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Neural perspectives on the other-race effect

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Psychological studies have long shown that human memory is superior for faces of our own-race than for faces of other-races. In this paper, we review neural studies of own- versus other-race face processing. These studies divide naturally into those focused on socioaffective aspects of the other-race effect and those directed at high-level visual processing differences. The socioaffective studies consider how subconscious bias and emotional responses affect brain areas such as the amygdala, anterior cingulate cortex, and parahippocampal gyrus. The visual studies focus on face-selective areas in the ventral stream, such as the fusiform face area (FFA). In both cases, factors such as experience, familiarity, social/emotional responses, cultural learning, and bias modulate the patterns of neural activity elicited in response to own- and other-race faces.

Keywords: Face; Other-race effect; Neural.

Over the last four decades, there have been hundreds of papers examining perceptual and memory components of the other-race effect with experimental behavioural approaches. This work began with the classic study of Malpass and Kravitz (1969). In perceptual terms, the other-race effect can be summed up with the adage, “They all look alike to me.” More formally, the phenomenon is characterized by a difficulty in differentiating among other-race faces, and thereby in perceiving the *uniqueness* of individual other-race faces. These perceptual problems give rise to difficulties in remembering individuals of other races. At the heart of these effects is one’s *experience* with people of other races. Social diversity (or lack thereof) sculpts face recognition capacity and ties perceptual and cognitive components of the effect to social and affective elements of face processing (Nelson, 2003; Quinn, Yarr, Kuhn, Slater, & Pascalis, 2002).

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The purpose of the present paper is to consider the neural foundations of the other-race effect. In the context of the 40 years or more of psychological study of the topic, this perspective represents a relatively new approach. Indeed, when Malpass and Kravitz (1969) first reported evidence for the other-race effect, almost nothing was known about the neural processing of faces. Although neuropsychological case reports of prosopagnosia offered hints about the organization of face processing centres in the brain, few tools were available for more detailed study of unimpaired individuals. In 1969, functional neuroimaging methods such as positron emission tomography (PET) were not used for research, and functional magnetic resonance imaging (fMRI) had not yet been invented. These tools have been used widely in the last two decades to examine the complex neural network that underlies human face processing. The neural correlates of own- and other-race face processing make up a small, but expanding, part of this literature.

This review is organized as follows. The first section leads off with a brief introduction to the neural architecture of cortical regions that are functionally selective for faces. Next, we will review what is known about the neural correlates of own- and other-race face processing. The papers we consider can be divided into those focused on the neural processing of socioaffective responses to own- versus other-race faces and those concerned with visual processing differences. Throughout the paper, we emphasize the findings for understanding the challenges of creating representations that are shaped by experience with faces. Although the role of experience in the other-race effect for humans has been controversial, an understanding of the diversity of neural embodiments of experience may help to bridge theoretical gaps that are left open with behavioural approaches.

SYNOPSIS OF THE FACE PROCESSING SYSTEM

The neural architecture of the face processing system includes multiple regions in ventral temporal and superior temporal cortex that are “functionally selective” for faces. This selectivity is operationalized typically in functional neuroimaging experiments as a contrast between the strength of neural activity elicited in response to faces versus objects. There are three well-established face-selective areas in high-level visual cortex. The fusiform face area (FFA) is a small area on the lateral fusiform gyrus in the inferotemporal cortex (Hoffman & Haxby, 2000; Kanwisher, McDermott, & Chun, 1997; McCarthy, Puce, Gore, & Allison, 1997). The occipital face area (OFA) is in the occipital gyrus and likewise responds more vigorously to faces than to objects¹

¹ Haxby, Hoffman, and Gobbini (2000) use the anatomical terms for these areas (i.e., inferior fusiform and occipital gyri). Here, we use the functional terms FFA and OFA.

(Halgren et al., 1999). Although some reports indicate that the FFA and OFA are localized more consistently in the right rather than left hemisphere, both of these areas are found bilaterally in many participants. The FFA and OFA are considered high-level visual regions in the *ventral* visual stream (DeYoe & Van Essen, 1988).

We digress briefly to note that although the face-selective properties of the FFA are well established, the exact nature of the specialized functions carried out by the FFA has been controversial (Gauthier, Tarr, Anderson, Skudlarski, & Gore, 1999; Grill-Spector, Knouf, & Kanwisher, 2004; Haxby et al., 2001; Kanwisher et al., 1997). The elements of this controversy reference a literature that is beyond the scope of this review, and so we simply state the three prominent perspectives. Kanwisher et al. (1997) originally posited the FFA as a modular face-specific processor. Haxby et al. (2001) argued for a representation of faces that includes the lateral fusiform gyrus, but is distributed more broadly across ventral temporal cortex. Gauthier et al. (1999) proposed that FFA is an area specialized for processing within-category object distinctions characteristic of expert processing. Despite the differences in perspectives, there is general agreement that the FFA is critical for processing facial identity from invariant feature- and structure-based information in the face. Moreover, a more detailed understanding of the function(s) of FFA is continually emerging in the literature as research techniques improve and as more data emerge on other brain structures important for face processing.

The role of OFA has been less controversial, with a recent review pointing to its role as a first stage processor for faces (Pitcher, Walsh, & Duchaine, 2011). This view is consistent with its responsiveness to face parts, including eyes, nose, and mouth (Pitcher, Walsh, Yovel, & Duchaine, 2007). Recent studies using transcranial magnetic stimulation (TMS) have indicated that OFA is critical for accurate face perception and that it plays its role at an early stage of processing (Pitcher et al., 2007).

In addition to the ventral temporal regions, an area in the posterior superior temporal sulcus (pSTS) responds strongly to facial movements, including expression, gaze, and facial speech (cf. Allison, Puce, & McCarthy, 2000; Hoffman & Haxby, 2000). This area is in the *dorsal* visual stream (DeYoe & Van Essen, 1988) and responds most consistently to moving faces (Fox, Iaria, & Barton, 2009; Pitcher, Dilks, Saxe, Triantafyllou, & Kanwisher, 2011).

An influential and now well-established neural framework for processing faces was proposed by Haxby et al. (2000). They posited a distributed neural network with two main subdivisions or “cores”, specialized to process the invariant and changeable aspects of faces, respectively. The former division includes the FFA and OFA in the ventral stream. These regions are thought to support the identification and categorization of faces. The latter division

comprises face-selective regions in the pSTS in the dorsal visual stream and supports social communication functions through the analysis of facial motions (e.g., expression, gaze, facial speech).

In the Haxby et al. (2000) model, the core regions project to an extended system of other brain structures that utilize the results of the analysis. The FFA-OFA core projects to anterior temporal regions involved in coding personal identity, name, and biographical information. From the pSTS, the extended system includes connections to the intraparietal sulcus for spatially directed attention (e.g., from gaze), the auditory cortex for the processing of facial speech, and the amygdala, insula, and limbic system for the processing of emotional information from facial expressions.

The Haxby et al. (2000) system has been refined further to consider representations of familiar people (Gobbini & Haxby, 2007). Familiar person codes include semantic, episodic, and emotional associations with faces. Gobbini and Haxby (2007) also consider personal trait knowledge, mental state knowledge, and the assessment of intention as “theory of mind” processing. Although somewhat beyond the scope of the present paper, we sketch out very briefly the elements of the model as they may relate to the neural areas that activate in response to socioaffective components of own- and other race face processing.

According to the Gobbini and Haxby (2007) model, mental state evaluation is attributed to the anterior paracingulate cortex. Consistent with what is known about the neural areas involved in social cognition (cf. Allison et al., 2000; Haxby et al., 2000), intent judgements are assigned to pSTS and the temporal parietal junction (TPJ). The retrieval of biographical knowledge and related semantic knowledge activates areas in the anterior temporal cortex. Episodic memory retrieval is attributed to the precuneus and posterior cingulate areas. The emotional component of the extended face system is consistent with the model of Haxby et al. (2000) and includes the amygdala, insula, and the striatum (Gobbini & Haxby, 2007).

In neural studies of own- and other-race face processing, we will see that the focus is on the ventral core system for the visual studies and on the extended dorsal system (the amygdala, in particular) for the socioaffective studies.

NEURAL BASIS OF OWN- AND OTHER-RACE FACE PROCESSING

The architecture of the face processing system suggests a relatively stark division between the analysis of identity and the analysis of social/emotional information in the face. Neural studies of the other-race effect are likewise divided along these lines. We begin with fMRI studies of socioaffective

TABLE 1
Summary of fMRI studies of socio-affective processing differences for own- versus other-race faces

<i>Study</i>	<i>Task</i>	<i>Neural areas</i>	<i>Direction of neural activation (own vs. other race faces)</i>	<i>MVPA analysis—classifying own- vs. other-race faces</i>
1. Hart et al. (2000)	gender categorization	amygdala	no difference in activation	—
2. Phelps et al. (2000) (tested only Caucasians, used familiar–unfamiliar faces)	one-back task	amygdala	other > own (only for unfamiliar faces)	—
3. Cunningham et al. (2004) (tested Caucasians)	judge whether stimulus appears to the left or right of fixation	amygdala superior frontal gyrus superior temporal cortex anterior cingulate	—faces presented for 30 ms: other > own	—
		dorsolateral prefrontal cortex (DLPFC)	—faces presented for 525 ms: other > own	—
4. Lieberman, Hariri, Jarcho, Eisenberger, and Bookheimer (2005)	perceptual and verbal encoding tasks	DLPFC hippocampus	own > other	—
5. Van Bavel, Packer, and Cunningham (2008)	ingroup/outgroup categorization	amygdala fusiform gyrus orbitofrontal cortex dorsal striatum	African-American > Caucasian faces (for all participants)	—
6. Greer, Vendemia, and Stancil (2012)	rating trust worthiness of faces	amygdala	in-group > out-group faces	—
		<i>In African-Americans:</i> inferior frontal gyrus parahippocampal areas	own-race faces	—
		amygdala anterior cingulate cortex (ACC) parahippocampal areas	other-race faces	—
		<i>In Caucasians:</i> inferior frontal gyrus ACC	own race faces	—
7. Brosch et al. (2013) (tested only Caucasians)	one-back task	early visual areas OFA	no difference in activation	successful classification
		amygdala	activation correlated with social-bias scores	—
		FFA	no difference in activation	successful classification (in “pro-Caucasians”)

TABLE 2
Summary of fMRI studies of visual processing differences for own- versus other-race faces

<i>Study</i>	<i>Task</i>	<i>Neural areas</i>	<i>Direction of neural activation (own vs. other race faces)</i>	<i>MVPA analysis—classifying own- vs. other-race faces</i>
1. Golby et al. (2001)	attention task	FFA, fusiform gyrus	own > other	—
2. Kim et al. (2006) (tested Koreans, used familiar/unfamiliar faces)	recognition task	FFA	own > other (only for unfamiliar faces)	—
3. Ng, Ciaramitaro, Anstis, Boynton, and Fine (2006) (used fMRI-adaptation)	race categorization	selectivity in inferior occipital cortex fusiform areas, cingulate gyrus	—	—
4. Feng et al. (2011) (tested Chinese participants)	race categorization	bilateral FFA bilateral OFA inferior frontal gyrus medial frontal cortex	own > other	—
5. Natu et al. (2011)	one-back task	bilateral FFA broader areas of VT cortex (FFA and lateral occipital areas)	own > other own > other	— successful classification
6. Ratner, Kaul, and Van Bavel (2012) (tested Caucasians)	ingroup/outgroup categorization	fusiform areas (face > rest contrast)	no difference in activation	successful classification

differences in own- versus other-race face processing. These studies examine the neural basis of social and emotional behaviour associated with race and racial group memberships (Hart et al., 2000; Lieberman, Hariri, Jarcho, Eisenberger, & Bookheimer, 2005; Phelps et al., 2000). As such, they have focused on brain areas associated with emotion and conflict, and have characterized the relationship between neural activity and individual variability in the conscious and subconscious evaluation of race (e.g., Brosch, Bar-David, & Phelps, 2013; Phelps et al., 2000). Next, we will review visual processing differences for own- and other-race faces. These studies concentrate on understanding how visually based face recognition systems are affected by the race of a face (e.g., Feng et al., 2011; Golby, Gabrieli, Chiao, & Eberhardt, 2001; Natu, Raboy, & O'Toole, 2011). We have summarized the results of the socioaffective and visual processing studies in Tables 1 and 2, respectively.

SOCIOAFFECTIVE PROCESSING DIFFERENCES FOR OWN- VERSUS OTHER-RACE FACES

The rationale for focusing on the amygdala in socioaffective studies is that social bias and implicit negative processing for “other” racial groups should differentially modulate neural activity in brain regions associated with the encoding of emotional memories (e.g., Phelps, 2004). Consistent with the hypothesis that the amygdala responds to threat and novelty, Cunningham et al. (2004) found greater amygdala activation in response to other-race faces than to own-race faces, but only for participants who showed greater “implicit own-race bias”. Moreover, this amygdala activation difference occurred when faces were presented for a short-duration (30 ms), but not when they were presented with longer exposure times (525 ms). In fact, when Caucasian participants were given more time to process faces, differential neural activation was observed in the dorsolateral prefrontal cortex and anterior cingulate cortex, two areas associated with inhibition and conflict resolution. Cunningham et al. speculated that social memberships elicit an automatic emotional response associated with implicit racial bias, followed by an attempt to inhibit prejudice towards members of different racial groups.

Enhanced amygdala activation for other-race faces, however, has not been found consistently. Phelps et al. (2000) reported greater amygdala activation for other-race faces, but only when they were unfamiliar. Specifically, amygdala response to other-race faces varied as a function of social memberships and individual experience with faces. Phelps et al. found that measures of subconscious race-bias correlated with amygdala and anterior cingulate cortex response for unfamiliar own- versus unfamiliar other-race

faces. No such differential response pattern was found for familiar faces. Phelps et al. conclude that familiarity with faces overrides social bias towards members of different races.

Lieberman et al. (2005) showed that amygdala responses varied across different encoding tasks related to processing racial information from faces. They did this by measuring differences in the amygdala response to African-American and Caucasian-American faces in both African-American and Caucasian-American participants. These measures were made while the participants performed perceptual and verbal encoding tasks. During the perceptual encoding task, participants matched faces based on race. During the verbal encoding task, participants judged whether the face presented was a Caucasian-American or an African-American face. In the perceptual encoding task, the amygdala activated more strongly to African-American than to the Caucasian-American faces, for *all* participants. In the verbal encoding task, Lieberman et al. found no differences. They interpreted the perceptual encoding results as a reflection of a culturally acquired social bias towards a racial group. The results also suggest that the mode of encoding race-based information (perceptual vs. verbal) may modulate the emotional responses of the amygdala.

In two other studies, differences in the amygdala activation to own- versus other-race faces vanished for tasks unrelated to race processing—even while participants viewed the faces (Brosch et al., 2013; Hart et al., 2000). In two separate scans, Hart et al. (2000) examined differences in the amygdala activation in African-American and Caucasian participants while they performed a gender categorization task for own- and other-race faces. Each face was presented on the screen for 1 s. During the first scan, the amygdala showed no differential activation to own- and other-race faces, inconsistent with the automated processing hypothesis (Cunningham et al., 2004). This suggests that during an unrelated task, the amygdala may be more responsive to the novelty of any face than to its race. In a second subsequent scan, Hart et al. found greater neural activation of the amygdala for other-race faces. They speculate that the second scan acts as a measure of neural habituation. By this account, the neural response in the first scan is due to the novelty of all faces in the study. The attenuated response to own-race faces in the second scan is due to faster neural habituation for the “more familiar” own-race faces. In addition to differences in the amygdala in the second scan, several other brain areas, including the hippocampus, temporal cortex, superior temporal gyrus, and parietal cortex, showed differential response to own- and other-race faces during both the first and second scans. Hart et al. speculated that these areas may be associated with encoding of biologically relevant facial or social characteristics as a function of experience.

In a second study, Brosch et al. (2013) attempted to relate subconscious racial measures with neural correlates in both visual and emotion-processing areas. They used decoding techniques to categorize neural patterns elicited in response to faces of different races. “Decoding” refers to multivoxel pattern analysis (MVPA) and is a method whereby neural activation patterns are classified statistically according to experimental conditions (cf. Haxby et al., 2001). Brosch et al. were not able to classify neural activity patterns elicited in response to own- versus other-race faces using voxel activity from the amygdala. This was true despite the finding that differential average magnitude correlated with implicit social bias. However, Brosch et al. reported successful race classification in early visual areas and in the OFA. Of note, classification by face-race in the FFA was possible only for participants who showed substantial own-race bias (we discuss these visual areas more in the next section). One limit of this study, however, is that Brosch et al. tested only Caucasian participants, making it difficult to unambiguously link their findings to the other-race effect. This limit was addressed in a related study by Natu et al. (2011), which we will discuss in the next section on visual processing.

Moving beyond the amygdala, Greer, Vendemia, and Stancil (2012) attempted to delineate the neural areas involved in social-evaluative processing of ingroup and outgroup face stimuli. African-Americans and Caucasians performed a trustworthiness task in which Caucasian and African American faces were presented with three facial expressions (i.e., happy, neutral, and angry). Greer et al. found little commonality in the pattern of neural activation for African-Americans and Caucasians viewing own- and other-race faces. In African-Americans, there was strong activation in the inferior frontal gyrus and parahippocampal gyrus for happy own-race faces. Caucasians showed greater activation in the inferior frontal gyrus and anterior cingulate cortex for happy own-race faces. Moreover, only African-Americans showed activation in the amygdala, parahippocampal gyrus, and anterior cingulate for neutral other-race faces. For African-American participants, Greer et al. also found a significant correlation between previous exposure to race-related events and amygdala response to Caucasian faces. This suggests that African-American, but not Caucasian participants, may rely on prior experience for interpreting social interactions. The result highlights a caution about assuming homogeneity of social experience effects for participants of different races.

In a final socioaffective study, the authors conclude that race is orthogonal to group-membership. Specifically, Van Bavel, Packer, and Cunningham (2008) probed the neural representation of ingroup processing, using mixed race, social group memberships (ingroup/outgroup mixed race members). Caucasian participants were randomly assigned to a mixed-race team (with African-American and Caucasian faces) and were told that their teams were competing. Participants were trained on both ingroup and outgroup faces

prior to fMRI scanning. Van Bavel et al. found greater activity in the amygdala, fusiform gyri, orbitofrontal cortex, and dorsal striatum for ingroup faces versus outgroup faces. The inferior occipital cortex, however, showed greater activation for other- as opposed to own-race faces. This finding is inconsistent with previous accounts of differential amygdala activity to these faces (e.g., Cunningham et al., 2004). Van Bavel et al. suggested that race-based differences in the amygdala stem from their motivational relevance and salience in the group context.

In summary, although researchers have examined the amygdala as the primary focus of the socioaffective processing of face race, there are many unanswered questions. Among this small number of studies, several factors including face familiarity (Phelps et al., 2000), cultural learning (Lieberman et al., 2005), socioemotional bias (Cunningham et al., 2004; Phelps et al., 2000), type of encoding/task (Lieberman et al., 2005), exposure time (Cunningham et al., 2004), and neural habituation (Hart et al., 2000) contribute to the reported effects for the amygdala.

One important caution in interpreting these findings is that in several of these studies, the race of the participants and the race of the face were not varied simultaneously (cf. Phelps et al., 2000; Cunningham et al., 2004; Brosch et al., 2013). This leaves open the possibility that some results are due to differences in the stimulus sets for the two races of faces, rather than to an other-race effect, *per se*. This concern is particularly worrisome when the results of various studies fail to converge.

A second caution is that the social and emotional associations we have with people of other races may trigger amygdala response. For example, the amygdala may act as a subconscious switch that is triggered in response to novel or unfamiliar faces (cf. Dubois et al., 1999; Gobbini & Haxby, 2006; Natu & O'Toole, 2011). Because other-race faces can be thought of as "unfamiliar", the greater response of the amygdala to these faces can be explained, in part, by their novelty. Familiarity, in turn, plays a role in processing members of one's own social group versus those of a different group (ingroup/outgroup). These social divisions may be associated with cultural and emotional attitudes and with prejudice towards different racial groups. Finally, individual experience with particular faces/people may counter all of these amygdala triggers, as personal knowledge of others becomes more salient than cultural or group biases.

This brings us to a third issue, in understanding the role of the amygdala in the context of other important brain structures related to person processing and conflict resolution. These structures include the anterior cingulate gyrus, parahippocampal gyrus, and dorsolateral prefrontal gyrus. Gobbini and Haxby's (2007) model of familiar person processing may offer some guidance in sorting through the potentially confounding effects of familiarity, cultural learning, and social and emotional responses to

other-race faces. Future studies need to consider these structures, in addition to the amygdala, to better understand the neural basis of socioaffective own- and other-race face processing.

VISUAL PROCESSING DIFFERENCES FOR OWN- AND OTHER-RACE FACES

Our ability to visually encode the uniqueness of own- and other-race faces is influenced by our experience with these faces (Kelly et al., 2007; Walker & Hewstone, 2006). In fact, race categorization is faster for other-race faces than for own-race faces, but at the cost of individuating other-race faces (Levin, 2000). On the other hand, own-race faces have an advantage in the early stages of perceptual encoding (Walker & Tanaka, 2003) and are processed more holistically than other-race faces (Tanaka, Kiefer, & Bukach, 2004).

In neural terms, the visual correlates of the other-race effect have been studied primarily in the face-selective fusiform gyrus (Feng et al., 2011; Golby et al., 2001). In European-American and African-American participants, Golby et al. (2001) were the first to report that both the right and left fusiform gyrus activated more strongly in response to own- versus other-race faces. However, only the left fusiform gyrus activation correlated with a behavioural measure of the recognition advantage for own-race faces. This led Golby et al. to propose that the left fusiform gyrus is important for race categorization, whereas the right fusiform gyrus is associated with face individuation within a racial category.

Notably, familiarity with own- and other-race faces nullifies the differences in the FFA activation. In a study by Kim et al. (2006), Korean participants viewed familiar and unfamiliar Korean and Caucasian faces. The FFA activated more strongly in response to own- versus other-race unfamiliar faces. There was no effect for familiar faces. This parallels the findings of Phelps et al. (2000), and reinforces the notion that familiarity and individual experience are neural markers of the other-race effect. Kim et al.'s finding is also consistent with behavioural differences in familiar and unfamiliar face processing (Johnston & Edmonds, 2009).

Moving beyond the FFA, three studies have extended the investigation of the other-race effect to include the inferior occipital gyrus and lateral temporal areas (Feng et al., 2011; Natu et al., 2011; Ng et al., 2006). Ng et al. (2006) found that the cortical regions exhibiting selectivity for visual configurations that specify ethnicity/race do not coincide with traditional face-selective areas. Rather, they are distributed across the fusiform gyrus, inferior occipital cortex, and cingulate gyrus.

Feng et al. (2011) observed greater activation to own-race versus other-race faces in the bilateral FFA and OFA, the right inferior frontal gyrus (rIFG),

and the right medial frontal cortex. Although the role of these frontal areas in race categorization remains unclear, a psychophysiological interaction (PPI) analysis revealed a correlation between the rIFG and bilateral-occipital cortex. This correlation was stronger for own- versus other-race faces. Feng et al. interpret this difference as a reflection of a greater engagement of expertise-based processing in the frontal lobe for own-race faces.

Natu et al. (2011) directly challenged the critical importance of the FFA for face categorization by race using an MVPA analysis of neural activity elicited in response to viewing own- versus other-race faces. In that study, Asian and Caucasian participants viewed Asian and Caucasian faces. Neural activity patterns for Asian versus Caucasian faces were discriminable in the brains of both Asian and Caucasian participants. However, this discrimination required a combination of the lateral-occipital and fusiform areas. The FFA, by itself, did not support accurate race classification. This is consistent with the Ng et al. (2006) finding of noncoincident regions of adaptation for demographic configurations.

In addition to race classification, Natu et al. (2011) also examined the time course of neural activation patterns in response to own- and other-race faces. They found that the initial response to own-race faces was greater than the response to other-race faces in both the FFA and in a broader swath of lateral occipital and ventral temporal areas. However, the own-race advantage reversed over the temporal sequence, with activation for other-race faces eventually overriding activation for own-race faces. This occurred in the brains of both the Asian and Caucasian participants. Critically, this provides corresponding neural evidence for automatic own-race processing, followed by a more time-consuming processing for other-race faces. Although the initial own-race activity advantage in the FFA is consistent with the results of Feng et al. (2011) and Golby et al. (2001), the general claim of greater FFA involvement in own-race face processing is perhaps incorrect. Instead it seems that the FFA may be engaged to an equal degree for other-race faces, albeit less automatically.

In a final study, Ratner et al. (2012) tested neural discriminability of race, manipulating both race and social group membership (ingroup/outgroup with own- and other-race members in both groups). They found no difference in face-selective fusiform activation for own- versus other-race faces. Moreover, they were able to decode face race in this face-selective region and in early visual cortex. The interpretation of these findings, however, is complicated by the simultaneous manipulation of social group membership, which was defined using both own- and other-race faces (social groups had both own- and other-race faces). It is also complicated by Ratner et al.'s definition of the face-selective fusiform gyrus. This definition did not use objects as a control, but instead used the contrast faces > rest. Most studies define face-selective regions with the contrast faces > objects. Because both of the Ratner et al.'s main findings are inconsistent with other

studies (Feng et al., 2011; Golby et al., 2001; Natu et al., 2011), it is difficult to definitively interpret these results.

To summarize, the neural markers of differential processing for own- and other-race faces are distributed widely across ventral-temporal areas, including the fusiform gyrus and lateral occipital areas. There are also important temporal markers of the other-race effect. A shortcoming of the current neuroimaging literature is the limited knowledge of how visual and socioemotional processing interact. Future neuroimaging studies should begin to consider the visual, emotional, and social systems as a whole to arrive at a more comprehensive understanding of the neural correlates of the other-race effect. An important theme of the current neuroimaging literature is the critical role that experience and familiarity play in driving both visual and social percepts of own- and other-race faces.

CONCLUSION

Differences in the pattern of neural activation for own- versus other-race faces, as well as in the time course of activation, provide a first look at the neural basis of the other-race effect. More focus on how these differences develop is needed to bridge the gap between the psychological and neural mechanisms of the other-race effect. The broader question of human social and emotional responses to own- versus other-race faces, however, is still difficult to formulate in the context of perceptual and memory limits for other-race faces. These responses, however, are at the core of human experience and ultimately have connections with the visual system. Both sides of the research equation must be considered to gain a more complete understanding the other-race effect.

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