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Picture-plane inversion leads to qualitative changes of face perception

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Abstract

Presenting a face stimulus upside-down generally causes a larger deficit in perceiving metric distances between facial features ("configuration") than local properties of these features. This effect supports a qualitative account of face inversion: the same transformation affects the processing of different kinds of information differently. However, this view has been recently challenged by studies reporting equal inversion costs of performance for discriminating featural and configural manipulations on faces. In this paper I argue that these studies did not replicate previous results due to methodological factors rather than largely irrelevant parameters such as having equal performance for configural and featural conditions at upright orientation, or randomizing trials across conditions. I also argue that identifying similar diagnostic features (eyes and eyebrows) for discriminating individual faces at upright and inverted orientations by means of response classification methods does not dismiss at all the qualitative view of face inversion. Considering these elements as well as both behavioral and neuropsychological evidence, I propose that the generally larger effect of inversion for processing configural than featural cues is a mere consequence of the disruption of holistic face perception. That is, configural relations necessarily involve two or more distant features on the face, such that their perception is most dependent on the ability to perceive simultaneously multiple features of a face as a whole.

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1. Introduction: holistic perception and face inversion

An inverted face is extremely difficult to recognize. This rather old observation (e.g., Hochberg & Galper, 1967) has become widely documented in the face processing literature, for several reasons. First, the effect of inversion is much larger for faces than for other object categories, a phenomenon known as the 'face inversion effect' (Yin, 1969). Together with the observation of recognition impairments limited for faces following brain injury (prosopagnosia: Bodamer, 1947; Wigan, 1844) and of neurons responding selectively to faces in the monkey inferotemporal cortex (Gross, Rocha-Miranda, & Bender, 1972), this face inversion effect is one of the first (and most compelling) sources of evidence that faces are processed by specific brain mechanisms (i.e., those that are particularly affected by inversion, Yin, 1969). Second, the effect of face inversion is extremely robust, and has been observed in a variety of conditions: for processing familiar and unfamiliar faces, in old/new recognition tasks or matching tasks, with or without delay between the stimuli to match, with upright and inverted trials blocked or randomized (for a review see Rossion & Gauthier, 2002; for more recent references: e.g., Barton, Keenan, & Bass, 2001; Barton, Zhao, & Keenan, 2003; Goffaux, in press; Goffaux & Rossion, 2007; Jacques, d'Arripe, & Rossion, 2007; Leder & Carbon, 2006; Le Grand, Mondloch, Maurer, & Brent, 2001; Mondloch, Le Grand, & Maurer, 2002; Rhodes, Hayward,

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& Winkler, 2007; Riesenhuber, Jarudi, Gilad, & Sinha, 2004; Russell, Biederman, Nederhouser, & Sinha, 2007; Yovel & Kanwisher, 2004).

Third and most importantly, since Yin (1969) reported that the participants of his experiment were unable to "*get a general impression of the whole picture*" (p. 145) for inverted faces, a number of empirical studies have supported this intuition. When a face stimulus is presented at upright orientation, the processing of a facial feature (e.g., eyes, nose, mouth,...) is affected by alterations to the identity or the position of one or several other features of the face (e.g., Farah, Wilson, Drain, & Tanaka, 1998; Homa, Haver, & Schwartz, 1976; Mermelstein, Banks, & Prinzmetal, 1979; Sergent, 1984; Suzuki & Cavanagh, 1995; Tanaka & Farah, 1993; Tanaka & Sengco, 1997; Young, Hellawell, & Hay, 1987). The most compelling illustration of this phenomenon comes from an adaptation of the so-called face composite effect (Young et al., 1987) to create a visual illusion in which identical top halves of faces are perceived as being slightly different if they are aligned with different bottom parts, even when the bottom parts are irrelevant and not attended to (Fig. 1a). This face composite illusion is a particularly clear demonstration that the features of a face (here the two halves of a single face) cannot be perceived in isolation. That is, the perception of the attended top part in this example *depends* on the identity of the bottom part and its position (since the illusion vanishes when the two parts are misaligned spatially; for empirical demonstrations in face matching tasks see e.g., Goffaux & Rossion, 2006; Hole, 1994; Le Grand, Mondloch, Maurer, & Brent, 2004; Michel, Rossion, Han, Chung, & Caldara, 2006; Rossion & Boremanse, in press). This empirical observation is generally interpreted as a deficit in the integration of the facial features into a Gestalt, a global picture, a so-called 'configural' (Sergent, 1984; Young et al., 1987) or 'holistic' (Farah et al., 1998; Tanaka & Farah, 1993) representation.

Strikingly, the face composite illusion is abolished or strongly reduced when faces are presented upside-down (Fig. 1b; e.g., Goffaux & Rossion, 2006; Hole, 1994; Le Grand et al., 2004; Michel et al., 2006; Rossion & Boremanse, in press). This dramatic impairment of the interdependence of facial features with inversion has been demonstrated in other behavioral paradigms measuring the interdependence between facial features (e.g., Farah et al., 1998; Leder & Carbon, 2005; Suzuki & Cavanagh, 1995; Tanaka & Farah, 1993; Tanaka & Sengco, 1997; see also Sergent, 1984; Thompson, 1980): the location and/or the identity of one or several facial feature(s) does not modulate the processing of a target feature when the face is presented upside-down.

These observations have been particularly important in the field because an extremely simple stimulus transformation like inversion, while preserving the low-level visual information of the stimulus, can be used to reduce the interdependence of facial features during face processing tasks. They have also supported the view that faces are perceived more holistically/configurally than other objects, and thus could be relatively more, or even selectively, impaired (i.e., by inversion, or following brain damage, prosopagnosia, e.g., Sergent & Signoret, 1992). More recently, neuroimaging (Mazard, Schiltz, & Rossion, 2006; Yovel & Kanwisher, 2004, 2005) and electrophysiological (Jacques et al., 2007) studies in humans have compared the discrimination of individual upright and inverted faces in order to clarify the neural underpinnings of this holistic/configural face processing.

It is important to stress that the terms 'holistic' or 'configural', which are sometimes used interchangeably in the literature among other terms, refer here to a perceptual *process* and not a cue that can be manipulated on a single face stimulus. In line with recent reviews on this topic (Maurer, Le Grand, & Mondloch, 2002; Rossion & Gauthier, 2002), I will only use the term 'holistic' in the remaining part of the text to refer to this process. Indeed, the term 'configural' seems more ambiguous to me, since various authors in the field have used 'configural' to refer either to a process (e.g., Sergent, 1984; Young et al., 1987), *or* to physical information that can be measured and manipulated on a stimulus (metric distances between features or configural relations, e.g., Rhodes, 1988). To avoid any ambiguity, in the remaining part of this paper, the term 'configural' will always refer to the metric distances between features (see Section 2 below).

Even though there is no formal and widely accepted definition of holistic face processing in the literature, the term 'holistic' has been widely used. In line with early (Galton, 1883) and more recent (e.g., Farah et al., 1998; Ingvalson & Wenger, 2005) proposals, most researchers would probably agree with a definition of holistic face processing as *the simultaneous integration of the multiple features of a face into a single perceptual representation*. Yet, admittedly, the empirical evidence collected so far and cited above essentially shows that facial features are *interdependent*. Empirical studies have not shown that the *whole* of the face stimulus is necessarily involved in this process, or that

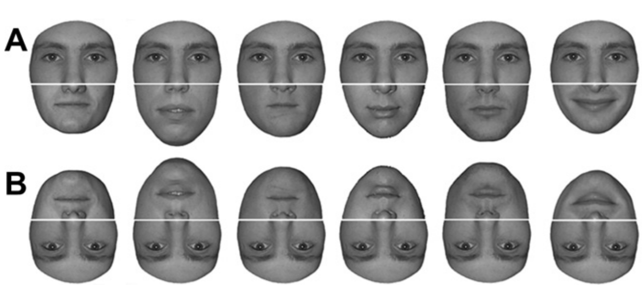

Fig. 1. The face composite illusion is a nice demonstration of the integrative nature of face perception and how it is affected by inversion. Above, upright faces: all top halves of the faces (above the white line) are identical, yet they are perceived as slightly different due to the presence of the different bottom parts. This illustrates how facial features influence each other for upright faces. Below, the illusion vanishes or is strongly reduced when the same stimuli are presented upside-down.