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Exploring face perception in disorders of development: Evidence from Williams syndrome and autism

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Abstract

Individuals with Williams syndrome (WS) and autism are characterised by different social phenotypes but have been said to show similar atypicalities of face processing style. Although the structural encoding of faces may be similarly atypical in these two developmental disorders, there are clear differences in overall face skills. The inclusion of both populations in the same study can address how the profile of face skills varies across disorders. The current paper explored the processing of identity, eye gaze, lip reading and expressions of emotion using the same participants across face domains. The tasks had previously been used to make claims of a modular structure to face perception in typical development. Participants with WS (n=15) and autism (n=20) could be dissociated from each other, and from individuals with general developmental delay, in the domains of eye gaze and expression processing. Individuals with WS were stronger at these skills than individuals with autism. Even if the structural encoding of faces appears similarly atypical in these groups, the overall profile of face skills, as well as the underlying architecture of face perception, varies greatly. The research provides insights into typical and atypical models of face perception in WS and autism.

Keywords: Williams syndrome, autism, face perception

The last two decades have seen a profusion of research exploring the successful interpretation of face cues. The prominent cognitive model endorses a modular conceptualisation of face perception (Bruce & Young, 1986). The model proposes separate mechanisms for the perception of identity versus changeable facial cues; such as eye gaze, expressions of emotion and head angle (Bruce & Young, 1986; but see Calder & Young, 2005). These different processes recruit separable neurocognitive resources within a dedicated 'face processing module' (Haxby, Hoffman & Gobbini, 2002). Haxby and colleagues support the structural independence of face perception mechanisms by emphasising independent neural substrates and separate pathways for processing different face demands. The inferior occipital gyri and superior temporal sulcus (STS) process changeable facial properties (eye gaze, expressions, lip movements), whilst the inferior occipital gyri and lateral fusiform gyrus play crucial roles in coding invariant face properties such as identity (Haxby et al., 2002).

The Bruce and Young (1986) model, and specifically the dissociation between processing changeable facial attributes and identity, is supported by evidence from numerous sources; adults with brain injury (e.g. prosopagnosia) show selective impairments of identity or expression (Tranel, Damasio & Damasio, 1988), adults without brain injury show differential brain activation when responding to identity versus expressions (Thomas et al., 2001). More recently the model has been supported by evidence from typically developing children (Bruce et al., 2000) and individuals with developmental disorders; non-specific developmental delay (Singh et al., 2005) and social developmental disorders (Hefter, Manoach & Barton, 2005). Certainly the Bruce and Young model has dominated our understanding of the architecture of face perception and where challenges have been made none have offered a widely accepted alternative (Calder & Young, 2005). The aim of the current research is to understand a profile of face skills and provide insights into the relationship between different face skills in atypical development using evidence from two neuro-developmental disorders; namely autism and Williams syndrome (WS).

Autism is a neuro-developmental spectrum disorder, which by its very nature presents itself with varying degrees of deficit (Wing, 1976). Although the aetiology of the disorder appears somewhat complex, the most likely risk factor is genetic liability (Rutter, 2005a). Typically individuals are characterized by a triad of impairments to areas of social relations, communication and imagination (DSM IV, American Psychiatric Association, 1994). The vast majority of affected individuals have learning difficulties and about 80% having an IQ below 70 (Peeters & Gillberg, 1999). Considerable research has explored face perception in autism, but more research does not imply more consensus of opinion. The ability to interpret faces varies greatly between individuals at different degrees of functioning on the autistic spectrum; however it is generally acknowledged that face processing deficits are likely to contribute to social difficulties (Klin et al., 1999). Although a generalised face processing deficit is evident the specific face domain (or skill) being used may impact upon performance, for example identity processing is relatively less problematic than interpreting eye gaze or expressions of emotion (Gepner, de Gelder & de Schonen, 1996). However, clear deficits have been reported regarding skills such as remembering faces (Boucher & Lewis, 1992), deciphering emotions (Teunisse & de Gelder, 1994), recognising familiar people and interpreting eye gaze (Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, 1993). Lower accuracy on a range of face tasks also co-occurs with atypical structural encoding; a predominance of featural face processing even for adults (e.g. Teunisse & de Gelder, 2003) where configural processing is typically more prominent. The current paper focuses on the processing of a range of facial cues as well as the possible structure of an overall model of face perception.

It can not be ignored that several studies have reported fewer face processing deficits than others, for example static gaze can trigger a typical shift of attention (Kylliäinen & Hietanen, 2004) and expressions of emotion can be identified (Castelli, 2005). Importantly, all these studies include different participants and therefore individual differences may impact upon performance. Extrapolating from other research studies involving individuals with autism, it

is already known that task demands (e.g. matching, recognising, sorting) and instructions (e.g. cueing) impact upon performance and any pattern of skill and deficit (e.g. Lopéz, Donnelly, Hadwin, & Leekam, 2004). Condensing findings across various studies with different task demands, face domains and participant characteristics becomes particularly complex when level of functioning on the autistic spectrum plays a central role. To accommodate this, a small number of studies have included the same individuals across face domains, although none have utilised a norm-based assessment battery. This type of study can address how the nature of assessment impacts upon performance and emphasise islets of specific skill or deficit (e.g. Deruelle, Rondon, Gepner, & Tardiff, 2004; Teunisse & de Gelder, 1994). Studies that include the same individual across face domains are particularly important to understand the range of face skills required for successful interpersonal communication as well as how this relates to deficits exhibited by individuals with autism. For example, more extensive problems interpreting communicative face cues than matching faces on identity may play a central role on communication deficits associated with the disorder (Deruelle et al., 2004).

In contrast to the deficits observed for individuals with autism, it has been claimed that people with WS demonstrate a relative 'sparing' of face recognition skills in comparison to other cognitive abilities (e.g. Bellugi et al., 1994). This genetic disorder has an approximate prevalence of 1:20,000 (Morris & Mervis, 1999) although recent research has proposed that this is considerably higher (1:7,500; Stromme, Bjornstad & Ramstad, 2002).The neuro-developmental disorder is caused by a deletion of approximately 28 genes at chromosome site 7q11.23 (Tassabehji, 2003) and individuals are characterised by a general IQ estimate between 40 and 90 (Searcy et al., 2004) as well as a dissociation between verbal and nonverbal processing (e.g. Bellugi, Lichtenberger, Mills, Galaburda, & Korenberg, 1999b). A clear difference between individuals with WS and those with autism occurs in the realm of sociability. Although both groups exhibit atypicalities of social functioning there are subtle but significant variations between the groups (see Brock et al., in press). In the case of autism

this atypicality relates to social withdrawal but individuals with WS are often described as 'hypersociable' (Jones et al., 2000). Although in some respects there seems to be a double dissociation between WS and autism regarding social functioning and face perception, it would be inappropriate to consider either as evidence of 'intact' skills. Subtle deficits and atypicalities relating to face processing proficiencies and strategies emphasise that this social skill is not developmentally 'intact' in either population. Showing atypical hypersociability and relating to the social significance of faces, individuals with WS may act overfriendly with strangers and rate unfamiliar faces with abnormally high levels of approachability (Bellugi, Adolphs, Cassady & Chiles, 1999a), process unfamiliar faces atypically (Riby, Doherty-Sneddon & Bruce, 2005) and exhibit prolonged face gaze (Doherty-Sneddon, Riby, Calderwood & Ainsworth, 2007). Researchers have proposed a 'social stimulus attraction' driving social interactions in WS (Frigerio et al., 2006) that varies dramatically from the lack of social drive associated with autism (e.g. Wing, 1967). Together WS and autism can inform researchers about core processes involved in perceiving and interpreting our social world (Johnson, 2005).

Evidence of proficient face processing in WS predominantly focused on face recognition, for example Bellugi et al. (1999b) reported strong performance on face recognition and memory tasks which lead to the assumption of 'preserved' skills. More sensitive assessments have revealed delays and deficits in the development of configural processing (Karmiloff-Smith et al., 2004). Similar to autism, those with WS exhibit featural structural encoding of faces even in adulthood. Regarding socio-communicative face skills, again task demands (e.g. discriminating, sorting or matching) and face domain (eye gaze, identity, emotions) are moderating factors. For example, emphasising the impact of task demands, participants are proficient at discriminating expressions from schematic faces (Karmiloff-Smith, Klima, Bellugi, Grant, & Baron-Cohen, 1995), however emotion sorting proves more difficult (Tager-Flusberg & Sullivan, 2000) and interpreting moving facial expressions is particularly troublesome (Plesa-Skwerer, Verbalis, Schofield, Faja & Tager-Flusberg, 2006). As with

research involving participants with autism, it is crucial to involve the same individuals across face domains. Two studies involving participants with WS have adopted such approach and in both investigations the specific domain of face skill impacted upon performance. Although previous research had suggested 'preserved' face skills (e.g. Bellugi et al., 1999b) explorations of various face processing abilities with the same individuals fails to find performance at the level predicted by chronological age (Deruelle et al., 1999, exp.1; Karmiloff-Smith, 1997; exp.2). Explicitly research has implied that alongside a general delay in face processing ability, the processing of lip movements is relatively preserved in comparison to other skills (such as matching faces based on identity, eye gaze or gender; Deruelle et al., 1999). The degree of configural processing required for task completion has also been said to plays a central role and contribute to stronger performance on eye gaze, lip reading and expression matching tasks compared to more 'fine-grained' matching of similar faces on identity (Karmiloff-Smith, 1997). To date research lacks consensus regarding a profile of face skills due to use of unsuitable tasks (e.g. ceiling effects, Deruelle et al., 1999 and Karmiloff-Smith, 1997). As with autism research, it seems adequate to suggest that performance varies with task demands, face domain and individual differences.

The aim of this investigation is to examine the profile of face skills for WS and autism. As well as revealing a profile of skills, the research will enable use to assess whether the Bruce and Young (1986) modular conceptualisation of face perception can be applied to these groups. The overarching aim is to therefore broaden our understanding of face perception associated with autism and WS within one study, using a methodology that is able to manipulate face domain (identity, expressions, eye gaze, lip reading) and task demands (matching, recognition) whilst controlling for individual differences across assessments.

The current exploration uses an assessment battery derived from face processing in typical development. Bruce et al. (2000) presented matching and recognition tasks assessing identification, eye gaze, expressions and lip reading to children aged 4-5, 6-7 and 10-11 years.

These tasks were used to reveal that the typical modular structure to face perception that is evident in adults is also present in children; evident by a lack of correlation between face domains (Bruce et al., 2000). The current study replicates the procedure to assess the applicability of this model of face perception to WS and autism. The study compares performance for individuals with WS and autism to those with general developmental delay as these participants have specific disorders that impact upon several aspects of development. Research has shown that children with general developmental delay exhibit a typical modular structure to face perception (Singh et al., 2005) and therefore the current study explores the differential effects associated with WS and autism.

Method

Participants

Fifteen participants with WS had a mean age of 10 years 5 months (ranging 6 years 0 months to 15 years 10 months) and were recruited via the Williams syndrome Foundation. All participants had been diagnosed phenotypically by clinicians and 11 participants had their diagnosis confirmed by fluorescent in-situ hybridisation testing. Twenty participants with autism aged 6 years 2 months to 16 years 0 months (mean 12 years 0 months) were recruited from local schools. Five attended the special education unit of a mainstream primary school with the remaining fifteen attending a special school for pupils with autistic spectrum disorders. The Childhood Autism Rating Scale completed by teachers (CARS; Schopler, Reichler, & Rocher Renner, 1988) classified 11 children with mild-moderate autism and 9 with severe autism. The CARS scores ranged between 33 and 54 across the sample.

Each participant was assessed on their verbal and nonverbal ability for the purposes of providing matching criteria. Verbal ability (VMA) was assessed using the British Picture Vocabulary Scale II (BPVS II; Dunn, Dunn, Whetton, & Burley, 1997) and nonverbal ability (NV) was assessed using the Ravens Coloured Progressive Matrices (Raven, Court, & Raven,

1990) These two assessments are frequently used as matching measures (Mottron, 2004) and provide quick and easy assessments across a wide age range.

Each participant with WS and autism was individually matched to two individuals with general developmental delay: one of comparable verbal ability and one of comparable nonverbal ability, to account for the uneven profile of cognitive skills. Participants with general developmental delay were classified as having global delay by clinicians based on IQ and adaptive behaviour. Unlike previous research involving individuals with general developmental delay (e.g. Singh et al., 2005; who included participants with Down syndrome) children were not included if there was a family history of learning difficulty, they suffered a known genetic syndrome, experienced neurological injury, had attention deficit hyperactivity, severe sensory or physical impairments. The matched groups did not differ in terms of the matching criteria (see Table 1 for full participant characteristics).

[Table 1]

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

Materials and Procedure

Tasks are taken directly from Bruce et al. (2000) and the procedure directly replicated those used in the previous research with typically developing participants.

Expressions

Tasks assessed the ability to interpret facial representations of ‘happy’, ‘sad’, ‘angry’, and ‘surprise’ with twelve trials in each task.

Expression-pair: Participants viewed pairs of faces and pointed to the person that was depicting an expression spoken by the researcher; happy, sad, angry, surprise.

Expression-match: A target face was shown at the top of the page and participants were asked to point to the face of the person at the bottom who 'feels the same way as the person at the top'. See Figure 1.

Eye Gaze

These tasks assessed the ability to match eye gaze directions and each task had twelve trials.

Gaze-pair: Participants pointed to the face (out of two) that was looking at them.

Gaze-match: Participants pointed to the person (out of two) who was looking in the same direction as the target face at the top of the page.

[Figure 1]

Identification

Participants matched unfamiliar faces on identity. In each task the participant chose, from two faces, the picture of the same child as the target face (16 trials).

ID-matching whole faces: Whole face stimuli were used with target and distracter faces of similar appearance (same gender, age, overall appearance). See Figure 1.

ID-matching internal features: The faces from the ID-matching whole face task were used but with the hair and ears (external features) removed.

Lip reading

Tasks assessed whether participants could use the mouth region to make a simple judgement about speech sounds, with 12 trials on each task.

Sound-pair: Participants viewed pairs of faces and pointed to the face that was saying 'ah', followed by blocks of 'ee', 'ff' trials and 'oo' in turn. The researcher pronounced the speech

sound and the participant chose the appropriate face depicting the sound. The participant could not see the researchers' mouth when the cue was provided.

Sound-match: The participant was required to point to the child (out of two) that was saying the same as the target child shown at the top of the stimuli.

Individual testing sessions, at home or in school, lasted approximately 20 minutes. Tasks were randomly assigned to test sessions and participants completed one task from each face processing domain in each session. Across tasks, participants pointed to the picture corresponding to the correct answer, with all tasks self-paced and a stimulus remaining in view until a response was provided. The black-and-white stimuli were presented on A4 paper. Bruce and colleagues conducted both computer and paper tasks finding no difference based on presentation.

As well as assessing task accuracy, the analysis investigated fractional success rates (FSR). Bruce and colleagues (2000) set out an FSR to assess task difficulty across different ages. Here the FSR identifies group differences and shows where mean accuracy is representative of the number of participants 'passing' the task. A 'pass' is determined by the participant reaching the 95% criterion on a binomial test, with a guessing probability of 0.5 (10 out of 12 or 12 out of 16).

Results

Williams syndrome

When processing expressions, an analysis of variance (ANOVA) with factors Task (Exp-pair, Exp-match) and Group (WS, VMA, NV) showed that participants found recognition easier than matching ($F(1,42)=26.81$, $p<.001$; recognition 81%, matching 75%). There was also a significant effect of Group ($F(2,42)=4.21$, $p<.05$) as participants with WS performed

significantly more accurately than those matched for VMA ($t(14)=2.63$, $p<.05$) and NV ability ($t(14)=2.93$, $p<.05$). The interaction between variables was not significant ($p=.09$).

An ANOVA with factors Expression (happy, sad, angry, surprised) and Group (WS, VMA, NV) revealed that performance differed by expression ($F(3,126)=14.37$, $p<.001$). T test analyses showed that happy and sad did not differ ($p=.30$), although happy was easier than both angry ($t(44)=6.22$, $p<.001$) and surprise ($t(44)=4.70$, $p<.001$). Similarly, sad was easier than both angry ($t(44)=4.09$, $p<.001$) and surprise ($t(44)=3.74$, $p<.01$) which did not differ ($p=.82$). There was a significant effect of Group ($F(2,42)=3.51$, $p<.05$) and post hoc t-tests revealed that across expressions participants with WS performed more accurately than the VMA and NV groups (WS-VMA $t(14)=2.80$, $p<.05$; WS-NV $t(14)=3.68$, $p<.01$) who did not differ ($p=.61$). The interaction between variables was not significant ($p=.24$).

For eye gaze, an ANOVA with factors Task (Gaze-pair, Gaze-match) and Group (WS, VMA, NV) revealed a significant effect of task demands as recognition was more accurate than matching ($F(1,42)=25.75$, $p<.001$; recognition 77%, matching 67%). There was a significant effect of Group ($F(2,42)=5.62$, $p<.01$) and participants with WS were more accurate than both comparison groups (WS-VMA $t(14)=3.55$, $p<.01$, WS-NV $t(14)=3.53$, $p<.01$), who did not differ ($p=.99$). The interaction between Task and Group was not significant ($p=.23$). In relation to each comparison group, more individuals with WS passed the gaze matching task based on FSR ($\chi^2(1)=7.58$, $p<.01$; for each comparison group). Compared to the verbal matches (but not the nonverbal group) more participants with WS also passed the gaze recognition task ($\chi^2(1)=3.89$, $p<.05$; see Table 2).

When matching identity, an ANOVA with factors Task (Identity whole, Identity internal) and Group (WS, VMA, NV) revealed a significant effect of Task, with greater accuracy for

matching whole faces than internal features ($F(1,42)=121.7$, $p<.001$; whole 69%, internal 47%). It is difficult to draw conclusions from internal feature matching as performance was around chance (compared to chance WS $p=.07$; VMA $p=.07$; NV $p=.06$). The effect of Group was not significant ($p=.15$) and the FSR revealed no group differences. The interaction between factors ($F(2,42)=5.63$, $p<.01$) indicated that individuals with WS were less affected by covering the external features than those with general developmental delay.

Similarly, for lip reading an ANOVA with factors Task (Lip reading recognition, Lip reading match) and Group (WS, VMA, NV) revealed an effect of Task, with greater accuracy for recognition than matching ($F(1,42)=37.19$, $p<.001$; recognition 76%, matching 69%) and no effect of Group ($p=.08$). The FSR revealed no difference in the number of participants passing the tasks and the interaction between variables was not significant ($p=.09$).

[Table 2]

Autism

Considering expressions, an ANOVA with factors Task (Exp-pair, Exp-match) and Group (Autism, VMA, NV) revealed an effect of task demands, with greater accuracy for recognition than matching ($F(1,57)=5.62$, $p<.05$; 73% and 70% respectively). There was an effect of Group $F(2,57)=3.75$, $p<.05$ and the interaction between Task and Group was also significant $F(2,57)=3.25$, $p<.05$. For expression matching individuals with autism performed significantly less accurately than both comparison groups (matching: autism-VMA t(19)3.37, $p<.01$; autism-NV $t(19)=5.09$, $p<.001$) but for expression recognition the autism group only performed less accurately than the NV group (recognition: autism-VMA $p=.99$; autism-NV $t(19)=.78$, $p<.05$). The FSR similarly revealed little difference in the number of participants passing the recognition task, but fewer participants with autism passing the expression matching task than those matched for NV ability ($\chi^2(1)=6.14$, $p<.05$).

Across expressions, an ANOVA with factors Group (autism, VMA, NV) and Expression (happy, sad, angry, surprise) revealed an effect of Expression ($F(3,171)=13.41$, $p<.001$). Happy and sad were equal in difficulty ($p=.30$) but happy was easier than both angry ($t(59)=3.13$, $p<.001$) and surprise ($t(59)=6.28$, $p<.001$). Sad was easier than surprise ($t(59)=4.67$, $p<.001$) but not different from angry ($p=.10$). Finally, surprise was also more difficult than angry ($t(59)=2.78$, $p<.01$) making it the most difficult expression to process. There was no Group effect ($p=.17$) but a significant interaction between Group and Expression ($F(6,171)=2.14$, $p=.05$) was evident as 'surprise' revealed poorer performance for those with autism than the comparison groups (autism-VMA $t(19)=2.11$, $p<.05$; autism-NV $t(19)=2.86$, $p<.05$).

When matching and recognising eye gaze directions, an ANOVA with factors Task (Gaze-pair, Gaze-match) and Group (Autism, VMA, NV) revealed an effect of group membership ($F(2,57)=6.18$, $p<.01$). Participants with autism performed less accurately than both comparison groups (autism-VMA $t(19)= 2.57$, $p<.05$; autism-NV $t(19)=3.77$, $p<.01$) who did not differ ($p=.46$). Compared to chance level, participants with autism were the only group who did not perform above chance ($p=.27$). There was also a significant effect of Task ($F(1,57)=42.41$, $p<.001$) as recognition was easier than matching (recognition 69%, matching 59%). The interaction between Task and Group was not significant ($p=.41$).

For identity matching, an ANOVA with factors Task (Identity whole, Identity internal) and Group (Autism, VMA, NV) revealing an effect of Task ($F(1,57)=103.11$, $p<.001$) as it was easier to match identity from whole faces than internal features (whole 67%, internal 49%). There was no effect of Group ($p=.73$) and the interaction between factors was not significant ($p=.09$), supported by the FSR.

When lip reading, an ANOVA with factors Task (Speech recognition, Speech match) and Group (Autism, VMA, NV) revealed an effect of Task ($F(1,57)=50.79$, $p<.001$) as recognition

was easier than matching (recognition 76%, matching 67%). There was no effect of Group (p=.14) and the interaction was not significant (p=.45), supported by the FSR.

Direct comparison: WS and autism

To allow the WS and autism groups to be matched, the sample was trimmed on the basis of chronological age and nonverbal ability. The resulting sample comprised 12 individuals with WS and 12 with autism. Eleven individuals with WS in this sample had been diagnosed phenotypically by clinicians and by positive FISH testing, whilst one individual was solely diagnosed phenotypically. The sample of individuals with autism ranged from 33 to 51 on the CARS completed by teachers. The two groups were comparable in terms of chronological age (WS mean 11 years 8 months, autism mean 10 years 10 months, p=.74) and nonverbal ability (WS mean 16, autism mean 16, p=.83). Due to the divergent cognitive phenotypes associated with the disorders, individuals with WS had a significantly higher verbal ability than those with autism ($t(11)=2.74$, $p<.05$).

To investigate any difference in the profile of abilities an ANOVA was conducted with factors Domain (expression, identity, gaze, lip reading) and Group (Williams syndrome, autism). The score for each domain was the combined accuracy for recognition and matching. The ANOVA revealed a significant effect of Domain $F(3,66)=4.79$, $p<.01$ as performance varied across face skills. There was an expected effect of Group $F(3,66)=5.63$, $p<.01$ as individuals with WS performed more accurately than those with autism (WS 81%, autism 67%). Finally, there was an interaction between factors $F(1,22)=8.37$, $p<.01$ as performance patterns varied depending on group membership.

Participants with WS and autism varied significantly in two domains, where individuals with WS performed more accurately than those with autism; the ability to process expressions of emotion ($t(11)=3.18$, $p<.01$) and eye gaze directions ($t(11)=3.78$, $p<.01$). Investigation of the effect size of the difference between groups on these two skills indicated particularly large

effect sizes (expression d= 1.18, eye gaze d=1.54). Use of lip reading cues (p=.55) and identity matching (p=.11) were not significantly different between groups.

Age, performance and the relationship between face tasks in WS and autism

Due to the relatively large number of comparisons being made the correlation analysis considers significant relationship as p<.01 but does also discuss the relevance of marginally significant relationships (p<.05). The relationship between age and performance was investigated with Spearman Rank correlations, although some care is required due to sample sizes. For participants with WS, Spearman Rank correlation revealed that chronological age was only marginally associated with identity processing (p<.05) as increased age was related to greater accuracy (Table 3). Chronological age was not correlated with performance in any domain for individuals with autism. However, when level of functioning was considered (CARS score), there was a significant negative correlation between this and task probing expression, eye gaze and identity processing but not lip reading (Table 4). A significant negative correlation indicates that greater severity is associated with lower accuracy. Chronological age therefore has little association with face processing abilities in both WS and autism, as might be expected due to the presence of developmental delay associated with these disorders. In autism, level of function on the autistic spectrum is a more reliable insight into face processing ability than chronological age.

[Table 3]

Investigating the relationship between face domains, Spearman Rank test revealed that individuals with WS showed few significant correlations between tasks probing different aspects of faces, consistent with the independence of skills. The relationship between performance on identity tasks and those probing changeable facial cues (expressions, eye gaze and lip reading) was not significant, suggesting evidence of the independence of these skills as cited in typical adults and children (Bruce & Young, 1986; Bruce et al., 2000). Significant

and near-significant correlations were seen only between expression and lip-reading tasks. Identity tasks did not correlate with any of the other tasks in this group.

A rather different picture emerges for the autistic group who show an abundance of significant and marginally significant correlations between identity tasks and tasks involving other face domains (Table 4). Identity processing is correlated with the processing of various changeable facial attributes; explicitly at the level $p<.01$ identity processing is correlated with eye gaze processing two skills usually considered to engage different processes and neural mechanisms. The marginally significant ($p<.05$) relationship between identity and expression processing is also suggestive of an atypical interplay between typically distinct face skills. Overall the significant and marginally significant correlation between identity tasks and those involving changeable facial cue processing for participants with autism stands against the pure independence of processing pathways for this group.

[Table 4]

Discussion

The current paper investigated a profile of face skills for individuals with WS and autism and illustrated that performance is affected by the face skill in use for both groups. Additionally, the results indicate that for participants with autism, but not for those with WS, there are correlations between aspects of face processing that are typically considered to be independent. The norm-based assessment battery used to investigate face processing abilities was derived from typically developing children and had previously been used to make claims of a modular structure to face perception in childhood (Bruce et al., 2000). The pattern of face skills evident here and the relationship between face skills found for individuals with autism represents a profile not found in typical development using these face tasks.

Regarding the resultant profile of face skills for each group, the range of tasks used here placed similar cognitive demands on participants across domains; identity, expression, eye gaze and lip reading. The data emphasised that the face perception abilities of individuals with WS and autism could be dissociated from general developmental delay, and from each other, on eye gaze and expression processing abilities. Deficits and proficiencies when processing these changeable and communicative face cues may be implicated in the social characteristics typically associated with autism and WS respectively. For example, the ability to interpret eye gaze cues and an interest in processing this facial attribute may relate to prolonged eye contact during social interactions in WS (e.g. Doherty-Sneddon et al., 2007), in contrast to the inverse profile of gaze avoidance in autism (Frith, 1999). Previous research showing contradictory findings regarding eye gaze in autism may be consolidated by evidence of a relationship between level of functioning on the autistic spectrum and gaze processing ability.

Previous research suggests similarly atypical structural encoding of faces in WS and autism linked to deficits and delays in the development of configural processing (e.g. Karmiloff-Smith et al., 2004; Teunisse & de Gelder, 2003). If individuals with WS and autism process faces in a similarly atypical manner it could be questioned as to why such clear differences occur when interpreting face cues. There are a number of suggestions to be made here. First, the structural encoding of faces using configural processing may not be central to all social activities mediated by faces. Even if similar atypicalities occur deep within the structural encoding node of processing, other independent aspects of face processing of the model may not be implicated. This may certainly be the case for individuals with WS as the current research results are generally consistent with the view that different face processing tasks proceed independently. Secondly, the tasks utilised here did not probe the manner in which tasks were performed and therefore the underlying processes by which participants completed tasks may have differed. Thirdly, and the most relevant to the processing of faces in everyday encounters, the social importance of the tasks and participant engagement may play a role in

performance. This issue is also touched on later in the discussion section. The current research may be useful in providing clues about the different cognitive mechanisms that underpin the differential social phenotypes associated with WS and autism. The divergent nature of performance when processing communicative cues of eye gaze and expressions may have a number of sources, even if participants with WS and autism process faces in a similarly atypical manner in some tasks.

Consistent with evidence from typical adults and children, it appears that in individuals with WS there is no correlation between processing faces for identity and other tasks involving more communicative skills. The observed correlation between expression processing and lip-reading in this group is interesting but also consistent with recent theoretical views from cognitive neuroscience, discussed below, which differentiate the processing of 'changeable' facial information from structural coding of identity. Ideally further research would seek to replicate these findings with a larger sample to allow a more sensitive assessment of the relationship between face skills.. Equally important to the current research is the finding of an uneven face profile in WS whereby this group is more accurate at processing eye gaze and expressions than individuals with general developmental delay. The communicative strengths compared to other groups may be implicated in the typical social phenotype associated with WS.

A different picture is evident for autism as the 20 participants tested here showed a relationship between processes typically independent of each other as well as specific deficits when interpreting expressions and eye gaze. Gepner and colleagues (1996) emphasised that autism is characterised by a general deficit of varying degrees across face domains and the present study supported the notion of differential deficits across face skills with a larger sample, including recognition as well as matching tasks and the impact of level of functioning. The apparent lack of modularity for face perception in autism might be explained by a general atypical and deficient mechanism linked to differing degrees to a variety of face

skills. If there is a core deficit or mechanism impacting upon performance across various face domains the nature of this deficit is currently unknown. However, this may relate to theories of social disengagement and disinterest. It has been proposed that face processing deficits are likely to contribute to social difficulties evident in autism (Klin et al., 1999) and indeed the current pattern of deficits to communicative face skills may be central to this notion. Future research linking communicative face skills to individual differences in social interaction abilities would be of benefit.

The general performance of individuals with WS and autism when processing faces may be linked to a more general property of task performance, for example a willingness to study faces as well as a more general task engagement issue. In typical development and WS there is no constraint on performance due to unrestricted face viewing and the variability between aspects of face skill (domains) may be shaped by different constraints. However, in autism the eyes might have negative valence (hence individuals do not look at faces typically) and atypical exposure to faces, or willingness to look at faces, may depress a variety of face skills. However, the differing impact of any core deficit on different face skills is certainly unclear.

Within the profiles presented here, identity matching and lip reading ability did not dissociate individuals with WS and autism from general developmental delay or from each other. The fact that the groups performed with equal accuracy when matching identity is particularly surprising given previous evidence. Consistent with recent research (e.g. Karmiloff-Smith et al., 2004) identity matching ability did not support earlier suggestions of an 'intact' skill (e.g. Bellugi et al., 1999). When accuracy is compared to previous research using the same tasks (Bruce et al., 2000), much younger typically developing children performed with greater accuracy than individuals with both WS and autism. The current exploration did not identify processing style and therefore tasks may have been completed atypically by individuals with both developmental disorders (Deruelle et al., 1999; Karmiloff-Smith et al., 2004). Using age-appropriate tasks across domains it is evident that although some face skills (eye gaze,

expressions) are ‘less affected’ in WS than in general developmental delay, other skills are equally impaired (identity, lip reading). Conversely, whilst some face skills are ‘more affected’ in autism than in general developmental delay, other skills are equally impaired. Interestingly, the same skills that are ‘less affected’ in WS are those that are ‘more affected’ in autism, possibly emphasising the fragile nature of such skills and their communicative importance given the social skills associated with these two groups.

Haxby and colleagues propose that the interplay between several brain regions is crucial for interpreting a full range of face cues (Haxby et al., 2002). Although they are not directly assessed here, the neural correlates related to the two domains that dissociate WS and autism (expressions and eye gaze) may be important. The inferior occipital gyri and STS process changeable facial properties (expressions, lip movement, eye gaze) and the amygdala is involved in processing emotional stimuli. Brothers (1990) proposed that the amygdala, orbito-frontal cortex and STS work together to form the neural basis of social intelligence. Amygdala involvement may be particularly important and has been implicated in both WS and autism. Baron-Cohen et al. (2000) proposed the importance of amygdala dysfunction / abnormality in the core symptomology of autism. Whereas, hypofunctioning of the amygdala in relation to emotional stimuli (Meyer-Lindenberg, Mervis & Berman, 2006) and atypical amygdala structure in terms of increased volume (Reiss et al., 2004) have both been cited regarding WS. Performance in face domains of importance for the current paper may link to underlying neural atypicalities, although future research would need to directly assess the link between behavioural performance and neural mechanisms in these groups.

The results presented here make a novel contribution to our understanding face perception dissociations in two neuro-developmental disorders. Although previous research has noted similar atypicalities of structural encoding, the current study suggests dissociations in the overall architecture of face perception and in the overall profile of skills and deficits. There are a number of ways in which future research can add to this picture, for example taking a

developmental cognitive neuroscience approach to investigate the interplay between the neural substrates of face perception and the structure face perception models relevant to WS and autism. Zebrowitz (2006) comments that there is much work to be done to fully comprehend how faces are interpreted within our social environment and disorders of development associated with atypicalities of social functioning and face perception may prove particularly insightful.

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Table 1: WS and comparison group details for chronological age as well as verbal and nonverbal abilities (standard deviation in parenthesis)

Group	N	Gender[1]	CA[2]	VMA[2]	NV score[3]
Williams syndrome	15	9:6	10y 5m *(36)*	7y 2m *(21)*	15 *(6)*
VMA Match	15	11:4	9y 6m *(25)*	7y 1m *(20)*	18 *(5)*
NV Match	15	12:3	8y 1m *(15)*	6y 0m *(20)*	15 *(5)*
Autism	20	16:4	12y 0m *(33)*	5y 11m *(14)*	15 *(7)*
VMA Match	20	12:8	7y 6m *(12)*	6y 0m *(15)*	13 *(5)*
NV Match	20	14:6	8y 10m *(30)*	6y 6m *(16)*	15 *(8)*

1 Gender ratio 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 ability is provided as mean score on the RCPM (max. 36)

Table 2: Summary of task accuracy (mean percentage correct, SD, and FSR) for all participant groups

	WS	VMA	NV	Autism	VMA	NV
Expressions						
Recognition	87 (9.4)	79 (9.9)	78 (11.6)	70 (15.0)	70 (12.2)	78 (13.3)
	11/15	8/15	6/15	8/20	6/20	10/20
Matching	81 (10.3)	73 (10.5)	71 (11.3)	63 (12.8)	71 (11.3)	75 (8.5)
	6/15	4/15	4/15	1/20	5/20	7/20
Overall Mean	84	76	71	66	71	76
Eye Gaze						
Recognition	83 (9.7)	72 (13.2)	75 (15.1)	58 (15.5)	73 (13.5)	75 (13.1)
	8/15	3/15	6/15	5/20	6/20	9/20
Matching	77 (11.0)	64 (11.6)	61 (14.3)	52 (18.3)	62 (10.6)	65 (11.4)
	6/15	1/15	1/15	3/20	1/20	0/20
Overall Mean	80	68	68	55	68	70
Identity						
Whole face	71 (15.3)	65 (16.0)	71 (16.5)	63 (14.8)	68 (12.9)	69 (11.6)
	6/15	6/15	9/15	8/20	8/20	7/20
Internal features	55 (8.7)	44 (12.0)	40 (13.0)	50 (15.0)	46 (12.1)	49 (10.1)
	1/15	0/15	0/15	1/20	1/20	2/20
Overall Mean	62	55	55	57	57	59
Lip Reading						
Recognition	84 (12.2)	73 (13.5)	73 (16.5)	81 (11.6)	73 (16.4)	73 (12.6)
	9/15	5/15	6/15	11/20	8/20	6/20
Matching	76 (11.6)	69 (17.7)	61 (20.2)	71 (13.3)	66 (16.6)	63 (12.2)
	7/15	4/15	3/15	7/20	4/20	3/20
Overall Mean	79	71	67	79	71	67

Table 3: Correlation between face processing tasks for participants with Williams syndrome

	Expressions		**Eye gaze**		**Lip reading**		**Identity**	
	recognition	matching	recognition	matching	recognition	matching	whole face	internal
chronological age	.27	.07	.42	.17	.434	.26	**.54***	**.54***
exp recognition		.39	.04	.30	**.52***	**.66****	.38	.33
exp matching			.15	.30	.25	.30	.41	.13
gaze recognition				.06	.09	.01	.17	.27
gaze matching					.04	.26	.13	.02
lip reading rec.						**.88****	.38	.32
lip reading match.							.46	.34
identity whole								**.70****

* *p<.05*

** *p<.01*

Table 4: Correlation between face tasks and then impact of chronological age and CARS score for participants with autism

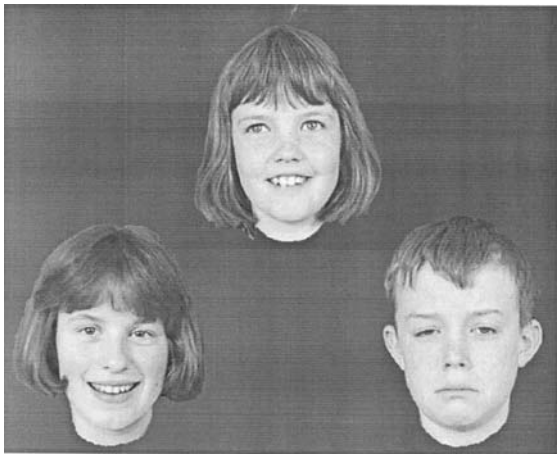
	Expressions		**Eye gaze**		**Lip reading**		**Identity**	
	recognition	matching	recognition	matching	recognition	matching	whole face	internal
CARS score	**-.66****	**-.45***	**-.46***	**-.57****	-.19	-.09	**-.53***	**-.60****
chronological age	-.44	-.28	-.21	-.21	.28	.05	.08	.02
exp recognition		**.59***	.41	.35	**.43***	.07	**.45***	**.50***
exp matching			.24	.26	.29	.32	**.51***	.23
gaze recognition				**.79****	**.51***	.39	**.47***	.34
gaze matching					**.50***	.44	**.59****	**.52***
lip reading rec.						**.76****	**.45***	**.46***
lip reading match.							.32	.22
identity whole								**.69****

** p<.05*

*** p<.01*

Figure 1: An example of matching tasks assessing (a) expressions and (b) identity

(a)



(b)