Development of the other-race effect in Malaysian-Chinese infants

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Abstract

Little is known about how infants born and raised in a multiracial environment process own- and other-race faces. We investigated face recognition of 3- to 4-month-old (N = 36) and 8- to 9-month-old (N = 38) Chinese infants from Kuala Lumpur, Malaysia, a population that is considered multiracial, using female and male faces that are of infants' own-race (Chinese), experienced other-race (Malay) and less experienced other-race (Caucasian-White). Three- to 4-month-olds recognised own-race female faces, whereas 8- to 9-month-olds also recognised experienced other-race female faces (Malay) in addition to own-race female faces (Chinese). Furthermore, infants from this population did not show recognition for male faces at any age. This contrasts with 8- to 9-month-old British-White infants (Tham, Bremner, & Hay, 2015), a group that is considered single-race, who recognised female and male own-race faces. It appears that for infants born and raised in a multiracial environment, there is a developmental shift from a female based own-race recognition advantage to a female based own and experienced other-race advantage that may relate to infants' social and caregiving experiences.

Keywords: the other-race effect, face perception, infants, multiracial population

Infants have been shown to be sensitive to differential experience with own- and other-race faces. For example, at a very early age, infants show spontaneous preference for own-race faces over other-race faces (e.g., Bar-Haim et al., 2006; Kelly et al., 2005, 2007a), and demonstrate face processing strategies (Ferguson, Kufkosky, Cashon, & Cassola, 2009) and scanning patterns that are dependent on race (see Lee, Quinn, Pascalis, & Slater, 2013 for a review). Critically, this sensitivity also extends to infants' ability to discriminate own- and other-race faces, namely the other-race effect (ORE). Studies in different cultures have revealed that the ORE becomes established within the first year of life (e.g., Kelly et al., 2007b, 2009). It is suggested that the ORE is a reflection of individuals' racial experience, arising from repeated experience with own-race faces as well as a relative lack of exposure to other-race faces, known as the contact hypothesis (Hancock & Rhodes, 2008; Malpass & Kraviz, 1969; Valentine, 1991). This hypothesis has been widely supported in studies of infants, children, and adults, particularly those raised in a predominantly single-race environment (Anzures, et al., 2014; Chiroro, Tredouzx, Radaelli, & Meissner, 2008; Chiroro & Valentine, 1995; Cross, Cross, & Daly, 1971; Feinman & Entwisle, 1976; Kelly et al., 2007b; Pezdek, Blandon-Gitlin, & Moore, 2003; Suhrke et al., 2014; Tham, Bremner, & Hay, 2017). However, studies of those with exposure to more than one racial group are few and have mixed results. While studies of infant face perception represent an important opportunity to inform us on the origin of this expertise, the limited studies of infants born and raised in multi-racial environments makes it difficult to understand the importance of exposure to multiple races for the development of the ORE.

To date, there are several variations of the contact hypothesis each of which explains the developmental trajectory of the ORE in infants differently but based in one way or another on the notion that experience with different types of faces matters in the emergence of the ORE. One of the favoured explanations of the other-race effect in infants is the

perceptual narrowing account (Nelson, 2001). Specifically, it is suggested that infants begin with a broadly tuned perceptual ability that allows processing faces in general. Then as they experience more faces of a specific type, there is a decline in sensitivity to rarely experienced faces and an increase in sensitivity to frequently experienced faces. For example, in a study testing 3-, 6-, and 9-month-old British-White infants with faces of four ethnic groups (Chinese, Caucasian-White, African-Black, and Middle-Eastern faces), Kelly et al. (2007b) found that 3-month-olds could distinguish between faces from all four ethnic groups, 6-month-olds could distinguish between faces in two ethnic groups (Chinese and Caucasian-White), and 9-month-olds could distinguish between own-race faces only (Caucasian-White). The same narrowing pattern was found in the Chinese population tested with Chinese, Caucasian-White, and African-Black faces (Kelly et al., 2009).

Although it has been generally agreed that the ORE develops within the first year, evidence on the age of onset of infants' recognition advantage for own-race over other-race faces is mixed. Whereas some studies have revealed that the ORE emerges in 9-month-old infants (Ferguson et al., 2009; Kelly et al., 2007b; 2009), others suggest that infants exhibit the ORE as early as 3 or 4 months of age (Chien, Wang, & Huang, 2016; Hayden, Bhatt, Joseph, & Tanaka, 2007; Sangrigoli & de Schonen, 2004; Tham, Bremner, & Hay, 2015). For example, both Hayden et al. (2007) and Sangrigoli and de Schonen (2004) showed that 3-month-old Caucasian-White infants were better at recognising female Caucasian-White faces than female Asian faces. According to Tham, Bremner, and Hay (2015), the emergence of the ORE at 3 months could be explained by specific aspects of the stimuli used. That is, those studies demonstrating early emergence of the ORE used only stimuli with female faces and limited external facial information. Tham et al. (2015) found that initial emergence of the ORE is dependent on face gender when using faces with limited external information. They tested 3- to 4- and 8- to 9-month-old Caucasian-White infants using female and male faces

with limited external information from three racial groups (Chinese, Malay, and Caucasian-White). For 3- to 4-month-old Caucasian-White infants, the ORE was limited to female faces whereas for 8- to 9-month-old Caucasian-White infants, the ORE was general across genders. In other words, relative to other-race faces, younger infants were better at recognising female own-race faces whereas older infants were better at recognising both female and male own-race faces. The authors suggested that when stimuli are controlled for external information to ensure that internal features of faces were processed, specialisation for own-race faces comes first for female faces. Differences in procedure regarding external features are likely important because including external information allows the possibility that infants discriminate on the basis of non-facial features such as hair shape. Thus, in studies using uncropped faces, the ORE may have emerged late because younger infants based their discrimination on external, non-facial information.

The finding of face gender differences in the ORE is complemented by evidence that infants' face processing is strongly influenced by their visual and social environment (Rennels & Davis, 2008; Sugden, Mohamad-Ali & Moulson, 2014). According to parental reports, during the first year of life, infants spend approximately 70% of their time with female adults when their primary caregiver is female (approximately 50% with a female caregiver and approximately 20% with other female adults; Rennels & Davis, 2008). Furthermore, the developmental events in infancy such as forming an attachment relationship with primary caregivers could have shaped the way faces are processed in infants (e.g., Scherf & Scott, 2012). For example, a general female preference emerges at three months, when the primary caregiver is female, whereas the opposite is found when the primary caregiver is male (Quinn et al., 2002; 2008). However, the face gender effect seems to be limited to the primary caregiver's racial group. For example, infants' preference for female over male faces was found when the faces were own-race but not when the faces were other-

race (Quinn et al., 2008). This implies an important role of the visual and social environment in tuning infants' face perception based on both the race and gender of the primary caregiver. Together, these findings of face gender differences coincide with our notion of the primary caregiver hypothesis, namely the tendency for very young infants to develop recognition and preference towards faces that represents their primary caregiver.

Studies have showed that, following the emergence of the ORE, face recognition remains flexible and responsive to environmental input. For example, short-term exposure to three other-race face exemplars (Sangrigoli & de Schonen, 2004), perceptual training to individuate other-race faces using picture books (Heron-Delaney et al., 2011), and daily exposure to videos in which other-race individuals each introduced themselves with a different name (Anzures et al., 2012), all reduced the ORE in infants, providing evidence for plasticity in infants' ability to process other-race faces at a level comparable to own-race faces. In addition, experience effects have been shown in the case of children adopted into families of different race. For example, Asian children who were adopted by Caucasian-White families from infancy showed a recognition advantage for both Caucasian-White and Asian faces in comparison to their age-matched (Asian) controls who showed a clear ORE in favour of own-race faces (de Heering, de Liedekerke, Deboni, & Rossion, 2010). In a separate study, a complete reversal of the ORE was found in Korean adults who have been adopted to Caucasian-White families for approximately 23 years (Sangrigoli, Pallier, Argenti, Ventureyra, & de Schonen, 2005). Although these exposure, training, and adoption studies provide important information regarding the flexibility of the ORE, the effects of exposure and training studies can be transitory (e.g., Hills & Lewis, 2011), and adoption studies are retrospective. These studies do not necessarily match the effects of permanent immersion in individuals born and raised in a multiracial environment.

Recently, face perception studies have begun to incorporate studies of infants raised in multiracial environments. Three-month-old infants exposed to individuals from their own race as well as those from another race showed no spontaneous preference for either race (Bar-Haim et al., 2006). In addition, 3-month-old monoracial (Caucasian-White and Asian) infants who were raised in a multiracial environment did not show any face recognition (as indicated by the lack of novelty preference) for either female Caucasian-White or Asian faces, whereas biracial (Caucasian-White and Asian mix) infants showed recognition for Caucasian-White faces despite the race of their mother/ primary caregiver being Asian (Gaither, Pauker, & Johnson, 2012). The authors suggest that young infants with more heterogeneous racial exposure may find it difficult to determine which faces are important to learn, thus delaying the development of face recognition or the ORE until later in infancy.

To our knowledge, there are no studies on face recognition in infants older than 3 months of age from these populations. In addition, face perception studies of infants older than 3 months from multiracial populations are limited to studies on visual preference and face scanning of own- and other-race faces. For example, in a visual preference study by Singarajah et al. (2017), the authors studied older infants (11-month-olds) from two ethnic groups (Hispanics and Caucasian-White) whose immediate facial environment was almost exclusively own-race and whose community environment was different (Hispanic infants inhabit communities that are more multiracial in comparison to Caucasian-White infants). Infants' extended facial environment, on the other hand, was similar (both from the United States with a population breakdown of > 60% Whites, < 20% Hispanics, and < 15% Blacks). Despite differences in Hispanic and Caucasian-White infants' immediate and community environment, these infants showed remarkably similar patterns of visual attention that reflected their experience within their extended environment. In another study, Ellis, Xiao, Lee, & Oakes (2017) found that eye-movement patterns for different face races varied

according to 8-month-olds' exposure and interaction with members of the community (single-race environment vs. multi-race environment). The effects of face race were seen in the proportion of fixations to the eyes, nose, and mouths in infants from a single-race environment whereas the effects of face race were seen in scan path amplitudes in infants from a multiracial environment. Although both studies suggest the importance of diversity of face exposure in shaping face processing strategies (e.g., visual attention, scanning patterns), they do not necessarily contribute to our understanding of the development of the other-race effect or face recognition in infants from a multiracial environment.

In the current study, we extend the Tham, Bremner, & Hay (2015) study of infants born and raised in a single-race environment to infants born and raised in an environment that is considered multiracial (Malaysia), to allow for a direct comparison of the ORE between these populations. We chose to observe Malaysian infants of Chinese descent (Malaysian-Chinese) from Kuala Lumpur (a community with an ethnic breakdown of: 45.2% Malays, 42.3% Chinese, 11.0% Indians, and 1.5% other minority groups; Department of Statistics Malaysia, 2010) because Kuala Lumpur is an integrated culture in terms of the high proportion of the three main races and also in terms of exposure to Western media (Yahya, 2001). As in Tham et al.'s (2015) study, three face races (Chinese, Malay, or Caucasian-White) of both genders were used to investigate face recognition in 3- to 4- and 8- to 9-month-old Malaysian-Chinese infants, whom we later demonstrate through our demographic questionnaire to have substantial differences in additional caregiving experiences. It appears that there are two possible outcomes of this investigation. According to the primary caregiver hypothesis, infants should show a recognition advantage for female own-race faces over male own-race faces, experienced other-race (Malay), and less experienced other-race (Caucasian-White) faces. Alternatively, according to studies showing the importance of infants' extended environment in visual preference (Singarajah et al., 2017) and face

scanning studies (Ellis et al., 2018), infants' face recognition might also reflect the racial and ethnic composition of a broad population such that infants will be good at recognising both Chinese and Malay faces but not Caucasian-White faces.

Method

Participants

The final sample consisted of 36 3- to 4-month-old (19 girls, mean age = 126.4 days, range = 106-153 days) and 38 8- to 9-month-old (16 girls, mean age = 275.6 days, range = 255-307 days) healthy full-term Malaysian-Chinese infants. Sample size was based on studies testing infants in similar face recognition (habituation-novelty) tasks (e.g., Kelly et al., 2007b, 2009; Tham et al., 2015), and specifically to allow direct comparison to Tham et al. (2015). Participants were considered to be Chinese and both parents self-identified as Chinese. An additional 7 infants took part but their data were not included for analysis due to fussiness (2) or equipment failure (5). Parents were compensated for their participation with a small gift and certificate for their infant.

Stimuli

See Figure 1 for an example of stimuli used. Stimuli consisted of a total of six adult female and six adult male faces (age range 18-30 years) from three ethnic groups (4 Chinese, 4 Malays, and 4 Caucasian-Whites). These images of students from Malaysia and the UK were previously selected by Tham et al. (2015), on the basis of high scores in clarity (in terms of quality of the stimuli) and face typicality, but average scores on attractiveness (based on ratings by 20 adults). Each was photographed in two views (frontal view and a ¾ profile view) leading to 24 images in total. All pictures were 15cm x 18cm color portraits (14° visual angle horizontally and 17° visual angle vertically), cropped to the same oval shape with little hair information (hairline information visible but overall hair shape absent), and were

approximately the same quality (e.g., on a black background, equal size, same eye and hair color).

Procedure

Parents provided consent for their infant's participation and completed a questionnaire with information about parents' maternity and paternity leave, and infants' social and caregiving environment. For the latter, the questionnaire asked about infants' level of interaction with own- and other-race (i.e., 'How frequently does your baby interact with these adults? Female Chinese, male Chinese, female Malay, male Malay, female Caucasian-White, male Caucasian-White'), and infants' other carers when parents are unavailable. They were also asked to rank the importance of these carers (i.e., 'Who would you consider as your infants' caregivers and rank their importance accordingly'). Following this, infants sat on a parent's lap 60 cm from a 45cm x 30cm (40° visual angle horizontally and 28° visual angle vertically) color display monitor. Habit X 1.0 software (Cohen, Atkinson, & Chaput, 2004) was used to control the presentation of the stimuli to the display monitor, record infants' looking times during each trial, and to calculate when infants met the habituation criterion.

As in the face discrimination procedures of Kelly et al. (2007b, 2009) and Tham et al. (2015), each infant was randomly assigned to one of the three face ethnic-group conditions (Chinese, Malay, and Caucasian-White) and one of the two view-order conditions (frontal-profile or profile-frontal). For example (in the female face block), following habituation to one female Caucasian-White face in the frontal orientation, infants were tested with the familiar stimulus paired with a novel female Caucasian-White stimulus, both displayed in the same 3/4 profile orientation. Face recognition was indicated by longer looking at the novel face. We varied face views between habituation and test phases to ensure that face recognition was tested as opposed to pattern recognition (Bruce & Young, 1986; Bruce et al.,

1999). Infants were habituated and tested with female and male face blocks with a 10 min break between counterbalanced blocks.

Habituation Phase. A full session consisted of the presentation of an attention-getter (animated rattle) prior to each trial of a single face in the middle of the screen. Habituation trials began once infants attended to the monitor and continued until 30 seconds had elapsed, or when infants looked away for two continuous seconds. The experimenter, who was blind to the stimulus presented, recorded infants' looking times on each trial using Habit X 1.0 (Cohen et al., 2004) by pressing a key while the infant fixated the image. When the trial ended or when the infant averted gaze from the screen for 2s, the attention-getter was reintroduced to get the infant's gaze back to the screen before the next trial began. Habituation trials ceased when infants' looking time (on any trial) was equal to or less than 50% of the average looking time for the first two trials. If this criterion was not met by the 12^{th} trial, data were excluded from the analysis.

Test Phase. The test phase consisted of two trials, in each of which two faces (the habituated face and a novel face) were presented. On each trial, the paired faces were presented for 5 seconds, and the left-right position of the faces reversed between trials. At the end of the first block of habituation and test trials, a 10min break was incorporated followed by the second block of habituation and test trials.

Results

Preliminary analyses of habituation and test trials revealed no significant main effects or interactions involving participant gender or stimulus view order, and so data were collapsed across these factors in subsequent analyses.

Habituation trials.

All infants reached habituation criterion. Two separate mixed ANOVA analyses were conducted, (1) total looking times across habituation trials and (2) the number of habituation trials. Total looking times across habituation trials were analyzed in a 2 (age: 3-4, 8-9 months) x 3 (face race: Chinese, Malay, Caucasian-White) x 2 (face gender: female, male) mixed ANOVA with face gender as a repeated measure. There were significant main effects of age, F (1, 68) = 5.56, p = .02, μ_p^2 = .08, and face gender, F (1, 68) = 6.56, p = .01, μ_p^2 = .09. Three- to four-month-olds (M = 71.34s, SE = 5.18s) took longer to habituate than 8- to 9-month-olds (M = 54.30s, SE = 5.05s), and the total habituation looking times for female faces (M = 69.95, SE = 5.16s) were longer than the total habituation looking times for male faces (M = 55.69s, SE = 3.88s). A significant face race x face gender interaction was also found, F (2, 68) = 3.89, p = .03, μ_p^2 = .10. Simple effects showed that the face gender effect was only significant for Chinese faces, t (24) = 3.02, p = .03, *Cohen's d* = 0.6, with longer fixation to Chinese female faces (M = 75.44s, SE = 9.62s) than to Chinese male faces (M = 49.26s, SE = 7.80s), and marginally significant for Caucasian-White faces, t (24) = 1.97, p = 0.06, *Cohen's d* = 0.53, with longer fixation to Caucasian-White female faces (M = 81.53s, SE = 11.48s) than Caucasian-White male face (M = 57.18s, SE = 6.03s). The face gender effect was not significant for Malay faces (p = .30) and no other comparisons were significant.

The number of habituation trials were analyzed in a similar 2 (age) x 3 (face race) x 2 (face gender) mixed ANOVA as before. There was a significant main effect of age, F (1, 68) = 5.54, p = .02, μ_p^2 = .08, such that 3- to 4-month-olds had significantly more habituation trials (M = 6.71, SE = 0.35) than 8- to 9-month-olds (M = 5.56, SE = 0.34). There were no other significant main effects or interactions.

Test trials.

Firstly, the proportion of looking at the novel face (novelty preference) was calculated for each infant for each face race and face gender by dividing looking times to the novel face

by total looking times (familiar plus novel). This measure was analyzed in a 2 (age: 3- to 4-month-olds, 8- to 9-month-olds) x 3 (face race: Chinese, Malay, Caucasian-White) x 2 (face gender: female, male) mixed ANOVA with face gender as a repeated measure. There was a significant interaction between face gender and face race, F (2, 68) = 4.07, p = .02, μ_p^2 = .11 (Figure 2). Novelty preference for female Chinese faces was significantly larger than novelty preference for male Chinese faces, t (24) = 2.36, p = .03, *Cohen's d* = .65, whereas face gender comparisons in Malay and Caucasian-White were not significant ($p \geq .17$). The face race difference was significant only in female faces, F (2, 71) = 7.05, p = .002, μ_p^2 = .17, but not in male faces (p = .96). Independent sample t-test comparison indicated that novelty preference scores differed between Chinese and White female faces, t (48) = 4.35, $p < .001$, *Cohen's d* = 1.23, Chinese and Malay female faces t (47) = 2.09, p = .04, *Cohen's d* = 0.60, but not between Malay and White female faces, t (47) = 1.35, p = .19, *Cohen's d* = 0.38.

The other-race effect.

Although the two-way interaction was not qualified by age, it is important to investigate whether these novelty preference scores were significantly above chance level (.5) within each age group, because chance performance indicates a lack of recognition rather than simply poorer recognition. Furthermore, using single sample t-tests relative to chance, Gaither et al. (2012) did not find any evidence of novelty preference by 3-month-old monoracial infants from a multiracial population. Thus, we wanted to see if this was the case for our 3- to 4-month-old infants. As in previous studies on infant face discrimination (Gaither et al., 2012; Tham et al., 2015, Kelly et al., 2007b, 2009), we ran a series of two-tailed single sample t-tests to compare infants' preference scores to .5. The rationale is that a novelty preference score significantly above .5 reflects discrimination. As seen in Table 1, novelty preference was above chance level for Chinese female faces at 3 to 4 months of age and 8 to 9 months of age, and female Malay faces at 8 to 9 months of age only. In contrast,

the novelty preferences were at chance level for female Malay faces at 3 to 4 months of age and female Caucasian-White faces for both age groups. The novelty preferences were at chance level for all male faces regardless of age group and face race.

Social and caregiving environment

Forty-five complete social and caregiving environment questionnaires were returned, on the basis of which we compared 3- to 4-month-old (n = 22) and 8- to 9-month-old (n = 23) Malaysian-Chinese infants' social environments in terms of exposure to female and male own- and other-race individuals. For all infants, parents were the same ethnicity as the infant. No parent reported other family members from an ethnicity different than the infant's. The questionnaire also asked parents about their infant's social and caregiving environment with regard to own- and other-race level of interaction, race and gender of other caregivers, and to rank the importance of each caregiver. Analyses of the social environment showed no age differences in level of interaction with female and male own- and other-race individuals and confirmed that Malaysian-Chinese infants had the highest proportion of interaction with Chinese faces (M = 68.68%, SE = 2.50%), little interaction with Malay faces (M = 22.36%, SE = 1.70%) and very little or no interaction with Caucasian-White faces (M = 8.96%, SE = 1.50%), F (2, 88) = 170.66, $p < .001$, $\mu_p^2 = .80$. In general, infants interacted with female faces more than male faces, t (44) = 2.38, p = .02, *Cohen's d* = 0.71. All parents reported the female own-race face type as their infant's primary caregiver (mother, grandmother, or own-race female nanny).

The overall sample consisted of mothers working outside the home (70%), bringing baby to work (6%), and stay at home mothers (24%). Working mothers work on average 40 hours per week and had an average of 57.8 days maternity leave (range between 30 days and 90 days) which meant that most 3-month-old infants with working mothers had other caregivers aside from their mother. Although all parents reported an own-race female as the

primary caregiver (e.g., mother, grandmother, own-race female nanny), some parents also reported other-race females as additional caregivers for their infants, either through the Malay daycare system (n = 2), live in domestic house helpers (n = 14), or part-time domestic house helpers (n = 2) from the Philippines and Indonesia.

Social and caregiving environment and the other-race effect

Because 9-month-old infants showed a novelty preference for female Malay faces, the next set of analyses examined whether direct exposure to other-race female faces through additional caregiving roles had an effect on infants' habituation and novelty preference for Malay faces. We analyzed 3- to 4- (n = 9) and 8- to 9- (n = 8) month-old infants in the Malay race condition whose parents had completed the social and caregiving environment questionnaire. Within each age group, infants with direct exposure (additional other-race caregivers) to other-race female faces were compared to infants without direct exposure (social environment) to other-race female faces. Total looking times across habituation trials for Malay faces showed no significant main effects or interactions in a 2 (direct vs indirect) x 2 (age) x 2 (face gender) mixed ANOVA. Importantly, there was no significant difference in total looking times for Malay faces between infants with direct exposure and without direct exposure to other-race female faces, F (1, 13) = 0.28, p = .61, μ_p^2 = .02.

The novelty preference for female Malay faces were not significantly above chance level in 3- to 4-month-old infants with direct other-race female exposure, t (5) = -0.88, p = .46, *Cohen's d* = 0.53 and without direct other-race female exposure, t (2) = -0.91, p = .42, *Cohen's d* = 0.20. The novelty preference in 8- to 9-month-old infants with direct exposure to other-race female faces was significantly above chance level, t (4) = 2.98, p = .04, *Cohen's d* = 1.33, whereas those without direct exposure to other-race female faces was not significantly above chance, t (2) = 0.94, p = .45, *Cohen's d* = 0.55. This suggests that other-race female exposure resulting from contact with additional caregivers may have enhanced recognition of

female Malay faces by 8- to 9-month-old infants. We also carried out separate analyses for those in the Chinese and Caucasian-White conditions that completed the demographic form. There were no differences between infants with direct and without direct exposure to other-race female in recognizing Chinese and Caucasian-White faces ($p \geq .21$).

Discussion

The purpose of the present study was to investigate the development of the ORE in face recognition in 3- to 4- and 8- to 9-month-old infants from Kuala Lumpur, Malaysia, a population that is considered multiracial. Malaysian-Chinese 3- to 4-month-old infants recognized female own-race faces whereas 8- to 9-month-old infants recognized both female own-race and female other-race (experienced) faces. The results confirmed the primary caregiver hypothesis found in 3-month-old infants from single-race populations, in that 3- to 4-month-old infants were better at recognizing faces that represent their primary caregiver (own-race Chinese female). Although this finding deviates from studies favoring the perceptual narrowing view whereby 3-month-old infants could discriminate within own- and other-race faces regardless of face gender (Kelly et al., 2007b, 2009), the female own-race recognition advantage resonates with several studies of comparable age range using female faces only (Chien, Wang, & Huang, 2016; Hayden, et al., 2007; Hsu & Chien, 2011; Sangrigoli & de Schonen, 2004) and faces with limited facial information (Tham, Bremner, & Hay, 2015).

Interestingly, 8- to 9-month-old infants from the multiracial population exhibited recognition for female experienced other-race (Malay) faces in addition to the existing female own-race (Chinese) faces. This finding must be interpreted with caution, because it was not reflected in a three-way interaction including age. But it is in contrast to the previous finding in 8- to 9-month-old British-White infants from a predominantly single-race population (Tham et al., 2015). They demonstrated an own-race recognition that becomes more general

(including both female and male Caucasian-White faces). The current study suggests that for infants born and raised in a multiracial population, female face recognition of own- and experienced other-race emerges before male face recognition when using faces that had limited peripheral information.

Although infants were born and raised in a multiracial community, the social and caregiving environment questionnaire showed that infants from both age groups still had considerably less social interaction with other-race Malay faces in comparison to own-race Chinese faces. However, because maternity leave for working mothers in our sample (70% of our sample) ranged between 30 to 90 days, infants from 3 months of age will naturally have other caregivers apart from their mother and father. From our questionnaire some infants had additional female own-race caregivers and female other-race caregivers who looked relatively similar to the Malay race (from Indonesia and the Philippines). While we did not set out to investigate this, we found that 8- to 9-month-old infants with additional female other-race caregivers showed better recognition for female Malay faces than those without additional female other-race caregivers. This is in line with a recent study by Rennels et al. (2017) showing malleability of the face processing system in the form of flexibility in relation to face gender when there is a change within infants' caregiving environment. The longitudinal study of Swedish 10-, 14-, and 16-month-old infants who previously had majority female primary caregiver experience between birth to 10 months showed differences based on existing caregiving experiences (female primary caregiver only vs female and male caregiver experience) in a visual search task (Task 2). However, this was not found in the familiarization-novelty preference task (Task 1, which we will return to in subsequent paragraphs). Based on Task 2, infants with a female primary caregiver showed difficulty in recognising a familiarised male among three other male faces whereas same aged infants with both female and male caregiving experiences successfully recognised both female and male

faces. The current study extends this finding suggesting that the face processing system can be flexible when there is a change in caregivers' gender and/or race within infants' natural environment. This also coincides with Scherf and Scott's (2012) claim that forming attachment relationships drives face processing. Accordingly, face processing is influenced by transitions in development. Specifically, infants in the current study with working mothers will naturally have other caregivers (e.g., day-care, house helpers) from 3 months of age. The transition from forming an attachment relationship with the female primary caregiver (mother) to other caregivers (e.g., female other-race) may have influenced the development of other-race female recognition. However, our results should be interpreted carefully given the very small sample sizes with social and caregiving environment data (~ 8 infants per condition). It would be beneficial to confirm these findings in a larger study.

Critically, our findings represent the first infant ORE study to show an ORE in infants from a multiracial community. The findings from this study link with the Gaither et al. (2012) study on monoracial infants born and raised in a multiracial environment. Although Gaither et al. (2012) did not show any ORE in 3-month-old infants, our study suggests that the ORE in face recognition for this type of population may emerge between 3- to 4-months of age, but is specific to faces representing their primary caregiver, extending to experienced other-race female faces by 8- to 9-months of age, particularly when they have an additional other-race caregiver.

Importantly, there was also a lack of recognition for male faces in our study. Both 3- to 4- and 8- to 9-month-old infants did not show any novelty-preference for male own-race over male other-race faces. In contrast, previous studies showed that 3- to 4-month-olds (Quinn et al., 2002; Kelly et al., 2007b; 2009), 8- to 9-month-olds (Tham et al., 2015), and 10-, 14-, and 16-month-olds (Task 1, Rennels et al., 2017) can discriminate between male own-race faces even when their primary caregiver was female. However, the male own-race

recognition in infants from the studies on 3- to 4-month-olds could be attributed to the stimuli used whereas the latter two age groups could be attributed to the population used. Tham et al. (2015) found that male own-race recognition was not evident in 3- to 4-month-olds when using faces with limited external facial information but the male own-race recognition was evident in 8- to 9-month-olds. They suggest that studies including both internal and external facial information (e.g., Quinn et al., 2002, Kelly et al., 2007b, 2009) may permit identification on the basis of low-level external cues whereas identification is harder and on the basis of high-level cues when only internal information is included. In other studies using the same habituation-novelty preference task on 8- to 9-month-old infants (Tham et al., 2015) and a familiarization-novelty preference task on 10-, 14-, and 16-month-old infants (Task 1; Rennels et al., 2017), infants recognized both female and male own-race faces regardless of caregiving experiences (female primary caregiver only vs. female and male caregivers). On the other hand, infants in our sample did not exhibit any male face discrimination. One major difference between previous studies and the current study is that previous studies recruited infants with little exposure to other racial group and with predominantly own-race face exposure, which may have allowed specialization for own-race to continue with male faces despite differences in caregiving experiences. In contrast, experience of a disproportionate number of female faces of different race and the limited amount of exposure to male faces may have delayed the onset of male own-race recognition in infants in the current study.

In conclusion, this study suggests that in a sample of infants raised in an environment that is considered multiracial, the own-race recognition advantage develops first for primary caregiver's gender, with some evidence that this is later extended to an experienced race of the same gender. Infants in our study who had a female Chinese primary caregiver showed recognition for female own-race Chinese faces which was then extended to experienced female other-race Malay faces. This is likely due to predominant exposure to female faces

and additional other-race experience from either having an additional female other-race caregiver, or a combination of social environmental input and having an additional female other-race caregiver. In contrast, previous studies of infants from a predominantly single-race population who had a female Caucasian-White primary caregiver demonstrated recognition for female own-race Caucasian-White faces, which was then extended to male own-race Caucasian-White faces (Tham et al., 2015). Importantly, the present study highlights the importance of obtaining social and caregiving information to completely understand the transition or flexible nature of the face processing system, particularly in infants. The findings are consistent with the primary caregiver hypothesis and the differential experience model of face processing, according to which infants' face processing is continually refined over time and depends on social and visual experiences (Nelson, 2001).

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Figure legend

Figure 1. Sample stimuli from the Chinese female and Malay male conditions.

Figure 2. Proportion of looking at the novel face (novelty preference) for female and male Chinese, Malay, and Caucasian-White faces in both age groups (3- to 4-month-olds and 8- to 9-month-olds).

Table 1

Mean novelty preference (standard deviation) and two-tailed above chance level (.50) t-tests within each age group, face race, and face gender.

Age	Face Race	Face Gender	Mean (SD)	Two-tailed t-test	Cohen's D
3-4 months	Chinese	Female*	0.60 (0.11)	t (11) = 3.04, p = *.01*	0.88
		Male	0.48 (0.16)	t (11) = -0.34, p = *.74*	*0.01*
	Malay	Female	0.44 (0.15)	t (11) = -1.26, p =*.23*	*0.36*
		Male	0.47 (0.11)	t (11) = -0.91, p = *.38*	*0.26*
	White	Female	0.45 (0.10)	t (11) = -1.59, p = *.14*	*0.46*
		Male	0.50 (0.18)	t (11) = 0.01, p = *.99*	*0.004*
8-9 months	Chinese	Female*	0.55 (0.07)	t (12) = 2.82, p = *.02*	*0.78*
		Male	0.51 (0.12)	t (12) = 0.42, p = *.68*	*0.12*
	Malay	Female**	0.57 (0.06)	t (11) = 3.92, p = *.002*	*1.13*
		Male	0.54 (0.10)	t (11) = 1.60, p = *.14*	*0.46*
	White	Female	0.48 (0.06)	t (12) = -1.26, p = *.23*	*0.35*
		Male	0.50 (0.09)	t (12) = 0.13, p = *.90*	*0.03*

** $p < 0.005$

* $p < 0.05$

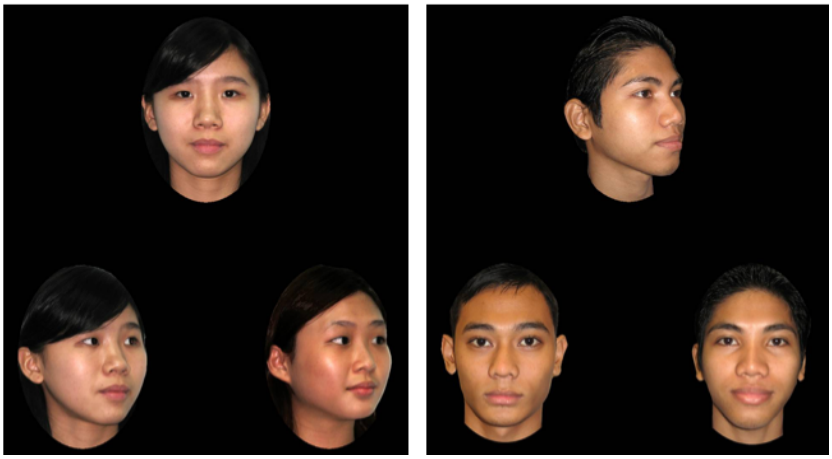

Figure 1. Sample stimuli from the Chinese female and Malay male conditions.

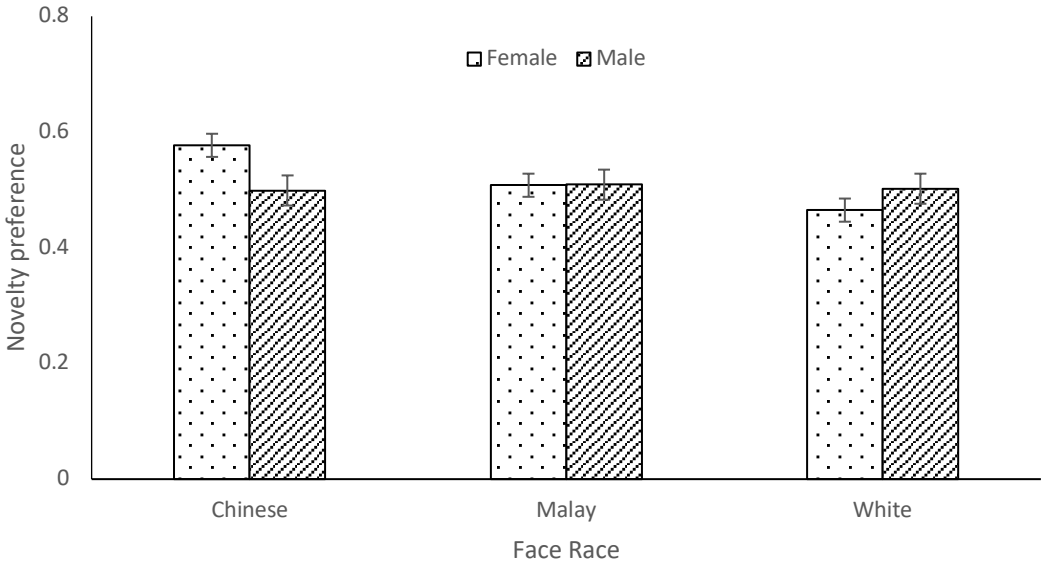

Figure 2. Proportion of looking at the novel face (novelty preference) for female and male Chinese, Malay, and Caucasian-White faces in both age groups (3- to 4-month-olds and 8- to 9-month-olds).