Status is fine for the in-group but out-group members watch out: Examining an optimal model of face processing using eye-tracking

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University of Northern Iowa

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STATUS IS FINE FOR THE IN-GROUP BUT OUT-GROUP MEMBERS
WATCH OUT: EXAMINING AN OPTIMAL MODEL OF FACE PROCESSING
USING EYE-TRACKING

An Abstract of a Thesis
Submitted
in Partial Fulfillment
of the Requirements for the Degree
Master of Arts

J. Daniel McCarthy
University of Northern Iowa
July 2010
ABSTRACT

Face recognition is an important factor in everyday social interaction. Bruce and Young's (1986) model of face processing has been largely accepted as a model for face processing, however, it fails to account for differential processing based on race. MacLin and MacLin (in press) propose the presence of a cognitive gating mechanism (CGM) that suggests different processing strategies are used for in-group and out-group members. To date, the model has only been examined using novel stimuli. The present research examined the model using famous and nonfamous African-American and Caucasian faces to determine if the CGM adequately explains the recognition of familiar faces. Reaction times and eye-movements were recorded while participants completed a racial categorization task or famousness classification task. Results indicate that familiarity with a face indeed plays a role in the processing of own- and other-race faces. Reaction times and eye-movements differed as a function of race, fame, and task type. Implications for a modified version of the CGM and other existing face models are discussed.
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has been approved as meeting the thesis requirement for the

Degree of Master of Arts

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CHAPTER 1
INTRODUCTION

Face recognition is an important part of everyday social interaction. Faces provide a large amount of information about a person including one’s age, gender, ethnicity, current emotional state, and individual identity. After years of research on the topic, it is still debated what factors are involved in the underlying process of face recognition, let alone their relationships to or independence from one another. Some factors include familiarity with a face, emotional expression, and race. The present research sought to investigate the interplay of race and familiarity in the recognition and encoding of faces. Specifically, a recent model of race-sensitive face processing, the cognitive gating mechanism (CGM; MacLin & MacLin, in press), is examined using faces differing in race and familiarity. A short review of existing face models and race issues in face processing is followed by an overview of the CGM, influences of familiarity, and behavioral implications from eye-tracking studies.

The classic model of face recognition proposed by Bruce and Young (1986) posits that faces are initially encoded for structure of facial features and subsequently routed to parallel processes that include extracting the face’s identity, emotional valence, and facial speech (see Figure 1). Identification is obtained through face recognition units and is believed to be independent from other factors such as emotional expression and the angle at which the face is viewed.

Recent research, however, has demonstrated that the recognition of familiar and unfamiliar faces is indeed influenced by emotion (Gobbini & Haxby, 2007; Haxby,
Hoffman, & Gobbini, 2000). Specifically, participants were faster at recognizing faces of famous individuals only when they had happy expressions; when expressing anger, however, famous faces took longer to recognize than unfamiliar faces with happy expressions. Thus, the differential processing of familiar and unfamiliar faces is influenced by emotional expression, bringing into question the functional independence of the parallel processes in Bruce and Young’s (1986) model.

Another largely ignored factor in this model that has been demonstrated to influence face recognition is a person’s race. The wealth of extant research addressing the issue of differential processing of faces as a function of race suggests that people show superior memory and recognition for faces of their own race, a phenomenon known as the own-race bias (ORB) or the cross-race effect (CRE; Malpass & Kravitz, 1969; Meissner & Brigham, 2001). It has been demonstrated that people allocate more attentional resources and take longer to classify a face of their own race and later show improved memory for own-race faces.

**Face and Race Processing**

The CRE is a robust effect that has been found reliably in many studies over the last 40 years (for a full review see Meissner & Brigham, 2001). One social explanation for its occurrence suggests that interracial interaction may be responsible for the differences in recognition for own- and other-race faces (Cross, Cross, & Daly, 1971; Li, Dunning, & Malpass, 1998). Another study, however, did not demonstrate such evidence for the contact hypothesis (Ng & Lindsay, 1994). Racial attitudes have also been proposed as an explanation such that people who are less prejudiced may be more
motivated to differentiate between other-race faces (Allport & Kramer, 1946; Lindzey & Rygolsky, 1950). Again, however, these results were not always supported and Elliott and Wittenberg (1955) suggested that more prejudiced individuals might be inclined to label more faces as out-group due to a response bias. Others have noted, however, that negative racial attitudes may lead people to have less contact with other ethnic groups (Brigham, 1993; Brigham & Barkowitz, 1978).

Other cognitive theories point to the use of different processing strategies for same and other-race faces as another explanation for the CRE. Diamond and Carey (1986) suggest that people use a top-down configural strategy when encoding same-race faces that takes into account features and their coordinates to one another and rely only on features when encoding other-race faces. This hypothesis is supported by research demonstrating that other-race faces are not as disrupted by inversion (Rhodes, Brake, Taylor, & Tan, 1989).

Other researchers have developed theories describing how faces may be stored in memory (Sporer, 2001; Valentine, 1991). They argue that own-race faces may be more accurately encoded due to more space available in memory for own-race faces and more precise featural representations for own-race features.

Additionally, some argue that the difference may be a result of categorical processes that code for race while largely ignoring other relevant individuating information (Levin, 1996). MacLin and Malpass (2001) supported this notion by demonstrating that participants differentially categorized ambiguous race faces and showed disparity in recognition accuracy when altering a single racial marker (i.e., hair).
Interestingly, the presence of a different racial marker on an ambiguous race face actually altered participants' perception of the stimuli. MacLin and Malpass (2003) also showed that participants reported an ambiguous race face as being darker when it was modified to have African-American hair compared to the same face without hair. Though only grayscale images were used in this study, this perceptual illusion of differing skin tone resulting solely from the addition of an African-American hairstyle signifies the importance of conducting further research on the effects of racial markers in face recognition. The above findings on differential processing as a function of race make it difficult to support earlier theories of face processing such as the Bruce and Young (1986) model. A new model, however, proposed by MacLin and MacLin (in press) provides a description of face processing that accounts for effects of race not explained by previous theories.

The Cognitive Gating Mechanism (CGM)

MacLin and MacLin (in press) propose that a CGM is involved in the encoding of faces and is especially sensitive to racial markers (see Figure 2). According to the model, racial markers (e.g., skin tone, hair) are detected early in the face recognition process. As a face passes through the CGM, it is scanned for the presence of racial markers; based on their presence or absence, the face is routed to different areas of the brain for separate processing strategies. Faces that do not contain other-race markers are processed along a standard channel as described in Bruce and Young's (1986) model of face processing. Along this standard route, a configural strategy is used, leading to higher-order processing and more individuating information being stored in memory. Alternatively,
when other-race features are detected, the face is routed for lower-level of processing that relies on featural information, resulting in more labeling and categorization based on stereotypical information (MacLin & MacLin, in press).

The CGM is supported by several neurophysiological studies. Event related potential (ERP) research on face processing has revealed effects as early as 120ms for race (Kubota & Ito, 2007). Ito, Thompson, and Cacioppo (2004) also demonstrated that other-race faces are processed faster than same-race faces. Specifically, out-group faces are associated with larger amplitudes (100ms, 200ms, and 300ms), which orient the brain to threat and are responsive to arousing stimuli. An in-group effect was also found with larger amplitudes at 250ms, signifying deeper processing for in-group members compared to out-group members.

Similar effects were demonstrated in a study examining participants’ response to threatening stimuli, with threat being perceived early in the face recognition process (Correll, Urland, & Ito, 2006). This suggests that threat may be related to other-race face processing, routing the face to areas of the brain associated with threat (e.g., amygdala). This was supported in several studies using fMRIs to examine blood flow in the brain while viewing different facial stimuli. Consistently, activation in the amygdala was higher when viewing other-race faces compared to faces of one’s own race (Cunningham et al., 2004; Hart et al., 2000; Phelps et al., 2000). Interestingly, Cunningham et al. (2004) also found higher levels of activation in the anterior cingulate cortex (associated with control and regulatory processes) when viewing other-race faces. This suggests that threat is perceived early on, but may later be attenuated by higher-order processes. Consistent
with the CGM model, this implies that though other-race faces may be originally routed into lower-level processes, they may later be “pushed” into higher-order processes through conscious effort (MacLin and MacLin, in press).

As opposed to earlier models of face processing which view the CRE as a deficit in one’s ability to process other-race faces, the CGM is an optimal model in which other-race faces are simply processed differently (MacLin & MacLin, in press). Past theories assume that poorer memory for other-race faces stems from an encoding deficit during the recognition process (Levin, 1996; Sporer, 2001; Valentine, 1991). Alternatively, the CGM suggests that other-race faces are processed optimally for threat; because of this speeded process, individuating information is lost and the face is instead coded according to group stereotypes. Therefore, it is not that people are bad at recognizing other-race faces; instead, they are actually very effective. Though this process results in poorer later memory for individual other-race faces, it is optimal for orienting oneself toward a possible threat from the out-group.

The CGM is a parsimonious model for explaining how novel faces are processed differently due to race. Unlike other previous explanations for an own-race bias in face processing, it can account for the use of separate processing strategies when viewing faces differing only by a single racial marker (MacLin & Malpass, 2001; 2003). However, the CGM has only been tested using novel stimuli. Because it is known that familiarity with a face also influences the way it is processed, it is necessary to determine whether or not the CGM is a plausible model for describing encoding strategies used when a face is personally familiar.
Familiarity Effects

As Bruce and Young's (1986) model suggests, faces are evaluated for familiarity early in the encoding process. Familiarity with a face not only includes visual familiarity, but also personal traits, biographical information, personality, and type of familiarity (e.g., family, famous, repeated exposure) associated with the face. Such attributes have been demonstrated to correlate with "theory of mind" areas in the brain (Gobbini & Haxby, 2007). For example, personally familiar faces (e.g., family, romantic partner, own) activate more visual core areas associated with semantic and person knowledge and produce higher fusiform gyrus activation in both hemispheres.

Alternatively, famous faces have only produced significant activation in the right hemisphere and elicited increased amygdala activation when compared to personally familiar faces (Taylor et al., 2009). There was no significant difference, however, for amygdala activation between famous and unfamiliar faces. Conversely, Gobbini and Haxby (2007) showed greater amygdala response for unfamiliar faces compared to famous faces although the difference in amygdala activation for personally familiar and famous faces was consistent with Taylor et al. (2009). Thus, it is clear that personally familiar faces elicit a decreased threat response while the results for famous faces are mixed. These disparate findings, however, may be due to the use of different famous stimuli.

Familiar and novel faces have also been demonstrated to produce variation in response time. Baird and Burton (2008) found that participants exhibited faster response times (RTs) when viewing familiar compared to unfamiliar faces; however, this effect
occurred only when faces were presented bilaterally (to both eyes). Consistently, Martens, Leuthold, and Schweinberger (2010) demonstrated faster RTs for familiar compared to unfamiliar faces in an identity task; RTs for familiar faces were also faster when displaying a happy expression, however this effect was only true for actors, not politicians. This difference in RTs was explained by the hypothesis that novel faces require more attention because there is no previous memory match; thus, famous faces were believed to be faster because the memory search stopped when a match was found.

Electrophysiological research has also found temporal familiarity effects. ERP research has revealed familiarity effects as early as 170ms for famous faces as well as one’s own face; specifically, these faces trigger larger amplitudes when compared to an unfamiliar face, indicating deeper processing (Caharel, Poiroux, & Bernard, 2002). Martens, et al., (2010) also demonstrated that famous faces elicited a larger N170 in the right hemisphere compared to unfamiliar faces, indicating an early effect of familiarity on attentional resources allocated toward the face. Interestingly, they also found that the P300 was smaller for unfamiliar faces compared to famous faces suggesting that the memory search was more cognitively taxing for unfamiliar faces. This finding is consistent with previous research demonstrating longer memory search processes for unfamiliar faces (Schweinberger & Sommer, 1991). Other research, however, has not found such early effects for familiarity. Alternatively, it has been demonstrated that the N170 is not sensitive to familiarity, but later responses between 200 and 500 ms are susceptible to familiarity effects (Gobbini & Haxby, 2007). Thus, the N170 component
may initiate an orienting response that does not contain information about the face’s identity but modulates later responses to the face.

As the above research suggests, the recognition of faces is modulated not only by whether or not the face is novel or familiar, but also the manner of the familiarity. For example, personally familiar faces (e.g., one’s own face, family) evoke a lowered amygdala response when compared to famous and unfamiliar faces (Gobbini & Haxby, 2007; Taylor et al., 2009). This is likely due to different semantic information that is available for faces in each respective category. Personally familiar faces may be associated with more specific information including episodic memories and emotional valence. Famous faces, on the other hand, may be associated with more general knowledge such as biographical information and status or occupation. Thus, to reduce differences in familiarity levels, the current study focused on recognition differences for famous and nonfamous faces differing in race.

**Eye-Tracking**

Previous face processing models have posited differential processing due to the involvement of different brain mechanisms, familiarity with a face, or sensitivity to race. Though they provide an explanation for cognitive mechanisms that may be involved, they do not address any behavioral differences that might influence the recognition and encoding of faces. Eye-tracking equipment is a technological advancement that allows researchers to physically record eye-movements (saccades) and fixations when viewing a variety of facial stimuli.
Betts, McCarthy, Peterson, MacLin, and MacLin (2009) used eye-tracking to examine differences in eye-movement while viewing novel Caucasian, African-American, and Hispanic faces. Though no significant results were obtained, mean differences in saccades and fixations were documented. Hirose and Hancock (2007) also found no eye-movement differences for same and other-race faces; however, participants recognized changes in same-race faces more readily than changes to other-race faces. Thus, participants attended to both face categories equally but were not as likely to notice a change in an other-race face.

Additionally, Goldinger, He, and Papesh (2009) demonstrated that other-race faces received fewer fixations (although they were longer) using Asian and Caucasian participants; participants’ pupils were also enlarged for other-race faces, indicative of a threat response and increased effort. Thus, it is possible that the initial perception of threat reduces the effort allocated to brain areas needed for individuation during encoding and the P200 response (associated with valence evaluation) triggers the activation of threat-related areas, reducing the amount of effort used to encode other-race faces (Schutter, de Haan, & van Honk, 2004). In addition, more attention was allocated to the eyes and hair and more features were sampled for own-race faces (Goldinger et al., 2009). This increase in regional sampling for own-race faces could be indicative of a configural processing strategy as proposed by Diamond and Carey (1986) while less sampling for other-race faces could be interpreted as a configural strategy.

Eye-tracking equipment was also used to examine differences in eye-movements for familiar and unfamiliar faces. Devue, Van der Stigchel, Brédart, and Theeuwes (2009)
found that participants fixated longer on their own face and a highly familiar face (a friend) when presented simultaneously with other unfamiliar faces; however, there was no difference between the two familiar face groups. Althoff and Cohen (1999) demonstrated that when viewing nonfamous faces, participants displayed a greater number of fixations, sampled more regions, and focused more on internal features (specifically the nose and mouth) when compared to famous faces. Interestingly, however, participants focused less on the nose and mouth and more on the eyes when viewing famous faces (Althoff & Cohen, 1999). This finding is consistent with fMRI research on typical and atypical scan paths when viewing faces. Morris, Pelphry, and McCarthy (2006) defined a typical scan path as those that sample the eyes and mouth in ninety percent of trials and atypical scan paths as those that sample the eyes and mouth less than ten percent of the time. They found that the fusiform gyrus was significantly activated only when participants were forced to perform a typical scan of the face. Therefore, famous faces may be processed more effectively due to a diminished threat response allowing more attention to focus on key elements necessary for facial encoding (Gobbini & Haxby, 2007; Schutter, et al., 2004; Taylor et al., 2009).

As stated previously, emotional expression also alters recognition of familiar and unfamiliar faces. A recent eye-tracking study by Bate, Haslam, and Hodgson (2009) found that when famous faces were viewed, participants exhibited more fixations and regional sampling only for those with an angry expression; however, fixation duration was not affected by emotional valence. Alternatively, nonfamous faces elicited less regional sampling, fewer fixations, and longer fixation durations when the face had an
angry expression (Bate, et al. 2009). Famous faces were also recognized faster than nonfamous faces (indicated by a keyboard response), but only when displaying a happy expression. Alternatively, participants exhibited quicker recognition for angry faces. These findings are interesting because the processing of famous faces was only facilitated with a happy expression whereas the processing of novel faces was improved when the face was angry. This is consistent with previous research that suggests famous faces are more easily processed with the presence of positive information while the processing of novel faces is enhanced when there is a perceived threat such as an angry expression (Correll, Urland, & Ito, 2006; Richeson & Trawalter, 2005). Although there has been eye-tracking research examining the interaction of familiarity with emotional expression, there are no eye-tracking studies that examine the interaction of familiarity and race. The present research sought to combine these two factors in order to discern if being familiar with other-race faces influences their perception compared to novel counterparts. To avoid confounds of emotional expression, only faces displaying a neutral expression were used in this study.

The Current Study

The current experiment examined differences in reaction times (RTs) and eye-movement when viewing famous and nonfamous African-American and Caucasian faces. Participants viewed a series of faces and were instructed to categorize each face presented by race or fame, depending on their assigned task. All faces had a neutral expression and were displayed only until participants made their decision on the appropriate category. Participants indicated their response via keyboard press while their
eye-movements were recorded. First, I sought to determine if RTs vary for famous and nonfamous faces differing in race. Secondly, I was interested if RTs differed across race categorization and famousness classification tasks. Finally, I used eye-tracking equipment to discern if there was any variation in eye-movements as a function of face type as well as the task participants were engaged in as demonstrated by Yarbus (1965).
The total sample was 53 introductory psychology students who participated in the study for partial course credit. Data were excluded for nine participants: six were non-White, two had difficulties calibrating their eyes to the screen, and one was unfamiliar with a majority of the famous stimuli. Thus, the final analysis was conducted on 44 (22 men, 22 women) Caucasian participants with an average age of 20.2 years. All participants in the final analysis reported normal or corrected vision.

Eye saccades and fixations were recorded using Nyan 2.0XT ©, an eye-tracking analysis program for the computer used in combination with LC-technologies, Inc. Eyegaze Analysis System. The software generates data that include information such as eye position, sync counter (sequential measurement), gaze point (location relative to the center of the monitor display), and pupil diameter. Additionally, gaze plots and gaze replay movies can be created for each image in order to view different areas of attention and the order in which features are examined. For an example of a gaze plot from the current study, see Figure 3. This system allows one to observe and evaluate participants’ eye-path on the computer monitor in relation to experimental stimuli. One can also define different areas of interest (AOIs) on the monitor to measure saccades and fixations for various areas, in this case different facial features of the stimuli. The apparatus consists of two small video cameras placed below the computer monitor and an infrared light
emitting diode (LED) which creates a reflection on the cornea and brightens the pupil. The illumination of the pupil allows the cameras to determine the location of the pupil and measure any subtle eye-movements (more than five pixels difference) while viewing different stimuli.

**Stimuli**

Stimuli consisted of forty digitized, color images of faces with full frontal view and neutral expressions (for sample stimuli, see Figure 4). Ten faces were included from each of the following categories: famous African-Americans (e.g., Denzel Washington), famous Caucasians (e.g., Johnny Depp), nonfamous African-Americans, and nonfamous Caucasians. Only male faces were used to control for effects of gender. Each image was 400 × 500 pixels. Famous faces were obtained from a famous face database (McCarthy et al., 2009). Nonfamous faces were acquired through various sites on the Internet. For this group, photos of male models were chosen do to similar photo artifacts (e.g., clothing, pose, attractiveness). Three additional photos from each category not used in the testing phase were used in a practice trial to familiarize participants with the Visual Basic program (McCarthy, 2010).

**Design**

For reaction times, a 2 (African-American vs. Caucasian) × 2 (famous vs. nonfamous) × 2 (fame task vs. race task) mixed design was used with race and fame as within-subjects factors and task as a between-subjects factor. The eye-tracking analysis used a 2 (race) × 2 (fame) × 8 (AOIs) × 2 (task) mixed design with race, fame, and AOIs as within-subjects variables and task as a between-subjects variable.
Procedure

After obtaining informed consent, participants were seated in front of the computer monitor with their chin placed on a chin rest approximately 24 inches from the screen. The chin rest aided in minimizing movement during the recording process. Camera angle and focus were adjusted during a calibration process that included nine different points on the computer monitor; calibration was only accepted if the maximum error allowed was less than .2 inches. The entire calibration process took roughly one minute to complete.

Following calibration, participants completed a practice trial to orient them with the program. They were informed that they would view a series of faces and their task was to indicate the appropriate category for each face presented by pressing any letter key on the left or right side of the keyboard corresponding to the button position on the screen. Button position was counterbalanced across participants. In the racial categorization task, participants indicated the race of the face by pressing a key for “African-American” or “Caucasian.” In the famousness classification task, participants were presented with stimuli and were asked to determine whether or not the face presented was famous by selecting the option “Famous” or “Nonfamous.” To familiarize participants with the procedure, a total of three faces from each category not used in the testing phase were presented randomly.

During the testing phase, participants viewed a total of 40 faces (10 from each category) presented randomly via computer. Instructions for this task were the same as the practice trial. Reaction times (RTs) and eye-movements were recorded for the faces in
each categorization task. Faces were visible until the point that participants made their decision. A standard five-second interval was used for presentation so that the interstimulus interval was equal to 5 seconds minus the RT for that face. After completing the first phase of the experiment, participants filled out a demographics questionnaire and were debriefed, thanked and dismissed.
CHAPTER 3

RESULTS

Reaction Times

The primary focus of the current study was to examine differences in responding to famous and nonfamous stimuli differing in race across famousness classification and racial categorization tasks. After controlling for correct responding, the reaction time data were analyzed using a $2 \times 2 \times 2$ repeated measures analysis of variance (ANOVA) with race and famousness as within-subjects variables and task type as a between-subjects variable. In the race condition, there was a marginal main effect for race, $F(1, 21) = 3.95$, $p < .06$, $\eta^2 = .16$. Simple effects revealed that famous African-Americans ($M = .78$, $SD = .20$) were processed the fastest compared to famous Caucasians ($M = .84$, $SD = .21$), $t(21) = -2.14$, $p < .05$, and nonfamous Caucasians ($M = .83$, $SD = .20$), $t(21) = -2.40$, $p < .03$ (see Figure 5). There were no significant differences between RTs for famous African-Americans and nonfamous African-Americans in the race task. In the famousness task, a main effect for fame emerged, $F(1, 21) = 10.92$, $p < .01$, $\eta^2 = .34$ (see Figure 6). This finding is consistent with previous research indicating that familiar stimuli are categorized faster due to a less demanding memory search (Baird & Barton, 2008; Martens, Leuthold, & Schweinberger, 2010). Simple effects indicated that famous African-Americans ($M = 1.25$, $SD = .33$) were again classified the fastest compared to nonfamous African-Americans ($M = 1.55$, $SD = .52$), $t(21) = -3.16$, $p < .01$, and nonfamous Caucasians ($M = 1.47$, $SD = .44$), $t(21) = -3.35$, $p < .01$. Famous Caucasians ($M = 1.30$, $SD = .33$) were also categorized faster than nonfamous Caucasians, $t(21) =$
2.67, \( p < .02 \), and nonfamous African-Americans, \( t(21) = -3.32, p < .04 \). A full list of reaction times across both tasks is available in Table 1.

Across the two conditions, there was also a significant main effect of task type, \( F(1, 42) = 46.68, p < .001, \eta^2 = .53 \), with reaction times in the famousness task taking longer overall. This effect is most likely due to task difficulty because a more demanding memory search is required to determine famousness than extracting a single cue to evaluate race (e.g., skin tone). There was also a significant main effect for fame across both tasks (\( F(1, 42) = 11.17, p < .01, \eta^2 = .21 \)) as well as a reliable fame x task interaction (\( F(1, 42) = 9.34, p < .01, \eta^2 = .18 \)) with nonfamous faces taking longer than other groups in the famousness task but not the race task. For a timeline of RTs across tasks and known ERP effects, see Figure 7.

**Overall Eye-Movements**

With respect to eye-movements, the first question we sought to answer was whether there was any difference in the total time spent on each face (gaze duration) and the total number of fixations. Fixations were defined as the eyes staying in a 5-pixel area for a duration of 100ms or longer. Total gaze duration and number of fixations were analyzed using a 2 x 2 x 2 repeated measures ANOVA with race and fame as within-subjects variables and task type as a between-subjects variable. Initially, there were no main effects for the race task for total fixation; however, the lack of any effects was caused by variation in response times. To control for RTs, total fixations were calculated as ratios relative to the mean RTs for each category across all participants. After calculating ratios there was a marginal main effect of fame with famous faces receiving
more total fixations on average, $F(1, 21) = 3.77, p < .07, \eta^2 = .15$. In the famousness task, a reliable race × fame interaction emerged, $F(1, 21) = 5.08, p < .04, \eta^2 = .20$. After controlling for RTs, a main effect of fame also reached significance, $F(1, 21) = 6.91, p < .02, \eta^2 = .25$ and the race × fame interaction remained significant. Simple effects revealed that nonfamous Caucasians ($M = 2.95, SD = 1.18$) received fewer fixations than nonfamous African-Americans ($M = 3.40, SD = 1.15$), $t(21) = -2.22, p < .04$, and famous Caucasians ($M = 4.10, SD = 1.67$), $t(21) = 2.82, p < .01$. The main effect of task was significant, $F(1, 42) = 26.56, p < .001, \eta^2 = .39$, along with a race × fame interaction, $F(1, 42) = 5.61, p < .03, \eta^2 = .12$. After controlling for RTs, the main effect of task disappeared; however, there was a main effect for fame across tasks, $F(1, 42) = 10.68, p < .01, \eta^2 = .20$, with famous faces receiving more overall fixations in both tasks (see Figure 8). There was also a reliable race × fame interaction across tasks, $F(1, 42) = 4.35, p < .05, \eta^2 = .09$, with nonfamous African-Americans receiving significantly more fixations than nonfamous Caucasians in the fame task but not in the race task. This is interesting because it is possible that the saliency of race in the racial categorization task may have led participants to avert their gaze away from out-group faces. This finding is consistent with Becker and Detweiler-Bedell (2009) who demonstrated that participants avoided looking at fearful or angry faces. Though threat in this study was caused by emotional expression, neurophysiological studies have also demonstrated increased amygdala activation (associated with threat and negative emotions) when viewing other-race faces (Cunningham et al., 2004; Hart et al., 2000; Phelps et al., 2000).
Results for total gaze duration were similar to the findings for total fixations. Consistently, a significant race \times fame interaction emerged for the fame task, $F(1, 21) = 6.72, p < .02, \eta^2 = .24$. After controlling for RTs, there was a main effect of fame, $F(1, 21) = 6.68, p < .02, \eta^2 = .24$ and the race \times fame interaction remained significant with famous Caucasians receiving more gaze time than all other face groups (see Figure 9). No significant effects were found for the race task even after controlling for RT variation. Before controlling for RTs, there was a main effect for task, $F(1, 42) = 10.94, p < .01, \eta^2 = .21$ as well as a race \times fame \times task interaction, $F(1, 42) = 4.15, p < .05, \eta^2 = .09$; however, these effects disappeared after controlling for variation in reaction times.

**Areas of Interest (AOIs)**

Our first question concerning eye-movements investigated differences in fixations and gaze duration for faces and task type in a global sense. Results indicated that famous faces received more fixations across both tasks regardless of race. Additionally, nonfamous Caucasians received significantly more fixations than nonfamous African-Americans in the race task but not the fame task; results for gaze duration were similar to those for fixations. In a more specific analysis, we investigated if fixations to different areas of interest (AOIs) and time spent on each AOI varied as a function of race, fame, or task type. Differences in gaze duration and fixations were analyzed for eight defined AOIs (i.e., right eye, left eye, right cheek, left cheek, nose, mouth, forehead, and chin). These AOIs were chosen based off previous eye-tracking research (Barton et al., 2006).
A 2 (race) x 2 (fame) x 8 (AOI) x 2 (task) repeated measures ANOVA was conducted with race, fame, and AOIs as within-subjects variables and task as a between-subjects variable. Mean gaze duration and mean fixations were again calculated as ratios to RTs for each face category to avoid any confounds due to differences in reaction time. A significant effect for AOI fixations emerged in the race task, $F(7, 15) = 3.41, p < .03, \eta^2 = .61$. Post-hoc tests revealed there were more fixations to the nose ($M = 1.78$) relative to the chin ($M = .92$), left cheek ($M = .92$), left eye ($M = .58$), and mouth ($M = .83$). A reliable race x AOI interaction also occurred, $F(7, 15) = 5.30, p < .01, \eta^2 = .71$, with more fixations to the nose for African-Americans ($M = 2.06$) compared to Caucasians ($M = 1.51$), $t(21) = 2.34, p < .03$, and more fixations to the right eye for Caucasians ($M = 1.58$) relative to African-Americans ($M = .97$), $t(21) = -2.29, p < .04$. These effects remained significant when differences in RTs were not considered. Thus, in the race task, the nose was an important feature for African-American faces and the right eye was an important feature for Caucasians (see Figure 10).

After controlling for RTs in the famousness task, the main effect of fame revealed that famous faces received more overall fixations ($M = 1.24$) compared to nonfamous faces ($M = 1.04$), $F(1, 21) = 5.92, p < .03, \eta^2 = .22$. There was also a significant race x fame interaction, $F(1, 21) = 6.79, p < .02, \eta^2 = .24$, and the main effect of race approached significance, $F(1, 21) = 4.14, p < .06, \eta^2 = .17$. Post-hoc tests revealed that famous Caucasians received more fixations to AOIs compared to other groups. An interaction occurred between fame and AOIs, $F(7, 15) = 2.81, p < .05, \eta^2 = .57$, and simple effects revealed there were more fixations to the mouth ($M = 1.79$) and right eye.
(M = 1.61) for famous faces compared to nonfamous faces (M = 1.17, .97), respectively (see Figure 11). When RTs were not considered, the main effects of race and fame disappeared but all other effects remained significant. These findings are interesting because even though famous faces were categorized faster than nonfamous faces, participants fixated more on famous faces during the task. Initially, there was a main effect for task, $F(1, 42) = 16.56, p < .001, \eta^2 = .28$; however, the main effect of task was not significant after controlling for RTs. The task $\times$ AOI interaction remained significant, $F(7, 33) = 2.61, p < .03, \eta^2 = .36$, with more fixations to the left eye, $t(42) = -2.67, p < .02$, and mouth, $t(42) = -2.80, p < .01$, in the fame task.

Results for the ratio of gaze duration to RTs were similar to those for fixations on both tasks. In the race task, there was a main effect for AOI, $F(7, 15) = 7.32, p < .01, \eta^2 = .77$, with the nose receiving more fixations than all other features except the left cheek. There was also a significant race $\times$ AOI interaction, $F(7, 15) = 3.41, p < .03, \eta^2 = .61$, with more time spent on the right eye for Caucasians ($M = .23$) compared to African-Americans ($M = .14$), $t(21) = -2.37, p < .03$, and more time spent on the nose for African-Americans ($M = .43$) than for Caucasians ($M = .28$), $t(21) = 2.29, p < .04$ (see Figure 12). Consistently, these effects remained the same when variation in RTs was considered.

After calculating ratios for the famousness task, more time was spent on AOIs for Caucasian faces compared to AOIs for African-American faces, $F(1, 21) = 6.53, p < .02, \eta^2 = .24$, and more time spent on AOIs for famous faces than AOIs for nonfamous faces, $F(1, 21) = 6.53, p < .01, \eta^2 = .33$. The race $\times$ fame interaction was also significant, $F(1,
21) = 6.54, \( p < .02, \eta^2 = .24 \), with famous Caucasians receiving the longest gaze durations relative to other groups. Additionally, there was a main effect for AOI, \( F(7, 15) = 6.05, p < .01, \eta^2 = .74 \), and post-hoc tests revealed there was more time spent on the nose (\( M = .26 \)) compared to the chin (\( M = .07 \)), forehead (\( M = .11 \)), left cheek (\( M = .13 \)), and right cheek (\( M = .15 \)), and longer gaze durations to the mouth (\( M = .22 \)) and right eye (\( M = .20 \)) relative to the chin (see Figure 13). Before controlling for RTs, there was also a fame \( \times \) AOI interaction, \( F(7, 15) = 2.75, p < .047, \eta^2 = .56 \), with more fixations to famous faces compared to nonfamous faces. Consistent with the results for fixations, the main effect of task was significant before controlling for RTs, \( F(1, 42) = 10.94, p < .01, \eta^2 = .21 \). This effect disappeared after RTs were considered, however, the task \( \times \) AOI interaction remained significant with more time spent on the mouth in the fame task, \( t(42) = -2.95, p < .01 \), and more attention to the nose in the race task, \( t(42) = 2.01, p < .05 \).

In summary, it appears that the nose was an important feature for determining racial category membership whereas the mouth and right eye were more important in the famousness task. In the race task, there was more focus on the nose for African-American faces and more attention to the right eye for Caucasian faces. Famous faces also received more fixations and gaze time to the right eye and mouth in the fame task. More attention to the right eye may have been due to a dominantly right-handed sample; however this is difficult to determine because a measure of handedness was not included in the current study. Nonetheless, the type of task influenced what AOIs were important for different face categories. Previous research demonstrated that typical scan paths include those that
sample the eyes or mouth in over ninety percent of trials and produce more activation in the fusiform gyrus than scan paths that do not sample those regions (Morris, et al., 2006). Accordingly, Caucasian faces in the race task and famous faces in the fame task should have elicited more activation in brain areas associated with the processing of faces. Additionally, African-American faces received fewer fixations and dwell time in the race task regardless of famousness. It is possible that this occurred because the saliency of race caused participants to be sensitive to threat and categorized out-group faces based on a very small number of fixations. In the fame task, however, famous faces received more fixations and dwell time even though they were categorized faster. Reasons for the mixed findings across tasks are explored further in the following section.
CHAPTER 4
DISCUSSION

The present research investigated the influence and interaction of race and familiarity in the face recognition process and extended research on MacLin and MacLin's (in press) cognitive gating mechanism by testing the model using famous and nonfamous facial stimuli. One central question was whether the model adequately describes the encoding processes for own- and other-race faces differing in level of familiarity. To test this query, I first examined differences in reaction times for famous and nonfamous African-American and Caucasian faces. At face value, one assumption of the model is that it is temporally constant for own- and other-race faces (see Figure 2). The RT data from the current study, however, indicate that this may not be the case when the individual is familiar. When categorizing faces by race, famous African-Americans were categorized the fastest relative to other groups; there were no significant differences between nonfamous African-Americans and both groups of Caucasians. It is possible that this occurred due to a less demanding memory search for familiar faces (Baird & Barton, 2008; Martens, et al., 2010). If this is the case, however, then famous Caucasians also should have taken less time relative to the nonfamous stimuli.

Another plausible explanation is that the novelty of high-status in an out-group member amplified the perception of threat. As stated earlier, familiarity constitutes several different factors, including visual familiarity, biographical information, occupation, valence, etc. For famous individuals, it is also likely that familiarity includes information about that persons' status, power, or level of social influence. Previous
research has demonstrated that high-status group members exhibit higher systolic blood pressure (increased cardiovascular resistance associated with threat) when intergroup relations are perceived to be unstable (Scheepers, Ellemers, & Sintemaartensdijk, 2009). Interestingly, males (the dominant group) in the aforementioned study experienced higher systolic pressure when discussing gender status changes and women in the study did not experience an increase. This is in accordance with Tajfel and Turner’s (1979, 1986) social identity theory that states that people experience threat from out-group members because of intergroup competition for resources. Thus, when an out-group member is perceived to have status and influence, they may be perceived as more threatening compared to unfamiliar group members because they hold the possibility of overturning the status hierarchy. Mendes, Major, McCoy, and Blascovich (2008) also note that the perception of threat is intensified when out-group members violate stereotypic expectations. Along these lines, a low-status out-group member who is known to have status and influence may be more threatening because they are incongruent with known stereotypes for the group. This could also be seen as an explanation for the current tea party movement and political unrest during Barack Obama’s presidency. The idea of a traditionally low-status group member rising to power may cause some anxiety among people who may be fearful of status loss.

In the famousness task, famous African-Americans faces were again categorized the fastest in comparison to nonfamous stimuli although there was no significant difference between the two famous groups. This effect is more likely due to the decreased demands of the memory search for familiar stimuli due to a preexisting memory match
(Baird & Barton, 2008; Martens, et al., 2010). Because the nonfamous faces in this study had similar photo artifacts to famous images (e.g., clothing, pose, attractiveness) they may also have taken longer due to an increased level of ambiguity. Distinctiveness may have played a role for famous African-Americans as well given the fact that the group is smaller and therefore a familiar member would be more readily recognized as famous. However, it is still possible that threat played a role in the speeded categorization.

Eye-movement differences when viewing faces from each respective category are somewhat more difficult to interpret. In the race task, the nose played an important role in racial categorization, especially for African-Americans. Alternatively, the right eye was of more interest for Caucasian stimuli. One notable finding is that even though famous African-Americans were categorized fastest by race, they still received more fixations and were looked at longer relative to nonfamous stimuli. Previous eye-tracking research regarding the viewing of threatening images is mixed. Some studies demonstrate that people actively avoid looking at threatening images, however, the stimuli varied in emotional expression, not race (Becker & Detweiler-Bedell, 2009; Goldinger, et al., 2009). Buckner, Maner, and Schmidt (2010) found that participants high in social anxiety had difficulty disengaging from threatening images. Again, however, this study used faces with negative emotional expressions, not racial stimuli. Because the current study did not obtain a measure of social anxiety, it is difficult to tease out which of these explanations is more likely. However, the face that eye-movement differences were discovered across race when using familiarity as a variable does counter previous research that found no race differences for novel faces (Hirose & Hancock, 2007).
The finding that famous faces received more fixations across both tasks is also consistent with previous research demonstrating that people look longer at faces that are personally familiar compared to novel faces (Devue, et al., 2009). In addition, famous faces received more fixations and longer dwell times in the fame task consistent with previous eye-tracking research (Althoff & Cohen, 1999; Morris, et al., 2006). Though there were no main effects for task type, the task did interact with AOIs indicating that there was more attention to the mouth and eyes in the fame task and more attention to the nose in the race task. This is consistent with previous research on feature saliency that indicates internal features (e.g., eyes, nose, mouth) are more important for the recognition of familiar faces (Ellis, Shepherd, & Davies, 1979). Thus, the presence of famous faces in the current study may have led participants to pay more attention to internal features of the face. Additionally, it appears that the fame task motivated participants to engage in more typical scan paths that attend to the mouth and eyes. Therefore, it is plausible that forcing participants to focus on whether or not a face is famous led them to employ more typical scan paths, eliciting more fusiform activation (Morris, et al., 2006). The fact that different AOIs were important as a function of task also supports previous research that demonstrated eye-movements differ according to task type (Yarbus, 1965). Thus, context may also play an important role in face recognition.

The results of the present research make it difficult to deny that there is interplay between race and familiarity. Currently, the CGM is only suitable to describe the processes involved in the recognition of novel faces. Therefore, it is necessary that the model be altered to account for familiar faces. One possibility is that the dotted line
leading from featural processing to the in-group channel is a route for familiar out-group members to be "pushed up" into higher-order processes (see Figure 14). This channel would allow familiar faces to access semantic information associated with the face to retrieve information about the person. In this modification, familiar other-race faces may be processed quickly because this route is faster than the lower channel. As discussed earlier, this could be due to the preexisting memory match or familiarity cueing an increased threat response in the out-group channel and accelerating the process. A second possibility is that a familiarity node exists within the CGM as a variable in own- and other-race face recognition (see Figure 15). In this modification, familiarity also accelerates the face recognition process. When a face reaches the familiarity assessment, it initiates a memory search for information about the face. If the face is determined to be familiar, it is accelerated through the encoding process and matched up with the previously stored information; if the face is unfamiliar, it continues through its original channel. Additionally, the lower processing channel is assumed to be faster, explaining faster RTs for African-Americans. This modification, however, is visually complex and a more parsimonious model may be sufficient for explaining the role of familiarity in the CGM.

Based on the eye-tracking data from the present study, a third modification to the CGM could include a familiarity node along the out-group channel (see Figure 16). In this modification, familiar faces are re-routed along the in-group channel for configural processing and unfamiliar out-group faces continue along the original out-group channel. The finding that famous faces received more fixations across both tasks may be
indicative of a configural processing strategy. Thus, familiar faces are processed
configurally regardless of race. This is difficult to verify, however, because there is no
precedent in eye-tracking research for configural and featural processing strategies.
Consistent with the first proposed modification, the dotted lines would indicate faster
processing, explaining faster RTs for famous African-Americans. Though this
modification is interesting because it explains some of the eye-tracking data, it is difficult
to confirm what type of strategy was actually used. Additionally, it leaves one to assume
that familiarity does not have effects for the in-group, which was not true based on RTs
from the current study. A fourth modification could be that the encoding process stops
when a face is determined to be familiar (see Figure 17). This model explains faster RTs
for famous faces in the fame task because the memory search stops when a match is
found. Additionally, the presence of a racial marker initially accelerates the process
resulting in faster RTs for famous African-Americans. This model is more parsimonious,
however, it does not address where information about the familiar face is obtained.

The recommended modification to the CGM is that familiarity accelerates the
face recognition process by bypassing configural and featural processing. In this
modification, familiarity serves as a parallel function in the encoding stage with feedback
loops to the two main channels (see Figure 18). If no familiarity is detected, the face gets
dropped back into its respective channel; if a face is determined to be familiar, however,
it stops the encoding process and is routed to its appropriate location previously stored in
memory. This is supported by the current research and previous findings that familiar
faces are processed quickly compared to novel faces (Baird & Burton, 2008; Martens, et
Electrophysiological research also supports the idea that race is detected before fame, as this modification demonstrates (Caharel et al., 2002; Kubota & Ito, 2007). Thus, due to the availability of previously stored information in memory, familiar faces are exempt from the latter encoding processes depicted in the model.

Although the recommended modification is an effective at explaining how familiarity can be incorporated into the CGM, it is also possible that the model is only capable of describing the recognition of novel faces. Based on the current data, it is apparent that race is influencing the face recognition process for both familiar and unfamiliar faces. Therefore, an alternative to assimilating familiarity into the CGM is to include race in Bruce and Young’s (1986) model of face recognition (see Figure 19). Consistent with the configural-featural hypothesis and the race-feature hypothesis, race is detected early on in the face recognition process and influences what facial features are encoded (Diamond & Carey, 1986; Levin, 1996). Therefore, the structural encoding processes may be sensitive to race such that when an other-race feature is detected, it inhibits the encoding of additional features and accelerates the face recognition process. This is supported by ERP research demonstrating race effects early on in the recognition process that influence the N170 and P200 orienting responses (Ito, Thompson, & Cacioppo, 2004; Kubota & Ito, 2007). The proposed modification would expand the Bruce and Young (1986) model to account for the vast amount of literature on the differential processing strategies for same- and other-race faces. Additionally, it creates
the opportunity for future research to examine the interaction of race with familiarity and emotion in the face recognition process.

One final possibility to explain the results without altering the CGM is to modify a recent model of face recognition proposed by Wild-Wall (2004). In this proposed model, face recognition is more of an interactive process and race again influences what structures of the face are encoded (see Figure 20). The benefit of this model is that the factors involved in face recognition are clearly depicted to influence one another in an associative process. Additionally, arousal and affective response are included in the model and impact expression evaluation and assessment of familiarity. This is important because past research demonstrates that negative emotional expressions and other-race faces trigger a threat response that can interfere with encoding process (Correll, et al., 2006; Cunningham et al., 2004; Hart et al., 2000; Phelps et al., 2000). Thus, this modification is a very parsimonious and inclusive model of face recognition that should be tested by future research.

One limitation of this study is that only Caucasian participants were included in the analysis. Future research should investigate eye-movement differences using participants from various racial groups. Additionally, this study only uses African-American and Caucasian faces as stimuli. Famousness effects on eye-tracking and face recognition should also be investigated using other racial stimuli; however, this may be difficult due to the low number of highly famous individuals that fall into other racial categories. Another limitation to this study and the proposed model is that only famous faces were used. Previous research demonstrates differences in eye-movements and the
involvement of different neural structures based on how a face is familiar (e.g., famous, friend, family, romantic partner). It is possible that faces differing in familiar type would produce alternative findings. Moreover, personally familiar faces would not likely trigger a threat response in the perceiver and may counter the rationale describing effects of the current research.

The current study also did not include a measure of valence to determine differences in affect induced by the stimuli. Past research has demonstrated RT differences for admired and disliked Caucasian and African-American exemplars (Richeson & Trawalter, 2005). Therefore, future research should investigate if the current findings are reliable when the famous individual is liked or disliked. In addition, emotional expression should be included as a variable in future research to examine the interaction of positively and negatively valenced emotional expressions with familiar and unfamiliar faces differing in race. Finally, the finding that task influences RTs as well as eye-movements demonstrates the importance of investigating the role of context in face recognition. The current study could be modified to include different types of categorization tasks (e.g., affect, emotion identification) and record differences in RTs and attentional focus. Alternatively, one could induce positive or negative affect to explore the role of emotional context in face recognition. Such research may have important implications because people may react differently or attend to different features when they are in a pleasant situation compared to a threatening situation. Despite these limitations, the results demonstrate further restrictions of previous theories to explain all
factors involved in the face recognition process (e.g., Bruce & Young, 1986; Levin, 1996; Valentine, 1991).

Future research should investigate the role of the aforementioned variables to verify the proposed modifications to the CGM and other existing models of face processing. Additionally, eye-tracking equipment should continue to be used as a method to explore the behavioral underpinnings of face recognition. Research on the neurophysiological processes involved in face recognition may also offer support for the proposed modifications to the CGM and other models of face recognition. Continuing to use recent technologies to explore the interactions of all factors involved in face recognition may bring about a new age of examining and understanding issues of race and face processing.
REFERENCES


Table 1.

*Means and standards deviations of reaction times (in seconds) for each face type across race and fame tasks.*

<table>
<thead>
<tr>
<th>Face Category</th>
<th>Race Task</th>
<th>Fame Task</th>
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<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
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<tr>
<td>FAA</td>
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<td>.20</td>
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<tr>
<td>NFAA</td>
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<td>FC</td>
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<td>NFC</td>
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*Note.* FAA = Famous African-American; NFAA = Nonfamous African-American; FC = Famous Caucasian; NFC = Nonfamous Caucasian.
Figure Captions

**Figure 1.** The Functional Model of Face Recognition (Bruce & Young, 1986)

**Figure 2.** The Cognitive Gating Mechanism (MacLin & MacLin, in press)

**Figure 3.** A gaze plot example from the current study. Larger circles represent longer fixations; lines represent saccades.

**Figure 4.** Sample stimuli.

**Figure 5.** Mean reaction times for each face type in the race categorization task. Error bars represent the standard errors of the means.

**Figure 6.** Mean reaction times for each face type in the famousness classification task. Error bars represent the standard error of the means.

**Figure 7.** A timeline of RTs across tasks and known ERP effects (in milliseconds).

**Figure 8.** The ratio of mean fixations to mean reaction times for each face category across tasks. Error bars represent the standard error of the means.

**Figure 9.** The ratio of mean gaze duration to mean reaction times for each face category across tasks. Error bars represent the standard error of the means.

**Figure 10.** Ratio of fixations to each AOI relative to RTs for each face category in the race task. Error bars represent the standard error of the means.

**Figure 11.** Ratio of fixations to each AOI relative to RTs for each face category in the fame task. Error bars represent the standard error of the means.

**Figure 12.** Ratio of mean gaze duration for each AOI relative to RTs for each face category in the race task. Error bars represent the standard error of the means.
Figure 13. Ratio of mean gaze duration for each AOI relative to RTs for each face category in the fame task. Error bars represent the standard error of the means.

Figure 14. One modification illustrating the role of familiarity in the CGM. The dotted line acts as a route for familiar out-group faces.

Figure 15. A second modification illustrating the role of familiarity in the CGM. Familiarity is obtained from long-term memory and accelerated later encoding processes.

Figure 16. A third modification illustrating the role of familiarity in the CGM. Familiar out-group members are processed configurally along the in-group channel.

Figure 17. A fourth modification illustrating the role of familiarity in the CGM. The encoding process stops when a face is determined to be familiar.

Figure 18. A proposed modification illustrating the role of familiarity in the CGM. Familiar faces are exempt from later encoding processes.

Figure 19. A proposed modification to the Bruce and Young's (1986) model of face recognition. Race influences the structural encoding process.

Figure 20. A possible modification to the Wild-Wall's (2004) model of face recognition. Race influences structural encoding.
Figure 1.
Figure 2.
Figure 3.
Famous Faces

Nonfamous Faces

*Figure 4.*
Figure 5.

Reaction Times (Race Task)
Figure 6.
Perceptual Time Course

Figure 7.
Figure 8.
Figure 9.
Figure 10.
Figure 11.
Figure 12.
Figure 13.
Figure 14.
Figure 15.

LONG-TERM MEMORY
Right Hemisphere/Frontal Lobe

Face & Semantic Info. (High LOP)

Stereotypes Labeling (Low LOP)

Left Hemisphere/Occipital-Temporal Lobe/Amygdala

CGM
Presence of Racial Marker? "No" if Default

Familiarity

Individual Processing Configural (Socially Based)

Categorical Processing Featureal (Action Based)
Figure 16.
Figure 17.
Figure 18.
Figure 19.
Figure 20.