The eyes or the mouth? Feature salience and unfamiliar face processing in Williams syndrome and autism

Deborah M Riby [1], Gwyneth Doherty-Sneddon [1] & Vicki Bruce [2]

[1] Department of Psychology, University of Stirling
[2] University of Edinburgh

Correspondence should be addressed to Dr. Deborah Riby, School of Psychology, Newcastle University, Framlington Place, Newcastle upon Tyne, NE2 4HH.
Telephone: +44 (0)191 222 6180. Fax: +44 (0)191 222 5622

Abstract

Using traditional face perception paradigms the current paper explores unfamiliar face processing in two neurodevelopmental disorders. Previous research indicates that autism and Williams syndrome (WS) are both associated with atypical face processing strategies. The current research involves these groups in an exploration of feature salience for processing the eye and mouth regions of unfamiliar faces. The tasks specifically probe unfamiliar face matching by using i) upper or lower face features, ii) the Thatcher illusion and iii) featural and configural face modifications to the eye and mouth regions. Across tasks, individuals with WS mirror the typical pattern of performance; with increased accuracy for matching faces using the upper than lower features, susceptibility to the Thatcher illusion and greater detection of eye than mouth modifications. Participants with autism show a generalised performance decrement alongside atypicalities; deficits for utilising the eye region and configural face cues to match unfamiliar faces.. The results are discussed in terms of feature salience, structural encoding and the phenotypes typically associated with these neurodevelopmental disorders.

The eyes or the mouth? Feature salience and unfamiliar face processing in Williams syndrome and autism

Typically developing adults and children show a preference for looking at the eyes and mouths of human faces (Yarbus, 1967; Walker-Smith, Gale, & Findlay, 1977; Mertens, Siegmund & Grusser, 1993). These two features play a crucial role when interpreting facial identity and communicative cues (Ellis, 1975). Variations of salience exist within these two important regions, with the mouth region (lower face) less salient and less useful for remembering faces than the eyes (upper face; e.g. Malcolm, Leung & Barton, 2005, McKelvie, 1976; Pellicano, Rhodes, & Peters, 2006). Exploring the processing of different face regions provides insights into the way individuals remember and process facial identity and any differences or atypicalities that occur may detrimentally impact upon interpersonal social communication. Neurodevelopmental disorders associated with both atypicalities of face perception and social communication may be particularly relevant here; two such disorders are autism and Williams syndrome (WS).

Recent research has emphasised that together autism and WS provide examples of atypical sociability, with both groups exhibiting social functioning abnormalities (Brock, Einav & Riby, in press). Individuals with the genetic disorder WS are typically characterised as hyper-sociable, showing an extreme desire to interact with both familiar and unfamiliar people and utilising extended face gaze strategies (e.g. Jones et al., 2000; Mervis et al., 2003). Conversely, social withdrawal and aversive eye contact are defining features of the spectral neurodevelopmental disorder of autism (Wing, 1976; Frith, 1999). Alongside the clear dissociations of social functioning exhibited by these groups are similar atypicalities when processing faces, the most important social cue in our environment. When focusing on identity processing, the vast majority of research has probed the structural encoding of faces. A predominance of featural processing for adults with autism and WS emphasises different developmental pathways for the emergence of configural processing and atypicalities of structural encoding for both groups (e.g. Karmiloff-Smith et al., 2004; Deruelle, Rondon, Gepner, & Tardiff, 2004). Even though similar atypicalities of structural encoding are evident, extreme differences occur in the general ability to interpret facial identity as well as communicative face cues (e.g. Riby, Doherty-Sneddon & Bruce, in press). Although individuals with autism are characterised by a generalised face processing deficit (e.g. Gepner, de Gelder & de Schonen, 1996), this skill is a relative strength for those with WS when compared to other nonverbal abilities (e.g. Bellugi, Marks, Birhle & Sabo, 1988). If faces are encoded in a similar atypical manner by individuals with autism and WS compared to the general population, the use of the important eye and mouth regions may also differ. Including these two groups in the same research program allows the possibility of comparing facets of face processing to wider issues of sociability.

The current paper explores identity processing and the use of the eye and mouth regions, however the majority of existing literature that considers the use of these face areas involves communicative face cues (e.g. expressions, eye gaze). Individuals with autism have difficulties interpreting communicative cues from the upper face region, specifically the eyes (e.g. Baron-Cohen, Wheelwright & Jolliffe, 1997a; Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001b; Gross, 2004), as well as problems identifying familiar people from this region (Langdell, 1978). The current paper extends the literature regarding the use of the eye and mouth regions to consider unfamiliar face matching in paradigms derived from typical face perception literature. Relatively less research has considered the processing of different facial features by individuals with WS as the majority of existing literature focuses on structural encoding (e.g. Karmiloff-Smith et al., 2004; Deruelle, Mancini, Livet, Casse-Perrot, & de Schonen, 1999). Given that individuals with WS exhibit a keen interest in interacting with people (both familiar and unfamiliar to them; e.g. Jones et al., 2000) and hold eye contact for extended periods of time (Mervis et al., 2003) use of the eye region is particularly interesting for understanding the link between identity processing and social interactions. The only existing study of feature use by individuals with WS indicates that the robust finding of increased salience for the eye versus mouth region during familiar face recognition may be less apparent in WS than in typical development (Tager-Flusberg, Plesa-Skwerer, Faja & Joseph, 2003). However, the use of facial features for matching unfamiliar faces has not previously been explored and may reveal facets of face processing that link to a characteristic drive to interact with unfamiliar people (Frigerio et al., 2006). Therefore, including participants with WS is particularly important given the divergent social phenotype when compared to autism and apparent differences in face perception proficiency alongside apparent similarities of structural encoding.

The paradigms used in the current paper have previously been applied to typical face perception with both children and adults and have been used to study the way faces are processed. Although the assessments therefore provide an insight into structural encoding of faces in WS and autism, here the primary aim is to explore the use of different features when matching unfamiliar faces. First, the Thatcher illusion (Thompson, 1980) involves a rotation of the eye and mouth regions with respect to other features and results in a particularly grotesque appearance, which is evident in upright faces but lessened by inversion. The illusion has been used to show that face manipulations are more readily detected by adults, children and infants when faces are upright than inverted (e.g. Lewis & Johnston, 1997; Lewis, 2003). The effect has also been found for adolescents with autism (Rouse et al., 2004). Thompson (1980) interprets this effect as the disruption of configural (second-order relational) information when the face is inverted but not when upright. To our knowledge, no research has explored the Thatcher illusion when either the eyes or mouth alone are rotated and this may provide an insight into the source of the illusion in both typical and atypical development. Based on the relative salience of the eye and mouth regions, we would predict eye manipulations to be detected more readily than mouth changes in typical development but not in autism. Evidence from WS may mirror either the typically developing group or those with autism, however given evidence of increased face gaze (in contrast to gaze avoidance associated with autism) it is likely that a typical pattern will be mirrored by this group.

The second paradigm is derived from research by Langdell (1978) who used a part-face recognition task to identify how well individuals could be recognised by different face features, including the eye or mouth regions. Langdell emphasised a lack of upper face advantage by participants with autism compared to those who developed typically and the current paper extends this phenomena to WS and to unfamiliar face matching. Changing the task to address unfamiliar face matching (rather than familiar face recognition) alters the task demands and addresses whether the findings extend across paradigms and across neurodevelopmental disorders. If previous findings are replicated under different task demands it is predicted that upper face (eye region) matching will be more accurate than lower face matching in typical development but not autism. Extending this to WS, we would predict a typical pattern of upper and lower feature use, relating to relatively proficient use of the eye region previously cited for eye gaze processing and identity tasks (e.g. Tager-Flusberg, Boshart & Baron-Cohen, 1998; Riby, et al., in press) and the proposed pattern for the Thatcher illusion task.

Finally, the current paper will apply separate face modifications (featural and configural changes) to the eye or mouth regions to investigate whether individuals with autism and WS can detect such changes when matching identity. Mondloch and colleagues (2002, 2003, 2004) have thoroughly applied this paradigm with children and adults to investigate processing styles, but here eye and mouth modifications are applied separately to explore feature use and salience. In the typical 'Jane' face paradigm designed by Mondloch and colleagues, configural modifications involve spacing changes spread throughout the face, but here the spacing of the eyes or mouth alone will be affected and for featural modifications the eyes or mouth will separately be swapped with those of another individual. Based on previous literature from different tasks we would expect typically developing individuals to find it easier to match faces where eye modifications occur than where less salient mouth modifications have been made. Although it is predicted that this pattern may be mirrored in WS, the same may not be evident in autism.

Together these tasks extend our understanding of the use of different face regions (eyes and mouth) adding to the literature regarding face perception in these neurodevelopmental disorders and linking to their dissociable social phenotypes.

Method

Participants

Two groups of participants with developmental disorders participated in the research; namely autism and Williams syndrome (WS). The fifteen participants with WS[1] ranged from 10 years 0 months to 18 years 8 months with a mean chronological age of 15 years 6 months. Participants were recruited via the national Williams syndrome Foundation and 4 participants had a diagnosis based on clinician reports whilst 11 participants had their diagnosis confirmed by a FISH test. Verbal mental age (VMA) was assessed using the British Picture Vocabulary Scale II (BPVS II; Dunn, Dunn, Whetton, & Burley, 1997) giving a mean verbal age of 10 years 10 months (9 years 1 month - 13 years 1 month). Nonverbal ability (NVMA) was assessed using the Ravens Coloured Progressive Matrices (RCPM; Raven, Court, & Raven, 1990) giving a mean score of 15 (ranging 9 - 28). These two assessments are frequently used as matching measures for these groups (c.f. Mottron, 2004) and provide quick and easy assessments for use across a wide age range.

The twenty individuals with autism[2] had a mean age of 14 years 9 months (9 years 11 months - 18 years 1 month) and were recruited from a school for pupils with autism spectrum disorders. Mean verbal mental age, as assessed by the BPVS II, for the autism group was 7 years 2 months (4 years 11 months - 12 years 0 months). Nonverbal ability was represented by a mean score of 15 (ranging 9 - 21) on the RCPM. All participants had previously been diagnosed by clinicians and referred to

[1] A sample size of 15 is comparable to published research including participants with WS, for example Karmiloff-Smith et al. (2004)
[2] A sample size of 20 is comparable to previous research exploring face processing in autism, for example, Deruelle et al. (2004)

the school through their local authority. All participants satisfied the diagnostic criteria for autistic spectrum disorder according to the DSM-IV (1994) and the Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Rocher Renner, 1988) classified 11 children as mild-moderately autistic, and 9 children as severely autistic. No participant in this group scored out with the autistic range when assessed using the CARS.

Each participant with WS and autism was matched to three typically developing participants on the basis of verbal ability (VMA), nonverbal ability (NVMA) and chronological age (CA). Typically developing participants were recruited from mainstream primary and secondary schools. The typically developing groups did not differ from the group with WS or autism on the ability for which they were matched and full participant details are evident in Table 1.

(Table 1 about here)

Informed consent was received for all participants prior to their involvement. Ethical approval was gained from the Psychology Department and Williams syndrome Foundation prior to carrying out the research and the local council provided their support for working in schools.

Materials and Procedure

Each participant completed a number of assessments probing unfamiliar face processing under different task demands and each is detailed in this section. Testing was carried out predominantly across two sessions, except for a small number of participants in the developmental disorder groups who carried out a larger number of sessions due to attention difficulties. Task order was rotated across participants and groups. All stimuli were created by the researchers based on tasks carried out in previous research with typically developing individuals, using faces from the Stirling University Face Database.

The Thatcher illusion

This task was based on research by Thompson (1980) and the testing procedures implemented by Rouse et al. (2004) involving participants with autism. Participants were asked to spot the face which looked ‘funny’ or ‘strange’. As well as using a traditional representation of the Thatcher illusion (eyes as well as mouth rotated), the task assessed rotations of only the eye or mouth regions.

Digital photographs of 12 individuals were used to create the task stimuli (all faces were unfamiliar to participants). Each photograph was converted into grey scale and cropped so only the head and shoulders were in view (seen in Figure 1). Using Adobe Photoshop 7.0 (Adobe Systems Inc, CA) images were manipulated to make the desired feature change. For each face three distinct changes were made; the mouth was rotated, the eyes were rotated or both eyes and mouth were rotated. All images were standardized to 300 x 200 pixels in size. Pairs of stimuli were made with the original image and one of the manipulated images side by side separated by a 1cm gap. The position of the original image was counterbalanced to appear on the left and right equally often. Equal numbers of trials appeared in the upright condition, at 90 degrees and fully inverted (180 degrees).

As practice trials participants viewed upright pairs of images with manipulated features. The practice comprised houses (e.g. one house in the pair with the windows and door in incorrect places) and faces (e.g. with features incorrectly placed or missing). The manipulations in these practice trials were particularly distinct to help participants understand the task demands. Participants were asked to point to the picture that looked ‘funny’ or ‘strange’. All participants successfully completed the practice trials. For experimental trials, participants viewed two black-and-white faces presented side-by-side and were asked to point to the face that looked funny or strange. Images remained in front of the participant while they made their choice and pointed to the correct face, completing 36 trials in total.

(insert Figure 1 about here)

Upper versus Lower Feature Matching

This part-face matching task was based on the upper versus lower face recognition task used by Langdell (1978). The task requirements and stimuli presentation vary from those originally used and here unfamiliar faces are utilized in contrast to familiar faces incorporated by Langdell (1978). Participants viewed a target face at the top of the page and had to match this with a face part shown at the bottom (see Figure 1). Only upper or lower features were available for matching. The target face shown at the top of the page differed from the correct answer and distracter on orientation (performance solely due to pattern matching was not possible). Forty-five degree and front view faces appeared as the target equally often across trials and the correct answer appeared equally often on the left and the right. Participants completed 6 trials in each of the upper and lower face conditions with the order randomized across participants. The stimuli were of individuals between 18 and 21 years of age and were unfamiliar to participants. Stimuli were presented as black and white images and all pictures were standardized to 200x300 pixels. Photographs were trimmed and the upper or lower regions removed using Adobe Photoshop 7.0 (Adobe Systems Inc, CA). Face-parts were removed from a midpoint of the nose either above or below this point depending on the desired region. Stimulus presentation was self-paced and the trial remained in front of the participant until they made their choice. Participants were required to point to the face at the bottom that matched the identity of the face at the top of the page.

Moving and Changing the Eyes or Mouth

For this same versus different judgment task, stimuli were created by making featural or configural modifications to one of two faces presented side-by-side. Changes were standardized across face stimuli and 4 unfamiliar faces were used as stimuli from the Stirling University Face Database. Eyes were made closer, reducing the interocular distance by 9 pixels[3] from the mid-point (each eye moved by 4.5 pixels), or wider by the same distance. The mouth was made higher or lower by 6 pixels. For feature changes the eyes or mouth were inter-changed with another person of similar appearance and features of the same size. Finally the whole face image was

[3] Pilot testing revealed that for typically developing children aged 6-10 years (n=88) eyes moved by 9 pixels were detected approximately 62% of the time and mouths moved by 6 pixels were detected with 61% accuracy.

standardized to 300 pixels in width. Each participant viewed 32 trials (16 same and 16 different) seeing each different face 8 times. For 'different' trials the modified face appeared equally often on the left and right.

Results

The results suggest that participants with autism perform poorly across unfamiliar face matching tasks and show specific difficulties using the eye region. In contrast individuals with WS have no difficulty using the eye region for processing unfamiliar face under various task demands. This summary of skills is emphasized across the various tasks implemented here and is particularly evident in Table Two with columns highlighted for each clinical group.

The results section includes analyses for each task and compares the clinical groups with individuals who are developing typically[4] (see Table 2). For each task the mean percentage of correct responses is used as an indicator of ability[5].

The Thatcher illusion

Investigating performance of participants with WS, a 4 x 3 ANOVA with factors Group (WS, VMA, NVMA, CA) and View (upright, 90 degree, inverted) was applied to the accuracy data for the traditional Thatcher illusion. Participants were significantly affected by orientation $F(2,96)=49.03$, $p<.001$ as upright Thatcherised

[4] It is not appropriate to directly compare performance for the autism and WS groups as they were not matched due to the rarity of the developmental disorders and participant availability.
[5] Reaction time data was also collected for some groups however accuracy data proved more reliable due to large variances within and between groups, low accuracy and participant characteristics.

faces were detected more accurately than 90 degree faces (t(51)=4.87, $p<.001$) which in turn were more accurate than inverted faces (t(51)=10.51, $p<.001$; mean upright 92%, 90 degree 78%, inverted 59%). There was also a Group effect F(3,48)=6.97, $p<.01$, as the CA and WS groups performed with equal accuracy ($p=.75$) and the WS group also did not differ from the VMA group ($p=.27$). It should be noted that the performance of the CA group is at ceiling for the upright condition, therefore conclusions that the WS group performed at CA level should be avoided. The WS group performed significantly better than the NVMA group (t(12)=4.16, $p<.01$, mean NVMA 69%). The interaction between variables was not significant (F(6,96)=.51, $p=.81$) indicating the same pattern across groups. Spearman's Rho correlation revealed that for the small group of participants with WS (n=13), there was an increase in overall task accuracy with age r=.92, $p<.01$ and the same was apparent for typically developing participants (groups combined, r=.83, $p<.01$). Investigation of inversion costs revealed that there was no difference in the effect of inversion across groups (F(3,51)=.18, $p=.91$). Table 2 highlights accuracy levels for each group when both eye and mouth regions were rotated as detailed here (upper section of Table)

By separating eye and mouth rotations, the mean accuracy for each group and feature was calculated (see Table 2 upper section). Performance on trials involving *either* eye or mouth rotations were investigated with a 4 x 3 x 2 ANOVA with the independent factor Group (WS, VMA, NVMA, CA) and repeated factors View (upright, 90 degree, inverted) and Feature (eyes, mouth). Overall participants were more accurate for eye than mouth manipulations F(1,48)=4.37, $p<.05$ (overall mean eyes 74%, mouth 69%) supporting the idea that the eyes are a more salient feature. Participants were also significantly affected by inversion F(2,96)=88.13, $p<.001$ (overall mean upright 87%, 90 degree 73%, inverted 53%). Post hoc t-tests showed that upright faces were detected more accurately than both 90 degree (t(51)=5.06, *p*<.001) and inverted faces (t(51)=14.67, *p*<.001) and in turn 90 degree faces were more accurate than inverted faces (t(51)=7.71, *p*<.001). There was a significant effect of Group F(3,48)=12.04, *p*<.001 as overall WS participants performed more accurately than those matched for nonverbal ability (mean WS 72%, NVMA 63%; t(12)=3.78, *p*<.01) and less accurately than those matched for CA (mean 80%; t(12)=3.76, *p*<.01). There was no difference in ability for the WS group and those matched for verbal ability (mean 70%; *p*=.34).

Considering the group with autism for the traditional Thatcher illusion, task accuracy was assessed with a 4 x 3 ANOVA with factors Group (Autism, VMA, NVMA, CA) and View (upright, 90 degree, inverted) and showed that participants were affected by orientation F(12,152)=97.41, *p*<.001 (see Table 2 upper section). Accuracy for upright faces was greater than 90 degree (mean upright 86%, 90 degree 78%; t(79)=4.00, *p*<.001) as well as inverted faces (mean inverted 59%; t(79)=13.60, *p*<.001). Additionally, inverted faces were processed with greater difficulty than 90 degree faces (t(79)=9.77, *p*<.001). There was an effect of Group F(3,76)=22.07, *p*<.001 created by the strong performance of the CA participants. Interestingly there was no difference in overall performance for the autism and VMA group (*p*=.12) and a trend for a difference between the autism and NVMA group (with higher accuracy for NVMA matches, t(19)=2.03, *p*=.06). The interaction between factors was not significant (F(6,152)=.81, p=.57) as all groups, including those with autism, showed greatest accuracy for upright than inverted trials. Indeed the cost of inversion was equivalent across groups (F(3,79)=1.42, *p*=.25). The correlation between age and performance revealed that typically developing participants (n=60) increased in overall accuracy with age ($r=.50$, $p<.01$) but the autism group (n=20) showed no significant correlation between age and overall performance ($p=.30$) or between CARS score and performance ($p=.44$).

Performance for trials involving either eye or mouth rotations were investigated with a 4 x 3 x 2 ANOVA with factors Group (Autism, VMA, NVMA, CA), View (upright, 90 degrees, inverted) and Feature (eyes, mouth). This revealed a significant main effect of Feature with participants more accurate using eyes than mouth $F(1,76)=13.08$, $p<.01$ (mean eyes 71%, mouth 66%). There was also a main effect of View created by a decrease in performance as the orientation moved away from upright $F(2,152)=103.48$, $p<.001$ (mean upright 79%, 90 degrees 72%, inverted 55%). Post hoc t-tests showed that upright faces were more accurately assessed than 90 degree faces ($t(79)=5.24$, $p<.001$) which in turn were more accurate than inverted faces ($t(79)=8.41$, $p<.001$). There was a significant main effect of Group $F(3,76)=32.59$, $p<.001$ as accuracy for those with autism differed significantly from all others (mean autism 60%, VMA 66%, NVMA 69%, CA 81%). Post hoc t-tests showed that participants with autism performed less accurately than those matched for VMA ($t(19)=4.14$, $p<.01$), NVMA ($t(19)=4.06$, $p<.01$) and CA ($t(19)= 8.60$, $p<.001$).

The important interaction between Feature and Group was significant $F(3,76)=5.55$, $p<.01$. Post hoc t-test analyses revealed that all typically developing participants were more accurate detecting eye than mouth manipulations (VMA $t(19)=3.81$, $p<.001$, NVMA $t(19)=2.16$, $p<.05$, CA $t(19)=2.87$, $p<.05$). However individuals with autism were equally accurate detecting eye and mouth manipulations ($p=.10$). In fact the trend was in the opposite direction to the typically developing groups, in that mouth manipulations were detected more accurately than eyes. All other effects were not significant. So, the group with autism showed the same level of susceptibility to the Thatcher illusion as the typically developing groups when the traditional illusion was applied, however if eye and mouth rotations were independently manipulated the effect was driven by different features.

(insert Table 2 about here)

Upper versus Lower Feature Matching

To investigate the performance of the group with WS, a 2 x 4 analysis of variance (ANOVA) was carried out on the percentage of correct answers with factors Part-of-Face (upper, lower) and Group (WS, VMA, NVMA, CA). There was a main effect of Part-of-Face $F(1,56)=30.72$, $p<.001$ as participants were more accurate using the upper than lower regions. There was also a significant effect for Group $F(3,56)=10.43$, $p<.00l$ predominantly created by the high performance of the CA matched group, however, there was no difference in performance levels for the WS, VMA and NVMA groups (WS-VMA $p=.13$, WS-NVMA $p=.34$). The interaction between factors was not significant ($F(3,56)=1.52$, $p=.22$) indicating the same pattern of performance across all groups. Spearman's Rho correlation test revealed that typically developing participants (groups combined) between the ages of 8 years 0 months to 18 years 6 months increased in accuracy with age ($r=.77$ $p<.01$) as did the group with WS ($r=.81$, $p<.01$). See mid-section of Table 2.

Repeating the analysis for participants with autism, the ANOVA revealed a main effect of Part-of-Face $F(1,76)=27.63$, $p<.001$, with upper feature accuracy greater than lower features. There was also a significant effect of Group $F(3,76)=32.29$, $p<.001$. and participants with autism did not perform as accurately as any typically developing group (compared to the VMA group $t(19)=2.96$, $p<.01$, the NVMA group $t(19)=5.68$, $p<.001$, the CA group $t(19)=8.98$, $p<.001$). There was a significant interaction between Group and Part-of-Face $F(3,76)=6.93$, $p<.001$ and simple main effects analyses showed that only the group with autism showed no difference for accuracy matching upper and lower features ($p=.48$). All typically developing groups found upper features easiest to match on identity. For upper features, the group with autism performed less accurately than all other groups (autism-VMA $t(19)=4.04$, $p<.01$, autism-NVMA $t(19)=6.11$, $p<.001$, autism-CA $t(19)=7.61$, $p<.001$). For lower features there was no difference in accuracy for participants with autism and those matched for VMA ($p=.52$), however performance was significantly lower than those matched for NVMA ($t(19)=3.87$, $p<.01$) and CA ($t(19)=7.53$, $p<.001$). For typically developing participants, performance increased with age ($r=.42$, $p<.01$) but for participants with autism there was no significant relationship between age and performance ($p=.74$) or score on the CARS and performance ($p=.78$).

Although individuals who developed typically and those with WS found it easier to match the identity of unfamiliar faces using the upper than lower features, this pattern was not found for participants with autism, where performance was characterized by poor ability to use the upper face region.

Moving and Changing the Eyes or Mouth

Based on the procedure used by Karmiloff-Smith et al. (2004) the analyses consider only the trials involving a 'difference detection'. Here, trials required the participant to correctly spot a manipulated aspect of the face, rather than noting that two faces were identical. Difference judgments may be based on either feature or configural modifications. Although the results indicate whether participants were able to detect featural and / or configural modifications, the main issue of interest here is the use of eye and mouth regions and detection of modifications to these features.

For participants with WS, performance was analysed with a three-way ANOVA with repeated factors Feature (eye, mouth) and Modification (featural, configural) and the independent factor Group (WS, VMA, NVMA, CA). There was a significant effect of Group $F(3,56)=27.06$, $p<.001$ and post hoc t-tests revealed that participants with WS performed with equal accuracy to their verbal matches ($p=.59$) but were more accurate than the nonverbal matches ($t(14)=2.87$, $p<.01$) and less accurate than the CA matches ($t(14)=7.12$, $p<.001$). Overall, participants were more accurate detecting eye than mouth changes evidenced by the significant main effect for Feature $F(1,56)=25.82$, $p<.001$ (overall mean eyes 78%, mouth 65%). The pattern was the same across groups as the interaction between Feature and Group was not significant ($F(3,56)=.51 p=.89$). There was also a significant effect of Modification $F(1,56)=20.93$, $p<.001$ with participants more accurate for featural than configural changes (overall configural 65%, featural 78%). The pattern was apparent for all groups as the interaction between Modification and Group was not significant ($F(3,56)=.31$, $p=.82$), as were the interaction between Modification and Feature

(F(1,56)=.02, *p*=.98) and the three-way interaction between Feature, Modification and Group (F(3,56)=.14, *p*=.25). Importantly, the results indicate the same performance *pattern* across participant groups as it was easier to detect eye than mouth changes and detect featural than configural modifications.

Considering participants with autism, performance was analysed with an ANOVA with the repeated factors Feature (eye, mouth) and Modification (featural, configural) and the between-subject factor Group (Autism, VMA, NVMA, CA). There was a significant main effect of Modification F(1,76)=29.07, *p*<.001 with greater accuracy for featural than configural changes (mean featural 75%, configural 64%). The interaction between Modification and Group was not significant, indicating the same pattern for all participants (F(3,76)=.04, *p*=.99). All typically developing groups were above chance on configural trials (combining eye and mouth trials), but the autism group did not differ from chance (compared to chance *p*=.43). All groups, including participants with autism, performed above chance for featural trials.

There was a significant main effect of the Feature F(1,76)=5.16, *p*<.05 with eye changes easier than mouth changes (overall mean eyes 72%, mouth 67%). However the significant interaction between Feature and Group indicated different patterns across groups F(3,76)=7.45, *p*<.001. Post hoc t-tests revealed that typically developing groups detected eye modifications more accurately than mouth modifications (CA t(19)=3.45, *p*<.01; VMA t(19)=2.30, *p*<.05; NVMA t(19)=2.28, *p*<.05). For the participants with autism, accuracy was significantly greater for mouth than eye trials (t(19)=3.08, *p*<.01). Not only was the relative advantage for eye trials absent from the data for participants with autism, performance appeared in the opposite direction for this group.

The effect of Group was significant $F(3,76)=21.64$, $p<.001$ and indicated that not only did the group with autism show a different pattern of results, but they performed with lower accuracy. Post hoc t-tests revealed the group with autism performed less accurately than all typically developing groups (autism-CA $t(19)=8.17$, $p<.001$; autism-NVMA $t(19)=5.21$, $p<.001$; autism-VMA $t(19)=1.93$, $p=.07$). The poor performance of the autism group is primarily due to performance on eye trials as mouth trials were performed with equivalent performance. No other effects were significant. See bottom section of Table 2.

Discussion

The current paper involved two groups with neurodevelopmental disorders known to impact upon face perception and social functioning. Participants completed a number of unfamiliar face matching tasks utilising paradigms derived from typical face perception literature. The paradigms had not previously been used to explore face perception in WS and autism within one research program. In summary, participants with autism performed relatively poorly across face tasks but importantly showed deficits when required to use the upper face region, specifically the eyes. Evidence from participants with autism did not suggest preferential processing of the mouth region, but an impairment using the eyes. In contrast, individuals with WS exhibit a typical pattern of performance across assessments, with greater accuracy using the eye than mouth regions. The divergent performance pattern for the autism and WS groups (when compared to their typically developing counterparts) emphasizes that although the results of previous research using assessments of structural encoding appear relatively similar, the use of individual facial features varies different. Including these groups within the same research program adds to the literature that dissociates and discusses the two neurodevelopmental disorders.

The current assessments probed use of the eye and mouth regions when matching unfamiliar faces on identity; however it is clear that use of these regions also has implications for deciphering social communicative cues. Autism and WS can be dissociated by the use of communicative face signals (e.g. eye gaze, expressions; Riby et al., in press) and the current paper emphasizes that when compared to typically developing individuals these groups can also be dissociated by the way they interpret identity. Upper feature (eye region) salience that is exhibited by typically developing individuals and those with WS is crucial for interpersonal communication and when this source of information is not used (in the case of autism) social deficits become evident. Therefore the results are consistent with the idea that individuals with autism do not processing information from the eyes in a typical manner which may have wider implications for social functioning and joint attention (Johnson, 2005). Interestingly the results corroborate previous research (Rutherford, Clements & Sekuler, 2007) and provide no evidence that individuals with autism utilise the mouth region preferentially or especially efficiently in the absence of processing in eye region. In general therefore the results not only suggest a specific eye region deficit (with implications for social communication), but are consistent with suggestions of generalised atypicalities of face perception (e.g. Boucher & Lewis, 1992; Ozonoff, Pennington, & Roger, 1990). Such atypicalities are unlikely to be isolated to the processing of identity but are likely to expand across face demands (e.g. expressions, eye gaze).

Fitting into wider issues of visual perception, the current results are in accordance with the idea that perceptual atypicalities are ingrained in social interaction and communicative deficits found in autism (cf. Dakin & Frith, 2005). Attentional and perceptual strategies may be distributed to different facial features for individuals with autism. As advocated by Dakin and Frith (2005) this group may see not only faces atypically but view the world around them in a different way. Furthermore assessments of face perception such as those used here, where attention may be drawn to specific facial regions, may be important alongside assessments of low-level visual perception when providing a unified account of the social and nonsocial aspects of autism.

Of course one of the perceptual aspects of face processing often explored in autism is structural encoding and literature in this area is dominated by evidence of atypicality due to configural processing deficits (Deruelle et al., 2004, Joseph & Tanaka, 2003). Although the autism group showed a typical Thatcher illusion effect (decreased accuracy for inverted than upright trials) associated with configural processing disruptions (Thompson, 1980), this paradigm may not be a stringent assessment due to susceptibility in groups where configural processing is not fully developed (Carey & Diamond, 1994; e.g. children, Donnelly & Hadwin, 2003, Lewis, 2003; infants, Bertin & Bhatt, 2004). However, the results of the moving and changing features task do reveal important aspects of structural encoding. The current evidence is consummate with the idea of a configural processing deficit as participants are less able to detect spacing modifications than feature changes. Detecting small details of elaborate figures and ignoring distracting global information is a defining feature of autism (Dakin & Frith, 2005) and may aid performance on tasks where small independent features (changed eyes or mouth) must be detected. Conversely, global / configural processing deficits are evident under numerous task demands, not only those involving faces (e.g. Navon tasks, Rinehart, Bradshaw, Moss, Brereton & Tonge, 2000) and here such spacing changes were particularly problematic. Again the current results converge with evidence of generalized visual perception atypicalities in autism and deficits utilising configural face cues.

Crucially, the autism group was the only group that failed to perform above chance when detecting configural face manipulations. Participants with WS did perform above chance and therefore, even though previous research indicates that autism and WS are linked to similarly atypical face processing strategies, when these groups are included in the same research program clear differences emerge. When using face perception as a tool to explore aspects of social communication as well as visual perceptual strategies, involving these two disorders in the same study can reveal subtle group differences. Here participants with WS and autism exhibit clear differences of processing ability and strategy that may relate to generalised group differences in social communication (cf. Brock et al., in press).

Adding to the literature regarding face perception and structural encoding in WS, under the task conditions used here configural processing was achieved by individuals with WS though not at a level predicted by chronological age. Isolating the spacing modifications to specific face regions (eyes or mouth) may have enhanced performance in WS (but not in autism) and account in-part for differences compared to previous research (e.g. Karmiloff-Smith et al., 2004). The inclusion of the eye region may be critical and support the notion that under certain task conditions configural processing can be confined to the extraction of local relations between critical face parts (Leder & Bruce, 2000). Therefore individuals with WS may be able to complete tasks by extracting localised configural relationships rather than using the whole face and this can be confirmed by further experimental manipulation.

Proficiency using of the eye region during identity processing for individuals with WS may be linked to evidence from communicative face cues such as eye gaze (e.g. Karmiloff-Smith et al., 1995; Riby et al., in press). Here the results show a typical performance pattern of increased proficiency using the eye than mouth region. Interestingly, the results do not suggest that participants with WS are unable to disengage from the eyes when other face regions must be used (e.g. the mouth). One interpretation of extended face gaze and eye contact in WS (Mervis et al., 2003) has been the idea of attentional disengagement difficulty (e.g. Scerif, Cornish, Wilding, Driver, & Karmiloff-Smith, 2004; Cornish, Scerif & Karmiloff-Smith, in press). Taking on board the current evidence, this interpretation gains less support than a general theory of ‘pro-social compulsion’ (Frigerio et al., 2006) leading to greater interest in faces per se. Although individuals with WS are relatively more able to process faces than other nonverbal stimuli (e.g. Bellugi et al., 1988), increased interest in faces and a pro-social drive does not lead to greater expertise interpreting faces for identity. If this were the case the WS group would show superior performance across tasks but this is not evident. Indeed even if individuals with WS spend more time than is typical holding eye gaze during social interactions (Mervis et al., 2003) this does not lead to exaggerate proficiency interpreting identity using the eye region. The current paper does not therefore support evidence of disengagement deficits in WS and emphasizes that further work is needed to understand the link between naturalistic face gaze strategies and the experimental use of facial features during identity processing.

As noted, the inclusion of participants with WS is central to the current paper as explorations of face processing may inform theories of pro-social compulsion associated with the disorder. Equally, including individuals with WS and autism in the same research program can show important differences of ability that may relate to the subtle dissociations of social functioning associated with the groups. The current research emphasises that it is useful to use modified assessments derived from work with typically developing individuals to explore aspects of the cognitive and social phenotypes typically associated WS and autism.

References

Baron-Cohen, S., Wheelwright, S., & Jolliffe, T. (1997a). Is there a ‘language of the eyes’? Evidence from normal adults and adults with autism or Asperger syndrome. *Visual Cognition, 4*, 311-331.

Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., Plumb, I. (2001b). The “reading the mind from the eyes” test revised version: A study with normal adults and adults with Asperger syndrome or high-functioning autism. *Journal of Child Psychology and Psychiatry, 42*, 241-251.

Bertin, E., & Bhatt, R. S. (2004). The Thatcher illusion and face processing in infancy. *Developmental Science, 7*, 431-436.

Brock, J., Einav, S., & Riby, D. M. (in press). The other end of the spectrum? Social cognition in Williams syndrome. In T. Striano & V. Reid (Eds.). *Social cognition: Development, Neuroscience, and Autism*. Oxford: Blackwell.

Bellugi, U., Sabo, H., & Vaid, J. (1988). Spatial deficits in children with Williams syndrome. In J. Stiles-Davis, M. Kritchevsky, & U. Bellugi (Eds). *Spatial cognition: Brain bases and development*. (pp. 273-298). Hillsdale, NJ, England: Lawrence Erlbaum Associates, Inc.

Boucher, J., & Lewis, V. (1992). Unfamiliar face recognition in relatively able autistic children. *Journal of Child Psychology and Psychiatry, 33*, 843-859.

Carey, S., & Diamond, R. (1994). Are faces perceived as configurations more by adults than by children? *Visual Cognition, 1*, 253-274.

Cornish, K., Scerif, G., & Karmiloff-Smith, A. (in press). Tracing syndrome-specific trajectories of attention across the lifespan. *Cortex.*

Dakin, S. & Frith, U. (2005). Vagaries of visual perception in autism. *Neuron, 48*, 497-507.

Deruelle, C., Mancini, J., Livet, M., Cassé-Perrot, C., & de Schonen, S. (1999). Configural and local processing of faces in children with Williams syndrome. *Brain and Cognition, 41*, 276-298.

Deruelle, C., Rondon, C., Gepner, B., & Tardiff, C. (2004). Spatial frequency and face processing in children with autism and Asperger syndrome. *Journal of Autism and Developmental Disorders, 34*, 199-210.

Donnelly, N. & Hadwin, J. A. (2003). Children's perception of the Thatcher illusion: Evidence for de+velopment in configural face processing. *Visual Cognition, 10,* 1001-1017.

Dunn, L. M., Dunn, L. M., Whetton, C., & Burley, J. (1997). *British Picture Vocabulary Scale II*. Windsor, UK: NFER-Nelson Publishing.

Ellis, H. D. (1975). Recognizing faces. *British Journal of Psychology, 66,* 409-426.

Frigerio, E., Burt, D. M., Gagliardi, C., Cioffi, G., Martelli, S., Perrett, D. I., & Borgatti, R. (2006). Is everybody always my friend? Perception of approachability in Williams syndrome. *Neuropsychologia, 44*, 254-259.

Frith, U. (1999). Cognitive development and cognitive deficit. In M. Darwin & A. Slater (Eds). *The Blackwell reader in development psychology*. Malden, MA, US: Blackwell Publishers. pp.509-522.

Gepner, B., de Gelder, B., & de Schonen, S. (1996). Face processing in autistics: Evidence for a generalised deficit. *Child Neuropsychology*, *2*, 123-139.

Gross, T. F. (2004). The perception of four basic emotions in human and nonhuman faces by children with autism and other developmental disabilities. *Journal of Abnormal Child Psychology, 32*, 469-480.

Johnson, M. H. (2005). *Developmental Cognitive Neuroscience: Second edition.* Malden, MA, US: Blackwell Publishing.

Jones, W., Bellugi, U., Lai, Z., Chiles, M., Reilly, J., Lincoln, A., & Adolph, R. (2000). Hypersociability: The social and affective phenotype of Williams syndrome. *Journal of Cognitive Neuroscience, 12,* 30-46.

Joseph, R. M., & Tanaka, J. (2003). Holistic and part-based face recognition in children with autism. *Journal of Child Psychology and Psychiatry, 44*, 529-542.

Karmiloff-Smith, A., Klima, E., Bellugi, U., Grant, J., & Baron-Cohen, S. (1995). Is there a social module? Language, face processing, and theory of mind in individuals with Williams syndrome. *Journal of Cognitive Neuroscience, 7,* 196-208.

Karmiloff-Smith, A., Thomas, M., Annaz, D., Humphreys, K., Ewing, S., Brace, N., Van Duuren, M., Pike, G., Grice, S., & Campbell, R. (2004). Exploring the Williams syndrome face processing debate: The importance of building developmental trajectories. *Journal of Child Psychology and Psychiatry, 45*, 1258-1274.

Langdell, T. (1978). Recognition of faces: An approach to the study of autism. *Journal of Child Psychology and Psychiatry, 19*, 255-268.

Leder, H., & Bruce, V. (2000). When inverted faces are recognized: The role of configural information in face recognition. *The Quarterly Journal of Experimental Psychology, 53,* 513-536

Lewis, M. B.,& Johnston, R. A. (1997). The Thatcher Illusion as a test of configural disruption. *Perception, 26*, 225-227.

Lewis, M. B. (2003). Thatcher's children: Development and the Thatcher illusion. *Perception, 32*, 1415-1421.

Malcolm, G. L., Leung, C., & Barton, J. J. (2005) regional variation in the inversion effect for faces: Differential effects for feature shape, feature configuration, and external contour. *Perception, 34*, 1221-1231.

McKelvie, S. J. (1976). The role of eyes and mouth in the memory of a face. *American Journal of Psychology*, *9,* 311-323.

Mertens, I., Siegmund, H., & Grusser, O. J. (1993). Gaze motor asymmetries in the perception of faces during a memory task. *Neuropsychologia, 31*, 989-998.

Mervis, C. B., Morris, C. A., Klein T., Bonita P., Bertrand, J. Kwitny, S., Appelbaum, L. G., & Rice, C. E. (2003) Attentional characteristics of infants and toddlers with Williams syndrome during triadic interactions. *Developmental Neuropsychology, 23*, 243-268.

Mondloch, C. J., Le Grand, R. & Maurer, D. (2002). Configural face processing develops more slowly than featural face processing. *Perception*, *31*, 553 – 566.

Mondloch, C. J., Geldart, S., Maurer, D. & Le Grand, R. (2003). Developmental changes in face processing skills. *Journal of Experimental Child Psychology, 86*, 67-84.

Mondloch, C. J., Dobson, K. A., Parsons, J., & Maurer, D. (2004). Why 8-year-olds cannot tell the difference between Steve Martin and Paul Newman: Factors contributing to the slow development of sensitivity to the spacing of facial features. *Journal of Experimental Child Psychology, 89*, 159-181

Mottron, L.(2004). Matching Strategies in Cognitive Research with Individuals with High-Functioning Autism: Current Practices, Instrument Biases, and Recommendations. *Journal of Autism and Developmental Disorders, 34*, 19-27.

Ozonoff, S., Pennington, B. F., Rogers, S. J. (1990). Are there emotion processing deficits in young autistic children? *Journal of Child Psychology and Psychiatry, 31*, 343-361.

Pellicano, E., Rhodes, G., & Peters, M. (2006). Are preschoolers sensitive to configural information in faces? *Developmental Science*, *9*, 270-277.

Raven, J. C., Court, J. H., & Raven, J. (1990*). Raven's Coloured Progressive Matrices*. Oxford: Oxfords Psychologists Press.

Riby, D. M., Doherty-Sneddon, G. & Bruce, V. (*in press*). Exploring face perception in disorders of development: Evidence from Williams syndrome and autism. *Journal of Neuropsychology*.

Rinehart, N. J., Bradshaw, J. L., Moss, S. A., Brereton, A. V., & Tonge, B. J. (2000). Atypical interference of local detail on global processing in high-functioning autism and Asperger's disorder. *Journal of Child Psychology and Psychiatry, 41*,769-778.

Rouse, H., Donnelly, N., Hadwin, J. A., & Brown, T. (2004). Do children with autism perceive second-order relational features? The case of the Thatcher Illusion. *Journal of Child Psychology and Psychiatry, 45*, 1246-1257.

Rutherford, M. D., Clements, K. A., & Sekuler, A. B. (2007). Differences in discrimination of eye and mouth displacement in autism spectrum disorders. *Vision Research, 47*, 2099-2110.

Scerif, G., Cornish, K., Wilding, J., Driver, J. & Karmiloff-Smith, A. (2004). Visual search in typically developing toddlers and toddlers with Fragile X or Williams syndrome. *Developmental Science, 7,* 116-130.

Schopler , E., Rechler, R. J., & Rochen Renner, B. R. (1988). *The Childhood Autism Rating Scale.* LA: Western Psychological Services.

Tager-Flusberg, H., Boshart, J., & Baron-Cohen, S. (1998). Reading the windows to the soul: evidence of domain-specific sparing in Williams syndrome. *Journal of Cognitive Neuroscience, 10,* 631-639.

Tager-Flusberg, H., Plesa-Skwerer, D., Faja, S. & Joseph, R. M. (2003). People with Williams syndrome process faces holistically. *Cognition, 89*, 11-24.

Thompson, P. (1980). Margaret Thatcher: A new illusion. *Perception, 9,* 483-484.

Walker-Smith, G. J., Gale, A. G., & Findlay, L. M. (1977). Eye movement strategies involved in face perception, *Perception, 6,* 313-326.

Wing, L. (1976). *Early childhood autism: clinical, educational and social aspects.* New York: Pergamon Press.

Yarbus, A. L. (1967). *Eye movements and vision*. New York: Plenum Press.

Figure One: Examples of a) upper feature matching task b) the Thatcher illusion (eyes and mouth rotated) c) modified features (changed mouth)

a) b) c)

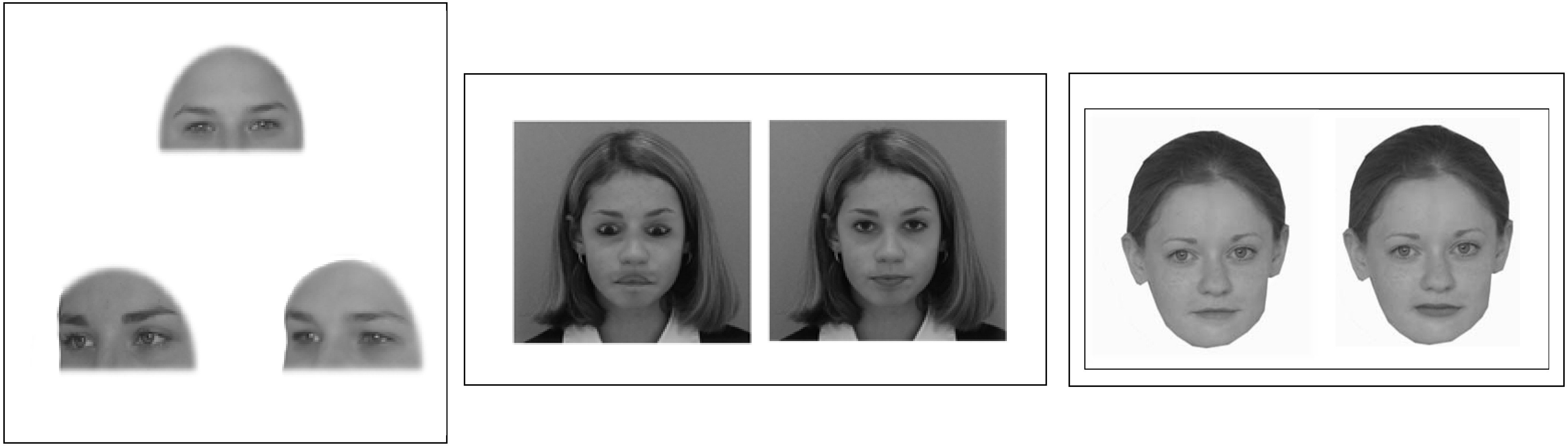

Table One: WS and comparison group details for chronological ages as well as verbal and nonverbal mental age abilities (standard deviation in parenthesis)

Group	N	Gender[1]	CA[2]	VMA[2]	VNMA score[3]
Williams syndrome	**15**	**9:6**	**15y 6m *(34)***	**10y 10m *(20)***	**15 *(6)***
VMA Match	15	10:5	11y 6m *(17)*	10y 11m *(24)*	26 *(5)*
NVMA Match	15	11:4	8y 4m *(16)*	8y 0m *(17)*	15 *(3)*
CA Match	15	10:5	15y 8m *(33)*	15y 0m *(19)*	31 *(6)*
Autism	**20**	**16:4**	**14y 9m *(29)***	**7y 2m *(23)***	**15 *(6)***
VMA Match	20	15:5	6y 6m *(18)*	7y 3m (*21)*	12 *(7)*
NVMA Match	20	14:6	7y 11m *(15)*	8y 2m *(18)*	15 *(5)*
CA MAtch	20	14:6	14y 11m *(27)*	14y 8m *(20)*	31 *(5)*

1 Gender ration presented as number of males:females

2 Chronological and verbal mental ages provided in years and full months for mean and full calendar months for standard deviations

3 Nonverbal mental age ability provided as mean score on the RCPM (max. score 36)

Table Two: Percentage correct (and standard deviation) for each task and condition, identifying where performance of the comparison groups differs significantly from the developmental disorder groups to whom they are matched

	WS	VMA	NVMA	CA	Autism	VMA	NVMA	CA
Thatcher illusion	***n=13***				***n=20***			
Overall accuracy	**79 (5)**	73 (4)	68 (7) [a]	84 (3)	**68 (4)**	71 (5)	72 (6)	85 (5) [b]
Upright trials	**92 (12)**	90 (11)	86 (13) [a]	98 (6)	**78 (16)**	82 (12)	86 (13)	98 (5) [b]
90 degree trials	**84 (19)**	73 (18) [a]	65 (16) [a]	88 (12)	**72 (11)**	74 (9)	76 (17)	90 (14) [b]
Inverted trials	**64 (16)**	56 (22) [a]	52 (21) [a]	66 (19)	**55 (13)**	58 (12)	55 (10)	68 (11) [b]
Eyes only - upright	**87 (13)**	87 (12)	83 (16)	98 (7) [a]	**61 (15)**	81 (18) [b]	84 (12) [b]	98 (5) [b]
Eyes only - inverted	**62 (13)**	56 (22) [a]	47 (17) [a]	63 (12)	**50 (16)**	59 (15)	54 (15)	72 (12) [b]
Mouth only - upright	**81 (15)**	84 (19)	78 (17)	94 (6) [a]	**69 (11)**	73 (7) [b]	75 (5) [b]	94 (13) [b]
Mouth only - inverted	**52 (12)**	52 (21)	44 (18) [a]	54 (14)	**55 (15)**	50 (16)	50 (12)	65 (8) [b]
Upper / Lower features	***n=15***				***n=20***			
Overall accuracy	**77 (12)**	83 (7)	81 (7)	92 (5) [a]	**61 (13)**	72 (10) [b]	80 (6) [b]	89 (7) [b]
Upper accuracy	**88 (13)**	88 (12)	85 (11)	98 (6) [a]	**60 (11)**	79 (10) [b]	77 (6) [b]	94 (10) [b]
Lower accuracy	**67 (19)**	78 (10)	76 (10)	92 (5) [a]	**63 (13)**	65 (12)	84 (8) [b]	86 (12) [b]
Manipulations	***n=15***				***n=20***			
Overall accuracy	**70 (5)**	68 (7)	62 (10) [a]	87 (8) [a]	**58 (11)**	65 (13) [b]	73 (9) [b]	84 (9) [b]
Featural trials	**78 (11)**	75 (16)	67 (12) [a]	93 (7) [a]	**64 (15)**	70 (17)	78 (12) [b]	90 (8) [b]
Configural trials	**61 (18)**	61 (16)	57 (17) [a]	81 (10) [a]	**53 (14)**	61 (17) [b]	67 (14) [b]	90 (8) [b]
Eye trials	**76 (11)**	73 (6)	68 (11) [a]	93 (9) [a]	**52 (11)**	71 (13) [b]	77 (13) [b]	89 (11) [b]
Mouth trials	**63 (12)**	63 (18)	55 (14) [a]	81 (12) [a]	**64 (16)**	60 (15)	68 (13)	78 (13) [b]

a Performance is significantly different from the group with WS (p<.05) to whom they are matched

b Perofrmance is significantly different from the autism group (p<.05) to whom they are matched