THE EFFECT OF RACE ON THE HOLISTIC PROCESSING OF FACES

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CHAPTER I

INTRODUCTION

It is the common wonder of all men, how among so many million faces, there should be none alike. – Sir Thomas Browne, author and physician, born 1605, died 1682

The world has changed greatly since Sir Thomas Browne's day, not least of all in terms of population. While Sir Thomas marveled at the diversity posed by millions of faces, he likely never conceived of a day when the world would house more than seven billion people. Yet this is reality in the 21^{st} century.

While the average person will encounter a scant fraction of the entire population, the number of individuals we will interact and cross paths with throughout our lifetime is staggering. Nevertheless, every day we rapidly identify the myriad people we see as friends, colleagues, and even strangers. Of course, merely being able to lump people into these crude categories is not enough; we also need to be able to recognize unique individuals. Remarkably, despite the visual complexity of faces, we are able to quickly and effortlessly do just this: in the case of familiar individuals, as soon as we know that we are looking at a face, we can also provide the specific identity of that face (Tanaka, 2001). Although this may not seem impressive at first glance, the fact that we can identify faces at the individual level (also known as the *subordinate level*) so quickly is actually somewhat unusual. In general, objects are most quickly and easily identified at the *basic level* of categorization (e.g., Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976), which is known as the *basic-level advantage*. For example, most people will be faster to identify something as a "dog" (basic level) than to say it is an "animal" (superordinate level) or an "English Bull Terrier" (subordinate level).

This is not the only way in which faces appear to be processed in a special way: while most objects are processed in a parts-based fashion where the individual features drive recognition, faces are processed *holistically*. A variety of tasks have consistently revealed that we perceive faces as unified wholes; it is extremely difficult for us to selectively attend to discrete facial features without also processing the rest of the face (Hayward, Rhodes, & Schwaninger, 2008; Hole, 1994; Tanaka & Farah, 1993; Young, Hellawell, & Hay, 1987). Holistic effects may occur because faces are encoded in terms of a template in which the parts are not independently represented (e.g., Farah, Wilson, Drain, & Tanaka, 1998; Tanaka & Farah, 1993; Tsao & Livingstone, 2008), or they may occur at the level of perceptual decisions, such that it is not possible to make independent judgments about the individual features within the face (Richler, Gauthier, Wenger, & Palmeri, 2008; Richler, Tanaka, Brown, & Gauthier, 2008; Richler, Wong, & Gauthier, 2011).

It has been argued that holistic processing is unique to faces (e.g., McKone & Kanwisher, 2005; McKone, Kanwisher, & Duchaine, 2007; Robbins & McKone, 2007). The inversion effect (Yin, 1969)—in which recognition of faces is disproportionately disrupted compared to other objects when rotated 180º in the picture plane—is commonly taken as evidence of this. An alternative, known as the expertise hypothesis, posits that holistic processing results from the specific type of experience we gain with faces, individuating and identifying them at the subordinate level. In accordance with this hypothesis, inversion effects have also been observed for objects of expertise, where individuation is also required (Curby, Glazek, & Gauthier, 2009; Diamond & Carey, 1986; Rossion & Curran, 2010). Interestingly, individuation expertise with a specific domain can also reduce the basic-level advantage for objects in much the same way as is seen for faces (Bukach, Vickery, Kinka, & Gauthier, 2011; Tanaka & Taylor, 1991; Wong, Palmeri, & Gauthier, 2009). Thus, it appears that experience individuating an object set has the potential to fundamentally change the way those objects are perceived and processed, ultimately shifting from a parts-based to a holistic strategy.

Despite its popularity, the inversion effect may not be ideal for assessing holistic processing. Instead, it may more effectively tap into configural processing, which codes the arrangement and spatial relations of features relative to one another (Rhodes, Brake, Taylor, & Tan, 1989). Although inversion appears to disrupt configural processing (Diamond & Carey, 1986; Rhodes et al., 1989; Rossion & Gauthier, 2002), it is less clear what effect this has on holistic processing (Murray, 2004; Richler, Mack, Palmeri, & Gauthier, 2011). As will be discussed in greater detail in the following section, the composite task currently offers the best measure of holistic processing. Using this method, holistic processing has been observed for faces (e.g., Hole, 1994) as well as a variety of visually homogenous non-face stimuli with which participants have considerable visual expertise such as cars (Bukach, Phillips, & Gauthier, 2010), musical notation (Wong & Gauthier, 2010), and novel stimuli following training in the laboratory (Gauthier & Tarr, 2002; Wong, Palmeri, & Gauthier, 2009).

Investigating Holistic Processing with the Composite Task

The role of holistic processing in face perception has been explored using a wide variety of tasks. One method is the parts-whole paradigm, which finds that individual features are better recognized within the context of the entire face as compared to on their own (Tanaka & Farah, 1993). More recently, the blurred-scrambled paradigm has been used, which compares face recognition for faces where the featural information is obscured but the configuration of parts is preserved (blurred condition) with faces in which configuration is disrupted but individual components are preserved (scrambled condition) (Hayward et al., 2008). Because face recognition is more heavily dependent on configural information, performance is better for blurred faces, where this information is preserved. In addition to these methods, the composite task has gained a good deal of popularity and is viewed as a more direct measure of holistic processing.

The composite task is based on an effect first demonstrated by Young and colleagues in 1987, in which they found that it was more difficult to identify the top half of a famous person's face when it was aligned with the bottom half of another celebrity's face. For example, it is more difficult to identify the top half of a face as belonging to Bill Clinton if it is aligned with the bottom half of George W. Bush's face. These faces, in which the top and bottom halves of different faces are recombined to form a new face, are known as *composite faces*. More recent implementations of this task have used matching of parts of composites of unfamiliar faces (e.g., Hole, 1994). In this version of the task, participants judge whether the top halves of two sequentially presented faces are the same or different.

Young et al. (1987) proposed that participants' difficulty with composite faces stems from the fact that when two face halves are aligned with each other, the configuration of the parts causes a powerful illusion of an entirely new face, and this face elicits holistic processing where each part of the face interferes with the independent identification of the other. In the composite task, the goal of participants is to limit their attention to just one half of the face, so processing parts of the face that they are meant to ignore could hurt performance. In essence, within the context of the composite task, holistic processing can be thought of as a failure of selective attention. Additionally, because processing stimuli holistically is actually counterproductive in this paradigm, the composite task also allows us to investigate how automatic or dominant a holistic processing strategy is for a particular object set. Consequently, the composite task has been used to investigate a wide variety of face-related phenomena in which holistic processing is thought to play a role such as: the development of face perception (De Heering, Houthuys, & Rossion, 2007; Mondloch, Pathman, Maurer, Grand, & De Schonen, 2007; Turati, Di Giorgio, Bardi, & Simion, 2010), cognitive impairments in face recognition as seen in autism, schizophrenia and prosopagnosia (Gauthier, Klaiman, & Schultz, 2009; Le Grand et al., 2003, 2006; Schwartz, Marvel, Drapalski, Rosse, & Deutsch, 2002; Teunisse & De Gelder, 2003) , evaluating computer models of vision (Dailey & Cottrell, 1999), the inversion effect (Mondloch & Maurer, 2008; Richler, Mack, et al., 2011), and the other-race effect (Michel, Corneille, & Rossion, 2007; Michel, Rossion, Han, Chung, & Caldara, 2006; Mondloch et al., 2010).

With tasks that manipulate the orientation of the face or the position of features within the face relative to one another, holistic and configural processing are difficult to tease apart and may be erroneously conflated (see Murray, 2004 for an example). The composite task, however, allows for holistic processing to be more directly assessed, thus it is not surprising to find it has been so widely adopted and embraced. According to a review by Richler & Gauthier (submitted), more than 70 papers using this task have been published. However, there are currently two versions of the composite task in use, and they often produce incompatible results, including—most critically—whether holistic processing does (Richler, Cheung, & Gauthier, 2011a; McGugin, Richler, Herzmann, Speegle & Gauthier, submitted) or does not (Konar, Bennett, & Sekuler, 2010; Wang, Li, Fang, Tian, & Liu, 2012) contribute to face recognition. Clearly the relationship between holistic processing and face recognition ability has important theoretical ramifications: the expertise hypothesis suggests that holistic processing arises due to our ample experience individuating and recognizing faces. If this is true, then it logically follows that recognition performance should be correlated with the amount of holistic processing that is elicited for faces. Unfortunately, the two versions of the composite task currently in use are not equivalent because they do not measure the same thing, and the version used can dramatically affect one's conclusions. Although this dissertation is not the place to discuss all the reasons why one of the designs is fundamentally flawed (for an extensive review of this issue, see Richler & Gauthier, submitted), the issue is important and serves as partial motivation for the subsequent studies outlined and conducted. As such, I will provide a brief overview of the two forms of the composite task that are currently in use, as well as why one version lacks validity and how this results in the need to revisit several of the questions about holistic processing that have been addressed in the literature.

The Partial Design versus the Complete Design

The two versions of the composite task are known as the *partial design* and the *complete design* (Gauthier & Bukach, 2007). Both involve same/different judgments on the top or bottom halves of sequentially presented composite faces made up of unfamiliar faces. In the partial design, the target half of the face can be either the same or different across the two composite faces, but the unattended portion of the face always changes across the two presentations. The critical manipulation in this design is whether the top and bottom halves of the composite faces are aligned or misaligned with one another. Within this framework, predictions about holistic processing can only be made for “same” trials (Robbins & McKone, 2007); specifically, holistic processing is thought to be reflected in an *alignment effect*, where accuracy on “same” trials is better when the faces are misaligned than when they are aligned. This is because if an item is processed holistically, the irrelevant part—which is always different—cannot be ignored and will therefore interfere with correctly identifying the target part as “same”.

In the complete design, the complementary portion of the condition matrix is also utilized, such that same/different trials where the irrelevant half does not change across presentations are also included (as opposed to always being different, as in the partial design). Consequently, trials can be “congruent” (where the correct response to the target half of the face is consistent with the response one would make to the irrelevant half of the face) or “incongruent” (where the correct response to the target half of the face conflicts with the response one would make to the irrelevant part of the face). This notion of congruency is integral to the complete design, and unlike the partial design, predictions can be made for both same and different trials. Here, congruency is what matters: if an item is processed holistically (i.e., one cannot selectively attend to one half of the object), then performance (as measured in terms of sensitivity: d′) should be better on congruent versus incongruent trials. This is known as the *congruency effect*. As in the partial design, alignment is often manipulated in the complete design, though this is not strictly necessary. When alignment of the composites is included as a factor, then holistic processing is identified through a congruency x alignment interaction. Specifically, the congruency effect (i.e., better performance on congruent than incongruent trials) should be present when the composite stimuli are aligned, but should be reduced or abolished when the parts are misaligned, as this disrupts holistic processing.

To understand why the partial design is fundamentally flawed, it is important to recall that according to signal detection theory, deciding whether the target half of a face is the same or different requires evaluating both perceptual information and an internal response bias. When one simply compares accuracy across two conditions, it is impossible to know whether these differences should be attributed to changes in perception or changes in one's criterion; separating these two components requires looking at both hits (i.e., correctly responding "same" on "same" trials) and false alarms (i.e., incorrectly responding "same" on "different" trials). However, as discussed above, only accuracy on "same" trials is analyzed in the partial design, meaning that it is impossible to know whether changes in perception or bias are driving the difference between aligned and misaligned trials. This is not an issue with the complete design as both "same" and "different" trials are used, so d′ can be calculated, which provides a measure of perceptual sensitivity that is independent of response bias. Additionally, in the complete design, decisional criterion (c) can also be calculated, so that the effect of a manipulation on bias can be directly assessed.

Some researchers have attempted to address the issue of bias in the partial design by using the "different" trials in their analyses to calculate d′ (e.g., Konar et al., 2010). While this controls for criterion shifts associated with alignment, there is another form of bias in the partial design that cannot be overcome in this way: changes in bias related to congruency. This critical problem is inherent to the partial design, because there is no way to estimate this bias with only the partial design trials. Congruency is confounded with correct response: "same" trials are always incongruent and "different" trials are always congruent. Using the complete design, it has been shown that congruency does affect bias, with participants more likely to respond "different" on incongruent trials (Farah et al., 1998; Richler, Mack, Gauthier, & Palmeri, 2009). To make matters worse, congruency and other factors such as alignment can interact to influence bias (Cheung, Richler, Palmeri, & Gauthier, 2008; Richler, Gauthier, et al., 2008; Richler, Tanaka, et al., 2008), which makes partial design results even more difficult to interpret.

The problem of bias contamination in the partial design cannot be overstated because it ultimately means that it is impossible to know what the alignment effect is actually measuring. There may be instances when the alignment effect accurately reflects holistic processing, but what about instances when the partial design and complete design result in discrepant conclusions about holistic processing? In many cases, the alignment effect, as measured in the partial design, can be accounted for in terms of changes in response bias resulting from the interaction between congruency and alignment (Cheung et al., 2008; Richler, Mack, et al., 2011). Additionally, holistic processing, when measured through the partial design, can be manipulated through explicit instructions (Richler, Cheung, & Gauthier, 2011b). By altering participants' beliefs regarding the proportion of "same" or "different" trials they would see (when in reality, the proportion was held constant), it was possible to change whether holistic processing, as inferred through the alignment effect of the partial design, was present or not. This finding stands in stark opposition to all theoretical accounts of holistic processing, which is considered automatic and relatively resistant to top-down control (Richler, Bukach, & Gauthier, 2009; Richler, Cheung, & Gauthier, 2011b; Richler, Wong, & Gauthier, 2011). In contrast, when using the complete design, holistic processing—as indexed by the congruency by alignment interaction in d'—was unaffected by instructional manipulations, with response bias changing instead. Thus, in the complete design, changes in strategy are reflected in shifts in criterion, but not in d', which only reflects changes in perceptual processing. In the partial design, changes in both perception and bias will be reflected in the alignment effect.

The partial design of the composite task not only results in counterintuitive judgments about the factors that can influence holistic processing, but also the role holistic processing plays in face recognition. According to the expertise hypothesis, holistic processing is believed to arise due to our extensive experience individuating faces (e.g., Diamond & Carey, 1986; Rhodes et al., 1989). Thus, one would logically expect that the extent to which faces are processed holistically should predict face recognition performance. Critically, this relationship is only confirmed when holistic processing is measured using the complete design (McGugin et al., submitted; Richler, Cheung, & Gauthier, 2011a), but not when the partial design is used (Konar et al., 2010; Wang et al., 2012).

Together, these pieces of evidence form a convincing argument against using the partial design, demonstrating it to be unreliable and invalid. Unfortunately, many aspects of face perception have been investigated almost exclusively using this flawed design. Thus, many of the conclusions that have been drawn regarding holistic processing based on partial design studies alone are potentially incorrect and misleading and must be re-evaluated using a valid design, such as the complete design composite task. One important area of face recognition literature that falls into this category is the role holistic processing plays in the perception of other-race faces.

The Other-Race Effect (ORE) and the Role of Holistic Processing

The Other-Race Effect (ORE; also known as the Cross-Race Effect and the Own-Race Bias) has fascinated researchers for nearly a century. First reported by Feingold in 1914, the ORE refers to the difficulty individuals of one race have in recognizing and remembering the faces of individuals from another race (Brigham

& Barkowitz, 1978; Malpass & Kravitz, 1969; Meissner & Brigham, 2001). Although countless studies have been conducted examining the nuances of the ORE in the past hundred years (see Meissner & Brigham, 2001 for a review), investigations into its underlying causes have been less extensive.

One theory as to why the ORE is observed is based on the expertise hypothesis, which suggests that our difficulty discriminating between other-race faces lies in our relative lack of experience individuating them (Lebrecht, Pierce, Tarr, & Tanaka, 2009; McGugin, Tanaka, Lebrecht, Tarr, & Gauthier, 2011; Rhodes et al., 1989; Tanaka & Pierce, 2009). As a result, we may process and encode the information that is important for identity less efficiently than we do same-race faces with which we have extensive individuation experience. Many studies examining the ORE have found that the size of the ORE is inversely related to one's experience with another race: the more one is exposed to other-race faces, the smaller the recognition deficit when dealing with them (Gajewski, Schlegel, & Stoerig, 2008; Hancock & Rhodes, 2008; Michel, Rossion, et al., 2006; Tanaka, Kiefer, & Bukach, 2004).

One possible explanation for why a lack of experience with other-race faces may make them harder to recognize and remember is that the features that are the most diagnostic for discriminating between faces may vary based on race. Anthropometric studies indicate that the size and relative distance of facial features, as well as the extent to which they vary, differs across race (Farkas, 1994). Moreover, principle component analyses (PCA) have revealed that the components that largely account for the variability across faces of a particular race are not the same as the principle components that are identified for faces of other races (O'Toole, Deffenbacher, Valentin, & Abdi, 1994), suggesting that the diagnostic qualities of a feature are race-specific. This may be why Caucasian and African individuals focus on different facial features when verbally describing same-race faces (Ellis, Deregowski, & Shepherd, 1975; Shepherd & Deregowski, 1981). Inherent to this notion that different features may play a larger role in identity for different races is the importance of experience. A lifetime of experience individuating faces of a particular race has taught us that certain features are more important than others for individuation. If the usefulness of these features does not carry over to other-race faces, however, then it is no surprise that recognition suffers. Hills & Lewis (2007) found that training participants to attend to the lower half of Caucasian faces on a discrimination task significantly reduced the ORE for African American faces, where the lower half of the face has been identified as being of considerable importance (Ellis et al., 1975; Shepherd & Deregowski, 1981). This improvement did not occur for participants who performed the discrimination training with Caucasian faces where the critical features were located in the top half of the face.

It would be shortsighted, however, to suggest that the only effect of experience individuating faces of a particular race is increased sensitivity to diagnostic features. Even when identical manipulations are made to the exact same features of same-race and other-race faces, the ORE is still observed (Rhodes et al., 2006). For example, when the eyes are altered in the exact same way on Caucasian and Asian faces, Caucasians were more sensitive to changes made to the Caucasian faces, whereas Asian participants were more sensitive to the changes made to Asian faces. If the ORE occurred solely because we are differentially sensitive to certain featural cues that vary based on race, then no difference between same-race and other-race faces should result when the exact same manipulations are performed on the two sets of faces. Differences in feature diagnosticity does not account for why Caucasians would be sensitive to changes in the eye region of Caucasian faces but not the same region of Asian faces. While it is certainly possible that extensive experience with a particular race makes us more sensitive to the diagnostic dimensions of same-race faces, the very nature of how the face as a whole is processed may be affected as well. It has been suggested that our lack of experience individuating other-race faces may result in them being processed in a qualitatively different fashion than same-race faces (Michel et al., 2006; Murray, Rhodes, Schuchinsky, 2003; Rhodes et al., 1989; Tanaka et al., 2004, but see Mondloch et al., 2010). Given the known link between perceptual expertise and holistic processing (Bukach et al., 2010; Gauthier & Tarr, 2002; Richler, Mack, et al., 2011; Wong, Palmeri, & Gauthier, 2009; Wong & Gauthier, 2010), it may be that while same-race faces are processed holistically, other-race face recognition may instead rely more exclusively upon more feature-based recognition mechanisms. Of course the difference between the two could also be quantitative in nature, that is, other-race faces are still processed holistically, but perhaps less holistic processing is elicited or is carried out less efficiently than for same-race faces. The possibility that experience could ultimately change the underlying mechanisms that carry out other-race and same-race face recognition (or at least change the efficiency with which they operate) may explain why the processing goals one has when acquiring experience with other-race faces appears to be important. Specifically, individuating other-race faces seems to be the key for improving performance on subsequent perceptual discrimination tasks with other-race faces (McGugin, Tanaka, et al., 2011) or on recognition memory tasks (Tanaka & Pierce, 2009). In comparison, training participants on an attentionally demanding perceptual discrimination task or merely having participants observe faces and identify their race does not appear sufficient to improve performance.

An alternative to the expertise hypothesis is that the ORE instead stems largely from top-down sociocognitive factors. Racial categorization can occur within 120 ms (Ito & Urland, 2003, 2005) and when items are segregated into ingroups and outgroups (such as same-race and other-race), outgroup items are more often processed in a categorical fashion, whereas ingroup items are individuated (Hugenberg & Sacco, 2008; Levin, 1996, 2000). Additionally, outgroups are often viewed as more homogenous than ingroups (Judd & Park, 1988), which may explain why the ORE is often driven by increased false alarms for other-race faces (Meissner & Brigham, 2001). Proponents of sociocognitive explanations argue that the ORE is not actually about race and perceptual learning, but instead occurs due to differential processing strategies that result from cognitive biases towards ingroups and outgroups (Young, Hugenberg, Bernstein, & Sacco, 2012). In support of this hypothesis, recognition deficits comparable to the ORE can be found when participants are encouraged to view a subset of same-race faces as belonging to a social outgroup, such as attending a rival university (Bernstein, Young, & Hugenberg, 2007; Hugenberg, Miller, & Claypool, 2007; Shriver, Young, Hugenberg, Bernstein, & Lanter, 2008; Young, Bernstein, & Hugenberg, 2010). In these instances, stimulus race is held constant, so these finding cannot be explained in terms of differences in the diagnosticity of features or changes in processing mechanisms as a result of perceptual expertise.

Faces have important social relevance, but we also have massive amounts of visual experience with them, so it seems reasonable to consider that both bottom-up perceptual and top-down cognitive factors contribute in some part to the ORE. One recent theory from this school of thought that attempts to account for findings that support the expertise hypothesis as well as more sociocognitive explanations is the Categorization-Individuation Model (Hugenberg, Young, Bernstein, & Sacco, 2010). This model posits that the following three processes convolve to determine whether the ORE is observed: 1) social categorization, which leads to perceptual homogenization; 2) motivation to individuate between outgroup faces; and 3) perceptual expertise. Although the importance of expertise is acknowledged in this model, proponents of the Categorization-Individuation Model believe that expertise is ultimately trumped by motivation to individuate because individuation requires more cognitive effort than simply categorizing individuals into larger groups.

Accordingly, they argue face recognition is malleable, as same-race recognition advantages can be reduced if participants are implicitly cued (e.g., assigning a same-race face social outgroup status) or explicitly instructed (e.g., experimental instructions) to attend to the category-diagnostic information of the face rather than those used for individuation (Young, Hugenberg, Bernstein, & Sacco, 2009). In much the same way, reduced perceptual expertise leading to the ORE can be overcome, either by emphasizing that other-race faces are important, such as by assigning them high-power status (Ackerman et al., 2006; Becker et al., 2010; Shriver & Hugenberg, 2010), or by making participants aware of the ORE and simply instructing them to pay close attention to the features that will differentiate other-race faces from one another (Hugenberg et al., 2007; Rhodes et al., 2009). Importantly, these results do not arise from a simple increase in global motivation to try harder or perform the task better (Hugenberg et al., 2007), which makes these findings all the more surprising. The advantages afforded by perceptual expertise generally require extensive training to develop, so it is hard to understand how merely telling people to perform as experts do on a difficult task would be as effective.

Although it appears that exposure to (and individuation of) other-race faces as well as attentional effects stemming from top-down cognitive biases are each capable of influencing recognition and memory of other-race faces, what is less clear is the extent to which holistic processing is affected by either of these factors. Several studies investigating perceptual expertise have demonstrated the limits of the generalizability of processing strategies to objects that are distant members of a trained category. For example, although structurally very similar (and technically members of the same basic-level category), holistic processing and discrimination improvements associated with modern car expertise do not generalize to antique cars (Bukach et al., 2010). Thus, it is possible for stimuli to share certain perceptual and conceptual features (as in the case of same-race and other-race faces) yet elicit different processing strategies. Similarly, McGugin et al., (2011) reported enhanced discrimination performance following individuation training limited solely to the race participants had been trained to individuate, suggesting that racial differences between faces may be sufficiently salient to disrupt generalization of processing strategy.

Even though there are claims that other-race faces elicit reduced holistic processing, the paradigms used to support this conclusion are either not well suited for measuring holistic processing specifically or have used the partial design version of the composite task (Hancock & Rhodes, 2008; Michel, Caldara, & Rossion, 2006; Michel et al., 2007; Michel, Rossion, et al., 2006; Rhodes et al., 1989; Rhodes, Hayward, & Winkler, 2006; Tanaka et al., 2004), which makes interpreting the results very difficult. To date, no studies investigating the link between the ORE and holistic processing have been published using the complete design, which is arguably the task for which the strongest case for construct validity has been made (Cheung et al., 2008; McGugin et al., submitted; Richler, Cheung & Gauthier, 2011a, 2011b; Richler, Mack, et al., 2011). This same problem also plagues findings arguing that, independent of low-level perceptual factors, top-down factors can modulate holistic processing. While there is some evidence that manipulating group and social status can produce differences in holistic processing for same-race faces (Hugenberg & Corneille, 2009; Ratcliff, Hugenberg, Shriver, & Bernstein, 2011), these results have only been demonstrated using the partial design, so their validity is unclear. As discussed earlier, the measure through which holistic processing is inferred in the complete design is impervious to manipulations of strategy (Richler, Cheung, & Gauthier, 2011b; Richler, Wong, & Gauthier, 2011). Instead, as would be expected, changes in strategy are reflected in criterion shifts. However, the alignment effect in the partial design is often correlated with changes in criterion, because inherent bias confounds make it impossible to measure perceptual processing on its own. Changes in strategy are reflected in criterion shifts, which are often reflected in the alignment effect. Central to this dissertation is the question of whether other-race and same-race faces vary in the type of processing or the amount of holistic processing they elicit, as well as the extent to which holistic processing is susceptible to top-down cognitive sets.

Time is of the Essence

Another important dimension to consider when investigating visual processing is time. Picking a single time point has the same pitfalls as averaging a large sample of data: important and interesting variance may be lost. Consequently, a single value may not accurately reflect a dynamic process. Moreover, expertise effects can arise not only in terms of the mechanism by which an object is processed, but also in terms of temporal advantages in the onset or rate of information acquisition. For example, Curby & Gauthier (2009) compared the timecourse of visual information extraction between novices and experts. Although the rate of perceptual processing was largely unaffected by object expertise, an important difference was found when examining the shorter encoding durations. Specifically, expertise appeared to afford participants a “head start”, whereby less time was required for expert observers to acquire sufficient information to accurately identify a stimulus, in large part because this diagnostic information begins to accumulate earlier for experts. This critical insight that expertise speeds up the onset of recognition would not have been possible if Curby & Gauthier had neglected to include a range of stimulus durations, particularly at the shorter end of the spectrum. If the ORE results from reduced expertise with other-race faces, it may be that more time is needed before there is sufficient information available to successfully individuate faces.

Expertise has also been shown to affect not only the appearance of holistic processing, but its onset and timecourse as well. As with other-race faces, it has been hotly debated whether inverted faces differ from upright faces on a qualitative or quantitative basis. A recent study conducted by Richler, Mack et al. (2011) used the complete design to directly measured holistic processing over time for both upright and inverted faces. By sampling a variety of stimulus durations, Richler and colleagues found that with upright faces, holistic processing was evident at all tested time points, even when the test composite face was only presented for 50 ms. With inverted faces, however, holistic processing required time to emerge, not appearing until 183 ms, and then continued to increase such that there was no difference in the magnitude of holistic processing between upright and inverted faces at later time points. Clearly then, time matters, as different conclusions about holistic processing and inverted faces could be drawn. Looking at the shortest duration, one would likely conclude that inverted faces fail to elicit holistic processing at all, which suggests they must be processed in a qualitatively different fashion from upright faces. However, examining the longest time point, the exact opposite is concluded: inverted faces are processed just as holistically as upright faces. By looking at the timecourse, the difference between inverted and upright faces is revealed to be a quantitative one; holistic processing is delayed and more time is required for information to accumulate for inverted faces.

What if, as Richler, Mack et al. (2011) found, the difference between other-race and same-race faces is not the type of mechanism used (Michel et al., 2006; Rhodes et al., 1989; Tanaka et al., 2004), but rather one of degree or efficiency? Perhaps other-race faces are processed holistically, but because of subtle structural differences between other-race and same-race faces, holistic processing strategies are more poorly generalized thereby requiring additional time for holistic processing to fully emerge. If this is the case, then only looking at a very early or very late timepoint in the processing stream would make it impossible to know to what extent, and in what capacity, holistic processing for other-race and same-race faces truly varies.

There are several interesting neurophysiological findings supporting a quantitative difference between other-race and same-race faces. Various ERP studies have examined how other-race faces affect the N170, a component observed over occipitotemporal areas that is believed to be associated with face detection and/or early face processing prior to explicit identification (Bentin, Allison, Puce, Perez, & McCarthy, 1996; Bentin & Deouell, 2000). Because the N170 is generally delayed and amplified when faces are inverted, this has been taken as evidence that the N170 reflects configural processing (Latinus & Taylor, 2006).The N170 is delayed for other-race faces as compared to same-race faces, suggesting that holistic processing may be postponed for faces of less familiar races (Stahl, Wiese, & Schweinberger, 2008; Wiese, Stahl, & Schweinberger, 2009). Moreover, when directly comparing other-race and inverted faces, Wiese and colleagues found that the delay in the N170 was comparable for other-race and inverted faces, and these two effects were additive. This suggests that our relative difficulties with both inverted and other-race faces may actually stem from the same source, namely that holistic processing is deployed less efficiently for both. Another goal of the studies conducted in this dissertation is to examine how the timecourse of holistic processing is affected by the perceptual and cognitive shifts associated with race.

Specific Aims

This dissertation describes a series of experiments aimed at addressing one fundamental question: how does race influence holistic processing? To-date, this seemingly straightforward question has proved uncannily difficult to answer. It has been argued that our poorer recognition memory for other-race faces stems from fundamental differences in *how* they are processed; however, while some evidence exists that other-race faces exhibit reduced holistic and configural processing (Hancock & Rhodes, 2008; Michel, Caldara, et al., 2006; Michel et al., 2007; Michel, Rossion, et al., 2006; Rhodes et al., 1989, 2006; Tanaka et al., 2004) and instead rely upon more feature-based recognition mechanisms, the use of flawed designs and suboptimal methods has cast doubt onto the validity of these claims.

Thus, Experiment 1 uses the complete design of the composite task to directly test the claim that holistic processing is reduced for other-race faces relative to same-race faces. Experiment 2 provides additional insight into the interplay between race and holistic processing by taking the factor of time into consideration, exploring the possibility that other-race faces may be processed less efficiently than same-race faces. Following the rationale of Richler, Mack et al., (2011) who found that inverted faces require additional time for holistic processing to fully emerge, I explored the possibility that this might also be true for other-race faces. If so, this would indicate that, like inverted faces, the difference in processing between other-race and same-race faces is quantitative rather than qualitative in nature.

As discussed earlier, explanations of the ORE have not been limited to those rooted in low-level perceptual learning. Another alternative is that when we see other-race faces, we quickly categorize them as “other” and assign them “outgroup” status. The Categorization-Individuation Model argues that separating faces into outgroups and ingroups can cognitively bias us to attend to the simpler features used for basic-level categorization (i.e., race) in the case of the former versus the subtler features useful for more demanding subordinate-level (i.e., individual identity) recognition in the case of the latter (Hugenberg et al., 2010). Moreover, this model posits that even when one has considerable perceptual expertise with a racial subset of faces, individuation is always more difficult than basic-level categorization, so even with same-race faces, the motivation to individuate is critical for determining whether a recognition (or even holistic processing) advantage is observed for same-race faces. Experiments 3 and 4 were designed to evaluate the Categorization-Individuation Model account of the ORE, specifically testing whether explicitly categorizing faces as coming from an outgroup would reduce holistic processing.

When using other-race faces there are both low-level perceptual and high-level cognitive factors at work that are impossible to tease apart. Thus the studies focusing specifically on the influence of top-down cognitive sets and ingroup/outgroup categorization on face recognition and holistic processing have been restricted to same-race faces so that perceptual expertise is held constant across the ingroup and outgroup faces. Manipulating group status of faces on the basis of university affiliation can produce a recognition deficit for outgroup same-race faces similar to the ORE (Hugenberg et al., 2007), and the partial design version of the composite task was used in a study reporting that the magnitude of holistic processing is also reduced under these conditions (Hugenberg & Corneille, 2009). Accordingly, Experiments 3 and 4 use the complete design to investigate the extent to which outgroup categorization alone can affect holistic processing, as well as the timescale at which these effects might emerge. Even if outgroup categorization can reduce holistic processing, it may be that top-down cognitive biases are not evident early on but require time to be observed.

The following experiments will show that contrary to claims that other-race and same-race faces are processed qualitatively differently, at least some other-race faces are processed as holistically as same-race faces (Chapter 2). Instead, it appears that the difference between other-race and same-race faces is more likely to be quantitative in nature. Examining the timecourse of the ORE revealed that holistic processing can be reduced for other-race faces, however, unlike inversion, the effect of race on holistic processing requires time to emerge (Chapter 3). Moreover, the ORE can also emerge in terms of an overall discrimination advantage for same-race faces that develops quickly and is independent of differences in holistic processing. Because holistic processing develops over time, and the durations sampled were rather limited, if there is a difference in holistic processing between other-race and same-race faces, it is likely that it is with respect to how early it arises, not whether it does in fact arise. Finally, top-down categorization does not affect holistic processing, although it may provide ingroup faces with an overall performance advantage that is evident early on (Chapter 4). Together these experiments demonstrate that other-race faces can be processed holistically, and there is little evidence that differences in how other-race and same-race faces are processed are anything but quantitative in nature. Moreover, both bottom-up perceptual factors as well as top-down cognitive biases can contribute to the ORE in terms of discrimination advantages for same-race and ingroup faces, whereas differences in holistic processing were less commonly observed. Thus, the ORE itself is unlikely to arise from differences in holistic processing between other-race and same-race faces.

CHAPTER II

DO OTHER-RACE FACES ELICIT REDUCED HOLISTIC PROCESSING?

Experiment 1: Investigating Holistic Processing for Same- and Other-Race Faces using the Complete Design

The other-race effect (ORE) is a robust phenomenon in which faces of unfamiliar races (referred to as other-race faces) are less well recognized and remembered than faces of the same-race faces as the observer (Meissner & Brigham, 2001). Although the ORE is well-established, it is less clear what mechanisms give rise to this effect.

Holistic processing plays an important role in the recognition of same-race faces (Richler, Cheung, & Gauthier 2011a), so it has been suggested that holistic processing may be reduced or absent for other-race faces, which ultimately impairs recognition. Although many different tasks have been used to investigate this question, as was discussed in Chapter 1, the best method we currently have for assessing and measuring holistic processing is the composite task. Unfortunately, few studies have employed the composite task to compare holistic processing for other-race versus same-race faces, and those that have done so have used the flawed partial design (Michel et al., 2006; Michel, Corneille & Rossion, 2007).

Consequently, it is unclear whether holistic processing actually differs between other-race and same-race faces.

Thus, the primary goal of Experiment 1 is to assess whether other-race faces are processed holistically, and if so, whether they are processed less holistically than same-race faces. Traditionally, the ORE is generally demonstrated using a memory task in which participants study a series of faces and then are later asked to identify the faces that they previously viewed (see Meissner & Brigham, 2001 for review). Here, only the composite task is used to assess the perceptual processing of other-race and same-race faces without a long-term memory component. Even though the "traditional" ORE is not being directly measured here, if differences in holistic processing arise, it is reasonable to presume that subsequent face recognition, whether measured through the Cambridge Face Memory Test (Duchaine & Nakayama, 2006) or using the memory task traditionally used to assess the ORE, would also be affected (e.g., Richler, Cheung, & Gauthier, 2011a).

On the composite task, holistic processing is defined as a failure of selective attention that is indexed by a congruency x alignment interaction. In addition to holistic processing, which is reflected in a difference score, overall discriminability of same-race and other-race faces can be assessed by averaging across all congruency and alignment conditions and would be reflected as an interaction between face race and participant race. Enhanced holistic processing for same-race faces relative to other-race faces would in and of itself be evidence of an ORE. However, the composite task might also reveal an ORE in terms of differences in overall discriminability for matching judgments on parts of same-race and other-race faces. If we are more sensitive to and better able to encode the subtle differences between same-race faces, this would result in improved recognition and subsequent memory for same-race faces as is seen in the traditional ORE. Relatively brief experience individuating other-race faces can enhance one's sensitivity to differences between other-race faces of the trained race (McGugin et al., 2011), so it may be that our individuation experience with same-race faces first asserts itself as a discrimination advantage for same-race faces, which then gives rise to enhanced same-race memory. Despite this prediction, McGugin and colleagues did not observe an improvement in recognition memory, even though discriminability for trained-race other-race faces improved on a two-alternative forced choice task following individuation training. However, it is possible that this is because they used the discrimination task as the study phase of their recognition task, which may have somehow diminished encoding. Additionally, their training was very short, so it is possible that perceptual effects may arise and be more easily discerned before differences in recognition memory are evident. In contrast, lengthier training paradigms have improved recognition performance using the standard ORE memory paradigm (Tanaka & Pierce, 2009).

Methods

Participants

Sixty-four participants with normal or corrected-to-normal vision participated in this experiment. Half of these participants were Caucasian individuals (20 female; age range 18 – 33; mean age 23.12) recruited from the Vanderbilt community, who were provided with either monetary compensation or course credit for their time. The remaining 32 participants were Asian individuals recruited from the University of Hong Kong community, who were provided with paid compensation for their participation. Age and gender was not recorded because of experimenter error, however, the Hong Kong sample was similar to the sample from Vanderbilt.

Stimuli

A total of 80 gray-scale faces (20 Asian Adult Male, 20 Asian Adult Female, 20 Caucasian Adult Male, 20 Caucasian Adult Female) were used to create the composite stimuli used in this experiment. Prior to manipulation of the images, all faces were cropped so that the hair, ears and neck were eliminated. For each Race x Gender condition, face images were split in half to create 20 face tops and 20 face bottoms. The top halves of ten of these faces were selected and paired with the bottom halves of the remaining ten faces in order to form composite faces. For each condition, a total of 56 composite faces were created: 28 where the tops and bottoms were aligned, and 28 where the tops and bottoms were misaligned. Within each set of 28 faces, composites were selected in pairs for the main experiment so that there were at least two composites that shared the same top half (but not the same bottom), and at least two composites shared the same bottom half (but not the same top) within each block. Misaligned faces were created by moving the top half of the face to the right by 50% of its width, while the bottom half of the face was moved to the left by 50% of its width so that the edge of one face half fell in the center of the other face half. A black line bisected the top and bottom halves along the horizontal plane to make it clear where the top half ended and the bottom half began. Aligned faces were 219 pixels wide, while misaligned faces were 340 pixels wide; all face images were 299 pixels tall.

Procedure

The experiment was run using Superlab Pro 1.75 on Apple computers running OS 9.

Each trial (see Figure 1) began with the presentation of a fixation cross (300 ms), followed by a brief blank screen (200 ms). An initial composite face was then presented (600 ms) followed by a blank screen (300 ms) and then a second composite face (3000 ms max). While this second face was presented, participants responded whether its top half was the Same ("Q" key) or Different ("P" key) as the top half of the first face. Making a response initiated the next trial. If participants failed to respond while the second face was on screen, the trial was discarded from analyses and the next trial automatically began. Given that participants had 3000 ms to make their response, trial time-outs were extremely rare.

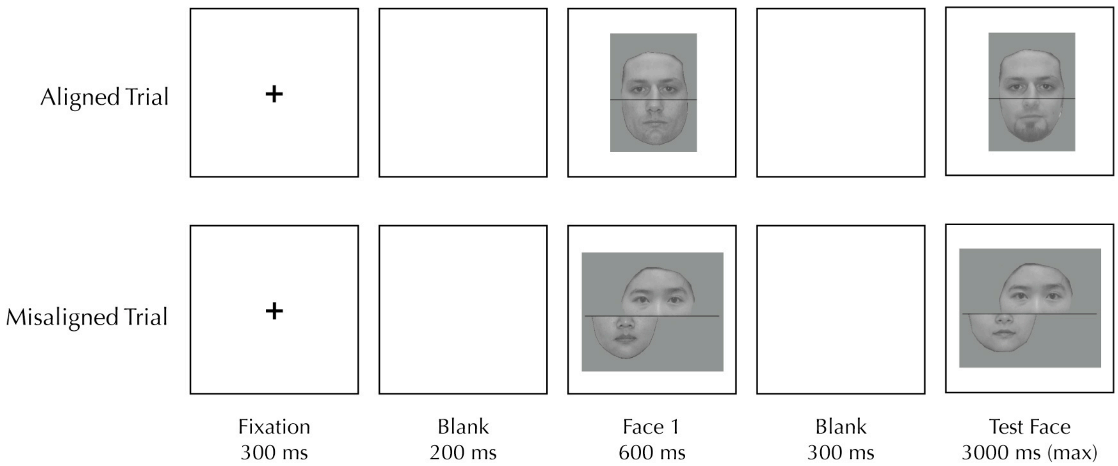

Figure 1. Timing of events in Experiment 1. The top row displays an example of a Caucasian-Aligned trial and the bottom row presents an example of an Asian-Misaligned trial. Participants were instructed to indicate whether the top halves of the two sequentially presented faces were the same or different. Note that in Experiment 1, both the study and test composite face was misaligned on Misaligned trials.

Participants completed five blocks, each consisting of 72 trials. Stimuli were blocked by race and alignment, such that within a given block, participants only viewed faces of one race (either Asian or Caucasian), and all of these faces shared the same alignment (either Aligned or Misaligned). As such, the four experimental blocks were as follows: Asian faces-Aligned; Asian faces-Misaligned; Caucasian faces-Aligned; Caucasian faces-Misaligned. At the start of the experiment, one of these blocks was randomly selected and used as a practice block so that participants could familiarize themselves with the task and response production. The order of the five blocks was randomized for each participant.

Within each block, there were nine trials for each combination of gender (male/female), correct response (same/different) and congruency (congruent/incongruent). In the final analyses, data was collapsed across gender, resulting in 18 trials for each Race x Alignment x Congruency x Correct Response condition.

Results

To limit the effect of outliers, winsorized (20%) means and variances were used in all analyses, following recommendations for robust estimation by Wilcox (2005).

Sensitivity (d')

Sensitivity (d') for Caucasian and Asian participants is plotted in Figure 2. To calculate d', hits were defined as trials on which participants correctly identified that the face halves were the same, and false alarms were trials where the two halves differed but participants erroneously said they were the same.

A 2 x 2 x 2 x 2 repeated-measures ANOVA on d' with factors Congruency (congruent/incongruent), Alignment (aligned/misaligned), Face Race (Caucasian/Asian) and Participant Race (Caucasian/Asian) revealed that performance was significantly better on congruent vs. incongruent trials ($F_{1,62} = 494.9$, $p < 0.0001$), on misaligned vs. aligned trials ($F_{1,62} = 31.2$, $p < 0.0001$), as well as for Caucasian faces vs. Asian faces ($F_{1,62} = 66.7$, $p < 0.0001$).

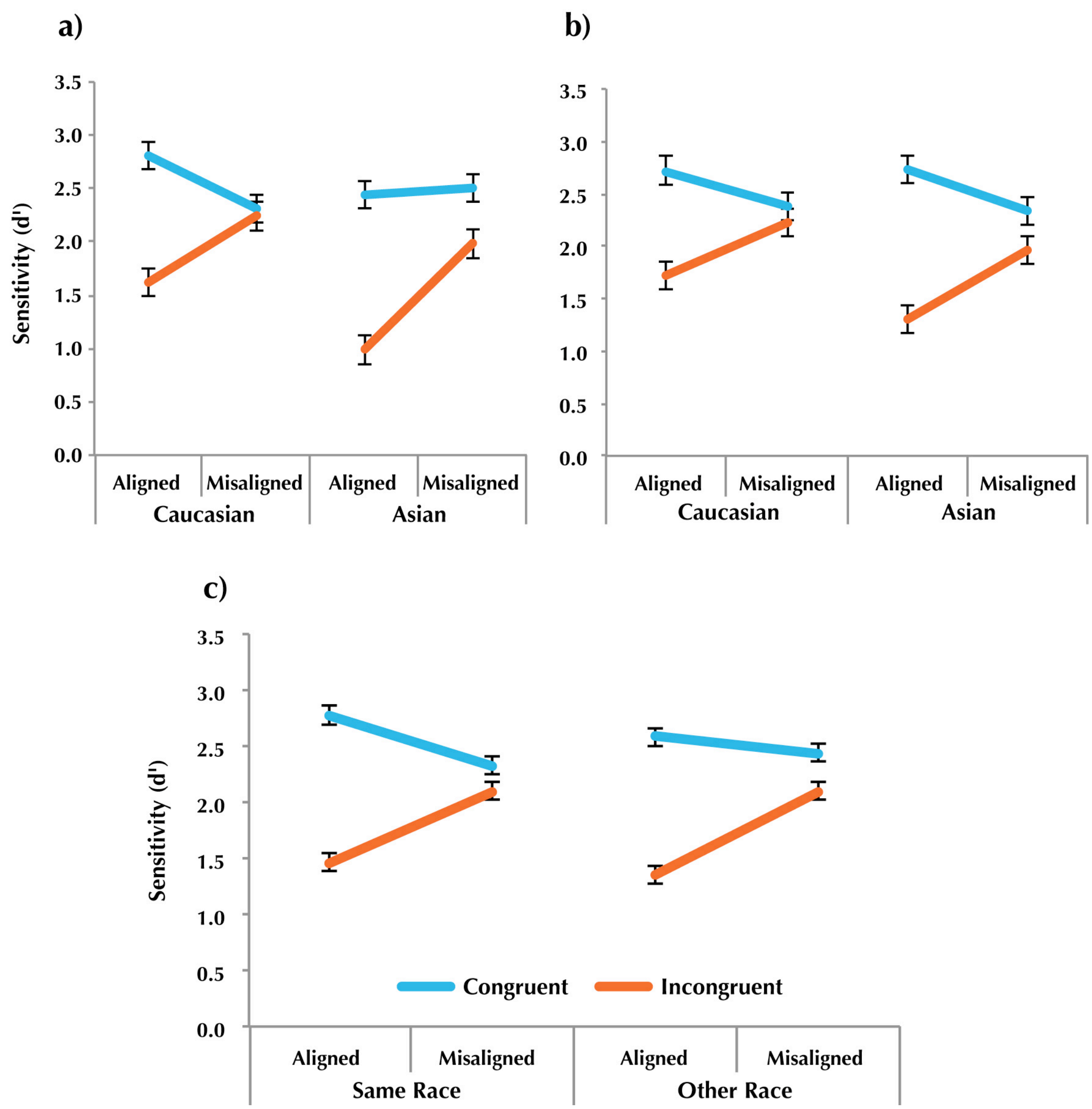

Figure 2. Sensitivity (d') results for Caucasian (a), Asian (b), and both groups participants averaged together (c) using the complete design. Congruent trials are presented in blue, and incongruent trials are presented in orange. Error bars show 95% confidence intervals of within-subject effects.

Critically, there was a significant Congruency x Alignment interaction ($F_{1,62}$ = 234.5, *p* <0.0001), the hallmark of holistic processing. However, the Congruency x Alignment x Face Race x Participant Race interaction was not significant ($F_{1,62}$ = 3.09, *p* = 0.084), indicating that the amount of holistic processing did not differ between same-race and other-race faces. As can be seen in Figure 3, the size of the Congruency x Alignment interaction, which measures holistic processing in this task, was not significantly different for same-race and other-race faces for either Caucasian or Asian participants. In addition, the Face Race x Participant Race interaction was not significant ($F_{1,62}$ = 2.69, *p* = 0.11) indicating that same-race and other-race faces were equally discriminable in this task.

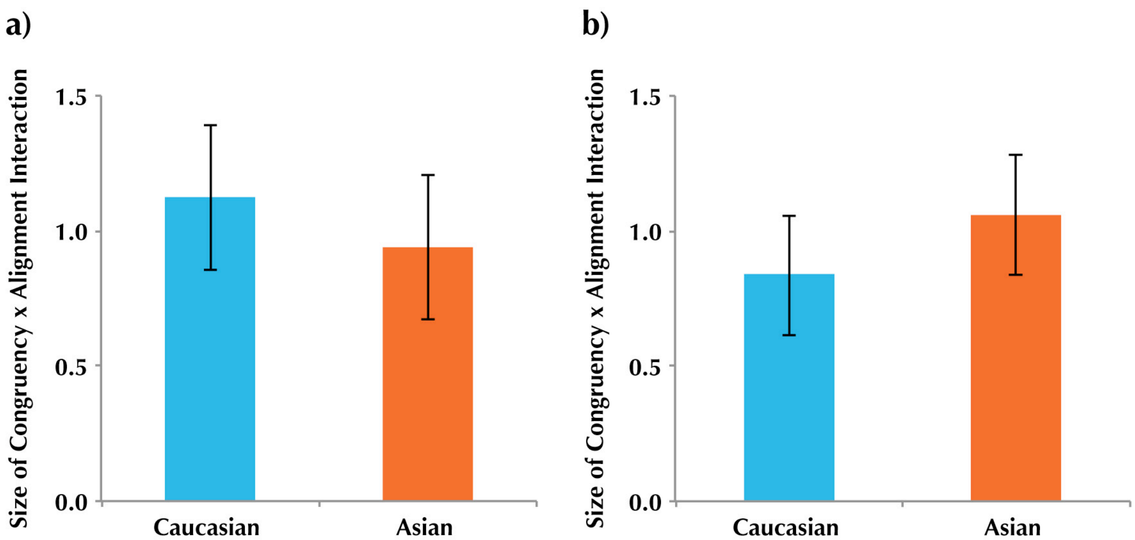

Figure 3. Holistic processing (as measured in terms of the congruency x alignment interaction in d′) for same-race and other-race faces for Caucasian (a) and Asian (b) participants. The magnitude of the interaction between congruency and alignment was calculated using the following formula: (d′ on Congruent Aligned trials – d′ on Incongruent Aligned trials) – (d′ on Congruent Misaligned trials – d′ on Incongruent Misaligned trials). Error bars show 95% confidence intervals of within-subject effects.

Correct Response Time (RT)

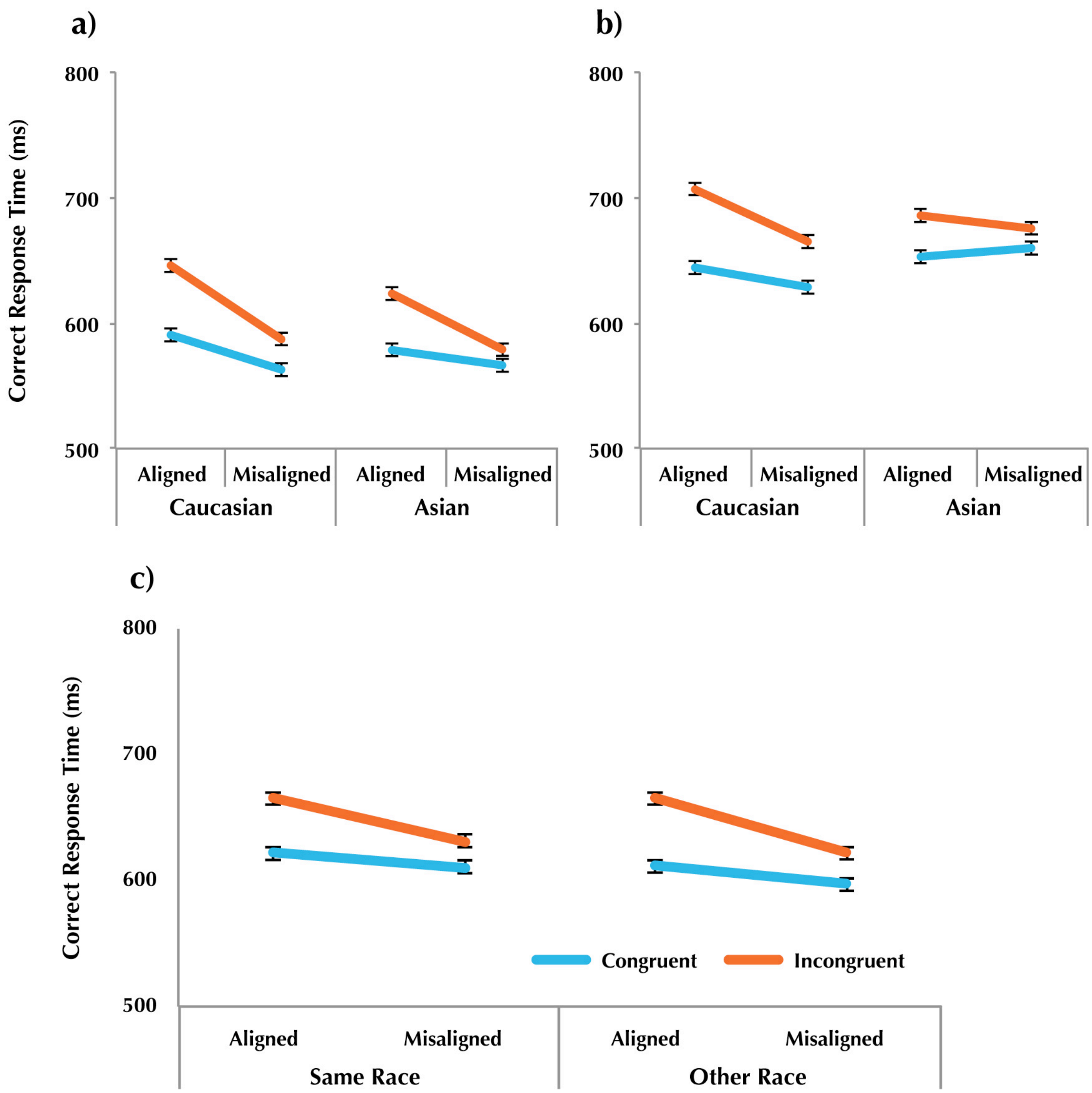

Figure 4. Response times for correct trials for Caucasian (a), Asian (b), and both groups of participants averaged together (c). Congruent trials are depicted in blue and incongruent trials are depicted in orange. Error bars show 95% confidence intervals of within-subject effects.

Correct RTs are plotted for Caucasian and Asian participants in Figure 4. With regards to RT, holistic processing is reflected in longer RTs on incongruent compared to congruent trials, and this difference is larger when faces are aligned.

A similar 2 x 2 x 2 x 2 repeated-measures ANOVA revealed that correct RTs mirrored the d′ data with respect to main effects for Congruency, Alignment and their interaction. However, unlike the d′ data, there was no main effect of Face Race ($F_{1,62}$ = 0.0892, p = 0.77), indicating that participants responded equally quickly to Caucasian and Asian faces. Thus, the overall discrimination advantage seen for Caucasian faces in the d′ data cannot be accounted for in terms of a speed-accuracy trade-off. Consistent with the sensitivity data, the four-way interaction between Congruency X Alignment X Face Race X Subject Race was not significant (($F_{1,62}$ = 0.62, p = 0.44).

Discussion

Experiment 1 used the complete design version of the composite task to investigate the extent to which holistic processing might differ between same-race and other-race faces. No differences in sensitivity were found between same-race and other-race faces for either Caucasian or Asian participants, suggesting that there was no overall discrimination advantage for same-race faces in this task. Further analyses of d′ and reaction times revealed that not only was holistic processing present for both types of faces, but other-race and same-race faces did not differ significantly in terms of the amount of holistic processing they elicited. Ultimately, there was little evidence for an ORE either in terms of a general discrimination advantage or enhanced holistic processing for same-race faces.

There are several reasons that might explain why Experiment 1 failed to produce evidence of an ORE. Overall, discrimination performance was better for Caucasian faces, regardless of participant race, which may indicate that the Caucasian faces used in this experiment were inherently more salient and heterogeneous than the Asian faces. At the very least, if the Caucasian faces were easier to discriminate, this may have artificially inflated Asian participants' performance with other-race faces, thereby negating any discrimination advantage that might exist for same-race faces for that group. An alternative explanation is that the participants tested here were not truly "novices" with respect to the "other race", as each group is likely to have had some experience with both Asian and Caucasian faces. Although this experience was certainly less than that with their own race, the difference may not have been sufficient to produce an obvious ORE in terms of discriminability or holistic processing. Perhaps if one is presented with a race that is exceedingly unfamiliar or dissimilar to one's own, this might not be the case.

There is another intriguing possibility that could explain the lack of an ORE in the d′ data. Experiment 1 used relatively lengthy stimulus durations, particularly in the case of the second test face, which was presented for a maximum of three seconds. This has two consequences: first, the leisurely timing may have made the task insufficiently demanding; performance was quite high on this task, so it is possible that ceiling effects, particularly in the congruent-aligned condition, could be obscuring differences in sensitivity for other-race and same-race faces that might become evident were the task slightly more difficult. A second consequence of these long stimulus presentations is that they potentially obscure any effects of time. That is, even if holistic processing does arise for other-race faces, it may have a different timecourse compared to same-race faces. Indeed, a recent study by Richler, Mack et al., (2011) investigating holistic processing of inverted faces concluded that *with sufficient exposure duration*, inverted faces are processed holistically to the same extent as upright faces. In that experiment, holistic processing for inverted faces was not apparent at short exposures and did not arise until the second face was presented for 183 ms. At this point, the magnitude of holistic processing was still smaller for inverted faces as compared to upright faces, however, holistic processing continued to increase for inverted faces, and was comparable to upright faces by 800 ms.

Broadly speaking, Experiment 1 provides evidence that holistic processing can and does arise for at least some other-race faces, with a magnitude comparable to same-race faces. But the question remains as to whether holistic processing occurs as quickly and efficiently for other-race faces as it does for same-race faces. Holistic processing is often considered automatic, but as Richler, Mack et al., (2011) have shown, it may be that when an object of expertise deviates from the conditions that form the basis of expertise, more time is required before holistic processing arises and reaches its full extent. If this is also true for other-race faces, then differences in holistic processing or discriminability may become apparent when examining performance under more limited presentation times. Also, limiting stimulus duration will increase task difficulty, thereby avoiding possible ceiling effects and increasing sensitivity to the ORE. The possibility that the ORE may arise early, but decrease with increased presentation time, is explored in Experiment 2.

CHAPTER III

IS HOLISTIC PROCESSING FOR OTHER-RACE FACES LESS EFFICIENT THAN FOR SAME-RACE FACES?

Experiment 2: Investigating the Timecourse of Holistic Processing and the ORE

One explanation for the ORE that has gained a good deal of traction is the expertise hypothesis, which suggests that we have a more difficult time recognizing and remembering other-race faces because we have less experience individuating them (Lebrecht et al., 2009; McGugin et al., 2011; Rhodes et al., 1989; Tanaka & Pierce, 2009). However, there has been considerable debate regarding how reduced experience with other-race faces may be reflected in perceptual processing. Some researchers have suggested that limited contact with other-race faces may result in a *qualitative* difference in how other-race and same-race faces are processed; proponents of this theory suggest that while same-race faces are processed holistically, other-race faces rely on a feature-based processing strategy (Rhodes et al., 1989; Tanaka et al., 2004; Michel, Caldara, et al., 2006; Michel et al., 2006; Murray et al., 2003). An alternative possibility, however, is that the difference in processing between other-race and same-race faces may be *quantitative* in nature, meaning that both types of faces recruit the same underlying processing mechanism (i.e., holistic processing), but due to our lack of familiarity with other-race faces, holistic processing may be less efficient than for same-race faces (Stahl et al., 2008; Wiese et al., 2009). In sum, qualitative explanations of the ORE dictate that other-race faces are processed in a fundamentally different fashion than same-race faces (i.e., featural vs. holistic processing), whereas a quantitative explanation proposes that both face types are processed the same way, though same-race faces may be processed more efficiently.

Investigations into the neural underpinnings of the ORE lend support to the notion that it arises due to a quantitative difference in processing between other-race and same-race faces. Golby and colleagues (2001) used functional magnetic resonance imaging (fMRI) to investigate the response of the fusiform gyrus to same-race and other-race faces. A particular subsection of ventral occipitotemporal cortex is known as the fusiform face area (FFA) because it tends to preferentially respond to faces compared to other objects (Kanwisher, McDermott, & Chun, 1997; Tong, Nakayama, Moscovitch, Weinrib, & Kanwisher, 2000). However, it may be that rather than being specialized for faces, the FFA is instead involved in holistic processing and reflects perceptual expertise, as it does respond robustly to objects with which participants have considerable individuation experience (Gauthier, Skudlarski, Gore, & Anderson, 2000; Gauthier, Tarr, Anderson, Skudlarski, & Gore, 1999; Wong., Palmeri, & Gauthier, 2009). Golby et al. found that same-race faces elicited greater activation in the left FFA than did other-race faces. These results suggest that other-race faces recruit the same mechanisms as same-race faces, but to a lesser extent. Given the link between holistic processing and FFA activity

(Bilalić, Langner, Ulrich, & Grodd, 2011; Gauthier & Tarr, 2002; Gauthier et al., 1999; Wong, Palmeri, Rogers, Gore, & Gauthier, 2009), this would suggest that other-race faces are processed less holistically than same-race faces. Notably, the difference in activation for same-race versus other-race faces in the FFA was correlated with the size of the memory advantage for same-race faces over other-race faces, consistent with the idea that the ORE stems from reduced holistic processing. The ERP literature provides further support for a quantitative difference in holistic processing, demonstrating that the N170, which is believed to reflect configural processing, is delayed for other-race faces, a result that suggests that holistic processing for other-race faces emerges later than for same-race faces (Stahl et al., 2008; Wiese et al., 2009). Additionally, this delay in the N170 is comparable for other-race faces and inverted faces, suggesting that the ORE and the inversion effect may have a common underlying basis (Wiese et al., 2009).

Like other-race faces, it has been suggested that inverted faces are processed via different mechanisms than upright faces, specifically that they do not engage holistic processing (Goffaux & Rossion, 2006, 2007; Hole, 1994; Michel, Rossion, et al., 2006; Rossion & Boremanse, 2008). However, many studies suggest that the difference is quantitative (Loftus, Oberg, & Dillon, 2004; Richler, Mack, et al., 2011; Riesenhuber, Jarudi, Gilad, & Sinha, 2004; Sekuler, Gaspar, Gold, & Bennett, 2004; Valentine & Bruce, 1988). Because there is a decrease in perceptual similarity for inverted faces relative to upright faces with which we have more experience, it may be that holistic processing is slightly reduced for inverted faces, or simply takes longer to emerge. Specifically, Richler, Mack et al., found that at very short stimulus durations, inverted faces failed to elicit holistic processing, however, with extended stimulus presentations, holistic processing emerged and was similar in magnitude to that observed for upright faces.

Experiment 1 demonstrated that other-race faces can sometimes be processed as holistically as same-race faces. However, the stimulus durations in Experiment 1 were relatively lengthy. If the processing difference between other-race and same-race faces is merely a question of efficiency, then these long face presentations may be unable to reveal real differences in holistic processing that may only be evident early on. Previous work has suggested that holistic processing of same-race faces is observed as soon as stimulus durations are long enough to support above-chance performance (Richler, Mack, et al., 2009). If other-race faces are processed less efficiently than same-race faces, then it may be that longer presentation times are required for holistic effects to emerge because more time is needed for performance to rise above chance. Accordingly, the aim of Experiment 2 was to investigate whether, as with the inversion effect, a more robust ORE (exhibited through increased discriminability or greater holistic processing for same-race faces) might arise early on, but then decrease with time. To address this question, a modified version of the composite task from Experiment 1 was used where exposure of the test face was titrated so that the timecourse of holistic processing during the first stages of perception could be assessed.

Methods

Participants

Eighty-three participants with normal or corrected-to-normal vision participated in this experiment. Of these participants, 43 were Caucasian individuals (26 female; age range 18 – 54; mean age 22.32) recruited from the Vanderbilt community, who were provided with either monetary compensation or course credit for their time. The remaining 40 participants were Asian individuals (28 female; age range 18 – 33; mean age 22.2) recruited from the University of Hong Kong community, who were provided with paid compensation for their participation. Two Caucasian participants were excluded from the final analyses because they failed to respond to over 20% of trials.

Stimuli

The stimuli were identical to those used in Experiment 1.

Procedure

The experiment was run using Matlab on Apple computers running OS 10.6.

The sequence of events in this experiment is very similar to Experiment 1 (Figure 5). The principal differences between the two experiments are the presentation durations of the study and test composite faces, as well as the introduction of a patterned mask between the two. Each trial began with the presentation of a fixation cross (500 ms), which was then followed by a study composite face (800 ms). A mask was then presented (500 ms), after which the test composite face appeared for a variable duration of either 50, 183, or 800 ms. A question mark then appeared on screen for a maximum duration of 2500 ms, during which participants were required to make their response. As in Experiment 1, participants were instructed to indicate whether the top halves of the two composite faces they had viewed were the Same ("Q" key) or Different ("P" key). Making a response initiated the next trial.

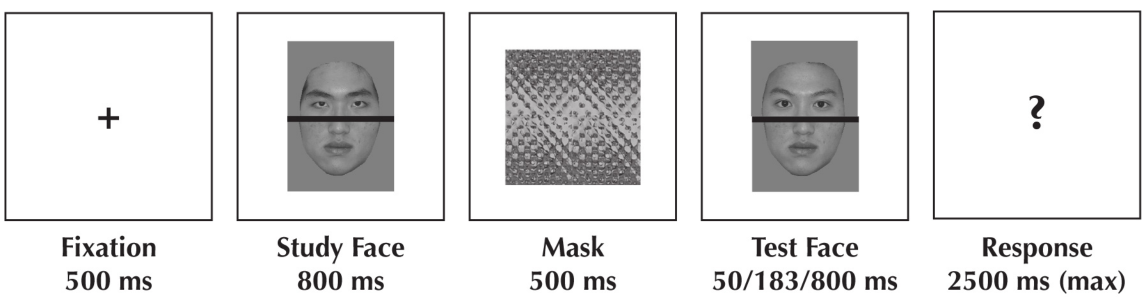

Figure 5. Timing of events in Experiment 2. Pictured is an example of an Aligned trial with Asian faces. When the question mark appeared, participants indicated whether the top halves of the two previously viewed faces were the same or different.

One additional difference between Experiment 1 and 2 involves the Misaligned trials. In Experiment 1, both study and test composite faces were misaligned on Misaligned trials. However, spurious congruency effects can be induced for novel non-face objects when study composites are misaligned, resulting in misidentification of holistic processing (Richler, Bukach, et al., 2009). When only the test composite is misaligned, holistic processing appears to be correctly indexed using the congruency effect. Consequently, it is possible that holistic processing may have been artificially inflated for other-race faces in Experiment 1, which could potentially explain why no ORE in terms of holistic processing was observed. Thus, in Experiment 2 (and all subsequent experiments), only the test composite was misaligned on Misaligned trials.

The specific presentation times for the test composite were selected with reference to the refresh-rate of the computer monitors used for testing (60 Hz) and to coincide with those used in Richler and colleagues' (2011) investigation of the timecourse of holistic processing for inverted faces. Additionally, 50 ms was selected as the minimum duration based on previous research suggesting that for upright faces, discrimination performance is not above chance levels for shorter durations (Richler, Mack, Gauthier & Palmeri, 2009).

Participants completed 20 blocks, each consisting of 48 trials for a total of 960 trials. Twenty trials for each combination of Face Race (Asian/Caucasian), Congruency (congruent/incongruent), Alignment (aligned/misaligned), Correct Response (same/different) and Test Duration (50/183/800 ms) were collected. Stimuli were blocked by face race, such that participants completed 10 blocks consisting exclusively of Caucasian faces, and 10 blocks of Asian faces. These blocks were randomly intermixed. All other factors (congruency, alignment, correct response, test composite presentation duration) were randomized.

Results

In this experiment, the presentation duration for the test composite face was parametrically manipulated so that I could directly compare and contrast how holistic processing develops for same-race and other-race faces. For this reason, it was critical to precisely control the exposure of the test composite, and as a result, participants were not able to respond until after the test stimulus was removed from the screen. By making participants wait until the second composite face was removed before they made their response, this helped to ensure that they were actually observing and processing the stimuli for the entirety of their allotted duration. Reaction times would be difficult to interpret in this experiment because an additional decisional component (i.e., determining when it is time to respond) must be factored in. Thus, in this experiment, analyses will be restricted to accuracy (as measured in terms of d′).

To limit the effect of possible outliers, winsorized (20%) means and variances were used in all analyses, following recommendations for robust estimation by Wilcox (2005).

d' for Caucasian Subjects

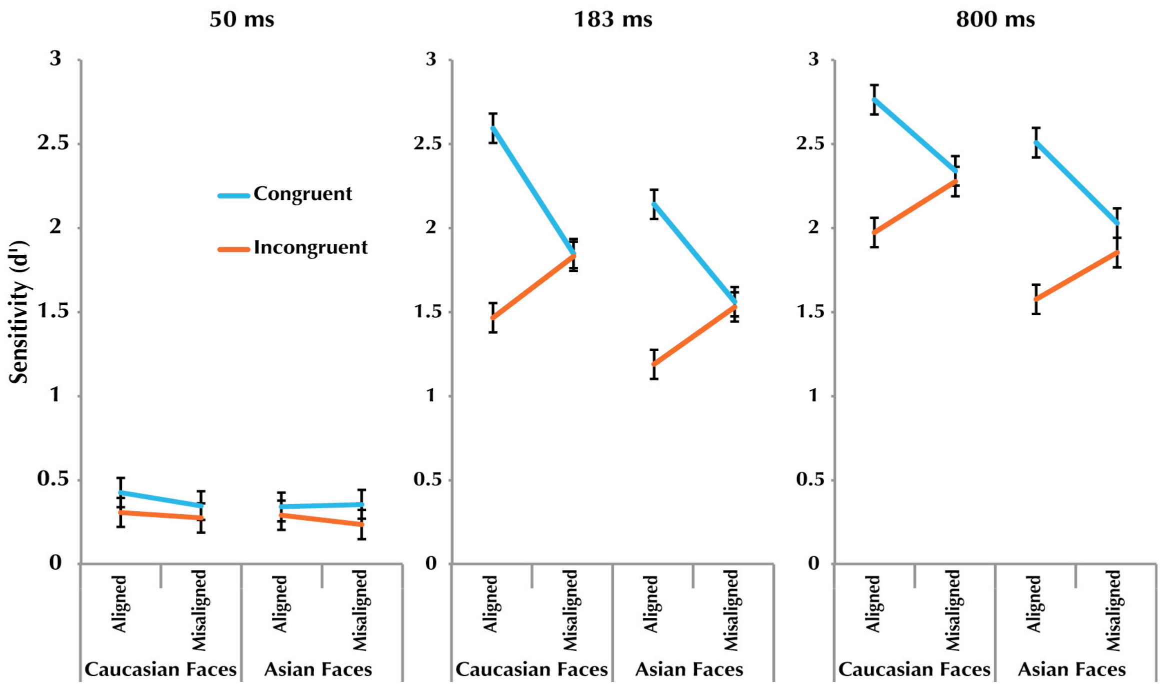

Figure 6. Sensitivity (d') for congruent (blue lines) and incongruent (red lines) trials as a function of alignment and stimulus race for Caucasian participants at each of the three exposure durations used in Experiment 2. Error bars show 95% confidence intervals of within-subject effects.

Sensitivity (d') is plotted for each of the three stimulus durations in Figure 6. A 2 x 2 x 2 x 3 repeated measures ANOVA was conducted with Congruency (congruent/incongruent), Alignment (aligned/misaligned), Face Race (Caucasian/Asian), and Exposure Duration (50/83/800 ms) as the key independent variables. There was a significant main effect of Congruency ($F_{1,40}$ = 151.1, $p <$ 0.0001) and Alignment ($F_{1,40}$ = 19.04, $p < 0.0001$), as well as a significant interaction between the two ($F_{1,40}$ = 148.0, p < 0.0001), indicating that holistic processing was present. However, there was no significant interaction between holistic processing and Face Race ($F_{1,40}$ = 1.33, p = 0.255), suggesting that for Caucasian participants, both Caucasian and Asian faces elicited equal amounts of holistic processing.

With respect to the importance of timing, there was a significant main effect of Exposure Duration with a significant improvement in overall discrimination performance with increased stimulus presentation ($F_{2,80}$ = 858.7, p < 0.0001). Interestingly, although, there was an overall discrimination advantage for Caucasian faces ($F_{1,40}$ = 87.6, p < 0.0001), this advantage for same-race faces required time to emerge: a significant interaction between Exposure Duration and Face Race revealed that the discrimination advantage Caucasian participants exhibited for Caucasian faces only occurred for stimulus presentations of 183 ms and longer ($F_{2,80}$ = 29.65, p < 0.0001).

Stimulus exposure duration also influenced holistic processing ($F_{2,80}$ = 53.6, p < 0.0001); as can be seen in Figure 6, significant Congruency x Alignment interactions were only observed for exposure durations of 183 ms and above (50 ms: min p = 0.393; 183 ms: max p < 0.0001; 800 ms: max p < 0.0001). Moreover, the magnitude of holistic processing present at 183 ms did not differ from the magnitude of holistic processing present at 800 ms ($F_{1,39}$ = 4.083, p = 0.05). Critically, the four-way Congruency x Alignment x Face Race x Exposure Duration interaction was not significant ($F_{2,80}$ = 0.746, p =0.48), indicating that holistic processing emerged at the same time and developed at the same rate for both same-race and other-race faces.

d' for Asian Subjects

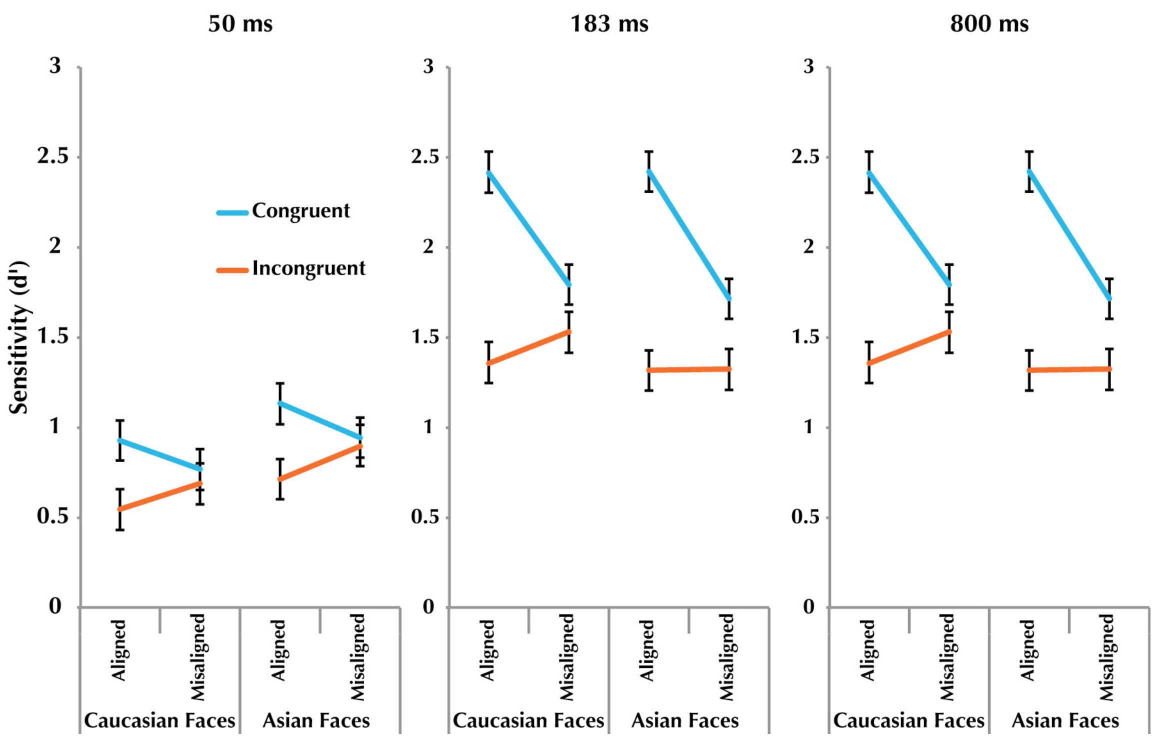

Figure 7. Sensitivity (d’) for congruent (blue lines) and incongruent (red lines) trials as a function of alignment and stimulus race for Asian participants at each of the three exposure durations used in Experiment 2. Error bars show 95% confidence intervals of within-subject effects.

Sensitivity (d’) is plotted for each of the three stimulus durations in Figure 7. As with the Caucasian participants, the same 2 x 2 x 2 x 3 repeated measures ANOVA was conducted and revealed a significant main effect of Congruency ($F_{1,39} = 153.0$, $p < 0.0001$) and Alignment ($F_{1,39} = 48.34$, $p < 0.0001$). There was also a significant interaction between the two ($F_{1,39} = 173.5$, $p < 0.0001$), indicating that holistic processing was present.

As with Caucasian participants, holistic processing interacted with Exposure Duration ($F_{2,78} = 20.26$, $p < 0.0001$), however it did so in a different way. Although holistic processing for both groups increased with time, for the Caucasian participants, it was an “all or none” improvement, where stimulus exposure affected whether holistic processing was observed, but once it was present, it did not increase in magnitude with longer presentation times. For Asian participants, however, holistic processing was evident for both other-race and same-race faces even at the shortest presentation duration (min $t(39) = 3.721$, max $p < 0.005$), and continued to increase with longer stimulus duration (max $p < 0.0005$). The most likely explanation for this difference is that processing was simply faster for Asian participants.

Additionally, in stark contrast to Caucasian participants, a significant interaction between Congruency, Alignment and Face Race was also observed ($F_{1,39} = 5.72$, $p < 0.05$), indicating that same-race and other-race faces elicited different amounts of holistic processing. Paired t-tests demonstrated a clear ORE: the Congruency x Alignment interaction was indeed larger for Asian faces ($t(39) = 2.394$, $p < 0.05$), indicating that Asian participants processed same-race faces more holistically than other-race faces. However, the interaction between holistic processing and Face

Race was modulated by stimulus exposure ($F_{2,78}$ = 6.99, $p < 0.005$), and post-hoc tests revealed that this relative boost in holistic processing for same-race faces took time to emerge, as it did not appear until 800 ms (50 ms: $p = 0.645$, 183 ms: $p = 0.631$; 800 ms: $p < 0.0001$).

While Caucasian participants did not demonstrate differential holistic processing for same-race and other-race faces, they did exhibit an overall discrimination advantage for same-race faces once holistic processing was present. For Asian participants, discrimination improved with each increase in stimulus duration ($F_{2,78}$ = 489.5, $p < 0.0001$), however there was no overall discrimination advantage for either same-race or other-race faces ($F_{1,39}$ = 0.078, p =0.78). Instead, Face Race and Exposure Duration interacted ($F_{2,78}$ = 25.972, $p < 0.0001$), such that there was an early discrimination advantage for same-race faces ($p < 0.0001$), which ultimately switched to a discrimination advantage for

Caucasian faces at 800 ms ($p < 0.005$). The early same-race advantage for Asian participants is particularly critical because it suggests that these results cannot be entirely explained by a stimulus-based advantage that might make the Caucasian faces easier to discriminate.

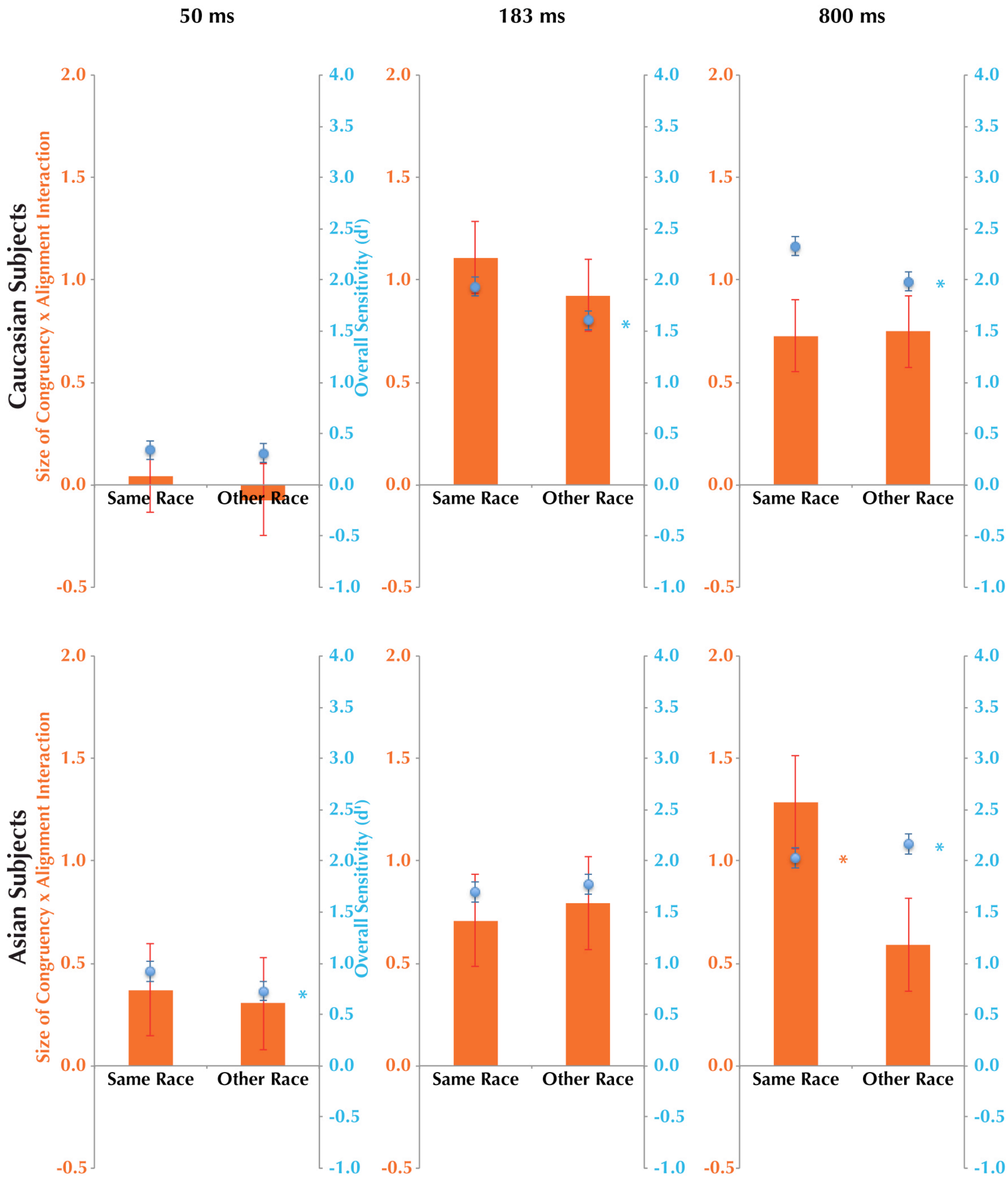

Figure 8. Plots of overall discrimination performance (blue; right axis) and magnitude of holistic processing (orange; left axis) for same-race and other-race faces across the three stimulus exposure durations. Overall discrimination performance was calculated by averaging across the four congruency x alignment conditions for each face race at each of the three time points, and size of the congruency x alignment interaction represents the amount of holistic processing. Caucasian participants (top) show an overall discrimination advantage for same-race faces that arises with time, whereas Asian participants (bottom) initially show a same-race discrimination advantage early on, and enhanced holistic processing for same-race faces with extended stimulus exposure. Error bars show 95% confidence intervals of within-subject effects.

Discussion

The primary goal of Experiment 2 was to assess how the ORE emerges when participants are given varying amounts of time to process the second composite in the composite task. In particular, the aim here was to investigate whether, like inverted faces, other-race faces are processed less efficiently than same-race faces and may therefore require more time for holistic processing to fully emerge.

First and foremost, Experiment 2 provided clear evidence that the ORE can, and does, assert itself in different ways. As can be seen in Figure 8, while holistic processing of same-race faces ultimately reached higher levels than for other-race faces for Asian participants, this was not true for Caucasian participants, for whom holistic processing of same-race and other-race faces was always equivalent. Instead, the ORE for Caucasian participants was reflected in an overall discrimination advantage for same-race faces that was apparent as soon as holistic processing was observed. This same-race discrimination advantage was also seen for Asian participants at the 50 ms exposure duration. This advantage in particular is important because results from Experiment 1 indicated that the Caucasian stimulus set may have been more easily discriminated; however, Asian participants showed a performance advantage for Asian faces early on, while Caucasian participants demonstrated a discrimination bias for Caucasian faces, which indicates that more than stimulus-based differences are at play. Rather, it appears that there may be a fast-acting attentional bias that boosts discrimination performance for same-race faces early on, independent of subsequent changes in holistic processing related to face race.

With respect to whether holistic processing takes longer to develop and emerge for other-race faces, the results from Experiment 2 indicate that this is not the case. Across both groups of participants, holistic processing appeared at the same time and was comparable for same-race and other-race faces even when stimulus exposure was extremely brief; it was only at the longer stimulus duration that an increase in holistic processing was observed for same-race faces, and this was limited to the Asian participants. These results indicate that if reduced holistic processing plays a role in the ORE at all, the difference only seems to be evident when presentation times are relatively long. This is very different from what is observed with inverted faces where increased presentation time results in increased holistic processing (Richler, Mack et al., 2011). Two important conclusions can be drawn as a result: 1) other-race faces are processed holistically, suggesting that they are not processed qualitatively differently from same-race faces; 2) there can be quantitative differences in holistic processing between other-race and same-race faces, but these are not due to holistic processing emerging earlier or developing at a faster rate for same-race faces.

It is not entirely clear why only one participant group exhibited reduced holistic processing for other-race faces. However, one thing that it is important to keep in mind is that it is impossible to equate the amount and type of experience each of the two groups had with their respective "other race" prior to the experiment, so the perceptual strategies they had developed for other-race versus same-race faces could very well differ on that basis. That said, another important factor to consider is that it is also difficult to understand what social implications the respective other-race faces hold for each of the groups: an Asian face may mean something very different to a Caucasian individual in Nashville, TN than does a Caucasian face to an Asian individual in Hong Kong.

Given that differences in holistic processing based on race (provided they exist) seem to emerge relatively late, it is possible that top-down sociocognitive judgments are largely driving this effect. However, in standard other-race studies where different races are contrasted with one another, it is impossible to tease apart and pinpoint the distinct contributions of low-level perceptual factors from those related to top-down biases regarding other-race faces. Experiments 3 and 4 were conducted to directly isolate the effect social judgments can have on holistic processing when perceptual expertise is held constant.

CHAPTER IV

THE EFFECT OF INGROUP/OUTGROUP CATEGORIZATION ON HOLISTIC PROCESSING

Experiment 3: Investigating the Effects of Explicit Ingroup/Outgroup Categorization on Holistic Processing over Time

Although the perceptual expertise explanation for the ORE has gained a good deal of popularity, there are some findings that are not well accounted for in its scope. In particular, studies that have controlled for the effects of perceptual learning have found that ORE-type effects can be found following manipulations that encourage participants to view same-race faces as belonging to social ingroups or outgroups (Bernstein et al., 2007; Shriver et al., 2008; Young et al., 2010). These results have prompted alternative theories, which argue that sociocognitive factors can largely account for the ORE. One such example is the Categorization-Individuation Model (Hugenberg et al., 2010; Young et al., 2012), which attempts to bridge the divide between the two schools of thought. Proponents of this model argue that there is an asymmetrical search for features in other-race and same-race faces, with individuals encoding those features that are most useful for individuation for same-race faces, but only attending to the features that define category membership (i.e., race) for other-race faces at the expense of those that support individuation (Hugenberg, Miller, & Claypool, 2007; Levin, 1996, 2000; MacLin & Malpass, 2001; Young & Hugenberg, 2012). However, by simply manipulating one's motivation to individuate, they argue that the recognition advantage for same-race faces (and disadvantage for other-race faces) can be augmented or eliminated.

The motivation to individuate can be achieved through explicit instructions, such as by informing participants about the ORE and the importance of individuation (Hugenberg et al., 2007; Rhodes et al., 2009). It also appears, however, that motivation to individuate can be implicitly manipulated by categorizing faces into ingroups and outgroups, or by making group memberships salient (Bernstein et al., 2007; Hugenberg et al., 2007; Levin, 1996, 2000). Because racial categorization happens relatively quickly (Ito & Urland, 2003, 2005), it is believed that when we identify a face as belonging to a race that is saliently different from our own, it is then also considered to belong to an outgroup (Levin, 2000). Consequently, the motivation to individuate may decrease and the category-defining features are encoded instead, resulting in the ORE.

Recently, it has been suggested that the reason why ingroup/outgroup classification matters is because it directly influences the extent to which faces are processed holistically (Hugenberg & Corneille, 2009). However, as mentioned earlier, it is unclear to what extent holistic processing can actually be influenced by top-down factors as the effect of group has only been demonstrated using the partial design of the composite task. These results are rather surprising, given that holistic processing is considered to be a fast, automatic process (Richler, Cheung, & Gauthier, 2011b). Holistic processing can be modulated by low-level manipulations of general attentional biases, such as by activating biases toward global or local processing with Navon letter tasks (Gao, Flevaris, Robertson, & Bentin, 2011). Additionally, negative mood has been reported to enhance processing of local features (Basso, Schefft, Ris, & Dember, 1996; Derryberry & Reed, 1998) as compared to positive or neutral moods. Similarly, induction of a positive mood reduces the ORE (Johnson & Frederickson, 2005) and has recently been shown to increase holistic processing measured with the composite task (Curby, Johnson, & Tyson, 2012). Holistic processing can also be reduced via competition for processing resources, such as when car experts complete a version of the composite task where face and car trials are interleaved (Gauthier, Curran, & Curby, 2003). Here the reduction in holistic processing appears to result from faces and expert objects tapping into a shared, but limited, resource that operates early and likely supports perceptual processing (e.g., McGugin, McKeeff, Tong, & Gauthier, 2011; McKeeff, McGugin, Tong, & Gauthier, 2010). To date, there is no evidence using the complete design of the composite task that holistic processing can be manipulated through more top-down, strategic factors. However, if the partial design results indicating that ingroup/outgroup categorization can alter holistic processing are valid (Hugenberg & Corneille, 2009), this might explain why the difference in holistic processing that was observed for Asian participants for same-race and other-race faces in Experiment 2 only appeared with longer stimulus durations. Top-down regulation of holistic processing (especially where group membership varies on a trial-by-trial basis) likely takes time to emerge, as categorization must first occur and then feedback signals must propagate to early visual areas.

As in Experiments 1 and 2, the experiments in this chapter will be conducted using the complete design version of the composite task. The complete design and partial design do not always produce compatible results (see Richler & Gauthier, submitted), and there are instances when a congruency x alignment interaction is observed in the complete design, implying holistic processing is present, yet there is no alignment effect in the partial design, such as when investigating the question of whether inverted faces elicit holistic processing (Richler, Mack et al., 2011). Moreover, there are instances when a manipulation fails to affect holistic processing as measured by the complete design, but is strongly reflected in the alignment effect within the partial design (Cheung et al., 2008; Richler, Cheung, & Gauthier, 2011b); in such cases, the results from the partial design generally reflect a decisional bias component rather than holistic processing. Because the alignment effect is so susceptible to response bias, and this bias itself is idiosyncratic and can vary greatly between subject samples, it is often difficult to replicate partial design results. Thus, any conclusions drawn from the partial design should be validated using other methods. Consequently, I did not begin by attempting to replicate Hugenberg & Corneille's (2009) findings using the partial design; there is already ample evidence that the two methods are often inconsistent, and the results of such a replication would tell us little about whether these results would bear out using the complete design. To put it another way, if the partial design found evidence of putative holistic processing that is not supported in the complete design, my assessment of these two methods would lead me every time to assume the partial design effect could not be trusted.

As such, the aim of Experiment 3 was to test whether classifying faces into ingroups and outgroups can influence holistic processing as measured via the complete design, and if so, whether these effects arise early or late.

Methods

Participants

Sixty-seven participants with normal or corrected-to-normal vision participated in this experiment. All participants were Caucasian individuals currently enrolled in an undergraduate degree program at Vanderbilt University (37 female; age range 18 – 23; mean age 20.04). Participants were provided with either monetary compensation or course credit for their time.

Stimuli

A subset of Caucasian faces collected and developed by Tanaka & Pierce (2009) were used in this experiment. All faces displayed neutral expressions, and the internal face features were placed within a standard face template so that all faces had identical hairstyles, face contours and clothing.

A total of 60 gray-scale adult male faces were used to create the composite stimuli used in this experiment. Twenty of these faces were randomly assigned "ingroup" status and twenty were assigned "outgroup" status. The remaining third were assigned neutral status and used during the practice phase of the experiment. The faces were then split into halves, so that each group (ingroup/outgroup/neutral) had a pool of 20 face tops and 20 face bottoms that could be randomly selected and combined to form composite faces. Faces were placed on a colored background, the color of which was determined by group status: for ingroup composites, the face halves were presented on black or yellow backgrounds (counterbalanced across subjects), whereas outgroup composites were presented on orange or white backgrounds (counterbalanced across subjects). Neutral composites were presented on a gray background. These specific colors were selected because they correspond to the school colors of Vanderbilt University (ingroup) and The University of Tennessee (outgroup), which would hopefully make group affiliation of the composite faces more salient. Additionally, the name of the school each composite attended was printed in white or black letters (depending on the colored background) above the top half of the face. These manipulations of color and text are comparable to those used by Hugenberg & Corneille (2009) to examine the effect of ingroup/outgroup categorization on holistic processing.

When combined, faces halves were separated by a line four pixels thick (in the same color as the background) so as to make the two halves visually distinct from one another. Misaligned faces were created by moving the top half of the face to the right by 50% of its width and the bottom half of the face to the left by 50% of its width so that the edge of one face half fell in the center of the other face half. Aligned composites were 324 pixels wide, whereas misaligned faces were 405 pixels wide; all composites were 394 pixels tall.

Procedure

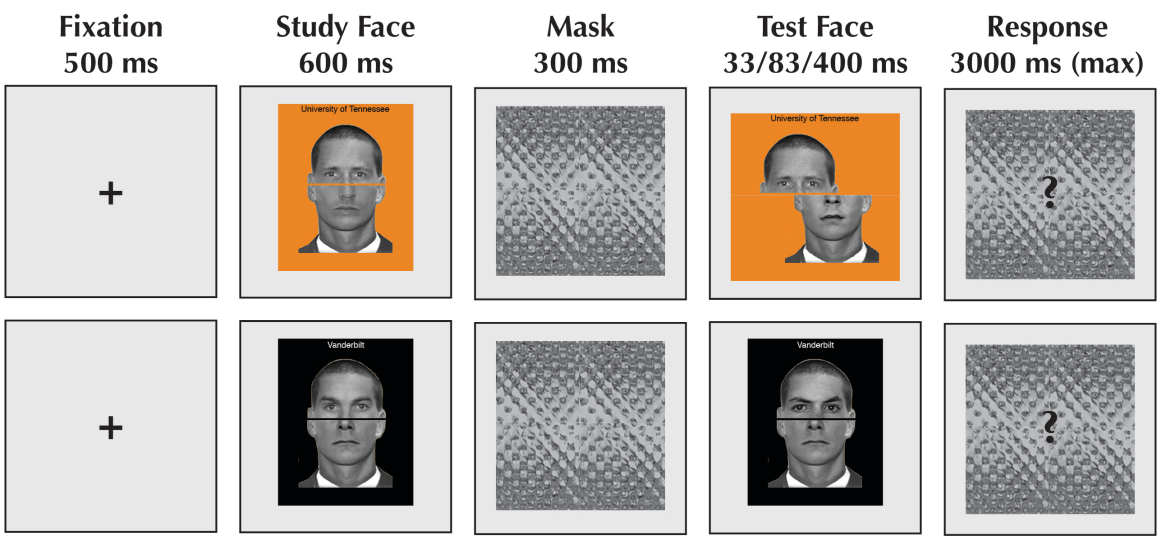

Figure 9. Timing of events in Experiment 3. A Misaligned Outgroup trial where the correct response is "Same" is shown in the top row, and an Aligned Ingroup trial where the correct response is "Different" is shown in the bottom row. Note that as in Experiment 2, only the test composite face is misaligned on Misaligned trials.

The experiment was run using Matlab on Apple computers running OS 10.6.

Prior to the start of the experiment, participants were informed that they would see faces of fellow Vanderbilt students as well as University of Tennessee students. They were informed that university affiliation depended on the background color that the face was presented upon, and that it would be presented in words above the face. They were also told that regardless of university affiliation, they should pay close attention to all of the faces. Experiment 3 also differed from Experiment 2 in terms of stimulus timings. Each trial began with the presentation of a fixation cross (500 ms), which was then followed by a study composite face (600 ms). A mask was then presented (300 ms), after which the test composite face appeared for a variable duration of either 33, 83, or 400 ms. A question mark then appeared on screen for a maximum duration of 3000 ms, during which time participants were required to make their response. As in previous experiments, participants were instructed to always indicate whether the top halves of the two composite faces they had viewed were the Same ("Q" key) or Different ("P" key). Making a response initiated the next trial.

The shorter presentation of the study face and the interstimulus mask were used to match the timings used by Hugenberg & Corneille (2009). As in Experiment 2, the exposure durations of the test composite were selected with reference to the refresh-rate of the computer monitors used for testing (60 Hz). In Experiment 2, one of the participant groups was already very good at 50 ms, so slightly shorter stimulus durations were selected to increase the likelihood that any potential differences at early time points would be captured and avoid ceiling effects.

Participants completed 20 blocks (plus one additional practice block of 16 trials), each consisting of 48 trials for a total of 960 trials. Twenty trials for each combination of Group Status (ingroup/outgroup), Congruency (congruent/incongruent), Alignment (aligned/misaligned), Correct Response (same/different) and Exposure Duration (50/183/800 ms) were collected. All factors were randomized within each block, including Group Status, to mirror the design used by Hugenberg & Corneille (2009) as closely as possible.

Results

As in the previous experiments, winsorized (20%) means and variances were used in all analyses, following recommendations for robust estimation by Wilcox (2005).

A 2 x 2 x 2 x 3 repeated measures ANOVA was conducted with Congruency (congruent/incongruent), Alignment (aligned/misaligned), Group Status (Ingroup/Outgroup), and Exposure Duration (33/83/400 ms) as the main factors of interest. There was a main effect of both Congruency ($F_{1,66} = 223.3$, $p < 0.0001$) and Alignment ($F_{1,66} = 31.36$, $p < 0.0001$), as well as an interaction between the two, indicating that holistic processing was present ($F_{1,66} = 52.8$, $p < 0.0001$). Congruency x Alignment also interacted with Exposure Duration ($F_{2,132} = 35.69$, $p < 0.0001$): as can be seen in Figure 10, holistic processing was not present at the shortest stimulus duration of 33 ms ($F_{1,66}$,=3.89, $p = 0.054$) for either group of faces, but was present at 83 ms ($F_{1,66}$,=46.2, $p < 0.0001$) and 400 ms ($F_{1,66}$,=64.6, $p <$

0.0001). Moreover, holistic processing continued to increase for both groups between 83ms and 400 ms ($F_{1,66}$=10.8, p < 0.005). There was also a main effect of Exposure Duration, indicating that overall discrimination performance improved with longer stimulus presentations ($F_{2,132}$ = 215.76, p < 0.0001).

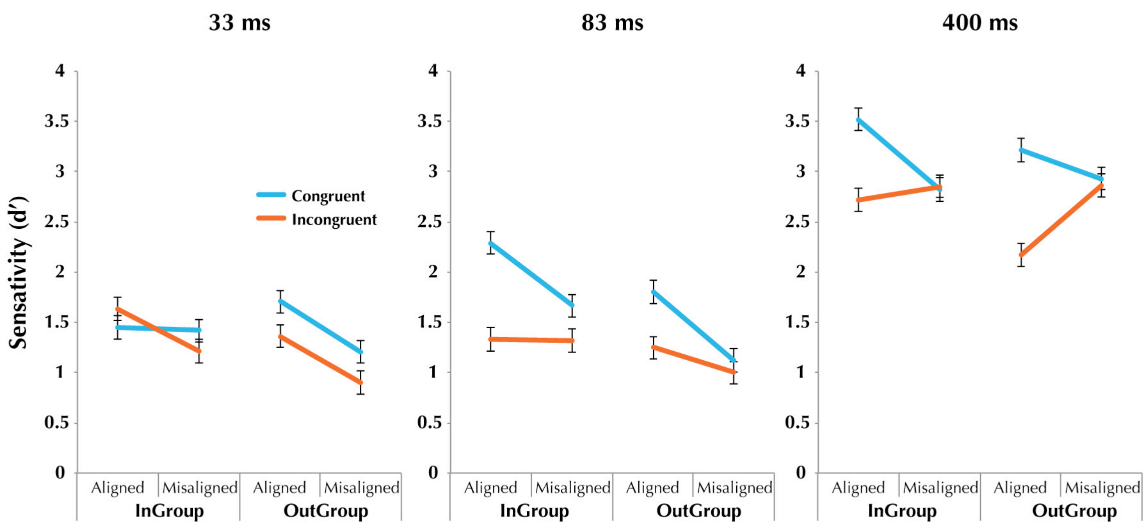

Figure 10. Sensitivity (d') for congruent (blue lines) and incongruent (orange lines) trials as a function of alignment and group status (ingroup/outgroup) at each of the three exposure durations used in Experiment 3. Error bars show 95% confidence intervals of within-subject effects.

Critically, there was no significant interaction between Congruency, Alignment and Group Status ($F_{1,66}$ 1.952, p = 0.167), indicating that ingroup and outgroup faces elicited equivalent amounts of holistic processing. Although there was a significant four-way interaction between Congruency x Alignment x Exposure Duration x Group Status ($F_{2,132}$ = 3.43, p < 0.05), suggesting that holistic processing for the two groups of faces might differ with time, this can be accounted for by the 33 ms time point. As can be seen in the first panel of Figure 10, neither ingroup nor outgroup faces were processed holistically at 33ms, although they did produce qualitatively different patterns of results (Congruency x Alignment x Group Status interaction at 33 ms: $F_{1,66} = 5.33$, $p < 0.05$). There was a significant congruency x alignment interaction for ingroup faces at 33 ms ($F_{1,66}=8.41$, $p < 0.01$), but performance was no better on aligned congruent trials compared to misaligned congruent trials ($p = 0.057$), suggesting that holistic processing was not present. Outgroup faces, on the other hand, showed no significant congruency x alignment interaction at this short presentation duration ($F_{1,66}=0.094$, $p = 0.76$), which also indicates that no holistic process was present. When analyses were restricted to stimulus durations of 83ms ($F_{1,66} =1.42$, $p = 0.238$) and 400 ms ($F_{1,66} =0.824$, $p = 0.367$), there was no longer a significant interaction between Congruency, Alignment and Group Status, indicating that when holistic processing was observed in this experiment, it did not differ in degree between ingroup and outgroup faces.

One interesting, but unexpected, result was a significant main effect of Group Status ($F_{1,66} = 59.9$, $p < 0.0001$). That is, participants were better at discriminating faces that were randomly assigned ingroup status than those that were assigned outgroup status. As can be seen in Figure 11, the performance advantage for ingroup faces was present at all time points (max $p < 0.05$), even when faces were presented as briefly as 33 ms. Further investigation of a significant Group Status x Exposure Duration interaction ($F_{2,132} = 7.218$, $p < 0.005$) revealed a significant increase in performance for ingroup faces with each subsequent exposure duration (max $p < 0.0001$), whereas performance for outgroup faces only improved when face presentation time extended from 83 ms to 400 ms (83 vs 33: $p = 0.999$; 83 to 400: $p < 0.0001$).

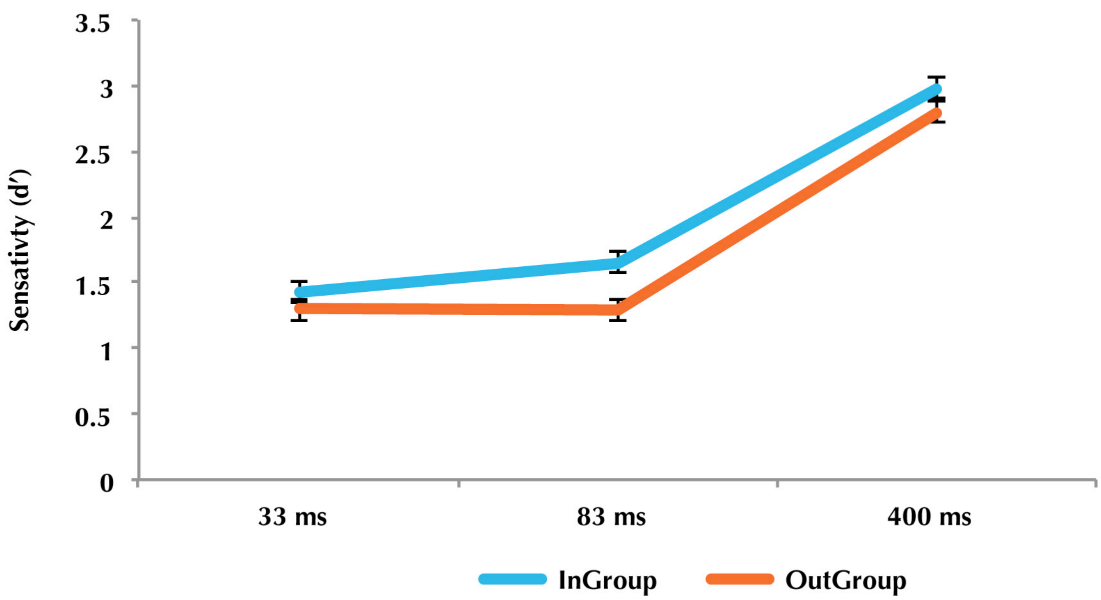

Figure 11. Overall discrimination performance (d′) for Ingroup (blue line) versus Outgroup (orange line) faces across the three stimulus exposure durations. Error bars show 95% confidence intervals of within-subject effects.

Discussion

Experiment 3 was designed to test Corneille & Hugenberg's (2009) claims that holistic processing can be reduced merely by categorizing a face into an outgroup. Moreover, this experiment extended beyond the original study by examining the time at which this effect might arise. Unfortunately, Experiment 3 did not support Corneille & Hugenberg's conclusions: despite using the same group manipulation with increased power owing to a larger sample size, there was no evidence that holistic processing differed on the basis of group status. Holistic processing appeared at the same time for both ingroup and outgroup faces, and also developed at the same rate. Although these results fail to replicate those produced by the partial design, they are consistent with previous results indicating that holistic processing is robust to top-down strategic influences (Richler, Cheung, & Gauthier, 2011b).

The failure to find an effect of group status on holistic processing is even more striking given that the experiment revealed an overall discrimination advantage for ingroup faces. Additionally, these findings are similar to the pattern of results observed for Caucasian participants in Experiment 2, where holistic processing did not differ between same-race and other-race faces, but same-race faces were better discriminated overall. As in the current experiment, the discrimination advantage for same-race faces appeared quite early.

Closer examination of the timecourse of discrimination suggests that group status may speed up the rate at which information is extracted from a face, as performance improved between 33 and 83 ms for the ingroup faces alone. Because the times I sampled are rather coarse, it would be difficult to accurately fit a function to the ingroup and outgroup data in order to best compare rates of perceptual processing between the two. An alternative is that the speed of information accumulation may not differ for ingroup and outgroup faces, but the time at which useful information is first available may be earlier for ingroup than for outgroup faces. Curby & Gauthier (2009) found that the rate of perceptual encoding is unaffected by expertise, however extraction of perceptual information begins sooner for items of expertise. With respect to expertise, this “head start” makes sense to some extent because experience will have taught us where to look to find the diagnostic information useful for discrimination, so we can be more efficient in our extraction of critical visual information. However, in Experiment 3, expertise was equated across ingroup and outgroup faces, so any advantage afforded to ingroup faces must be the result of top-down biases that boosts attention for ingroup faces in a more general fashion.

Experiment 4: Investigating the Effects of Ingroup/Outgroup Categorization with Prolonged Stimulus Durations

Despite carefully replicating Hugenberg & Corneille’s (2009) group manipulation and instantiating it in the same fashion, I failed to find that this had an effect on holistic processing. This is likely because the alignment effect is notoriously fickle because of demonstrated confounds (Cheung et al., 2008; Richler, Cheung, & Gauthier, 2011b; Richler, Mack et al., 2011; see Gauthier & Richler, submitted, for a review), so the fact that the complete design results did not replicate those obtained with the partial design is not really surprising. However, there is also the possibility that a potential difference in holistic processing for ingroup versus outgroup faces may require more than 800 ms to appear. Although this may seem unlikely, the difference in holistic processing between other-race and same-race faces observed for Asian participants in Experiment 2 did take time to emerge. To determine whether this is in fact the case, Experiment 4 used the exact same timing parameters as Hugenberg & Corneille's study where the test composite face was presented up to 3000 ms. Additionally, because participants were not allowed to immediately respond but instead had to wait for the appropriate response window, reaction time data was difficult to measure in the previous experiment. Experiment 4 placed no restrictions on when participants could respond, meaning that reaction time could be analyzed in addition to d′.

Methods

Participants

Forty-four participants with normal or corrected-to-normal vision participated in this experiment. All participants were Caucasian individuals currently enrolled in an undergraduate degree program at Vanderbilt University (31 female; age range 18 – 22; mean age 19.34). Participants were provided with either monetary compensation or course credit for their time. Additionally, all participants who participated in Experiment 4 were ineligible from participating in Experiment 3 (and vice versa).

Stimuli

The stimuli were identical to those used in Experiment 3.

Procedure

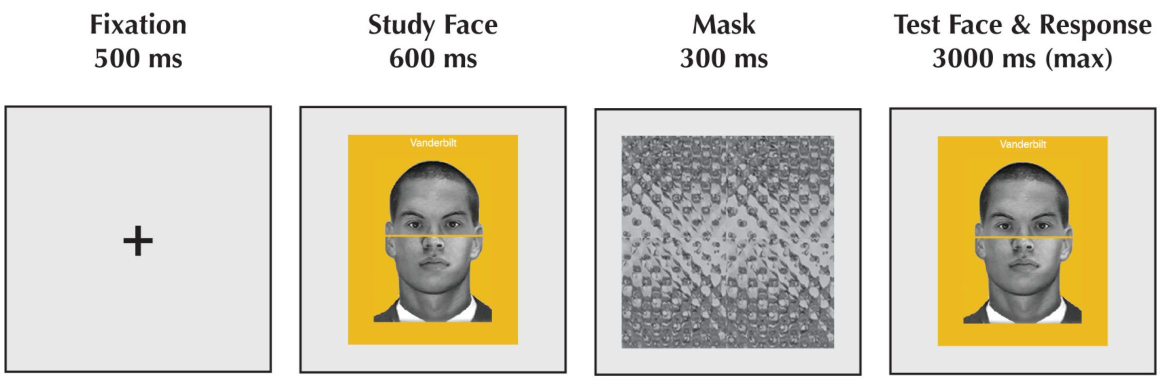

Figure 12. Timing of events in Experiment 4. A Congruent Aligned Ingroup trial where the correct response is "Same" is shown.

The design and sequence of events in this experiment (Figure 12) was nearly identical to that of Experiment 3 and is direct replication of the procedure used by Hugenberg & Corneille (2009), with the exception that the additional trials required in the complete design of the composite task were included. The sole difference between Experiment 3 and 4 is that in this experiment, rather than precisely limiting stimulus exposure and having a separate response window, the test composite face was always presented for a maximum of 3000 ms, during which time participants were required to make their response. As in previous experiments, participants were instructed to always indicate whether the top halves of the two composite faces they had viewed were the Same ("Q" key) or Different ("P" key). Making a response initiated the next trial.

As in Experiment 3, prior to the start of the experiment, participants were informed that they would see faces of fellow Vanderbilt students as well as University of Tennessee students. They were informed that university affiliation depended on the background color that the face was presented upon, and that the university name would be presented above the face. They were also told that regardless of university affiliation, they should pay close attention to all of the faces.

Participants completed five blocks (plus one additional practice phase composed of eight trials), each consisting of 64 trials for a total of 320 trials. Twenty trials for each combination of Group Status (ingroup/outgroup), Congruency (congruent/incongruent), Alignment (aligned/misaligned), and Correct Response (same/different) were collected. All factors were randomized within each block, including Group Status.

Results

Winsorized (20%) means and variances were used in all analyses, following recommendations for robust estimation by Wilcox (2005).

Sensitivity (d')

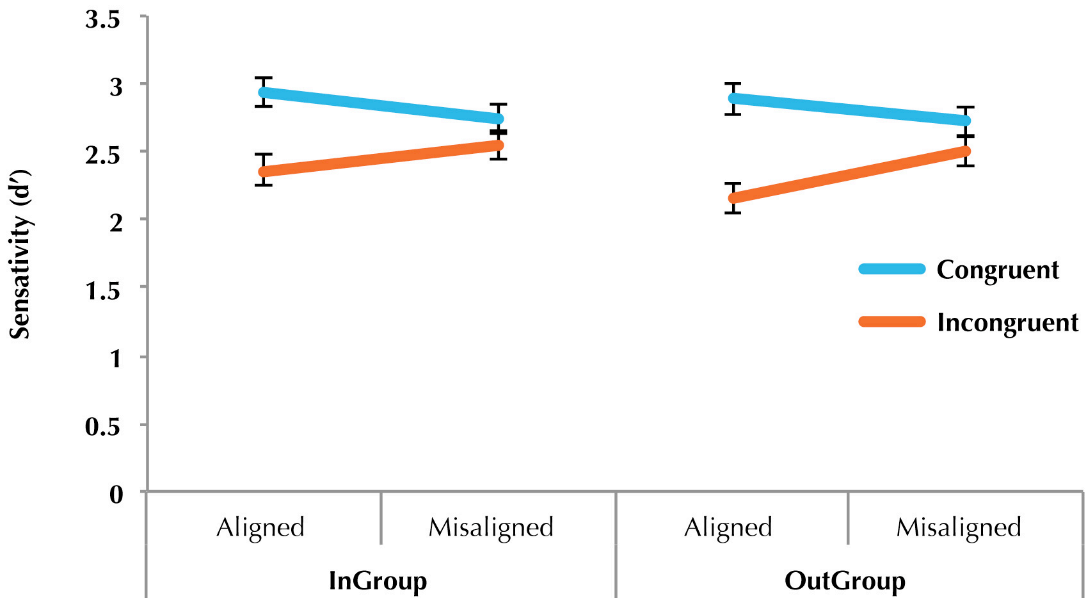

Figure 13. Sensitivity (d') for congruent (blue lines) and incongruent (orange lines) trials as a function of alignment and group status (ingroup/outgroup). Error bars show 95% confidence intervals of within-subject effects.

Sensitivity (d') is plotted in Figure 13. A 2 x 2 x 2 repeated-measures ANOVA with factors Congruency (congruent/incongruent), Alignment (aligned/misaligned), and Group Status (ingroup/outgroup) revealed a main effect for Congruency ($F_{1,43}$ = 109.7, $p < 0.0001$), as well as significant interaction between Congruency x Alignment ($F_{1,43}$ = 26.74, $p < 0.0001$), indicating the holistic processing was present. Additionally, there was a main effect of Group Status ($F_{1,43}$ = 4.31, $p < 0.05$), whereby ingroup faces were discriminated better than outgroup faces.

However, Group Status did not interact with holistic processing ($F_{1,43}$ = 0.5068, p =0.48), failing to replicate the findings of Corneille & Hugenberg (2009) where ingroup faces elicited more holistic processing than outgroup faces.

Correct Response Time (RT)

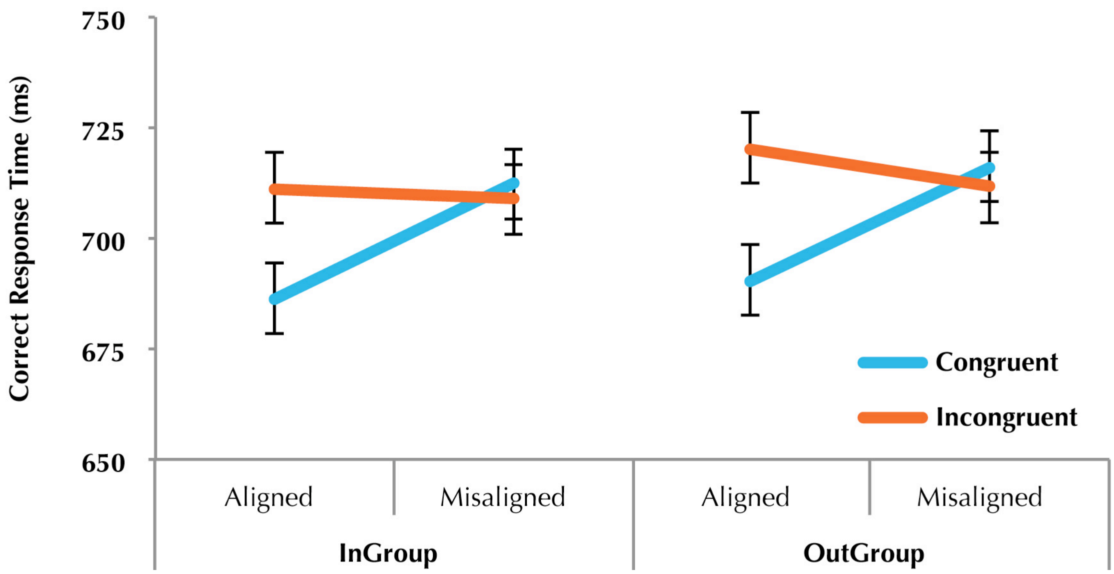

Figure 14. Correct response times for congruent (blue lines) and incongruent (orange lines) trials as a function of alignment and group status (ingroup/outgroup). Error bars show 95% confidence intervals of within-subject effects.

A similar 2 x 2 x 2 repeated-measures ANOVA was conducted on mean correct response time. As can be seen in Figure 14, the response time data largely mirrored the d′ results, however there were a few key differences. There was a significant main effect of Alignment ($F_{1,43}$ = 7.79, p <0.01), but the effect of Group Status was only marginally significant ($F_{1,43}$ = 3.22, p =0.08), indicating that there was, at best, only a small ingroup advantage in reaction time but certainly no speed-accuracy tradeoff. Critically, the response time data corroborated the lack of a Congruency x Alignment x Group Status interaction ($F_{1,43}$ = 0.290, p =0.59), which also failed to emerge in the d′ data.

Discussion

The results of Experiment 4 replicated those of Experiment 3: once again, although an overall discrimination advantage was observed for ingroup faces, a similar holistic processing advantage was not. Thus, even though the parameters used were identical to those of Hugenberg & Corneille (2009), I failed to find evidence that ingroup and outgroup categorization affects holistic processing when examining d′ or correct response time and when holistic processing is measured with the complete design of the composite task.

This failure to replicate was consistent regardless of whether the current data were analyzed in terms of the complete design or the partial design. Given how much the alignment effect can be influenced by response bias, it is not surprising that this measure is unreliable. Not only did I fail to find a larger alignment effect for ingroup faces than outgroup faces ($F_{1,43}$ = 1.02, p = 0.318), but the partial design actually failed to produce any alignment effects whatsoever ($F_{1,43}$ = 2.41, p = 1.28), which would be taken as evidence that neither type of face was processed holistically at all! This is also an important reminder that there may be a publication bias at play with respect to the alignment effect: studies are generally only published when the partial design provides evidence for holistic processing, whereas the potentially many instances when it fails to produce such evidence are unlikely to be published.

On another note, Experiments 1 and 2 failed to find consistent evidence that the race of a face influences holistic processing. With that in mind, it is not all that strange that ingroup and outgroup categorization failed to modulate holistic processing on its own, given that social group is presumably encompassed by race (Levin, 2000).

In the end, while it is not possible to definitively explain why the paradigm in Experiment 4 worked for Hugenberg & Corneille (2009) but failed to replicate here using either the complete or partial designs, the most likely explanation is that the original results are spurious given that they stem from a flawed method.

CHAPTER V

GENERAL DISCUSSION

First reported nearly a century ago (Feingold, 1914), the ORE continues to captivate and puzzle psychologists today. With accessibility to international media and travel at its peak, interracial contact is greater than it has ever been; and yet, the ORE persists. Despite the numerous studies that have attempted to understand what factors give rise to the ORE, it remains bewilderingly difficult to nail down its underlying cause. Given the importance of holistic processing in face recognition (McGugin et al., submitted; Richler, Cheung, & Gauthier, 2011a), one of the most promising possibilities is that our poorer memory for other-race faces may be due to differences in terms of how they are processed. Some have argued that this difference may be qualitative in nature, with other-race faces relying more greatly on feature-based recognition mechanisms like those that subserve object processing (Michel et al., 2006; Murray etl., 2003; Rhodes et al., 1989; Tanaka et al., 2004). However, another possibility is that the difference between other-race and same-race faces is quantitative in nature, such that holistic processing still arises for other-race faces but either takes more time to do so or perhaps occurs to a lesser extent (Stahl et al., 20008; Wiese et al., 2009).

Reduced or less efficient holistic processing has been accounted for by theories involving low-level perceptual expertise (Michel et al., 2006; Rhodes et al., 1989; Tanaka et al., 2004; Wiese et al., 2009), as well as accounts that emphasize the importance of top-down cognitive biases (Hugenberg et al., 2010; Young et al., 2012). The expertise point of view stems from evidence that experience individuating visually-homogenous stimuli gives rise to holistic processing (Bukach et al., 2010; Gauthier & Tarr, 2002; Wong, Palmeri, & Gauthier, 2009). Because there are subtle structural differences between faces of different races (Farkas, 1994), our relative lack of experience individuating other-race faces results in diminished (or less effectively deployed) holistic processing. In contrast, recent sociocognitive theories have argued that we identify race very quickly (Ito & Urland, 2003, 2005), and in so doing, we separate same-race and other-race faces into ingroups and outgroups, respectively (Levin, 1996, 2000). This social group categorization is thought to affect how faces are processed, with ingroup faces eliciting more holistic processing than outgroup faces, irrespective of race (Corneille & Hugenberg, 2009). Unfortunately, reduced holistic processing for other-race and outgroup faces has only been inferred using the partial design of the composite task which has serious validity concerns (see Richler & Gauthier, submitted, for an in-depth review). As a result, the fundamental aim of this dissertation was to investigate how race might affect the holistic processing of faces using an experimental paradigm that has stronger construct validity.

Experiments 1 and 2 found that when using the complete design of the composite task, other-race faces can elicit holistic processing. Moreover, contrary to results from the partial design (Michel et al., 2007; Michel, Rossion, et al., 2006), holistic processing of other-race faces was generally comparable to that observed for same-race faces. Although one group of participants in Experiment 2 did show evidence of a holistic-processing-based ORE, the most consistent ORE that I observed was an overall discrimination advantage for same-race faces that could not be explained in terms of enhanced holistic processing. Together, these experiments demonstrate that other-race and same-race faces appear to recruit the same underling mechanisms, and any difference between them is likely quantitative in nature.

When looking at the timecourse of the ORE in Experiment 2, I was surprised to find that when differences in holistic processing were observed between other-race and same-race faces, these differences took time to emerge and were only apparent at later time points. This was unexpected, because work with inverted faces has found the opposite pattern: differences in holistic processing between upright and inverted faces are observed early on, but disappear with time (Richler, Mack et al., 2011). If other-race faces are processed less efficiently than same-race faces, one would expect a similar pattern. One possible explanation for this discrepancy is that the reduced holistic processing that I observed for other-race faces arose due to top-down cognitive biases, the effects of which might be slower to evolve and become apparent. I tested this possibility in Experiments 3 and 4, but did not find any evidence that explicit categorization of faces into social ingroups and outgroups had any effect on holistic processing. These findings are consistent with previous work demonstrating that holistic processing is a fast, automatic process that is robust to top-down manipulations (Richler, Bukach, et al., 2009; Richler, Cheung, & Gauthier, 2011b; Richler, Gauthier, et al., 2008; Richler, Mack, et al., 2009; Richler, Wong, & Gauthier, 2011) and contradict earlier partial design results suggesting that changes in holistic processing that might give rise to the ORE can be accounted for solely in terms of social biases (Hugenberg & Corneille, 2009). Similar to the same-race faces in Experiments 1 and 2, although no underlying changes in holistic processing were observed, ingroup faces benefited from an overall discrimination advantage that arose early on. Because low-level perceptual differences cannot explain this finding, it appears that sociocognitive factors may induce general attentional biases that can contribute to the ORE.

The conclusion that group membership does not influence holistic processing is inconsistent with prior work (Hugenberg & Corneille, 2009; Ratcliff et al., 2011). However, it is important to remember that the alignment effect that was used to index holistic processing in that work often reflects changes in response bias rather than legitimate differences in holistic processing (Cheung et al., 2008; Richler, Cheung, & Gauthier, 2011b; Richler, Mack, et al., 2011). Thus, it is possible that studies claiming that top-down judgments can influence holistic processing (Hugenberg & Corneille, 2009; Ratcliff et al., 2011) are merely detecting changes in decision criteria rather than true modulation of the underlying perceptual mechanism subserving face recognition. As discussed earlier in this dissertation, there are two types of bias that can potentially contaminate the partial design. It is possible to address bias related to changes in alignment by using both same and different trials to calculated d′, however this value will still be contaminated by differences in criterion related to the congruency of the two halves of the composite face. Because "same" trials are always incongruent and "different" trials are always congruent, this latter type of bias is inherent to the partial design and cannot be removed, even when using signal detection measures. Unfortunately, bias related to congruency (or congruency x alignment interactions) cannot be measured using the partial design, so it is not possible to determine whether results produced using only the partial design are driven by bias. In the present experiments, I did not find any notable changes in response bias due to group categorization, and this may explain, in part, why I failed to replicate Hugenberg & Corneille's (2009) alignment effect findings when I examined the data from Experiments 3 and 4 within the partial design framework, and also why the congruency effect was unaffected by group status.

The results from the preceding studies are consistent with theories like the Categorization Individuation Model that claim that both low-level perceptual expertise as well as top-down social judgments play a roll in the ORE (Hugenberg et al., 2010; Young et al., 2012). However, my results also suggest that the two factors may tap into separate mechanisms that ultimately give rise to enhanced same-race face recognition and memory. Although I found evidence that ingroup versus outgroup categorization can broadly boost attention and produce a fastrising discrimination advantage, there was no evidence that this manipulation had any effect on holistic processing; however, Experiment 2 demonstrated that, with time, holistic processing differences can sometimes be observed for same-race and other-race faces. As there was no evidence that top-down explanations can account for this finding, it seems as though a disparity in previous perceptual experience with same-race and other-race faces most likely accounts for any modulations of holistic processing. This suggests, then, that although both sociocognitive biases and low-level expertise may contribute to the ORE, they do so in different ways.

Indeed, given prior work investigating the links between expertise and holistic processing, it is somewhat surprising that no consistent difference was found in holistic processing between other-race and same-race faces, either in terms of the amount of holistic processing observed or the rate at which it appeared. Changes in holistic processing routinely follow extensive experience with cars and even novel visual objects (Bukach et al., 2010; Gauthier & Tarr, 2002; Wong, Palmeri, & Gauthier, 2009), and individuation training (which leads to holistic processing) is known to improve other-race face recognition (McGugin, Tanaka, et al., 2011; Tanaka & Pierce, 2009), so why did same-race faces not show a reliable holistic processing advantage in these experiments?

One possibility is that participants were too familiar with the so-called “other race” used in this experiment. Exposure to and experience individuating Caucasian and Asian faces may no longer be all that unusual for individuals living and attending university in Hong Kong and the United States, respectively. Consequently, any differences in holistic processing between same-race and other-race faces may have been minimal at best. Perhaps if a truly novel or unusual race had been used for the other-race faces, a greater reduction in holistic processing would have been apparent. Indeed, while a roughly linear relationship between expertise and holistic processing has been suggested (Gauthier & Tarr, 2002; Richler, Cheung, & Gauthier 2011a) it is possible that over a much wider range of expertise, the relationship is not linear and that given enough expertise with faces, a certain propensity to process faces holistically is reached and such mechanisms generalize more easily to less familiar members of the face class.

Another important reason why more obvious differences in holistic processing for same-race and other-race faces were not observed could be due to the specific races that were used in these experiments. Irrespective of individuals' experience with these races, the importance of possible similarities in the underlying structure and general physiognomy of faces across different races should not be overlooked. Faces from different races often vary in terms of which features are the most diagnostic for discrimination and individuation (Ellis et al., 1975; O'Toole et al., 1994), but it is possible that in this instance, the dimensions that were most useful for individuating the Caucasian faces largely overlapped with those best used for discriminating the Asian faces. As a result, the processing strategies employed for one race may have been more easily and effectively generalized to faces of the other race. It is possible that if two different races had been contrasted (such as

Asian and African American), a more pronounced difference in holistic processing would have been observed. Nonetheless, it should be again noted that with these two races I was still able to find evidence of a face race x subject race interaction (Experiment 2).

It is also possible that we may process other-race and same-race faces equally holistically, and the critical difference between them is actually the degree to which they engage configural processing. With respect to holistic processing, it may be that the structural similarity between faces of different races is sufficiently similar that they can all be represented using a similar template, such that the individual features are not explicitly represented (e.g., Farah, Wilson, Drain, & Tanaka, 1998; Tanaka & Farah, 1993; Tsao & Livingstone, 2008), or cannot be judged independently of one another (Richler, Gauthier, Wenger, & Palmeri, 2008; Richler, Tanaka, Brown, & Gauthier, 2008; Richler, Wong, & Gauthier, 2011). However, experience with faces of a particular race may make us more sensitive to changes in the spatial relations (i.e., configural information) between features in same-race faces, which would not only result in the observed recognition advantage for same-race faces in the ORE, but could also explain why I frequently observed an overall discrimination advantage for same-race faces. Such an explanation would be consistent with findings of same-race advantages from the parts-whole, blurred-scrambled, and inversion paradigms (Hancock & Rhodes, 2008; Hayward et al., 2008; Rhodes et al., 2009, 1989, 2006; Tanaka et al., 2004), all of which may better tap into configural rather than holistic proessing.

Additionally, this would be consistent with what we know about the inversion effect: inverted and upright faces are both processed holistically, but differ in terms of configural processing (Murray, 2004; Richler, Mack, et al., 2011).

Finally, it should also be noted that even though I was not able to definitively identify any differences in the onset or timing of holistic processing in these experiments, that does not mean that a subtle but important one does not exist. The shortest stimulus duration in Experiment 2 was 50 ms, whereas Experiment 3 used 33 ms; it is possible that important differences between other-race and same-race (or ingroup and outgroup) faces may appear earlier than this. Additionally, because I only sampled three stimulus durations, I did not have the temporal resolution to assess whether the rate at which holistic processing evolved was truly unaffected by race. Given the results of all four experiments, if race or social categorization do have a pronounced effect on holistic processing, then they are likely do so in terms of how early holistic processing is observed for same-race faces relative to other-race faces. In Experiments 2 and 3, discrimination performance was already well above chance even at the shortest stimulus durations, so it was not possible to determine whether information begins to accumulate sooner for same-race or ingroup faces. To determine whether this is in fact the case, conducting a delayed recognition task similar to Curby & Gauthier (2009) with briefer stimulus durations would be necessary. A finer sampling of stimulus durations at the shorter end of the spectrum would allow for curve fitting so that potential differences in the rate at which information is encoded could also be compared.

In this study, I investigated the ORE using the composite task, in an attempt to determine whether poorer recognition memory for other-race faces could be attributed to differences in holistic processing or overall sensitivity for same-race and other-race faces. Although I did not find strong evidence that the magnitude of holistic processing differs for the other-race and same-race faces used in these studies, my analyses were focused on group means, which may have failed to capture some important variability. Indeed, a study that was published after data collection for the studies in this dissertation had been completed corroborates this notion. Bukach and colleagues (2012) used the complete design of the composite task to assess the link between prior experience individuating other-race faces and the amount of holistic processing they elicited. Consistent with my findings, no differences in the magnitude of holistic processing were observed for other-race and same-race faces when examining the participant group means. However, examinations at the level of individual differences revealed a significant negative correlation between prior other-race individuation experience and the extent to which holistic processing was reduced for other-race faces relative to same-race faces. Given these results, it could be worth explicitly exploring the link between holistic processing and the ORE as it is traditionally measured in terms of individual differences. Perhaps with a large enough sample, one might find that participants with the poorest memory for other-race faces show a tendency to process them less holistically. It might also be interesting to include a task like the Affective Lexical Priming Score (ALPS, Lebrecht et al., 2009), which measures implicit social biases for different races. This would allow for a direct examination of the extent to which differences in holistic processing for other-race and same-race faces can be accounted for by cognitive bias and racial attitudes.

Conclusion

In summary, the studies in this dissertation provide little evidence that other-race and same-race faces differ in terms of holistic processing. These results stand in stark contrast to previous work using the partial design that finds differences in holistic processing based on race or group status (Hugenberg & Corneille, 2009; Michel et al., 2007; Michel, Rossion, et al., 2006; Ratcliff et al., 2011). This demonstrates how important it is for conclusions that are based solely on the partial design method to be reevaluated using the complete design. Consistent with previous findings that holistic processing is robust to top-down manipulations, sociocogntive biases did not appear to influence holistic processing, although they can result in consistent discrimination advantages for same-race and ingroup faces, which arise early and may, in turn, translate into enhanced recognition memory as is seen in the ORE. In the studies I ran, the ORE was rarely reflected in holistic processing, thus it appears that at least for the conditions tested in this dissertation, the structural similarity between the same-race and other-race faces was high enough to support generalization of holistic processing mechanisms across the two types faces. However, one experiment did indicate that in some instances, differences in holistic processing for same-race and other-race faces can arise, which would likely impact recognition memory performance. This difference cannot be accounted for by top-down biases, so if reduced holistic processing is observed for other-race faces, it is likely the result of lesser perceptual expertise.

REFERENCES

Ackerman, J. M., Shapiro, J. R., Neuberg, S. L., Kenrick, D. T., Becker, D. V., Griskevicius, V., Maner, J. K., et al. (2006). They all look the same to me (unless they're angry): from out-group homogeneity to out-group heterogeneity. *Psychological Science*, *17*(10), 836-840.

Basso, M. R., Schefft, B. K., Ris, M. D., & Dember, W. N. (1996). Mood and global-local visual processing. *Journal of the International Neuropsychological Society*, *2*(3), 249-255.

Becker, D. V., Anderson, U. S., Neuberg, S. L., Maner, J. K., Shapiro, J. R., Ackerman, J. M., Schaller, M., et al. (2010). More Memory Bang for the Attentional Buck: Self-Protection Goals Enhance Encoding Efficiency for Potentially Threatening Males. *Social Psychological and Personality Science*, *1*(2), 182-189.

Bentin, S., Allison, T., Puce, A., Perez, E., & McCarthy, G. (1996). Electrophysiological studies of face perception in humans. *Journal of Cognitive Neuroscience*, *8*(6), 551-565.

Bentin, S., & Deouell, L. Y. (2000). Structural encoding and identification in face processing: ERP evidence for separate mechanisms. *Cognitive Neuropsychology*, *17*(1), 35-55.

Bernstein, M. J., Young, S. G., & Hugenberg, K. (2007). The cross-category effect: mere social categorization is sufficient to elicit an own-group bias in face recognition. *Psychological Science*, *18*(8), 706-712.

Bilalić, M., Langner, R., Ulrich, R., & Grodd, W. (2011). Many faces of expertise: fusiform face area in chess experts and novices. *The Journal of Neuroscience*, *31*(28), 10206-14.

Brigham, J. C., & Barkowitz, P. (1978). Do "They all look alike?" The effect of race, sex, experience, and attitudes on the ability to recognize faces. *Journal of Applied Social Psychology*, *8*(4), 306-318.

Bukach, C. M., Cottle, J., Ubiwa, J., & Miller, J. (2012). Individuation experience predicts other-race effects in holistic processing for both Caucasian and Black participants. *Cognition*, *123*(2), 319-324.

Bukach, C. M., Phillips, W. S., & Gauthier, I. (2010). Limits of generalization between categories and implications for theories of category specificity. *Attention, Perception, & Psychophysics*, *72*(7), 1865-1874.

Bukach, C. M., Vickery, T. J., Kinka, D., & Gauthier, I. (2011). Training experts: Individuation without naming is worth it. *Journal of Experimental Psychology: Human Perception and Performance*, *38*(1), 14-17.

Cheung, O. S., Richler, J. J., Palmeri, T. J., & Gauthier, I. (2008). Revisiting the role of spatial frequencies in the holistic processing of faces. *Journal of Experimental Psychology: Human Perception and Performance*, *34*(6), 1327-36.

Curby, K. M., & Gauthier, I. (2009). The temporal advantage for individuating objects of expertise: Perceptual expertise is an early riser. *Journal of Vision*, *9*(6), 1-13.

Curby, K. M., Glazek, K., & Gauthier, I. (2009). A visual short-term memory advantage for objects of expertise. *Journal of Experimental Psychology: Human Perception and Performance*, *35*(1), 94-107.

Curby, K. M., Johnson, K. J., & Tyson, A. (2012). Face to face with emotion: Holistic face processing is modulated by emotional state. *Cognition & Emotion*, *26*(1), 93-102.

Dailey, M. N., & Cottrell, G. W. (1999). Organization of face and object recognition in modular neural network models. *Neural Networks*, *12*(7-8), 1053-1074.

De Heering, A., Houthuys, S., & Rossion, B. (2007). Holistic face processing is mature at 4 years of age: evidence from the composite face effect. *Journal of Experimental Child Psychology*, *96*(1), 57-70.

Derryberry, D., & Reed, M. (1998). Anxiety and attentional focusing: trait, state and hemispheric influences. *Personality and Individual Differences*, *25*(4), 745-761.

Diamond, R., & Carey, S. (1986). Why faces are and are not special: an effect of expertise. *Journal of Experimental Psychology: General*, *115*(2), 107-117.

Duchaine, B. C., & Nakayama, K. (2006). The Cambridge Face Memory Test: results for neurologically intact individuals and an investigation of its validity using inverted face stimuli and prosopagnosic participants. *Neuropsychologia*, *44*(4), 576-85.

Ellis, H. D., Deregowski, J. B., & Shepherd, J. W. (1975). Descriptions of White and Black Faces by White and Black Subjects. *International Journal of Psychology*, *10*(2), 119-123.

Farah, M. J., Wilson, K. D., Drain, H. M., & Tanaka, J. W. (1998). What is "special" about face perception? *Psychological Review*, *105*(3), 482-98.

Farkas, L. G. (1994). *Anthropometry of the Head and Face*. (L. G. Farkas, Ed.) *New York* (Vol. 6, pp. 344-505).

Feingold, G. A. (1914). The influence of environment on identification of persons and things. *Journal of the American Institute of Criminal Law and Criminology*, *5*(1), 39-51.

Gajewski, P. D., Schlegel, K., & Stoerig, P. (2008). Effects of human race and face inversion on the N170. *Journal of Psychophysiology*, *22*(4), 157-165.

Gao, Z., Flevaris, A. V., Robertson, L. C., & Bentin, S. (2011). Priming global and local processing of composite faces: revisiting the processing-bias effect on face perception. *Attention, Perception, & Psychophysics*, *73*(5), 1477-1486.

Gauthier, I., & Bukach, C. M. (2007). Should we reject the expertise hypothesis? *Cognition*, *103*(2), 322-330.

Gauthier, I., Curran, T., & Curby, K. M. (2003). Perceptual interference supports a non-modular account of face processing. *Nature Neuroscience*, *6*(4), 428-432.

Gauthier, I., Klaiman, C., & Schultz, R. T. (2009). Face composite effects reveal abnormal face processing in Autism spectrum disorders. *Vision Research*, *49*(4), 470-478.

Gauthier, I., Skudlarski, P., Gore, J. C., & Anderson, A. W. (2000). Expertise for cars and birds recruits brain areas involved in face recognition. *Nature Neuroscience*, *3*(2), 191-7.

Gauthier, I., & Tarr, M. J. (2002). Unraveling mechanisms for expert object recognition: bridging brain activity and behavior. *Journal of Experimental Psychology: Human Perception and Performance*, *28*(2), 431-446.

Gauthier, I., Tarr, M. J., Anderson, A. W., Skudlarski, P., & Gore, J. C. (1999). Activation of the middle fusiform "face area" increases with expertise in recognizing novel objects. *Nature Neuroscience*, *2*(6), 568-573.

Goffaux, V., & Rossion, B. (2006). Faces are “spatial”--holistic face perception is supported by low spatial frequencies. *Journal of Experimental Psychology: Human Perception and Performance*, *32*(4), 1023-39.

Goffaux, V., & Rossion, B. (2007). Face inversion disproportionately impairs the perception of vertical but not horizontal relations between features. *Journal of Experimental Psychology: Human Perception and Performance*, *33*(4), 995-1002.

Golby, A. J., Gabrieli, J. D., Chiao, J. Y., & Eberhardt, J. L. (2001). Differential responses in the fusiform region to same-race and other-race faces. *Nature Neuroscience*, *4*(8), 845-50.

Hancock, K. J., & Rhodes, G. (2008). Contact, configural coding and the other-race effect in face recognition. *British Journal of Psychology*, *99*(Pt 1), 45-56.

Hayward, W. G., Rhodes, G., & Schwaninger, A. (2008). An own-race advantage for components as well as configurations in face recognition. *Cognition*, *106*(2), 1017-27.

Hills, P. J., & Lewis, M. B. (2006). Reducing the own-race bias in face recognition by shifting attention. *Quarterly Journal of Experimental Psychology*, *59*(6), 996-1002.

Hole, G. (1994). Configurational factors in the perception of unfamiliar faces. *Perception*, *23*(1), 65-74.

Hugenberg, K., & Corneille, O. (2009). Holistic processing is tuned for in-group faces. *Cognitive Science*, *33*(6), 1173-81.

Hugenberg, K., Miller, J., & Claypool, H. M. (2007). Categorization and individuation in the cross-race recognition deficit: Toward a solution to an insidious problem. *Journal of Experimental Social Psychology*, *43*(2), 334-340.

Hugenberg, K., & Sacco, D. F. (2008). Social Categorization and Stereotyping: How Social Categorization Biases Person Perception and Face Memory. *Social and Personality Psychology Compass*, *2*(2), 1052-1072.

Hugenberg, K., Young, S. G., Bernstein, M. J., & Sacco, D. F. (2010). The categorization-individuation model: an integrative account of the other-race recognition deficit. *Psychological Review*, *117*(4), 1168-1187.

Ito, T. A., & Urland, G. R. (2003). Race and gender on the brain: electrocortical measures of attention to the race and gender of multiply categorizable individuals. *Journal of Personality and Social Psychology*, 85, 616-626.

Ito, T. A., & Urland, G. R. (2005). The influence of processing objectives on the perception of faces: an ERP study of race and gender perception. *Cognitive, Affective, & Behavioral Neuroscience*, *5*(1), 21-36.

Johnson, K. J., & Frederickson, B. L. (2005). We all look the same to me. *Psychological Science*, *16*(11), 875-881.

Judd, C. M., & Park, B. (1988). Out-group homogeneity: Judgments of variability at the individual and group levels. *Journal of Personality and Social Psychology*, *54*(5), 778-788.

Kanwisher, N., McDermott, J., & Chun, M. M. (1997). The fusiform face area: a module in human extrastriate cortex specialized for face perception. *The Journal of Neuroscience*, *17*(11), 4302-11.

Konar, Y., Bennett, P. J., & Sekuler, A. B. (2010). Holistic processing is not correlated with face-identification accuracy. *Psychological Science*, *21*(1), 38-43.

Latinus, M., & Taylor, M. J. (2006). Face processing stages: impact of difficulty and the separation of effects. *Brain Research*, *1123*(1), 179-187.

Le Grand, R., Cooper, P. A., Mondloch, C. J., Lewis, T. L., Sagiv, N., De Gelder, B., & Maurer, D. (2006). What aspects of face processing are impaired in developmental prosopagnosia? *Brain and Cognition*, *61*(2), 139-158.

Le Grand, R., Maurer, D., Mondloch, C. J., Duchaine, B. C., Sagiv, N., & De Gelder, B. (2003). What types of configural face processing are impaired in prosopagnosia? *Journal of Vision*, *3*(9), 827.

Lebrecht, S., Pierce, L. J., Tarr, M. J., & Tanaka, J. W. (2009). Perceptual other-race training reduces implicit racial bias. *PLoS One*, *4*(1), 1-7.

Levin, D. T. (1996). Classifying faces by race: The structure of face categories. *Journal of Experimental Psychology: Learning, Memory & Cognition*, *22*(6), 1364-1382.

Levin, D. T. (2000). Race as a visual feature: using visual search and perceptual discrimination tasks to understand face categories and the cross-race recognition deficit. *Journal of Experimental Psychology: General*, *129*(4), 559-574.

Loftus, G. R., Oberg, M. A., & Dillon, A. M. (2004). *Linear theory, dimensional theory, and the face-inversion effect. Psychological Review* (Vol. 111, pp. 835-863).

MacLin, O. H. O., & Malpass, R. S. (2001). Racial categorization of faces: The ambiguous race face effect. *Psychology, Public Policy, and Law*, *7*(1), 98-118.

Malpass, R. S., & Kravitz, J. (1969). Recognition for faces of own and other race. *Journal of Personality and Social Psychology*, *13*(4), 330-334.

McGugin, R. W., McKeeff, T. J., Tong, F., & Gauthier, I. (2011). Irrelevant objects of expertise compete with faces during visual search. *Attention, Perception, & Psychophysics*, *73*(2), 309-17.

McGugin, R. W., Richler, J. J., Herzmann, G., Speegle, M., & Gauthier, I. The Vanderbilt Expertise Test and the contribution of general object recognition abilities to face recognition. Manuscript submitted for publication.

McGugin, R. W., Tanaka, J. W., Lebrecht, S., Tarr, M. J., & Gauthier, I. (2011). Race-specific perceptual discrimination improvement following short individuation training with faces. *Cognitive Science*, *35*(2), 330-47.

McKeeff, T. J., McGugin, R. W., Tong, F., & Gauthier, I. (2010). Expertise increases the functional overlap between face and object perception. *Cognition*, *117*(3), 355-60.

McKone, E., & Kanwisher, N. (2005). Does the human brain process objects of expertise like faces? A review of the evidence. In S. Dehaene, J. Duhamel, M. Hauser, & G. Rizolatti (Eds.), *From Monkey Brain to Human Brain*. Cambridge: MIT Press.

McKone, E., Kanwisher, N., & Duchaine, B. C. (2007). Can generic expertise explain special processing for faces? *Trends in Cognitive Sciences*, *11*(1), 8-15. Elsevier.

Meissner, C. A., & Brigham, J. C. (2001). Thirty years of investigating the own-race bias in memory for faces: A meta-analytic review. *Psychology, Public Policy, and Law*, *7*(1), 3-35.

Michel, C., Caldara, R., & Rossion, B. (2006). Same-race faces are perceived more holistically than other-race faces. *Visual Cognition*, *14*(1), 55-73.

Michel, C., Corneille, O., & Rossion, B. (2007). Race categorization modulates holistic face encoding. *Cognitive Science*, *31*(5), 911-924.

Michel, C., Rossion, B., Han, J., Chung, C.-S., & Caldara, R. (2006). Holistic processing is finely tuned for faces of one's own race. *Psychological science*, *17*(7), 608-15.

Mondloch, C. J., Elms, N., Maurer, D., Rhodes, G., Hayward, W. G., Tanaka, J. W., & Zhou, G. (2010). Processes underlying the cross-race effect: An investigation of holistic, featural, and relational processing of own-race versus other-race faces. *Perception*, *39*(8), 1065-1085.

Mondloch, C. J., & Maurer, D. (2008). The effect of face orientation on holistic processing. *Perception*, *37*(8), 1175-1186.

Mondloch, C. J., Pathman, T., Maurer, D., Grand, R. L., & De Schonen, S. (2007). The composite face effect in six-year-old children: Evidence of adult-like holistic face processing. *Visual Cognition*, *15*(5), 564-577.

Murray, J. E. (2004). The ups and downs of face perception: Evidence for holistic encoding of upright and inverted faces. *Perception*, *33*(4), 387-398.

Murray, J. E., Rhodes, G., & Schuchinsky, M. (2003). When is a face not a face? In M. A. Peterson & G. Rhodes (Eds.), *Perception of faces, objects, and scenes: Analytic and holistic processes* (pp. 75–91). New York: Oxford University Press.

O'Toole, A. J., Deffenbacher, K. A., Valentin, D., & Abdi, H. (1994). Structural aspects of face recognition and the other-race effect. *Memory & Cognition*, *22*(2), 208-24.

Ratcliff, N. J., Hugenberg, K., Shriver, E. R., & Bernstein, M. J. (2011). The allure of status: high-status targets are privileged in face processing and memory. *Personality & Social Psychology Bulletin*, *37*(8), 1003-15.

Rhodes, G., Brake, S., Taylor, K., & Tan, S. (1989). Expertise and configural coding in face recognition. *British Journal of Psychology*, *80 (Pt 3)*, 313-331.

Rhodes, G., Ewing, L., Hayward, W. G., Maurer, D., Mondloch, C. J., & Tanaka, J. W. (2009). Contact and other-race effects in configural and component processing of faces. *British Journal of Psychology*, *100*(4), 717-728.

Rhodes, G., Hayward, W. G., & Winkler, C. (2006). Expert face coding: configural and component coding of own-race and other-race faces. *Psychonomic Bulletin & Review*, *13*(3), 499-505.

Richler, J. J., Bukach, C. M., & Gauthier, I. (2009). Context influences holistic processing of nonface objects in the composite task. *Attention, Perception, & Psychophysics*, *71*(3), 530-540.

Richler, J. J., Cheung, O. S., & Gauthier, I. (2011a). Holistic processing predicts face recognition. *Psychological Science*, *22*(4), 464-471.

Richler, J. J., Cheung, O. S., & Gauthier, I. (2011b). Beliefs alter holistic face processing... if response bias is not taken into account. *Journal of Vision*, *11(13)*(17), 1-13.

Richler, J. J. & Gauthier, I. This is not a meta-analysis of holistic face processing (and why). Manuscript submitted for publication.

Richler, J. J., Gauthier, I., Wenger, M. J., & Palmeri, T. J. (2008). Holistic processing of faces: perceptual and decisional components. *Journal of Experimental Psychology: Learning, Memory & Cognition*, *34*(2), 328-342.

Richler, J. J., Mack, M. L., Gauthier, I., & Palmeri, T. J. (2009). Holistic processing of faces happens at a glance. *Vision Research*, *49*(23), 2856-61.

Richler, J. J., Mack, M. L., Palmeri, T. J., & Gauthier, I. (2011). Inverted faces are (eventually) processed holistically. *Vision Research*, *51*(3), 333-42.

Richler, J. J., Tanaka, J. W., Brown, D. D., & Gauthier, I. (2008). Why does selective attention to parts fail in face processing? *Journal of Experimental Psychology: Learning, Memory & Cognition*, *34*(6), 1356-1368.

Richler, J. J., Wong, Y. K., & Gauthier, I. (2011). Perceptual expertise as a shift from strategic interference to automatic holistic processing. *Current Directions in Psychological Science*, *20*(2), 129-134.

Riesenhuber, M., Jarudi, I., Gilad, S., & Sinha, P. (2004). Face processing in humans is compatible with a simple shape-based model of vision. *Proceedings of the Royal Society B Biological Sciences*, *271 Suppl* (6), S448-S450.

Robbins, R., & McKone, E. (2007). No face-like processing for objects-of-expertise in three behavioural tasks. *Cognition*, *103*(1), 34-79.

Rosch, E., Mervis, C. B., Gray, W. D., Johnson, D. M., & Boyes-Braem, P. (1976). Basic objects in natural categories. (D. A. Balota & J. E. EMarsh, Eds.)*Cognitive Psychology*, *8*(3), 382-439.

Rossion, B., & Boremanse, A. (2008). Nonlinear relationship between holistic processing of individual faces and picture-plane rotation: evidence from the face composite illusion. *Journal of Vision*, *8*(4), 3.1-13.

Rossion, B., & Curran, T. (2010). Visual expertise with pictures of cars correlates with RT magnitude of the car inversion effect. *Perception*, *39*(2), 173-183.

Rossion, B., & Gauthier, I. (2002). How Does the Brain Process Upright and Inverted Faces? *Behavioral and Cognitive Neuroscience Reviews*, *1*(1), 63-75.

Schwartz, B. L., Marvel, C. L., Drapalski, A., Rosse, R. B., & Deutsch, S. I. (2002). Configural processing in face recognition in schizophrenia. *Cognitive Neuropsychiatry*, *7*(1), 15-39.

Sekuler, A. B., Gaspar, C. M., Gold, J. M., & Bennett, P. J. (2004). Inversion leads to quantitative, not qualitative, changes in face processing. *Current Biology*, *14*(5), 391-396.

Shepherd, J. W., & Deregowski, J. B. (1981). Races and faces—a comparison of the responses of Africans and Europeans to faces of the same and different races. *British Journal of Social Psychology*, *20*(2), 125-133.

Shriver, E. R., & Hugenberg, K. (2010). Power, individuation, and the cross-race recognition deficit. *Journal of Experimental Social Psychology*, *46*(5), 767-774.

Shriver, E. R., Young, S. G., Hugenberg, K., Bernstein, M. J., & Lanter, J. R. (2008). Class, race, and the face: social context modulates the cross-race effect in face recognition. *Personality and Social Psychology Bulletin*, *34*(2), 260-74.

Stahl, J., Wiese, H., & Schweinberger, S. R. (2008). Expertise and own-race bias in face processing: an event-related potential study. *Neuroreport*, *19*(5), 583-7.

Tanaka, J. W. (2001). The entry point of face recognition: Evidence for face expertise. By Tanaka. *Journal of Experimental Psychology: General*, *130*(3), 534- 543.

Tanaka, J. W., & Farah, M. J. (1993). Parts and wholes in face recognition. *The Quarterly Journal of Experimental Psychology Section A : Human Experimental Psychology*, *46*(2), 225-245.

Tanaka, J. W., Kiefer, M., & Bukach, C. M. (2004). A holistic account of the own-race effect in face recognition: evidence from a cross-cultural study. *Cognition*, *93*(1), B1-9.

Tanaka, J. W., & Pierce, L. J. (2009). The neural plasticity of other-race face recognition. *Cognitive, Affective, & Behavioral Neuroscience*, *9*(1), 122-131.

Tanaka, J. W., & Taylor, M. J. (1991). Object categories and expertise: Is the basic level in the eye of the beholder? *Cognitive Psychology*, *23*(3), 457-482.

Teunisse, J.-P., & De Gelder, B. (2003). Face processing in adolescents with autistic disorder: the inversion and composite effects. *Brain and Cognition*, *52*(3), 285-294.

Tong, F., Nakayama, K., Moscovitch, M., Weinrib, O., & Kanwisher, N. (2000). Response properties of the human fusiform face area. *Cognitive Neuropsychology*, *17*((1/2/3)), 257-279.

Tsao, D. Y., & Livingstone, M. S. (2008). Mechanisms of face perception. *Annual Review of Neuroscience*, *31*(1), 411-37. Annual Reviews.

Turati, C., Di Giorgio, E., Bardi, L., & Simion, F. (2010). Holistic face processing in newborns, 3-month-old infants, and adults: evidence from the composite face effect. *Child Development*, *81*(6), 1894-1905.

Valentine, T., & Bruce, V. (1988). Mental rotation of faces. *Memory & Cognition*, *16*(6), 556-566.

Wang, R., Li, J., Fang, H., Tian, M., & Liu, J. (2012). Individual differences in holistic processing predict face recognition ability. *Psychological Science*, *23*(January), 169-77.

Wiese, H., Stahl, J., & Schweinberger, S. R. (2009). Configural processing of other-race faces is delayed but not decreased. *Biological Psychology*, *81*(2), 103-9.

Wilcox, R. (2005). *Introduction to Robust Estimation and Hypothesis Testing*. (G. J. Lieberman & I. Olkin, Eds.)*Statistical Modeling and Decision Science* (p. 588). Academic Press.

Wong, A. C.-N., Palmeri, T. J., & Gauthier, I. (2009). Conditions for facelike expertise with objects: becoming a Ziggerin expert--but which type? *Psychological Science*, *20*(9), 1108-17.

Wong, A. C.-N., Palmeri, T. J., Rogers, B. P., Gore, J. C., & Gauthier, I. (2009). Beyond shape: how you learn about objects affects how they are represented in visual cortex. *PloS One*, *4*(12), e8405.

Wong, Y. K., & Gauthier, I. (2010). Holistic processing of musical notation: Dissociating failures of selective attention in experts and novices. *Cognitive, Affective, & Behavioral Neuroscience*, *10*(4), 541-51.

Yin, R. K. (1969). Looking at upside-down faces. *Journal of Experimental Psychology*, *81*(1), 141-145.

Young, A. W., Hellawell, D., & Hay, D. C. (1987). Configural information in face perception. *Perception*, *16*(9), 747-759.

Young, S. G., Bernstein, M. J., & Hugenberg, K. (2010). When Do Own-Group Biases in Face Recognition Occur? Encoding versus Post-Encoding. *Social Cognition*, *28*(2), 240-250.

Young, S. G., & Hugenberg, K. (2012). Individuation Motivation and Face Experience Can Operate Jointly to Produce the Own-Race Bias. *Social Psychological and Personality Science*, *3*, 80-87.

Young, S. G., Hugenberg, K., Bernstein, M. J., & Sacco, D. F. (2009). Interracial contexts debilitate same-race face recognition. *Journal of Experimental Social Psychology*, *45*(5), 1123-1126.

Young, S. G., Hugenberg, K., Bernstein, M. J., & Sacco, D. F. (2012). Perception and motivation in face recognition: A critical review of theories of the cross-race effect. *Personality and Social Psychology Review*, *16*(2), 116-142.