



# The role of face shape and pigmentation in other-race face perception: An electrophysiological study

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## ARTICLE INFO

### Article history:

Received 19 September 2008

Received in revised form 3 October 2009

Accepted 7 October 2009

Available online 15 October 2009

### Keywords:

Face recognition

Other-Race Effect

Event-related potentials

## ABSTRACT

Adult observers generally find it difficult to recognize and distinguish faces that belong to categories with which they have limited visual experience. One aspect of this phenomenon is commonly known as the “Other-Race Effect” (ORE) since this behavior is typically highly evident in the perception of faces belonging to ethnic or racial groups other than that of the observer. This acquired disadvantage in face recognition likely results from highly specific “tuning” of the underlying representation of facial appearance, leading to efficient processing of commonly seen faces at the expense of poor generalization to other face categories. In the current study we used electrophysiological (event-related potentials or ERPs) and behavioral measures of performance to characterize face processing in racial categories defined by dissociable shape and pigmentation information. Our goal was to examine the specificity of the representation of facial appearance in more detail by investigating how race-specific face shape and pigmentation separately modulated neural responses previously implicated in face processing, the N170 and N250 components. We found that both components were modulated by skin color, independent of face shape, but that only the N250 exhibited sensitivity to face shape. Moreover, the N250 appears to only respond differentially to the skin color of upright faces, showing a lack of color sensitivity for inverted faces.

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## 1. Introduction

The so-called “other-race” effect describes the phenomenon in which observers typically find faces difficult to recognize and distinguish from one another if they belong to an ethnic or racial group to which the observer has had little exposure (Sporer, 2001). Anecdotally, this is often expressed as a subjective impression that members of an other-race group look alike (Malpass, 1981; Malpass & Kravitz, 1969). Empirically, observers display distinct impairments in face memory for other-race faces (Meissner & Brigham, 2001), both in terms of recognition accuracy and response bias (Slone, Brigham, & Meissner, 2000). In natural scenes, changes to other-race faces are detected more slowly than changes to own-race faces, despite the fact that observers attend to both face types equally (Hirose & Hancock, 2007). Beyond these basic differences in accuracy, observers also appear to process other-race faces in qualitatively different ways. For example, there is some evidence that holistic processing is not applied to other-race faces to the same degree as it is to own-race faces (Michel, Rossion, Han, Chung, & Caldara, 2006). Whole/Part effects (Tanaka & Farah, 1993) appear to be more evident for own-race faces than for other-race faces

(Tanaka, Kiefer, & Bukach, 2004), and there also appears to be an overall own-race advantage for both “component” and “configural” processing (Hayward, Rhodes, & Schwaninger, 2007). In the context of visual search, other-race faces are easier to detect in a field of own-race distracters than the reverse situation (Chiao, Heck, Nakayama, & Ambady, 2006; Levin, 2000). This is more or less consistent with other search asymmetry results insofar as a disparity in the fidelity of target and distracter encoding tends to produce similar effects (Rosenholtz, 2001, 2004). Finally, category-contingent after effects have been reported for own- and other-race faces (Little, DeBruine, Jones, & Waitt, 2008) suggesting that distinct neural populations may support the processing of these face types.

One simple way to summarize a great deal of the behavioral literature regarding other-race face perception is to say that other-race faces do not appear to be processed by “expert” or “face-like” mechanisms to the same degree as own-race faces. That is not to say they are not perceived as faces, but rather that the efficient, expertise-based strategies adopted for the processing of own-race faces are either applied less skillfully or simply with less success to other-race faces. Conceptually, one could say that other-race faces fall outside the “tuning” of facial appearance used by whatever representation supports recognition behavior. An important question then is to determine the specificity of the neural representation of facial appearance in the context of own- and other-race face perception. We continue by briefly discussing existing results relevant to this issue, concentrating on the literature describing

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own- and other-race face perception using event-related potentials (ERPs) since this is the methodology we have adopted in the current study.

It is very challenging to summarize previous results concerning the electrophysiological response to own- and other-race faces. To date, multiple studies have compared ERPs to faces belonging to “in-group” and “out-group” faces, but significant variability in task design, experimental stimuli, and analysis techniques make it difficult to condense existing results into a coherent picture of how other-race face processing may differ from that of own-race faces. For example, many studies have been conducted using White observers (and thus White “own-race” faces) but in some cases a comparison between White and Black faces is made (Ito & Urland, 2003, 2005) while in others a comparison between White and East Asian faces is made (Caldara et al., 2003; Hermann et al., 2007; Stahl, Wiese, & Schweinberger, 2008). Few studies have employed more than one “other” race type (see Willadsen-Jensen & Ito, 2006 for an exception). Although it is tempting to assume that the processing of all other-race faces is the same, as yet there is no clear evidence that this is true. Furthermore, task demands vary even more dramatically across different studies. In some cases, observers are asked to categorize faces by race and/or gender (Ito & Urland, 2003) while other experiments require an old/new judgment for previously studied items (Stahl et al., 2008). Other tasks have required observers to make judgments as simple as a secondary target detection task during recording (Caldara et al., 2003) and as complex as deciding whether or not to shoot at an individual who may be carrying either a cell phone or a firearm (Correll, Urland, & Ito, 2006). Beyond these substantial differences in task, different studies tend to focus on different ERP components including the N170 (Caldara et al., 2003), the P2 (Ito & Urland, 2003), or the N250r (Hermann et al., 2007) or adopt tools like Principal Components Analysis (Ito, Thompson, & Cacioppo, 2004), making it still more difficult to determine how different results might fit together into a coherent theoretical package. While many of these studies have reported a variety of differences between the ERPs elicited by own-race faces and other-race faces, we are left with a fairly loose confederacy of results that are not easily relatable to one another.

Given the lack of agreement regarding the nature of the ORE in electrophysiology, the primary goal of the current study was to ask a fundamental question regarding the “tuning” of face-specific ERP components along dimensions relevant to other-race face perception: To what extent do shape cues and pigmentation cues independently contribute towards the modulation of ERP responses to own- and other-race faces? We emphasize that this question addresses how physical differences in the stimulus affect subsequent processing as measured by ERP responses. This is in contrast to studies designed to investigate social or emotional responses to other-race faces (Bernstein, Young, & Hugenberg, 2007), which often attempt to equalize image-level differences between faces belonging to “in-group” and “out-group” categories (Chiao, Heck, Nakayama, & Ambady, 2001; MacLin & Malpass, 2001). We also have not adopted a complex cognitive task in our design, concentrating instead on how image properties related to racial categorization of the face modulate the neural response in the absence of demanding task requirements. We present the results of analyzing the N170 and the N250, two components which have been implicated as taking part in various stages of face processing. Multiple studies have reported larger responses to other-race faces at these components (Caldara, Rossion, Bovet, & Hauert, 2004; Itier & Taylor, 2002; Ito & Urland, 2003; Scott, Tanaka, Sheinberg, & Curran, 2006) without isolating the cues that are responsible for the differential response. Our study thus represents an attempt to characterize the neural other-race effect in more depth by teasing apart physical stimulus variables that may contribute independently to

other-race face perception, concentrating on perceptual factors relevant to the ORE, and simultaneously examining multiple relevant components of the ERP response.

We chose to concentrate on the potentially separate contributions of face pigmentation and face shape to the ORE since previous behavioral work has indicated that these visual cues make independent contributions to face recognition in general (Russell, 2003; Russell & Sinha, 2007; Russell, Sinha, Biederman, & Nederhouser, 2006) and the social perception of other-race faces in particular (Dixon & Maddox, 2005). These behavioral results raise the important question of how the neural representation of facial appearance is “tuned” along these dimensions, which is of direct relevance to the study of own- and other-race face perception. Since perceived category membership (deciding that a face is White or Black) is a function of both shape and pigmentation data, we suggest that knowing how race-specific visual data of each type modulates behavioral and neural responses is crucial. Thus far, we have little information regarding how shape and pigmentation may separately contribute to the behavioral ORE (Bar-Haim, Seidel, & Yovel, 2009). In many studies, the visual features that define racial categories are confounded either by using natural faces as stimuli or adopting ‘race morphing’ techniques to define a continuum of faces that progress between one category and another via global modification of all differences between face types (Walker & Tanaka, 2003). These techniques have made it difficult to understand how face shape and pigmentation may separately contribute to the ultimate perceptual representation of a face as belonging to one racial group or another.

Our contribution to the characterization of the neural response to other-race faces was therefore to examine the nature of the response to faces which contain dissociated shape and pigmentation information obtained from distinct racial categories. To accomplish this goal, we employed computer-generated stimuli that permitted independent manipulation of face shape and face pigmentation via a “morphable model” of facial appearance (Blanz & Vetter, 1999). We were thus able to create faces that were completely matched for 3D shape, for example, but had race-specific pigmentation applied to their surfaces (and vice-versa). We begin by describing a straightforward behavioral experiment we conducted to ensure that the synthetic faces we created were sufficient to induce a behavioral ORE. We then continue by describing the results of our ERP analysis, which use the same images to examine the neural response to dissociated shape and pigmentation information.

## 2. Experiment 1—a behavioral ORE for synthetic faces with dissociated shape and pigmentation information

Before examining ERP responses to the synthetic faces we used to dissociate shape and pigmentation information, we first conducted a simple match-to-sample ORE behavioral experiment with our stimuli. This task allowed us to determine whether or not we could obtain a behavioral ORE with computer-generated stimuli, providing an important foundation for our prospective ERP results. We therefore treated this preliminary behavioral assay as a means of determining whether the faces we created had sufficient ecological validity.

An additional question we chose to build into our study was how the ORE (if evident) interacted with the well-known face inversion effect (FIE). Behaviorally, inverting a face makes it harder to recognize (Yin, 1969) and discriminate, impairs observer efficiency (Sekuler, Gaspar, Gold, & Bennett, 2004), and may induce a less holistic strategy relative to upright face recognition (Friere, Lee, & Symons, 2000). These behavioral consequences resemble accounts of the behavioral other-race effect as discussed above, making the perception of inverted faces a potentially useful “model system”

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