

Configural information in gender categorisation

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Abstract. *The role of configural information in gender categorisation was studied by aligning the top half of one face with the bottom half of another. The two faces had the same or different genders. Experiment 1 shows that participants were slower and made more errors in categorizing the gender in either half of these composite faces when the two faces had a different gender, relative to control conditions where the two faces were nonaligned or had the same gender. This result parallels the composite effect for face recognition (Young et al, 1987 Perception 16 747 ^ 759) and facial-expression recognition (Calder et al, 2000 Journal of Experimental Psychology: Human Perception and Performance 26 527 ^ 551). Similarly to responses to face identity and expression, the composite effect on gender discrimination was disrupted by inverting the faces (experiment 2). Both experiments also show that the composite paradigm is sensitive to general contextual interference in gender categorisation.*

1. Introduction

The crucial role of configural information has been extensively demonstrated in studies of face recognition (for a review, see Hancock et al 2000; Rakover 2002), and also in the processing of other types of facial information, such as emotional expression (eg Calder et al 2000). The decrease in performance observed when the configuration of the face is not accessible or is altered has led many authors to conclude that the processing of configural and/or relational information is at the heart of human expertise for face processing (eg Carey and Diamond 1977; Davidoff 1986). Configural information refers to the information about the relations between facial components, and it includes both first-order relations, which refer to the relative positions of the features (eg the eyes above the nose), and second-order relations, which refer to the distance between the features (eg close or distant eyes). This information is contrasted with local information which refers to the properties of individual parts, the texture, or the colour of the elements. One of the most famous demonstrations of the dominance of configural information in face recognition is the Margaret Thatcher illusion (Thompson 1980). When the eyes and the mouth are inverted within an upright normal face, this face looks monstrous. However, on viewing this upside-down, the monstrous aspect disappears and it is much more difficult to see the altered features. This illusion is interpreted as illustrating the importance of configural information in face processing, with inverted features being distorted relative to the configural context of the upright face. The effect is reduced when faces are turned upside-down because configural information is less salient in inverted faces (see Bartlett and Searcy 1993). More generally, configural information in facial-information processing has been extensively studied by comparing performance for normal upright versus upside-down faces (see Rakover 2002; Valentine 1988). Inversion affects many aspects of face recognition, including identity matching for unfamiliar faces,

familiarity and semantic decisions, and famous-face recognition (eg Bruyer et al 1993; Rock 1974; Valentine 1991; Valentine and Bruce 1986, 1988; Yin 1969). Inversion effects can be reduced in children (Flin 1985) or even eliminated (Carey and Diamond 1977; Carey et al 1980). The effect also disappears after damage to the right hemisphere (Yin 1970), or when faces are presented in the right visual field (Leehey et al 1978). Inversion appears to affect particularly the perception of distance relations between facial features (Bartlett and Searcy 1993; Leder and Bruce 1998, 2000; Leder et al 2001; Searcy and Bartlett 1996). It may also disrupt the processing of other kinds of facial information, including gender (Bruce et al 1993; Bruce and Langton 1994; Bruyer et al 1993). In other studies, evidence for the involvement of configural processing comes from differences between performance when face parts and whole faces are presented. For example, the recognition of a specific feature (eg nose) can be better when it is pre-sented in a normal full face (eg Davidoff and Donnelly 1990; see also Tanaka and Farah 1993). In contrast, whole faces can disrupt performance when the task is to attend to face parts. Young et al (1987) combined the top part of a famous face with the bottom part of another. When both parts were perfectly aligned creating a new composite face recognition from the part faces was more difficult than when the faces were misaligned. When the faces were inverted, this disruptive effect of the whole face was no longer significant. Calder et al (2000) reported a similar composite effect in the recognition of facial emotion: the emotion of each half part was more difficult to recognise when the other part displayed another emotion and was aligned. Again, this effect disappeared with face inversion. In the present paper, we extend the composite-face effects reported by Young et al (1987) in face recognition, and by Calder et al (2000) in emotion recognition, to gender categorisation. Previously, the role of configural information in gender categorization has been demonstrated with the inversion paradigm (Bruce et al 1993; Bruce and Langton 1994; Bruyer et al 1993). These studies show that configural information can provide an important cue for gender, since decreasing the salience of configural information (by inversion) reduces performance. However, the inversion paradigm does not provide a test of whether gender categorisation is disrupted when inappropriate configural cues are present. In this paper we test for the effect of such cues, using the composite-face procedure. In this paradigm, a new facial configuration is created by the alignment of two halves of different faces. Thus, configural information is not disrupted (unlike when faces are inverted) but it can be ambiguous for the task (eg if female and male faces are combined, in a gender categorisation task). By testing for interference from this new configural information, we learn something about the priority of configural processing in a particular task; disruption from a face composite should only come about if configural cues have greater priority than the processing of local parts and features. This last point is particularly important for understanding the task of gender classification. Many studies have shown that some specific features (ie particular local cues) play an important role in gender categorisation. They include the eyebrows (Brown and Perrett 1993; Yamaguchi et al 1995) and the distance between the eye-brow and the eyelid (Campbell et al 1999), the face outline (Yamaguchi et al 1995), and the jaw (Brown and Perrett 1993). Yamaguchi et al (1995) also found that

changing only two features—the eyebrows and the face outline—reversed the categorization from one gender to the other. The question, then, is whether configural information is just one gender cue among others, or if configural information plays a more dominant role in gender categorisation than local feature cues (making gender categorization similar in this respect to recognising facial identities and emotions). To address this issue, a first experiment was designed to test whether a composite effect can be observed in gender categorisation (cf Calder et al 2000; Young et al 1987). In this study, participants had to decide whether the top or bottom halves of faces were female or male faces. The other half faces could either have the same or a different gender, and the two halves were either aligned or nonaligned. If configural information is dominant, then there should be interference from an irrelevant half face of the opposite gender. Moreover, this should occur when the halves are aligned and not when they are nonaligned.

2. Experiment 1

2.1 Method

2.1.1 Participants.

Sixteen individuals (fifteen females and one male) volunteered. They were aged between 18 and 25 years (mean = 19.9 years). All had normal or corrected-to-normal vision.

2.1.2 Material.

We used colour photographs of ten women (aged from 19 to 30 years) and ten men (aged from 20 to 28 years). Each face was placed in a surrounding oval in order to conceal information about the hairstyle and the top part of the body. The size of the oval was 381 pixels in width and 650 pixels in height. Top and bottom versions were built by cutting the oval across the middle, corresponding to location of the bridge of the nose. The top and bottom parts of these faces were presented to a control group of eight subjects who had to judge whether each part belonged to a woman or to a man. For each part, at least seven to eight subjects correctly categorised the gender. Each face was linked to two other faces, one of the same gender and one of the opposite gender. Composite and noncomposite faces were then built by horizontally abutting the top/bottom part of a face with the bottom/top part of each linked face (see figure 1 for an illustration). In this way we built 40 composite and 40 noncomposite faces, of which one quarter corresponded to two women, one quarter to two men, one quarter to a woman at the top and a man at the bottom, and one quarter to a man at the top and a woman at the bottom. The faces of two other women and two men were also used to build composite and noncomposite faces for the training session.

2.1.3 Procedure.

A trial started with the presentation of a fixation cross (500 ms) followed by a blank screen (500 ms). The target face then appeared and remained until the subject responded. The 40

composite and 40 noncomposite faces were presented two times in two distinct sessions. In the first session, half the subjects had to respond as accurately and as fast as possible if the top part was a woman or a man; the other subjects responded to the bottom part. In the second session, the subjects performed the reverse task. The part to which subjects responded was always presented at the centre of the screen in the horizontal axis. For the noncomposite faces, the other part was shifted to the right for half the trials in each experimental condition, and to the left for the other half. The side towards which the shift was made was alternated between participants.

2.2 Results

There were three within-subjects factors: gender of the other part (same versus different), type of face (composite versus noncomposite), and part for decision (top versus bottom). The dependent variables were latency for correct response and percentage of errors. For latency, responses to more than 2 standard deviations from the mean in each condition were not included. The errors were analysed to ensure that participants did not use different strategies according to the type of the face. These analyses also allowed us to assess if any interference was limited to response time or whether interference effects were also present in participants making the wrong response to the gender of the correct facial part. Two three-factor analyses of variance (part for decision \times gender of the other part \times type of face) were carried out on the latency and error data. The means and standard errors for correct response times and accuracy in the various conditions are presented in table 1.

2.2.1 Response times (RTs).

There was a main effect of gender of the other part; participants responded faster when the other part was of the same gender [819 ms when the other part was of same gender versus 914 ms when the other part was of different gender ($F(1, 15) = 24.68, p < 0.001$)]. The main effect of type of face was significant:

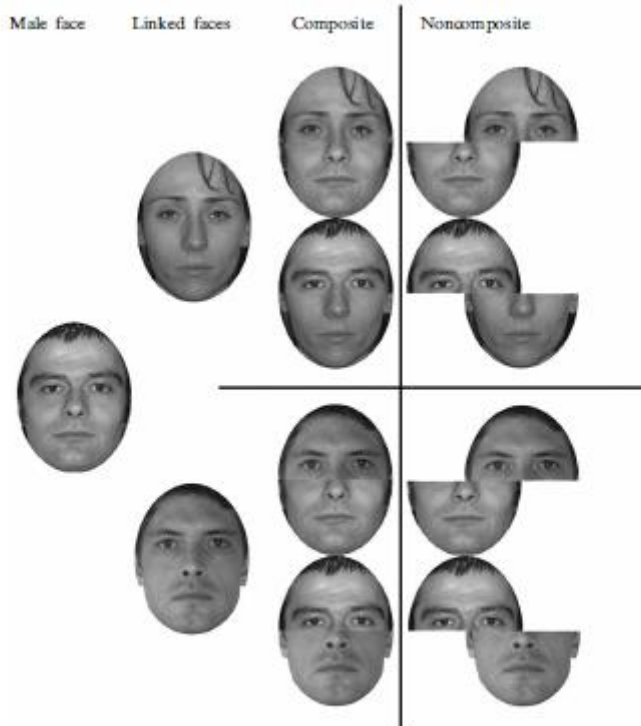


Figure 1. Illustration of composite and noncomposite faces: different-gender faces above, same-gender faces below. A colour version of this figure can be viewed on the *Perception* website at <http://www.perceptionweb.com/misc/n3d03/>

Table 1. Mean latencies for correct responses and error rates according to the part for decision, the type of face, and the gender of the other part. Standard errors are shown in parentheses.

Latency and error rate	Bottom part		Top part					
			noncomposite		composite noncomposite			
	different gender	same gender	different gender	same gender	different gender	same gender	different gender	same gender
RT/ms	1071 (85)	878 (64)	821 (41)	803 (40)	966 (57)	831 (47)	798 (36)	764 (36)
Error/%	7.5 (1.6)	2.2 (1.3)	5.9 (1.5)	2.2 (0.9)	10.3 (1.8)	1.9 (0.8)	2.5 (0.9)	2.5 (0.9)

composite faces were responded to more slowly (937 ms for composite versus 796 ms for noncomposite faces ($F(1, 15) = 23.82, p < 0.001$). The interaction between type of face and gender of the other part was also significant ($F(1, 15) = 9.96, p < 0.01$). An effect of same ^ different gender occurred for composite faces [1018 ms with different gender versus 855 ms with same gender ($F(1, 15) = 18.35, p < 0.001$)], but not for noncomposite faces ($F(1, 15) = 3.09, p > 0.05$). RTs were longer for composite than for noncomposite faces when the gender differed between the two half-faces (1018 ms versus 809 ms, respectively, difference = 209 ms; $F(1, 15) = 25.24, p < 0.001$), and also, but to a lesser extent, when the gender was the same (855 ms versus 783 ms, respectively, difference = 72 ms; $F(1, 15) = 5.86, p < 0.05$). Finally, the face part used for the decision had no effect either alone ($F(1, 15) = 1.75$) or in interaction with other factors (part for decision \times type of face: $F(1, 15) = 1.16$, part for decision \times gender of the other part: $F(1, 15) = 0.38$, overall interaction: $F(1, 15) = 2.20$).

2.2.2 Errors.

The main effect of gender of the other part was significant: participants were less accurate when the gender of the other part was different rather than the same (6.6% versus 2.2%, respectively; $F(1, 15) = 39.73, p < 0.0001$). The main effect of type of face was also significant: participants made more errors for composite faces (5.5% for composite versus 3.3% for noncomposite faces; $F(1, 15) = 12.05, p < 0.01$). The interaction between type of face and gender of the other part was also significant ($F(1, 15) = 9.80, p < 0.01$), but this was qualified by an interaction between type of face, gender of the other part, and part for decision ($F(1, 15) = 4.95, p < 0.05$). The interaction between type of face and gender of the other part was significant when the decision was to the top ($F(1, 15) = 12.79, p < 0.01$), but not when the decision was to the bottom ($F(1, 15) = 0.57$). When the decision was to the top, an effect of same ^ different gender occurred for composite faces (10.3% with different gender versus 1.9% with same gender; $F(1, 15) = 21.74, p < 0.001$), but not for noncomposite faces ($F(1, 15) = 0.00$). Errors were more frequent for composite than for noncomposite faces when the gender differed between the two half-faces (10.3% versus 2.5%, respectively; $F(1, 15) = 14.67, p < 0.01$), but not when it was the same ($F(1, 15) = 0.48$). When the decision was to the bottom part, the main effect of gender of the other part was significant; participants made more errors when the other part was of opposite gender (6.7% with different gender versus 2.2% with the same gender; $F(1, 15) = 14.48, p < 0.01$).

2.3 Discussion

The results suggest that there is configural processing of the gender of faces which interferes in the processing of facial parts. Participants were slower to process the gender of a half-face when it was aligned with another face of the opposite gender, than when the opposite face was shifted or when there was an aligned face of the same gender. This observation parallels those by Calder et al (2000) and Young et al (1987) for expression recognition and face recognition, respectively. The results cannot be accounted for in terms of an Eriksen-type interference effect when face parts are response-incompatible (ie a conflict in the response to the two parts; Eriksen and Eriksen 1974), since the incongruity effect arose strongly in the composite condition. In other words, both parts had to be aligned, thus creating a new facial configuration, to generate maximal interference. Consequently, the results of experiment 1 indicate that configural information plays an important role in gender categorisation. Even if subjects rely on specific facial features to realise the task (eg eyebrow shape and density for the top half, facial texture and chin shape for the bottom half), it is clear that perturbation of the configuration by adding features of the opposite gender to a facial composite increased response latency. The alignment of both parts appeared to create a new configuration, with an ambiguous gender, when both parts were of opposite gender. This ambiguity interfered with the categorisation of each, unambiguous, part. Nevertheless, an interference effect also occurred for same-sex faces shown as composites rather than noncomposites: RTs were slower to composites than to noncomposites. This may again reflect a contribution of a new

facial 'Gestalt' when the faces were aligned. In this Gestalt, there may be a lack of correlation between the gender-related features in the top and bottom halves of the face, slowing RTs. We also found that more errors occurred when the decision was to the bottom part and the top part was of different gender, whatever the composite versus noncomposite type of face. We return to this point in section 4. To ensure that the composite effect did really result from configural information, Young et al (1987) as well as Calder et al (2000) replicated their experiments by contrasting upright stimuli with upside-down ones. Configural information is assumed to be less salient when faces are inverted than when they are upright (Yin 1969). Any interference consequent on the facial configuration should at least reduce with inverted faces, and this is what Calder et al and Young et al reported. Experiment 2 was designed to test whether the same pattern of results occurs in a gender-categorisation task. The same stimuli were presented to a new group of participants in two conditions: upright or upside-down. If configural information is crucial, the composite effect for gender categorisation should be present with upright, but not with upside-down faces.

3. Experiment 2

3.1 Method

3.1.1 Participants.

Sixteen people (fifteen females and one male) volunteered. They were aged between 18 and 22 years (mean = 19.7 years). All had normal or corrected-to-normal vision.

3.1.2 Material.

We used the same material as in experiment 1.

3.1.3 Procedure.

The procedure was the same as in experiment 1, except that participants performed four sessions. Two sessions were identical to experiment 1. The two others were identical on all points except that the stimuli were presented upside-down. Half the participants performed the two sessions (top and bottom) with upright faces first; the other half performed the two sessions with upside-down faces first. The order of top versus bottom sessions was alternated between participants.

3.2 Results

The factors analysed were orientation (upright versus upside-down), gender of the other part (same versus different), type of face (composite versus noncomposite), and part for decision (top versus bottom). All these factors were manipulated within subjects. The dependent variables were latency of the correct response and error rate. For latency, responses to more than 2 standard deviations from the mean in each condition were not included. The means

and standard errors for correct response times and accuracy in the various conditions are presented in table 2. Two four-factor analyses of variance (orientation \times part for decision \times gender of the other part \times type of face) were carried out on the latency and error data.

3.2.1 RTs.

The main effect of orientation was significant: participants responded faster to upright than to upside-down faces (816 ms versus 918 ms; $F(1, 15) = 16.37, p = 0.01$). The main effect of gender of the other part was significant: participants responded faster when the other part was of the same gender (854 ms when the other part was of same versus 880 ms when the other part was of different gender; $F(1, 15) = 7.80, p = 0.05$). There was also a main effect of type of face: composite faces were responded to more slowly (890 ms for composite versus 845 ms for noncomposite faces; $F(1, 15) = 19.26, p = 0.001$). There was a significant interaction between gender of the other part and orientation ($F(1, 15) = 16.20, p = 0.01$), but it was qualified by a significant interaction between type of face, gender of the other part, and orientation ($F(1, 15) = 8.39, p = 0.05$). There was an interaction between type of face and gender of the other part when the faces were upright ($F(1, 15) = 5.27, p = 0.05$). This did not occur when the faces were upside-down ($F(1, 15) = 0.07$). When the faces were upright, an effect of same \times different gender occurred for composite faces (890 ms with different gender versus 774 ms with same gender; $F(1, 15) = 12.68, p = 0.01$), but not for noncomposite faces ($F(1, 15) = 0.01$). RTs were longer for composite than for noncomposite faces when the gender differed between the two half-faces (890 ms versus 799 ms, respectively; $F(1, 15) = 7.07, p = 0.05$), but not when it was the same ($F(1, 15) = 1.65$).

Table 2. Mean latencies for correct responses and error rates according to the orientation, the part for decision, the type of face, and the gender of the other part. Standard errors are shown in parentheses.

Latency and error rate	Bottom part		Top part					
	composite		noncomposite		composite		noncomposite	
	different gender	same gender	different gender	same gender	different gender	same gender	different gender	same gender
<i>Upright:</i>								
RT/ms	954 (98)	799 (60)	823 (59)	815 (68)	827 (76)	749 (64)	776 (76)	789 (75)
Error/%	11.9 (1.8)	4.7 (1.3)	6.3 (1.6)	4.7 (1.3)	15.3 (2.7)	3.8 (1.1)	4.1 (1.4)	3.1 (0.9)
<i>Upside-down:</i>								
RT/ms	1030 (107)	1041 (105)	928 (86)	911 (81)	869 (87)	851 (78)	839 (78)	876 (88)
Error/%	19.1 (2.1)	13.4 (1.6)	18.1 (2.3)	13.1 (1.8)	8.8 (1.3)	6.3 (1.3)	9.1 (1.3)	8.1 (1.3)

The main effect of part for decision was significant: participants responded faster to the top than to the bottom part (822 ms versus 912 ms; $F(1, 15) = 16.55, p = 0.01$). This effect was qualified by type of face and part for decision interaction ($F(1, 15) = 6.49, p = 0.05$); when the decision was to the bottom part, RTs were slower for composite faces (956 ms for composite versus 869 ms for noncomposite faces; $F(1, 15) = 12.49, p = 0.01$). The difference was not

significant when the decision was to the top part ($F(1, 15) = 0.12$). The effect of part for decision was also qualified by an interaction between gender of the other part and part for decision ($F(1, 15) = 9.09$, $p = 0.005$): when the decision was to the bottom part, RTs were slower when the other part was of different gender (933 ms when the other part was of different versus 891 ms when the other part was of same gender; $F(1, 15) = 9.89$, $p = 0.001$). The difference was not significant when the decision was to the top part ($F(1, 15) = 2.26$). These effects were not qualified by orientation (part for decision \times orientation: $F(1, 15) = 2.13$; part for decision \times gender of the other part \times orientation: $F(1, 15) = 0.56$; part for decision \times type of face \times orientation: $F(1, 15) = 3.53$; overall interaction: $F(1, 15) = 3.22$).

3.2.2 Errors.

The main effect of orientation was significant: participants made more errors for an upside-down than for an upright face (12% versus 6.7%; $F(1, 15) = 43.82$, $p = 0.0001$). The main effect of gender of the other part was significant: participants made more errors when the other part was of different gender (11.6% versus 7.1% when the other part was of same gender; $F(1, 15) = 33.35$, $p = 0.0001$). The main effect of type of face was significant: participants made more errors for composite than for noncomposite face (10.4% versus 8.3%; $F(1, 15) = 7.62$, $p = 0.005$). The main effect of part for decision was significant: participants made more errors to the bottom than to the top part (11.4% versus 7.3%; $F(1, 15) = 11.49$, $p = 0.001$). The interactions between orientation and type of face ($F(1, 15) = 10.09$, $p = 0.001$) and between gender of the other part and type of face ($F(1, 15) = 16.36$, $p = 0.001$) were significant. The interaction between type of face, gender of the other part, and orientation was also reliable ($F(1, 11) = 19.64$, $p = 0.001$). This last effect arose because the interaction between type of face and gender of the other part was significant when faces were upright ($F(1, 15) = 29.82$, $p = 0.0001$), but not when they were upside-down ($F(1, 15) = 0.53$). For upright faces, participants made more errors for composite faces with a difference of gender relative to both (i) composite faces with the same gender (13.6% versus 4.2%; $F(1, 15) = 34.79$, $p = 0.0001$) and (ii) noncomposite faces with different genders (13.6% versus 5.2%; $F(1, 15) = 25.37$, $p = 0.001$). The other conditions did not differ (all $F_s < 2.73$). For upside-down faces, the effect of type of face was not significant ($F(1, 15) = 0.07$), but the effect of gender of the other part was: participants made more errors when the other part was of different gender (13.4% versus 10.2% when the other part was of same gender; $F(1, 15) = 8.24$, $p = 0.005$). The interaction between part for decision, orientation, and gender of the other part was also significant ($F(1, 15) = 11.43$, $p = 0.001$). Gender of the other part significantly interacted with orientation when the decision was to the top part ($F(1, 15) = 5.24$, $p = 0.005$), but not when it was to the bottom part ($F(1, 15) = 0.33$). When the decision was to the top part, participants made more errors for upright faces when the bottom was of a different rather than the same gender (9.7% versus 3.4%; $F(1, 15) = 19.74$, $p = 0.001$); there was no significant difference for upside-down faces ($F(1, 15) = 1.63$). When the decision was to the bottom part, participants made more errors when the top was of a different rather than the same gender for both upright (9.1% versus 4.7%; $F(1, 15) = 17.93$, $p = 0.001$).

0:001) and upside-down faces (18.6% versus 13.3%; $F(1, 15) = 10.86, p = 0.01$). The overall interaction was not significant ($F(1, 15) = 0.93$), and there were no other significant interactions.

3.3 Discussion

Overall, the results of experiment 2 matched those of experiment 1, i.e. the presence of opposite-gender faces interfered with gender categorisation when faces were upright, and this was significant only when both parts were aligned to create a new facial configuration. This configuration-based interference effect disappeared when faces were upside-down, when the salience of configural information in the face is reduced. However, the interference effect for same-sex faces shown as composites rather than non-composites in experiment 1 was not replicated in experiment 2. There was nonetheless also another interference effect from different-gender faces that did not rely on the creation of a new configuration: participants were less accurate in recognizing the gender when the other part was of a different gender, whether the faces were composite or not. This effect disappeared with upside-down faces when the decision was to the top part, but not when the decision was to the bottom part.

4. General discussion

To recapitulate the results of both experiments, participants were slower and less accurate in categorising the top or bottom half of a face as female or male when the other part had a different gender and was aligned to create a new facial configuration. This interference effect disappeared when faces were inverted (experiment 2). This observation indicates that configural information is an important cue to gender categorisation, and that inappropriate configural information can interfere with the responses based on local feature information. The results of both experiments also indicate that decisions to the gender of the bottom half part of a face are sensitive to interference from the top half part. This last observation did not result from a configural effect since it did not depend on the alignment of the two half parts. Moreover, it was also observed when faces were upside-down, suggesting that the interference effect relies on facial properties which are not disrupted by inversion. So, the composite paradigm is sensitive to general contextual interference in gender categorisation. Mainly, the top part of the face interfered in gender categorisation responses to the bottom part, and this effect did not rely on the creation of a new configuration. This can be due to a particular weight of some of top features in gender categorisation. For example, the eye region and the eyebrows have frequently been reported as important cues to gender (e.g. Bruce et al 1993; Campbell et al 1999; Yamaguchi et al 1995). It then appears that the single presentation of gender-specific features from the top part of a face interferes in the categorisation of the gender of features from the top part of the face, whether they are aligned or not, and whatever the orientation of the two parts. This suggests that these top features are categorised automatically, and consequently interfere in the response to bottom features. The reverse is not true. According to the literature, eyebrows are good candidates to be these top features, since they are among the top features the

most important in gender categorisation (see Brown and Perrett 1993). Overall then, the results of this study allow a better understanding of the mechanisms underlying the processing of gender of face. As discussed in section 1, previous studies demonstrate the role of some distinct features in gender categorisation, including the eyebrows, jaw, or face outline (eg Brown and Perrett 1993; Yamaguchi et al 1995). The results here show that configural information not only contributes in addition to any local features (eg Bruce et al 1993; Bruyer et al 1993), but that it is also given high priority. Thus, inappropriate configural information disrupts the categorisation task. To account for the data, models of gender categorisation have to integrate configural information processing. Nevertheless, local information is not silent in gender categorisation, as top features are given stronger weighting than bottom features. This differs from studies of identity and facial expression judgments, where neither Young et al (1987) nor Calder et al (2000) found an interference effect from the top (or indeed either) part across the composite and nonaligned conditions. Hence, different face tasks may 'weight' differently the contrasting properties of faces, though configural information plays a role in each case.

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