



Other-race and inversion effects during the structural encoding stage of face processing in a race categorization task: An event-related brain potential study

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ABSTRACT

To investigate the mechanisms underlying the other-race effect, in particular at what stage of face processing differences between same-race (SR) and other-race (OR) stimuli occur, electrophysiological and behavioral data were obtained on Caucasian participants viewing photographs of Caucasian, Asian, and African faces in upright and inverted orientations. During a race categorization task, reaction times were faster for African than Asian faces, and both of them faster than Caucasian ones, independent of their orientation. The face-sensitive N170 component was low in amplitude for Caucasian, intermediate for Asian, and maximal for African faces. The face inversion effect was observed for all ethnic groups on N170 amplitudes, but was more evident for Caucasian faces. According to the perceptual expertise hypothesis, our results indicate that SR faces involve more configural/holistic processing OR faces.

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1. Introduction

Although human adults gain perceptual expertise in face processing, this proficiency seems not to apply to all kinds of faces to the same extent. For instance, the “other-race effect” (ORE) is a well established phenomenon in the face processing literature, whereby face recognition of individuals from the same race (SR) as the perceiver is more accurate and faster than those from other races (OR) (for a review, see Meissner and Brigham, 2001). In addition to this own-race advantage in face identification, some studies report an OR advantage in the form of faster categorization of OR than SR faces (Caldara et al., 2003, 2004; Levin, 1996, 2000; Valentine and Endo, 1992; Zhao and Bentin, 2008). Whereas several theoretical explanations of this ORE have been put forward (the race-feature hypothesis: Levin, 1996, 2000; the multidimensional space hypothesis: Valentine and Endo, 1992), it is widely accepted that perceptual expertise plays a crucial role in shaping it. The origin of the ORE is probably due to the greater experience people usually have with SR relative to OR faces (Rhodes et al., 1989; Slone et al., 2000; Valentine and Endo, 1992; Walker and Hewstone, 2006, 2008), leading to more expert face-coding mechanisms in the processing of faces of one's own race. The configural and/or holistic processing represents specific mechanisms invoked as a function of the degree of

expertise individuals acquire with a particular stimulus category (Diamond and Carey, 1986; Gauthier and Tarr, 1997; Gauthier et al., 1998; Valentine, 1988). So, according to the perceptual expertise account of the ORE, configural/holistic information is more critical than featural information in the processing of SR faces while the reverse trend seems to be proven in the processing of OR faces (Tanaka et al., 2004). Evidence for this theoretical perspective can be found in several behavioral studies based on the “Thatcher effect” (Murray et al., 2003; Rhodes et al., 2006), the “whole-versus-part superiority effect” (Tanaka et al., 2004), the “face composite effect” (Michel et al., 2006a,b), or the “face inversion effect” (FIE) (Buckhout and Regan, 1988; Fallshore and Schooler, 1995; Hancock and Rhodes, 2008; Rhodes et al., 1989; Sangrigoli and de Schonen, 2004; Valentine, 1991; Valentine and Bruce, 1986).

Since the original work of Yin (1969), the FIE has become one of the most widely used stimulus manipulation to show to what extent faces are “special” (for reviews, see Rossion and Gauthier, 2002; Valentine, 1988). It is well-known that picture-plane inversion qualitatively changes face perception by impairing some of the specific mechanisms typically involved in the processing of upright faces. Whereas upright faces are perceived in a configural/holistic manner, inverted faces involve mostly feature-based processing as in object recognition (e.g., Bartlett and Searcy, 1993; Leder and Bruce, 2000; Sergent, 1984; for a review, see Maurer et al., 2002). For example, even minimal changes in the space between facial features are easily detectable with upright but not with inverted faces (Kemp

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et al., 1990; Leder et al., 2001; Rhodes et al., 1993). In the same way, as exemplified by the “Thatcher effect” (Thompson, 1980), face inversion reduces the subjective impression of “monstrosity” caused by eye–mouth inversions in upright faces. As inverted faces are processed on the basis of individual features, trait alterations do not affect this type of processing. However, it is noteworthy that results related to the inversion effect on the processing of ethnic faces remain relatively mixed. While several reports underline that OR face recognition is less affected by the FIE than SR face recognition (Fallshore and Schooler, 1995; Hancock and Rhodes, 2008; Rhodes et al., 1989; Sangrigoli and de Schonen, 2004), others obtained inverse results (Valentine, 1991; Valentine and Bruce, 1986), or else similar FIE for OR and SR faces² (Buckhout and Regan, 1988).

The perceptual expertise account of the ORE has also been investigated by examining the time course of neural processing of OR and SR faces. A majority of studies focused mainly on the face-sensitive N170 event-related brain potential (ERP), a negative deflection peaking between 140 and 180 ms over occipito-temporal sites. The N170 component represents the earliest stages of face processing related to the structural encoding of faces (Bentin and Deouell, 2000; Eimer, 2000). Given that amplitude and/or latency enhancement of the N170 tends to reflect the difficulty in configural/holistic information processing when faces are inverted (Jacques and Rossion, 2009, 2010; Rossion et al., 2000), the investigation of this component appears justified to examine the ORE. However, no consistent race effects on either amplitude or latency of the N170 component has emerged so far (Caldara et al., 2003, 2004; Gajewski et al., 2008; Herrmann et al., 2007; Ito et al., 2004; Ito and Urland, 2005; James et al., 2001; Stahl et al., 2008; Walker et al., 2007; Wiese et al., 2009), probably due to the wide range of task demands and the use of different ethnic groups as face stimuli. While certain researchers (Herrmann et al., 2007; Walker et al., 2007) reported an increase in the classical N170 face-sensitive component at occipito-temporal electrodes for OR (Asian or African) faces relative to SR faces in Caucasian participants during non-social categorization tasks,³ others (Ito and Urland, 2005) found the opposite (i.e. larger N170 in response to Caucasian than to African faces) during a social (gender) categorization task. In contrast, some studies (Caldara et al., 2003, 2004; James et al., 2001) found that the N170 was insensitive to race. Using a target detection task, Caldara et al. (2003) observed no race modulation of the N170 component at lateral occipito-temporal electrodes (P9/P10 and PO9/PO10). However, increased amplitudes around 160 ms over the Oz occipital electrode were found for OR faces in contrast to SR faces, though this effect was not replicated by the same authors in their next study (Caldara et al., 2004). In contrast, Caldara et al. (2004) identified the occurrence of the OR advantage in categorization at around 240 ms, a stage related to the processing of visual information at the semantic level. In addition, some authors found that inversion affects the latency (Gajewski et al., 2008) or the amplitude (Vizioli et al., 2010) of the N170 predominantly for faces from the same race of the participants, while others found that the effects of race and inversion are additive and do not interact (Wiese et al., 2009). Thus, it is yet unclear at the present time whether the ORE is based on differential configural/holistic information processing at the time of the initial face-encoding stage.

Our first objective was to investigate whether racial membership of faces influences the early perceptual encoding stage (N170). To shed light on the relationship between the ORE and configural/holistic processing on the N170, we also examined whether race and inversion effects interact at this early stage of face processing. To address

these objectives, behavioral and electrophysiological data were recorded in Caucasian participants performing a race categorization task with Caucasian, African, and Asian faces, instead of two used in most ERP studies (Caldara et al., 2003, 2004; Herrmann et al., 2007; Ito et al., 2004; Ito and Urland, 2005; James et al., 2001; Stahl et al., 2008; Walker et al., 2007; Wiese et al., 2009). The race categorization task appeared to be particularly relevant because race modulation of the N170 appears to depend on task demands (Ito and Urland, 2005) and previous researchers investigated the N170 sensitivity to race in the framework of the FIE by using tasks for which race information was irrelevant (Gajewski et al., 2008; Vizioli et al., 2010; Wiese et al., 2009). Finally, given the findings of greater inversion effects for SR compared to OR faces (Fallshore and Schooler, 1995; Hancock and Rhodes, 2008; Rhodes et al., 1989; Sangrigoli and de Schonen, 2004), indicating a higher level of configural/holistic information processing for faces of the observer's own race (Michel et al., 2006a,b; Tanaka et al., 2004), our main hypotheses were that the N170 component is influenced by ethnic groups and should be differentially modulated by inversion as a function of the race of faces.

2. Materials and methods

2.1. Participants

Thirteen right-handed Caucasian volunteers (10 females, 3 males; mean age: 24.9 ± 2.6 years) participated in the experiment. All participants had normal or corrected-to-normal visual acuity and none had extensive social contact with members of other racial (Asian and African) groups.⁴

2.2. Stimuli

Photographs of Caucasian, Asian, and African faces were used (20 per race and half women). The faces were presented in a frontal view with a neutral expression without distinctive features. Adobe® Photoshop® software was used to remove background, hair, and clothing in all pictures, calibrated in black and white to identical shape and size (visual angle of approximately $2.8 \times 3.7^\circ$). Resulting faces were equated for mean pixel luminance with the “image/adjustments/brightness” function of Photoshop. Each face was presented in upright and inverted orientations.

2.3. Procedure

After electrode-cap placement, participants were comfortably seated in front of a computer screen at a distance of 90 cm. Subjects had to identify as fast and correctly as possible whether face stimuli belonged to their own race or not by pressing with the right hand one of two computer keys. Key assignment was counterbalanced across participants. Stimuli were displayed against a light grey background. At the start of each trial, a fixation point appeared at the center of the screen for 200 ms, followed by a face stimulus lasting 800 ms. The offset of each stimulus was followed by a blank-screen during a random inter-stimulus interval (ISI) ranging from 1000 to 1400 ms

² Buckhout and Regan (1988) found a larger inversion effect for SR than OR faces for Black subjects, but not for White subjects.

³ Herrmann et al. (2007) used a priming task, in which the subjects had to determine whether the second face was identical or different to the first one. In Walker et al. (2007), participants responded when they detected a stimulus that repeated over immediately successive trials.

⁴ The degree of interracial contact of our participants was inferred from a self-report questionnaire which included five items for each of the both other-race groups. Items were worded as follows: ‘How many Asian (African) people did you meet during your childhood?’, ‘How many Asian (African) people do you mix with in your family?’, ‘How many Asian (African) people do you mix with among your friends?’, ‘How many Asian (African) people do you mix with in your job/main activity?’, and ‘How many Asian (African) people did you meet these last few days?’. Responses to all items were on a 4-point scale anchored by 0 (no contact) and 3 (high contact) with the following answer choices: *None*, *Between 1 to 3*, *Between 4 to 6*, and *More than 7*. The internal consistency of this multi-item measure was acceptable for both Asian (Cronbach's $\alpha = 0.70$) and African (Cronbach's $\alpha = 0.77$) groups. Means (and standard deviations) of responses to the measures were $0.58 (\pm 0.55)$ for Asian and $0.86 (\pm 0.57)$ for African group.

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