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Research report

Long-term information and distributed neural activation are relevant for the "internal features advantage" in face processing: Electrophysiological and source reconstruction evidence

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ABSTRACT

In face processing tasks, prior presentation of internal facial features, when compared with external ones, facilitates the recognition of subsequently displayed familiar faces. In a previous ERP study (Olivares & Iglesias, 2010) we found a visibly larger N400-like effect when identity mismatch familiar faces were preceded by internal features, as compared to prior presentation of external ones. In the present study we contrasted the processing of familiar and unfamiliar faces in the face-feature matching task to assess whether the so-called "internal features advantage" relies mainly on the use of stored face-identity-related information or if it might operate independently from stimulus familiarity. Our participants ($N = 24$) achieved better performance with internal features as primes and, significantly, with familiar faces. Importantly, ERPs elicited by identity mismatch complete faces displayed a negativity around 300–600 msec which was clearly enhanced for familiar faces primed by internal features when compared with the other experimental conditions. Source reconstruction showed incremented activity elicited by familiar stimuli in both posterior (ventral occipitotemporal) and more anterior (parahippocampal (ParaHIP) and orbitofrontal) brain regions. The activity elicited by unfamiliar stimuli was, in general, located in more posterior regions. Our findings suggest that the activation of multiple neural codes is required for optimal individuation in face-feature matching and that a cortical network related to long-term information for face-identity processing seems to support the internal feature effect.

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1. Introduction

Faces are visual stimuli with both high complexity and stable organization. Several cognitive studies on face perception and face recognition have explored how specific parts of the face contribute to more effective processing of the person's identity. In particular, some behavioural experiments have shown that internal features (eyes, eyebrows, nose, cheeks and mouth) are more relevant than external features (hairstyle, chin, and ears) for successful recognition of familiar faces. That is, highly known faces are more rapidly or accurately recognized when they are preceded by internal versus external features (Brunas, Young, & Ellis, 1990; Ellis, Shepherd, & Davies, 1979; Young et al., 1985). On the other hand, external features have been considered important when new face representations or unfamiliar faces are being processed (Haig, 1986; Megreya & Bindemann, 2009; Sergent, 1986; Veres-Injac & Schwaninger, 2009). In fact, developmental studies have found that external features are crucial for face recognition in both infants and children (Campbell, Walker, & Baroncohen, 1995; Megreya & Binderman, 2009; Mondloch et al., 1999; Mondloch, Le Grand, & Maurer, 2002; Pascalis, De Schonen, Morton, Deruelle, & Febre-Grenet, 1995; Rose, Jankowski, & Feldman, 2008; Simion, Cassia, Turati, & Valenza, 2001). Interestingly, neuropsychological research has reported that prosopagnosics are impaired in the perception and recognition of both internal and external facial features (Caldara et al., 2005; Le Grand et al., 2006). More recently, neuroimaging research has shown that both types of features seem to be represented holistically in face selective regions of the visual cortex (Andrews, Davies-Thompson, Kingstone, & Young, 2010; Axelrod & Yovel, 2010). All this suggests that visual inputs conveyed by both parts of the face could be required for optimal face processing.

One finding reported in the behavioural experiments previously mentioned is that internal features are processed more effectively in familiar than in unfamiliar faces, whereas there is no difference in the processing of external features between both types of faces (Ellis et al., 1979; Young, Hay, Mcweeny, Flude, & Ellis, 1985; but see also Fletcher, Butavicius, & Lee, 2008). As suggested by the authors, a conclusion that can be drawn from such results is that one difference between the processing of familiar and unfamiliar faces lies in how their internal features are used (Young et al., 1985). Since the differential relevance of the internal features in familiar faces was found only when participants made use of structural (vs pictorial) face codes, a question to be addressed is whether the "internal features advantage" (Campbell et al., 1995) is primarily based on the retrieval of stored memories for faces or whether such features can also facilitate the encoding of a face structural description even from the first time a face is perceived.

In a previous study (Olivares & Iglesias, 2010) we found a larger and longer lasting N400-like effect when identity mismatch familiar faces were preceded by internal features than when preceded by external ones. This effect was considered the first electrophysiological correlate of the "internal feature advantage" in face recognition. Source reconstruction using LORETA (Pascual-Marqui, Michel, & Lehmann, 1994, 2002) showed increased brain activity in those brain regions (i.e., bilateral frontal and left temporal) that support a face-identity-related neural network (Barbeau et al., 2008; Gorno-Tempini et al., 1998; Haxby, Hoffman, & Gobbini, 2000; Ishai, 2008; Leveroni et al., 2000). Accordingly, we suggested that prior presentation of internal features would facilitate the activation and retrieval of both high-level visual and semantic information associated with known faces to a greater extent than external features. To better understand the functional meaning of the "internal features advantage" the present study aims to investigate whether this effect (as reflected by an enhanced N400) relies mainly on the availability of face-related long-term information or, conversely, if such features are particularly effective for activating an individuation mechanism which operates independently from stimulus familiarity. With this aim, we presented both familiar and unfamiliar stimuli in the face-feature matching task. To date there is no electrophysiological evidence of the differential relevance of internal features in face processing directly contrasting familiar and unfamiliar face processing in the same group of participants. We hypothesized that prior presentation of internal features in the face-feature matching task would elicit a more apparent mismatch effect (namely, larger negative amplitude elicited by identity mismatch targets around 300–500 msec) when compared with prior presentation of external features in familiar faces. In turn, this ERP effect might not be as significant in the case of unfamiliar faces, indicating a lack of rich contextual long-term information associated with this type of stimulus.

In order to study the neural generators underlying expected ERP effects in both familiar and (if elicited) unfamiliar face processing, in the present experiment we have used a novel EEG source reconstruction method known as "Bayesian Model Averaging (BMA)" (Trujillo-Barreto, Aubert-Vazquez, & Valdés-Sosa, 2004), which has proved to provide optimal inverse solutions (ISs) in ERP source analyses (Bobes et al., 2010). Source reconstruction would reveal that the underlying neural generators of this effect represent a distributed neural network that supports familiar face recognition. This network is believed to include "core" regions (i.e., posterior occipital and fusiform) related to high visual analysis of invariant aspects of faces and "extended" regions (i.e., anterior temporal, orbitofrontal, precuneus/posterior cingulate) involved in retrieval of episodic memory and biographical information related to identity processing (Gobbini & Haxby, 2007; Gorno-Tempini et al., 1998; Haxby et al., 2000; Ishai, 2008; Ishai, Schmidt, & Boesiger, 2005; Leveroni et al., 2000).

2. Method

2.1. Participants

Thirty-eight right-handed healthy university students took part in this experiment [mean age: 23.41 (SD: 5.0), 28 females]. When checking for EEG recording artefacts, we decided to analyse only those EEGs with at least 24 artefact-free epochs (around 50% of total trials in the experiment). Twenty-four participants [mean age: 22.70 (SD: 4.1), 18 females] fulfilled