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The Perception and Parameters of Intentional Voice Manipulation

Susan M. Hughes · Justin K. Mogilski · Marissa A. Harrison

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Abstract Evidence suggests that people can manipulate their vocal intonations to convey a host of emotional, trait, and situational images. We asked 40 participants (20 men and 20 women) to intentionally manipulate the sound of their voices in order to portray four traits: attractiveness, confidence, dominance, and intelligence to compare these samples to their normal speech. We then asked independent raters of the same- and opposite-sex to assess the degree to which each voice sample projected the given trait. Women's manipulated voices were judged as sounding more attractive than their normal voices, but this was not the case for men. In contrast, men's manipulated voices were rated by women as sounding more confident than their normal speech, but this did not hold true for women's voices. Further, women were able to manipulate their voices to sound just as dominant as the men's manipulated voices, and both sexes were able to modify their voices to sound more intelligent than their normal voice. We also assessed all voice samples objectively using spectrogram analyses and several vocal patterns emerged for each trait; among them we found that when trying to sound sexy/attractive, both sexes slowed their speech and women lowered their pitch and had greater vocal hoarseness. Both sexes raised their pitch and spoke louder to sound dominant and women had less vocal hoarseness. These findings are discussed using an evolutionary perspective and implicate voice modification as an important, deliberate aspect of communication, especially in the realm of mate selection and competition.

Keywords Voice manipulation · Voice attractiveness · Voice pitch · Dominance · Intelligence · Confidence

S. M. Hughes (✉)
Department of Psychology, Albright College, Reading, PA 19612, USA
e-mail: shughes@alb.edu

J. K. Mogilski
Oakland University, Rochester, MI, USA

M. A. Harrison
Penn State Harrisburg, Middletown, PA, USA

Intentional voice manipulation can be observed in a variety of social contexts. For instance, individuals tend to raise the pitch of their voice when attempting to deceive another person (Ekman et al. 1976; Streeter et al. 1977) and individuals who are confident in what they are saying tend to speak faster and louder (Kimble and Seidel 1991). Women's voices tend to sound more competent when speaking to their bosses than when speaking to their subordinates or peers, while men's voices sound more competent when speaking to their peers (Steckler and Rosenthal 1985). Speech directed towards men is rated to sound more dominant and formal than when directed towards women, regardless of the speaker's sex (Hall and Braunwald 1981). These findings suggest that vocal manipulation is an understood part of our social landscape, be it an unconscious or conscious understanding.

Vocal Modulation in Mating Contexts

Voice manipulation seems to play an especially important role when it comes to advertising traits related to mate selection and competition. With respect to mate attraction, Anolli and Ciceri (2002) showed that men who exercised greater vocal modulation and gradually deepened their voices during conversations with unfamiliar women were more successful at getting future dates in a simulated dating scenario. Similarly, both men and women tend to use a lower-pitched voice and demonstrate greater physiological arousal when they speak to an attractive versus an unattractive, opposite-sex target in order to sound more attractive themselves (Hughes et al. 2010). Even when asked to deliberately sound "sexy," Tuomi and Fisher (1979) found that both men and women lowered their voices and spoke more slowly.

It appears that the vocal changes directed toward romantic interests are effectual since they can be easily discerned by listeners. For instance, Montepare and Vega (1988) reported that women were rated as sounding more approachable, sincere, submissive, and "scatterbrained" when talking to intimate male partners than when talking to male friends during telephone conversations. A later study also showed that raters were able to decipher if a speaker was talking to their newly in-love, romantic partner or to a close friend when being exposed to only minimal vocal information from a phone conversation (Farley et al. 2013). Thus, voice manipulation can be a useful tool in conveying romantic and/or sexual interest that can be clearly gleaned by others. In addition to speech directed toward a romantic interest, vocal manipulation also occurs when directed toward mate competitors. Puts et al. (2006) found that self-perceived physically dominant men lowered the pitch of their voices in response to a competitor in a dating game scenario, whereas men who considered themselves to be less physically dominant raised their pitch when confronted with a male competitor.

Experimental Manipulation of Voice

Studies involving the experimental manipulation of human voices have provided additional evidence of how modifying the sound of a voice influences perception of the speaker. When Feinberg et al. (2005) experimentally lowered the fundamental frequencies (i.e., average pitch) of recorded male voices, this increased women's ratings of masculinity, size, and age of the speaker. Women also preferred manipulated voices with lowered fundamental frequency over those with raised fundamental frequency. In addition, Puts et al. (2006, 2007) systematically manipulated male voices and found that those with a lower pitch were rated by other men as being more physically and socially dominant. Likewise, when female voices were manipulated to have a lower fundamental frequency, they were also rated as being more dominant (Borkowska and Pawlowski 2011). Exaggerating the intonation of synthesized voices can increase benevolence ratings of speakers (Brown et al. 1973), while decreasing the variance of fundamental frequency of male speaking voices can decrease ratings of benevolence and competence (Brown et al. 1974). Further, Apple et al. (1979) manipulated the rate and pitch of male speaking voices, and found that listeners perceived men who spoke with higher-pitched voices as being smaller, thinner, less truthful, less empathic, and more nervous. They also found that men who spoke more slowly were rated as being less fluent, less truthful, and more passive. In all, these data strongly support the notion that listeners are reactive to vocal modulations, whether it is naturally or experimentally manipulated.

Audience-Directed Speech

Projecting certain speech intonations are particularly dependent upon whom the listener is. When people speak to infants, they tend to use exaggerated vocal intonation, having a higher pitch, broader pitch range, slower rate, and longer pauses (Burnham et al. 2002; Cooper and Aslin 1994; Kitamura et al. 2002). This exaggerated prosodic profile is known as infant-directed speech (Cooper and Aslin 1994), formerly referred to as "motherese" (e.g., Fernald 1985; Fernald and Kuhl 1987). People also tend to speak in this manner to their pets, termed pet-directed speech (Burnham et al. 2002; Prato-Previde et al. 2006). Similarly, romantic partners use prosodic exaggeration, or "loverese," when speaking to each other (Chang and Garcia 2011). Burnham et al. (2002) suggested that speakers have an intuitive sense of the emotional and linguistic needs of their listeners and will adjust their speech parameters accordingly.

What the Sound of the Voice Conveys

The sound of an individual's voice appears to be an important external attribute that is used as a cue for assessing potential mates and plays a vital role in interpersonal attraction (Oguchi and Kikuchi 1997). One reason why the human voice is so important is that it serves as a good index for several physical attributes that are related to biological fitness and therefore, mate value. For instance, studies have found that participants were able to accurately predict the age, height, and weight of a speaker based solely on hearing his or her voice (Krauss et al. 2002) and were particularly keen in assessing age as dependent upon the reproductive viability of speakers throughout the lifetime (Hughes and Rhodes 2010). Additionally, ratings of vocal attractiveness are positively related to a speaker's bilateral symmetry, a marker of the ability to resist developmental perturbations and thus a signal of good genes (Hughes et al. 2002; Hughes et al. 2008). Voice attractiveness is also related to greater shoulder-to-hip ratio in men and to lower waist-to-hip ratio in women, both indicators of ideal sex-specific hormonal status (Hughes et al. 2004). Further, both sexes can accurately predict the physical strength of other individuals, especially men, based only on hearing the sound of their voice, and such estimates of strength are thought to be used to assess fighting ability (Sell et al. 2010). Given that the sound of an individual's voice can be indicative of physical traits that are desirable in a potential mate, it may be advantageous for an individual to attempt to manipulate the patterns of his or her voice in order to try to advertise these desirable traits to potential mates, whether it be an honest signal or not.

Along these lines, we can make predictions based on evolutionary theory of conditions in which each gender would benefit at being adept at conveying a particular vocal image. Because men with lower-pitched voices tend to have larger body sizes (Evans et al. 2006), higher testosterone levels (Dabbs and Mallinger 1999), greater reproductive success (Apicella et al. 2007), and are generally preferred by women (Feinberg et al. 2005), it may be the case that when asked to make their voice sound dominant, attractive, intelligent or confident, a man will intentionally decrease the pitch of his voice. Because men have a preference for higher-pitch female voices (Feinberg et al. 2008) and place emphasis on female attractiveness (Buss 1989; Buss et al. 2001), women may try to make their voices sound more attractive and use a higher-pitch when attempting to attract potential mates. Considering that the tone of voice can convey information about one's status and/or mate value, it is possible that a speaker has the aptitude to modify the sound of his or her voice in order to portray a desired state or trait to potential mates and/or competitors. In the animal kingdom, even some non-human primates are able to manipulate their vocal tract to project "false" indicators of the vocalizer's body size to rivals (Fitch and Hauser 1995). Because human vocalizations are argued to be parallel to animal affect vocalizations (Scherer 1995), it is likely humans also possess this ability.

The Present Study

Previously, Tuomi and Fisher (1979) investigated speakers' ability to intentionally make their voice sound "sexy" by examining two underlying acoustical parameters (i.e., fundamental frequency and duration) of the speakers' utterances, and by gauging independent raters' perceptions. In the present study, we attempted to replicate and extend those procedures by: (1) asking both sexes to intentionally speak using not only their most attractive/sexy voice, but also their most confident, dominant, and intelligent voices—traits often associated with mate selection and competition—to compare with their normal speaking voices; (2) having independent raters of the same- and opposite-sex assess the extent to which the desired vocal image was portrayed by each speaker; and (3) examining more extensively the acoustical parameters of intentional vocal manipulations.

Based on evolutionary theory, we hypothesized that both men and women would be able to effectively portray vocal images of the sex-specific traits that best advertise or enhance their mate value and are most important for mate selection and competition. Because the sexiness/attractiveness of a woman is seen across cultures as being one of the most highly desired traits by men (Buss 1989; Buss and Schmitt 1993; Buss et al. 2001), we predicted that women would be able to manipulate their voices convincingly to sound more attractive and with greater ability than they would for the other traits that are less desired by men. Further, men perceive higher-pitched, raspy female voices as sounding the most attractive (Feinberg et al. 2008; Karpf 2006); therefore, we expected that women would raise the pitch of their voice, speak softer, and show more hoarseness, as measured by the acoustic parameters of jitter and shimmer, in order to portray their most attractive voice.

For men, traits such as dominance, as related to male–male competition, confidence, as related to competition and financial prospects, and intelligence, also related to earning potential, have been rated by females across different cultures as being the most highly desired traits for a mate (Buss 1989; Buss and Schmitt 1993; Buss et al. 2001). It has long been established that women tend to prefer men who demonstrate physical dominance and competence (Touhey 1974), both of which would have been signs of a male's ability to provide resources and protection in our ancestral environment. Women also show a greater preference for men whom they perceived as more intelligent (Prokosch et al. 2009), a trait also thought to be related to genetic fitness (Luxen and Buunk 2006; Prokosch et al. 2005). Thus, manipulating one's voice to sound more dominant, confident, and intelligent could influence others' perceptions of a man's mate value. We therefore predicted that men would be most capable of modifying their voices to communicate these traits effectively so as to advertise their mate value. We expected that men may use louder, lower-pitched voices that have high vocal clarity to intentionally portray these traits, as suggested from previous studies (see Puts et al. 2007).

Methods

Participants

Undergraduate students enrolled at a small northeastern liberal arts college in the US were recruited to participate in this study; some participated in exchange for course credit, while others volunteered with no compensation. Potential participants were screened for factors that could affect the sound of their natural voice (e.g., illness, being a chronic smoker) and were excluded from the study if any of these factors were present. The final sample consisted of 40 undergraduate students (20 men and 20 women) who each provided 5 voice samples that were used as stimuli for this study. Their mean age was 20.37 ($SD = 1.11$; range = 18–23). All procedures of this study were approved by the local Institutional Review Board.

Voice Stimuli

Participants were first instructed to count from one to ten using their normal speaking voice at a pace of about one number per second. A number recitation was used in order to obtain vocal samples that were both neutral and of comparable content, and followed the procedures of previous vocal analyses studies (e.g., Hughes et al. 2002, 2004, 2008, Pipitone and Gallup 2008). Their voices were recorded using an Olympus DS-40 Digital Voice Recorder. Participants then repeated the number count four more times but were instructed to manipulate the sound of their voice each time to sound attractive, dominant, intelligent, or confident. When asked to portray their most attractive voice, participants were instructed to speak as if they were trying to impress someone with whom they were romantically interested. For their dominant voice, they were instructed to speak as if they were trying to assert authority. For their intelligent voice, they were asked to speak as if they were at a scholarly conference giving a presentation. For their confident voice, they were directed to speak as if they were trying to make others trust and believe in their ability to do something. To reduce carry-over effects, we always asked participants to provide their normal voice sample first. After this first recording, the order in which participants were asked to manipulate their voices for the four traits was counterbalanced.

Independent Raters

Another 40 participants (20 men and 20 women) served as independent raters to assess the voice samples. The mean age of the raters was 19.48 ($SD = 0.5$, range = 17–35). None of the participants reported suffering from a hearing impairment that may have interfered with their rating of the voice samples. Also, no participant reported holding an exclusively homosexual orientation, which may have affected some ratings for voice attractiveness. These participants were recruited from the same college but were from summer and freshman introductory classes so that it was unlikely that raters would have known or recognized the individuals who provided the voice samples who were of upper level classmen. Nonetheless, participants were asked not to rate any voice of a person they thought they recognized.

Subjective Ratings

Participants were first asked to read and sign an informed consent form and complete a brief demographic questionnaire. Investigators instructed participants that they would be rating a series of male and female voices for attractiveness, confidence, dominance, and intelligence. The voice samples were presented in a randomized order to the participants using SuperLab 4.0 software but were presented in sets for each trait rating and target sex, approximately 10 voices per set. For instance, participants heard and rated a series of male dominant voices, then heard and rated a series of male intelligent voices, etc. Raters would eventually rate all four traits for a particular speaker, but due to the large number of voice samples needing ratings, and to avoid fatigue effects, not all 40 speakers were heard by each rater. Each voice sample was assessed by approximately 10–12 raters, with about an equal proportion of male and female raters. Each participant rated a selection of approximately 80 total voice samples, a task which took a little over 10 min that included having short breaks between sets with additional instructions given. Manipulated voice samples were rated on 7-point scales (1 = *lowest*; 7 = *highest*) for how much each voice sample conveyed the intended trait (e.g., the manipulated "attractive" voice samples were rated for how attractive they sounded). Normal voices were also rated separately on the same scales for each of the four traits to allow for comparisons. Thus, normal voice samples from each speaker were heard four times, but were randomly embedded in different sets of ratings so as to make it extremely difficult to know if a voice was repeated. Raters were either exposed to only the manipulated voices to make the four trait ratings, or only the normal voices to make the four trait ratings. Our main objective was to compare normal speech voice samples, rated for each of the 4 traits, with the intentionally manipulated voice samples, rated only for the projected trait. Participants were not provided with any information regarding the persons whose voices they were rating, nor were they told that they were hearing several voice samples from the same speaker.

For the same-sex ratings, participants were told to rate voice attractiveness based on how attractive they thought the voice may sound to someone who was the opposite sex of the speaker and not based on how sexually attractive the voice may sound to the participant.

Acoustic Measures: Spectrogram Analysis

The acoustic properties of all voice samples were analyzed using Pratt version 5.2 spectrogram analysis software. Voice samples were unedited, and all 40 participants' voice samples were free of extraneous sounds and abnormal speech pauses. The acoustic properties measured included duration of the recording, mean fundamental frequency (i.e., average pitch), mean amplitude (i.e., loudness), local jitter and local shimmer, measures of vocal hoarseness, and mean harmonics-to-noise ratio (HNR), an index of harmonic to irregular vocal components or "voice quality".

Results

Subjective Voice Ratings

We conducted four 2 (normal vs. manipulated) ×2 (sex of the speaker) ×2 (opposite-sex vs. same-sex raters) mixed model analyses of variance to examine the mean independent voice ratings for each trait: attractiveness, confidence, dominance, and intelligence. Figures 1 and 2 show the mean opposite- and same-sex ratings, respectively, of normal versus manipulated voices across traits for each sex.

Attractiveness Ratings

There was a main effect of voice condition, $F(1, 38) = 6.46$, $p = .015$, $\eta^2 = .145$, whereby voices manipulated by participants to sound attractive ($M = 3.96$, $SE = .160$) were rated as sounding overall more attractive than normal speech ($M = 3.59$, $SE = .111$). There was also a main effect of rater sex, $F(1, 38) = 11.33$, $p = .002$, $\eta^2 = .230$, whereby opposite-sex ratings ($M = 3.95$, $SE = 1.29$) yielded higher attractiveness scores than same-sex ratings ($M = 3.59$, $SD = .129$). There was no main effect for sex of speaker (male: $M = 3.68$, $SE = .166$; female: $M = 3.87$, $SE = .166$), $F(1, 38) = .678$, $p = .415$. There was, however, a significant interaction between speaker sex and voice condition, $F(1, 38) = 10.47$, $p = .003$, $\eta^2 = .216$. While women were rated as sounding significantly more attractive when using their manipulated attractive voice ($M = 4.29$, $SD = 1.24$) than when using their normal voice ($M = 3.45$, $SD = 0.83$), $t(19) = 4.08$, $p = .001$, $d = .80$, there was no such difference between manipulated attractive voices ($M = 3.63$, $SD = 0.72$) and normal voices ($M = 3.73$, $SD = 0.55$) for men, $t(19) = 0.49$, $p = .628$.

Confidence Ratings

Again, there was a main effect of voice condition, $F(1, 38) = 11.31$, $p = .002$, $\eta^2 = .229$, whereby voices manipulated by participants to sound confident ($M = 4.66$, $SE = .187$) were rated as sounding overall more confident than normal voice samples ($M = 4.19$, $SE = .170$). In addition, there was a three-way interaction between voice sex, voice condition, and rater sex, $F(1, 38) = 4.88$, $p = .033$, $\eta^2 = .114$. For male speakers, manipulated voices ($M = 5.14$, $SD = 1.32$) were rated by the opposite sex as sounding more confident than normal voices ($M = 4.20$, $SD = 1.26$), $t(19) = 3.43$, $p = .003$, $d = .73$; however, same-sex ratings of male speakers revealed no such significant difference between the manipulated voices ($M = 4.65$, $SD = 0.99$) and the normal voices ($M = 4.44$, $SD = 0.82$), $t(19) = 0.81$, $p = .429$. For female speakers, both opposite-sex and same-sex ratings revealed no significant differences between confident and normal voices [same-sex manipulated voices: $M = 4.39$, $SD = 1.45$, same-sex normal voices: $M = 3.87$, $SD = 1.48$, $t(19) = 2.00$, $p = 060$; opposite-sex manipulated voices: $M = 4.46$, $SD = 1.33$, opposite-sex normal voices: $M = 4.03$, $SD = 0.93$, $t(19) = 1.85$, $p = .079$].

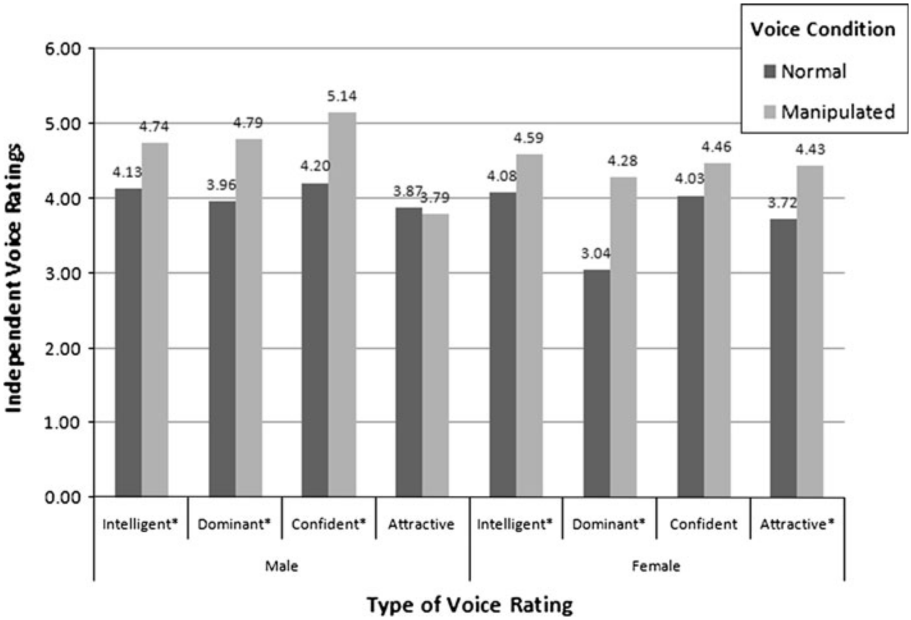

Fig. 1 Mean values representing opposite-sex ratings of intelligence, dominance, confidence, and attractiveness for both normal speech and intentionally manipulated voices (*Note*: $*p < .05$ for each pairwise comparison)

Dominance Ratings

There was a main effect of voice condition, $F(1, 38) = 38.85$, $p = .000$, $\eta^2 = .506$, whereby voices manipulated by participants to sound dominant ($M = 4.58$, $SE = 1.98$) were rated as sounding more dominant than normal voices ($M = 3.52$, $SE = 1.54$). There was also a main effect for the sex of speaker, $F(1, 38) = 5.27$, p = .027, $\eta^2 = .122$. Overall, male voice recordings ($M = 4.41$, $SE = .220$) were rated as sounding more dominant than female voices ($M = 3.69$, $SE = .220$). In addition, there was a significant interaction between speaker sex and voice condition, $F(1, 38) = 4.16$, $p = .048$, $\eta^2 = .099$. Men's normal speech ($M = 4.05$, $SD = 0.87$) was rated as sounding significantly more dominant than women's normal speech ($M = 2.99$, $SD = 1.06$), $t(38) = 3.46$, $p = .001$, $d = 1.10$. However, when asked to manipulate their voices to sound more dominant, women's voices ($M = 4.40$, $SD = 1.36$) were rated as sounding equally as dominant as men's voices ($M = 4.77$, $SD = 1.14$), $t(38) = .92$, $p = .363$.

Intelligence Ratings

There was a main effect of voice condition, $F(1, 38) = 17.04$, $p = .000$, $\eta^2 = .310$, whereby voices manipulated by participants to portray intelligence ($M = 4.64$, $SE = 1.55$) were rated as sounding more intelligent than normal speech samples ($M = 4.04$, $SE = 1.20$). There were no other significant main effects or interactions for this trait.

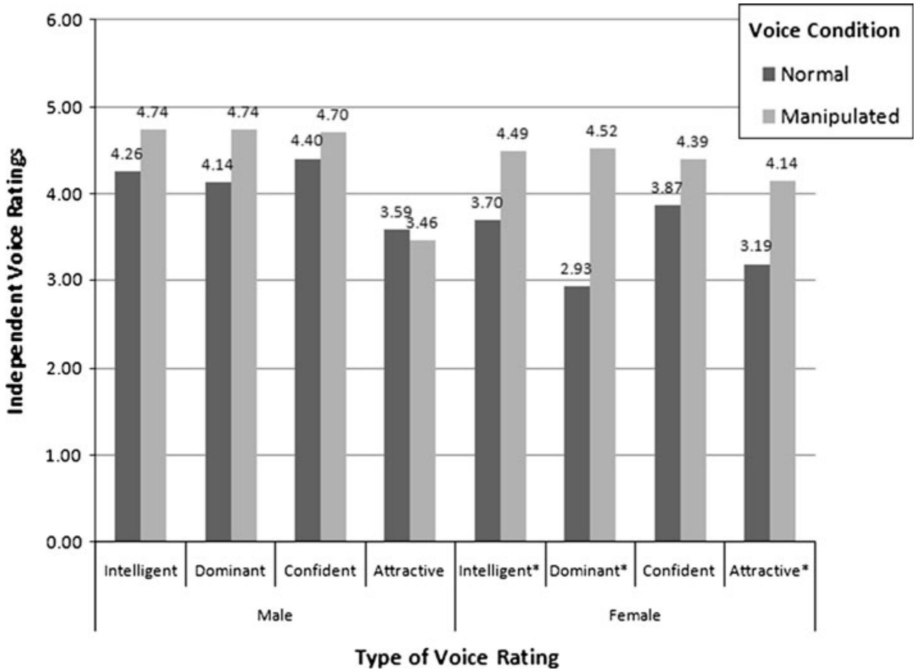

Fig. 2 Mean values representing same-sex ratings of intelligence, dominance, confidence, and attractiveness for both normal speech and intentionally manipulated voices (*Note*: $*p < .05$ for each pairwise comparison)

Spectrogram Analysis

The descriptive statistics for voice duration (in seconds), mean pitch (in Hz), mean amplitude (in dB), local jitter, local shimmer, and mean HNR of voice recordings for each sex and for each manipulation type are presented in Table 1. All spectrogram analyses were performed separately for men and women using repeated measures analyses of variance.

Voice Duration

Men spoke for a significantly longer duration when portraying an attractive voice ($M = 8.61$ s, $SE = 0.36$) than when using their normal voice ($M = 7.83$ s, $SE = 0.26$), as well as when using their confident voice ($M = 7.74$ s, $SE = 0.27$) and dominant voice ($M = 7.67$ s, $SE = 0.34$), $F(4, 76) = 4.22$, $p = .004$, $\eta^2 = .182$. Similarly, women showed significantly slower speech production when attempting to portray their attractive voice ($M = 9.08$ s, $SE = 0.52$) in comparison to their normal voice ($M = 7.49$ s, $SE = 0.28$), as well as their intelligent ($M = 7.90$ s, $SE = 0.39$) and dominant voice ($M = 7.81$ s, $SE = 0.~35$). Women spoke the fastest when using their confident voice ($M = 7.27$ s, $SE = 0.32$), $F(4, 76) = 15.02$, $p < .001$, $\eta^2 = .441$.

Table 1 Descriptive statistics for spectrogram analyses of normal and manipulated voices

Vocal measure	Normal		Attractive		Confident		Dominant		Intelligent	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Duration (in sec)										
Male	7.83	1.14	8.61	1.61	7.74	1.21	7.66	1.52	8.04	1.52
Female	7.48	1.27	9.08	2.32	7.27	1.45	7.81	1.56	7.90	1.73
Mean pitch (in Hz)										
Male	110.32	12.32	115.66	18.27	116.92	13.53	123.76	18.38	118.63	16.48
Female	208.71	26.02	201.09	24.68	214.67	26.95	221.30	25.49	211.45	23.07
Amplitude (in dB)										
Male	47.73	2.75	48.01	3.74	50.70	3.60	54.23	6.13	49.29	3.31
Female	49.07	2.97	49.43	2.60	51.85	3.47	54.19	3.11	50.34	3.32
Jitter (local, db)										
Male	1.56	0.39	1.77	0.54	1.59	0.33	1.47	0.40	1.61	0.44
Female	1.51	0.57	1.64	0.48	1.34	0.47	1.10	0.26	1.42	0.48
Shimmer (local)										
Male	1.09	0.13	1.10	0.18	1.10	0.10	1.07	0.15	1.10	0.16
Female	0.92	0.12	0.92	0.14	0.94	0.10	0.85	0.10	0.92	0.13
HNR										
Male	6.09	1.23	6.09	1.44	6.13	1.60	6.13	1.60	6.20	1.65
Female	8.64	1.77	8.65	1.81	8.24	1.64	9.11	1.54	8.28	1.40

Mean Fundamental Frequency (Pitch)

Men had a significantly higher pitch when portraying their confident ($M = 116.92$, $SE = 3.03$), dominant ($M = 123.76$, $SE = 4.11$), and intelligent ($M = 118.63$, $SE = 3.68$) voices in comparison to the mean pitch used in their normal speech ($M = 110.32$, $SE = 2.76$), $F(4, 76) = 4.89$, $p = .001$, $\eta^2 = .205$. However, when portraying attractive voices ($M = 115.66$ Hz, $SE = 2.76$), male voices did not significantly differ from any of the other voice samples. Furthermore, the mean pitch used for the dominance voices ($M = 123.76$, $SE = 4.11$), was significantly higher than those used for confidence voices ($M = 116.92$, $SE = 3.03$).

Women had used a significantly lower pitch when trying to sound attractive ($M = 201.09$, $SE = 5.52$) in comparison to all other vocal manipulations: intelligent ($M = 211.45$, $SE = 5.16$), confident ($M = 214.67$, $SE = 6.03$), and dominant ($M = 221.30$, $SE = 5.70$) voices, $F(4, 76) = 6.49$, $p < .001$, $\eta^2 = .254$. Women had also used a significantly higher mean pitch when portraying their dominance voice ($M = 221.30$, $SE = 5.70$) in comparison to their normal voice ($M = 208.71$, $SE = 5.82$).

Mean Amplitude (Loudness)

Men used a significantly louder voice when portraying dominance ($M = 54.23$ dB, $SE = 1.37$), confidence ($M = 50.70$ dB, $SE = 0.81$), and intelligence ($M = 49.29$ dB, $SE = 0.74$) than when speaking with their normal voice ($M = 47.73$ dB, $SE = 0.62$), $F(4, 76) = 24.68$, $p < .001$, $\eta^2 = .565$. However, there was no significant difference in mean amplitude between men's attractive voices ($M = 48.01$, $SE = 0.84$) and their normal voices ($M = 47.73$ dB, $SE = 0.62$). Whereas attractive voices were significantly quieter than all other vocal manipulations, dominant voices were significantly louder than all other vocal manipulations (see Table 1). Lastly, men spoke significantly louder when portraying confidence than all other voice manipulations except for dominance.

Similar patterns were shown when examining the mean amplitude of female voices. Women used a significantly louder voice when portraying dominance ($M = 54.19$, $SE = 0.70$), confidence ($M = 51.85$, $SE = 0.78$), and intelligence ($M = 50.34$, $SE = 0.74$) than when speaking with their normal voice ($M = 49.07$, $SE = 0.66$), $F(4, 76) = 29.78$, $p < .001$, $\eta^2 = .610$. There were no differences found in mean amplitude between women's attractive voices ($M = 49.43$, $SE = 0.58$) and their normal and intelligent voices. Similar to men, women's dominant voices were significantly louder than all other vocal manipulations (see Table 1). Aside from dominance, women's confident voices were also spoken using a significantly louder voice than all other manipulations.

Jitter (Local) Measures

There were no differences found in local jitter between the different male voice recordings, $F(4, 76) = 1.99$, $p = .103$. In contrast, several differences in voice jitter were found between the female voice recordings, $F(4, 76) = 9.28$, $p < .001$, $\eta^2 = .328$. Female voices portraying dominance ($M = 1.10$, $SE = 0.06$) had significantly lower jitter than all other voice types: normal ($M = 1.51$, $SE = 0.13$), attractive ($M = 1.64$, $SE = 0.11$), confident ($M = 1.35$, $SE = 0.11$), and intelligent ($M = 1.42$, $SE = 0.11$). On the other hand, women had higher jitter measures (i.e., more hoarseness) for their attractive voices than their confident, dominant, and intelligent voices.

Shimmer (Local) Measures

Similar patterns emerged when examining another measure of vocal hoarseness: shimmer (local). Whereas there were no significant differences found in shimmer for male voice recordings across conditions, $F(4, 76) = 0.48$, $p = .749$, differences were found for female voice recordings, $F(4, 76) = 3.23$, $p = .017$, $\eta^2 = .145$. Female voices portraying dominance ($M = 0.85$, $SE = 0.02$) had significantly lower voice shimmer (i.e., less hoarseness) than the normal ($M = 0.92$, $SE = 0.03$), confident ($M = 0.94$, $SE = 0.02$), and intelligent ($M = 0.92$, $SE = 0.03$) voice samples.

Harmonics-to-Noise Ratio (HNR)

There were also no differences found between the male vocal samples for harmonics-to-noise ratio (HNR), $F(4, 76) = 0.10$, $p = .983$. However, significant differences were found for female voice recordings for HNR, $F(4, 76) = 2.77$, $p = .033$, $\eta^2 = .127$. Women had a significantly higher HNR when using their dominant voices ($M = 9.11$, $SE = 0.34$) than when portraying their confident ($M = 8.24$, $SE = 0.37$) and intelligent ($M = 8.28$, $SE = 0.32$) voices.

Comparison of Subjective and Acoustic Assessments

Following Tuomi and Fisher (1979), we also compared the subjective ratings of the manipulated voices with the acoustic parameters taken for each voice sample. The results

Table 2 Male voices: Pearson correlations between subjective vocal ratings and objective vocal measures of manipulated voices

Rater sex	Subjective ratings							
	Attractive		Confident		Dominant		Intelligent	
	Opp.	Same	Opp.	Same	Opp.	Same	Opp.	Sex
Objective measures								
Duration	−.011	.230	.175	.035	.125	.196	−.057	−.101
Mean pitch	−.269	.171	−.087	−.115	.238	−.074	.146	.134
Mean amplitude	.354	−.035	.319	.346	.219	.328	.254	.278
Jitter	−.315	.034	−.026	−.048	−.254	−.253	.113	.102
Shimmer	.152	−.003	.168	.023	−.304	−.182	.103	.082
HNR	.118	.378	−.267	−.350	.208	.018	−.209	−.084

None of the correlations was significant

Table 3 Female voices: Pearson correlations between subjective vocal ratings and objective vocal measures of manipulated voices

Rater sex	Subjective ratings							
	Attractive		Confident		Dominant		Intelligent	
	Opp.	Same	Opp.	Same	Opp.	Same	Opp.	Sex
Objective Measures								
Duration	.309	.129	.172	.486*	.405	.439	.233	.344
Mean Pitch	.196	.111	−.236	−.049	.003	.174	−.316	−.383
Mean Amplitude	−.380	−.181	.064	.060	.567**	.341	−.498*	−.302
Jitter	−.264	−.511*	−.157	−.223	−.304	−.528*	.085	.243
Shimmer	−.019	−.302	−.114	−.225	−.268	−.475*	.069	.194
HNR	.244	.118	−.445*	−.223	−.147	.029	−.212	−.377

* Correlation is significant at the .05 level (two-tailed)

** Correlation is significant at the .01 level (two-tailed)

of the correlational analyses for male speakers are presented in Table 2, and results for female speakers are presented in Table 3.

Discussion

Subjective Assessment of Normal and Manipulated Voices

We asked participants to intentionally manipulate the sound of their voices and speak using their most attractive, confident, dominant, and intelligent voices. We then asked independent raters to assess the degree to which each voice sample projected the given trait. Although, in general, the manipulated voice samples were judged as conveying the targeted trait better than normal voices, there were some notable differences found across the traits and between the sexes that support our hypotheses based on evolutionary reasoning.

Attractiveness

With respect to attractiveness, listeners of both sexes rated women's manipulated voices as sounding more attractive than their normal voices. Interestingly, however, this was not the case for ratings of men's voices. Thus, as hypothesized, our data suggest that a woman can effectively make her voice sound more attractive, whereas a man cannot. This finding can be explained from an evolutionary perspective. Voice attractiveness predicts attractive body and face characteristics (Hughes et al. 2002, 2004; Saxton et al. 2009), and men place greater emphasis on female attractiveness than do women when searching for a mate (Buss 1988; 1989; Buss and Schmitt 1993; Buss et al. 2001). Therefore, it would be beneficial for a woman to effectively manipulate her voice to sound more attractive so as to enhance her apparent mate value to potential mates, as well as female rivals competing for a man's attention.

Confidence

Women rated men's manipulated voices as sounding more confident than men's normal voices, whereas same-sex ratings made by other men had revealed no such difference. For female voices, both same- and opposite-sex ratings showed no difference in confidence ratings between manipulated and normal voice samples. This finding also supported our hypothesis explained from an evolutionary perspective as it relates to mate selection. When choosing a mate, women place an emphasis on a prospective mate's earning potential and financial resources (Sprecher 1989) and confidence appears to be related to a man's earning potential, power in society, and other personality characteristics related to success (Buss 1989). Therefore, it is prudent for men to have the ability to project a voice of confidence, and for women to be susceptible to detecting this trait in a potential mate. The fact that men did not perceive increased confidence in other male speakers may be a testament to men's evolved ability to detect posturing accurately. Indeed, other social primates such as male baboons use vocal cues to assess rival males (Roux and Bergman 2012). Furthermore, men tend to engage in competitor derogation more often than self-promotion as an intra sexual competition strategy (Fisher et al. 2009). It is possible, then, that men are preprogrammed to underrate the competition. Moreover, Buss (1988) showed that men are more likely than women to use intra sexual competition tactics involving resource display and possession. Thus, men may be more likely to assess a competitor's mate value more from physical signs of earning power and social dominance rather than they are to rely on indirect signs of these subtle vocal manipulations.

Dominance

Not surprisingly, men's normal speech samples were rated as sounding more dominant than were women's normal voices; however, this did not hold true for the manipulated voices. While we hypothesized that men would be able to effectively manipulate the sound of their voices to convey dominance, we did not expect that woman would also possess this ability that would be comparable to men. Sounding dominant or appearing formidable is not usually a trait associated with female mate value or female–female competition, as it is with men. While studies have shown that men change their voices to sound more dominant, especially in competitive scenarios (Puts et al. 2006, 2007), other studies suggest similar patterns can occur with modified female voices (Borkowska and Pawlowski 2011). As with men, women whose voices were experimentally manipulated to have a lower pitch were generally perceived as being more dominant and the relationship was linear (Borkowska and Pawlowski 2011).

The sound of a dominant voice also relates to perceptions of leadership. Klofstad et al. (2012) found that both men and women believe those with lower voices make for better leaders and suggested that because women, on average, have higher-pitched voices than men, voice pitch could be a factor that contributes to fewer women holding leadership roles than men. Likewise, Karpf (2006) suggested that women consciously try to deepen their voices so as to adopt more masculine roles in life. Thus, the use of lower-pitched voices may be a byproduct of women recently becoming more involved in traditionally male-oriented occupational roles in our culture. Indeed, former British Prime Minister, Margaret Thatcher, had received vocal coaching to allow for her voice to sound more domineering and lower-pitched (Karpf 2006). Therefore, in line with these data, it seems plausible to conclude that women can effectively modify their voices to allow for a more dominant percept, as can men, and this trait may be culturally mediated.

Intelligence

There was an overall effect whereby voices manipulated by participants to sound intelligent were rated as sounding more intelligent than their normal speech, and no sex differences were observed. This is not surprising considering that intelligence is a trait that holds similarly high ranking in mate preferences of both men and women across cultures (Buss et al. 2001), so it would be adaptive to portray this trait vocally. Further, signs of intelligence have been shown to be positively correlated with body symmetry (Luxen and Buunk 2006; Prokosch et al. 2005), an honest signal of developmental stability (Gangestad and Thornhill 2003; Jones et al. 2001; Schieb et al. 1999). In men, voice ratings for intelligence are also directly related to greater bilateral symmetry (Hughes et al. 2008). Thus, being able to project an intelligent-sounding voice has implications for both men and women in terms of signaling fitness and a high mate value.

Same-Sex Ratings

There were interesting effects found when considering same-sex ratings. Similar to men's ratings, women also rated other women's manipulated voices intended to project attractiveness, dominance, and intelligence, but not confidence, differently than normal speech. Women's keenness in detecting differences in other women's vocal modification may be linked to intra sexual mate tactics. Women often use verbal tactics such as gossip and reputation smearing for intra sexual competition more often than do men (Buss 1990). In fact, disparaging another woman's reputation can affect perceptions of that woman's overall attractiveness (Rucas et al. 2006). The ability of a woman to manipulate her voice to enhance potential mates' perceptions of her would be an important adaptation for self-promotion, and the ability of a woman to detect these types of manipulation in other females may be an adaptive way to identify potential competitors.

A different picture emerged from men's ratings of male voices; men rated other men's manipulated voice samples no differently than normal speech across all four traits. We can conclude that men must possess some ability to modify their voices to accurately portray different traits because female raters were able to detect differences in male voices. Men must also possess some sensitivity to detect intended vocal projections, because they were able to detect differences in female voices. Therefore, it is interesting to speculate why male raters in our study were not as sensitive to vocal cues in other men. Studies that have documented men's sensitivity to other male voices have pointed to lower pitch as being the salient cue. For instance, O'Connor and Feinberg (2012) asked participants to imagine their partner going on a weekend trip with another, and they showed that men exhibited more jealousy in response to a masculine-voiced (i.e., lower pitch) man accompanying their female partner. Because the men in our sample did not lower the pitch of their voice from their normal speaking voice for any of the four projected traits, it is possible that our male raters were just not attuned to these vocal changes, as such changes would not be significant in competitor interactions in ancestral environment. Aside from detection of a lower pitch, men may look more towards physical traits such as body size or shoulder-to-hip ratios (e.g., Dijkstra and Buunk 2001) to ascertain the threat of a competitor.

The observed gender differences in the decoding and/or production of some of the vocal stimuli may also be due to the overall gender differences seen in social conditioning and sensitivity to nonverbal cues (Brody and Hall 1993; Hall 1978; Jansz 2000). It may be the case that because emotional restrictiveness is reinforced in men, men are less often required to assess nonverbal cues and thus have little experience practicing decoding these types of signals (Jansz 2000). As such, Brody and Hall (1993) noted that men have an advantage in a competitive environment if they do not display emotions. Alternatively, Ickes et al. (2000) suggested that women experience greater incentive to practice decoding nonverbal cues, therefore have greater sensitivity to them. This interpretation is not incompatible with an adaptationist perspective. Perhaps women have greater motivation to assess nonverbal signals of mate quality due to their more discriminative mating choices, and motivation to assess nonverbal cues of same-sex competitors due to the less physical nature of female–female competition tactics (Buss 1988, 1990, Buss and Schmitt 1993). In other words, nonverbal cues would afford additional, valuable information that women could use to make more informed mating decisions and to accurately assess competitor threat.

Acoustic Parameters of Normal and Manipulated Voices

Spectrogram analyses revealed a number of similarities and differences in the vocal parameters that men and women use when attempting to portray intended traits. In line with our hypothesis and a replication of Tuomi and Fisher's (1979) work examining "sexy" versus "normal" voices, we also found that both sexes in our sample slowed their speech in comparison to their normal speech when trying to sound attractive/sexy. These findings also support Hughes et al. (2010) who showed that both men and women spoke more slowly to attractive, opposite-sex targets than to unattractive targets. Perhaps the slowing of one's voice in a mating scenario is an attempt to convey approachability, as decreased speaking rate was found to increase the benevolence ratings of a speaker (Brown et al. 1974). Also in line with previous investigations (Tuomi and Fisher 1979; Hughes et al. 2010), we found that women used a lower pitch when trying to portray their most attractive-sounding voice in comparison to other vocal manipulations. Further, women showed more vocal hoarseness when trying to sound sexy, which parallels the common stereotype in our culture that deems a sexy female voice as one that sounds husky, breathy, and lower-pitched (Karpf 2006). Perhaps the deliberate changes in both the pitch and hoarseness of women's voices from normal speaking voice were the important acoustic elements that made the women's voices sound sexier, as was not the case with men's voices.

Both male and female participants raised their pitch and spoke louder in an intended effort to portray their most dominant-sounding voice. The findings presented in the literature with regards to what acoustic parameters underscore the percept of a dominant voice are not consistent. Some reports showed that lower-pitched voices are rated as sounding more dominant (Borkowska and Pawlowski 2011; Puts et al. 2006), while other studies showed higher-pitch voices are associated with dominance judgments (Floyd and Ray 2003; Tusing and Dillard 2000). Others have shown sex differences in this trait; Floyd and Ray (2003) reported that men who spoke with a higher pitch were perceived as being less affiliative and more dominant, while women who spoke with higher pitch were perceived as being more affiliative and less dominant (Floyd and Ray 2003). The differences seen across studies may be due to the conditions under which "dominance" was elicited from participants providing voice samples. Puts et al. (2006) measured voice samples collected from individuals that were put into a scenario in which male participants were competing with another man for a date with a woman, while Tusing and Dillard (2000) had participants evaluate recorded video messages of actors delivering short, influential messages trying to exert power over the listeners. In the present study, we asked participants to manipulate their voice as if the participant were trying to assert authority. Unlike the previous studies, participants in our study were very cognizant that they were to manipulate the sound of their voices; however, we did not specify the sex of the audience nor the age of the audience as part of the instructions for their vocal manipulation. (As a side note, a few participants revealed to us afterwards that they pretended they were reprimanding their younger sibling in order to portray dominance.) Thus, it seems that individuals may manipulate their voice to express different types of dominance depending on the context and/or audience. Additionally, participants were asked to manipulate their voice while reciting a number count from one to ten and this may reveal different patterns than would be the case during conversational speech.

Also in support of our hypotheses, we found that men increased their pitch and spoke louder in comparison to their normal voice in order to sound more confident and intelligent, albeit less of an increase as their dominant voice. Women had spoken the fastest when trying to modify their voices to sound confident. Similarly, Kimble and Seidel (1991) also showed that when individuals are confident in what they are saying, they tend to speak faster and louder.

Differences in the acoustic measures of vocal quality and vocal hoarseness were only found for women's manipulated voices, but not men's voices. Women exhibited less vocal hoarseness (i.e., lower measures of jitter and shimmer), and higher voice quality (i.e., HNR) when portraying their dominant voices than for other vocal manipulations, but had greater vocal hoarseness when presenting their most attractive voice. Our culture tends to deem a huskier female voice as one that sounds more sexy (Karpf 2006), and seemingly, the women in our study had confirmed this stereotype. As for the dominant voices, it seems likely that a clear and unwavering voice would be perceived as one that sustains dominance. Having an abnormally higher shimmer and jitter has been associated with increased pathogenesis of muscles related to voice (Jiang et al. 1999; Shao et al. 2010), suggesting that increased levels of jitter and shimmer may be signs of poor health and weakness. It would therefore be advantageous for individuals to reduce the hoarseness (i.e., lower jitter and shimmer) of their voice when trying to sound more dominant, especially given a competitive situation.

It is curious that we found few relationships between subjective ratings and acoustical voice parameters. As with previous investigations (Hughes et al. 2008), it is often difficult to make predictions about overall perceptual elements of a voice heard by the human ear by parsing apart the individual acoustic parameters of a particular vocal profile. As such, future investigations could attempt to examine more in-depth vocal configurations to see if there is a Gestalt pattern of vocal parameters that underlie certain vocal manipulations in certain contexts.

Limitations

This study had some limitations. First, participants were asked to manipulate their voice while reciting a number count from 1 to 10. Although the focus of our study was to investigate intentional, conscious modifications of the voice rather than content of speech, perhaps if these manipulations had been uttered using conversational speech, participants may have projected the desired manipulation in a different manner. It is also possible that the use of non-conversational content (i.e., number recitation) could influence the speaker's intonation profile and vocal pitch. Therefore, future research efforts could replicate this study using more content-driven speech. The voice manipulations used for this study were gathered in a laboratory setting rather than in a natural setting, such as during a conversation between two individuals. Nonetheless, our data were capturing the conscious intent of vocal changes, whereas in normal conversations, vocal modification may not be conscious. Our spectrogram analyses also had shown that the physical qualities of our voice manipulations changed similarly to the voices in other studies that have demonstrated these changes in real conversation (Anolli and Ciceri 2002; Hughes et al. 2010), suggesting that our gathered manipulations were valid. An aim of this study was to create a controlled situation where both the speech producer and receiver were explicitly cued on the vocal manipulations so that we could examine deliberate vocal modulation in comparison to normal speech. It may be more difficult to capture deliberate vocal modification in a conversation where it was to be "natural" without it relying on some acting skill or previous coaching/experience.

Some differences between manipulated voices and normal voices failed to reach statistical significance, and our sample size ($N = 200$ voice samples) may have contributed to this. A post hoc power analysis showed that for an effect to be detected as significant at the alpha = .05 level, an n of approximately of 341 voice samples would be needed to obtain statistical power at the recommended .80 level (Cohen 1988). Nonetheless, the effect sizes of the findings we reported were comparable to previous investigations on the topic (see Tuomi and Fisher 1979). Another limitation is that female participants were also not asked to give information about birth control pill use nor their menstrual cycles. Perceptions of female voice attractiveness have been shown to vary across the menstrual cycle (Amir and Biron-Shental 2004; Pipitone and Gallup 2008). Therefore, future studies of this type could account for hormonal variation in female vocal quality. Future investigations could also attempt to replicate these findings using forced-choice scenarios where participants would be asked to recognize which trait the speaker was attempting to portray amongst an array of choices.

Conclusion

While previous studies have explored different contexts and situations in which individuals modify the sound of their voice, few have examined conditions of deliberate, conscious attempts to modify one's voice to convey a certain trait. The present study sheds light onto what patterns emerge when men and women intentionally modify their voice to project traits that are related to mate selection and competition, how others perceive those vocal modifications, and what acoustic parameters underlie those changes. To summarize, we found that when trying to sound sexy/attractive, both sexes slowed their speech and women lowered their pitch and had greater vocal hoarseness. However, only women were perceived by both sexes to be adept at intentionally making their voice sound sexier, whereas men were not. Both sexes raised their pitch and spoke louder in order to sound dominant and women had less vocal hoarseness. Indeed, these vocal manipulations made by both sexes were effective to create a perception of sounding more dominant to listeners. Men increased their pitch and spoke louder in comparison to their normal voice in order to sound more confident and intelligent, albeit less of an increase as their dominant voice, and were perceived as such by women. Women had spoken the fastest when trying to modify their voices to sound confident, but were not successful in conveying this trait as were men.

Overall, these findings support our predictions that corroborate with evolutionary reasoning and expand upon our knowledge of how the human voice can play an important role in mating and competition. Further, these findings could have implications and/or practical applications in the realm of vocal coaching, especially for those in the professional fields of public speaking, acting/entertainment, customer service, and advertisement. With knowledge concerning what acoustic parameters are needed and used by each sex to effectively convey certain traits via the tone of one's voice, and knowledge about what parameters are perceived by the target male or female audience, one essentially could become a more effective communicator.

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