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Research Report

Effects of previous experience and associated knowledge on retrieval processes of faces: An ERP investigation of newly learned faces

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ABSTRACT

Conspicuously absent from face recognition research is a direct comparison of well-known faces with newly learned faces for which the associated biographical knowledge and the perceptual expertise were experimentally manipulated. Such a comparison can test competing assumptions made by serial and interactive activation and competition (IAC) models about the role of previous experience and biographical knowledge in face recognition. We measured behavioral performance and event-related potentials (ERPs) for four classes of faces: unfamiliar faces, faces of celebrities, and two classes of experimentally familiarized faces learned one week prior to the recognition test either with or without associated biographical knowledge. Newly learned faces associated with biographical knowledge showed distinct priming and old/new effects starting around 420 ms in the ERP when compared to faces without such information, and when compared to famous faces. In addition, faces for which all biographical facts were successfully remembered showed not only faster recognition performance than faces without biographical knowledge, but also a priming effect in the N170 latency. Previous experience including biographical knowledge associated with a face thus influenced retrieval processes of faces both in late, semantic and early, pre-semantic processing stages. These findings provide novel evidence in favor of IAC models. In addition, famous faces had the same ERP effects as faces learned without associated facts. Our results show that newly learned faces are experimentally indistinguishable from famous faces yet provide superior experimental control.

1. Introduction

When recognizing a familiar person, a primary cue to familiarity and identity is the face. Although there is much research about the recognition of familiar faces, little is known about the role of varying levels of previous experience and person-specific biographical knowledge (including the name) for the retrieval of faces. Cognitive models of face recognition (e.g., Bruce and Young, 1986; Brédart et al., 1995; Burton et al., 1990) make different claims about whether person-identity knowledge may influence face recognition. We addressed this question on the behavioral level and with event-related brain potentials (ERPs) by comparing recognition processes for unfamiliar, newly learned, and famous faces. New faces were experimentally memorized either with or without person-identity facts and names in an extensive and

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standardized learning session that manipulated the depth of person-related knowledge and perceptual expertise with the faces. We concentrated on new faces that were thoroughly learned and for which memory was consolidated over one week (including seven nights of sleep, Wagner et al., 2003, 2007) as opposed to unfamiliar faces that were encountered for the first time immediately before recognition testing (e.g., Curran and Hancock, 2007; Kaufmann et al., 2009; Nessler et al., 2005; Tanaka et al., 2006).

Cognitive models of face recognition (e.g., Bruce and Young, 1986; Brédart et al., 1995; Burton et al., 1990) propose that, after an initial stage of structural encoding common to both unfamiliar and familiar faces, face recognition units (FRUs) are activated. FRUs are conceived as stores in long-term memory (LTM) that hold invariant structural features for each face known to an individual. After activating FRUs, so-called person-identity nodes (PINs) are triggered, leading to the activation of person-identity facts stored in semantic information units (SIUs; Burton et al., 1990) during previous encounters with the person. The final stage following PIN activation is the retrieval of the person's name. In the serial model (Bruce and Young, 1986), familiarity decisions are assumed to be made at pre-semantic stages, in particular at the level of FRUs. In interactive activation and competition (IAC) models (Brédart et al., 1995; Burton et al., 1990), familiarity decisions are thought to depend on the activation of PINs, which hold bidirectional connections to the SIUs. Serial and IAC models also differ in their claims about whether person-identity knowledge can influence pre-semantic processing stages. The serial model postulates that access to representations of faces, person-identity facts, and names proceeds in discrete, sequential steps. In this case, person-identity or name knowledge is irrelevant for face recognition. The IAC model, in contrast, allows for top-down feedback between subsequent stages. Here, person-identity or name knowledge can affect structural encoding and/or FRU activation.

To determine the influence of varying degrees of previous experience and person-identity knowledge on face recognition processes, we measured both ERPs and recognition performance in a priming experiment. Priming has been a fundamental experimental paradigm for the construction of the serial and IAC face recognition model (Bruce and Young, 1986; Burton et al., 1990). Repetition priming, with exposition times and inter-stimulus intervals allowing for conscious recognition of the prime stimuli, has traditionally been considered to activate domain-specific memory representations for faces (FRUs and PINs). The priming manipulation is taken to facilitate the access to the FRUs and PINs. The priming-facilitated access to FRUs and PINs during face recognition is reflected in variations of specific ERP components as will be explained later.

ERPs are indeed a particularly well-suited tool because research on face recognition has identified several ERP components that possess specific functional significance. The occipital P100 component is elicited by any kind of visual stimuli. It is commonly taken as a familiarity-independent indicator of early, domain-general visual processes (Itier and Taylor, 2004; Pfütze et al., 2002). A recent study provides evidence for a possible influence of associated knowledge on the P100 (Abdel Rahman and Sommer, 2008). Abdel Rahman and Sommer (2008) found that objects associated with extensive knowledge elicited smaller P100 amplitudes than objects associated with minimal knowledge. Although this study is broadly in favor of top-down effects of knowledge on perception, it did not address the effects of varying degrees of familiarity on perceptual processes.

The occipito-temporal N170 component is elicited by any visual object and is typically larger for face stimuli than for other non-face objects (e.g. Bentin et al., 1996). That manipulations of a portrait (e.g., turning it upside-down) affect the amplitude and latency of the N170 (e.g., Itier and Taylor, 2002) is taken as evidence that the N170 reflects the structural encoding of faces regardless of their familiarity. Indeed, the N170 appears to be mostly unaffected by the familiarity of a face (Herzmann and Sommer, 2007; Pfütze et al., 2002; Schweinberger et al., 2002; Tanaka et al., 2006). However, some studies investigating face recognition processes for personally familiar faces do suggest an effect of face familiarity already at the level of the N170 (Caharel et al., 2006; Kloth et al., 2006).

Familiarity has been consistently found to influence the ERP starting around 250 ms. In repetition priming paradigms, face familiarity modulates the early and late repetition effects (ERE and LRE, respectively). The ERE (or N250r), the ERP difference wave between primed (i.e., preceded by the same face) and unprimed (i.e., preceded by an unrelated face) faces appearing between 250 and 300 ms post stimulus, consists of an increased negativity at inferior temporal electrode sites and an increased positivity at frontal sites. The ERE was often found to be smaller or even absent for unfamiliar as compared to familiar faces (e.g. Pfütze et al., 2002; Schweinberger et al., 2002), and larger for personally familiar than for famous faces (Herzmann et al., 2004). These findings indicate that the ERE depends on the existence of representations of individual faces in LTM. The ERE was suggested to be generated at pre-semantic, early processing stages and related to the temporary activation of FRUs because it was not found when the person's name, for example "Barak Obama," preceded the face of Barak Obama or when a different but related face, Michelle Obama, preceded the face of Barak Obama (associative priming; cf. Schweinberger, 1996). EREs were also found for newly learned faces (Herzmann and Sommer, 2007; Itier and Taylor, 2004; Kaufmann et al., 2009; Tanaka et al., 2006).

The LRE (or N400), the ERP difference wave between primed (i.e., preceded by the same face) and unprimed (i.e., preceded by an unrelated face) faces, is characterized by increased centro-parietal positivity at latencies of 300–600 ms (Herzrzmann et al., 2004; Pfütze et al., 2002). It is larger for familiar than for unfamiliar faces (e.g., Pfütze et al., 2002; Schweinberger et al., 2002) and for personally familiar than for famous faces (Herzmann et al., 2004). The LRE is domain-general and can be elicited by both faces and names of familiar people if it is preceded by the name or face of the same or a related person (Schweinberger, 1996). The LRE is therefore thought to reflect the activation of late, semantic processing stages like PINs (Bruce and Young, 1986) or SIUs (Burton et al., 1990). The LRE has been suggested to resemble modulations of the N400 component, which is associated with semantic context integration or retrieval from semantic memory (Kutas and