Perception, 1999, volume 28, pages 1217 – 1226

DOI:10.1068/p2972

Effects of face configuration change on shape perception: A new illusion

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Received 20 February 1999, in revised form 19 July 1999

Abstract. We report two experiments indicating that varying the configuration of face features changes perception of an oval aperture windowing the face: as the eyes and mouth of a frontal-view face photograph are moved vertically toward face boundaries, the oval appears increasingly elongated, taller, and narrower; when eyes and mouth are moved toward the nose, the oval appears increasingly rounder, shorter, and wider. This shape illusion is maximised when faces appear upright within the oval, and major face features (eyes, nose, and mouth) appear in their correct relative locations. These results establish that processing of a face configuration can affect perception of a geometric shape that shares visual space with a face. Whether the illusion is face-specific or a special case of a more general geometric illusion is discussed.

1 Introduction

Researchers in the field of face processing have identified several factors affecting face perception and recognition. One important factor is face configuration, defined narrowly as comprising information about distances between major face components (eyes, nose, and mouth). Research indicates that we are extremely sensitive to variations in face configuration (eg Haig 1984; Rhodes et al 1993), and that changes in configuration can affect judgments of aesthetic appeal (Bartlett and Searcy 1993; Searcy and Bartlett 1996) and emotional expression (Köhler 1940). Face processing is also influenced by inversion. The 'face inversion effect' refers to the finding that recognition of faces is disproportionately hampered by stimulus inversion, relative to recognition of other objects (Yin 1969). The importance of orientation to face processing is also evident in Thompson's (1980) Thatcher illusion: when the eyes and mouth of a face photograph are inverted, the face appears grotesque if viewed upright, but relatively normal if the altered face is turned upside down. Both the face inversion effect and the Thatcher illusion have been attributed to a disruption of processing of configural information from faces viewed in a noncanonical orientation (eg Bartlett and Searcy 1993; Young et al 1987).

Research on the phenomena described above deals with how processing of configural information affects face perception and recognition. To date, there has been no direct demonstration that processing of face configural information affects processing of non-face objects. This is an important issue because several researchers have proposed models of face processing that suggest that: (a) face processing is highly dependent on configural information, and (b) there exists an active interaction between the processing of faces and that of objects (eg Farah 1996; Moscovitch et al 1997). An important prediction derived from these two suggestions is that processing of face configurations should affect non-face object processing and vice versa. This prediction is indirectly supported by evidence from patients with prosopagnosia (Farah 1996) or object agnosia with face recognition intact (Moscovitch et al 1997). However, no direct evidence from adults with normal perceptual capacities has been obtained to substantiate this prediction. Such evidence is of significance because it would suggest that the above models, derived from studies of patients with agnosia, can also be applied to the general population.

The present study was designed to examine directly the interaction between processing of the configural information of faces and that of non-face objects. Specifically, we investigated whether changes in face configuration affect the perception of geometric shapes that share the same visual space with a face. To examine this issue, a face photograph was first altered with computer graphics techniques that have been used by several researchers in recent years (Haig 1984; Rhodes et al 1993; Searcy and Bartlett 1996). These techniques involve manipulation of distances between the eyes, nose, and mouth to derive new faces from an original photograph, while keeping the main facial features unaltered. We then windowed the original and new faces in an oval aperture, obscuring the ears, hairline, and face contour (see figure 1). A dramatic illusion indeed results: as the distance between the nose and eyes and that between the nose and mouth increases (resulting in a long face), the oval appears more elongated; as these distances decrease (resulting in a short face), the same oval appears more round. The oval also appears to change in height and width as a function of face configuration.

Two experiments were conducted to confirm the observations made above and to identify factors affecting the extent of this shape illusion. The critical effects examined

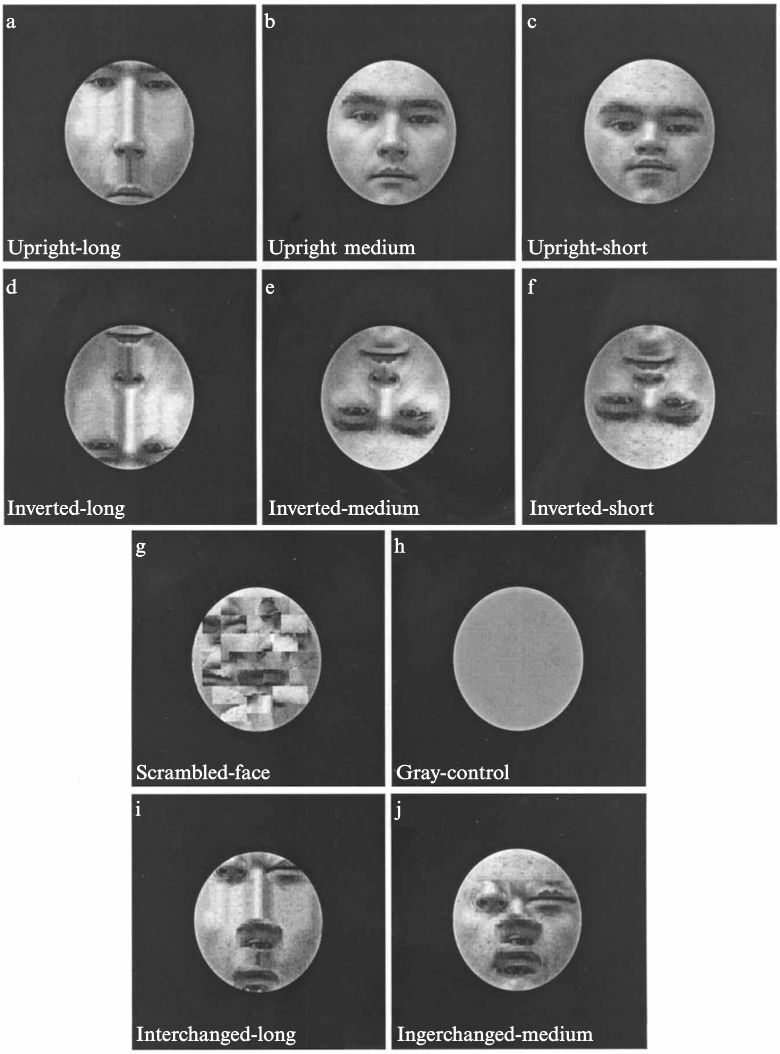


Figure 1. Stimuli used in the study (experiment 1: a – h; experiment 2: a, b, h, i, and j).

were those of configuration and inversion of faces. First, on the basis of our informal observations, we expected that varying the configuration of face features would change the perception of a surrounding oval contour. Second, given that inversion disrupts processing of configural information from faces (eg Bartlett and Searcy 1993), an inversion effect should be obtained if processing of facial configuration contributes to the illusion. An inversion effect would be indicated by a configuration by orientation interaction. That is, an oval which surrounds an inverted long face would appear less elongated, shorter, and wider than the same oval windowing an upright long face. Conversely, an oval which surrounds an inverted short face would appear more elongated, taller, and narrower than the same oval windowing an upright short face.

2 Experiment 1

2.1 *Method*

2.1.1 *Participants.* Forty students (twenty-four women and sixteen men) in an undergraduate introduction to psychology course participated and received course credit. Participants were predominantly but not exclusively white.

2.1.2 *Materials.* A video gray-scale image of a white male face was captured in Adobe Photoshop and retained as a 'medium' face. This image was altered by moving the eyes vertically to immediately beneath the hairline and the mouth down to immediately above the chin, creating a 'long' face. The procedure was reversed to create a 'short' face: eyes and mouth were moved vertically toward the nose as far as it was possible to do so without features overlapping. Each face was then windowed in a 5.76 cm (height) × 5.22 cm (width) oval aperture surrounded by a black square (9.67 cm × 9.67 cm). Six stimuli containing faces were used (figures 1a through 1f): upright-long, inverted-long, upright-medium, inverted-medium, upright-short, and inverted-short. Two stimuli served as controls. The first is the scrambled-face stimulus (figure 1g): the oval had the same dimensions as the other stimuli; the interior was created by cutting the original face image into rectangular segments (1 cm wide × 0.7 cm high) and pasting these in the oval, such that the orientation of the segments was unaltered and rectangles did not overlap. Thus, although the face configuration was destroyed, parts of the features remained visible. The last stimulus was the gray-control (figure 1h). Dimensions of the gray-control were equivalent to those in all other stimuli. All stimuli were laser printed and glued on 9.67 cm × 9.67 cm cardboard squares.

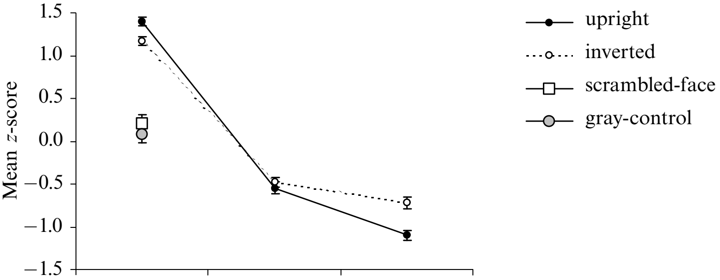
2.1.3 *Procedure.* Participants were tested individually, by a magnitude estimation procedure (Stevens 1958). Stimuli were shuffled and placed before the participants. They were asked to assign numbers to the ovals in each stimulus on each of three dimensions (ovalness, height, and width), corresponding to their perception of each. They were instructed to use any scale deemed appropriate, although larger numbers should correspond to more oval, taller, and wider shapes. After providing estimates on one dimension, participants rated stimuli on a second dimension, and then on the third. Orders of the three dimension estimates were randomised and randomly assigned. Once three estimates were completed, participants were asked to re-rate stimuli using a new order of dimensions. Therefore, each participant provided two estimations for each dimension of each stimulus.

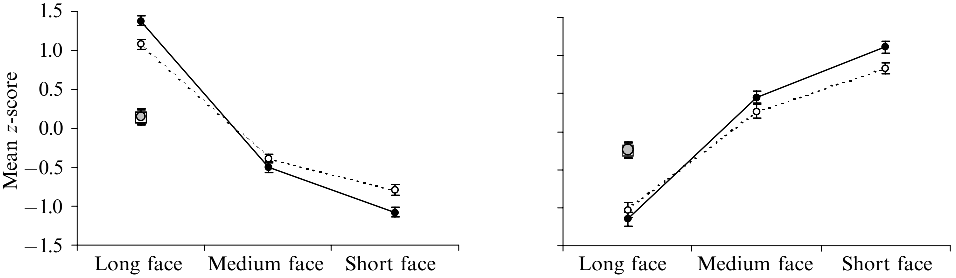
2.2 *Results*

Because individuals used scales of their choosing, estimations were normalised for each participant within each dimension in the following way: first, the two estimations for each dimension of each stimulus were averaged; next, within each dimension, the mean and standard deviation of these averages for the eight stimuli were calculated; finally, the mean and standard deviation of the appropriate dimension were used to obtain standard z-scores for each averaged estimation. Only analyses of results for the ovalness dimension are presented below: results for height and width estimations were consistent with those of ovalness estimations.

Figure 2 shows mean z-scores of ovalness, height, and width estimations for all stimuli. A 2 (Orientation) $\times$ 3 (Configuration) repeated-measures ANOVA on ovalness estimations revealed a significant effect of Configuration, $F_{2,78} = 472.77$, $p < 0.001$ ($\eta^2 = 0.92$, observed power $= 1.00$). The interaction was also significant, $F_{2,78} = 13.53$, $p < 0.001$ ($\eta^2 = 0.26$, observed power $= 0.997$). Different face configurations produced different illusions. Inversion reduced the shape illusion on the ovalness dimension: the oval contour surrounding the upright-long face was perceived as more elongated than that around the inverted-long face; conversely, the oval windowing the upright-short face was seen as less elongated than that surrounding the inverted-short face. t-Tests comparing ovalness estimations of face stimuli and the scrambled-face stimulus with that of the gray-control indicated that all ovals in the face stimuli were perceived as significantly different from the gray-control, but the oval in the scrambled-face stimulus was not. Ovals windowing upright-long and inverted-long faces were perceived as more elongated than the gray-control, while ovals windowing upright-medium and inverted-medium faces, and surrounding upright-short and inverted-short faces, appeared less elongated.

(a) Ovalness




(b) Height

(c) Width

Figure 2. Mean z-scores of magnitude estimations for the (a) ovalness, (b) height, and (c) width dimensions of stimuli used in experiment 1.

2.3 *Discussion*

Results supported our observations regarding the shape illusion: changes in face configuration produced perceptual distortions of an oval windowing the faces. These results indicate that configurations of face features not only have consequences for face perception and recognition (eg Searcy and Bartlett 1996), but also can affect perception of geometric shapes when they share visual space with a face. Ovals surrounding upright-long and inverted-long faces appeared more elongated, taller, and narrower than the gray-control stimulus. Oval contours around medium and short faces, both upright and inverted, were perceived as rounder and shorter than the control oval.

An inversion effect was also confirmed. Significant interactions of Configuration and Orientation indicate that inversion led ovals on face stimuli to appear more similar to the gray-control on all dimensions; that is, inversion reduced the shape illusion. It should be noted that, although differences in magnitude estimation between upright and inverted conditions were numerically small, the inversion effect was substantial given that the dependent measures were standardised z-scores and that the standard deviation for each mean was very small (see figure 2). The inversion effect indicates that the shape illusion cannot be fully attributed to perceptual salience of isolated elements in the faces, for example the length of the nose. Corresponding upright and inverted stimuli were equivalent in terms of these attributes, yet the illusion was significantly stronger when faces were upright.

Results of experiment 1 therefore suggest that face configuration and orientation are important determinants of the extent to which the shape illusion is observed. Upright faces produce the strongest illusions. Specifically, a long configuration in an upright orientation maximises appearance of the surrounding oval as more elongated, taller, and narrower than its actual dimensions. An upright, short configuration maximises perception of the oval as rounder, shorter, and wider. It should be noted, however, that the extent of the illusion may vary according to the specific characteristics of the original face (eg the location of hairline, face contour, and shapes of eyes, nose, and mouth, etc). Therefore, description of the face stimuli in the present experiment as 'long'; 'short'; and 'medium' only reflects the appearance of the faces relative to each other; the same procedure used to create these stimuli on a different original face may result in different looking 'long'; 'short'; and 'medium' faces. Nevertheless, the same illusion should remain.

3 Experiment 2

Experiment 1 leaves open the question whether the shape illusion is such that any face-like configuration of face features—two elements above one element above one element, or 2-1-1 configuration—suffices to maximise perceptual distortions to a surrounding oval, or if it is also necessary that features be in their normal relative locations (eyes above nose above mouth). In experiment 2 we examined this question by using the original upright-long and upright-medium stimuli and two new stimuli. The two new stimuli were created by moving the mouth and nose of the original upright-long and upright-medium faces to where the eyes should be, one eye to where the nose would be normally located, and the other eye to where the mouth should be (see figures 1i and 1j). While the new stimuli shared similar 2-1-1 configurations with the original faces, they were unlike any face one would ever naturally encounter. The magnitude estimation procedure was again used. If maximising the shape illusion requires perceiving faces as they appear in everyday encounters, a reduced illusion should be observed with faces in which features are interchanged. Alternatively, if any face-like 2-1-1 configuration maximises perceived distortions, the illusion should be observed to the same extent with original and new stimuli.

3.1 *Method*

3.1.1 *Participants.* Forty additional introductory psychology students (twenty-six women and fourteen men) participated and received course credit. Participants were predominantly but not exclusively white.

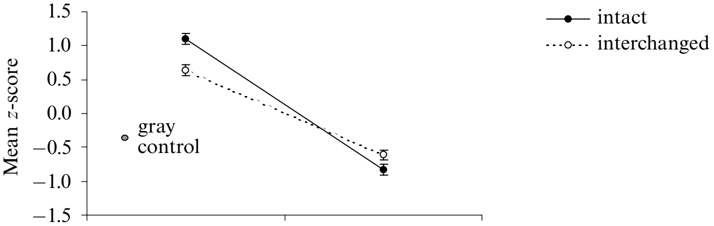
3.1.2 *Materials.* Upright-long and upright-medium faces and the gray-control stimulus were again used. Two new stimuli were created: interchanged-long and interchanged-medium faces, in which locations of face components were switched. Short faces were not used because creating an interchanged analogue of the upright-short face was impossible, as face components would be overlapping.

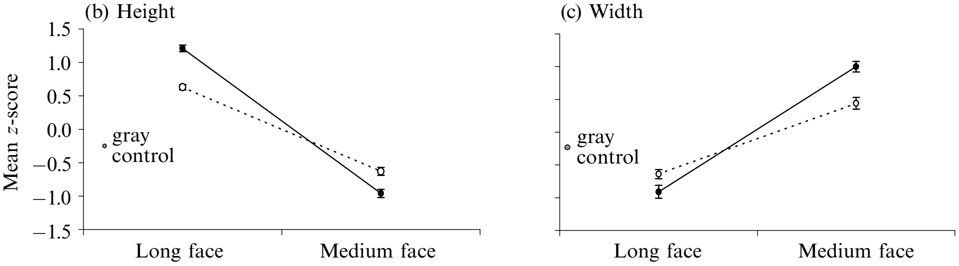
3.1.3 *Procedure.* The procedure was the same as in experiment 1.

3.2 *Results*

Analyses of results for ovalness estimations are presented below. As in experiment 1, results for height and width estimations were consistent with those of ovalness estimations.

Figure 3 shows mean *z*-scores of ovalness, height, and width estimations for all stimuli. A 2 (Configuration: long vs medium) × 2 (Intactness: intact vs interchanged) repeated-measures ANOVA on the ovalness estimations revealed a significant effect of configuration, $F_{1,39} = 216.38$, $p < 0.001$ ($\eta^2 = 0.85$, observed power $= 1.00$). The interaction was also significant, $F_{1,39} = 16.28$, $p < 0.001$ ($\eta^2 = 0.30$, observed power $= 0.98$): interchanged faces reduced the shape illusion on the ovalness dimension. *t*-Tests revealed that ovals surrounding upright-long and interchanged-long faces appeared more elongated than the gray-control stimulus, while those windowing upright-medium and interchanged-medium faces were perceived as less elongated.


(a) Ovalness


(b) Height

(c) Width

Figure 3. Mean *z*-scores of magnitude estimations for the (a) ovalness, (b) height, and (c) width dimensions of stimuli used in experiment 2.

3.3 *Discussion*

The present results show that face features must be in their natural relative locations (and orientation) to maximise the shape illusion, supporting the contention that the extent to which the illusion is perceived depends on the integrity of the face. This finding suggests that faces must be interpreted as such for the greatest distortions to a surrounding contour to be achieved. Nevertheless, the fact that 'faces' with interchanged elements also produce perceived distortions indicates that as long as a stimulus contains a face-like configuration, the configuration alone is sufficient to produce a similar, albeit reduced, shape illusion. As a result, the oval windowing the interchanged-long face is perceived as significantly more elongated, taller, and wider than the gray-control, while that surrounding the interchanged-medium face is seen as less elongated, shorter, and narrower than the gray-control.

4 General discussion

We have confirmed the shape illusion, and have shown that the configuration of a face has the greatest influence in determining the extent of the illusion. We also note that the illusion cannot be attributed to effects of eliminating external contours of faces: when ovals are expanded to show the entire head, a slightly diminished but similar illusion is observed (see figure 4). Further, the illusion remains after shading information is removed (again, see figure 4). Finally, similar illusions result when a circle or different ovals are used to window faces of varying configuration. Taking together present findings and these additional observations, we establish that processing of a face's configuration can affect perception of a geometric shape that shares visual space with the face.

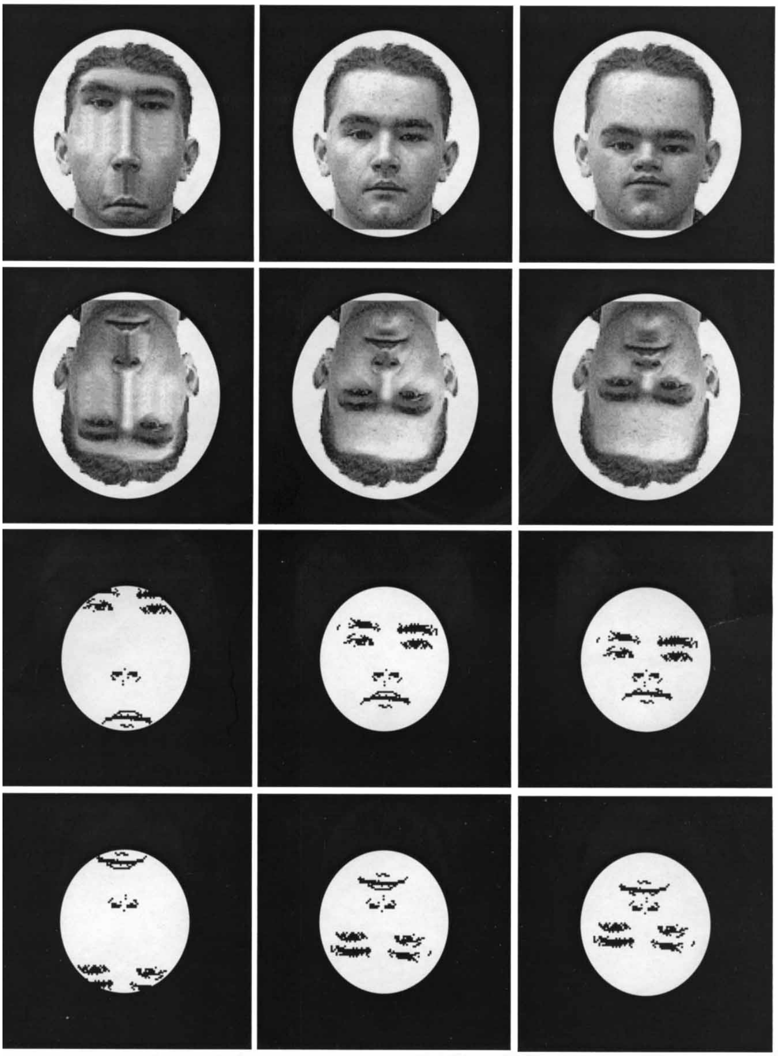


Figure 4. Additional face stimuli for which the shape illusion is observed.

One could argue that the shape illusion is a special case of the horizontal – vertical illusion (Wundt 1896/1912). Observers may impose an imaginary horizontal line between the eyes and an imaginary vertical line from the middle of this horizontal line to the mouth. Owing to the horizontal – vertical illusion, the vertical line is perceived as longer, and the horizontal line as shorter, than its actual length. The oval surrounding the long faces is therefore perceived as more elongated, taller, and narrower than that in the gray-control stimulus. However, this interpretation cannot account for two results obtained in experiment 1. First, Schiffman and Thompson (1975) found that the horizontal–vertical illusion is enhanced when the vertical line appears above the horizontal line, relative to when it appears below. If participants were imposing horizontal and vertical lines on the faces as described above, perceptual distortions should have been greater for inverted faces. Our results show that distortions were greater on all stimulus dimensions when faces were upright. More importantly, the horizontal–vertical illusion remains when line length is reduced: that is, a vertical line is *always* perceived as longer than its actual length, while a horizontal line *always* appears shorter. When the vertical distance between the mouth and eyes was reduced in the present experiment, however, perception of the ovals surrounding the faces switched from longer and narrower than their veridical dimensions to shorter and wider. For example, the oval windowing the upright-short face was perceived as shorter than its true height and wider than its true width, the opposite of the horizontal–vertical illusion.

The main purpose of the present study is to demonstrate the interaction between processing of the configural information of faces and that of objects. Nevertheless, it is worth noting that our results raise the issue whether the illusion is a special case of a more general geometric illusion or a face-specific phenomenon. The first possibility appears to be supported by results of experiment 2, in which faces with interchanged components were used instead of intact faces and an illusion resulted, albeit a reduced one. Further, in the course of discovering the present face shape illusion, we also discovered a similar and novel geometric illusion: when T-shapes of different dimensions are substituted for faces, the shape of a surrounding oval appears to vary (figure 5, top row); an illusion also remains when the T-shapes are inverted (figure 5, second row). These observations again suggest that the face shape illusion may be a specific case of a more general geometric illusion. That is, it is possible that the configuration of the eyes, nose, and mouth is perceived as T-like and hence leads to a shape illusion in the face context.

However, it is premature to draw such a conclusion. As observed by one of the anonymous reviewers of this paper, it is equally plausible that the T illusion is in fact a special case of a face-specific shape illusion. Consider figure 5 again: all these images, despite being very rudimentary and not very face-like in terms of fine detail, nevertheless are face-like at a very gross level. Indeed, the same reviewer observed that the T-stimuli looked somewhat like medieval battle helmets. Similarly, several participants in experiment 2 commented that the interchanged faces were still faces, although 'weird' ones. It is thus possible that our face-processing system is very readily engaged, treating any configuration grossly resembling that of a real face as a face configuration. Consequently, the T-stimuli result in similar illusions as the face stimuli. This explanation is consistent with our finding that the shape illusion is strongest when faces are upright and intact.

This possibility is also consistent with at least one recent account of stimulus attributes critical for face processing. Moscovitch et al (1997) tested an object agnosic with preserved face-recognition ability on various face and object processing tasks. For example, they presented the patient with stimuli that had non-face objects arranged in face-like configurations or face features embedded in non-face contexts. Their observations led them to conclude:

> "The face must be upright. The crucial information for facial identity is carried by a spatial configuration formed of the internal features of a face—the eyes, the nose, and the mouth. The particular elements of which a face is composed are *immaterial* as long as the required configurational properties of the face are preserved. Thus, any configuration that is facelike will do, whether it is a caricature (experiment 6), a cartoon (experiment 7), an object in the shape of a face (experiment 19), or a face whose separate features are composed of objects (experiment 18)" (page 592, italics added).

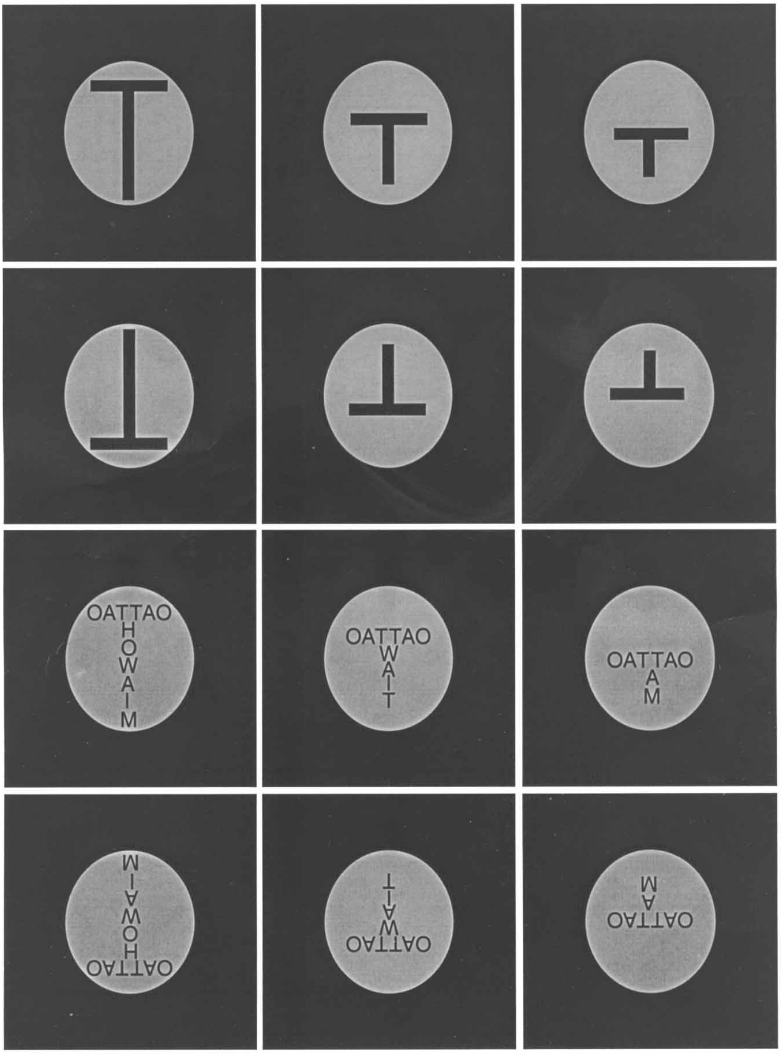


Figure 5. T-shaped stimuli.

The stimulus attributes mentioned in the first part of this quote are strikingly similar to the attributes critical to maximising the shape illusion in the present study — orientation and configuration. The latter part of the quote reflects the readiness with which the perceptual system treats even a very basic configuration as face-like.

Future research needs to examine directly whether the shape illusion we have described is T-driven or face-driven. One of the methodological challenges to addressing this issue is how to overcome our perceptual system's strong tendency to perceive certain configurations as face-like. One approach is to create stimuli that preserve the basic T configuration but discourage the engagement of the face-processing system. For example, one can force the observer to perceive the elements of a stimulus as non-face objects (eg by constructing a T out of words; see figure 5, rows 3 and 4). Another approach is to show the face and T-shaped stimuli to both prosopagnosics and object agnosics. If the shape illusion is face-driven, object agnosics with preserved face processing will perceive this illusion in both face and T contexts, but prosopagnosics will not perceive the illusion in either. If the shape illusion is T-driven, prosopagnosics will perceive the T-shape illusion and not the face illusion, but object agnosics will not perceive the illusion in either case.

Finally, although we have focused on effects of facial configurations on geometric shape perception, the shape illusion may also shed light on issues related to face processing itself. Prior research has established that manipulation of distances between major face features affects discriminability of faces (eg Rhodes et al 1993) and attractiveness ratings (Bartlett and Searcy 1993; Searcy and Bartlett 1996). Our observations provide evidence of an additional role for face configurations in face perception. Because the oval aperture in our stimuli resembles roughly the external contour of a face, we suggest that the shape illusion documented here may be an accentuated and special case of an effect occurring in our everyday perception of faces. Individuals have unique configurations of face features, which may affect our perception of their external face contours. In particular, faces with features in close proximity may appear rounder than they actually are, and faces with features at greater vertical distances from each other may appear longer and narrower than their actual dimensions. Perhaps when we describe someone as having a 'round' or 'long' face, our description is based on two factors: the face contour, which is physically round or long, and a perceptual distortion to the contour due to the particular layout of the eyes, nose, and mouth within the face.

Acknowledgements. This research was supported by a Natural Sciences and Engineering Research Council of Canada grant to Kang Lee. The authors would like to thank Darwin Muir, David Murray, Lawrence Symons, Nikolaus Troje, Ron Weisman, and three anonymous reviewers for their constructive comments on earlier versions of the manuscript.

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