Men's facial masculinity: when (body) size matters

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Abstract

Recent studies suggest that judgments of facial masculinity reflect more than sexually dimorphic shape. Here, we investigated whether the perception of masculinity is influenced by facial cues to body height and weight. We used the average differences in 3D face shape of 40 men and 40 women to compute a morphological masculinity score, and derived analogous measures for facial correlates of height and weight based on the average face shape of short and tall, and light and heavy men. We found that facial cues to body height and weight had substantial and independent effects on the perception of masculinity. Our findings suggest that men are perceived as more masculine if they appear taller and heavier, independent of how much their face shape differs from women's. We describe a simple method to quantify how body traits are reflected in the face and to define the physical basis of psychological attributions.

Keywords: 3D face shape, morphological masculinity, perceived masculinity, height, weight

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1 Introduction

A plethora of published studies has examined the role of men’s facial masculinity on mate choice and interpersonal judgments such as leadership or dominance (e.g., Little, Burriss, Jones, & Roberts, 2007; Perrett et al., 1998). Despite this, studies to date have failed to provide a clear and comprehensive account of what constitutes a “masculine” face when non-shape cues such as skin texture and facial hair are controlled for. Measures of sexual dimorphism in face shape have been found to account for as little as 6–11% of variance in ratings of masculinity (Koehler, Simmons, Rhodes, & Peters, 2004; Komori, Kawamura, & Ishihara, 2011; Pound, Penton-Voak, & Surridge, 2009). Moreover, although ratings of masculinity have been linked to judgments of attractiveness (Koehler et al., 2004; Rhodes, Simmons, & Peters, 2005; Rhodes et al., 2007; Scott, Pound, Stephen, Clark, & Penton-Voak, 2010), several studies have failed to find a relationship between morphological masculinity and attractiveness (Koehler et al., 2004; Penton-Voak et al., 2001; Scott et al., 2010; Stephen et al., 2012; Thornhill & Gangestad, 2006; Waynforth, Delwadia, & Camm, 2005). This has led some researchers to conclude that morphological measures of masculinity are not overly useful, as they fail to capture masculinity as perceived by raters. Others have reasoned that perceptual ratings of masculinity are problematic, as they appear to be confounded by unknown parameters. Komori et al. (2011) termed these parameters "sex-irrelevant characteristics" and suggested they reflect sexual stereotypes of personality.

Here, we tested a different hypothesis. Given the sexual dimorphism in body height and weight of men and women (e.g., Gaulin & Boster, 1985), we investigated whether facial correlates of these variables affect the perception of men’s masculinity. Height and weight affect face structure (e.g., Coetzee, Chen, Perrett, & Stephen, 2010; Mitteroecker, Gunz, Windhager, & Schaefer, 2013), and the resultant facial cues may affect not only the perception of body size but also masculinity.

Some researchers have challenged the validity of using 2D photographs in studies assessing the perception of gender, since 2D images do not fully depict the prominence of features that differ between men and women (e.g., eyebrow ridge or jaw protuberance; Bruce et al., 1993; Burton, Bruce, & Dench, 1993; see also Swaddle & Reierson, 2002). Valenzano, Mennucci, Tartarelli, and Cellerino (2006) and Komori et al. (2011) described an objective score of sexual dimorphism based on the average difference between men and women's 2D face shape. We extrapolated these previous methods to calculate the morphological masculinity of 3D faces. In addition, we calculated the average shape difference between short and tall men, as well as the average difference between men with a low and high body mass index (BMI), to test whether facial correlates of body height and weight predict perceptions of height and weight. Furthermore, we examined whether facial cues to height and weight may account for previously unexplained variance in ratings of masculinity. We hypothesized that within a healthy weight range both morphological cues to weight and height would be positively associated with the perception of facial masculinity.

2 Methods

2.1 Computing Morphological Scores Based on Group Differences

Data Set. Facial images of 40 Caucasian women (age: mean=20.3±1.6 years) and 40 Caucasian men (age: mean=20.3±1.8 years) were taken with a 3D camera (www.3dMD.com). Images were captured of participants with a neutral facial expression and their hair pulled back, at a set distance from the camera. Faces were delineated in *Morphanalyser 2.4.0* (Tiddeman, Duffy, & Rabey, 2000) with 51 landmarks (see Figure 1; Appendix A provides definitions of the landmarks used). The landmark templates of all digitized head models were aligned in orientation, rotation and scale using Procrustes superimposition. In addition, *Morphanalyser* re-samples the surface map of each face in accordance to a standard head delineated with the same set of landmarks. Thus, after the alignment process the surface maps of each head model have the same number of tessellations between corresponding landmarks on individual heads. This establishes homology for the entire facial surface of each head in the set, and allows using whole surfaces rather than landmark templates for further analyses and visualisations.

Figure 1. 3D head model delineated with 51 landmarks.

Height and weight were measured after removing footwear and excess clothing to calculate body mass index (BMI, [kg/m^2]). Participants' BMI ranged between 18.3 and 24.4, which is within a healthy weight range (World Health Organization, www.who.int). Men were on average 13.5 cm taller ($t(78)=-9.72$, $p<.001$) and had a 0.7kg/m^2 higher BMI ($t(78)=-1.85$, $p=.069$) than women.

Morphological Masculinity. Head models were subjected to a principal component analysis (PCA) (e.g., O'Toole, Abdi, Deffenbacher, & Valentin, 1993; Oosterhof & Todorov, 2008). The resulting 80 principal component (PC) scores served as the computational basis for morphological masculinity (Komori et al., 2011; Valenzano et al., 2006). Average male scores and the (androgynous) sample average of each component were computed. We defined the morphological masculinity axis as the direction from the androgynous sample average $(\vec{a})$ to the male average $(\vec{m})$ (arrows are denoting vectors). We calculated individual masculinity scores (MS) as the distance along the morphological masculinity axis from the component scores for a subject's face $(\vec{i})$ to the point on the morphological masculinity axis closest to the male average component scores $(\vec{a})$. This distance was then normalized by dividing by the magnitude of the masculinity axis (i.e. the distance between male and sample average) to ensure that androgynous faces receive a score of 0, and faces with average masculinity receive a score of 1. That is, each individual face $\vec{i}$ was projected onto the morphological masculinity axis $(\vec{m}-\vec{a})$ using:

$$MS(\vec{i}) = \frac{(\vec{i}-\vec{a}).(\vec{m}-\vec{a})}{\|\vec{m}-\vec{a}\|^2}$$

where $\|.\|$ gives the magnitude (length) of the vector. Figure 2 visualizes facial correlates of this shape vector.

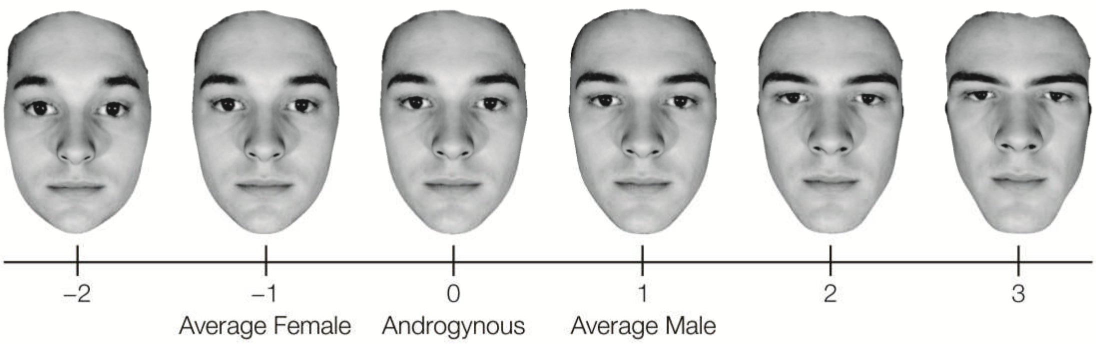

Figure 2. Masculinity scores were based on the shape difference between the (androgynous) sample average (0) and the average male face (1). The hypermasculine faces 2 and 3 illustrate changes in facial shape along this vector towards higher masculinity and were generated by

applying 200%, respectively 300% of the difference between androgynous and male average face to the androgynous face; similarly, the hyperfeminine face −2 visualizes changes towards higher femininity (all face were rendered with the same skin texture for illustration purposes). Individual masculinity scores in our sample of 40 men ranged from −0.4 to 2.1.

To test whether the calculated scores were indeed detecting morphological differences related to sex, we also calculated the morphological masculinity of female faces, and both female and male scores were employed in a discriminant analysis. The resulting discriminant function yielded correct sex classifications for 92.5% of the faces (Wilks' λ=.264; df=1; $\chi 2$=103.3, p<.001).

Facial Correlates of Height and BMI. In addition to morphological masculinity, analogous morphological scores were calculated separately for height and BMI. Average PC scores were calculated for short and tall men, as well as men with high and low BMI (see Appendix B), and the resulting shape vectors were used to assign each face a score on facial correlates of height and BMI, respectively (see Figure 3 for visual representations of the two vectors). Men in the low and high BMI groups were matched so they did not differ in height (mean difference=1.8 cm, $t(17)=-0.67$, p=.520); likewise men in the low and high height groups were matched so they did not differ in BMI (mean difference=0.04 kg/m^2, $t(15)=0.05$, p=.959). Resulting morphological scores of height and BMI were not correlated (Pearson's $r(40)=-.16$, p=.316).

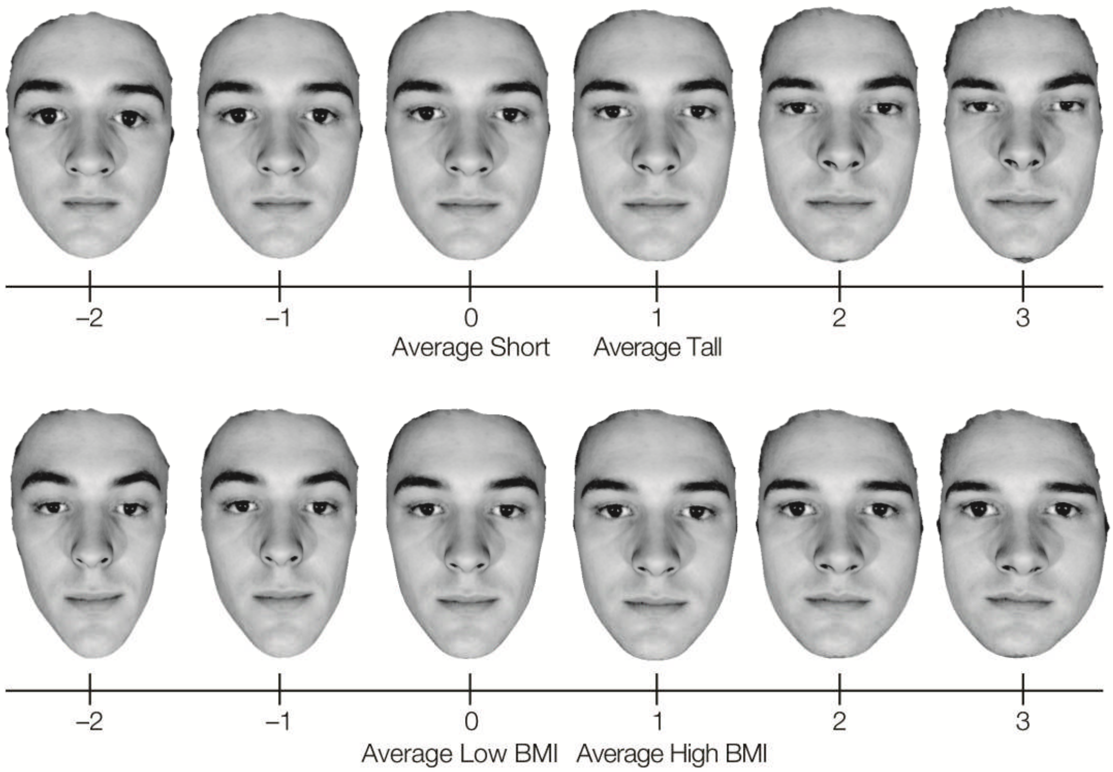

Figure 3. Morphological height and BMI scores were based on the shape difference associated with short (0) and tall (1) height (top row), and low (0) and high (1) BMI (bottom row). The synthetic faces −2 and −1 illustrate shape changes towards lower height/BMI, while the synthetic faces 2 and 3 illustrate changes towards higher height/BMI. Individual height scores in the sample ranged from −1.3 to 2.1, while BMI scores ranged from −0.9 to 3.1.

2.2 Experimental Validation

Stimuli. Stimuli were the 40 male 3D face models. To eliminate the influence of hairstyle and clothing on perceptual ratings, all 3D heads were masked to show faces only. To disentangle colour/textural and shape cues (e.g., Jones, Little, Burt, & Perrett, 2004; Said & Todorov, 2011; Scott et al., 2010), an average male face texture image was created using *Psychomorph 4* (Tiddeman, Burt, & Perrett, 2001). All faces were rendered with this standardized texture, so that only face shape differed between each of the 3D face models.

Procedure: Perceived Masculinity. Twenty Caucasian female students (age 21.4±2.5 years) from the University of St Andrews rated the masculinity of the faces on a 7-point Likert-type scale (1="not masculine at all", 7="very masculine"). Prior to the rating, participants were presented with frontal 2D images of all face models to provide an overview of stimulus variability. The 3D face stimuli were presented on a computer screen in randomized order. They were rotated from −50º to +50º from left to right at a speed of $10^{o}s^{-1}$ while simultaneously being rotated from −15º to +15º up and down at a speed of $25^{o}s^{-1}$, resulting in the stimuli "bobbing" in a sinusoidal manner. Images were presented individually against a black background and remained visible until a rating was made.

Procedure: Perceived Weight. Seventeen students (2 male, age 21.6±3.6 years) from the University of St Andrews rated the body weight of persons depicted in the face stimuli on a 7-point Likert-type scale from 1="very underweight" to 7="very overweight". The experimental set-up was the same as described above.

Procedure: Perceived Height. Thirty-nine participants (12 male, age 26.8±10.1 years) rated body height of depicted persons on a 7-point Likert-type scale from 1 "very short", to 7 "very tall" in an online study.

For all studies, informed consent of participants was obtained either in written form or electronically. All procedures were approved by the University of St Andrews Teaching and Research Ethics Committee. Inter-rater reliability was high for all ratings (Cronbach's α masculinity=.82, perceived weight=.92, perceived height=.93).

3 Results

Ratings of masculinity, height and weight were averaged separately for each of the 40 faces. Regression analyses were used to test the predictive value of morphological scores for perceptual judgments.

Morphological masculinity significantly predicted perceived masculinity (β=.33, R^2=.11, F(1,38)=4.57, p=.039, see Fig. 4). The morphological BMI score was a strong predictor of perceived weight (β=.65, R^2=.43, F(1,38)=28.13, p<.001). Actual BMI was not a significant predictor of perceived weight, although it showed a moderate relationship in the expected direction (β=.26, R^2=.07, F(1,38)=2.67, p=.110; Fig. 5, bottom row). The morphological height score was a strong predictor of perceived height (β=.42, R^2=.18, F(1,38)=8.04, p=.007), whereas actual height was not related to perceived height (R^2=.01, F(1,38)=0.52, p=.475; Fig. 5, top row).

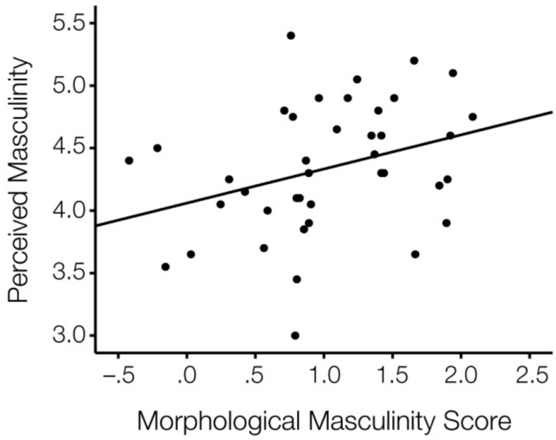

Figure 4. Morphological masculinity was calculated based on shape differences between the (androgynous) sample average and the average male face (denoted by 0 and 1 on x-axis), and was a moderate predictor of perceived masculinity (R^2=.11, n=40).

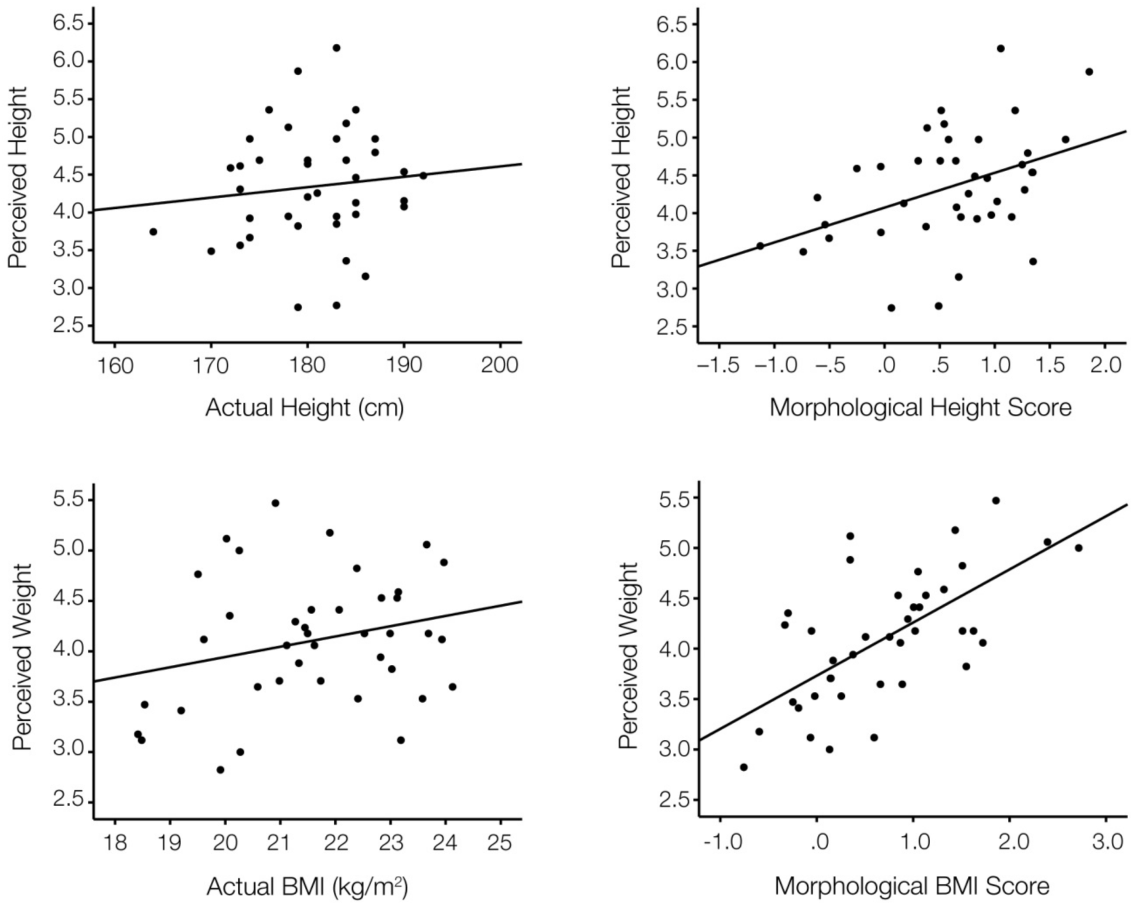

Figure 5. Correlations of actual height/BMI and ratings of height/weight, as well as respective morphological scores and ratings (n=40). Morphological scores were better predictors of perceived height and weight than actual height and BMI (height: actual R^2=.01 vs. morphological R^2=.18; BMI: actual R^2=.07 vs. morphological R^2=.43).

Adding the morphological height and BMI scores to the regression model increased the variance explained from 11% for masculinity scores as sole predictor (AIC=−54.9) to 34% (R^2=.34, F(3,36)=6.18, p=.002; AIC=−61.5). All three morphological scores were found to be significant predictors of perceived masculinity, with morphological masculinity scores being the strongest predictor (β=.46, p=.006), followed by morphological scores of height (β=.42, p=.011) and BMI (β=.35, p=.016; tolerance for all variables>.75; variance inflation factor<1.3). These statistical relationships were essentially the same when an estimate of original head size was added as a factor in regression (see Appendix C). While morphological masculinity was not significantly related to facial cues to BMI (Pearson's $r(40)=.20$, $p=.210$), it was significantly negatively correlated with facial cues to height (Pearson's $r(40)= -.49$, $p=.001$).

Brand and Bradley (2012) have argued that the use of average-based rating scores inflates effect sizes (but see McCormick, 2013). We also examined the association of morphological variables and masculinity ratings of *individual* raters. We compared the average fit of models using only morphological masculinity as a predictor of individually perceived masculinity (simple models) with those using all three morphological scores (masculinity, height and BMI) as predictors (full models). Full models (mean $R^2=0.14$, mean adjusted $R^2=0.07$, mean AIC=126.4) were not found to explain substantially more variance than simple models (mean $R^2=.04$, mean adjusted $R^2=0.01$, mean AIC=127.4) as indicated by the minor change in the mean AIC. Thus, observed effect sizes in the group-based analysis were indeed bigger than in the individual-based analysis, but pointed in the same direction (McCormick, 2013).

4 Discussion

Our results show that it is possible to derive meaningful morphological scores of body height and BMI from 3D face shape. Morphological scores of height and BMI strongly predicted perceived height and weight. Though morphological masculinity alone moderately predicted perceived masculinity of men's colour- and texture-standardized faces, morphological correlates of height and BMI made additional and independent contributions to the perception of men's masculinity.

The physical characteristics that influence the perception of masculinity have proven remarkably elusive. Like others, we find that sex differences in face structure explain only 11% of perceived masculinity (6–11% in Koehler et al., 2004; Komori et al., 2011; Pound et al., 2009). Since morphological masculinity predicted gender in our sample correctly for 92.5% of faces, we suggest that the weak relationship between morphological and perceived masculinity cannot be explained by an inadequate structural estimation of sexual dimorphism. In line with others, we propose it is the perception of masculinity that is poorly understood. Whereas Komori et al. (2011) explain some of the discrepancy of morphological and perceptual masculinity with social stereotypes of personality, the aim of the current study was to investigate *why* specific social perceptions may be driven by certain face shape features. In particular, we tested whether face shape correlates of body dimensions impact on the perception of masculinity. We used a simple computational method to show that face structure associated with quantitative anthropometric variables such as body height and BMI affects the perception of facial masculinity. Men are perceived as masculine not only based on how much their face shape differs from the average woman's, but also based on morphological cues to height and weight. Given that height and weight are sexually dimorphic, it seems plausible that facial cues to these traits are used in forming perceptions of masculinity.

As the men in our sample were taller and had higher BMIs than women, this difference would have been reflected in the average male and female faces on which our masculinity scores were based. That individual variation in facial cues to height and BMI contributed to the perception of masculinity beyond the average shape dimorphism suggests an over-generalization of facial trait correlates (e.g., Macrae, Milne, & Bodenhausen, 1994; Montepare & Dobish, 2003; cf. Oosterhof & Todorov, 2008). Such over-generalization is also revealed in the finding that both morphological scores of height and BMI were better predictors of perceived height and weight than were actual body height and BMI. Previous studies have shown that tall people have a more elongated face shape than short people (Mitteroecker et al., 2013; Windhager, Schaefer, & Fink, 2011), and observers may overestimate differences in height based on this cue. Thus, the association between actual height and its facial correlates, such as elongation, may be over-generalized to produce a perceptual relationship that is stronger than the correlation between facial correlates of height and actual physical height. Interestingly, we found that facial cues to height were negatively correlated with morphological masculinity, while both variables were positively linked to perceived masculinity. This may seem counterintuitive but it may be explained by focusing on two simplified characteristics associated with masculinity and height: width and elongation of faces. With increasing morphological masculinity, faces get wider; with increasing height, faces get longer. Both morphological masculinity and height are perceived as masculine (from a variety of surface traits, e.g., increased brow prominence), but the more elongated a face, the less wide it will be. This may partly account for the weak relationship between morphological and perceptual masculinity found in previous studies.

In order to interpret observed effects of masculinity on other interpersonal judgments, it is useful to understand the facial traits that influence perception of masculinity. The finding that the perception of facial masculinity is affected by not only sex-specific morphological features that are dependent on sex hormone levels, but also by traits that are linked to body size (independent of gender) aligns with studies on craniofacial allometry in humans and non-human primates (Mitteroecker et al., 2013; Schaefer, Mitteroecker, Gunz, Bernhard, & Bookstein, 2004). Schaefer et al. (2004) suggested that the two dimensions of sexually dimorphic shape—sex-specific and size-dependent—may have been subject to different selection pressures; thus, they may have differential effects on social perceptions and preferences. That is, the effect that masculinity has on judgments such as attractiveness or leadership ability may depend not only on the extent to which a face is perceived to look masculine, but also on whether this perception of masculinity was formed based on cues to size or cues to sex hormone levels. Methods such as the one presented here provide the means to uncover distinct physical origins of social and stereotypic judgments that have to date been rolled into a singular concept of masculinity.

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Appendix A

List of definitions and operationalization of used landmarks (following Farkas, 1994)

1	*Nasion*; on midsagittal plane, in lateral view on lowest point above the nose
2	Centre of right pupil
3	Centre of left pupil
4	*Exocanthion* right; outer corner of the right eye fissure where eyelids meet
5	*Endocanthion* right; inner corner of the eye fissure where eyelids meet
6	Highest point of right iris
7	Lowest point of right iris
8	*Endocanthion* left
9	*Exocanthion* left
10	Highest point of left iris
11	Lowest point of left iris
12	*Alare* right; most lateral point on the right ala
13	*Alare* left
14	*Cheilion* right; right corner of the mouth where the outer edges of upper and lower vermillion meet
15	*Cheilion* left
16	*Labrale superius*; midpoint of the upper vermillion line
17	*Labrale inferius;* midpoint of the lower vermillion line
18	Mid-cleft of upper vermillion
19	Mid-cleft of lower vermillion
20	*Trichion*, midpoint of the hairline
21	*Gnathion*; midpoint of chin
22	Frontal view: right outermost feature of face along the horizontal axis of the

	mouth Lateral view: turning point of Ramus mandibulae and Corpus mandibulae
23	Frontal view: left outermost feature of face along the horizontal axis of the mouth Lateral view: turning point of Ramus mandibulae and Corpus mandibulae
24	*Glabella*; on midsagittal plane, joins the superciliary ridges; lateral view: most protuberant point
25	Tip of the nose; lateral view: most protuberant point on nose
26	*Subnasale*; on the local midline of the junction formed by lower border of nasal septum and cutaneous portion of upper lip
27	Lateral view: deepest point between lip red and chin
28	Lateral view: most protuberant point of chin
29	Lowest point of attachment of right external ear to the face
30	Lowest point of attachment of left external ear to the face
31	*Superciliare mediale* right; most medial point of eyebrow
32	Midpoint of right eyebrow (horizontally and vertically)
33	*Supercilare laterale* right; most lateral point of right eyebrow
34	*Superciliare mediale* left
35	Midpoint of left eyebrow
36	*Superciliare laterale* left
37	*Crista philtrum* right; right crest of the philtrum, i.e. the vertical groove in the median portion of upper lip, located on the vermillion border
38	*Crista philtrum* left
39 40	Evenly spaced between 21 and 22 along jaw line
41 42	Evenly spaced between 21 and 23 along jaw line

43	On midsaggital plane beneath chin
44	Lateral view: right intersection of sternocleidomastoid muscle and jaw
45	Lateral view: left intersection of sternocleidomastoid muscle and jaw
46	Right intersection of pupil line and hairline
47	Left intersection of pupil line and hairline
48	Evenly spaced along hairline between 20 and 46
49	
50	Evenly spaced along hairline between 20 and 47
51	

Note. Italics indicate names of traditional anthropometric landmarks.

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Appendix B

Male height and weight in the sample used. Face-morphological scores of height were based on the differences in face shape between short and tall men; morphological scores of weight were based on differences in face shape between men with low and high BMI. Note: due to constraints in sample size in constructing BMI-controlled height scores and height-controlled BMI scores, the numbers of faces that defined the height and weight vectors differ.

		Height (in cm)	**BMI**
All Men	M	180.8	21.6
	SD	6.4	1.6
	N	40	40
Low	M	171.9	19.3
	SD	3.2	0.7
	N	9	9
High	M	189.0	23.5
	SD	2.1	0.4
	N	8	10

Appendix C

Head Size

C.1 Details of methods

In geometric morphometric studies, it is common to use the natural logarithm (ln) of centroid size (CS) to augment shape coordinates before PCA (Mitteroecker et al, 2004). In our manuscript we removed size from the principal component analysis (PCA) and face morphology vector calculations, but we capture shape associated with size (e.g., facial elongation for height, roundness for BMI, and protruding brows for masculinity). We have tested the addition of ln CS to our statistical models in which facial morphology is used to predict perception. Thus, rather than maintaining size throughout PCA, we first removed it but then reinstate the centroid size in analysis. Such analysis has the advantage of allowing us to quantify the perceptual influences of original head size (and associated shape cues) independent of other factors influencing face shape (i.e. weight and height and sex).

C.2 Statistical results

Ln CS is sexually dimorphic ($t(78)=-10.56$, $p<.001$) and correlates with men's height (Pearson's $r(40)=.48$, $p=.002$) as well as men's BMI (Pearson's $r(40)=.38$, $p=.017$). Ln CS, however, does not correlate with morphological masculinity (Pearson's $r(40)=.03$, $p=.867$), perceived facial masculinity (Pearson's $r(40)=.12$, $p=.481$), height perceived from faces (Pearson's $r(40)=-.083$, $p=.611$) or weight perceived from faces (Pearson's $r(40)=-.016$, $p=.923$). Furthermore, entering ln CS into models of face perception does not alter any of the main findings or qualify any of the conclusions we reached before.

C.2.1 Masculinity

Morphological masculinity as sole predictor of perceived masculinity explained 11% of the variance in perceived masculinity ratings. Adding ln CS to the regression model did not improve the model (morphological masculinity: β=.33, p=.039; ln CS: β=.11, p=.497; R^2 change=.01, F change=.47, p=.497). Using all three morphological scores as predictors of perceived masculinity had explained 34% of the variance in perceived masculinity ratings. Adding ln CS to the regression model did not improve the model (morphological masculinity: β=.45, p=.008; morphological height: β=.41, p=.014; morphological BMI: β=.37, p=.012; ln CS: β=.13, p=.340; R^2 change=.02, F change=.94, p=.340). Hence masculinity was related to morphological manifestations of sex, height, and weight in the face but was unrelated to an index of head size.

C.2.2 Height

Perceived height was predicted by face morphological height (β=.42, R^2=.18, F(1,38)=8.04, p=.007), and entering ln CS did not improve the model (p=.448; morphological height: β=.43, p=.007; ln CS: β=−.14, p=.448; R^2 change=.01, F change=.59). Hence, height perceived from male faces was related to morphological manifestation of height, but again was unrelated to an index of head size.

C.2.3 Weight/BMI

Perceived weight was predicted by face morphological weight (β=.65, R^2=.43, F(1,38)=28.13, p=.007), and entering ln CS did not improve the model (morphological weight: β=.67, p<.001; ln CS: β=.09, p=.463; R^2 change=.01, F change=.55, p=.463). Hence, in our experiment the perception of weight was influenced by the morphological correlates of BMI within the face; importantly weight perception of male faces was not related to an index of head size.

C.3 Explanation

One note of potential explanation for the lack of influence of centroid size is that we presented size-normalised stimuli in our perceptual experiments. This is a common procedure in face perception studies, most of which work with faces that have been aligned in size by standardizing inter-pupillary distance, or more recently, by using Procrustes superimposition. Head size could influence perception of masculinity, height and weight when faces are presented in their original varying size.

Moreover, we note that when working with facial images (as opposed to skeletal craniofacial morphology, i.e. skulls), centroid size likely reflects both skeletal frame size as well as body weight/facial adiposity. As our new analyses show, facial correlates of skeletal frame size (height) as well as weight (BMI) explain the perception of masculinity, height and weight better than overall head size as measured by centroid size.

References

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