VOICE PITCH AND COMPETITIVENESS

VOICE PITCH AFFECTS WOMEN'S PERCEPTIONS OF DOMINANCE, BUT NOT IN A WAY THAT RELATES TO COMPETITIVENESS

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Lay Abstract

Low voice pitch is associated with perceptions of dominance, size, attractiveness, higher socio-economic status, and low cooperativeness. Since men lower their voice pitch in competitive scenarios, we predicted low pitch would be tied to perceptions of competitiveness of the speaker. We manipulated pitch in men's and women's voices, and female participants chose which voice they thought belonged to the person who was more physically/socially dominant, competitive, cooperative, larger, higher in socio-economic status, and more attractive. Women chose low voices as being more physically/socially dominant, less cooperative, larger, higher in socio-economic status, and (for male voices only) more attractive than higher voices. Pitch had no effect on perceptions of competitiveness, it did not affect perceptions of dominance for male speakers more than female speakers, neither did it affect perceptions of dominance more than attractiveness. This challenges the idea that low pitch in men evolved to primarily signal success in intrasexual competition.

Abstract

A theory of the evolution of low voice pitch in men suggests that (a) voice pitch is used as an indicator of success in mate competition; (b) pitch is used as an indicator of dominance more for men's voices than women's; (c) pitch affects dominance ratings more than attractiveness ratings. While early studies supported these ideas, several subsequent studies have failed to replicate these results with mainly male raters, because of the idea that men's perceptions affect selection more than women's do.

We tested the extent to which these findings apply to women's perceptions of the aforementioned characteristics, as well as to other characteristics related to voice pitch and dominance: perceived body size, competitiveness, cooperativeness, socio-economic status, and attractiveness. We manipulated pitch in men's and women's voices and tested women's perceptions thereof. Women chose low voices as belonging to a speaker that is more physically/socially dominant, less cooperative, larger, higher in socio-economic status, and (for men's voices) more attractive. In contrast to hypotheses of theories on the evolution of low voice pitch in men, pitch had no effect on perceptions of competitiveness, nor did it affect either physical or social dominance ratings more than it affected attractiveness ratings. Surprisingly, pitch affected dominance perceptions of women's voices more than men's. Thus, despite previous evidence that some men modify their voices in competitive scenarios, our data are unable to support the

idea that this information is used by women to infer dominance related to competitiveness. We contribute to the growing literature that finds no difference in the amount that voice pitch affects dominance and attractiveness ratings or fails to find stronger effects for male than female voices. Our data are consistent with theories that dominance ratings are the result of a general response bias to stimuli varying in pitch.

Acknowledgements

I would like to thank my supervisor, Dr. David Feinberg, for his wonderful guidance, support, understanding, and kindness throughout this process.

Thank you to my family, for their unending love and support of all my endeavors. Thank you for encouraging me to do what I love.

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I am most grateful to you all.

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Declaration of Academic Achievement/Materials Prepared for Publication

My involvement with this project is extensive. I played a major role in the design of this study, the acquisition of data and its analysis, the interpretation of the results, and – naturally – the drafting and revision of this manuscript. The project and results outlined here are in preparation to be submitted for publication in a journal as a paper, of which I am primary author (followed by my colleague, Marie Armstrong, and my supervisor, Dr. David R. Feinberg).

I would like to thank my colleague, Marie Armstrong, for her help in recruiting and running participants for this study, her thoughts on our results, and for editing this manuscript.

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Introduction

According to a prevalent theory, low voice pitch in males is thought to have evolved due to male-male competition (Puts et al., 2016). This theory is based on the idea that (a) voice pitch indicates success in competition; (b) the association between voice pitch and dominance-related constructs is stronger for men's voices than women's voices (Puts, Gaulin, & Verdolini, 2006); and (c) voice pitch affects ratings of male dominance more than ratings of male attractiveness (Puts et al., 2016; Puts, 2005). Since the initial data that were the foundation of these ideas were published, several other studies have been published as well. Therefore, to update our understanding of the background of this theory, here we evaluate literature relevant to these three ideas.

a) Does voice pitch indicate success in competition?

One of the main ideas of the abovementioned theory is that low voice pitch evolved as a result of male-male intrasexual competition. But firstly, do men compete more than women do? Cashdan (1998) ran two studies examining who men and women compete with, over what, and how. In the first study, the participants recorded in journals any competitive situations they had found themselves in throughout a university term. Competition was defined as follows: "Typically, competition involves trying to improve one's position relative to

someone else's, or trying to have something that someone else wants. … For our purposes, competition is defined very broadly, and need not take place as a discrete event. If you are feeling competitive about something, it counts as competition." Though sex differences were few, men were found to have competed more with the same sex, women competed more by looking attractive while men did so through sport, and men used physical aggression more than women did. The second study addressed whether one sex felt more competitive than another. It was found that both sexes felt equally competitive, but men were felt more so in the domains of sports and attention from the opposite sex while women felt more competitive about looking attractive. A further finding of this study was that, for male participants, competition for financial success was correlated with competition for attention from the opposite sex.

These studies contain a definition of competitiveness and provide an interesting look at competitiveness and its differences between the sexes, ones that lend support for strong male-male competition. But how does voice pitch play a role and does it indicate competitiveness and success in competition?

Though no study has examined directly the association between voice pitch and actual perceptions of a speaker's competitiveness, pitch has been found to be associated with traits that may be related to competitiveness. For instance, there are several studies that use questionnaires to suggest that men with low pitched voices are successful fighters (Puts, Apicella, & Cardenas, 2012; Sell et al., 2010; Wolff & Puts, 2010). However, we know of no study that replicates these findings

with objective data on actual fight results, rather than subjective ratings of who is a good fighter.

Voice pitch is thought to be an honest indicator of body size and strength (Evans, Neave, & Wakelin, 2006; Evans, Neave, Wakelin, & Hamilton, 2008; Kordsmeyer, Hunt, Puts, Ostner, & Penke, 2018; Puts et al., 2012; Rendall, Vokey, & Nemeth, 2007; Sell et al., 2010; Smith & Patterson, 2005; Smith, Olkhov, Puts, & Apicella, 2017). However, when measured objectively, the relationships between voice pitch and body size and voice pitch and strength are so weak that we cannot detect them in ecologically valid samples (Collins, 2000; Han et al., 2017; Pisanski, Fraccaro, Tigue, O'Connor, Röder, et al., 2014; Pisanski, Fraccaro, Tigue, O'Connor, & Feinberg, 2014; Rendall, Vokey, & Nemeth, 2007; Dunbar, 1992). Nevertheless, studies have demonstrated that more than half of men who self-identified as dominant lowered their voice pitch in laboratory simulated dominance bouts (Puts et al., 2016; Puts, 2005; Puts, Gaulin, & Verdolini, 2006; Puts, Hodges, Cárdenas, & Gaulin, 2007). Therefore, we predict that lowering and raising voice pitch may affect perceptions of competitiveness, even if pitch is not tied to objective measures of physical prowess.

b) Is voice pitch used as an indicator of dominance more for men's voices than women's voices?

Two studies (Puts, Gaulin, & Verdolini, 2006, 2007) showed that voice pitch affected dominance ratings of men's voices more than it affected dominance ratings of women's voices. However, another study did not replicate this sex difference (Jones, Feinberg, DeBruine, Little, & Vukovic, 2010). Studies on social dominance suggest that voice pitch affects real-world dominance outcomes such as voting preferences, election outcomes, and job success in both men's and women's voices relatively equally. For example, when voting, people tend to perceive candidates with low pitched voices as better leaders and prefer to vote for them; regardless of sex, low pitched candidates are also perceived as being stronger, more competent, and older, and low pitched male and female voices are preferred when hiring job candidates (Anderson & Klofstad, 2012; Klofstad, Anderson, & Peters, 2012; Klofstad, Anderson, & Nowicki, 2015; Tigue, Borak, O'Connor, Schandl, & Feinberg, 2012). If selection was indeed only acting on men's voices as an indicator of dominance that mainly affects men's mating success (Kordsmeyer, Hunt, Puts, Ostner, & Penke, 2018; Puts et al., 2016; Puts, Gaulin, & Verdolini, 2006; Puts, 2007), we would not expect women's voice pitch to affect competition outcomes, such as election and job success, to an equal degree as pitch affects these outcomes in men's voices. Therefore, we tested whether voice pitch affected perceptions of dominance and related characteristics among men's and women's voices differently.

c) Does voice pitch affect dominance ratings more than it affects attractiveness ratings?

Regarding male voice pitch and its association with dominance, testosterone levels in puberty thicken male vocal folds, resulting in a lower voice pitch for males than females (Dabbs & Mallinger, 1999; Harries, Walker, Williams, Hawkins, & Hughes, 1997). Additionally, higher testosterone levels in men increase their perceived masculinity and dominance (Mazur & Booth, 1998; Swaddle & Reierson, 2002). Indeed, men with a lower voice pitch are perceived by other men as being more physically and socially dominant (Puts et al., 2016; Puts, 2005; Puts, Gaulin, & Verdolini, 2006; Puts, Hodges, Cárdenas, & Gaulin, 2007).

Voice pitch is also associated with perceptions of attractiveness. Feinberg et al. (2005; 2012) and Jones et al. (2010) found that low pitched male voices were deemed attractive by female raters. Conversely, a high voice pitch is positively associated with oestrogen levels in women (Abitbol, Abitbol, & Abitbol, 1999), with high levels of the hormone being positively associated with reproductive health, development, and femininity (Alonso & Rosenfield, 2002). Studies have consistently found that men find a high female voice pitch attractive (Feinberg, Jones, DeBruine, Moore, Law Smith, Cornwell, Tiddeman, Boothroyd, & Perrett, 2005a; Feinberg, DeBruine, Jones, & Perrett, 2008; Jones et al., 2010). Often, a low male voice pitch and a high female voice pitch are thought to reflect “good genes,” whereby the pitch of the voice is thought to demonstrate the speaker’s

underlying mate quality, such as physical health and fertility. (Abitbol, Abitbol, & Abitbol, 1999; Feinberg et al., 2005; 2005a; 2008; 2012).

When comparing the effect of voice pitch on dominance as opposed to attractiveness ratings, Puts et al. (Puts, Gaulin, & Verdolini, 2006; Puts et al., 2007) and Jones et al. (2010) both found that voice pitch affected dominance ratings more than attractiveness ratings. However, Kordsmeyer et al. (2018) found no difference between the strength of the relationships between voice pitch and dominance, and voice pitch and attractiveness ratings. Here, we test this idea again, among women listeners.

Beyond dominance and attractiveness, low voice pitch is also associated with a higher socio-economic status (O'Connor et al., 2014); this may be related to competitiveness, since Cashdan (1998) found that competition for financial success was tied to mate competition in men. Further, a low voice pitch is often attributed to a speaker who is less cooperative (Knowles & Little, 2016). Thus, in addition to the attributes mentioned above, we also tested whether voice pitch affected perceptions of socio-economic status and cooperativeness more than it affected perceptions of attractiveness and whether voice pitch affected perceptions of these constructs more in men's voices than in women's voices.

To test the assumptions of the theory in question, we raised and lowered the voice pitch of men's and women's voices and asked participants to rate them using a forced-choice paradigm on several attributes: physical dominance, social

dominance, physical size, socio-economic status, attractiveness, cooperativeness, and competitiveness. First, to investigate associations between voice pitch and each of the above attributes, we compared whether pitch affected perceptions of each attribute against chance, collapsed across the sexes. Then, to examine whether the sex of the stimulus voice influenced how pitch affected our female raters' perceptions of each attribute, we checked for differences in participants' ratings of the male and female vocal stimuli. Finally, we compared attractiveness ratings to ratings of each of the other attributes (which include dominance and its related constructs), collapsing across the sex of the stimulus voice, in order to examine whether pitch affected ratings of dominance and related constructs more than it affected attractiveness ratings.

Predictions

In our sample of women, we predict that a low voice pitch will be positively associated with perceptions of a speaker's attractiveness (for male voices only, as we have female raters), physical/social dominance, socio-economic status, physical size, and competitiveness; that voice pitch will be a cue to dominance more for male voices rather than female voices; and that pitch will affect ratings of a speaker's dominance and its related constructs more than pitch will affect ratings of the speaker's attractiveness.

However, there may be an alternate explanation for the associations between voice pitch and attractiveness and dominance constructs that may not require an association between pitch and competitiveness. Several individual studies and meta-analyses (Collins, 2000; Pisanski, Fraccaro, Tigue, O'Connor, Röder, et al., 2014; Pisanski, Fraccaro, Tigue, O'Connor, & Feinberg, 2014; Rendall, Vokey, & Nemeth, 2007) have found that participants often assume that a speaker with a lower pitched voice is physically larger than a speaker with a higher pitched voice, and also that a physically larger speaker is more dominant. However, when examining the actual relationship between voice pitch and physical size, all of these studies found none. What the authors suggest is the existence of a perceptual bias, whereby people falsely assume someone is larger and more dominant based on a low voice pitch. Therefore, the idea that a low voice pitch need not be associated with competitiveness to be associated with dominance and related constructs, as this could rather be due to such a bias, is a plausible alternative to the theory we are testing.

Methods

All protocols were approved by the McMaster Research Ethics Board.

Stimuli

Based on stimuli generated in previous studies (Feinberg et al., 2012; Feinberg et al., 2012; Feinberg, Jones, Little, Burt, & Perrett, 2005; Jones, Feinberg, DeBruine, Little, & Vukovic, 2008; Montano, Tigue, Isenstein, Barclay, & Feinberg, 2017), five women's and five men's voices speaking the English vowel sounds - "ah" /ɑ/, "ee" /i/, "eh" /ɛ/, "oh" /o/ and "oo" /u/ - were selected from our voice database such that when manipulated, they would span the normal range of voice pitch within each sex. Voices were recorded in an anechoic sound attenuated booth (WhisperRoom Inc. SE 2000 Series Sound Isolation Enclosure) with a Sennheiser MKH 800 P48 condenser microphone using the cardioid pickup pattern (Pisanski et al., 2014). Voices were encoded digitally with a 96kHz sampling rate and 24-bit amplitude quantization in Soundforge Pro 11.0 software.

Following Montano et al. (2017), using the Pitch-Synchronous Overlap Add (PSOLA) method in Praat Acoustic Phonetics Software (Boersma & Weenink, 2016), we manipulated the fundamental frequency and corresponding harmonics +/- 0.5 Equivalent Rectangular Bandwidths (ERBs). The ERB scale corresponds better to human hearing than the Hz scale as it compensates for the log-linear relationship between frequency and perceived pitch (Apicella & Feinberg, 2009; Traunmüller, 1990). The PSOLA manipulation allows for manipulation of voice

pitch, independently of time, formant frequencies, and other spectrotemporal features (Boersma & Weenink, 2016; Feinberg et al., 2005). The manipulations resulted in 5 pairs of men's and 5 pairs of women's voices, both raised and lowered in pitch. There were 20 stimuli in total.

Participants

Participants were recruited using McMaster University's Psychology research participants system (SONA) and were 56 female undergraduate students (aged 17–23, mean = 18.79, s.d. = 1.3). For compensation, each participant received a one-hour SONA course credit or $10 as per the participant's choosing.

Procedure

Stimuli were presented using Psychopy (Peirce, 2007). Attributes to be rated were: attractiveness, size, competitiveness, cooperativeness, physical dominance, social dominance, and socio-economic status. Attributes were rated in separate blocks, but men's and women's voices were rated in the same block. Since we used a forced-choice paradigm, and each voice was compared to itself, not other voices, it is unlikely that perceptions of one sex affected judgements of the other sex. In judgements of masculinity/femininity, adaptation to female vocal stimuli due to repeated exposure affects a participant's subsequent judgements of

other female vocal and facial stimuli but does not affect judgements of male stimuli (Little, Feinberg, DeBruine, & Jones, 2013). Therefore, voices were not separated into blocks based on sex.

In each block, participants listened to the 10 pairs of voices (5 female and 5 male pairs) for a total of 20 voices per block. The order of presentation of each stimulus within a pair, the order of stimulus pairs within blocks, and the order between blocks were all randomized for each presentation. For each pair of voices, participants chose which voice of the pair sounded more attractive, competitive, cooperative, more physically dominant, more socially dominant, higher in socio-economic status, and larger. Of the above attributes, only three were explicitly defined for the participant. As used by various studies, and first by Mazur, Halpern, and Udry (1994), someone possessing physical and social dominance were defined as follows, respectively, “A physically dominant person is someone who would probably win, if they were in a fight with an average person of the same gender,” and, “A socially dominant person tells other people what to do, is respected, influential, and often a leader. Submissive people are not influential or assertive, and are usually directed by others.” Following the procedure used by O’Connor et al. (2014), socio-economic status was defined as follows, “Socio-economic status is based on occupational prestige, years of education, and annual income. For example, a lawyer will have a higher calculated socio-economic status than a taxi driver.”

For each attribute, we coded the choice of a lower pitched voice as 0 and a higher pitched voice as 1.

Due to computer error (i.e. program crashing during testing), attractiveness, social dominance, socio-economic status, and size ratings all had n=56 raters whereas competitiveness, cooperativeness, and physical dominance had n=55 raters.

Analysis

Three types of analyses were carried out using SPSS Statistics. First, in order to examine associations between voice pitch and each of the seven tested attributes, as collapsed across the two sexes, we performed one-sample t-tests for each attribute against a chance-discrimination baseline. Next, in order to examine if sex of the stimulus voice influenced how pitch affects perceptions of the attributes, we ran paired-sample t-tests between participants' ratings of the male and female stimulus voices (all raters were female). Finally, we compared attractiveness ratings to each of the other six attributes (including dominance) using paired-sample t-tests, collapsed across sex, in order to investigate whether voice pitch affected dominance ratings more than it affected attractiveness ratings.

Results

We performed separate analyses for male and female voices. For our analyses, we used a chance value of 0.5. Corrected p-values are reported.

One sample t-tests showed that lower pitch was rated as more attractive than higher pitch in men's voices (men's voices: $t_{55} = -7.415$, $p < 0.0014$; women's voices: $t_{55} = -0.238$, $p = 11.382$). In both sexes, relatively lower voice pitch was also rated as more physically dominant (male voices: $t_{54} = -9.370$, $p < 0.0014$; female voices: $t_{54} = -7.249$, $p < 0.0014$), socially dominant (male voices: $t_{54} = -2.997$, $p = 0.056$; female voices: $t_{54} = -4.731$, $p < 0.0014$), higher in socio-economic status (male voices: $t_{55} = -4.307$, $p < 0.0014$; female voices: $t_{54} = -3.545$, $p < 0.0014$), larger (male voices: $t_{55} = -6.796$, $p = 0.0014$; female voices: $t_{55} = -12.263$, $p < 0.0014$), and less cooperative (male voices: $t_{54} = 3.944$, $p < 0.0014$; female voices: $t_{54} = 5.345$, $p < 0.0014$). Voice pitch had no effect on perceptions of competitiveness (male voices: $t_{54} = 0.914$, $p = 5.11$; female voices: $t_{54} = -0.392$, $p = 9.758$).

Paired sample t-tests were performed on male and female voice pairs for each attribute to examine potential sex differences. Voice pitch affected attractiveness ratings more for men's voices than women's voices ($t_{55} = 5.476$, $p < 0.007$). However, voice pitch also did not affect the perception of competitiveness ($t_{54} = -1.275$, $p = 1.456$), cooperativeness ($t_{54} = 1.105$, $p = 1.918$), physical dominance ($t_{54} = -0.99$, $p = 6.454$), social dominance ($t_{55} = -1.375$, $p = 1.225$), and socio-economic status ($t_{54} = 0.633$, $p = 3.703$) for male voices more than

female voices. The sex difference in the effect size of voice pitch on the perception of body size for males was significant but did not remain so after a correction for multiple comparisons (t_{55} = - 2.582, number of comparisons = 7; Bonferroni p = 0.091). Figure 1 depicts these results.

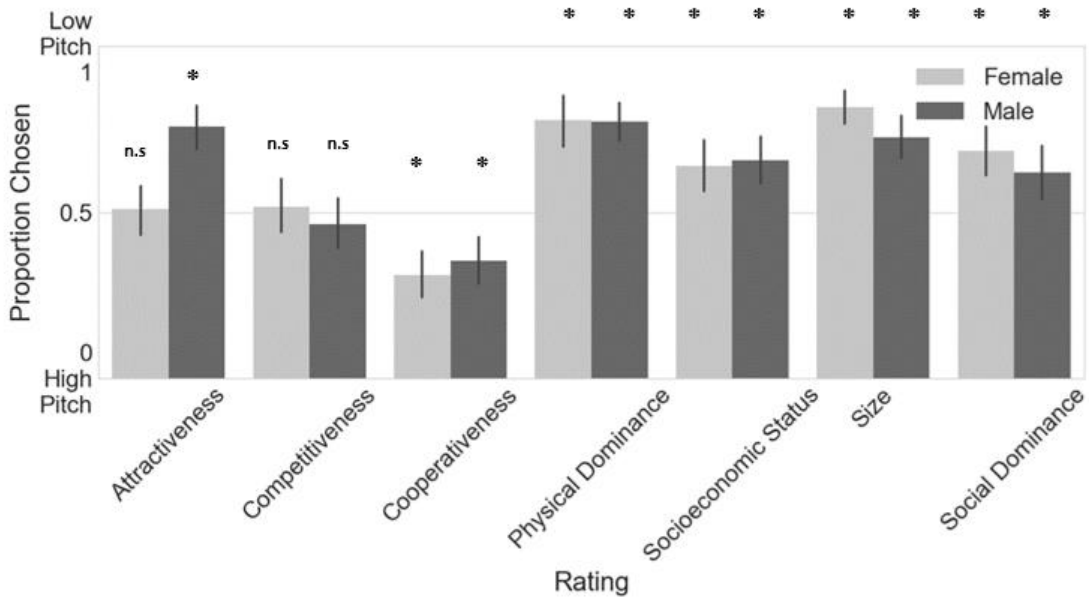

Figure 1. Proportion of voices (high vs. low pitch) chosen by raters on each attribute tested.

Following Puts, Gaulin, & Verdolini (2006), paired sample t-tests investigated whether voice pitch affected physical dominance ratings more than voice pitch affected attractiveness ratings. We found that for women's voices (t_{54}= 4.969, p < 0.012), but not men's voices (t_{54}= -0.206, p = 10.044), voice pitch significantly affected judgements of physical dominance more than it affected judgements of attractiveness. For men's voices, voice pitch affected ratings of

attractiveness significantly more than ratings of competitiveness (t_{54} = -5.610, p < 0.012) and cooperativeness (t_{54} = -8.620, p < 0.012). However, when comparing the magnitude of the difference of the effects of voice pitch on attractiveness versus cooperativeness (t_{54}= -2.146, number of comparisons = 15; Bonferroni p = 0.54), ratings of socio-economic status (t_{54} = -2.30, number of comparisons = 15; Bonferroni p = 0.30), social dominance (t_{55} = -2.561, number of comparisons = 15; Bonferroni p = 0.195), size (t_{55} = -0.685, p = 5.952), and physical dominance (t_{54}= -0.206, p = 10.044), we find no evidence that voice pitch affects constructs related to physical or social dominance more than it affects attractiveness for men. These results are depicted below in Table 1.

Contrary to theories that perceptions of dominance related to voice pitch among women are not important for sexual selection (Kordsmeyer et al., 2018; Puts et al., 2016; Puts, Gaulin, & Verdolini, 2006; Puts et al., 2007), voice pitch affected ratings of cooperativeness (t_{54} = -4.002, p < 0.012), physical dominance (t_{54}= 4.969, p < 0.012), size (t_{55} = 6.766, p < 0.012), and social dominance (t_{55} = 3.503, p = 0.012) more than it affected ratings of attractiveness in women's voices. However, voice pitch did not significantly affect ratings of competitiveness when compared with ratings of attractiveness (t_{54} = 0.094, p = 11.112) nor did it affect ratings of socio-economic status (t_{55} = 2.821, p = 0.084) more than attractiveness for female voices. These findings are depicted below in Table 2.

Table 1. Attractiveness vs. Dominance Constructs for Male Voices

Attributes Being Compared	**T statistic**	**P-value**
Attractiveness vs. Physical Dominance	t_{54}= -0.206	10.044
Attractiveness vs. Social Dominance	t_{55} = -2.561	0.195
Attractiveness vs. Size	t_{55} = -0.685	5.952
Attractiveness vs. Socio-economic Status	t_{54} = -2.30	0.30
Attractiveness vs. Cooperativeness	t_{54}= -2.146	0.54
Attractiveness vs. Competitiveness	t_{54} = -5.610	0.012 **+**

Table 1. Does voice pitch affect ratings of a speaker's dominance and related constructs more than it affects ratings of attractiveness? The effect of pitch on attractiveness vs. each dominance construct is displayed here for **male voices**. The only significant effect is that pitch affected attractiveness ratings more than competitiveness ratings for male voices, marked here with a '**+**'.

Table 2. Attractiveness vs. Dominance Constructs for Female Voices

Attributes Being Compared	**T statistic**	**P-value**
Physical Dominance vs. Attractiveness	t_{54}= 4.969	p < 0.012 **+**
Social Dominance vs. Attractiveness	t_{55} = 3.503	p = 0.012 **+**
Size vs. Attractiveness	t_{55} = 6.766	p < 0.012 **+**
Socio-economic Status vs. Attractiveness	t_{55} = 2.821	p = 0.084
Cooperativeness vs. Attractiveness	t_{54} = -4.002	p < 0.012 **+**
Competitiveness vs. Attractiveness	t_{54} = 0.094	p = 11.112

Table 1. Does voice pitch affect ratings of a speaker's dominance and related constructs more than it affects ratings of attractiveness? The effect of pitch on attractiveness vs. each dominance construct is displayed here for **female voices**. Here, pitch affected physical and social dominance, size, and

cooperativeness ratings more than it affected attractiveness. These significant results are marked here with a '**+**'.

Discussion

Using female raters, we found that low voice pitch was associated with perceptions of physical and social dominance, attractiveness, and size, while high pitch was associated with increased cooperativeness. Surprisingly, we did not find any relationship between voice pitch and competitiveness in either men's or women's voices with our female participants. We found that voice pitch affected all other perceptions we tested, replicating prior work, suggesting that this result is not an anomaly. Thus, although other studies have found that some men change their voice pitch in response to laboratory-based, fictitious dominance bouts (Puts et al., 2016; Puts et al., 2006, 2007), we show that voice pitch does not directly affect perceptions of competitiveness, at least in our female sample. In order for behavioural changes in voice pitch to have an effect downstream on sexual selection, they must first affect perception. We found no evidence that voice pitch affects women's perceptions of how competitive voices sound. Thus, our data are more consistent with the idea that dominance perceptions need not based on an internal evaluation of how likely someone is to win at competition, but are perhaps the result of perceptual bias. Previous work (Collins, 2000; Pisanski, Fraccaro, Tigue, O'Connor, Röder, et al., 2014; Pisanski, Fraccaro, Tigue, O'Connor, & Feinberg, 2014; Rendall, Vokey, & Nemeth, 2007) has demonstrated that participants consistently assume a lower pitched voice belongs to a physically larger speaker, who is in turn perceived as being more dominant. However, when the actual association between pitch and physical size was explored in these

experiments, none was found. Rendall, Vokey, & Nemeth (2007) in particular explain the bias as arising out of adaptive sound-size associations in the natural world, whereby a lower-frequency sound is typically produced by a large object (e.g. a rockslide, avalanche, falling tree, waterfall, etc). These authors hypothesize that the perceptual bias encountered with voices results because people apply, or generalize, these environmental sound-size associations to speech, thereby resulting in the mentioned false perceptions. In our results, the lack of an association between pitch and perceptions of competitiveness but the replicated associations between voice pitch and perceptions of attractiveness, dominance and related constructs including size could lend support for this alternative explanation of perceptual bias.

Consistent with Kordsmeyer et al. (2018), we found that voice pitch affected perceptions of dominance and attractiveness relatively equally. While earlier studies (Jones et al., 2010; Puts et al., 2007) found that voice pitch affected dominance perceptions more than it affected attractiveness perceptions, later studies have failed to replicate this finding. Thus, there is poor evidence to support the theory that voice pitch evolved to signal dominance but *not* attractiveness (Kordsmeyer et al., 2018; Puts et al., 2016; Puts, Gaulin, & Verdolini, 2006; Puts et al., 2007), since we find no difference in how strongly voice pitch relates to people's perceptions of these attributes.

We also found that voice pitch affected women's perceptions of women's voices just as much as, if not more than, it affected perceptions of men's voices.

Jones et al. (2010) investigated potential sex differences in how voice pitch affects perceptions of attractiveness and dominance. This study found that men prefer a feminine, high pitch when judging voices based on attractiveness while women prefer masculine, low pitched voices when judging this same trait; this is called an opposite-sex bias. However, while this study found an opposite-sex bias when participants judge voices on attractiveness, no such bias was found when voices were judged based on dominance. Therefore, our finding here can lend support for this idea that men and women perceive the way voice pitch affects dominance-related constructs similarly.

Nonetheless, it is important to note that a main limitation of this study is that it does not include male participants, but rather relies on exclusively female raters and their perceptions. Therefore, these results cannot be generalized to a wider population that includes men. Our results could very well prove to be quite different with male participants. For instance, though voice pitch did not significantly affect women's perceptions of the various dominance constructs in male voices, voice pitch could certainly affect men's perceptions of these same attributes. Given the fact that men mainly compete with each other (Cashdan, 1998), it is possible that men may be more sensitive to dominance cues in other men's voices than women are. Likewise, our finding that pitch affected ratings dominance constructs more than it affected ratings of attractiveness in female voices could be the result of a similar kind of same-sex sensitivity to dominance cues. Perhaps even the lack of an association between voice pitch and competitiveness may be due to the lack of

male raters; since intrasexual competition is thought to be stronger among males then females, an inclusion of male participants may reveal an association between pitch and competitiveness. Future studies should include both sexes as participants, allowing for comparisons between male and female perceptions of voices and speaker attributes.

A further limitation is related to ratings of competitiveness. Because competitiveness was not defined for participants, perhaps our null result between pitch and this trait is due to low participant agreement on how competitiveness is defined. Because this study only used a small number of voices as stimuli, a test of inter-rater reliability, Cronbach's alpha, cannot be performed to meaningfully assess participant agreement in this case. As such, future work could explore this same question while using more stimuli voices in order to assess participant agreement on competitiveness ratings.

In conclusion, our data offer little support that low voice pitch in men evolved only as an indicator of competitiveness (Kordsmeyer et al., 2018; Puts et al., 2016; Puts, Gaulin, & Verdolini, 2006; Puts et al., 2007), at least with female raters. Instead, our results lend support for the idea that ratings of dominance are based on a response bias where low pitch sounds large and dominant (Pisanski, Fraccaro, Tigue, O'Connor, Röder, et al., 2014; Pisanski, Fraccaro, Tigue, O'Connor, & Feinberg, 2014; Rendall, Vokey, & Nemeth, 2007), but not competitive. However, more work is needed to test whether dominance perceptions are the result of sexual selection, or biases in perception, or both and

whether our findings with female raters are similar or different from results obtained when including the perceptions of both sexes.

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