Mating context and menstrual phase affect women's preferences for male voice pitch

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Abstract

Fundamental frequency (F_0) is the vocal acoustic parameter closest to what we perceive as pitch. Men speak at a lower F_0 than do women, even controlling for body size. Although the developmental and anatomical reasons for this sex difference are known, the evolutionary reasons are not. By examining fertility-related variation in women's preferences for men's voices, the present study tests the hypothesis that female choice for good genes influenced the evolution of male voice pitch (VP). Unlike previous correlational studies that did not consider the effects of menstrual phase and mating context on women's preferences for male VP, the present study includes these variables and utilizes experimental pitch (P) manipulations. Results indicate that low VP is preferred mainly in short-term mating contexts rather than in long-term, committed ones, and this mating context effect is greatest when women are in the fertile phase of their ovulatory cycles. Moreover, lower male F_0 correlated with higher self-reported mating success. These findings are consistent with the hypothesis that an association between low male VP and heritable fitness led to the evolution of the observed patterns in women's P preferences and men's mating success and that these patterns influenced the evolution of low VP in men. However, alternative explanations are considered.
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1. Introduction

Voice pitch is the most salient acoustic feature of human speech (Banse & Scherer, 1996). Voice pitch is also sexually dimorphic; males speak up to an octave lower than females do, on average (e.g., Klatt & Klatt, 1990). This sexual dimorphism is not due merely to sex differences in body size. Relative to both height and body volume, vocal fundamental frequency (F_0, the acoustic parameter most closely related to pitch) is lower in adult males than in adult females and prepubescent children of both sexes (Titze, 2000).

The proximate and developmental causes of this male secondary sex characteristic are known. Adult males have 60% longer membranous portions of the vocal folds, which vibrate at a lower F_0. Vocal anatomy is masculinized under the influence of pubertal androgens, which cause males' vocal folds to increase in size faster than the overall rate of body growth (Hollien, 1960). Moreover, circulating androgens appear to maintain masculine vocal fold morphology in adults; F_0 correlates negatively with androgen levels in men (Dabbs & Mallinger, 1999) and decreases with androgen treatment (Need, Durbridge, & Nordin, 1993).

By contrast, little is known about why men evolved this developmental pattern. Some evidence suggests that low F_0 increased males' attractiveness to females. Oguchi and Kikuchi (1997) found that male voices rated as highly attractive by Japanese university students were significantly lower in voice pitch (VP) than were the voices rated as less attractive. Additionally, Collins (2000) found that Dutch women rated lower male voices as being significantly more attractive. However, because of their correlational designs, these studies could not demonstrate that pitch (P), in itself, affects vocal attractiveness.

Nonetheless, if female choice shaped male VP over human evolution, this preference requires explanation. Mate preferences are costly and generally evolve because they provide compensatory benefits (Andersson, 1994). In many species, female preferences apparently function in recruiting mates of high genetic quality, and androgen-dependent traits are often the foci of such preferences (Andersson, 1994). The degree of expression of androgen-dependent traits may signal fitness because androgens are immunosuppressant (Grossman, 1985) and can be produced at high levels only by otherwise healthy individuals (Folstad & Karter, 1992; see also Zahavi & Zahavi, 1997). Evidence from nonhuman animals (reviewed in Andersson, 1994) and humans (e.g., Gangestad & Thornhill, 2003; Scheib, Gangestad, & Thornhill, 1999) suggests that some masculine traits are reliable fitness indicators, and genetic transmission of these fitness benefits has been demonstrated in some species (e.g., Norris, 1993; Reynolds & Gross, 1992).

In humans, female preferences for androgen-dependent (masculine) features show signs of complex design (Williams, 1966) for recruiting good genes. For example, women's mate preferences vary with probability of conception, such that women in the follicular (fertile) phase of their menstrual cycles exhibit preference shifts toward more masculine facial features (Johnston, Hagel, Franklin, Fink, & Grammer, 2001; Penton-Voak et al., 1999; Penton-Voak & Perrett, 2000) and odors (Grammer, 1993). Moreover, women's preferences for androgen-dependent features may be greater when evaluating men as short-term sex partners rather than as long-term mates (Penton-Voak et al., 1999; reviewed in Penton-Voak & Perrett, 2001). Because low VP is androgen dependent, it may also signal heritable fitness,

and women's preferences for low VP may similarly depend on mating context and menstrual phase. Indeed, some studies have found that women prefer the voices of men who carry other fitness markers, such as external body symmetry and a high shoulder-to-hip ratio (Hughes, Dispenza, & Gallup, 2004; Hughes, Harrison, & Gallup, 2002).

The present study thus evaluates the predictions of one hypothesis for the evolution of low voice pitch in human males: Women prefer males with low voices because VP reflected heritable fitness in ancestral environments. Specifically, I test whether low male VP (1) increases short-term, sexual attractiveness more than long-term relationship attractiveness, (2) is more attractive to women nearer peak fertility, and (3) predicts higher mating success. Unlike previous studies (Collins, 2000; Oguchi & Kikuchi, 1997), this study uses an experimental, rather than correlational, design by examining the effects of computer-based pitch manipulations on attractiveness ratings.

2. Methods

2.1. Participants

One hundred eleven male and 142 female self-identified heterosexual undergraduate students from the University of Pittsburgh participated. The mean age of the males was 18.9 years (range=18–24, S.D.=1.2), and the mean age of the females was 19.1 years (range=18–30, S.D.=1.7). Male participants were native English-speaking nonsmokers who reported not being involved in committed relationships. Female participants reported not taking hormonal contraception and having regular menstrual cycles.

2.2. Procedures

2.2.1. Male participants: VP in competition for mates

To create more ecologically valid stimuli for female raters than the stimuli used in previous studies (Collins, 2000: vowel recitation; Oguchi & Kikuchi, 1997: sentence reading), male participants were recorded attempting to attract a female in a protocol similar to that of Simpson, Gangestad, Christensen, and Leck (1999; see also, Puts, Gaulin, Sporter, & McBurney, 2004). Upon arrival at the voice laboratory, each male participant was seated at a computer monitor in a soundproof recording room (approximately 2.5×3 m). The participant received a combination headphone/headset microphone, and the experimenter's recorded voice instructed him that he would be competing to win a lunch date with a woman in another room. In actuality, the participant saw a previously recorded video of a woman. The participant's voice was recorded using GoldWave digital audio software as he described himself to the woman (courtship recording).

Average F_0 was later measured from each "courtship" recording using Praat voice analysis software, which uses an acoustic periodicity detection algorithm based on an autocorrelation method described in Boersma (1993). Parameters were set to a pitch floor of 75 Hz and a pitch ceiling of 300 Hz, with all other values set to default. Each courtship recording (mean

length=20.5 s, mean F_0=112.7 Hz, range=82.9–158.9 Hz) was then both raised one semitone and lowered one semitone in P without affecting tempo using the sound-editing program, CoolEdit 2000, and saved as separate sound files. Praat pitch analysis validated F_0 manipulations. A one semitone pitch shift change corresponded to slightly more than twice the just noticeable difference (JND) with this sound-editing program (Gaulin and Puts, unpublished data), thus, P manipulations produced audible differences. However, no rater reported any suspicion of recordings having been altered. Thus, for each male, three courtship recordings differing in P were produced. Because one unmodified recording was not lowered in P due to experimenter error, this resulted in a total of 332 courtship recordings (F_0 range=78.2–168.4 Hz).

Courtship recordings were divided into 9 sets of 30 and 2 sets of 31 recordings (11 sets total) to be used as stimuli for female raters. Recordings were divided among stimulus sets so that each set included (1) no more than one version of a single male participant's recording and (2) nearly equal numbers of raised, lowered, and unmodified recordings (from different participants). To minimize order effects, recordings alternated regularly between raised, lowered, and unmodified recordings, and as much as possible, different versions of individual male participants' recordings were located in the same (randomly determined) positions within complementary stimulus sets.

After the dating "competition" recordings, male participants were given a questionnaire designed to assess mating success and several variables relevant to another study. Mating success was assessed by the number of female sex (sexual intercourse) partners the men reported for the past year (Faurie, Pontier, & Raymond, 2004; Pérusse, 1993). Eight participants did not answer this item.

2.2.2. Female participants: rating vocal attractiveness

Female raters attended rating sessions (12.9±2.3 raters per session) in audio-equipped classrooms. Raters received rating sheets for evaluating the sexual attractiveness and long-term relationship attractiveness of male voice recordings. The experimenter explained the importance of obtaining independent ratings and directed raters not to react audibly or visibly to recordings or to pay attention to others. The experimenter then played a compact disc of the following: (1) a description of the stimulus set: approximately 30 recordings of men attempting to win a date with a woman; (2) instructions to listen to each recording and then rate each man's attractiveness, first for a "short-term, purely sexual relationship, such as a one-night stand," and then for a "long-term, committed relationship;" (3) five sample recordings illustrating the range of variation; (4) 30 or 31 modified and unmodified courtship recordings of males, each followed by 10 seconds of silence for the rating task; and (5) instructions to fill out a questionnaire. All recorded instructions were spoken by a 25-year-old female in a pleasant, professional tone.

Raters assessed attractiveness by placing a mark anywhere on a line from *extremely unattractive* to *extremely attractive*. One hundred unlabelled tick marks on each line enabled the experimenter to assign values from 0 to 100 for attractiveness ratings according to the placement of the rater's mark. Due to a missing rating sheet, one rater evaluated only 24 recordings. Raters were also asked to circle the number of days in their typical menstrual

cycle on a list ranging from <22 to >38 and to circle the date of onset of their last menstrual bleeding on a calendar. These methods have been found to reduce reporting errors for menstrual cycle data (Gangestad, personal communication).

2.3. Data treatment

2.3.1. Conception risk

Menstrual cycle information was used to estimate conception risk according to the following method. First, each rater's day of ovulation within her current cycle was estimated by calculating the expected onset of her next menstrual bleeding and assuming that ovulation occurs 15 days prior (Dixon, Schlesselman, Ory, & Blye, 1980). Next, each rater's cycle day relative to ovulation was calculated (e.g., 0=day of, −2=2 days before, and 2=2 days after ovulation), and a conception risk value was assigned accordingly. Conception risk is the probability of conception from a single act of unprotected intercourse on a particular day relative to ovulation. These probabilities were obtained by averaging daily fecundability estimates from five published medical studies (Bremme, 1991; Colombo & Masarotto, 2000; Schwartz, MacDonald, & Heuchel, 1980; Wilcox, Weinberg, & Baird, 1995, 1998) and weighting each estimate by the reported number of cycles resulting in pregnancies (919 total cycles). To obtain more reliable conception risk estimates, six women who reported cycle lengths greater than 35 days (2 S.D. above the mean of 29.2 days) were eliminated from subsequent analyses. Raters were divided into "fertile" and "nonfertile" groups, following Gangestad and Thornhill (1998). Thirty-eight women, estimated to be within 6 days before and 1 day after ovulation, were included in the fertile group (mean conception risk=0.155, S.D.=0.089). The remaining 98 women were included in the nonfertile group (conception risk <0.01).

2.3.2. Male attractiveness scores

Courtship recordings received attractiveness scores for short- and long-term relationships, by fertile and nonfertile raters. Thus, courtship recordings received four attractiveness scores: short-term/fertile, short-term/nonfertile, long-term/fertile, and long-term/nonfertile. For each recording, the four attractiveness scores were obtained by averaging the ratings given by each set of women considering each mating context. To increase comparability between recordings rated by different groups of females, each female's ratings were normalized to zero before being used to calculate male attractiveness scores. That is, the mean (short- or long-term) rating made by a rater was subtracted from each of her (short- or long-term) ratings. Thus, a female's normalized ratings included negative (those she rated below her mean rating) and positive values (those she rated above her mean rating). The attractiveness scores for a particular courtship recording, then, are the average of the normalized ratings made by the females who listened to it. Normalization did not alter the results.

2.3.3. Number of sexual partners

Because number of sexual partners was positively skewed, this variable was log transformed to produce a distribution that did not differ significantly from normality.

2.4. Analyses

Analyses examined relationships between VP, attractiveness ratings, and number of sexual partners. Because directional predictions could be made in all cases, *P* values are one tailed and considered statistically significant if <.05.

3. Results

An initial regression analysis revealed a moderate but significant linear relationship—and, in each case, a less significant quadratic relationship—between unmanipulated VP and each of the four categories of attractiveness ratings (short-term/fertile, short-term/nonfertile, long-term/fertile, and long-term/nonfertile). Linear relationships between F_0 (predictor variable) and attractiveness ratings ranged from $p=.003$, $\beta=-.27$, and $r^2=.07$ for short-term/fertile to $p=.036$, $\beta=-.17$, and $r^2=.03$ for long-term/nonfertile ($p=.023$, $\beta=-.22$, and $r^2=.05$ for short-term/nonfertile; $p=.006$, $\beta=-.26$, and $r^2=.07$ for long-term/fertile; $n=111$ male voices for all regressions). Thus, at least over the normal range, male VP appears to be linearly and negatively associated with attractiveness ratings.

When the voices experimentally raised by one semitone were compared with the same voices lowered by one semitone under each of the four mating context-by-fertility conditions, multifactor repeated-measures analysis of variance (ANOVA) revealed no significant main effect of P manipulation [$F(1,106)=1.31$, n.s.]. On the other hand, there was a significant three-way interaction between P manipulation, mating context, and fertility [$F(1,106)=3.24$, $p=.037$], as predicted (Fig. 1). Lowered-P recordings obtained significantly higher
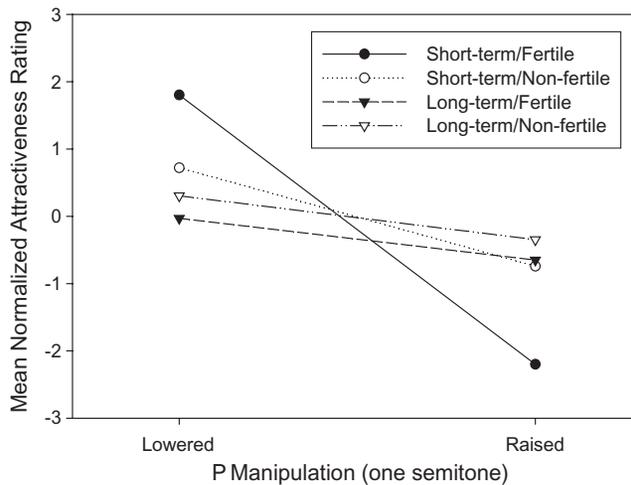

Fig. 1. Three-way interaction between P manipulation, relationship context, and fertility [$F_{(1,106)}=3.24$, $p=.037$]. VP manipulation significantly affected attractiveness ratings only for women in the fertile phase of their cycles evaluating men for short-term, sexual relationships [paired $t_{(106)}=2.09$, $p=.020$].

attractiveness scores than did the raised-P recordings only for short-term/fertile attractiveness [paired $t(106)=2.09$, $p=.020$]. Equivalent comparisons showed that lowered- and raised-P recordings did not differ significantly in long-term/fertile [$t(106)=0.37$, n.s.], long-term/nonfertile [$t(106)=0.47$, n.s.], or short-term/nonfertile [$t(109)=1.11$, n.s.] attractiveness scores. A significant two-way interaction was also found between P manipulation and mating context [$F(1,106)=8.61$, $p=.002$] but not between P manipulation and fertility [$F(1,106)=0.88$, n.s.].

Finally, unmanipulated VP (measured by F_0) negatively predicted male participants' self-reported number of sexual partners over the past year [Pearson's $r(103)=-.17$, $p=.043$].

4. Discussion

Women prefer the utterances of men who speak at a low pitch. This conclusion is supported by previous studies (Collins, 2000; Oguchi & Kikuchi, 1997) as well as by the present study, in which significant negative linear relationships were observed between the F_0 of spontaneous male utterances and women's ratings of those utterances. However, these correlations do not appear to be driven by an effect of VP itself on attractiveness ratings. In the present study, variations among utterances, such as those due to content, tempo, amplitude, enunciation, and accent, were experimentally controlled by manipulating VP and comparing utterances to themselves at a different P. The result was that VP had no main effect on attractiveness ratings.

Although experimental P manipulation did not influence attractiveness to females as a main effect, it did affect attractiveness under specific conditions. This was demonstrated by a significant three-way interaction between P manipulation, mating context, and fertility status. Lowered-P voices were significantly more attractive than the same voices raised in P, but only to women in the fertile phase of their ovulatory cycles, rating the men's voices with respect to a short-term mating context. Attractiveness ratings of lowered-P and raised-P voices did not differ in any other mating context-by-fertility status condition.

A significant two-way interaction was also found between VP manipulation and mating context. An order effect of rating short-term attractiveness before long-term attractiveness seems unlikely to explain this result because VP would have had to affect ratings differently depending on rating order. More probably, VP has a greater effect on sexual attractiveness than it does on attractiveness for committed relationships. The increased importance of VP for short-term mating contexts may help explain why men who spoke at a lower F_0 reported more sexual partners in the past year.

The above evidence is consistent with the hypothesis that women prefer fertile-phase sexual liaisons with low-voice-pitch males because such behavior acquired favorable genes for the offspring of ancestral females. Males who are putatively of high genetic quality (those with high testosterone levels) appear to invest less in their mates (reviewed in Penton-Voak & Perrett, 2001; Puts, 2003). It may, therefore, have benefited ancestral females to prefer such males primarily for sexual, rather than committed, relationships and mainly during the fertile menstrual phase.

The present study thus supports the role of female mate choice for good genes in shaping male voice pitch. However, alternative interpretations are possible. For example, low voices may have helped ancestral males win mates through male dominance competition (Ohala, 1982, 1983; 1984; Puts, Gaulin, & Verdolini, in review). This explanation does not account for the observed menstrual- and mating context-related patterns in women's preferences for male voice pitch, but the two explanations are not mutually exclusive.

Male voice pitch and female preferences for it could also have evolved via Fisherian "runaway sexual selection" (Fisher, 1930). According to this model, the heritable benefit associated with a male trait is increased attractiveness of sons. Although a widespread sexual preference of fertile-phase women could plausibly maintain low male VP in human populations, this hypothesis does not explain how the female preference became widespread in the population. According to Fisher (1930), a female preference initially spreads because the preferred male trait is linked to some other selective benefit. As suggested above, masculine traits such as low VP may be linked to heritable health (see Section 1). Additionally, some evidence indicates an association between fertilization ability and the expression of testosterone-dependent traits such as low VP in nonhuman animals (Andersson, 1994) and humans (Puts, in press). For example, in the Australian frog *Uperoleia laevigata*, females prefer larger males, which produce lower frequency calls and leave fewer eggs unfertilized (Robertson, 1990). An association between fertilization ability and VP in men could also select for mating context- and fertility status-related variation in women's preferences for male VP (Puts, in press).

In summary, women in the fertile phase of their menstrual cycles prefer low male voice pitch in short-term mating contexts, and males who speak at lower pitches when courting females report more sexual partners. Female preferences are thus likely to have been important selection pressures on male voice pitch and probably contributed to human sexual dimorphism in this trait, although male dominance competition may also have been involved. Female preferences for low male VP may have evolved because males with a low VP offer increased fertilization ability or heritable benefits, including healthier and more attractive offspring.

Acknowledgments

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