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Qualitatively similar processing for own- and other-race faces: Evidence from efficiency and equivalent input noise

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ABSTRACT

The other-race effect is the finding of diminished performance in recognition of other-race faces compared to those of own-race. It has been suggested that the other-race effect stems from specialized expert processes being tuned exclusively to own-race faces. In the present study, we measured recognition contrast thresholds for own- and other-race faces as well as houses for Caucasian observers. We have factored face recognition performance into two invariant aspects of visual function: efficiency, which is related to neural computations and processing demanded by the task, and equivalent input noise, related to signal degradation within the visual system. We hypothesized that if expert processes are available only to own-race faces, this should translate into substantially greater recognition efficiencies for own-race compared to other-race faces. Instead, we found similar recognition efficiencies for both own- and other-race faces. The other-race effect manifested as increased equivalent input noise. These results argue against qualitatively distinct perceptual processes. Instead they suggest that for Caucasian observers, similar neural computations underlie recognition of own- and other-race faces.

1. Introduction

Human visual face perception has long been regarded as “special”. Broadly speaking, this concept refers to the idea that observers utilize separate, expert neural processes when recognizing faces, distinct from general-purpose mechanisms that underlie recognition of non-face visual stimuli (Farah, Wilson, Drain, & Tanaka, 1995, 1998; McKone, Kanwisher, & Duchaine, 2007; Moscovitch, Winocur, & Behrmann, 1997; Rhodes, 2013; Yin, 1969). These processes have further been described as holistic vs. part-based, suggesting global vs. local recognition strategies differentiate between the two (see Behrmann, Richler, Avidan, & Kimchi, 2015, for a review; Rossion, 2008; Tanaka & Farah, 1993, 2003; Van Belle, De Graef, Verfaillie, Rossion, & Lefevre, 2010). A variety of paradigms designed to probe these mechanisms have supported the notion of a holistic face-processing strategy (see Maurer, Grand, & Mondloch, 2002, for a review) including the part/whole advantage, in which subjects perform better in recognizing the features of a face (e.g. eyes, nose, and mouth) presented in the context of a whole face as opposed to viewing them in isolation (Tanaka & Farah, 1993); the composite face effect, where subjects incorrectly perceive changes in half of a face (e.g. upper) when it is fused with a half (e.g. bottom) from a different face (Hole, 1994; Young, Hellawell, & Hay, 1987); and the face-inversion effect (Yin, 1969) in which perception is substantially impaired when viewing inverted faces compared to upright.

It has further been suggested that global strategies may be specialized for own-race faces (e.g., Rhodes, Tan, Brake, & Taylor, 1989). Human observers show a significant impairment in the ability to discern and discriminate identity in other-race faces (Meissner & Brigham, 2001). This diminished performance, termed the *other-race effect*, is consistent with the idea that other-race faces may not benefit from specialized expert processing that is primarily tuned for own-race faces. Indeed, Hancock and Rhodes (2008) found the magnitude of the other-race effect in face recognition to be associated with cross-race differences in configural coding in a group of Caucasian and Chinese individuals that varied in their contact with the other race. Several other studies suggest more holistic processing for own-race compared to other-race faces based on greater part/whole advantage (Michel, Caldara, & Rossion, 2006; Tanaka, Kiefer, & Bukach, 2004) and larger composite face effects (Michel, Rossion, Han, Chung, & Caldara, 2006) for own-race faces. One caveat is that these effects are most evident in Caucasian observers, whereas Asian observers tend to demonstrate similar holistic processing for both own- and other-race faces (Mondloch et al., 2010; Tanaka et al., 2004). As the other-race effect is observed reliably for both Asian and Caucasian observers, a lack of holistic processing may not necessarily be at the root of this phenomenon.

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Nevertheless, these results on holistic processing do not rule out the possibility that the dramatically diminished performance with other-race faces may stem from qualitatively distinct specialized processing tuned specifically to own-race faces.

In the present study we examine processing differences involving own- versus other-race faces without making assumptions regarding the specific strategies or computations involved (e.g. holistic vs. part-based). Instead, we focus on a black-box model of neural processing and aim to test whether observers' visual performance is consistent with distinct and dissociable mechanisms, or a common mechanism for both own- and other-race faces. We have reasoned that any specialized processing devoted to a particular stimulus category must satisfy a basic requirement: it must provide substantially superior processing ability exclusive to this object of expertise. Comparing human ability across visual object categories is not trivial due to challenges in separating the effects of physical attributes of the stimulus set, task demands and differences in neural processing strategies. One way to account for task difficulty and assess true human ability is to compare human performance to that of an ideal observer (Gold, Bennett, & Sekuler, 1999; Pelli, Burns, Farell, & Moore-Page, 2006; Pelli & Farell, 1999; Tjan, Braje, Legge, & Kersten, 1995). The ideal observer is a computer simulation that goes through the same task as the human observer and performs in a statistically optimal fashion (Burgess, 1990; Kersten, 1990; Tjan et al., 1995). As such, the ideal's performance provides a benchmark against which human performance can be compared. Utilizing an ideal observer makes it possible to calculate *efficiency*, which "*strips away the intrinsic difficulty, leaving a pure measure of human ability*" (Pelli et al., 2006, p. 4649).

Efficiency concerns performance in the presence of external noise. In the absence of external noise, the ideal observer performs perfectly. On the other hand, the human observer is limited even when no external noise is present. This is considered to be due to internal noise that distorts neural signals in addition to added external noise. Therefore, performance in a visual task can be factored into two aspects of visual function: efficiency, related to the neural computations underlying the recognition task, and internal noise, related to signal deterioration within the visual system (Pelli, 1990; Pelli & Farell, 1999). Qualitatively distinct specialized processing would be seen in substantially higher efficiencies, whereas superior performance stemming from quantitative differences based on common mechanisms would result in lower internal noise, and comparable efficiency. This approach has been utilized successfully to study a variety of visual tasks e.g., to examine whether detection of first- and second-order patterns are based on common or dissociable mechanisms (Allard & Faubert, 2006) and to investigate differences in processing of upright vs. inverted faces (Gaspar, Bennett, & Sekuler, 2008), among others. Here we apply this methodology to examine potential differences in recognition processes between own- vs. other-race faces by testing Caucasian observers in three stimulus conditions: Caucasian faces, East Asian faces, and houses. In what follows, we will use the term "recognition" to indicate the ability to correctly identify a pattern among a set of known alternatives, as has been utilized in many previous studies of face perception (Butler, Blais, Gosselin, Bub, & Fiset, 2010; Guo, Oruc, & Barton, 2009; Martelli, Majaj, & Pelli, 2005; Nasanen, 1999), and distinct from another meaning, which has also been often used in the field, to represent acknowledgment of a face as having been seen before (e.g., in an old/new task).

2. Preview

We expected to find substantially higher efficiencies in the recognition of own-race faces compared to those of other-race. In addition, we expected that other-race face recognition efficiencies would be comparable to those of house recognition, our control stimulus category, which was included to provide an efficiency benchmark for recognition of non-face object category of comparable complexity. Instead, we found that both own- and other-race face recognition efficiencies surpassed house recognition efficiency by more than sixfold. The two face categories did not differ in efficiency. Other-race face recognition was associated with significantly higher internal noise compared to own-race faces.

3. Methods

3.1. Subjects

24 adults (21 females, ages 19–35) with normal or corrected-to-normal vision participated in the study. The protocol was approved by the review boards of the University of British Columbia and Vancouver Hospital, and informed consent was obtained in accordance with the principles in the Declaration of Helsinki. Prior to participation, subjects completed a social exposure questionnaire that collected detailed biographical information as well as information that allowed us to gauge each subject's experience with Caucasian and East Asian faces. The inclusion criteria were: (1) subjects should be born and raised, until age 16, in a predominantly Caucasian community that does not provide significant exposure to East Asian faces; (2) subjects should not have lived in a predominantly East Asian community for more than 3 years; (3) subjects' self-rated exposure to Caucasian faces should be at least 4/5 and self-rated exposure to East Asian faces should be at most 2/5 on a scale where 1 represents "no contact" and 5 represents "extremely frequent and regular contact". The remainder of the questionnaire collected information that was used to confirm the consistency and accuracy of responses and self-rated exposure values. In case of perceived inconsistencies, potential subjects were contacted again and asked to clarify the conflicting responses.

The actual exposure statistics of the subjects were as follows: All subjects were born and raised in a predominantly Caucasian country. The subjects' self-rated exposure scores to Caucasians while growing up were uniformly 5/5 whereas mean exposure score to Asians while growing up was 1.29/5 ($SD = 0.46$). All subjects uniformly reported that 100% of their close relatives were Caucasian, indicating that there were not family members of multi-ethnic heritage. Thus, subjects self-reported minimal exposure during the first 16 years of life to East Asian individuals.

This lack of experience with East Asian faces growing up was also paralleled in the subjects' exposure in their adult years as well. When asked about their closest friends, Caucasians made up 91.25% ($SD = 9.91$) whereas East Asians made up 3.75% ($SD = 6.47$) of the friend group. In subjects' larger circle of colleagues and acquaintances 76.88% ($SD = 14.59$) are Caucasian compared to 17.50% ($SD = 12.34$) East Asian. Such continued limited exposure into adulthood ensured that subjects had substantial exposure to own-race Caucasian faces and minimal exposure to other-race East Asian faces.

To ensure that media exposure was not influencing results, we also asked about hours per week spent watching TV or movies with predominantly Caucasian and East Asian casts. On average, subjects watched 8 ($SD = 5.73$) hours of television, movies or internet videos per week. The overwhelming majority of that time is spent watching Caucasian casts at 7.13 ($SD = 4.68$) hours. Four subjects reported watching Japanese-style cartoons (anime)—between those four subjects, the average number of hours watched per week was 2 ($SD = 0.82$). Subjects reported watching 0 h of live-action media with predominantly East Asian casts.

In each possible comparison, subjects' exposure to Caucasian and East Asian faces conformed to our inclusion criteria by a large margin, thus satisfying the conditions to be labeled as a *Caucasian group* for the purposes of our study.

3.2. Experimental setup

We utilized a computer equipped with a Cambridge Research