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Original Article

Men's voice pitch influences women's trusting behavior☆

Kelyn J. Montano [a], Cara C. Tigue [a], Sari G. E. Isenstein [a], Pat Barclay [b], David R. Feinberg [a,*]

[a] Department of Psychology, Neuroscience & Behaviour, McMaster University, 1280 Main Street West, Hamilton, ON, Canada L8S 4L8
[b] Department of Psychology, The University of Guelph, 50 Stone Road East, Guelph, ON, Canada N1G 2W1

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ABSTRACT

Women tend to trust men with low-pitched voices as political leaders but trust men with high-pitched voices in mating scenarios. To elucidate the role of pitch in perceptions of trust, we used a one-decision variant of the trust game in which female participants were given the choice to trust males to divide the money, or to end the game, taking a smaller than equal sum. Male receivers were simulated using pitch-manipulated voice recordings. Women trusted raised pitch voices more than lowered pitch voices. These results suggest that although people with masculine voices are entrusted to lead our governments, people with masculine voices are not trusted to divide up financial resources equitably on a personal level.

1. 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; Stirrat & Perrett, 2010; Wilson & Eckel, 2006) cues from others that may influence the likelihood of us trusting them. We use both vocal (Klofstad, Anderson, & Peters, 2012; O'Connor, Re & Feinberg, 2011; Tigue, Borak, O'Connor, Schandl, & Feinberg, 2011; Vukovic et al., 2011) and facial masculinity (Little, Roberts, Jones, & DeBruine, 2012; Perrett et al., 1998; Oosterhof & Todorov, 2009; Boothroyd, Jones, Burt, & Perrett, 2007; Stirrat & Perrett, 2010), when evaluating trustworthiness of an individual.

Earlier work on social perception suggested 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 that 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), odor (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., 2011). Research shows that masculinity influences judgments of attractiveness but also may carry positive and negative connotations in different modalities and domains.

1.1. Voice pitch and trust

Prior work has demonstrated that men with lower pitched, more masculine voices (see Feinberg, Jones, Little, Burt, & Perrett, 2005) are perceived as more trustworthy leaders (Klofstad et al., 2012; Tigue et al., 2011) but as less trustworthy (i.e., more likely to cheat) romantic partners (O'Connor, Re & Feinberg, 2011) than 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 less trustworthy. Thus, work on voice pitch and trustworthiness is currently inconclusive or at least seems to be context dependent.

1.2. Other cues to vocal masculinity

Voice pitch is not the only acoustic feature that affects perceptions of masculinity (Feinberg et al., 2005). Formant frequencies, the resonant frequencies of the supralaryngeal vocal tract, also affect perceptions of masculinity (Feinberg et al., 2005) and may therefore influence perceptions of trust. Although large vocal tracts are associated with large body size (Fitch, 1997, 2000a, 2000b; Fitch & Giedd, 1999), 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

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* Corresponding author. 1280 Main St West, Hamilton, ON, Canada L8S 4K1.
E-mail address: feinberg@mcmaster.ca (D.R. Feinberg).

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perceived as better leaders (Re et al., 2012). Indeed, Knowles and Little (2016) found that people with larger apparent vocal tracts (i.e. lower formants) sounded more cooperative than people with shorter apparent vocal tracts. Cooperativeness and trust are interrelated (Knowles & Little, 2016).

1.3. Measuring trust using economic games

Stirrat and Perrett (2010) observed that in an economic game, players were more likely to trust less masculine men (as indexed by a face width-to-height ratio). However, face width-to-height ratio has later been exposed and is actually not a sexually dimorphic trait (Lefevre et al., 2012), although it is tied to perceived dominance (Stirrat & Perrett, 2010). Thus, there is equivocal evidence that masculinity affects trust in economic games. While it may be adaptive to select masculine men as leaders because of their ability to deal with difficult financial situations such as recession (Tigue et al., 2011), it may also be adaptive to distrust the same masculine men as committed romantic partners (Boothroyd et al., 2007; Vukovic et al., 2011) and to distribute financial resources in one-on-one interactions (Stirrat & Perrett, 2010).

Taken together, the results of past studies indicate that the relationship between men's voice and perceptions of trust and trustworthiness is complicated, not well understood, and often contradictory. One tool that economists design to shed light on more realistic trusting behavior is economic games. One game in particular, the trust game (Berg, Dickhaut, & McCabe, 1995), and its variants (see Johnson & Mislin, 2011) have been used for over a decade to study attitudes toward different traits in faces such as self-resemblance (DeBruine, 2002, 2005) and dominance (Stirrat & Perrett, 2010). Yet surprisingly, no studies have tested whether vocal masculinity influences behavior in the trust game.

To test how research on perceptions of trust extends to a behavior in economic games, we tested whether men's voice pitch and apparent vocal tract length 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 was real.

Here, we test two opposing hypotheses on perceptions of trust from the voice. On one hand, research on politics, leadership, economic policy, and cooperation suggests that men with lower pitched voices and lower formants (longer apparent vocal tracts) are perceived as more trustworthy and/or cooperative sounding than men with higher pitched voices and/or higher formants (shorter apparent vocal tracts) (Klofstad et al., 2012; Knowles & Little, 2016; Stirrat & Perrett, 2010; Tigue et al., 2011). On the other hand, feminine male vocal (i.e. high pitch) and facial features are perceived as more honest, cooperative, and/or trustworthy than masculine male vocal (i.e. low pitch) and facial features in romantic and neutral contexts (Boothroyd et al., 2007; Knowles & Little, 2016; Perrett et al., 1998; Vukovic et al., 2011). If men with potentially masculine faces are relatively more likely to exploit people in economic games (Stirrat & Perrett, 2010), we predict that women will trust voices with masculine vocal features less than they will trust voices with feminine vocal features in the trust game.

2. Methods

2.1. Participants

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

2.2. 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, DeBruine, Jones, & Perrett, 2008; Feinberg et al., 2006; 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.

2.3. Voice pitch manipulation

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) method in Praat software (Boersma & Weenink, 2012). This method selectively manipulates fundamental frequency and related harmonics (the physical basis for pitch perception) while holding all other features of the acoustic signal relatively constant (Feinberg et al., 2005). 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 (Apicella & Feinberg, 2009; Feinberg, DeBruine, Jones, & Perrett, 2008; 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).

2.4. Formant manipulation

In Praat acoustic phonetics software (Boersma & Weenink, 2012), we independently manipulated formant frequencies as a whole to simulate differences in the length of the supralaryngeal vocal tract of each voice stimulus. We first re-sampled the sound either 15% above or below the original sampling rate, which raised or lowered all frequencies by 15%, and then manipulated the fundamental frequency back to the baseline level using PSOLA, leaving only the formant frequencies shifted as described in Feinberg et al. (2005), which is the same technique implemented in the "change gender" button in Praat. Using this technique, we created two versions of each voice stimulus: one with formant frequencies 15% lower than the original (lengthened apparent vocal tract) and one with formant frequencies 15% higher than the original (shortened apparent vocal tract).

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 normalized the amplitude of each stimulus to 70 dB RMS SPL, using Praat (Boersma & Weenink, 2012). We used 6 original voices because prior studies on perception of voice pitch in humans using 4–6 voices (Feinberg et al., 2005; Feinberg, DeBruine, Jones, & Little, 2008; Jones, Feinberg, DeBruine, Little, & Vukovic, 2010; Vukovic et al., 2008) have found similar effects to those using hundreds of voices (Feinberg, DeBruine, Jones, & Perrett, 2008; Puts, Apicella, & Cárdenas, 2012; Puts, Gaulin, & Verdolini, 2006).

2.5. 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 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.

Trials 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 ® over-the-ear 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.

2.6. 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 20 with two-tailed probability estimates and alpha = 0.05.

3. Results

A mixed-design ANOVA [within-subject factor: manipulation type (pitch/formants) 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 ($F_{1,35} = .678$, $p = .416$). 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 ($t_{36} = -1.911$, $p = .064$). 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 ($t_{36} = -1.859$, $p = .071$). See Fig. 1.

Furthermore, in the pitch manipulation condition, pitch was positively correlated with proportion trusted ($r_{12} = .58$, $p = .047$, see Fig. 2).

We estimated apparent vocal tract length using all known measures reported in Pisanski et al. (2014) including formant position, average formant, the regression method, and individual formants, but not confirmatory factor analysis as our sample size is 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.

4. Discussion

Women did not trust men with low-pitched voices to divide money equitably. Masculine men are perceived to be better politicians (Klofstad et al., 2012; Little et al., 2012; Tigue et al., 2012), are more likely to win elections (Gregory & Gallagher, 2002; Klofstad, 2015), and garner higher salaries as CEOs than feminine men (Mayew, Parsons, & Venkatachalam, 2013). Thus, one potential explanation for these outcomes is that masculine men could be relatively exploitative (Stirrat & Perrett, 2010). But how can people trust potentially exploitative men with low-pitched voices to be leaders of their government and help a nation recover from economic situations like recession (Tigue et al., 2011)?

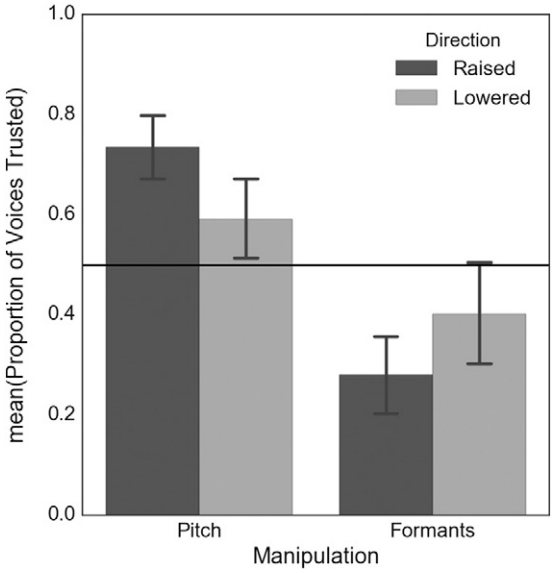

Fig. 1. Proportion of voices trusted in the pitch and formant manipulations. Raised formants correspond to shortened apparent vocal tract lengths, lowered formants correspond to lengthened apparent vocal tract lengths. 0.5 indicates trust at the chance level. People trusted high-pitched voices significantly more than chance and significantly more than low-pitched voices. People trusted longer apparent vocal tracts more than shorter apparent vocal tracts.

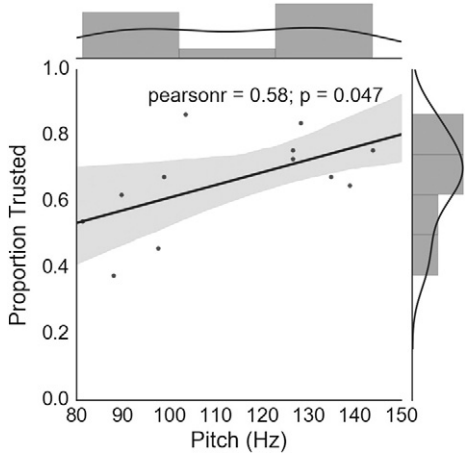

Fig. 2. The positive linear relationship between pitch and proportion of voices trusted. The higher the pitch, the more likely the voice was trusted. Histograms of each variable are plotted on their axis with normal distribution curves. The line is a linear regression and the shading represents 95% confidence intervals.

One idea is that as in-group members, the cost of being exploited by a masculine person could be offset by the benefit of that same person using this tactic against out-groups. Thus, even if smaller scale resources are not shared equally among in-group members, in-group members still benefit from the larger scale exploitation of an out-group if their net gain is relatively higher for doing so. Therefore, both perceptions, that low pitch is trustworthy and untrustworthy in different contexts, can coexist and be potentially adaptive.

We found that voice pitch was positively correlated with the proportion of voices trusted. The higher in pitch the voice, 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 (i.e. lower formants). The findings support Knowles and Little (2016), who found that women rated men with lower formants as relatively more cooperative. The aforementioned result is also important because it demonstrates that our findings that high pitch but low formants were trusted show that the results are not due to a general response bias toward masculine or dominant stimuli, or a low-level frequency response, but may be due to other information encoded in voice pitch that is not present in formant frequency structure. Further research is needed to fully understand the effect of apparent vocal tract length on trusting behavior. Taken together, these results suggest that women are not always more likely to trust more feminine men than more masculine men in an economic game, but that trusting behavior is sophisticated and nuanced.

Our results on pitch are consistent with research that examined facial masculinity and femininity and trust. Past studies have suggested that masculine faces are less trustworthy in both relationships and parenting (Boothroyd et al., 2007; Perrett et al., 1998). Furthermore, wider and more dominant-looking faces are perceived as relatively less trustworthy (Stirrat & Perrett, 2010). Since Lefevre et al. (2012) show that face width-to-height ratio is not sexually dimorphic, it was important to test these ideas with different traits that indicate masculinity (i.e. voice pitch and apparent vocal tract length). The consistency between the results found in faces and our results is not surprising as masculinity and dominance in faces and voices are related to pubertal testosterone levels. During puberty, there are elevated testosterone levels causing the vocal folds to grow longer and thicker in males (Harries, Hawkins, Hacking, & Hughes, 1998). Similarly, sexual dimorphism in the face is partly the result of elevated sex hormones (Verdonck, Gaethofs, Carels, & de Zegher, 1999).

This study only looked at how women trusted men's voices. Future studies may examine how men use voice pitch as an indicator of trustworthiness in women or how women use voice pitch as an indicator of trustworthiness in other women. Future research should also test whether people with lower voices actually divide up money less equitably than people with higher pitched voices.

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 for altered pitch to have different effects for real versus simulated partners. Nevertheless, 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.

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 (2016) 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 & Fienberg et al., 2010) and prefer them as political leaders (Klofstad et al., 2012; Tigue et al., 2011). Further research is needed to tease apart the effects of trust ratings from cooperativeness and alliance formation ratings.

In summary, we found that women trust men with feminized voices more than they trust men with masculinized voices in an economic game. We show that women trust men with higher, not lower, voices to divide and share money more equitably. This research reinforces the idea that, regardless of its validity, we live in a world where people behave as if masculine men do have some positive traits such as leadership ability and the ability to deal with complex economic situations (Tigue et al., 2011) but they are not trustworthy people as relationship partners (O'Connor & Fienberg et al., 2011; O'Connor & Re et al., 2011) or to divide up money in an equitable fashion.

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