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Voice pitch alters mate-choice-relevant perception in hunter–gatherers

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In humans, voice pitch is thought to be a cue of underlying quality and an important criterion for mate choice, but data from non-Western cultures have not been provided. Here we test attributions to and preferences for voices with raised and lowered pitch in hunter–gatherers. Using a forced-choice playback experiment, we found that both men and women viewed lower pitched voices in the opposite sex as being better at acquiring resources (e.g. hunting and gathering). While men preferred higher pitched women's voices as marriage partners, women showed no overall preference for voice pitch in men. However, women who were currently breastfeeding had stronger preferences for higher pitched male voices whereas women not currently breastfeeding preferred lower pitched voices. As testosterone is considered a costly signal associated with dominance, heritable immunity to infection and low paternal investment, women's preferences potentially reflect a trade-off between securing good genes and paternal investment. Men's preferences for higher pitched female voices are probably due to an evolved preference for markers of fecundity, reflected in voice pitch.

Keywords: vocal attractiveness; attributions; hunter–gatherers; voice pitch

1. INTRODUCTION

Voice pitch, similar to other phenotypic features such as faces, may be an indicator of underlying mate quality in humans (Feinberg 2008). Vocal attractiveness is correlated with body attractiveness (Hughes *et al.* 2004) and facial attractiveness in both men (Saxton *et al.* 2006) and women (Collins & Missing 2003). The relationship between facial and vocal attractiveness in men may be mediated by testosterone's masculinizing effects across different modalities. Producing a low-pitched voice in men is thought to be costly, since testosterone, which lowers voice pitch during puberty, is associated with suppressed immune function (Folstad & Karter 1992; Chen & Parker 2004) and risky social and sexual behaviour (Archer 2006). Voice pitch in men, due to its association with testosterone, may provide a signal of immunocompetence and genetic quality (Zahavi 1975; Folstad & Karter 1992) and dominance (Mazur & Booth 1998). Indeed, it has been found that in Hadza hunter–gatherers, men with lower pitched voices have greater reproductive success compared with their higher pitched counterparts (Apicella *et al.* 2007*a*). In addition, both men and women use male voice pitch that is used to gauge dominance (Feinberg *et al.* 2006; Puts *et al.* 2006, 2007). Given these findings, it is not surprising that women generally prefer men with more masculine or lower pitched voices (Collins 2000; Feinberg *et al.* 2005, 2008*a*).

In women, high voice pitch may signal low testosterone and/or high oestrogen levels (Feinberg 2008). Women's voices are judged more attractive mid-cycle (Pipitone & Gallup 2008) and voice pitch increases as women near ovulation (Bryant & Haselton 2008) when oestrogen levels are high. Higher pitched female voices are associated with attributions of femininity (Feinberg *et al.* 2008*b*) and youth (Collins & Missing 2003) although they are more closely tied to femininity (Feinberg *et al.* 2008*b*). Research on men's preferences for vocal dimorphism in women has found that they prefer more feminine or higher pitched voices (Collins & Missing 2003; Feinberg *et al.* 2008*b*).

To date, little work on vocal attributions and preferences has been conducted in non-Western populations where exposure to media and influences from other cultures are limited. Here we test attributions and preferences for vocal dimorphism in the Hadza, an isolated and evolutionarily relevant population of hunter–gatherers. Specifically, we were interested in whether voice pitch affects attributions individuals make about a male speaker's ability to hunt and a female speaker's ability to gather. We predict that lower pitched voices will be associated with the perception of greater hunting ability in men and greater gathering ability in women. The basis for this prediction is the intuition that performance in these activities, which are strenuous, labour intensive and require strength and muscularity, may be androgen dependent. Voice pitch may then be used as a signal of androgen exposure.

In this study, we also test Hadza vocal dimorphism preferences when choosing a marriage partner. Although Hadza men value voice pitch in women, they also place considerable importance on fecundity (Marlowe 2004) and as a result, they should prefer higher pitched voices in women when choosing for a mate. This prediction is consistent with previous findings using Western samples. We make no prediction in regard to women's preferences for voice pitch when choosing for a marriage partner. While women are generally found to prefer lower pitch

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voices in men, studies also demonstrate that women prefer more feminine male voices as long-term partners (Puts 2005), at non-fertile menstrual cycle phases (Puts 2005; Feinberg *et al.* 2006) and when using hormonal contraceptives (Feinberg *et al.* 2008*a*). Each of these situations is also associated with preferences for facial femininity and increased male investment (Feinberg 2008).

2. MATERIAL AND METHODS

(a) *Participants*

The Hadza occupy remote savannah–woodland areas in northern Tanzania around Lake Eyasi and subsist on game killed with bow and arrow and foraged foods such as berries, baobab fruit and tubers. They are approximately 1000 in number and live in camps of approximately 30 individuals. The majority of Hadza are monogamous although approximately 4 per cent of men have two wives. Although parents may have some influence over the choice of marriage partners, individuals can freely choose their spouses. Preference data were gathered from participants in eight different Hadza camps and interviewed in private by one of the authors (C.L.A.). All interviews were conducted in Swahili as the Hadza are fluent in it. Raters included 46 Hadza men (aged 19–59, mean = 37.27, s.d. = 11.54) and 42 Hadza women (aged 18–47, mean = 31.45, s.d. = 7.87). Of these women, 20 reported that they were not currently breastfeeding, 19 reported that they were currently breastfeeding and 3 women did not report these data.

(b) *Stimuli manufacture*

The UK (Feinberg *et al.* 2005, 2006, 2008*a*) and Hadza (Apicella *et al.* 2007*a*) voices were recorded using identical methods to prior studies where words and sentences of neutral content were used. Hadza voices were collected in a distant camp from where preference data were collected. Hadza voices were recorded in private, by one of the authors (C.L.A.), inside a landrover. Participants were instructed to speak the Swahili word *hujambo*, which loosely translates to hello in English, into a microphone. There was no indication that the voices were recognized by any participants. Voices were raised and lowered in pitch, independently of other acoustic vocal features using Praat software and the pitch-synchronous overlap add algorithm. Voices were raised ± 0.5 equivalent rectangular bandwidth (ERB), which is roughly equivalent to a ± 20 Hz manipulation at a centre frequency of 120 ± 20 Hz and ± 0.5 ERB manipulations have been used in many previous studies and are adequate to alter voice preferences (Feinberg *et al.* 2005, 2006, 2008*a*; Jones *et al.* 2008). Examples of voice pitch manipulations for the Hadza and UK voices are available as electronic supplementary material. Here, the ERB scale was used so that manipulations at different centre frequencies would be more perceptually equivalent than Hz, semitone, mel and bark scales (Traunmuller 1990; Stevens 1998). Descriptive statistics on acoustics are highlighted in table 1.

(c) *Procedure*

Following other studies on voice preferences, participants were presented with five pairs of voices from the UK and five pairs of voices from the Hadza in a two-alternative forced-choice paradigm. Each pair consisted of the same voice with both raised and lowered pitch versions at a constant volume. Participants chose which of each pair they preferred as a marriage partner. Specifically, participants were asked which individual they would like to marry. In addition, men chose which voice out of each pair of women's voices would be a better gatherer and women chose which voice out of each pair of men's voices would be a better hunter. All orders (presentation within and between pairs of voices, and order of questions) were randomized. Participants were allowed to listen to voices as often as they wanted before making decisions.

Table 1. Descriptive statistics of voice pitch after manipulations.

	feminized (Hz)	masculinized (Hz)	feminized (ERB)	masculinized (ERB)
mean pitch	146.90	109.03	4.15	3.21
s.d. of pitch	17.75	17.73	0.41	0.43

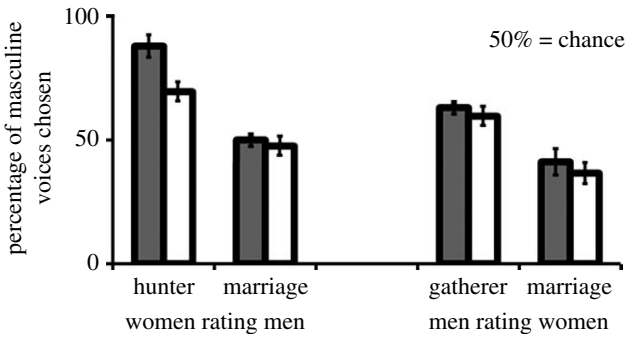

Figure 1. Attributions to and preferences for voices with raised and lowered pitch. Filled bars, Hadza; open bars, UK.

3. RESULTS

(a) *Men rating women*

Hadza men judged the lower pitch UK ($t(44) = 2.50$, $p = 0.016$) and Hadza ($t(44) = -2.89$, $p = 0.006$) voices to be better gatherers. While higher pitch female European voices were chosen significantly more as marriage partners ($t(44) = 3.61$, $p = 0.001$), the preference for higher pitch female Hadza voices as marriage partners only neared significance ($t(44) = 1.97$, $p = 0.055$). Age of raters did not predict any responses (all Pearson's $r < 0.190$, all $p > 0.207$). On average, Hadza men preferred women with higher pitched voices as marriage partners to women with lower pitched voices ($t(44) = 3.27$, $p = 0.002$). Figure 1 displays these results.

(b) *Women rating men*

Hadza women selected both lower pitch male European ($t(41) = 5.09$, $p < 0.0001$) and Hadza ($t = 14.71$, $p < 0.0001$) voices as better hunters compared with higher pitch male voices. Women did not, however, exhibit a general preference for voice pitch for European ($t(41) = -4.24$, $p = 0.674$) or Hadza ($t(41) = 0$) voices when choosing a marriage partner. Age of raters did not significantly predict any responses (all Pearson's $r < 0.211$, all $p > 0.179$).

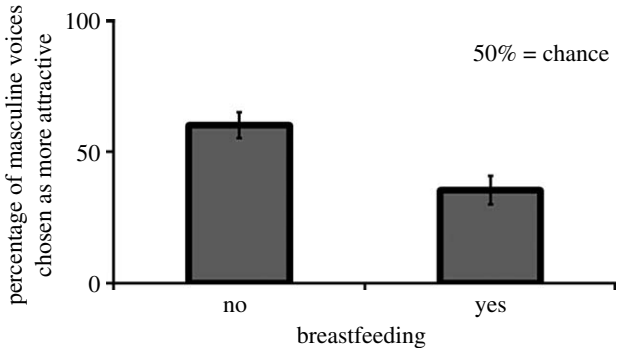

Figure 2. Breastfeeding predicts women's preferences for raised and lowered pitch in men's voices.

(c) *Exploratory analysis*

As recent reviews and empirical papers highlight the necessity to consider individual differences in voice preferences (Feinberg *et al.* 2005, 2006, 2008*a*; Puts 2005; Feinberg 2008), we investigated individual differences in women's preferences further. As there was no significant difference in women's preferences for masculinity in the Hadza and UK voices (paired sample $t(41) = -0.374$, $p = 0.70$), percentage of all masculine voices chosen was used in subsequent analyses. A univariate ANOVA (dv = percentage of masculine voices chosen; between-subject factor = breastfeeding (no/yes); covariate = age) demonstrated that breastfeeding, strongly predicted women's vocal masculinity preferences (model: $F_{2,36} = 7.81$, $p = 0.02$; breastfeeding: $F_{2,36} = 14.34$, $p < 0.0001$), independently of age ($F_{2,36} = 0.486$, $p = 0.49$). Independent sample *t*-tests revealed significant differences in marriage preferences for voice pitch between women who were breastfeeding compared with women who were not for both Hadza ($t = -3.17$; d.f. = 37; $p = 0.003$; equal variances assumed) and European ($t = -3.36$; d.f. = 37; $p = 0.002$; equal variances assumed) male voices. That is, the mean percentage of masculine Hadza and European voices chosen as a marriage partner for women who are breastfeeding is lower than that for women who were not breastfeeding (figure 2).

4. DISCUSSION

Lower pitched voices in men and women are associated with greater hunting and gathering abilities, respectively. Hunting and gathering are physically challenging and labour intensive, and thus require strength and muscularity. We speculate that the perceptual link between lower voice pitch and increased foraging ability is due to testosterone's joint effect on voice pitch and muscle mass and strength. Through the lengthening and thickening of the vocal folds, which are rich in androgen receptors, men's voice pitch is lowered at puberty (Titze 1994; Jenkins 1998). Experiments with animals demonstrate a positive dose–response relationship of androgens on laryngeal growth (Beckford *et al.* 1985). Voice pitch is also negatively associated with circulating testosterone in adult men (Dabbs & Mallinger 1999) and in boys during late adolescence (Pedersen *et al.* 1986). While testosterone is not associated with lower pitch in boys during puberty, testes volume is (Harries *et al.* 1997). Evidence that testosterone also lowers women's voice pitch also exists (Van Borsel *et al.* 2000). Importantly, testosterone, through protein catabolism, also promotes muscularity (Griggs *et al.* 1989). Indeed, there is a large literature linking testosterone with increased muscle mass and strength and most convincingly, testosterone dose-dependent changes in muscle size, strength and power have been found (Bhasin *et al.* 2001). Thus, it is not surprising that studies have implicated increased androgen levels with increased physical performance in both men and women (Peltenburg *et al.* 1984; Constantini & Warren 1995; Rickenlund *et al.* 2003). Testosterone may also increase performance via its effect on both confidence (Wrangham 1999) and increased competitiveness (Mehta & Josephs 2006).

We do not know whether men with lower pitched voices are actually better hunters since this association between voice pitch and perception of hunting ability could arise via multiple pathways. For example, hunting ability in foragers is positively correlated with reproductive success (Kaplan & Hill 1985) and men with lower pitched voices have higher reproductive success compared with men with higher pitched voices (Apicella *et al.* 2007*a*) so the association between hunting and voice pitch could arise via pure observation of offspring count. An alternative explanation for the observed relationship between lower voice pitch and increased food acquisition ability is the association of both variables with greater height. However, there is no evidence linking voice pitch to body size in humans (see Fitch 2000 for review). In our sample of Hadza, pitch does not predict height in either men ($\beta = -0.06$; $p = 0.68$) or women ($\beta = -0.003$; $p = 0.98$), holding age constant. When age is removed as a control, the relationship remains unchanged. This is not surprising since the vocal folds comprise soft tissue and can grow independently of the rest of the body. For instance, in the face of testosterone deficiency, men's voices do not lower and muscle mass remains lean but bone growth continues under the influence of growth hormone. Also, there is no evidence to suggest that increased stature is positively associated with resource acquisition in hunter–gatherers. In fact, among !Kung San foragers of southern Africa, shorter men are more successful hunters over the course of the lifetime compared with taller men (Lee 1979). Finally, there is no evidence that people misuse pitch as a cue to body size when making mate-choice-relevant decisions in Western societies (Feinberg *et al.* 2005) although we cannot be sure that this did not occur in this current study.

Although increased testosterone may be beneficial to women for successful acquisition of food resources, it may be at the expense of reproduction. In the light of this, and consistent with the findings in Western studies (Collins & Missing 2003; Feinberg *et al.* 2008*b*), we found that men preferred women with higher pitched voices as marriage partners. Although gathering is an important quality for men when seeking a partner, markers of fecundity such as femininity and youth, both cued by high voice pitch are apparently more important when choosing for a mate. One explanation may be that marrying the best gatherer does not increase a man's reproductive success as much as marrying a woman with greater reproductive value and/or a hormonal profile that signals fecundity. This is further bolstered by the fact that Hadza foraging returns are shared in an egalitarian fashion within camps and thus it is unlikely that a given child will suffer greatly if his/her mother is not as skilled at gathering resources.

This assertion has yet to be examined. An alternative explanation for men's preferences for women with higher pitched voices is that they perceive them to be more nurturing and better at child care. However, if youth and pitch are positively correlated, then a high-pitched voice may instead signal inexperience in mothering ability. This is an interesting topic for future research.

Although women perceive men with lower pitched voices to be better hunters, we found that they showed no preference for voice pitch when choosing for marriage partners. Since approximately half of our sample consisted of women breastfeeding, we examined whether this lack of general preference could be explained by variation in women's preferences by reproductive state. We found that women who are breastfeeding preferred higher pitched voices for marriage partners while women not breastfeeding preferred lower pitched voices. Studies suggest that women display strategic shifts in masculinity preferences, depending on the balance between seeking men who exhibit high testosterone levels and possibly good genes but who may be less likely to invest in relationships and offspring, and seeking men who have less testosterone, but may be more willing to invest (Gangestad *et al.* 2005). Thus, preferences shift towards resource acquisition during times when the benefits of investment outweigh the benefits of enhanced immunocompetence or good genes and dominance (Jones *et al.* 2005*a*).

Breastfeeding is a metabolically costly activity that often results in a negative energy balance for the mother and a period of lactational amenorrhoea (Ellison 2003). In the Hadza, male provisioning is critical during this time (Marlowe 2003). While Hadza women's food returns decrease when they have nurslings, their mates' food returns make up for this reduction (Marlowe 2003). Accordingly, during lactation women should value traits in men that signal a willingness to invest since investment at this time is crucial. This result is consistent with the finding that women exhibit stronger preferences for femininity in men's faces during times in the menstrual cycle when conception is unlikely (Penton-Voak *et al.* 1999; Johnston *et al.* 2001; Jones *et al.* 2005*a*). Also, women using hormonal contraceptives (most often progesterone based) prefer more feminine voices and faces, whereas women not using hormonal contraceptives prefer more masculine voices and faces (Feinberg *et al.* 2008*a*). We know of no study that has investigated whether masculinity preferences for long-term mates differ as a function of whether the woman is lactating, although studies have demonstrated that pregnant women display stronger preferences for perceived health (Jones *et al.* 2005*a*) and symmetry (Little *et al.* 2007) in faces, compared with non-pregnant women.

It has been proposed that progesterone may be a hormone associated with increases in femininity preferences (Jones *et al.* 2005*a*), given that pregnancy, oral contraceptives and the luteal menstrual-cycle phase are all characterized by higher progesterone levels and decreased fecundity (Dunson *et al.* 1999; Wilcox *et al.* 2000). However, the hormonal profile associated with lactation is marked by lowered progesterone and oestrogen. Prolactin and oxytocin, hormones elevated during lactation, also have known psychological and behavioural effects. For instance, sexual appetence is reduced in response to elevated prolactin levels (Krüger *et al.* 2002) while anxiety and depression are increased (Kellner *et al.* 1984). Elevated oxytocin has been linked to increased maternal bonding (Feldman *et al.* 2007), trust (Kosfeld *et al.* 2005) and reduced anxiety (Kirsch *et al.* 2005). Future research should investigate potential hormonal influences in mating preferences. One limitation of this study is that we did not collect hormonal profiles for the women in our study and so we cannot examine their association with masculinity preferences nor can we be sure that some of the women breastfeeding in our sample were not cycling. Finally, it is possible that changes in preferences are not hormonally mediated and instead occur owing to social feedback, rational choice or even a preference for pitch indicative of infant-directed speech.

Worth noting is the finding that preferences were not contingent upon the raters understanding the language heard. In other words, voice preferences were present when Hadza rated voices speaking English. However, voice-pitch dependent preferences for cues to social interest do not surface when reversed speech is used (Jones *et al.* 2008). In other words, evolutionarily relevant preferences for voice pitch may transcend language barriers, but not for sounds that are humanly impossible to produce (i.e. reversed speech). This suggests that hearing natural human sounds supersedes comprehension when ascribing evolutionarily relevant attributions to speech.

In conclusion, this is the first cross-cultural study of preferences for voice pitch. The overall results of this study suggest that Hadza and Western preferences for voice pitch are not dissimilar and when they do diverge, they diverge in an evolutionarily congruent fashion. Future research with the Hadza will examine whether actual voice pitch is related to hunting and gathering abilities. Since the Hadza are an isolated and evolutionarily relevant population, this study lends further support for voice preferences being evolved adaptations for mate selection rather than an artefact of arbitrary cultural values and ideals. Nevertheless, experience may play an important role in voice preferences as has been demonstrated for face preferences (Little & Mannion 2006; Apicella *et al.* 2007*b*; Jones *et al.* 2007).

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