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The relationship between sexual dimorphism in human faces and fluctuating asymmetry

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Previous studies have found both support and lack of support for a positive relationship between masculinity and symmetry, two putative signs of mate quality, in male faces. We re-examined this relationship using an explicit measure of facial fluctuating asymmetry, as well as other measures of asymmetry, and measures of facial masculinity/femininity. We also used ratings of these traits for faces. Further, we examined the relationship between facial sexual dimorphism and body asymmetry. We found no significant correlations between facial masculinity and any of our measures of asymmetry or ratings of symmetry in males. Facial femininity was not consistently associated with facial symmetry in females, but was associated with body symmetry. Therefore, for females, but not males, facial femininity and body symmetry may reflect similar aspects of mate quality. We also examined the relationships between trait ratings and measurements. Our results provide validation of our ability to measure aspects of asymmetry that are perceived to be symmetrical, and aspects of sexual dimorphism that are perceived as feminine in females and masculine in males.

Keywords: fluctuating asymmetry; mate quality; masculinity; femininity

1. INTRODUCTION

Certain traits in faces are attractive and putative signals of mate quality (Thornhill & Gangestad 1999). Two traits found to be attractive and conjectured to signal mate quality are symmetry and masculinity/femininity (for reviews see Fink & Penton-Voak 2002; Rhodes & Zebrowitz 2002). If symmetry and sexual dimorphism signal the same aspects of mate quality then the ability to produce large traits in males should be related to the ability to produce symmetrical traits, resulting in a negative relationship between asymmetry and trait size. Numerous studies found such relationships in male animals (reviewed in Møller & Cuervo 2003).

Three studies examined the relationship between masculinity and symmetry in human male faces. Gangestad & Thornhill (2003) and Scheib *et al.* (1999) found a small, but significant, negative relationship between masculinity and asymmetry in male faces whereas Penton-Voak *et al.* (2001) did not. Although Gangestad & Thornhill failed to find a linear relationship between measures of masculinity and asymmetry in females, curvilinear associations were found between measured masculinity and asymmetry for both sexes.

The masculinity index of Penton-Voak *et al.* (2001) was based on five traits (eye size, lower face height, cheekbone prominence, face width and eyebrow height), whereas that of Scheib *et al.* (1999) was based on just two (lower face length and cheekbone prominence). Gangestad & Thornhill (2003) conducted a principal-axis-factor analysis on five sexually dimorphic traits (chin length, jaw width, lip width, eye height and eye width). The scores on two factors that captured sexual differences in face morphology were used as their measure of masculinity. Only Scheib *et al.* and Penton-Voak *et al.* collected symmetry ratings. The symmetry measures and ratings of Penton-Voak *et al.* correlated, whereas those of Scheib *et al.* did not, raising doubts about their validity.

There are problems with the measures used in all studies. Most importantly, none explicitly measured fluctuating asymmetry (FA), which is the theoretically relevant concept (see Polak (2003) and references therein). All used the asymmetry measure of Grammer & Thornhill (1994), which includes directional asymmetry, which may not reflect developmental instability (Simmons *et al.* 2004). Furthermore, the methods used to obtain subject photographs were not standardized, thus steps were required to control for the resulting differences in image size. A single linear measure was used to normalize for size, which may not capture overall size in the complex structure of the face. Penton-Voak *et al.* (2001) used inter-pupil distance whereas the other two studies used face width at the mouth for horizontal measures and the distance from the hairline to the chin for vertical measures. The use of the hairline is clearly problematic because it is not a structural facial feature, is highly affected by a receding hairline, and as Gangestad & Thornhill (2003) noted, required estimation on some occasions.

Individual traits may be poor indicators of organism-wide developmental instability making it necessary to assess multiple traits (Gangestad *et al.* 2001). The failure of Gangestad & Thornhill (2003) to find a significant correlation between body and facial asymmetry led them to suggest that composite facial FA could be a poorer indication of developmental instability than body FA if most facial traits were highly integrated developmentally (Gangestad & Thornhill 2003). Gangestad & Thornhill therefore examined the relationship between measured facial masculinity and measured body asymmetry. Measured facial masculinity and measured body asymmetry correlated negatively in males whereas no significant correlation was found in females.

Our aim was to re-examine the relationship between facial and body FA and facial masculinity/femininity in males and females. Unlike previous studies, we included an explicit measure of facial FA in addition to facial total asymmetry (TA), facial horizontal asymmetry (HA; following the method of Grammer & Thornhill (1994)) and rated facial symmetry. We also included an explicit measure of body FA as well as body TA. We controlled for differences in overall face size by keeping the distance between the camera and poser constant. Thus, unlike

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previous studies, no correction for variations in the size of face images was required.

Some studies found that certain traits are attractive when rated, but not when measured, and vice versa (e.g. Scheib *et al.* 1999). Therefore, a subsidiary aim of our study was to determine whether perceptions (ratings) of symmetry and masculinity/femininity correspond with measurements of the same traits in faces. Significant correlations between trait perceptions and measurements would increase confidence that both are valid trait indicators.

2. METHOD

(a) *Participants*

Seventeen male and 22 female raters with a mean age of 23.9 years (s.d. = 9.5, range of 17–51), and 19.9 years (s.d. = 6.9, range of 17–50), respectively, participated. Twenty-seven raters completed the study for course credit, 10 were reimbursed for travel expenses and the rest were volunteers.

(b) *Stimuli*

Coloured frontal view facial photographs, with no jewellery or occluding hair, of 94 males and 100 females, with a mean age of 23.7 years (s.d. = 5.7, range of 18–46) and 25.3 years (s.d. = 6.3, range of 17–51), respectively, were obtained from Simmons *et al.* (2004). All posers had a neutral expression. These faces were photographed from a standard distance, with 190 cm between posers' toe tips and the camera. All photographs were 550×600 pixels with a resolution of 72 pixels per inch. Adobe Photoshop was used to rotate photographs so that both pupil centres were located on the same *y*-coordinate, and to mask faces from hairline to chin.

Male and female photographs were divided into two sets of 50 faces, except that the second male set contained 44 faces. SuperLab controlled stimuli presentation order and recorded responses on a Macintosh computer.

(c) *Procedure*

(i) *Ratings*

Female participants rated each male face's masculinity (1 = not masculine, 7 = very masculine), whereas male participants rated each female face's femininity (1 = not feminine, 7 = very feminine). Twelve males and 12 females rated each set. Fifteen participants (five males) rated set 1 only, 15 participants (five males) rated set 2 only, and nine participants (seven males) rated both sets. Because familiarity may influence ratings, if participants recognized a face (e.g. from around campus or a previous study) then it was removed for that participant ($M = 1.08$ faces per stimulus set, s.d. = 1.87). Participants' inter-rater reliability was high (male faces set 1: Cronbach's $\alpha = 0.83$; male faces set 2: $\alpha = 0.84$; female faces set 1: $\alpha = 0.81$; female faces set 2: $\alpha = 0.80$). Mean masculinity/femininity ratings were calculated for each face. Opposite-sex symmetry and attractiveness ratings for these same faces were taken from Simmons *et al.* (2004).

(ii) *Face measurements*

Masculinity/femininity was measured by positioning points on various locations using NIH Image 1.62 (see figure 1). All but one of the points used to measure FA by Simmons *et al.* (2004), which had high positioning reliability scores, were also used to measure masculinity/femininity. A second experimenter independently positioned points used solely for the masculinity/femininity measurements in this study (P16–P25) on a subset of 40 (20 males) faces. A very high point positioning reliability was obtained (males: $r = 0.99$, $p < 0.001$; females: $r = 0.99$, $p < 0.001$).

Linear measurements were used to assess mean eyebrow height (average distance between P1 and P19, P17 and P21, P3 and P23, P4 and P24, P18 and P22, P2 and P20), cheekbone width (distance between P5 and P6), jaw width (distance between P9 and P10), nostril width (distance between P7 and P8) and lower face length (average distance between P17 and P25, P18 and P25). Face (below the pupils) and chin areas were measured by calculating the area formed by connecting a specified set of points (face: P5, P17, P18, P6, P10, P15, P14 and P9; chin: P14, P15 and P16). Eye area was measured using a mouse to trace around the eye, where the eyelids meet the eye. Lip area was measured using a mouse to trace around the outside edge of the lips.

Measures of each face's composite FA and HA were taken from Simmons *et al.* (2004). Briefly, 35 pairwise distances on the left and right hemi-face were made on two replicate photographs of each face, 12 of which had the statistical properties characterizing strict FA in males and seven in females. There was significantly greater variation between subjects than between repeated measures of the same subject (average repeatability, male faces 0.76 ± 0.02; female faces 0.70 ± 0.02) and the signed left–right values were normally distributed about a mean of zero). These were used to calculate a composite facial FA (FA17 in Palmer & Strobeck 2003). Asymmetry values were first scaled for trait size and then the sum of scaled FAs was divided by the number of traits in the composite. In addition to this strictly conservative measure of FA, we calculated TA as the composite of all 35 asymmetry measures, irrespective of whether they conformed to the statistical properties of FA. Measures of each subject's composite body FA were taken from Rhodes *et al.* (2004). Seven bilaterally paired body traits—foot width, foot length, ankle width, wrist width, elbow width, ear length and ear width were measured directly on each subject. Again, signed asymmetries were significantly repeatable (average repeatability, male bodies 0.76 ± 0.03; female bodies 0.71 ± 0.05). Asymmetry in two traits for male bodies (foot length, wrist width), and three for female bodies (foot width, ankle width, wrist width), met the strict statistical criteria for FA and were used to calculate composite body FA as described for faces. In addition, we calculated TA as the composite of all seven asymmetry measures.

3. RESULTS AND DISCUSSION

On average, males had significantly larger faces (below the pupils), lips and chins, wider cheekbones, jaws and nostrils and longer lower faces, but significantly lower positioned eyebrows, than females (see electronic Appendix A, table 2; available on The Royal Society's Publications Web site). Eye area was the only trait that did not differ significantly between the sexes. From this multivariate dataset we conducted a principal axis factor analysis. The first four axes had eigenvalues of 4.02, 1.31, 1.04 and 0.95, and collectively explained 81% of the variance. We rotated (varimax) and extracted two factors (see electronic Appendix A, table 3). The first factor was defined by face size (standard score coefficient: 0.23), chin (0.20), cheekbone (0.23), jaw (0.24), eyebrow height (−0.24) and lower face length (0.21) and the second by lip area (0.42), nostril width (0.44) and eyebrow height (0.57). Scores for the first factor discriminated significantly between the sexes ($F_{1,191} = 119.02$, $p < 0.0001$; mean score for males 0.63 ± 0.081, females -0.60 ± 0.08). Consistent with Gangestad & Thornhill (2003) this component captured expected differences in traits that characterize masculinity. Scores on the second factor did not differ significantly between the sexes ($F_{1,191} = 1.67$, $p = 0.198$) and were not considered further.

For male faces, there was no significant correlation between any of our measures of asymmetry or rated symmetry and either our factor score or rated masculinity (see table 1). For females, with the exception of facial HA, none of our measures of asymmetry correlated significantly with either our factor score or rated femininity (see table 1). The correlation between facial HA and rated femininity was not robust to Bonferroni correction. Rated symmetry correlated positively with rated femininity, even after Bonferroni correction, suggesting that these traits may signal the same aspects of mate quality.

Inconsistent findings, when ratings and measurements were used, suggest that the association between facial symmetry and femininity in females should be interpreted with caution. Overall, these results offer little support for the hypothesis that FA and sexual dimorphism in the human face signal the same (if any) aspects of mate

Table 1. Zero-order Pearson product–moment correlations between rated attractiveness, rated symmetry, three measures of facial symmetry, rated masculinity/femininity and our sexual dimorphism factor score (high values indicate masculinity), for females (above diagonal) and males (below diagonal).
(Values in bold show correlations with $p < 0.05$, two-tailed. An asterisk indicates significance after Bonferroni corrections for multiple comparisons.)

	attractiveness	rated facial symmetry	face FA	face TA	face HA	body FA	body TA	rated masculinity/ femininity	sexual dimorphism factor score
attractiveness	—	**0.482*** **$p < 0.001$** **($n = 100$)**	−0.057 $p < 0.572$ ($n = 100$)	−0.071 $p < 0.485$ ($n = 100$)	−0.178 $p < 0.076$ ($n = 100$)	−0.147 $p < 0.145$ ($n = 99$)	**−0.297** **$p < 0.003$** **($n = 99$)**	**0.778*** **$p < 0.001$** **($n = 100$)**	**−0.300** **$p < 0.003$** **($n = 99$)**
rated facial symmetry	**0.279** **$p < 0.006$** **($n = 94$)**	—	**−0.381*** **$p < 0.001$** **($n = 100$)**	**−0.366*** **$p < 0.001$** **($n = 100$)**	**−0.286** **$p < 0.004$** **($n = 100$)**	0.021 $p < 0.833$ ($n = 99$)	−0.066 $p < 0.517$ ($n = 99$)	**0.504*** **$p < 0.001$** **($n = 100$)**	−0.004 $p < 0.967$ ($n = 99$)
face FA	0.089 $p < 0.394$ ($n = 94$)	**−0.240** **$p < 0.020$** **($n = 94$)**	—	**0.921*** **$p < 0.001$** **($n = 100$)**	**0.533*** **$p < 0.001$** **($n = 100$)**	−0.034 $p < 0.736$ ($n = 99$)	−0.011 $p < 0.915$ ($n = 99$)	−0.004 $p < 0.971$ ($n = 100$)	−0.053 $p < 0.603$ ($n = 99$)
face TA	−0.012 $p < 0.905$ ($n = 94$)	**−0.290** **$p < 0.005$** **($n = 94$)**	**0.855*** **$p < 0.001$** **($n = 94$)**	—	**0.742*** **$p < 0.001$** **($n = 100$)**	−0.072 $p < 0.477$ ($n = 99$)	−0.018 $p < 0.859$ ($n = 99$)	−0.096 $p < 0.339$ ($n = 100$)	−0.050 $p < 0.625$ ($n = 99$)
face HA	−0.05 $p < 0.629$ ($n = 94$)	**−0.336** **$p < 0.001$** **($n = 94$)**	**0.753*** **$p < 0.001$** **($n = 94$)**	**0.911*** **$p < 0.001$** **($n = 94$)**	—	−0.178 $p < 0.079$ ($n = 99$)	−0.037 $p < 0.718$ ($n = 99$)	**−0.285** **$p < 0.004$** **($n = 100$)**	0.152 $p < 0.133$ ($n = 99$)
body FA	0.013 $p < 0.897$ ($n = 94$)	−0.059 $p < 0.572$ ($n = 94$)	0.108 $p < 0.298$ ($n = 94$)	0.082 $p < 0.431$ ($n = 94$)	0.071 $p < 0.498$ ($n = 94$)	—	**0.558*** **$p < 0.001$** **($n = 99$)**	−0.011 $p < 0.911$ ($n = 99$)	**0.199** **$p < 0.050$** **($n = 98$)**
body TA	−0.057 $p < 0.588$ ($n = 94$)	−0.148 $p < 0.154$ ($n = 94$)	0.013 $p < 0.900$ ($n = 94$)	−0.03 $p < 0.772$ ($n = 94$)	−0.026 $p < 0.805$ ($n = 94$)	**0.821*** **$p < 0.001$** **($n = 94$)**	—	−0.114 $p < 0.260$ ($n = 99$)	**0.226** **$p < 0.025$** **($n = 98$)**
rated masculinity/femininity	**0.368*** **$p < 0.001$** **($n = 94$)**	0.171 $p < 0.099$ ($n = 94$)	0.095 $p < 0.364$ ($n = 94$)	0.049 $p < 0.637$ ($n = 94$)	−0.031 $p < 0.763$ ($n = 94$)	−0.003 $p < 0.973$ ($n = 94$)	−0.098 $p < 0.346$ ($n = 94$)	—	**−0.368*** **$p < 0.001$** **($n = 99$)**
sexual dimorphism factor score	−0.140 $p < 0.178$ ($n = 94$)	−0.039 $p < 0.705$ ($n = 94$)	−0.009 $p < 0.933$ ($n = 94$)	−0.065 $p < 0.533$ ($n = 94$)	−0.067 $p < 0.515$ ($n = 94$)	0.105 $p < 0.312$ ($n = 94$)	0.152 $p < 0.144$ ($n = 94$)	**0.301** **$p < 0.003$** **($n = 94$)**	—

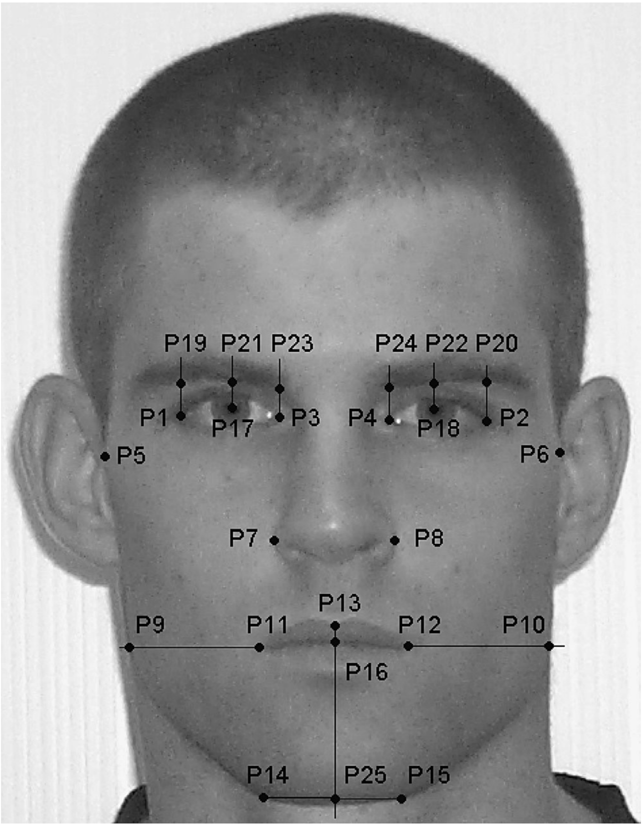

Figure 1. Positioning of points for the masculinity/femininity measurements (P1–P12, P14–P25) and FA measurements (P1–P15) of Simmons *et al.* (2004).

quality. Perhaps we failed to find an association between these two traits because facial FA is a poor indicator of developmental instability (Gangestad & Thornhill 2003). However, unlike Gangestad & Thornhill, we also failed to find significant correlations between body asymmetry and masculinity in males (body FA and factor score: $r_{93} = 0.105$, $p < 0.321$; body TA and factor score: $r_{93} = 0.152$, $p < 0.144$; body FA and rated masculinity $r_{93} = -0.003$, $p < 0.973$; body TA and rated masculinity: $r_{93} = -0.098$, $p < 0.346$, all two-tailed). For female bodies, FA and TA correlated positively with our factor score, $r_{97} = 0.199$, $p < 0.025$ and $r_{97} = 0.226$, $p < 0.025$, respectively, but not with rated femininity, $r_{98} = -0.011$, $p < 0.911$ and $r_{98} = -0.114$, $p < 0.260$, respectively (all two-tailed). These results are inconsistent with Gangestad & Thornhill's findings of no significant correlation between body asymmetry and measured facial masculinity in females.

A subsidiary aim of our study was to examine the relationship between ratings and measurements of the same trait. Rated symmetry correlated negatively with all measures of asymmetry (see table 1) suggesting that ratings and measurements capture common information about symmetry. Rated masculinity was positively correlated, and rated femininity negatively correlated, with our factor score, suggesting that we are able to measure aspects of faces perceived as masculine/feminine (see table 1).

Male attractiveness correlated positively with rated symmetry and rated masculinity (see table 1) while female attractiveness correlated positively with rated symmetry and rated femininity, and negatively with our factor score.

In summary, our study offers little support for the claim that facial masculinity and either facial or body FA (or any other measure of facial or body asymmetry) signal the same aspects of mate quality in males. The findings for facial femininity and facial/body asymmetry in females were mixed. For faces, we found an association between rated femininity and symmetry as well as between rated femininity and HA, suggesting that these traits could signal the same aspects of mate quality. However, failure to find a similar association using facial FA, which is the theoretically relevant concept, suggests that the conclusion regarding female faces be viewed with caution. Nevertheless, it is intriguing that for females, body symmetry, both FA and TA, correlated negatively with measured facial masculinity. That is, females with less feminine faces had higher body asymmetry. These females were also rated as unattractive by males. These findings suggest that for females, body symmetry and femininity may tap the same underlying variation in mate quality. The different findings for facial and body asymmetry are consistent with the claim of Gangestad & Thornhill (2003) that body asymmetry may be a better indicator of developmental instability than facial asymmetry, at least in females.

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