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Configural processing and perceptions of head tilt

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Abstract. Configural processing is important for face recognition, but its role in other types of face processing is unclear. In the present study, participants made judgments of head tilt for faces in which the vertical position of the internal facial region was varied. We found a highly reliable relationship between inner-face position and perceived head tilt. We also found that changes in inner-face position affected the perceived dimensions of an individual unchanged facial feature: compared to control faces, nearly two-thirds of faces in which the features had been moved down were judged to have a longer nose. This finding suggests an early integration of configural and featural processing to create a stable holistic percept of the face. The demonstration of holistic processing at a basic perceptual level (as opposed to during face recognition) is important as it constrains possible models of the relationships between featural and configural processing.

1 Introduction

It has long been recognised that the configuration of the facial features is as important in face recognition as details about individual features themselves, and a general distinction between the processing of configural and featural information has been demonstrated by a variety of research (eg Searcy and Bartlett 1996; Leder and Bruce 1998; Collishaw and Hole 2000).

Recent efforts have focused on clarifying the nature of configural processing and its relationship to featural processing. Evidence has highlighted distinctions between at least three types of configural processing (Maurer et al 2002): perceiving the face as a face on the basis of its *first-order configuration* (ie eyes above nose above mouth), perceiving the face *holistically* (ie as an undecomposed unitary representation), and analysing the face in terms of specific *second-order relational* cues (eg intereye distance; distance ratio of eyes – nose and nose – mouth). There has been considerable debate whether face recognition involves primarily holistic representations (eg Tanaka and Farah 1993), or relies on specific second-order relational cues (eg Leder et al 2001). Recent theories have suggested more complicated alternatives, in which different subtypes of configural processing may be differentially involved at different stages of face processing (Maurer et al 2002). However, whilst numerous studies have addressed questions about the nature of configural processing in relation to the recognition and perception of facial identity, only a few studies have examined these questions in relation to other forms of face perception. This is an important gap in our understanding, given the fundamental difference between the need to code view-invariant facial properties for representing facial identity, and the need to be sensitive to view-variant properties in the perception of other facial attributes (eg expression, gaze perception, etc).

In this paper we aim to establish whether configural processing is important in computing a perceptual representation of head tilt, and to test what form of configural processing might be involved. The rationale for focusing on head tilt is twofold. First, head tilt is an important aspect of face perception. It contributes to the computation of gaze direction (eg Perrett et al 1992; Campbell et al 1999; Langton et al 2000), and affects face-expression processing (Lyons et al 2000; Mignault and Chaudhuri 2003), gender categorisation (Campbell et al 1996, 1999), judgments of attractiveness (Geldart et al 1999), and ratings of social dominance (Mignault and Chaudhuri 2003). Understanding which aspects of the facial image are used to compute head tilt is therefore of theoretical interest.

Second, as illustrated in figure 1, both the positioning of the facial features relative to the face outline and the dimensions of individual features change as a face is tilted forward or backwards. One simple description of the positional changes involved relates to the vertical placing of the inner-face features relative to the face outline. As the face is tilted backwards, the facial features appear to move upwards within the facial frame; as the face is tilted forwards the facial features appear to move downwards within the facial frame. At the same time, head tilt also affects the appearance of individual facial features. Most prominently, the nose is markedly foreshortened when the face is tilted backwards.

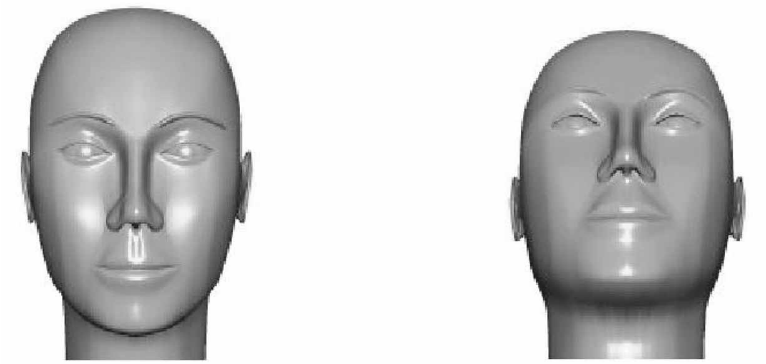

Figure 1. An illustration of changes that occur to the facial image when the head is tilted up. The position of the inner-face features relative to the face outline changes. The whole face and the nose appear foreshortened.

In task 1 of the present study we test the hypothesis that the vertical position of the facial features within the face outline is a reliable predictor of estimated head tilt. This would provide strong evidence for some form of configural processing of head tilt (as defined in a general sense to refer to the configuration or position of the facial features within the face outline).

In task 2 we distinguish between possible *holistic* and *relational* interpretations of a correlation between inner-face position and perceived head tilt. First, it is possible that changing the position of the facial features alters the perception of the face as a whole. Alternatively, changing the position of the facial features may affect the perception of some particular critical relational cue or cues (eg relative height of the ears and the eyes). Previous research on face recognition has been able to implicate the role of holistic representations by demonstrating that the whole-face context influences the *recognition* of individual (unchanged) face parts (eg Tanaka and Farah 1993; Tanaka and Sengco 1997). In a similar vein, we are using task 2 to test whether positional changes, expected to influence perceived head tilt, would influence the *perception* of an individual (unchanged) face part. Figure 1 shows that when a face is tilted backwards the face and its features appear foreshortened. It is hypothesised that changes in apparent head tilt due to the vertical displacement of the inner-face area will lead to changes in the perception of the dimensions of individual features so as to create a stable and internally consistent representation of the face and its features. Specifically, we use task 2 to test whether variations in inner-face position that affect estimated head tilt also affect a viewer's perception of nose length. It is expected that faces that are rated as tilted upwards will also have noses perceived as foreshortened. If confirmed, such a finding would point to the early integration of featural and relational information and to the role of holistic representations in face perception.

2 Method

2.1 *Participants and design*

Nine participants were recruited (seven men and two women aged from 18 to 51 years). Four participants first completed task 1 and then task 2, whilst five participants completed task 2 first. Participants were naïve about the purposes of the study.

2.1.1 *Task 1: Perceived head tilt.* Participants were asked to judge the vertical tilt of a series of faces in which the facial features had been moved, by a distance which was a percentage of the interpupillary distance, downwards by 10%; downwards by 5%; not moved; upwards by 5%; or upwards by 10% (FD10, FD5, OR, FU5, FU10, respectively).

Four male Caucasian target faces, without beard or glasses and unknown to participants, were used in the study. Photographs were taken from full-face view, with little or no tilt forwards or backwards. Modified versions of each face were created in Adobe Photoshop by selecting an area within the facial outline that included the 'internal features' (eyebrows, eyes, nose, and mouth). This area was then displaced vertically by a distance of 5% or 10% of the interpupillary distance. Pixels in adjacent areas were either replicated or overwritten, and the Photoshop 'smudge' tool was used to mask these changes.

The twenty different stimuli used in this task were each shown four times, giving a total of eighty trials (four trials × five modified versions × four targets). Stimuli were displayed with SuperlabPro 1.05 software. Faces measured approximately 85 mm by 120 mm as displayed to participants, with participants tested at a viewing distance of 60 cm (faces thus subtended about 8.06 deg horizontally). Participants were asked to adjust the angle of a moveable disk with a diameter of 19.5 cm to match the perceived tilt of the faces shown to them on the computer screen. A needle attached to the disk moved along a grating displaying the angle of tilt of the disk. Backward tilt is described in terms of positive angles, and forward tilt in terms of negative angles. Participants were unable to see the readings displayed. The apparatus was positioned to the right of the computer screen at head height, within reach of the participant. Trials were randomised for each participant. For each trial, the face was shown on the screen and the participant indicated her/his perception of the tilt of the face. The experimenter recorded the angle of tilt and reset the position of the disk to an angle of $+50°$ before progressing to the next trial. The disk was reset prior to each trial to ensure that the tilt of each face had to be judged anew, ie participants could not simply make minor adjustments according to the previous position of the disk.

2.1.2 *Task 2: Perceived length of the nose.* For task 2, the two extreme instances (FU10 and FD10) of each face were shown as pairs (see figure 2), and participants were asked to decide which had the longest nose. There were forty-eight trials per participant, with each of the four target pairs shown twelve times. The two faces within a pair were shown in nonadjacent positions, and the positions of the two faces varied between presentations. The order of the forty-eight trials was randomised. Pairs of faces were displayed for 1200 ms, followed by a prompt of 'left or right'. Participants then had to respond using the keyboard to indicate which face had the longer nose.

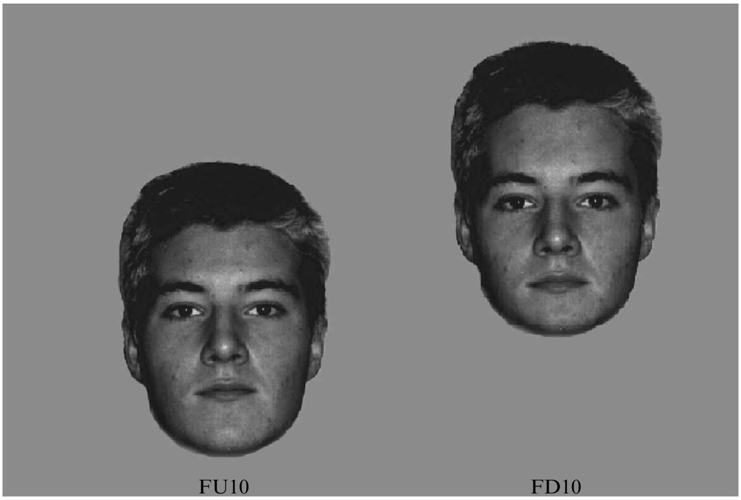

Figure 2. Sample stimuli used in task 2. Pairs of faces consisted of two versions where the inner-face area had been displaced either upwards or downwards by 10% of the interpupillary distance (FU10 and FD10).

3 Results

3.1 *Task 1: Perceived head tilt*

Table 1 shows mean perceived head tilt for FD10, FD5, OR, FU5, and FU10 versions, summarised for each of the nine participants and for each of the four target faces, as well as the overall mean perceived angle (and the standard deviation) for each level of vertical feature displacement. These results display a highly reliable relationship between feature position and perceived tilt that held for every face and every participant. A repeated-measures analysis of variance of the data averaged over the four target faces showed a significant relationship between movement of the internal features and

Table 1. Mean perceived head tilt by varying inner-face displacement presented as a percentage of interpupillary distance (IPD) where FD10 and FD5 indicate a downwards displacement of 10% and 5%, respectively, OR indicates no change, and FU5 and FU10 indicate displacements upwards of 5% and 10%, respectively.

	Displacement of inner-face/%IPD				
	FD10	FD5	OR	FU5	FU10
By participant					
Participant 1	−0.3	3.1	3.4	5.9	8.4
Participant 2	2.4	3.9	6.5	7.4	7.4
Participant 3	3.0	5.1	7.3	7.2	13.1
Participant 4	−5.9	1.6	2.4	11.3	15.7
Participant 5	2.1	4.2	6.2	7.2	9.3
Participant 6	0.9	2.8	3.8	6.9	11.1
Participant 7	9.6	8.1	11.8	11.6	14.7
Participant 8	10.3	11.7	14.8	16.3	22.6
Participant 9	1.0	4.9	6.3	11.8	14.2
By target face					
Face 1	1.9	3.1	5.0	8.6	11.4
Face 2	9.0	11.2	14.1	14.9	20.0
Face 3	4.1	7.5	8.4	12.5	15.4
Face 4	−4.3	−2.4	0.3	2.1	5.0
Mean	**2.6**	**5.0**	**6.9**	**9.5**	**12.9**
SD	(4.9)	(3.1)	(4.0)	(4.7)	(3.4)

perceived head tilt ($F_{1,11} = 29.41$, $p < 0.001$). Polynomial contrast analysis showed a significant linear component to this relationship ($F_{1,8} = 37.84$, $p < 0.001$). Nonlinear trends were not significant.

3.2 *Task 2: Perceived length of the nose*
Figure 3 shows the percentage of trials in which participants chose FD10 and FU10 versions of faces as having the longer nose. Results are shown for each target face. Averaged across faces, participants reported the FD10 versions as having the longer nose 63.2% of the time (SD = 16.0). A one-sample *t*-test showed that this value differed significantly from chance response (ie 50%): ($t_8 = 2.48$, $p = 0.04$).

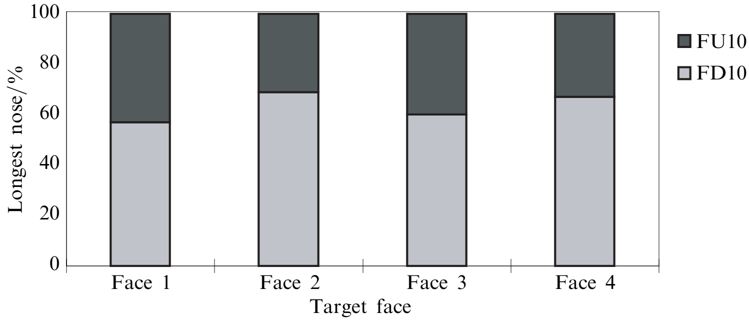

Figure 3. Task 2. Perceived nose length for pairs of faces differing in the direction of vertical displacement of the facial features. Percentage of trials in which FU10 (inner-face area displaced upwards by 10% of interpupillary distance) and FD10 (features displaced downwards) were judged as having the longest nose.

4 Discussion
A strong linear relationship was found between vertical displacement of the facial features and perceived head tilt. This was apparent for every participant and every face. For every 1.5 mm change in inner-face position there was a 2.5° change in perceived head tilt. The extent of the difference in perceived tilt between the FD10 and FU10 versions is equivalent to a face at a distance of 5 m looking at one of two points that are nearly 1 m apart. Clearly, the vertical position of the facial features within the face outline provides a powerful cue to the perception of head tilt.

Changes in the vertical position of the facial features affected perceived tilt even in the absence of actual featural changes in the displayed images that are usually correlated with head tilt (eg foreshortening). Even more striking, changes in the vertical position of the inner-face area gave rise to illusory changes in the perception of an individual facial feature within that region. The second task showed that when the facial features were moved up in the face, the nose was perceived as shorter more often than when the facial features were moved down. The results probably provide a conservative estimate of the size of this effect given that pairs of faces were shown at the same time, allowing a direct comparison of the size of the nose in the two images (the actual size of the nose of course did not differ).

Our interpretation of this finding is that when the facial features are moved up, the face is perceived as tilted backwards, and the nose is perceived *as if* foreshortened, so that a stable, internally consistent representation of the face is created. Perceived nose length, therefore, depends on the perceived tilt of the whole face. Together, the results provide evidence for holistic processing of faces at a basic perceptual level.

These results are interesting for several reasons. They demonstrate the close and complex relationship between configural and featural processing—changes in the positioning of the face features altered the perception of the size of an individual face-part (the nose), even when the spatial relationships between the nose and adjacent features (the eyes and mouth) had not changed. Also, although interactive processing effects have been identified before in face recognition (eg Sergent 1984; Tanaka and Farah 1993; Tanaka and Sengco 1997), effects of this kind have only rarely been demonstrated at a basic perceptual level (Maurer et al 2002). It is also worth noting that previous studies of face recognition (eg Haig 1984; Hosie et al 1988) have used face-matching paradigms to demonstrate the importance of the vertical position of the facial features relative to one another. People are extremely sensitive to changes to the distance between mouth and nose or between nose and eyes. However, participants in these studies have tended to be insensitive to changes in the vertical position of the internal facial features relative to the face outline (when moved together as here). Sensitivity to changes in the position of facial features therefore depends on the experimental task and on which aspect of the face processing system is examined. It appears that some configural information is not important in coding identity but is, nevertheless, accurately perceived and used for making other types of judgment about faces.

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