD persons labeled the primary emotion (out of seven) conveyed by each picture, plus an optional secondary component. Similarity measures derived from the naming data were processed by multidimensional scaling. Obtained structures were comparable for the AS and TD groups in the number and interpretation of dimensions. Both groups revealed the laterality bias whereby the emotion displayed in the left half-face dominates the labeling. Notably, laterality bias was stronger in the AS group. This precludes models of FE processing in which AS subjects attend more to the 'configural' aspect, as opposed to the 'featural' aspect of FEs.

The capacity to recognize emotional expressions, paramount for social interaction, is impaired in individuals with Asperger Syndrome (AS), a form of autistic spectrum disorder (Asperger, 1944). While the causes of AS are not fully understood, its onset during early infancy is considered to involve both genetic and environmental factors (Baron-Cohen, 1995). Persons with AS do not exhibit significant delay or impairment in their cognitive development; they have, however, sustained and often severe impairments in social interaction that manifest themselves as lack of eye contact, poor response to emotional displays and inability to process salient information from faces (Dawson *et al*., 2005).

It has been shown that AS individuals utilize an atypical decoding strategy for processing facial expressions (FEs) while relying more on individual parts of the face than the overall configuration and, in particular, looking less on the eye region (for a review see Boraston & Blakemore, 2007). Further, AS persons are asserted to employ verbal mediation to process FEs: in Grossman *et al*.'s (2000) study they performed equally well with a TD group in recognising FEs of basic emotions alone but significantly worse when these FEs were paired with mismatching words, as if relying on verbal rather than affective information in the visual stimuli.

One line of FE research focuses on the left visual field (LVF) bias in face processing. When people view asymmetric chimeric faces composed of a smiling half and a neutral half, the judgement of the emotion is dominated by the expression occupying their LVF (Campbell, 1978). This is thought to reflect a right cerebral hemisphere processing advantage, probably enhanced by eye-movement patterns trained for left-to-right reading (Butler & Harvey, 2006). The bias has been confirmed for sad/neutral chimeras (Burt & Perrett, 1997) and for chimeric composites of happy, sad and angry (Drebing *et al*., 1997).

Table 1. Demographic characteristics and Standardised Age Score (SAS) for the Asperger (AS) and age-matched typically developing (TD) participants. (NB: Average SAS = 100)

AS participants					**TD** participants				
Init-ials	Age (y.o.)	Sex	SAS Verbal	SAS Nonverbal	Init-ials	Age (y.o.)	Sex	SAS Verbal	SAS Nonverbal
JHy	14	M	117	110	MB	14	M	126	127
LD	14	M	113	104	GB	15	M	118	113
JHm	14	M	113	123	NF	15	F	109	99
RB	15	M	40	N/A	HS	14	F	99	111
BS	15	M	22	94	RS	15	M	126	121

There are indications that hemispheric laterality in AS individuals differs from that in TD persons (cf. Baron-Cohen, 1995). Ashwin *et al.* (2005) found a comparable LVF bias in AS and control groups. However, their task asked subjects to judge the emotional intensity (rather than identify the emotion) of happy/neutral and angry/neutral chimeras compared to their mirror images. Using photographs of upper-face expressions, Shamay-Tsoory and colleagues (2010) concluded that AS individuals' performance in emotional processing indicated left hemisphere dysfunction.

In the present study we questioned whether the LVF bias would manifest in AS persons for chimeric faces that, in addition to half-neutral composites, present emotions, positive and negative, on both sides. This stimulus variety may shed light on the relative weighting of the two aspects of processing emotional faces by AS individuals, i.e. the left face bias vs. eye fixation dwelling on the mouth region, while confirming that lateralization is the same for negative as well as positive expressions (rather than depending on emotional valence). In addition, we extended the response format and applied a multidimensional scaling analysis to the data, sensitive to any minor perceptual differences that might be present in the AS group.

Method

Participants

Five male adolescents aged 14-15 years old (M_{AS}=14.4) diagnosed with AS were recruited from a local private secondary school in North-West England. Five TD participants, three males and two females, matched in age (M_{TD}=14.6) were recruited from a local comprehensive secondary school in the same region. Details for the participants are shown in Table 1. Signed consent forms were provided by parents or guardians of all participants.

Stimuli

Photographs of FEs were selected from Ekman and Friesen (1976) to represent the prototype emotions: *Happiness*, *Surprise, Anger, Sadness, Fear, Disgust* and *Neutral*. Seven images featured a female poser MO while the other seven a male poser WF. Each prototype FE picture was split into vertical halves down the middle of the face, using *Paint Shop Pro Ultimate X2 Photo*. Separate "MO series" and "WF series" of chimeric images were created from juxtaposing all combinations of different 'parent' prototype emotional half-faces (Figure 1). These juxtapositions were repeated using horizontally-mirrored reflections of the FE halves, making a total of 91 stimuli (=7 + 7 x 6 x·2) in each of the MO and WF series. Each picture was a 10.5 x 14.8 cm grey-scale image fixed on cardboard.

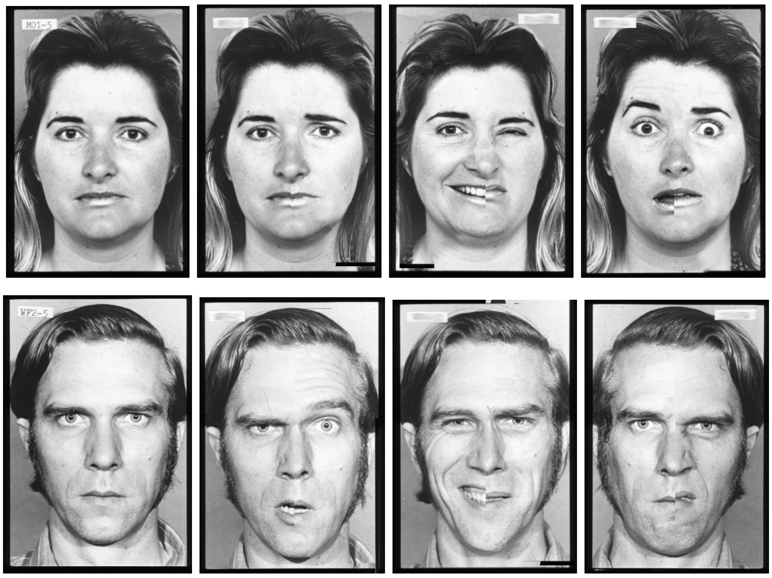

Fig. 1. Examples of the FE stimuli. Upper row: MO-series. Left to right: *Neutral* prototype; chimeric FEs for *Neutral-Sadness*, *Happiness-Disgust*, *Surprise-Fear*. Lower row: WF-series. Left to right: *Neutral* prototype; chimeric FEs for *Anger-Surprise*, *Happiness-Sadness*, *Neutral-Disgust*. Underlined identifiers indicate stimuli composed from mirrored half-faces.

Procedure

The free-viewing chimeric FE task was carried out individually in a quiet room. Participants were requested to read the seven emotion labels printed on a sheet of paper and select the label which would describe emotion in the image shown. If a single emotion label did not suffice, they were invited to name a second emotion (with the same seven choices). Participants were reminded to make clear the emotion they recognized first. A sheet with definitions of the emotions from the Oxford English Dictionary was provided in addition.

The experimenter (TA), seated opposite to the subject, presented the images one by one at a viewing distance of ca. 40 cm. Photographs of the basic FEs were first presented, in a pseudo-random order, with images of the MO- and WF-series interleaved. These initial 14 prototype images were followed by chimeric stimuli, again in pseudo-random order. The task took ca. 70 min to complete per subject.

Analysis of raw data

Each stimulus was quantified as a seven-part emotion profile, combining the emotion-label data across the AS group and separately across the TDs as follows. Each subject contributed three points to each profile: all three accruing to a single label if that was the only emotion ascribed to the image; if two emotions were ascribed, the first and second accrued 2 and 1 point respectively (Shepard & Carroll, 1966). For each of the 42 pairings of emotions, the two profiles describing the chimeric images from original and mirrored prototypes were averaged, reducing each subject group's data to 49 profiles for the MO-series and 49 for the WF-series.

Redundancies within these 7-dimensional profiles make it possible to summarise them within a lower-dimensional space. Non-metric multidimensional scaling (MDS) was applied to the matrix of covariances among the profiles to examine their overall structure (Shepard & Carroll, 1966). MDS was applied to data from the AS and TD groups together, doubling the number of points, to facilitate a comparison between them. This did not noticeably distort the structure from either group analyzed in isolation (implying that they were using the emotion labels in a similar way).

Table 2. Mean number of responses accrued for each emotion label from the AS and TD groups. Significant between-group differences in label usage are indicated in bold.

	Happiness	Surprise	Anger	Sadness	Fear	Disgust	Neutral		Surprise + Fear
AS	4.83	**5.00**	3.83	**2.98**	3.44	4.20	**5.66**		**8.44**
TD	5.13	**5.86**	3.90	**2.12**	3.74	4.59	**4.63**		**9.60**

Results and Discussion

The chimeric stimuli can seem forced or unnatural (Figure 1), requiring subjects to decode the emotional content the two half-faces simultaneously. This task is difficult but not excessively so, as shown by the structured nature of responses.

Some broad trends within the data can be seen by averaging the profiles across all stimuli for the AS and TD groups (Table 2). Repeated-sample *t*-test ($p<.01$) indicated that the AS participants reported significantly fewer 'Surprise' responses than the TD group, but more 'Sadness' and 'Neutral' responses.

MDS analysis resulted in a spatial solution, i.e. a 'map' in which 49 emotion label profiles of the prototypes and chimeras are represented as points. For both the MO- and WF-series 4D solutions were chosen with $stress_1$ values of 0.111 and 0.105 respectively. The solutions were rotated to reveal the *semantic structure* of the emotion labels as much as the perceptual structure of the stimuli. All four dimensions were unipolar, with the *Neutral* prototype at one extreme and the other extremes occupied by the prototypes of *Happiness* (*D*1), *Fear/Surprise* (*D*2), *Disgust* (*D*3) and *Sadness* (*D*4), as shown in Figure 2 for the MO-series. Hollow circles indicate plots for AS observers and solid grey circles for TD observers; the emotion prototypes are singled out with larger circles. The solution for the WF-series did not differ substantially and according to Canonical Correlation analysis it shared the same un-

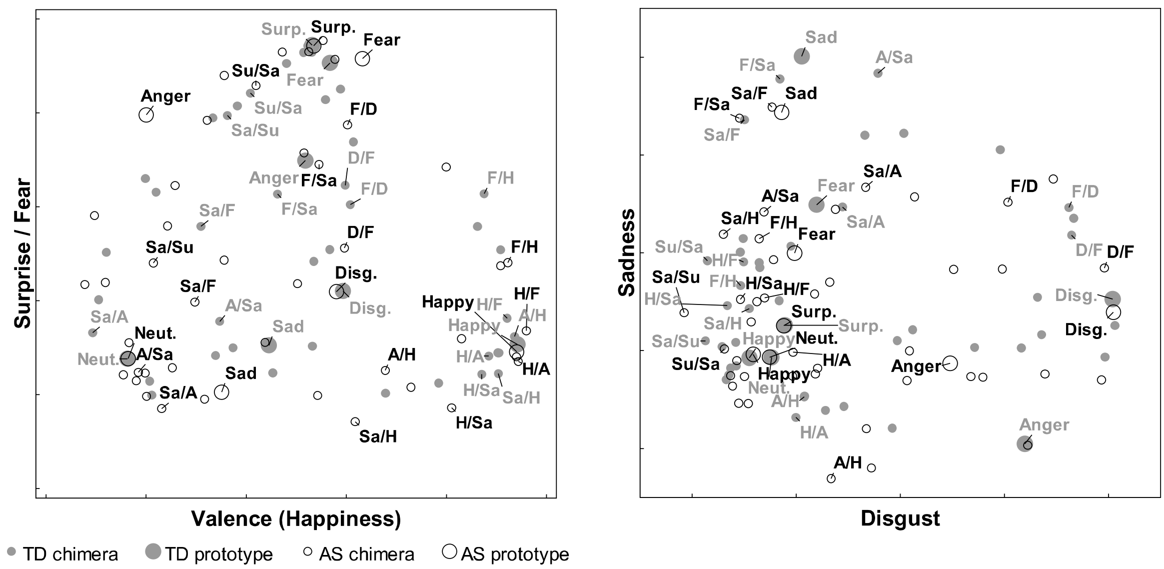

Figure 2. Projections of the 4D solution for the MO-series stimuli (female poser) onto the *D*1/*D*2 (left panel) and *D*3/*D*4 (right panel) planes, for observers with Asperger syndrome (AS) and typically developing individuals (TD). Not all chimeric stimuli are labelled.

derlying dimensions.

Some clustering of stimuli within the solutions is evident (e.g. the stimuli containing a left or right half of the *Happiness* prototype are generally closer to that prototype than to the emotions providing their other halves). The effects of laterality can also be seen, by comparing pairs of chimeras such as *H/F* and *F/H* where the *Happiness* component is the left and right half respectively. In this example, the former is closer to the *Happiness* prototype, for both AS and TD groups and both stimulus series. This LVF-bias seems to be as strong for negative-valence expressions (e.g. for *F/N* vs. *N/F* stimuli) as for combinations of *Happiness*.

To measure the LVF bias for each observer group, AS and TD, two factors were involved: the similarity of the response profile of a given chimera to that of the prototypes providing its left-hand (L) and right-hand (R) sides. To the extent that one group is more LVF biased than the other, the L similarity will be higher across stimuli while the R will be lower. Both factors were quantified by taking the binomial correlation r between the corresponding profiles (see Table 3).

A direct index of LVF bias was computed for the 21 pairs of emotions by comparing the profiles of each L/R chimera and the corresponding R/L chimera. It was more convenient to calculate this using absolute differences rather than correlations. For instance, for the MO-series *Anger-Happiness* combination, descriptions from AS observers gave 8 more points of 'Happiness' to the *H/A* chimera than to the *A/H* chimera; 5 fewer 'Anger' points; and so on, these differences totalling to a "Laterality value" of 22. Table 3 tabulates mean values for these indicators of LVF bias within the AS and TD groups; it also tests the significance of any between-group difference in LVF bias (using repeated-measures t tests).

Overall, the LVF bias is stronger for the AS group: compared to TD observers, the AS observers' response profiles indicate consistently less awareness of the R component of each chimera, i.e. each profile is on average more dissimilar from the profile of the corresponding R prototype. A stronger bias among AS observers shows up directly in the left-correlation column and in the Laterality index for the MO- but not the WF-series (see Table 3).

Taking into consideration that AS observers fixate predominantly on the mouth region (Boraston & Blakemore, 2007), we also questioned whether *Happiness* was seen as more salient than expressions of other basic emotions and tended to dominate the latter in combinations. To test this, we examined the *mean* of the R/L and L/R profiles for each pair of emotions, to cancel out the effect of LVF. The question was whether each mean is equidistant from the two prototypes, or displaced towards a particular prototype. If *mp1* and *mp2* are the absolute differences between a mean chimeric profile and the two 'parent' prototype profiles,

Table 3. Laterality estimates for the AS and TD group [mean (SE)]: Binomial correlations r between the response profiles of the chimeras and corresponding prototypes; Laterality index is absolute difference (summed over seven emotion labels) between the response profile of each L/R chimera and that of its R/L counterpart.

MO-series

	r with **L**-hand prototype	r with **R**-hand prototype	Laterality index	Asymmetry index
AS	0.70 (0.04)	0.42 (0.05)	15.1 (1.2)	5.0 (0.6)
TD	0.62 (0.04)	0.53 (0.04)	8.4 (1.1)	10.1 (0.9)
p	**0.049**	**0.015**	**< 0.0005**	**< 0.0005**

WF-series

	r with **L**-hand prototype	r with **R**-hand prototype	Laterality index	Asymmetry index
AS	0.59 (0.05)	0.47 (0.05)	12.19 (0.42)	9.9 (1.0)
TD	0.57 (0.05)	0.55 (0.05)	11.86 (0.82)	11.1 (1.0)
p	n.s.	**0.042**	n.s.	n.s.

an Asymmetry index is defined as *Asym* = |*mp1* – *mp2*| (see Table 3). Contrary to predictions, *Asym* proves to be significantly higher for the TD observers. Closer examination indicates that this divergence arises largely from half-*Happiness* chimeras, which are always closer to the *Happiness* prototype, but more so for the TD observers and MO-series.

There is robust evidence for greater LVF-bias among AS observers, consistent with Shamay-Tsoory *et al.*'s. (2010) conclusion of left hemisphere dysfunction in AS. The present result though is at odds with Ashwin *et al.* (2005), and may indicate that the conflicting stimuli in our task (most having a different expression in each half-face as opposed to a neutral half-face) were more demanding for AS observers. They may have attended more to the left face and verbally mediated the emotion (cf. Grossman *et al.*, 2000), while ignoring affective information in the right face, resulting in the enhanced LVF-bias.

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