Perception, 1993, volume 22, pages 829-840

What gives a face its gender?

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Received 8 September 1992, in revised form 5 February 1993

Abstract. An experiment is reported in which the attribution of gender to isolated facial features and to faces whose features have been interchanged with those of a face of the opposite gender has been examined. Sixteen male faces were averaged to create a prototype male face and sixteen female faces averaged to create a prototype female face. The prototypes were then masked to exclude ears, neck, hair, and hairline. Individual features (brows, eyes, nose, mouth, and chin) and pairs of features (brows & eyes, eyes & nose, nose & mouth, mouth & chin) from the prototypes were then presented in isolation for classification according to their perceived gender. The results showed that, for the faces used, the brows & eyes, brows alone, eyes alone, the whole jaw, the chin, the nose & mouth, the mouth alone (in descending order), ie all the features except the nose, carried some information about gender when they were seen in isolation. In the second part of the experiment different features from one prototype face were grafted into the prototype of the opposite gender and the resulting composite faces classified by their perceived gender. The results of this feature substitution showed the jaw, brows & eyes, chin, and brows (in descending order) effecting significant change in perceived gender. The difference in gender information carried by feature(s) when they were viewed in isolation from that when they were substituted for each other is attributed to the role of configuration in the perception of the gender of a face.

1 Introduction

Most of us think we have a clear concept of what makes a face female or male and yet we cannot say precisely how we make that judgment. Apart from male facial hair and different hairstyles, we cannot say exactly when a property of a face is male and when it is female. We do not know whether individual features (in the common sense of eyes, nose, mouth) carry information about gender or whether the gender of a face is expressed in some other factor, eg the pattern of the features within the whole, or the surface contours of the face, or the shape of its external border, or some combination of those factors.

Liggett (1974) notes that the female face is only about four fifths the size of the male and that the female nose is also proportionately smaller and proportionately wider than the male. Its shape is more concave and its bridge more depressed. He also makes the point that these characteristics of the female nose—smallness, wideness, and concavity—are also pronounced in children. He says that the female mouth is relatively smaller and the upper lip often shorter than the male and that the female jaw and browridges are less pronounced. The female eyes are larger with darker shading surrounding them, particularly in the young, and the scantier female eyebrows become thinner with increase in age. By contrast the male brows are generally thinner in youth but grow thicker, longer, and coarser with age.

Nakdimen (1984) quotes Laidman (1979): "a man's eyebrows are heavier, straighter and closer to the eyes. A woman's ... are usually more arched". He also says that high cheekbones in men are a rather severe, bony feature whereas in women they are covered by a pad of soft tissue and appear more rounded.

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Enlow (1982, page 6) maintains that "the male nose is proportionately larger than the female nose" and says this is because the male needs to fill larger lungs to support the oxygen requirements of his larger body. This larger size of the nose is said to lead to differences in the shape of the forehead and cheekbones. Linney and Coombes (personal communication), using a laser scanning technique which is described in Moss et al (1987), have produced three-dimensional (3-D) images of an average male and an average female head. They too have found that the male average has a more protruberant nose, more protruberant brows and chin/neck than the female average, while she has slightly more protruberant cheeks. These differences were found in the 3-D surface structure of the face as a whole rather than in the detail of the individual features. Indeed, the shapes of individual features which are normally made visible by their pigmentation are not very clearly portrayed in the images of the average 3-D head models. Although the differences between the two genders assessed by this method of measuring 3-D distances are objective, that does not mean that untrained human observers can perceive gender on the basis of those differences. Nor does it mean that feature shape, defined by pigmentation and visible in two-dimensional (2-D) images such as photographs, will be capable of supporting gender perception.

Harmon (1973) showed that information about the gender of an unfamiliar face can be extracted from a coarsely quantised 2-D image of the face. Sergent (1986), using the same technique, notes that in coarsely quantised images detailed information about individual features is indiscernible so that assessment of gender cannot be based on the features. Gender discrimination could instead be based on the available configurational cues, ie the relative positions of the features in the face or head as a whole. Haig (1984) has shown that we are sensitive to very small displacements of features in judgments of identity. It is therefore plausible that we may also be sensitive to relative feature position for judgments of gender. These findings beg the question of whether individual features by themselves play any part at all in assessment of gender.

Roberts and Bruce (1988) attempted to assess the role of individual features by masking with tape either the eyes, the nose, the mouth, or none of the features of photographs of frontal images of unfamiliar faces and then recorded observers' response times taken to judge stimulus gender. They do not specify whether 'eyes' refers to the whole eye region including the brows or the eyes alone without brows. Results showed response times increasing when eyes, mouth, or nose were masked, suggesting that some information about gender is given by the eyes, a little more by the mouth, and more again by the nose. When the features were presented in isolation (ie the rest of the face was masked), it was found that the eyes provided the most reliable information for gender judgment and the nose the least. The difference between the effect of masking the nose and presenting it in isolation was interpreted as meaning that the nose did not carry information about gender in itself, but its position in the overall configuration of the face did. This again suggests an important role for configuration in perception of gender in a face.

The following experiment was therefore devised to investigate further the role of individual features in the perception of gender. Using a different method from that of Roberts and Bruce we examined the extent to which features presented in isolation may allow discrimination of gender. A second method of assessing the gender value of a facial feature tested the effect on perceived gender of the interchange of features between faces of opposite genders. Davies et al (1977) and Haig (1986) had shown that interchanging different features had varying effects on perception of face identity. Davies et al manipulated the features contained in a Photofit Kit and found that hair and forehead substitutions were noticed most accurately, then eye or mouth substitutions, followed by nose substitutions. Chin substitutions were more or less noticeable depending how different the substituted chin was from the original. Haig found a similar pattern, with changes in the head outline being most noticeable, then changes in the combined eye–eyebrow region, then the mouth and last the nose. A similar order of importance might also hold to be the case in perception of gender.

To isolate individual features of a number of examples of male and female faces, as Roberts and Bruce did, would not be difficult. To interchange features between them in a way which took account of all possible combinations of different types of facial feature would be impossibly complex. It was therefore decided to use two prototype faces created by averaging a number of faces of males and females. According to the logic of Galton (1878, 1883), if it was true that male brows were heavier and closer to the eyes than female brows, then a face which was an average of several male faces should embody that characteristic. If female faces are smaller than male faces, a face which was an average of several female faces should be smaller than a face which was an average of several male faces. If the gender of a face is expressed in the arrangement or configuration of the features within the whole then an average female face should have a different configuration from an average male face. It would be possible to interchange the features of those average faces in a controlled way and assess the effect of such interchange.

2 Method

For the purposes of the experiment the eyebrows and chin were counted as features as well as the eyes, nose, and mouth, which had been tested by Roberts and Bruce. Features were presented in pairs and singly because it is possible that gender only becomes apparent when the distance between two features is seen, eg brows–eyes, nose–mouth. The features and pairs of features were isolated by dividing the face into horizontal slices.

To test the effect of feature substitutions on the perceived gender of a face, male features were grafted into the female face and female features into the male face. The resulting composite faces were then presented for classification as male or female. The number of times the perceived gender changed from that of the original face was taken as a measure of the influence which that feature had on the perceived gender of the face.

2.1 *Stimuli*

Stimuli (illustrated in figure 1) were created by isolating and manipulating parts of a male prototype face and a female prototype face that had already been created in a previous study (Brown and Perrett 1993) by the following method. Photographs were obtained of the faces of sixteen female undergraduates and sixteen male undergraduates from Aberdeen University. Each student adopted a neutral expression, wore no eyeglasses or adornments and the males were clean shaven. The photographs were blended into a prototypical female face and a prototypical male face respectively by using the technique for creating composite faces, described by Benson and Perrett (1992). Each facial image was first frame-grabbed on a video camera, and digitized to 512 square pixels at 256 grey levels per pixel. The interpupillary distance for each face was standardised. Images were then transferred to a Silicon Graphics IRIS 3130 graphics computer for processing. For each image, the x and y coordinates of 224 feature points were defined manually and then the average coordinates of feature positions for the sixteen female and for the sixteen male faces were computed separately. These procedures gave the average shape and configuration of a female face and the average shape and configuration of a male face. The original image of each face was then distorted into the average configuration and the sixteen resulting distorted female images were blended digitally to create the female prototype (figure 1, stimulus 5). The process was repeated for the sixteen male faces, which were blended to create the male prototype (figure 1, stimulus 10). Each face was

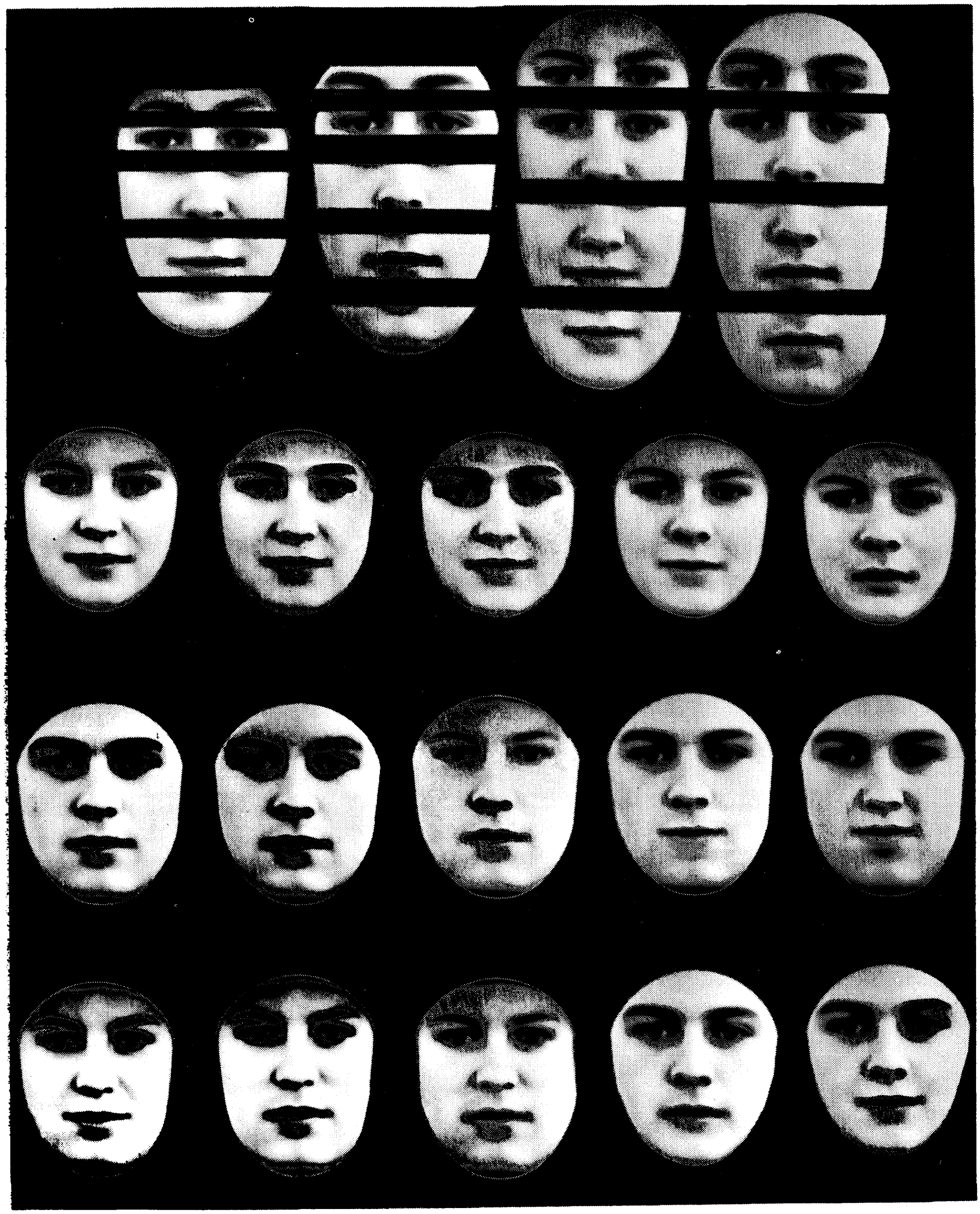

Figure 1. Stimuli used in the experiment. Top row, left to right: (1) single parts of female faces; (2) single parts of male faces; (3) pairs of female face parts; (4) pairs of male face parts. Second row, left to right: (5) female prototype face; (6) female face with male brows; (7) female face with male brows & eyes; (8) female face with male nose; (9) female face with male nose & mouth. Third row, left to right: (10) male prototype face; (11) male face with female brows; (12) male face with female brows & eyes; (13) male face with female mouth; (14) male face with female nose & mouth. Bottom row, left to right: (15) female face with male chin; (16) female face with male jaw (version 2); (17) female face with male jaw (version 1); (18) male face with female chin; (19) male face with female jaw.

masked to exclude ears, neck, hair, and hairline by a border area which was rendered black. The border was defined by the jawline and ear positions and an arc centred half way down the bridge of the nose, extending from the point where the top of the right ear joined the head to the point where the left ear joined the head.

To ascertain whether male faces vary in shape or configuration of features more than female faces (or vice versa) we examined the delineation points recorded from the original faces. Figure 2 illustrates the standard deviations of the x and y coordinates of a representative number of the 224 points delineated when creating the prototype faces. A large number of the points that are not illustrated delineate the hairline, ears, and head outline and were not used in the test stimuli.

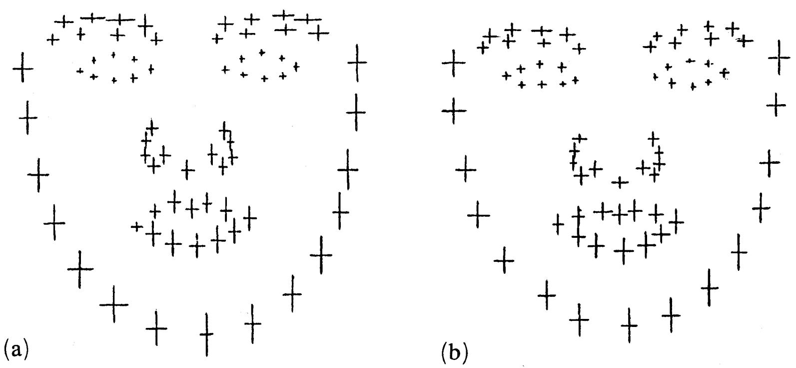

Figure 2. Standard deviations of the x and y coordinates of points delineated when creating the prototype faces. (a) Male and (b) female prototype face.

Eighteen images of parts of the prototype male and female faces were made by masking them horizontally to form slices of face which contained one or two features. Single features isolated in this way were brows, eyes, nose, mouth, and chin. Combinations of features isolated were brows & eyes, eyes & nose, nose & mouth, mouth & chin (hereafter referred to as the jaw because that name better describes the area of face contained in the slice).

Nineteen new images were formed by grafting a 'part' from the prototype face of one gender onto the face of the other gender, keeping the rest of the recipient face as it was. This was done using the 'Designer Paint' software of the Pluto 24i graphics system. This allows part of an image to be copied in any other desired position using a 'cut and paste' function. The edges of the grafted part were then blended into the rest of the recipient image by grading pixel intensities across the join. In this way nine images of the male face with female features and ten images of the female face with male features were made. The features changed were brows, eyes, nose, mouth, chin, brows & eyes, eyes & nose, nose & mouth, and jaw. Two versions of the female face with male jaw were made because the male jaw was wider than the appropriate part of the female face. In version 1 the width of the male jaw was reduced and in version 2 the width of the female cheeks was increased. The effect of both types of alteration were tested in the experiment. When joining the male face and female jaw only one version was made, by reducing the width of the male cheeks slightly.

Each continuous-tone black-and-white image was photographed from the computer graphics monitor screen by means of a Minolta 7000 camera, FP4 black-and-white film, and 1 s exposure.

2.2 *Subjects*

Subjects were ten females aged from 22 to 74 (average 45) years, and ten males aged from 14 to 52 (average 39) years.

2.3 *Procedure*

The 21 photographs of whole faces (2 prototypes and 19 with features substituted) were mixed at random and subjects were asked to place them in two piles, one for faces perceived as female and one for faces perceived as male. They were allowed as much time as they needed but were asked to give their first impression of the gender of the face rather than a considered opinion. The experimenter recorded which images had been perceived as male. The photographs were mixed at random again and the subject was asked to repeat the task until each photograph had been classified four times. Exactly the same procedure was then followed with the 18 photographs of parts of faces. Parts of faces were always presented after whole faces to avoid encouraging any tendency for subjects to concentrate on details of a face instead of processing the whole of it.

3 Results

3.1 *Faces with feature substitutions*

The results for faces with feature substitutions were analysed as a percentage of the total number of trials on which a prototype face was assigned the wrong gender or on which a face with feature(s) substituted was assigned a gender which was different from that of the original prototype face. The differences in the response for each of the two versions of the female face with a male jaw was subjected to a Wilcoxon test and proved not to be significant, so the data from version 2 were used in analysis of the results and those from version 1 were not. Because the stimuli had been classified by a forced choice a fixed number of times the data were transformed using an inverse sine transformation.

A 2 (gender of subject) × 2 (original gender of facial image) × 10 [feature(s) substituted or no substition] mixed ANOVA showed a significant main effect of the original gender of the face, male faces being assigned a different gender more frequently than female faces, $F_{1,18} = 14.65$, $p = 0.0012$. The main effect of feature substituted was significant, $F_{9,162} = 15.56$, $p < 0.0001$. A posteriori protected least significant difference (PLSD) tests (Snedecor and Cochran 1980) showed that substitutions of eyes, brows, chin, brows & eyes, and jaw (in ascending order) resulted in significantly increased assignation of the opposite gender to a face compared with that to the appropriate prototype face.

The interaction between feature(s) substituted and original gender of the face was significant, $F_{9,162} = 3.59$, $p = 0.0004$. The main effect of subject gender was not significant, but gender of subject interacted significantly with gender of the original face, $F_{1,18} = 10.41, p < 0.005$.

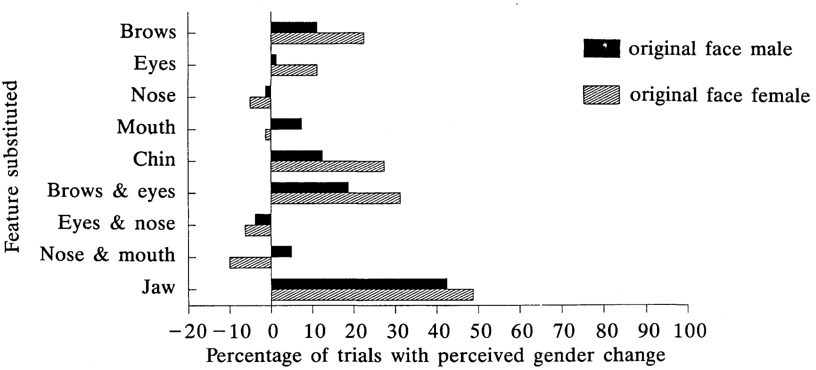

Figure 3. Percentage of total number of trials when each face with substituted feature(s) was classified as having a gender different from that of the original face. Normalised data.

The prototype male face was classified as female more often than the female prototype was classified as male (see figure 5) suggesting that the male prototype was less male than the female was female. The response values were therefore adjusted by subtracting the individual subject's scores for the prototype faces from each of their scores for faces with feature substitutions. These normalised results are shown in figure 3. A 2 (gender of subject) × 2 (original gender of facial image) × 9 [feature(s) substituted] ANOVA of the normalised data showed a significant main effect of feature substituted, $F_{8,144} = 15.1$, $p < 0.0001$. Main effects of gender of subject ($p = 0.45$) and original gender of facial image ($p = 0.66$) were not significant. The interaction between the original gender of the facial image and the particular feature substituted was significant, $F_{8,144} = 3.9$, $p = 0.0004$. Other interactions were not significant.

A posteriori PLSD tests showed that substitutions of brows, chin, brows & eyes, or jaw (in ascending order) effected a significant change ($p < 0.05$) in the perceived gender of the prototype faces. Jaw substitutions were significantly more effective than all other feature substitutions. There was no significant difference between the effects of brows and of brows & eyes substitutions, showing that the brows were the most important part of the eye region in bringing about the change in perceived gender.

A posteriori PLSD analysis of the interaction between the feature substituted and the gender of the original prototype face indicated that substitutions of male jaw and male brows & eyes into the female prototype effected a significant change in perceived gender ($p < 0.05$) whereas other substitutions did not. For substitutions of female features into the male prototype face, brows, chin, brows & eyes, and jaw were effective

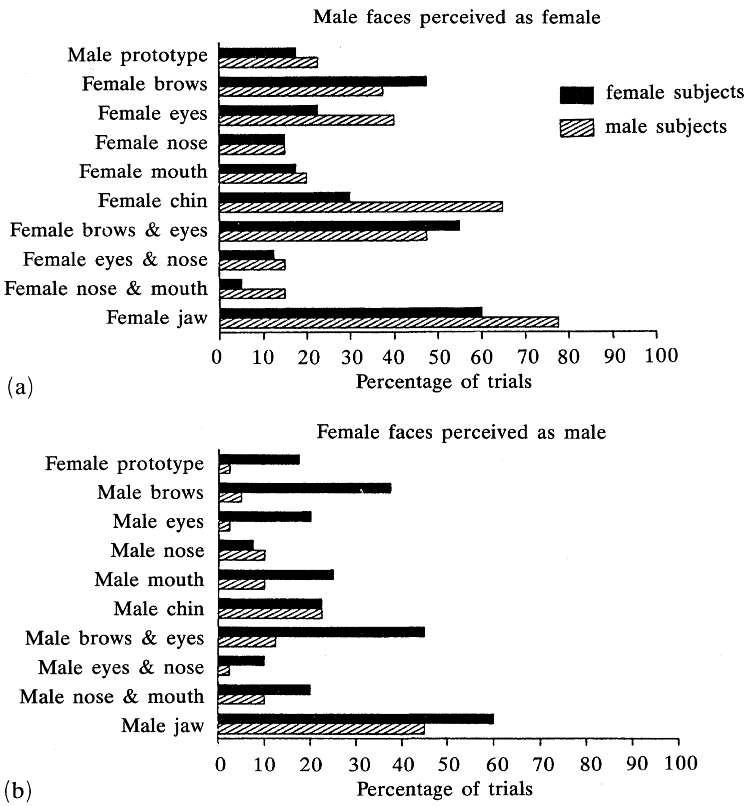

Figure 4. The percentage total number of trials when male and female subjects (a) classified the male face with female feature substitutions as female; (b) classified the female face with male substitutions as male.

in significantly changing its perceived gender. Of these four feature substitutions only brows and jaw were significantly different in their effect.

The interaction between gender of subject and original gender of facial image, which was significant before normalisation of the data, was not significant after normalisation. The significant interaction before normalisation is nevertheless of interest because it shows differences between male and female subjects' assignment of gender to the same faces. The male prototype and male faces with female feature substitutions were perceived as female more often by male than by female subjects. The female prototype and female faces with male feature substitutions were perceived as male less often by male than by female subjects. The difference between male and female subjects' responses is illustrated in the two graphs in figure 4.

The female subjects' responses were very similar for the various feature substitutions whether the original face was male or female. When subjects were females correlation of the results for male and female faces gave a correlation coefficient which was highly significant (Spearman's $r = 0.83$, $p < 0.005$). When subjects were males the correlation was not significant (Spearman's $r = 0.54$, $p > 0.05$).

3.2 *Parts of faces*

The percentage of the total number of trials on which each of the stimulus face parts was classified as male is shown in figure 5. Data for classification of the prototype faces are also included in the graph for comparison. The data were transformed using an inverse sine transformation as for whole faces and submitted to a 2 (gender of subject) × 2 (gender of facial image) × 9 (part of face) mixed ANOVA. This shows a significant difference between male and female face parts, $F_{1,18} = 60.5$, $p < 0.0001$, all parts from the male prototype face being classified as male more frequently than those from the female prototype face. There was a highly significant main effect of part of face, $F_{8,144} = 7.8$, $p < 0.0001$, some parts being classified male more often than others, and there was a highly significant interaction between the part of the face represented by a picture and its gender, $F_{8,144} = 3.03$, $p = 0.004$. There was no significant main effect of gender of subject.

The main effects of the gender of face parts and of the part of face were not of interest for the purposes of the experiment but the interaction between part of face and its gender was, that is, the difference between the way a part taken from a male face was classified and the way the equivalent part taken from a female face was classified.

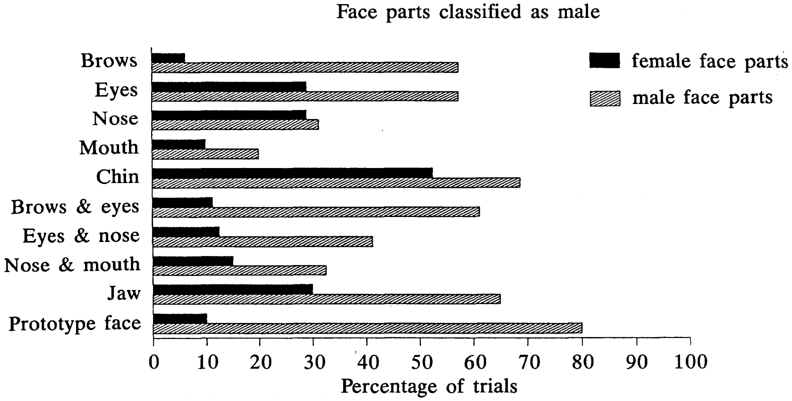

Figure 5. The percentage of total number of trials when each photograph of part of a face was classified as male compared with the percentage number of times the prototype faces were classified as male.

A posteriori PLSD tests showed that the difference in the way male and female versions of parts of faces were classified was significant ($p < 0.05$) for all parts except the nose. The other parts were ranked in ascending order of the magnitude of difference in classification of male and female face part, from mouth, through nose & mouth, chin, jaw, eyes, brows, to brows & eyes. The magnitude of the difference varied significantly between mouth and nose & mouth, between nose & mouth and eyes, between eyes and brows, and between brows and brows & eyes.

4 Discussion

The significant interaction between the way a male face part was classified and the way the corresponding female face part was classified when they were presented in isolation shows clearly that individual features do carry information about gender, the male and female versions of each part, except for the nose, being classified differently. The results confirm those of Roberts and Bruce (1988) which showed that, when features are viewed in isolation, the eyes carry more information about gender than the mouth and the mouth more than the nose. This is in contrast to the statements by Liggett (1974), Enlow (1982), and Nakdimen (1984) about differences between the male and female nose and also the 3-D measurements by Linney and Coombes (personal communication) which confirm those statements. That could mean that the physical differences between male and female noses are not of psychological significance. Alternatively the lack of importance of the nose in the experiment reported here and in that of Roberts and Bruce may be because the nose shape is not clearly visible unless it is viewed in profile or three-quarter view. The latter seems intuitively to be the most likely explanation.

One thing is very clear from the results of this part of the experiment. That is that the smallest area of face, ie the eyebrows, carried more information about gender than the largest, ie eyes & nose together. It is also apparent when the features are substituted for each other that the particular parts changed matter more than the total area of the face changed, brows again having more effect on perceived gender than larger areas such as nose & mouth or eyes & nose.

The results for feature substitutions are roughly in agreement with those of Davies et al (1977) and Haig (1986) in their investigations of the effects of feature substitutions on identity. The results cannot be compared precisely because the substitutions are a little different but the previous authors found alterations to the outline of the face and to the eye area more noticeable than alterations to the mouth and nose. In the present experiment alterations to the jaw area (which change the outline) and to the eye area are most effective in changing the perceived gender. This may indicate that gender is usually perceived in the same way that colour of eyes might be; that is, as a part of identity rather than as a separate characteristic of a face. Of course, both eye colour and gender can be classified independently of identity if required.

There is a difference in the order of magnitude of gender information carried by parts of a face depending whether they are viewed in isolation or grafted into a face of the opposite gender. Ascending order of importance for parts seen in isolation is mouth, nose & mouth, chin, jaw, eyes & nose, brows, and brows & eyes. For feature substitutions it is brows, chin, brows & eyes, and jaw. This may be because, when features are interchanged in whole faces, configurational information comes into play, whereas it does not when the features are viewed in isolation. Substitutions of brows shift the balance of the pattern of features within the shape of the face (the male brows being heavier than the female). There is also a difference in the gap between the two brows, which is proportionately smaller in the male face than in the female, and that too would change the pattern or configuration of the face as a whole. Chin and jaw substitutions alter the vertical dimension between base of nose and tip of chin.

The fact that the two versions of the female prototype face with a male jaw were not classified differently suggests that the vertical dimension is more important than the horizontal in the jaw area. This experiment shows that the individual features of a face carry gender information in themselves and also in the pattern or configuration they form within the face as a whole.

Although statistical analysis after normalisation of the data showed that the male prototype face was not significantly more susceptible overall to change as a result of feature substitutions there was, nevertheless, a difference in the number of substitutions which effected change in the perceived gender of the male face and the number of substitutions effecting change in the perceived gender of the female face. Substitutions of the jaw and of the brows & eyes changed significantly the perceived gender of both the prototype faces, whereas substitutions of brows and chin changed the male prototype face but not the female prototype face. Figure 5 also indicates that most of the male parts were classified as being less strongly male than the female parts were female. Liggett's statements about differences in developmental changes between males and females, particularly in the eye region, could explain some of that. The original faces used in the creation of the prototype faces were those of young undergraduate students so the male eyebrows would be thinner than those of a mature male while the female ones would be thicker than those of a mature female. If childlike features are perceived as being more female then immature faces, being more childlike than mature ones, would appear more female. If mature adult faces had been used instead of youthful ones, the whole faces and parts of faces might have been perceived as being more masculine.

Several subjects remarked that some of the whole faces looked like a nun, one that some were like a North African woman and another like an Arab woman. The masking of hair, hairline and ears was intended to exclude obvious clues about gender from hairstyles or hairlines, but it seems to have given the illusion of a veil and possibly biased perception of the faces towards the female.

A surprise finding in the experiment was the interaction between gender of the original face and gender of subject. Male subjects required more masculinity to classify a face as male than females did and consequently less femininity to classify it as female. The two sexes gave different values to the evidence about gender in a face. For example, female subjects took more account of brows than male subjects (see figure 4). The raw data also showed large variation between gender judgments of subjects of the same sex indicating that the perception of gender is subjective rather than absolute. Any attempt to define in absolute terms what is male and what is female would therefore be doomed to failure. It would only be possible to find average concepts of gender characteristics.

The results of this experiment demonstrate that the averaging technique can be used to establish consistent differences in facial features. It is interesting to note that the prototype faces produced for use in this experiment are very similar to those produced by Katz (1953). He used sophisticated photographic superposition techniques to make average male and female faces from 14 faces of Swedish male students of about 24 years of age and 14 faces of Swedish female students of about 23 years of age. The group he used was thus very similar in number and age to the Scottish students whose photographs were employed to make the prototype faces used here. It seems that the average Causasian male and female faces have not changed in 40 years.

On examination of figure 2 it is clear that standard deviations of the points of delineation of the faces are similar in the various different regions of the face for male and female faces. The distortion of male faces into the average shape and configuration of a male face was not greater than the distortion of female faces into the average shape and configuration of a female face, or vice versa. Because all the faces were normalised by standardising interpupillary distance there is more deviation in the regions of the face which are furthest away from the pupils (eg the jawline). On first impression the illustration suggests that there is more horizontal than vertical deviation in the eyebrows and more vertical than horizontal deviation in the other features. However, when delineating features of the original faces the operator placed the points on the outline of a feature in such a way as to trace its shape most accurately. That means that only the two end points of the eyebrows indicate the true horizontal variation in the positions of the brows whereas the other points indicate the operator's choice of the best delineation of eyebrow shape.

This study used a different technique from that of the Roberts and Bruce (1988) study but confirmed their results. It also showed similar salience of the various features of the face in perception of gender as was demonstrated in perception of identity by Davies et al (1977) and Haig (1986). The results of the experiment point to an important role for configuration but show that it is not the only factor signifying gender in a face. The effectiveness of the use of average faces for this experiment and the evidence that different subjects use different criteria when assigning gender to a face suggest that we each form average concepts of a male and a female face against which to measure the gender information in faces we encounter.

5 Summary

In this experiment the capacity of individual features of a face viewed in isolation to convey information about its gender was assessed. The effect on perceived gender of grafting male features into a female face and female features into a male face was also tested. The results show that, for the faces used, all features except the nose carried information about gender when they were seen in isolation. The jaw, brows & eyes, chin, and brows (in descending order) caused significant change in perceived gender when they were grafted into a face of the opposite gender. A probable role for configuration in perception of gender is indicated by the effects of feature substitutions. Differences in perception of gender by male and female subjects were also revealed.

Acknowledgements. We thank Dr I Craw, Department of Mathematics, University of Aberdeen for the frame-grabbing of faces to make the prototypes, P Benson for the construction of averages, K May for extracting the standard deviations of the x and y coordinates in figure 2 and M Oram for advice on statistics. The work was performed using equipment provided by ESRC (XC15250005) and SERC (GR/F97591) project grants.

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