A bias for the female face in the right hemisphere

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In the present study we assessed the contribution of the two hemispheres to the attribution of gender of faces in male and female observers. Normal and chimeric faces were presented in their canonical orientation and upside-down in a tachistoscopic paradigm. Chimeric faces were composed of two halves (left and right) obtained from photos of individuals of the same sex or from individuals of different sexes. All faces were presented tachistoscopically with a central fixation, the two halves falling in the two visual fields of the observer, who was required to rapidly judge the sex of the face. A left half-face (right-hemispheric) bias for gender attribution with upright faces was observed both in male and female participants, as previously reported. Strikingly, however, the bias depended entirely on female-left/male-right chimeras, revealing a right-hemispheric advantage for the recognition of female faces. The results are discussed in the light of a behavioural bias during development (i.e., maternal cradling).

A right-hemispheric bias for face recognition has been reported since at least three decades ago in the neuropsychological literature (Gilbert & Bakan, 1973). When right-handers process facial stimuli an attentional bias is usually found, favouring the left half-face (that falling in the observer’s left visual field) over the right half-face. The leftward bias for facial stimuli appears to be the result of a greater activation of the right hemisphere, arising from that hemisphere’s specialisation for the perception of facial...
(Benton, 1980; Etcoff, 1984) and visuospatial information (Laeng, Chabris, & Kosslyn, 2003). Experiments using chimeric stimuli (Burt & Perrett, 1997; Luh, Rueckert, & Levy, 1991) have shown that the right hemisphere is more involved than the left hemisphere in processing facial identity and other features, such as emotion, age, sex, and attractiveness: when judging these dimensions in either tachistoscopic or free-vision experiments, participants rely more on the features of the left half-face (Hoptman & Levy, 1988).

Little is known in general about sex differences in face processing, especially with respect to gender judgement. For instance, Cellerino, Borghetti, and Sartucci (2004) found a striking difference in categorisation of male and female faces, female participants being more efficient in recognising female faces. This evidence is in line with a previous study (Lewin & Herlitz, 2002) reporting that females perform at a higher level than males in the recognition of female faces, although no sex differences in the recognition of male faces were found.

Moreover, it is well known that observers take longer and are less accurate in recognising inverted faces rather than upright faces, as compared to other objects, a phenomenon known as the “face inversion effect” or FIE (Diamond & Carey, 1986; Farah, Drain, & Tanaka, 1995; Yin, 1969). This advantage for upright faces has been attributed to our expertise with a highly homogeneous class of stimuli seen in a specific orientation in everyday life (Valentine, 1988). Some studies show that there is a hemispheric explanation to this effect, in that the right hemisphere has an advantage in holistic processing, whereas the left has an advantage in parts-based processing (Bradshaw & Sherlock, 1982; Haxby et al., 1999; Leehey, Carey, Diamond, & Cahn, 1978; Rhodes, 1993). Thus it seems likely that the processing of inverted faces takes place differently from upright faces.

A further issue, lateralisation of gender judgement has been investigated in a number of recent research works (Butler, Gilchrist, Perrett, Jones, & Harvey, 2005; Butler & Harvey, 2005, 2006), one of these (Butler & Harvey, 2005) also including inverted faces among the stimuli tested. Whereas those studies confirmed a right-hemispheric bias in gender judgement for upright faces and extended this result to inverted faces, they did not go into much detail about the possible interactions between the sex of the observers and the gender of the parts of the chimeric stimuli (their left halves) that are processed by the right hemisphere, supposedly in control of the judgement.

In the present study we tried to confirm whether such right-hemispheric advantage for gender judgement is present for upright and inverted chimeric faces, but the main focus was on the hypothesis that the two possible combinations of sexes of the two component half-faces (a male on the left and a female on the right versus a female on the left and a male on the right) might exert some differential influence on the pattern of lateralisation of male and female observers. In particular, the results of Cellerino et al. (2004)
and Lewin and Herlitz (2002) allow us to predict that the right-hemispheric bias would be stronger for female–male chimeras in female observers.

Moreover, we tried to gather further information on the question of whether and how the face inversion effect takes part in gender decision about a chimeric face. That is, if we rotate a chimeric face 180°, will the participant continue to rely on the left half-face in retinocentric coordinates, as for the faces in canonical orientation, or on the right half-face, showing a possible lateralisation based on face-centric coordinates? To answer these questions, participants were shown chimeric faces composed of two halves of different sexes (male-left/female-right; female-left/male-right), presented both in their canonical orientation and upside-down.

Most importantly, results were also accurately compared in terms of sex differences, as different lateralisation patterns in gender recognition could be contingent upon the sex of the observer. One further assumption that led us to expect interactions between faces’ and observers’ gender is the hypothesis that human lateralisation might have evolved in order to coordinate social interactions (Ghirlanda & Vallortigara, 2004; Vallortigara, 2006; Vallortigara & Rogers, 2005). The existence of sex-contingent perceptual asymmetries in face gender decision could thus be useful in understanding how sexual selection shaped the establishment and the evolution of human lateralisation (Tommasi, 2005).

METHOD

Participants

A total of 64 participants (32 females and 32 males), all students attending the University of Chieti, (mean age: 22.4 years), took part in the study on a voluntary basis. They were all right-handed as assessed by the Edinburgh Inventory (Oldfield, 1971) and had normal or corrected-to-normal vision.

Stimuli

A total of 200 different faces were used to create 120 stimuli, subdivided into two main sets: 60 upright faces and 60 inverted faces. Both sets included 10 chimeric male-left/female-right faces, 10 chimeric female-left/male-right faces, 10 chimeric male-left/male-right faces, 10 chimeric female-left/female-right faces, 10 non-chimeric male faces, and 10 non-chimeric female faces (see Figure 1 for examples). No face was used twice in creating stimuli. Photographs of faces were obtained on the Internet from websites featuring personal information pages of Members of the Parliament of Romania, Italian minor sport teams, and other open-access sources. The
photographs were selected with the constraints that they displayed neutral faces in front view and without visible emotional expressions. All photographs were converted from colour to grey-level, and had an original resolution in the range of 72–100 ppi. Moreover, faces were chosen so that all possible additional features that could have made gender recognition easy were absent: e.g., beard, earrings, make-up. For the production of chimeric stimuli we used two photographs depicting faces, joining the right half of one photo together with the left half of the other, keeping the distance between eyes and the length of the vertical midline constant. The two halves were not blended but simply juxtaposed. Moreover, differences in luminance levels among the two halves were digitally reduced, and the faces’ salient features (nose, chin, lips, etc.) were made to spatially correspond as much as possible by slightly modifying the size of one of the two faces, in order to obtain two halves that appeared as belonging to only one face. Afterwards, faces were enclosed in a standard white frame with an oval hole through which they were visible and that made them all appear the same shape and size (see Figure 1.

Figure 1. Examples of stimuli used. Upper row: whole face, chimeric same-sexes face, chimeric different-sexes face. Lower row: inverted whole face, inverted chimeric same-sexes face, inverted chimeric different-sexes face.
Figure 1). We used the same procedure for the same-sexes chimeric stimuli. Non-chimeric stimuli were also treated digitally to eliminate luminance discrepancies across the two halves and were also made equally oval in shape and the same size as the chimeric stimuli. All this was made with Photoshop 7.0.

To presenting the stimuli we used the software Superlab®. The experiment was subdivided into two blocks of 60 randomised trials. Each trial contained three subsequent events: a central cross-shaped fixation point (subtending 1 deg × 1 deg; duration: 1000 ms); the stimulus (subtending 4 deg × 5 deg; duration: 250 ms) centred on the fixation point, and a blank (a white screen whose presence was terminated by the participant’s response). The duration of the experimental session was approximately 10 minutes.

Procedure

The stimuli were presented on an LCD computer screen in a dimly-lit room, and the participant’s head was positioned at a distance of 44 cm from the screen. Participants were first instructed about the response they had to give in each trial (whatever was the nature of the stimulus) which consisted in deciding, in the shortest possible time, the gender of the face by pressing one of two response buttons (keys “Q” and “P” of a standard keyboard, labelled “M” for male and “F” for female). Response buttons were reversed for half the participants, so that half of them (16 male and 16 female) had the M button on the left and F button on the right, and the other half vice versa. Especially because one third of the stimuli were composed of hemi-faces of the two sexes (and thus both responses were allowed), participants were encouraged to base their judgements on a global impression (the first impression).

Data analysis

The mean proportion of correct responses (± SEM) for whole faces and same-sexes chimeric faces was calculated for each participant, whereas for different-sexes chimeric faces a lateralisation index LI was computed as the number of judgements based on the left half-face of the chimeras divided by the number of stimuli observed in that condition. The index LI thus ranges from 0 to 1, where LI = 0 means that the judgement is based entirely on the right half-face, LI = 1 means that the judgement is based entirely on the left half-face and LI = 0.5 means that the judgement is randomly based on both half-faces.
RESULTS

Whole faces

The proportion of correct judgements for whole faces was on average very high for upright faces (0.95 ± 0.01) and weaker for inverted faces (0.83 ± 0.01), revealing the presence of the inversion effect. A repeated measures ANOVA (see Figure 2) in fact showed a main effect of face orientation \((F_{1, \ 62} = 99.57, \ p < .001)\). A main effect of face sex was also found \((F_{1, \ 62} = 11, \ p < .01)\), depending on the fact that the inversion effect was stronger for female faces (female upright: 0.94 ± 0.01; female inverted: 0.78 ± 0.02) than for male faces (male upright: 0.96 ± 0.01; male inverted: 0.88 ± 0.02), as confirmed by the significant interaction found between orientation and face sex \((F_{1, \ 62} = 5.467, \ p < .05)\). Post-hoc comparisons (Fisher’s LSD; \(p < .05\)) showed that performance with inverted female faces was not only impaired with respect to upright female faces but also worse than inverted male faces. No main effect or interaction involving observer sex was found.

Same-sexes chimeric faces

With same-sexes chimeric faces the proportion of correct responses was 0.91 ± 0.01 for upright faces and 0.81 ± 0.01 for inverted faces, another confirmation of the FIE (see Figure 3). In fact, a repeated measures ANOVA showed a main effect of face orientation \((F_{1, \ 62} = 34.68, \ p < .001)\). Again, a main effect of face composition was found \((F_{1, \ 62} = 4.92, \ p < .05)\).

![Figure 2](image_url)

**Figure 2.** Proportion correct of gender decision for whole upright and inverted faces. Data of the subsample of male observers are in the left panel, and those for the subsample of female observers are in the right panel. Bars represent SEMs.
due to the fact that the upright male–male chimeras were recognised better than the upright female–female chimeras (male–male upright: 0.94 ± 0.01; male–male inverted: 0.81 ± 0.02; female–female upright: 0.88 ± 0.02; female–female inverted: 0.81 ± 0.02), also suggested by the result for the interaction between orientation and face sex ($F_{1, 62} = 3.14, p = .081$). No main effect or interaction involving observer sex was found.

By comparing the results in Figure 2 and Figure 3 it also seems that recognition of same-sexes upright chimeras and whole upright faces of the corresponding sex could differ in favour of the whole faces. This was confirmed when comparing performance with female–female chimeras and female whole faces (female observers: female whole faces: 0.95 ± 0.02; female–female chimeric faces: 0.89 ± 0.02; $t_{31} = -2.3; p < .05$; male observers: female whole faces: 0.93 ± 0.02; female–female chimeric faces: 0.87 ± 0.03; $t_{31} = -2.5; p < .05$) but not when comparing performance with male–male chimeras and male whole faces (female observers: male whole faces: 0.96 ± 0.02; male–male chimeric faces: 0.96 ± 0.01; $t_{31} = 0; ns$; male observers: male whole faces: 0.96 ± 0.01; male–male chimeric faces: 0.92 ± 0.03; $t_{31} = -1.5; ns$). Female–female chimeras were thus recognised with a reduced performance compared female whole faces, suggesting a special status of the chimeric faces composed of two female halves.
Different-sexes chimeric face

With different-sexes chimeric faces (see Figure 4), laterality indices obtained were $LI_{Up} = 0.59 \pm 0.02$ for upright faces (one sample $t$ test against chance: $t_{63} = 4.11; p < .001$) and $LI_{In} = 0.6 \pm 0.01$ for inverted faces (one sample $t$ test against chance: $t_{63} = 7.28; p < .001$). These values indicate the presence of a comparable left half-face bias in gender decision for both upright and inverted chimeric faces ($t_{63} = -0.561; p > .05$).

However, a repeated measures ANOVA showed a main effect of face composition ($F_{1, 62} = 9.5; p < .01$), in that female–male chimeras exerted a higher laterality ($LI_{FM} = 0.64 \pm 0.02$; one sample $t$ test against chance: $t_{63} = 5.87; p < .001$) than male–female chimeras ($LI_{MF} = 0.54 \pm 0.02$; one sample $t$ test against chance: $t_{63} = 2.2; p < .05$). A significant interaction between orientation and composition of faces ($F_{1, 62} = 5.59, p < .05$) was found. Post-hoc comparisons (Fisher’s LSD; $p < .05$) showed that (i) for upright faces the female–male chimeras ($LI_{UpFM} = 0.67 \pm 0.03$; one sample $t$ test against chance: $t_{63} = 6.071; p < .001$) differed from male–female chimeras ($LI_{UpMF} = 0.51 \pm 0.02$; one sample $t$ test against chance: $t_{63} = 0.243; p > .05$), thus revealing that the laterality index obtained with upright faces $LI_{Up}$ depended entirely on the female–male chimeras; (ii) for inverted faces no difference was found between male–female faces ($LI_{InMF} = 0.58 \pm 0.02$; one sample $t$ test against chance: $t_{63} = 3.100; p < .05$) and female–male faces ($LI_{InFM} = 0.62 \pm 0.03$; one sample $t$ test against chance: $t_{63} = 3.799$);

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Figure 4. Laterality index for upright and inverted different-sexes chimeric faces. Data of the subsample of male observers are in the left panel, and those of the subsample of female observers are in the right panel. Bars represent SEMs.
indicating that the laterality index $LI_{tw}$ did not depend on face composition.

No main effect of face orientation was found but, most strikingly, no main effect or interaction involving observer sex was found, indicating that the same laterality pattern held true for both male and female observers.

**DISCUSSION**

The results here reported are strongly consistent with the already known advantage of the right hemisphere for face processing, in particular for judging about gender. As previously reported, in fact, when participants have to decide the gender of a chimeric face they tend to rely more on the features of the left half-face (Burt & Perrett, 1997; Butler & Harvey, 2005, 2006). In the present study this result was confirmed but further analyses of the data revealed that it applied mostly to half of the chimeric faces used as stimuli, namely those constructed by adjoining a female left half-face to a male right half-face. This confirms our initial hypothesis about female observers (i.e., that female would be more lateralised with female–male rather than male–female chimeras), but also extends it to male observers, revealing an unsuspected bias of the right hemisphere for the female face.

The fact that the lateralisation index $LI_{tp}$ found for the whole set of faces suggested a general left half-face (right-hemispheric) bias for gender recognition was thus concealing a rather different story, which might have gone unnoticed in the previous studies on this same phenomenon: the right hemisphere seems to be, at least with the very special category of chimeric faces, very sensitive to the female facial template, a result strongly reinforced by the fact that the asymmetry pattern was the same in both subsamples of observers, males and females.

It must be noticed that recognition of the female faces could not be biased per se as a result of a higher prototypicality or of a better appreciation of the features present in the female (and not in the male) components of our chimeras, since the subset of stimuli consisting of whole faces, taken from the same photographic sources and digitally treated in a similar fashion, exerted a comparably high performance for male and female faces. Furthermore, the performance achieved when participants judged chimeras constructed with half-faces of the same sex was higher for chimeras constructed as male-left/male-right than for chimeras constructed as female-left/female-right. This latter result further supports the fact that the half-faces used were not differentially recognisable per se in favour of the female gender, rather it seems that the opposite was likely true. Although the female-left bias suggested a better recognition of female–female versus male–male chimeras, as well as a better recognition of female than male whole faces, neither
pattern was found. This puzzling set of results suggests that composition of the faces (whole faces, same-sexes chimeras, different-sexes chimeras) must have affected the results in a way that is not simply explained by the sole female/male attribution to left and right halves, but calls for a form of interaction of halves on the whole and vice-versa, strongly depending on the gender of the two halves and the chimericity of the faces. One possibility is that the left-female bias is influenced by symmetry (highest for whole faces) and by a competing role of the left hemisphere (right half-face) in judging the gender of chimeras. This account is supported by another result: the difference in performance between the recognition of female-left/female-right chimeras and female whole faces (but not between recognition of male-male chimeras and male whole faces) points to the possibility that face symmetry as a cue in recognising gender is more important in the recognition of female than male faces.

Although the correct performance measured with chimeras constructed with half-faces of the same sex and the laterality index measured with different-sexes chimeras are not comparable measures, the results obtained with the same-sexes chimeras seem to suggest a meaningful participation of the right half-face (left hemisphere) in the global judgement of gender—had the right hemisphere exclusively controlled the decisions of the observers with an absolute preference for the female face, a better performance (fewer errors) should be expected for the female-left/female-right over the male-left/male-right chimeras, but this was not the case. Recognition of male and female faces is based on structurally (e.g., Cellero et al., 2004) and cognitively (e.g., Lewin & Herlitz, 2002) different processes that might also involve participation of the left hemisphere: the gender of the right half-face and its possible status as a distractor or as a facilitator in the analysis of chimeras by the two hemispheres must thus be considered in devising future studies.

A further note of caution should be put forth when considering that the present result was obtained using chimeric faces, because studies carried out in the past provided quite contradictory results using a number of other paradigms with whole faces. For instance, Hugdahl, Iversen, and Johnsen (1993) reported no effect of face gender when male and female observers had to judge the emotion of whole faces presented in their left or right visual field (see also Sergent, 1982). Quite surprisingly, however, in a recent study that made use of rTMS (Brüne, Bahramali, Hennessy, & Snyder, 2006), an advantage of the right hemisphere for the recognition of female facial expressions of anger (and an advantage of the left hemisphere for the recognition of male facial expressions of anger) was found, although the experiment was carried out on only a few female participants. Rhodes (1985) found a slight advantage for classifying female faces presented tachistoscopically in the left visual field, and for classifying male faces presented
centrally, although the task required a comparison among a chimera and a whole face. No other evidence of an absolute bias in favour of the female face in the right hemisphere was found in any behavioural or neuroimaging study we considered, although a meta-analysis of the issue would require a detailed scrutiny of the methodology of a huge amount of studies, as most of the time the interaction between the sex of faces used as stimuli and the sex of observers tested is irrelevant to the purpose of the studies, and either no such results are provided or, if they are provided, they are certainly not central to the study and must be deduced approximately.

The presence of the face inversion effect was indicated by the lower performance obtained with the inverted whole faces and the inverted same-sexes chimeras with respect to the corresponding categories of stimuli in upright orientation. However, the lateralisation pattern obtained with the inverted different-sexes chimeras evidenced a bias in favour of the right hemisphere even for this type of stimuli, as also shown by Butler and Harvey (2005). In one of the very few other studies carried out using inverted chimeras, Young, Hellawell, and Welch (1992) tested a patient who suffered from a right parietal stroke and showed symptoms of neglect (inattention to the left side of space). It was shown that the patient’s deficit for the recognition of the left half-face of chimeras also held true for inverted stimuli, evidencing that face processing took place in retinocentric coordinates rather than in face-centric coordinates. In the present study, confirming the result of Butler and Harvey (2005) and supporting again a right-hemispheric bias, gender decisions for inverted chimeras were based on the left half-face, although a sex difference emerged (female observers being more lateralised in this respect), and the bias turned out to be largely determined by the inverted faces having a female left half-face and a male right half-face. This result suggests that the female left half-face, which the right hemisphere seems to be particularly “tuned to”, does not need to be analysed in canonical orientation but can be easily decoded when upside-down, a result that, despite being potentially explained by the right-hemispheric superiority for mental rotation (Corballis, 1997), might imply that the hemispheric bias depends on a processing that takes place in retinocentric coordinates.

In summary, the present study showed the existence of a bias for the female face template in the right hemisphere of both male and female observers. Such attentional bias for the features present in the female face might depend on a number of possible developmental and evolutionary reasons. One candidate explanation is the fact that during the early stages of development, babies are cradled asymmetrically. Cradling behaviour has been shown to occur preferentially on the left side of the body’s midline in humans as well in other primates (Saling & Tyson, 1981; Salk, 1960; Manning & Chamberlain, 1990). The reasons of this phenomenon have been
suggested to be (1) the fact that in this way mothers monitor the babies in their left field of view (thus favouring emotional monitoring of the baby by the right hemisphere), and (2) the fact that the left side of the mother’s face (that expressing more strongly emotions) is more visible to the baby (Bourne & Todd, 2004; Turnbull & Lucas, 1996). Although the second fact seems to point to a prediction opposite to the results here reported (the left side of the mother’s face would correspond to the right half of an observed face), it must be stressed that what is relevant in this context is not which half-face of the mother mostly experiences by a baby being cradled, but rather which visual field the baby mostly uses while being cradled, and it appears likely that from the point of view of the cradled baby it is the left visual field that is used most to monitor the caregiver. What is certainly likely is that babies are cradled more by mothers than by fathers or other male individuals, thus favouring the hypothesis of an experience-dependent bias, which deserves further investigation.

REFERENCES


