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Research report

Neural correlates of memory encoding and recognition for own-race and other-race faces in an associative-memory task

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ABSTRACT

The ability to recognize faces of family members, friends, and acquaintances plays an important role in our daily interactions. The other-race effect is the reduced ability to recognize other-race faces as compared to own-race faces. Previous studies showed different patterns of event-related potentials (ERPs) associated with recollection and familiarity during memory encoding (i.e., Dm) and recognition (i.e., parietal old/new effect) for own-race and other-race faces in a subjective-recollection task (remember-know judgments). The present study investigated the same neural correlates of the other-race effect in an associative-memory task, in which Caucasian and East Asian participants learned and recognized own-race and other-race faces along with background colors. Participants made more false alarms for other-race faces indicating lower memory performance. During the study phase, subsequently recognized other-race faces (with and without correct background information) elicited more positive mean amplitudes than own-race faces, suggesting increased neural activation during encoding of other-race faces. During the test phase, recollection-related old/new effects dissociated between own-race and other-race faces. Old/new effects were significant only for own-race but not for other-race faces, indicating that recognition only of own-race faces was supported by recollection and led to more detailed memory retrieval. Most of these results replicated previous studies that used a subjective-recollection task. Our study also showed that the increased demand on memory encoding during an associative-memory task led to Dm patterns that indicated similarly deep memory encoding for own-race and other-race faces.

1. Introduction

We encounter faces of family members, friends, and acquaintances every day, and the ability to recognize these faces plays an important role in our daily interactions. When this ability is compromised, it can negatively impact social exchanges by limiting those with whom one communicates and forms relationships. Experimentally, one example of this reduced ability to individuate faces arises when a participant of one race views a face of a different race. This so-called other-race effect, the phenomenon by which other-race faces are not recognized as well as own-race faces, has been investigated both behaviorally and electrophysiologically (Herzmann, et al., 2011; Horry et al., 2010; Lucas et al., 2011; Marcon et al., 2009; Meissner et al., 2005). Most of these studies have used a subjective-recollection task, in which participants make remember-know judgments (Herzmann et al., 2011; Lucas et al., 2011; Marcon et al., 2009; Meissner et al., 2005). A behavioral study has shown comparable results for recollection processes in the other-race effect using an associative-memory task, where participants were required to retrieve the faces together with additional context information (Horry et al., 2010). Here we investigated the neural correlates of the other-race effect in an associative-memory task.

The other-race effect has a robust foundation in behavioral studies; a memory advantage exists for own-race faces as compared to other-race faces. This memory advantage is often expressed in terms of the dual-process theory of recognition memory, which posits that recognition memory is composed of two sub-processes, recollection and familiarity, and that these components are dissociable (Mandler, 1980; Yonelinas, 2002). A common method of assessing recollection and familiarity is the Remember-Know procedure (Tulving, 1985), in which participants are asked to identify previously seen stimuli as either “remembered” (the face and some detail from the learning episode is remembered explicitly) or “known” (the face is familiar but participants cannot remember specific details from the learning episode). Behavioral studies on the other-race effect using a Remember-Know paradigm, or a modification of it, found that own-race faces were recognized more accurately and were accompanied by higher “remember” hit rates, which indicates enhanced recollection-

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related processing for own-race faces (Herzmann et al., 2011; Horry et al., 2010; Marcon et al., 2009; Meissner et al., 2005). Studies also found similar enhancements in familiarity-related processing, as evidenced by higher "know" hit rates (Herzmann et al., 2011) and lower false alarms rates for own-race faces (Herzmann et al., 2011; Horry et al., 2010; Marcon et al., 2009; Meissner et al., 2005).

In addition to numerous behavioral studies, electrophysiological studies on the other-race effect have revealed consistent neural patterns. Under the assumption of the dual-process theory, several distinct event-related potentials (ERPs) have been shown to reliably index differential recollection and familiarity processes for own-race and other-race faces. The neural correlate that characterizes the process of memory encoding, called the difference due to memory (Dm), reflects subsequent memory effects and is typically observed between 300 and 1000 ms as a central-parietal positivity (Herzmann et al., 2011; Yovel and Paller, 2004). Dms measure the amplitude differences between subsequently recognized and forgotten faces in the study phase. A previous study found that recollection-related amplitudes during memory encoding were reduced for own-race faces as opposed to other-race faces (Herzmann et al., 2011). This reduction in brain activation for own-race faces has been attributed to more efficient memory encoding and less recruitment of neural resources for own-race faces (Herzmann et al., 2011). In addition, Dms for recollection ("remember" responses) and familiarity ("know" responses) were indistinguishable for own-race but significantly different for other-race faces. Similar brain activation for subsequent recollection and familiarity was taken to indicate automatically deeper, or more elaborate, memory encoding (Herzmann et al., 2011) because studies that required participants to deeply encode stimuli reported similar pattern of results (Friedman and Trott, 2000; Smith, 1993). Only one other study also investigated subsequent memory effects for own-race and other-race faces and found, contrarily, smaller Dms for other-race as compared to own-race faces (Lucas et al., 2011). This study did not use the Remember-Know procedure. Its results therefore reflect a different contrast than in Herzmann et al. (2011) and cannot easily be compared. Lucas et al. (2011) interpreted diminished Dms for other-race faces as evidence for reduced semantic elaboration during the encoding of other-race faces (Lucas et al., 2011) which was assumed to be associated with reduced neural activation. Taken together, memory encoding appears to be more effortful when learning other-race in comparison to own-race faces.

The recollection-related ERP correlate during memory retrieval, typically referred to as the parietal old/new effect (Rugg and Curran, 2007), has also been shown to contribute to the other-race effect. The parietal old/new effect is usually observed as a parietal positivity in the test phase between 500 and 800 ms (Curran, 2000; Curran and Hancock, 2007; Rugg and Curran, 2007; Yovel and Paller, 2004) and reflects the amplitude differences between "remembered" old faces and "familiar" old faces in the Remember-Know paradigm. In experiments that do not use the Remember-Know paradigm but require "old" and "new" responses, the parietal old/new effect is taken as the contrast between old and new items during 500 and 800 ms (Rugg and Curran, 2007). A prior study found a robust parietal old/new effect for own-race faces but a different pattern of activation for other-race faces (Herzmann et al., 2011). Other-race faces were accompanied by additional activation of frontal regions, which was interpreted as the need to engage in post-retrieval monitoring in order to recollect these faces. The retrieval of other-race faces thus appeared to be more demanding than retrieval of own-race faces (Herzmann et al., 2011). Differential recollection-related old/new activation patterns have also been observed in studies of a related phenomenon, the own-age bias (Wiese et al., 2012, 2008), which is thought to arise by analogous mechanisms (Wiese et al., 2008).

Recognition-memory studies also typically report an old/new effect related to familiarity, referred to as the FN400 or mid-frontal old/new effect (Curran and Hancock, 2007; Rugg and Curran, 2007). The FN400 is marked by a frontal positivity between 300 and 500 ms during the test phase (Rugg and Curran, 2007). In the Herzmann et al. (2011) study, however, there was no evidence that the familiarity-related ERP correlate showed significant other-race effects. This same lack of familiarity old/new effects was seen in the Wiese et al. (2008) own-age bias study.

Although the majority of previous other-race studies have used subjective-recollection tasks, associative-memory tasks allow for a more objective assessment of recollection processes because they include an additional contextual component (e.g., a colored background, a fictional occupation) that is learned with the faces during the study phase (Curran and Hancock, 2007; Horry et al., 2010; MacKenzie and Donaldson, 2007; Yovel and Paller, 2004). During the test phase, the ability to recall the contextual detail as well as recognize the face is operationally defined as recollection, whereas the inability to recall the contextual detail but preserved ability to recognize the face represents familiarity. One behavioral other-race study (Horry et al., 2010) that used an associative-memory paradigm reported behavioral results similar to those of the subjective-recollection studies, replicating the findings of higher false alarm rates for other-race faces and higher "remember" hit rates for own-race faces.

No ERP study on the other-race effect has, to our knowledge, utilized an associative-memory task. However, several face recognition ERP studies have used such a task. One study found significant recollection-related Dms between 400 and 600 ms; familiarity-related Dms were insignificant (Yovel and Paller, 2004). Yovel and Paller's (2004) findings differ from those of Herzmann et al.'s study (2011), which showed that recollection-related and familiarity-related Dms for own-race faces were indistinguishable (Herzmann et al., 2011). This could potentially point to an influence of the associative-memory task on the neural correlates of the other-race effect in memory encoding.

The majority of associative-memory studies have consistently found that the parietal old/new effect is modulated by contextual information (Curran and Hancock, 2007; MacKenzie and Donaldson, 2007; Rugg et al., 1998; Yick and Wilding, 2014; Yovel and Paller, 2004). A study by Rugg et al. (1998) compared subjective-recollection and associative-memory tasks and found that recollection-related old/new effects were qualitatively similar in both tasks. This recollection-related old/new effect is also reliably found for own-race/own-age faces in subjective-recollection studies (Herzmann et al., 2011; Wiese et al., 2008).

Previous face recognition studies have yielded conflicting results regarding the role of the FN400 in associative-memory tasks (Curran and Hancock, 2007; Guillaume and Etienne, 2015; MacKenzie and Donaldson, 2007; Yick and Wilding, 2014; Yovel and Paller, 2004). A study by Yovel and Paller (2004) concluded that the neural correlates of recollection and familiarity were not dissociable, as both were modulated by contextual recollection. However, several more recent studies have found that familiarity old/new effects are independent of contextual recollection (Curran and Hancock, 2007; Guillaume and Etienne, 2015). A potential explanation for these inconsistent findings might be that the FN400 contributes to recollection of some contextual details but not to task-relevant ones. Other studies have argued that familiarity-related old/new effects are affected by the unitization of the target stimuli with its associated contextual detail (Ecker et al., 2007; Diana et al., 2011; Mollison and Curran, 2012). Other-race/other-age studies using subjective-recollection tasks have failed to observe FN400 old/new effects (Herzmann et al., 2011; Lucas et al., 2011; Wiese et al., 2008).

It is important to note that the controversial role of FN400 in associative-memory tasks could also be influenced from the larger disagreement over whether this ERP component accurately represents the neurocognitive process of familiarity. Some studies that have used unfamiliar stimuli (e.g., unfamiliar faces, geometric patterns), with relatively few conceptual representations, have argued that the lack of FN400 effects provides evidence that this component is an index of conceptual priming (Voss and Paller, 2009; Yovel and Paller, 2004).