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ORIGINAL PAPER

# Familiar Face Recognition in Children with Autism; the Differential use of Inner and Outer Face Parts

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**Abstract** We investigated whether children with autistic spectrum disorders (ASD) have a deficit in recognising familiar faces. Children with ASD were given a forced choice familiar face recognition task with three conditions: full faces, inner face parts and outer face parts. Control groups were children with developmental delay (DD) and typically developing (TD) children. Children with ASD and children with DD recognised slightly fewer faces than did TD children, but there was no ASD-specific deficit. All groups displayed the same pattern of face part superiority: full-face superiority over inner face, and inner face superiority over outer face. Therefore, the pattern of familiar face recognition by children with ASD was similar to the pattern found in other children.

**Keywords** Autism · Children · Familiar face · Part face

**Abbreviations**

| | |
|---|---|
| ASD | Autistic Spectrum Disorders |
| DD | Developmental Delay |
| TD | Typically Developing |
| BPVS | British Picture Vocabulary Scale |
| VMA | Verbal Mental Age |
| CA | Chronological Age |

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## Introduction

Face recognition, which involves processing and recalling faces, is a key skill required for effective communication and socialisation. Faces provide a channel for communication during infancy (Nelson, 2001) and remain integral to communication and socialisation throughout childhood and into adulthood (Schultz et al., 2000). In particular, the ability to learn unfamiliar faces and to recall familiar faces are important aspects of social functioning. For these reasons the development of face processing abilities has been extensively studied in typical and atypical development.

In typical development the processing style used to recognise faces reflects a developmental progression from the use of featural to configural information (Carey & Diamond, 1994; Maurer, Le Grand, & Mondloch, 2002). Faces are initially recognised using featural information with a trend towards greater reliance on the spatial relationship between features (the configuration) with age (Maurer et al., 2002). There is also evidence that a difference in processing style for familiar and unfamiliar faces emerges with age (e.g. Bonner & Burton, 2004; Campbell et al., 1999; Want, Pascalis, Coleman, & Blades, 2003).

Children initially recognise familiar and unfamiliar faces using similar methods, however by adulthood unfamiliar and familiar faces are processed differently (Burton, Wilson, Cowan, & Bruce, 1999). An important aspect of this difference is that the *inner face parts* (see Fig. 1) are relied on more for *familiar* face recognition, but the *outer face parts* (see Fig. 2) are relied on to a greater extent in *unfamiliar* face recognition (Bruce et al., 1999; Ellis, Shepherd, & Davies, 1979;

**Fig. 1** Inner face part

**Fig. 2** Outer face part

Hancock, Bruce, & Burton, 2000; Want et al., 2003). Typically developing (TD) children do not show this distinction in processing style between unfamiliar and familiar faces until about 7 years of age. Initially infants and young children rely to a greater extent on *external* face part information for *both* familiar and unfamiliar face recognition. Unfamiliar faces are recognised better by their outer face parts throughout childhood and adulthood (Want et al., 2003). In contrast, for familiar faces there is a switch about 7 years of age, when internal face parts are relied on to a greater extent than external face parts (Bonner & Burton, 2004). In Bonner and Burton's study children were shown pictures of classmates and asked to decide whether two images of different views were the same or a different person. The faces had to be recognised from their inner or outer face parts. With increased age faces were more accurately matched on the basis of their internal face parts.

Research into face processing in children with autistic spectrum disorder (ASD) has focussed on unfamiliar faces. Deficits and abnormalities in unfamiliar face recognition have been found in matching/identity tasks (Davies, Bishop, Manstead, & Tantam, 1994; de Gelder, Vroomen, & van der Heide, 1991; Klin et al., 1999), inversion tasks (Hobson, Ouston, & Lee, 1988) and composite tasks (Joseph & Tanaka, 2003). The results of these studies show that children with ASD have problems in identifying unfamiliar faces and that the processing deficit may be due to difficulty processing the facial configuration. For example, Hobson et al. (1988) and Joseph and Tanaka, (2003) found that children with ASD did not show the usual decrement in recognition when configuration was disrupted by inverting or merging faces. Some researchers have however found intact unfamiliar face processing with evidence of configural processing, in both behavioural tasks (Joseph & Tanaka, 2003; Rouse, Donnelly, Hadwin, & Brown, 2004) and in imaging tasks that show evidence of normal activation of the fusiform face area (Hadjikhani et al., 2004).

Only one group of researchers have investigated unfamiliar face processing style by using the inner and outer face parts in children with ASD (Rondan, Gepner, & Deruelle, 2003). Children had to decide which of two stimuli matched a face above. The faces were shown in their inner and outer face parts. No difference in matching was found on the basis of inner and outer face parts in the ASD group, but children with developmental delay (DD) and TD children showed the usual outer face part advantage.

Despite the research into unfamiliar face processing in ASD there has been little research focussing on the processing style used in familiar face recognition. Langdell, (1978) found that children with ASD recognised familiar peers by attending to lower facial features, but TD controls attended more to upper facial features. More recently, Boucher, Lewis, and Collis (1998) investigated familiar face recognition by asking children to post photographs of staff they recognised into a box representing their school, and photographs of unfamiliar faces in another box. Boucher et al. found that, compared to a control group of children with DD, the children with ASD were not as accurate at putting the faces into the correct boxes. These two studies considered familiar face recognition accuracy, but as yet no researchers have investigated familiar face processing style.

It is important to investigate processing style in ASD to find out whether both unfamiliar and familiar face processing are disrupted in ASD or whether familiar face processing style remains intact. Normal activation when processing familiar faces has been demonstrated in adults with ASD, using fMRI, but abnormal activation has been found for unfamiliar faces (Pierce, Haist, Sedaghat, & Courschense, 2004; Pierce, Muller, Ambrose, Allen, & Courchense, 2001). Abnormalities in both unfamiliar and familiar face processing might indicate a central aspect of face processing that is impaired, but spared familiar face processing would imply that effective face processing skills can be used by children with ASD.

As noted above, from the age of 7 years TD children process unfamiliar faces better by external face parts, but they process familiar faces better by internal face parts. We therefore investigated whether children older than 7 years with ASD showed the typical inner part superiority for processing familiar faces. The method of inner and outer face parts is the only technique that can distinguish reliably between the way familiar and unfamiliar faces are processed.

We predicted, from the recognition deficits displayed by children with ASD on a familiar face processing task (Boucher et al., 1998) that the children with ASD in our study would be poorer than controls at recognising familiar faces.

We did not have a specific prediction about processing style. On the one hand we could have expected abnormalities in processing style for familiar faces, because Rondan et al. (2003) found that children with ASD had an abnormal use of face feature information in an unfamiliar face recognition task. Such abnormal processing might also apply to familiar faces. On the other hand, Pierce et al. (2004) found normal brain activation when children with ASD processed familiar faces, and this could mean that processing style for familiar faces might be the same for children with ASD and for control children.

## Methods

### Participants

The children selected for testing were from a school for children with ASD, a school for children with DD and a school for TD children. The children had a mean age of 8 years, and at this age we expected the TD group to be using internal feature information (Bonner & Burton, 2004; Campbell, Walker, & Baron-Cohen, 1995). The DD control group was matched for chronological (CA) and verbal mental age (VMA). The TD control group was matched for CA. The two control groups were the same mean CA as the ASD group to control for years of exposure to faces (Dawson et al., 2002). The DD group was matched for VMA to control for the effects of language level on task performance (Boucher et al., 1998; Klin et al., 1999).

Seventeen children with ASD, 17 children with DD without autism and 17 TD children participated in the experiment (see Table 1). Mental age was calculated using the British Picture Vocabulary Scale (BPVS) (Dunn, Dunn, Whetton, & Bradley, 1997). The children with ASD were selected on the basis of psychologists' diagnoses of impaired socialisation, communication and imagination (Wing & Gould, 1979). The information was based on a parent interview and on observation of the child. These criteria are comparable to the DSM IV (American Psychiatric Association, 1994) criteria for autism. In the majority of cases the diagnoses were confirmed by independent paediatricians' and speech therapists' diagnoses based on the Childhood Autism Rating Scales (Schopler, Reichler, Renner, & Jacobsen, 1988). The children were recruited from a school specifically for children with autism.

**Table 1** Sex ratio, mean of chronological ages (CA) and mean verbal mental ages (VMA) in months for each group of participants: children with autistic spectrum disorder (ASD), children with developmental delay (DD) and typically developing children (TD)

| Group | *n* | Males: females | CA mean and range (months) | VMA mean and range (months) |
|---|---|---|---|---|
| ASD | 17 | 15:2 | 102.7 (83–130) | 65.7 (40–105) |
| DD | 17 | 13:4 | 104.7 (73–126) | 65.9 (36–106) |
| TD | 17 | 17:0 | 99.3 (78–128) | – |

The DD group were selected from children with non-specific mental delay, by pairwise matching of VMA (based on the BPVS) and for CA with the ASD group. None of the DD group had received any diagnoses or current suspicion of ASD. There were slightly more females in the DD group to match VMA as closely as possible. The TD group were matched by CA and were all male. The school for TD children was selected because it had 30 staff that the children saw regularly.

Matching for levels of familiarity with staff is difficult until it has been measured by a task such as face recognition. However the three schools were matched as far as possible, in line with past familiar face recognition studies (Boucher et al., 1998; Campbell & Tuck, 1995). Only children who had attended their schools full-time for at least 1 year prior to the experiment were included to ensure that they were fully familiar with staff, and only staff who had been members of a school for at least a year were included. Children in the three schools had similar exposure to the 30 staff members in their schools, because all three schools were day schools with similar working day length and age of entry. The school for TD children was larger than the DD and ASD school, however it was a relatively small school compared to most schools for TD children. In all three schools there was movement of staff between groups and classes of children, and contact between staff and children also occurred during recesses and lunchtimes. In each school the staff confirmed that all the children would be familiar with the 30 faces used.

### Materials

Colour photographs of 30 male and female staff from each school were taken a week prior to testing. Staff included teachers, classroom assistants, lunchtime staff and office staff who were all seen by the children on a regular basis. There were more female than male staff in all three schools: in the school for children with ASD (28 females, 2 males), in the school for children with DD (28 females, 2 males) and in the school for TD children (23 females, 7 males). This was unavoidable because more females than males work in primary education.

The photographs of staff were cropped at the top of the neck, and cut precisely around the face and hair line using Adobe Photo Shop version 7.0, so that only the face and hair were included in the picture. One set of photographs consisted of full-face pictures. A second set of photographs consisted of cropped images with only the inner features: eyes, nose and mouth. A third set of photographs consisted of cropped images with only the outer features: hair, ears, chin and forehead. Earrings were edited from the pictures, because earrings are not a consistent feature, but spectacles were not removed as they are a consistent feature of faces.

Each set of 30 pictures was paired with matched (full, inner part or outer part) photographs of adults not from the school based on sex. Photographs were not matched for similarity as familiar face recognition is not dependent on discriminating familiar people from very similar faces. The paired stimuli were printed on 21 cm × 30 cm card. The full-face stimuli were 15 cm × 10 cm in size. The test materials for each school therefore consisted of 30 pairs of full faces, 30 pairs of inner faces and 30 pairs of outer faces (see Fig. 3 for examples).

The test materials for each school were split into three groups of ten faces or part faces. The face pairs were then divided according to the groups so that for each school nine sets of stimuli were created: full sets 1, 2 and 3, inner sets 1, 2 and 3 and outer sets 1, 2 and 3.

### Procedure

A pretest was conducted 2 months prior to the experiment to select the children with ASD. A stimuli set was created using four pairs of cartoon pictures of

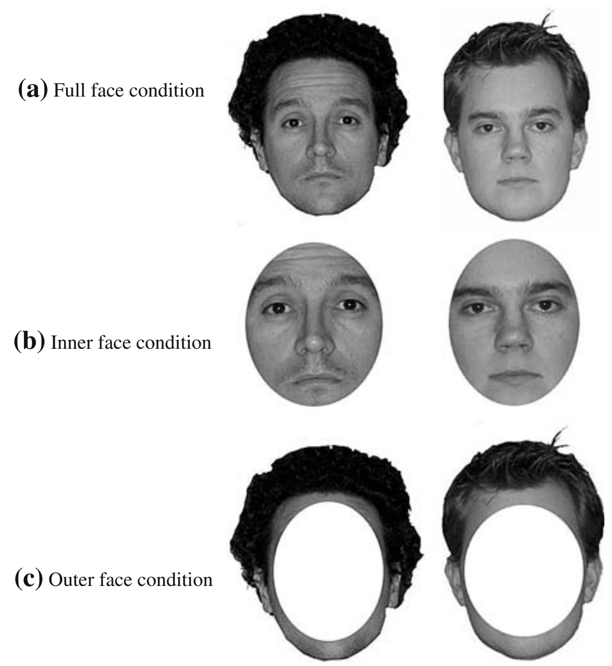


**Fig. 3** Examples of the three types of stimuli. (**a**) Full-face condition. (**b**) Inner face condition. (**c**) Outer face condition

well-known UK television characters: Bob the Builder, Postman Pat, Pingu and Winnie the Pooh. These were paired with French book cartoon characters of the same size. The French characters were all unfamiliar to the children.

Thirty children with ASD were presented with the four pairs of stimuli in a forced choice recognition task. The children had to choose the character from each of pair that they recognised, in response to the instructions ‘‘Touch the one you know from TV.’’ Nineteen children with ASD who understood the task were selected for the experiment (because they could comply with the instructions and chose one of the faces). It was not important that the children recognised all the pictures correctly, only that they could comply with the task instructions by touching one of the pictures after being asked. The pretest was repeated in the school for children with DD to ensure that the DD children matched on VMA could also comply with the task, and all 19 of the children tested could do so. The task was not repeated for the TD children because it was not considered necessary for this group. The BPVS was administered 2 weeks before the face recognition tests to obtain a VMA for each child in the ASD and DD groups.

The forced choice face recognition tests were administered over the period of a week. The three conditions were full face, inner parts and outer parts. Each child was presented with three different sets of stimuli (e.g. full 1, inner 2 and outer 3) so that no face was used more than once for recognition by each child. Only 10 faces (rather than the full 30) were used for each condition to ensure that face recognition was being measured rather than picture recognition. The order of presentation of the conditions was counterbalanced between children for the inner and outer parts, but the full-face pictures were presented first so that the initial task was not too unusual.

Before presentation of the face pictures, the children were shown stimuli of TV characters (as in the pretest, described above) and asked to, ''Touch the one you know from TV,'' to familiarise the children with the procedure. The children were then presented with the pairs of faces or face parts and asked to, ''Touch the one you know from school.'' The children were given as long as they needed to respond. The experiment was stopped and restarted later if a child lost interest, i.e. left the table or stopped looking. This was necessary for only one child with ASD. One child with ASD refused to participate and one child with ASD did not attend to the task. These two children (and their matched pairs) were excluded from further analysis.

## Results

The children's responses were scored as correct if the face of the adult from their school was touched in response to the instructions. The mean and standard deviations of the number of correct responses for each group out of the set of ten faces for each of the full, inner and outer conditions are shown Table 2.

The number of correct answers in each condition was analysed using a three (group: ASD, DD, TD) by three (condition: full, inner, outer) analysis of variance. There was an effect of group, $F(2, 48) = 5.43$, $p < .01$. Post hoc least significance difference (LSD) tests showed that there was a difference between the TD group and the ASD group ($p < .05$), and between the TD group and the DD group ($p < .05$), but not between the ASD group and the DD group ($p > .05$).

**Table 2** Means (and standard deviations) for each group of participants: children with autistic spectrum disorder (ASD), children with developmental delay (DD) and typically developing children (TD) in each condition. The maximum possible score was 10

| Group | Condition | | |
|---|---|---|---|
| | Full faces | Inner parts | Outer parts |
| ASD | 9.12 (1.05) | 7.65 (2.21) | 6.24 (1.71) |
| DD | 9.00 (1.17) | 7.76 (1.75) | 6.70 (1.45) |
| TD | 9.76 (.04) | 8.41 (.19) | 8.17 (.13) |

There was an effect of face part, $F(1, 48) = 90.64$, $p < .001$. Post hoc (LSD) tests showed that all conditions (full, inner, outer) differed from each other ($p < .05$). There was no interaction between group and condition, $F(2, 48) = 3.05$, $p > .05$. Student *t*-tests were conducted to confirm that all results differed significantly from chance.

## Discussion

We had predicted that children with ASD would show a deficit in recognising familiar faces. Our results showed that both the ASD and DD groups were poorer at recognising faces (in all three conditions) than the TD group. The deficit in recognition accuracy was therefore not specific to children with ASD, because the children with DD also showed this impairment. We had expected that the deficit would be ASD-specific, but our results did not support this prediction. Instead it appeared that the children's recognition accuracy matched their VMA.

Despite the fact that the ASD had a lower accuracy score than the TD group, in actual terms their performance was only slightly poorer. In the full-face condition the TD children correctly identified 98% of the faces, and the children with ASD identified 91% of the faces. The high percentage for the children with ASD suggests that they should have little difficulty recognising familiar people.

Our results contrast with those of Boucher et al. (1998) who found that children with ASD were less accurate than children with DD in a familiar face recognition task. In both our study and in Boucher et al. the children were asked to recognise familiar adult faces of school staff, but we used a forced choice recognition task whereas Boucher et al. used a posting box task. In the posting box task children looked at one picture and had to decide whether that face was familiar before posting it in the box for familiar faces. Such a task means that a child must compare the picture with his or her memory of all the adult faces in school. If a child, incorrectly, considers a face to be slightly familiar he or she may then post it in the wrong box. In the forced choice task children were asked to make a comparison between two simultaneously presented faces, and in such a task children can make a judgement on the basis of which one of the two faces looks more familiar. Even if both faces look familiar to the child, one will look more familiar than the other and the correct choice can be made. In other words, the forced choice task may have lower task demands than the posting box task and this may result in better performance by the children with ASD (Joseph & Tanaka, 2003).

A further difference between our study and Boucher et al. (1998) was that the children in our study had a higher VMA (5 years 6 months) than the children in Boucher et al. (4 years 2 months) and this may also have accounted for the better performance in our study. We should also note that despite the overall poorer performance of children in Boucher et al., many of the children with ASD in that study had scores within the range of the control children. This would indicate that some children with ASD who are younger than the ones in our study can perform well in familiar face recognition tasks.

All three groups of children in our study had the same pattern of performance. For all the groups the faces were better recognised by their inner than by their outer face parts, showing no difference in processing style between the groups. The lack of evidence for processing differences in children with ASD supported recent fMRI research which has shown typical patterns of activation when children with ASD process familiar faces (Pierce et al., 2004).

The lack of processing differences for familiar faces is in contrast to the differences found for processing unfamiliar faces (Rondan et al., 2003). We did not find evidence of abnormal processing style for familiar faces by the ASD group. All three groups in our study showed better recognition using inner than outer face parts, a pattern consistent with the pattern of familiar face recognition found for TD children over the age of 7 years (Bonner & Burton, 2004). The research with TD children has shown that by the age of 7 years children rely to a greater extent on internal face parts than external face parts, and this pattern of face recognition was displayed by all three groups in our study. The lack of processing difference for the ASD group suggests that although unfamiliar faces may be processed differently from TD children (Rondan et al., 2003) familiar faces are processed "typically." It was previously thought that face processing abnormalities displayed by children with ASD might result from the impaired processing of the spatial configuration of faces. Our study however found no evidence of these impairments as the faces were recognised better by the internal face parts and this can be said to be an aspect of spatial configuration information (Maurer et al., 2002; Want et al., 2003).

Our results have implications for both research and for clinical practice. The present study demonstrated that children with ASD are able to recognise familiar adults, and that they used the same face feature information as controls in recognition. Further studies could focus on why distinctions between processing familiar and unfamiliar faces have been found in children with ASD. The exact nature of the processing style could be ascertained by combining fMRI with forced choice recognition of unfamiliar and familiar face processing. With reference to clinical practice our study showed that face processing intervention may not be essential for familiar face recognition, but instead, interventions could be focussed on learning new faces, and on learning facial expression interpretation (Hobson et al., 1988).

In conclusion, we did not find an ASD-specific impairment in accuracy of familiar face recognition. Nor did we find evidence for an abnormal processing style for familiar faces in children with ASD. In other words, the children with ASD were as efficient as other children with the same MA, at recognising familiar adults, and the children with ASD had the same pattern of reliance on inner and outer face parts as did the non-ASD children.

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