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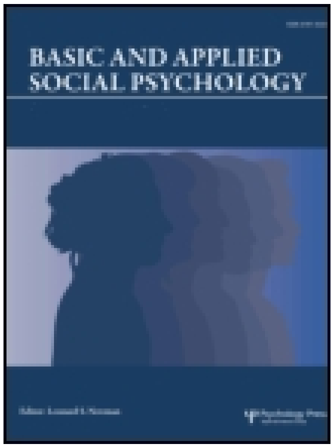

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Perceptual Processes in the Cross-Race Effect: Evidence From Eyetracking

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The cross-race effect (CRE) is the tendency to have better recognition accuracy for same-race than for other-race faces due to differential encoding strategies. Research exploring the nature of encoding differences has yielded few definitive conclusions. The present experiments explored this issue using an eyetracker during a recognition task involving White participants viewing White and African American faces. Participants fixated faster and longer on the upper features of White faces and the lower features of African American faces. When instructing participants to attend to certain features in African American faces, this pattern was exaggerated. Gaze patterns were related to improved recognition accuracy.

The cross-race effect (CRE) or own-race bias is a robust phenomenon, observed across a variety of racial and cultural groups, in which individuals are better at recognizing members of their own race or group than members of other races or groups (Brigham, 2008; Brigham, Bennett, Meissner, & Mitchell, 2007; Meissner & Brigham, 2001). It manifests in both more hits and fewer false alarms for own-race than other-race targets, accompanied by differences in discrimination accuracy as well as response criterion (i.e., better sensitivity and a more conservative response criterion for own-race targets; see Meissner & Brigham, 2001; Slone, Brigham, & Meissner, 2000).

Recent research has demonstrated considerable support for encoding-based factors in the CRE (e.g., Bornstein, Laub, Meissner, & Susa, 2013; Evans, Marcon, & Meissner, 2009; Hancock & Rhodes, 2008; Meissner, Brigham, & Butz, 2005). Rather than a simple difference in time spent encoding own-race versus other-race faces, they appear to be processed differently (Tullis, Benjamin, & Liu, 2014). For example, own-race faces are perceived as more memorable, familiar, and distinctive than other-race faces, and these qualitative differences in encoding are conducive to better recollection of own-race faces (Meissner et al., 2005; see also Hancock & Rhodes, 2008; O'Toole, Deffenbacher, Valentin, & Abdi, 1994). Instructing participants on the CRE at the time of encoding, such as explaining the nature of the CRE and telling participants to pay particular attention to other-race faces, can eliminate the effect, presumably by moderating the differential encoding (Hugenberg, Miller, & Claypool, 2007; Young, Bernstein, & Hugenberg, 2010).

These findings beg the question of what, exactly, people encode when viewing faces of different races. For witnesses to identify members of other races correctly, they must focus on the characteristics that distinguish that person from others, and there are differences between faces of one race and faces of another race in terms of feature variability. For example, White European faces show more variability in hair color than Black African faces, whereas lower facial features (e.g., mouth and nose) show more variability in Black faces (Shepherd & Deregowski, 1981). There is evidence that a failure to attend to features useful for later recognition of other-race faces underlies the CRE (Hills & Lewis, 2006; Hills & Pake, 2013; Levin, 2000); that is, individuals learn which features are most useful for discriminating among others of their own race, but they then overgeneralize and use those same features for other-race faces, where they are less diagnostic. Indeed, individuals of different races mention different features when describing faces (e.g., Ellis, Deregowski, &

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Shepherd, 1975; Shepherd & Deregowski, 1981). The present study was designed to contrast differences in how participants view own-race faces in comparison to how they view other-race faces by employing an eyetracker, which monitors where participants are looking as they process complex visual stimuli.

Tracking eye movements is an effective way to study attentional allocation when processing visual information, and several studies have applied eyetracking technology to the topic of eyewitness memory and face processing. For example, Flowe (2011; Flowe & Cottrell, 2011) has used a video-based eyetracker to investigate perceptual processes at the retrieval (lineup) stage of eyewitness memory. In simultaneous lineups, participants spent a longer time looking at individual faces that were positively identified than faces that were not identified, especially on the first "visit" to the face (Flowe & Cottrell, 2011); and lineup presentation affected the amount of time spent looking at the faces, especially if the face was a foil (Flowe, 2011). Using a similar procedure, Mansour, Lindsay, Brewer, and Munhall (2009) found that witnesses spend longer looking at lineup faces when they reject a lineup (i.e., fail to make an identification) than when they make any positive identification. In terms of specific facial features, participants are more accurate in discriminating among briefly presented faces when attending to internal features (eyes, nose, and mouth) relative to external facial features (hair, chin, and ears; Fletcher, Butavicius, & Lee, 2008; Nakabayashi, Lloyd-Jones, Butcher, & Liu, 2012).

Several previous studies have employed eyetracking in an examination of the CRE. For example, using White and Asian faces, Goldinger, He, and Papesh (2009) found that participants made more rapid (and hence more) fixations and wider ranging eye movements to own-race than to other-race faces. Participants also attended to different features in processing faces of different races. For example, White participants made more fixations to the eyes and hair of White faces but more fixations to the nose and mouth of Asian faces. They observed a reciprocal pattern among Asian participants, suggesting that participants were not necessarily attending to the more diagnostic features of own-race versus other-race faces; rather, it suggests a bias in attending to upper facial features in own-race faces but to lower facial features in other-race faces. Wu, Laeng, and Magnussen (2012) also found a similar more rapid active scanning strategy for White participants when viewing own-race versus other-race Asian faces. Critically, an increase in pupil diameter was observed when viewing other-race faces, possibly due to the increase in cognitive resources necessary to encode a relatively unfamiliar other-race versus own-race face.

In contrast to Goldinger et al. (2009) finding that participants attend more to the upper facial region of own-race versus other-race faces, Elis et al. (1975) observed that Black Africans attend more to lower facial features when examining Black African (compared to White) faces. Similarly, Fu, Hu, Wang, Quinn, and Lee (2012) determined that Chinese participants spent more time fixated on the eye region of White relative to Chinese faces and increased time scanning the lower region of own-race (Chinese) relative to other-race (White) faces, arguably as a result of eye contact cultural norms of in-group social members. Research by Caldara and colleagues (Blais, Jack, Scheepers, Fiset, & Caldara, 2008; Caldara, Zhou, & Miellet, 2010) partially supports this interpretation. They found that in normal scanning of faces for subsequent recognition, White participants fixated more on the eyes (and to some extent the mouth), whereas East Asian participants fixated more on the nose, largely regardless of the race of the target face. Black observers, on the other hand, tend to focus more on the nose than do White observers (Hills & Pake, 2013). Thus, it is clear that faces of different races elicit different gaze patterns, but the exact nature of that difference appears to vary depending on participants' own race, at least insofar as race is associated with different cultures.

Faces of different races elicit different scanning strategies at recognition as well as during encoding. For example, White participants making recognition judgments pay more attention to the mouths of African American faces than to the mouths of White faces, whereas they pay more attention to the eyes of same-race (White) faces (Nakabayashi et al., 2012). As with attention during face encoding, however, there are cultural differences in gaze patterns at recognition. When they are relatively unconstrained, Whites attend more to the eyes when making recognition judgments, whereas East Asians attend more to the nose (Caldara et al., 2010).

EXPERIMENT 1

In looking at the correlates of eyetracking with recognition performance, several previous studies (e.g., Goldinger et al., 2009; Wu et al., 2012) have examined overall scanning patterns during encoding, but they did not explore the relationship between attention to specific facial features and recognition performance. The present research extends these findings by addressing this question; it also provides generalizability by applying eyetracking in the CRE to another racial comparison. Most prior research has compared Whites and Asians (Caldara et al., 2010; Fu et al., 2012; Goldinger et al., 2009; Tullis et al., 2014; Wu et al., 2012), as opposed to Whites and African Americans (Hills & Pake, 2013). Although the CRE is fairly stable across racial groups (Meissner & Brigham, 2001), there is some evidence that the magnitude of the effect varies depending on the particular races involved (Anthony, Copper, & Mullen, 1992), and culture specifically influences face processing (e.g., Blais et al., 2008).

We make three hypotheses: First, we expect to obtain a CRE such that participants will do better recognizing own-race than other-race faces. Second, we expect differences in gaze patterns when viewing own-race (White) than other-race (African American) faces, such that participants will attend preferentially to facial features that are more diagnostic for each race—upper facial features for White faces and lower facial features for African American faces. Third, we expect an association between these differences in gaze patterns and subsequent recognition performance such that better performance will reflect greater attention to more diagnostic features.

Method

Participants

Participants were 37 White undergraduate students from a large midwestern university who received extra course credit. Although we did not collect data on participants' age and gender in the experiments reported here, the participant pool is typically 60% to 70% women, and the vast majority are in the 18- to 25-year-old age range. All were naïve as to the purpose of the experiment, which took place in a single 30-min session.

Materials

The eyetracker was an SR Research Ltd. EyeLink II binocular system (Mississauga, Ontario, Canada), with high spatial resolution and a sampling rate of 500 Hz. Thresholds for detecting the onset of a saccadic movement were acceleration of $8000°/s^2$, velocity of 30°/s, and distance of 0.5° of visual angle. Movement offset was detected when velocity fell below 30°/s and remained at that level for 10 consecutive samples. The average error in the computation of gaze position was less than 0.5°. A 9-point calibration procedure was performed at the beginning of the experiment, followed by a 9-point calibration accuracy test for participants' dominant eye. Calibration was repeated if any point was in error by more than 1° or if the average error for all points was greater than 0.5°. Participants completed the experiment on a Pentium IV PC seated approximately 44 cm from the computer screen (20° image viewing angle). Face stimuli were 64 photographs of college-aged men, derived from a larger set of 160 faces and pretested to control for memorability (see Evans et al., 2009; Meissner et al., 2005). In the encoding phase, faces were color head-and-shoulder shots in full frontal pose against a gray background; targets were smiling and wore everyday clothes. In the recognition phase, faces were again in head-and-shoulder, full frontal pose against a gray background, but all wore the same clothing and had a neutral expression. Emotion and clothing of the faces were varied between the encoding and recognition phase to further ecological validity given that in a natural setting, recognition of an individual normally involves more than pure memorization of a specific expression or attire (see Figure 1 for an example of the African American and White faces used during the encoding and recognition phases and an example mapping of the regions of interest). As facial structure systematically varies across people, we utilized five regions of interest templates that varied minimally in size, matching the best-fit template to each face. The regions of interest were the eyes, hair, mouth, and nose. The regions of interest (ROIs) were controlled for size across the different images, where we individually selected the appropriate ROI sizes per each feature per each face. Obviously, however, the interest areas could differ in size between features (i.e., the nose is a much smaller interest area than the hair).

FIGURE 1 Example stimuli for African American and White faces during the encoding and recognition phases. *Note*. The boxes in the encoding phase denote the four regions of interest.

Procedure

The experiment consisted of three phases: encoding, filler task, and recognition. To initiate each trial, participants fixated on the center fixation point and pressed the space bar, which then offset to signal the trial had begun. During the encoding phase, participants viewed 32 male faces (16 White and 16 African American), presented at a 3-s rate (see the appendix for task instructions). The 32 faces were drawn from a larger set of 64 faces, which were divided into two subsets (see Evans et al., 2009; Meissner et al., 2005). Half of the participants viewed one of these sets of faces at encoding, whereas the other half of the participants viewed the other set of faces. On the later recognition test, all participants saw all faces, meaning that the target set for one group of participants served as the distractor set for the other group of participants and vice versa. Within the set of 32 faces, the images were displayed in a random order for each participant. The filler phase consisted of a general trivia questionnaire, lasting approximately 10 min. In the recognition phase, participants viewed 64 male faces (32 old, 32 new, with races mixed) presented for 3 s each. After face offset, participants indicated whether each face was old or new and gave a confidence judgment on a 7-point scale. Target and distractor faces were in a randomized order per each participant.

Results

Recognition

To assess the CRE on recognition data, we compared hits and false alarms for White and African American faces. Participants made more hits for White ($M = 9.73$, $SD = 2.05$) than for African American faces ($M = 8.65$, $SD = 2.26$), $t(36) = 2.54$, $p = .02$, $d = .50$. There was not a significant difference in false alarms, $t(36) = -.72$, $p = .47$, $d = .14$, although the pattern was in the predicted direction, with slightly more false alarms for African American faces ($M = 4.76$, $SD = 2.19$ vs. $M = 4.46$, $SD = 2.35$). It is not uncommon to obtain a CRE on some measures but not others (Meissner & Brigham, 2001), and the effect for hits was large. Thus, we obtained good evidence of a CRE. We also calculated signal detection d' (a measure of sensitivity) and C values (response bias) for White ($d' = .33$, $C = .16$) versus African American faces ($d' = .24$, $C = .19$) as another measure of discriminability. Both comparisons were in the predicted direction, showing better sensitivity for own-race (White) faces, $t(36) = 2.08$, $p = .04$, $d = .69$, but a nonsignificant difference in response, $t(36) = .74$, $p = .46$, $d = .25$.

Eye Movements

Next, we examined the extent to which race (White or African American) predicted first fixation time and percentage dwell time on each facial region (eyes, hair, mouth, nose), with the purpose of determining whether the effect of race on eye movements was greater for certain facial regions. If a participant did not fixate on a certain facial region per each face presented we recoded the value as 3,000 ms for first fixation time (representing the longest first fixation time in a 3-s trial) and 0 for percentage dwell time. There were very few fixations outside of the ROIs, and thus we did not include these in our analyses. As responses to the four facial regions are all nested within the same participants, a mixed or multilevel model is required. To that end, eye movements within each facial region were specified as a multivariate outcome. To compare the magnitude of the race effect across facial regions while controlling for the fact that differences between regions within the same person were likely to be highly correlated, a multivariate analysis of variance was used, which entails specifying each facial region as a multivariate outcome with related variances but independent residuals (distributed as multivariate normal with a mean of 0 and a variance of 1). Accordingly, the relationship between the residuals of each region is modeled directly through the fixed effects. This approach allowed us to compare the difference between two scores generated within the same person with the difference between two other scores generated within that same person while accounting for the fact that the difference in those two scores may differ between people across conditions. Analyses were performed on the full data matrix, with dependency among observations controlled directly through inclusion of random effects (Raudenbush & Bryk, 2002; see Barr, 2008, for a tutorial using eyetracking data). Models were estimated via SAS PROC MIXED using maximum likelihood estimation and Satterthwaite denominator degrees of freedom. The significance of fixed effects was evaluated via Wald test p values. The significance of random effects was evaluated via $-2\Delta LL$ tests (likelihood ratio test using degrees of freedom equal to the difference in the number of estimated parameters). SAS ESTIMATE statements were used to estimate simple effects implied by the model.

Percentage dwell time. There was a main effect of face region, $F(1, 65.1) = 89.14$, $p < .001$, where participants spent the most time looking at an individual's eyes, followed by the nose, mouth, and hair (see Figure 2). There was also a significant interaction with race, $F(1, 99.6) = 54.74$, $p < .001$, indicating that the effect of race on dwell time varied with face region. Participants spent longer looking at the hair on own-race (White) than on other-race (African American) targets (4.35% vs. 2.54%), but they showed the opposite pattern for looking at the mouth (Whites 15.35% vs. African

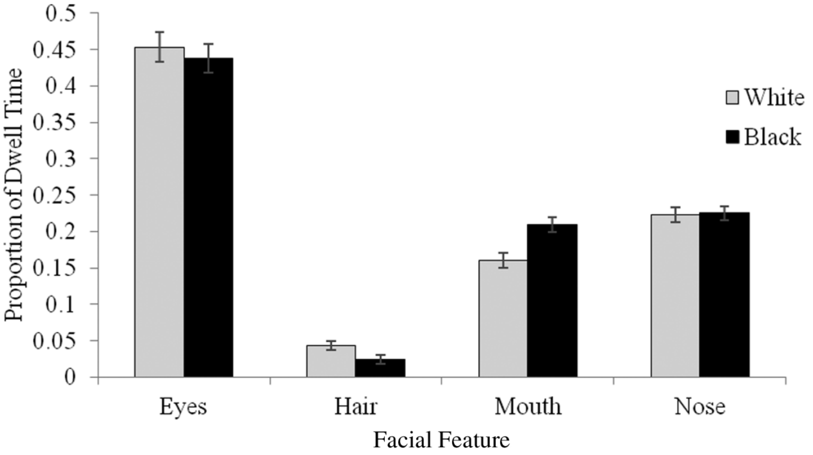

FIGURE 2 Proportion of dwell time as a function of facial feature (eyes, hair, mouth, and nose) for White and African American faces in Experiment 1. *Note*. Error bars indicate the standard error for each estimate.

Americans 20.53%). Gaze duration did not differ for the eyes or nose. The effect of race was significant for the hair ($b = -.02$, $SE = .004$, $p < .001$) and the mouth ($b = .05$, $SE = .007$, $p < .001$). For the hair, dwell time was shorter on African American versus White faces, whereas for the mouth, dwell time was shorter on White versus African American faces. Comparing the magnitude of the race effect across face regions indicates that the effect of race on mouth dwell time was greater in magnitude than eye dwell time ($b = -.06$, $SE = .01$, $p < .001$), hair dwell time ($b = -.07$, $SE = .009$, $p < .001$), and nose dwell time ($b = .05$, $SE = .01$, $p < .001$). The effect of race on hair dwell time was greater in magnitude than nose dwell time ($b = -.02$, $SE = .009$, $p = .03$). No other effects were significant.

First fixation time. As with dwell time, there was a main effect of face region, $F(1, 54.1) = 19.51$, $p < .001$, where participants were quickest to fixate on the nose—unsurprising, as the nose was roughly in the center of the screen where the eyes had to be positioned to initiate a trial—followed by the eyes, mouth, and hair (see Figure 3). There was also a significant interaction with race, $F(1, 69.1) = 19.71$, $p < .001$, indicating that the effect of race on first fixation time varied with face region. The effect of race was significant for the hair ($b = 154.97$, $SE = 40.99$, $p < .001$), for the nose ($b = 362.39$, $SE = 50.94$, $p < .001$), and for the mouth ($b = -545.22$, $SE = 57.39$, $p < .001$) but not for the eyes ($b = 71.05$, $SE = 41.37$, $p = .09$). First fixation time on the hair and nose occurred later for African American versus White faces, whereas first fixation time on the mouth occurred earlier for African American versus White faces. Comparing the magnitude of the race effect across face regions indicates that the effect of race on first fixation time to the mouth was greater in magnitude than to the hair ($b = 700.19$, $SE = 70.53$, $p < .001$) and to the nose ($b = -907.61$, $SE = 76.74$, $p < .001$). The effect of race on first fixation time to the hair was greater in magnitude than to the nose ($b = -207.42$, $SE = 65.38$,

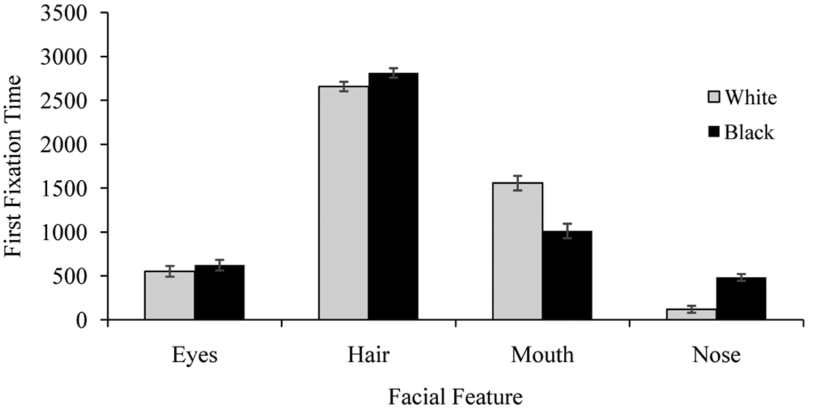

FIGURE 3 First fixation time as a function of facial feature (eyes, hair, mouth, and nose) for White and African American faces in Experiment 1. *Note*. Error bars indicate the standard error for each estimate.

$p = .002$). In sum, fixation times for the nose and hair were significantly faster for White than for African American faces, whereas mouth fixation time was significantly faster for African American faces.

Accuracy

Finally, we examined whether recognition accuracy can be predicted based on participants' eye movements and gaze behavior. The use of random effects mixed modeling was necessary when predicting accuracy in the recognition phase of the experiment from eye movements in the encoding phase due to several factors related to dependency. Because each participant encoded 32 faces (16 African American, 16 White), identification responses are most likely correlated as a result of the systematic differences across participants. Furthermore, accuracy in this case is a function of the percentage time dwelled in each of the four facial regions as well as the time it takes to fixate on a certain region. As participants are able to fixate on only one facial region at any given time, the responses to the four facial regions are not independent from one another. Accordingly, there are 32 identification responses (trials) nested within each of the 37 participants, resulting in 1,184 identification observations. Random effects mixed modeling allows us then to account for the dependencies in the data. Given that accuracy is a dichotomous outcome (correct or incorrect identification), a repeated-measures logistic regression modeling the logit of the probability of correct identification was selected for analysis. Parameter estimates, therefore, are presented on the logit scale, which is unbounded and symmetric around zero. A logit of 0 means that identification was equally likely to be correct as incorrect. Note that a logit of 0 is equivalent to a probability p of .50—that is, $p = \exp(\text{logit})/[1 + \exp(\text{logit})]$. When the logit is positive, correct identification is more likely to occur than not ($p > .50$); when the logit is negative, correct identification is less likely to occur than not ($p < .50$). The logistic transformation of identification accuracy allows the model to be interpreted the same as more conventional models (e.g., ANOVA); however, as the logit scale does not impart as intuitively meaningful an interpretation as, for example, milliseconds do, results are also plotted in terms of probability. Models were estimated within SAS PROC GLIMMIX using maximum likelihood estimation and Satterthwaite denominator degrees of freedom. Analyses were performed on the full data matrix, with dependency among observations controlled directly through inclusion of random effects (Raudenbush & Bryk, 2002; see Barr, 2008, for a tutorial using eyetracking data).

To examine how eye movements (percentage dwell time and first fixation time) on different facial features are associated with correct identifications, eye movements on each facial feature were submitted as separate, person-mean centered predictors. Given that eye movements vary across trials and subjects, effects of eye movements on accuracy potentially explain both within- and between-person variance. To parse these two sources of variance, it is necessary to include two predictors per facial feature, one that predicts within-person variance and one that predicts between-person variance. By centering one predictor at each person's mean, between-person variance is partitioned out, leaving a pure within-person predictor. By centering each person's mean at the sample mean, within-person variance is partitioned out, leaving a pure between-person predictor. Thus, within-person effects describe how the outcome changes as a person moves his or her eyes differently than he or she usually does, whereas between-person effects describe how the outcome changes as a person moves his or her eyes differently than others do.

Accordingly, the extent to which target race (White or African American) and eye movements (percentage dwell time or first fixation time) on different facial features (eyes, hair, mouth, nose) predicted the logit of the probability of correct identification was examined in a sample of 1,184 observations, where binary identification responses to 32 faces by the same participant are predicted by a set of processing variables, modeling the systematic differences between two subsets of the 32 faces (16 White faces, 16 African American faces). The cross-classified model included a random intercept for mean differences between trials, $-2\Delta\text{LL}(1) = 44.0$, $p < .001$, and a random intercept for mean differences between subjects, $-2\Delta\text{LL}(1) = 11.5$, $p < .001$. Separate models were conducted for the eyetracking measures of percentage dwell time and first fixation time when predicting accuracy due to both scale and pattern differences among these variables.

Percentage dwell time. Overall, the grand mean of the logit of the probability of a correct identification was significant, $t(32.9) = 2.55$, $p = .016$, indicating that correct identifications were more likely to occur than incorrect identifications ($M_{probability} = .57$, $SE_{probability} = .03$). There were no significant linear or quadratic between-person effects of dwell time ($p\text{s} > .20$). Thus, effects of dwell time reported next reflect within-person effects.

Overall, parameter estimates for the effect of dwell time were negative for all but the hair of White faces. That is, longer dwell time on any of the four facial features reduced the probability of correctly identifying White or African American faces, the exception being the hair of White faces, for which longer dwell time increased the probability of correct identification.

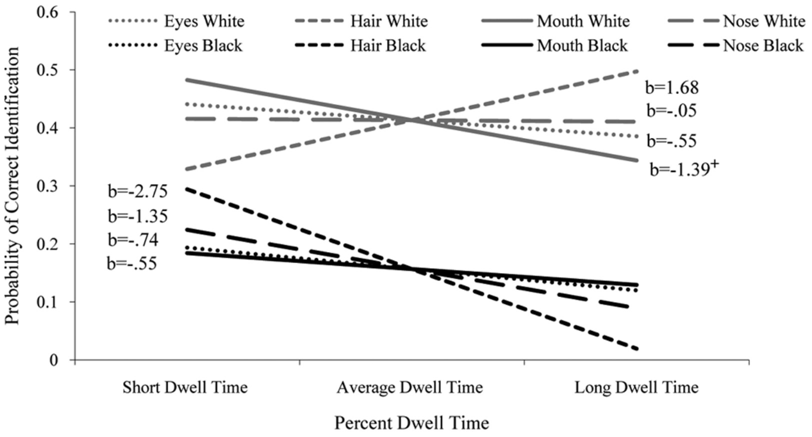

FIGURE 4 Correct identification (in logits) as a function of percent time dwelling on each facial feature (eyes, hair, mouth, and nose) for White and African American faces in Experiment 1. *Note*. $^+$Marks a marginally significant effect ($p < .10$).

For the hair, the main effect of dwell time was not significant ($F < 1$), but there was a significant Dwell Time × Race interaction, $F(1, 1118) = 3.76$, $p = .05$, indicating that the effect of dwell time differed for White and African American faces. For White faces, longer dwell time on hair increased likelihood of correct identification, whereas for African American faces, longer dwell time on hair reduced likelihood of correct identification. However, the simple effect of hair dwell time was not significant for White ($b = 1.68$, $SE = 1.42$, $p = .22$) or African American ($b = -2.75$, $SE = 1.73$, $p = .12$) faces.

For the mouth, the main effect of dwell time was marginally significant, $F(1, 1101) = 3.09$, $p = .07$, such that longer dwell time on the mouth reduced the probability of correct identification. The Dwell Time × Race Race interaction was not significant ($F < 1$). The simple effect of mouth dwell time for White faces was marginally significant ($b = -1.39$, $SE = .83$, $p = .09$), such that longer dwell time on the mouth reduced the probability of correct identification; the effect was not significant for African American faces ($b = -.55$, $SE = .73$, $p = .47$).

For the nose, neither the main effect of dwell time, $F(1, 1097) = 1.75$, $p = .18$, nor its interaction with race, $F(1, 1123) = 1.67$, $p = .19$, was significant. Dwell time on the eyes likewise did not significantly influence the likelihood of correct identification ($ps > .11$). In sum, for White faces, dwelling longer on the hair increased correct identifications, whereas dwelling on the mouth reduced correct identifications. For African American faces, longer dwell time on hair reduced the likelihood of correct identification (see Figure 4).

First fixation time. Overall, the grand mean of the logit of the probability of a correct identification was significant, $t(33.1) = 2.18$, $p = .036$, indicating that correct identifications were more likely to occur than incorrect identifications ($M_{probability} = .56$, $SE_{probability} = .11$).

For the mouth, the main effect of first fixation time was not significant ($F < 1$), but its interaction with race

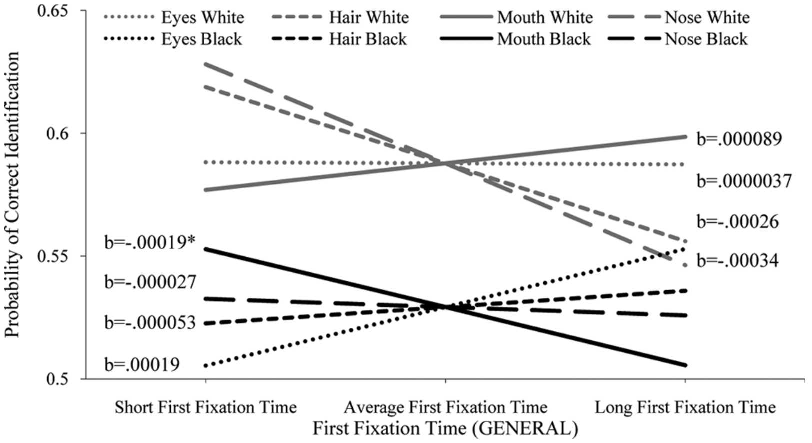

FIGURE 5 Correct identification (in logits) as a function of first fixation time on each facial feature (eyes, hair, mouth, and nose) for White and African American faces in Experiment 1. *Note*. *Marks a statistically significant effect ($p < .05$).

was $F(1, 1136) = 3.99$, $p = .046$. The simple effect of first fixation time was significant for African American faces, such that faster fixation to the mouth increased the likelihood of correct identification ($b = -.00019$, $SE = .000095$, $p = .047$); the effect was not significant for White faces ($b = .000089$, $SE = .0001$, $p = .38$). There was also a significant between-person main effect, $F(1, 35.6) = 8.54$, $p = .006$, as well as a significant context effect ($b = .00040$, $SE = .00017$, $p = .022$), where a context effect refers to the interaction effect on the outcome accuracy between multiple sources of variance. For White faces, the context effect was significant ($b = .00057$, $SE = .00023$, $p = .016$). For African American faces, the context effect was not significant ($b = .00023$, $SE = .00021$, $p = .30$).

For the nose, the main effect of first fixation time was marginally significant, $F(1, 1113) = 3.0$, $p = .08$, such that later first fixation time reduced the likelihood of correct identification. The interaction of first fixation time and race was not significant, $F(1, 1132) = 2.15$, $p = .14$.

The timing of the first fixation to the eyes or on the hair did not significantly influence the likelihood of correct identification (ps $> .25$). In sum, faster first fixations on the mouth increased the likelihood of correct identification of African American faces (see Figure 5).

Discussion

In summary, a CRE was observed, where participants made more hits and had better sensitivity for own-race White faces relative to African American faces. As it relates to eye movements, participants spent longer looking at the hair on White compared to other-race (African American) targets, but they showed the opposite pattern for attending to the mouth. Accordingly, participants were faster to fixate on the hair of White compared to African American faces, but mouth first fixation time was significantly faster for African American faces. These differential eye movement patterns influenced the ability to correctly identify faces, where for own-race White targets, longer time spent dwelling on the hair increased correct identifications, whereas dwelling on the mouth reduced correct identifications. For African American faces, longer dwell time on the hair and longer first fixation time to the mouth reduced the likelihood of correct identification.

EXPERIMENT 2

The results of Experiment 1 provide clear evidence that own-race and other-race faces are processed differentially with regard to various facial features. To some extent, the differential processing during encoding was associated with recognition accuracy, where looking longer at the hair of own-race faces, spending less time looking at the hair of other-race faces, and fixating faster on the mouth of other-race faces were all associated with increased recognition accuracy. Critically, these differential gaze patterns occurred naturally. In Experiment 2, we examined whether instructing participants to attend to certain facial features would result in improvements in cross-race recognition. General instructions on the CRE have been found to mitigate the effect (Hugenberg et al., 2007), as has guiding observers to attend to more diagnostic features (Hills & Pake, 2013). Further, instructing participants to attend to lower facial features of African American faces has been shown to reduce the CRE (Hills & Lewis, 2006) due to the variability in these facial regions among Black compared to White faces (Ellis et al., 1975; Shepherd & Deregowski, 1981). Thus, we sought to determine if instructing participants to alter eye movements toward more diagnostic features of African American faces improves performance.

Method

Participants

Participants were 48 White undergraduate students from a large midwestern university who received extra course credit. All were naïve as to the purpose of the experiment, which took place in a single 30-min session.

Materials and Procedure

The materials, apparatus, and procedure were identical to those used in Experiment 1, with the exception that the current experiment did not utilize a filler task. Further, the current experiment included a manipulation where participants were randomly assigned to either a *features* or *general* instruction condition. In the features instruction condition, prior to the encoding phase, participants were presented with a definition of the CRE and then given instructions on how to reduce this bias (e.g., "When looking at African American faces, White learners tend to do better if they focus more on the mouth, and less on the hair and eyes"). In the general instruction condition, participants were also presented with a definition of the CRE but not given an explanation on how to avoid the bias (see the appendix).

Results

Recognition

A 2 (race [African American, White]) × 2 (instruction [feature, general]) mixed-groups ANOVA showed a main effect of race on hits, $F(1, 46) = 15.126, p < .001, \eta_p^2 = .25$, with more hits for White ($M = 10.38$, $SD = 1.77$) than

African American ($M = 8.81$, $SD = 2.54$) faces. Neither the main effect for instruction, $F(1, 46) = .838$, $p = .36$, nor the Race × Instruction interaction, $F(1, 46) < 1$, was significant.

There was a main effect for race on false alarms, $F(1, 46) = 19.33$, $p < .001$, $\eta_p^2 = .30$, such that participants committed more false alarms for African American ($M = 5.04$, $SD = 2.55$) than White ($M = 3.56$, $SD = 2.30$) faces, as well as a main effect of instruction, $F(1, 46) = 6.65$, $p = .013$ $\eta_p^2 = .13$, where participants committed more false alarms in the general ($M = 5.02$, $SD = 2.49$) relative to the feature condition ($M = 3.52$, $SD = 2.12$). The Race × Instruction interaction was not significant, $F(1, 46) < 1$.

To examine signal detection d', a 2 (race [African American, White]) × 2 (instruction [feature, general]) mixed-groups ANOVA showed a main effect of race, $F(1, 46) = 25.32$, $p < .001$, $\eta_p^2 = .36$, with more sensitivity for White ($M = 1.28$, $SD = .70$) than African American ($M = .69$, $SD = .65$) faces, providing evidence for a CRE. There was also a main effect of instruction, $F(1, 46) = 7.82$, $p < .01$, $\eta_p^2 = .15$, with more sensitivity for the feature ($M = 1.20$, $SD = .70$) than general condition ($M = .79$, $SD = .68$). The Race × Instruction interaction was not significant, $F(1, 46) < 1$. In regards to response bias, both main effects and the interaction between Race × Instruction were not significant, $Fs(1, 46) < 1$.

Percentage Dwell Time

There was a main effect of face region, $F(1, 94.8) = 112.97$, $p < .001$, with participants spending the most time examining the eyes, followed by the nose, mouth, and hair. There were also main effects of race, $F(1, 97.9) = 2.87$, $p = .09$, and instruction, $F(1, 94.8) = 3.28$, $p = .07$, which were qualified by significant two-way interactions of face region and race, $F(1, 176.1) = 56.76$, $p < .001$, and face region and instruction, $F(1, 94.8) = 9.66$, $p < .001$, as well as by the three-way interaction, $F(1, 115.1) = 5.88$, $p = .02$. For the eyes, the Race × Instruction interaction was significant ($b = -.056$, $SE = .02$, $p = .01$), indicating that the effect of race was larger in the feature (i.e., less dwell time on eyes for African American vs. White faces, $p = .002$) versus general condition (no difference in dwell time between African American and White faces, $p = .58$). For the hair, only the effect of race was significant ($b = -.014$, $SE = .0032$, $p < .001$), such that dwell time was shorter on African American versus White faces. Critically, for the mouth, the Race × Instruction interaction was significant ($b = .035$, $SE = .016$, $p = .03$), indicating that the effect of race was larger in the feature versus general condition (more dwell time on mouth for African American versus White faces ($p < .001$). Specifically, for African American faces, participants spent longer dwelling on the mouth in the feature relative to the general condition (27% vs. 19%). Although to a lesser extent, the same pattern was observed for White faces (20% vs. 15%). Therefore, instructing participants to attend to a facial feature associated with superior cross-race identification (the mouth) was effective for African American faces, in the sense that they spent longer looking at that feature in the feature relative to the general condition where no such instruction was given. No other effects were significant (see Figure 6).

First Fixation Time

There was a main effect of face region, $F(1, 84.9) = 5.65$, $p = .02$, where participants were fastest to

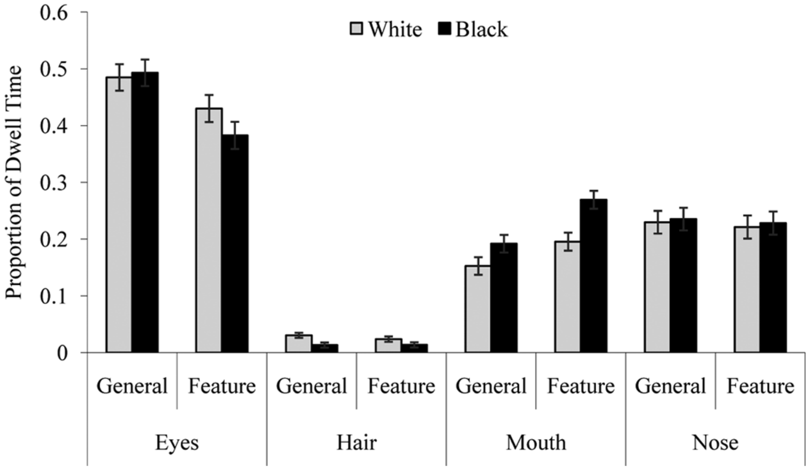

FIGURE 6 Proportion of dwell time as a function of facial feature (eyes, hair, mouth, and nose) for White and African American faces in the feature and general condition in Experiment 2. *Note*. Error bars indicate the standard error for each estimate.

fixate on the nose, followed by the eyes, mouth, and hair. There were also main effects of race, $F(1, 86.4) = 69.67$, $p < .001$, and instruction, $F(1, 84.9) = 3.96$, $p = .05$, which were qualified by significant two-way interactions of face region and race, $F(1, 170.7) = 19.96$, $p < .001$, and face region and instruction, $F(1, 84.9) = 7.74$, $p = .006$. The three-way interaction was not significant ($F < 1$). For the hair, the effect of race was significant ($b = 145.72$, $SE = 33.92$, $p < .001$), such that first fixation time was later on African American versus White faces. For the mouth, the effect of race was significant ($b = -772.37$, $SE = 54.34$, $p < .001$), such that first fixation time was earlier on African American versus White faces. The effect of instruction was also significant ($b = -210.65$, $SE = 96.49$, $p = .03$), indicating that first fixation time on the mouth occurred earlier in the feature versus general condition. Specifically, for African American faces, participants were faster to fixate on the mouth in the feature relative to the general condition (510.92 ms vs. 662.24 ms). The same pattern was also observed for White faces (1223.96 ms vs. 1493.94 ms). By instructing participants that White learners tend to do better and thus lessen the CRE when they focus more on the mouth of other-race African American faces, participants were faster to fixate to this critical diagnostic region in the feature relative to the general condition. For the nose, the effect of race was significant ($b = 529.80$, $SE = 53.54$, $p < .001$), such that first fixation time was later for African American versus White faces. Comparing the magnitude of the race effect across face regions indicates that the effect of race on first fixation time to the mouth was greater in magnitude than to the hair ($b = -626.65$, $SE = 64.06$, $p < .001$) and to the nose ($b = -242.57$, $SE = 76.28$, $p = .002$). The effect of race on first fixation time to the nose was greater in magnitude than to the hair ($b = -384.08$, $SE = 63.38$, $p < .001$). No other effects were significant (see Figure 7).

Accuracy

The analytic method was the same as in Experiment 1. Thus, the extent to which race (White or African American), instruction (general or feature), and eye movements (percentage dwell time or first fixation time) on different facial features (eyes, hair, mouth, nose) predicted the logit of the probability of correct identification was examined in a sample of 1,536 observations, which were nested within 32 trials and within 48 participants, in which trials and subjects were crossed. The cross-classified model included a random intercept for mean differences between trials, $-2\Delta LL(1) = 172.2$, $p < .001$, and a random intercept for mean differences between subjects, $-2\Delta LL(1) = 54.7$, $p < .001$.

Percentage dwell time. Overall, the grand mean of the logit of the probability of a correct identification was significant, $t(39.8) = 2.58$, $p = .01$, indicating that correct identifications were more likely to occur than incorrect identifications ($M_{probability} = .60$, $SE_{probability} = .04$).

For the eyes, there was an effect of dwell time for White faces in the feature condition ($b = -1.72$, $SE = .96$, $p = .05$), such that longer dwell time reduced the likelihood of correct identification. There was also a between-person effect of dwell time for African American faces in the feature condition ($b = -4.16$, $SE = 2.08$, $p = .04$), such that longer dwell time reduced the likelihood of correct identification. For the hair, there was a marginally significant Dwell Time × Instruction interaction, $F(1, 1467) = 2.99$, $p = .08$, indicating that the positive effect of dwell time in the general condition ($b = 4.38$, $SE = 1.79$, $p = .01$) was larger than the positive effect of dwell time in the feature condition ($b = .52$, $SE = .24$, $p = .03$). Thus, longer dwell time on the hair increased the likelihood of correct identification more

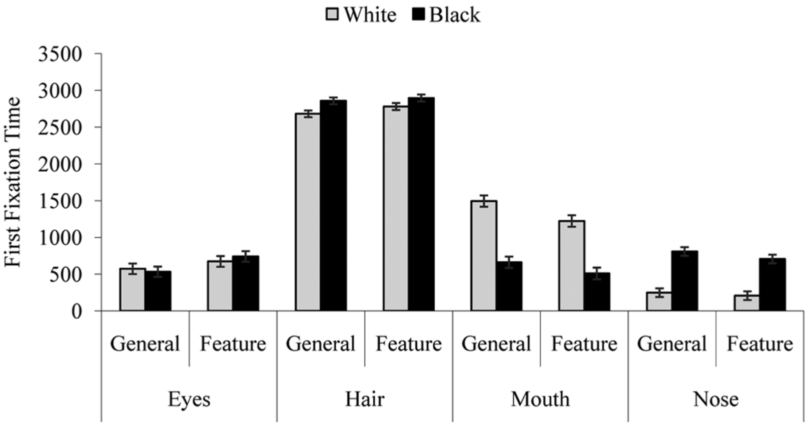

FIGURE 7 First fixation time as a function of facial feature (eyes, hair, mouth, and nose) for White and African American faces in the feature and general condition in Experiment 2. *Note*. Error bars indicate the standard error for each estimate.

so in the general than the feature condition. For the mouth, there was a marginally significant effect of dwell time for White faces in the general condition ($b = 1.45$, $SE = .83$, $p = .07$), such that longer dwell time increased the likelihood of correct identification. For the nose, there was a marginally significant between-person effect of dwell time for African American faces in both the general ($b = 3.81$, $SE = 2.02$, $p = .06$) and the feature ($b = 3.94$, $SE = 1.89$, $p = .04$) condition, such that longer dwell time increased the likelihood of correct identification. In sum, longer dwell time on the eyes of White faces decreased the likelihood of correct identification (see Figure 8).

First fixation time. Overall, the grand mean of the logit of the probability of a correct identification was significant, $t(44.9) = 2.96$, $p = .005$, indicating that correct identifications were more likely to occur than incorrect identifications ($M_{probability} = .62$, $SE_{probability} = .04$).

For the hair, there was an effect of first fixation time in the general condition for White faces ($b = -.0004$, $SE = .00021$, $p = .03$), such that later first fixation times reduced the likelihood of correct identification. For the nose, there was a marginally significant effect of first fixation time in the general condition for White faces ($b = -.00032$, $SE = .00018$, $p = .07$), such that later first fixation times reduced the likelihood of correct

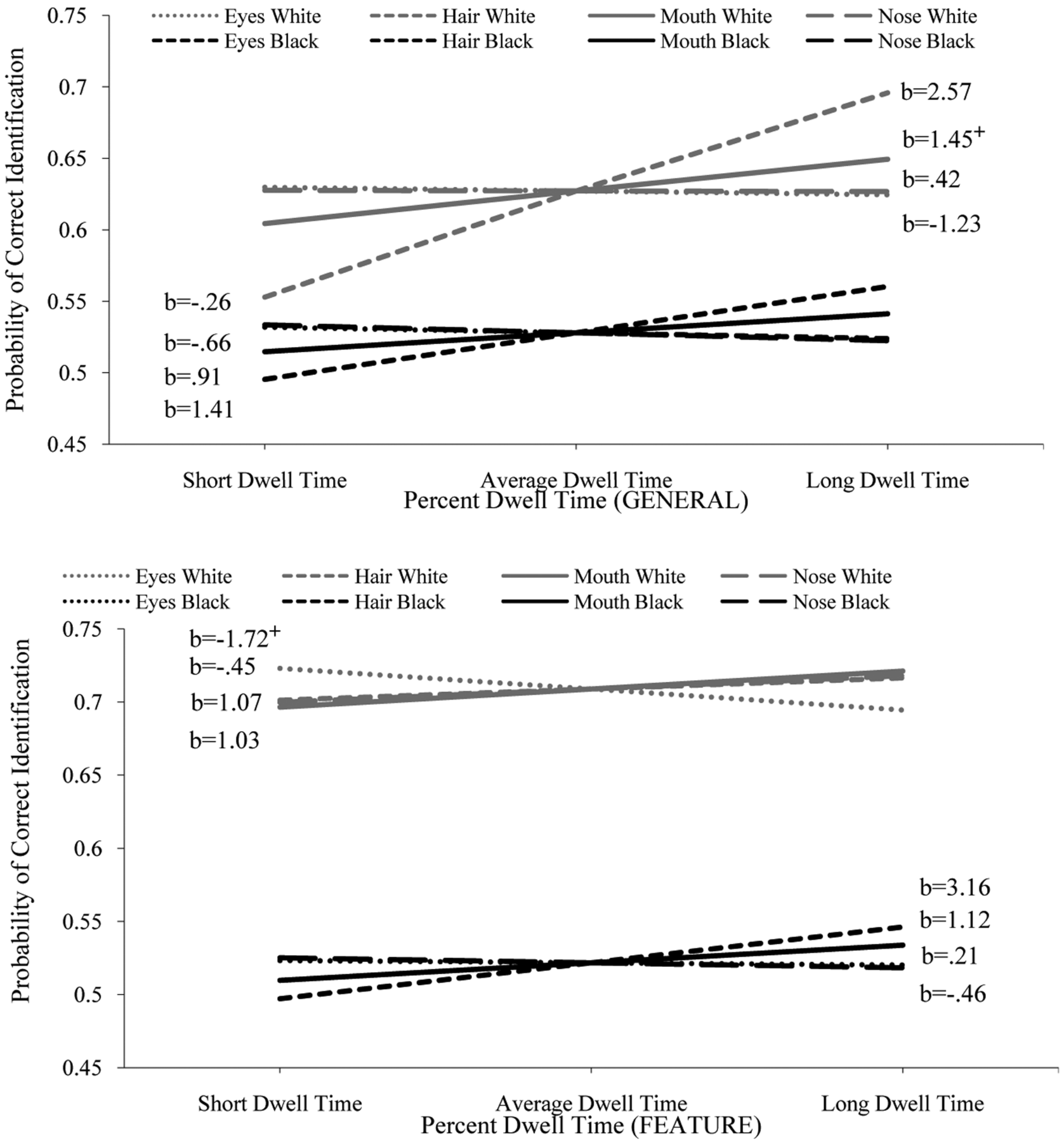

FIGURE 8 Correct identification (in logits) as a function of percentage time dwelling on each facial feature (eyes, hair, mouth, and nose) for White and African American faces for the general and feature condition in Experiment 2. *Note.* $^{+}$Marks a marginally significant effect ($p < .10$).

identification. For the mouth, there was a marginally significant First Fixation Time × Instruction interaction, $F(1, 1461) = 2.94$, $p = .08$, such that later fixation time reduced the likelihood of correct identification, the effect of which was larger in the general versus feature condition. There was also a significant within-person effect of first fixation time in the general condition for White faces ($b = -.0004$, $SE = .00013$, $p = .002$), such that later first fixation times reduced the likelihood of correct identification. There was also a nearly significant between-person effect of first fixation time in the general condition for White faces ($b = .0008$, $SE = .00039$, $p = .07$), such that later first fixation time increased the likelihood of correct identification. There was also a significant context effect of first fixation time in the general condition for White faces for the mouth ($b = -.0012$, $SE = .00045$, $p = .01$), indicating that the within- and between- person effects differed in magnitude. For the eyes, there were no effects of race, instruction, or first fixation time ($Fs < 1$). In sum, faster first fixation times on the eyes of White faces increased the likelihood of correct identification. Instructing participants to attend to specific facial features had little effect on top of their natural variability in gaze patterns (see Figure 9).

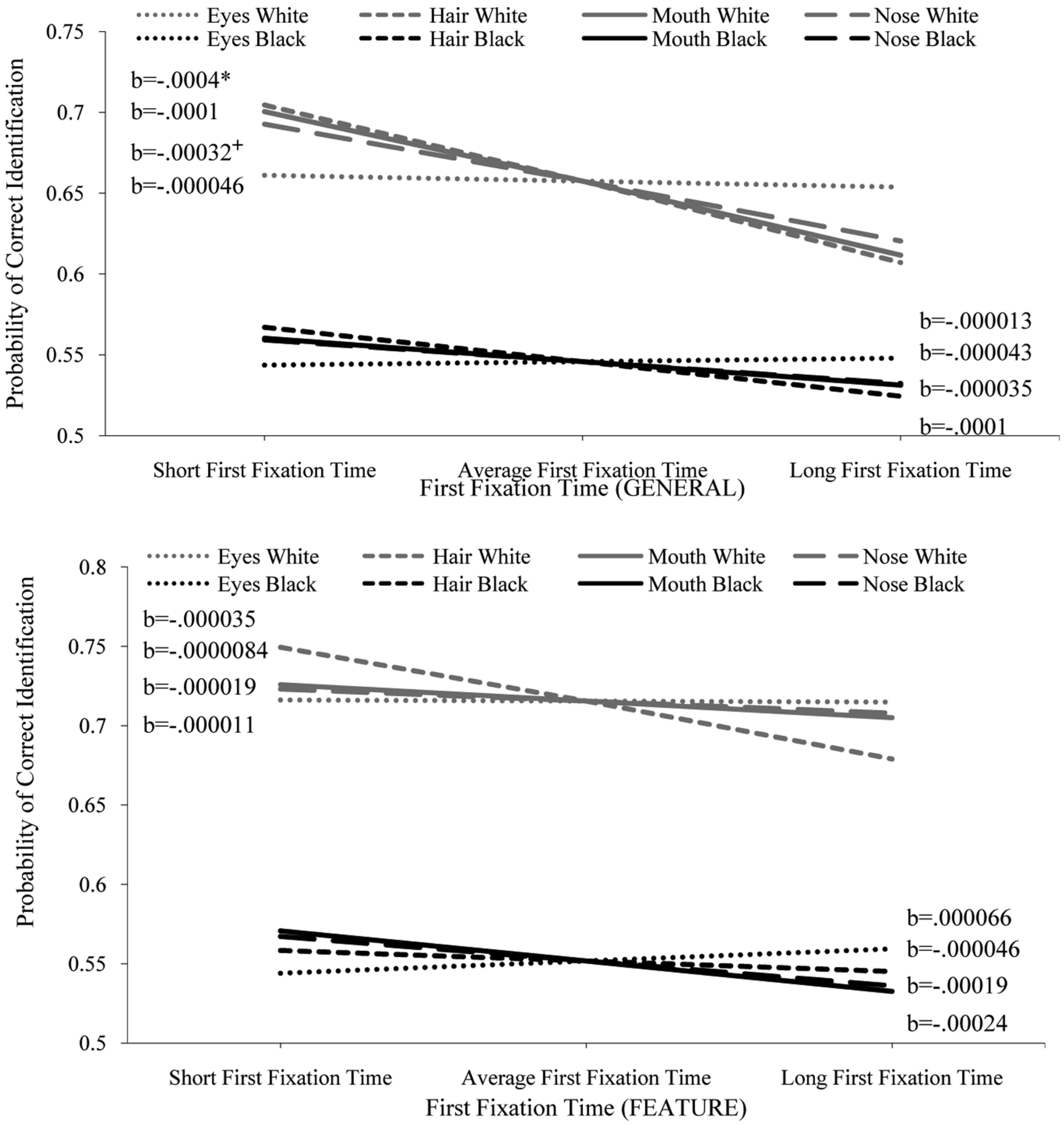

FIGURE 9 Correct identification (in logits) as a function of first fixation time on each facial feature (eyes, hair, mouth, and nose) for White and African American faces for the general and feature condition in Experiment 2. *Note*. $^+$Marks a marginally significant effect ($p < .10$). *Marks a statistically significant effect ($p < .05$).

Discussion

Similar to Experiment 1, a CRE was observed, where participants showed more sensitivity for White compared to African American faces. Furthermore, in support of the effectiveness of the instruction manipulation, participants' demonstrated greater sensitivity when responding to faces in the feature relative to the general condition. Of interest, the signal detection *d′* was significantly higher in Experiment 2 relative to Experiment 1. This was the case even when comparing Experiment 1 and the general condition of Experiment 2, where these conditions were identical with the exception that participants in the general condition were provided with a definition of the CRE and instructions to pay particularly close attention to other-race faces. It is possible then that the instructions of the general condition in Experiment 2 increased motivation and/or prompted participants with more effective cognitive strategies after they were alerted to the possibility of errors, and therefore increased sensitivity for identifying these faces.

In regards to eye movements, instructions to attend to the mouth of African American faces was successful, where participants spent longer dwelling on the mouth in the feature versus the general condition. Further, participants were faster to fixate on the mouth of African American compared to own-race White faces, and this pattern was exacerbated in the feature relative to the general condition. Although participants were more likely to attend to this diagnostic region in African American faces, improvements in accuracy were not observed.

GENERAL DISCUSSION

The general pattern of attention to facial features was consistent with previous research (Flowe, 2011; Henderson, Williams, & Falk, 2005; Nakabayashi et al., 2012): Participants looked longest at the eyes, followed by the nose, mouth, and hair. This makes sense, considering that the eyes are regarded as the "windows to the soul," are strongly involved in emotional displays, and children in Western societies are typically taught to look other individuals in the eye (cf. Fu et al., 2012).

However, as predicted, there were differences in how White participants processed own-race versus other-race faces. They spent longer looking at—and were faster to fixate on—the hair of White targets, whereas they spent longer, and were faster to fixate on, the mouths of African American targets. In terms of feature diagnosticity, this pattern makes sense. There is greater variability in hair color among Whites than among African Americans, so hair is potentially more useful for distinguishing among White individuals, whereas lower facial features might be more useful for distinguishing among African American faces (Ellis et al., 1975).

The findings are consistent with previous research supporting the importance of encoding processes in the CRE (e.g., Hugenberg et al., 2007; Meissner et al., 2005; Tullis et al., 2014). Part—though probably not all—of the difference in how individuals encode faces of different races lies in their differential attention to discrete facial features, such as selective attention to "Afrocentric" features when processing African American faces (Blair et al., 2004). The findings are also consistent with research showing that Whites attend to upper facial features when viewing own-race faces (Ellis et al., 1975; Goldinger et al., 2009; Nakabayashi et al., 2012). It is also possible that mouth characteristics (shape, size, etc.) vary more among African Americans than among Whites. Although we know of no anthropological data supporting such a possibility, Black Africans do report using lower facial features, such as the lips and mouth, when encoding other Black African faces (Ellis et al., 1975), suggesting that those features are particularly informative.

These differences in gaze patterns were also, to some extent, associated with differences in recognition performance. In Experiment 1, longer time spent dwelling on the hair for White faces resulted in more accurate recognition, whereas the reverse pattern was observed for African American faces. In terms of first fixation, later first fixations on the mouth reduced the likelihood of correct identification of African American faces.

By instructing participants to attend more to the mouth (and less to the hair and eyes) of African American faces in the feature condition of Experiment 2, fewer false alarms were observed compared to the general condition, where participants were simply informed of the CRE. Although the feature manipulation to direct eye movements toward the mouth region of African American faces was successful, eye movement patterns were inconsistent as they related to accuracy performance. The major finding from Experiment 2 was that faster fixation to the hair of White faces was associated with greater accuracy. Although the precise findings varied somewhat across the two experiments, the overall pattern showed that attending more to the upper facial features of own-race (White) faces, especially the hair, was associated with greater subsequent recognition accuracy (longer dwell time in Experiment 1, and faster first fixation time in Experiment 2), whereas attending more to the lower facial features of other-race (African American) faces was associated with greater accuracy (faster fixation to the mouth in Experiment 1). Thus, differential attention to facial features that vary in their diagnosticity has the potential to lead to better memory (Hills & Lewis, 2006). However, instructing participants to pay more attention to certain features does not improve performance above and beyond their natural variability in gaze patterns, suggesting that differences in gaze pattern might be associated with other cognitive processes (Wu et al., 2012).

Although face processing is largely automatic (Blair et al., 2004; Bruce, Burton, & Hancock, 2007), Experiment 2 showed that instructing participants to attend preferentially to a facial feature associated with superior cross-race identification was effective, in the sense that they spent longer looking at that feature. Although the feature instructions resulted in a comparable decrease in false alarms for White and African American faces—suggesting an overall criterion shift, rather than a selective shift depending on face race—this finding is consistent with the more general principle that instructions about the CRE given prior to encoding can moderate performance (Hugenberg et al., 2007; Young et al., 2010), at least under some conditions (for failures of instructions to moderate the CRE, see Bornstein et al., 2013; Tullis et al., 2014). Similar effects have been obtained by directing observers to more diagnostic features (Hills & Pake, 2013) or constraining the amount of a face that they can view (Caldara et al., 2010), which suggests that efforts to reduce or eliminate the CRE through training have the potential to be successful (Brigham, 2008). Indeed, Hills and Lewis (2006) found that training White participants to encode lower facial features reduced the CRE. Thus, feature-specific training offers considerable promise. It is important to note that differences were observed, particularly in the accuracy data, when comparing the results from Experiment 1 and those from the general condition in Experiment 2. For instance, in Experiment 1 less time spent looking at the mouths of White targets was associated with greater accuracy, whereas the opposite pattern was observed in Experiment 2. These conditions were primarily identical with the exception that participants in the general condition were provided with a definition of the CRE and instructed to pay close attention to other-race African American faces. It therefore appears then that instructing participants on the CRE significantly influences how individuals are using visual information.

Differences in viewing other-race versus own-race faces are observed in 3-month-olds, with preferential viewing of own-race faces increasing with age (Kelly et al., 2009). These differences are at least partially fueled by the required resources necessary to encode a relatively unfamiliar other-race versus own-race face (Wu et al., 2012), which may be especially prevalent in parts of the world with little racial diversity. It is unsurprising, then, that individuals from different racial/ethnic groups differentially attend to various portions of a face dependent upon the target face's race.

Limitations and Applications

There are two main limitations to the present study. First, participants were of only one race. Although it is not uncommon for CRE studies to include participants of only one race (e.g., Evans et al., 2009; Fu et al., 2012; Hills & Lewis, 2006; Nakabayashi et al., 2012; Tullis et al., 2014, Experiments 2 and 3; Wu et al., 2012), it is clearly desirable to replicate findings among members of multiple racial/ethnic groups. The findings on differences in facial processing as a function of race (both target and participant race) suggest that perceptual processes in viewing faces are not as simple as "White-versus-minority" or even "ingroup-versus-outgroup" (cf. Sporer, 2001) but vary in complex and subtle ways across various racial groups (Meissner & Brigham, 2001; O'Toole et al., 1994). Not only are the diagnostic facial features of different races important in how we process and subsequently try to recognize faces, but cultural norms can also dictate the way in which we attend to faces (Blais et al., 2008). For instance, Fu et al. (2012) determined that individuals of Chinese descent were more likely to fixate on the eyes of White relative to Chinese faces, possibly due to cultural norms of eye contact of in-group social members. Because African Americans and White Americans are, to a considerable extent, from the same culture, it is perhaps easier to generalize from a Whites-only sample making a White–African American comparison than it would be when comparing Whites to other racial or ethnic minorities. Nonetheless, the present findings should be replicated with an African American sample. It would also be of interest to utilize a Black African sample as culture affects gaze patterns when looking at faces, though it is important to note that the CRE occurs with both Africans and African Americans (e.g., Ellis et al., 1975).

A second limitation is that the present study employed a face recognition procedure, as opposed to a more naturalistic eyewitness situation. The former research paradigm typically involves a series of faces during the study phase, followed by an old–new recognition task, whereas the latter paradigm typically involves one individual performing an action during the study phase, followed by a lineup identification task (Penrod & Bornstein, 2007). The eyewitness literature generally shows that the effects of various factors are, if anything, stronger in studies using more naturalistic materials and procedures (Penrod & Bornstein, 2007), and the CRE is no exception. For example, Meissner and Brigham's (2001) meta-analysis found that the magnitude of the CRE was larger, in terms of hits, for studies using an identification paradigm than for studies using a face recognition paradigm; the effect sizes did not differ in terms of false alarms. Moreover, there is no reason why the perceptual processes observed here would differ whether one is viewing a single individual engaged in some activity versus a series of individuals shown in a stationary pose. Thus, it is unlikely that the present results are peculiar to any one particular research paradigm.

Perceptual mechanisms of face processing would be classified as estimator variables, in that the legal system cannot modify identification procedures to exploit them (Wells, 1978). Nonetheless, it is important to understand the role of estimator variables, for several reasons. First, they are useful for those who must assess eyewitness credibility, such as police, prosecutors, jurors, and judges; second, they can suggest strategies for training high-frequency witnesses (e.g., police, bank tellers, convenience and liquor store owners, etc.; Brigham, 2008); finally, they have implications for developing psychological theories of face processing (Bruce et al., 2007).

Conclusions

The present experiments demonstrated that when viewing faces, Whites attend to different features depending on whether the face is African American or White. Specifically, they attend more to the upper facial features (hair) of own-race faces but more to the lower facial features (mouth) of other-race faces. This natural tendency could be modified by instruction, but such instruction did little to improve recognition performance. These findings hold promise both for understanding the mechanisms that underlie the CRE and possibly for ameliorating it.

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APPENDIX: PARTICIPANT TASK INSTRUCTIONS

Experiment 1 Instructions

This experiment concerns your ability to memorize faces. During this phase of the experiment, you will be shown a series of photographs of individuals. You should look carefully at each photograph and try and remember as much as possible for a recognition test later.

Experiment 2 Instructions (italicized sentences were used only in the Feature condition)

This experiment concerns your ability to memorize faces. You will see a series of faces on the computer screen, some White, and some African American. Pay close attention to the faces, in order to recognize them later.

Previous research has shown that people reliably show what is known as the Cross-Race Effect (CRE) when learning faces. Basically, people tend to confuse faces that belong to other races. For example, a White learner will tend to mistake one African American face for another. *One reason for this is that we don't naturally pay attention to the facial features that will help us tell faces of other races apart. When looking at African American faces, White learners tend to do better if they focus more on the mouth, and less on the hair and eyes.* Now that you know this, we would like you to try especially hard when learning faces in this task that happen to be of a different race. Do your best to try to pay close attention to what differentiates one particular face from another face of the same race, especially when that face is not of the same-race as you.

Remember, pay very close attention to the faces, especially when they are of a different race than you in order to try to avoid this CRE. *For African American faces pay particular attention to the mouth; but notice other facial features as well.*