Voice-based assessments of trustworthiness, competence, and warmth in blind and sighted adults

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Author Note

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Abstract

The study of voice perception in congenitally blind individuals allows researchers rare insight into how a lifetime of visual deprivation affects the development of voice perception. Previous studies suggest that blind adults outperform their sighted counterparts in low-level auditory tasks testing spatial localization and pitch discrimination, as well as verbal speech processing, however blind persons generally show no advantage in nonverbal voice recognition or discrimination tasks. The present study is the first to examine whether visual experience influences the development of social stereotypes that are formed on the basis of nonverbal vocal characteristics (i.e., voice pitch). Twenty-seven congenitally or early-blind adults and twenty-three sighted controls assessed the trustworthiness, competence and warmth of men and women speaking a series of vowels, whose voice pitches had been experimentally raised or lowered. Blind and sighted listeners judged men's and women's voices with lowered pitch as more competent and trustworthy than voices with raised pitch. In contrast, raised-pitch voices were judged as warmer than were lowered-pitch voices, but only for women's voices. Crucially, blind and sighted persons did not differ in their voice-based assessments of competence or warmth, or in their certainty of these assessments, whereas the association between low pitch and trustworthiness in women's voices was weaker among blind than sighted participants. This latter result suggests that blind persons may rely less heavily on nonverbal cues to trustworthiness compared to sighted persons. Ultimately, our findings suggest that robust perceptual associations that systematically link voice pitch to social and personal dimensions of the speaker can develop without visual input.

Introduction

Acoustic Perception in Blind Persons

There are three key competing hypotheses regarding general acoustic perception in blind persons (Kupers & Ptito, 2014). The first hypothesis states that blind persons may possess degraded acoustic perception compared to sighted persons, particularly if visual experience is necessary to calibrate the other senses. This first hypothesis has not garnered a great deal of support, as it is now known that congenital blindness or the loss of vision early in life can cause substantial structural reorganization of the brain, wherein structures typically specialized for vision are recruited for the processing of stimuli in other modalities including audition, allowing normal hearing to develop without vision (reviewed in Kupers & Ptito, 2014; Rauschecker, 1995). Hence, a second hypothesis posits that blind persons will process sound similarly to sighted persons, although this ability may develop through alternative mechanisms. A third and most recent hypothesis posits that blind persons may posses 'supra-normal' non-visual sensory capabilities, either as a result of perceptual learning (Gagnon, Ismaili, Ptito, & Kupers, 2015), or reorganization of various brain areas (e.g., the occipital cortex, Leclerc, Saint-Amour, Lavoie, Lassonde, & Lepore, 2000), suggesting that blind persons may outperform their sighted counterparts in non-visual auditory tasks. This latter hypothesis has gained support from studies testing spatial sound localization (Fieger, Röder, Teder-Sälejärvi, Hillyard, & Neville, 2006), simple tone discrimination (Gougoux et al., 2004), and human echolocation (Schenkman & Nilsson, 2010).

The Special Case of Voice Perception

Previous findings on general acoustic perception in blind persons cannot, however, be directly applied to voice perception. Indeed, compared to non-vocal sounds, vocalizations are acoustically complex, broadband and typically periodic signals (Titze, 1994) and are selectively processed in higher-level regions of the auditory cortex near the superior temporal sulcus (STS) (Belin, Fecteau, & Bédard, 2004; Belin, Zatorre, & Ahad, 2002; Pernet et al., 2015). Perhaps most crucially, voice perception often involves complex social cognition. Voices play a critical role in everyday nonverbal communication, not only allowing us to readily recognize familiar others, but also to gauge a speaker's sex, age, body size, ethnicity, social status, and emotional or motivational state (Kreiman & Sidtis, 2011; Pisanski et al., 2014; Puts, Jones, & DeBruine, 2012).

Even within the category of vocal sounds, listeners process voices differently when attending to verbal (i.e. speech) compared to nonverbal (i.e. social and indexical) information from the voice. The neural processing of verbal and nonverbal vocal sounds appears to involve functionally divergent pathways in the brain (Belin, Bestelmeyer, Latinus, & Watson, 2011). Importantly, although behavioral studies provide some evidence for superior verbal or speech processing abilities in blind persons, for example in verbal memory (Amedi, Raz, Pianka, Malach, & Zohary, 2003) and speech sound discrimination tasks (Hugdahl et al., 2004; Muchnik, Efrati, Nemeth, Malin, & Hildesheimer, 1991), blind persons generally show no advantage in nonverbal, voice recognition or discrimination tasks (Gougoux et al., 2009; Günzburger, Bresser, & Keurs, 1987; Winograd, Kerr, & Spence, 1984; but see Bull, Rathborn, & Clifford, 1983). Moreover, blind persons perform no better or worse than their sighted counterparts in estimating the relative height of men using only nonverbal voice cues (Pisanski, Oleszkiewicz, & Sorokowska, 2016). Thus, although there is some evidence that blind persons may process voices differently than sighted persons, these differences appear to arise predominantly in the processing of verbal rather than nonverbal information.

Voice-Based Assessments of Social Traits

To our knowledge, the present study is the first to examine whether blind and sighted persons differ in their judgment of social character traits based solely on nonverbal voice cues. The most salient nonverbal feature of the human voice is pitch, the perceptual correlate of fundamental frequency ($F0$) and its harmonics (Titze, 1994). Voice pitch is determined by the rate of vocal fold vibration, which in turn is influenced by pubertal and circulating levels of testosterone that affect the length of the vocal folds (Dabbs & Mallinger, 1999; Harries, Walker, Williams, Hawkins, & Hughes, 1997). Voice pitch is highly sexually dimorphic and changes systematically throughout the lifetime, thereby reliably signaling an individual's sex and general age (Kreiman & Sidtis, 2011).

Voice pitch also influences listeners' assessments of various socially relevant traits. Recent studies have focused on traits that are particularly important in a mating context, such as attractiveness, masculinity or femininity, and dominance (reviewed in Kreiman & Sidtis, 2011; Pisanski & Bryant, 2016; Puts et al., 2012). However, within a broader social context, competence and warmth are considered universal dimensions of social perception (see Fiske, Cuddy, & Glick, 2007 for review). These dimensions explain more than 80% of the variance in our personality judgments of others (Wojciszke, Bazinska, & Jaworski, 1998). Competence broadly reflects traits related to ability, such as dominance and intelligence, whereas warmth reflects perceived intent, including sincerity and kindness.

In addition to competence and warmth, we also investigated the effect of voice pitch on perceived trustworthiness. Trustworthiness may be particularly important for blind persons, who must routinely rely on the opinion and assistance of others in everyday life (Lewis & Weigert, 1985), but who cannot rely on visual (e.g., facial, Oosterhof & Todorov, 2008) indicators of trustworthiness. Moreover, although trustworthiness has often been discussed as an element of warmth (Fiske et al., 2007), it remains unknown whether voice pitch affects judgments of warmth and trustworthiness in the same way. Indeed, studies with sighted listeners indicate that speakers with low voice pitch are typically perceived as more competent and trustworthy than are speakers with higher voice pitch (Klofstad, Anderson, &

Nowicki, 2015; McAleer, Todorov, & Belin, 2014; Tigue, Borak, O'Connor, Schandl, & Feinberg, 2012; Tsantani, Belin, Paterson, & McAleer, 2016). In contrast, studies examining voice-based assessments of warmth have produced equivocal results (Berry, 1991; Hughes, Pastizzo, & Gallup Jr., 2008; Ko, Judd, & Stapel, 2009; McAleer et al., 2014). Recently, McAleer et al. (2014) reported a positive relationship between listeners' voice-based judgments of warmth and trustworthiness, both of which correlated negatively with judgments of competence and dominance. However, like previous studies, the researchers did not experimentally manipulate voice pitch.

In the present study, we predicted that blind listeners would associate low voice pitch with relatively higher competence and trustworthiness, and that the strength of this association would be similar among blind and sighted listeners. We made no a priori predictions regarding assessments of warmth, for which the results with sighted listeners in previous studies have been mixed.

Methods and Materials

Voice Stimuli

Voice recordings were conducted in a sound-controlled booth using a Sennheiser condenser microphone with a cardioid pick-up pattern and at a distance of 5-10 cm. Recordings were obtained from four men and four women speaking the monophthong vowels /ɑ/ /i/ /ɛ/ /o/ and /u/. Audio was digitally encoded at a sampling rate of 96 kHz and 32-bit amplitude quantization and stored onto a computer as WAV files. Voice editing and manipulation was performed in Praat v 5.2.15 (Boersma & Weenink, 2015). Vowels were first separated by 200 ms of silence. The pitch of each voice was than raised or lowered by adding or subtracting 0.75 equivalent rectangular bandwidths (ERBs) of the baseline *F*0, respectively, creating a high pitch and low pitch version of each voice (Table 2). The ERB scale is pseudo-logarithmic and controls for the difference between *F*0 and perceived pitch. All voice stimuli were amplitude normalized to 70 dB RMS SPL.

Participants

Fifty men and women participated in the study, including twenty-seven healthy blind adults (17 females; aged 24-65 years, *M* = 37.9±11.1), and twenty-three age-matched controls with normal vision (15 females; aged 20-65 years, *M* = 38.7±14.5). All but two blind participants were blind since birth (congenitally blind), whereas two women had lost their sight in the first month of life (early blind; Rombaux et al., 2010). All participants reported normal hearing and no neurological impairments, provided written informed consent, and were compensated for their participation. The study was performed in accordance with the Declaration of Helsinki on Biomedical Studies Involving Human Subjects and was approved by the University of Wroclaw Institutional Review Board.

Procedure

Participants completed the experiment in individual sessions. A standardized interview was first used to collect demographic information and to confirm the absence of hearing disorders, head injuries or diseases, and the use of medication that could influence hearing. Participants were then randomly assigned to assess either male or female voices. They were instructed that they would hear a series of voices, and that after each voice they would be asked to assess the person speaking on one of three traits (competence, trustworthiness, or warmth) using a 7-point scale ranging from 1 (*s/he definitely is not*) to 7 (*s/he definitely is*). Participants assessed each voice stimulus on each of three traits, wherein trials were blocked by trait and the presentation order of blocks, as well as voice stimuli within each block, was fully randomized. Voices were presented to participants via a custom computer interface and through Sennheiser HD-280 PRO headphones. The experimenter executed the experiment and inputted participants' verbal responses, which automatically loaded the next trial. Each participant rated 24 voices in total, and the entire task took approximately 10 minutes.

To create identical testing conditions, sighted participants were asked to close their eyes during the experiment and all participants were seated with their backs to the computer. Following the auditory task, all participants were asked to rate to what extent they were confident in their judgments on a scale from 1 (*not at all*) to 7 (*completely*).

Results

We conducted a series of linear mixed models (LMMs) with maximum-likelihood estimation, one for each sex of voice and each trait. Listener ID was included as a random subject variable, sex of listener as a random factor, and sightedness (blind, sighted) and voice pitch manipulation (raised, lowered) as fixed factors. A Mann–Whitney *U* test revealed no difference in confidence judgments between sighted and blind participants (U=234.5, p=.13).

Men's voices

The LMM examining listeners' assessments of men's competence revealed a main effect of voice pitch manipulation ($F_{1, 146}$ = 6.03, p=.015), wherein lowered-pitch voices were rated as more competent than were raised-pitch voices (Table 1). There were no other main or interaction effects (all F<0.66, all p>.42). The model examining assessments of men's warmth revealed no main or interaction effects (all F<0.3, all p>.58). Finally, the model examining assessments of trustworthiness revealed a main effect of voice pitch manipulation ($F_{1, 146}$ = 8.8, p=.004), wherein lowered-pitch voices were rated as more trustworthy than were raised-pitch voices, with no other main or interaction effects (all F<1.15, all p>.28).

Women's Voices

The LMM examining listeners' assessments of women's competence revealed a main effect of voice pitch manipulation ($F_{1, 201}$ = 30.2, p<.001), wherein lowered-pitch voices were rated as more competent than were raised-pitch voices. There were no other main or interaction effects (all F<.66, all p>.42). The model examining assessments of warmth revealed a main effect of voice pitch manipulation ($F_{1, 201}$ = 8.6, p=.004), wherein raised-pitch voices were rated as warmer than were lowered-pitch voices, with no other effects (all F<2.0, all p>.17). Finally, the model examining assessments of trustworthiness revealed main effects of voice pitch manipulation ($F_{1, 201}$ = 9.5, p=.002) and sightedness ($F_{1, 27}$ = 4.9, p=.035), as well as an interaction between pitch manipulation and sightedness ($F_{1, 201}$ = 4.6, p=.033). Here, lowered-pitch voices were assessed as more trustworthy than were raised-pitch voices, and this effect of pitch on assessments of women's trustworthiness was greater for sighted than blind participants (Table 1).

Discussion

Social judgments represent an adaptation to life in a group. Effectively assessing unobservable character traits of others based on limited information helps us to determine whether someone is a friend or foe (Fiske et al., 2007) or a suitable potential partner (Puts et al., 2012). Until now, this ability has only been investigated in sighted persons. Our results indicate that both blind and sighted adults judged men's and women's voices with experimentally lowered pitch as significantly more competent and more trustworthy than those same voices with raised pitch. In contrast, raised voice pitch was associated with warmth, however only for women's voices. Critically, manipulations of voice pitch elicited analogous assessments of competence and warmth regardless of whether the listener was sighted or blind. Differences between blind and sighted persons emerged only in judgments of women's trustworthiness, wherein the association between low pitch and trustworthiness was stronger among sighted than blind participants.

Studies have generally failed to find differences between sighted and blind adults in voice recognition tasks (Gougoux et al., 2009; Günzburger et al., 1987; Winograd et al., 1984). Blind persons can also estimate body size from the voice as accurately as can sighted persons (Pisanski et al., 2016). In line with these previous findings, our study provides novel evidence that blind persons process socially relevant information (i.e., competence and warmth) from nonverbal voice cues similarly to sighted persons. There are several potential and non-mutually-exclusive explanations for this finding. At an ultimate level, assessing others on the basis of their vocalizations represents an evolutionarily primitive and ecologically relevant ability that is widespread among vocalizing mammals (Taylor & Reby, 2010), and may therefore be innate or require little to no visual experience to develop. Both sighted and blind persons may, for instance, be capable of gathering reliable social information from a person's behavioral patterns and may consequently learn to form general associations between specific social traits and vocal traits even in the absence of visual information. Associations between voice pitch and social traits may also stem from general perceptual biases. Indeed, cross-modal pitch correspondences have been observed across human cultures and are highly general, applying to tonal, musical as well as vocal pitch (Eitan & Timmers, 2010; Ohala, 1984; Parise, 2015).

Voice pitch did, however, have a stronger effect on sighted than blind listeners' assessments of women's trustworthiness. This finding is of interest for two key reasons. First, it suggests that blind persons may rely less heavily on nonverbal cues to trustworthiness compared to sighted persons, potentially because blind persons might be more cautious when deciding whether to rely on someone. Second, this finding suggests that voice-based assessments of trustworthiness and warmth, although closely related (McAleer et al., 2014), may enjoy some degree of independence.

Women's voices with raised pitch were judged as relatively warmer than voices with lowered pitch, whereas voice pitch did not influence judgments of men's warmth. Ko et al. (2009) similarly reported that although job applicants with masculine voices were judged as more competent, vocal masculinity/femininity did not predict judgments of warmth. Warmth entails 'other-profitable' traits with immediate benefits to the assessor, and costs if misjudged (Fiske et al., 2007). Thus, people may require cues from multiple modalities to judge the warmth of others, particularly of men. However, evidence that warmth-related judgments are formed on minimal premises and significantly faster compared to competence-related judgments suggests that this is unlikely (Ybarra, Chan, & Park, 2001). Alternatively, high voice pitch may activate connotations with femininity that are related to perceived warmth (see e.g., Eagly & Mladinic, 1989), and that may have conflicting and cancelling effects on warmth judgments of men. Additional research is needed to disambiguate the effect of voice pitch on warmth judgments and its potential interaction with the sex of the speaker.

In the current study, we manipulated the pitch of voices speaking vowel sounds, further indicating that a single and briefly presented nonverbal vocal parameter can provide a clear premise for social inferences (McAleer et al., 2014). Listeners judged each voice independently using a Likert scale (following e.g., Feinberg, Jones, Little, Burt, & Perrett, 2005; Pisanski & Rendall, 2011). Although some previous studies have used a two-alternative forced-choice rating paradigm (e.g., Jones, Feinberg, DeBruine, Little, & Vukovic, 2010; Tsantani et al., 2016) or a scale/forced-choice hybrid (e.g., Vukovic et al., 2011), a Likert scale allows for more variance in listeners' responses than does a binary task, and may therefore increase our likelihood of uncovering potentially subtle group differences.

Our findings suggest that blind persons assess character traits on the basis of a person's voice pitch in a similar way as do sighted persons, and that such associations can therefore develop without visual input. Thus, while the current study extends our limited knowledge about social perception in blind persons, it also offers novel insight into the potential mechanisms and development of social voice perception more generally. Given that voice pitch influences critical social decisions such as which leaders we choose to vote for (Klofstad et al., 2015; Tigue et al., 2012) or which candidates we hire following a job interview (Schroeder & Epley, 2015), understanding how these vocal stereotypes develop is paramount.

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Table 1. Voice pitch (measured as fundamental frequency, *F*0) of voice stimuli following manipulation

	Pitch Manipulation	Pitch (*F*0, Hz)
Female Voices	Raised	251.1
	Lowered	190.2
Male Voices	Raised	137.3
	Lowered	81.5

Table 2. Voice-based assessments of competence, trustworthiness and warmth by sighted and blind adults.

	Competence							
	Raised pitch				Lowered pitch			
	female voices		male voices		female voices		male voices	
	sighted	blind	sighted	blind	sighted	blind	sighted	blind
M	3.50	3.42	3.38	3.70	4.75	4.20	3.95	4.27
sd	1.085	1.362	1.237	1.042	.890	1.154	.941	.932
n	13	15	10	11	13	15	10	11
	Warmth							
	Raised pitch				Lowered pitch			
	female voices		male voices		female voices		male voices	
	sighted	blind	sighted	blind	sighted	blind	sighted	blind
M	4.58	4.18	4.05	4.07	4.21	3.70	3.88	4.02
sd	.632	1.144	1.039	1.084	1.015	1.158	1.120	1.252
n	13	15	10	11	13	15	10	11
	Trustworthiness							
	Raised pitch				Lowered pitch			
	female voices		male voices		female voices		male voices	
	sighted	blind	sighted	blind	sighted	blind	sighted	blind
M	3.77	3.65	3.38	3.73	4.83	3.95	4.20	4.11
sd	1.214	.949	.680	1.339	.753	.769	.864	1.348
n	13	15	10	11	13	15	10	11

M = mean; *sd* = standard deviation; *n* = samples size