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Exploring the Development of Featural and Configural Face Processing in School-age Children and Its Association with Empathy

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Face perception involves both configural and featural processing. The developmental progression of configural versus featural processing in childhood remains debated. To date, most studies focused on western children; furthermore, the link between face processing and empathy in children is less well-understood. The present study investigated the development of featural and configural processing in Taiwanese children; we also explored the association between individuals' empathy, gender, and their face recognition performance. We tested 33 Taiwanese adults and 72 7- to 12-year-old children. Each participant received an Empathy Quotient (EQ)questionnaire and a computerized face discrimination task, which included four conditions (by altering a featural or a configural information): *change identity, change eyes, widen eye spacing, and move up mouth*. The results showed that (1)the accuracy of the "change identity" was the highest, followed by the "change eyes," the "widen eye spacing," and the "move up mouth" conditions. (2)Girls performed better than boys, but female and male adults were about equal. (3)Adults performed better than children in almost all conditions, except that the 11-12-year-old girls' accuracies on the "change eyes" and the "widen eye spacing" conditions were no different from the adults'. (4)Girls had a higher EQ score than boys, but women and men had similar EQ scores, and the correlations were higher with the Caucasian faces. In sum, our study suggests that in school-age children, girls had higher empathy and better face recognition accuracy than boys; 11-12-year-old girls were particularly mature. Meanwhile, the majority of children still performed significantly worse than the adults, meaning that children's configural and featural face processing continues to improve in adolescence.

Keywords: *configural processing; Empathy Quotient (EQ); face perception; featural processing; school-age children*

Extended Abstract

Unlike the perception of inanimate objects, face perception is unique to human beings. Developmental studies have revealed that newborn infants are attracted to faces or face-like patterns even though their vision is relatively poor (Fantz, 1958; Goren, Sarty, & Wu, 1975; Johnson, Dziurawiec, Ellis, & Morton, 1991; Valenza, Simion, Macchi Cassia, & Umilta, 1996; Turati & Valenza, 2001; Turati, 2004; Chien & Hsu, 2012). Moreover, face recognition not only involves identifying the shapes of individual features (eyes, nose), but also engages the so-called holistic or configural processing capabilities that humans possess to assess the spatial relationships among facial features (Yin, 1969; Carey & Diamond, 1977; Sergent, 1984; Maurer, Grand & Mondloch, 2002). Notwithstanding the impressive face processing abilities of young infants, face recognition capabilities undergo continuous development during the first decade of life. Adult-like expertise in face recognition does not emerge until late childhood. However, the mechanisms underlying such improvements in face recognition abilities remain poorly understood.

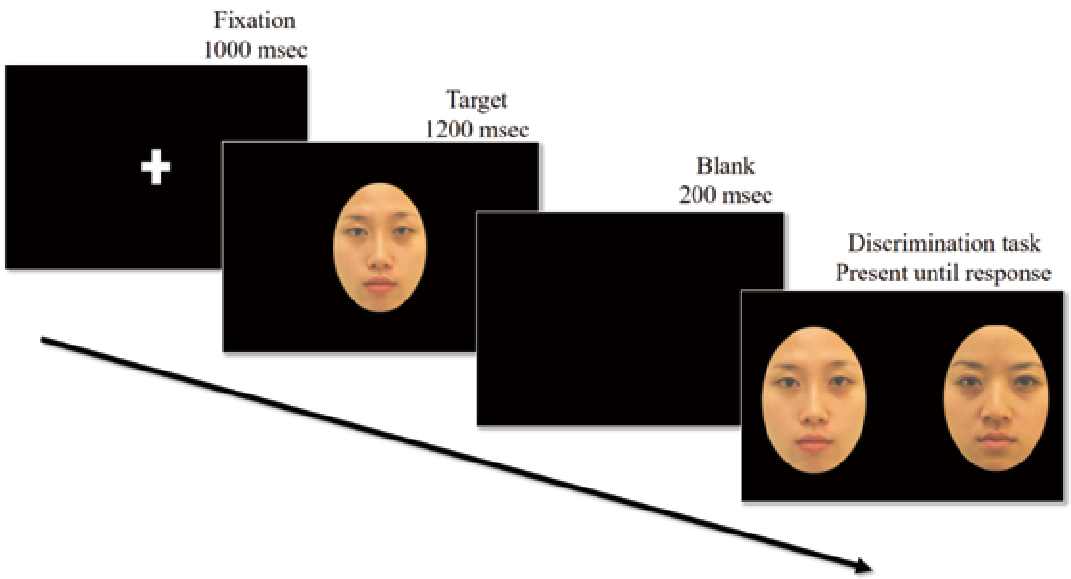
One explanation for age-related changes is differences in the modes of face processing. Young children may preferentially engage featural processing over configural processing, which implies that over time they develop a greater reliance on second-order configural information in faces (i.e., the distance between the eyes and the nose, or the nose and the mouth) (Diamond & Carey, 1977; Mondloch et al., 2002; Schwarzer, 2000). Mondloch et al. (2002) examined the recognition performance of adults and children aged 6, 8, and 10 years for unfamiliar upright and inverted faces. By altering a single face (called "Jane"), the authors created three sets of faces that differed in featural (i.e., the shapes of the features), configural (i.e., the spacing between the features), and contour (i.e., the shape of the external contour) information. They found that children of all age groups performed as well as the adults on the featural and contour stimulus sets. However, younger children performed worse than adults when processing configural information, and inversion only disrupted the recognition of faces in the configural set. More importantly, only 10-year-olds showed a similar inversion effect on the configural set when compared to adults, suggesting that younger children have reduced sensitivity to configural information.

Using the "distinctive face" paradigm developed by Leder and Bruce (1998), Gilchrist and McKone (2003) roposed an opposite viewpoint. They examined recognition memory for faces in 7-year-old children and in adults. Gilchrist and McKone (2003) enhanced the distinctiveness of the target faces either by featural (e.g., making eyebrows bushier) or configural (e.g., shifting the eyes closer together) manipulations. They found that the performance of the children was strikingly similar to that of the adults, regardless of whether the distinctiveness of the target faces was enhanced featurally or configurally. Moreover, in all of the participants, featural information was processed for recognizing upright and inverted faces while configural changes were processed only for upright faces. Based on this evidence, they claimed that children, at least by age 7, are capable of coding spatial relations between facial features. In a follow-up study that used the same paradigm, McKone & Boyer (2006) tested 4-year-old children and reached a similar conclusion. Using the configural change paradigm developed by Tanaka and Sengco (1997), Pellicano, Rhodes, & Peters (2003) investigated the use of configural information for upright and inverted faces by 4- and 5-year-old children. They found that for upright faces, preschoolers and adults recognized target features better when tested in the context of a face with the same configuration as the study face, than when the features were embedded in a face with a new spatial configuration or when the features were presented in isolation. These results suggest that adult-like styles of face processing are present in children from 4 years of age onwards and continue to improve, providing evidence against the hypothesis that configural processing for face recognition develops more slowly than featural processing.

The developmental progression of configural versus featural processing in childhood remains a matter of some debate. To date, most studies have focused on children from western countries, and the link between individual capacity in face processing and empathy level in children has not been well-understood. The current study sought to provide cross-cultural evidence by testing Asian school-aged children; in particular, we investigated the development of featural and configural processing in Taiwanese adults and in children aged between 7 and 12. We also explored the association between empathy, gender, and face recognition performance. Thirty-three adults (17 females; mean age: 22.35 years) and 72 children participated in the study. The children were divided into three age groups, 7-8-year-olds (N = 24; 12 boys), 9-10-year-olds (N = 24; 12 boys), and 11-12-year-olds (N = 24; 12 boys). All of the participants answered an Empathy Quotient (EQ) questionnaire and performed a computerized face discrimination task. For adults, we adopted the Chinese version of the EQ questionnaire, which was developed by Sheh et al. (2011) based on the one developed by Baron-Cohen and Wheelwright (2004) (40 questions). For children, we adopted the Chinese version of the Child EQ questionnaire, as translated by Huang (2015) and based on the original developed by Auyeung et al. (2009) (32 questions). Adults filled in

Figure 1

Illustration of the face discrimination task. The example is showing an Asian female "change-identity" condition



the EQ questionnaire by themselves while parents filled in the Child EQ questionnaire. We found that girls had higher EQ scores than boys (*M* = 25.553, *SE* = 1.326; *M* = 18.405, *SE* = 1.369), but women and men had similar EQ scores (*M* = 44.07, *SE* = 11.38; *M* = 43.31, *SE* = 9.7).

The computerized face discrimination task used four Asian and four Caucasian female faces, selected from the Taiwanese Facial Expression Image Database (TFEID; Chen & Yen, 2007) and the NimStim Face Stimulus Set (Tottenham et al., 2009), respectively, as the stimuli. The face images were presented in the frontal view with a neutral expression, and were oval-cropped to eliminate external cues. We then used Unlead PhotoImpact X3 (Corporation, Canada) to create four stimulus conditions by altering featural or configural information: (1) change identity, (2) change eyes, (3) widen eye spacing, and (4) move up mouth. Figure 1 illustrates a sample trial under the "change identity" condition. Each trial began with a fixation cross (1 s), followed by a single target face (1.2 s), and then a pair of faces, i.e., one target face and one comparison face, side-by-side. Participants had to choose the face that was different from the target face using a keypress. The next trial began after the participant gave a response.

The results showed several important trends, the first of which was gender differences. Among the children, girls had a higher mean accuracy than boys. The mean accuracy for girls and boys in the 7-8-year-old group was 0.670 (*SE* = 0.021) and 0.608 (*SE* = 0.020), respectively; in the 9-10-year-old group it was 0.684 (*SE* = 0.021) and 0.621 (*SE* = 0.021), respectively; and in the 11-12-year-old group it was 0.740 (*SE* = 0.020) and 0.622 (*SE* = 0.022), respectively. Among the adults, however, women (*M* = 0.765, *SE* = 0.018) and men (*M* = 0.753, *SE* = 0.018) performed equally well. Second, the accuracy in the "change identity" condition was the highest (*M* = 0.845, *SE* = 0.013), followed by the "change eyes" (*M* = 0.735, *SE* = 0.012), "widen eye spacing" (*M*= 0.612, *SE*= 0.013), and "move up mouth" (*M* = 0.539, *SE* = 0.013) conditions. Third, adults performed better than children in almost all conditions. The only exception was that the 11-12 year-old girls showed similar accuracies to adults for the "change eyes" and "widen eye spacing" conditions (See Figure 2 lower panel). Finally, girls had higher EQ scores than boys, but women and men had similar EQ scores. The association between EQ scores and face discrimination performance was stronger when Caucasian faces were presented as stimuli.

In conclusion, the present study revealed that in school-aged children, girls had higher empathy and better recognition accuracy than boys; 11-12-year-old girls in particular were more mature in this regard. The majority of children aged 7 to 12 performed significantly worse than the adults when presented with either featural or configural manipulations. Overall, our results suggest that both configural and featural processing can occur during face recognition in early childhood and continues to improve during adolescence. In sum, our findings provide a cross-cultural comparison of the development of featural and configural processing during face perception in Taiwanese school-aged children.

Figure 2

The mean accuracy of males (upper) and females (lower) of all ages with four conditions