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Voice pitch predicts reproductive success in male hunter-gatherers

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The validity of evolutionary explanations of vocal sexual dimorphism hinges upon whether or not individuals with more sexually dimorphic voices have higher reproductive success than individuals with less dimorphic voices. However, due to modern birth control methods, these data are rarely described, and mating success is often used as a second-rate proxy. Here, we test whether voice pitch predicts reproductive success, number of children born and child mortality in an evolutionarily relevant population of hunter-gatherers. While we find that voice pitch is not related to reproductive outcomes in women, we find that men with low voice pitch have higher reproductive success and more children born to them. However, voice pitch in men does not predict child mortality. These findings suggest that the association between voice pitch and reproductive success in men is mediated by differential access to fecund women. Furthermore, they show that there is currently selection pressure for low-pitch voices in men.

Keywords: voice pitch; reproductive success; mating

1. INTRODUCTION

Voice pitch, a sexually dimorphic trait, is the perceptual correlate of vocal fundamental frequency. Most studies have found that women find lower pitch male voices to be more attractive (Collins 2000; Feinberg *et al.* 2005*a*, 2006; Saxton *et al.* 2006) and judge them to be more dominant, older, healthier and more masculine (Collins 2000; Feinberg 2004; Feinberg *et al.* 2005*a*, 2006; Puts 2005), while men find higher pitch voices in women to be more attractive, subordinate, feminine, healthier and younger (Collins & Missing 2003; Feinberg 2004; Feinberg *et al.* 2005*b*, in press). Furthermore, women's preferences for low-pitch voices in men are greater in the fertile phase of the menstrual cycle (Puts 2005; Feinberg *et al.* 2006) and when judging for short-term sexual relationships (Puts 2005), suggesting that low voice pitch, like other masculine traits, may signal mate quality (Folstad & Karter 1992; Feinberg *et al.* 2005*a*,*b*). Although studies have found that high testosterone levels predict low voice pitch in adult men (Dabbs & Mallinger 1999; Bruckert *et al.* 2006), and that voice pitch is causally linked to pubertal testosterone levels (Harries *et al.* 1998) and predictive of increased mating success (Hughes *et al.* 2004), there are no studies in humans that link it directly to reproductive success. The purpose of this study is to examine the effect of voice pitch on reproductive outcomes in an evolutionarily relevant natural fertility population of hunter-gatherers.

2. MATERIAL AND METHODS

The Hadza are a population of hunter-gatherers who occupy a savannah woodland habitat in Tanzania. They number approximately 1000. Women dig for tubers and gather fruits, while men mainly collect honey and hunt animals. Marriages are not arranged, so both sexes are free to choose their spouses, though the approval of their parents is often sought. The Hadza are mostly monogamous although approximately 4% of men have two wives (Marlowe 2003). The divorce rate is fairly high (Blurton-Jones *et al.* 2000), so the mating system can be best described as serial monogamy. Approximately 20% of Hadza stay married to the same person their whole life, and divorce when it occurs is often the result of women not tolerating men's extramarital affairs (Marlowe 2004). Women's extramarital affairs appear to be mostly the result of women deciding to take new husbands when their old husbands leave camps for extended periods of time (Marlowe 2004). Nine different Hadza camps were visited for this study. All adults present in each camp, barring the very old, were invited to participate and all agreed. The sample included 49 men between the ages of 19–55 ($M=38.18$; s.d.$=11.38$) and 52 women between the ages of 18–53 ($M=32.71$; s.d.$=9$).

We collected voice recordings and self-reported reproductive histories from all participants. Interviews were conducted privately, in Swahili, by C. L. Apicella with the help of a Tanzanian research assistant. Each participant was asked to provide the names of all children born to them and report whether they were alive or dead. Participants were also instructed to speak into a microphone the word 'hujambo' which loosely translates to 'hello' in English. Voices were recorded inside a Land Rover with a Seinnheiser MKH-60 microphone and encoded in mono directly onto computer hard disk, using Sonic Foundry's Sound Forge at 44.1 kHz sampling rate and 16-bit quantization, and saved as uncompressed 'wav' files. Fundamental frequency, the acoustic correlate of voice pitch, was analysed using Praat software and measured using Praat's (Boersma & Weenink 2007) autocorrelation algorithm using techniques described elsewhere (Feinberg *et al.* 2005*a*). Anthropometrics including height, weight and upper-arm muscle mass were also collected but are not reported here, since they do not predict any reproductive outcomes in either sex after controlling for age, and did not significantly increase the r^2 values in the models reported below.

3. RESULTS

Multivariate regressions, controlling for age, were used for all analyses (for review of multivariate techniques see Licht (1995)). A standard test of normality for the residuals in each model presented below fails to reject the null, hence we use standard ordinary least squares inference for all tests. Descriptive statistics of voice pitch, reproductive success (number of living children), number of children born, number of children died and child mortality rate (number of children died/number of children born) are included in table 1. Voice pitch was not found to be a significant predictor of women's reproductive success ($\beta=-0.058$; $p=0.678$), number of children born ($\beta=-0.111$; $p=0.375$), number of children died ($\beta=0.023$; $p=0.869$) or mortality rate ($\beta=0.215$; $p=0.148$) after controlling for age. However, there was a significant effect for voice pitch, controlling for age, as a predictor of men's reproductive success ($\beta=-0.322$; $p=0.006$). In other words, men

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Table 1. Summary statistics of variables used in analyses.

	reproductive success	no. of children born	no. of children died	mortality rate	voice pitch
men	$M=3.00$; s.d.$=2.58$; $N=51$	$M=4.8$; s.d.$=3.76$; $N=52$	$M=1.92$; s.d.$=1.96$; $N=51$	$M=0.450$; s.d.$=0.287$; $N=44$	$M=115.76$; s.d.$=19.75$; $N=53$
women	$M=2.42$; s.d.$=1.97$; $N=52$	$M=3.56$; s.d.$=2.49$; $N=52$	$M=0.962$; s.d.$=1.15$; $N=52$	$M=0.273$; s.d.$=0.322$; $N=49$	$M=209.71$; s.d.$=36.76$; $N=54$

with low voice pitch have more surviving children (figure 1). This model explained approximately 42% of the variance in men's reproductive success ($r^2=0.418$; $F=16.85$; d.f.$=47$; $p<0.001$). While voice pitch in men did not predict the number of their children who died ($\beta=-0.052$; $p=0.692$) or child mortality rate ($\beta=0.280$; $p=0.069$), it did predict the number of children born to them ($\beta=-0.245$; $p=0.020$), controlling for age. Both age and voice pitch alone accounted for 50% of the variance in the number of children men report that they fathered ($r^2=0.505$; $F=24.50$; d.f.$=48$; $p<0.001$; figure 2). Age also had significant quadratic effects on all reproductive outcomes in men and on the number of children born in women. However, when controlling for both linear and quadratic effects of age simultaneously, the significance of voice pitch in the models did not change. However, importantly, the effect of voice pitch on reproductive success ($r^2=0.483$; $F=14.30$; d.f.$=46$; $p<0.001$; $\beta=-0.291$; $p=0.01$) and the number of children born ($r^2=0.556$; $F=19.6$; d.f.$=47$; $p<0.001$; $\beta=-0.217$; $p=0.032$) in men decreased slightly. Finally, there were no associations between voice pitch and age in either men ($r=0.085$, $p=0.549$) or women ($r=0.048$, $p=0.732$).

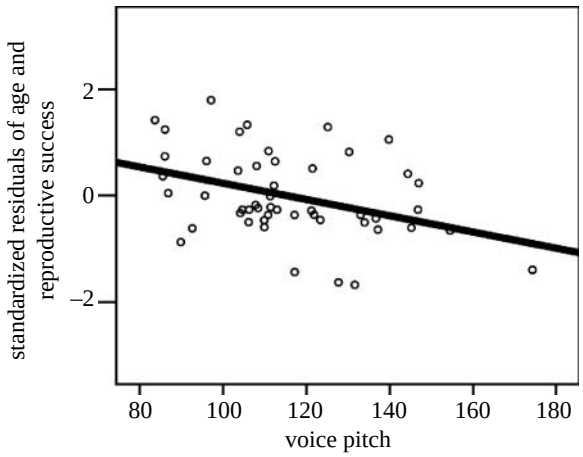

Figure 1. Residuals from regression of reproductive success on age plotted against voice pitch. This scatter plot shows a negative relationship between male voice pitch and reproductive success.

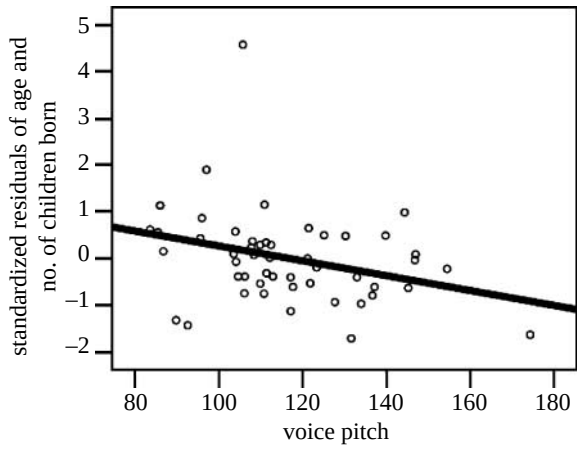

Figure 2. Residuals from regression of the number of children born on age plotted against voice pitch. This scatter plot shows a negative relationship between male voice pitch and the number of children born. Note that this relationship remains unchanged when the person with most children born is removed from the analysis.

4. DISCUSSION

This is the first study to examine the effect of voice pitch on Darwinian fitness in humans. Here, we demonstrate that voice pitch in a natural fertility population of hunter-gatherers predicts reproductive success in men but not in women. Furthermore, we find that while voice pitch in men predicts the number of children fathered, it does not predict the number of their children who have died. Since men with lower voice pitch have more children than men with higher pitch, we also examined whether voice pitch had an effect on the mortality rate of men's children. As expected, men with higher voice pitch have a higher child mortality rate although the result only neared significance. On the basis of these findings, we speculate that the associations reported between reproductive success and voice pitch in men are likely to be mediated by greater access to fecund women. Future research should examine whether men with lower-pitched voices have more mates, higher-quality mates, shorter inter-birth intervals and/or start reproducing at an earlier age. Finally, we were unable to confirm paternity, so we cannot rule out the possibility that, men with low voice pitch may just have more confidence in their paternity than men with high voice pitch.

Although high-pitch voices in women may signal fecundity (Abitbol *et al.* 1999; Alonso & Rosenfield 2002; Collins & Missing 2003; Feinberg *et al.* 2005*b*), we did not find it to be related to fitness outcomes, possibly because there is less variance in reproduction in our sample of women or because the effect is subtle. Also, since Hadza women engage in very strenuous labour and contribute substantially to subsistence, it is possible that there exist tradeoffs between increased resource competition, and thus a higher androgen/oestrogen ratio and increased fertility (Cashdan 2003).

In general, our findings suggest that there is currently selection pressure for low-pitch voices in men and that men with low-pitch voices enjoy higher reproductive success most probably as a result of increased access to mates. This finding is in line with a number of animal studies that find that male acoustic signals, which may reflect underlying quality, influence female choice (for review, see Andersson (1994)). For future work, we plan to examine experimentally whether men with low voice pitch are preferred as marriage partners and perceived as better hunters, whether voice pitch itself in Hadza men is correlated with measures of mate quality, such as hunting ability, and whether there is assortative mating in regards to voice pitch.

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