The Development of the Other-Race Effect:

A Comparison between Populations

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DECLARATION

I declare this that this thesis is my own work and no portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification at this or any other university or other institute of learning.

ABSTRACT

The other-race effect (ORE) refers to the impoverished recognition of other-race faces relative to own-race faces. The aim of this thesis was to investigate the ORE in two populations (single-race and multi-race) from infancy to adolescence/adulthood as a means of testing and clarifying both the perceptual expertise account and the categorisation-individuation model (CIM). Of six experiments using age-relevant measures, four investigated the ORE when all other factors (social/motivation) are equal, and two investigated when non-race based social categorisation is manipulated. Using a more refined set of stimuli (limited to external facial information), Experiments 1 to 4 supports the assertion that recognition is affected by racial experiences. Furthermore, the interpretations extended the perceptual expertise account by suggesting that such experiences can also differ across face gender and face race at different stages of development. Experiments 5 and 6 extended the categorisation-individuation model by suggesting that population differences and the subjective importance of motivation to individuate faces could modify the ORE when non-race based social categorisation (personality affiliation) was manipulated. These findings were interpreted using a principle of concept of broadly tuned versus narrowly tuned representation within Valentine's (1991) multidimensional face-space model. The findings from this thesis address the importance of considering a combination of face experiences (e.g., race, gender), the social importance of individuating faces at different stages of development (social relationships), and how broadly tuned face representation can have a different effect on ORE compared with a narrowly tuned face representation.

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CHAPTER ONE

LITERATURE REVIEW ON THE OTHER-RACE EFFECT

This chapter introduces the other-race effect, or the common observation that people find it difficult in discriminating between faces of a different race relative to faces of their own-race. The literature review details potential mechanisms underlying the effect, and highlights several influential theoretical models of the other-race effect in explaining the effect from infancy to adulthood. The review suggests that the first signs of ORE are influenced specifically by experience of individuating faces. These findings confirm that early visual exposure can be retained and updated even with exposure to other racial groups later in life. With development, it is plausible that the face representation interacts with other social-cognitive factors in understanding face-processing advantages. Evidence on the social-cognitive account, on the other hand suggests that in adulthood, other social factors such as attention and motivation can play a role in influencing the ORE. To identify which explanation is the best in uncovering the ORE is an entirely different issue. However, it remains clear that differential visual experience with own-race versus other-race faces holds the highest level of explanation for development of the other-race effect.

1 Introduction

Faces are perhaps one of the most dominant categories of visual stimuli in our environment. From birth onwards, humans encounter thousands of faces. These faces vary in terms of identity, gender, age, attractiveness, species, and race. Faces are multidimensional visual stimuli and they provide rich sources of visual information with social significance. This information can be categorised as either transient (face states, i.e., emotional expression) or permanent in nature (face traits, i.e., species type, race, gender, age). Despite the facility with which such facial information can be processed, face traits are subject to numerous advantages or variation in ability. These advantages are typically defined by the ability to discriminate and recognise faces within one's own species, race, gender, and age more accurately than within another species, race, gender, and age respectively. Although it is still controversial as to whether humans' superior face processing advantages reflect an innate, subcortical mechanism or a more general phenomenon of visual learning resulting from extensive exposure to faces (e.g., Diamond & Carey, 1986; Johnson & Morton, 1991), most researchers agree that expert face processing is tuned by experiences.

When viewing a face, at least two automatic processes are triggered: categorisation of a face belonging or not belonging to our own group or species, and individuation of the face at an individual level. Before any individual recognition occurs, categorisation occurs very rapidly and may even facilitate recognition (Ge et al., 2009). It has been suggested that whereas novices categorise visual objects at the basic level of abstraction, perceptual experts identify objects at a more specific, subordinate level. For example, a novice will identify a brown object with feathers and wings at the basic level of "bird", but an expert bird watcher will identify the same object at a more subordinate level of "sparrow". Thus, a hallmark of perceptual expertise is a downward shift in recognition to a more specific, subordinate level of recognition. On the other hand, face expertise accounts for the most specific, downward shift in recognition in that a familiar face can be identified at an individual level (e.g., Sam, Vicky) rather than categorised at the more generic level of species or race (e.g., Tanaka, 2001).

A great deal has been learned about humans' ability to process faces. Two types of face processing style have been identified: featural-based and configural-based. Featural-based processing (sometimes termed "piecemeal" or "component" processing) refers to processing in terms of the independent component parts of faces, whereas configural-based processing refers to processing the spatial relationship between features (i.e., spacing between the eyes, nose, and mouth) of faces (e.g., Diamond & Carey, 1986; Rhodes et al., 1989; Tanaka & Farah, 1993).

Two distinctions have been made among the different types of featural-based information; internal facial features (eyes, nose, mouth) and external facial features (hairstyle, face contour). While both types of feature are considered important, the internal facial features are considered as more important in adult face processing expertise (e.g., Ellis, Shepherd, Davies, 1979; Ge, Anzures, Wang, Kelly, Pascalis, Quinn, Slater, Yang, & Lee, 2008). On the other hand, both internal and external facial information are considered important in infants' and children's face processing style (Pascalis, de Schonen, Morton, Deruelle & Fabre-Grenet, 1995; Rose et al 2008; Turati, Macchi Cassia, Simion & Leo, 2006). This is a point that will be returned to in the subsequent section.

In contrast to featural-based processing, Maurer, Le Grand, and Mondloch (2002) suggest that there are three different types of configural processing: (1) sensitivity to first-order relations (i.e., two eyes above a mouth; Diamond & Carey, 1986); (2) sensitivity to second-order relations (i.e., the processing of discrete spatial dimensions between independent features in the face (Diamond & Carey, 1986; Rhodes, 1988); and (3) holistic processing (i.e., processing the face as a perceptual whole or gestalt without decomposing the target into specific features; Tanaka & Farah, 1993; 2003). Although there are different types of configural processing, this thesis will not explore which configural processing style is most effective for expert face processing. However, to be consistent with the typical use of the term in the majority of the literature on face processing, the present chapter will use the term configural/holistic processing to refer to the processing of second-order relation and holistic processing.

There is a great deal of agreement within the literature that faces are processed configurally more so than any other type of visual object (e.g., Carey 1992; Farah, Wilson, Drain, & Tanaka, 1998; McKone, Martini, & Nakayama, 2001; Rossion & Gauthier, 2002). Although featural-based information may be useful for adult face recognition, researchers have shown that adults rely heavily on, and are highly proficient at processing configural information. Thus, becoming a face recognition expert means that one needs to acquire not only the ability to process featural information but also configural information.

One of the best-documented examples of face recognition advantage or expert face processing is the tendency for perceivers to have more accurate recognition memory for own-race faces than for other-race faces. The other-race effect (ORE), also known as the own-race bias or cross-race effect is one of the best-replicated phenomena in face perception (Goldstein & Chance, 1985) and has been shown to generalise across a number of research paradigms (Meissner & Brigham, 2001) and participant populations (e.g., Ng & Lindsay, 1994; Sporer, 2001). Regardless of the straightforward nature of the ORE, isolating a primary mechanism responsible for the effect and its development has proven vexing. Consequently, a number of theoretical perspectives, which largely emphasise the role of differential experience and social categorisation with certain faces, have been advanced to explain the ORE. Broadly, this thesis examines the perceptual expertise model and its possible interactions with social categorisation that may affect the development of the ORE from infancy to adulthood. This chapter will begin by introducing the ORE in more detail and outline a comprehensive overview of the current theoretical frameworks for understanding the ORE in infants, children, and adults.

2 The Other-Race Effect

The ORE refers to the finding that discrimination and recognition accuracy tends to be poor for other-race relative to own-race faces (Brigham & Barkowitz, 1978; Cross, Cross, & Daly, 1971; Goldstein & Chance, 1980; Malpass & Kravitz, 1969). The effect is one of the most widely replicable phenomena within the face perception literature (see Brigham, Bennett, Meissner, & Mitchell, 2007; Meissner & Brigham, 2001; Sporer, 2001 for reviews).

The other-race effect is not exclusive to Caucasian-White individuals; indeed, the ORE has been observed using various ethnic groups as participants, such as East Asian, African-Black, Hispanic, and Middle Eastern participants (Bar-Haim, Ziv, Lamy & Hodes, 2006; Chance, Turner, & Goldstein, 1982; de Heering, De Liedekerke, Deboni & Rossion, 2010; Ellis & Deregowski, 1981; Feinman & Entwisle, 1976; Goodman et al., 2007; Gross 2009; Kelly et al., 2009; MacLin, MacLin, & Malpass, 2001; Megreya, White, & Burton, 2011; Ng & Lindsay, 1994; Pezdek, Blandon-Gitlin, & Moore, 2003; Sangrigoli, Pallier, Argenti, Ventureyra, & de Schonen, 2005). In addition, many different countries aside from the USA and Canada (around 85 studies from these countries; Meissner & Brigham 2001) have replicated this phenomenon. For example, the ORE have been demonstrated in South Africa, United Kingdom, as well as other European nations, Middle Eastern nations, and Eastern cultures (e.g., Chiroro & Valentine, 1995; Goodman et al., 2007; Megreya et al., 2011; Ng & Lindsay, 1994; Sporer, 2001; Tanaka, Kiefer, & Bukach, 2004). Aside from showing the ORE in majority group status within a given country, the other-race effect have also been observed in both majority and minority groups (e.g., Gross, 2009; Platz & Hosch, 1988; Wright, Boyd, & Tredoux, 2001; 2003). For example, Gross (2009) had participants from four majority and minority ethnic groups within the USA (Caucasian-White, African-Black, East Asian, and Hispanic) and performed a recognition task with faces of each ethnic group. Data showed that all participants exhibited the ORE at recognition irrespective of majority or minority group status. However, all ethnic groups did exhibit greater recognition for Caucasian-White race (the majority group within the USA) after their own-race. Overall, this evidence shows that the ORE has generality across racial group memberships, culture, and majority minority group status.

3 Theoretical Frameworks for Understanding the Other-Race Effect in Adults

The majority of research on the other-race effect emphasises the role of differential experience with certain faces as an important factor in developing these advantages. For example, a lack of contact with other-race individuals results in a lack of perceptual expertise with other-race faces, which results in deficient other-race face processing, encoding, and recognition (e.g., Chiroro & Valentine, 1995; Malpass & Kravitz, 1969; Rhodes, Brake, Taylor, & Tan, 1989; Sangrigoli & de Schonen, 2004a; Tanaka, Kiefer, & Bukach, 2004; Valentine, 2001). More recently, there has been a marked interest in social-cognitive processes, such as attention/motivational factors that influences face processing (e.g., Bernstein, Young, & Hugenberg, 2007; Shriver, Young, Hugenberg, Bernstein, & Lanter, 2008). Theories that adopt social-cognitive accounts of own-race face processing advantages, share the assumption that there is a tendency to process out-group (other-race) targets in a categorical manner while instead individuating in-group (own-race) targets. Both of these frameworks have been used extensively to explain the other-race effect in adults.

3.1 Perceptual Expertise Theories.

In perceptual learning/expertise models, more experienced types of faces are recognised better than less experienced types of faces. Specifically, expertise theories propose that perceivers develop greater expertise processing and distinguishing between faces from the members of their own-race relative to faces of other-races (see McKone, Crookes, Kanwhisher, 2009 for a review). As a result of different expertise with own-race and other-race faces, models are proposed based on different processing style (Diamond & Carey, 1986) and models on how faces are differentially represented in memory (Valentine, 1991).

3.1.1 Face processing style and the other-race effect. Models based on different processing styles indicate that own-race faces tend to be processed more configurally, whereas other-race faces tend to be processed in a more feature-based manner (e.g., Hancock & Rhodes, 2008; Hayward, Rhode, & Schwaninger, 2008; Michel, Caldara, & Rossion, 2006; Michel, Corneille, & Rossion, 2007, 2010; Michel, Rossion, Han, Chung, & Caldara, 2006; Rhodes, Ewing, Hayward, Maurer, Mondloch, & Tanaka, 2009; Tanaka, Kiefer, & Bukach, 2004). Depending on the specificity of experimental test, it is argued that the other-race effect arises from configural or holistic (CH) processing of own-race faces and featural or piecemeal (FP)[1] processing of other-race faces (e.g., Tanaka & Farah, 1993; Yin, 1969).

[1] The terminology differs substantially across theorists. Some use *holistic* versus *piecemeal* processing, whereas others emphasise *configural* versus *featural* processing. Recently, it has been noted that these

Several methods have been devised to experimentally test the argument for differential processing styles for own-race and other-race faces. The most common are face inversion (Yin, 1969), face-composite effect (Goffaux & Rossion, 2006; Young, Hellawell, & Hay, 1987), and whole/part (Tanaka & Farah, 1993; Tanaka et al., 2004) methods. Each of these methods measures configural processing of faces in which the configuration of typically observed features is somehow disrupted. The logic of such tasks is that if own-race faces are processed in a more configural or holistic manner than other-race faces, then the disruption of the normal face configuration should affect the processing of own-race faces more than the processing of other-race faces.

It is suggested that the face inversion effect (originally detected by Yin, 1969) arises because inverting faces at encoding disrupts the configuration of eyes-over-nose-over-mouth, which impairs subsequent recognition. For example, utilising inversion decrement as a marker of CH processing, Rhodes et al. (1989) found that own-race face recognition dropped to that of other-race recognition levels while inverting other-race faces had relatively little influence on other-race recognition. The results support the notion that own-race faces are processed in a CH manner whereas other-race faces are processed in a FP manner.

Evidence for differential processing style has also been found through application of the face composite effect (Goffaux & Rossion, 2006; Young, et al., 1987). In this method, participants are shown two faces in quick succession and are asked to determine whether the top halves (or bottom halves) of the two faces are

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different terminologies are not interchangeable and that configural and holistic encoding have specific distinct definitions (e.g., McKone & Yovel, 2009). Nevertheless, these different terms share a broad focus on the processing of second-order characteristics (i.e., relationship between facial features). In this current review, configural/holistic and piecemeal/featural encoding will be adopted as catchall terms.

identical or different. It is more difficult to make the same/different judgement when the top (or bottom) part of a face is aligned with the bottom (or the top) part from another identity (namely face composite effect) than when these two parts are presented in a misaligned format (see Figure 1). This alignment of target (top half) and novel (bottom half) faces creates a 'new face' (that results in more error when making a same/different judgement to top half of the new face) even when that top half is identical to the top half of the target face. This is because the global configuration or holistic representation of the new face will cause the exact eyes and nose to appear different from the original target face when aligned with different mouths and chins (because the spatial relations between these features are processed without decomposition into the individual parts). Recent work by Michel et al. (2006; also see Michel, Corneille, & Rossion, 2007, 2010) had Caucasian-White and Asian participants perform the composite face task involving two races of stimuli (Caucasian-White and Asian faces). They found that both Caucasian-White and Asian participants showed a stronger face-composite effect for own-race than for other-race faces, indicating that CH processing is stronger for own-race faces than other-race faces.

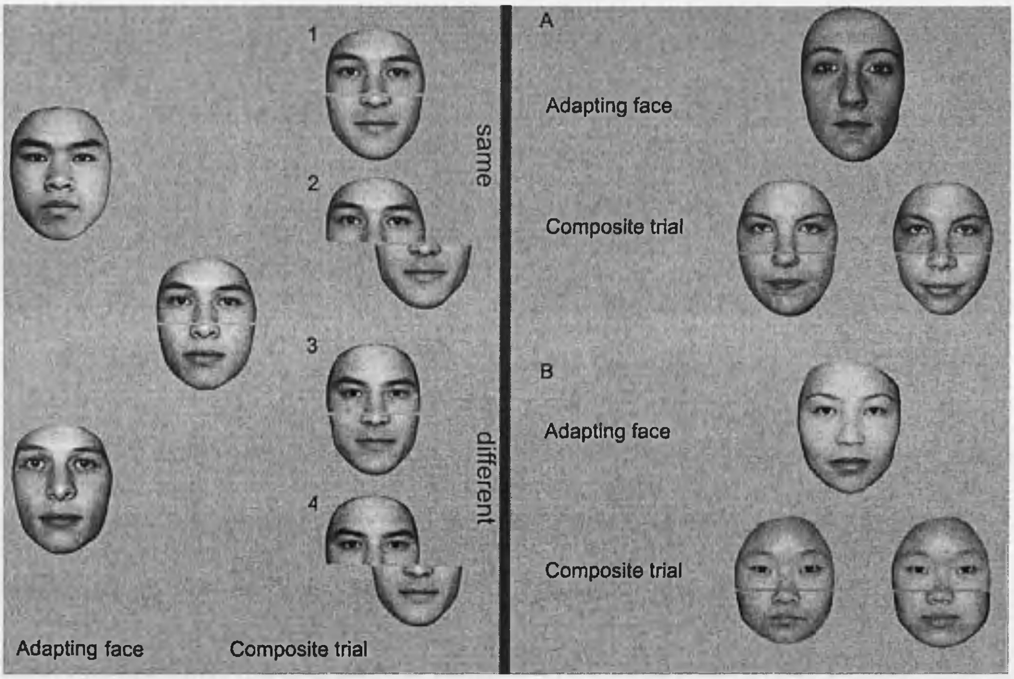

***Figure 1*. Extracted from Michel et al. (2010) illustration of the face-composite measure**

In contrast to the face-composite paradigm, the whole/part method measures the interdependence between FP and CH information in the face representation (e.g., Tanaka & Farah, 1993; Tanaka et al., 2004). In this method, participants see a target face which is immediately followed by the presentation of the original whole face paired with a whole novel face (as a measure of CH processing) or an isolated facial feature from the original face paired with an isolated facial feature from a novel face (as a measure of FP processing: see Figure 2 for an example). Tanaka and colleagues (2004) found that Caucasian-White participants were better at recognising own-race whole faces than other-race whole faces (demonstrating CH processing for the recognition of Caucasian-White faces) while the opposite pattern was found with respect to face parts; Caucasian-White participants were better at recognising other-race than own-race face parts (demonstrating FP processing for the recognition of other-race Asian faces).

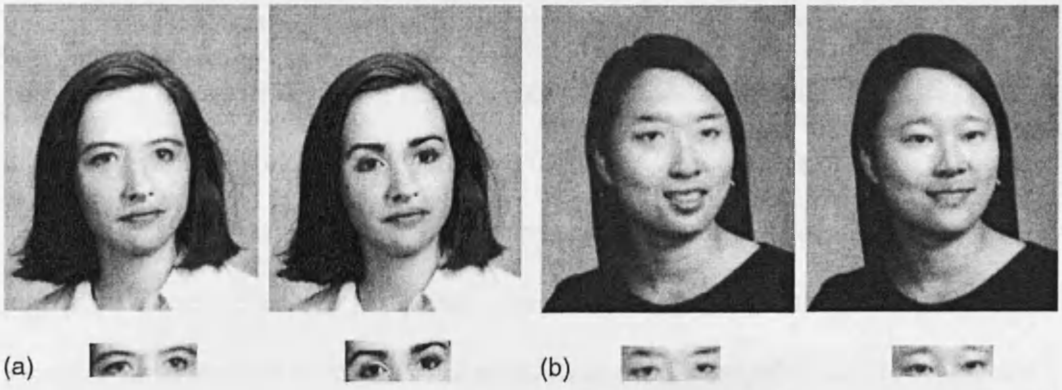

Figure 2. **Extracted from Tanaka et al (2004) sample of Caucasian (a) and Asian (b) target and foil stimuli shown in the whole face and the isolated part test conditions.**

Overall, these methodologies show that CH processing for other-race faces is not as finely tuned as CH processing for own-race faces. Given the critical role of CH processing for face expertise, this differential encoding pattern may account for one's difficulty at recognising individual other-race faces.

3.1.2 The multidimensional representation face-space account. An alternative variation of the perceptual expertise model in explaining the ORE is Valentine's (1991) multidimensional representation face-space (MDS) model. Rather than explaining the ORE as a result of differential processing, Valentine (1991) claims that faces are encoded as dimensions within the multi-dimensional face space, and that each individual's face-space is derived from their unique perceptual experience. Valentine (1991, 2001) and Valentine and Endo (1992) advocate that any useful feature that aids discrimination between faces can be considered a "dimension".

In Valentine's (1991, 2001) MDS account, he proposed two differing models of face-space in his original hypothesis: (1) a norm-based, or prototype-based model, and (2) an exemplar-based model. In the norm-based model, faces are encoded by reference to an abstracted norm (also termed prototype), which lies at the centre of face-space (Valentine & Bruce, 1986). Faces that are more typical deviate less from the prototype face while highly distinctive faces deviate more from the prototype. The exemplar-based model predicts a similar arrangement, in that perceptually similar points are densely clustered around the central tendency. Unlike the prototype model, however, an abstracted norm does not exist. Rather, only specific faces (or category exemplars) are stored as single points (encoded faces) in the multidimensional space. The model assumes that the similarity between two faces is represented by the distance that separates them in multidimensional space. Therefore, face recognition errors tend to occur when encoded faces are in close proximity to one another in face-space, as in the case of the exemplar-based model, or when encoded vectors are highly similar, as in the norm-based model. Because both of these models can account for many face-space effects (e.g., distinctiveness, caricatures, adaptation), it has been difficult to determine which kind of coding is used[2].

The core assumption of this framework is that faces are stored corresponding to various dimensions representing features or more usually the interrelationships between features that allow exemplars to be maximally discriminated. Recognition of a face involves encoding the face along these dimensions and detecting the distance between the new and existing exemplars. The concept of exemplar density captures the idea that some faces will have more neighbours in the face-space than will others. Therefore, the difficulty that is experienced in recognition of a typical face is because of the increased exemplar density, which leads to greater interference effects in memory than when recognition of a distinctive face is required. Recognition of

[2] There is a great deal of debate within the literature regarding the norm-based and exemplar-based model. Resolving these issues is beyond the scope of this thesis, but remains an important empirical question for future research.

distinctive faces are thought to show fewer interference effects in memory because they are encoded further away from the central tendency in regions of the space with low exemplar density.

In terms of the other-race effect, Valentine (1991, 2001) and Valentine and Endo (1992) argue that because we tend to encounter own-race faces more than other-race faces, and because face-space is a representation of all the faces we have encountered to date, the dimensions by which faces will be encoded will be the dimensions that are appropriate for discriminating between own-race but not other-race faces. The result is that the other-race faces will be differentially encoded and densely cluster far away in the periphery of the face-space far away from the most average face in the representational space because they are drawn from a different racial population. In comparison to own-race encoded faces that are widely spread in the face-space, other-race points are geographically closer together in the face-space and are more difficult to discriminate between and therefore recognised less accurately. Further support in favour of the exemplar density explanation of the ORE came from the Caldara and Abdi (2006) simulation of Valentine's MDS model. They found that own-race faces were widely distributed and were less similar compared to other-race faces. As an example, the more experience individuals have with particular type of faces; they are therefore encoded close to the centre or prototypic average of the MDS and more widely spread while less frequently experienced faces are encoded farther from the centre and more densely clustered together (see Figure 3). Importantly, this dense clustering in the periphery of face-space leads a particular stimulus to activate multiple nearby exemplars rather than just a single exemplar (e.g., Byatt & Rhodes, 2004). As a result, when asked to indicate whether an other-race face has been seen before, many other-race face exemplars will be simultaneously activated, making it difficult to determine if a specific other-race face is, in fact, familiar or merely similar to the exemplars currently stored in the face-space. This leads to greater false alarm rates for other-race faces than own-race faces, thereby hindering recognition accuracy.

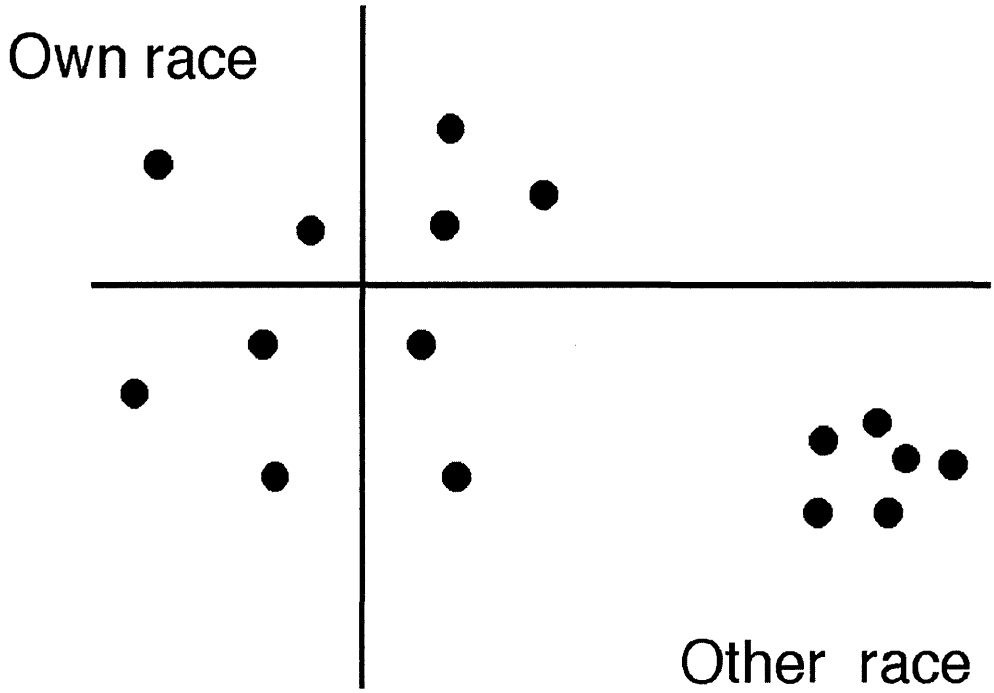

***Figure 3.* An example of the differential distribution of own-race and other-race exemplars in the hypothetical two-dimensional face-space.**

Support for the representational account of the ORE comes from studies measuring perceptual experience with own race and other-race (e.g., Chiroro & Valentine, 1995; Elliot, Wills & Goldstein, 1973; Goldstein & Chance, 1985; Hancock & Rhodes, 2008; Rhodes et al., 2009), perceptual training paradigms (Hills & Lewis, 2006; Malpass, Lavigueur, & Weldon, 1973), feature processing, and adaptation aftereffects (Jaquet, Rhodes, Hayward, 2008; Rhodes, Jeffery, Watson, Clifford, & Nakayama, 2003; Webster & MacLin, 1999). Studies addressing increased interracial contact suggest that this improves other-race recognition. For example, self-reported contact with members of another race (Hancock & Rhodes, 2008) and time spent living in a predominantly multiracial population predict the magnitude of the ORE (Cross, Cross & Daley, 1971; Rhodes, et al., 2009). The MDS account has also derived evidence from controlled laboratory perceptual training paradigms (Hills & Lewis, 2006; Malpass, Lavigueur, & Weldon, 1973). As additional exemplars (from laboratory training) are added to the face-space[3], recognition should improve and this is what was found. Accordingly, the face representation becomes modified as new exemplars are added into the face-space. Thus, both long-term developmental experience and brief, experimentally induced other-race experience were found to improve recognition.

The MDS framework is also broadly supported by literature suggesting that we may use different features for discriminating between own-race and other-race faces (e.g., Bar-Haim, Saidel, & Yovel, 2009, Davies, Ellis, & Shepherd, 1977; Ellis, Deregowski, & Shepherd, 1975; Schyns, Bonnar, & Gosselin, 2002). For instance, there is evidence that Caucasian-White participants encode own-race faces using representations of the eyes in relation to the nose and mouth (e.g., Ellis et al., 1975; Schynn et al., 2002), but other evidence suggests that nose, lips and jaw line might be the most useful for discrimination of African-Black faces (e.g., Davies et al., 19787; Ellis et al., 1975; Hills & Lewis, 2006, 2011). Thus, extraction of the kinds of information typically diagnostic for own-race faces (based on experience; Valentine & Endo, 1992) might not be the "right" kind of information to support the recognition of other-race faces and might actually be detrimental to recognition.

[3] In this thesis, I will be using face-space and face representation interchangeably to refer to the hypothetical face representation space proposed by Valentine (1991).

Studies on adaptation aftereffects indicate that adults' prototype is a malleable face "average" that is continually updated by experience. Repeated exposure to faces distorted in a similar direction (e.g., with compressed features) produces a temporary shift in the prototype, making unaltered faces appear distorted in the opposite direction while making distorted faces appear more attractive (Rhodes et al., 2003; Webster & MacLin, 1999). When this paradigm is applied to the ORE, differential adaptation effects are observed for own-race and other-race faces (race-contingent opposing aftereffects; Jaquet, Rhodes, & Hayward, 2008) suggesting evidence for independent coding. Race-contingent opposing aftereffects suggest that adults possess multiple prototypes representing specific race categories. For an opposite adaptation to occur for each race, there must be distinct average coding of the two face groups. It should be possible to adapt the norm for Chinese faces one way, simultaneously adapting the norm for Caucasian-White faces in the opposite direction. This was found in Jaquet et al's (2008) study. When participants are adapted to Caucasian-White faces with eyes manipulated to be far apart (convex distortion) and Chinese faces with eyes instead placed close together (concave distortion), opposite aftereffects are observed for each race, such that participants subsequently rate Caucasian-White faces with convex distortion and Asian faces with concave distortion appearing more normal compared to faces with non-manipulated eye distances. Importantly, this finding is consistent with the existence of separate "average" exemplars of different races stored in different areas of the face-space (as seen in Figure 3). Opposing aftereffects have been found for faces that differ according to race (Jaquet et al., 2008; Little, DeBruine, Jones, & Waitt, 2008), and this indicates that the coding mechanisms responsible for the two face categories (i.e., own-race Caucasian and other-race Chinese) are dissociable from one another.

Altogether, interracial contact, distinctiveness, perceptual training, feature processing, and opposing aftereffects showed support for the multidimensional space model that encapsulates the importance of exemplar density and the existence of multiple prototypes representing specific face categories.

3.2 Challenges for Perceptual-Expertise Theories of the ORE

While the above studies predicted the relation between level of contact and the ORE, such a relation is not always evident (e.g., Barkowitz & Brigham, 2006; Malpass & Kravitz, 1969). For example, Ng and Lindsay's (1994) cross-cultural study found no significant relationship between interracial contact and recognition accuracy. They compared face recognition ability of both White and Oriental students residing in Canada and in Singapore which consist of the majority racial population (Canada-White and Singapore-Oriental) and minority racial population (Singapore-White and Canada-Oriental). Nonetheless, participants in both studies showed a superior recognition towards recognising faces of their own-race despite being immersed in another culture. Canada-White and Singapore-White recognised White faces better than Oriental faces while Canada-Oriental and Singapore-Oriental recognised Oriental faces better than White faces. Other studies using Caucasia-White and African-Black faces have also failed to find a correlation between interracial contact and recognition accuracy (Brigham & Malpass, 1985) while some have even found the opposite relationship between other-race contact and other-race recognition (Lavrakas, Buri, & Mayzner, 1976). Meissner and Brigham's (2001) meta-analysis investigating evidence on the ORE gathered in the past thirty years found that only 2% of the variance in the ORE was accounted for by differential contact with other racial groups. The small effect may partly reflect low variance in the contact measure in many studies and the need to consider the quality (Sporer, 2001) as well as the amount of contact (where regular contact that does not require individuation of other-race people may have little effect on recognition performance).

Support for the distinction between configural versus featural processing as a basis for differential recognition of own-race and other-race faces have also been inconsistent. Specifically, the inversion paradigm (e.g., Yin, 1969), one of the most popular methods for assessing configural processing, has elicited mixed findings. Some studies found evidence for an increased inversion effect for own-race but not other-race faces (e.g., Rhodes et al., 1989), whereas some studies have failed to find this inversion by race interaction (Buckhout & Regan, 1988) and other studies have even found a larger inversion effect for other-race faces (Valentine & Bruce, 1986). In addition, the MDS framework has also been challenged. Although, this framework has proven to be a useful paradigm in explaining the ORE, it has been criticised for not indicating the actual dimensions/features responsible for how exemplars are stored in the face-space (Levin, 1996).

Despite the empirical evidence running counter to the perceptual-expertise account, the advantages of perceptual expertise explanations outweigh the disadvantages in understanding face processing. Specifically, the perceptual expertise view has been consistently used to understand numerous face processing advantages (e.g., species, race, age, gender) and its development from infancy through to adulthood (which will be discussed in the later sections) that could not entirely be explained by alternative accounts on the other-race effect.

3.3 Social-Cognitive Theories

As an alternative to the perceptual expertise theories, social-cognitive theories propose that factors beyond perceptual expertise such as social categorisation and motivational factors during encoding of own-race and other-race faces are responsible for the ORE. At the core of both classic and contemporary social-cognitive theory is the tendency for perceivers to perceive out-group members (i.e., other-race, other university) categorically while instead perceiving in-group members (i.e., own-race, same university) in a more individuated manner (Allport, 1954; Levin, 2000; Rodin, 1987; Sporer, 2001). Categorical perception involves a reliance on broad social group membership (e.g., race, gender, age), whereas individuation relies instead on processing the unique characteristics of a target[4]. In regards to the other-race effect, people may be less likely to encode other-race faces at the individual level and are more likely to classify these other-race faces as members of a broader racial group (e.g., Chinese and African-Black races). A social tendency to categorise leads to the equivalent of categorical perception – the loss or reduction in ability to discriminate between exemplars. Thus, the automatic inclination to categorise other-race faces may distract from the encoding of individuating information, and thereby lead to poorer performance when recognising other-race faces. As a result of social-cognitive influences, several models claim that different attention processes are devoted to recognition of own-race and other-race faces. In this review, three forms of the social-cognitive account will be examined: the feature selection model (Levin, 1996, 2000), cognitive disregard (Rodin, 1987), and the in-group out-group model (Sporer, 2001).

3.3.1 Feature selection. According to Levin's (1996, 2000) feature-selection or race categorisation model of the other-race effect, during encoding there are differential search patterns (cognitive) for in-group and out-group faces. He proposed

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[4] Although within the categorisation literature the term categorisation implies individuation, in this chapter the terms *categorisation* and *individuation* refer to different ways of processing faces during encoding. In particular, *categorisation* (or categorical perception) is the act of classifying exemplars into a group along shared dimensions (e.g., classifying symbols as letters), while *individuation* is the act of discriminating among exemplars of a category (e.g., discriminating among letters in alphabets).

that the contrast between other-race and own-race faces is coded as a feature-present / feature-absent relationship in which people code race specifying features in other-race faces but code own-race faces as having no such features. Having encoded only the race specifying information in other-race faces, it is proposed that individuals will have difficulty in distinguishing one other-race face from another other-race face resulting to the ORE.

Support for feature selection hypothesis mainly comes from visual search tasks that require classification of faces by race (originally introduced by Triesman & Gormican. 1988), rather than recognition tasks. Levin argues other-race features are feature positive while own-race features are feature negative in a feature present versus feature absent search of facial feature. As an example, a feature-negative target (norm face) is an own-race face, and the feature-positive stimulus is an other-race face (i.e., a norm face + other-race feature). Although a White perceiver is likely to see a Black face's skin tone, lip size, or nose size as features indicative of the face as Black (making them feature-positive targets) such features are absent in own-race White faces (making them feature-negative targets). Thus, visual search for a feature-positive target among feature-negative distractors is faster than the reverse (i.e., searching for a feature-negative target among feature-positive distractors). Levin (1996, 2000) hypothesises that having encoded only the race-specifying features of other-race faces, individuals will have real difficulty distinguishing one other-race face from another other-race face at recognition, resulting in the ORE; and that categorising an other-race face by race should be quicker than categorising an own-race face by race. Indeed, this was what Levin observed. More recently, Ge and colleagues (2009) replicated and extended Levin's findings and indicated that faster reaction times to categorise other-race faces by race predicted slower and less accurate other-race recognition. These findings suggest that categorical perceptual and individuation processes compete during encoding phase of face recognition. Other-race categorisation advantage predicts weak other-race recognition and poorer ability to discriminate among other-race faces (Susa, Meissner & de Heer, 2010).

Motivated by Levin's (1996, 2000) feature-selection model, inducing individuation of other-race members during encoding would reduce the ORE. Indeed, when perceivers were provided with an awareness of the ORE and motivating them to attend to individuating features of other-race members led to the elimination of the ORE (e.g., Hugenberg et al., 2007; Pauker et al., 2009).). For instance, Hugenberg et al. (2007) conducted a recognition test on Caucasian-White perceivers using Caucasian-White and African-Black faces after the motivational instruction:

> "Previous research has shown that people reliably show what is known as the Cross-Race Effect (CRE) when learning faces. Basically, people tend to confuse faces that belong to other races. For example, a White learner will tend to mistake one Black face for another. Now that you know this, we would like you to try especially hard hen learning faces in this task that happen to be of a different race. Do your best to try to pay close attention to what differentiates one particular face from another face of the same race, especially when that face is not of the same-race as you…
>
> Remember, pay very close attention to the faces, especially when they are of a different race than you in order to try to avoid this Cross Race Effect" (Hugenberg et al., 2007, p336-337).

They found that memory for other-race faces improved among perceivers who were motivated to individuate these out-group faces. In contrast, perceivers who were in the control condition replicated the ORE – low recognition for African-Black as compared to Caucasian-White faces. The motivational instruction increased the likelihood that other-race faces would be associated with the in-group and this motivational influence was the only measure for improved memory.

3.3.2 Cognitive disregard model. An alternative model to the socio-cognitive account of the ORE is the cognitive disregard model (Rodin, 1987). This account assumes that perceivers are hesitant to allocate processing resources to targets or stimuli that they deem irrelevant. Rather than processing individual identity of others, social category information (e.g., other-race faces, other-university, other personality) signals that the identity of the target is irrelevant and can thus be perceptually disregarded. In a recent eye-tracking experiment, Goldinger, He and Papesh (2009) found that participants gaze fewer times and gaze over fewer face regions when viewing other-race faces compared to own-race faces, and these differences are more obvious when participants are provided with longer encoding time (from 5 seconds to 10 seconds).

Additionally, the subjectively important social in-group out-group distinctions such as university and personality affiliations (e.g., Bernstein et al., 2007; Hehman et al., 2010), socioeconomic status (Shriver et al., 2008; Young, Bernstein & Hugenberg, 2010), social power, or physical power (Shriver & Hugenberg, 2010) can demonstrate a recognition advantage for in-group members and recognition disadvantage for out-group members despite holding constant prior contact, interracial experiences, and perceptual expertise. For example, Hehman and colleagues (2010) introduced group memberships (e.g., university affiliation) to reduce the ORE by describing faces of Caucasian-White and African-Black races as members of own University (in-group) or as members of a rival University (out-group). Recognition was superior for own university faces and there was no ORE. Holding experience constant, the model explains that in-group memory advantages results from perceivers being insufficiently motivated to attend to out-group faces.

3.3.3 The In-group Out-group model (IOM). Sporer's (2001) in-group/out-group model (IOM) sees face processing as essentially social. As such, social categorisation and motivation can elicit differential processing of in-group (own-race) and out-group (other-race) faces. The model suggests that on encountering a face, the perceiver firstly socially categorises the face as belonging to an in-group or out-group. Next, faces that belong to the in-group (e.g., own-race) will elicit configural/holistic processing (e.g., Diamond & Carey, 1986; Rhodes et al., 1989; Tanaka & Farah, 1993) while the same processing are not employed as effectively for out-group faces (e.g., Hancock & Rhodes, 2008; Michel et al., 2006; Rhodes et al., 2009; Tanaka et al., 2004). When presented with out-group faces, cues to out-group status (e.g., skin tone, size of facial features) initiate categorical perceptual processes before typical face-processing strategies can begin. In-group categorical perception bypasses the categorical perceptual phase when presented target conforms to in-group membership therefore elicit configural and/or holistic processing.

Instead of perceptual experience with own-race and other-race faces dictating differential processing, the IOM indicates that different motives engaged by in-group and out-group labels could dictate differential processing. For example, when racially ambiguous faces are labelled as racial in-group members, perceivers showed equivalent configural processing as unambiguous own-race faces (Corneille, Goldstone, Queller & Potter, 2006), whereas labelling the same ambiguous faces as racial out-group members disrupted configural processing.

Just as labelling can cue whether or not to individuate, characteristics of target can motivate perceivers to individuate faces. For example, when Shriver and Hugenberg (2010) presented Caucasian-White participants with Caucasian-White and African-Black targets who were paired with labels indicative of either neutral behaviours or behaviours indicating a target possesses powers (e.g., wealth or status, and aggression), it was found that powerful other-race faces were as well recognised as own-race neutral faces. These findings support the central prediction of IOM that differential categorical perception and motivation to individuate of in-group and out-group faces acts as predictors of how faces are processed.

3.4 Challenges for Social-Cognitive Accounts

Still, the socio-cognitive model has failed to explain some evidence in the literature. One prediction of the socio-cognitive perspective is that the ORE reflects spontaneous coding of race-specifying information in other-race faces at the expense of individuating information (feature selection hypothesis; Levin, 1996, 2000). Notably, recent evidences indicate that manipulations intended to increase accessibility of race-specifying information in own-race faces (Rhodes, Locke, Ewing, & Evangelista, 2009) had no influence on either discrimination or memory, contrary to the race feature-selection hypothesis. Rhodes and colleagues (2009) reasoned that if the feature selection hypothesis was operating, then requiring participants to code race-specifying information for own-race faces should reduce or eliminate the ORE. Instead, they found that the ORE was either unaffected or marginally increased.

Other researchers challenged the direct connection between racial categorisation accessibility and subsequent performance on memory task in Levin's feature-selection hypothesis. According to this hypothesis, racial categorisation of other-race faces should be better than racial categorisation of own-race faces. Specifically, in one of his studies, Levin (1996) finds a racial categorisation advantage for African-Black faces in Black participants living in a majority-Black environment, which seems incongruous with the feature-selection account of the ORE. Based on Levin's hypothesis, these Black participants should show an advantage in categorising White faces. Instead, the opposite pattern of performance was found.

Alternatively, the spontaneous coding of race specifying information could also be explained by Valentine's (1991) MDS account. When faces are classified on the criterion of race, other-race faces are classified faster than own-race faces. The concept of exemplar density captures the differences in encoding style. For example, the high-density pattern for other-race faces results from the small amount of variation across dimensions that are optimal for discriminating own-race faces. The classification advantage for other-race faces could be accounted for by faster activation of nearby individuals, all leading to a small, high-density cluster compared to a larger one (for own-race faces).

In another study, Rhodes Lie, Ewing, Evangelista, & Tanaka (2010) conducted a similar study as Corneille et al's (2006) study on ambiguous face morphs. Instead of showing an effect of social groups when ambiguous faces were labelled as either own-race or other-race, Rhodes et al (2010) found no effect of discrimination or memory from labelling. Furthermore, other studies using non-race based social categorisation (i.e., university affiliation) of own-race and other-race faces did not eliminate the ORE. For example, Shriver et al (2008) presented Caucasian-White and African-Black faces on different backgrounds labelled as own-university and other-university. Instead of showing an overall effect university affiliation, only recognition of own-race faces was reliably reduced when categorised as out-group members but not the recognition of other-race faces.

Finally, a large number of studies seem to be based on research on adults from multiracial societies (e.g., North America, Australia). The generalisation of results from these studies (Bernstein et al., 2007; Hugenberg et al., 2007; Shriver et al., 2008) to perceivers living in a largely single-race population is debatable. The face representation is certainly broader in multiracial populations than in single-race populations (de Heering et al., 2010; Feinman & Entwisle, 1976; Gaither, Pauker, Johnson, 2012; Goodman et al., 2007). Consequently, the ORE is relatively small and could more easily be eliminated by training participants to individuate faces (e.g., Tanaka & Pierce, 2009) or providing them with extra motivational instructions (e.g., Hugenberg et al., 2007) than would be the case for individuals from single-race populations. Along the same lines, participants' different visual experience with other-race faces has not been controlled in any of the above-mentioned studies, except in that of Rhodes et al. (2009) who did not observe a significant interaction between encoding race specifying information and face race. Therefore, it remains plausible that perceivers with multi-racial experiences may use different face processing strategy than perceivers with single-race experiences when social factors are involved.

3.5 The Categorisation-Individuation Model

Hugenberg et al. (2010) proposed a categorisation-individuation model (CIM). This model integrates perceptual expertise, the feature-selection hypothesis, cognitive disregard, and in-group out-group model of other-race faces. Consistent with evidence that own-race faces tend to be processed more configurally than other-race faces, the core tenet of CIM is that the other-race effect derives from selective attention to identity-diagnostic information (configural information) in own-race faces but to category-diagnostic information (e.g., skin tone, size of facial features) in other-race faces (see Hugenberg et al., 2010, *p* 1170). Unlike other social-cognitive theories, the CIM incorporates the importance of perceptual experiences. Thus, suggesting the other-race effect has its roots in both perceptual experience and motivated processing.

The model proposes that selective attention to identity- versus category-diagnostic information in faces is determined by a number of factors. First, it is hypothesised that presentation of a target face leads to spontaneous category activation (i.e., upon presentation of a face, a social category is activated, such as race). In the ORE context, category activation is typically stronger for other-race faces than own-race faces (Levin, 1996, 2000). Second, perceivers' motives to individuate (or lack of such motives) also play a potent role in face memory. Category activation from before can serve as a signalling function, informing perceivers that a target is either important or irrelevant. Relevant signals direct selective attention to attend to the unique, identity diagnostic characteristics of faces. In addition, this motivation to individuate can be elicited by social categorisation, characteristics of the targets, or by motivational instructions.

Third, the CIM proposes that perceivers' prior individuating experience (e.g., perceivers' prior experience discriminating within a race of faces) plays a potent role in the ORE. However, the CIM also argues that it is not mere exposure to a category of stimuli but, rather, motivation to individuate that builds individuation experience. Specifically, it is only when a target's identity is seen as sufficiently important that perceivers attend to the identity-diagnostic characteristics of those faces. This means that even the individuation expertise typical for own-race targets will not necessarily translate into strong own-race face memory, unless the perceiver is also motivated to individuate own-race targets.

The CIM predicts that social categorisation, target characteristics, and motivational instructions can serve as signalling function cueing perceivers that a group of faces is either important and requires individuation or is instead relatively unimportant and can be processed superficially. As discussed in studies motivated by models from the social-cognitive account, these factors have successfully reduce the ORE showing an overall effect of motivation to individuate other-race faces. However, not all these manipulations successfully create or eliminate the ORE (Rhodes et al., 2010). Instead, some studies showed the same motivational effect but only for own-race faces and not for other-race faces (e.g., Shriver et al., 2008).

Even though it is clear that social categorisation, characteristics of targets, and individuation instruction did not provide additional perceptual experience in discriminating between the other-race faces, it is likely that these social cues interact with pre-existing individuating experiences thus showing conflicting findings. The studies supporting the social-cognitive account did not directly investigate this. However, more recently, the interaction between perceiver expertise and motivation to individuate was explored. Young and Hugenberg (2011) demonstrated that motivation elicited by motivational instruction to individuate other-race faces translated into superior other-race recognition only when perceivers have relatively extensive experience individuating or recognising other-race faces. In another study, they also found that with a sufficiently high level of motivation elicited by characteristics of target (using angry faces), even those with lack of other-race experience can be motivated to individuate other-race faces. In line with the CIM, they propose that different levels of motivation together with different levels of other-race experience will facilitate different recognition performance.

The aforementioned conclusion could explain the finding that showed motivational effects for own-race face but not for other-race faces (e.g., Shriver et al., 2008). In Shriver et al's (2008) investigation, they investigated recognition effects of own-race and other-race faces using both university affiliation and social class as indicators of in-group out-group status. They failed to find evidence that in-group specifying information enhanced other-race recognition. This finding highlights the importance of perceivers' prior individuating experience and the effectiveness of motivation to individuate. Because of de facto segregation (single-race population), most perceivers have significantly more individuation experience with own-race than other-race faces, and have developed processing strategies that lead to efficient extraction of identity-specifying information from own-race faces. Thus, in the Shriver et al studies, participants may have attempted to shift their attention to identity-diagnostic information for in-group categorised other-race faces but, due to lack of perceptual experience, were unsuccessful.

Although Young and Hugenberg's study was the first study to directly investigate and find a link between experience and motivation, it was difficult to tell whether the effect is a consequence of motivation and perceptual experience, motivation only or perceptual experience only. This is because the majority of their participants with high-level other-race experience were in the experimental (motivational instruction) condition and very few were in the control (no motivational instruction) condition. This design weakness may have introduced a confounding factor that explains the result.

3.6 Overview of Theoretical Frameworks for Understanding the ORE in Adults

Although both perceptual expertise and socio-cognitive frameworks have provided inconsistent evidence throughout, it is clear that these two accounts need to be used as an integrated whole in explaining the other-race effect. Firstly, from the review above there is the clear need for perceptual expertise account to take into consideration the quantity of experience with other-race faces and also the quality of experiences (that includes social factors) to understand the ORE. Secondly, the conflicting finding in social-cognitive account could be attributed to the lack of control of perceivers' other-race experiences. While some found a main effect of social categorisation for own-race and other-race faces (e.g., Corneille et al., 2006; Pauker et al., 2009), others found an effect of social categorisation for own-race faces only (e.g., Bernstein et al., 2007; Shriver et al., 2008). As mentioned earlier, it is possible that this is due to testing different population groups. Perceivers from a multiracial population are likely to have a broadly tuned face representation and are therefore more susceptible to social-cognitive influences than perceivers from a single-race population that is likely to have a specifically tuned face representation and less susceptible to social-cognitive influences.

On the whole, there are several perceptual expertise encoding processes that can be brought to bear on faces. Why these are brought to bear on individual faces is determined by a host of factors such as familiarity, race, and gender. In line with the categorisation-individuation model, social manipulations provide the motivations for determining which existing encoding schemes will be used. So, encoding is modified by social factors. Thus, these social factor accounts do not compete with the encoding model accounts but modify encoding between featural and configural processing. The next section will provide a review and comparison of the current frameworks with respect to the development of the ORE in infancy.

4 Theoretical Frameworks in Understanding the Development of the Other-Race Effect in Infancy

Studies over the past decades have investigated the origins of face expertise in infancy. Preferential looking techniques such as the novelty-preference method, which capitalises on infants' preference for novelty after either a familiarisation or habituation period, have been successfully used in understanding face recognition of newborns (Kelly, Quinn, Slater, Lee, Gibson, Smith, Ge & Pascalis, 2005; Pascalis et al., 1995; Pascalis & de Schonen, 1994; Slater, Von Der Schulenburg, Brown, Badenoch, Butterworth, Parsons & Samuels, 1998; Slater, Bremner, Johnson, Sherwood, Hayes & Brown, 2000) and even monkeys (e.g., Pascalis & Bachevalier, 1998; Wright & Roberts, 1996).

Although the previous sections have primarily discussed the ORE, this effect is still relatively new within the infant literature. Thus, this section will also incorporate discussions of other face processing advantages (e.g., own-species, female faces), which could lead to an overall account that could also explain the ORE development. This section will begin with the ontogeny of face processing followed by a review of some theoretical frameworks for explaining the ORE in infancy.

4.1 The Nature versus Nurture Debate in Face Processing

The ontogeny of face processing abilities is still a matter of active debate. Some have argued that ability honed through initial ability with faces stems from an innate neural module (e.g., de Schonen & Mathivet, 1989; Farah, Rabinowitz, Quinn, & Liu, 2000; Johnson & Morton, 1991) and others argue that face processing abilities and the underlying neural specialisation are acquired through experience (e.g., Gauthier & Nelson, 2001; Le Grand, Mondloch, Maurer, & Brent 2001, 2003).

Early work suggests that humans are born with a predisposition to attend to faces. Despite their lack of experience with faces, newborns prefer a face-like schematic stimulus more than a bull's-eye pattern (Fantz 1963), and will visually track a face-like stimulus more than a stimulus with the features scrambled or inverted (Goren, Sarty, & Wu, 1975; Johnson, Dziurawiec, Ellis, & Morton, 1991). Although this early preference for faces is not debated, the mechanisms responsible for this preference are in question.

One view is that newborn preference for faces stems from an innate subcortical mechanism (CONSPEC: Johnson & Morton, 1991). CONSPEC leads infants to attend preferentially to face-like stimuli (even two blobs over a single blob). After the second month of life, CONSPEC is replaced by CONLERN, an experientially based mechanism that involves a diffuse network of cortical areas and allows for continued cortical specialization and tuning of conspecifics (Johnson & Morton 1991). An alternative view is that newborn preference for faces over non-face stimuli can be attributed to certain properties of faces that are not face specific. For example, newborns prefer stimuli with more elements in the upper relative to the lower half of a stimulus (Simion, Macchi Cassia, Turati, & Valenza, 2001). These researchers suggest that a preference can be found for any stimulus regardless of whether or not the configuration of those elements is consistent with the first-order relations of facial features (Macchi Cassia, Turati & Simion, 2004; Simion, Valenza, Macchi Cassia, Turati & Umilta, 2002; Turati, Simion, Milani & Umilta, 2002). Although these differing views are important for understanding the origins of face processing, it has proven difficult to determine whether newborns prefer faces and stimuli with more elements in the upper half or whether if this general preference may stem from a face preference because any figure that is top heavy is more face-like.

In contrast to the argument for an innate predisposition to attend to faces, Morton and Johnson's notion of CONLERN has been more readily accepted by studies showing how perceptual experiences influence face processing. Infants are born with the ability to process any type of face, prefer face-like stimuli than non face-like stimuli (Johnson & Morton, 1991), imitate others' facial movements (Meltzoff & Moore, 1977), prefer familiar over unfamiliar faces (Bushnell, Sai & Mullin, 1989; Pascalis et al., 1995), and prefer attractive over unattractive faces (Slater et al., 2000). Despite newborns ability to process faces, several studies have focused on understanding how early perceptual experience influences face processing during the first year of life. Research in this area has revealed several preferences and discrimination advantages arising within the first year of life. This includes preference for own species (DiGiorgio, Leo, Pascalis & Simion, 2012; Heron-Delaney et al., 2011), own-race (Bar-Haim et al., 2006; Kelly et al., 2005, 2007a), as well as preference for female relative to male faces in infants whose primary caregiver is female (Quinn, Yahr, Kuhn, Slater & Pascalis, 2002; Quinn, Uttley, Lee, Gibson, Smith, Slater & Pascalis, 2008). In addition discrimination advantages such as for own-species (Pascalis, de Haan, & Nelson, 2002; Pascalis et al., 2005; Sugita 2008), and own-race faces (Hayden, Bhatt, Joseph & Tanaka, 2007; Kelly et al., 2007b, 2009; Sangrigoli & de Schonen, 2004b) have been found. These perceptual advantages are not surprising given a recent report suggesting that the majority of infants' time is spent interacting with own-race females (Rennels & Davis, 2008) and this underscores the importance of early experience with faces to the development of face processing advantages.

4.2 Perceptual Narrowing

Infants enter the world with broad abilities or fairly undifferentiated representation spaces for processing faces, languages, and music (Scott, Pascalis, & Nelson, 2007). Then, as visual input becomes more finely tuned to the visual environment that is more prevalent in the infant's life, the perceptual system narrows (or tunes) to develop expert discrimination on familiar visual information. This developmental process, namely *perceptual narrowing,* is thought to shape expertise for faces. Initially infants are able to identify and differentiate different species and races. The ability to discriminate faces of another species or race appear to decline from 6 months to 9 months of age (Kelly et al., 2007; Pascalis, de Haan, & Nelson, 2002; Pascalis et al., 2005; Scott & Monesson, 2009). For example, 6-month-old infants could discriminate between two monkey faces and between two human faces, whereas 9-month-old infants are better at discriminating between two human faces than two monkey faces (Pascalis et al., 2002). The perceptual narrowing in face perception at the broader species level has also been found within species, that is, in relation to different human races.

Although the ORE is not present at birth (Kelly et al., 2005), many studies have shown that infants appear to develop a preference and discrimination advantage for own-race versus other-race faces that is complete by the end of the first year of life (Anzures, Quinn, Pascalis, Slater, & Lee, 2010; Ferguson, Kulkofsky, Cashon, & Casasola, 2009; Hayden, Bhatt, Zieber, & Kangas, 2009; Kelly et al., 2007b, 2009; Liu, Quinn, Wheeler, Xiao, Ge & Lee, 2010; Vogel, Monesson, & Scott, 2012). Three- and four-month-olds showed evidence of discriminating and processing holistically both own-race and other-race faces (e.g., Ferguson, Kulkofsky, Cashon, & Casasosla, 2009; Kelly et al., 2007b, 2009). Six-month-olds can still recognise faces from certain unfamiliar racial groups (i.e., other-race Chinese) in addition to their own-race (i.e., Caucasian-White) but fail to do so with faces from other racial groups (i.e., other-race African-Black, Middle Eastern) (Kelly et al., 2007b, 2009). And by 8 and 9 months of age, infants show a robust recognition advantage and holistic processing of own-race faces, but not other-race faces (Ferguson et al., 2009; Kelly et al., 2007b, 2009). This specialization is found to persist into childhood and adulthood with continuous single-race exposure (Goodman et al., 2007; Pezdek, Blandon-Gitlin, & Moore, 2003).

The perceptual narrowing phenomenon adheres to the same principle as in the language domain in which younger infants are able to discriminate almost all phonemes in any language in the world but later become particularly sensitive to phonemes of the language to which they have the most exposure to in their environment (Werker & Tees, 1999). For example, English contains a contrast between /r/ and /l/, whereas Japanese does not. English does not, however, contain a distinction between the retroflex /D/ and the dental /d/ that is common in Japanese. Numerous studies have demonstrated that adults are unable to differentiate between contrasts such as these which fall outside their native language, but infants are able to make discriminations despite having never heard such sounds (e.g., Aslin, Pisoni, Hennessy, & Perey, 1981; also see Werker & Tees, 2005).

As a result of the perceptual narrowing evidence, there is an extensive body of work pointing to the development and refinement of face preferences and recognition advantages (e.g., species, race, gender) within the first year of life (e.g., Hayden et al., 2007a; Kelly et al., 2005, 2007a, 2007b, 2009; Pascalis et al., 2002, 2005; Pascalis & Bachevalier, 1998; Sangrigoli and de Schonen, 2004b). Face preferences and recognition advantages for species, race, and gender are initially absent. Through experience within the first year of life, infants show a gradual increase of specialization towards faces that they have more experience with (i.e., own-species, own-race, and female faces). For example, it is found that 6-month-old human infants do not exhibit an own-species face recognition advantage (Pascalis et al., 2002, 2005; Scott & Monesson, 2009) despite the disproportionate (and likely exclusive) contact with and experience recognising human compared to non-human primate and non-primate faces. The own-species advantage is not found in human infants until the age of 9 months (Pascalis et al., 2002, 2005; Scott & Monesson, 2009). Consistent with the perceptual narrowing phenomenon, the developmental trajectory of the emergence of own-species recognition advantage is directly related to experience individuating faces (Sugita, 2008; Scott & Monesson, 2009, 2010). Similarly, increased specialization according to perceptual narrowing is found in relation to gender of faces. At birth, infants do not exhibit a preference for female or male faces (Quinn et al., 2008). Nevertheless, Quinn and colleagues (2002) reported a spontaneous preference and recognition for adult female, own-race faces in 3- to 4-month-old infants who had female adult primary caregivers. In contrast, infants who had male adult primary caregivers tended to show a spontaneous preference for adult male faces.

Although the face processing system becomes tuned to own-race faces very early in life, it still retains flexibility to process other-race faces, given sufficient training or exposure (e.g., Anzures, et al., 2010, Anzures et al., 2012; de Heering et al., 2010; Sangrigoli & de Schonen, 2004b; Sangrigoli et al., 2005). For example, the ORE in young infants (3- to 6-month-olds) can be easily eliminated via brief exposure to photos (Anzures et al., 2010; Sangrigoli & de Schonen, 2004b) and videos (Anzures et al., 2012) of other-race faces. The flexibility to process other-race faces was also evident in older infants (6- to 9-month-olds) even after perceptual narrowing to own-race faces has occurred (e.g., Anzures et al., 2012; Heron-Delaney et al., 2011).

Rather than characterizing the perceptual narrowing phenomenon in face recognition as a "loss" in the ability to perceptually discriminate faces within unfamiliar groups, this phenomenon is characterised as a "specialisation" for familiar groups of faces that were learned at the individual level (e.g., Scott, Pascalis & Nelson, 2007; Scott & Monesson, 2010). Specifically, training studies such as Scott and Monesson's (2010) demonstrated increased brain activity (e.g., ERP component related to face category) response or neural specialisation after individual-level training that was otherwise not present prior to training. In their individual-level training, infants were trained with monkey faces labelled with names such as Dario, Boris, and Anice. Alternatively, infants who learned these same faces categorically (i.e., all faces were labelled "monkey") or were simply exposed to these face (i.e., faces were not labelled) did not result in increased behavioural response, suggesting that the neural mechanisms responsible for face processing are specifically dependent on early experience individuating faces.

Overall, it appears that at birth infants' visual representation of faces is broadly tuned with no pre-existing race-based visual preference or recognition advantages. However, with continued individuating experience with own-race faces and lack of experience with other-race faces during the first year of life results in a system that is finely tuned to differentiate between and recognise own-race faces.

4.3 The Multidimensional Face-Space Model Applied to Infancy

One model from the adult literature that could be used to address infants' face processing advantages is the multidimensional face-space (MDS) model (Valentine, 1991). As explained earlier in the review of the adult literature, the MDS model states that faces are encoded relative to the central tendency (or face prototype) based on distinctiveness and experience of the encoded face. This model has been used successfully to explain the attractiveness effect, and other face processing advantages (i.e., other-race effect, other-species effect, female preference)

4.3.1 Facial attractiveness effect. One of the main infant studies that provided support for the MDS model in infancy is the facial attractiveness effect. The tendency to prefer attractive faces appears to be inborn or at least developed very quickly after birth (Slater et al., 1998). Studies have shown that newborns prefer and thus look longer at attractive female adult faces relative to unattractive female adult faces (Slater et al., 1998, 2000). The attractiveness effect is frequently interpreted in terms of prototype formation and a cognitive averaging process. When several faces of the same species, gender, age, and race are computer-averaged, the resulting average or prototype is typically perceived as more attractive and less distinctive than the exemplars, and therefore, averageness has been claimed to be an important factor of attractiveness (Slater et al., 1998). It has been suggested that infants prefer attractive or prototypical faces because they are easier to classify as faces (Langlois, Roggman & Rieser-Danner, 1990). The preference for average-placed features (Cooper et al, 2006) and preference for averaged faces (Rhodes et al., 1989; Rubenstein, Kalakanis & Langlois, 1999; Valentine, Darling & Donnelly, 2004) is consistent in infant, children, and adult literature.

Recently, direct support for the early use of facial prototypes in relation to the perception of attractiveness is provided in evidence on adaptation aftereffects in adult and children literature (Anzures et al., 2009). As mentioned at the beginning in the adult literature, adaptation aftereffects indicate that the prototype is a malleable face 'average' that is continuously updated by experience. Adaptation to faces distorted in a similar direction (e.g., compressed features) produces a temporary shift in the prototype, making unaltered faces appear distorted in the opposite direction while making distorted faces appear more attractive (Rhodes et al., 2003; Webster & MacLin, 1999). Thus, this suggests that children and adults are able to incorporate facial information from newly encountered faces into their existing face prototype, and that the face prototype is also constantly updated as new faces are encountered.

Within the infant literature, the attractiveness effect is robust in that it has been replicated with faces of Caucasian female and male adults, African-American female adults and even faces of Caucasian infants (Langlois et al., 1991, Van Duuren, Kendell-Scott & Stark, 2003). This early preference for attractiveness also generalises to other types of faces, so that infants as young as 3-months prefer looking at attractive cat and tiger faces relative to unattractive cat and tiger faces (Quinn et al., 2008). Studies investigating the attractiveness effect provide evidence that the newborns are hard-wired to a general face prototype (e.g., CONSPEC) and this prototype is continuously updated according to experience with multiple exemplars. The next sub-section will introduce how the face-space develops and how it accommodates faces of different categories (own-race versus other-race faces).

4.3.2 Development of face-space in infants. The first paper that directly addressed the development of face-space in infancy within the MDS framework is by de Haan, Humphreys, and Johnson (2002). According to these authors, the face-space in infancy contains fewer entries as far fewer faces have been encountered. They also suggest that infants begin to form a face-space based on the faces they see at around 3 months of age. For example, de Haan, Johnson, Maurer, and Perrett (2001) tested 1-month-old and 3-month-old infants' abilities to recognise an individual face and an "average face" prototype following familiarisation to four individual faces. The average face prototype is the morph of the four individual faces. Although both 1- and 3-month-olds were able to recognise individual faces, only the 3-month-olds showed evidence of recognising the average face prototype. This suggests that the 3-month-olds have mentally computed the average of the four stimuli. Even when the recognition test was made easier, 1-month-olds still failed to recognise the prototype (de Haan et al., 2001). These results indicate that it is only about 3 months of age that infants start to process faces in relationship to one another and begin to form a prototype of 'face' based on the faces they see, rather than as isolated occurrences

In line with the specialisation account, perceptual narrowing for faces might similarly enhance ability to discriminate commonly experienced faces - that is, discrimination of own-species and own-race faces might be initially crude and subsequently improve concurrent with the reduced ability to discriminate other-species and other-race faces. Potentially consistent with this prediction, Humphreys and Johnson (2007) found that the physical difference between own-race faces required to produce novelty preference was smaller in 7-month-olds than in 4-month-olds. In other words, the deviation in the face input (identity regions) within the face-space appears to become smaller or more refined during development. Two continua of face morphs were created by blending together face A with face B. The proportions used were 90:10, 70:30; 50:50: 30:70, 10:90. The face stimuli were referred to in terms of the proportion of the second face in the face blend (0.1, 0.3, 0.5, 0.7, and

0.9). In the study phase, infants were habituated to the face morph at one end of the continuum (i.e., A90B10). During the test phase, the target face and faces along the same continuum were presented randomly to test for dishabituation. Within the 0.1, 0.3, 0.5, 0.7, and 0.9 face morphs, 4-month-old infants dishabituated to 0.9 face morphs but not to any other face morphs – treating the rest (0.1, 0.3, 0.5, 0.7) as identical faces. On the other hand, 7-month-old infants dishabituated both 0.9 and 0.7 face morphs while adults were able to discriminate the target face from 0.9, 0.7, and 0.5 face morphs. This study indicates that identity regions of the multidimensional face space model (or the extent to which a face can deviate before it is classed as a separate identity) may become more refined from the age of 4-months to 7-months and from 7-months to adulthood.

While studies have showed a perceptual tuning and specialisation to own-race faces, it has been suggested that these own-race faces were represented through categorisation (e.g., the formation of distinct groups, each composed of similar yet distinguishable exemplars), whereas the lack of discrimination for other-race faces suggests that they were represented through categorical perception (e.g., the formation of distinct groups composed of similar exemplars that are difficult to discriminate)[5] (Slater et al., 2010). In other words, the pattern of results implies that when recognition is tuned to own-race faces, the own-race and other-race faces are represented by different processes and hence, occupy different locations in the hypothetical face-space. In particular, the representation of own-race faces includes subordinate information about the individual identities of the faces whereas the representation of other-race faces remains at the summary, category level and does

[5] Categorisation here refers to the formation of distinguishable exemplars whereas categorisation within the categorisation-individuation model (CIM; Hugenberg et al., 2010) refers to perceivers attending or encoding category-level information.

not contain exemplar-individuating information. As seen in Kelly et al. (2007b, 2009), Hayden et al. (2007), and Sangrigoli and de Schonen (2004b), infants show evidence of tuning and refinement to recognising faces of their own-race between 3- to 9-months of age. This conclusion however, arises from investigation of infants with single-race experiences.

Infants with experience of individuals from another race as well as those from their own race do not show the same specialization to own-race faces only. Instead, they show no visual preference for faces belonging to either group (Bar-Haim et al., 2006), and no difference in discrimination ability for own-race and other-race faces at 3-month-olds (Gaither, Pauker, & Johnson, 2012). In contrast, infants with no training and with single-race experiences already showed a specialization of own-race faces by 3 months of age (Hayden et al., 2007a; Sangrigoli & de Schonen, 2004b). The impact from different types of racial experience will be discussed later on in the section on the developmental trajectory of the ORE from infancy to adulthood.

5 Processing Facial Information

Previous studies have established that the ability to process facial identity begins at birth. Several studies have shown that newborns are able to discriminate between their mothers face and a female stranger's face (Bushnell, 2001; Bushnell et al., 1989; Pascalis et al., 1995). Such recognition ability has also been replicated with female strangers' faces (Pascalis & de Schonen, 1994; Turati et al., 2006; 2008).

However, there are developmental changes in processing facial information. Although newborns have shown recognition based on internal facial features alone (Turati et al., 2006), their recognition abilities appear to be primarily driven by their recognition of outer facial features such as hair and external facial contour (Pascalis et al., 1995; Turati et al., 2006). This finding is further supported by previous studies that have found that infants at 1 month typically scan a limited part of the external contour (Hainline, 1978; Haith, Bergman & Moore 1977; Maurer and Salapatek, 1976) and, after repeated exposure to an individual face, they respond to changes in the external features but not to changes in the internal features (Turati et al., 2006). The shift from external to internal processing may be attributed to experience with faces. For example, when infants' mother's face is wearing a headscarf, newborns did not look longer at their mother's face than at a stranger's face (Bartrip, Morton & De Schonen, 2001; Pascalis et al., 1995). In contrast, a group of 35- to 40-day old infants was able to make the discrimination with mother and stranger wearing headscarves. A shift away from dependence on external facial information of unfamiliar faces is found after 5 months of age (Rose et al., 2008). For example, when recognising unfamiliar faces, it is found that 5-month-old infants rely on external features whereas 7- to 9-month-old infants can recognise those unfamiliar faces on the basis of their internal features (Rose et al., 2008). Thus, it could be suggested that the primitive facial identity is based on both internal and external facial information with the external facial information dominating initially.

Beyond the infant literature, there is evidence showing processing external versus internal facial information varies according to face familiarity. Research on adults and children demonstrated that familiar faces are recognised more accurately from internal rather than external facial information, but that unfamiliar faces are recognised equally well from both types of feature sets (Ellis et al., 1979; Want, Pascalis, Coleman & Blades, 2003; Young, Hay, McWeeny, Flude & Ellis, 1985). For example, 5- to 9-year-olds are more accurate using external than internal features in processing unfamiliar faces (Ge et al., 2008; Want et al., 2003), and relied more on internal than external features in recognition of familiar faces (Ge et al., 2008; Wilson, Blades, & Pascalis, 2007). Taken together, the studies on infants, children, and adults suggest that there is a shift in the relative importance of internal versus external facial information in face recognition and that this shift is related to the degree of familiarity or unfamiliarity of the face.

In addition to differences in processing internal and external facial information, there are some empirical evidence suggesting fundamental differences between the way young children and older children process featural and configural/holistic information. As mentioned earlier on in this chapter, one of the most robust findings in the adult literature is that inversion disproportionately impairs recognition of faces by disrupting configural/holistic information (Diamond & Carey, 1986; Yin, 1969). Despite the robustness of face inversion effect in adults, it was surprising to find that young children failed to exhibit a similar effect. In a seminal study, Carey and Diamond (1977) showed 6-, 8-, and 10-year old children upright and inverted pictures of unfamiliar faces. Immediately after seeing the photographs, they were asked to identify previously seen "old" and previously never been seen "new" faces. Carey and Diamond found that like adults, 10-year-olds' recognition of faces was disproportionately impaired by inversion whereas 6- and 8-year-olds' recognition of faces and houses were less impaired than older children. The finding that 6-year-olds performed similarly across two orientations led Carey and Diamond to hypothesise that young children (up to the age of 6 years) encode faces in a piecemeal fashion (featural processing) whereas older children switch to encode the spatial relations between individual features (configural/holistic processing). This speculation was named the "encoding switch hypothesis".

Other researchers have challenged Carey and Diamond's encoding switch claims (Flin, 1985; Tanaka & Farah, 1993). Flin argued that the recognition task used in Carey and Diamond's study may have been too demanding for 6-year-olds thus exhibiting a floor effect. Using an old/new recognition task in which inversion effects were measured as differences in *d'* between upright and inverted face, Flin found that the magnitude of *d'* differences was the same for the 6-, 8-, and 10-year-olds. Flin argued that when age-related performance differences are taken into account, there is little evidence to support the encoding switch hypothesis.

Although face inversion studies reveal performance differences between younger and older children, they provide little insight into the cognitive operations that might produce these differences. There was no operational definition of featural versus configural/holistic processing. Using a whole/part paradigm (Farah & Tanaka, 1993), the memory for face part is probed when the part is presented in isolation and in the whole face. The difference in performance between the two test conditions serves as an index of configural/holistic processing. Tanaka, Kay, Grinnel, Stansfield, and Szechter (1998) tested 6-, 8-, and 10-year-old children using the whole/part method (see *Figure 2*) to learn a set of unfamiliar faces. They were then required to recognize target facial features (eyes, mouth, nose) with features sometimes presented in the whole face and sometimes presented alone. Tanaka et al. reasoned that if children represent faces configurally/holistically, then they should recognise a facial feature better when it is embedded in the whole face than when it is presented alone. Indeed, children showed an advantage for recognizing features in whole upright faces but the whole-face advantage disappeared for inverted faces. For inverted faces, recognition performance was similar in the whole and part condition. Similar results have been found with adults (Tanaka & Farah, 1993). These studies altogether suggest that both children and adults use configural/holistic processing to recognise faces.

Studies of infants' use of facial information for face recognition have showed that infants are initially sensitive to changes in featural information prior to sensitivity to configural/holistic information. For example, newborns are able to detect changes in the shape of individual internal features to differentiate between different face-like configurations (Simion et al., 2002). In contrast, sensitivity to configural changes among facial features (distance between the eyes, and distance between nose and mouth) was evident by 3-months of age (Quinn & Tanaka, 2009), and sensitivity to configural changes within the normal range of variability emerges some time between 3 and 5 months of age (Hayden et al., 2007b). Finally, more refined holistic face processing develops between 6 and 8 months of age (Schwarzer & Zauner, 2003).

While there is a general consensus that children process facial identity as a gestalt, 7- and 10-year-olds are still slower and prone to make more errors in their identity judgments for the top portion of upright composite faces of familiar classmates and familiarized adults (Carey & Diamond, 1994). Replicating the findings of Carey and Diamond, using the composite face task (see *Figure 1*), 4-year-olds (de Heering et al., 2007), and 6-year-olds (de Heering et al., 2007; Mondloch et al., 2007) made more errors on composite faces with the same top halves than on misaligned faces. The findings regarding children's difficulty in processing facial configural information appear to contradict the findings with infant studies. The seemingly contradictory findings may result from an important distinction in face recognition. According to Lee et al (2010), the infant studies have specifically examined the ability to discriminate different facial configurations, which is a stricter perceptual indication of facial recognition. In contrast, studies on children have typically examined *identity judgments*, which is a mixture of perceptual and higher-order conceptual processs indicative of facial recognition. Thus, existing evidence points to the conclusion that the ability to discriminate facial configural/holistic information is already present at infancy but to use such ability for recognizing facial identity may take a substantial amount of time to develop.

However, there are several reasons why this should not be considered as a weaker version of the encoding switch hypothesis. Firstly, most of the existing studies comparing children's featural and configural/holistic processing abilities have not matched the task difficulty with adults. Thus children's poorer performance in configural task relative to featural task may reflect discriminability differences among the faces used in the two tasks rather than chidlren's difficulty with face configural information per se. Secondly, it is uncertain whether children's seeming difficulty with face configural information is occurring at the encoding stage. One possibility is that children may be able to encode both featural and configural information but may have difficulty in reaining the latter in long-term memory relative to the former. Both issues need to be resolved before one can ascertain the validity of the encoding switch hypothesis.

6 The Developmental Trajectory of the ORE Across Infancy to Adulthood

As indicated already, the face processing system in infants is initially undifferentiated and becomes increasingly specific during the first year of life (Anzures et al., 2010; Ferguson et al., 2009; Hayden et al., 2009; Kelly et al., 2005, 2007a, 2007b, 2009; Liu et al., 2010; Vogel et al., 2012). However, the exact onset of the ORE may be dependent on the nature of the face stimuli. For example, when 3-month-old White infants were shown faces with both internal and external features, these infants were able to discriminate between faces of all races (Caucasian-White, Chinese, Middle Eastern, and African-Black; Kelly et al., 2007b). It is only by 9 months that these infants show specialisation to their own race. In contrast, when 3-month-old Caucasian-White infants were shown faces with internal features only, they were able to discriminate between faces of their own-race only (Hayden et al., 2007a; Sangrigoli & de Schonen, 2004b). The inconsistency of onset of the ORE in infancy may or may not be due to the nature of the face stimuli. Nonetheless, it is clear that the development of the ORE in infants is related to infants' facial experiences.

Recently, new technologies such as eye-tracking have provided powerful tools to investigate how infants visually scan own- and other-race faces, and own- and other-species faces. Liu et al. (2011) reported that Chinese infants fixated significantly less on the noses of Caucasian-White faces but no changes in age were seen when scanning own-race Chinese faces. In addition, Wheeler et al. (2011) reported that with increased age, Caucasian-White 6- to 10-month-old infants fixated more on the eyes of own-race faces and lesser on the mouths of own-race faces but the amount of time spent fixating these areas of the other-race faces did not change. Species specific eye-tracking study showed that 3-month-old infants not only preferred the human face when paired together with a monkey face but that the fixations were more concentrated on the eye area of human faces. Taken together, these results reveal that infants indeed scan the internal region of experienced and less experienced face types differently.

The ORE also extends to childhood (e.g., Chance et al., 1982; Feinman & Entwisle, 1976; Goodman et al., 2007; Pezdek et al., 2003; Sangrigoli & de Schonen, 2004b), adolescent (Walker & Hewstone, 2006) and adult years (Meissner &

Brigham, 2001) where own-race recognition is typically better than other-race recognition. However, the representational space for faces tuned to faces in the perceiver's environment is not necessarily reflective to their own-race (see Scherf and Scott 2012 for a review). Interracial experiences from exposure training, and the natural environment are also found to shape the ORE. For example, laboratory exposure training studies have been successful in reducing the ORE in infant, child, and adult face recognition (Anzures et al., 2012; Elliot et al., 1973; Goldstein & Chance, 1985; Lebrecht, Pierce, Tarr, & Tanaka, 2009; Sangrigoli & de Schonen, 2004b; Tanaka & Pierce, 2009). Malpass, Lavigueur, and Weldon (1973) used a simple 1-hour visual training paradigm, whereby Caucasian-White participants were shown African-Black and Caucasian-White faces and were given feedback (training) for a four-alternative-forced-choice recognition test. Training successfully improved recognition accuracy scores.

Additionally, children raised in mixed-race environments show little or no other-race effect (Bar-Haim et al., 2006; Cross et al., 1971; de Heering et al., 2010), and in some cases a reversal of the ORE (Sangrigoli et al., 2005). For example, de Heering and colleagues (2010) studied 6- to 14-year-old Asian children who were adopted by Caucasian-White families in Europe between the ages of 2 and 26 months. While the age-matched (Asian) controls showed a clear ORE in favour of own-race faces, the adopted participants performed equally well with Caucasian-White faces and Asian faces when tested. Sangrigoli and collaborators (2005), on the other hand, tested Korean adults who were adopted by Caucasian-White families. Adopted Korean adults performed as well as Caucasian-White adults, and could identify Caucasian faces better than Asiatic ones. These adoption studies could also be interpreted according to the perceptual expertise account, social-cognitive account, and the categorisation-individuation model. According to the perceptual expertise account, lifelong experience distinguishing among a race of faces can yield sufficient experience to reduce and even reverse the ORE. On the other hand, the social-cognitive account could explain this finding. Being adopted by Caucasian-White families could also give these children extensive motivation to individuate Caucasian-White faces. As another alternative is that the adoptee's ability to better recognise Caucasian-White faces than Asian faces could be the result of a combination of external exposure to these faces and chronic motivation to individuate faces of social in-group.

Although both training studies and adoption studies provided important implications in understanding the development of the ORE, training studies do not indicate anything permanent (e.g., Hills & Lewis, 2011) while adoption studies are retrospective. The differences between perceivers with single-race experience and perceivers with multi-race experiences provide a natural comparison that has been neglected. Earlier on in this chapter, the author noted the importance of differentiating between perceivers with single-race experience from perceivers with multi-race experiences, as the latter type may have a face representation that is broadly tuned.

Infants with experience of individuals from another race as well as those from their own race do not show the similar specialization to own-race faces only. Instead, 3-month-olds showed no visual preference for faces belonging to either group (Bar-Haim et al., 2006), and no difference in discrimination ability for own-race and other-race faces (Gaither, Pauker, & Johnson, 2012). In contrast, infants with single-race experiences already showed a gradual specialization of own-race faces by 3-months of age (Hayden et al., 2007a; Sangrigoli & de Schonen, 2004b). Like infant studies of the ORE, evidence on American-White and American-Black children from socially integrated schools and neighbourhoods showed a smaller ORE and weaker own-race recognition than those children from segregated schools and neighbourhoods (Cross et al., 1971). The lack of own-race recognition advantage at 3-months of age (Gaither et al., 2012) and weaker own-race recognition (Cross et al., 1971) in children with multi-racial experiences indicates the importance of conducting population comparisons to understand how the ORE develops naturally in perceivers with single-race versus multi-race exposure.

So far, much of the work characterising the developmental trajectory of the other-race effect appears to be fairly consistent with the expertise account. The race bias is flexible at all ages tested, but this flexibility hinges on intensive experience individuating faces from less familiar race. Although the social-cognitive account finds support in adult literature as an explanation of the other-race effect, it is difficult to use the same account to explain empirical evidence found in infants and children. The social-cognitive account largely assumes that individuals categorise a face according to race and/or in-group out-group categorisation. However, evidence to date does not suggest that infants discriminate faces on the basis of race and/or in-group out-group categorisation. Between the ages of 10-months and 2-years of age, infants readily accept and share toys equally with own-race and other-race individuals (Kinzler & Spelke, 2011). There is no race bias in choosing friends between the ages of 3 and 4 years (Abel & Sahinkaya, 1962). However, there is a tendency for 3-year-olds to show a positive attitude to own-race and own-gender targets (e.g., Aboud, 1988) and by 5 years of age, children tend to choose their own-race as playmates or friends (Abel & Sahinkaya, 1962; Kinzler & Spelke, 2011). More generalised in-group favouritism on other dimensions seems to emerge later in childhood (between 6- and 10-years; Baron & Banaji, 2006). As 5- to 6-year-olds begin to develop in-group favouritism to faces of their own-race, they still tend to prefer other-race individuals that speak with the same native accent than other-race individuals that do not speak with the same native accent (Kinzler, Shutts, DeJesus, Spelke, 2009; Kinzler & Spelke, 2011). Therefore, it is likely that face race is only one of several factors used in children's evaluation of in-group/out-group membership. And to explain the development of the other-race effect in infants and children according to the social-cognitive account and categorisation-individuation model may not be as convincing as doing so through the perceptual expertise account. Such processes are not engaged much during infancy and may be beyond the infants' ability.

7 Summary and Conclusions

The other-race effect is one of the most replicable phenomena in face perception. The review above has demonstrated that the ORE could be explained by the perceptual expertise account, the social-cognitive account, or the categorisation-individuation model. However, the development of the ORE from infancy to adulthood is found to be continuously shaped according to experience with own- and other-race individuals even after perceptual narrowing has occurred. Minimal subsequent exposure from training and the naturalistic environment can remove the disadvantages in other-race face recognition. Furthermore, it is possible that perceivers with multi-race exposure have a more broadly tuned face representation than perceivers with single-race exposure thereby showing inconsistencies in the social-cognitive perspective and the categorisation-individuation model. Finally, these two social perspectives are yet to be tested on children. The difficulty in doing so may reflect cognitive demands involved in forming in-group/out-group categories that are more conceptually based than earlier perceptually based race categories. Therefore further investigation on different populations and younger age group is necessary to fill the gaps in the literature.

CHAPTER TWO

RATIONALE OF THE THESIS

This thesis aims to find empirical evidence for the role of different face experience on the development of the ORE in infants, children, and adults when all factors are equal and when non-race based social categorisation is involved. This is achieved by comparing face recognition of perceivers from a single-race population (Homogeneous) and a multi-race population (Heterogeneous) through standardised face stimuli and age-appropriate face perception tasks.

1 Overall Rationale

In chapter 1, the review of the ORE and its development indicated the importance of the perceptual expertise view and, in particular, the role of the MDS face-space model of face processing (Valentine, 1991). On the other hand, others have proposed social-cognitive factors in understanding the ORE. Instead of explaining these accounts as alternatives to one another, the current thesis is open to the possibility that the two approaches interact. Whether one or more models are required to explain the ORE and its development, there is considerable potential to clarify the contribution of different models by carrying out a development investigation of the ORE in both single-race (homogeneous) and multi-race (heterogeneous) cultures when all factors are equal (motivation/attention) and when social/motivational factor is present.

Even though the perceptual expertise view could explain the developmental trajectory of the ORE, this account gained support from studying individuals with homogeneous experiences (i.e., the UK, Africa, and China; Chance et al., 1982; Kelly et al., 2007b, 2009; Michel et al., 2006; Rhodes, Brake, Taylor, & Tan, 1989; Tanaka, Kiefer, & Bukach, 2004) where exposure is predominantly to the majority race. Very few studies investigated individuals with multi-racial heterogeneous experiences.

Approaches such as laboratory training to increase exposure to other-race faces (e.g., Lebrecht et al., 2009; Malpass et al., 1973; Tanaka & Pierce, 2009) and adoption studies (de Heering et al., 2010; Sangrigoli et al., 2005) have shown support for the flexibility of the ORE with increased other-race experiences. However, the effects from training studies are found to be short-lived (e.g., Hills & Lewis, 2011; Lavrakas, Buri, & Mayznen, 1976). Furthermore, although adoption studies provide a good indication of how experience can improve other-race recognition (de Heering et al., 2010) and in some case, even reverse the other-race recognition (Sangrigoli et al., 2005), these studies are retrospective and suggest that it takes at least 4 years for children's face-space to tune according to faces experienced most frequently in their environment and about 20 years to completely reverse the effect.

In contrast, the social-cognitive view has gained support from studying populations that are likely to have heterogeneous racial experiences. By predominantly testing this population, it is possible that the ORE could be more easily eliminated with social/motivational factors than when studying populations with homogeneous racial experiences. The categorisation-individuation model provided support for this notion and showed differing effects from studying perceivers with single-race and multi-race exposure. Different levels of motivation to individuate were differentially found for recognition of own-race and other-race faces in perceivers with homogeneous and heterogeneous experiences (Young & Hugenberg, 2011). The motivation to individuate using motivational instruction was found to reduce the ORE in perceivers with heterogeneous experiences. On the other hand, the

ORE was not reduced in perceivers with homogeneous experience using the same motivational instruction. Instead, a reduction of ORE was found when perceivers were provided with a stronger motivation to individuate (i.e., angry faces). Although only one study motivated by the CIM has successfully integrated the perceptual expertise and social-cognition accounts, the CIM is arguably more fully integrative account for the ORE. However, having the advantage of being advanced most recently, it is yet to gain support from developmental studies of the other-race effect.

Therefore, instead of increasing other-race exposure through laboratory training, making retrospective assumptions to explain the flexibility of the ORE, this thesis will compare ORE of infants, children, and adults between homogeneous and heterogeneous populations to understand the effect of racial experiences on the development of the ORE. Rather than selecting one specific explanation in understanding the ORE, the author is open-minded about which theory will be best supported by her data.

2 Populations Used in this Thesis

The country selected for the homogeneous population was the UK with participants from North-West England and Wales (population estimate: 89% - 93% Caucasian-Whites and 7% - 11% other minority groups; Office for National Statistics, 2011). On the other hand, the country selected for heterogeneous population is Malaysia with participants from Kuala Lumpur (population estimate: 45.2% Malays, 42.3% Chinese, and 11% Indians; Department of Statistics Malaysia, 2008). Malaysia is considered as heterogeneous not just in terms of the three main races, but also in the way that it provides an environment that could potentially reduce or even eliminate the ORE because of the frequent social interaction between races at different ages of development.

As a whole, a heterogeneous population like Malaysia provides a unique way of studying effects of social interaction and mere exposure. The target participants from this population would be of Chinese ethnicity because (1) the household provides an interesting aspect to the role of experience in infants by having a live-in female Malay house helper from birth; and (2) it is one of the main races of the heterogeneous population group. To measure the differences that occur for other-race recognition, an inter-racial contact questionnaire will be provide. These cross-cultural comparisons will be made in Experiments 3 to 6. Finally, the face races used in this thesis will be Chinese, Malay, Caucasian-White, and African-Black faces.

3 Aims and General Hypotheses

In light of the reviewed literature, this thesis begins with the assumption, central to the perceptual expertise view, that the other-race effect derives from limited perceptual experience of other-race relative to own-race faces, resulting in limited ability to individuate the former. The overarching aim is thus to investigate this phenomenon in a multi-racial population and also to make comparisons with a homogeneous population across infancy to adulthood. This overarching aim includes three more specific aims.

3.1 Reinvestigation of the Development of ORE in Infancy

Chapter 3 reports three experiments aimed to test whether and how experience modulates the ORE within infancy (4-month-olds and 9-month-olds). As yet, there have been no direct comparison of ORE between female and male faces within the infant literature. In line with previous studies showing an onset of the ORE for female faces at 3-months, it is hypothesised that there will be a face race by face gender interaction in the younger age group. Female own-race faces will be discriminated better than male own-race faces and other-race faces. In addition, in line with the experiential hypothesis, infants born and raised in a heterogeneous environment will show the same female own-race recognition advantage and an additional female other-experienced-race recognition advantage. An interesting possibility in explaining the result may be related to infant-caregiver relationship. At the same time, another experiment is designed to test if face gender preference interacts with the ORE in 4- and 9-month-olds.

3.2 Investigating of the Role Experience on the ORE

In Chapter 4, one experiment was designed to examine the role of inter-racial experiences on the ORE of school-aged children and adolescence. The cross-cultural comparison between children from heterogeneous and homogeneous populations provides important information of how experiences from infancy become tuned to recognition according to experiences in 5- to 6-year-olds and 13- to 14-year-olds.

3.3 Exploring the Integrative Categorisation-Individuation Model.

Two experiments in Chapter 5 are designed to (1) test whether and how social category membership influences the ORE when perceivers have one or more racial experiences, and (2) extend the CIM explanation of the ORE in children and adolescents. According to the perceptual expertise model, it is hypothesised that regardless of the motivation to individuate other-race faces, recognition is better for more experienced faces relative to less experienced faces. In contrast, according to the categorisation-individuation model, motivation to individuate non-race based in-group faces is only seen for experienced face races. This research strategy should allow evaluation of the perceptual expertise model against the CIM.

4 General Methodological Approaches

The literature review notes that differences between studies in the onset of the ORE within infants and children probably relate to methodological differences (i.e., the form of the stimuli and task design). In this thesis, face processing of a combination of Chinese, Malay, Caucasian-White, and African-Black faces was used to investigate the ORE in infants (Experiments 1-3), children (Experiments 4 and 6) and adults (Experiment 5) from the UK and Malaysia. Faces were standardized accordingly, and the tasks were designed to be as close to standard as possible, with variations to take account of the wide age range of participants.

4.1 Stimuli

Some studies using faces without an external contour have found an onset of ORE at 3-months (Hayden et al., 2007a; Sangrigoli & de Schonen, 2004b) while studies using faces with an external contour have found an onset of ORE at 9-months (Kelly et al., 2007b; 2009). It has been suggested that stimuli including external facial information could be beneficial for young infants who tend to fixate more on external facial features than on internal facial information (Liu et al., 2010; Rose et al., 2008) whereas a shift away from dependence on external facial information is found from 7 months of age (Rose et al., 2008). However, the specific age of shift may be attributed to experience with faces. As an example, when infants' mother's face is wearing a headscarf, newborns did not look longer at their mother's face than at a stranger's face (Pascalis et al. 1995). In contrast, a group of 1-month old infants were able to make the discrimination with mother and stranger wearing headscarves. It is possible that the headscarf makes the face harder to recognise for newborns but with about 1-month of experience, infants can recognise faces based on their internal features.

In order to ensure that recognition is not due to reliance of external facial information (e.g., Maurer, 1983), a batch of faces (with dark hair) was created by using the same oval shape to retain internal facial information and remove external hairline information. These faces with reduced external information were superimposed on a black background (see Figure 4) so that the remaining hair information would blend into the background. Therefore, these faces with limited external information should allow face recognition to be assessed in relation to infants' experiences with faces and without any biases in attending to external information when processing faces. Instead, processing of internal facial information is experienced.

In additional to reducing emphasis on external facial information, the stimuli used in this thesis also incorporated faces in two orientations: full-frontal and ¾ profile views. This made it possible to vary between familiarisation and testing. For example, in the frontal-profile condition, perceivers previously familiarised with full-frontal faces were tested on the same faces that is of a ¾ profile view intermixed with novel faces that is also of the ¾ profile view and vice versa for the profile-frontal condition. These static presentations of faces in ¾ profile view are known to be easily recognisable for infants (Turati, Bulf, & Simion, 2008), and adults (Logie, Baddeley, & Wood- head, 1987; O'Toole, Edelman, & Bulthoff, 1998; Patterson & Baddeley, 1977; Valentine, Abdi, & Edelman, 1997). The varied face view between familiarisation and testing is preferred to using identical pictures because it ensures that face recognition – as opposed to picture recognition (i.e., image matching) – is tested (Bruce, Henderson, Greenwood, Hancock, Burton & Miller, 1999; Bruce &

Young, 1986). All experiments investigating face discrimination (Experiments 1, 3, 4, 5, and 6) used this change in pose, while the experiment on gender preference (Experiment 2) incorporated full-frontal faces only.

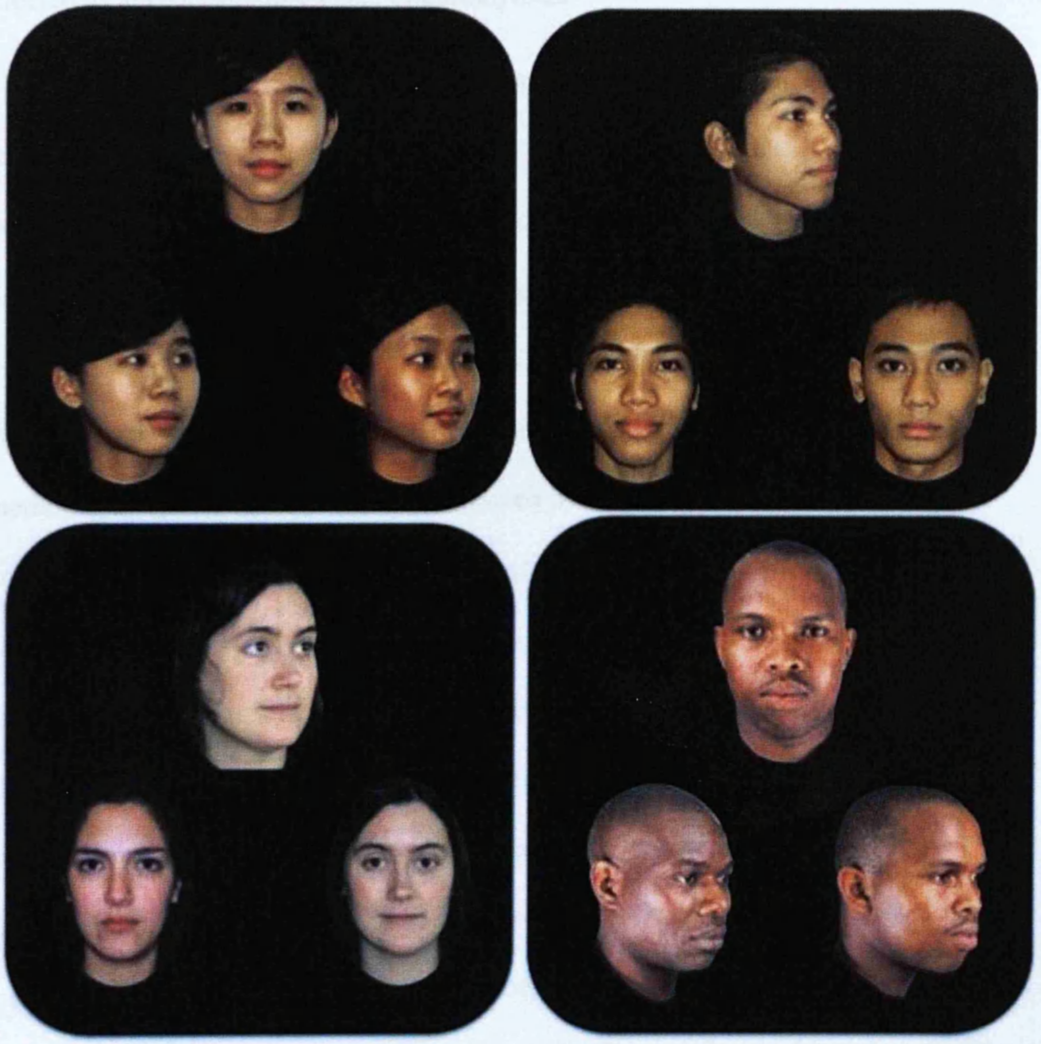

Figure 4. **Sample stimuli of full-frontal and ¾ profile views of Chinese, Malay, Caucasian-White and African-Black.**

4.2 Tasks Design

Designing one task that is suitable to measure infants', children's, and adults' discrimination of faces is difficult, if not impossible. Infants' ORE is typically measured by visual attention paradigms (such as, habituation-recovery, spontaneous preference, or novelty preference) whereas children's and adults' ORE is typically measured using recognition paradigms (such as old/new recognition method and the two alternative forced-choice method). Therefore, in this thesis, these paradigms were selected as appropriate to the age of participants.

There are three methods used to study infants' discrimination of and preference for faces (Fantz, 1963; Hayden et al., 2007a; Kelly et al., 2007b, 2009; Sangrigoli & de Schonen, 2004b). Habituation is the decrease in a behavioural response (such as looking) after repeated exposure to that stimulus over a period of time. The decrease in looking or orienting is generally thought to reflect a developing memory representation of the habituated stimulus. In the *habituation-recovery* method (Fantz, 1964), habituation is followed by a test presenting a novel stimulus and looking time is recorded. An increase in infants' looking time to the novel stimulus (called "visual recovery") indicates discrimination between the novel and the familiarized stimulus. The second method, the *spontaneous preference paradigm* (Fantz, 1963) is most commonly used to determine visual preferences for one stimulus over another (see Rose, Feldman, & Jankowski, 2004 for a review). For example, this procedure has been used to investigate infants' preferences for their mothers' face over that of an unfamiliar woman's face (Bushnell, 2001; Field, Cohen, Garcia & Greenberg, 1984; Pascalis et al., 1995). The *novelty-preference procedure* is used to investigate infants' discrimination of stimuli. This procedure, an extension of the habituation-recovery method, is similar to the habituation paradigm in that it relies on infants' preferences for novel stimulus following habituation. Following habituation, infants are tested with the familiar stimulus side-by-side with a novel stimulus. The rationale is that if infants can differentiate one face from the other, they should look longer at the novel face (novelty-preference) when paired with the previously habituated face. On the other hand, if infants cannot differentiate the paired faces, they should look equally (no preference) at both the novel and familiar faces.

Overall, one method measures spontaneous preference, and although preference implies discrimination, the other two methods (habituation-recovery, novelty preference) explicitly measure recognition memory for learned faces. The novelty-preference measure is generally thought to be a more sensitive measure for face perception. Thus, the current study used the novelty preference procedure to assess the developmental course of the ORE (Experiments 1 and 3) and the spontaneous preference method as an indicator of infants' gender preference (Experiment 2), across two age groups (4- and 9-month-olds)

The ORE in children and adults has been extensively investigated utilising various methods. Two main tasks used to investigate face recognition abilities are the two-alternative forced-choice paradigm (2AFC; Carey & Diamond, 1977) and the old/new recognition paradigm (Barkowitz & Brigham, 1982; Shepherd, Deregowski, & Ellis, 1974). The difference between these tasks is that the 2AFC task requires participants to identify the face that they have seen before in a varied display (of two), while the old/new recognition paradigm requires an "old" or "new" response depending on whether the participant recalls seeing the individually presented face before. Another difference in both tasks is that the 2AFC task is less cognitively demanding. In the 2AFC task, participants could choose the familiar face that is paired with a novel face whereas the old/new recognition paradigm requires participants to identify the familiar face from a mixture of familiar and novel faces that are presented individually. For children especially, if the task is too demanding, this may result in children responding but without fully understanding the task

(Chance et al., 1982; Goodman et al., 2007). Still, both tasks have showed evidence of the ORE across children as young as 4-years (e.g., de Heering Hothuys, Rossion, 2007; Goodman et al., 2007; Pellicano & Rhodes, 2003).

The old/new recognition and the 2AFC methods were used in the investigation of ORE in children and adults. To investigate the role of experience in the ORE (Experiment 4), the old/new recognition task is applied across two age groups (5- to 6-year olds and 13- to 14-year olds). These age groups were selected because of (1) previous conflicting research indicating onset of ORE between 5- to 7-year olds (Chance et al., 1982; Goodman et al., 2007; Pezdek et al., 2003), and (2) evidence that 13-14 year olds' recognition being on par with adults' face recognition ability (Goodman et al., 2007; Pezdek et al., 2003).

On the other hand, the 2AFC method was applied to explore the integrative CIM (Experiments 5 and 6) because of the wide age range (5- to 6-year-olds; 9- to 10-year-olds; 13- to 14-year-olds; adults) and cognitive demands from these experiments. The effects on the ORE of motivation through a non-race based in-group out-group categorisation (personality type; Bernstein et al., 2007) were tested. Prior to the 2AFC method, all participants completed a bogus personality test that categorised them as having either "orange" or "purple" personality type. During familiarisation, faces were labelled as either having the same personality or different personality type as perceivers. The 2AFC method was used because of the additional cognitive demands associated with categorising faces belonging as in-group and out-group members. Therefore, the 2AFC recognition procedure was selected to ensure that the task as a whole was not too cognitively demanding for children as young as 5 years while at the same time being applicable to other age groups (9-10, 13-14, and 18- to 23-year-olds).

5 Analysis Strategy

The majority of experiments reported in this thesis were analysed through a mixed-factorial ANOVA test. If preliminary analysis revealed no significant effects or interactions of certain factors, the data were collapsed across these factors in subsequent analysis. If a two-way interaction is qualified by a three-way interaction, further analysis will be carried out for the three-way interaction and not the two-way interaction.

6 Concluding Remark

As a whole, this thesis aims to offer a more complete perspective to understanding the ORE by investigating infants, children, and adults from a heterogeneous population and comparing their performance with that of perceivers from a homogeneous population. Through comparing across populations and multiple age groups, and by controlling the form of stimuli and task designs, the results of these studies may provide important contributions to existing literature that may explain the onset of the ORE in infants, and the impact of perceptual expertise and CIM in understanding the ORE.

CHAPTER THREE

REINVESTIGATING THE DEVELOPMENT OF THE ORE IN INFANTS: AN EXAMINATION OF THE ROLE OF EXPERIENCE

The primary aim of this chapter is to re-examine how experience affects the development of the other-race effect (ORE) in infants. Three experiments were carried out to investigate whether there is a relationship between experience and specialisation with gender and race of faces at 4-months and 9-months when stimuli have reduced external facial information. The results indicated that 4-month-olds could discriminate between female own-race faces (Experiments 1 and 3: homogeneous vs. heterogeneous population) and other female experienced-race (Experiment 3: heterogeneous population). The likely interpretation for differences found between populations is racial exposure in homogeneous and heterogeneous populations. The female recognition advantage could also be explained by 4-month-old infants' preference to attend to female faces (Experiment 2). On the other hand, 9-month-olds showed a reduced preference for female faces, which could explain 9-month-olds' recognition advantage for both female and male own-race faces. In addition to demonstrating the importance of experience in the development of the ORE, there are also population differences in recognition of own-race faces. Four-month-olds from the heterogeneous population showed a weaker own-race recognition advantage than 4-month-olds from the homogeneous population. Overall, the results demonstrate that the onset of ORE is found in 4-month-old infants and the shape of the ORE is shaped by experiences in infants' environment. These findings are consistent with the hypothesis that the system underlying face processing at 3-months is grounded in infants' differential exposure to faces. A novel finding from this chapter is that infants with heterogeneous racial experience may have a weaker

recognition advantage for own-race faces than infants with homogeneous racial experiences. The implication from this novel finding is discussed in accordance to the face-space model.

1 Introduction

Studies of the ontogeny of the other-race effect (ORE) suggest that within the first year of life, infants' representation of faces becomes more specific or narrowed with development and particularly attuned to the types of faces that infants most often encounter. The developmental trajectory of face perception has supported Nelson's (2001) notion of "perceptual narrowing". Specifically, infants begin life with a broad perceptual ability that allows the processing of faces in general. Then, as visual input becomes more finely tuned to faces that are more prevalent to infants' life, the system narrows to develop expertise on familiar type(s) of face; same-species faces (Pascalis, et al., 2002), female faces (Quinn, 2002; Quinn et al., 2002; Ramsey, Langlois, & Marti, 2005), and own-race faces or faces of commonly experience race (Bar-Haim et al., 2006; Hayden et al., 2007a; Kelly et al., 2005, 2007a, 2007b, 2009; Quinn et al., 2002; Quinn et al., 2008). These studies measured face processing through infants' spontaneous preference and novelty-preference to faces (the latter as an indicator of recognition of familiar stimuli). Overall, it appears that at birth, one's visual representation of faces is broadly tuned with no pre-existing race-based visual preference or recognition bias. However, with continued experience with own-race faces and lack of experience with other-race faces lead to perceptual narrowing within infants' first year of life.

Studies of newborns (Di Giorgio et al., 2012; Kelly et al., 2005; Quinn et al., 2008; Sugita, 2008) have showed that spontaneous preference and recognition of a specific category (i.e., race, gender) is not present at birth, which suggests that own-race preferences and recognition result from differential exposure to faces from one's particular racial group (Quinn et al., 2002). For example, in a study by Kelly et al (2007a), three different age groups of Caucasian-White infants (3-, 6-, and 9-month-olds) were tested on face stimuli from four distinct ethnic groups (African-Black, Middle-Eastern, Chinese, and Caucasian-White). The 3-month-olds were able to recognise faces from all four ethnic groups, the 6-month-olds from two groups (Chinese and Caucasian-White), and the 9-month-olds only recognised own-race faces (Caucasian-White). The observed decreased processing abilities for other-race face is consistent with Nelson's (2001) notion of "perceptual narrowing".

Although studies generally agree that ORE develops within the first year of life, there is an inconsistency in the evidence regarding the age of onset. Some studies found that 3-month-old infants showed an own-race recognition advantage (Barerra & Maurer, 1981; Hayden et al., 2007a; Sangrigoli & de Schonen, 2004b) while Kelly and colleagues (2005, 2007a, 2009) found a developmental trajectory of ORE narrowing between 6 and 9 months. The different age of onset in these studies could be explained by numerous methodological differences such as facial information and face gender. Therefore, the main aim of this chapter was to examine the impact of facial information and face gender in shaping the own-race and other-race face processing.

1.1 Internal and External Facial Information

While both internal and external facial information are important for face recognition, internal features are considered more critical in adult face processing expertise (Ellis et al., 1979; Ge et al., 2008; Tanaka & Farah, 1993)[6]. Infants are seen to rapidly acquire the ability to process internal feature of a face (Cohen & Cashon, 2001) and it is between late infancy and early childhood that featural processing becomes adult-like (Ellis et al., 1979; Want et al., 2003; Young et al., 1985). However, there is a developmental story concerning featural processing.

As indicated in Chapter 1, when looking at faces, there is evidence that very young infants tend to process the external features (low-level sensory cues) better than their internal details (Bartrip et al., 2001; Hainline, 1978; Haith et al., 1977; Maurer and Salapatek, 1976; Pascalis et al., 1995; Rose et al., 2008; Turati et al., 2006). Young infants are less likely than older ones to scan the inner features of the face (Maurer & Salapatek, 1976) and a shift away from dependence on external facial information is found after 5-months of age (Rose et al., 2008). However, the specific age of shift is attributed to experience with faces. As mentioned in Chapters 1 and 2, when infants' mother's face is wearing a headscarf, newborns did not look longer at their mother's face than at a stranger's face (Pascalis et al., 1995; Bartrip et al., 2001) but a group of 35- to 40-day old infants was able to make the discrimination with mother and stranger wearing headscarves. When recognising unfamiliar faces, it is found that 5-month-old infants rely on external features whereas 7- to 9-month-old infants can recognise those unfamiliar faces on the basis of their internal features (Rose et al., 2008). These data altogether suggests that there is a shift in the relative importance of different sources of information in face recognition over the first year of life and that this shift is attributed to familiar and unfamiliar own-race faces.

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[6] There are two types of information that are identified as crucial for face processing (Tanaka & Gordon, 2011) – featural and configural information. However, for the purpose of this thesis, we will only focus on featural information as none of our experiments explored configural information which uses specific paradigms as seen in the Literature review chapter.

Differences in findings of the ORE may relate to the different facial stimuli used. Studies that found a broad recognition ability at 3 months and an onset of ORE at 9 months had faces with external information (Kelly et al., 2007b; 2009) while other studies that found an onset of ORE at 3 months had faces without external information (Hayden et al., 2007a; Sangrigoli & de Schonen, 2004b). Therefore, the inclusion of external facial contour in the Kelly et al. (2007b, 2009) studies may have led to comparable recognition of own-race and other-race faces in 3-month-olds due to infants' initial reliance on external features (e.g., Rose et al., 2008) when recognising unfamiliar own-race and other-race faces. On the other hand, the absence of external facial information in Hayden et al and Sangrigoli and de Schonen's studies may have led to 3-month-old infants demonstrating an own-race recognition advantage. Thus, it is possible that infants may be relying on external facial features when recognising unfamiliar type of faces, but can rely on internal facial features when recognising unfamiliar faces that they have experience with.

1.2 Face Gender and the Other-Race Effect

Previous studies on 3- to 4-month-olds have found a female face preference and recognition advantage (Quinn et al., 2002). By two days of age, infants can perceptually discriminate their mother's face from that of another (dissimilar looking) woman's face (Bushnell, et al., 1989; Pascalis et al., 1995; Walton, Bower & Bower, 1992). And if given ample familiarisation to a stranger's face, 3-month-old infants can discriminate between two similar-looking female strangers (Barrera & Maurer, 1981). Interestingly, they do not have these same perceptual discrimination abilities when it comes to their father's face (Walton et al., 1992).

Recent studies have found a more direct link between the gender and race of the primary caregiver and infant's recognition abilities. At birth, infants do not exhibit a preference for female or male faces (Quinn et al., 2008). Nevertheless, Quinn and colleagues (2002) reported a spontaneous preference and recognition advantage for adult female faces in 3- to 4-month-old infants who had female adult primary caregivers. The female gender advantage however, is not extended to female other-race faces (Quinn et al., 2008). In contrast, infants who had male adult primary caregivers tended to show a spontaneous preference for adult male faces. These data together suggest that young infants (3- to 4-month-olds) exhibit a face processing advantage specific to characteristics of infants' primary caregiver – which is also infants' most experienced face type.

With regards to the conflicting onset of the other-race effect in infants, the genders of stimuli used in these studies varied. The stimuli used in Hayden et al. (2007) and Sangrigoli and de Schonen's (2004b) studies with an ORE onset of 3 months were carried out using female faces only while the stimuli used in the Kelly et al. (2007b, 2009) studies with an ORE onset of 9 months were carried out using both female and male faces. Therefore, the female ORE found in 3-month-old infants (Sangrigoli & de Schonen, 2004b; Hayden et al., 2007a) is not surprising due to infants' processing advantage specific to characteristics of infants' primary caregiver (e.g., female, own-race). On the other hand, the absence of the ORE and face gender differences in work by Kelly et al. (2007b; 2009) could be related to 3-month-old infants' reliance in processing external facial information in general rather than processing faces according to experience. Thus, two possible interpretations (face gender and facial information) from previous work (Kelly et al., 2007b; 2009) need to be teased apart by the right investigation.

1.3 Overview of Infant Experiments

From the review above, infants' experiences with different types of face may benefit recognition and processing of internal facial information. Although there is a female processing advantage in young infants (3- to 4-month-olds), there are no studies to our knowledge that systematically investigated gender asymmetry in face recognition across infants' first year of life. When Kelly and colleagues (2007b, 2009) investigated the development of ORE in 3-, 6-, and 9-month-olds, they found no female recognition advantage in their study, which could be explained by infants' reliance on external contour in face recognition. Young infants tend to rely on processing external facial information when available and find it difficult to process internal information when external facial information is limited (e.g., Pascalis et al., 1995). In addition, no study has investigated the interaction between face gender and the other-race effect. In summary, discrimination on the basis of external facial information is not necessarily face recognition as such – possibly hairstyle recognition. Therefore, further investigation across infants' first year of life is necessary by using stimuli with reduced external facial information and both face genders.

Three experiments are reported in this chapter. Experiment 1 aimed to reinvestigate the development of the ORE by ensuring that recognition is not attributable to low-level sensory cues such as external contour. In fact, the stimuli in all experiments de-emphasise external facial cues (see Figure 4 in Chapter 2). Experiment 2 on the other hand, investigated whether the female gender preference found in 3-month-olds is extended to older infants. Finally, Experiment 3 aimed to test the role of experience when infants are raised in a heterogeneous environment. In all experiments, two age groups (4- and 9-month-olds) were selected because of evidences on face gender asymmetry at 3- to 4-months and evidence on the development of the ORE by 9-months of age. A novelty-preference task previously used in face discrimination studies was carried out on Experiments 1 and 3, while a spontaneous preference task previously used in gender preference studies was used for Experiment 2 (see Chapter 2 for rationale of tasks).

2 Experiment 1

Experiment 1 examines British-White infants' development of the ORE using faces with reduced external facial information. Stimuli of three racial groups were tested on both age groups. These stimuli included both female and male Caucasian-White (own-race), Chinese, and Malay faces. Based on the findings explored earlier in this chapter, it is hypothesised that when external cues are reduced, 4-month-olds will be better at recognising own-race female faces in comparison with own-race male faces and other-race Chinese and Malay faces. In contrast, it is uncertain whether the female own-race recognition advantage will extend to 9-month-olds or whether there will be an absence of a female recognition advantage.

2.1 Method

2.1.1 Participants. Ninety-four babies from the UK aged 4-months (age range = 104 – 138 days, 25 females and 24 males, mean age = 123 days) and 9-months (age range = 259 – 293 days, 15 females and 30 males, mean age = 276 days) were tested. However, some infants were excluded from the final analysis due to fussiness (n = 9); side bias during testing (> 95% looking time to one side; n = 5); and equipment failure (n = 4). This resulted in the inclusion of 37 four-month-olds and 39 nine-month-olds in the final analysis. All participants were healthy, full term infants recruited from the maternity unit of the Lancaster Royal Infirmary, Lancaster, United Kingdom, using a database maintained at the Centre for Research in Human Development and Learning (CRHDL), Lancaster University. Parents were contacted and recruited by telephone when the infant approached a suitable age for testing. All parents indicated that their infant's primary caregiver was female.

2.1.2 Apparatus. Testing sessions were conducted in a small, dimly lit infant testing room in the CRHDL, Lancaster University. Infants sat on a parent's lap 60 cm from a 45cm X 30cm Sony coloured monitor, placed on a table at infants' eye level. A video camera was positioned in front of the Sony colour monitor. The video camera was fed on to a different monitor in an adjoining control room to allow the experimenter to record infants' looking times. Habit X 1.0 software (Cohen, Atkinson, & Chaput, 2004) running on a Macintosh computer was used to present the stimuli, record infants' looking times during each trial, and calculate when infants met the habituation criterion. The film was digitised to be analysed by two independent observers using QuickTime Player 7.

2.1.3 Stimuli. The photographs comprised 90 faces (30 Chinese, 30 Malays, and 30 Whites) of individuals in their 20s and 30s. The images used were photos of students - the Caucasian-White faces were obtained from Sheffield University and Lancaster University face bank while the Chinese and Malay faces were students of Sunway University, Malaysia. Forty independent observers from Malaysia and the United Kingdom rated the pool of photographs (including both full frontal and ¾ profile view) using scales from 1 to 7 based on clarity, face typicality, and attractiveness. As a result of these ratings, twelve adult faces from the higher end of the scale (of both orientations) were selected (age range = 18 - 30 years, 6 males and 6 females) from three different ethnic groups (4 Chinese, 4 Malays, and 4 Caucasian-

Whites). Each of the selected 12 adults faces were photographed in two orientations (frontal orientation and a ¾ profile orientation) leading to 24 photos in total. All faces had dark hair and dark eyes so that infants were unable to recognise the photos on the basis of these features.

The final set of 12 face identities (4 Chinese, 4 Malays, and 4 Whites) were paired according to ethnicity and gender (6 pairs: 1 male pair and 1 female pair for each of the three ethnic groups) and were comparable in clarity, face typicality, and attractiveness ratings. All pictures were colour portraits, cropped to the same oval shape (using Adobe Photoshop) with little hair information within the cropped shape, and were approximately the same quality (e.g., face size, photo clarity, and included a black background).

2.1.4 Design. The experiment used a 2 x 2 x 3 x 2 x 2 mixed factorial design. The independent variables were participant age (4-months, 9-months), participant gender (female, male), face race (Chinese, Malay, White), orientation (frontal-profile, profile-frontal), and face gender (female, male), with face gender as a repeated measure.

The images for each combination of face race and face gender consisted of a habituation face and two test faces: a novel and the familiar face. Both test faces were always displayed in the same orientation, and this orientation was always different from the orientation of the face seen during habituation (see Figure 4 for an example). There were two different orientation conditions that are varied between familiarisation (habituation) and testing (novelty-preference): frontal-profile and profile-frontal (see Chapter 2 for an explanation).

2.1.5 Procedure. All infants were tested in a quiet room at the CRHDL, Lancaster University. They sat on their parent's lap. Before the start of each session, all parents were instructed to fixate centrally above the screen, remain as quiet as possible during testing, and to stroke infants' hands to reassure them.

Each infant was randomly assigned to one of the three ethnic-group conditions (Chinese, Malay, and Whites) and one of the two orientation order conditions (frontal-profile or profile-frontal). Infants were tested with both male and female faces with a 10 min break in between; testing was counterbalanced according to gender, with half the infants assigned to the male-faces condition first followed by the female-faces condition, and the other half in the reversed order. For example, for a participant that was tested on the Chinese ethnic group of the frontal-profile condition, the session began with habituation to one female Chinese face (frontal orientation) followed by the novelty-preference task in which the familiar face (¾ profile orientation) was paired with a novel female Chinese face (¾ profile orientation. Following a 10 min break, the same participant was tested on the same ethnic group and orientation but on male faces instead. The dependent variable was proportion of time spent looking at novel face during the novelty-preference task.

2.1.5.1 Habituation Phase. During this phase, each infant was presented with a single face measuring 15cm X 18cm on the 45cm X 30cm monitor screen. The habituation session began with the presentation of an attention-getter, an animated tilting sounding rattle presented prior to each trial to direct the infant's gaze toward the monitor. Only one face was presented across habituation trials. Trials began once infants attended to the monitor. The habituation trial was played until 30-seconds had elapsed or when infants looked away for two continuous seconds once they had attended a minimum of 1 second. The experimenter, who was blind to the stimulus presented, recorded the infant's looking times to each trial using Habit X 1.0 (Cohen et al., 2004) by pressing a key continuously while the infant fixated the image. When the infant averted gaze from the screen for two continuous seconds, the trial ended by the image disappearing. The habituation attention getter was then repeated to get the infant's gaze back to the screen. The experimenter then presented the image again, with the next trial beginning when the infant fixated the screen. Replicating the Kelly et al. (2007b, 2009) studies, habituation trials ceased when the infant's looking time (on a single trial) was equal to or less than 50% of the average looking time from the infant's first two trials. The measure of looking time during this phase was total looking across trials until the habituation criterion was reached. If habituation was not met by the 12th trial, data were excluded from the analysis.

2.1.5.2 Test Phase. The test phase consisted of two trials. First, two faces (novel and familiar) measuring 15 cm x 18 cm were displayed on the television screen. The faces appear on the left and right sides of the screen and were separated by 9 cm gap (edge to edge). Similarly, to habituation trials, prior to all test trials, the attention getter rattle was presented to direct the infant's gaze toward the monitor. As soon as the infant's gaze was fixated on the screen, the experimenter presented the test faces using Habit X 1.0 for 5 seconds. At the end of the countdown, the faces disappeared from the screen followed by another attention getter. The faces were then displayed a second time with their left and right positions reversed on the screen.

Fixations were recorded throughout test trials, and the film was digitised to be analysed frame by frame (25 frames per second) by two independent observers using QuickTime Player 7. For each frame, observers coded whether the infant was looking at the image on the left, at the image on the right, or away from the screen. Importantly, the observers did not know which ethnic group and orientation were presented to the infant they were coding or the left/right positions of the novel and familiar faces. Looking times to the two images were calculated by separately summing the time spent looking at the novel image across both test trials and converting this into a proportion of total looking times to novel images (the average proportion of time spent looking at the novel image of trial 1 and the novel image of trial two).

2.2 Results

2.2.1 Habituation trials. Preliminary analysis revealed no significant effects or interactions of participant gender or face orientation, so the data were collapsed across these factors in subsequent analyses. Habituation time (total looking time across trials) was analysed in a 2 (participant age: 4- or 9-months) x 3 (face race: Chinese, Malay, or Caucasian-White) x 2 (face gender: female face or male face) mixed analysis of variance with face gender as within factors. The subsequent ANOVA yielded a significant effect of face gender, $F(1, 60) = 20.668, p < .001, \eta^2 = .256$, in which male faces were habituated to in a shorter time ($M = 35.1$s, range =31.29 – 38.9) than females faces ($M = 47.25$s, range = 42.16 – 52.34). The ANOVA also yielded a marginal main effect of participant age, $F(1, 60) = 3.531, p = .065, \eta^2 = .056$, in which 9-month-olds habituated faster ($M = 37.78$s, range = 32.84 – 42.72) than 4-month-olds ($M = 44.57$s, range = 39.29 – 49.85).

A significant face gender x age interaction was found, $F(1, 60) = 4.308, p = .042, \eta^2 = .067$ (see Table 1). Simple main effects showed that female faces were habituated to more slowly than male faces in 4-month-olds, $F(1, 32) = 5.505, p = .025, \eta^2 = .056$, and 9-month-olds, $F(1, 28) = 14.04, p = .001, \eta^2 = .334$. In addition, age differences in habituation were found with female faces, $t(64) = -2.172, p = .034$, and not with male faces, $t(64) = -.393, p = .696$. Four-month-olds habituated more slowly to female faces than 9-month-olds. Thus, the main effect of face gender is explained by the data from both the younger and older infants, and the age effect is explained by female faces.

Table 1.

Mean and standard deviation for habituation trials as a function of age, and face gender, Experiment 1

	Female faces (SD)	Male Faces (SD)
4-months	52.52 (25.61)	35.91 (15.01)
9-months	41.26 (15.91)	34.43 (15.36)

Note. Total looking times during habituation trials

2.2.2 Test trials. Again, a preliminary analysis yielded no significant effects or interactions of participant gender or face orientation, so the data were collapsed across these factors in subsequent analyses. The proportions of time spent looking at the novel stimulus (novelty-preference) were combined from both trials of the test phase in a 2 (age: 4- or 9-month-olds) x 3 (face race: Chinese, Malay, or Caucasian-White) x 2 (face gender: female face or male face) mixed analysis of variance with face gender as a within factor. There were no significant main effects, but the ANOVA revealed 3-way interaction of age x face race x face gender, F (2, 69) = 7.453, p = .001, η^2 = .178. To investigate this interaction, separate analyses were carried out for each age group.

The data for 4-month-olds showed a significant two-way face race x face gender interaction, F (2, 34) = 5.761, p = .007, η^2 = .253. Simple main effects yielded face gender differences for Caucasian-White faces, t (10) = 2.342, p = .041. At 4-

months, Caucasian-White female faces ($M = 68.17$) were discriminate better than male faces ($M = 40.87$). In contrast, simple main effects did not show any face gender differences for Chinese (t (12) = -1.027, $p = .325$) and Malay (t (12) = -1.112, $p = .288$) faces. Simple main effects for female faces yielded face race differences for female faces, F (2, 34) = 5.608, $p = .008$, but not for male faces, F (2, 36) = 1.849, $p = .173$. Further comparison on female faces showed novelty-preference for Caucasian-White female faces to be significantly higher than novelty-preference for Chinese ($p = .03$) and Malay ($p = .009$) female faces.

In contrast, the face race x face gender interaction was not significant for 9-month-olds, F (2, 35) = 1.722, $p = .193$, $\eta^2 = .090$. Instead, there was a significant main effect of face race, F (2, 35) = 3.368, $p = .046$, $\eta^2 = .161$. A post-hoc Tukey test revealed significant differences between Chinese and Caucasian-White faces ($p = .049$), but not between Chinese and Malay faces ($p = .886$), and Malay and White faces ($p = .143$). This indicates that both female and male own-race faces had significantly higher novelty-preference than Chinese and Malay faces.

To further investigate novelty-preferences within each age group, we conducted a series of two-tailed t-tests to determine whether the time spent looking at novel stimuli differed from the chance level 50%. As seen in Figure 5, 4-month-olds demonstrated significantly above chance novelty-preferences for female Caucasian-White faces ($p = .009$) while 9-month-olds demonstrated significantly above chance novelty-preference for both female ($p = .033$) and male ($p = .004$) Caucasian-White faces. Above chance level familiarity preference for Caucasian-White male faces was not found in 4-month-olds ($p = .243$). The other-race novelty-preferences were found to be at chance level for both 4- and 9-month-olds (Chinese faces, $p \geq .219$; Malay faces $p \geq .434$).

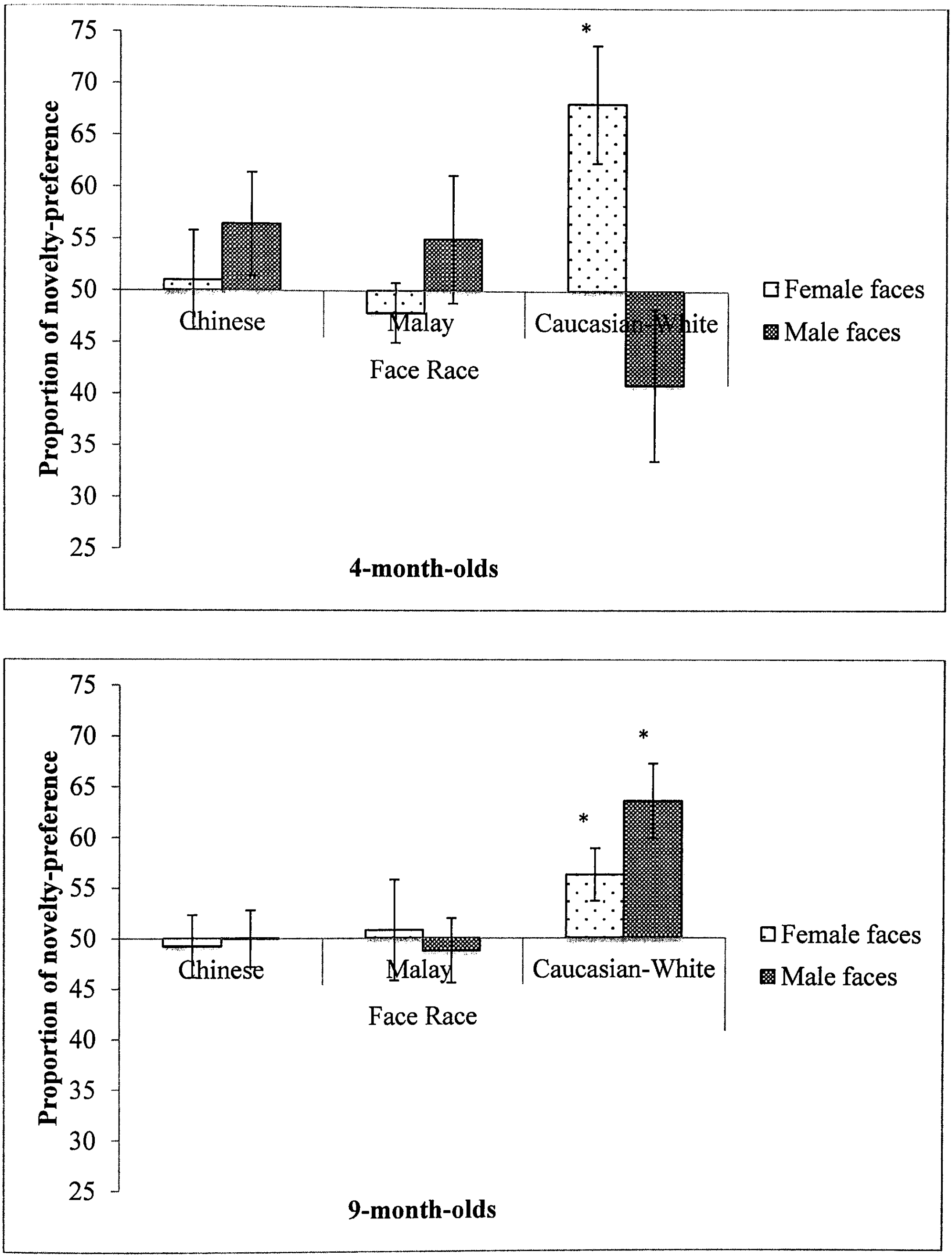

Figure 5. **Proportion of novelty-preference as a function of age, face race, and face gender, Experiment 1.** Note. 'Rising' bars indicate novelty-preference whereas 'falling' bars indicate familiarity preference. * $p < .05$

2.3 Discussion

Two major findings emerged from this investigation. Firstly, the recognition of faces at 4 months is dependent on face gender and face race. At 4 months, infants showed an increase in looking at the novel face only when they were habituated to female own-race faces. Secondly, the recognition of faces at 9 months is no longer dependent on gender. Instead, recognition is dependent simply on race. Infants are better at recognising both female and male own-race faces compared with other-race less experienced faces.

The current finding poses the question of how this set of results is to be interpreted in comparison with Kelly et al. (2007b, 2009) who found a comparable discriminative ability across all race and gender of stimuli within the younger age group. Possibly younger infants in Kelly and colleagues' study were able to rely on external detail in face recognition. It is possible that the gender effect at 4 months (in the current study) is specific to internal detail and so at that age only emerges clearly when reliance on external detail is prevented. The suggestion is consistent with previous work that showed better face recognition from the external features than the internal ones in young infants (e.g., Pascalis & de Schonen, 1994; Pascalis et al., 1995; Turati et al., 2006). Therefore, young infants may find it easier to recognise both gender (female and male faces) and race (own-race and other-race) when external features are intact. The female face recognition advantage at 4 months of age is specifically related to configural encoding of facial features.

On the other hand, 9-month-olds showed recognition specific to race of the primary caregiver. In most instances, young infants have more exposure to adult female faces than they have to adult male faces (Ramsey et al., 2005; Ramsey-Rennels & Langlois, 2006; Rennels & Davis, 2008). For example, parents of 2-, 5-, 8-

, and 11-month-olds report twice as many interactions between their infant and female strangers than between their infant and male strangers during a typical week (Rennels & Davis, 2008). However, between the ages of 2- to 5-months, there was 4 times increase in experience with male strangers (see Rennels & Davis, 2008, p.671). Therefore, the fact that the current study together with the Kelly et al. (2007b, 2009) studies showed comparable recognition of own-race female and male faces in 9-month-olds is not surprising based on this dramatic increase of experience with male own-race faces.

The results of this study are consistent with the findings of Sangrigoli and de Schonen (2004b), and Hayden et al. (2007) indicating that for younger (3-month-old) Caucasian-White infants, the ORE for female faces was found when internal facial information was highlighted. Thus, the inconsistencies in the onset of ORE are likely to be as a consequence of methodological differences. When study is controlled for low-level perceptual cues, infants' recognition is found to be dependent on face gender and race at 4 months, and race at 9 months. It is interesting to note that these data, particularly those for 4-month-olds are open to interpretation in terms of the race and gender of the primary caregiver

Habituation data from this study showed an interaction between face gender and age. Four-month-old infants took longer to habituate to female faces while 9-month-old infants did not take as long to habituate to these faces as 4-month-olds. In other words, 4-month-old infants may have the initial tendency to prefer looking at female faces but this gender preference may be reduced by 9 months of age due to an increase in male facial experience. Alternatively, young infants simply take longer to encode female faces than older infants. However, further studies on own-race faces are necessary to explore these speculations. We know that 3-month-old infants have a spontaneous preference for female own-race faces but we do not know whether this gender preference is lost by 9-month-olds, which would provide an explanation of the lack of a gender effect in the present data for that age group. Experiment 2 is designed to explore this further.

3 Experiment 2

The most important findings in Experiment 1 were that younger infants (4-month-olds) were better at processing female own-race faces. In contrast, older infants (9-month-olds) were equally good at recognising both male and female own-race faces. The own-race female face advantage in younger infants (3- to 6-months) has been widely studied within the past decade, the general finding being that infants are more proficient at processing (Ramsey-Rennels & Langlois, 2006; Rennels & Davis, 2008), and categorising (Quinn et al., 2002; Ramsey et al, 2005) female than male faces. This finding has been observed in other spontaneous preference data, with a preference for female faces emerging at 3 months (Bar-Haim et al., 2006; Quinn et al., 2002). However, little is known of older infants' spontaneous gender preference. Therefore, Experiment 2 is designed to explore both younger (4 month) and older (9 month) infants' face gender preference by using the spontaneous preference technique. This investigation should help us better understand how face recognition is influenced by spontaneous gender preferences. Specifically, if the early emergence of ORE for female faces arises from preference and experience with female faces, we might expect that the general ORE across genders found at 9-months to be underpinned by a lack of preference for female or male faces.

3.1 Method

3.1.1 Participants. A total of 34 infants were tested of which 19 were 4-month-olds and 15 were 9-month-olds. Among the infants, five were excluded due to side biases (n =2), and fussiness (n = 3). The final sample consists of 29 infants, 12 4-month-olds (age range = 116 – 147 days, 7 females, 8 males, mean age = 129 days) and 16 9-month-olds (age range = 260 – 297 days, 5 females, 9 males, mean age = 279 days). All had female (own-race) primary caregivers.

3.1.2 Apparatus. A 45cm x 30cm Sony colour monitor was used for presenting the stimuli to infants. Two cameras were used – a webcam for live feed (so experimenter can ensure infant is within the recording frame and a digital camera for latter coding purposes. Habit X 1.0 software (Cohen et al., 2004) running on a Macintosh computer was used to present the stimuli.

3.1.3 Stimuli. A total of 16 Caucasian-White adults (age range = 18 - 30 years, 8 males and 8 females) served as models for the stimuli. Each of the selected 16 adults photographs were presented full-face in a frontal orientation, and standardised with dark hair and dark eyes so that infants are unable show a preference on the basis of these features. These faces were selected based on twenty adult raters' (10 female and 10 male) judgments on a 7-point scale of attractiveness with 7 being 'extremely attractive' and 1 being 'extremely unattractive from a pool of 30 pictures. Faces that were judged as average were selected as stimuli for this experiment. This was carried out to ensure that none of the faces was distinctively attractive which could result to spontaneous preference (e.g., Slater et al., 1998) towards attractive female and male faces. The female faces had a mean rating of 4.25 (SD = .42) and the male faces had a mean rating of 4.36 (SD = .62).

3.1.4 Procedure. As of Experiment 1, infants were tested in a quiet room at CRHDL, Lancaster University. Infants were presented with six 10 sec preference trials, each of which paired a male face with a female face. The pairings were of different faces and were randomly selected for each infant on each trial. The left-right positioning of the two genders was counterbalanced across infants. Each trial began with a presentation of an attention getter (rattle) until infants direct their gaze to the screen.

The film from the digital camera was analysed frame by frame (25 frames per second) by an independent observer after the study. For each frame, the observer coded whether the infant was looking at the image on the left, at the image on the right, or away from the screen. Importantly, the observer did not know the left/right positions of the male and female faces.

3.2 Results

To determine whether 4- and 9-month-olds showed a spontaneous visual preference for one of the two face genders, preference scores for female faces were calculated for each infant (Quinn et al., 2002). The length of time for which each infant looked at the female face was divided by the total time spent looking at both female and male stimuli. The score was then converted into percentage and averaged across trials to yield a proportion of preference score for female faces in 4-month-old and 9-month-old infants.

Four-month-olds mean preference for females ($M = 57.8\%$; SD = 9%) was reliably different from chance, $t\ (13) = 3.255$, $p = .006$, and 12 out of 14 infants had preferences above 50%, binomial probability, $p = .01$. By contrast, 9-month-olds preference for female over male faces was not significantly different from chance, M

= 51.38% (SD = 7%), t (13) = .721, p = .484, and only 6 of 14 infants had above 50% preferences (binomial probability, p = .79). Moreover, the two female preference means at 4- and 9-months were reliably different from each other, t (26) = 2.09, p = .047.

3.3 Discussion

Experiment 2 was conducted to test whether there are gender preferences at different ages, which might partly explain the results of Experiment 1. Results indicated that 4-month-old infants reared by Caucasian-White caregivers and exposed predominantly to Caucasian-White faces since birth showed a spontaneous preference towards female over male faces. This preference for female faces at 4 months is likely due to the fact that the primary caregiver is female (Quinn et al., 2002), with a possible additional contribution from predominant experience of female non-caregiver faces (Rennels & Davis, 2008).

More importantly, 9-month-old infants did not show preference for either gender. Instead, the evidence from this age group extended earlier findings by demonstrating that preference for female faces by infants reared by female caregivers diminishes by 9-months of age. Once again, this could be explained by the role of experience. Unlike the large discrepancy in infants' experience with other-race (8%) and own-race faces (92%; see Rennels & Davis, 2008 for a full review of facial experiences within infants' first year of life) that contributed to the early development of own-race visual preferences and own-race recognition advantage (e.g., Bar-Haim et al., 206; Hayden et al., 2007a; Kelly et al., 2005; 2007a; Sangrigoli & de Schonen 2004b), the discrepancy in infants' experience with female and male faces is not as large. About 30% of infants' interactions during the first year were with a male.

Specifically, there is a significant increase in experience with adult male faces at 5-months of age (three times as much male facial experience at 5-months than at 2-months of age; Rennels & Davis, 2008). This dramatic increase in male facial experience may be related to the absence of gender preference in 9-month-olds. Therefore, the findings from the current study suggest that the absence of gender preference observed in 9-month-old infants is an experientially based effect – combination of father's face and other non-caregiver adult male faces between 4- and 9-months of life.

The overall findings are consistent with the notion that infants' preference leads them to attend more closely, and to process more deeply (Bar-Haim et al., 2006; Kelly et al., 2005, 2007a; Quinn et al., 2002). Commonly experienced face types are preferred more than less commonly experienced face types. Therefore, the findings suggest that the emergence of ORE for female faces at 4-months and a general ORE across genders at 9-months arises from preference and experience with faces.

As reflected in the discrimination data of Experiment 1, infants are expert in processing experienced own-race faces between 3- to 4-months of age. However, all these findings arise from investigations of infants in a homogeneous culture in which the ORE remains stable through to adulthood. The subsequent experiment aims to explore development of the ORE in a heterogeneous population.

4 Experiment 3

The findings from Experiment 1 and previous research have revealed a strong ORE between 6 and 9 months towards the most experienced type of face regardless of the gender of face (Kelly et al., 2007b; 2009). In addition, as seen in Experiment 1, there is also an own-race female recognition advantage within the first half of infants' first year (e.g., Hayden et al., 2007a; Quinn et al., 2002, 2008; Sangrigoli & de Schonen, 2004b). However, all these findings arise from investigations of infants in a homogeneous culture.

Recently, a study by Gaither, Pauker, and Johnson (2012) showed that 3-month-old infants raised in a heterogeneous environment did not show any evidence of recognition within own- and other-race faces. Specifically, these infants did not discriminate between exemplars of own-race and other-race female faces. This was in contrast to infants from the homogeneous population who showed discrimination of own-race female faces at 3-months of age (Hayden et al., 2007a; Sangrigoli & de Schonen, 2004b), Gaither et al. (2012) suggest that the ORE may not develop as early for infants who grow up in a racially diverse environment. However, it remains unclear as to how and when the own-race recognition advantage develops for infants from the heterogeneous population. To the author's knowledge, no study to date has compared performance of infants from a homogeneous population against performance of infants from a heterogeneous population. This type of comparison is important to test the generality of effects obtained in both cultures, and to discover any population differences in face perception.

Therefore, Experiment 3 aims to extend Experiment 1 on infants from a heterogeneous environment. This was carried out by testing face discrimination ability of infants from Malaysia as a multi-racial environment. Malaysian-Chinese infants were chosen because not only is their general environment multiracial, they also generally have a female Malay carer (their households have Malay live-in house helpers). These domestic helpers are mainly foreign, typically from Indonesia (predominantly Malay ethnic group) and are there to help with washing, cooking, cleaning, and babysitting (Chin, 1998).

Malaysian-Chinese infants who have multi-racial (heterogeneous) experience will be compared with age-matched Caucasian-White infants (from Experiment 1) who were almost exclusively exposed to own-race faces (homogeneous) during their development. The stimuli used were similar to Experiment 1 (Caucasian-White, Chinese, and Malay faces). The differences in racial experience between both populations is that Malaysian-Chinese infants have experience with both Chinese and Malay faces while the British-White infants (a subset of infants from Experiment 1) have experience with Caucasian-White faces only. Therefore, the ORE for infants from the heterogeneous population is expected to take a different form than infants raised in a homogeneous population.

4.1 Method

4.1.1 Participants. A total of 35 infants from two age groups (4- and 9-month-olds) were recruited from Malaysia. Infants were of Chinese descent and were recruited through hospitals and private paediatricians' clinics. All parents indicated that the infants had no regular exposure to Caucasian-White faces but have regular exposure to female Malay live-in carer. Among the infants, 12 were excluded due to equipment failure (n = 7) failure to habituate (n = 1), side biases (n = 2), and fussiness (n = 2). The final sample consisted of 23 infants, half 4-months-olds (age range = 113 – 146 days, 6 females and 5 males, mean age = 128 days) and half 9-month-olds (age range = 252 – 276 days, 4 females and 7 males, mean age = 266 days). Twenty-three age-matched Caucasian-White infants were selected from among the participants in Experiment 1 (age range: 113 – 276 days; 9 females, 13 males) for cross-cultural comparisons.

4.1.2 Apparatus, stimuli, and procedure. All apparatus and stimuli used were similar to Experiment 1. The procedure also remained unchanged.

4.2 Results

4.2.1 Habituation trials. Preliminary analysis revealed no significant main effects or interactions of participant gender or face orientation, so the data were collapsed across participants' gender and face orientation in subsequent analyses. Face race are classified as own-race, Malay race, and other-race. Own-race and other-race will depend on the population at test. For example if the population in question is Malaysian-Chinese, own-race will be Chinese faces while other-race will be Caucasian-White faces. Habituation time (total looking time across trials) was analysed in a 2 (population: heterogeneous or homogeneous) x 2 (age: 4- or 9-months) x 3 (face race: own-race, Malay, other-race) x 2 (face gender: female face or male face) mixed analysis of variance with face gender as the repeated measure. The ANOVA yielded a significant effect of face gender, $F(1, 31) = 4.152, p = .05, \eta^2 = .118$, where male faces were habituated to faster ($M = 34.62$s, range = 27.71 – 41.53) than female faces ($M = 42.79$s, range = 35.92 – 49.66). No other effects or interactions with population, age, and face race were significant.

4.2.2 Test trials. As in Experiment 1, the preliminary analysis yielded no significant main effects or interactions of gender of participants and orientation of stimulus, so data were collapsed across participant's gender and orientation of stimulus in subsequent analyses. Proportions of time spent looking at the novel stimulus were combined from both trials of the test phase. A 2 (population: heterogeneous or homogeneous) x 2 (age: 4 or 9 months) x 3 (face race: own-race, Malay, other-race) x 2 (face gender: female face or male face) mixed analysis of variance was conducted with face gender as a within factor. The ANOVA revealed a main effect of face race, F (2, 34) = 5.589, p = .008, η^2 = .246, and Tukey post-tests revealed that the proportion time spent looking at novel faces was significantly higher for own-race faces (M = 57.56, range 54.31 – 60.82) than for Malay faces (M =48.55, range 43.9 – 53.19) (p = .012) but not in comparison to other-race faces (M = 52.77, range 49.11 – 56.43) (p = .18).

There was also a significant two-way interaction between face gender and age, F (1, 34) = 6.854, p = .013, η^2 = .166. Post-hoc comparisons showed that there is a face gender difference in 4-month-olds t (23) = 2.52, p = .019 (see Table 2) but not in 9-month-olds, t (21) = -.688, p = .499. This demonstrates a significantly higher female novelty-preference in the younger age group. Age differences were found in novelty-preference for male faces, t (44) = -2.44, p = .019, and not in female faces, t (44) = 1.502, p = .14. Nine-month-olds showed higher novelty-preference for male faces than 4-month-olds did.

Table 2.

Mean proportion of looking times to the novel face and standard deviation on test trials as a function of age, and face gender, Experiment 3

	Female faces (SD)	Male Faces (SD)
4-months	59.77 (15.02)	46.85 (13.78)
9-months	54.02 (10.29)	56.19 (12.0)

These effects were qualified by a four-way interaction between population, age, face race, and face gender, F (2, 34) = 3.494, p = .05, η^2 = .171. To investigate this interaction, separate analyses were carried out for each population group on 3-way interactions. The means for the homogeneous culture are plotted in Figure 6 while the means for the heterogeneous population are plotted in Figure 7. For the homogeneous culture, the three-way interaction between face race, face gender and age was replicated, F (2, 17) = 3.614, p = .049, η^2 = .298. This is to be expected since the data are a subset of the original data. Four-month-olds were found to be better at discriminating own-race Caucasian-White female faces F (2, 9) = 5.541, p = .027, η^2 = .552 while 9-month-olds revealed no differences in discriminating between gender and race of faces, F (2, 8) = 1.622, p = .256, η^2 = .28. Identical to Experiment 1, a main effect of face race was found for the older age group, F (2, 35) = 6.998, p = .003, η^2 = .286, indicating an other-race effect favouring own-race faces.

Infants in the heterogeneous group did not show a three-way interaction that is seen in the homogeneous group, F (2, 17) = .172, p = .844, η^2 = .020. Instead, the analysis yielded a face gender x age interaction, F (1, 17) = 8.227, p = .011, η^2 = .326. Simple main effects showed that the proportion of looking at novel faces was larger in female faces than male faces in 4-month-olds, F (1, 9) = 7.626, p = .022, η^2 = .459, while no face gender differences was found in 9-month-olds F (1, 8) = 1.376, p = .274, η^2 = .147. Four-month-olds had marginally higher novelty-preference than 9-month-olds for female faces, t (21) = 2.009, p = .058. However, an age difference was not found for male faces, t (21) = -1.705, p = .103. The means are explained in Table 3

Table 3.

Mean proportion of looking times and standard deviation for test trials of heterogeneous population as a function of age, and face gender, Experiment 3

	Female faces (SD)	Male Faces (SD)
4-months	59.81 (11.49)	46.57 (12.06)
9-months	51.36 (8.26)	53.94 (8.07)

Note. Proportion of looking times to novel face

To further interpret the 4-way interaction revealed in the overall analysis, simple main effects also showed differences between populations. In particular, 4-month-olds showed a significant population difference for recognition of female Malay faces, t (4) = 2.954, p = .042, where infants from the heterogeneous population demonstrated higher novelty-preference than infants from the homogeneous population for the female Malay faces. Of interest, a marginally significant population difference for female own-race faces was also recorded for 4-month-olds, t (8) = -2.005, p = .080 whereby infants from the homogeneous population demonstrated stronger novelty-preference than infants from the heterogeneous population. Population comparisons for the remaining face race and face gender were not significant ($p \geq 1.0$). However, population comparisons for 9-month-olds were not significantly difference from each other ($p \geq .322$). It is worth noting that novelty preference for own-race faces for this age group was larger in infants from the homogeneous population (M = 61.94, range = 55.23 – 68.65) than infants from the heterogeneous population (M = 56.96, range = 50.25 – 63.68).

To investigate whether novelty-preferences within each age group and condition were above chance level, a series of two-tailed t-tests was conducted. Due to the limited number of participants in this study, effects that are marginally significant were also taken into consideration. As seen in Figure 6, infants in the homogeneous group showed above chance level novelty-preference on female own-race Caucasian-White faces at 4 months ($p = .048$) but not for male own-race faces ($p = .18$). Marginally significant novelty-preferences for both female ($p = .06$) and male ($p = .14$) Caucasian-White faces were also found in 9-month-olds. This indicates that both age groups are discriminating faces of their own-race. However, novelty-preference for both female and male Chinese ($p \geq .20$) and Malay faces ($p \geq .45$) was at chance level in 4- and 9-month-old infants from the homogeneous population.

On the other hand, 4-month-old infants in the heterogeneous group showed above chance level novelty-preference on female Malay faces ($p = .03$) and a marginally significant novelty-preference on female Chinese faces ($p = .08$). Novelty preference for male Malay ($p =.677$), male Chinese ($p = .905$) and both female and male Caucasian-White faces ($p \geq .256$) were found to be at chance level. In contrast, 9-month-olds showed a significant novelty-preference for male Chinese ($p = .03$) and a marginally significant preference for female Chinese ($p = .13$) faces but not for the female Malay faces ($p = .30$) and male Malay faces ($p = .21$) as evident in Figure 7.

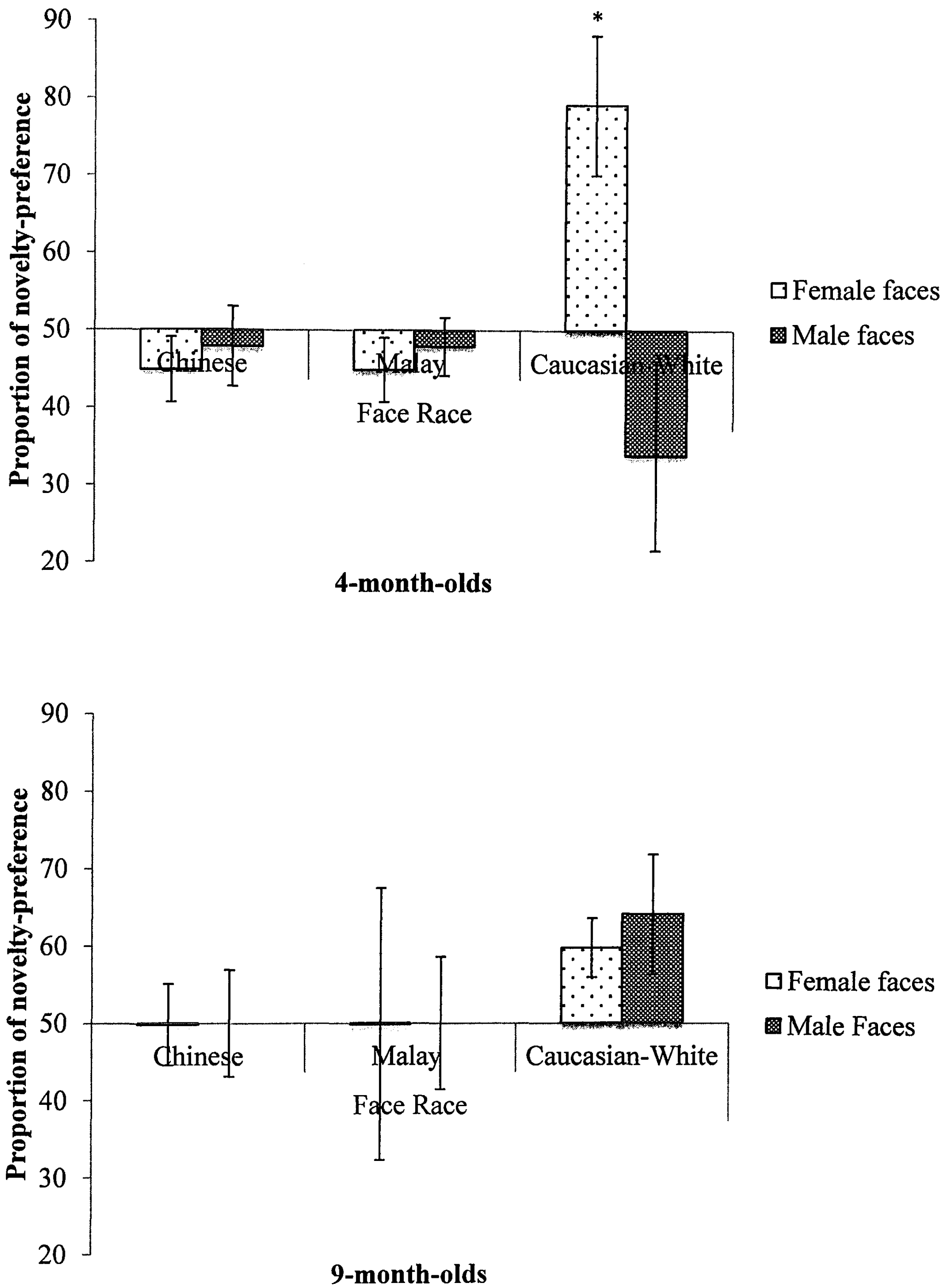

Figure 6. **Homogeneous populations proportion of novelty-preference as a function of age, face race, and face gender, Experiment 3.** Note. 'Rising' bars indicate novelty-preference whereas 'falling' bars indicate familiarity preference. * $p < .05$

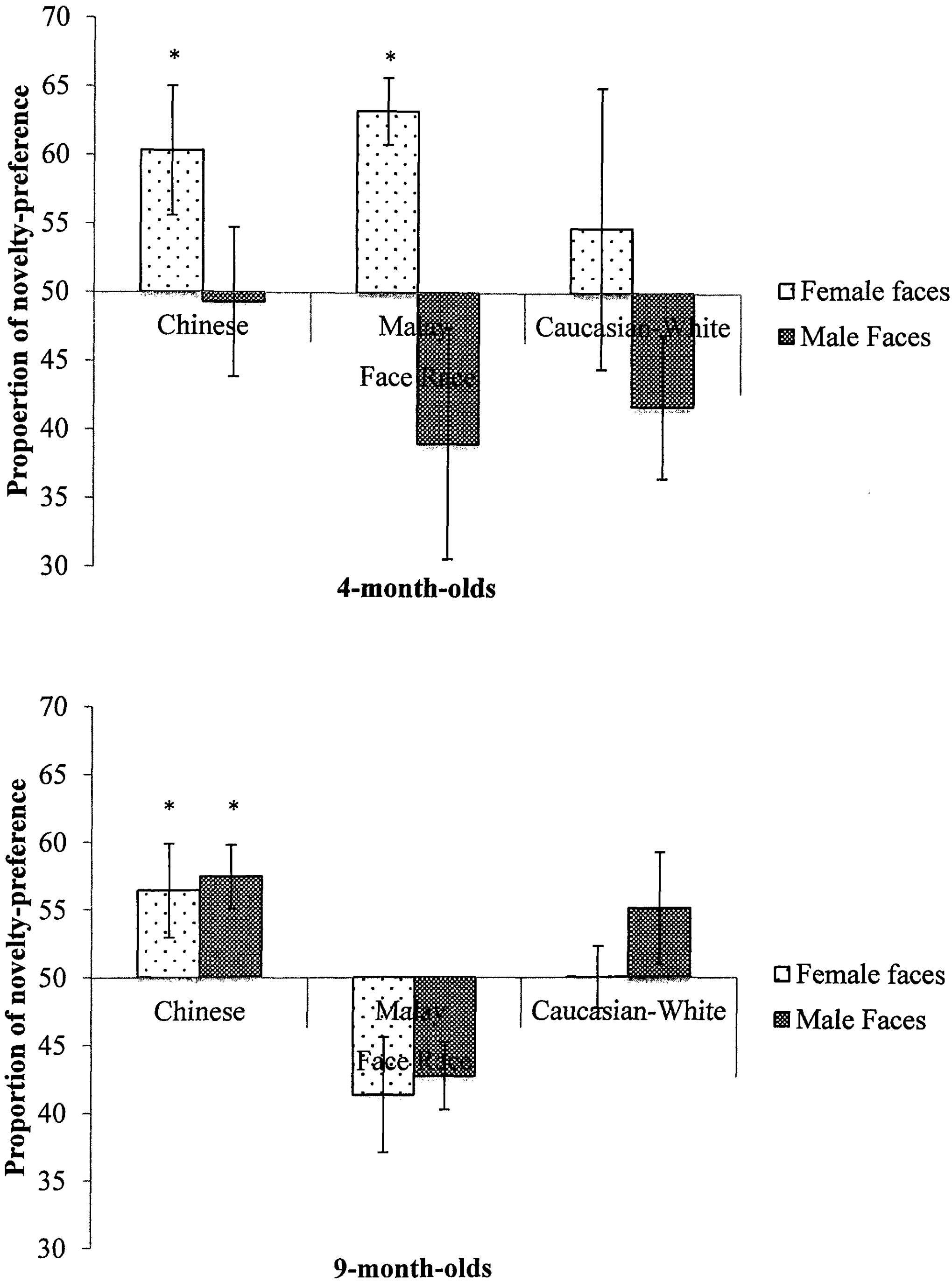

Figure 7. **Heterogeneous population's proportion of novelty-preference as a function of age, face race, and face gender, Experiment 3.** Note. 'Rising' bars indicate novelty-preference whereas 'falling' bars indicate familiarity preference. * $p < .05$

4.3 Discussion

The aims of Experiment 3 were to investigate on the role of differential racial experiences by testing face discrimination ability of infants that are exposed to more than one racial group and to uncover any population differences as suggested by Gaither et al (2012). The younger age group from both populations showed the other-race effect for female faces that they have exposure with. Four-month-old infants from the heterogeneous group could discriminate female Chinese (own-race) and female Malay (other race) faces. This is consistent with previous research showing an onset of ORE by 3- to 4-months of age when testing female faces alone (e.g., Hayden et al., 2007a; Sangrigoli & de Schonen, 2004b; Experiment 1). Perceptual narrowing for female faces in the heterogeneous population was not to one race (as in the homogeneous population) but to two races, with only Caucasian-White faces being poorly recognise.

By 9-months of age, infants from both the homogeneous and heterogeneous populations showed an improvement in their ability to recognise own-race male faces. At this age, there is no longer an advantage for Malay faces. As in Experiment 1, 9-month-olds from the heterogeneous population have developed expertise in discriminating faces that resemble the race of their primary caregiver - male and female Chinese faces. This is in line with the own-race recognition by 9-months of age found by Kelly et al. (2007b, 2009). Like Experiment 1, the potential explanation for the differences in recognition at 4 months and 9 months may be related to characteristics of primary caregivers, which we will discuss later on in the General Discussion of this chapter.

A marginal population difference was also seen in younger infants' recognition advantage of own-race female faces. Both 4- and 9-month-old Malaysian-

Chinese infants' novelty-preference (for Chinese faces) is lower than 4- and 9-month-old British-White infants' novelty preference (for Caucasian-White faces). However, the strength of the recognition advantage is significantly weaker in 4-month-olds. This suggests that more heterogeneous racial exposure may delay the emergence of recognition advantage (for experienced race and gender). The finding extends the Gaither et al. (2012) study that attributes the absence of the ORE in 3-month-old infants to heterogeneous infants' unrefined perceptual system. It seems that by 4 months of age, infants from the heterogeneous population begin to show evidence of own-race recognition advantage but one that is not as apparent as the ones seen in infants from the homogeneous population. Thus, it may be the case that infants with homogeneous exposure have an earlier onset of the ORE (3 months: Hayden et al., 2007a; Sangrigoli & de Schonen, 2004b) while infants with heterogeneous exposure have a slightly delayed (and possibly weaker) onset of the ORE - not 3 months (Gaither et al., 2012) but by 4 months of age.

Aside from gaining information regarding the role of experience in shaping infants' face representation, infants in our heterogeneous sample overall exhibit recognition ability for Chinese and Malay faces but no recognition for Caucasian-White faces. The fact that 4-month-olds showed good recognition of female Chinese and Malay faces allows us to rule out one interpretation of the result of Experiment 1: namely that the other-race effect for those races arose because these faces were hard to discriminate.

Altogether, these findings provide us with a general understanding of the onset of the ORE in infants born into a heterogeneous environment. The findings demonstrated (1) that 4-month-olds can recognise female faces of Chinese and Malay races; (2) 9-month-olds can recognise female and male faces of the Chinese race but no longer have an advantage in Malay faces; (3) extended Gaither et al (2012) findings by showing indication of recognition advantage by 4-months; and (4) confirmed that the results from Experiment 1 can be extended to infants from a different ethnic group.

To our knowledge, Experiment 3 is one of the first two studies (Gaither et al., 2012) that investigated the development of the other-race effect of infants with multi-racial experiences. The findings have been consistent with previous studies (Hayden et al., 2007a; Kelly et al., 2007b, 2009; Sangrigoli & de Schonen, 2004b) on onset of the ORE and provided additional insights in regards to population differences. Although there remains need for more refinement in terms of participant number, the findings have answered several questions regarding the development of ORE in infancy, and the importance of different types of experiences.

5 General Discussions

5.1 Background and Summaries of Findings

The general purpose of the experiments in this chapter was to examine the role of experience in the development of the ORE when low-level sensory cues provided by external features were reduced. Evidence from Experiment 1 and Experiment 3 demonstrates that the ORE is already evident at 4-months. In particular, findings showed that, contrary to what has been previously claimed (Kelly et al., 2007b, 2009), at 4-months expert recognition of female own-race faces are present. Moreover, this pattern extended to female Malay faces in the Malaysian-Chinese population. However, the female recognition advantage in heterogeneous population is found to be weaker than homogeneous population. The likely interpretation is that infants experiencing faces of more than one racial group since birth may have a slightly delayed development of expert recognition (Gaither et al., 2012). For example, Gaither et al. (2012) did not find recognition for own-race and other-race faces in 3-month-old infants raised in a heterogeneous environment. It is plausible that experiences with multiple racial groups since birth may have kept young infants' face representation broadly tuned and not yet focused to distinguishing exemplars of experienced face types. When the face representation is tuned to more than one race, there may be a trade-off effect (e.g., Rossion & Michel, 2011) with own-race and other-race recognition thereby showing weaker own-race recognition in multi-racial population than single-race population but stronger other-race recognition (e.g., female Malay faces) in multi-racial population than single-race population.

Another conclusion that could be drawn from these experiments is that visual preferences can result in specialized or expert face processing and better face recognition abilities for certain types of faces (Bar-Haim et al., 2006; Kelly et al., 2005, 2007a; Quinn et al., 2002). For example, the pattern of findings indicating an emergence of ORE for female faces at 4 months and general ORE across genders at 9 months is similar with the pattern of findings indicating a spontaneous preference for female faces at 4 months and no gender preference at 9 months. Although we cannot easily identify the unique role of preference and experience, a combination of experience with particular faces along with a preference should doubly ensure deeper encoding (both through general experience with a few close faces and through the attention-focusing effects of preference).

5.2 Theoretical Implications

Specific theoretical implications have been noted in the discussion sections of all three experiments. In the next subsection, broader implications such as how infants process facial information, perceptual narrowing, different components of experience in explaining the ORE, and ideas for future research are discussed.

5.2.1 Processing facial information. Previous literature on infants' processing of internal and external facial information indicates that internal facial processing is initially poor and improves with experience (Pascalis et al., 1995; Turati et al., 2006). If efficient internal feature processing emerges with specific experience, then it should emerge first for the faces infants are exposed to (Pascalis et al., 1995; Rose et al., 2005). Thus, the current finding showing an onset of ORE at 4-months together with previous finding showing an onset of ORE at 9-months (Kelly et al., 2007b, 2009) may indirectly imply that, although external and internal features of the face are usable for recognition, the processing of the latter requires higher level of experience (see Pascalis et al., 1995; Rose et al., 2008; Turati et al., 2006). In the case of the current study, we can assume that 4-month-olds infants have a particularly high level of experience with female faces, and it may be the case that this experience leads to discrimination of those types of face when only internal information is available. This coincides with previous studies indicating an onset of 3-months when external features were eliminated (e.g., Hayden et al., 2007a; Sangrigoli & de Schonen, 2004b). The current report together with previous research on processing internal and external facial information also suggests that the 3-month-old infants in work by Kelly et al. (2007b, 2009) were predominantly relying on external facial information when processing both other-race faces and own-race faces. Using external information for both cases possibly allowed infants to operate at a simpler level that did not impose the same load as internal processing.

In contrast, instead of showing broad recognition ability from 3 months through to 9 months of age (e.g., Kelly et al., 2007b, 2009), the ORE onset of 9 months in work by Kelly et al. (2007b, 2009) could be explained by the shift in processing strategy (Liu et al., 2011; Rose et al., 2008; Wheeler et al., 2012). For example, Rose et al. (2008) found that when inverting internal and external features separately, recognition was disrupted for 5-month-olds when either feature set was inverted, whereas 7- and 9-month-olds showed impaired recognition only when the internal features were inverted. This finding suggests a shift in reliance from internal and external facial information in young infants to internal facial information only in older infants. This conclusion could explain ORE onset of 9-month-olds found by Kelly et al. (2007b, 2009) because of the shift in reliance to processing internal facial information only.

Recent studies have found infants to show different internal fixation patterns for own-race and other-race faces with development (e.g., Gaither et al., 2012; Liu et al., 2011; Wheeler, Anzures, Quinn, Pascalis, Omrin, & Lee, 2011). For example, with increased age, Caucasian-White 6- to 10-month-old infants fixated more on the eyes of own-race faces and less on the mouths (Wheeler et al., 2011). In another study, Chinese 4- to 9-month-old infants fixated significantly less on the noses of Caucasian-White faces but no changes in age were seen when scanning own-race Chinese faces (Liu et al., 2011). Thus, it is also possible that infants in Kelly et al. (2007b, 2009) who showed an onset of ORE at 9-months of age are beginning to shift their fixation to internal facial information and process faces by using strategies developed for own-race and other-race recognition.

5.2.2 Perceptual narrowing. There is evidence in support of the proposal that the face-perception system is broad and unspecified and becomes tuned and shaped by the faces experienced in the environment in the first few months of life. For example, no preference for race, gender, and species is found in newborns (Kelly et al., 2005; Quinn et al., 2008; Sugita, 2008) but preferences for own race (Kelly et al., 2005, 2007), female gender (Quinn et al., 2002, 2008), and own species (Di Giorgio et al., 2012a, Di Giorgio et al., 2012b) emerge at about 3-months of age. Thus, the face perception system for species, race and gender is not specified at birth, but three months of visual experience with exemplars of a particular category are sufficient to shape and specialize the face system to become race, gender, and species specific. In the same vein, studies of face discrimination also showed an initial broad discrimination ability for species (Sugita, 2008) and race (Kelly et al., 2007b, 2009) that becomes specialised to experienced faces with development. However, if 3-month-old infants (broad discrimination of own-race and other-race faces) in the work by Kelly et al. (2007b, 2009) were discriminating faces according to external facial information, it remains unclear if infants have a broad perceptual ability where they can discriminate faces within their own-race and other-race when external facial information is reduced.

Together, these findings suggest that, although certain facets of face processing expertise (such as an initial broad perceptual ability to identify faces) are seen early in life, not all are. Specifically, an initial broad perceptual ability was found in preferential studies (on human infants) for species, race, and gender, and discrimination studies (on non-human primates) of own- and other-species. However, the initial broad perceptual ability in discrimination studies on human infants remains to be unanswered. One of the tasks for future research is to understand how these various aspects of face processing develop and interact with each other. In particular, when external facial information is reduced, will the initial broad perceptual ability still be found in infants younger than 4-months?

5.2.3 What experience matters? A related question of interest is what particular component of experience is most responsible for improving infants' visual responsiveness and discrimination: characteristics of the caregiver's face versus characteristics of face from general experiences. For example, within the homogeneous population, most infants' primary caregiver is female of the same race. In addition, they have general experiences with non-caregiver female, same race faces (Ramsey-Rennels & Langlois, 2006; Rennels & Davis, 2008). It is unclear whether it is the single caregiver's face or the multiple non-caregiver faces or their combination that is providing the crucial experience. However, based on the findings of Malaysian-Chinese infants, it is certain that general exposure alone (to Malay faces) is not sufficient to lead to a recognition advantage for these faces: at 4 months the advantage is limited to female Malay faces. The female Malay recognition advantage would appear to result either from specific exposure to a female Malay carer, or exposure to a number of female Malay faces. Therefore, it is still possible that infants' representation derives either from experience with a primary caregiver, or from a combination of experience of caregiver and other females.

Importantly, the current research suggests early experiences to be critical for learning to individuate faces. This leads to another relevant question, that is, what kind of experience is sufficient to lead to discrimination within a particular category? Scherf and Scott (2012) proposed that the developmental task of forming an attachment relationship fundamentally drives face recognition advantages (species, race, gender) and that the developmental trajectory of these recognition advantages follows the formation of an attachment relation. It would seem that the current findings suggest infants initially form an attachment relationship to a female Chinese and a female Malay in the heterogeneous population and to a female Caucasian-White in the homogeneous population. According to an attachment-based account, as infants establish additional attachment relationships with other individuals (e.g., male caregivers), their representational space for faces will self-organise to reflect the perceptual characteristics of these other individuals. Therefore, instead of suggesting a purely experienced-based explanation in understanding the ORE in infants, it is likely that social factors such as attachment relationships may influence how infants attend and process certain faces.

Furthermore, this suggestion could also explain why 9-month-old infants from the heterogeneous population did not demonstrate any novelty-preferences for female Malay faces. One possible explanation is that the quality of experience with the Malay race differs at different points of development. Although all infants in this study have a live-in Malay house helper through to the current age of testing (9-months old), the domestic helper's caregiving role may be more prominent in younger infants in comparison to older infants. These differences in caregiving role at different points of development could be explained by traditional confinement practices (Pillsbury, 1978) that many new mothers in Malaysia perform after birth[7]. Nonetheless, these are all speculations at present.

As far as experience is concerned, findings from the homogeneous population suggest that the quantity of experience is on its own sufficient to explain the other-race effect in infants. In contrast, the differences in pattern of findings for 4- and 9-month-olds Malaysian-Chinese infants in recognising female Malay faces suggests the importance of considering quality of interactions at different age points. Given the uncertainties about quantity and quality of interactions, future research should aim to quantify information about infants' facial experience with familiar and unfamiliar

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[7] Confinement practices are postnatal exercises aimed at helping a new mum to recover from the rigours of pregnancy, labour, and birth. During the one-month confinement period, mothers will have either a confinement lady and/or a live-in Malay house helper to assist in bathing the baby, feeding, and generally caring for the baby (Devashayam & Brooks, 2012; Brooks, 2012) so that the new mother can rest.

individuals over the course of development and how these differ at different age points.

6 Summary and Conclusions

Overall, the current research demonstrated an onset of ORE at 4 months of age and that it coincided with infants' experiences with gender and race at that period of time. Recognition at 4 months is initially limited to female own-race faces, and in the Malaysian-Chinese sample this extends to female Malay faces. A plausible basis for these results is that specialisation occurs for faces resembling the gender and race(s) of infants' primary caregiver(s). In contrast, by 9 months specialisation is broadened with respect to gender to apply to male and female faces corresponding to the race of both parents. At the same time, the advantage for Malay faces disappears and this may be explained by traditional confinement practices. A population difference was also found in the 4-month-old novelty preference for own-race female faces, which may be explained by the delayed onset of own-race recognition advantage for infants from a heterogeneous population (Gaither et al., 2012) compared with infants from a homogeneous population (Hayden et al., 2007a; Sangrigoli & de Schonen, 2004). Finally, it has also been suggested that the emergence of ORE at different ages arises from experience as well as preference with faces.

Although the experiments in this chapter leave for room to expand in terms of exploring discriminative ability of infants younger than 3 months of age, and quantifying infants' gender and racial experiences, the findings from this chapter still provide important information on the development of the other-race effect. In particular, information is provided regarding the role of experience, how infants process facial information, and population differences that appear to differentially influence the developmental trajectories of the other-race effect. By investigating heterogeneous and homogeneous populations, it is possible that both quantity and quality of experiences are important in understanding the ORE and the ever-changing face representation.

CHAPTER FOUR

DEVELOPMENTAL TRAJECTORY OF THE ORE IN CHILDREN: A CROSS-CULTURAL INVESTIGATION

In the previous chapter, we reinvestigated the development of the ORE within the first year of life. The current chapter aims to explore the role of experience on school-aged children by comparing children with multiple racial experiences against children with single-race experience. The same populations as Experiment 3 (Malaysian-Chinese and British-White) of two age groups (5- to 6- year olds and 13- to 14-year olds) were tested by implementing an old/new recognition method on four races of stimuli (Chinese, Malay, Caucasian-White, African-Black). Unlike the British-White children that have predominant experience with Caucasian-White faces, the Malaysian-Chinese children have experiences with Chinese, Malay, and Caucasian-White races. The results corroborate the experience account showing British-White children can recognise own-race Caucasian-White faces while Malaysian-Chinese children can recognise Chinese, Malay, and Caucasian-White faces at the same level but perform more poorly with African-Black faces. In addition, no age-related difference in the magnitude of the ORE was found but instead, a female recognition advantage was established in younger children of the heterogeneous population. Implications of these findings are discussed in relation to the experience account and how the developmental trajectory from infancy to childhood may influence the face representation of perceivers with single-race exposure and multi-race exposure.

1 Experiment 4

1.1 Introduction

As indicated in Chapter 1, the most widely accepted explanation of the ORE is the perceptual expertise account. According to this account, the ORE is due to lack of experience in processing other-race faces as opposed to own-race faces in most single-race populations (Chance, Turner, & Goldstein, 1982; Michel, Rossion, Han, Chung, & Caldara, 2006; Rhodes, Brake, Taylor, & Tan, 1989; Tanaka, Kiefer, & Bukach, 2004). However, recently there has been little agreement about how differential experience with own-race and other-race faces underlie the ORE (Slone, Brigham, & Meissner, 2000). As mentioned in the previous chapter on infants, the majority of studies of the other-race effect are from homogeneous populations and very little work has been done on heterogeneous populations, which is even more important in studying the effect of exposure on developing the other-race effect. For example, the conventional experience account is mostly confirmed by studies using individuals living in homogeneous countries where exposure is to faces of a single majority race (e.g., the UK, Africa). Such environments increase the ORE (see Meissner & Brigham, 2001 for a review). However, countries with heterogeneous populations that have considerable exposure to other-race faces such as Malaysia provide environments that could potentially reduce or even eliminate the ORE because of general exposure, social interaction, and media contact (e.g., Tan, Whitehead, & Sheppard, 2012). While studies of exposure training with adults are useful in addressing research questions regarding experience on the ORE, a developmental approach seems better suited to examine how the ORE develops naturally in infants and children. Experiments 1 and 3 have already addressed the

ORE in infants. Therefore, the main aim of Experiment 4 was to extend previous cross-cultural investigation on infants (Experiment 3) to children.

1.1.1 ORE studies in children. Studies of children from 3 years of age using more typical recognition paradigms for discrimination of more than two faces (i.e., forced choice and old/new recognition paradigms), revealed evidence of perceptual narrowing with age that can be explained by the experience account (Chance, Turner, & Goldstein, 1982; Corenblum, 2003; Corenblum & Meissner, 2006; Cross et al., 1971; Feinman & Entwisle, 1976; Sangrigoli & de Schonen, 2004b). These studies were conducted on Caucasian-White individuals where recognition is good for own-race faces, and the interpretation is that this is the result of experience with the majority Caucasian-White race. Further cross-cultural studies testing non-Caucasian-White individuals (i.e., East Asian, African-Black) reinforced the evidence of the ORE (Ellis & Deregowski, 1981; Feinman & Entwisle, 1976; Kelly et al., 2009; Pezdek, Blandon-Gitlin, & Moore, 2003; Sangrigoli et al., 2005). The majority of these studies were conducted on children with single-race experience and showed the typical other-race effect (recognition of own-race better than recognition of other-race), which is consistent with the experience account.

Although Chapter 3 and studies of children with single-race experiences provided evidence showing an own-race recognition advantage (regardless of face gender) from 9 months of age, early racial experiences may not have a lasting impact on this aspect of face processing (e.g., Cross, Cross, & Daly, 1971; de Heering et al., 2010; Hills & Lewis, 2006; Malpass, Lavigueur, & Weldon, 1973). Additional lines of evidence indicate that children's representational space for faces is tuned to represent the race(s) of their ambient environment, not necessarily their own-race (for a review, see Scott et al., 2007). For example, children raised in mixed-race environments show little or no other-race effect (Bar-Haim, et al., 2006; Cross, Cross, & Daly, 1971; de Heering et al., 2010; Feinman & Entwisle, 1976). Specifically, Caucasian-White school-aged children and adolescents from racially integrated neighbourhoods and schools demonstrated comparable recognition between own-race (Caucasian-White) and other-race (African-Black) faces, and made fewer false identifications of African-Black faces than Caucasian-White children and adolescents from racially segregated neighbourhoods (Cross et al., 1971; Feinman & Entwisle, 1976). The differences in pattern of recognition between children raised in single-race population and children raised in multi-race population could certainly be attributed to experiences with certain racial group(s).

1.1.2 Developmental trajectory of the ORE in children. Six studies investigating the ORE in school-age children and early adolescence have produced conflicting evidence regarding the developmental trajectory of the ORE. Some reported age-related changes (Chance, et al., 1982; Goldstein & Chance, 1980; Goodman et al., 2007) whereas others reported no age-related changes (Cross et al., 1971; Feinman & Entwisle, 1976; Pezdek et al., 2003) in the magnitude of the ORE. For example, Chance et al. (1982) tested Caucasian-White children through to adolescence (6-8, 9-11, 12-15 year) in recognition on Caucasian-White and Japanese faces and found developmental increase in the magnitude of the ORE where no ORE was found for the younger age group but ORE was reported in the older age groups. In contrast, one study tested Caucasian-White and African-Black children aged 6-, 8-, and 11-years on their recognition of Caucasian-White and African-Black faces, and found no age-related changes (Feinman & Entwisle, 1976). While recognition memory improved with age, the ORE was evident at all ages. Unfortunately, none of the studies mentioned above had information on the differences in relative and/or meaningful contact that the participants had with individuals outside their race. This information can help reconcile these conflicting findings.

1.1.3 Rationale. Although studies of children from integrated neighbourhoods and schools demonstrate that they can recognise faces of their own- and other-races that they encounter in their general environment, this was not found for our infants in Experiment 3. Instead, Malaysian-Chinese infants from the heterogeneous population showed discrimination ability based on characteristics of their primary caregiver (i.e., female Chinese, female Malay, male Chinese) but not the general environment (male Malays) that they may have encountered. In addition, Malaysian-Chinese infants' recognition for own-race faces was weaker than British-White infants' recognition for own-race faces. Therefore, it is plausible that there are population differences in how faces are represented in the multidimensional face-space.

The current experiment is carried out with the aim to extend findings from infants to school-aged children. This was done to test the magnitude of the ORE when children are immersed socially and perceptually in an environment that has faces of multiple racial groups (including those that are not of race and gender of their primary caregivers)[8] and to uncover any population differences such as weaker own-race recognition found in Malaysian-Chinese infants. As a comparison, population of children that are immerse socially in an environment that has very few faces of other racial groups will also be tested. A second aim of this study was to investigate

[8] This study is in no way a direct comparison between infant and children's ability to recognise faces. It is impossible to do so perceptually and cognitively. The study is carried out with the aim to show that recognition ability is interchangeable even after the face representation has been developed to maximally distinguish between exemplars of familiar categories. Predominant studies on individuals from a homogeneous culture show a consistent pattern of ORE from infancy to childhood. However, by investigating on individuals from a heterogeneous culture, the pattern of ORE from infancy to childhood could address useful questions regarding how ORE develops and modify naturally.

whether there is a developmental trajectory of the ORE across younger and older children. Therefore, two age groups will be examined in each culture.

Experiment 4 is designed as a cross-cultural comparison between Malaysian-Chinese and British-White children. Across both cultures, children from two age groups (5- to 6-year-olds and 13- to 14-year-olds) will be tested on four races of faces (Chinese, Malay, Caucasian-White, African-Black) on an old/new recognition task. The younger age group was chosen because 5- to 6-year-olds have at least 2 years of experience in school where social interactions with other racial groups are readily available, whereas 13- to 14-year-olds were chosen because of previous findings indicating adult-like expertise by that age (Carey, Diamond, & Woods, 1980; O'Hearn, Schroer, Minshew, & Luna, 2010). In addition, a questionnaire based on three types of contact (everyday contact, cross-race friendship, and media contact) will be included to show demographic differences in levels of experience across population and race.

An interaction between face race and population is expected. If experience (in the form of population data) is sufficient to explain the other-race effect within the heterogeneous population, then children will show comparable levels of performance for experienced Chinese and Malay faces but will demonstrate the other-race effect with less experienced Caucasian-White and African-Black faces. Alternatively, if these children turn out to be good at Caucasian-White and/or African-Black faces, the contact questionnaire results will be incorporated to determine modifying influence of the relevant social factors. Children from the homogeneous population, on the other hand, were hypothesised to show indication of the other-race effect with superior performance on their own-race Caucasian-White faces and poorer performance on the less experienced races (Chinese, Malay, and African-Black). Furthermore, based on the finding from Experiment 3, showing weaker own-race recognition advantage in the heterogeneous population than the homogeneous population, a specific portion of the face race and population interaction will be investigated.

Finally, in investigating the developmental trajectory of the ORE across children and adolescence, main effects of age and face race would suggest no age-related changes, whereas first-order interaction between age and face race and/or second-order interaction between age, face race, and population would suggest age-related changes in the magnitude of the ORE.

1.2 Method

1.2.1 Participants. A total of 90 Malaysian (52 girls, 38 boys) and 83 British-White (45 girls, 38 boys) children between the ages of 5 to 6 and 13 to14 years were recruited from pre-schools and secondary schools in Kuala Lumpur, Malaysia, and in Lancashire and Pembrokeshire, United Kingdom. The majority of participants recruited from Malaysia were of the Chinese ethnic group (n = 68) while the others were a mixture of Malay (n = 7), mixed race (n = 12), Indian (n = 3), and non-Malaysian (n = 15) ethnic groups. Only those of the Chinese ethnic group were included in the analysis. The final sample consisted of 68 Malaysian-Chinese children (5- to 6-year-olds: n = 37; 20 girls, 17 boys; 13- to 14-year-olds: n = 31; 14 girls, 17 boys) and 83 Caucasian-White children (5- to 6-year-olds: n = 48; 23 girls, 20 boys; 13- to 14-year-olds: n = 35; 18 girls, 17 boys). All participants had normal or corrected vision.

1.2.2 Stimuli and measures. The stimuli were selected from the original 90 faces (30 Malaysian-Chinese, 30 Malaysian-Malay, and 30 Caucasian-White) from Chapter 3 and 30 African-Black faces. Sixty-four images were selected for the experimental trials based on 40 independent observers from Malaysia and the United Kingdom ratings on clarity, face typicality and attractiveness. This set consisted of 16 Malaysian-Chinese, 16 Malaysian-Malay, 16 Caucasian-White, and 16 African-Black faces, with an equal number of males and females in each race. Each of the selected 64 adults faces were photographed in two orientations (frontal orientation and a ¾ profile orientation) leading to 128 images in total. In addition, 8 pictures served as "practice" stimuli (famous Disney cartoon characters; Mickey Mouse, Minnie Mouse, Donald Duck, and Daisy Duck, and four novel human faces not used in the experimental trials). As in Experiment 1 and 3, the selected photographs were full-faced, colour portraits, cropped to the same oval shape (using Adobe Photoshop) with little hair information within the cropped shape, and approximately the same quality (e.g., face size, photo clarity, and included a black background). All pictures including the practice stimuli measured 3 x 4 inches, were laminated, and presented in the form of picture cards.

A questionnaire about children's opportunity of contact, cross-race friendship, and media contact with the four races (Chinese, Malay, Caucasian-White, and African-Black) was administered. The questionnaires differed according to age of participant. For the younger age group, the questions were presented in the form of an informal chat and children's replies were circled by the experimenter based on a 3-point Likert scale. For the older age group, the questions were presented in the form of a questionnaire and participants themselves answered the questions based on a 5-point Likert scale. Each question was asked for each of the four races in succession.

1.2.2.1 Younger age group. The opportunity for contact measure consisted of one item: "Do you see a lot of (insert race) people outside your school and home?" (1 = never, 2 = sometimes, 3 = all the time). Higher scores reflected greater contact. The cross-group friendship measure consisted of two items: “How many friends do you have inside school who are (insert race)?” (1 = none, 2 = one to four, 3 = five or more), “How often do you spend time with your (insert race) friends when you are inside school?” (1 = never, 2 = sometimes, 3 = all the time). Higher scores indicated more cross-group friendship. Two items of opportunity for media contact was also measured: “How often do you see (insert race) people on the television?” and “How long do you spend watching (insert race) on the television?” (For both items, 1 = never, 2 = sometimes, 3 = all the time). Higher scores indicated more media contact.

1.2.2.2 Older age group. The opportunity for contact measure consisted of one item: “How often do you see people of these racial groups outside school and home?” (1 = never, 2 = occasionally, 3 = sometimes, 4 = quite a lot, 5 = all the time). Higher scores reflected greater opportunity for contact. The cross-group friendship measure had two additional items given that the study was in the context of a high school. The measure consisted of four items: “How many close friends do you have outside school who are (insert race)?” (1 = none, 2 = one, 3 = two to five, 4 = five to ten, 5 = over ten), “How often do you spend time with these friends when you are outside school?” (1 = never, 2 = occasionally, 3 = sometimes, 4 = quite a lot, 5 = all the time), “How many close friends do you have inside school who are (insert race)?” (1 = none, 2 = one, 3 = two to five, 4 = five to ten, 5 = over ten), “How often do you spend time with these friends when you are inside school?” (1 = never, 2 = occasionally, 3 = sometimes, 4 = quite a lot, 5 = all the time). Higher scores indicated more cross-group friendship. Two items of opportunity for media contact was also measured: “How often do you see these people in the media (television/magazine)?” and “How long do you spend viewing media (television/magazine) of these racial groups?” (For both items, 1 = never, 2 = occasionally, 3 = sometimes, 4 = quite a lot, 5 = all the time). Higher scores indicated more media contact.

1.2.3 Design. The experiment used a 2 x 2 x 2 x 2 x 4 x 2 mixed factorial design. The independent variables were population (heterogeneous, homogeneous), participant age (5 to 6 years, 13 to 14 years), participant gender (girls, boys[9]), order of stimuli orientation (frontal-profile, profile-frontal), face race (Chinese, Malay, Caucasian-White, African-Black), and face gender (female, male), with the latter two as repeated measures.

As in Experiment 1 and Experiment 3, the images for each combination of face race and face gender consisted of familiarisation and test faces. The test faces were always displayed in the same orientation, and this orientation was always different from the orientation of the familiarisation faces. There were two different orientation order conditions. In the frontal-profile condition, children were familiarised to frontal view faces followed by test faces in a ¾ profile view. In the profile-frontal condition, the familiarised faces were in ¾ profile view and the test stimuli were in frontal view. The changing of face orientation between the familiarisation phase and test phase helped to ensure that children demonstrated genuine face recognition abilities rather than just pattern matching.

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[9] We will address participant gender as girls and boys to avoid any confusion between face gender's (female and male) label

1.2.4 Procedure. Each participant went through one practice recognition test and three blocks of recognition tests followed by a questionnaire phase. Within each recognition test, the children began with a familiarisation phase, followed by a 2-minute unrelated filler task and a subsequent recognition memory test.

1.2.4.1 Familiarisation phase. Participants were told that the study was concerned with the memory and judgement of faces and were informed that they should indicate, for each picture in the photo album, whether the target person is attractive or not. However, data for attractiveness were not analysed as the rating exercise was included to ensure that participants were attending to each face when familiarising themselves with them. Participants then viewed and judged 4 practice pictures, one at a time. All faces were shown for approximately 3 seconds or until the child provided a response. Although research by Ellis and Flin (1990) suggests that inspection and delay intervals are of minimal importance to the face recognition of children at the ages examined here, a period of 3 second was chosen because it is common for this type of face recognition research in children (e.g., Baenninger, 1994; Friere & Lee, 2001). Immediately following picture presentation, a 2-minute unrelated interactive filler task (trivial questions) was administered (refer to Appendix A for an example).

1.2.4.2 Test phase. This phase entailed an old/new recognition task on an intermixed set of previously seen and novel faces. During this phase, participants were told that the task now involved memory for faces and were asked to indicate which faces they thought they have been shown previously. Participants were sequentially shown 4 practice study pictures of a different orientation from the original (i.e., ¾ profile) intermixed with 4 practice distracters of the same ¾ profile orientation. They were not told the number of target pictures seen previously. After each practice response, feedback was given. Once the experimenter was confident that the children understood the recognition task, the actual recognition test was carried out.

The difference between the practice recognition test and the actual recognition test was in the number and types of pictures used, and whether feedback was provided. In the actual recognition test, a series of 8 pictures were studied (Chinese female, Chinese male, Malay female, Malay male, Caucasian-White female, Caucasian-White male, African-Black female, and African-Black male) and 16 were tested (8 old and 8 new). No feedback was provided for the actual recognition test. In total, there were three blocks of recognition tests.

1.2.4.3 Questionnaire phase. During this phase, the younger children had an informal chat with the investigator, whereas the older children completed the questionnaire about their experiences with all four races. Two faces (1 female and 1 male) of each race were shown to indicate the race referred to in the questions (8 faces in total).

1.3 Results

1.3.1 Data transformation. Within the other-race effect literature focussing on children and adults, the common means of indexing recognition is using signal detection parameters. Signal detection theory attributes responses to a combination of sensitivity and bias (Pollack & Norman 1964). For the purpose of this experiment, a non-parametric measure of sensitivity, A-prime scores (A') and an additional non-parametric measure of response bias (B"D) was recorded. These scores were based on hits and false alarms from the face recognition test. Correct identification of target faces produces a "hit", and inappropriately identifying a novel/foil face as a target produces a “false alarm”. By calculating the sum of hits and false alarms, signal detection can be used to produce nonparametric estimates of signal strength relative to noise (A’), and response strategy/bias (B”D). The nonparametric (A’) was used because the parametric (D’) is not normally distributed and violates the assumptions underlying ANOVA.

A’ ranges between 0 and 1 where zero means no discrimination and one is perfect discrimination. The estimate of performance bias B”D on the other hand ranges between -1 and +1. Participants can either exhibit a conservative response bias of minus 1 (i.e., incorrectly responding that a target is absent, or committing a “miss”), or a liberal response bias of plus 1 (i.e., responding incorrectly that a target face is present when it is actually absent) or a value of zero that signifies no response bias (Macmillan & Creelman, 1991).

1.3.2 Discriminative performance. Preliminary analysis on discriminative performance (A-prime) revealed no significant effect or interactions associated with orientation of stimuli, so the data were collapsed across this factor in subsequent analyses. The transformed data were analysed using a 2 (Population: heterogeneous vs. homogeneous) 2 (Age: 5- to 6-year-olds vs. 13- to 14-year-olds) x 2 (Participant gender: girls vs. boys) x 4 (Face race: Chinese, Malay, Caucasian-White, African-Black) x 2 (Face gender: female vs. male) analysis of variance (ANOVA) with face race and face gender as within-participant factors. The ANOVA yielded three main effects. Firstly, there was a significant main effect of face race, F (3, 429) = 21.45, $p < .001$, $\eta^2 = .130$. Post-hoc Bonferroni comparisons show that Caucasian-White faces (M = .784, range = .760 - .809) were discriminated significantly better than Malay (M = .697, range = .666 - .727) ($p < .001$), Chinese (M = .692, range = .663 - .722) ($p < .001$) and African-Black faces (M = .636, range = .610 - .663) ($p < .001$). Chinese and

Malay faces were also discriminated better than African-Black faces ($p \leq .016$) but discriminative performance was comparable across Chinese and Malay faces (p = 1.0).

Secondly, the ANOVA yielded a main effect of age, $F(1, 143) = 40.967, p < .001, \eta^2 = .223$ where the discriminative score was higher for the older age group (M = .755, range = .731 - .780) than the younger age group (M = .650, range = .628 - .671). Finally, population group yielded a significant main effect, $F(1, 143) = 5.303, p = .023, \eta^2 = .036$. The heterogeneous group (M = .722, range = .698 - .745) performed better than the homogeneous group (M = .684, range = .661 - .706).

These main effects were qualified by first-and second-order interactions. Three first-order interactions (face race x population, face race x participant gender, face race x face gender), and two second-order interactions (face race x face gender x age, and face gender x population x age) were significant. One first-order interaction (face race x face gender) is qualified by a second-order interaction, so the subsequent analysis will look at each first-order interaction apart from the qualified one, then the two second-order interactions.

As seen in Figure 8, the interaction between face race and population, $F(3, 429) = 5.377, p = .001, \eta^2 = .036$, was due to different face race effects between the two populations. The homogeneous group, $F(3, 237) = 19.412, p < .001$, recognised Caucasian-White faces better than Chinese, Malay, and African-Black faces ($p < .001$). Other comparisons were not significantly different from each other ($p \geq .259$). In contrast, the heterogeneous group, $F(3, 192) = 7.18, p < .001$, had significantly better recognition performance on Caucasian-White and Chinese faces ($p \leq .006$), and marginally better recognition performance on Malay faces ($p = .079$) in comparison with African-Black faces. No differences were found across recognition of Chinese, Malay, and Caucasian-White faces ($p \geq .550$). Population differences were found in recognition of Chinese faces, $F(1, 149) = 12.259$, $p = .001$; the heterogeneous group recognised Chinese faces better than the homogeneous group. However, group differences were not found in recognition of Caucasian-White ($p = .220$), Malay ($p = .122$), and African-Black ($p = .075$) faces.

To test for population differences in own-race recognition, a separate analysis was carried out. A comparison between populations was conducted for own-race faces only (homogeneous: Caucasian-White; heterogeneous: Chinese), $F(1, 149) = 4.385$, $p = .038$. Own-race recognition for heterogeneous population ($M = .745$, range = .701 = .788) was significantly lower than own-race recognition for homogeneous population ($M = .806$, range = .772 - .84).

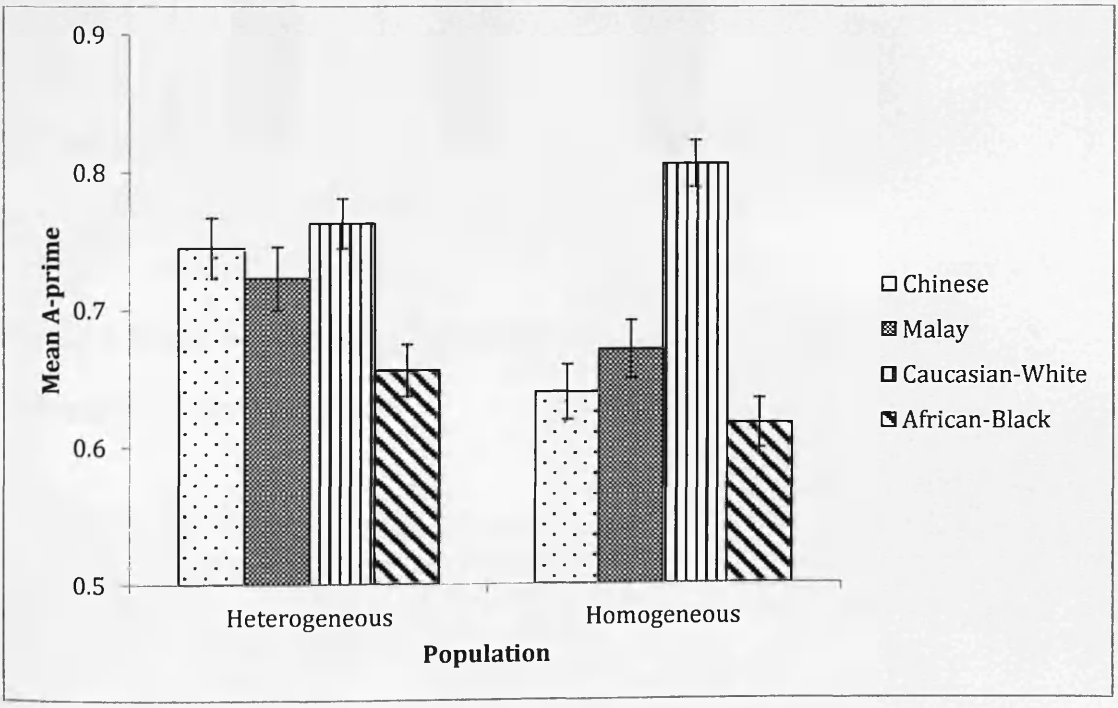


Figure 8. **Mean A-prime and standard error as a function of population and face race, Experiment 4.**

Next, a significant face race x gender interaction, $F(3, 429) = 3.161, p = .029, \eta^2 = .022$, arose because girls were better at recognising both Malay, $F(1, 149) = 6.115, p = .015$, and African-Black faces, $F(1, 149) = 11.294, p = .001$, compared with boys. No gender differences were found for recognition of Chinese ($p = .694$) and Caucasian-White ($p = .273$) faces. See Figure 9 for an illustration.

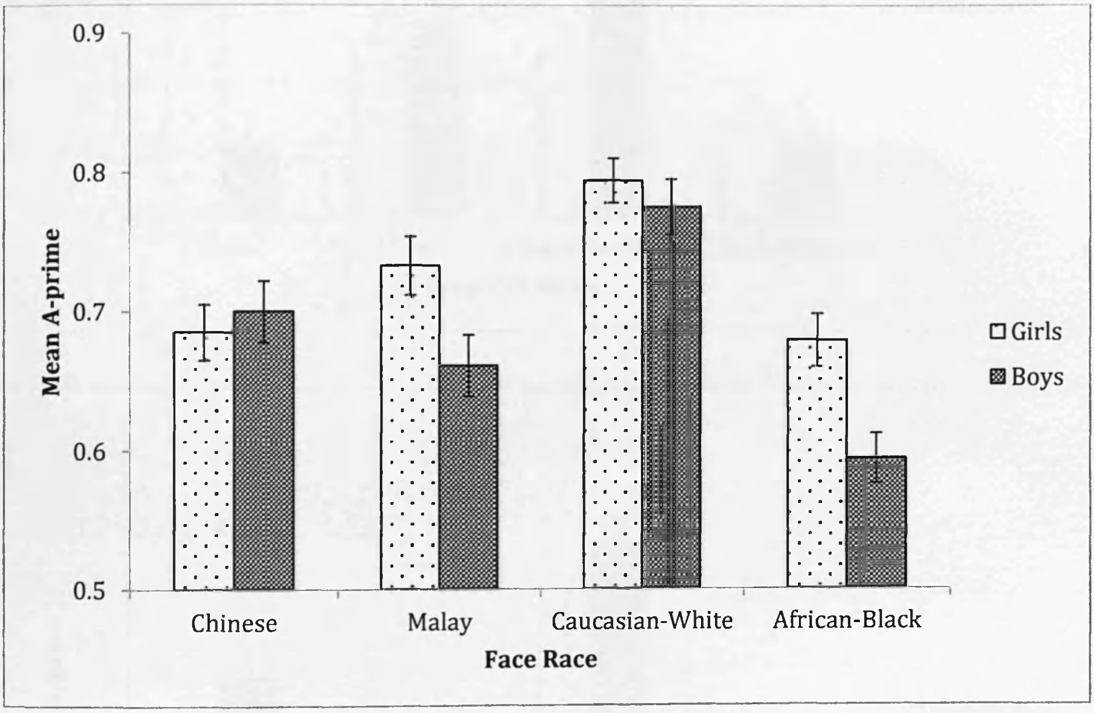


Figure 9. **Mean A-prime and standard error as a function of face race and participant gender, Experiment 4**

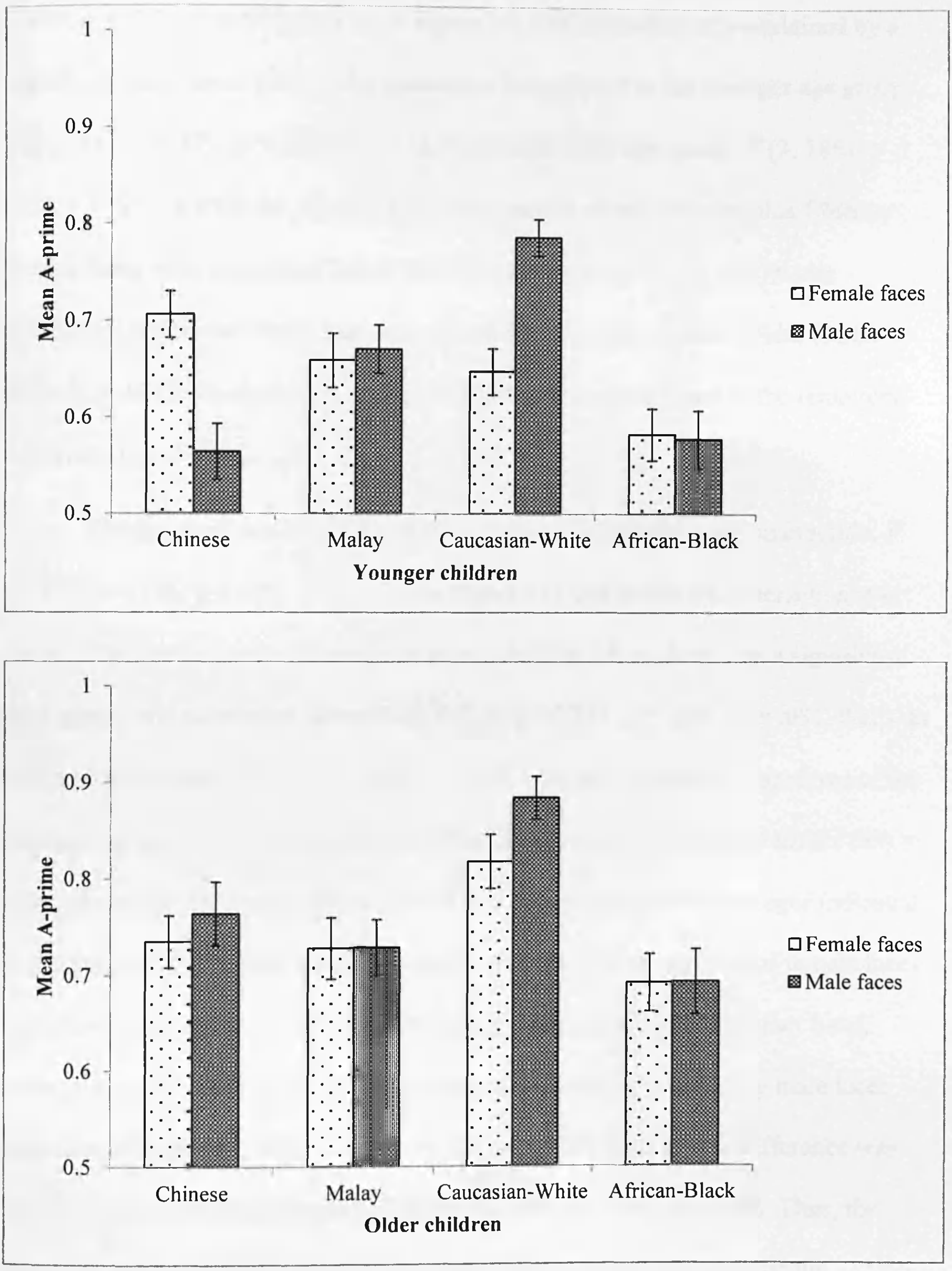


Figure 10. **Mean A-prime and standard error scores for younger children and older children as a function of face race and face gender, Experiment 4.**

The significant face race x face gender interaction, $F(3, 429) = 5.871, p < .001, \eta^2 = .039$, was qualified by a second order interaction with age, $F(3, 429) =$

3.699, $p = .012$, $\eta^2 = .025$. As seen in Figure 10, this interaction was explained by a significant face race x face gender interaction being found in the younger age group, $F(3, 243) = 10.577$, $p < .001$, $\eta^2 = .115$, but not the older age group, $F(3, 186) = .538$, $p = .657$. Within the younger age group, simple effects revealed that Chinese female faces were recognised better than Chinese male faces ($p < .001$) while Caucasian-White male faces were recognised better than Caucasian-White female faces ($p < .001$). No significant face gender differences were found in the remaining face races ($p \geq .646$).

Finally, there was a significant face gender x population x age interaction, $F(1, 143) = 4.876$, $p = .029$, $\eta^2 = .033$ (see Figure 11). As before this interaction was the result of performance difference in young children where there was a significant face gender and population interaction, $F(1, 81) = 7.175$, $p = .009$, $\eta^2 = .081$, that was not in older children, $F(1, 62) = .356$, $p = .553$, $\eta^2 = .006$. Subsequent analyses of the younger age group showed population difference at recognising female faces $t(83) = 4.045$, $p < .001$. Additional comparison of female recognition between ages indicated that young children in the heterogeneous group had better recognition of female faces such that it is comparable with the older age group ($p = .264$). On the other hand, young children from the homogeneous group were better at recognising male faces than female faces $F(1, 46) = 4.432$, $p = .041$, $\eta^2 = .088$. Face gender difference was not found in heterogeneous group $F(1, 35) = 2.956$, $p = .094$, $\eta^2 = .078$. Thus, the three-way interaction is explained by the data from younger children, and the population difference is explained by female faces.

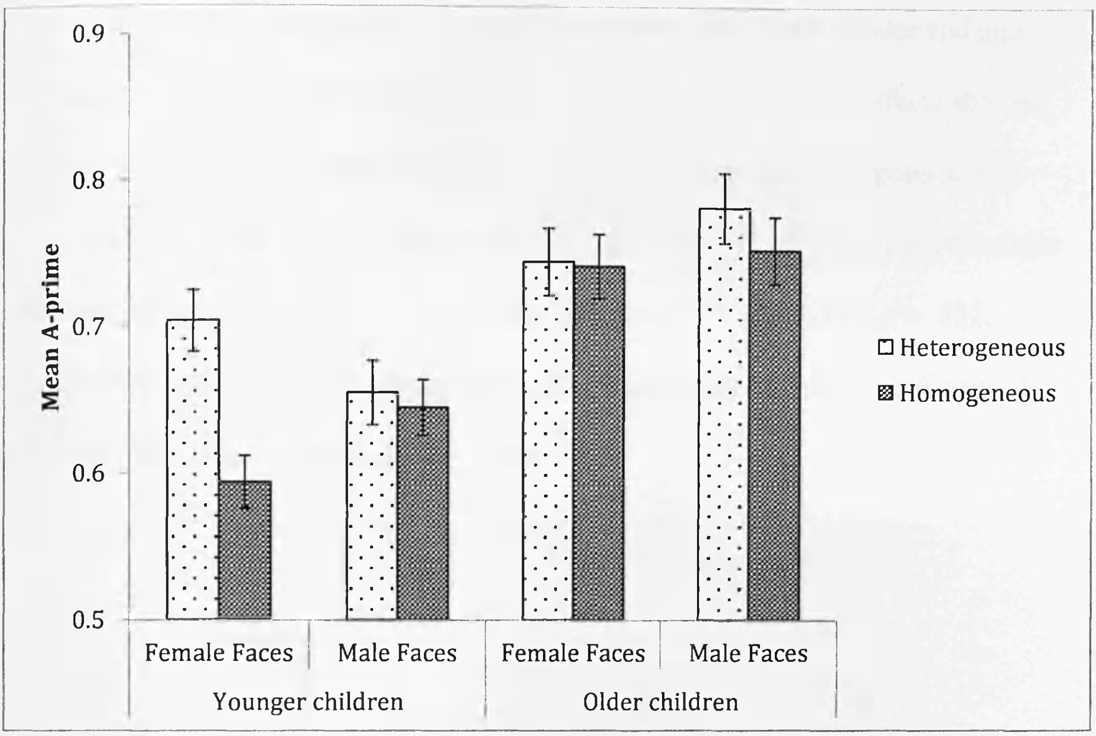


Figure 11. **Mean A-prime and standard error as a function of face gender, population, and age, in Experiment 4.**

1.3.3 Response bias. For response bias (B"D), preliminary analysis revealed no effect of or interactions with orientation of stimuli. In addition, all values were positive (liberal) indicating that a target face is present when it is actually absent. A 2 (Population: heterogeneous vs. homogeneous) x 2 (Age: 5- to 6-year-olds vs. 13- to 14-year-olds) x 2 (Gender of participant: girls vs. boys) x 4 (Face race: Chinese, Malay, Caucasian-White, African-Black) x 2 (Face gender: female vs. male) mixed analysis of variance (ANOVA) with face race and face gender as within-participant factors was conducted. Main effects of age, $F(1, 143) = 12.105, p = .001, \eta^2 = .078$, and face gender, $F(1, 143) = 5.542, p = .020, \eta^2 = .037$, were significant. Younger children responded more liberally than older children did. Response bias for male faces was less liberal than response bias for female faces.

Illustrated in Figure 12, the interaction between participant gender and age was significant, $F(1, 143) = 4.221, p = .042, \eta^2 = .029$. Simple main effects showed younger girls ($M = .673$, range = .582 to .763) to have more liberal responses than older girls ($M = .388$, range = .284 - .492), $F(1, 77) = 17.727, p < .001$, but that there was no such age difference in response bias for boys, $F(1, 66) = .878, p = .352$. Analyses by age revealed no gender differences in response bias for 5- to 6-year-olds ($p = .147$) or 13- to 14-year-olds ($p = .156$).

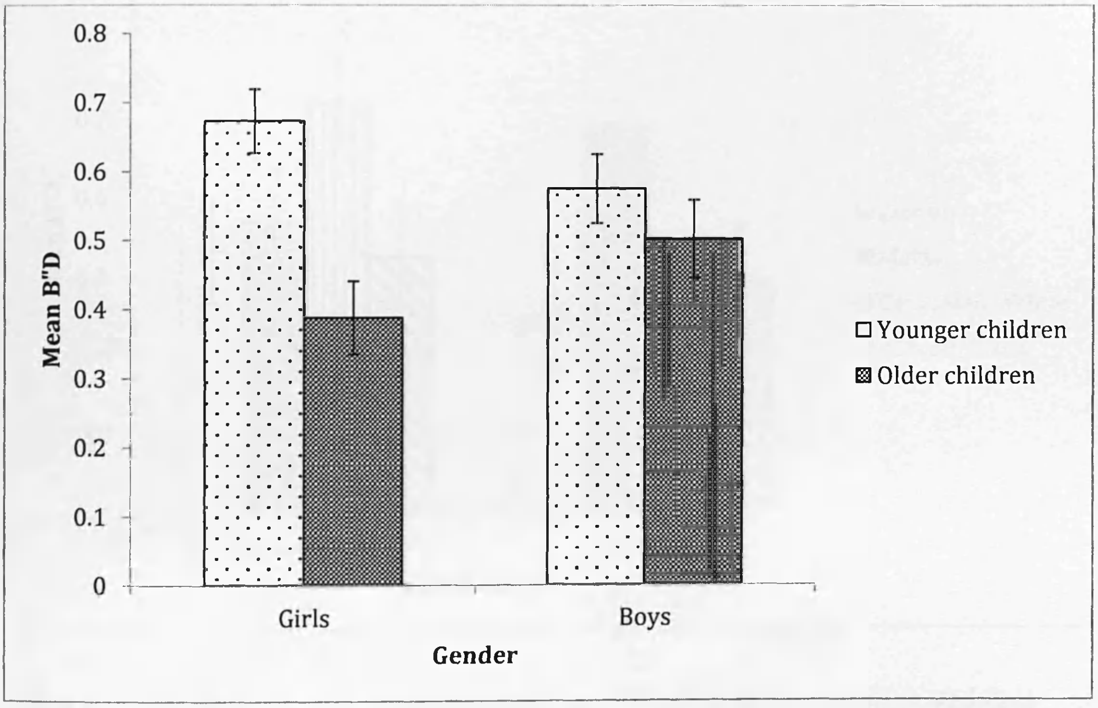


Figure 12. **Mean B"D and standard error as a participants' age and participants' gender, Experiment 4.**

Finally, the face race by face gender interaction was significant, $F(3, 429) = 5.852, p < .001, \eta^2 = .039$. A face gender difference was found in Caucasian-White faces, $t(150) = 4.531, p < .001$, in which there were less liberal responses for male faces than female faces (see Figure 13). No face gender difference in response bias was found in Chinese ($p = .213$), Malay ($p = .15$), and African-Black faces ($p = 1.0$).

Separate analyses by face gender revealed female Caucasian-White faces to yield significantly more liberal response than female African-Black faces, t (150) = 2.431, p = .016, and marginally significant liberal response than female Chinese faces, t (150) = -1.863, p = .064 and female Malay faces, t (150) = -1.902, p = .059. On the other hand, male Malay faces yield the most liberal response than male Chinese, Caucasian-White and African-Black faces, t (150) ≥ 2.148, p ≤ .033.

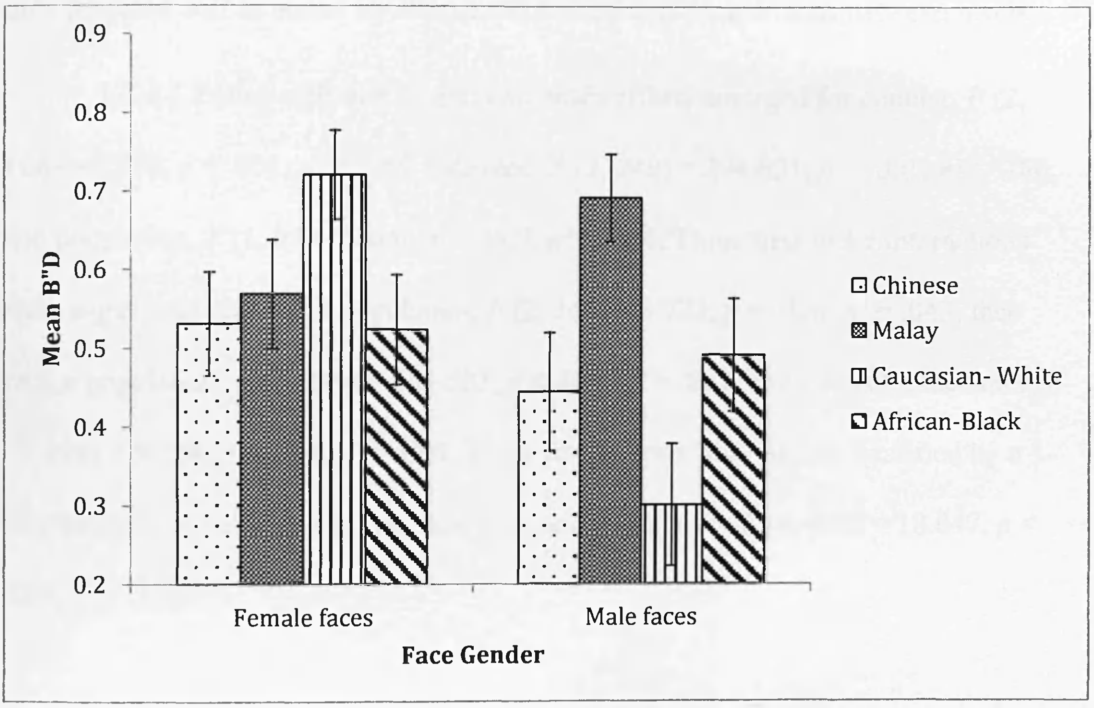


Figure 13. Mean B"D and standard error as a function of face gender and face race, Experiment 4.

1.3.4 Contact scores. Due to the nature of the contact questionnaire (young children using a 3-point likert scale and older children using a 5-point likert scale), separate analyses were carried out for each age group. Of importance is how frequently children from both the homogeneous and heterogeneous populations are exposed to the four racial groups. The results were split into 3 different categories of contact: (1) opportunity of contact (OC); (2) cross-race friendship (CRF); and (3) media contact (MC). Thus, a 3 (Contact: OC, CRF, MC) x 4 (Face race: Chinese, Malay, Caucasian-White, African-Black) x 2 (Population: heterogeneous vs. homogeneous) mixed analysis of variance (ANOVA) was carried out for each age group (5- to 6-year-olds vs. 13- to 14-year-olds) with items and face race as within-participant factors. For this part of the analysis, F-values for main effects and interactions will be reported. However, for the ease of interpreting a large dataset, only p-values will be stated for simple main effect and comparisons between levels.

1.3.4.1 Young children. Significant main effects emerged for contact, $F(2, 166) = 7.670, p = .001, \eta^2 = .085$, face race, $F(2, 249) = 294.621, p < .001, \eta^2 = .780$, and population, $F(1, 83) = 7.640, p = .007, \eta^2 = .084$. Three first-order interactions were significant: contact x population, $F(2, 166) = 3.722, p = .026, \eta^2 = .043$, face race x population, $F(3, 249) = 651.503, p < .001, \eta^2 = .887$, and contact x face race, $F(6, 498) = 9.128, p < .001, \eta^2 = .099$. These interactions were further qualified by a 3-way interaction between contact, face race, and population, $F(6, 498) = 18.047, p < .001, \eta^2 = .179$.

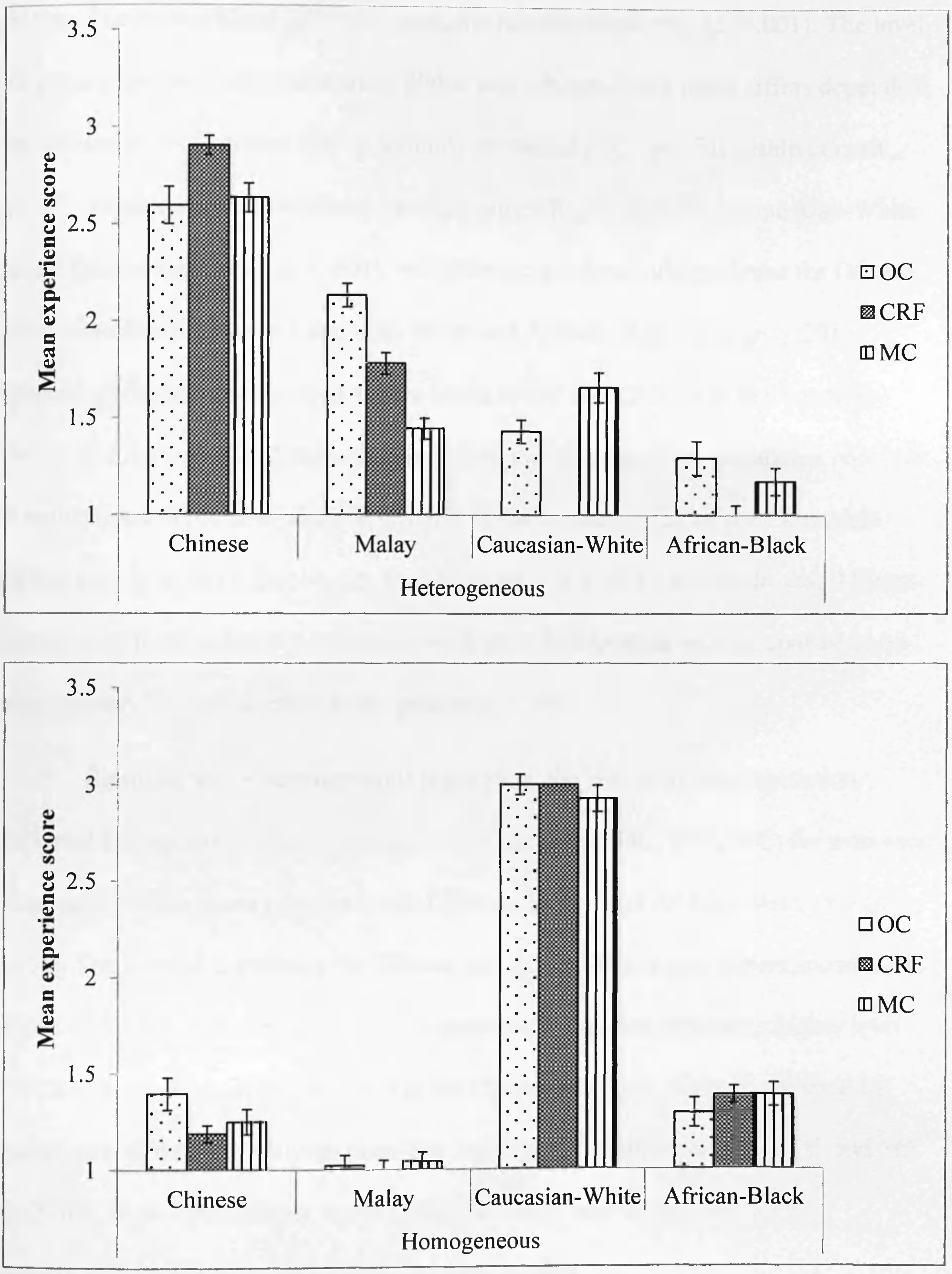


***Figure 14*. Mean and standard error for young children as a function of contact, face race, and population, Experiment 4.**

As seen in Figure 14, the heterogeneous population showed the highest level of experience in all categories (OC, CRF, MC) for own-race Chinese compared with

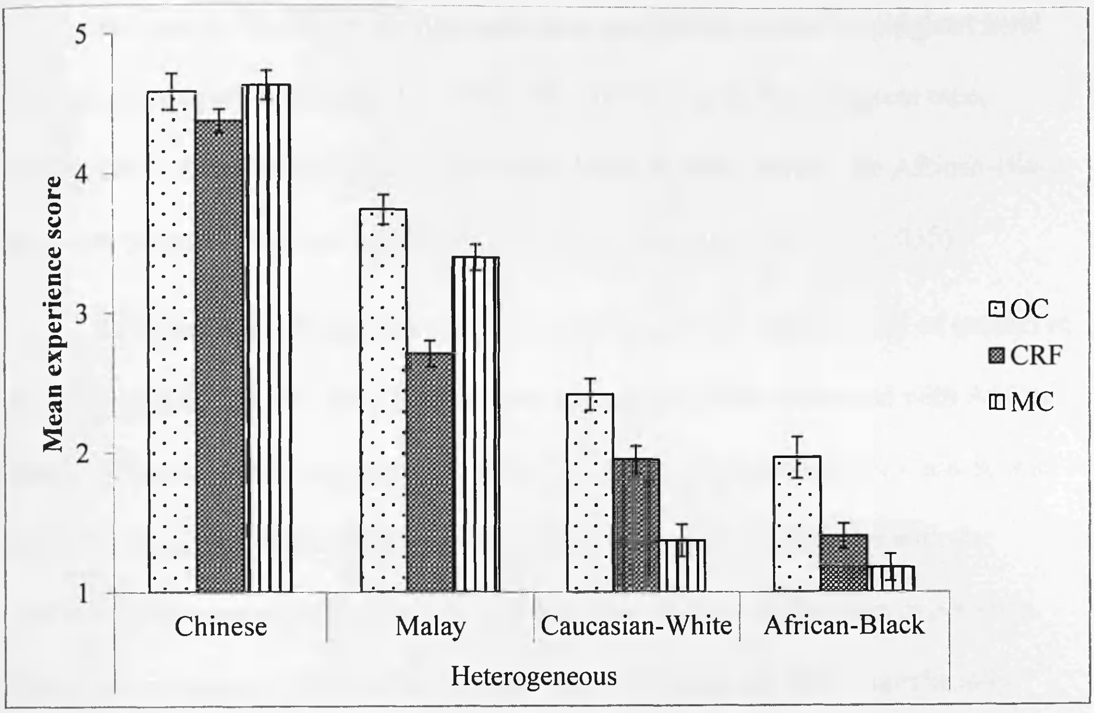
Malay, Caucasian-White, and the lowest, the African-Black race ($p < .001$). The level of experience for Malay, Caucasian-White, and African-Black races differs dependant on the category of contact. For opportunity of contact (OC) and friendship contact (CRF), experience with the Malay race is reported higher than both Caucasian-White and African-Black races ($p < .001$). No differences in level of experience for OC and CRF were found between Caucasian-White and African-Black races ($p \geq .201$). Instead, children reported close to zero levels of OC and CRF for both Caucasian-White and African-Black races. Children from the heterogeneous population reported a higher level of racial experience through media contact (MC) for the Caucasian-White race ($p \leq .034$), followed by the Malay race ($p < .001$), and the lowest African-Black race. In all comparisons, contact with the African-Black race is reported to be significantly lower than other racial groups ($p < .001$)

Similarly to the heterogeneous population, the homogeneous population reported the highest level of experience in all categories (OC, CRF, MC) for own-race Caucasian-White when compared with Chinese, Malay, and African-Black race ($p < .001$). The level of experience for Chinese and African-Black race differs according to types of contact. Children from the homogeneous population reported a higher level of CRF for the African-Black race than the Chinese race ($p = .027$). In contrast, no significant differences between these two racial groups were reported for OC and MC ($p \geq .08$). In all comparisons, contact with the Malay race is reported to be significantly lower than other racial groups ($p < .001$)

Subsequent analyses showed significant differences between population groups in each contact for each race. The heterogeneous population had a significantly higher level of experience in all three categories for Chinese and Malay races than with the homogeneous population ($p < .001$). On the other hand, the homogeneous population reported a higher level of experience in all three categories for Caucasian-White race compared with the heterogeneous population. Finally, the homogeneous population showed significantly higher CRF and MC with the African-Black race in comparison with the heterogeneous population ($p \leq .028$). No differences between populations were found for opportunity of contact (OC) with the African-Black race ($p = .962$).

An additional analysis was carried out to test whether there is population difference in own-race contact measure. A comparison between populations was conducted for contact scores of own-race faces only (homogeneous: Caucasian-White; heterogeneous: Chinese). Population differences were found for opportunity of contact (OC) $F(1, 83) = 22.063, p < .001$, cross-race friendship (CRF) $F(1, 83) = 10.936, p = .001$, and media contact (MC) $F(1, 83) = 9.975, p = .002$. In all comparisons, self-report contact scores for the homogeneous population were significantly higher than for the heterogeneous population.

1.3.4.2 Older children. The contact results for the older children were very similar to those of younger children. The ANOVA revealed three main effects; a main effect for contact, $F(2, 142) = 34.161, p < .001, \eta^2 = .325$, face race, $F(3, 213) = 181.215, p < .001, \eta^2 = .718$, and population, $F(1, 71) = 25.823, p < .001, \eta^2 = .267$. In addition, three first-order interactions were significant: contact x population, $F(2, 128) = 27.566, p < .001, \eta^2 = .128$, face race x population, $F(3, 213) = 405.111, p < .001, \eta^2 = .851$, and contact x face race, $F(6, 426) = 7.746, p < .001, \eta^2 = .098$. These interactions were also qualified by a 3-way interaction between contact, face race, and population, $F(6, 426) = 13.393, p < .001, \eta^2 = .159$.



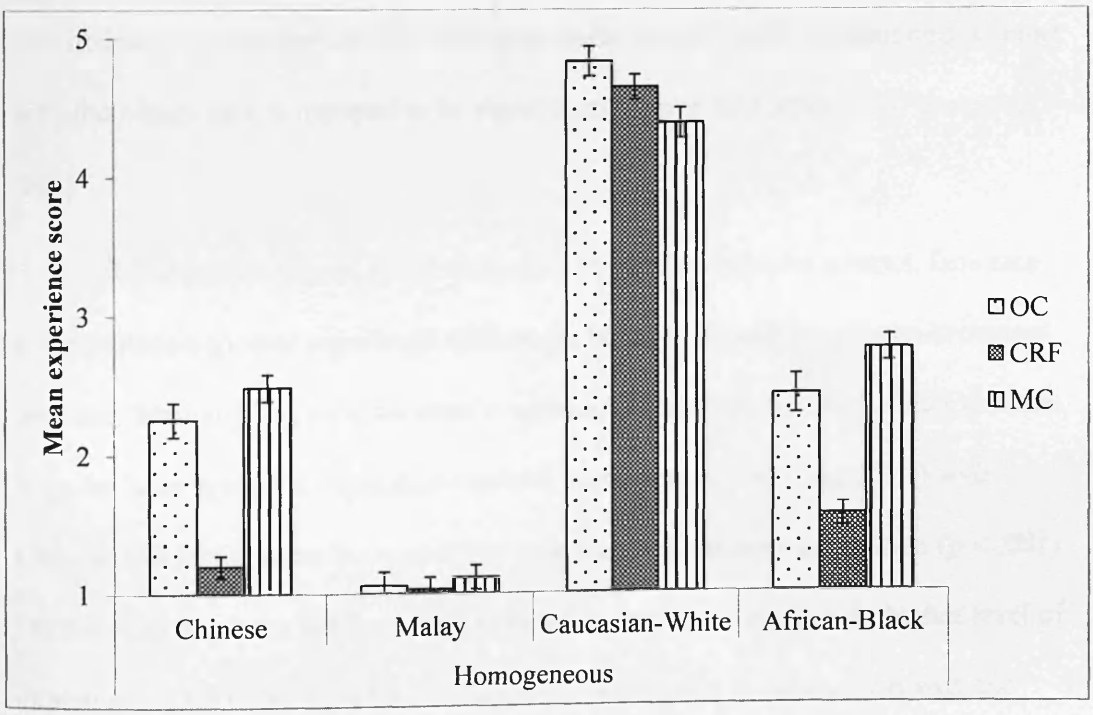


***Figure 15*. Mean and standard error for older children as a function of contact, face race, and population, Experiment 4**

As seen in Figure 15, the heterogeneous population showed the highest level of experience in all categories (OC, CRF, MC) for their own-race Chinese race, subsequently followed by Malay, Caucasian-White, and the lowest, the African-Black race. All comparisons were significantly different from each other ($p \leq .035$).

In contrast, the homogeneous population yielded the highest level of contact in all categories (OC, CRF, MC) for own-race Caucasian-White compared with African-Black, Chinese, and Malay race ($p < .001$). The levels of experience for Chinese and African-Black race differ dependent on the type of contact. Experience with the African-Black race according to CRF and MC was reported higher than experience with Chinese race ($p \leq .035$). On the other hand, OC does not differ significantly between the African-Black and Chinese race ($p = .404$). Instead, children reported a similar level of everyday contact with these racial groups. In all comparisons, contact with the Malay race is reported to be significantly lower than other racial groups ($p < .001$)

Subsequent analyses of the three-way interaction between contact, face race and population showed significant differences between population groups in contact and race. Similarly to young children's report of contact and face race, older children from the heterogeneous population reported more contact (OC, CRF, MC) with Chinese and Malay races in comparison with the homogeneous population ($p < .001$). On the other hand, the homogeneous population reported significantly higher level of experience (OC, CRF, MC) for the Caucasian-White race in comparison with the heterogeneous population ($p < .001$). Finally, the homogeneous population reported significantly higher media contact with the African-Black race in comparison with heterogeneous population but no differences between populations were found for opportunity of contact ($p = .118$) and friendship contact ($p = .118$) with African-Black race, which were low in both cases.

Finally, an additional analysis was carried out to test whether there is population difference in own-race contact measure. In contrast to the analysis of young children, no population difference was found across self-report contact measures (OC, CRF, and MC), $F(1, 64) \leq 2.41, p \geq .125$.

1.3.5 Correlation analyses. A correlation analysis was conducted to investigate relations between the level of contact and discriminative performances of Caucasian-White faces for the Malaysian-Chinese children. This was done to test whether high discriminative scores found for discriminating Caucasian-White faces were related to experiences they have with that race. Since discriminative scores for races did not interact with age, the contact scores were reduced to make it equal across age. The 5-point likert scale for older children was converted into a 3-point likert scale (level1 becoming the new level 1; levels 2, 3, 4 becoming the new level 2; and level 5 becoming the new level 3). This was done to allow the age groups to be combined so as to reveal any relationships between the other variables.

Table 4

Correlations between levels of contact and discriminative score of Caucasian-White race for Malaysian-Chinese children ($N = 68$)

	Opportunity of contact	Cross-race friendship	Media contact
Caucasian-White	0.33**	0.323**	-0.113

$p < .01$**

As seen in Table 4, for children from the heterogeneous population, there is a positive correlation between discriminative score of Caucasian-White race and opportunity of contact (p = .006) and cross-race friendship (p = .007). Supporting the experience account, children that reported higher-levels of Caucasian-White racial experience (environmentally and socially) showed better discriminative ability for that race. On the other hand, the relationship between discriminative score for the Caucasian-White race and media contact was not significant (p = .359).

1.4 Discussion

Experiment 4 examined the ORE in children and adolescents with the aim of extending the investigation of ORE in infants and to understand whether there is a developmental trajectory of the ORE. Firstly, the first-order interaction between age and face race and second-order interaction including population was absent suggesting no age-related changes in the ORE from young children to adolescence. In other words, there is no developmental trajectory of the ORE during childhood. Secondly, the typical other-race effect (recognition of own-race better than recognition of other-race faces) was not demonstrated amongst the heterogeneous group but was found in the homogeneous group. This is likely to be due to differential racial experiences for both populations. Other population differences such as female recognition advantage and in own-race recognition accuracy were also found in this investigation. Finally, further analysis showed that the contact measure may not entirely explain some of these population differences.

1.4.1 Developmental trajectory from childhood to adolescence. As mentioned in the introduction, studies investigating the ORE in school-age children and early adolescence have produced inconclusive evidence regarding whether there is a developmental trajectory of the ORE. In line with the findings on no age-related changes in the magnitude of the ORE (Feinman & Entwisle, 1976; Pezdek et al., 2003) between childhood and adolescence, the magnitude of the ORE was similar across children aged 5-6 years and 13-14 years.

The inconsistency between the results of the present study and those that found age-related changes (e.g., Chance et al., 1982; Goldstein and Chance, 1980; Goodman et al., 2007) might be explained by some shortcomings of their findings. Firstly, although Chance et al. (1982) and Goldstein and Chance (1980) showed evidence of the ORE in Caucasian-White adolescents and adults, 6- to 8-year-olds' discrimination scores were comparable in their recognition of Japanese and Caucasian-White faces. In their study, they reported that the d' scores for the 6- to 8-year-old children were less than chance (i.e., d' < 1.0). The data in the present study of 5- to 6-year-olds and 13- to 14-year-olds showed above chance level discriminative scores $t\ (\geq 65) \geq 4.23, p < .001$. This suggests that perhaps the ORE in younger children in the previous studies was masked by a floor effect, resulting in no own-race recognition advantage.

Secondly, Goodman et al. (2007) also showed evidence of the ORE in 9-year-olds to adulthood but not in 5- to 7-year-olds. However, they combined their analysis of biracial and monoracial children, which could have influenced the data. As seen in the present study, perceivers that have multi-racial experience showed a weaker own-race discriminative score than perceivers with single-racial experience. A point that we will return to in the following section. Instead of interpreting the biracial and monoracial children as a whole, the findings from the current experiment indicate that performance of perceivers with different racial experiences should be interpreted separately in order to fully understand age-related changes of the ORE.

Alongside the information on differences in relative contact that children have with own-race and other-race faces, the current study may have helped to reconcile these conflicting findings in children and provided additional support for no age-related differences in the magnitude of the ORE when racial experiences are consistent.

1.4.2 Contact measure and the ORE. The different ORE patterns found in both populations could be attributed to differential racial experiences. However, the weak correlation may suggest other underlying factors in explaining the ORE. Children from the homogeneous culture showed evidence of the typical other-race effect (Chance, Turner, & Goldstein, 1982; Corenblum, 2003; Corenblum & Meissner, 2006; Cross et al., 1971; Feinman & Entwisle, 1976; Sangrigoli & de Schonen, 2004b) where recognition of own-race (Caucasian-White) was better than recognition of less experienced other-race (Chinese, Malay, and African-Black) faces. The discrimination data for the homogeneous population coincides with the self-reported contact data. In contrast, instead of showing the typical other-race effect seen in homogeneous populations, Malaysian-Chinese children performed equally well on faces that they have experience with in their environment (Chinese and Malay) but they also showed comparable performance on Caucasian-White faces. Self-reported general and social experiences with the Caucasian-White race were found to be positively related to discriminative performance of this race. Although the findings were significant, self-reported contact only explains about 10% of the variance of the discrimination data. So, the contact measure does imply a role but probably a small one.

Nevertheless, this pattern of result is consistent with a recent study of Malaysian-Chinese adults (Tan, Whitehead, & Sheppard, 2012) who performed equally well at recognising Chinese and Caucasian-White faces, but less well at recognising African-Black faces. Tan et al. (2012) explained their findings in terms of Malaysian-Chinese individuals' greater exposure to the Western culture as reflected in the high percentage of English radio stations (an indirect effect) and Western movies shown in Malaysia cinema (Davies, 2011; Epstein, 2011). Still, the self-report media contact with Caucasian-White faces was low in the current study.

The low self-report media contact may be attributed to subjective measures of contact. Recent advances suggest limitations of subjective measures of contact when attempting to understand the relationship between contact and discriminative score (e.g., Meissner & Brigham, 2001; Rhodes et al., 2009). When Rhodes et al. (2009) used two measures of contact with Chinese participants living in Australia (an objective measure - time in Western country; and a subjective measure - self-reported contact), only the former showed a relationship with accuracy scores. It would appear that self-report measures are intrinsically vulnerable to forgetting and memory biases (e.g., over reliance on recent events), and Rhodes and collaborators suggested that this explained the weak effects for that measure. The weak correlation between self-reported Caucasian-White media contact and discriminative scores observed in this thesis and previous studies (e.g., Meissner & Brigham, Rhodes et al., 2009) could arise for this reason. Weak relationships obtained when using subjective measures suggest the importance of taking into account objective measures (Rhodes et al., 2009; Tan et al., 2012) and perhaps even measures from participants' friends and family members (e.g., Turner et al., 2008).

Overall, it appears that the self-report contact measure could explain findings in the homogeneous population but only weakly for findings in the heterogeneous population. This indicates that until objective measures of contact are taken into consideration, it will not be possible to assess the contribution of contact to recognition scores.

1.4.3 Female recognition advantage. Population differences were also found in young children's face gender processing. Young children from the heterogeneous population were more accurate in discriminating female faces across face race[10] in comparison with young children from the homogeneous population. Unlike the older age group, it is found in general that younger children's facial exposure is predominantly female (Rennels & Davis, 2008; Brookes & Devasahayam, 2010). However, the female face recognition advantage seen in 5- to 6-year-old Malaysian-Chinese children may be related to interracial experiences either since infancy or during pre-school. As seen in Experiment 1 and 3, Malaysian-Chinese infants showed that they could discriminate female faces of more than one race whereas British-White infants only discriminated female faces of their own-race. One explanation for female recognition advantage seen in the current study would relate to having had experience with more than one race since infancy. An alternative to this explanation arises from children's experience with female faces of more than one race when immersed into an environment with multiple other-race faces during pre-school. Preschool day-care providers are typically female of more than one race (e.g., Chinese, Malay, and Indian) in comparison with young children from the homogeneous population who also experienced female day-care providers but from a single racial group (Caucasian-White). The female recognition advantage seen in 5- to 6- year old Malaysian-Chinese children may be as a consequence of either

[10] Subsequent population comparisons on female race showed that the means for each race was higher for the Malaysian-Chinese children than the British-White children. However, these means were significantly different for comparisons with female Chinese ($p = .005$), Malay ($p = .009$), and African-Black ($p = .01$) faces but not for female Caucasian-White ($p = .351$) faces.

experiences since infancy or experiences since pre-school or a combination of these experiences.

Based on the contact measure, these arguments could explain the female recognition advantage for Chinese, Malay, and maybe the Caucasian-White faces (based on correlation scores). However, it does not explain children's recognition advantage for females of the African-Black race because children reported virtually no experience with the African-Black race. Possibly, this further calls in doubt the validity of the contact measure. Alternatively, it is possible that the Malaysian-Chinese children were viewing African-Black faces as of Indian race because of their skin colour and attending more to the African-Black race as a consequence. The Indian race is one of the three main races in Malaysia. In more than one case, Malaysian-Chinese children commented on African-Black faces being similar to their year teacher, who was Indian. Therefore, it is plausible that young children with heterogeneous racial experience have a broadly tuned and unspecified face representation for female faces than children with homogeneous racial experience that have a more specified face representation tuned to own-race faces.

1.4.4 Face representation. The current study seems to imply that (1) children from the heterogeneous population have a broader face-space that maximally distinguishes faces of multiple experienced racial groups, and (2) that younger children from the heterogeneous population have a broader face-space that is female-based. In contrast, children from the homogeneous population have a narrowly tuned face representation to distinguish own-race faces only. While the broadly tuned face representation can optimally process experienced other-race faces, such a broad tuning could make the perceiver process own-race faces relatively more weakly than another perceiver with a representation that is narrowly tuned to own-race faces only

(Rossion & Michel, 2011). Indeed, this is what was found. Although Malaysian-Chinese children can discriminate other-race (Malay) faces better than British-White children, discriminative performance for own-race faces was weaker for the Malaysian-Chinese children than the British-White children. This replicated findings in Experiment 3. The current study seems to indicate that there is a recognition trade-off between breadth of face-space and accuracy for faces. Unlike perceivers with a narrowly tuned face-space that process own-race faces more holistically than other-race faces, perceivers with a broadly tuned face-space could process both own-race and other-experienced-race faces holistically (e.g., Michel et al., 2006; Mondloch et al., 2010; Tanaka et al., 2004). To strengthen this argument, it was found that recognition for other less-experienced race (African-Black) for both populations to be modestly stronger in the heterogeneous population than homogeneous population (F $(1, 149) = 3.207, p = .075$). Thus, suggesting a broadly tuned face representation for the heterogeneous population even for other less-experienced race. Nevertheless, this broadly tuned face-space makes the perceiver to process own-race faces less holistically (Rossion & Michel, 2011) and less accurately (Experiment 3 and Experiment 4) than perceivers with a more specifically tuned face-space do.

Interestingly, there is direct evidence for such trade-offs in the data that have investigated the other-age effect. For example, de Heering and Rossion (2008) found that adult preschool teachers (child and adult expert: broadly tuned) processed children's faces more holistically than adults without visual experience with child faces (child novice and adult expert: narrowly tuned). However, the data from their study suggested a reverse effect for adult faces, with more holistic processing by the child novice group (narrowly tuned) than the child expert group (broadly tuned). In the context of own-race and other-race recognition, a similar observation was found suggesting that face representation can either be broadly or narrowly tuned to a specific morphology of faces, depending on the range of visual experience with faces. Moreover, we could also speculate that the face representation has a trade-off effect between breadth of face-space and accuracy for faces.

1.4.5 Gender differences. Further to the main investigation of face recognition advantages, girls were better than boys when recognising other-race faces. Specifically, girls have an advantage over boys in recognising Malay and African-Black faces, whereas both genders performed equally well for faces of the Chinese and Caucasian-White races[11]. Older girls also showed the least response bias in face recognition. A potential explanation as to why gender differences was not found for Chinese faces could relate to the race of the experimenter (Chinese). Therefore, both girls and boys may have selectively attended to these faces. On the other hand, an explanation for the Caucasian-White faces may relate to the nature of the stimuli. This is a point that I will return to extensively in Chapter 5.

Nevertheless, these gender differences are consistent with the finding that females tend to outperform males on face recognition and emotion expression identification tasks (Cross et al., 1971; Ellis et al., 1973; Feinman & Entwisle, 1976; McClure, 2000; Rehnman & Herlitz, 2006, 2007; Temple & Cornish, 1993; Herlitz & Yonker, 2002; Hill et al, 1995). A potential explanation for this effect may have to do with gender differences in visual processing of faces at encoding. For example, Heisz, Pottruff, and Shore (2013) used eye-tracking technology and found that males made fewer fixations than females did when encoding a face. This suggests that they may

[11] When separate analyses was conducted for each population, girls showed stronger advantage in recognition of less-experienced races. In particular, girls in the heterogeneous population had higher accuracy score than boys for African-Black faces (p = .019) while girls in the homogeneous population had higher accuracy score than boys for both Malay faces (p = .004) and African-Black faces (p = .017)

have gathered less perceptual information to establish a memory representation of the newly learned faces. However, gender differences could be reduced with increased exposure (Heisz et al., 2013). In the present study, no gender differences were found for Chinese and Caucasian-White faces but for Malay and African-Black faces. Instead of showing a recognition advantage based on experience, we could speculate that the existing face representation together with social/motivational factors (such as selective attention) may be important in explaining the differences of recognition ability found in girls and boys.

1.4.6 Infancy to childhood. In line with the experience account in understanding the development of the ORE, there seems to be an age-related change in the pattern of performance from infancy to childhood. Although the author is not directly comparing infants' discriminative performance with children's discriminative performance, the aim was to understand whether the same pattern of ORE found in infants could be extended to children. In Experiment 1 and 3, 9-month-old infants from homogeneous and heterogeneous populations showed discrimination ability for both female and male own-race faces. The current study demonstrates that the ORE from 9 months of age can be modified when children are immersed into environments where they reported exposure to other-race faces. This conclusion is in line with studies of adopted children (e.g., de Heering et al., 2010; de Schonen, 2004). Both of these studies showed evidence of modified ORE when infants and children were immersed in an environment with other-race faces.

The overall transition of face processing advantages from infancy to childhood supports Scott and Scherf's (2012) explanation of the discontinuities in face-processing abilities (e.g., transition from a primary caregiver-based gender advantage in infancy to a own-gender advantages in childhood/adulthood). They predict that specific developmental tasks (e.g., forming an attachment relationship with a primary caregiver in early infancy; the social reorientation towards peers in adolescence) fundamentally influence the "computational goals" of the perceptual system, which are ultimately reflected in face-processing advantages. In other words, the face-processing system reorganises itself according to these developmental tasks that are derived from individual's environment. For example, Malaysian-Chinese face-processing abilities make a transition from a "primary-caregiver-based" gender and race advantage into a "broader experienced-based" recognition advantage due to changes in what is important to them in their environment (i.e., female faces). This speculation might also explain why the ORE remains constant from infancy to adulthood when individuals from a homogeneous population are investigated. The experiences for this population are predominantly faces of their own-race unlike the varied races experienced in perceivers from a heterogeneous population. Even though it is impossible to draw firm conclusions without using identical measures across infants and children and a sensitive measure of contact, the current study of the heterogeneous population certainly provides a unique opportunity to understand how the face representation re-organises itself to accommodate changes in experience from infancy to childhood.

1.5 Summary and conclusion.

To summarise, the data indicate that children's face representation remains plastic enough to be modified when confronted with faces of different races and genders at different stages of development. As children immerse socially and perceptually into environments where they are exposed to numerous types of face, children from the heterogeneous population show an interesting developmental trajectory relative to infancy. Firstly, young children from the heterogeneous population showed a female recognition advantage in comparison to young children from the homogeneous population. Secondly, children from the heterogeneous population showed comparable level of recognition for races experienced through everyday, social, and media contact. Thirdly, these children had weaker own-race recognition relative to children from the homogeneous population. The implication is that any face processing advantages and behaviours are functionally related to perceptual and social tasks from infancy to adolescence and the face representation reorganises itself accordingly (broadly tuned or narrowly tuned). However, if racial experiences are consistent throughout development (from childhood to adolescence), no age-related changes are observed. The changes in race and gender processing in the Malaysian-Chinese population may provide us with a unique opportunity to understand how the face representation organises itself to accommodate these changes.

Furthermore, self-reported experiences with different racial groups do not entirely explain the ORE seen in this study. It seems that the contact measure can easily clarify the ORE in the homogeneous population. In contrast, the subjective measure of contact could not entirely explain the ORE in heterogeneous population and findings such as female recognition advantage, weaker own-race recognition advantage, and gender differences. Therefore, in addition to using subjective racial experiences to explain the other-race effect, the findings, especially from the heterogeneous population, suggest that objective measures of contact interacts together with the quality of contact (social and attentional factors) in explaining different face processing differences.

CHAPTER FIVE: A CROSS-CULTURAL INVESTIGATION OF THE INTEGRATION BETWEEN PERCEPTUAL EXPERTISE AND SOCIAL-COGNITIVE MODELS

The ORE in adults has been explained according to two theories: perceptual expertise and social-cognitive accounts. Due to the inconsistency of perceptual expertise and social-cognitive accounts, a new model that integrates these opposing views has recently been developed – the Categorisation-Individuation Model (CIM; Hugenberg, Young, Bernstein & Sacco, 2010). Because previous research on the social-cognitive account and the CIM (Shriver, Young, Hugenberg, Bernstein & Lanter, 2008; Hugenberg et al., 2010; Young, Hugenberg, Bernstein & Sacco, 2012) has predominantly tested this model on adults and has not taken into account the levels of interracial experiences apart from Young and Hugenberg's (2011) study, it is uncertain whether the CIM is applicable to younger age groups and perceivers with different interracial experiences. Therefore, the primary aim of Experiment 5 and Experiment 6 is to test this model by examining the effects of motivation through a non-race based in-group out-group categorisation (personality type) on the ORE. This was carried out with adults (Experiment 5) and children (Experiment 6) from the heterogeneous and homogeneous populations. The findings were that personality affiliation had a different effect depending on population and age. Findings from adults of the homogeneous population support the CIM prediction (interaction between experience and social categorisation) while adults of the heterogeneous population showed an overall recognition advantage for faces categorised as in-group than out-group, which did not support the CIM prediction but the social-cognitive account. In contrast, results for children coincide with the perceptual expertise account. The differing effect from both populations is discussed along the

lines of perceivers face representation. On the other hand, the lack of an effect of the in-group out-group manipulation in children suggests that personality affiliation may not be a suitable basis for in-group out-group social categorisation.

1 Introduction

As mentioned in Chapter 1, there is considerable theoretical debate surrounding the cause of the ORE (see Meissner & Brigham, 2001). Experiments 1 to 4 have demonstrated that the face representation is subject to alteration depending on race and gender experiences at different stages of development and highlights the possibility that perceivers could have a face representation ranging from broadly to narrowly tune. This supports the perceptual expertise account (e.g., Michel, Rossion, Han, Chung & Caldara, 2006; Rhodes, Brake, Taylor & Tan, 1989; Tanaka, Kiefer, & Bukach, 2004). On the other hand, social-cognitive (or sometimes called attentional) accounts argue that the ORE arises as a consequence of perceivers failing to pay attention to other-race individuals and that they automatically encode race specifying information instead of encoding individuating information (Allport, 1954; Levin, 2000; Rodin, 1987; Sporer, 2001). Both the perceptual expertise and social-cognitive accounts have support in the literature (see Chapter 1). However, not all of the motivational or social categorisation manipulations from the social-cognitive account could successfully create or eliminate the ORE (Rhodes, Lie, Ewing, Evangelista, & Tanaka, 2010). Some found an overall effect of motivation to individuate own-race and other-race faces (e.g., Hugenberg, Miller & Claypool, 2007; Pauker, Weisbuch, Ambady, Sommers, Adams & Ivcevic, 2009) while others showed the same effect but only for own-race faces (Bernstein, Young & Hugenberg, 2007; Hugenberg & Corneille, 2009; Shriver et al., 2008).

More recently, rather than continuing the debate between these two accounts, researchers have aimed to integrate the expertise and social-cognitive accounts of the ORE (Hugenberg & Sacco, 2008; Hugenberg et al., 2010; Young & Hugenberg, 2011). The integrative categorisation-individuation model (CIM) suggests that perceiver experience and motivation can act conjointly to produce or even, reduce the ORE. At the core of the CIM is the well established finding that there are two different ways of processing faces during face encoding: categorisation and individuation[12]. The ORE is due to the tendency to *selectively attend* to identity-diagnostic characteristics among own-race faces (i.e., configural information) but to attend to the category-diagnostic features (i.e., skin tone, lip size) of other-race faces (see Hugenberg et al., 2010, *p.* 1170). The CIM also predicts that perceiver experience and motivation to individuate can interact to reduce and create the ORE, which is what we aim to investigate in this chapter.

1.1 Perceiver Prior Experience and Motivation to Individuate

The CIM proposes that a higher level of other-race experience means that less effort is required to individuate and recognise other-race faces, but that experience alone does not necessarily translate into strong other-race recognition. Instead, such experience can be translated into strong face recognition most effectively when perceivers are motivated to individuate. The motivation to individuate has been illustrated in three types of signal to attend: (1) providing perceivers with motivational instructions to individuate other-race faces; (2) characteristics of targets;

[12] Although within the categorisation literature categorisation implies individuation, the terminologies here in Hugenberg et al's Categorisation-Individuation model refers to attention to category level attributes. *Individuation* is the act of discriminating among individual faces within a racial group in which it requires attending to facial characteristics that are identity diagnostic rather than characteristics that are category diagnostic (Hugenberg & Sacco, 2008). Conversely, *categorisation* is the act of attending to the facial characteristics diagnostic of category membership (i.e., characteristics that make a target appear similar to other category members; see Levin, 2000) and does not mean discrimination within that category.

and (3) introducing non-race based in-group out-group social categorisation. For example, Young and Hugenberg (2011) demonstrated that motivation elicited by motivational instruction to individuate other-race faces translated into superior other-race recognition only when perceivers have relatively extensive experience individuating or recognising other-race faces (heterogeneous) and not when they have lack of these experiences (homogeneous). In another study by Young and Hugenberg (2011), it was found that with a sufficiently high level of motivation elicited by characteristics of the targets (using angry faces), even those with lack of other-race experience can be motivated to individuate other-race faces. Based on these findings, Young and Hugenberg propose that different levels of motivation together with different levels of racial experience will facilitate different recognition performance. Specifically, when motivation is weak, high and low experience perceivers will have equally poor recognition. However, at moderate levels of motivation, higher levels of experience will facilitate strong recognition. Finally, very strong levels of motivation are predicted to elicit strong recognition (and eliminate the ORE) for both high and low experience perceivers. The study by Young and Hugenberg (2011) is the first to bridge the expertise and social-cognitive hypotheses by using two of the three signals to attend - motivational instructions and characteristics of targets. However, no studies (to the author's knowledge) have used social categorisation on perceivers with different level of racial expertise to explain the integrated account.

Previous studies motivated by the social-cognitive account (alone) have used non-race based social categorisation (i.e., personality affiliation, university affiliation, social classification) to understand the ORE and face processing (e.g., Bernstein et al., 2007; Cassidy, Quinn, Humphreys, 2011; Hehman, Mania, & Gaertner, 2010; Hugenberg et al., 2007; Shriver et al., 2008). These studies showed an overall effect of social categorisation regardless of experience. Extending Rodin's (1987) logic that social categories can serve as cues for cognitive disregard[13], the CIM predicts that social categories can also serve as a signalling function, cuing perceivers that a group of faces is either important and requires individuation, or is instead relatively unimportant and can be processed superficially. For example, individuals who were categorised as having either "red" or "green" personality types recognised members of their newly found personality type better than members of the other personality type (Bernstein et al., 2007). However, according to the CIM, the success of signal to attend relies on existing racial experiences. Shriver et al. (2008) replicated the in-group out-group effects using different social categorisation cues (i.e., university affiliation, social classification). These non-race based in-group out-group differences, however, were only found for own-race faces and not other-race faces. It is plausible that these demonstrations come from experiments examining perceivers from the homogeneous populations where they have little other-race exposure. If this is true, then findings from Shriver et al (2008) studies are in line with the CIM: high experts (with own-race faces) could show the deployment of (own-race) recognition when those faces are categorised as members of an out-group. On the other hand, low experts (with other-race faces) are suggested to show the typical ORE and no effect from non-race based social categorisation. In other words, perceivers from the homogeneous population show the typical in-group out-group effects for own-race faces only but not for other-race faces.

[13] The cognitive disregard approach suggests that humans act like *cognitive misers* seeking cues for categorisation of individuals as out-group members, enabling them to preserve cognitive resources for more elaborate or individuated processing of in-group members.

1.2 Overview of the Experiments

The review above has summarised recent studies that have attempted to integrate perceptual expertise and social-cognition in understanding the ORE. However, participants' differential visual experiences with other-race faces have not been controlled or noted in any of the above-mentioned studies performed with own- and other-race faces, except in that of Young and Hugenberg (2011). In their study, they observed superior other-race recognition elicited by motivational instructions and characteristics of target. There seem to be different motivational effects in perceivers with heterogeneous versus homogeneous experiences. However, it is uncertain if perceivers' prior racial experiences could explain the effect from using social categorisation cues, and whether the CIM is applicable to younger age groups.

In the current research, the primary aim is to investigate the effect of social categorisation on the perceptual encoding of own-race and other-race faces, with a view to testing and clarifying the Categorisation-Individuation Model. One possible way to provide a coherent picture of social categorisation is to compare perceivers from a single-race population with perceivers from a multi-race population and to investigate the developmental progress of this signalling function. This chapter examines how personality affiliation (Bernstein et al, 2007) affects face processing for experienced- and less-experienced races. Identical to Experiments 3 and 4, the experiments in this chapter will compare recognition of Malaysian-Chinese (heterogeneous) and British-White (homogeneous) participants using stimuli from multiple racial groups (Chinese, Malay, Caucasian-White, and African-Black). As seen in Experiment 4, the Malaysian-Chinese population has multiple racial experiences (Chinese, Malay, Caucasian-White) and could recognise faces of these three races reasonably well (e.g., Tan, Stephen, Whitehead & Sheppard, 2012) as compared with the British-White population (Caucasian-White only).

Two experiments are reported in this chapter. Experiment 5 aimed to investigate the effects of in-group out-group personality affiliation on the perceptual encoding of experienced- and less-experienced races in adults from different population groups. Experiment 6 investigated whether the same pattern of effects would emerge in the younger age groups (5- to 6-year-olds, 9- to10-year-olds, 13- to 14-year-olds). In both experiments, a two alternative forced-choice (2AFC) recognition test was carried out. This 2AFC method was chosen because of the wide age range and cognitive demands from this experiment. Replicating Bernstein et al. (2007), prior to the recognition test all participants completed a personality test that categorised them as having either an "orange" or a "purple" personality type. No description of the personality types was provided. Participants then studied faces of 36 people labelled as belonging to these personality types (i.e., 18 people per personality type).

2 Experiment 5

Experiment 5 examines the effects of non-race based in-group out-group categorisation (personality affiliation) on face processing, comparing adults from heterogeneous and homogeneous populations. Based on past research (Bernstein et al., 2007; Young & Hugenberg, 2011; Shriver et al., 2008), we expect perceivers from the homogeneous population to replicate findings from Bernstein et al. (2007), showing recognition advantage for own-race (Caucasian-White) faces of their newly found personality type. On the other hand, these perceivers are expected to show a deployment of (own-race) recognition when those faces are categorised as members of an out-group and an overall recognition disadvantage for members of other less-experienced races (Chinese, Malay, African-Black). In contrast, perceivers from a heterogeneous population would be expected to show a recognition advantage for experienced races (Chinese, Malay, Caucasian-White) that are categorised as members of their in-group (i.e., own-personality) and recognition deployment for members of the other personality type (Chinese, Malay, Caucasian-White) and an overall recognition disadvantage for the other less-experienced race (African-Black). The recognition advantage-deployment for a specific race would be referred to as an in-group out-group effect for that race. As from Experiments 3 and 4 showing population differences in own-race recognition advantage, specific population comparisons for own-race faces will be conducted to test if the same effect occurs for when social categorisation manipulation is involved.

2.1 Method

2.1.1 Participants. Thirty-four British-White (26 females, 18 males) and 30 Malaysian-Chinese (26 females, 4 males) university undergraduates between the ages of 18-22 from Lancaster, United Kingdom (homogeneous) and Kuala Lumpur, Malaysia (heterogeneous) participated in this study.

2.1.2 Stimuli and measures. The stimuli were the same as in Experiment 4, with the exceptions that the stimuli had coloured borders during familiarisation trials and the study was presented via the PsyScript software (custom written for the Department of Psychology, Lancaster University) on a MacBook Pro. Like Experiments 4, the 64 faces were taken in two orientations (full frontal and ¾ profile view) and the orientation during familiarization was different from orientation at test.

Half of the 32 stimuli in the familiarisation phase were labelled with a purple border and the remaining half were labelled with an orange border. In total, participants were exposed to 16 pictures that had the purple border (i.e., 2 female and male Chinese, 2 female and male Malay, 2 female and male Caucasian-White, 2 female and male African-Black) and another 16 with the orange border (i.e., 2 female and male Chinese, 2 female and male Malay, 2 female and male Caucasian-White, 2 female and male African-Black). These sets were counterbalanced according to colour and orientation.

A personality test was used to create the artificial in-group out-group categorisation. Forty questions taken from the Big Five Personality Test (John & Srivastava, 1999; Appendix C) were presented to participants one at a time on the computer screen. Each question remained on the screen until a response was made. Responses were given on 5-point Likert scales, with higher values indicating greater agreement. The data were not analysed because the assignment to "personality group" was random.

2.1.3 Design. The experiment used a 2 x 2 x 2 x 2 x 4 x 2 mixed factorial design. The independent variables were population (heterogeneous, homogeneous), order of orientation of stimuli (frontal-profile, profile-frontal), personality colour (purple, orange), IGOG (in-group, out-group), face race (Chinese, Malay, Caucasian-White, African-Black), and face gender (female, male), with the latter two as repeated measures. Gender was not considered as a factor in the design because of unequal number of female and male participants.

2.1.4 Procedure. Each participant went through a personality identification test followed by four blocks of recognition tests. Within each recognition test, the participant began with a familiarisation phase, followed by a 2- to 3-minute unrelated filler task and a subsequent recognition memory test phase.

2.1.4.1 Personality identification. Participants were asked to answer a computerized personality test. After completing this test, the computer ostensibly analysed their responses, and informed them that they were either a “purple” or a “orange” personality type. As in Bernstein and colleague’s (2007) study, participants were then provided with the following description:

> “This personality measure has been found to be very good at predicting future success both socially and monetarily. The measure itself is often used by businesses and organisations as a means of identifying strong candidates for competitive positions. Further, psychologists who study relationships often use this personality inventory to identify future success in relationships.”

Participants were given no further description of the personality types. Instead of providing participants with coloured wristband to wear (Bernstein et al., 2007), a purple or orange card indicating their personality type was then presented on the table in between the participant and the computer. They were told that it was to identify them as a member of their particular group.

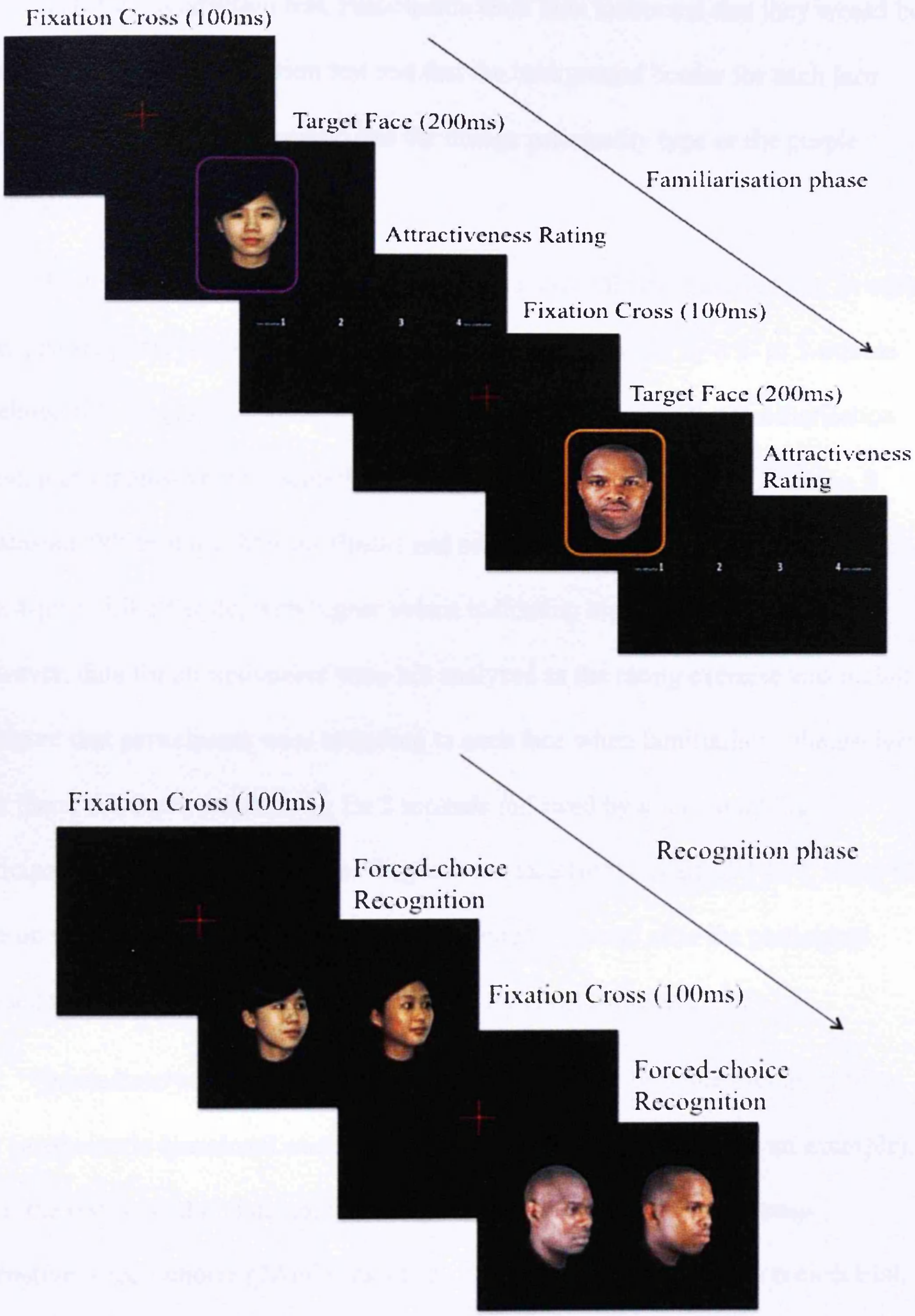


***Figure 16.* Example forced-choice recognition test sequence, Experiment 5 and Experiment 6**

2.1.4.2 Recognition test. Participants were then instructed that they would be administered a face recognition test and that the background border for each face would denote whether that person had the orange personality type or the purple personality type.

Four blocks of familiarisation and recognition trials were carried out. In each block, participants began with a familiarisation phase followed by a 2- to 3-minute unrelated filler task and a subsequent recognition phase. During the familiarisation phase, participants were presented with a series of 8 faces (2 Chinese, 2 Malay, 2 Caucasian-White and 2 African-Black) and asked to judge the attractiveness of each on a 4-point Likert scale, with higher values indicating higher attractiveness. However, data for attractiveness were not analysed as the rating exercise was included to ensure that participants were attending to each face when familiarising themselves with them. All faces were shown for 2 seconds followed by a screen telling participants to rate attractiveness of the just seen face from a scale of 1 to 4, using the keys on the computer. The next face was presented 1 second after the participant pressed the key to give a rating (see Figure 16 for an illustration).

Immediately after the familiarisation phase, a 2- to 3-minute unrelated filler task (mathematic questions) was administered (refer to Appendix B for an example). Next, the test was administered, involving eight trials, each requiring a two-alternative forced-choice (2AFC) response. Two faces were presented on each trial, one of the eight previously viewed faces paired with a novel face. Participants were told that the task now involved memory for faces and were asked to indicate for each pair which picture they thought they have been shown previously. As already mentioned, pairings of faces were matched for race and gender. For example, if the previously seen picture were a male Malay face, the paired distracter would be a novel male Malay face. During this phase of the study, participants were told to respond as quickly as possible. If they do not respond within 3 seconds, a blank screen will appear until the participant indicates a respond using the appropriate key. Upon completion of all four blocks of familiarisation trials and recognition test trials, participants were debriefed verbally. Participants were firstly asked to indicate if they had noted anything suspicious about the study and were asked to guess at the nature of the research. The majority of the participants suspected that the experiment involved social categorisation and memory for in-group faces. None of the participants noted that the experiment was looking at the other-race effect. Next, the experimenter told participants the true nature of the study and that the personality test was not a true indication of their personality type.

2.2 Results

2.2.1 Data Transformation. Unlike the old/new recognition task in Experiment 4, the scores in this experiment were transformed into proportions of hits, which on 2AFC paradigm provide numerical estimates of system sensitivity given by D-prime (D'). This measure ranges between 0 and 1, where zero indicates no discrimination and one indicates perfect discrimination. Indication of performance bias could not be measured in this task.

2.2.2 Discriminative performance. Preliminary analysis of discriminative performance (D') revealed no significant main effects or interactions involving orientation of stimuli or personality colour, so data were collapsed across these factors in subsequent analyses. The data were analysed using a 2 (Population: heterogeneous vs. homogeneous) x 2 (IGOG: in-group vs. out-group) x 4 (Face race: Chinese, Malay, Caucasian-White, African-Black) x 2 (Face gender: female vs. male) mixed analysis of variance (ANOVA) with face race, face gender and IGOG as within-participant factors. Two main effects were significant: face race F (3, 186) = 8.388, $p < .001$, $\eta^2 = .119$, and IGOG, F (1, 62) = 10.325, $p = .002$, $\eta^2 = .143$. For face race, post-hoc Bonferroni comparison showed that recognition score was significantly lower for African-Black faces ($M = .720$, range = .679 - .760) in comparison with Chinese ($M = .836$, range = .803 - .868) ($p < .001$), Malay ($M = .798$, range = .761 - .836) ($p = .006$), and Caucasian-White ($M = .817$, range = .780 - .854) ($p = .002$) races. Comparisons between Chinese, Malay, and Caucasian-White were not significantly different from each other ($p \geq .255$). Main effect for IGOG showed better recognition for faces categorised as in-group ($M = .825$, range = .798 - .851) than out-group ($M = .761$, range = .729 - 792)

The ANOVA also revealed an IGOG by population interaction, F (1, 62) = 5.272, $p = .025$, $\eta^2 = .078$. As seen in Figure 17, only the heterogeneous population showed significantly better recognition for in-group faces than out-group faces, F (1, 29) = 11.344, $p = .002$, $\eta^2 = .281$, and no in-group out-group differences were found for homogeneous population F (1, 33) = .581, $p = .451$, $\eta^2 = .017$.

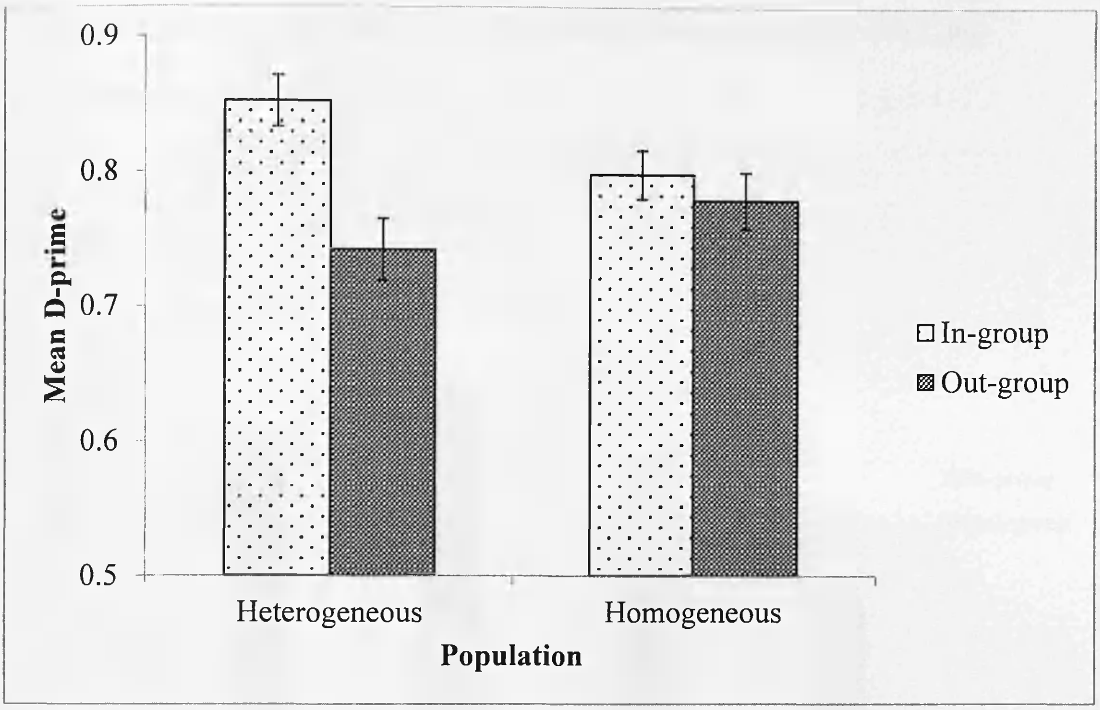


Figure 17. **Mean D-prime and standard error as a function of population and IGOG membership, Experiment 5.**

Although the three-way interactions between face race, IGOG, and population was not significant, $F\,(1, 62) = .269, p = .606$, planned comparisons between IGOG and face race were carried out separately for heterogeneous and homogeneous populations to test whether the in-group out-group effect is found for experienced race(s). For the heterogeneous population the experienced races are the Chinese, Malay, and Caucasian-White. However, IGOG differences were significant for all races; African-Black ($p = .026$), Chinese ($p = .032$), Malay ($p = .039$) races, and marginally significant for Caucasian-White ($p = .16$) race. See Figure 18 for an illustration. In-group faces categorised in these racial groups were recognised better than faces that were categorised as members of the out-group regardless of experience. For the homogeneous population, the experienced race is the Caucasian-White race and the in-group out-group effect was found to be marginally significant for this race ($p = .16$) only and not for Chinese ($p = 1.0$), Malay ($p = .721$), and African-Black ($p = 1.0$) races.

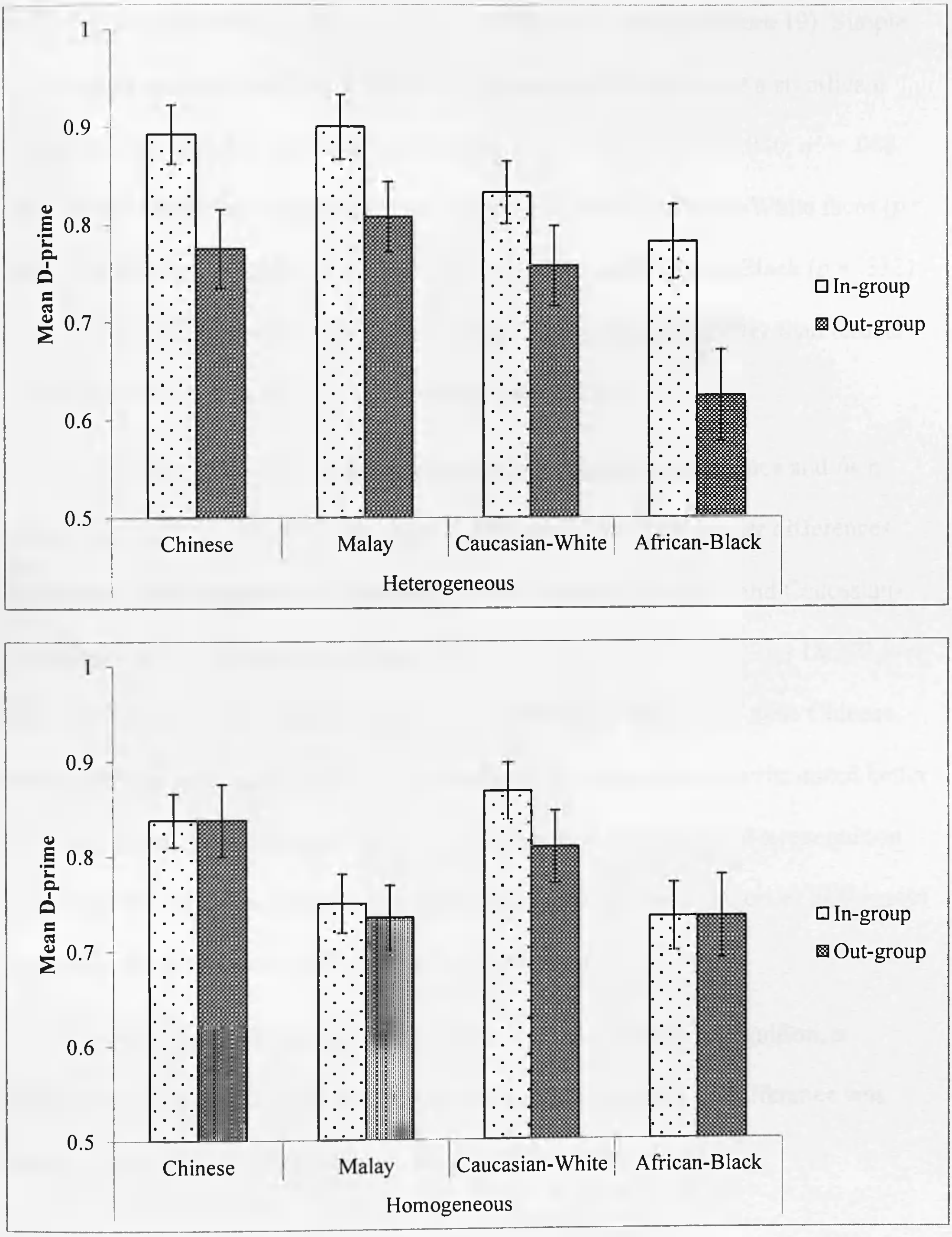


***Figure 18.* Mean D-prime and standard error as a function of population, IGOG membership, and face race, Experiment 5.**

Lastly, a face race by face gender interaction was significant, $F\,(3, 186) = 6.045, p < .001, \eta^2 = .165$. This interaction was qualified by a three-way interaction including population, $F\,(3, 186) = 7.042, p < .001, \eta^2 = .102$ (see Figure 19). Simple main effects revealed that for the heterogeneous population there was a significant interaction between face race and face gender, $F\,(3, 87) = 2.784, p =.046, \eta^2 = .088$. Face gender differences were only seen for recognition of Caucasian-White faces ($p = .002$), but not for Chinese ($p = .745$), Malay ($p = .229$), and African-Black ($p = .332$) faces. Male Caucasian-White faces were recognised significantly better than female Caucasian-White faces for the heterogeneous population.

The homogeneous population also showed a significant face race and face gender interaction, $F\,(3, 99) = 18.202, p < .001, \eta^2 = .355$. Face gender differences were found for recognition of Chinese ($p < .001$), Malay ($p = .001$), and Caucasian-White ($p < .001$) faces but not African-Black faces ($p = .374$), $F\,(3, 99) = 18.202, p < .001, \eta^2 = .355$. Female Chinese faces were discriminated better than male Chinese faces, whereas both male Malay and Caucasian-White faces were discriminated better than their female counterparts. This showed that both populations had a recognition advantage for male Caucasian-White faces, and the remaining face gender differences were seen for adults from the homogeneous population.

Finally, to test for the population difference in own-race recognition, a separate analysis on own-race faces was conducted. No population difference was found for recognition of own-race faces, $F\,(1, 62) = .020, p = .887$

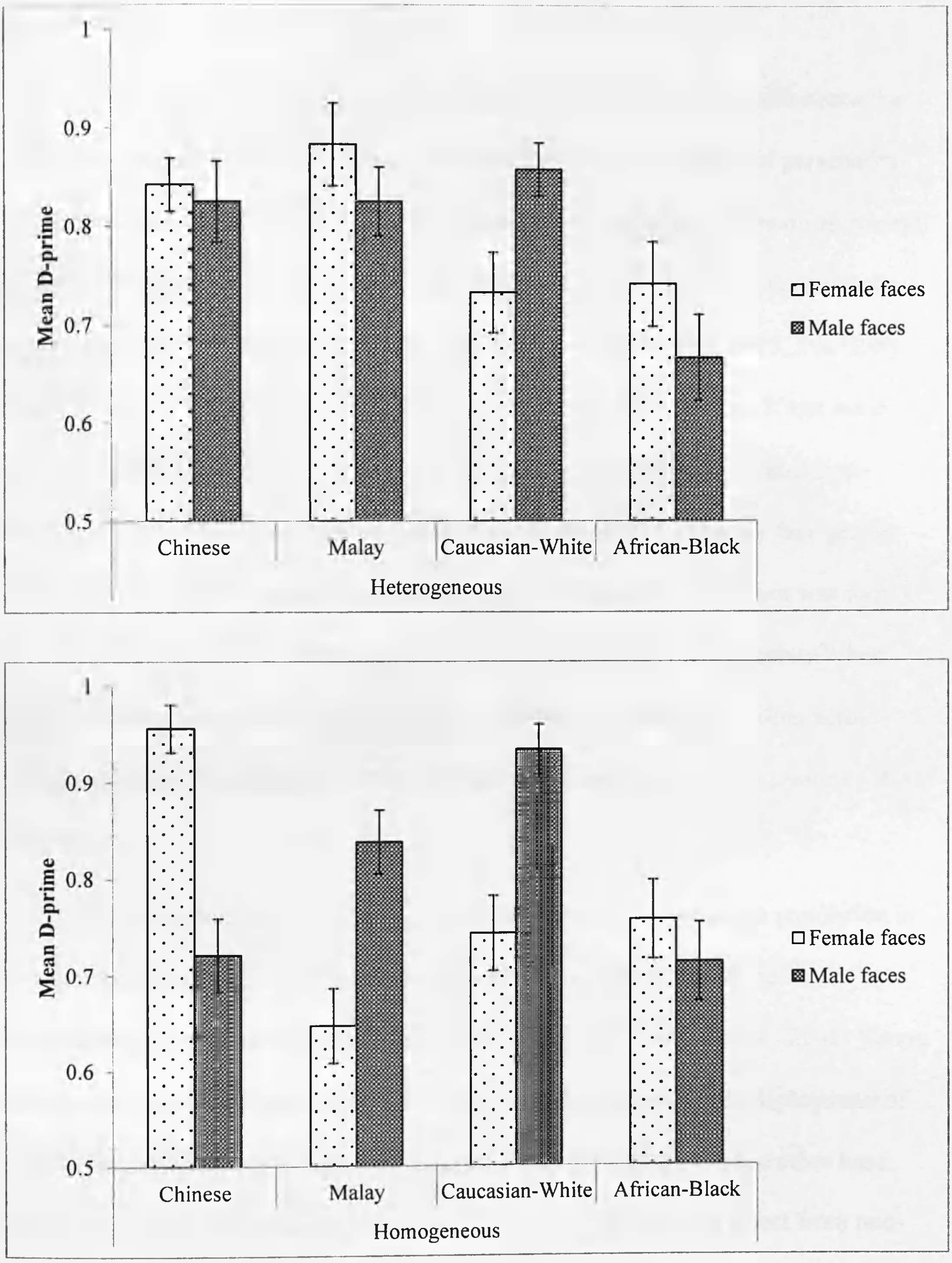


Figure 19. **Mean D-prime and standard error as a function of population, face race, and face gender, Experiment 5.**

2.3 Discussion

Experiment 5 was designed to examine how racial experience influences the perceptual encoding of own-race and other-race faces in the presence of personality affiliation. The results in adults from the heterogeneous population showed an overall in-group out-group effect for all races while the homogeneous population showed a weak in-group out-group effect for own-race faces. As seen in Figure 19, it is likely that the result is influenced by an advantage in recognising Caucasian-White male faces that reduced the effects of in-group out-group categorisation of Caucasian-White faces in general (also seen in Experiment 4). Further analyses by face gender supported this claim[14]. For both population groups, personality affiliation was found for recognition of female Caucasian-White faces but not of male Caucasian-White faces. Instead, recognition of male Caucasian-White faces was near ceiling across both populations. The author will return to this point in the general discussion of this chapter.

The evidence of in-group out-group effects in the homogeneous population in recognition of own-race faces is consistent with previous findings of the categorisation-individuation model (Bernstein et al., 2007; Shriver et al., 2008; Young & Hugenberg, 2011). High experts (with own-race faces) showed the deployment of such expertise when those faces were categorised as out-groups. On the other hand, low experts (with other-race faces) showed the typical ORE and no effect from non-race based social categorisation.

Contrary to the CIM prediction, adults from the heterogeneous population

[14] Prior analyses showed marginal in-group out-group differences for Caucasian-White faces in both heterogeneous ($p = .16$) and homogeneous ($p = .16$) groups. When analysed according to face gender, heterogeneous population revealed social categorisation for female Caucasian-White faces ($p = .10$) and not male Caucasian-White faces ($p = .79$). Similarly, homogeneous population showed social categorisation for female Caucasian-White faces ($p = .08$) and not male Caucasian-White faces ($p = .66$)

demonstrated a general in-group out-group effect. Instead of showing an in-group out-group effect for experienced races only (Chinese, Malay, and Caucasian-White), these participants' performance in recognising (less-experienced) African-Black race when categorised as members of an in-group was better than recognising the same face when categorised as members of an out-group (p = .026). The overall motivation to individuate regardless of experience is coincidentally consistent with the social-cognitive account. Thus, the differences in findings on the homogeneous and heterogeneous population indicate the differential impact population differences have on social/motivational cues to individuate own-race and other-race faces.

One possible explanation may relate to population differences in the ability to inhibit race salience. Perceivers from a heterogeneous population are not necessarily recognising faces according to racial groups. When non-race based in-group out-group categorisation information is available, it is likely that race salience becomes reduced and may encourage perceivers to selectively attend to faces according to social categories. For example, Hehman et al. (2010) investigated the impact of university affiliation on the encoding of own-race and other-race faces that were organised either by race or by university affiliation. It was suggested that faces organised by race enhance race salience whereas faces grouped by university affiliation were suggested to enhance the non-race based in-group out-group categorisation. Based on this reasoning, Hehman et al. (2010) found the typical ORE when faces were grouped by race. On the other hand, when faces were grouped by university affiliation, participants had superior recall for own-university faces than other-university faces, regardless of race. The finding from the aforementioned study suggests that a resilient ability to ignore salience of race is required for recognition according to non-race based social information. Thus, it could be suggested that perceivers with heterogeneous racial experiences can easily ignore the salience of race information and recognise faces according to non-race based social information when both types of information are available. On the other hand, perceivers with homogeneous racial experiences may find it difficult to ignore the salience of race therefore showing in-group out-group effects for faces they have experience with.

Another interesting finding in this study is the absence of weaker own-race recognition in the heterogeneous population. When all other factors were equal, the recognition trade-off effect was evident (Experiments 3 and 4). However, when social/motivational factor was included, own-race recognition in the heterogeneous population was on par with own-race recognition in the homogeneous population (Experiment 6). Thus, it would seem that when heterogeneous perceivers are sufficiently motivated to individuate, own-race recognition based on existing facial experiences could be enhanced to the same level as homogeneous perceivers' recognition of own-race faces. This is a point that I will return to in the general discussion of this chapter.

Although the effect of racial experience on personality affiliation is marginally significant for the homogeneous population, it needs to be interpreted with caution. The pattern may support previous findings (e.g., Bernstein et al., 2007; Shriver et al., 2008) but the reasons as to why the weak in-group out-group effects for own-race faces may be related to a number of factors: number of racial groups and gender of stimuli used. Previous findings that showed a strong effect of social categorisation for own-race faces used stimuli of two races (own-race Caucasian-White and other-race African-Black: Bernstein et al., 2007; Hehman et al., 2010; Shriver et al., 2008). Instead, the stimuli used in the current study consist of four races (own-race Caucasian-White, Chinese, Malay, and African-Black). Based on the earlier notion of race salience, it is plausible that race salience is enhanced when multiple racial groups are presented intermittently. Cassidy, Quinn, and Humphreys (2011) proposed that faces presented in an inter-racial context keep race salient as a dimension for categorisation therefore showing a “default” processing strategy for own-race faces. In line with this proposal, the weak social categorisation based on experience in the homogeneous population could be attributed to race salience when multiple races are presented in an intermixed context. A suggestion for future research would be to compare and contrast findings using racial groups that are presented in different context and using different number of racial groups.

In addition to the in-group out-group effects, British-White adults showed several face gender differences based on racial groups. It was found that female Chinese faces were recognised better than male Chinese faces. A possible explanation for this may be the characteristics of the experimenter. Because the experimenter was female Chinese, participants may have actively recognised more female Chinese faces to appear socially desirable. In future investigations, it might be possible to use an experimenter of a racial group that is not investigated in the experiment (i.e., female or male Indian) to reduce this bias. Another finding specific to the homogeneous population showed that they could recognise male Malay faces better than female Malay faces. It is possible that this effect is exclusive to university-aged British-White perceivers. The findings on children of both populations (Experiment 4) and adults of the heterogeneous population (Experiment 5) did not show any face gender differences for this specific racial group. Because adults from the homogeneous population were predominantly female (approximately 76%), it may be that these students find male Malay faces highly socially relevant (i.e., attractive) in comparison to other sub-categories of faces used in this study. Further work is required to establish this.

Overall, population differences in personality affiliation suggest that race salience may be easily inhibited in perceivers that have heterogeneous racial experiences in comparison to perceivers that have homogeneous racial experiences. The difficulty in inhibiting race salience together with the number of races used in this study may have resulted to weaker social categorisation in British-White adults.

Thus far, studies bridging the gap between perceptual expertise and social-cognitive accounts have predominantly tested adults and to researcher's knowledge, none of these studies have been carried out on children. In order to understand the development of this integration, studies on children are necessary.

3 Experiment 6

Experiment 6 examines the effects of in-group out-group induction (through personality affiliation) on the ORE in children from a homogeneous population versus heterogeneous population. There is little research directly testing the development of in-group out-group recognition advantages in very young children. However, there is research detailing when children become sensitive to social group distinctions more generally (e.g., Dunham, Baron, & Banaji, 2008). For example, children by 3 years of age show a positive attitude to own-race and own-gender targets (e.g., Aboud, 1988), but more generalised in-group favouritism on other dimensions emerge later in childhood (between 6- and 10-years; Baron & Banaji, 2006). Although Experiment 4 demonstrated that children as young as 5 years could recognise more experienced faces better than less experienced faces, Baron and Banaji's (2006) work suggests that the in-group out-group distinction may not be evident at that age. Given the uncertainty over the point of emergence, the current study investigates three age groups (5- to 6-year-olds, 9- to 10-year-olds, and 13- to 14-year-olds).

3.1 Method

3.1.1 Participants. A total of 116 British children from Lancaster, United Kingdom (homogeneous) and 128 Malaysian children Kuala Lumpur, Malaysia (heterogeneous) participated in this study. Nine participants had to be excluded from the analyses due to failure to co-operate and incomplete answers. In addition, due to the strict ethnicity criteria regarding population (British-White and Malaysian-Chinese), data from 38 participants (15 Malay race; 9 Indian race; 8 other-Malaysian race; and 6 other Malaysian mixed race) had to be removed. This resulted in a final sample of 113 British-White (74 girls, 39 boys) and 84 Malaysian-Chinese (38 girls, 46 boys) children. The homogeneous population consisted of 5- to 6- (n = 33; 19 girls, 14 boys), 9- to 10- (n = 38; 21 girls, 17 boys), and 13- to 14-year-old (n = 42; 34 girls, 8 boys) participants, while the heterogeneous population consisted of 5- to 6- (n =29; 18 girls, 11 boys), 9- to 10- (n = 24; 9 girls, 15 boys), and 13- to 14-year-old (n = 31; 11 girls, 20 boys) participants.

3.1.2 Stimuli and measures. The stimuli were as in Experiment 4 and 5. For the youngest age group, a practice test was also carried out. Eight pictures served as practice stimuli (famous Disney cartoon characters; Mickey Mouse, Minnie Mouse, Donald Duck, and Daisy Duck, and 2 female and 2 male Malay faces).

In addition, age appropriate personality tests were used to create the artificial in-group out-group categorisation. The same Big Five Personality Test (John & Srivastava, 1999) administered to adults in Experiment 5, was administered to 13- to 14-year-olds. The 5- to 6-year-olds and 9- to 10-year-olds had personality questions extracted from the web (see Appendix D for examples). Once again, the questions were not systematically representative of personality dimensions and the data were not analysed.

3.1.3 Procedure. Each participant went through a personality identification test followed by a practice test and then four blocks of familiarisation trials and recognition test trials. Following the age appropriate personality identification test, participants were provided with a description of their personality specific to their age group. For the two older age groups (9- to 10-year-olds and 13- to 14-year-olds), a computerised description was used:

> "Your personality is very important to you. It dictates the person that you will become in the future. This questionnaire is often used by schools to identify good students in classes. Further, psychologists who study relationships often use this questionnaire to identify future success in relationships."

For 5- to 6- year-olds, a verbal description was used:

> "Your personality is very important to you. It dictates the person that you will become in the future. This questionnaire is often used by schools to identify good students in classes."

During the practice test, participants viewed and judged four practice pictures, one at a time. While viewing the pictures, the experimenter pointed out the border on the practice picture to ensure that children understood that the colours represent either their personality type or a different personality type. This was immediately followed by a 2-min filler task and then a test phase (two-alternative forced choice) where they were sequentially shown four practice study pictures paired with four practice distracters. Participants were told to choose the picture that they have seen previously.

After answering on each pair, feedback was provided to ensure understanding. Once the experimenter was confident that the children understood the task, the actual recognition was carried out.

3.2 Results

Again, preliminary analysis of discriminative performance (D-prime) revealed no significant main effects or interactions involving orientation of stimulus or personality colour, so data were collapsed across these factors in subsequent analyses. The D-prime data were analysed using a 2 (Population: heterogeneous vs. homogeneous) x 2 (Participant gender: girls vs. boys) x 3 (Age: 5-6, 9-10, 13-14 years) x 4 (Face race: Chinese, Malay, Caucasian-White, African-Black) x 2 (Face gender: female vs. male) x 2 (IGOG: in-group vs. out-group) mixed analysis of variance (ANOVA) with face race, face gender and IGOG as within-participant factors. Three main effects were significant: face race, F (3, 555) = 28.979, $p < .001$, $\eta^2 = .135$; population, F (1, 185) = 4.155, $p = .043$, $\eta^2 = .022$; and age, F (1, 185) = 25.689, $p < .001$, $\eta^2 = .217$. These main effects were qualified by first-order interactions. Post-hoc Bonferroni comparisons for face race showed that African-Black faces (M = .593, range = .563 - .623) were discriminated significantly worse than Chinese (M = .669, range = .645 - .694) ($p < .001$), Malay (M = .714, range = .687 - .741) ($p < .001$) and Caucasian-White faces (M = .753, range = .727 - .778) ($p < .001$). Chinese faces were also discriminated worse than Caucasian-White faces ($p \leq .001$) but discriminative performance was comparable across Chinese and Malay faces ($p = .091$). Secondly, British-White children (M = 698, range = .677 - 719) performed better than Malaysian-Chinese children (M = .666, range = .643 - .689). Thirdly, post-hoc Bonferonni comparisons for age showed that all comparisons were significantly different from each other ($p \leq$. 30): 13-14-year-olds held the highest recognition score than 9-10-year-olds (*M* = .67, range = .642 - .697) and the lowest recognition score was from 5-6-year-olds (*M* = .619, range = .593 - .646).

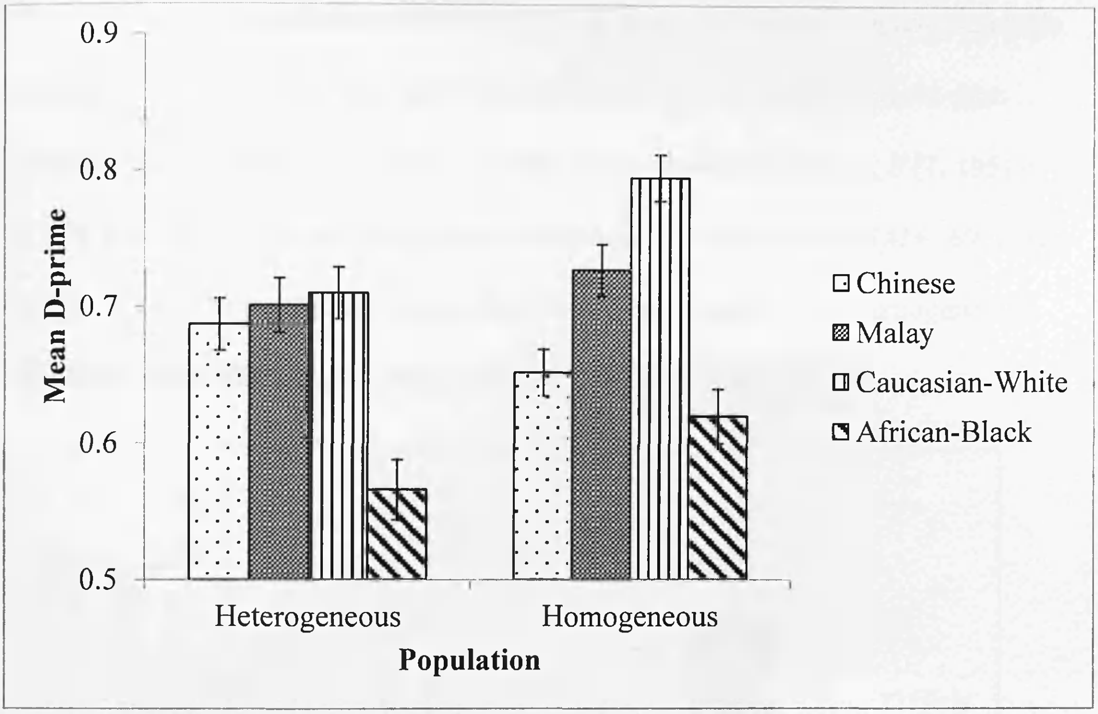


***Figure 20.* Mean D-prime and standard error as a function of population and face race, Experiment 6**

The face race by population interaction was significant, $F(3, 555) = 4.024$, $p = .008$, $\eta^2 = .021$. As seen in Figure 20, both population groups replicated the pattern found in Experiment 4. A significant main effect of face race was found for the heterogeneous population, $F(3, 234) = 12.362$, $p < .001$, $\eta^2 = .137$, and the homogeneous population, $F(3, 321) = 21.533$, $p < .001$, $\eta^2 = .168$. The heterogeneous group had comparable recognition across Caucasian-White, Chinese, and Malay faces ($p = 1.0$) but performed poorly with African-Black faces in comparison with the initial three face races ($p < .001$). The homogeneous group had higher recognition accuracy for Caucasian-White than African-Black ($p < .001$), Chinese ($p < .001$) and Malay faces ($p = .006$). Surprisingly, recognition for Malay faces within the homogeneous group was also significantly higher than recognition for African-Black (p = .001) and Chinese faces (p = .019).

To test for population differences in own-race recognition, a separate analysis was carried out. A comparison between populations was conducted for own-race faces only (homogeneous: Caucasian-White; heterogeneous: Chinese), F (1, 195) = 24.439, p < .001. Own-race recognition for heterogeneous population (M = .69, range = .656 - .724) was significantly lower than own-race recognition for homogeneous population (M = .809, range = .776 - .841).

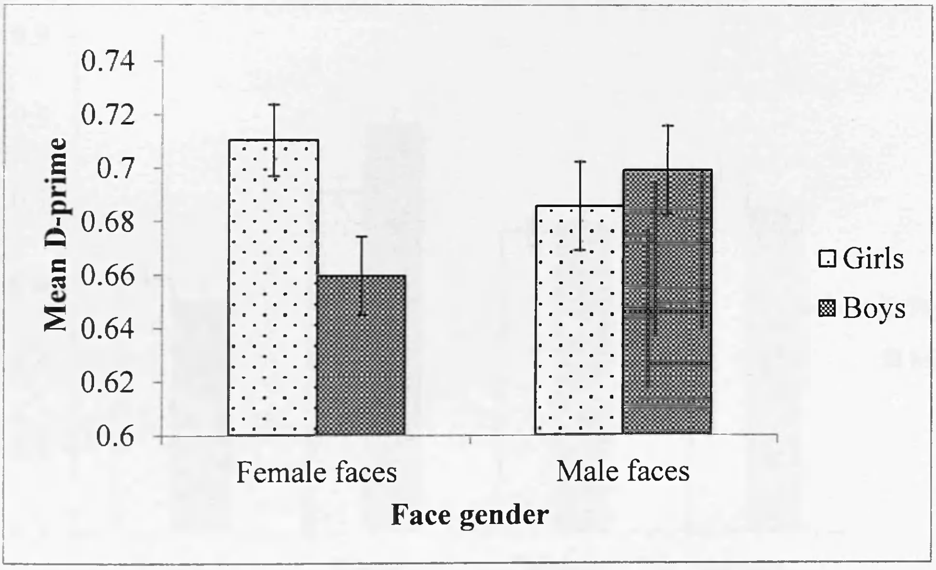


Figure 21. **Mean D-prime and standard error as a function of face gender and participant gender, Experiment 6**

The interaction between face gender and participant gender was significant, F (1, 185) = 4.080, p = .045, η^2 = .022. Simple main effects showed that face gender effect was not significant in girls, F (1, 106) = 1.341, p = .25, η^2 = .012, or boys, F (1, 79) = 2.774, p = .10, η^2 = .034. On the other hand, girls were overall better in recognition of female faces (M = .71, range = .684 - .737) than boys (M = .66, range = .627 - .692), F (1, 195) = 5.807, p = .017 (see Figure 21). No differences were found for recognition of male faces in girls and boys, $F(1, 195) = .367, p = .545$. Thus, indicating gender differences for female faces only.

Finally, the face race and face gender interaction was significant, $F(3, 555) = 5.215, p = .001, \eta^2 = .027$. Replicating Experiments 4 and 5, face gender difference was found for recognition of Caucasian-White faces only $t(196) = -3.635, p < .001$. Once again, male Caucasian-White faces were recognised better than female Caucasian-White faces. Other face gender comparisons were not significantly different from each other ($p \geq .081$). See Figure 22 for an illustration

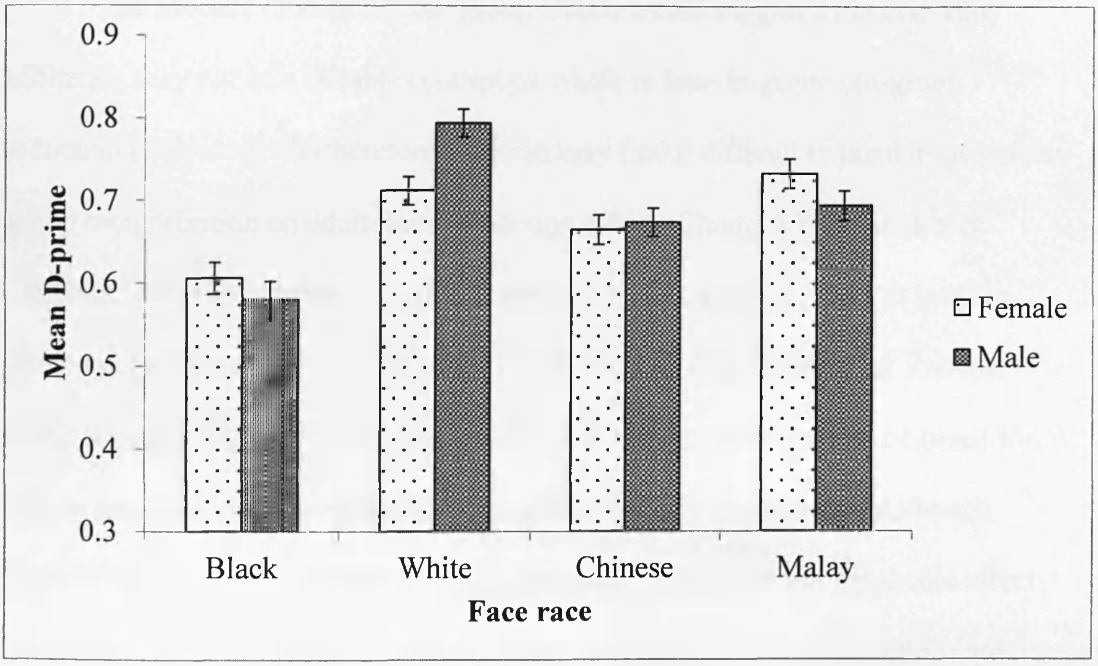


Figure 22. **Mean D-prime and standard error as a function of face race and face gender, Experiment 6**

3.3 Discussion

The current study examined how racial experiences of children influence the perceptual encoding of own-race and other-race faces in the presence of in-group out-group effects through personality affiliation. The findings indicated that, regardless of experience, children did not show any in-group out-group effects. For the heterogeneous population, children were overall better at recognising Chinese, Malay, and Caucasian-White faces than African-Black faces. Children from the homogeneous population showed higher discriminative performance for Caucasian-White faces when compared with Chinese, Malay, and African-Black faces. In addition, the trade-off effect between breadth of experience and recognition accuracy was found: own-race recognition was better for homogeneous population than heterogeneous population. These findings are in line with Experiment 4 and the perceptual expertise account.

The absence of in-group out-group effects would suggest that personality affiliation may not be a suitable concept on which to base in-group out-group induction in children. Furthermore, children may find it difficult to instil in-group out-group categorisation on adult faces (other-age effect - Chung, 1997; Crookes & McKone, 2009) as compared to adult perceivers that may find it easier to instil in-group out-group categorisation on their own age group (e.g., Anastasi & Rhodes, 2006; Wright & Stroud, 2002). Because of these considerations, non-race based social categorisation in children might be important if properly manipulated. Although Hugenberg et al. (2010) predicted that in-group out-group distinctions should affect face memory across different contexts, which in-group out-group distinctions are subjectively important enough to elicit these effects will certainly vary across age. Personality type may not be important enough to elicit the motivation to individuate faces that are categorised as members of their in-group. And if not, it may not be an appropriate basis on which to base in-group out-group social categorisation of adult faces. Based on these findings, the developmental onset of non-race based in-group out-group categorisation of own-race and other-race faces remains inconclusive.

Further to findings relevant to evaluation of the CIM, Experiment 6 showed compelling findings in support of previous face recognition studies. Firstly, girls were better at recognising female faces than boys were. This result is consistent with previous findings on own-gender recognition advantage. Many studies investigating the face gender asymmetry in adults have reported that women tend to exhibit a stronger own-gender recognition advantage (i.e., enhanced recognition performance for other female compared to male faces) than do men (Armony & Sergerie, 2007; Cross, Cross & Daly, 1971; Lewin & Herlitz, 2002; Loven, Herlitz, & Rehnman, 2011). In some other studies women exhibit better recognition of male faces than men do (Rehnman & Herlitz, 2007). However, the latter difference is often small or not statistically significant (e.g., McKelvie, 1981; Rehnman & Herlitz, 2007). Although participant gender differences was not investigated in our adult study (due to incomparable number of male participants), the current findings extended previous literature on adults by indicating the own-gender asymmetry to be consistent in both the heterogeneous and homogeneous population groups, and that the gender asymmetry is evident across childhood, adolescence, and adults.

4 General Discussion

The results of Experiments 5 and 6 demonstrate that own- and other-race face processing is sensitive to personality affiliation in adults and not in children aged between 5 to 14 years. Across these studies, evidences were found for the CIM, social-cognitive account, and the perceptual expertise account. The result from the adult study is partially in line with the CIM (Bernstein et al., 2007; Shriver et al., 2008; Young & Hugenberg, 2011). Only perceivers from the homogeneous population showed integration between experience and motivation. Perceivers from the heterogeneous population showed an overall in-group out-group effect regardless of experience, which is consistent with the social-cognitive account. On the other hand, results from children are consistent with the perceptual expertise account. However, the finding in children suggests that the manipulations and stimuli used may not be strong bases for in-group out-group induction. The current evidence indicates that neither an experience nor a motivational perspective alone can sufficiently account for the ORE across all contexts. This suggests that the manipulation of in-group out-group may not be appropriate for children. Thus, it would seem that population type and the subjectively relevant motivation to individuate can modify the ORE.

4.1 Population difference and Subjective Motivation to Individuate

Although face expertise is either narrowly tuned or broadly tuned (e.g., Michel & Rossion, 2011, Michel et al., 2006), the way in which less-experienced faces are processed when social/motivational factors are involved could be different for each population. Processing less experienced other-race faces is almost certainly more challenging for perceivers with a narrowly tuned face representation. Therefore, greater motivation to individuate may be required for these narrowly tuned perceivers to devote the attention and the processing effort needed to recognise the less-experienced race in comparison to perceivers with a broadly tuned face representation. However, if the motivation to individuate is not subjectively relevant to both narrowly tuned and broadly tuned perceivers (as seen in Experiment 6), it would seem that perceivers would resort to recognition when all other factors (social/motivation) are equal. This indicates that when social/motivational cues are subjectively important to perceivers (Experiment 5), ORE may be eliminated depending on population type and the ability to inhibit salience of race (see Experiment 5 for a discussion). On the other hand, when these cues are not subjectively important (Experiment 6), the perceivers tend to recognise faces based on existing experiences.

In some ways, this argument is compatible with Hugenberg et al's (2010) CIM account of the ORE in which it is proposed that different levels of experience together with different levels of motivation to individuate could influence the ORE. In other words, perceivers may become especially motivated to individuate other-race faces when cues are important to them. However, we extend this argument by suggesting that the increased motivation to individuate is specifically linked with population type. For example, initiating a social reorientation to identity-diagnostic characteristic of non-race based in-group member is easier for perceivers with heterogeneous racial experience than perceivers with homogeneous racial experience. Instead, perceivers with homogeneous racial experience require much stronger motivation to individuate other-race faces (e.g., threatening or powerful faces: Ackerman, et al., 2006, Young & Hugenberg; 2011).

4.2 Limitation

Both Experiment 5 and Experiment 6 indicate that male Caucasian-White faces were recognised better than female Caucasian-White faces. This is consistent with Experiment 4 where male Caucasian-White faces yielded higher accuracy and lower response bias. The findings may be explained by the stimuli used, in which male Caucasian-White faces were more distinguishable than the other sub-category of races. Although precautions were made to ensure the stimuli used clarify three important criteria (i.e., attractiveness, typicality, and clarity), the original faces that they were standardised from were not taken in a standardised setting. Unlike the Chinese, Malay, and female Caucasian-White faces, the male Caucasian-White faces were extracted from multiple databases with (quite possibly) different quality.

Therefore, the different quality of these faces could have affected recognition of the male Caucasian-White faces.

5 Summary and Conclusion

The overall finding from these investigations questions the validity of each account in understanding the ORE of perceivers from a heterogeneous and homogeneous population. Rather than trying to explain the findings according to one account, the findings support the perceptual expertise, categorisation-individuation model, and social-cognitive account. Results of Experiment 6 in children can be explained by the perceptual expertise account. Although this may be due to the unsuitability of personality affiliation to create in-group out-group categorisation, these children still resort to recognising faces according to experiences with different racial groups. In the case of the homogeneous population in Experiment 5, the categorisation-individuation model can explain the results whereas in the case of the heterogeneous population in Experiment 5, there was a general effect from social group categorisation regardless of experience.

It is important to note that the aim of this study is not to establish which account explains the other-race effect. Rather, the aim was to investigate the effect of social categorisation on the perceptual encoding of own-race and other-race faces, with a view to testing and clarifying the Categorisation-Individuation Model. Indeed, when all other factors (motivation, attention, etc.) are equal, Experiment 1 – 4 showed that the ORE is explained by the experience account. This account does not state that attentional, motivational, or more general social factors do not play any role in face recognition memory. From the review and evidence above, they obviously do.

However, what we have observed is that the motivation to individuate faces is influenced by the population of the perceivers and subjective motivation to individuate. Adult perceivers with heterogeneous experience show an effect of motivation to individuate faces categorised as members of their in-group while perceivers with homogeneous experience do not show such an effect. It is possible that perceivers with heterogeneous experiences generally have a broadly tuned face representation that can easily inhibit the salience of race than perceivers with homogeneous experiences that have a narrowly tuned face representation. However, there is no evidence supporting non-race based social categorisation in the work on children. Experiment 6 is the first to investigate the synthesis between perceptual expertise and social-cognition models on children. Although these results differ from the predictions of the CIM (Hugenberg et al., 2010; Young & Hugenberg, 2011), they are consistent with the perceptual expertise account. Thus, the developmental of non-race based in-group out-group effects in children remains inconclusive.

With respect to the adult data, the results provide evidence that whether social categorisation has an effect on the perceptual encoding of own- and other-race faces depends on the population of perceivers. Rather than positing that either perceiver experience or categorisation-individuation model explains the ORE, the current study showed that when non-race based social categorisation is involved, the influence it has on face processing depends on the population group.

CHAPTER SIX

GENERAL DISCUSSION

The current chapter summarises the studies reported within this thesis, drawing general conclusions regarding the different accounts and pointing to future research foci. The thesis aimed to explain the development of the other-race effect by employing a cross-cultural investigation of multiple age groups. Across three infant studies (Experiments 1 – 3), and three child and adult studies (Experiments 4 – 6), these experiments demonstrated that experience plays a strong role in understanding the ORE and its development when all other factors are equal. The impact social categorisation manipulation was also found to affect the processing of experienced and less experienced races (Experiment 5). Importantly, however, this effect is modulated by population type. The implications of these findings for the Perceptual Expertise account, Social-Cognitive account, and the recent Categorisation-Individuation Model are discussed together with wider theoretical and practical implications for our understanding of the other-race effect.

1 Background and Aims of the Thesis

The overarching aim of this thesis was to investigate the other-race effect in a multi-racial population (Heterogeneous: Malaysian-Chinese) across infancy to adulthood, making comparisons with a single-race population (Homogeneous: British-White). More specifically, the thesis aimed to (1) reinvestigate the development of the ORE in infancy; (2) understand the role of experience in determining the other-race effect; and finally, (3) explore the categorisation-individuation model to clarify inconsistencies found in testing different population types.

As mentioned throughout the thesis, there are three frameworks for understanding the other-race effect (ORE): perceptual expertise, social-cognitive, and the categorisation-individuation model (CIM). The perceptual expertise view successfully explains several diverse studies of the ORE in individuals with homogeneous racial experiences where exposure is predominantly to the majority race (i.e., the UK, Africa, and China; Chance, Turner, & Goldstein, 1982; Kelly et al., 2007b, 2009; Michel, Rossion, Han, Chung, & Caldara, 2006; Rhodes, Brake, Taylor, & Tan, 1989; Tanaka, Kiefer, & Bukach, 2004). However, what remains missing is a clear account of *what experiences matter* and *how these experiences constrain the discrimination of own- and other-race members* when all other factors (social/motivational) are equal and when social/motivational factors are involved.

In Chapter 2, it was suggested that two approaches were necessary for demonstrating a more comprehensive understanding of the ORE. The first was a developmental approach and the second was a cross-cultural approach. The developmental approach asks whether there are any age-related changes while the cross-cultural approach asks whether perceivers with multi-racial experience show any population differences from perceivers with single-racial experience. The following sections address how existing experience and social categorisation manipulation, fulfil each of these criteria.

2 Summary of Findings and Implications

2.1 Developmental Trajectory and Population Comparisons when All Other Factors are Equal

The studies described in Chapter 3 (Experiments 1, 2, 3) aimed to clarify inconsistencies found during the onset of the ORE in infants while the study described in Chapter 4 (Experiment 4) aimed to clarify any age-related changes from childhood to adolescence/adulthood. Using a more refined set of stimuli (limited external facial information), both chapters support the assertion that recognition is affected by racial experiences. Furthermore, the interpretations extend the perceptual expertise account by suggesting that such experiences can also differ across face gender and face race at different stages of development.

2.1.1 Implications of developmental effects. The converging evidence from Experiments 1 to 4 offers strong evidence that experiences from both face gender and face race at different periods of development play significant roles in understanding the ORE. In particular, within the first year of life, expertise develops for female own-race faces by 4 months that then develops for male own-race faces by 9 months of age. Although evidence from the homogeneous population showed that the magnitude of ORE is similar across 9 months to 14 years, the findings for the heterogeneous population certainly differed according to face gender and face race at different stages of development.

Developmental findings for the homogeneous population across 9 months to 14 years could be explained by the typical perceptual expertise account where racial experiences explain the ORE. Contrary to the experience account, developmental findings in infants (from 4 months to 9 months) for both populations, and children from the heterogeneous population may not be interpreted well if considering racial experiences only. These can be illustrated in three empirical findings. First, 4-month-old infants did not demonstrate recognition of own-race male faces until 9 months of age. Second, infants from the heterogeneous population who had general exposure to male Malay faces did not exhibit any recognition of that particular type of face at 4 months and at 9 months. Third, 5- to 6-year-old children from the heterogeneous population demonstrated better recognition accuracy for female faces than male faces, even those including female faces of the less-experienced race (African-Black). It is clear that general racial exposure alone is not sufficient to explain the age-related differences found in Experiments 1 to 4.

One way in which the pattern of results might be explained is in terms of relationships with significant others (whether or not attachment is involved). For example, in the heterogeneous population, the transition from own-race recognition advantage (9-month-olds) to female recognition advantage regardless of face race, found in 5- to 6-year-olds, suggests that children are selectively attending to female faces because they may be deemed as important (caregiving) figures. These children would have had more other-race female experience than children from the homogeneous population. In the same vein, children from the heterogeneous population would have had at least two years in pre-school in which experiences with adult females of own- and other-race are more common than experiences with adult male faces. Although both heterogeneous and homogeneous children have very little experience with African-Black race, as reported in Chapter 4, some children from the heterogeneous population referred to the African-Black race as "Indian" which is one of the three main races in Malaysia. Similarly, female experienced faces may be deemed as more important at 4 months than male own-race faces because of primary care-giving role(s) of females. The subjective importance of these faces (relating to characteristics of the caregiver) at different stages of development could have contributed to the own-race other-race recognition.

These speculations coincide with Scherf and Scott's (2012) functionalist approach of multiple face advantages. They argue that there are both continuous and discontinuous aspects of developmental trajectory for face processing, which occur as a function of age-appropriate developmental tasks and goals. As perceivers' developmental tasks are different across age groups (e.g., forming relationships with a primary caregiver in early infancy; social reorientation toward important figures in schools), the representational space of face may adapt itself accordingly. Faces of individuals in infants' environments with whom they have not formed an attachment and/or social relationship, whatever the frequency of exposure to these faces (e.g., male faces), are not expected to influence the representational space of faces in these infants.

2.1.2 Implications from population comparisons. In light of the discussion above, there are obvious population differences in the ORE that could be explained by Valentine's (1991) multidimensional face-space model. On the one hand, the dimensions underlying the multidimensional face space for British-White perceivers are optimal for discrimination of own-race faces. The resulting sub-optimal encoding of other-race faces leaves them more densely clustered in the space. On the other hand, Malaysian-Chinese perceivers' experience tends to be with more than one racial group and the dimensions underlying the multidimensional space for these racial groups are readily accessed during discrimination. It seems possible that specific racial experiences enable perceptual learning mechanisms to 'tune' the dimensions on which faces are coded so that they represent variations within a familiar population (Furl, Philips & O'Toole, 2002; Meissner & Brigham, 2001). As a result, the representation is relatively broadly tuned or narrowly tuned to a specific morphology of faces (e.g., Rossion & Michel, 2011) that is dependent on the breadth of experience in the culture in question

An important finding that was replicated across all cross-cultural comparisons in this thesis (Experiments 3, 4, and 6) is that Malaysian-Chinese perceivers showed weaker own-race recognition than British-White perceivers. This finding coincides with Rossion and Michel's (2011) prediction of different face representation for perceivers with homogeneous and heterogeneous experiences. They suggest that broad tuning would make the perceiver process own-race faces relatively less holistically than another perceiver with a representation that is narrowly tuned to own-race faces only. In other words, a trade-off between breadth of experience and recognition accuracy for own-race faces should be observed. A good example can be found in the case discussed in Chapter 4 concerning the other-age effect (de Heering & Rossion, 2008). In their study, they found that adult preschool teachers (heterogeneous experience) processed children's faces more holistically than adults who are child novice (homogeneous experience). In contrast, the data from their study suggested a reverse effect for adult faces, with more holistic processing by the homogeneous group than the heterogeneous group. As for the present studies (Experiments 3, 4, and 6), even though infants and children from the heterogeneous population showed novelty preference and recognition accuracy of other-race faces and own-race (Chinese) faces, the own-race recognition level was not as large as those seen in the homogeneous population. Although no ORE studies have explicitly shown the same trade-off effect seen in the other-age effect, three out of four cross-cultural experiments in this thesis did provide evidence to support this notion. However, the recognition trade-off effect between breadth of discrimination and discrimination accuracy is only evident when all other factors are equal and not when social/motivational factors are present. We will return to this point in the next section on social/motivational factors.

In summary, the traditional perceptual expertise view successfully explained most findings from the homogeneous population from late infancy to adolescence/adulthood. However, this is not a convincing explanation of the ORE for perceivers from the heterogeneous population. As developmental tasks (relationships with significant others) differ across ages, racial and gender experiences from these developmental tasks are also varied. Therefore, it is clear that we have to consider a combination of both quality and quantity of experiences that in particular relates to face gender. In addition, it is plausible that perceivers with heterogeneous racial experience have a more broadly tuned face representation than perceivers with homogeneous racial experience, something that will be discussed further in the next section.

2.2 Development of ORE in Homogeneous and Heterogeneous Populations when Social/Motivational Factors are Involved

Chapter 6 aimed to use the categorisation-individuation model (CIM; Hugenberg, Young, Bernstein & Sacco, 2010) as a mean to understand how faces are encoded in heterogeneous versus homogeneous populations when non-race based social categorisation is introduced. Although findings from both populations in Experiments 1 to 4 corroborate and extend the perceptual expertise view, it is possible that there are specific developmental and population differences when perceivers are provided with the motivation to individuate faces. Chapter 6 (Experiment 5: adults; Experiment 6: 5- to 14-year-olds) investigated the impact of own-personality versus other-personality categorisation (social categorisation manipulation) on the recognition of experienced and less experienced faces in the heterogeneous and the homogeneous population.

Contrary to the previous set of results which showed age-related changes in face gender recognition (Experiment 4: 5- to 14-year-olds), the evidence documented in Experiment 6 for the same age groups did not produce any support for the same age-related changes. As discussed in Chapter 5, the only age-related contribution is the susceptibility to personality affiliation between Experiment 5 and Experiment 6. Since the impact of personality affiliation was found only in the adult population and not the children/adolescence population, the next section will discuss the implications from population comparisons through findings in adults.

2.2.1 Implications from population comparisons. Experiment 5 revealed population differences, which ran counter to the experience account and unexpectedly in support of both the social-cognitive account (for the heterogeneous population) and the CIM (for the homogeneous population). The implication from this study is that neither the perceptual expertise account, nor the motivation to individuate (social-cognitive account), nor the combination of experience and motivation to individuate (Categorisation-Individuation Model) can explain the recognition of own- and other-race faces. Instead, the empirical findings point to the importance of population type when considering social factors in understanding the other-race effect.

According to the social-cognitive account, social categorisation (manipulation) can demonstrate a recognition advantage for in-group members and recognition disadvantage for out-group members despite holding constant prior interracial experiences. However, the social-cognitive view is not sufficient to explain the result from the homogeneous population as the social categorisation manipulation did not show the predicted overall effect. Instead, these perceivers showed an in-group out-group effect for own-race faces only. In the same vein, the CIM could not explain the in-group out-group effect found in the less experienced race (African-Race) for the heterogeneous group. According to the CIM prediction, social categorisation manipulation interacts with pre-existing individuating experiences. For less experienced racial group(s), the CIM would predict no effect from social categorisation manipulation. However, the data from Experiment 5 did not support this prediction. A further prediction from the CIM is that low experienced perceiver can improve other-race recognition when a strong motivation to individuate was introduced. In a way, this prediction is identical to the initial social-cognitive view. If we consider the social categorisation manipulation as a strong motivator to individuate, indeed, this would support the findings in heterogeneous population but not for findings in the homogeneous population showing no indication of in-group out-group effect for less experienced races. Thus, it would seem that both the CIM and the social-cognitive account could explain the findings in the study for each population respectively. Furthermore, the CIM could potentially explain the findings from both populations. However, as an extension to the CIM, it would suggest that each population may have a (1) different perception on how motivated they are to individuate; and/or (2) different perceptual processes that inhibits the salience of race when provided with the same social categorisation cue. As a result, the multidimensional face space account for the heterogeneous and the homogeneous population (Valentine, 1991; Rossion & Michel, 2011) may be used together with the CIM to produce an affirmative conclusion. It is plausible that differentially tuned representations may differentially perceive and recognise faces when social/motivational factors are involved.

In Chapter 6, it was speculated that perceivers from a heterogeneous population are not necessarily influenced by the salience of race when social categorisation manipulation is available. Specifically, the reduced salience of race allows perceivers to categorise faces using other in-group out-group social categorisation cues (e.g., Hehman, Mania & Gaertner, 2010). On the other hand, perceivers with homogeneous racial experience may find it difficult to ignore race, unless they are sufficiently motivated (e.g., Young & Hugenberg, 2011). But, until homogeneous perceivers are sufficiently motivated, we could tentatively suggest that personality affiliation is a subjectively weak motivator to individuate other-race faces and ignore salience of race for the homogeneous population but is a subjectively strong motivator to reduce the ORE and ignore salience of race for the heterogeneous population.

This speculation coincides with both Rossion and Michel's predictions of population differences based on the MDS (Valentine, 1991), and the predictions of the CIM (Hugenberg et al., 2010). Rossion and Michel (2011) suggest that perceivers with a broadly tuned representation could easily handle another race that they have never encountered before compared to perceivers who have mainly been exposed to single-race faces throughout their life. On the other hand, according to the predictions of the CIM (Hugenberg et al., 2010), different levels of motivation to individuate (i.e., social categorisation, motivational instructions, characteristics of target) together with different levels of other-race experience will facilitate different recognition performance[15].

However, no support was found for Rossion and Michel's prediction in the earlier studies on heterogeneous population when social categorisation manipulation was not included (Experiment 3, 4, 6). Furthermore, the data from Experiment 5 did not find any support for CIM, as the subjective strength to individuate was different for both populations. It would seem that Rossion and Michel's prediction would suit the heterogeneous population when social factors were considered (Experiment 6) and that the CIM could explain the findings in Experiment 6 when population difference

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[15] When motivation is weak, high and low experience perceivers will have equally poor recognition. Higher levels of experience will facilitate strong recognition at moderate levels of motivation. Only very strong levels of motivation is predicted to elicit strong other-race recognition for low experience perceivers

was considered. Therefore, it would seem that the predictions from Rossion and Michel could be applied if heterogeneous perceivers were provided with motivational cues to individuate other-race faces. In contrast, the motivational cues to individuate other-race faces may need to be stronger (Hugenberg et al., 2010) for the homogeneous perceivers.

Overall, we could speculate that there are population differences in the subjective motivation to individuate: heterogeneous perceivers may be more susceptible to these cues whereas homogeneous perceivers may require stronger motivational cues to reduce the ORE. Further support for the aforementioned suggestion is the recognition trade-off effect between breadth of experience and recognition accuracy for own-race faces. As mentioned earlier, when no social/motivational factors are involved, the trade-off effect was evident. This included the experiment during which children were not sensitive to personality affiliation as a basis of social categorisation. In contrast, when personality affiliation had an effect on the ORE (Experiment 5), the recognition trade-off effect was no longer evident. Therefore, the absence of a trade-off effect together with the susceptibility of motivation to individuate, suggests that population difference is certainly one factor that should not be considered lightly.

3 Which Experiences Matter? How Do These Experiences Constrain the Discrimination of Own- and Other-Race Faces?

In answering the earlier questions set out in this thesis of *which experiences matter?* and *how do these experiences constrain the discrimination of own- and other-race members?*; we could speculate from these studies that the social importance of face race and face gender experiences at different points of development matters and can certainly constrain the discrimination of own-race and other-race recognition. Furthermore, when social/motivational factors (non-race based social categorisation manipulation) are involved, the magnitude of the ORE would depend on the subjective importance of recognising or individuating faces and the relative ease with which face race can be ignored. One may perceive the social/motivational factor as important while another may perceive it as unimportant. Rather than trying to explain the findings according to one account, the findings in this thesis support the perceptual expertise, categorisation-individuation model, and social-cognitive account. As an extension to these accounts, the empirical findings point to a combination of factors when considering the development and social/motivational factors on the ORE. Firstly, experiences from faces (e.g., race, gender, and potentially, age) at different stages of development. Secondly, the social importance (e.g., social relationships, social/motivational manipulations) in individuating faces. Thirdly and most importantly, population type: a broadly tuned face representation can have a different effect from a narrowly tuned face representation (e.g., own-race recognition trade-off effect, inhibit salience of race).

4 Improvement/Extensions for Future Work

Relating to theory, the experiments reported here provide some important pointers to a number of key issues that future research should address. These are outlined below.

4.1 Internal and External Facial Information

All the faces used in this study were standardised by limiting external facial information. This was particularly designed to investigate the conflicting onset of the

ORE in infants in which Kelly et al (2007b, 2009) showed an onset of 9 months when using whole faces, while Hayden et al (2007), and Sangrigoli and de Schonen (2004) showed an onset of 3 months when using faces with internal facial information. A complete investigation at the onset of the ORE would require examining faces with both internal and external facial information to test if the populations used in this thesis replicate the broad recognition ability found in Kelly et al. (2007b, 2009). This would establish definitively whether ORE in female faces relates specifically to processing internal information and would disappear if whole faces were provided. Whole faces could allow relatively crude discrimination that is not sensitive to gender effects.

4.2 Developing a Consistent Method of Investigation for Face Discrimination

Different methods and different levels of task complexity may have contributed to the findings in this thesis. Although the measures for children and adults are consistent, the method used in infancy was different from that used in children and adults. The use of consistent methods across ages is very important for drawing conclusions regarding developmental changes in face perception and recognition. Recently, with the development of eye-tracking technology, it has become possible to compare face processing strategies (i.e., fixation patterns) of infants through to adults (e.g., Rennels & Cummings, 2013). Eye-tracking studies may provide accurate and interesting information on how perceivers encode faces but may be difficult in understanding face discrimination across the developmental trajectory. Indeed, a number of factors needed to be considered: number of stimuli and races used, potential of fatigue. Therefore, it remains difficult to use one method across the age range for studies on face discrimination

4.3 Expanding the Face Representational Model

In terms of progressing with the understanding of how faces are represented in perceivers from heterogeneous and homogeneous populations, more research needs to consider how perceivers with a varied level of racial experiences process faces. To create a coherent explanation of how faces are represented in face space, without consideration of population type as a contributor to experience is a significant oversight, especially when experiences from different environments (i.e., schools, university, media) developments in children's experience is in the direction of greater racial diversity. From past research, we already know that experience with different racial groups has a significant effect on recognition (Cross et al., 1971; Feinman & Entwisle, 1976) and that changes in social/motivational cues can affect the outcome of recognition (Hugenberg et al., 2007; Young & Hugenberg, 2011). As it stands, the term heterogeneous/multi-racial and homogeneous/single-race is loosely defined. While previous studies have used perceivers that have experience with two racial groups, the current study tested perceivers with experience of at least four racial groups. Careful cross-cultural studies that track variation in racial exposure and link this with recognition accuracy for experienced and less experienced races, in addition to experiments that examine differences in social/motivational cues, will be essential in extending the face representational model.

4.4 Testing the Categorisation-Individuation Model on Children

This thesis has demonstrated greater tendency to individuate other-race faces in perceivers with heterogeneous racial experience than perceivers with homogeneous racial experience when using personality affiliation as a social/motivational cue to individuate faces. However, the social categorisation manipulation was successful for adults but was not effective for children/adolescence. As explained earlier, this may be due to the weak social relevance of personality affiliation and/or adult faces, leaving open the possibility that the lack of effects of social categorisation in children may reflect the particular stimulus materials used rather than general principles of face recognition in children. Therefore, to ensure that findings in adults could be replicated in children/adolescents, two alternatives are possible for future research. First, by using socially relevant measures such as school affiliation and age-relevant faces as dimensions of in-group out-group categorisation, we could eliminate the limitations from this thesis of weak social relevance of personality affiliation and adult faces. Second, we could test whether different levels of motivation to individuate found in adult studies could also be applied on children/adolescents by providing with motivational instructions (Hugenberg et al., 2007) to individuate or even present them with angry faces (Young & Hugenberg, 2011). The latter has been suggested to inject the highest level of motivation to individuate (e.g., Ackerman et al., 2006; Young & Hugenberg, 2011). Therefore, socially relevant measures and stimuli for social categorisation or other signals to individuate may provide us with better data in understanding how different levels of motivation to individuate influences the magnitude of the ORE in children/adolescents.

4.5 The Transition from Own-Race Recognition to Multi-Race Recognition

As discussed earlier, the investigation of perceivers from the heterogeneous population has provided us with important and novel findings on the ORE. A challenge for future studies is to determine exactly when and how the Malaysian-Chinese infants switch from only discriminating faces of own-race Chinese to comparable recognition of Chinese, Malay and Caucasian-White faces at 5 years of age. It is uncertain whether it is secondary experiences from parents watching White media and/or being surrounded by Malay faces when they are out of the house that encourages this recognition accuracy. Furthermore, it is also uncertain whether the experiences are stronger for female faces. Thus, more tests on children between infancy and 5 years are necessary together with a highly sensitive measure of contact that includes gender experiences.

4.6 Processing Faces of Experienced and Less Experienced Race in the Heterogeneous Population

The experiments in this thesis have focused predominantly on discrimination and accuracy. However, the author did not discuss different ways in which faces may be processed. While it is well-known that configural/holistic processing is used for processing own-race (experienced) faces while featural/part-based processing is used for processing other-race (less-experienced) faces (e.g., Diamond & Carey, 1977, Yin, 1969), this is typically found in perceivers with homogeneous racial experiences. Indeed, previous researches have tested on perceivers with at least two racial experiences and found that they can process both own-race and experienced other-race faces holistically (e.g., Michel et al., 2006, 2009). An interesting extension of this would be to discover whether a heterogeneous population demonstrates the same configural/holistic processing for own-race faces, experienced other-race faces, and for less-experienced other-race faces, or indeed whether their broader tuned face space predisposes them rather more to featural processing in relation to the poorer own-race accuracy of the heterogeneous group.

Furthermore, studies on a homogeneous population revealed that perceivers have culturally specific visual scanning patterns (e.g., Liu et al., 2011; Wheeler et al., 2011). Indeed, a recent eye-tracking study on Malaysian-Chinese adults (Tan et al., 2012), found that these adults used both Eastern and Western visual scanning patterns (showing recognition for Chinese and Caucasian-White faces but not African-Black faces). An interesting connection between the findings in Chapter 6 and Tan et al's study would be to identify how Malaysian-Chinese adults' fixation style differs for African-Black faces when social/motivational factors are involved. This would show how Malaysian-Chinese adults switch from processing faces based on experience to processing faces when social/motivational factors are involved, which could potentially demonstrate how the salience of race (using typical visual scanning patterns) may be inhibited.

5 Concluding Remarks

The aim of this thesis was to investigate the other-race effect in a heterogeneous population and to make comparisons with a homogeneous population across infancy to adulthood when social/motivational factors are or are not manipulated.

When social categorisation is not manipulated, the evidence from this thesis finds that whilst face recognition by infants, children is dependent on racial experience, these experiences may be biased to specific gender and race preferences perceivers have during different stages of development. This progression may be explained by changes in developmental tasks facing individuals across infancy to adolescence/adulthood (e.g., Scherf & Scott, 2011). Whilst face recognition by infants and children/adults is dependent on experiences with different types of faces, there are also specific population differences in how faces are represented in the representational face space. The representation can relatively broadly tuned or narrowly tuned to a specific morphology of faces that is dependent on the breadth of experience in the culture in question. When the motivation to individuate faces is involved, the impact of social categorisation using personality affiliation on own- and other-race faces is dependent on population type, which also contributes to how faces are represented in memory. This was found in adults but not in children. Nonetheless, if the motivation to individuate is weak or not socially relevant, it would seem that recognition is dependent on existing experiences treating social/motivational factors as equal. The findings from this thesis highlight the importance of considering different population types. In addition, it also explains how faces are represented in the multidimensional face-space, yielding a more comprehensive insight into the other-race effect.

A big question for future work is the relationship between social development and face perception. For example, attachment, early relationships, peer relationships, adult relationships could contribute to multiple face processing advantages (race, gender, age). There is a dire need to investigate the relationship of all these factors to face recognition. Future research should probably use age appropriate faces. For infants, adult faces are appropriate because infants interact with adults rather than other infants. But by preschool, the balance has shifted and at some point peer faces are likely to be more important. Incorporating a cross-cultural and cross-sectional investigation of ORE, gender effect and even age effect may be able to simultaneously explain the way faces are represented in the memory from infancy to adulthood.

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APPENDICES

Appendix A

Filler Task for Young Children

What do many children ride on to go to school? A. A school bus B. A boat C. A plane D. A truck	What colour does the sky appear to be when it rains? A. White B. Blue C. Gray D. Red
What is the sum of 5+2? A. 10 B. 8 C. 7 D. 3	What farm animal gives us milk to drink? A. Dog B. Horse C. A cow D. Chicken
In "Snow White" what does the Prince do to wake her? A. He shook her B. He kisses her C. He yelled at her D. He touched her	What does the teacher use to get chalk off the blackboard? A. A chalk eraser B. Her shirt C. A rag D. A napkin
What animal purrs and is known for chasing mice? A. A seal B. A cat C. A mule D. A kangaroo	In the nursery rhyme "Jack and Jill", what do Jack and Jill go up the hill to fetch? A. A pail of water B. Jack's watch C. Jill's locket D. Their mother
5+5 = what? A. 9 B. 15 C. 12 D. 10	What colour is the grass and leaves on trees? A. Yellow B. Blue C. Green D. Red
If you wanted to dig a hole, which would you use? A. A hoe B. A spade C. A spanner D. A hammer	On a clock, if the big hand is on 12 and the little is on 3, what time would it be? A. 9 o'clock B. 12 o'clock C. 3 o'clock D. 5 o'clock

If you counted all of your fingers and toes, how many would you have? A. 10 B. 20 C. 5 D. 15	What colours would you use to make the colour purple? A. Blue and orange B. Green and red C. Red and blue D. Blue and yellow
What animal is pink and has a curly tail? A. A cat B. A cow C. A horse D. A pig	What is 10-2? A. 6 B. 8 C. 5 D. 9
What vehicle runs on a track and blows whistle? A. An airplane B. A train C. A helicopter D. A car	What colour is a stop sign? A. Yellow and black B. Pink and green C. Green and blue D. Red and white

Appendix B

Filler task for 9- to 10-year olds, 13- to 14-year-olds, and Adults (Extracted from http://puzzles.about.com/od/animalwordsearch/ig/AnimalWordSearch/HousePets.htm?p=1 ;

http://puzzles.about.com/od/wordsearches/ig/FoodDrinkWS/IceCream.htm)

House Pets Word Search

Can you find the names of these common and unusual pets?

P	A	N	F	T	I	B	B	A	R	A	C	Y	T	Y
S	D	F	R	R	A	N	A	U	G	I	A	S	T	B
D	O	R	R	G	Q	Y	X	O	C	Y	N	C	S	G
R	T	H	A	V	A	R	Q	O	L	A	A	U	F	O
I	U	C	R	Z	K	E	C	G	K	F	R	H	I	D
B	R	N	A	B	I	K	S	E	U	F	Y	X	S	P
E	T	I	T	G	A	L	F	L	T	P	T	Z	H	A
V	L	F	D	T	O	E	L	P	N	A	P	C	T	L
O	E	U	I	A	C	Y	L	Q	A	L	C	Y	E	U
L	B	E	V	F	R	O	G	D	I	R	S	P	M	T
A	L	F	E	R	R	E	T	B	O	Y	R	I	Y	N
H	A	M	S	T	E	R	R	W	W	O	C	O	F	A
M	P	A	R	A	K	E	E	T	F	E	P	U	T	R
U	P	B	B	T	G	I	P	A	E	N	I	U	G	A
X	L	H	S	I	F	D	L	O	G	D	C	I	Z	T

BUDGIE
CANARY
CAT
COCKATIEL
FERRET
FINCH
FISH
FROG
GERBIL
GOLDFISH
GUINEAPIG
GUPPY
HAMSTER
IGUANA
LAPDOG
LIZARD
LOVEBIRDS
MICE
PARAKEET
PARROT
POODLE
RABBIT
RAT
SNAKE
TARANTULA
TURTLE

Ice Cream Word Search

Find the names of these tasty treats that are perfect for hot weather.

V	Z	Z	O	X	F	U	D	G	E	R	I	P	P	L	E	N
Y	E	E	F	F	O	C	D	E	N	O	C	W	O	N	S	Y
D	B	U	U	C	H	L	H	V	K	X	Q	S	E	N	O	C
C	H	O	C	O	L	A	T	E	C	H	I	P	H	E	S	P
S	C	L	Q	A	R	S	R	A	R	U	M	Y	U	F	H	O
S	H	X	C	H	B	N	T	O	L	R	N	A	Z	K	E	P
E	C	C	H	L	U	E	A	R	C	L	Y	J	P	T	R	E
I	T	U	D	U	T	Y	T	T	A	K	I	B	Z	L	B	C
K	O	O	F	O	T	P	S	A	I	W	Y	N	N	H	E	I
O	C	U	K	G	E	N	O	Q	L	L	B	R	A	L	T	X
O	S	R	D	E	R	H	R	O	K	O	O	E	O	V	C	B
C	R	K	M	L	P	N	B	K	C	B	C	P	R	A	Y	D
O	E	G	I	A	E	O	E	D	V	S	D	O	A	R	D	M
E	T	K	G	T	C	C	T	U	O	K	I	B	H	E	Y	Q
R	T	S	J	O	A	G	K	D	E	P	Z	D	M	C	N	K
O	U	T	U	G	N	P	I	I	E	A	D	N	U	S	I	B
U	B	L	S	X	U	P	I	S	T	A	C	H	I	O	O	T

BUTTERPECAN
BUTTERSCOTCH
CHERRY
CHOCOLATE
CHOCOLATECHIP
COFFEE
CONES
FUDGERIPPLE
GELATO
ICEPOP
MAPLE
NEAPOLITAN
OREOCOOKIES
PISTACHIO
ROCKYROAD
SCOOP
SHERBET
SNOWCONE
SORBET
SUNDAE
STRAWBERRY
VANILLA

Appendix C

The Big Five Inventory (BFI) (John & Srivasta, 1999)

Disagree strongly 1	Disagree a little 2	Neither agree nor disagree 3	Agree a little 4	Agree strongly 5

I see Myself as Someone Who…

___1. Is talkative

___2. Tends to find fault with others

___3. Does a thorough job

___4. Is depressed, blue

___5. Is original, comes up with new idea

___6. Is reserved

___7. Is helpful and unselfish with others

___8. Can be somewhat careless

___9. Is relaxed, handles stress well

___10. Is curious about many different things

___11. Is full of energy

___12. Starts quarrels with others

___13. Is a reliable worker

___14. Can be tense

___15. Is ingenious, a deep thinker

___16. Generates a lot of enthusiasm

___17. Has a forgiving nature

___18. Tend to be disorganised

___19. Worries a lot

___20. Has an active imagination

___21. Tends to be quiet

___22. Is generally trusting

___23. Tend to be lazy

___24. Is emotionally stable, not easily upset

___25. Is inventive

___26. Has an assertive personality

___27. Can be cold aloof

___28. Preservers until the task is finished

___29. Can be moody

___30. Values artistic, aesthetic experiences

___31. Is sometimes shy, inhibited

___32. Is considerate and kind to almost everyone

___33. Does things efficiently

___34. Remains calm in tense situations

___35. Prefers work that is routine

___36. Is outgoing, sociable

___37. Is sometimes rude to others

___38. Makes plan and follows through with them

___39. Gets nervous easily

___40. Likes to reflect, play with ideas

___41. Has few artistic interests

___42. Likes to cooperate with others

___43. Is easily distracted

___44. Is sophisticated in art, music, or literature

Appendix D

Personality Tests for Children

Five- to six-year-olds (Pillow Talk – extracted from http://www.imom.com/espresso-minute/20-pillow-talk-questions-for-you-and-your-child/)

1. What do you like to dream about?
2. Who is your hero? Why?
3. What is the best thing about your teacher?
4. What is something that makes you angry?
5. If you were an animal what one would you be? Why?

Nine- to ten-year-olds (Teen Personality Quiz - extracted from http://www.allthetests.com/quiz13/quiz/1114365326/Teen-Personality-Quiz)

1. What 2 words best describe you in the morning?
    a. Sad and Tired
    b. Cranky and Grumpy
    c. Ready and Sleepy
    d. Energetic and Excited

2. Time to go to bed. What do you most likely say to your parents?
    a. Can I watch some TV first?
    b. Not now..
    c. I'm not tired
    d. Awww

3. It's after school and you have homework, what do you do?
    a. Rush through my homework and then play outside
    b. I don't feel like doing it. I have a cold
    c. I'll do it in a little bit
    d. Pout about all the homework you got

4. Where would you rather go?
    a. A candy store
    b. A zoo
    c. A movie
    d. An amusement park

5. Who is your favourite singer out of.. ?
    a. Justin Bieber
    b. Rihanna
    c. Lady Gaga

   d. Britney Spears

6. Your motto is
   a. Love yourself
   b. Live life to the fullest
   c. Surround yourself with people that love you
   d. PARTY HARD

7. What is your favourite sport?
   a. Basketball
   b. Football
   c. Netball
   d. Dancing

8. Which words best describe you?
   a. Humorous and Crazy
   b. Athletic, Fun-loving
   c. Flirty and Outgoing
   d. Quiet and Shy

9. You are queuing for your lunch. Someone senior pushes past you in line. So you –
   a. Do nothing. It's just not worth it. Everyone gets their food right?
   b. Tap him on the shoulder and say, "excuse me, I believe I was next."
   c. Roll your eyes, but do nothing else
   d. Tap the person behind you and whisper, "who is that!"
   e. Say, "um.. I don't mean to be rude but.. I was.. uh.. next in line.."

10. Your favourite subject is
    a. Art and science
    b. Lunch
    c. Math
    d. P.E
    e. Reading/English

11. Do your friends come to you for advice?
    a. Yes
    b. All the time!
    c. Every now and then
    d. Not really. I go to them for advice
    e. Sometimes

12. Do you have a boyfriend/girlfriend?
    a. Yeah, and I'm the big boss!
    b. I did, but "I let them go" because I needed to focus more on the rest of my life
    c. Nope
    d. Yes
    e. No. I'm not all that interested

13. Your signature is
    a. Written in huge bubbly letters
    b. All over the place
    c. In simple cursive
    d. Really sloppy (I don't have time to worry about what my signature)
    e. Written in tiny print with little doodles all around it