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Brief article

Face inversion and acquired prosopagnosia reduce the size of the perceptual field of view

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ABSTRACT

Using a gaze-contingent morphing approach, we asked human observers to choose one of two faces that best matched the identity of a target face: one face corresponded to the reference face's fixated part only (e.g., one eye), the other corresponded to the unfixated area of the reference face. The face corresponding to the fixated part was selected significantly more frequently in the inverted than in the upright orientation. This observation provides evidence that face inversion reduces an observer's perceptual field of view, even when both upright and inverted faces are displayed at full view and there is no performance difference between these conditions. It rules out an account of the drop of performance for inverted faces – one of the most robust effects in experimental psychology – in terms of a mere difference in local processing efficiency. A brain-damaged patient with pure prosopagnosia, viewing only upright faces, systematically selected the face corresponding to the fixated part, as if her perceptual field was reduced relative to normal observers. Altogether, these observations indicate that the absence of visual knowledge reduces the perceptual field of view, supporting an indirect view of visual perception.

1. Introduction

The human face is commonly considered the quintessential whole, or Gestalt, i.e., a visual stimulus that is different from the sum of its parts (Biederman & Kalocsai, 1997; Pomerantz & Kubovy, 1986). Supporting this view, behavioral studies have shown that a part is better recognized if it is presented in a whole face than if it is presented in isolation (Tanaka & Farah, 1993). Also, performance at recognizing half of a face is decreased when it is aligned with half of another face (for a review Rossion, 2013; Young, Hellawell, & Hay, 1987). These effects are substantially reduced if the face is presented upside-down, suggesting that they depend on internal representations that have probably been derived from visual experience. The dominant account of these observations is that an upright face is perceived as a Gestalt, i.e., holistically/configurally, while an inverted face is perceived part-by-part (Farah, Wilson, Drain, & Tanaka, 1998).

An implication of this holistic/configural view is that an upright face is associated with a larger *perceptual field*, namely, the area of vision from which diagnostic information can be extracted, than an inverted face (Rossion (2009, 2013)). Faced with the exact same stimulus, an observer would perceive the whole face when it is upright, i.e., with a large perceptual field, but would see only a single part at a time when it is inverted, i.e., with a reduced perceptual field (Rossion, 2009, 2013; Xu & Tanaka, 2013). However, in contrast to the holistic/configural view, it has also been suggested that upright and inverted faces are processed the same way, using part-based local information more efficiently for upright than inverted faces (Sekuler,

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Gaspar, Gold, & Bennett, 2004; see also Gold, Mundy, & Tjan, 2012).

Clarifying this issue would contribute to our understanding of one of the most important phenomena observed in experimental psychology, namely, the detrimental effect of inversion on recognition of faces relative to other object categories (Yin, 1969).

To this end, we used a paradigm that differs from previous studies at two levels: (1) there is no decrease of performance (i.e., efficiency of processing) for inverted relative to upright faces and (2) only full faces are presented, rather than isolated local parts. This paradigm is inspired by the gaze-contingency (GC) technique developed in reading (McConkie & Rayner, 1975), and later applied to face stimuli with a gaze-contingent window and mask (Van Belle, de Graef, Verfaillie, Busigny, & Rossion, 2010b; Van Belle, de Graef, Verfaillie, Rossion, & Lefèvre, 2010a). Most recently, Miellet, Caldara, and Schyns (2011) developed a GC approach in which two face identities are displayed on top of each other, simultaneously providing one identity information on the window of fixation corresponding roughly to one face part, and the other identity information outside of that fixated part. Using this approach with famous faces, these authors showed that a given observer can use both kinds of information, which they called local and global, respectively, to recognize a face. Here, a similar GC approach was used in which a displayed full face was composed of a combination of two individual faces: one that corresponded to the fixated part in a gaze-contingent way, and the other one to the unfixated area of the face (Fig. 1). If inversion reduces the perceptual field, inverting the exact same face should increase the proportion of responses based on the fixated part ("part-based responses"), all other parameters remaining constant. Furthermore, with upright faces, we hypothesized that a brain-damaged patient with prosopagnosia who has normal peripheral vision but impaired holistic face perception (PS, Rossion et al., 2003) would systematically provide responses based on her fixated part only.

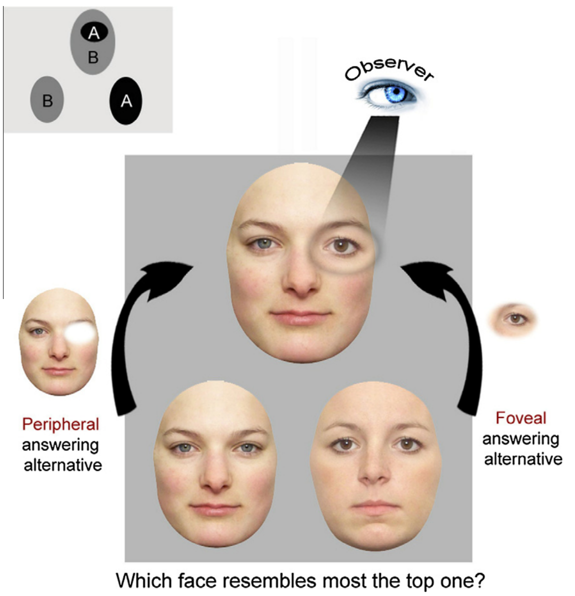

Fig. 1. Schematic illustration of the paradigm. On each trial, two full faces (A and B) are presented at the bottom of the screen, one of which must be chosen as more similar in identity to the target face above. The target face is made of a combination of the two faces, so that there is no 'correct' or 'incorrect' response. One of the faces corresponds to the fixated 'window' of the target face, which changes dynamically with fixation, while the other face corresponds to the information outside of fixation.

2. Materials and methods

2.1. Participants

Fourteen naïve participants (2 males, age range: 22–26 yrs., all but one right-handed), with normal or corrected-to-normal visual acuity were tested individually. The prosopagnosic patient PS (Rossion et al., 2003), and seven age-matched controls (age range 59–61, average age 61, all right-handed) were also tested. Following brain damage, PS suffers face-selective recognition impairment (Busigny, Graf, Mayer, & Rossion, 2010). Her case has been described in behavioral and neural studies: relevantly, she shows no face inversion effect (Busigny & Rossion, 2010), and shows no evidence for interactivity of processing between facial parts (Ramon, Busigny, & Rossion, 2010). Importantly, PS has a small left paracentral scotoma, but her peripheral vision is intact (Sorger, Goebel, Schiltz, & Rossion, 2007). The scotoma falls completely within the gaze-contingent window, so that, if anything, it could only reduce the proportion of choices based on the fixated part, not the periphery (contrary to our hypotheses). All other participants were specifically asked and did not report any difficulty at face recognition.

2.2. Procedure/experimental setup

Participants' eye movements were recorded while they performed a 2-alternative forced-choice task. Each trial started with a standard drift correction with a central fixation cross, followed by two faces presented side by side on the lower half of the screen and one target face on the top half. The target face was composed of a combination of the two bottom faces in a gaze-contingent way. That is, the fixated ('central' window) part corresponded to one of the two faces, while the remaining part (periphery, outside the fixated window) corresponded to the other face (Fig. 1). Therefore, the target face constantly changed, following changes in gaze position of the participant ("dynamic fixated window"). However, since the face remained constant during fixations, and changed only over saccades, the changes did not disturb the participants' natural perception of the face.

During the unlimited exploration of the faces, an average face in greyscale constantly covered the non-fixated faces (Van Belle et al., 2010a, 2010b). Thus, at each moment in time, only one face was visible. This procedure was used so that the target face was not identical to one of the two alternatives (i.e., the face corresponding to the periphery of fixation) when participants did not fixate on