Why are inverted faces hard to recognize? A test of the relational feature hypothesis

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Inverted faces are very hard to recognize. One explanation for this difficulty is that spatial relations within a face are difficult to encode when a face is upside-down. This account predicts that faces with distinctive isolated features (e.g., glasses, mustache, baldness) should be easier to recognize when inverted than faces that must be recognized using distinctive relational features. We tested this prediction by examining the effect of inversion on recognition of famous faces with distinctive isolated features and those without such features (for which recognition depends on relational features). As predicted, inverted faces were easier to recognize if they had a distinctive isolated feature than if they did not.

Faces present a difficult problem to the visual system, because they all share a configuration, with the same basic parts in the same basic arrangement. Nevertheless, we are all experts at recognizing faces. A productive approach to understanding this expertise has been to study why inverted faces are so hard to recognize (Bartlett & Searcy, 1993; Carey & Diamond, 1994; Diamond & Carey, 1986; Rhodes, Brake & Atkinson, 1993; Searcy & Bartlett 1996; Thompson, 1980; Valentine, 1988; Yin, 1969, 1970). Although most objects are more difficult to recognize upside-down than upright, the inversion decrement is especially large for faces (Yin, 1969). Something about the way we mentally represent and recognize faces makes them particularly vulnerable to inversion.

To see what that something might be, consider the kind of features that can be used to recognize faces. A few faces can be recognized using distinctive isolated features, such as a handle-bar mustache or a tell-tale scar. For most faces, however, recognition seems to rely more on distinctive relational features, such as the spacing between internal features and ratios of distances between these parts (Diamond & Carey, 1986; Rhodes, 1988). Recent studies, in which isolated and relational features have been manipulated in unfamiliar faces, indicate that relational features are particularly difficult to encode in inverted faces (Bartlett & Searcy, 1993; Rhodes, et al., 1993; Searcy & Bartlett, 1996; Young, Hellawell & Hay, 1987), so that reliance on such features may explain why inverted faces are so hard to recognize. Just *why* relational features are so difficult to encode in inverted faces is not yet understood, but the need to compare multiple parts that must each be located within an oriented frame of reference probably plays a role.The idea that reliance on relational features makes faces particularly vulnerable to inversion predicts that inverted faces that have distinctive isolated features (e.g., glasses, mustache, baldness) should be easier to recognize than inverted faces without such features, and for which recognition would depend on distinctive relational features. More generally, recognition of faces with distinctive isolated features should be less affected by inversion than recognition of faces that have only distinctive relational features. We tested these predictions in the present study, by examining the effect of inversion on recognition of famous faces, some of which had distinctive isolated features and some of which did not.

Method

Subjects

Twenty adults (8M, 12F) participated in the experiment.

Stimuli

Images of 40 famous faces were collected from magazines. They included politicians, entertainers, movie and television stars from New Zealand and overseas. Twenty had a distinctive isolated feature (IF faces) that was characteristic of (although not necessarily unique to) that person, or to the character role they played. The distinctive isolated features were baldness or hairstyle (N = 4), glasses (N = 3), headgear (N = 3), moustache (N = 1), beard (N =1), gap in teeth (N = 1), pointed ears (N = 1), large ears (N = 1), large nose (N = 1), black eye make-up (N = 1), Asian eyes (N = 1), dimple (N = 1) and birthmark (N = 1). The other twenty faces had no obvious distinctive isolated feature, so that recognition would rely more heavily on distinctive relational features (RF faces). The black and white xeroxed faces, which measured 45mm x 30 mm, were pasted onto cards measuring 125mm x 75mm. The quality of these reproductions was not high, but the (upright) faces were quite recognizable.

Procedure

Each face was shown for 3 seconds and subjects were given 30 seconds to identify the face. A response was considered correct if the person named the face or otherwise indicated that they knew who the person was (e.g., main character in "Absolutely Fabulous"). Each subject saw half the faces of each type (10 IF and 10 RF) upright and the other half inverted. The assignment of faces to upright and inverted presentations was counterbalanced across subjects. The faces were presented in four different random orders, with 5 subjects getting each order.

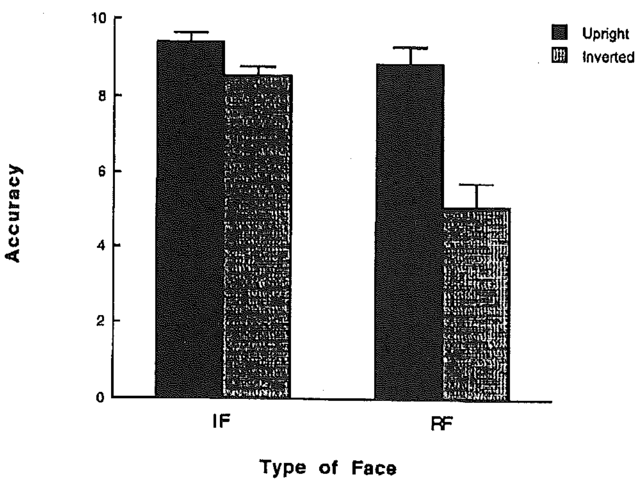

Figure 1. *Mean number of correct reponses (max = 10) as a function of orientation and type of face (IF = isolated feature face, RF relational feature face). SE bars are shown.*

Results

A two-way ANOVA was carried out on the mean number of correct responses, with orientation (upright, inverted) and type of face (IF, RF) as repeated measures factors. Upright faces ($M = 9.1$) were recognized significantly better than inverted faces ($M = 6.8$), $F(1,19) = 47.64$, $p < .00001$. Faces with a distinctive isolated feature ($M = 9.0$) were recognized significantly better than faces without such a feature ($M = 7.0$), $F(1,19) = 29.52$, $p < .00001$. As predicted, there was a significant interaction between type of face and orientation, $F(1,19) = 16.16$, $p < .0007$ (Figure 1). Simple tests of main effects showed that the effect of face type was significant for inverted faces, $F(1,19) = 33.52$, $p < .0001$, but not for upright faces, $F(1,19) = 1.72$, ns., and that the effect of orientation was significant for both types of face, $F(1,19)$ 34.47, $p < .0001$ (RF faces), $F(1,19) = 11.07$, $p < .004$ (IF faces).

Discussion

Our results support the hypothesis that reliance on relational features makes face recognition vulnerable to inversion. As predicted, inverted faces with distinctive isolated features (e.g., glasses, mustache, baldness) were recognized more accurately than inverted faces that must be recognized using distinctive relational features. Recognition of faces with distinctive isolated features was also less disrupted by inversion than recognition of faces without such features. However. with near perfect recognition of upright faces, it is possible that a ceiling effect contributed to this interaction.

Additional support for the relational feature hypothesis comes from a recent study by Farah and her colleagues (Farah, Tanaka & Drain, 1995). They found that the inversion decrement was reduced when relational features were disrupted by presenting faces with their parts (head outline, eyes, nose and mouth) in spatially separated frames.

Farah, et al., (1995) interpret their result in a slightly different way, as showing that the inversion decrement is reduced when *holistic* processing is disrupted (see also Tanaka & Farah, 1993). In holistic coding there is little or no explicit representation of parts. Disruption of either relational feature coding or of holistic coding could account for Farah, et al.'s results. It is less clear how our results can be explained by holistic coding. If faces are represented holistically, and inversion disrupts holistic coding, then why should faces with features like a bald head, a large nose, or pointed ears be easily recognized upside-down? Such features should be as integral to the holistic representation, and therefore as difficult to encode in inverted faces, as any others. The holistic account cannot explain why *some* faces are more disrupted by inversion than others. The relational feature account, by contrast, not only explains why some faces are more disrupted by inversion than others, but also predicts *which ones* will be most affected. Therefore, although the two accounts are clearly very similar, we prefer the relational feature account of why inverted faces are hard to recognize.

Initially, the large inversion decrement for faces was interpreted as evidence for a special face recognition process, because recognition of other complex, mono-oriented objects was less affected by inversion (Yin, 1969). However, Diamond and Carey (1986) have shown that recognition of dogs by dog experts is just as seriously disrupted by inversion, as is face recognition. Therefore, a large inversion decrement seems to reflect something about the way that experts discriminate between objects that share a configuration. Our results suggest that they use relational features.

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