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How race and age experiences shape young children's face processing abilities

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ABSTRACT

Despite recent advances in research on race and age biases, the question of how race and age experiences combine to affect young children's face perception remains unexplored. To fill this gap, the current study tested two ethnicities of 3-year-old children using a combined cross-race/cross-age design. Caucasian children with and without older siblings and Mainland Chinese children without older siblings were tested for their ability to discriminate adult and child Caucasian faces as well as adult and child Asian faces in both upright and inverted orientations. Children of both ethnicities manifested an own-race bias, which was confined to adult faces, and an adult face bias, which was confined to own-race faces. Likewise, sibling experience affected Caucasian children's processing of own-race child faces, but this effect did not generalize to other-race faces. Results suggest that race and age information are represented at the same hierarchical level in young children's memory.

Introduction

It is well established that, in adults, discrimination and recognition can be superior for some categories of faces compared with others, giving rise to a number of face processing biases. In fact, human adults are better at processing human faces than non-human animal faces (i.e., own-species bias; see review in Dufour, Pascalis, & Petit, 2006), same-race faces than other-race faces (i.e., own-race bias; see review by Meissner & Brigham, 2001), and adult faces than other-age faces (i.e., own-age bias;

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see review by Rhodes & Anastasi, 2012). Despite recent advances in research on each of these face processing biases, the question of how, or even whether, different biases combine to affect individuals' face perception has been largely neglected by researchers (for exceptions, see Corenblum & Meissner, 2006; Wiese, 2012).

The nature of face processing biases has been interpreted within several theoretical frameworks, all of which share the idea that intergroup contact has some influence on the direction and magnitude of face processing biases. Recent proposals have argued for an integrative framework where both social cognitive variables and perceptual expertise may interact as they both contribute to an individual's motivation to focus on individuating facial characteristics (Hugenberg, Young, Bernstein, & Sacco, 2010; Sporer, 2001; Young, Hugenberg, Bernstein, & Sacco, 2012). Accordingly, recent literature on the own-race bias shows that, in adults, social categorization mechanisms determining the in-group or out-group status of a face, perceiver motivation to individuate in-group faces, and perceiver experience with faces belonging to the relevant category work together to promote the recognition advantage for own-race compared with other-race faces (e.g., Lebrecht, Pierce, Tarr, & Tanaka, 2009; Short & Mondloch, 2010; Young & Hugenberg, 2012).

In particular, adult research has shown that extensive experience with a given face category (e.g., human faces, own-race faces) induces the emergence of perceptual expertise, leading to a well-refined prototype and to enhanced sensitivity to the featural and/or configural cues that differentiate individual faces from the over-experienced category (e.g., Kuefner, Macchi Cassia, Vescovo, & Picozzi, 2010; Mondloch et al., 2010; Tanaka, Kiefer, & Bukach, 2004).

Recent developmental studies have greatly contributed to the interpretation of face processing biases by showing that the developmental trajectory of certain biases is directly related to early environmental exposure to different face types. For example, with regard to the own-race bias, infant studies have shown that 3-month-old infants prefer to look at own-race faces, but only if they are raised in a monoracial environment, and this own-race preference disappears when infants are exposed to faces from different races (Bar-Haim, Ziv, Lamy, & Hodes, 2006; Kelly et al., 2005). Monoracial exposure also leads to a phenomenon known as perceptual narrowing (Nelson, 2001); between 3 and 9 months of age, infants show decreased ability to visually discriminate other-race faces while maintaining the ability to discriminate own-race faces (Kelly et al., 2007, 2009; Spangler et al., 2013) unless during this period (Heron-Delaney et al., 2011), or immediately after (Anzures et al., 2012), they are experimentally exposed to faces of other races.

Studies with children, which—unlike infant studies that primarily rely on looking time measures—have used the same type of tasks and manipulations used to examine adult participants, also show that the direction and magnitude of the own-race bias is related to the racial diversity of children's social environment. Sangrigoli and de Schonen (2004) demonstrated that Caucasian 3-year-old children, just like adults, are most accurate when discriminating between own-race adult faces and show an increased use of expert face processing strategies for these faces compared with other-race faces, as revealed by the size of the inversion effect (Yin, 1969). The inversion effect is a commonly used measure of perceptual expertise (see Maurer, Le Grand, & Mondloch, 2002 for a review) because it is larger for faces and other objects of expertise than for non-face objects for which participants have not developed specific expertise (e.g., Ashworth, Vuong, Rossion, & Tarr, 2008; Diamond & Carey, 1986). Accordingly, the stronger or selective inversion effect observed for own-race versus other-race faces (e.g., Rhodes, Tan, Brake, & Taylor, 1989) and for own-age versus other-age faces (e.g., Kuefner, Macchi Cassia, Picozzi, & Bricolo, 2008) in adults is interpreted as arising from asymmetrical race and age experience. In fact, changes in the proportional size of racial groups occurring as a consequence of cross-cultural adoption during early (de Heering, de Liedekerke, Deboni, & Rossion, 2010) or late (Sangrigoli, Pallier, Argenti, Ventureyra, & de Schonen, 2005) childhood can mitigate or reverse the size of the own-race bias.

With regard to the attribute of age, a recent study showed that infants' discrimination abilities narrow to adult human faces within the same time frame when narrowing to own-race faces occurs; newborn face discrimination decreases between 3 and 9 months of age, whereas adult face discrimination is maintained (Macchi Cassia, Bulf, Quadrelli, & Proietti, 2013). These findings highlight the importance of early perceptual and social experience in shaping infants' face representation, with evidence based on parents' reports showing that infants during the first year of life are more massively engaged in interactions with adult individuals than with individuals of any other age (Rennels & Davis, 2008).

Further evidence for the impact of facial age diversity on early face processing skills comes from studies showing that young children's expertise at processing infant, child, young, and elderly adult faces varies as a function of the predominant age traits of the faces that are present in children's everyday environment. In these studies, 3-year-old children without younger or older siblings were more accurate at discriminating adult faces compared with infant or child faces and showed a selective inversion effect for adult faces. In contrast, children with younger siblings showed comparable discrimination abilities and a generalized inversion effect for adult and infant faces (Macchi Cassia, Kuefner, Picozzi, & Vescovo, 2009; see Macchi Cassia, Proietti, & Pisacane, 2013, for similar evidence from 6-year-old children). Similarly, those with older siblings were equally skilled at processing adult and child faces (Macchi Cassia, Pisacane, & Gava, 2012). Likewise, 3-year-old children with limited experience with elderly people were better at differentiating among young adult faces than among older adult faces, and this bias was reversed in children who, from the time of their birth, had extensive contact with grandparents and other elderly adults. Of particular relevance, contact showed significant correlation with the accuracy of older adult face discrimination and the size of the inversion effect for these faces (Proietti, Pisacane, & Macchi Cassia, 2013). These findings, taken together, suggest that face representation in young children is typically tuned to adult faces (see also Corenblum & Meissner, 2006) and that repeated contact with individuals from other age groups can modulate this early representational bias.

Overall, extant developmental research suggests that, during the first years of life, face representation adapts to represent the most predominant race and age traits of the faces present in the environment, which is reflective of children's specific living conditions and social experience. As a result, by 3 years of age, children manifest adult-like age and race biases, which are often, but not always, in favor of adult faces and own-race faces. One major shortcoming of the current evidence is that it derives entirely from studies conducted with children from one single ethnic group (Caucasians), leaving open the question of whether the over-representation of adult faces from participants' own ethnic group in young children's memory is a universal cross-cultural phenomenon. Indeed, just like adult research, developmental research leaves open the important question of how, or even whether, the effects of differential environmental exposure to faces of various races and ages interact to shape face processing abilities. Individuals' faces provide us with a wide range of simultaneous demographic information. Thus, it is inevitable that differential exposure to faces varying in, say, the attribute of race will also provide critical differential age experience and the reverse.

Evidence from infant research has shown that race experience is more relevant than gender experience in driving infants' attention to faces. In fact, the phenomenon by which 3-month-old, but not newborn, Caucasian infants prefer same-race over other-race faces occurs for both male and female faces (Kelly et al., 2007), whereas the preference for female faces occurs for own-race but not other-race faces (Quinn et al., 2008). This finding is seen as consistent with a hierarchical processing model in which race information is superordinate to and processed before gender information (O'Toole, Peterson, & Deffenbacher, 1996). It is possible that the same model would apply for age as well, with research based on caregiver reports suggesting that the majority of infants' facial experience is with individuals of the same ethnicity, gender, and age as their primary caregiver (Rennels & Davis, 2008). However, differences exist between the characteristics of experience accumulated with faces varying in age versus gender, which may warrant a different model for the relationship between the representation of race and age information in children's representational space for faces.

Although changeable across an individual's life span, age experience may be more stable and motivationally relevant than gender experience, especially during the first years of life when infants are surrounded by adults and are highly motivated to attend to, and engage in interactions with, adult faces. Indeed, it was recently proposed that the essential developmental task of forming attachment relationship with caregivers during the first year of life, which revolves around seeking proximity and perceptually discriminating the primary caregivers from all others, makes adult faces the most socially and emotionally relevant of all faces in an infant's world (Scherf & Scott, 2012; see Macchi Cassia, 2011 for a similar argument). Recent evidence from adult literature has shown that motivational relevance is capable of modulating face-related brain responses (Van Bavel, Packer, & Cunningham,

2011) and face processing biases even when experience is held constant (e.g., Bernstein, Young, & Hugenberg, 2007; Cassidy, Quinn, & Humphreys, 2011). Therefore, it is possible that both perceptual experience and motivational relevance jointly contribute to the setup of a representational bias toward own-race faces during infancy and early childhood, which is specific to adult faces.

To test this hypothesis, in the current study we tested two ethnicities of 3-year-old children using a combined cross-race/cross-age design. Specifically, we compared discrimination and matching abilities for adult and child Caucasian faces as well as for adult and child Asian faces in two groups of Caucasian children (Experiment 1) and a group of Mainland Chinese children (Experiment 2) living in racially homogeneous environments. One group of Caucasian participants included first-born children, and the other group included children who, from their time of birth, had daily exposure to child faces through the presence of older siblings in their home. All Chinese participants in China were the only children in their families due to China's one-child family planning policy. We chose to test Chinese children living in China, rather than American Asian children (e.g., Gaither, Pauker, & Johnson, 2012), because we were interested in studying the combined effects of race and age experiences in children who are all raised in a monoracial environment. Although various studies have tested face perception abilities in monoracial Chinese children living in China (e.g., Ge et al., 2008; Liu et al., 2013), only one of these studies has investigated how Chinese children process own- and other-race faces (Kelly et al., 2011) and none has tested how they process faces of different ages. Because we were interested in assessing children's processing of adult faces with demographic characteristics of the primary caregiver, the adult face stimuli used in the study were images of young female Caucasian and Asian adults and recruiting of participants in the studies was limited to children raised by female primary caregivers in both Italy and Mainland China.

All participants were tested with the same delayed two-alternative forced-choice matching-to-sample task used in earlier studies on age (Macchi Cassia et al., 2009, 2012) and race (Sangrigoli & de Schonen, 2004) biases in 3-year-old children. Participants were instructed to match a briefly presented target face to one of two simultaneously presented test faces appearing shortly after the target. To investigate the effects of experience on perceptual processing strategies adopted by participants in discriminating own- and other-race adult and child faces, we presented the stimuli in both the upright and inverted orientations and measured the size of the inversion effect for the four face types. The inversion effect has been reported to be face specific in children as young as 3 years (Picozzi, Macchi Cassia, Turati, & Vescovo, 2009). Moreover, at this age, like during adulthood, the effect is modulated by asymmetrical race and age experience, being larger for own-race than other-race faces (Sangrigoli & de Schonen, 2004) and for adult than newborn or child faces unless experience with younger or older siblings occurred (Macchi Cassia et al., 2009, 2012). Based on this earlier evidence, we used the size of the inversion effect in the current study as a measure of perceptual learning engendered by experience with own-race adult faces in monoracial Caucasian (Experiment 1) and Chinese (Experiment 2) children without older siblings and with own-race child faces in monoracial Caucasian children with older siblings (Experiment 1).

In light of existing evidence from studies with Caucasian children, and based on the hypothesis that race and age experiences have combined effects on children's face processing abilities, we hypothesized that Caucasian children in the no-sibling group, unlike those in the sibling group, would show a discrimination advantage and a larger or selective inversion effect for own-race adult faces compared with own-race child faces and other-race faces of both ages. We generalized this same prediction to Mainland Chinese children based on the hypothesis that, in these children, perceptual experience and motivational factors related to attachment relationships with adult caregivers would lead to a processing bias toward own-race adult faces not dissimilar to the bias manifested by Caucasian children.

Experiment 1

The aim of Experiment 1 was to determine whether, in 3-year-old Caucasian children, (a) the own-race bias previously reported for adult faces is also present for child faces, (b) the previously reported processing bias toward adult own-race faces is also present for other-race faces, and (c) the effect of experience acquired with an older sibling's face can be generalized to other-race faces. We tested discrimination and matching abilities for Caucasian and Asian adult and child faces in the upright and inverted orientations in two groups of 3-year-old children of Caucasian origins living in a monoracial environment. One group consisted of first-born children (i.e., without older siblings). The other group consisted of children who, from the time of their birth, had daily exposure to at least one child face through the presence of at least one older sibling in their home.

Method

Participants

Participants in this experiment were 18 3-year-old children without older siblings (12 girls and 6 boys, mean age = 3;10 [years;months], range = 3;1–4;6) and 18 children with one or more older siblings (9 girls and 9 boys, mean age = 3;9, range = 3;1–4;5). All participants were Caucasian, reared by a female primary caregiver, and from a middle-class Caucasian European family. All children lived in a primarily Caucasian neighborhood within the city area and attended a racially homogeneous preschool where 100% of the teachers and 88% of the children were of Caucasian origins. To obtain a direct measure of children's racial exposure, parents completed a demographic questionnaire that included specific inquiries aimed at assessing whether their children currently or previously had contact with individuals (e.g., friends, nannies) from other race groups. If the response was positive, parents were asked to specify the racial groups to which the individuals belonged. All children included in the sample had either no contact or only sporadic contact with adults and/or children of non-Caucasian origins, and none of them had any contact with Asian individuals.

All children were attending preschool full-time at the time of testing. All children had started preschool after 3 years of age and had spent 5 to 8 h per day at preschool. The average numbers of months during which children had been attending preschool before being tested were similar for the two groups (no-sibling group: M = 7 months 17 days; sibling group: M = 7 months 22 days). In addition, five children in the no-sibling group and four children in the sibling group had attended day care for at least 6 months before entering preschool. Within the sibling group, two children had two older siblings, two children had three older siblings, and one child had four older siblings. The mean age of the youngest among the older siblings at the time of participants' birth was 3 years 2 months (range = 1;0–4;10). An additional nine children were excluded from the sample due to being distracted during the test.

Materials

Stimuli consisted of 80 grayscale images showing 20 Caucasian and 20 Asian (i.e., Chinese) female adult faces (20–30 years old) and 20 Caucasian and 20 Asian child faces (3–4 years old). All faces were taken from our own database (see Kuefner et al., 2008, for Caucasian faces). No efforts were made to keep gender constant for child faces because biometric and morphometric studies suggest that stable interindividual patterns of sexual dimorphism in facial morphology are not readily apparent during early childhood (Bulygina, Mitteroecker, & Aiello, 2006; Farkas, 1988). Therefore, it is unlikely that, in 3-year-old children, gender acts as a grouping factor driving social categorization processes that have been found to affect face encoding in adults (e.g., Short & Mondloch, 2010). All faces were unfamiliar to the participants and displayed a full-front neutral expression with open eyes. Faces within each age category were normalized to be the same size, pasted on a gray background, and cropped in a standard oval to discourage reliance on salient external features (Fig. 1). To reflect the natural differences in the size and shape of real adult and child faces, adult face stimuli were slightly taller and thinner than child face stimuli. In fact, adult faces subtended a vertical visual angle of 6.04° and a horizontal angle of 4.43° and child faces subtended visual angles of 5.81° × 5.33° when viewed from approximately 40 cm. Faces were presented as grayscale images to facilitate stimulus pairing in light of existing evidence that skin color plays a minor role relative to other facial features in the own-race recognition bias in both adults (Bar-Haim, Saidel, & Yovel, 2009) and infants (Anzures, Pascalis, Quinn, Slater, & Lee, 2011). An attempt was made to pair faces based on subjective criteria of luminance and overall similarity so as to generate 10 pairs for each face type. Inverted stimuli were created by a 180° rotation of each face so that each target and test pair was shown twice: once upright and once in-

Fig. 1. Examples of adult and child Caucasian and adult and child Asian face stimuli used in the study. To reflect the natural differences in the size and shape of real adult and child faces, adult face stimuli were slightly taller and thinner than child face stimuli. When viewed from approximately 40 cm, adult faces subtended a vertical visual angle of 6.04° and a horizontal angle of 4.43° and child faces subtended visual angles of 5.81° × 5.33°.

verted. An additional 16 face images (four for each face type) were used as stimuli in the practice trials.

Procedure

We obtained informed consent from parents of all children. Children provided verbal assent. Each participant completed a two-alternative forced-choice matching-to-sample task. On each trial, a target face appeared in the center of the screen for 5 s, followed by a blank interstimulus interval (1000 ms) and then two probe stimuli, the target face and a novel face, that appeared side by side until the participant responded. Children were instructed to provide their responses either by pointing to the target or by pressing a computer key, and recognition accuracy was recorded as the dependent variable. The experimenter determined the start of the next trial by pressing the mouse. The target face and the two choices appeared in the same orientation. The left or right position of the target and novel faces was counterbalanced across trials. The target and novel status of each face within the test pairs was kept constant across participants, whereas it was counterbalanced across orientations so that each face appeared as the target in the upright orientation and as the novel face in the inverted orientation. Trials from each face race, face age, and orientation condition were presented in blocks, and participants completed one block of 10 trials for each condition (80 total trials). Own- and other-race trials were administered in two sessions separated by a minimum of 1 week, and all participants completed own-race trials in the first session. For each race, upright and inverted trials were also administered in separate sessions, with a mean interval of 2 days. All participants completed the upright trials first, whereas face age was alternated between blocks, with the ages of faces in the first block counterbalanced across participants. At the beginning of each session, children participated in four practice trials (two for each face age) to ensure that they understood the task.

Results and discussion

One-sample *t* tests showed that accuracy was significantly above chance for all upright conditions in both groups ($ps < .05$), whereas it was at chance level for inverted Caucasian ($M = 58.2\%$) and Asian ($M = 54.6\%$) adult faces in the no-sibling group and for inverted Caucasian child faces ($M = 56.4\%$) in the sibling group.

To compare the discrimination performance of children in both groups, a preliminary analysis of variance (ANOVA) was performed with face race (Caucasian or Asian), face age (adult or child), and stimulus orientation (upright or inverted) as within-participants factors, experience group (sibling or no sibling) as the between-participants factor, and participant gender (male or female) as an additional factor. The preliminary ANOVA revealed no significant main effect or interaction involving the factor gender (all $ps > .13$). Therefore, data were collapsed across this factor in the subsequent four-way repeated-measures ANOVA, which revealed a significant interaction among all four factors, $F(1,34) = 20.55$, $p < .001$, $\eta_p^2 = .377$.

To further explore this interaction, separate $2 \times 2 \times 2$ ANOVAs were performed on accuracy data for each sibling group. The analysis on the no-sibling group revealed significant main effects of race and stimulus orientation ($ps < .02$) as well as significant interactions between each of these factors and age ($ps < .02$). Crucially, these two-way interactions were qualified by a significant Face Race × Face Age × Stimulus Orientation interaction, $F(1,17) = 9.85$, $p = .006$, $\eta_p^2 = .367$ (Fig. 2A), indicating that accuracy for adult and child faces in the two stimulus orientation conditions differed for Caucasian and Asian faces. Children without older siblings showed superior discrimination of upright adult faces compared with upright child faces in the own-race Caucasian condition (adult faces $M = 80.7\%$ vs. child faces $M = 61.6\%$), $t(17) = 3.85$, $p = .001$, but not in the other-race Asian condition (upright adult $M = 60.0\%$ vs. upright child $M = 65.6\%$, $p = .154$). Moreover, they were better at discriminating upright adult faces compared with inverted adult faces in the own-race Caucasian condition (upright faces $M = 80.7\%$ vs. inverted faces $M = 58.2\%$), $t(17) = 3.94$, $p = .001$, but not in the other-race Asian condition (upright faces $M = 60.0\%$ vs. inverted faces $M = 54.6\%$, $p = .193$). Finally, they manifested a discrimination advantage for own-race faces compared with other-race faces in the adult upright condition (Caucasian faces $M = 80.7\%$ vs. Asian faces $M = 67.2\%$), $t(17) = 4.02$, $p = .001$, but not in the child upright condition (Caucasian faces $M = 61.6\%$ vs. Asian faces $M = 65.6\%$, $p = .331$).

The ANOVA performed on the sibling group revealed significant main effects of face race, face age, and stimulus orientation (all $ps < .05$) as well a significant Face Race × Stimulus Orientation interaction, $F(1,17) = 5.90$, $p = .027$, $\eta_p^2 = .258$ (Fig. 2B). Unlike first-born children, those with older siblings did not show any discrimination advantage for upright adult faces compared with upright child faces in either of the two face race conditions ($ps > .37$). Moreover, they showed a generalized inversion effect for both Caucasian adult faces (upright $M = 79\%$ vs. inverted $M = 59.8\%$), $t(17) = 3.89$, $p = .001$, and Caucasian child faces (upright $M = 74.3\%$ vs. inverted $M = 56.4\%$), $t(17) = 4.65$, $p < .001$, but not for Asian adult or Asian child faces ($ps > .46$). Finally, children with older siblings manifested a discrimination advantage for own-race faces compared with other-race faces, which was marginal for upright adult faces (Caucasian faces $M = 79\%$ vs. Asian faces $M = 67.2\%$), $t(17) = 2.06$, $p = .055$, and significant for upright child faces (Caucasian faces $M = 74.3\%$ vs. Asian faces $M = 61.1\%$), $t(17) = 2.67$, $p = .016$. Between-group comparisons revealed that children in the sibling group performed 12.8% better than children in the no-sibling group at discriminating upright own-race child faces, $t(34) = 2.48$, $p = .018$, with all other comparisons being nonsignificant ($ps > .10$).

Overall, results showed that, when presented with own-race Caucasian faces, Caucasian children in the no-sibling group manifested a selective inversion effect and a discrimination advantage for adult faces compared with child faces, whereas children in the sibling group exhibited similar discrimination abilities and inversion effects of comparable magnitude for both adult and child faces. Crucially, when children in both groups were presented with Asian faces, neither face age nor stimulus orientation affected their performance. Moreover, although children in both groups manifested a discrimination advantage for Caucasian adult faces over Asian adult faces, for children in the sibling group the own-race advantage was also apparent for child faces.

Results for the no-sibling group replicated and extended earlier findings of an own-race bias (Sangrigoli & de Schonen, 2004) and a processing bias toward adult faces (Macchi Cassia et al., 2009, 2012;

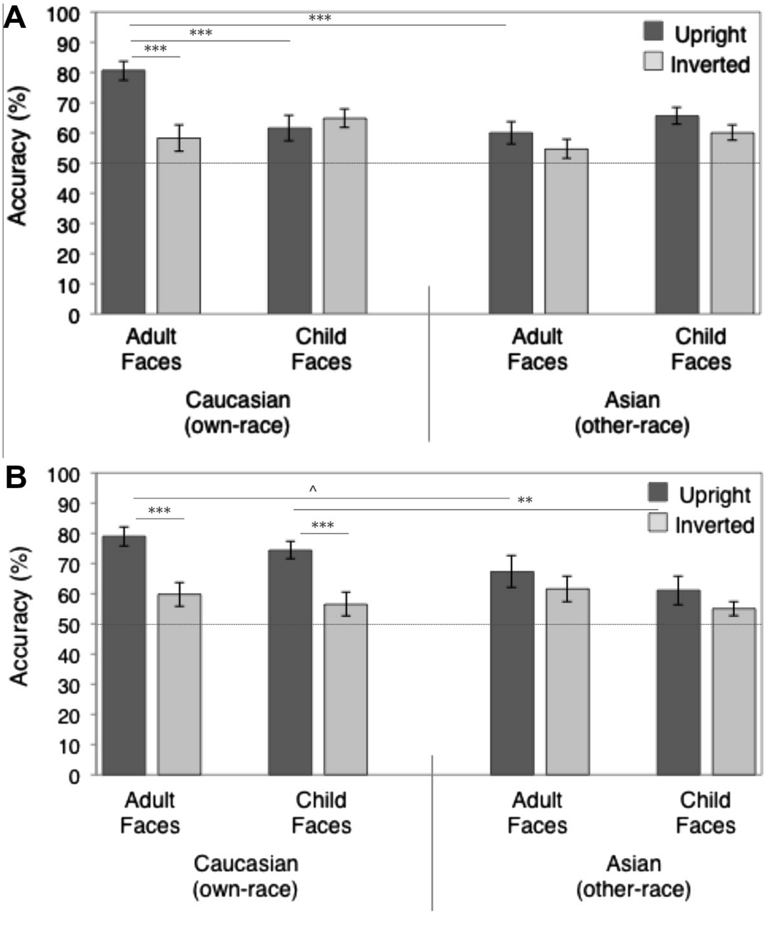

Fig. 2. Mean recognition accuracy rates for Caucasian own-race and Asian other-race adult and child faces in the upright and inverted orientations shown by Caucasian children without older siblings (A) and Caucasian children with older siblings (B) in Experiment 1. Error bars represent standard errors of the means. $^{\wedge}p = .055$; $^{**}p < .05$; $^{***}p \leqslant .001$.

Proietti et al., 2013) in Caucasian 3-year-old children, showing that at this age the race bias is specific to adult faces and the age bias is specific to own-race faces. Likewise, the comparison between the performance of children in the sibling group and that of children in the no-sibling group extended earlier evidence for the effect of sibling experience to other-race faces. While confirming earlier demonstrations that sibling experience improves Caucasian children's ability to process own-race child faces (Macchi Cassia et al., 2012), our results provided the first demonstration that Caucasian children do not generalize perceptual learning engendered by sibling experience to Asian child faces.

Because Caucasian children tested in this study were raised in a highly homogeneous monoracial environment, obtained results can be taken as suggesting that young children's face processing abilities are influenced by the amount of differential experience they have accumulated with own-race individuals of various ages. In particular, evidence for a generalized own-race bias for adult and child faces in children with older siblings provides compelling evidence that the bias is driven by discrepancies in the amount of differential experience that children have with adult and child faces from their own ethnic group versus other ethnic groups.

In Experiment 2, we further explored the role of differential race and age experiences in driving processing biases toward own-race adult faces by testing a group of Chinese children without older siblings. Should our results show a reversed bias toward own-race adult faces in Chinese children, it would rule out the possibility that differences in stimuli characteristics, and not the amount of differential experience, are responsible for the age and race effects exhibited by Caucasian children in Experiment 1. Moreover, the possibility exists that order effects have contributed to the discrimination advantage for own-race adult faces manifested by Caucasian children in Experiment 1 given that all children were tested with own-race faces in the first testing session and with other-race faces in the second session. Although the two sessions were separated by a minimum of 1 week, which excludes the intervention of fatigue effects, it is still possible that motivational factors affected children's performance in the two sessions by modulating their engagement in the task. To explore the possibility that order effects may have influenced the performance of Caucasian children with own- and other-race faces, in Experiment 2 the order of the own- and other-race trial blocks was counterbalanced between participants.

Experiment 2

Method

Participants

The sample consisted of 28 children without older siblings (14 girls and 14 boys, mean age = 3;7, range = 3;3–4;0). All were native Chinese, reared by female primary caregivers, and living in a primarily Chinese, racially homogeneous city in the southwestern interior region of Mainland China. They were attending preschool full-time at the time of testing, spending 5 to 8 h per day at a local preschool where all of the teachers and children were Chinese. According to parental and teacher reports, none of the participants had direct contact with other-race individuals. An additional nine children were excluded from the sample due to being distracted and uncooperative during testing.

Stimuli and procedure

The stimuli and procedure were the same as in Experiment 1, with the only exception being that in the first testing session face race was counterbalanced between participants.

Results and discussion

One-sample *t* tests confirmed that accuracy rates were significantly above chance in all conditions ($ps < .01$). A preliminary ANOVA showed no significant main effects or interactions with participant gender and order (all $ps > .16$); thus, the analysis was collapsed across these variables. A 2 (Face Race: Caucasian or Asian) × 2 (Face Age: adult or child) × 2 (Stimulus Orientation: upright or inverted) ANOVA revealed a significant interaction between the factors race and age, $F(1,27) = 8.72$, $p = .006$, $\eta_p^2 = .244$, as well as a significant Race × Age × Stimulus Orientation interaction, $F(1,27) = 4.46$, $p = .041$, $\eta_p^2 = .146$ (Fig. 3). All other main effects and interactions were nonsignificant ($ps > .08$). Chinese children were more accurate at discriminating upright adult faces compared with upright child faces in the own-race Asian condition (adult faces $M = 73.6\%$ vs. child faces $M = 59.3\%$), $t(27) = 4.17$, $p < .001$, but not in the other-race Caucasian condition (adult faces $M = 61.6\%$ vs. child faces $M = 65.9\%$, $p = .231$). Moreover, they were better at discriminating upright faces compared with inverted faces in the Asian adult face condition (upright faces $M = 73.6\%$ vs. inverted faces $M = 62.1\%$), $t(27) = 2.83$, $p = .009$, but not in the Asian child condition (upright faces $M = 59.3\%$ vs. inverted faces $M = 62.5\%$, $p = .431$) or the Caucasian adult condition (upright faces $M = 61.6\%$ vs. inverted faces $M = 61.1\%$, $p = .902$). Finally, Chinese children manifested a discrimination advantage for own-race faces compared with other-race faces in the adult upright condition (Asian faces $M = 73.6\%$ vs. Caucasian faces $M = 61.6\%$), $t(27) = 2.82$, $p = .009$, but not in the child upright condition (Asian faces $M = 59.3\%$ vs. Caucasian faces $M = 65.9\%$, $p = .177$).

Because the primary question of the current study concerned the comparison between the effects of age experience and those of race experience in Caucasian and Chinese children, data from Experiment 2 were compared with those from Caucasian children in the no-sibling group of Experiment 1

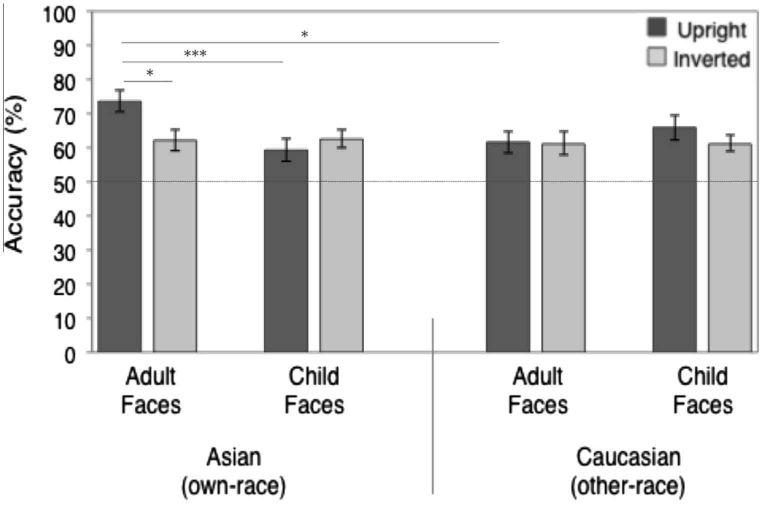

Fig. 3. Mean discrimination accuracy rates for Asian own-race and Caucasian other-race adult and child faces in the upright and inverted orientations shown by Asian children in Experiment 2. Error bars represent standard errors of the means. $^{*}p < .01$; $^{***}p \leqslant .001$.

through a four-way ANOVA with face race, face age, and stimulus orientation as within-participants factors and children's ethnic group as the between-participants factor. The analysis revealed a significant interaction among all factors, $F(1,44) = 12.14$, $p = .001$, $\eta_p^2 = .216$, confirming that the processing advantage for upright adult faces was modulated by face race in opposite directions for Chinese children and Caucasian children. Between-groups comparisons revealed that Chinese children performed 13.57% better than Caucasian children at discriminating upright Asian adult faces, $t(44) = 2.79$, $p = .008$, whereas Caucasian children performed 19.1% better than Chinese children at discriminating upright Caucasian adult faces, $t(44) = 3.87$, $p < .001$. All other comparisons were nonsignificant ($ps > .11$).

Overall, unlike Caucasian children in Experiment 1, Chinese children performed better at discriminating upright adult faces compared with upright child faces when presented with Asian (own-race) faces and showed an inversion effect for Asian adult faces but not for Asian child faces. In contrast, neither face age nor stimulus orientation affected Chinese children's performance with Caucasian faces.

Therefore, just like monoracial Caucasian children in the no-sibling group of Experiment 1, monoracial Chinese children without siblings in the current experiment manifested a processing bias toward adult faces, which was confined to own-race faces, and an own-race bias, which was confined to adult faces. Importantly, because order of the own- and other-race trial blocks was counterbalanced between Chinese participants and no order effects emerged, results of Experiment 2 confirm that order was not a confound in the results of Experiment 1 either, where all Caucasian participants were tested with own-race faces first.

Of note, for both Chinese and Caucasian children without siblings, own-race adult faces were not only more easily discriminated but also more configurally processed compared with own-race child faces and other-race faces of both ages, as shown by the inversion effect being significant for adult faces of children's own ethnicity and nonsignificant for all of the other conditions. Nonetheless, the argument could be made that a possible restriction of range issue has intervened in driving the finding of a selective inversion effect for own-race adult faces in both Experiments 1 and 2. Indeed, like in the majority of previous studies investigating face processing biases in adults and children (e.g., de Heering & Rossion, 2008; Hancock & Rhodes, 2008; Kuefner et al., 2008; Macchi Cassia et al., 2009; Sangrigoli & de Schonen, 2004), in neither of the two experiments did we match performance for the upright conditions so that the sizes of the inversion effects have been calculated with respect to different baselines. There is evidence that matching performance for the upright stimuli can provide enough room for inversion effects to emerge (e.g., Crookes & McKone, 2009), and future investigations might attempt to determine whether inversion effects for faces of different races and/or ages might obtain when upright faces were equally easy to discriminate. Nevertheless, it should be noted that children's performance in the current study was significantly above chance for all upright conditions in all groups (*ps* < .05), making it unlikely that the absence of inversion effects for own-race child faces as well as for other-race adult and child faces in Chinese and Caucasian children without older siblings resulted entirely from floor effects in children's performance.

On the whole, results of Experiment 2 replicate and extend those of Experiment 1, showing that race and age experiences have combined effects on Chinese children's face perception abilities that are not dissimilar to those observed in Caucasian children.

General discussion

Faces provide us simultaneously with a variety of demographic information so that differential exposure along one facial dimension provides critical experience along other dimensions as well. Yet, the effects of experience with different facial dimensions on face processing abilities have been almost always examined in isolation, especially in children. In the current study we explored how race and age experiences combine to affect perceptual learning and face perception abilities during early childhood by testing the ability of monoracial 3-year-old children from two ethnicities to process and discriminate same- and other-race adult and child faces.

Both Caucasian and Chinese children without older siblings showed a processing bias toward own-race faces, as well as a bias toward adult faces. Crucially, however, for both ethnicities the race bias was confined to adult faces and the age bias was confined to own-race faces. The finding of a crossover interaction, with Asian upright adult faces discriminated more efficiently by Chinese children and the opposite result occurring for Caucasian children without older siblings, provides direct evidence that experiential factors, rather than characteristics intrinsic to the stimulus material, drive the race and age effects exhibited by children of both ethnicities. Given that children in the current study had extensive exposure to members of their own race and very little exposure to racial out-group members, results are consistent with claims that early experience with own-race faces promotes perceptual expertise and learning of identity-diagnostic characteristics of these faces (e.g., Ferguson, Kulkofsky, Cashon, & Casasola, 2009; Gaither et al., 2012; Sangrigoli & de Schonen, 2004).

By providing cross-race evidence for the processing bias toward adult faces in children without siblings, the current study is the first to demonstrate that the over-representation of own-race adult faces in young children's face processing system is a cross-cultural phenomenon. For Caucasian children, there is converging evidence that interactions with the primary caregiver and other individuals with demographic characteristics of the caregiver provide massive facial experience that shapes infants' face processing abilities during the first year of life (Kelly et al., 2007; Macchi Cassia et al., 2013; Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002; Quinn et al., 2008; Rennels & Davis, 2008). Accordingly, results from Experiment 1 add to earlier demonstrations that Caucasian female adult faces are processed more efficiently than other-age faces by 3-year-old children reared by female primary caregivers (Macchi Cassia et al., 2009, 2012; Proietti et al., 2013). It could be interesting for future research to determine whether a similar processing advantage is apparent for male adult faces in children reared by male caregivers.

Direct evidence concerning the structure of infants' facial experience and its influence on early abilities to process different facial dimensions is not available for Chinese children, and future studies should aim to fill this gap in the literature. There is some evidence that cultural norms may contribute to the shaping of face processing abilities from very early in development. For example, eye-tracking studies have shown that 7- to 12-year-old children of Chinese and Caucasian origins, just like adults from the same ethnicities, adopt differential scanning strategies in exploring own- and other-race faces, possibly as a result of gradual learning of culture-specific norms governing mutual gaze during social interaction (Fu, Hu, Wang, Quinn, & Lee, 2012; Kelly et al., 2011). Recent evidence suggests that this difference may emerge as early as infancy due to cross-cultural differences in face-to-face interactions between parents and infants (Liu et al., 2011; Wheeler et al., 2011). Evidence from the current study provides some insight into this topic, suggesting that the structure of age and race experience during the first years of life and the effects of this experience on children's face perception abilities are similar across Chinese and Caucasian ethnicities.

Another critical finding from the current study is the difference in performance between Caucasian children in the sibling and no-sibling groups, which replicated earlier demonstrations of the effects of sibling experience on 3-year-old children's processing of own-race faces (Macchi Cassia et al., 2009, 2012) and extended this evidence to other-race faces. In fact, the current study is the first to compare the effects of perceptual learning engendered by sibling experience on children's ability to process own-race faces versus other-race faces. As for the processing of own-race faces, results replicated earlier demonstrations (Macchi Cassia et al., 2012) that, unlike children without siblings, those who had at least one older sibling are equally good at processing and discriminating adult and child faces from their same ethnicity, showing no sign of perceptual bias toward adult faces. Given that children in both the sibling and no-sibling groups attended preschool for equal amounts of time and had equal potential exposure to other children's faces, these findings are consistent with earlier interpretations that continuous daily experience with the sibling's face allowed the child to bootstrap perceptual learning of own-race child faces (see Macchi Cassia et al., 2012, 2013). Of note, the extent to which the effects of perceptual learning engendered by sibling experience are specific to the sibling's face age group or can be generalized to child faces of different ages has yet to be determined. In the current study, like in earlier investigations on the same topic (Macchi Cassia et al., 2012, 2013), the age of the older sibling at the time of the participant's birth (*M* = 3 years 2 months) was roughly matched to the age of the child faces that children were asked to discriminate (i.e., 3–4 years). It is an open question whether children's processing of child faces would benefit from sibling experience in the same way as in the current study if the sibling's age and the age of face stimuli are not matched.

It is important to note that, in addition to experiential factors, motivational mechanisms also may have contributed to the improved processing of child faces in children with older siblings. Indeed, it is possible that the motivational relevance of the sibling's face played a crucial role in boosting perceptual learning of the critical features of child faces up to the point of allowing children to generalize perceptual expertise to new child identities. The contribution of experiential and motivational mechanisms to the effects of sibling experience are hard to disentangle, and in accord with most recent theoretical accounts of face processing biases (e.g., Hugenberg et al., 2010; Sporer, 2001), they are most likely to be inherently interconnected. In any case, the critical finding emerging from the current study is that the effects of perceptual learning engendered by sibling experience affected the processing of own-race child faces but were not transferred to other-race faces. This is consistent with the finding provided by Caucasian and Chinese children without siblings that the processing advantage for adult over child faces was confined to faces of the participants' own ethnicity and was not generalized to other-race faces.

The lack of transfer of age experience to other-race faces resonates with the observation that Caucasian infants do not generalize their gender experiences to other-race faces. Quinn et al. (2002) demonstrated that 3-month-old infants raised by female Caucasian caregivers displayed a preference for female over male faces. However, this preferential response was apparent when the faces were Caucasian but not when they were Asian (Quinn et al., 2008). In light of the earlier demonstration that infants' preference for own-race faces occurred for both male and female faces (Kelly et al., 2007), these findings were interpreted as evidence indicating that race information is superordinate to gender information in triggering infants' attention. In fact, this pattern of findings suggests not only that the effect of gender on infants' visual preference is interrupted by other-race faces but also that the effects of race and age operate independently, as predicted by models that assume that different social signals in faces are processed by independent systems (e.g., Bruce & Young, 1986).

Of course, there are important potential differences between face preference and face recognition/matching abilities, which makes the results of the current study not necessarily inconsistent with those emerging from infant studies on the effects of race and gender experience. Nevertheless, the current results suggest a different picture for the relation between race and age information. In fact, our findings show that age experience was not generalized to other-race faces and also that race experience was not generalized to non-adult faces given that the own-race bias occurred only for adult faces in both Caucasian and Chinese children without older siblings. It has been scarcely investigated just how race and age experiences interact and affect face processing abilities in adults. However, one recent study showed increased recognition memory for own-race/own-age faces in Caucasian adults tested with both younger and older Caucasian and Asian adult faces (Wiese, 2012). These findings resemble very closely the results we obtained with children in the current study, suggesting that the face attributes of race and age are represented in a similar way in children's and adults' memory. Specifically, contrary to what has been proposed for gender, race and age seem to be represented at the same hierarchical level in adults' and children's representational space for faces.

Certainly, future studies are needed to evaluate this possibility more fully. Evidence from adaptation studies shows that adults maintain different perceptual norms for visually distinct categories of faces such as faces of different species, races, genders, and ages (e.g., Jaquet, Rhodes, & Hayward, 2007; Little, DeBruine, Jones, & Waitt, 2008; Schweinberger et al., 2010). Although the current picture emerging from developmental studies is that children represent faces in a multidimensional representational space that has some adult-like properties from at least 4 years of age onward (e.g., Jeffery, Read, & Rhodes, 2013; Jeffery et al., 2011; see review by Jeffery & Rhodes, 2011), there is only one study suggesting that 8-year-olds, and possibly even 5-year-olds, maintain category-specific norms, or prototypes, for faces of different races (Short, Hatry, & Mondloch, 2011). However, because race is a stable characteristic of a face, whereas age slowly but continually changes, differences between characteristics of race and age experience warrant more research to explore whether younger children possess age-specific face prototypes like adults or whether they represent faces of different ages as deviations from a unique norm built on experience with adult faces.

Overall, results from the current study extend the literature on race and age biases in young children in various ways. First, they provide the first cross-race evidence for an own-race bias in 3-year-old children. Second, they provide the first demonstration of a processing bias toward own-race adult (over non-adult) faces in non-Caucasian children, thereby showing that the over-representation of adult faces in young children's face space is a cross-cultural phenomenon. Third, they add to earlier demonstrations of the effects of sibling experience on children's face processing skills, providing the first evidence that the effects of such experience do not transfer to other-race faces. Together, these results provide an important contribution to our understanding of how the structure of early facial experience affects face perception abilities, suggesting that face representation of young children is shaped by the regularity with which specific race and age traits co-occur within the facial environment during the first 2 or 3 years of life.

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