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Autistic children do not exhibit an own-race advantage as compared to typically developing children

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ABSTRACT

The characteristics of aberrant face processing in individuals with autism spectrum disorder (ASD) have been extensively studied, but the aspect regarding sensitivity to race is relatively unexplored. The present study hypothesized that the magnitude of the other-race effect shall be reduced in individuals with ASD owing to their inattention to faces since infancy. Using a sequential face discrimination task, we tested the other-race effect of 18 ASD (mean age = 7.5 years) and 13 age-matched typically developing (TD) children (mean age = 7.6 years). The stimuli were cropped Asian and African faces, each with four levels of difficulty: *easy* (change identity), *medium* (replaced eyes), *hard-eye* (widen eye spacing), and *hard-mouth* (moved up mouth). The TD children showed a significant own-race advantage such that the best performance was found in the Asian easy condition. The ASD children did not exhibit such advantage at all. Moreover, ASD children showed the highest error rates in the hard-eye condition instead of the hard-mouth condition, indicating insensitivity to eyes region. In sum, our findings support the hypothesis that the other-race effect is reduced in ASD children, reflecting an incomplete development of an expert face system.

1. Introduction

Autism spectrum disorders (ASD) are a group of developmental disorders characterized by impairments in social interactions, communication difficulties, and stereotyped or repetitive behaviors of restricted interests (DSM-V, American Psychiatric Association, 2013). Alongside these core deficits, anomalies in face processing in individuals with ASD have been the focus of intense investigation, as face perception is undoubtedly a very important foundation for normal social development soon after birth (Golarai, Grill-Spector, & Reiss, 2006). Substantial evidence indicated that several aspects of face processing are impaired in autism, including anomalies in gaze processing (Senju, Tojo, Dairoku, & Hasegawa, 2004; Senju, Yaguchi, Tojo, & Hasegawa, 2003), viewing and visual scanning for faces (Osterling, Dawson, & Munson, 2002; Sasson, Reznick, Paul, Goldman, & Piven, 2002; Klin, Jones, Schultz, Volkmar, & Cohen, 2002), and facial identity recognition

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(Gepner, de Gelder, & de Schonen, 1996; Serra et al., 2003; Faja, Aylward, Bernier, & Dawson, 2008; Joseph, Ehrman, McNally, & Keehn, 2008; Wilson, Freeman, Brock, Burton, & Palermo, 2010). If we consider face recognition as a perceptual expertise built based on an innate propensity and with extensive experience soon after birth (Nelson, 2003), the *other-race effect* (ORE), sometimes referred to as the *own-race advantage*, which suggests that people are better at recognizing and remembering faces of their own race as opposed to faces of other races (Meissner & Brigham, 2001), can be a sensitive measure to indicate whether one has become a native face expert.

In adults, ORE has been reliably tested with a variety of ethno-cultural groups (Carroo, 1986; Valentine, Chiroro, & Dixon, 1995; Valentine & Endo, 1992; Hayward, Rhodes, & Schwaninger, 2008). Although the exact mechanisms for ORE remain elusive, it is agreed that our perceptual system is unable to generalize its expertise in processing own-race faces to other-race faces, leading to differential representations for own-race and other-race faces (O'Toole, Deffenbacher, Valentin, & Abdi, 1994; Chiroro & Valentine, 1995). In children, two earliest developmental studies reported an inception of ORE around 6 (Chance, Turner, & Goldstein, 1982) or 8 years old (Feinman & Entwhistle, 1976). Recent studies showed a lowered age about 3–5 (Pezdek, Blandon-Gitlin, & Moore, 2003) and that the effect size seems to increase with age (Sangrigoli & de Schonen, 2004). Recently, de Heering, de Liedekerke, Deboni, and Rossion (2010) tested a group of 6- to 14-year-old Asian children adopted to Western European Caucasian families and a group of age-matched Caucasian children. The latter group showed a strong other-race effect that was rather stable from 6–14 years of age.

Up to date, only one published study examined the other-race effect in children with ASD. Using a two-alternative forced-choice face identity matching task, Wilson, Palermo, Burton, and Brock (2011) reported that both groups of ASD and typically developing (TD) children exhibited a small but significant advantage for recognizing own- over other-race faces. In addition, ASD and TD groups responded similarly to stimulus manipulations (i.e., identical view vs. different view or whole face vs. cropped face), though the variability within the ASD group was large. Further analysis showed that a subgroup of ASD children with impaired face recognition did not perform better in the own-race condition. In short, they concluded that some ASD individuals with age-appropriate face-matching abilities have a normal ORE, while those with severely overall impaired facial identity recognition skills do not exhibit the typical advantage for recognizing own- over other-race faces. However, the latter part of conclusion remains somewhat tentative; caution needs to be taken because the overall accuracy of the impaired subgroup still exhibited a trend in the direction of an own-race advantage.

In the present study, we adopted a similar sequential same/different face discrimination task to investigate the other-race effect in ASD and TD children with two specific goals. First, taking human face recognition proficiency as an expertise built through massive encounters with own-race faces, we hypothesized that the magnitude of the other-race effect shall be much reduced in the ASD group. This is a reasonable hypothesis as many studies suggested that ASD individual's inattention to faces during infancy could impair the development of face recognition skills (Osterling et al., 2002). Thus, we aimed to examine the magnitude of the other-race effect in ASD and TD children with optimal stimulus manipulations. Second, We examined whether ASD children's limitation in discriminating faces of own- and other-race is related to an insensitivity to eyes for it is reported that eyes are the most important features for recognizing identity and other attributes such as emotion, age, and gender (Emery, 2000; Whalen, Kagan, Cook, Davis, & Kim, 2004; Itier & Batty, 2009), and that individuals with ASD spend less time looking at the eyes and more time looking at the mouth than individuals without ASD (Klin et al., 2002; Dalton, Nacewicz, Johnstone, Schaefer, & Gernsbacher, 2005; Jones, Carr, & Klin, 2008; Riby & Hancock, 2009).

To achieve these goals, we implemented several critical stimulus manipulations. First of all, to optimize the stimulus condition for both groups, we adopted cropped faces as both TD and ASD children respond better with the cropped version than the whole face version (Wilson et al., 2011). Second, we extended the presentation time of the target face to 3000 ms to ensure a more complete perceptual encoding. Third, to maximize the other-race effect in the first place, we adopted Asian (own-race) and African (other-race) female faces and conducted the task in two separate blocks. We chose African faces instead of Caucasian faces because in both Kelly et al. (2009) and Hsu and Chien (2011) showed that African faces could induce a greater ORE in Asian participants. Lastly, to reveal whether ASD children's limitation in face processing is related to an insensitivity to eyes region or to a more general deficit in configural processing, we encompassed four levels of difficulty of the test stimuli: *easy* (change identity), *medium* (replace eyes), *hard-eye* (widen eye spacing), and *hard-mouth* (move mouth up) conditions. Relatively worse performances in the *medium* and *hard-eye* conditions in ASD as opposed to TD would be an evidence for insensitivity to eyes region.

2. Methods

2.1. Participants

A total of 31 children (aged between 6 and 10 years), recruited from the Department of Physical Medicine & Rehabilitation, China Medical University Bei-Gang Hospital, participated the study. All participants had normal or corrected-to-normal vision (20/20). The parent's written informed consent and the child's assent were obtained before participation. The experimental procedures were in accordance with the ethical standards of the Regional Research Ethics Center (RREC) and with the Helsinki Declaration of 1975. The ASD group had 18 children who met established criteria for ASD as specified in DSM-IV (American Psychiatric Association, 2006) and were issued with a Handbook of Disabilities in Autism by the Taiwanese Ministry of Health and Welfare. Their diagnoses were conducted at the Center for Joint Assessments of Child

Table 1
Participant group characteristics.

	ASD group ($N = 13$)	TD group ($N = 13$)
Gender (male:female)	10:3	9:4
Mean age (months)	90.8 ±16.9	91.1 ±17.3
Age range (months)	71–117	71–120
Verbal scores	24.3 ±30.0	77.5 ±10.3***

*** $p < 001$.

Development at the St. Joseph's Hospital in Yun-Lin County. Five children in the ASD group were later excluded from the data set due to an inability to complete at least one block of test. The final sample size was 13 (10 boys, 3 girls) with a mean age of 90.8 ± 16.9 (SD) months. The typically developing (TD) group had 13 healthy age- and gender-matched children (9 boys, 4 girls) with a mean age of 91.1 ± 17.3 (SD). All children in the TD group were able to complete at least one block of the test and thus remained in the final data set. Table 1 illustrates the group characteristics. There was no significant difference in chronological age and gender ratio between the two groups. Children's verbal ability was assessed on site upon parental informed consent with the Language Test for The Pre-School Age Children-Revised Scale (LTPSC-R) (Lin, Huang, Huang, & Hsuan, 2008) or Language Test for School Age Children-Revised Scale (LTSC-R) (Lin, Huang, Huang, & Hsuan, 2009). The results of the assessment confirmed that children in the ASD group had significantly lower language scores than those of the TD children.

2.2. Stimuli

The stimuli were color images of Asian (own-race) and African (other-race) female adult faces. The Asian faces were selected from the Taiwanese Facial Expression Image Database, TFEID (Chen & Yen, 2007), while the African faces were from the NimStim Face Stimulus Set (Tottenham et al., 2009). The skin tones of individual faces within the same race were rendered equal to reduce differences in color and luminance by PhotoImpact 10 software (Ulead System, Taipei). In addition, to remove the background and external cues such as hair, hairline and ear, all face images were cropped and framed by an oval-shape window. Each face image was then mounted onto a black background and the stimuli were resized to the same dimensions to ensure uniformity. The oval-shaped faces were about 11.5 cm (width) by 13.5 cm (height) in size, which were about 13.8 by 16.2 degrees of visual angle when viewed at a distance of approximately 50 cm. In each race block, the sequential face discrimination task contained a single target face presented at the center of the screen and a pair of comparison faces, presented side by side with a distance of 15.5 cm in between. In the comparison face pairs, one image was always the same target face paired with one "new" image from one of the four levels of difficulty manipulations: (1) *easy condition*: a new face of a different identity, (2) *medium condition*: the same face with two eyes replaced, and (3) *hard-eye condition*: the same face with eyes spacing widen by 14 pixels (7 pixels for each eye), (4) *hard-mouth condition*: the same face with mouth moved up by 10 pixels. The locations of the new and the old target face images were counterbalanced. The face stimuli are illustrated in Fig. 1.

2.3. Procedures

The experimental program was compiled with E-Prime Professional 2.0 (Psychological Software Tools, Sharpsburg, PA) and run on a 15.6″ inch laptop computer (Acer emachines E732Z). Each participant received two testing blocks, the Asian and the African face conditions, in one visit. The test order was counter-balanced among participants. Each block included 24 trials (i.e., 4 levels of difficulty*2 locations *3 repetitions = 24) presented in random order. Each block took approximately 5–6 min to complete. The participants could take a short break in between blocks. Prior to testing, each child completed

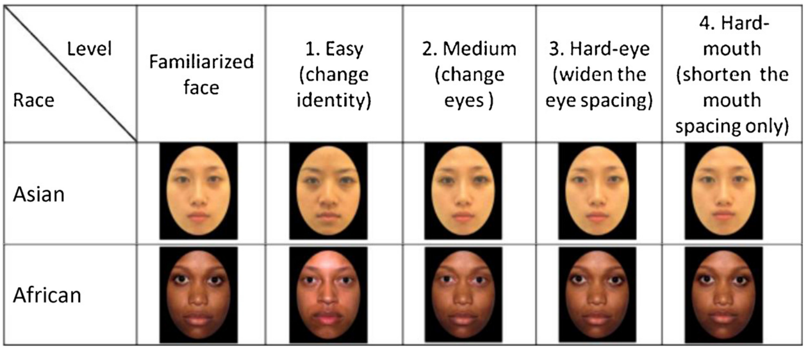

Fig. 1. Sample Asian and African female face images used in the present study.

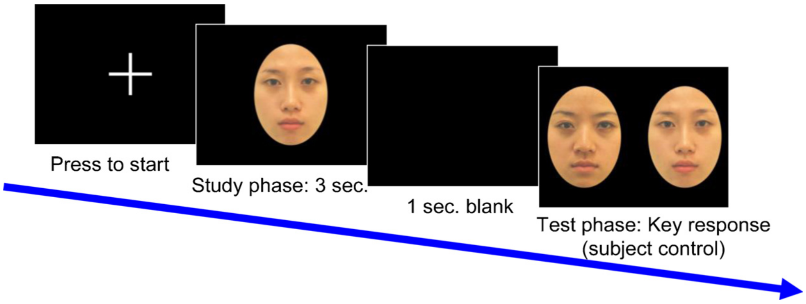

Fig. 2. Illustration of the sequential two-alternative-forced-choice face discrimination task. The example is showing the Asian easy condition.

4 practice trials with images of different Asian (2 trials) and African female faces (2 trials) that were not included in the formal test stimulus set. Feedback was given during the practice trials.

Fig. 2 illustrates the procedure of a sequential two-alternative-forced-choice discrimination trial. Each child sat by himself or herself in front of the laptop monitor at a distance of about 50 cm, and the experimenter sat nearby the child. Each trial started with a large central fixation cross (4 cm × 4 cm), followed by a target face that appeared for 3000 ms to ensure sufficient encoding time for children of both groups. After the target face disappeared, two comparison face images were presented side-by-side after a one-second blank, and the child was asked to select the image that was different from the previous target by key press (i.e., "left" or "right"). Here "different" means not exactly identical. Accuracy rather than speed was encouraged and emphasized to the participants. The pair of comparison face images remained on the screen until the participant made a response; no time limit was enforced. In addition, no feedback was given by the response in a particular trial, but participants were verbally encouraged and praised by the experimenter throughout the task. As soon as a response was made, the fixation cross of the next trial appeared on the screen. The accuracy of each trial was recorded for data analysis.

3. Results

We first conducted a three-way mixed ANOVA in which race (Asian, African) and difficulty (easy, medium, hard-eye, hard-mouth) were the within-subject factors while group (ASD, TD) was the between-subject factor. Averaged across race and difficulty, the mean accuracy for TD children (*M* = 75.95%, *SE* = 1.53%) was slightly higher than that for ASD children (*M* = 72.96%, *SE* = 1.53%), but the group main effect was not significant. Likewise, the mean accuracy for the Asian condition (*M* = 76.12%, *SE* = 1.86%) was slightly higher than that for the African condition (*M* = 72.80%, *SE* = 1.49%) averaged across group and difficulty, but the race main effect was not significant, either.

3.1. Comparing the rank order of difficulty levels in ASD and TD

As we had expected, there was a highly significant main effect of difficulty, $F_{(3,\ 72)} = 99.53$, $p < .001$, $\eta_p^2 = .806$. Moreover, there was a significant interaction between difficulty and group, $F_{(3,\ 72)} = 9.29$, $p < .001$, $\eta_p^2 = .279$, indicating that the rank order or the magnitudes of difference among the four difficulty levels were dissimilar in ASD and TD children. No other two-way or three-way interaction terms reached statistical significance. To further analyze the interaction effect, we first tested the group simple main effects. The TD children outperformed the ASD children in the easy ($p = .017$), medium ($p < .001$), and hard-eye conditions ($p = .002$), whereas the ASD children outperformed the TD children only in the hard-mouth condition ($p = .005$). Thus, compared with the TD group, the ASD group showed worse performance in conditions involving a critical difference in the eyes region. On the contrary, ASD group performed better when the critical difference lies in the mouth region.

The above statement was further supported by testing the difficulty simple main effects. For the TD children, the simple main effect of difficulty was highly significant, $F_{(3,\ 36)} = 137.73$, $p < .001$, $\eta_p^2 = .920$. Further analyses showed that the accuracy in both the easy condition (*M* = 97.43%, *SE* = 1.87%) and the medium condition (*M* = 94.22%, *SE* = 2.37%) was above 90% but the difference between them was not significant, $t(12) = 1.562$, $p = 144$. This is suggesting that TD children performed fairly well in both conditions. Noticeably, the performance dropped drastically (about 30%) in the hard-eye condition (*M* = 60.25%, *SE* = 2.47%) as compared to the medium condition, $t(12) = 14.41$, $p < 001$, and the hard-mouth condition dropped another 10% down to the chance level (*M* = 51.92%, *SE* = 4.33%), $t(12) = 2.44$, $p = .03$. For the ASD children, the simple main effect of difficulty was also significant, $F(3, 36) = 27.28$, $p < .001$, $\eta_p^2 = .695$, but the order of the four difficulty levels was different. The best performance was in the easy condition (*M* = 92.30%, *SE* = 1.87%), followed by the medium condition (*M* = 82.04%, *SE* = 2.37%) with a significant 10% gap in accuracy, $t(12) = 4.99$, $p < 001$. Most interestingly, the order for the two hard conditions was reversed; ASD children actually performed better in the hard-mouth condition (*M* = 66.67%, *SE* = 4.33%) than in the hard-eye condition (*M* = 50.85%, *SE* = 2.47%), $t(12) = 4.64$, $p < 001$. In other words, compared to the TD group, the ASD group could discriminate the test images better when a difference in spacing lies in between the mouth and the nose (i.e., moving mouth up) instead of lies in between the eyes region (i.e. widen eyes).

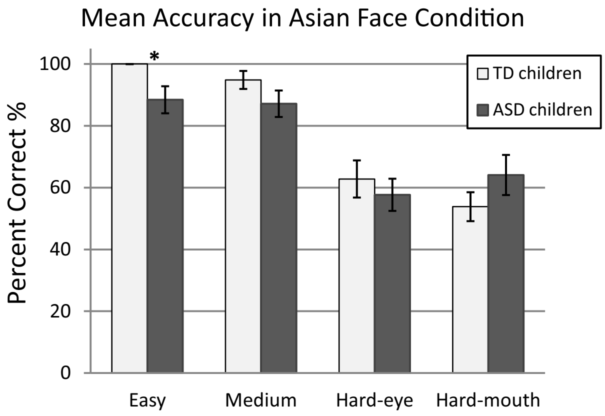

Fig. 3. The group mean accuracies for the own-race (Asian) condition. The abscissa represents the four levels of difficulty and the ordinate depicts the percent correct response (%). Results of the TD and ASD groups are shown in light-gray and dark-gray bars, respectively. The error bars represent the standard errors (±SE) of the group means.

3.2. Comparing ASD and TD's performance for each race and at each difficulty level

One important goal of the present study was to examine how well the ASD and TD children could discriminate own- versus other-race faces at four difficulty levels, and whether ASD children exhibit a reduced other-race effect in certain conditions. Thus, a three-way interaction effect among race, group, and difficulty was expected initially, but the 3-way race*group*difficulty interaction was not significant. Nevertheless, we reasoned that the other-race effect can be subtle and may only exist in a very small fraction of conditions (i.e., easy condition). Thus, to better reveal these possibly subtle effects, we conducted separate sets of two sample independent *t*-tests, assuming unequal variance for TD and ASD, for each race. Fig. 3 illustrates TD and ASD children's performances in the own-race (Asian) block. In the easy condition where the new image was a different person's face, all children in the TD group had a 100% accuracy, indicating that the Asian easy condition was indeed effortless for them. Strikingly, the mean accuracy of the ASD group was only 88.45% (SE = 4.38%), and the difference between the two groups was significant, $t(12) = 2.637$, $p = .022$. The decrease in recognition accuracy suggests that some ASD children might still have problems discriminating two different own-race faces. In the medium condition, the TD group (M = 94.86%, SE = 2.91%) performed slightly better than the ASD group (M = 87.16%, SE = 4.28%), but the difference was not significant. In the hard-eye condition, the TD (M = 62.81%, SE = 6.01%) and ASD (M = 57.69%, SE = 5.21%) groups were about equal. Lastly in the hard-mouth condition, the ASD group (M = 64.10%, SE = 6.49%) was better than the TD group (M = 53.84%, SE = 4.68%) but the difference was not significant. In short, the results in the Asian block alone showed that, TD children did better than the ASD children in the easy condition. Although not significant yet, TD children also showed a tendency of better performance in the medium and hard-eye conditions, while ASD children showed a tendency of better performance in the hard-mouth condition.

Fig. 4 illustrates the group mean accuracies in the other-race (African) block. In the easy condition, both groups performed well; the mean accuracies for TD (M = 94.86%, SE = 2.22%) and ASD (M = 96.15%, SE = 2.77%) were not statistically different. In

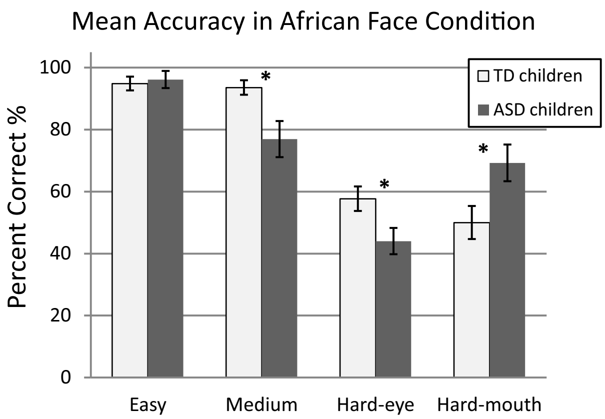

Fig. 4. The group mean accuracies for the other-race (African) condition. The abscissa represents the four levels of difficulty and the ordinate depicts the percent correct response (%). Results of the TD and ASD groups are shown in light-gray and dark-gray bars, respectively. The error bars represent the standard errors (±SE) of the group means.

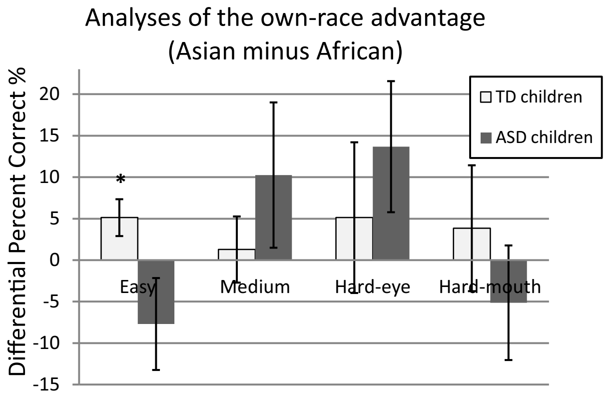

Fig. 5. The differential percent correct scores for both TD and ASD children at each difficulty level. The abscissa represents the four levels of difficulty. The ordinate depicts the differential percent correct score (%). Results of the TD and ASD groups are shown in light-gray and dark-gray bars, respectively. The error bars represent the standard errors (±SE) of the group means.

the medium condition, the TD group (M = 93.57%, SE = 2.34%) performed significantly better than the ASD group (M = 76.92%, SE = 5.83%), $t(12)$ = 2.651, p = .011. In the hard-eye condition, again the TD group (M = 57.68%, SE = 3.96%) was significantly better than the ASD group (M = 44.00%, SE = 4.25%), $t(12)$ = 2.355, p = .027. Lastly, in the hard-mouth condition, the ASD group (M = 69.24%, SE = 5.92%) outperformed the TD group (M = 50.00%, SE = 5.34%), $t(12)$ = 2.413, p = .024. Again, the results in the African block alone showed that, as compared to TD group, the ASD group could discriminate the test images better when the critical difference lies in the mouth area, and that they performed worse when the critical difference lies in the eyes region, regardless of featural (replacing eyes) or configural changes (widen eyes spacing). In addition, they performed equally well in the African easy condition.

3.3. Analyzing the own-race advantage in ASD and TD

Finally, to reveal whether an own-race advantage exist in any given difficulty level and in either group, we computed the *differential percent correct* scores for both TD and ASD children by subtracting their accuracies at the four difficulty levels in the Asian block with the correspondent performances in the African block. As such, a positive value would mean better performance in the Asian block, signifying an own-race advantage at a given difficulty condition. On the other hand, a negative value would mean better performance in the African block, indicating a reversed other-race effect. Values close to zero mean no difference. Fig. 5 illustrates the differential percent correct scores at each difficulty level for both TD and ASD children. As shown in Fig. 5, the TD children showed a tendency of having positive differential scores at all difficulty levels, but only the easy condition (M = 5.13%, SE = 2.22%) was significantly greater than zero, $t(12)$ = 2.221, p = .039. Here we consider that TD children showed an own-race advantage for the easy condition. On the contrary, the ASD children showed a negative differential percent correct scores for the easy (M = −7.69%, SE = 5.54%) condition, but it was not statistically different from zero. Thus, ASD children did not exhibit an own-race advantage for the easy condition as TD children did. Interestingly, ASD children showed positive scores for the medium and hard-eye conditions, and a negative score for the hard-mouth condition, but none of these scores were statistically different from zero.

4. Discussions

Using a sequential same/different face discrimination task with cropped Asian and African female faces and each with four levels of difficulty: *easy* (change identity), *medium* (replaced eyes), *hard-eye* (widen eye spacing), and *hard-mouth* (moved up mouth), we investigated the other-race effect in ASD and TD children aged between 6 and 10 years and obtained three major results. First of all, the TD children exhibited a small but significant own-race advantage (i.e., 5% difference in accuracy) such that the best performance was found in the Asian easy condition, which is consistent with de Heering et al.'s (2010) report that 6- to 14-year-old Caucasian children showed an own-race recognition advantage in favor of Caucasian faces (Caucasian: 73% vs. Asian: 66%, p .184).

Secondly, the ASD children did not exhibited an own-race advantage in the Asian easy condition as compared to the TD children. We hypothesized that the magnitude of the other-race effect shall be reduced in the ASD group, with the rationale that ASD children's inattention to faces during infancy could impair their face recognition skills, leading to an aberrant development of an expert face system optimized for processing own-race faces. Revealed by the differential percept correct scores (Asian minus African) in Fig. 5, the TD group indeed exhibited a significant own-race advantage in the easy condition, but the ASD group did not show such advantage at all. This piece of evidence was supported by an important finding that all children in the TD group were 100% correct in the Asian easy condition,[1] indicating that it was indeed effortless for them to discriminate faces of two own-race individuals. Strikingly, the mean accuracy of the ASD group was only 88.45%. The ASD children did not find it effortless to discriminate two different own-race faces, suggesting that individuals with ASD may be lacking an "expert-like" ability for recognizing faces of their own-race. We consider our results partially replicated Wilson et al. (2011) study. They tested a larger sample of ASD children ($N = 27$) aged between 7 and 16 years and observed a within-group heterogeneity in face recognition ability. Importantly, the subgroup of ASD children who had impaired facial identity recognition ability did not exhibit a typical own-race advantage. Yet, we tested a smaller sample of ASD children ($N = 13$) with a younger mean age, and found that the ASD children group did not show an own-race advantage in the Asian easy condition, which was comparable to the cropped face with identical view condition in Wilson et al. (2011).

Thirdly, studies on face scanning reported that individuals with ASD spend less time looking at the eyes and more time looking at the mouth than individuals without ASD (Klin et al., 2002; Dalton et al., 2005; Jones et al., 2008; Riby & Hancock, 2009). By directly manipulating four levels of difficulty in the face images, we tested whether the ASD group performed worse than the TD groups when the critical differences lied in the eyes region. Indeed, the TD children outperformed the ASD children throughout the easy, medium, and hard-eye conditions, while the ASD children outperformed the TD children in the hard-mouth condition. Moreover, the rank order of task difficulty for TD children was easy $\geq$ medium $>$ hard-eye $>$ hard-mouth condition among which the hard-mouth condition was the most difficult one. This order was consistent with our previous data of adults (Chien, Wang, & Hsu, 2013, July) wherein adults also found it most difficult to detect a spacing difference near the mouth area. However, for ASD children, the order of difficulty was easy $>$ medium $>$ hard-mouth $>$ hard-eye condition; they actually found the hard-eye condition was the most difficult one. Taken together, our results lent support for the previous reports that ASD individuals spend less time looking at the eyes and more time looking at the mouth.

5. Conclusions

The multifaceted task of face recognition is complex and undoubtedly important in everyday living. Convergent evidence from behavioral, electrophysiological, brain imaging and developmental studies provide solid evidence for a highly specialized neural circuit dedicated to native expert face processing and such expertise seems to develop early (Anzures et al., 2013; Slater et al., 2010; Chien & Hsu, 2012). For typically developing children, substantial experience with own-race faces helps fine-tune the system to better discriminate own-race faces than other-race faces in early childhood and beyond. For ASD children, their inattention to faces during infancy could impair face recognition skills, leading to an aberrant development of an expert face system. The present study provides evidence for the absence of own-race advantage in children with ASD, reflecting an incomplete development of an expert face system for own-race faces.

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[1] We tested a group of 22 adults in our previous studies and they also showed 100% correct in the Asian easy condition, just like TD children's performance in the present study (Chien et al., 2013, July).

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