



Original Article

Vocal modulation during courtship increases proceptivity even in naive listeners



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ABSTRACT

Speakers modulate their voice when talking to infants, but we know little about subtle variation in acoustic parameters during speech in adult social interactions. Because tests of perception of such variation are hampered by listeners' understanding of semantic content, studies often confine speech to enunciation of standard sentences, restricting ecological validity. Furthermore, apparent paralinguistic modulation in one language may be underpinned by specific parameters of that language. Here we circumvent these problems by recording speech directed to attractive or unattractive potential partners or competitors, and testing responses to these recordings by naive listeners, across both a Germanic (English) and a Slavic (Czech) language. Analysis of acoustic parameters indicates that men's voices varied F_0 most in speech towards potential attractive versus unattractive mates, while modulation of women's F_0 variability was more sensitive to competitors, with higher variability when those competitors were relatively attractive. There was striking similarity in patterns of social context-dependent F_0 variation across the two model languages, with both men's and women's voices varying most when responding to attractive individuals. Men's minimum pitch was lower when responding to attractive than unattractive women. For vocal modulation to be effective, however, it must be sufficiently detectable to promote proceptivity towards the speaker. We showed that speech directed towards attractive individuals was preferred by naive listeners of either language over speech by the same speaker to unattractive individuals, even when voices were stripped of several acoustic properties by low-pass filtering, which renders speech unintelligible. Our results suggest that modulating F_0 may be a critical parameter in human courtship, independently of semantic content.

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1. Introduction

The human voice is remarkably variable. Aside from communication through verbal content, paralinguistic elements of the voice during speech enable individual recognition and assessment of the speaker's physical characteristics such as sex (Puts, Apicella, & Cárdenas, 2012), body size (Feinberg, Jones, Little, Burt, & Perrett, 2005; Xu, Lee, Wu, Liu, & Birkholz, 2013), physical strength (Sell et al., 2010), femininity (Feinberg et al., 2005; Feinberg, 2008), attractiveness (Feinberg et al., 2005; Feinberg et al., 2005; Xu et al., 2013), conception risk (Pipitone & Gallup, 2008), and sexual maturity (Mulac & Giles, 1996). In humans, perceived attractiveness and mate quality can be manipulated by artificially lowering the pitch of male voices or artificially increasing it in female voices, commensurate with sex-typical vocal properties (Collins, 2000; Feinberg et al., 2005). In fact, there is evidence for increased reproductive success in traditional

societies for both low-pitched males (Apicella, Feinberg, & Marlowe, 2007), and high-pitched females (Atkinson et al., 2012).

In addition, vocal parameters can be intentionally varied, for example altering the intensity (loudness), rhythm and pitch. The classic example of such intentional modulation is infant directed speech (IDS) (Ferguson, 1977; Falk, 2005), in which adults alter vocal characteristics such as pitch, cadence and intonation contours when speaking to infants. Infants prefer these altered signals over adult-directed speech (Fernald & Kuhl, 1987), and it has been suggested that IDS aids human acquisition of vocal language (Burnham, Kitamura, & Vollmer-Conna, 2002) and might underpin the origins of musicality (Dissanayake, 2000; Trehub, 2003). In human and animal social interactions, modulations of the intensity of speech or vocalisations are often associated with hostility (Collias, 1960; Kudo, 1987) and dominance (Ohala, 1982; Tusing & Dillard, 2000), and changes in intensity contribute to emotional expression (Baker, 2001). Regarding pitch modulations, men lower their voices during competitive interactions when they perceive themselves as physically dominant (Puts, Gaulin, & Verdolini, 2006), and while women have been found

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to increase voice pitch when directing speech towards attractive faces (Fraccaro et al., 2011), both men and women have also been found to lower their voice pitch when speaking attractive targets of the opposite sex (Hughes, Farley, & Rhodes, 2010). This suggests that, while more evidence for specific types of modulation is needed (e.g. in the case women responding to attractive opposite-sex stimuli), modulations do actually occur. Similar subtle modulation in voices might be expected in courtship contexts. In fact, there is evidence of vocal differences between speech directed towards romantic partners and same-sex friends which can be detected by listeners (Farley, Hughes, & LaFayette, 2013), and intentional voice manipulations make female voices, but not male voices, sound more attractive (Hughes, Mogilski, & Harrison, 2013; see also Fraccaro et al., 2013). Indeed, such modulations occur in other species including frogs (Ryan, 1980), koalas, *Phascogale cinereus* (Charlton, Ellis, Brumm, Nilsson, & Fitch, 2012), fallow deer, *Dama dama* (Charlton & Reby, 2011), red deer, *Cervus elaphus* (Reby et al., 2005; Reby, Charlton, Locatelli, & McComb, 2010), and birds. For example, in the zebra finch, *Taeniopygia guttata*, males sing more rapidly to females than when they sing alone, producing syllables with lower spectral variability (Kao & Brainard, 2006).

Studies aiming to measure the effects that acoustic parameters have on human communication are hampered by the confounding influence of verbal content. To address this issue, many studies record voices enunciating vowel sounds or speaking standard sentences, or measure responses to voices with artificially manipulated vocal parameters (e.g. Feinberg et al., 2005; Puts, Hodges, Cárdenas, & Gaulin, 2007). These methodologies have provided important insights into the role that vocal parameters play in human communication. Similarly, to study vocal modulation, and unlike research on animals or IDS (where infants understand little or none of the semantic content), it is necessary to control the confounding influence that verbal content may play. Some studies have used scripted speech (e.g. Hughes et al., 2010; Fraccaro et al., 2011), therefore eliminating prosodic variation in vocal acoustic parameters. Although challenging, testing free, unscripted speech is ideal, as standard sentences may not accurately reflect the levels of natural vocal variation; standardised sentences likely limit the kind of spontaneous paralinguistic variation found in normal free speech, as well as the nuance and range of paralinguistic modulation known at least to occur in IDS, which is characterised by an extreme range of pitches, typically starting from a high pitch and containing many glissandos. Finally, while some studies have successfully tested natural vocal variation during speech (e.g. Hodges-Simeon, Gaulin, & Puts, 2010, 2011), apparent paralinguistic modulation in one language may be underpinned by specific parameters of that language (e.g. rhythm, intonation, and use of specific phonemes). Here we circumvented these issues (i.e. the confounding influence of verbal content, using unscripted speech, and the potential effects of one language in paralinguistic modulation) by adopting a cross-language design involving two model languages.

Based on evolutionary theory and the current knowledge of human voices, we hypothesized that males and females would modulate their acoustic parameters (study 1), depending on the sex and attractiveness of the target, to affect the way in which they would be perceived. Because speech intensity is associated with hostility and dominance (Collias, 1960; Ohala, 1982; Kudo, 1987) we expected participants to speak with increased intensity in responses to same-sex targets, in comparison to opposite-sex targets. Furthermore, because emotional expressiveness is attractive (Sprecher, 1989), and changes in intensity improve emotional expression (Baker, 2001), we expected participants to speak with increased variability in intensity when responding to opposite-sex targets, and especially when those targets were attractive. In addition, based on the body of knowledge produced by studies testing perception of manipulated pitch, we predicted that women, and especially men, would emphasise sex-specific vocal characteristics when responding to attractive

individuals of the opposite sex (i.e. lowering F_0 in men, and increasing it in females), and that both sexes would increase F_0 variability, in order to sound more attractive to those attractive targets. Additionally, we predicted that these modulations would be detectable by naive listeners (study 2), and that speakers would sound more attractive when speaking to attractive versus unattractive targets.

2. Study 1

First, we tested the possibility that individuals might alter vocal parameters in speech directed at potential romantic partners or competitors depending on the attractiveness of the listener. Recorded voice samples from speakers of two different languages were used to avoid the possibility that apparent paralinguistic modulation in one language might be reinforced by specific parameters of that language (e.g. rhythm, intonation, and use of specific phonemes).

2.1. Method

2.1.1. Participants

We recruited 110 heterosexual participants who were students at the Universities of Liverpool and Stirling (UK) or Charles University (Czech Republic). Of these, 30 were English speaking males (mean age $\pm$ SD = 22.6 ± 4.17), 30 English speaking females (21.8 ± 3.96), 25 Czech speaking males (22.8 ± 2.30), and 25 Czech speaking females (21.8 ± 1.84) not suffering from voice hoarseness or nasal congestion. No participant suffered from speech impediments, and all were fluent in English. All participants signed a written consent form.

2.1.2. Target videos

The stimuli were selected from a group of 40 videos, of about 20 seconds in length (mean length $\pm$ SD = 19.3 ± 2.60), half of which pictured men (mean age $\pm$ SD = 22.5 ± 2.41) and half women (22.1 ± 1.65). Individuals were visible from the waist upwards before a white background and were filmed having been asked to introduce themselves to an attractive person of the opposite sex. Each video was rated for attractiveness on a 1 to 7 scale, by an independent panel of 24 opposite-sex raters. From these, the 3 most attractive and the 3 least attractive male and female videos were selected (12 in total). Individuals seen in the videos did not take part in any of the other experiments.

2.1.3. Experimental procedure

After the experiment had been explained and written informed consent obtained, participants were shown the twelve target videos, played without sound to avoid possible effects of pitch convergence (Gregory, Green, Carrothers, Dagan, & Webster, 2001), and asked to record a response message to each one. Participants were told that these messages would be presented to opposite-sex participants who would judge them as a potential date: in the case of responses to opposite-sex targets, participants believed that their messages were going to be presented to the target they were responding to (i.e. the person in the video), while in the case of responses to same-sex targets, participants were told that their responses were going to be presented to all the opposite-sex targets. Participants were instructed to either explain whether and why they would like to date the person in the video (for opposite-sex targets) or why they should be chosen over the person in the video for a date (for same-sex targets). This scenario was based on a study which produced demonstrable effects on mate preferences (Gangestad, Simpson, Cousins, Garver-Apgar, & Christensen, 2004).

After recording their response to each presented target video, participants were debriefed. In total, 1304 recordings were obtained (4 recordings were not collected because the participant recognised the target, and 12 were discarded because of background noise that affected audio quality), with length ranging from 6 to 46 seconds

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