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The effects of skin tone on race-related amygdala activity: an fMRI investigation

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Previous work has shown differential amygdala response to African-American faces by Caucasian individuals. Furthermore, behavioral studies have demonstrated the existence of skin tone bias, the tendency to prefer light skin to dark skin. In the present study, we used functional magnetic resonance imaging (fMRI) to investigate whether skin tone bias moderates differential race-related amygdala activity. Eleven White participants viewed photographs of unfamiliar Black and White faces with varied skin tone (light, dark). Replicating past research, greater amygdala activity was observed for Black faces than White faces. Furthermore, dark-skinned targets elicited more amygdala activity than light-skinned targets. However, these results were qualified by a significant interaction between race and skin tone, such that amygdala activity was observed at equivalent levels for light- and dark-skinned Black targets, but dark-skinned White targets elicited greater amygdala activity than light-skinned White targets.

Keywords: skin tone bias; functional magnetic resonance imaging; amygdala

Scholars have argued that overt racial bias in the United States has declined due to the formation of egalitarian social norms (McConahay, 1986; Sears, 1988). However, an abundance of research also suggests that implicit racial bias persists (Bargh and Chen, 1997; Devine, 1989; Fazio *et al.*, 1995; Greenwald *et al.*, 1998). Such studies have consistently shown that negative, automatic evaluations of racial outgroup members are elicited on indirect measures of racial bias despite explicit, self-reported nonprejudiced attitudes.

Recently, social neuroscience researchers have used functional magnetic resonance imaging (fMRI) to explore the neural correlates of race evaluation (for a review, see Eberhardt, 2005). The primary focus has been on differential activity within the amygdala, a subcortical structure that reflects arousal triggered by fast unconscious assessment of potential threat elicited by sensory, social and emotional stimuli (Adolphs *et al.*, 1994). Numerous fMRI studies have demonstrated greater amygdala response to African-American faces than Caucasian-American faces (Phelps *et al.*, 2000; Cunningham *et al.*, 2004; Lieberman *et al.*, 2005; for a review, see Eberhardt, 2005). For instance, among Caucasians, Phelps *et al.* (2000) found significantly different blood oxygen-level-dependent (BOLD) response in the amygdala to photos of racial out-group *vs* in-group faces, suggesting that amygdala responses to human faces are affected by the perceived race of the stimulus face and that of the subject. Interestingly, these effects occurred even when face stimuli were presented so briefly that conscious awareness of the content of the stimuli was not possible (Cunningham *et al.*, 2004). Furthermore, Phelps *et al.* (2000) demonstrated that Caucasian participants showed stronger amygdala activation to Black *vs* White faces, and the strength of this activation was correlated with implicit, but not explicit, measures of racial bias. In sum, these studies suggest that amygdala activity indexes early neural assessment of potential threat associated with unfamiliar members of a racial out-group.

Recent research has challenged the idea that race-related amygdala activity might not result from the novelty of out-group faces, but rather from cultural learning (Lieberman *et al.*, 2005). In one study, it was demonstrated that *both* Caucasian-American and African-American participants showed greater amygdala response to African-American targets than Caucasian-American targets. This study suggests that race-related amygdala activity may result from sensitivity to cultural learning.

Although perceivers may use many social cues for racial categorization, skin tone is one of the most salient race-related phenotypic features used in social perception (Maddox, 2004). Indeed, distinguishing others' racial category according to phenotypic facial characteristics appears to occur spontaneously and to meaningfully affect interpersonal thoughts, feelings and behavior (Brigham, 1971; Fiske, 1998; Hamilton, 1981).

One theory of racial bias states that White Eurocentric phenotypic characteristics (e.g. lighter skin and eye color, longer and straighter hair, narrower nose and thinner lips) are preferable to features toward the opposite end of the

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continuum (e.g. darker skin, kinkier hair, broader nose and fuller lips; Maddox, 2004). Although a great deal of past research has focused on between-group racial bias (e.g. Caucasian *vs* African-American), there has been a recent shift in attention to within-race differentiation and its social consequences. For example, Maddox and colleagues (Maddox and Gray, 2002; Maddox and Chase, 2004; Maddox, 2004) examined the role of skin tone in cognitive representations of African-Americans. These studies were based on the assumption that skin tone plays an important role in determining racial category membership, thus influencing social perception of individual category members. Maddox and Gray (2002) demonstrated that variation in skin tone can influence both Caucasian and African-American perceivers to rate African-American targets more or less favorably; that is, light-skinned targets were preferred to dark-skinned ones. Moreover, there were differences in perceived cultural stereotypes of African-Americans based on skin tone by both African-American and Caucasian individuals. Results from these studies suggest the existence of skin tone bias, the tendency to perceive or behave differently toward members of a racial category based on the lightness or darkness of their skin.

In the present research, we furthered this past work by investigating whether skin tone would moderate differential amygdala activation to Black faces *vs* White faces. Eleven White participants were exposed to photos of light- and dark-skinned Black and White targets while measuring BOLD response within the amygdala. Consistent with past research, it was hypothesized that participants would show stronger amygdala activation when exposed to Black faces than White faces. It was further expected that dark skin would elicit higher activity in the amygdala than light skin. An important further question we hoped to address was the extent to which skin tone would moderate amygdala activity *within* the racial group of the target (i.e. Black *vs* White targets). Such moderation would be reflected in an interaction between race and skin tone.

METHOD

Participants

A total of 11 Caucasian-American males (ages 18–36 years) volunteered to participate in the study. All participants were right-handed and had normal or corrected-to-normal vision.

Materials

The experimental stimuli were a subset of five male White faces and five male Black faces identical to those used in Maddox (1998) with neutral expression that varied in skin tone (dark *vs* light) and matched across conditions using Photoshop 8.0 (Adobe Systems, Inc; Figure 1). Also, to serve as control stimuli, each face was Fourier-transformed into a scrambled image with the same amplitude but random phase spectrum. Stimuli were presented using MATLAB and projected onto a high-resolution screen at the base of the MRI bore, and were visible indirectly to participants through mirrors.

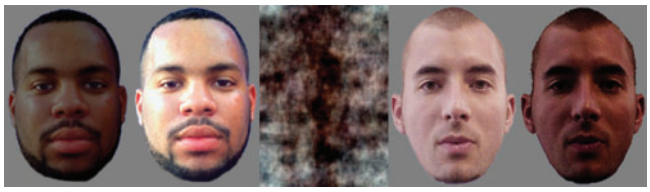

Fig. 1 Example of experimental stimuli presented to participants during the functional scan (i.e. dark-skinned Black face, light-skinned Black face, control image, light-skinned White face, dark-skinned White face).

Design and procedure

All participants passed MRI safety screening prior to the experimental procedure and provided written informed consent. The experiment consisted of a 2 (Race: Black *vs* White) × 2 (Skin Tone: Dark *vs* Light) within-subjects block design. In a single run, each participant completed four blocks of each condition in random order (i.e. light-skinned White faces, dark-skinned White faces, light-skinned Black faces, and dark-skinned Black faces) as well as the corresponding four blocks of the nonface control stimuli, counterbalanced across participants. Each face and each control stimulus was presented for 1 s, followed by a fixation point for 2 s; thus, each block consisted of five stimulus presentations and lasted 15 s, resulting in a total functional scan time of 8 min. During the functional scan, participants were instructed to view face and nonface stimuli and press one of two keys on a keypad to indicate their response to each stimulus presented on the screen, depending on the task. For the face stimuli, participants were to engage in a social categorization task identical to Wheeler and Fiske (2005) wherein they were asked to determine if the person was older or younger than 24 years of age. For the nonface control stimuli, participants were asked to determine whether a recognizable object was visible in the abstract image.

Scanning

A Siemens 3T Magnetom MRI scanner at the USC Dana and David Dornsife Cognitive Neuroimaging Center was used for brain image acquisition. Initially, a localizer scan (22 s) was conducted to identify our a priori anatomical region of interest (i.e. the amygdala). Three-dimensional (3D) structural images as well as a T1-weighted anatomical image were acquired in addition to the functional images. The 3D structural image consisted of 192 contiguous slices (slice thickness = 1 mm, field of view = 256 mm, TR = 2070 ms, TE = 4.14 ms). The T1-weighted anatomical images consisted of 10 contiguous slices in the functional scan (slice thickness = 3.5 mm, FOV = 256 mm, TR = 580 ms, TE = 17 ms). Slice selection covered areas from the superior frontal gyrus, below the superior temporal gyrus, to the

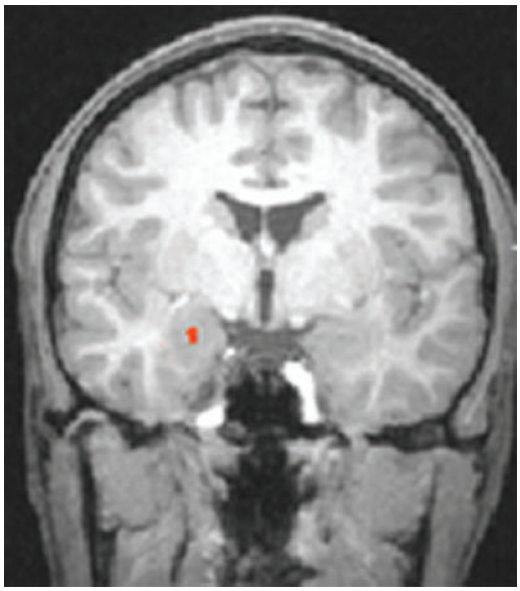

Fig. 2 Region of the right amygdala (centered on 24, −5, −15, with a 5 mm diameter) that was more active during the presentation of dark-skinned and light-skinned Black faces and dark-skinned White faces relative to light-skinned White faces.

lateral occipital gyrus. Centered on the amygdala in an oblique orientation, functional images were acquired using echo-planar (EPI) pulse sequence (slice thickness = 3.5 mm, FOV = 22 mm, TE = 34 ms, TR = 1500 ms). Prior to beginning the functional scan, we visually inspected a dummy echo-planar image scan (8 s) to ensure the quality of the functional data.

RESULTS

Prior to conducting statistical analyses, all data were preprocessed using BrainVoyager QX (Brain Innovation, B.V.). Data were motion corrected, temporally filtered to correct for slice acquisition time, and smoothed with a Gaussian spatial filter. Subsequently, functional data were co-registered to in-plane anatomical images and transformed to standard stereotaxic Talairach space (Talairach & Tournoux, 1988). This pre-processed data was used in the final analyses.

Our primary analytical strategy was a region-of-interest (ROI) analysis of the left and right amygdala to test our hypotheses. Although both the left and right amygdalae were inspected for significant voxels, only the right amygdala showed significant activity (Figure 2). We used a random effects general linear model (GLM) series of planned contrasts as our statistical method, using participant as the random factor. To reduce the possibility of Type I error due to multiple comparisons, an anatomic mask was created to analyze only voxels within this a priori region of interest (Talairach coordinates centered at 24, −5, −15, within a 5 mm diameter). For the planned contrast weights presented subsequently, we use the following order for reference: light-skinned White faces, dark-skinned White faces, light-skinned Black faces, dark-skinned Black faces.

First, we demonstrated that the control stimuli would not significantly predict amygdala activity within each of the critical contrasts (e.g. light-skinned White scrambled *vs* dark-skinned Black scrambled). As expected, none of the contrasts predicted amygdala activity. Next, we replicated prior findings showing a main effect of race, wherein greater amygdala activity was observed for Black faces than White faces, (−1, −1, 1, 1), $t\,(10) = 3.084$, $P = 0.012$ (118 voxels, Talairach coordinates 24, −1, −14). Subsequently, we tested for a main effect of skin tone (−1, 1, −1, 1); findings indicated greater amygdala activity for dark-skinned faces than light-skinned faces, $t\,(10) = 2.95$, $P = 0.015$ (51 voxels, Talairach coordinates 26, −1, −17). A significant race × skin tone interaction also emerged, $t\,(10) = 2.50$, $P = 0.031$, (58 voxels, Talairach coordinates 24, −3, −16) indicating that the effect of skin tone differed by race of target. To examine the nature of this interaction, we conducted paired comparisons where each of the simple cells (White light, White dark, Black light, Black dark) was compared with control (a combination of all scrambled images). Importantly, amygdala activity for these paired comparisons was observed in the same cluster of voxels as the interaction (Talairach coordinates 24, −3, −16). While no significant voxels were observed for light-skinned White faces compared with control, $t\,(10) = 0.63$, ns, significant voxels were observed for all other race-skin tone pairs. Both dark-skinned and light-skinned Black faces elicited significant amygdala activity $t\,(10) = 2.36$, $P < 0.05$ (163 voxels) and $t\,(10) = 2.61$, $P < 0.03$ (174 voxels), respectively. Interestingly, there was also significant amygdala activity in response to dark-skinned White faces, $t\,(10) = 2.30$, $P < 0.03$ (70 voxels). Thus, amygdala activity was observed at approximately equivalent levels for light- and dark-skinned Black targets, but dark-skinned White targets elicited greater amygdala activity than light-skinned White targets. Figure 3 presents mean percent signal change in BOLD activity within the right amygdala for these critical contrasts.

Finally, a series of paired sample *t*-tests were conducted to determine whether there were any significant differences in mean percent signal change between each of the simple cells. Analyses indicated that while White light differed significantly from all other conditions, no significant differences existed between White dark, Black light, and Black dark (Table 1). We also conducted an exploratory whole brain analysis on areas covered by our slice selection in order to identify other brain regions that were affected by our experimental manipulations. A summary of these analyses is found in Table 2.

DISCUSSION

A number of studies now demonstrate that (at least among White perceivers) viewing Black faces results in higher amygdala activity relative to viewing White faces (for a

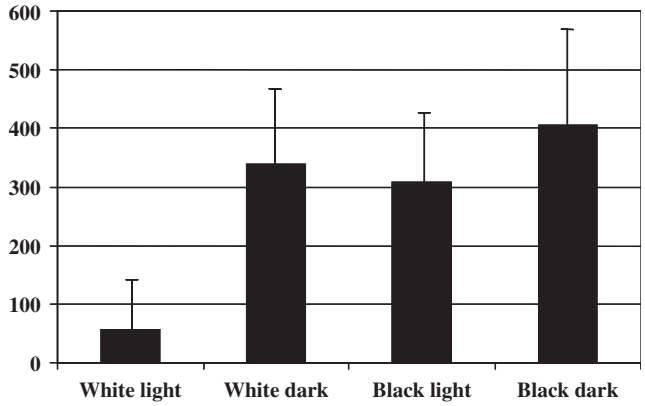

Fig. 3 A graphical representation of the interaction between race and skin tone. Bars represent right amygdala activity (mean percent signal change) where each of the simple cells (White light, White dark, Black light, Black dark) is greater than control (A combination of all scrambled faces) at Talairach coordinates 24, −3, −16. Error bars represent standard error of the mean.

Table 1 Follow-up analyses to race × skin tone interaction

Race-skin tone pair	Mean difference	Standard error of mean	t(10)
White light–White dark	2.83*	0.987	−2.87
White light–Black light	2.53*	0.873	−2.90
White light–Black dark	5.19*	1.57	−2.24
White dark–Black light	0.297	0.171	1.74
White dark–Black dark	0.671	0.654	−1.03
Black light–Black dark	0.967	0.739	−1.31

Note: *indicates $P < 0.05$.

Table 2 Other brain activations

Region	t(10)	Talairach coordinates			Number of voxels
Dark > Light					
Fusiform gyrus	3.463	−27	−59	−8	186
Lentiform nucleus	3.106	−20	−1	−6	44
Midbrain	3.028	10	−15	−15	111
Light > Dark					
Anterior cingulate	3.97	6	20	−4	97
Black > White					
Claustrum	3.396	−25	18	−5	74
Culmen	5.133	−29	−33	−25	64
Fusiform gyrus	5.069	33	−42	−15	99
Inferior Frontal gyrus	3.317	48	22	9	66
Insula	6.340	−28	19	−3	189
Lentiform nucleus	4.449	11	2	−4	26
Middle temporal gyrus	4.186	55	−13	−16	143
Parahippocampal gyrus	3.670	−29	−13	−20	41
White > Black					
N/A	N/A	N/A			N/A
Interaction [(Black dark–Black light) > (White dark–White light)]					
N/A	N/A	N/A			N/A
Interaction [(White dark–White light) > (Black dark–Black light)]					
Inferior frontal gyrus	4.187	−47	13	−5	71
Midbrain	4.866	13	−27	−12	83
Middle temporal gyrus	3.702	52	−36	−5	110
Parahippocampal gyrus	4.476	21	−30	−13	68
Superior temporal gyrus	3.945	51	−6	3	21

Note: Threshold at $P < 0.01$, 20 voxel extent. Slice selection was centered in an oblique position, covering areas from the superior frontal gyrus, below the superior temporal gyrus, to the lateral occipital gyrus. Anatomical regions were mapped to Talairach coordinates using http://ric.uthscsa.edu/projects/talairachdaemon.html (Lancaster *et al.*, 1997).

review, see Eberhardt, 2005). Our study replicates this finding; however, the novel aspects of our data concern the role of skin tone on race-related amygdala activity. Indeed, this study is the first to show that skin tone affects amygdala activation. Past behavioral research has shown that light skin is preferred to dark skin [Maddox and Gray, 2002; see Maddox (2004) for a review]. Our findings add to these results and indicate that skin tone also affects amygdala activation, with darker skin leading to higher levels of amygdala activation. This is consistent with past behavioral research showing that as skin tone moves away from the White Eurocentric norm, negative outcomes increase (Maddox, 2004). Disconcertingly, to the extent that Afrocentric features increase the likelihood of making stereotypic inferences, this may result in severe consequences for those possessing high levels of Afrocentric features. For instance, it has been shown that African-American and Caucasian-American criminals with more Afrocentic features were given harsher prison sentences than those with less Afrocentric features (Blair *et al.*, 2004a; Eberhardt *et al.*, 2006). Termed racial phenotypicality bias, individuals with facial features that are highly typical of a particular racial category are more likely to be viewed through the lens of category-specific beliefs and evaluations (Maddox, 2004).

Although our study did not include any direct measures of evaluation, the findings may help shed light on the neural mechanisms underlying this bias. Blair *et al.*, (2002) provided evidence that individuals with more Afrocentric features—be they African Americans or Caucasian Americans—were evaluated in a manner consistent with the (predominantly negative) African-American stereotype. Similarly, Livingston and Brewer (2002) found more negative, automatic responses to faces of Blacks that were highly prototypical of the category compared with faces that were less prototypical. These findings suggest that individuals may be judged based on the extent to which they manifest a group's phenotypic features, and that this process is mediated in part by affective responses to phenotypic features. Our findings support (albeit indirectly) this prior work by showing that the amygdala is sensitive to variation in racial phenotypic features (i.e. skin tone). Thus, automatic responses to racial phenotypic features may be primarily affective in nature, as the amygdala is a primitive affect-processing brain structure. However, our results do not rule out the possibility that semantic information associated with racial categories may also play a role in judgments (Blair *et al.*, 2002; Maddox and Gray, 2002).

Interestingly, our results indicated that the strongest skin tone effects occurred for White targets. That is, White perceivers showed amygdala activity for dark-skinned White targets but not light-skinned White targets. On the other hand, dark-skinned Black targets did not elicit significantly higher levels of amygdala activity than the light-skinned Black targets. This pattern may have occurred because, in general, Black targets may have other Afrocentric features in common that minimize the relative importance of skin tone. Alternatively, viewing a White target with a single salient feature that is common among African-Americans (i.e. dark skin) produces amygdala activity even among members of the same racial group. This pattern of results supports the finding that individuals may evaluate members of their *own* racial group through the lens of another group's racial stereotype if the target possesses physical features typical of that group (Blair *et al.*, 2002; 2004b). This reasoning would also suggest that darker skin tone among Black targets might elicit greater amygdala response if there is also greater variation on other features that influence judgments of racial category membership.

Recent work by Blair *et al.* (2004b) showed that individuals are largely unaware of using Afrocentric features to make stereotypic inferences and do so unavoidably. Given that activation of the amygdala has been shown to correlate with implicit negative racial attitudes (Cunningham *et al.*, 2004), our study also provides indirect support for the automaticity of feature-based stereotyping. However, as mentioned earlier, our study does not discount the possibility of category-based stereotyping (i.e. judgments guided by semantic associations with racial categories). Future work might examine the extent to which amygdala activity varies as a function of category-based associations *vs* feature-based associations.

Our findings also have implications for the role of cultural learning in the automaticity of affective responses to racial phenotypes. An abundance of cross-cultural and developmental research suggests that negative associations coincide with dark skin while positive connotations coincide with light skin among children and adults in the United States, Europe and Asia (as cited in Maddox, 2004). For example, Clark and Clark (1958) found that African-American and Caucasian-American children preferred light-skinned dolls to dark-skinned dolls, indicating a cultural preference for light skin in general. Recently, Lieberman *et al.*, (2005) demonstrated that the amygdala may be sensitive to cultural learning, as both African-American and Caucasian-American perceivers showed greater amygdala activity to Black faces than White faces. Although the present study only included Caucasian-American perceivers, future studies might also include African-American participants in order to further explore the relationship between race and skin tone. Nonetheless, our findings provide converging evidence that the amygdala may be responsive to cultural knowledge.

In sum, our findings suggest that the use of race-related phenotypic features (such as skin tone) is a key component to furthering our understanding of the neural mechanism underlying social perception and its consequences. Our data suggest that Afrocentric features may be enough to produce an automatic, negative affective response toward individuals possessing this phenotype, regardless of their racial category.

Conflict of Interest

None declared.

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