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Children with Autism Spectrum Disorder scan own-race faces differently from other-race faces

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ABSTRACT

It has been well documented that people recognize and scan other-race faces differently from faces of their own race. The current study examined whether this cross-racial difference in face processing found in the typical population also exists in individuals with Autism Spectrum Disorder (ASD). Participants included 5- to 10-year-old children with ASD ($n = 29$), typically developing (TD) children matched on chronological age ($n = 29$), and TD children matched on nonverbal IQ ($n = 29$). Children completed a face recognition task in which they were asked to memorize and recognize both own- and other-race faces while their eye movements were tracked. We found no recognition advantage for own-race faces relative to other-race faces in any of the three groups. However, eye-tracking results indicated that, similar to TD children, children with ASD exhibited a cross-racial face-scanning pattern: they looked at the eyes of other-race faces longer than at those of own-race faces, whereas they looked at

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the mouth of own-race faces longer than at that of other-race faces. The findings suggest that although children with ASD have difficulty with processing some aspects of faces, their ability to process face race information is relatively spared.

Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by sociocommunicative impairments as well as restricted and repetitive interests and behaviors (American Psychiatric Association, 2013). One associated impairment observed in individuals with ASD is their nontypical face processing patterns, specifically inclusive of deficits in face recognition and discrimination that have been extensively reported in the previous literature (e.g., Dawson, Webb, & McPartland, 2005; Klin et al., 1999; Langdell, 1978). In addition to behavioral deficits, nontypical face-scanning patterns in individuals with ASD have been consistently reported in previous eye-tracking studies. That is, individuals with ASD display decreased attention to faces and their major features, especially the eye region, relative to the typical population (e.g., Corden, Chilvers, & Skuse, 2008; Falck-Ytter, 2008; Jones, Carr, & Klin, 2008; Klin & Jones, 2008; Klin, Jones, Schultz, Volkmar, & Cohen, 2002a, 2002b; Pelphrey et al., 2002; Speer, Cook, McMahon, & Clark, 2007; Yi et al., 2013, 2014). The findings of nontypical face processing in ASD, however, have been based only on faces from the same race as the participants. The current study examined whether children with ASD process other-race faces differently from faces of their own race.

A growing body of literature has demonstrated a robust "other-race effect" (ORE) in typically developing (TD) individuals across ages and races (Meissner & Brigham, 2001). That is, observers recognize and discriminate own-race faces more accurately than faces from other racial groups (e.g., Ellis, Deregowski, & Shepherd, 1975; Walker & Tanaka, 2003). The ORE suggests that people's face recognition abilities are shaped by their visual experiences with human faces (e.g., Blais, Jack, Scheepers, Fiset, & Caldara, 2008; Liu et al., 2010; Wheeler et al., 2011).

Studying how individuals with ASD process other-race faces allows us to better understand whether visual experience shapes face processing for nontypical populations in the same way as it does for the typical population, that is, whether individuals with ASD would also show differential processing between own- and other-race faces. One possibility is that individuals with ASD would process own- and other-race faces similarly due to their limited visual experiences with human faces. Alternatively, if there are some aspects of face processing that are spared in individuals with ASD in spite of their limited visual experiences with faces, then individuals with ASD should be sensitive to those aspects of experience and process own- and other-race faces differently, similar to the TD individuals reported in previous studies (Anzures, Quinn, Pascalis, Slater, & Lee, 2013; Anzures et al., 2013).

To date, only three published studies have investigated whether individuals with ASD process other-race faces differently from own-race faces. Using an immediate two-alternative identity-matching paradigm, Wilson, Palermo, Burton, and Brock (2011) found that some children with ASD (i.e., those with age-appropriate face-matching ability) performed like typically developing children and displayed a recognition advantage for own-race faces over other-race faces. However, a subgroup of children with ASD (i.e., those with severely impaired face recognition ability) performed differently from typically developing children and did not exhibit the ORE. Chien, Wang, Chen, Chen, and Chen (2014) and Yi and colleagues (2015) also found no own- over other-race face processing advantage in children and adults with ASD, respectively. In view of the individual differences observed in Wilson and colleagues (2011), and the difference in findings between the sample of children with age-appropriate face-matching ability in Wilson and colleagues (2011) and the sample of children tested by Chien and colleagues (2014), the current study provides another measure of face race processing by examining face-scanning patterns with eye-tracking in addition to the behavioral measurement of the ORE.

The eye-tracking technique goes beyond behavioral performance to explore the microstructure of processing. In typically developing individuals, eye gaze patterns associated with face processing have been shown to be different when scanning own- versus other-race faces in several studies (e.g., Blais et al., 2008; Kelly et al., 2011; Liu et al., 2010; Wheeler et al., 2011). For example, Westerners tend to focus on the eye regions, whereas Chinese observers tend to focus on the central part of faces (e.g., the nose region; Fu, Hu, Wang, Quinn, & Lee, 2012). This nose-centric strategy in Chinese observers may be driven by internalization of Chinese cultural norms, which discourage excessive direct eye contact in face-to-face interaction (Kisilevsky et al., 1998). However, the findings have been contradictory regarding whether this nose-centric scanning pattern in Chinese individuals exists only when viewing own-race faces (Fu et al., 2012; Hu, Wang, Fu, Quinn, & Lee, 2014; Liu et al., 2010) or can be observed for both own- and other-race faces (Blais et al., 2008; Kelly et al., 2011).

Yi and colleagues (2015) examined eye gaze patterns when viewing own- and other-race faces in young adults with ASD and found that, like typical individuals, individuals with ASD also showed cross-racial differences in face-scanning patterns: they looked more at the eyes of Caucasian faces and looked more at the nose and mouth of Chinese faces. Given the previous literature with regard to the processing of face race information by younger child participants with ASD (Chien et al., 2014; Wilson et al., 2011), the current study used eye-tracking to explore the scanning patterns in Chinese children with ASD in the age range from 5 to 10 years, their age-matched TD peers (TD–age), and ability-matched TD children (TD–ability). In a face recognition paradigm, Chinese children were asked to remember a series of Chinese and Caucasian faces and were then asked to recognize these faces while their eye movements were recorded.

Given the prevailing evidence on cross-racial face-scanning patterns in typical Chinese adults, children, and infants (e.g., Fu et al., 2012; Hu et al., 2014; Liu et al., 2010), we expected that children in the TD groups would fixate for a shorter amount of time on the eyes but for a longer amount of time on the nose or mouth of Chinese faces relative to Caucasian faces. For children with ASD, we tested predictions based on the two possibilities outlined above. One possibility is that due to their relatively limited visual experiences with all human faces, even own-race faces, children with ASD would not show significant differences in scanning own- versus other-race faces. Another possibility is that in spite of their limited visual experiences with faces, children with ASD are still sensitive to face race information and, thus, will process own- and other-race faces differently, similar to the differential processing of own- versus other-race faces by TD children.

Method

Participants

Participants, as listed in Table 1, included 29 children with ASD (5.2–10.11 years old, $M = 7.90$, $SD = 1.45$), 29 age-matched TD peers (4.11–10.3 years old, $M = 7.86$, $SD = 1.38$), and 29 ability-matched TD peers (4.4–8.9 years old, $M = 5.74$, $SD = 1.01$). We recruited the ASD group from a special school for ASD in Guangzhou, China. They were examined by experienced clinicians and met the diagnostic criteria for Autism Spectrum Disorder according to the fourth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV; American Psychiatric Association, 2000). The diagnosis was confirmed by using the Chinese version of the Autism Spectrum Quotient: Children's Version (AQ–Child; Auyeung, Baron-Cohen, Wheelwright, & Allison, 2008). TD children were recruited from a typical kindergarten and primary school in Guangzhou, China. One group of TD children was matched to the ASD group by their chronological age, $t(56) = 0.09$, $p = .93$; the other group of TD children was matched with the ASD group by their nonverbal IQ (NVIQ) as measured by the Combined Raven Test (CRT–C2), $t(55) = 0.004$, $p = .997$.

Stimuli and procedure

We used 24 photos of adult female faces as experimental stimuli: 12 Chinese and 12 Caucasian (width: 500 pixels; height: 700 pixels; resolution: 72 pixels/inch). Of the 24 female faces, 6 served

Table 1
Participant characteristics in each group

		n	Male/ Female	Mean age in years (*SD*)	NVIQ[a] raw score (*SD*)	Standardized NVIQ (*SD*)	Autism Quotient (*SD*)
ASD		29	25/4	7.90 (1.45)	22.29 (10.80)	77.93 (20.03)	85.48 (14.90)
TD–Age		29	25/4	7.86 (1.38)	29.90 (9.96)	89.39 (11.11)	62.74 (12.57)
TD–Ability		29	25/4	5.74 (1.01)	22.28 (7.90)	98.27 (9.34)	64.03 (12.21)
Difference (*t* test)	ASD vs. TD–Age	N/A	N/A	0.09	−2.77**	−2.66*	6.15***
	ASD vs. TD–Ability	N/A	N/A	6.56***	0.00	−4.71***	6.00***
	TD–Age vs. TD–Ability	N/A	N/A	6.69***	3.23**	−2.93**	−0.39

[a] IQ was measured by the Combined Raven Test (CRT–C2).
* $p < .05$.
** $p < .01$.
*** $p < .001$.

as study faces and the other 18 were foils (faces not previously shown in the study blocks). All face stimuli were rendered gray and were shown in frontal view, with external features including hair and ears removed. The faces of the two races were selected to match on attractiveness and distinctiveness based on the results of a pilot study using different participants; they were also matched on brightness using Photoshop.

Children were tested individually and presented with a series of face photos. Children were seated approximately 60 cm from the display screen, and their eye movements during picture viewing were recorded with a Tobii T60 eye-tracker (sample rate: 60 Hz). Before the formal experiment, children became familiar with the rules of the task in the practice session with children's faces as sample stimuli. The calibration procedure, conducted with the Tobii five-point calibration program, was considered successful when all five points for the two eyes were caught by the eye-tracker with small error vectors (< 0.5 degrees of visual angle). Following the calibration procedure, each child completed three study blocks and nine test blocks (as shown in Fig. 1B). In each study block, children were asked to view two faces (one Chinese face and one Caucasian face) and to remember them. Each face was presented for 3 s. Each study block was followed by three test blocks in which children were asked to identify whether the face shown was seen before. There were four pictures in each test block: two target faces (balanced in race) that were the same as the faces in the study block and two foil faces (balanced in race) that were not previously shown in the study block. In the test blocks, the face stimuli were presented until participants responded. Feedback was given after each trial, as shown in Fig. 1.

Data analysis

For the eye-tracking data, we predefined five areas of interest (AOIs) in each face stimulus: the whole face, the left eye, the right eye, the nose, and the mouth (see Fig. 1 for examples). Each AOI included the face feature plus 50 pixels of edges, and each AOI was defined individually for each face due to the slight variability in the feature sizes of each face. A constant look at the AOI of more than 100 ms was defined as a fixation. Two fixation indices were computed for each AOI: the total fixation duration and the proportional fixation duration. The total fixation duration was calculated by summing the durations of all fixations within each AOI. The proportional fixation duration was computed by dividing the total fixation time on each AOI by the total fixation time on the whole face (excluding fixations on areas beyond the oval overlaying the face).

Preliminary analyses revealed that the fixation patterns on target faces were highly similar during the familiarization, test, and review trials and that the fixation patterns on foil faces were highly similar during test trials. Thus, we combined all data for the target and foil faces during all phases

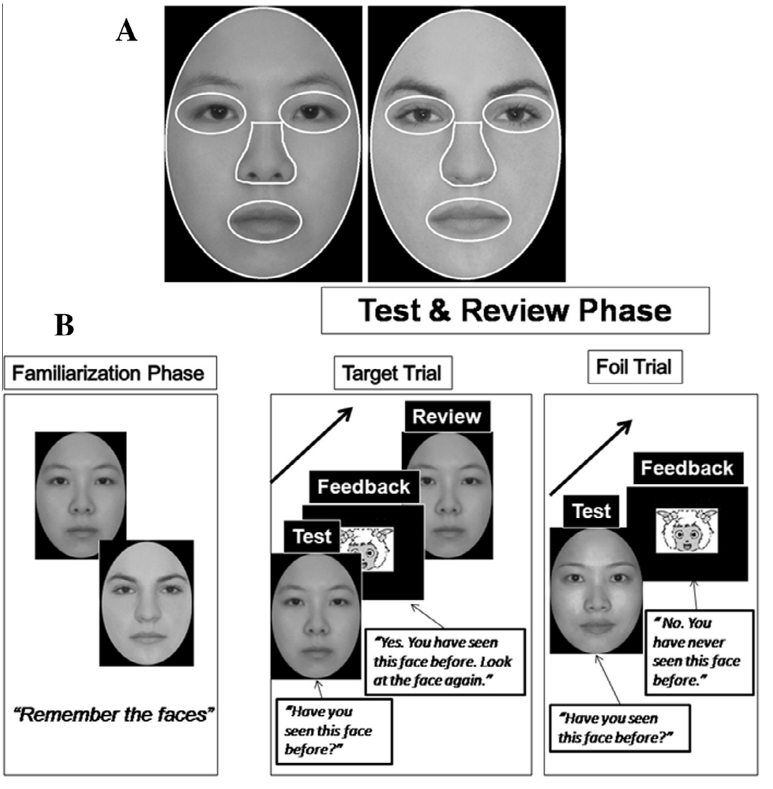

Fig. 1. Own- and other-race sample faces with area of interest (AOI) plots (A) and schematic representation of the experimental design (B).

for subsequent data analysis. To compare differences in accuracy and looking time between groups and races, we conducted mixed-design analyses of variance (ANOVAs) to test the effects of race, group, and their interactions. We also conducted simple effect analyses for the cross-racial difference within each individual group and a priori contrasts to compare the performance of the ASD group with that of the two TD groups, respectively. To control for the possibility of Type I error, we performed the false discovery rate (FDR) procedure for all of the above analyses, with all p values corrected by FDR.

Results

Accuracy

Recognition accuracies (%) for own- and other-race faces by group are listed in Table 2. First, we used one-sample t tests to compare recognition accuracy with chance performance (i.e., 50%) using one-sample t tests. Results showed that for both TD groups, recognition accuracies for both own- and other-race faces were significantly above chance ($ps < .001$). For the ASD group, recognition accuracies for both races did not differ from chance, $t(28) = 1.43$, $p = .16$, $\eta^2 = .07$, and $t(28) = 1.50$, $p = .14$, $\eta^2 = .07$, respectively. We then compared differences between group and race using a 2 (Race: own vs. other) × 3 (Group: ASD vs. TD–age vs. TD–ability) mixed-design ANOVA. Results of the two-way ANOVA showed a group effect, $F(2, 82) = 32.79$, $p < .001$ (corrected by FDR), $\eta^2 = .44$. A priori contrasts showed that the ASD group was less accurate in face recognition than both TD groups,

Table 2
Means (and standard deviations) of accuracy and total and proportional fixation durations by group and race

		ASD		TD–Age		TD–Ability	
		Own-race	Other-race	Own-race	Other-race	Own-Race	Other-race
Behavioral performance	Accuracy (proportion)	.54 (.16)	.54 (.15)	.82 (.13)	.81 (.15)	.70 (.15)	.73 (.13)
Total fixation duration (ms)	Whole face	2443.17 (763.95)	2538.91 (800.68)	2911.28 (584.05)	2907.64 (616.23)	3243.81 (938.95)	3253.29 (919.76)
	Non-face area	645.39 (557.58)	639.11 (479.82)	180.36 (141.61)	190.27 (123.70)	533.20 (285.49)	611.47 (318.37)
Proportional fixation duration	Eyes	.28 (.14)	.33 (.16)	.32 (.16)	.40 (.18)	.32 (0.10)	.37 (0.11)
	Nose	.25 (.09)	.24 (.10)	.26 (.10)	.22 (.11)	.22 (0.09)	.20 (0.08)
	Mouth	.13 (.08)	.11 (.08)	.17 (.10)	.15 (.08)	.12 (0.07)	.09 (0.07)
	Non-feature areas	.35 (.11)	.32 (.13)	.26 (.09)	.23 (.10)	.34 (0.15)	.34 (0.15)

Note. Standard deviations are shown in parentheses.

$p < .001$ (corrected by FDR). No race effect or Race × Group interaction was found, $F(1, 82) = 0.038$, $p = .54$ (corrected by FDR), $\eta^2 = .01$, and $F(2, 82) = 0.68$, $p = .64$ (corrected by FDR), $\eta^2 = .02$, respectively.

Fixation durations

Table 2 lists means and standard deviations for the total fixation duration and the proportional fixation duration within each AOI. We conducted a series of 3 (Group: ASD vs. TD–age vs. TD–ability) × 2 (Race: own vs. other) mixed-design ANOVAs to test the effects of group and race on the total and proportional fixation durations, respectively. Results indicated a significant group effect for the total face fixation duration, $F(2, 84) = 7.30$, $p = .003$ (corrected by FDR), $\eta^2 = .15$. A priori contrasts showed that the ASD group fixated on the face for a significantly shorter period of time than the TD–ability group, $p = .001$, and marginally shorter than the TD–age group, $p = .063$ (corrected by FDR). No race effect or Group × Race interaction was found, $F(1, 84) = 0.62$, $p = .54$ (corrected by FDR), $\eta^2 = .01$, and $F(2, 84) = 0.52$, $p = .60$ (corrected by FDR), $\eta^2 = .01$, respectively. For the total fixation duration on the non-face area, the ANOVA showed a significant group effect, $F(2, 84) = 14.76$, $p < .001$ (corrected by FDR), $\eta^2 = .26$. A priori contrasts revealed that the ASD group looked significantly longer at the non-face area than the TD–age group, $p < .001$ (corrected by FDR); there was no significant difference between the ASD group and the TD–ability group, $p = .44$ (corrected by FDR). No race effect or Group × Race interaction was found for the total fixation duration on the non-face area, $F(1, 84) = 2.15$, $p = .24$ (corrected by FDR), $\eta^2 = .03$, and $F(2, 84) = 1.94$, $p = .19$ (corrected by FDR), $\eta^2 = .04$, respectively.

When combining the proportional fixation durations of both eyes, we found a significant race effect, $F(1, 84) = 81.37$, $p < .001$ (corrected by FDR), $\eta^2 = .49$. Simple effect analyses showed that participants in the ASD, TD–age, and TD–ability groups spent significantly longer fixation time on the eye region of other- than own-race faces, $F(1, 84) = 23.58$, $p < .001$, $F(1, 84) = 42.33$, $p < .001$, and $F(1, 84) = 18.16$, $p < .001$, respectively (corrected by FDR).

For the proportional fixation duration on the nose, we found a significant race effect, $F(1, 84) = 13.78$, $p = .003$ (corrected by FDR), $\eta^2 = .14$. Simple effect analyses showed that the TD–age group looked longer at the nose of own- than other-race faces, $t(1, 84) = 13.01$, $p = .004$ (corrected by FDR); no race effect was found for the ASD group or TD–ability group, $F(1, 84) = 0.63$, $p = .49$, and $F(1, 84) = 4.10$, $p = .12$, respectively (corrected by FDR). There was no group effect, $F(2, 84) = 1.60$, $p = .28$ (corrected by FDR), $\eta^2 = .04$, or Group × Race interaction, $F(2, 84) = 1.98$, $p = .23$ (corrected by FDR), $\eta^2 = .05$.

We also found a race effect on proportional fixation duration on the mouth, $F(1, 84) = 24.10$, $p < .001$ (corrected by FDR), $\eta^2 = .22$. Simple effect analyses showed that the ASD and TD–ability groups spent a

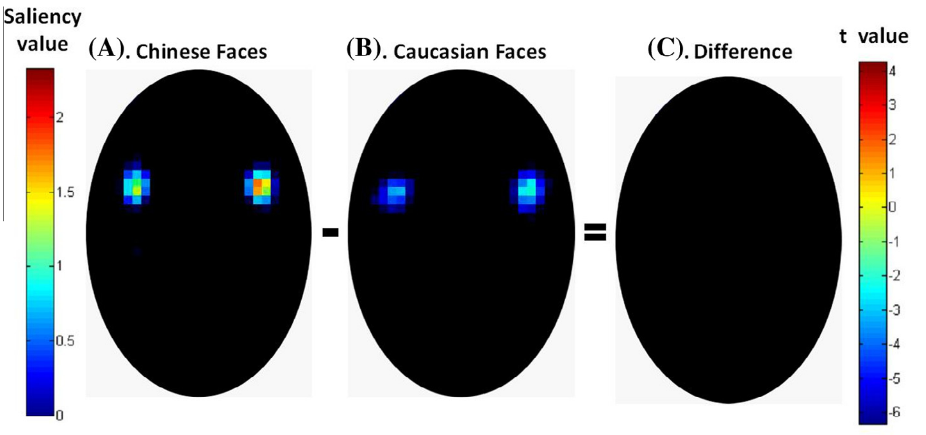

Fig. 2. Mean saliency maps for the Chinese faces (A) and Caucasian faces (B) and the significant difference *t* map (C). The *x* and *y* axes represent the mean horizontal and vertical coordinates of each pixel of the Chinese and Caucasian faces. The colors in panels A and B refer to the mean saliency values of the Chinese and Caucasian faces, with warm colors representing high saliency values and cold colors denoting low saliency values. The colors in panel C represent the *t* values of the differences in salience between the Chinese and Caucasian faces; only significant *t* values are shown. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

longer time looking at the mouth of own- than other-race faces, $F(1, 84) = 7.71$, $p = .019$, and $F(1, 84) = 13.27$, $p < .001$, respectively (corrected by FDR); the TD–age group displayed marginally longer looking time at the mouth of own- than other-race faces, $F(1, 84) = 4.34$, $p = .064$ (corrected by FDR).

Race and group effects on the proportional fixation duration on the non-feature areas of the face were found, $F(1, 84) = 9.22$, $p = .026$ (corrected by FDR), $\eta^2 = .10$, and $F(2, 84) = 5.57$, $p = .021$ (corrected by FDR), $\eta^2 = .12$, respectively. Simple effect analyses revealed that the ASD and TD–age groups fixated longer on the non-feature areas of own- than other-race faces, $F(1, 84) = 6.51$, $p = .026$, and $F(1, 84) = 6.08$, $p = .026$, respectively (corrected by FDR); no cross-racial difference was found for the non-feature looking time in the TD–ability group, $F(1, 84) = 0.06$, $p = .93$ (corrected by FDR). A priori contrasts further showed that the ASD group's looking time on the non-feature areas was longer than that of the TD–age group, $p = .017$ (corrected by FDR), but did not differ from that of the TD–ability group, $p = .85$ (corrected by FDR).

Saliency analysis

We performed a saliency analysis on the face images to rule out the possibility that children's differential viewing patterns to the Chinese and Caucasian face images were due to the saliency differences between the two classes of images rather than the hypotheses we proposed. Thus, we used the Saliency Toolbox (Walther & Koch, 2006) to calculate the saliency value for each pixel in a face image based on a psychologically plausible neural network model. Then, we compared the saliency value between images of Chinese and Caucasian faces for each pixel of the images.

We averaged saliency values of the images to derive mean saliency maps for each race of faces (see Fig. 2A and B), and their saliency differences are shown in Fig. 2C. The saliency analyses revealed similar saliency patterns between Chinese and Caucasian faces; both classes of faces were highly salient in the eye region but not in the nose or mouth region. No significant difference was found between the salience values of Chinese and Caucasian face images.

Discussion

The current study examined whether children with ASD displayed different visual scanning patterns when processing own- and other-race faces. Results from the eye movement analysis indicated that children with ASD exhibited a cross-racial difference in face scanning that has been observed in TD individuals; they tended to look longer at the eyes of Caucasian faces and at the mouth of Chinese faces. These results are consistent with those of Yi and colleagues (2015), who reported similar cross-racial differences in face scanning in young adults with ASD. The findings also confirm previous findings by Fu and colleagues (2012), Hu and colleagues (2014), and Liu and colleagues (2010) with typical Chinese adults, children, and infants. The cross-racial difference in face scanning is not accounted for by the salience difference between Chinese and Caucasian faces given that the salience analysis did not yield any significant difference in the salience of Chinese and Caucasian faces.

The finding that children with ASD display similar cross-racial face-scanning patterns as TD individuals provides evidence that children with ASD are sensitive to experiential differences when scanning own- versus other-race faces. These results are in accord with the suggestion that although children with ASD may show impaired social communication skills, they may process social category information (e.g., race, gender) in ways that are similar to typically developing individuals (Hirschfeld, 2013; Hirschfeld, Bartmess, White, & Frith, 2007).

The current study also examined face recognition accuracy for own- and other-race faces by children with ASD compared with a group of age-matched TD peers and a group of ability-matched TD peers. Two conclusions emerge from the comparisons. First, recognition accuracies for both groups of TD children were above chance level, whereas children with ASD did not perform differently from chance. The performance of children with ASD was less accurate than that of both groups of TD children, which is consistent with previous research reporting impaired face recognition ability in individuals with ASD (e.g., Klin et al., 1999; Langdell, 1978). This finding indicates that although children with ASD are sensitive to face race information as reflected by the eye-tracking data, their face recognition ability is still impaired compared with typically developing children.

Second, an "other-race effect" was not revealed in the behavioral measure of the current study given that all groups recognized own- and other-race faces similarly. As indicated by a meta-analysis by Meissner and Brigham (2001), the size of the ORE may depend on several factors such as characteristics of the face stimuli, the task, and the participants. For example, Caucasian participants tend to display a larger ORE than participants of other races, and identification tasks tend to yield a larger ORE than recognition tasks. Previous studies have also provided varied evidence on the existence of the ORE in ASD (Chien et al., 2014; Wilson et al., 2011; Yi et al., 2015). Such variation may reflect differences in task demands, stimulus types, and participant characteristics used across the studies. In the current study, the face pictures were standardized by balancing overall brightness and luminance and removing all contour information, which may increase the similarity between Chinese and Caucasian faces. In addition, the relatively longer display time for the study faces may attenuate the effect of face race on recognition performance. A congruent absence of a behavioral ORE in typical populations has been reported in previous studies using similar face stimuli and a comparable stimulus presentation duration (Hu et al., 2014; Yi et al., 2015).

It may be of interest to speculate on why children with ASD did not exhibit above-chance performance on their behavioral response on the face recognition task, whereas both TD groups did. Children with ASD may have limited communicative ability to comprehend the task, or they may have poor face memory such that they could not perform well in the task. It is also noteworthy that we recruited a relatively wide range of ages (i.e., 5–10 years) due to difficulties in recruitment of children with ASD, which may affect the results if there are age differences in face processing. Moreover, nuances in experimental manipulations (e.g., types of tasks, display settings) might also have affected the results.

One potential critique of the current study is the lack of a strong diagnostic confirmation of ASD due to the current state of development and use of the Autism Diagnostic Observation Schedule (ADOS) and Autism Diagnostic Interview–Revised (ADI-R) scales with Chinese-speaking populations. We did, however, confirm the ASD diagnosis using the AQ–Child scale. In addition, the Raven test used in the current study as a measure of nonverbal IQ may overestimate the nonverbal abilities of the ASD population and, thus, may be questioned as a matching index (Dawson, Soulières, Gernsbacher, & Mottron, 2007). Future studies should also include a measurement for verbal ability (e.g., Wechsler Intelligence Scale for Children, WISC) because verbal IQ not only is important for understanding verbal instruction and verbal feedback during the task but also could be related to face-scanning patterns such as looking time at the mouth region.

There are several aspects of the current study that should be considered when conducting future research. First, the current study included only ASD and TD Chinese children. The question arises as to whether looking at the other-race eyes and own-race mouth is specific to the Asian population. The role of culture in face processing needs to be factored in when generalizing the conclusions of the current study to other populations. In Asian culture, observers tend to avoid direct eye contact with others, which is viewed as socially inappropriate (Fu et al., 2012; Kisilevsky et al., 1998). A different pattern has been found in Caucasian participants, who look longer at the eyes of both own- and other-race faces compared with Asians who fixate more on the nasal area (Blais et al., 2008). Therefore, future research should include children with ASD and their counterparts from different cultures (e.g., Caucasians) to obtain a more comprehensive understanding of cross-racial differences in face-scanning patterns in ASD. Second, the current study tested only 5- to 10-year-old mid-functioning children with ASD. Future studies should explore face-scanning patterns in own- and other-race faces in children with ASD with a wider age range (e.g., adolescents and younger children) and a broader range of cognitive functioning. Such studies could examine the possibility of age differences in performance. Third, as discussed above, face-scanning patterns in ASD may depend on the type of face stimuli and task. Future research should use faces from additional races and tasks with different demands (e.g., passive viewing, categorizing faces by race or gender). Only through systematic exploration can we gain more comprehensive knowledge of nontypical face processing and social interaction in individuals with ASD.

In conclusion, we have found similar cross-racial differences in the face-scanning patterns of both children with ASD and TD children; all groups spent longer looking time on the eyes of other-race faces than on those of own-race faces and spent shorter looking time on the mouth of other-race faces than on that of own-race faces. However, we did not find an other-race effect in behavioral performance in face recognition for any group. The findings suggest that, similar to TD children, children with ASD are sensitive to face race information in terms of how they scan own- and other-race faces differentially.

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