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Multivariate intra-sexual selection on men's perceptions of male facial morphology.

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Abstract

Objectives: Intra-sexual selection has shaped the evolution of sexually dimorphic traits in males of many nonhuman primates, including humans. In men, sexual dimorphism in craniofacial shape (i.e. facial masculinity) and facial hair have both been shown to communicate aspects of social and physical dominance intra-sexually. However, less attention has been given to how variation in physical and social dominance among receivers impacts on perceptions of facial masculinity and beards as intra-sexual signals of formidability.

Methods: In the current study, male participants (N = 951) rated male faces varying in masculinity and beardedness when judging masculinity, dominance and aggressiveness. These participants also responded to scales measuring their psychological dominance, sexual jealousy, status seeking and masculine morphology (facial masculinity, facial hair, and height).

Results: Beardedness exerted strong effects over clean-shaven faces on ratings of masculinity, dominance and aggressiveness. Trait ratings of masculinity, dominance, and aggressiveness rose linearly with increasing craniofacial masculinity. The significant facial masculinity × facial hair interaction suggests that beardedness caused strong effects on all trait ratings over clean-shaven faces at every level of facial masculinity. Participants with full beards also reported higher scores on dominance and assertiveness scales. Participants high in dominance and assertiveness also gave higher ratings for dominance, but not masculinity or aggressiveness, to bearded over clean-shaven faces. Participants low in intra-sexual jealousy rated clean-shaven and/or feminised faces as less dominant, less masculine, and less aggressive.

Conclusions: These findings demonstrate that facial hair enhances perceptions of masculinity, dominance and aggressiveness above ratings of facial masculinity, potentially by augmenting masculine craniofacial features. Individual differences in intra-sexual dominance showed associations with judgments of facial hair but not facial masculinity. Our study demonstrates that when two sexually dimorphic androgen dependent facial traits are judged in concert, ornamental rather than structural masculine facial features underpin men's intra-sexual judgments of formidability.

Key words: Sexual selection; intra-sexual competition; facial hair; facial masculinity.

1. Introduction

Intra-sexual selection has shaped the evolution of weapons, dominance displays, and signals of social status employed in male-male competition in many species (Emlen, 2008; Rico-Guevara et al., 2019), including humans (Archer, 2009; Puts, 2010; Puts et al., 2015). Androgens shape sex differences in bodily, facial, and vocal secondary sexual characters (Randall, 2008). Compared to women, men have a more v-shaped physique (Dixson et al., 2014), are taller (Stulp & Barrett, 2016), have greater upper body musculature (Lassek & Gaulin, 2009) and deeper voices (Puts, 2010). One of the most researched sexually dimorphic androgen dependent characters is facial masculinity, which refers to a suite of features including jaw size, the midface, and brow ridge that are more pronounced in men compared to women (Whitehouse et al., 2015). Androgens exert organizational effects on facial masculinity *in utero* (Whitehouse et al., 2015), during pubertal surges of androgens (Marečková et al., 2011), and early adulthood (Roosenboom et al., 2018). Although facial masculinity was suggested to be associated with men's circulating androgens (Penton-Voak & Chen, 2004), recent studies have not reproduced this association (Kordsmeyer et al., 2019). Similarly, some studies reported men's facial masculinity was associated with greater long-term health (Rhodes et al., 2003; Thornhill & Gangestad, 2006) and more rapid immune response (Rantala et al., 2012), while others have not (Boothroyd et al., 2013; Zaidi et al., 2019). Associations between facial masculinity and immune response may be mediated by adiposity (Rantala et al., 2013), whereby a combination of facial masculinity and facial muscularity better reflect male immune response than facial masculinity alone (Phalane et al., 2017). Thus, facial masculinity may provide some information regarding health that influences mate choices among women, while associations between facial sexual dimorphisms and genetic immunity require further exploration.

Although debate surrounds whether men's facial masculinity communicates genetic quality indirectly, evidence that it provides an index of male social dominance and formidability is more consistent (Scott et al., 2013; Puts, 2010). Androgens influence suites of coordinated characters, and male facial masculinity is positively associated with body size, height, and physical strength (Butovskaya et al., 2018; Fink et al., 2007; Holzleitner & Perrett, 2016; Windhager et al., 2011). Facial masculinity is also positively associated with men's behavioural dominance, assertiveness, and aggressiveness (Puts, 2010; Scott et al., 2013; Geniole et al., 2015; Sell et al., 2012). While mothers and their offspring may benefit directly via resources and protection from partners displaying well-developed masculine morphology (Scott et al., 2013; Puts, 2010), women's preferences for male facial masculinity varies across cultures (Borras-Guevara et al., 2017; Dixson et al., 2017b; Scott et al., 2014; Marcinkowska et al., 2019). Yet men with more masculine faces, bodies, and voices have higher mating success than their less masculine peers (Hill et al., 2013; Kordsmeyer et al., 2018). Some evidence supports women's preferences for facial masculinity are stronger under social and economic conditions characterised by high male-male competition (Brooks et al., 2011), when an intra-sexually competitive partner may directly benefit mothers and their offspring.

Like facial masculinity, sex differences in facial hair develop due to androgens during early adolescence and are fully developed by young adulthood (Randall, 2008). Compared to clean-shaven male faces, bearded faces are judged as being older, more masculine, socially dominant (Addison, 1989; Muscarella & Cunningham, 1996; Neave & Shields, 2008; Saxton et al., 2016; Sherlock et al., 2017), and aggressive (Geniole & McCormick, 2015; Muscarella

& Cunningham, 1996; Neave & Shields, 2008). Facial hair may augment judgments of masculinity, dominance, and threat by exaggerating masculine craniofacial traits, including facial length and jaw prominence (Dixson et al., 2017a; Sherlock et al., 2017). Beards enhance explicit aggressiveness ratings, as well as speed and accuracy in recognition of angry facial expressions over clean-shaven faces (Craig et al., 2019; Dixson & Vasey, 2012). Facial hair unambiguously communicates age, sexual maturity, and masculinity (Dixson et al., 2017a; Neave & Shields, 2008), which may explain why women rate men with beards as most attractive when judging long-term relationships (Neave & Shields, 2008; Dixson et al., 2016) and fathering abilities (Clarkson et al., 2019; Dixson & Brooks, 2013; Dixson et al., 2019; Stower et al., 2019). Women's stated preferences for men's facial hair are reflected in mate choices (Dixson et al., 2013; Štěrbová et al., 2019; Valentova et al., 2017) and are strongest under socio-economic conditions of high male intra-sexual competition (Barber, 2001; Dixson et al., 2017c; 2019).

If intra-sexual selection has shaped male cognition to assess physical formidability and social dominance among their contemporaries, men should accurately assess physical strength and social status from facial, bodily, and vocal characteristics (Puts, 2010; Sell et al., 2012). Assessing physical strength from masculine facial structures and expansive body postures occur as early as age 3 (Terrizzi et al., 2019). During adolescence, positive associations between male physical strength, physical aggression, and nonphysical aggression are strongest in early and mid-adolescence, with aggressiveness becoming less physically and more socially orientated among older adolescents of 17-18 years (Isen et al., 2015; Muñoz-Reyes et al., 2012). By late adolescence, males accurately assess physical strength in faces and bodies (Gallup et al., 2010). In adulthood, physical strength is accurately judged from gait among men from Chile, Germany, and Russia (Fink et al., 2017), but possibly not among the Maasai of Tanzania (Fink et al., 2019; Durkee, 2019). People also accurately assess physical strength from facial shape, bodily morphology (Fink et al., 2007; Sell et al., 2009; Windhager et al., 2011), and voices (Raine et al., 2018; Sell et al., 2010). Men from the USA accurately assess fighting ability from male faces and bodies of US college students, Andean pastoralists, and Bolivian horticulturalists (Sell et al., 2009). Among professional mixed martial fighters, facial masculinity is positively associated with victories in fights and ratings of aggressiveness (Třebický et al., 2013; 2014; Zilioli et al., 2015). In non-physical intra-sexual contexts, physical formidability may translate into greater bargaining power, higher social rank, and social status (Lukaszewski et al., 2016; von Rueden et al., 2016), which may maintain social group cohesion (Lukaszewski et al., 2016). Finally, men's mate value is positively associated with social status in industrialized (Hill et al., 2013; Kordsmeyer et al., 2018) and non-industrialized (von Rueden & Jaeggi, 2016) societies.

In a similar vein to judgments of facial masculinity, children of 2-5 years of age associated beardedness with judgments of men's age, masculinity, and dominance, but not attractiveness (Nelson et al., 2019). The onset of facial hair is an important milestone in pubertal development and adolescent boys with facial hair report feeling more physically attractive than boys without facial hair (Tobin-Richards, Boxer, & Petersen, 1983). Adolescent boys who participated in competitive sports developed thicker facial hair than age-matched boys who did not compete in sports (Singal et al., 2006). During puberty, judgments of masculinity, dominance, and attractiveness become more adult-like (Nelson et al., 2019) and adults consistently judge beards higher for age, masculinity, social status, dominance, and aggressiveness compared to clean-shaven faces (for review see Dixson et al., 2018c). However, unlike craniofacial masculinity there is no evidence that beards are associated with men's fighting performance (Dixson et al., 2018c). Individual differences in beardedness are primarily attributable to genetic factors (Adhikari et al., 2016) and facial

hairs are expressed via the conversion of testosterone to dihydrotestosterone within the dermal papillae of hair follicles rather than total testosterone that underpins other masculine secondary sexual traits (Randall, 2008). These differences have implications for how beards may function as a sociosexual signal (Dixson & Rantala, 2016; Dixson et al., 2016). Thus, facial hair enhances dominance and aggressiveness in men by exaggerating the size of masculine structural features, including the size of jaw and facial length (Dixson et al., 2017a; Sherlock et al., 2017). Less masculine male faces are judged as significantly more masculine and dominant when bearded than masculine clean-shaven faces (Dixson et al., 2017a; Sherlock et al., 2017). Beards enhance aggressiveness ratings as well as the speed and accuracy of recognition of angry facial expressions over clean-shaven faces (Dixson & Vasey, 2012; Craig et al., 2019). Rather than communicating physical formidability, beards may function as a badge of status advertising men's age, masculinity, and social aspects of dominance (Dixson et al., 2018c).

Agonistic displays that lead to fights provide an opportunity for individuals to assess the formidability and fighting ability of opponents relative to their own (Pinto et al., 2019). Among US and Fijian men, physical strength was negatively associated with judgments of height, body size, and muscularity in a hypothetical rival (Fessler et al., 2014). Taller men are less sensitive to facial masculinity and lower vocal pitch when assessing male dominance than shorter men (Watkins et al., 2010a). Men reporting higher social dominance were also less sensitive to facial masculinity when judging male dominance than less socially dominant men (Watkins et al., 2010b). Facially masculine men report higher mating success (Hill et al., 2013; Kordsmeyer et al., 2018; Peters et al., 2008; Rhodes et al., 2005), less restricted sociosexualities (Boothroyd et al., 2008, 2011), stronger preferences for short-term relationships (Rhodes et al., 2005), and more mate poaching (Arnocky et al., 2018; Polo et al., 2019) than less masculine men. As a result, men concerned with guarding their mates may be sensitive to physical cues of masculinity in potential rivals. Indeed, men's sexual jealousy when assessing socially dominant, physically attractive, and high status males is negatively associated with their height (Buunk et al., 2008) and masculine men are more jealous of facially and vocally masculine men than less masculine men (O'Connor & Feinberg, 2011). Thus, men's responses to intra-sexually selected traits in male conspecifics may vary due to their own degree of social dominance, status seeking, and formidability.

The current study tests a series of hypotheses regarding how individual differences in men's social dominance, status seeking, intra-sexual jealousy, and masculine morphology are associated with judgments of male facial masculinity and beardedness. We employed stimuli varying in five levels of masculinity (60% and 30% feminised, unmanipulated, and 30% and 60% masculinised) and two levels of facial hair (clean-shaven and full beards), which male participants rated for masculinity, social dominance, and physical aggressiveness. After completing their ratings, participants responded to questionnaires quantifying their drive for success and achievement, social status and dominance, intra-sexual jealousy, and morphology (height, facial hair, and facial masculinity). Previous research has shown that ratings of male masculinity, dominance, and aggressiveness are enhanced by masculine facial features and beards (Dixson et al., 2017a; Sherlock et al., 2017). Thus, men high in self-reported dominance and assertiveness may assign lower ratings of dominance and aggressiveness to facial masculinity (Hypothesis 1) and beardedness (Hypothesis 2). Rather than communicating physical strength, beardedness may reflect age, masculinity, and social aspects of dominance that translate into higher social status (Carter & Astrom, 2004). We hypothesised that men high in status seeking, as measured using the Success and Dedication scale, would ascribe lower ratings to facial masculinity (Hypothesis 3) and beardedness (Hypothesis 4). Facially masculine men report more open sociosexualities (Boothroyd et al.,

2008, 2011), pursue more short-term relationships (Rhodes et al., 2005), are more likely to poach mates (Rhodes et al., 2013), and sexually dimorphic masculine traits are judged as more intra-sexually threatening in mating contexts (Buunk et al., 2008; O'Connor & Feinberg, 2011). In contrast, beardedness has been associated with traditional views of masculine gender roles in some populations (Oldmeadow & Dixson, 2016). Therefore, men high in intra-sexually jealousy may ascribe higher ratings of dominance and aggressiveness to facial masculinity (Hypothesis 5), but not necessarily to beardedness (Hypothesis 6). Past research has shown that taller men were less sensitive to masculine characteristics in hypothetical rivals (Watkins et al., 2010). We hypothesised that men's judgments of facial masculinity and beardedness when rating masculinity, dominance, and aggressiveness may be negatively associated with their height, facial masculinity, and beardedness (Hypothesis 7).

2. Methods

2.1. Facial hair stimuli. Thirty-seven men (mean age ± SD = 27.86 ± 5.75 years) of European ethnicity were photographed posing neutral facial expressions in front and profile view using a Canon digital camera (8.0 megapixels resolution), 150 cm from the participant under controlled lighting (Dixson et al., 2017a; Janif et al., 2014). Males were photographed when clean-shaven and with 4-8 weeks of natural beard growth (Figure 1).

2.2. Facial masculinity manipulation. A composite male and female face were created from a separate face set of 40 male and 40 European females based on the same 189 landmarks. To manipulate facial masculinity, the linear shape differences between the average male and female faces were applied to the clean-shaven and bearded composites at 60%, and 30% feminised, unmanipulated and 30% and 60% masculinised while keeping colour and textural information of the original face constant (Figure 1). Participants also rated the un-manipulated composite (i.e. 100%). This procedure manipulated the images on the dimension representing sexual dimorphism while retaining the identity of the original composite is a standard approach for manipulating sexual dimorphism in faces (Benson & Perrett, 1993; Perrett et al., 1998) and has been used in several previous studies on perceptions of men's facial hair (Clarckson et al., 2020; Dixson et al., 2018a, 2018b; McIntosh et al., 2017).

FIGURE 1 HERE.

Figure 1. An example of the stimuli that were used in the current study. Faces are composites of the same five men when bearded (top row) and clean-shaven (bottom row). The composites were manipulated to appear 60% and 30% feminised, unmanipulated, and 30% and 60% masculinised.

2.3. Procedure. The study was constructed on Qualtrics and administered on-line. Participants first read an information sheet and then provided consent to partake in the study. Participants were shown three male composite faces that varied on five levels of masculinity (60% and 30% feminised, unmanipulated, and 30% and 60% masculinised) that were either bearded or clean-shaven. Faces were presented in a random sequence to participants. In total, participants saw 50 (25 bearded, 25 clean-shaven) male faces. Participants were asked to rate how masculine, socially dominant, and physically aggressive they thought the faces looked using scales where 0 = extremely low to 100 = extremely high.

2.4. Demographics. Participants reported their sexuality using the seven-point Kinsey sexual orientation scale where 0 = exclusively heterosexual and 6 = exclusively homosexual. They then provided their age (in years), biological sex (male, female, other), ethnicity (open question) and their relationship status (single or currently in a relationship).

2.5. Success Dedication Scale. To quantify male status seeking behaviour, participants completed the Success Dedication Subscale of the Masculine Behaviour Scale (MBS; Snell, 1989). The success dedication subscale of the MBS is designed to measure concern with success attainment. This subscale was a 5-point Likert scale for all items ranging from +2 (agree) to -2 (disagree) with a midpoint of 0 (agree nor disagree). All scale items were positively scored (e.g., "I do whatever I have to in order to work toward job success"). Thus, higher scores reflect a greater emphasis on success accomplishments via status acquisition. Internal reliability in the current study for the total score was high ($\alpha = .93$).

2.6. Dominance and Assertiveness Scale. The IPIP/CPI scales for dominance and assertiveness was used to assess participants' individual differences (Goldberg et al., 2006). Responses were recorded using a 5-point scale where 1 = disagree to 5 = agree. An example item from the 11-item dominance scale is: "I am quick to correct others". An example item from the 10-item Assertiveness scale is: "I know how to convince others". This scale has been used in previous studies of male perceptions of facial masculinity (Watkins, Jones, & DeBruine, 2010). In the current study, internal reliability was high for the dominance subscale ($\alpha = .88$) and the assertiveness subscale ($\alpha = .83$). The scales were moderately correlated (r (19) = .47, p <.001) and the internal consistency for the combined 21-item scale was high ($\alpha = .89$).

2.7. Intra-sexual jealousy scale. Participants also completed the Intra-sexual Jealousy Scale (Buunk & Fisher, 2009), a 12-item scale in which participants rate each statement using a 7-point scale ranging from 1 (not at all applicable) to 7 (completely applicable). This scale measures the degree of competitiveness present in confrontation with same-sex individuals especially in contexts that involve the opposite sex. Examples of the scale items include, "I always want to beat other men" and "I wouldn't hire a very attractive man as a colleague." Internal consistency in participant's responses to the scale were high ($\alpha = .94$).

2.8. Morphological masculinity measures. Participants were asked to report their height (in inches and feet) and weight (in pounds). Participants also reported how masculine they thought their face was using a scale where 1 = Much less masculine than average and 7 = Much more masculine than average (Debruine et al., 2006). Participants stated the level of facial hair that was the most appropriate of ten possible facial hair styles (0 = clean-shaven, 1 = stubble, 2 = moustache, 3 = goatee (without moustache), 4 = Goatee (with moustache), 5 = Sideburns, 6 = Sideburns and moustache, 7 = moustache and soul patch, 8 = Full beard (trimmed), 9 = Full beard (bushy); Figure 2). For our analyses, we created three categories; 1) the 'clean-shaven' category included the percentage of men with no facial hair of any kind (image 0), 2) the 'beard' category included the percentage of men with trimmed and bushy full beards (8&9), and 3) the 'non-beard facial hair' category included the percentage of men in all classes of facial hair except clean-shaven and full beards (1-7).

FIGURE 2 HERE.

Figure 2. The stimuli participants used to rank their own degree of facial hair. Each participant selected the stimulus image they thought best represented their own facial hair from ten possible facial hair styles: 0 = clean-shaven, 1 = stubble, 2 = moustache, 3 = goatee (without moustache), 4 = Goatee (with moustache), 5 = Sideburns, 6 = Sideburns and moustache, 7 = moustache and soul patch, 8 = Full beard (trimmed), 9 = Full beard (bushy).

***2.9. Participants*.** Participants were recruited through the web-based marketplace research program Amazon Mechanical Turk (MTurk), which provides researchers with large non-student samples (Mason & Suri, 2012). Participants were first screened for gender so that only males remained in the study. After removing those who did not satisfy the selection criteria, a total of 951 male participants completed the survey (Mean age = 37.47 years, *SD* = 12.09) remained. The survey took approximately 15 minutes to complete and participants recieved $1.00 USD for their time. Of the sample, 78% described themselves as White or Caucasian, 9% were Black or African American, 6% were Asian, 5% were Hispanic and the remaining 2% were classified as other. The majority of participants lived in the USA (98.1%). The study was approved from the University of Queensland's Behavioural and Social Sciences Ethical Review Committee and the School of Psychology's Ethics Review Panel (Ethics Approval Number: 18-PSYCH-4G-13-JMC).

***2.10. Statistical analyses*.** For Analysis 1, masculinity, dominance, and aggressiveness ratings were the dependent variables in repeated-measures MANOVAs where facial masculinity (very low, low, neutral, high, very high) and facial hair (bearded, clean-shaven) were entered in as within-subject factors. Effect sizes are reported as eta squared (η^2). Effect sizes for post-hoc Bonferroni corrected t-tests are reported as Cohen's d. We repeated the analyses using Bayesian repeated measures ANOVAs. Bayesian analyses were undertaken to ascertain the presence or absence of a hypothesized effect over the competing null effect. The Bayes Factor (BF_{10}) provides an estimation of the strength of support a hypothesis receives relative to another competing hypothesis. A BF_{10} of 1-3 is considered weak evidence, a BF_{10} of 3-10 is considered moderate evidence, and a BF_{10} above 10 is considered strong evidence (van Doorn et al., 2019). All analyses were conducted using JASP 3.

For Analysis 2, data were analysed using linear mixed effects modelling using the lme4 (Bates, Mächler, Bolker, & Walker, 2015) and lmerTest (Kuznetsova, Brockhoff, & Christensen, 2015) packages in R (R Core Team, 2013). Three separate models were conducted with each judgement of dominance, masculinity, and aggressiveness as the outcome variables. All models had the same predictors. At the participant level, predictors included participant's score on Success and Dedication subscales of the Masculine Behavior scale, the Dominance and Assertiveness Scale, the Intra-sexual Jealousy Scale, and the morphological data. At the stimulus level, predictors included the level of facial masculinity manipulation, and whether faces were clean-shaven or bearded (coded as -.5 and .5 respectively). All continuous predictors were z-standardised at the appropriate group-level. All two-way interactions between participant-level predictors and stimulus-level predictors were also included. Random intercepts were specified for each participant and each stimulus identity. Random slopes were specified maximally following recommendations in Barr, Levy, Scheepers, and Tily (2013) and Barr (2013). Here, we report the fixed effects from each model; for full model specifications and results, including random effects, see the supplementary materials.

3. Results

3.1. Analysis 1: The effect of facial masculinity and beardedness on men's masculinity, dominance and aggressiveness ratings

3.1.1. Masculinity ratings. There was a significant main effect of facial hair on masculinity ratings (Table 1), which received strong support in Bayesian analyses (Table 2). This reflects that beards received higher masculinity ratings than clean-shaven faces (t= 35.14, $p < 0.001$, $d = 1.14$). There was also a significant main effect of facial masculinity on masculinity ratings (Table 1) that received strong support in Bayesian analyses (Table 2). Very high masculinity was judged as more masculine than all other degrees of facial masculinity (all $t \geq 12.23$, all $p \leq 0.001$, $d = 0.40$-0.85). High masculinity received higher masculinity ratings than medium, low, and very low masculinity (all $t \geq 9.31$, all $p \leq 0.001$, $d = 0.30$-0.75). Medium facial masculinity was judged as more masculine than low and very low masculinity (all $t \geq 12.71$, all $p \leq 0.001$, $d = 0.41$ and 0.65 respectively), while low masculinity was judged as more masculine than very low masculinity ($t = 11.72$, $p < 0.001$, $d = 0.38$).

There was also a significant facial hair × facial masculinity interaction (Table 1), which received strong support in Bayesian analyses (Table 2). This reflects that masculinity ratings rose linearly with both full bearded and clean-shaven stimuli (Figure 2A). Full beards received significantly higher masculinity ratings than clean-shaven faces within each level of facial masculinity. Beards were rated more masculine than clean-shaven faces for very high masculinity ($t = 30.51$, $p < 0.001$, $d = 0.99$), high masculinity ($t = 32.32$, $p < 0.001$, $d = 1.05$), medium masculinity ($t = 33.06$, $p < 0.001$, $d = 1.07$), low masculinity ($t = 33.74$, $p < 0.001$, $d = 1.09$), and very low masculinity ($t = 34.10$, $p < 0.001$, $d = 1.11$). Further, faces with very low masculinity and full beards received higher masculinity ratings than clean-shaven faces with very high facial masculinity ($t = 18.91$, $p < 0.001$, $d = 0.61$; Figure 2A).

3.1.2. Dominance ratings. There was a significant main effect of facial hair on dominance ratings (Table 1), received strong support in Bayesian analyses (Table 3). This reflects that beards received significantly higher dominance ratings than clean-shaven faces ($t = 28.75$, $p < 0.001$, $d = 0.93$). There was also a significant main effect of facial masculinity on dominance ratings (Table 1), which received strong support in Bayesian analyses (Table 3). This reflects very high masculinity was judged as more dominant than all other degrees of facial masculinity (all $t \geq 10.66$, all $p \leq 0.001$, $d = 0.35$-0.76). High masculinity received higher dominance ratings than medium, low, and very low masculinity (all $t \geq 7.08$, all $p \leq 0.001$, $d = 0.23$-0.65). Medium facial masculinity was judged as more dominant than low and very low masculinity (all $t \geq 10.95$, all $p \leq 0.001$, $d = 0.35$-0.54), while low masculinity was judged as more dominant than very low masculinity ($t = 8.24$, $p < 0.001$, $d = 0.27$).

There was also a significant facial hair × facial masculinity interaction (Table 1), which received strong support in Bayesian analyses (Table 3). This reflects that dominance ratings rose linearly with both full bearded and clean-shaven stimuli (Figure 2B). Full beards received significantly higher dominance ratings than clean-shaven faces within each level of masculinity. Thus, beards were rated more dominant than clean-shaven faces for very high masculinity ($t = 23.84$, $p < 0.001$, $d = 0.77$), high masculinity ($t = 26.31$, $p < 0.001$, $d = 0.85$), medium masculinity ($t = 26.90$, $p < 0.001$, $d = 0.87$), low masculinity ($t = 27.28$, $p < 0.001$, $d = 0.89$), and very low masculinity ($t = 27.27$, $p < 0.001$, $d = 0.88$). The additive effect of beards on dominance ratings is also reflected in the significantly higher ratings for faces with

very low masculinity and full beards over very high masculinity clean-shaven faces (t = 13.74, $p < 0.001$, $d = 0.45$; Figure 2B).

3.1.3. Aggressiveness ratings. There was a significant main effect of facial hair on aggressiveness ratings (Table 1) and strong support in Bayesian analyses (Table 4). Beards received significantly higher aggressiveness ratings than clean-shaven faces (t= 23.84, $p <$ 0.001, $d = 0.77$). There was also a significant main effect of facial masculinity on aggressiveness ratings (Table 1), which received strong support in Bayesian analyses (Table 4). This reflects very high masculinity was judged as more aggressive than all other degrees of facial masculinity (all $t \geq 8.87$, all $p \leq 0.001$, d = 0.29-0.55). High masculinity received higher masculinity than medium, low, and very low masculinity (all $t \geq 6.62$, all $p \leq 0.001$, d = 0.22-0.42). Medium facial masculinity was judged as more aggressive than low and very low masculinity (all $t \geq 8.67$, all $p \leq 0.001$, d = 0.28-0.30), while low masculinity was not judged as more aggressive than very low masculinity (t = 1.66, p = 0.976, d = 0.05).

There was also a significant facial hair × facial masculinity interaction (Table 1), received strong support in Bayesian analyses (Table 4). This reflects that masculinity ratings rose linearly within both full bearded and clean-shaven stimuli (Figure 2C). However, full beards received significantly higher masculinity ratings than clean-shaven faces within each level of masculinity. Thus, beards were rated more masculine than clean-shaven faces for very high masculinity (t = 30.51, $p < 0.001$, $d = 0.99$), high masculinity (t = 32.32, $p < 0.001$, $d = 1.05$), medium masculinity (t = 33.06, $p < 0.001$, $d = 1.07$), low masculinity (t = 33.74, p < 0.001, $d = 1.09$), and very low masculinity (t = 34.10, $p < 0.001$, $d = 1.11$). Faces with very low masculinity and beards were rated higher for aggressiveness than clean-shaven faces with very high facial masculinity (t = 11.84, $p < 0.001$, $d = 0.38$; Figure 2C).

FIGURE 3 HERE.

Figure 3. The effect of men's facial hair (full beard = black circle with solid black line and clean-shaven = white circle with dotted line) and facial masculinity (60% and 30% feminised, 0% (i.e. unmanipulated), and 30% and 60% masculinised) on men's judgments of o male masculinity (A.), dominance (B.), and aggressiveness (C.). Data are the mean ratings (± 1 SEM). Note the rating scale on Y axis ranges from 0-100.

3.2. Analysis 2: Predictors of men's masculinity, dominance, and aggressiveness ratings for facial masculinity and beardedness. We first explored correlations among the psychological and morphological predictors of male dominance. Self-rated facial masculinity was positively correlated with success and determination (r = 0.179, $p < .001$), dominance and assertiveness (r = .262, $p < .001$), and intra-sexual jealousy (r = 0.164, $p < .001$), but not height (r = -.02, p = .53). There was a significant negative relationship between men's height and their self-reported intra-sexual jealousy, (r = -.279, $p < .001$), but associations were not statistically significant between height and success and determination (r = -.045, p = .416) or dominance and assertiveness (r = -.035, p = .280). Men's self-reported facial hair was positively associated with self-reported dominance and assertiveness (r = .119, $p < .001$), self-perceived facial masculinity (r = .158, $p < .001$), and with intra-sexual jealousy (r = .065, p = .046), but not with height (r = -.031, p = .332). Self-reported success and determination

scores were positively associated with dominance and assertiveness (r = .507, p < .001) and intra-sexual jealousy (r = .15, p < .001). Self-reported dominance and assertiveness was also positively associated with their self-reported intra-sexual jealousy (r = .276, p < .001).

FIGURE 4 HERE.

Figure 4. The associations between psychological measures (top row: self-reported success and dedication, dominance and assertiveness) and morphological characters (bottom row: facial masculinity, height and facial hair) and men's masculinity ratings of male faces varying in facial hair (+/- 95% CI) when judging bearded (red line) and clean-shaven faces (blue line). ** < .01; *** < .001.

The self-reported psychological and morphological data were then analysed using linear mixed effects modelling to test for association with facial masculinity and beardedness. Separate models were run for masculinity, dominance, and aggressiveness ratings and are presented in Table 5. Across all models, we found significant main effects for Dominance and Assertiveness and intra-sexual jealousy, such that participants low in Dominance and Assertiveness, and high in intra-sexual jealousy rated faces higher overall in dominance, masculinity, and aggressiveness. We also found a significant, positive main effect of Success and Dedication on dominance ratings, but this was not significant for masculinity or aggressiveness ratings. There was a significant main effect of self-rated masculinity in all three models, such that men who rated themselves as more facially masculine gave higher dominance, masculinity, and aggressiveness ratings overall. Taller participants also gave lower aggressiveness ratings, but this relationship was non-significant for dominance and masculinity ratings. As with the ANOVAs, there were significant main effects for facial masculinity, such that masculinised faces were rated as more dominant, masculine, and aggressive. We also found significant main effects of facial hair, such that bearded faces were rated as more dominant, masculine, and aggressive compared to clean-shaven faces (Table 5).

FIGURE 5 HERE.

Figure 5. The associations between psychological measures (top row: self-reported success and dedication, dominance and assertiveness) and morphological characters (bottom row: facial masculinity, height and facial hair) and men's masculinity ratings of male faces varying in facial masculinity (+/- 95% CI) when judging feminised (red line) and masculinised faces (blue line). ** < .01; *** < .001.

We hypothesised that men reporting higher Dominance and Assertiveness scores would assign lower ratings of dominance and aggressiveness to facial masculinity (Hypothesis1) and beardedness (Hypothesis 2) than participants reporting lower Dominance and Assertiveness. We found no significant negative associations between judgments of facial masculinity and self-reported Dominance and Assertiveness scores. While there we report a significant interaction between stimulus beardedness and participant Dominance and Assertiveness in all three models, such that participants high in Dominance and Assertiveness rated bearded faces as more masculine (Figure 3), dominant (Figure 5), and aggressive (Figure 7). These results suggest that men are more sensitive to beards as a badge of dominance and status if they themselves report high social dominance.

FIGURE 6 HERE.

Figure 6. The associations between psychological measures (top row: self-reported success and dedication, dominance and assertiveness) and morphological characters (bottom row: facial

masculinity, height and facial hair) and men's dominance ratings of male faces varying in facial hair (+/- 95% CI) when judging bearded (red line) and clean-shaven faces (blue line). ** < .01; *** < .001.

We hypothesised that men high in status seeking, as measured using the Success and Dedication scale, would ascribe lower ratings to facial masculinity (Hypothesis 3) and beardedness (Hypothesis 4). However, we found no significant associations between self-reported status seeking and judgments of facial hair or facial masculinity. Across all three models we found significant interactions between both stimulus beardedness and masculinity, and participant intra-sexual jealousy (Table 2). We had hypothesised that men high in intra-sexually jealousy should ascribe higher ratings of social dominance and aggressiveness to facial masculinity (Hypothesis 5), but not beardedness (Hypothesis 6). However, we found that participants reporting lower in intra-sexual jealousy rated clean-shaven and/or feminised faces as less dominant, less masculine, and less aggressive than participants reporting higher intra-sexual jealousy.

FIGURE 7 HERE.

Figure 7. The associations between three psychological measures (top row: self-reported success and dedication, dominance and assertiveness) and three morphological characters (bottom row: facial masculinity, height and facial hair) and men's dominance ratings of male faces varying in facial masculinity (+/- 95% CI) when judging feminised faces (red line) and masculinised faces (blue line). ** < .01; *** < .001.

Hypothesis 7 was that men high in masculine secondary sexual trait development would be less sensitive to facial masculinity and beardedness when judging masculinity, dominance and aggressiveness. For ratings of facial hair, there was a significant interaction between height and trait ratings (Table 2). However, rather than reflecting lower ratings ascribed to full beards among taller male participants, ratings of clean-shaven faces were significantly lower among taller than shorter participants when judging masculinity (Figure 3), dominance (Figure 5), and aggressiveness (Figure 7). For ratings of facial masculinity there was also a significant interaction involving participant's height and trait ratings (Table 2), so that ratings were lower among taller than shorter men when rating feminised but not masculine faces for masculinity (Figure 4), dominance (Figure 6), and aggressiveness (Figure 8). There were no significant interactions between either self-reported success and dedication or participant's self-rated facial masculinity with either stimuli beardedness or facial masculinity. There were also no significant main effect or interactions involving self-reported beardedness.

FIGURE 8 HERE.

Figure 8. The associations between three psychological measures (top row: self-reported success and dedication, dominance and assertiveness) and three morphological characters (bottom row: facial masculinity, height and facial hair) and aggressiveness ratings of male faces varying in facial hair (+/- 95% CI) when judging bearded faces (red line) and clean-shaven faces (blue line). * < .05; ** < .001.

FIGURE 9 HERE.

Figure 9. The associations between three psychological measures (top row: self-reported success and dedication, dominance and assertiveness) and morphological characters (bottom row: facial

masculinity, height and facial hair) and aggressiveness ratings (+/-95% CI) of male faces varying in facial masculinity when judging feminised (red line) and masculinised faces (blue line). ** < .01.

4. Discussion

A growing body of research implicates intra-sexual selection in shaping the evolution of men's secondary sexual traits, dominance, and status seeking (Lukaszewski et al., 2016; Puts, 2010; Rosenfeld et al., 2019). The current study reports men's ratings of masculinity, dominance, and aggressiveness for male faces increased linearly with craniofacial masculinity, being lowest for the least masculine faces and highest for the most masculine faces. Beards were also judged as more masculine, dominant, and aggressive than clean-shaven faces. However, the effects of craniofacial masculinity on judgments of male faces were dwarfed by the effect of facial hair, such that ratings for masculinity, dominance, and aggressiveness were higher at each level of facial masculinity for bearded compared to clean-shaven faces. Our findings replicate previous studies reporting that beards exert stronger effects than facial masculinity on judgments of men's masculinity and dominance (Dixson et al., 2017a; Sherlock et al., 2017). As an example of the size of these effects, we report significantly higher ratings (all p <.001) for bearded faces with very feminine facial shape over the most masculine clean-shaven faces for ratings of masculinity (d = .61), dominance, (d = .45) and aggressiveness (d = .38), highlighting that facial hair potentially enhances male intra-sexual formidability through amplifying underlying masculine craniofacial features such as jaw width, facial length and width.

Converging evidence demonstrates that men's facial masculinity predicts men's intra-sexual formidability (Puts, 2010; Sell et al., 2012). Men with more masculine faces have greater upper body strength (Fink et al., 2007; Windhager et al., 2011), fighting ability (Třebický et al., 2013, 2015, 2018a; Ziolli et al., 2015), and higher mating success (Hill et al., 2013; Kordsmeyer et al., 2018) than less facially masculine men. The degree to which men are sensitive to other men's secondary sexual traits, including facial masculinity, when assessing their dominance may vary due to their own physical and psychological dominance (Puts, 2010; Sell et al., 2012; Watkins et al., 2010a, 2010b). In the current study, we did not find that men high in social dominance (Hypothesis 1) or status seeking (Hypothesis 3) were less sensitive to facial masculinity when ranking male facial masculinity, dominance, or aggressiveness than less dominant men (Watkins et al., 2010b). We also tested whether men's physical masculinity was negatively associated with their judgments of facial masculinity (Hypothesis 7). Thus, height is positively associated with men's social dominance (Puts, 2010), aggressiveness (Archer, 2009), and fighting ability (Sell et al., 2012). While we found that height was negatively associated with judgments of male masculinised and feminised faces for ratings of masculinity, dominance, and aggressiveness, the significant interaction was driven by lower ratings for feminised rather than masculinised faces. This provides partial support that taller men are less sensitive to cues of facial dominance in male faces, but does not directly replicate past findings that height in negatively associated with dominance judgments for male facial masculinity (Watkins et a., 2010a). We also found that participants with higher self-reported facial masculinity gave higher ratings of dominance, masculinity, and aggressiveness ratings. However, there were no associations between self-reported facial masculinity and self-reported social dominance, assertiveness, or success and dedication on men's judgments of male facial masculinity.

Facially masculine men report more open sociosexualities (Boothroyd et al., 2008), greater interest in short-term relationships (Arnocky et al., 2018), having more short-term partners (Rhodes et al., 2005), and greater likelihood of poaching other men's partners

(Rhodes et al., 2013). Thus, men with more masculine faces and better developed secondary sexual characters may be less jealous of masculine looking men than their less masculine contemporaries. Indeed, previous research has shown that men's height is negatively associated with their self-reported intra-sexual jealousy (Buunk et al., 2008). While we also found that taller men reported lower intra-sexual jealousy (r = -.279), we did not find that taller, more facially masculine, or bearded men were less jealous of facial masculinity in male faces. Instead, participants reporting lower intra-sexual jealousy rated clean-shaven and less masculine faces as less masculine, dominant, and aggressive than masculine or bearded faces. This could simply reflect that men attribute lower threat in mating contexts to less masculine and physically formidable looking men. However, with regards men's intra-sexual jealousy and judgments of beardedness, to our knowledge the only study measuring associations between women's sexual openness and attractiveness ratings of male facial hair reported a positive association between female sexual openness and preferences for beards (Stower et al., 2019). At present, there is no published data relating beardedness to men's sociosexuality and whether the decision to wear facial hair is a reflection of men's sociosexual attitudes is an important question for future research.

Compared to the body of research on intra-sexual selection and judgments of male facial masculinity, fewer studies have assessed individual differences in men's dominance and their judgments of male beardedness. Past research has shown that bearded men reported higher aggressive sexism scores than clean-shaven men in the U.S.A and India (Oldmeadow and Dixson; 2016a), but not Sweden (Hellmer & Stenson, 2016; Hellmer et al., 2018). Men with facial hair report feeling more masculine (Wood, 1986) and had higher serum androgens (Knussman & Christiansen, 1988) than men favouring a clean-shaven appearance. In the current study, self-reported beardedness was positively associated with self-perceived facial masculinity (r = .158) and self-reported dominance (r = .119). Participants who reported higher scores on dominance and assertiveness personality scales also gave significantly higher masculinity, dominance, and aggressiveness ratings to bearded but not clean-shaven faces compared to participants lower in dominance and assertiveness. These findings complement growing evidence highlighting that beards enhance intra-sexual communication of masculine social dominance (Craig et al., 2019; Dixson & Vasey, 2012; Dixson et al., 2017a) and provide the first evidence that facial hair is positively associated with male self-perceived social dominance. Importantly, this correlation cannot determine whether socially dominant men choose to grow their beards or whether keeping a beard augments men's self-reported social dominance due to positive social feedback from peers. There is some evidence that bearded men have higher mating success when sex ratios are more male-biased (Barber, 2001) and that beards (and female preferences for them) are more common in larger cities, with low average incomes and high life expectancies (Dixson et al., 2017c). Future research exploring the causal effects of men's grooming decisions on social dominance and mating success would be valuable.

Comparative research among nonhuman animals can shed light on the roles of facial masculinity and beards in intra-sexual communication. Researchers working on nonhuman animals distinguish between the role of male weaponry and ornamentation in intra-sexual competition, such that weapons are employed during direct physical confrontations whereas ornaments communicate status and dominance without necessarily being associated with physical formidability (McCullough et al., 2016). Weapons involved in direct competition and fights are rarely false signals of male quality (Berglund et al., 1996) and may augment attractiveness to females when selecting for males bearing direct benefits (Wong & Candolin, 2005). Our results failed to support several past studies that found associations between men's intra-sexual competitiveness and judgments of male facial masculinity. This was

surprising as masculine facial structure is positively associated with men's upper body strength (Fink et al., 2007; Windhager et al., 2011), muscularity (Holzleitner & Perrett, 2016), stature (Zaidi et al., 2019) and fighting ability (Třebický et al., 2015; Zilioli et al., 2015). Mixed martial arts fighters with more masculine facial features are more often winners than less facially masculine fighters (Třebický et al., 2015; Zilioli et al., 2015) and fighters with greater anaerobic fitness are rated as better fighters (Třebický et al., 2018). Our results may have differed had we included more interactive behavioural paradigms rather than comparisons of self-report measures of dominance. For example, recent research in which men were assigned to compete in either violent or non-violent video games revealed that men who competed in violent video games were slower to retreat from a hypothetical physical confrontation with a masculine looking male, and were slower to recognise threatening facial expressions than participants in competing in non-violent video games (Denson et al., 2019). It may be beneficial to repeat our studies using more interactive experimental approaches to test whether psychologically and physically masculine men are less sensitive to masculine traits.

In contrast to sexually selected weapons, ornaments can communicate dominance without being directly involved in combat (McCullough et al., 2016). For example, in mountain gorillas (*Gorilla beringei beringei*) male dominance rank, success in male-male dyadic contests, and number of females in the social group is positively associated with cranial adipose crest size and back breadth (Wright et al., 2019). In some cases, weaponry may not reliably communicate physical formidability (Berglund et al., 1996). Thus, in male fiddler crabs (*Uca mjoebergi*) claw size is associated with attractiveness, resource holding, and in assessing fighting ability between rival males (Reaney et al., 2008). However, when males lose their claws during fights or due to predation the regrown claws are of similar size to their original claws but less robust, yet rival males are unable to discern weapon quality and overestimate their opponents fighting ability (Lailvaux et al., 2009). Similarly, male slender crayfish (*Cherax dispar*) with larger claws successfully dominate males with small claws despite any positive association between their claw size and muscle development (Wilson et al., 2009). Beardedness is possibly the most sexually dimorphic of men's secondary sexual characters (Dixson et al., 2005; Grueter et al., 2015) and enhances ratings of age, masculinity, dominance, and aggressiveness by enlarging the size of the jaw (Dixson et al., 2017a), the midface (Sherlock et al., 2017) and the saliency of agonistic expressions (Dixson & Vasey, 2012; Craig et al., 2019). However, facial hair is unlikely to reflect aspects of male fighting ability (Dixson et al., 2018c) and may serve to enhance perceptions of masculinity, dominance, and aggressiveness to curtail intra-sexual conflicts from escalating into costly physical contests. Future research investigating whether bearded men are more successful than their clean-shaven counterparts in social rather than physical forms of intra-sexual competition would be valuable. Presently, our study provides some support for a role of intra-sexual selection in men's judgments of male facial masculinity and reports the first data on individual differences in men's judgments of male facial hair, which suggest beards are intra-sexually selected badges of status.

Conflict of interest statement: The authors have no competing interests.

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