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The Development of Facial Gender Categorization in Individuals with and without Autism: The Impact of Typicality

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Abstract While much research has examined the development of facial recognition abilities, less is known about the ability of individuals with and without autism to categorize facial gender. The current study tested gender categorization abilities in high-functioning children (5–7 and 8–12 years), adolescents (13–17 years), and adults (18–53 years) with autism and matched controls. Naturalistic videos depicted faces that were either typical or less typical of each gender. Both groups improved in their performance across development. However, control children reached expertise that was similar to control adults by 8–12 years; whereas, adults with autism never reached this level of expertise, particularly with less typical gender faces. Results suggest that individuals with autism employ different face processing mechanisms than typically developing individuals.

Keywords Gender categorization · Typicality · Face perception · Autism

Introduction

By adulthood, humans are experts at perceiving and recognizing faces. The arrangement of facial features allows us to identify faces as a common, basic-level category; however, the ability to recognize *individual* faces, including someone's age or gender requires that faces be perceived at a more detailed, subordinate level. Perceptual expertise, which develops with time and experience, is required to discriminate subordinate categories (see, Gauthier et al. 2010). Thus, it is not surprising that the ability to recognize individual faces, based on subordinate level information, begins in infancy, develops through childhood (see, Mondloch et al. 2010), and may continue to emerge through adolescence and adulthood (Rump et al. 2009). Moreover, the ability to perceive differences in subtle facial information (e.g., facial expression) may indicate a developmental trajectory that distinguishes typically developing (TD) individuals from those with an autism spectrum disorder (ASD; Rump et al. 2009). Therefore, the current study investigates the *development* of subtle facial gender discrimination in TD individuals and those with autism.

Facial gender is a subordinate facial category that TD adults discriminate with a high rate of accuracy and speed (O'Toole et al. 1998). The categorization of facial gender is based on a fine-grained discrimination of the features (e.g., nose length, eye size, forehead size) that are maximally distinctive between male and female faces (Brown and Perrett 1993; Chronicle et al. 1995). Intriguingly, TD adults identify gender most quickly when a face is rated as typical of its gender. For instance, a male face that has been rated

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as very masculine is classified faster than a male face that has been rated as less masculine (O'Toole et al. 1998).

This typicality effect can be explained by Valentine's (2001) face space framework. Research suggests that adults store faces in a multidimensional space called a "face space" framework. The face space is proposed to be an *n*-dimensional normal distribution of faces with both featural (e.g., noses) and configural information (e.g., eye separation) represented. The center of the face space represents the central tendency or prototype of all facial information. Faces with more typical features are stored closer to the center of the face space than faces with less typical features. O'Toole et al. (1998) further suggests that faces are stored according to two gender-specific prototypes. The distance of a particular face from the gender-specific prototype is indicative of how prototypically masculine or feminine a face is. Hence, faces that are gender-typical (i.e., closer to the prototype) are accurately classified by gender more quickly.

The ability to categorize facial gender emerges within the first year of life (Leinbach and Fagot 1993; Newell et al. 2010; Slater et al. 2010; Quinn et al. 2002) but, there are no studies with either TD individuals or those with ASD that have assessed the developmental change in the ability to categorize face-based gender cues that vary on gender typicality, and thus the difficulty of the discrimination. There is, however, research describing the ability of individuals with ASD to make facial gender category judgments with typical exemplars. Early studies suggest that when children with autism are asked to categorize gender on the basis of internal facial information, they have difficulty (Hobson 1986; Hobson et al. 1988; Weeks and Hobson 1987). Moreover, a case study of three children with Asperger's syndrome found gender discrimination difficulties (Nijiokiktjien et al. 2001). Deruelle et al. (2004) found that, while their performance was above chance, children with autism had more difficulty categorizing face-based gender than matched controls; and, Behrmann et al. (2006) found that adults with autism categorize gender as accurately as matched controls; however, their speed of processing appeared to be significantly slower. Finally, adults with autism appear to categorize gender less accurately than controls when gender categorization is based on the eye region alone (Best et al. 2010). Thus, although the literature is somewhat limited, these studies indicate that gender categorization is somewhat impaired in ASD in both childhood and adulthood.

No studies have investigated the effects of development or typicality on the ability of TD individuals or ASD individuals to categorize facial gender. Thus, the current study was designed to explore the ability of children, adolescents and adults, with and without autism, to categorize face-based gender that varied on typicality. The course of development for categorizing typical versus less typical exemplars of gender is not known for either population. Given results from previous studies of typical-gender face categorization and the effects of typicality on object categorization in individuals with autism (Gastgeb et al. 2006), it was predicted that while individuals with autism would display somewhat normative abilities to categorize gender when faces are prototypic exemplars of men and women (i.e., very typical of each gender), difficulty may emerge when presented with exemplars that are less typical. In addition, prior research suggests that while TD infants and preschool-age children appear to accurately categorize typical exemplars of gender, they have difficulty with less typical exemplars of gender (Newell et al. 2010). Therefore, we also predicted that with development, the gender categorization abilities of TD individuals should improve, particularly with less typical exemplars of gender.

Method

Participants

Participants consisted of 101 individuals with high-functioning autism and 82 TD individuals, represented by four different age groups: young children (5- to 7-year-olds); older children (8- to 12-year-olds); adolescents (13- to 17-year-olds) and adults (18- to 53-year-olds). At each age group, the individuals with autism and the TD control groups were matched on gender, age and intelligence. The youngest group consisted of 5- to 7-year-old children with autism ($n = 19$) and TD children ($n = 18$) matched on the standard score equivalent of Verbal Mental Age (VMA) as determined by the Peabody Picture Vocabulary Test-Revised (PPVT-R; Dunn and Dunn 1981). The older child group consisted of 8- to 12-year-old children with autism ($n = 29$) and matched controls ($n = 21$) matched on verbal (VIQ), performance (PIQ), and full scale IQ (FSIQ) as determined by the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler 1999). Finally, the two oldest age groups consisted of adolescents with ($n = 24$) and without ($n = 15$) autism and adults with ($n = 29$) and without ($n = 28$) autism who were also matched using the WASI IQ scores. Tables 1, 2, 3, and 4 summarize the participants' demographic characteristics. No significant differences were found between control and autism groups on age, FSIQ, VIQ, or PIQ (or VMA for the youngest age group).

Participants were recruited through advertisements and fliers. Participants with autism met criteria for autism on the Autism Diagnostic Observation Schedule (ADOS; Lord et al. 2000) and the Autism Diagnostic Interview-Revised (Lord et al. 1994), which was verified by expert clinical opinion. Individuals on the autism spectrum without a

Table 1 Demographic characteristics of autism and control groups for younger children

	Autism group ($N = 19$)		Control group ($N = 18$)	
	M	*SD*	*M*	*SD*
Age	76.58	9.45	72.00	9.65
VMA	97.89	15.86	105.61	11.99
ADOS	13.43	3.48	–	–
Gender (M/F)		13/5		11/7
Ethnicity		18 Caucasian/1 other		18 Caucasian

Age is indicated in months. *VMA* verbal mental age. Ethnicity was obtained by self report

Table 2 Demographic characteristics of autism and control groups for older children

	Autism group ($N = 29$)		Control group ($N = 21$)	
	M	*SD*	*M*	*SD*
Age	10.07	1.22	10.76	1.22
VIQ	102.59	11.42	105.00	10.44
PIQ	104.62	14.78	107.86	9.01
FSIQ	104.21	11.94	107.48	9.72
ADOS	13.67	2.83	–	–
Gender (M/F)	26/3		19/2	
Ethnicity	26 Caucasian		19 Caucasian	
	1 African American		2 Unknown/Other	
	2 Unknown/Other			

Age is indicated in years. *SD* standard deviation, *VIQ* verbal IQ, *PIQ* performance IQ, *FSIQ* full scale IQ. Ethnicity was obtained by self report

Table 3 Demographic characteristics of autism and control groups for adolescents

	Autism group ($N = 24$)		Control group ($N = 15$)	
	M	*SD*	*M*	*SD*
Age	14.46	1.06	14.53	1.25
VIQ	100.54	14.20	106.13	10.57
PIQ	107.54	16.03	107.73	9.35
FSIQ	104.29	14.32	108.53	10.07
ADOS	12.67	3.50	–	–
Gender (M/F)	20/4		13/2	
Ethnicity	24 Caucasian		13 Caucasian	
			2 Unknown/Other	

Age is indicated in years. *SD* standard deviation, *VIQ* verbal IQ, *PIQ* performance IQ, *FSIQ* full scale IQ. Ethnicity was obtained by self report

Table 4 Demographic characteristics of autism and control groups for adults

	Autism group ($N = 29$)		Control group ($N = 28$)	
	M	*SD*	*M*	*SD*
Age	26.59	9.90	22.75	4.00
VIQ	102.55	14.18	108.32	8.79
PIQ	107.86	12.94	110.25	10.31
FSIQ	106.10	12.03	110.32	9.57
ADOS	13.11	2.94	–	–
Gender (M/F)	26/3		26/2	
Ethnicity	26 Caucasian		26 Caucasian	
	3 Unknown/Other		2 African American	

Age is indicated in years. *SD* standard deviation, *VIQ* verbal IQ, *PIQ* performance IQ, *FSIQ* full scale IQ. Ethnicity was obtained by self report

specific diagnosis of autism (e.g., Asperger's syndrome; PDD-NOS) were not included.

Apparatus

Participants sat in front of a 43-cm LCD monitor controlled by a computer and responded using a modified keyboard with large keys (approximately 2.54 cm squares) that is commercially available for young children. Black felt covered all of the keys except for the two response keys on the left and right side of the keyboard. The response keys were labeled with the gender names (adults: male and female/children: boy and girl). For half of the participants the label "male/boy" was on the right side of the keyboard and for the other half of the participants it was on the left side of the keyboard.

Stimulus Materials

Stimuli consisted of 80 digital videos of male and female adults ranging in age from 18 to 30 years wearing a black robe and a backwards, black baseball cap to hide clothing and hair cues. The videos provided a dynamic display of the face only. To elicit a natural pose from the individuals, they recited a common nursery rhyme (Hickory, Dickory, Dock) during filming, although the sound was not recorded.

Twenty undergraduate students rated each of the 80 videos for typicality of gender on a 7-point scale, with 1 being very atypical of that gender and 7 being very typical of that gender (i.e., very masculine or very feminine). The 20 most typical male and female videos (referred to as "typical") and the 20 least typical male and female (referred to as "atypical") were selected. The "atypical" faces were then presented to a second group of 20 undergraduate students who were asked to categorize the gender of each face to ensure that all of the selected faces were easily categorized by adults. Static examples of a typical and atypical face for each gender can be seen in Fig. 1.

Procedure

To ensure that the 5- to 7- year old children understood the task, they were initially shown ten full body pictures of both genders in random order and asked to say whether each picture was a "man" or "woman". If they got all ten correct, they were included in the study. All participants in every age group were then shown a total of 40 videos with an equal number of male and female faces, and an equal number of typical and atypical faces. The experimenter made sure that the participant's attention was focused on the screen before each video commenced. For each trial, participants saw a video of a male or female face, which remained on the screen until a response was made by pushing the "male/boy" or "female/girl" keyboard button. The computer recorded both accuracy and reaction time.

Results

Accuracy

Of primary interest were the accuracy differences (as measured by the proportion of correct answers) between the control and autism participants, and whether accuracy was affected by either stimulus typicality or participant age. A three-way ANOVA was conducted on mean accuracy scores with Group (autism vs. control) and Age (young children vs. older children vs. adolescents vs. adults) as between-subjects variables and Typicality (typical vs. atypical faces) as a within-subjects variable. There was a significant main effect of typicality $F(1,174) = 140.6$, $p < .001$, indicating that across all ages and diagnostic groups, accuracy was greater for typical ($M = .95$) than atypical ($M = .84$) faces. There was also a main effect of Group $F(1,174) = 43.80$, $p < .001$, indicating that across age and typicality, controls ($M = .94$) were more accurate than individuals with autism ($M = .86$).

More importantly, there was a significant three-way interaction among Age, Group, and Typicality $F(3,174) = 8.39$, $p < .001$. To better interpret this interaction, separate two-way ANOVAs that included Age and Group as between-subjects variables were conducted for the typical and atypical stimuli. The ANOVA conducted on accuracy for trials presenting typical face stimuli revealed a significant Age X Group interaction $F(3,174) = 5.65$, $p < .001$. As seen in Fig. 2, the younger children ($t(34) = 2.90$, $p < .01$) and older children ($t(48) = 4.05$, $p < .001$) demonstrated group differences in which the control children performed significantly better than the children with autism. However, by adolescence this group difference disappeared, with adolescents and adults with and without autism categorizing the typical faces equally well. Post hoc

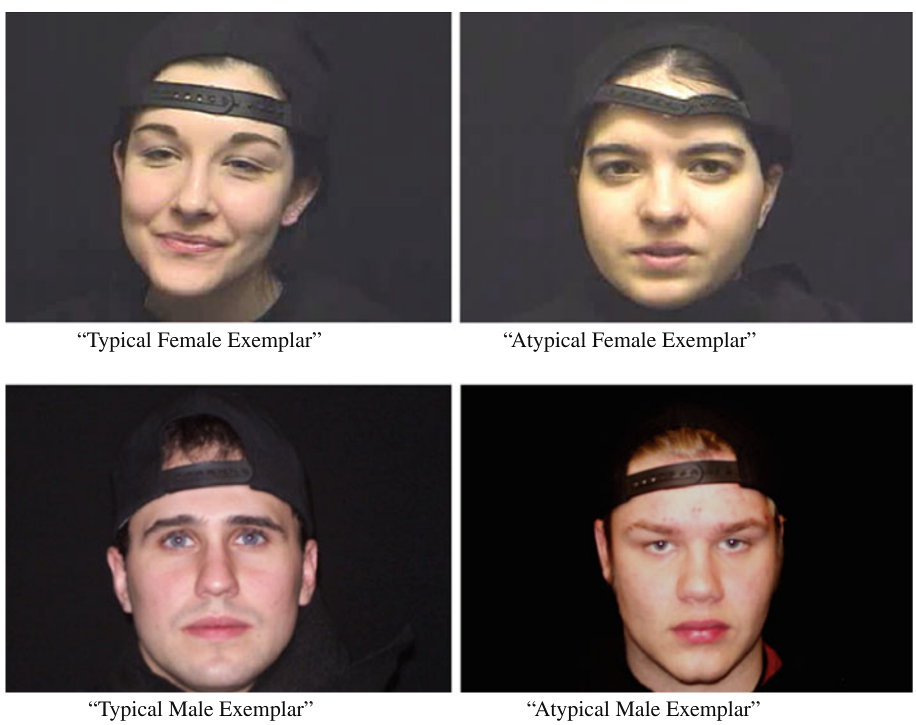

Fig. 1 Static examples of typical and atypical gender faces

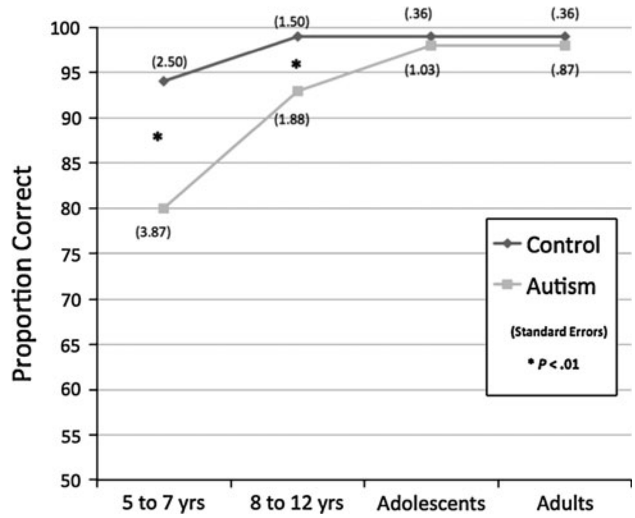

Fig. 2 Proportion of correct responses at all ages for categorization of typical gender faces

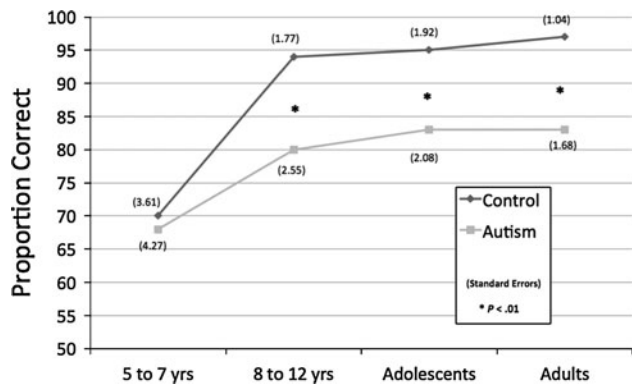

Fig. 3 Proportion of correct responses at all ages for categorization of atypical gender faces

comparisons (Scheffé tests, $p < .05$) indicated that while control children improved in accuracy from the younger to the older child groups, there were no accuracy improvements past 8–12 years. In contrast, children with autism demonstrated delayed development with improvements in performance occurring from childhood to adolescence, but not between the younger and older child age groups. Adolescents and adults with and without autism did not differ in accuracy.

These results contrast with the ability of the two groups to categorize the atypical gender stimuli. The two-way ANOVA conducted on accuracy for trials presenting the atypical face stimuli also showed there was a significant Age X Group interaction, $F(3,174) = 27.70$, $p < .001$. As illustrated in Fig. 3, 5- to 7-year-old children demonstrated no group difference, with both the control and autism groups performing relatively poorly. In contrast, the control participants categorized the atypical faces significantly more accurately than did the autism participants at 8–12 years, ($t(48) = 4.15$, $p < .001$), adolescence ($t(37) = 3.24$, $p < .01$) and adulthood ($t(55) = 6.34$, $p < .001$). Essentially, control participants reached adult levels of gender categorization with atypical faces by 8–12 years of age as demonstrated by Scheffé post hoc comparisons. In contrast, while participants with autism demonstrated improvement from early childhood, their performance reached a plateau later in childhood (as indicated by Scheffé post hoc comparisons), and they never reached the level of expertise with atypical faces demonstrated by the control participants.

Correlations Between Accuracy and Intelligence

To determine whether the ability to categorize facial gender was related to intelligence in any group, correlations were conducted between the accuracy and FSIQ scores (see Table 5) in the older children, adolescents, and adults. Correlations were not calculated for the younger child groups because there was no FSIQ equivalent. For the participants with autism, both the adolescents and adults demonstrated significant correlations between accuracy in categorizing the atypical faces and FSIQ. For the children with autism, this correlation was marginally significant. In contrast, for the control participants, the accuracy performance on accuracy in categorizing the atypical faces did not correlate with FSIQ. Figure 4 is a scatterplot showing the relationship between FSIQ and percent accuracy to categorize the atypical faces that includes the older children, adolescents and adults. For the typical faces, there were no significant correlations regardless of diagnostic group.

Reaction Time

Six of the youngest aged children with autism had attentional control problems that made their reaction time data invalid, and they were eliminated from the analyses. To analyze the reaction time data, an initial three-way

Table 5 Correlations between accuracy and FSIQ

	Autism	Control
Atypical faces		
Older children	.35*	−.24
Adolescents	.41**	.10
Adults	.38**	.05
Typical faces		
Older Children	−.10	.15
Adolescents	.11	.06
Adults	−.13	−.22

** $p < .05$; * $p = .06$

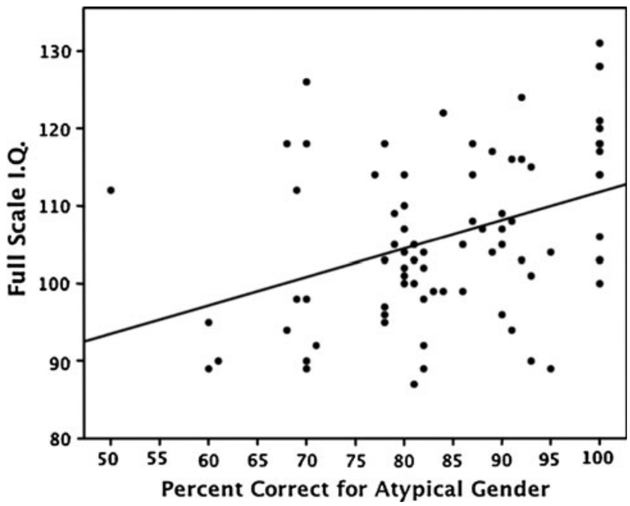

Fig. 4 Scatterplot of FSIQ and percent correct for atypical faces including older children, adolescents, and adults

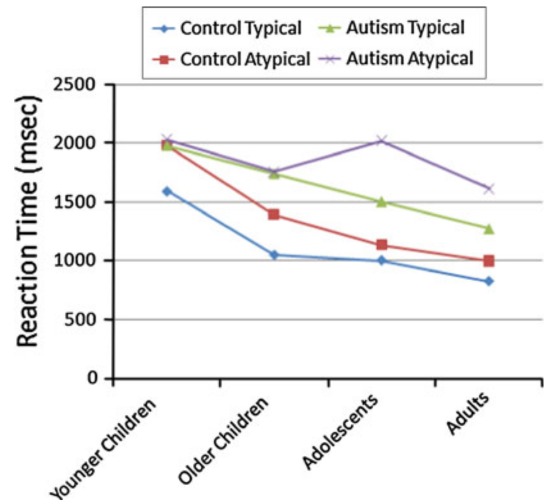

Fig. 5 Reaction times at all ages for categorization of typical and atypical gender faces

ANOVA was conducted on mean reaction times with Group (control vs. autism) and Age (young children vs. older children, vs. adolescents vs. adults) as between-subjects variables and Typicality (typical vs. atypical faces) as a within-subjects variable. Results revealed a main effect of Age, $F(3,169) = 10.32$, $p < .001$, indicating that with development, reaction time decreased (see Fig. 4). There was also a main effect of Group, $F(1,169) = 30.38$, $p < .001$, indicating that TD individuals were faster to respond than individuals with autism. A significant main effect of Typicality, $F(1,169) = 51.02$, $p < .001$, indicated that all participants were faster to accurately categorize typical faces than atypical faces.

Importantly, there was a significant three-way interaction among all three of these variables ($F(3,169) = 2.92$, $p < .05$). As seen in Fig. 5, the fastest reaction times were demonstrated by controls categorizing typical faces. A one-way ANOVA of these reaction times indicated that there was also a significant trend for reaction times to decrease with development ($F(3,93) = 5.10$, $p < .01$). The next fastest reaction times were demonstrated by controls categorizing atypical faces. A one-way ANOVA indicated that these reaction times decreased with development ($F(3,93) = 13.77$, $p < .001$). The third fastest reaction times were demonstrated by participants with autism categorizing typical faces. A one-way ANOVA on these reaction times again indicated that reaction times decreased with development ($F(3,76) = 18.97$, $p < .001$). Finally, the slowest reaction times were demonstrated by participants with autism categorizing atypical faces. In contrast to the other three trends, a one-way ANOVA of these reaction times indicated that they did not significantly decrease with development. Thus, similar to the pattern found with accuracy scores, there was limited development in the ability of individuals with autism to categorize atypical faces.

Discussion

The current study examined the development of gender categorization abilities from early childhood to adulthood, specifically comparing performance in TD individuals and individuals with autism. In contrast to previous investigations of gender, this study manipulated the degree of gender-typicality of the faces. Findings suggest that expertise for atypical examples of gender continued to develop through childhood in the TD group. While 5- to 7-year-old TD children were skilled at categorizing typical exemplars, they had difficulty discriminating atypical exemplars, displaying only 70% accuracy. In fact, TD children did not reach an adult level of accuracy with atypical gender exemplars until 8–12 years of age. In contrast, results with individuals with autism demonstrated that 5- to 7-year-old children had difficulty categorizing both typical and atypical gender exemplars relative to control participants. Not until adolescence did individuals with autism display gender discrimination abilities equivalent to TD 8- to 12-year-old children for the typical examples of facial gender. With respect to the atypical faces, the participants with autism demonstrated improvement from early to later childhood; however, their ability to categorize the atypical faces reached a plateau at this age with respect to both accuracy and reaction time, with no further improvement in performance. Thus, with the atypical exemplars of gender, adults with autism never reached the categorization abilities of control adults and, indeed, performed worse than the control 8- to 12-year-old children.

Results also indicated a correlation between accuracy and IQ only for individuals with autism, which suggests that perhaps individuals with autism actually process faces differently than TD individuals (e.g., Curby et al. 2010). Given that even nonverbal infants can categorize gender (Newell et al. 2010), most researchers would consider gender categorization to be an implicit ability that does not require explicit learning strategies. However, since performance on the current gender categorization task was correlated with IQ for the individuals with autism (and not for control individuals), it appears that individuals with autism may have used explicit strategies to perform well on the task.

The current results raise an important question about what might account for the difference in the gender categorization abilities between TD individuals and individuals with autism. As previously discussed, one of the most useful models for understanding how TD individuals organize their developing knowledge of facial information is Valentine's (2001) multidimensional experience-based "face space" for representing faces. It has been suggested (e.g., Mondloch et al. 2010) that one reason for the prolonged development of face perception and recognition abilities is that the face space takes a significant amount of time (i.e., experience with varying facial information) to become fully representational. Extending this idea to individuals with ASD, it could be argued that, perhaps from birth, individuals with autism pay less attention to faces than TD children do (e.g., Curby et al. 2010). If so, one possible issue underlying the marked difference in gender categorization abilities observed between the control and autism groups may stem from the fact that it may actually take individuals with autism significantly longer to acquire an adequate representation of faces and their dimensional variations. Indeed, even as adults, the individuals with autism had difficulty categorizing the atypical faces. Additionally, the finding that the performance of only the individuals with autism correlated with IQ, suggests that the two groups may have used different processes to categorize gender.

Both the "face space" model and general models of categorization suggest that we categorize exemplars by comparing them to central representations of the category (see Murphy 2004). Recent studies with individuals with ASD suggest that they have difficulty abstracting prototypes of categories. Studies have found that individuals with autism may not be able to abstract object prototypes (Klinger and Dawson 2001; Klinger et al. 2006; Plaisted 2000) and this in turn may impact their ability to categorize objects residing at category boundaries or atypical exemplars of even common categories such as cats, chairs, and couches (Gastgeb et al. 2006). With respect to faces, two recent studies have found that individuals with autism are unable to abstract prototypic representations of both schematic faces (Gastgeb et al. 2009) and naturalistic faces (Gastgeb et al. 2011). Thus, the difficulty that individuals with autism have in categorizing atypical gender faces may be related to their limitations in forming prototypic representations that are necessary to compare and categorize boundary or atypical exemplars of gender.

Finally, it may be that the individuals with autism relied on bottom-up processes for gender categorization; whereas, TD individuals relied on top-down processes for gender categorization. Although speculative, it may be that individuals with autism in the current task searched for simple or definitive features that allowed them to discriminate the gender of the faces (e.g., wide versus narrow eyebrows). This notion fits with prior suggestions that individuals with autism depend more on basic bottom-up perceptual mechanisms when they process faces. For example, studies have shown that individuals with autism are biased to process local features and less likely to perceive global or holistic aspects of both faces and objects (Frith and Happé 1994; Mottron et al. 2006). Such definitive features may be apparent in typical faces but not in atypical faces, and might explain the difficulty individuals with autism demonstrated with atypical gender exemplars. Consider for example some of the facial dimensions that separate male and female faces. In contrast to males, females have narrower eyebrows, wider eyes, thicker lips, and higher cheekbones. These aspects of the face can be considered spatial or configural dimensions; yet, for typical faces the values for males and females are widely separated and almost qualitatively different. That is, men have "wide" eyebrows and women have "narrow" eyebrows. Thus, typical faces can easily be categorized based on these almost qualitatively different features. We are suggesting that individuals with autism may be relatively good at processing these localized and definitive features that identify gender and that their ability to use this strategy improves with development and is related to FSIQ.

In contrast, categorizing atypical gender faces where the dimensional values are only slightly different from each other may require a "norm based" process in which an exemplar is categorized by deciding whether it is closer to experienced acquired norms for male versus female faces. In addition to the discussed research on facial prototypes, recent research using an aftereffects paradigm demonstrates that we have experience acquired norms for male versus female faces that are used to categorize gender (Bestelmeyer et al. 2008; Jaquet and Rhodes 2008; Rose and Leopold 2011). We are suggesting that individuals with autism may never acquire norm-based representations of male versus female faces and, therefore, must rely on a feature approach to categorizing facial gender. While this feature approach is efficient for typical faces, it limits the ability of individuals with autism to categorize atypical faces.

Our interpretation presents an interesting challenge to the development of intervention strategies for improving face processing in individuals with ASD. Several intervention strategies (Faja et al. 2008; Wolf et al. 2008) have focused on improving the abilities of individuals with ASD to process configural facial information. While improvements have been documented in these studies, they have been quite modest. It may be that if individuals with autism have not acquired facial norms, such strategies may never be highly successful. In contrast, capitalizing on the abilities of individuals with autism to perceive facial features may prove to be a more successful intervention strategy. Clearly more research on normative and featural approaches to processing faces will be required to develop truly effective interventions.

In summary, the current study revealed three important findings. First, while the ability to categorize gender begins during infancy, the current study demonstrates that TD children do not reach adult levels of expertise in categorizing atypical gender faces until later childhood. In contrast, individuals with autism demonstrate limited improvement in performance across development. Even as adults, individuals with autism do not perform at levels comparable to TD 8- to 12-year-old children. As has been demonstrated with both facial and non-facial categorical stimuli, perceptual expertise depends on the ability to abstract central representations of categories and to use these representations to help make fine discriminations of subtle spatial information (e.g., Gauthier et al. 2010). In other words, perceptual expertise depends on the gradual improvement of top-down processes. These implicit learning processes may be deficient in individuals with autism, thus limiting the development of expertise with respect to the categorization of gender (Newell et al. 2010).

Second, the current study illustrates the importance of studying autism from a developmental perspective and in varying the difficulty of tasks. If this were a study comparing only adults with and without autism, and the task used only relatively typical exemplars of gender, one would have incorrectly concluded that there were no group differences in the ability to categorize gender. Rump et al. (2009) found a similar result with respect to the discrimination of emotional expressions. When tested with prototypical examples of expressions, there were no differences between individuals with and without autism. However, when tested with subtle exemplars of expression, differences were found between the two groups. Similar to the current study, it was also found that expertise in recognizing subtle facial expressions develops though childhood and adolescence.

Finally, because the youngest age tested in this study was 5–7 years, it is important for future research to examine categorization difficulties in younger children to explore how early these difficulties arise in children with ASD. Younger age groups are particularly important to study since we know that processes such as the categorization and the abstraction of prototypical representations of categories is demonstrated by TD infants in the first year of life. It is possible that difficulties with categorization, be it gender categories or other object categories, may emerge much earlier than the ages tested in this study with respect to children with autism. Thus, future research should study the emergence of categorization abilities in infants who are at genetic risk for developing autism due to having an older sibling with ASD (Newell et al. 2010).

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