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The perception and identification of facial emotions in individuals with autism spectrum disorders using the *Let's Face It!* Emotion Skills Battery

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Background: Although impaired social–emotional ability is a hallmark of autism spectrum disorder (ASD), the perceptual skills and mediating strategies contributing to the social deficits of autism are not well understood. A perceptual skill that is fundamental to effective social communication is the ability to accurately perceive and interpret facial emotions. To evaluate the expression processing of participants with ASD, we designed the *Let's Face It!* Emotion Skills Battery (*LFI!* Battery), a computer-based assessment composed of three subscales measuring verbal and perceptual skills implicated in the recognition of facial emotions. **Methods:** We administered the *LFI!* Battery to groups of participants with ASD and typically developing control (TDC) participants that were matched for age and IQ. **Results:** On the Name Game labeling task, participants with ASD ($N = 68$) performed on par with TDC individuals ($N = 66$) in their ability to name the facial emotions of happy, sad, disgust and surprise and were only impaired in their ability to identify the angry expression. On the Matchmaker Expression task that measures the recognition of facial emotions across different facial identities, the ASD participants ($N = 66$) performed reliably worse than TDC participants ($N = 67$) on the emotions of happy, sad, disgust, frighten and angry. In the Parts–Wholes test of perceptual strategies of expression, the TDC participants ($N = 67$) displayed more holistic encoding for the eyes than the mouths in expressive faces whereas ASD participants ($N = 66$) exhibited the reverse pattern of holistic recognition for the mouth and analytic recognition of the eyes. **Conclusion:** In summary, findings from the *LFI!* Battery show that participants with ASD were able to label the basic facial emotions (with the exception of angry expression) on par with age- and IQ-matched TDC participants. However, participants with ASD were impaired in their ability to generalize facial emotions across different identities and showed a tendency to recognize the mouth feature holistically and the eyes as isolated parts. **Keywords:** ASD, computer-based assessment, facial emotions, perceptual skills, social communication.

Introduction

Autism is a pervasive developmental disorder (PDD) involving impairment in reciprocal social interaction as well as impairments in verbal and nonverbal communication, a lack of imaginative play, and repetitive and restricted solitary activities. Autism is highly heritable and involves developmental differences in brain growth, organization and function. Autism presents with a range of severity and associated features, and its heterogeneity, is commonly referred to as autism spectrum disorder (ASD). According to the current DSM-IV-TR standards, individuals diagnosed with autism display an impaired ability to understand the emotions and feelings of others and a 'lack of social reciprocity'. This, in turn, creates difficulties in social interactions that Kanner (1943) has characterized as a 'disorder of affective contact'. Although the social deficits of autism are likely to have multiple origins, the facility to recognize and interpret facial expressions during face-to-face interactions is critical to normal social functioning. In everyday social encounters, a person's facial expression is the outward manifestation of their internal emotional state or the emotional state that they wish to convey to the external observer (Ekman & Friesen, 1971). Therefore, success in social interactions relies on the capacity to recognize and interpret facial emotions in a social context. If individuals with ASD have difficulties perceiving facial expressions, it follows that they would be at a disadvantage when interpreting the emotional state and intention of others (Leppanen & Nelson, 2006) and this would invariably lead to difficulties in everyday social exchanges. Indeed, it has been speculated that deficits in face processing skills and abnormalities in the neural circuits that meditate these functions may

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play a causative factor in the social deficits of autism (Dawson et al., 2005; Schultz, 2005).

Emotion recognition

Despite the clear link between facial expression and social function, the empirical results present a mixed picture as to whether individuals with autism are impaired in their ability to perceive and interpret facial emotions. For example, some studies show that individuals with ASD perform worse than control participants on tasks requiring the labeling of primary basic emotions, such as anger, disgust, and sadness (Bolte & Poustka, 2003; Boraston, Blakemore, Chilvers & Skuse, 2007; Celani, Battacchi & Arcidiacono, 1999) and secondary social emotions, such as trustworthiness and jealousy (Adolphs, Sears, & Piven, 2001; Rump, Giovannelli, Minshew, & Strauss, 2009). In contrast, other studies indicate that the perception of expression is not disrupted relative to control participants (Castelli, 2005; Grossman, Klin, Carter, & Volkmar, 2000; Ozonoff, Pennington, & Rogers, 1990).

There are multiple factors that might account for the presence (or absence) of expression recognition differences between ASD and typically developing control (TDC) groups. The disparate findings across studies can be attributed to differences in the age of the ASD and control participants, the criteria on which the two groups are matched and the cognitive complexity of the tasks employed (Harms, Martin, & Wallace, 2010). With respect to age, it has been argued that expression recognition abilities develop more slowly and reach their peaks sooner in the ASD population than the TDC population (Gepner, Deruelle, & Grynfeltt, 2001). Consequently, emotion recognition differences between ASD and TDC children that are undetected in younger children may become apparent by adolescence and young adulthood (O'Connor, Hamm, & Kirk, 2005). Second, decisions on what factors used to match the participants can either enhance or mask facial expression variation in performance on facial recognition tasks between the ASD and TDC groups (Burack, Iarocci, Flanagan, & Bowler, 2004). Given that verbal IQ scores of persons with ASD are typically lower than their nonverbal IQ scores, several studies have shown emotional impairments when participants with ASD were matched on nonverbal intelligence, but no differences when the groups were matched for verbal intelligence (Fein, Lucci, Braverman, & Waterhouse, 1992; Ozonoff et al., 1990). Third, expression tasks that are perceptually or cognitively more taxing are more likely to reveal ASD and TDC differences than simpler tasks. For example, some studies have shown that participants with ASD were not impaired in their recognition of basic emotions presented in static photographs (Castelli, 2005; Grossman et al., 2000; Ozonoff et al., 1990). By contrast, other studies have shown group differences when using dynamic, video stimuli (Rump et al., 2009; Smith, Montagne, Perrett, Gill, & Gallagher, 2010) or when more subtle, secondary social emotions (e.g., trustworthiness) were tested (Adolphs et al., 2001).

To investigate the expression recognition skills of participants with autism, we developed the *Let's Face It!* (*LFI!)* Emotion Skills Battery. The *LFI!* Emotion Skills Battery is a complement to the *Let's Face It!* Skills Battery that assesses the recognition of facial identity (Wolf, Tanaka, Klaiman, Cockburn, Herlihy, Brown, et al., 2008). The *LFI!* Emotion Battery consists of three subscales: Name Game, Matchmaker Expression and Parts–Wholes Expression. The Name Game is a subscale that assesses the child's ability to label basic facial emotions of happy, sad, angry, disgust, surprise and fear. Matchmaker Expression is a test in which the child is asked to match a target expression (e.g., happy) depicted in one person to the corresponding expression shown in one of three new faces (Celani et al., 1999). The purpose of the task is to assess the child's ability to generalize expressions across identities. The Parts–Wholes Expression test assesses the child's use of analytic and holistic encoding strategies to identify happy and angry expressions. On tests of facial identity, children with ASD tend to focus more on the mouths and less on the eyes than TDC children (Joseph & Tanaka, 2003; Wolf et al., 2008). The Parts–Wholes Expression test examines whether a similar mouth strategy is employed during the perception of facial emotions. In the present study, we administered the emotion battery to a large sample of participants diagnosed with ASD ($N = 85$) and a control sample of TDC ($N = 130$) participants. To avoid potential age and IQ confounds, participants from the two groups were matched on each separate subscale in the battery for chronological age and full scale IQ. After controlling for age and IQ, we hypothesized that individuals with ASD should differ from TDC individuals in their ability to label emotions, to generalize emotions across identities and in their reliance on expression information in eye and mouth regions of the face.

Method

Participants

This study was approved by the institutional review boards of Yale University School of Medicine and the University of Victoria. All participants (or parents of minor participants) gave written informed consent after study procedures were fully explained to them.

Participants of the present study included 85 participants, adolescents, and young adults with ASD, and 130 TDC participants, adolescents, and young adults. Participants in the ASD group were recruited on the basis of previous diagnoses of Autistic Disorder, Asperger's Disorder, or Pervasive Developmental Disorder, Not Otherwise Specified (PDD-NOS), through presentations at schools and parent organizations, and through existing relationships with families of participants on the autism spectrum. TDC participants were recruited through word of mouth and through local churches and school systems. TDC participants were excluded if they had significant symptoms of a DSM-IV Axis I disorder (based on the Child Symptom Inventory; Gadow & Sprafkin, 1994). TDC and ASD participants were excluded if they had vision worse than 20–100 in both eyes, or if, in the judgment of an experienced clinician, they were unable to comprehend the instructions of the experimental tasks.

Diagnoses of ASD were confirmed based on DSM-IV criteria through use of the Autism Diagnostic Interview, Revised (ADI-R; Rutter, Le Couteur, & Lord, 2003) and the Autism Diagnostic Observation Schedule – Generic (ADOS-G; Lord, Rutter, DiLavore, & Risi, 1999) by a clinician trained in their administration, with more than 5 years of experience working with individuals with ASD. In some cases, ADOS-G or ADI-R data were missing (ADOS: four missing, ADI: seven missing), or participants did not meet criteria for an ASD on one of these measures (ADOS: 16 did not meet; ADI: 7 did not meet; note that there is no overlap in these numbers; i.e., all participants met criteria on at least one of the two diagnostic measures). In these instances, a final diagnostic decision was made by consensus among two or more clinicians with more than 5 years of experience in the field of ASD, independent of any knowledge of how the child performed on the *LFI!* Skills Battery.

IQ scores were obtained for all participants using the Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999), the Wechsler Intelligence Scale for Children, 3rd edition (Wechsler, 1991), the Wechsler Adult Intelligence Scale, 3rd edition (Wechsler, 1997), or the Differential Abilities Scales (Elliott, 1990). In cases in which a participant had an IQ test administered clinically within the last year, an IQ measure was not re-administered, and scores from the previous administration were utilized for the purposes of the present study.

The TDC group was composed of 130 participants (87 males and 53 females) with a mean age of 11.96 years (range: 5.10–18.10 years of age) and a mean full scale IQ of 113.28 (range: 81–119 points). The ASD group consisted of 85 participants (71 males and 14 females) with a mean age of 11.58 (range: 5.81–20.72 years of age) and a mean full scale IQ of 99.74 (range: 58–147 points). The ASD group comprised 36 individuals with Autistic Disorder, 21 with Asperger's Disorder, and 28 with PDD-NOS. From this pool of participants, subsamples were created for each analysis in which the ASD and TDC groups were carefully matched on age and IQ. The ASD group contained a higher proportion of males (84% males) than the TD group (63% male). However, no gender differences were found between the males and females in the ASD group or males and females in the TD group on Name Game, Matchmaker Expression, Parts–Wholes Expression subtests, $p > .05$. Because some of the subtests in the *LFI!* Skills Battery were under development at the outset of the study, group matching was conducted separately for each of the measures, blindly with respect to dependent variables of interest. As shown in Table 1, for all analyses, groups were matched for both age and full scale IQ such that no means differed by more than 0.1.

Procedure

Participants were administered the *LFI!* Skills Battery in addition to other neuropsychological and behavioral measures. The *LFI!* Skills Battery was administered over a 2-day period. Half of the items were administered on Day 1 of testing, and a parallel set of items was administered on Day 2 of testing.

Description of Let's Face It! Skills Emotion Battery. Name Game: This assessment examined the child's ability to match a word label to its facial expression. At the beginning of each trial, an emotional face was centrally presented on a computer screen with a list of the six emotion names (happy, angry, sad, disgust, surprise, and frighten) shown on the right side of the display (see Figure 1A). The child's task was to click on the emotion name that was depicted in the face. To minimize reading demands, the computer software spoke the emotion name when the participant scrolled their mouse over the label. The face remained on the screen until the participant made a response. After the response, there was a 1-s inter-trial interval followed by the presentation of the next item. The faces were color images from the NimStim set of facial expressions (Tottenham et al., 2009). There were a total of 66 trials composed of 11 items for each of the six emotions (happy, sad, angry, disgust, frighten, and surprise). The face images subtended visual angles of 2.5° and 4° in the horizontal and vertical dimensions, respectively.

Matchmaker Expression: This assessment examined the child's ability to match emotional expressions across changes in facial identity without explicit verbal labels. A study face depicting a basic emotion (i.e., happy, angry, sad, disgust, and frighten) was presented in front view for one second followed by three probe faces of different identities (see Figure 1B). In a three-alternative forced choice task, the participant was

Table 1 Group characteristics for the three subscales

Task	Group	*N*	Age		Full scale IQ	
			M	*SD*	*M*	*SD*
Name Game	TDC	68 (43 males)	11.9	3.1	106.8	7.8
	ASD	66 (56 males)	11.9	4.0	106.8	20.9
Matchmaker Expression	TDC	66 (42 males)	11.9	3.1	106.8	7.7
	ASD	67 (57 males)	12.0	4.0	106.8	20.7
Parts–Wholes Expression	TDC	67 (42 males)	11.9	3.1	106.8	7.8
	ASD	66 (56 males)	11.9	4.0	106.8	20.9

Group matching was conducted separately for each analysis based on both age and full scale IQ. Note: No gender differences were found between males and females in the ASD or TD groups. TDC, typically developing control; ASD, autism spectrum disorder.

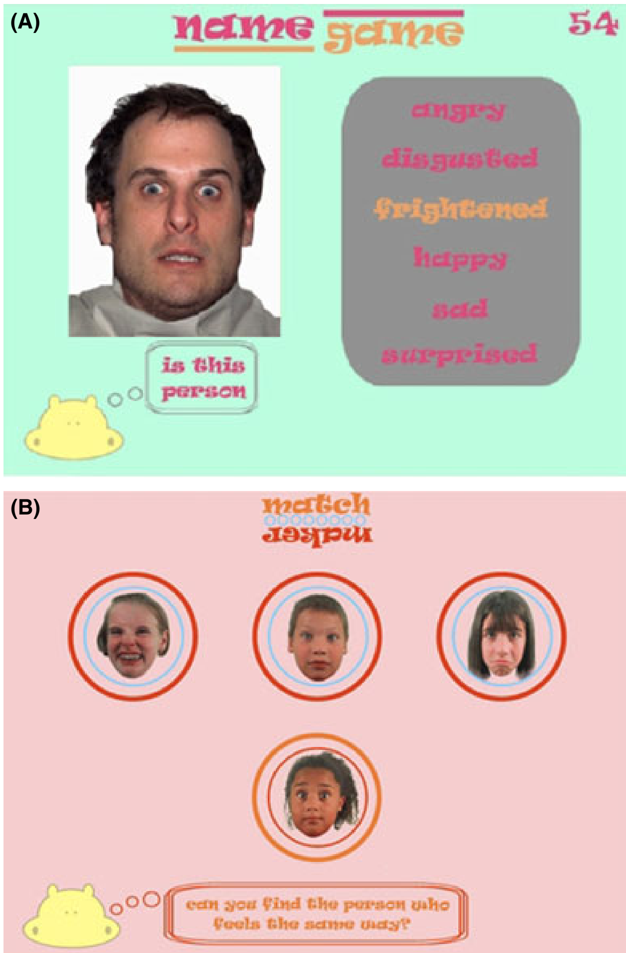

Figure 1 (A) Name Game assessment: emotional face test. (B) Matchmaker Expression assessment test using images from the NonStim face database

asked to select the probe face that matched the emotion depicted in the study face. Both the study face and probe faces remained on the screen until a response was made. After the response, there was a 1-s inter-trial interval followed by the presentation of the next item. There were 30 trials with six items per emotional expression (happy, angry, sad, disgust, and frighten). The face stimuli were color images from the NimStim face database (Tottenham et al., 2009) that subtended a visual angle of 2° in the horizontal dimension and 3.5° cm in the vertical dimension.

Parts–Wholes Expression: This assessment examined the child's use of featural and holistic strategies to recognize the facial expressions of happiness and anger. A study face depicting a consistent expression or inconsistent expression was presented for 2 s. The 'consistent' expression depicted a face in which the top and bottom halves were the same expression. The 'inconsistent' expressions were constructed by combining the top half of one expression (e.g., angry) with the bottom half of the other (e.g., happy) from the same individual (see Figure 2A and B for examples of consistent and inconsistent expressions). At test, the participant's memory for a face part (eyes or mouth) was evaluated by presenting the face part and its foil either in isolation or in a whole face. In the whole face condition, the faces were identical with the exception of the

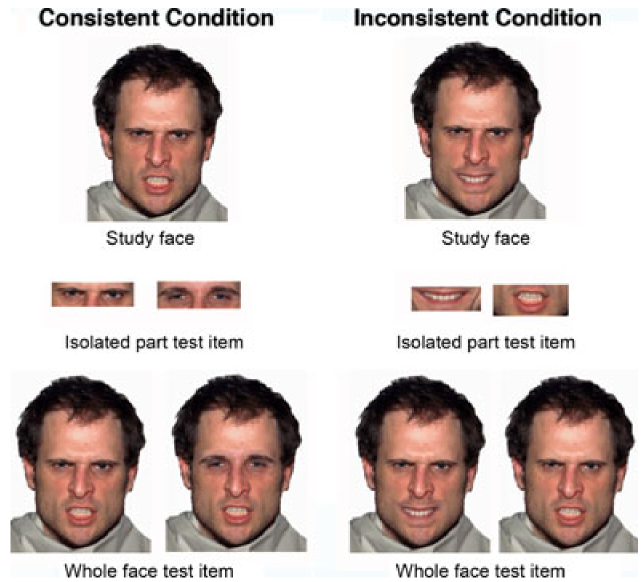

Figure 2 Consistent and inconsistemt expressions from the Parts–Wholes Expression assessment test

target face part and its foil. For example, if the critical face part was the eyes, the target and foil eye parts were tested in isolation or embedded in a face with the exact same mouth and nose features. The measure of holistic processing is the difference between performance in the whole face test condition versus performance in the part test condition. The measure of emotional processing is the difference in performance between the consistent expression condition and inconsistent expression condition. Four faces were used in the assessment and were normed for expression from the NimStim set of facial expressions (Tottenham et al., 2009). Recognition memory for eye and mouth features was tested in the part and whole conditions in both the consistent and inconsistent conditions. The factors of condition (part, whole), feature (eyes, mouth), consistency (consistent, strong inconsistent, weak inconsistent) yielded a total of 48 trials. The face images subtended visual angles of 2.5° and 4° in the horizontal and vertical dimensions, respectively.

Results

Results (including effect sizes) from the Name Game, Matchmaker Expression and Parts–Wholes Expression subscales are reported in Table 2.

Name Game

A 2 × 6 ANOVA was conducted on the Name Game data, with group (ASD, TDC) as a between-group variable and Expression (happy, sad, disgust, angry, surprise, frighten) as a within-group variable. The main effect of group approached significance, $F(1, 132) = 2.86$, $p = .09$, with the TDC group demonstrating higher overall accuracy than the ASD group. Results demonstrated a significant main effect of Expression, $F(5, 660) = 77.52$, $p < .001$, but no Expression × Group interaction, $F(5, 660) = 1.43$, $p > .05$. In both groups, the highest accuracy was on happy

Table 2 Mean percentages of correct responding and effect sizes (Cohen's *d*) for the Name Game, Matchmaker Expression and Parts–Wholes Expression subscales

Expression tasks	ASD	TDC	Effect size
Name Game			
Angry	82.4 (21.2)	89.3 (13.4)	.39*
Disgust	87.5 (18.0)	92.8 (12.2)	.34
Sad	91.7 (13.5)	94.7 (9.7)	.25
Happy	98.1 (6.7)	97.5 (5.8)	−.10
Frighten	67.5 (22.0)	69.2 (20.8)	.08
Surprise	86.6 (18.6)	87.8 (14.6)	.07
Matchmaker Expression			
Sad	65.9 (22.4)	82.3 (16.8)	.83*
Angry	84.3 (15.3)	94.2 (9.9)	.76*
Frighten	74.1 (22.2)	86.9 (16.9)	.65*
Disgust	66.7 (20.1)	75.8 (16.6)	.49*
Happy	96.8 (9.7)	99.5 (2.9)	.40*
Parts–Wholes Expression			
Consistent expression			
Part eyes	83.9 (19.3)	88.1 (13.5)	.25
Whole eyes	81.8 (19.1)	88.9 (13.1)	.43*
Part mouth	92.4 (12.2)	92.5 (11.5)	.01
Whole mouth	92.2 (11.6)	90.1 (13.5)	−.16
Inconsistent expression			
Part eyes	75.4 (18.2)	76.5 (15.5)	.06
Whole eyes	80.1 (18.6)	87.3 (14.7)	.43*
Part mouth	83.3 (14.9)	83.0 (15.8)	−.02
Whole mouth	90.3 (13.5)	89.0 (15.5)	−.09

Standard deviations are indicated in parentheses. ASD, autism spectrum disorder; TDC, typically developing control.
*$p < .05$ (significant differences between ASD and TDC groups).

Expressions (where both groups reached near ceiling performance), and the lowest accuracy was on frighten expressions. Group comparisons on the individual expressions revealed that the ASD group performed reliably worse in labeling the angry expression, $p < .01$, but did not differ from the TDC group on the other expressions of happy, sad, disgust, surprise, and frighten (see Figure 3A).

Matchmaker Expression

A 2 × 5 ANOVA was conducted on the Matchmaker Expression data, with Group (ASD, TDC) as a between-group variable and Expression (happy, angry, frighten, sad, and disgust) as a within-group variable. Results demonstrated a significant main effect of expression ($F(4, 524) = 76.49$, $p < .001$), a significant main effect of group ($F(1, 131) = 35.42$, $p < .001$), and a significant Expression × Group interaction ($F(4, 524) = 3.97$, $p < .01$). The TDC group had significantly higher accuracy than the ASD group on all five expressions (happy: $t(131) = 2.19$, $p < .05$; angry: $t(131) = 4.40$, $p < .001$; fear: $t(131) = 3.72$, $p < .001$; sad: $t(131) = 4.78$, $p < .001$; disgust: $t(131) = 2.84$, $p < .01$ (as shown in Figure 3B).

Parts–Wholes Expression

A 2 × 2 × 2 × 2 ANOVA was conducted with the between-group variable of group (ASD, TD) and within-group variables of Condition (part, whole), Feature (eyes, mouth) and Consistency (consistent, inconsistent). A significant main effect of Condition was found, $F(1, 131) = 18.94$, $p < .001$, such that face parts were recognized better when tested in the whole face than in isolation. The main effect of Consistency, $F(1, 131) = 59.26$, $p < .001$, was also significant, indicating that participants were more accurate when recognition was tested with study faces with consistent expressions (e.g., happy eyes, happy mouth) than with inconsistent expressions (e.g., happy eyes, angry mouth). Consistency also interacted with Condition, $F(1,131) = 26.85$, $p < .01$, indicating a stronger whole face advantage for consistent than inconsistent expressions. Finally, the main factor of Feature was reliable, $F(1, 131) = 52.26$, $p < .001$, showing that recognition of the mouth was better than the eyes.

Overall, there were no group differences between the ASD and TDC cohorts, $F(1,131) = 1.35$, $p > .10$. However, Group did significantly interact with Feature, $F(1,131) = 10.82$, $p < .01$, such that the ASD group performed reliably worse than the TDC group in their recognition of eyes, but performed as well as TDC participants on their recognition of the mouth. The three-way interaction between Group, Condition and Feature was also significant, $F(1, 131) = 4.30$, $p < .05$. Whereas the TDC group recognized the eye feature better when tested in the whole face than in isolation, $p < .05$, participants in the ASD group showed no whole face advantage for recognition of the eyes. However, the ASD group recognized the mouths better in the whole face than in isolation, $p < .05$; this was not the case for the TDC group. No

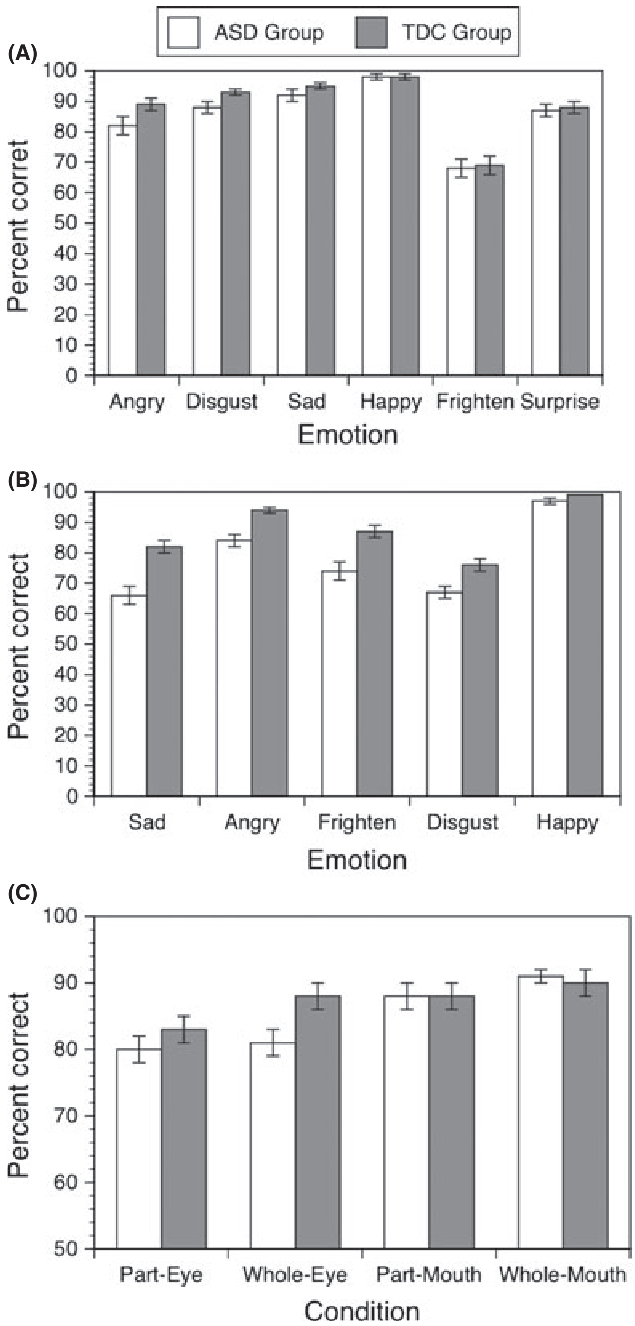

Figure 3 Comparative results between the autism spectrum disorder (ASD) and typically developing control (TDC) groups for the (A) Name Game, (B) Matchmaker Expression, and (C) Parts–Wholes Expression assessment tests

other interactions were significant. These results are depicted in Figure 3C.

Correlational analyses

We also correlated performance on the *Let's Face It!* Emotion Skills Battery (*LFI!* Battery) with age, IQ, and ADOS scores.

Age correlations

For the TDC group, age correlated with the three emotion tasks: Match Maker Expression, $r(119) = .268$, $p < .01$; Name Game, $r(123) = .318$, $p < .001$; and Parts–Wholes Expression, $r(119) = .314$, $p < .001$. For the ASD group, age correlated with performance on Match Maker Expression measure, $r(83) = .291$, $p < .01$. Age did not reliably correlate with performance on the Name Game, $r(83) = .149$ or the Parts–Wholes Expression $r(83) = .196$, measures.

IQ correlations

For the TDC group, IQ was reliably correlated with overall performance on the Parts–Wholes Expression subscale, $r(119) = .182$, $p < .05$. IQ did not correlate with performance on the Name Game subscale, $r(119) = .137$, $p > .10$, or performance on the Matchmaker Expression subscale, $r(119) = .004$, $p > .10$.

For the ASD group, IQ reliably correlated with performance on all three measures in the *LFI!* – Emotion Battery. IQ correlated with Matchmaker Expression, $r(83) = .324$, $p < .01$ and the ability to label an expression as indexed by the Name Game test, $r(83) = .436$, $p < .001$. IQ also correlated with the specific expressions of angry, $r(83) = .319$, disgust, $r(83) = .408$, frighten, $r(83) = .257$, sad, $r(83) = .251$, $p < .02$, and surprise, $r(83) = .353$, $p < .01$. Finally, there was a significant correlation between IQ and overall performance on the Parts–Wholes Expression subscale, $r(82) = .408$, $p < .01$. The correlations between IQ and *LFI!* performance were significantly stronger for the ASD group than the TDC on the Name Game and Matchmaker Expression subscales, $p < .05$ (two-tailed) and marginally stronger on the Parts–Wholes Expression task, $p < .09$ (two-tailed).

Autism Diagnostic Observation Schedule – Generic

We also correlated social impairment as measured by Module 3 of the ADOS with performance on the *LFI!* Battery. Matchmaker Expression scores reliably correlated with ADOS Total Score, $r(53) = -.394$, $p < .01$, and the ADOS Social scores, $r(53) = -.332$, $p < .05$. The ADOS Social scores also correlated with Name Game performance, $r(69) = -.274$, $p = .05$.

Discussion

The goal of this study was to investigate the processing of facial emotions by individuals from ASD and TDC groups across three expression tasks. The study included a large sample of individuals from the ASD ($N = 85$) and the TDC ($N = 130$) group. Subsamples of participants were created by matching individuals from each group on chronological age and full scale intelligence. For the Name Game Task, participants were shown an expressive face and then asked to select the corresponding emotional label from a set of given alternatives of happy, angry, sad, disgust, frighten, and surprise. On this measure, individuals from the ASD group showed a slight deficit, $p < .10$, compared with individuals from the TDC group. Comparisons on the individual expressions revealed that participants with ASD performed reliably worse than TDC participants only on their identification of the angry expression. Anger is considered a 'top half' emotion where the majority of the expressive information is conveyed in the upper half of the face (Smith et al., 2010). Given the tendency of individuals with ASD to avoid the eye region of the face in deference to information in the lower mouth region (Klin, Jones, Schultz, Volkmar, & Cohen, 2002; Riby, Doherty-Sneddon, & Bruce, 2009; Rutherford, Clements, & Sekuler, 2007; Wolf et al., 2008), it was not surprising that perception of anger would be differentially compromised relative to the other facial expressions.

Our main Name Game finding of no major differences between the ASD and TDC groups is consistent with other null findings reported in the literature (Castelli, 2005; Grossman et al., 2000; Ozonoff et al., 1990). However, other studies have found expression naming impairments in autism (Bolte & Poustka, 2003; Celani et al., 1999). The divergent results may be explained by differences in tasks demands (e.g., perceptual vs. memory) and response characteristics (e.g., free naming vs. recognition). In Name Game, response demands were minimized by presenting the basic emotion labels in written and auditory form and by allowing the study faces to remain on the screen until a response was made.

We found robust differences between the ASD and TDC groups on the Matchmaker Expression measure. This test assesses the child's ability to generalize facial emotions across different facial identities. Consistent with previous findings (Celani et al., 1999; Riby, Doherty-Sneddon, & Bruce, 2008), we found that the ASD group's matching performance was significantly below the performance of the TDC group on all five of the tested expressions of happy, angry, sad, frighten, and disgust, $p < .05$. The poor performance of the ASD group on the Matchmaker task is somewhat unexpected given the intact labeling performance assessed in the Name Game measure. Labeling would be an effective strategy for completing the Matchmaker task where study and probe faces could be matched according to their emotional names. As discussed below, the strong correlation between IQ and Matchmaker Expression performance suggests that verbal labeling is a good predictor of expression recognition for individuals with ASD.

The perceptual strategies of ASD and TDC participants were further explored in the Parts–Wholes Expression subscale. ASD and TDC individuals differed in their abilities to recognize the eyes and mouth features in an expressive face. When presented with an emotional face, the TDC individuals recognized eyes holistically and mouths analytically. In contrast, the ASD individuals showed the opposite pattern, recognizing mouths holistically and the eyes analytically. These results are consistent with results from previous parts–wholes studies where ASD participants have shown deficits in eye recognition and equal or superior recognition of the mouth (Joseph & Tanaka, 2003; Wolf et al., 2008).

Our correlational findings suggest a connection between social competency and impaired perception of facial emotion. We found that individuals with ASD who exhibited greater impairment in their ability to label facial emotion and to recognize expressions across different identities showed greater deficits in social function as assessed by Module 3 of the ADOS measure. These results support the claim that impaired face processing causes a cascade of negative consequences in social function (Dawson et al.,2005; Schultz, 2005). However, it is equally plausible that impaired social functioning can produce deficits in attending to and interpreting facial emotions.

An unanticipated finding in our study was the robust correlation between IQ and performance on the *LFI!* Emotion Battery for individuals with ASD. Results from previous studies have shown that face recognition skills are not strongly linked to general cognitive abilities in autism (Campbell et al., 2006; Langdell, 1978). However, these studies have focused on the recognition of facial identity. On tests of emotion perception and recognition, IQ reliably correlated with the ability to label an expression (Name Game, $r = .44$), to match a target expression across changes in identity (Matchmaker Expression, $r = .32$), and to identify an expression part in isolation or in a whole face (Parts–Wholes Expression, $r = .41$). The strong correlation between IQ and emotion processing for individuals with ASD stands in contrast to the modest or nil correlations for TDC individuals on these same measures (Name Game, $r = .14$; Matchmaker Expression, $r = .01$; Parts–Wholes Expression, $r = .18$). Group differences in IQ–emotion correlations suggest that the two populations adopt divergent strategies to decode facial emotions. For individuals with ASD, recognizing emotions may tap into higher-level, intellectual processes involving more deliberate problem-solving methods, whereas TDC individuals may employ affective rather than cognitive strategies (Grossman et al., 2000). If the emotion tasks in the *LFI!* Battery were more taxing for the ASD than the TDC group, the obtained group differences might reflect differences in cognitive function that are not necessarily specific to emotional processing. To test the specificity of the impairment, the performance of ASD and TDC groups could be compared on nonface control tasks that are equal in their cognitive complexity as the LFI! measures.

Conclusion

The *LFI!* Battery provides an informative look into emotional face processing of participants with ASD. Our findings show that participants with ASD are able to label the basic facial emotions (with the exception of angry expression) on par with age- and

IQ-matched TDC participants. However, participants with ASD are impaired in their ability to generalize facial emotions across different identities and show a tendency to recognize mouth holistically and perceive the eyes as isolated parts. Results from the *LFI!* Battery have practical implications for designing effective interventions to improve the emotion processing skills of children with ASD (Golan et al., 2010; Tanaka et al., 2010). Our findings suggest that treatment programs should promote the generalization of emotion recognition across a variety of people and social settings. Instruction should cue the child to emotional information conveyed in the eyes and its perceptual integration with information in the whole face. Fostering expression recognition abilities in individuals with ASD should enhance skills in social reciprocity and build confidence and competency in everyday social interactions.

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Key points

- Children with autism spectrum disorder (ASD) have significant deficits in their ability to recognize and interpret facial expressions.
- The cognitive strategies underlying expression recognition in autism have not been well characterized in the literature.
- The *Let's Face It!* Emotion Skills Battery is a computer-based assessment that measures the perceptual and cognitive skills that children use in recognizing facial expressions.
- Children with ASD recognize the basic facial expressions of happy, angry, sad, and disgusted as well as age- and IQ-matched control children.
- In contrast, children with ASD are impaired in their ability to recognize expressions across different people and to encode the eyes in expression recognition.
- These findings suggest treatment approaches for training facial emotion skills in children with ASD.

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