PERCEPTIONS OF FACIAL AND VOCAL ATTRACTIVENESS AND DOMINANCE

THE INFLUENCE OF HUMAN FACIAL AND VOCAL FEATURES ON SOCIAL PERCEPTIONS OF ATTRACTIVENESS, DOMINANCE, AND LEADERSHIP ABILITY

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TITLE: The Influence of Human Facial and Vocal Features on Social Perceptions of Attractiveness, Dominance, and Leadership Ability

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ABSTRACT

Research shows that human facial and vocal features influence social perceptions of attractiveness and dominance. In general, more feminine facial and vocal features are perceived as more attractive in women and more masculine facial and vocal features are perceived as more attractive in men. More masculine facial and vocal features are generally perceived as more dominant in both women and men. Given that attractiveness and dominance closely relate to inter- and intra-sexual selection, respectively, and that leaders can influence an individual's fitness, humans likely possess evolved mechanisms for assessing leadership ability. Thus, in prior work, facial and vocal features have been related to perceptions of leadership ability. In this dissertation, I address three previously unanswered questions. First, how do vocal acoustics influence perceptions of leaders and voting preferences? Second, how do vocal acoustics influence perceptions of leaders in different social contexts? Third, how do different methods of stimuli presentation influence the results of studies on face and voice perception? Herein, I demonstrate that participants prefer to vote for lower pitched men's voices, and that it is unclear precisely how women's voice pitch influences voting preferences. I also show that the influence of voice pitch on perceptions of leaders depends on the social context. Third, I establish that several methods of stimuli presentation are equally valid to use in studies on face and voice perception. Overall, the studies in this dissertation demonstrate that facial

and vocal features influence perceptions of attractiveness, dominance, and leadership ability in a potentially adaptive manner.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

DECLARATION OF ACADEMIC ACHIEVEMENT

This dissertation is organized in the sandwich format, as approved by the McMaster University School of Graduate Studies, comprised of six chapters. Each of the four empirical chapters (Chapters 2-5) is a complete manuscript, either published or in preparation for submission. Chapters 2 and 4 are published manuscripts. In these chapters, the publication pages have been renumbered for continuity within this dissertation, but the statistical notation and references styles of each particular journal have been retained. These publications are reprinted with permission from the copyright holders. Chapter 3 is a manuscript in preparation for submission. Chapter 5 is revised version of a manuscript that was previously submitted for publication.

I am the primary author of each of the four manuscripts. I developed each research question and experiment in this dissertation in consultation with my supervisor, David Feinberg. I created the stimuli (except where noted below), programmed the experiments, collected and analyzed the data, and wrote each chapter. These four manuscripts accurately reflect my doctoral research, and therefore, they comprise the main body of this dissertation. The role of each coauthor in each manuscript is documented below.

CHAPTER 1: General Introduction

I am the sole author of this chapter, which was written in consultation with David Feinberg.

CHAPTER 2: Men's judgments of women's facial attractiveness from two- and three-dimensional images are similar

Reference: Tigue, C.C., Pisanski, K.P., O'Connor, J.J.M., Fraccaro, P.J., & Feinberg, D.R. (2012). Men's judgments of women's facial attractiveness from two- and three-dimensional images are similar. *Journal of Vision, 12*(12): 3, 1-7, doi:10.1167/12.12.3.

Coauthor Contributions:

Pisanski, K.P.—stimuli and data collection, manuscript contributions

O'Connor, J.J.M.—stimuli and data collection, manuscript contributions

Fraccaro, P.J.—stimuli and data collection, manuscript contributions

Feinberg, D.R.—experiment development, manuscript contributions

Research Conducted: 2011-2012

CHAPTER 3: Acoustic predictors of voting ratings of men's and of women's voices

Coauthor Contributions:

Pisanski, K.P.—stimuli and data collection

Fraccaro, P.J.—stimuli and data collection

O'Connor, J.J.M.—stimuli and data collection

Feinberg, D.R.— experiment development, stimuli and data collection, manuscript contributions

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CHAPTER 4: Voice pitch influences voting behavior

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Coauthor Contributions:

Borak, D.J.—data collection, manuscript contributions

O'Connor, J.J.M.—data collection, manuscript contributions

Schandl, C.—data collection

Feinberg, D.R.— experiment development, stimuli collection and creation, manuscript contributions

Research Conducted: 2010-2011

CHAPTER 5: Voice pitch and formant frequencies influence voting preferences for men' and for women's voices differently

Coauthor Contributions:

Fraccaro, P.J.—stimuli and data collection, manuscript contributions

O'Connor, J.J.M. —stimuli and data collection, manuscript contributions

Pisanski, K.P. —stimuli and data collection, manuscript contributions

Feinberg, D.R. —experiment development, manuscript contributions

Research Conducted: 2011-2013

CHAPTER 6: General Discussion

I am the sole author of this chapter, which was written in consultation with David Feinberg.

CHAPTER 1: GENERAL INTRODUCTION

In this dissertation, I examine the influence of human vocal and facial characteristics on perceptions of attractiveness, dominance, and leadership ability. First, I review the literature on perceptions of voices and faces and point out the previously unanswered research questions that I investigate in the subsequent four chapters. In Chapter 6, I discuss the results and implications of these studies.

Facial and Vocal Qualities Related to Perceptions of Attractiveness and Dominance

Attractiveness and Dominance in Relation to Sexual Selection

In 1871, Darwin developed the theory of sexual selection to help explain the evolution of secondary sex characteristics (Darwin, 1871). Secondary sex characteristics are traits that distinguish sexually mature males and females of a species, but are not functionally necessary for reproduction, such as the gonads or reproductive organs (Wilson, 1975, 2000, p. 318). Since Darwin, the term "sexual selection" has been used in many different ways and the details of sexual selection theory have been debated and have changed over time (Andersson, 1994; Carranza, 2009; Clutton-Brock, 2004). In this dissertation, sexual selection is defined as a type of natural selection that operates differentially on males and females (Carranza, 2009; Clutton-Brock, 2004; Clutton-Brock & Albon, 1979). Herein, I use the term sexual selection to mean sex-dependent selection (Carranza, 2009).

Although there are many mechanisms by which sexual selection can operate, this dissertation will focus on two of them: inter-sexual (or, epigamic) selection and intra-sexual selection (Huxley, 1938). Inter-sexual selection is selection that favours traits in one sex that attract mates (Huxley, 1938), as these traits are heritable indicators of fitness. Intra-sexual selection is selection that favours the ability in one sex to successfully compete among each other for mating success (Huxley, 1938). Both of these mechanisms of sexual selection favour traits that increase the quantity and/or quality of mates an individual obtains, which can increase reproductive success. Although inter-sexual and intra-sexual selection each select for traits that maximize reproductive success, the traits that increase attractiveness and those that increase dominance are not necessarily the same. Thus, the specific mechanism by which sexual selection operates is important to understand the evolution of sexually selected traits.

Human faces (for reviews see: Little, Jones, & DeBruine, 2011; Pisanski & Feinberg, 2013; Rhodes, 2006; Thornhill & Gangestad, 1999) and voices (for reviews see: Feinberg, 2008; Pisanski & Feinberg, 2013) influence perceptions of attractiveness and dominance, two qualities that closely relate to inter- and intra-sexual selection, respectively. This dissertation examines how facial and vocal characteristics influence perceptions of attractiveness and dominance, which may be closely related to leadership ability in humans, in order to better understand the evolution of sex differences in human facial and vocal features.

Although humans most likely evolved in egalitarian groups that emphasized resource sharing, individuals varied greatly in their ability to acquire resources, as they do today (Wilson, 1975, 2000, p. 548). Thus, some individuals may have naturally emerged at the top of the social hierarchy as leaders (Wilson, 1975, 2000, p. 549). A group leader can influence a group member's ability to survive and reproduce within a group (Darwin, 1871; Trivers, 1972). Therefore, it is likely that humans possess evolved mechanisms for assessing leadership ability in others, even though the social and political structures of modern humans may be quite different from those of ancestral populations.

Although dominance and leadership ability are closely related concepts, in this dissertation, dominance specifically refers to the ability to successfully compete among same-sex individuals for access to resources. Thus, the same qualities that make an individual more dominant may also make one a good leader. However, in democratic societies, leaders must not only possess dominant qualities, they must also possess the ability to gain respect, status, and to win elections.

Facial Features

Past research has identified the human facial characteristics that influence perceptions of attractiveness and dominance (for reviews see: Little et al., 2011;

Rhodes, 2006; Thornhill & Gangestad, 1999). Specifically, masculinity/femininity of face shape is one important component of facial attractiveness and dominance (Perrett et al., 1998; Rhodes, 2006). Masculine face shape is characterized by a prominent brow ridge, square jaw, thin lips, and small eyes (Keating, 1985). Ratings of men's facial masculinity (Penton-Voak & Chen, 2004), and of men's facial attractiveness (Rantala et al., 2012; Roney, Hanson, Durante, & Maestripieri, 2006) are each positively related to testosterone levels, though there is variation in women's preferences for masculinity in men's faces (the specific factors that influence women's masculinity preferences are discussed in more detail below). Feminine face shape, characterized by large eyes, large lips, and a less prominent brow ridge (Perrett, May, & Yoshikawa, 1994), is positively related to estrogen levels in women (Law-Smith et al., 2006).

It is also important to note that masculinity and femininity of face shape are not the only facial features that influence perceptions of attractiveness and dominance. Several other facial features influence perceptions of these qualities such as averageness (Langlois & Roggman, 1990; Valentine, Darling, & Donnelly, 2004), facial symmetry (Perrett et al., 1999; Rhodes, Proffitt, Grady, & Sumich, 1998), skin condition (Jones, Little, Burt, & Perrett, 2004), skin colouration (Fink, Grammer, & Matts, 2006; Stephen et al., 2012), and eye gaze direction (Conway, DeBruine, & Jones, 2006). Perceptions of facial masculinity/femininity and perceptions of the facial features listed above can interact to produce one's overall impression of a face.

Vocal Features

According to the source-filter theory of voice production (Fant, 1960; Titze, 1994, p. 136), the sound of the human voice is produced when air expelled from the lungs vibrates due to vibrations of the vocal folds inside the larynx. Voice pitch is the perception of fundamental frequency at which the vocal folds vibrate the air (*i.e.,* usually the lowest frequency of a periodic waveform (Titze, 1994, p. 172)) and/or its harmonics (*i.e.,* component frequencies of a periodic waveform that are integer multiples of the fundamental frequency (Titze, 1994, p. 120)). The relationship between physical frequency and perceived pitch is approximately logarithmic (Moore, 1995) above 500 Hz. Thus, it is more difficult to hear the difference between frequencies in high frequency voices than in low frequency voices (Moore, 1995). Voice pitch is sexually dimorphic in adult humans (Titze, 1989; also see Table 1), with men having lower pitched voices than do women on average.

Table 1. Mean adult fundamental frequency values reported in the literature.

Sex	Voice Pitch (Hz)	Reference
Male	124.6	(Childers & Wu, 1991)
	120	(Pisanski & Rendall, 2011)
Female	220.0	(Childers & Wu, 1991)
	207	(Pisanski & Rendall, 2011)
	207.82	(Feinberg, DeBruine, Jones, & Perrett, 2008)

Low voice pitch is often *misattributed* to large body size within adults of the same sex (Rendall, Vokey, & Nemeth, 2007), likely because voice pitch corresponds to differences in body size between children and adults (Peterson & Barney, 1952) and between sexes in adulthood (Titze, 1989). It remains controversial, though, whether pitch is reliably related to body size within same-sex adults (Evans, Neave, & Wakelin, 2006; Hamdan et al., 2012; Pisanski et al., 2013; Rendall, Kollias, Ney, & Lloyd, 2005) because the soft tissue of the larynx grows independently from the rest of the body and is not constrained by skeletal structure (Fant, 1960).

The supralaryngeal vocal tract (henceforth: vocal tract) acts as a resonating chamber that filters the sound produced in the larynx (Figure 1). Formant frequencies, the resonant frequencies of the vocal tract (Titze, 1994, p. 143), are also sexually dimorphic in adult humans (Titze, 1989), with men's voices having lower formants than do women's voices on average. The formants act as filters by allowing specific frequencies of sound to pass through and by blocking others (Fitch, 2000). Formant frequencies are, for the most part, functionally and anatomically independent from the fundamental frequency and harmonics because formants depend on the length and shape of the vocal tract, rather than on the characteristics of the vocal folds (Fant, 1960). Unlike the larynx, the size of the vocal tract is constrained by the anatomy of the head and neck.

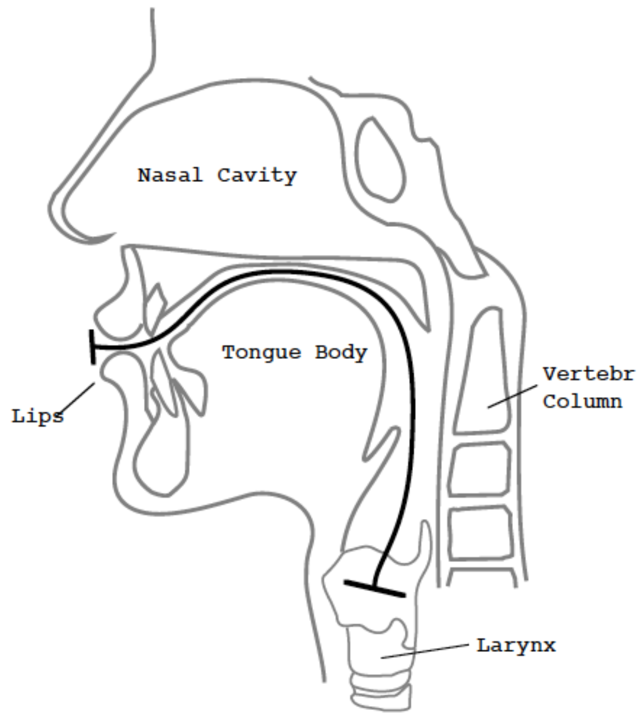

*Figure 1.*The human vocal tract, indicated by the dark line (reproduced from Fitch, 1994).

The voices of larger individuals, whose vocal tracts are longer (Fitch & Giedd, 1999), contain lower formant frequencies than do the voices of smaller individuals, when compared between children and adults (Hillenbrand, Getty, Clark, & Wheeler, 1995) and across adult sexes (Gonzalez, 2006; Rendall et al., 2005). Yet, it is unknown whether formant frequencies reliably predict body size within same-sex adults because the strength, direction, and statistical significance level of published within-sex correlations between formants and height varies widely (Bruckert, Lienard, Lacroix, Kreutzer, & Leboucher, 2006; Collins & Missing, 2003; Gonzalez, 2004; Gonzalez, 2007; for meta-analysis see: Pisanski et al., 2013; Puts, Apicella, & Cardenas, 2012; Rendall et al., 2005).

Formant frequencies can change during speech production because they depend on the shape of the pharynx and mouth as well as the placement of the tongue within the mouth (Titze, 1994, p. 148-49). These changes in vocal tract shape result in the production of different vowel sounds, which are identified by the two lowest formants (Titze, 1994, p. 149). Thus, when measuring formants for a given individual's voice, each of the first four formants is typically measured separately for each vowel sound and then averaged across vowels to obtain an average measure of each formant (Bruckert et al., 2006; Collins & Missing, 2003; Feinberg, Jones, Little, Burt, & Perrett, 2005; Pisanski, Mishra, & Rendall, 2012; Pisanski & Rendall, 2011; Rendall et al., 2005).

Like facial masculinity, vocal masculinity is related to underlying levels of sex hormones. Specifically, men's pubertal and adult voice pitch are each negatively related to testosterone levels at puberty (Harries, Walker, Williams, Hawkins, & Hughes, 1997) and in adulthood (Dabbs & Mallinger, 1999; Evans, Neave, Wakelin, & Hamilton, 2008; Puts, Apicella et al., 2012). Across sexes, men have higher levels of pubertal testosterone than do women on average, resulting in men having voice pitch half as low as women in adulthood (Childers & Wu, 1991). Women's voice pitch decreases with increasing age, which can be explained in part by the increase in testosterone relative to estrogen that occurs at menopause (Abitbol, Abitbol, & Abitbol, 1999). Thus, individuals with lower pitched voices also had higher levels of testosterone at puberty than did individuals with higher pitched voices. Increased testosterone levels are associated with longer and thicker vocal folds, which vibrate at lower frequencies than do shorter and thinner vocal folds.

Sex hormones may directly influence vocal fold growth, as studies have identified estrogen and progesterone receptors (Brunings, Schepens, Peutz-Kootstra, & Kross, 2013; Newman, Butler, Hammond, & Gray, 2000) as well as androgen receptors (Newman et al., 2000) in vocal fold tissue. The mechanism by which these sex hormones affect the vocal folds could also be indirect, as other studies have failed to identify estrogen, progesterone, or androgen receptors in the vocal folds (Nacci et al., 2011; Schneider et al., 2007).

Some studies have described changes in women's voice pitch (Bryant & Haselton, 2009; Puts et al., 2013) and voice attractiveness (Pipitone & Gallup, 2008, 2012) across the ovulatory cycle, but these results have not been consistently replicated (Fischer et al., 2011). Changes in women's behaviour across the menstrual cycle have been documented, though (Haselton, Mortezaie, Pillsworth, Bleske-Rechek, & Frederick, 2007; Miller, Tybur, & Jordan, 2007), and suggest that these vocal changes are most likely behavioural and probably not caused directly by fluctuating sex hormones acting directly on the vocal folds.

Other acoustic properties of the voice also influence how the voice is perceived. The spectral tilt of a sound describes how the amplitude decreases with increasing frequency (Titze, 1994, p. 120). The spectral tilt of a voice is usually measured in decibels (dB) per octave, where each octave is a doubling of frequency, but it can also be quantified by the slope of the best-fit line of the linear regression of frequency on amplitude. A spectral slope of 12 dB/octave is considered “normal”, with larger slopes described as sounding “fluty,” and smaller slopes described as “brassy” (Titze, 1994, p. 120). Additionally, spectral tilt varies between sexes (Hanson & Chuang, 1999; Mendoza, Valencia, Munoz, & Trujillo, 1996) and may be a vocal cue to the sex of the vocalizer.

Jitter, cycle-to-cycle variability in fundamental frequency, increases with increasing age (Ramig et al., 2001). Shimmer, cycle-to-cycle variability in amplitude, may be one component of noise in a vocal signal. Increased levels of both jitter and shimmer are also associated with less healthy vocal folds (Oguz et al., 2007; Stajner-Katusic, Horga, & Zrinski, 2008). In averaged voices synthesized by auditory morphing, less noisy voices (*i.e.,* voices with higher harmonics-to-noise ratios) sound more attractive than do noisier voices with lower harmonics-to-noise ratios (Bruckert et al., 2010). In natural voices, however, breathy voices, characterized by having reduced energy at higher frequencies (greater spectral tilt) and a relatively prominent first harmonic, may sound more attractive (Xu, Lee, Wu, Liu, & Birkholz, 2013) than do “normal” (not breathy) voices, yet the relationship between vocal noise and attractiveness is not well understood.

Perceptions of Attractiveness and Dominance from Faces and Voices

Perceptions of Women's Faces

In general, more feminine women's faces are found to be more attractive than are more masculine women's faces among natural, un-manipulated stimuli (Cunningham, 1986; Jones & Hill, 1993; Law-Smith et al., 2006; Thornhill & Gangestad, 2006). Feminized women's faces (*i.e.,* images manipulated using computer graphics techniques to exaggerate the vector differences between corresponding features of average female and average male faces (Perrett et al., 1994)) generally look more attractive than do masculinized women's faces among stimuli that have been so transformed (*i.e.,* masculinized or feminized) (Burriss, Welling, & Puts, 2011; Jones, DeBruine, & Little, 2007; Jones, Little, Watkins, Welling, & DeBruine, 2011; Perrett et al., 1998; Perrett et al., 1994).

A meta-analysis found a strong association between femininity and attractiveness in women's faces, with large effect sizes across studies (Rhodes, 2006). Preferences for feminine women's faces have been replicated cross-culturally among populations in the United States (Jones & Hill, 1993), Brazil (Jones & Hill, 1993), Jamaica (Penton-Voak, Jacobson, & Trivers, 2004), the United Kingdom (Perrett et al., 1998), Japan (Perrett et al., 1998), New Zealand (Rhodes, Hickford, & Jeffery, 2000), China (Rhodes et al., 2000), and Germany (Roeder, Fink, Feinberg, & Neave, 2013). It has also been reported, though, that men tend to prefer femininity more in women's faces from their own cultural population than in faces from other populations (Penton-Voak et al., 2004; Perrett et al., 1998). Furthermore, preferences for facial symmetry (Little, Apicella, & Marlowe, 2007) and averageness (Apicella, Little, & Marlowe, 2007) among the Hadza hunter-gatherers of Tanzania are consistent with those found in Western cultures.

Natural women's faces rated as more masculine are perceived as more dominant than are feminine women's faces (Quist, Watkins, Smith, DeBruine, & Jones, 2011). Some prior work on dominance perceptions in humans has drawn a distinction between physical dominance and social dominance (Puts, Gaulin, & Verdolini, 2006; Watkins, Jones, & DeBruine, 2010). It has been suggested that perceptions of physical dominance may be more closely related to masculine traits in faces and voices than are perceptions of social dominance (Puts et al., 2006; Watkins et al., 2010). For example, among manipulated images of women's faces, masculinized women's faces are perceived as more *physically* dominant than are feminized women's faces, but feminized women's faces are perceived as more *socially* dominant than are masculinized women's faces (Watkins, Quist, Smith, Debruine, & Jones, 2012).

Thus, it may be important to distinguish between these two types of dominance in research on face and voice perception. In this dissertation, a physically dominant person is defined as a person who would be likely to win a fist-fight with the average same-sex peer (modified from Puts et al., 2006) and a socially dominant person is defined as a person who tells other people what to do, is respected, influential, and is often a leader; whereas a submissive or subordinate person is not influential or assertive and is usually directed by others (modified from Mazur, Halpern, & Udry, 1994).

Perceptions of Men's Faces

Some studies have found that women prefer more masculine men's faces to more feminine men's faces using natural (Penton-Voak et al., 2001; Scheib, Gangestad, & Thornhill, 1999) and manipulated (DeBruine et al., 2006; Feinberg, DeBruine, Jones, & Little, 2008) stimuli. Other studies have found that women prefer more feminine men's faces to more masculine men's faces in manipulated stimuli (Perrett et al., 1998; Rhodes et al., 2000).

The variation in women's preferences for men's facial masculinity can be explained in part by between-individual differences in partnership status (Little, Jones, Penton-Voak, Burt, & Perrett, 2002), relationship context (Little et al., 2002), oral contraceptive use (Little et al., 2002), self-rated attractiveness (Little, Burt, Penton-Voak, & Perrett, 2001), attractiveness rated by men (Penton-Voak et al., 2003), waist-to-hip ratio (Penton-Voak et al., 2003), menstrual cycle phase (Frost, 1994; Johnston, Hagel, Franklin, Fink, & Grammer, 2001; Penton-Voak & Perrett, 2000; Penton-Voak et al., 1999), state progesterone level, which fluctuates between menstrual cycle phases (rather than trait level, which is averaged across menstrual cycle phases) (Jones et al., 2005), state testosterone level (Welling et al., 2007), second-to-fourth digit ratio (Scarbrough & Johnston, 2005), age (Little et al., 2001), paternal investment (Penton-Voak et al., 2004), sociosexual orientation (Sacco, Jones, DeBruine, & Hugenberg, 2012), perceptions of trust (Smith et al., 2009), pathogen disgust (DeBruine, Jones, Tybur, Lieberman, & Griskevicius, 2010; Jones et al., 2013), and regional variation in health indices (DeBruine, Jones, Crawford, Welling, & Little, 2010).

Although Brooks et al. (2011) showed that national income inequality also predicted regional variation in women's facial masculinity preferences, DeBruine et al. (2011) demonstrated that health index is a better predictor of women's masculinity preferences than is income inequality or homicide rate, even when controlling for the effects of homicide rate and income inequality in separate analyses. Nevertheless, more masculine men's faces are consistently perceived as more dominant than are more feminine men's faces (Boothroyd, Jones, Burt, & Perrett, 2007; Perrett et al., 1998), though these studies did not distinguish between physical and social dominance.

Perceptions of Women's Voices

Several studies have demonstrated that perceptions of women's facial and vocal attractiveness are positively correlated (Collins & Missing, 2003; Feinberg, DeBruine, Jones, & Little, 2008; Saxton, Burriss, Murray, Rowland, & Roberts, 2009). Thus, women who have attractive faces also tend to have attractive voices. Higher pitched, more feminine women's voices sound more attractive than do lower pitched women's voices in both natural (*i.e.,* un-manipulated) voices (Collins & Missing, 2003; Feinberg, DeBruine, Jones, & Perrett, 2008) and in pitch-manipulated stimuli (Collins & Missing, 2003; Feinberg, DeBruine, Jones, & Perrett, 2008; Jones, Feinberg, DeBruine, Little, & Vukovic, 2008, 2010; Puts, Barndt, Welling, Dawood, & Burriss, 2011). Feinberg et al. (2005) found that in both natural and manipulated faces, women with more feminine faces also had higher pitched voices and that women with high-pitched voices had more attractive faces than did women with low-pitched voices.

Nonetheless, there are also between-individual differences in the extent to which men prefer femininity in women's voices and faces. That is, not all men prefer femininity to the same extent, but those that prefer more feminine women's faces also prefer more feminine women's voices (Fraccaro et al., 2010). Pubertal development is one factor that has been shown to predict variation in adolescent boys' attractiveness judgments of female faces and voices (Saxton, Debruine, Jones, Little, & Roberts, 2009; Saxton et al., 2010) and individual differences in these preferences persist throughout adolescence (Saxton, DeBruine, Jones, Little, & Roberts, 2013). Overall, though, lower pitched women's voices sound more dominant (with no distinction between physical or social dominance) than do higher pitched women's voices (Borkowska & Pawlowski, 2011; Jones et al., 2010) and so do lower formants when combined with lower pitch (Feinberg et al., 2006).

Perceptions of Men's Voices

Lower pitched men's voices sound more attractive to women than do higher pitched men's voices in both natural and manipulated voice stimuli (Collins, 2000; Feinberg, DeBruine, Jones, & Little, 2008; Feinberg et al., 2006; Feinberg, Jones, Little et al., 2005; Jones et al., 2010). In addition, both women (Jones et al., 2010) and men (Jones et al., 2010; Ohala, 1982; Puts et al., 2006; Puts, Hodges, Cardenas, & Gaulin, 2007; Wolff & Puts, 2010) perceive lower pitched men's voices as more dominant than are higher pitched men's voices. Women also perceive lower pitched men's voices as older than are higher pitched men's voices (Collins, 2000; Feinberg, Jones, Little et al., 2005).

Men's voices with lower formants also sound more attractive (Feinberg et al., 2011; Pisanski et al., 2012; Pisanski & Rendall, 2011), dominant (Puts et al., 2007; Wolff & Puts, 2010), and older (Collins, 2000; Feinberg, Jones, Little et al., 2005) than do men's voices with higher formants. Although Feinberg et al. (2005) found no overall attractiveness preference for low formants in men's voices among women, women's height and weight positively predicted their preferences for men's voices with lower manipulated formants. There is also evidence that the effects of voice pitch and formant frequencies on men's voice attractiveness interact. Feinberg et al. (2011) showed that women preferred men's low voice pitch more when combined with lower, rather than higher, formants and preferred men's lower formants more when combined with low, rather than high, pitch.

Perceptions of Leaders

Voice, Face, and Body Features Related to Perceptions of Leadership Ability

Although much is known about perceptions of men's and women's faces and voices in the context of mate choice, the factors that predict perceptions of leadership ability may differ from those that predict perceptions of attractiveness. In fact, Jones et al. (2010) showed that voice pitch manipulations influence perceptions of dominance and of attractiveness differently. There is correlative evidence suggesting that leaders' voices influence perceptions. Politicians with both attractive faces and voices were perceived as more competent, trustworthy, qualified, and better leaders than were those with attractive faces but unattractive voices (Surawski & Ossoff, 2006). More specifically, more acoustic energy concentrated at lower vocal frequencies predicted the winners of U.S. Presidential elections (Gregory & Gallagher, 2002). In addition, a recent study found that male CEOs with lower pitched voices managed larger companies and earned more money than did their counterparts with higher pitched voices (Mayew, Parsons, & Venkatachalam, 2013).

Faces and bodies can also influence perceptions of men's leadership ability. Todorov et al. (2005) found that competence judgments from 1-second exposure to faces predicted the winners of U.S. Congressional elections. In addition, taller candidates are more likely to win U.S. Presidential elections than are shorter candidates (Sorokowski, 2010). Even women's conception risk (measured by menstrual cycle phase) can influence voting decisions. Navarrete et al. (2010) demonstrated that women who were more likely to conceive were more likely to report that they intended to vote for Barack Obama in 2008, possibly because he displayed indices of high mate quality. They also showed that the effect of fertility status on voting preferences was strongest among women who perceived Obama as mostly white, and weakest among women who perceived him as mostly black (Navarrete et al., 2010). The authors suggest that women's perceptions of unfamiliar men may change at times of peak fertility (Navarrete et al., 2010), although it is also possible that women's fertility status influences perceptions of race. These results demonstrate that mate-choice relevant factors (such as changes in conception risk across the menstrual cycle) can interact with perceptions of political candidates and influence voting preferences.

Experimental evidence also supports the above correlational findings. For instance, Little et al. (2007) showed that participants preferred to vote for manipulated men's faces with more masculine, dominant features over those with more feminine, less dominant features. Furthermore, faces perceived to belong to taller men and women are perceived to be better leaders than are those perceived to belong to shorter people based on judgments of three-dimensional (3D) facial images alone (Re et al., 2012). However, actual (rather than perceived) height did not influence perceived leadership ability (Re et al., 2012).

When height is manipulated in full-body photographs, taller men and women are rated as better leaders than are shorter people (Blaker et al., 2013). It is unknown, however, whether a candidate's formant frequencies, which depend on vocal tract length (Fitch & Giedd, 1999), predict voting preferences for him or her. Two past studies have found that participants preferred to vote for both men and women with lower pitched voices more often than to vote for those with higher pitched voices (Anderson & Klofstad, 2012; Klofstad, Anderson, & Peters, 2012), but there has been relatively little work examining perceptions of women as leaders.

An open research question in this area is the relative strength of perceptions of attractiveness and dominance at predicting voting preferences. Given that male facial (DeBruine et al., 2006; Perrett et al., 1998) and vocal (Feinberg et al., 2006; Feinberg, Jones, Little et al., 2005; Puts et al., 2006) masculinity have larger effects on perceptions of dominance than on perceptions of attractiveness (for review see: Puts, Jones, & DeBruine, 2012), one could predict that dominance perceptions may have a stronger influence on voting preferences than do attractiveness perceptions. Furthermore, dominance may be a more important quality in a leader than is attractiveness because dominant individuals may be better at competing for resources than are submissive individuals. By choosing a dominant leader, an individual may be able to increase his/her reproductive success within a group.

On the other hand, the vocal attractiveness stereotype (Zuckerman & Driver, 1989) predicts that vocal attractiveness will positively predict voting preferences. Indeed, one study found that candidate attractiveness was positively correlated with vote share received (King & Leigh, 2009). Thus, in order to better understand voting decisions, it is crucial to disentangle the effects of attractiveness and dominance perceptions on voting behaviour.

Perceptions of Leaders in Different Contexts

Several studies have compared perceptions of leaders in hypothetical war versus peace contexts. In a hypothetical war context, participants preferred leaders with more masculine faces more strongly than in a hypothetical peace context (Little, Burriss et al., 2007; Re, DeBruine, Jones, & Perrett, 2013). Another study found that participants preferred leaders with attractive faces in simulated wartime and preferred leaders with trustworthy faces in simulated peacetime (Little, Roberts, Jones, & DeBruine, 2012).

Furthermore, during a wartime scenario, Spisak (2012) found that people preferred leaders with faces manipulated to look older over those with faces manipulated to look younger. Although men's voices with lower pitch and/or lower formants sound older than do men's voices with higher pitch and higher formants (Feinberg, Jones, Little et al., 2005), it is unknown if perceptions of age from the voice influence voting preferences.

The level of disease threat is another context that has been shown to influence preferences for leaders. White, Kenrick, & Neuberg (2013) found that candidates rated as more physically attractive were more likely to be elected in U.S. Congressional districts with elevated levels of disease threat. They also demonstrated that people preferred to vote for physically attractive candidates more when disease threat was experimentally elevated than when disease threat was not elevated (White et al., 2013). The authors argue that people preferred physically attractive leaders in environments where disease threat is high because physically attractive traits are cues to good health (White et al., 2013).

Yet, there has been relatively little work on perceptions of leaders' voices in different contexts. Sell et al. (2010) found that participants accurately judged men's physical strength from the voice alone, but that men's voice pitch was not correlated with strength directly. Additionally, stronger men were more likely to favour military force than were weaker men (Sell, Tooby, & Cosmides, 2009). These results suggest that candidates' voice pitch may influence voters' perceptions of their attitudes toward military force. If leaders' voices influence perceptions of their physical strength (Sell et al., 2010) and of their attitudes toward military force (Sell et al., 2009), then leaders' voices may also influence voting preferences in war versus peace contexts such that voters may prefer leaders with low voice pitch more during times of war than during times of peace.

Potential Limitations of Facial and Vocal Stimuli Presentation Methods

Most prior studies on face perception used front-facing, two-dimensional (2D) images created by or presented via computer, but we often perceive naturally occurring faces in 3D. It is possible that some of the 3D facial features related to perceptions of attractiveness and dominance may be best viewed from viewpoints other than head-on, such as the profile (Valentine et al., 2004). It had been debated in the past whether face processing in the human visual system depends on the viewpoint from which a face is seen or not (Jeffery, Rhodes, & Busey, 2006; Jeffery, Rhodes, & Busey, 2007; Jiang, Blanz, & O'Toole, 2006; Welling et al., 2009). This debate led some to question the ecological validity of using 2D face stimuli in these studies because camera angle and head tilt could create potential confounds in these images which could alter perceptions (Penton-Voak et al., 2001) and because attractiveness ratings from static and dynamic stimuli did not always correlate (Lander, 2008; Penton-Voak & Chang, 2008; Rubenstein, 2005). Therefore, more research is needed in order to determine whether using facial images that can be viewed from more than one angle on a 2D surface in face perception research yields systematically different results than using static, 2D facial images.

Many past studies on face and voice perception used a two-alternative forced choice (2AFC) methodology. In these experiments, participants were given a choice between two versions of the same person's face or voice, manipulated in one dimension, which allows the experimenter to control for all other variables except the one feature that is manipulated. A potential limitation of 2AFC studies is that participants' recognition of the manipulation may artificially create or alter perceptions (Penton-Voak, 2011; Peters, Simmons, & Rhodes, 2009; Scott, Clark, Boothroyd, & Penton-Voak, 2013). DeBruine (2013) empirically tested this claim and found that facial masculinity preferences measured with a 2AFC paradigm were significantly positively correlated with masculinity preferences measured with a single-stimulus rating paradigm and that preferences found with the 2AFC paradigm were not artificially more different from chance than were preferences found with the rating paradigm.

There are many contexts, such as mate choice or voting decisions for example, in which people make a choice between two different people. Therefore, although the validity of measuring masculinity preferences from 2AFC paradigms has been empirically demonstrated (DeBruine, 2013), it is still important to know if the results of prior studies, when participants are given a choice between two versions of the same person's face or voice, are comparable to those from studies when participants are given a choice between two different people. More research is needed to clarify this issue.

Puts (2005) used a rating paradigm, but divided manipulated men's voice stimuli between two groups of participants such that one group of women rated the raised pitch version and the other group of women rated the lowered pitch version. The results of this study showed that women rated lower pitched men's voices as more attractive than higher pitched men's voices (Puts, 2005), similar to results from studies that used 2AFC paradigms to investigate women's perceptions of men's voice attractiveness (Feinberg, DeBruine, Jones, & Little, 2008; Jones et al., 2010).

Prior voice perception studies have also used different types of speech content, such as individual vowel sounds (Collins, 2000; Collins & Missing, 2003; Feinberg, DeBruine, Jones, & Perrett, 2008; Jones et al., 2010) or whole sentences (Jones et al., 2008; Puts et al., 2011; Puts et al., 2006). Thus, it is important to clarify whether the results of past studies are generalizable across different types of speech.

Finally, knowledge of the vocalizer could also influence how a voice is perceived. Therefore, it is important to know if perceptions differ when the vocalizer is a public figure, such as a politician, versus when the vocalizer is unknown to the listener. Comparing the results of experiments that manipulate the speech content and knowledge of the vocalizer could help to shed light on this issue.

The Current Dissertation

The objective of this dissertation is to investigate how facial and vocal features influence perceptions of attractiveness, dominance, and leadership ability. Vocal features influence perceptions of attractiveness (Collins, 2000; Collins &

Missing, 2003; Feinberg, DeBruine, Jones, & Perrett, 2008; Feinberg et al., 2011; Feinberg et al., 2006; Feinberg, Jones, Little et al., 2005; Jones et al., 2008, 2010; Puts et al., 2011), dominance (Borkowska & Pawlowski, 2011; Jones et al., 2010; Ohala, 1982; Puts et al., 2006; Puts et al., 2007; Wolff & Puts, 2010), and leaders' voices relate to voting preferences (Anderson & Klofstad, 2012; Gregory & Gallagher, 2002; Klofstad et al., 2012; Surawski & Ossoff, 2006). Therefore, in Chapter 3 of this dissertation, I examine the specific acoustic properties of the voice that are related to voting ratings of leaders' voices. In Chapters 4 and 5, I investigate how manipulating voice pitch and formant frequencies, separately, influences perceptions of leaders and voting preferences.

In Chapters 3 and 5, I examine whether vocal acoustics influence perceptions of male and female leaders differently. There have been relatively few studies examining perceptions of women as leaders (for examples see: Anderson & Klofstad, 2012; Klofstad et al., 2012). Furthermore, evidence suggests that perceptions of leaders differ between war and peace contexts (Little, Burriss et al., 2007; Little et al., 2012; Re et al., 2013; Spisak, 2012) and different levels of disease threat (White et al., 2013). Thus, in Chapter 4, I examine whether vocal masculinity influences perceptions of male leaders differently in different hypothetical social contexts. In order to further differentiate the effects of attractiveness and dominance perceptions on voting preferences, in Chapters 3 and 4, I investigate whether perceptions of attractiveness or dominance from the voice are a stronger predictor of voting preferences.

Finally, I investigate how methods of stimuli presentation influence the results of studies on face (Chapter 2) and voice (Chapter 4) perception. In Chapter 2, I investigate whether men's attractiveness judgments of women's faces differ when facial stimuli are presented in static, front-facing 2D images or 3D images viewed from multiple angles, both on 2D surfaces. In Chapter 4, I investigate whether the speech content and knowledge of the vocalizer influence results in 2AFC vocal perception studies. The subsequent chapters of this dissertation attempt to resolve the unanswered questions described above.

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CHAPTER 2: MEN'S JUDGMENTS OF WOMEN'S FACIAL ATTRACTIVENESS FROM TWO- AND THREE-DIMENSIONAL IMAGES ARE SIMILAR

Tigue, C.C., Pisanski, K.P., O'Connor, J.J.M., Fraccaro, P.J., & Feinberg, D.R. (2012). Men's judgments of women's facial attractiveness from two- and three-dimensional images are similar. *Journal of Vision, 12*(12): 3, 1-7, doi:10.1167/12.12.3.

Preface

In Chapter 2, I investigate whether men's perceptions of women's facial attractiveness from three-dimensional (3D) images are similar to those from two-dimensional (2D) images. Although our primary visual experience with faces in the physical world is in 3D, most prior studies on facial attractiveness have used static, front-facing 2D images. It is important to know if using 3D facial images that can be viewed from several angles yield systematically different results from using 2D facial images when designing future experiments on face perception. In this chapter, I demonstrate that men's perceptions of women's facial attractiveness from 2D and 3D images are similar. This result indicates that 3D facial images are an ecologically valid stimulus format to use in future studies and that 2D facial images contain similar information for assessing facial attractiveness as do 3D facial images. Furthermore, 3D facial images may be useful in subsequent studies investigating perceptions of facial expressions, emotions, or specific facial features that may be perceived more accurately in 3D than in 2D.

Abstract

Although most research on human facial attractiveness has used front-facing two-dimensional (2D) images, our primary visual experience with faces is in three dimensions. Because face coding in the human visual system is viewpoint-specific, faces may be processed differently from different angles. Thus, results from perceptual studies using front-facing 2D facial images may not be generalizable to other viewpoints. We used rotating 3-dimensional (3D) images of women's faces to test whether men's attractiveness ratings of women's faces from 2D and 3D images differed. We found a significant positive correlation between men's judgments of women's facial attractiveness from 2D and 3D images (r = .707), suggesting that attractiveness judgments from 2D images are valid and provide similar information about women's attractiveness as do 3D images. We also found that women's faces were rated significantly more attractive in 3D images than in 2D images. Our study verifies a novel method using 3D facial images, which may be important for future research on viewpoint-specific social perception. This method may also be valuable for the accurate measurement and assessment of facial characteristics such as averageness, identity, attractiveness, and emotional expression.

Keywords: Face; attractive; preferences; three-dimensions; face processing; view-specific

Introduction

The majority of research on human facial attractiveness has utilized two-dimensional (2D) facial images (for reviews: Little, Jones, & DeBruine, 2011; Rhodes, 2006; Thornhill & Gangestad, 1999). Results from prior work using 2D images provide evidence that invariant facial characteristics such as averageness (Langlois & Roggman, 1990; Valentine, Darling, & Donnelly, 2004), femininity (Perrett et al., 1998; Rhodes, Hickford, & Jeffery, 2000), and fluctuating asymmetry (Perrett et al., 1999; Rhodes, Proffitt, Grady, & Sumich, 1998) are important determinants of women's facial attractiveness. Variant facial characteristics such as skin condition (Jones, Little, Burt, & Perrett, 2004), skin coloration (Fink, Grammer, & Matts, 2006; Stephen et al., 2012), and gaze direction (Conway, Jones, DeBruine, & Little, 2008) can also influence perceptions of facial attractiveness. Most of the 2D images used in previous work have been front-facing, but in the real world, we experience faces from multiple viewing angles. Because the human visual system may process three-dimensional (3D) objects differently depending on the viewing angle, studies that use front-facing facial images may be limited.

It has been debated whether object recognition is view-specific (Tarr & Bulthoff, 1995) or view-invariant (Biederman & Gerhardstein, 1993) in the human visual system. This debate has centered on understanding how the visual system recognizes the same object from different angles when that object projects different shapes onto the retina from different viewpoints (Hayward, 2003).

Structural description models argue that object recognition does not depend on viewpoint because the visual system uses information from 3D structures to identify an object (Hayward, 2003). On the other hand, view-based models state that the visual system uses a 2D projection of an object from a specific viewpoint to identify it (Hayward, 2003). Although the debate over the so-called "viewpoint problem" has waned, the relative roles of 3D structural information and 2D view-based information in object recognition remain unclear.

Although objects and faces are processed differently in the visual system, the neural mechanisms underlying object and face perception each show sensitivity to viewpoint. Prior work on the monkey visual system has demonstrated that there are neurons in the superior temporal sulcus that are sensitive to face view (Perrett et al., 1985) and that face coding is view-specific in macaques (Perrett et al., 1991; Perrett, Hietanen, Oram, & Benson, 1992). Similarly, studies on viewpoint aftereffects in humans suggest that humans also have neurons tuned to specific viewing angles (Fang & He, 2005). More specifically, face viewpoint aftereffects, or changes in the responses of neurons that code faces following habituation to a specific viewpoint, have been demonstrated for a variety of facial features (Chen, Yang, Wang, & Fang, 2010). Some researchers have interpreted the finding that face aftereffects transfer across viewpoints as evidence that face perception is viewpoint-invariant (Jiang, Blanz, & O'Toole, 2006). Others have pointed out that because there is only partial transfer of face aftereffects across viewpoints, face coding must be viewpoint-specific (Jeffery, Rhodes, & Busey, 2006; Jeffery, Rhodes, & Busey, 2007). Recent work has provided stronger evidence for view-specific face processing by showing that aftereffects can be induced simultaneously in opposite directions, suggesting that aftereffects for different viewpoints are dissociable (Welling et al., 2009).

Whether face processing in the human visual system is view-specific or view-invariant is crucial to research on facial attractiveness because perceptions of key determinants of facial attractiveness, such as averageness, femininity, emotion, and symmetry, may be affected by viewing angle. If face processing is view-specific, then results from facial attractiveness studies using front-facing 2D images may not be generalizable to other viewpoints. Indeed, some researchers have argued that 2D images are not ecologically valid stimuli for face attractiveness research because attractiveness ratings from static images did not correlate with ratings from dynamic stimuli (Lander, 2008; Penton-Voak & Chang, 2008; Rubenstein, 2005). For example, Rubenstein (2005) found that men's and women's ratings of women's facial attractiveness from videos were not significantly correlated with attractiveness ratings from static freeze-frame images. In addition, Lander (2008) found that attractiveness ratings of men's and women's moving and static faces were significantly positively correlated when rated by members of the opposite, but not the same, sex. Furthermore, Penton-Voak & Chang (2008) showed that dynamic men's, but not women's, faces were rated more attractive than were static faces.

By contrast, other work indicates that 2D images are ecologically valid because attractiveness ratings are consistent across stimulus presentation formats and modalities. For example, Roberts et al. (2009) found strong positive correlations between attractiveness ratings from static and dynamic facial images of both men and women. Rhodes et al. (2011) also found a positive correlation between attractiveness ratings of men's faces from static images and videos. It has also been shown that women's preferences for men's vocal and facial masculinity in videos are positively correlated (O'Connor et al., 2012), replicating preferences observed in studies using still images. Furthermore, studies that have used profile views of the face have found that people judged emotional expressions (Matsumoto & Hwang, 2011) and symmetry and averageness (Valentine et al., 2004) equally well from front-facing and profile facial stimuli. Finally, Saxton et al. (2009) found that attractiveness ratings of the face, body, and voice were each positively correlated with each other. Taken together, there is evidence both for and against the use of 2D images in research on facial attractiveness.

Using 3D images that allow the face to be viewed from more than one angle may minimize confounds associated with front-facing 2D images. For example, camera angle and head tilt can influence perceptions of femininity and symmetry in 2D (Penton-Voak et al., 2001), but not 3D, images. Previous studies have used 3D imaging techniques to study different aspects of face perception, including attractiveness (Blanz, O'Toole, Vetter, & Wild, 2000; Caharel, Jiang, Blanz, & Rossion, 2009; O'Toole, Price, Vetter, Bartlett, & Blanz, 1999), but did not directly compare attractiveness ratings from 2D and 3D facial images. To test whether facial attractiveness judgments from 2D and 3D images differ, we presented men with both 2D and 3D images of women's faces. The 3D images contained information from 180-degrees of the face (from ear to ear), while the 2D images contained information from only the front of the face. Given that facial attractiveness ratings are generally positively correlated across presentation formats and modalities, we predicted that men would rate women's facial attractiveness similarly in 2D and 3D images.

Methods

Stimuli Collection

We collected 2D and 3D facial images from 39 White women (*mean age*= 18.69 ± 1.00 years, *range*=17-22 years) who received course credit or payment for participation. The 2D and 3D images were captured in random order.

2D Facial Images

We captured a 2D color facial photograph of each participant using a Nikon D90 digital single-lens reflex camera (Nikon, Tokyo, Japan) with an AF Micro Nikkor 60 mm lens (Nikkor, Tokyo, Japan) under standardized lighting. We photographed each participant looking straight-on at the camera with neutral facial expression. Participants wore a headband to pull hair off of the face and removed glasses, makeup, and facial piercings. Images were captured in RAW format and exported to JPEG format using Nikon ViewNX version 1.1.1 (Nikon Corporation) software.

3D Facial Images

We captured a 3D facial image of each participant with neutral expression using the 3dMDface System (3dMD LLC, Atlanta, GA) under standardized lighting. This system projects an invisible infrared speckled light pattern onto the face and uses four stereo cameras and two color cameras to generate the geometry and surface texture, respectively, of the face using a distance-calibrated stitching algorithm. It captures 180-degree facial images at a capture speed of <1.5 ms and a geometry accuracy of < 200 μm. The system was calibrated daily prior to image acquisition. 3D images were captured in TriSpectives 3D drawing file (.TSB) format and converted to videos in Audio Video Interleavd (.AVI) format using 3dMDpatient software version 4.0 (3dMD LLC, Atlanta, GA). This method of 3D image capture has been used successfully in prior work (Aldridge, Boyadjiev, Capone, DeLeon, & Richtsmeier, 2005).

Stimulus Creation

To control for size of 2D images, we standardized inter-pupillary distance using PsychoMorph for Windows version 8.4.11 software (Tiddeman, Burt, & Perrett, 2001). We also used PsychoMorph to mask each 2D image to reduce visual cues outside of the face that could influence attractiveness ratings (Figure 1a). 2D images were presented at 1350 by 1800 pixels in size.

We converted the .AVI videos of 3D images into QuickTime format (.MOV) with an H.264 video codec using Adobe Media Encoder CS5 version 5.0.1.0 (64-bit, Adobe [Adobe Systems Incorporated, San Jose, CA]). Each video was recorded so that the face started facing 90 degrees to the left, rotated around the y-axis toward the viewer 180 degrees to face 90 degrees to the right and back again. This sequence repeated twice. Each video lasted 10 seconds total. 3D images were presented against a black background (Figure 1b). 3D images were presented at 654 by 480 pixels in size. Similar methods of 3D face presentation have been used successfully in prior studies of facial attractiveness (O'Toole et al., 1999).

Figure 1. Examples of *(a)* 2D facial image and *(b)* screen shot of 3D facial image of the same woman that were used as stimuli.

Raters

Raters were 31 self-reported heterosexual men (*mean age*= 18.74 ± 1.65 years, *range*= 17-26 years) who rated the women's 2D and 3D facial images for attractiveness.

Rating Procedure

Raters viewed each 2D and 3D facial image on a computer screen (30-inch Apple Cinema HD display at 2650 x 1600 pixel resolution [Apple Inc., Cupertino, CA]) and rated it for attractiveness on a 7-point scale (1= very unattractive, 7= very attractive). For the 3D images, participants double-clicked on each image to play the video on the computer screen. We instructed participants to wait for the video to stop completely before making their rating. 2D and 3D faces were presented in separate randomized blocks (both within and between blocks).

Statistical Analyses

We performed statistical analyses using SPSS 20 (IBM, Armonk, NY) with two-tailed probability estimates and $\alpha = .05$.

Results

For each stimulus identity, we averaged across all men's attractiveness ratings. Inter-rater reliability was excellent for the 2D (Cronbach's $\alpha = .952$) and 3D images (Cronbach's $\alpha = .948$). The distributions of attractiveness ratings from 2D and 3D images were not significantly different from normal (Shapiro-Wilk tests; 2D images: W_{39} = .948, p = .068; 3D images: W_{39} = .951, p = .086). Because the p-values of these tests were close to the alpha level of .05, we preformed both parametric and non-parametric statistical tests.

To test if men's attractiveness ratings of women's faces were related in 2D and 3D images, we performed a Pearson correlation. We found a significant positive relationship between attractiveness ratings in 2D and 3D images (r = .707, $p < .001$, N = 39; Figure 2). Controlling for the age of the women whose faces were used as stimuli did not change the statistical significance of this result (*partial* r_{36} = .696, $p < .001$). Using non-parametric tests did not change the statistical significance of these correlations (Spearman's *rho* = .705, $p < .001$, N = 39; partial *rho* controlling for age = .692, $p < .001$, N = 39). We also repeated the above correlation analyses excluding the identity with the highest 2D and 3D attractiveness ratings. Excluding this data point did not change the statistical significance of the Pearson correlation (r = .684, $p < .001$, N = 38) or the Spearman correlation (Spearman's *rho* = .683, $p < .001$, N = 38).

To test if women's faces were rated more attractive in 3D than in 2D images, we performed a paired samples t test. We found that women's faces were rated significantly more attractive from 3D images ($M \pm SEM$ = 2.61 ± 0.12) than from 2D images ($M \pm SEM$ = 2.43 ± 0.11; t_{38} = -2.08, p = .045).

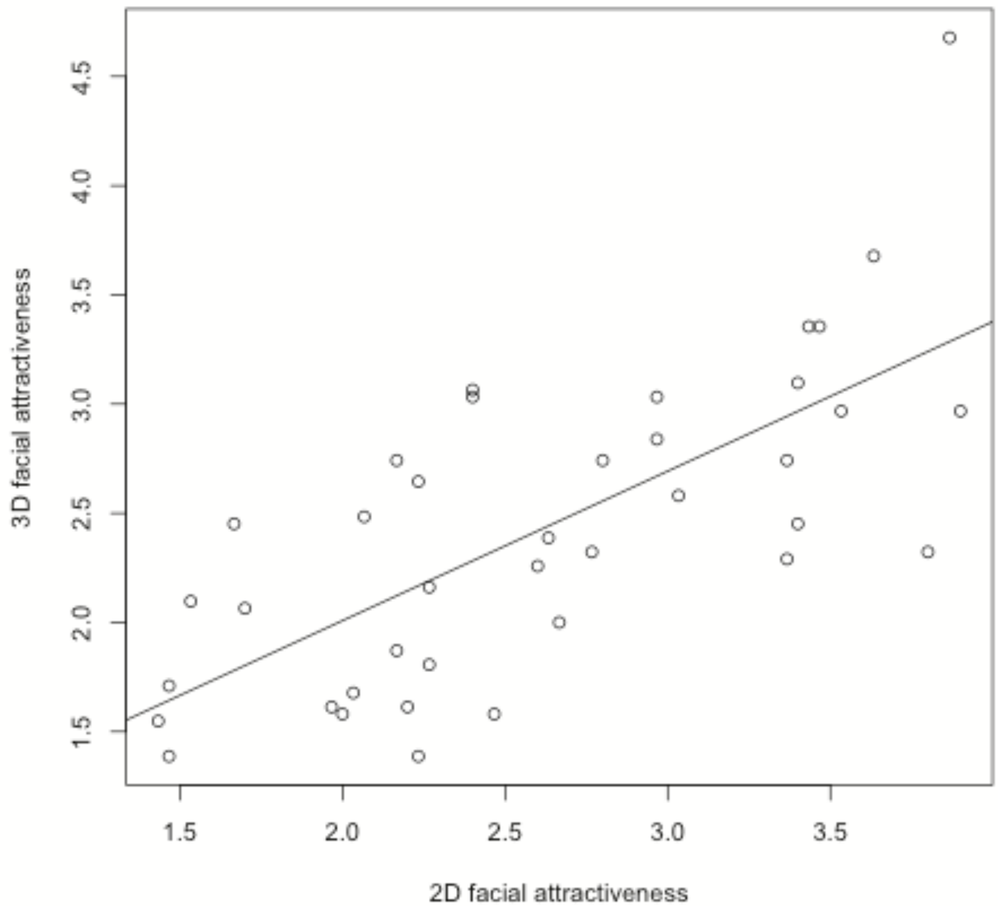

Figure 2. Men's attractiveness ratings of women's faces from 2D images were significantly positively correlated with their attractiveness ratings from 3D images ($N = 39$).

Discussion

We found that men's judgments of women's facial attractiveness from 2D and 3D images were correlated. This result is consistent with results from previous studies showing that facial attractiveness judgments from 2D images are valid and can be replicated in different stimulus presentation formats (O'Connor et al., 2012; Rhodes et al., 2011; Roberts et al., 2009; Saxton et al., 2009). This study, along with other recent studies, provides converging evidence that 2D and 3D facial images contain similar information about women's attractiveness and that women's attractiveness can be judged accurately from 2D images.

Our result suggests that 2D facial images from a single viewpoint and 3D images with 180-degree views contain similar information about women's attractiveness. That 2D and 3D faces were rated similarly in attractiveness when evaluated from either a single viewpoint (2D images) or several viewpoints (3D images), is *not* inconsistent with work showing that face coding is view-specific in both monkeys (Perrett et al., 1991, 1992) and humans (Jeffery et al., 2006, 2007). Rather, it is most likely that 2D images contain enough information about 3D structural elements of the face to accurately assess attractiveness.

We also found that women's faces were rated more attractive in 3D than in 2D images. Although 2D images likely contain enough visual information to accurately access facial attractiveness, 3D images contain more information, which may cause them to be perceived as more attractive overall. It is also possible that raters gave higher ratings to the 3D images because the 3D images were presented as videos, whereas the 2D images were static photographs. Raters may have found the videos of 3D faces more attractive in general because they were more visually stimulated by moving images than by static ones. Furthermore, it should be noted that we standardized inter-pupillary distance in the 2D images but not in the 3D images. Because we found a significant positive correlation between attractiveness ratings in 2D and 3D images despite this difference between stimuli in the two image formats, it is likely that the observed relationship is independent of image size.

It remains to be tested whether perceptions of facial features such as averageness, sexual dimorphism, and symmetry differ in 2D and 3D images. Future studies should test whether perceptions of averageness differ in 2D and 3D facial images. Additionally, it is possible that some of the key determinants of facial masculinity, such as protrusion of the brow ridge and angularity of the jaw, may be easier to assess in 3D than in 2D facial images. For this reason, 3D facial images may be especially important to future research on facial masculinity. 3D images may also provide more accurate measurements of facial symmetry. Lateral head rotation, a potential confound in previous studies on facial symmetry using 2D images (Penton-Voak et al., 2001), does not influence symmetry measurements in 3D images.

Our finding also demonstrates that using 3D images is as valid as using 2D images for research on facial attractiveness and face perception because ratings of facial attractiveness from 3D and 2D images were correlated. By validating this novel method of stimuli presentation, we have introduced a potentially more generalizable method of evaluating perceptions of facial characteristics. This 3D approach could be used in future studies on the influence of gaze direction on attractiveness and other attributions since gaze direction has been shown to influence perceptions of attractiveness (Conway et al., 2008; Jones, DeBruine, Little, Conway, & Feinberg, 2006). Three-dimensional facial images could also be useful to studies investigating view-specific face coding in humans (Jeffery et al., 2006; Jeffery et al., 2007) and could add to our understanding of how viewing angle influences perceptions of different facial features.

Conclusions

In sum, we have shown that women's facial attractiveness is judged similarly from 2D and 3D images. Our data demonstrate that 2D and 3D facial images provide similar information about women's attractiveness and that 2D images are acceptable stimuli, despite the criticism they have received. Nevertheless, 3D images may be important to future work investigating aspects of face perception that are view-specific or that may be measured more accurately in 3D than in 2D.

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CHAPTER 3: ACOUSTIC PREDICTORS OF VOTING RATINGS OF MEN'S AND OF WOMEN'S VOICES

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Preface

In Chapter 2, I found that men's perceptions of women's facial attractiveness from 2D and 3D images were similar. Indeed, 3D facial images have since been used successfully in studies that investigated perceptions of leadership ability from the face. Given this prior work, and that perceptions of facial and vocal attractiveness are positively correlated, I next examine perceptions of leadership ability from the voice. In Chapter 3, I investigate how the acoustic properties of natural men's and of women's voices relate to perceptions of attractiveness, dominance, and voting ratings. It is important to better understand the factors that influence how we choose our leaders because leaders' policies directly affect our everyday lives. Prior studies have related men's and women's voices to perceptions of attractiveness, dominance, and election outcomes, yet the specific acoustic parameters of men's and of women's voices that predict voting ratings are not well understood. In Chapter 3, I demonstrate that men's voice pitch negatively predicts participants' voting ratings, but that no acoustic parameter of women's voices predicts voting ratings. This result indicates that men with lower pitched voices may have an advantage over men with higher pitched voices in elections. In addition, this result highlights the need to better understand perceptions of women's voices in relation to voting ratings, especially because the number of women in leadership positions continues to rise.

Introduction

Human vocal acoustics influence perceptions of attractiveness and dominance (for review see: Feinberg, 2008). Voice pitch, the perception of fundamental frequency (F_0) and/or harmonics, is on average twice as low in men's voices than in women's voices (Titze, 1989). F_0 is produced by vocal fold vibrations in the larynx (Fant, 1960; Titze, 1994, p. 136) and harmonics are component frequencies of a periodic waveform that are integer multiples of F_0 (Titze, 1994, p. 131). Women generally perceive lower pitched men's voices as more attractive than they perceive higher pitched men's voices to be, in natural and pitch-manipulated stimuli (Collins, 2000; Feinberg, DeBruine, Jones, & Little, 2008; Feinberg et al., 2006; Feinberg, Jones, Little, Burt, & Perrett, 2005; Jones, Feinberg, DeBruine, Little, & Vukovic, 2010). Men, on the other hand, generally perceive higher pitched women's voices as more attractive than are lower pitched women's voices in natural and manipulated stimuli (Collins &

Missing, 2003; Feinberg, DeBruine, Jones, & Perrett, 2008; Fraccaro et al., 2010; Jones, Feinberg, DeBruine, Little, & Vukovic, 2008; Jones et al., 2010; Puts, Barndt, Welling, Dawood, & Burriss, 2011).

Lower pitched men's voices also sound more dominant than do higher pitched men's voices to both women (Jones et al., 2010) and men (Jones et al., 2010; Ohala, 1982; Puts, Gaulin, & Verdolini, 2006; Puts, Hodges, Cardenas, & Gaulin, 2007; Wolff & Puts, 2010). Similarly, lower pitched women's voices are also perceived as more dominant than are higher pitched women's voices (Borkowska & Pawlowski, 2011; Jones et al., 2010). Perceptions of physical dominance and social dominance may be separable and perceptions of physical dominance may be more closely related to masculine traits than are perceptions of social dominance (Puts et al., 2006; Watkins, Jones, & DeBruine, 2010). Thus, we have distinguished between these two types of dominance in the current study.

Formant frequencies, or vocal tract resonances, are also lower in men's than in women's voices on average (Titze, 1989). In general, men's voices with lower formants are perceived as more attractive (Feinberg et al., 2011; Pisanski, Mishra, & Rendall, 2012; Pisanski & Rendall, 2011) and dominant (Puts et al., 2007; Wolff & Puts, 2010) than are men's voices with higher formants. Additionally, it has been shown that women's own height and weight predict their attractiveness ratings of lowered versus raised formants in men's voices (Feinberg, Jones, Little et al., 2005). Women's voices with low formants also sound more dominant but less attractive than do women's voices with high formants when low formants are combined with low pitch (Feinberg et al., 2006).

Although voice pitch (Evans, Neave, & Wakelin, 2006; Hamdan et al., 2012; Rendall, Kollias, Ney, & Lloyd, 2005; Rendall, Vokey, & Nemeth, 2007) and formant frequencies (Bruckert, Lienard, Lacroix, Kreutzer, & Leboucher, 2006; Collins & Missing, 2003; Gonzalez, 2004; Gonzalez, 2007; Pisanski & Rendall, 2011; Puts, Apicella, & Cardenas, 2012; Rendall et al., 2005) have each been related to perceptions of same-sex adult body size, it is unclear how well either acoustic parameter relates to body size within same-sex adults.

The functional constraints on voice pitch depend on the length and thickness of the vocal folds, which grow independently from the rest of the body due to testosterone levels at puberty (Harries, Walker, Williams, Hawkins, & Hughes, 1997) and adulthood (Abitbol, Abitbol, & Abitbol, 1999; Dabbs & Mallinger, 1999; Evans, Neave, Wakelin, & Hamilton, 2008; Puts et al., 2012). Unlike voice pitch, formant frequencies are negatively related to vocal tract length (Fitch & Giedd, 1999). Thus, formant frequencies may provide more accurate acoustic cues to a person's height than does voice pitch (for meta-analysis see: Pisanski et al., 2013).

There is also evidence that voice pitch facilitates accurate body size assessments and that the dense harmonic spectrum of low-pitched voices increases the accuracy of size assessments based on formant frequencies (Pisanski, Fraccaro, Tigue, O'Connor, & Feinberg, In Press). People also made a higher proportion of correct size judgments when asked to choose which stimulus sounded larger using information from formants in synthesized stimuli with low F_0 than in stimuli with high F_0 (Charlton, Taylor, & Reby, 2013). Perceptions of body size are important for voting because taller candidates are more likely to win U.S. Presidential elections than are shorter candidates (Sorokowski, 2010) and because taller people are rated as better leaders than are shorter people (Blaker et al., 2013; Re, DeBruine, Jones, & Perrett, 2013; Re, Dzhelyova et al., 2012).

Vocal noise, of which there are several different types, also influences perceptions of a person's voice. Jitter, perturbations in cycle-to-cycle period length of F_0, increases with increasing age (Ramig et al., 2001) and decreasing vocal fold health (Oguz et al., 2007; Stajner-Katusic, Horga, & Zrinski, 2008). The harmonics-to-noise ratio (HNR) is the signal-to-noise ratio of the periodic component of the voice (*i.e.,* F_0) to the aperiodic background noise. Synthesized voices with high HNRs (*i.e.,* less noise) sound more attractive than do synthesized voices with low HNRs (*i.e.,* more noise) (Bruckert et al., 2010). Voices with higher HNR were also rated as more emotionally genuine than were voices with lower HNR (Livingstone, Choi, & Russo, 2014). In natural voices, though, breathier voices sound more attractive than do normal voices (Xu, Lee, Wu, Liu, & Birkholz, 2013), perhaps because HNR is not a good measure of breathiness. Therefore, it is unclear how vocal noise influences voting ratings of voices.

Given that the acoustic parameters of men's and women's voices influence perceptions of attractiveness and dominance, prior work has also explored how voice qualities influence perceptions of leadership ability. A correlative study found that U.S. Presidential candidates whose voices had higher concentrations of acoustic energy at low frequencies were more likely to win the elections (Gregory & Gallagher, 2002). In addition, male CEOs' voice pitch negatively predicted the size of the company they managed and the amount of money they earned (Mayew, Parsons, & Venkatachalam, 2013). Thus, men with low-pitched men's voices may be perceived as better leaders than are men with high-pitched voices, but this was not specifically tested in these studies.

Evidence from studies using pitch-manipulated voices also indicate that participants perceive men with lower pitched voices as better leaders than men with higher pitched voices (Anderson & Klofstad, 2012; Klofstad, Anderson, & Peters, 2012; Tigue, Borak, O'Connor, Schandl, & Feinberg, 2012). Participants preferred to vote for lower pitched men's voices more often than for higher pitched men's voices (Anderson & Klofstad, 2012; Klofstad et al., 2012; Tigue et al., 2012). Tigue et al. (2012) also found that participants perceived lower pitched men's voices as more dominant, attractive, better leaders, more trustworthy, more intelligent, and more honest than were higher pitched men's voices.

Klofstad et al. (2012) also found that participants preferred to vote for lower pitched women's voices more often than for higher pitched women's voices. Subsequent work by the same authors found that the voting preference for lower pitched women's voices was consistent even in the case of hypothetical leadership roles traditionally held by women, such as school board and parent-teacher organization presidents (Anderson & Klofstad, 2012).

Although Anderson & Klofstad (2012) *argued* that voice pitch-based perceptions of leadership ability were consistent across contexts, there were no formal tests of this hypothesis in their work. By contrast, others have *demonstrated* that perceptions of leadership ability are context-dependent. Men's vocal (Tigue et al., 2012) and facial (Little, Burriss, Jones, & Roberts, 2007; Re et al., 2013) dominance positively predicted voting preferences more strongly in hypothetical wartime scenarios than in hypothetical peacetime scenarios. Additionally, participants preferred leaders with attractive faces in stimulated wartime, but preferred leaders with trustworthy faces in stimulated peacetime (Little, Roberts, Jones, & DeBruine, 2012).

There has been little prior work examining the influence of acoustic parameters other than pitch on perceptions of leaders' voices. Therefore, more work is needed to understand the relationship between formant frequencies and voting preferences. Furthermore, to our knowledge, no study has investigated the influence of jitter or HNR on perceptions of leaders' voices. Given that these acoustic properties are related to age (Ramig et al., 2001), health (Oguz et al., 2007; Stajner-Katusic et al., 2008), and attractiveness (Bruckert et al., 2010; Xu et al., 2013), it is important to understand how they influence perceptions of leadership ability.

Therefore, the purpose of this study was to examine how vocal acoustic parameters relate to voting ratings of men's and of women's voices. We measured acoustic parameters from men's and from women's natural voices and had the same voices rated for voting, attractiveness, physical dominance, and social dominance to examine how the acoustics and perceptions of these qualities related to voting ratings.

Given that lower pitched men's voices are perceived as more dominant (Jones et al., 2010; Ohala, 1982; Puts et al., 2006; Puts et al., 2007; Wolff & Puts, 2010) and attractive (Collins, 2000; Feinberg, DeBruine, Jones, & Little, 2008; Feinberg et al., 2006; Feinberg, Jones, Little et al., 2005; Jones et al., 2010; Puts, 2005) than are higher pitched men's voices, and that prior studies have consistently demonstrated a voting preference for lower pitched men's voices (Anderson & Klofstad, 2012; Gregory & Gallagher, 2002; Klofstad et al., 2012; Tigue et al., 2012), we expected to find a significant negative association between men's voice pitch and voting ratings. Given that higher pitched women's voices are perceived as attractive (Collins & Missing, 2003; Feinberg, DeBruine, Jones, & Perrett, 2008; Feinberg, Jones, DeBruine et al., 2005; Jones et al., 2008, 2010; Puts et al., 2011), but lower pitched women's voices are perceived as dominant (Borkowska & Pawlowski, 2011; Jones et al., 2010), and that prior work on women's voice pitch and voting preferences has not been replicated in independent samples (Anderson & Klofstad, 2012; Klofstad et al., 2012), we expected to clarify the relationship between women's voice pitch and voting ratings. Finally, given that no prior study had investigated the influence of jitter or HNR on voting ratings, we expected to identify which of these acoustic parameters relate to voting ratings.

Methods

Stimuli

The Research Ethics Board at McMaster University approved this study. Stimuli were 30 men's and 30 women's voices speaking five English vowel sounds (International Phonetic Alphabet symbols in parentheses: "ah"(α), "ee"(i), "eh"(ε), "oh"(o), "oo"(u)). The men's voices ranged in F_0 from 93 Hertz (Hz) to 144 Hz (*mean*= 114.66 ± 14.34 Hz) and women's voices ranged in F_0 from 170 Hz to 267 Hz (*mean*= 210.32 ± 24.56 Hz). These mean F_0 values correspond well to previously published values for mean adult F_0 for each sex (Table 1).

Table 1. Published mean F_0 values for adults of each sex.

	Mean F_0 ± SEM (Hz)	Sample Size	Reference
Men's Voices	124.6 ± 3.95	27	(Childers & Wu, 1991)
	120	57	(Pisanski & Rendall, 2011)
	109.99 ± 3.18	32	(Re, O'Connor, Bennett, & Feinberg, 2012)
Women's Voices	220.0 ± 5.48	25	(Childers & Wu, 1991)
	207	57	(Pisanski & Rendall, 2011)
	210.82 ± 20.67	32	(Re, O'Connor et al., 2012)
	207.82 ± 20.52	123	(Feinberg, DeBruine, Jones, & Perrett, 2008)

Prior studies on voice pitch and voting preferences used stimuli that encompassed a narrower range of natural voice pitch than the range we used in this study. Klofstad et al. (2012) used stimuli that ranged from 91-116 Hz (*mean*= 107 Hz) for men's voices and 162-207 Hz (*mean*= 187 Hz) for women's voices. Anderson & Klofstad (2012) used stimuli that ranged from 91-116 Hz (*mean*= 107 Hz) for men's voices and 181-207 Hz (*mean*= 195 Hz) for women's voices. In this study, we used stimuli with a wider range of natural voice pitch than was used in prior studies in order to study voting ratings across the entire range of adult voice pitch.

Acoustic Measurements

We performed all acoustic measurements in Praat acoustics phonetics software version 5.3.42 (Boersma & Weenink, 2013). For F_0, jitter, and HNR, we took measurements from the entire utterance of each vocalizer. For formant frequencies, we took measurements from the steady-state portion of each vowel separately and then averaged across all five vowels within each vocalizer. We measured the mean of the F_0 using the autocorrelation algorithm in Praat with a search range of 60-300 Hz for men's voices and 100-600 Hz for women's voices. We then converted the F_0 measurements in Hz to the equivalent rectangular bandwidth (ERB) scale, following Glasberg & Moore (1990, p. 114): ERB = 21.4

* $\log_{10}$ (0.00437*Hz + 1). The ERB scale maps onto perceptual differences in voice pitch more closely than does the Hz scale (Traunmüller, 1990).

We also measured the first four formant frequencies (F_1-F_4; Gonzalez, 2004; Rendall et al., 2005) of each vowel with the Burg Linear Predictive Coding algorithm in Praat (© France Telecom, Boersma & Weenink, 2013; Moulines & Charpentier, 1990). We first overlaid formants on a spectrogram and then manually adjusted them to obtain the best fit. We then calculated from these formant values apparent vocal tract length (VTL) derived from formant spacing (VTL(ΔF)) in centimeters (Reby & McComb, 2003), the strongest acoustic predictor of within-sex differences in body size in a recent meta-analysis (Pisanski et al., 2013). Following Reby & McComb (2003), we calculated formant spacing (ΔF) as the slope of the linear regression line fitted to the frequency values of the first four formants against $(2i-1)/2$ increments, where i is the formant number, and an intercept set equal to zero. We then calculated VTL using the equation VTL = $c/2(\Delta F)$, where c is the speed of sound set equal to 35000 cm/s (Reby & McComb, 2003).

We also measured five jitter parameters (local, local absolute, rap, ppq5, and ddp) with the cross-correlation algorithm in Praat. We then conducted a principal components analysis (PCA) on the five jitter measures to obtain a single measure of jitter for each stimulus. There was one female stimulus and one male stimulus whose jitter measures were statistically significant outliers, so we conducted the PCA again, excluding these two stimuli. Finally, we measured the harmonics-to-noise ratio (HNR) for each stimulus[1].

Participants

We recruited 41 men (*mean age*= 18.56 ± 2.91 years, *age range*= 17-36 years) and 40 women (*mean age*= 18.80 ± 2.36 years, age *range*= 17-31 years) as laboratory participants from the undergraduate psychology participant pool at McMaster University and compensated them with course credit or payment. We also recruited 65 women (*mean age*= 39.26 ± 10.86 years, age *range*= 20-64 years) and 52 men (*mean age*= 37.67 ± 10.40 years, age *range*= 21-76 years) online. The online participants were recruited either through Amazon Mechanical Turk (*N*= 98; www.mturk.com) and compensated with payment of $1-2 or they volunteered through Facebook (*N*= 19; www.facebook.com).

Ratings Procedure

To create stimuli for ratings, we inserted 350 ms of silence between each vowel sound of each voice identity using Praat to standardize the inter-stimulus interval and normalized the amplitude of each vowel separately to 70 dB root mean squared sound pressure level in Praat.

[1] We did not include shimmer in our analysis because head movement confounds periodic variability in amplitude and our microphone was not head mounted. Shimmer measurements were also highly correlated with HNR measurements (Pearson's r = -.649 for women's voices and r = -.887 for men's voices).

Laboratory participants (*N*= 81) listened to each stimulus through over-ear headphones connected to a computer and clicked on a play button on the computer screen to play each stimulus. Laboratory participants rated each stimulus on scale of 1 to 7 for each of four attributions, in separate blocks: (1) How attractive is this voice? (1= Very unattractive, 7= Very attractive); (2) How physically dominant is this voice? (1= Not at all physically dominant, 7= Very physically dominant); (3) How socially dominant is this voice? (1= Not at all socially dominant, 7= Very socially dominant); (4) How likely are you to vote for this person in an election? (1= Very unlikely, 7= Very likely). We presented voice stimuli in random order within randomized separate blocks by sex of voice and by attribution category. The order in which laboratory participants completed each attribution category and the order of voice identities within each category were each fully randomized between participants.

We asked participants to read the following definitions for physical and social dominance before rating the voices: *Physical dominance:* A physically dominant person would be likely to win a fist-fight with the average same-sex undergraduate (modified from Puts et al., 2006 to include both sexes, instead of only men); *Social dominance:* A socially dominant person tells other people what to do, is respected, influential, and often a leader; whereas submissive people are not influential or assertive and are usually directed by others (modified from Mazur, Halpern, & Udry, 1994, who used this definition for dominance in general, rather than social domiance specfically).

Online participants (*N*= 117) completed the experiment via www.voiceresearch.org and were instructed to listen to each stimulus through headphones connected to a computer or through the computer's speakers. Online participants rated each stimulus for voting likeliness only. Stimuli were grouped by sex and the order in which online participants listened to men's and women's voices and the order of voice identities within each group were fully randomized.

Political Attitudes Survey

After completing the voice ratings, both laboratory and online participants completed an online survey about their political attitudes based on the Wilson-Patterson Issue Battery (Wilson & Patterson, 1968), following Oxley et al. (2008). For each of the 27 survey items, participants were asked to "Please indicate whether you agree or disagree with the topic listed below" by choosing one of the following options: Agree, Disagree, or Uncertain. The order of survey items was randomized between participants.

Following Oxley et al. (2008), we computed a single additive score for each participant based on their responses to the survey items relating to policies concerned with protecting the interests of the participants' group from threats. For survey items for which agreement indicated *more* support for protective policies (military spending, warrantless searches, death penalty obedience, patriotism, war, school prayer, biblical truth), we scored responses as agree=1, disagree=0, and uncertain=0.5. The survey items for which agreement indicated *less* support for protective policies (pacifism, illegal immigration, gun control, foreign aid, compromise, premarital sex, gay marriage, abortion rights, pornography) were reverse coded so that agree=0, disagree=1, and uncertain=0.5. We then calculated the sum of these responses for each participant, so that higher values of this variable indicated more agreement with protective policies.

Results

We used linear mixed effects modeling with non-random slopes to test for effects of vocal acoustics on participants' voting ratings using R (R Core Team, 2013), *lme4* (Bates, Maechler, Bolker, & Walker, 2014), and *lmerTest* (Kuznetsova, Bruun Brockhoff, & Haubo Bojesen Christensen, 2013). We used voting rating as the dependent variable, measured at the observation level and grouped by voice stimulus, with voice stimuli grouped by participant. As random effects, we had intercepts for stimulus and participant. As fixed effects, we entered participant age, participant sample (laboratory or online), participant sex, stimulus sex, stimulus F_0 (ERB), stimulus VTL (ΔF) (cm), stimulus jitter, stimulus HNR, participant agreement with protective policies, as well as the interaction between participant age and participant sample and all possible interactions between participant sample, participant sex, stimulus sex, and each acoustic variable and participant agreement with protective policies.

Analysis of the full model showed no significant interactions with jitter, HNR, participants' support for protective policies, or participant sample (all $z \leq 1.82$, all $p \geq .068$), except the 3-way interaction between participant sample, stimulus sex, and VTL(ΔF) ($z = 2.06$, $p = .039$). We removed the highest order non-significant interactions from the model, but left non-significant interactions in the model where the differences between these interactions were significant. We then compared the reduced model to the null model including only random intercepts for stimulus and participant and found that the reduced model predicted voting ratings significantly better than did the null model ($\chi^2(15) = 62.05$, $p < .001$).

Analysis of the reduced model showed a significant 3-way interaction between stimulus VTL(ΔF), stimulus sex, and participant sample ($z = 2.47$, $p = .013$) and a significant 2-way interaction between stimulus sex and participant sample ($z = -2.19$, $p = .03$). Stimulus VTL(ΔF) had no significant effect on laboratory participants' voting ratings of men's ($z = -1.22$, $p = .23$) or women's voices ($z = -1.28$, $p = .21$), nor on online participants' voting ratings of men's ($z = -1.76$, $p = .09$) or women's voices ($z = -1.02$, $p = .32$).

The reduced model also showed that there was a significant interaction between stimulus F_0 and stimulus sex ($z = -2.82$, $p = .007$). Stimulus F_0 had a significant negative effect on voting ratings of men's voices ($z = -3.42$, $p = .001$), but had no significant effect on voting ratings of women's voices ($z = -0.20$, $p = .85$). There was also a significant interaction between stimulus F_0 and participant sex in the reduced model ($z = 2.59$, $p = .01$). Stimulus F_0 significantly negatively predicted women's ($z = -3.99$, $p < .001$) and men's ($z = -3.96$, $p < .001$) voting ratings of men's voices. Stimulus F_0 did not significantly predict women's ($z = -0.42$, $p = .68$) or men's voting ratings ($z = 0.69$, $p = .49$) of women's voices.

There was a significant main effect of participant sample ($z = 1.99$, $p = .046$) whereby online participants reported higher voting ratings than did laboratory participants. There was also a significant main effect of participant sex ($z = -2.81$, $p = .005$) whereby men reported higher voting ratings than did women. There were no other significant interactions or main effects in the reduced model (all $z \leq 1.78$, all $p \geq .08$).

To test if the relationship between stimulus F_0 and voting ratings was quadratic rather than linear, we substituted (stimulus F_0)^2 for stimulus F_0 in the reduced model. We found no significant effects of (stimulus F_0)^2 in this model, suggesting that the relationship between stimulus F_0 and voting ratings is more accurately represented by a linear equation than by a quadratic one.

Next, we tested for effects of attractiveness, social dominance, and physical dominance ratings on laboratory participants' voting ratings. To test for collinearity among attractiveness, physical dominance, and social dominance ratings, we first built a linear mixed effects model with voting rating as the dependent variable, intercepts for stimulus and participant as random effects, and participant age, participant sex, stimulus sex, attractiveness, social dominance, and physical dominance ratings as fixed effects, with no interactions. We calculated the variance inflation factor (VIF) of each predictor in this model using the *vif* function in R and found no evidence for collinearity among these predictors (all VIF ≤ 1.06, all Pearson's $r \leq .404$ among attractiveness, physical dominance, and social dominance ratings of men's or women's voices, separately), so we included each of them in our model.

We analyzed a linear mixed effects model similar to the full model described above except that we removed participant sample as a fixed factor as well as all interactions with participant sample. We added to the model attractiveness, social dominance, and physical dominance ratings as fixed factors, as well as all possible interactions between participant sex and stimulus sex with attractiveness, social dominance, and physical dominance ratings.

There were no significant interactions with jitter, HNR, VTL(ΔF), or participants' support for protective policies (all $z \leq 1.40$, all $p \geq .16$). We removed the highest order non-significant interactions from the model, but left non-significant interactions in the model where the differences between these 2nd order interactions were significant at the 3rd order. We then compared the reduced model to the null model including only random intercepts for stimulus and participant and found that the reduced model predicted voting ratings significantly better than did the null model ($\chi^2(21) = 122.94$, $p < .001$).

The reduced model showed significant 3-way interactions between attractiveness, stimulus sex, and participant sex ($z = -1.99$, $p = .046$) and between social dominance, stimulus sex, and participant sex ($z = 2.50$, $p = .012$). There were also significant 2-way interactions between physical dominance and stimulus sex ($z = -1.97$, $p = .049$) and between physical dominance and participant sex ($z = -2.61$, $p = .009$). Attractiveness ratings had a significant positive effect on women's voting ratings of men's ($z = 2.30$, $p =.022$) and women's voices ($z = 2.42$, $p = .016$), and on men's voting ratings of women's ($z = 4.06$, $p < .001$), but not men's voices ($z = -0.18$, $p = .86$). Social dominance ratings had a significant positive effect on men's ($z = 2.65$, $p = .008$) and women's voting ratings of women's voices ($z = 3.88$, $p < .001$), but had no significant effect on men's ($z = 1.52$, $p =.13$) or women's voting ratings of men's voices ($z = -0.89$, $p = .37$). Physical dominance ratings positively predicted women's voting ratings of women's voices ($z = 3.88$, $p < .001$), but had no significant effect on women's voting ratings of men's voices or men's voting ratings of men's or women's voices (all $z \leq 1.45$, all $p \geq .15$). There was also a significant main effect of stimulus sex ($z = 2.87$, $p = .006$). There were no other significant interactions or main effects in the reduced model (all $z \leq -1.96$, all $p \geq .050$). The *p*-value for the interaction between participant sex and social dominance ratings was close to, but not less than, the alpha level of .05 ($z = -1.96$, $p = .0504$).

We also tested for effects of vocal acoustics on laboratory participants' ratings of attractiveness, social dominance, and physical dominance. We analyzed three separate linear mixed effects models similar to those described above except that we used attractiveness, social dominance, or physical dominance ratings as the dependent variable. When we compared each of these models to its corresponding null model, separately, we found that each model predicted the dependent variable significantly better than did the null model (all $\chi^2(12) \geq 34.40$, all $p < .001$). Analyses of these models showed that men's F_0 significantly negatively predicted men's ($z = -2.37$, $p = .02$) and women's ($z = -5.48$, $p < .001$) attractiveness ratings. Women's F_0 significantly positively predicted men's attractiveness ratings ($z = 2.90$, $p = .007$), but not women's attractiveness ratings ($z = .016$, $p = .99$).

Men's F_0 significantly negatively predicted men's ($z = -3.89$, $p < .001$) and women's ($z = -2.97$, $p = .006$) social dominance ratings. Women's F_0 did not significantly predict men's ($z = .12$, $p = .90$) or women's ($z = -1.24$, $p = .22$) social dominance ratings. Men's F_0 significantly negatively predicted men's ($z = -8.21$, $p < .001$) and women's ($z = -10.05$, $p < .001$) physical dominance ratings. Women's F_0 also significantly negatively predicted men's ($z = -4.12$ $p < .001$) and women's ($z = -3.59$, $p = .001$) physical dominance ratings. Men's and women's VTL did not significantly predict men's or women's social dominance ratings (all $z \leq -1.03$, all $p \geq .31$). Men's VTL significantly negatively predicted women's ($z = -2.08$, $p = .047$) ratings of physical dominance. Women's VTL did not significantly predict men's or women's physical dominance ratings, and men's VTL did not significantly predict men's physical dominance ratings (all $z \leq -1.19$, all $p \geq .24$).

Discussion

The purpose of this study was to investigate how the acoustic properties of the voice predict voting ratings. First, we found that voice pitch significantly negatively predicted men's and women's voting ratings of men's voices. Thus, men and women reported that they were more likely to vote for men with lower pitched voices, which is consistent with the results of prior studies (Anderson & Klofstad, 2012; Klofstad et al., 2012; Tigue et al., 2012). The significant interaction between stimulus voice pitch and participant sex also showed that men's voice pitch had a stronger effect on women's voting ratings than it did on men's voting ratings. This result implies that men's voice pitch may influence women's voting decisions more strongly than it influences men's voting decisions.

We also found that voice pitch did not significantly predict men's or women's voting ratings of natural women's voices. By contrast, two prior studies found that participants preferred to vote for lower pitched women's voices more often than higher pitched women's voices in pitch-manipulated stimuli (Anderson & Klofstad, 2012; Klofstad et al., 2012). Anderson & Klofstad (2012) also argued that the voting preference for low-pitched women's voices extends across different voting contexts. The result of the current study showing no significant relationship between natural women's voice pitch and voting ratings, however, indicates that the relationship between women's voice pitch and voting preferences may not be as well understood as Anderson & Klofstad (2012) imply.

The two previously published studies on women's voice pitch and voting preferences used pitch-manipulated stimuli within a relatively narrow range of voice pitch (Anderson & Klofstad, 2012; Klofstad et al., 2012). Those stimuli included the lower end, but not the higher end, of the natural range of women's voice pitch. It is possible that within this narrow range of women's voice pitch, people prefer to vote for lower pitched women's voices. In the current study, when we used stimuli encompassing a wider range of women's natural voice pitch, including higher pitched women's voices typical of younger women, we found no significant influence of women's voice pitch on voting ratings. Thus, it may be that the pattern of results reported in prior studies is true for women's voices with low, but not high, voice pitch.

Compared to research on perceptions of men's leadership ability from the voice, there has been relatively little work on perceptions of women's leadership ability from the voice. To our knowledge, the results of two published experimental studies have not been replicated by other researchers using independent samples (Anderson & Klofstad, 2012; Klofstad et al., 2012). It is also unclear whether these two studies used overlapping stimuli sets. The number (10), mean age (33 years), pitch range (91-116 Hz), and mean pitch (107 Hz) of the men's voices used in both studies are exactly the same (Anderson & Klofstad, 2012; Klofstad et al., 2012). The features of the women's voice stimuli used in these two studies are also similar. In Anderson & Klofstad (2012) and Klofstad et al. (2012), respectively, the mean ages of women's voices were 28 and 31 years, the pitch ranges were 181-207 Hz and 162-207 Hz, and the mean pitch values were 195 Hz and 187 Hz.

Given the close similarity between the women's voice stimuli used in both prior studies that manipulated women's voice pitch, it is possible that the effects they observed are specific to stimuli with those particular characteristics. Our current study did not manipulate women's voice pitch. In order to more fully understand how women's voice pitch influences voting ratings, it is important to measure voting preferences for women's voices manipulated in pitch in a set of stimuli that is more representative of women's voices on the whole. Given that the set of women's voice stimuli we used in the current study includes a wider range of voice pitch than stimuli in prior studies (Anderson & Klofstad, 2012; Klofstad et al., 2012), and that the average pitch of our sample is closer to the average pitch values reported in the literature (see Table 1), we predict that the results reported here may be more generalizable to the broader population than those reported by other studies (Anderson & Klofstad, 2012; Klofstad et al., 2012).

We also found that apparent VTL did not significantly predict men's or women's voting ratings of men's or women's voices. Apparent VTL was negatively related to online participants' voting ratings of men's voices more strongly than it was related to laboratory participants' voting ratings of men's voices. Apparent VTL was also negatively related to laboratory participants' voting ratings of women's voices more strongly than it was related to online participants' voting ratings of women's voices. These effects were not significant and this trend was not consistent for other acoustic features, providing little evidence that differences between laboratory and online participants' ratings are due to differences in equipment or other random factors.

Given that formant frequencies provide vocal cues to height within sexes (for meta-analysis see: Pisanski et al., 2013), we predicted that people would prefer to vote for voices with longer apparent VTL. This prediction was based on prior work showing that taller candidates are more likely to win U.S. Presidential elections than are shorter candidates (Sorokowski, 2010) and that taller men are rated as better leaders than are shorter men (Blaker et al., 2013). Although we found no support for the prediction that people prefer to vote for voices with longer apparent VTL, this relationship needs to be investigated more thoroughly, perhaps using stimuli with manipulated formants. To our knowledge, no study has examined the influence of manipulated formant frequencies on voting preferences (see Chapter 5 of this dissertation).

We found no significant effects of jitter or HNR on voting ratings. Prior studies have found that jitter influences perceptions of health (Oguz et al., 2007; Stajner-Katusic et al., 2008) and age (Ramig et al., 2001) and that HNR influences perceptions of attractiveness (Bruckert et al., 2010; Xu et al., 2013). Here, we found no evidence that jitter or HNR influenced voting ratings. Given that the influence of jitter and HNR on voting preferences has not been investigated previously, and that our study did not manipulate these parameters, future experimental studies will be important to further investigate how these acoustic factors influence voting preferences. Indeed acoustic characteristics such as women's voice pitch appear to predict voting preferences in manipulated (Anderson & Klofstad, 2012; Klofstad et al., 2012), but not natural voices, so it is reasonable to assume jitter and/or HNR could also affect voting ratings when selectively manipulated.

Additionally, we found no evidence that participants' support for policies concerned with protecting the interests of their group from threats influenced voting ratings. Importantly, participants' support for protective policies did not significantly interact with any of the acoustic variables in our model. Thus, the results reported here cannot be explained by individual differences in political attitudes.

We found that women's attractiveness ratings positively predicted their voting ratings of both men's and women's voices, and that men's attractiveness ratings positively predicted their voting ratings of women's, but not men's voices. Therefore, men and women said they were more likely to vote for more attractive women's voices, and women said they were more likely to vote for more attractive men's voices. The men and women in our sample also rated lower pitched men's voices as more attractive than higher pitched men's voices. While men rated higher pitched women's voices as more attractive, women did not. This result supports prior studies showing that women do not perceive high-pitched women's voices as attractive (Collins & Missing, 2003; Feinberg, DeBruine, Jones, & Perrett, 2008; Puts et al., 2011).

These results are consistent with prior work showing that perceptions of attractiveness positively predicted voting preferences for men's voices (Tigue et al., 2012). This result is the first, to our knowledge, to demonstrate that perceptions of women's voice attractiveness positively predict voting ratings of women's voices. Interestingly, this finding held despite the result that voice pitch did not predict men's or women's voting ratings of women's voices, and that voice pitch did not predict women's attractiveness ratings of women's voices. Importantly, this result shows that the social perception of the voice influences voting choices, not a lower level general response to stimuli varying in pitch.

Prior work found that participants preferred to vote for lower pitched women's voices (Anderson & Klofstad, 2012; Klofstad et al., 2012), which are generally perceived to be less attractive than are higher pitched women's voices (Collins & Missing, 2003; Feinberg, DeBruine, Jones, & Perrett, 2008; Jones et al., 2008, 2010; Puts et al., 2011). Therefore, the results of prior studies imply that participants in those studies preferred to vote for less attractive women's voices, but these studies did not measure attractiveness ratings. In our study, where we measured both attractiveness ratings and voting ratings, we found that people preferred to vote for attractive voices, regardless of the relationship between voice pitch and attractiveness. It is important for future studies to measure perceptions of women's voice attractiveness as well as voting preferences so that the nature of the relationship between perceptions of women's attractiveness and voting preferences can be more fully understood.

We also found that social dominance ratings positively predicted voting ratings of women's, but not of men's, voices. Participants were more likely to vote for women's voices that they perceived as more socially dominant. Again, this relationship was independent of any relationship between women's voice pitch and perceived social dominance. Participants' perceptions of men's social dominance, however, did not significantly predict their voting ratings. In addition, physical dominance ratings significantly positively predicted women's voting ratings for women's voices. Thus, women said they were more likely to vote for women's voices they perceived as more physically dominant. In contrast, physical dominance ratings did not significantly predict women's voting ratings of men's voices, or men's voting ratings of men's or women's voices. Our results suggest that perceptions of women's physical dominance influence women's voting ratings more strongly than they influence men's voting ratings.

To our knowledge, this study is the first to show that perceptions of women's attractiveness and dominance positively predicted men's and women's voting ratings. Thus, while voice pitch influences perceptions of women's attractiveness and dominance in opposite directions, perceptions of women's attractiveness and dominance influenced voting ratings in the same direction. This result again supports the idea that perceptions of attractiveness and dominance each independently influence voting ratings regardless of the relationships between women's voice pitch and these perceptions.

We found no evidence that perceptions of men's social or physical dominance influenced voting ratings. This result does not support a prior study showing that perceptions of men's dominance positively predicted voting preferences, especially in hypothetical wartime (Tigue et al., 2012). This prior study did not distinguish between social and physical dominance perceptions and the current study did not test voting preferences in different hypothetical contexts. Prior work suggests that participants' voting preferences are particularly sensitive to cues to men's dominance in hypothetical wartime and are less sensitive to these cues when voting in a hypothetical national election (Tigue et al., 2012). The voting context in the current study was generic: "How likely are you to vote for this person in an election?" Given that prior work suggests that perceptions of men's dominance influence voting preferences differently in different contexts, it is possible that in this generic voting context, perceptions of men's dominance did not influence voting ratings at all. It could be that perceptions of men's dominance only influence voting in contexts where there is some cue to threat or the use of force.

To test this hypothesis, future work could measure perceptions of men's social and physical dominance and voting ratings in a range of hypothetical contexts. We would predict that perceptions of men's dominance positively predict voting ratings most strongly in contexts related to the use of force and would predict voting ratings weakly or not at all in contexts related to peace. Thus, while dominance is an important construct for leadership (Little et al., 2007; Tigue et al., 2012) and perceptions of dominance are often related to voice pitch (Feinberg et al., 2006; Puts et al., 2007; Wolff & Puts, 2010), we found that the relationship between dominance and voting is not perfect, and also varies depending on context (Tigue et al., 2012).

We found no effect of participant age on voting ratings. Thus, we found no evidence that voting ratings differed among younger or older participants. The age range of the participants in the current study (17-76 years, *N*= 198) includes the mean age of participants in Anderson & Klofstad's (2012) two studies (20.6 years for men and 20.4 years for women, *N*= 71 and 19.8 years for men and 20.7 yrs for women, *N*= 75). Neither Anderson & Klofstad (2012) nor Klofstad et al. (2012) reported the age *range* of the participants in their studies, but it would be useful to compare voting preferences among participants of different age groups in future studies. Nevertheless, given the similarity in mean ages between this study and previous studies, it is reasonable to assume that these samples are comparable. In addition, participant sample did not interact with participant age in our model.

We also found no evidence that vocal acoustics influenced voting ratings significantly differently between the laboratory and online participants. Thus, we found no evidence to suggest that the results of prior studies that investigated the influence of voice pitch on voting preferences among undergraduate participants

(Anderson & Klofstad, 2012; Klofstad et al., 2012; Tigue et al., 2012) would differ among participants outside the laboratory.

In summary, we found that natural voice pitch negatively predicted voting ratings of men's, but not of women's, voices. This result supports those of prior studies that showed that participants preferred to vote for manipulated lower pitched men's voices. Our results also suggest that the relationship between women's voice pitch and voting preferences is not as well understood as previous studies implied. Additionally, we found no evidence that apparent VTL (*i.e.,* formant frequencies), jitter, or HNR significantly predicted voting ratings of men's or of women's voices.

We found that perceived attractiveness had a positive effect on voting ratings of men's voices rated by women and of women's voices rated by men and women. Perceptions of social dominance also had a positive effect on voting ratings of women's voices, while perceptions of physical dominance had a positive effect only on women's voting ratings of women's voices. Finally, we found no evidence that participants' age, political attitudes, or whether they completed the study in the laboratory or online significantly affected their voting ratings. Thus, there is no evidence to suggest that the results of studies on voice-based voting preferences among undergraduates differ from those in other voter demographics. Our results add to the growing evidence that low voice pitch is an important predictor of voting ratings of men's voices, but that the relationship between women's voice pitch and voting ratings remains unclear.

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CHAPTER 4: VOICE PITCH INFLUENCES VOTING BEHAVIOR

Tigue, C.C., Borak, D.J., O'Connor, J.J.M., Schandl, C., & Feinberg, D.R. (2012). Voice pitch influences voting behavior. *Evolution and Human Behavior, 33,* 210-216.

Preface

In Chapter 3, I found that men's voice pitch negatively predicted voting ratings of natural men's voices. Therefore, in Chapter 4, I investigate how voting preferences for men's voices are affected by manipulating men's voice pitch. Manipulating voice pitch allows me to isolate the effect of voice pitch on voting preferences while holding all other acoustic variables constant. In Chapter 4, I demonstrate that participants prefer to vote for lower pitched men's voices more often than to vote for higher pitched men's voices. This result is consistent with the results of Chapter 3, indicating that men with lower pitched voices may have an advantage in elections. In this chapter, I also demonstrate that perceptions of men's dominance predict voting preferences better than do perceptions of men's attractiveness in hypothetical wartime. This result indicates that cues to men's dominance may be more important qualities in leaders than are cues to men's attractiveness in wartime. Furthermore, I demonstrate that participants prefer to vote for lower pitched men's voices regardless of whether the voices are known or unknown to them and regardless of whether they listen to two versions of the same identity or two different identities. Overall, the results of Chapter 4 suggest that men's voice pitch influences voting preferences in a potentially adaptive manner. Humans likely possess evolved mechanisms that allow them to extend judgments about the efficacy of individual force to the use of coalitional force in military combat.

Abstract

It may be adaptive for voters to recognize good leadership qualities among politicians. Men with lower pitched voices are found more dominant and attractive than are men with higher pitched voices. Candidate attractiveness and vocal quality relate to voting behavior, but no study has tested the influence of voice pitch on voting-related perceptions. We tested whether voice pitch influenced perceptions of politicians and how these perceptions related to voting behavior. In Study 1, we manipulated voice pitch of recordings of U.S. presidents and asked participants to attribute personality traits to the voices and to choose the voice they preferred to vote for. We found that lower pitched voices were associated with favorable personality traits more often than were higher pitched voices and that people preferred to vote for politicians with lower pitched rather than higher pitched voices. Furthermore, lower voice pitch was more strongly associated with physical prowess than with integrity in a wartime voting scenario. Thus, sensitivity to vocal cues to dominance was heightened during wartime. In Study 2, we found that participants preferred to vote for the candidate with the lower pitched voice when given the choice between two unfamiliar men's voices speaking a neutral sentence. Taken together, our results suggest that candidates' voice pitch has an important influence on voting behavior and that men with lower pitched voices may have an advantage in political elections.

1. Introduction

Natural selection may have favored the ability to detect qualities of effective leadership because the choice of a leader affects an individual's ability to survive and reproduce within a social group (Darwin, 1871; Trivers, 1971). Today, group leaders are often chosen in national elections. Government officials directly affect social policies that contribute to reproductive success via allocation of vital resources. Therefore, choosing good leadership qualities in political candidates may be adaptive.

Despite the ubiquity of visual media technology, the sound of politicians' voices alone may influence voters' perceptions of candidates. Indeed, it has been shown that politicians with more attractive voices are perceived more positively than politicians with less attractive voices (Surawski & Ossoff, 2006). Furthermore, Gregory and Gallagher (2002) analyzed audio tapes from 19 U.S. presidential debates between 1960-2000 and found that those candidates who had more acoustic energy concentrated at lower vocal frequencies won the popular vote of all eight elections they analyzed.

Studies of men's vocal attractiveness have identified voice pitch as a strong acoustic correlate of male vocal attractiveness (Collins, 2000). Subsequent studies have demonstrated that both men and women find men with lower pitched voices to be more attractive (Feinberg et al., 2008; Feinberg et al., 2005; Jones et al., 2010) and dominant (Jones et al., 2010; Puts et al., 2006; Puts et al., 2007) than those with higher pitched voices. Jones et al. (2010) demonstrated that both men and women are equally sensitive to the relationship between voice pitch and male dominance.

Low voice pitch may have in part evolved as a dominance cue among men (Puts, 2010 for review). Subordinate men change their vocal pitch and speech patterns to match those of dominant men (Gregory & Webster, 1996), and men who think they are relatively more dominant lower their voice pitch in response to mate competition, whereas men who think they are relatively less dominant raise the pitch of their voices in response to mate competition (Puts et al., 2006).

Although voting decisions result from a complex interaction of factors, mate-choice relevant factors can influence voting behavior. Recently, Navarrete et al. (2010) showed that women's conception risk positively predicted their intention to vote for Barack Obama in the 2008 U.S. presidential election, and that this effect was strongest among women who perceived him as more white than black. Little et al. (2007) demonstrated that voters preferred to vote for candidates with relatively more masculine and dominant faces, but not relatively more attractive faces. Furthermore, a candidate's facial appearance can influence voters' perceptions in a very short period of time. Todorov et al. (2005) showed that inferences of competence from a 1-second exposure to candidates' faces accurately predicted the outcomes of U.S. congressional elections from 2000-2004. Little et al. (2007) also showed that voters preferred masculine and dominant faces in wartime but preferred attractive faces in peacetime.

When at war, it may be particularly important to choose an effective group leader. There is recent evidence that people can accurately assess upper body strength from men's voices and that these vocal cues can be used to assess men's fighting ability (Sell et al., 2010). Unlike strength, perceptions of body size based on voice pitch are often wrong and exhibit a consistent misattribution bias (Rendall et al., 2007). Vocal cues to physical strength may be more important in a leader during wartime than in peacetime because stronger men are more likely to favor the use of military force than are weaker men (Sell et al., 2009).

While facial appearance alters voting behavior (Little et al., 2007; Todorov et al., 2005), and voice qualities are related to election outcomes and voting behavior (Gregory & Gallagher, 2002; Surawski & Ossoff, 2006), no study has investigated the role of voice pitch in voting-related perceptions. In Study 1, we addressed this gap in the literature using voice recordings of past U.S. presidents. We manipulated the voice pitch of each recording and asked participants to attribute personality traits and to choose the version of the voice they preferred to vote for. We hypothesized that voice pitch would be negatively related to voting choices. We also hypothesized that the relationship between voice pitch and dominance would more strongly influence voting behavior in the wartime scenario than in the general national election scenario.

In Study 2, we tested whether the effects we observed in Study 1 could be replicated using unfamiliar male voices speaking a neutral sentence. We manipulated the pitch of each voice and asked participants to choose the voice they preferred to vote for between a high pitch version of one person's voice and the low pitch version of a different person's voice. Again, we hypothesized that voice pitch would be negatively related to voting choices.

2. Study 1

2.1 Methods

2.1.1 Participants

Participants (*N*=125) included 61 females (*mean age* = 19.61 ± 2.23 years) and 64 males (*mean age* = 21.59 ± 4.23 years) who received course credit or payment in exchange for participation.

2.1.2 Stimuli

We obtained voice recordings of nine United States presidents from the online archive of the Vincent Voice Library of Michigan State University (http://vvl.lib.msu.edu; Appendix). We created a lower pitched and higher pitched version of each president's voice using the Pitch-Synchronous Overlap Add (PSOLA ® France *Telecom*) method in Praat software (Boersma & Weenink, 2009). The PSOLA method selectively manipulates fundamental frequency and related harmonics while controlling for other spectrotemporal features of the acoustic signal (Feinberg et al., 2005). We manipulated voice pitch by raising or lowering the pitch by 0.5 equivalent rectangular bandwiths (ERBs) of the baseline frequency, which is perceptually equivalent to lowering the pitch of an average male voice (120 Hz) by 20 Hz and corrects for the difference between actual fundamental frequency and perceived fundamental frequency (Traunmüller, 1990). This level of pitch manipulation has been used successfully in previous studies on voice pitch (Apicella & Feinberg, 2009; Feinberg et al., 2008; Jones et al., 2008, 2010; Vukovic et al., 2008).

2.1.3 Procedure

We organized trials into two blocks, each comprised of nine trials (one for the two versions of each president's voice) for each of five attributions, for a total of 45 trials per block. In one block, the five attribution categories presented were: "Choose the voice that (1) sounds more attractive; (2) would be a better leader; (3) is a more honest leader; (4) sounds more trustworthy; and (5) you are most likely to vote for in a national election." The five attribution categories in the other block were: "Choose the voice that (1) sounds more dominant; (2) you think would better handle the current economic situation; (3) sounds more intelligent; (4) you think is more likely to be involved in a government scandal; and (5) you are more likely to vote for in a time of war." The order of attribution categories was randomized within each block and the order of the two blocks was counterbalanced between participants.

In each trial, the lower and higher pitched versions of one president's voice were presented on a computer screen in a two-alternative forced choice paradigm. Participants listened to each version of the voice consecutively through headphones connected to the computer. The side of the screen on which the play button for each version of the voice was displayed was randomized. Presidents' identities were grouped by attribution category, but were randomly ordered within attribution categories.

2.1.4 Statistics

For each attribution, we calculated the proportion of trials in which each participant chose the lower pitched voice. Therefore, each variable used in our analyses reflects the proportion of trials in which lower pitched voices were chosen for that particular attribution. We used SPSS Statistics 19.0 with two-tailed *p* values.

2.2 Results

2.2.1 Initial processing of data

To test for differences in the responses of men and women, we preformed independent samples *t* tests. After Bonferroni correction for multiple comparisons at the α =.005 level, we found that women chose lower pitched voices significantly more often than men for the attribution of intelligence (t_{123} = -3.305, *p* = .003), while the difference between sexes for ability to handle the current economic situation was very close to significance (t_{123} = -2.801, *p* = .006). There were no other sex differences in responses after correcting for multiple comparisons at the α =.005 level (all $|t|_{123} < 2.470$, all $p \geq .015$). Therefore, we combined the responses of both sexes in subsequent analyses.

2.2.2 Influence of voice pitch on perceptions

To determine if participants chose lower pitched voices more or less often than predicted by chance (0.50), we performed one-sample *t* tests for each attribution, separately (Table 1). After Bonferroni correction for multiple comparisons at the α =.005 level, we found that participants chose lower pitched voices significantly more often than predicted by chance for each of the attributions (all $|t|_{124} > 3.493$, all $p \leq .001$) except likelihood of involvement in a government scandal, for which participants chose lower pitched voices significantly less often than predicted by chance ($t_{124} = -3.724$, $p < .001$). We repeated the above *t* tests using only the first attribution category that each participant completed and found that there were no differences in the directions of the relationships reported above.

Table 1. Proportion of trials in which participants (N=125) chose the lower pitched voice in Study 1.

Attribution	Mean ± SE	*t* value	*p* value
Dominance	.778 ± .020	13.571	<.001***
Attractiveness	.732 ± .020	11.716	<.001***
Leadership	.685 ± .023	8.186	<.001***
Voting in national election scenario	.671 ± .022	7.835	<.001***
Voting in wartime scenario	.667 ± .024	6.989	<.001***
Ability to handle current economic situation	.663 ± .021	7.590	<.001***
Trustworthiness	.653 ± .021	7.372	<.001***
Intelligence	.634 ± .023	5.835	.001*
Honesty	.580 ± .023	3.493	<.001***
Likelihood of involvement in government scandal	.410 ± .024	-3.724	<.001***

All *p* values survived Bonferroni correction for multiple comparisons at the α= .005 level.

* *p* <.05, *** *p* <.001

2.2.3 Principal Component Analysis

We used principal component analysis with varimax rotation to reduce the number of factors predicting reported voting behavior in the model. This approach has been used previously to identify underlying dimensions from trait judgments of faces (Oosterhof & Todorov, 2008). This analysis produced two factors that were extracted using the regression technique. The first factor explained 27.96% of the variance and had an eigenvalue of 2.24. High scores on this factor indicated a higher proportion of trials in which lower pitched voices were associated with trustworthiness, honesty, intelligence, ability to handle the current economic situation and likelihood of being involved in a government scandal. We labeled this factor *integrity.* The second factor explained 21.20% of the variance and had an eigenvalue of 1.70. High scores on this factor indicated a higher proportion of trials in which lower pitched voices were associated with dominance, leadership, and attractiveness. We labeled this factor *physical prowess* (Table 2). Before executing subsequent analyses, we transformed integrity and physical prowess into binary variables split at the median: all values above the median (N=62) were assigned a value of 1 and all values below and including the median (N=63) were assigned a value of 0. We used α =.05 for all subsequent analyses.

Table 2. Rotated component matrix and factor loadings for principal component analysis in Study 1.

Proportion of trials in which lower pitched voices associated with:	Integrity	Physical Prowess
Trustworthiness	.737	.171
Honesty	.629	-.057
Intelligence	.623	.100
Ability to handle current economic situation	.611	.310
Likelihood of involvement in government scandal	-.702	.052
Dominance	-.052	.757
Leadership	.191	.754
Attractiveness	.071	.642

2.2.4 Influence of voice pitch on voting

To analyze the relationship between the degree to which lower pitched voices were associated with integrity and physical prowess and the degree to which lower pitched voices were chosen in each of the two voting scenarios, we performed a MANCOVA [dependent variable: voting scenario (national election, time of war); between subjects factor: sex (male, female); covariates: integrity, physical prowess]. There were significant main effects of the degree lower pitched voices were associated with integrity ($F_{1, 121} = 10.789$, $p = .001$) and physical prowess ($F_{1, 121} = 20.967$, $p < .001$) on the proportion of trials in which lower pitched voices were chosen in the national election scenario. In the wartime scenario, there were significant main effects of sex ($F_{1, 121} = 5.237$, $p = .024$) and the degree to which lower pitched voices were associated with physical prowess ($F_{1, 121} = 24.451$, $p < .001$) on the proportion of trials in which lower pitched voices were chosen. There were no other significant main effects or interactions (all $F_{1, 121} < 2.122$, all $p > .149$; Table 3).

Table 3. Proportion of lower pitched voices chosen (mean ± SE) in each voting scenario in Study 1 and Pearson correlations as a function of the influence of voice pitch on perceptions of integrity and physical prowess and sex of participant.

		Voting Scenario					
Degree of influence of voice pitch on perception	Sex	National Election Proportion	Pearson *r*	*p* value	Time of War Proportion	Pearson *r*	*p* value
High Influence on Integrity	Male (n=29)	.743 ± .04	.397*	.033	.770 ± .05	.213	.267
	Female (n=33)	.751 ± .04	.375*	.032	.603 ± .06	.378*	.030
	All (n=62)	.747 ± .03	.355**	.005	.681 ± .04	.180	.163
Low Influence on Integrity	Male (n=35)	.552 ± .04	.486**	.003	.679 ± .03	-.369*	.029
	Female (n=28)	.651 ± .04	-.241	.216	.631 ± .05	-.029	.885
	All (n=63)	.596 ± .03	.310*	.013	.653 ± .03	-.238	.060
High Influence on Physical Prowess	Male (n=32)	.743 ± .04	-.123	.503	.851 ± .02	-.018	.921
	Female (n=30)	.793 ± .03	.247	.188	.696 ± .05	.252	.180
	All (n=62)	.767 ± .02	.005	.971	.776 ± .03	.193	.133
Low Influence on Physical Prowess	Male (n=32)	.535 ± .04	.409*	.020	.580 ± .04	.098	.592
	Female (n=31)	.620 ± .04	.319	.080	.538 ± .05	.411*	.022
	All (n=63)	.577 ± .03	.392**	.001	.559 ± .03	.211	.096

*$p < .05$, **$p < .01$

2.2.5 Differences between voting scenarios

We performed a paired *t* test to determine if participants chose lower pitched voices more often in the national election or wartime scenario. There was no significant difference between how often lower pitched voices were chosen in the two scenarios (t_{124} = .160, p = .874). To test whether the degree lower pitched voices were associated with integrity and physical prowess differed significantly between the two voting scenarios, we performed an ANCOVA [within-subjects factor: voting scenario (national election, time of war); between-subjects factor: sex (male, female); covariates: integrity, physical prowess]. There were significant interactions between voting scenario and sex of participant ($F_{1, 121}$ = 5.09, p = .026) and voting scenario and perceptions of integrity ($F_{1, 121}$ = 9.37, p = .003). There were no other significant main effects or interactions (all $F_{1, 121}$ < .494, all p > .484; Table 3).

Prior research shows that perceptions of attractiveness and dominance based on voice pitch are separable (Jones et al., 2010; Puts, 2010). Although perceptions of both attractiveness and dominance contributed to the physical prowess factor, we sought to directly test whether perceptions of attractiveness or dominance were driving the difference between the two voting scenarios. We performed an ANCOVA [dependent variable: voting scenario (national election, time of war); covariates: attractiveness, dominance]. In the national election scenario, perceptions of both attractiveness ($F_{1, 124}$ = 5.837, p = .017) and dominance ($F_{1, 124}$ = 7.255, p = .008) significantly predicted voting preferences. In the wartime scenario, voting preferences were predicted by perceptions of dominance ($F_{1, 123}$ = 11.971, p = .001), but not by perceptions of attractiveness ($F_{1, 123}$ = 1.736, p = .190).

3. Study 2

The aim of Study 2 was to test if the influence of voice pitch on voting preferences we observed in Study 1 could be replicated using voices of non-politicians speaking non-political content in a situation where participants chose between the voices of two different people rather than two versions of the same person's voice.

3.1 Methods

3.1.1 Participants

Participants (N= 40) were 20 females (*mean age* = 22.75 ± 3.48 years) and 20 males (*mean age* = 22.85 ± 3.66 years) who received payment in exchange for participation.

3.1.2 Stimuli

We obtained voice recordings of six males speaking the sentence "When the sunlight strikes raindrops in the air, they act as a prism and form a rainbow" (Fairbanks, 1960). We created a lower pitched and higher pitched version of each voice using the same method described in Study 1. Each of the voices that we lowered in pitch (*mean pitch* = 97.06 ± 15.99 Hz) was lower than each of the voices that we raised in pitch (*mean pitch* = 135.22 ± 18.27 Hz).

3.1.3 Procedure

We organized trials into two blocks and randomly assigned each participant to one block. Each block consisted of 15 trials of the same two-alternative forced choice paradigm described in Study 1, except that in Study 2 all trials presented a choice between two different speaker identities. In each trial, participants were asked to "Choose the voice that you are most likely to vote for in a national election" between the raised-pitched version of one person's voice and the lowered-pitched version of another person's voice. The raised pitch and lowered pitch versions of each speaker identity were reversed in the two blocks. We asked participants to indicate if they recognized any of the voices by clicking on a button at the bottom of the screen. We calculated the proportion of trials in which each participant chose the lower pitched voice as described in Study 1.

3.2 Results

To determine if participants chose lower pitched voices more often than predicted by chance (0.50), we performed a one-sample *t* test. We found that participants chose lower pitched voices significantly more often than predicted by chance (*mean*= .698 ± .03, $t_{39} = 7.099$, $p < .001$). A one-way ANOVA [dependent variable: proportion of lower pitched voices chosen; independent variables: sex, block] revealed no differences between the responses of the two sexes, neither between the two blocks, nor was there a sex by block interaction (all $F_{1, 36} <$ 45.94, all $p > .093$). No participants indicated recognizing any of the speaker identities.

4. Discussion

In Study 1, we found that lower pitched voices were associated with favorable personality traits more often than were higher pitched voices (Table 1). This finding is consistent with previous work demonstrating that lower pitched men's voices sound more dominant and attractive than do higher pitched men's voices (see Feinberg, 2008 for review; Jones et al., 2010; Puts et al., 2006; Puts et al., 2007). Our research suggests that the relationship between voice pitch and dominance is relevant for a range of social situations that can alter fitness, including political decisions.

Since voice pitch is negatively related to testosterone levels (Dabbs & Mallinger, 1999; Harries et al., 1997), and dominant men have higher testosterone levels than subordinate men do (Mazur & Booth, 1998; Swaddle & Reierson, 2002), the pattern of attributions we observed is potentially adaptive because voice pitch is likely a valid cue to men's dominance. Our results also provide converging evidence that dominant sounding male voices are perceived positively while dominant male faces are perceived negatively (Perrett et al., 1998). Recent work, however, demonstrated that lower pitched men's voices are associated with high perceived infidelity risk (O'Connor et al., 2011). Future research should investigate similarities and differences in perceptions of vocal and facial masculinity in different social contexts.

A potential alternative explanation for the above pattern of attributions is that participants demonstrated a general response bias to lower pitched voices. If our results were due to a general response bias to masculine stimuli, participants would have always selected the lower pitched voices over the higher pitched voices. This did not happen. Participants chose the higher pitched voices significantly more often than expected by chance when asked to choose the voice more likely to be involved in a government scandal (Table 1). It is also unlikely that these results are due to potential demand characteristics because we found no differences in the directions of the relationships when we analyzed only the first attribution category completed by each participant. Additionally, we reduced the potential influence of demand characteristics by randomizing the order of attribution categories within each block.

Furthermore, we found in Study 1 that participants preferred to vote for politicians with lower pitched voices over politicians with higher pitched voices in both the national election scenario and the wartime scenario. Lower voice pitch was more strongly associated with integrity in the national election scenario than in the wartime scenario, while lower voice pitch was associated with physical prowess to the same degree in both voting scenarios. In the national election scenario, the more likely people were to associate lower pitched voices with integrity and physical prowess, the more likely they were to say they would vote for politicians with lower pitched voices. In the wartime scenario, if people perceived lower pitched voices as indicative of physical prowess, they were more likely to say they would vote for lower pitched voices. If people perceived lower pitched voices as possessing more integrity, however, they were no more likely to say they would vote for lower pitched voices. Therefore, in the wartime scenario, voting decisions were influenced by vocal cues to physical prowess, but not by vocal cues to integrity, suggesting that perceptions of integrity influenced voting decisions less strongly than physical prowess in this scenario.

Although low voice pitch was associated with both attractiveness and dominance, voting preferences in the wartime scenario were more closely tied to perceptions of dominance than to attractiveness. Recently, Sell et al. (2010) demonstrated that people can accurately assess upper body strength from men's voices alone, which is consistent with the pattern of pitch-based perceptions we present here. Puts et al. (2011) also found that formant position, another measure of vocal masculinity, negatively predicted men's arm strength. Even though elected officials do not usually participate in warfare directly, Sell et al. (2009) found that stronger men were more likely to favor the use of military force than were weaker men. Our research supports the hypothesis that voters possess evolved mechanisms for accurately assessing vocal cues to strength and dominance in potential leaders, which may be adaptive if strength and dominance were accurate predictors of success in warfare throughout our evolutionary history.

In Study 2, we found that the preference to vote for men with lower pitched voices was not specific to politicians speaking political content, nor was it specific to a forced choice between two versions of the same person's voice. The results of Study 2 extend our findings to a more ecologically valid scenario: a choice between two different candidates, one with a higher voice pitch and one with a lower voice pitch. When given the choice between two unfamiliar candidates speaking a neutral sentence, participants preferred to vote for the candidate with the lower pitched voice more often than the one with the higher pitched voice.

To our knowledge, our study is the first to investigate the influence of voice pitch on perceptions of politicians. Our results suggest that men with lower pitched voices may have an advantage in political elections. It is possible that artificially lowering one's voice pitch in audio recordings could help candidates gain votes. In addition, voters may pay more attention to vocal cues of dominance during wartime. Although political leaders do not normally take part in physical combat, voters' sensitivity to vocal cues to strength may be adaptive if men's strength predicts their likelihood to use military force.

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Appendix. Supplementary data. Description of the stimuli used in Study 1.

Speaker	Stimulus	Duration (seconds)
Harry S. Truman	"The supreme need of our time is for men to learn to live together in peace and harmony."	8.06
John F. Kennedy	"To halt this offensive buildup, a strict quarantine on all offensive military equipment under shipment to Cuba is being initiated."	10.01
Lyndon B. Johnson	"But if the nation's problems are continuing, so are this great nation's assets."	9.76
Richard M. Nixon	"Tonight I shall present to the Congress six great goals. I shall ask not simply for more new programs in the old framework. I shall ask to change the framework of government itself."	14.33
Gerald R. Ford	"As we begin our bicentennial, America is still one of the youngest nations in recorded history."	7.09
James E. Carter, Jr.	"Our children who will be born this year will come of age in the twenty-first century."	8.96
Ronald W. Reagan	"It's my duty to report to you tonight on the progress that we have made in our relations with other nations, on the foundation we've carefully laid for our economic recovery."	10.44
George H.W. Bush	"The events of the year just ended, the revolution of eighty-nine, have been a chain reaction, changes so striking that it marked the beginning of a new era in the world's affairs."	14.26
William J. Clinton	"Tonight I stand before you to report that America has created the longest peacetime economic expansion in our history."	9.18

CHAPTER 5: VOICE PITCH AND FORMANT FREQUENCIES INFLUENCE VOTING PREFERENCES FOR MEN'S AND FOR WOMEN'S VOICES DIFFERENTLY

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Preface

In Chapter 4, I found that participants preferred to vote for lower pitched men's voices that were manipulated in pitch. Perceptions of men's dominance influenced voting preferences especially strongly in hypothetical wartime. Although in Chapter 3 I found no relationship between natural women's voice pitch and participants' voting ratings, in Chapter 5, I examine the effect of manipulated women's voice pitch on voting preferences. In this chapter, I demonstrate that participants prefer to vote for higher pitched women's voices more often than to vote for lower pitched women's voices among pitch-manipulated stimuli. Leaders' perceived height positively influences voting preferences and formant frequencies are a vocal cue to height. Yet, I found no relationship between formants and voting ratings of natural voices in Chapter 3. In this chapter, I investigate the influence of manipulated formant frequencies on voting preferences for men’s and for women’s voices. I demonstrate that participants prefer to vote for women’s voices with lower formants more often than to vote for women’s voices with higher formants, but that participants prefer to vote for lower pitched men’s voices regardless of formants. Overall, the results of Chapter 5 indicate that voice pitch and formant frequencies influence voting preferences for men’s and for women’s voices differently. These results provide converging evidence that people prefer to vote for men with lower pitched voices, but that we do not yet fully understand how women’s voice pitch influences voting decisions.

Abstract

In prior studies, participants preferred to vote for men with lower pitched voices in both natural (Chapter 3 of this dissertation) and pitch-manipulated (Chapter 4 of this dissertation) stimuli. Participants preferred to vote for women with lower pitched voices in manipulated, but not in natural (Chapter 3), stimuli. Although a prior study found that formant frequencies did not influence voting ratings of men's or of women's voices (Chapter 3), no study has tested whether manipulating formants influences voting preferences. Therefore, we investigated the influence of voice pitch and formant frequencies on voting preferences for men's and for women's voices. In separate studies, participants listened to women's voices manipulated in pitch (Study 1) and to women's and to men's voices manipulated in formants (Study 2). In Study 1, participants preferred to vote for women's voices with higher, more often than lower, pitch. In Study 2, participants preferred to vote for women's voices with lower, more often than higher, formants, but preferred to vote for lower pitched men's voices regardless of formants. Our results suggest that voice pitch and formant frequencies influence voting preferences for men's and for women's voices differently.

Introduction

Voice pitch, the perception of fundamental frequency and/or its harmonics, is negatively related to testosterone levels at puberty (Harries, Walker, Williams, Hawkins, & Hughes, 1997) and adulthood (Dabbs & Mallinger, 1999; Evans, Neave, Wakelin, & Hamilton, 2008), but it is unclear whether voice pitch is reliably related to body size within sexes (for meta-analysis see: Pisanski et al., 2013). Formant frequencies, the resonant frequencies of the vocal tract, negatively correlate with vocal tract length and negatively relate to body size within sexes more reliably than does voice pitch (Fitch, 2000 for review; for meta-analysis see: Pisanski et al., 2013).

Men with lower pitched voices are perceived to be more attractive (Feinberg, DeBruine, Jones, & Little, 2008; Feinberg, Jones, Little, Burt, & Perrett, 2005; Jones, Feinberg, DeBruine, Little, & Vukovic, 2010) and dominant (Jones et al., 2010; Puts, Gaulin, & Verdolini, 2006; Puts, Hodges, Cardenas, & Gaulin, 2007) by both men and women than are men with higher pitched voices. Conversely, higher pitched women's voices sound relatively attractive (Collins & Missing, 2003; Feinberg, DeBruine, Jones, & Perrett, 2008; Puts, Barndt, Welling, Dawood, & Burriss, 2011), particularly to men (Feinberg, DeBruine, Jones, & Perrett, 2008), but lower pitched women's voices sound relatively dominant (Borkowska & Pawlowski, 2011; Jones et al., 2010). Furthermore, low formants are tied to perceptions of dominance (Puts et al., 2006; Puts et al., 2007;

Wolff & Puts, 2010) and attractiveness in men's voices (Feinberg et al., 2011; Feinberg, Jones, Little et al., 2005; Pisanski & Rendall, 2011) and dominance in men's and in women's voices when combined with lowered pitch (Feinberg et al., 2006).

Perceptions of attractiveness, dominance, and leadership ability are closely related in men's voices (Tigue, Borak, O'Connor, Schandl, & Feinberg, 2012). In prior studies using manipulated voices, participants preferred to vote for both men (Tigue et al., 2012) and women (Anderson & Klofstad, 2012; Klofstad, Anderson, & Peters, 2012) with lower pitched voices. When participants rated natural, un-manipulated voices, they said they were more likely to vote for lower pitched men's voices (Chapter 3). Women's voice pitch, however, did not predict participants' voting ratings (Chapter 3).

Tigue et al. (2012) found that perceptions of men's attractiveness and dominance each positively predicted voting preferences both in a hypothetical national election. In hypothetical wartime, though, perceptions of men's dominance alone positively predicted voting preferences (Tigue et al., 2012). In Chapter 3, we found that women's (but not men's) perceptions of men's attractiveness positively predicted voting ratings and that perceptions of men's dominance did not predict voting ratings. Perceptions of women's attractiveness and social dominance each positively predicted men's and women's voting ratings (Chapter 3). Other studies have found that voting preferences for masculine and/or dominant leaders were stronger during hypothetical-wartime than -

peacetime scenarios (Little, Burriss, Jones, & Roberts, 2007; Re, DeBruine, Jones, & Perrett, 2013), suggesting that voting preferences for masculine and/or dominant leaders are context-dependent.

Leaders' actual and perceived height can also influence voting preferences. Taller candidates are most likely to win U.S. presidential elections (Sorokowski, 2010). Given that the faces of taller people are perceived to be better leaders than are those of shorter people (Re, Dzhelyova et al., 2012), especially in hypothetical wartime (Re et al., 2013), formants, a reliable cue to body size within sexes (Pisanski et al., 2013), may also influence voting preferences for leaders. Yet, in Chapter 3 of this dissertation, we found that formants did not predict participants' voting ratings of natural, un-manipulated men's or women's voices. Therefore, examining voting preferences in voices with manipulated formants would help to further investigate if formants relate to voting preferences. Manipulating formants allows us to isolate the effect of formants on voting preferences while holding all other acoustic features of the voice constant. This would control for any acoustic features masking a potential relationship between formant frequencies and voting choices in natural voices.

Given that the two published studies that have examined the influence of manipulated women's voice pitch on voting preferences were done by one group of authors (Anderson & Klofstad, 2012; Klofstad et al., 2012) and that in Chapter 3 we did not replicate their results using natural voices, in Study 1 of this chapter, we tested the influence of manipulated voice pitch on voting preferences for female politicians. Although prior studies used anonymous women's voices as stimuli (Anderson & Klofstad, 2012; Klofstad et al., 2012), Tigue et al. (2012) found that measuring voting preferences for men's voices using politicians' voices and anonymous voices yielded similar results. Thus, we used politicians' voices in Study 1 of this chapter. If lower pitched women's voices sound relatively dominant (Borkowska & Pawlowski, 2011; Jones et al., 2010), then participants may prefer to vote for women with lower pitched voices. In Study 2 of this chapter, we tested the influence of manipulated formant frequencies on voting preferences. If taller people are perceived as relatively more dominant and as better leaders (Re, Dzhelyova et al., 2012; Sorokowski, 2010), and formants negatively predict height reliably within sexes (Pisanski et al., 2013), then participants may prefer to vote for leaders with relatively lower formants.

Study 1

Methods

Participants

Participants (N=93) included 59 female (*mean age*=18.31±1.07 years) and 34 male (*mean age*=18.74±0.96 years) undergraduates who received course credit.

Stimuli

We obtained voice recordings of two American (Hillary Clinton, Nancy Pelosi) and two Canadian (Kim Campbell, Andrea Horwath) female politicians from audio files publicly available online (Table 1). Although prior studies on voice pitch and voting preferences used more than four voice identities (Anderson & Klofstad, 2012 used 10 men's and 10 women's voices; Klofstad et al., 2012 used 10 men's and 17 women's voices; Tigue et al., 2012 used 9 men's voices), we used four voice identities because prior voice perception studies using four to six voices (Feinberg, DeBruine, Jones, & Little, 2008; Feinberg, DeBruine, Jones, & Perrett, 2008; Feinberg, Jones, DeBruine et al., 2005; Feinberg et al., 2011; Feinberg et al., 2006; Jones et al., 2010; O'Connor, Re, & Feinberg, 2011; Vukovic et al., 2008) found similar effects as studies using many more voice stimuli (Collins, 2000; Collins & Missing, 2003; Puts, 2005). Thus, we chose to use a small number of original voices because small numbers of manipulated voice stimuli produce results that are comparable to those produced by much larger numbers of stimuli.

Table 1. Description of and source information for stimuli in Study 1.

Stimulus Identity	Sex	Nationality	Name of source	Hyperlink to Source
Hillary Clinton	Female	American	American Rhetoric Online Speech Bank	http://www.americanrhetoric.com/
Nancy Pelosi	Female	America	American Rhetoric Online Speech Bank	http://www.americanrhetoric.com/
Kim Campbell	Female	Canadian	CBC radio	http://www.cbc.ca/podcasting/pastpodcasts.html?92#ref87
Andrea Horwath	Female	Canadian	The Dean Blundell Show	http://www.edge.ca/DJsandShows/TheDeanBlundellShow/Audio.aspx

We manipulated the pitch of each voice recording to create a higher pitched and lower pitched version using the Pitch-Synchronous Overlap Add (PSOLA, France Telecom) algorithm in Praat software (Boersma & Weenink, 2013). This method selectively manipulates fundamental frequency and related harmonics while holding other features of the acoustic signal (including formants) relatively constant (Feinberg, Jones, Little et al., 2005). We raised or lowered fundamental frequency by 0.5 equivalent rectangular bandwidths (ERB) of the baseline frequency (Table 2). This level of manipulation has been used successfully in prior studies investigating the influence of voice pitch on voting behaviour (Anderson & Klofstad, 2012; Klofstad et al., 2012; Tigue et al., 2012). We normalized the amplitude of each stimulus to 70 decibels (dB) root mean squared (RMS) sound pressure level (SPL) using Praat (Boersma & Weenink, 2013).

Table 2. Mean ± SEM voice pitch measurements (in Hz) for voice stimuli used in Studies 1 and 2.

Study	Voice Quality Manipulated			
Women's Voices				
		Un-manipulated pitch (Hz)	Raised pitch (Hz)	Lowered pitch (Hz)
1	Voice Pitch	213.52 ± 52.48	237.51 ± 53.24	191.48 ± 49.32
2	Formant Frequencies	228.10 ± 63.48	N/A	N/A
Men's Voices				
2	Formant Frequencies	124.93 ± 25.59	N/A	N/A

Procedure

Trials (*n*=12) consisted of a two-alternative forced choice between the raised-pitch version of one identity and lowered-pitch version of a different identity. We paired two different identities in each trial to simulate an election in which voters must choose between two candidates as closely as possible. Although prior studies on the influence of voice pitch on voting preferences paired a raised-pitch and lowered-pitch version of the same identity in each trial (Anderson & Klofstad, 2012; Klofstad et al., 2012; Tigue et al., 2012, Study 1), a prior study also showed that voice pitch influenced voting preferences for men's voices similarly whether participants chose between the same or different voice identities (Tigue et al., 2012 Study 2).

All trials were blocked into four separate attribution categories, in each of which participants responded to a different question: "Choose the voice that (1) you are most likely to vote for in a national election; (2) you are more likely to vote for in a time of war; (3) sounds more attractive; (4) sounds more dominant." We separately randomized the order of the four attribution categories, the order of the trials within each attribution category, and the side of the screen on which the play button for each version of the voice was displayed. Participants listened to the voices consecutively through headphones connected to a computer and clicked on play buttons on the computer screen to play each stimulus.

Analysis

In two trials, the raised version of one identity was lower than the lowered version of another identity. We excluded those trials from further analysis, leaving 10 trials in each of the four attribution categories. We separately calculated the proportion of trials that participants chose the lower pitched voice for each attribution category. We used SPSS Statistics version 20 with two-tailed *p* values and α=.05 for all statistical analyses.

Results

There were no significant differences between the responses of men and women in any of the four blocks (all independent samples $|t|_{91} \leq .999$, all $p \geq .321$). We combined men's and women's responses in subsequent analyses. Participants chose the higher pitched women's voices for voting in a national election (t_{92}=-2.418, p=.018), voting in a time of war (t_{92}=-2.071, p=.041), and as more attractive (t_{92}=-2.003, p=.048), but not as more dominant (t_{92}=-0.555, p=.580; Figure 1; Table 3).

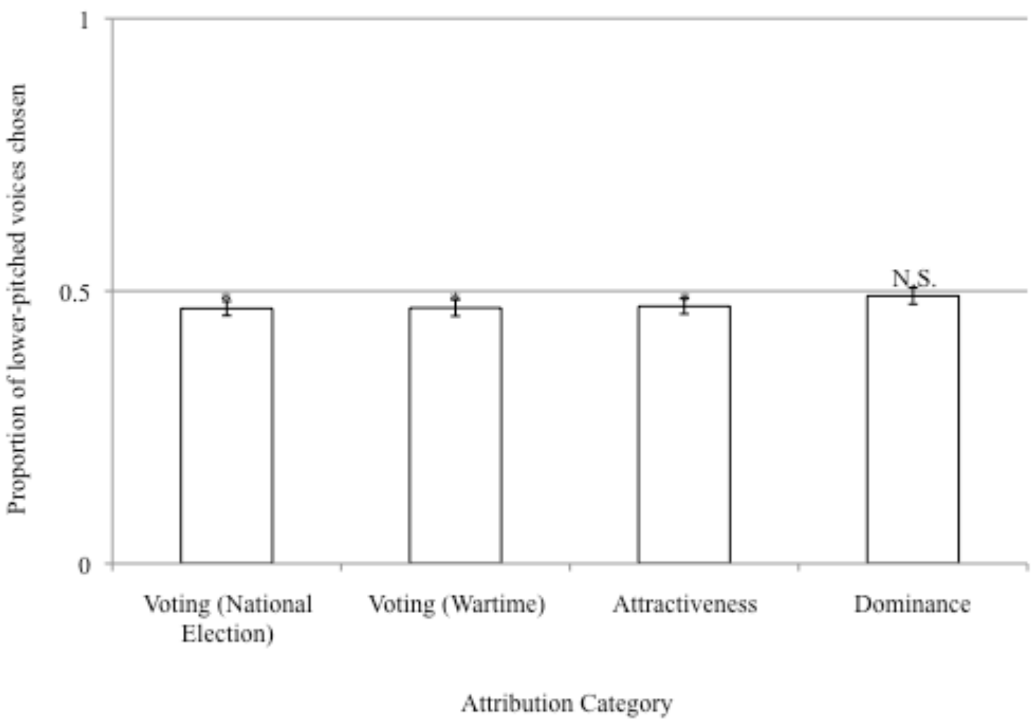

Figure 1. Proportion (*mean±SEM*) of lower pitched women's voices chosen for each attribution category in Study 1 (N=93). *p<.05

Study 2

Methods

Participants

Participants were 88 female undergraduates (*mean age*=20.27±4.79 years) who received course credit.

Stimuli

We obtained voice recordings of 6 female (*mean age*=18.17±0.41 years) and 6 male (*mean age*=18.67±1.21 years) undergraduates (Table 2). All 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 a USB-2 audio interface (M-Audio Fast Track Ultra) at 96 kHz sampling rate and 32-bit amplitude quantization using Adobe Soundbooth CS5 3.0 and saved as uncompressed .wav files. Each person was recorded speaking the first sentence of the Rainbow Passage (Fairbanks, 1960). We manipulated formant frequencies of stimuli using Praat (Boersma & Weenink, 2013) at a level of ±6% from baseline for male voices or ±5% for female voices because these percentages correspond to one just-noticeable difference (JND) for formant frequencies in men's and women's voices, respectively (Pisanski & Rendall, 2011). We normalized the amplitude of each stimulus to 70 dB RMS SPL.

To examine voting preferences based on acoustic features other than formants, we also measured the mean fundamental frequency (F_0), harmonics-to-noise ratio (HNR), and jitter of each stimulus in Praat. We measured F_0 using the autocorrelation algorithm in Praat with a search range of 60-300 Hz for men's voices and 100-600 Hz for women's voices. We measured five jitter parameters (local, local absolute, rap, ppq5, and ddp) with the cross-correlation algorithm in Praat. We then performed a principal components analysis (PCA) without rotation on the five jitter measurements to obtain a single measurement of jitter for each stimulus. For each unique voice pairing, we determined which voice was lower in F_0, jitter, and HNR.

Procedure

Trials consisted of a two-alternative forced-choice between the lowered-formant version of one identity and raised-formant version of a different identity of the same sex, similar to the design of Study 1 (for justification of this design, see Study 1: Procedure). We organized trials into two blocks and assigned participants to one block in counterbalanced order. Each block consisted of 15 trials of female voices and 15 trials of male voices. The lowered and raised formant versions of each speaker identity were reversed in the two blocks, as in Tigue et al. (2012) Study 2. In each trial, participants were asked, "If they were running against each other in an election, which voice would you vote for?"

following Klofstad et al. (2012). All other aspects of the procedure were the same as Study 1.

Analysis

We separately calculated the proportion of trials that participants chose the lower formant, lower pitched, lower jitter, and lower HNR voice for each sex of voice. There were five trials in which the F_0 difference between the two voices was less than one JND for voice pitch perception (Pisanski & Rendall, 2011), so we excluded these trials from the analysis.

Results

Participants chose to vote for the lowered-formant version for male voices (t_{87}=3.786, p<.001) and for female voices (t_{87}=2.773, p=.007; Table 3). A one-way ANOVA [dependent variables: proportion of lowered-formant male voices chosen, proportion of lowered-formant female voices chosen; independent variable: block] revealed no difference between participants in the two blocks in their voting preference for formants in female voices ($F_{1,86}$=1.944, p=.167, η^2=.022), but there was a difference between participants in the two blocks in their voting preference for formants in male voices, wherein higher formants were chosen in one block, but lower formants were chosen in the other ($F_{1,86}$=70.947, p<.001, η^2=.452).

Table 3. Proportion of stimuli with lower value chosen in Studies 1 and 2.

Study	Sex of Voice Stimuli	Voice Quality Analyzed	Attribution	Mean ± SEM	t-value	p-value
1	Female	Pitch	Voting (National election)	.468 ± .013	-2.418	**.018***
1	Female	Pitch	Voting (Wartime)	.469 ± .015	-2.071	**.041***
1	Female	Pitch	Attractiveness	.472 ± .014	-2.003	**.048***
1	Female	Pitch	Dominance	.491 ± .015	-0.555	.580
2	Female	Formants	Voting (Block 1)	.586 ± .027	3.205	**.003***‡
2	Female	Formants	Voting (Block 2)	.529 ± .031	0.920	.363
2	Female	Pitch	Voting (Block 1)	.446 ± .021	-2.579	**.013***
2	Female	Pitch	Voting (Block 2)	.453 ± .020	-2.319	**.025***
2	Female	HNR	Voting (Block 1)	.711 ± .026	8.043	**<.001***‡
2	Female	HNR	Voting (Block 2)	.586 ± .017	4.958	**<.001***‡
2	Female	Jitter	Voting (Block 1)	.414 ± .027	-3.205	**.003**‡
2	Female	Jitter	Voting (Block 2)	.389 ± .024	-5.672	**<.001***‡
2	Male	Formants	Voting (Block 1)	.436 ± .023	-2.721	**.009***
2	Male	Formants	Voting (Block 2)	.758 ± .030	8.552	**<.001***‡
2	Male	Pitch	Voting (Block 1)	.688 ± .020	9.495	**<.001***‡
2	Male	Pitch	Voting (Block 2)	.723 ± .016	13.988	**<.001***‡
2	Male	HNR	Voting (Block 1)	.430 ± .013	-5.185	**<.001***‡
2	Male	HNR	Voting (Block 2)	.606 ± .016	6.798	**<.001***‡
2	Male	Jitter	Voting (Block 1)	.409 ± .022	-4.141	**<.001***‡
2	Male	Jitter	Voting (Block 2)	.327 ± .020	-8.704	**<.001***‡

***p* < .05,** *t*- and *p*- values reflect one sample *t*-tests compared to chance, 0.5.
†*p*-value survived Bonferroni correction for multiple comparisons at the α = .0125 level.
‡*p*-value survived Bonferroni correction for multiple comparisons at the α = .00625 level.

We hypothesized that the difference in the proportion of lower formant versions of male voices chosen between the two blocks might be due to the effect of another acoustic feature, regardless of formants. Given that whether participants heard the raised- or lowered-formant version of any particular voice identity was reversed in the two blocks, the pattern of results we observed (preference for low formants in one block and preference for high formants in the other block) could occur if participants preferred to vote for the same identities in both blocks, regardless of the formant manipulation. One possible reason why participants may prefer to vote for the same identities in both blocks could be that their voting preferences were driven by the pitch, jitter, or HNR of the voice.

We found that participants chose to vote for the higher pitched women's voices (t_{87}=-3.485, p=.001) and lower pitched men's voices (t_{87}=16.087, p<.001; Table 3). When we repeated these *t*-tests including the five trials originally excluded (because the pitch difference between the two voices was less than one JND), participants chose to vote for the lower pitched male voices (t_{87}=16.738, p<.001), but had no significant voting preference for higher pitched women's voices (t_{87}=-.841, p=.402).

To test for differences in the responses of participants between the two blocks in which stimulus identities were reversed, we performed a one-way ANOVA [dependent variables: proportion of lower pitched male voices chosen, proportion of lower pitched female voices chosen; independent variable: block]. We found no difference between the responses of participants in the two blocks in their voting preference for higher pitch in female voices ($F_{1,86}$=.057, p=.812, η^2=.001) nor in their voting preference for lower pitch in male voices ($F_{1,86}$=2.007, p=.160, η^2=.023). When we repeated this ANOVA including all trials, we again found no difference between the responses of participants in the two blocks.

We also found that participants preferred to vote for women's voices with lower HNR (t_{87}= 8.738, p< .001) and higher jitter (t_{87}= -5.937, p<.001), and preferred to vote for men's voices with higher jitter (t_{87}= -8.587, p< .001). No other voting preferences were significant based on the acoustic features we measured (all$|t|_{87} \leq 1.377$, all $p \geq .172$; Table 3).

To test for differences in the responses of participants between the two blocks, we performed a multivariate ANOVA with the proportion of lower HNR and jitter men's and women's voices chosen as the dependent variables and the block as the independent variable. We found that participants' voting preference for lower HNR in women's ($F_{1,81}$= 15.61, p< .001, η^2= .154) and men's voices ($F_{1,81}$= 72.84, p< .001, η^2= .459) and for lower jitter in men's voices ($F_{1,81}$= 7.64, p= .007, η^2=.082) differed significantly between the two blocks. There were no other significant differences between the two blocks (all $F_{1,81} \leq 3.10$, all $p \geq .082$; Table 3).

Discussion

In both pitch-manipulated (Study 1) and formant-manipulated (Study 2) women's voices, participants preferred to vote for women with higher pitched voices more often than to vote for women with lower pitched voices. We replicated this result in two different samples of participants using two different types of voice stimuli. The voting preference for higher pitched women's voices was consistent regardless of the speech content or of how the question was phrased.

It should also be noted that when we analyzed voting preferences for voice pitch in Study 2 and included all trials, participants preferred to vote for the lower pitched male voices, but had no voting preference for pitch in women's voices. We found a similar pattern of results in Chapter 3, which suggests that the effects of natural voice pitch on voting preferences can be replicated using unique stimuli sets.

Our results contrast with previous studies (Anderson & Klofstad, 2012; Klofstad et al., 2012) showing that participants preferred to vote for women with lower pitched voices. A possible explanation for these incongruent findings may be that the voice pitch of the stimuli differed between these studies and our own. In the two previous studies, the mean un-manipulated pitch of the female voices was 187 Hz (Klofstad et al., 2012) and 195 Hz (Anderson & Klofstad, 2012), whereas the mean un-manipulated pitch of female voices was 213 Hz in our Study 1 and 228 Hz in our Study 2 (Table 2). Average women's voice pitch has been reported at 220±5.48 Hz (Childers & Wu, 1991), 207±20.52 Hz (Feinberg, DeBruine, Jones, & Perrett, 2008), 207 Hz (Pisanski & Rendall, 2011), and 210.82 ± 20.67 (Re, O'Connor, Bennett, & Feinberg, 2012).

The stimuli used in prior studies gave participants a choice between a low-pitched female voice (approximately 146 and 153 Hz when manipulated) and an average-pitched female voice (approximately 189 and 196 Hz when manipulated; because these prior studies did not report the pitch of their manipulated stimuli, we calculated the above values using the Hz to ERB conversion formula used by

Praat (Moore & Glasberg, 1983)). In our current two studies, participants chose between a low-pitched female voice and a high-pitched female voice and preferred to vote for the high-pitched voices. Participants in prior studies (Anderson & Klofstad, 2012; Klofstad et al., 2012) did not listen to female voice stimuli that were higher than average in pitch, and therefore, could not have chosen higher than average-pitched female voices.

Other potential explanations for the difference between our results and those of prior studies may be the differences in methodology. In prior studies on the influence of women's voice pitch on voting preferences, participants chose between raised-pitch and lowered-pitch versions of the same identity (Anderson & Klofstad, 2012; Klofstad et al., 2012). In our Studies 1 and 2, participants chose between two different identities. The strength of our methodology is that it more closely simulates an election choice between two different candidates. The potential limitations of our methodology are that preferences could be driven by variables other than the one manipulated, the content of the utterances may not be comparable across vocalizers, and the gap in pitch between pairs of voices varies for each forced choice.

These potential explanations are unlikely to explain the pattern of results we found for three reasons. First, we found similar voting preferences for higher pitched women's voices whether or not we manipulated voice pitch. In Study 1, we manipulated voice pitch and found that participants preferred to vote for the higher pitched women's voices. In Study 2, we manipulated formant frequencies while holding pitch constant and again found that participants preferred to vote for the higher pitched women's voices.

In Study 2, we also found that participants preferred to vote for women's voices with more noise, as indicated by lower HNR and higher jitter. The extent to which participants preferred to vote for lower HNR also differed between the two blocks. Participants also preferred to vote for men's voices with higher jitter, but showed no consistent preference for HNR in men's voices. The extent to which participants preferred to vote for men's voices with higher jitter differed between the two blocks (Table 3). These results indicate that several acoustic features other than formants predicted participants' voting preferences in Study 2. Only men's voice pitch appears to predict voting preferences across studies (Anderson & Klofstad, 2012; Klofstad et al., 2012; Tigue et al., 2012; Chapter 3).

In addition, the results reported here are consistent with those reported in Chapter 3 of this dissertation, which suggest that voice pitch influences voting preferences for men's and for women's voices differently. Furthermore, these results provide evidence that participants may prefer to vote for noisier voices (*i.e.,* lower HNR and higher jitter) rather than less noisy voices. This result is consistent with a study showing that among natural voices, people also prefer more noise (Xu, Lee, Wu, Liu, & Birkholz, 2013). Thus, this result is consistent with the idea that people prefer to vote for voices they find attractive.

Second, we found that participants preferred to vote for higher pitched women's voices regardless of the speech content. Klofstad et al. (2012) suggested that the relationship between voice pitch and voting preferences may be different between "electorally-relevant" speech content and other types of speech content. The stimuli in Study 1 of this chapter were female politicians' voices from natural speech (the content differed across identities) while the stimuli in Study 2 of this chapter were female undergraduates speaking the first sentence of the Rainbow Passage (*i.e.,* "When the sunlight strikes raindrops in the air, they act as a prism and form a rainbow"). We found that participants either preferred to vote for higher pitched women's voices (Studies 1 and 2 of this chapter), or had no voting preference for women's voice pitch at all (Chapter 3 of this dissertation) in studies each using different speech content. These results challenge the idea that people prefer to vote for women with low-pitched voices (Anderson & Klofstad, 2012; Klofstad et al., 2012). However, our findings on men's voices are consistent with other studies demonstrating that participants preferred to vote for lower pitched men's voices in politicians' voices, each speaking a different sentence (Tigue et al., 2012, Study 1), the Rainbow Passage (Tigue et al., 2012, Study 2), or "I urge you to vote for me this November" (Klofstad et al., 2012).

Third, to test if the gap in pitch between pairs of voices in Study 1 influenced how often participants chose the higher pitched women's voices, we calculated a Pearson correlation coefficient between the pitch difference (in Hz) in each trial and the proportion of trials in which participants chose the higher pitched voice. The pitch difference between the two voices was not significantly correlated with the proportion of time that participants chose the higher pitched voices (r = .282, p = .374, n = 12). Although this relationship was not significant, the null result may have been caused by a small number of voice pairs in Study 1 of this chapter. Although studies have shown that forced-choice preferences measured from a small number of manipulated voices generalize to larger populations (Feinberg et al., 2008; Feinberg et al., 2006; Jones et al., 2010), an n of 12 is often too small for correlational analyses of this type. Thus, the evidence to support the argument that participants were more likely to choose the higher pitched voice when the gap between the higher and lower pitched voices was larger is weak. Based on this analysis alone, it is unclear whether or not this non-significant relationship reflects a real effect.

In Study 2, participants preferred to vote for women's voices with lower, rather than higher, formants. People may prefer female leaders with lower formants because voices with lower formants are perceived as older and larger than are voices with higher formants (Feinberg, Jones, Little et al., 2005; Smith, Patterson, Turner, Kawahara, & Irino, 2005; Smith, Walters, & Patterson, 2007). People may prefer female leaders with low formants because they sound older and more experienced. In contrast, women's voices with raised formants may be perceived as too young to be effective leaders. People also prefer the faces of taller people as leaders (Re et al., 2013; Re, Dzhelyova et al., 2012), and we see some evidence of this in preferences to vote for women's voices with relatively low formants.

One explanation for the apparent contradiction between voting preferences for high pitch but low formants in women's voices is that voice pitch and formant frequencies may indicate different underlying qualities. Voice pitch is an indicator of underlying hormone levels (Abitbol, Abitbol, & Abitbol, 1999; Dabbs & Mallinger, 1999; Harries et al., 1997), but formants also relate to men's testosterone levels (Bruckert, Lienard, Lacroix, Kreutzer, & Leboucher, 2006). Little is known about how women's formants are related to underlying hormone levels. Formants are more reliable cues to body size within sexes than is voice pitch (Evans, Neave, & Wakelin, 2006; Hamdan et al., 2012; Pisanski et al., 2013; Rendall, Vokey, & Nemeth, 2007).

In Chapter 3, we found no voting preference for women's voice pitch in natural stimuli. In Study 1 of this chapter, we found a voting preference for higher pitched women's voices in pitch-manipulated stimuli. Klofstad et al. (2012) and Anderson & Klofstad (2012) found that participants preferred to vote for lower pitched women's voices in pitch-manipulated stimuli. Thus, in Study 1 of this chapter and in Chapter 3, we did not replicate the results of prior studies related to voting preferences for women's voices (Anderson & Klofstad, 2012; Klofstad et al., 2012). Given that we did not replicate the results of prior work using neither pitch-manipulated nor natural stimuli, the results of prior studies may not generalize and remain equivocal.

In Chapter 3, we found no voting preference for women's formants in natural stimuli. In Study 2 of this chapter, we found a voting preference for lower formants in formant-manipulated women's voices. Therefore, the results related to voting preferences for women's formants were not consistent when using natural versus manipulated voices. Pitch and formants interact to influence perceptions of attractiveness from men's voices. That is, women prefer low pitch in men's voices more when combined with low formants and prefer low formants more when combined with low pitch (Feinberg et al., 2011). To our knowledge, the interaction of pitch and formants has not been tested in relation to perceptions of women's voice attractiveness or leadership ability. Given that there have only been two prior studies on women's voice pitch and voting preferences (Anderson & Klofstad, 2012; Klofstad et al., 2012) and that the current study is the first to examine the influence of formants on voting preferences, future studies should investigate perceptions of women's voices in the context of voting and leadership. More data are needed to disentangle the effects of women's voice pitch and formant frequencies on voting preferences.

In men's voices, however, participants preferred to vote for lower pitched voices regardless of formant manipulations. We found that participants preferred to vote for lower pitched men's voices across studies, but did not prefer to vote for the voices of men with lower formants across studies. This result is consistent with the results of prior studies that found that participants preferred to vote for lower pitched men's voices (Klofstad et al., 2012; Tigue et al., 2012). This result is also consistent with the results in Chapter 3 of this dissertation showing that men's natural voice pitch significantly negatively predicted participants' voting ratings, but that men's formants did not.

A potential limitation of this study is that our results reflect the voting preferences of undergraduate students only and in Study 2, of women raters only. Thus, it is unknown whether or not our results generalize to other populations. It should be noted, though, that in Study 1 of this chapter and in a prior study (Tigue et al., 2012), we found no difference between the voting preferences of men and women raters. Thus, there is no evidence to suggest that the results of Study 2 would differ among men. In Chapter 3, we also found no effect of participants' age or whether they completed the study in the laboratory or online on their voting ratings. Thus, there is no evidence that voice-based voting preferences of undergraduates differ from those of other voters. Taken together, our results suggest that voice pitch and formants influence voting preferences for men's and for women's voices differently.

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CHAPTER 6: GENERAL DISCUSSION

In this dissertation, I have examined the influence of human vocal and facial characteristics on perceptions of attractiveness, dominance, and leadership ability. In this chapter, I discuss the results and implications of these studies.

In Chapter 2, I found that men judged women's facial attractiveness similarly from 2D and 3D images (viewed on a 2D surface). This result suggests that using 3D images in face perception research yields similar results as using 2D images. Going forward, the use of 3D images may help to answer important remaining questions about face perception in future studies. For example, jaw shape and brow ridge protrusion may be better evaluated in 3D than in 2D because viewing these facial features from different angles may influence perceptions of attractiveness and dominance.

In Chapter 3, I found that only voice pitch predicted voting ratings of natural men's voices, and that no acoustic feature significantly predicted voting ratings of natural women's voices. I also found that perceptions of men's and women's attractiveness, as well as perceptions of women's social dominance, positively predicted voting ratings. These results underscore the need for future studies to more thoroughly examine perceptions of women's voices in the context of leadership. Moreover, I found no evidence that participants' age, political attitudes, or whether they completed the study in the laboratory or online significantly predicted voting ratings. Thus, I found no evidence that voting ratings of voices differed across these voter demographics.

In Chapter 4, participants listened to men's voices manipulated in pitch and chose which voice they preferred to vote for. Participants chose to vote for lower pitched men's voices more often than they chose to vote for higher pitched men's voices in national election scenarios. Furthermore, I found that participants associated personality traits that are favourable in politicians (*e.g.,* leadership, trustworthiness, honesty, and intelligence) with lower pitched, more often than with higher pitched, men's voices. I also found that perceptions of men's attractiveness and dominance positively predicted voting preferences in a hypothetical national election scenario, but that perceptions of dominance alone positively predicted voting preferences in a hypothetical wartime scenario.

Additionally, in Chapter 4, I found that participants preferred to vote for lower pitched men's voices regardless of (1) whether they chose between two versions of the same identity or between two different identities; (2) whether the identity of the vocalizer was known (voices of U.S. Presidents) or unknown (voices of undergraduates) to the listener; and (3) whether the speech content was from natural, variable speech or a standardized, neutral sentence. These results suggest that men's voice pitch influences voting decisions in a potentially adaptive manner, and highlights the need to similarly investigate voting preferences for women's voices in pitch-manipulated stimuli.

In Chapter 5, I conducted two experiments. In the first experiment (Study 1), I manipulated the pitch of women's voices and tested participants' voting preferences for these voices. In the second experiment (Study 2), I manipulated the formant frequencies of both men's and of women's voices and tested participants' voting preferences for these voices. In Study 1, I found that participants preferred to vote for manipulated women's voices with higher pitch more often than to vote for women's voices with lower pitch. In Study 2, I found that participants preferred to vote for manipulated women's voices with lower formants and that participants preferred to vote for manipulated men's voices with lower pitch regardless of formants. These results suggest that voice pitch and formant frequencies influence voting preferences for men's and for women's voices differently. I discuss the implications of these results below.

Men's Voice Pitch and Voting Preferences

One important finding that emerged from the data presented in this dissertation is that across studies, participants preferred to vote for men with lower pitched voices more often than they preferred to vote for men with higher pitched voices. This finding transcended several different methods, each with its own strengths and weaknesses. First, in Chapter 3, I presented participants with natural, un-manipulated voices and asked them to rate how likely they would be to vote for the person on a 7-point scale. Participants reported that they would be more likely to vote for lower pitched men's voices than to vote for higher pitched men's voices. The strength of this method is that it allowed me to examine voting ratings across a wide range of natural men's voice pitch. The limitation of this method is that from these data, I cannot rule out the possibility that other voice features may account for the relationship between voice pitch and voting ratings because I did not manipulate the stimuli.

Second, in Chapter 4, when participants listened to men's voices manipulated in pitch, they preferred to vote for lower pitched men's voices more often than higher pitched men's voices in two distinct studies with two different participant samples and two unique stimuli sets. The strength of this method is that the two-alternative forced choice (2AFC) paradigm simulates election choices between two candidates more closely than does the single-stimulus rating paradigm in Chapter 3. Manipulating voice pitch also allowed me to determine if variation in voice pitch caused variation in voting preferences. The limitations of this method are that I used fewer voice identities that spanned a narrower range of voice pitch than did the stimuli in Chapter 3.

Third, in Chapter 5, when participants listened to men's voices with manipulated formant frequencies, they preferred to vote for the lower pitched men's voices regardless of the formant manipulation. The strengths of this method are that manipulating formants allowed me to isolate the effect of formants on voting preferences, while also measuring the relationship between natural pitch and voting. The limitations of this method are that I cannot determine if variation in pitch caused variation in voting preferences and that I cannot directly compare voting preferences based on manipulated formants to voting preferences based on manipulated pitch. Taken together, the results of these three experiments (Chapters 3, 4, and 5) on men's voice pitch and voting decisions provides strong evidence that men's voice pitch influences voting decisions and that men with lower pitched voices tend to have an advantage over men with higher pitched voices in simulated election scenarios.

This set of results is important because prior to the studies reported in this dissertation, it was unknown if and how men's vocal masculinity influenced voting behaviour. Although prior studies had shown that men's facial masculinity influenced voting preferences (Little, Burriss, Jones, & Roberts, 2007; Little, Roberts, Jones, & DeBruine, 2012) and correlative data indicated that vocal acoustics related to election outcomes (Gregory & Gallagher, 2002), no study had tested how manipulating voice pitch influenced voting decisions. Unlike previous correlative studies, I manipulated voice pitch while holding all other acoustic parameters of the voice constant, which allowed me to isolate the effect of voice pitch alone on voting preferences (Chapter 4). The correlative data presented in Chapters 3 and 5 are also important because they show that these effects are found in natural stimuli, which may be more ecologically valid than manipulated stimuli. The correlative data also demonstrate that the effect of men's voice pitch on voting preferences exists across a wide range of men's voice pitch.

Thus, to my knowledge, the data presented in this dissertation are the first to empirically demonstrate that participants prefer to vote for men with relatively low-pitched voices (Tigue, Borak, O'Connor, Schandl, & Feinberg, 2012). Furthermore, two other studies have since demonstrated that participants preferred to vote for lower pitched men's voices (Anderson & Klofstad, 2012; Klofstad, Anderson, & Peters, 2012), which supports the data in this dissertation. Given that the results herein relating to men's voice pitch and voting preferences have since been replicated by an independent group of authors, it is likely that the effects reported here are robust and can be replicated in other laboratories. Additionally, in Chapter 3, I found that the influence of men's voice pitch on voting ratings did not differ between younger, undergraduate participants in the laboratory and older, online participants. This finding suggests that the effect of men's voice pitch on voting preferences does not differ between participants inside or outside of the laboratory.

Women's Voice Pitch and Voting Preferences

By contrast, my research revealed that the relationship between women's voice pitch and voting behaviour is unclear. In Chapter 3, I found no significant relationship between women's voice pitch and voting ratings in natural stimuli. In Chapter 5, I found that participants preferred to vote for higher pitched women's voices more often than to vote for lower pitched women's voices in two independent samples using different methods. These results, together with the results of two other studies that found voting preferences for lower pitched women's voices (Anderson & Klofstad, 2012; Klofstad et al., 2012), suggest that the relationship between women's voice pitch and voting decisions is not as well understood as the relationship between men's voice pitch and voting preferences.

There are several possible explanations for the conflicting results across studies relating to voting preferences for women's voice pitch. One potential explanation is that there may be between-individual differences in voting preferences for women's voice pitch. That is, some participants may prefer to vote for higher pitched women's voices and others may prefer to vote for lower pitched women's voices, and these effects cancel each other out when the data are analyzed in aggregate.

In Chapter 3, I measured participants' attitudes toward policies relating to protecting the interests of the participants' group from threats (*i.e.,* military spending, warrantless searches, death penalty, obedience, patriotism, war, school prayer, biblical truth, pacifism, illegal immigration, gun control, foreign aid, compromise, premarital sex, gay marriage, abortion rights, pornography) using a previously validated survey instrument. I found that participants' attitudes toward these issues had no effect on their voting ratings of women's (or of men's) voices. Thus, this explanation is unlikely. Future work that identifies other variables that may account for different voting preferences for women's voices and controls for their effects may help to more accurately describe how women's voice pitch influences voting preferences.

Another set of explanations for the conflicting results related to voting preferences for women's voice pitch is the different methodologies used across studies. When using natural, un-manipulated women's voices (Chapter 3), I found no significant relationship between voting ratings and women's voice pitch. When using either pitch-manipulated or formant-manipulated stimuli (Chapter 5), I found a significant voting preference for higher pitched women's voices. Yet, two studies by Klofstad and colleagues (Anderson & Klofstad, 2012; Klofstad et al., 2012) found significant voting preferences for manipulated lower pitched women's voices.

The first methodological explanation for these different results could be that there was some different acoustic feature of the natural versus manipulated women's voices. However, this explanation is unlikely to explain the pattern of results observed because I found consistent results for voting preferences for men's voices using both natural and manipulated stimuli. It would be useful if future studies using manipulated voices used more voice identities that cover a wider range of voice pitch, similar to the pitch range of the stimuli used in Chapter 3.

Another potential explanation could be that I measured voting preferences for the natural women's voices using a rating paradigm (*i.e.,* "How likely are you to vote for this person in an election? 1= very unlikely, 7= very likely"), while voting preferences for manipulated women's voices were measured using a 2AFC paradigm (*i.e.,* "Choose the voice you are more likely to vote for in an election"). It is unclear how this difference in methodology would translate into the different results. Furthermore, this explanation is unlikely to explain the different pattern of results I found in natural and manipulated women's voices because I found consistent voting preferences for men's voices when using a rating paradigm and a 2AFC paradigm.

However, there are other methodological differences that may explain the conflicting results. Briefly, the major differences between Chapters 3 and 5 of this dissertation and the two published studies (Anderson & Klofstad, 2012; Klofstad et al., 2012) are that: (1) in Chapters 3 and 5, I used women's voice stimuli with a wider range of natural voice pitch than Anderson & Klofstad (2012) or Klofstad et al. (2012) used; (2) in Chapter 5, Study 1 participants made a forced choice between two different voice identities while in prior studies participants made a forced choice between two versions of the same identity; (3) the speech content was vowel sounds in Chapter 3, variable natural utterances of real politicians in Chapter 5, and was a full sentence in the two published studies (Anderson & Klofstad, 2012; Klofstad et al., 2012); and (4) the difference in voice pitch between the two vocalizers differed across trials in Chapter 5, whereas the difference in voice pitch was perceptually equivalent (0.5 equivalent rectangular bandwidth (ERB)) across trials in the previous studies. I discuss how each of these methodological differences may translate into the different results in detail below.

Due to the narrow range of women's voice pitch of the stimuli in the two published studies (181-207 Hz in Anderson & Klofstad, 2012; 162-207 Hz in Klofstad et al., 2012), participants in these studies did not listen to high-pitched women's voices. Given that women's voice pitch decreases with increasing age (Abitbol, Abitbol, & Abitbol, 1999), and that it is reasonable to assume that many women who run for public office are older, these low-pitched women's voice stimuli may accurately represent the voices of actual female politicians. However, these stimuli did not give participants' the opportunity to choose high-pitched, younger sounding, women's voices.

The stimuli in Chapter 3, in contrast, gave participants the opportunity to rate low-pitched, average-pitched, and high-pitched women's voices. Therefore, the results of prior studies (Anderson & Klofstad, 2012; Klofstad et al., 2012) only apply to a small range of women's voice pitch, whereas the results of Chapter 3 apply to a much wider range of women's voice pitch. Moreover, in Chapter 5 Study 1, I used the voices of actual Canadian and American female politicians as stimuli. Using these stimuli, I did not replicate the effects found in prior studies, suggesting that the effects reported by others (Anderson & Klofstad, 2012; Klofstad et al., 2012) are not robust to different stimuli sets.

In prior studies (Anderson & Klofstad, 2012; Klofstad et al., 2012), participants chose between a low-pitched women's voice and an average-pitched women's voice. It is theoretically possible that if the stimuli in these studies started at the average women's voice pitch (approximately 207-210 Hz; Feinberg, DeBruine, Jones, & Perrett, 2008; Pisanski & Rendall, 2011; Re, O'Connor, Bennett, & Feinberg, 2012), rather than low women's voice pitch, the results could be different. If it were true that voting preferences for women's voice pitch differed when participants choose between a low-pitched and a high-pitched woman's voice (rather than between a low-pitched and an average-pitch woman's voice), then we would predict a quadratic relationship between women's voice pitch and voting ratings. In Chapter 3, I found no evidence of a quadratic relationship between women's voice pitch and voting ratings. Therefore, it is unlikely that this explanation can account for the different results I observed.

Furthermore, it is unlikely that the speech content of the stimuli can account for the difference in voting preferences for women's voices between Chapters 3 and 5 of this dissertation and prior studies (Anderson & Klofstad, 2012; Klofstad et al., 2012). Prior studies on men's voices found similar voting preferences for men's voice pitch in three distinct studies that each used different speech content in their voice stimuli (Anderson & Klofstad, 2012; Klofstad et al., 2012; Tigue et al., 2012).

Moreover, I found consistent voting preferences for lower pitched men's voices regardless of whether the identity of the vocalizers was known or unknown (Chapter 4). I also found consistent voting preferences for men's voice pitch regardless of whether participants chose between two versions of the same identity that each differed in pitch by perceptually equivalent amounts, or different identities that differed in pitch by different amounts (Tigue et al., 2012). Furthermore, in Chapter 5 Study 1, I found no significant relationship between the pitch difference between the two voices and the proportion of time that participants chose the higher pitched voices. I found no evidence that the size of the gap in pitch between the higher and lower pitched voices affected how often the voices were chosen. Therefore, there is no evidence that the speech content, the identity of the vocalizer, or the difference in pitch between voice identities influenced the relationship between women's voice pitch and voting preferences. It is doubtful that these variables can explain the different results across studies. Nevertheless, it is possible that speech content not tested here could have an effect on the relationship between voice quality and voting choices.

Prior work has shown, however, that men found higher pitched women's voices more attractive when the content of the woman's vocalization indicated that she was interested in the listener than when her speech content indicated that she was not interested (Jones, Feinberg, DeBruine, Little, & Vukovic, 2008). This finding indicates that men integrate information from voice pitch and cues to social interest of a woman's voice to form attractiveness preferences. In a voting context, it may be possible that participants' voting preferences for women's voices may be formed in part by an interaction between speech content relevant to voting and women's voice pitch. It is important to note that Jones et al. (2008) only manipulated cues to social interest in women's voices, which was not a feature that varied among the stimuli used in Chapters 3 and 5 or in prior studies on voting preferences (Anderson & Klofstad, 2012; Klofstad et al., 2012).

In the future, it would be important to test if manipulating information in speech content other than social interest influences voting preferences for women's voices. To test if voting-relevant speech content influences voting preferences, we would need to design an experiment to measure voting preferences similar to that described in Jones et al. (2008) in which voting-relevant speech content and voice pitch are each manipulated independently. Given that the relationship between men's voice pitch and voting preferences is affected by wartime scenarios (Chapter 4), it would be interesting to study voting preferences for women's voice pitch in war- or military-related speeches versus domestic policy speeches. This manipulation would help to examine which, if any, types of speech content influence the relationship between women's voice pitch and voting preferences. Based on the results of Chapter 4, I would predict stronger preferences for women's low voice pitch in military-related speeches than in domestic policy speeches.

Therefore, it is not yet fully understood how women's voice pitch influences voting decisions. In order to clarify the relationship between women's voice pitch and voting preferences, an important next step would be to independently replicate either the results reported in Chapters 3 and 5 of this dissertation or the results reported by Klofstad et al. (2012) and Anderson & Klofstad (2012). In this dissertation, I did not replicate the results relating to voting preferences for women's voices reported by two previous studies (Anderson & Klofstad, 2012; Klofstad et al., 2012). In short, more data are needed in order to better understand how women's voice pitch influences voting behaviour. For now, the studies reported in this dissertation may cause doubt about the generalizability of prior work on women's voices and voting behaviour.

Vocal Acoustics Other Than Pitch and Voting Preferences

To my knowledge, this dissertation is the first to investigate the relationships between vocal acoustics other than voice pitch and voting preferences for men's and for women's voices. In Chapter 3, I found that no acoustic parameter other voice pitch significantly predicted voting ratings of men's or of women's voices. In Chapter 5, I found that participants had no significant voting preference for manipulated formants in men's voices. In formant-manipulated women's voices, I found that participants preferred to vote for women's voices with lower formants more often than those with higher formants.

In men's voices, I found no evidence that vocal acoustics other than pitch influenced voting preferences. These results were somewhat unexpected given that other studies have shown that men's actual (Blaker et al., 2013; Sorokowski, 2010) and perceived height (Re, DeBruine, Jones, & Perrett, 2013; Re, Dzhelyova et al., 2012) influence voting preferences and that formant frequencies are a reliable vocal cue to men's height (Fitch & Giedd, 1999; Pisanski et al., 2013). Although lower pitched voices are often perceived as being produced by relatively larger individuals within sexes (Rendall, Vokey, & Nemeth, 2007), formant frequencies indicate body size within sexes more reliably than does voice pitch (Pisanski et al., 2013). Therefore, the misattribution of low voice pitch to large body size may account in part for the voting preferences I found for lower pitched men's voices.

I found no evidence that men's formant frequencies influenced voting preferences. It could be that men's voice pitch was a more salient cue to leadership ability than were formant frequencies in this set of experiments. One way to test this prediction would be to independently manipulate voice pitch and formant frequencies at perceptually equivalent levels in a set of men's voices in order to more thoroughly investigate the relative importance of voice pitch and formant frequencies at determining voting preferences for men's voices.

In Chapter 5 Study 2, I manipulated men's formants by ±6%, which corresponds to one just-noticeable difference (JND) for formant frequencies in men's voices (Pisanski & Rendall, 2011). Therefore, the raised and lowered formant versions of the voices in Chapter 5 Study 2 differed by 2 JNDs, or approximately 12% of baseline. The JND for voice pitch perception in men's voices is also 6% (Pisanski & Rendall, 2011). In Chapter 4, I manipulated men's voice pitch by ±0.5 ERB. The average un-manipulated pitch of men's voices in Chapter 4 Study 2 was 115 Hz, the average raised pitch was 135 Hz, and the average lowered pitch was 97 Hz. On average, these voices were raised by 20 Hz and were lowered by 18 Hz. On average, the difference between the pitch-manipulated voices was 38 Hz, or 33% of the baseline. Therefore, the voice pitch manipulation I used was perceptually larger than the formant manipulation by 21%, or 3.5 JNDs. This difference may explain in part why I found effects of manipulated men's voice pitch, but not of manipulated formants, on voting preferences.

Among natural women's voices (Chapter 3), there was no significant relationship between formant frequencies and voting ratings. Yet, participants preferred to vote for manipulated women's voices with lower formants more often than those with higher formants (Chapter 5, Study 2). Women's voices with lower formants sound larger (Feinberg, Jones, Little, Burt, & Perrett, 2005; Smith, Patterson, Turner, Kawahara, & Irino, 2005) and older (Smith & Patterson, 2005) than do women's voices with higher formants. Given that throughout human history, men have held, and continue to hold, the majority of leadership positions, it may be that a woman's voice must sound larger and older than the average woman in order to be perceived as a good leader.

To my knowledge, Chapters 3 and 5 of this dissertation are the first to investigate the influence of formant frequencies on voting ratings of women's voices. Chapter 5 provides preliminary evidence that formant frequencies influence voting preferences for women's voices, but the results of Chapter 3 do not support this conclusion. Thus, more data are needed to understand how formant frequencies influence voting preferences for women's voices.

Perceptions of Leaders' Voices in Different Contexts

In Chapter 4, I investigated voting preferences for manipulated men's voices in two hypothetical contexts: a national election and a time of war. I found that participants preferred to vote for lower pitched, more often than for higher pitched, men's voices in both scenarios. The extent to which participants preferred to vote for lower pitched men's voices was similar in the two hypothetical scenarios. Additionally, I found that perceptions of men's attractiveness and dominance each positively predicted participants' voting preferences in the national election scenario. Thus, participants were more likely to vote for men's voices they perceived as more attractive and as more dominant in the national election scenario. In the wartime scenario, perceptions of men's dominance alone positively predicted voting preferences. Therefore, participants were more likely to vote for men's voices they perceived as more dominant, but not those they perceived as more attractive, in the wartime scenario.

The results above showing that perceptions of men's dominance and attractiveness predicted voting preferences differently in different scenarios (Chapter 4) indicate that men's voice pitch influences voting preferences differently in different social contexts. More specifically, voice pitch-based perceptions of men's dominance are relatively more important at predicting voting preferences than are perceptions of men's attractiveness in a wartime scenario. These results are consistent with the results of prior studies showing that participants preferred to vote for attractive men's faces in hypothetical peacetime, but preferred to vote for masculine and dominant men's faces in hypothetical wartime (Little et al., 2007). Furthermore, participants preferred leaders with trustworthy faces in hypothetical peacetime, but preferred leaders with attractive 2D faces in hypothetical wartime (Little et al., 2012). Additionally, another study found that participants preferred 3D facial cues to perceived height and masculinity in leaders more in hypothetical wartime than in hypothetical peacetime (Re et al., 2013). Chapter 2 showed that 2D and 3D facial attractiveness are positively correlated. Thus, it is likely that results from studies on facial appearance and voting in 2D and 3D generalize to each other. Furthermore, at least some of these constructs appear to be consistent across modalities.

Taken together, the results from Chapter 4 and those from prior studies suggest that voting preferences for facial and vocal masculinity in leaders are context-dependent and that perceived dominance is particularly important to voting preferences in hypothetical wartime. It is also important to note here that despite the evidence presented in Chapter 4 that voting preferences depend on social context (*i.e.,* war versus peace), some authors argue that voice-pitch based perceptions of leadership ability are consistent across contexts and different types of leadership roles (Anderson & Klofstad, 2012).

For example, Anderson & Klofstad (2012) found that participants preferred to vote for lower pitched women's voices in hypothetical school board and parent-teacher organization elections. Based on this result, the authors argue that voice pitch influences perceptions of leadership ability consistently across different types of leadership roles (Anderson & Klofstad, 2012). Unlike political leadership positions usually held by men, women typically hold these school-related leadership positions. However, they also found that men preferred to vote for lower pitched men's voices in both hypothetical school-related elections, but that women had no voting preference for men's voice pitch in these two voting scenarios (Anderson & Klofstad, 2012). This result, that women had no voting preference for men's voice pitch in school-related elections, supports the conclusion in Chapter 4 that voting preferences for men's voice pitch depend on context. In other words, women's voting preferences for men's low voice pitch was not the same in the hypothetical political elections and in the hypothetical school-related elections. Therefore, there is insubstantial evidence to support Anderson & Klofstad's (2012) claim that voting preferences for leaders' voice pitch are independent of context.

The majority of prior work has focused on comparing voting preferences between war and peace scenarios. In future experiments, it would be important to investigate how vocal masculinity influences voting preferences in other social contexts such as economic recession or the threat of pathogen contagion. In addition, it would be interesting to further examine how social context influences voting preferences for leaders' masculinity using different methods to manipulate context. Most prior work has measured voting preferences in different contexts by directly asking participants which voice or face they would vote for in a particular context. More salient and/or ecologically valid manipulations could be used in future studies in order to simulate these contexts in the laboratory more validly.

For example, in a prior study, participants viewed a slideshow of colour images manipulated to provide visual cues to either high or low pathogen contagion and then rated faces for masculinity preference (Little, DeBruine, & Jones, 2011). In another study, participants completed a questionnaire to prime concerns about either pathogen threat or resource scarcity, after which they completed a face perception test (Watkins, DeBruine, Little, Feinberg, & Jones, 2012). Lastly, images indicative of economic recession (or control) have also been used to manipulate participants' perceptions of the economic environment (Griskevicius et al., 2013). Future studies on politics and masculinity could incorporate these methods to further our understanding.

Perceptions of Attractiveness Versus Dominance

As described in Chapter 1 of this dissertation, prior work demonstrated that lower pitched men's voices generally sound more attractive than do higher pitched men's voices (Collins, 2000; Feinberg, DeBruine, Jones, & Little, 2008; Feinberg et al., 2006; Feinberg et al., 2005; Jones et al., 2010). Past studies have also shown that lower pitched men's voices sound more dominant than do higher pitched men's voices (Jones et al., 2010; Ohala, 1982; Puts, Gaulin, & Verdolini, 2006; Puts, Hodges, Cardenas, & Gaulin, 2007; Wolff & Puts, 2010). In this dissertation, I replicated the results of prior studies relating to voice pitch-based perceptions of men's attractiveness and dominance. Specifically, In Chapter 4, I found that men and women perceived manipulated lower pitched men's voices as more attractive and dominant than were higher pitched men's voices (see Chapter 4, Table 1). In Chapter 3, I found that men and women rated naturally lower pitched men's voices as more attractive, socially dominant, and physically dominant than naturally higher pitched men's voices.

These results replicate the effects of manipulated and natural voice pitch on perceptions of men's attractiveness and dominance found in prior studies (Collins, 2000; Feinberg, DeBruine, Jones, & Little, 2008; Feinberg et al., 2006; Feinberg et al., 2005; Jones et al., 2010; Puts et al., 2007; Wolff & Puts, 2010). Given that the effects I found have been replicated using independent stimuli sets (Feinberg et al., 2005 used the voices of men from Rutgers University in the U.S.; Jones et al., 2010 used the voices of white adult undergraduate students at the University of St Andrews, U.K.) and participant samples (Feinberg, DeBruine, Jones, & Little, 2008 used online participants; Feinberg et al., 2006 used laboratory participants in the U.K.; Feinberg et al., 2005 used laboratory participants in the U.K.; Jones et al., 2010 used online participants), there is further evidence that these effects are robust.

In this dissertation, I also replicated the results of prior studies relating to perceptions of women's attractiveness and dominance based on voice pitch. In Chapter 3, I found that men, but not women, rated naturally higher pitched women's voices as more attractive than naturally lower pitched women's voices. I also found that men and women rated naturally lower pitched women's voices as more physically dominant, but not socially dominant, than naturally higher pitched women's voices (Chapter 3). In Chapter 5 Study 1, I found that participants chose manipulated higher pitched women's voices more often than lower pitched women's voices as more attractive. These results replicate the effects of women's natural (Collins & Missing, 2003; Feinberg, DeBruine, Jones, & Perrett, 2008) and manipulated (Collins & Missing, 2003; Feinberg, DeBruine, Jones, & Perrett, 2008; Jones, Feinberg, DeBruine, Little, & Vukovic, 2008, 2010; Puts, Barndt, Welling, Dawood, & Burriss, 2011) voice pitch on perceptions of attractiveness and dominance found in prior studies, suggesting that these effects are also robust.

Voice-pitch based perceptions of attractiveness and dominance have been shown to be separable because there is an opposite-sex bias in how voice pitch influences perceptions of attractiveness, but not of dominance (Jones et al., 2010). More specifically, women had stronger preferences for low voice pitch in men's voices than did men and men had stronger preferences for high voice pitch in women's voices than did women (Jones et al., 2010). However, the strength of men's and of women's associations of low voice pitch with perceptions dominance did not differ between same sex and opposite sex voices (Jones et al., 2010). This pattern of results suggests that perceptions of attractiveness and dominance based on voice pitch are dissociable. Therefore, another objective of this dissertation was to examine the relative strength of perceptions of attractiveness and dominance at predicting voting preferences.

In Chapter 4, I found evidence that voice pitch-based perceptions of men's dominance are more closely tied to voting preferences than are perceptions of men's attractiveness, especially in a hypothetical wartime context. This result suggests that the effect of men's voice pitch on voting preferences, at least in hypothetical wartime, most likely cannot be explained by an attractiveness halo effect in which participants preferred to vote for lower pitched men's voices simply because they sound more attractive than do higher pitched men's voices (Zuckerman & Driver, 1989). Participants preferred to vote for men's voices that sounded more attractive, but not necessarily *because* they sounded more attractive.

In Chapter 3, however, I found that perceptions of men's attractiveness positively predicted voting ratings, but that perceptions of men's social and physical dominance did not. This result does not support the results of Chapter 4 showing that perceptions of men's dominance positively predicted voting preferences. Given that prior work suggests that perceptions of men's dominance influence voting preferences differently in different contexts, it is possible that perceptions of men's dominance did not influence voting ratings in the generic voting context in Chapter 3. As suggested in Chapter 3, perceptions of men's dominance may only influence voting in contexts where there is some cue to threat or the use of force.

Although I demonstrated that perceptions of men's dominance influenced voting preferences more strongly in wartime than in peacetime in Chapter 4, I did not specifically test potential explanations for why this relationship exists. Prior work demonstrated that participants can accurately assess men's physical strength from the voice alone (Sell et al., 2010) and that physically stronger men are more likely to favour the use of military force than are weaker men (Sell, Tooby, & Cosmides, 2009). Sell et al. (2009) suggest that relatively strong men favour military force more than do relatively weak men because the costs associated with physical combat are relatively lower and the benefits relatively higher for strong rather than weak individuals. Furthermore, these authors argue that humans possess evolved mechanisms that allow them to extend judgments about the efficacy of individual force to the use of coalitional force, even to modern international military conflicts between governments (Sell et al., 2009).

One explanation for the stronger relationship between men's perceived dominance and voting preferences in wartime is that participants may perceive dominant men as more likely to support the use of military force or as better able to employ military force than less dominant men. Future work could explore how voice pitch influences perceptions of leaders' attitudes. It is important to better understand how vocal acoustics influence perceptions of leaders' attitudes because voters' perceptions of a candidate's attitude on a particular issue can influence the outcome of an election. Although there are many ways that voters gather information about a candidate's attitudes, information from the voice alone plays a role.

In Chapter 3, participants' social dominance ratings positively predicted voting ratings for women's voices. Therefore, participants said they were more likely to vote for women's voices that they perceived as more socially dominant. Women's physical dominance ratings also positively predicted their voting ratings for women's voices. Thus, women said they were more likely to vote for women's voices they perceived as more physically dominant. Therefore, the results of Chapter 3 provide evidence that perceptions of women's social dominance from the voice positively influence both men's and women's voting ratings. The results of Chapter 3 also suggest that perceptions of women's physical dominance positively influence women's voting preferences, but not men's.

The relationships between perceived attractiveness and dominance from women's voices and voting preferences has only been investigated explicitly in this dissertation (see Chapter 3). Although other studies found that participants preferred to vote for lower pitched women's voices (Anderson & Klofstad, 2012; Klofstad et al., 2012), the participants in these studies did not rate the voice stimuli for perceived attractiveness or dominance. Importantly, in Chapter 3, we found that perceived attractiveness and social dominance each positively predicted voting ratings of women's voices, although women's voice pitch did not. These results suggest that social perceptions of women's voices predicted voting ratings, independent of the relationship between these perceptions and women's voice pitch.

Therefore, across studies in this dissertation, the relationship between voice pitch, dominance, and voting preferences appears to surface most strongly in hypothetical wartime scenarios, and is weaker (Chapter 4), non-existent for men's voices (Chapter 3), or limited to social dominance among women's voices (Chapter 3). In non-wartime scenarios, attractiveness appears to more consistently predict voting preferences (Chapters 3-5; Little et al., 2007).

Implications of Data Relating to Stimuli Presentation Methods

In Chapter 2, I investigated whether using 3D facial images (viewed on a 2D surface) in face attractiveness research yields systematically different results than using 2D facial images. I found that it did not, suggesting that using 3D images yields similar results as using 2D images. The results of Chapter 2 validate the results of prior work that investigated perceived leadership ability from 3D facial images (Re, Dzhelyova et al., 2012) by showing that the results from studies on facial appearance and voting in 2D and 3D generalize to each other.

Future studies could employ 3D images to study specific facial features important to face perception. It is possible that some of the 3D facial features that influence perceptions of attractiveness and dominance, such as the shape of the jaw line and protrusion of the brow ridge, may be better evaluated in 3D images than in 2D images because 3D images allow the viewer to view the object from several different viewing angles. Future studies could examine how viewing these facial features in 3D from different angles influences perceptions of facial attractiveness and dominance. Furthermore, this result has applications for 3D printing which recently become much cheaper and more accessible than it was in the past. Future studies could use 3D printouts of faces to examine perception of facial features in 3D models, rather than in images.

The results reported in this dissertation also have implications for criticisms of the 2AFC methodology used in face and voice perception studies. Studies that used a 2AFC paradigm have been criticized by claims that participants' recognition of the manipulations artificially creates or alters perceptions of faces (Penton-Voak, 2011; Peters, Simmons, & Rhodes, 2009; Scott, Clark, Boothroyd, & Penton-Voak, 2013). I found evidence that results from 2AFC experiments that give participants a choice between two versions of the same person's voice are comparable to those from experiments when participants are given a choice between two different people. First, In Chapter 4, I found that participants preferred to vote for lower pitched men's voices regardless of whether they chose between two versions of the same identity (Study 1) or between two different identities (Study 2). In the future, we can expect 2AFC experiments using either the same identity or different identities to yield similar results.

Next, I found no evidence that the type of speech content influenced voting preferences for voices. Participants preferred to vote for lower pitched men's voices when listening to vowel sounds (Chapter 3), variable speech taken from political speeches (Chapter 4, Study 1), and a standardized, neutral sentence (Chapter 4, Study 2). These results indicate that there is no evidence that the speech content affected how voice pitch influenced voting preferences. Based on the results of Chapter 4, future studies should also explore how war- or military-related speech content may influence the relationship between voice pitch and voting preferences.

Finally, I found no evidence that participants' knowledge of the vocalizer affected the relationship between voice pitch and voting preferences. I found that participants preferred to vote for lower pitched men's voices both when the vocalizer was a U.S. President (Chapter 4, Study 1) and an anonymous undergraduate voice (Chapter 3 and Chapter 4, Study 2). These results suggest that there is no evidence that knowledge of the vocalizer affected the relationship between voice pitch and voting preferences.

General Limitations

One limitation of the data reported in this dissertation is that all but one of the studies (Chapter 3) contains data collected only from undergraduate students, except Chapter 3, which contains data collected from both undergraduates and online participants. Prior voice perception studies have demonstrated that the ratings of undergraduate participants in the laboratory and those of online raters are similar, but it would be important to conduct studies on voting preferences for leaders' voices among other demographics in order to better understand the extent to which voting preferences generalize across voter demographics.

In addition, as mentioned above, my experiments relied on hypothetical voting scenarios by directly asking participants who they would vote for in a time of war or peace. Thus, it is unknown if participants' voting preferences in these hypothetical scenarios generalize to war and peace contexts that exist outside the laboratory. Data from experiments that manipulate war and peace contexts in a more salient manner would help to shed light on this issue.

Conclusions

Voting decisions are complex and are influenced by myriad factors, of which voice pitch is just one. There is strong evidence that men with relatively low-pitched voices have an advantage over men with relatively high-pitched voices in elections, particularly in wartime. It remains unclear, however, precisely how women's voice pitch influences voting decisions. The potentially adaptive manner in which voice pitch influences perceptions of leaders suggests that humans possess evolved mechanisms for evaluating leadership ability.

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