BRAIN RESEARCH 1124 (2006) 70–80

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BRAIN RESEARCH

Research Report

Memory systems for structural and semantic knowledge of faces and buildings

Friederike M. Engst[a,*], *Manuel Martín-Loeches*[b], *Werner Sommer*[a]

[a]*Institut für Psychologie, Humboldt-Universität zu Berlin, Germany*
[b]*Universidad Complutense de Madrid and Instituto de Salud Carlos III, Spain*

ARTICLE INFO

Article history:
Accepted 13 September 2006
Available online 7 November 2006

Keywords:
Event-related potential
Face recognition
Object recognition
Structural knowledge
Semantic knowledge

ABSTRACT

It is an ongoing debate whether specific neurocognitive systems are involved in face and object recognition, particularly for analyses that require the access to stored structural and semantic knowledge. Here we compared the processing of familiar (at the exemplar level) and unfamiliar faces and buildings by recording event-related potentials in a repetition priming paradigm. We focused on the early repetition effect (ERE/N250r) which has been proposed to indicate the access to stored structural knowledge and the late repetition effect (LRE/N400), a possible indicator of semantic knowledge. An ERE/N250r was present for familiar buildings and smaller than for faces, but indistinguishable in terms of scalp topography. In contrast, the LRE/N400 was stimulus specific in topography. These findings suggest initial access to a common store of structural knowledge followed by the activation of category-specific cortical representations of person- and building-related semantic knowledge.

1. Memory systems for structural and semantic knowledge of faces and buildings

Whether specific neurocognitive systems are involved in face and object recognition is an ongoing debate (e.g., Haxby et al., 2001; Kanwisher, 2000; Tarr and Gauthier, 2000). This issue is highly interesting because of the importance of human faces in social interaction and communication and the apparent ease of remembering and discriminating many different faces despite of their uniform basic structure. The extraordinary skills of humans in dealing with faces on their own may indicate the existence of specialized processing modules unrelated to those involved in visual object processing (e.g., McNeil and Warrington, 1993). Alternatively, face and object recognition may be mediated by the same neurocognitive systems with differences between faces and non-face objects arising from specific demands on these systems (e.g., Tarr and Cheng, 2003).

Functional models of face and object recognition follow similar lines. In the widely accepted model of face recognition by Bruce and Young (1986) the initial processing stages include pictorial and structural encoding, providing the necessary information, among others, for the so-called face recognition units (FRUs). In FRUs the products of structural encoding are matched with stored structural representations of known faces. Information from the activated FRUs facilitates the access to person identity nodes (PINs), from where identity-specific semantic information and the names of persons can be activated. Object recognition models (e.g., Ellis and Young, 1996) posit that after perceptual and structural encoding of an object, its structural representation is matched to representations stored in object recognition units (ORUs). This allows the

* *Corresponding author*. Institut für Psychologie, Technische Universität Dresden, Zellescher Weg 17, 01062 Dresden, Germany. Fax: +49 351 46333522.
E-mail address: engst@psychomail.tu-dresden.de (F.M. Engst).

0006-8993/$ – see front matter
doi:10.1016/j.brainres.2006.09.038

access to semantic representations and name retrieval. The present study focuses on processes related to accessing stored structural representations and identity-specific semantic information. In the following we will describe proposed similarities and differences in face and object recognition in terms of cognitive and neuronal processes taking place at these stages.

1.1. *Pictorial and structural encoding*

The perception of objects and faces relies to some extent on different mechanisms and stimulus properties (e.g., Tanaka and Farah, 1993; for an overview see Bruce and Humphreys, 1994). In the literature different views regarding the underlying neural substrates of pictorial and structural encoding of faces and objects have been discussed (Chao et al., 1999; Haxby et al., 2001; Ishai et al., 2000; Kanwisher et al., 1997; McCarthy et al., 1997; Spiridon and Kanwisher, 2002).

Of interest for the issues here are ERP components that have been related to different stages of face and object processing. In this regard, the P100 is a positive-going deflection in the ERP with a peak latency of about 100 ms at occipital electrode sites and is thought to reflect early visual processes in extra-striate areas. It is sensitive to contrast, brightness, and size of a picture (Schendan et al., 1998). As yet there is little evidence that the P100 reflects face-specific processes (for an exception see Itier and Taylor, 2002, 2004a).

The subsequent N170 is a negativity around 150–200 ms at occipito-temporal sites that has been held to be face-specific (Bentin et al., 1996; Xu et al., 2005). However, several studies suggest that the N170 might not be face-specific but reflect the processing of fine-grained shape information for both face and non-face stimuli (e.g., Kiefer, 2001; Tanaka et al., 1999). Most of the pertinent studies failed to find familiarity effects (e.g., Eimer, 2000; Schweinberger et al., 2002a) or repetition effects in N170 (e.g., Eimer, 2000; Henson et al., 2004; Pfütze et al., 2002; Schweinberger et al., 1995; Tsivilis et al., 2001), suggesting that this component reflects structural encoding in general rather than recognition of individuals.

1.2. *Accessing stored structural representations*

Following perceptual encoding, models of face and object recognition posit the access to stored representations of both objects and faces. On the one hand, studies of brain damaged patients suggest the existence of double dissociations between face and object recognition (e.g., DeRenzi, 1986; McNeil and Warrington, 1993; Moscovitch et al., 1997). However, double dissociations do not necessarily indicate that the dissociated tasks are served by entirely independent modules because they might rely to a quantitatively different degree on the same mechanisms (Plaut, 1995) and may also depend on the categorization level and expertise of the patient (Gauthier et al., 1999).

On the other hand, there is an ongoing debate in the imaging literature whether familiarity of faces or objects activates category-specific regions in inferotemporal cortex such as the FFA. As reviewed by Henson et al. (2002) there are both positive and negative findings of familiarity effects in these regions. Even though, direct comparisons of familiarity effects for faces and non-face objects are relatively rare and not free of several interpretation problems. For instance, in the Gorno-Tempini and Price (2001) study the data indicate some category-specificity at a postperceptual level but they do not allow a distinction between the access to stored perceptual representations and semantic representations. In the study by Grill-Spector et al. (2004) the task for faces involved the identification of an individual face, whereas non-face discriminations (e.g., roses vs. other flowers) occurred at the subordinate level at best.

A further source of evidence about category specificity on a postperceptual level is the ERPs. In repetition priming Schweinberger et al. (1995) observed more negative ERP amplitudes for repeated relative to non-repeated faces over occipito-temporal regions and more positive amplitudes over fronto-central regions. This effect appeared rather early (around 250–300 ms) and was therefore termed early repetition effect (ERE) or – more recently – N250r. Several lines of evidence support the suggestion that the ERE/N250r reflects the access to domain-specific stored perceptual representations. The ERE/N250r is more pronounced for familiar than for unfamiliar persons (Herzmann et al., 2004; Pfütze et al., 2002; Schweinberger et al., 1995) and it is absent when faces are primed by portraits of different but semantically related persons (Lady Di → Prince Charles). In addition, when different portraits of the same person are presented as prime and target the ERE/250r is present, albeit smaller than when the same pictures are used (Schweinberger et al., 2002a). Brain electric source analysis (Schweinberger et al., 2002b, 2004) indicated a generator for the ERE/N250r in the fusiform gyrus, a region that has been found to be involved in face recognition (Kanwisher et al., 1997) and face repetition priming (Henson et al., 2000, 2002).

Two recent studies compared the ERE/N250r to faces and objects. In an immediate repetition paradigm Schweinberger et al. (2004) used pictures of faces and, among others, cars, an object category with perceptually homogeneous features. The authors observed an ERE/N250r for faces but not for cars. In a rapid-stream-stimulation paradigm Martín-Loeches et al. (2005) found ERE/N250rs to faces and names of famous persons and also to pictures of various common objects. The latter ERE/N250r, however, was markedly different in scalp topography from that to faces. Overall, these results seem to suggest different processes involved in accessing stored representations of faces and objects. However, in both studies the non-face objects were not accessed at exemplar level but at basic (Martín-Loeches et al., 2005) or subordinate level (Schweinberger et al., 2004). For that reason it remains unclear whether the findings of face-specific ERE/N250r relate to the different entry levels or to the different categorization processes performed on the stimuli. Therefore, it was the primary aim of the present study to compare faces and non-face objects that can likewise be accessed at the exemplar level in terms of their ERE/N250r.

1.3. *Accessing semantic memory*

The access to stored perceptual representations of familiar faces and objects is considered to be followed by the