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What makes a voice masculine: Physiological and acoustical correlates of women's ratings of men's vocal masculinity

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ABSTRACT

Men's voices contain acoustic cues to body size and hormonal status, which have been found to affect women's ratings of speaker size, masculinity and attractiveness. However, the extent to which these voice parameters mediate the relationship between speakers' fitness-related features and listener's judgments of their masculinity has not yet been investigated.

We audio-recorded 37 adult heterosexual males performing a range of speech tasks and asked 20 adult heterosexual female listeners to rate speakers' masculinity on the basis of their voices only. We then used a two-level (speaker within listener) path analysis to examine the relationships between the physiological (testosterone, height), acoustic (fundamental frequency or F0, and resonances or ΔF) and perceptual dimensions (listeners' ratings) of speakers' masculinity. Overall, results revealed that male speakers who were taller and had higher salivary testosterone levels also had lower F0 and ΔF, and were in turn rated as more masculine. The relationship between testosterone and perceived masculinity was essentially mediated by F0, while that of height and perceived masculinity was partially mediated by both F0 and ΔF.

These observations confirm that women listeners attend to sexually dimorphic voice cues to assess the masculinity of unseen male speakers. In turn, variation in these voice features correlate with speakers' variation in stature and hormonal status, highlighting the interdependence of these physiological, acoustic and perceptual dimensions.

Introduction

Male masculinity is linked to the expression of sexually selected morphological traits that emerge at sexual maturity (Andersson, 1994) and which are associated with individuals' hormonal and physical quality. For example, sexually dimorphic, masculine facial (i.e. large jaws and pronounced brows) and bodily (i.e. broad shoulders, narrow hips, tallness) traits positively correlate with health status, physical strength and self-reported mating success (Fink et al., 2007; Gallup et al., 2007; Hönekopp et al., 2007; La Batide-Alanore et al., 2003; Prokop and Fedor, 2013; Samson et al., 2000; Smith et al., 2000; Thornhill and Gangestad, 2006).

To the extent that masculinity correlates with underlying fitness, perceiving its variation is crucial when choosing a mate. Indices of masculinity in men's faces and bodies are indeed attractive to women, especially when most fertile during their menstrual cycle (Little et al., 2007; Welling et al., 2007; Zebrowitz and Rhodes, 2002) and when explicitly asked to judge for short-term mating (Little et al., 2002; Rhodes et al., 2005).

Along with facial and bodily features, the human voice is a sexually dimorphic trait: compared to women, men speak at a lower fundamental frequency (F0 — lower pitch), and lower, more closely spaced formant frequencies (deeper timbre) (Titze, 1994). These differences are at least partly affected by hormonally induced changes occurring during male puberty. Pubertal exposure to androgens causes a 60% increase in men's vocal fold length relative to women, and a corresponding decrease in its inverse acoustic correlate, mean F0 (Harries et al., 1998; Titze, 1994). Under the influence of androgens, pubertal males also grow 7% taller than women on average (Gaulin and Boster, 1985) and develop a further descended larynx, causing an increase in the lengthening of their vocal tract and thus a permanent drop in its inverse acoustic correlate, formant spacing or ΔF (Fitch and Giedd, 1999; Vorperian et al., 2009).

Because of the relationship between sexually dimorphic acoustic properties and underlying biological dimorphisms such as testosterone levels and body stature, acoustic variations amongst adult males may provide indexical cues of fitness-related features, with lower frequency (more masculine) values signalling greater fitness. For example, according to the immunocompetence handicap hypothesis, testosterone controls the development of sexual markers, while causing immunosuppression (Folstad and Karter, 1992). Thus, cues to testosterone are considered to signal better fitness because only males with strong

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immune systems can afford to express these costly traits (Folstad and Karter, 1992; Thornhill and Gangestad, 2006). Testosterone has also has been found to positively correlate with disease resistance (Rantala et al., 2012), perceived masculinity (Penton-Voak and Chen, 2004), dominance (Mazur and Booth, 1998), social status (Eisenegger et al., 2011) and mating success (Peters et al., 2008), though it is also associated with decreased parental investment (Fleming et al., 2002), higher rates of antisocial behaviour (Booth et al., 2006) and infidelity (Booth and Dabbs, 1993). Moreover, in most mammals body size has been shown to play a major role in acquiring mates and resources, as larger males are more likely to win fights (Lindenfors et al., 2007), and are more attractive to females (Charlton et al., 2007, 2012; McElligott et al., 2001). In humans, taller men have been found to be healthier (La Batide-Alanore et al., 2003; Smith et al., 2000), enjoy higher reproductive (Nettle, 2002; Pawlowski et al., 2000), academic (Hensley, 1993) and socioeconomic (Harper, 2000; Judge and Cable, 2004) success, and are more attractive to Western women (Mautz et al., 2013; Stulp et al., 2014; Swami et al., 2008; Yancey and Emerson, 2014) than shorter men, despite possible costs associated with male tallness (i.e. energy allocation trade-off between growth and reproduction: see Pisanski and Feinberg (2013) for a review). In a recent study (Kempe et al., 2013), height has also been found to positively correlate with other indices of masculinity, including greater weight and arm strength (though not with circulating testosterone). Correspondingly, taller men are consistently perceived to be more masculine than shorter men (Bogaert and McCreary, 2011; Jackson and Ervin, 1992; Little et al., 2007; Melamed, 1992).

Alongside body and facial sexually dimorphic traits, acoustic components of the voices have been shown to act as cues to testosterone and height. In particular, men's individual mean F0 has been found to negatively correlate with circulating levels of testosterone (Dabbs and Mallinger, 1999; Evans et al., 2008; Puts et al., 2012) and higher mating success rates (Apicella et al., 2007; Hodges-Simeon et al., 2011), while at least one study (Bruckert et al., 2006) has also reported a negative relationship between ΔF and testosterone, though more recent studies have failed to replicate these findings (Evans et al., 2008; Puts et al., 2012).

ΔF also seems to moderately correlate with speakers' body size, and in particular men's height (Evans et al., 2006; Greisbach, 2007; Rendall et al., 2005; but see Van Dommelen and Moxness, 1995), with taller men speaking with lower ΔF. However, there appears to be no consistent relationship between stature and F0 within sexes: while two studies have reported significant correlations between height and F0 (Graddol and Swann, 1983; Puts et al., 2012), other studies have failed to identify such a relationship (e.g. Evans et al., 2006; Künzel, 1989; Rendall et al., 2005; Sell et al., 2010; Van Dommelen and Moxness, 1995).

If vocal frequencies signal hormonal (i.e. testosterone levels) and physical (i.e. height) attributes of speakers, attending to such acoustic cues may have important consequences when assessing potential mates. Indeed, psychoacoustic studies (where voice frequencies are artificially manipulated) report that pronounced sexually dimorphic (more masculine) features in men's voices positively affect women's masculinity ratings (Feinberg et al., 2005, 2006, 2008; Jones et al., 2010), as also shown for men's faces and bodies (Feinberg et al., 2008; Little et al., 2002, 2007). Moreover, in line with research on facial and bodily traits (Feinberg et al., 2008; Johnston et al., 2001; Little et al., 2002, 2007), preferences for masculine voices are strongest when the benefits of choosing more masculine mates outweigh the costs, such as when women are at the peak of their fertility during their menstrual cycle and when rating men as short-term rather than long-term mating partners (Feinberg et al., 2006; Puts, 2005).

However, the complex relationships between fitness-related, acoustic and perceived dimensions of males' masculinity remain under-investigated. The present study tests the hypothesis that the natural variation in sexually dimorphic voice cues (F0 and ΔF) of male speakers mediates the effects of their fitness-related characteristics (testosterone and height) on masculinity attributions made by women listeners. More specifically, in line with most previous research we expect F0 to mainly mediate between testosterone and perceived masculinity: higher testosterone men are expected to speak with lower F0 and be perceived as more masculine than their lower-testosterone counterparts. We also expect ΔF to mainly mediate between height and perceived masculinity: taller men are expected to speak with lower ΔF and in turn be perceived as more masculine than their shorter counterparts. However, given previous reports of negative correlations between testosterone and ΔF as well as between height and F0, we investigate all possible relationships amongst height, testosterone, F0, ΔF, and perceived masculinity.

Methods

Participants

We recorded voices from 37 self-reported heterosexual men with no history of chronic diseases or hormonal abnormalities, all native speakers of British English and aged 20 to 25 ($M = 20.6$, $SD = 1.7$). None were currently suffering from any conditions that might affect their voice (e.g. colds, sore throats). Listeners were 20 undergraduate female students from the University of Sussex, Brighton (UK), aged 20 to 25 ($M = 21.8$, $SD = 1.5$). All women were self-reported heterosexuals, with no history of hearing impairments and with British English as their first language. All participants gave their written informed consent prior to taking part in the production and perception experiments. Approval for both procedures was granted by the School of Life Sciences Research Governance Committee (Certificates of approval: DRVC0409 and DRVC0711).

Physical masculinity

Speakers were individually audio-recorded in a soundproofed booth at the University of Sussex. Prior to the recording of their voices, participants' body height was measured to the nearest 0.1 cm using a Seca Leicester stadiometer, from the top of the participant's head to the soles of his feet (shoes off and feet together), with the participant standing erect and looking straight ahead. Saliva samples were taken from speakers immediately after the recordings. Participants were asked to confirm that they had not eaten, drank, chewed gum or brushed their teeth for at least 30 min before sampling, and were asked to rinse their mouth for 10 s prior to collection. Collection was performed using a *Salimetrics Oral Swab* (SOS) under the front of the speakers' tongue: speakers kept the swab in their mouth for three minutes (without chewing it), and then placed it in its plastic storage tube, without touching the swab with their hands. Samples were stored in a freezer at −20 °C and sent to Salimetrics for testosterone analysis via immunoassay. All assays passed quality control.

All saliva collections were carried out between 9 am and 11 am, to control for the effect of diurnal variation in F0 and testosterone levels (Evans et al., 2008). Range, means and standard deviations for body height and salivary testosterone levels across the 37 speakers are reported in Table 1.

Table 1
Ranges, means and standard deviations ($N = 37$) for the physical measures (height, testosterone), acoustic parameters (F0, ΔF) and perceived masculinity ratings across speech types.

Measures	Range	Mean	SD
Height(cm)	170.50–190.10	180.10	4.80
Testosterone (pg/mL)	87.10–253.25	153.60	40.69
F0 (Hz)	81.61–128.36	112.1	13.67
ΔF (Hz)	957.24–1073.54	1008	32.87
Perceived masculinity	1–7	4.95	1.52