

# Taller men are less sensitive to cues of dominance in other men

Christopher D. Watkins,<sup>a</sup> Paul J. Fraccaro,<sup>a</sup> Finlay G. Smith,<sup>a</sup> Jovana Vukovic,<sup>a</sup> David R. Feinberg,<sup>b</sup> Lisa M. DeBruine,<sup>a</sup> and Benedict C. Jones<sup>a</sup>

<sup>a</sup>School of Psychology, University of Aberdeen, Aberdeen AB24 3FX, Scotland, UK and <sup>b</sup>Department of Psychology, Neuroscience and Behavior, McMaster University, Hamilton L8S 4K1, Ontario, Canada

Male dominance rank, physical strength, indices of reproductive success, and indices of reproductive potential are correlated with masculine characteristics in many animal species, including humans. Accordingly, men generally perceive masculinized versions of men's faces and voices to be more dominant than feminized versions. Less dominant men incur greater costs when they incorrectly perceive the dominance of rivals. Consequently, it may be adaptive for less dominant men to be particularly sensitive to cues of dominance in other men. Because height is a reliable index of men's dominance, we investigated the relationship between own height and men's sensitivity to masculine characteristics when judging the dominance of other men's faces and voices. Although men generally perceived masculinized faces and voices to be more dominant than feminized versions, this effect of masculinity on dominance perceptions was significantly greater among shorter men than among taller men. These findings suggest that differences among men in the potential costs of incorrectly perceiving the dominance of rivals have shaped systematic variation in men's perceptions of the dominance of potential rivals. *Key words:* dominance, sexual dimorphism. [*Behav Ecol*]

Sexually dimorphic traits, such as body size, are correlated with male dominance rank (Espmark 1964; Owen-Smith 1993; Yamane et al. 1996; Schuett 1997; Isaac 2005), fighting ability (Owen-Smith 1993; Andersson 1994), physical strength (Peters and Mech 1975), and reproductive success (Le Boeuf and Reitter 1988; Poole 1989; Schuett 1997; McElligott et al. 2001) in many nonhuman animal species. Sexually dimorphic characteristics other than body size are also correlated with male dominance rank in many species (Schaller 1963; Rohwer S and Rohwer FC 1978; Bakker and Sevenster 1983; Schafer and O'Neil Kerkorian 1983; Coltman et al. 2002). Collectively, findings such as these suggest that sexually dimorphic physical characteristics may play an important role in within-sex competition (Andersson 1994).

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

Boothroyd et al. 2007; Main et al. 2009; Jones, DeBruine, et al. 2010; Jones, Feinberg, et al. 2010).

Because competition between males can be extremely costly (e.g., there is a high risk of serious injury during fights between males, Andersson 1994), it is likely that costs associated with incorrectly perceiving the dominance of rivals have shaped the mechanisms and processes that underpin perceptions of dominance. Indeed, fossil record evidence suggests that aggressive conflict among ancestral males may have been an important selection pressure (Manson and Wrangham 1991; Keeley 1996), potentially leading to adaptations that reduce the costs of aggressive conflicts (Sell et al. 2009). This being the case, less dominant men may be particularly sensitive to cues of dominance in other men, such as facial and vocal masculinity, because increased sensitivity to cues of dominance would reduce the likelihood of less dominant men incorrectly judging the dominance of potential rivals and, consequently, would reduce the costs they might otherwise incur during ill-judged conflicts with more dominant men. In other words, less dominant men may associate high dominance with masculine characteristics in other men more strongly than relatively dominant men do.

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

Address correspondence to B.C. Jones. E-mail: Ben.jones@abdn.ac.uk.

Received 2 March 2010; revised 20 April 2010; accepted 14 May 2010.

might influence systematic variation in men's perceptions of other men's dominance.

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

## MATERIALS AND METHODS

### Voice stimuli

First, recordings of 10 men saying "Hi, I'm a student" were made using an Audio-Technica AT4041 microphone in a quiet room. Recordings were made in mono, using Soundforge recording software, at a sampling rate of 44.1 kHz and with 16-bit amplitude quantization. Next, we manufactured 2 versions of each voice recording: a version with lowered voice pitch (i.e., a masculinized version) and a version with raised voice pitch (i.e., a feminized version).

Masculinized and feminized versions of voices were manufactured by raising and lowering pitch using the pitch-synchronous overlap add (PSOLA) algorithm in Praat (Boersma and Weenink 2007) to  $\pm 0.5$  equivalent rectangular bandwidths (ERBs) of the original frequency. This PSOLA method has been used successfully in other studies of human voice perception (Feinberg et al. 2005, 2006; Puts et al. 2006; Feinberg, DeBruine, Jones, and Little 2008; Feinberg, DeBruine, Jones, and Perrett 2008; Jones, Feinberg, et al. 2008; Vukovic et al. 2008; Jones, Feinberg, et al. 2010) and in studies of voice quality and dominance in other mammalian species (Reby et al. 2005; Ghazanfar et al. 2007). Whereas the PSOLA method alters voice pitch, other aspects of the voice are perceptually unaffected (Feinberg et al. 2005; Feinberg, DeBruine, Jones, and Little 2008; Feinberg, DeBruine, Jones, and Perrett 2008; Jones, Feinberg, et al. 2010). The manipulation performed here is roughly equivalent to  $\pm 20$  Hz in this particular sample and takes into account the fact that pitch perception is on a log-linear scale in comparison to the natural frequencies (i.e., Hertz, Traunmuller 1990). The ERB scale was used here because of its better resolution at human average speaking frequencies than the tonotopic Bark, semitone, or Mel scales (Traunmuller 1990). A manipulation roughly equivalent to 20 Hz was used because it has been shown to be sufficient to alter perceptions of voices in prior studies (Feinberg et al. 2005, 2006; Feinberg, DeBruine, Jones, and Little 2008; Feinberg, DeBruine, Jones, and Perrett 2008; Jones, Feinberg, et al. 2008; Vukovic et al. 2008; Jones, Feinberg, et al. 2010). Indeed, manipulating the pitch of male voices using these methods has been shown to reliably alter perceptions of vocal masculinity, such that voices with lowered pitch are perceived to be more masculine than voices with raised pitch (Feinberg et al. 2005). After manipulation, amplitudes were scaled to a consistent presentation volume using the root-mean-squared method.

This process created 10 pairs of voices in total (each pair consisting of raised-pitch and lowered-pitch versions of the same recording). The mean fundamental frequency of the feminized versions was 142.8 Hz (standard deviation [SD] = 16.4 Hz). The mean fundamental frequency of the masculinized versions was 104.6 Hz (SD = 15.3 Hz).

### Face stimuli

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

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

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

### Procedure

Fifty male participants (mean age = 20.36 years, SD = 2.58 years), all of whom were heterosexual undergraduate students at the University of Aberdeen, took part in the study. Each participant completed 2 dominance perception tests; one that involved judging the dominance of men's voices and another that involved judging the dominance of men's faces.

In the voice perception test, participants listened to the 10 pairs of voices (each pair consisting of a masculinized and feminized version of the same voice) and were instructed to indicate which voice in each pair sounded more dominant. For each pair of voices, participants also indicated whether they thought the more dominant voice sounded "much more dominant," "more dominant," "somewhat more dominant," or "slightly more dominant" than the less dominant voice. The order in which pairs of voices were played was fully randomized, as was the order in which the masculinized and feminized versions in each pair were played.

In the face perception test, participants were shown 10 pairs of faces (each pair consisting of a masculinized and feminized



**Figure 1**  
Examples of masculinized (left) and feminized (right) face images used to assess men's perceptions of facial dominance in our study.

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

In addition to completing the face and voice perception tests, each participant's height was measured in centimeters (to the nearest 5 millimeters) and each participant rated his own dominance using a 1 (not very dominant) to 7 (very dominant) scale.

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

### Initial processing of data

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

- 0 = feminized stimuli judged much more dominant than masculinized stimuli,
- 1 = feminized stimuli judged more dominant than masculinized stimuli,
- 2 = feminized stimuli judged somewhat more dominant than masculinized stimuli,
- 3 = feminized stimuli judged slightly more dominant than masculinized stimuli,
- 4 = masculinized stimuli judged slightly more dominant than feminized stimuli,
- 5 = masculinized stimuli judged somewhat more dominant than feminized stimuli,
- 6 = masculinized stimuli judged more dominant than feminized stimuli,
- 7 = masculinized stimuli judged much more dominant than feminized stimuli,

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

## RESULTS

### Initial analyses

One-sample *t*-tests comparing responses on each of the dominance perception tests with what would be expected by chance alone (i.e., 3.5) showed that participants perceived the masculinized stimuli to be more dominant than the feminized stimuli in both the face ( $t_{49} = 8.44$ ,  $P < 0.001$ ,  $M = 4.46$ , standard error of the mean [SEM] = 0.11) and voice ( $t_{49} = 12.40$ ,  $P < 0.001$ ,  $M = 4.88$ , SEM = 0.11) perception tests. Taller men tended to rate their own dominance higher than shorter men did, although this correlation was not significant ( $r = 0.25$ ,  $N = 50$ ,  $P = 0.085$ ).

### Participant height and dominance sensitivity

To investigate the effect of height on perceptions of dominance, scores on the 2 dominance perception tests were first analyzed using analysis of covariance (ANCOVA) (within-subjects

factor: "domain" [face and voice]; covariates: "participant age" and "participant height"). This analysis revealed a significant main effect of participant height ( $F_{1,47} = 4.18$ ,  $P = 0.046$ ) and no other significant effects (all  $F < 0.55$ , all  $P > 0.46$ ).

A regression analysis with "mean dominance sensitivity score" as the dependent variable and both participant age and participant height as predictors showed that participant height was negatively correlated with sensitivity to cues of dominance (beta =  $-0.29$ ,  $t = -2.05$ ,  $P = 0.046$ , Figure 2) and that there was no significant relationship between participant age and mean dominance sensitivity score (beta =  $-0.10$ ,  $t = -0.74$ ,  $P = 0.46$ ). An additional analysis revealed no significant quadratic relationships between mean dominance sensitivity score and either participant age or participant height (both  $P > 0.16$ ).

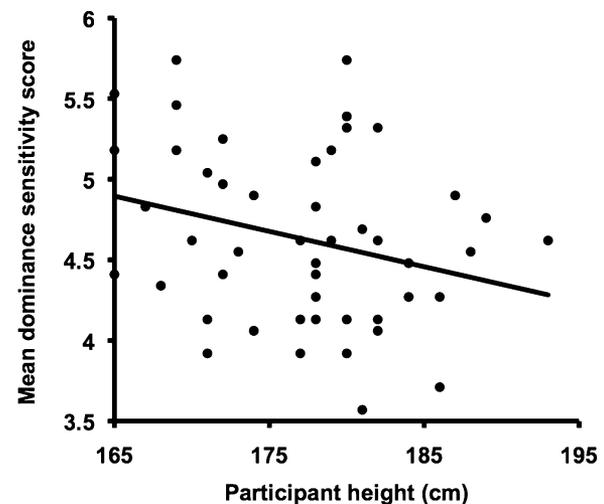
### Self-rated dominance and dominance sensitivity

Next, we investigated the relationship between scores on the 2 dominance perception tests and "self-rated dominance" using ANCOVA (within-subjects factor: domain [face and voice]; covariates: participant age and self-rated dominance). This ANCOVA revealed no significant effects (all  $F < 1.10$ , all  $P > 0.30$ ). An additional analysis revealed no significant quadratic relationships between dominance sensitivity and either self-rated dominance or participant age (both  $P > 0.21$ ).

### Participant height, self-rated dominance, and dominance sensitivity

Finally, we compared the effects of participant height and self-rated dominance on scores on the dominance perception tests in a final ANCOVA (within-subjects factor: domain [face and voice]; covariates: participant age, participant height, and self-rated dominance). This analysis revealed a significant main effect of participant height ( $F_{1,46} = 4.72$ ,  $P = 0.035$ ) and no other significant effects (all  $F < 0.79$ , all  $P > 0.38$ ).

We conducted a regression analysis with mean dominance sensitivity score as the dependent variable and participant age, self-rated dominance, and participant height as predictors. This analysis showed that participant height was negatively correlated with sensitivity to cues of dominance (beta =  $-0.32$ ,  $t = -2.17$ ,  $P = 0.035$ ) and that there were no significant relationships between participant age and mean dominance



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

sensitivity score ( $\beta = -0.11$ ,  $t = -0.77$ ,  $P = 0.45$ ) or self-rated dominance and mean dominance sensitivity score ( $\beta = 0.12$ ,  $t = 0.80$ ,  $P = 0.43$ ). An additional analysis revealed no significant quadratic relationships between dominance sensitivity and self-rated dominance, participant age, or participant height (all  $P > 0.23$ ).

## DISCUSSION

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

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

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

Although taller men tended to rate themselves as more dominant than shorter men, the effect of height on dominance perception was independent of men's beliefs about their own dominance. In other words, a relatively objective index of men's dominance (i.e., height) was a better predictor of dominance sensitivity than men's beliefs about their own dominance. This pattern of results suggests that greater sensitivity to dominance among shorter men is unlikely to reflect a conscious or deliberate strategy. Indeed, findings for other potentially adaptive aspects of social perception (e.g., attraction to symmetric individuals; Perrett et al. 1999; Little and Jones 2006) have also demonstrated this apparent dissociation between awareness and behavior (see also, e.g., Smith et al. 2009). Individual differences among men in their experience

of aggressive conflicts with other men (e.g., number of previous conflicts and rate of success in such conflicts) may nonetheless contribute to the negative association between height and men's dominance sensitivity that we observed. Indeed, the nature of past experiences in aggressive conflicts appears to mediate the relationship between male body size and dominance rank in some nonhuman animal species (e.g., Schuett 1997).

Our findings demonstrate that taller (i.e., more dominant) men are less sensitive to cues of dominance in other men. Thus, our findings suggest that differences among men in the potential costs of incorrectly perceiving the dominance of rivals have shaped systematic variation in dominance perception. Many previous studies have demonstrated potentially adaptive variation in women's preferences for dominant men (Gangestad and Simpson 2000; Fink and Penton-Voak 2002; Little et al. 2002; Jones, DeBruine, et al. 2008). By contrast with these findings for women's mate preferences, our study emphasizes potentially adaptive variation in men's perceptions of other men's dominance. Further research on this issue may provide important insights into the mechanisms and processes through which intrasexual selection (i.e., male-male competition) has shaped male dominance perception.

## FUNDING

Sixth Century Studentship from the College of Life Sciences and Medicine, University of Aberdeen, to C.D.W.; Social Science and Humanities Research Council of Canada (410-2009-2924 to D.R.F.).

## REFERENCES

- Andersson M. 1994. Sexual selection. Princeton (NJ): Princeton University Press.
- Apicella CL, Feinberg DR, Marlowe FW. 2007. Voice pitch predicts reproductive success in male hunter-gatherers. *Biol Lett.* 3:682-684.
- Archer J, Thanzami V. 2007. The relation between physical aggression, size and strength, among a sample of young Indian men. *Pers Individ Dif.* 43:627-633.
- Bakker TCM, Sevenster P. 1983. Determinants of dominance in male sticklebacks (*Gasterosteus aculeatus L.*). *Behaviour.* 86:55-71.
- Boersma P, Weenink D. 2007. Praat: doing phonetics by computer. Available from: [www.fon.hum.uva.nl/praat/](http://www.fon.hum.uva.nl/praat/).
- Boothroyd LG, Jones BC, Burt DM, Perrett DI. 2007. Partner characteristics associated with masculinity, health and maturity in male faces. *Pers Individ Dif.* 43:1161-1173.
- Buckingham G, DeBruine LM, Little AC, Welling LLM, Conway CA, Tiddeman BP, Jones BC. 2006. Visual adaptation to masculine and feminine faces influences generalized preferences and perceptions of trustworthiness. *Evol Hum Behav.* 27:381-389.
- Buunk AP, Park JH, Zurriaga R, Klavina L, Massar K. 2008. Height predicts jealousy differently for men and women. *Evol Hum Behav.* 29:133-139.
- Coltman DW, Festa-Bianchet M, Jorgenson JT, Strobeck C. 2002. Age-dependent sexual selection in bighorn rams. *Proc R Soc Lond B Biol Sci.* 269:165-172.
- DeBruine LM, Jones BC, Little AC, Boothroyd LG, Perrett DI, Penton-Voak IS, Cooper PA, Penke L, Feinberg DR, Tiddeman BP. 2006. Correlated preferences for facial masculinity and ideal or actual partner's masculinity. *Proc R Soc Lond B Biol Sci.* 273:1355-1360.
- DeBruine LM, Jones BC, Smith FG, Little AC. Forthcoming. Are attractive men's faces masculine or feminine? The importance of controlling confounds in face stimuli. *J Exp Psychol Hum Percept Perform.*
- Espmark Y. 1964. Studies in dominance-subordination relationship in a group of semi-domestic reindeer (*Rangifer tarangus L.*). *Anim Behav.* 12:420-426.
- Feinberg DR, DeBruine LM, Jones BC, Little AC. 2008. Correlated preferences for men's facial and vocal masculinity. *Evol Hum Behav.* 29:233-241.

- Feinberg DR, DeBruine LM, Jones BC, Perrett DI. 2008. The relative role of femininity and averageness in aesthetic judgments of women's voices. *Perception*. 37:615–623.
- Feinberg DR, Jones BC, Law Smith MJ, Moore FR, DeBruine LM, Cornwell RE, Hillier SG, Perrett DI. 2006. Menstrual cycle, trait estrogen level and masculinity preferences in the human voice. *Horm Behav*. 49:215–222.
- Feinberg DR, Jones BC, Little AC, Burt DM, Perrett DI. 2005. Manipulation of fundamental and formant frequencies influence the attractiveness of human male voices. *Anim Behav*. 69:561–568.
- Fink B, Neave N, Seydel H. 2007. Male facial appearance signals physical strength to women. *Am J Hum Biol*. 19:82–87.
- Fink B, Penton-Voak IS. 2002. Evolutionary psychology of facial attractiveness. *Curr Dir Psychol Sci*. 11:154–158.
- Gangestad SW, Simpson JA. 2000. The evolution of human mating: trade-offs and strategic pluralism. *Behav Brain Sci*. 23:675–687.
- Ghazanfar AA, Tureson HK, Maier JX, van Dinther R, Patterson RD, Logothetis NK. 2007. Vocal-tract resonances as indexical cues in rhesus monkeys. *Curr Biol*. 17:425–430.
- Hensley WE. 1993. Height as a measure of success in academe. *Psychol J Hum Behav*. 30:40–46.
- Isaac JL. 2005. Potential causes and life-history consequences of sexual size dimorphism in mammals. *Mamm Rev*. 35:101–115.
- Jones BC, DeBruine LM, Little AC, Conway CA, Welling LLM, Smith FG. 2007. Sensation seeking and men's face preferences. *Evol Hum Behav*. 28:439–446.
- Jones BC, DeBruine LM, Main JC, Little AC, Welling LLM, Feinberg DR. 2010. Facial cues of dominance modulate the short-term gaze-cueing effect in human observers. *Proc R Soc Lond B Biol Sci*. 277:617–624.
- Jones BC, DeBruine LM, Perrett DI, Little AC, Feinberg DR, Law Smith MJ. 2008. Effects of menstrual cycle phase on face preferences. *Arch Sex Behav*. 37:78–84.
- Jones BC, Feinberg DR, DeBruine LM, Little AC, Vukovic J. 2008. Integrating cues of social interest and voice pitch in men's preferences for women's voices. *Biol Lett*. 4:192–194.
- Jones BC, Feinberg DR, DeBruine LM, Little AC, Vukovic J. 2010. A domain-specific opposite-sex bias in human preferences for manipulated voice pitch. *Anim Behav*. 79:57–62.
- Jones BC, Little AC, Boothroyd L, DeBruine LM, Feinberg DR, Law Smith MJ, Cornwell RE, Moore FR, Perrett DI. 2005. Commitment to relationships and preferences for femininity and apparent health in faces are strongest on days of the menstrual cycle when progesterone level is high. *Horm Behav*. 48:283–290.
- Keeley LH. 1996. *War before civilization*. Oxford: Oxford University Press.
- Le Boeuf BJ, Reitter J. 1988. Lifetime reproductive success in northern elephant seals. In: Clutton-Brock TH, editor. *Reproductive success*. Chicago (IL): University of Chicago Press. p. 344–362.
- Little AC, DeBruine LM, Jones BC. 2005. Sex-contingent face after-effects suggest distinct neural populations code male and female faces. *Proc R Soc Lond B Biol Sci*. 272:2283–2287.
- Little AC, Jones BC. 2006. Attraction independent of detection suggests special mechanisms for symmetry preferences in human face perception. *Proc R Soc Lond B Biol Sci*. 273:3093–3099.
- Little AC, Jones BC, Penton-Voak IS, Burt DM, Perrett DI. 2002. Partnership status and the temporal context of relationships influence human female preferences for sexual dimorphism in male face shape. *Proc R Soc Lond B Biol Sci*. 269:1095–1100.
- Main JC, Jones BC, DeBruine LM, Little AC. 2009. Integrating gaze direction and sexual dimorphism of face shape when perceiving the dominance of others. *Perception*. 38:1275–1283.
- Manson J, Wrangham R. 1991. Intergroup aggression in chimpanzees and humans. *Curr Anthropol*. 32:369–390.
- McElligott AG, Gammell MP, Harty HC, Paini DR, Murphy DT, Walsh JT, Hayden TJ. 2001. Sexual size dimorphism in fallow deer (*Dama dama*): do larger, heavier males gain greater mating success? *Behav Ecol Sociobiol*. 49:266–272.
- Mueller U, Mazur A. 1996. Facial dominance in *Homo sapiens* as honest signaling of male quality. *Behav Ecol*. 8:569–579.
- Owen-Smith N. 1993. Comparative mortality rates of male and female kudu: the costs of sexual size dimorphism. *J Anim Ecol*. 62:428–440.
- Pawlowski B, Dunbar RIM, Lipowicz A. 2000. Tall men have more reproductive success. *Nature*. 403:156–157.
- Penton-Voak IS, Perrett DI, Castles D, Burt M, Koyabashi T, Murray LK. 1999. Female preference for male faces changes cyclically. *Nature*. 399:741–742.
- Perrett DI, Burt DM, Penton-Voak IS, Lee KJ, Rowland DA, Edwards R. 1999. Symmetry and human facial attractiveness. *Evol Hum Behav*. 20:295–307.
- Perrett DI, Lee KJ, Penton-Voak IS, Rowland DR, Yoshikawa S, Burt DM, Henzi SP, Castles DI, Akamatsu S. 1998. Effects of sexual dimorphism on facial attractiveness. *Nature*. 394:884–887.
- Peters R, Mech LD. 1975. Behavioural and intellectual adaptations of selected mammalian predators to the problem of hunting large animals. In: Tuttle RH, editor. *Socioecology and psychology of primates*. The Hague (The Netherlands): Mouton. p. 279–300.
- Poole J. 1989. Mate guarding, reproductive success and female choice in African elephants. *Anim Behav*. 37:842–849.
- Puts DA. 2005. Mating context and menstrual phase affect female preferences for male voice pitch. *Evol Hum Behav*. 26:388–397.
- Puts DA, Gaulin SJC, Verdolini K. 2006. Dominance and the evolution of sexual dimorphism in human voice pitch. *Evol Hum Behav*. 27:283–296.
- Puts DA, Hodges C, Cardenas RA, Gaulin SJC. 2007. Men's voices as dominance signals: vocal fundamental and formant frequencies influence dominance attributions among men. *Evol Hum Behav*. 28:340–344.
- Reby D, McComb K, Cargnelutti B, Darwin C, Fitch WT, Clutton-Brock T. 2005. Red deer stags use formants as assessment cues during intrasexual agonistic interactions. *Proc R Soc Lond B Biol Sci*. 272:941–947.
- Rhodes G, Simmons LW, Peters M. 2005. Attractiveness and sexual behavior: does attractiveness enhance mating success? *Evol Hum Behav*. 26:186–201.
- Rohwer S, Rohwer FC. 1978. Status signalling in Hartis sparrows: experimental deceptions achieved. *Anim Behav*. 26:1012–1022.
- Rowland DA, Perrett DI. 1995. Manipulating facial appearance through shape and colour. *IEEE Comput Graph Appl*. 15:70–76.
- Schafer SF, O'Neil Krekorian C. 1983. Agonistic behaviour of the galapagos tortoise *Geochelone elephantopus*, with emphasis on its relationship to saddle-backed shell shape. *Herpetologica*. 39:448–456.
- Schaller FB. 1963. *The mountain gorilla: ecology and behavior*. Chicago (IL): University of Chicago Press.
- Schuett GW. 1997. Body size and agonistic experience affect dominance and mating success in male copperheads. *Anim Behav*. 54:213–224.
- Sell A, Cosmides L, Tooby J, Szyner D, von Rueden C, Gurben M. 2009. Human adaptations for the visual assessment of strength and fighting ability from the body and face. *Proc R Soc Lond B Biol Sci*. 276:575–584.
- Smith FG, DeBruine LM, Jones BC, Krupp DB, Welling LLM, Conway CA. 2009. Attractiveness qualifies the effect of observation on trusting behavior in an economic game. *Evol Hum Behav*. 30:393–397.
- Thornhill R, Gangestad SW. 2008. Human oestrus. *Proc R Soc Lond B Biol Sci*. 275:991–1000.
- Trautmüller H. 1990. Analytical expressions for the tonotopic sensory scale. *J Acoust Soc Am*. 88:97–100.
- Vaz M, Hunsberger S, Diffey B. 2002. Prediction equations for hand-grip strength in healthy Indian male and female subjects encompassing a wide age range. *Ann Hum Biol*. 29:131–141.
- von Rueden C, Gurven M, Kaplan H. 2008. The multiple dimensions of male social status in an Amazonian society. *Evol Hum Behav*. 29:402–415.
- Vukovic J, Feinberg DR, Jones BC, DeBruine LM, Welling LLM, Little AC, Smith FG. 2008. Self-rated attractiveness predicts individual differences in women's preferences for masculine men's voices. *Pers Individ Dif*. 45:451–456.
- Welling LLM, Jones BC, DeBruine LM, Conway CA, Law Smith MJ, Little AC, Feinberg DR, Sharp M, Al-Dujaili EAS. 2007. Raised salivary testosterone in women is associated with increased attraction to masculine faces. *Horm Behav*. 52:156–161.
- Welling LLM, Jones BC, DeBruine LM, Smith FG, Feinberg DR, Little AC, Al-Dujaili EAS. 2008. Men report stronger attraction to femininity in women's faces when their testosterone levels are high. *Horm Behav*. 54:703–708.
- Yamane A, Doi T, Ono Y. 1996. Mating behaviors, courtship rank and mating success of male feral cat (*Felis catus*). *J Ethol*. 14:35–44.