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EFFECTS OF ACOUSTICAL MANIPULATIONS ON PERCEPTIONS OF FEMALE VOCAL ATTRACTIVENESS AND THREAT POTENTIAL

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Abstract

Good genes sexual selection theory states that individuals will evolve preferences indicators of high quality mates. It stands to reason, then, that mechanisms for recognizing high quality competitors would additionally develop in both men and women, as this would contribute to economical allocation of mating effort. Modes of intrasexual competition in one sex should mirror the mate selection criteria of the other sex; i.e., the ways in which sexes compete with each other should be those ways which will make them most attractive to the opposite sex. It is also these characteristics that should be monitored by same sex competitors. Previous studies have shown that men prefer more feminine voices. Other women should also be able to perceive this as increased attractiveness toward the potential mates in question. In the present study, I manipulated women's voices using the vocal parameters fundamental frequency and formant dispersion to test the effects of vocal femininity on perceived threat potential by same-sex competitors. Specifically, female listeners evaluated attractiveness to heterosexual males and flirtatiousness. I additionally examined the effects of vocal femininity on men's interest for short- or long-term mating contexts. I found that vocal femininity increased women's attractiveness to men, and increased the apparent threat potential to other women, both in terms of perceived attractiveness to men and perceived sexual interest (flirtatiousness). Men preferred feminine voices most for a short-term/ sexual mating context.

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Introduction

There is a growing body of research pertaining for vocal preferences in both men and women. Most of this research focuses around women's preferences for masculine voices, and men's preferences for feminine voices. Vocal masculinity/femininity is determined by multiple anatomical sex differences, perhaps most notably those in the vocal folds and in the supra-laryngeal vocal tract. The size and thickness of the vocal folds determines the lowest frequency produced, or the fundamental frequency (F_0); longer, thicker vocal folds give rise to a lower fundamental frequency (Collins & Missing, 2003). Fundamental frequency is the most salient acoustic parameter of voice and the one most closely associated with pitch. Longer vocal folds which have less tension on them lead to a lower voice pitch (Titze, 2000). The shape of the vocal tract determines the articulatory possibilities, and thus possible formant patterns in speech (Fitch, 1999). There are multiple formant frequencies, and formant dispersion (D_f) is calculated as the averaged difference between successive formant frequencies (Fitch, 1997). Lengthening of the vocal tract will lead to a decrease in the average spacing between successive formants and lower the subsequent D_f, which gives the voice a more resonant sound and deeper timbre. Because men have both longer, thicker vocal folds and longer supralaryngeal vocal tracts (Fitch & Giedd, 1999), they have a lower F_0 and D_f than do women (Puts et al., 2006).

Increasing vocal masculinity increases female ratings of masculinity, size and age (Feinberg et al., 2005). Low male voice pitch is preferred mainly in short-term mating contexts (Puts, 2005), and the effect is greatest when women are in the fertile phase of their cycle (Puts, 2005; Puts, 2006; Feinberg et al., 2006). There is strong agreement among studies of male preferences that higher-frequency female voices are assessed as being more attractive (Collins & Missing, 2003; Feinberg, 2008; Jones et al., 2008; Jones et al., 2010). There is also growing evidence that voice may signal other physiological information relevant to mate selection. Women with smaller waist-hip ratios have voices consistently rated as more attractive (Hughes et al., 2004). Female voice attractiveness ratings increase as the risk of conception increases across the menstrual cycle (Pipitone & Gallup, 2008). Additionally, there are indicators of pitch elevation in women's voices near the onset of ovulation (Bryant & Haselton, 2009).

It has been shown in previous studies that men and women have differing mate selection processes and therefore differing intrasexual competition tactics (Buss, 1988). Female intrasexual competition has not been studied to the same extent that male competition has, but it is a growing field of research. Men, more than women, prefer a mate who is physically attractive (Buss, 1988; 1989). Women are less likely to engage in the use of physical force or threat of force in competition for mates, and generally favor other means; such as looking attractive and youthful, appearing faithful (Cashdan, 1996, 1998; Schmitt & Buss, 1996; Buss, 1988; Fisher, 2004; Puts, 2010), and using competitor derogation aimed at making other women seem less desirable (Buss & Dedden, 1990; Fisher & Cox 2009). Because attractiveness is the primary domain in which women compete for mates (Puts, 2010), women are expected to strive to increase their attractiveness relative to that of their competitors (Buss & Dedden, 1990; Fisher, 2004). Women should be the most competitive for mates when it matters the most to their reproduction, and this may be especially true near ovulation. Indeed, women in the high conception risk phase of their menstrual cycle rated female faces significantly less attractive than women within the non-fertile phase did of the same stimuli (Fisher, 2004).

Evidence of female intrasexual competition has been found in women's sensitivity to and derogation of their competitors' facial attractiveness (Fisher, 2004; Fisher & Cox, 2009). If men judge feminine voices to be more attractive, then women should be sensitive to vocal femininity in assessing the threat potential of competitors. Women should not only be able to recognize those female voices that men would find most attractive, but because men prefer feminine voices, one might also expect that women trying to gain the attentions of a man would increase vocal femininity. If so, then women should also be able to recognize this apparent sexual interest in competitors and designate those feminized voices to sound more flirtatious.

In the present study, I tested the hypotheses that women would perceive more feminine female voices to be more attractive to heterosexual men and more flirtatious. I also sought to replicate the finding that men prefer increased vocal femininity as well as to investigate the effects of mating context upon these preferences. That is, do men prefer more feminine voices for short-term, sexual relationships or for long-term, committed relationships? Finally, I examined the relative effects of F_0 and D_f on these various perceptions by manipulating each acoustic parameter by the same perceptual amount.

Methods

Participants

Eighty-three men and sixty-six women took part in this university IRB-approved study. Twenty male and twenty female university student participants were recruited (average age 22.2, range=18-30) for a just-noticeable difference (JND) study. Participants were recruited through on-campus advertising, word of mouth and announcements made in classes. Sixty-three men and forty-six women, all university students (average age 19.3, range=18-29) were recruited to participate in the main study. Participants were recruited through the university's psychology department research subject pool. For both studies, participants were asked to indicate if they had any significant hearing loss, and none reported hearing loss. For the main study, participants additionally completed a questionnaire targeting sexual orientation using the Kinsey scale (Kinsey, 1948). I selected participants with Kinsey scores of 0-2 (0=completely heterosexual, 6=completely homosexual) on both the Attraction and Fantasy Kinsey scales for further analysis. Two women did not fit these criteria, and one woman did not answer these items. One man reported 6 on these variables; three men did not answer these items. Results did not differ with all participants included in analysis.

JND Study

In order to explore the relative contributions of formant dispersion (timbre) and fundamental frequency (pitch) to perceptions of attractiveness and flirtatiousness, I conducted a JND study to enable me to manipulate these acoustic parameters by equivalent perceptual amounts. Although JNDs for vocal parameters have been determined in previous studies, it is logical to find my own JND based upon my methods and stimuli.

Voice stimuli were obtained from recordings produced in another study (Puts, unpublished). Briefly, 160 women (20.43 yrs±1.53) were recorded reading the first four sentences of the Rainbow Passage (Fairbanks, 1960) in an anechoic, soundproof booth using a Shure SM58 vocal cardioid microphone. A curved wire projection from the microphone stand kept the participant's mouth a standard 9.5 cm from the microphone. Voices were recorded using Goldwave software in mono at a sampling rate of 44,100 Hz. Each of the recordings was digitally analyzed using Praat voice analysis software (version 4.4.11). All settings were in accordance with the programmers' recommendations (Boersma & Weenink, 2009).

The four sentences were divided into individual sound clips (mean duration=4s). I selected four different voices at random, each reading a different sentence to avoid monotony. Using subjective assessment, I choose recordings that were articulated in a clear voice, with average tone and pitch, and in which the passage was read correctly without unnecessary pauses.

Each voice was manipulated for both F_0 and D_f using Praat version 5.1.20. F_0 manipulations were in increments of .05 ERB, while D_f was manipulated in increments of .25%. F_0 manipulations ranged from .05 to .50 ERBs, and D_f manipulations ranged from 1.25% to 3.25%; plus the unmanipulated recordings for both. ERBs are considered a more linear equivalent of what we hear acoustically (Stevens, 1998; Jones et al., 2010). Each voice was manipulated a total of 18 times – 9 times raised from the null and 9 times lowered from the null. After manipulations, voice files were measured to ensure that manipulations were in the correct direction and within a specified distance from the desired manipulation. All F_0 manipulations were within .01 of the expected ERB, and all D_f manipulations were within .09% of the expected percentage shift. Next, each manipulated file was measured for the parameter (F_0 or D_f) that was not meant to be manipulated. If this secondary parameter was unintentionally shifted during the manipulation of the intended parameter, then further manipulations of secondary parameter and continued measurements of the primary parameter were made to correct for this. When D_f was the parameter of interest and was manipulated, F_0 shifts did not differ significantly from zero (beta= .089, t= -.553. p= .583); when F_0 was the parameter of interest, D_f shifts did not differ significantly from zero (beta= .025, t= .145, p= .886).

The study interface was created using the stimulus presentation software Superlab version 4.0. Voices were paired for presentation so that each voice clip was paired with the clip that was equidistant from the null; i.e., an F_0 clip that was raised .35 ERB was paired with the clip that was lowered .35 ERB. Pairs were made only between clips of the same speaker and only within D_f or F_0. Each rater listened to all of the voice pairs and was asked to indicate if he or she could hear a difference between the two voices. To analyze the results, I tabulated every subject's response for a given equidistant pair, if they had indicated yes or no, and then summed the totals for men, for women, and for both sexes. Because there were no sex differences in responses, data from both sexes were pooled. The JND was then interpolated using best fit line for the 2 manipulation points above and below a 50% detection rate. For F_0, the JND was 0.2145 ERB, and for D_f, the JND was 5.5256%.

Main Study

Seventy-two voice clips were selected from the same set of voice recordings to be used in the main study. Stimuli were selected using the same criteria as the JND study. For the main study, the stimuli comprised the same 1st and 2nd sentences as in the JND study; however, the 3rd sentence included an additional part to make the stimuli more similar in length: “There is according to legend a boiling pot of gold at one end, *people look but no one ever finds it*.” The fourth sentence was not selected. The average length of each voice clip was 5.5 seconds. Thirty-six voice clips were both raised and lowered by 1 JND in F_0 (.2145 ERB), and the remaining 36 voice clips were raised and lowered by 1 JND in D_f (5.526%) Stimuli were created and checked for accuracy (and manipulated back in the secondary acoustic parameter, if necessary) within both vocal parameters using the same process as used in the JND study above. All F_0 manipulations were within .01 of the expected ERB and all D_f manipulations were within 0.9% of the expected percentage shift. F_0 manipulations did not differ significantly from target values (mean difference=.0001, t_{71}=.14, p=.891), and D_f was not shifted significantly in the process (mean difference from zero=.236, t_{71}=-.18, p=.855). D_f manipulations did not differ significantly from target values (mean difference=.367, t_{71}=.43, p=.671), and F_0 was not shifted significantly in the process (mean difference from zero=.292, t_{71}=1.52, p=.133)

Stimuli were split equally into two large sets, A and B, that had the same number of F_0 and D_f manipulations, equal amounts of both raised and lowered, and any given stimuli would appear in only one of the sets. Subjects were randomly assigned to listen to one set of the study so that they did not have to listen to every one of the stimuli created, however we could still collect data for all of the stimuli and have more inclusive results. Order of voice presentation (whether feminized or masculinized voice was presented first) was counterbalanced across sets, as was order of presentation of the questions on which participants were asked to evaluate. Male participants were asked to evaluate voices for short-term, purely sexual relationship attractiveness and long-term, committed relationship attractiveness. Female participants were asked to evaluate voices for perceived attractiveness to heterosexual males and flirtatiousness. These variables were assessed on a scale of 1-8; 1-4 for the first voice with 1 being the strongest preference and 5-8 for the second voice with 8 being the strongest preference.

Results

Women

Data were analyzed using repeated-measures ANOVA with 2 factors (acoustic parameter and characteristic assessed), each with two levels (F_0 vs. D_f and attractiveness vs. flirtatiousness, respectively). D_f had a significantly larger main effect than did F_0 ($F_{1,42}$=37.61, p<.0001). Overall, vocal femininity did not affect attractiveness more than flirtatiousness ($F_{1,42}$=2.23, p=.143). However, post-hoc repeated-measures ANOVA revealed that F_0 had a marginally significantly larger effect on flirtatiousness that it did on attractiveness ($F_{1,42}$=4.03, p=.051), but that D_f did not differently affect attractiveness and flirtatiousness ($F_{1,42}$=0.62, p=.436). Attractiveness and flirtatiousness were both significantly more strongly related to D_f than to F_0 ($F_{1,42}$=25.25, p<.0001, and $F_{1,42}$=35.73, p<.0001, respectively).

When evaluating attractiveness to the average heterosexual man, the average heterosexual woman's preference for female voices with a feminized F_0 differed significantly from 4.5 (no preference) (one-sample t-test: t_{43}=4.38, p<.0001). When evaluating flirtatiousness to the average heterosexual man, the average heterosexual woman's preference for female voices with a feminized F_0 differed significantly from 4.5 (no preference) (one-sample t-test: t_{43}=8.01, p<.0001). When evaluating attractiveness to the average heterosexual man, the average heterosexual woman's preference for female voices with a feminized D_f differed significantly from 4.5 (no preference) (one-sample t-test: t_{43}=8.44, p<.0001). When evaluating flirtatiousness, the average heterosexual woman's preference for female voices with a feminized D_f differed significantly from 4.5 (no preference) (one-sample t-test: t_{43}=14.09, p<.0001). Voices feminized in either F_0 or D_f were perceived as more attractive to men and more flirtatious (Fig. 1).

	T	*d.f.*	*p* (2-tailed)
Mean F_0 Attractive	4.377	42	<.0001
Mean F_0 Flirtatiousness	8.010	42	<.0001
Mean D_f Attractive	8.440	42	<.0001
Mean D_f Flirtatiousness	14.089	42	<.0001

Table 1: One Sample Test – Increased vocal femininity was significant for all given conditions.

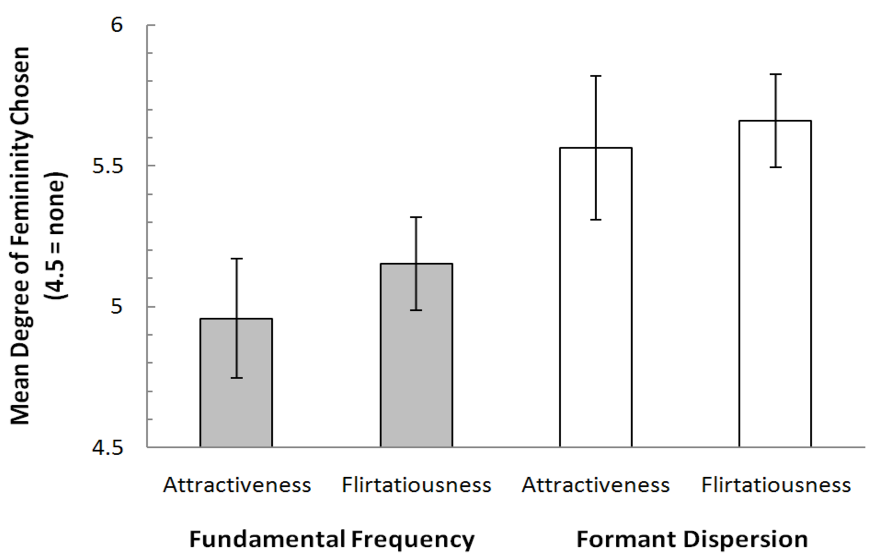

Fig. 1: Results for Women – Formant dispersion had a larger overall effect than fundamental frequency and increased femininity had effects on both attractiveness and flirtatiousness but more so on flirtatiousness.

Men

As with women's data, men's data were analyzed using repeated-measures ANOVA with 2 factors (acoustic parameter and characteristic assessed), each with two levels (F_0 vs. D_f and short- vs. long-term attractiveness, respectively). In general, men preferred feminized female voices (Fig. 2). D_f had a significantly larger main effect than did F_0 ($F_{1,58}$=45.70, p<.0001). Vocal femininity affected short-term attractiveness more than it did long-term attractiveness ($F_{1,58}$=15.33, p<.001). Post-hoc repeated-measures ANOVA revealed that F_0 and D_f individually had significantly larger effects on short-term attractiveness than they did on long-term attractiveness (F_0: $F_{1,58}$=17.08, p<.001; D_f: $F_{1,58}$=9.78, p<.003). Short-term and long-term attractiveness were both significantly more strongly related to D_f than to F_0 ($F_{1,58}$=26.47, p<.0001, and $F_{1,58}$=23.98, p<.0001, respectively).

For a short-term relationship, the average man's preference for female voices with a feminized F_0 differed significantly from 4.5 (no preference) (one-sample t-test: t_{58}=6.63, p<.0001). For a long-term relationship, the average man's preference for female voices with a feminized F_0 did not differ significantly from 4.5 (no preference) (one-sample t-test: t_{58}=1.52, p=.133). For a short-term relationship, the average man's preference for female voices with a feminized D_f differed significantly from 4.5 (no preference) (one-sample t-test: t_{58}=9.23, p<.0001). For a long-term relationship, the average man's preference for female voices with a feminized D_f differed significantly from 4.5 (no preference) (one-sample t-test: t_{58}=5.22, p<.0001).

	T	$d.f.$	p (2-tailed)
Mean F_0 Short-Term	6.63	58	<.0001
Mean F_0 Long-Term	1.52	58	.133
Mean D_f Short-Term	9.23	58	<.0001
Mean D_f Long-Term	5.22	58	<.0001

Table 2: One Sample Test: Increased vocal femininity was significant for all given conditions except for that of fundamental frequency manipulations on considerations of long term relationships.

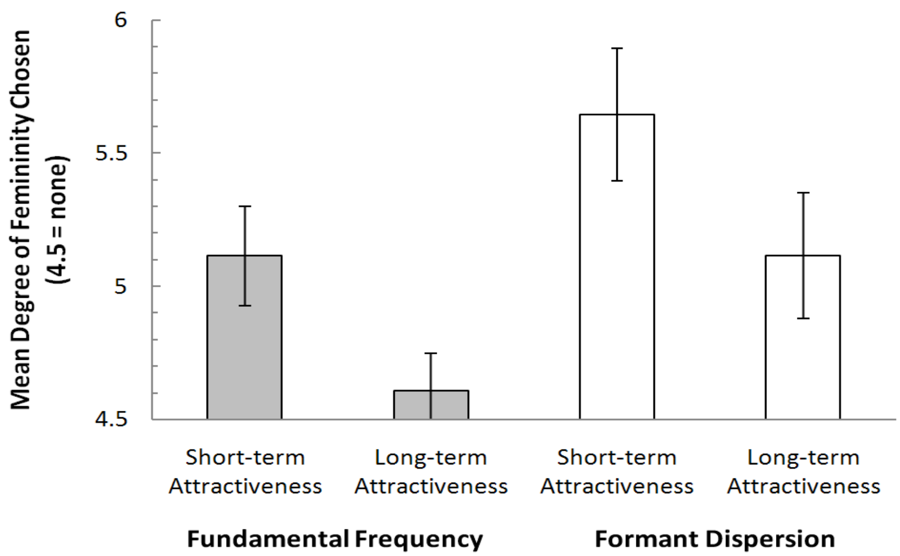

Fig. 2: Results for Men – Formant dispersion had a larger overall effect than fundamental frequency. Increased vocal femininity has significantly larger effects upon short-term attractiveness as opposed to long term.

Discussion

Women's & Men's Ratings

I found that increased vocal femininity tended to be selected across conditions by both men and women. This is consistent with previous findings regarding men's preferences for women's voices (Collins & Missing, 2003; Feinberg, 2008; Jones et al, 2010). It is also congruent with the general hypothesis that women should be most attuned to those female voices that men find most attractive. I found that vocal femininity affected short-term attractiveness to men more than it did long-term attractiveness. I also found that women rated the more vocally feminine voices as being more flirtatious and more attractive to men. This supports the intrasexual competition prediction that those women with more feminine voices will be perceived as having a greater threat potential, possibly due to the fact that men find those same voices to be the most sexually attractive, and that a hyper-feminine voice may signal sexual interest in women.

It has been suggested that the female voice could serve as a cue of youth and fertility (Collins & Missing, 2003). Given the overall neotenous nature of women's features (Cunningham, 1986; Jones & Hill, 1993; McArthur & Berry, 1983, Thornhill & Grammer, 1999) and the well known tendency for men to prefer younger partners (Kenrick & Keefe, 1992; Buss, 1989), it is a reasonable hypothesis that intersexual selection maintained high, neotenous voices in women. For men however, there is stronger evidence that their deeper voices are more likely the product of intrasexual signals of dominance rather than of sexual selection steered by female preferences (Puts et al., 2006; Puts et al. 2007; Puts 2010).

This study replicated the finding that men prefer increased vocal femininity; under no condition was a masculinized pitch favored, and in three of four contexts, a preference for feminized voices was statistically significant. Only for F_0 manipulations and a long-term mating context was the trend for men to prefer a more feminine voice not statistically significant.

The effect of mating context on men's preferences for feminine voices was also illuminating. Assuming that women compete to gain male investment (Cashdan, 1996; Fisher & Cox, 2009), sexual selection should favor traits in women to attract this investment, and a feminine voice might be one such trait. If so, then one might predict that feminine voices would be preferred more in long-term, committed mating contexts than in short-term, sexual ones. However, it is also possible that feminine voices function in enticing a man to consider a sexual relationship, given that such relationships often lead to investment over the longer term. Our results show that vocal femininity has the largest effect upon men's preferences for a short-term relationship. This may be the result of more feminine voices signaling a more attractive speaker (Hughes et al., 2004), and so a more desirable sexual partner, or because there are number of other significant considerations that go into selecting a long-term mate, whereas obvious signs of fertility are of predominant importance in selecting short-term sex partners.

If traits such as increased vocal femininity are those that men use to discriminate between potential partners then at some level, consciously, unconsciously or both, women should attend to these traits. Along the same lines, women also need to be aware of the quality of traits displayed by other women so that they can compete appropriately—for example, by directing their efforts toward competitors who are most capable of stealing the attentions of a mate. My study showed that women perceive voices in which femininity was experimentally increased to be more attractive to heterosexual males, which, as previously discussed, are indeed attractive to men. I then showed that women also consider those feminized voices to sound more flirtatious than the same female voices masculinized. Those women whose voices sound most attractive as well as most flirtatious would likely represent the greatest competitors for desirable mates and would thus pose the greatest threats.

Fundamental Frequency & Formant Dispersion

I also investigated the potential differential effects of F_0 and D_f by manipulating these acoustic parameters by the same perceptual amounts (increasing and decreasing voice clips by 1 JND in each acoustic parameter). For both men and women's assessments, D_f had a significantly larger main effect than F_0 did. For female listeners, attractiveness and flirtatiousness were both significantly more strongly related to D_f than to F_0. However, F_0 had a marginally significantly larger effect on flirtatiousness than it did on attractiveness, but D_f did not differently affect attractiveness and flirtatiousness. For male listeners, I also found that short-term and long-term attractiveness were both significantly more strongly related to D_f than to F_0. However, F_0 and D_f individually had significantly larger effects on short-term attractiveness than they did on long-term attractiveness.

These results might suggest that D_f is more salient than F_0 in perceptions of attractiveness and flirtatiousness. However, it is also possible that manipulating a voice by one JND for F_0 and one JND for D_f may produce differing changes in apparent masculinity/femininity. This might be the case if one acoustic parameter was manipulated by a greater proportion of the natural within-sex variation (e.g., more standard deviations, SD). Bryant & Haselton (2009) reported on the SD of F_0 and D_f in women during low and high fertility. Averaged across cycle phases, the SD obtained by Bryant and Haselton for F_0 was 22.65 Hz and for D_f the SD was 49.65 Hz. In the present study, stimulus voices were raised or lowered on average by 10.56 Hz when F_0 was manipulated, which corresponds to approximately 0.47 SD. D_f was manipulated up and down by an average of 62.64 Hz, which is approximately 1.26 SD. Because my manipulations were shifted more SDs in D_f, the reason for the larger main effect of D_f may have been that vocal femininity was modified to a greater extent when D_f was manipulated than when F_0 was manipulated, despite both manipulations being equally audible (i.e., both manipulations equal to 1 JND). Future research should explore this possibility by manipulating different acoustic parameters by the same number of standard deviations.

There is much debate over the evolutionary causes of the sexual dimorphism of the human voice. The proximate causes of these differences in fundamental frequency and formant dispersion are sex differences in the anatomy of the vocal folds and throat. F_0 is determined by the length and thickness of the vocal folds; longer and thicker vocal folds vibrate more slowly and produce a lower pitch (Collins, 2000; Puts et al., 2006), whereas the locations of formants and subsequent D_f are influenced by the length and shape of the vocal tract; longer tracts are associated with lower, more closely-spaced formants (Feinberg et al., 2005). These sex differences are larger than would be predicted by the sex difference in stature. Men are only 7-8 percent taller, yet their vocal tracts are 15 percent longer (Fant, 1960) and their vocal folds are 60% longer (Titze, 2000). This is partly due to a drop in the larynx at puberty (Hollien, 1994; Gonzalez, 2004), and the hypertrophic growth of the vocal folds (Titze, 1989), changes initiated by gonadal androgens (Dabbs & Mallinger, 1999).

Low voices in men are likely due to contest competition (Puts et al., 2006; Puts, 2010) and, as previously stated, it is plausible that women's higher pitch also serves as an incentive for mate selection and may function in obtaining high quality mates. The ultimate cause of the sex differences, in terms of what both F_0 and D_f signal to mates and competitors, is not so readily evident. Why are these acoustic properties of the voice worth paying attention to? The current working hypothesis is that it F_0 and D_f are generally honest signals of the quality of a competitor or potential mate (Collins, 2000; Collins & Missing, 2003; Hughes et al., 2004). Demographic information such as sex (Bennett & Montero-Diaz, 1982; Childers & Wu, 1991) and age (Linville, 1996; Mulac & Giles, 1996) may also be estimated through the voice. Being able to distinguish the sex of another is important for discerning potential mates from potential competitors. Although such characteristics can most easily be discerned visually, there are benefits for having redundant signals that can confirm initial assessments. Indicators of age would be of particular importance in women, who have a restricted window of fertility between puberty and menopause. Even more pertinent, as mentioned earlier it could further indicate the specific fertility of a given woman's ovulatory cycle.

In the present study, as with any study, there is room for improvement. Future studies looking to expand upon this work or merely to replicate it may want to consider using the same stimuli sources for both F_0 and D_f. I used different stimuli to include a wider spectrum of vocal variation; there were some participants from our JND study who commented that they disliked the (mid-Michigan) accent of some of the voices. Having an increased number of unique stimuli is more congruent with natural populations. However, using the same stimuli might produce more stark comparisons between the conceptually linked criteria subjects are rating for.

Future research should further tease out the perceptual differences between F_0 and D_f, as well as attempting to explain what messages they are sending to both potential mates and competitors. There is more to be studied about female intrasexual competition in regards to the potential influence of social dominance on competitor assessment and derogation, as well.

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