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Inverting houses and textures: Investigating the characteristics of learned inversion effects

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Abstract

Faces, more than other objects, are identified more accurately when upright than inverted. This inversion effect may be linked to differences in expertise. Here, we explore how stimulus characteristics and expertise interact to determine the magnitude of inversion effects. Observers were trained to identify houses or textures. Inversion effects were not found with either stimulus before training, but were found following 5 days of practice. Additionally, the learning-induced inversion effects showed partial transfer to novel exemplars. Although similar amounts of learning were observed with both types of stimuli, inversion effects were significantly larger for textures. Our results suggest that the size of the inversion effect is not a reliable index of face-specific processing.

Keywords: Inversion; Learning; Expertise; Transfer; Faces; Houses; Textures

1. Introduction

Objects are recognized more rapidly at their canonical orientations than when rotated within the picture plane (Jolicoeur, 1985), or in depth (Lawson & Humphreys, 2000). However, rotation (inversion) seems to impair face processing with particular severity, both in terms of accuracy and reaction time (e.g., Diamond & Carey, 1986; Yin, 1969; for a more extensive review, see Valentine, 1988). The impairment is so much more pronounced for faces than for other objects, that the inversion effect has become a hallmark of hypothesized face-specialized processing, particularly configural processing mechanisms (e.g., Farah, Tanaka, & Drain, 1995; Leder & Bruce, 2000; Moscovitch & Moscovitch, 2000; Rhodes, Jeffery, Jacquet, Winkler, & Clifford, 2004; Tanaka & Farah, 1993).

However, recent research suggests that the difference between upright and inverted face processing may be quantitative in nature, rather than qualitative. For example, studies using the classification image and bubbles techniques have shown that observers rely heavily on the eye and eyebrow region when identifying both upright (Gold, Sekuler, & Bennett, 2004; Gosselin & Schyns, 2001; Schyns, Bonnar, & Gosselin, 2002; Sekuler, Gaspar, Gold, & Bennett, 2004) and inverted (Sekuler et al., 2004) faces, but the efficiency with which observers use available information in this region is reduced when faces are inverted (Gaspar, Bennett, & Sekuler, accepted for publication; Sekuler et al., 2004). This difference in processing efficiency between upright and inverted faces mirrors the change in processing efficiency for objects seen as a result of practice (Gold, Bennett, & Sekuler, 1999a; Gold et al., 2004), suggesting that the superiority of upright processing may reflect greater practice identifying upright faces than inverted ones. Consistent with this idea, sizeable inversion effects have been observed for other non-face objects, when observers have developed expertise with that object class. For example, Diamond and Carey (1986) found that dog experts exhibited inversion effects when discriminating amongst breeds for which they had developed expertise (an effect that did not generalize to dogs in general), whereas novices did not perform significantly differently

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across orientations (but see Robbins & McKone, 2007). Similarly, inversion effects have been reported for body position discrimination (Reed, Stone, Bozova, & Tanaka, 2003), and inversion effects were larger when discriminating amongst bodies in biologically possible positions than in biologically impossible positions. Because observers likely have far more exposure to biologically possible positions than impossible ones, these results are consistent with the notion that inversion effects emerge for expertly processed stimuli.

Furthermore, there is some evidence that practice can induce inversion effects. The most compelling evidence comes from McLaren (1997), who trained observers to discriminate amongst checkerboard patterns, and demonstrated a strong inversion effect after practice: not only was upright performance greater for familiar than unfamiliar checkerboards, but inverted performance was actually impaired for familiar checkerboards relative to unfamiliar exemplars. Practice-induced inversion effects also have been reported for Greebles (a specially designed class of novel stimuli; Gauthier & Tarr, 1997). Observers who had been trained previously to recognize upright Greebles discriminated configural changes faster (though not more accurately) for upright stimuli than for inverted stimuli; observers who received no previous experience with Greebles did not differ in their performance across orientations. Similarly, in a separate task involving Greeble recognition (Gauthier, Williams, Tarr, & Tanaka, 1998), both novices and experts initially showed a small RT advantage for upright Greebles (relative to Greebles misoriented by 60, 120 and 180 degrees). Recognition became faster with practice on the task for both experts and novices, but upright performance benefited disproportionately for experts, such that the inversion effect was enhanced for experts but lost for novices. Moreover, practice-induced inversion effects do not seem to be limited to the visual modality, because face perception and training of pattern discrimination in the tactile domain also can induce inversion effects (Behrmann & Ewell, 2003; Kilgour & Lederman, 2006; Newell, Ernst, Tjan, & Bulthoff, 2001). Taken together, these results show that inversion effects are present for expertly processed stimuli, and can be induced through laboratory training tasks with novel stimuli.

However, many of the characteristics of practice-induced inversion effects remain largely unexplored. For example, it is not clear whether the size of trained inversion effects depends on prior knowledge brought to the task, such as knowledge about the canonical orientation of the object class. Further, the limited number of studies that have induced inversion effects through practice have not examined whether these inversion effects transfer to novel members of that class (a characteristic of face inversion effects). Finally, there is a suggestion within this body of research that the size of the inversion effect is a direct indicator of expertise (for faces or other highly trained object classes). Yin (1969), for example, emphasized the greater size of inversion effects for faces relative to other object classes, and studies of expertise generally have demonstrated larger inversion effects for experts than for novices (Behrmann & Ewell, 2003; Diamond & Carey, 1986; Gauthier et al., 1998; McLaren, 1997; Reed et al., 2003). The extent to which inversion effects differ across object sets with an equal extent of practice remains unknown.

The following experiments explore some of the characteristics of learned inversion effects by comparing face inversion effects to inversion effects generated before and after practice on house and texture discrimination tasks. If knowledge of the canonical orientation is sufficient to induce an inversion effect, then houses, but not textures, should exhibit inversion effects prior to practice. Further, practice with upright houses might be expected to induce larger inversion effects than practice with inverted houses. If inversion effects that are induced by training are qualitatively similar to face inversion effects, then these inversion effects should, like faces, transfer to novel houses. Finally, if the size of the inversion effect is a direct indicator of expertise, then equivalent amounts of training on house and texture discrimination tasks should result in similarly sized inversion effects.

2. Experiment 1

Experiment 1 examined whether performance improvements on a house discrimination task would be specific to the trained orientation. Different sets of observers were trained across 11 days to differentiate either amongst 10 upright houses or amongst 10 inverted houses, and both sets of observers subsequently were tested at both orientations.

2.1. Methods

2.1.1. Observers

Twelve observers (mean age = 25.6 years; range: 19–45) were recruited from McMaster University's Vision and Cognitive Neuroscience Lab participant pool. Observers were undergraduate and graduate students at McMaster University, and received $10/h for their participation. All observers had normal or corrected-to-normal visual acuity, and all were naïve with respect to the purpose of the study.

2.1.2. Stimuli and apparatus

Object classes differ in their degree of structural homogeneity. For example, faces are a highly homogenous stimulus category: the relative locations of eyes, nose and mouth are consistent across all exemplars. By contrast, houses are far more heterogeneous: the numbers and locations of doors and windows usually vary significantly across exemplars. Different strategies may well be needed to differentiate members of homogenous and heterogeneous classes, because the demands are likely to differ. For example, the most distinctive differences between the stimuli are more likely to be in a spatially predictable location in a homogenous class, than in a heterogeneous class.