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A face inversion effect without a face

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ABSTRACT

Numerous studies have attributed the face inversion effect (FIE) to configural processing of internal facial features in upright but not inverted faces. Recent findings suggest that face mechanisms can be activated by faceless stimuli presented in the context of a body. Here we asked whether faceless stimuli with or without body context may induce an inversion effect as large as the FIE. In Study 1 participants performed a sequential matching task for upright and inverted faces, faceless heads with full, minimal or no body context, headless bodies and bodies viewed from the back. Results show inversion effects as large as the FIE for faceless heads with full or minimal body context, but not for faceless heads without body context, headless bodies or bodies viewed from the back. These findings remarkably show that in contrast to the well-established configural explanation for the FIE, the FIE does not necessarily depend on the processing of internal facial features, but can be also triggered for faceless stimuli presented in body context. In Study 2 participants rated the extent to which they detected a face in stimuli presented with or without faces briefly followed by a mask. We found that faceless stimuli that generated a large inversion effect were rated higher for the existence of a face than faceless stimuli that generated small or no inversion effects. These findings further suggest that the FIE can be generated by a contextually induced face percept at the face detection stage rather than the face identification stage.

1. Introduction

The face inversion effect (FIE) is the disproportionate drop in recognition for inverted relative to upright faces, in comparison to other visual stimuli (Yin, 1969) and has been considered a well-established marker for specialized face processing mechanisms. This extensively studied phenomenon has been typically attributed to disruption in the representation of spatial relations among internal facial features, reflecting a unique mechanism of holistic processing that is either absent or weaker in inverted relative to upright faces (Farah, Wilson, Drain, & Tanaka, 1998; Maurer, Grand, & Mondloch, 2002; McKone & Yovel, 2009; Richler, Mack, Palmeri, & Gauthier, 2011; Tanaka & Farah, 2003; Young, Hellawell, & Hay, 1987). More recent studies further showed that this FIE is strongly linked with face-selective neural mechanisms (Mazard, Schiltz, & Rossion, 2006; Yovel & Kanwisher, 2005). These findings highlight the importance of the FIE as a useful tool for understanding special cognitive and neural mechanisms of face perception.

Recent studies of face-body cross-category processing have introduced the fascinating idea that face-processing mechanisms can be activated by faceless stimuli presented in the context of a body (Andrews, Davies-Thompson, Kingstone, & Young, 2010; Cox, Meyers, & Sinha, 2004; Ghuman, McDaniel, & Martin, 2009). In particular, an fMRI study by Cox et al. (2004) presented participants with faces, headless bodies, degraded faces with no internal features and contextually defined faces, which were

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composed of the same degraded face figures presented in natural configuration on top of the body figures. They reported that the response of the fusiform face area (FFA) to contextually-defined faces was as strong as the response to intact faces and stronger than the response to degraded faces alone. Importantly, the response of the FFA to degraded faces with no body context was similar to its response to non-preferred stimuli such as natural scenes and headless bodies. These findings indicate that face areas are not only selective to internal facial features, but also to faceless heads presented in body context. Additional evidence for the link between the representation of faces and bodies is reported in a recent behavioral adaptation study by Ghuman et al. (2009), who used a cross-category adaptation paradigm to measure the aftereffect of body processing on the representation of faces (see also Lai, Oruc, & Barton, 2011). Remarkably, they found that prolonged viewing of a headless body shifts the perceptual tuning curve for faces, suggesting that an inference about a missing face is sufficient to induce adaptation to faces, even in the absence of the facial features themselves.

This body-induced activation of face mechanism by faceless stimuli may also account for recent findings of an inversion effect for faceless body stimuli, which was as large as the inversion effect for faces (Minnebusch, Suchan, & Daum, 2009; Reed, Stone, Bozova, & Tanaka, 2003; Yovel, Pelc, & Lubetzky, 2010). Although this body inversion effect (BIE) was at first attributed to specialized body processing mechanisms (Reed, Stone, Grubb, & McGoldrick, 2006), the BIE was not associated with body-selective neural mechanisms, but rather was found to be associated with face-selective brain areas (Brandman & Yovel, 2010). Furthermore, the behavioral BIE is abolished for headless bodies, but not for other types of incomplete bodies, reflecting a central role of the head in the generation of the BIE (Minnebusch et al., 2009; Yovel et al., 2010). Taken together, these findings suggest that unlike the FIE, which has been shown to be associated with face-selective mechanisms (Mazard et al., 2006; Yovel & Kanwisher, 2005), the BIE is not a marker of specialized processing of its stimulus category (bodies). Instead, the BIE is associated with face or head processing mechanisms, and may therefore reflect a head or face inversion effect.

Taken together the BIE and the recently found body-induced activation of face mechanisms, we hypothesized that the inversion effect found for whole faceless bodies reflects a FIE resulting from contextual processing of body cues rather than an effect of body-selective processing. More specifically, we asked what type of body context is necessary to induce an inversion effect as large as the FIE for faceless stimuli. To test our hypothesis, we conducted a series of behavioral experiments comparing the magnitude of the inversion effect for faces and various types of faceless stimuli to determine whether a *full inversion effect* can be induced for faceless stimuli. For future reference throughout this paper, a full inversion effect is defined as an inversion effect that is as large as the FIE. In addition, we asked if the same faceless stimuli that produce a full inversion effect also generate a percept of a face in a briefly masked face detection paradigm. In other words, we asked whether a full inversion effect could be the result of contextually-induced detection of a face that activates the face system.

2. Study 1: inversion effect

In Study 1 participants were allocated to one of seven sequential matching tasks for upright and inverted stimuli. Each task measured the magnitude of inversion effect for a stimulus category that differed in either face identity, body pose or head pose.

2.1. Materials and methods

2.1.1. Participants

Ninety-eight participants (age 20–27, females: $n = 79$) with normal or corrected to normal vision took part in the study in exchange for course credit. Fourteen participants were allocated to each of the seven tasks. Each participant performed only one of the tasks, in order to avoid possible perceptual influences among the different categories. All participants signed a consent form approved by the Tel-Aviv University ethics committee. Six additional participants were removed from analysis due to near-chance performance in the upright condition.

2.1.2. Stimuli

The body and head stimuli were created from gray-scale male figures generated with Poser 7.0 software (e frontier America Inc.), used in a previous study by Yovel et al. (2010). The Poser figures were used to create images of whole bodies, headless bodies (Fig. 1a), heads with shoulders, heads alone (Fig. 1b) and bodies viewed from the back (Fig. 1c). All body and head stimuli were of the same identity, and differed only in pose. A set of 18 physically possible upright body poses were constructed, and a set of 18 different-body pairs was created by altering the positions of one arm, one leg, and the head of each figure. Face stimuli were (Fig. 1a) created with FACES software (IQ Biometrix, Inc.), used in a previous study by Yovel et al. (2010). Face stimuli included 18 different-face pairs that differed in the shape of the eyes, nose and mouth.

To hide facial features, the faces of the Poser figures were covered by a gray ellipsoid. Headless bodies were created by removing the heads from the whole body images. Body parts were removed from the neck down to create faceless head stimuli, and from the chest down to create images of faceless heads in minimal body context. Additionally, body figures were rotated in depth 180° to generate whole bodies viewed from the back. The size of the body and face images was approximately 220×330 pixels. The size of the faceless head stimuli was approximately 90×120 pixels. The size of the heads with minimal body context was approximately 220×160 pixels. Head size was identical between the two types of faceless head stimuli in order to avoid potential differences in face visualization due to different head size. The inverted stimuli were in plane rotations (180°) of the same stimuli used in the upright trials.