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Own- Versus Other-Race Face Perception: Social Contact and the Human Brain



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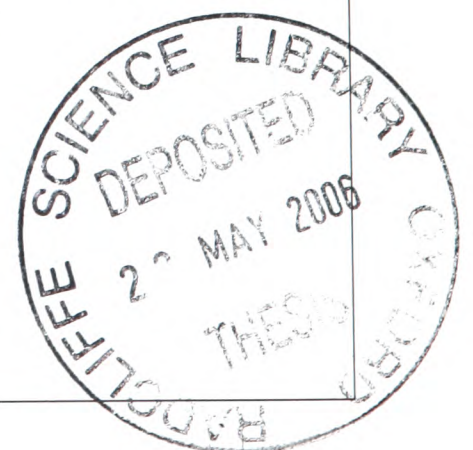
Jesus College

Hillary Term 2006

A thesis awarded the degree of Doctor of Philosophy in the

Department of Experimental Psychology

University of Oxford



Acknowledgements

First and foremost I would like to thank my supervisors, Professor Miles Hewstone and Dr. Kia Nobre. I am very grateful for all their time, encouragement, suggestions and tireless dedication to providing thorough comments and insights on my work, all of which have made my time here so edifying and enjoyable.

I would like to thank Anling Rao for all her help in the running of subjects, her great sense of humour and her critical eye for generating perfect charts and figures. I would also like to extend appreciation to Laetitia Silvert for her support and help in my extensive data analyses.

A special thank you is also due to my dear friend and ‘mentor’ Dr. Ivan Griffin. Had it not been for his phenomenal sense of humour, high achieving attitude, and motivational commentary, I may not have grown to love neuroscience and Vinnie’s as much as I now do, and be quite as driven to finish my Thesis on time. Another special thank you is due to my advisor and ‘moral tutor’ Professor Kathy Sylva, who shared many a deep discussion with me over a drink at Vinnie’s. Thank you also to Sir Peter and Stephanie North, for their kindness and support during my time at Jesus College, and to all of my mentors at Oberlin College who prepared me for my degree here at Oxford. My most sincere appreciation goes to Dr. Jim Tanaka who first introduced me to the world of neuropsychology.

I would also like to extend thanks to my Brain and Cognition Laboratory mates; Tamara Cristescu, Paul Taylor, Patricia Gough and Jonas Vibell who all provided so much added enjoyment during my time in the Lab. Rhiannon, Tania, Nicole and Christiana are members of my Social Psychology Laboratory who offered fantastic companionship during experimental testing (even in far off places) and group gatherings.

Another thank you goes to the hockey players I have had the pleasure of being on the same team as, as well as my legendary coach, Lesley Hobley, during my time in the Women’s Blues. My years spent training and playing with them was a very special part of my time at Oxford.

I would also like to thank all of my friends from St. Catz and Jesus College who have helped me keep a positive perspective on the life of a D.Phil. student in Oxford, with a most heartfelt mention to Dominic, Pauline, Kate, Aj, Rhodri, Gemma, and Greg. Without them I would have had a much harder time braving through the tediously grey, rainy days and new cultural experiences.

Finally my greatest thanks go to my family for their unfailing love, support and encouragement, not only for the past three years, but for the past twenty five.

Abstract

Own- versus Other-Race Face Perception: Social Contact and the Human Brain

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A thesis submitted for the degree of Doctor of Philosophy in the University of Oxford, Michaelmas Term, 2005.

The experiments in this thesis used behavioural measures and event-related potentials (ERPs) to investigate the influence of race on face processing in the brain. Previous behavioural research has highlighted an own-race effect in face processing, whereby individuals are more accurate at recognizing own-race compared to other-race faces. The current Thesis examined the own-race effect at perceptual and neural levels. Social influences on the own-race effect were also investigated, such as other-race experience, anxiety and implicit social bias, as these may account for differential own- versus other-race face processing. The main aim of the experiments contained in this thesis was to delve deeper into the examination of own and other-race face perception through a series of original experiments. Participants performed a variety of perceptual discrimination and identification tasks, and completed measures of explicit other-race experience and implicit racial bias to record their perceptions of other-race individuals. Chapters 2-4 saw the development of a new paradigm that tested the own-race effect in perception, in contrast to traditional recognition memory investigations. In Chapter 2 the own-race effect was investigated developmentally and found across three age-groups, and was larger in the two older age-groups. Chapters 3 and 4 found that the own-race effect differed across racial groups, and that social variables such as other-race experience influenced the strength of the own-race effect. In the latter experimental chapters, ERPs revealed that the behavioural own-race effect was evident at a neural level. Chapter 7 demonstrated that face-related stages of processing in the brain were sensitive to race of face. In Chapters 8 and 9, the sensitivity of face processing to own and other-race emotional expression processing was also examined. The additional social factor of emotional expression was explored in order to further the investigation of socially relevant information processing from the face. Findings from the last two experimental chapters demonstrated differential emotional face processing for own- versus other-race faces. Confirming the findings of the behavioural experiments, own- versus other-race emotion processing varied across racial groups and was subject to social influences such as other-race experience, intergroup anxiety and implicit racial bias. Overall, behavioural and neural investigations of the own-race effect demonstrated the influence of social variables such as other-race experience, intergroup anxiety and implicit racial bias on the way in which individuals processed own- versus other-race faces in the human brain.

Detailed Abstract

Chapter 1 – Faces

Chapter 1 introduced face perception, the process by which individuals can recognize and discriminate between faces. It considered the major theoretical models as well as findings from various behavioural investigations of face expertise and own-versus other-race face processing (otherwise known as the own-race effect). Face recognition was shown to be a specialized and unique ability in humans, which is evident from infancy. Previous research on the own-race effect has examined a bias in recognition memory for own- versus other-race faces, with limited insight into the perceptual basis of this effect. Finally, the contact hypothesis was discussed as a potential explanation for differential race of face processing. That is, both quality and quantity of other-race contact may, in part, account for differences in accuracy when recognizing and perceiving own- versus other-race faces.

Chapter 1 discussed the limitations in the current research, which this Thesis endeavoured to address, in order to form a more complete picture of how race can influence face processing, and whether other-race social experience can account for the own-race effect. Much of the research into the own-race effect has been a) behavioural, focused on a recognition memory bias whereby people were better at recognizing faces of their own race versus other-race rather than an initial bias in face encoding, and b) measured quantity rather than quality of other-race contact, as previous research assumed that amount of other-race exposure accounted for differential own- versus other-race face processing.

Chapter 2 - A Developmental Investigation of Other-race Attitudes, Contact and the Own-Race Face Effect

Experiment 1 (Chapter 2) explored the developmental component of the own-race effect employing a perceptual discrimination paradigm (subsequently replicated in Experiments 2 & 3) coupled with a questionnaire, which measured explicit racial bias and other-race experience. Participants discriminated between own and other-race normal and morph face stimuli. The morph face stimuli were generated by morphing own and other-race parent faces together along a linear continuum. In a same/different perceptual discrimination task participants judged whether the face stimuli (morphs and parent faces) were physically identical to or different from the original parent faces. The questionnaire sought to expand upon previous other-race quantity of contact questionnaires to include measures of (a) intergroup anxiety (Stephan & Stephan, 1985), which is proposed to narrow the focus during other-race contact, resulting in increased stereotyping and potentially viewing the other race as more similar to each other than are members of the ingroup (Wilder & Simon, 2001), (b) individuating experience, which is an indicator of the degree of one's personal other-race experience, and (c) inclusion of the other in the self (Aron, Aron, & Smollan, 2002), a quality of contact measure of the salience of close relationships with other-race individuals.

Experiment 1 was a developmental investigation of the own-race effect in the context of White-South Asian relations in the U.K.; White primary (aged 7-11years), secondary (aged 11-15 years) and university students (aged 17-22 years) were tested. To date, there are no data examining the own-race effect at a level of perceptual encoding in children, and the recognition memory data that exist are either dated or narrow in age-range. Moreover, previous developmental recognition memory data

have failed to demonstrate a significant own-race effect across all age categories. All participants in Experiment 1 were tested on perceptual discrimination accuracy of own- versus other-race faces as well as administered the questionnaire. Results revealed a significant race of face effect for the White participants in each development category (primary, secondary and university), whereby participants were better at discriminating White faces relative to the South Asian faces. A significantly larger own-race effect was observed in university and secondary students compared to primary students. Regression analyses failed to find the self-report measures of other-race bias and experience as predictors of the own-race effect across all three age-groups.

Chapter 3 – A Case Study of the Own-Race Effect in White and South Asian Students

Experiment 2 attempted to replicate and extend the findings of Experiment 1 by testing the identical face discrimination paradigm on both White and South Asian populations in a city in northern England with a history of racial tensions. The questionnaire from Experiment 1 was extended to include a more detailed measure of individuating experience, which was appropriate for the participants' age group (secondary school) and specifically, investigated the quality of other-race friendships. Results replicated the accuracy findings of Experiment 1 only for the White participants; South Asian participants were equally accurate at discriminating both White and South Asian faces. Regression analyses revealed that individuating experience was an accurate predictor of the own-race effect observed in the White students.

Chapter 4 – The Own-Race Effect, Implicit Racial Bias, and Signal Detection Theory

Experiments 3 and 4 presented in this Chapter sought to apply the established perceptual discrimination paradigm to White and Black faces in White and Black participants (Experiment 3) and White, Black and South Asian faces in White and South Asian participants (Experiment 4). These experiments aimed to determine whether participants would show an own-race effect to Black faces, as they are more physiognomically different from White faces than White compared to South Asian faces (Blair, Judd, & Fallman, 2004) or whether due to the distinct nature of the Black face stimuli, participants would be more accurate at perceptually discriminating Black faces versus White or South Asian faces, irrespective of racial group membership. Experiments 3 and 4 included a measure of implicit racial bias, the Implicit Association Test (IAT; Greenwald, McGee, & Schwartz, 1998). Results from Experiment 3 demonstrated only a weak cross-over own-race effect, which was not significant for either individual subgroup (White or Black).

Due to the weak own-race effect observed in Experiment 3, Experiment 4, tailored the perceptual discrimination paradigm to incorporate signal detection theory (SDT), a more sensitive accuracy measure than the traditional hits analysis used in Experiments 1-3, as SDT included hits as well as false alarm scores. Experiment 4 investigated the own-race effect in White and South Asian participants, and results showed own-race effects for White and South Asian participants discriminating own-race versus other-race (White/South Asian and Black) faces. Moreover, individuals who demonstrated an own-race effect for one other-race also showed an own-race effect for the second other-race. These results suggested that despite the physiognomic differences between face stimuli, individuals demonstrated a perceptual

discrimination advantage for own-race versus other-race faces. Furthermore, these findings were linked to implicit racial bias and other-race individuating experience demonstrating that social variables played a role in the strength of the own-race effect.

Chapter 5 – Face Processing in the Brain

Chapter 5 discussed the main findings from neurophysiology, neuroimaging and lesion studies of face, race and emotion processing. Neurophysiological, neuroimaging and lesion research alike present evidence of face-specific expertise in the human brain (Bentin, Allison, Puce, Perez, & McCarthy, 1996; Kanswisher, McDermott, & Chun, 1997; Farah, 1994) as well as of specific networks for the processing of emotion. Neurophysiological evidence has demonstrated a face-specific event-related potential originating in the fusiform gyrus and peaking around 170 ms post stimulus onset. Neuroimaging evidence has confirmed the specialization of the middle fusiform gyrus to face processing as compared to object or animal stimuli processing, and lesion evidence from prosopagnosia patients has suggested a double dissociation between object and face processing in the brain.

Recently, researchers have begun to investigate the influence of race on face-specific neural activity, however, these studies have yet to paint a clear, consistent picture of the nature of race processing in the brain. It is still unclear whether colour, rather than race, may account for certain ‘race’ effects reported to date, and whether other social factors such as emotional expression, or social variables such as other-race experience and attitudes facilitate or impede other-race face processing. Some evidence suggests that implicit racial bias may account for differential brain activity to own- versus other-race faces although such findings have yet to be replicated.

Neural processing of facial expressions of emotion, has received greater attention. The limbic system is discussed in Chapter 5 as an example of the neural pathways involved in emotion processing, and neurophysiological research is presented suggesting that emotional expressions can be processed almost automatically, as part of an early warning system in the brain. The question remains, however, whether individuals process own- versus other-race emotional expressions differently, and whether other-race emotional faces receive the same early automatic processing as own-race faces.

Unfortunately both behavioural and neural research findings to date present incomplete accounts of the influence of race on face processing. Moreover, neural investigations of the modulation of face processing by race or emotion have provided evidence for perceptual level encoding of these two factors independently, yet the interaction of race by emotion may engage different modulatory mechanisms than these two factors do separately.

Chapter 6- Event-Related Potentials

Chapter 6 introduced the Electroencephalogram (EEG) recordings and event-related potential (ERP) measurements technique. EEGs are continuous recordings of changes in electrical activity recorded at the scalp; ERPs are EEGs that are time-locked to certain sensory, motor, or cognitive process. ERPs are a selective measure of neural activity in that they characterize the net electrical fields associated with large populations of synchronously active neurons. The recording of ERPs from the scalp surface, the processing, analysis and assessment of the resulting waveforms are considered in this Chapter. There are certain advantages to ERPs over other cognitive neuroscience techniques. Specifically, their high temporal resolution (the order of

milliseconds) offers a direct measure of neural and cognitive processes in real time. Disadvantages to ERP recordings include their poor spatial resolution. ERPs were used in Experiments 5-7 (Chapter 7-9) as they offer a window into the timecourse of face processing in the brain and can track the specific neural stages during which race and emotion influence face processing in the brain.

Chapter 7- The Influence of Race on Face Processing in the Brain

Chapter 7 investigated the influence of race on face processing at a neural level. Neurophysiological data, although consistent in its support of face specific brain expertise (e.g., N170 component from ERP and fusiform area activation from ERP and fMRI research), is inconsistent in the realm of social variables intimately connected to face perception: specifically race and facial expression of emotion. Experiment 5 paired an electrophysiological test of the own-race effect with explicit other-race experience and implicit racial bias in order to determine whether environmental, social variables might facilitate or impede own– versus other-race face processing in the brain.

In order to elucidate the influence of race on face processing, the timecourse of face processing in the brain was isolated and tested for its sensitivity to experimental manipulations to face stimuli, namely orientation, colour and race. White participants viewed White and Black faces with neutral expressions. To identify ERP components that were specific for processing faces several control stimuli were included – face stimuli rotated upside-down, face stimuli presented in reversed colour, and versions of face stimuli blurred with a Gaussian transformation that were not identifiable as faces. Comparing face versus blur stimuli processing, a timecourse of face-specific processing was identified and further substantiated by

comparing upright versus inverted face processing. Race and colour effects on face specific stages of processing were investigated. Whereas colour processing modulated early non-face specific perceptual processing from around 100 ms post stimulus onset, race affected processing from the first stage of face structural encoding, around 170 ms. The race modulations of face specific processing were also linked to other-race experience, whereby greater experience facilitated other-race face processing in the brain. These findings signified the importance of accounting for stimulus colour in investigations of race processing, as well as social variables such as other-race experience, which may account for differences in own- versus other-race face processing observed across participants.

Chapter 8 – The Effect of Emotional Expression on Race of Face Processing in the Brain

Event-related potentials were used in Experiment 6 to compare the processing of emotional expressions in own- versus other-race faces by White participants. Participants viewed pictures of White and Black faces showing different emotional expressions (neutral, angry, happy). Effects of race of face, emotion and the interaction of race by emotion were investigated on face-related components highlighted in the previous experiment (Experiment 5). Three additional components discussed in the emotion literature were also investigated for modulatory effects. The results showed that both race and emotion modulated early processing, however, the interaction of these two factors was only evident during later stages of processing, from 240 ms post stimulus onset. The race by emotion interaction effects further correlated with implicit racial bias and other-race experience, replicating and

extending findings in Experiment 5, whereby greater other-race experience and lower implicit racial bias were linked to a reduced own-race effect at a neural level.

Chapter 9 - Own- versus Other-Race Emotional Face Processing in Majority versus Minority Group Members

Chapter 9 (Experiment 7) sought to compare the emotional face processing of own- versus other-race faces in majority and minority racial groups. Experiment 7 employed the same experimental format as Experiment 6, with a racially-balanced design. White and South Asian participants viewed White and South Asian faces (neutral, angry and happy) and completed extended explicit other-race bias and experience and implicit racial bias measures. Results replicated certain race and emotion effects reported in Chapters 7 and 8 (Experiments 5 & 6), however, Experiment 7 found differential own and other-race face and emotional expression modulations for White versus South Asian participants. South Asian participants showed different own- versus other-race face processing from face structural encoding (170 ms), whereas White participants did not demonstrate such an effect until the following stage of processing (240 ms). As in Experiments 5 and 6, the effects observed in the current Experiment were linked to explicit bias and other-race experience as well as implicit racial bias. However, the additional measure of intergroup anxiety was a consistent correlate of the neural own-race effect observed in South Asian participants, but not White participants. Therefore, the specific variables linked to and the exact nature of these effects differed for White versus South Asian participants. These findings were discussed in relation to group status and the significance of environmental, social influences on race of face and emotion processing in the brain.

Chapter 10 – General Discussion

Chapter 10 provided an overview of the findings from the experimental chapters regarding the conclusions drawn about the influence of race on face processing in the human brain, and suggested areas for future research. Firstly, the experiments showed the sensitivity of perception and neural processing to the social factor of race. Although research to date has demonstrated that individuals are experts for own-race faces, results presented in the current Thesis showed that participants had greater difficulty discriminating between, identifying and processing other-race faces. The deficit in other-race face expertise was also apparent when processing own- versus other-race facial expressions of emotion, and this effect was shown to vary across racial groups, potentially dependent upon group status (minority vs. majority) and social influences. Secondly, own- versus other-race face processing was sensitive to social variables. That is, other-race social-contact, individuating experience, intergroup anxiety as well as implicit racial bias can influence how individuals process own- versus other-race faces and facial expressions of emotion. Moreover, the influence of such social variables varied depending on the race of participant. Majority versus minority racial group members showed slight differences in which social variables influenced own- versus other-race face processing, both behaviourally and at a neural level.

In sum, experimental results have suggested that face processing is sensitive to race of face and emotional expression. The size and nature of the own-race effect, however, can vary depending on racial group membership, social influences (e.g., other-race experience) and implicit racial bias. Furthermore, the findings presented in this Thesis provide scope for future laboratory and field research alike, to further

investigate the nature of social divisions by race in our societies and the environmental influences that actively shape our social brains.

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Chapter 1

Faces

1.1 Introduction

Face recognition is a formidable human ability. The significance of faces is fascinating both socially and scientifically, as individuals are able to recognize countless faces, find a familiar face in a crowd and recognize subtle differences between faces. Perception of other-race individuals, however, has been anecdotally reported and experimentally shown to be a hindrance in human face expertise. The current chapter will discuss the background of human face expertise research and explore own- versus other-race face processing, as well as the cognitive and social implications of the so-called own-race effect.

1.2 Attraction to faces

Human attraction to faces is apparent soon after birth. Newborns prefer to look at faces than objects and show an affinity for face-like patterns rather than non-face-like patterns (de Haan, Pascalis & Johnson, 2002; Fantz 1965; Morton & Johnson, 1991; Valenza, Simion, Cassia, & Umiltà, 1996; Wilcox, 1969). Research has shown that infants nine minutes old will track face-like stimuli farther than scrambled face-like stimuli, as well as demonstrate an innate orienting of visual attention to faces (Goren, Sarty, & Wu, 1975; Johnson, Dziurawiec, Ellis, & Morton, 1991; Johnson & Morton, 1991). This early attraction to faces is considered to reflect an innate mechanism that may serve as a survival tool for newborns (Le Grand, Mondloch, Maurer, & Brent, 2003).

Memory for familiar faces is also evident early in life. Even in the first days of life an infant will look longer at his mother's face when it is paired with a comparable

(same gender, complexion and hair color) stranger's face (Bushnell, Sai & Mullin, 1989). Yet, memory specific for faces is not initially finely tuned, but rather develops quickly during the first year of life. Morton (1993) demonstrated that when an infant is shown only internal features of a face it does not seem to recognize its mother's face until it is at least 90 days old. Further research has suggested that four-month olds are able to discriminate familiar people from strangers; however, not until six or seven months do infants display robust recognition memory for faces (Fagan, 1973).

Moreover, long term effects of infant cataracts confirm that face expertise develops soon after birth. Le Grand and colleagues (2003) showed that expert face processing in adulthood requires visual input to the right hemisphere during infancy. Le Grand found that infants with bilateral or left-eye-only cataracts were significantly impaired in processing faces later on, as face-specific expertise developed rapidly during the first few weeks of life. In sum, a wide variety of research substantiates an affinity for faces early on in life, which rapidly specializes in face recognition and discrimination.

1.3 Models of Face Processing

For over 50 years researchers have been intrigued by the special relationship humans have with face processing. Face perception and recognition theory have emerged to elucidate human face expertise. Pioneered by Bruce and Young (1986) with a cognitive model and followed by Farah (1990, 1994) with a Two-Process Theory of face processing, current researchers are still speculating on the exact social, cognitive and neuropsychological steps involved in human face processing.

1.3.1 Bruce and Young Model of Face Processing

One of the most widely-cited theories of face processing, the Bruce and Young model (1986), argues that understanding faces as they normally appear (upright, without disfiguration) involves several independent sub-processes working in unison. These sub-processes or *stages* range from basic perceptual manipulations on the sensory information to derive person-specific details (e.g., age, gender, attractiveness) to the recollection of meaningful details (e.g., name and relevant past experiences with the person). The initial stage of face processing is described as involving a ‘view centered description’ whereby simple physical aspects of the face are encoded and used to work out age, gender or basic facial expressions, typically analyzed on a feature-by-feature basis. Initial information is then used to create a structural model of the face for comparison to faces previously stored in memory. Finally, structurally encoded face representations are transferred to *face recognition units* which, along with *person identity nodes*, lead to the identification of an individual by retrieved information from *semantic memory*¹ (see Figure 1.1).

Thus, the Bruce and Young model theorizes and accounts for differences in familiar and unfamiliar face recognition (e.g., processing, accuracy, and speed). It also explains why at times individuals cannot retrieve names without any other semantic information and why individuals feel a face is familiar without knowledge of anything else. Upon evaluation of this theory, however, some controversies have emerged. First, the model provides little detail regarding the processing of unfamiliar faces and the cognitive system it depicts is poorly specified. Furthermore, it fails to account for face specific processing deficits (such as prosopagnosia, see Chapter 5).

¹ As defined by Bruce and Young (1986), recognition of familiar faces involves a match between the products of structural encoding and previously stored structural codes describing the appearance of familiar faces, held in face recognition units. Identity-specific semantic codes are then accessed from person identity nodes, and subsequently name codes are retrieved. The cognitive system plays an active role in deciding whether or not the initial match is sufficiently close to indicate true recognition or merely a resemblance.

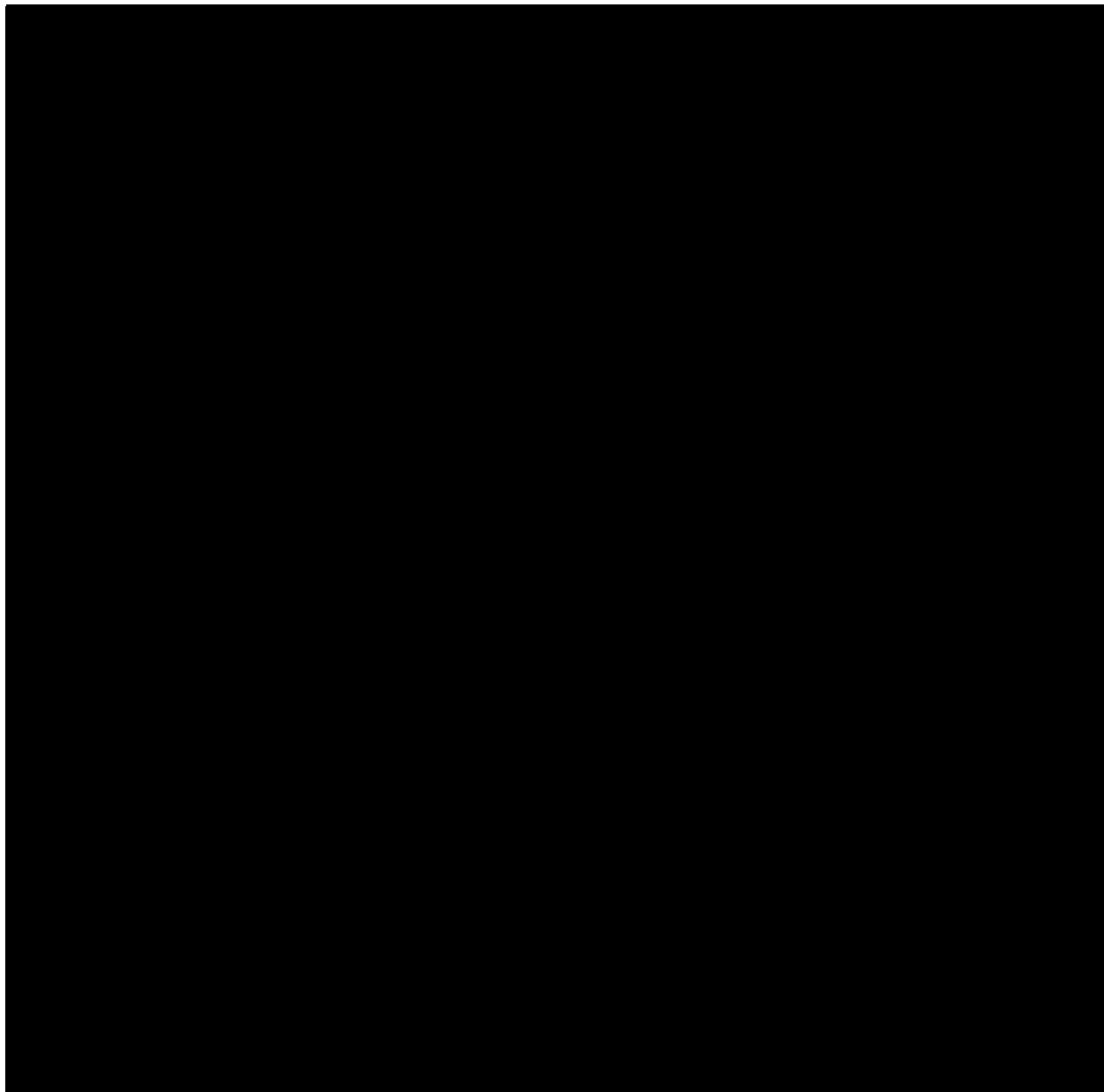


Figure 1.1. The Bruce and Young Model (1986) of face processing.

The model proposes that faces are initially encoded feature-by-feature irrespective of view-point, yet studies of upright versus inverted faces may suggest otherwise (Farah, 1990, 1994).

1.3.2 A Two-Process Theory of Face Processing

The two-process theory (Farah, 1990, 1994) proposes a model for face recognition that accounts for the processing of unfamiliar faces and the processing differences in upright versus inverted faces. Farah (1990, 1994) demonstrated that upright faces are processed *holistically* (as a single unit) whereas inverted faces are

processed *featurally* (analysis by parts). When differentiating between faces, research has suggested that there are two types of structural information encoded in holistic upright face recognition. *Feature information* refers to discrete features that can be characterized independently of other object parts, while *configural information* refers to the basic arrangement of those object features (James et al., 2001; Rhodes, 1988). Although there is evidence that objects are recognized on the basis of their features (Biederman & Gerhardstein, 1993), faces are generally differentiated on the basis of configural differences (Tanaka & Farah, 1993). In their study, Tanaka and Farah asked participants to study faces on which they were subsequently tested for recall of individual features, in normal and scrambled faces (see Figure 1.2). Results showed that parts of faces were most readily recognized in the old configuration, less easily in the new configuration and most poorly recognized in isolation. This effect, however, was not found for scrambled faces, inverted faces, or houses (control stimuli), suggesting that parts of faces cannot be assessed independently.

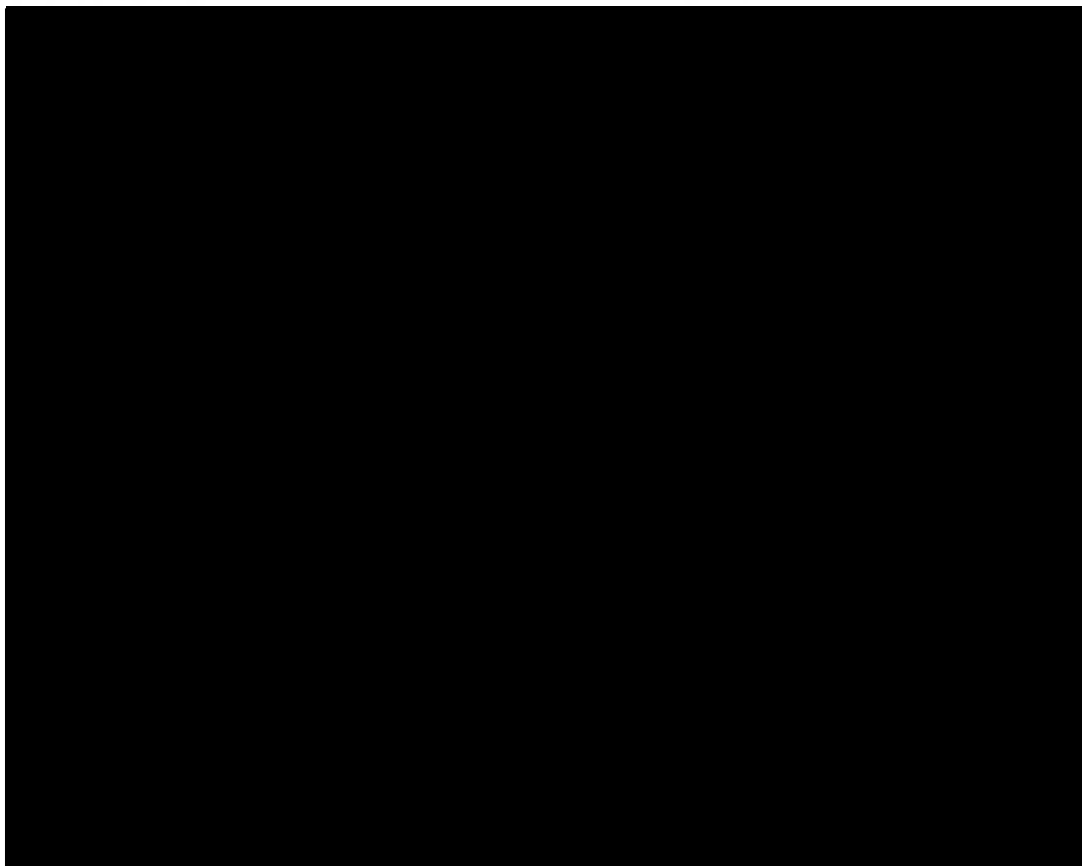


Figure 1.2. Tanaka and Farah (1993) Task: participants learned the old configuration in the study phase and were subsequently tested on the old versus a new configuration of facial features; in the current example the nose is the feature tested.

The “Thatcher” illusion (Thompson, 1980) also illustrates the disruption in holistic processing when faces are inverted (see Figure 1.3) by demonstrating that the inversion of face components (such as eyes and mouth) creates a strong illusion of the “grotesque” when the face is upright. When the face is inverted, however, this effect disappears.

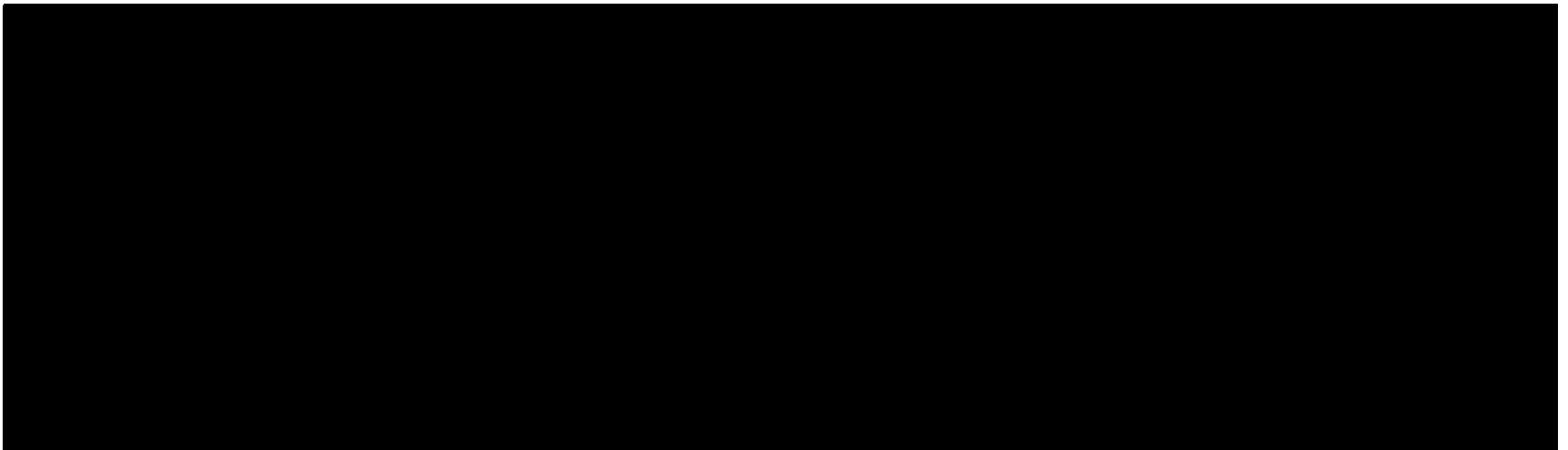


Figure 1.3. The “Thatcher” illusion (Thompson, 1980): (a) Face stimuli inverted, demonstrate that the inverted mouth and eyes of face ‘1’ do not create an out-of the ordinary illusion, however, when viewed upright (b) face ‘1’ with inverted mouth and eyes looks grotesque.

A similar effect was demonstrated by Moscovitch, Behrmann, and Winocur (1997) whereby the perception of the face in the classic painting by Arcimboldo disappears when the painting is inverted (see Figure 1.4).

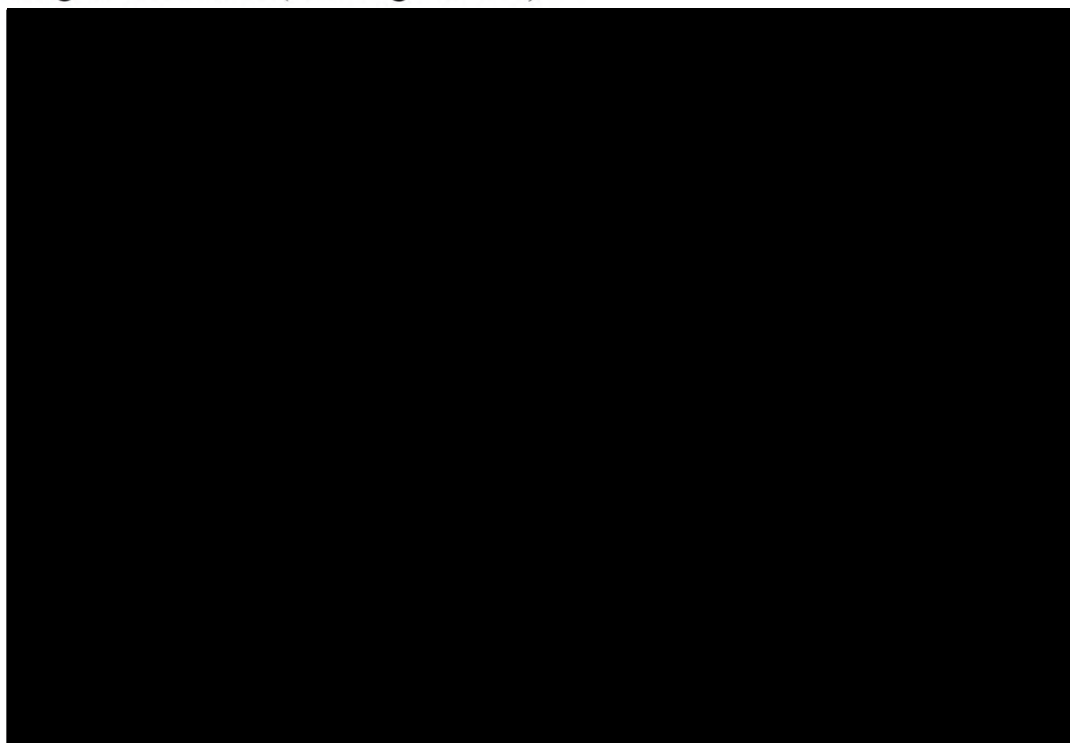


Figure 1.4. Moscovitch and colleagues (1997) demonstrated that perception of face disappears when faces are inverted (painting by Arcimboldo).

Recent behavioural and neural imaging evidence suggests that to use configural differences as the basis for recognition, one must have expertise with the stimulus class (see Tanaka & Gauthier, 1997, for a review), thus, not all faces are recognized using configural processing: when faced with relatively novel stimuli such as other-race or inverted faces, configural processing is found to be greatly reduced (Rhodes, Brake, Taylor, & Tan, 1989).

In contrast to the Bruce and Young model, the two-process theory demonstrates that retrieval of semantic information can occur only when faces are processed holistically (upright). When processed featurally (e.g., from an inverted view-point) name-retrieval is disrupted. Furthermore, Farah's model proposes that both familiar and unfamiliar faces are processed by the same perceptual encoding processes (holistically, with simultaneous encoding of feature configurations when upright) and succumb to the same disruption of holistic processing when inverted.

1.4 The Own-Race Effect on Face Processing

Despite well-documented findings of face-expertise, anecdotal and experimental evidence has highlighted a deficit in other-race face processing. As recognizing faces regardless of race is essential for social communication and interaction, a deficit in the recognition and perception of other-race faces can have serious social implications. Social divisions between racial groups are predicated upon not only cultural and historical differences, but to some extent featural and colour differences as well (Maddox, 2004). Hence, if differences exist in the way in which individuals actually *perceive* other-race faces, social divisions may reflect cognitive and potentially neural divisions. That is not to say that an affinity for own-race faces is natural or innate, but rather that social segregation between groups may result in a cognitive (and potentially neural) deficit in

perceiving other-race faces as they are less frequently experienced and considered more perceptually similar.

First illustrated by Malpass and Kravitz (1969), the own-race effect has also been referred to as the 'own-race bias', 'cross-racial identification effect', or 'own-race advantage'. Past findings show a systematic bias in memory for faces of a participant's own race than for faces of other races (Bothwell, Brigham, & Malpass, 1989; Kassin, Ellsworth, & Smith, 1989; Lindsay, Jack, & Christian, 1991; Yarmey & Jones, 1983). The own-race effect in recognition might be due to the initial encoding of the face stimulus. Recent work in social and object expertise has shown that experience shapes the way stimuli are perceived in the environment. (von Hippel, Hawkins, & Narayan, 1994).

1.4.1 The Own-Race Effect in Recognition versus Perception

Individuals reportedly find it much easier to recognize individuals from their own racial group than to recognize individuals from an unfamiliar racial group. Experimentally, the 'own-race effect' has been tested under a wide variety of conditions and across several racial populations. An advantage for the recognition of own-race faces has been shown in short term memory experiments with a retention interval of 5 minutes (O'Toole, Defenbacher, Valentin & Abdi, 1994) and in long term memory experiments with a retention interval of up to four days (Sloan, Brigham & Meissner, 2000). Using an eyewitness memory paradigm, South African and British participants were better able to identify suspects from a crime scene scenario if suspects were from their own race than if they were from a different race (Wright, Boyd & Tredoux, 2001). The own-race effect is not attributable to perceptual differences in the physiognomic structure of the face, as other studies have shown a cross-over interaction in the own-race effect, such that both

Caucasian participants and East Asian participants showed superior recognition for own-race versus other-race faces (O'Toole et al., 1994; Walker & Tanaka, 2003). Meta-analyses of own-race effect research have confirmed the general pattern of results, establishing that recognition memory is better for own-race faces than faces of a less familiar race (Meissner, & Brigham, 2001; Bothwell et al., 1989). Thus, almost three decades of research has attested to the robustness of the 'own-race effect'.

The effect in recognition might be due to the initial encoding of the face stimulus. Walker and Tanaka (2003) found that Caucasian and Asian participants alike showed a significant own-race effect when asked to perceptually discriminate Caucasian and Asian face stimuli. Categorical perception theories have also been used as a means for investigating the own-race effect. Traditionally, it has been assumed that categorical perception occurs only in cases where natural continua are divided categorically by long-term learning or innate perceptual programming. Recent research, however, suggests this may not be true. Levin and Angelone (2002) found that continua running from a Black face to a White face do, indeed, show stronger categorical perception effects than continua between two black faces or two white faces and that these effects are further enhanced when those participants are, in turn, members of different stimulus categories. These findings suggest that different race faces have distinct perceptual cues and therefore individuals demonstrate a perceptual advantage for the structural cues of own-race faces.

1.4.2 Theories for Category Bias in Face Processing: The Own-Race Effect

Despite within-race physical similarity among faces, slight changes are sufficient to allow quick and unequivocal identification of a familiar face among tens and even hundreds of unfamiliar faces. Since this ability for face recognition is not matched by the

ability to identify other visual stimuli that are similarly complex and even more frequently encountered, it has been suggested that face recognition is achieved by a special-purpose mechanism that most likely uses different processing strategies than those used for the visual identification of most other objects or animals (Tanaka & Farah, 1993; see also Farah 1990). In addition to the face processing models of Bruce and Young (1986), and Farah (1990), both Valentine (1991 a, b) and Levin (1996, 2000) have proposed specific variations of these models to enhance the explanation of category (or race) bias in face processing and recognition.

1.4.2.1 A Multidimensional Face-Space

Valentine (1991 a, b) proposed that adults store faces as reference points in a multidimensional face-space (see Figure 1.5). He describes the face-space framework as an organized value system that is based on various dimensions of internal facial features. Faces are stored in a normal distribution around a central tendency of facial dimensions according to their values. As a result, faces with typical features cluster together and are stored densely around the central tendency, whereas more atypical faces are scattered loosely around the periphery (i.e., faces with average length noses cluster closer together within the face-space than those faces with more extreme or distinctive feature values, such as very short or very long noses). Moreover, with experience of specific faces, face-space representations become more distinctive.

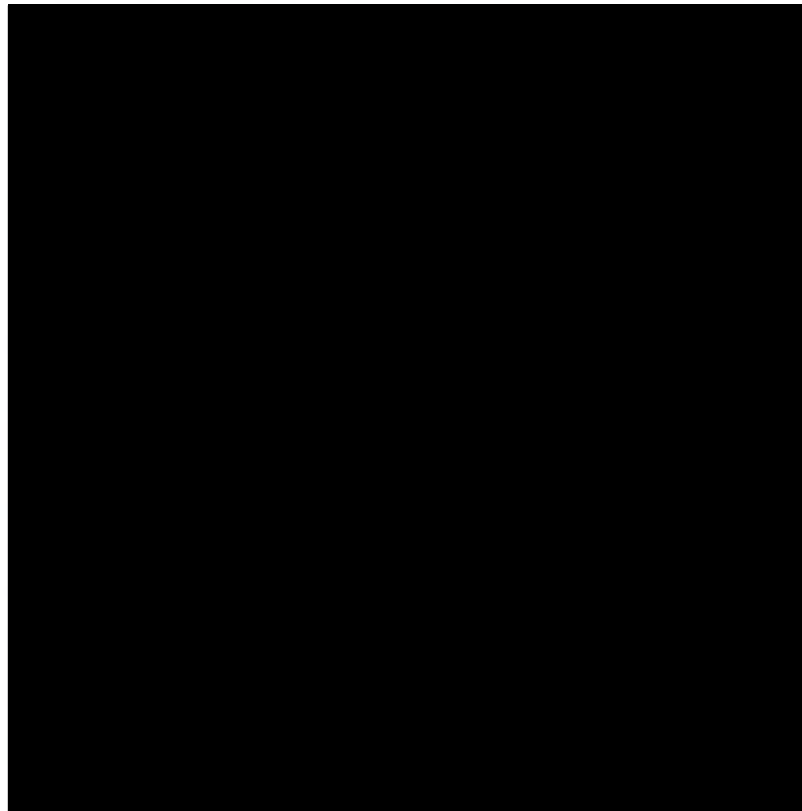


Figure 1.5. Depiction of Valentine's multidimensional face-space using FaceGen faces (Blanz & Vetter, 1999)

When an individual must recall a specific face, the model explains that a comparison is made between the face to be identified and the stored face representations within the face space. Recognition accuracy and reaction times are worse for typical than distinctive faces due to the greater density of stored typical faces than distinctive faces. Hence, it is more difficult for the individual to recognize a more typical face than a distinctive face.

Valentine's face-space model has been widely cited to explain several known effects in the adult face perception and recognition literature, and specifically, the own-race effect. It is theorized that through repeated exposure to own-race faces, a person develops a typicality structure in which there are many exemplars as well as an abstract prototype of an average own-race face. Within the multidimensional face-space that Valentine proposes, featural values of own-race faces are represented much more frequently than featural values of other-race faces. The featural values of other-race faces are under-represented and with less precision as to where certain featural boundaries are located. Valentine (1991 a, b) argues that although other-race faces are located away

from the central tendency of own-race faces, as a group they are more difficult to discriminate as they are more densely clustered within the multidimensional face-space. Hence, without experience, a typicality structure is not readily in place to differentiate individual other-race faces.

1.4.2.2 Race Encoded as a Visual Feature

An alternative hypothesis of own- versus other-race face processing proposes that visual information indicating race face is coded as a feature and, as in pop-out effects (Levin, 1996, 2000), results in a faster detection and classification for those faces. Levin proposed that when individuals view other-race faces rather than own-race faces, they encode race-specifying information at the expense of individuating information. Using both perceptual pop-out effect paradigms and old-new recognition memory tasks (Levin, 1996, 2002), Levin demonstrated that White participants were better at recognizing White than Black faces in the old-new task, but were faster at identifying a Black face in a sea of White faces, than a White face in a sea of Black faces. Levin's feature-based encoding theory explains these results, such that participants who are poor at recognizing Black faces appear to code "blackness" and not "whiteness" as a physical feature. Levin theorizes that race is a specific visual feature that people use in perceiving faces.

Furl, Phillips and O'Toole (2002) proposed a middle ground between these two theories (i.e., Levin's and Valentine's), such that a consequence of the perceptual difficulties in discriminating other-race faces results from the fact that race is a more salient aspect of human face encoding strategies for other-race than own-race faces. Hence, Levin's theory is, in part, compatible with perceptual expertise and similarity hypotheses (Valentine, 1991 a, b).

1.5 The Contact hypothesis and the Own-Race Effect

Research evidence indicates that intergroup contact is linked to more positive intergroup perceptions and attitudes (Pettigrew, 1997, 1998). As such, the “contact hypothesis” has been proposed as one possible account of the own-race effect. The contact hypothesis (Allport, 1954; Williams, 1947) developed during the racial turmoil in the United States during the 1930s and 1940s and remains one of the most widely cited and applied theories for intergroup relations and prejudice reduction. The fundamental principle of the contact hypothesis is that conditions fostering intergroup contact can ultimately lead to intergroup bias and prejudice reduction. Intergroup contact research works to elucidate the phenomena of prejudice, stereotyping and discrimination, considered here under the umbrella term ‘intergroup bias’ (Hewstone, Rubin, & Willis, 2002).

The contact hypothesis therefore predicts that individuals with more interracial experience will show a diminished own-race effect (i.e., the relative difference between own-race and other-race face recognition will be reduced) than individuals with less interracial experience. It is assumed that individuals have more experience or contact with own-race faces than other-race faces (Brigham & Barkowitz, 1978; Cross, Cross, & Daly, 1971; Malpass & Kravitz, 1969; Slone et al., 2000).

1.5.1 Experimental Measures of the Contact Hypothesis

Researchers have used a plethora of experimental measures to investigate the link between contact and intergroup bias. Explicit questionnaires investigating prejudice, intergroup anxiety (Easterbrook, 1959; Stephan & Stephan, 1985), empathy (Tam, Hewstone, Harwood, Voci, & Kenworthy, 2005), perspective taking (Harwood,

Hewstone, Paolini, & Voci, 2005) and quality and quantity measures of contact (Islam & Hewstone, 1993; Voci & Hewstone, 2003) have evolved as robust indicators for predicting the optimal conditions whereby the contact hypothesis is effective (for a review, see Brown & Hewstone, 2005). The experiments reported in this thesis, however, focus primarily on intergroup anxiety, quantity of social contact and individuating experience as a measure of close personal contact.

Intergroup anxiety, a negative emotional reaction that often characterizes intergroup encounters, is one of the primary factors influencing not only the quantity of interactions and interpretations of other-race contact, but also the processing of other-race information (Stephan & Stephan, 1985). Theoretically, intergroup anxiety originates from the negative expectations one places on interactions with out-group individuals. Research on intergroup anxiety suggests that the anticipation of an encounter, as well as the encounter itself, can result in a negative bias for out-group information processing (Greenland & Brown, 1999; Islam & Hewstone 1993; Stephan & Stephan, 1985). Ultimately, this may nullify any positive effects of contact and potentially lead to the avoidance of future contact. Furthermore, heightened anxiety also narrows the focus of attention. In the case of the own-race effect, the processing of other-race faces may require more attention than own-race faces and therefore increased intergroup anxiety is likely to result in poor other-race face information processing.

Individuating other-race experience plays a key role as the facilitator of intergroup bias reduction (Cook & Seltiz, 1955), alongside quantity of contact, and is a robust predictor of prejudice (Voci & Hewstone, 2003). Nevertheless, contact with a sample of the out-group must be able to generalize to the entire out-group in order to disconfirm stereotypical beliefs about the group as a whole and improve intergroup relations (Hewstone & Brown, 1986). Therefore, the *more* contact we have (particularly

the more one-on-one close personal contact we have with members of the outgroup) the greater the chances for reduction of intergroup bias (Cook, 1978).

Sociologically, Boehm (1994) provides an excellent example of the integral role individuating experience plays in reducing intergroup bias. In his ethno-history of Montenegrin feuds, Boehm describes how not knowing the out-group members as *individuals*, allows for more stereotyping and indiscriminate prejudice. Furthermore, Rieder's (1985) study of an all-White town, *Canarsie* (New York, USA), uncovered that newcomer African-Americans were not recognized as individuals in Canarsie nor as members of a social class, and therefore intergroup cooperations did not develop. Rieder stated, "...the notion that one could not tell blacks apart bespeaks the intricate way urban dwellers scan their environment, sift visual and other clues for forecasts of danger, and make guesses about the intentions of strangers..." (1985, p.177). In this instance, Rieder highlights a case study wherein, without individuating experience, the individuating of other-race members is difficult (the own-race effect), ultimately leading to increased anxiety and intergroup bias.

1.5.2 Behavioural research links to the own-race effect

Consistent with the prediction that other-race contact can reduce the own-race effect in face perception, several studies have shown that individuals with more other-race contact (especially recent contact) demonstrate improved recognition for other-race faces (Caroo, 1986; Chiroro & Valentine, 1996; Slone et al., 2000; Brigham, Maass, Snyder, & Spaulding, 1982).

However, some studies have provided support for the contact hypothesis, overall findings have been inconsistent. In an example of these conflicting results, a study by

Cross and colleagues (1971) found White children from segregated neighbourhoods displayed a greater own-race face advantage than did White children from integrated neighbourhoods, but the same was not true for Black American children from segregated and integrated neighbourhoods. Other studies (Brigham & Barkowitz; 1978, Luce, 1974; Malpass & Kravitz, 1969) have also found no correlation between reported interracial contact and recognition for other-race faces. Therefore, the measure of quantity of contact with other-race individuals is not necessarily a reliable predictor of how well other-race faces will be recognized. A recent series of studies by Levin (2000) has suggested that a difference in own-race versus other-race face recognition exists due to differential usage of classification cues or information. Levin concluded that individuals focus on race-specific cues in order to discriminate other-race faces, disabling them to classify other-race faces on the basis of individuating features (as one would for faces of one's own race). In contrast to the contact hypothesis, he argues that it is individuation-based experience and not social experience *per se* that allows individuals to develop an expertise for face discrimination.

1.6 Summary

Face perception is an essential part of human social interaction. Behavioural research suggests that humans are experts at recognizing faces, particularly of their own race (Brigham & Barkowitz, 1978) and that this 'own-race effect' may be linked to interracial experience. The following experiments will investigate the own-race effect in face perception developmentally (Chapter 2), across majority and minority racial groups (Chapters 3 & 4), in relation to other-race experience (Chapters 2, 3, & 4) and implicit social bias (Chapter 4).

Prior to both the behavioural and electrophysiological experiments in this Thesis, the experimenter conducted power analyses in order to determine the minimum sample sizes necessary for detecting the effects associated with the experimental hypotheses. Therefore, Cohen's (1988) 'd' statistic was used as a measure of effect size and was set .5 (medium effect size) for the behavioural studies (bar the South Asian sample in Experiment 1 footnote 2, and the Black sample in Experiment 4 which used an effect size of .8) and at .8 (a large effect size) for the electrophysiological experiments in the latter half of the Thesis. The traditional alpha of .05 was used for all experiments, and the experimenter aimed for power of approximately .75 - .95 for the experiments reported in this Thesis. All experiments reported in this Thesis meet the minimum sample size requirements based on the aforementioned power analyses.

Chapter 2

A Developmental Investigation of Other-Race Attitudes, Contact and the Own-Race Face Effect

2.1 Experiment 1: Introduction

As people develop physically and cognitively they improve on many tasks. Reading and writing become more proficient, memory increases, practical skills such as cycling and driving improve. Evidence for perceptual development has likewise been noted (Kemler, 1983; Smith, 1989b). When individuals move from childhood to young-adulthood to adulthood, an own-race effect for faces may develop as well. Research points to an own-race face effect in adults, such that faces of an individual's own-race are more accurately discriminated at both perceptual and recognition memory levels (Bothwell et al., 1989; Kassin et al., 1989; Lindsay et al., 1991; Walker & Tanaka, 2003). Whether or not this advantage is present during earlier stages of development is less certain.

To date, there are no data examining the own-race effect at a level of perceptual encoding in children. The recognition memory research which exists is limited and inconclusive, lending no consistent support to an own-race effect in children under the age of 10. Moreover, this small body of research examines only the own-race effect for White versus Chinese or Black faces, no data exist with regard to South Asian faces. It can be argued that South Asian faces are structurally more similar to White faces than are Chinese or Black faces (Blair, Judd, Sadler, & Jenkins, 2002; Farnsworth, 1965), hence a perceptual paradigm might prove to be the most sensitive in picking up a potentially subtle own-race effect.

Currently, Chance, Turner and Goldstein (1982) have been the only researchers to investigate an own-race effect across school age-groups (primary, secondary) and university students. They used a recognition memory paradigm wherein participants studied slides of White and Chinese faces followed by an old/new recognition memory test. Participants were grouped into four age categories of 6-8, 9-11, 12-15 and 20 years. An own-race effect was found from the age of 9 onwards, with an increase in face recognition abilities from the age of 6 to 20, and an increase in the own-race effect between 9 year olds and 12 year olds, as well as between 12 year olds and 20 year olds.

A more recent study by Pezdek, Blandon-Gitlin and Moore (2003) investigated the own-race effect in White and Black children aged 5, 8 and adults aged 21-26. They used a line-up recognition memory task, whereby participants viewed a video-recorded scene of two men (one White, one Black) and subsequently had to identify each man in a six person line-up. Results demonstrated a robust own-race effect for Black participants in all three age categories, however, only 5 year old and adult White participants demonstrated an own-race effect. Furthermore, no increase in the own-race effect was observed across age-categories; that is, the own-race effect of 5 year olds was as robust as that demonstrated by adult participants.

Conversely, research by Sangrioli and de Schonen (2004) has suggested that infants aged three-months demonstrate a memory own-race effect which is seen to decrease once other-race face stimuli are learned. Likewise, neurophysiology data support age-related increases in brain activity, from childhood to adulthood, to face stimuli (Taylor, McCarthy, Saliba, & Degiovanni, 1999).

The underlying explanation of the own-race effect observed in adults, and less consistently in children, remains uncertain. Researchers have sought to pair the 'contact hypothesis' with recognition and perceptual tasks as a possible bridge between our

experiences and our cognitive/perceptual abilities. The contact hypothesis (Allport, 1954) proposes that social-contact between majority and minority group members will reduce prejudice. A recent meta-analysis has supported the claim that intergroup contact (especially the quality of contact; cooperative, and equal-status contact, as found in cross-group friendships), is an effective means for reducing outgroup directed bias and prejudice (Pettigrew & Tropp, 2000). A key way the contact hypothesis works is through the reduction of anxiety towards the outgroup. Close relationships with outgroup individuals have been postulated as integral to the reduction of anxiety and intergroup bias. Inclusion of the other in the self (IOS: Aron & Aron, 1986, 1996) provides a measure of the closeness of personal relationships with members of the outgroup. Aron and colleagues (2002) argue that in close contact, the outgroup is included in the perception of the self. Thus, this quality of contact measure is used as a means of investigating the contact hypothesis as it may impact our unconscious biases (for instance a perceptual own-race effect).

In light of the ‘contact hypothesis’, the own race effect might not be attributable to racial factors per se, only that a person’s race is a useful indicator of own-race experience. Thus, the own-race effect could be explained in terms of the differential experience a person has with their own racial group compared to other racial groups (Brigham & Barkowitz, 1978; Cross et al., 1971; Malpass & Kravitz, 1969; Slone et al., 2000). One prediction derived from the contact hypothesis is that individuals with more interracial experience will show a diminished own-race effect (i.e., the relative difference between own-race and other-race face recognition will be reduced) in comparison to individuals with less interracial experience.

Research investigating own and other-race face recognition accuracy in children has suggested that other-race contact during this early stage is the most consistent

predictor of the development of own- versus other-race face expertise (Cross et al., 1971; Feinman & Entwisle, 1976). Feinman and Entwisle (1976) looked at own- versus other-race face recognition abilities in African American and White children aged 6-8 and 11. Using a standard old/new face recognition task, results showed that children from integrated neighbourhoods and schools were better at the recognition of other-race faces than were children from segregated areas. A similar study by Cross and colleagues (1971) investigating African American and White adolescent populations, found that White children from integrated neighbourhoods showed a smaller own-race effect than White children from segregated neighbourhoods. African American children, however, did not show this same effect, discriminating both African American and White faces equally well irrespective of neighbourhood category.

Computer-based neural network modeling has recently become a tool for delving deeper into the experience and neurological components of the own-race effect. Researchers in this field have theorized that early experience with faces *warps* the perceptual space to accommodate distinctions that are specifically important for discriminating faces of one's own race (Kuhl, 1994, 1998). Therefore, the developmental element of contact with faces moulds the perceptual space to maximize discrimination abilities for different facial cues of one's own race. Once this structure becomes fixed it is applied to everyday perceptions and discriminations of faces of all races (Furl et al., 2002; Kuhl, 1998). This theory parallels research investigating language sensitivity, whereby infants can discriminate speech sounds from their native language and other languages equally until approximately one year of age when they begin to demonstrate an advantage for native language discriminations (Carey & Diamond, 1977; Kuhl et al., 1992; Werker, Gilbert, Humphrey, & Tees, 1981). Just as the ability to discriminate native speech sounds increases and the ability to discriminate foreign speech sounds

decreases between 6 and 10 months of age, research by Pascalis, de Haan and Nelson (2002) has demonstrated a similar finding for infant face-processing abilities. Six-month old infants demonstrated equal discrimination abilities for human and monkey faces alike, whereas by the age of 9 months, infants were only able to discriminate faces of their own species.

The importance of investigating the perceptual basis of the own-race effect developmentally can be substantiated by research on perceptual learning. Developmental evidence has demonstrated that children are more susceptible to certain types of learning during an early ‘critical period’ (Gazzaniga, 2000). Perhaps a more quickly developing perceptual process, such as the ability of young infants to discriminate speech sounds from their native language and other languages alike (Werker, et al., 1981), offers support for more slowly developing face perception skills.

The present study employs a perceptual discrimination paradigm to investigate the own-race effect at a level of perceptual encoding in contrast to past methods involving recognition memory for other-race faces. Following the technique applied in previous studies (Beale & Keil, 1995; Calder et al., 1996; Walker & Tanaka, 2003), a South Asian parent face and a White parent face are morphed together generating a continuum of South Asian-to-White morph faces. In a match-to-sample discrimination task, participants are asked to judge whether the morph faces are physically identical to or different from their parent faces. The current study sought not only to determine whether the own-race effect increased across age category, but also to find evidence for the own-race effect in the youngest age category. As Chance and colleagues (1982) investigated recognition memory, perhaps the perceptual discrimination paradigm used here would act as a sensitive test for the own-race effect for each age-group, and would detect an own-race effect in the children as young as 7-9 years.

The present experiment aimed to examine the perceptual basis of the own-race effect developmentally in White participants. Furthermore, this experiment investigated whether social experience factors (social-contact, individuating experience and quality of contact) were consistent predictors of the own-race effect across all three age-groups. The participant's intergroup anxiety was also measured as research has proposed it provides an influential link to quantity and subsequently quality of contact (Stephan & Stephan, 1985). Hence, the questionnaire used in this study incorporated questions assessing prior other-race contact as well as intergroup anxiety vis à vis South Asians.

2.2 Methods

Participants

Participants were 55 White primary students, 31 White secondary students and 99 White university students. The primary students were aged 7-11 years, the secondary students 12-15, and the university students were 17-23. Eighty-eight of the participants were male (27 primary, 15 secondary and 46 university students) and 97 were female (28 primary, 16 secondary, and 53 university students).

Stimuli and Materials

Photographs of 112 university-aged, male and female, White and South Asian individuals were taken with a digital camera. The individuals were photographed in a frontal pose with a neutral expression at a distance of 75 cm. Of the 112 individuals photographed, 16 faces (4 White males, 4 White females, 4 South Asian males, and 4 South Asian females) that contained no facial hair or glasses and little hair covering the forehead were selected as face stimuli. The face images were converted to grayscale and hair and clothing information were removed using the *Adobe Photoshop*™ graphics

program. The faces were then scaled to an image size of 339 x 400 pixels. Two of the unselected faces (one male, one female) were inverted and tiled in *Photoshop*™ and used as masking stimuli.

The 16 faces were paired according to gender and similar face shape (each South Asian male face with a White male face; each South Asian female face with a White female face). Using the program *Morph 2.5*, face pairs were averaged together on a linear continuum, equivalent to a process described by Beale and Keil (1995). Key points for facial features were kept constant, with 12 points on the mouth, 7 points on each eye, 9 points on the nose, 5 points on each eyebrow, and 22 points for the outline of the face. In the morphing process, a Delaunay tessellation technique was applied in which neighboring control points were connected to form non-crossing triangular regions on a planar surface. The triangular regions were optimized such that pixels within a given region were closer to the control points at the triangle's vertices than to any other control points on the surface. Applying a warping algorithm, control points for the morph face were generated by moving 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% of the total distance along the vector that connected corresponding control points in parent face 1 and parent face 2. The locations of intervening pixels were linearly interpolated across the surface based on the position of the nearest control point (Wolberg, 1990). A fade process was then employed in which the brightness values for each corresponding pixel were weighted according to the contribution of each parent image.

The morphing method generated a gradient of morph faces of 10/90, 20/80, 30/70, 40/60, 50/50, 60/40, 70/30, 80/20, 90/10 where the numerator indicated the percent contribution to the morph face from the South Asian parent and the denominator indicated the percent contribution of the White parent (see Figure 2.1).

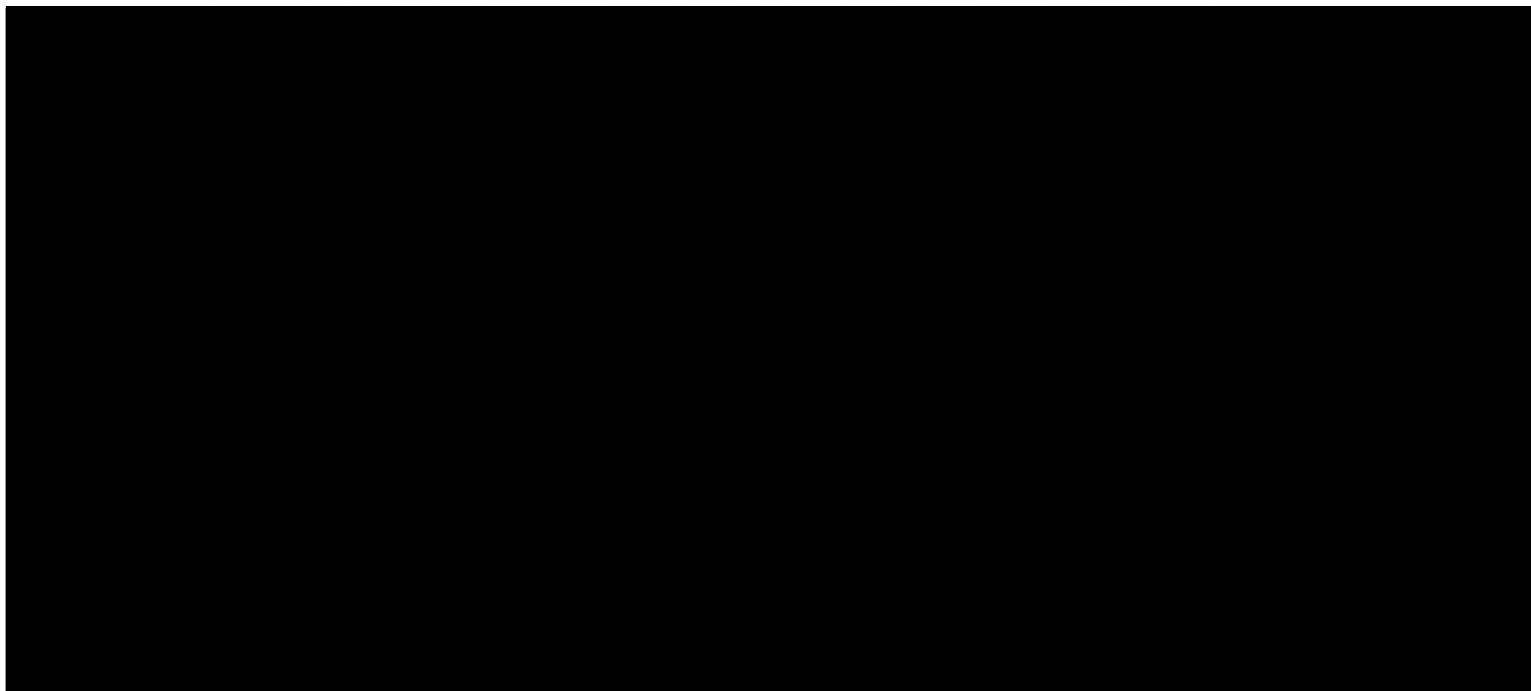


Figure 2.1. Example of the continuum of male morph faces produced by image averaging of a South Asian and White face pair. Morph faces in the continuum were produced in 10% intervals ranging from 10% contribution from the Asian (or White) parent face up to 90%.

Faces subtended a visual angle of 11 degrees and 7 degrees in the vertical and horizontal dimension, respectively. Face stimuli were presented on a computer monitor with a resolution of 72 dots per inch. Parent and morph faces were displayed in *Superlab*. Each trial in *Superlab* consisted of a parent face, followed by a mask, then either the same face (same trial) or a morph face (different trial).

Questionnaire

The questionnaire used in this study contained 21 questions, which sought to determine the participants’ relative exposure to, experiences with, and anxiety towards the other race. The 21 items were grouped into categories examining (1) intergroup anxiety, (2) social-contact, and (3) individuating experience, along with a one item quality of contact measure comprising inclusion of other in the self (Aron & Aron, 1986). Each question had a scale of 1-5, where 1 signaled low anxiety, low contact, low inclusion and 5 signaled high anxiety, high contact, and high inclusion. White participants of all three age categories were asked about their anxiety towards and experiences with the other race (South Asian).

Intergroup anxiety - The intergroup anxiety scale was adapted from the Stephan and Stephan (1985) scale. Participants were asked to imagine being the only White student in a class of all South Asians. On a 5-point semantic-differential scale (*Relaxed-Nervous, Pleased-Worried, Comfortable-Tense and Fine-Scared*) participants were asked to indicate how they would feel.

Social-contact - The social-contact scale consisted of 8 items. Item 1 asked, “How many South Asian people do you know very well?” with answer choices: *Up to 2, Up to 5, Up to 8, Up to 12, and More than 12*. Items 2-8 used the following scale: *strongly agree, sort of agree, not sure, sort of disagree, strongly disagree* and were worded as: 2) “I often play with South Asian people”, 3) “I often talk to/ play with South Asian people in class”, 4) “I often see South Asian people outside of school”, 5) “I often see South Asian people in the playground to hang out with/play with”, 6) “I often have South Asian people round to my house”, 7) “I often go round to the houses of South Asian people”, and 8) “I often see South Asian people”.

Individuating experience - Participants were asked how often they engaged in activities with other-race individuals using the following scale: *very often, quite often, sometimes, hardly ever, and never*. The seven items were: 1) “I have looked after or helped a South Asian person when someone was causing them trouble or being mean to them”, 2) “A South Asian person has looked after me or helped me when someone was causing me trouble or being mean to me”, 3) “I have comforted a South Asian person when they have been feeling sad”, 4) “A South Asian person has comforted me when I have been feeling sad”, 5) “I have asked a South Asian person to be on my team or in my group during sports or activities”, 6) “I have helped a South Asian person with a problem they had with school work”, and 7) “I have received help from a South Asian person when I have had a problem with school work”.

Inclusion of the other in the self - A single item quality of contact pictorial measure (Aron & Aron, 1986) used overlapping circles on a 5-point scale to show how close the participant felt to the South Asian person they knew best. The scale used circles ranging from complete overlap (5) to completely separate (1). Those who were very close to an individual are thought to feel that there is a large degree of overlap between themselves and the friend or group, whereas those who do not feel as close would view the relationship as completely separate.

Procedure

At the beginning of each trial, the participant viewed a South Asian or White parent face for 1s that was then masked for 1s and followed by either the same parent face or a different morph face. The participant was instructed to judge whether the second probe face was the 'same' as or 'different' from the first face via a keyboard response. Instructions emphasized that a 'same' response indicated that the participant believed that the two faces were physically identical. After each response, a blank screen appeared for 1s and then the next trial began. During different trials, the South Asian (White) parent face was followed by a morph face consisting of 90, 80, 70, 60 or 50 percent contribution from that parent face and the remaining percent contribution provided by the White (South Asian) parent face. Hence, for each parent face, there were five "different" trials and an equal number of 'same' trials where same parent face was shown for the first and second presentations. Male and female face trials were blocked and separated by a short break, and the presentation order of these two sections was counterbalanced across participants. Within each gender block the South Asian and White trials were presented randomly. There were 80 'same' trials and 80 'different' trials for a total of 160 trials in the experiment. After the 'same' or 'different' face perceptual task, participants completed a

social attitudes and contact questionnaire using the keyboard numbers to enter their responses.

2.3 Results

Face Discrimination Accuracy

Participant performance on the discrimination task was evaluated by assessing the number of times participants were able to correctly identify a “different” trial (hits). A 3 (Age-Group of participant: primary school vs. secondary school vs. university students) by 2 (race of the face stimulus: Asian vs. White) by 5 (Level of Morph: 90% vs. 80% vs. 70% vs. 60% vs. 50%) mixed model analysis of variance (ANOVA) with repeated measures on the last two factors was computed.

The ANOVA yielded a significant main effect of Age-Group of participant, $F(2,182)=11.30$, $p<.001$, $np^2=.11$ such that accuracy scores on the face discrimination task were significantly different across school-age-groups. Newman Keul’s post-hoc tests revealed that secondary school and university students alike were more accurate at face discrimination than were primary students, $p<.05$, but did not differ significantly from each other (see Figure 2.2). The within-participants factor Morph Level was reliable, $F(4,182)=293.8$, $p<.0001$, $np^2=.62$.

The within participants factor of race of face was also reliable, $F(1, 182)=42.65$, $p<.0001$, $np^2=.19$. Since all participants were White, this effect indicated participants were more accurate at discriminating faces of their own race (White faces) relative to South Asian faces.

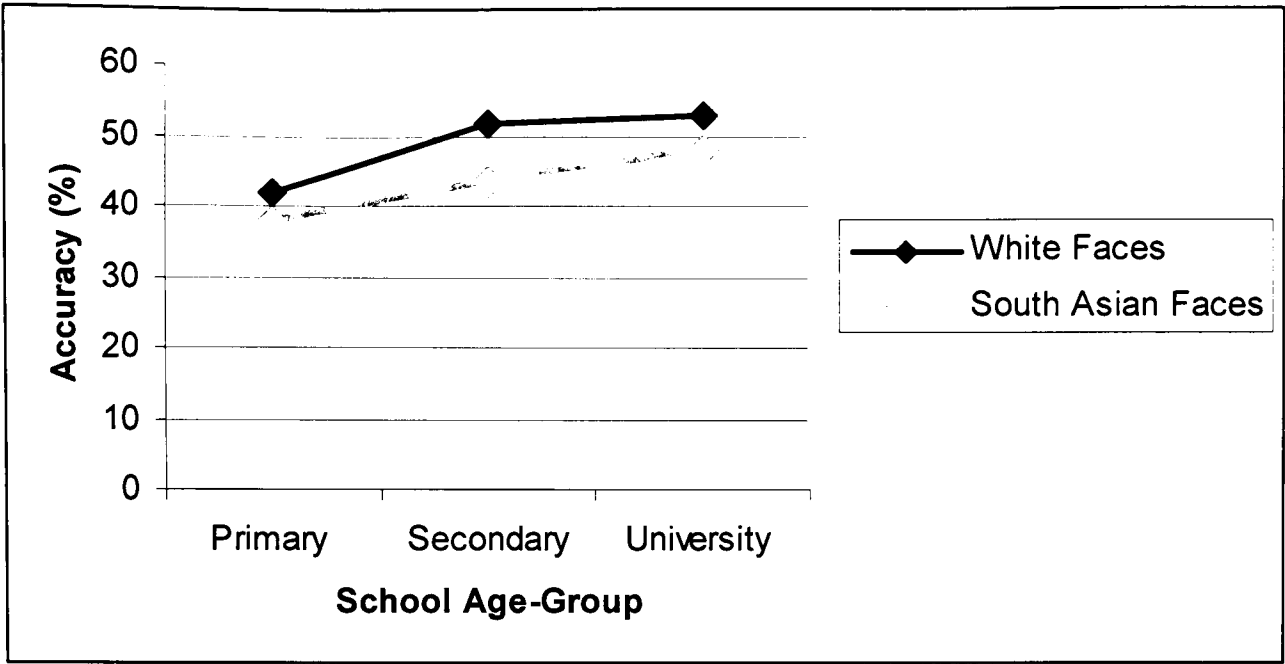


Figure 2.2. The own-race effect as a function of School Age-Group.

Separate comparisons of the subgroups demonstrated that primary school, secondary school and university students alike were significantly better at discriminating faces of their own race (White) over those of the other (South Asian), [primary school participants: $F(1,54)=12.42$, $p<.001$, $np^2=.19$; secondary school participants: $F(1,30)=29.48$, $p<.0001$, $np^2=.50$; university participants: $F(1,98)=14.67$, $p<.0001$, $np^2=.13$] (see Figure 2.2).

A significant interaction of race of face by Age-Group was also found, $F(2, 182)=3.04$, $p=.05$, $np^2=.09$. Post-hoc independent samples t-tests were performed using the overall difference score between own and other-race faces for each age-group to determine where the differences in the own-race effect between the groups lay. Results demonstrated that primary school students showed a significantly smaller own-race effect than secondary school students, $t(84)= -2.19$, $p<.05$, and a marginally smaller own-race effect than university students, $t(152)= -1.87$, $p=.06$, whereas secondary school and university students showed no difference in the magnitude of their respective own-race effects.

There was also a significant interaction between Level of Morph and Age-group, $F(4, 182)=24.81$, $p<.0001$, $\eta p^2=.21$, such that the two older age-groups (secondary school and university) were better at discriminating faces at the lower levels of morph than were the younger participants (see Table 2.1).

Level of Morph					
Age-Group	50%	60%	70%	80%	90%
Primary School	4.25 (.18)	3.66 (.20)	2.88 (.20)	2.74 (.19)	2.33 (.17)
Secondary School	6.00 (.24)	4.68 (.27)	3.68 (.26)	2.57 (.26)	2.15 (.22)
University	6.36 (.14)	5.49 (.15)	3.88 (.15)	2.61 (.14)	1.81 (.12)

Table 2.1. Means and Standard Deviations (indicated in parenthesis) of overall face discrimination accuracy per Level of Morph (out of a possible 8 points) by age-group.

Newman Keul’s post hoc tests revealed that secondary school and university students alike were more accurate at face discrimination than were primary students at the levels of 50, 60, and 70% morph, $p<.05$, and only differed from each other at the 60% morph level, where the university students were more accurate than were secondary students, $p<.05$.²

Questionnaire

The reliability of the three multi-item measures (anxiety, social-contact and individuating experience), using Cronbach’s alpha, were as follows: (1) intergroup anxiety: .94 (.83 for primary; .92 for secondary; and .89 for university subgroups), (2)

² Follow-up data was collected from twenty South Asian adult participants using the same experimental method as that employed for all three White developmental categories. A significant main effect of race of face was found, $F(1,19)=4.44$, $p<.05$, $\eta p^2=.19$, whereby South Asian participants were better at discriminating own-race faces (South Asian faces mean=20.35) than other-race faces (White faces mean=18.35). The fact that the identical set of faces produced opposite effects in South Asian and White populations suggests that differences in discrimination performance were not artifacts of the stimuli, but were related to the participant’s racial background. Level of Morph was also reliable, $F(4,76)=35.97$, $p<.001$, $\eta p^2=.79$, in line with data from White participants such that 90% morphs were the most difficult to discriminate from the parent faces, and 50% morphs were the most discriminable. Walker and Tanaka (2003) tested the same sequential same/different matching task using morphs of East Asian and White faces on both East Asian and White populations and obtained a significant cross-over interaction of accuracy results offering further support for the sensitivity of the paradigm to the own-race effect and not simply a stimulus effect.

social-contact: .71 (.81 for primary; .71 for secondary; and .60 for university subgroups), and (3) individuating experience: .90 (.89 for primary; .80 for secondary; and .92 for university subgroups). Indices of other-race anxiety, social-contact, and individuating experience were constructed for each respondent by computing the mean response to the number of items in each of these three reliable measures. Table 2.2 reports the means and standard deviations for all three subgroups.

The indices of anxiety, contact and experience were then used, along with participant responses to the one-item inclusion of other in the self measure (IOS: a quality of contact measure, Aron & Aron, 1986) and respondent’s age-group, to predict their accuracy scores for White versus South Asian faces.

Measure	Primary Students	Secondary Students	University Students
1. Anxiety*	3.64 (1.01)	3.38 (1.08)	1.67 (.67)
2. Social-contact	1.81 (.78)	2.40 (.63)	2.70 (.56)
3. Individuating experience	2.48 (1.07)	2.58 (.69)	3.09 (.90)
4. Inclusion of other in self	2.40 (1.41)	2.81 (1.42)	1.84 (1.27)

Table 2.2. Means and Standard Deviations (indicated in parentheses) of responses (on a 5-point scale) to the Social Anxiety and Contact Questionnaire; * indicates that the measure was reverse scored.

A regression analysis was performed, collapsing across groups, to determine which, if any, of the reliable questionnaire measures predicted participant discrimination accuracy on the other-race (South Asian) faces (number of other-race face hits). None of the measures was found to accurately predict performance on the face discrimination task across all three groups.

2.4 Discussion

A clear own-race effect on the face discrimination task was demonstrated across all three age subgroups. This effect confirmed the hypothesis that White participants would be more accurate at discriminating faces of their own-race over those of another race (in this case the South Asian faces), supporting previous studies, and demonstrating an own-race effect in face processing. Unique to this study, however, a perceptual bias in face processing has been found at each of the three stages of development examined (primary school, secondary school, and university students). Perhaps the sensitivity of the perceptual discrimination paradigm can explain the consistent own-race effect observed for White primary students in this study and not in the recognition memory paradigms employed by Chance and colleagues (1982) and Pezdek and colleagues (2003). In contrast to memory-reliant tasks used with adults and children alike, the perceptual discrimination paradigm offers evidence of an encoding advantage for discriminating own- versus other-race faces untainted by potential memory biases. The current data set is therefore unique in its identification of an effect which previously could be considered a bias in stimulus recognition and retrieval. The same/different sequential matching task employed in the current study may also provide additional explanation for the own-race effect observed in the youngest age category. A recent study by Sangrioli and de Schonen (2004) devised a similar task investigating an own-race effect in three-month old infants (2004a), as well as three-year olds (2004b). Although the Sangrioli and de Schonen testing method was that of a recognition memory paradigm (habituation phase followed by a simultaneous matching task), the simultaneous matching task itself calls for perceptual discrimination, hence supporting the perceptual component of race-face expertise.

The current own-race effect substantiates previous theory offered by Valentine's exemplar-based coding model for faces (1991, 1992, 2001), whereby other-race faces are assumed to be more *psychologically* similar than are own-race faces, explaining why individuals presented a deficit in making subtle other-race perceptual discriminations. On the other hand, these findings conflict with Levin's (2000) feature-selection explanation of the own-race effect, stipulating the existence of a recognition bias towards own-race faces, which reverses at a level of perceptual expertise; feature-based encoding is optimal for classification (perception) but not for recognition. Levin (2000) found that participants (7 White, 3 Hispanic, and 3 Asian) who showed a memory advantage for White faces paradoxically exhibited a perceptual advantage for Black faces in a discrimination test. Different encoding strategies employed for our sequential same/different task versus Levin's simultaneous match-to-sample task, differences between our White participant population and his smaller racially-mixed population, or differences between South Asian and Black faces might account for the disparate findings between studies.

The current study is not only the first to date to demonstrate an own-race effect across all three age-groups, but is also the first to obtain quantitative support for an increase in the own-race effect observed between primary and secondary school students. The main effect of Age-Group and interaction of Age-Group by Level of Morph demonstrated that participants in the two eldest school-age-group categories showed a stronger own-race effect and were significantly better at the face discrimination task. Research on perceptual learning has shown a similar disparity in the perceptual skills of children versus adults (Kemler, 1983; Smith, 1989a). Smith (1989a) found children to demonstrate difficulty in isolating dimensions (e.g., brightness and size of a shape).

Whereas adults can make these discriminations with ease; such perceptual dimensions seem to be more tightly integrated for children.

An increase in general perceptual skills was expected from the primary school-aged students to university aged, however, the discovery of the increased own-race effect between the primary and secondary/university students as well as per level of morph suggests that life experience may play a role in the own-race effect. Environmental factors such as contact may account in part for the effect. Nevertheless, regression analyses yielded no consistent predictors for the own-race effect across all three age-groups. Consistent with previous recognition memory tests of contact and the own-race effect, the current study found no correlation between face accuracy and self-reported other-race experience. Perhaps, we have yet to develop effective and consistent measures for the evaluation of the own-race effect. Measures of self report tend to be, by nature, inherently biased regardless of age, and therefore experimental manipulations of contact may prove, in future investigations, to be better predictors of the own-race effect.³ Moreover, it may be that the current questionnaire's items were not adequately tailored to the individual age-groups, and should have used language specifically relevant to the individual groups. This was not possible to do in the current experiment as the central aim was to use a questionnaire which could act as a consistent measure across all three age-groups, however, future studies should perhaps tailor separate questionnaires for the individual age-groups, and make connections between the groups post hoc.

³ In his literature review of the own-race effect, Sporer (2001) discusses self-report measures of the contact hypothesis as consistently ineffective. Direct experimental manipulations of other-race contact, on the other hand, have proven successful. Dunning, Li and Malpass (1998) studied fans of the National Basketball Association, USA (wherein 75% of NBA players were black), separating fans in two categories, "experts" and "novices". Findings showed that White Basketball experts performed on par with Black fans in the recognition memory experimental test, whereas the White novices performed significantly worse. This example of individuating, expert contact appears to be a testable, and moreover a reliable, measure of the contact hypothesis.

On the other hand, in line with Kuhl's (1998) perception modeling based theory, the explanation of an increase in the own-race effect from primary to secondary school/university students, may be primarily perceptual. Younger children's perceptual skills are more malleable, and hence with age, perceptual abilities for own- versus other-race face discrimination become more rigid and less effective.

To conclude, the current study found evidence of an own-race effect at a level of perceptual encoding across all three school-age categories. A robust increase in the effect was observed from primary to secondary and university students. However, self-report measures of social anxiety and contact were not found to influence the own-race effect.

Chapter 3

A Case Study of the Own-Race Effect in White and South Asian Students

3.1 Experiment 2: Introduction

Racial tensions and intergroup conflicts are an age old problem. Stereotypes of minority groups are commonly recognized and readily circulate throughout society. Alongside such overt other-race biases, individuals of the majority race tend to report a covert bias for own-race faces, suggesting that those in the minority “all look alike”. The own-race effect in face perception and recognition has been suggested as a cognitive manifestation of other-race stereotypes, such that the outgroup is perceived as more similar than the ingroup due to lack of other-race contact.

The own-race effect in recognition memory, where individuals are more accurate at recognizing faces of their own race versus other races, has been tested and validated under a wide variety of experimental conditions (Bothwell et al., 1989; Kassin et al., 1989; Lindsay et al., 1991; Yarmey & Jones, 1983). For instance, the own-race effect has been shown in memory experiments with a retention interval as short as 2 minutes (O'Toole, Deffenbacher, Valentin, & Abdi, 1994) and also as long as four days (Slone et al., 2000). The own-race effect has been tested in infants (Sangrioli & de Schonen, 2004), as well as developmentally (Chance et al., 1982; Pezdek et al., 2003; Walker & Hewstone, in press), and in adult populations (see Meissner & Brigham, 2001, for a review). Employing an eyewitness memory paradigm, Wright, Boyd and Tredoux (2001) found that South African and British participants were better able to identify suspects from a crime scene scenario if they were from their own race than if they were from a different race. Developmentally, Chance and colleagues (1982), along with Pezdek and

colleagues (2003) have found evidence for a recognition memory own-race effect in children as young as eight years. Recent research by Sangrioli and de Schonen (2004) has demonstrated that three-month old infants, once habituated to a series of own and other-race faces, are better at recognizing seen-before own-race versus other-race faces. The own-race effect is therefore measured by researchers as the interaction between the race of the participant and the race of the face stimuli. When participants are statistically more accurate at recognizing faces of their own-race versus those of another, the own-race effect is demonstrated (Wells & Olson, 2003).

The own-race effect seems not to be connected to the physiognomy of a particular racial group as this advantage has been shown independently of the race of the participants and the race of the face stimuli. For instance, O'Toole and colleagues (1994) found that both East Asian and White participants demonstrated a recognition advantage for faces of their own race when tested with an identical set of East Asian and White face stimuli. The robustness of the own-race effect has been substantiated by meta-analytic studies (Anthony, Cooper, & Mullen, 1992; Bothwell et al., 1989; Meissner & Brigham, 2001) where an own-race face effect was demonstrated across a broad range of experiments. Thus, more than two decades of research has validated the claim that people are better at recognizing faces from their own racial group than faces from other racial groups.

The own-race effect in recognition might be due to the initial encoding of the face stimulus (Meissner, Brigham, & Butz, 2005; Walker & Hewstone, in press; Walker & Tanaka, 2003). Walker and Tanaka (2003) found White and East Asian participants alike showed a significant own-race effect when asked to perceptually discriminate White and East Asian face stimuli. Other tests of perceptual differences in own- versus other-race face expertise have used age, sex, and emotional expression discrimination tasks.

Montepare and Opeyo (2002) had participants view pairs of faces that differed simultaneously along two facial dimensions (e.g., race and age). The participants were then required to make face similarity judgments along one of the dimensions (e.g., race). Response-speed and accuracy results revealed that participants judged race of face more quickly and with fewer errors compared to age, gender and emotional expression. These results support a perceptual basis for the discrimination of race of face.

Categorical perception theories have also been used as a means for investigating the own-race effect. Traditionally, it has been assumed that categorical perception occurs only in cases where natural continua are divided categorically by long-term learning or innate perceptual programming. Recent research, however, suggests this may not be true. Levin and Angelone (2002) found that continua running from a Black face to a White face do indeed show stronger categorical perception effects than continua between two black faces or two white faces, and that these effects are further enhanced when the participants are members of different stimulus categories. These findings suggest that different-race faces have distinct perceptual cues; hence, individuals demonstrate a perceptual advantage for the structural cues of own-race faces.

The most straightforward account of the own-race effect is that people have more exposure to members of their own racial group (i.e., their ingroup) than to individuals outside their racial group (the outgroup). Specifically, the contact hypothesis (Allport, 1954) proposes that social-contact between ingroup and outgroup members will reduce outgroup-directed prejudice, subsequently leading to decreased intergroup segregation and tensions. The theory that intergroup contact is an effective means for reducing outgroup-directed bias, particularly when it involves common goals and cooperation, has been validated by a substantial body of research (see meta analysis: Pettigrew & Tropp, 2000). In light of the contact hypothesis, the own-race effect might not be attributable to

racial factors *per se*, but rather that a person's race is a useful indicator of own-race experience. Thus, the own-race effect could be explained in terms of the differential experience a person has with their own racial group compared to other racial groups (Brigham & Barkowitz, 1978; Cross et al., 1971; Malpass & Kravitz, 1969; Slone et al., 2000). One prediction derived from the contact hypothesis is that individuals with more inter-racial experience will show a diminished own-race effect (i.e., the relative difference between own-race and other-race face recognition will be reduced) in comparison to individuals with less interracial experience.

Consistent with this prediction, several studies have shown that individuals with more other-race contact (particularly recent contact) demonstrate improved recognition of other-race faces (Brigham, Mass, Snyder & Spaulding, 1982; Caroo, 1986; Chiroro & Valentine, 1996; Slone et al., 2000). Other research linking the contact hypothesis and other-race face recognition abilities has provided mixed results. For example, Cross and colleagues (1971) found White children from segregated neighborhoods displayed a greater own-race face effect than did White children from integrated neighborhoods, but the same was not true for African American children from segregated and integrated neighborhoods. Other studies (Brigham & Barkowitz, 1978; Luce, 1974; Malpass & Kravitz, 1969) have also found no correlation between reported interracial contact and recognition for other-race faces. Therefore, quantity of contact with other-race individuals, on its own, does not appear to be a consistent predictor of how well other-race faces will be recognized.

Quality, individuating other-race experience plays a key role as the facilitator of intergroup bias reduction (Cook & Seltiz, 1955) and, alongside quantity of contact, a robust predictor of prejudice (Voci & Hewstone, 2003). Pettigrew (1997, 1998) elaborated on the individuating, quality contact hypothesis, suggesting the importance of

the development of long-term *cross-group friendships*, as friendships involve the processes of cooperation and repeated equal-status contact over an extended period of time. Nevertheless, contact with only a sample of the outgroup, must be able to generalize to the entire outgroup in order to disconfirm stereotypical beliefs about the group as a whole and improve intergroup relations. Therefore, the *more* contact we have, and particularly the more one-on one close personal contact one has with members of the outgroup, the greater the chances for reduction of cognitive intergroup bias (Cook, 1978).

The importance of investigating individuating experience has been highlighted as perhaps the most salient factor influencing the own-race effect (Levin, 2000; Walker & Tanaka, 2003). Levin (2000) has suggested that while people appear to individuate members from their own racial group, they tend to ignore individuating information that would differentiate members of other races. Hence, individuals with less interracial individuating experience would be more likely to demonstrate difficulty in discriminating other-race faces than those individuals who had learned to individuate other-race faces.

As mentioned in Chapter 1, Boehm (1994) provides an excellent example of the integral role individuating experience plays in intergroup bias, whereby not-knowing outgroup members on an individual level results in stereotyping and intergroup bias. Likewise Rieder's (1985) study on new-comer African-Americans to an all-White town, *Carnasie* (New York, USA), showed that without one-on-one personal contact, the visual and cognitive individuation of other-race members is difficult (the own-race effect). In *Carnasie*, the lack of individuating experience between White and Black-American towns people ultimately led to increased intergroup bias.

As one might understand the contact hypothesis to suggest, if (a) the reduction of prejudice occurs through intergroup individuating experience, and (b) the reduction of the own-race effect occurs by means of individuating experience, then are the other-race

effect and prejudice linked? No research to date has substantiated such a link. Yet, the lack of experimental evidence connecting prejudice and the own-race effect is understandable, considering that face perception is a low-level cognitive process, whereas prejudice is a high-level social phenomenon. Hence, prejudice may persist due to social norms even when interracial contact is high (South Africa under apartheid, the Southern United States). It is plausible that the contact hypothesis will impact low-level face perception more readily than social prejudice. Specifically, evidence from training experiments has shown that training individuals to recognize other-race faces can reduce the own-race effect (Elliot, Wills, & Goldstein, 1973; Goldstein & Chance, 1985; Malpass, Lavigneur, & Weldon, 1973). Similarly, recent research by Pascalis and colleagues (2005) has demonstrated that training infants on non-native faces (Barbary macaques) facilitated discrimination of monkey faces. Hence, face-training may enable a reduction in the own-race effect, but would likely be too simple a solution for prejudice reduction. From this perspective, the contact hypothesis suggests a possible link between examinations of inter-group biases and face perceptual expertise, thus forming a bridge between our conscious attitudes and our unconscious behaviors.

Further to the contact hypothesis, the link between *social-contact* and *perceptual contact* (of faces) lies in the encoding and processing of frequently experienced objects (Diamond & Carey, 1986). Perceptual expertise enables familiar objects to be encoded as a single unit or *holistically*, whereas unfamiliar objects are coded on their part-based featural make-up (Yin, 1969). Consequently, perceptual expertise enables efficient exemplar-individuation for more familiar versus unfamiliar objects, and similarly own-race versus other-race faces. Following from the perceptual expertise humans develop for frequently experienced upright faces (versus infrequently experienced inverted faces), the “inversion effect” for faces demonstrates a change in the spatial configuration of face

information whereby inverting the face drastically impairs face recognition but not object recognition (Farah, Wilson, Drain, & Tanaka, 1995). Rhodes, Tan, Brake and Taylor (1989) showed that the inversion effect disrupts own-race perception, but not other-race face perception. Using a face-inversion paradigm, Tanaka, Kiefer and Buckach (2004) found that other-race faces were perceptually encoded in the same way as own-race inverted faces, that is, as a collection of features rather than holistically. In sum, individuals rely on holistic information when processing and perceiving own-race, but not other-race faces.

Nevertheless, individuating experience can provide the link between social and perceptual contact. The influence of individuating experience on perception has been demonstrated in studies of women with eating disorders (von Hippel, Hawkins & Narayan, 1994) where it was found that women with anorexia were better able to identify words of high caloric foods (e.g., cake, candy) than non-anorexic women. With regards to face perception, children who were subjected to physical abuse have shown greater bias towards perceiving an angry expression in a morphed face stimulus than age-matched control participants (Pollak, 2002). These findings indicate the extent to which experience can modulate the perceptual encoding of socially salient stimuli (von Hippel, Sekaquaptewa, & Vargas, 1995). The relationships of anorexics with food and the reaction of abused children to angry facial expressions may result from individuating experience that has facilitated deeper-level stimuli encoding.

The significance of individuating experience on perceptual discrimination abilities has, subsequently, been validated by computer modeling. Furl, Phillips and O'Toole (2002) found that 'experience-based models' demonstrated an own-race effect only when the representational system was developed through experience that warped the perceptual space to emphasize features that individuated the faces of different races. These computer

models replicated an own-race effect that occurs in human participants who have not only other-race contact, but also individuating experience capable of penetrating typical perceptual methods for the encoding and discrimination of other-race faces. The present experiment examines the role of individuating experience in own- versus other-race face perception, as an exploration of perceptual as well as social individuating experience.

The current study investigated the own-race effect in a Northern England city with a history of intergroup conflict. Despite it being one of Britain's best known multicultural centres, the past decade has witnessed increasing divisions between the city's ethnic communities as well as serious outbursts of hostilities. Presently, South Asians form the largest minority group in the United Kingdom and represent 4.37% of the British population. Of those who are South Asian, 45% are Indian, 32% are Pakistani, 12% are Bangladeshi and 11% originate from other South Asian countries. Those of South Asian origin, regardless of their nationality of origin or religion, are usually referred to as South Asian in the U.K.. Two secondary schools from racially segregated communities within the Northern England city were chosen as comparative populations (one British White and the other South Asian) for the present investigation of intergroup experience and the perceptual basis of the own-race effect. The students' other-race social-contact and individuating experience were also measured as these may have influenced unconscious other-race face discrimination skills. The current study included a questionnaire with measures assessing both quantity and quality of other-race contact. These measures extended items used in previous studies that may have only scratched the "contact" surface, and, more specifically, investigated the link between quality, individuating other-race experience and the own-race effect. Hence, the questionnaire used in this study incorporated questions assessing the quantity of social-contact, and the

type of close personal experience (individuating experience) that participants have had with other-race individuals. Responses to all items were on a 5-point scale.

The current study sought to replicate and extend the work of Walker and Tanaka (2003) by utilizing different ethnic samples of participants and employing in-depth interracial experience measures. Walker and Tanaka tested White American and East Asian visiting students (from China) and, subsequently, were the first to demonstrate a perceptual own-race effect for both races of participants. Their questionnaire, however, only examined the role of quantity of social-contact in predicting the own-race effect. Therefore, the Walker and Tanaka perceptual discrimination paradigm was adapted to test the own-race effect of British White and South Asians (immigrants and first generation individuals from India, Pakistan and Bangladesh) on British White and South Asian Faces. The own-race effect test followed a technique applied in previous face perception studies (Beale & Keil, 1995; Calder et al., 1996; Levin, 2000; Walker & Tanaka, 2003); a British White parent face and a South Asian parent face were morphed together generating a continuum of White-to-South Asian morph faces. South Asian and British White participants viewed either a White or South Asian Parent face, followed by a mask, and then either the same parent face (a “same” trial), or a White-South Asian morph face (a “different” trial). The participants judged whether the two faces were the “same” or “different”. The main prediction was that individuals would exhibit an own-race advantage whereby they would be more accurate at the detection of “different” trials for own-race faces than for other-race faces. The sequential same/different matching task provides a good test of the perceptual encoding advantage as it requires very little memory processing.

3.2 Methods

Participants

Participants were 49 British White secondary students and 45 British South Asian secondary students. All 94 participants were male and between the ages of 13-16.⁴

Stimuli and Materials

The same White and South Asian face stimuli used in Experiment 1 were used in the current experiment. That is, 16 faces (4 South Asian males, 4 South Asian females, 4 White males, and 4 White females) were selected as face stimuli as they contained no facial hair or glasses and had little hair covering the forehead. These face stimuli were converted to grayscale and hair and clothing information were removed using *Adobe Photoshop*™ graphics program. The faces were then scaled to an image size of 339 x 400 pixels. Two of the unselected faces (one male, one female) were inverted and tiled in *Photoshop*™ and used as masking stimuli.

The current experiment used the morph images of the 16 faces generated for the previous experiment. Please see section 2.2 for details and Figure 3.1 for an example of the face stimuli. Faces subtended a visual angle of 11 degrees and 7 degrees in the vertical and horizontal dimension, respectively. Face stimuli were presented on a computer monitor with a resolution of 72 dots per inch. Parent and morph faces were displayed in *Superlab*. Each trial consisted of a parent face, followed by a mask, then either the same face (same trial) or a morph face (different trial).

⁴ One of our participating schools was all male, therefore limiting the analyses to only male subjects so that both races of participants could be equally evaluated. Moreover, documented age and gender biases in recognition memory (Grady & Craik, 2000; McKelvie, 1981; Lindholm, 2005; Perfect & Moon, 2005; Wright & Sladden, 2003; Wright & Stroud, 2002) support the use of an age and gender controlled test population looking at faces of a similar age-group. Therefore, the teenage participants in the current study viewed faces of individuals in their teens/late teens.

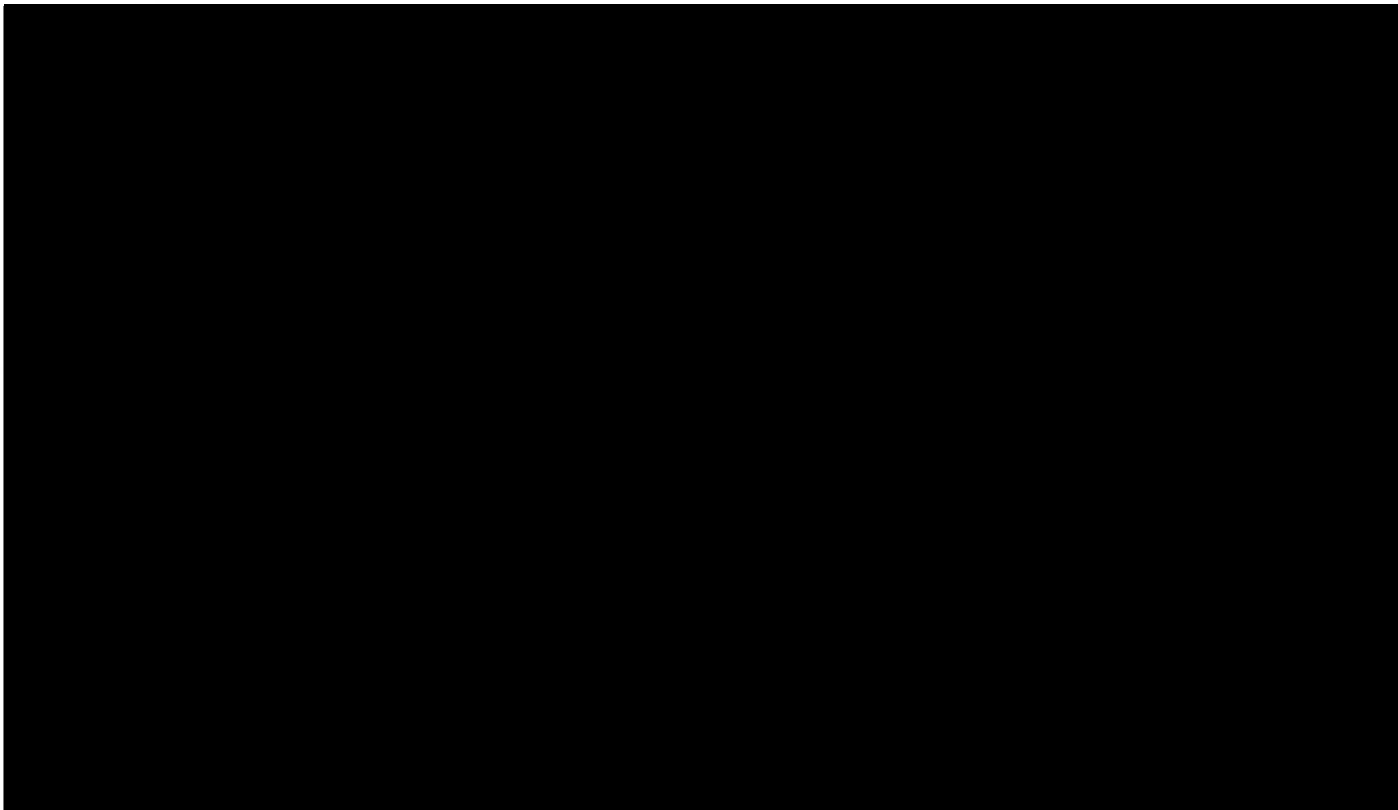


Figure 3.1. Example of the continuum of morph faces produced by image averaging of a South Asian and White face pair. Morph faces in the continuum were produced in 10% intervals ranging from 10% contribution from the South Asian (or White) parent face up to 90%.

The questionnaire used in this study contained 10 items, which sought to assess the participants' relative exposure to, and experiences with, the other race. These items were similar to those of the social-contact and individuating experience scales used in Experiment 1, however, here they have been reworded in certain cases to use language specific to the age-group in question. The 10 items were grouped into categories examining (1) quantity of social-contact and (2) individuating experience. Each question had a scale of 1-5, where 1 signaled low contact, and 5 signaled high contact. Both White and South Asian participants were asked about their experiences with the other race.

Social-contact - The social-contact scale consisted of 5 items. Item 1 asked "How many South Asian (White) people do you know very well?" with answer choices: *Up to 2*, *Up to 5*, *Up to 8*, *Up to 12*, and *More than 12*. Items 2-5 were worded as follows: "I often spend time with South Asian (White) people", "I spend a lot of my free time doing things with South Asian (White) people", "I often go round to the houses of South Asian (White) people", and "South Asian (White) people often come around to my house" (all

using the following scale: *strongly agree, sort of agree, not sure, sort of disagree, strongly disagree*).

Individuating experience - Participants were asked how often they engaged in activities with other-race individuals using the following scale: *very often, quite often, sometimes, hardly ever, and never*. The five items were: 1) “ I have looked after or helped a South Asian (White) friend when someone was causing them trouble or being mean to them”, 2) “ A South Asian (White) person has looked after me or helped me when someone was causing me trouble or being mean to me”, 3) “I have comforted a South Asian (White) friend when they have been feeling sad”, 4) “A South Asian (White) person has comforted me when I have been feeling sad”, and 5) “ I have asked a South Asian (White) person to be on my team or in my group during sports or activities”.

Procedure

At the beginning of each trial, each participant viewed a South Asian or White parent face for 750 ms that was then masked for 1s and followed by either the same parent face or a different morph face. The participant was instructed to judge whether the second probe face was the “same” as or “different” from the first face via a keyboard response. Instructions emphasized that a “same” response indicated that the participant believed that the two faces were physically identical. After each response, a blank screen appeared for 1s and then the next trial began. During different trials, the South Asian (White) parent face was followed by a morph face consisting of 90, 80, 70, 60 or 50 percent contribution from that parent face and the remaining percent contribution provided by the White (South Asian) parent face. Hence, for each parent face, there were five “different” trials and an equal number of “same” trials where the same parent face was shown for the first and second presentations. Male and female face trials were blocked and separated by a short break, and the presentation order of these two sections

was counterbalanced across participants. Within each gender block, the South Asian and White trials were presented randomly. There were 80 “same” trials and 80 “different” trials for a total of 160 trials for each participant. After the “same” or “different” face perceptual task, participants completed the questionnaire using the keyboard numbers to enter their responses.

3.3 Results

Face Discrimination Accuracy

Participant performance on the discrimination task was evaluated by assessing the percent hits (the percent of times participants were able to correctly identify a “different” trial)⁵. Own and other-race face discrimination accuracy was correlated for both test populations, White participants: $r=.60$, $p<.001$ and South Asian participants: $r=.57$, $p<.001$. A 2 (Race of Participant: South Asian vs. White) by 2 (Race of the Face stimulus: South Asian vs. White) by 5 (Level of Morph: 90% vs. 80% vs. 70% vs. 60% vs. 50%) mixed model analysis of variance (ANOVA) was performed, with repeated measures on the last two factors.

The ANOVA showed that the main effect of within-participants factor Morph Level was reliable, $F(4, 368)=152.93$, $p<.001$, $\eta_p^2=.62$, demonstrating, as predicted, that “different” trials with morphs closer to the parent face (e.g., 90% parent face) were more difficult to discriminate than more composite morphs (e.g., 50% parent face). The within participants factor Race of Face was not reliable, $p>.05$, demonstrating that overall, no difference existed between discrimination accuracy of South Asian versus White face

⁵ Nearly 100% accuracy was achieved on the perceptual discrimination task “same” trials for White and South Asian participants alike (preliminary t-tests found no significant difference for own- versus other-race same trial accuracy, $p=.71$) and were therefore excluded from subsequent analyses, White participants: White faces mean % accuracy = 97.71, $SD=6.58$, South Asian faces, $M=98.90$, $SD=7.85$; South Asian participants: White faces, $M=98.62$, $SD=8.75$, South Asian faces, $M=98.01$, $SD=9.08$.

stimuli. An interaction of Race of Face by Race of Participant was significant, $F(1, 92)=11.49, p<.001, \eta_p^2=.11$ (see Figure 3.2).

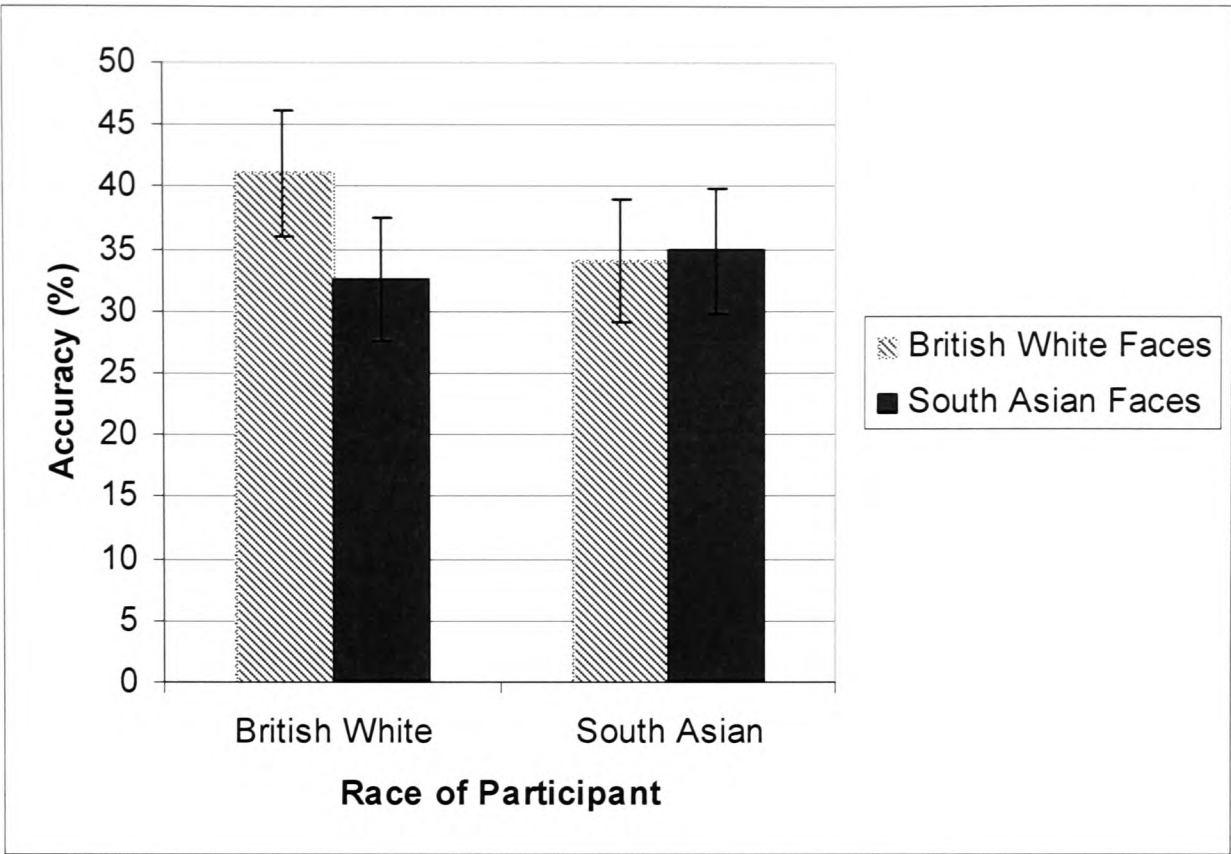


Figure 3.2. The interaction of Race of Face by Race of Participant on overall own- versus other-race face discrimination accuracy (%); error bars represent 95% confidence intervals.

Separate comparisons of the subgroups demonstrated that White participants were significantly better at discriminating faces of their own race over those of the other (White faces: $M=46.28, SD=1.90$, South Asian Faces: $M=39.27, SD=1.61$; $F(1,48)=20.03, p<.001, \eta_p^2=.29$). However, South Asian participants demonstrated a non-reliable tendency to discriminate own-race faces more accurately than other-race faces (White faces: $M=36.64, SD=1.77$, South Asian Faces: $M=38.87, SD=2.55$; $p=.41$). Furthermore, White participants were significantly better at discriminating White faces than were South Asian participants, $F(1, 92)=13.35, p<.001, \eta_p^2=.13$.

Contact Questionnaire

The reliability of the two multi-item measures (quantity of social-contact, individuating experience), were high: (1) social-contact (Cronbach’s alpha=.83; .85 for

South Asian and .78 for White subgroups), and (2) individuating experience (Cronbach's $\alpha=.89$; .85 for South Asian and .91 for White subgroups). Indexes for each measure were constructed for each respondent by computing the mean response to the number of items in each of these three reliable measures. Table 1 presents the means and standard deviations for both race groups.

Measure	White Participants	South Asian Participants
1. Social-contact	2.01(.80)	2.24 (1.07)
2. Individuating experience	2.31 (1.00)	2.62 (.99)

Table 3.1. Mean and Standard Deviations (indicated in parentheses) of responses (on a 5-point scale) to the Social-contact Questionnaire.

Despite being qualitatively different measures of contact, the measures of quantity of social-contact and individuating experience were correlated, $r=.47, p<.01$. This finding is expected as both are measures of contact, and the more social-contact one experiences the greater opportunity one has for individuating experience. These indices were then used, along with respondent's ethnic subgroup, to predict their accuracy scores for White and South Asian faces.

Due to the reliable own-race effect observed in White participants, their accuracy scores for other-race faces, collapsed across level of morph, were regressed on all three measures, to determine their predictive ability of the own-race effect. It was predicted that own-race face accuracy, and overall social other-race contact must be accounted for when considering the predictive influence of individuating experience. Own-race face accuracy was entered in the first step in order to control for overall face discrimination abilities. Social-contact and individuating experience were subsequently entered into the second step. The regression of South Asian faces, as predicted, indicated a positive effect

of own-race face accuracy (standardized $\beta=.55$, $p<.001$) and of individuating experience for Whites (standardized $\beta=.32$, $p<.05$). Moreover, this effect explains 42.9% of the residual variance (of which the significant factor of individuating experience explained 7%) observed in White participants for other-race face discrimination accuracy. These results demonstrate that when controlling for the variance of own-race face accuracy, and quantity of other-race social-contact, individuating experience plays a significant role in the ability of the White participants to discriminate South Asian faces. As no own-race effect for South Asian participants was observed, no subsequent regression analyses were performed to investigate the predictive influence of social-contact or individuating experience on such an effect. Furthermore, correlation analyses found no correlations between questionnaire measures and face discrimination.

The regression results demonstrated that the level of other-race experience was a predictor for the performance of the White participants on the facial discrimination task. Specifically, White participants with higher levels of individuating experience with South Asians showed increased discrimination accuracy for South Asian faces.

3.4 Discussion

Intuitively, one might assume that among two groups of individuals living parallel lives in racially and ethnically segregated communities (Cantle Report, 2001), a robust own-race effect would be observed for both races. Nevertheless, the current study has demonstrated that an own-race effect in face discrimination is only present for one of the two communities: that which also happens to be the majority race in the United Kingdom, White. Specifically, White participants were significantly better at discriminating White faces than South Asian faces. South Asian participants on the other

hand, were equally accurate at discriminating South Asian and White faces overall. This study, therefore, replicated the findings of past studies of both face recognition and perceptual expertise for the White participants, yet failed to produce the same overall effect for the South Asian participants.

The current own-race effect observed for White participants substantiates previous theory offered by Valentine's exemplar-based coding model for faces (1991, 1992, 2001), whereby other-race faces are assumed to be more cognitively similar than are own-race faces, and therefore individuals will demonstrate a deficit in making subtle other-race perceptual discriminations. With regard to the South Asian participants, the minority race, it is possible they have developed exemplars for both South Asian and White faces, therefore readily accessing both schemas when discriminating own and other-race faces.

Conversely, these findings conflict with Levin's (2000) feature-selection explanation of the own-race effect, stipulating the existence of a recognition bias towards own-race faces, which reverses at a level of perceptual expertise; feature-based encoding is optimal for classification (perception) but not for recognition. Levin (2000) demonstrates in a discrimination task that participants (7 White, 3 Hispanic, and 3 East Asian) who showed a memory advantage for White faces paradoxically exhibited a race classification perceptual advantage for Black faces. Levin suggests that the perceptual classification own-race effect occurs because race encoding information (for processing other-race faces) distracts the encoding of individuating features. In the current study, neither White nor South Asian participants demonstrated better perceptual discrimination for faces of the other-race. Contrary to Levin's task, however, the current task was not one of perceptual classification by race but rather a simple perceptual discrimination (same/different). Different encoding strategies employed for this experiment's sequential

same/different task versus Levin's simultaneous match-to-sample race classification task, the fact that both White and South Asian participant populations were tested in the current investigation, or differences between South Asian and Black faces might account for the disparate findings.

Using a similar face discrimination task, Walker and Tanaka (2003) were able to demonstrate an own-race face effect for both White and East Asian participants in the United States and Canada. That is, White and East Asian participants alike were significantly better at discriminating own-race versus other-race faces. The East Asian participants in the Walker and Tanaka (2003) study were, however, international students who had not been brought up in North America and, therefore, were less familiar with White faces, than were the South Asian secondary students in the present study, the majority of whom were born and raised in the U.K..

The own-race effect in recognition memory may also be regarded as a type of visual expertise such that objects in the domain of expertise, in this case own-race faces, become more differentiated as a consequence of perceptual learning and expertise (see Goldstone, 1998, for a discussion of perceptual learning and expertise). As own-race experts, individuals see faces from their own race as perceptually more distinctive and unique than faces of other-races, which are viewed as perceptually more homogenous.

In the present study, results from the questionnaire's measure individuating experience, were able to account for a significant amount of the total variance explained for White participants on the face discrimination task and, hence, a substantial component of the own-race effect observed for White participants. White participants who reported high levels of individuating experience were better at discriminating South Asian faces than were White students who reported low levels of individuating experience.

The contact hypothesis suggests that greater other-race experience may lead to superior other-race face processing. Although the contact hypothesis was validated by data from the White participants, the current study failed to show an own-race effect or a correlation between experience and face-discrimination accuracy for South Asian participants. Nevertheless, task performance by South Asian participants may still be explained in terms of the length of time in the country. A study by Dehon and Brédart (2001) in Belgium obtained similar results wherein only White participants, and not African participants, demonstrated an own-race effect. Dehon and Brédart proposed that as the African participants had lived in the predominantly White country for at least five years, their exposure to Whites in various circumstances (at work, in school, socially, in the mass media, etc.) was inevitable and hence influenced their ability to discriminate other-race faces. As the predominant race in Belgium is White, it is much easier to understand how White participants could have much less experience with African individuals. Moreover, Wright, Boyd and Tredoux (2003) found a similar result when testing the own- versus other-race face recognition accuracy of White and Black students in South Africa. Only the White students exhibited an own-race effect, however, it was argued that as the majority of the teachers and other authority figures were White, the Black students were subsequently “experts” in White face recognition.

From infancy the South Asian participants in the current study were exposed to television, newspapers, magazines, and professional sport in the United Kingdom. More importantly, the majority of teachers at their school were White. Although the current study’s questionnaire touched on various types of experience, it failed to focus on student-teacher interactions as well as other experiences with and exposure to White authority figures. Authority figures could be considered as extremely influential for young students (Formanek & Woog, 1971; Raviv et al., 2003; Ryan, 1996) as they

controlled the everyday lives of these students, in that the students had to follow their direction in fear of punishment or negative consequences (Eisenberg et al., 1985; Scarlett, 1989). Therefore, it might be argued that the South Asian students became other-race face experts in order to differentiate teachers and staff. Fiske (1993) offers the explanation that individuals of lower status and power are more motivated to differentiate outgroup (individuals of higher status and power) members, as the information regarding those in powerful groups is important to everyday life interactions. Thus, over time, the South Asian students may have developed finely tuned other-race face perceptual discrimination skills.

Research by Goldstein and Chance (1985) lends support to the hypothesis that the South Asian students learned to differentiate other-race face cues and improved their recognition abilities for other-race faces. They trained participants to learn 64 other-race face digit pairs over a period of 1-5 months. A reduction of the own-race effect in recognition memory was observed in test participants, supporting the theory that repeated exposure and training can increase the ability to discriminate other-race faces. As was true for the White students trained by Goldstein and Chance (1985), the South Asian students in the current study may have felt under pressure to learn White faces, and perhaps it was this motivation which spurred their learning and equalized their abilities for the discrimination of own and other-race faces.

To summarize, the present study employed a perceptual discrimination task in which a minimal demand was placed on memory processing. Using this perceptual paradigm, an own-race effect was found for White secondary students, such that the White students were more accurate in detecting differences in White faces than in South Asian faces. Individuating experience was a reliable predictor of the own-race effect in White participants. This finding supports the contact hypothesis, whereby individuals

with more individuating other-race experience were more accurate in discriminating other-race faces. The results indicate that individuating experience can predict an own-race effect not simply at the stage of recognition, but at the stage of perceptual encoding. The absence of an own-race effect in the South Asian students may reflect their extensive experience with Whites, as discussed, despite the inability of the current study's questionnaire to shed light on this matter.

Chapter 4

The Own-Race Effect, Implicit Racial Bias and Signal Detection Theory

4.1 General Introduction

From the age of four through adulthood, humans anecdotally report and experimentally demonstrate higher accuracy for recognizing faces of their own race versus those of other-races (the own-race effect; Pezdek et al., 2003; Walker & Hewstone, in press, a, b; see Meissner & Brigham, 2001, for a meta-analysis; Valentine, Chiroro & Dixon, 1995, for a review). As discussed in the previous two Chapters, the own-race effect typically demonstrated in recognition might be due to the initial encoding of the face stimulus (Walker & Tanaka, 2003). Recent research by Walker and Tanaka (2003) and Walker and Hewstone (in press a, b: Chapters 2 & 3) on the encoding of own-versus other-race faces has offered evidence for a perceptual basis of the effect, untainted by memory processing.

Specifically, research has revealed that individuals are better at within-own-race than other-race discriminations of faces (Valentine, 1991a), but faster at other-race face classification (Levin, 1996). As mentioned in section 1.3.2, two theoretical models have been proposed to explain the cognitive processing difference in discriminating own-versus other-race faces. Valentine (1991 a, b) proposed a multi-dimensional face-space, whereby through repeated exposure to own-race faces, a person develops a typicality structure in which there are many exemplars as well as an abstract prototype of an average own-race face. Within the multi-dimensional face-space that Valentine proposes, featural values of own-race faces are represented much more frequently than featural values of other-race faces; the featural values of other-race faces are under-represented

with less precision as to where certain featural boundaries are located. Valentine (1991 a, b) argues that although other-race faces are located away from the central tendency of own-race faces, they are, as a group, more difficult to discriminate because they are densely clustered within the multidimensional face space. Conversely, Levin (1996) explained that visual information indicating the *race* of other-race faces is coded as a feature, creating a pop-out effect⁶, which results in faster identification and classification for those faces (Treisman & Gormican, 1988). Levin proposed that when individuals view other-race faces rather than own-race faces, they encode race-specifying information at the expense of individuating information.

Using both perceptual pop-out effect paradigms and old-new recognition memory tasks (Levin, 2000), Levin demonstrated that White participants were better at recognizing White than Black faces in the old-new task, but were faster at identifying a Black face in a sea of White faces, than a White face in a sea of Black faces. According to Treisman and Gormican (1988), and Levin (1996, 2000) this phenomenon is due to the fact that other-race faces are featurally encoded and stand out amongst own-race faces, whereas an own-race face is not as easily detected in a sea of other-race faces which act as distractors. Levin's feature-based encoding theory explains these results, such that participants who are poor at recognizing Black faces appear to code 'blackness' and not 'whiteness' as a physical feature. Levin theorizes that race is a specific visual feature that people use when encoding faces. Hence, both Valentine's and Levin's theories explaining the own-race effect emphasize characteristically different ways in which own- versus other-race faces are processed.

The current experiments use between-category morphed face stimuli (White and Black faces morphed together on a linear continuum as in Levin, 2000) to determine

⁶ Treisman and Gormican (1988) proposed a pop-out effect whereby a visual search for a feature-positive target among feature-negative distractors was faster than for a feature-negative target among feature-positive distractors. Levin (2000) repeated this task using White and Black faces for the visual search.

whether participants will be more accurate at discriminating subtle differences between morphs of own-race faces, as Valentine might suggest. Alternatively, if Levin's feature based hypothesis is true, morphs of other-race faces will be more readily detected. Like Levin (2000), the current studies use face stimuli generated by morphing White and Black faces together on a linear continuum (see methods). However, the current task varies from Levin's simultaneous matching task, in that it employs an A|X sequential presentation, perceptual discrimination test of the own-race effect.

The current task has previously demonstrated a significant own-race effect in Whites and East Asians (Walker & Tanaka, 2003) and Whites and South Asians (Walker & Hewstone, in press a, b: Chapters 2 and 3), whereby participants were worse at discriminating other-race face morphs than own-race face morphs; but it has yet to be tested on the White-Black continuum of morphed faces. It has been suggested (Maddox, 2004) that Afrocentric features are particularly distinctive from Caucasian features; and Asian features more closely resemble Caucasian than do Afrocentric features. Therefore, the pop-out effect Levin reported may be different from the own-race effect observed by Walker and colleagues (2003, in press a, b) as it can be argued that Asian features are similar to Caucasian and therefore these faces are not featurally coded by race, but rather coded in the same manner as own-race faces.

Presently, further data is required to elucidate the perceptual own-race effects (Walker & Tanaka, 2003, Walker & Hewstone in press a, b) and race pop-out effect (Levin, 1996, 2000). Therefore, Experiment 3 examines the own-race effect in White and Black participant populations. Experiment 4 expands upon and clarifies the findings of Experiment 3 by testing two races of participants (White and South Asian) on the same White and Black stimuli from Experiment 3, along with a similar set of South Asian face stimuli.

Further to a theoretical explanation of the encoding strategies of own- versus other-race faces is an exploration of the way in which we acquire experience for own- versus other race faces. The contact hypothesis has been previously examined as a potential predictor of the own-race effect (Chapters 2 & 3), whereby the more other-race experience an individual has, the better they are at discriminating and recognizing other-race faces (in line with Valentine's experience-based encoding of faces). Moreover, explicit measures of racial contact, attitudes and bias are also considered indicators of the way in which we selectively encode own- versus other-race faces. Therefore, the current experiments include measures of these effects.

Implicit measures are also used to examine racial bias. As explicit self report measures are more easily controlled by conscious decision, implicit bias, is tested as a less controllable measure of other-race attitudes. The Implicit Association Test (Greenwald, McGhee, & Schwartz, 1998) provides a well documented measure of racial bias and was employed in both Experiments 3 and 4 of the current Chapter as an indirect test of racial bias. The measure of implicit racial bias used here tested uncontrollable behavioural response, demonstrating an association between one group with pleasant attributes and the other with unpleasant attributes. Specifically, participants responded to a series of items that were classified into four categories; two represented a concept discrimination, in the current paradigm *Black faces* versus *White faces*, and two represented an attribute discrimination such as *pleasant* versus *unpleasant* words. Participants responded rapidly with a right-hand key press to items representing one concept and one attribute (e.g., *White faces* and *pleasant*), and with a left-hand key press to items from the remaining two categories (e.g., *Black faces* and *unpleasant*). Participants then performed a second task in which the key assignments for one of the pairs was switched (such that *Black faces* and *pleasant* shared a response, as did *White*

faces and *unpleasant*). The IAT produces measures derived from latencies of responses to these two tasks.

Typically, the IAT scores are interpreted in terms of association strengths (socially learned or developed associations) by assuming that participants respond more rapidly when the concept and attribute map on to the same response are strongly associated (e.g., *White faces* and *pleasant*) than when they are weakly associated (e.g., *Black faces* and *pleasant*).

In sum, Experiments 3 and 4 in the present Chapter seek to elucidate the own-race effect in perception on the White-Black continuum in White and Black test populations (Experiment 3) and on the White-Black and White-South Asian continuum in White and South Asian test populations (Experiment 4). The present experiments endeavoured to determine whether an own-race effect is observed for White versus Black faces (Experiments 3 and 4) and whether individuals who showed an own-race effect for one other race showed a generalized effect towards more than one other race (Experiment 4). In Experiments 3 and 4 the own-race effect was investigated in light of explicit social factors and implicit racial bias, which may inhibit or facilitate the perception of other-race faces.

4.2 Experiment 3: Introduction

This experiment was undertaken to replicate the cross-over own-race effect observed by Walker and Tanaka (2003) testing White and Black participants using the morph face perceptual discrimination task (Walker & Tanaka, 2003). Furthermore, the relationship between the own-race effect and the Implicit Association Test, and their subsequent correlations with other-race attitudes and experience were investigated.

The current study explores four main predictions: (1) an own-race effect will be observed in line with previous findings using the same experimental paradigm (Walker & Hewstone, in press, a, b; Walker & Tanaka, 2003), (2) the Implicit Association Test is expected to reveal an anti-Black bias in White participants and a null-to-anti-White bias in Black participants⁷, (3) the own-race effect is predicted to correlate with the IAT and finally, (4) the own-race effect and IAT are predicted to correlate with measures of the social attitudes and contact questionnaire.

4.2.1 Methods

Participants

Participants were 30 White (13 male, 17 female) and 14 Black (5 male, 9 female) university students.

Stimuli and Materials

Photographs of 62 university-aged, male and female, White and Black individuals were taken with a digital camera. The individuals were photographed in a frontal pose with a neutral expression at a distance of 75 cm. Of the 62 individuals photographed, 16 faces (4 White males, 4 White females, 4 Black males, and 4 Black females) that contained no facial hair or glasses and little hair covering the forehead were selected as face stimuli. The face images were converted to grayscale and hair and clothing information were removed using the *Adobe Photoshop*TM graphics program. The faces

⁷ American data has previously suggested that almost half of Black Americans who take the IAT demonstrate anti-Black/pro-White bias (Banaji, Nosek & Greenwald, 2004); this effect is discussed as reflecting the history in the United States of strong associations between Black and bad, White and good. As there is no available British data on this topic, and the White-Black climate in the U.K. may be different from that in the U.S.A. the current experiment did not predict that Black participants would show an anti-Black/pro-White effect, but rather a no-bias-to anti-White/pro-Black bias.

were then scaled to an image size of 339 x 400 pixels. Two of the unselected faces (one male, one female) were inverted and tiled in *Photoshop*TM and used as masking stimuli.

As in the previous two experiments, the 16 faces were paired according to gender and similar face shape (each Black male face with a White male face; each Black female face with a White female face). Using the program *Morph 2.5*, face pairs were averaged together on a linear continuum, equivalent to a process described by Beale and Keil (1995), and more specifically in Chapters 2 and 3.

The morphing method generated replicated that described in Experiment 1, see section 2.2 for details, and Figure 4.1 for examples of the face stimuli. As in the previous two experiments, face stimuli were presented on a computer monitor with a resolution of 72 dots per inch. Parent and morph faces were displayed in *Superlab*. Each trial in *Superlab* consisted of a parent face, followed by a mask, then either the same face (same trial) or a morph face (different trial).

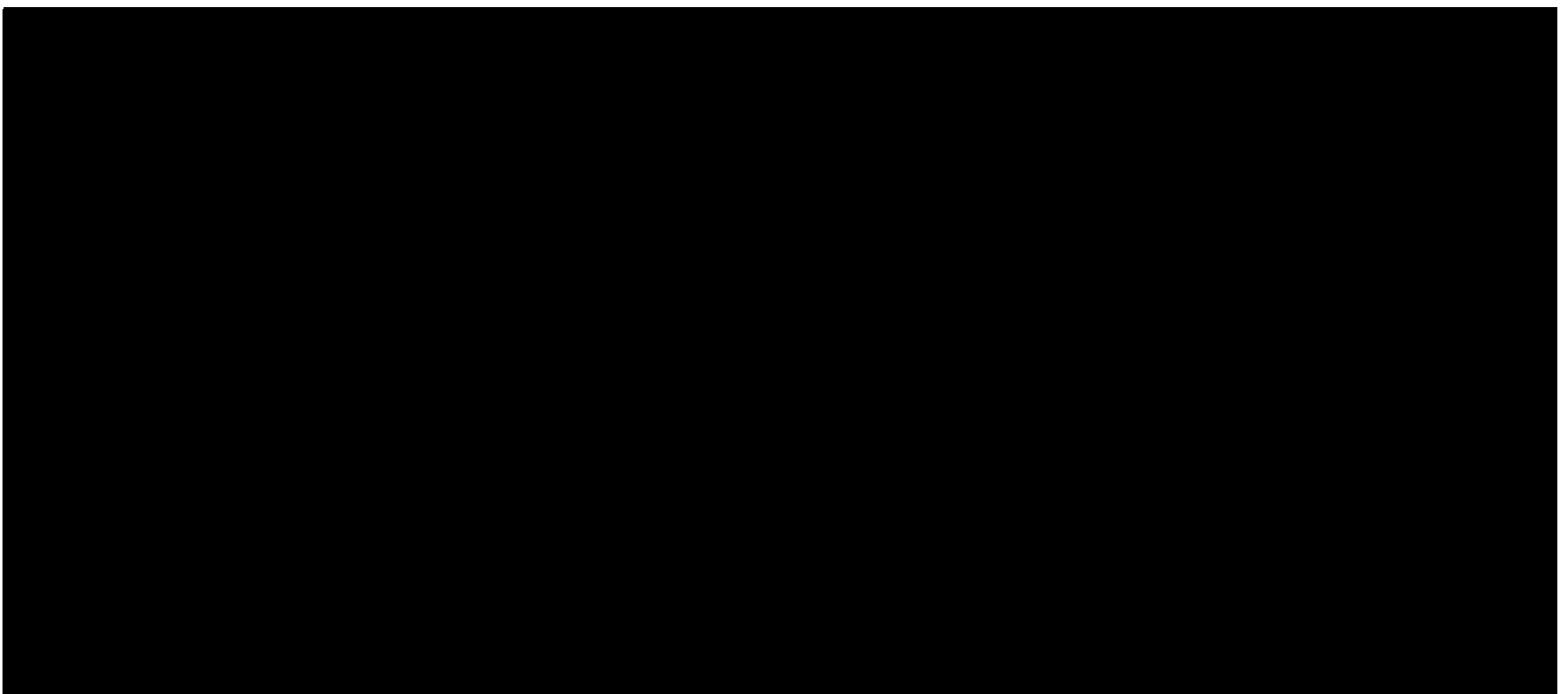


Figure 4.1. Example of the continuum of morph faces produced by image averaging of a Black and White face pair. Morph faces in the continuum were produced in 10% intervals ranging from 10% contribution from the Black (or White) parent face up to 90%.

Participants completed the Implicit Association Test as described in this Chapter's introduction. Faces (White and Black: neutral faces not used in the discrimination paradigm) as well as words (pleasant and unpleasant) were viewed during this task. Faces stimuli used in the IAT were identical to the parent faces used in the perceptual discrimination task. The pleasant and unpleasant words used in the current experiment were taken from those validated by Greenwald and colleagues (1999) initial IAT study, and were as follows, positive words: wonderful, love, happy, joy, smile, and bliss; the negative words: evil, grief, horrible, death, and miserable. See Table 4.1 below for the experimental variables and task description.

Block	No. of Trials	Function	Items assigned to left-key response	Items assigned to right-key response
1	20	Practice	White faces	Black faces
2	20	Practice	Pleasant words	Unpleasant words
3	20	Practice	Pleasant words + White faces	Unpleasant words + Black faces
4	40	Test	Pleasant words + White faces	Unpleasant words + Black faces
5	20	Practice	Black faces	White faces
6	20	Practice	Pleasant words + Black faces	Unpleasant words + White faces
7	40	Test	Pleasant words + Black faces	Unpleasant words + White faces

Table 4.1. Sequence of Trial Blocks in the Black vs. White IAT; *Note.* For half of the participants, Blocks 1, 3, and 4 are switched with those of Blocks 5, 6, and 7 respectively. The procedure in Blocks 3, 4, 6, and 7 is to alternate trials that present either a pleasant or an unpleasant word with trials that presented either a White or Black face. (Greenwald, et al., 1998).

The questionnaire used in this study contained 25 questions, which sought to determine the participants’ relative exposure to, experiences with, and anxiety towards the other race. The 25 items were grouped into categories examining (1) prejudice, (2) anxiety, (3) social-contact, and (4) individuating experience. Each question had a scale of

1-5, where 1 signaled low prejudice, low anxiety, low contact, and 5 signaled high prejudice, high anxiety and high contact. White participants were asked about their attitudes, anxiety towards and experiences with Black people, whilst Black participants were asked about their attitudes, anxiety towards and experiences with White people.

Prejudice - The prejudice scale includes items adapted from Dunton and Fazio's prejudice suppression scale (1997). Participants expressed their attitudes on a 1-5 scale: *strongly agree, sort of agree, not sure, sort of disagree, strongly disagree*⁸, in response to the following items: (1) If I have a prejudiced thought or feeling I keep it to myself, (2) Sometimes I tell jokes that might offend people of other races, (3) In today's society it is important that one is not perceived as prejudiced in any manner, (4) I get angry with myself when I have thoughts or feelings that might be considered prejudiced, (5) It is important to me that other people don't think I'm prejudiced, (6) I try not to treat other-race people differently from people of my own-race, and (7) Sometimes I express prejudiced thoughts or feelings accidentally/non-accidentally in the wrong company.

Intergroup anxiety - The intergroup anxiety scale was adapted from the Stephan and Stephan (1985) scale. Participants were asked to imagine being the only member of their own race in a room of all other-race individuals. On four 5-point semantic-differential scales (*Relaxed-Nervous, Pleased-Worried, Comfortable-Tense and Fine-Scared*) participants were asked to indicate how they would feel.

Social-contact - The social-contact scale consisted of 6 items. Item 1 asked, 'How many Black (White) people do you know very well?' with answer choices: *Up to 2, Up to 5, Up to 8, Up to 12, and More than 12*. Items 2-8 used the following scale: *strongly agree, sort of agree, not sure, sort of disagree, strongly disagree* and were worded as: (2) I often talk to Black (White) people in college, (3) I often see Black (White) people outside of

⁸ The prejudice scale was reversed during analyses (except for question 7) such that 1 signaled low prejudice and 5 signaled high prejudice.

college, (4) I often hang out with Black (White) people, (5) I often have Black (White) people round to my house/college room, and (6) I often go round to the houses/college rooms of Black (White) people.

Individuating experience - Participants were asked to indicate how often they engaged in activities with other-race individuals using the following scale: *very often, quite often, sometimes, hardly ever, and never*. The seven items were: (1) I have looked after or helped a Black (White) person when someone was causing them trouble or being mean to them, (2) A Black (White) person has looked after me or helped me when someone was causing me trouble or being mean to me, (3) I have comforted a Black (White) person when they have been feeling sad, (4) A Black (White) person has comforted me when I have been feeling sad, (5) I have asked a Black (White) person to be on my team or in my group during sports or activities, (6) I have helped a Black (White) person with a problem they had with course work, and (7) I have received help from a Black (White) person when I have had a problem with course work.

The reliability of the four multi-item measures (prejudice, intergroup anxiety, social-contact, individuating experience), were all reliable: (1) prejudice (Cronbach's $\alpha=.74$; .75 for Black and .70 for White subgroups), (2) anxiety (Cronbach's $\alpha=.85$; .84 for Black and .85 for White subgroups), (3) social-contact (Cronbach's $\alpha=.92$; .80 for Black and .72 for White subgroups), and (4) individuating experience (Cronbach's $\alpha=.94$; .82 for Black and .92 for White subgroups).

Procedure

At the beginning of each trial, the participant viewed a Black or White parent face for 750ms that was then masked for 1s and followed by either the same parent face or a different morph face. The participant was instructed to judge whether the second probe face was the 'same' as or 'different' to the first face via a keyboard response. Instructions

emphasized that a ‘same’ response indicated that the participant believed that the two faces were physically identical. After each response, a blank screen appeared for 1s and then the next trial began. During different trials, the Black (White) parent face was followed by a morph face consisting of 90, 80, 70, 60 or 50 percent contribution from that parent face and the remaining percent contribution provided by the White (Black) parent face. Hence, for each parent face, there were five ‘different’ trials and an equal number of ‘same’ trials where same parent face was shown for the first and second presentations. Male and female face trials were blocked and separated by a short break, and the presentation order of these two sections was counterbalanced across participants. Within each gender block, the Black and White trials were presented randomly. There were 80 ‘same’ trials and 80 ‘different’ trials for a total of 160 trials in the experiment. Half of the participants completed the IAT prior to, and the other half after, the face discrimination task. Following both behavioural tasks, participants completed the questionnaire.

4.2.2 Results

Face Discrimination Accuracy

Participant performance on the discrimination task was evaluated by assessing the number of hits (the number of times participants were able to *correctly* identify either ‘same’ or ‘different’ trials). A 2 (Race of participant: Black vs. White) x 2 (race of the face stimulus: Black vs. White) x 6 (Level of Morph: 100% vs. 90% vs. 80% vs. 70% vs.

60% vs. 50%)⁹ mixed-model analysis of variance (ANOVA) was performed, with repeated measures on the last two factors.

The ANOVA showed that the main effect of Race of participant was not significant, $p > .05$, in that neither race outperformed the other. The within-participants factor Morph Level was reliable, $F(5, 210) = 112.18$, $p < .001$, $\eta p^2 = .73$, demonstrating, as predicted, that trials with morphs closer to the parent face (e.g., 90% parent face) were more difficult to discriminate than more composite morphs (e.g., 50% parent face). The within-participants factor race of face was not reliable, $p > .5$, demonstrating that overall, no difference existed between discrimination accuracy of Black versus White face stimuli. A marginal interaction of Race of participant by race of face was found, $F(1, 42) = 3.74$, $p = .06$, $\eta p^2 = .09$. Subsidiary ANOVAs per subgroup revealed that both White and Black participants demonstrated a non reliable tendency to discriminate own-race faces more accurately than other-race faces $p > .05$ (percent mean accuracy: White participants - White faces, $M = 71.70$, $SD = 12.70$, Black faces, $M = 70.38$, $SD = 13.04$; Black participants – White faces, $M = 65.24$, $SD = 12.97$, Black faces, $M = 74.58$, $SD = 15.95$).

Implicit-Association task

IAT scores (where .22 suggests no bias, scores above suggest anti-Black bias/pro-White bias and scores below show anti-White/pro-Black bias) to assess indirect race bias demonstrated an anti-Black bias for White participants, $D = .47$, $SD = .39$. Conversely, Black participants demonstrated no racial bias, $D = .22$, $SD = .38$. For both race groups, IAT scores were consistent from practice to test blocks (White participants: Cronbach's $\alpha = .76$; Black participants: Cronbach's $\alpha = .68$).

⁹ 100%, or 'same' trial hits were included in the repeated measures ANOVA analysis as preliminary analyses (t-tests) showed a difference for same trial detection for own- versus other-race faces. In studies 1 and 2 of this thesis only different trial hits were included as same-trial accuracy was not found to be different for own or other-race faces.

A one-factor ANOVA with Race of participant as a fixed factor and IAT score (*D*) as the dependent variable was marginal, $F(1,42)=3.91$, $p=.055$, $\eta p^2=.087$, such that White participants demonstrated a tendency of greater bias towards pairing White + pleasant, Black + unpleasant, than did Black participants.

Questionnaire

Indexes for each of the four measures were constructed for each respondent by computing the mean response to the number of items in each of these three reliable measures. Table 4.2 presents the means and standard deviations for both race groups. These indices were then used, along with respondent’s ethnic subgroup, to predict their accuracy scores for White and Black faces.

Measure	White Participants	Black Participants
1. Prejudice*	4.03 (.38)	3.66 (.76)
2. Intergroup anxiety*	4.19 (.65)	4.46 (.60)
3. Social-contact	2.09 (.57)	4.21 (.50)
4. Individuating experience	3.17 (.93)	4.27 (.46)

Table 4.2. Means and Standard Deviations (indicated in parentheses) of responses (on a 5-point scale) to the Social Anxiety and Contact Questionnaire; * indicates scale was reverse scored.

One-way ANOVAs were performed, on each dependent measure, to determine between-group differences. The between-subjects factor of Race of participant was significant for three of the four measures: prejudice, $F(1,42)=4.63$, $p<.05$; social-contact, $F(1,42)=142.97$, $p<.001$; individuating experience, $F(1, 42)=12.39$, $p<.001$; anxiety, $p>.05$. As seen in Table 4.2, Black participants reported significantly more other-race

social and individuating experience than did Whites, whereas White participants reported significantly more prejudice than did Blacks.

IAT Correlations

As no significant own-race effect in face discrimination accuracy was demonstrated in either White or Black participant subgroups, no analyses were performed for potential correlates of the effect. However, due to negative-Black bias observed in White participants' IAT scores ($D=.47$), D -scores were correlated with individual questionnaire measures to determine whether other-race prejudice, anxiety, or contact measures influenced White participants' IAT scores. Prejudice was found to correlate with White participant IAT scores, $r=.63$, $p<.05$, such that individuals reporting more explicit prejudice also demonstrated greater implicit racial bias on the IAT. None of the other questionnaire measures were found to correlate with the IAT bias observed in White participants, nor the no-bias observed in Black participants.

4.2.3 Discussion

The current experiment demonstrated a marginal Race of participant by race of face interaction, with participants showing a tendency to discriminate own-race faces more accurately than other-race faces. However, this interaction was not qualified by main effects of race of face for either Black or White participant subgroups. The four main experimental predictions were investigated through the data analyses.

Firstly, only a marginal Race of participant by race of face interaction was observed. In order to explain this effect, we must first investigate potential differences in stimuli used in the literature to date versus those used in the current experiment. Using the present experiment paradigm, this study was the first attempt to morph Black faces on

a White to Black linear continuum (described in the Methods section). However, despite employing the same task as Walker and Tanaka (2003) and Walker and Hewstone (in press, a, b: Chapters 2 & 3), the morphing technique applied here may have created perceptually different stimuli than when morphing Asian faces (Asian – White continuum). Previous research has discussed the uniqueness of Afrocentric features when compared to White or South Asian (Blair, Judd, & Chapleau, 2004; Maddox, 2004) features. Moreover, despite the difference in skin tone between White and South Asian faces, they are, nonetheless, featurally more similar to each other than either is to Black faces. This featural difference may create a pop-out effect (Levin, 2000) for morphed Black-White faces due to the fact that the morphing of the features generates greater change between the parent faces and the morphs than has previously been seen with the Asian-White face morphs. Therefore, despite a potential, ability to discriminate own-race faces more accurately than other-race faces (as suggested by the marginal own-race effect), the stimuli created through the Black-White morphing continuum used here may have more obvious featural differences subsequently making the faces easier to discriminate from one another.

Conversely, the similarity of the South Asian and White facial features makes the morphing process ideal, as featural similarities should, in theory, facilitate holistic processing. We therefore propose that the morphing technique may work for featurally similar different race faces; however, if faces are featurally very dissimilar, the morph stimuli generated may cue the participants to more readily identify morphs versus parent faces.

Secondly, despite the marginal own-race effect recorded in the current experiment, participants' IAT results show an anti-black bias for Whites and no bias for Blacks. The difference between *D* scores was shown to be marginally significant. A

comparison of White and Black participant IAT scores demonstrated a marginal effect of Race of participant, whereby White participants tended to express implicit bias towards pairing Black faces with unpleasant words, and White faces with pleasant words, whereas Black participants demonstrated no such bias.

Finally, as no significant own-race effect was found, we were unable to correlate face discrimination scores with the IAT *D*-scores. Nevertheless, regression analyses showed that the negative-Black bias observed in White participants was correlated with their level of prejudice, such that more prejudiced individuals had higher *D*-scores (greater pro-White/anti-Black bias) than did their low-prejudice counterparts. These findings support the IAT as a measure of implicit racial bias (Greenwald et al., 1998), whereby individuals with more other-race prejudice demonstrate higher implicit prejudice towards the other-race. None of the questionnaire measures was found to correlate with the IAT *D*-scores of Black participants; this may, however, be due to the small sample size of this group, such that it was not possible to determine which attitude or social-contact factors influenced their IAT score.¹⁰

Hence, a follow up study is necessary to disentangle these questions, and to determine whether the Black-White morph faces generate a stimulus effect or a weak own-race effect. Moreover, the follow-up study should account for the difference in same-trial hits by altering the experimental design to directly assess false alarm responses.

¹⁰Due to the racial demographic composition of the test environment (University of Oxford), Black participants are few in number, I was unable to obtain more Black participants than the small number who participated in experiment.

4.3 Experiment 4: Introduction

Due to the weak own-race effect observed in Experiment 3, Experiment 4 used Signal Detection Theory (SDT: for a review see Stainslaw & Todorov, 1999) as the basis for an altered experimental design to discover what, if any, is the impact of false alarms on the own-race effect. The primary concern from Experiment 3 was the difference in ‘same’ trial hits for own- versus other-race faces. Therefore, the experimental design of Experiment 4 altered the perceptual discrimination paradigm slightly so that it was no longer a forced choice task, but instead a simple button response on different trials alone. Correct identifications of ‘different’ trials were considered ‘hits’ whereas incorrect responses to ‘same’ trials were ‘false alarms’ (Stainslaw & Todorov, 1999). Methodologically, SDT can be applied whenever two stimulus categories are discriminated, and was first used in studies of perception, where participants discriminated between *signal* (stimuli: hits) and *noise* (no stimuli: false alarm). Dprime (d') is the SDT statistic which measures the distance between the signal and the noise means in standard deviation units (z-scores). Therefore, a value of ‘0’ demonstrates an inability to discriminate signals from noise and values above indicate a correspondingly greater ability to distinguish signals from noise; negative values reflect sampling error or response confusion (e.g., responding ‘different’ when intending not to respond and vice versa). The measure d' is not influenced by response bias provided that the signal and the noise distributions are both normal and the signal and noise distributions have the same standard deviation (d' assumptions).

The experimental predictions of Experiment 3 were once again tested, but with White and South Asian participants. Furthermore, SDT was incorporated into the current experiment as a sensitive measure of the own-race effect. The traditional accuracy analysis (as used in the previous experimental Chapters) was predicted to replicate the

own-race effect observed in Experiments 1, 2 and 3, in that White and South Asian participants were expected to show an own-race effect towards White versus South Asian faces towards Black faces. The sensitive d' analysis was predicted to show an own-race effect for both South Asian and White participants discriminating White, South Asian and Black faces. Furthermore, it was most interesting to determine whether individuals who demonstrated an own-race effect towards one other race (as in chapters 3 and 4 or this thesis) would also demonstrate an own-race effect towards a second other race. To date, the own-race effect has only been investigated in relation to one other-race group. Therefore, the current study investigates the crucial issue: whether the own-race effect in face perception can be regarded as a general deficit in other-race face perception and whether a generalized own-race effect can be explained in terms of social factors such as intergroup contact, attitudes, anxiety and implicit racial bias.

This study investigated the own-race effect in White and South Asian populations looking at White, South Asian and Black faces. Finally, the questionnaire used in Experiment 3 was extended to include the additional measures of opportunity for contact, perspective taking, empathy and an extended intergroup anxiety.

4.3.1 Methods

Participants

Participants were 21 White (10 male, 11 female) and 18 South Asian (8 male, 10 female) university students.

Stimuli and Materials

Black and White face morph stimuli from Experiment 3 were used along with the White and South Asian morph and parent face stimuli from Experiment 2. A total of 60

morph female faces (20 White, 20 South Asian, 20 Black) and 60 morph male faces (20 White, 20 South Asian, 20 Black) were used as target stimuli. The same proportions of parent face stimuli (60 female, 60 male) were included as non-target stimuli.

Two Implicit Association tasks (IAT; Greenwald et al., 1998) were used in Experiment 4 to measure the relative ease with which participants were able to make automatic associations between their own-race and both other-races. Both White and South Asian participants completed one IAT comparing White and South Asian faces, pleasant and unpleasant words, and a second comparing their own-race faces (either White or South Asian) and Black faces, pleasant and unpleasant words. The *IAT effect* was computed in the same manner as in Experiment 3 for each of the two IATs. The presentation of the two IATs was counterbalanced across participants.

The questionnaire used in this study replicated measures from Experiment 3 with the addition of new measures. The questionnaire was completed in two sections, for two other-race groups (e.g., White participants completed questionnaires asking about their attitudes and experiences with South Asian and Black individuals). The new measures included four sets of items; the following examples are from the questionnaire for White participants asking about their experiences with South Asian individuals.

Opportunity for contact - The opportunity for contact measure contained two items on a scale of 1-5, with end points: 1=None and 5=All: (1) How many people in your university are South Asian?, and (2) How many people in your neighbourhood are South Asian?.

Perspective taking - Perspective taking items were taken from Stephan (1999) and Davis (1994). Participants were asked about their ability to take on the perspective of individuals of the other races in the following two questions. On a scale of 1-5, 1 signaling *strongly disagree*, 5 signaling *strongly agree* participants responded to the

statements (1) I think I am able to see the world through the eyes of South Asian people, and (2) I find it easy to put myself in the shoes of a South Asian person and see things from their point of view.

Empathy - The empathy scale, adapted from Davis (1994), contained three items on a scale of 1-5, 1 signaling *strongly disagree*, 5 signaling *strongly agree*: (1) If I heard that a South Asian person was upset and suffering in some way, I would also feel upset, (2) If I saw a South Asian person being treated unfairly, I think I would feel angry at the way they were being treated, and (3) If a South Asian person I knew was feeling sad, I think I would also feel sad.

Intergroup anxiety - This measure was adapted from Stephan and Stephan (1984), an earlier and extended version of their 1985 scale used in Experiment 3. This extended version was included in the present study to obtain a more detailed perspective of the participants' level of other-race anxiety and included 11 items on a 1-5 scale where 1 signaled *strongly disagree*, 5 signaled *strongly agree*: (1) I would feel nervous if I had to sit alone in a room with a South Asian person and start a conversation, (2) I just do not know what to expect from South Asian people, (3) Although I do not consider myself a racist, I do not know how to present myself around South Asians, (4) My lack of knowledge about the South Asian culture prevents me from feeling completely comfortable around South Asians (5) I can interact with South Asians without experiencing much anxiety (this item was reverse scored), (6) If I were at a party, I would have no problem starting a conversation with an South Asian person (reverse scored), (7) It makes me uncomfortable to bring up the topic of racism around South Asian people, (8) I experience little anxiety when I talk to South Asians (reverse scored), (9) The cultural difference between South Asians and Whites makes interactions between South Asians and Whites difficult, (10) I would experience some anxiety if I were the only

White in a room full of South Asians, and (11) I worry about coming across as a racist when I talk with South Asians.

The reliability of the four multi-item measures for White or Asian attitudes and contact (prejudice, extended intergroup anxiety, opportunity for contact, quantity of contact, individuating experience, perspective taking, and empathy), were as follows: (1) prejudice (Cronbach's $\alpha=.72$; .78 for White and .70 for Asian subgroups), (2) extended anxiety (Cronbach's $\alpha=.82$; .85 for White and .73 for Asian subgroups), (3) social contact (Cronbach's $\alpha=.89$; .82 for White and .83 for Asian subgroups), and (4) individuating experience (Cronbach's $\alpha=.93$; .93 for White and .91 for Asian subgroups). Scale reliability for participant attitudes and experience with Black friends/individuals were also high: (1) prejudice (Cronbach's $\alpha=.71$; .75 for White and .70 for Asian subgroups), (2) extended anxiety (Cronbach's $\alpha=.92$; .93 for White and .92 for Asian subgroups), (3) social contact (Cronbach's $\alpha=.81$; .75 for White and .85 for Asian subgroups), and (4) individuating experience (Cronbach's $\alpha=.95$; .96 for White and .93 for Asian subgroups).

Procedure

At the beginning of each trial, the participant viewed a South Asian, Black or White parent face for 500 ms that was then masked for 1s and followed by either the same parent face or a different morph face. The participant was instructed to respond to 'different' face trials (target trials) where the second face in the trial was a morph, therefore different from the first face, via a keyboard response. After each response, a blank screen appeared for 1s and then the next trial began. During different target trials, the Black (White, or South Asian) parent face was followed by a morph face consisting of 90, 80, 70, 60 or 50 percent contribution from that parent face and the remaining percent contribution provided by the White (Black) parent face. Hence, for each parent

face, there were five ‘different’ trials and an equal number of ‘same’ (non response) trials where same parent face was shown for the first and second presentations. Male and female face trials were blocked and separated by a short break, and the presentation order of these two sections was counterbalanced across participants. Within each gender block, the South Asian, Black and White trials were presented randomly. There were 120 target (different) trials and 120 non-target (same) trials for a total of 240 trials in the experiment. Half of the participants completed the IAT prior to, and the other half after, the face discrimination task. Following both behavioural tasks, participants completed a social attitudes and contact questionnaire.

4.3.2 Results

Face Discrimination Accuracy

Participant performance on the discrimination task was evaluated by assessing the number of hits (the number of times participants were able to correctly identify a ‘different’ trial). A 2 (Race of participant: South Asian vs. White) by 3 (race of the face stimulus: White vs. South Asian vs. Black) by 5 (Level of Morph: 90% vs. 80% vs. 70% vs. 60% vs. 50%) mixed-model analysis of variance (ANOVA) was performed, with repeated measures on the last two factors.

The ANOVA showed no main effect of Race of participant, $p > .05$, in that neither race outperformed the other. The within-participants factor Morph Level was reliable, $F(4, 148) = 212.35$, $p < .0001$, $\eta^2 = .85$, demonstrating, as predicted, that trials with morphs closer to the parent face (e.g., 90% parent face) were more difficult to discriminate than more composite morphs (e.g., 50% parent face). The within-participants factor race of face was not reliable, $p > .5$, demonstrating that overall, no

difference existed between discrimination accuracy of South Asian versus Black versus White face stimuli. A significant interaction of Race of participant by race of face was found, $F(1, 74)=7.37, p<.005, \eta p^2=.16$ (see Figure 4.3).

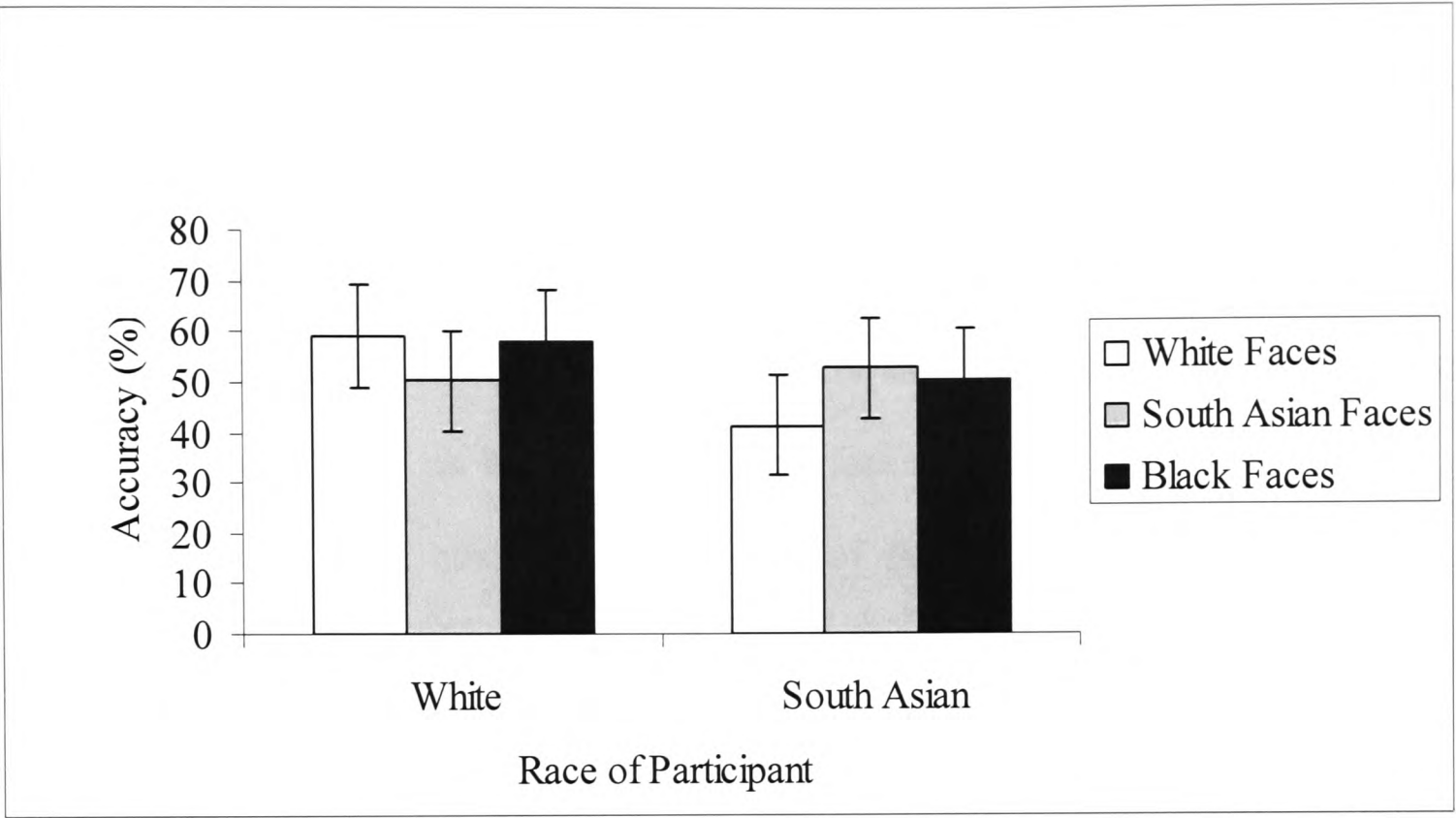


Figure 4.3. The own-race effect in discrimination accuracy measured by percent correct hits.

To investigate the significant Race of participant by race of face interaction, Newman-Keuls post hoc tests were performed on the White, South Asian and Black face means for White and South Asian participant subgroups. Results showed a significant difference for White participant own- versus South Asian face discrimination, $p<.05$, but not for own- versus Black face discrimination: White faces, $M=59.10, SD=2.74$, South Asian faces, $M=50.38, SD=4.38$, Black faces $M=58.25, SD=4.43$. Similarly, South Asian participant accuracy for South Asian faces, $M=52.88, SD=2.55$, was significantly better than for White faces, $M=41.51, SD=2.98, p<.05$, demonstrating a robust own-race effect for South Asian versus White faces, but not for South Asian versus Black faces, $M=50.60, SD=4.79$.

d Prime Analysis

For each participant, standardized (z-score) hit and false alarm rates (for own and other-race faces) were calculated and combined in d Prime (d') scores.¹¹ For the White participants, the d' scores were 1.59, 1.32 and 1.26 for White, South Asian and Black faces, respectively. For the South Asian participants, the d' scores were 1.22, 1.65 and 1.24 for White, South Asian and Black faces, respectively. A repeated measures analysis of variance (ANOVA) test was performed on the d' values with Race of participant (White vs. South Asian) as a between subjects factor and race of face stimulus (White vs. South Asian vs. Black) as the within subjects factor. Neither the factor of Race of participant, $F(1,37)=.01$, nor the factor of race of face, $F(1,37)=.83$, was significant, $p>.05$. The interaction between Race of participant and race of face was significant, $F(1,74)=6.10$, $p<.01$, $\eta p^2=.14$, replicating the Race of participant by race of face interaction observed in the percent correct hits analysis (see Figure 4.4).

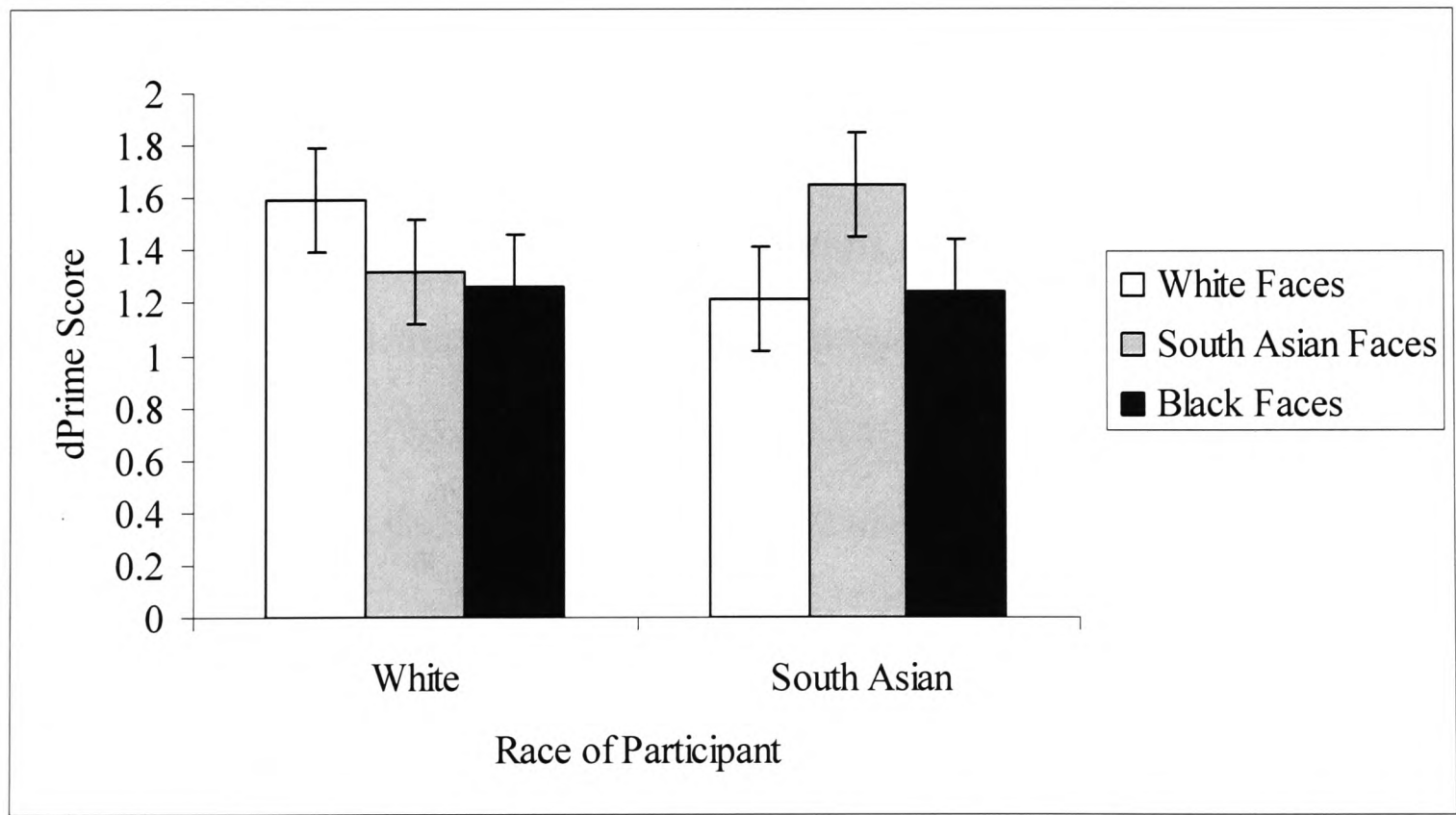


Figure 4.4. The own-race effect in discrimination accuracy measured by d Prime for White and South Asian participants.

¹¹ Signal Detection theory: $d'=z(\text{hit rate}) - z(\text{false alarm rate})$

To investigate the significant Race of participant by race of face interaction, Newman-Keuls post hoc tests were performed on the White, South Asian and Black face means for White and South Asian participant subgroups. Results for White participants showed a significant own-race effect for White versus South Asian faces, $p < .05$ and a marginal own-race effect for White versus Black faces, $p = .06$, with no difference between South Asian and Black faces. South Asian participants were significantly more accurate discriminating South Asian versus both White and Black faces, $p < .05$, but there was no difference between White and Black faces.

These findings suggest that even though no own-race effect was found for percent hits, for either group (White or South Asian) when discriminating own-race versus Black faces, the high false alarm rate (accounted for in the d' measure) affected participant d' scores, ultimately demonstrating an own-race effect for both White and South Asian participants when looking at own- versus other-race faces.

Implicit-Association task

Participants completed two separate IAT tasks, one measuring White-South Asian bias and the other measuring White-Black (for White participants) or South Asian-Black (for South Asian participants). For both race groups, IAT scores were consistent from practice to test blocks (White participants: Asian IAT Cronbach's $\alpha = .82$, Black IAT Cronbach's $\alpha = .79$; South Asian participants: White IAT Cronbach's $\alpha = .71$, Black IAT Cronbach's $\alpha = .70$). IAT scores (where .22 suggests no bias, scores above suggests anti-other-race bias, pro-own-race bias, and scores below suggest anti-own-race, pro-other-race bias) to assess indirect racial bias demonstrated an anti-other-race bias for White participants, anti-South Asian bias, $D = .28$, $SD = .08$, anti-Black Bias, $D = .515$, $SD = .07$. Conversely, South Asian participants demonstrated no racial bias towards Whites, $D = .17$, $SD = .09$, and a reverse IAT effect towards Blacks, $D = -.36$, $SD = .08$ such

that Black faces were associated with pleasant words, and South Asian faces with unpleasant words.

A repeated measures ANOVA was performed on the IAT *D*-scores with Race of participant (White vs. South Asian) as a between subjects factor and other-race bias IAT score (White/South Asian vs. Black) as the within subjects factors. The main effect of Race of participant was significant, whereby White participants demonstrated greater other-race bias overall than South Asian participants, $F(1, 37)=31.79, p<.001, \eta p^2=.32$. Furthermore, the interaction of Race of participant by IAT was significant, $F(1, 37)=38.57, p<.001, \eta p^2=.33$.

To investigate the significant Race of participant by IAT score interaction, paired samples t-tests were performed on IAT means for South Asian and White participants. Results for White participants demonstrated a significantly greater anti-Black bias than anti-South Asian bias as measured by the IAT, $t(20)=-3.09, p<.01$. Conversely, South Asian participants demonstrated a robust anti-White bias IAT scores versus and anti-South Asian/pro-Black bias, $t(17)=5.79, p<.01$.

Finally, IAT and d' scores were found to correlate for both races, for all own-race face effects observed (White Participants: South Asian d' and White-South Asian IAT, $r=.47, p<.05$, Black d' and White-Black IAT, $r=.51, p<.05$; South Asian participants: White d' and White-South Asian IAT, $r=.54, p<.05$, Black d' and South Asian-Black IAT, $r=.64, p<.01$).

Questionnaire

Indices for each measure were constructed for each respondent by computing the mean response to the number of items in each of these three reliable measures. Table 4.3 presents the means and standard deviations for both race groups. These indices were then

used, along with respondent’s ethnic subgroup, to predict their accuracy and *d'* scores for White, South Asian and Black faces.

Measure	<u>White Participants</u>		<u>South Asian Participants</u>	
	<u>Target Group</u>			
	South Asian	Black	White	Black
1. Prejudice*	3.99 (.14)	4.09 (.13)	3.71 (.14)	3.84 (.12)
2. Anxiety	3.89 (.11)	3.89 (.11)	3.54 (.16)	3.59 (.18)
3. Opportunity for contact	2.26 (.90)	2.05 (.67)	4.03 (.61)	1.75 (.55)
4. Social-contact	2.36 (.14)	2.04 (.13)	3.50 (.17)	1.73 (.19)
5. Individuating experience	3.20 (.18)	3.16 (.25)	3.60 (.18)	2.35 (.27)
6. Perspective taking	3.12 (.57)	3.05 (.84)	3.31 (.97)	3.03 (.99)
7. Empathy	4.48 (.52)	4.56 (.44)	4.17 (.92)	4.30 (.63)

Table 4.3. Means and Standard Deviations (indicated in parentheses) of responses (on a 5-point scale) to the Social Anxiety and Contact Questionnaire; * indicates that the scale was reversed-scored.

Repeated measures ANOVAs were performed per subgroup to determine any differences in their amount of contact with, and perceptions of, both other-races (see Table 4.3 for means and standard deviations). White participants demonstrated a marginal difference in prejudice levels for Black versus South Asian individuals, $F(1,20)=3.39, p=.08, \eta p^2=.15$, such that White participants tended to express more other-race prejudice towards Blacks versus South Asians. Moreover, White participants showed a significant difference in amount of other-race contact, $F(1,20)=5.24, p<.05, \eta p^2=.21$, reporting more contact with South Asians than Blacks. South Asian participants reported significantly less prejudice towards Black individuals than Whites, $F(1,17)=5.67, p<.05, \eta p^2=.25$, yet significantly more opportunity for contact, $F(1,17)=49.60, p<.001, \eta p^2=.57$, contact, $F(1,17)=83.93, p<.001, \eta p^2=.83$, and individuating experience, $F(1,17)=13.69, p<.01, \eta p^2=.45$ with Whites than Blacks.

d Prime Regressions

Correlational analyses demonstrated a link between questionnaire measures and the own-race effect. For White participants, individuating experience significantly correlated with South Asian and marginally correlated with Black face d' scores, $r=.43$, $p=.05$, and $r=.42$, $p=.059$, respectively. For South Asian participants, intergroup anxiety, opportunity for contact and individuating experience correlated with White face d' scores, $r=.52$, $p<.05$, $r=.74$, $p<.001$, and $r=.61$, $p<.01$, respectively; and individuating experience correlated with Black face d' scores, $r=.69$, $p<.005$. Own and other-race d' scores were also intercorrelated. For White participants, own-race face d' scores correlated with South Asian and Black face d' scores, $r=.74$, $p<.001$, and $r=.56$, $p<.01$, respectively. For South Asian participants, own-race face d' scores correlated with White and Black face d' scores, $r=.62$, $p<.05$, and $r=.57$, $p<.05$, respectively. This effect demonstrates that White and South Asian participants who were better at discriminating own race faces were also better at discriminating both race of other-race faces. Furthermore, other-race d' score were correlated for both White and South Asian participants, $r=.78$, $p<.01$, and $r=.62$, $p<.05$, respectively, such that participants who demonstrated on own-race effect for one other race, also demonstrated and own-race effect for the second other race.

Regression analyses of White and South Asian participants' d' scores were subsequently performed for the observed own-race effects, and in all regressions, d' scores for own-race faces were entered as independent variables in the first step to control the intercorrelation of the d' variables. First, a regression analysis was performed for White participants with South Asian d' scores as the dependent variable and individuating experience as the independent variable. This regression was significant, $B(\text{standardized})=.51$, $p<.01$, $R^2=.66$, such that White participants reporting greater individuating experience with South Asians, showed less of an own-race effect as

measured by the d' score, whereas White participants reporting lower levels of individuating experience showed a greater own-race effect¹². A second regression was performed for White participants, with Black face d' scores as the dependent variable and individuating experience as the independent variable. This regression was also significant, $B(\text{standardized})=.47$, $p<.01$, $R^2=.56$, such that White participants reporting greater individuating experience with Blacks, showed less of an own-race effect as measured by the d' score, whereas White participants reporting lower levels of individuating experience showed a greater own-race effect.

Two regression analyses were also performed for South Asian participant data. The first included White face d' scores as the dependent variable, intergroup anxiety, opportunity for contact and individuating experience as independent variables. The regression was significant only for individuating experience, $B(\text{standardized})=.51$, $p<.01$, $R^2=.84$. That is, when controlling for both contact measures simultaneously, only individuating experience was a significant predictor of the own-race effect observed for South Asian participants looking at White faces. Hence, greater individuating experience, significantly predicted a smaller own-race effect as measured by participant d' scores for South Asian participants. A second regression was performed for South Asian participants, with Black face d' scores as the dependent variable and individuating experience as the independent variable. The regression was also significant, $B(\text{standardized})=.50$, $p<.05$, $R^2=.72$, such that South Asian participants reporting greater individuating experience with Blacks, showed less of an own-race effect as measured by the d' score, whereas South Asian participants reporting lower levels of individuating experience showed a greater own-race effect.

¹² The R^2 values reported in the text explain the effect of the predictive influence of own-race face accuracy (d') combined with the questionnaire measures entered in the second step. Hence for White participants, own-race face accuracy explains 40% of the regression effect and for South Asian participants own-race face accuracy (expertise) explain 53% of the effect.

IAT Correlations

Correlational analyses were performed to determine whether explicit bias, as measured by the questionnaire, was found to correlate with implicit racial bias as measured by the IAT. For White participants, none of the explicit questionnaire measures was found to correlate with the anti-South Asian/pro-White implicit bias recorded by the IAT. However, anxiety was found to correlate with the anti-Black bias/pro-White, such that the more anxiety White participants expressed towards Black individuals the greater the anti-Black/pro-White bias, $r=.43$, $p=.05$. For South Asian participants, individuating experience, $r=-.46$, $p=.05$, perspective taking, $r=-.50$, $p<.05$, and empathy, $r=-.54$, $p<.05$ were all found to correlate with the IAT for Whites. That is, the more individuating experience, perspective taking and empathy South Asians expressed explicitly towards Whites correlated with their lower IAT bias scores. Finally, individuating experience was found to correlate with the pro-Black/anti-South Asian bias observed in South Asian participants, $r=.48$, $p<.05$, whereby greater individuating experience with Blacks, was linked to lower IAT *D*-scores (greater pro-Black/anti-South Asian bias).

4.3.3 Discussion

The main objective of this experiment was to test the perceptual own-race effect in White and South Asian populations and to determine whether an own-race effect for one other-race can, in fact be a generalized effect towards other-races. Furthermore, two different measures of the own-race effect were used in the current experiment to compare the findings of the traditional accuracy analysis, versus those measured by the more sensitive Signal Detection theory. In order to do this White and South Asian participants

were tested on White, South Asian *and* Black faces as well as on measures of prejudice, anxiety, contact and implicit racial bias.

Four experimental predictions were explored. (1) The traditional accuracy analysis was predicted to replicate the weak own-race effect for own-race versus Black faces from Experiment 3, whilst demonstrating robust own-race effects for White and South Asian other-race faces. (2) The sensitive d' measure was expected to detect an own-race effect for White and South Asian participants discriminating both sets of other-race faces (White/South Asian and Black). (3) IATD-scores were predicted to correlate with face discrimination accuracy, and (4) measures of social attitudes and contact were predicted to be potential predictors of the own-race effect (d') and implicit other-race bias (IAT).

Employing the traditional accuracy analysis (as in Experiment 1, 2 and 3), the predicted cross-over interaction between Race of participant and race of face (South Asian or White) was significant. White participants were significantly more accurate at identifying White face morph trials than South Asian face morphs, whereas South Asian participants were significantly better at identifying South Asian versus White morph trials. As predicted, however, the percent correct hits analysis found that neither White nor South Asian participants demonstrated an own-race effect when looking at own-race versus Black faces. Conversely, the SDT d' analysis showed an own-race effect for White and South Asian participants when viewing *both* other-race faces (Whites viewing South Asian and Black versus White faces; South Asians viewing White and Black versus South Asian faces). This finding supports the initial hypothesis that despite no significant difference in hit rate accuracy for own-race versus Black faces, the own-race effect was detected when incorporating the false alarm rate into the analysis. Chiroro and Valentine (1995), using a standard old-new recognition memory paradigm, also found

that White participants had a higher false alarm rate to Black faces than White faces. As discussed in Experiment 3, there may also exist a stimulus effect for Black morph faces, which can explain the high hit rate for Black morphs. On the other hand, the featural dissimilarity between own-race (White or South Asian) and Black faces may account for the uncertainty rate in decision making and therefore the larger number of false alarms for Black face trials. Moreover, the fact that the own-race effect was observed for both groups of participants for both sets of other-race faces demonstrates a generalized own-race effect. Furthermore, the intercorrelation of other-race face (d') accuracy scores supports that the own-race effect is not directed towards a single other-race, and demonstrates an expertise for own-race versus other-race faces in general.

The robust own-race effect detected by the d' analysis (but not the traditional accuracy analysis) was subsequently correlated with implicit racial bias and predicted by the questionnaire other-race experience measure. The own-race effects observed for both groups of participants correlated with implicit racial bias as measured by the IAT. This correlation suggests that the perceptual own-race effect is also linked to implicit social categorization, offering support for the role of subconscious implicit racial bias in race information processing. Questionnaire measures were also linked to the own-race effect. The own-race effect observed for White participants was significantly predicted by other-race individuating experience (for both other-races). This finding demonstrates that the greater close, personal other-race experience White participants engaged in, the smaller the own-race effect they demonstrated on the face discrimination task. Similarly, South Asian participants also showed that individuating experience was the most reliable predictor of other-race face processing ease. These findings demonstrate that other-race individuating experience and not merely general contact are tantamount to perceiving

individuals of other-race as we do those of own own-race and subsequently reducing a very salient barrier between racial groups.

Correlations were also observed between the IAT and questionnaire measures. The anti-Black/pro-White bias demonstrated by White participants was found to correlate with anxiety. That is, White participants reporting more anxiety towards Black individuals showed a greater tendency to associate Black + unpleasant, White + pleasant in the IAT pairings. On the other hand, South Asian participants' White-IAT scores correlated negatively with their amount of individuating experience, perspective taking and empathy. Moreover, South Asian participants' Black-IAT scores correlated negatively with individuating experience as well.

The difference in the significant predictors of the IAT bias for each race reflects the nature of each group's scores. As reported in Experiment 3, the White participants demonstrated an anti-other-race bias, whereas the minority race (South Asian) showed no bias. In Experiment 3, prejudice was found to correlate with White participant anti-Black bias (measured by the IAT), and in the current experiment anxiety correlated with this bias (White participants also reported the most other-race anxiety on the questionnaire). Conversely the null-IAT-effect observed in the South Asian participants was correlated with other-race individuating experience, perspective taking and empathy which are measures of other-race experience, such that the greater experience with Whites, the less bias South Asian participants showed in their IAT scores. Interestingly, when White and South Asian participants performed the own-race versus Black face IAT, White participants demonstrated a very strong bias pairing Black faces with unpleasant words, and White with pleasant. However, South Asian participants showed the reverse effect, pairing Black faces with pleasant words, South Asian faces with unpleasant words. This finding for South Asian participants echoes what is sometimes found in studies of

African American versus White bias, whereby African Americans have shown anti-African American/pro-White American bias. Such findings have been discussed as reflecting the American climate, whereby individuals have been socialized to associate White with good and Black with bad (Nosek, Banaji, & Greenwald, 2002). Hence, African American or White American individuals have demonstrated this learned association in their IAT scores. It may be that the cultural climate in the U.K. has created a different effect with South Asian individuals whereby they perceive themselves, compared to Blacks in a more negative light. This may be because more anti-South Asian, than anti-Black prejudice is prevalent in the U.K. Nevertheless, this particular issue would have to be investigated further to determine the specific nature of the effect.

Individuating experience was found to correlate the anti-South Asian/pro-Black finding in South Asian participants, such that the more individuating experience South Asians had with Black individuals, the greater their tendency was towards pairing Black faces with pleasant words. Likewise, the reverse IAT-effect may demonstrate an *anti-bias* over-compensation whereby, due to their similar minority status, South Asian participants may have a greater capacity through their experience with Blacks to affiliate with them and implicitly share their group status.

Furthermore, individuating experience in both South Asian and White participants significantly predicted participants' d' own-race effect scores. The more individual contact and close experience participants had with the other-race, the less of an own-race effect participants demonstrated on the perceptual discrimination task. It may be that regardless of racial group membership, individuating experience with other-race individuals facilitated perceptual familiarization other-race faces. Therefore, individuating experience alone was sufficient for predicting the own-race effect observed in White and South Asian participants.

Finally, the correlation of both the experimental behavioural measures (IAT D -scores and face accuracy d -scores) coupled with their shared predictor variables, demonstrated a link between other-race directed unconscious bias and our perceptual discrimination accuracy for own- versus other-race faces as gated by other-race individuating experience.

4.4 General Discussion

The current experiments investigated the own-race effect in three different racial groups on three different races of faces. Experiment 3 found weak support for the own-race effect using a traditional accuracy analysis, whilst Experiment 4 found support for the own-race effect using Signal Detection Theory. Accounting for the false alarm rate as well as the hit rate, SDT was able to uncover a robust own-race effect where the traditional analysis could not. Moreover, Experiment 4 was the first experiment to date to demonstrate that an own-race effect is not necessarily specific to one other-race, but rather, the effect can be observed in response to other-race faces in general. Furthermore, other-race experience for majority and minority race groups alike was a significant predictor of the own-race effect.

Theoretically, Experiments 3 and 4 elucidated the own-race effect cognitive models of Valentine (1991 a, b) and Levin (2000), offering support for Valentine's multi-dimensional face space model. Although findings from Experiment 3 are inconclusive on this point, Experiment 4 finds that when false alarm rates are taken into account, an own-race effect is found for both test races (White and South Asian) looking at White, South Asian and Black faces. Furthermore, the predictive influence of individuating experience on the own-race effect observed in Experiment 4 supports the dense clustering of other-

race faces in the multi-dimensional face space, which is changed only through personal experience with other-race faces. As the results show, it does not appear that all forms of contact equally disentangle the dense representations of other-race faces. As a rule, only close, personal experience which enables one to encode, store and retrieve other-race faces in the same way as own-race faces. Thus, the contact hypothesis can offer a bridge for the gap between other-race quality contact, implicit racial bias and own- versus other-race face expertise.

In sum, the current experiments support Valentine's multi-dimensional face space model for own- versus other-race face processing, as well as a link between a perceptual own-race effect (systematically predicted by other-race individuating experience) and unconscious other-race bias (measured by the IAT).

Due to robust behavioural findings, future research on the own-race effect should investigate the neural basis of perceptual differences in processing own- versus other-race faces. Specifically, in order to elucidate the perceptual basis of this effect, it must be investigated as a potential modulation of face encoding. Moreover, the link between social factors such as other-race experience and the own-race effect can substantiate the influence of other-race contact on individual's perceptual processing of own- versus other-race faces.

Chapter 5

Face Processing in the Brain

5.1 Introduction

A large body of research confirms that the brain is finely-tuned for face processing (Farah, Wilson, Drain, & Tanaka, 1995b; Fodor, 1983; Nachson, 1995; Yin, 1970). Evidence from the following six domains supports that face processing is carried out by specialized brain mechanisms: (1) innate orienting of babies to faces (see section 1.1), (2) the severe impairment of face recognition by stimulus inversion (see section 1.2, Tanaka & Farah 1993; Yin, 1969), (3) the face-specific neuropsychological deficit (see prosopagnosia section 5.1.5; Farah, 1990), (4) the existence of cortical cells responding specifically to faces in non-human primates (Perrett, Rolls, & Caan, 1982; Perrett, Mistlin, & Chitty, 1987), as well as in humans (Rolls, 1992), (5) the face-specific area with strongest activation to faces in the middle fusiform gyrus (Allison, Puce, Spencer, & McCarthy, 1999; Kanwisher et al., 1997), and (6) the face-sensitive components in electrical brain activation (N170: Bentin et al., 1996; VPP: Jeffreys, 1989) potentially reflecting the subcortical activation of the fusiform area.

Evidence for the face-specific processing in the brain has been fervently challenged and the *expertise hypothesis* has developed in parallel (for a review see Tanaka & Gauthier, 1997). The expertise hypothesis suggests that the areas involved in face processing are not necessarily face-specific, but rather expertise-specific. According to this view, experts in other domains (e.g., dogs, birds, greebles¹³: Diamond & Carey, 1986; Gauthier et al., 1999, 2000; Tanaka & Curran, 2001; Tanaka & Taylor, 1991) should demonstrate similar fusiform and N170 activation to objects of expertise as well

¹³ Families of nonsense objects developed by Gauthier et al. 1999.

as to faces. However, recent neuroimaging data (Grill-Spector, Knouf, & Kanwisher, 2004) as well as magnetoencephalography (MEG) data (Xu, Liu, & Kanwisher, 2005) offer evidence for a face-specific processing in the fusiform gyrus, such that objects of expertise do not demonstrate the identical pattern of activation as faces. Hence, little question remains that specific brain processes and areas are specialized (be it innately, or through rapid learning) for faces.

5.1.1 Neurophysiological Studies: Single-Unit Recordings

The underlying biology of human cortical brain activity in response to faces has been investigated by numerous researchers in animals. These animal experiments have important implications for neurological research in humans. Investigating animal systems can be particularly advantageous as researchers have more liberty to employ certain invasive methods not possible in human participants. Single-unit recordings in macaque monkeys have led to the discovery of a subset of neurons in the inferotemporal (IT) cortex which respond selectively to faces (Bruce, Desimone, & Gross, 1981; Desimone, 1991; Gross, Rocha-Miranda, & Bender, 1972; Perrett et al., 1987; Rolls et al., 1994; Sciallone, Wilson, & Goldman-Rakic, 1999; Young & Yamane, 1992) but not to other evolutionary-relevant stimuli such as snakes, spiders or food (Baylis, Rolls, & Leonard, 1985; Saito et al., 1986). These IT cells have subsequently earned the name “face-selective neurons”. Face neurons are selectively responsive to parts of faces (Perrett et al., 1982), facial expressions (Hasselmo et al., 1989) or visual angle of faces (Perrett et al., 1991). To date no experiment has found single IT neurons that are specialized and responsive to both face and non-face objects, suggesting that separate neuronal populations code faces and objects.

Notably, Scaldie and colleagues (1999) recorded visual responses of over 1500 neurons throughout the wide expanse of the prefrontal cortex (Brodman's areas 12, 9, 46, 8 and 45) to passively viewed faces or viewing faces as part of a memory task. Face-selective neurons were found to concentrate almost exclusively in three distinct subregions within the projection region of the temporal lobe visual areas. These results were consistent across memory-task trained and untrained monkeys, suggesting that the firings in response to face stimuli are naturally occurring properties of prefrontal cortex neurons. Similarly, Rolls and colleagues (1994) recorded single neurons in the superior temporal sulcus of macaques, who were shown jumbled faces and normal faces in a backward masking paradigm. Results found neurons that responded specifically to faces; the total number of active neurons was greater for faces in their normal configuration than for jumbled faces, as some of the face-selective neurons are sensitive to the spatial arrangement of the features.

Further research suggests that face-specific cells do not respond individually to different faces, but rather produce a graded response to several faces. Young and Yamane (1992) confirmed that individual faces are represented by a unique pattern of activation across a population of cells. This pattern codes the distances between facial parts (e.g., eyes, nose, mouth) in a holistic part-configuration process (Tanaka & Farah, 1993). The receptive fields of single face-selective neurons are partially overlapping and complementary, such that the combined activity of the entire cluster of neurons forms a population code of the face stimulus. As the cell population increases, the number of potential face representations grows exponentially (Abbott, Rolls, & Tovée, 1996). (Wang, Tanaka, & Tanifuji, 1996) combined optical imaging with electrophysiology and identified patchy cellular activity on the cortical surface of monkeys in response to faces, suggesting that face cells are organized into functional columns, consistent with the

columnar organizations found in many other visual areas (e.g., V1 and V5). Instead of discrete columns, however, Wang found overlapping activation to face orientations, suggesting that face stimuli may be continuously encoded for changing features. Likewise, investigations by Perrett in the 1980s revealed the existence of neurons in the inferotemporal cortex of monkeys that showed bursts of action potential firing, when the monkey was shown pictures of monkey faces that were particularly sensitive to the orientation of the face presented to them. The cells also responded to human faces, but not to pictures of other body parts or inanimate objects. Notably, monkeys reared in laboratory environments, compared to those reared in the wild, have reportedly greater populations of face-selective neurons which respond to human faces versus monkey faces (Mikami, Nakamura, & Kutoba, 1994). It is argued that the large amount of experience these monkeys have with humans influences their face-selective neurons in a potentially adaptive fashion (Kobatake, Wang, & Tanaka, 1998). The single-cell recordings in animals have shed on the face-specific processing in humans and offered insight in to the neural organization of face-selective cells.

5.1.2 Neurophysiological Studies: Intracranial Recordings

Further to the single-cell recordings in animals, intracranial depth electrodes have been used in humans, allowing for a significantly closer, less obstructed view of brain event-related potentials (ERPs) than when these are recorded from the scalp. Therefore, ERPs have been recorded intracranially (as well as from the scalp) to identify the timecourse and the localization of face processing in humans. Both intra and extracranial electrophysiological studies of human face perception have highlighted a specific modulation of a negative going component in response to faces, peaking around 170 ms (Bentin et al., 1996).

Allison and colleagues (1999) completed a series of subdural recordings and stimulation on patients prior to surgical treatment of epilepsy, in order to create a functional map of the patients' brains. Brain regions were identified which activated to faces but not to other visual stimuli. Electrical stimulation of these brain areas has been shown to selectively disrupt face identification and evoke face-related hallucinations (also see Vignal, Chauvel, & Halgren, 2000). A surface negative going potential between 170-210 ms, peaking around 200 ms (N170 when recorded from the scalp) was revealed in the ventral occipitotemporal cortex and the temporal gyrus. Analyses of the response properties of these face neurons indicated that face detection is carried out by neurons in the ventral occipitotemporal cortex while face recognition occurs milliseconds later in the middle fusiform. The N200 component appeared consistently larger in the right hemisphere and was determined to be the initial stage of structural face processing. Furthermore, the component showed little or no habituation to face familiarity, semantic priming, face-name learning or identification. Hence, the N200 recorded by Allison and colleagues (1999 a, b, c) is considered to reflect the operation of a face-specific area in the human brain. Further evidence suggests the ventral and lateral occipitotemporal cortex is a complex mosaic of functionally discrete patches of cortex of variable number, size and location. The occipitotemporal cortex has a posterior-to-anterior trend specifically in the ventral cortex for the location of patches, in the order letter-strings, form, hands, objects, faces and face parts (Puce, Allison, & McCarthy, 1999).

5.1.3 Neurophysiological Studies: Scalp Recordings

The most salient scalp ERP in response to face stimuli is a dipolar component with the negative deflection peaking around 170 ms at bilateral occipitotemporal sites termed the N170 (Bentin et al., 1996), as well as a corresponding positivity at

centrofrontal sites termed the vertex positive potential VPP (Jeffreys, 1989). Early studies on the time course of face processing, using a small set of channels along the midline referenced to the mastoids, described a large positive potential, named the VPP, which peaked at frontocentral sites between 140 and 180 ms in response to face stimuli versus objects or scenes (Bötzel & Grusser, 1989; Jeffreys, 1989; for a review see Jeffreys, 1996). More recently, studies with higher densities of channels covering a large portion of the head (Tucker, 1993), have revealed a large negative component peaking at the same latency over occipitotemporal regions, commonly known as the N170. Recent research has proposed that both the VPP and the N170 are two reflections of the same brain generators (George, Evans, Fiori, Davidoff & Renault, 1996; Joyce & Rossion, in press). The majority of present-day research using high-density electrodes most commonly refers to the N170 as an indicator of face processing, therefore for purposes of comparison between the experiments reported in this thesis and the general literature, the current thesis focuses on the N170 rather than the VPP as an indicator of face encoding.

Recent electrophysiological recordings from the scalp surface have consistently substantiated the face N170. Research has deduced that the N170 is specific to the structural encoding of the face stimuli and is not modulated by familiarity.¹⁴ The N170 has been described as reflecting the integration of facial physiognomic information into a perceptual representation (Bentin & Carmel, 2002; Carmel & Bentin, 2002). The integration procedure is performed by complex neural mechanisms which process face stimuli holistically whilst detecting distinct physiognomic features (e.g., eyes). Bentin and Carmel (2002) combined ERP and neuroimaging evidence to support the intracranial findings of Allison and colleagues (1999) whereby the global processing of faces is accomplished by a neural network located in the fusiform gyrus, whereas part-based

¹⁴That is, except with respect to an identity priming effect which creates a slightly reduced N170 amplitude, see Campanella et al., 2000.

processing (e.g., object processing or when face orientation is disrupted) is performed by networks located in the superior temporal sulcus and the posterior inferior temporal gyrus.

Upright faces are reportedly processed as a whole (holistic or configural processing) whereas objects are processed as a set of features (see Farah 1990, 1994, section 1.2.2), and therefore recognition of inverted faces, but not objects, is impaired as they are processed featurally (Yin, 1969). Electrophysiological evidence confirms this impairment, as inverted faces magnify the amplitude, and more frequently, delay the timing in the peak of the component (latency) of the N170 (Rossion et al., 1999; Rossion et al., 2000). This electrophysiological finding parallels the behavioural face inversion effect discussed in Chapter 1, whereby inverted faces are more difficult to recognize and are considered to be recognized featurally rather than holistically.

In contrast to inversion effects on the N170, objects have been shown to elicit a greatly reduced N170 peak compared to faces; yet, a handful of studies report having replicated the face N170 as well as the inversion effect for greebles (families of nonsense objects) by greeble experts (Gauthier, 1999, 2000). Despite the controversy over the face versus expertise sensitivity of the N170, this thesis considers the N170 as a consistent marker of face processing and does not attempt to disprove its role in expertise.

5.1.4 Neuroimaging Studies

Hemodynamic brain imaging has highlighted specialized regions for face processing. Originally, (Haxby et al., 1991) used Positron Emission Tomography (PET) to investigate the dissociation between face and spatial visual processing. Results demonstrated that face processing activated a pathway in the ventral/occipitotemporal cortex whereas location processing activated a dorsal occipitoparietal pathway. Following

these results, Sergent, Ohta, and MacDonald (1992) examined face processing in the brain and found evidence in support of the ventral/occipitotemporal pathway for face processing. Since then several research groups have used both PET and functional Magnetic Resonance Imaging (fMRI) to investigate various aspects of face processing.

fMRI provides a good spatial resolution to investigate face processing. Specifically, fMRI studies have shown that the posterior and middle areas of the fusiform gyrus responds much more strongly to faces than other forms of stimuli (e.g., letters, common objects, animals, human body parts: Puce et al., 1996; Kanwisher et al., 1997; Kanwisher, Stanley, & Harris, 1999) (see Figure 5.1). This fusiform area is the same region implicated in prosopagnosia (section 5.1.5) (McCarthy, Puce, Gore, & Allison, 1997).

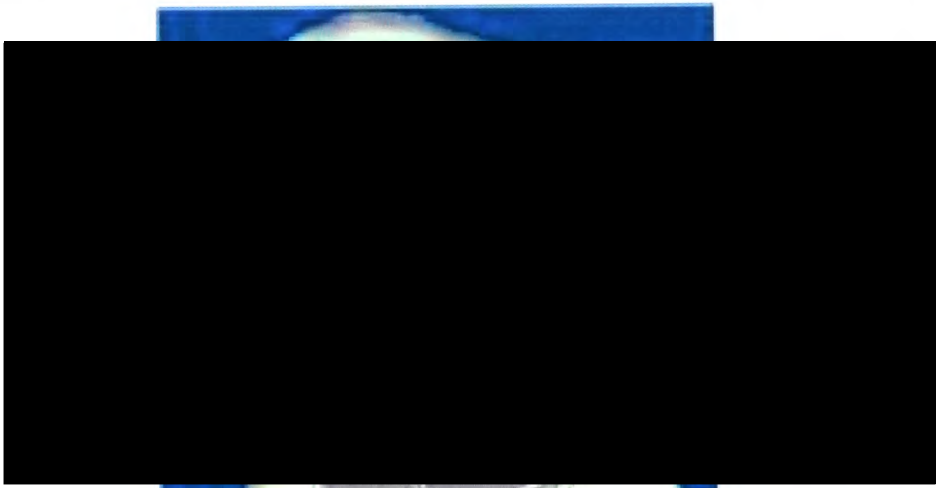


Figure 5.1. Haxby and colleagues (2000) fMRI imaging: the fusiform gyrus face-specific area (above). Fusiform gyrus activation to faces vs. places (below).



The involvement of this fusiform area in face processing is well documented, but its face-specificity has been under debate. Functional MRI studies have shown elevated middle fusiform responses to objects of expertise including greebles, birds and cars (Gauthier, 1999, 2000). Moreover, it has been difficult to compare fMRI studies as they often use different criteria to define the face-sensitive fusiform area (reviewed in Kanwisher, 2000). Recently, however, Grill-Spector, Knouf and Kanwisher (2004) tested car experts and found that for most non-face objects (including cars) within-category discrimination performance was correlated with activation in other regions of the ventral occipitotemporal cortex, not this fusiform area. These results indicate that the fusiform gyrus is involved in the detection and identification of faces, but has little involvement in within-category identification of non-face objects (including those of expertise). In sum the fusiform gyrus plays a substantial role in face processing, and demonstrates the sensitivity of neuronal cells in humans to face detection and identification.

5.1.5 Lesion Studies

In humans, face-specific perception is supported by the double dissociation between both visual agnosiac patients who cannot recognize objects while their ability to recognize faces is spared (e.g., Moscovitch et al., 1997) and prosopagnosiac patients who cannot recognize familiar faces despite an intact ability to identify other objects (Bentin, Deouell & Soroker, 1999; for a review see De Renzi, 1997).

5.1.5.1 Prosopagnosia

The name 'prospopagnosia' is taken from the Greek *pospon* for 'face' and *agnosia* for 'ignorance' or 'lack of knowledge'. Farah (1990) reported that 94% of prosopagnosiacs

had damage to the right hemisphere (65% bilateral) as well as damage to the ventral occipital or temporal lobes, supporting the existence of a face-specific area residing in the right ventral occipitotemporal regions of the brain. Lesion evidence from patients with non-face object agnosia and intact face recognition (anti-prosopagnosiacs) has shown damage to the left occipital and temporal lobes with a posterior left hemisphere recognition area for non-face objects that is complementary to the posterior right hemisphere face-specific area (Feinberg, Gonzalez-Rothi, & Heilman, 1986; McCarthy & Warrington, 1986; McMullen et al., 2000; Moscovitch et al., 1997).

Typically, the impairment of the prosopagnosiac patient is confined to the identification of faces (i.e., associating a face with a person). However, the patient's ability to distinguish between faces and other visual stimuli (in some cases even to match between faces of the same individual seen from different angles) is significantly better or even intact compared to their ability to recognize specific faces (Benton & van Allen, 1972; Malone, Morris, Kay & Levin, 1982). Such evidence from prosopagnosiacs has led to further dissociation between a specific visual mechanism responsible for the structural encoding of faces and a higher-level mechanism responsible for associating the structural representation of a face with semantic information about the person to whom the face belongs. This face-related impairment is further explained by the Bruce and Young model for face recognition (1986, see Chapter 1) whereby an abstract tridimensional structural representation of the face is initially constructed by a face-specific visual encoding process. The structural representation is compared with a set of face recognition units; if a positive match results, the person's identity nodes are activated in semantic memory.

Nevertheless, some prosopagnosiac patients retain the ability to recognize emotional cues from faces (Etcoff, 1984; Tranel, Damasio & Damasio, 1988). A

distinction can be made between *associative* and *apperceptive* prosopagnosia (Damasio, Tranel, & Damasio, 1990; see also Farah, 1991). In associative prosopagnosia, the perceptual system is intact, allowing for recognition, although recognition cannot take place. This form of prosopagnosia is typically caused by bilateral lesions to the inferior occipital and temporal visual cortices (inferior components of Brodmann areas (BA) 18 and 19) as well as posterior temporal lesions (BA 37). Patients suffering from apperceptive prosopagnosia fail to recognize faces due to impairments in visual perception. As these patients are unable to visually process faces they cannot recognize them. Apperceptive prosopagnosiacs generally suffer from lesions in the right visual association cortices, within the occipital and parietal regions.

5.1.5.2 Prosopamnesia

A further lesion-related impairment in face processing was documented by Tippet, Miller and Farah (2000) as prosopamnesia, which was documented as the result of a lesion to the inferior temporal cortex. Prosopamnesia is seen to selectively impair the learning of new faces, but recognition of old faces was retained. In normal face processing, face information is typically encoded in the inferior temporal cortex and then projected to the hippocampus and surrounding structures, finally returning to the inferior temporal cortex whereby we can then retrieve the face from memory (Farah et al., 1998). The lesion suffered by prosopamnesiacs, however, acts as an anatomical disconnection, whereby the brain maintains the ability to perceive faces, but not make the final step to recalling them, whilst object perception and recollection remain intact.

5.2 Race of Face Processing

Recent experimental interest in the biological bases of human social behaviour and intergroup relations has spurred research into the modulation of brain processes by evaluative social features such as race. Specifically, human processing of different race faces has elicited increasing attention in the behavioural literature (section 1.4), yet to date only a handful of studies exist exploring the neural basis of race information processing from faces.

5.2.1 Neurophysiological Studies

Few studies to date have investigated the modulation of electrical brain activity by race of face. The N170 is consistently reported as a neurological marker of structural face processing, yet whether or not race of face disrupts this stage of encoding remains uncertain (Caldara et al., 2003; Ito & Urland, 2005). Results have thus far been inconsistent as to whether race modulates the way in which we perceive and experience faces. Race of face has, however, been seen to modulate the perception of faces 200 ms post stimulus presentation, although no face-sensitive component has been consistently discussed in the literature as sensitive to race differences (either colour and/or features). For instance, Ito and Cacioppo (2004) reported a negative going component around 240 ms, which was larger for own-race faces than other-race faces. Conversely, Caldara and colleagues (2004) reported no mean amplitude modulation of the N240 component, but, rather a latency effect in topographical maps was evident during this time period, whereby other-race faces were processed more quickly than own-race faces. Caldara and colleagues proposed that this effect reflected either the exemplary density face-space explanation proposed by Valentine (1999; see section 1.4.2) or a more elaborate

processing based on the activation of the visually derived semantic information suggested by the Bruce and Young model (1986). These suppositions have yet to be experimentally validated.

5.2.2 Neuroimaging Studies

Currently, fMRI measures comprise the largest body of neural correlate research on race processing. FMRI has been used in a variety of studies to investigate the racial bias of face processing at a neural level. To date, fMRI studies have investigated the relationship between automatic (implicit, unconscious) and controlled (explicit, conscious) bias with the processing of race (Cunningham et al., 2004; Phelps et al., 2000, Phelps, Cannaistraci, & Cunningham, 2003). Determining the neural basis of overt racial bias is an important step in understanding implicit processes involved in cognitive racial bias. Unlike electrophysiological measures which can provide information regarding the timecourse of race processing, hemodynamic measures, such as fMRI, can elucidate the location of the phenomenon in the brain.

Experimentally, recent research has reported findings linking racial perception, social categorization and activity in the amygdala. The amygdala, a limbic structure with outputs to the prefrontal cortex, high-level association areas of the neocortex and autonomic centres of the hypothalamus and basal forebrain, has a clear role in response to stimuli that signal danger or threat, and is implicated in emotional processing. (Hart et al., 2000) demonstrated the role of the amygdala in race processing. They recorded brain activity whilst Black and White participants were presented with Black and White face stimuli. The results demonstrated no initial differential amygdala activation to Black versus White faces, however, the amygdala was found to habituate to own-race faces much faster than other-race faces. Hart and colleagues proposed two potential

explanations for this effect; either greater own-race experience results in the quicker habituation, or alternatively, differential amygdala responses may be linked to racial bias. Considered from the latter viewpoint, the selective amygdala delay in habituation to other-race faces may be the result of an innate fight/flight defence mechanism.

Subsequently, Phelps and colleagues (2000) investigated the link between differential amygdala activation and implicit racial bias. White participants viewed Black and White faces in the fMRI scanner, after which they completed the Modern Racism Scale (McConahay, 1986) as well as an implicit measure of racial bias, the Implicit Association Test (Greenwald et al., 1998). No overall difference was found for amygdala activation to White versus Black faces, however, White participants who demonstrated the most bias on the IAT also showed the greatest amygdala activation to Black faces. It was suggested that racial bias prompted amygdala activation to unfamiliar Black faces, therefore in a follow up study, participants viewed Black versus White famous faces and no correlation was found between amygdala activation and the IAT. These findings highlight the modulatory effects of social learning and personal experience on amygdala activation and behavioural responses.

A recent study by (Wheeler & Fiske, 2005) has further supported the modulation of amygdala activation to own- versus other-race faces. They found that other-race faces elicited greater amygdala activation than own-race faces when participants were socially categorizing the faces (whether the person was older or younger than 21) whereas no differential amygdala activation was evident during visual search tasks or individuation tasks (whether or not the person liked a certain kind of vegetable). These findings show the sensitivity of the amygdala to social categories of faces (i.e., race) rather than non-social information.

An explanation for the difficulty previous studies have had in isolating brain activity in response to own- versus other-race faces across tasks has been proposed by Cunningham and colleagues (2004). Cunningham and colleagues argued that the inconsistent results across tasks were due to the long duration of the stimulus presentation, and faces presented subconsciously were best for producing the innate neural response. They investigated the impact of conscious control of bias towards Blacks versus Whites on activation in the frontal cortex and decreased activation in the amygdala. When faces were presented subconsciously, Black faces elicited more amygdala activation than White in White participants. When presented consciously, Black faces elicited greater activation in the prefrontal cortex and the cingulate gyrus.

Further to this viewpoint, Richeson and colleagues (2003) expanded the investigation of the link between prefrontal activity and automatic racial bias, by focusing on the potential consequences of increased prefrontal activity to interracial interactions. Richeson and colleagues used the IAT as a measure of implicit racial bias, coupled with a Stroop task. This investigation revealed that White individuals exhibiting Black evaluative bias (as measured by the IAT) demonstrated cognitive resource depletion when interacting with Blacks versus Whites (i.e., exhibited impaired cognitive task performance after a brief interaction with a Black individual). Following this study, Richeson and colleagues collected neuroimaging evidence which suggested that greater racial bias was associated with greater prefrontal activation to Black versus White faces in White participants, with prefrontal activation mediating the relationship between racial bias and cognitive task performance. Richeson and colleagues therefore suggested a resource depletion model in racially biased Whites, such that they engage more executive function processes during interactions with Black individuals resulting in temporary cognitive dysfunction.

Evidence for the involvement of the prefrontal cortex in racial bias suggests that it may not be possible for implicit measures of prejudice to be untainted by executive processing attempts to control responses. Therefore, the automatic control of the prefrontal cortex on task performance can be tracked by paradigms such as Richeson and colleagues (2003), and is likely to reflect a parallel confirmation of bias.

The neural circuitry involved in the categorization by race of face has also been examined separately from racial bias. Golby and colleagues (2001) exposed White and Black participants to White and Black faces in the scanner followed by an old-new face recognition test. Greater middle fusiform activation was found for own- versus other-race faces, with greater own- versus other-race face activation for those individuals with worse other-race face recognition. Similarly, Golarai and colleagues (2004) found greater middle fusiform activation for White whole and scrambled faces versus Black faces. These findings suggest that this fusiform area may be more sensitive to racial category membership than to familiarity of face or to structural changes to the face. In sum, the aforementioned research suggests that race of face processing in the brain calls upon different neural structures (not simply the fusiform gyrus), whose involvement in race perception is highly context-dependent.

5.3 Emotional Expression Processing

A further social influence of face processing is emotional expression. Research on emotional face perception has demonstrated that humans have an innate ability for instantaneous judgments of facial affect (Barrett & Campos, 1987; Izard & Malatesta, 1987). A set of six emotional expressions have been highlighted as universal (Ekman, 1972, 2003; Izard, 1971), and although some variation may exist cross-culturally, the

expressions of surprise, anger, fear, sadness, happiness and disgust are considered the 'basic' set of emotional expressions in the current research and literature.

5.3.1 Behavioural Studies: The Universality of Emotional Expressions

Over the past 50 years, psychologists have debated the universality of emotional expressions, that is, whether emotions are universal or whether they vary by culture.¹⁵ On the one hand a universal innate emotional structure is proposed. Matsumoto (1989) has argued that emotions are biologically programmed, yet, the process of learning to control expression and perception of emotions is highly dependent on cultural factors. On the other hand, Russell (1994) suggested that certain emotional categories are culturally specific and that only the broad dimensions (e.g., valence and arousal) have a universal biological origin.

Proponents of the universality of emotions theory have substantiated their hypotheses through cross-cultural investigations of emotional expression recognition. Ekman (1972) and Izard (1971) conducted landmark studies showing members of both literate and pre-literate cultures pictures of Americans expressing the 'basic' emotions (anger, happiness, fear, surprise, sadness, disgust), and found the emotions to be recognized in both populations above chance level. These results confirm that a small group of basic emotions can be universally recognized.

More recent research has paid closer attention to the *level* of accuracy in emotion recognition cross-culturally. As with the own-race effect observed in own- versus other-race face recognition, an in-group advantage has emerged in cross-cultural data, whereby variability in cross-cultural emotion recognition has been attributed to in-group

¹⁵Facial expression of emotion falls under the broader category of emotional behaviour: the outward expressions and actions that accompany emotional experience (Mesquita et al., 1997).

familiarity. Such findings suggest that recognition accuracy is higher when emotions are both expressed and perceived by members of the same cultural group. This tendency has been termed *ethnic bias* (Kilbride & Yarczower, 1983; Markham & Wang, 1996) or in-group advantage (Elfenbein & Ambady, 2002 a, b). Ekman (1972) and Matsumoto (1989), however, suggest that this advantage may not be due to social pressures or norms, but rather to subtle stylistic differences in emotional expression across cultures.

A recent meta-analysis by Elfenbein and Ambady (2002b) found support for an interactionist interpretation of emotion recognition whereby evidence for cross-cultural recognition of emotions suggested that certain core components of emotions are universal and likely biological, whereas more complex emotional expression is culturally specific. Moreover, they found evidence suggesting that emotions may be more accurately understood when they are judged by members of the same national, ethnic or regional group that had expressed the emotion. These results indicate that, as Ekman found, a basic set of emotions can be recognized cross-culturally; however, an in-group advantage does exist, suggesting subtle differences between cultures.

5.3.2 The Limbic System

Research on the neural circuitry of emotion recognition from the face recruits a broad yet relatively discrete network of brain regions, specifically the occipitotemporal cortex, amygdala, orbitofrontal cortex, basal ganglia and right parietal cortex (Adolphs, 2002, 2003; Phan et al., 2002; Sprengelmeyer et al., 1998). Regions in the occipitotemporal cortex, in particular the superior temporal gyrus, process dynamic, changeable features of the face that are integral to expressions of facial affect, such as, mouth and eye movements (Allison et al., 2000). Furthermore, the occipitotemporal

cortex has bidirectional projections to and from the amygdala, integral to the assessment of valence of emotional stimuli (Adolphs, 2002).

The limbic and paralimbic cortical regions, including the insula, can facilitate emotion recognition from the face by ‘simulating’ the emotional state conveyed in the emotional expression (Adolphs, 2002; Wild et al., 2001). Interestingly, researchers have uncovered substantially more evidence for the neural substrates responding to negative emotions (fear, disgust, anger) than those involved in processing pleasurable emotions (happiness, contentment). This difference can be explained in terms of evolutionary importance. That is, out of the basic emotions, negative emotions are those which have direct evolutionary and developmental relevance (Matsumoto, 1989). Recognition of these emotions transfers survival information without personal experience. Consequently, highly developed and specialized neural systems have evolved for processing these emotions (e.g., disgust developed from distaste of poisonous foods; fear required/requires a fight or flight response).

Panskepp (1998) demonstrated that neural systems for emotion are similar across vertebrates, and amongst members of a species. Moreover, such similar neural systems organize similar behaviour and similar physiological/hormonal changes. Several neural systems interact during affective experience and recognition, and at the core of the limbic system is the amygdala. On the basis, in part, of animal studies demonstrating a direct short-latency pathway from the thalamus to the amygdala (LeDoux, et al., 1985), LeDoux (1996) has proposed that the amygdala might survey emotionally valenced stimuli without awareness.

Research by Ervin and Martin (1986) showed that electrical stimulation of the limbic system in conscious patients induced emotional experience. Furthermore, the amygdala contains nuclei important for the experience of positive and negative emotions

(Isaacson, 1982). Information from other brain areas is integrated in the amygdala where the association with emotional significance is attached (Aggleton & Mishkin, 1986). Similarly, research on monkeys with amygdala lesions has shown effects of normal sensation but little affect. Likewise, the amygdala has consistently been implicated in the processing of fearful stimuli receiving early (<120 ms) subcortical as well as late (~170 ms) cortical input from the temporal lobes. On the other hand, the insula/basal ganglia are involved in the processing of disgust. Evidence from animal studies shows that gustatory cortex (insula) lesions impair taste aversion in rats. Similarly, human patients suffering from Huntington's disease, Tourette's syndrome and Obsessive Compulsive Disorder express taste aversion and nausea in response to insula stimulation (Calder, Lawrence & Young, 2001; Phillips et al., 1997). Finally, Wicker and colleagues (2003) demonstrated that the responses elicited by watching videos of faces with emotional expressions of disgust and pleasure, as well as responses induced by smelling aversive and pleasant odours activated the same areas in the anterior insula and to a lesser extent in the anterior cingulate cortex.

5.3.3 Neurophysiological Studies: Single-Unit Recordings

Kawaski and colleagues (2001) found early responses of single neurons (120-160 ms after stimulus onset) to emotional faces and scenes in the human ventral prefrontal cortex, suggesting that some information about stimulus valence is extracted in anterior limbic areas prior to completing the analysis in the visual cortex. Single-cell recordings of face processing in humans were more recently conducted by Ojemann and colleagues (1992). Neuronal activity was measured in 21 neural populations at 13 sites in the right superior and middle temporal gyri. Significant neural changes in activation were recorded in response to identity matching and expression labeling (62% and 52% respectively).

Moreover, the facial expression task showed greater localized response to patterns in the middle temporal gyrus, suggesting specificity of neuronal response to faces.

5.3.4 Neurophysiological Studies: Scalp Recordings

Recent electrophysiological studies have demonstrated the process of facial expression recognition starts very early in the brain, by approximately 100 ms after stimulus onset (Eger et al., 2003; Eimer & Holmes, 2002; Felmingham et al., 2003; Pizzagalli et al., 1999; Werheid, Alpay, Jentzsch, & Sommer, 2005; Williams et al., 2004) and is perceived preattentively (80-120 ms) to the structural encoding of faces (which occurs around 170 ms). Some research suggests an early preattentive emotion modulation of the P1 (Eger et al., 2003; Eimer & Holmes, 2002; Felmingham et al., 2003; Pizzagalli, Regard, & Lehman, 1999; Williams et al., 2004). These findings are in line with theoretical models of emotions processing whereby researchers such as Zajonc (1980) have argued that the initial responses to affective stimuli are automatic and beyond conscious awareness.

The first perceptive stage during which an individual completes the structural encoding of the face is considered to be separate from early unconscious as well as later complex emotional processing (Junghofer et al., 2001; Lane et al., 1998; Pizzagalli, Regard, & Lehman, 1999). The suggestion that expression encoding is a parallel process to structural encoding of faces is consistent with neuropsychological models of face processing (Bruce & Young, 1986; Ellis & Young, 1988; Young, 1998). However, certain ERP investigations of modulations of emotional expression processing on the N170 have validated simultaneous expression and structural encoding (Ashley, Vuilleumier, & Swick, 2004; Eger et al., 2003; Krolak-Salmon, et al., 2001).

More consistent evidence of the emotional modulations of face processing is found 200 ms after stimulus presentation. This N2 ERP component occurs approximately 200–300 ms post-stimulus onset at centroparietal sites (Liddell et al., 2004) and has been directly linked to amygdala activity in depth-recording studies (Halgren, 1992; Halgren & Marinkovic, 1995; Krolak-Salmon et al., 2004). The N2 has been associated with automatic orienting to stimuli of biological importance (such as fearful, angry and sad faces) and novelty processing, consistent with the amygdala activation (Glascher & Adolphs, 2003). Marinkovic and Halgren (1998) found emotional expressions to evoke a larger N2 component than neutral faces. The authors suggested that this emotional modulation was likely linked to emotional valence processing in the amygdala and attentional control of stimulus processing. A later positive component between 200–300 ms over lateral temporal sites has also been identified in previous studies. Streit and colleagues (2000) evaluated differences in ERPs in emotional and structural face processing and found pictures of facial expressions versus non-expressive faces to modulate a peak around 240 ms. Streit and colleagues suggest that this component might represent specific processes underlying the decoding of facial expressions.

Later components have been observed over posterior scalp sites in response to emotional stimuli. The P300 has a posterior topography and is associated with controlled contextual processing (Halgren, 1992) and social evaluative judgments (Cacioppo et al., 1994; Ito & Cacioppo, 2000). Moreover, studies of specific emotions have revealed greater P300 amplitude for angry compared to happy face stimuli (Kestenbaum & Nelson, 1992; Lang, Nelson & Collins, 1990). The emotional modulation of the P300 component is also evidenced in clinical studies. Lew and colleagues (2005) demonstrated a significantly larger P300 in healthy participants versus traumatic brain injury patients in response to emotional faces.

5.3.5 Neuroimaging Studies

Evidence from neuroimaging studies has shown that visual presentation of emotional stimuli activates emotion-specific brain areas as well as the extrastriate cortex (Fredrikson et al., 1995; Linkenkaer Hansen et al., 1998; Marinkovic et al., 2000). Extrastriate activity is functionally interconnected with the activation of the amygdala and is crucial in emotional processing (Adolphs, Tranel, & Damasio, 1998; Calder et al., 1996; Davidson, 2001; LeDoux, 1996).

Recent neuroimaging evidence from humans has demonstrated activation within the amygdala in response to facial expressions of emotion (Breiter et al., 1996; Morris et al., 1996; Whalen et al., 1998). A study by Blair and colleagues (1999) demonstrated that angry expressions elicited more activation in the right orbitofrontal cortex and bilateral activation in the anterior cingulate cortex than did other facial expressions of emotion. Furthermore, negative emotional expressions are considered to have a separate processing system than positive emotions.

Blair and colleagues suggest the involvement of at least two dissociable, but interlocking systems in the processing of negative facial expressions. One system responds to facial stimuli (sad, fearful) involved in socially aversive conditions; the other system implicates regions involved in behavioural extinction by responding to angry facial expressions. The differential activation patterns obtained by Sprengelmeyer and colleagues (1998) for fear, anger and disgust support this position.

With regard to positive emotions, happiness and smiling appear to be innate: an infant will produce the first smile anywhere from 2 to 12 hrs after birth (Camras, Holland, & Patterson, 1993; Cohn & Elmore, 1988; Izard & Malatesta, 1987; Lewis & Michalson, 1983) and even blind and deaf babies smile (Freedman, 1964). To date, no

consistent pattern of activation specific to positive emotion faces has been isolated. Morris and colleagues (1996) found no activation in the amygdala for the contrast of happy-fearful expressions. On the other hand, Breiter and colleagues (1996) found the left amygdala responded preferentially to happy vs. neutral faces, suggesting a possible generalized response to emotionally valenced stimuli in the amygdala. Yang and colleagues (2002) found reliable bilateral amygdala activation to happy as well as sad, angry and fearful faces. Gorno-Tempini and colleagues (2001) found bi-lateral activation in the orbitofrontal regions (BA11 and 47) in both implicit and explicit processing of happy expressions. Furthermore, a PET study by Dolan and colleagues (1996) found significant activation in the left ventral prefrontal cortex, left anterior cingulate cortex, thalamus and the right fusiform gyrus in response to the presentation of happy faces.

In sum, it appears that there is a differential activation pattern for negative and positive facial expressions. Processing of negative facial expressions involved regions that specifically have been damaged in clinical populations such as the amygdala for fear and the basal ganglia for disgust, yet these patients remain competent in processing positive emotional stimuli (Adolphs et al., 1996). LeDoux's (1996) concept of the "low and high roads" for processing emotional stimuli is in line with the dissociation of positive and negative emotional stimulus processing. LeDoux's "low road" provides a crude representation of the stimuli to the amygdala, whereas the "high road" involves elaborated processing in the sensory cortex. Instinctual, negative fight/flight emotions are likely to be quickly processed through the low road, whereas positive emotions which are heavily influenced by social context are processed through the high road.

5.3.6 Lesion Studies

Evidence for the interconnectedness of seemingly distinct neural circuitries involved in processing basic emotions can be seen in patients with Klüver-Bucy Syndrome who suffer from flat affect. This condition results from bilateral lesions to the amygdala and inferior temporal cortex. Klüver-Bucy sufferers are typically indifferent to emotionally salient stimuli. More generally, amygdala lesion patients have demonstrated deficits in learning emotional expressions (Boucsein et al., 2001) and reduced fusiform and occipital cortex activation in response to negative emotional expressions (Vuilleumier et al., 2004) as compared to age-matched controls. Furthermore, Pegna and colleagues (2004) demonstrated that patients with bilateral lesions in the visual cortex resulting in cortical blindness, are able to correctly guess emotional expressions of face stimuli, but not the emotional valence of other types of emotion/non-emotional stimuli. Moreover, these patients demonstrate activation in the right amygdala (typically associated with emotion processing) during unconscious processing of the stimuli. In sum, evidence from lesion studies confirm the critical involvement of the amygdala in processing facial expressions of emotion.

5.4 Summary

In sum, the human brain is specialized in face processing and sensitive to socially relevant differences in faces (race and emotional expression). Evidence of face-specific cells in primates, of a face-specific region in the fusiform gyrus, and of face-specific ERP components demonstrates neural sensitivity to face processing. Moreover, evidence suggests that race of a face may influence the way in which individuals perceive their environment at a neural level. Likewise, emotional expressions are uniquely important in the encoding of a face at a neural level. The composite influence of race and emotion on

face processing, however, has yet to be investigated. The following experiments investigate whether race can influence the way in which individuals perceive others at the neural level (Chapters 7, 8, & 9) and whether emotional expression processing is affected by race of face (Chapters 8 & 9). Finally, race and emotion perception are investigated in light of other-race anxiety, experience and implicit racial bias (Chapters 8 & 9).

Chapter 6

Event-Related Potentials

6.1 Introduction

Scalp recording of voltage fluctuation over time is known as the Electroencephalogram (EEG). Event-related potentials (ERPs) are sections of the continuous EEG, and represent changes in electrical activity at the scalp, which are time locked to some sensory, motor or cognitive process. ERP measurement is a widely respected and applied electrophysiological technique which monitors the brain's electrical activity during the processing of information and can provide a direct measure of the neural correlates of mental functioning in real time.

6.2 The Physiology of ERPs

Event-related potentials represent the variations in electrical activity of the neurons produced through sensory stimulation. Specifically, voltage signals recorded from the scalp reflect shifts in the polarization of discrete neuronal membranes producing localized electromagnetic fields (Wood, 1987).

The electromagnetic fields are the result of ionic and capacitative current flow across the active neuronal cell membranes, which subsequently generate electrical potential differences in the extracellular space (Rugg & Coles, 1995). All-or-nothing action potentials, which propagate down the axon as a result of activation of voltage-gated ion channels, and graded postsynaptic potentials at the synapses, which result from activation of ligand-gated ion channels as a direct or indirect consequence of neurotransmitter binding to receptors on postsynaptic neurons, constitute two distinct types of transmembrane current flow generating extracellular electric fields, transmitting

and processing information within and between neurons. Allison and colleagues (1986) support that ERPs are mostly determined by post-synaptic potentials. However, certain slow currents associated with action potentials may also contribute to scalp recorded ERPs. ERP recordings at the scalp tend to be based on the activity of populations of neurons; when numerous excitatory synaptic contacts at the soma cause current to flow into the cell body towards the dendritic projections where the current eventually crosses back through the membrane and returns to the vicinity of the cell body through the extracellular medium. This current flow through the neuron, combined with its particular directional geometry, produces a dipolar charge separation¹⁶.

Post-synaptic potentials of a single neuron cannot, however, be recorded from the scalp. For a signal to be detectable from the scalp surface, the number, proximity, relative orientation, and synchronicity of the underlying neurons are extremely important. Around ten billion synapses are under each centimeter of cortical surface (Pakkenberg, 1997). The spread of voltage from the dipolar field decays with distance from the initial site. Nevertheless, voltage can be recorded at the scalp comprising the EEG recording. The synchronous activation of several similarly oriented cells summates individual electrical fields into one detectable dipolar field (Rugg & Coles, 1996). These configurations of neurons are known as a net “open fields” and tend to involve neurons aligned in parallel (Lorente de No, 1947). However, populations of neurons arranged in an open field configuration that are not activated synchronously are undetectable at the scalp. Conversely, net “closed fields” can result when individual neurons are not oriented in parallel, regardless of synchronous activity, and subsequently the activity of neurons arranged in this manner is undetectable at the scalp. A structure such as the amygdala is

¹⁶ A dipole is a pair of electrical charges (positive and negative) or magnetic poles of equal magnitude but with opposite polarity. The dipolar field has positive and negative charges through which post-synaptic potentials currents flow.

an example of the co-occurrence of the problems of orientation and distance. The alignment of amygdala neurons, resulting in a net closed field, and the distance of this structure from the cortical surface do not allow for electrical activity generated in the amygdala to be recorded from the scalp.

Consequently, ERPs are a selective measure, representing net open fields with sufficiently synchronous activity in response to discrete stimuli, and are potentially a key reflection of cortical activity (Allison et al., 1986). A small proportion of cells can determine the measured signal at the scalp. That is, 1% of synchronous pyramidal cells in a cortical area of 1 cm^2 can be responsible for 97% of the total signal (Hari et al., 1997).

The fact that EEG potentials can only be produced by brain structures with specific cellular geometries and relative distance from the scalp is not necessarily a limitation. ERPs provide a biased measure in the sense that only select neural clusters can produce scalp potentials, yet ERPs are still a complicated measure of neural activity, making it relatively impossible to localize the intracranial sources of electrical activity measured from the scalp. However, plausible models of intracranial sources can be deduced, and when ERPs are used in conjunction with complementary methodology (such as fMRI) evidence of intracranial sources is obtainable. Therefore, on the one hand, ERPs cannot isolate the exact neural generators of electrical activity recorded at the scalp. Yet, on the other hand, ERPs can provide excellent temporal and spatial information to allow for comparisons between tasks and certain types of stimulus processing, which can subsequently constrain ideas regarding the underlying functional neuroanatomy.

6.3 EEG Recording and Signal Extraction

Variations in neural electrical activity over time can be measured as differences in potentials between distinct points on the scalp. In order to localize the precise scalp sites

for electrode placement and to standardize their position on the scalp, the international 10-20 system (Chatrian et al., 1985, 1988; Jasper, 1958; Klem et al., 1999) has been proposed and is used in all of the ERP studies reported in this thesis. The 10-20 system defines the electrode locations according to their distance along the anterior-posterior and lateral (left/right) axes. The position of an electrode is represented by the letter F, C, P, T, or O when they are localized in the center of the frontal, central, parietal, temporal or occipital regions. This letter is followed by an even number for the right hemisphere, or an odd number for the left hemisphere, or by the letter Z to indicate the midline (see Figure 6.1).¹⁷ ERPs reflect the difference in voltage between two electrode sites. Typically, scalp activity is recorded at multiple locations in relation to a common reference (a selected site considered to be uninfluenced by electrical activity generated by experimental stimuli, for example: nose, ear lobes, or the mastoid bones behind the ears). Hence, ERPs represent the difference between the voltage at recording and reference electrodes, subsequently negating any common electrical activity.

The ERP activity in response to experimental stimuli is weak in comparison to the background brain activity (spontaneous EEG), muscle activity in the head region (electromyographic activity) and the environment (ambient noise). The essential role of the EEG amplifiers is to amplify the signal prior to averaging and analyses. The averaging and filtering improve the signal-to-noise ratio by reducing background noise, isolating a clear event-related potential. The extraction of the ERP relies on the amplification technique of filtering and averaging the electrical activity. Filtering the electrical activity limits the spread of the frequency recorded in the signal. The averaging of ERPs relies on the assumption that variation in the ‘event-related’ activity is ‘related’ (correlated) to the event in a systematic way, whereas the fluctuations of background

¹⁷ For instance, an electrode on the left hemisphere of the frontal lobe would be F3.

activity are not correlated with the ‘events’. Therefore, averaging successive sequences of ERPs (each time-locked to the same event) is an efficient method of signal extraction. In sum, averaging attenuates unrelated activity whilst maintaining the activity consistently related to the stimulus present in each EEG sequence.

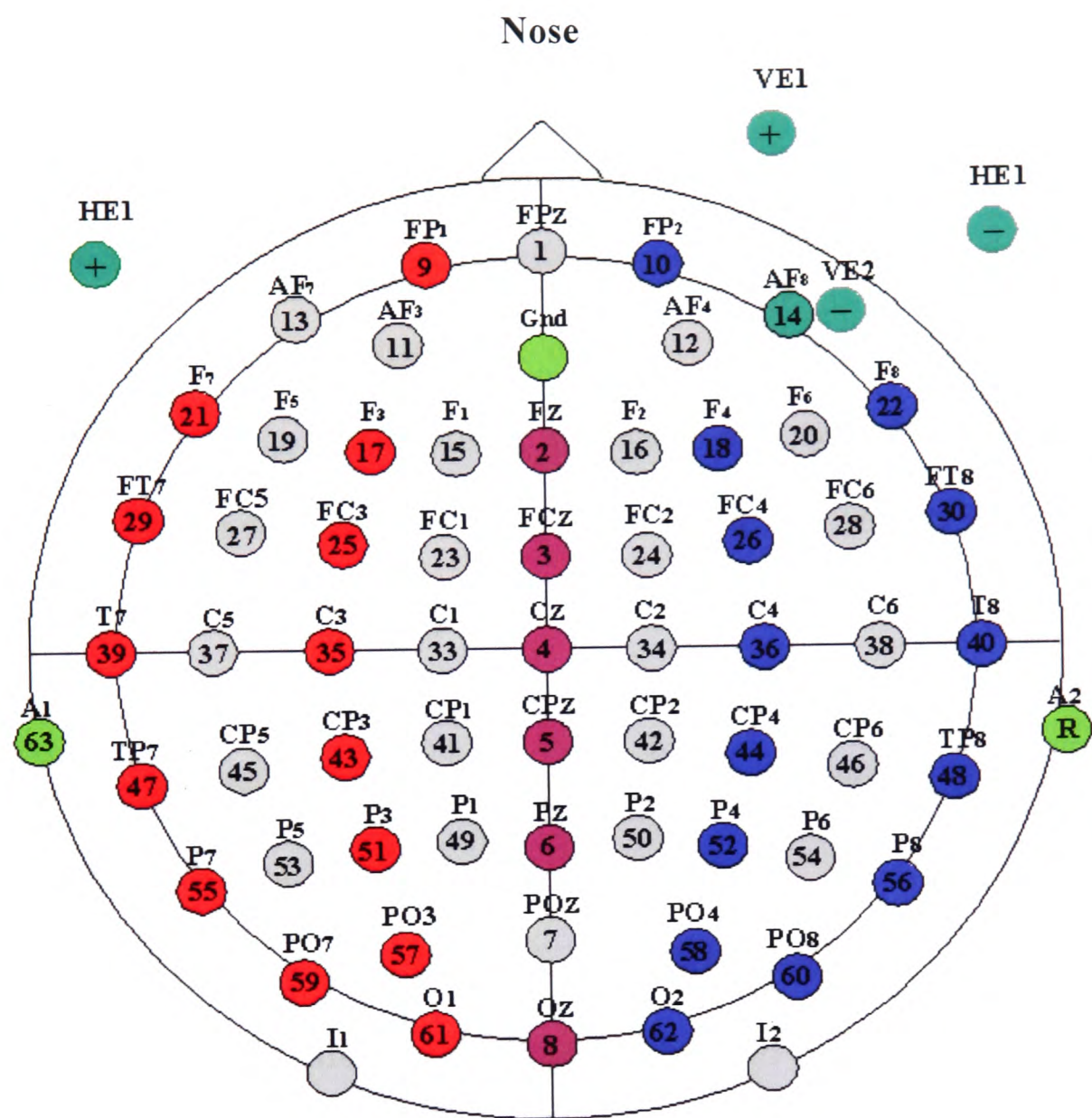


Figure 6.1. Electrode montage used for the experiments reported in this thesis (colour electrodes used in Experiments 7 and 8; all electrodes used in Experiment 9), positioned according to the 10-20 International System. The anterior scalp is shown at the top, and the right scalp is shown at the right side. The mastoid and ground electrodes are coloured in light green. Eye movements were monitored by recording the horizontal and vertical electro-oculograms, coloured here in dark green. All experiments in this thesis used the nose as the recording reference (electrode not shown).

Additionally, the signal-to-noise ratio can be enhanced by removing specific trials before averaging. Eye-movements and eye-blinks are the most common source of distortion in ERP recordings. Specifically, the eye-ball acts as a dipole (with an anteriorly

oriented positive pole, the cornea, and a posteriorly oriented negative pole, the retina) and with every rotation, generates a large amplitude alternate current field, detectable by electrodes near the eyes. Eye-blinks, or vertical eye-movements, cause the positive pole (cornea) to move closer to frontopolar electrodes (FP1-FP2), generating symmetric downward deflections. When the eye moves downwards, the positive pole moves away from frontopolar electrodes resulting in an upward deflection. Lateral eye-movements affect electrodes F7 and F8, and/or nearby sites depending on the experimental montage, such that left lateral eye movement generates the positive pole to move towards the left and away from the right. Hence, with every eye-movement, current dipoles change orientation, subsequently contaminating potentials recorded at the scalp. In order to monitor these eye-movements for subsequent identification and removal from the averaged waveforms, the electro-oculogram (EOG) monitors eye-movements. To do this, electrodes are also placed laterally to each eye, at the outer canthii, as well as above and below one of the eyes, in order to derive bipolar signals relating to the horizontal and vertical electrooculogram.

As the absence of overt shifts of eye-movements is crucial for the experiments reported in this thesis, an infrared eye tracker was used as an additional check on gaze position, and participants were observed to perform the tasks in the absence of eye movements.

6.4 The Structure and Extraction of ERP Components

The average ERP waveforms contain peaks and troughs, typically described in terms of polarity, latency and amplitude. These peaks are generally referred to as components, which are either negative or positive going, followed by a number representing their ordinal position or latency (e.g., P100 is for the first positive going

peak with a peak latency around 100 ms post stimulus onset; the N170 is for the first negative going peak with a peak latency around 170 ms post stimulus onset; the P400 is for a positive peak with a peak latency around 400 ms).

Components, however, do not necessarily represent a single neural generator in the brain, nor imply one single stage of information processing. Each component generally reflects the sum of neural activities in multiple brain regions occurring in the same temporal window. Moreover, the electrical activity generated in one region of the brain may be propagated passively through the brain tissue, cerebral-spinal fluid, skull, and skin, resulting in the summation of activity from several different sources with different time courses and registering on differing scalp locations: this process is known as 'spatial summation'. Voltage signals also interact over time, resulting in 'temporal summation', and therefore ERP waveforms may not directly correspond with the temporal characteristics of individual neural generators.

Both spatial and temporal summation factors lead to the 'inverse problem', such that it is impossible to establish a unique solution to the location of intracranial generators of electrical activity recorded at the scalp. The inverse problem, described originally by Helmholtz (1880's), establishes that there are infinite possible configurations of neural generators within a 3-dimensional volume (such as the brain) for any given 2-dimensional distribution of voltage measured at the surface (scalp). A more simple case involves the reverse scenario; a solvable process, known as the 'forward problem' occurs when the computation of the distribution of voltage observed at the scalp is from a known configuration of dipoles. However, as initial knowledge of neural generators is difficult to establish, and several different brain areas can be simultaneously active during task performance, calculating the probable distribution of a single pre-defined dipole is not

particularly useful. Comparative methodologies, such as fMRI could be employed to identify candidate neural generators, offering a potential solution to these problems.

Traditionally, the identification of components is based on the analysis of ERP polarity, amplitude and latency. Näätänen and Picton (1987) suggest that a component should be defined by both its sensitivity to experimental manipulations, and characteristics linked to its neural generators such as its latency, amplitude, and scalp distribution. This perspective, however, can neither account for spatial and temporal overlap nor for intrinsic difficulties in localizing neural generators of ERP effects. An alternative view has been proposed by Donchin (1979), stating that a component can be defined by the information processing operation with which it is correlated. According to this approach, differences in components evoked under distinct experimental conditions are analyzed. It is, however, a complex matter to create distinct experimental conditions differing only with respect to one specific cognitive process under investigation. These definitions are similar in the fact that each suggests the component reflects independent brain mechanisms that contribute to the variance of the signal, whose modulations can be evidenced by experimental manipulations. According to this theoretical approach, the components associated with different stages of sensory and cognitive processing can become evident and will vary in terms of amplitude and/or latency (i.e., reflecting intensity of processing and/or timing differences in the engagement of the same neural generators) in response to manipulations to experimental conditions.

The investigation of components, as markers for the engagement of specific mental processes can take two forms: inferences not based on prior knowledge and inferences based on prior knowledge (Otten & Rugg, 2001). In the first instance, ERPs can be employed to elucidate cognitive processes even with no prior significant information of specific ERP features or components acting as markers for the

engagement of the cognitive processes of experimental interest. Specifically, inferences can be drawn from ERP waveforms regarding information about the timing, degree of engagement and the functional relationship with underlying cognitive processes. By investigating the time course, amplitude and distribution of the signal across the scalp in response to finely tuned experimental stimuli, deductions of the correlation between recorded ERPs and underlying cognitive function can be substantiated. This is particularly useful when seeking to compare experimental versus control conditions. A reliable difference in ERP components and/or scalp distributions of electrical activity measured between control and experimental conditions implies that the cognitive processes associated with the two conditions differ in some respect, be it conditions, timing, or both.

In the second instance of inferences based on prior knowledge of ERP waveforms (with regard to activity of neuronal populations and associated cognitive processes), experimentally substantiated components can shed light on the variance of cognitive functioning across conditions, which can also be linked to other measures of brain activity. Ultimately, such inferences depend on carefully designed experiments in which meticulously selected conditions manipulate cognitive processes. Hence, functional interpretations of ERP waveforms tend to be deduced through the comparison of conditions developed to isolate the components and underlying processes of interest. Although components can never act as surrogate signals for cognitive processing, using certain components as potential or hypothetical physiological markers of cognitive and neural processes can allow researchers a shared language across experiments, paradigms and fields (Otten & Rugg, 2001). Furthermore, known components can serve as a basis for integrating ERP data with other measures of brain activity. When sufficient

information accumulates in relation to certain components, their functional significance can (broadly speaking) be deduced.

Generally, inferences made from ERP waveforms are correlational, such that ERP components and underlying cognitive processes are only correlated, and whether one is necessary for the other to occur is uncertain. Despite strong correlations between experimental manipulations and resulting waveforms, it is still impossible to ascertain whether the recorded activity is a direct result of the mental processes necessary for the task.

By investigating patients with brain lesions, or through the temporary disruption of neural activity by Transcranial Magnetic Stimulation (TMS: Cowey & Walsh, 2001) one can study the relationship between cognitive functioning and specific neural generators. If the mental process in question is subsequently affected, one can infer that the neural generator and the cognitive process are related. Typically, if a disruption occurs, then the neural correlate can be deduced to be critically involved in the function. However, if a disruption of the mental process is not found when the neural generator in question is disrupted, it is difficult to conclude the functional relationship between the neural generator and cognitive function, for instance, the area of interest may be involved, but there may be a parallel circuit that makes the process run smoothly nonetheless.

6.5 Topographic Analysis

Topographical mapping of EEG is another, complementary approach to the component analysis of event-related potentials, focusing primarily on the spatial distributions of ERP data over the scalp for each moment in time, rather than the shape (topology) of the waveforms over particular electrode(s) (Kayser & Tenke, 2005). The

surface moment-by-moment electrical field can be reconstructed by EEG mapping such that any change in configuration of the field over time or between conditions is seen in a change in the active neuronal populations in the brain. Topographic maps are displayed as projections from the 3-dimensional volume (the brain) onto a surface map of the scalp. As real measured points are distinct (electrodes), interpolation algorithms are used to represent the scalp topography with equipotential lines or color-coded equipotential areas. Topographic maps are reference independent, as comparisons of topographies require the use of normalized data (McCarthy & Wood, 1985) in order to distinguish genuine differences in topography from distinct magnitudes of a localized component across conditions. As the electric 'zero potential' is arbitrary the recoding reference influences all waveform parameters (amplitude, polarity and latency) without changing the spatial configuration (the topography) of the maps (Michel et al., 2001). Instantaneous measures of global field power (GFP)¹⁸ can provide reference-free normalized data.

A specific approach to topographic analysis is provided by Cartography ToolTM, which investigates the scalp distributions of electrical activity for significant changes in topographies over time and condition. This technique relies on the assumption that changes in topographies reflect changes in underlying neural processes. Specifically, a change in electrical field topography results from changes in the distribution of the active neurons in the brain. Hence, significant topographic differences between maps directly demonstrate the changes in configuration of the neural sources, which are contributing to the brain activity. As a result brain function is considered to be reflected by specific patterns of neuronal activity, and therefore distinct topographic maps represent discrete functions (Schnider, Valenza, Morand, & Michel, 2002).

¹⁸ Global field power is the spatial standard deviation of a map referred to the average reference.

A disadvantage of the reference-free topographic approach provided by the aforementioned methodology lies in the global averaging of electric activity. It may be that certain components evident at a few electrode sites do not generate enough global electrical activity to represent a change in topographic map. These small, yet significant components can be missed out in the topographical analysis. Hence, a combined analysis of scalp waveforms (morphology) and topography can successfully be applied to ERP data in order to comprehensively decompose EEG data (Spencer et al., 1999, 2001).

In sum, the most complete approach to ERP analysis uses the complementary processes of topology and topography analyses, which together provide the most sensitive measure of changes in the amount and type of neural activity over time and across conditions.

6.6 The Advantage of ERP Methodology

The electrophysiological measure of ERPS has certain advantages, particularly in the context of face processing research. In comparison with behavioural measures, ERPs provide a continuous measure mental processing from stimulus to response, rather than only the final outcome of stimulus processing provided by behavioural measures. ERPs can likewise provide a measure of brain activity and information processing in the absence of requirements of motor responses. This is particularly useful when the mental process in question, in the current Thesis, race and emotional face processing, is not tied to a particular response, but rather the mental processing of the stimulus is of primary interest. Moreover, the high-temporal resolution of ERPs (in the order of milliseconds) provides information of the exact timing of cognitive processing impossible to infer from behavioural measures alone, subsequently allowing for the investigation of social influences such as race and emotion on the perception of faces. ERPs therefore offer a

window into stimulus processing in the brain, useful in studies investigating the implicit processing.

ERPs represents a superior measure of temporal resolution when compared to hemodynamic measures of brain activity such as Positron Emission Tomography (PET) or functional Magnetic Resonance Imaging (fMRI), which measure slow changes in blood flow, on the order of seconds, as ERPs permit the on-line tracking of neural activity in real time. Event-related fMRI can be used to look at single events within individual trials, however, this technique measures changes in blood flow over several seconds, not in real time, and therefore can only indirectly be linked to neuronal electrical activity.

Single-unit recordings provide a focal measure of ERPs with high temporal and spatial resolution. Single-unit recordings, however, are invasive and not readily conducted in human participants. Therefore, recordings in non-human primates can only suggest a relationship between certain neurons and cognitive functioning, and cannot guarantee the same neural sources are present in the same location and organization in humans. Intracranial ERP recordings of epileptic patients, however, have been conducted. In particular, Allison and colleagues (1999) have used this technique to shed light on the neural generators of face processing in real time. Nevertheless, ERP recordings from the scalp possess an advantage over single-unit and intracranial recordings as they can be recorded non-invasively from humans, which is important for the investigation cognitive processes involved in the implicit processing of socially-salient variables, such as race and emotion which are intertwined with human face processing. In sum, the excellent temporal resolution of ERPs can isolate information regarding the specific timing of cognitive processing which other testing methods cannot deduce, making this recording

technique ideal for exploring the influence of race and emotion on face processing in the brain.

6.7 Summary

In sum, ERPs measure variations in brain activity over time. These recordings can provide information correlating brain activity with discrete cognitive functioning, with or without previous knowledge of the correlation in question. Although limited in its ability to determine the precise location of neural generators, the high temporal resolution of ERPs allows for a direct measure of neural activity in real time, which behavioural and hemodynamic measurements (PET, fMRI) cannot provide. Ultimately, ERPs provide an appropriate measure to investigate the brain activity associated with the processing of own- versus other-race faces and emotional expressions.

Chapter 7

The Influence of Race on Face Processing in the Brain

7.1 Experiment 5: Introduction

The complexity of human social behaviour reflects the interactions of numerous social factors with underlying neural systems integral for the perception of social signals (Adolphs, 2001). Face perception is a key example of a well-tuned system, whereby individuals are able to recognize countless numbers of familiar faces, subsequently facilitating interpersonal communication. The neural basis of face perception has been investigated over the past two decades, and both hemodynamic and electrophysiological brain-imaging research have provided substantiating evidence for neural specialization in face perception.

The initial discovery of face-specific brain activity in humans was by Ojemann, Ojemann and Lettich (1992) who recorded from populations of neurons in the middle fusiform gyrus and found specific populations of neurons selective to face perception. Allison and colleagues (1994a) developed this initial investigation, recording field potentials intracranially in epilepsy patients, and found discrete portions of the fusiform and inferior temporal gyri which responded selectively to intact face stimuli and not scrambled faces, objects or butterflies. In the fusiform and inferior temporal gyri, face stimuli evoked large field potentials peaking between 170-210 ms (N200). These initial neurophysiological findings suggest that the human ventral objects recognition system (Puce et al., 1996) contains a localized subsystem particularly sensitive to the perception of faces. Hemodynamic brain imaging investigations have offered further evidence that an area in the right middle fusiform gyrus is sensitive to face processing (Kanwisher et al., 1997). This fusiform area has been noted as more active during face recognition than

object recognition (Grill-Spector et al., 2004; Sergent et al., 1992), when matching faces versus locations (Courtney et al., 1997; Haxby et al., 1991; Haxby et al., 1994), and when viewing intact faces versus scrambled faces (Clark et al., 1996; Puce et al., 1995). This fusiform area has subsequently been interpreted as face module or expertise area, fine-tuned to face perception (Gauthier et al., 1999; Tong et al., 2000).

Event-related potentials (ERPs) provide a real-time measure of information processing triggered by individual stimuli, from perception to action. Scalp recordings of ERPs exploring face-specific processing (Bentin et al., 1996; Eimer, 2000) have highlighted two components which reflect structural encoding of faces around 170 ms post stimulus onset, known as the vertex positive potential (VPP) and the N170 (Bentin et al., 1996; Jeffreys, 1989). Early studies on the time course of face processing, which used a small set of channels along the midline referenced to the mastoids, described a large positive potential, named the VPP, which peaked at frontocentral sites between 140 and 180 ms in response to face stimuli versus objects or scenes (Bötzel & Grusser, 1989; Jeffreys, 1989; for a review see Jeffreys, 1996). Studies with higher densities of channels covering a large portion of the head (Tucker, 1993), revealed an additional large negative component peaking at the same latency over occipitotemporal regions, the N170. Recent research has proposed that both the VPP and the N170 are two reflections of the same brain generators (George et al., 1996; Joyce & Rossion, in press).

Bentin and colleagues (1996) were the first to isolate the N170 component which was larger and earlier for faces than for any other stimuli, particularly over the right occipitotemporal scalp region. They also found that eyes presented in isolation elicited a larger N170 than whole faces, and noses and lips elicited a smaller component and proposed that as the N170 reflects face structural encoding. The replication of this effect by Eimer (1998) supports the view that the N170 reflects the encoding of the faces as a

whole. The absence of the N170 to faces observed in prosopagnosia patients (Eimer & McCarthy, 1999) as well as the fact that the N170 is unaffected by face familiarity (Bentin & Deouell, 2000) is also consistent with the current view that the N170 reflects the processes involved in face structural encoding.

Indeed, modulations of the N170 component are consistent with face-specific behavioural effects, such as the face-inversion effect, whereby inverted faces are more difficult to recognize and match than upright faces. Specifically, modulations of the N170 are consistently reported when face stimuli are inverted by a 180-degree rotation (Rossion et al., 1999; Rossion et al., 2000). For example, increased N170 amplitudes have been observed for inverted versus upright faces when participants engage in face discrimination tasks. George and colleagues (1996) suggest that the increased N170 to inverted faces may reflect the greater difficulty in processing inverted versus upright faces resulting in more processing negativity at the stage of structural encoding. Moreover, the N170 is seen to be delayed for inverted faces compared with upright faces (Rossion et al., 1999, 2000). This delay is also considered to reflect the greater difficulty in face processing at the stage of structural encoding when face stimuli are not in their most frequently experienced upright orientation, and, more generally, the processing of inadequate configural information (Rossion et al., 1999). Consistent with this proposal, latency shifts have also been reported for faces without eyes compared to intact faces (Eimer, 1998), and when participants process face components analytically rather than holistically (Jemel, George, Chaby, Fiori, & Renault, 1999).

The aforementioned knowledge of face processing in the brain can be used to investigate the neural basis of a pervasive social and cognitive phenomenon, known as the own-race effect. Anecdotally, individuals report poor other-race face recognition which may propagate interracial social division. Experimentally, a modulation of face

processing by race is well documented in the behavioural literature, whereby individuals demonstrate greater difficulty in recognizing other-race faces versus own-race faces. This social-cognitive phenomenon has been noted as an impediment in interracial social communication and eye-witness identification (Sporer, 2001; Wright, Boyd & Tredoux, 2003). Differences in own- versus other-race face processing have been investigated and validated under a variety of behavioural experimental conditions, demonstrating a perceptual (Walker & Tanaka, 2003; Walker & Hewstone, in press a, b) and recognition memory (see Slone et al., 2000, for a review) bias for own- versus other-race faces.

To date, the own-race effect in perception and recognition has received little empirical investigation at a neural level. The neural circuitry involved in the categorization by race of face has been examined by functional Magnetic Resonance Imaging (fMRI). Golby and colleagues (2001) found greater middle fusiform activation in response to own- versus other-race faces, and Golarai and colleagues (2004) found greater middle fusiform activation for intact own-race as well as scrambled own-race faces versus other-race faces, suggesting that the middle fusiform gyrus may be sensitive to racial category membership.

Brain imaging studies have also investigated the relationship between automatic (implicit, unconscious) and controlled (explicit, conscious) bias with the processing of other- versus own-race faces (Cunningham et al., 2004; Phelps et al., 2000; Phelps et al., 2003). In particular, activity in the amygdala, has been shown to be sensitive to race of face stimuli (Cunningham et al., 2003; Hart, et al., 2000). The amygdala is a limbic structure implicated in emotional processing, and particularly in responding to stimuli that signal danger or threat, with outputs to the prefrontal cortex, high-level association areas of the neocortex and autonomic centres of the hypothalamus and basal forebrain (for a review see Zald, 2003). With regard to race processing, the amygdala has been

shown to habituate faster to own- versus other-race faces (Hart et al., 2000), to show greater activation to other-race faces during social-categorization tasks (Wheeler & Fiske, 2005), and when faces are presented subliminally versus consciously (Cunningham et al., 2004). Moreover, amygdala activation to other-race faces has been found to correlate with measures of implicit social bias (Phelps et al., 2000), such that White participants demonstrating greater implicit anti-Black/pro-White bias on an implicit association test (Greenwald et al., 1998) also showed greater amygdala activation to Black versus White faces. Altogether, these findings support the involvement of the amygdala in explicit as well as implicit race evaluation.

Evidence about the timecourse of the effects of racial factors on face processing is crucial to the understanding of the own-race effect at a neural level. Event-related potential studies on the time course of face processing have the ability to clarify whether social factors such as race can influence early stages of perceptual analysis (such as structural encoding reflected by the N170) or whether they bias later, more controlled post-perceptual aspects of face recognition. However, to date, electrophysiological evidence of race-of-face processing is inconclusive. The effect of race has been investigated in a handful of studies (Caldara et al., 2004; Caldara et al., 2003; Ito & Urland, 2003, 2005; Ito, Thompson & Cacioppo, 2004; James, Johnstone, & Hayward, 2001), and whether or not components implicated in various stages of face and information processing are in fact modulated by race remains undetermined. Certain researchers reported no modulation of the N170 and suggested that race-of-face processing does not begin during face structural encoding, but rather later, around 240 ms after stimulus onset (Caldara et al., 2003, 2004; Ito et al, 2004, experiment 1; James et al., 2001). Ito and colleagues (2003, 2004, & 2005), however, found own-race faces to elicit a larger N170 than other-race faces during social categorization tasks than during non-

social categorization tasks. The findings by Ito and colleagues are important in demonstrating that the context in which we look at a face may dictate the priority of initial information extraction during structural encoding.

Nevertheless, research to date has failed in two ways: (1) the influence of race on face processing has been investigated in the context of complex tasks, the majority of which may bias the participants prior to viewing face stimuli and subsequently results across such studies have not been consistent, and (2) adequate control stimuli have yet to be included in experiments investigating race effects, and such controls are necessary to determine which modulations on the timecourse of face processing are *race*-related versus *colour*-related.

In the current study, ERPs were used as a tool to investigate components sensitive to differences in processing own- versus other-race faces. Recordings from White participants were compared when they viewed White versus Black faces. The experiment used a two-tiered strategy. First, to identify brain activity sensitive to face stimuli (including the N170 component) in general, processing of upright White faces was compared to processing of control stimuli with the same overall size, shape and luminance as White upright faces but without any facial features (blurred faces); as well as to processing of face stimuli rotated by 180 (inverted faces). Second, the effect of race upon face-related components was tested. Furthermore, in order to interpret whether race-related modulations reflected racial characteristics or the overall luminance pattern of the stimuli, the processing of White and Black faces was compared when these were presented in normal colour versus contrast-reversed.

7.2 Methods

Participants

Thirteen healthy right-handed (Oldfield, 1971) White female participants (age range 18-24 years) took part in the experiment. All participants had normal or corrected-to-normal vision. The experimental methods were non-invasive and had ethical approval from the Department of Experimental Psychology, University of Oxford, U.K..

Stimuli and Materials

A five item self-report measure of quantity of social-contact and ten item measure of individuating experience were completed by all participants (completion of this measure was counterbalanced: half of the participants completed it prior to, and the other half completed it after EEG recording), in order to investigate correlations between race-related effects on neural components and other-race familiarity.

The social-contact scale included five items. Item (1) asked, ‘How many Black people do you know very well?’ with the answer choices: *Up to 2, Up to 5, Up to 8, Up to 12, and More than 12*. Items 2-8 used the following scale: *strongly agree, sort of agree, not sure, sort of disagree, strongly disagree* and were worded as: (2) ‘I often talk to Black people in college’, (3) ‘I often see Black people outside of college’, (4) ‘I often hang out with Black people’, and (5) ‘I often see Black people at social events I attend’.

The individuating experience scale included 10 items and used the following scale: *Never, rarely, once in a while, sometimes, frequently* and were worded as: (1) How often have you helped someone Black with a problem they had in class?, (2) How often have you asked for/received help from someone Black when you had a problem in class?, (3) How often have you given a Black person advice on a personal problem?, (4) How often have you received advice from a Black person when you are having a personal problem?, (5) How often have you comforted a Black person when they were upset/sad?,

(6) How often have you been comforted by a Black person when you were upset/sad?, (7) How often have you worked with Black classmates on projects?, (8) How often have you had a Black person on your team during sports or your group during other activities?, (9) How often do you spend time with Black friends/friend at their place?, and (10) How often do you have Black friends round to your place?

The reliability of the two multi-item measures (social-contact, and individuating experience), were both reliable: (1) social-contact (Cronbach's $\alpha=.87$), and (2) individuating experience (Cronbach's $\alpha=.94$). Overall participants reported slightly below mid-point social-contact, $M=2.21$, $SD=.70$, and average individuating experience, $M=3.11$, $SD=.82$.

Participants viewed face stimuli of 5 White and 5 Black males with neutral expression from a frontal viewpoint. The stimuli were black-and-white photographs taken by the experimenter. From these face stimuli, further experimental stimuli were generated: (1) White face stimuli were blurred using a Gaussian transformation and rotated 180°, subsequently no longer identifiable as faces (referred to as “blurs”) (2) White face stimuli were inverted (rotated 180°), and (3) White and Black faces were contrast-reversed as a control for the colour differences between White and Black race faces (see Figure 7.1).

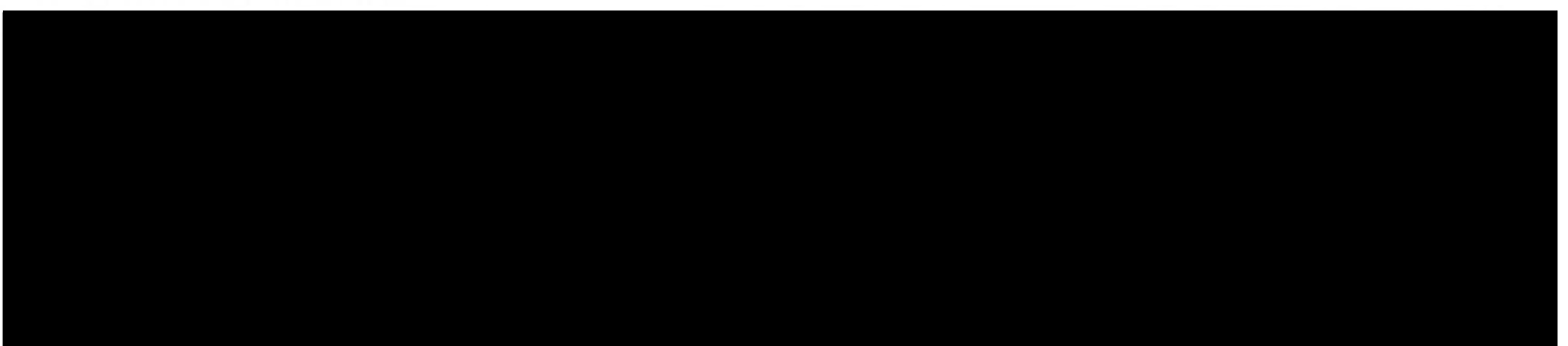


Figure 7.1. Face stimuli from left to right: White upright; White Blur; White inverted; White colour contrast reversed; Black upright; Black colour contrast reversed.

In total, participants were presented with 30 distinct face stimuli: 5 upright White, 5 upright Black, 5 blurs, 5 inverted White, 5 reversed White, and 5 reversed Black. Each stimulus was presented 12 times in a constrained randomized order, preventing more than two stimuli of the same category from appearing successively. An additional six stimuli per category (10% of all experimental trials) were designated as “targets”, appearing directly after an identical stimulus (repeats). In total, there were 396 trials.

Each experimental trial consisted of a fixation point presented in the centre of the screen for 1000 ms followed by a face or transformed face stimulus for 500 ms. Trials were separated by an interval that ranged randomly between 1000 and 2500 ms. Participants were asked to respond when they detected a stimulus that repeated over immediately successive trials (targets) by pressing the right mouse button with their right index finger.

Procedure

For task performance, participants were seated in a dimly lit and electrically shielded room, facing a computer monitor approximately 100 cm away. They were given the task instructions, and completed a block of 12 practice trials in order to familiarize themselves with the task. They were asked to minimize blinking and to maintain visual fixation in the centre of the screen at all times during task performance.

ERP Recording

The electroencephalogram (EEG) was recorded continuously from 34 scalp sites using Ag/AgCl electrodes mounted on an elastic cap (Easy-Cap, FMS, Germany), positioned according to the 10-20 International System (AEEGS, 1991). The montage included 6 midline sites (FZ, FCZ, CZ, CPZ, PZ, and OZ); 14 sites over each hemisphere (FP1/FP2, F3/F4, F7/F8, FC3/FC4, FT7/FT8, C3/C4, T7/T8, CP3/CP4, TP7/TP8, P3/P4, P7/P8, PO3/PO4, PO7/PO8, and O1/O2); and both mastoids. Two additional electrodes

were used as reference and ground sites: the EEG was referenced to the nose, the electrode between FPZ and FZ served as the ground. Electrodes were also placed laterally to each eye, at the outer canthii, and below the right eye, in order to derive bipolar signals relating to the horizontal and vertical electrooculogram. Data were digitized at a sampling rate of 500 Hz, using a 200 Hz low-pass signal and no high-pass signal (DC).

Event-related potentials were averaged offline. Epochs started 200 ms before and ended 600 ms after stimulus onset. Epochs containing excessive noise or drift (in excess of $\pm 100 \mu\text{V}$) at any electrode were excluded. Epochs with eye-movement artifacts (blinks or saccades) were rejected. Blinks were identified as large deflections ($\pm 50 \mu\text{V}$) in the HEOG and VEOG electrodes. Saccades or breaks in central fixation were also monitored with an infrared video-based eye tracker (iView, SMI); trials with breaks in fixation were subsequently removed from analysis. Analysis concentrated on non-target trials, in order to avoid any contribution from components related to response-related processes.

ERP Analysis

The main aim of the experiment was to identify ERP components sensitive to differences in processing own- versus other-race faces. Specifically, the experiment compared the processing of White and Black male faces of neutral expression by White female participants. To guide the interpretation of ERP differences, ERP components related to face processing were isolated by comparing the processing of upright White faces to control stimuli: blurs and White inverted faces. The effect of stimulus colour versus race of face was assessed by comparing the processing of White and Black faces to the contrast-reversed versions of the same stimuli.

As a first step toward identifying face-related ERP components, the morphologies and topographies of ERPs elicited by upright White faces and blurs were compared. As a follow-up, ERP morphologies elicited by White faces were compared to those elicited by

inverted faces. The comparison of upright and inverted faces aimed at revealing neural processing related to the overall configuration and orientation of facial features as well as latency differences related to identification of face stimuli. Modulation of face-related ERP components by race effects was assessed by comparing the morphology of ERPs elicited by faces in the two races in their natural versus contrast-reversed tones. Only effects of race that could not be explained by colour effects were treated as of potential interest.

Topographical ERP analyses

To identify significant differences in the nature of neural processing engaged by face stimuli compared to control stimuli with similar overall luminance and shape, the ERPs elicited by upright White faces and blur stimuli were summarized by a limited number of scalp potential fields referred to as “segmentation maps” (Ortigue et al., 2004), using Cartool software (Brunet, Functional Brain Mapping Laboratory, Geneva, Switzerland). These segmentation maps represent periods of stable electric field patterns and reflect dissociable “functional microstates” of the brain (Pasqual-Marqui, Michel, & Lehman, 1995). Each functional microstate is thought to reflect activity in a unique distribution of active neuronal generators and thus a discrete stage of information processing (Lehman, 1987; Michel, Henggeler, & Lehman, 1992). Between microstates, the distribution of active neural generators and/or the weighting of their activity can be inferred to differ. By comparing the maps and their durations across experimental conditions, it is possible to determine whether functional states differ in nature or in time-course between conditions. The segmentation procedure used here has been described in detail elsewhere (Khateb et al., 1999).

To perform this segmentation analysis, ERPs for each subject¹⁹ and each condition were first recalculated against the average reference and normalized to their global field power (GFP, Lehman & Skrandies, 1980) before group averaging. This measure is calculated as the square root of the mean of the squared value recorded at each electrode (vs. the average reference) and is equivalent to the spatial standard deviation of the scalp electric field.

Second, the most dominant scalp topographies appearing in the group averaged ERP, from each condition over time, were identified through the segmentation process, an analysis akin to a spatio-temporal cluster-analysis. This analysis was completed from 0-600 ms after stimulus onset and given scalp topography constrained to at least 3 consecutive data points (more than 6 ms at a 500-Hz digitization rate) in the group averaged data. The optimal number of maps that best explain the entire data set was defined by a cross-validation criterion (Pascual-Marqui et al., 1995). This step of the analysis results, for each condition, in a sequence of non-overlapping scalp-topography configurations of variable duration as can be seen in Figure 7.2.

The last step of the analysis consists in statistical analysis across the individual subjects in order to define the significance of each map for a given condition (fitting procedure). In the relevant time windows, the segmentation maps derived from the group grand-averaged ERPs were compared by strength-independent spatial correlation with the moment-by moment scalp topographies of the individual-subject ERPs elicited by face and blur stimuli. In other words, the scalp topography data for individual subjects in each condition and for each time-point were compared to the different segmentation maps and subsequently labeled according to the one with which they were best correlated (Pegna, Khateb, Spinelli, Seeck, Landis, & Michel, 1997).

¹⁹ In keeping with the Neuroscience writing format, I will be referring to participants as 'subjects' in the remaining experimental Chapters.

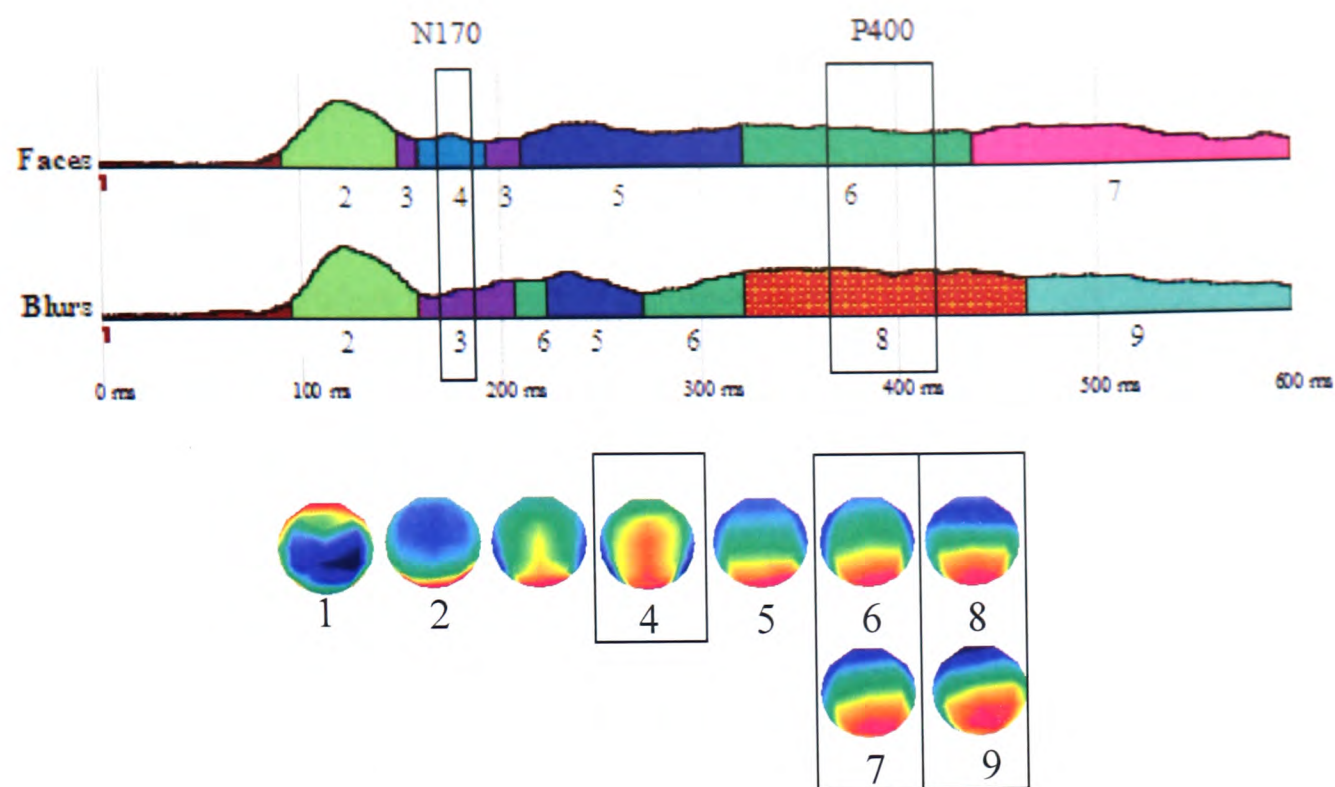


Figure 7.2. Faces versus Blurs segmentation maps and scalp topographies; the segmentation map numbers correspond to the scalp topography numbers.

This comparison allows for not only the verification of the presence of particular maps in each condition in each set of subject data, but serves also to determine the total amount of time a given topography was observed for the experimental conditions across subjects (e.g., Brandeis, Naylor, Halliday, Callaway, & Yano, 1992). Repeated-measures ANOVAs were then performed on these latter values. If one segmentation map differentiated activity of faces from that of blurs, the ANOVAs should show that this map was significantly more present in one condition (faces) than the other condition (blurs).

Morphological ERP Analysis

Waveforms of the upright White faces compared to blur stimuli were characterized by early visual responses over lateral posterior sites, a later negative peak over frontocentral sites, and a late positive frontal peak. The identifiable electrophysiological events (components) were named according to their polarity and approximate peak latencies. Of interest were components shown to be related to

processing of face stimuli – N170, N210 and P400 – as well as the early visual P120 component (the traditional P1 component which peaked in the current experiment around 120 ms). The mean amplitudes and latencies of components were compared between experimental conditions using repeated-measures ANOVAs.

Mean amplitudes were measured over symmetrical electrode clusters where the component was largest, using the time period around the peak latency in the group data. The visual P120 component was measured between 100-140 ms at electrodes PO3/PO4 and O1/O2; N170 was measured at P7/8 and PO7/8 between 160-180 ms; N210 was measured at CP3/CPZ/CP4 and P3/PZ/P4 between 200-220 ms; and P400 was measured at F3/FZ/F4 and FC3/FCZ/FC4 between 360-420 ms (see Figure 7.3).

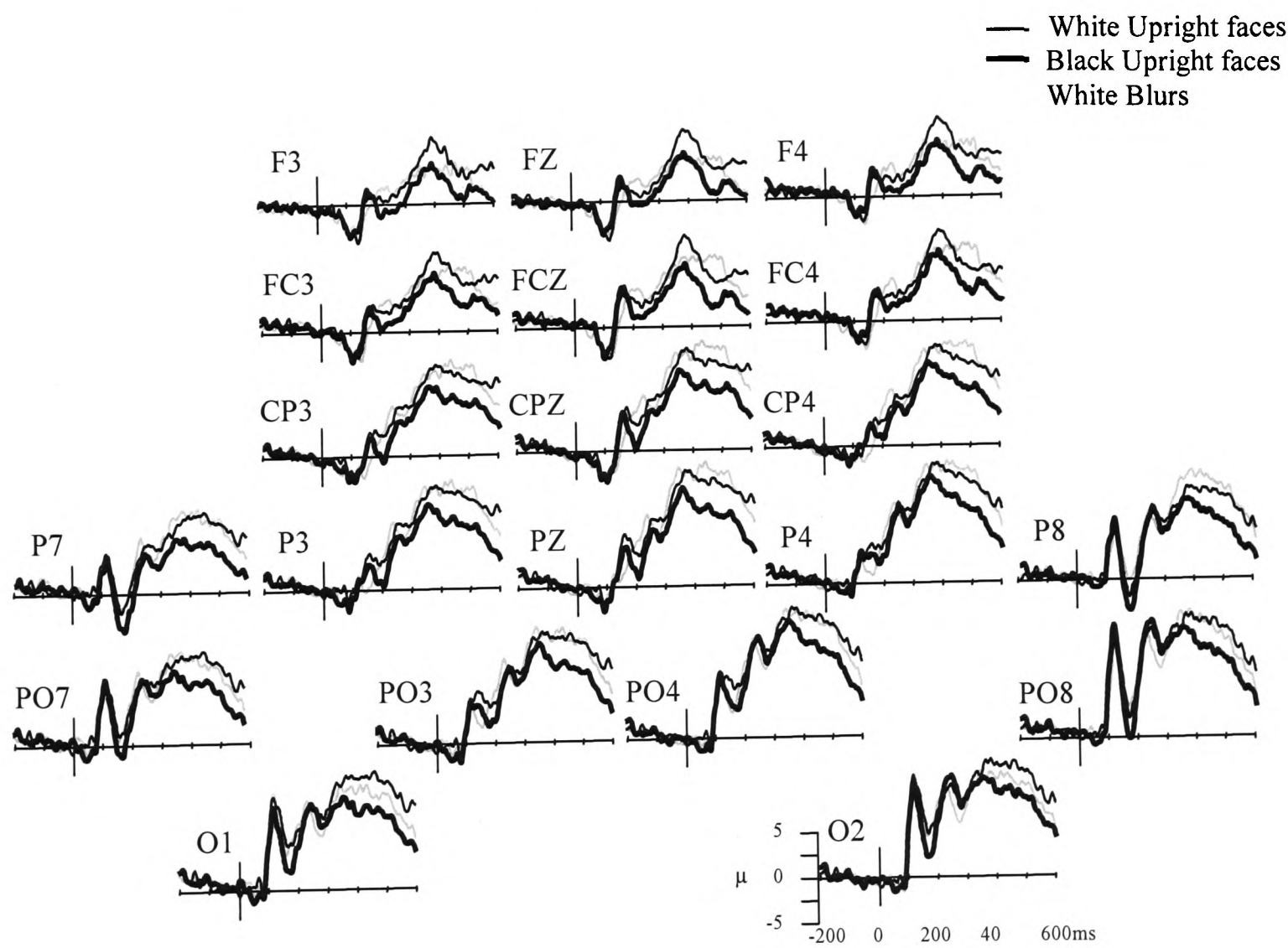


Figure 7.3. ERP grand average waveforms of 20 of the 34 electrodes recorded. White upright faces are overlaid with Black upright faces and White face blurs for comparison.

Measures of peak latency were taken at the single electrode where the component was maximal in the group data, using a more extensive time window to allow for

individual variability. The P120 peak latency was measured at O2 between 90-150 ms; N170 was measured at P8 between 140-200 ms; N210 was measured at CPZ between 180-300 ms; and P400 was measured at FZ between 300-500 ms (see Figure 7.4). Repeated-measures ANOVAs assessed the effects of the experimental manipulation of interest, i.e. stimulus type, on each component measure. Stimulus type included first upright White faces versus blurs, second, upright White faces versus inverted White faces for the second ANOVA, and third, Race of face (White versus Black race faces) and Colour of face (white versus black: white faces are White normal colour and Black contrast-reversed faces, black faces are Black normal colour and White contrast-reversed faces). For mean amplitudes, the ANOVAs included the factors of stimulus type, as well as electrode location and electrode side. For peak latencies, the ANOVAs included the factor of stimulus type only. The Greenhouse-Geiser epsilon correction for nonsphericity was applied where appropriate (Jennings & Wood, 1976). Only corrected probability values and degrees of freedom are reported. For all components, effects of interest only included main effects or interactions involving stimulus type.

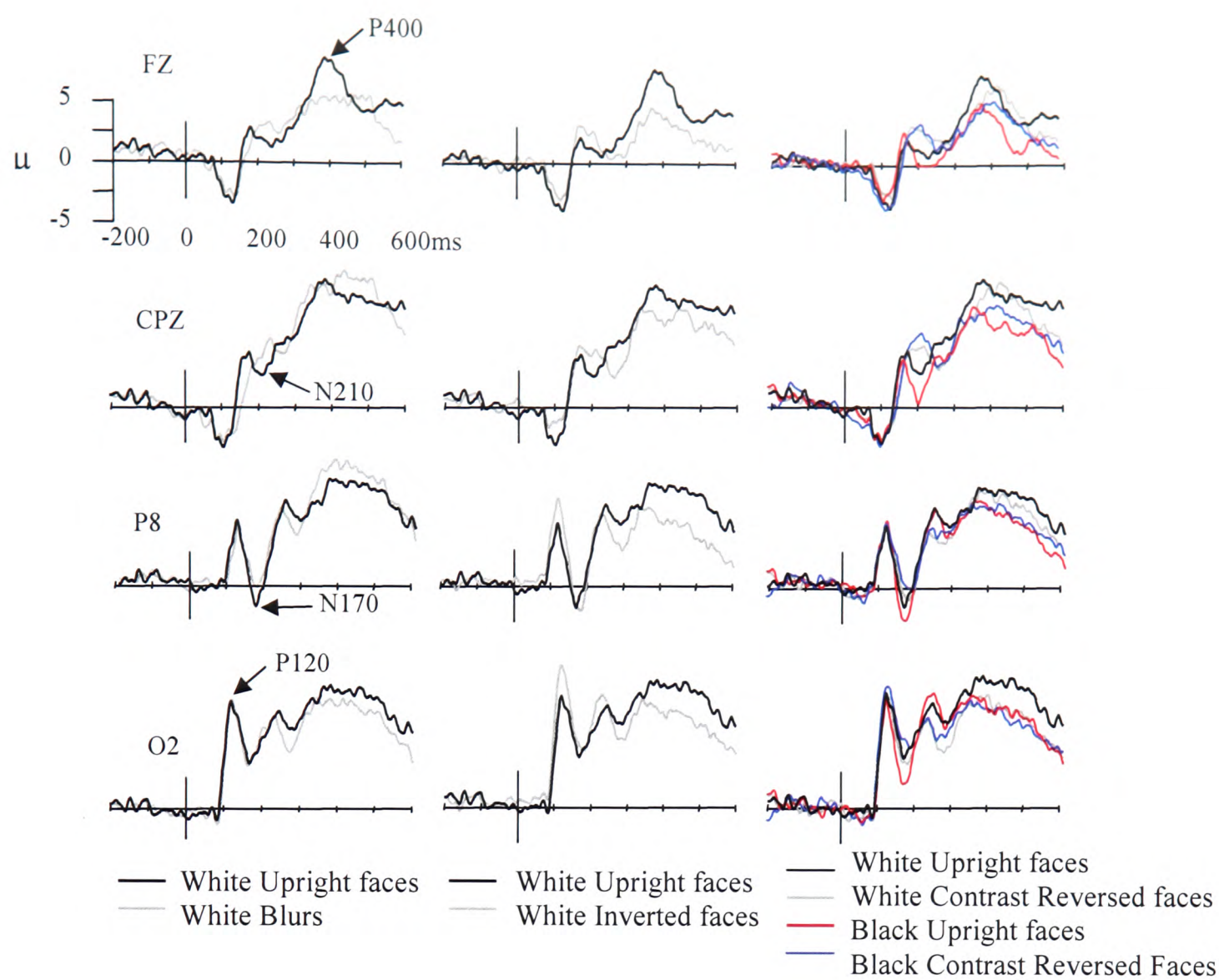


Figure 7.4. ERP grand average waveforms of the four components: P400 (at FZ), N210 (at CPZ), N170 (at PO8), and P120 (at O2).

7.3 Results

Behavioural Results

Overall participants were highly accurate at detecting immediate repetitions of the different stimulus types (92% across conditions). The high levels of accuracy indicated that participants remained alert and processed the stimuli attentively. The small number of target stimuli in the each of the categories precluded rigorous statistical comparisons, yet no overall differences were observed for the different types of stimulus repetitions.

ERP Results

See Figures 7.3 for White versus Black versus Blurs waveform comparison, and 7.4 for peak latencies.

Upright White faces versus blurs

The analysis of ERPs elicited by upright White faces and blurs revealed the traditional face-specific N170 component over lateral posterior sites and identified two further components associated with processing faces but not control blur stimuli: a negative peak over central-parietal sites around 210 ms, and a late positive frontal peak around 400 ms.

Topographical Analysis

The segmentation analysis completed from 0-600 ms for upright White face versus blur stimuli yielded a total of 9 maps (see Figure 7.2). An early difference between conditions appeared from 158-192 ms (map 4 for faces versus map 3 for blurs) encompassing the peak of the traditional face-specific N170 component (Bentin et al., 1996), and a later difference occurred between 322-438 ms (map 6 for faces versus map 8 for blurs). Within each time window, the fitting procedure revealed the total amount of time a given topography was observed in a given condition across subjects. Repeated-measures ANOVAs were then performed on these values for both time windows using experimental condition (face/blur) and segmentation map (4/3 for 156-202 ms and 6/8 for 322-438 ms) as within-subject factors. In the 158-192 ms time period, we observed a significant interaction of condition by map, $F(1, 12)=4.95$, $p<.05$, $\eta p^2=.26$, reflecting that map 4 was observed significantly more often in the face than in the blur condition. During the second time window (322-438 ms), the ANOVA also revealed a significant interaction of condition by map, $F(1, 12)=31.62$, $p<.001$, $\eta p^2=.62$, such that map 6 occurred more frequently in the face condition, and map 8 occurred more frequently in the blur condition. In sum, the topographical segmentation analysis supported the occurrence of face-specific components between 156-202 ms and 322-438 ms.

Component-based analyses confirmed these findings, and indicated these time periods to be associated with face-specific N170 and P400 components.

Morphological Analysis

Comparisons of the mean amplitudes of the ERP components elicited by White faces and blurs showed multiple components sensitive to the nature of the stimulus. The first of these was the N170. Faces elicited a significantly larger N170 component over right lateral posterior electrodes, as revealed by an interaction between stimulus type and hemisphere, $F(1,12)=6.50$, $p<.05$, $\eta p^2=.36$. Following the N170, a brief negative component over the central parietal scalp region peaking around 210 ms (N210) was observed for face but not blur stimuli. Though this component was not brought to the fore by the topographical analysis, analysis of mean amplitudes during this time period showed a main effect of stimulus whereby the N210 was more negative for faces than blurs, $F(1,12)=4.81$, $p<.05$, $\eta p^2=.31$. Finally, the interaction of face by electrode modulated the mean amplitude of the P400, such that the component was significantly larger for face versus blur stimuli at frontal sites, $F(1, 12)=7.05$, $p<.01$, $\eta p^2=.37$. Thus, topographical and morphological analyses have isolated the N170 and P400 components as face specific; and the morphological analysis isolated a further face-related N210 component. Latency analyses of all three components yielded no significant effects between face and blur conditions.

Upright versus Inverted White Faces

Face orientation was found to modulate the latency and/or amplitude of multiple components, including those representing general visual processing as well as face-related brain activity. Both the amplitude and the latency of the early visual P120 component were affected. Amplitude modulation involved an interaction between orientation and electrode site, such that the component was largest for inverted faces at

O1/O2, $F(1,12)=7.05$, $p<.05$, $np^2=.30$. The peak latency of the P120 component was earlier for inverted faces than for upright faces, $F(1, 12)=8.23$, $p<.05$, $np^2=.41$. Face orientation modulated the latency, $F(1, 12)=6.16$, $p<.05$, $np^2=.29$, but not the amplitude of the face-related N170 component, with a delayed peak for inverted faces. Both mean amplitude and latency of the face-related N210 component were modulated by orientation. Orientation interacted with hemisphere and electrode site in modulating mean amplitude, $F(1.94, 23.22)=4.15$, $p<.05$, $np^2=.27$, and the N210 was found to be maximal for upright faces at P4. The N210 showed a delayed peak for inverted versus upright faces, $F(1, 12)=16.02$, $p<.005$, $np^2=.56$. Finally, face orientation also modulated the mean amplitude of the P400, $F(1, 12)=8.12$, $p<.05$, $np^2=.38$, with inverted faces showing a diminished amplitude.

Effects of Race and Colour of faces

Face-related processing was modulated by race, starting from the structural encoding phase. The earliest visual P120 component was not affected by race, but instead its mean amplitude was sensitive to the colour of the stimulus. Stimulus colour interacted with electrode site, $F(1, 12)=4.55$, $p=.05$, $np^2=.24$, revealing larger amplitudes for white colour faces (White normal colour and Black contrast-reversed faces) versus black colour faces (Black normal colour and White contrast-reversed faces) at O1/O2 (see Figure 7.5).

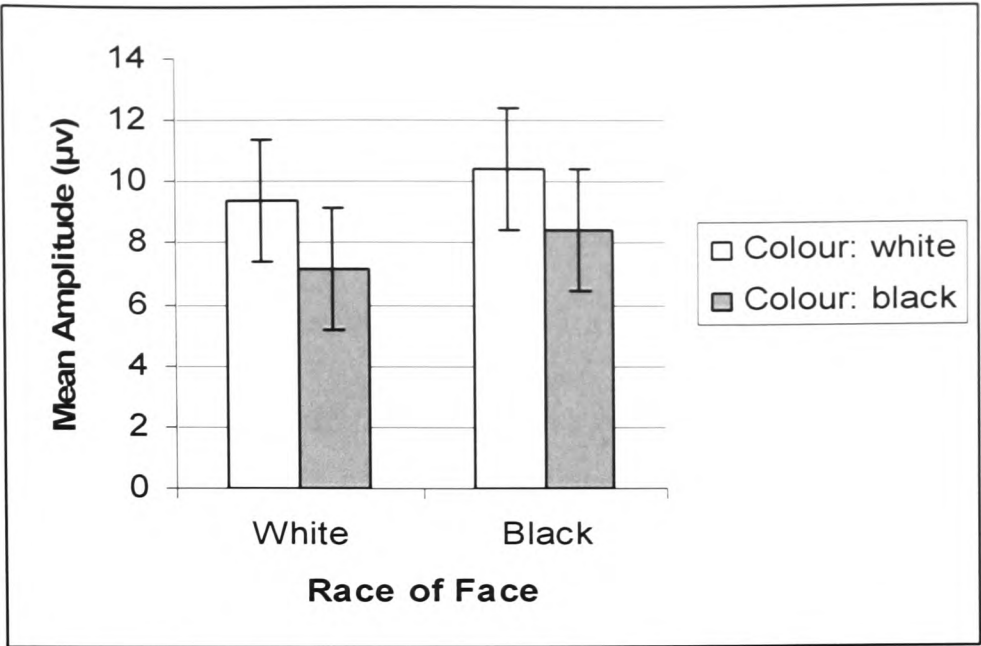


Figure 7.5. The main effect of colour on the P120 component averaged across O1/O2.

The mean amplitude of the N170 was modulated by a main effect of stimulus colour, $F(1, 12)=10.56$, $p<.01$, $np^2=.47$, which further interacted with race, $F(1, 12)=9.82$, $p<.01$, $np^2=.45$, and electrode site, $F(1, 12)=4.94$, $p<.05$, $np^2=.29$, such that the effect was maximal at P7/P8 electrodes. No main effect of race was observed. Subsidiary analyses for White versus Black faces at P7/P8 revealed that there was no difference observed between the mean amplitudes to White normal colour faces and White contrast-reversed faces (which were black in colour), $p>.05$. Yet the N170 component triggered by normal-colour Black faces was significantly larger than that triggered by contrast-reversed black faces (white in colour), $F(1, 12)=11.18$, $p<.01$, $np^2=.48$ (see Figure 7.6).

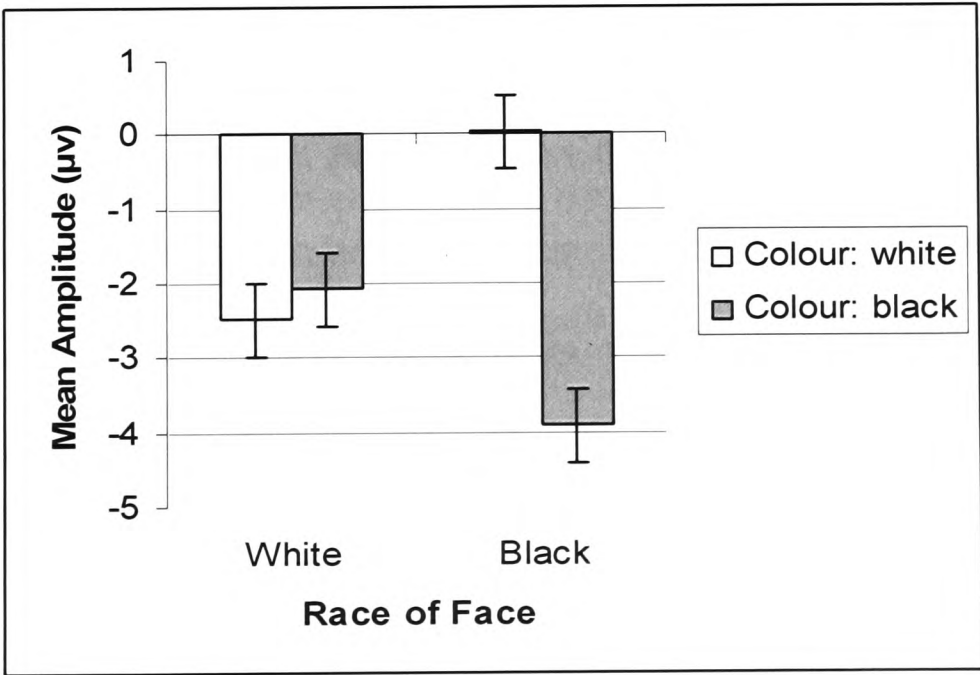


Figure 7.6. The colour by race interaction on the mean amplitude of the N170 averaged across P7/P8.

A similar interaction between race, colour and electrode was observed for the modulation of the amplitude of the N210 component, $F(1.95, 23.39)=8.55$, $p<.01$, $np^2=.42$ such that the interaction of race by colour was maximal at CPZ (see Figure 7.7). Subsidiary analyses revealed that contrast-reversed faces elicited significantly smaller amplitudes than normal colour faces for both White, $F(1, 12)=8.29$, $p<.05$, $np^2=.38$, and Black faces $F(1, 12)=22.71$, $p<.001$, $np^2=.65$. From these results it appears that contrast reversal has a larger effect on the difference between Black normal versus contrast-reversed faces than it has on White faces.

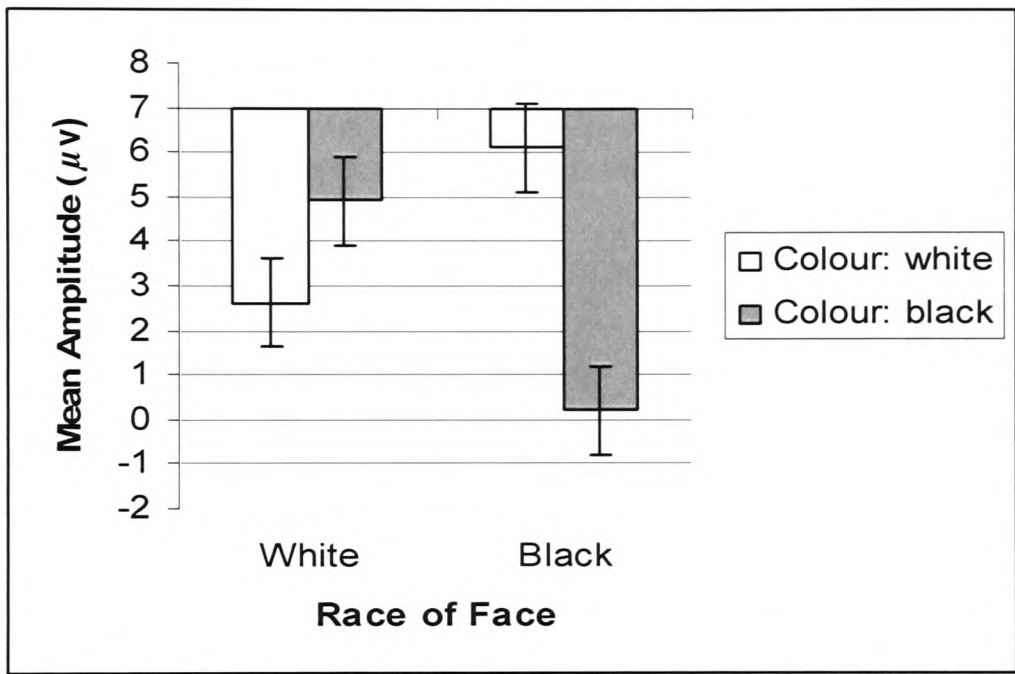


Figure 7.7. The interaction of colour by race on the mean amplitude of the N210 at CPZ.

The latency of the N210 was also modulated by an interaction between race and colour, $F(1,12)=13.59$, $p<.01$, $np^2=.53$ (see Figure 7.8). Subsidiary analyses revealed that there was no difference between the peak latencies to White normal colour faces and White contrast-reversed faces (which were black in colour), $p>.05$; however, the N210 component triggered by normal-colour Black faces was significantly earlier than that triggered by contrast-reversed black faces (white in colour), $F(1, 12)=17.36$, $p<.01$, $np^2=.59$.

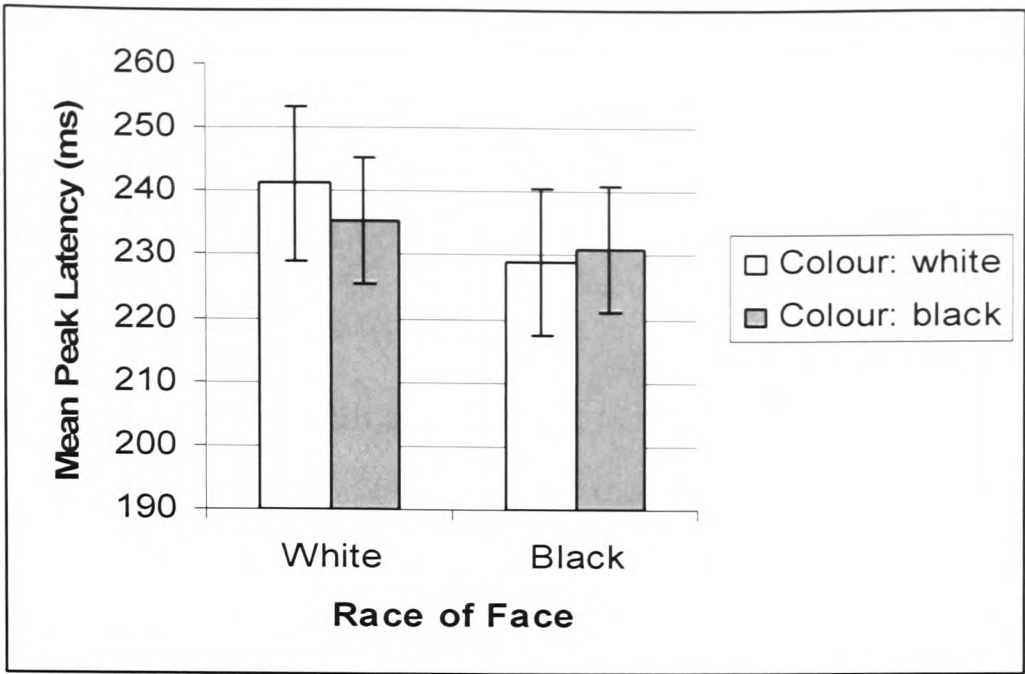


Figure 7.8. The interaction of colour by race on the latency of the N210 at CPZ.

At the P400 stage, race modulated processing independently of stimulus colour. The amplitude of the P400 was larger for White than Black faces, regardless of the actual colour of the faces, $F(1, 12)=10.78, p<.01, np^2=.49$. No effect on the latency of the P400 was observed (see Figure 7.9).

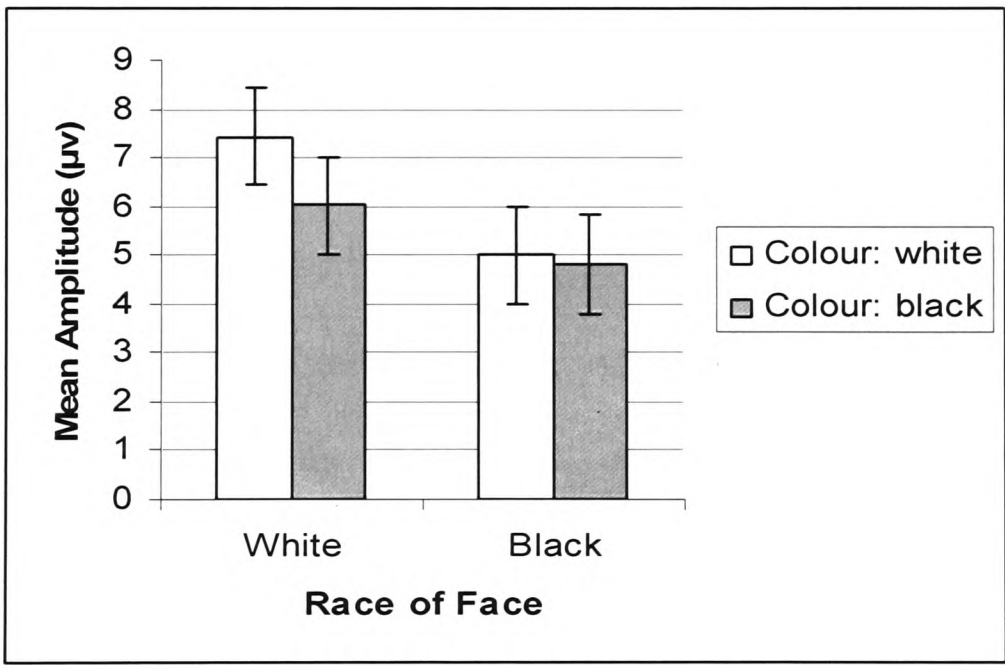


Figure 7.9. The main effect of race on the mean amplitude of the P400 averaged across F3/FZ/F4, FC3/FCZ/FC4.

Contact Correlations with Neural Components

For each ERP component modulated by the interaction between race and colour, (N170 and N210) contrast scores (White normal colour minus White contrast-reversed versus Black normal colour minus Black contrast-reversed) were computed that

represented the effect of race by colour (Ito & Urland, 2004). To investigate the main effect of race on the P400, contrast scores for this component were computed by subtracting Black from White faces. To maximize sensitivity, contrasts were computed at the electrode at which the effect was maximal.

These scores were entered into a bivariate correlation with the self-report measures of *social-contact* and *individuating experience* to determine whether greater other-race exposure was linked to less of a difference in own- versus other-race face processing. Contrast scores for the mean amplitudes of the N170 and the N210 were found to correlate negatively with individuating experience, $r = -.56$, $p < .05$, and $r = -.60$, $p < .05$, respectively, whereby participants who reported more other-race individuating experience demonstrated less of a difference in N170 and N210 mean amplitudes to own- versus other-race faces. Moreover, contrast scores for the latency of the N210 and the mean amplitude of the P400 were found to correlate negatively with participant-reported social-contact, $r = -.62$, $p < .05$, and $r = -.61$, $p < .05$, respectively. That is, participants reporting more other-race contact demonstrated less difference in White versus Black face processing on the N210 and the P400 components, suggesting that level of other-race contact may play a role in the ease with which individuals perceive other-race faces compared to own-race faces. No other correlations between other-race experience and neural components were found.

7.4 Discussion

The current experiment adopted a two-tier approach in order to isolate face-related processing and test its modulation by the social factor of race. Experimental results demonstrated that this approach was successful. By comparing both the morphologies and the topographies of brain activity related to face versus blur stimuli,

three face-specific components were isolated. The first face-related component identified by morphological and topographical analyses was the well-known N170 (Bentin et al., 1996) which peaked between 160-180 ms over right posterior electrode sites. Second, morphological and topographical analyses revealed a late face-related component, the P400, peaking between 360-420 ms over frontocentral sites. This second face-related component is similar to reports of late face-related potentials recorded intracranially (Allison et al., 1999; Puce et al., 1999), but has not been commonly reported in scalp ERP studies. Puce and colleagues (1999) intracranially recorded a P350 component from the anterior temporal gyrus and found it was specific to faces versus objects and subject to top-down influences. The P400 recorded in the current study may reflect the same stage of face-related processing as the intracranial P350, and therefore represent a stage of face processing sensitive to top-down influences.

A third component was isolated by the morphological analysis: the N210. The N210 was a brief intermediary centroparietal component peaking between 200-220 ms. The brevity and spatially focal nature of this effect, as well as its overlap with the larger P2 component in the same time region may have made the topographical analysis less sensitive to this component. In their 1999 depth electrode investigation, Puce and colleagues found face-related activity post structural encoding to be sensitive to semantic priming. Therefore it is possible that the N210, which directly follows face structural encoding, may be involved in the semantic analysis of face information related to the identification of differences between faces as well as the recognition of familiar faces. Other researchers (Caldara et al., 2003; Ito & Urland, 2005) have referred to the 200-300 ms time window as reflecting the activation of face-related semantic information in reference to cognitive models of face processing such as the Bruce and Young model (1986). However, in order to substantiate such supposition, a further investigation of

face-related semantic processing during the 200-300 ms time window would have to be directly tested. Finally, one further component, the early visual P120, was evoked by face stimuli, although neither the latency nor amplitude of this component differed significantly between face and control blur stimuli.

The experimental manipulation of face orientation validated the identification of the three aforementioned face-related components. The N170, N210 and P400 were systematically modulated by the orientation of face stimuli. Specifically, face orientation latency effects observed on the N170 were in line with previous ERP findings showing a delayed N170 to inverted faces (Bentin et al., 1996; Eimer, 2000; McCarthy, Puce, Belger & Allison, 1999; Rebai, Poiroux, Bernard, & Lalonde, 2001; Rossion et al., 2000; Rossion, Joyce, Cottrell, & Tarr, 2003; Taylor, Edmonds, McCarthy, & Allison, 2001). Behavioural face-inversion effects suggest that there is disruption of the structural encoding of face stimuli when faces are inverted, such that inverted faces are likely processed as a collection of individual features, whereas upright faces are processed holistically and configurally (Latinus & Taylor, 2005). The modulation of the N170 by face orientation may show the disruption to the configural processing when the face is inverted, and therefore inverted faces may take more time than upright faces to process. This effect is potentially due to the lack of familiarity with inverted versus upright faces.

Face orientation also modulated face processing post-structural encoding, on the N210, whereby the N210 was smaller and delayed to inverted versus upright faces. It may be that the semantic analysis of the face is disrupted when the stimulus is inverted, subsequently slowing face processing at this stage. By the P400 stage of face processing, face orientation no longer elicited a latency shift. Here, upright faces elicited a larger component than inverted faces, potentially reflecting greater top-down modulation of processing upright versus inverted faces.

The non face-related component, the P120, was also affected by face orientation, such that inverted faces elicited a larger component than upright faces. This finding is in line with previous research (Itier & Taylor, 2004a, b). The modulation of the P120 by face orientation demonstrates that inverted faces are sufficiently different in face-unrelated perceptual attributes to elicit a significantly larger P120 than faces. This particular finding raises a note of caution when attributing changes in ERPs to face-related processing without careful controls in place (e.g., faces vs. blurs, faces vs. objects).

Equipped with distinct markers of face-related processing from the stage of structural encoding to cognitive evaluation, it was possible to assess the effect of race on face-related processing. Due to the close relationship between race and the salient visual feature of colour, the colour-contrast of the face stimuli was also experimentally manipulated. This measure was an experimental control, in order to determine whether race-related effects occurred over and above those related to face colour.

Race affected all three stages of face-related processing identified in the face versus blur comparison. The effects at the earlier stages of processing (N170, N210) interacted with colour; however, by the final stage (P400) race of face became independent of colour processing. The first stage of visual perception, reflected by the P1, was only modulated by colour and not race.

The mean amplitude of the first face-related component, the N170, was modulated by the interaction of race by colour. This interaction demonstrated that the colour-contrast manipulation to Black faces significantly impacted the structural encoding of Black faces, whereas White faces were not disturbed by the colour-contrast manipulation. Subsequent correlations between mean amplitudes of White versus Black faces and other-race individuating experience showed that participants with greater other-

race one-on-one contact showed less of a difference in N170 mean amplitudes during the structural encoding of White versus Black faces. Although this is the first report of such an effect, this finding suggests that familiarity plays a role in the way in which one encodes own- versus other-race faces. Hence, it may be that greater familiarity with own-race faces facilitates more fluid processing of own-race faces despite manipulations of colour contrast. Conversely, manipulations of the colour-contrast of the less familiar other-race faces may make structural encoding of other-race faces less fluid and more difficult.

To date, the literature presents no consistent modulation of the N170 by race. In fact, experimentally reported race modulations of the N170 appear to be highly task-dependent. As seen in the studies by Ito and colleagues, own-race faces elicited larger N170s than did other-race faces. These race modulations of the N170, however, were only observed when participants completed social-categorization tasks. In contrast, Caldara and colleagues (2003) and James and colleagues (2001) employed recognition memory tasks and found no modulation of the N170 component by race. The modulation of the N170 by the interaction of colour contrast by race of face observed in the present study, suggests that structural encoding may be affected by both race-related configural features and by the colour of the stimuli, therefore making stimuli with which individuals have less experience (contrast-reversed Black faces) more difficult to encode. Less interference with face processing may occur when individuals perceive own-race faces (in the current instance White) which are colour contrast-reversed versus other-race (Black) contrast-reversed stimuli, as *experience* was shown in the current investigation to play a role in facilitating fluid face processing.

The N210 mean amplitude and latency were affected by race and colour in a similar manner to the N170. As such, these findings showed that other-race face

processing was more disrupted by contrast-reversal than was processing of own-race faces. Because this component has not previously been isolated, effects of race on this component have not been discussed in the literature. Nevertheless, the current findings demonstrate the continued effects of race over consecutive stages of face processing. Correlations between White versus Black N210 activity and other-race contact (social-contact and individuating experience) confirms that quantity and quality of contact may facilitate own- versus other-race face processing (and potentially semantic analysis) post-structural encoding.

The late stage of face-processing, the P400, was affected by race independently of colour. Specifically, the mean amplitude of the P400 was larger for own-race than other-race faces. As discussed above, this component is likely to be subject to top-down processes and evaluations. The increased amplitude of the P400 to own-race faces may reflect the cognitive evaluation of race and category-related information. This race effect was also correlated with other-race social-contact, demonstrating that greater other-race contact facilitates similar own- versus other-race face processing (i.e., less difference in P400 mean amplitudes to White versus Black faces).

Lastly, the perceptual face-unrelated component, the P120, was not affected by race, but rather by colour. The current finding that face colour modulated the P120, with white faces eliciting a larger peak than black faces, is understandable as neurons in visual areas V1 and V2 are known to contribute to the P120 sensitivity to luminance and colour differences (Baumann, van der Zwan, & Peterhans, 1997). The absence of a race effect on the P120 suggests that race does not influence visual processing during early perceptual analysis. It is possible that future ERP experiments could incorrectly attribute colour effects seen on the P120 to race, particularly if the experiment is not careful to control for overall luminance and colour of stimuli, which affect processing at this stage.

Of course there remains the possibility of race effects at this stage which ERPs do not have the resolution to reveal. This dilemma, however, would be likewise hard to tackle with other available methods, as fMRI lacks the temporal resolution to interpret the timing of modulations in perceptual areas, even if they were to occur.

In sum, the present findings demonstrate that effects of race occur relatively early, during perceptual analysis of faces (N170), and percolate through multiple stages of face processing. Differences in own- versus other-race face processing at the neural level substantiate previous behavioural research on the own-race effect. Results from correlational analyses revealed that race effects may be related to the degree of experience an individual has with different races. Indeed, individuals with more other-race experience show more similarity in the processing of own and other-race faces, whilst those with less experience show greater disparity and disruption in the processing of other- versus own-race faces. Nevertheless, as only White participants were examined in the current experiment, a further study would have to be conducted to determine whether the present findings can be generalized across race. Furthermore, future studies could investigate race of face processing differences in light of further social measures such as intergroup prejudice and anxiety, perceived outgroup homogeneity (i.e., how similar members of the other-race are perceived to be to each other) and implicit racial bias. The present findings present a strong basis for future research on differential race of face processing in the brain.

Chapter 8

The Effect of Emotional Expression on Race of Face Processing in the Brain

8.1 Experiment 6: Introduction

Facial expressions allow for rapid communication of socially and evolutionary relevant information. Recognizing facial expressions of emotion is a fundamental component of everyday social interaction. Research suggests that the recognition of emotional expressions is universal and specific to a subset of six basic facial expressions of emotion: happiness, anger, sadness, fear, disgust, and surprise (Ekman, 1987; Izard, 1971; Matsumoto, 1993).

Recent evidence on recognition of emotional expressions suggests that individuals are more accurate at identifying emotions expressed by members of their own-race (Elfenbein & Ambady, 2002a, b). Matsumoto (1993) has proposed that subtle differences in display rules exist across cultures that may impact emotion recognition. Hence, an effect in own- versus other-race emotion recognition may be due to variations in expressions across-cultures. The own-race emotion-recognition effect can be likened to the own-race effect observed in the perception and recognition of neutral faces, whereby individuals are better at the perceptual discrimination between (Walker, & Tanaka, 2003, Walker & Hewstone, in press a, b) and recognition (Slone et al., 2000) of faces of their own-race versus other-races (see Chapter 1 and experimental Chapters 2, 3, 4, & 7). The neural basis of the behavioural effect in own- versus other-race emotion recognition is, however, unknown.

At a neural level, perceptions of emotional expressions and race have been investigated independently of one another, with the former receiving a great deal more

attention in the literature than the latter. In recent years, the neural structures and pathways involved in the perception of emotions (Adolphs, 2002, 2003; Phan et al., 2002; Sprengelmeyer et al., 1998) as well as the timecourse of emotional expression processing and its modulations of face processing in the brain (Balconi & Pozzoli, 2003; Eimer, 2000; Pizagalli et al., 1999), have been explored. Neuroimaging studies have identified a broad, yet relatively discrete network involving the occipitotemporal cortex, the amygdala, orbitofrontal cortex, basal ganglia and the right parietal cortex in the recognition of emotions (Adolphs, 2002, 2003; Phan et al., 2002; Sprengelmeyer et al., 1998).

Neurophysiological studies on the timecourse of emotional face processing have suggested that the initial perception of emotional faces occurs during very early stages of processing from 85 ms post stimulus onset (Eger et al., 2003; Eimer & Holmes, 2002; Felmingham et al., 2003; Halgren et al., 2000). Specifically, researchers have identified an early frontal component which peaks around 100 ms and is sensitive to emotional expression (Eimer & Holmes, 2002; Holmes, Vuilleumier, & Eimer, 2003), the N1. Holmes and colleagues (2003) found fearful faces to elicit a reduced N1 compared with neutral faces. This effect suggests that emotionally relevant stimuli, such as facial expressions of emotion, can act as a warning and rapidly trigger prefrontal cortical circuits. Kawasaki and colleagues (2001) recorded single neurons in the ventral prefrontal cortex and found that emotional visual stimuli elicited responses in these neurons around 100 ms. Holmes and colleagues (2003) propose that the frontal N1 recorded from the scalp may reflect this subcortical sensitivity to emotional valence, and may potentially represent the activity of an early warning system linked to the amygdala. Similarly, emotional expression has modulated a positive component implicated in specific early visual processing (see Chapter 7), the P1 (Pourtois et al., 2004). Moreover, emotion has

modulated the N2 component discussed in the previous chapter (Lidell et al., 2004), which may reflect semantic information processing (Ito & Urland, 2005) and later components sensitive to emotional content such as the P300 and the Late Positive Potential (Halgren et al., 1998; Kestenbaums et al., 1992; Krolak-Salmon et al., 2001).

Research to date has yielded inconsistent data on the effect of emotional expression on face structural encoding. Few studies have shown an emotional modulation of the N170 (Eger et al., 2003; Krolak-Salmon et al., 2001), previously highlighted as reflecting face-specific structural encoding in the brain (Bentin et al., 1996). Theoretically, one might expect facial expression of emotion to modulate the N170, as structural encoding is necessary for encoding the configuration of specific facial features that denote facial affect. On the other hand, the absence of an emotional modulation of the N170 may simply suggest that structural encoding is uninfluenced or unimpeded by emotion, which is separately encoded when semantic meaning begins to be extracted from the face stimulus, around 200 ms (Hassler, 1979; John, 1990). The suggestion that expression encoding is a parallel process to structural encoding of faces is consistent with neuropsychological models of face processing (Bruce & Young, 1986; Ellis & Young, 1998; Young, 1998) and electrophysiological evidence, which have failed to show an emotional modulation of the N170 but showed effects of emotion of face processing during earlier and later stages (Halgren, 1992). These findings suggest that further investigation of the influence of emotional expression on face processing is required.

Consistent evidence of emotional modulations on face processing is found 200 ms after stimulus presentation. The N2 component has been observed approximately 200–300 ms post-stimulus onset at centroparietal sites (Lidell et al., 2004). These are considered sensitive to the processing of biologically-relevant stimuli (such as fearful, angry and sad faces) as well as the processing of novel stimuli (Halgren & Marinkovic,

1995) as the N2 may be sensitive to semantic meaning (see Chapter 7). Similarly, the P240 component has been discussed as sensitive to emotional faces. This component has been described in the literature as sensitive to face identity processing (Halit et al., 2000; Latinus & Taylor, 2005), and emotional expression (Eimer, Holmes, & McGlone, 2003; Stekelenburg & de Gelder, 2004). Intracranial recordings in the temporal lobe have also shown a P2 component sensitive to face-name association (Puce, Allison, & McCarthy, 1999), offering further support for the sensitivity of this component to face identity and emotion. Finally, a later component, the P300, has also been shown as sensitive to emotional face processing. Early research by Papanicolaou and colleagues (1985) demonstrated that stimulus intensity and valence are salient influences on the P300 amplitude. Moreover, emotionally valenced stimuli are reported to elicit larger P300 peaks than neutral stimuli (Halgren, 1998; Orozco et al., 1998).

Less data exist on the processing of own and other-race faces in the brain. As discussed in the previous Chapter, race of face has elicited differential activation in a region of the fusiform gyrus sensitive to faces (Golby et al., 2001) as well as in the amygdala (Richeson et al., 2003; Wheeler & Fiske, 2005). The small body of electrophysiological research on the timecourse of race of face processing has suggested that race perception occurs during later stages of face processing around 200 ms post stimulus onset (Caldara et al., 2004; Caldara et al., 2003; James et al., 2001). Yet, findings from the previous Chapter have suggested race of face does indeed influence early face structural encoding from around 160 ms post stimulus onset. Specifically, findings in Experiment 5 showed that race of face perception in the brain is likely to being no earlier than 170 ms after stimulus onset and subsequently percolates through the later stages of stimulus processing.

Despite the existing body of research investigating emotion and race independently no research has investigated emotional face processing *in light of* race of face. As race and emotion are highly important social factors for communication and interaction, their impact on face processing is tantamount to furthering our understanding of intergroup behaviour (Caldara et al., 2003; Caldara et al., 2004; Ito & Urland, 2003, 2005; Ito et al., 2004; James et al., 2001). Although the neural basis of emotion recognition and race perception has been investigated, it remains unknown how social factors in our environment, such as race, affect how emotions are perceived at a neural level. ERPs offer the unique ability to track the neural processing of these social factors (race and emotion) through time, and can establish at which stages these factors interact with each other and modulate the way in which individuals process faces. Ultimately, ERPs offer a window into the neural functioning related to the processing of salient social information.

Theoretically, the contact hypothesis (see section 1.5) is applicable to the current experimental investigation as it has been investigated previously in relation to own-versus other-race face processing. With regard to both the own-race effect and the own-race emotion-recognition effect, evidence suggests that it is the other-race contact individuals engage in which allows them to differentiate other-race faces and recognize other-race faces as they would their own. Moreover, as individuals engage with those of other racial groups, it is likely they are able to learn the subtle racial differences in facial features and expressions of emotion (Albas, et al., 1976; Elfenbein & Ambady, 2003; Rosenthal et al., 1979). Therefore, the current study included explicit self-report measures of other-race contact to determine whether other-race experience (quantity, quality or both), plays a role in the fluidity and accuracy of processing own compared to other-race faces and emotional expressions.

The Implicit Association Test (Greenwald et al., 1998) has previously been used as a measure of implicit racial bias in behavioural research (Cunningham, Preacher & Banaji, 2001; Dasgupta & Greenwald, 2001; Greenwald et al., 1998) and in neuroimaging research (Phelps et al., 2000, 2003) as it evaluates the degree to which social groups (e.g., Black vs. White) are automatically associated with positive or negative group evaluations. That is, participants categorize faces as Black or White while simultaneously categorizing words such as ‘good’ (happiness, love, pleasure) or ‘bad’ (evil, horrible, devil) and the reaction times and accuracy of these responses are tabulated into a bias score (see Chapter 4 for a detailed discussion).

The central aim of the current study was twofold. First the impact of own- versus other-race emotion perception on face processing in the brain was examined. In order to do this, however, the effects of race, emotional expression, and their interaction on face processing were tested.²⁰ Specifically, ERPs were recorded in White participants who viewed White and Black faces with neutral, happy or angry emotional expressions. Second, the extent to which interracial experience and bias variables affected own- versus other-race emotion perception in the brain was investigated. Therefore, explicit other-race contact (as measured by a questionnaire) and implicit other-race bias (as measured by the IAT) were assessed.

8.2 Methods

Participants

Two groups of 13 (26 in total) healthy right-handed (Oldfield, 1971), White female participants (age range 18-24 years) took part in the experiment. All participants had normal or corrected-to-normal vision. The experimental methods were non-invasive

²⁰ The current experiment sought to replicate the race-related findings reported in Chapter 7.

and had ethical approval from the Department of Experimental Psychology, University of Oxford, U.K..

Stimuli and Materials

Face Stimuli

Participants viewed face stimuli of 5 White and 5 Black males with neutral, happy and angry expressions from a frontal viewpoint (see Figure 8.1). The stimuli were black-and-white photographs taken by the experimenter. In total, participants were presented with 30 distinct face stimuli: 15 White faces (5 neutral, 5 happy, 5 angry) and 15 Black faces (5 neutral, 5 happy, 5 angry). All emotional face stimuli had previously been evaluated by 22 individuals, confirming that the face stimuli (neutral, happy and angry)

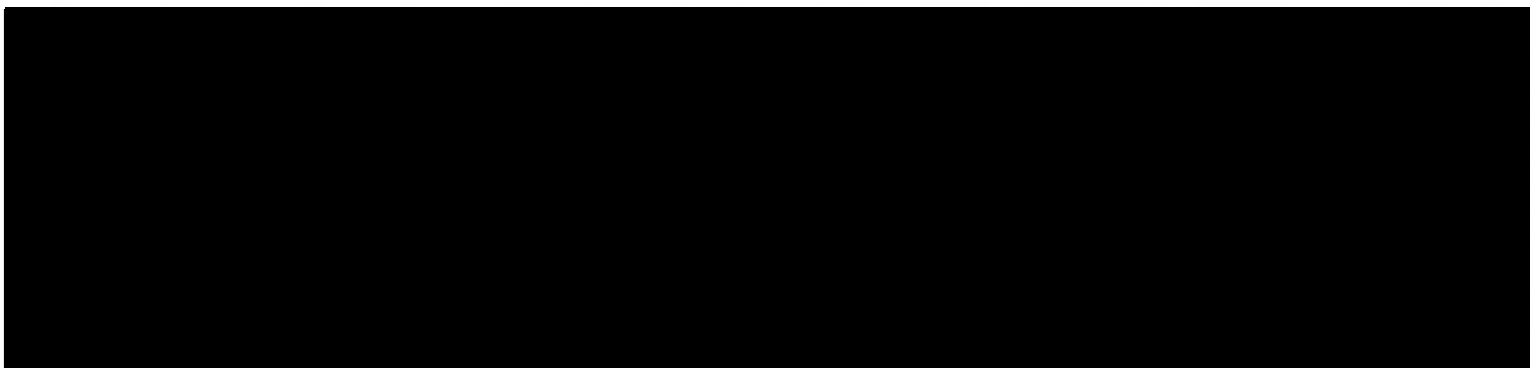


Figure 8.1. Examples of White and Black emotional face stimuli.

Valence and Arousal Ratings

As emotional and neutral pictures can differ in terms of valence and arousal (Osgood & Tammenbaum, 1957), the emotional face stimuli used in the current experiment, were rated by participants on valence and arousal scales. All participants completed two questions regarding the valence of face stimuli, followed by two questions

²¹ Prior to the current experiment, 22 female participants (13 White and 9 Black) were given prints of the 30 face stimuli and were asked to identify (in writing) which emotional expression they recognized on each of the faces. Accuracy on identifying the emotional expressions was high for both participant groups: (a) White participants: White neutral faces $M=99.81\%$, $SD=.10\%$; White happy faces $M=99.95\%$, $SD=.51\%$; White angry faces $M=99.20\%$, $SD=1.01\%$; Black neutral faces $M=98.70\%$, $SD=.79\%$; Black happy faces $M=99.31\%$, $SD=.89\%$; Black angry faces $M=99.31\%$, $SD=.89\%$, and (b) Black participants: White neutral faces $M=99.80\%$, $SD=.99\%$; White happy faces $M=99.89\%$, $SD=1.10\%$; White angry faces $M=99.96\%$, $SD=.22\%$; Black neutral faces $M=98.2\%$, $SD=1.50\%$; Black happy faces $M=100\%$, $SD=.00\%$; Black angry faces $M=99.20\%$, $SD=.50\%$.

regarding arousal. The participants were asked to rate each of the faces on a scale of 1-7. On the valence scale, 1 represented most negative/bad and 7 represented most positive/good. On the arousal scale, 1 represented afraid/anxious whereas 7 represented not afraid/not anxious. Typically, negatively valenced images elicit low responses, neutral images elicit responses in the middle of the scale, and positively valenced images elicit responses at the high end of both scales.

The reliability of the 2 measures (valence and arousal), were both reliable: (1) valence (Cronbach's $\alpha=.89$), and (2) arousal (Cronbach's $\alpha=.92$).

Implicit-Association task

The IAT (Greenwald et al., 1998) was used to measure the relative ease with which participants made automatic associations. As in Chapter 4, participants were presented with White and Black faces (with neutral expressions) and words with pleasant versus unpleasant connotations. The *IAT effect* was computed from performance speeds in two classification tasks over practice and test blocks, wherein association strengths influence participant performance. The current IAT was the same as that used in Experiments 3 and 4 (see Chapter 4 for details of the presentation of blocks and trials). Participants used two response keys to classify four categories of stimuli, White versus Black faces and 'pleasant' (e.g., happy, joy, bliss) versus 'unpleasant' (e.g., horrible, death, evil) words.

Contact Questionnaire

The questionnaire used in this study contained 14 questions, which sought to determine the participants' relative exposure to and experiences with individuals from the other race. The 14 items were grouped into categories examining (1) social-contact, (2) individuating experience, and (3) 'inclusion of other in the self', which served as a one-

item quality-of-contact measure (Aron & Aron, 1986). Each question had a scale of 1-5, where 1 signaled low contact, and 5 signaled high contact.

Social-contact - The social-contact scale was identical to that used in the two previous experimental chapters (see Chapter 4 for scale items).

Individuating experience - The individuating experience scale was identical to that used in Chapter 4.

Inclusion of other in the self - A single-item quality-of-contact pictorial measure (Aron & Aron, 1986) used overlapping circles on a 5-point scale to show how close the participant felt to the Black person they knew best, see Chapter 2 for the details of this measure.

The reliability of the 2 multi-item measures (social-contact, individuating experience), were both reliable: (1) social-contact (Cronbach's $\alpha=.84$), and (2) individuating experience (Cronbach's $\alpha=.90$).

ERP tasks

Each of the participants completed one of two behavioural tasks during EEG recording, in which they viewed face stimuli of their own (White) or the other (Black) race with different emotional expressions.

Half of the participants (13) completed an identity-match task (task 1) whereby they were instructed to respond when the identity of the person depicted by the stimulus repeated over immediately successive trials (targets). That is, participants were to respond when they saw the exact same person irrespective of emotional expression appear twice in a row.

The other half of the participants (13) completed a physical-match task (task 2). Participants were instructed to respond when they detected a stimulus that repeated over immediately successive trials (targets). That is, participants were to respond when they

saw the exact same person with the exact same emotional expression appear twice in a row.

Procedure

Prior to the EEG recording, participants completed the Implicit-Association Task in order to obtain ratings of implicit racial bias and to familiarize the participants with the faces they would be presented with during the EEG recording. The order in which participants completed the social-contact questionnaire and the valence and arousal ratings of the face stimuli was counterbalanced: half of the participants completed the valence and arousal ratings prior to EEG recordings and the contact questionnaire after the EEG recordings, whilst the other half completed the contact questionnaire prior to EEG recording and the valence and arousal ratings after.

During EEG recording, participants were seated in a dimly lit and electrically shielded room, facing a computer monitor approximately 100 cm away. They were given the task instructions, and completed a block of 12 practice trials in order to familiarize themselves with the task. Each experimental trial consisted of a fixation point presented in the centre of the screen for 1000 ms followed by a face stimulus (neutral, happy or angry) for 500 ms. Trials were separated by an interval that ranged randomly between 1000 and 2500 ms.

In both ERP tasks (1 and 2), each face stimulus was presented 12 times in a constrained randomized order, allowing no more than 2 stimuli of the same category to appear successively. An additional six stimuli per category (10% of all experimental trials) were designated as “targets”, appearing immediately after a face stimulus of the same identity (task 1) or of the same identity and expression (task 2). In total, there were 396 trials. Participants were instructed to respond to target trials according to their particular task instructions (either identity or stimulus repeat) by pressing the left mouse

button with their right hand. Participants were asked to minimize blinking and to maintain visual fixation in the centre of the screen at all times during task performance.

ERP Recording

The EEG was recorded continuously from 34 scalp sites using Ag/AgCl electrodes mounted on an elastic cap (Easy-Cap, FMS, Germany), positioned according to the 10-20 International System (AEEGS, 1991). The montage included 6 midline sites (FZ, FCZ, CZ, CPZ, PZ, and OZ); 14 sites over each hemisphere (FP1/FP2, F3/F4, F7/F8, FC3/FC4, FT7/FT8, C3/C4, T7/T8, CP3/CP4, TP7/TP8, P3/P4, P7/P8, PO3/PO4, PO7/PO8, and O1/O2); and both mastoids. Additional electrodes were used as ground and reference sites: the EEG was referenced to the nose, the electrode between FPZ and FZ served as the ground. Electrodes were also placed laterally to each eye, at the outer canthii, and below the right eye, in order to derive bipolar signals relating to the horizontal and vertical electrooculogram. Data were digitized at a sampling rate of 500 Hz, using a 200 Hz low-pass signal and no high-pass signal (DC).

Event-related potentials were constructed offline. Epochs started 200 ms before and ended 600 ms after stimulus onset. Epochs containing excessive noise or drift (in excess of $\pm 100 \mu\text{V}$) at any electrode between -200 and $+600$ ms were excluded. Epochs with eye-movement artifacts (blinks or saccades) were rejected. Blinks were identified as large deflections ($\pm 50 \mu\text{V}$) in the HEOG and VEOG electrodes. Saccades or breaks in central fixation were also monitored with an infrared video-based eye tracker (iView, SMI). Analysis concentrated on non-target trials, in order to avoid any contribution from components connected to response-related processes.

ERP Analysis

The main aim of the experiment was to identify ERP components sensitive to differences in processing emotional expressions of own- versus other-race faces. More

specifically, the experiment compared the processing of White and Black male faces showing neutral, happy, and angry expressions viewed by White female participants.

Waveforms elicited by emotional face stimuli were characterized by early visual responses over frontal and posterior sites, later negative peaks over posterior and central sites, and late positive frontal and central peaks. The identifiable electrophysiological events (components) were named according to their polarity and approximate peak latencies. Of interest were components shown to be related to processing of face stimuli identified in the previous chapter – N170, N210 and P400 – as well as the early perceptual P120. Visual inspection of the waveforms also revealed a frontal N110 component, a tempoparietal P240 and a centroparietal P300 component. As in the previous chapter, mean amplitudes were measured over symmetrical electrode clusters where the component was largest, using the time period around the peak latency in the group data. The P120, N170, N210 and P400 mean amplitudes were measured at the same electrodes sites and during the same time windows as reported in the previous chapter. The early frontal N110 component was measured between 100-140 ms at electrodes FC3/FCZ/FC4 and C3/CZ/C4, the P240 component was measured between 230-250 at TP7/TP8 and P7/P8, and the P300 was measured between 300-600 ms at CP3/CPZ/CP4 and P3/PZ/P4. Measures of peak latency were taken at the single electrode where the component was maximal in the group data, using a more extensive time window to allow for individual variability. The latencies of P120, N170, N210 and P400 were measured at the same electrodes sites, during the same time windows as reported in the previous chapter. The frontal N110 peak latency was measured at FCZ between 90-150 ms and the P240 peak latency was measured at TP8 between 200-300 ms. The latency of the P300 was not analyzed, as it was not possible to identify a clear peak in the majority of participants.

Mixed-effects ANOVAs tested for modulations in the mean amplitudes or latencies of ERP components by the between-subject factor of task (1: identity vs. 2: stimulus) and the within subject factors of race (White vs. Black) and emotion (neutral vs. happy vs. angry). For mean amplitudes, the ANOVAs also included the factors of electrode location and electrode side. As reported in the previous chapter, the Greenhouse-Geiser epsilon correction for nonsphericity was applied where appropriate (Jennings & Wood, 1976) and only corrected probability values and degrees of freedom are presented. For all components, effects of interest only included main effects or interactions involving task, race and/or emotion.

8.3 Results

Valence and Arousal Ratings

As predicted, valence and arousal scales showed that the three expressions (angry, happy and neutral) elicited different ratings. Angry faces yielded negative valence and arousal ratings; happy faces yielded positive valence and arousal ratings; and neutral faces yielded intermediate valence and arousal ratings. The mean ratings and their standard deviations for all emotions of Black and White faces are given in Table 8.1 below.

White faces				Black Faces		
	Neutral	Happy	Angry	Neutral	Happy	Angry
Valence	4.07 (.48)	5.48 (1.04)	2.08 (.80)	4.19 (.61)	6.42 (.45)	2.19 (.49)
Arousal	4.85 (.78)	5.59 (1.33)	2.71 (1.04)	5.32 (1.16)	6.61 (.51)	2.85 (.78)

Table 8.1. Mean valence and arousal ratings; Standard deviation values are given in parentheses.

Mixed-effects ANOVAs tested for differences across emotion conditions and according to race of face for valence and arousal ratings, with the within subject factors of race (White vs. Black) and emotion (neutral vs. happy vs. angry). The ANOVA for valence scores showed a main effect of race, $F(1,12)=22.23, p<.001, \eta p^2=.65$, with Black faces receiving higher valence scores than White faces. A main effect of emotion was also observed, $F(1.61, 19.34)=15.99, p<.001, \eta p^2=.36$. Post hoc within-subjects contrasts showed that angry faces received lower valence scores than neutral and happy, $F(1, 24)=134.86, p<.001, \eta p^2=.91$, whilst happy faces received higher valence scores than neutral and angry faces, $F(1, 24)=145.86, p<.001, \eta p^2=.92$.²² An interaction of race of face by emotions was also observed, $F(1.32, 15.79)=6.64, p<.05, \eta p^2=.36$. Within-subjects contrasts demonstrated that Black happy faces had significantly higher valence scores than White happy faces, $F(1, 24)=7.85, p<.01, \eta p^2=.39$, whereas White versus Black neutral and angry face valence scores were the same.

ANOVA results for arousal scores revealed a significant main effect of race, $F(1,12)=15.64, p<.01, \eta p^2=.57$; Black faces received higher arousal scores than White faces. A main effect of emotion was also observed, $F(1.62, 19.46)=72.38, p<.001, \eta p^2=.86$. Within-subjects contrasts for the main effect of emotion, showed that angry faces received significantly lower valence scores than neutral or happy faces, $F(1, 24)=88.90, p<.001, \eta p^2=.88$, whilst happy faces received significantly higher scores than neutral and angry faces, $F(1, 24)=104.41, p<.001, \eta p^2=.89$. There were no interaction effects for arousal scores.

²² Post hoc, within-subjects difference contrasts were conducted on all emotion effects described in this chapter. The difference contrast allowed for comparison either between two individual facial expressions (e.g., neutral versus happy) or between one emotion and the other two (e.g., neutral versus happy +angry), depending on the nature of the effect.

Implicit-Association task

IAT scores were consistent from practice to test blocks (see Chapter 4, Table 4.1) (Cronbach's $\alpha=.92$). IAT scores demonstrated a relative implicit bias against the other race and/or pro the own race in the participants (anti-Black/pro-White bias, $D=.59$)²³.

Contact Questionnaire

Indices for each measure were constructed for each respondent by computing the mean response to the number of items in the social-contact, individuating experience and inclusion of other in the self scales. Table 8.2 presents the means and standard deviations of these measures, on the 1-5 scale. These indices were then used to explore correlations with behavioural and neural measures during the tasks. The social-contact and individuating experience measures were correlated, $r=.54$, $p<.01$, although neither of these measures was correlated with IOS, $p>.05$.²⁴

Measure	Mean (Standard Deviation)
(1) Social-contact	2.09 (.64)
(2) Individuating experience	2.95 (.93)
(3) Inclusion of other in the self	2.96 (1.39)

Table 8.2. Questionnaire measures Mean values; standard deviation values are given in parentheses.

Behavioural Results

Accuracy on the behavioural tasks 1 and 2 during EEG recording, was evaluated by assessing the number of correct identifications of immediate repeat trials (hits). A

²³ As stated in Chapter 4, .22 suggests no bias, scores above .22 suggests a bias against the other race and/or pro the own-race, and scores below .22 suggest a bias against the own-race and/or pro the other race.
²⁴ As the questionnaire measures of social-contact and individuating experience were correlated, the individual items were entered into a factor analysis with a varimax rotation. Results of the factor analysis showed the variables loaded on two separate components, and therefore the social-contact and individuating experience measures were kept as separate scales.

mixed-effects ANOVA tested for differences in accuracy scores with the between-subject factor of task (1: identity vs. 2: stimulus) and the within subject factors of race (White vs. Black) and emotion (neutral vs. happy vs. angry).

The between-subjects factor of task was significant, $F(1, 23)=17.51$, $p<.0001$, $\eta p^2=.65$, demonstrating that performance on the identity task was lower than on the stimulus task, $M=64.22$, $SD=4.77$, $M=88.08$, $SD=4.59$, respectively. The ANOVA also showed a main effect of race, $F(1, 23)=5.34$, $p<.05$, $\eta p^2=.27$, whereby accuracy for White target trials was higher than for Black target trials, irrespective of task: White faces $M=69.74$, $SD=3.83$, Black faces: $M=62.56$, $SD=3.45$. A main effect of emotional expression was also observed, $F(1.96, 45.04)=3.78$, $p<.05$, $\eta p^2=.24$. Post hoc within-subjects contrasts revealed that angry faces were more accurately identified than both neutral and happy faces, $F(1, 24)=7.77$, $p<.01$, $\eta p^2=.24$. The expression of the target face drove this effect in both tasks 1 and 2. Behavioural task did not interact with emotion in the mixed-effects ANOVA, and it appears that angry faces, irrespective of task, were the most readily identified faces. There were no interactions between the race, emotion or task group variables.

Behavioural Correlations

Measures of the social-contact questionnaire were found to correlate with the behavioural data. The own-race effect observed in accuracy scores on the EEG tasks 1 and 2 was found to correlate significantly with the three questionnaire measures: (a) social-contact, (b) individuating experience, and (c) inclusion of other in the self, $r=-.43$, $p<.05$; $r=-.47$, $p<.05$; and $r=-.41$, $p<.05$, respectively. Participants who reported greater other-race contact and higher quality, individuating experience, showed less of a difference in detecting own- versus other-race target faces on both EEG tasks. Social-contact and individuating experience were also found to correlate with participants' IAT

D-scores, $r=-.41$, $p<.05$, $r=-.459$, $p<.02$, respectively, in that participants with more social-contact and individuating experience recorded less implicit racial bias on the IAT. The behavioural tasks did not correlate with the IAT.

ERP Results

The experimental factors of race and emotion modulated visual and face-related components from early perception through the end stages of face processing. The factors of race and emotion interacted on the P120 and P400 components, and simultaneously yet independently modulated the N110, N170, N210 and P300 components.

Interaction of Race by Emotion

Race and emotion interacted at three processing stages. The interaction of race by emotion was found to modulate the P120, the P240 and the P400.

Race of face modulated the latency of the P120, $F(1,24)=8.04$, $p<.01$, with Black faces eliciting an earlier peak than White faces. The latency of the P120 was also modulated by emotion, $F(1.86,44.64)=3.45$, $p<.05$, $\eta p^2=.22$, and within-subjects contrasts revealed that angry faces peaked later than happy and neutral faces, $F(1, 24)=12.40$, $p<.01$, $\eta p^2=.34$. Furthermore, race interacted with emotion and electrode site on the mean amplitude of the P120, $F(1,24)=4.82$, $p<.05$, $\eta p^2=.31$. Follow-up subsidiary analyses compared the P120 elicited at electrode sites PO3/PO4 for White versus Black faces separately, for neutral, happy and angry conditions. No main effect of emotion was observed for White faces, $p>.05$, however, for Black faces, the main effect of emotion was significant, $F(1.62, 38.71)=4.14$, $p<.05$, $\eta p^2=.15$. Within-subjects contrasts showed that Black angry and happy faces elicited a larger peak than neutral faces, $F(1, 24)=14.31$, $p<.001$, $\eta p^2=.37$.

The mean amplitude of the P240 was modulated by emotion interacting with electrode site, $F(1.68, 36.66)=4.82$, $p<.05$, $\eta p^2=.17$ and race, $F(1, 24)=3.90$, $p<.05$,

$\eta p^2=.20$, such that at TP8 an effect of race by emotion was observed (see Figure 8.2). Subsidiary analyses per race revealed a main effect of emotion for White faces, $F(1.55, 40.45)=3.98$, $p=.05$, $\eta p^2=.14$ and Black faces, $F(1.66, 38.51)=3.87$, $p<.05$, $\eta p^2=.13$, whereby for White and Black faces alike, angry faces elicited a larger peak than happy or neutral faces, $F(1, 24)=10.01$, $p<.01$, $\eta p^2=.30$, and $F(1, 24)=7.64$, $p<.05$, $\eta p^2=.26$, respectively. However, Black neutral and Black happy faces elicited significantly lower peaks than White happy, $F(1, 24)=3.65$, $p=.05$, $\eta p^2=.13$, Black angry, $F(1, 24)=3.97$, $p<.05$, $\eta p^2=.15$, and White angry, $F(1, 24)=4.10$, $p<.05$, $\eta p^2=.15$ faces. No peak difference was observed between White neutral, Black neutral and Black happy faces. That is, Black angry faces elicited a similar peak to White angry and happy faces, and larger than the P240 elicited by neutral or Black happy faces.

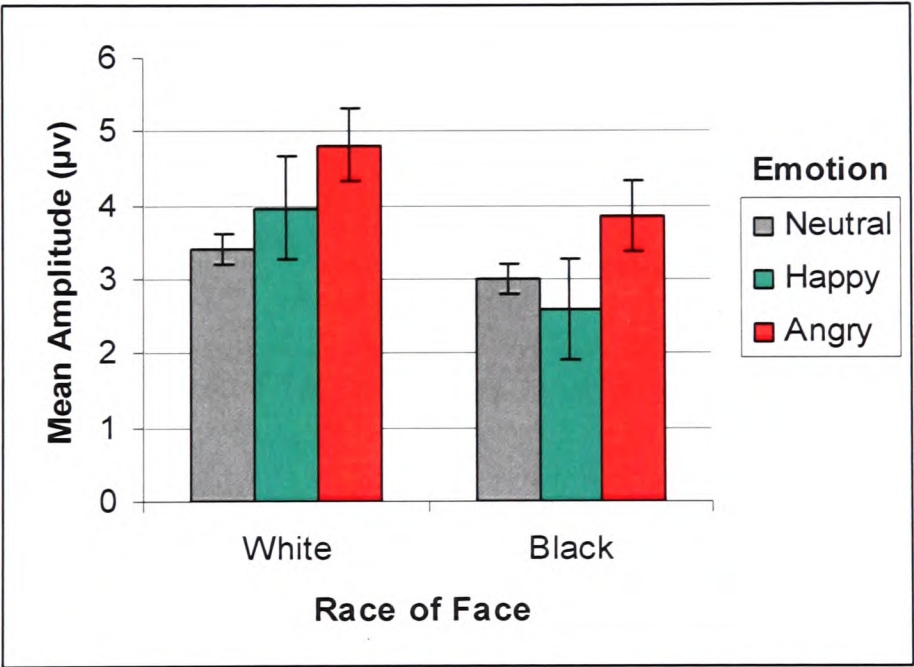


Figure 8.2. The interaction of race of face by emotion on the mean amplitude of the P240 at TP8.

On the amplitude of the P400, race of face significantly interacted with task. P400 components elicited by participants in ERP task 1 (identity repeats) showed a larger amplitude for Black faces, whereas the P400s of participants in ERP task 2 (stimulus repeats) elicited a larger amplitude to White faces, $F(1,23)=18.301$, $p<.001$, $\eta p^2=.50$ (see Figure 8.2 b & c). On the latency of this component, race interacted with emotion,

$F(1.99, 47.96)=4.41, p<.05, \eta p^2=.16$ (see Figure 8.3). Follow-up subsidiary analyses compared the P400 latency for White versus Black faces separately, for neutral, happy and angry conditions. The main effect of emotion for White faces was marginal, $F(1.70, 40.87)=4.14, p=.09, \eta p^2=.10$, and within-subjects contrast demonstrated that White emotional faces elicited a P400 peak that was earlier for neutral faces than for emotional faces, $F(1, 24)=5.26, p<.05, \eta p^2=.18$. For Black faces, however, no effect of emotion was observed, $p>.05$. In sum, race and emotion were interdependent on the P120, P240 and the P400.

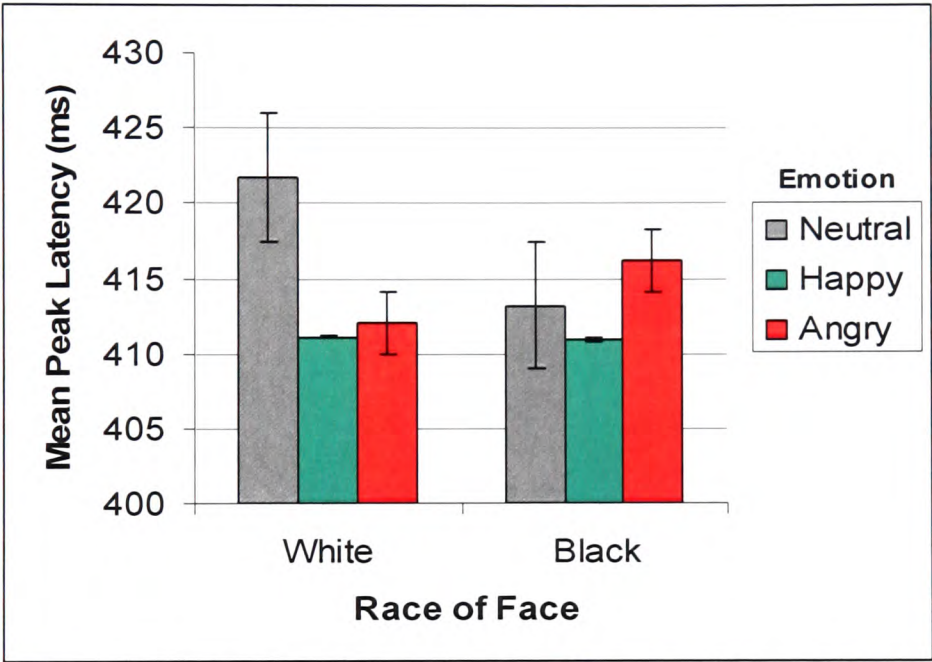


Figure 8.3. The interaction of race of face by emotion on the latency of the P400 at FZ.

Race of face

Race modulated face processing independently of emotion during early, face structural encoding and late stages of face processing. That is, the N110 amplitude, the N170 amplitude, the N210 amplitude and the P300 amplitude all showed systematic modulations by race, whereby White versus Black faces showed different effects on these components.

The first race effect interacted with electrode site and was on the frontal N110 component. Statistically, the mean amplitude of the N110 was larger for Black versus White faces at C4, $F(1.76,42.29)=4.53, p<.05, \eta p^2=.30$ Race of face also modulated the

structural encoding of faces. The mean amplitude of the N170 was significantly larger to Black than White faces, $F(1,23)=13.07, p<.001, \eta p^2=.56$ The same effect was evident on the following face-sensitive component, the N210. The N210 mean amplitude showed that Black faces elicited a larger negative peak than did White faces, $F(1,23)=10.30, p<.005, \eta p^2=.50$, maximal at PZ, $F(1.98,45.47)=9.79 p<.001, \eta p^2=.47$. The later P300 component was also modulated by race, in that White faces elicited a larger peak than Black faces, $F(1,23)=14.74, p<.001, \eta p^2=.58$. In sum, race modulated early general perception as well as later face-related processing stages (see Figure 8.4).

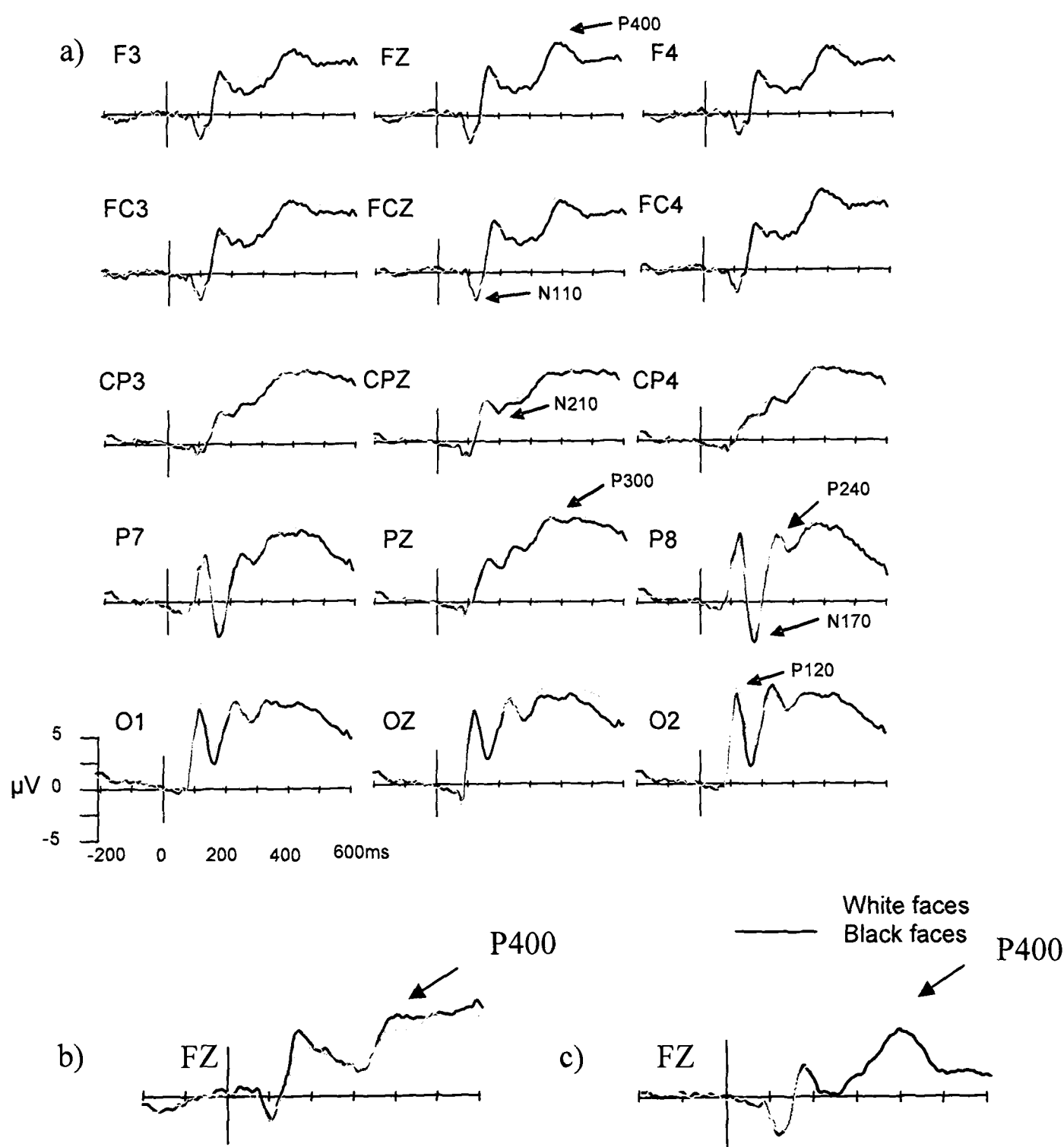


Figure 8.4. ERP grand average waveforms of 12 of the 34 electrodes recorded. a) White faces are overlaid with Black faces for comparison for ERP tasks 1 and 2 merged, b) P400 at FZ during ERP task 1 (identity repeats), and c) P400 at FZ during ERP task 2 (stimulus repeats).

Emotion

The emotional expressions of White and Black faces alike affected several stages of stimulus processing, including the frontal N110 amplitude, the N170 amplitude, the N210 amplitude, and the P300 amplitude. The latencies of the N170 were also modulated by emotion.

The first effect of emotion on early perception was evident on the mean amplitude of the frontal N110, $F(1.97, 47.19)=3.71, p<.05, \eta p^2=.14$. Post hoc tests of within-subjects contrasts revealed that this component was larger for happy faces than neutral faces, $F(1, 24)=3.93, p=.05, \eta p^2=.15$, however, no difference in mean amplitude was observed between neutral and angry, or happy and angry faces, $p>.05$. Emotion continued to affect stimulus processing during face structural encoding. The mean amplitude of the N170 was modulated by emotion interacting with electrode site, $F(1.87, 42.93)=3.77, p<.05, \eta p^2=.38$. That is, at PO7/PO8, neutral and happy faces showed a larger negative component than angry faces, $F(1, 24)=12.39, p<.01, \eta p^2=.34$. Moreover, the effect of emotion on the N210 was significant, $F(1.90, 43.79)=7.69, p<.005, \eta p^2=.25$, and in the same direction as the N170 emotion effect. Within-subjects contrasts demonstrated that neutral and happy faces elicited a larger negative peak than angry faces, $F(1, 24)=17.71, p<.001, \eta p^2=.43$. The final effect of emotion on face processing was on the P300, $F(1.61, 36.98)=3.50, p=.05, \eta p^2=.13$. Within-subjects contrasts showed that emotional faces elicited larger peaks than neutral faces, $F(1, 24)=9.93, p<.01, \eta p^2=.29$.

The latency of the N170 showed a main effect of emotion. The latency of the N170 component was modulated by emotion $F(1.61, 36.92)=3.76, p<.01, \eta p^2=.15$, and within-subjects contrasts showed that the N170 was delayed for emotional (angry and happy) versus neutral faces, $F(1, 24)=10.32, p<.01, \eta p^2=.30$.

In sum, emotion is seen to exert consistent effects on face stimulus processing from early perception through later face-sensitive processing stages (see Figure 8.5 a & b for waveforms of emotional faces for White vs. Black faces).

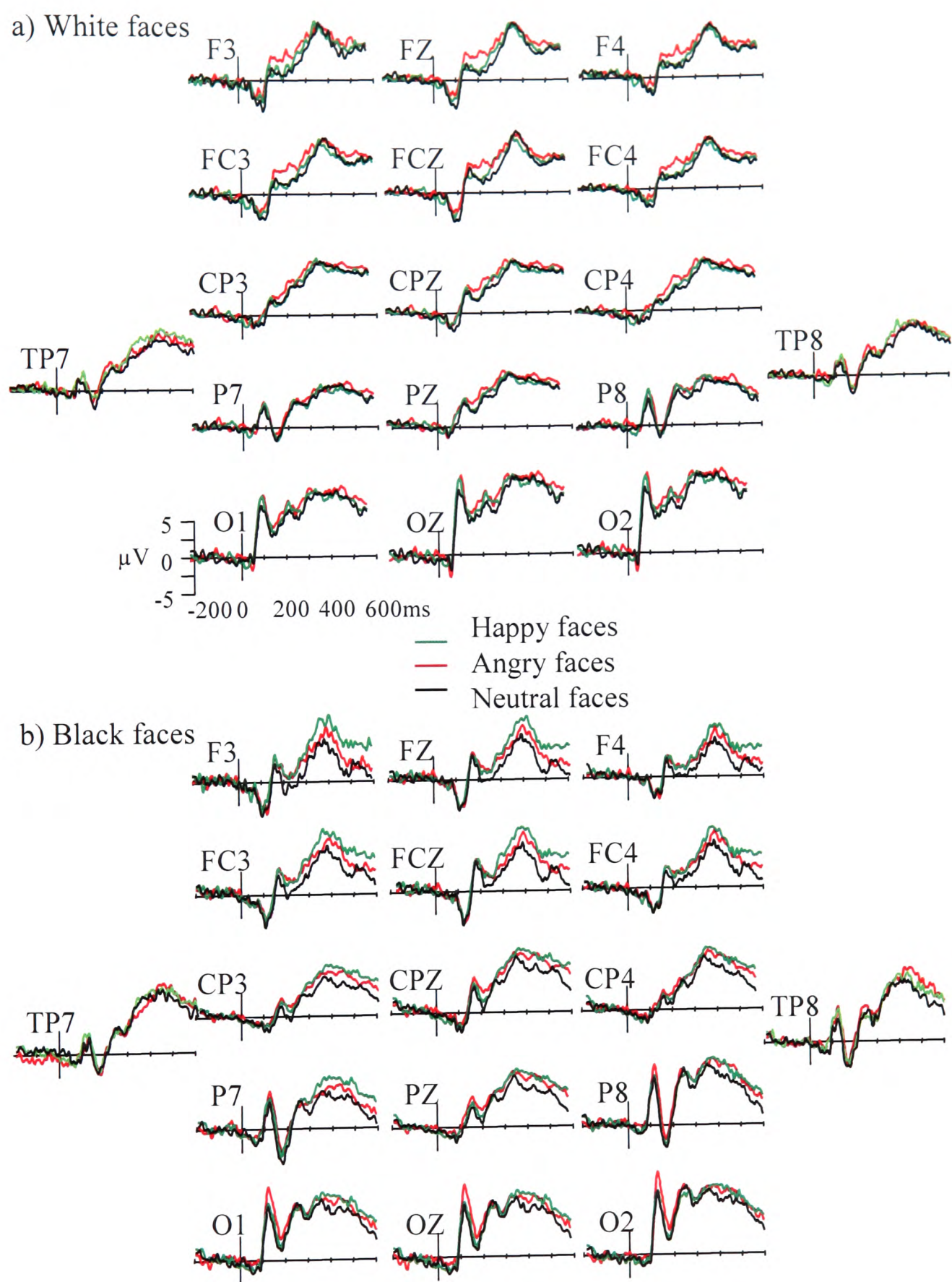


Figure 8.5. ERP grand average waveforms for 12 of the 34 electrodes recorded from: a) White faces: neutral, happy and angry expressions overlaid, b) Black faces: neutral, happy and angry expressions overlaid.

Correlations

To elucidate the interaction effects observed on ERP components, correlational analyses were conducted between the neural effects and IAT and questionnaire results. The interaction of race by emotion was seen on the mean amplitude of the P120, the mean amplitude of the P240 and the latency of the P400. As the previous chapter has demonstrated that race effects prior to 170 ms are likely to be colour, rather than race-related, only correlations with the later interaction on the P400 are investigated below. Clearly, we cannot rule out emotion effects during this stage of early perception, however, the interaction of emotion by race may reflect the disruption in processing abilities of light-coloured (White) versus dark-coloured (Black) emotional stimuli, rather than a true race effect.

In order to investigate which cognitive and social factors may be linked to the interactions of race by emotion on the mean amplitude of the P240 and the latency of the P400, contrast scores were computed that represented the interaction effect of race and emotional expression (Ito & Urland, 2004). That is, difference scores of mean amplitudes (P240) and latencies (P400) were generated for: a) emotional minus neutral White faces versus emotional minus neutral Black faces, and b) emotional White (happy + angry) versus emotional Black (happy + angry) faces. To maximize sensitivity, contrasts were computed for the electrode at which the components were maximal (TP8 and FZ respectively), that is, where latency effects were investigated. These scores were subsequently entered into bivariate correlations with the IAT *D*-scores and the questionnaire measures of social-contact, individuating experience and inclusion of other in the self.

The IAT *D*-scores were found to correlate with the amplitude contrast scores for the P240 race by emotion effect, $r=.48$, $p<.05$, and latency contrast scores computed for White emotional faces versus Black emotional faces on the P400, $r=.40$, $p<.05$. That is, participants who demonstrated less anti-Black/pro-White bias on the IAT showed less of a difference in the mean amplitude of the P240 and peak latency of the P400 to White versus Black faces.

Measures from the contact questionnaire were found to correlate with the race by emotion effects on the P240 and the P400. Bivariate correlations between P240 contrast scores and questionnaire measures demonstrated that individuating experience as measured by the questionnaire negatively correlated with the contrast scores for White versus Black emotional versus neutral faces, $r=-.38$, $p=.05$. That is, those participants reporting greater individuating experience with Black individuals showed a reduced race by emotion effect on the P240.

Correlations between P400 contrast scores and questionnaire measures demonstrated that the contrast scores for White versus Black emotional versus neutral faces negatively correlated with social-contact, $r=-.45$, $p<.05$, and individuating experience, $r=-.42$, $p<.05$, such that greater and more personal self-reported experience with other-race individuals was linked to a smaller difference in P400 latencies to own- versus other-race- emotional versus neutral face processing. No other correlations between questionnaire measures and neural components contrast scores were observed.

8.4 Discussion

The current experiment investigated the interaction of two salient social factors: race of face and emotional expression. This study sought to replicate the race-related modulations observed in the previous chapter, as well as investigate the own-race effect

in emotion-recognition at the neural level. To do so, ERPs were recorded to White and Black faces with different emotional expressions and race and emotional effects, and both independent and interaction effects were investigated. During ERP recording, participants completed an immediate-repeats task. Participants were also tested on measures of implicit racial bias (the IAT) and explicit other-race experience (contact questionnaire).

Behavioural results on the immediate-repeats task revealed an own-race effect, whereby participants were more accurate at detecting repeats of own- versus other-race face stimuli. This effect correlated with all three of the questionnaire's contact measures (social-contact, individuating experience, and IOS) demonstrating that the more other-race experience participants reported, the less of an own-race effect they demonstrated on the immediate-repeats task. This own-race effect, however, did not interact with emotion, and therefore no own-race emotion recognition advantage for either the immediate identity repeats or the immediate stimulus repeats task was observed. It may be that the smaller number of stimuli in each emotional expression category did not offer enough data to determine a race-by-emotion effect. The IAT demonstrated that, overall, participants reported anti-Black/pro-White bias, and these scores, like the behavioural results, correlated with social-contact and individuating experience, whereby participants reporting higher levels of contact demonstrated less anti-Black bias on the IAT.

The central aim of the ERP investigation was to highlight the modulations of ERP components specifically related to face processing in response to the presentation of own- and other-race emotional faces (neutral, happy, angry). Race and emotion modulations of face processing were investigated in relation to the three components identified as sensitive to face processing in the previous chapter: N170, N210, and P400. In addition, race and emotion modulations were investigated on components isolated in previous research as sensitive to emotional stimuli, the N110, the P240 and the P300 as well as the

early perceptual P120 component. Results of experimental manipulations to face stimuli (race and emotional expression) showed modulations on the frontal N110, P120 and P300, as well as on the isolated face components, N170, N210 and P400. However, the interaction of race by emotion only modulated the later P240 and P400 components.

Race and emotion processing did not interact on the N110, the N170, the N210 or the P300. Both race and emotion modulated very early stages of processing through structural encoding and late stages of face processing. Race modulated the N110, the N170, N210 independently of emotion. The race modulation of the N110, is the first to be reported, but may reflect the sensitivity of this component to valenced stimuli and therefore can activate the early warning system discussed by Holmes and colleagues (2003). The race effects on the mean amplitudes of the face-related components (N170, N210) mirror those of the previous experiment, whereby from structural encoding race modulated the way in which face stimuli were processed: structurally (Bentin et al., 1996), semantically (Caldara et al., 2003; Ito & Urland, 2005; Puce et al., 1999) and evaluatively (Puce et al., 1999). As discussed in the previous chapter, race effects on the N170 have previously been specific to social-categorization tasks (Ito & Urland, 2003, 2005; Ito et al., 2004), however, in two separate studies and two separate socially-irrelevant tasks (Experiments 5 and 6), the N170 has shown consistent modulation by race. It may be that the complexity of the paradigms used in other experiments can account for the disparate findings.

Lastly, the race effect on the P300 further demonstrated the impact of race on face processing. Previous ERP research has identified face-unrelated central-posterior P300 linked to evaluative judgments (Cacioppo, Crites, Bernston & Coles, 1994; Donchin, 1981; Ito & Cacioppo, 2000; Johnson, 1988). Cuthbert and colleagues (2000) described the P300 as typically occurring between 300-700 ms post stimulus onset in response to

emotionally salient stimuli. This component is interpreted as reflecting the allocation of attention to motivationally relevant input (Cuthbert et al., 2000). The amplitude of the P300 is reported to vary as a function of valence (larger for behaviourally significant stimuli); (see Johnson 1988, for a review) and is sensitive to social stimuli, such as members of different racial groups (Ito et al., 2004) as it is sensitive to the underlying evaluative precept (Rosenfeld, Angell, Johnson, & Qian, 1991). The modulation of the P300 in the current experiment by race is in line with previous research suggesting that at this stage of stimulus processing category-based evaluative judgments take place.

The second social factor investigated in the current experiment, emotion, modulated the early N110, the N170, the N210 and the P300 independently of race of face processing. The early modulation on the N110 and subsequent effects on face processing are in line with previous research suggesting that emotion can be detected very early on and percolate through later stages of stimulus processing. The emotion effect on the N110 confirms previous findings of early sensitivity to emotion (Eger et al., 2003; Felmingham et al., 2003), and a particular reduced negativity of the component to emotional versus neutral faces (Eimer & Holmes, 2002; Holmes et al., 2003). As Holmes and colleagues (2003) suggest, it may be that emotional faces are rapidly detected prior to face structural encoding as part of an automatic warning system. Moreover, these early findings may suggest that differentiating facial expressions relies on pre-programmed or highly over-learned configural patterns (Holmes et al., 2003), which may be more easily activated than the structural encoding of the face as a whole (which occurs ~170 ms). That is, early affective encoding may result from only a coarse affective impression.

As in the current experiment, Eger and colleagues (2003) also found that emotion modulated face processing around 170 ms. This finding confirms that encoding of emotional expressions can occur alongside face structural encoding. Pizagalli and

colleagues (2002) found differential activation to liked versus disliked faces, around 160 ms post stimulus presentation, which was localized to the fusiform gyri (shown in intracranial and fMRI studies to be critically involved in the structural encoding of faces). These results support the present findings, such that emotional expression can modulate face structural encoding, demonstrating that emotion influences the way in which individuals encode faces.

A larger body of evidence demonstrates the sensitivity of the later N2 component to emotional processing. Intracranial research by Krolak-Salmon and colleagues (2004) attributed affect modulation of the N2 to amygdala activation. Krolak-Salmon and colleagues tested epileptic patients during presurgical evaluation on a series of emotional faces and obtained the first amygdala response around 200 ms to fearful faces. Using magnetoencephalography (MEG), Streit and colleagues (1999) found emotional expressions to modulate face processing between 180-250 ms, and Streit and colleagues (2000) found emotional faces to elicit a larger N2 component than blurred faces. Conversely, Williams and colleagues (2004) found an increased N2 to fearful versus neutral faces only when faces were perceived subconsciously. When perceived consciously, no emotional modulation of the N2 was apparent. As an emotional modulation of the N2 elicited in response to consciously presented stimuli was found in the current experiment, perhaps it was the particular target-mask task and the very short (10-170 ms) stimulus presentation time that Williams and colleagues used which placed a different demand on face and emotion encoding than in the present experiment, eliciting different results. Nevertheless, as suggested previously, it is likely that the N2 represents the processing of semantic information necessary for the identification of faces and differentiating faces and emotional expressions.

The emotion effect observed on the P300 is in line with previous findings. Krolak-Salmon and colleagues (2001) found emotional faces to elicit a larger component than neutral faces between 250-450 ms, and suggested this effect demonstrated that emotional versus non-emotional stimuli are discriminated during the commencement of higher-level cognitive processing. Similarly, Kestenbaum and Nelson (1992) found differential emotional expression processing in both adults and children on the P300, and Kayser and colleagues (1997) also found an increase in the P300 to faces displaying facial trauma prior to corrective plastic surgery versus neutral post-surgery faces. The current results support previous research and confirm the sensitivity of the P300 to emotional versus neutral stimulus discrimination and social categorization into emotionally salient versus non-emotionally salient groups.

The interaction of race by emotion was observed on the early P120, the P240 and the P400. However, as demonstrated in the previous chapter, the early 'race' modulations to the P120 are likely to be colour- rather than race-related. Therefore, the interaction of race by emotion observed on the P120 is unlikely to reflect a true race by emotion effect. Following the colour effect on the P1 demonstrated in the previous chapter, the interaction between race and emotion here is likely to reflect differences in luminance of the various emotional face stimuli of White and Black faces (i.e., differences in luminance of wrinkles, amount of white of the eye showing) and does not denote a true race by emotion effect.

The P240 has previously been described as sensitive to face-identification (Halit, de Haan, & Johnson, 2000; Latinus & Taylor, 2005), and emotional expression (Eimer et al., 2003; Stekelenburg & de Gelder, 2004), and in the current experiment the mean amplitude of this component was modulated by the interaction of race by emotion. That is, other-race angry faces showed the same mean amplitude as own-race faces, whereas

other-race happy and neutral faces showed reduced mean amplitudes than own-race faces and other-race angry faces. The present findings are the first to demonstrate the sensitivity of this component to race of face. The correlation between the race by emotion effect on the P240 and individuating experience, further supports the experimental findings in the previous chapter, whereby greater individuating other-race experience may facilitate other-race face processing.

The P400 is an established component sensitive to face and race processing (Experiment 5). The interaction observed on this component likely reflects the cognitive evaluation of for own- versus other-race faces (Puce et al., 1999). The latency of the P400 component was modulated by the interaction of race by emotional expression whereby White (own-race) versus Black (other-race) neutral and emotional face processing elicited opposite effects. White faces showed an earlier peak for angry followed by happy then neutral faces, whereas Black neutral faces peak before Black emotional faces. This finding substantiates the behavioural own-race emotion recognition effect (Elfenbein & Ambady 2002a, b), whereby facial expressions of emotions by other-race individuals are more difficult to recognize than those expressed by own-race individual. The fact that this interaction occurs during the late stage of face-related processing which is subject to top-down influences (Puce et al., 1999) demonstrates that the interaction of race and emotion likely reflects the speed and ease with which own-race emotion faces are cognized compared with other-race emotional faces.

Correlational analyses revealed that the race by emotion latency effect on the P400 was linked to implicit racial bias, as measured by the IAT. That is, participants who showed less anti-Black/pro-White bias elicited similar P400 peak latencies to Black (other-race) and White emotional faces, whereas participants with greater implicit racial bias, showed a larger difference in P400 peak latencies to Black versus White faces.

These findings are particularly important in that they demonstrate the link between other-race bias and the race by emotional expression interaction for the P400 component.

Furthermore, questionnaire measures of social-contact and individuating experience correlated with the interaction of race by emotion on the latency of the P400. That is, participants reporting greater other-race contact in social settings and greater other-race individuating experience showed less of a difference in P400 latencies to own- versus other-race emotional versus neutral faces. This effect suggests that greater other-race experience plays a role in the fluidity and ease with which we process other-race faces in comparison to own-race faces. This finding is in line with those in the previous chapter whereby race effects were correlated with level of other-race experience. In sum, greater other-race contact appears to enable individuals to process other-race faces more similarly to their own at a neural level.

Only the mean amplitude of the P400 showed an effect of task on race processing. As discussed in the previous chapter, the P400 may be subject to top down influences; the race by task interaction illustrates the impact of top-down factors (in this instance task criteria) on this component. That is, in the stimulus immediate-repeats task White faces elicited a larger component at frontal sites than did Black faces, whereas in the identity immediate-repeats task, Black faces elicited a larger component than White faces. This finding shows that cognitive influences such as task instructions can significantly alter the way in which stimuli are evaluated during late stages of processing.

In sum, the present findings replicated certain race modulations found in the previous experiment. Moreover, the interaction of race by emotion, which modulated the late P240 and P400 components, demonstrated the own-race effect in emotion recognition at a neural level. These findings may reflect that after face structural encoding when faces are differentiated based on semantic information (P240) and

meaning is be extracted (P400) from the face stimulus, facial expressions can influence other-race versus own-race face processing. The correlations between these interactions and implicit racial bias, as well as measures of other-race experience, demonstrate that the race by emotion modulations can be subject to social influence. Future investigations of the own-race emotion-recognition effect should include detailed measures of social variables such as anxiety, empathy and perspective taking in order to explore a range of social variables which may influence race and facial expression processing.

Chapter 9

Own- versus Other-Race Emotional Face Processing in Majority versus Minority Group Members

9.1 Introduction: Experiment 7

Research on the own-race effect over the past few decades has stressed the importance of testing at least two racial groups on the recognition and perception of own and other-race faces. Only an interaction of Race of participant by race of face can denote a true own-race effect (Wells & Olson, 2003). That is, without an interaction effect (such that two racial groups perceive own- versus other-race faces differently) one cannot be certain that an effect observed when testing only one racial group is not due to a stimulus effect.

Behavioural research supports the cross-over effect in face perception (Walker and Tanaka, 2003) and recognition (Brigham & Meissner, 2001; Michel, Caldara, & Rossion, in press), and, as demonstrated in Chapter 3, differential processing of own- versus other-race faces can be different for minority versus majority group members. A similar effect in emotion recognition has also been described in the literature and investigated in the previous chapter. Research has shown that individuals are better at recognizing facial expressions of own-race rather than other-race faces (Elfenbein & Ambady, 2002b). The own-race effect in emotion recognition shares several common features with the general own-race effect. Specifically, both effects demonstrate that individuals tend to focus on facial cues representative of their own racial group (features, expression lines). However, these cues may not be as distinguishable in other-race faces (Elfenbein & Ambady, 2002a).

Previous neurophysiological investigations of differential own- versus other-race face processing have not investigated a cross-over race effect, in emotion or race perception. That is, research on the modulation of face processing by race has only tested one racial group looking at faces of their own-race and one other-race (Caldara et al., 2003; Caldara et al., 2004; Ito & Urland, 2003, 2005; Ito, Thompson & Cacioppo, 2004; James, Johnstone & Hayward, 2001). Furthermore, prior to the previous chapter, research had not considered the interaction between race and emotion. Experiment 6, which presents the first neurophysiological findings of differences in own- versus other-race face and emotion processing, only included White participants. Therefore, a balanced investigation of the own-race emotion-recognition effect is necessary to substantiate race and race-by-emotion modulations of face processing recorded in studies testing only one racial group.

Theoretically, own-race effects in face processing may result from differential other-race experience and racial bias (as discussed in the previous chapters). Group status may also play a salient role in own- versus other-race face processing. Behavioural research has showed that the own-race emotion-recognition effect is unequal across racial groups of different social status (Elfenbein & Ambady, 2002 a, b). Individuals of the majority race have shown greater accuracy when recognizing the emotional expressions of majority group members than those of minority group members, yet members of racial minority groups have demonstrated equal accuracy when recognizing the emotional expressions of both groups (Elfenbein & Ambady, 2002a). These findings must be taken into consideration when investigating the own-race emotion-recognition effect at a neural level. Depending on group status, two different racial groups might show different effects. Conversely, it may be that group status alone does not dictate own-race face expertise, but rather social variables such as other-race experience, intergroup anxiety

and racial bias have a more salient influence on the way in which individuals perceive own and other-race faces.

As discussed in the previous two chapters, ERPs provide an excellent tool for tracking cognitive functioning through time, and therefore can offer unique insight into differences between groups on the same task. ERPs are ideal for examining when and how social factors, such as race and emotion, can influence the way we perceive (and subsequently interact with) our environment. Moreover, race and emotion effects on face processing in the brain may differ depending on group status and/or social variables relating to intergroup experience. ERPs provide a sensitive measure, which enables us to uncover between-group differences in social information processing from face stimuli.

In the current study, ERPs were used as a tool to investigate components sensitive to differences in processing own- versus other-race emotional faces in two racial groups of different status in the U.K.: White (majority group status in the U.K.) and South Asian (minority group status in the U.K.) (For population and demographic specifics see Chapter 3, section 3.1).²⁵ ERPs were recorded from twice the number of electrodes used in Experiments 5 and 6 in order to determine whether further components sensitive to race of face and emotion processing were evident. Recordings from White and South Asian participants were compared when they viewed White versus South Asian emotional faces.

The main aim of the current experiment was two-fold. The first objective was to replicate the findings from Experiments 5 and 6 for White participants (race and emotion effects) and South Asian participants (emotion effects only). As race-of-face processing

²⁵ In contrast to Experiments 6 and 7, which looked at the influence of White versus Black race on face processing in White participants, the present study investigated White versus South Asian face processing in White and South Asian participants. In order to examine group status influences on face processing and to qualify the behavioural results of White and South Asian participants presented in the behavioural chapters of this Thesis, the present experiment tested White and South Asian participants who viewed White and South Asian faces.

and the interaction of this factor with emotion processing may vary across participants as a function of group status or social influences (e.g., experience, anxiety, racial bias), differences in modulations of face processing according to race may be evident for White participants compared to South Asian participants. Second, a more detailed questionnaire than those used in the previous chapters was included in order to obtain more extensive information from participants regarding numerous social variables which might account for differences in own- versus other-race emotional face processing at a neural level. The current questionnaire included not only measures of other-race experience, but also scales of prejudice, intergroup anxiety, empathy, self-disclosure, perspective taking and perceived outgroup homogeneity. Furthermore the IAT (Greenwald et al., 1998) was used to measure implicit racial bias in both racial groups to determine whether implicit bias plays a role differential brain activation to own- versus other-race faces.

9.2 Methods

Participants

Twenty-five healthy right-handed (Oldfield, 1971) White (12) and South Asian (13) female participants (age range 18-24 years) took part in the experiment. All participants had normal or corrected-to-normal vision. The experimental methods were non-invasive and had ethical approval from the Department of Experimental Psychology, University of Oxford, U.K.

Stimuli and Materials

Face Stimuli

Participants viewed face stimuli of 5 White and 5 South Asian males with neutral, happy and angry expressions from a frontal viewpoint. The stimuli were black-and-white photographs taken by the experimenter. In total, participants were presented with 30

distinct face stimuli: 15 White faces (5 neutral, 5 happy, 5 angry) and 15 South Asian faces (5 neutral, 5 happy, 5 angry). The 15 White-face-stimuli were the same as those used in the previous experiments (Chapters 7 & 8); an example of the South Asian-face-stimuli is shown in Figure 9.1.

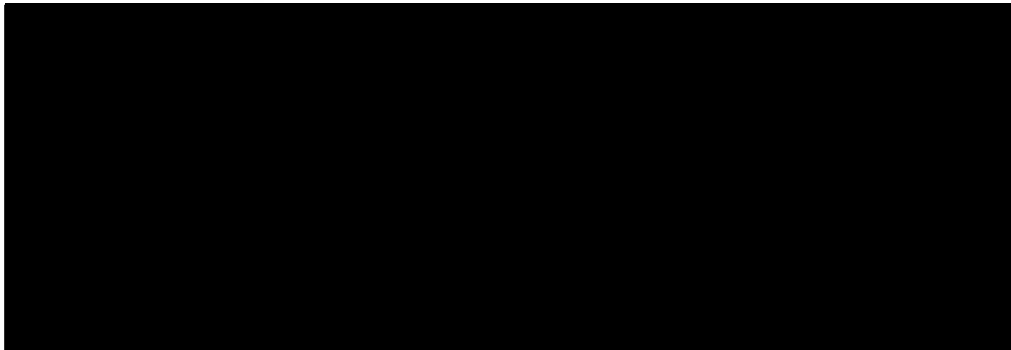


Figure 9.1. South Asian face stimuli; from left to right: neutral, happy and angry emotional expressions.

All emotional face stimuli (White and South Asian) had previously been evaluated by 31 individuals, confirming that the emotional expression of the face stimuli (neutral, happy and angry) were representative of neutral, happy and angry faces.²⁶

Valence and Arousal Ratings

As emotional and neutral pictures can differ in terms of valence and arousal (Osgood & Tannenbaum, 1957), the emotional face stimuli used in the current experiment (as in the previous experiment), were rated by participants on valence and arousal scales. Prior to the experiment, all participants completed two questions regarding the valence of face stimuli, followed by two questions regarding arousal. Participants were asked to rate each of the faces on the same 1-7 scale as described in the previous chapter (see section 8.2).

²⁶ Prior to the current experiment, 31 female participants (16 White and 15 South Asian) were given prints of the 30 face stimuli and were asked to identify (in writing) which emotional expression they recognized on each of the faces. Accuracy on identifying the emotional expressions was high in both (a) White participants: White neutral faces $M=99.30\%$, $SD=.18\%$; White happy faces $M=99.71\%$, $SD=.05\%$; White angry faces $M=99.65\%$, $SD=.21\%$; South Asian neutral faces $M=98.90\%$, $SD=.20\%$; South Asian happy faces $M=99.55\%$, $SD=.69\%$; South Asian angry faces $M=98.90\%$, $SD=.33\%$, and (b) South Asian participants: White neutral faces $M=98.79\%$, $SD=1.05\%$; White happy faces $M=99.99\%$, $SD=.70\%$; White angry faces $M=99.90\%$, $SD=.50\%$; South Asian neutral faces $M=99.13\%$, $SD=.20\%$; South Asian happy faces $M=99.55\%$, $SD=.33\%$; South Asian angry faces $M=99.0\%$, $SD=1.00\%$.

The reliability of the 2 measures (valence and arousal), were reliable: (1) valence (Cronbach's $\alpha=.84$), and (2) arousal (Cronbach's $\alpha=.93$).

Implicit-Association task

As in the previous chapter, the IAT (Greenwald et al., 1998) was used to measure the relative ease with which participants were able to make automatic associations. As discussed in Chapter 4 and 8, participants were presented with White and South Asian faces and with words with pleasant versus unpleasant connotations. The *IAT effect* was computed from performance speeds in two classification tasks across practice and test blocks (see Chapter 4 for details), wherein association strengths influence participant performance. The current IAT used the same set-up of presentation blocks and trials as that in Experiments 3 and 4. However, in the current paradigm, we had not one but three different IATs, each only presenting face stimuli with one of the three facial expressions: neutral, happy or angry. The three IATs were completed by participants in counterbalanced order, and three separate IAT scores were recorded for each participant, one in the context of own- versus other-race neutral faces, one happy faces and one angry faces. In each of the three IATs, participants used two response keys to classify four categories of stimuli: White versus South Asian faces and 'pleasant' (e.g., happy, joy, bliss) versus 'unpleasant' (e.g., horrible, death, evil) words.

Questionnaire

The questionnaire used in this study contained 44 items, which sought to determine the participants' relative attitudes and anxiety towards, and experiences with individuals from the relevant other race. That is, White participants answered questions regarding South Asian individuals and South Asian participants answered questions regarding White individuals. The 44 items were grouped into categories examining (1) prejudice, (2) opportunity for contact, (3) social-contact, (4) individuating experience, (5)

‘inclusion of other in the self’, (6) intergroup anxiety, (7) perceived outgroup homogeneity, (8) self disclosure, (9) empathy, and (10) perspective taking. Each question had a scale of 1-5, where 1 signaled low prejudice, low anxiety and low contact, and 5 signaled high prejudice, high anxiety and high contact.²⁷

Most questionnaire measures used in this study replicated measures from previous experiments in this Thesis. However the prejudice, social-contact, and opportunity-for-contact measures were altered. Therefore, these scales are reported below, along with the new scales of perceived outgroup homogeneity and self disclosure. The extended measures from previous chapters and new measures included the following items:²⁸

Prejudice- The prejudice scale included the items in Dunton and Fazio’s (1997) scale (see Chapter 4) as well as two additional items. Participants expressed their attitudes on a 1-5 scale: *strongly agree, sort of agree, not sure, sort of disagree, strongly disagree*: (1) When I see someone from the Asian community being treated unfairly I sometimes don’t feel much pity for them, and (2) Sometimes certain prejudiced thoughts or feelings I may have slip out in the wrong company.

Social-contact - The social-contact scale was identical to that used in Experiment 5 (5 items) with the addition of 5 new items. The first three items were on a 1-5 scale: *all or mostly White people, majority Whites/some South Asians, half and half, majority South Asians/some White, all or mostly Asian people*, preceded with a stem: (1) On an average day in your hometown you would be most likely to meet, (2) On an average day in your university town you would be most likely to meet, and (3) What proportion of your friends are South Asian? The fourth question was on a scale of 1-5, where 1 signaled *very low* and 5 signaled *very high*: (4) Please rate the amount of overall contact you have had

²⁷ Prejudice, anxiety, perceived group homogeneity measures were reversed-scored.

²⁸ Below are sample items from the questionnaire White participants completed. South Asian participants completed an identical questionnaire asking about their attitudes towards and experiences with White individuals.

with Asian people during your life. The final new question was on the following 1-5 scale: *I have no South Asian friends, once a year or less, once a month or less, once a week or less, more than once a week*: (5) How often do you communicate face-to-face with South Asian acquaintances and friends?

Opportunity for contact - The opportunity for contact measure used in Chapters 4 and 8 contained one additional item on a scale of 1-5, 1 being *None* and 5 being *All*: (1) How many people in your lectures are South Asian?

Perceived outgroup homogeneity - The perceived outgroup homogeneity scale included three items seeking to determine the participant's perception of how similar they perceived the outgroup to be on a 1-5 scale, 1 being *Never* and 5 being *All the time*: (1) Do you think your South Asian friends dress alike?, (2) Are the homes of your South Asian friends similar?, and (3) Are the voices of your South Asian friends similar to each other?

Self-disclosure - The self-disclosure scale contained 4 items on a 1-5 scale, 1 being *Never* and 5 being *All the time*: (1) How often do you talk about how you are feeling to people who are South Asian?, (2) How often do South Asian people talk to you about how they are feeling?, (3) When you have problems that are worrying you how often do you go to a South Asian friend/person to talk to them about it?, and (4) If a South Asian friend/person was worried about something how often do they come to you to talk to you about it?

The reliability of the nine multi-item measures for White or South Asian participants (prejudice, extended intergroup anxiety, quantity of contact, individuating experience) were reliable: (1) prejudice (Cronbach's $\alpha=.73$; .70 for White and .77 for South Asian subgroups), (2) opportunity for contact (Cronbach's $\alpha=.84$; .71 for White and .80 for South Asian subgroups), (3) social-contact (Cronbach's $\alpha=.91$; .74 for White and .88 for South Asian subgroups), (4) individuating experience (Cronbach's

alpha=.91; .87 for White and .87 for South Asian subgroups), (5) intergroup anxiety (Cronbach's alpha=.87; .88 for White and .74 for South Asian subgroups), (6) perceived outgroup homogeneity (Cronbach's alpha=.72; .80 for White and .70 for South Asian subgroups), (7) self-disclosure (Cronbach's alpha=.92; .95 for White and .74 for South Asian subgroups), (8) empathy (Cronbach's alpha=.76; .75 for White and .81 for South Asian subgroups), and (9) perspective taking (Cronbach's alpha=.76; .78 for White and .70 for South Asian subgroups).

ERP task

Each of the participants completed a behavioural task during EEG recording, in which they viewed face stimuli of their own (White or South Asian) or the other (South Asian or White) race with different emotional expressions to perform a matching task. All participants completed a physical-match task. Participants were instructed to respond when they detected a stimulus that repeated over immediately successive trials (targets). That is, participants were to respond when they saw the exact same person with the exact same emotional expression appear twice in a row.

Procedure

Prior to the EEG recording, participants completed the IAT in order to obtain ratings of implicit racial bias and to familiarize the participants with the faces they would be presented with during the EEG recording. The order in which participants completed the questionnaire and the valence and arousal ratings of the face stimuli was counterbalanced: half of the participants completed the valence and arousal ratings prior to EEG recordings and the social-contact questionnaire after the EEG recordings, whilst

the other half completed the social-contact questionnaire prior to EEG recording and the valence and arousal ratings after.²⁹

During EEG recording, participants were seated in a dimly lit and electrically shielded room, facing a computer monitor approximately 100 cm away. They were given the task instructions, and completed a block of 12 practice trials in order to familiarize themselves with the task. Each experimental trial consisted of a fixation point presented in the centre of the screen for 1000 ms followed by a face stimulus (neutral, happy or angry) for 500 ms. Trials were separated by an interval that ranged randomly between 1000 and 2500 ms.

In the ERP task, each face stimulus was presented 12 times in a constrained randomized order, allowing no more than 2 stimuli of the same category to appear successively. An additional six stimuli per category (10% of all experimental trials) were designated as “targets”, appearing immediately after a face stimulus of the same identity and expression. In total, there were 396 trials. Participants were instructed to respond to target trials according to the task instructions by pressing the left mouse button with their right hand.

Participants were asked to minimize blinking and to maintain visual fixation in the centre of the screen at all times during task performance.

ERP Recording

The EEG was recorded continuously from 72 scalp sites using Ag/AgCl electrodes mounted on an elastic cap (Easy-Cap, FMS, Germany), positioned according to the 10-20 International System (AEEGS, 1991). The montage included 9 midline sites (FPZ, FZ, FCZ, CZ, CPZ, PZ, POZ, OZ and IZ); 31 sites over each hemisphere (AF3/AF4, AF7/AF8, FP1/FP2, F1/F2, F3/F4, F5/F6, F7/F8, F9/F10, FC1/FC2,

²⁹ As in the previous 6 experiments presented in this Thesis, tests for order effects of task completion were conducted post hoc. No effects were found.

FC3/FC4, FC5/FC6, FT7/FT8, FT9/FT10, C1/C2, C3/C4, C5/C6, T7/T8, CP1/CP2, CP3/CP4, CP5/CP6, TP7/TP8, P1/P2, P3/P4, P5/P6, P7/P8, P9/P10, PO3/PO4, PO7/PO8, PO9/PO10, O1/O2 and I1/I2); and both mastoids. Additional electrodes were used as ground and reference sites: the EEG was referenced to the nose, the electrode between FPZ and FZ served as the ground. Electrodes were also placed laterally to each eye, at the outer canthii, and below the right eye, in order to derive bipolar signals relating to the horizontal and vertical electrooculogram. Data were digitized at a sampling rate of 500 Hz, using a 200 Hz low-pass signal and no high-pass signal (DC).

Event-related potentials were constructed offline. Epochs started 200 ms before and ended 600 ms after stimulus onset. Epochs containing excessive noise or drift (in excess of $\pm 100 \mu\text{V}$) at any electrode between -200 and $+600$ ms were excluded. Epochs with eye-movement artifacts (blinks or saccades) were rejected. Blinks were identified as large deflections ($\pm 50 \mu\text{V}$) in the HEOG and VEOG electrodes. Saccades or breaks in central fixation were also monitored with an infrared video-based eye tracker (iView, SMI). Analysis concentrated on non-target trials, in order to avoid any contribution from components connected to response-related processes.

ERP Analysis

The main aim of the experiment was to identify ERP components sensitive to differences in processing emotional expressions of own- versus other-race faces. More specifically, the experiment compared the processing of White and South Asian male faces of neutral, happy, and angry expressions by White and South Asian female participants.

Waveforms elicited by emotional face stimuli (White and South Asian) were characterized by very early responses over frontal and posterior sites, an early negative peak over lateral occipital sites, a later positive peak over lateral temporal sites, and late

positive central and frontal peaks. The identifiable electrophysiological events (components) were named according to their polarity and approximate peak latencies. Of interest were components shown to be related to processing of face stimuli identified in Experiment 5 — N170, N210 and P400. However, visual inspection of the waveforms did not show a clear N210 (evident in the previous two chapters) and therefore this component was not included in the ERP analysis. The early frontal N110, visual P110 (the same component as the P120 in the previous chapter; the peak of the component here is slightly earlier), the P240 and late P300 components, were also analysed. As in the previous two chapters, mean amplitudes were measured over symmetrical electrode clusters where the component was largest, using the time period around the peak latency in the group data. The N110, P110, N170, P240 and P300 mean amplitudes were measured at the same electrode sites and during the same time windows as reported in the previous chapter (see section 8.2). The P400 in the current experiment was measured in a longer window than the previous two chapters: between 360-440 ms at F3/FZ/F4 and FC3/FCZ/FC4. Measures of peak latency were taken at the single electrode where the component was maximal in the group data, using a more extensive time window to allow for individual variability. The latencies of the N110, the P110, and P240 were measured at the same electrodes during the same time windows as reported in the previous chapter. The latency of the N170 was measured at PO8 between 140-200 ms, and the P400 was measured at F3 between 300-500 ms. As in the previous experiment, the latency of the P300 was not analyzed, as it was not possible to identify a clear peak in the majority of participants.

Mixed-effects ANOVAs tested for modulations in the mean amplitudes or latencies of ERP components by the between-subject factor of Race of participant (White vs. South Asian) and the within subject factors of race of face (own- vs. other-race) and

emotion (neutral vs. happy vs. angry). For mean amplitudes, the ANOVAs also included the factors of electrode location and electrode site. As reported in the previous two chapters, the Greenhouse-Geiser epsilon correction for nonsphericity was applied where appropriate (Jennings & Wood, 1976) and only corrected probability values and degrees of freedom are reported. For all components, effects of interest only included main effects or interactions including Race of participant, race of face or emotion.

9.3 Results

Valence and Arousal Ratings

As predicted, valence and arousal results showed that the three expressions (neutral, happy and angry) elicited different ratings. Angry faces yielded negative valence and arousal ratings; happy faces yielded positive valence and arousal ratings; and neutral faces yielded intermediate valence and arousal ratings. The mean ratings and their standard deviations for all emotions of South Asian and White faces are given in Table 9.1.

Mixed-effects ANOVAs tested for differences across emotion conditions and according to race of face for valence and arousal ratings. The ANOVAs included the between subjects factor of Race of participant (White vs. South Asian) with the within subject factors of race (own- vs. other-race) and emotion (neutral vs. happy vs. angry). The ANOVA for valence scores showed a main effect of emotion, $F(1.36, 32.57)=214.25$, $p<.001$, $\eta p^2=.90$. Post hoc, within-subjects difference-contrasts tested valence scores to angry faces directly against valence neutral and happy face valence scores.

a) White Participants						
White faces				South Asian Faces		
	Neutral	Happy	Angry	Neutral	Happy	Angry
Valence	4.33 (.50)	6.18 (.58)	2.37 (.18)	3.87 (.58)	5.97 (.47)	2.31 (.55)
Arousal	4.92 (1.08)	6.24 (.58)	3.24 (1.06)	4.81 (.66)	6.38 (.56)	3.08 (.73)

b) South Asian Participants						
White faces				South Asian Faces		
	Neutral	Happy	Angry	Neutral	Happy	Angry
Valence	4.58 (.51)	6.17 (.82)	2.54 (1.14)	4.18 (.54)	6.35 (.44)	2.58 (1.10)
Arousal	5.79 (1.04)	6.38 (.68)	3.94 (1.50)	5.48 (1.16)	6.55 (.51)	3.93 (1.35)

Table 9.1. Mean valence and arousal ratings for White and South Asian neutral, happy and angry faces: a) for White participants, and b) for South Asian participants; standard deviation values are given in parentheses.

Results showed that angry faces received lower (that is, more negative) valence scores than neutral and happy faces, $F(1, 23)=206.56, p<.001, \eta p^2=.90$, whilst happy faces received higher (that is, more positive) valence scores than neutral and angry faces, $F(1, 21)=290.14, p<.001, \eta p^2=.92$. No main effect of Race of participant or race of face or interaction effects were observed for valence scores.

Results for arousal scores revealed a significant main effect of emotion, $F(1.50, 36.07)=94.26, p<.001, \eta p^2=.80$. Within-subjects contrasts showed that angry faces received significantly lower valence scores than neutral or happy faces, $F(1, 23)=102.32, p<.001, \eta p^2=.81$, whilst happy faces received significantly higher scores than neutral and angry faces, $F(1, 23)=133.55, p<.001, \eta p^2=.85$. The between-subjects factor of Race of participant was also significant, $F(1, 23)=5.96, p<.05, \eta p^2=.21$, such that South Asian participants attributed higher levels of arousal to the face stimuli (irrespective of race of

face stimulus). No main effect of race of face or interaction effects were observed for arousal scores.

Implicit-Association task

Participants completed three IATs: 1) with White and South Asian neutral faces, 2) with White and South Asian happy faces, and 3) with White and South Asian angry faces. IAT scores were consistent from practice to test blocks (see Chapter 4, Table 4.1) (Cronbach's $\alpha=.89$). IAT scores (where .22 suggests no bias, scores above .22 suggests a bias against the other race and/or pro the own-race, and scores below .22 suggest a bias against the own-race and/or pro the other race) are presented in the table below (Table 9.2). White participants demonstrated an anti-South Asian/pro-White bias, and South Asian participants demonstrating an anti-White/pro- South Asian bias.

IAT	White Participant D-scores	South Asian Participant D-scores
Neutral faces	.43 (.43)	.03 (.40)
Happy faces	.33 (.44)	.11 (.23)
Angry faces	.36 (.38)	.15 (.34)
Mean of all three	.37 (.30)	.09 (.25)

Table 9.2. Mean IAT *D*-scores for White and South Asian participants for each IAT and their overall *D*-score across all three measures. Standard deviation values are given in parentheses.

Mixed-effects ANOVAs tested for differences across IAT conditions as within-subjects factors (neutral vs. happy vs. angry IATs) for the between subjects factor of Race of participant (White vs. South Asian). Only a main effect of participant was observed, $F(1, 23)=6.16$, $p<.05$, $\eta p^2=.21$, whereby White participants had higher *D*-scores overall (demonstrating anti-South Asian/pro-White bias) and South Asian

participants had lower *D*-scores (demonstrating anti-White/pro-South Asian bias). No overall effect of IAT condition (neutral vs. happy vs. angry IAT) was detected.

Questionnaire

Indices for each questionnaire measure were constructed for each respondent by computing the mean response to the number of items in the 10 scales. Table 9.3 presents the means and standard deviations of these measures. These indices were then used to explore correlations with behavioural and neural measures during the tasks. On the 1-5 scale, participants reported an average amount of other-race contact.

Measure	White Participants	South Asian participants
1. Prejudice*†	4.15 (.65)	3.87 (.56)
2. Opportunity for contact†	2.31 (.50)	3.83 (.44)
3. Social-contact †	2.28 (.62)	3.75 (.83)
4. Individuating experience †	3.33 (.86)	4.32 (.61)
5. Inclusion of the other in the self	3.08 (1.28)	4.00 (1.08)
6. Anxiety*†	3.42 (.62)	4.37 (.59)
7. Perceived outgroup homogeneity	3.67 (.83)	3.51 (.60)
8. Self-disclosure†	2.97 (.99)	4.12 (.70)
9. Empathy	4.56 (.70)	4.51 (.46)
10. Perspective taking	3.08 (1.02)	3.62 (.92)

Table 9.3. Questionnaire measures Mean values; standard deviation values are given in parentheses (* indicates that the item was reverse scored; † indicates significant difference between groups, $p<.05$).

Behavioural Results

Accuracy on the behavioural task during EEG recording was evaluated by assessing the number of correct identifications of immediate repeat trials (hits). A mixed-

effects ANOVA tested for differences in accuracy scores with the between-subject factor of Race of participant (White vs. South Asian) and the within subject factors of race of face (White vs. South Asian) and emotion (neutral vs. happy vs. angry).

The between-subjects factor of Race of participant was not significant, $p > .05$ demonstrating that neither race group out-performed the other on the task.³⁰ The ANOVA showed no main effect of race or emotion. However, the interaction of Race of participant by race of face was significant, $F(1,23)=22.01$, $p < .001$, $\eta p^2 = .49$. Subsidiary analyses were performed for each racial group. The ANOVA for White participants demonstrated a significant main effect of race, $F(1,11)=4.76$, $p = .05$, $\eta p^2 = .30$, whereby repetitions of White faces were more accurately identified than repetitions of South Asian faces, irrespective of the facial expression of emotion. Likewise, the ANOVA for South Asian participants demonstrated a significant main effect of race of face, $F(1,12)=22.68$, $p < .001$, $\eta p^2 = .65$, whereby repetitions of South Asian faces were more accurately identified than repetitions of White faces.

Behavioural correlations

Measures of the social-contact questionnaire were found to correlate with the IAT data, but not with the own-race effect observed in accuracy scores on the EEG task, nor were the IAT and the ERP task correlated. As there was no significant difference between the 3 IATs, an overall *D*-score was generated by averaging the individual *D*-scores of the 3 separate IATs together. For White participants, this average score did not correlate with any of the questionnaire measures. However, for South Asian participants, the average *D*-score was found to correlate with explicit prejudice, $r = -.60$, $p < .05$, and perceived outgroup homogeneity, $r = -.61$, $p < .05$. That is, participants with higher scores on the

³⁰ White participants accuracy: White faces, $M=80.08$, $SD=10.06$, South Asian faces, $M=78.56$, $SD=10.44$; South Asian participant accuracy: South Asian Faces, $M=78.67$, $SD=7.02$, White faces, $M=69.45$, $SD=10.99$.

prejudice measure demonstrated greater anti-White/pro-South Asian bias on the IAT. Likewise, those who perceived the other-race to be more homogenous demonstrated more anti-White/pro-South Asian bias on the IAT.

ERP Results

As in the previous chapter, the experimental factors of race of face and emotion modulated stimulus processing from early perception. All three experimental factors modulated the N170, the P240 and the P300 components, whereas the P400 was modulated by Race of participant interacting with race of face but not emotion. The mean amplitude of the P110 was modulated by the Race of face but not by emotion. Conversely, the mean amplitude of the N110 was modulated by emotion but not by race of face.

Interaction of Race of participant by race of face by emotion

Own- versus other-race face processing interacted with emotion at three different processing stages from face structural encoding through later stages of processing. The three-way interaction of Race of participant by race of face by emotion was found to modulate the latency of the N170, the latency of the P240 and the mean amplitude of the P300.

The three major factors of interest interacted in modulating the latency of the N170: Race of participant by race of face by emotion, $F(1.49, 34.24)=4.02$, $p<.05$, $\eta p^2=.15$. Follow-up subsidiary analyses found that South Asian participants showed a significant race of face by emotion interaction, $F(1.74, 20.92)=4.06$, $p<.05$, $\eta p^2=.37$, whereas White participants did not, $p>.05$ (see Figure 9.2). Furthermore South Asian participants only demonstrated a significant main effect of emotion for White faces, $F(1.56, 18.74)=3.68$, $p=.05$, $\eta p^2=.24$, and not South Asian faces. Post hoc within-subjects contrasts showed that for South Asians, neutral and happy White faces elicited the same

peak latencies as the South Asian faces, but angry White faces elicited a significantly later N170, $F(1, 12)=5.65, p<.05, \eta p^2=.32$.³¹

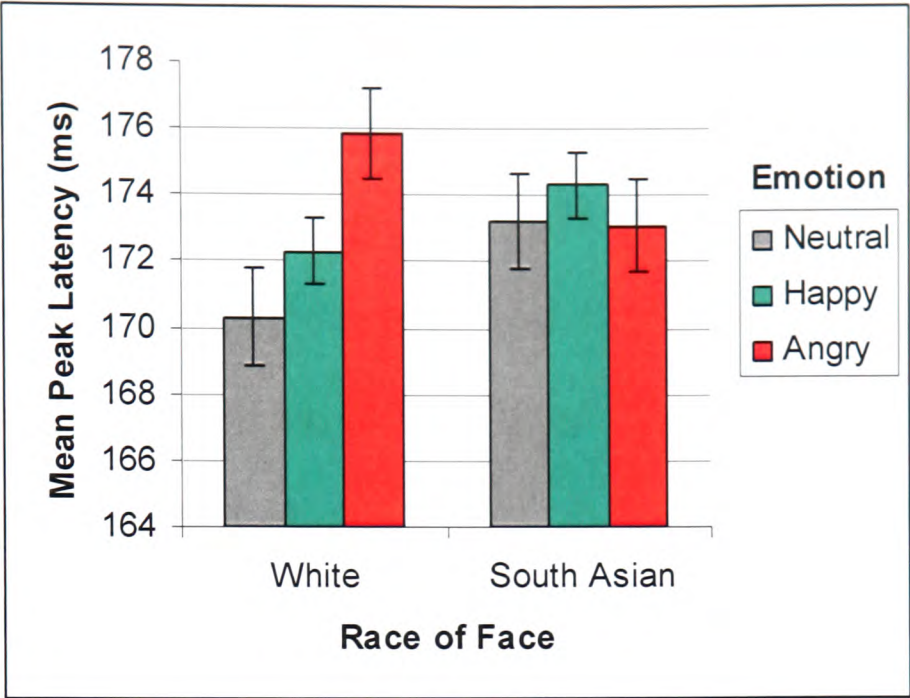


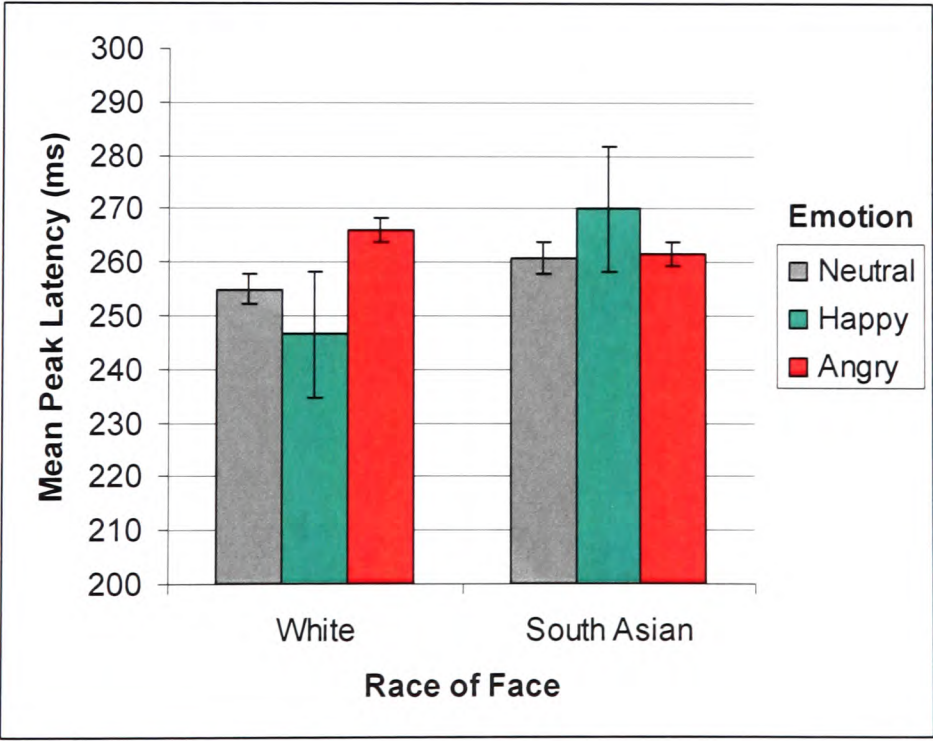
Figure 9.2. The Race by race of face by emotion interaction on the N170 at PO8 for South Asians only

The three-way interaction of Race of participant by race of face by emotion significantly modulated the latency of the P240 component, $F(1.74, 40.02)=3.25, p<.05, \eta p^2=.13$ (see Figure 9.3). Follow-up analyses were performed per subgroup. For White participants, a marginal race of face main effect was observed, $F(1, 11)=3.66, p=.07, \eta p^2=.22$, whereby White faces elicited earlier peaks than South Asian faces. This effect was further qualified by a marginal race of face by emotion interaction, $F(1.64, 18.07)=3.10, p=.07, \eta p^2=.20$. Within-subjects contrasts for White participants showed that White angry faces peaked marginally earlier than neutral and happy faces, $F(1, 11)=3.84, p=.06, \eta p^2=.26$, and White neutral faces peaked marginally earlier than White happy faces, $F(1, 11)=3.92, p=.06, \eta p^2=.26$. However, no latency difference was observed for South Asian neutral, happy or angry faces.

³¹ All post-hoc within subjects contrasts performed in this experiment were difference contrasts. As the factor of emotion had three levels, the difference contrasts allowed for comparison between one facial expression and another, or between one expression and the other- two depending on the nature of the effect.

South-Asian participants also showed a marginal interaction effect of race by emotion on the latency of the P240, $F(1.53, 18.41)=3.39, p=.07, \eta p^2=.29$. Within-subjects contrasts for South Asian participants demonstrated that South Asian angry faces peaked earlier than South Asian neutral and happy faces, $F(1, 12)=4.21, p=.05, \eta p^2=.29$, and the P240 peak to South Asian neutral faces was marginally earlier than happy faces, $F(1, 12)=3.98, p=.07, \eta p^2=.22$. For South Asian participants, White angry faces elicited a similar peak latency to South Asian angry faces, marginally earlier than White neutral and White happy faces, $F(1, 12)=3.30, p=.07, \eta p^2=.21$; White neutral and happy faces did not show a difference in peak latencies. That is, White participants elicited significantly different peak latencies to White emotional faces in the order of angry, neutral and happy, and elicited significantly later peaks to South Asian faces but no peak latency differences for South Asian faces were observed. Conversely, South Asian participants showed different P240 peak latencies to both own-race and other-race faces.

a) White Participants



b) South Asian Participants

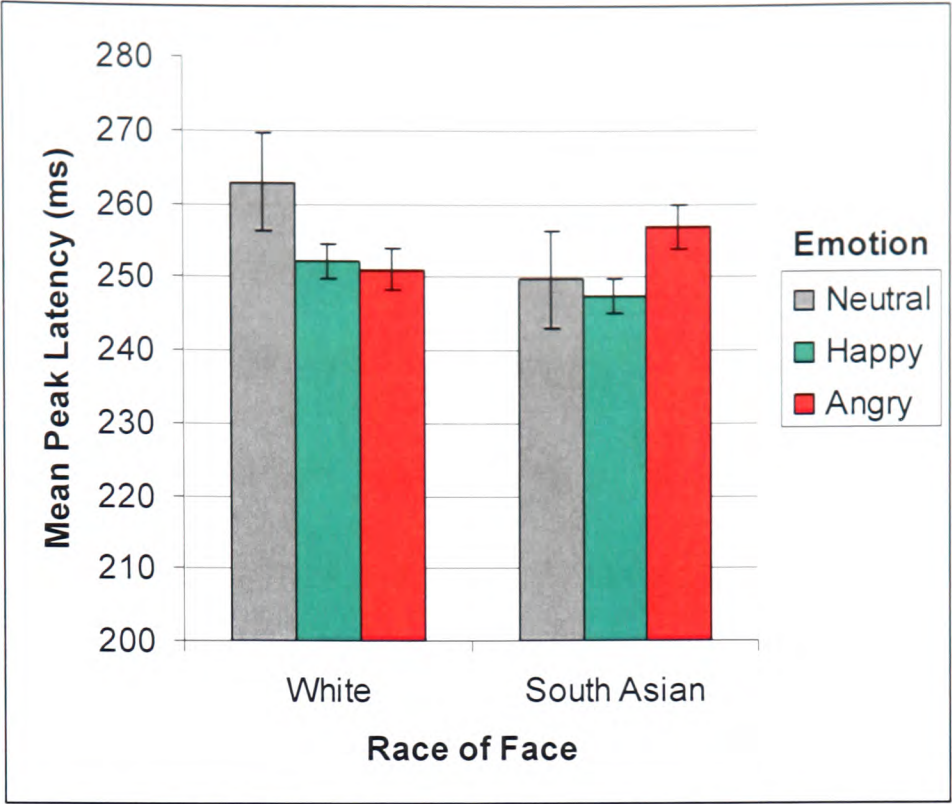


Figure 9.3. The Race by race of face by emotion interaction on the latency of the P240 at TP8 for (a) White participants, and (b) South Asian participants.

Finally, on the mean amplitude of the P300, emotion interacted with electrode site, $F(1.01, 43.85)=4.65, p=.01, \eta p^2=.31$, such that the effect was largest at CP3/CPZ/CP4, and further interacted with Race of participant and race of face, $F(1.91, 43.85)=3.84, p<.05, \eta p^2=.28$ (see Figure 9.4).

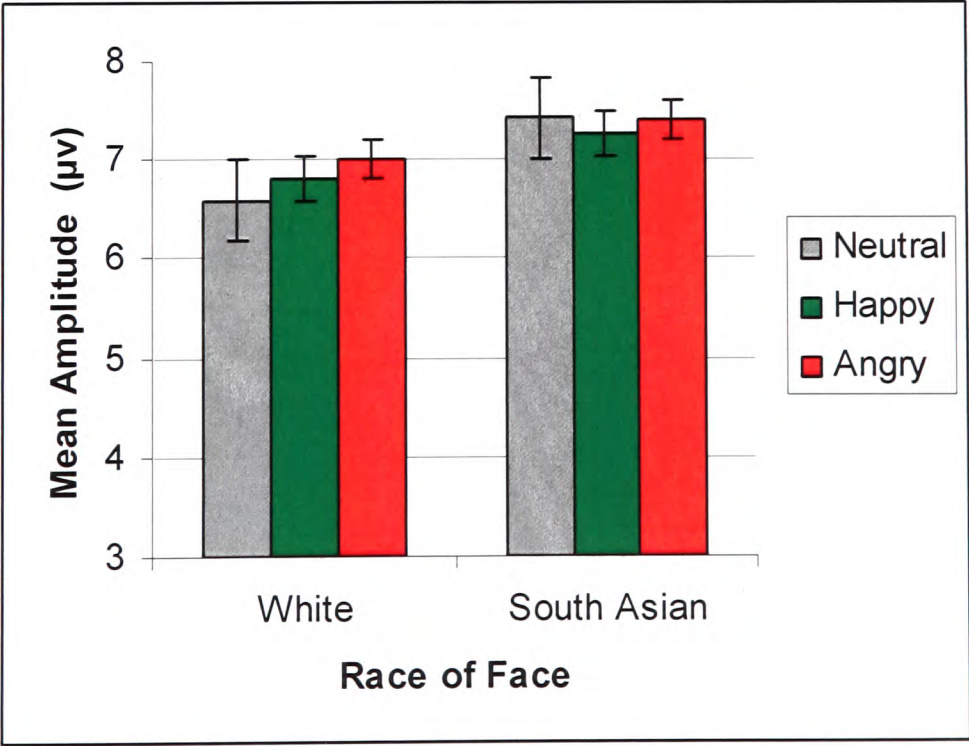
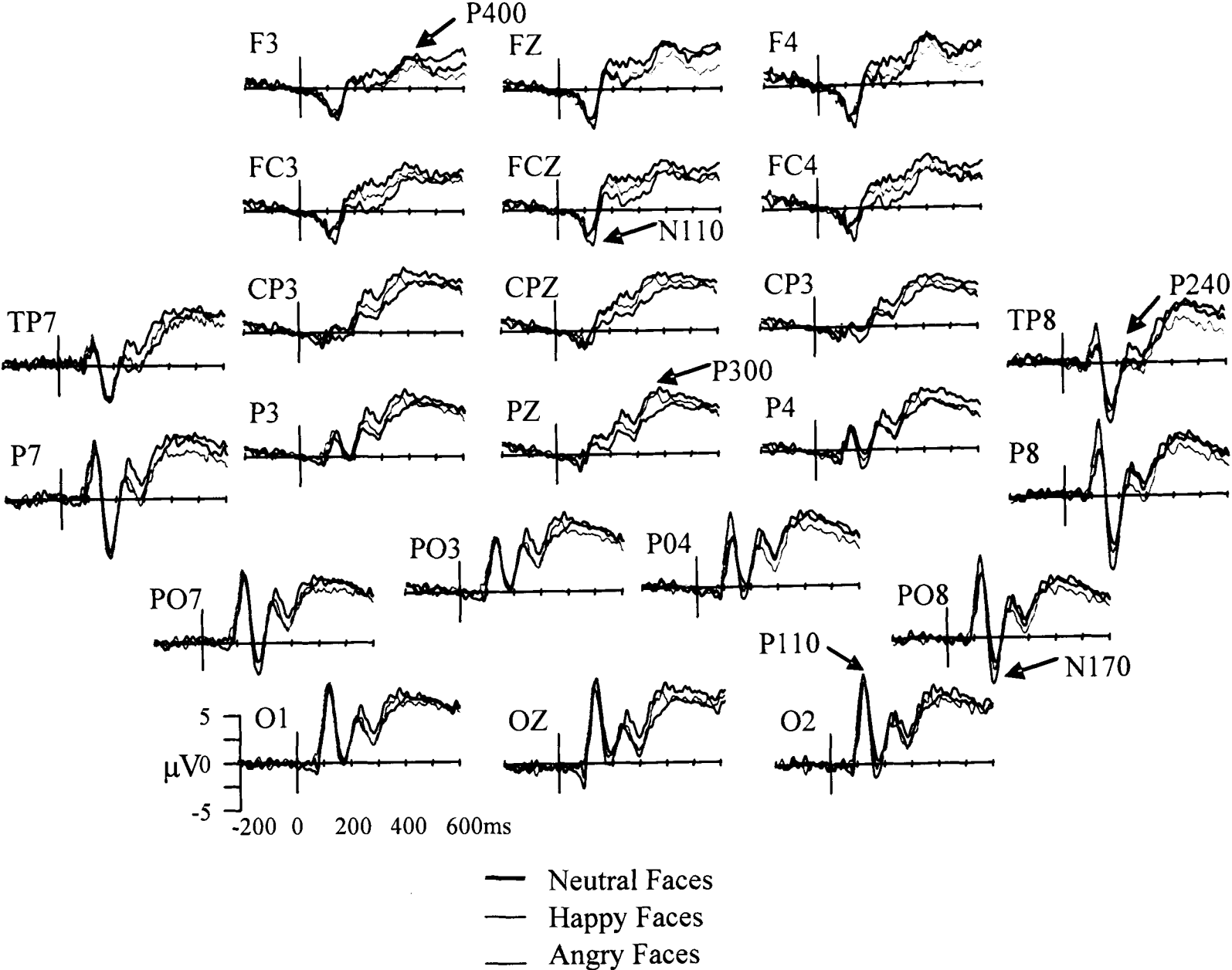


Figure 9.4. The Race by race of face by emotion interaction on the mean amplitude of the P300 averaged across CP3/CPZ/CP4 for South Asian participants.

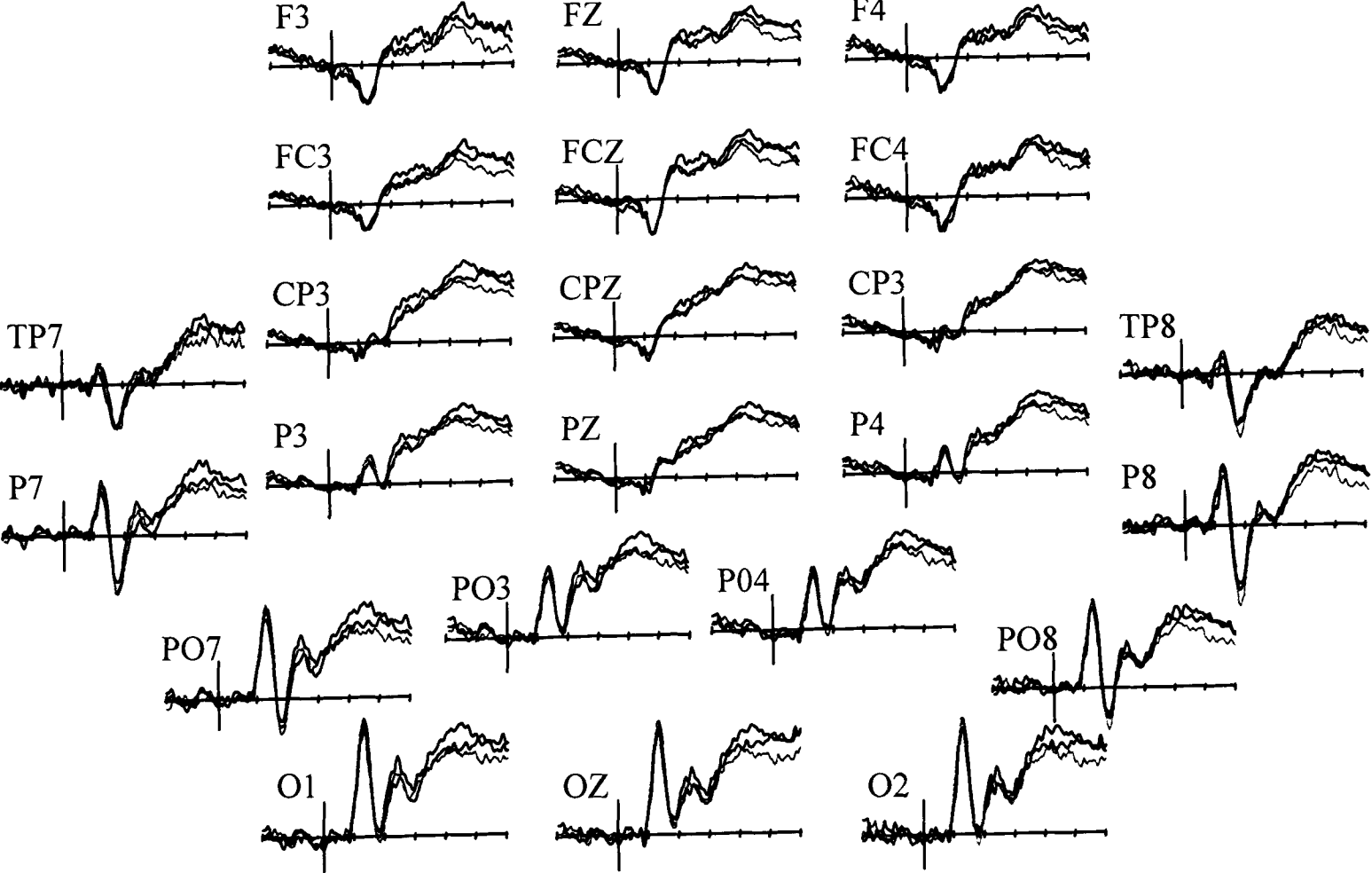
Subsidiary analyses revealed that the race of face by emotion interaction was only significant for South Asian participants, whereby at CP3/CPZ/CP4 White neutral and White happy faces elicited significantly smaller peaks than White angry faces and South Asian faces [contrasts for White neutral faces compared to White angry and South Asian faces, $F(1,12)=4.01$, $p<.05$, $\eta p^2=.29$, and White happy faces compared to White angry and South Asian faces, $F(1,12)=3.79$, $p=.05$, $\eta p^2=.26$].

In sum, the differences in own- versus other-race face processing of emotion were evident on the N170, P240 latencies and the P300 mean amplitude (see Figure 9.5 for waveforms).

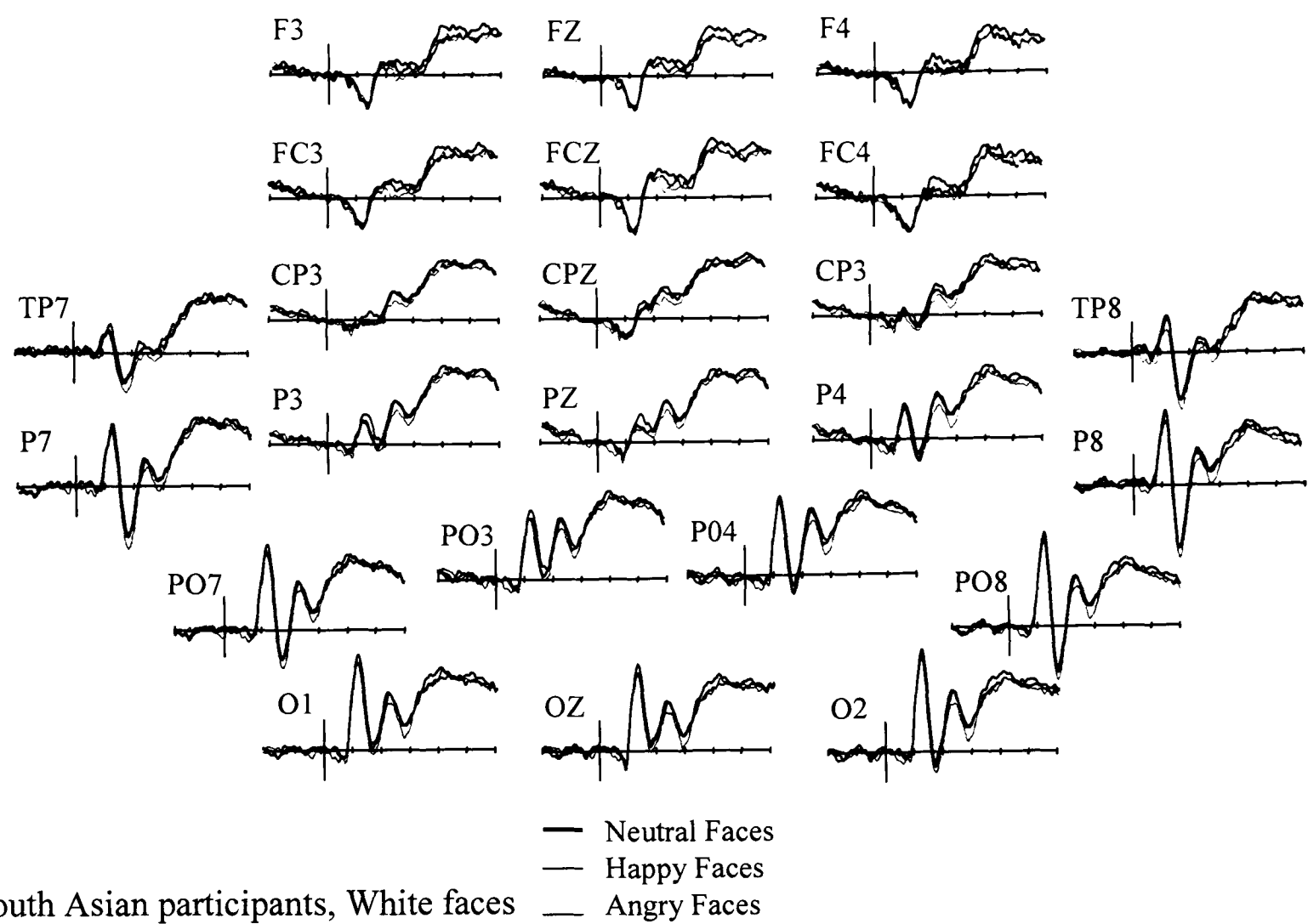
a) White participants, White faces



b) White participants, South Asian faces



c) South Asian participants, South Asian faces



c) South Asian participants, White faces

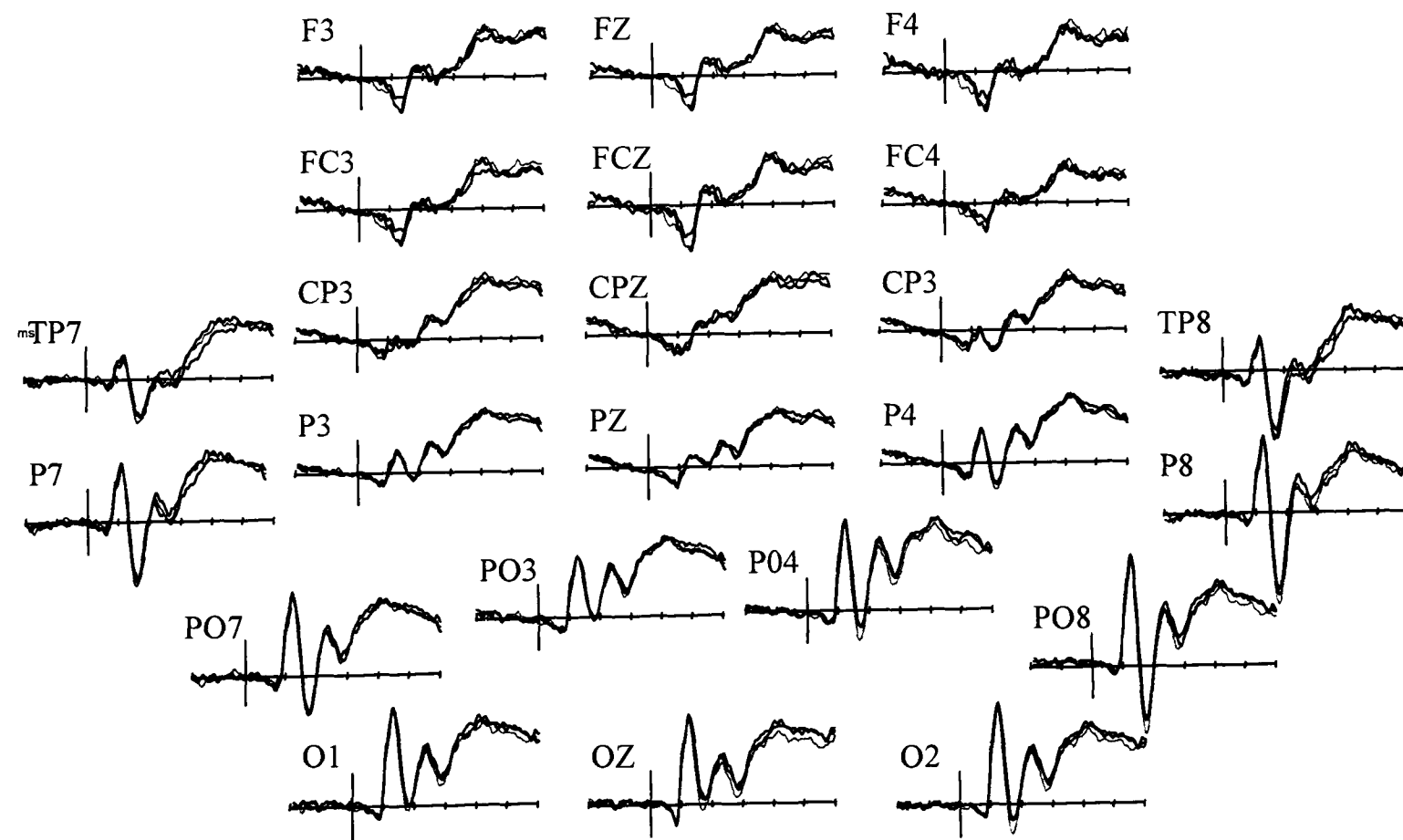


Figure 9.5. ERP grand average waveforms of 23 of the 74 electrodes recorded. ERPs to neutral, happy, and angry faces overlaid for a) White participants looking at White faces, b) White participants looking at South Asian faces, c) South Asian participants looking at South Asian faces, and d) South Asian participants looking at White faces.

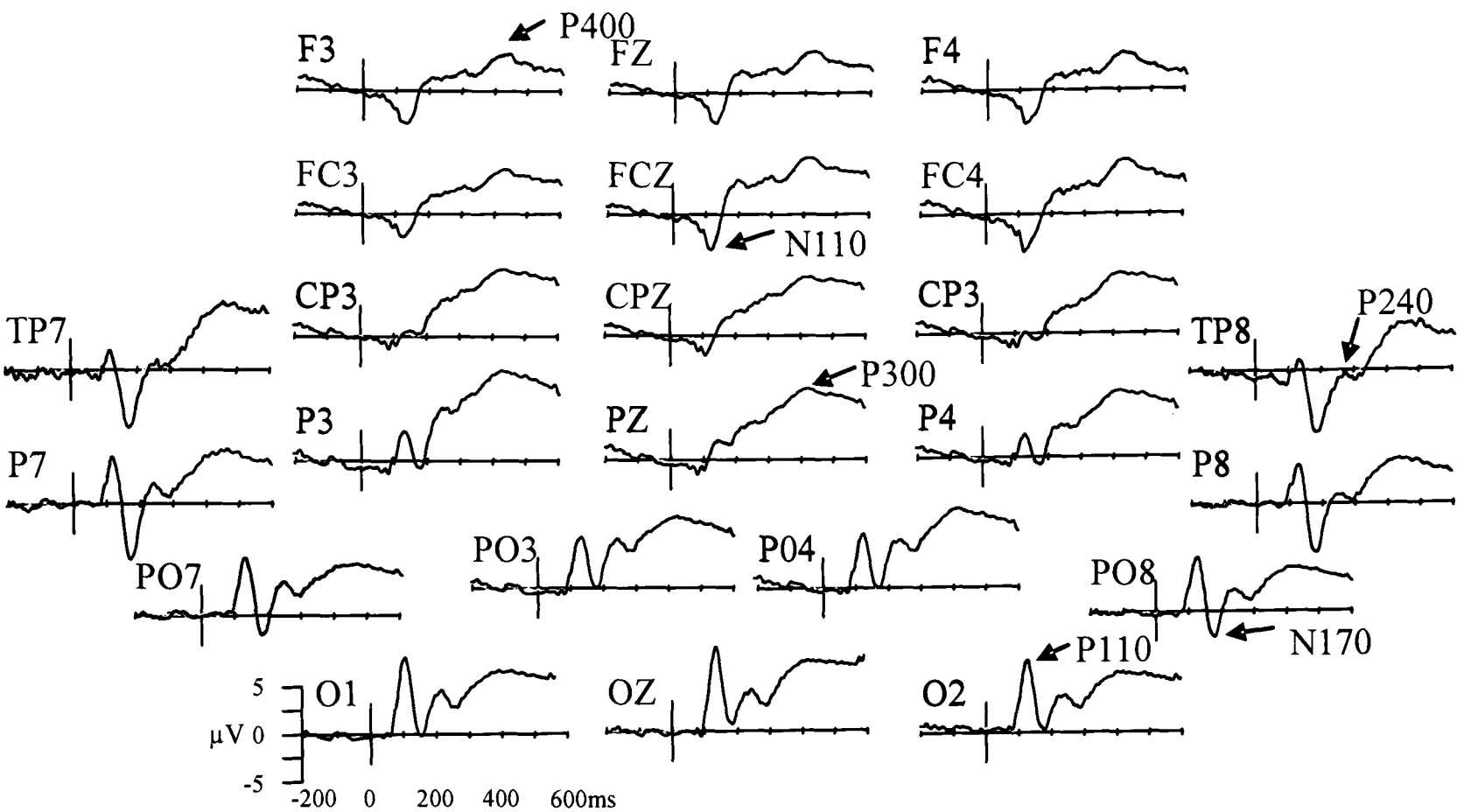
Interaction of Race of participant by race of face

The interaction of Race of participant by race of face modulated the N170, the P240 and the P400 components (see Figure, 9.6 for waveforms). Race of participant interacted with race of face and electrode site, modulating the mean amplitude of the N170 component, $F(1, 23)=5.59$, $p<.05$, $\eta p^2=.21$. Subsidiary analyses were performed for White versus South-Asian participants at PO7/PO8. Separate ANOVAs revealed that for South-Asian participants only, the effect of race of face was significant, $F(1, 12)=4.30$, $p=.05$, $\eta p^2=.28$, whereby South-Asian participants showed a larger N170 to White versus South-Asian faces. White participants did not show a significant difference in the mean amplitude of the N170 to White versus South-Asian faces.

The mean amplitude of the P240 component was modulated by a marginal interaction of Race of participant by race of face, $F(1, 23)=3.33$, $p=.07$, $\eta p^2=.13$. Subsidiary analyses revealed that for White and South Asian participants mean amplitudes for own-race faces were higher than for other-race faces. That is, White participants showed a larger P240 to White faces than South Asian faces, $F(1, 11)=4.76$, $p<.05$, $\eta p^2=.26$, whereas South Asian participants showed a larger P240 to South Asian faces than White faces, $F(1, 12)=4.32$, $p=.05$, $\eta p^2=.22$.

The interaction of Race of participant by race of face independent of emotion, modulated face processing on the latency of the P400, $F(1, 23)=7.85$, $p<.01$, $\eta p^2=.26$. Although mean peak latencies suggested that participants elicited earlier P400s for other-race than own-race faces, subsidiary analyses by Race of participant revealed this interaction was only significant for South Asian participants, $F(1, 12)=17.52$, $p<.001$, $\eta p^2=.59$. That is, South Asian participants elicited earlier P400s to White faces than South Asian faces.

a) White participants



White Faces

b) South Asian participants

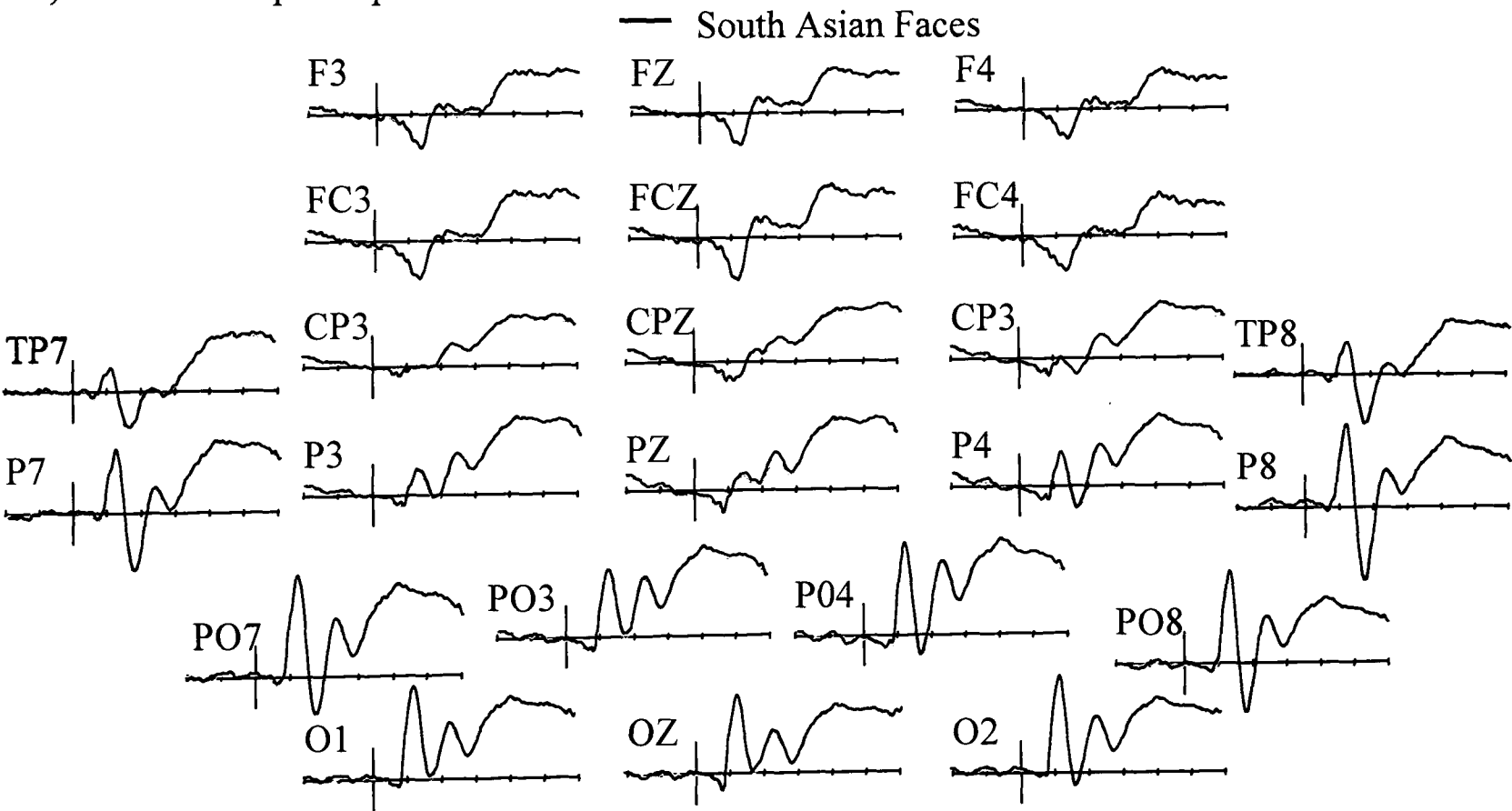


Figure 9.6. ERP grand average waveforms of 23 of the 74 electrodes recorded. ERPs to White faces are overlaid with South Asian faces (all expressions) for comparison a) White participants and b) South Asian participants.

Race of face

In the current experiment, an independent effect of race of face was only evident on the mean amplitude of the P110 and interacted with electrode site, $F(1.44, 33.02)=4.76, p<.05, \eta p^2=.32$. That is, both White and South Asian participants showed a larger P110 to White versus South Asian face stimuli at PO3/PO4. This finding replicates the colour effect on the P110 in Experiment 5, whereby light faces elicited a larger component than dark faces.

Emotion

Only on the early N110 did emotion modulate processing independently of race of face or Race of participant. This effect was evident on the mean amplitude of the frontal N110, $F(1.61, 36.92)=4.05, p<.05, \eta p^2=.21$. Post hoc tests of within-subjects contrasts revealed that this component was larger for happy and angry faces than neutral faces, $F(1, 23)=4.72, p<.05, \eta p^2=.17$.

Qualified by the preceding Race of participant by race of face effects, emotion also modulated the mean amplitudes of the N170 and P240. During face structural encoding, emotion modulated the amplitude of the N170, $F(1.84, 42.39)=3.88, p<.05, \eta p^2=.14$, and further interacted with electrode site, $F(1.95, 44.79)=5.87, p<.01, \eta p^2=.20$, such that, at P7/P8, happy faces elicited a larger negative component than neutral or angry faces, $F(1, 23)=9.91, p<.01, \eta p^2=.30$. Furthermore, emotion modulated the mean amplitude of the P240, $F(1.99, 45.86)=5.12, p<.01, \eta p^2=.19$, and interacted with electrode site, $F(1.69, 38.86)=4.88, p<.05, \eta p^2=.18$, such that the effect of emotion was maximal at TP8. Within-subjects contrasts demonstrated that neutral faces elicited a larger negative peak than happy and angry faces, $F(1, 23)=11.71, p<.01, \eta p^2=.34$.

Correlations between neural component effects of Race of participant by race of face by emotion and social variables

The interaction of Race of participant by race of face by emotion was seen on the latency of the N170, the latency of the P240 and the mean amplitude of the P300. As in the previous chapter, contrast scores of peak latencies for the N170 and P240 and of mean amplitude for the P300 were computed, representing the interaction effect of race and emotional expression (Ito & Urland, 2004). Correlational analyses were used to investigate which social variables (implicit racial bias and questionnaire measures) may be linked to the neural component effects of Race of participant by race of face by emotion in the current experiment. That is, difference scores of latencies of the N170 and the P240 and the mean amplitude of the P300 were generated for: a) White emotional minus White neutral faces versus South Asian emotional minus South Asian neutral faces, and b) emotional White versus emotional South Asian faces. To maximize sensitivity, contrasts were computed at the electrode where latency scores were computed and the component was maximal (PO8 for the N170, CPZ for the P240, and PZ for the P300). These scores were subsequently entered into bivariate correlations with the IAT *D*-scores (average *D*-score across all three IATs), and the questionnaire measures.

The IAT *D*-scores were found to correlate marginally with the latency contrast scores computed for the interaction of race of face by emotion for South Asian participants on the N170, $r = -.48$, $p = .09$. That is, South Asian participants who demonstrated less anti-White/pro-South Asian bias on the IAT also showed less difference in own- versus other-race emotional versus neutral face processing on the N170. Furthermore, *D*-scores of South Asian, but not White participants, were also significantly correlated with the race of face by emotion interaction on the P240, $r = -.77$, $p < .01$, whereby participants reporting less anti-White/pro-South Asian bias on the IAT

also demonstrated less of a difference in own- versus other-race emotional versus neutral face processing, whereas those reporting more anti-White/pro-South Asian bias on the IAT showed greater difference in own- versus other-race emotional versus neutral face processing on the P240.

Measures from the questionnaire were found to correlate with the Race of participant by race by emotion effect on the N170, the P240 and the P300. As post-hoc results of ERP component analyses revealed that only South Asian participants showed a race by emotion effect on the N170 and the P300, only correlations with South Asians' components were conducted on the N170 and P300.

Bivariate correlations between N170 contrast scores and questionnaire measures demonstrated that for South Asian participants, social-contact and intergroup anxiety were found to correlate with the contrast scores for White versus South Asian emotional faces, $r = -.55$, $p < .05$, $r = .56$, $p < .05$, respectively. That is, the greater the other-race contact South Asian participants reported, the less of a difference in their peak latency scores was observed to own- versus other-race emotional faces on the N170. Moreover, intergroup anxiety was correlated with White versus South Asian emotional face processing, such that less participant-reported anxiety was linked to a reduced interaction effect on the N170.

The interaction of Race of participant by race of face by emotion on the P240 was also correlated with questionnaire measures. For White participants, opportunity for contact, $r = -.58$, $p < .05$, social-contact, $r = -.62$, $p < .05$, individuating experience, $r = -.66$, $p < .05$, and perceived outgroup homogeneity scores, $r = .64$, $p < .05$ significantly correlated with the race of face by emotion interaction on latency of the P240. That is, participants reporting high opportunity for contact, social-contact, and individuating experience showed a reduced difference between latency scores to own- versus other-race emotional

versus neutral faces on the P240. White participants who perceived the outgroup (South Asians) as very similar showed greater difference in peak latencies to own- versus other-race emotional versus neutral faces. Moreover, for White participants, perspective taking was correlated with contrast scores for White versus South Asian emotional faces, $r = -.64$, $p < .05$, such that participants who reported higher levels of other-race perspective taking showed less of a difference in own- versus other-race emotional face processing on the P240. For South Asian participants, individuating experience was found to correlate with the observed race of face by emotion interaction, $r = -.53$, $p < .05$, such that greater contact and experience was linked to less difference in participants' peak latencies to own- versus other-race emotional versus neutral faces. Furthermore, South Asian participants' intergroup anxiety, $r = .55$, $p < .05$, empathy, $r = -.57$, $p < .05$, and perspective taking scores, $r = -.61$, $p < .05$, were correlated with contrast scores for White versus South Asian emotional faces on the P240. Less intergroup anxiety, greater perspective taking and empathy were linked to less of a difference in peak latencies to own- versus other-race emotional faces.

Finally, questionnaire measures significantly correlated with the race of face by emotion interaction for South Asians on the mean amplitude of the P300. Correlations showed that individuating experience correlated with the race of face by emotion interaction, $r = -.54$, $p = .05$, such that participants reporting greater other-race individuating experience showed less of a difference in the mean amplitude of the P300 to own- versus other-race emotional versus neutral faces. Moreover, social-contact, and intergroup anxiety were correlated with contrast scores for White versus South Asian emotional faces on the P300, $r = -.66$, $p < .05$, and, $r = .59$, $p < .05$, respectively. That is, participants reporting greater social-contact showed less of a difference in own- versus other-race emotional face processing, whereas those who reported more intergroup anxiety showed

a greater difference in own- versus other-race face processing on the mean amplitude of the P300. No further correlations between neural components and questionnaire measures were observed.

9.4 Discussion

The current experiment investigated the influence of race and emotion on face processing in White and South Asian participants. The present study sought to replicate race-related modulations observed in Chapter 7, as well as race of face by emotion modulations reported in Chapter 8. Overall, findings in the current experiment showed a similar pattern to those reported in the previous chapters. That is, for both groups of participants, race of face and emotional expression independently modulated very early stages of processing, whereas these factors both affected face structural encoding and later emotion-sensitive and face-sensitive components

Emotion and race of face processing were observed to modulate only very early components independently of Race of participant and one another. As found and discussed in the previous experiment, the N110 observed here was modulated by emotion. The frontal N1 has previously been described as sensitive to emotional expression (Holmes et al., 2003), and the current findings replicate this effect. Holmes and colleagues (2003) discussed this component as potentially part of neural circuitry from the prefrontal cortex with direct links to subcortical structures, such as the amygdala (Kawasaki et al., 2001), acting as an early warning system. This N110 component is further described as reflecting automatic emotional processing, and the findings in the previous chapter and the current experiment support the sensitivity of this component to emotional content.

Race of face affected the visual P110 component, independently of Race of participant and emotion. White faces elicited a larger component than South Asian faces in both White and South Asian participants. This race modulation on the P110 replicated the colour effect observed in Experiment 5, whereby white faces elicited a larger component than dark faces. As the South Asian face stimuli were darker than the White face stimuli this colour modulation is similar to that found in Experiment 5. It may be that this race modulation would not be observed when comparing White and fair coloured East Asian faces or with Albino faces. As such, these results confirm that race modulations on the P1 are likely colour, rather than race-related.

During the following stages of face processing the variables of Race of participant, race of face and emotion were processed interdependently of one another. On the N170, P240 and P300 all three variables (Race, race and emotion) modulated face processing. The effect of Race of participant by race of face by emotion on the N170 showed that South Asian participants had a delayed peak to other-race angry faces compared to own-race faces and other-race neutral and happy faces. This effect shows the sensitivity of the N170 to the structural encoding of other-race emotional expressions whereby other-race angry faces disrupted encoding eliciting the delayed peak. This effect correlated with implicit racial bias (measured by the IAT), as well as social-contact and anxiety. These correlations demonstrate the influence of environmental, social variables on the way in which South Asian participants encoded own- versus other-race faces and offer a provisional explanation for the effect observed on the N170. The correlations of the IAT *D*-scores with face processing suggest that anti-other-race bias/pro-own-race bias may facilitate or hinder other-race face processing during structural encoding. Furthermore, the social variables of contact and intergroup anxiety influenced face processing. The correlation of this effect with social-contact replicates findings in the

previous two experiments, and offers further support for the role of other-race contact in facilitating more fluid other-race face processing. The correlation of the race by emotion effect with intergroup anxiety, however, is the first reported to date, and shows that individuals expressing greater other-race anxiety elicit a larger race by emotion effect on the N170. Intergroup anxiety is considered to narrow the focus of attention and perception (Easterbrook, 1959; Kahneman, 1973; Stephan & Stephan, 1985), and this can lead to an inattention to specific details or cues (Heuer & Resiburg, 1990) and a reduction in the processing capacity (Mueller & Thompson, 1984), which may be necessary for face identification. Stephan and Stephan (1985) have suggested that high levels of anxiety result in minimal processing of social information, and cognitive shortcuts, such as stereotypes, are used instead of more detailed cognitive appraisal. The effect observed in the current experiment suggests that participants who experienced greater other-race anxiety may have narrowed and in turn inhibited their perception of other-race faces. As such, participants who expressed greater other-race anxiety had greater difficulty encoding other-race faces at a neural level.

The race by emotion effect was not evident on the N170 for White participants. White participants, however, reported significantly less other-race anxiety compared to South Asians, and it may be that their reduced other-race anxiety facilitated more fluid face processing during structural encoding. The direct effect of anxiety on face structural encoding would have to be directly tested in an anxiety priming scenario in order to substantiate this interpretation.

A cross-over Race of participant by race of face by emotion effect was observed on the P240. That is, White and South Asian participants elicited larger components to own- versus other-race faces, and both race groups showed race of face by emotion effects on the latency of the P240. Specifically, own-race angry faces were processed

earlier than own-race neutral and happy faces. For White participants, other-race faces were processed later than own-race faces and showed no difference in peak latencies. For South Asian participants, however, angry other-race faces were processed earlier than other-race neutral and happy faces, and these latencies were not significantly different from those to own-race faces. This effect suggests that for both race groups, the P240 is more sensitive to own-race than other-race facial expressions, as both groups elicited different peak latencies to own-race angry versus neutral versus happy faces. Moreover, both White and South Asian participants processed angry faces prior to other faces. Interestingly, White participants only showed this early effect for own-race angry faces, whereas South Asian participants processed own-race and other-race angry faces prior to the other expressions. These findings demonstrate that own-race threatening (angry faces) elicit earlier processing than own-race neutral and happy faces. Furthermore, only the minority status group shows the same effect for other-race angry faces. It may be that for White participants, an angry expression elicited by own-race members is an important social signal which requires faster processing than less socially salient expressions (neutral and happy).

Whereas for South Asian individuals, angry expressions from both own-race and majority race faces are socially important, as they may see the majority group as well as their own-group members as a threat, majority group members (White) may only consider majority group threat signals as relevant. Members of the minority group, South Asians, may have learned to attune to White outgroup members. This effect also provides evidence that the own-race emotion-recognition effect is mediated by group status, as the South Asian (minority group) participants have demonstrated similar own- and other-race face processing on the P240, whereas the White (majority group) participants have shown differential own- versus other-race emotional face processing. As described in the

previous chapter, effects of emotion on the mean amplitude of the P240 have been frequently discussed (Eimer et al., 2003; Halit et al., 2000; Latinus & Taylor, 2005; Stekelenburg & de Gelder, 2004). However, effects on the latency of this component have not yet been found. Likewise, this is the first time this component has been explored in relation to other-race emotion processing. The current findings demonstrate that the latency of the P240 is sensitive to differences in both race and emotions in face stimuli. These findings support the involvement of the P240 in face encoding and identification, which are necessary for distinguishing between own and other-race faces and emotional expressions.

The race by emotion effect on the P240 for both White and South Asian participants correlated with social variables. For White participants, greater other-race contact (opportunity for, social and individuating) facilitated other-race face processing. These findings are consistent with the previous two experiments which found other-race contact was linked to increased fluidity in other-race face processing. Moreover, White participants reporting greater perceived outgroup homogeneity showed greater disparity in own- versus other-race face processing on the P240. Specifically, participants who perceived other-race members to be more similar than own-race members showed greater differences in processing own- versus other-race faces on the P240. Lastly, White participants reporting greater perspective taking of other-race individuals also showed more fluid own- versus other-race emotional face processing. The correlations observed here suggest a firm link between social influences and the way participants perceive own- versus other-race emotional faces.

The race by emotion effect observed for South Asian participants on the P240 was correlated with implicit racial bias and questionnaire measures. Specifically, participants showing smaller own-race effects on the ERP task showed less difference in own- versus

other-race face processing on the P240. This finding directly links the own-race effect in recognition to the interaction between race of face and emotion observed at a neural level. Furthermore, implicit racial bias was correlated with the race by emotion effect on the P240. That is, South Asian participants with stronger anti-White/pro-South Asian bias on the IAT, showed a greater race by emotion effect on the P240. This finding follows that observed on the N170, and confirms that neural processing is influenced by implicit bias and associations. Furthermore, social measures correlated with the race by emotion effect on the P240. South Asian participants reporting more experience, greater other-race empathy and perspective taking showed less difference in own- versus other-race emotional face processing. Furthermore, intergroup anxiety was correlated with the race by emotion effect for South Asians, and as observed on the N170, participants reporting greater intergroup anxiety showed greater difference in processing own- versus other-race faces.

The final Race of participant by race of face by emotion interaction was evident on the mean amplitude of the P300. As discussed in the previous chapter, the P300 is sensitive to emotional valence (Cuthbert et al., 2000), and the present findings confirm the sensitivity of this component not only to emotional content, but to social content of stimuli as well. Subsidiary analyses revealed that, although both racial groups showed emotion effects on the P300, the interaction of race by emotion on this component was only significant for South Asian participants. Furthermore, this effect was correlated with questionnaire measures of social-contact, individuating experience and intergroup anxiety.

The correlations with the race by emotion effect for South Asian participants on the P300 are in line with those observed on the N170 and the P240, whereby contact and anxiety appear to be salient social influences on own- versus other face processing in the

brain. That is, greater social and individuating experience appears to reduce differential own- versus other-race face processing (emotional and neutral) in the brain. Moreover, the effect of intergroup anxiety was observed consistently on all three race by emotion modulations of ERP components observed for South Asian participants. These findings confirm that social variables are highly influential on the way in which we process own and other-race faces and emotional expressions in our environment.

In contrast to the previous chapter, participants did not show a race of face by emotion effect on the late stage of face processing, the P400. A Race of participant by race of face interaction was evident. However, only South Asian participants showed an earlier peak for other-race faces, whereas White participants showed no such effect. It may be that the different race stimuli used in the present experiment can account for this disparity in effects. The different race of face context in both experiments as well as the difference in tasks may in part explain the difference in effect on the late P400 component.

Overall, the current experiment showed that differential race of face processing was more evident in South Asian compared to White participants. This finding is contrary to what one might have expected if race and emotion processing effects were due to group status. That is, if the majority group demonstrated greater difficulty in discriminating other-race faces than did the minority group at the neural level, the White participants should have demonstrated more race by emotion modulations on timecourse of face processing. This was not the case. Only on the latency of the P240 could the Race of participant by race of face by emotion effect be considered a potential effect of group status. Moreover, taken together, the correlations between the race by emotion effects on face processing at a neural level and social variables such as implicit racial bias, contact, anxiety, and perceptions of the other-race, suggest that the different effects observed in

White and South Asian participants are not necessarily due to group status. Rather, it appears that social variables are salient influences on face processing, on an individual-by-individual basis. That is, specific personal experience with other-race individuals and perceptions of other races shapes the way the individual perceives (socially and at a neural level) members of other-racial groups. It does not appear that group status alone plays a salient role in own- versus other-race emotional face processing, but rather, individual members of different racial groups may have similar social experiences and levels of other-race-directed anxiety, which may account for group effects.

In sum, the current experiment replicated certain race and emotion effects previously discussed in this Thesis. In the current experiment, race of face and emotion were shown to influence very early stages of processing independently. However, these two factors, as well as the Race of participant interdependently modulated face processing from structural encoding. These findings suggest that information about race of face and emotion simultaneously influence face processing from as early as 170 ms after stimulus onset, and that these effects continue through later stages of face processing. Yet, these interactions between race and emotion were not equal across both race groups. Own- versus other-race emotional face processing appeared to be less fluid for South Asian participants than White participants. Social variables, and in particular other-race social-contact, individuating experience and intergroup anxiety, were found to be salient influences on own- versus other-race emotional face processing in the brain. It appears that social influences, rather than group status per se, shape individual perceptions and experiences, and it is the social variables which play an important role in facilitating race of face and emotional expression processing in the brain.

Chapter 10

General Discussion

10.1 Overview

Human expertise in face recognition is an established cognitive and neural phenomenon. The influence of social factors, such as race of face and emotional expression, on face processing is, however, less well understood. Therefore, the central aim of this thesis was to explore the own-race effect, typically reported in recognition memory, on perceptual and neural levels. More specifically, by investigating the modulation of the own-race effect by social factors both behaviourally and neurally, a deeper understanding of this phenomenon can be obtained. Furthermore, the link between the own-race effect and social variables such as other-race implicit and explicit biases were investigated in this Thesis.

For the Experiments reported in this Thesis, participants performed novel tasks in which they discriminated morphs of own- versus other-race faces, or identified sequential repeats of own- versus other-race faces. Behavioural measures revealed that the own-race effect in perception of own- versus other-race faces was greater for adults than children, and differed across racial groups. It was also shown that implicit bias against the other-race (as measured by the IAT) and explicitly reported social and individuating other-race experience were the most consistent predictors of the own-race effect. These findings were also replicated at a neural level.

Event-related potential (ERP) recordings during presentations of own- versus other-race faces of neutral or emotional expressions, characterized the neural dynamics of face processing as well as the modulation of stimulus processing by orientation, stimulus colour, race of face and emotional expression. This electrophysiological exploration

highlighted the timecourse of face processing, and the sensitivity of specific stages of processing to race of face and its interaction with emotional expression at a neural level. Race of face consistently affected face processing from early structural encoding stages across all three neurophysiological experiments reported in this Thesis. Moreover, emotion and race interacted to modulate face processing, confirming behavioural reports of an own-race effect in emotion-recognition. Race of face and race of face by emotion effects also varied as a function of Race of participant. That is, modulatory effects were different for the majority (White) versus the minority (in this case South Asian) group. However, group status alone was not enough to account for the findings. Rather, social variables - in particular implicit racial bias, social-contact and individuating experience - influenced race of face (and race by emotion) processing in the majority group. In particular, implicit racial bias, intergroup anxiety, social-contact and individuating experience influenced minority group face information processing. These findings suggest that social variables have a salient influence on race of face information processing.

The specific findings from each experiment have been considered in their respective discussion sections. This chapter will provide a brief summary of the main results presented in this Thesis, followed by a methodological discussion of their implications for the broader topic of how race information is extracted from the face, and highlighting the important areas for future research.

10.2 Summary of results

Experiment 1 (Chapter 2) investigated the own-race effect developmentally in three age-groups of White participants: primary school students, secondary students, and university students. A robust own-race effect was found for each of the three groups, such

that the participants were significantly better at perceptually discriminating own- versus other-race faces. Furthermore, this effect was significantly larger for the two oldest groups. Despite testing a battery of explicit racial bias and contact measures, however, no specific social variables were found to predict this effect significantly across all three developmental groups.

Experiment 2 (Chapter 3) narrowed the own-race effect investigation of Chapter 2, to a case study of two male secondary schools (one White, one South Asian) in a racially volatile city in Northern England. White and South Asian participants took part in the same perceptual discrimination task employed in Chapter 2, and completed a social-contact questionnaire, which extended the measures tested in the previous chapter and made them specific to the age-group in question. Results showed an own-race effect only in the racial majority group (White), and found that individuating experience was a significant predictor of this effect. That is, the more personal individuating experience the participants had with South Asians, the less of an own-race effect they demonstrated. South Asian participants were equally accurate at discriminating between South Asian and White faces. This effect was attributed to their minority-group status in a majority-White country. The South Asian participants were undoubtedly exposed to countless White personalities in the media and in positions of authority (teachers, community leaders), potentially accounting for their equal facility with own and other-race faces.

Chapter 4 discussed the findings of two further experiments. Experiment 3 tested White and Black university students on the face perceptual discrimination task employed in the previous two chapters. This behavioural task was paired with the Implicit Association Test (Greenwald et al., 1998) as a measure of other-race implicit bias and an extended social experience questionnaire. Results found a weak own-race effect, and the IAT recorded anti-Black bias in White participants and no-bias in Black participants. In

Experiment 4, the perceptual discrimination paradigm was altered to incorporate Signal Detection Theory (SDT). That is, hits as well as false alarms were analyzed in order to provide a more sensitive accuracy measure for own- versus other-race face discrimination. White and South Asian participants were tested on White, South Asian and Black faces; and completed the IAT to measure own- versus other-race implicit biases. Results found that SDT did, in fact, provide a sensitive measure for detecting the own-race effect, as an own-race effect was detected in both White and South Asian participants for both other-race groups (White/South Asian and Black faces). Furthermore, individual differences were observed; other-race face accuracy scores were correlated, such that individuals who had difficulty discriminating faces of one other race also had difficulties discriminating faces of the second other-race. The own-race effects observed for White and South Asian participants subsequently correlated with the IAT *D*-scores. The own-race effects further correlated with other-race contact (particularly individuating experience) and other social variables measured in the current study. Experiments 3 and 4 offered support for the link between implicit racial bias, other-race experience and the perceptual own-race effect.

Experiment 5 (Chapter 7) used ERPs to investigate the effect of race on face processing. Firstly, the timecourse of face processing was isolated by comparing topographies and morphologies of brain electrical activity elicited by faces compared to control stimuli, and comparing processing of upright and inverted faces. The effect of race was subsequently characterized, controlling for differences in stimulus colour as well as race. Race was determined to influence face processing as early as 170 ms post stimulus onset. Prior to face structural encoding, components were sensitive to stimulus colour rather than race. Other-race social-contact and individuating experience correlated

with the race effects observed from structural encoding, and greater other-race experience was considered to facilitate processing of faces of the other-race.

Experiment 6 (Chapter 8) investigated the interaction between processing race and emotional expression during face recognition at the neural level. Experiment 6 replicated race-related findings from Experiment 5, and demonstrated the modulation of neural components related to face recognition by emotional expression, as well as by the interaction of both social factors: race and emotion. White participants viewed White and Black faces. Emotion processing began as early as 100 ms post stimulus onset, however, it did not interact with race of face processing until around 200 ms post stimulus onset. The interaction between race and emotion on the P240 emotion-recognition and the P400 face-recognition components demonstrated differential emotional face processing for own- versus other-race faces. These effects correlated with implicit racial bias and other-race experience, suggesting that implicit racial bias and other-race individuating contact can facilitate emotional face processing of other-race compared to own-race faces.

Finally, Experiment 7 (Chapter 9) sought to investigate the race- and emotion-related effects of Experiments 5 and 6 in majority versus minority racial groups. Specifically, Experiment 7 investigated own- versus other-race emotional face processing in White and South Asian participants looking at White and South Asian faces. Race and emotion factors had differential effects on neural measures of face recognition in White and South Asian participants. These effects were further correlated with social variables - in particular, social-contact and individuating experience for White participants and intergroup anxiety as well as individuating other-race experience and implicit racial bias for South Asian participants. Results suggest that group status alone cannot account for differential race of face processing. Environmental social variables and implicit racial

bias play an important role, affecting the processing of race and emotion on an individual-by-individual basis.

10.3 General conclusions

Combining social, cognitive and neuroscientific theory and methodology from historically distinct fields allows for the exploration of cognitive and neural correlates of social phenomena. Although still in its infancy, this combined methodological approach, known as social-cognitive-neuroscience, has begun to lay the foundation for deeper understandings of the social brain. Research in the area of social-cognitive-neuroscience is innovative, as it can demonstrate a neurological map of the external social influences that have shaped our automatic and unconscious responses. In turn, this research endeavors to demonstrate that humans are not hard-wired for social division by race or group, and therefore potentially offers hope that intergroup biases may be permeable.

Social-cognitive-neuroscience methodology was employed in this Thesis to offer cognitive and neuroscientific evidence which might clarify societal perceptions of race. Investigating the influence of race on face perception - a well-established human expertise - at cognitive and neural levels, allowed for deeper understanding of the anecdotally reported “they all look alike” phenomenon. Moreover, the opportunity to link cognitive and neural effects with social influences, such as other-race experience, enabled further comprehension of social perceptions of race. As race perception and racial bias in today’s society may be culturally influenced (i.e., linked to social norms and the ethnic make-up of the given society) the social component to investigating race-related information processing is paramount. That is, both social and environmental influences may impact the way in which individuals in a given society process race information. However, in order to investigate *how individuals process race information* in the brain,

one must look to cognitive-neuroscientific methodology, in order to investigate these issues in tandem.

Recently, such interdisciplinary explorations have been carried out in the hope of furthering the understanding of how social factors may actively shape neural processes. As discussed in the Introduction section of this Thesis, behavioural, and to a lesser extent neural, evidence suggest that human face expertise can be sensitive to social factors such as race of face or emotional expression. A complete picture of this effect, however, has not yet been obtained. Moreover, prior to the experiments presented in this Thesis, the extent to which social influences affected the processing of race-related information at basic cognitive and neural levels was unknown.

The research described in this Thesis provided evidence suggesting that neurological activation and behavioural responses of race evaluation are heavily shaped by social learning; and that personal experience with members of these groups can modulate bias. More specifically, the experiments in this Thesis demonstrated that the own-race effect is not limited to behavioural measures of recognition memory (Experiments 1-7) or even to other-race faces with drastically different physiognomies (Experiments 1-7). Perceptual own-race effects were seen in children and adults alike (Experiments 1-7). Furthermore, the behavioural effect was reflected in modulations of the neural processing of face stimuli (Experiments 5-7), and both behavioural and neural effects were subject to social influences (Experiments 2-7). These findings extended the notion that a cognitive deficit in recognizing other-race faces has a neural basis, as well as links to social experience – namely personal contact with other-race members. Both the behavioural and neural findings of the own-race effect and the own-race emotion-recognition effect are consistent with previous anecdotal and experimental reports of superior recognition for own- versus other-race faces.

Moreover, the link between the perceptual and neural own-race effect with measures of other-race close personal contact is in line with the contact hypothesis (see Chapter 1: Allport, 1954). That is, greater personal experience with members of other racial groups enables individuals to learn and subsequently generalize the new physiognomic cues of individual other-race faces to the perception of all faces of that racial group. Furthermore, evidence suggests that implicit racial bias and intergroup anxiety, when high, can also influence own- versus other-race face and emotion processing. In sum, individuals with less other-race experience, greater anxiety and implicit racial bias tended to show a robust own-race effect in comparison to individuals with greater other-race experience and reduced implicit bias and anxiety. Taken together, the link between social experience, implicit bias, intergroup anxiety and the own-race effect confirms the significance of environmental, social influences on cognitive and neural information processing from face stimuli.

Differences in the intensity of the own-race effect and in social correlates of the effect were observed between the racial groups tested. Specifically, White participants demonstrated a consistent own-race effect, which was most consistently linked with individuating other-race experience and, in the later chapters, implicit racial bias. Conversely, South Asian participants did not show a consistent own-race effect across all experiments, and yet did show differential own- versus other-race facial expression processing, at a neural level. Nevertheless, differences in own- and other-race face processing for South Asians, like White participants, were also linked to other-race individuating experience and to a lesser extent, social-contact. The neural own-race effect was linked to intergroup anxiety. As the findings in the current Thesis were inconclusive in relation to an own-race effect in Black participants, this would have to be investigated further in future studies in order to determine whether Black participants show a similar

own-race face effect, which is influenced by similar social factors as the effects observed in White and South Asian participants.

Ultimately, these findings have important implications for future research exploring the influence of social factors on cognitive and neural stimulus processing, as well as for research investigating social divisions between racial groups.

10.4 Future studies

The experiments presented in this Thesis provide an effective foundation for future research. Within the domain of race of face processing, experiments thus far have tended to investigate the own-race effect as a phenomenon linked to recognition memory. This Thesis offers both perceptual and neural measures of the own-race effect, which could be further investigated and substantiated with different tasks and experimental paradigms.

Future neurophysiological research investigating the influences of race on emotional face processing could look at the subconscious presentation of own- versus other-race neutral and emotional faces in order to determine whether race of face and social information processing occur automatically, or are only processed consciously (Cunningham et al., 2004; Graham & Lowery, 2004). Neuroimaging research could also investigate the own-race emotion-recognition effect to determine the brain regions and pathways involved in the processing of own- and other-race facial expressions. Moreover, the link between these potential effects and social variables should also be investigated in order to confirm the sensitivity of neural processes to social variables across studies.

As social variables proved to be salient predictors of the own-race effects discussed in this Thesis, future behavioural and neural investigations of the own-race effect could manipulate various social variables, such as contact, individuating experience, anxiety, prejudice, and empathy (to name a few explored here) to determine the direct effects and the extent to which these social variables influence face processing at the cognitive and neural levels (Pause, Ohrt, Prehn, & Ferstl, 2004; Russo, Fox, & Bowles, 1999). For instance, training paradigms could be tested both behaviourally and at a neural level to determine the impact of quantity of contact versus individuating experience on race of face processing. Simultaneous ERP-fMRI recordings to own- and other-race emotional faces could provide a link between the race modulations on the timecourse of face processing and the activity of cortical neural generators. Furthermore, this technique could be investigated in the context of training participants to become experts on other-race faces. A training paradigm would offer further insight into the type of contact which could best reduce the own-race effect and whether, once trained, participants would still show sensitivity to social influences (e.g., prejudice, anxiety, and empathy) on other-race face processing.

Finally, eye-tracking could also be used to investigate the patterns of eye movement involved in encoding own- versus other-race faces and the emotional expressions. Eye movements provide a rich natural measure of perception and attention and could be used to compare face recognition in high prejudice versus low prejudice participants, and/or high anxiety versus low anxiety participants. It may be that individuals with high prejudice or high anxiety use different strategies for scanning and encoding other-race faces than participants low in prejudice and intergroup anxiety. Alternatively, participants with average intergroup anxiety could be tested twice, once to obtain baseline face-scanning eye movements, and another time to experimentally induce

anxiety prior to eye tracking, to determine whether intergroup anxiety does indeed have direct effect on other-race face processing. Such an experiment would need to be carefully counterbalanced to control for training effects and the like.

Practical applications of the research presented in this Thesis include scope for intervention programmes in the educational domain as well as in the workplace. The findings in the current Thesis suggest that contact schemes (with an emphasis on individuating contact) might be successful in reducing intergroup bias in areas where racial segregation is high. For students, these schemes might include school exchanges, community activities and youth clubs aimed at linking White, South Asian, and Black communities in the U.K. and internationally. Any form of integration that encourages close, individuating interracial experience should be emphasized. For adults, be it in the workplace, community committees and clubs, forming links with comparable groups from different racial or ethnic communities might make integration possible and would not only be a positive step for those individuals, but allow them to act as models for their children. These programmes could be successful in any community provided that both the local governments and members are committed to reducing race and ethnic segregation.

The Home Secretary Charles Clark MP launched “Improving Opportunity, Strengthening Society: The Government’s Strategy to Increase Race Equality and Community Cohesion” on January 19, 2005. This strategy set out one strand of the Government’s overall drive to foster the cohesion necessary to enable people from minority and majority communities to work together for social and economic progress. As stated by the Home Office, Community Cohesion is necessary for a strong and healthy society and was recognised following the 2001 disturbances in Burnley, Oldham and Bradford. Reports into the disorder identified a common theme of a lack of

interaction between individuals of different cultural, religious and racial backgrounds in society. The research presented in this Thesis offers evidence in support of the integration of segregated communities.

10.5 Summary

The experiments presented in this Thesis have revealed several main findings, leading to the following general conclusions regarding the nature of own- versus other-race face processing in the brain and its subsequent links to social experience. First, race of face is a salient social factor, which influences how individuals process faces. Second, the own-race effect is consistently evident in members of the majority race whether adult or child. Third, there is evidence of a neural difference in own- versus other-race face processing and emotional expression processing from the stage of face structural encoding. Finally, these perceptual and neural effects are linked to social variables such as implicit racial bias, and most consistently to close personal experience with other-race individuals. Overall, it can be seen that race influences recognition of face identity and emotional expression and the subsequent effects are indeed linked to other-race experience. Ultimately these findings offer support for increasing interracial one-on-one contact in order to decrease interracial biases (social, cognitive and neural) in society.

Although still in its infancy, this research does shed light on the sensitivity of face processing to social factors, in particular race, which are important for daily interactions and communications, as well as for more specific activities such as eye-witness testimony and criminal-identification (Kassin, Tubb, Hosch, & Memon, 2001). Furthermore, this research has implications for race-related divisions in our societies (Rieder, 1985) and intervention programmes, which may work to reduce intergroup bias. In sum, the present research offers potential that social variables, such as individuating experience and

intergroup anxiety, could be manipulated through experience and social programmes to aid in the reduction of racial biases and incite social change.

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