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ORIGINAL PAPER

Voice Correlates of Mating Success in Men: Examining "Contests" Versus "Mate Choice" Modes of Sexual Selection

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Abstract Men's copulatory success can often be predicted by measuring traits involved in male contests and female choice. Previous research has demonstrated relationships between one such vocal trait in men, mean fundamental frequency (F_0), and the outcomes and indicators of sexual success with women. The present study investigated the role of another vocal parameter, F_0 variation (the within-subject *SD* in F_0 across the utterance, F_0-*SD*), in predicting men's reported number of female sexual partners in the last year. Male participants ($N = 111$) competed with another man for a date with a woman. Recorded interactions with the competitor ("competitive recording") and the woman ("courtship recording") were analyzed for five nonlinguistic vocal parameters: F_0-*SD*, mean F_0, intensity, duration, and formant dispersion (D_f, an acoustic correlate of vocal tract length), as well as dominant and attractive linguistic content. After controlling for age and attitudes toward uncommitted sex (SOI), lower F_0-*SD* (i.e., a more monotone voice) and more dominant linguistic content were strong predictors of the number of past-year sexual partners, whereas mean F_0 and D_f did not significantly predict past-year partners. These contrasts have implications for the relative importance of male contests and female choice in shaping men's mating success and hence the origins and maintenance of sexually dimorphic traits in humans.

Keywords Dominance · Formant dispersion · Fundamental frequency · Mate choice · Mating success · Voice pitch

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Introduction

Building on arguments by Trivers (1972), Perusse (1993) pioneered the research strategy of using (heterosexual) copulatory success as a proxy for male reproductive success, a method that has yielded many insights into the force of sexual selection in humans. In general, traits that are associated with elevated copulatory success and exhibit considerable sexual dimorphism are strong candidates for having been targets of sexual selection (Andersson, 1994; Darwin, 1871). A relatively small set of sexually dimorphic phenotypic traits have been associated with elevated copulatory success in men, including muscle mass (Frederick & Haselton, 2007; Lassek & Gaulin, 2009), body shape (Hughes & Gallup, 2003; Rhodes, Simmons, & Peters, 2005), height (Mueller & Mazur, 2001; Pawlowski, Dunbar, & Lipowicz, 2000; Rhodes et al., 2005), facial morphology (Johnston, Hagel, Franklin, Fink, & Grammer, 2001; Keating, 1985; however, see Cunningham, Barbee, & Pike, 1990; Jones & Hill, 1993; Penton-Voak et al., 1999; Perrett et al., 1998; Swaddle & Reierson, 2002), and voice characteristics (Apicella, Feinberg, & Marlowe, 2007; Hughes, Dispenza, & Gallup, 2004; Puts, 2005).

Thus, sexually dimorphic characteristics are often predictive of mating success, and indeed a historical association with mating success may explain why these characteristics are dimorphic in the first place. However, a review of the literature demonstrates the difficulty in identifying which mode of sexual selection has been most important in shaping a particular characteristic. Sexual selection comprises multiple subprocesses (Andersson, 1994): some individuals may garner a disproportionate share of matings because they are attractive to members of the opposite sex and/or because they are good at excluding members of their own sex from mating by force or threat of force. These two forms of sexual selection, mate choice and contests, respectively, produce different outcomes: adornments in the former

case and weapons in the latter. Yet, among humans, it can be difficult to discern the degree to which mate choice and contests have shaped these types of traits. For example, many male traits that seem clearly designed for combat (e.g., muscle mass and strength) are also preferred by women (e.g., Dixson, Halliwell, East, Wignarajah, & Anderson, 2003; Gangestad, Simpson, Cousins, Garver-Apgar, & Christensen, 2004).

For several reasons, we believe that the voice is well-suited for examining the relative importance of these two types of sexual selection in humans. First, men's voices differ from women's in a number of ways: Men's voices have lower pitch (measured by fundamental frequency, F_0) (Titze, 1994) and lower formant dispersion (D_f, "resonance," an acoustic correlate of vocal tract length) (Fitch, 1997). Second, mating success has been associated with variance in voice characteristics: In North America, men with low-pitched voices had more total sex partners (Puts, 2005) and, among Hadza hunter-gatherers, low voice pitch was associated with higher numbers of offspring (Apicella et al., 2007). Third, voice characteristics are implicated in both mate choice and contest competition. Men whose voices were rated as attractive also reported earlier first coitus, more total sex partners, and more extra-pair copulations (Hughes et al., 2004). Two studies found that women prefer lower pitched male voices, especially when they are ovulating (Feinberg et al., 2006; Puts, 2005). In addition, lower male voices were rated as older, taller, heavier, and more dominant (Collins, 2000; Feinberg, Jones, Little, Burt, & Perrett, 2005; Puts, Gaulin, & Verdolini, 2006; Puts, Hodges, Cardenas, & Gaulin, 2007).

The Present Study

Habitual voice pitch is normally measured as mean fundamental frequency (F_0) across an entire utterance. Mean F_0 depends upon dimensions of the vocal folds that are under the influence of testosterone (Harries, Walker, Williams, Hawkins, & Hughes, 1997). Due to the relationship between testosterone levels and immune competence (Folstad & Karter, 1992; Grossman, 1985), mean F_0 could provide evidence of heritable disease resistance (Feinberg et al., 2006; Puts, 2005). Mean F_0 might then be important to both men and women in assessing the "quality" of potential competitors and mates. A low mean F_0 is rated as more attractive by women (Collins, 2000; Feinberg et al., 2005; Puts, 2005) and as more physically dominant by men (Puts et al., 2006, 2007).

In fact, F_0 is not constant for any given speaker; it can be more or less variable within an utterance, and thus the amount of within-utterance variation in F_0 is itself a variable of potential interest. Although there have been few empirical studies of nonsemantic variance in F_0, the amount of F_0 variation differs among speakers, and men may vary F_0 less when speaking than women do (Brend, 1975; Daly & Warren, 2001). Arousal and nervousness may affect muscles of the larynx via the vagus nerve and the autonomic nervous system (Charous, Kempster, Manders, & Ristanovic, 2001). Therefore, arousal may affect features of the voice, including within-utterance F_0 variation (Banse & Scherer, 1996; Goedeking, 1988), potentially revealing whether the speaker feels confident or threatened. If this is true, F_0 variation may provide information about socially variable relationships and therefore should be especially relevant in contest competition. In a recent study, Hodges-Simeon, Gaulin, and Puts (2010) showed that men attended strongly to F_0 variation—more so than to mean F_0—when judging male physical dominance. This raises the question of whether mean F_0 or F_0 variation better explains male mating success.

This question is of more than mere empirical interest; it addresses the fundamental character of sexual selection in humans. With a few notable exceptions (e.g., Archer, 2004; Buss & Shackelford, 1997; Daly & Wilson, 1988; Lassek & Gaulin, 2009; Sell et al., 2009), most literature on human sexual selection has tacitly assumed that mate-choice processes have predominated (e.g., Shackelford, Schmitt, & Buss, 2005). But a variety of hard facts about human biology—for example, the large sex differences in muscle mass mentioned above, as well as parallel sex differences in aggressiveness (Archer, 2004)—suggest that male–male competition was probably at least as important in shaping men's traits (Lassek & Gaulin, 2009; Puts, 2010).

Several different sources of information may provide evidence in this choice-versus-competition debate. First, to the extent that men and women attend more strongly to different male attributes when judging dominance and attractiveness, respectively, we can expect that mating outcomes will reflect this selective attention. When judging men's attractiveness, women attended strongly to mean F_0, whereas when assessing men's dominance, men attended strongly to F_0 variation (Hodges-Simeon et al., 2010). Thus, if male mating success is more closely associated with low mean F_0 (which women found attractive) then a significant role for "good genes" mate choice may be indicated. Alternatively, if low F_0 variation (which men perceived as dominant) better predicts mating success, it may be that male–male interactions are more important in mediating men's sexual access to women. Second, if vocal characteristics during competition with another man explain more of the variance in mating success than vocal characteristics during courtship, an effect of male–male competition is supported. Finally, if the linguistic content rated as "dominant" by males more strongly predicts mating success than linguistic content rated as "attractive" by females, then a significant role for male–male competition may be indicated.

Method

Participants

Participants (178 males, 35 females) were drawn from university undergraduate populations ($M = 19.4$ years; age range: 18–37).

Two groups of subjects participated: mock dating game participants (111 males) and raters of transcribed content (67 [different] males, 35 females). All were heterosexual (recruited on the basis of self-labeling), native speakers of American English.

Procedure and Measures

Acoustic Stimuli

Participants took part in a simulated dating game (Puts, 2005; Puts et al., 2006; Simpson, Gangestad, Christensen, & Leck, 1999), which produced three recordings. On arrival in the voice-recording laboratory, each participant was seated at a computer monitor in a private, soundproof room (approximately 2.5 × 3 m) and supplied with a combination headphone/headset microphone. The participant was first instructed via a recorded message to read a standard passage containing all of the phonemes of American English ("control recording"). Next, he was told that he would be competing with another man to win a lunch date with a woman, who were in separate other rooms and were in contact via audio. In reality, both the competitor and potential lunch date were pre-recorded in digital audio and audio–video, respectively, which was spliced into a single digital audio–video recording, and used in all 111 trials. Participants were first asked to describe themselves to the woman ("courtship recording"). They were then instructed to address their competitor and describe why they are respected or admired by other men ("competitive recording"). All participants' responses were recorded using GoldWave digital audio software.

After the dating game segment, participants completed a questionnaire assessing age, number of female sex partners in the past year (cf. Perusse, 1993), and several variables not relevant to the present study. The number of past-year sexual partners was chosen because it represents an interval over which participants' recollections were expected to be accurate and voice characteristics measured in the present study would likely have been stable. Participants also completed the Sociosexual Orientation Inventory (SOI; Simpson & Gangestad, 1991), which consists of 7 items concerned with past sexual encounters, expected future relations, and attitudes toward uncommitted sex (attitudes were assessed on a 9-point Likert-type scale ranging from "strongly disagree" to "strongly agree").

Acoustic Analyses

Each of the recordings was digitally analyzed using Praat voice analysis software (version 4.4.11) for five acoustic parameters: mean F_0, F_0 variation (operationalized as the within-subject *SD* of F_0; hereafter called F_0-*SD*), utterance duration (i.e., speaking time in seconds), intensity (decibels, dB), and formant dispersion (D_f). All settings were in accordance with the programmers' recommendations for adult male voices (Boersma & Weenik, 2009). Formants were measured using the long-term average spectrum (LTAS; Gonzalez, 2004; Xue & Hao, 2003), and D_f was computed by taking an average of the distance between each of the first four formants (Fitch, 1997).

Content Analysis

To control for differences in linguistic content across male speakers, recordings were transcribed and rated separately for both dominant and attractive content. Each male rater read a selection of 30 or 31 passages transcribed from the competitive recording. Following procedures described by Mazur et al. (1994), raters were told that "a [socially] dominant person tells other people what to do, is respected, influential, and often a leader; whereas submissive people are not influential or assertive and are usually directed by others." Raters were asked to read each passage and assess the target's social dominance on a 7-point Likert scale (1 = "extremely submissive" and 7 = "extremely dominant"; M = 4.34). Regarding physical dominance, raters were asked to indicate the extent to which they agreed or disagreed (1 = "strongly disagree" and 7 = "strongly agree"; M = 4.12) with the following statement: "If this man got in a fistfight with an average male undergraduate student, this man would probably win." Because bivariate analyses revealed that physical dominance ratings of content were more strongly correlated with copulatory success than were social dominance ratings, the former variable was selected as a candidate predictor of mating success in a multiple-regression model (Table 1).

Female raters read 30 or 31 transcripts of the courtship recording and rated each for short-term or long-term attractiveness. Specifically, they rated each from 1 ("extremely unattractive") to 7 ("extremely attractive") for a "short-term, purely sexual relationship, such as a one-night stand" (M = 3.74), and then for a "long-term, committed relationship" (M = 3.60). Because, in a bivariate context, short-term attractiveness ratings were more strongly correlated with copulatory success than were long-term attractiveness ratings, we again selected the stronger predictor for inclusion in multiple regression analyses (Table 1).

Data Analysis

Due to the positive skew in the reported number of sexual partners, a log transformation was performed in order to produce a normal distribution. In addition, collinearity diagnostics revealed variance inflation factors to be less than 1.3 in all models; therefore, our results were unlikely to be confounded by multicollinearity.

Results

Mean F_0 was 112.7 Hz (SD = 15.1) for the courtship and 113.2 Hz (SD = 14.5) for the competitive recordings. F_0 variation (F_0-*SD*) was 11.6 Hz (SD = 3.9) for the courtship and 12.3 Hz

Table 1 Multiple regression predicting number of past-year sexual partners

	Predicting number of past-year partners (competitive recording)			
Model $R^2 = .40$	β	*SE B*	*B*	*r*(zero-order)
F_0-*SD*	−0.05	.01	−.34***	−.39***
F_0 Mean	0.00	.01	−.03	−.15
D_f	0.00	.00	−.05	.02
Duration	0.01	.01	.06	.09
Intensity	0.01	.01	.05	−.01
SOI	−0.27	.06	−.35***	−.37***
Age	0.12	.05	.27**	.20*
Content[a] (male raters)	0.13	.06	.19*	.24*
	Predicting number of past-year partners (courtship recording)			
Model $R^2 = .26$	β	*SE B*	*B*	*r*(zero-order)
F_0-*SD*	−0.02	.02	−.12	−.21*
F_0 Mean	−0.01	.01	−.12	−.17†
D_f	0.00	.00	−.04	−.16
Duration	0.00	.01	.01	−.06
Intensity	0.02	.02	.10	.06
SOI	−0.30	.07	−.39***	−.37***
Age	0.14	.05	.26**	.20*
Content[b] (female raters)	−0.09	.09	−.10	−.01

Note: B's and β's derive from multiple regression; *r*'s reflect the zero order correlation with number of past-year sex partners. F_0-*SD* = F_0 variation, D_f = Formant dispersion, SOI = Sociosexual Orientation Inventory. $N = 111$

[a] Content ratings were based on males' ratings of physical dominance

[b] Content ratings were based on females' ratings of short-term attractiveness

† $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

(*SD* = 4.5) for the competitive recordings. F_0 and F_0-*SD* were correlated with each other in both the courtship, $r(109) = .44$, $p < .001$, and competitive, $r(109) = .35$, $p < .001$, recordings. Bivariate (zero-order) correlations between copulatory success and each of the predictors are shown in the right-most column of Table 1.

All five vocal parameters (mean F_0, F_0-*SD*, intensity, formant dispersion, duration), as well as content ratings (with males rating competitive recordings and females rating courtship recordings) and two control variables (age and SOI), were simultaneously entered into two separate multiple regressions (one for competitive recordings, one for courtship recordings) predicting the number of sexual partners in the last year ($M = 1.35$, $SD = 1.75$, range = 0–10). Our model for the competitive recordings explained 40% of the variance ($R = .63$) in men's number of sexual partners in the past year. For the courtship recordings, a similarly structured analysis explained 26% of the variance, $R = .51$.

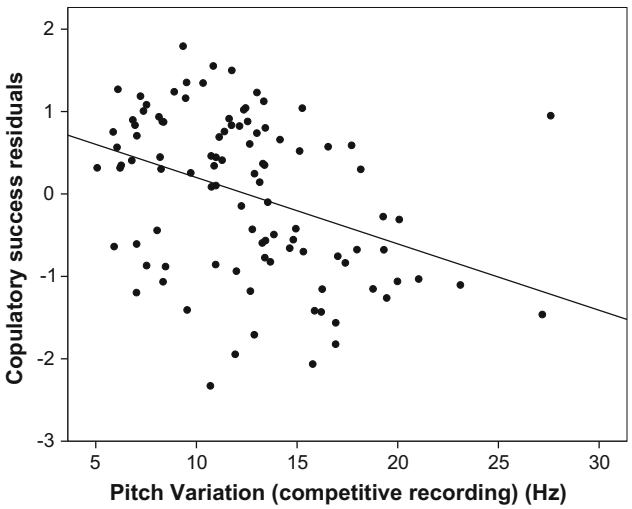

Fig. 1 Residual copulatory success (the number of sexual partners in the last year) regressed on pitch variation (competitive recording)

Low F_0-*SD* in the competitive recording significantly predicted the number of past-year sexual partners, $\beta = -0.34$, $p < .001$. F_0-*SD* in the courtship recording was not a significant predictor of past-year partners ($\beta = -0.12$, *ns*), although in the bivariate analysis courtship F_0-*SD* was significantly related to past-year sex partners. Neither mean F_0 (competitive: $\beta = -0.03$, *ns*; courtship: $\beta = -0.12$, *ns*) nor D_f (competitive: $\beta = -0.05$, *ns*; courtship: $\beta = -0.04$, *ns*) captured significant variance in the number of partners. Physically dominant linguistic content in the competitive recording (male raters) was a significant predictor of partner number, $\beta = 0.19$, $p < .05$; however, attractive content in the courtship recording (female raters) did not predict copulatory success, $\beta = -0.10$. See Table 1 for the full models. Residuals of F_0-*SD* from the competitive recording were regressed on the number of past-year sexual partners and are depicted in Fig. 1.

Age (competitive: $\beta = 0.27$, $p < .01$; courtship: $\beta = 0.26$, $p < .01$) and SOI (competitive: $\beta = -0.35$, $p < .001$; courtship: $\beta = -0.39$, $p < .001$) were also significant predictors of sexual partners in the past year.

Discussion

Multiple acoustical features of male voices probably shape mating success, but F_0 variation appears to be a particularly strong predictor. More monotone men reported greater numbers of heterosexual sex partners in the past year. Previous studies have found that mean F_0 predicted both mating success (Puts, 2005) and reproductive success (Apicella et al., 2007), but the present study showed that mean F_0 did not explain additional variance in mating success beyond that explained by F_0 variation (and control variables).

There are several possible explanations for the relationship between low F_0 variation and mating success in this study and perhaps more generally. First, low F_0 variation may be attractive to women and attractiveness may facilitate access to mates. However, elsewhere (Hodges-Simeon et al., 2010), we reported that F_0 variation did not consistently predict attractiveness judgments made by women. Furthermore, in the present study, F_0 variation in the courtship recording did not predict mating success, contrary to expectations if F_0 variation was part of a mating display.

Second, low F_0 variation may deter competitors and aid in attaining dominance. In most social species, access to contested resources or mates is mediated by relative dominance (Alcock, 2005). The majority of contests to establish hierarchies involve elaborate multi-modal signaling displays wherein each individual attempts to convey his physical prowess to competitors. An individual who perceives himself to be less dominant than his competitor will concede the resource. We have argued elsewhere (Hodges-Simeon et al., 2010) that high F_0 variation may signal low relative dominance because high F_0 variation communicates fear, self-perception of low dominance, and intent to concede because of its association with arousal and nervousness (Banse & Scherer, 1996; Charous et al., 2001; Goedeking, 1988). In other words, if F_0 variation is an honest signal of arousal and nervousness, then competitors who use this information to their advantage may be favored. It is also possible that signaling nervousness may be advantageous to the sender so that costly aggression may be avoided.

Third, the relationship between low F_0 variation and mating success could show bidirectional effects. In this study, men who had previous success with women presumably felt more assured when placed in a mating context. This assurance may have relaxed male subjects, stabilizing their F_0. If so, then this suggests that when men feel confident, they speak with lower F_0 variation. Low F_0 variation may be one modality through which confidence is communicated to others. Thus, although previous research has shown that women find low mean F_0 attractive (Feinberg et al., 2005; Puts, 2005), and men rate low mean F_0 as more physically dominant, older, stronger, and more masculine (Collins, 2000; Feinberg et al., 2005; Puts et al., 2007), F_0 variation may be more instructive about variable emotional, physiological, or intentional states.

In addition, our results suggest independent effects of linguistic and non-linguistic features of speech on mating success. Physically dominant linguistic content (rated by an independent group of raters) predicted variance in mating success. When placed in an ecologically valid competitive interaction, successful men used both dominant language and a dominant tone of voice. To our knowledge, this is the first study to show such a result.

What do the findings of the present study say about the "mate choice" versus "contest competition" question? First, copulatory success was better predicted by a strong correlate of vocal dominance (F_0-*SD*) than by a strong correlate of vocal attractiveness (F_0). Second, vocal behavior during the competitive encounter explained more variance in mating success than did vocal behavior during the courtship encounter. Finally, dominant content predicted mating success, but attractive content did not. This pattern of results lends support for the idea that contest competition was an important selection pressure on the evolution of men's vocal and verbal behavior, and may be more important in the origin and maintenance of human sex differences than has generally been acknowledged.

A potential limitation of the present study is that we relied on self-reported copulatory success, which is subject to imperfect memory or intentional distortion. However, unless such inaccuracies were systematically correlated with the independent variables of interest, such contamination should be random and thus not inflate the risk of Type I error. The present study might also be improved by assessing a broader range of ages in order to sample a greater range in partner number.

Another potential limitation is that we did not experimentally manipulate the vocal parameters of interest. Mating success may be due to other traits and behaviors that are correlated with vocal traits, resulting in spurious relationships between voice characteristics and mating success. In other words, men with low F_0 variation may have been more successful with women because of traits that co-occur with F_0 variation. We fully expect many traits to vary in tandem with vocal traits. As already mentioned, vocal characteristics, such as mean F_0 and D_f, are at least partly determined by testosterone, which has wide ranging effects on a variety of traits that vary in parallel with one another. However, it would be nearly impossible to study the relationship between actual mating success and vocal traits experimentally. The only feasible empirical route is to control for potential confounds through multiple regression, as was done in this study.

In summary, this study presented a number of novel findings. First, this was the first study to show that F_0 variation was associated with mating success: low F_0 variation was a highly significant predictor of men's number of female sexual partners, while controlling for other acoustic parameters, content, and other potentially confounding variables. Second, examining both linguistic and non-linguistic components of communication simultaneously, our results suggest that both the words that men use and the way that they say them influence sexual success. Third, the present study used naturalistic speech samples in a mating situation—one that included both mate choice and contest competition components. In this context, men who displayed dominant vocal traits during male–male competition also reported greater mating success. The same was not true of men who displayed attractive vocal traits during courtship. Although these results do not constitute conclusive evidence in the choice versus competition debate, they nonetheless lend support for the notion that contest competition was an important selection pressure on the evolution of men's vocal and verbal behavior, and may be more important in the origin and maintenance of human sex differences than has generally been acknowledged. Future research should continue to explore the relative effects of mate choice and contests on sexually dimorphic human traits.

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