

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

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4 Valeriya Mefodeva¹. Morgan J. Sidari¹. Holly Chau¹. Brett Fitzsimmons¹. Gabrielle Antoine¹.
5 Tessa R. Clarkson¹. Samuel Pearson¹, Anthony J. Lee². Barnaby J. W. Dixson^{1,3}.

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7 ¹ School of Psychology, University of Queensland, Brisbane, Queensland, Australia.

8 ² Institute of Neuroscience and Psychology, University of Glasgow, Scotland, UK

9 ³To whom correspondence should be addressed at the School of Psychology, University of
10 Queensland, Brisbane, Queensland, Australia.

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32 **Abstract**

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

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

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

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

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

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69 1. Introduction

70 Intra-sexual selection has shaped the evolution of weapons, dominance displays, and
71 signals of social status employed in male-male competition in many species (Emlen, 2008;
72 Rico-Guevara et al., 2019), including humans (Archer, 2009; Puts, 2010; Puts et al., 2015).
73 Androgens shape sex differences in bodily, facial, and vocal secondary sexual characters
74 (Randall, 2008). Compared to women, men have a more v-shaped physique (Dixson et al.,
75 2014), are taller (Stulp & Barrett, 2016), have greater upper body musculature (Lassek &
76 Gaulin, 2009) and deeper voices (Puts, 2010). One of the most researched sexually dimorphic
77 androgen dependent characters is facial masculinity, which refers to a suite of features
78 including jaw size, the midface, and brow ridge that are more pronounced in men compared
79 to women (Whitehouse et al., 2015). Androgens exert organizational effects on facial
80 masculinity *in utero* (Whitehouse et al., 2015), during pubertal surges of androgens
81 (Marečková et al., 2011), and early adulthood (Roosenboom et al., 2018). Although facial
82 masculinity was suggested to be associated with men's circulating androgens (Penton-Voak
83 & Chen, 2004), recent studies have not reproduced this association (Kordsmeyer et al., 2019).
84 Similarly, some studies reported men's facial masculinity was associated with greater long-
85 term health (Rhodes et al., 2003; Thornhill & Gangestad, 2006) and more rapid immune
86 response (Rantala et al., 2012), while others have not (Boothroyd et al., 2013; Zaidi et al.,
87 2019). Associations between facial masculinity and immune response may be mediated by
88 adiposity (Rantala et al., 2013), whereby a combination of facial masculinity and facial
89 muscularity better reflect male immune response than facial masculinity alone (Phalane et al.,
90 2017). Thus, facial masculinity may provide some information regarding health that
91 influences mate choices among women, while associations between facial sexual
92 dimorphisms and genetic immunity require further exploration.

93 Although debate surrounds whether men's facial masculinity communicates genetic
94 quality indirectly, evidence that it provides an index of male social dominance and
95 formidability is more consistent (Scott et al., 2013; Puts, 2010). Androgens influence suites
96 of coordinated characters, and male facial masculinity is positively associated with body size,
97 height, and physical strength (Butovskaya et al., 2018; Fink et al., 2007; Holzleitner &
98 Perrett, 2016; Windhager et al., 2011). Facial masculinity is also positively associated with
99 men's behavioural dominance, assertiveness, and aggressiveness (Puts, 2010; Scott et al.,
100 2013; Geniole et al., 2015; Sell et al., 2012). While mothers and their offspring may benefit
101 directly via resources and protection from partners displaying well-developed masculine
102 morphology (Scott et al., 2013; Puts, 2010), women's preferences for male facial masculinity
103 varies across cultures (Borras-Guevara et al., 2017; Dixson et al., 2017b; Scott et al., 2014;
104 Marcinkowska et al., 2019). Yet men with more masculine faces, bodies, and voices have
105 higher mating success than their less masculine peers (Hill et al., 2013; Kordsmeyer et al.,
106 2018). Some evidence supports women's preferences for facial masculinity are stronger
107 under social and economic conditions characterised by high male-male competition (Brooks
108 et al., 2011), when an intra-sexually competitive partner may directly benefit mothers and
109 their offspring.

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

115 & Cunningham, 1996; Neave & Shields, 2008). Facial hair may augment judgments of
 116 masculinity, dominance, and threat by exaggerating masculine craniofacial traits, including
 117 facial length and jaw prominence (Dixson et al., 2017a; Sherlock et al., 2017). Beards
 118 enhance explicit aggressiveness ratings, as well as speed and accuracy in recognition of angry
 119 facial expressions over clean-shaven faces (Craig et al., 2019; Dixson & Vasey, 2012). Facial
 120 hair unambiguously communicates age, sexual maturity, and masculinity (Dixson et al.,
 121 2017a; Neave & Shields, 2008), which may explain why women rate men with beards as
 122 most attractive when judging long-term relationships (Neave & Shields, 2008; Dixson et al.,
 123 2016) and fathering abilities (Clarkson et al., 2019; Dixson & Brooks, 2013; Dixson et al.,
 124 2019; Stower et al., 2019). Women's stated preferences for men's facial hair are reflected in
 125 mate choices (Dixson et al., 2013; Štěrbová et al., 2019; Valentova et al., 2017) and are
 126 strongest under socio-economic conditions of high male intra-sexual competition (Barber,
 127 2001; Dixson et al., 2017c; 2019).

128 If intra-sexual selection has shaped male cognition to assess physical formidability
 129 and social dominance among their contemporaries, men should accurately assess physical
 130 strength and social status from facial, bodily, and vocal characteristics (Puts, 2010; Sell et al.,
 131 2012). Assessing physical strength from masculine facial structures and expansive body
 132 postures occur as early as age 3 (Terrizzi et al., 2019). During adolescence, positive
 133 associations between male physical strength, physical aggression, and nonphysical aggression
 134 are strongest in early and mid-adolescence, with aggressiveness becoming less physically and
 135 more socially orientated among older adolescents of 17-18 years (Isen et al., 2015; Muñoz-
 136 Reyes et al., 2012). By late adolescence, males accurately assess physical strength in faces
 137 and bodies (Gallup et al., 2010). In adulthood, physical strength is accurately judged from
 138 gait among men from Chile, Germany, and Russia (Fink et al., 2017), but possibly not among
 139 the Maasai of Tanzania (Fink et al., 2019; Durkee, 2019). People also accurately assess
 140 physical strength from facial shape, bodily morphology (Fink et al., 2007; Sell et al., 2009;
 141 Windhager et al., 2011), and voices (Raine et al., 2018; Sell et al., 2010). Men from the USA
 142 accurately assess fighting ability from male faces and bodies of US college students, Andean
 143 pastoralists, and Bolivian horticulturalists (Sell et al., 2009). Among professional mixed
 144 martial fighters, facial masculinity is positively associated with victories in fights and ratings
 145 of aggressiveness (Třebický et al., 2013; 2014; Zilioli et al., 2015). In non-physical intra-
 146 sexual contexts, physical formidability may translate into greater bargaining power, higher
 147 social rank, and social status (Lukaszewski et al., 2016; von Rueden et al., 2016), which may
 148 maintain social group cohesion (Lukaszewski et al., 2016). Finally, men's mate value is
 149 positively associated with social status in industrialized (Hill et al., 2013; Kordsmeyer et al.,
 150 2018) and non-industrialized (von Rueden & Jaeggi, 2016) societies.

151 In a similar vein to judgments of facial masculinity, children of 2-5 years of age
 152 associated beardedness with judgments of men's age, masculinity, and dominance, but not
 153 attractiveness (Nelson et al., 2019). The onset of facial hair is an important milestone in
 154 pubertal development and adolescent boys with facial hair report feeling more physically
 155 attractive than boys without facial hair (Tobin-Richards, Boxer, & Petersen, 1983).
 156 Adolescent boys who participated in competitive sports developed thicker facial hair than
 157 age-matched boys who did not compete in sports (Singal et al., 2006). During puberty,
 158 judgments of masculinity, dominance, and attractiveness become more adult-like (Nelson et
 159 al., 2019) and adults consistently judge beards higher for age, masculinity, social status,
 160 dominance, and aggressiveness compared to clean-shaven faces (for review see Dixson et al.,
 161 2018c). However, unlike craniofacial masculinity there is no evidence that beards are
 162 associated with men's fighting performance (Dixson et al., 2018c). Individual differences in
 163 beardedness are primarily attributable to genetic factors (Adhikari et al., 2016) and facial

164 hairs are expressed via the conversion of testosterone to dihydrotestosterone within the
165 dermal papillae of hair follicles rather than total testosterone that underpins other masculine
166 secondary sexual traits (Randall, 2008). These differences have implications for how beards
167 may function as a sociosexual signal (Dixson & Rantala, 2016; Dixson et al., 2016). Thus,
168 facial hair enhances dominance and aggressiveness in men by exaggerating the size of
169 masculine structural features, including the size of jaw and facial length (Dixson et al.,
170 2017a; Sherlock et al., 2017). Less masculine male faces are judged as significantly more
171 masculine and dominant when bearded than masculine clean-shaven faces (Dixson et al.,
172 2017a; Sherlock et al., 2017). Beards enhance aggressiveness ratings as well as the speed and
173 accuracy of recognition of angry facial expressions over clean-shaven faces (Dixson &
174 Vasey, 2012; Craig et al., 2019). Rather than communicating physical formidability, beards
175 may function as a badge of status advertising men's age, masculinity, and social aspects of
176 dominance (Dixson et al., 2018c).

177 Agonistic displays that lead to fights provide an opportunity for individuals to assess
178 the formidability and fighting ability of opponents relative to their own (Pinto et al., 2019).
179 Among US and Fijian men, physical strength was negatively associated with judgments of
180 height, body size, and muscularity in a hypothetical rival (Fessler et al., 2014). Taller men are
181 less sensitive to facial masculinity and lower vocal pitch when assessing male dominance
182 than shorter men (Watkins et al., 2010a). Men reporting higher social dominance were also
183 less sensitive to facial masculinity when judging male dominance than less socially dominant
184 men (Watkins et al., 2010b). Facially masculine men report higher mating success (Hill et al.,
185 2013; Kordsmeyer et al., 2018; Peters et al., 2008; Rhodes et al., 2005), less restricted
186 sociosexualities (Boothroyd et al., 2008, 2011), stronger preferences for short-term
187 relationships (Rhodes et al., 2005), and more mate poaching (Arnocky et al., 2018; Polo et
188 al., 2019) than less masculine men. As a result, men concerned with guarding their mates
189 may be sensitive to physical cues of masculinity in potential rivals. Indeed, men's sexual
190 jealousy when assessing socially dominant, physically attractive, and high status males is
191 negatively associated with their height (Buunk et al., 2008) and masculine men are more
192 jealous of facially and vocally masculine men than less masculine men (O'Connor &
193 Feinberg, 2011). Thus, men's responses to intra-sexually selected traits in male conspecifics
194 may vary due to their own degree of social dominance, status seeking, and formidability.

195 The current study tests a series of hypotheses regarding how individual differences in
196 men's social dominance, status seeking, intra-sexual jealousy, and masculine morphology are
197 associated with judgments of male facial masculinity and beardedness. We employed stimuli
198 varying in five levels of masculinity (60% and 30% feminised, unmanipulated, and 30% and
199 60% masculinised) and two levels of facial hair (clean-shaven and full beards), which male
200 participants rated for masculinity, social dominance, and physical aggressiveness. After
201 completing their ratings, participants responded to questionnaires quantifying their drive for
202 success and achievement, social status and dominance, intra-sexual jealousy, and morphology
203 (height, facial hair, and facial masculinity). Previous research has shown that ratings of male
204 masculinity, dominance, and aggressiveness are enhanced by masculine facial features and
205 beards (Dixson et al., 2017a; Sherlock et al., 2017). Thus, men high in self-reported
206 dominance and assertiveness may assign lower ratings of dominance and aggressiveness to
207 facial masculinity (Hypothesis 1) and beardedness (Hypothesis 2). Rather than
208 communicating physical strength, beardedness may reflect age, masculinity, and social
209 aspects of dominance that translate into higher social status (Carter & Astrom, 2004). We
210 hypothesised that men high in status seeking, as measured using the Success and Dedication
211 scale, would ascribe lower ratings to facial masculinity (Hypothesis 3) and beardedness
212 (Hypothesis 4). Facially masculine men report more open sociosexualities (Boothroyd et al.,

213 2008, 2011), pursue more short-term relationships (Rhodes et al., 2005), are more likely to
 214 poach mates (Rhodes et al., 2013), and sexually dimorphic masculine traits are judged as
 215 more intra-sexually threatening in mating contexts (Buunk et al., 2008; O'Connor &
 216 Feinberg, 2011). In contrast, beardedness has been associated with traditional views of
 217 masculine gender roles in some populations (Oldmeadow & Dixson, 2016). Therefore, men
 218 high in intra-sexually jealousy may ascribe higher ratings of dominance and aggressiveness to
 219 facial masculinity (Hypothesis 5), but not necessarily to beardedness (Hypothesis 6). Past
 220 research has shown that taller men were less sensitive to masculine characteristics in
 221 hypothetical rivals (Watkins et al., 2010). We hypothesised that men's judgments of facial
 222 masculinity and beardedness when rating masculinity, dominance, and aggressiveness may be
 223 negatively associated with their height, facial masculinity, and beardedness (Hypothesis 7).

224 2. Methods

225 **2.1. Facial hair stimuli.** Thirty-seven men (mean age \pm SD = 27.86 \pm 5.75 years) of
 226 European ethnicity were photographed posing neutral facial expressions in front and profile
 227 view using a Canon digital camera (8.0 megapixels resolution), 150 cm from the participant
 228 under controlled lighting (Dixson et al., 2017a; Janif et al., 2014). Males were photographed
 229 when clean-shaven and with 4-8 weeks of natural beard growth (Figure 1).

230 **2.2. Facial masculinity manipulation.** A composite male and female face were created from
 231 a separate face set of 40 male and 40 European females based on the same 189 landmarks. To
 232 manipulate facial masculinity, the linear shape differences between the average male and
 233 female faces were applied to the clean-shaven and bearded composites at 60%, and 30%
 234 feminised, unmanipulated and 30% and 60% masculinised while keeping colour and textural
 235 information of the original face constant (Figure 1). Participants also rated the un-
 236 manipulated composite (i.e. 100%). This procedure manipulated the images on the dimension
 237 representing sexual dimorphism while retaining the identity of the original composite is a
 238 standard approach for manipulating sexual dimorphism in faces (Benson & Perrett, 1993;
 239 Perrett et al., 1998) and has been used in several previous studies on perceptions of men's
 240 facial hair (Clarkson et al., 2020; Dixson et al., 2018a, 2018b; McIntosh et al., 2017).

241 **FIGURE 1 HERE.**

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

246 **2.3. Procedure.** The study was constructed on Qualtrics and administered on-line.
 247 Participants first read an information sheet and then provided consent to partake in the study.
 248 Participants were shown three male composite faces that varied on five levels of masculinity
 249 (60% and 30% feminised, unmanipulated, and 30% and 60% masculinised) that were either
 250 bearded or clean-shaven. Faces were presented in a random sequence to participants. In total,
 251 participants saw 50 (25 bearded, 25 clean-shaven) male faces. Participants were asked to rate
 252 how masculine, socially dominant, and physically aggressive they thought the faces looked
 253 using scales where 0 = extremely low to 100 = extremely high.

254 **2.4. Demographics.** Participants reported their sexuality using the seven-point Kinsey sexual
 255 orientation scale where 0 = exclusively heterosexual and 6 = exclusively homosexual. They
 256 then provided their age (in years), biological sex (male, female, other), ethnicity (open
 257 question) and their relationship status (single or currently in a relationship).

258 **2.5. Success Dedication Scale.** To quantify male status seeking behaviour, participants
 259 completed the Success Dedication Subscale of the Masculine Behaviour Scale (MBS; Snell,
 260 1989). The success dedication subscale of the MBS is designed to measure concern with
 261 success attainment. This subscale was a 5-point Likert scale for all items ranging from +2
 262 (agree) to -2 (disagree) with a midpoint of 0 (agree nor disagree). All scale items were
 263 positively scored (e.g., “I do whatever I have to in order to work toward job success”). Thus,
 264 higher scores reflect a greater emphasis on success accomplishments via status acquisition.
 265 Internal reliability in the current study for the total score was high ($\alpha = .93$).

266 **2.6. Dominance and Assertiveness Scale.** The IPIP/CPI scales for dominance and
 267 assertiveness was used to assess participants’ individual differences (Goldberg et al., 2006).
 268 Responses were recorded using a 5-point scale where 1 = disagree to 5 = agree. An example
 269 item from the 11-item dominance scale is: “I am quick to correct others”. An example item
 270 from the 10-item Assertiveness scale is: “I know how to convince others”. This scale has
 271 been used in previous studies of male perceptions of facial masculinity (Watkins, Jones, &
 272 DeBruine, 2010). In the current study, internal reliability was high for the dominance
 273 subscale ($\alpha = .88$) and the assertiveness subscale ($\alpha = .83$). The scales were moderately
 274 correlated ($r(19) = .47, p < .001$) and the internal consistency for the combined 21-item scale
 275 was high ($\alpha = .89$).

276 **2.7. Intra-sexual jealousy scale.** Participants also completed the Intra-sexual Jealousy Scale
 277 (Buunk & Fisher, 2009), a 12-item scale in which participants rate each statement using a 7-
 278 point scale ranging from 1 (not at all applicable) to 7 (completely applicable). This scale
 279 measures the degree of competitiveness present in confrontation with same-sex individuals
 280 especially in contexts that involve the opposite sex. Examples of the scale items include, “I
 281 always want to beat other men” and “I wouldn’t hire a very attractive man as a colleague.”
 282 Internal consistency in participant’s responses to the scale were high ($\alpha = .94$).

283 **2.8. Morphological masculinity measures.** Participants were asked to report their height (in
 284 inches and feet) and weight (in pounds). Participants also reported how masculine they
 285 thought their face was using a scale where 1 = Much less masculine than average and 7 =
 286 Much more masculine than average (DeBruine et al., 2006). Participants stated the level of
 287 facial hair that was the most appropriate of ten possible facial hair styles (0 = clean-shaven, 1
 288 = stubble, 2 = moustache, 3 = goatee (without moustache), 4 = Goatee (with moustache), 5 =
 289 Sideburns, 6 = Sideburns and moustache, 7 = moustache and soul patch, 8 = Full beard
 290 (trimmed), 9 = Full beard (bushy); Figure 2). For our analyses, we created three categories; 1)
 291 the ‘clean-shaven’ category included the percentage of men with no facial hair of any kind
 292 (image 0), 2) the ‘beard’ category included the percentage of men with trimmed and bushy
 293 full beards (8&9), and 3) the ‘non-beard facial hair’ category included the percentage of men
 294 in all classes of facial hair except clean-shaven and full beards (1-7).

295

FIGURE 2 HERE.

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

301

302 **2.9. Participants.** Participants were recruited through the web-based marketplace research
303 program Amazon Mechanical Turk (MTurk), which provides researchers with large non-
304 student samples (Mason & Suri, 2012). Participants were first screened for gender so that
305 only males remained in the study. After removing those who did not satisfy the selection
306 criteria, a total of 951 male participants completed the survey (Mean age = 37.47 years, $SD =$
307 12.09) remained. The survey took approximately 15 minutes to complete and participants
308 received \$1.00 USD for their time. Of the sample, 78% described themselves as White or
309 Caucasian, 9% were Black or African American, 6% were Asian, 5% were Hispanic and the
310 remaining 2% were classified as other. The majority of participants lived in the USA
311 (98.1%). The study was approved from the University of Queensland's Behavioural and
312 Social Sciences Ethical Review Committee and the School of Psychology's Ethics Review
313 Panel (Ethics Approval Number: 18-PSYCH-4G-13-JMC).

314

315 **2.10. Statistical analyses.** For Analysis 1, masculinity, dominance, and aggressiveness ratings
316 were the dependent variables in repeated-measures MANOVAs where facial masculinity
317 (very low, low, neutral, high, very high) and facial hair (bearded, clean-shaven) were entered
318 in as within-subject factors. Effect sizes are reported as eta squared (η^2). Effect sizes for post-
319 hoc Bonferroni corrected t-tests are reported as Cohen's d. We repeated the analyses using
320 Bayesian repeated measures ANOVAs. Bayesian analyses were undertaken to ascertain the
321 presence or absence of a hypothesized effect over the competing null effect. The Bayes
322 Factor (BF_{10}) provides an estimation of the strength of support a hypothesis receives relative
323 to another competing hypothesis. A BF_{10} of 1-3 is considered weak evidence, a BF_{10} of 3-10
324 is considered moderate evidence, and a BF_{10} above 10 is considered strong evidence (van
325 Doorn et al., 2019). All analyses were conducted using JASP 3.

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

342

343 **3. Results**

344 **3.1. Analysis 1: The effect of facial masculinity and beardedness on men's masculinity,**
345 **dominance and aggressiveness ratings**

346 **3.1.1. Masculinity ratings.** There was a significant main effect of facial hair on masculinity
 347 ratings (Table 1), which received strong support in Bayesian analyses (Table 2). This reflects
 348 that beards received higher masculinity ratings than clean-shaven faces ($t = 35.14, p < 0.001,$
 349 $d = 1.14$). There was also a significant main effect of facial masculinity on masculinity
 350 ratings (Table 1) that received strong support in Bayesian analyses (Table 2). Very high
 351 masculinity was judged as more masculine than all other degrees of facial masculinity (all $t \geq$
 352 $12.23, \text{ all } p \leq 0.001, d = 0.40\text{-}0.85$). High masculinity received higher masculinity ratings
 353 than medium, low, and very low masculinity (all $t \geq 9.31, \text{ all } p \leq 0.001, d = 0.30\text{-}0.75$).
 354 Medium facial masculinity was judged as more masculine than low and very low masculinity
 355 (all $t \geq 12.71, \text{ all } p \leq 0.001, d = 0.41 \text{ and } 0.65$ respectively), while low masculinity was
 356 judged as more masculine than very low masculinity ($t = 11.72, p < 0.001, d = 0.38$).

357 There was also a significant facial hair \times facial masculinity interaction (Table 1),
 358 which received strong support in Bayesian analyses (Table 2). This reflects that masculinity
 359 ratings rose linearly with both full bearded and clean-shaven stimuli (Figure 2A). Full beards
 360 received significantly higher masculinity ratings than clean-shaven faces within each level of
 361 facial masculinity. Beards were rated more masculine than clean-shaven faces for very high
 362 masculinity ($t = 30.51, p < 0.001, d = 0.99$), high masculinity ($t = 32.32, p < 0.001, d = 1.05$),
 363 medium masculinity ($t = 33.06, p < 0.001, d = 1.07$), low masculinity ($t = 33.74, p < 0.001, d$
 364 $= 1.09$), and very low masculinity ($t = 34.10, p < 0.001, d = 1.11$). Further, faces with very
 365 low masculinity and full beards received higher masculinity ratings than clean-shaven faces
 366 with very high facial masculinity ($t = 18.91, p < 0.001, d = 0.61$; Figure 2A).

367 **3.1.2. Dominance ratings.** There was a significant main effect of facial hair on dominance
 368 ratings (Table 1), received strong support in Bayesian analyses (Table 3). This reflects that
 369 beards received significantly higher dominance ratings than clean-shaven faces ($t = 28.75, p$
 370 $< 0.001, d = 0.93$). There was also a significant main effect of facial masculinity on
 371 dominance ratings (Table 1), which received strong support in Bayesian analyses (Table 3).
 372 This reflects very high masculinity was judged as more dominant than all other degrees of
 373 facial masculinity (all $t \geq 10.66, \text{ all } p \leq 0.001, d = 0.35\text{-}0.76$). High masculinity received
 374 higher dominance ratings than medium, low, and very low masculinity (all $t \geq 7.08, \text{ all } p \leq$
 375 $0.001, d = 0.23\text{-}0.65$). Medium facial masculinity was judged as more dominant than low and
 376 very low masculinity (all $t \geq 10.95, \text{ all } p \leq 0.001, d = 0.35\text{-}0.54$), while low masculinity was
 377 judged as more dominant than very low masculinity ($t = 8.24, p < 0.001, d = 0.27$).

378 There was also a significant facial hair \times facial masculinity interaction (Table 1),
 379 which received strong support in Bayesian analyses (Table 3). This reflects that dominance
 380 ratings rose linearly with both full bearded and clean-shaven stimuli (Figure 2B). Full beards
 381 received significantly higher dominance ratings than clean-shaven faces within each level of
 382 masculinity. Thus, beards were rated more dominant than clean-shaven faces for very high
 383 masculinity ($t = 23.84, p < 0.001, d = 0.77$), high masculinity ($t = 26.31, p < 0.001, d = 0.85$),
 384 medium masculinity ($t = 26.90, p < 0.001, d = 0.87$), low masculinity ($t = 27.28, p < 0.001, d$
 385 $= 0.89$), and very low masculinity ($t = 27.27, p < 0.001, d = 0.88$). The additive effect of
 386 beards on dominance ratings is also reflected in the significantly higher ratings for faces with

387 very low masculinity and full beards over very high masculinity clean-shaven faces ($t =$
388 13.74, $p < 0.001$, $d = 0.45$; Figure 2B).

389 **3.1.3. Aggressiveness ratings.** There was a significant main effect of facial hair on
390 aggressiveness ratings (Table 1) and strong support in Bayesian analyses (Table 4). Beards
391 received significantly higher aggressiveness ratings than clean-shaven faces ($t = 23.84$, $p <$
392 0.001 , $d = 0.77$). There was also a significant main effect of facial masculinity on
393 aggressiveness ratings (Table 1), which received strong support in Bayesian analyses (Table
394 4). This reflects very high masculinity was judged as more aggressive than all other degrees
395 of facial masculinity (all $t \geq 8.87$, all $p \leq 0.001$, $d = 0.29-0.55$). High masculinity received
396 higher masculinity than medium, low, and very low masculinity (all $t \geq 6.62$, all $p \leq 0.001$, d
397 $= 0.22-0.42$). Medium facial masculinity was judged as more aggressive than low and very
398 low masculinity (all $t \geq 8.67$, all $p \leq 0.001$, $d = 0.28-0.30$), while low masculinity was not
399 judged as more aggressive than very low masculinity ($t = 1.66$, $p = 0.976$, $d = 0.05$).

400 There was also a significant facial hair \times facial masculinity interaction (Table 1),
401 received strong support in Bayesian analyses (Table 4). This reflects that masculinity ratings
402 rose linearly within both full bearded and clean-shaven stimuli (Figure 2C). However, full
403 beards received significantly higher masculinity ratings than clean-shaven faces within each
404 level of masculinity. Thus, beards were rated more masculine than clean-shaven faces for
405 very high masculinity ($t = 30.51$, $p < 0.001$, $d = 0.99$), high masculinity ($t = 32.32$, $p < 0.001$,
406 $d = 1.05$), medium masculinity ($t = 33.06$, $p < 0.001$, $d = 1.07$), low masculinity ($t = 33.74$, p
407 < 0.001 , $d = 1.09$), and very low masculinity ($t = 34.10$, $p < 0.001$, $d = 1.11$). Faces with very
408 low masculinity and beards were rated higher for aggressiveness than clean-shaven faces with
409 very high facial masculinity ($t = 11.84$, $p < 0.001$, $d = 0.38$; Figure 2C).

410 **FIGURE 3 HERE.**

411 **Figure 3.** The effect of men's facial hair (full beard = black circle with solid black line and
412 clean-shaven = white circle with dotted line) and facial masculinity (60% and 30% feminised,
413 0% (i.e. unmanipulated), and 30% and 60% masculinised) on men's judgments of male
414 masculinity (A.), dominance (B.), and aggressiveness (C.). Data are the mean ratings (± 1
415 SEM). Note the rating scale on Y axis ranges from 0-100.

416

417 **3.2. Analysis 2: Predictors of men's masculinity, dominance, and aggressiveness ratings**
418 **for facial masculinity and beardedness.** We first explored correlations among the
419 psychological and morphological predictors of male dominance. Self-rated facial masculinity
420 was positively correlated with success and determination ($r = 0.179$, $p < .001$), dominance
421 and assertiveness ($r = .262$, $p < .001$), and intra-sexual jealousy ($r = 0.164$, $p < .001$), but not
422 height ($r = -.02$, $p = .53$). There was a significant negative relationship between men's height
423 and their self-reported intra-sexual jealousy, ($r = -.279$, $p < .001$), but associations were not
424 statistically significant between height and success and determination ($r = -.045$, $p = .416$) or
425 dominance and assertiveness ($r = -.035$, $p = .280$). Men's self-reported facial hair was
426 positively associated with self-reported dominance and assertiveness ($r = .119$, $p < .001$),
427 self-perceived facial masculinity ($r = .158$, $p < .001$), and with intra-sexual jealousy ($r = .065$,
428 $p = .046$), but not with height ($r = -.031$, $p = .332$). Self-reported success and determination

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

432 **FIGURE 4 HERE.**

433 **Figure 4.** The associations between psychological measures (top row: self-reported success and
 434 dedication, dominance and assertiveness) and morphological characters (bottom row: facial
 435 masculinity, height and facial hair) and men's masculinity ratings of male faces varying in facial hair
 436 (+/- 95% CI) when judging bearded (red line) and clean-shaven faces (blue line). ** < .01; *** < .001.

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

453 **FIGURE 5 HERE.**

454 **Figure 5.** The associations between psychological measures (top row: self-reported success and
 455 dedication, dominance and assertiveness) and morphological characters (bottom row: facial
 456 masculinity, height and facial hair) and men's masculinity ratings of male faces varying in facial
 457 masculinity (+/- 95% CI) when judging feminised (red line) and masculinised faces (blue line). ** <
 458 .01; *** < .001.

459 We hypothesised that men reporting higher Dominance and Assertiveness scores
 460 would assign lower ratings of dominance and aggressiveness to facial masculinity
 461 (Hypothesis 1) and beardedness (Hypothesis 2) than participants reporting lower Dominance
 462 and Assertiveness. We found no significant negative associations between judgments of
 463 facial masculinity and self-reported Dominance and Assertiveness scores. While there we
 464 report a significant interaction between stimulus beardedness and participant Dominance and
 465 Assertiveness in all three models, such that participants high in Dominance and Assertiveness
 466 rated bearded faces as more masculine (Figure 3), dominant (Figure 5), and aggressive
 467 (Figure 7). These results suggest that men are more sensitive to beards as a badge of
 468 dominance and status if they themselves report high social dominance.

469 **FIGURE 6 HERE.**

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

472 masculinity, height and facial hair) and men's dominance ratings of male faces varying in facial hair
 473 (+/- 95% CI) when judging bearded (red line) and clean-shaven faces (blue line). ** < .01; *** < .001.

474

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

486

FIGURE 7 HERE.

487 **Figure 7.** The associations between three psychological measures (top row: self-reported success and
 488 dedication, dominance and assertiveness) and three morphological characters (bottom row: facial
 489 masculinity, height and facial hair) and men's dominance ratings of male faces varying in facial
 490 masculinity (+/- 95% CI) when judging feminised faces (red line) and masculinised faces (blue line).
 491 ** < .01; *** < .001.

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

506

FIGURE 8 HERE.

507 **Figure 8.** The associations between three psychological measures (top row: self-reported success and
 508 dedication, dominance and assertiveness) and three morphological characters (bottom row: facial
 509 masculinity, height and facial hair) and aggressiveness ratings of male faces varying in facial hair (+/-
 510 95% CI) when judging bearded faces (red line) and clean-shaven faces (blue line). * < .05; ** < .001.

511

FIGURE 9 HERE.

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

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

516 4. Discussion

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

534 Converging evidence demonstrates that men's facial masculinity predicts men's intra-
535 sexual formidability (Puts, 2010; Sell et al., 2012). Men with more masculine faces have
536 greater upper body strength (Fink et al., 2007; Windhager et al., 2011), fighting ability
537 (Třebický et al., 2013, 2015, 2018a; Ziolli et al., 2015), and higher mating success (Hill et al.,
538 2013; Kordsmeyer et al., 2018) than less facially masculine men. The degree to which men
539 are sensitive to other men's secondary sexual traits, including facial masculinity, when
540 assessing their dominance may vary due to their own physical and psychological dominance
541 (Puts, 2010; Sell et al., 2012; Watkins et al., 2010a, 2010b). In the current study, we did not
542 find that men high in social dominance (Hypothesis 1) or status seeking (Hypothesis 3) were
543 less sensitive to facial masculinity when ranking male facial masculinity, dominance, or
544 aggressiveness than less dominant men (Watkins et al., 2010b). We also tested whether men's
545 physical masculinity was negatively associated with their judgments of facial masculinity
546 (Hypothesis 7). Thus, height is positively associated with men's social dominance (Puts,
547 2010), aggressiveness (Archer, 2009), and fighting ability (Sell et al., 2012). While we found
548 that height was negatively associated with judgments of male masculinised and feminised
549 faces for ratings of masculinity, dominance, and aggressiveness, the significant interaction
550 was driven by lower ratings for feminised rather than masculinised faces. This provides
551 partial support that taller men are less sensitive to cues of facial dominance in male faces, but
552 does not directly replicate past findings that height is negatively associated with dominance
553 judgments for male facial masculinity (Watkins et al., 2010a). We also found that participants
554 with higher self-reported facial masculinity gave higher ratings of dominance, masculinity,
555 and aggressiveness ratings. However, there were no associations between self-reported facial
556 masculinity and self-reported social dominance, assertiveness, or success and dedication on
557 men's judgments of male facial masculinity.

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

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

577 Compared to the body of research on intra-sexual selection and judgments of male
578 facial masculinity, fewer studies have assessed individual differences in men's dominance
579 and their judgments of male beardedness. Past research has shown that bearded men reported
580 higher aggressive sexism scores than clean-shaven men in the U.S.A and India (Oldmeadow
581 and Dixon; 2016a), but not Sweden (Hellmer & Stenson, 2016; Hellmer et al., 2018). Men
582 with facial hair report feeling more masculine (Wood, 1986) and had higher serum androgens
583 (Knussman & Christiansen, 1988) than men favouring a clean-shaven appearance. In the
584 current study, self-reported beardedness was positively associated with self-perceived facial
585 masculinity ($r = .158$) and self-reported dominance ($r = .119$). Participants who reported
586 higher scores on dominance and assertiveness personality scales also gave significantly
587 higher masculinity, dominance, and aggressiveness ratings to bearded but not clean-shaven
588 faces compared to participants lower in dominance and assertiveness. These findings
589 complement growing evidence highlighting that beards enhance intra-sexual communication
590 of masculine social dominance (Craig et al., 2019; Dixon & Vasey, 2012; Dixon et al.,
591 2017a) and provide the first evidence that facial hair is positively associated with male self-
592 perceived social dominance. Importantly, this correlation cannot determine whether socially
593 dominant men choose to grow their beards or whether keeping a beard augments men's self-
594 reported social dominance due to positive social feedback from peers. There is some evidence
595 that bearded men have higher mating success when sex ratios are more male-biased (Barber,
596 2001) and that beards (and female preferences for them) are more common in larger cities,
597 with low average incomes and high life expectancies (Dixon et al., 2017c). Future research
598 exploring the causal effects of men's grooming decisions on social dominance and mating
599 success would be valuable.

600 Comparative research among nonhuman animals can shed light on the roles of facial
601 masculinity and beards in intra-sexual communication. Researchers working on nonhuman
602 animals distinguish between the role of male weaponry and ornamentation in intra-sexual
603 competition, such that weapons are employed during direct physical confrontations whereas
604 ornaments communicate status and dominance without necessarily being associated with
605 physical formidability (McCullough et al., 2016). Weapons involved in direct competition
606 and fights are rarely false signals of male quality (Berglund et al., 1996) and may augment
607 attractiveness to females when selecting for males bearing direct benefits (Wong & Candolin,
608 2005). Our results failed to support several past studies that found associations between
609 men's intra-sexual competitiveness and judgments of male facial masculinity. This was

610 surprising as masculine facial structure is positively associated with men's upper body
611 strength (Fink et al., 2007; Windhager et al., 2011), muscularity (Holzleitner & Perrett,
612 2016), stature (Zaidi et al., 2019) and fighting ability (Třebický et al., 2015; Zilioli et al.,
613 2015). Mixed martial arts fighters with more masculine facial features are more often winners
614 than less facially masculine fighters (Třebický et al., 2015; Zilioli et al., 2015) and fighters
615 with greater anaerobic fitness are rated as better fighters (Třebický et al., 2018). Our results
616 may have differed had we included more interactive behavioural paradigms rather than
617 comparisons of self-report measures of dominance. For example, recent research in which
618 men were assigned to compete in either violent or non-violent video games revealed that men
619 who competed in violent video games were slower to retreat from a hypothetical physical
620 confrontation with a masculine looking male, and were slower to recognise threatening facial
621 expressions than participants in competing in non-violent video games (Denson et al., 2019).
622 It may be beneficial to repeat our studies using more interactive experimental approaches to
623 test whether psychologically and physically masculine men are less sensitive to masculine
624 traits.

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

651

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

653

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