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Spatio-temporal localization of the face inversion effect: an event-related potentials study

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Abstract

Event-related potentials (ERPs) from 58 electrodes at standard EEG sites were recorded while 14 subjects performed a delayed-matching task on normal and inverted faces. A large and single difference between normal and inverted face processing was observed at occipito-temporal sites about 160 ms following stimulus onset, mainly in the right hemisphere (RH). Although the topographies indicate that similar areas are involved at this latency in processing the two types of stimuli, the electrophysiological activity, which corresponds to the previously described N170, was larger and delayed for inverted as compared to normal face processing. These results complement and specify, at a neural level, previous behavioral and divided visual field studies which have suggested that the loss of configural face information by inversion may slow down and increase the difficulty of face processing, particularly in the RH.

Keywords: Event-related potentials; Face inversion effect; Face processing; N170

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1. Introduction

The question as to whether face and object recognition involve different processes underlined by different neural structures, is a central concern of visual cognitive neuroscience. Several lines of evidence from cognitive psychology (Yin, 1969; Bruce, 1988; Tanaka and Farah, 1993), neuropsychology (Farah, 1991; Moscovitch et al., 1997), neurophysiology (Desimone, 1991; Perrett et al., 1992) and more recently neuroimaging studies (Sergent et al., 1992; Kanwisher et al., 1997; McCarthy et al., 1997) support the thesis of an autonomous processing system specifically dedicated to faces. An alternative view challenges the notion of a specialized face system and argues that general recognition mechanisms are sufficiently complex and plastic to account for apparently face-specific effects obtained with normal and brain-injured subjects (Damasio et al., 1982; Gauthier and Tarr, 1997; Gauthier et al., 1999).

According to the dominant modular view, faces are special because their recognition relies more on configural[1] information than recognition of other visual objects (Tanaka and Farah, 1993; Rhodes, 1993; Moscovitch et al., 1997). This configural information, such as the spatial relations between different parts of the face, plays a more important role in face processing than isolated features. Strong support for this view comes from studies showing that vertical inversion, which disrupts the coding of configural cues (Rhodes et al., 1993; Rhodes, 1993; Young et al., 1987), impairs recognition of faces more than recognition of other classes of mono-oriented objects. This disproportionate inversion effect has been regarded as the first evidence for specialized face recognition mechanisms (Yin, 1969, 1970; Diamond and Carey, 1986; Tanaka and Farah, 1993). To summarize, inversion of a face preserves the low-level visual features but would not involve specific face configural mechanisms (Moscovitch et al., 1997).

Studying how the human brain processes normal as compared to inverted faces may thus be a first critical stage to the understanding of the spatio-temporal neural networks involved in configural face processing.

Few studies have addressed directly the question of face inversion processing with respect to its neural basis and characteristics. A recent fMRI study (Kanwisher et al., 1998) showed a reduced activation of the 'face fusiform area', a right-hemisphere region previously described as being face specific (Kanwisher et al., 1997), for inverted faces but the difference between normal and inverted faces was small and inconsistent across subjects. Moreover, subjects were scanned in two conditions: a passive stimulation of both kinds of stimuli, and an active 1-back matching

[1] The terms configural or holistic information are often used interchangeably in the face recognition litterature (Tanaka and Farah, 1993; Kanwisher et al., 1997). Here, we will avoid the term holistic as it is not clear whether the holistic information conveyed by faces refers to the canonical configuration shared by all faces (the first order configuration, according to Diamond and Carey, 1986) or the individual variations within the fixed configuration, termed the second order relational features (Diamond and Carey, 1986). Following Rhodes (1993), the simpler term configural information will be used throughout the paper to refer to the latter, which is the only kind of configural information that varies between faces and used with expertise.