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Configural information is processed differently in perception and recognition of faces

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Abstract

Several previous studies have stressed the importance of processing configural information in face *recognition*. In this study the *perception* of configural information was investigated. Large overestimations were found when the eye–mouth distance and the inter-eye distance had to be estimated. Whereas configural processing is disrupted when inverted faces have to be recognized the perceptual overestimations persisted when faces were inverted. These results suggest that processing configural information is different in perceptual as opposed to recognition tasks.

Keywords: Configural encoding; Face recognition; Face perception; Perceptual illusion; Horizontal vertical illusion

1. Introduction

Processing facial information is one of the most relevant skills in everyday life. Although faces seem to look quite different from each other, they do in fact form a very homogeneous stimulus class when seen from an image-based point of view. Each face has the same components (eyes, nose, mouth, etc.) in the same basic arrangement. Therefore, reliably recognizing faces entails detecting subtle differences between components and their spatial interrelationship (configural information). Whereas component processing seems to be relatively unaffected by orientation changes, the processing of configural information is strongly impaired when faces are rotated. Indeed, many researchers have argued that turning faces upside–down disrupts configural processing much more than component processing (e.g. Leder & Bruce, 2000; Murray, Yong, & Rhodes, 2000; Schwaninger & Mast, 1999; Searcy & Bartlett, 1996; Sergent, 1984). More than 30 years ago, it was found that face recognition is disproportionately affected by inversion when compared to the recognition of other mono-oriented objects such as airplanes, houses, and stick figures of men in motion (Yin, 1969). Since face recognition is highly orientation-sensitive and the processing of configural information is strongly impaired when faces are turned upside–down many researchers have devoted a special role to processing configural information in face recognition. Whereas many previous studies have investigated the role of configural information for recognizing faces this study examines the perception of configural information in upright and rotated faces.

2. Experiment 1

Face recognition is characterized by a high sensitivity for configural information. For example Haig (1984) revealed for unfamiliar faces that configural alterations, which were induced by changing the distance between facial components are sometimes detected at the visual acuity threshold level. Similar results were reported by Hosie, Ellis, and Haig (1988) for familiar faces.

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Whereas these studies were concerned with detecting alterations of configural information in faces the aim of Experiment 1 was to investigate whether human observers have a veridical percept of configural information.

2.1. Method

2.1.1. Participants

Twenty undergraduates from the University of Zurich voluntarily participated in this study. The participants were randomly assigned to two groups of 10 participants. All had normal or corrected to normal vision.

2.1.2. Materials and procedure

Photographs were made from 10 people (five females) who had agreed to be photographed and to have their pictures used in psychology experiments. The faces in the original grayscale pictures were front facing and had a neutral expression. In digital versions the hair was removed and the faces were placed on a black background.

The experiments were conducted in a dimly lit room. The viewable screen area on the TFT display was limited to a 750×750 pixel square (23.5° of visual angle) by a cardboard covering the 14.1 in. screen. The viewing distance was maintained by a head rest so that the center of the screen was at eye height of participants and the height and width of displayed faces covered 8.5° and 6.7° of visual angle, respectively.

The method of adjustment was applied. The length of a simultaneously presented white line (comparison stimulus) had to be adjusted in order to appear as long as the standard stimulus. For half the participants the standard stimulus was the eye–mouth distance, for the other half of participants the standard stimulus was the inter-eye distance (Fig. 1). The latter was defined as the distance between the pupils (mean distance was 84 pixel or 2.6° of visual angle). The eye–mouth distance was defined as the vertical distance between the point in the middle of the upper contour of the mouth and the point where a vertical line through this point would cross a horizontal line connecting the two pupils (mean distance was 86 pixel or 2.7° of visual angle). Adjustments were made with the preferred hand by turning a small wheel on a mouse device. Each trial was started by pressing a button on this device. The adjustment line (comparison stimulus) was one pixel in width and its initial length was either 20 or 180 percent of the standard stimulus. For the two standard stimuli (inter-eye distance and eye–mouth distance) the line comparison stimulus was presented horizontally to the right of the standard stimulus and vertically on bottom of the standard stimulus (Fig. 1).

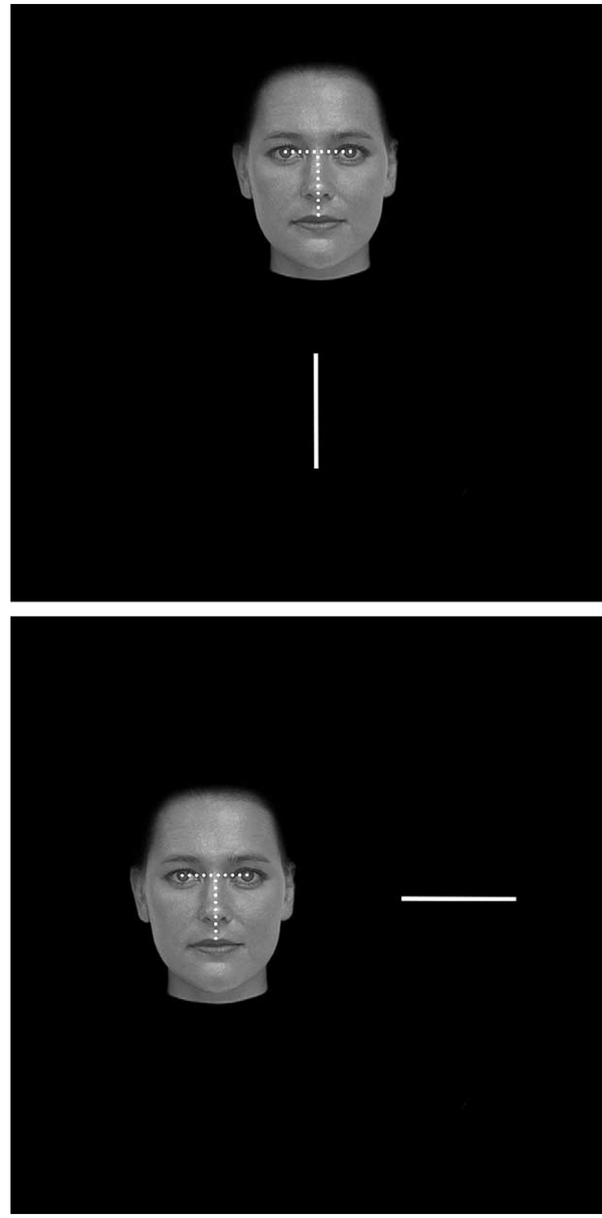

Fig. 1. The two positions of standard and comparison stimuli (line) for one face as standard stimulus. Dotted lines indicate the inter-eye distance and eye–mouth distance and were not shown in the experiments.

There were 40 trials for each standard stimulus: 10 (faces) $\times$ 2 (initial line lengths) $\times$ 2 (positions). The order of faces, initial line lengths, and line positions was counterbalanced across participants using latin squares.

2.2. Results and discussion

Individual data were averaged across the two measurement conditions, the two initial line lengths and the 10 faces. The eye–mouth distance was overestimated by

39 percent (SE = 5.96) and the inter-eye distance by 11 percent (SE = 4.02). [1]

Several previous studies have found a high sensitivity for detecting subtle configural changes (Bruce, Doyle, Dench, & Burton, 1991; Haig, 1984; Hosie et al., 1988; Kemp, McManus, & Pigott, 1990). The large overestimations revealed in the present study indicate that the ability of skilled perceptual discrimination does not necessarily imply very precise veridical percepts. In contrast, the overestimations found in Experiment 1 are of a magnitude that exceeds most known perceptual size illusions (e.g. Coren & Girgus, 1978).

3. Experiment 2

The processing of configural information in recognition and detection tasks is strongly impaired when faces are inverted (Leder & Bruce, 2000; Rhodes, Brake, & Atkinson, 1993; Schwaninger & Mast, 1999; Sergent, 1984; Young, Hellawell, & Hay, 1987). If there was a difference in the perception of configural distances between upright and inverted faces, then the face inversion effect could be related to perceptual processes. In contrast, if the overestimations found in Experiment 1 would persist to the same degree in inverted faces, the orientation-dependent nature of configural processing in face recognition cannot be explained based on limitations on the perceptual level.

A second aim of Experiment 2 was to investigate a possible role of the horizontal vertical illusion (HVI). This perceptual phenomenon has been first reported by Fick (1851) and refers to the observation that vertical lines or distances appear longer than horizontal ones of the same physical length. The HVI has been shown to affect also the perception of various objects including complex stimuli such as houses (e.g. Higashiyama, 1996; Yang, Dixon, & Proffitt, 1999). In Experiment 2 a potential effect of the HVI upon the perception of configural information in faces was investigated by showing the faces in four angles of clockwise rotation (0°, 90°, 180°, 270°) and comparing the overestimations of configural information to the overestimation of line length.

[1] Based on the horizontal vertical illusion (HVI), the horizontal vs. vertical placement of the comparison line could be expected to influence the adjustments. Indeed, separate analyses for the two measurement conditions (horizontal vs. vertical placement of the comparison line) revealed for both facial distances significant effects: When the comparison line was horizontally oriented (as opposed to vertically oriented), the overestimation of the eye–mouth distance was 10 percent larger, $t(9) = 2.98$, $p < 0.05$, and the overestimation of the inter-eye distance was 8 percent larger, $t(9) = 3.71$, $p < 0.01$. In order to reduce such effects based on the placement of the comparison line, the data were averaged across the two measurement conditions.

3.1. Method

3.1.1. Participants

Twenty-four undergraduates from the University of Zurich volunteered in this study. All had normal or corrected to normal vision.

3.1.2. Materials and procedure

One male and one female face from Experiment 1 served as stimuli. The experimental setup was identical to Experiment 1. The length of a simultaneously presented white line (comparison stimulus) had to be adjusted in order to appear as long as the standard stimulus. For 12 randomly selected participants the standard stimulus was the inter-eye distance and the eye–mouth distance of the simultaneously presented face (both distances were 83 pixel or 2.6° of visual angle). The distances were explained to the participants the same way as in Experiment 1. In order to ensure that the participants understood the definitions of the distances precisely the distances were indicated with white lines on a face presented on a cardboard above the computer screen. The eye–mouth and the inter-eye distances were adjusted in separate blocks, counterbalanced across subjects. For the other 12 randomly selected participants the standard stimulus was a simultaneously presented white line that was one pixel in width and 83 pixel in length. Adjustments were made as in Experiment 1. Again, the adjustment line (comparison stimulus) was one pixel in width and its length was either 20 or 180 percent of the standard stimulus. The comparison stimulus was presented horizontally to the right or left of the standard stimulus and vertically on top or bottom of the standard stimulus, so that in half the trials the comparison line was at the same orientation as the facial distance, whereas in the other half of the trials the comparison line was perpendicular to it.

The standard stimuli were presented in four angles of clockwise rotation (0°, 90°, 180°, 270°) around their center.

There were two blocks of 64 trials resulting in 128 trials for the group in which the eye–mouth distance and the inter-eye distance served as standard stimuli: 2 (adjustments for the male and female face) × 2 (initial lengths of comparison stimulus) × 4 (positions of standard and comparison stimuli) × 4 (angles of rotation of the standard stimulus) × 2 (blocks: eye–mouth distance and inter-eye distance). Since for the second group the standard stimulus was a line instead of facial distances only one block (64 trials) was used: 2 (adjustments) × 2 (initial lengths of comparison stimulus) × 4 (positions of standard and comparison stimuli) × 4 (angles of rotation of the standard stimulus). The order of positions, rotations, length of comparison stimulus as well as order of faces and blocks (group one only) was counterbalanced across participants using a mixed latin square design.

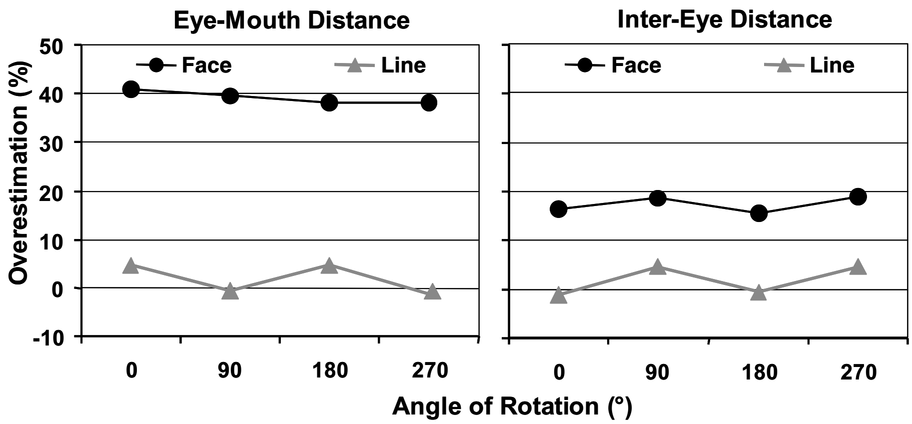

Fig. 2. Large overestimation of configural information in faces and the effect of orientation. Left: eye–mouth distance, right: inter-eye distance.

3.2. Results and discussion

Individual data were averaged across the four measurement conditions, the two initial lengths of the comparison stimulus as well as the two adjustments. As shown in Fig. 2, the line was overestimated when presented vertically and slightly underestimated when presented horizontally. This result reflects the well known horizontal vertical illusion.

The results from Experiment 1 were replicated. The eye–mouth distance was overestimated by 41 percent and the inter-eye distance by 16 percent in upright faces. [2] A two factor analysis of variance (ANOVA) with standard stimulus (eye–mouth distance vs. line) as between-subjects factor and orientation as within-subjects factor revealed that the eye–mouth distance was much more overestimated than the line, $F(1,22) = 13.79$, $MSE = 2422.01$, $p < 0.01$. There was also a main effect of orientation, [3] $F(2.33, 51.23) = 18.89$, $MSE = 6.16$, $p < 0.001$, and an interaction between orientation and standard stimulus (eye–mouth distance vs. line), $F(2.33, 51.23) = 10.73$, $p < 0.001$. As indicated by the interaction the HVI affected perceived line length more than the perception of the eye–mouth distance.

A separate two factor ANOVA with standard stimulus (inter-eye distance vs. line) as between-subjects factor and orientation as within-subjects factor revealed larger overestimations of the inter-eye distance than of line length, $F(1,22) = 4.86$, $MSE = 1177.18$, $p < 0.05$. There was a main effect of orientation, $F(2.28, 50.09) = 26.90$, $MSE = 6.63$, $p < 0.001$. Again, there was an interaction between orientation and standard stimulus (inter-eye distance vs. line), $F(2.28, 50.09) = 3.19$, $p < 0.05$, confirming that also the perception of the inter-eye distance is less affected by the HVI than the perception of lines.

The effects of orientation were further examined using Bonferroni corrected pairwise comparisons of means (Table 1). There were no significant differences neither for the inter-eye distance nor for the eye–mouth distance. More specifically, the large overestimations were similar for upright and inverted faces, [4] which contrasts with the often reported strong inversion effect for processing configuration in face recognition tasks.

4. General discussion

Many previous studies have stressed the importance and orientation-sensitivity of configural processing for recognizing faces. In the present study we investigated the *perception* of configural information in faces and found new and surprising results. Whereas people are very sensitive in detecting configural differences (Bruce et al., 1991; Haig, 1984; Hosie et al., 1988; Kemp et al., 1990) our study shows that configural information is not

[2] As mentioned in Footnote 1, the placement of the comparison line had a modulatory effect on the overestimations in Experiment 1. Similar effects were found in Experiment 2. On average, the overestimation was 8 percent larger for horizontal vs. vertical placements of the comparison line. This effect was comparable across conditions since separate ANOVAs for the eye–mouth and the inter-eye distance with measurement condition as within-subjects factor (horizontal vs. vertical placement of the comparison line) and standard stimulus (line vs. facial distance) as between-subjects factor gave no significant interactions between these two factors. As in Experiment 1, we averaged across the two measurement conditions in order to reduce modulatory effects caused by the placement of the comparison line.

[3] In all analyses of this study, if Mauchly's (1940) test of sphericity showed a significant deviance ($\alpha \geqslant 0.25$) from equicorrelation for a repeated factor or for a combination of factors including at least one repeated factor, Greenhouse and Geisser's (1959) Epsilon was used to adjust the degrees of freedom for the averaged tests of significance.

[4] However, the small mean difference of 2.8 percent between adjustments of the eye–mouth distance for upright vs. inverted faces was significant when a paired-samples t-test was used (without Bonferroni adjustment for multiple comparisons), $t(11) = 2.56$, $p < 0.05$.

Table 1
Bonferroni corrected pairwise comparisons between the four angles used in Experiment 2

(*I*) ANGLE	(*J*) ANGLE	Eye–mouth distance			Inter-eye distance		
		MD (*I*–*J*)	SE	*p*	MD (*I*–*J*)	SE	*p*
0	90	1.623	1.306	1.000	−2.170	1.108	0.456
0	180	2.843	1.110	0.159	0.855	1.117	1.000
0	270	2.930	1.046	0.103	−2.496	1.044	0.215
90	180	1.220	1.045	1.000	3.025	1.213	0.179
90	270	1.306	0.708	0.552	−0.326	0.623	1.000
180	270	0.087	0.776	1.000	−3.351	1.139	0.080

Note: MD = mean difference, SE = standard error.

perceived veridical but is instead overestimated by 11–41 percent. Inversion strongly impairs configural processing in detection and recognition tasks (e.g. Leder & Bruce, 2000; Murray et al., 2000; Rhodes et al., 1993; Schwaninger & Mast, 1999; Searcy & Bartlett, 1996; Sergent, 1984; Young et al., 1987). In contrast, our study revealed that the perception of configural information is much less orientation-sensitive. Moreover, a comparison between overestimations of distances in upright and in 90° rotated faces showed that the HVI affects the perception of the eye–mouth and the inter-eye distance less than it is the case for lines of the same length and thus fails to provide a simple explanation of the large overestimations.

In short, this study revealed a new and large perceptual illusion in faces and indicates that configural processing does not obey the same rules in perceptual tasks as opposed to detection and recognition tasks.

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