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ORIGINAL PAPER

Orientation and Affective Expression Effects on Face Recognition in Williams Syndrome and Autism

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Abstract We sought to clarify the nature of the face processing strength commonly observed in individuals with Williams syndrome (WS) by comparing the face recognition ability of persons with WS to that of persons with autism and to healthy controls under three conditions: Upright faces with neutral expressions, upright faces with varying affective expressions, and inverted faces with neutral expressions. No differences were observed under the upright/neutral expression condition. However, the WS group was more accurate than the autism group when discriminating upright faces with varying affective expressions, whereas the opposite pattern emerged when discriminating inverted faces. We interpret these differences as a reflection of the contrasting social features of the two syndromes.

Keywords Autism · Williams syndrome · Emotion · Affect · Face processing · Visual discrimination

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Introduction

The ability of humans to discriminate faces is an important evolutionary basic skill that has helped drive the development of our social behavior. Specifically, attention to the face is an anlage of attachment behavior and becomes a reference and source of information for social communication. It is believed that at least three types of skills are typically employed in the evaluation of facial features and underpin the capacity for face discrimination (Maurer, Le Grand, & Mondloch, 2002). The first involves the identification of first-order relations—interpreting an image as a face because of the specific features and configuration of two eyes above a nose above a mouth. The ventral occipitotemporal cortex, including the lateral fusiform gyrus, is particularly sensitive to first order relations. The second component of face recognition is holistic processing, which entails the ‘‘gluing’’ together of the components into a gestalt. The neural correlates of holistic processing are not well understood. Lastly, face processing entails an analysis of second-order relations—a spatial/configural analysis of face components and the distances among the components. As with holistic processing, the neural correlates of second order relations are as yet not well understood. Interestingly, there are specific developmental disorders in which there is either a relative strength or a relative deficit in processing faces. We hypothesized that by comparing individuals with such discrepancies in face processing ability, it might be possible to further delineate the role of these underlying components of face processing and gain a better understanding of the abnormal social behavior related to the attention to faces in each disorder.

Williams syndrome (WS) is a rare genetic disorder associated with the hemideletion of the gene for elastin and its surrounds on chromosome 7. The condition is characterized by dysmorphic facies, a specific cardiac defect, and cognitive impairment characterized by mild to moderate mental retardation and a non-uniform cognitive profile (Bellugi, Lichtenberger, Jones, Lai, & St. George, 2000). For example, individuals with WS typically demonstrate moderate to severe visuospatial deficits, but a relative strength in language skills compared to their intellectual deficits. Furthermore, within the visual domain there exists unevenness in the WS profile such that severe spatial processing deficits are contrasted with a near-normal ability to visually discriminate familiar and unfamiliar faces (Bellugi et al., 2000; Jones, Hickock, & Lai, 1998; Jones & Lai, 1997; Rossen, Jones, Wang, & Klima, 1995; Udwin & Yule, 1991). For example, Bellugi, Wang and Jernigan (1994) found that adults with WS were significantly more accurate than IQ-matched children with Down syndrome, and no different from chronological age-matched healthy controls on the Benton Test of Facial Recognition (Benton, Hamsher, Varney, & Spreen, 1983). Similarly, Udwin and Yule (1991) found that children with WS actually scored significantly higher than chronological age-matched normal controls on the face recognition task of the Rivermead Behavioral Memory Test.

It is becoming increasingly apparent, however, that normal or near-normal scores on face recognition tests in WS do not necessarily indicate a normal neural substrate (Grice et al., 2001; Mills et al., 2000; Mobbs, Garrett, Menon, Bellugi, & Reiss, 2004). Mills et al. (2000), for example, demonstrated that despite similar scores on a face recognition task, adults with WS show a different and highly specific event-related potential (ERP) wave form compared to healthy controls. The pattern was characterized by an abnormally large spike in the N200 component and an abnormally small N100 component, suggesting increased attention to faces in WS. Importantly, the particular pattern identified has not been observed in other clinical groups, including individuals with Developmental Language Disorder and focal lesion patients (Mills, personal communication, February 2002). Additionally, Mobbs et al. (2004) used functional magnetic resonance imaging (fMRI) to better understand the neural organization of face processing in WS. In that study, individuals with WS and healthy controls viewed a series of faces and were asked to make gaze direction judgments. The WS group's accuracy of judgments was not significantly different from controls. More importantly, despite the WS group accuracy on the task, they showed increased activation in several anterior brain regions and decreased activation in posterior regions compared to the controls, who showed the reverse pattern. Regions traditionally associated with face processing, including the bilateral fusiform gyrus, superior temporal sulcus, and amygdala showed similar levels of activation in both groups. Mobbs et al. (2004) hypothesized that the anterior activation may reflect compensatory neural development in the presence of aberrant development in posterior brain regions (c.f., Galaburda & Bellugi, 2000; Galaburda, Holinger, Bellugi, & Sherman, 2002; Reiss et al., 2000).

Normal to near-normal face discrimination accuracy in the context of atypical neural organization begs the question: How are individuals with WS processing faces? The answer to this question remains elusive and controversial. There is general agreement that in typically developing individuals, the ability to discriminate faces depends in large part on configural and holistic processes as opposed to more feature-based strategies seen in the processing of non-face objects (Bartlett & Searcy, 1993; Bradshaw & Wallace, 1971; Diamond & Carey, 1986; Farah, 1996; Farah, Wilson, Drain, & Tanaka, 1998). Evidence for this conclusion is based on a number of studies, including the observation that the discrimination of faces breaks down if the faces are presented upside down. The standard interpretation of this so-called "inversion effect" is that inverting the face disrupts the expected configuration of the face that facilitates holistic processing and forces a more feature-based strategy for identification (Farah, Tanaka, & Drain, 1995; Rhodes, 1988; Rhodes, Brake, & Atkinson, 1993; Yin, 1969; however, see Maurer et al., 2002, for an alternative interpretation of the inversion effect).

Some researchers (e.g., Dereulle, Mancini, Livet, Casse-Perrot, & de Schonen, 1999; Elgar & Campbell, 2001; Karmiloff-Smith, 1997) have reported a reduced inversion effect in WS relative to healthy controls, suggesting that individuals with WS process faces using a local, or piecemeal, strategy rather than the holistic strategy employed by the normal population. However, an analysis of the data presented in the Dereulle et al. report revealed a stronger inversion effect for faces compared to houses though small sample sizes may have obfuscated the statistical significance of the difference. Similarly, Karmiloff–Smith rather informally evaluated upright versus inverted face processing in a small sample of WS participants that again may have made the detection of an inversion effect difficult. Thus, neither of these studies provides clear and convincing evidence of a feature-based face processing strategy in WS. Recently, Tager-Flusberg, Plesa-Skwerer, Faja, and Joseph (2003), provided evidence for holistic processing in WS. In sum, while there is strong evidence of atypical neural organization supporting face processing in WS, there remains some controversy regarding the processes used to discriminate faces.

Herein lies a paradox. Research has identified atypical neural organization in visual cortices (Atkinson et al., 2001; Galaburda et al., 2002) in addition to atypical functional activation patterns when processing faces in WS, but the processing strategy used by individuals with WS is as yet unclear despite performance at or near normal levels, at least for upright face processing. What mechanism is there to support this performance? One possibility, as Pober and Dykens (1996) have suggested, is that the increased social behavior of WS might be linked to a particular interest in faces. Specifically, we hypothesize that deficient cerebral development along the dorsal visual pathway (Galaburda et al., 2002; Schmitt et al., 2002) in the WS brain results in compensatory re-organization in anterior/limbic brain regions, ultimately increasing the salience of social stimuli. In WS, then, the observed increased attention to faces may reflect top-down processing secondary to the social importance of faces (Ellis, 1990). The study by Mobbs et al. (2004) provides initial support for this hypothesis by demonstrating increased activation in cerebral structures known to be relevant in socioemotional processing.

If increased social interest supports face recognition in WS, then it follows that social indifference or disinterest might lead to an entirely different pattern of face processing compared to both typically developing children and individuals with WS. Individuals with autism (AUT) characteristically exhibit marked deficits in reciprocal social interaction and communication skills beginning very early in development (APA, 1994). Furthermore, research has demonstrated in autism a preference for inanimate objects, a lack of interest in viewing the human face, and deficits in nonverbal social communication (Baird et al., 2000; Baron-Cohen et al., 1996; Cohen & Volkmar, 1997), a pattern of social behavior that differs dramatically from the social phenotype of WS. More importantly, in addition to findings of disinterest in viewing faces, studies have shown that individuals with autism are impaired in face recognition (Boucher & Lewis, 1992; Corsello, 2000; Davies, Bishop, Manstead, & Tantam, 1994; Hauck, Fein, Maltby, Waterhouse, & Feinstein, 1998; Klin et al., 1999) and that they process faces in a different manner than that seen in the typically developing population (Tanaka & Farah, 1993; Pelphrey et al., 2002).

Similarly, various studies suggest that facial expressions of emotion do not have the same degree of salience and most likely not the same emotional impact for autistic as for non-autistic individuals. That is, while non-autistic individuals use different strategies for affective versus non-affective face recognition, autistic individuals appear to use a general strategy of focusing on the perceptual pattern of the face and miss the message that the face is attempting to convey (Hobson, Ouston, & Lee, 1988; Ozonoff, Pennington, & Rogers, 1990).

The present study examined the ability of persons with WS and AUT to discriminate faces when facial expression changes compared to a neutral expression and when faces are inverted. If attention to social information does affect face recognition, we predicted that compared to individuals with autism, the WS group will demonstrate preserved face recognition when faces vary by affective expression, but greater difficulty when faces are inverted. We predicted that the individuals with WS relative to typically developing controls and persons with AUT will demonstrate a relatively strong inversion effect because inverting a face makes holistic processing more difficult because there is no pattern or ‘‘face template’’ to recognize, which presumably develops as a consequence of the continued experience of processing faces. The autism group, in contrast, was predicted to demonstrate better recognition in the inverted faces condition relative to the affective expression condition due to relatively stronger visuospatial skills and the marked social disengagement characteristic of this group. In particular, the autistic group was predicted to process unfamiliar faces as static objects void of affective or social salience, such that changes in facial expression are processed as a change in ‘‘object’’. This object-like processing style would therefore facilitate recognition only when stimulus and target are identical, regardless of orientation. Thus, we predicted a group by face identity interaction were individuals with WS would show relative proficiency in recognizing upright neutral faces and upright faces that vary in affect of expression, while also demonstrating relatively greater difficulty in recognizing inverted faces when compared to typically developing controls and persons with AUT. Moreover, we predicted virtually the opposite for persons with AUT, such that they would demonstrate proficiency on object-like inverted faces and upright neutral faces, but shown greater difficulty discriminating faces that vary only by the expression of facial affect.

Methods

Research Participants

Three groups of participants: WS, autism (AUT), and a normal control (NC) group, participated in the study. Demographic data are summarized in Table 1. In addition to the individual criteria described below, participants in all groups were screened for the existence of medical or psychological conditions (other than those associated with diagnosis of WS or AUT) that would impact cognitive functioning.

The WS group consisted of 19 individuals (age range = 10.03–44.29 years) recruited as part of an ongoing program project to UB (NICHD P01 HD33113). The diagnosis of WS was confirmed for all participants using established clinical criteria including physiological, developmental, behavioral, and cognitive features consistent with a diagnosis of WS (American Academy of Pediatrics, 2001). In addition, all 19 participants tested positive for the absence of one copy of the gene for elastin using fluorescent in situ hybridization (FISH; Korenberg, et al., 2000).

The AUT group consisted of 16 children and adolescents (age range = 7.25–13.58 years) who participated as part of a programmatic research project conducted at the Developmental Neuropsychology Laboratory of Alliant International University. All AUT participants met diagnostic criteria for autism according to the *DSM-IV* criteria (APA, 1994) as well as the Autism Diagnostic Interview-Revised (Le Couteur et al., 1989) and the Gilliam Autism Rating Scale (Gilliam, 1995).

The normal control group (NC) consisted of 17 volunteers (age range = 7.17–15.58 years) recruited through the public school system in the San Diego area.

The WS group was significantly older than both the AUT and NC groups, $t(49) = 15.82$, $p < .0001$ and $t(49) = 15.81$, $p < .0001$, respectively, whereas the AUT and NC groups did not differ in age, $t(49) = .27$, $p > .05$. Age was not judged to be a confounding variable, however, since research has demonstrated largely adult-level face processing strategies by age 10 in the typically developing population (Mondloch, LeGrand, & Maurer, 2002).

Table 1 Demographic and background information for Williams syndrome, Autism, and Normal Control groups

	n	Age M (*SD*)	Gender M:F	VIQ M (*SD*)	PIQ M (*SD*)
WS	19	26.17 (1.63)	7:12	69.18 (5.92)	62.73 (7.86)
AUT	16	10.29 (1.59)	13:3	72.43 (16.01)	93.67 (22.41)
NC	17	10.04 (1.92)	15:2	107.00 (10.54)	93.33 (12.66)

Because matching for verbal and cognitive ability is important for this type of face discrimination experiment, we chose two parallel approaches that we believe lessened the need for statistical control of verbal or cognitive ability, thereby avoiding the potential to violate the assumption of homogeneity of regression since we believed that each group was likely to be using different neural mechanisms and processes to accomplish face recognition. First, we had to consider how strikingly different the cognitive style is between persons with WS and AUT. The former is characterized a relatively better language compared to visual-spatial and motor processing, while persons with AUT show relative verbal deficits compared to their more proficient spatial processing and motor skills. We, therefore, decided to match the WS and AUT participants on the basis of Verbal IQ scores, $t(14.11) = 1.966$, $p > .05$ (controlling for a violation of the assumption of homogeneity of variance). This approach, however, results of their being a large discrepancy between the non-verbal abilities between these two groups, with the latter having relatively higher Performance IQs. To account for the higher Performance IQs in the AUT group we matched them to the Performance IQ of typically developing controls (Performance IQ scores, $t(28) = .033$, $p > .05$) (see Table 1). This approach was appropriate because we were primarily interested in evaluating a group by condition (Upright Neutral, Inverted Neutral, Upright Affect) interaction with virtually opposite predictions for WS and AUT.

There were differences in the gender distribution across groups, with the WS group having substantially more female than male participants relative to both the AUT and NC groups, where males were more prevalent (see Table 1). We were unable to find any reports of gender-based differences in the face processing capacity of any of the populations under investigation. Furthermore, data from our laboratory on 104 WS individuals has not identified any gender-related differences on measures of general intelligence and face recognition (unpublished data). The difference in gender distribution between groups is therefore unlikely to have had a significant impact on results. Subsequent analysis using repeated measures ANOVA confirmed this assumption: there were no main effects of gender on any of the tasks used in this study, either within or across diagnostic groups (for all analyses, $p > .05$).

Procedure

The experimental tasks were part of a computer-administered battery assessing recognition and discrimination of facial and affective stimuli in both the visual and auditory modalities. The tasks were previously administered to 89 typically developing children and 22 children with lateralized brain lesions as part of a study investigating cortical circuitry subserving affective processing in the human brain (Lai, 1992). The images used in the present study, which were used previously by Voeller (1986) and Lai (1992), consisted of black and white photographs of child faces against a black background with the hairline covered. There were an equal number of girl and boy faces.

The stimuli were used to construct three face experimental conditions: (1) Upright Neutral, in which 27 pairs of faces were presented upright and contained neutral emotional expressions; (2) Upright Affect, in which both faces from each of 30 pairs were presented upright but with different facial expressions (happy, sad, angry, surprised, and afraid; *It is important to note that as in the other conditions, the Upright Affect task* does not *require the participant to evaluate or recognize or differentiate or label a particular facial expression, but only requires that they decide if the pair of faces are the same or different person. Thus, the relative complexity of the facial expression is not at issue, only the relative ability of the participant to evaluate facial identity. The additional three pairs of stimuli in this condition allowed for a minimum of 6 pairwise trials of each emotion.*); and (3) Inverted Neutral, in which both faces from each of 27 pairs were presented upside down with a neutral affective expression.

Stimuli were presented on a Macintosh Performa computer using HyperCard software. Each participant was seated in front of the computer monitor at a distance of approximately 60 cm. Because the tasks were part of a larger computerized battery, the three tasks were administered in a fixed order. Stimulus pairs for each of the three conditions were administered in a fixed random order. For each trial, the first face of a pair was presented for 500 ms followed by an interstimulus interval of 500 ms, in turn followed by the second face visible for 500 ms. Participants evaluated whether the identity of the first and second face was the same or different by answering verbally and/or by touching cards that indicated same/not same. There was no time limit for responding and reaction time was not recorded. A sequential presentation mode was chosen to maximize ecological validity, given that same/different discrimination outside the laboratory typically requires one to compare a face stimulus to one that occurred previously, as opposed to simultaneously. The experimenter recorded each response on the computer. Before each task, participants were trained in order to ensure complete understanding of the task demands.

Results

Data were analyzed using repeated measures analysis of variance (ANOVA), with group as the between subjects factor and condition (Upright Neutral, Upright Affect, and Inverted Neutral) as the within subjects repeated measure. This is a true repeated measure design because the participant is required to perform exactly the same task across each of the three experimental conditions. A multivariate analysis of variance would not be appropriate for the following analyses because it essentially would treat each condition as a separate dependent variable and would create a synthetic variable that accounted for the shared variance of the dependent variables, and then evaluate whether the groups differed from one another on that synthetic variable. Our interest was in determining how manipulating facial orientation (Upright or Inverted) or expression (Affect) would influence the accuracy in recognizing whether the pairs of presented faces were simply of the same or different individual.

The overall effect of group was not significant, $F(2, 49) = .96, p = .39$. However, the effect of face condition was significant, $F(2, 98) = 94.39, p < .0001$, as was the Group × Face interaction, $F(4, 98) = 22.88, p < .0001$; (see Fig. 1 and Table 2). The interaction effect was explored further using univariate ANOVA and planned contrasts between groups and face recognition condition. For all analyses alpha was set at .05.

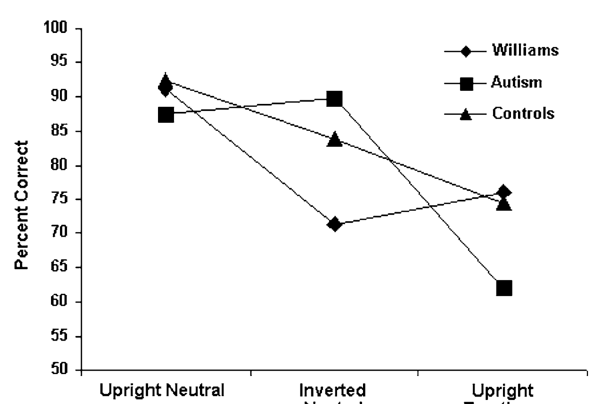

Fig. 1 Williams syndrome, Autism, and Control group performance (% correct) across face recognition tasks

Table 2 Williams, Autism, and Control group performance (percent correct) across the Three Face recognition conditions

Group	*n*	Upright neutral M (*SD*)	Inverted neutral M (*SD*)	Upright emotion M (*SD*)
WS	19	91.03 (10.86)	71.35 (14.01)	75.96 (13.03)
AUT	16	87.50 (10.20)	89.81 (7.71)	62.08 (11.86)
NC	17	92.37 (11.22)	83.88 (10.14)	74.51 (11.36)

In the Upright Neutral condition, the three groups did not differ in their ability to discriminate faces, $F(2,49) = .896$, $p > .05$. Furthermore, the accuracy of each group was quite high, ranging from 87.5% correct for the AUT group to 92.3% correct for the NC group. Thus, each group could determine whether they had viewed identical or different upright faces with equal and high accuracy so long as the facial expressions were neutral. In contrast, in the Upright Affect condition, the WS and NC groups performed significantly better than the AUT group but did not differ from each other (AUT vs. WS: $t(49) = 3.368$, $p < .001$; AUT vs. NC: $t(49) = 2.937$, $p < .005$; NC vs. WS: $t(49) = -.359$, $p > .05$). Finally, in the Inverted Neutral condition the AUT and NC groups did not differ from one another in identity judgments, but both groups performed significantly better than the WS group (AUT vs. NC: $t(49) = 1.531$, $p > .05$; AUT vs. WS: $t(49) = 4.89$, $p < .0001$; NC vs. WS: $t(49) = 3.373$, $p < .001$).

Analysis of variance and planned comparisons were used to determine whether there were within group differences in the pattern of performance on the three tasks, with alpha set at .005 to correct for multiple comparisons. Within the NC group there was a significant difference in the accuracy of performance on the three tasks, $F(2, 32) = 29.83$, $p < .0001$. The NC group was most accurate in the Upright Neutral condition, less accurate in the Inverted Neutral condition, and, least accurate in the Identity Affect condition. The control participants therefore exhibited an inversion effect, as expected, but were least accurate when the affective expression was different between stimulus and target. The analysis of the WS group performance also revealed a significant difference across the three conditions, $F(2, 36) = 37.85$, $p < .0001$. The WS group scored significantly higher on the Upright Neutral condition than on the Upright Affect condition, which in turn was significantly higher than on the Inverted Neutral task. WS subjects, therefore, showed a strong inversion effect. In fact, the data revealed a stronger inversion effect than the one exhibited by the NC group. Lastly, the AUT group analysis was also significant, $F(2, 30) = 65.667$, $p < .0001$. The AUT group showed no difference between their mean scores on the Upright Neutral and Inverted Neutral conditions, both of which were significantly higher than the mean score on the Upright Affect condition. The AUT group therefore had greater difficulty discriminating facial identity when affective expression changed relative to no change in affect (Upright Neutral) and relative to facial inversion (Inverted Neutral).

Discussion

This study examined face recognition in a group of individuals with WS, AUT and NC children to determine whether the degree of social information (i.e., facial expression) supports this relative strength in WS. The WS group in this study performed at a level equal to both the AUT and NC groups when recognizing upright faces with neutral expressions, suggesting that the groups were well matched on their baseline level of face processing. Although the performance of individuals with WS declined relative to the Upright Neutral condition when the emotional expression between stimulus and target varied, the level of decline was no different from that of the NC group and was significantly higher than that of the AUT participants. The AUT group, therefore, demonstrated a relatively greater degree of difficulty recognizing facial identity with changing expressions. The opposite pattern was observed when the faces were inverted. Individuals with WS exhibited considerable difficulty making same/different judgments in the inverted condition, as the WS group mean score was significantly lower than both controls and autism groups, but individuals with autism were equally able to make effective judgments regardless of the orientation of the stimuli, so long as the facial expressions of the stimuli remained neutral.

All groups demonstrated a decline in accuracy in the Upright Affect condition relative to the Neutral Affect condition. However, while a change of facial emotion did not interfere with the WS participants' ability to discriminate faces to any greater degree than that observed in the NC group, the AUT group's performance on the Upright Affect condition was significantly worse than either the NC or WS group's performance. Thus, a change in facial expression significantly interfered with the ability of AUT individuals to determine whether they were viewing the face of the same person or a different person. Conversely, a 180° rotation of a face did not interfere with the AUT participants' ability to discriminate faces relative to controls. Indeed, there was no inversion effect at all, contrary to what was observed in the WS and NC groups. In contrast, a 180-degree rotation significantly interfered with the ability of WS individuals to discriminate faces compared to the AUT and NC group's performance, as well as to their own performance on the Upright Neutral condition.

Clues to the source of the observed dissociation in face processing between autism and WS might be found in the social behavior of the two groups. Upright faces, regardless of the emotional expression, convey much social information (Haxby, Hoffman, & Gobbini, 2002; Critchley et al., 2000; Senior et al., 1999). Recent work by Gauthier and colleagues (Gauthier, Williams, Tarr, & Tanaka, 1998; Tarr & Gauthier, 2000) suggests the fusiform gyrus, long implicated in face processing, may in fact be essential to identifying subclasses of objects with which one has considerable expertise. Pierce, Muller, Ambrose, Allen and Courchesne (2001), in an fMRI face processing study with autistic children found no increases in activation of the fusiform gyrus. Those authors suggested that the reduced social interest exhibited by children with autism limits early experience in viewing and discriminating faces, which affects the specialized development of the fusiform face area. Those authors, and others (e.g., Grelotti, Gauthier, & Schultz, 2002), hypothesized that there is a critical period for fusiform face area development that autistic subjects miss as a result of their social avoidance. Indeed, Hauck et al. (1998) reported a positive correlation between measures of social development and face memory in autism. Thus, early social disinterest may alter the development of face processing in autism. Individuals with WS, in contrast, demonstrate an exceptionally strong social drive with a concomitant focus on faces during development (Jones et al., 2000). It is possible, then, that early in development individuals with WS obtain normal to above-normal experience in viewing faces and subsequent "expertise" in discrimination. The limiting factor to the WS performance may be that the face stimuli must be viewed in a socially relevant, or upright, context. Under such conditions performance is no different from that of mental age-matched controls. When faces are inverted, the social component of face processing may be reduced and as a result persons with WS exhibit a level of difficulty in recognizing faces commensurate with their well-established deficits in visuospatial processing. Individuals with autism, in contrast, who characteristically exhibit social avoidance and disinterest in viewing faces throughout development, show no such face recognition deficit under the inverted condition, but exhibit considerable difficulty when facial affect changes. Unfamiliar faces, therefore, appear to be processed as static "objects" in a fragmented fashion within autism, an interpretation that has some support in the literature (e.g., Davies et al., 1994; Hobson et al., 1988; Klin et al., 1999; Weeks & Hobson, 1987). Indeed, the performance of our autism sample under the changing facial expression condition was significantly below both the WS and NC groups despite highly accurate performance under the Upright Neutral *and* the Inverted conditions. This finding would suggest that individuals with autism have a primary deficit in the face "template" for processing, using instead a more static method of processing similar to what is used in object recognition.

The strong social drive associated with WS may serve to enhance face processing by enlisting and activating additional cortical regions or through atypical neural processing when viewing faces. Preliminary support for this view is found in electrophysiological studies of face processing (e.g., Mills et al, 2000; Alvarez & Neville, 1995). Specifically, Mills found in WS a highly specific ERP wave form when viewing faces using a recognition paradigm. This pattern has not been seen in normal controls or in other developmentally delayed populations such as Down syndrome, Language Impaired, and focal lesion patients and therefore suggests that the neural systems underlying face processing are abnormally developed in persons with WS. It will be important to assess the performance of autistic participants in this paradigm, and such studies are ongoing.

If both individuals with Williams and with autism do indeed process faces using a featural strategy as some researchers have argued (Deruelle et al., 1999; Happe, 1999; Karmiloff-Smith, 1997), why did not the two groups perform similarly on the Inverted condition relative to their performance on the Upright Neutral condition? We again relate the differences to the social behavior of the groups. As noted above, Mills et al. (2001) have demonstrated an atypical pattern of neural processing on face recognition tasks, a pattern not seen in the typically developing population or other developmentally disabled groups. Furthermore, research has shown that children with WS are drawn to looking at faces throughout development (Jones et al., 2000), thereby gaining experience in recognizing the invariance of identity despite changes in expression. Children with autism, in contrast, do not acquire this level of experience (Phillips, Baron-Cohen, & Rutter, 1992). These data suggest that individuals with WS and autism may *not* be processing faces in an identical manner. Genetically influenced changes in neural development in addition to the extensive early experience in viewing faces seen in WS that may have produced a bias or expectancy to view faces in an upright orientation are hypothesized sources of the WS performance on these tasks.

Lastly, our data identified a strong inversion effect in the WS group relative to both the AUT group and mental age matched controls, whereas Karmiloff-Smith (1997) and Deruelle et al. (1999) observed reduced inversion effects in WS relative to controls. Our data therefore support those of Tager-Flusberg et al. (2003) that suggest individuals with WS process faces holistically despite a commonly found local bias in visual processing. Why, then, have other researchers found a reduced inversion effect? One reason may be related to experimental design. Both Karmiloff-Smith (1987) and Deruelle et al. (1999) used a simultaneous presentation of stimulus and target, whereas the present study employed a serial presentation: the first face was presented for 500 ms followed by a 500 ms ISI and then the second face for 500 ms. Our study, therefore, made higher demands on immediate visual memory and visual processing speed (Crisco, Dobbs, & Mulhern, 1988; Jarrold, Baddely, & Hewes, 1999; Wang & Bellugi, 1994), which may account for the larger inversion effect in our Williams sample due to reduced visual immediate memory. Similar changes in the size of observed inversion effects due to design variables are noted by Mondloch et al. (2002). It is also possible that had we matched our WS participants to typically developing controls on the basis of PIQ (which would have required an additional control group for the present study) then less of an inversion effects would have been observed. However, this would have necessitated identifying mentally retarded control participants, because the PIQ of persons with WS is typically in the low mild to moderate range of mental retardation. This was not feasible for the present study, but should be considered in future studies. Future studies are needed to clarify the effect of design variables on face processing strategies.

The current data provide further evidence that individuals with WS process faces in a manner distinct from that of typically developing individuals, as well as from other developmentally disordered populations. One of the most interesting aspects of this study is that our WS group performed better than autistic participants did when the emotional expression varied from stimulus to target. We propose that individuals with WS may have a strong ability to conserve the uniqueness of facial identity due to a socially motivated heightened attention to faces regardless of the emotional expression. It is only when the faces lose the ‘‘social’’ component, such as during inverted presentation, that processing fails, particularly under conditions requiring rapid processing. Similarly, it will be important to confirm whether the abnormal ERP waveform to faces seen in WS does, in fact, indicate abnormal neural development that leads to processing novel faces as familiar. Such inquiry will provide strong clues to the neural subsystems underlying social cognition.

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