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**Face processing in a multiracial environment :
differential experience in face recognition, face
categorisation and kinship detection.**

Pei Jun Woo

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THÈSE

Pour obtenir le grade de

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Spécialité : **Sciences Cognitives, Psychologie et Neurocognition**

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Face processing in a multiracial environment: differential experience in face recognition, face categorisation and kinship detection

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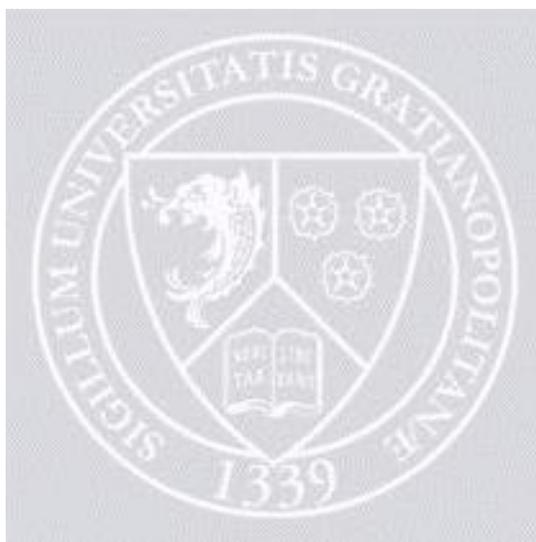
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Face processing in a multiracial environment: differential experience in face recognition, face categorisation and kinship detection.

1 January 2021



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RÉSUMÉ

La capacité de reconnaître et de catégoriser les visages présente des avantages sociaux. Cette thèse aborde deux questions: 1) comment l'expérience différentielle affecte le développement du traitement du visage, pour la reconnaissance et la catégorisation des visages et 2) comment l'expérience différentielle affecte la façon dont les enfants utilisent les indices phénotypiques (La couleur de la peau) pour détecter la parenté relation. 4 études ont été menées : l'effet de l'expérience différentielle (EDE) sur la reconnaissance faciale des nourrissons (étude 1) ; L'EDE chez les enfants et la reconnaissance faciale des adultes (étude 2); L'EDE sur la catégorisation des visages par les enfants (étude 3) et l'EDE sur la détection chez les enfants d'âge préscolaire des relations de parenté entre des visages étrangers (étude 4).

Dans l'étude 1, la reconnaissance de visage a été comparée entre des nourrissons d'une population multiraciale (Malaisie) et ceux d'une population monoraciale (UK). Nous avons étudié la reconnaissance de nourrissons chinois de 4 et de 9 mois pour de visages du type du nourrissons (chinois), d'un autre type expérimentée (malais) et d'autres moins expérimentés (Caucasien). Les enfants de 4 mois reconnaissaient les visages féminins chinois, tandis que les enfants de 9 mois reconnaissaient les visages féminins chinois et malais. Les nourrissons ne reconnaissaient pas les visages masculins. Par contre les nourrissons britanniques reconnaissaient les visages des femmes et des hommes de leur propre type. Il semble que pour les nourrissons nés et élevés dans un environnement multiracial, il y a un changement d'un avantage de reconnaissance de la race propre fondé sur la femme à un avantage propre et éprouvé d'une autre race fondé sur la femme qui peut être lié à la vie sociale.

Dans l'étude 2, l'effet de l'autre type a été étudié chez des adultes et des enfants malais. Les adultes développent une capacité égale à reconnaître leurs visages et ceux des autres types fréquemment exposés. Chez les enfants, le développement de l'avantage de la reconnaissance de son type par rapport à l'avantage de la reconnaissance des autres types à haute fréquence change durant l'enfance. Bien qu'il semble qu'une certaine exposition à d'autres visages raciaux joue un rôle, la relation entre l'exposition et la reconnaissance faciale est difficile à comprendre, ce système cognitif est encore malléable pendant l'enfance.

Dans l'étude 3, nous avons étudiés la catégorisation de visages par des enfants malaisiens et des adultes (a) de leur propre type, (b) d'autre type à haute fréquence et (c) à basse fréquence. L'avantage de la catégorisation des autres types a été trouvé dans les données d'exactitude des adultes malais. Il est particulièrement important de constater que les enfants et les adultes malaisiens chinois ont catégorisé plus rapidement les visages chinois de leur propre type que les visages malais. Ainsi, l'avantage de la catégorisation de l'autre type semble être davantage un avantage pour les catégories raciales de moindre expérience, que ces catégories de visage soient de son propre type ou non.

Dans l'étude 4, nous avons examiné si la capacité de détecter la parenté dans des visages non apparentés chez les enfants d'âge préscolaire était influencée par leur exposition à différents visages raciaux. Nous avons comparé les enfants d'âge préscolaire et élevés dans un

environnement multiracial (Malaisie) ou monoracial (France). L'environnement multiracial a donné un avantage dans la détection des performances de parenté, les enfants issus de familles métisses étaient meilleurs dans la performance des tâches de correspondance de parenté. Les résultats suggèrent qu'une expérience directe avec des familles métisses est peut-être une clé pour que les enfants comprennent l'héritage biologique.

Nos résultats fournissent des informations sur l'EDE en matière de reconnaissance faciale, de catégorisation et de détection de parenté.

ABSTRACT

The ability to recognize and categorise different faces proficiently may have social and evolutionary advantages. This thesis addresses two questions: 1) how differential experience affects the development of face processing, specifically in two areas: recognition and categorising of faces and 2) how differential experience affects the way children use phenotype cues (i.e., skin colour) in detecting kinship relation. To answer these questions, four studies were conducted: The effect of differential experience in infants face recognition (Study 1); The effect of differential experience in children and adult face recognition (Study 2); The effect of differential experience on children categorisation of faces (Study 3) and the effect of differential experience on pre-schoolers detection of kinship relations among stranger faces (Study 4)

In the first study (Chapter 5), face recognition was compared between infants from a multiracial population (Malaysia) and infants from a monoracial population (United Kingdom). 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 recognized own-race female faces, whereas 8- to 9-month-olds also recognized 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 from a previous study, a group that is considered single-race, who recognized 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.

In a second study (Chapter 6), the other race effect was investigated in Malaysian adults and children. In adults, with increasing exposure to multi-races over the years, Malaysian adults develop equal ability to recognise own and frequently exposed other race faces. In children, development of own race recognition advantage to high-frequency other-race recognition advantage begins to change in childhood. The development of the ORE is

unclear during childhood. While it appears that certain exposure to other-race faces affects the ORE, the relationship between exposure and face recognition is inconsistent within the Malaysian children tested indicating the ORE is still malleable during childhood.

In the third study (Chapter 7), Malaysian children (7 and 9-year-old) and adult's categorization of (a) own-race faces, (b) high-frequency other-race faces and (c) low-frequency other-race faces were investigated. Whereas the other-race categorization advantage was in evidence in the accuracy data of Malay adults, other aspects of performance were supportive of either the social categorization or perceptual expertise accounts and were dependent on the race (Malay vs. Chinese) or age (child vs. adult) of the participants. Of particular significance is the finding that Malaysian Chinese children and adults categorized own-race Chinese faces more rapidly than high-frequency other-race Malay faces. Thus, in accord with a perceptual expertise account, the other-race categorization advantage seems to be more an advantage for racial categories of lesser experience regardless of whether these face categories are own-race or other-race.

In the fourth study (Chapter 8), we examined whether the ability to detect kinship in unrelated faces in preschool children was influenced by their exposure to different race faces. We compared pre-schoolers who were born and raised in a multiracial environment (Malaysia) and those who were raised in a monoracial environment (France). Being raised in a multiracial environment did give an advantage in the detection of kinship performance. Instead, pre-schoolers from mixed-race families were better in the kinship-matching task performance. The results suggest that perhaps a direct experience with mixed-race families is a key for children to understand biological inheritance. Hence, within the Malaysian sample, direct experience with mixed-race families, increased pre-schoolers understanding of biological inheritance.

Taken together, the results provide insights on the effect of differential experience in face recognition, categorisation and kinship detection.

Keywords: multiracial, face recognition, face categorization, kinship detection

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INTRODUCTION

Why face recognition?

The ability to recognize and categorise different faces proficiently may have social and evolutionary advantages, including allowing us to identify efficiently different individuals, remember specific individuals' behavior in social situations, rapidly categorise their age, gender, detect emotions, intentions as well as recognizing in-group and out-group members. Thus, investigating how people learn and process information about a face is of particular interest for human social behavior.

We can recognise a person we know at a glance, in different lighting, different hairdo or makeup and even after several years of aging. From birth, we are surrounded by faces and in contrast to other visual stimuli that are present in our environment, faces demand more of our attention and are undoubtedly very important. Faces are essential for social interaction and provide us information on an individual age, gender, attractiveness, emotions and intentions. In addition, we can use unique features of a face to recognise individuals which allows us to identify our family members, friends and acquaintances. Faces allow us to distinguish those whom we have encountered before and those who are strangers. Because faces play a crucial social role, and humans have great ability to recognise a diverse range of faces, researchers have been interested to understand how human remembers and process faces.

In this thesis, the role of experience in the development of face processing (specifically in two areas: recognition and categorising of faces) will be explored in a heterogeneous population. An overview of current knowledge of face processing will first be discussed before exploring the importance of experiences in the way we categorise and remember faces. In addition, I will also look at whether differential experience affects the way children associate genetic relatedness to cues in faces.

Chapter 1: The development of face processing.

1.1 Face Preference

Faces are undoubtedly the most frequently encountered visual stimuli in an infants' environment and hence may be a stimulus that is preferred compared to other classes of visual categories. Infants as young as 1 month of age were found to consistently prefer face-like stimuli over non-face-like patterns (Fantz, 1961). He demonstrated that infants looked longer at a schematic face than other non-face-like patterns such as a bull's eye, printed text and different coloured disks. In 1963, he later replicated this finding with newborn infants up to 5 day-olds. This is further supported by Goren, Sarty & Wu (1975) and Johnson, Dziurawiec, Ellis & Morton (1991) studies that showed newborns' greater tracking behaviour for moving face-like patterns compare to non-face-like patterns. Goren, Sarty and Wu (1975) investigated 40 newborns' responses in four types of stimuli mounted on paddles: a face, a moderately scrambled face, a scrambled face and a blank image (see figure 1). The newborns' head and eye movements were recorded while the experimenter moves the paddle across the infant's visual field. They noted that newborns preferred to look at a schematic face as compared to the other stimuli, indicating that perhaps infants are predisposed early on to detect a face. Early face preferences has also been evidenced for static schematic faces (Kleiner, 1987; Macchi Cassia, Simion, & Umiltà, 2001; Mondloch, Lewis, Budreau, Maurer, Dannemiller, Stephens, & Kleiner-Gathercoal, 1999; Simion, Valenza, Umiltà, & Dalla Barba, 1998; Valenza, Simion, Macchi Cassia, & Umiltà, 1996) and photographs of real faces (Macchi Cassia, Turati, Zulian, & Simion, 2004). Macchi Cassia et al. (2004) compared photographs of real faces with inverted features of the faces and found that infants consistently have a bias to look at upright faces. Regardless of whether a face is static or moving, these evidence collectively, demonstrates that newborns have a strong visual preference for human faces or human face-like stimuli.

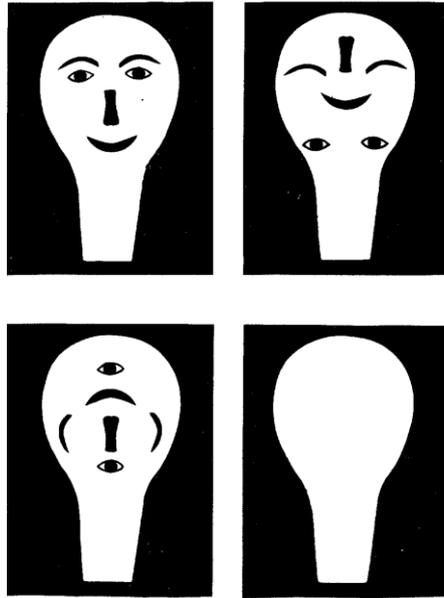


Figure 1. Stimuli used by Goren et al. (1975). Reproduced from Goren et al. (1975).

1.2 Face recognition

Another important aspect of face processing is face recognition. It is crucial for humans to remember whether they have encountered a face before and to evaluate it for familiarity. Recognising a face is vital for social interaction and social bonding. Recognition of a face has been demonstrated in mother face preference, attractive face preference and recognition of unfamiliar faces.

1.2.1 Mother face preference.

A mother's face is inevitably one of the most important individuals to recognise for the development of mother-infant attachment and emotional bonding (Bowlby, 1969). Researchers have attempted to understand when and how an infant first recognises his/ her mother's face using both the picture and real face of mothers. Infants' discrimination of mother versus a stranger's face was first investigated by Field, Cohen, Garcia and Greenberg (1984). Newborns infants, shortly after birth, viewed a live face of a mother and female stranger face in a visual preference task and was found to look longer at the mother's face. Subsequently, following a short learning trial of their mother's face, these newborns rapidly learn to distinguish their mother's face from the female stranger's face demonstrating that recognition of a mother's face develops rapidly early on in life.

However, one possible confound in this study was that the newborns may recognise the mother's face due to olfactory cues which may be present during the live face viewing. To address this issue, Bushnell, Sai and Mullin (1989) replicated the study by masking the olfactory cues using a perfume spray in the testing room. They also ensured that the mother and stranger's hair colour and hair length were matched to control for other possible confounds. Using a visual preference paradigm, a mother's face bias was found in this study after controlling for olfactory and hair cues. To further eliminate any unconscious facial expression by mothers during the live presentation of the previous two studies, static images and video recording of mothers and strangers face have been used in two different studies with newborns and 3-month-old infants (Barerra & Maurer, 1981; Walton, Bower and Bower, 1992). In both subsequent studies, a mother preference was established. Newborns were also found to be able to recognise their mothers face after a delay of 3 minutes (Pascalis et al., 1995) and 15 minutes (Bushnell, 2000) of last exposure of their mother's face. Collectively, these studies demonstrate that preference for a mother's face may be well-conditioned early on.

Sai (2005) has demonstrated that mother's voice also plays a vital role in the learning of mother face by their newborns. In this study, Sai found that newborns recognise their mother's face if they had postnatal exposure to their mother's voice, but no mother face preference was found when such exposure was not available. It appears that newborns become familiar with their mother's voice during gestation and input of mother's voice after birth facilitated learning of the mother's face.

1.2.2. Attractive face preference.

Slater and colleagues have conducted a series of experiments, on newborn's visual preference for attractive faces. All attractive and less attractive faces in these studies had been rated by adult judges as attractive or less attractive. In 1998, using a paired comparison of attractive versus unattractive faces rated by adults, Slater et al. found that newborns preferred looking at the attractive female faces (Slater, von der Schulenburg, Brown, Badenoch, Butterworth, Parsons, & Samuels, 1998). Infants have also been found to prefer attractive male faces compare to unattractive male faces (Samuels and Ewy, 1985). The preference for faces rated as attractive has also been found for other types of faces such as attractive cat and tiger faces (Quinn et al., 2008), attractive infant faces (Langlois et al., 1991) and attractive other-race faces (Langlois et al., 1991).

In 2000, two other studies were carried out to investigate the specific aspect of a face that contributes to these preferences. Slater, Bremner, Johnson, Sherwood, Hayes and Brown (2000) examined the role of inner and outer features of the attractive and unattractive faces. Pairs of attractive and unattractive faces (rated by adult observers) with either identical internal features or external features were shown to newborns (See figure 2). Stimuli were manipulated to produce new stimuli that consisted of attractive and unattractive inner and outer features. A preference for an attractive face was found when newborns were shown faces that differed in terms of internal features. In contrast, no preference was found when different external features were shown. Results from this study indicate that infants use internal features of a face in making preference of attractiveness of a face.

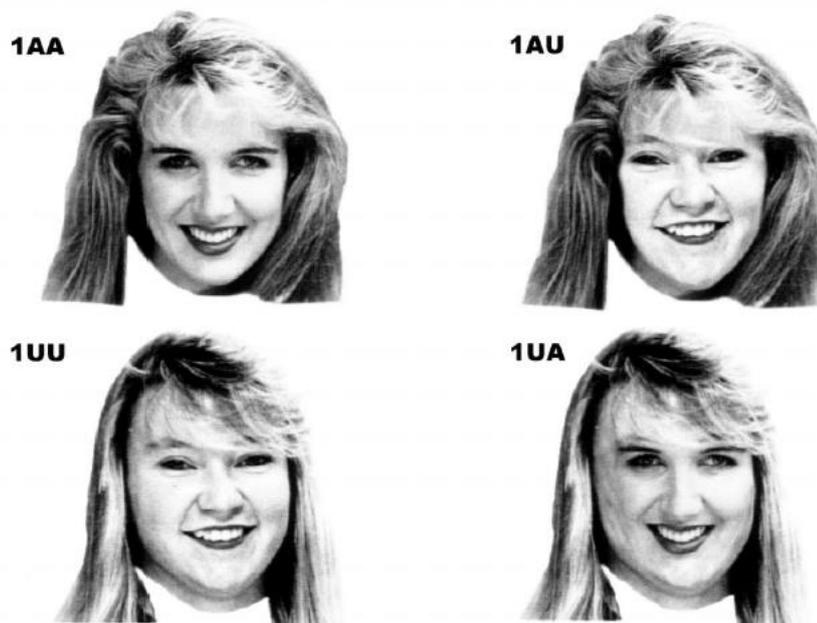


Figure 2: Stimuli used in Slater, Bremner, Johnson, Sherwood, Hayes and Brown (2000) study. AA= Attractive exterior with attractive interior; AU = Attractive exterior with unattractive interior; UU = Unattractive exterior with unattractive interior; UA = Unattractive exterior with attractive interior.

In another study, Slater, Quinn, Hayes and Brown (2000) investigated whether the attractiveness of a face was affected by the orientation of a face. Newborns were shown attractive and unattractive faces either in an upright or an inverted (180 degree) orientation. Similar to previous studies, a preference for attractive faces was found when faces were presented in an upright orientation but not when the faces were inverted. The authors

concluded that infants have a representation of a face that is orientation-specific early on in life.

Based on findings from previous studies (Fantz 1961; Goren, Wu & Sarty 1975; Field et al., 1984; Bushnell et al., 1989; Pascalis et al., 1995; Slater et. al., 1998; 2000) it can be concluded that infants can process both internal and external features of a face early in life and have a face representation that is innate and rapidly learned.

Children's perception of attractive faces has also been investigated. Copper et al., 2006, found that differential experience affects age-related changes in children's perception of internal facial features of an attractive face. By twelve years of age, children demonstrate an adult-like pattern of attractive preference and judge faces with average-placed features as most attractive compare to features placed in low or high height in a face. However, 9-year-olds show no difference in attractiveness judgements for faces with low and average placed features. The authors explained that this is because children at that age are frequently exposed to own-age peers' faces (whose internal features are typically placed on the low location of a face) and adult faces (whose internal face features are usually on the average location of a face). This study demonstrates that our everyday experience seeing faces affects perceptions of attractiveness.

1.2.3. Recognition of unfamiliar face.

The ability of infants to recognise unfamiliar faces has also been investigated by several studies. Whereas in face preference studies, we typically present two faces side by side and measure looking time of an infant for each face, other methods have been used to measure recognition of a face using the novelty preference and habituation technique. In this procedure, the infant is habituated to a face followed by the presentation of two faces: the familiar face (seen in habituation) and a novel face. Young infants have a preference for novel stimuli, and it is assumed that if the infant can discriminate and recognise a familiar face, they should subsequently demonstrate greater interest (measured via looking time) in the novel stimulus. Hence, a novelty preference indicates recognition of the familiar face.

Using this technique, several researchers have examined whether infants are able to recognise a stranger's face which does not hold significant social meaning, unlike the mother's face. Pascalis and de Schonen (1994), using this procedure tested newborn's recognition of female stranger's faces. Recognition for the unfamiliar face was found

immediately and after a 2-minute delay indicating that young infants can also rapidly learn and discriminate an unfamiliar face.

Other researchers have also investigated whether internal or external features of a face facilitate recognition. Turati, Cassia, Simion & Leo (2006), habituated newborns to a stranger's face in one of three conditions (full face, internal feature or external feature condition) and then test recognition of either the internal or external feature of a face. Results of the study found that newborns can recognize a stranger's face using external cues but can also succeed with inner features when faces shown in habituation and test are not visually distinct. While younger infants tend to focus on external regions of the face, older infants have been found to focus more on the internal regions of the face (Farroni et al., 2007; Haith et al., 1977; Maurer and Salapatek, 1976) as they grow older due to the importance of processing features of a face that brings various social meaning and communication. This shift of attention to internal regions of a face also assists in coding features of the face and increased the likelihood of better facial recognition in infants (Farroni et al., 2007).

Long-term face recognition has been examined with older infants from 3 months of age and beyond. Studies (Fagan 1973, Pascalis et al., 1998, Turati et al., 2008) have shown that infants can learn and recognise a face from different points of view (i.e., habituated to a frontal face and then tested using a $\frac{3}{4}$ profile face).

Infants have also been found to be able to recognise (individuate) faces of different races and species that they have no prior experience with (Kelly et al., 2007; Pascalis, de Haan & Nelson, 2002).

Collectively, the above studies and many others (Pascalis & deSchonen, 1994; Turati et al., 2006, 2008) demonstrates that newborns are able to quickly learn and recognise a novel face from another face even when these faces are unfamiliar and hold no significant social meaning to them rapidly within the first few months of life.

While adults have been viewed as experts in processing faces, the face recognition of children are considered to be poorer due to specific deficits in face processing ability (Carey & Diamond, 1977) or due to general poorer memory capacity, attention and other general cognitive factors in children (Crookes & McKone, 2009). While we know that some face processing abilities are already present in newborns, there is a general debate about when face processing expertise develops and becomes adult-like in children. Carey & Diamond (1977, 1994) proposed (face-specific perceptual development theory) that face recognition ability in children is immature before 10 years of age and development of specific face

perceptual abilities linked to expert face processing (see section 1.7 on featural vs configural processing) is only achieved in late childhood. These face processing abilities continue to develop in late childhood and adolescence before reaching full adult levels (Ericsson, Krampe, & Tesch-Römer, 1993; Mondloch, LeGrand & Maurer, 2002; Pearson & Lane, 1991). An alternative view, known as the general cognitive development theory, is that expert face processing mechanism is developed much earlier in childhood by 5 to 7-year-olds (Crookes & McKone, 2009; Want, Pascalis, Coleman and Blades, 2003) and the improvements of face recognition found in later childhood are due to improvements in general cognitive developments such as attentional, memory factors. Want et al. (2003) noted that children's competence at face recognition increases with age and varies depending on how they are tested rather than a change in specific face-processing mechanisms in late childhood as proposed by Carey & Diamond (1977, 1994). Experiments using children-specific tasks can increase children's performance level and even young children can show good performance using the appropriate methods of testing. For example, Bruce et al. (2000) using a forced-choice matching task found that preschool children of 4-to 5- years of age were able to achieve 80% accuracy performance. In another study using picture books, Bruce et al. (2001) found that children as young as 2 – 4-year-olds can recognise faces with a 73% accuracy level, while older children 5–6-year-olds performed up to a 93% accuracy level given that the task is cognitively appropriate for children. In a study looking at face recognition of human faces relative to monkey and sheep faces, Pascalis, Demont, de Haan & Campbell (2001) found that 5-and 8-year-olds were able to discriminate human faces better than monkey and sheep faces and that 8-year-olds had better face recognition performance than 5-year-olds. Face recognition in children has been found in various studies to improve with age across children aged 5 to 10 years of age (see Want, et al., 2003 for a review) when simplified tasks appropriate for children's cognitive capacity are used. According to Crookes & McKone, 2009, these face recognition improvements are due to the general improvements in children's ability to attend and focus on the demands of the task. Hence, based on newer evidence, the face recognition system is present early in life and in childhood and the increased performances are due to improvement in general cognitive abilities rather than specific face processing abilities.

Recently, Weigelt et al., 2014 proposed a theory that the development of face perception and face memory are different, with face perception mechanism developing earlier than face memory. Face perception is defined as a face processing mechanism that individuates faces with minimal to no memory requirement such as those in holistic

processing whereas face memory is defined as the ability to retain and remember faces in long term memory such as in tasks that identify whether a face has been previously seen (e.g., old-new paradigm).

Wiegelt et al. presented evidence (see Wiegelt et al., 2013) that the face expert processing mechanism may not be the same as the mechanism for face memory. Specifically, they noted that face perception reaches adult level early in life (i.e., 5 years of age) but memory for faces continues to improve until 10 years of age and that this developmental slope is steeper for faces than other class of stimuli indicating a domain-specific development.

While face expertise and memory continue to develop in childhood, face recognition is also influenced by several factors such as differential experience with own and other-race faces, male and female faces, and own and other age faces.

Race. Past studies have noted that we are better at recognising faces of our own race versus other races, a phenomenon known as the Other-race effect (ORE). This effect has been found to be present early in infancy and continues to adulthood. The development of this effect will be further discussed in Chapter 2.

Gender. Face recognition ability is also susceptible to the influences of male and female faces. 3-and 4-month-old infants who are primarily taken care by female caregivers recognize a familiar female face but not a familiar male face when presented with both female and male faces (Quinn et al., 2002). Quinn et al. (2002) also noted that the opposite effect has also been seen in a small number of infants who are primarily taken care by male caregivers. This differential experience with male and female faces diminishes as the infants are exposed to more different gender faces in the environment. This indicates that experience with male and female faces influences the level of human face representation in our memory leading to different recognition levels for different gender faces. Recognition of male and female faces in childhood and adolescence has been investigated. Results are inconsistent with some studies finding females having better recognition of female faces compare to male faces known as the own-gender advantage in face recognition. However, this own gender advantage in recognition was only found among females and not male children. (Cross et al., 1971; Feinman and Entwisle, 1976, Ellis et al., 1973, Ge et al. 2008, Rehman & Herlitz, 2006). Similarly, this effect has been found in some studies with adults, where women are reported to have better memory for female faces compared to men (see review by Herlitz & Loven, 2013). Some proposed explanations to this effect are 1) we have larger female than male faces experience during early years as most infants are taken care by female primary

caregivers (Rennel & Davis, 2008) 2) infant girls attend and have more eye-to-eye contact than boys (Connellan et al, 2000).

Age. Own-age bias is a term that refers to better recognition memory of faces belonging to a person within the own age range compare to another age group (Rhodes & Anastasi, 2012; Wiese, Komes & Schweinberger, 2013). Children aged 5-to 8-years-olds when presented with photographs of children, younger adults, middle-aged adults and older adults were shown to have better recognition accuracy of children faces (children photographs) compare to other-age faces (Anastasi & Rhodes, 2005). Similarly, Crookes and McKone (2009) have also demonstrated similar findings among 5-to 6-year-olds and 10-to 11-years-olds, showing better recognition of own-age faces than adult faces in the study. In another study, Macchi Cassia et al. (2009) found that 3-year-old children who have younger siblings had better recognition of newborn faces than 3-year-old children without younger siblings indicating experience with a particular age range face have an impact on face recognition performance. In contrast, studies that have looked at individuals who have had extensive contact with another age group (Cassia, Kuefner, et al., 2009; Harrison & Hole, 2009; Kuefner et al., 2010) had a decrease own-age bias further supporting the role of experience in affecting memory for faces.

1.3 Understanding what disrupts face processing

In order to understand how humans, process a face, researchers have attempted to uncover what process disrupts these processes. Understanding what causes the system to fail can provide important clues on how face processing is optimized.

1.4 Face-Inversion effect

One important aspect of when face recognition is disrupted is when viewing an inverted (upside-down) face. Studies have found that accuracy and reaction time in recognising an inverted face is poorer but not for other non-face objects such as cars, furniture or houses (Yin 1969; Leder & Bruces 2000). This phenomenon where identifying an inverted face is more difficult than inverted objects is known as the face-inversion effect. The inversion effect states that faces are identified and distinguish more accurately and faster

when presented in an upright orientation compare to an upside-down orientation (Yin, 1969). Yin (1969) found that adults generally had more difficulty viewing mono-oriented objects, objects usually seen in one orientation when it is inverted. When presenting both inverted mono-oriented objects (such as planes, cars and houses) and faces to adult participants, participants had more difficulty remembering inverted faces compared to inverted objects. These findings led the author to suggest that faces are special and processed differently compare to objects.

One explanation of the inversion effect that has been proposed is the configural information hypothesis (see next section for details). This hypothesis states that we process a face holistically (as a whole) using configural information while objects are processed featurally (in parts). When a face is inverted it disrupts configural processing, forcing the face to be processed featurally like other objects. This in turn causes a slower reaction time and less accuracy when viewing an inverted face.

1.5 Configural vs Featural Processing

Studies have suggested that unlike other objects, faces are a special category of stimuli with the unique position of face features (eyes, nose, mouth, etc) that are homogenous and have to be discriminated based on relational information such as distance between eyes or eyes and nose or nose and lips (Leder & Bruce, 2000). **Configural processing**, a term used to describe the ability to process this relational information, is hypothesized by researchers to happen as a result of experiences (Diamond and Carey, 1986; Gauthier and Tarr, 1997, Maurer, LeGrand & Mondloch, 2002). Mondloch, LeGrand & Maurer (2002) noted that expertise in face processing takes many years to develop and we do not just distinguish a face based on the shape of the features, a process known as **featural processing**, but also the relations among these features (configural processing). As humans have years of experience perceiving upright faces, face processing is disrupted when we view an inverted face. The inversion effect states that faces are identified and distinguish more accurately and faster when presented in an upright orientation compare to an upside-down orientation (Yin, 1969). Configural information required to recognise a face becomes disrupted when a face is inverted, resulting in the use of a less accurate featural processing strategy (Diamond and Carey, 1986). As features of a face are often represented in memory in an upright orientation, an inverted face must be uprighted mentally before it can be

identified. This becomes more difficult when complex information such as relations between features and contours are an important distinguishing feature in faces as well. Hence, researchers have typically used the failure to recognise an inverted face as an indirect measure of configural processing. The face inversion effect has been demonstrated in adults using a variety of face stimuli such as schematic faces (Yin, 1969), famous faces (Yarney, 1971) and photographs of real faces (Carey and Diamond, 1977) using different types of testing paradigms (Yin, 1969; Valentine and Bruce, 1986; Freire et al., 2000).

In a series of experiments, Carey and colleagues (Carey & Diamond, 1977, 1994; Diamond & Carey, 1977; Carey, Diamond & Woods, 1980) proposed the encoding switch hypothesis that children encode faces using distinctive features such as eyes and nose (featural processing) while adults use configural processing (encode spatial relationship information between face features) when recognising a face. However, as children's exposure to faces increases, their processing strategy is said to switch from featural to configural processing when recognising an individual. It is with this shift of processing strategy that their levels of face recognition performance improve. Carey and Diamond proposed this happens in older children at about 10 years of age. This assertion was initially based on evidence that young children's recognition of faces is less affected by the inversion effect than adults. Support for this was shown in their study (Carey and Diamond, 1977) where the inversion effect disrupts 10 year-olds' performance in faces more than houses but not for 6- and 8-year-old children in the study. Based on the assumption that inversion impairs configural processing, it was concluded that adult-like configural processing is only fully developed at around 10-years of age. However, some subsequent studies with infants and children have challenged this account (Brace et al., 2001; Want et al., 2003, Cohen & Cashon, 2001; Turati, Sangrigoli, Ruel & de Schonen, 2004).

Several preferences have also been found to be disrupted when the face stimuli are inverted in children younger than 10-years old. For example, Slater et al. (2000) found that newborn's preference for attractive faces was eliminated when the face was presented inverted. Similarly, Quinn et al. (2002) found that 3-month-old infants' preference for female faces was abolished when these faces were displayed in an inverted orientation. Findings from these two studies seem to suggest that configural processing may be already present in very young infants.

The inversion effect has also been found in infants as young as 4 months of age (Turati et al., 2004). Four months old infants were found to be able to recognise an upright

face and an inverted face when the same face was used in familiarisation and test. However, when a face is learned at different poses, recognition of the inverted face is lost. In 2001, Cohen and Cashon demonstrated evidence that configurational processing is already present in 7-month-old infants when viewing an upright face and that featural processing is used in an inverted face. Cohen and Cashon (2001) habituated thirty-two 7-month-old infants to two female faces and then tested them on a familiar face, a switched face consisting of a combination of internal and external features from the two habituated female faces and a novel face. It was hypothesised that if infants only process independent features of a face during recognition, the switch face would be viewed as a familiar face since the features of the switch face have been seen during habituation by the infant. However, if infants use configural processing (i.e. process relational information among features), the switch face should look novel to the infant. A group of infants was shown upright faces and a second group of infants was shown the inverted faces. Results showed that infants looked longer at the switch face in the upright face condition indicating that infants are processing some level of configurational information when viewing upright face. On the contrary, in the inverted face condition, infants fail to look longer at the switch face indicating that perhaps a featural processing strategy was used when viewing an inverted face. Infants in this study were already demonstrating adult-like patterns of response at 7 months of age and were already sensitive to configural face information. Further evidence for configural processing in infants was found in Zauner and Schwarzer (2003) study, using schematical drawn face stimuli. In this study, 6- and 8-month-old infants were found to process relational information whereas a featural approach was found in 4-month-old infants. Using the switch face approach, Schwarzer et al. (2007) found that there is a shift of featural to configural face processing in infants 4 to 10-months of age. In this study, the eyes and mouth of the habituated faces were switched to produce the switch faces. Results showed that 10-month-old infants processed eyes and mouth configurally, while 4-month-old infants processed eyes and mouth featurally. The 6-month-old infants processed the mouth holistically but the eyes featurally indicating a transitional stage of processing.

Results from the above studies indicate mixed results, implying that while configural processing is observed in infants around 6-to 7-month-olds, it is not adult-like in its pattern. Younger infants appear to use the featural approach when certain stimuli are employed (Zauner & Schwarzer, 2003).

1.6 Holistic Processing

An alternative account to the featural-configural processing hypothesis is the view that both featural and configural information are processed simultaneously and equally important when processing a face. The term holistic processing has been used by researchers to describe the claim that the face is perceived as a whole and not based on separate features. The holistic processing view is based on the Gestalt principle and was first introduced by Francis Galton (Galton, 1883). The face holistic processing has been evidenced using two experimental paradigms: 1) The composite face paradigm (Young, Hellaway, & Hay, 1987) and 2) the whole-part paradigm (Tanaka & Farah, 1993).

In the composite face paradigm, a composite face stimulus is created by combining the top half of a face with the bottom half of another face. The composite face results in a novel face that neither resembles the original faces used. In this paradigm, participants learned a series of faces and are presented with the new composite faces either in aligned or misaligned positions (see figure 3). Participants are asked to judge if the top half of the face has been seen during the learning trials (familiar) or unfamiliar. Participants often have more difficulty recognising the top half of the face when it is aligned over the misaligned face, indicating that in the aligned condition, the faces are processed holistically and viewed as a new face. In the misaligned condition, the accuracy of recall is better as the two halves are processed independently.

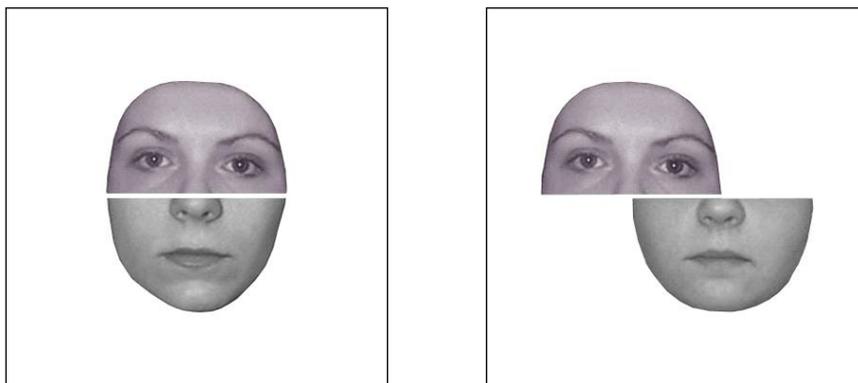


Figure 3. Examples of Aligned and Misaligned composite faces; the top half is the same in both pictures. Reproduced from de Heering et al. (2007).

In the whole-part face paradigm, participants learned a series of faces and memory for one feature of the learned face (e.g., eyes, nose or mouth) is then tested in isolated part condition or embedded in a whole face condition. Participants were found to have better recognition performance when the feature is presented in the whole face condition over the isolation condition (Tanaka & Farah, 1993). This is then taken as evidenced that holistic processing is in place when viewing a face as memory for a feature is better identified when it is presented in a whole face context as memory of a feature is remembered in a whole face representation rather than in isolation.

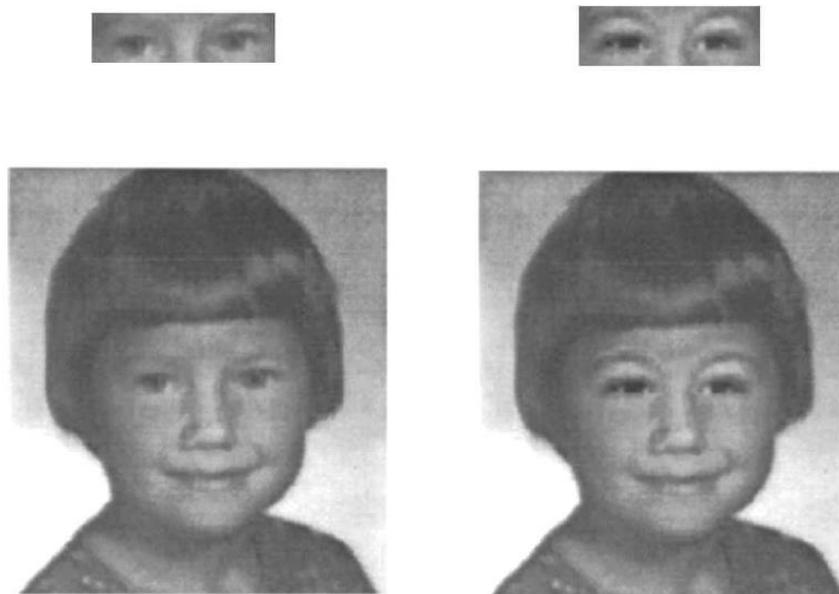


Figure 4: Example of composite face images for isolated parts and whole-part test used in Tanaka et al. (1998).

The holistic face processing using either composite face and whole-part face paradigm have been seen in adults and children (Michel, Caldara & Rossion, 2006; Michel, Rossion, Chung, Caldara, 2006; Farah, Wilson, Drain & Tanaka, 1998, de Heering, Houthuys, and Rossion, 2007; Pellicano & Rhodes, 2003). Using the part-whole face paradigm, Farah and colleagues (Farah et al., 1998; Tanaka & Farah, 1993) demonstrate that adults were better at identifying a single facial feature presented in a whole face than when it is presented separately. When this was tested with scrambled or inverted faces and houses, this advantage disappeared. Similarly, Tanaka et al. (1998) found that children age 6 –to 10 years old were more accurate in recognizing facial features when presented in a whole face

context than in isolation (see figure 4). This advantage again diminishes when the faces were inverted, supporting that holistic processing is essential in an upright face. Pellicano and Rhodes (2003) and de Heering et al. (2007) using the face composite paradigm later found evidence for holistic processing in children as young as 4 years of age.

However, when children aged 2- 5-year-olds were asked to categorize faces, they used a single facial feature strategy instead of categorizing the faces holistically (Schwarzer,2002). In Schwarzer, 2002 study they found that a shift in holistic categorizing is only present between 6 to 10 years of age. Hence Schwarzer concluded that the ability to process face holistically, specifically recognising changes in a face, emerges early in childhood, the usage of holistic information in categorization of faces develops later in childhood.

Holistic processing has also been investigated in infants. Turati et al. (2010), using the composite face paradigm, tested newborns, 3-month-olds and adults using an eye-tracker and found the presence of holistic processing in infants as young as 3 months of age. Nakabayashi and Liu (2014) proposed that while holistic information has been observed to be present in infants, children and adults, it is the holistic interference effect that accounts for the difference between children's and adults' recognition performance. Specifically, they suggest that featural processing rather than holistic processing takes longer to develop. The interference effect can be observed in the whole-part paradigm when participants have difficulty with recognising a specific face part when this learned part is presented in a whole face context at the test. Nabayashi and Liu (2013) subsequently showed that 6-year-old children have more difficulty ignoring irrelevant information in a whole face during part recognition (interference effect) as compare to 9-10-year-olds or adults (see Nakabayashi and Liu; 2014 for review of the interference effect).

1.7 Facial categories

When we view a face, we process different information about the face such as the race of the person, age, gender, etc. This information can be classified into different facial categories such as age, gender, race and species. Forming categories or concepts is important for organising information in our memories and helps direct our responses to novel objects. In the 1970s, researchers accepted that categories are identifiable by extracting similar attributes within a category (attribute correlations) (Mervis & Rosch, 1981; Cohen & Younger, 1983).

Species. Since infants have been shown to be able to distinguish face and non-face stimuli, researchers were also interested in understanding whether infants are able to distinguish different species base on facial information/ perceptual cues. Quinn and Eimas (1996) found infants 3-months of age were able to categorise cat and dog faces based on internal facial features and external contours of the head (Quinn and Eimas, 1996). Similarly, Spencer et al. (1997) demonstrated that 4-month-olds infants were able to categorize cats and dogs based on information from the head and face region of the stimuli presented. Results from eye-tracking studies by Quinn et al., (2009) further suggest that the use of head information to categorise cats and dogs indicate a pre-existing bias of attending to face information during categorisation. Experience with pets has also been found to influence older infants' categorization of animals such as cats and dogs (Kovack-Lesh et al., 2008).

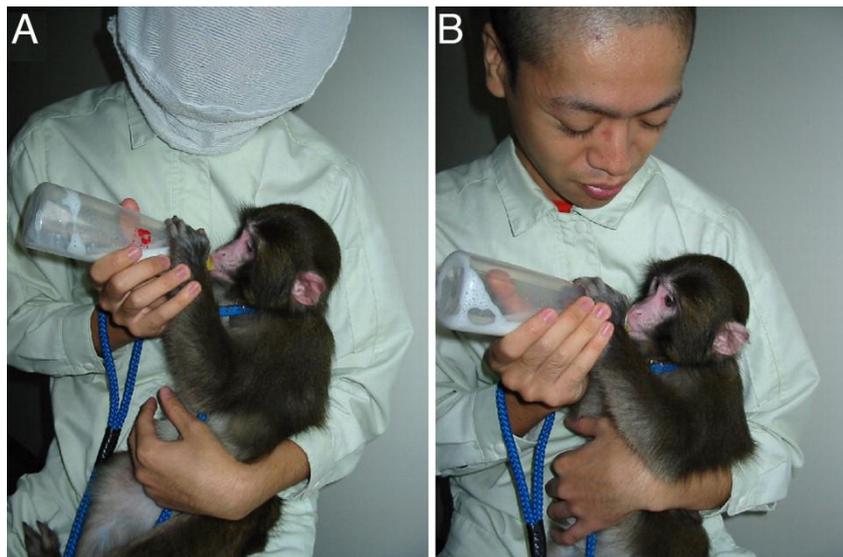


Figure 5. Examples of an infant monkey and a caregiver with (A) and without (B) a facemask. Reproduced from Sugita (2008).

Heron-Delaney, Wirth & Pascalis (2011) showed that infants as young as 3.5 months had a preference for human representation over non-human species (i.e., gorilla or monkey) when the head and or body information were presented, indicating an early own species preference early in life. This early preference to own species is learned through experience. Sugita (2008) demonstrated in a study with rhesus infant monkeys that were reared with no exposure to any faces demonstrated an equal preference for monkey and human faces (see

figure 5). Once the monkeys were exposed to either monkey faces or human faces, these monkeys discriminated against the exposed species face selectively indicating the influence of experience on species face preference and discrimination.

In summary, the ability to categorise species appears to be developed early in life and the ability to recognise own species is learned.

Race. Faces have different facial physiognomy and skin tone is evident from different races (e.g., Caucasian faces have lighter skin tones, higher and narrow noses, higher cheekbones; African faces have darker skin tones, wider noses). Infants' ability to categorize based on race has been demonstrated in infants 9 months old (Anzures et al., 2010). Infants were familiarized with different faces from the same race group and then tested with female faces of another ethnic group (see Figure 6). 9-months-old infants successfully differentiate between both race categories and looked longer at the novel race face. Caucasian 6-months-old in this study was only able to show discrimination of different race categories after familiarisation with Asian faces but not Caucasian faces, indicating that the ability to categorise other-race faces is still developing at 6-months of age. Infant's spontaneous preference for own-race faces (Bar-Haim et al., 2006; Kelly et al., 2005) may have also influenced the 6-month's old infant's racial categorisation performance. Infants have been found to prefer looking at own-race faces compared to other-race faces (Kelly et al., 2005). Infants' preference for looking at one's own race may have then hindered looking time at novel other-race faces after being familiarised with own-race faces.

Are infants able to form distinct different categories for other-race faces or do they group them as belonging to one other race category? In 2016, Quinn and colleagues investigated this issue on how infants categorise different classes of other-race faces by familiarizing 6- and 9-months old Caucasian infants with African or Asian other-race faces. They then tested whether infants had longer looking time at a novel African versus a novel Asian face. 6-month-olds infant demonstrated novel category preferences for other-race faces (e.g infants familiarised with African faces, would look longer at the novel Asian face at test trials). The findings suggest that 6-month-old infants distinctly categorised different classes of other-race faces. However, by 9-months-old, within the same study, older infants were unable to display a novel category preference. Further investigation revealed that 9 months old infants had developed a broad categorisation of other-race faces inclusive of both African and Asian faces in this study. The authors suggest that perceptual narrowing of different other race categorization takes place between 6 to 9-months of age; from being able to form

distinct other race categorisation at 6-months-old to having a broad representation of other race categories at 9-months-old.

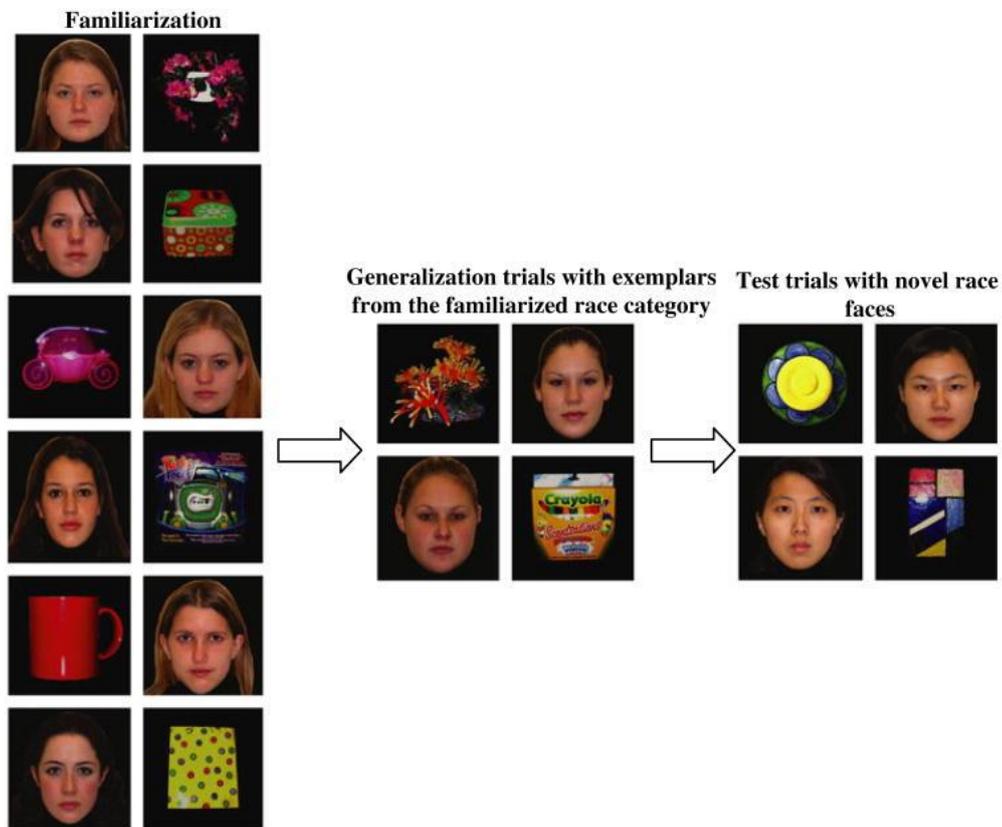


Figure 6: Examples of face stimuli and objects used in categorisation task in Anzures et al (2010) study.

Gender. Studies on children's categorisation of the gender of faces have shown infants as young as 5-months-old are able to form a different gender category of male and female faces (Cornell, 1974). However, Younger and Fearing (1999) using colour photographs of male and female faces only found gender category formation at 10-months old but not at 7-months of age. Younger infants, however, show a different pattern of responsiveness in gender categorisation tasks as reported by Quinn et al. (2002). They investigated 3-4 months old infants' ability to categorise male and female faces and found that young infants looked longer at novel female over a novel male face after familiarising them to different male faces but no preference for either novel male or female faces were found after familiarizing infants to female faces. These asymmetry findings were thought to be driven by a spontaneous preference for female faces attributed to infant's greater experience with female faces which arise from having female caregivers. This hypothesis was

further supported by Rennels and Davis (2008) findings that most North American infants are exposed to a significantly greater amount of interaction with females rather than male individuals. To date, there is a lack of studies on how face gender categorisation is developed in children. However, current evidence seems to indicate that gender categorisation is influenced by experience with faces in one's environment.

Age categories. In addition to being able to form species, race and gender categorisation, infant and children's sensitivity to age categorisation has also been investigated. Brooks and Lewis (1976) investigated whether infants are able to respond differently to strangers of different sizes and ages and found infants as young as 7 months display different behaviour towards young children and adult strangers suggesting that facial cues were used to categorise this information. Children age 2 years old were also found to be able to categorize schematic faces into categories of "baby", "boy" and "man" in Montepare and McArthur (1986) study. Downs and Walz (1981) on the other hand found preschool children age 3 years old to rank photographs of young, middle-aged and old female adult faces accurately. It is suggested that children used features such as wrinkles to judge younger-looking versus older-looking faces (Montepare and McArthur, 1986). A facial configuration such as internal facial features (i.e., eye and nose) and head shape were also used by children to judge the age of schematic faces in past studies (George et al., 2000; Gross, 1997).

Improvement in the judgement of facial age has also been demonstrated in studies. Adults generally performed better than adolescents and children and adolescents performed better than young children in detecting age judgement of adult face (20 – 80 years old) (Gross, 2004; 2007). This developmental change in facial age judgement may be influenced by differential expertise with faces from different age categories. Young children may have less experience with adult faces of varying age groups compared to adults and hence may perform poorer when making facial age judgements.

In summary, age, race, gender and species categorisation seem to be influenced by differential experience with faces.

Chapter 2: The other-race effect (ORE)

When we view a face, two automatic processes are triggered: categorisation of whether the face belongs to our own group or species and recognition of the face at an individual level (Pascalis et al., 2011). Recognition of a face has also been found to be disrupted with the other-race effect (ORE).

The other-race effect (ORE) is the well-established phenomenon that individuals discriminate more easily between faces of their own race than between faces of other races (Meissner & Brigham, 2001; Rhodes, Locke, Ewing, & Evangelista, 2009). Other researchers have used other terms such as Cross Race Effect (CRE), Other Race Bias (ORB) and Own Race Advantage (ORA) to refer to this same phenomenon. ORE was first demonstrated by Malpass and Kravtitz in 1969 via a yes-no recognition task (MacLin & Malpass, 2001) to identify which faces they have seen previously, and which faces were new. Since then, ORE has received much attention and has been shown through different research paradigms (Hugenberg, Miller, & Claypool, 2007), different countries and racial groups (Crookes, Favelle, & Hayward, 2013).

The ability to remember and distinguish faces has important implications as it allows us to have appropriate social interactions with others. However, these abilities do not extend equally well to faces of other races (Hancock & Rhodes, 2008) and this inequality often leads to some problems when interacting with people from a different race (Hugenberg et al., 2007). Recent studies have also implied a possible link between own and other-race face processing with stereotyping and racial biases (Xiao et al., 2017, Qian et al., 2016, Lee et al., 2017) as well as misidentification of individuals in more severe situations such as problems in eyewitness identification. Several studies have found that witnesses are more likely to be accurate in identifying suspects of their own race as compare to suspects of a different race (e.g. Behrman & Davey, 2001; Brigham et al., 1982; Valentine, Pickering, & Darling, 2003). These studies implied that race of witness and race of suspect might have affected the recognition accuracy in eyewitness identification, perhaps as a result of the ORE phenomenon.

2.1 Behavioural Testing paradigm used in investigating the Other Race Effect

Many different testing paradigms have been used to investigate the ORE. The most common method used with adult populations is the **old/new paradigm**. In this paradigm, participants are asked to learn a set of faces and then later asked to differentiate between the faces that they have seen before (old faces) and faces that they have not seen before (new faces). Correct discrimination between old and new faces of own-race faces versus other-race faces is taken as evidence of the ORE effect.

Other testing paradigms such as the **eyewitness memory paradigm** have also been employed to investigate the ORE effect in an applied setting. In this paradigm, participants are asked to identify a suspect from a series of line-up identification faces. Researchers would usually compare whether the participants would be better in identifying the suspect from their own race versus if the suspect was from another race.

Force choice / Matching-to-sample task is another paradigm that is commonly used with children as this task is cognitively less demanding compare to the old/new paradigm. In this paradigm, participants are shown a face and then asked to identify among two faces presented side by side, which is the face that they have just seen. In investigating the ORE effect, researchers would compare the participants' accuracy of identifying the correct face in their own race versus other-race faces.

With infants, two common paradigms are used. The **Visual Preference (VP) paradigm** is typically used to see if an infant has a spontaneous preference for a particular race face as compared to another race face. This is one of the simplest paradigms, in which two faces (own versus other-race face) are shown side by side on a screen to the infants. Infants looking time at these faces are measured. Longer-looking time on one race face versus another is taken as evidence of a preference for that particular race face.

Novelty preference and habituation paradigm also known as Visual-Paired-Comparison (VPC) paradigm, is another task that is used to measure ORE in infants. The VPC procedure indexes the participant's level of interest for one stimulus in a pair after one of these stimuli has been learned during a prior familiarization or habituation period. Recognition memory is inferred from the participant's tendency to fixate toward the novel stimulus. Forgetting or lack of encoding of the original stimulus is inferred when the fixation times for the familiarized and the novel test stimuli are equal. In most ORE studies employing this method, ORE is inferred when infants successfully discriminate between

familiar and novel own-race faces (infants look longer at novel faces) but fail to discriminate familiar and novel other-race faces (infants look equally between familiar and novel faces).

2.2 Development of the ORE

2.2.1 Infant studies.

The role of experience in face recognition and categorisation has been studied in many homogenous countries and early visual and sociocultural experiences seem to shape one's ability to recognise familiar and unfamiliar faces resulting in the ORE effect (Anzures et al. 2013). This effect has also been documented in infant and children (Kelly et al., 2007; Walker & Houston 2006; Anzures et. al., 2013; Heering, Liedekerke, Deboni & Rossion, 2010), implying that ORE has its origins in infancy and is developed with increased exposure to a particular class of faces (own race). Kelly et al. (2005) using a visual preference method, showed newborns and 3-month-old infants own and other-race faces and found that 3-month-old infants but not newborns, who are exposed primarily to their own race prefer to look at faces of their own race as compared to faces from another race. The race preference can be nullified when infants experience both own- and other-race faces regularly (Bar-Haim, Ziv, Lamy, & Hodes, 2006). The own-race preference is, however, not observed at 6 months and reverses to an other-race preference at 9 to 11 months (Liu et al., 2015; Singarajah et al., 2017). The change in preference in the case of the race from own-race in younger infants to other-race in older infants has been interpreted as evidence that older infants process information about an own-race face sufficiently rapidly to leave time within the procedure for infants to explore the novel other-race face (Liu et al., 2015). It has also been interpreted as evidence that older infants are responding to other-race faces as an out-group because of their distinctiveness (Singarajah et al., 2017).

In a subsequent study in 2007, Kelly et. al. found, 3-month-olds discriminate among familiar own-race faces as well as among less familiar other-race, whereas 9- to 10-month-olds continue to discriminate own-race but show decreased discrimination among other-race. This is consistent with the notion of 'perceptual narrowing' (Nelson, 2001) where infants begin with a broadly tuned perceptual ability that allows the processing of faces in general and becomes more sensitive to their own race faces as they experience faces of their race.

Some studies have found that ORE emerged in infants as young as three months of age (such as Bar-haim, Ziv, Lamy, & Hodes, 2006; Hayden, Bhatt, Joseph, & Tanaka, 2007;

Sangrigoli & Schonon, 2004). Assessing using novel preference paradigm, infants in these studies had found to look longer in the novel faces for own-race condition but not for other-race condition. These studies suggested that infants were able to individuate /recognise own-race faces which are more readily available in their environment as compared to other-race faces. As infants in these studies interacted mainly with their own-race population, they showed better recognition for their own-race faces compared to other-race faces. Overall, empirical evidence with infants seems to indicate that the initial face space of infants is broadly based and becomes perceptually narrowed to differentiate and recognise own-race faces with experiences (Scott, Pascalis & Nelson; 2007).

2.2.2 Children studies.

The other race effect also has been investigated in children. The ORE has been consistently found in children older than 7 years of age (Cross et al., 1971; Chance, Turner, & Goldstein, 1982; Feinman & Entwisle, 1976; Goodman et al., 2007; Pezdek et al., 2003; Walker & Hewstone, 2006) but the ORE has been inconsistently found in children between the ages of 5 and 7 years.

One of the very first studies by Cross, Cross & Daly (1971) with children aged 7-, 12- and 17-year-olds (and an adult comparison group) found that African Americans children and adults had equal recognition of Black and White faces, while White Americans were better in recognizing White faces over Black faces. In addition, they found that White Americans who were in integrated neighborhoods, in which they had more exposure of African Americans in the community had less recognition error of Black faces when compared to White Americans who did not have such exposure. Similarly, Feinman and Entwisle (1976) demonstrated the presence of ORE in children from grade one to six. White children were more accurate in recognizing White faces over Black faces. Similarly, Black children were better at recognizing own-race faces than white faces. In addition, they also found significant improvement of face recognition memory with age.

On the other hand, Chance, Turner and Goldstein (1982), using a developmental study approach, tested White children aged six to 20 years, using the old new paradigm on their ability to recognize White and Japanese faces. The ORE effect was only found for older children and college adults but not with the first and second-grade children. In a similar vein, Goodman et al. (2007) demonstrated that 8-year-old children and adults had better

recognition memory for own-race faces over other-race faces whereas comparable results for own and other races were found with 5-to 7-year-old children.

Although Chance et al. (1982) and Goodman et al. (2007) failed to find evidence of ORE in younger children, other studies (Pezdek et al., 2003; Sangrigoli & de Schonen, 2004) have identified the presences of ORE effect in children as young as 3 to 5 years of age. Anzures et al. (2014) have claimed that the failure to identify the ORE effect in younger children could have been due to a methodological issue. Using a cognitive less demanding method such as the sample to matching task to test younger children, Anzures and colleagues have found a presence of ORE in children as young as 5 years old. This effect continues to be maintained with increasing age and experience with own-race faces in children up to 10 years old. Most studies that have found a consistent other-race effect in children is with predominantly monoracial population. This effect has been replicated in individuals of different monoracial backgrounds, including Caucasian White, African Black and Chinese parentage.

More recently, studies investigating children in the multiracial environment have been studied. Tham, Bremner, and Hay (2017) tested 5- to 6-year-old and 13- to 14-year-old British children and Malaysian Chinese children on their recognition of Chinese, Malay, and African faces. They reported a typical other-race effect for the British children, whereas the Malaysian Chinese children had a recognition advantage for both frequently experienced Chinese and Malay faces relative to the less frequently experienced African faces. Tham et al. concluded that children from a multiracial environment who have experience with another race of faces early in life may be able to maintain a more malleable face representation when exposure to other-race faces is plentiful. Similarly, the finding of a lack of an own-race face recognition advantage in Japanese descent children born and living in Brazil (Fioravanti-Bastos, Filgueiras, & Landeira-Fernandez, 2014) indicates that the development of ORE account is different for a monoracial and multiracial society.

Recently McKone et al. (2019) suggested that there is a critical period in which experience affects our recognition of faces, specifically in the other-race effect. They found that by approximately 12 years of age, exposure to other-race faces does not decrease the recognition bias of other-race faces. They proposed that exposure to other-race contact needs to happen before 12 years old for it to affect face recognition abilities- specifically in recognising other-race faces accurately. In their study, the age at which other-race contact was experienced was measured. If sufficient other race contact takes place during childhood

(before 12 years of age), poor other race recognition was eliminated. In contrast, other race contacts after 12 years of age or in adulthood did not increase recognition of other-race faces.

2.2.3 Adult studies.

In contrast to children's studies, ORE studies in adults suggest a consistent robust own race face advantage. Adults are better at recognising own-race faces compared to other-race faces (for example, Barzut & Zdravković, 2013; Chance, Goldstein, & McBride, 1975; Ge et al., 2009; Meissner & Brigham, 2001). Chance et al. (1975) conducted an ORE study using White and Black participants. White faces, Black faces and Japanese faces were used as stimuli. The participants were required to remember as many stimuli as possible during the familiarisation phase. They were later tested for memory recall of the faces and found White participants showed more accurate recognition for White faces (own-race face), followed by Black faces and lastly, Japanese faces. Whereas for Black participants, they were better at recognising Black faces (own-race face), followed by White faces, then Japanese faces.

ORE can also be found across different racial groups. For example, Ge and colleagues (2009) study used old/new paradigm to investigate ORE among the Chinese and Caucasian population. Compared to own-race faces, Chinese participants in Ge and colleagues' (2009) study were faster and better in recognising own-race faces and slower and less accurate in recognising other-race faces. Similarly, this was also the case for Caucasian participants. Besides in China, the ORE has also been investigated with the Serbian population. Barzut & Zdravković (2013) also found that the Serbian population showed higher recognition accuracy for own-race faces as compared to other-race faces. Similarly, the effect has also been demonstrated with other ethnic groups such as the Middle Eastern participants (Megreya, White & Burton, 2006), Hispanic participants (Gross, 2009; Herrera, McQuiston, MacLin & Malpass, 2000; MacLin, MacLin & Malpass, 2001), Black participants (Ellis, Deregowski & Sheperd, 1975; Sheperd & Deregowski, 1981; Gross, 2009), and Asian participants (Goldstein & Chance; 1978; Michel, Caldara, & Rossion, 2006). In short, the ORE effect has been demonstrated universally with different populations. The face system is tuned in to the most frequent class of face (i.e., race face) in their environment but has difficulty recognising faces that are new and unfamiliar to the individual.

2.3 Theoretical Framework

Given the long history of the ORE phenomenon, multiple theories have been proposed in the past. Some of the older theories were not supported. Three major classes of theories that receive the most support in explaining the ORE bias are 1) Perceptual Learning Models 2) Social Cognitive Theories and 3) Categorisation-Individual Model.

2.3.1 Perceptual Learning Models

One of the most supported and researched explanations for the ORE account can be generally categorised as the Perceptual Learning Models. Different theories fall under this model with the core explanation that different experience leads people to encode same and other-race faces differently. In particular, greater experience with own-race faces leads to superior encoding and recognition of own-race faces relative to other-race faces. Similarly, it is the lesser interracial contact that leads to poorer encoding and memory for other-race faces. Different theories proposed different processing styles or representations of own and other-race faces. We will review the three theories that fall under this umbrella of differential learning below.

2.3.1.1 Contact Hypothesis

Many hypotheses were proposed to explain the occurrence of the other-race effect and the contact hypothesis has been consistently used to explain this phenomenon. Contact hypothesis was first introduced by Allport in 1954, who postulates that the ability to recognise the other-race faces is influenced by the degree of contact with them (Brigham & Malpass, 1985). It was believed that poorer and slower recognition of the other race faces was due to the low degree of contact with these class of faces (Byatt & Rhodes, 1998; Wright et al., 2003). However, the contact hypothesis also posits that a higher amount of contact with people of the other race will lead to better discrimination of that race face (Chiroro & Valentine, 1995; Cross, Cross & Daly, 1971; Pettigrew, 1998; Sangrigoli et al., 2005; Sheperd, Deregowski & Ellis, 1974).

Early evidence for the contact hypothesis was found in Cross, Cross and Daly (1971) study, in which they investigated the other-race effect among children living in segregated and integrated neighbourhoods. In their study, the children were told to look at the White and Black face pictures and to choose if any of the faces were beautiful, handsome or pretty. They

were allowed to pick as many faces as they liked. After that task, 24 pictures were shown to them, in which 12 faces they had previously seen and 12 novel faces. Then, they were asked to identify the faces that they had previously seen before. As predicted, the Caucasian children from segregated neighbourhoods demonstrated a greater other-race effect for the Black faces as compared to Caucasian children living in integrated neighbourhoods. Further evidence for the contact hypothesis can also be found in a series of studies conducted by Walker and colleagues (Walker & Tanaka, 2003; Walker & Hewstone, 2006; 2008) who studied the relationship between amount and type of other-race contact and the ability to perceptually differentiate other-race faces. Participants with greater other-race experience were consistently more accurate at discriminating between other-race faces than were participants with less other-race experience. These findings suggest that increasing quantity and/or quality of interactions with other race group members would improve recognition of that race and hence, reducing ORE (Barzut & Zdravković, 2013; Hancock & Rhodes, 2008).

2.3.1.2 Multidimensional Face Space Model

Valentine's (1991; Valentine & Endo, 1992) multidimensional face space model proposes that as we experience more faces in our daily lives, these faces are stored into our cognitive face space and forms a prototypical average. Each face that we remember is encoded in a location in our face space and is coded based on the different face properties in several dimensions in the face space. These exemplars of faces increase as we see more faces. Valentine's theory proposes that the spatial relationship between these exemplars in the face space explains a variety of face phenomenon. With regards to the ORE effect, the face space framework hypothesis when a person has fewer exemplars of other-race faces in their face-space; these faces are densely clustered in the face space. These faces are assumed to be more cognitively similar than own-race faces leading to a deficit in differentiating and recognising other-race faces as many neighbouring exemplars are interfering with the accurate recall of a face. On the other hand, many exemplars of our own race faces are available leading to a sparsely clustered face space (see Figure 7). Due to this, it is easier to recognise and individuate own race faces as there are fewer surrounding exemplars that will interfere with the accurate identification of a particular face. In essence, the multidimensional face space model complements the contact hypothesis explanation. As more exemplars of own-race faces are seen, the face is more distinctively represented in the face space leading to an easier recall of the face (see Figure 8). Based on these two theories, people who have more contact

with their own race will have multiple face exemplars from their race as compared to other races, therefore, developed expertise at recognising their own-race faces.

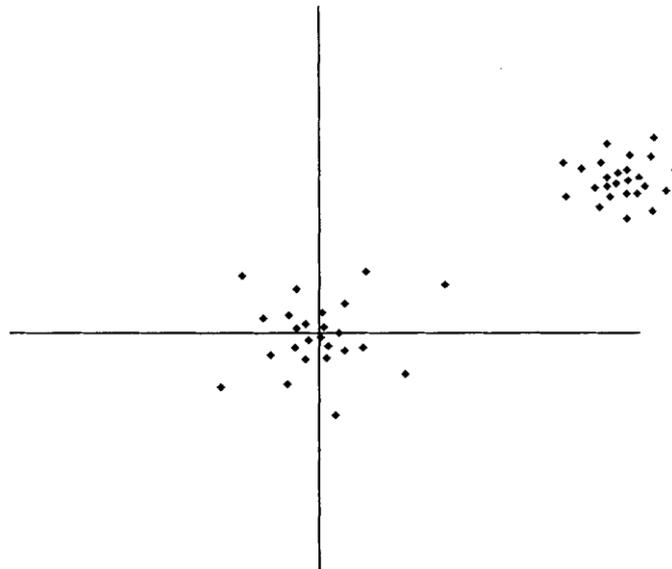


Figure 7: An exemplar model the face space model in which own and other race face is represented. Circles in the middle represent own race faces and circles on the right represent other race faces. Own race faces showed a wider range of face dimensions. Reproduced from Valentina and Endo (1991).

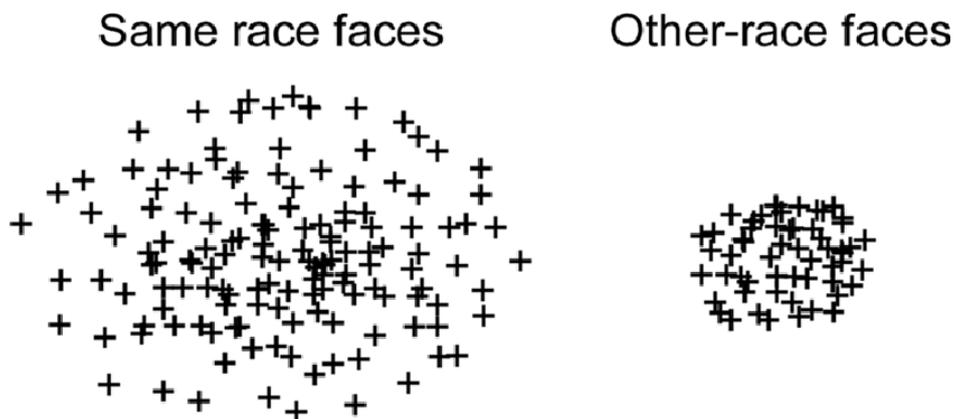


Figure 8: Conceptualisation of the face space model by Caldara & Herve (2006).

2.3.1.3 Configural/ Holistic Processing

As described in Chapter 1, configural processing, a term used to describe the ability to process spatial relational information between features in a face while holistic processing integrates the processing of all features and spatial information as a whole (Maurer, LeGrand

& Mondloch, 2002). However, these two terms are sometimes used interchangeably in studies. Using the inversion effect, Rhodes, Brake, Taylor and Tan (1989) looked at how configural information was used in processing own and other-race faces with European and Chinese participants. They found that both groups of participants showed an increase in inversion effect for own-race faces over other-race faces. The researchers concluded that configural strategy was processed when identifying own-race faces and a featural strategy was adopted when other-race faces were recognised.

Other studies using different paradigms have shown evidence of a holistic processing advantage for own-race faces. Tanaka, Kiefer and Bukach (2003) using the part-whole paradigm (see chapter 1 for details on the different paradigms), found that Caucasian participants were better able to recognise features of a face when it is presented in the whole face condition. Their results suggest that own-race faces are processed more holistically when compare to other-race faces. Michel, Rossion, Han, Chung and Caldara (2006) later on did a cross-cultural study comparing Belgian and Korean participants using the composite face paradigm and found that own-race faces were processed more holistically for both groups of participants. Hayward, Rhodes and Schaninger (2007) further showed that holistic processing was adopted when recognising own-race faces when they tested Caucasian and Hong Kong Chinese participants in their study.

Hence, according to the configural/holistic processing hypothesis, greater experience with own-race faces allows for better discrimination between own-race faces and to adopt a holistic processing strategy for these faces. On the other hand, other-race faces are processed on a featural/ piecemeal basis due to a lower expertise/experience with these faces.

Hancock & Rhodes (2008) further tested the relationship between interracial contact and holistic processing by measuring participants contact with own and other-race group using a self-reported contact questionnaire. They tested Caucasian and Chinese participants on upright and inverted faces and found that a higher level of interracial contact predicted a smaller ORE effect in holistic processing. Similarly, Bukach et al. (2012) using the composite task, found a negative relationship between individuating experience and the size of the other-race effect in holistic processing. Both studies found that the quality of contact is important in the holistic processing of the ORE. Quantity of contact on the other hand was found to have a weak influence on ORE in holistic processing (Rhodes et al., 2009).

Recent studies have also begun testing the linkage of the other-race effect in holistic processing with recognition memory of ORE. DeGutis et al. (2013) using a regression analysis found that the ORE recognition memory is significantly correlated with the ORE

holistic processing. Other studies, however, have found holistic processing for both own and other-race faces (Harrison et al., 2014, Horry et al., 2015). Overall, configural and holistic processing in ORE have used a variety of paradigms and have yielded mixed results. The issue of holistic processing in ORE continues to be debatable and researched currently.

2.3.2 Social Cognitive Models

Besides the perceptual learning models, the Social Cognitive theories have been proposed to explain the ORE. The social cognitive theories emphasize that different social categorisation of own and other-race faces results in the different encoding of these faces.

Levin (1996, 2000) in his feature selection model proposed that we see race as a visual feature. Rather than being a perceptual expert in processing own-race faces, we are experts in categorise a face as an ingroup or outgroup. This categorisation then leads us to encode features in a face differently. He suggested that race specifying information is selected in other-race faces (i.e. is this a black or not black face) whereas individuating information is processed in own-race faces. These different encoding systems are then thought to result in recognition bias in the ORE. Similarly, Rodin (1987) in his cognitive disregard model, proposed that we have a better memory of our own faces as we are motivated to pay attention to these faces due to social reasons and we do not attend to other-race faces leading to poorer recognition for other-race faces. Sporer (2001) using an in-group/out-group model explicate that individuals tend to perceive and classify out-group members by using categorization cues which results in superficial encoding, while in-group members are automatically processed in a more individuating manner using configural processing due to extensive expertise with in-group faces. Hugenberg, Young and Bernstein (2010) on the other hand postulate that the motivation of the perceivers to individuate a face in addition to perceiver experience is responsible for the ORE and ORA effect.

Some studies support the social cognitive accounts. In 2008, Shriver, Young, Hugenberg, Bernstein & Lantern, investigated whether the social context predicted ORE rather than the perceptual expertise mechanism. They conducted three experiments to test whether different social contexts would modulate the ORE effect. Thirty white middle-class university students were shown white and black faces in wealthy implying (i.e., large homes) and impoverished implying (i.e., poor homes) context. Participants were then tested on their recognition memory of the faces. Poorer recognition for white faces on impoverished backgrounds was found over white faces on wealthy backgrounds. In addition, they

demonstrated that this was because white faces on impoverished background were categorised as outgroup members supporting Sporer's (2001) model. In their last experiment, they manipulated university affiliation as ingroup versus outgroup categories and found that ingroup White faces were more accurately recall than outgroup White faces. Recognition for other-race faces (i.e., Black faces) was not affected by ingroup or outgroup classification in their experiments. Similarly, Hehman, Mania & Gaertner (2009) showed evidence that when Black and White faces were grouped by race, White university students had better recognition of same-race faces over other-race faces. However, when the faces were grouped by university affiliations, faces belonging to one's own university affiliation (ingroup) were recognised better than outgroup university affiliation regardless of race. White and Black own university faces were equally recalled and white ingroup faces were better recognised than white outgroup faces supporting the social categorisation explanation of the ORE effect. Using identical and ambiguous Hispanic-Black faces, Maclin and Malpass (2001) tested Hispanic university students using different racial hair markers to imply ingroup versus outgroup categorisation. Participants perceived a face as their own race when they saw an own race hair 'racial marker'. Their results demonstrated that racial feature was sufficient to alter perceptions and recognition of these ambiguous faces, challenging the perceptual expertise account.

However, not all studies were supportive of the social-categorisation account. In a recent study Kloth, Shields and Rhodes (2014), using a similar paradigm as Hehman et al. (2010), did not find a significant relationship between university affiliation on the ORE effect. Kloth et al. had replicated Hehman et al. study on Caucasian-Asian participants in Australia. One reason that could account for the contrasting results was the different facial stimuli used in the studies. Kloth et al.'s stimuli did not include hair and clothing and had used a black background instead of different colour background. They proposed that these differences could have prevented participants from using external cues to improve recognition of individual images.

While studies are supporting the social cognitive accounts, these studies are mostly carried out with adult participants and do not sufficiently explain the ORE phenomenon found in infants. Moreover, there are mixed findings with past studies assessing whether social categorisation modulates ORE.

2.3.3 Categorization-Individual Model

In a recent Categorization-Individuation Model proposed by Hugenberg et al. (2010), it has been suggested that the ORE happens partly due to our susceptibility for processing other race faces at a categorical level and own-race faces at an individual level. That is, a Caucasian person would categorise an individual Chinese face as simply Chinese, resulting in homogenization of the other-race faces. In contrast, when processing faces of our own race, we process individual unique traits (such as familiarity, personality, attractiveness, memory) of that face and hence are better at remembering and individuating own-race faces. Having extensive experience with own-race faces allows us to overcome categorisation at an individual level. While Hugenberg, acknowledges the importance of perceptual expertise in the ORE, his model emphasizes the motivation with a group of faces that is important for remembering the outgroup faces. According to Hugenberg, the categorisation of a face is not only elicited by race but can be influenced by social or cultural identity. This motivation affects how we categorised the face; either as our own or outgroup which then affects how we remember the face. For example, people are more willing to individuate faces of their own races and are less motivated to individuate faces of other races. However, when social or cultural identity stresses group belonging, we are more likely to individuate other-race faces. This idea is evident in several studies (Hehman et al., 2010; Van Bavel and Cunningham, 2012; Chen & Hamilton, 2012). Hehman et al. (2010) demonstrated that while university students showed the typical ORE when faces were grouped by race, this memory bias shifted when these faces were grouped by university affiliation. Participants were better at remembering faces of their own university than those of the outgroup university. Importantly, the participants were equally able to recognise own and other-race faces of their own university affiliation. In addition, poorer recognition memory was found for own-race faces of outgroup university affiliation when compared to other-race own university affiliation. Similar results were replicated by Van Bavel and Cunningham (2010).

While the categorisation-individual model provides a new perspective in explaining the ORE account, it does not sufficiently explain the early emergence of the ORE account in infants.

2.4 Plasticity of the ORE effect

While different studies have supported different theoretical accounts of the ORE, adoption and training studies have provided evidence in support of the Contact Hypothesis. Several adoption and training studies have demonstrated that the ORE can be readily reversed given experience with other-race faces (de Heering et al. 2010; Anzures et al., 2012; Heron-Delaney et al. 2011; Sangrigoli & de Schonen, 2004). Sangrigoli & de Schonen (2004) showed that the ORE in infants can be reduced with just a short-term familiarisation to a few exemplars of another racial group. In a similar vein, Heron-Delaney and colleagues (2011) trained 6-month-old Caucasian infants in recognizing Chinese faces using a picture book for 3 months. By 9 months, Caucasian infants who were exposed to Chinese faces were able to maintain the ability to discriminate Chinese faces at 9 months of age as compared to Caucasian infants who did not have training. Bar-Haim et al. (2006), on the other hand, investigated infants who are raised in a cross-race environment and found that African-Israeli 3-month-old infants, who have cross-race exposure, do not show the ORE effect. Specifically, these infants looked equally at Caucasian and African faces. In a more recent study, Fioravanti-Bastos, Filgueiras & Landeira-Fernandez (2014) investigated the ORE effect in Caucasian and Japanese children (5-7-year-old and 9-11-year-old) born and living in Brazil. They were presented with coloured images of Caucasian and Japanese children's faces. Using matching to sample task, comparable recognition for own and other-race faces was found for Japanese children who had exposure to both Japanese and Caucasian faces in Brazil. Caucasian children of both age-grouped demonstrated the typical ORE effect. In another study, Tham, Bremner and Hays (2017) compared British White and Malaysian Chinese children (aged 5-7 and 13-14 years) on the role of experience in the ORE effect. Malaysian children were from a multiracial society having exposure to Malay, Chinese, Indian and some Caucasian faces in their country. British children demonstrated the typical ORE effect and had recognition deficits for three other-race faces (Malay, Chinese, African Black) in the study, whereas Malaysian children only showed poorer recognition for other race African Black faces but not with frequently experienced faces and less frequently experience Caucasian faces. These studies demonstrate the importance of visual experience within one's environment is crucial for shaping face representation early in life.

Training studies in adults have also been shown to reduce ORE in participants (such as Elliott, Wills, & Goldstein, 1973; Goldstein & Chance, 1985). In 1985, Goldstein and Chance used pair-associate training as the researchers believed that the quality of the

interaction was more important than the quantity of the interaction. After 1 month and 5 months of intensive training in recognising Japanese faces, Caucasian participants showed improvement in recognising novel Japanese faces. This study revealed that frequent exposure to other races can reduce ORE in adults. Using a similar method, White participants in Elliott and colleagues' (1973) study also found improvement in recognising other-race faces (Asian face) after the training. Mastery in other-race face recognition following exposure to other-race faces via photographs or videos has also been demonstrated in adulthood (Rhodes, Locke, Ewing, & Evangelista, 2009; Tanaka & Pierce, 2009).

Adoption studies conducted by Sangrigoli, Pallier, Argenti, Ventureyra and Schonen in 2004 also demonstrate that children's ORE is reversible. In this study, adult participants of Korean origin who were adopted by European Caucasian families when they were children (age three- to five years old) showed better recognition of Caucasian faces as compare to Asian faces despite Asian faces were considered as their own-race faces and Caucasian faces as other-race faces. Sangrigoli and colleagues further explained that as the participants had been exposed to Caucasian faces more frequently than Asian faces since young, they processed Caucasian faces more accurately compared to Asian faces. However, it is unclear in this study whether the adult participants showed a reversal of the ORE effect due to their experience accumulated with Caucasian faces while the face-processing system was still developing and/or because of their extremely long experience with Caucasian faces since their adoption (23 years on average). Heering and colleagues' (2010) study addressed this issue by testing Asian children between 6 to 14 years of age, who were adopted to Caucasian families in Western Europe when they were between 2 to 26 months and found that these children performed equally well for both own-race faces, and other-races faces. Both these studies showed that increased interaction with other-race faces during childhood is able to modify the face-processing system.

The other-race effect has also been shown to be moderated by other-race contact and can be reversed if sufficient exposure to the other-race contact is achieved. For instance, training studies (Anzures et al., 2012; Lebrecht, Pierce, Tarr, & Tanaka, 2009; Tanaka & Pierce, 2009) have found that the other-race effect can be reduced if infants, children, and adults are provided with video, picture book, or image-based experience with other-race faces. In addition, children who are adopted into an other-race family have been found to have a similar recognition of own- and other-race faces (de Heering, de Liedekerke, Deboni, & Rossion, 2010), while a reversal of the other-race effect was found in adults who were adopted into an other-race family when they were young

(Sangrioli, Pallier, Argenti, Ventureyra, & de Schonen, 2005). Thus, the other-race effect is a phenomenon that seems to be developed through perceptual experience and is malleable given experience with other-race faces.

The other-race effect has further been linked to implicit racial bias in preschoolers (Xiao et al., 2015). Xiao and colleagues found that preschoolers as young as 4 years of age demonstrate an implicit racial bias towards another race, and that perceptual individuation training with other-race faces can reduce such bias. These results indicate that processing other-race faces at a perceptual level can affect implicit bias against other-race individuals at a social level.

2.5 Summary

From the review of previous studies, ORE is found to exist in different populations and has been found to develop early in life. While many theories have been proposed to account for the ORE phenomenon, the mechanism behind this account is still being debated. However, evidence from developmental studies, adoption and training studies suggest that experience is rooted in the development of the ORE effect and can be reversed with increased exposure with another face race.

Chapter 3: Introduction to the Other Race Categorisation Advantage (ORA)

Another relevant area of face recognition that is less researched is how we categorise faces. Contrary to the ORE, individuals categorise other race faces faster than own-race faces (Levin, 1996; Valentine & Endo, 1992, Zhao & Bentin, 2008; Ge et al., 2009). When an individual is asked to categorise a face by race, they are faster and sometimes more accurate in categorising other-race faces than in categorising own-race faces. This phenomenon is known as the other-race-categorisation advantage (ORA). Whereas results in the literature for the ORA has been mixed due to methodological differences, Ge et al. (2009) found an antagonistic interaction between the other-race effect and other race advantage, suggesting a common underlying processing mechanism, where recognising a face with a high level of expertise interferes with categorising of that face. Feng et al. (2011) using an fMRI method further elucidates that more cortical resources are engaged during the categorisation of own-race faces which explains the longer reaction time when categorising same-race faces.

3.1 Theories

3.1.1 *Multidimensional Space Hypothesis*

As have been explained in Chapter 2, the multidimensional space hypothesis proposed by Valentine (1991) states that faces are encoded as a location in a multidimensional cognitive space. As we see a face, it is encoded in the face space. Given that we see more of our own race faces, there are more exemplars of these faces in the face space resulting in a more widely represented space. On the other hand, as we do not see as many other-race faces, these faces are said to be tightly clustered in our face space, which results in more difficulty individuating these faces due to more interference from surrounding exemplars of the other race face space. Based on this framework, other-race faces will be categorised as a “face” faster as they match the prototype more closely than own-race faces resulting in the other race categorisation advantage.

3.1.2 Contact Hypothesis

Several social cognitive models have been postulated to resolve these two paradoxical phenomena. For example, the contact hypothesis has been consistently used to explain the ORE phenomenon in which familiarity due to experience with the members of a particular race (own or others) increased the accuracy of recognition (see the previous chapter for details). In a series of studies, Walker and colleagues showed the relationship between amount and type of other-race contact and the ability to perceptually differentiate other-race faces (Walker & Tanaka, 2003; Walker & Hewstone, 2006; 2008). Participants with greater other-race experience were consistently more accurate at discriminating between other-race faces than were participants with less other-race experience. Similarly, the contact hypothesis is also used to explain the ORA. Caldara, Rossion, Bovet and Hauert (2004) using event-related potential recordings, found that Caucasian participants were faster in categorizing other-race faces than their own race faces, in particular at the semantic stage of visual information processing. Caldara et al. concluded that lesser experience with other-race faces accounts for fewer semantic representation which leads to faster categorization of these faces.

3.1.3 Feature Selection Hypothesis

Expanding on the contact hypothesis, Levin (1998, 2000) proposed a feature selection hypothesis to explain the ORE and ORA effect. In this model, Levin suggests that individuals are experts in classifying other race faces rather than own-race faces. He explains that when we see an other-race face, we identify whether a race specifying feature is present or not. For example: When a Caucasian White individual see a Black face (other-race faces), “race is not coded as Black or White; it is coded as Black or not Black” (Levin, 1998, p. 1366). It suggested that race specifying information is selected in other-race faces whereas individuating information is processed in own-race faces. He noted that it is easier to detect the presence rather than the absence of race specifying feature, resulting in the other race categorisation advantage. Similarly, Sporer (2001) using an in-group/out-group model explicate that individuals tend to perceive and classify out-group members by using categorization cues which results in superficial encoding (i.e. coding of race, gender information), while in-group members are automatically processed in a more individuating manner using configural processing due to extensive expertise with in-group faces.

Hugenberg, Young and Bernstein (2010) on the other hand postulate that the motivation of the perceivers to individuate a face in addition to perceiver experience is responsible for the ORE and ORA effect. These models while different in the way they explain how faces are processed, all agree that extensive experience with same-race faces leads to higher perceptual expertise with these faces.

3.2 Evidences of the presence of ORA

The ORA effect has received support from behavioural and neuroimaging evidence especially with the adult population (Caldara, Rossion, Bovet, and Hauert, 2004; Caharel et al., 2011; Castano Yzerbyt, Bourguignon & Seron, 2002; Feng et al., 2011; Ge et al., 2009; Valentino & Endo, 1992; Zhao & Bentin, 2008). For example, Zhao & Bentin (2008) with a group of Chinese and Israeli participants who had minimal experience with other-race faces in the study found both groups of participants were faster in categorising other-race faces than own-race faces. Similarly, Ge et al. (2009) using Chinese and Caucasian participants also found the same ORA in their study. Caharel et al. (2011) using both behavioural and electrophysiological data found that Caucasian participants were faster in classifying African and Asian other race faces compare to their own race face. In addition, they also found a higher face inversion effect for Caucasian own race face on the face-sensitive N 170 amplitude indicating that same-race faces use more configural processing due to higher perceptual expertise for these faces. Feng et al. (2011) using fMRI method in their study with Chinese and Caucasian faces further lend supports that more neurological resources as demonstrated in higher neural activations in the bilateral ventral occipitotemporal cortex (VOT) are engaged during categorisation of own-race faces resulting in slower reaction time during categorisation of own-race faces as oppose to other-race faces. Consistently, the ORA effect has been demonstrated in adults from various populations.

While some studies demonstrate the ORA effect in the adult population, however, less is known about the development of ORA in children. To date, no data are examining the ORA effect in children and only two studies looking at categorising of faces according to race in infants. Anzures, et al. (2010) found that 9-month-old infants were able to categorise their own race Caucasian face more sophisticatedly than other race Asian faces. In a more recent study, Quinn, et al. (2016) investigated categorization during infancy. Caucasian 6-month-olds responded to the perceptual differences between African and Asian face classes,

whereas Caucasian 9-month-olds formed a broad other-race grouping of faces that can be a foundation or be a precursor of an initial race-based ingroup (the category of faces that the infant is predominantly experiencing)–outgroup (face that does not match the ingroup) differentiation of faces. Other early studies have also found that infants can form discrete facial categories early in life such as categories for cat and dog faces (Quinn and Eimas, 1996).

3.3 Summary:

While the ORE effect has been extensively researched, less is known about the ORA effect. A few theoretical accounts have attempted to explain the ORA effect in line with the ORE effect and several adult studies have demonstrated the presence of ORA in various populations. However, less is known about the developmental aspect of the ORA given that only two infant studies have investigated this phenomenon and none with children population have been found.

Chapter 4: Thesis Aims

Based on the review in chapter 2 and chapter 3, past studies collectively indicate that while face processing ability is very much experience-driven, this system remains plastic to experience in the early years. Because most studies of the ORE and ORA have been done with monoracial populations, it is important to investigate this effect with a multiracial society to further explore the influence of consistent exposure to different faces on the ORE and ORA.

Although previous training studies and adoption studies have attempted to either artificially expose infants and adults to other-race faces, or investigate these effects retrospectively, the effects from training studies can be transitory and do not indicate the effects of permanent immersion in multiracial environments.

In addition, there are very few studies that have investigated whether live social interactions with other-race individuals lead to a faster reduction of the ORE. Live social interaction may provide a rich representation of faces through varied emotional expression, varied viewpoints and social contexts (Anzures et al., 2013). To date, only a handful of studies have investigated the ORE effect in a multiracial population. For example, Bar-Haim et al. (2006) found that three-month-old single race infants living in a multiracial environment showed no other-race effect for own and other experience race faces. Studies with children and adults in the multiracial environment also showed similar recognition for own and other experienced race faces (e.g., Cross et al., 1971; Tham, Bremner & Hay, 2017; Fioravanti-Bastos, Filgueiras, & Landeira-Fernandez, 2014).

To extend the literature in this area, the present Ph.D. aims to investigate the developmental effect of recognition (ORE effect) and categorisation (ORA) phenomenon in a multiracial country. Malaysia is a country that represents a unique opportunity to investigate those issues. Malaysia's population consists of 68.8% Malay, 23.2% Malaysian Chinese, 7%, Malaysian Indian and 1% other ethnic groups (Department of Statistics Malaysia, 2017). In addition, another aim of the thesis is to also investigate whether differential experience affects the way children detection of kinship relations among stranger's faces.

A multiracial environment in Malaysia provides a good “natural experiment” to understand how live interaction with different ethnic group influence the way the face-

processing system has developed. As there is only one study on adult face recognition done in Malaysia showing Malaysian adopt a mixture of Eastern and Western fixation pattern in recognizing faces (Tan, Stephan, Whitehead, & Sheppard, 2012) and another in Malaysian children (Tham, Bremner & Hay, 2017), there is a need to research and replicate this area further using other behavioural methods and participants to provide a better understanding on how Malaysian adults and children process own and other-race faces.

Chapter 5: Experiment 1: Development of the other-race effect in Malaysian-Chinese infants

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(Note: As this chapter is published, the introduction repeats information written in other chapters).

5.1 Introduction

Infants have been shown to be sensitive to differential experiences with their own and other-race faces. For example, at a very early age, infants show a spontaneous preference for own-race faces over other-race faces (e.g., Bar-Haim, Ziv, Lamy, & Hodes, 2006; Kelly et al., 2005; Kelly, Liu, et al., 2007), 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, Quinn, et al., 2007; Kelly et al., 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; Valentine, 1991; Malpass & Kravitz, 1989). 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 & Valentine, 1995; Chiroro, Tredoux, Radaelli, & Meissner, 2008; Cross, Cross, & Daly, 1971; Feinman & Entwisle, 1976; Kelly, Quinn, et al., 2007; Pezdek, Blandon-Gitlin, & Moore, 2003; Suhrke et al., 2014; Tham, Bremner, & Hay, 2017). However, studies on populations with exposure to more than one racial group are scarce 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 multiracial

environments make 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 favored 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, Quinn, et al. (2007) found that 3-month-olds could distinguish between faces 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., 2009; Kelly, Quinn, et al., 2007), 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 et al., 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 recognizing female Caucasian White faces than female Asian faces. According to Tham et al. (2015), the emergence of the ORE at 3 months could be explained by specific aspects of the stimuli used. That is, those studies demonstrating the early emergence of the ORE used only stimuli with female faces and limited external facial information. Tham et al. (2015) found that the 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 recognizing female own-race faces, whereas older infants were better at recognizing 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 procedures regarding external features are likely important because including external information allows the possibility that infants discriminate based on 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., 2008; Quinn, et al., 2002). 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 toward faces that represent their primary caregiver.

Studies have shown 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 races. 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 with their age-matched (Asian) controls who showed a clear ORE in favor 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 mono-racial (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 with 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, and 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 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.

5.2 Method

5.2.1 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. The 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 if 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.

5.2.2 Stimuli

See Figure 9 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), based on 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 $\frac{3}{4}$ 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).

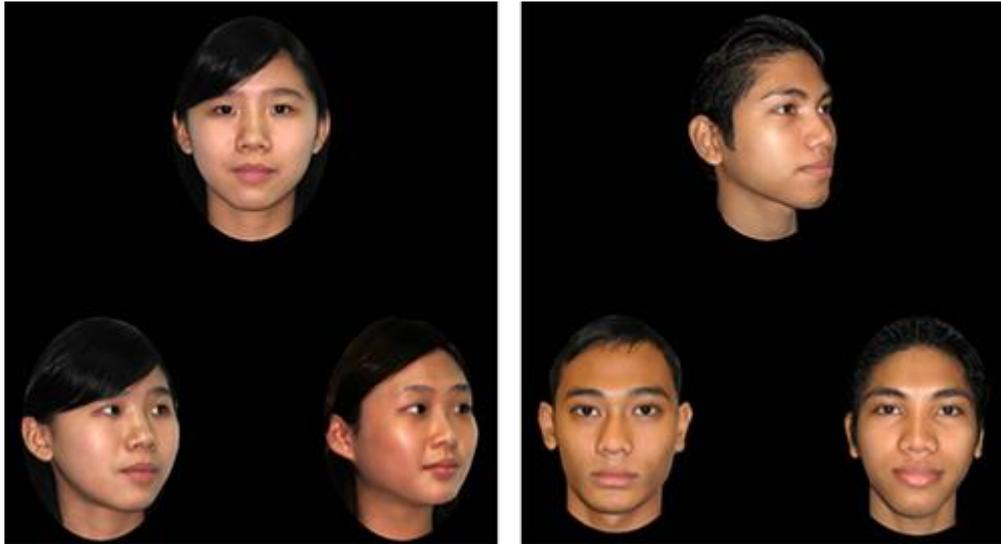


Figure 9: Sample stimuli from the Chinese female and Malay male conditions

5.2.3 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 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.

5.2.3.1 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 12th trial, data were excluded from the analysis.

5.2.3.2 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 was 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.

5.3 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.

5.3.1 *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, $F(1, 68) = 5.56, p = .02, \mu_p^2 = .08$, and face gender, $F(1, 68) = 6.56, p = .01, \mu_p^2 = .09$. 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, $F(2, 68) = 3.89, p = .03, \mu_p^2 = .10$. 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, $F(1, 68) = 5.54, p = .02, \mu_p^2 = .08$, 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.

5.3.2 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, $F(2, 68) = 4.07, p = .02, \mu_p^2 = .11$ (Figure 10). 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, $F(2, 71) = 7.05, p = .002, \mu_p^2 = .17$, 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.

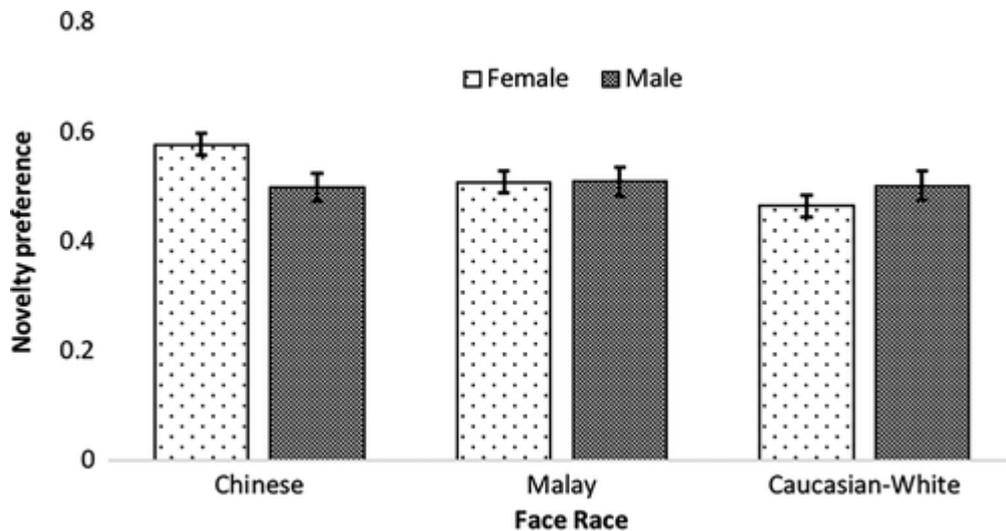


Figure 10: Proportion of looking at the novel face (novelty preference) for female and male Chinese, Malay, and Caucasian White faces in both age groups (3- to 4-month-olds and 8- to 9-month-olds)

5.3.3 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.

Table 1. Mean novelty preference (standard deviation) and two-tailed above chance level (0.50) 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)	$t(11) = 3.04, p = 0.01$	0.88
		Male	0.48 (0.16)	$t(11) = -0.34, p = 0.74$	0.01
	Malay	Female	0.44 (0.15)	$t(11) = -1.26, p = 0.23$	0.36
		Male	0.47 (0.11)	$t(11) = -0.91, p = 0.38$	0.26
	White	Female	0.45 (0.10)	$t(11) = -1.59, p = 0.14$	0.46
		Male	0.50 (0.18)	$t(11) = 0.01, p = 0.99$	0.004
8–9 months	Chinese	Female*	0.55 (0.07)	$t(12) = 2.82, p = 0.02$	0.78
		Male	0.51 (0.12)	$t(12) = 0.42, p = 0.68$	0.12
	Malay	Female**	0.57 (0.06)	$t(11) = 3.92, p = 0.002$	1.13
		Male	0.54 (0.10)	$t(11) = 1.60, p = 0.14$	0.46
	White	Female	0.48 (0.06)	$t(12) = -1.26, p = 0.23$	0.35
		Male	0.50 (0.09)	$t(12) = 0.13, p = 0.90$	

** $p < 0.005$;

* $p < 0.05$.

5.3.4 Social and caregiving environment

Forty-five complete social and caregiving environment questionnaires were returned, based on 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 of the same ethnicity as the infant. No parent reported other family members from an ethnicity different than the infants. 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.

5.3.5 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, $F(1, 13) = 0.28$, $p = .61$, $\mu_p^2 = .02$.

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 females in recognizing Chinese and Caucasian-White faces ($p \geq .21$).

5.4 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). This 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 based on 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 groups 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, the experience of a

disproportionate number of females faces of different races 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).

Chapter 6: Experiment 2 & 3: The other-race effect in Malaysian adults and children in a multiracial context.

6.1 Introduction

The ability to recognize and categorise different faces proficiently may have social and evolutionary advantages, including allowing us to identify different individuals, remember specific individuals' behavior in social situations and detecting emotions as well as recognizing in-group and out-group members. Thus, investigating how people learn and process information about a face is of particular interest for human social behavior.

As explained in Chapter 2, the ORE effect is a well-established phenomenon with various populations. Different theories have been proposed to explain this phenomenon, with the contact hypothesis being one of the most supported explanations. Previous developmental studies (Kelly et al., 2005, 2007; Anzures et al., 2010, 2013, Fioravanti-Bastos et al., 2014; Tham et al., 2017) and adoption and training studies (de Heering et al., 2010; Sangrigoli & de Schonen, 2004) suggests that experience is rooted in the development of the ORE effect and can be reversed with increased exposure with another face race.

However, there are very few studies that have investigated whether live social interactions with other-race individuals lead to a faster reduction of the ORE. Live social interaction may provide a rich representation of faces through varied emotional expression, varied viewpoints and social contexts (Anzures et al, 2013). Three such studies have recently been reported. Tham et al. (2017) tested 5- to 6-year-old and 13- to 14-year-old monoracial British children and multiracial Malaysian Chinese children on their recognition of Chinese, Malay, Caucasian, and African faces. They reported a typical other-race effect for the British children, whereas the Malaysian Chinese children had a recognition advantage for both frequently experienced Chinese and Malay faces relative to the less frequently experienced Caucasian faces. Tham et al. concluded that children from a multiracial environment who have experience with another race of faces early in life may be able to maintain a more malleable face representation when exposure to other-race faces is plentiful. Similarly, the finding of a lack of an own-race face recognition advantage in Japanese descent children born

and living in Brazil (Fioravanti-Bastos, Filgueiras, & Landeira-Fernandez, 2014) indicates that the development of ORE account is different for a monoracial and multiracial society. Tan, Stephan, Whitehead & Sheppard (2012) in their eye-tracking study found that Malaysian Chinese adults used a different approach in fixation strategy compared to British White adults and reported that Malaysian Chinese adults in their study had an ORE for African faces, but not East Asian and White Western Faces. They reported the lack of ORE for White Western faces could be due to the exposure of the study participants to western people and culture who were studying in a British university campus in Malaysia.

To extend the literature in this area, the present study aims to investigate the recognition (ORE effect) in a multiracial country. As explained previously, the multiracial environment in Malaysia provides a good “natural experiment” to understand how live interaction with different ethnic group influence the way the face-processing system has developed. As there are only two studies on adult and children face recognition done in Malaysia there is a need to research and replicate this area further using other behavioural methods and participants to provide a better understanding of how Malaysian adults and children process own and other-race faces. As Malaysians are exposed to a different ethnic group in their day-to-day interaction, it would be of interest to determine whether children and adults from a multiracial environment would manifest the typical ORE for other-race faces of minimal experience and also for other-race faces of consistent experience.

We will, therefore, use the term, “**low-frequency other-race**” to refer to the Caucasian faces used in the study, “**own-race**” to refer to faces of the same race as the participants (i.e., Malay faces for Malay participants and Chinese faces for Malaysian Chinese participants), and “**high-frequency other-race**” to refer to faces to which participants are exposed frequently in Malaysia but are not from their own race (i.e., Chinese faces for Malay participants, and Malay faces for Malaysian Chinese participants). According to the contact hypothesis, the ORE should decrease as exposure increases. That is the recognition accuracy should be lowest for low-frequency other-race faces and higher for own-race and high-frequency other-race faces.

Two experiments were conducted to test the facial recognition memory of Malaysian adults and children. As previously mentioned in Chapter 2, the old new paradigm is best used to test adults and the less cognitive demanding matching-to-sample paradigm is used with children. Hence, Experiments 2 and 3 are conducted separately using different testing paradigms to test Malaysian adults and children.

6.2 Experiment 2

6.2.1 Method

6.2.1.1 Participants

27 Malay and 27 Malaysian Chinese (with 25 males and 29 females) with a mean age of 19.7 years old from Kuala Lumpur, Malaysia participated in the study. Participants reported limited direct contact with Caucasian white individuals. In Kuala Lumpur, the population consists of 45.2% Malays, 42.3% Chinese, 11.0% Indians, and 1.5% other minority groups (Department of Statistics Malaysia, 2010).

6.2.1.2 Stimuli

24 Malay, 24 Malaysian Chinese and 24 European adult upright faces with a neutral expression (half male and half female) were used. All photographs of faces were full colour images taken at frontal and profile position and cropped to eliminate hair and neck information. Refer to Figure 11 for an example of stimuli used.





Figure 11: Sample stimuli of Caucasian, Malay and Chinese faces in experiment 2a.

6.2.1.3 Design and Procedure

The experiment was a 3 x 2 factorial design, with face race (Malay versus Malaysian Chinese versus European) as the within-subject factor and participant race (Malay versus Malaysian Chinese) as the between-subject factor. Participant's recognition memory was examined using the old-new paradigm. All participants went through a learning phase followed by a recognition phase for 3 race conditions (Malay face, Malaysian Chinese face, European face). To ensure that participant face recognition is based on face identity information and not photographic processing and view-dependent matching of images, the pose of the stimulus face was altered across learning and recognition trials. If participants view a face in frontal orientation during the learning phase, they will see a profile orientation of that learned face during the recognition phase.

In the learning phase of each race condition, participants first passively viewed and were asked to remember either 12 faces of Malay faces, 12 faces of Malaysian Chinese faces or 12 European faces. Each face was presented three times to enhance memorisation of the face. After the learning phase, participants viewed 12 learned faces and 12 unlearned faces of the same race condition presented in random order. Participants were asked to press either "k" or "l" on the computer keyboard to indicate whether the face had been previously seen or not. All race conditions were counterbalanced between participants in which 20 participants will view the Malay face condition first, 20 participants will view the Malaysian Chinese face condition first, and 20 participants will view the European face condition first. To ensure participants understood the task, they were first asked to complete a practice session with eight trials of photographs of objects.

All faces in the experiment were presented with E-Prime (Psychology Software Testing, Pittsburgh, PA) via a computer. In the learning phase, each face was presented for 2000ms and an inter-stimulus fixation crosshair was presented for 500ms between each face

stimulus. In the recognition phase, the faces were presented for up to 5000ms depending on key press. Participants were asked to respond as fast and as accurately as possible.

6.2.2 Results

Recognition scores in terms of percentage face accurately identified and response time for own and other-race faces were computed for each participant. Preliminary analysis showed that the effects of participant gender and face gender were not significant. Thus, participant gender and face gender were not included in subsequent analysis.

6.2.2.1 Accuracy

A 2 (participant race: Malay, Malaysian Chinese) x 3 (Stimulus face race: Caucasian face, Malay face and Chinese face) analysis of variance (ANOVA) was performed on the accuracy data measured by percentage correct responses (Figure 12) to assess the ORE effect. There was a significant main effect for face race, $F(2,104) = 6.63, p < .01, \eta^2 = .11$. Post hoc tests revealed that participants were significantly more accurate in recognising Malay faces ($M = 0.65, SD = 0.09$) compare to Caucasian faces ($M = 0.60, SD = 0.09, p < .01$). Participants had similar recognition performance for Malay and Chinese faces ($M = 0.62, SD = 0.09, p = .08$). There was no significant interaction effect between face race and participant race, $F(2, 104) = 2.19, p = .12$ and no main effect for participant race, $F(1, 52) = 1.02, p = .32$. Details of accuracy scores are in Table 2.

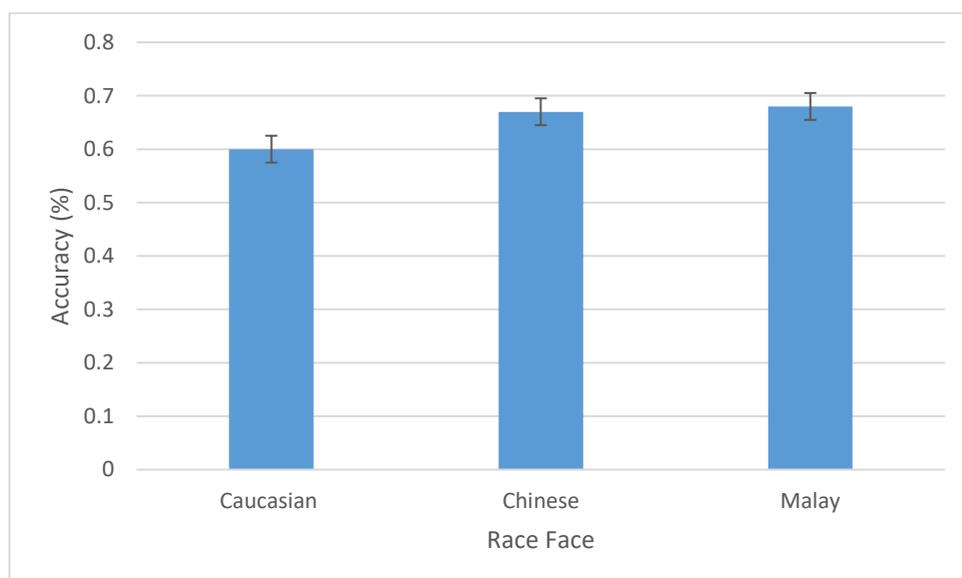


Figure 12: Mean accuracy according to face race with standard error.

6.2.2.2 Reaction Time (RT)

A 2 (participant race: Malay, Malaysian Chinese) x 3 (Stimulus face race: Malay face, Chinese face and European face) analysis of variance (ANOVA) was performed on the RT data measured in milliseconds to assess how quickly participants responded. There was no main effect of the face race, $F(2,104) = 1.17, p = .32$, no interaction effect between face race and participant ethnicity, $F(2,104) = 0.53, p = .59$ and no main effect for participant race, $F(1, 52) = 3.352, p = .07$. Details of the RT scores are in Table 2.

Table 2. Descriptive Statistics for accuracy (ACC) and response time (RT) for each face race.

	N	Mean	Std. Deviation
Caucasian ACC	54	.59	.09
Chinese ACC	54	.62	.10
Malay ACC	54	.65	.09
Caucasian RT	54	1403.69	444.85
Chinese RT	54	1414.41	408.66
Malay RT	54	1335.07	375.55

6.2.3 Discussion

In the present study, we examined how the ORE was manifested in adults who were born and raised in a multiracial environment. It was proposed that ORE should decrease as exposure increases in accordance with the Contact Hypothesis. That is the recognition accuracy should be lowest for low-frequency other-race faces and higher for own-race and high-frequency other-race faces.

We found that Malaysian adults had better recognition accuracy for Malay faces relative to Caucasian faces. There was no significant difference between Malay and Chinese faces. For both Malay and Chinese Malaysian adults, the lowest recognition accuracy was found for the low-frequency other race Caucasian face indicating a typical ORE effect. When we look at own and high-frequency other-race faces, both Malay and Chinese participants had equal recognition accuracy for both these class of faces, a finding that is consistent with a version of the contact hypothesis in which other-race faces need to surpass some threshold of experience in order to be responded to as own-race faces (Liu et al., 2015). Adults in Kuala Lumpur have had extensive experience with both Malay and Chinese Malaysian faces, explaining why there is no difference between own and high-frequency other-race faces. As

predicted, Caucasian faces were recognised least given that it is a low-frequency other-race face in Malaysia. The remaining question would be to determine how many years are necessary to observe such a null difference. The best way to solve this issue is to test children who will have less experience with faces. Considering the literature on adopted children we expect that some ORE might be observed for less frequent faces. Malay children might be less efficient at processing Chinese Malaysian faces and Chinese Malaysian children will have the same issue with Malay faces.

6.3 Experiment 3

The following three experiments (3a, 3b & 3c) have been adapted from Experiment 2 to test Malaysian children. Specifically, a two-force choice paradigm similar to Anzures et al. (2013), was used to test children rather than the old-new paradigm used with adults. This was found in recent studies to be a better paradigm to use with children. The original children experiment had three race face conditions: Caucasian-white face, Malay face and Chinese face condition. However, it was later found that the Caucasian-white face stimuli were not well controlled and were deemed to be too easy to recognise due to eye colour and skin tone differences. This was confirmed through testing of the children study stimuli with adult participants. Hence, the Caucasian-white race face condition is removed from the analysis of the studies below.

Similar to Experiment 2, it is hypothesized that ORE should decrease as exposure increases. However, as younger children may not have the same level of contact and exposure with other-race faces as adults, it is hypothesized that some level of ORE may be observed for less frequent faces. Unlike Malaysian adults (see results of Experiment 2), younger Malay children may experience lower recognition performance with Malaysian Chinese faces due to less experience with this category of faces. Similarly, it is predicted that younger Malaysian Chinese children may experience lower recognition performance with Malay faces. However, as Malaysian children have increased exposure to other-race faces as they get older, we expect their recognition performances to change and be more similar to recognition performance of Malaysian adults.

6.3.1 Experiment 3a

6.3.1.1 Method

6.3.1.1.1 Participants

Forty-nine 7-year-old children (23 Male, 26 Females) with a mean age of 6-year 8 months and forty-five 10-year-old children (22 males, 23 females) with a mean age of 9-year 7-months from Kuala Lumpur, Malaysia participated in the ORE children Study 3a. Of all the children, there were 52 Malay and 42 Chinese children.

6.3.1.1.2 Stimuli

20 Malay and 20 Malaysian Chinese adult upright faces with a neutral expression (half male and half female) were used. All photographs of faces were full colour images taken at frontal and profile position with hair information. Refer to Figure 13 for an example of stimuli used.

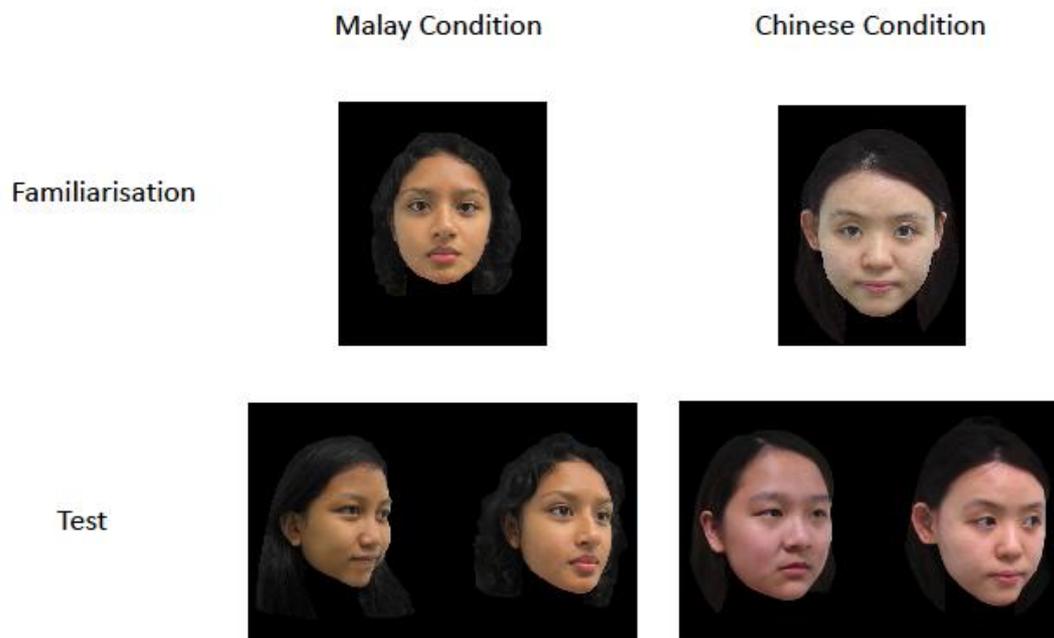


Figure 13: Example of female faces used in Caucasian, Malay and Chinese condition in Experiment 3a.

6.3.1.1.3 Design and Procedure

The experiment was a 2 x 2 x 2 factorial design, with face race (Malay versus Malaysian Chinese) as the within-subject factor and participant race (Malay versus Malaysian Chinese) and participant age (6–7-year-olds and 9–10-year-olds) as the between-subject factors.

Participant's recognition memory was examined using the two-alternative force-choice matching-to-sample paradigm. All participants went through a familiarisation phase followed by a test (recognition) phase for 3 race conditions (Malay face, Malaysian Chinese face, European face). To ensure that participant face recognition is based on face identity information and not photographic processing and view-dependent matching of images, the pose of the stimulus face was altered across familiarisation and test trials. If participants view a face in frontal orientation during the familiarisation trial, they will see a profile orientation of that familiar face paired with a novel face during the test trial and vice versa. The pose of familiarisation and test was always different. After familiarisation, participants were asked to choose the familiar face.

Participants completed the recognition task for Malay, Malaysian Chinese and Caucasian-White faces. All conditions were randomised in a single block. Each race condition consists of a total of 10 trials (with 5 male faces and 5 female faces). All children were familiarised with the target face for 1500ms followed by an inter-stimulus fixation crosshair of 1000ms. After that, participants were presented with the target face paired with a novel face until participants responded with a keypress. Participants were given a practice session with six trials of the two-alternative forced-choice matching-to-sample paradigm with photographs of toys and animals.

6.3.1.2 Results

Recognition scores in terms of percentage face accurately identified and response time for own and other race faces were computed for each participant. Preliminary analysis showed that the effects of participant gender and face gender were not significant. Thus, participant gender and face gender were not included in subsequent analysis.

6.3.1.2.1 Accuracy

A 3-way ANOVA (2 Face Race: Malay vs Chinese Face x 2 Participant Ethnicity: Malay vs Chinese x 2 Age Group: 6-7 vs 9–10-year-old) found a significant interaction effect for FaceRace X Age Group Interaction $F(1, 90) = 8.04, p < .01$, partial eta square = .08 and a significant interaction effect for FaceRace X Ethnicity X Age Group, $F(1, 90) = 12.59, p < .01$, partial eta square = .12 (see Figure 14). Post hoc paired sample t-test found that 7 years old Chinese children were better at recognizing Chinese faces compare to Malay faces, $t(20) = 4.365, p < .001$ but 7-year-old Malay children had equal recognition performance for Chinese and Malay faces, $t(27) = -0.263, p = .795$. On the other hand, 10-year-old Chinese children were better at recognizing Malay faces compare to Chinese faces, $t(20) = -2.098, p = .049$ and no recognition performance difference was found for Malay children on both types of faces $t(23) = .461, p = .649$. No other main or interaction effect was found. Details of accuracy scores are in Table 3.

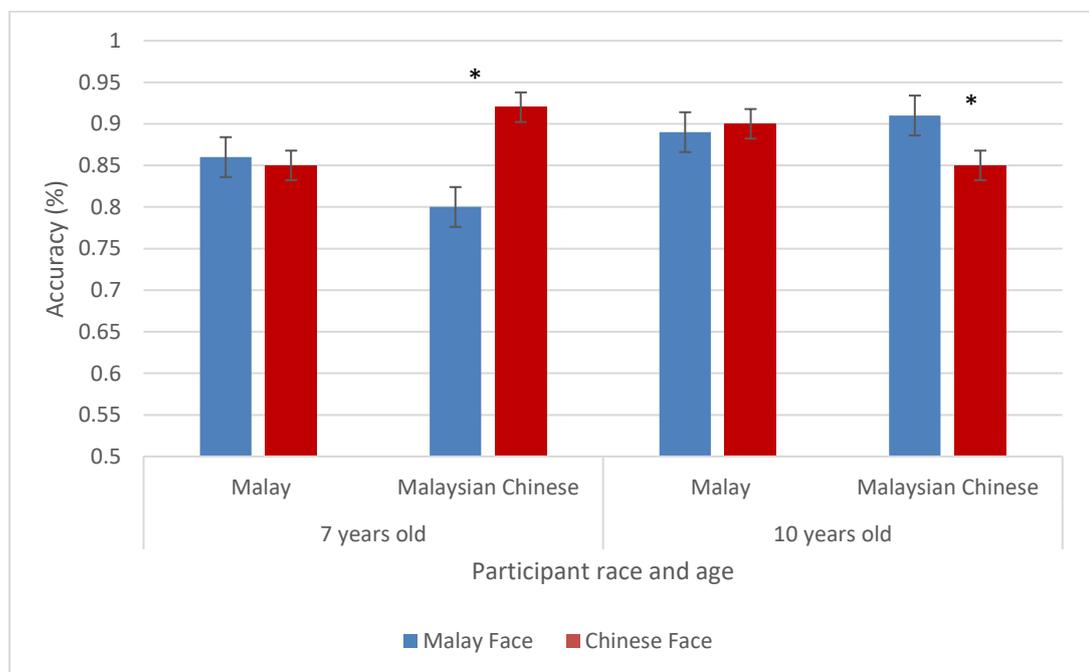


Figure 14: Mean accuracy according to face race, participant race and age with standard error.

6.3.1.2.2 Reaction Time (RT)

A 3-way ANOVA (2 Face Race: Malay vs Chinese Face x 2 Participant Ethnicity: Malay vs Chinese x 2 Age Group: 6-7 vs 9–10-year-old) was performed on the RT data measured in milliseconds to assess how quickly participants responded. There was no main effect of the face race, or interaction effect between face race and participant ethnicity, and participant age. A significant main effect for participant age was found, $F(1, 90) = 32.13$, $p < .01$, partial eta square = .26 with older children performing faster ($M = 1366.23$, $SD = 484.08$) than younger children ($M = 1914.87$, $SD = 556.05$).

Details of the RT scores are in Table 3.

Table 3. Descriptive Statistics for accuracy (ACC) and response time (RT) for each face race.

AgeGroup	Ethnicity		N	Mean	Std. Deviation
6-7 years old	Chinese	Malay ACC	21	.80	.10
		Chinese ACC	21	.92	.10
		Malay RT	21	1865.62	622.10
		Chinese RT	21	1851.39	577.99
	Malay	Malay ACC	28	.86	.10
		Chinese ACC	28	.85	.14
		Malay RT	28	1901.59	498.81
		Chinese RT	28	1962.49	544.73
9-10 years old	Chinese	Malay ACC	21	.91	.10
		Chinese ACC	21	.85	.13
		Malay RT	21	1291.16	422.93
		Chinese RT	21	1333.16	565.10
	Malay	Malay ACC	24	.89	.10
		Chinese ACC	24	.90	.09
		Malay RT	24	1312.75	359.08
		Chinese RT	24	1395.17	410.77

6.3.1.3 Discussion

In the present study, I examined how the ORE was manifested in children of two age groups who were born and raised in a multiracial environment. It was hypothesized that younger children would have an ORE with other-race faces seen in Malaysia (Malaysian

Chinese faces for Malay children and Malay faces for Malaysian Chinese children) compare to older children. It is predicted that older Malaysian children will have similar recognition performance for both Malay and Chinese faces.

Based on the result of experiment 3a, both younger and older Malay children did not display an ORE effect indicating that they were equally efficient in recognising both their own race face and high-frequency other-race faces. Results for the Chinese children however was not the same. An ORE effect was found for 6 to 7-year-old Chinese children, and a reverse ORE effect was found for the older Chinese children, in which they were better at recognising high-frequency other race Malay faces relative to their own race face.

The results of the Chinese children were as predicted. Younger Chinese children had a better recognition performance with their own race faces indicating a lack of exposure to the other race Malay face in Malaysia.

However, as they get older and have more exposure and contact with other races in Malaysia, this own race advantage is no longer seen. Instead, older Malaysian Chinese children had better recognition performance toward other race Malay faces. They may have become increasingly aware of the high social status of Malay face resulting in a reverse ORE as seen in experiment 3a result. This face processing pattern continues to change as children become older as we do not see a reverse ORE in Malaysian adults

The results for Malay children are not as predicted. Malay younger and older children had equal recognition performance to both Malay and Chinese faces. Participants in this experiment were tested in an area of Kuala Lumpur known as Petaling District which has a significantly more Chinese population compared to other parts of the country which may have resulted in Malay children having more exposure to the Chinese population. In addition, some Malay children may have attended Chinese vernacular schools which may have resulted in higher exposure to Chinese faces.

One limitation of the present study is that we are unable to measure the exact exposure of different races that each child experiences due to reliability issues of self-report accuracy in younger children. The present study only relies on population statistics as a prediction of exposure.

An important note is that in this study, we have used a full-face stimulus (without cropping of external stimuli), and children's performance could have been influenced by these external stimuli (i.e., hair information) rather than real face recognition performance. Hence, a second study (experiment 3b) was conducted to remove peripheral features such as

hair information and presented only internal regions of the stimulus face, to see if similar results are replicated.

6.3.2 Experiment 3b

6.3.2.1 Method

6.3.2.1.1 Participants

A different group of seventy-three Malay children (35 Male, 38 Females) and sixty-six Chinese children (32 males, 34 females) participated in the ORE children experiment 3b. There were 44 6–7-year-old children (mean age = 6 years 7 months), 41 9–10-year-old children (mean age = 9 years 8 months) and 54 12- 13year-old children (mean age= 12 years 2 months).

6.3.2.1.2 Stimuli

20 Malay and 20 Malaysian Chinese adult upright faces with a neutral expression (half male and half female) were used. All photographs of faces were full colour images taken at frontal and profile position and cropped to eliminate hair information. Refer to Figure 15 for an example of stimuli used.

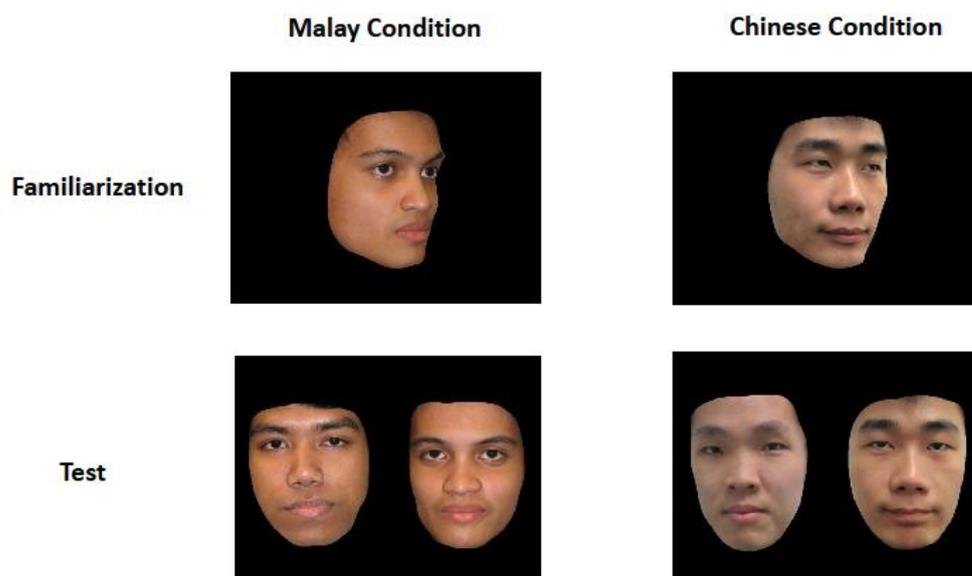


Figure 15: Example of male faces used in Caucasian, Malay and Chinese conditions in Experiment 3b.

6.3.2.1.3 Design and Procedure

The procedure was identical to the procedure in Experiment 3a except for different stimuli used.

6.3.2.2 Results

Recognition scores in terms of percentage face accurately identified and response time for own and other-race faces were computed for each participant. Preliminary analysis showed that the effects of participant gender and face gender were not significant. Thus, participant gender and face gender were not included in subsequent analysis.

6.3.2.2.1 Accuracy

A 3-way ANOVA (2 Face Race: Malay vs Chinese Face x 2 Participant Ethnicity: Malay vs Chinese x 3 Age Group: 6-7 vs 9-10 vs 12-13 years old) found a significant main effect for FaceRace, $F(1, 133) = 13.27, p < .01$, partial eta square = .09 which was qualified by a significant interaction effect for FaceRace X Ethnicity, $F(1,133) = 4.23, p = .04$, partial eta square = .03 (See Figure 16a and b). Post hoc paired sample t-test found that Malay children had equal accuracy performance for Malay and Chinese faces, $t(72) = 1.23, p = .22$, indicating an absence of ORE but Chinese children had better recognition performance for Chinese faces compare to Malay faces, $t(65) = 4.21, p < .01$, indicating a presence of ORE for Chinese children.

A significant main effect was also found for age group, $F(1, 133) = 28.38, p < .01$, partial eta square = .30. Older children, 12-13 years old had better accuracy recognition performance compare to 10-9 years old children, followed by 6-7 years old children (all p-values were significant).

No other main interaction effect was found. Details of the accuracy scores are in Table 4.

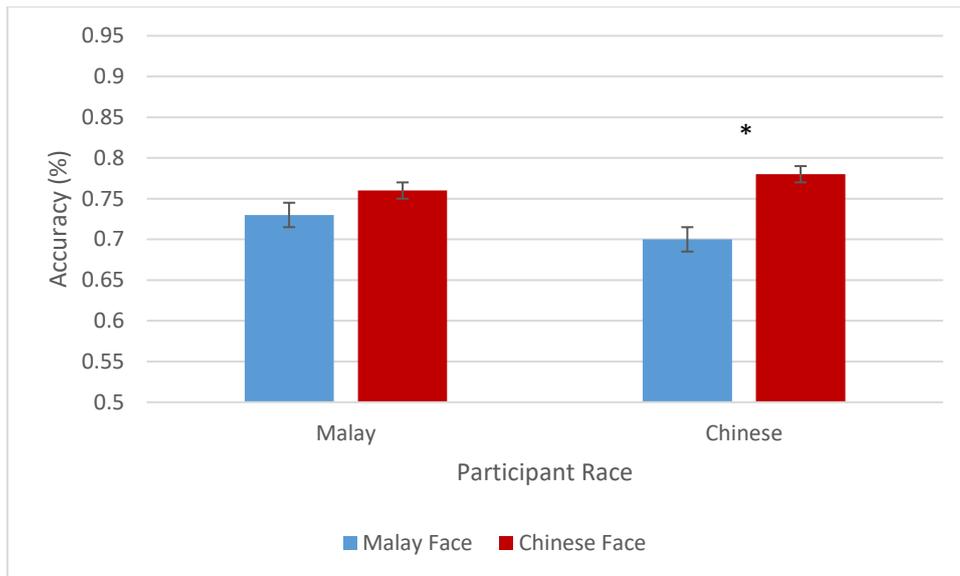


Figure 16a: Mean accuracy according to face race and participant race with standard error.

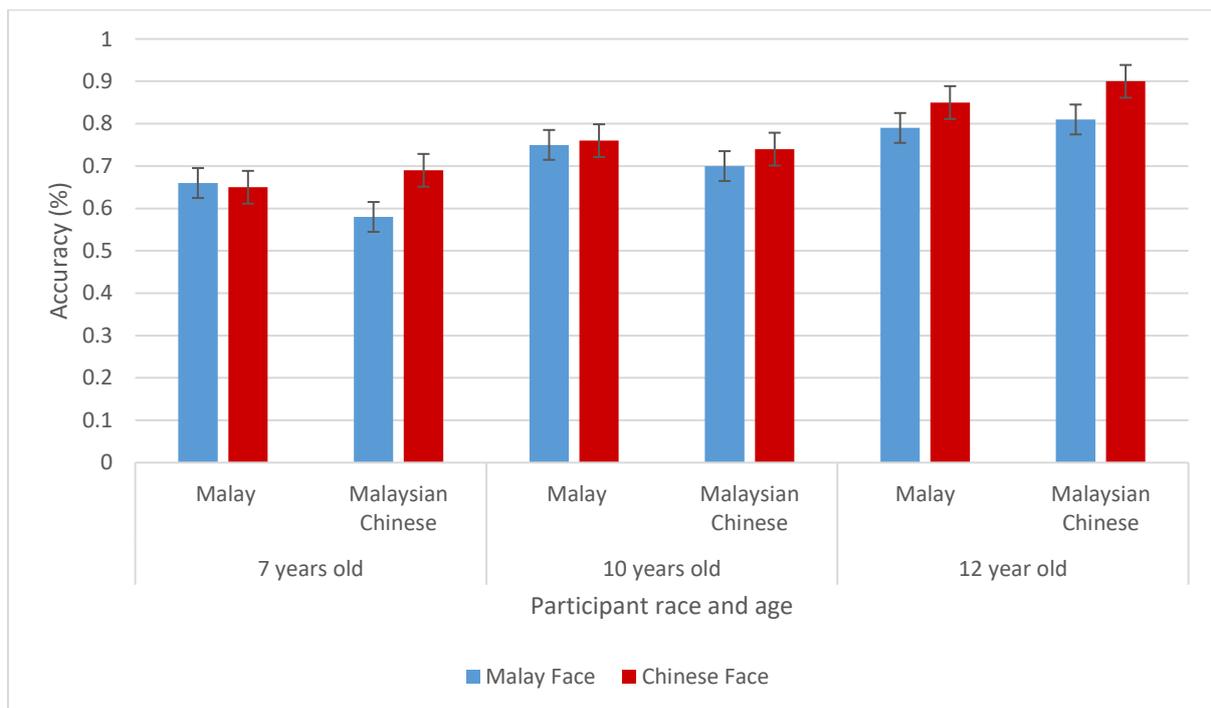


Figure 16b: Mean accuracy according to face race, participant race and age with standard error.

6.3.2.2.2 Reaction Time(RT)

A 3-way ANOVA (2 Face Race: Malay vs Chinese Face x 2 Participant Ethnicity: Malay vs Chinese x 3 Age Group: 6-7 vs 9-10 vs 11-12-year-old) was performed on the RT data measured by in milliseconds to assess the how quickly participants responded. There

was a main effect of the face race, $F(1, 133) = 6.642, p = .01$, partial eta square = .05. and an interaction effect between face race and participant age, $F(2, 133) = 4.23, p = .02$, partial eta square = .06. Post-hoc paired sample t-test indicates that only the youngest children had significant different reaction times for the two race faces, $t(70) = 2.72, p < .01$. The youngest children were faster in reacting to Chinese face ($M = 1796.34, SD = 761.52$) than Malay faces ($M = 1980.79, SD = 761.52$).

A **significant main effect for participant age** was found, $F(2, 133) = 22.98, p < .01$, partial eta square = .26 with 11–12-year-old children performing similarly to 9–10-year-olds ($M = 1204.08, SD = 631.94$ vs $M = 1385.61, SD = 631.70$ respectively) and faster than 6–7-year-olds ($M = 2048.91, SD = 643.14$). RT scores of the youngest children with 10–11-year-old and RT scores of the youngest children with 11–12-year-olds were significantly different (all $p < .01$). Details of the RT scores are in Table 4.

Table 4. Descriptive Statistics for accuracy (ACC) and response time (RT) for each face race.

Age group	Participant Ethnicity	N	Mean	Std. Deviation	
6-7 years old	Chinese	Malay ACC	20	.58	.17
		Chinese ACC	20	.69	.16
		Malay RT	20	2228.47	1121.95
		Chinese RT	20	2016.71	936.35
	Malay	Malay ACC	24	.66	.15
		Chinese ACC	24	.65	.19
		Malay RT	24	2119.62	842.62
		Chinese RT	24	1830.83	750.61
9-10 years old	Chinese	Malay ACC	20	.70	.18
		Chinese ACC	20	.74	.18
		Malay RT	20	1358.15	601.40
		Chinese RT	20	1412.81	549.08
	Malay	Malay ACC	21	.75	.15
		Chinese ACC	21	.76	.16
		Malay RT	21	1494.63	793.11
		Chinese RT	21	1276.88	397.46
11-12 years old	Chinese	Malay ACC	26	.81	.13
		Chinese ACC	26	.90	.09
		Malay RT	26	1112.38	515.61
		Chinese RT	26	1093.74	475.40
	Malay	Malay ACC	28	.79	.17

Chinese ACC	28	.85	.10
Malay RT	28	1271.41	439.75
Chinese RT	28	1338.80	418.45

6.3.2.3 Discussion

Similar to Experiment 3a, the removal of peripheral features in our stimuli and additional older age group children (12-13 years old) in Experiment 3b, we found 1) Malaysian Chinese children show a typical ORE effect where they were better at recognising Chinese faces compare to Malay faces. Malay children had an equal performance for both types of faces and did not display an ORE effect. The recognition performance difference between younger and older children in Experiment 3a is not present in Experiment 3b. Removing the peripheral information (i.e., hair) presented in the stimuli made the task more difficult as seen in lower accuracy performance in participants.

All faces of different races were tested in one randomized block rather than a separate block in Experiment 3a and 3b. Based on the featural-configural/ holistic processing hypothesis, there is a possibility that testing all race faces in one block may have disrupted the different processing strategies used in familiar vs unfamiliar faces. Several studies have suggested that more holistic processing mechanisms are used for own-race faces, as opposed to less experienced other-race faces (Michel, Caldara & Rossion, 2006; Tanaka, Kiefer & Bukach, 2004; DeGutis, Mercado, Wilmer & Rosenblatt, 2013). It could be the case that when both same and other-race faces are put together in the same block, the holistic processing strategy for own-race faces could be disrupted. Hence, in a third study (Study c) participants will be tested in different blocks for Malay faces and Chinese faces. Similar to Experiment 3b, only internal faces (excluding peripheral information) of the stimuli are shown to participants.

6.3.3 Experiment 3c

6.3.3.1 Method

6.3.3.1.1 Participants

A different group of eighty-eight Malay children (38 Male, 50 Females) and ninety-three Chinese children (44 males, 49 females) participated in experiment 3c. There were 62 7–8-year-old children (mean age = 7 years 2 months), 59 9–10-year-old children (mean age = 10 years 1 months) and 60 12- 13year-old children (mean age= 12 years 5 months).

6.3.3.1.2 Stimuli

The same stimuli used in experiment 3b were used in this experiment.

6.3.3.1.3 Design and Procedure

The procedure was identical to the procedure in Experiment 3b with the exception that race faces were tested in separate blocks with Malay faces tested in one block and Chinese faces in another block. Presentation of the race condition (blocks) was randomized such that half the participants saw the Malay face condition first and the other half saw the Chinese face condition first.

6.3.3.2 Results

Recognition scores in terms of percentage face accurately identified and response time for own and other-race faces were computed for each participant. Preliminary analysis showed that the effects of participant gender and face gender were not significant. Thus, participant gender and face gender were not included in subsequent analysis.

6.3.3.2.1 Accuracy

A 3-way ANOVA (2 Face Race: Malay vs Chinese Face x 2 Participant Ethnicity: Malay vs Chinese x 3 Age Group: 7-8 vs 9-10 vs 12-13 years old) found a significant main effect for FaceRace, $F(1, 175) = 21.18, p < .000$, partial eta square = .108 which was qualified by a significant interaction effect for FaceRace X Ethnicity, $F(1, 175) = 14.22, p < .000$, partial eta square = .075. Post hoc paired sample t-test found that Malay children had equal accuracy performance for Malay and Chinese faces, $t(87) = 0.514, p = .608$, indicating an absence of ORE but Chinese children had better recognition performance for Chinese faces ($M = .89, SD = 0.09$) compare to Malay faces ($M = .81, SD = 0.12$), $t(92) = 6.323, p < .000$, indicating a presence of ORE for Chinese children (see Figure 17a & b).

A significant main effect was also found for age group, $F(2, 175) = 7.97, p < .000$, partial eta square = .084. Older children, age 12-13 years old and 9-10 years old children had similar accuracy performance ($p = .28$) but had higher performance compared to 7-8 years old children (all p-values were significant).

No other main interaction effect was found. Details of the accuracy scores are in Table 5.

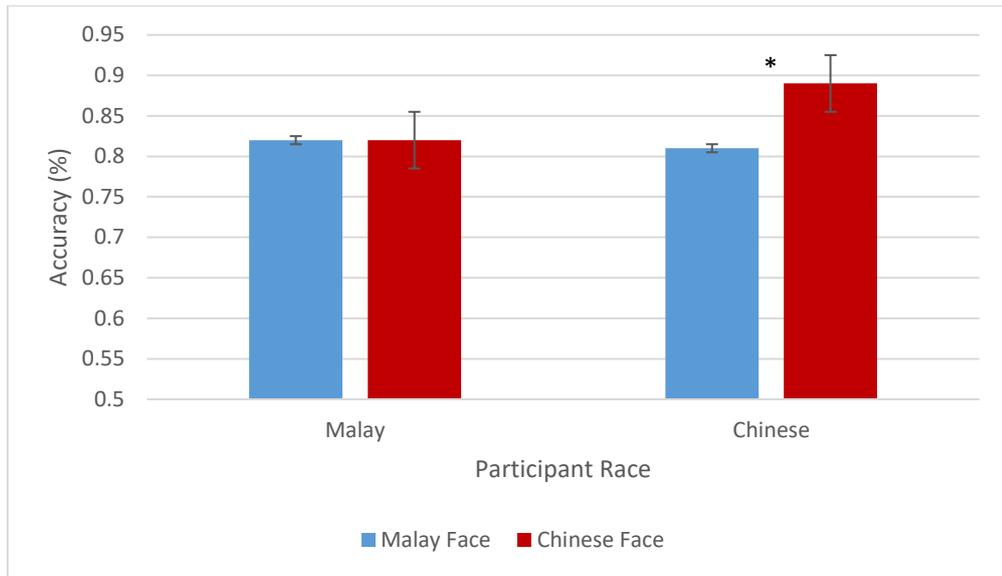


Figure 17a: Mean accuracy according to face race and participant race with standard error.

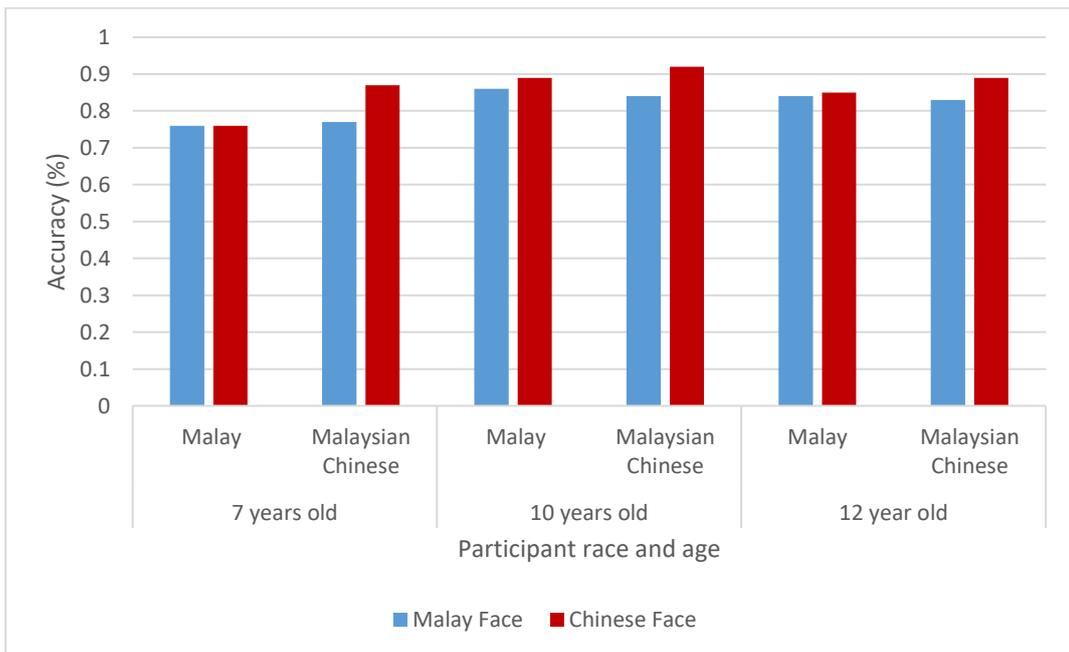


Figure 17b: Mean accuracy according to face race, participant race and age with standard error.

6.3.3.2.2 Reaction Time (RT)

A 3-way ANOVA (2 Face Race: Malay vs Chinese Face x 2 Participant Ethnicity: Malay vs Chinese x 3 Age Group: 6-7 vs 9-10 vs 11–12-year-old) was performed on the RT data measured by in milliseconds to assess the how quickly participants responded. There was no main effect of the face race, or interaction effect between face race and participant ethnicity, and participant age. A significant main effect for participant age was found, $F(2, 175) = 12.53, p < .00$, partial eta square = .13 with 11 to 12-year-olds performing faster than 9–10-year-olds ($M = 1692.19, SD = 642.17$ vs $M = 1442.71, SD = 644.48$ respectively, $p = .03$) and faster than 6–7-year-olds ($M = 2025.57, SD = 642.17, p < .00$). A significant main effect for participant race was also found, $F(1, 175) = 8.66, p < .01$, partial eta square = .05, with Malay participants responding faster than Chinese participants ($M = 1579.51, SD = 643.29$ vs $M = 1860.80, SD = 642.39$ respectively, $p < .01$). Details of the RT scores are in Table 5.

Table 5. Descriptive Statistics for accuracy (ACC) and response time (RT) for each face race.

AgeGroup	Participant Ethnicity		N	Mean	Std. Deviation
7-year-old	Chinese	Malay ACC	31	.77	.12
		Chinese ACC	31	.87	.10
		Malay RT	31	2308.68	884.08
		Chinese RT	31	2204.14	813.45
	Malay	Malay ACC	31	.76	.18
		Chinese ACC	31	.76	.21
		Malay RT	31	1859.39	779.30
		Chinese RT	31	1730.08	613.33
10-year-old	Chinese	Malay ACC	32	.84	.12
		Chinese ACC	32	.92	.08
		Malay RT	32	1465.58	428.11
		Chinese RT	32	1559.33	466.81
	Malay	Malay ACC	27	.86	.11
		Chinese ACC	27	.89	.08
		Malay RT	27	1401.37	513.08
		Chinese RT	27	1344.54	415.93
12-year-old	Chinese	Malay ACC	30	.83	.11
		Chinese ACC	30	.89	.09
		Malay RT	30	1816.62	903.08
		Chinese RT	30	1810.47	932.83

Malay	Malay ACC	30	.84	.17
	Chinese ACC	30	.85	.19
	Malay RT	30	1602.62	867.18
	Chinese RT	30	1539.08	580.44

6.3.3.3 Discussion

Similar to the two previous conditions, with the removal of peripheral features in the stimuli, and race faces condition tested in individual blocks, we found 1) Malaysian Chinese children having a typical ORE effect where they were better at recognising Chinese faces compare to Malay faces. Malay children, however, had an equal performance for both types of faces. Results from Experiment 3b were not due to a difference in the presentation of stimuli in different blocks.

6.3.4 General discussion for Experiment 3a, 3b & 3c

Two possible reasons could account for our results: 1) Malaysian Chinese children were tested mainly from Chinese vernacular school (which consist mainly of Chinese students and teachers) and 2) Children were tested in an area with significantly more Chinese population (Petaling district) compared to other parts of the country, hence Malay children would have more exposure to the Chinese population. Given this increased exposure, it is not surprising that Malay children can recognise Chinese faces and Malay faces equally well.

Consistently in all three children's studies, despite the different type of stimuli (whole vs internal facial stimuli) and testing procedure (randomized testing in one single block or testing in separate blocks), we found that Malay children age 7 – 13 years old had equal accuracy performance for own race Malay face and frequently exposed Chinese face. On the other hand, Chinese children were more accurate with their own-race Chinese faces compared to the frequently exposed Malay race. This could be due to the exposure of more Chinese faces in their school environment. Despite being a multiracial country, living areas and primary education systems among the races are not always integrated. Vernacular schools still exist for primary school education and it is common to find children studying at vernacular schools within their own race group and using their native language as one medium of learning instruction (i.e., Chinese children studying in Chinese schools, Indian children in Tamil schools) (Hussiin & Nordin, 2002). Integration at school only happens at

the secondary education level where only one national type school is available (vernacular schools are no longer available at the secondary school level). Hence, one plausible explanation could be that the Chinese children are still more exposed to people of their own race at school and in their living area, and while they may have some interaction with other race children outside of the school context, it is not sufficient to alter the ORE effect at the primary school level. On the other hand, Malay children have equal exposure to both races from school and their surroundings in Kuala Lumpur.

This study is different from Tham et al. (2017) in two ways: 1) the testing paradigm used and 2) the sample. While Tham et al. (2017) used the old-new paradigm in their ORE study with Malaysian children, we have used the alternative-force-choice paradigm which is deemed more suitable for children's limited cognitive capacity (Anzures et al., 2013). In addition, Tham et al. (2017, personal communication) tested children from private schools, while the children from this study were from vernacular Chinese schools and public schools which could have resulted in different race composition within the different schools. In addition, Tham et al. (2017) only tested Malaysian Chinese children, while this study compared Malay and Malaysian Chinese children.

Overall, our study findings were not consistent with Tham et al.'s (2017) findings. While they did not report an ORE effect for Malaysian children age 5 – 13-year-olds, Malaysian Chinese children in our study (age 6–12-year-old) reveal an ORE effect while the Malay children did not. At this point, the inconsistent findings could be due to the different testing paradigm used or different samples from different types of schools. Further investigations will need to be carried out to rule out these possibilities.

6.4 Summary

In summary, the development of the ORE is unclear during childhood. While it appears that certain exposure to other-race faces affects the ORE, the relationship between exposure and face recognition is inconsistent within the Malaysian children tested. More testing needs to be carried out to understand the mechanism behind the ORE development in children. From Experiment 1 and 2 with infants and adults, we know that infants develop an own-race recognition advantage for own-race female faces with some evidence that this is later extended to an experienced race of the same gender.

In adults, with increasing exposure to multi-races over the years, Malaysian adults develop equal ability to recognise own and frequently exposed other-race faces. From

experiment 3, we see that this development of own-race recognition advantage to high-frequency other-race recognition advantage begins to change in childhood. Overall, the three experiments demonstrate that experience with different classes of face shapes the face recognition system.

Chapter 7: Experiment 4: The Other-Categorisation Advantage in Malaysian children and adults in a multiracial context.

Part of the chapter has been published in Woo PJ, Quinn PC, Méary D, Lee K, Pascalis O. (2020). A developmental investigation of the other-race categorization advantage in a multiracial population: Contrasting social categorization and perceptual expertise accounts. *Journal of Experimental Child Psychology*. 197: 104870 DOI: 10.1016/j.jecp.2020.104870.

(Note: As this chapter is published, the introduction repeats information written in other chapters).

7.1 Introduction

The ability to recognize and categorize different faces proficiently may have social and evolutionary advantages, allowing us to identify different individuals, remember the behavior of specific individuals in social situations, detect emotions, and recognize ingroup and outgroup members (Pascalis et al., 2014). Investigating how people learn and process information about faces is of particular interest for understanding human social behavior.

7.1.1 *The other-race effect (own-race recognition advantage)*

Past empirical studies have confirmed that individuals process their own race and other-race faces differently. One well-established effect, the other-race effect (also known as the own-race recognition advantage), indicates that individuals recognize faces of their own race more accurately and faster relative to faces of other races (Ge et al., 2009; Rhodes, Locke, Ewing, & Evangelista, 2009; Slone, Brigham, & Meissner, 2000; Walker & Tanaka, 2003). This effect has been studied extensively in infants, children, and adults from various populations (for reviews, see Hugenberg, Young, Bernstein, & Sacco, 2010; Lee, Anzures, Quinn, Pascalis, & Slater, 2011; Meissner & Brigham, 2001). For example, the effect has

been demonstrated in infants aged 6 to 9 months (Kelly et al., 2007, Kelly et al., 2009) as well as in children aged 3 years and over (Anzures et al., 2014; Sangrigoli & de Schonen, 2004).

The other-race effect has also been shown to be moderated by other-race contact and can be undone if sufficient exposure to an other-race category is achieved. For instance, training studies (Anzures et al., 2012; Heron-Delaney et al., 2011; Lebrecht, Pierce, Tarr, & Tanaka, 2009; Tanaka & Pierce, 2009) have found that the other-race effect can be prevented or eliminated if infants, children, and adults are provided with video, picture book, or image-based experience with other-race faces. In addition, children who are adopted into an other-race family were found to have a similar recognition of own-race and other-race faces (de Heering, de Liedekerke, Deboni, & Rossion, 2010), whereas a reversal of the other-race effect was found in adults who were adopted into an other-race family when they were young (Sangrigoli, Pallier, Argenti, Ventureyra, & de Schonen, 2005). Thus, the other-race effect is a phenomenon that seems to be developed through perceptual experience and is malleable given experience with other-race faces.

The other-race effect has further been linked to implicit racial bias in preschoolers (Xiao et al., 2015). Xiao et al. (2015) found that preschoolers as young as 4 years demonstrate implicit racial bias toward another race and that perceptual individuation training with other-race faces can reduce such bias. These results indicate that processing other-race faces at a perceptual level can affect implicit bias against other-race individuals at a social level.

7.1.2 The other-race categorization advantage

Another relevant area of face processing that is less researched is how we categorize faces. Contrary to the own-race recognition advantage, individuals categorize other-race faces faster, and sometimes with greater accuracy, than they categorize own-race faces (Levin, 1996; Valentine & Endo, 1992). This phenomenon is known as the other-race categorization advantage. For example, Zhao and Bentin (2008) found that Chinese and Israeli participants categorized other-race faces more quickly and accurately than own-race faces. The other-race categorization advantage has been demonstrated to be robust with various populations and research paradigms (Feng et al., 2011; Li, Tse, & Sun, 2018; Zhao & Bentin, 2011). In addition, like the own-race recognition advantage, the other-race categorization advantage has been linked to social bias. In a recent study, Setoh et al. (2019) found that children's racial categorization performance was associated with implicit racial bias in a multiracial

population. In particular, children who were more accurate in categorizing other-race faces had higher implicit racial bias.

Investigators have also been interested in the relation between the other-race categorization advantage and the own-race recognition advantage. For example, Ge et al. (2009) reported a negative relation between the two. Specifically, using a within-participant design, other-race faces were found to be more rapidly categorized, but recognized less accurately and more slowly, compared with own-race faces. This result, in turn, suggests a negative relation between the processing of face identity and category information.

7.1.3 Theoretical accounts.

Perceptual expertise and social categorization frameworks have been postulated to account for the own-race recognition and other-race categorization advantages (Meissner & Brigham, 2001; Sporer, 2001). The perceptual expertise model has previously been applied to explaining aspects of perceptual and cognitive development (Gauthier & Nelson, 2001; Quinn, 2010), and in the case of race, the model postulates that extensive contact or experience with own-race members and a lack of contact with other-race members increase the accuracy of recognition of own-race faces due to the perceptual processes that are used (Tanaka, Kiefer, & Bukach, 2004) and how familiar and unfamiliar faces are represented in memory (Valentine, 2001). For example, Tanaka et al. (2004) reported that perceptual expertise engenders more holistic perceptual processes when we view a familiar racial category of faces (i.e., own-race faces) compared with other-race faces. Such holistic processing of own-race faces, but not other-race faces, is in turn believed to slow down the response time (RT) of participants in racial categorization tasks (Zhao & Bentin, 2011).

Valentine (2001), in his face space model, explained that less encountered other-race faces are densely clustered in face space as compared with more frequently encountered own-race faces. Within a cluster, neighboring exemplars can more readily interfere with accurate recall of a face, leading to a deficit in differentiating and recognizing other-race faces. Concurrently, the same cluster would give support to the other-race categorization advantage because the other-race faces would activate in the face space as a group due to the proximity of the neighboring exemplars.

In accord with the perceptual expertise hypothesis, there is support for the idea that extensive contact influences the own-race recognition advantage. In a series of studies, Walker and colleagues have reported a relationship between amount and type of other-race

contact and the ability to perceptually differentiate other-race faces (Walker & Hewstone, 2006; Walker, Silvert, Hewstone, & Nobre, 2008; Walker & Tanaka, 2003). Participants with greater other-race experience were consistently more accurate at recognizing other-race faces than participants with less other-race experience. The amount of contact with other-race faces has also been used to explain the other-race categorization advantage. Caldara, Rossion, Bovet, and Hauert (2004), using event-related potentials, found that Caucasian participants were faster at categorizing other-race faces than own-race faces. Caldara et al. concluded that lesser experience with other-race faces leads to a less rich identity-specific representation, which in turn yields faster categorization of these faces. However, this study did not measure or test the influence of face experience directly.

Social categorization models (e.g., Tajfel, 1970) have also been used to explain own-race recognition and other-race categorization advantages. Sporer (2001) proposed that both effects arise from differential processing of ingroup versus outgroup members. When encountering a face, we rapidly categorize it as belonging to our ingroup or an outgroup (Levin, 2000), which leads individuals to perceive and classify outgroup members using categorization cues, resulting in superficial encoding and poorer recognition memory. By contrast, ingroup members are automatically processed in a more individuating manner, resulting in superior recognition memory (see Bernstein, Young, & Hugenberg, 2007, for supporting evidence). Moreover, Hugenberg et al. (2010), in their categorization–individuation model, suggested that one motivational factor associated with categorizing a face as ingroup or outgroup is the perceived relevance or importance of a face.

A social categorization model that is developmental in nature is the Meltzoff (2007) “like me” model (see also Cvencek & Meltzoff, 2015). Although originally framed in terms of human agency, the “like me” notion of recognizing self–other equivalence and difference implies that even as early as infancy, others would be categorized as ingroup or outgroup based on their similarity to the categorizer. Consistent with such a model, Fawcett and Markson (2010) reported that children as young as 3 years categorize toy dolls as being similar or dissimilar to them and even show an evaluative preference for similar dolls.

7.1.4 The current study

Given that most prior studies of own-race recognition and other-race categorization have been studied with predominantly monoracial populations living in racially homogeneous environments, there is a need for work examining the processing of face race in children and adults who have extensive experience with another race of faces. A study by Tham, Bremner,

and Hay (2017) is particularly relevant in the current context. These investigators tested 5- and 6-year-old and 13- and 14-year-old British children and Malaysian Chinese children on their recognition of Chinese, Malay, Caucasian, and African faces. A typical own-race recognition advantage was observed for the British children; however, the Malaysian Chinese children displayed a recognition advantage for both frequently experienced Chinese and Malay faces relative to the less frequently experienced African faces. Tham et al. concluded that children from a multiracial environment who have experience with another race of faces early in life may be able to maintain a more malleable face representation when exposure to other-race faces is plentiful. This conclusion is further supported by recent evidence indicating that experience with other-race faces during early childhood (i.e., elementary school ages and younger) is predictive of a reduced own-race recognition advantage (McKone et al., 2019; Zhou, Elshiekh, & Moulson, 2019), a reduction that is not evident if the exposure to other-race faces happens during adolescence or adulthood.

Is the other-race categorization advantage also modifiable with ample exposure to other-race faces? A major point of the perceptual expertise hypothesis is that the other-race categorization advantage is related to the frequency of exposure to a category of faces. Hence, the other-race categorization advantage should be largest for racial groups with the least exposure to other-race faces. As noted, previous studies investigating the other-race categorization advantage have generally tested populations with near-zero contact with other races. For example, both Valentine and Endo (1992) and Levin (1996) recruited their participants from a majority pool (i.e., the race of the participants was the majority race in that country). Whereas Valentine and Endo tested Caucasian British and Japanese Asians, Levin tested Caucasian Americans. The other-race categorization advantage has also been established in other racial groups such as Chinese Asians (Feng et al., 2011), Hispanics (MacLin & Malpass, 2001), and Israelis (Zhao & Bentin, 2008). However, all these populations lacked experience with other-race faces. Moreover, knowledge of the development of the other-race categorization advantage is still scarce. To date, only two studies have investigated race-based category formation for faces by infants. Anzures, Quinn, Pascalis, Slater, and Lee (2010) found that 9-month-old infants formed distinct categories for own-race Caucasian faces versus other-race Asian faces. In a more recent study, Quinn, Lee, Pascalis, & Tanaka, (2016) investigated other-race category formation during infancy. Caucasian 6-month-olds responded to the perceptual differences between African and Asian face classes, whereas Caucasian 9-month-olds formed a broad other-race grouping of faces inclusive of both African and Asian faces, although exclusive of Caucasian faces. Still, in

these infant studies, the other-race categories were also the categories of infrequent experience. With regard to children, older studies have reported that children are able to categorize race from as young as 4 years, but such studies have not necessarily used real face images as stimuli (Clark & Clark, 1947).

Moreover, Dunham, Stepanova, Dotsch, and Todorov (2015) investigated the race categorization abilities of 4- to 9-year-olds and reported that even children as old as 9 years categorize face-race based more on skin tone than on physiognomic features (i.e., form of the internal features and their spacing), whereas adults rely more on physiognomic features than on skin tone. A lengthy time course for categorization of face race fits with a study of face gender categorization in 7- to 9-year-olds in which only the 9-year-olds were above chance (Wild et al., 2000). Furthermore, Roberts and Gelman (2015) studied the categorization of face race in Black and White children aged 4 to 13 years and found that it was not until 10 years that children consistently showed sensitivity to multiracial faces. All these studies suggest that children's categorization of face race undergoes a protracted period of development.

Given this background, there is a need to study the other-race categorization advantage during development and in a multiracial society, where children and adults have consistent exposure to a variety of faces from different races early on. Studying the other-race categorization in a multiracial environment also makes it possible to disentangle the effects of social categorization versus perceptual expertise. A hypothesis based on social categorization implies that the other-race categorization advantage results from the race of a face (own vs. other) determining the way we categorize faces, with the race of a face and its similarity to the categorizer being determined by its skin color, physiognomic features, or some combination of the two. The perceptual expertise hypothesis instead predicts that the other-race categorization advantage depends on the frequency of exposure to faces in the multiracial environment.

Therefore, we sought to determine whether children and adults from a multiracial environment would manifest the typical other-race categorization advantage for other-race faces of minimal experience and also for other-race faces of consistent experience. The study was conducted in Malaysia, a multiracial country that consists of 68.8% Malay, 23.2% Malaysian Chinese, 7% Malaysian Indian, and 1% other ethnic groups (Department of Statistics Malaysia, 2017).

Participants were Malay and Malaysian Chinese. In addition to categorizing Malay and Malaysian Chinese faces, participants were also asked to categorize Caucasian faces with

which they had limited direct exposure. Therefore, we use the term *low-frequency other-race* to refer to the Caucasian faces used in this study, *own-race* to refer to faces of the same race as the participants (i.e., Malay faces for Malay participants and Chinese faces for Malaysian Chinese participants), and *high-frequency other-race* to refer to faces to which participants are exposed frequently in Malaysia but are not from their own race (i.e., Chinese faces for Malay participants and Malay faces for Malaysian Chinese participants).

According to the perceptual expertise hypothesis, the other-race categorization advantage should decrease as exposure increases. In other words, average RT and accuracy for categorizing face race should be faster and higher for low-frequency faces and should be slower and less accurate for high-frequency faces. Specifically, for both Malay and Chinese participants, the fastest RT and highest accuracy should be observed for Caucasian faces followed by Chinese faces and then Malay faces. In contrast, by the social categorization hypothesis, other-race faces of low and high frequency should yield equivalent RT and accuracy, and both should be faster and more accurate than own-race faces. This prediction implies that the findings will differ for Malay versus Chinese participants. In particular, for Malay participants, faster RT and higher accuracy should be observed for both Caucasian and Chinese faces relative to Malay faces. However, for Chinese participants, faster RT and higher accuracy should be observed for Caucasian and Malay faces relative to Chinese faces. Finally, because of the lack of prior data on the determinants of other-race categorization in children and adults growing up in a multiracial society, we did not have clear expectations for similarities or differences between the two age groups. Given that social categorization entailing ingroup–outgroup distinction is observed during early childhood (Bigler & Liben, 2007; Fawcett & Markson, 2010) with possible beginnings during infancy (Quinn et al., 2016), and the rudiments of perceptual expertise may be present in infants (Quinn, 2010; Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002), one would anticipate at least some commonality in child and adult performance. However, social categorization and perceptual expertise also undergo developmental change beyond infancy and childhood (Rhodes & Baron, 2019; Scherf & Scott, 2012), thereby raising the possibility for difference in child and adult performance.

7.2 Method

7.2.1 Participants

The participants were 40 Malaysian adults from two ethnic groups (20 Malay, 20 Malaysian Chinese) with a mean age of 24 years, 53 6- to 7-year-old children (28 Malay and 25 Malaysian Chinese) with a mean age of 6.6 years, and 50 9- to 10-year-old children (25 Malay and 25 Malaysian Chinese) with a mean age of 9.6 years. All the participants were from Klang Valley, Malaysia. Sixteen of the adult participants were male and twenty-four were female. Forty-nine of the child participants were male and fifty-four were female. All participants reported minimal contact with Caucasian individuals.

7.2.2 Stimuli and materials

For the adult categorization task, we used 16 Malay, 16 Chinese, and 16 Caucasian adults' upright faces with a neutral expression, half male and half female (examples shown in Figure 18). For the child categorization task, the procedures were similar to the task used with adults, but the number of stimuli presented was reduced to 12 Malay, 12 Chinese, and 12 Caucasian adults upright face with a neutral expression (half male and half female). Adult faces for children were used to maintain consistency with the adult experiment. In addition, there are some studies (Cassia, Luo, Pisacane, Li, & Lee, 2014; Wild et al., 2000) that have reported that children are either as accurate or more accurate in recognizing adult faces compared with child's faces. In particular, in a recognition task with child and adult faces, Wild et al. (2000) reported that both adult recognition and child recognition were as accurate with adult faces as with child's faces. Similarly, Cassia et al. (2014) found that children without siblings and adults were better at recognizing adult faces than child faces (i.e., an adult face bias). All photographs of faces were full-color images taken in a frontal position on a white background.



Figure 18: Sample stimuli used in the study. From left to right: Caucasian male, Malay male, and Chinese male.

7.2.3 Procedure

All participants were given a practice session before the start of the face categorization task to familiarize themselves with the procedure. They were asked to categorize 16 toy and animal pictures. In addition, to ensure understanding of the different racial groups presented, the children were shown examples of Malay, Chinese, and Caucasian faces prior to the start of the study. The categorization task was administered in three blocks. In each block, participants were asked to categorize two races of faces (e.g., Block 1: Malay vs. Caucasian faces; Block 2: Malay vs. Chinese faces; Block 3: Chinese vs. Caucasian faces), with a total of 32 trials per block for adults and 24 trials per block for children. Each face was presented one at a time, and participants were instructed to respond as quickly and accurately as possible by pressing one of two keys to indicate which race they had seen. Instructions for all the blocks were the same, with the particular face race contrast to be responded to being stated at the beginning of each block. The order of presentation of the blocks was counterbalanced across participants. In each block, the order of presentation of the face stimuli was randomized. Stimuli were presented with E-Prime (Version 2.0; Psychology Software Tools, Pittsburgh, PA, USA). Each face was presented for up to 5 s, depending on the latency of the keypress response, with an interstimulus interval of 500 ms between each face. A fixation crosshair appeared during each interstimulus interval.

Accuracy and RT of face categorization were entered as the dependent variables in the statistical analysis. The calculation of mean RT included only correct responses.

7.3 Results

The full design of the experiment was a 3 (Face Race) x 2 (Face Gender) x 3 (Age Group) x 2 (Participant Race) x 2 (Participant Gender) mixed design, with Face Race (Caucasian, Chinese, or Malay) and Face Gender (female, or male) as within-participant factors. Age Group (6- to 7-year-olds, 9- to 10-year-olds, or adults), participant race (Malay, or Malaysian Chinese) and participant gender (male, or female) were between-participant factors.

Face Race was nested within blocks. For each participant, we averaged the results from the different blocks to obtain a mean accuracy (percentage correct) and mean response time for each face race (Caucasian, Chinese, Malay). Preliminary analysis revealed that response time and accuracy scores were not influenced by the different blocks (i.e., no main effects or interaction), hence subsequent analyses did not include block analysis.

Mixed-design analyses of variance (ANOVAs) were conducted using R (R Core and Team, 2014) and the library `udsAnova` (Roulin, 2015). Due to the bounded nature of percentage correct data, we applied the arc-sinus transformation $x_t = \text{asin}[(x/100)0.5]$ to the data before analysis. In addition, because a preliminary inspection of the data indicated a positive skew of the distributions of RT, we applied a logarithmic transformation to the data $x_t = \ln(x)$ before analysis. Accuracy and correct RT reported below are the back-transformed values. Accordingly, we used 95% confidence intervals (CIs) to represent the variability of the mean dependent variables.

7.3.1 Accuracy

Mean percentage of correct scores are presented in the top row of Figure 19. We examined individual percentage correct scores for each Face Race according to Age Group and participant Race. Accuracy was dependent on face race, $F(2, 274) = 30.81, p < .001, \mu_p^2 = .18$). The Caucasian faces, having low frequency in Kuala Lumpur, were categorized more accurately ($M = 94.7\%$, 95% $CI = 92.6-96.4$) than the more frequent Chinese and Malay faces ($M_s = 90.0\%$, and 86.6% , respectively, 95% $CI_s = 87.7-92.1$ and $84.4-88.6$). Post-hoc comparison using Fisher's LSD indicated that the three means were different from each other (all $p_s < .01$). As expected, accuracy also increased with age $F(2, 137) = 64.8, p < .001, \mu_p^2 =$

.48. Post-hoc comparison indicated that the mean accuracy for 6- to 7-year-olds ($M = 78.9\%$, $CI = 74.9-82.7$), the 9- to 10-year-olds ($M = 91.8\%$, $CI = 90.0-93.6$), and the adults ($M = 97.4\%$, $CI = 96.7-98.0$) were different from each other (all $ps < .001$).

We additionally found a significant interaction between age group and face race, $F(4, 274) = 5.88$, $p < 0.001$, $\mu_p^2 = .078$). Figure 19 shows that adults were more accurate for both Caucasian ($M = 99.3\%$, $CI = 98.7-99.8$) and Chinese faces ($M = 98.6\%$, $CI = 97.6-99.3$) relative to Malay faces ($M = 91.7\%$, $CI = 89.1-93.9$, Fisher's LSD, all $ps < .001$). No difference was found between Caucasian and Chinese face race (Fisher's LSD, $p = .27$). In contrast, 9- to 10-year-old children were more accurate for Caucasian faces ($M = 96.3\%$, $CI = 94.1-97.9$) than for both Chinese ($M = 89.0\%$, $CI = 86.1-91.6$, Fisher LSD $p < .001$) and Malay faces ($M = 89.2$, $CI = 86.5-91.7$, Fisher's LSD, $p < .001$). The difference between Chinese and Malay faces was not significant (Fisher's LSD, $p = .90$). A similar result was found for the youngest age group. Children aged 6 to 7 years were more accurate for the Caucasian faces ($M = 83.0\%$, $CI = 76.5-88.7$) than for both the Chinese ($M = 76.2\%$, $CI = 71.8-80.2$, Fisher's LSD, $p = .004$) and Malay faces ($M = 77.2\%$, $CI = 72.4-81.6$, Fisher's LSD, $p = .013$). The difference between Chinese and Malay faces was not significant (Fisher's LSD, $p = .69$).

One point of difference between the 6- to 7-year-olds and the 9- to 10-year-olds is that while the results of the older children were similar for the two races of participants, we can see from Figure 19 that participant race was more influential in the younger children. In particular, Malaysian Chinese participants were less accurate for Chinese faces ($M = 70.9\%$, $CI = 64.9-76.5$) than the Malay participants ($M = 81.1\%$, $CI = 75.5-86.2$, Fisher's LSD, $p < .001$).

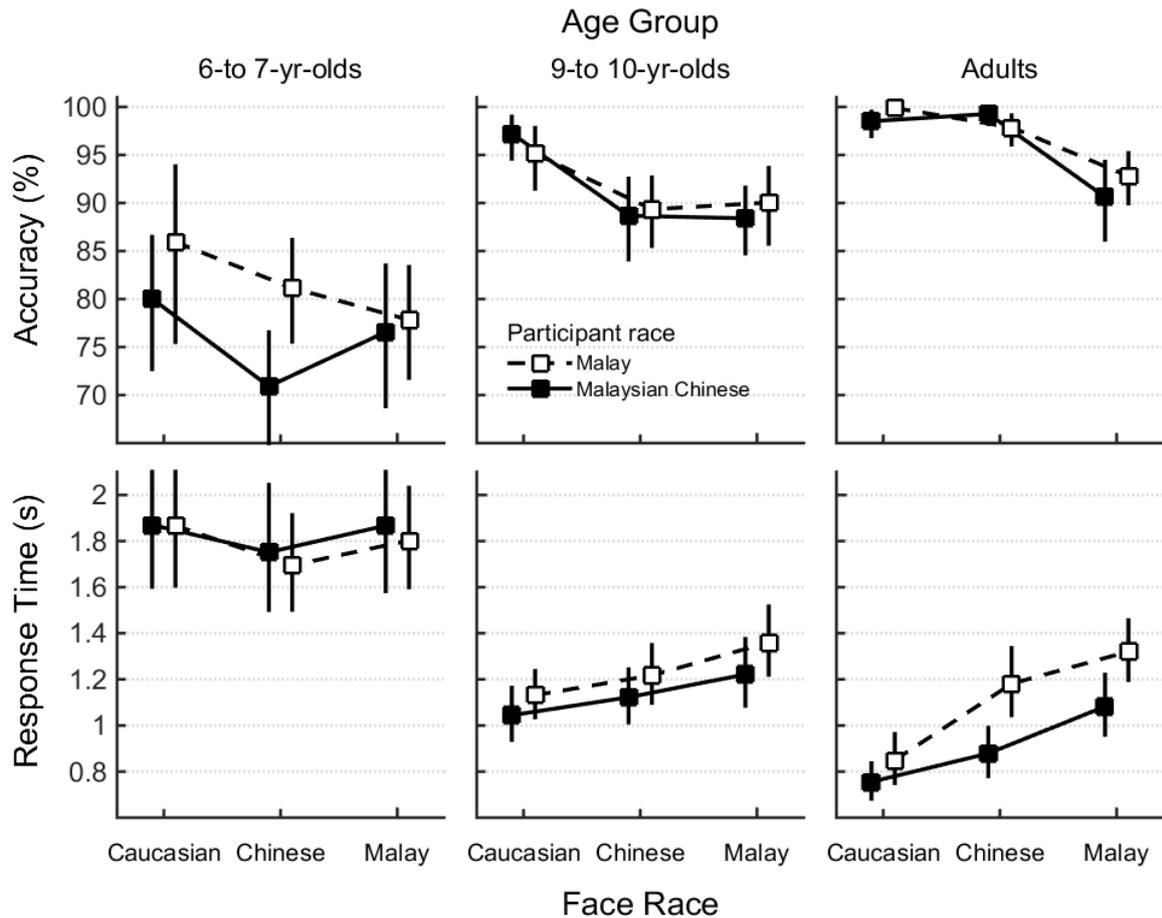


Figure 19. Mean accuracy (top row) and response time (bottom row) according to face race, age group, and participant race. Bars give the upper and lower limit of the 95% CI for the mean.

7.3.2 Response Time

Mean response times (RTs) are presented in the lower row of Figure 19. The outcomes of the ANOVA yielded a main effect of Face Race, $F(2, 274) = 45.25, p < .001, \mu_p^2 = .25$, a main effect of Age Group, $F(2, 137) = 57.2, p < 0.001, \mu_p^2 = .45$, and an Age x Face Race interaction, $F(4, 274) = 20.54, p < .001, \mu_p^2 = .23$. Figure 19 illustrates these effects. Caucasian faces ($M = 1.18$ s, $CI = 1.09-1.27$) were categorized faster than Chinese faces ($M = 1.27$ s, $CI = 1.19-1.35$). Malay faces yielded the longest response time ($M = 1.41$ s, $CI = 1.33-1.50$). Post-hoc comparison using Fisher's LSD indicated that the three means were different from each other (all $ps < .001$).

As indicated by the interaction, however, the effect of race depended on age. For the 6- to 7-year-olds, both Caucasian ($M = 1.86$ s, $CI = 1.67-2.08$) and Malay ($M = 1.83$ s, $CI =$

1.66-2.03) faces led to longer RTs than Chinese faces ($M = 1.72$ s, $CI = 1.56-1.89$, Fisher's LSD, $p = .011$, and $p = .049$, respectively). In contrast, in the 9- to 10-year-olds, the effect of face race was best described by a linear increase in RT. Caucasian faces led to shorter RT ($M = 1.08$ s, $CI = 1.01-1.16$) than the more frequent Chinese faces ($M = 1.17$ s, $CI = 1.09-1.26$, Fisher's LSD, $p = .027$) and Chinese faces led to shorter RT than Malay faces which are the most frequent in Kuala Lumpur population ($M = 1.29$, $CI = 1.19-1.4$, Fisher's LSD, $p = .003$). The same trend was found in adults, Caucasian faces led to shorter RT ($M = 0.8$ s, $CI = 0.73-0.87$ s) than Chinese faces ($M = 1.01$ s, $CI = 0.92-1.12$, Fisher's LSD, $p < .001$) and Chinese faces led to shorter RT than Malay faces ($M = 1.19$ s, $CI = 1.1-1.3$, Fisher's LSD, $p < .001$).

7.4 Discussion

In the current study, we examined how the other-race categorization advantage was manifested in children and adults who were born and raised in a multiracial environment. We also investigated how the other-race categorization advantage was affected by participant and face race. Two hypotheses were proposed: the perceptual expertise hypothesis and the social categorization hypothesis. Based on the perceptual expertise hypothesis, the other-race categorization advantage should decrease as exposure increases. In contrast, by the social categorization hypothesis, other-race faces of low and high frequency should result in equivalent correct RTs and accuracies, and both should be faster and more accurate than own-race faces.

The correct RT data are entirely consistent with the perceptual expertise hypothesis given that both Malay and Chinese 9- to 10-year-old children and adults responded fastest for Caucasian faces followed by Chinese faces and then Malay faces, except for RT for 6- to 7-year-old children. The youngest children responded fastest to Chinese faces instead of Caucasian faces. One possibility could be these children took longer to look at the Caucasian faces due to the curiosity of this group of unfamiliar faces. In the correct RT data, of particular significance is the finding that 9- to 10-year-old Chinese children and adults responded to own-race Chinese faces as intermediate between other-race Caucasian and Malay faces. Here then is an instance where a classic other-race categorization advantage is not observed in that the two classes of other-race faces were not responded to more rapidly than the own-race Chinese faces.

One other aspect of the RT results that deserves further comment is the overall faster response to all classes of faces by Chinese participants relative to Malay participants. We

would speculate that such a result could reflect the minority status of Chinese in Malaysia. In particular, it could be argued that a minority population presented with different races of faces responds with more categorization responses than recognition responses. Such a suggestion would also slow responding overall for recognition of faces of different races, a proposal that would need to be confirmed with further research. One additional aspect of the RT data worthy of comment was the overall faster RT by adults for Caucasian faces. Given the prior research indicating that children in a multiracial population who were more accurate in categorizing other-race faces had higher implicit racial bias (Setoh et al., 2019), the current findings would imply that such bias may increase from 9 years of age to adulthood, although such an implication runs counter to the prevailing view that implicit bias remains stable from childhood to adulthood (e.g., Dunham, Chen, & Banaji, 2013).

The accuracy data were more nuanced because of the age by face race interaction. For children, accuracy was greater for Caucasian faces relative to Chinese and Malay faces. In the case of 6-to 7-year-old Malay children, in accordance with the perceptual expertise hypothesis, Caucasian faces were responded with the greatest accuracy followed by Chinese and then Malay faces. However, these accuracy patterns change as children get older. In 9- to 10-year-old Malay children, the Chinese faces were responded to more as own-race faces than other-race faces, a finding that is consistent with a version of the perceptual expertise hypothesis in which other-race faces need to surpass some threshold of experience in order to be responded to as own-race faces. In other words, a minority group of faces, even though lesser experienced, can be responded to like own-race faces if it passes some threshold amount of experience (see Liu et al., 2015, for an analogous proposal in how infants may respond to male vs. female faces). In the case of Chinese children, 6-to 7-year-old Chinese children responded to Caucasian and Malay faces with greater accuracy compared to own-race faces. Again, this responding pattern changes in older children. Like the 9- to 10-year-old Malay children, the same pattern of accuracy outcomes suggests that high-frequency other-race faces (i.e., Malay faces) are treated like own-race faces, a finding that is again consistent with a version of the perceptual expertise hypothesis in which some threshold amount of experience can be surpassed in order for other-race faces to be responded to as own-race faces.

For adults, accuracy was greater for Caucasian and Chinese faces relative to Malay faces. As with the child accuracy data, this outcome carries different meanings for Malay and Chinese participants. For Malay adults, the results are in accord with the classic form of the other-race categorization advantage in which own-race faces differ from different classes of

other-race faces, which are not different from each other. These findings are consistent with the social categorization hypothesis. For Chinese adults, own-race Chinese faces are responded to more as low-frequency other-race Caucasian faces than as high-frequency own-race faces. Here then is another aspect of the data that is inconsistent with the typical format of the other-race categorization advantage.

The overall pattern of findings accords well with what Tham et al. (2017) reported for the own-race recognition advantage, where Malaysian Chinese children were found to display a recognition advantage for both frequently experienced Chinese and Malay faces relative to the less frequently experienced African faces. Similarly, the lack of an own-race recognition advantage in children of P.J. Woo et al. / *Journal of Experimental Child Psychology* 197 (2020) 104870-9 Japanese descent that were born and raised in Brazil (Fioravanti-Bastos, Filgueiras, & LandeiraFernandez, 2014) provides additional evidence that experience with faces within one's local environment shapes the face-processing system during development. The current data indicate that the effects of other-race face experience extend to the other-race categorization advantage. Most broadly, our data imply that the other-race categorization advantage is an appropriate term to describe performance only when the other-race categories are categories of minimal experience.

Of interest in the accuracy data is the developmental transition in how Chinese participants respond to other-race categories of low and high frequency (i.e., Caucasian and Malay faces, respectively) relative to their own-race category. That is, in children it is the high-frequency other-race category (i.e., Malay) that is responded to like the own-race category, whereas in adults it is the low-frequency other-race category (i.e., Caucasian) that is responded to like the own-race category. A possible account is that with increased age, there is increasing experience with majority group Malay faces and they become responded to as if they were the own-race category with the true own-race, but with lower-frequency Chinese faces becoming more like an other-race category. This account would predict that if one were to test even younger Chinese participants, the own-race Chinese faces would be categorized less accurately relative to both Caucasian and Malay faces.

A limitation of our study is that we did not measure interracial experience directly. Amount of contact with other-race faces has been found in some studies to moderate different aspects of responding to face race (McKone et al., 2019; Roberts & Gelman, 2015; Zhou et al., 2019). Future work using contact measures may provide further information about individual variations with other-race contact and how it influences the development of the other-race categorization advantage.

To our knowledge, the current study is the first to examine the other-race categorization advantage in children and adults in a multiracial environment. The significance of the work derives from being able to contrast how participants responded to own-race faces and different classes of other-race faces that varied by how prominent they are in the population. This composition in turn allowed us to test competing predictions from the perceptual expertise and social categorization hypotheses. Notably, in the case of the correct RT measure, Chinese participants responded to own-race Chinese faces as intermediate between other-race Caucasian faces (fastest) and Malay faces (slowest). Here then is an instance where a classic other-race categorization advantage is not observed, and the findings follow the perceptual expertise account of the advantage rather than the social categorization account. Future studies with different age groups and samples of participants, and with different classes of other-race faces, are needed to evaluate the generalizability of these novel findings. A similar study with biracial children and adults with multiracial experience within both the local family and broader neighborhood environments could provide further information on how categorical responses to face race are influenced by the frequency of exposure.

Chapter 8: Experiment 5: The role of experience in kinship detection

8.1 Introduction

Facial cues such as emotion (Ekman, 1993), attractiveness (Perrett et al. 1998; Slater et al. 2000; DeBruine, Jones, Unger, Little & Feinberg, 2007), and health (Jones, Little, Burt, & Perrett, 2004) have been studied extensively in research as it provides important social meaning. Using facial cues, humans are able to identify each other faces quickly and easily. Facial features also provide cues for humans to detect kinship and ascribe relatedness among individuals.

8.1.1 Kinship Recognition

Humans like many other species possess some mechanisms for kin recognition: the ability to identify and differentiate their close genetic kin from non-kin members. Recognizing kin and discriminating between them plays an important role in relationships and social interactions. In humans, these are important to avoid inbreeding and also to provide care and help to family and close relatives. Studies on kin recognition have been done in many species such as *peacocks*, *Barbary macaques*, *social amoebae*.

How do organisms recognise their kin? It is believed that organisms recognise their kin through 1) contextual cues and/ or 2) phenotypic cues. In contextual cues, the organism uses environmental factors such as spatial location, time spent together and mating history to learn about their kin. In phenotypic cues, an organism uses physical similarities such as odour and facial resemblance to recognise its kin.

In a study on cross-fostering of Belding ground squirrels, Holmes & Sherman (1982) tested whether kin recognition was influenced by contextual cues (such as being raised together) or phenotypic cues (such as odour similarity). In this study, squirrel litter was reared by an unrelated mother from birth. The cross-fostered squirrels treated their related and unrelated littermates identically, suggesting the use of contextual but not phenotypic cues. However, when the squirrels encountered unfamiliar squirrels (not from their litter), they

treated related and unrelated squirrels differently which suggests that phenotypic cues in recognising unfamiliar individuals are important. The use of contextual and phenotypic cues in recognising kin is, therefore, adaptive depending on situations.

Similarly, these contextual and phenotypic mechanisms are not mutually exclusive in humans as we learn associations with our family (i.e., living together, childhood experiences) and also phenotypic matching by paying attention to the familial resemblance in appearance. Humans often discriminate relatedness via assessment of facial similarities and correctly associate siblings with one another (Maloney & Dal Martello 2006; DeBruine et al. 2008) as well as identify parents with their children (Nesse et al., 1990; McLain et al., 2000; Oda et al. 2005; Alvergne et al., 2007).

It is generally believed that the kin recognition mechanism develops early on with associations with familiar kin and self and in animals, these are done via phenotype matching by discrimination of odour and the facial resemblance.

Humans like many other organisms possess some mechanisms for recognising kin. This ability is important as humans provide more assistance and help to kin than to non-kin and to close rather than distant kin (Essock-Vitale & McGuire, 1985; Burnstein et al., 1994; Kruger, 2003; Stewart-Williams, 2007). In addition, humans also avoid inbreeding via kin recognition due to adverse effects on fertility such as increased chances of miscarriages and infant mortality. As kinship plays an important part in the human social drive, some researchers believed that the ability to detect kin among strangers has developed in our species (Waldman 1988; Kaminski et al. 2009).

8.1.1.1 Research studies on kinship in humans.

Humans undeniably are attracted to faces as it serves many important social behavioural roles. As such, facial resemblance may act as a cue to detect kinship resemblance. Children are expected to resemble their biological parents as genotype traits are partly expressed phenotypically. Several studies have studied how human faces express genetic relatedness between parents and children (Alvergne, Faurie and Raymond, 2007; Bressan and Grassi, 2004; Kaminski, Meary, Mermillod & Gentaz, 2010; McLain, Setters, Moulton & Pratt, 2000; Oda, Matsumoto-Oda & Kurashima, 2002) as well as between siblings (Maloney & Dal Martello, 2006) and other distant relatives such as grandparents (Michalski & Shackelford 2005), aunts/uncles (Gaulin et al. 1997) and cousins (Jeon & Buss 2007).

8.1.1.2 Ability of adults to detect kinship resemblance

Several studies have demonstrated that adults can discriminate kin from non-kin individuals using only visual perceptive abilities. Most such studies measure discrimination of relatedness through an assessment of facial similarities between individuals. For example, Maloney & Dal Martello (2006) ask adults to rate how similar a set of children's pictures are depending on these pairs of children were real siblings or not. Their study found that adult judges were able to detect real siblings' pair reliably above chance level and that the similarities judgement were higher for children who are real siblings. Alvergne, Faurie and Raymond (2007) on the other hand, studied kinship resemblance by asking non-related adult judges to identify the true parent of a child using photographs of adults and child pairs. Participants were given a photograph of a child's face and asked to identify which of three adult faces presented was the parent of the child. They found that adult judges were reliably able to detect child-parent resemblance above chance level. Alvergne, et al. (2007) also found that newborns were judged to resemble their mothers more but as the child gets older (approximately 2 – 3 years old in this study) they were also judged to resemble their fathers. However, Bressan and Grassi (2004) and Bredart & French (1999) did not find a difference in mother-child versus father-child resemblance in photos of children aged 1 to 5 years indicating that children's facial resemblance has equal probability to father and mother. The studies reported here and many others (Christenfeld & Hill, 1995; McLain, Setters, Moulton & Pratt, 2000; Oda, Matsumoto-Oda & Kurashima, 2005) with different cultural groups have consistently found that child-parent kinship resemblance can be detected via visual facial similarity tasks. Most studies report a probability of around 1.1 – 1.47 times higher than the probability of chance in guessing the correct child-parent pair (Bressan & Grassi, 2004).

The ability of adults to detect kinship resemblance is also affected by the degree of relatedness. Kaminski, Dridi, Graff and Gentaz (2009) asked 59 undergraduate university students to judge whether or not two individuals' photos displayed on a computer screen belonged to the same family. The photos in the experiment consist of photos of siblings, parents, grandparents, aunts/uncles, cousins in the same family and those who are not in the same family. Kinship resemblance in distant relatives such as grandparents, aunts/uncles and cousins were investigated in this study in addition to close family kinship detection (parent-child). Kaminski, et al. (2009) found that adults' accuracy of detecting facial resemblance of two kin individuals increases with the degree of relatedness. It was easier for participants to recognise pairs that show the same individual at different ages (high degree of relatedness) as

compared to pairs of different related individuals (i.e., distant relatives). Participants were also accurate in judging non-kin pairs.

While humans are able to detect facial resemblance between kin, this ability is influenced by several factors such as gender of raters (Slone et al., 2000; Lewin and Herlitz 2002), different characteristics of evaluated faces such as distinctiveness and attractiveness of evaluated faces, perceptual similarities of evaluated faces, the colour of images (Kaminski et al., 2010) and presence of background distractions such as colours of clothes (Solomon, 2002).

8.1.1.3 Ability of children to detect kinship resemblance

The ability to detect kinship resemblance in ascribing relatedness has been largely investigated using adult participants. As face processing ability is also well developed in children (Crookes and McKone, 2009), the development of kinship resemblance in children has recently been investigated. Kaminski, Gentaz, and Mazens (2012) investigated 5 – to 11-year-old children's ability to detect parent-infant resemblance in unfamiliar faces. Using a matching task, children were asked to identify which of three adult faces were the parent of an infant (parent comparison task) and in another task, to identify which of three infant faces were the offspring of a parent (infant comparison task). They found that pre-schoolers were able to identify facial resemblance slightly above chance and that this ability increased as the children were older. Kinship detection rates were better in infant comparison tasks. This study suggests that kinship resemblance detection may partially increase with experience with faces. In another study Kaminski, Berger, Jolly and Mazens (2013) using a similar matching task tested 5-, 7-, 9- and 11-year-old children on their ability to detect kinship resemblance. In this study, only the parent comparison task was used. They found that children from the age of 9 and above were able to match a newborn face with his or her birth mother.

8.1.2 Inheritance understanding

Using different theoretical frameworks and methodological approaches, some studies investigate the conceptual development in the domain of biology, particularly how children understand biological inheritance. The understanding of biological inheritance refers to the knowledge that genetic traits are passed down from parents to their offspring via biological

reproduction. As adults, we understand that certain traits such as skin colour, facial features, height are heritable whereas other characteristics such as occupation, languages and beliefs are not.

Unlike kinship detection studies that focus on the perceptual task as their study methodology, studies that investigate biological inheritance understanding often present children with a switch at birth stories or adoption stories and ask verbal questions to assess children's knowledge about what traits are heritable. In studying children's understanding of the biological inheritance concept, different methodologies have been employed by researchers. Specifically, there are three subareas of inheritance concept that have been examined: 1) concepts of the origin of features (children's belief of what traits can be inherited) 2) inheritance causal mechanism (when children begin to understand the reasons and biological mechanism of inheritance) 3) concepts of family relatedness (William & Smith, 2010). In studying children's representation of biological inheritance, a generalisation task is usually used. For example, adoptive and biological family relationships have been contrasted in stories about offspring who have both birth parents and adoptive parents. Children are asked to reason about which parent the offspring will resemble on several kinds of properties (physical traits vs. beliefs).

Several studies have shown that preschool children already display some understanding of inheritance (Gelman & Wellman, 1991; Gimenez & Harris, 2002; Hirschfeld, 1995; Springer, 1992; Springer, 1996; Springer & Keil, 1989), while others do not report coherent understanding before the age of 7-8 (Johnson & Solomon, 1997; Solomon, 2002; Solomon, Johnson, Zaitchik & Carey, 1996; Weisman & Kalish, 1999). These conflicting findings may be due to methodological differences: the variability of tasks, the nature of stimuli (animals, humans), the nature of properties to be generalized (physical characteristics, mental traits), and the nature of the relation to be considered (birth origin, biological relatedness, resemblance to parents, *etc*). Weissman and Kalish (1999) investigated children's conceptions about mechanisms for trait inheritance rather than their knowledge about the emergence of traits before or after birth. The study shows that not only preschool children do not necessarily know that offspring resembles parents but also, they do not know the mechanisms responsible for this resemblance. Young children misconceive that intention can play a role in parent-offspring resemblance. Children seem to have different intuitions about the mechanisms of inheritance from adults. In a recent paper, Williams and Smith

(2010) examined children's consistency in inheritance understanding using different tasks. Their results suggest that children have implicit concepts at the age of 4 years but that explicit concepts of inheritance are not clear until the age of 7.

Overall, previous studies on children's development of biological inheritance understanding have shown that children as young as 4 years of age have a basic understanding that physical features are inherited from their biological parents (Gelman & Wellman, 1991; Gimenez & Harris, 2002; Hirschfeld, 1995; Springer, 1992; Springer, 1996; Springer & Keil, 1989). By about 7-10 years of age, children begin to explain the genetic mechanism behind parent-offspring resemblance (Johnson & Solomon, 1997; Solomon, 2002; Solomon, Johnson, Zaitchik & Carey, 1996; Weisman & Kalish, 1999). However, it is not until approximately 14-years of age that children can use the knowledge of inheritance to inform their understanding of kinship closeness and relatedness (i.e. how siblings, grandparents and cousins are related and to which degree of closeness).

Besides using stories to investigate the understanding of biological inheritance, kinship detection methods have also been used to understand whether children can have a naïve theory of kinship resemblance based on physical similarities. Using kinship detection methods has been suggested to be a better method with young children due to its lower processing costs, and reduced language demand from the children (Kaminski, Berger, Jolly & Mazens, 2013). This method is able to access children's non-verbal knowledge, rather than having to make inferences from children's verbal response, which is often used in causal mechanism tasks (such as switch at birth stories, adoption stories).

8.2 Present study

There are not many studies on kinship resemblance detection in children, but existing evidence seems to suggest that children may have some ability to detect kinship resemblance using facial cues (Kaminski et al., 2012, 2013). Studies have shown that children as young as 5 years have some understanding that babies resemble their parents (Gelman & Wellman, 1991; Gimenez & Harris, 2002; Hirschfeld, 1995; Springer, 1992; Springer, 1996; Springer & Keil, 1989) in both animal and human relationships, although this understanding is mostly implicit/ elementary and not fully developed until the age of 7 years or older (Williams and Smith; 2010).

We know that the facial recognition system is in place early in life. Infant studies have indicated that early in life, infants have an innate face-oriented mechanism (Johnson, Dziurawiec, Ellis & Morton, 1991) and that facial recognition is not species-specific until infants are approximately 6 months of age (Pascalis, de Haan & Nelson, 2002). This perceptual narrowing phenomenon reflects the cortical specialisation of the brain due to exposure to faces (Nelson, 2001). Abundant studies have shown that with experience, the face-processing system becomes more specialised. This has been shown in the “other-race effect”, a phenomenon in which humans are better at recognising faces of one’s cultural group compared to faces from another cultural group. This effect has also been shown in infants and children (for a review, see Meissner & Brigham, 2001). The ORE effect can be reversed when children and infants are exposed to new types of faces (Sangrioli et al., 2005).

Some studies have shown that children understand that race is immutable (Hirschfeld, 1995; Gaither et al., 2014). Hirschfeld (1995) investigated whether 3- to 7-year-old children understand race on a biological basis and whether they know that reproduction plays a fundamental role in racial identity (a child from both Caucasian parents cannot be African for example). The paradigm consists to show a target (an adult whose race, occupation and body build were portrayed) and comparison pictures of two children, each of whom shared with the target adult two of the three properties (body build, race, and occupation). Children have to choose one of the two children in three different conditions. Family condition: which child is the child of the target adult? Growth condition: which child was a picture of the target adult when he was a child? Similarity condition: which child is most like the target? Results show that pre-schoolers conceive race as immutable, derived from the family and sensible to biological causality principles.

Based on Chapter 2, we know that experience plays a role in affecting how we process faces and accounts for the ORE effect. In particular, greater experience with own-race faces leads to superior encoding and recognition of own-race faces relative to other-race faces. Similarly, it is the lesser interracial contact that leads to poorer encoding and memory for other-race faces. One issue that has not been studied so far is the role of experience children may have of different races or mix race children on their understanding of biological inheritance. While past studies have shown that kinship resemblance (detection of mother-child pairs) is not affected by the other-race effect (Alvergne et al., 2009), it is of interest to test whether greater experience with faces of different races predicts an increase in children’s understanding that skin colour (i.e. dark skin, light skin) is inherited. In addition, we are also interested in understanding whether the effect of exposure to different ethnicities in the children’s

environment, affects this understanding. We will be assessing whether there are any differences in kinship detection performance in children from a monoracial environment versus children who come from a more multi-racial environment. Pre-schoolers from France (representing monoracial environment) and pre-schoolers from Malaysia (representing multiracial environment) performances on facial kinship detection task will be compared. Preschoolers were tested in this study because previous studies indicated that children's facial perception is mature at this age (Crookes and McKone, 2009). In this task, we asked children to detect parent-offspring resemblance in unrelated and unfamiliar faces. To do so, we asked children to match a pair of parents' faces (one representing mother and one representing father) to one of four children's faces. All faces used are not genetically linked as we want to test whether children can use skin colour in addition to other facial features as the phenotype cue to ascribe relatedness.

We expect that French children will have a problem performing this task given that they have less experience seeing mixed-race faces. In Malaysia, however, children are more likely to have been confronted with mixed-race couples and to have interacted with mix-race children. If this is true, Malaysian children may have an earlier understanding of kinship relationships and may be able to better detect kinship relationships in mixed-race couples. We hypothesised that 1) Malaysian children will be better in detecting facial resemblance than French children 2) Malaysian children from a mixed-race family would perform better in detecting facial resemblance than Malaysian children from the same race family.

8.2.1 Pilot study method

A pilot study on adults was performed to test the experimental design and whether the offspring's face is easily associated with the parent's faces.

8.2.1.1 Participants

A total of 20 French adults and 22 Malaysian adults with a mean age of 23 years old were tested in the pilot study. Of the total, 12 were males and 30 were females.

8.2.1.2 Stimuli and materials

Twenty-four coloured adult faces (half male and half female faces) of African, Caucasian and Chinese race and forty-eight coloured children face (half male and half female) of African, Caucasian, Chinese and mix-race were used in the study. All adult faces

were cropped to eliminate hair and neck information. This was done to eliminate parent-offspring picture matching based on hair information. Children's faces were not cropped.

A total of 6 picture stimuli is presented in each slide of the experiment using Microsoft PowerPoint presentation. A picture of the father and mother is presented at the top (target stimuli) and four children's pictures below (comparison stimuli) (see Figure 20a & b). A total of 12 sets of slides including two practice slides were shown to each participant. The presentation of parent-offspring slides was counterbalanced using 4 different versions of the experiment.



Figure 20a: Example of adult and children faces used in the experiment. This is an example where both parents are of the same race (Intra-racial item).



Figure 20b: Example of adult and children faces used in the experiment. This is an example where both parents are of a different race (Inter-racial item).

8.2.1.3 Procedure

Informed consent was obtained from participants. Participants were tested individually and shown the PowerPoint presentation consisting of the parent-offspring pairs. Participants were shown a mum and dad from the same or different race and were asked to determine which child at the bottom of the picture is likely to be their child. The choice of children comparison stimuli was between a child of African, Caucasian, Chinese or mix race. Each face of parent and child was only seen once by participants to avoid learning effects. None of the faces were known to the participants. All slides were presented to the participant one at a time on a computer screen. For each of the slides, participants were asked to select the child of the parent pair from four possible children's choices. Participants were told: *“Look at these four children's faces. One of them is the child of this father and mother. Can you guess which is the parents' child?”* Each item was presented without a time limit and no feedback was provided. Each participant was presented on all 12 parent-offspring sets. The experiment lasted approximately 10 to 15 minutes per participant.

8.2.2 Result

Participant choice for each presentation slide was scored as 1 for accurate kin-matching and 0 for inaccurate kin-matching. If the mom and dad are of the same race (i.e., Caucasian), we expect the correct kin-matching to be of the same race (i.e., Caucasian). If the mom and dad are of a different race (i.e., African and Caucasian), we expect the correct kin-matching to be of mixed race (i.e., African Caucasian mix). To explore kinship detection ability, we calculate the total number of items that each participant had answered correctly. Kin-matching score can range from a maximum accurate score of 10 to a minimum score of 0. We subsequently also divided the analysis based on two different types of items: 1) Intra-racial items: Items that had both parents in the same race 2) Inter-racial items: Items that had both parents of different races. There was a total of 6 intra-racial items and 4 inter-racial items in the experiment.

A one-way ANOVA was performed to assess if French and Malaysian adults differ in the total items of answered correctly, intra-racial and inter-racial items. Results revealed no significant difference ($p > .05$) between French and Malaysian adults on all items indicating that both groups were successfully accurate in detecting kin-matching using relevant features as cues (see table 6) with above 90% accuracy for total items and intra-racial items and 80% accuracy for mixed-racial items.

Table 6. Mean and standard deviation between French and Malaysian adults.

	<i>Score range</i>	French (n = 20)		Malaysian (n = 22)	
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Total items	0-10	9.05	0.89	9.00	1.02
Intra-racial items/6	0-6	5.85	0.37	5.68	0.57
Mixed-racial items/4	0-4	3.20	0.89	3.31	0.84

8.2.3 Summary

Results from the pilot study suggest that adults were able to perform the task accurately and there was no difference in performance between both groups of participants. The same task is then performed on pre-school children.

8.3.1. Main Study Method

8.3.1.1 Participants

A total of 39 French preschool children with a mean age of 6 years old and 74 Malaysian preschool children (21 Malay, 21 Malaysian Chinese, 21 Malaysian Indian and 11 Mixed ethnicities) with a mean age of 5.6 years old participated in this study. French children were from Grenoble, France and Malaysian children were from Kuala Lumpur, Malaysia. Fifty-eight children were male and fifty-five were female. All children were tested one at a time in their school.

8.3.1.2 Stimuli and materials

The same stimuli and materials as those used in the pilot study were used with the pre-school children.

8.3.1.3 Procedure

Informed consent was obtained from the parents of the children. Subsequently, the same procedure as the one stated in the pilot study was performed with the pre-school children.

8.3.2 Results

8.3.2.1 Are Malaysian children better at detecting facial resemblance than French children?

Participant choice for each presentation slide was scored as 1 for accurate kin-matching and 0 for inaccurate kin-matching. If the mom and dad are of the same race (i.e., Caucasian), we expect the correct kin-matching to be of the same race (i.e., Caucasian). If the mom and dad are of a different race (i.e., African and Chinese), we expect the correct kin-matching to be of mixed race (i.e., African Chinese mix). To explore kinship detection ability in children, a one-way ANOVA was performed for total items, intra-racial items and inter-

racial items. Results reveal a significant difference between French and Malaysian children, $F(1,112) = 16.95, p < .01$ for total kin-matching items and for intra-racial items, $F(1,112) = 25.38, p < .01$ (see Table 7). There was no significant difference between the two groups for inter-racial items, $F(1,112) = 0.004, p = .95$ (see Table 7). Results revealed that French children performed better in kin-matching compared to Malaysian children in the task with the exception of the inter-racial items.

Table 7. Mean and standard deviation for French and Malaysian children.

	Score range	French (n = 39)		Malaysian (n = 74)	
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Total items	0-10	5.46	1.41	4.13	1.73
Intra-racial items/6	0-6	4.66	1.15	3.34	1.41
Mixed-racial items/4	0-4	0.79	1.03	0.78	0.88

8.3.2.2 Is there a difference between Malaysian children of a same race versus mixed race children?

When we compare Malaysian children, who were from the same race parents versus children who were of mixed race, one-way ANOVA revealed that mixed-race children had higher performance in total kin-matching task compared to children who were from the same race parents, $F(1,73) = 4.11, p = .04$ and in intra-racial items, $F(1,73) = 4.82, p = .03$. No significant difference was found for inter-racial items, $F(1,73) = 0.26, p = .61$ (see table 8).

Table 8. Mean and standard deviation between Malaysian children from single race and mixed-race families.

	Single race (n = 63)		Mixed-race (n = 11)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Total items	3.96	1.61	5.09	2.17
Intra-racial items	3.19	1.35	4.18	1.54
Mixed-racial items	0.76	0.87	0.91	0.94

8.3.2.3 Is kinship detection ability reliable in preschool children?

Further analysis, using one sample t-test was performed to assess whether detection rates were significantly different from those expected by chance (i.e. different from ¼) for French and Malaysian children. For French children, one sample t-test revealed that performance for total kin-matching task ($M = 0.55$, $SD = 0.14$) and intra-racial items ($M = 0.78$, $SD = 0.19$) were significantly above chance level, $t(38) = 13.10$, $p < .01$ and $t(38) = 17.13$, $p < .01$, respectively. Performance for inter-racial items ($M = 0.20$, $SD = 0.26$) did not significantly differ from chance level, $t(38) = -1.243$, $p = .22$ indicating French children had difficulty with these items (see Table 9). For Malaysian children, one sample t-test revealed that performance for total kin-matching task ($M = 0.41$, $SD = 0.17$), intra-racial items ($M = 0.56$, $SD = 0.24$) were significantly above chance level, $t(73) = 8.128$, $p < .01$ and $t(73) = 11.158$, $p < .01$. However, Malaysian children had below chance performance for inter-racial items ($M = 0.20$, $SD = 0.22$), $t(73) = -2.113$, $p = .04$ (see Table 9).

Table 9. Mean and standard deviation of different kinship detection items for French and Malaysian children (Test value =0.25).

	French (n = 39)		Malaysian (n = 74)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Total items	0.55	0.14	0.41	0.17
Intra-racial items	0.78	0.19	0.56	0.24
Mixed-racial items	0.20	0.26	0.20	0.22

8.3 Discussion

In the present study, we examined whether the ability to detect kinship in unrelated faces in preschool children was influenced by their exposure to different race faces. We compared pre-schoolers who were born and raised in a multiracial environment (Malaysia) and those who were raised in a more monoracial environment (France). We hypothesized that if the experience with different classes of faces influences the ability to detect kinship in a stranger, then we expect Malaysian pre-schoolers to outperform French pre-schoolers in this task.

The result of the study indicates that French children outperform Malaysian children in the kinship detection task. Specifically, French pre-schoolers were better than Malaysian children in the intra-racial items but not in the mixed-racial items. Details revealed that the children's overall performance was significantly above chance level for the intra-racial items for both French and Malaysian children, indicating that they were able to perform the task. However, performance for mixed-racial items was at chance level for French children, indicating that the French pre-schoolers had significant difficulty with these items. On the other hand, Malaysian pre-schoolers' performance for inter-racial items was significantly below chance level. Overall, our hypothesis that Malaysian children may have an advantage in the kinship matching task was not supported. There could be several reasons for this.

While Malaysian, in general, may be exposed to a multiracial population, we are unsure of the extent of multiracial and mixed-race exposure for Malaysian pre-schoolers. As mentioned in Chapter 7, pre-schoolers' exposure to other-race faces could be limited. In addition, Malaysian children are not exposed to Caucasian or African people, race faces that were used in the present study and hence these faces are unfamiliar to the children. On the other hand, French children living in Grenoble have some exposure to African and Asian faces. Another consideration is that French children were slightly older than Malaysian children by 6 months. Past studies have shown that as children mature, they have a better understanding of biological inheritance. French children may have a better concept of kinship resemblance than Malaysian children. Again, this age difference is minimal, and we do not know the impact of this minor age difference on the task. Another alternative explanation to consider is the effect of second language learning on biological inheritance understanding. Byers-Heinlein & Garcia (2015), compared monolinguals, simultaneous and sequential bilinguals on their belief about the innateness of physical and behavioural traits of humans and animals. They found that second language learning (sequential bilinguals) reduces

children's essentialist bias. Children who are sequential bilinguals tend to believe that human and animal traits (i.e., human language, vocalization and physical traits) are acquired through the environment rather than innate. The researchers concluded that everyday experience in one domain (i.e., second language learning) has a generalised effect on children's beliefs about a wide range of domains, reducing children's understanding of the heritability of human traits. It is common for Malaysian preschools to start teaching a second language and sometimes a third language to children (i.e., Malay, English or Mandarin). Hence, most Malaysian pre-schoolers would have learned a second language which may have influenced their judgement about kinship matching in this task.

When we compare Malaysian children from single-race families and those from mixed-race families, pre-schoolers from mixed-race families were better in the total kinship-matching task performance and on intra-racial items. As predicted, they had slightly better performance in mixed-race items as well, although this was near significant. The results suggest that perhaps a direct experience with mixed-race families is a key for children to understand biological inheritance using skin colour as a feature. Hence, within the Malaysian sample, direct experience with mixed-race families, increased pre-schoolers understanding of biological inheritance. A possibility is that caregivers of mixed-race children discuss race issues with their children more often than parents of other children, or direct comparison between different skin tones of each parent by their children, lead to a belief change. Future studies are needed to test this possibility.

Future work involving older children is needed to understand the development of this ability, in particular at what age does children begin to be able to understand the concept of biological inheritance in the mixed-race couple. Including a baseline task with animals, examples could also be included to ensure that children in the study have some understanding of biological inheritance.

Chapter 9: General Discussion and Conclusion

This chapter serves as a general discussion for the whole thesis. The present thesis attempts to further the current scientific understanding of the development of face recognition (Other Race Effect), face categorization (Other Race Categorization Advantage), and kinship detection using skin colour as a perceptual cue in a multiracial population.

The thesis attempts to investigate three questions:

- 1 How does differential experience in a multiracial environment affect facial recognition (ORE) in infants, children, and adults?
- 2 How does differential experience in a multiracial environment affect face categorization (ORA) in children and adults?
- 3 How does differential experience from a multiracial environment affect pre-schoolers' ability to detect kinship relations? Would an individual who has more experience with mixed-race kinship be able to have an earlier understanding of biological inheritance?

The precise results obtained in each chapter of the current thesis will not be repeated here, but will instead be summarized according to each of those three questions.

9.1 How does differential experience in a multiracial environment affect facial recognition (ORE) in infants, children and adults?

Perceptual expertise and social categorization frameworks have been postulated to account for the own-race recognition and other-race categorization advantages (Meissner & Brigham, 2001; Sporer, 2001). The perceptual expertise model has previously been applied to explaining aspects of perceptual and cognitive development (Gauthier & Nelson, 2001; Quinn, 2010), and in the case of race, the model postulates that extensive contact or experience with own-race members and a lack of contact with other-race members increase the accuracy of recognition of own-race faces due to the perceptual processes that are used (Tanaka, Kiefer, & Bukach, 2004) and how familiar and unfamiliar faces are represented in memory (Valentine, 2001).

Multiple pieces of evidence were found in this thesis that supports differential perceptual experience affecting the other-race effect (ORE) in infants, children and adults born and living in a multiracial population, such as Malaysia.

Chapter 5 demonstrates that Malaysian-Chinese infants showed an ORE effect between 3- to 4-months of age, but is specific to faces representing their primary caregiver. This ORE effect was also extended to experienced other-race female faces by 8 to 9-months of age, particularly when they have an additional other-race caregiver. The study suggests that in a sample of infants raised in an environment that is considered multiracial, the own-race recognition advantage develops first for the 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).

Evidence consistent with the perceptual experience theory was found in Malaysian adults in Chapter 6. Malaysian adults develop equal ability to recognise own and frequently experience other-race faces with increasing exposure to multi-races over the years, a finding that is consistent with a version of the contact hypothesis in which other-race faces need to surpass some threshold of experience in order to be responded to as own-race faces (Liu et al., 2015).

In contrast, the development of the ORE effect was less clear in childhood. Malay children age 7 – 13 years old had equal accuracy performance for own race Malay face and frequently exposed Chinese face, while Chinese children were more accurate with own-race

Chinese faces compare to frequently exposed Malay race. One limitation in this particular study was that children's exposure and contact to different race faces were not measured. As Chinese children were recruited from Chinese vernacular schools, part of the results could reflect the exposure of more Chinese faces in their school environment. However, this needs to be confirmed with future studies measuring the amount of contact in children.

It appears that face recognition performance is dependent on the frequency of race exposures. These exposures may change throughout childhood but become stable in adulthood. Hence, the face recognition system in particular the ORE is still malleable during childhood.

Overall, the experiments demonstrate that the development of ORE in a multiracial environment is complex and dependent on experience with a different class of faces. Exposures to a different class of faces (own versus others) may change from infancy to childhood and only becomes stable in adulthood. The study highlights the importance that face recognition performance seems to be more advantageous for racial categories of higher experience regardless of whether these face categories are own race or other race.

9.2 How does differential experience in a multiracial environment affects face categorization (ORA) in children and adults?

Another relevant area of face processing that is less researched is how we categorize faces. Contrary to the own-race recognition advantage, individuals categorize other-race faces faster, and sometimes with greater accuracy, than they categorize own-race faces (Levin, 1996; Valentine & Endo, 1992). This phenomenon is known as the other-race categorization advantage. Given that most prior studies of own-race recognition and other-race categorization have been studied with predominantly monoracial populations living in racially homogeneous environments, there is a need for work examining the processing of face race in children and adults who have extensive experience with another race of faces. Is the other-race categorization advantage also modifiable with ample exposure to other-race faces?

In Chapter 7, Malaysian children (7 and 9-year-old) and adult's categorization of (a) own-race faces, (b) high-frequency other-race faces and (c) low-frequency other-race faces were investigated. Whereas the other-race categorization advantage was in evidence in the accuracy data of Malay adults, other aspects of performance were supportive of either the

social categorization or perceptual expertise accounts and were dependent on the race (Malay vs. Chinese) or age (child vs. adult) of the participants. Of particular significance is the finding that Malaysian Chinese children and adults categorized own-race Chinese faces more rapidly than high-frequency other-race Malay faces. Thus, in accord with a perceptual expertise account, the other-race categorization advantage seems to be more advantage for racial categories of lesser experience regardless of whether these face categories are own-race or other-race.

9.3 How does differential experience from a multiracial environment affects pre-schoolers' ability to detect kinship relations? Would an individual who has more experience with mixed-race kinship be able to have an earlier understanding of biological inheritance?

There are not many studies on kinship resemblance detection in children, but existing evidence seems to suggest that children may have some ability to detect kinship resemblance using facial cues (Kaminski et al., 2012, 2013). Studies have shown that children as young as 5 years have some understanding that babies resemble their parents (Gelman & Wellman, 1991; Gimenez & Harris, 2002; Hirschfeld, 1995; Springer, 1992; Springer, 1996; Springer & Keil, 1989) in both animal and human relationships, although this understanding is mostly implicit/ elementary and not fully developed until the age of 7 years or older (Williams and Smith; 2010).

In Chapter 8, we examined whether the ability to detect kinship in unrelated faces in preschool children was influenced by their exposure to different race faces. We compared pre-schoolers who were born and raised in a multiracial environment (Malaysia) and those who were raised in a monoracial environment (France). Being raised in a multiracial environment did give an advantage in the detection of kinship performance. Instead, pre-schoolers from mixed-race families were better in the kinship-matching task performance. The results suggest that perhaps a direct experience with mixed-race families is a key for children to understand biological inheritance. Hence, within the Malaysian sample, direct experience with mixed-race families, increased pre-schoolers understanding of biological inheritance. Future work involving older children is needed to further understand the development of this ability.

In this thesis, I have tried to investigate face perception and kinship detection in a multiracial society. This had led to several insights on the effect of differential experience in face recognition, categorisation and kinship detection in infants, children and adults living in a multiracial society.

References

- Alvergne, A., Faurie, C., & Raymond, M. (2007). Differential facial resemblance of young children to their parents: Who do children look like more? *Evolution and Human Behavior*, 28, 135-144.
- Alvergne, A., Oda, R., Faurie, C., Matsumoto-Oda, A., Durand, V., & Raymond, M. (2009). Cross-cultural perceptions of facial resemblance between kin. *Journal of Vision*, 9, Article 23. <https://doi.org/10.1167/9.6.23>
- Anastasi, J.S. & Rhodes, M.G. (2005). An own-age bias in face recognition for children and older adults. *Psychonomic Bulletin & Review*, 12, 1043– 1047.
- Anzures, G., Quinn, P. C., Pascalis, O., Slater, A. M., & Lee, K. (2010). Categorization, categorical perception, and asymmetry in infants' representation of face race. *Developmental Science*, 13, 553–564. doi: 10.1111/j.1467-7687.2009.00900.x
- Anzures, G., Quinn, P.C., Pascalis, O., Slater, A.M., Tanaka, J.W. & Lee, K (2013). Developmental origins of the other race effect. *Current Direction in Psychological Science*, 22, 173-178.
- Anzures, G., Quinn, P.C., Pascalis, O., Slater, A.M., & Lee, K. (2010). Categorization, categorical perception, and asymmetry in infants' representation of face race. *Developmental Science*, 13, 553–564.
- Bar-Haim, Y., Ziv, T., Lamy, D., & Hodes, R. M. (2006). Nature and nurture in own-race face processing. *Psychological Science*, 17(2), 159-163.
- Brace, N.A., Hole, G.J., Kemp, R.I., Pike, G.E., Van Duuren, M. & Norgate, L. (2001). Developmental changes in the effect of inversion: Using a picture book to investigate face recognition. *Perception*, 30, 85-94.
- Bredart, S., & French, R. M. (1999) Do babies resemble their fathers more than their mothers? A failure to replicate Christenfeld & Hill (1995). *Evolution and Human Behavior*, 20, 129–135
- Bressan, P., & Dal Martello, M. F. (2002). Talis Pater, Talis Filius: Perceived resemblance and the belief in genetic relatedness. *Psychological Science*, 13(3), 213–218. <https://doi.org/10.1111/1467-9280.00440>
- Bressan, P., & Grassi, M. (2004). Parental resemblance in 1-year-olds and the Gaussian curve. *Evolution and Human Behavior*, 25, 133-141.

- Brooks, J., & Lewis, M. (1976). Infants' responses to strangers: Midget, adult, and child. *Child Development*, 47, 323–332.
- Bruce, V., Campbell, R.N., Doherty-Sneddon, G., Import, A., Langton, S., McAuley, S. & Wright, R. (2000). Testing face processing skills in children. *British Journal of Developmental Psychology*, 18, 319-333.
- Bukach, C.M., Cottle, J., Ubiwa, J., & Miller, J. (2012). Individuation experience predicts other-race effects in holistic processing for both Caucasian and Black participants. *Cognition*, 123, 319-324,
- Burnstein E., Crandall C., & Kitayama S. (1994). Some neo-Darwinian decision rules for altruism: Weighing cues for inclusive fitness as a function of the biological importance of the decision. *Journal of Personality and Social Psychology*, 67, 773–789 ([doi:10.1037/0022-3514.67.5.773](https://doi.org/10.1037/0022-3514.67.5.773))
- Caldara, R., Rossion, B., Bovet, P., & Hauert, C-A. (2004). Event-related potentials and time course of the 'other-race' face classification advantage. *Cognitive Neuroscience and Neuropsychology*, 15, 905-910, doi: 10.1097/01.wnr.0000119729.93564.3e
- Carey, S. (1992). Becoming a face expert. *Philosophical Transactions of the Royal Society of London*, 335, 95-103.
- Carey, S., & Diamond, R. (1977). From piecemeal to configurational representation of faces. *Science*, 195, 312–314
- Carey, S., & Diamond, R. (1994) Are faces perceived as configurations more by adults than by children? *Visual Cognition*, 1, 253-274.
- Cassia, V. M., Picozzi, M., Kuefner, D., & Casati, M. (2009). Why mix-ups don't happen in the nursery: Evidence for an experience-based interpretation of the other-age effect. *Quarterly Journal of Experimental Psychology*, 62, 1099–1107. doi:10.1080/17470210802617654
- Christenfeld, N. J. S., & Hill, E. A. (1995). Whose baby are you? *Nature*, 378, 669.
- Connellan, J., Baron-Cohen, S., Wheelwright, S., Batki, A., & Ahluwalia, J. (2000). Sex differences in human neonatal social perception. *Infant Behavior and Development*, 23, 113-118. doi:10.1016/S0163-6383(00)00032-1
- Cross, J. F., Cross, J., & Daly, J. (1971). Sex, race, age, and beauty as factors in recognition of faces. *Perception & Psychophysics*, 10(6), 393-396.
- Chance, J.E., Turner, A.L. & Goldstein, A.G. (1982). Development of differential recognition for own race and other race faces. *The Journal of Psychology*, 112, 29-37.

- Cohen, L. B., & Cashon, C. H. (2001). Do 7-month-old infants process independent features or facial configurations? *Infant and Child Development*, 10, 83–92.
- Cohen, L.B., & Younger, B.A. (1983). Perceptual categorization in the infant. In *New Trends in Conceptual Representation*, ed. E Scholnick, pp. 197–220. Hillsdale, NJ: Erlbaum
- Crookes, K., Favelle, S., & Hayward, W. G. (2013). Holistic processing for other-race faces in Chinese participants occurs for upright but not inverted faces. *Frontiers in Psychology*, 4(29), 1–9.
- Crookes, K. & McKone, E. (2009). Early maturity of face recognition. No childhood development of holistic processing, novel face encoding, or face space, *Cognition*, 111, 219-247
- Dailey, M. N., & Cottrell, G. W. (1999) Organization of face and object recognition in modular neural networks. *Neural Networks*, 12, 1053-1074.
- de Heering, A., Houthuys, S. & Rossion, B. (2007). Holistic face processing is mature at 4 years of age: Evidence from the composite face effect. *Journal of Experimental Child Psychology*, 96, 57-70.
- DeBruine, L. M., Jones, B. C., Little, A. C., & Perrett, D. I. (2008). Social perception of facial resemblance in humans. *Archives of Sexual Behavior*, 37, 64-77
- DeBruine, L. M., Jones, B. C., Unger, L., Little, A. C., & Feinberg, D. R. (2007). Dissociating averageness and attractiveness: Attractive faces are not always average. *Journal of Experimental Psychology: Human Perception and Performance*, 33(6), 1420–1430.
- DeBruine, L.M., Smith, F.G., Jones, B.C., Roberts, S.C., Petrie, M. & Spector, T.D. (2009). Kin recognition signals in adult faces. *Vision Research*, 49, 38-43. doi: 10.1016/j.visres.2008.09.025
- DeGutis, J., Mercado, R.J., Wilmer, J. & Rosenblatt, A. (2013) Individual Differences in Holistic Processing Predict the Own-Race Advantage in Recognition Memory. *PLoS ONE* 8(4): e58253. doi:10.1371/journal.pone.0058253
- Department of Statistics, Malaysia. (2017). Current Population Estimates, Malaysia, 2016-2017. Retrieved from Department of Statistics Malaysia website: <https://www.dosm.gov.my/v1/index.php?r=column/pdfPrev&id=a1d1UTFZazd5ajJiRWFHNDduOXFFQT09>
- Diamond, R., & Carey, S. (1986). Why faces are and are not special: An effect of expertise. *Journal of Experimental Psychology: General*, 115, 107– 117.

- Downs, A.C., & Walz, P.J. (1981). Sex differences in preschoolers' perceptions of young, middle-aged, and elderly adults. *The Journal of Psychology*, *109*, 119–122.
- Ekman, P. (1993). Facial expression and emotion. *American Psychologist*, *48*, 384–392
- Ellis, H., Shepherd, J., & Bruce, A. (1973). The effects of age and sex upon adolescents' recognition of faces. *Journal of Genetic Psychology*, *123*, 173-174.
doi:10.1080/00221325.1973.10533202
- Ellis, H. D., Deregowski, J. B., & Shepherd, J. W (1975). Descriptions of white and black faces by white and black subjects. *International Journal of Psychology*, *10*,119-123.
- E-Prime Standard (Version 2.0) [Computer software]. (2006). Sharpsburg, PA: Psychology Software Tools, Inc.
- Epstein, R., & Kanwisher, N. (1998). "A cortical representation of the local visual environment". *Nature*. *392*, 598–601. doi:10.1038/33402.
- Essock-Vitale, S. M. & McGuire, M. T. (1985). Women's lives viewed from an evolutionary perspective. I. Sexual histories, reproductive success, and demographic characteristics of a random sample of American women. *Ethology and Sociobiology*, *6*, 155–173
- Ericsson, K.A., Krampe, R.T., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological review*, *100*, 363.
- Fantz, R.L. (1961). The origin of form perception. *Scientific American*, *204*(5), 66-72.
- Fantz, R.L. (1963). Pattern vision in newborn infants. *Science*, *140*, 296-297.
- Farah, M. J., Wilson, K. D., Drain, M., & Tanaka, J. N. (1998). What is “special” about face perception? *Psychological Review*, *105*, 482–498.
- Farroni, T., Massaccesi, S., Menon, E., & Johnson, M.H. (2007). Direct gaze modulates face recognition in young infants. *Cognition*, *102*, 396–404.
- Feinman, S., & Entwisle, D. R. (1976). Children's ability to recognize other children's faces. *Child Development*, *47*, 506–510.
- Feng, L., Liu, J., Wang, Z., Li, J., Li, L., Ge, L., ... & Kang, L. (2011). The other face of the other-race effect: An fMRI investigation of the other-race face categorization advantage. *Neuropsychologia*, *49*, 3739-3749, doi: 10.1016/j.neuropsychologia.2011.09.031
- Fioravanti-Bastos, A. C. M., Filgueiras, A., & Landeira-Fernandez, J. (2014). The other-race effect in Caucasian and Japanese-descendant children in Brazil: Evidence of developmental plasticity. *Psychology*, *5*, 2073-2083. doi: 10.4236/psych.2014.519210

- Gaither, S. E., Schultz, J. R., Pauker, K., Sommers, S. R., Maddox, K. B., & Ambady, N. (2014). Essentialist thinking predicts decrements in children's memory for racially ambiguous faces. *Developmental Psychology, 50*(2), 482–488. <https://doi.org/10.1037/a0033493>
- Galton, F. (1883). *Inquiries into human faculty and its development*. London: Macmillan
- Gaulin, S. J., McBurney, D.H., Brakeman-Wartell, S.L. (1997) Matrilateral biases in the investment of aunts and uncles: A consequence and measure of paternity uncertainty. *Human Nature, 8*, 139–151
- Ge, L., Zhang, H., Wang, Z., Quinn, P.C., Pascalis, O., Kelly, D., & Lee, K. (2009). Two faces of the other-race effect: Recognition and categorization of Caucasian and Chinese faces. *Perception, 38*, 1199-1210. doi: 10.1068/p6136
- Ge, L., Anzures, G., Wang, Z., Kelly, D. J., Pascalis, O., Quinn, P. C., . . . Lee, K. (2008). An inner face advantage in children's recognition of familiar peers. *Journal of Experimental Child Psychology, 101*, 124_136. doi:10.1016/j.jecp.2008.05.006
- Gelman, S.A., & Wellman, H.M. (1991). Insides and essences: Early understanding of the nonobvious. *Cognition, 38*, 213-244.
- George, P.A., Hole, G.J., & Scaife, M. (2000). Factors influencing young children's ability to discriminate unfamiliar faces by age. *International Journal of Behavioral Development, 24*, 480– 491.
- Gimenez, M., & Harris, P.L. (2002). Understanding constraints on inheritance: Evidence for biological thinking in early childhood. *British Journal of Developmental Psychology, 20*, 307-324.
- Goldstein, A. G., & Chance, J. E. (1978). Judging face similarity in own and other races. *The Journal of Psychology, 98*(2), 185-193.
- Goldstein, A. G., & Chance, J. E. (1985). Effects of training on Japanese face recognition: Reduction of the other-race effect. *Bulletin of the Psychonomic Society, 23*(3), 211-214.
- Gross, T.F. (1997). Children's perception of faces of varied immaturity. *Journal of Experimental Child Psychology, 66*, 42– 63.
- Gross, T.F. (2004). Children's perceptions of and beliefs about facial maturity. *The Journal of Genetic Psychology, 165*, 81– 97.
- Gross, T.F. (2007). Developmental changes in the perception of adult facial age. *The Journal of Genetic Psychology, 168*, 443– 464.

- Gross, T.F. (2009). Own-ethnicity bias in the recognition of Black, East Asian, Hispanic, and White Faces. *Basic and Applied Social Psychology*, 31(2), 128-135.
- Haith, M.M., Bergman, T., & Moore, M. (1977). Eye contact and face scanning in early infancy. *Science*, 198, 853– 855.
- Hancock, K. J., & Rhodes, G. (2008). Contact, configural coding and the other-race effect in face recognition. *British Journal of Psychology*, 99, 45–56.
<https://doi.org/10.1348/000712607X199981>
- Harrison, S. A., Gauthier, I., Hayward, W. G., and Richler, J. J. (2014). Other-race effects manifest in overall performance, not qualitative processing style. *Visual Cognition*, 22, 843–864. doi:10.1080/13506285.2014.918912
- Harrison, V., & Hole, G. J. (2009). Evidence for a contact-based explanation of the own-age bias in face recognition. *Psychonomic Bulletin & Review*, 16, 264–269.
 doi:10.3758/PBR.16.2.264
- Hasnah Binti Hussin, & Mardiana Nordin. (2002). Pengajian Malaysia. (Edisi Kedua). Kuala Lumpur: Fajar Bakti, Sdn. Bhd.
- Haxby, J.A. & Martin, A. (1999). "The Effect of Face Inversion on Activity in Human Neural Systems for Face and Object Perception". *Neuron*, 22(1): 189–199.
- Hayward, W. G., Rhodes, G., & Schwaninger, A. (2008). An own-race advantage for components as well as configurations in face recognition. *Cognition*, 106(2), 1017–1027. <https://doi.org/10.1016/j.cognition.2007.04.002>
- Helman, E., Mania, E. W., & Gaertner, S. L. (2009). Where the division lies: Common ingroup identity moderates the cross-race facial-recognition effect. *Journal of Experimental Social Psychology*, 1-4. doi: 10.1016/j.jesp.2009.11.008
- Herrera, V., MacLin, M.K. & Malpass, R.S. (2002). The Criminal Schema: Content and Origins. Poster presented at the meetings of the American Psychology – Law Society, Austin, TX.
- Heron-Delaney, M., Anzures, G., Herbert, J.S., Quinn, P.C., Slater, A.M.,... Pascalis, O. (2011) Perceptual Training Prevents the Emergence of the Other Race Effect during Infancy. *PLoS ONE* 6(5): e19858. doi:10.1371/journal.pone.0019858
- Hirschfeld, L.A. (1995). Do children have a theory of race? *Cognition*, 54, 209-252.
- Hugenberg, K., Miller, J., & Claypool, H. M. (2007). Categorization and individuation in the cross-race recognition deficit: Toward a solution to an insidious problem. *Journal of*

- Experimental Social Psychology*, 43, 334-340. Retrieved from, <http://dx.doi.org/10.1016/j.jesp.2006.02.010>
- Hugenberg, K., Young, S., Bernstein, M., & Sacco, D. F. (2010). The categorization-individuation model: an integrative account of the other-race recognition deficit. *Psychological Review*, 117, 1168–1187. doi: 10.1037/a0020463
- Holmes, W. G., and Sherman, P. W. (1982). The ontogeny of kin recognition in two species of ground squirrels. *American Zoologist*, 22, 491–517.
- Horry, R., Cheong, W., and Brewer, N. (2015). The other-race effect in perception and recognition: Insights from the complete composite task. *Journal of Experimental Psychology: Human Perception and Performance*, 41, 508–524. doi: 10.1037/xhp0000042
- Index Mundi (2013). Malaysia demographics profile 2013. Retrieved from http://www.indexmundi.com/malaysia/demographics_profile.html
- Jeon, J., & Buss, D. M. (2007). Altruism towards cousins. *Proceedings. Biological Sciences*, 274(1614), 1181–1187. <https://doi.org/10.1098/rspb.2006.0366>
- Johnson, M., Dziurawiec, S., Ellis, H. & Morton, J. (1991). Newborns' preferential tracking of faces and its subsequent decline. *Cognition*, 40, 1-19. 10.1016/0010-0277(91)90045-6.
- Johnson, S.C., & Solomon, G.E.A. (1997). Why dogs have puppies and cats have kittens: The role of birth in young children's understanding of biological origins. *Child Development*, 68, 404-419.
- Jones, B. C., Little, A. C., Burt, D. M., & Perrett, D. I. (2004). When facial attractiveness is only skin deep. *Perception*, 33, 569–576.
- Kaminski, G., Berger, C., Jolly, C. Mazens, K. (2013). Children's consideration of relevant and non-relevant facial cues in kinship detection. *Année Psychologie*, 113, 321-334.
- Kaminski, G., Dridi, S., Graff, C., & Gentaz, E. (2009). Human ability to detect kinship in strangers' faces: effects of the degree of relatedness. *Proceedings of the Royal Society B*, 276, 3193-200.
- Kaminski, G., Meary, D., Mermillod, M., & Gentaz, E. (2010). Perceptual factors affecting the ability to assess facial resemblance between parents and newborns in humans. *Perception*, 39, 807-818
- Kanwisher, N. & Yovel, G. (2006). "The fusiform face area: a cortical region specialized for the perception of faces 9". *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, 361(1476), 2109–2128. doi:10.1098/rstb.2006.1934

- Kanwisher, N., Tong, F. & Nakayama, K. (1998). The effect of face inversion on the human fusiform face area. *Cognition*, *68*, 1-11.
- Kelly, D. J., Liu, S., Ge, L., Quinn, P. C., Slater, A. M., Lee, K., et al. (2007). Cross-race preferences for same-race faces extend beyond the African versus Caucasian contrast in 3-month-old infants. *Infancy*, *11*, 87-95.
- Kelly, D.J., Liu, S.; Lee, K., Quinn, P.C., Pascalis, O; Slater, A.M. & Ge, L. (2009). Development of the Other-Race Effect in Infancy: Evidence Towards Universality? *Journal of Experimental Child Psychology*, *104*(1):105-14.
- Kelly, D. J., Quinn, P. C., Slater, A. M., Lee, K., Ge, L., & Pascalis, O. (2007). The other-race effect develops during infancy: Evidence of perceptual narrowing. *Psychological Science*, *18*, 1084-1089.
- Kelly, D. J., Quinn, P. C., Slater, A. M., Lee, K., Gibson, A., Smith, M., Ge, L., & Pascalis, O. (2005). Three-month-olds, but not newborns, prefer own-race faces. *Developmental Science*, *8*, F31-F36.
- Kovack-Lesh, K.A., Horst, J.S., and Oakes, L.M. (2008). The cat is out of the bag: The joint influence of previous experience and looking behavior on infant categorization. *Infancy*, *13*, 285 – 307.
- Kruger D. J. (2003) Evolution and altruism: combining psychological mediators with naturally selected tendencies. *Evolution and Human Behavior*, *24*, 118–125 ([doi:10.1016/S1090-5138\(02\)00156-3](https://doi.org/10.1016/S1090-5138(02)00156-3))
- Kuefner, D., Cassia, V. M., Vescovo, E., & Picozzi, M. (2010). Natural experience acquired in adulthood enhances holistic processing of other age faces. *Visual Cognition*, *18*, 11–25. doi:10.1080/13506280802396507
- Leder, H., & Bruce, V. (2000). When inverted faces are recognized: The role of configural information in face recognition. *Quarterly Journal of Experimental Psychology*, *53A*, 513-536.
- Lee, K., Anzures, G., Quinn, P. C., Pascalis, O., & Slater, A. (2011). Development of face processing expertise. In A. J. Calder, G. Rhodes, J. V. Haxby, & M. H. Johnson (Eds.), *The handbook of face processing* (pp. 753-778). Oxford, UK: Oxford University Press.
- Liu, S., Xiao, W. S., Xiao, N. G., Quinn, P. C., Zhang, Y., Chen, H., Ge, L., Pascalis, O., & Lee, K. (2015). Development of visual preference for own- versus other-race faces in infancy. *Developmental Psychology*, *51*(4), 500-511. <https://doi.org/10.1037/a0038835>

- Liu S, Quinn PC, Wheeler A, Xiao N, Ge L, et al. (2011) Similarity and difference in the processing of same- and other-race faces as revealed by eye-tracking in 4- to 9-month-old infants. *Journal of Experimental Child Psychology*, *108*, 180–189.
- Lee, K. (2015). Development of visual preference for own- versus other-race faces in infancy. *Developmental Psychology*, *51*, 500-511.
- Lewin, C., & Herlitz, A. (2002). Sex differences in face recognition – Women’s faces make the difference. *Brain and Cognition*, *50*, 121–128.
- Levin, D. T. (1996). Classifying faces by race: The structure of face categories. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *22*, 1364-1382. doi: 10.1037/0278-7393.22.6.1364
- Levin, D. T. (2000). Race as a visual feature: Using visual search and perceptual discrimination tasks to understand face categories and the cross-race recognition deficit. *Journal of Experimental Psychology: General*, *129*, 559-574.
- Li, Y., Tze, C., & Sun, J. (2018). Other-race categorization advantage in a binary vs. ternary-response race categorization task. *Journal of Cognitive Psychology*, *30*, 242-256. doi: 10.1080/20445911.2017.1414822
- Liu, S., Xiao, N. G., Quinn, P. C., Zhu, D., Ge, L., Pascalis, O., & Lee, K. (2015). Asian infants show preference for own-race but not other-race female faces: The role of infant caregiving arrangements. *Frontiers in Psychology*, *6*, 593. doi: 10.3389/fpsyg.2015.00593
- MacLin, O. H., & Malpass, R. S. (2001). Racial categorization of faces: The ambiguous race face effect. *Psychology, Public Policy and Law*, *7*(1), 98–118.
- Macchi Cassia, V., Kuefner, D., Picozzi, M., & Vescovo, E. (2009a). Early experience predicts later plasticity for face processing: Evidence for the reactivation of dormant effects. *Psychological Science*, *20*, 853– 859.
- Malach, R., Reppas, J.B., Benson, R.R., Kwong, K.K., Jiang, H., Kennedy, W.A., Ledden, P.J., Brady, T.J. & Rosen, B.R. (1995). "Object-related activity revealed by functional magnetic resonance imaging in human occipital cortex". *Proceedings of the National Academy of Sciences of the United States of America*, *92*(18): 8135–8139.
- Maloney, L. T., & Dal Martello, M. F. (2006). Kin recognition and the perceived facial perceptual similarity of children. *Journal of Vision*, *6*, 1047-1056.
- Maurer, D. & Salapatek P. (1976). Developmental changes in the scanning of faces by young infants. *Child Development*, *47*, 523– 527.

- McLain, D.K., Setters, D., Moulton, M.P. & Pratt, A.E. (2000) Ascription of resemblance of newborns by parents and nonrelatives. *Evolution and Human Behavior*, 21, 11–23. doi:10.1016/S1090-5138(99)00029-x
- Megreya, A.M., White, D., & Burton, A.M. (2006). The other-race effect does not rely on memory: Evidence from a matching task. *Quarterly Journal of Experimental Psychology*, 64(8), 1473 – 1483.
- Meissner, C. A., & Brigham, J. C. (2001). Thirty years of investigating the own-race bias in memory for faces: A meta-analytic review. *Psychology, Public Policy, and Law*, 7, 3-35. doi: 10.1037//1076-8971.7.1.3
- Mervis, C.B., & Rosch, E. (1981). Categorization of natural objects. *Annual Review of Psychology*, 32, 89–115.
- Michalski, R. L. & Shackelford, T. K. (2005) Grandparental investment as a function of relational uncertainty and emotional closeness with parents. *Human Nature*, 16, 292–304.
- Michel, C., Caldara, R. & Rossion, B. (2006). Same-race faces are perceived more holistically than other-race faces. *Visual Cognition*, 14(1), 55-73.
- Michel, C., Rossion, B., Han, J., Chung, C. S., & Caldara, R. (2006). Holistic processing is finely tuned for faces of our own race. *Psychological Science*, 17, 608–615.
- Mondloch, C.J., Le Grand, R., & Maurer, D. (2002). Configural face processing develops more slowly than featural face processing. *Perception*, 31, 553– 566.
- Montepare, J.M. & McArthur, L.Z. (1986). The influence of facial characteristics on children’s age perceptions. *Journal of Experimental Child Psychology*, 42, 303– 314.
- Nesse, R. M., Silverman, A., & Bortz, A. (1990). Gender differences in ability to recognize family resemblance. *Ethology and Sociobiology*, 11, 11-21.
- Oda, R., Matsumoto-Oda, A., & Kurashima, O. (2002). Facial resemblance of Japanese children to their parents. *Journal of Ethology*, 20, 81–85.
- Oda, R., Matsumoto-Oda, A., & Kurashima, O. (2005). Effects of belief in genetic relatedness on resemblance judgments by Japanese raters. *Evolution and Human Behavior*, 26, 441-450.
- O’Toole A J, Deffenbacher K A, Valentin D & Abdi H, (1994). Structural aspects of face recognition and the other-race effect. *Memory & Cognition*, 22, 208 -224
- Pascalis, O. & de Schonen, S. (1994). Recognition memory in 3- to 4-day-old human neonates. *NeuroReport*, 5, 1721– 1724.

- Pascalis, O., Demont, E., de Haan, M. & Campbell, R. (2001). Recognition of faces of different species: A developmental study between 5 and 8 years of age. *Infant and Child Development*, *10*, 39-45.
- Pascalis, O., de Haan, M., & Nelson, C. A. (2002). Is face processing species specific during the first year of life? *Science*, *296*, 1321–1323.
- Pascalis, O., Loevenbruck, H., Quinn, P. C., Kandel, S., Tanaka, J. W., & Lee, K. (2014). On the linkage between face processing, language processing, and narrowing during development. *Child Development Perspectives*, *8*, 65-70. doi: 10.1111/cdep.12064
- Pearson, D.A., & Lane, D.M. (1991). Visual attention movements: A developmental study. *Child Development*, *61*, 1779-1795.
- Pellicano, E., & Rhodes, G. (2003). Holistic processing of faces in preschool children and adults. *Psychological Science*, *14*, 618–622.
- Perrett, D. I., Lee, K., Penton-Voak, I. S., Rowland, D., Yoshikawa, S., Burt, D. M., et al. (1998). Effects of sexual dimorphism on facial attractiveness. *Nature*, *394*, 884–887.
- Pezdek K., Blandon-Gitlin, L. & Moore, C. (2003). Children’s face recognition memory: More evidence for the cross race effect. *Journal of Applied Psychology*, *88*, 760-763.
- Pitcher, D., Duchaine, B., Walsh, V., Yovel, G. & Kanwisher, N. (2011). The role of lateral occipital face and object areas in the face inversion effect. *Neuropsychologia*, *49*(12): 3448–3453.
- Porter, R. H., Cernoch, J. M., & Balogh, R. D. (1984) Recognition of neonates by facial-visual characteristics. *Pediatrics* *74*, 501-505
- Quinn, P. C., Lee, K., Pascalis, O., & Tanaka, J. (2016). Narrowing in categorical responding to other-race faces by infants: Evidence for an outgroup category in 9-month-olds. *Developmental Science*, *19*, 362–371. doi: 10.1111/desc.12301
- R Core Team (2014). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <http://www.R-project.org/>.
- Ramsey-Rennels, J. L., & Langlois, J. H. (2006). Infants’ differential processing of female and male faces. *Current Directions in Psychological Science*, *15*, 59-62. doi:10.1111/j.0963-7214.2006.00407.x
- Rehman, J., & Herlitz, A. (2006). Higher face recognition ability in girls: Magnified by own-sex and own-ethnicity bias. *Memory*, *14*, 289-296. doi:10.1080/09658210500233581

- Rennels, J. L., & Davis, R. E. (2008). Facial experience during the first year. *Infant Behavior and Development, 31*, 665-678. doi:10.1016/j.infbeh.2008.04.009
- Rhodes G, Locke V, Ewing L, & Evangelista E, (2009). Race coding and the other-race effect in face recognition. *Perception, 38*(2), 232 – 241
- Rhodes, G., Ewing, L., Hayward, W., Maurer, D., Mondloch, C., & Tanaka, J. (2009). Contact and other-race effects in configural and component processing of faces. *British Journal of Psychology, 100*, 717-28. 10.1348/000712608X396503.
- Rhodes, M. G., & Anastasi, J. S. (2012). The own-age bias in face recognition: A meta-analytic and theoretical review. *Psychological Bulletin, 138*, 146-174. doi:10.1037/a0025750
- Roulin, J-L. (2015). udsAnova V2.31.1. Creative Commons, License: GpV3
- Sangrigoli, S., & de Schonen, S. (2004). Recognition of own-race and other-race faces by three-month-old infants. *Journal of Child Psychology and Psychiatry, 45*, 1219-1227.
- Schwarzer G, Zauner N & Jovanovic B. (2007). Evidence of a shift from featural to configural face processing in infancy. *Developmental Science, 10*, 452–463.
- Schwarzer, G. & Zauner, N. (2003). Face processing in 8 month old infants: evidence for configural and analytical processing. *Vision Research, 26*, 2783- 2793.
- Shepherd, J. W., & Deregowski, J. B. (1981). Races and faces—a comparison of the responses of Africans and Whites to faces of the same and different races. *British Journal of Social Psychology, 20*, 125–133.
- Shriver, E. R., Young, S. G., Hugenberg, K., Bernstein, M. J., & Lanter, J. R. (2008). Class, race, and the face: Social context modulates the cross-race effect in face recognition. *Personality and Social Psychology Bulletin, 34*, 260-274. doi: 10.1177/0146167207310455
- Singarajah, A., Chanley, J., Gutierrez, Y., Cordon, Y., Nguyen, B., Burakowski, L., & Johnson, S. P. (2017). Infant attention to same- and other-race faces. *Cognition, 159*, 76-84.
- Slater A, Bremner G, Johnson SP, Sherwood P, Hayes R, Brown E. Newborn infants' preference for attractive faces: the role of internal and external facial features. *Infancy. 2000*, 265–274.
- Slone, A. E., Brigham, J. C., & Meissner, C. A. (2000). Social and cognitive factors affecting the own-race bias in whites. *Basic and Applied Social Psychology, 22*, 71–84.
- Solomon, G.E.A. (2002). Birth, kind and naïve biology. *Developmental Science, 5*, 213-218.

- Solomon, G.E.A., Johnson, S.C., Zaitchik, D., & Carey, S. (1996). Like father, like son: Young children's understanding of how and why offspring resemble their parents. *Child Development, 67*, 151-171.
- Spencer, J., Quinn, P.C., Johnson, M.H., & Karmiloff-Smith, A. (1997). Heads you win tails you lose: Evidence for young infants categorizing mammals by head and facial attributes. *Early Development and Parenting, 6*, 113–126
- Sporer, S. L. (2001). Recognizing faces of other ethnic groups: An integration of theories. *Psychology, Public Policy, and Law, 7*, 36-97. doi: 10.1037//1076-8971.7.1.36
- Springer, K. (1992). Children's awareness of the biological implications of kinship. *Child Development, 63*, 950-959.
- Springer, K. (1996). Young children's understanding of a biological basis for parent-offspring relations. *Child Development, 67*, 2841-2856.
- Springer, K., & Keil, F.C. (1989). On the development of biologically specific beliefs: The case of inheritance. *Child Development, 60*, 637-648.
- Stewart-Williams S. (2007). Altruism among kin vs. nonkin: Effects of cost of help and reciprocal exchange. *Evolution and Human Behavior, 28*, 193–198
(doi:10.1016/j.evolhumbehav.2007.01.002)
- Tan, C.B.Y., Stephen, I.D., Whitehead, R. & Sheppard, E. (2012). You look familiar: How Malaysian Chinese recognize faces. *PLOS One, 7*, 1-4.
- Tanaka, J. W., Kay, J. B., Grinnell, E., StanWeld, B., & Szechter, L. (1998). Face recognition in young children: When the whole is greater than the sum of its parts. *Visual Cognition, 5*, 479–496.
- Tanaka, J.W., Kiefer, M., & Bukach, C.M. (2004) A holistic account of the own-race effect in face recognition: evidence from a cross-cultural study. *Cognition, 93*, 1–9.
- Tham, D. S. Y., Bremner, J. G., & Hay, D. (2017). The other-race effect in children from a multiracial population: A cross-cultural comparison. *Journal of Experimental Child Psychology, 155*, 128-137. doi: 10.1016/j.jecp.2016.11.006
- Tham, D. S. Y., Woo, P. J., & Bremner, J. G. (2019). Development of the other-race effect in Malaysian-Chinese infants. *Developmental Psychobiology, 61*(1), 107–115. <https://doi.org/10.1002/dev.21783>
- Turati, C., Macchi Cassia, V., Simion, F., & Leo, I. (2006). Newborns' face recognition: Role of inner and outer facial features. *Child Development, 77*, 297– 311.
- Turati, C., Bulf, H., & Simion, F. (2008). Newborns' face recognition over changes in viewpoint. *Cognition, 106*, 1300– 1321.

- Turati, C., Sangrigoli, S., Ruel, J., & de Schonen, S. (2004). Evidence of the face inversion effect in 4-month-old infants. *Infancy*, *6*, 275–297.
- Valentine, T. (1991). A unified account of the effects of distinctiveness, inversion, and race in face recognition. *Quarterly Journal of Experimental Psychology*, *43A*, 161-204.
- Valentine, T., & Endo, M. (1992). Towards an exemplar model of face processing: The effects of race and distinctiveness. *The Quarterly Journal of Experimental Psychology Section A: Human Experimental Psychology*, *44*, 671-703. doi: 10.1080/14640749208401305
- Waldman, B. (1988). The ecology of kin recognition. *Annual Review of Ecology, Evolution and Systematics*, *19*, 543–571
- Walker, P.M. & Hewstone, M. (2006). A developmental investigation of other race contact and the other race effect. *British Journal of Developmental Psychology*, *24*, 451-463.
- Walker, P. M., Silvert, L., Hewstone, M., & Nobre, A. C. (2008). Social contact and other-race face processing in the human brain. *Social Cognitive and Affective Neuroscience*, *3*, 16–25.
- Walker, P.M. & Tanaka, J.W. (2003). An encoding advantage for own race versus other race faces. *Perception*, *32*, 1117-1125.
- Want, S.C., Pascalis, O., Coleman, M. & Blades, M. (2003). Recognising people from the inner or outer parts of their faces: Developmental data concerning ‘unfamiliar’ faces. *British Journal of Developmental Psychology*, *21*, 125-135.
- Weigelt, S., Koldewyn, K., Dilks, D.D., Balas, B., McKone, E. & Kanwisher, N. (2014) Domain-specific development of face memory but not face perception. *Developmental Science*, *17*, 47-58.
- Weissman, M.D., & Kalish C.W. (1999). The inheritance of desired characteristics: Children’s view of the role of intention in parent-offspring resemblance. *Journal of Experimental Child Psychology*, *73*, 245-265.
- Wiese, H., Komes, J., & Schweinberger, S. R. (2013). Aging faces in aging minds: A review on the own-age bias in face recognition. *Visual Cognition*, *21*, 1337-1363, doi:10.1080/13506285.2013.823139
- Williams, J.M., & Smith L.A. (2010). Concepts of kinship relations and inheritance in childhood and adolescence. *British Journal of Developmental Psychology*, *28*, 523-546.
- Wiskott, L. (1997) Phantom faces for face analysis. *Pattern Recognition*, *30*, 837-846.

- Woo, P.J., Quinn, P.C., Meary, D., Kang, L. & Pascalis, O. (2020). A developmental investigation of the other-race categorization advantage in a multiracial population: Contrasting social categorization and perceptual expertise accounts. *Journal of Experimental Child Psychology*, *197*, 104870, <https://doi.org/10.1016/j.jecp.2020.104870>
- Qian, M., Quinn, P., Heyman, G., Pascalis, O., Fu, G., & Lee, K. (2017). Perceptual individuation training (but not mere exposure) reduces implicit racial bias in preschool children. *Developmental Psychology*, *53*, 845–859.
- Qian, M. K., Heyman, G. D., Quinn, P. C., Messi, F. A., Fu, G., & Lee, K. (2016). Implicit racial biases in preschool children and adults from Asia and Africa. *Child Development*, *87*, 285–296.
- Quinn, P. C., & Eimas, P. D. (1996). *Perceptual organization and categorization in young infants*. In C. Rovee-Collier & L. P. Lipsitt (Eds.), *Advances in infancy research*, Vol. *10* (p. 1–36). Ablex Publishing.
- Quinn, P. C., Yahr, J., Kuhn, A., Slater, A. M., & Pascalis, O. (2002). Representation of the gender of human faces by infants: A preference for female. *Perception*, *31*, 1109_1121.doi:10.1068/p3331
- Quinn, P.C., Doran, M.M., Reiss, J.E., & Hoffman, J.E. (2009) Time course of visual attention in infant categorization of cats versus dogs: evidence for a head bias as revealed through eye tracking. *Child Development*, *80*, 151–161
- Xiao, N. G., Quinn, P. C., Xiao, W. S., Liu, S., Ge, L., Pascalis, O., & Lee, K. (2018). Older but not younger infants associate own-race faces with positive music and other-race faces with negative music. *Developmental Science*, *21*(2), 10.1111/desc.12537. <https://doi.org/10.1111/desc.12537>
- Yin, R.K. (1969). Looking at upside-down faces. *Journal of Experimental Psychology*. *81*(1): 141–145.
- Yovel, G. & Kanwisher, N. (2005). The Neural Basis of the Behavioral Face-Inversion Effect. *Current Biology*. *15* (24): 2256–2262.
- Young, A. W., Hellawell, D., & Hay, D. C. (1987). Configurational information in face perception. *Perception*, *16*, 747–759
- Zauner, N., & Schwarzer, G. (2003). Entwicklung der Gesichtsverarbeitung im ersten Lebensjahr. *Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie*, *35*(4), 229–237.

- Zhao, L., & Bentin, S. (2008). Own- and other-race categorization of faces by race, gender, and age. *Psychonomic Bulletin & Review*, *15*, 1093-1099. doi: 0.3758/PBR.15.6.1093
- Zhao, L., & Bentin, S. (2011). The role of features and configural processing in face-race classification. *Vision Research*, *51*, 2463-2472. doi: 10.1016/j.visres.2011.10.001