

This is a pre-copyedited, author-produced PDF of an article accepted for publication in Behavioral Ecology following peer review. The version of record Watkins, C.D., et al. 2010. Taller men are less sensitive to cues of dominance in other men. *Behavioral Ecology*. 21(5): pp.943-947. is available online at: <http://dx.doi.org/10.1093/beheco/arq091>

1 **Taller men are less sensitive to cues of dominance in other men**

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18

19 **Abstract**

20 Male dominance rank, physical strength, indices of reproductive success, and
21 indices of reproductive potential are correlated with masculine characteristics
22 in many animal species, including humans. Accordingly, men generally
23 perceive masculinized versions of men's faces and voices to be more
24 dominant than feminized versions. Less dominant men incur greater costs
25 when they incorrectly perceive the dominance of rivals. Consequently, it may
26 be adaptive for less dominant men to be particularly sensitive to cues of
27 dominance in other men. Since height is a reliable index of men's dominance,
28 we investigated the relationship between own height and men's sensitivity to
29 masculine characteristics when judging the dominance of other men's faces
30 and voices. Although men generally perceived masculinized faces and voices
31 to be more dominant than feminized versions, this effect of masculinity on
32 dominance perceptions was significantly greater among shorter men than
33 among taller men. These findings suggest that differences among men in the
34 potential costs of incorrectly perceiving the dominance of rivals have shaped
35 systematic variation in men's perceptions of the dominance of potential rivals.

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48 **Introduction**

49 Sexually dimorphic traits, such as body size, are correlated with male
50 dominance rank (Espmark, 1964; Isaac, 2005; Owen-Smith, 1993; Schuett,
51 1997; Yamane et al., 2006), fighting ability (Andersson, 1994; Owen-Smith,
52 1993), physical strength (Peters & Mech, 1975), and reproductive success (Le
53 Boeuf & Reitter, 1988; McElligott, 2001; Poole, 1989; Schuett, 1997) in many
54 non-human animal species. Sexually dimorphic characteristics other than
55 body size are also correlated with male dominance rank in many species
56 (Bakker & Sevenster, 1983; Coltman et al., 2002; Rohwer and Rohwer, 1978;
57 Schafer & O'Neil Krekorian, 1983; Schaller, 1963). Collectively, findings such
58 as these suggest that sexually dimorphic physical characteristics may play an
59 important role in within-sex competition (Andersson, 1994).

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61 Among human males, facial masculinity is positively correlated with indices of
62 physical strength (Fink et al., 2007), reproductive potential (Rhodes et al.,
63 2005), and dominance rank (Mueller & Mazur, 1996). Indeed, Sell et al.
64 (2009) found that observers could accurately judge men's fighting ability and
65 physical strength from facial photographs alone, potentially reflecting the
66 association between facial masculinity and physical strength (Fink et al.,
67 2007). Masculine characteristics in men's voices (e.g., low pitch) are positively
68 correlated with men's reported reproductive success in natural fertility
69 populations (Apicella et al., 2007) and with indices of reproductive potential in
70 samples of undergraduate men (Puts, 2005). Consistent with these findings
71 that link masculine facial and vocal cues to indices of men's dominance,
72 masculinized versions of men's faces and voices are generally perceived as
73 more dominant than feminized versions (Boothroyd et al., 2007; Feinberg et
74 al., 2006; Jones et al., 2010a, 2010b; Main et al., 2009; Perrett et al., 1998;
75 Puts et al., 2006, 2007).

76

77 Since competition between males can be extremely costly (e.g., there is a
78 high risk of serious injury during fights between males, Andersson, 1994), it is
79 likely that costs associated with incorrectly perceiving the dominance of rivals
80 have shaped the mechanisms and processes that underpin perceptions of
81 dominance. Indeed, fossil record evidence suggests that aggressive conflict

82 among ancestral males may have been an important selection pressure
83 (Manson & Wrangham, 1991; Keeley, 1996), potentially leading to
84 adaptations that reduce the costs of aggressive conflicts (Sell et al., 2009).
85 This being the case, less dominant men may be particularly sensitive to cues
86 of dominance in other men, such as facial and vocal masculinity, because
87 increased sensitivity to cues of dominance would reduce the likelihood of less
88 dominant men incorrectly judging the dominance of potential rivals and,
89 consequently, would reduce the costs they might otherwise incur during ill-
90 judged conflicts with more dominant men. In other words, less dominant men
91 may associate high dominance with masculine characteristics in other men
92 more strongly than relatively dominant men do.

93

94 Height is positively correlated with men's reproductive success (e.g.,
95 Pawlowski et al., 2000), physical strength (e.g., Vaz et al., 2002), physical
96 aggression (e.g., Archer & Thanzami, 2007), fighting ability (e.g., von Rueden
97 et al., 2008), and social status (e.g., Hensley, 1993). Such findings suggest
98 that, in addition to facial and vocal masculinity, height is a reliable index of
99 male dominance (for a recent review see Buunk et al., 2008). Consequently, if
100 less dominant men are particularly sensitive to cues of dominance in rivals,
101 shorter men may be more likely to attribute dominance to masculinized
102 versions of men's faces and voices than taller men are. While there have
103 been many studies of variation in women's preferences for cues of dominance
104 in men (for reviews see Fink & Penton-Voak, 2002; Jones, DeBruine et al.,
105 2008; Thornhill & Gangestad, 2008), far less is known about the factors that
106 might influence systematic variation in men's perceptions of other men's
107 dominance.

108

109 In the current study, we investigated the relationship between men's height
110 and sensitivity to masculine characteristics when judging the dominance of
111 men's faces and voices. We predicted that male participants' height would be
112 negatively correlated with the extent to which they attributed high dominance
113 to masculine men, which would present evidence for potentially adaptive
114 systematic variation in men's perceptions of the dominance of their rivals. In
115 addition to considering the possible effects of height on perceptions of men's

116 dominance, we also investigated the relationship between men's perceptions
117 of their own dominance and sensitivity to facial and vocal cues of dominance
118 in other men.

119

120 **Methods**

121 ***Voice stimuli***

122 First, recordings of 10 men saying "Hi, I'm a student" were made using an
123 Audio-Technica AT4041 microphone in a quiet room. Recordings were made
124 in mono, using Soundforge recording software, at a sampling rate of 44.1 kHz,
125 and with 16-bit amplitude quantization. Next, we manufactured two versions of
126 each voice recording: a version with lowered voice pitch (i.e., a masculinized
127 version) and a version with raised voice pitch (i.e., a feminized version).

128

129 Masculinized and feminized versions of voices were manufactured by raising
130 and lowering pitch using the pitch-synchronous overlap add (PSOLA)
131 algorithm in Praat (Boersma & Weenink, 2007) to ± 0.5 ERBs (equivalent
132 rectangular bandwidths) of the original frequency. This PSOLA method has
133 been used successfully in other studies of human voice perception (Feinberg
134 et al., 2005, 2006, 2008a, 2008b; Jones et al., 2008b; Jones et al., 2010a;
135 Puts et al., 2006; Vukovic et al., 2008) and in studies of voice quality and
136 dominance in other mammalian species (Reby et al., 2005; Ghazanfar et al.,
137 2007). While the PSOLA method alters voice pitch, other aspects of the voice
138 are perceptually unaffected (Feinberg et al., 2005, 2008a, 2008b; Jones et al.,
139 2010a). The manipulation performed here is roughly equivalent to ± 20 Hz in
140 this particular sample, and takes into account the fact that pitch perception is
141 on a log-linear scale in comparison to the natural frequencies (i.e., Hz,
142 Traunmüller, 1990). The ERB scale was used here because of its better
143 resolution at human average speaking frequencies than the tonotopic Bark,
144 semitone, or Mel scales (Traunmüller, 1990). A manipulation roughly
145 equivalent to 20 Hz was used because it has been shown to be sufficient to
146 alter perceptions of voices in prior studies (Feinberg et al., 2005, 2006, 2008a,
147 2008b; Jones et al., 2008b; Jones et al., 2010a; Vukovic et al., 2008). Indeed,
148 manipulating the pitch of male voices using these methods has been shown to
149 reliably alter perceptions of vocal masculinity, such that voices with lowered

150 pitch are perceived to be more masculine than voices with raised pitch
151 (Feinberg et al., 2005). After manipulation, amplitudes were scaled to a
152 consistent presentation volume using the RMS (root-mean-squared) method.

153

154 This process created ten pairs of voices in total (each pair consisting of
155 raised-pitch and lowered-pitch versions of the same recording). The mean
156 fundamental frequency of the feminized versions was 142.8 Hz (SD=16.4 Hz).
157 The mean fundamental frequency of the masculinized versions was 104.6 Hz
158 (SD=15.3 Hz).

159

160 ***Face stimuli***

161 Following previous studies of systematic variation in perceptions of masculine
162 versus feminine faces (Buckingham et al., 2006; DeBruine et al., 2006, in
163 press; Jones et al., 2005, 2007, 2010b; Penton-Voak et al., 1999; Little et al.,
164 2005; Welling et al., 2007, 2008), we used prototype-based image
165 transformations to objectively manipulate sexual dimorphism of 2D shape in
166 digital face images.

167

168 Here, 50% of the linear differences in 2D shape between symmetrized
169 versions of the male and female prototypes were added to or subtracted from
170 face images of 10 young White adult men. This process creates masculinized
171 and feminized versions of the individual face images that differ in sexual
172 dimorphism of 2D shape and that are matched in other regards (e.g., identity,
173 skin color and texture, Rowland & Perrett, 1995). Examples of masculinized
174 and feminized face images are shown in Figure 1.

175

176 INSERT FIGURE 1 AROUND HERE

177

178 This process created 10 pairs of images in total, each pair consisting of a
179 masculinized and a feminized version of the same individual. Previous studies
180 have demonstrated that this method for manipulating masculinity of 2D face
181 shape affects perceptions of facial masculinity in the predicted manner
182 (DeBruine et al., 2006; Jones et al., 2007, 2010b; Welling et al., 2007, 2008).

183

184 **Procedure**

185 Fifty male participants (Mean age=20.36 years, SD=2.58 years), all of whom
186 were heterosexual undergraduate students at the University of Aberdeen,
187 took part in the study. Each participant completed two dominance perception
188 tests; one that involved judging the dominance of men's voices and another
189 that involved judging the dominance of men's faces.

190 In the voice perception test, participants listened to the ten pairs of voices
191 (each pair consisting of a masculinized and feminized version of the same
192 voice) and were instructed to indicate which voice in each pair sounded more
193 dominant. For each pair of voices, participants also indicated whether they
194 thought the more dominant voice sounded 'much more dominant', 'more
195 dominant', 'somewhat more dominant', or 'slightly more dominant' than the
196 less dominant voice. The order in which pairs of voices were played was fully
197 randomized, as was the order in which the masculinized and feminized
198 versions in each pair were played.

199 In the face perception test, participants were shown ten pairs of faces (each
200 pair consisting of a masculinized and feminized version of the same face) and
201 were instructed to indicate which face in each pair looked more dominant. As
202 in the voice perception test, participants also indicated whether they thought
203 the more dominant face in each pair appeared 'much more dominant', 'more
204 dominant', 'somewhat more dominant', or 'slightly more dominant' than the
205 less dominant face. The order in which these pairs of faces were shown was
206 fully randomized, as was the side of the screen on which the masculinized
207 and feminized versions were presented. Participants were instructed to simply
208 indicate which voice or face was more dominant, rather than judging social
209 and physical dominance separately, because Puts et al. (2006) previously
210 found that masculinizing men's voices increases perceptions of both social
211 and physical dominance.

212 In addition to completing the face and voice perception tests, each
213 participant's height was measured in centimetres (to the nearest five
214 millimetres) and each participant rated his own dominance using a 1 (not very
215 dominant) to 7 (very dominant) scale.

216 The order in which participants completed the voice perception test, the face
217 perception test, rated their own dominance, and had their height measured
218 was fully randomized across participants.

219

220 ***Initial processing of data***

221 Responses on the face and voice dominance perception tests were coded
222 using the following scale:

223

224 0 = feminized stimuli judged much more dominant than masculinized stimuli

225 1 = feminized stimuli judged more dominant than masculinized stimuli

226 2 = feminized stimuli judged somewhat more dominant than masculinized stimuli

227 3 = feminized stimuli judged slightly more dominant than masculinized stimuli

228 4 = masculinized stimuli judged slightly more dominant than feminized stimuli

229 5 = masculinized stimuli judged somewhat more dominant than feminized stimuli

230 6 = masculinized stimuli judged more dominant than feminized stimuli

231 7 = masculinized stimuli judged much more dominant than feminized stimuli

232

233 For each participant, we calculated his average dominance sensitivity score
234 on the face perception test and his corresponding score on the voice
235 perception test.

236

237 **Results**

238 ***Initial analyses***

239 One-sample t-tests comparing responses on each of the dominance
240 perception tests with what would be expected by chance alone (i.e., 3.5)
241 showed that participants perceived the masculinized stimuli to be more
242 dominant than the feminized stimuli in both the face ($t(49)=8.44$, $p<.001$,
243 $M=4.46$, $SEM=0.11$) and voice ($t(49)=12.40$, $p<.001$, $M=4.88$, $SEM=0.11$)
244 perception tests. Taller men tended to rate their own dominance higher than
245 shorter men did, although this correlation was not significant ($r=.25$, $N=50$,
246 $p=.085$).

247

248 ***Participant height and dominance sensitivity***

249 To investigate the effect of height on perceptions of dominance, scores on the
250 two dominance perception tests were first analyzed using ANCOVA [within-

251 subjects factor: *domain* (face, voice); covariates: *participant age*, *participant*
252 *height*]. This analysis revealed a significant main effect of *participant height*
253 ($F(1,47)=4.18$, $p=.046$) and no other significant effects (all $F<0.55$, all $p>.46$).

254

255 A regression analysis with *mean dominance sensitivity score* as the
256 dependent variable and both *participant age* and *participant height* as
257 predictors showed that *participant height* was negatively correlated with
258 sensitivity to cues of dominance ($\beta=-.29$, $t=-2.05$, $p=.046$, Figure 2) and
259 that there was no significant relationship between *participant age* and *mean*
260 *dominance sensitivity score* ($\beta=-.10$, $t=-0.74$, $p=.46$). An additional analysis
261 revealed no significant quadratic relationships between *mean dominance*
262 *sensitivity score* and either *participant age* or *participant height* (both $p>.16$).

263

264 INSERT FIGURE 2 AROUND HERE

265

266 ***Self-rated dominance and dominance sensitivity***

267 Next, we investigated the relationship between scores on the two dominance
268 perception tests and *self-rated dominance* using ANCOVA [within-subjects
269 factor: *domain* (face, voice); covariates: *participant age*, *self-rated*
270 *dominance*]. This ANCOVA revealed no significant effects (all $F<1.10$, all
271 $p>.30$). An additional analysis revealed no significant quadratic relationships
272 between dominance sensitivity and either *self-rated dominance* or *participant*
273 *age* (both $p>.21$).

274

275 ***Participant height, self-rated dominance and dominance sensitivity***

276 Finally, we compared the effects of *participant height* and *self-rated*
277 *dominance* on scores on the dominance perception tests in a final ANCOVA
278 [within-subjects factor: *domain* (face, voice); covariates: *participant age*,
279 *participant height*, *self-rated dominance*]. This analysis revealed a significant
280 main effect of *participant height* ($F(1,46)=4.72$, $p=.035$) and no other
281 significant effects (all $F<0.79$, all $p>.38$).

282

283 We conducted a regression analysis with *mean dominance sensitivity score*
284 as the dependent variable and *participant age*, *self-rated dominance* and

285 *participant height* as predictors. This analysis showed that *participant height*
286 was negatively correlated with sensitivity to cues of dominance ($\beta = -.32$, $t =$
287 2.17 , $p = .035$) and that there were no significant relationships between
288 *participant age* and *mean dominance sensitivity score* ($\beta = -.11$, $t = -0.77$,
289 $p = .45$) or *self-rated dominance* and *mean dominance sensitivity score*
290 ($\beta = .12$, $t = 0.80$, $p = .43$). An additional analysis revealed no significant
291 quadratic relationships between dominance sensitivity and *self-rated*
292 *dominance*, *participant age* or *participant height* (all $p > .23$).

293

294 **Discussion**

295 Previous research has demonstrated correlations between sexually dimorphic
296 physical characteristics and indices of male dominance in non-human animal
297 species (e.g., Owen-Smith, 1993; Isaac, 2005; Peters & Mech, 1975;
298 Espmark, 1964; Le Boeuf & Reitter, 1988). Other research has demonstrated
299 correlations between sexually dimorphic characteristics and indices of both
300 men's actual dominance (Archer & Thanzami, 2007; Fink et al., 2007; Mueller
301 & Mazur, 1996; Vaz et al., 2002; von Rueden et al., 2008) and their perceived
302 dominance (Boothroyd et al., 2007; Jones et al., 2010a, 2010b; Main et al.,
303 2009; Perrett et al., 1998; Puts et al., 2006, 2007). Consistent with these
304 findings, we found that men generally perceived masculinized versions of
305 men's faces and voices to be more dominant than feminized versions.

306

307 Although the men in our study generally perceived masculinized versions of
308 men's faces and voices to be more dominant than feminized versions, we also
309 observed systematic variation in men's perceptions of the dominance of other
310 men (i.e., potential rivals). As we had predicted, relatively short men were
311 more sensitive to masculine cues when judging the dominance of other men's
312 faces and voices than taller men were. Many previous studies have presented
313 evidence that height is positively correlated with indices of dominance in men
314 (for a recent review see Buunk et al., 2008). Thus, the effect of male height on
315 sensitivity to cues of male dominance that was observed in our study may
316 reflect the greater costs (e.g., increased risk of serious injury and loss of
317 status) that will be incurred by less dominant men if they incorrectly perceive
318 the dominance of rivals.

319

320 The negative correlation between height and men's sensitivity to cues of
321 dominance in potential rivals that was observed in the current study is
322 consistent with Buunk et al. (2008). When participants were asked to imagine
323 their partner flirting with a dominant male, Buunk et al. (2008) found that taller
324 men were less jealous of these male rivals than shorter men. Our findings
325 extend Buunk et al.'s work by demonstrating that men's height is related to
326 individual differences in fundamental perceptions of the dominance of rivals, in
327 addition to variation in behavioral responses that may be elicited by dominant
328 men (i.e., jealousy). Moreover, our findings raise the possibility that
329 the inverse relationship between height and men's jealousy of dominant men
330 (Buunk et al., 2008) may partly reflect systematic variation among men in their
331 sensitivity to physical cues of other men's dominance.

332

333 Although taller men tended to rate themselves as more dominant than shorter
334 men, the effect of height on dominance perception was independent of men's
335 beliefs about their own dominance. In other words, a relatively objective index
336 of men's dominance (i.e., height) was a better predictor of dominance
337 sensitivity than men's beliefs about their own dominance. This pattern of
338 results suggests that greater sensitivity to dominance among shorter men is
339 unlikely to reflect a conscious or deliberate strategy. Indeed, findings for other
340 potentially adaptive aspects of social perception (e.g., attraction to symmetric
341 individuals, Little & Jones, 2006; Perrett et al., 1999) have also demonstrated
342 this apparent dissociation between awareness and behavior (see also, e.g.,
343 Smith et al., 2009). Individual differences among men in their experience of
344 aggressive conflicts with other men (e.g., number of previous conflicts and
345 rate of success in such conflicts) may nonetheless contribute to the negative
346 association between height and men's dominance sensitivity that we
347 observed. Indeed, the nature of past experiences in aggressive conflicts
348 appears to mediate the relationship between male body size and dominance
349 rank in some non-human animal species (e.g., Schuett, 1997).

350

351 Our findings demonstrate that taller (i.e., more dominant) men are less
352 sensitive to cues of dominance in other men. Thus, our findings suggest that

353 differences among men in the potential costs of incorrectly perceiving the
354 dominance of rivals have shaped systematic variation in dominance
355 perception. Many previous studies have demonstrated potentially adaptive
356 variation in women's preferences for dominant men (Fink & Penton-Voak,
357 2002; Gangestad & Simpson, 2000; Jones et al., 2008a; Little et al., 2002). By
358 contrast with these findings for women's mate preferences, our study
359 emphasizes potentially adaptive variation in men's perceptions of other men's
360 dominance. Further research on this issue may provide important insights into
361 the mechanisms and processes through which intra-sexual selection (i.e.,
362 male-male competition) has shaped male dominance perception.

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567 **Figure 1.**

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570 **Figure 1.** Examples of masculinized (left) and feminized (right) face images

571 used to assess men's perceptions of facial dominance in our study.

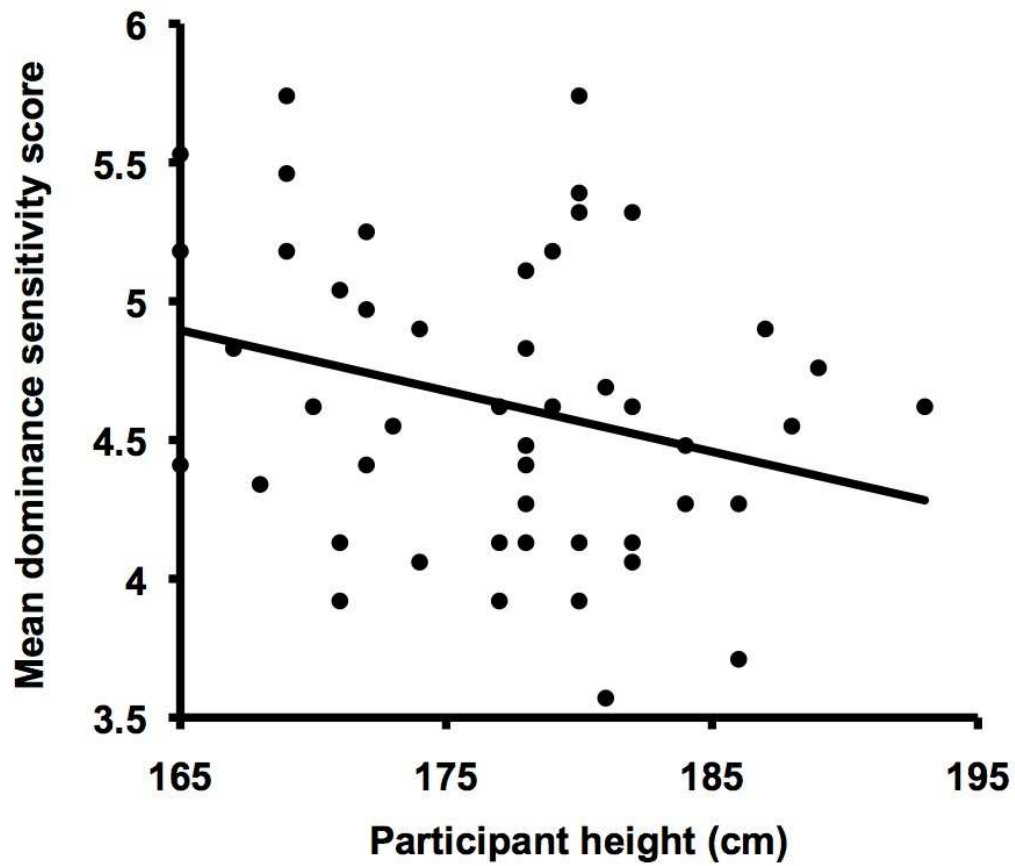
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574 **Figure 2.**

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579 **Figure 2.** The negative relationship between men's height and their sensitivity
580 to cues of dominance in other men.

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