



# High voice pitch mitigates the aversiveness of antisocial cues in men's speech

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Speech contains both explicit social information in semantic content and implicit cues to social behaviour and mate quality in voice pitch. Voice pitch has been demonstrated to have pervasive effects on social perceptions, but few studies have examined these perceptions in the context of meaningful speech. Here, we examined whether male voice pitch interacted with socially relevant cues in speech to influence listeners' perceptions of trustworthiness and attractiveness. We artificially manipulated men's voices to be higher and lower in pitch when speaking words that were either prosocial or antisocial in nature. In Study 1, we found that listeners perceived lower-pitched voices as more trustworthy and attractive in the context of prosocial words than in the context of antisocial words. In Study 2, we found evidence that suggests this effect was driven by stronger preferences for higher-pitched voices in the context of antisocial cues, as voice pitch preferences were not significantly different in the context of prosocial cues. These findings suggest that higher male voice pitch may ameliorate the negative effects of antisocial speech content and that listeners may be particularly avoidant of those who express multiple cues to antisociality across modalities.

Social perceptions, such as trustworthiness and attractiveness, are readily influenced by multiple sources of visual (e.g., Kruger, 2006; O'Connor & Feinberg, 2012; Smith *et al.*, 2009; Stirrat & Perrett, 2010) and auditory information (e.g., O'Connor & Barclay, 2017; Rezlescu *et al.*, 2015; Tigue, Borak, O'Connor, Schandl, & Feinberg, 2012). Speech is a rich source of social information, containing both explicit information in semantic content and implicit cues in voice frequencies, such as pitch. Explicit semantic information can either match or conflict with social perceptions from voice pitch, but it is currently unclear how people integrate these two sources of information when forming social perceptions. Here, we investigate whether voice pitch interacts with semantic cues to influence listeners' perceptions of trustworthiness and attractiveness.

## **Voice pitch, testosterone, and trustworthiness**

When people assess others' trustworthiness and attractiveness, they are readily influenced by vocal frequencies, particularly by voice pitch. Voice pitch is the perception of fundamental frequency ( $f_0$ ) and is determined by the rate of vocal fold vibration (Titze, 1994). All else being equal, larger vocal folds vibrate at a slower rate than do smaller vocal folds and therefore produce lower frequencies than do smaller vocal folds (Titze, 1994). During puberty, testosterone causes the vocal folds to increase in mass, thus lowering voice

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pitch (Harries, Hawkins, Hacking, & Hughes, 1998). Voice pitch continues to be inversely related to men's testosterone levels through adolescence (Hodges-Simeon, Gurven, & Gaulin, 2015) and into adulthood (Cartei, Bond, & Reby, 2014; Dabbs & Mallinger, 1999; Evans, Neave, Wakelin, & Hamilton, 2008; Hodges-Simeon *et al.*, 2015; Puts, Apicella, & Cárdenas, 2012), especially among men with relatively low levels of cortisol (Puts *et al.*, 2016). In these studies, trait testosterone levels explain between 2.25% (Dabbs & Mallinger, 1999) and 22% (Cartei *et al.*, 2014) of the variance in adult male voice pitch.

Testosterone is not only associated with individual difference in voice frequencies, but also with variation in trust-related behaviours. Men with relatively high testosterone (Takagishi, Takahashi, & Yamagishi, 2011), and men who possess facial cues to endogenously higher levels of testosterone, are more likely to exploit their partner's trust in economic games (Stirrat & Perrett, 2010) or to use deception for financial gain (Haselhuhn & Wong, 2012). The effects of exogenous testosterone are less clear: multiple studies show that administering testosterone decreases trusting behaviour (Boksem *et al.*, 2013; Bos, Hermans, Ramsey, & van Honk, 2012; Bos, Terburg, & van Honk, 2010), but different studies show conflicting results about whether administering testosterone increases trustworthiness (i.e., reciprocity in the trust game; Boksem *et al.*, 2013) or has no effect on trust-related behaviours (Zethraeus *et al.*, 2009). However, the influence of exogenous testosterone has been tested primarily among female samples, including young adult women (Boksem *et al.*, 2013; Bos *et al.*, 2010, 2012) and post-menopausal women (Zethraeus *et al.*, 2009). Whether these findings would be replicated among male participants is unclear. Regardless, it is endogenous hormones that affect facial structures, and endogenous testosterone-related traits are related to trustworthiness (Haselhuhn & Wong, 2012; Stirrat & Perrett, 2010). Players then use this facial information to avoid exploitation in economic games, as indicated by decisions not to trust money to men possessing facial cues to testosterone (Stirrat & Perrett, 2010). Therefore, at least among men, endogenous testosterone levels and testosterone-dependent traits are associated with untrustworthy economic behaviour.

Men with relatively higher levels of endogenous testosterone may also be less trustworthy in mating-related contexts, as men with relatively higher levels of testosterone are more likely to report higher frequencies of extrapair sex (Booth & Dabbs, 1993; Fisher *et al.*, 2009, 2012), sustained interest in sex outside of their current relationship (McIntyre *et al.*, 2006), lower reported commitment to their current relationship (Caldwell Hooper, Gangestad, Emery Thompson, & Bryan, 2011), and stronger interest in uncommitted sex (Puts *et al.*, 2015). The above findings suggest that men with higher levels of testosterone, and hence, lower-pitched voices, may be relatively less trustworthy in both economic and romantic contexts.

### ***The influence of voice pitch and semantic content on social perceptions***

Based on the relationships between testosterone and voice pitch, and between testosterone and trustworthiness, we would expect that people perceive lower-pitched male voices as less trustworthy than higher-pitched male voices. In comparison with lower-pitched voices, women tend to trust higher-pitched, feminine-sounding male voices more in general (McAleer, Todorov, & Belin, 2014; O'Connor & Barclay, 2017), financial (Montano, Tigue, Isenstein, Barclay, & Feinberg, 2017; O'Connor & Barclay, 2017), and romantic contexts (O'Connor & Barclay, 2017; O'Connor, Pisanski, Tigue, Fraccaro, & Feinberg, 2014a; O'Connor, Re, & Feinberg, 2011). In contrast, other work finds that lower-pitched male voices are perceived as more trustworthy in general than are

higher-pitched male voices (Oleszkiewicz, Pisanski, Lachowicz-Tabaczek, & Sorokowska, 2017; Tigue *et al.*, 2012), or have failed to detect a significant main effect of male voice pitch on perceptions of trustworthiness (Klofstad, Anderson, & Peters, 2012; Vukovic *et al.*, 2011). Therefore, the evidence for the influence of male voice pitch on perceptions of trustworthiness is mixed. In addition, recent work has indicated the influence of within-word pitch contours on perceptions of trustworthiness (Belin, Boehme, & McAleer, 2017). Although the influence of speech intonation is certainly of value to social perception research, the present studies focus on trait (average) voice pitch, rather than on pitch contour.

Despite the perceptual association between low male voice pitch and untrustworthiness, women generally prefer lower-pitched over higher-pitched male voices in potential mates (for review, see Feinberg, 2008; Puts, Jones, & DeBruine, 2012). Women's preferences for lower male voice pitch may be owing to the value of testosterone-dependent traits, such as male voice pitch, as indicators of good health (Feinberg, 2008; Puts, Jones, *et al.*, 2012; Rantala *et al.*, 2012) and/or dominance (for review see Puts, Jones, *et al.*, 2012).

Studies investigating the influence of voice pitch manipulations on social perceptions, such as trustworthiness, typically use spoken vowel sounds (e.g., /a/ 'ah', /i/ 'ee', /ɛ/ 'eh', /o/ 'oh', /u/ 'oo') or other brief utterances, such as the word 'hello' (McAleer *et al.*, 2014; O'Connor & Barclay, 2017). This approach to testing voice preferences is optimal when the aim is to examine only the effect of voice pitch without the potential influence of semantically meaningful speech content. However, in everyday life, the acoustic properties of voice are encountered at the same time as language, which conveys meaningful information about the speaker and subsequently influences perceptions of attractiveness. For instance, women prefer men who are attributed with prosocial rather than neutral (Barclay, 2010) or antisocial statements (Clark, Jack, Morrison, & Penton-Voak, 2009). Although these studies used written rather than spoken statements, the value of the semantic content as prosocial information is unlikely to be qualitatively different between these two modalities.

Voice pitch may interact with speech content to influence social perceptions. For instance, men's preferences for higher-pitched female voices are stronger in the context of semantic cues to social interest versus disinterest (i.e., 'I really like you' vs. 'I don't really like you', Jones, Feinberg, DeBruine, Little, & Vukovic, 2008). Voice pitch also interacts with linguistic cues to social status to influence perceptions of attractiveness (O'Connor, Fraccaro, *et al.*, 2014). O'Connor and colleagues found that listeners' preferences for lower-pitched (relative to high-pitched) male voices were stronger when selecting from speech containing linguistic cues to low status than when selecting from speech containing linguistic cues to high status. These findings demonstrate the importance of considering other aspects of the speech signal when investigating social perceptions of voices.

Other research has examined the integration of social information and other non-vocal indexical traits, such as facial masculinity. Similar to masculine men's voices, masculine men's faces are perceived as less trustworthy in general (Smith *et al.*, 2009; Stirrat & Perrett, 2010) and in mating-related contexts (Kruger, 2006; O'Connor & Feinberg, 2012) than are men with relatively feminine faces. Quist, DeBruine, Little, and Jones (2012) examined whether semantically cued social information regarding fidelity interacted with male facial masculinity to influence women's perceptions of attractiveness. The authors found that in the context of cues to fidelity, women had stronger preferences for masculinity rather than femininity in male faces, but there were no significant differences

in face preferences in the context of cues to infidelity. These findings suggest that positive social information can offset negative perceptions of testosterone-dependent cues, resulting in increased attractiveness.

### **Current study**

In this study, we examine how prosocial semantic cues interact with voice frequencies to influence women's social perceptions of men's voices as being trustworthy and attractive. Given prior research (see section The influence of voice pitch and semantic content on social perceptions), we predicted that women would perceive lower-pitched men's voices as relatively more attractive, but as less trustworthy than higher-pitched men's voices. If positive semantic information can offset negative perceptions of men's vocal masculinity, then women may perceive lower-pitched voices as both more attractive and as more trustworthy in the context of speech cues to prosociality, and prosocial speech cues may be more important for perceptions of attractiveness in the context of lower-pitched, rather than higher-pitched voices.

Alternatively, voice pitch and semantic cues may interact in an additive manner. If relatively higher male voice pitch is perceived as generally prosocial (i.e., economically and romantically trustworthy), then prosocial semantic cues may be perceived even more positively in the context of higher-voice pitch. Similarly, if lower male voice pitch is perceived as generally antisocial (i.e., economically and romantically untrustworthy), then antisocial semantic cues may be perceived even more negatively in the context of lower voice pitch.

Lastly, it is possible that voice pitch and speech content have independent effects on social perceptions. In this case, listeners' preferences for voice pitch would be unaffected by speech content, and preference for speech content would be unaffected by voice pitch.

## **STUDY I**

### **Method**

#### **Participants**

Protocols for this study were approved by the institutional Research Ethics Board. Heterosexual women ( $n = 85$ ; mean age = 18.21 years,  $SD = 0.91$ ) were recruited from the University of Guelph and compensated with partial course credit for participation. Participants were recruited until estimated sample size requirements ( $n = 84$ ) were met to detect a medium effect size ( $r = .3$ ) with 80% power using a correlation with  $\alpha = .05$  (G\*Power; Faul, Erdfelder, Lang, & Buchner, 2007). For additional details, see *Participant Recruitment* in Supporting Information.

#### **Stimuli**

Voice stimuli were collected from males ( $n = 4$ , mean age  $\pm SD = 18.00 \pm 0.82$  years) who were recorded speaking single words, the order of which was randomized across speakers. The recordings used in this study were selected from a larger corpus on the basis of recording quality, speech clarity, and averageness of male voice pitch (i.e., proximity to 120 Hz). The words used in this study are caring, cheater, fair, fraud, honest, helpful, liar, and corrupt.

We created two versions of each recording, a feminized version with raised pitch and a masculinized version with lowered pitch. Feminized and masculinized voice pairs were created using Praat software (Boersma & Weenink, 2018) by adding or subtracting (respectively) 0.5 equivalent rectangular bandwidths (ERBs) of the baseline frequency. This manipulation is equivalent to a change of approximately 20 Hz for a pitch of 120 Hz and does not affect other vocal parameters such as speech rate or formant frequencies. This degree of manipulation (approximately 16%) is greater than previously reported just noticeable differences for pitch discrimination (e.g., 6%, Pisanski & Rendall, 2011; 4.1%, Re, O'Connor, Bennett, & Feinberg, 2012). See Supporting Information for recording procedures and descriptive statistics of voice stimuli.

### **Procedure**

Voice pairs varied in either manipulated voice pitch or word valence, but belonged to the same identity. Prosocial–antisocial word pairs were matched for syllable count: ‘caring–cheater’, ‘fair–fraud’, ‘honest–liar’, and ‘helpful–corrupt’. Comparisons of prosocial–antisocial word pairs occurred only within each pair and not across pairs.

Participants rated four types of voice pairs presented in a two-alternative forced-choice paradigm: feminized pitch versus masculinized voice pitch when word valence was prosocial, feminized pitch versus masculinized voice pitch when word valence was antisocial, prosocial versus antisocial word valence when both voices were masculinized, and prosocial versus antisocial word valence when both voices were feminized. Condition order was randomized. Participants rated the same 32 voice pairs in each condition, for a total of 128 trials per participant.

Voice pairs were presented in two separate, randomized blocks (attractiveness and trustworthiness) and were fully randomized for order of speaker identity and side of screen presentation. Participants received verbal instructions prior to the initiation of voice ratings, as well as on-screen text instructions immediately prior to each voice rating condition. Participants were instructed ‘in this experiment, you will be asked to listen to pairs of voices. Each voice will be speaking single words, which describe the speaker’s personality and behaviour’. Participants were then asked to ‘pick the voice of the person that you think sounds more attractive’ and ‘pick the voice of the person that you think sounds more trustworthy’.

Participants listened to voices played through Sennheiser HD 280 Pro headphones (Sennheiser, Wedemark, Germany). The number of participants per experimental session varied between one and eight. Participants sat at individual computer corrals with privacy screens on either side of the desk. Voice pairs were presented on individual computer screens at each corral. One experimenter was present in the room at an unobtrusive position at a separate computer corral.

## **Results**

### **Manipulation check**

We calculated the proportion of trials in which participants selected the masculinized voice or prosocial word from each voice pair, separately for each rating context. We confirmed our word valence manipulation by conducting one-sample *t*-tests against chance (0.5) on the proportion of trials that listeners selected the prosocial word as more trustworthy than the antisocial word, for each word pair separately (all  $t \geq 8.19$ , all

$p < .001$ , see Table 1). Therefore, for subsequent analysis, we collapsed across individual words within each 'prosocial' and 'antisocial' word category.

### Statistical analysis

We analysed listeners' selection of masculinized voices and prosocial words separately, as the strength of these manipulations may not be perceptually equivalent (O'Connor, Fraccaro, *et al.*, 2014). If we analysed masculinized voices and prosocial words together, it would be impossible to determine whether or not any significant effects were owing to differences in the strength of the manipulation of voice pitch versus word content; therefore, they must be analysed separately. We conducted repeated measure ANOVAs for listeners' selection of masculinized voices (within-subject factors: rating context [trustworthiness, attractiveness], word valence [prosocial, antisocial]) and listener's selection of prosocial words (within-subject factors: rating context [trustworthiness, attractiveness], voice pitch [feminized, masculinized]). All analyses used two-tailed probability estimates ( $\alpha = .05$ ). See Supporting Information for descriptive statistics and one-sample  $t$ -tests against chance for each measure separately.

### Listeners' selection of prosocial words

Listeners chose prosocial words more often than chance, whether they were choosing based on attractiveness,  $M = 0.66$ ,  $SE = .019$ , one-sample  $t(84) = 8.25$ ,  $p < .001$ ,  $d = 0.89$ , or on trustworthiness,  $M = 0.79$ ,  $SE = .019$ , one-sample  $t(84) = 15.75$ ,  $p < .001$ ,  $d = 1.70$ . We found a significant effect of rating context,  $F(1, 84) = 45.30$ ,  $p < .001$ ,  $\eta_p^2 = .350$ , where listeners chose a higher proportion of prosocial words when rating trustworthiness ( $M = 0.79$ ,  $SE = .019$ ) than when rating attractiveness ( $M = 0.66$ ,  $SE = .019$ ; see Figure 1).

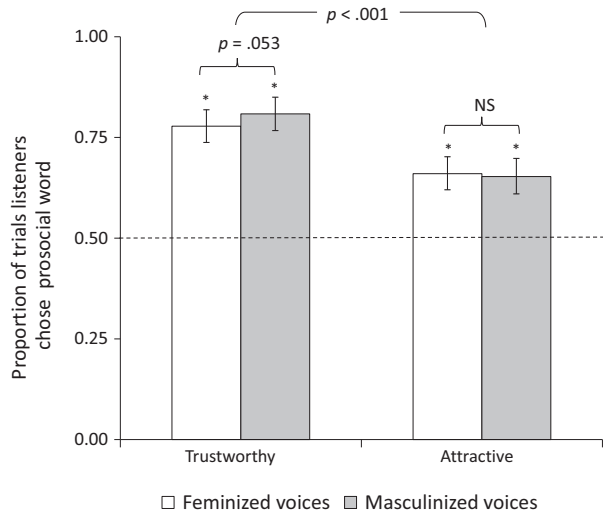
The interaction between rating context and pitch manipulation was marginally significant,  $F(1, 84) = 3.99$ ,  $p = .049$ ,  $\eta_p^2 = .045$ . When rating trustworthiness, listeners tended to select more prosocial words when choosing between masculinized voice pairs ( $M = 0.81$ ,  $SE = .020$ ) than when choosing between feminized voice pairs,  $M = 0.78$ ,  $SE = .020$ ;  $t(84) = -1.97$ ,  $p = .053$ ,  $d = 0.21$ , but this did not quite reach traditional

**Table 1.** Mean ( $SE$ ) and one-sample  $t$ -tests against chance (0.5) on the proportion of trials listeners chose the positive word of a stimulus pair as more trustworthy than the negative word

Rating	Caring versus cheater	Fair versus fraud	Honest versus liar	Helpful versus corrupt
Feminized voices				
Mean ( $SE$ )	0.79 (.026)	0.79 (.025)	0.78 (.025)	0.75 (.030)
$t(84)$	10.96***	11.62***	11.01***	8.19***
$d$	1.20	1.12	1.21	0.95
Masculinized voices				
Mean ( $SE$ )	0.79 (.026)	0.84 (.025)	0.82 (.027)	0.78 (.028)
$t(84)$	10.69***	13.34***	12.10***	9.85***
$d$	1.21	1.34	1.31	1.16

Note. \*\*\* $p < .001$ .





**Figure 1.** Mean and 95% CI of the proportion of trials in which listeners chose the prosocial word of a word pair. Significant differences between rating contexts (attractiveness, trustworthiness) and pitch manipulations (feminized voices = open bars, masculinized voices = filled bars) are indicated by the associated  $p$  value. \* indicates significant difference from chance (0.5), indicated by the dashed line. NS = non-significant.

significance. When rating attractiveness, listeners selected prosocial words at similar rates regardless of whether they were choosing among masculinized ( $M = 0.66$ ,  $SE = .022$ ) or feminized voice pairs,  $M = 0.67$ ,  $SE = .021$ ,  $t(84) = 0.667$ ,  $p = .507$ ,  $d = 0.07$ . The effect of pitch manipulation was not significant,  $F(1, 84) = 0.538$ ,  $p = .465$ ,  $\eta_p^2 = .006$ .

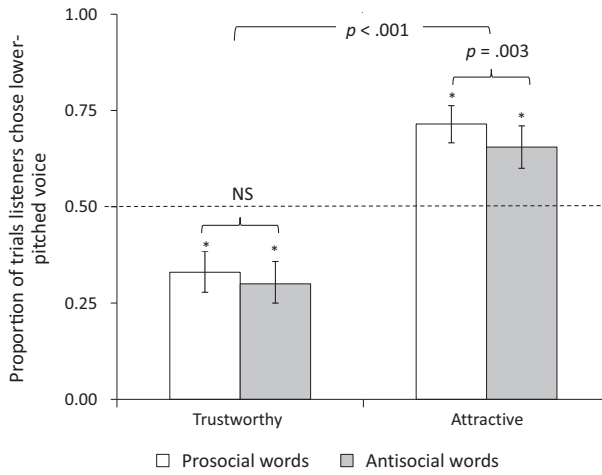
### Relationship between word selection measures

Listeners who selected prosocial words when rating trustworthiness also selected prosocial words when rating attractiveness, when voice pairs were both feminized ( $r = .516$ ,  $p < .001$ ,  $n = 85$ ) and masculinized ( $r = .366$ ,  $p = .001$ ,  $n = 85$ ).

### Listeners' selection of masculinized voices

We found a significant effect of rating context,  $F(1, 84) = 124.32$ ,  $p < .001$ ,  $\eta_p^2 = .597$ , where listeners chose masculinized voices on a significantly higher proportion of trials when rating attractiveness ( $M = 0.69$ ,  $SE = .024$ ) than when rating trustworthiness ( $M = 0.32$ ,  $SE = .025$ ). Listeners selected masculinized voices significantly more often than chance (0.5) when rating attractiveness,  $t(84) = 7.92$ ,  $p < .001$ ,  $d = 0.81$ , but significantly less often than chance when rating trustworthiness,  $t(84) = -7.20$ ,  $p < .001$ ,  $d = 0.79$ ; see Figure 2.

There was a significant effect of word pair valence,  $F(1, 84) = 8.73$ ,  $p = .004$ ,  $\eta_p^2 = .094$ . An examination of the simple effects indicated that listeners chose a higher proportion of masculinized voices when selecting from prosocial word pairs than when selecting from antisocial word pairs when rating voices for attractiveness, prosocial:  $M = 0.71$ ,  $SE = .024$ ; antisocial:  $M = 0.65$ ,  $SE = .028$ ,  $t(84) = 3.10$ ,  $p = .003$ ,  $d = 0.34$ . This pattern was in the same direction for ratings of trustworthiness, but the difference



**Figure 2.** Mean and 95% CI of the proportion of trials in which listeners chose the masculinized version of a voice pair. Significant differences between rating contexts (attractiveness, trustworthiness) and word valence (prosocial = open bars, antisocial = filled bars) are indicated by the associated  $p$  value. \* indicates significant difference from chance (0.5), indicated by the dashed line.

between valences did not reach significance, prosocial:  $M = 0.33$ ,  $SE = .027$ ; antisocial:  $M = 0.30$ ,  $SE = .026$ ,  $t(84) = 1.55$ ,  $p = .125$ ,  $d = 0.17$ . The interaction between rating context and word pair valence was not significant,  $F(1, 84) = 1.64$ ,  $p = .203$ ,  $\eta_p^2 = .019$ .

### Relationship between pitch selection measures

When we examined individual differences in masculinity preferences, there was no significant relationship between how attracted listeners were to masculine voices and how much they trusted masculine voices, either for prosocial words ( $r = .071$ ,  $p = .519$ ,  $n = 85$ ) or for antisocial words ( $r = .143$ ,  $p = .192$ ,  $n = 85$ ).

## STUDY 2

In Study 1, we examined whether voice pitch interacted with semantic cues to influence women's perceptions of men's trustworthiness and attractiveness. We found that, across rating contexts, listeners selected masculinized voices more often in the context of prosocial words than in the context of antisocial words. This difference was more apparent when listeners rated attractiveness than when they rated trustworthiness; however, the interaction between word valence and rating context was not significant. Given that Study 1 was conducted using a two-alternative forced-choice design, this finding could be driven by two non-mutually exclusive effects: (1) preferences for higher-pitched voices in the context of antisocial semantic cues and/or (2) preferences for masculinity in the context of prosocial semantic cues. In Study 2, we replicate and extend the findings from Study 1. To determine whether either of these two potential explanations account for this effect, in Study 2, we used scale ratings of attractiveness and trustworthiness, which allow for the direct comparison of ratings across each combination of voice pitch and word valence.



## Method

### Participants

Protocols for this study were approved by the institutional Research Ethics Board. We recruited 63 heterosexual females (mean age  $\pm$  *SD* = 18.9  $\pm$  1.98 years) from the University of Guelph, whom we compensated with partial course credit for participation. Participants were recruited until the end of the semester testing period to obtain as many data points as possible. The minimum estimated sample size requirements ( $n = 24$ ) were met to detect a medium effect size ( $f = .25$ ) with 80% power using a repeated-measures ANOVA with  $\alpha = .05$  (G\*Power; Faul *et al.*, 2007).

### Voice stimuli

The voice stimuli in Study 2 are identical to those used in Study 1.

### Procedure

Participants rated voices in two separate, randomized blocks: attractiveness and trustworthiness. The order of voice stimuli was fully randomized within each block. Participants were instructed ‘in this experiment, you will be asked to listen to a pair of voices. Each voice will be speaking single words, which describe the speaker’s personality and behaviour’. Listeners assigned each voice a rating between 1 (very unattractive/very untrustworthy) and 7 (very attractive/very trustworthy). All other aspects of the procedure were identical to Study 1, with the exception that single voices, rather than voice pairs, were presented on individual computer screens.

## Results

### Statistical analyses

We calculated voice ratings by averaging participants’ responses across stimuli within each combination of word valence, pitch manipulation, and rating context. The result is eight scores for each listener, comprised of four scores per rating context: (1) ratings of feminized voices/prosocial words, (2) ratings of feminized voices/antisocial words, (3) ratings of masculinized voices/prosocial words, (4) ratings of masculinized voices/antisocial words, for both attractiveness and trustworthiness rating contexts (see Table 2 for descriptive statistics). We analysed voice ratings with a repeated-measures ANOVA (within-subject variables: word valence [prosocial, antisocial], pitch manipulation [feminized, masculinized], rating [trustworthiness, attractiveness]), and used paired *t*-tests to examine significant interactions. Inter-rater agreement was good to excellent for each category of voice ratings (see Table 3).

### Analysis of voice ratings

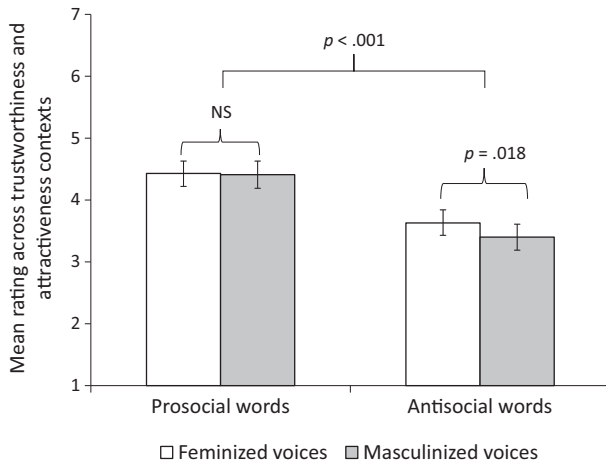
We found a significant main effect of word valence,  $F(1, 62) = 104.46$ ,  $p < .001$ ,  $\eta_p^2 = .628$ , where listeners rated prosocial words higher than antisocial words. We also found a significant interaction between valence and pitch manipulation,  $F(1, 62) = 13.80$ ,  $p < .001$ ,  $\eta_p^2 = .182$ , see Figure 3. Across rating contexts, listeners gave lower ratings to antisocial words when voice pitch was masculinized ( $M = 3.40$ ,  $SE = .106$ ) than when it

**Table 2.** Average rating (and SE)/Cronbach's alpha of Study 2 measures

Voice stimuli	Attractiveness <i>M (SE)/α</i>	Trustworthiness <i>M (SE)/α</i>	Average <i>M (SE)</i>
Masculinized voice			
Prosocial word	4.45 (.12)/.891	4.38 (.11)/.904	4.41 (.109)
Antisocial word	3.76 (.13)/.902	3.04 (.12)/.872	3.40 (.107)
Average	4.10 (.118)	3.71 (.095)	
Feminized voice			
Prosocial word	3.99 (.13)/.910	4.87 (.10)/.862	4.43 (.102)
Antisocial word	3.53 (.13)/.857	3.74 (.12)/.883	3.63 (.101)
Average	3.76 (.104)	4.30 (.090)	

**Table 3.** Comparison of findings from Studies 1 and 2

Finding	Study 1	Study 2
Prosocial words chosen more often/rated higher than antisocial words across rating contexts	Yes	Yes
Prosocial words had a stronger influence on perceptions of trustworthiness than on perceptions of attractiveness	Yes	Yes
Masculine voices chosen/rated as more attractive than feminized voices	Yes	Yes
Feminized voices chosen/rated as more trustworthy than masculinized voices	Yes	Yes
Choice/rating of masculinized voices lower for antisocial versus prosocial words	Yes	Yes



**Figure 3.** Mean rating and 95% CI of voices by pitch and word valence, collapsed across trustworthiness and attractiveness rating contexts. Significant differences are indicated by the associated *p* value. NS = non-significant.

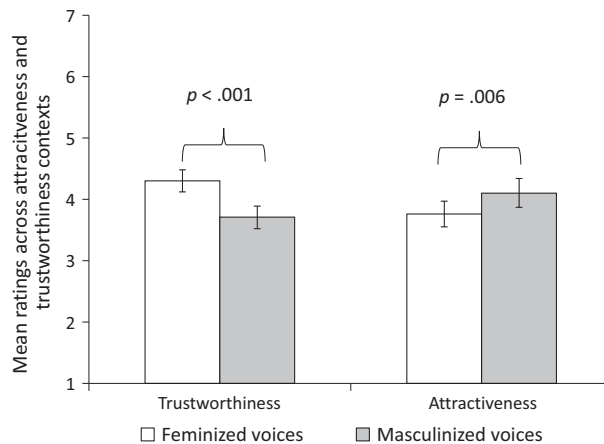
was feminized,  $M = 3.63$ ,  $SE = .101$ ,  $t(62) = 2.44$ ,  $p = .018$ ,  $d = 0.31$ , but did not differ in their ratings of prosocial words from masculinized ( $M = 4.41$ ,  $SE = .109$ ) and feminized voices,  $M = 4.43$ ,  $SE = .102$ ,  $t(62) = 0.182$ ,  $p = .856$ .

There was a significant interaction between rating context and word valence,  $F(1, 62) = 34.56$ ,  $p < .001$ ,  $\eta_p^2 = .358$ ; see Table 2. Listeners rated prosocial words higher when judging trustworthiness ( $M = 4.62$ ,  $SE = .094$ ) than when judging attractiveness,  $M = 4.22$ ,  $SE = .107$ ;  $t(62) = -5.85$ ,  $p < .001$ ,  $d = 0.74$ , but rated antisocial words higher when judging attractiveness ( $M = 3.65$ ,  $SE = .101$ ) than when judging trustworthiness,  $M = 3.39$ ,  $SE = .105$ ,  $t(62) = 3.83$ ,  $p = .006$ ,  $d = 0.36$ .

There was also a significant interaction between pitch manipulation and rating context,  $F(1, 62) = 63.46$ ,  $p < .001$ ,  $\eta_p^2 = .506$ ; see Figure 4, where listeners rated feminized voices ( $M = 4.30$ ,  $SE = .090$ ) as more trustworthy than masculinized voices,  $M = 3.71$ ,  $SE = .095$ ;  $t(62) = 6.44$ ,  $p < .001$ ,  $d = 0.81$ , but rated masculinized voices ( $M = 4.10$ ,  $SE = .118$ ) as more attractive than feminized voices,  $M = 3.51$ ,  $SE = .096$ ;  $t(62) = -2.88$ ,  $p = .006$ ,  $d = 0.36$ .

## GENERAL DISCUSSION

In Study 1, we found that listeners perceived masculinized voices as both more trustworthy and more attractive than feminized voices when speaking prosocial versus antisocial words (see Figure 2). However, this effect could have been driven by either (1) stronger preferences for vocal masculinity from prosocial speakers or (2) stronger preferences for vocal femininity from antisocial speakers. In Study 2, listeners gave higher trustworthiness and attractiveness ratings to antisocial speakers with feminized rather than masculinized voices, but gave higher trustworthiness and attractiveness ratings to prosocial speakers regardless of voice pitch. Therefore, we determined that Study 1 findings were driven by preferences for feminized voices in the context of antisocial cues. These results suggest that prosocial semantic cues influence social perceptions in a positive manner regardless of voice pitch and that antisocial semantic cues are even more



**Figure 4.** Mean rating and 95% CI of voices by pitch and rating context, collapsed across prosocial and antisocial word valences. Higher scores on the y-axis indicate higher ascribed trustworthiness/attractiveness (1 = very untrustworthy/unattractive, 7 = very trustworthy/attractive). Significant differences are indicated by the associated  $p$  value.

aversive when paired with relatively lower-pitched voices. Men with lower-pitched voices are perceived as less trustworthy in economic (Montano *et al.*, 2017; O'Connor & Barclay, 2017) and romantic contexts (O'Connor & Barclay, 2017; O'Connor & Feinberg, 2012; O'Connor *et al.*, 2011; O'Connor, Pisanski, *et al.*, 2014). These negative associations appear to be amplified by the adverse effects of antisocial semantic cues. Therefore, listeners may be particularly avoidant of potential social and romantic partners who express multiple cues to antisociality across modalities.

This pattern of results contrasts with comparable research by Quist *et al.* (2012), who found evidence that women had stronger preferences for facial masculinity rather than femininity in the context of cues to fidelity, but did not differ in their face preferences in the context of cues to infidelity. This pattern of results suggests that positive social information (i.e., fidelity) can offset negative impressions from masculine men's faces. The pattern of results in the present studies do not corroborate this finding, as we found that women did not differ in their ratings of masculinized and feminized voices in the context of prosocial semantic cues. The lack of agreement in study findings could stem from differences in the strength or kind of perceptual influences between facial and vocal stimuli. For instance, masculinity in men's voices is reliably rated as more attractive than femininity, whereas masculinity in men's faces is not (for review, see Feinberg, 2008; Puts, Jones, *et al.*, 2012). Also, Quist and colleagues explicitly cued information regarding romantic fidelity/infidelity, whereas the present study examined relatively more general cues to prosociality/antisociality. Future studies may attempt to examine whether the context specificity of semantic cues differently impacts perceptions of men's voices.

### **Women's perceptions of male voice pitch**

In both Study 1 and Study 2, we found that women perceived masculinized voices as more attractive, but as less trustworthy than feminized voices (see Table 3 for a comparison of findings from Studies 1 and 2). These results are consistent with prior work finding that lower-pitched male voices are perceived as more attractive but as less trustworthy than are higher-pitched male voices (Montano *et al.*, 2017; O'Connor & Barclay, 2017; O'Connor & Feinberg, 2012; O'Connor *et al.*, 2011; O'Connor, Pisanski, *et al.*, 2014). Some other research has either failed to detect a main effect of voice pitch on trustworthiness (Klofstad *et al.*, 2012; Vukovic *et al.*, 2011) or has found that lower-pitched male voices are perceived as relatively trustworthy (Oleszkiewicz *et al.*, 2017; Tigue *et al.*, 2012). The reason for this disagreement among findings is currently unclear, but is unlikely to be driven by the magnitude of pitch manipulation. Nearly all prior work has manipulated pitch by  $\pm 0.5$  ERBs (Klofstad *et al.*, 2012; O'Connor & Barclay, 2017; Vukovic *et al.*, 2011), with the exception of a  $\pm 0.75$  ERB manipulation by Oleszkiewicz *et al.* (2017). Differences among study findings are also unlikely to be driven by speech content. In the present study, voice stimuli were single words. Our results agree with other research using isolated English vowel sounds (high pitch as trustworthy, O'Connor & Barclay, 2016). However, there is no consistent pattern of results according to stimuli speaking vowel sounds (low pitch as trustworthy, Oleszkiewicz *et al.*, 2017; no main effect of pitch on trustworthiness, Vukovic *et al.*, 2011) or short sentences (no main effect of voice pitch on trustworthiness, Klofstad *et al.*, 2012; low pitch as trustworthy, Tigue *et al.*, 2012). Future research may aim to identify potential explanations for the discrepancy across study findings.

Our results contribute to the growing number of findings that higher-pitched, rather than lower-pitched, male voices are perceived as relatively trustworthy (McAleer *et al.*, 2014; Montano *et al.*, 2017; O'Connor & Barclay, 2017). As low male voice pitch is a testosterone-dependent trait, our results agree with findings that relatively higher levels of testosterone are associated with untrustworthy behaviour across social contexts (Booth & Dabbs, 1993; Fisher *et al.*, 2009, 2012; Stirrat & Perrett, 2010; Takagishi *et al.*, 2011). Importantly, we did not find any significant relationship between perceptions of attractiveness and perceptions of trustworthiness. Some studies have observed a positive relationship between ratings attractiveness and other attributes, such as perceptions of masculinity and body size (e.g., Pisanski, Mishra, & Rendall, 2012). However, other research does not support a general response bias favouring masculine male voices for perceptions of social attributes (e.g., O'Connor & Barclay, 2017; O'Connor, Fraccaro, & Feinberg, 2012; Tigue *et al.*, 2012). Therefore, the pattern of results in the present study is unlikely to be due to women perceiving attractive voices positively on other social dimensions, such as trustworthiness.

### **Women's perceptions of semantic word content**

In both Study 1 and Study 2, we found that semantic cues to prosociality had a beneficial influence on both perceptions of attractiveness and perceptions of trustworthiness, although this effect was significantly stronger for judgements of trustworthiness than for judgements of attractiveness (see Table 3). This suggests that social information regarding prosociality may have a stronger impact on the selection of social partners than on the selection of potential mates. Traits that communicate a prosocial disposition, such as those used in the present study (e.g., helpful, honest), may be perceived as a reliable indicator of one's willingness to cooperate. In the context of a biological market of potential social partners who are *able* to cooperate, those who signal they are *willing* to cooperate will be preferred and thusly advantaged (Barclay, 2013, 2016).

Although the observed effects of prosocial cues were stronger for perceptions of trustworthiness than for perceptions of attractiveness, prosocial words are demonstrably beneficial to perceptions of attractiveness. Prior work has found that women prefer men who are attributed with prosocial rather than neutral (Barclay, 2010) or antisocial statements (Clark *et al.*, 2009). The importance of prosociality to attractiveness is more broadly evidenced by longitudinal findings that prosocial individuals are more likely to be in a steady relationship a year after initial measurement (Stavrova & Ehlebracht, 2015). Furthermore, men who score higher on measures of altruism report a higher number of casual and lifetime sex partners than do other men (Arnocky, Piché, Albert, Ouellette, & Barclay, 2016). In the present study, the selection of prosocial words as relatively attractive was significantly higher than what would be expected given chance (0.5), providing converging evidence that women desire prosocial traits in potential romantic partners.

### **Limitations**

We manipulated both voice pitch and word valence to examine listener social perceptions of men's voices. In Study 1, we analysed listeners' selection of masculinized voices separately from listeners' selection of prosocial words. This was because of the potential differences in the perceptual equivalence of voice pitch and word valence manipulations. In Study 2, we could not use separate analyses because listeners rated individual voices on a scale from 1 to 7. Therefore, the relative contributions and/or interactions between

voice pitch and word valence in Study 2 could potentially be overshadowed or weakened by differences in the strength and/or salience of the manipulations.

Listeners were asked to rate the attractiveness and trustworthiness of voices speaking isolated words that were either prosocial or antisocial in nature. We instructed participants that these words 'describe the speaker's personality and behaviour'. This manner of presenting voices describing themselves with positive words is arguably a common occurrence. Conversely, it may be more unusual for individuals to describe themselves using negative traits. Therefore, our findings may be limited by the ecological validity of this manner of stimuli presentation. However, this potential limitation did not prevent us from detecting significant effects of word valence, as we found that prosocial words were rated as both more trustworthy and as more attractive than were antisocial words. Therefore, our experimental findings may represent attenuated real-world responses to antisocial cues.

### **Summary**

We tested women's perceptions of trustworthiness and attractiveness from male voices that were independently manipulated in voice pitch and word valence. Across two studies, we found that women perceived lower-pitched male voices as relatively attractive, but as untrustworthy. Listeners gave lower ratings to antisocial words from lower-pitched voices than from higher-pitched voices, but did not differ in their ratings of voices varying in pitch that were speaking prosocial words. Across levels of voice pitch, semantic cues to prosociality had a beneficial influence on both perceptions of attractiveness and perceptions of trustworthiness, but this effect was stronger for judgements of trustworthiness than for judgements of attractiveness. In sum, the findings from this study suggest that social information regarding antisociality is perceived even more negatively when paired with lower-pitched voices and that higher male voice pitch can ameliorate these effects. Our findings may have practical implications when considering the content and delivery of messages, whether regarding trustworthiness or desirability. News reports, political speeches, or marketing messages containing prosocial content may not benefit from relatively higher- or lower-pitched speaker, but audiences may perceive messages containing antisocial semantic content more negatively when delivered by a speaker with a lower-pitched voice. Future research may examine the potential interaction between semantic content and voice pitch on the persuasiveness and credibility of such communications.

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### **Supporting Information**

The following supporting information may be found in the online edition of the article:

**Appendix S1.** Participant recruitment, recording procedures, and descriptive statistics of voice stimuli.

**Table S1.** One-sample *t*-tests against chance (0.5) on the proportion of trials listeners selected the masculinized version of a voice pair.

**Table S2.** One-sample *t*-tests against chance (0.5) on the proportion of trials listeners selected the prosocial version of a word pair.

**Data S1.** Raw data.