Voice Frequency Manipulations, Cooperation, and Trust

Voice Frequency Manipulations Affect Women's Perceptions of Trustworthiness and Cooperativeness

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A Thesis
Submitted to the School of Graduate Studies
In Partial Fulfillment of the Requirements
For the Degree
Master of Science

McMaster University

McMaster University MASTER OF SCIENCE (2016) Hamilton, Ontario (Psychology)

TITLE: Voice Frequency Manipulations Affect Women's Perceptions of Trustworthiness and Cooperativeness

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NUMBER OF PAGES: ix, 67

Abstract

The focus of this thesis is to investigate the role of voice pitch (the perception of fundamental frequency and/or corresponding harmonics) and apparent vocal tract length (VTL-the perception of the vocal tract resonances i.e. formant frequencies) in perceptions of trustworthiness and other related social attributions. Past research has found that women trust men with relatively higher pitched voices as long-term romantic partners. People with relatively higher pitched voices are also judged as more cooperative than people with relatively lower pitched voices. However, women choose men with relatively lower pitched voices when asked to select which leaders are more trustworthy and make better economic decisions. In study 1, I used "The Trust Game" to determine whether women trust men with higher or lower pitched voices to evenly divide a sum of money. Women trusted men with relatively higher pitched voices more often. Thus, even though men with lower pitched voices are more often elected to office, and are CEOs of larger companies that make more money, women trust men with relatively low pitched voices less than men with relatively high pitched voices to equitably distribute money.

Surprisingly, no studies have examined the relationship between VTL and trust, but one recent study examined the relationship between VTL and perceptions of cooperation. In study 2, I was the first to test the role of voice pitch and VTL on perceptions of trust *and* cooperation. In general, people with higher frequency voices (high pitch and a shorter VTL) were relatively more cooperative

and trustworthy than people with lower frequency voices (low pitch and a longer VTL). Despite correlations between the effects of voice frequency manipulations on ratings of trustworthiness and cooperativeness, the amount to which people thought pitch and VTL affected cooperativeness and trustworthiness was different enough to determine that these two constructs overlap, but are not synonymous.

Together, these studies show that despite the fact that masculine men tend to win political elections and run large and successful companies, they are viewed as uncooperative and untrustworthy. Future research should investigate if those who win political elections and run successful companies do so because they keep more than their fair share of money.

Acknowledgements

I would first like to thank my Supervisor, David Feinberg, for knowing more about the field of voice perception than I could ever imagine. Thank you to my committee for your support and advice. Thank you to the PNB girls who laughed at my jokes and became my friends. To my lab mate and now close friend, Sari, thank you for going on this journey with me. To my best friends, Arianne and Abby, you make me want to be the best I can be and because of you I never give up. To Brandon, thank you for being proud of me and making me believe I can do anything. Last but not least, thank you to my family for their ongoing support, their belief in me and letting me come home whenever I needed.

Materials Prepared/Submitted for Publication

The manuscript in Chapter 1: “Men’s Voice Pitch Influences Women’s Trusting Behaviour” is a manuscript submitted for publication to the Journal of Evolution and Human Behavior and is now in revision.

Montano, K.J., Tigue, C.C., Isenstein, S.G.E., Barclay, P., Feinberg, D. R. (2015). Men’s voice pitch influences women’s trusting behavior (in revision)

Author roles:

Montano, K.J.: data analysis, wrote paper
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Isenstein, S.G.E: data analysis, edited paper
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The manuscript in Chapter 3: “The Effects of Pitch and Vocal Tract Length on Perceptions of Trustworthiness and Cooperativeness” is a manuscript prepared for publication

Montano, K.J., Isenstein, S.G.E., Feinberg, D.R. (2016). The effects of pitch and vocal tract length on perceptions of trustworthiness and cooperativeness (prepared).

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Feinberg, D.R.: original voice recordings, voice manipulations, experimental design, theoretical advisor, data analysis, edited paper

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General Introduction

Voice qualities serve as indicators of many traits. McAleer, Todorov, and Belin (2014) showed that several traits are judged instantaneously from speech. Among those are attractiveness, dominance, masculinity and trust. Voice pitch, the perception of fundamental frequency and/or corresponding harmonics and the perception of apparent vocal-tract length (VTL), the perception of the formant frequencies (the resonances of the supralaryngeal vocal-tract) have both been known to influence attractiveness, masculinity and dominance judgments (Feinberg, Jones, Little, Burt, & Perrett, 2005; Feinberg, 2008; Puts, Hodges, Cárdenas, & Gaulin, 2007; Puts, Jones, & DeBruine, 2012; Puts, Apicella, & Cárdenas, 2012).

We may be able to judge attractiveness, dominance, masculinity and trustworthiness instantaneously (McAleer et al., 2014) because being able to decipher who is likely friend from foe and lover versus loser is essential for reproductive success (Apicella, Feinberg, & Marlowe, 2007; Buss, 1989; Feinberg et al., 2005a; see Jennions & Petrie, 1997; Miller, 1998; Puts et al., 2012a for reviews). Throughout our evolutionary history it has also been of the utmost importance for people to know who they can trust.

The Theory of Reciprocal Altruism (Trivers, 1971) suggests that we can provide benefits to non-kin as long as we will also receive some benefit in the future. Reciprocal altruism is illustrated by the "Prisoner's Dilemma Task" (Rapoport & Chammah, 1965). In the task, if players choose to cooperate they will

both benefit and not face any punishment; however, if they both defect or if one defects and the other does not, they both risk being punished. In this task, trust in your partner *not* to defect makes for the most beneficial outcome for both parties.

Reciprocal altruism could only evolve because we as species evolved in groups (Trivers, 1971). Dunbar and Shultz (2007) argued that our brains evolved to a large size because of the social demands of living in groups and especially because of the form of pair bonding we see amongst primates. This idea is known as the "social brain hypothesis" (Barton and Dunbar, 1997). While controversial, this hypothesis is supported by research from Cosmides and Tooby (1989, 1992) whose work suggests that our brains have evolved to make decisions based on social interactions. Cosmides and Tooby (1992) argued that people are unable to solve many logical problems (e.g. Wason card selection task (Wason, 1966)), unless the inferences needed to be made are socially relevant.

Furthermore, we know that there are several areas of the brain that seem to have evolved to process social information in the world. In the temporal lobe, there are voice and face selective areas of the brain. The fusiform face area is significantly more active when participants view faces compared to objects (Kanwisher, McDermott, & Chun, 1997) and the right superior temporal sulcus, also known as the temporal voice area (Pernet et al., 2015), is highly selective to vocal sounds (Belin, Zatorre, & Ahad, 2002) and appears to play a role in distinguishing voices (Belin & Zatorre, 2003).

Given that cooperation and trust are important for relationships and ultimately reproductive success (Axelrod, 2006; Ostrom & Walker, 2003; Trivers, 1971) it may be evolutionarily adaptive to be able to detect trustworthy and non-trustworthy features (Debruine, 2002). Similarly, to be able to detect those who may be cooperative or want to form a social alliance with us is also potentially adaptive (Trivers, 1971).

There has been less research on the relationship between voice quality and traits such as trust and cooperation than on the relationship between voice quality and attractiveness. To measure trust, past research has used both behavioural and self-report data. There are advantages and disadvantages to both methods. Self-report data or survey data is easy to collect and efficient; however, there may be self report bias and the data collected is not always context specific. Ermisch, Gambetta, Laurie, Siedler, and Noah Uhrig (2009) used both a survey and behavioural method and found that trust as indexed by the survey did not predict trusting behaviour in a game. Thus, they argued that the behavioural method is a much more valid tool than self-report measures. Researchers have used The Trust Game first developed by Camerer and Weigelt (1988) and then simplified by Berg, Dickhaut, and McCabe (1995) to measure trust. This game allowed for the first behavioural measure of trust and allowed for the measurement to be context specific. The Trust Game measures trust in an investment setting (Berg et al., 1995). In this thesis, I used a one-decision variant of the Trust Game based on that used by DeBruine (2002), in which participants are given the choice to trust

the receiver to equally divide some money or to end the game. If participants choose to end the game, they leave with a smaller sum than if the receiver chose to divide the money equally. Since its development many researchers have used this game and its variants (Johnson & Mislin, 2011). The meta-analysis conducted by Johnson and Mislin (2011) revealed that the way in which and where the game is played can have vast effects on the results. For example, using a real vs. simulated counterpart and geographical location greatly impacts trusting behaviour. Despite the development of the Trust Game, many studies examining the effect of voice frequencies on trust have continued to use self-report measures. Tigue, Borak, O'Connor, Schandl, and Feinberg (2011) found that men with low voices are trusted more in political scenarios than men with high voices, while Vukovic et al. 2011 found that high voices are trusted more than low voices in relationship contexts. Tigue et al. (2011) and Vukovic et al. (2011) studied the perception of trust rather than actual trusting behaviour. This work is still very interesting and an important line of research because it is valuable to know if perceptions and behaviour diverge. In this thesis, I use both perceptual and behavioural methods to see if they converge and if they do, then this result provides more compelling evidence for the effects of voice frequencies on trust and cooperation.

Cooperation is a major component of trust (Ostrom & Walker, 2003). As such, it appears that trusting behavior predicted from the Trust Game may also be confounded with cooperative behavior. As no study has tried to control for the

effects of cooperation on trust I will attempt to parse out the relationship. The following thesis will use both self-report and behavioral measures to illustrate indicators that we use to determine trustworthy and cooperative individuals and how these two pro social traits may be related.

Chapter 1: Men's Voice Pitch Influences Women's Trusting Behaviour

Introduction

Trust is essential for social interactions. As such, it is important to understand how individuals decide whom to trust and to identify the cues in others that influence trusting behavior. We use social (Oosterhof & Todorov, 2009; Todorov, Pakrashi, & Oosterhof, 2009) and biological (DeBruine, 2002; Wilson & Eckel, 2006; Stirrat & Perrett, 2010) cues from others that may influence the likelihood of us trusting them. Earlier work on social perception suggests that we might trust attractive individuals because of an attractiveness-halo effect whereby what we find attractive is good (Dion, Berscheid, & Walster, 1972; Feingold, 1992). However, subsequent work has revealed the picture is more complex than a simple stereotype. Another attribute that may be used to help evaluate trustworthiness in others is masculinity. Masculinity manifests across modalities in the face (Perrett et al., 1998), body (Little, Jones, & Burriss, 2007; Pawlowski & Jasienska, 2005), odour (Cornwell et al., 2004; Saxton, Lyndon, Little, & Roberts, 2008), and voice (Feinberg, 2008; Puts, 2005), and preferences for masculinity are correlated across several modalities (Feinberg, DeBruine, Jones & Little, 2008; O'Connor et al., 2011a). Research shows that masculinity influences judgments of attractiveness but also may carry positive and negative connotations in different modalities and domains.

Trust and Facial Masculinity

People tend to trust individuals with more feminine faces in general (Oosterhof & Todorov, 2009; Perrett et al., 1998), as well as specifically in both

relationship (Boothroyd, Jones, Burt, & Perrett, 2007) and economic contexts (Stirrat & Perrett, 2010). Perrett et al. (1998) found that in ratings of male faces, increased masculinity resulted in decreased ratings of honesty and cooperation. Similarly, Oosterhof and Todorov (2009) found that more neotenous looking men (and therefore more feminine looking, see Perrett et al. (1998) and DeBruine et al. (2006)) are found to be more trustworthy than older (i.e. more masculine looking, see Perrett et al. (1998) and DeBruine et al. (2006)) men. In relationship contexts, Boothroyd et al. (2007) found that women perceive masculine men as relatively less faithful. Stirrat and Perrett (2010) also observed that in an economic game, players were more likely to trust less masculine men (as indexed by a face width to height ratio).

Facial and Vocal Masculinity

Faces and voices each contain cues to hormone levels and these cues tend to be positively correlated (Collins & Missing 2003; Feinberg et al., 2005a; Saxton, Caryl, & Roberts, 2006). Human voice pitch is sexually dimorphic (Wu & Childers, 1991) and dependent on the expression of pubertal testosterone (Abitol, Abitol, & Abitol, 1999; Harries, Hawkins, Hacking, & Hughes, 1998; Jenkins, 2000). Similarly, facial masculinity is related to sex hormones (primarily testosterone, progesterone and estrogens, (see Penton-Voak & Chen 2004; Smith et al., 2006). In general, lower-pitched men's voices are perceived as more attractive and more dominant than are higher-pitched men's voices (see Feinberg, 2008 for review). As vocal/facial masculinity and attractiveness are positively correlated (Collins &

Missing, 2003; Feinberg et al., 2008a; Saxton et al., 2006) and preferences for vocal and facial masculinity are positively correlated (Feinberg et al., 2008a; Fraccaro, Feinberg, Debruine, Little, & Jones, 2010; O'Connor et al., 2011a; O'Connor et al., 2013) it is interesting that few studies have investigated perceptions of trust based on vocal rather than facial indicators. It would be especially important to examine vocal cues because research on the relationship between vocal cues and trust is inconsistent across contexts.

Voice Pitch and Trust

Prior work has demonstrated that men with lower pitched, more masculine voices (see Collins 2000; Feinberg et al., 2005b) are perceived as more trustworthy leaders, who are better at economic decision making (Klofstad, Anderson, & Peters, 2012; Tigue et al., 2011). These perceptions are backed-up with real-world data. Presidential candidates with lower pitched voices are more likely to be elected to office (Gregory & Gallagher, 2002; Tigue et al., 2011), and male CEOs with relatively lower-pitched voices are more liklely to run larger, more successful companies than men with relatively higher-pitch voices (Mayew, Parsons, & Venkatachalam, 2013). On the other hand, men with lower pitched voices, are perceived as less trustworthy (i.e., more likely to cheat) romantic partners (O'Connor, Re, & Feinberg, 2011) than are men with more feminine (higher-pitched) voices. Furthermore, Vukovic et al. (2011) found that women who perceived men with masculine voices as more attractive for short term (e.g. single date, brief affair or one-night stand) relationships also perceived men with

masculine voices as relatively less trustworthy. Men with low-pitched voices are also perceived to be relatively less cooperative (Knowles & Little 2015). Indeed, men with high testosterone (which lowers voice pitch at puberty (Jenkins, 2000)) spend less time and resources with/on their partners and children (Fleming, Corter, Stallings, & Steiner, 2002; Gray, Kahlenberg, Barrett, Lipson, & Ellison, 2002; Gray et al., 2004; Gray, Yang, & Pope, 2006; Hooper, Gangestad, Thompson, & Bryan, 2011; Storey, Walsh, Quinton, & Wynne-Edwards, 2000). Thus, work on voice pitch and trustworthiness is currently inconclusive or at least seems to be context dependent.

Other Cues to Vocal Masculinity

Voice pitch is not the only acoustic feature that affects perceptions of masculinity (Collins, 2000; Feinberg et al., 2005b). Apparent vocal-tract length (VTL), the perception of the formant frequencies (the resonances of the supralaryngeal vocal-tract) also affects perceptions of masculinity (Collins, 2000; Feinberg et al., 2005b) and may therefore influence perceptions of trust. Although, large vocal tracts are associated with large body size (Fitch & Giedd, 1999; Fitch, 2000a, 2000b) it is currently unknown if people trust short or tall men more. Taller sounding people are rated as more dominant, and dominant individuals' faces tend to be perceived as better leaders (Re et al., 2012). Therefore, we hypothesize that auditory cues to height and/or good leadership skills might also positively affect perceptions of trust.

Measuring Trust using Economic Games

Taken together, the results of past studies (Klofstad et al., 2012; O'Connor et al., 2011b; Tigue et al., 2011; Vukovic et al., 2011) indicate that the relationship between men's voice pitch and perceptions of trust is not well understood. It is unknown if perceptions of trust in men with low frequency voices as good leaders who make good economic decisions also carries over into trusting people to be economically fair on a one-on-one level. The Trust Game (Berg et al.,1995), and its variants (see Johnson & Mislin, 2011) have been used for many years to study how people trust individuals to divide up money based on different traits in faces such as self-resemblance (DeBruine, 2002; DeBruine, 2005) and masculinity (Stirrat & Perrett, 2010).

To test how research on perceptions of trust extends to a behavior in economic games, we tested whether men's voice pitch and VTL influenced women's trusting behavior in the Trust Game. We used a one-decision variant of the Trust Game based on that used by DeBruine (2002), in which the female sender was given the choice to trust the male receiver or to end the game. The male players in our experiment were simulated using voice recordings that we manipulated in pitch and vocal tract length. All women were informed before the experiment that neither their counterparts nor the money involved were real. We predicted that women may be more likely to trust male counterparts with relatively higher-pitched voices than those with relatively lower-pitched voices as people perceive masculine men's faces as less honest than feminine men's faces (Perrett et al., 1998) and because people are less likely to trust men with a greater facial

width ratio (more dominant), than men with a lower facial width ratio in a trust game (Stirrat & Perrett, 2010). We also predicted that women would be more likely to trust men with relatively shorter vocal tracts as previous studies have found that longer vocal tracts are related to increased masculinity perceptions (Feinberg, Debruine, Jones, & Perrett, 2008). By contrast, if men with lower frequency voices are perceived to be better economic decision-makers as leaders, we predicted that men with lower frequency voices would be trusted relatively more often in The Trust Game.

Methods

Participants

Thirty-seven female undergraduates participated in the experiment (*mean age* = 18.59 years, *SD* = 1.54 years) and received course credit for participation.

Stimuli Collection

We obtained voice recordings of 6 male undergraduates (*mean age* = 19.17 years, *SD* = 1.83 years) speaking the word, "hello". Voices were selected from a larger pool of voices to span the normal range of men's voices once manipulated (Feinberg et al., 2006; Feinberg et al., 2008b; O'Connor, Pisanski, Tigue, Fraccaro, & Feinberg, 2014) The men's voices were recorded in an anechoic sound attenuated booth (Whisper Room SE 2000) with a Sennheiser MKH 800 microphone using the cardioid pickup pattern. Audio recordings were digitally encoded with an M-Audio Fast Track Ultra at 96 kHz sampling rate and 32-bit

amplitude quantization using Adobe Soundbooth CS5 3.0 and saved in waveform audio file format (.wav). Prior to any manipulation, the original mean pitch of the voices used as stimuli was 113.37 Hz, *SD* = 12.31 Hz.

Voice Pitch Manipulation

All acoustic measurements and manipulations were performed using Praat software (Boersma & Weenink, 2012). We manipulated the pitch of each voice stimulus to create a higher-pitched and lower-pitched version of each voice using the Pitch-Synchronous Overlap Add (PSOLA, France Telecom). This method selectively manipulates fundamental frequency and related harmonics (the physical basis for pitch perception) while holding all other features of the acoustic signal constant (Feinberg et al., 2005b). We raised or lowered voice pitch by 0.5 equivalent rectangular bandwidth (ERB) of the baseline pitch, which corrects for the difference between perceived pitch and actual fundamental frequency. This method has been used in several other studies (Apicella & Feinberg, 2009; Jones, Feinberg, DeBruine, Little, & Vukovic, 2008; Jones, Feinberg, DeBruine, Little, & Vukovic, 2010; Vukovic et al., 2008). After manipulation, each of the voices that we lowered in pitch (*mean pitch* = 93.11 Hz, *SD* = 7.78 Hz) was lower than each of the voices that we raised in pitch (*mean pitch* = 131.92 Hz, *SD* = 8.39 Hz).

VTL Manipulation

We manipulated VTL, independently of pitch by +/-15% of each voice stimulus using a technique identical to the formant manipulation used in the "Change gender" function in Praat (see Feinberg et al., 2005b for details) The

above manipulations produced two versions of each voice stimulus, one with a shortened VTL and one with a lengthened VTL. Each stimulus was then normalized in amplitude to 70 dB RMS SPL.

The above manipulations produced 4 versions (raised pitch, lowered pitch, shortened apparent vocal tract, and lengthened apparent vocal tract) of each of the 6 original voices, for 24 unique stimuli total. We used 6 original voices because prior studies on perception of voice pitch in humans using 4-6 voices (Feinberg et al. 2008a; Jones et al., 2010a; Vukovic et al., 2008) have found similar effects to those using over a hundred voices (Feinberg et al., 2008b; Puts, Gaulin, & Verdolini, 2006; Puts et al., 2012b).

Procedure

At the start of the experiment, each participant was presented with instructions on a computer screen describing the Trust Game and asked to read the instructions before beginning the experiment. The instructions were as follows:

> **Instructions:** In this experiment, you will play a series of economic games for theoretical money. No real money is involved. For each game, you will be assigned another person as your counterpart. This person has previously participated in this experiment and had their voice recorded. You are not playing with a real person. For each game, you will first listen to a recording of your counterpart's voice and then make a decision about whether or not to trust your counterpart.
>
> **The Game:** Imagine a scenario in which you have been given $6. You have 2 choices about what to do with this money:
>
> 1. End the game. If you choose this option, the $6 will be divided equally and both you and your counterpart each receive $3.
>
> 2. Trust your counterpart. If you choose this option, your counterpart

> will be given $8 and can choose to divide the money equally (you each receive $4) or unequally (you receive $2 and your counterpart keeps $6).
> In each game, after listening to your counterpart's voice, you will be asked to choose to either end the game or to trust your counterpart. You will be informed of the results of your counterparts' decisions at the very end of the experiment. You will not find out your counterparts' decisions after each decision you make. Do you understand these instructions? If you have any questions, please ask the experimenter now.

After reading these instructions, participants could ask the experimenter for clarification or click "Start" to begin the experiment.

Stimuli were organized into 2 blocks of 12 trials each for a total of 24 trials. Within each block, 6 trials contained voice stimuli that had been manipulated in pitch (3 raised and 3 lowered) and 6 trials contained voice stimuli that had been manipulated in apparent vocal tract length (3 shortened and 3 lengthened). To minimize the possibility that participants would hear the same stimulus identity in consecutive trials, each identity was played 4 times throughout the experiment in a random order. Each identity appeared raised in pitch and lengthened in vocal tract length in the first block of trials, and lowered in pitch and shortened in vocal tract length in the second block of trials or vice versa. The order of blocks was counterbalanced between participants and the order of trials within each block was randomized.

Participants listened to each voice stimulus through Monoprice Sonic Elegance Hi-Fi ® headphones connected to a computer. In each trial, participants clicked on a play button on the computer screen to listen to the voice stimulus. The

following question appeared at the top of the computer screen: "Do you trust this person to divide the money? (1 = No. End the game. You each get $3. 2 = Yes. Your counterpart will divide $8)." After listening to the voice, participants typed a "1" or a "2" into a box on the screen and the next trial began. After completing all 24 trials, participants received a message on their screen that read: "Results: 43% of people repaid your trust" regardless of their responses in the experiment.

Analysis

We calculated the proportion of trials in which each participant trusted the voices that had been lowered or raised in pitch and lengthened or shortened in vocal tract length, separately. We performed statistical analyses using SPSS 23 with two-tailed probability estimates and alpha = 0.05.

Results

A mixed-design ANOVA [within-subject factor: manipulation type (pitch/VTL) and manipulation level (feminized/masculinized), between-subject factor: version] revealed a two-way interaction of manipulation type and manipulation level ($F_{1, 35}$ = 14.847, $p < .001$) and a main effect of manipulation type ($F_{1, 35}$ = 46.345, $p < .001$). There was no main effect of version ($F_{1, 35}$ = .678, p = .416). As shown in Figure 1, subsequent one sample *t*-tests revealed that participants trusted feminized voices and masculinized voices more than chance (t_{36} = 7.334, $p < .001$) and (t_{36} = 2.217, p = .033), respectively. Participants also trusted voices with short apparent vocal tracts significantly less than chance (t_{36} = -5.400, $p < .001$) and long apparent vocal tracts marginally less than chance (t_{36} = -1.911, p = .064). As shown in

Figure 1, paired-sample *t*-tests revealed that participants trusted high pitched voices more than low pitched voices (t_{36} = 3.183, p = .003) and tended to trust people with longer apparent vocal tracts more than those with shorter apparent vocal-tracts (t_{36} = -1.859, p = .071).

Figure 1: Proportion of Voices Trusted in the Pitch and VTL Manipulations

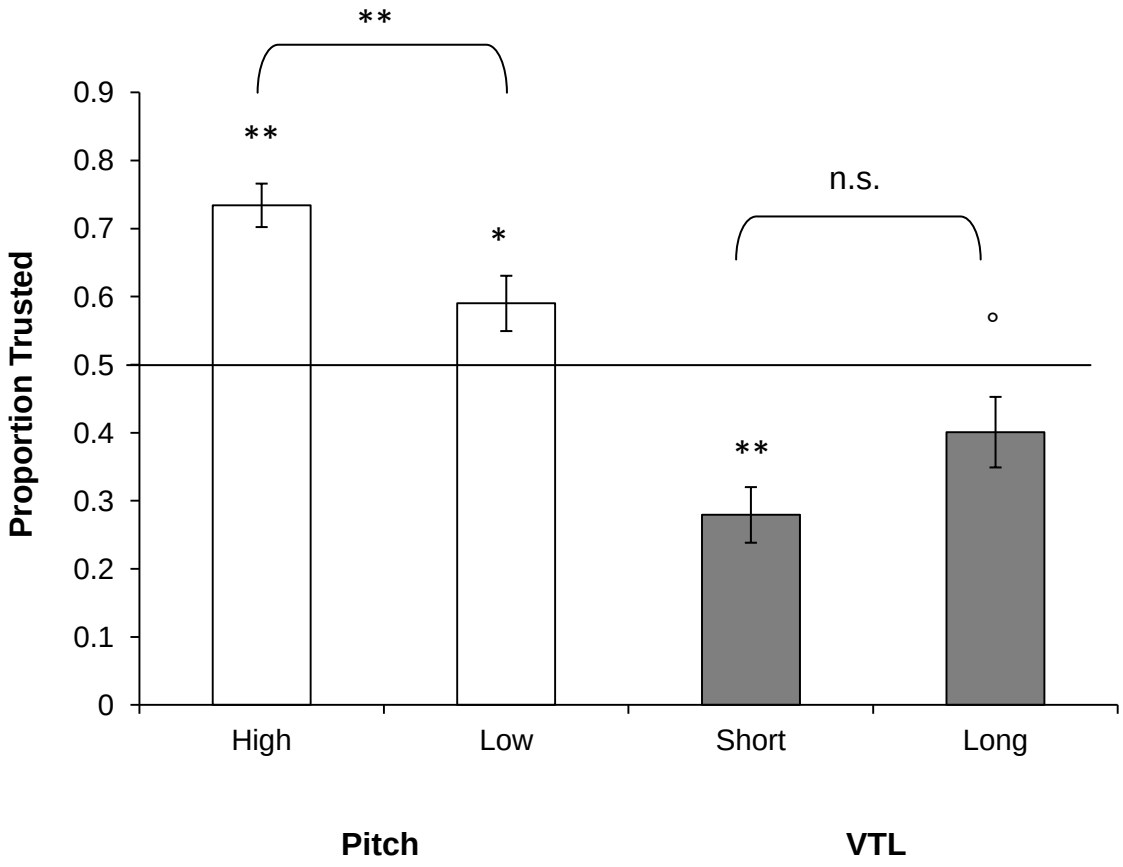

Figure 1: Proportion of voices trusted in the pitch and VTL manipulations. 0.5 indicates trust at the chance level. People trusted high-pitched voices significantly more than chance and significantly more than low-pitched voices. * Denotes significant p-values (p<0.05), ** Denotes highly significant p-values (p<0.01), and ° denotes marginal effects (p<0.1).

Further, in the pitch manipulation condition, as shown in Figure 2, pitch was positively correlated with proportion trusted (r_{11} = .610, p = .035). We estimated apparent vocal-tract length using all known measures reported in Pisanski et al. (2014a) including Formant Position, Average Formant, the Regression Method, and individual formants, but not confirmatory factor analysis as our sample size was too small to converge on a model. Our strongest relationship was found using

Formant dispersion, but still did not significantly predict the proportion of masculine voices trusted (r_{12} = -.530, p = .076). No estimates of vocal tract length significantly predicted proportion of masculine voices trusted (all r < .470 and all p > .122). Spearman correlations did not change any aforementioned significance levels.

Figure 2: The Relationship between Voice Pitch and Proportion of Voices Trusted

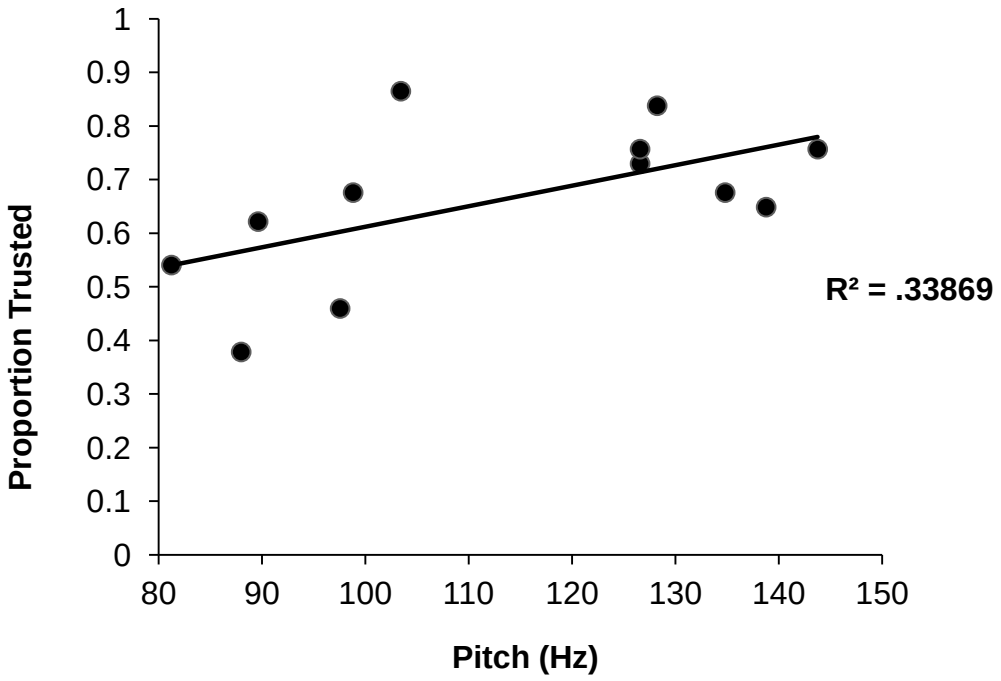

Figure 2: The positive linear relationship between pitch and proportion of voices trusted. The higher the pitch, the more likely the voice was trusted.

Discussion

While men with low-pitched voices are more likely to win political elections (Gregory & Gallagher, 2002), run larger and more successful companies (Mayew et al., 2013), and are perceived to be better economic decision-makers (Tigue et

al., 2011) as leaders than are men with high-pitched voices, we found that women distrusted men with lower-pitched voices to divide a small pot of money equally. Our findings set the stage to determine if the perception that men with low voices are better economic-decision makers is valid. This could be especially important with regards to selfish behaviour being associated with propensity for higher earnings and gaining entry to political office, and whether or not we can detect this from the sound of someone's voice.

Voice pitch was also positively correlated with the proportion of voices trusted. The higher the voice pitch, the more likely the women were to trust the male counterpart. There was a marginal effect of apparent vocal tract length on trust, where women tended to trust men with longer apparent vocal tracts. These results are important because as pitch and VTL predicted trust in opposing directions, this demonstrates that the findings regarding pitch were not an artifact of a general response bias towards masculine, dominant, low frequency stimuli, but may be due to other information encoded in voice pitch that is not present in VTL. Indeed, changes in pitch and VTL are processed by different higher-level neural substrates, despite the overlap in social perceptions between the two voice features (von Kriegstein, Warren, Ives Patterson, & Griffiths, 2006).

Our results on pitch are consistent with research that examined facial masculinity/femininity and trust. Past studies have suggested that masculine faces are less trustworthy in relationships (Perrett et al., 1998) Further, wider and more dominant looking faces are perceived as relatively less trustworthy than less

dominant faces (Stirrat & Perrett, 2010). The consistency between the results found in faces and our results are not surprising as masculinity in faces and voices is related to pubertal testosterone levels. During puberty, there are elevated testosterone levels causing the vocal folds to grow longer and thicker in males (Harries et al., 1998; Jenkins, 2000). Similarly, sexual dimorphism in the face is partly the result of elevated sex hormones (Verdonck, Gaethofs, Carels, & de Zegher, 1999). Our results are consistent with research on trust and mate preferences. People perceive men with low-pitched voices to be more untrustworthy and unfaithful (O'Connor et al., 2011b; Vukovic et al., 2011) however, they are inconsistent with the research showing both that men and women trust men and women with lower pitched voices in leadership contexts (Klofstad et al., 2012; Tigue et al., 2011). These inconsistencies suggest that trustworthiness as indicated by voice pitch may be context dependent. Our results provide the first source of evidence that men with feminine voices make more trustworthy counterparts in an economic game. Stirrat and Perrett (2010) found that men with a higher facial width ratio, more masculine/dominant faces were more likely to exploit the sender's trust than were men with more narrow, more feminine/subordinate faces. It could be that the women in our experiment were especially sensitive to cues to masculinity and dominance in their counterpart to avoid exploitation.

This study only looked at how women trusted men from the sound of their voices. Future studies may examine how men use voice pitch as an indicator for

trustworthiness in women or how women use voice as pitch as an indicator for trustworthiness in other women. Also, this game did not use a real counterpart. Although Johnson and Mislin (2011) suggested that participants send less money to a computer counterpart in economic games, this decrease should occur in all conditions rather than interact with our experimental manipulations. There is no *a priori* reason, or any other reason we can think of from outside the established literature for altered pitch to have different effects for real versus simulated partners. It would be useful to replicate this study and see if we get the same or stronger results using a real counterpart rather than one that is computer simulated. However, by using real people, rather than manipulated stimuli, one would never know if the effects were causally related to voice pitch and VTL.

Importantly, our study cannot distinguish whether the information encoded in voice pitch is related to trust or to alliance formation. It could be that alliance formation is the result of trust or that trust is the result of alliance formation. Knowles and Little (2015) found that higher pitch was associated with higher cooperativeness ratings. This relationship could explain the findings in this current experiment. One could also predict trusting less masculine men because they are less likely to be exploited by feminine men or one could predict trusting more masculine men because they would be stronger partners in intergroup rivalries. For example, people reflexively follow the gaze of more dominant individuals (Jones et al., 2010b) and prefer them as leaders (Anderson & Klofstad, 2012; Klofstad et al., 2012; Tigue et al., 2011).

In summary, our results suggest that in one-on-one interactions, women distrust men with low-pitched voices to give them their fair share of a pot of money. This is particularly interesting because other research shows that men with low-pitched voices are perceived to be strong leaders who make good economic decisions (Tigue et al., 2011), and that this is backed up with real-world data (Mayew et al., 2013). Whether women's behaviour in our study was to let the masculine man have more money out of fear of retribution, to form alliances, attract them as mate, and/or because these men are less trustworthy is yet to be determined.

Chapter 2: The Relationship between Trustworthiness and Cooperativeness

Trustworthiness and cooperativeness are two traits that are highly related (Ostrom and Walker, 2003). Interestingly, no study that has examined trustworthiness and cooperativeness has tried to disentangle the two. Ostrom and Walker (2003) wrote that trust is important for social and economic interactions and what we get out of these interactions depends on how much we trust others to cooperate and not take advantage of us. As we evolved in groups (Barton & Dunbar, 1997; Dunbar, 2007) we naturally formed cooperative alliances with others. Forming alliances involves trusting those in the alliance to cooperate with us. Without trust, those alliances would have dissolved. Thus, cooperation is essentially a major component in trust.

In the following chapter, I am the first to attempt to investigate the relationship between cooperation and trust and examine if the indicators we use to judge trust are the same used to judge cooperation. I used a forced-choice task to test the perceptions of trust and cooperation because in study 1 we found that The Trust Game (a behavioural method) yielded the same result as other work that examined perceptions (Tigue et al., 2011; Vukovic et al., 2011). Subsequent studies should use more complex tasks (e.g. economic games) to see if perceptions and behaviour converge as to achieve a more comprehensive understanding on the effects of voice frequencies on trust and cooperation.

Chapter 3: The Effects of Pitch and Vocal Tract Length on Perceptions of Trustworthiness and Cooperativeness

Introduction

Voice pitch (the perception of fundamental frequency and/or corresponding harmonics) and VTL (the perception of formant frequencies, the resonant frequencies of the supralaryngeal vocal tract) are the two most salient vocal features (Bachorowski & Owren, 1999; Banse & Scherer, 1996). Pitch and formant frequencies (hereafter referred to as vocal tract length (VTL)) are sexually dimorphic (Huber, Stathopoulos, Curione, Ash, & Johnson, 1999; Puts, Gaulin, & Verdolini, 2006). During puberty, men develop longer and thicker vocal folds than do women (Harries et al., 1998). This change is the result of pubertal testosterone expression (Abitol et al., 1999; Jenkins, 2000). The difference in vocal anatomy results in lowered voice pitch in men (Harries et al., 1998). Men also have longer vocal tracts and lower formants than women (see Pisanki et al., 2014a). People perceive longer vocal tracts and low pitch as more masculine while shorter vocal tracts and high pitch are perceived as more feminine (Collins, 2002; Collins & Missing, 2003; Feinberg et al., 2005b; Feinberg et al., 2008b).

We use the aforementioned sexually dimorphic vocal qualities to evaluate various attributes of others. McAleer et al. (2014) contend that very short vocalizations (e.g. "hello") can elicit instantaneous judgments of attractiveness and trustworthiness (among other vocal features). In general, we perceive lower-pitched men's voices as more attractive than higher-pitched men's voices. In contrast, we perceive higher-pitched voices in women as more attractive than lowered-pitch voices (for reviews, see Feinberg, 2008; Puts et al., 2012a).

Voice Pitch, Cooperation, and Trust

Voice pitch affects perceptions of cooperativeness and trustworthiness (O'Connor et al., 2011b; Vukovic et al., 2011; Tigue et al., 2011; Knowles & Little, 2015). People consider high-pitch voices as more cooperative than lower-pitch voices (Knowles & Little, 2015). Similarly, we perceive men with higher pitch as more trustworthy (i.e. less likely to cheat on) romantic partners than men with lower pitch (O'Connor et al., 2011b). Likewise, Vukovic et al. (2011) found that women who prefer masculine men as long-term partners also perceive those men as more trustworthy than do women who prefer masculine men as short-term partners. In contrast, people associate lower pitch in men with trustworthy leadership (Klofstad et al., 2012; Tigue et al., 2011). Although the relationship between trustworthiness and voice pitch overlaps with attractiveness, trust is context dependent. Knowles and Little (2015) suggest that a high voice pitch is non-threatening and indicates friendliness. If high voice pitch is associated with someone who is non-threatening and friendly, then this may help explain why in relationships, women find feminine men to be more trustworthy than masculine men (O'Connor et al., 2011b; Vukovic et al., 2011), as friendliness is important in personal relationships but may not be as important for leadership contexts.

VTL, Cooperation, and Trust

To the best of our knowledge, no studies have measured the effects of VTL on perceptions of trustworthiness. However, one study has investigated the role of VTL on perceptions of cooperativeness (Knowles & Little, 2015). People perceived

a lengthened VTL as more cooperative than a shortened VTL (Knowles & Little, 2015). According to Knowles and Little (2015, p. 13), as VTL is tied to height (see Pisanski et al., 2014a for review), "taller individuals have greater social status…which may make them more favorable as potential cooperators". Indeed, those with low voice pitch are perceived to be more dominant and taller than those with high voice pitch, and low voice pitch is associated with real-world prestige outcomes (Mayew et al., 2013; Tigue et al., 2011), yet the authors did not make the same hypothesis for low-pitched voices, nor did their findings on pitch support that idea. Therefore, in contrast to Knowles and Little (2015), we predicted that relatively shorter sounding people (i.e. those with higher pitch or a shorter VTL) would be perceived as relatively more cooperative because they are more likely to be followers than leaders because they are less dominant, more subordinate, and thus by definition, more likely to do what is asked of them (i.e. cooperate).

Self-Perceived Dominance and Self-Perceived Attractiveness

An individual's own dominance and attractiveness are known to influence perceptions of masculinity, dominance and attractiveness of others (Watkins et al., 2010a; Vukovic et al., 2008; Knowles & Little, 2015). Taller, more dominant men are less sensitive to dominance cues than shorter, less dominant men in masculinized voices (Watkins et al., 2010a). Vukovic et al. (2008) showed that women who perceived themselves as relatively more attractive had a stronger preference for males with masculinized voices. Knowles and Little (2015) found that men's self-reported dominance was positively rated to how much people

ascribed cooperativeness to voices with high pitch. Men with high dominance scores rated men with high-pitched voices to be more cooperative than did men with low dominance scores.

It is reasonable to assume that someone who is cooperative may also be perceived as trustworthy. However, to the best of our knowledge, no study has examined how ratings of trust and cooperation may be related and in fact how past research assessing both of these attributes may have been confounded by these similar characteristics.

In the present study we hope to extend findings in Knowles and Little (2015) and help determine the role of voice pitch and VTL on trustworthiness, cooperativeness, and attractiveness. We predicted that participants would rate men's low-pitched voices as more attractive but less cooperative and trustworthy than high-pitched voices. For women's voices, we predicted that participants would rate high-pitched voices as more cooperative and trustworthy than low-pitched voices. As mentioned above, despite findings by Knowles and Little (2015), we found it more logical to predict that decreasing VTL length would *increase* ratings of cooperativeness in voices, rather than *decrease* their perceived cooperativeness. What is unclear from prior work is whether trustworthiness ratings would be tied more closely to attractiveness ratings or cooperativeness ratings, and whether pitch and VTL affect perceptions of these attributes differently. To test these hypotheses, we manipulated the voice pitch and VTL of

men and women's voices, and played these to women who rated their perceived attractiveness, trustworthiness, and cooperativeness.

Methods

Participants

Thirty female undergraduates rated voices that were manipulated in pitch (*mean age* = 18.47 years, *SD* = 1.14 years) and a separate group of thirty female undergraduates rated voices that were manipulated in VTL (*mean age* = 18.67 years, *SD* = 1.15 years). All sixty participants received course credit for participation.

Stimuli Collection

We obtained voice recordings of 12 undergraduates (*males* = 6, *females* = 6) speaking the word, "hello". Voices were selected from a larger pool of voices to span the normal range of men's and women's voices once manipulated (Feinberg et al., 2006; Feinberg et al., 2008a; O'Connor et al., 2014). We used 6 original voices for each sex because prior studies on perception of voice pitch in humans using 4-6 voices (Feinberg et al., 2005; Feinberg et al., 2008a; Jones et al., 2010a; Vukovic et al., 2008) show similar effects to studies that have used hundreds of voices (Feinberg et al. 2008b; Puts et al., 2006; Puts et al., 2012b). We recorded the voices in an anechoic sound attenuated booth (Whisper Room SE 2000) with a Sennheiser MKH 800 condenser microphone using the cardioid pickup pattern. We digitally encoded audio recordings with an M-Audio Fast Track Ultra at 96 kHz

sampling rate and 32-bit amplitude quantization using Adobe Soundbooth CS5 3.0 and saved them in waveform audio file format (.wav).

Voice Pitch Manipulation

All acoustic measurements and manipulations were performed using Praat software (Boersma & Weenink, 2012). We used the Pitch-Synchronous Overlap Add (PSOLA, ®France Telecom) to manipulate the pitch of each voice stimulus to create a higher pitched and lower pitched version of each voice. This method selectively manipulates fundamental frequency and related harmonics (the physical basis for pitch perception) while holding other features of the acoustic signal constant (Feinberg et al., 2005b). We raised or lowered voice pitch by 0.5 equivalent rectangular bandwidth (ERB) of the baseline pitch, which is roughly equivalent to a ±20 Hz manipulation at a base frequency of 120 Hz. This method has been successfully used in many studies (Apicella & Feinberg, 2009; Jones et al., 2008; Jones et al., 2010a; Vukovic et al., 2008). This process corrects for the difference between perceived pitch and actual fundamental frequency (Traunmüller, 1990). After manipulation, each of the women's voices that we lowered in pitch (*mean pitch* = 210.55 Hz, *SD* = 41.49 Hz) was lower than each of the women's voices that we raised in pitch (*mean pitch* = 261.77 Hz, *SD* = 45.62 Hz) and each of the men's voices that we lowered in pitch (*mean pitch* = 94.78 Hz, *SD* = 10.56 Hz) was lower than each of the men's voices that we raised in pitch (*mean pitch* = 131.57 Hz, *SD* = 9.13 Hz).

VTL Manipulation

We manipulated VTL, independently of pitch by +/-15% of each voice stimulus using a technique identical to the formant manipulation used in the "Change gender" function in Praat (see Feinberg et al., 2005 for details) The above manipulations produced two versions of each voice stimulus, one with a shortened VTL and one with a lengthened VTL. Pitch and VTL manipulations produced 48 unique stimuli total. Each stimulus was normalized in amplitude to 70 dB RMS SPL.

Procedure

The following procedure was also used for participants rating VTL except we used VTL manipulations (lengthened vs. shortened) instead of voice pitch manipulations.

Stimuli were organized into seven blocks of six trials, each for a different attribute per sex of voice. Within each block, all trials contained voice stimuli that had been manipulated in pitch (6 raised and 6 lowered) and the participants had to choose between the raised and lowered version for each trial. The side of the screen that either play button for each voice was on was randomized. Three blocks contained only female voices and four blocks contained only male voices (as the relationship context for attractiveness ratings was only used for opposite-sex voices). The order of blocks and voices were presented in random order. Two blocks were for trust ratings (male stimuli and female stimuli), two blocks were for cooperativeness ratings (male stimuli and female stimuli) and attractiveness ratings were distributed across three blocks. One block had female stimuli and the

other two contained male stimuli to rate for attractiveness for either a short-term or long-term relationship.

Participants listened to each voice stimulus through Sennhesier HD 280 Pro headphones connected to a computer. In each block, the computer instructed whether participants were rating men or women's voices for trustworthiness, cooperativeness, and attractiveness. For each trial, participants clicked on the "play" buttons on the computer screen to listen to the voice stimuli and then using a forced choice task, they chose between the pairs of voices.

For each attribute, participants selected how much more attractive/ cooperative/ or trustworthy a voice was by selecting one of the phrases above the stimulus: "much more attractive/cooperative/ trustworthy", "somewhat more attractive/ cooperative/ trustworthy", "slightly more attractive/cooperative/ trustworthy", or "guess".

***Trustworthiness*:** "You will hear 2 men's/women's voices. Choose the voice that is more trustworthy to you."

Cooperativeness*:* We used the definition of cooperativeness from Knowles and Little (2015). "You will hear 2 men's/women's voices. Choose the voice that sounds more cooperative to you. This is a measure of how likely you think a person might be to work with you toward a mutually beneficial goal-e.g. writing a presentation or contributing to group work. In these situations, cooperative people will do their fair share of the work. A person who is uncooperative is not likely to

contribute their fair share of work or resources, but will still enjoy the rewards of effort provided by others."

Attractiveness: When participants were rating female stimuli they read, "You will hear 2 women's voices. Choose the voice that sounds more attractive to you."

Attractiveness (short-term relationship)*:* We used the definition of "short-term relationship" first defined by Penton-Voak et al. (2003) and also used by O'Connor et al. (2014). *"*You will hear 2 men's voices. Choose the person you think is more attractive for a short-term relationship. "Short-term" implies that the relationship may not last a long time. Examples of this type of relationship would include a single date accepted on the spur of the moment, an affair within a long-term relationship, and possibility of a one-night stand."

Attractiveness (long-term relationship): We used the definition of "long-term relationship" first defined by Penton-Voak et al. (2003) and also used by O'Connor et al. (2014). *"*You will hear 2 men's voices. Choose the person you think is more attractive for a long-term relationship. Examples of this type of relationship would include someone you may want to move in with, someone you may consider leaving a current partner to be with, and someone you may, at some point, wish to marry (or enter into a relationship on similar grounds as marriage)."

Once participants completed the ratings they filled out a questionnaire on the computer that asked them about their self-perceived attractiveness, self-perceived social dominance and self-perceived physical dominance. For self-perceived dominance we adapted questions of social and physical dominance

from Puts et al. (2006) and Watkins, Jones, and DeBruine (2010), we asked participants, "how socially dominant are you? 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." Participants chose among a 7-point scale of "very socially submissive" to "very socially dominant. For self-perceived physical dominance we asked participants, "how physically dominant are you? A physically dominant person would be likely to win a fist-fight with the average same-sex undergraduate." Participants chose among a 7-point scale of "very physically submissive" to "very physically dominant". For self-rated attractiveness, we used a standard question from Little, Burt, Penton-Voak and Perrett (2001), "how attractive do you consider yourself to be?" Participants chose among a 7-point scale of "very unattractive" to "very attractive".

Analysis

We conducted several analyses to assess how participants chose between the higher and lowered pitch stimuli and the shortened and lengthened vocal tract for all attributes. We performed statistical analyses using SPSS 23 with two-tailed probability estimates and alpha = 0.05.

Results

We used one-sample *t*-tests to determine the effects of manipulations of pitch and VTL on women's judgments of trustworthiness, attractiveness, and cooperativeness. The results for the pitch manipulation are listed in Table 1 and

illustrated in Figure 3 and the results for the VTL manipulations are listed in Table 2 and illustrated in Figure 4.

Table 1
Women's Ratings of Pitch Manipulated Voices

Variable	One-sample t-tests					
	M	SD	T	df	Sig. (2-Tailed)	Cohen's d
Female voice attractiveness	3.561	1.066	.314	29	.756	0.057
Female voice cooperativeness	2.500	1.189	-4.606	29	<.0001**	-0.841 ǂ ǂ ǂ
Female voice trustworthiness	3.033	1.308	-1.956	29	.060	-0.357 ǂ ǂ
Male voice attractiveness (long-term relationship)	3.683	1.391	.722	29	.476	0.132 ǂ
Male voice attractiveness (short-term relationship)	4.628	1.960	5.165	29	<.0001**	0.943 ǂ ǂ ǂ
Male voice cooperativeness	2.161	1.276	-5.745	29	<.00001**	-1.049 ǂ ǂ ǂ
Male voice trustworthiness	2.622	1.203	-3.995	29	<.001**	-0.729 ǂ ǂ

Note. One-sample t-tests for women's ratings of pitch manipulated voices. Means greater than 3.5 indicate a preference for low-pitch voices while means less than 3.5 indicate a preference for high-pitch voices. * Denotes significant p-values ($p<0.05$), and ** denotes highly significant p-values ($p<0.01$). ǂ Denotes small effect size ($d>0.2$), ǂ ǂ denotes medium effect size ($d>0.5$), and ǂ ǂ ǂ denotes large effect size ($d>0.8$).

Figure 3: Women's Ratings of Men and Women's Pitch Manipulated Voices

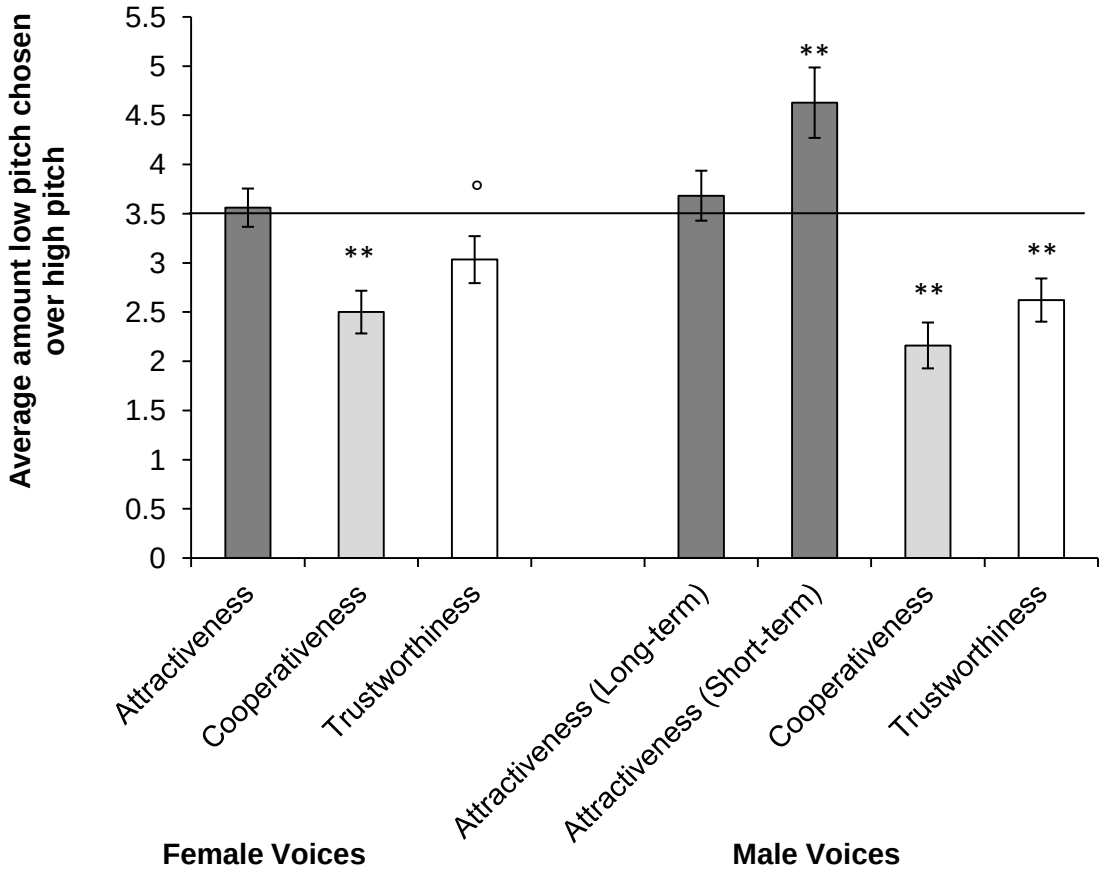

Figure 3: Women's ratings of pitch manipulated voices. Values over 3.5 indicate a preference for low-pitch voices while values less than 3.5 indicate a preference for high-pitch voices. * Denotes significant p-values ($p<0.05$), ** denotes highly significant p-values ($p<0.01$), and ° denotes marginal effects ($p<0.1$).

Table 2
Women's Ratings of VTL Manipulated Voices

	One-sample t-tests					
Variable	M	SD	t	df	Sig. (2-Tailed)	Cohen's d
Female voice attractiveness	3.577	1.561	.273	29	.787	0.050
Female voice cooperativeness	4.100	1.390	2.364	29	.025*	0.431 ł
Female voice trustworthiness	4.194	1.430	2.659	29	.013*	0.485 ł
Male voice attractiveness (long-term relationship)	4.428	1.260	4.031	29	<.001**	0.736 ł ł
Male voice attractiveness (short-term relationship)	4.428	1.439	3.532	29	.001**	0.645 ł ł
Male voice cooperativeness	2.783	1.007	-3.895	29	.001**	-0.711 ł ł
Male voice trustworthiness	3.417	1.347	-.339	29	.737	-0.062

Note. One-sample t-tests for women's ratings of VTL manipulated voices. Means greater than 3.5 indicate a preference for a lengthened VTL while means less than 3.5 indicate a preference for a shortened VTL. * Denotes significant p-values ($p<0.05$), and ** denotes highly significant p-values ($p<0.01$). ł Denotes small effect size ($d>0.2$), ł ł denotes medium effect size ($d>0.5$), and ł ł ł denotes large effect size ($d>0.8$).

Figure 4: Women's Ratings of Men and Women's VTL Manipulated Voices

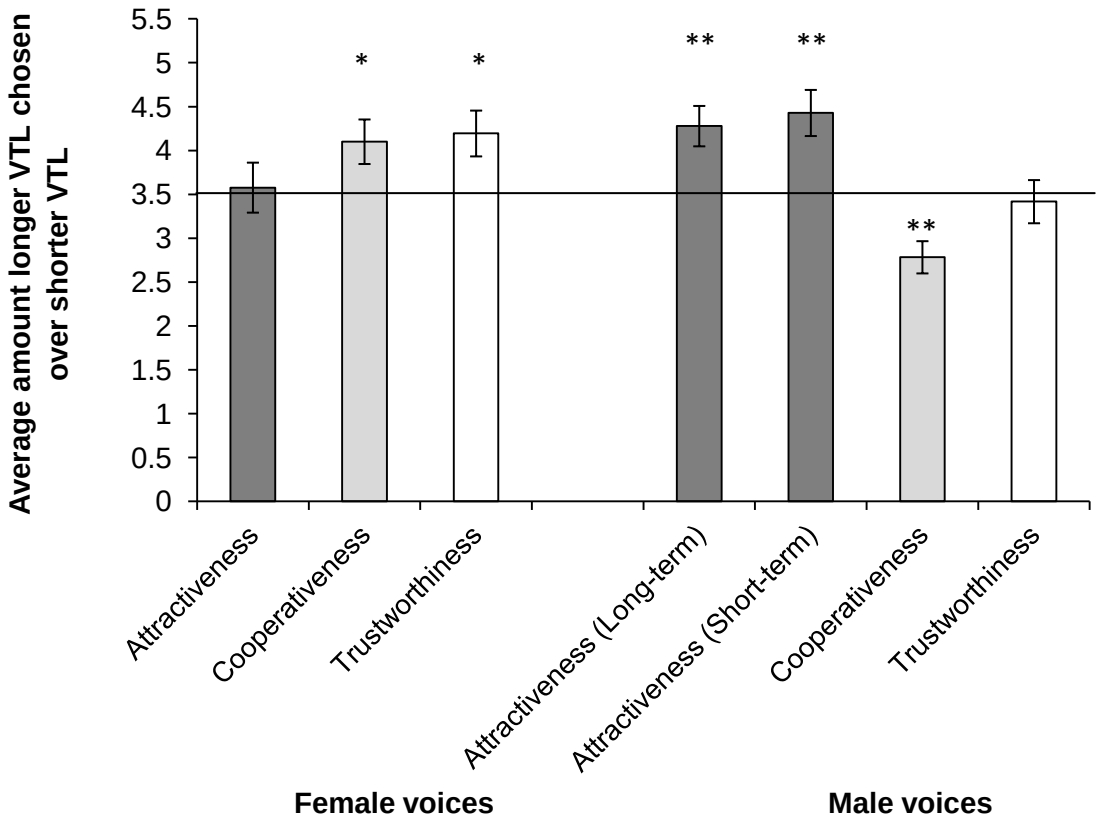

Figure 4: Women's ratings of VTL manipulated voices. Values greater than 3.5 indicate a preference for a lengthened VTL while Values less than 3.5 indicate a preference for a shortened VTL. * Denotes significant p-values ($p<0.05$), and ** denotes highly significant p-values ($p<0.01$).

We then used a mixed-design ANOVA [within-subject factor: relationship context (short-term/long-term), between-subject factor: manipulation (pitch/VTL)] which revealed a two-way interaction between relationship context (short-term vs. long-term) and manipulation (pitch vs. VTL) ($F_{1, 58} = 5.110$, $p = .028$, $\eta_p^2 = .081$) and a main effect of relationship context ($F_{1, 58} = 5.110$, $p = .028$, $\eta_p^2 = .081$). Post-hoc paired sample *t*-tests revealed that relationship context only affected attractiveness ratings using the pitch manipulation ($t_{29} = -2.987$, $p = .006$, $d =$

0.729) but not the VTL manipulation (t_{29} = 0.000, p = 1.000, d = 0.000) whereby women rated low-pitched men's voices as more attractive in short-term relationships contexts but not in long-term relationship contexts.

To test for effects and interactions among the sex of the vocalizer and the different voice manipulations on the different rating types, we conducted a mixed-design ANOVA [within-subject factors: sex of voice (male/female), rating (attractiveness/cooperativeness/trustworthiness), between-subject factor: manipulation (pitch/VTL)]. We discovered a three-way interaction among sex of voice, rating, and manipulation ($F_{2,57}$ = 3.471, p = .034, η_p^2= .056), a two-way interaction between sex of voice and rating ($F_{2,57}$ = 25.497, p <.0001, η_p^2 = .305), a two-way interaction between rating and manipulation ($F_{2,57}$ = 6.716, p = .002, η_p^2 = .102), and a main effect of rating ($F_{1.768,\ 102.537}$ = 26.968, p <.0001, η_p^2 = .317) Mauchly's test of Sphericity indicated that sphericity was violated (χ_2^2 = 11.433, p = .003), thus, we used Huynh-Feldt degrees of freedom where sphericity (ε) = 0.884).

We used post-hoc *t*-tests to examine the aforementioned interactions. To examine the three-way interaction (Sex of voice x Rating x Manipulation), we analyzed the effect of sex of voice on each rating for each manipulation separately. VTL manipulations had a greater effect on male voices for attractiveness (t_{29} = -2.753, p = .010, d = .624) and cooperativeness ratings (t_{29} = 3.783, p = .001, d = 1.088), but had a greater effect on female voices for trustworthiness ratings (t_{29} = 2.203, p = .036, d = 0.559). We also found that pitch

had a greater effect on male voices for attractiveness ratings (t_{29} = -2.435, p = .021, d = 0.585). To examine our two-way interaction (Sex of Voice x Rating) we used paired-sample *t*-tests and found that the pitch and VTL manipulations as a whole had a greater effect on male voices for all three attributes (see figure 5): attractiveness (t_{59} = -3.687, p < .001, d = 0.605), cooperativeness (t_{59} = 4.061, p < .001, d = 0.609), and trustworthiness (t_{59} = 2.816, p = .007, d = 0.423).

Figure 5: Effects of Sex of Voice on Ratings across Pitch and VTL Manipulations

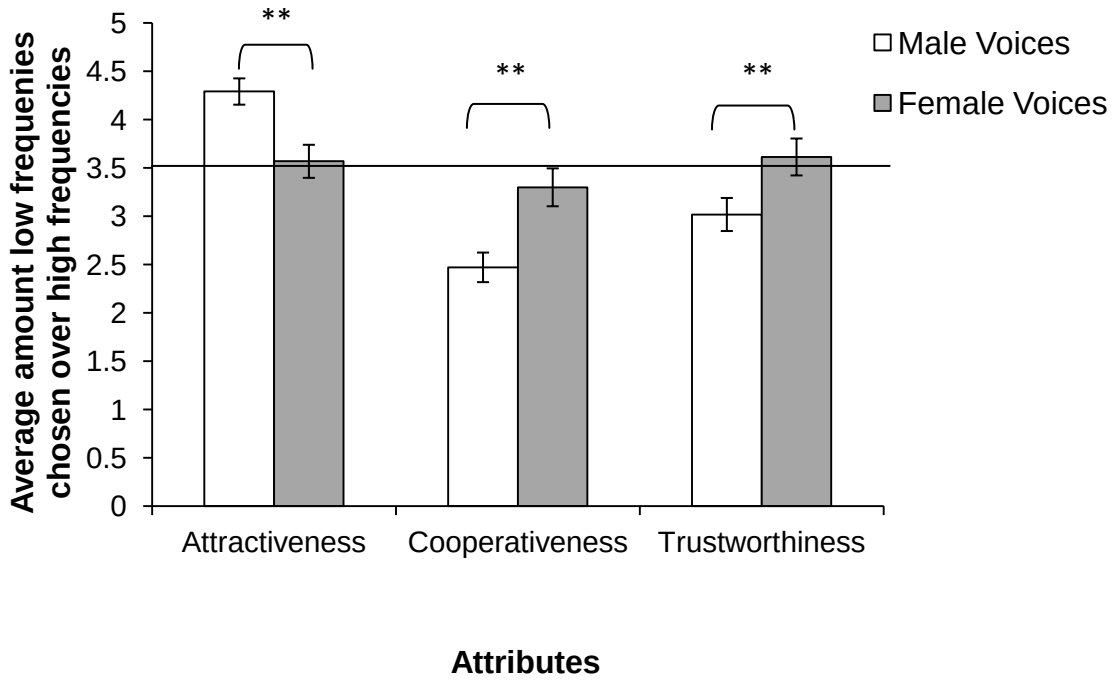

Figure 5: Effects of the average of pitch and VTL manipulations on mean ratings of male and female voices. Deviations furthest from 3.5 indicate a greater effect for sex of voice. Means greater than 3.5 indicates a preference for lower pitch and/or lengthened VTL and less than 3.5 indicates a preference for higher pitch and/or shortened VTL. * Denotes significant p-values ($p<0.05$), and ** denotes highly significant p-values ($p<0.01$).

To examine our other two-way interaction (Rating x Manipulation) we examined the effect of each manipulation on an average of ratings for male and female voices using an independent-sample *t*-test with manipulation type (pitch/VTL) as a grouping variable (see Figure 6). We found that there was no effect of manipulation type on attractiveness ratings (t_{58} = .602, p = .550, d = 0.155). There was an effect of manipulation type on cooperativeness ratings where pitch had a greater effect than VTL (t_{58} = 4.473, p <.0001, d = 2.057) and on

trustworthiness ratings where pitch had a greater effect than VTL (t_{58} = 3.640, p = .001, d = 0.948).

Figure 6: Effects of Manipulation Type on Ratings across Men and Women's Voices

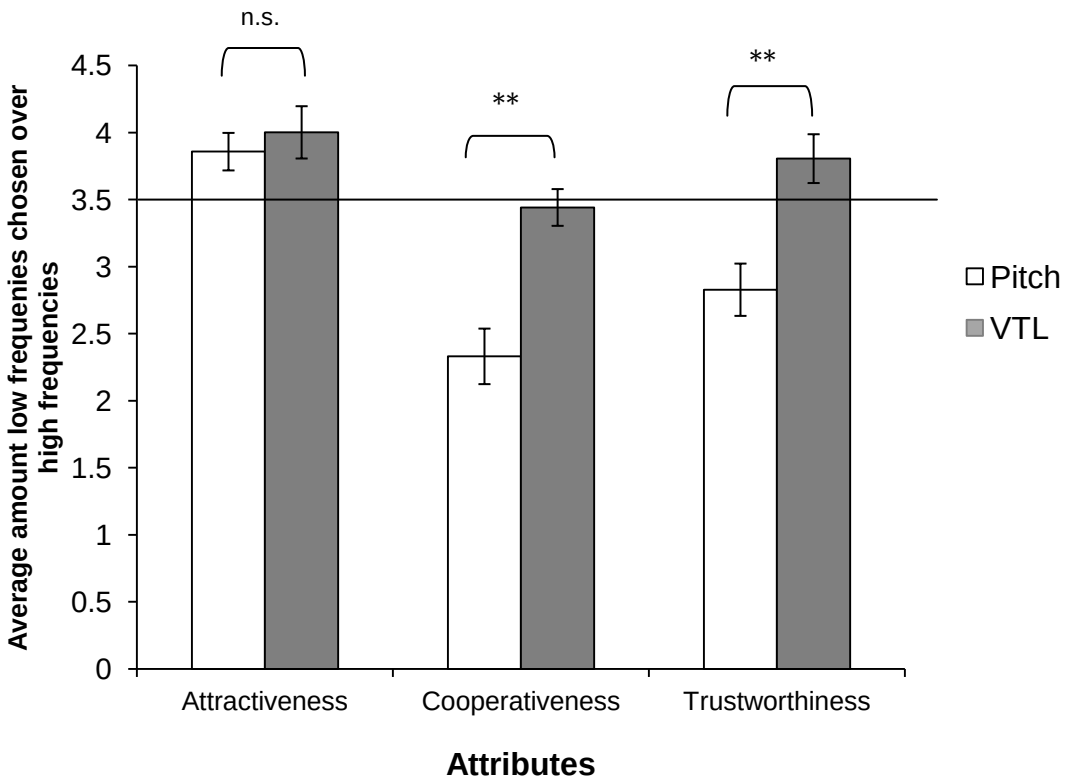

Figure 6: Effects of Pitch and VTL Manipulations on the average of men and women's voices. Deviations furthest from 3.5 indicate a greater effect of manipulation type (pitch/VTL). Means greater than 3.5 indicates a preference for lower-pitch and/or lengthened vocal tracts and means less than 3.5 indicate a preference for higher-pitch and/or shortened vocal tracts. * Denotes significant p-values ($p<0.05$), and ** denotes highly significant p-values ($p<0.01$).

We then computed Pearson correlations to specifically address if trust and cooperation were related. The results are illustrated in Table 3.

Table 3
Relationship between Attributes of Trust, Attraction and Cooperation

	Pearson correlations		
	r	N	Sig. (2-tailed)
Female voice attractiveness and cooperativeness	.303	60	.018*
Female voice cooperativeness and trustworthiness	.628	60	<.0001**
Male voice attractiveness (long-term relationship) and cooperativeness	.285	60	.028*
Male voice cooperativeness and trustworthiness	.592	60	<.0001**
Male voice trustworthiness and attractiveness (long-term relationship)	.379	60	.003**

Note. * Denotes significant p-values ($p<0.05$), and ** denotes highly significant p-values ($p<0.01$).

Subsequent Pearson correlations between our measures of self-perceived dominance and self-perceived attractiveness and our attributes of trustworthiness, cooperativeness, and attractiveness revealed a significant negative correlation between the effect of high voice frequencies (i.e. the average of raised pitch and shortened VTL) on female voice attractiveness and self rated social dominance (r_{60} = -2.82, p = .029). The more socially dominant women perceived themselves to be, the less attractive they found women with high frequency voices. The relationship between self-rated attractiveness and female voice trustworthiness was marginally significant. There was a trend where women's self-perceived attractiveness positively predicted how much they trusted other women with high

frequency voices (r_{60} = .216, p = .098). No other correlations were significant (all p>.098).

Discussion

Women rated raised-pitch men's voices as more trustworthy and cooperative than lowered-pitch voices. However, women rated lowered-pitch men's voices as more attractive than raised-pitch voices. This result is consistent with our predictions and past research in that the high-pitched voices are more trustworthy and cooperative than low-pitched voices (O'Connor et al., 2011b; Vukovic et al., 2011; Knowles & Little, 2015) while low-pitch voices are more attractive than high-pitched voices (for reviews, see Feinberg, 2008; Puts et al., 2012a). Women preferred a relatively longer VTL in men's voices. In contrast, women rated men's voices with a relatively shorter VTL as more cooperative than voices with a relatively longer VTL. This result is consistent with our predictions in that we thought participants would rate men with a shorter VTL as more cooperative because they are more likely to be less dominant, more subordinate, and thus by definition, more likely to cooperate. Participants rated women's higher-pitched voices as more cooperative than lowered-pitched women's voices. This result is consistent with our predictions and past research in that people perceive high-pitched voices as cooperative (Knowles & Little, 2015). Participants also rated other women with a relatively longer VTL as more cooperative and trustworthy than women with a relatively shorter VTL. This result is contrary to our predictions where we expected a shorter VTL to be more cooperative and trustworthy than a

longer VTL. We also found that trust and cooperation were positively correlated in both male and female voices. In our predictions, we were unsure whether trust would be more closely tied to attractiveness ratings or cooperativeness ratings. From our results, it is clear that trust is more closely tied with cooperation than attraction. The idea that these two attributes are closely related makes sense because according to Ostrom and Walker (2003), cooperation is a major component of trust. Finally, we found a significant negative relationship between female voice attractiveness and self rated social dominance. This result is directly in line with intrasexual competition wherein women use strategies to compete with other women for access to potential mates (Darwin, 1871; Fisher, 2004). One strategy that women may use to secure mates is derogating other women. Fisher (2004) found that fertile women derogated other women in that they gave them low attractiveness ratings. This finding may help explain why the socially dominant women in our study were more likely to rate high frequency (more feminine, more attractive) voices as less attractive than women low in social dominance. It is possible that socially dominant women may be better competitors and as a consequence, they derogate other women more than do less socially dominant women.

Women in our study rated men with low-pitched voices as more attractive for short-term relationships than men with high-pitched voices. This finding is supported by past studies showing that women prefer masculine men for short-term relationships more than long-term relationships, as masculine men are less

likely to invest in relationships and offspring, but have better quality genes (Gangestad, Garver-Apgar, Simpson, & Cousins, 2007; Little, Jones, Penton-Voak, Burt, & Perrett, 2002; Penton-Voak et al., 2003; Puts, 2005; Vukovic et al., 2011). We found that women trusted men with higher-pitched voices more than they trusted men with lower-pitched voices. This finding is similar to other studies that show that women rate men with higher-pitched voices as relatively more trustworthy, and that this predicts how much women prefer masculine men as long-term partners as opposed to how much they prefer masculine men as short-term relationship partners (Vukovic et al., 2011). This may be because men with low-pitched voices are perceived to invest less in offspring and relationships (O'Connor et al., 2011b), than are men with high-pitched voices and that this is reflected in actual behaviour of men with higher testosterone (Fleming et al., 2002; Gray et al., 2002; Gray et al., 2004; Gray et al., 2006; Hooper et al., 2011; Storey et al., 2000).

In contrast to women's distrust of men with low-pitched voices as faithful relationship partners, women trust men with low-pitched voices in leadership contexts such as political leaders or other similar positions of power (Klofstad et al., 2012; Tigue et al., 2011). Thus it appears we trust different qualities when perusing a high quality mate than when perusing a leader, even though both may reflect cues to high social dominance such as voice pitch.

Similar to Knowles and Little (2015), we found that men and women with high-pitch voices are considered to be more cooperative then those with low-

pitched voices. However, we did not replicate Knowles and Little's (2015) findings that a longer VTL was associated with cooperativeness in male voices. In fact, we found the opposite. As we predicted, participants perceived men's voices with relatively shorter VTLs as more cooperative than men's voices with relatively longer VTLs. We also found that women perceived other women with a lengthened VTL as more cooperative than women with a shorter VTL, suggesting that there could be sex differences in cooperativeness ratings. It is unlikely that the contrasting results between our study and Knowles and Little's (2015) could be the result of using manipulated voices as opposed to the natural voices because our other results have been replicated in studies using un-manipulated voices (i.e. Collins (2000); Collins and Missing (2003); Feinberg et al., (2008b); Knowles and Little (2015); Oguchi & Kikuchi (1997); Saxton et al., 2006). It is also possible the contrasting results could be due to the geographic regions in which the studies were conducted (i.e. Canada and Scotland). However, past research from Canada and Scotland examining vocal attractiveness and trust has found similar results (Feinberg et al., 2008a, 2008b; Feinberg et al., 2005a, 2005b; Jones et al., 2008; Jones et al., 2010a; O'Connor et al., 2011b; O'Connor et al., 2014, Puts, 2005; Vukovic et al., 2011). There is nothing we know about Canadian versus Scottish culture, language, etc. or prior research that would lead us to predict that VTL would predict cooperativeness ratings differently, but that the predictions for trustworthiness and attractiveness would be consistent in the two countries. We suggest further research here.

One unexpected result was that for women's voices, where pitch and VTL predicted cooperativeness ratings in opposite directions. Given that both voice qualities predict most other attributes in the same direction (i.e. attractiveness (Feinberg et al., 2005b), age (Feinberg et al., 2005b), size (Pisanski et al., 2014a; Pisanski, Fraccaro, Tigue, O'Connor, & Feinberg, 2014) and masculinity (Feinberg et al., 2005b)), we would have expected cooperativeness ratings to predict both pitch and VTL in the *same* direction.

The positive correlation between the effect of pitch on both cooperativeness and trust suggests that these two traits are overlapping concepts. However, because pitch and VTL predicted cooperativeness and trustworthiness differently enough in men and women's voices, this result suggests that these concepts are also separable. We also found that participants rated a relatively shorter VTL as more cooperative in male voices but there were no such effects for trust ratings. Thus in both men and women's voices, although voice based perceptions of trustworthiness and cooperativeness overlap, they are not a single unitary construct and can have diverse effects in different scenarios.

General Discussion

In this thesis I examined the effects of voice pitch and VTL on perceptions of attractiveness, trustworthiness, and cooperativeness using both behavioural and self-report methods. I found that in an economic game, women trusted men with high voices and that when using a forced-choice task, high pitch voices were perceived to be more cooperative and trustworthy than low pitch voices. Also, women perceived a shortened VTL as more cooperative than a lengthened VTL in male voices. These findings are important because they provide further evidence that we have evolved to use qualities in the voices to judge various attributes in others. As we evolved in groups (Barton & Dunbar, 1997; Dunbar, 2007), it was of the upmost importance to determine who we should form alliances with and who we should trust. We know that trust and cooperation are related as evidenced by the Prisoner's Dilemma Task (Rapoport & Chammah, 1965), Trust Games (Berg et al., 1995; Cox, 2004) and by my thesis where we saw that trust and cooperation were positively correlated. However, we now know that they are not exactly the same as we saw that in some cases trust and cooperation predicted voice frequency manipulations differently. This result suggests that past research attempting to measure trust should control for or at least address the issue of cooperation. Thus, I am first to find that although related, voice based perceptions of cooperativeness and trustworthiness are separable. Further research should examine how men use these various indicators and study two should be replicated using an economic game rather than a forced choice task.

I also illustrated the difference in methods researchers use to try to determine trustworthiness e.g. behavioural games vs. rating tasks. It appears that the different methods used can produce distinctive results e.g. VTL was not predictive of trust in an economic game but it was in a forced-choice task. Despite these differences, the relationship between high-pitched voices and trust remained robust between both methods. This result contradicts the findings in leadership and political scenarios wherein low voices are trusted more than high voices (Klofstad et al., 2012; Tigue et al., 2011) and wherein low voices are perceived to be better leaders than those with high voices (Anderson & Klofstad, 2012; Klofstad et al., 2012; Tigue et al., 2011). These perceptions are reflected in real life situations wherein those with low frequency voices are more likely to be elected to office (Gregory & Gallagher, 2002) and be CEOs of powerful companies (Mayew et al., 2013). Thus, it appears that we trust men with low voices to make economic policy and business decisions, yet, in everyday interactions, people do not trust these same men to divide a pot of money equally or cooperate with them. This suggests that the indicators we use to trust those to make economic policy decisions and whether or not to divide money equally or in situation without context are different. Our findings provide the first source of evidence that the perception that men with low voices are better economic-decision makers may depend on the type of economic decision beings made. Finally, my thesis provides further evidence that the human voice is fundamentally important for social perceptions.

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