Facial shape provides a valid cue to sociosexuality in men but not women

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Abstract

Existing work suggests that observers' perceptions of sociosexuality from strangers' faces are positively associated with individuals' self-reported sociosexuality. However it is not clear what cues observers use to form these judgements. Over two studies we examined whether sociosexuality is reflected in faces, which cues contain information about sociosexuality, and whether observers' perceptions of sociosexuality from faces are positively associated with individuals' self-reported sociosexuality. In Study One, Geometric Morphometric Modelling (GMM) analysis of 103 Caucasian participants revealed that self-reported sociosexuality was predicted by facial morphology in male but not female faces. In Study Two, 65 Caucasian participants judged the sociosexuality of opposite sex faces (faces from Study One) at zero acquaintance. Perceived sociosexuality predicted self-reported sociosexuality for men, but not women. Participants were also presented with composites of faces of individuals with more unrestricted sociosexuality paired with composites of faces of individuals with more restricted sociosexuality and asked to indicate which was more unrestricted. Participants selected the more unrestricted sociosexuality male, but not female, facial composites at rates significantly above chance. GMM analyses also found that facial morphology statistically significantly predicted perceived sociosexuality in women's and, to a greater extent, in men's faces. Finally, facial shape mediated the relationship between perceived sociosexuality and self-reported sociosexuality in men's but not women's faces. Our results suggest that facial shape acts as a valid cue to sociosexuality in men's but not women's faces.

Introduction

People make rapid judgements about others' personality traits, including cooperativeness (Verplaetse et al., 2007), deceptiveness (Bond et al., 1994) and sociosexuality (Boothroyd et al., 2008, 2011; Simpson & Gangestad, 1991; Stillman & Maner, 2009), based on the information they retrieve from faces. There is evidence that these judgements are associated with individuals' actual personality traits. However, the cues used to form these judgements, and the strength of their associations with actual personality traits, are typically unknown.

A number of valid facial cues to aspects of underlying physiology and psychology have been identified, such as facial adiposity cueing body size (Coetzee et al., 2009) and skin color cueing fruit and vegetable intake (Stephen et al., 2011; Tan et al., 2017). However, these studies have typically examined a single facial cue, such as skin color, symmetry, or facial width-to-height-ratio, in isolation, and have required that the cue of interest be specified *a priori*. More recently, geometric morphometric modelling (GMM) has been used as a bottom-up data-driven approach that allows the statistical model to identify important variation in facial shape, removing the requirement to specify cues of interest *a priori* (Said & Todorov, 2011). This technique has been used to predict aspects of physiological health, such as BMI, blood pressure, and body composition, from photographs of faces, thus identifying the facial shape correlates of these aspects of health (Stephen et al., 2017; Wolffhechel et al., 2015). These facial shape variables are also used by observers when making health judgements from faces, indicating that they act as valid cues to health (Stephen et al., 2017).

GMM has also been used to identify the facial shape cues that influence the perception of psychological variables such as intelligence (Kleisner et al., 2014) and subjective perceptual judgements such as attractiveness (Holzleitner et al., 2019). Other psychological variables, such as sociosexuality, may therefore also be identifiable using GMM.

A number of studies have shown that observers can make judgements of sociosexuality with some degree of accuracy, with women's ratings of men's sociosexuality from short video clips correlating positively with the men's scores on the sociosexuality inventory (SOI; Boothroyd et al., 2008; Gangestad et al., 1992; Simpson & Gangestad, 1991; Stillman & Maner, 2009). The faces of individuals with more unrestricted sociosexuality are perceived as having more unrestricted sociosexuality than faces of individuals with more restricted sociosexuality (Boothroyd et al., 2008). Composite faces made from photographs of individuals with more unrestricted sociosexuality are perceived as having more unrestricted sociosexuality and as being more attractive (female faces) and more masculine (male faces) than composites made from the faces of more restricted sociosexuality individuals (Boothroyd et al., 2011).

The ability to detect levels of sociosexuality in potential mates may hold significant advantages for both sexes. For example, women may be able to use this information to identify men that are more likely to commit to long-term relationships, thus decreasing the chances of abandonment following conception (Boothroyd et al., 2011; Cashdan, 1996). Men may be able to use this information to identify both women with restricted sociosexuality who may offer enhanced paternity certainty in long-term relationships (sociosexuality is positively correlated with infidelity; Rodrigues et al., 2016), and women with unrestricted sociosexuality who may offer short-term mating opportunities (Boothroyd et al., 2008).

One explanation for how facial shape may act as a valid cue to sociosexuality relates to the influence of testosterone on both sociosexuality and facial appearance. Just as men tend to have more unrestricted sociosexuality than women, within sexes, individuals with more masculine 2D:4D digit ratios (a proxy for *in utero* exposure to testosterone; Galis et al., 2010; Manning et al., 1998; Puts et al., 2008) tend to have more unrestricted sociosexuality, suggesting that a division of brain areas involved with sociosexuality occurs very early in development due to *in utero* testosterone. It should be noted, however, that the use of 2D:4D digit ratio as a proxy for *in utero* testosterone levels has been challenged (Alonso et al., 2018), with critics suggesting that the sexual dimorphism in digit ratios may simply be a function of men's larger hands (Lolli et al., 2017). Higher levels of circulating testosterone at birth (Weinberg et al., 2015; Whitehouse et al., 2015) and higher current levels of testosterone (Penton-Voak & Chen, 2004) are also associated with more masculine facial features, such as more robust lower face (Schaefer et al., 2005). Administration of testosterone to teenagers results in the growth of more masculine facial features (Verdonck, 1999). This suggests that facial masculinity may be used by observers as a cue to men's sociosexuality. Indeed, Boothroyd et al. (2011) show that composite faces produced from men with more unrestricted sociosexuality were perceived as more masculine than composite faces produced from men with more restricted sociosexuality. However, it is not known whether more morphologically masculine individuals are perceived as having more unrestricted sociosexuality, nor whether more morphologically masculine individuals have more unrestricted self-reported sociosexuality.

When women were asked to rate the masculinity of other women's faces, sexually unrestricted women are rated as having more masculine faces (Campbell et al., 2009), this result conflicts with other research showing that more unrestricted sociosexuality is associated with more attractive appearance in women (Boothroyd et al., 2008, 2011; Clark, 2004), which is typically associated with more feminine appearance (Marcinkowska et al., 2014). More recent research suggests that facial width to height ratio (a typically masculine trait) does not predict women's sexual desire (Zhang et al., 2018). This study will therefore examine the role of masculinity and attractiveness of faces in predicting both self-reported and perceived sociosexuality.

While several studies have reported statistically significant positive correlations between the perceived sociosexuality of face photographs and the self-rated sociosexuality of the individuals in the photographs, little research has addressed the question of which facial cues are involved in this relationship, or whether the perceived sociosexuality of individuals is positively correlated with the individuals' self-reported sociosexuality and can therefore be considered a valid cue to sociosexuality (Coetzee et al., 2009; Scott-Phillips, 2008; Stephen et al., 2015). Arnocky et al. (2018) found that facial width to height ratio positively predicts sociosexuality and intended infidelity among men but not women, but it is not known whether other aspects of facial shape act as cues to sociosexuality.

Here, we report the results of two studies in a sample of male and female young Caucasian adults that examine whether: a) sociosexuality is reflected in facial morphology, as measured using geometric morphometric methodology, b) observers' perceptions of sociosexuality, as judged from facial photographs, can be predicted using GMM, c) observers' ratings of sociosexuality, as judged from facial photographs predict individuals' self-reported sociosexuality, d) facial morphology mediates the relationship between perceived sociosexuality and self-reported sociosexuality. All work was approved by the Macquarie University Human Research Ethics Committee, and was conducted in accordance with the Declaration of Helsinki. All participants gave prior, informed consent in writing.

Study One

Study One aimed to predict sociosexuality scores using GMM analysis of facial shape. We predicted that aspects of facial shape will predict individuals' self-reported sociosexuality.

Participants

One hundred and twenty three Caucasian participants (63 female, 60 male; M_{age} = 20.21 years, SD = 3.56) took part in this study in exchange for course credit or AU$10. Participants completed the sociosexuality (revised) (SOI-R) scale (Penke & Asendorpf, 2008), and self-reported sex, age and ethnicity. Scores on the SOI-R for our sample were slightly lower (more restricted) than published norms (men *M* = 4.12, *SD* = 1.54; women *M* = 2.96, *SD* = 1.28), and men reported significantly higher (more unrestricted) scores than women ($t(107.35) = 4.32$, $p < .001$, *d* = .81). The SOI-R scale showed good internal consistency in our sample (Cronbach's α = .87).

Photography. Participants were photographed under standardized conditions. Participants stood in a booth painted with Munsell N5 neutral grey paint, wearing plain grey shorts and singlet. Illumination was provided by 15 d65 daylight simulation fluorescent tubes mounted in high frequency fixtures to reduce the effects of flicker. Light was diffused using Perspex diffusers and no other light source was present in the room (Brierley et al., 2016). All settings on the Canon EOS 70D DSLR camera were held constant for all participants, and the camera was mounted on a fixed tripod 3m from the participant. Pictures were taken facing the camera, and participants were instructed to maintain a neutral facial expression (Brierley et al, 2016). Images were captured at 3648 x 5472 pixels.

Geometric morphometric methodology

When using GMM, landmarks are digitized on each image to describe overall facial form (Mitteroecker et al., 2013). For each of the facial images, 167 landmarks were placed on each of the faces (Following Stephen et al, 2017; Figure 1) using Psychomorph (Tiddeman et al., 2001).

Figure 1: Location of the 167 landmark points delineated on an average face for illustrative purposes. Photographs of real faces were used in the study.

Using the Geomorph toolbox for R (Adams et al., 2014), all arrangements of landmarks were superimposed by generalized Procrustes analysis (GPA) to remove rotation, translation and scale variability (Mitteroecker et al., 2013).

An exploratory factor analysis (chosen since it has recently been shown to provide a more stable representation of the latent structure of data than does principal components analysis; Widaman, 2018) with Oblimin rotation was then performed to identify the latent dimensions of variation in landmark data. However, since all correlations in the factor correlation matrix were < .32, the factor analysis was rerun using a Varimax rotation

(Tabachnick & Fidell, 2007, p646). Parallel analysis using Glorfeld's technique (Glorfeld, 1995) indicated that 12 factors should be retained, explaining 64.21% of variance in face shape (see Figure S1 and Table 1 for visualizations and descriptions of the Factors).

Linear regression was used to predict self-reported sociosexuality (SOI-R scores) from the 12 Factors. Sex was included as a predictor variable in the model. Predictor variables were retained using the stepwise AIC method (Venables & Ripley, 2002). Cases with Cook's distance values > 4/n were removed. For each statistically significant model, leave one out cross-validation (LOOCV) was performed. Correlating cross-validated scores with predicted scores from the model allowed us to assess the generalizability of the model.

	Higher values of the Factor represent:	Sexual dimorphism	Relationship with self-reported sociosexuality	Relationship with perceived sociosexuality
Factor 1	Head tilted back. Broader jaw. Smaller forehead.	M > F, p = .034, d = -.41	r = .26, p = .005	r = .33, p < .001
Factor 2	Face turned to the left. Narrower face.	M > F, p = .017, d = -.46	r = .02, p = .809	r = .03, p = .747
Factor 3	Longer, more robust face.	p = .747, d = .06	r = .08, p = .397	r = .02, p = .827
Factor 4	Smaller face. Wider-set eyes.	p = .174, d = *.26*	r = -.06, p = .496	r = -.01, p = .905
Factor 5	Narrower face. Smaller eyes. Smaller lips. Higher forehead.	M > F, p = .032, d = -.41	r = -.01, p = .886	r = .10, p = .289
Factor 6	Wider-set eyes. Longer face.	M > F, p = .024, d = -.43	r = .10, p = .289	r = .28, p = .003
Factor 7	More rounded, feminine face. Larger eyes. Larger lips	M < F, p < .001, d = .67	r = -.17, p = .063	r = -.26, p = .006
Factor 8	More angular face. Smaller, higher-set eyes. Wider mouth.	M < F, p = .051, d = .37	r = -.09, p = .326	r = -.12, p = .223
Factor 9	Wider face. Broader jaw. Wider-set eyes. Shorter forehead.	p = .288, d = .20	r = -.14, p = .142	r = -.07, p = .486
Factor 10	Wider, more robust, more angular, more masculine face. Wider-set eyes. Wider mouth.	M > F, p = .005, d = -.54	r = .17, p = .066	r = .05, p = .613
Factor 11	Shorter, rounder face. Thinner lips. Larger eyes.	M > F, p < .001, d = -1.21	r = .19, p = .048	r = .19, p = .043
Factor 12	More robust, longer face.	p = .148, d = .28	r = -.03, p = .734	r = .10, p = .282

Table 1: Descriptions of the facial shape Factors and bivariate relationships with self-reported and perceived sociosexuality.

Results

Four female and one male participants were removed from analysis due to self-reporting an ethnicity other than Caucasian, another female participant was also excluded because she had her mouth open during the photograph, and one male participant was excluded due to extensive facial scarring. One male and three female participants were excluded due to having failed to answer one or more of the SOI-R items.

Models predicting self-reported sociosexuality

A regression model predicting self-reported sociosexuality from the Factor scores was calculated for male and female data combined. The model accounted for 34.2% of the variance in self-reported sociosexuality ($R^2 = .34$, $F\ (6,97) = 8.39$, $p < .001$). Participant sex (β = .34, $p < .001$), and Factors 1 (β = .21, p = .013), 5 (β = -.14, p = .098), 7 (β = -.16, p = .074), 8 (β = -.15, p = .090), and 10 (β = .16, p = .059) remained in the model as predictors. No problems of multicollinearity were detected (all VIFs < 1.44). LOOCV values were highly correlated with predicted values, ($r(102) = .95$, $p < .001$), indicating good generalizability of the model. Since male participants reported significantly greater sociosexuality than female participants, the analysis was rerun as a hierarchical regression, in order to determine the predictive power of the face shape Factors over and above the predictive power of participant sex. Participant sex was entered in the first step. Factors 1,5,7,8, and 10 (which remained in the stepwise model) were entered in the second step. The Factors explained 11.76% additional variance over and above what was explained by participant sex alone ($R^2_{change} = .12$, $F_{change}(1,102) = 29.47$, $p < .001$).

Since men report higher SOI-R scores than women, separate regression models were produced for male and female faces. In male faces alone, a regression model predicting scores on the SOI-R based on the Factor scores was calculated (Figure 2). The model explained

35.03% of variance in self-reported sociosexuality (R^2 = .35, F (6,43) = 3.86, p = .004). Factors 1 (β = .36, p = .007), 2 (β = -.25, p = .058), 7 (β = -.19, p = .137), 8 (β = -.17, p = .185), 9 (β = -.18, p = .153), and 10 (β = .29, p = .025) remained in the model. No problems with multicollinearity were detected (all VIFs < 1.07). LOOCV values were highly correlated with predicted values (r(48) = .90, p < .001) indicating good generalizability of the model.

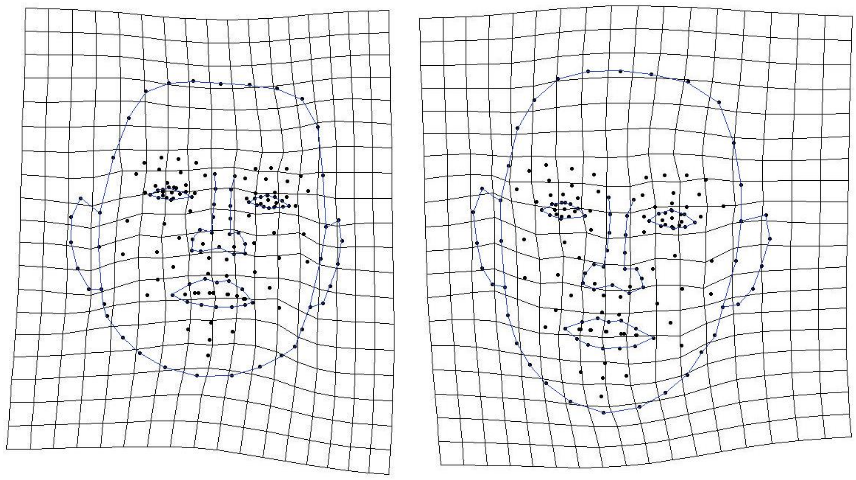

Figure 2: Thin plate spline visualizations of the model predicting low (left) and high (right) levels of sociosexuality in male faces. Higher sociosexuality is predicted by longer face, longer nose, higher forehead, and larger eyes.

In female faces, a significant regression model predicting self-reported sociosexuality from the facial shape Factors was not produced (R^2 = .04, F(1,47) = 3.21, p = .080).

There is no standard test for comparing the R^2 values of regression models built from different data. However, Goldstein and Healy (1995) and Payton et al. (2003) suggest that if bootstrapped 84% confidence intervals of the R^2 values do not overlap, this can be considered equivalent to statistical significance at the α = .05 level. Therefore, to determine whether the ability of the model to predict sociosexuality based on face shape was significantly better in male than in female faces, bootstrapped estimates of the 84% confidence intervals for R^2 of the regression model using Factors 1, 2, 5, 7, 8, 9, and 10 as predictors were calculated separately for male (R^2 = .35 [.18, .41]) and female (R^2 = .14 [-.01, .17]) samples. The confidence intervals did not overlap, suggesting that facial shape predicts sociosexuality significantly more effectively in men's than in women's faces.

To determine whether the predictive value of facial shape for self-reported sociosexuality is defined primarily by masculinity, morphological masculinity scores were calculated for each face. A linear discriminant model was produced, predicting sex from the 12 face shape Factors. This model correctly classified 93.75% of faces. Discriminant scores were saved for each face as they represent morphological masculinity, such that negative scores represented more feminine face shape and positive scores represented more masculine face shape (Scott et al, 2010). For the combined male and female data, hierarchical linear regression was performed with self-reported sociosexuality as the outcome variable. In the first step, masculinity score was entered as the predictor variable. The model accounted for 21.2% of the variance in self-reported sociosexuality (R^2 = .21, F(1,102) = 27.37, p < .001). In the second step, Factors 1, 5, 7, 8, and 10 were added. This new model accounted for an additional 10.22% of variance (R^2_{change} = .10, F_{change}(5,97) = 2.89, p = .017), suggesting that, while masculinity explains part of the ability to predict self-reported sociosexuality based on face shape, other face shape information also plays a role.

Repeating these hierarchical regression analyses for the male and female data separately did not find that masculinity score was a significant predictor of self-reported sociosexuality scores within male (R^2 = .04, F(1,54) = 2.06, p = .157) or female (R^2 = .00, F(1,53) = .07, p = .788) faces. The hierarchical linear regression modelling was therefore stopped.

To determine whether the predictive value of facial shape for self-reported sociosexuality is defined primarily by attractiveness, hierarchical linear regression was performed with self-reported sociosexuality as the outcome variable. In the first step, rated attractiveness (see Study 2 methods for details) was entered as a predictor variable. In the second step, Factors 1, 5, 7, 8, and 10 were added. This was repeated for the male and female data separately. Rated attractiveness was not found to be a significant predictor of self-reported sociosexuality scores in either the male ($F(1,54) = .79$, $p = .377$), female ($F(1,50) = .41$, $p = .526$), or combined ($F(1,100) = .13$, $p = .72$) data. The hierarchical linear regression modelling was therefore stopped.

Summary

Self-reported sociosexuality was predicted by face shape in the model that included both sexes. However when the data was split by sex, facial shape was found to predict sociosexuality only in the male data. Further, while morphological masculinity predicted sociosexuality in the combined data, this was likely due to the fact that men reported more unrestricted sociosexuality than women. When male and female data were examined separately, morphological masculinity did not predict sociosexuality in either sex. Self-reported sociosexuality was not predicted by rated attractiveness in either sex or in the combined data.

Study Two

Study two had three related aims. First, it aimed to test whether people’s perceptions of unfamiliar individuals’ sociosexuality (estimated from face photographs) correlates with those individuals’ self-reported sociosexuality (measured using the SOI-R scale; Boothroyd et al., 2008). As a second test of this hypothesis, observers were asked to judge which of a pair of composites of high and low self-reported sociosexuality faces was which (Boothroyd et al., 2008, 2011).

Second, Study 2 aimed to test whether facial shape contributes to perceptions of sociosexuality from face photographs. If so, facial morphology (shape Factors) is expected to predict observers' perceptions of sociosexuality.

Third, Study 2 aimed to determine whether facial shape mediates the relationship between perceived and self-reported sociosexuality, and is therefore a valid cue to sociosexuality.

Participants

Sixty-five Caucasian participants who were not enrolled in Study 1 (45 female, 20 male; M_{age} = 22.03, *SD* = 2.68) took part in Study 2, in exchange for AU$10 or course credit.

Stimuli

This study contained two types of facial image stimuli. First, images of participants' faces from the first study were used.

Second, pairs of facial composites (produced using Psychomorph; Tiddeman, Burt and Perrett, 2001) were used in a two-alternative forced choice paradigm. The 15 male individuals with the highest scores on the SOI-R (*M* = 5.12) were used for the high-sociosexuality male composite. To produce the composite, the average location of each delineated landmark point across these faces was calculated to produce an average high-sociosexuality male face shape. Each component face was then warped to this average shape, and average color at each pixel was calculated across the component faces. Texture was maintained. This process was repeated for low sociosexuality male (*M* = 1.55) and high (*M* = 3.95) and low (*M* = 1.19) sociosexuality female faces (Figure 3).

All images were resized to 391 x 479 pixels for presentation on a standard computer screen.

Procedure

Following a brief demographic questionnaire (sex, age, ethnicity, sexuality), participants completed three blocks of ratings of opposite sex faces. In one, they rated the sociosexuality of the real faces collected in Study 1. Five questions were used, adapted from the SOI-R scale, and following Boothroyd et al. (2008) (e.g. “How likely is this person to fantasize about someone other than their current partner?”), and each was answered on a 7-point Likert scale from very unlikely to very likely. One item was reverse scored. Along with each rating, participants were also given the option to indicate that they knew the person in the photograph, in which case no rating was given for that specific trial. This box was checked a total of four times across all participants. In the second block, participants were presented with the pair of facial composites (high and low sociosexuality) and asked to rate which they thought was more likely to fit each of the 5 sociosexuality descriptions (e.g. “Which person is more likely to have a one night stand?”), on a 6-point Likert scale from left image highly more likely to right image highly more likely. In the third block, participants rated the attractiveness of each real face. The order of the blocks, and the order of presentation of the faces within each block, was randomized. For the composite task, the sides of the screen that each face appeared on was randomized.

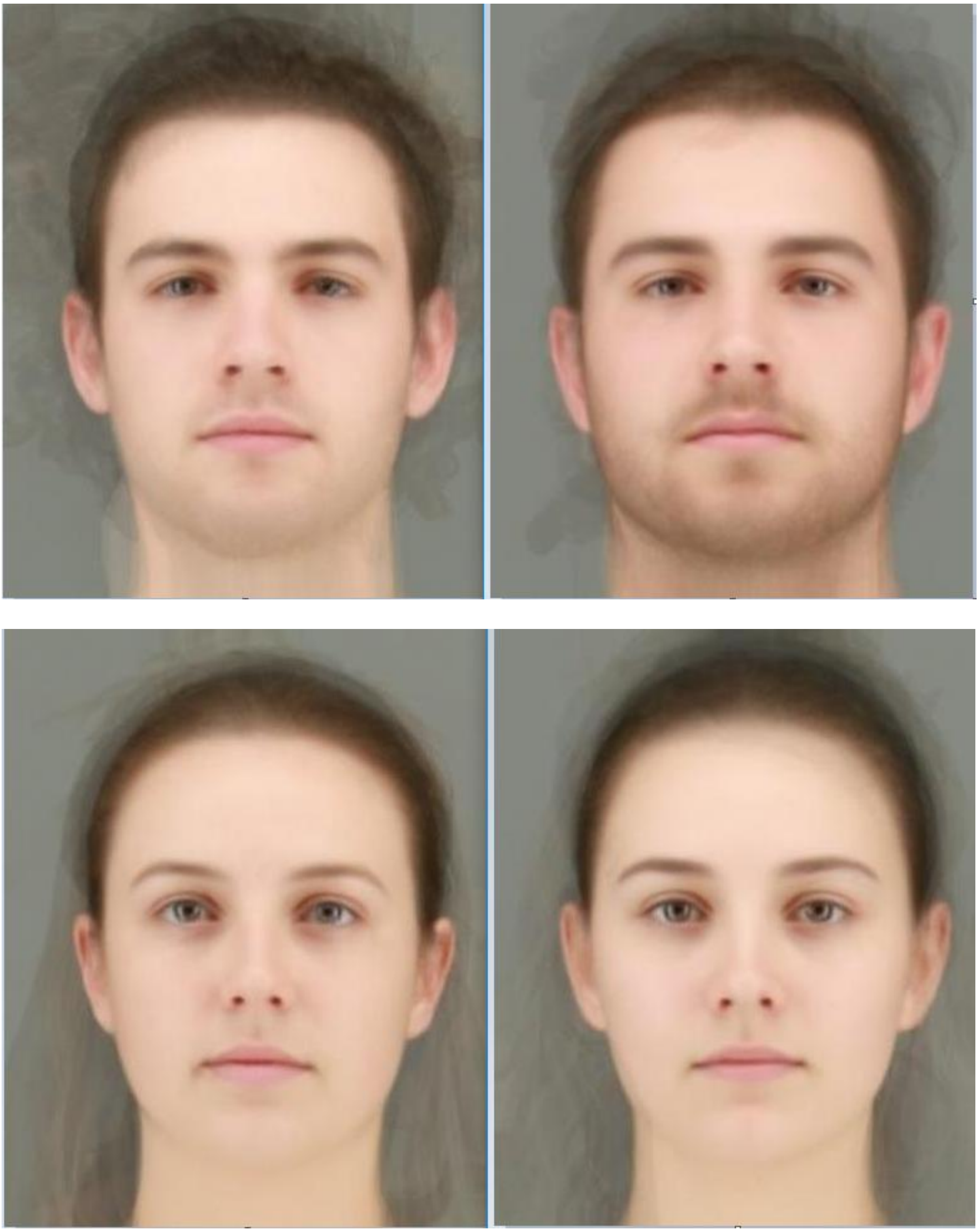

Figure 3: Composite image of 15 lowest (left) and highest (right) sociosexuality men (top) and women (bottom).

Statistical methods

Cronbach's alpha showed good internal consistency for the five items measuring perceived sociosexuality for individual faces ($\alpha = .82$). Perceived sociosexuality scores were therefore calculated for each individual face/observer pair by averaging across the five questions. In order to test whether observers' perceived sociosexuality ratings reflected individuals' self-reported sociosexuality, linear mixed effects modelling was used, with perceived sociosexuality score as the outcome variable, and self-reported sociosexuality as a fixed factor. To avoid pseudoreplication, observer ID and face ID were included in the model as random factors. Self-reported sociosexuality and face sex were grouped by face ID. Models were also produced (without face sex as a random effect) for male and female data separately. Observations with Cook's distance scores greater than 4/n were excluded.

To address the question of whether facial shape predicts perceived sociosexuality, a linear mixed effects model predicting perceived sociosexuality scores based on the Factor scores was calculated. To avoid pseudoreplication, observer ID and face ID were included in the model as random factors. Face sex was grouped by face ID. Models were also produced (without face sex as a random effect) for male and female data separately. Observations with Cook's distance scores greater than 4/n were excluded. Factors were identified for retention using Satterthwaite's stepwise method.

For each statistically significant model, ten-fold cross-validation was performed. Correlating cross-validated scores with predicted scores from the model allowed us to assess the generalizability of the model.

For the composite rating data, the five sociosexuality rating questions showed good internal consistency (Cronbach's $\alpha = .86$). A perceived sociosexuality score was therefore calculated for each pair of composites for each observer by averaging the scores across the five questions and centering on 0. Possible scores ranged from -3 (in which observers perceived the restricted sociosexuality face as definitely unrestricted on every question) to 3 (in which observers perceived the unrestricted sociosexuality face as definitely unrestricted on every question). To determine if observers could correctly recognize the more unrestricted sociosexuality composite, one-sample t-tests compared the scores against the midpoint value of 0 separately for each sex of facial composites. To determine whether the more unrestricted sociosexuality composite was correctly recognized in male composites significantly more than in female composites, a paired-samples t-test was performed.

To determine whether facial shape, as represented by the facial shape Factors, mediate the relationship between perceived and self-reported sociosexuality, multiple mediation analysis was conducted (Hayes, 2013; Yu & Li, 2017). Perceived sociosexuality was the outcome variable, and self-reported sociosexuality was the predictor variable. Participant sex was included as a covariate, and the twelve facial shape Factors were included as potential mediators. Mediators were identified as variables that significantly correlated with both the predictor and outcome variables, controlling for the effects of all other predictors (Yu & Li, 2017). 95% confidence intervals of the effects were estimated using bootstrapping. This analysis was repeated separately for male and female faces (without sex as a covariate).

Results

Seven female observers indicated that they were homosexual, and their data was removed from the analysis. However, including them in analyses did not change the pattern of results.

Is there a relationship between self-rated sociosexuality and perceived sociosexuality?

A statistically significant linear mixed-effect model was produced, The model predicting perceived sociosexuality from self-rated sociosexuality accounted for 13% of variance ($F(1,94.66) = 4.38$, $\beta = .14$, $p < .039$, $R^2_m = .13$). When split by sex, statistically significant models were produced for men's (F(1,54.98) = 4.64, β = .18, p = .036, R^2_m = .03) but not for women's (F(1,51.06) = .69, β = .07, p = .409, R^2_m = .00) faces. This provides evidence that there is some accuracy in perceptions of men's sociosexuality from their faces, but no evidence of this in women's faces. Bootstrapped 84% confidence intervals of R^2_m for the male [.02,.03] and female data [.00,.01] do not overlap, suggesting that self-rated sociosexuality is more strongly associated with perceived sociosexuality in male than in female faces.

Models predicting perceived sociosexuality

A model was found (R^2_m = .08) that accounted for 8% of the variance in perceived sociosexuality from face sex (β = .35, t(90.17) = < .001), and Factors 2 (β = -.10, t(174.94) = 3.69, p = .001), 4 (β = .10, t(129.10) = 2.38, p = .019) and 11 (β = -.18, t(141.90) = -3.18, p = .002). No problems with multicollinearity were detected (all VIFs < 1.10). Ten-fold cross-validation values were strongly correlated with predicted values from the model, (r(107) = .99, p < .001), indicating good generalizability of the model.

In male faces, a model predicting perceived sociosexuality scores from the Factors accounted for 14% of variance (R^2_m = .14). Factors 1 (β = .39, t(45.28) = 2.41, p = .020), 4 (β = .18, t(56.27) = 2.24, p = .029), 5 (β = -.16, t(65.38) = -3.08, p = .003), 7 (β = -.16, t(65.38) = -2.82, p = .006), and 10 (β = -.26, t(61.14) = -3.48, p < .001) remained in the model (Figure 4). No problems with multicollinearity were detected (all VIFs < 1.45). Ten-fold cross-validation values were strongly correlated with predicted values from the model, r(55) = .99, p < .001, indicating good generalizability of the model.

In female faces, Factor scores accounted for 10% of variance in perceived sociosexuality (R^2_m = .10). Factors 2 (β = -.15, t(71.09) = -3.21, p = .002), 5 (β = -.15, t(67.92) = -2.64, p = .010), 6 (β = .14, t(53.72) = 2.40, p = .020), 7 (β = .12, t(114.41) = 2.60, *p* = .011), 10 (β = .12, *t*(74.51) = 2.83, *p* = .006), and 11 (β = -.31, *t*(59.82) = -5.52), *p* < .001) remained in the model (Figure 4). No problems of multicollinearity were detected (all VIFs < 1.65). Ten-fold cross-validation values were strongly correlated with predicted values from the model, *r*(51) = .99, *p* < .001, indicating good generalizability of the model. Bootstrapped 84% confidence intervals for R^2_m for the male [.12, .15] and female [.07, .12] faces do not overlap, suggesting that facial shape accounts for more variance in perceived sociosexuality in male than in female faces.

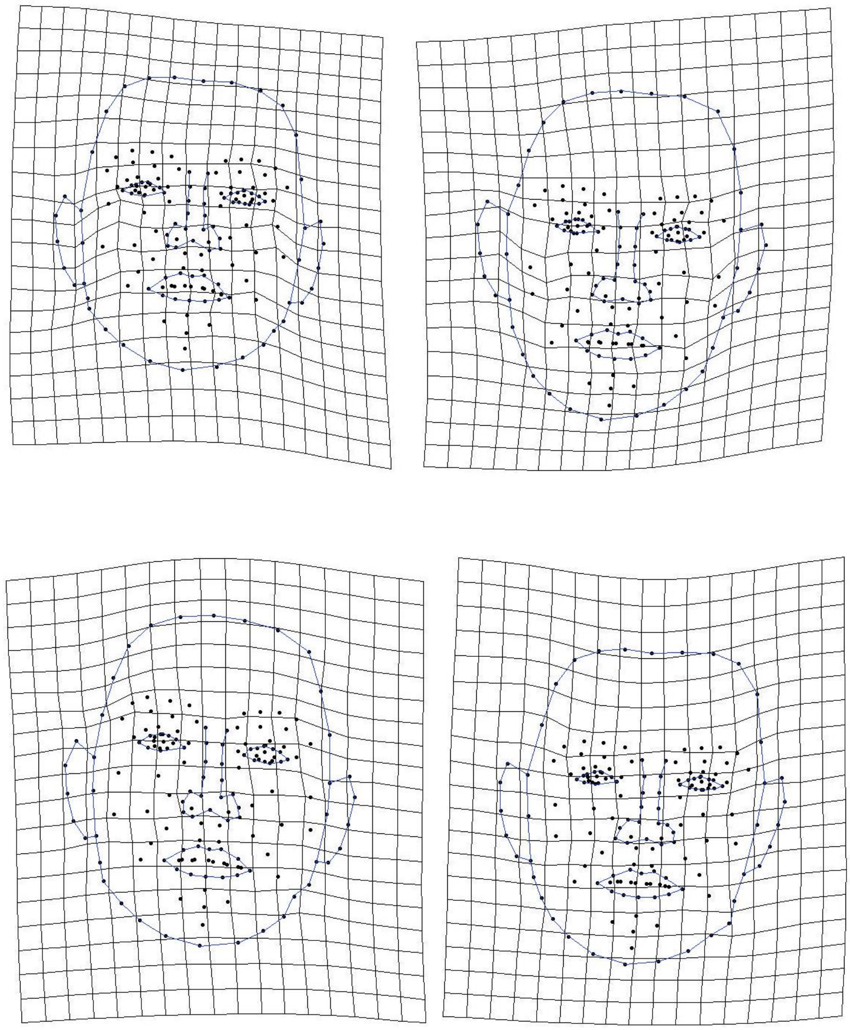

Figure 4: Thin plate spline visualizations of the models predicting low (left) and high (right) levels of perceived sociosexuality in male (top) and female (bottom) faces. Male faces perceived as higher sociosexuality are longer, have higher foreheads, longer noses, and larger

eyes. Female faces perceived as higher sociosexuality are smaller, more gracile, and have smaller eyes and smaller lips.

Morphological masculinity was not found to be a statistically significant predictor of perceived sociosexuality in the combined data (*t*(77.86) = .72, *p* = .474) or in male faces (*t*(39.67) = 1.42, *p* = .163). For female faces, morphological masculinity was found to be a significant negative predictor of perceived sociosexuality (β = -.24, *t*(56.43) = -2.92, *p* = .005, R^2_m = .03). In the second step of a hierarchical linear mixed model, Factors 2, 5, 6, 7, 10, and 11 were added. The second step predicted an additional 4.5% of variance over and above the variance predicted by morphological masculinity alone ($R^2_{m\ change}$ = .045, $\chi^2(6)$ = 22.19, *p* = .001). This suggests that, while feminine women's faces are perceived as higher in sociosexuality, some additional variance is explained by other aspects of facial shape.

Rated attractiveness was not found to be a statistically significant predictor of perceived sociosexuality in the combined data (*β* = -.04, *t*(175.10) = .30, *p* = .760) or in male (*β* = .12, *t*(94.20) = .87, *p* = .386) or female faces separately (*β* = -.09, *t*(97.22) = 1.26, *p* = .210).

Can people distinguish between restricted and unrestricted composites?

One-sample t-tests against the scale midpoint of 0 showed that participants correctly identified the high sociosexuality male composite at an above-chance rate (*M* = .44, *SD* = .87, *t*(25) = 2.58, *p* = .016, *d* = .51), but this effect was not statistically significant for female composites (*M* = -.07, *SD* = .58, *t*(11) = -.40, *p* = .696, *d* = .-12). Participants correctly identified the more unrestricted composite significantly more frequently in the male than in the female stimuli (*t*(31.28) = 2.13, *p* = .041, *d* = .51).

Does facial shape mediate the relationship between perceived and self-reported sociosexuality?

Only Factor 1 was identified as a significant mediator of the relationship between self-rated and perceived sociosexuality (identified as correlating with both self-rated and perceived sociosexuality, controlling for all other shape Factors) in the combined male and female data. The indirect effect of perceived sociosexuality on self-reported sociosexuality via Factor 1 was significant (Figure 5), suggesting that Factor 1 may represent a valid cue to sociosexuality.

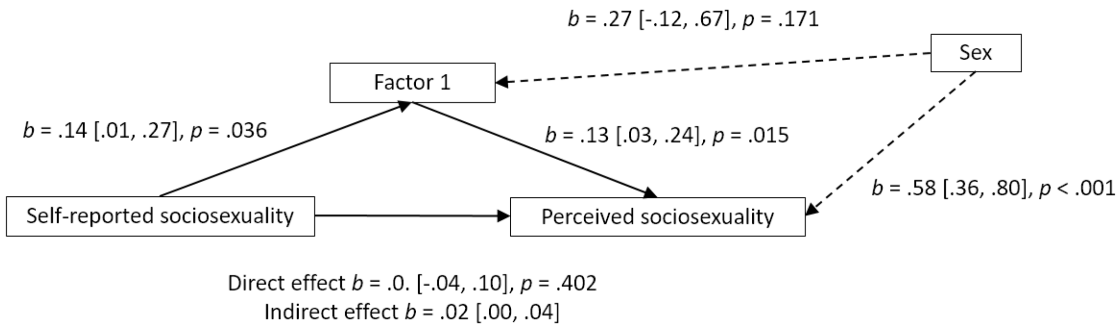

Figure 5: The significant mediation model showing the indirect effect of self-reported sociosexuality on perceived sociosexuality via face shape Factor 1. Combined male and female data.

In male faces, only Factor 1 was identified as a significant mediator. The indirect effect of perceived sociosexuality on self-reported sociosexuality via Factor 1 was significant (Figure 6), suggesting that Factor 1 may represent a valid cue to sociosexuality in male faces. In female faces, none of the Factors was identified as a significant mediator.

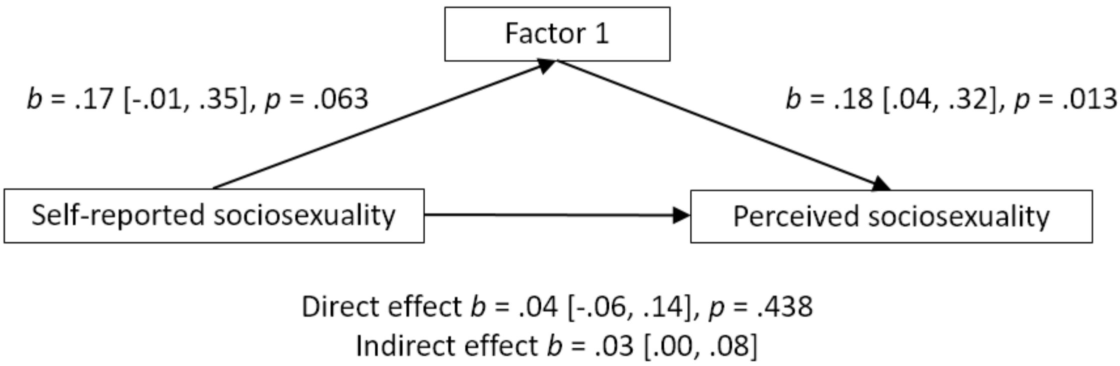

Figure 6: The significant mediation model showing the indirect effect of self-reported sociosexuality on perceived sociosexuality via face shape Factor 1. Male data.

Summary

Study Two aimed to test whether observers' perceptions of the sociosexuality of strangers is predicted by those strangers' own self-reported sociosexuality. We found that perceived sociosexuality scores were predicted by self-reported sociosexuality scores for men, but not women. Multiple mediation analysis revealed that this relationship was mediated through facial shape Factor 1.

Participants were able to correctly identify the high sociosexuality composite better than chance for men's but not women's faces.

Study Two also aimed to test whether facial morphology predicted perceived sociosexuality. This hypothesis was supported in men and in women, and non-overlapping bootstrapped confidence intervals of R^2_m suggest that facial morphology was a significantly better predictor of perceived sociosexuality in male than in female faces.

General Discussion

The results of the two studies demonstrated that (for men more than women), facial shape predicts both self-reported sociosexuality and perceived sociosexuality (made by opposite sex raters). The perceived sociosexuality ratings are statistically significantly associated with self-reported sociosexuality, and this relationship is mediated by facial shape in men but not women's faces. For men but not women, composite faces made from high sociosexuality individuals were correctly identified.

Relationship between sociosexuality and facial morphology.

Both perceived and self-reported sociosexuality are associated with longer faces, higher foreheads, longer noses, and larger eyes in men's faces. Self-reported sociosexuality is associated with perceived sociosexuality in men, and this relationship is mediated via facial shape (Factor 1), suggesting that facial shape acts as a valid cue to male sociosexuality. Further, observers correctly identified the composite face composed of more unrestricted sociosexuality individual faces at a rate significantly above chance. This suggests that some common mechanism may affect the development of unrestricted sociosexuality and of facial morphology in men. Whether this mechanism is increased levels of testosterone during development driving masculinization of facial morphology and sociosexuality is, however, unclear.

Several of the facial shape Factors are sexually dimorphic, with more masculine values associated with more unrestricted self-reported (Factors 1, 7, 8, 10) and perceived sociosexuality (Factors 1 and 7, but not 5 and 10) in men, suggesting that these aspects of facial masculinity are associated with more unrestricted sociosexuality. However, morphological masculinity was not found to be a statistically significant predictor of either self-reported or perceived sociosexuality in men's faces. Whether or not the influence of testosterone upon the development of both masculine facial morphology (Penton-Voak & Chen, 2004; Weinberg et al., 2015; Whitehouse et al., 2015), and more unrestricted sexual strategies is therefore unclear. Future studies should directly examine the role of current and developmental testosterone levels (which were not measured in the current study) in the relationship between self-reported sociosexuality, perceived sociosexuality and facial morphology.

This ability to accurately perceive men's sociosexuality from facial shape may have been selected due to the advantage it provides in mate selection. By identifying men who are more or less unrestricted in their reproductive strategy, women may be able to make strategic mate choice decisions, such as choosing men who may be more willing to invest in offspring for long-term relationships (there is a positive relationship between sociosexuality and propensity for infidelity; Rodrigues et al., 2016), and identifying men who may be willing to engage in short term relationships when that is what she seeks.

In female faces, no statistically significant model was found predicting self-reported sociosexuality from facial morphology, and non-overlapping confidence intervals suggested that facial morphology was significantly more predictive of self-reported sociosexuality in men's than in women's faces. While testosterone is associated with increased sociosexuality in men, some evidence suggests that this relationship does not exist in women (Boothroyd et al., 2008; Puts et al., 2015), meaning that there may be no physiological mechanism by which sociosexuality is reflected in the morphology of women's faces. This conclusion was further supported by the fact that perceived sociosexuality was not significantly associated with self-reported sociosexuality in women.

The morphology of women's faces was, however, found to be predictive of men's perceptions of sociosexuality. In particular, more feminine scores on the sexually dimorphic

Factors 2, 5, 7, and 11 (but not 6 and 10) were predictive of more unrestricted perceived sociosexuality. This was further confirmed by the fact that more feminine morphological masculinity scores were associated with more unrestricted women's perceived sociosexuality. This is in line with previous findings showing that composites of more unrestricted women's faces are perceived as more feminine than composites of more restricted women's faces (Boothroyd et al, 2008, but see Boothroyd et al, 2011 for a conflicting result). However, the data do not seem to support a hormonal explanation for this connection. First, morphological facial femininity (the inverse of morphological masculinity) does not predict self-reported sociosexuality in our sample, and second, previous studies have found relationships between more unrestricted sociosexuality and increased masculine personality traits (Bártová et al., 2020; Waldis et al., 2020) and between more unrestricted sociosexuality and more masculine 2D:4D ratio (Clark, 2004).

One potential explanation for the relationship between perceived sociosexuality and morphological femininity lies in the fact that facial femininity is strongly associated with women's facial attractiveness (Foo et al., 2017; Law Smith et al., 2006; Moore et al., 2011; Rhodes, 2006). More attractive and thus more feminine women may have more mating opportunities than less attractive and thus less feminine women. Previous studies have found that unrestricted composite faces were perceived as more attractive than restricted composites (Boothroyd et al., 2008, 2011), while unrestricted sociosexuality was weakly positively correlated with attractiveness in a student sample (Fisher et al., 2016). However, in the current study, women's rated facial attractiveness was not found to be predictive of either their self-reported or their perceived sociosexuality.

We failed to find evidence supporting the hypothesis that women's facial morphology acts as a valid cue to sociosexuality. Observers were also unable to identify the female facial composite composed of unrestricted sociosexuality individuals' faces at a level above chance.

Perceived sociosexuality was not found to be predictive of women's self-reported sociosexuality, and no mediating role was found for any of the facial morphology Factors.

While there may be considerable selective advantage for men who are able to identify women's sociosexuality from facial appearance, our data suggests that this does not occur, likely because women's facial morphology does not reliably cue sociosexuality.

Human beings make both personality and behavioral assumptions of strangers based on their appearance and research has demonstrated that sometimes these perceptions reflect reality. Here we demonstrate, in men but not in women, that facial morphology acts as a valid cue to sociosexuality.

Competing Interests

All authors declare that they have no competing interests.

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