SOCIAL PERCEPTIONS OF VOCAL AND FACIAL SEXUAL DIMORPHISM

SOCIAL PERCEPTIONS OF VOCAL AND FACIAL SEXUAL DIMORPHISM IN RELATION TO MATE CHOICE: ATTRACTIVENESS, FITNESS RISKS & INTRASEXUAL COMPETITION

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ABSTRACT

Previous research indicates that vocal and facial masculinity and femininity influence perceptions of attractiveness. Men generally perceive women with feminine traits as more attractive than less feminine women. This may be because women who possess more feminine traits are likely to be healthier and more fertile mates than are less feminine women. Masculine male traits also influence women's perceptions of attractiveness. Although women do not always prefer masculine male traits, preferences for masculinity are observed under circumstances where women may gain the fitness benefits of heritable health and dominance. Masculine traits in men and feminine traits in women are further associated with the potential fitness risks of infidelity and reduced investment in mates. Here I address three previously unanswered questions concerning the influence of masculinity and femininity on social perceptions. First, how do male vocal and facial masculinity influence perceptions of attractiveness when these two traits are presented simultaneously? Second, does vocal masculinity influence perceptions of the potential fitness risks of infidelity and reduced relationship investment in mates? Third, do male masculinity and female femininity influence perceptions of potential same-sex rivals? In this dissertation I demonstrate that simultaneously presented male vocal and facial masculinity influence women's perceptions of men's attractiveness, that perceivers are somewhat aware of the potential fitness risks associated with preferring high quality mates, and that vocal and facial masculinity influence mate choice and intrasexual

competition in similar ways. Overall, these studies demonstrate the pervasive influence of masculinity and femininity on mate-choice relevant social perceptions.

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Declaration of Academic Achievement

I am the primary author of the four publications included in this "sandwich" dissertation. The publication pages have been renumbered for continuity within this dissertation, but the statistical notation and reference style of the journal of publication has been retained. My research questions directed each and every experiment, which were developed in consultation with my supervisor David Feinberg. I created the stimuli used in each experiment (with the exception of video stimuli used in *Female preferences for male vocal and facial masculinity in videos*), collected and analyzed the data, and authored each publication. These publications comprise my doctoral research and are therefore the main body of the thesis. All publications have been reprinted with permission from both the respective copyright holders and the publication's coauthors. The roles of coauthors for each paper, as well as the year of data collection, are documented below.

O'Connor, J.J.M., Re, D.E., & Feinberg, D.R. (2011). Voice pitch influences perceptions of sexual infidelity. *Evolutionary Psychology, 9,* 64-78.

Re, D.E. – data collection, manuscript contributions

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

Research conducted 2009-2010

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

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Fraccaro, P.J. – stimuli collection and creation, data collection

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CHAPTER 1: GENERAL INTRODUCTION

In this dissertation, I examine the influence of vocal and facial sexual dimorphism on social perceptions in relation to mate choice. I first review the extant literature on voice and face preferences. I then identify unanswered research questions which I examine in the subsequent four chapters. Chapter 6 contains a synthesized discussion of these studies.

Vocal and Facial Sexual Dimorphism

Men's and women's faces and voices are sexually dimorphic, as they differ in many ways. Here I will focus on two such sexually dimorphic traits: voice pitch and facial femininity/masculinity.

Voice Pitch

Men's and women's voices differ in many of their characteristics. One of these sexually dimorphic vocal characteristics is voice pitch. On average, adult male voice pitch for spoken vowel sounds is approximately 120-125 Hz (Childers & Wu, 1991; Pisanski & Rendall, 2011). Recent work estimates average female voice pitch for spoken vowels to be approximately 207 Hz (Feinberg, DeBruine, Jones, & Perrett, 2008b; Pisanski & Rendall, 2011; Vukovic, Feinberg, DeBruine, Smith, & Jones, 2010a), although other

studies using smaller samples have found a higher average fundamental frequency for spoken vowels (e.g. 220 Hz; Childers & Wu, 1991).

Voice pitch is the perceptual correlate of fundamental frequency and/or corresponding harmonics, which is tied to the rate of vocal fold vibration. The rate of vocal fold vibration is influenced by vocal fold size, length, and thickness (Titze, 1994). Assuming equal tension, thicker and longer vocal folds are capable of producing lower frequencies than are thinner vocal folds, which are capable of producing higher frequencies (Titze, 1994). Pubertal testosterone levels cause an increase in vocal fold mass, which results in lower voice pitch (Harries, Hawkins, Hacking, & Hughes, 1998). Due to relatively higher levels of pubertal testosterone among males, adult male voice pitch is on average half that of the mean adult female voice pitch (Childers & Wu, 1991). Voice pitch continues to be negatively related to men's testosterone levels in adulthood (Dabbs & Mallinger, 1999; Evans, Neave, Wakelin, & Hamilton, 2008; Puts, Apicella, & Cárdenas, 2012a).

There is also evidence that further changes in voice pitch occur later in adulthood. Some research suggests that increasing age is associated with increases in male voice pitch and decreases in female voice pitch (Awan, 2006; Nishio & Niimi, 2008). However, other research suggests that in both men and women, voice pitch declines with increasing age until approximately 60 years of age (Stathopoulos, Huber, & Sussman, 2011). Older adult male voice pitch may subsequently increase at approximately 60 years of age, whereas women's voice pitch may increase at approximately 80 years of age

(Stathopoulos et al., 2011). Vocal fold tissue degrades over time, thus reducing vocal fold tension and subsequent pitch (Biever & Bless, 1989). This may explain decreases in voice pitch prior to age 60. A further explanation for the lowering of female voice pitch prior to age 60 is the decrease in estrogen relative to testosterone that occurs during menopause (Awan, 2006), which could increase vocal fold mass and hence decrease average fundamental frequency (Titze, 1994). After age 60, increases in voice pitch may be due to vocal fold thinning (Stathopoulos et al., 2011). Although age related changes in voice pitch and voice pitch preferences are of empirical value, this dissertation will focus on voice pitch and voice pitch preferences within a relatively small age range of young adults aged approximately 18-24 years. Preferences and perceptions relating to mate selection are likely to be particularily relevant to this age group, as higher numbers of younger than older adults may be actively seeking mates.

Facial Femininity/Masculinity

Sexual dimorphism in face shape emerges at puberty (Enlow, 1982; Tanner, 1978). A masculine facial appearance is facilitated by testosterone (Marečková et al., 2011; Verdonck, Gaethofs, Carels, & De Zegher, 1999), and is thought to be inhibited by estrogen (Thornhill & Gangestad, 1996). Indeed, the accurate categorization of pubescent children's faces as male rather than female is better predicted by testosterone levels than by the chronological age of the child (Marečková et al., 2011). Furthermore, the faces of pubescent females with comparatively high testosterone levels for their age group were

more likely to be incorrectly identified as male (Marečková et al., 2011), suggesting that facial masculinization during puberty is sensitive to testosterone levels in both male and female adolescents.

Masculine male faces are characterized by thin lips, small eyes, a broad jaw, and a prominent brow ridge (Keating, 1985). Women with feminine faces tend to have large eyes and small chins, full lips, and high cheekbones (Cunningham, 1986; Jones & Hill, 1993; Perrett, May, & Yoshikawa, 1994). In adulthood, increased facial femininity amongst women is positively associated with higher levels of estrogen (Law Smith et al., 2006; Law Smith et al., 2012) and increased facial masculinity amongst men is associated with higher levels of testosterone (Penton-Voak & Chen, 2004; Rantala et al., 2012a; Roney, Hanson, Durante, & Maestripieri, 2006). However, some research has failed to find a significant relationship between adult levels of testosterone and male facial masculinity (Moore et al., 2011a; Peters, Simmons, & Rhodes, 2008). One potential explanation for these null findings may be that adult male testosterone levels are highly responsive to social factors such as competition (Booth, Granger, Mazur, & Kivlighan, 2006), which may subsequently influence the relationship between male facial masculinity and testosterone levels. For instance, Pound, Penton-Voak, and Surridge (2009) randomly assigned men to lose or win a bet on a Sumo competition and found that men's measured facial masculinity was predicted by increased post-competition testosterone levels amongst winners, but not amongst those randomly assigned to lose. Hence, fluctuations in testosterone levels as a result of competition outcomes may be an

important mediator of the relationship between adult levels of testosteorne and men's facial masculinity.

Femininity and Women's Mate Quality

Men's Preferences for Feminine Women's Faces

One of the many characteristics that influence whether a face is perceived as attractive or unattractive is masculinity/femininity. Men prefer feminized women's faces over masculinized women's faces (Burriss, Welling, & Puts, 2011; Fraccaro et al., 2010; Jones et al., 2007; Jones, Little, Watkins, Welling, & DeBruine, 2011a; Little, Cohen, Jones, & Belsky, 2007a; Moore, Law Smith, Taylor, & Perrett, 2011b; Perrett et al., 1994; Perrett et al., 1998; Smith, Jones, DeBruine, & Little, 2008). Femininity in unmanipulated women's faces is also positively associated with attractiveness (Gray & Boothroyd, 2012; Law Smith et al., 2006; Thornhill & Gangestad, 2006). Both heterosexual and homosexual men prefer femininity over masculinity in women's faces, although heterosexual men's preferences for femininity in women's faces are significantly stronger than are homosexual men's preferences for femininity in women's faces (Glassenberg, Feinberg, Jones, Little, & DeBruine, 2010).

Men's Preferences for Feminine Women's Voices

Women with relatively feminine faces, as measured objectively via facial metrics and subjectively via ratings, also have higher pitched voices (Feinberg et al., 2005, Collins & Missing, 2003). Men's preferences for femininity extend to women's voices. Higher pitched women's voices are rated as more feminine than are lower pitched women's voices (Feinberg et al., 2008b). Men rate unmanipulated women's voices as more attractive when they are higher rather than lower in pitch (Collins & Missing, 2003; Feinberg et al., 2008b). Men also prefer feminized over masculinized women's voices (Feinberg et al., 2008b; Jones, Feinberg, DeBruine, Little, & Vukovic, 2008b; Jones, Feinberg, DeBruine, Little, & Vukovic, 2010b), regardless of whether women's voice pitch is low (~200 Hz), average (~220 Hz), or high (~241 Hz) before their voice pitch is manipulated to be higher or lower (Feinberg et al., 2008b). Women also select the higher pitched version of a female voice as more attractive than the lower pitched version, although only for low (~200 Hz) and average (~220 Hz) levels of pre-manipulation pitch, and not for higher levels of pre-manipulation pitch (~241 Hz). Hence, sex differences exist in the extent to which voice pitch influences women's vocal attractiveness.

Some research suggests that the positive relationship between female vocal attractiveness and voice pitch has an upper limit of approximately 262 Hz, after which the relationship becomes negative (Borkowska & Pawlowski, 2011). Other research suggests that female vocal attractiveness increases with increasing fundamental frequency up to (i.e. 273 Hz; Feinberg et al., 2008b) and well beyond normal female voice pitch (i.e. 300

Hz; Re, O'Connor, Bennett, & Feinberg, 2012). Therefore, whether female vocal attractiveness is positively associated with attractiveness at supra-normal values of voice pitch is not well established.

Fitness Benefits of Mating with Feminine Women

Between-individual differences in fertility.

Feminine female voices and faces may be preferred by men due to associations amongst feminine traits, estrogen, and fertility. Both vocal and facial femininity in women are associated with relatively higher levels of estrogen (Abitbol, Abitbol, & Abitbol, 1999; Law Smith et al., 2006; Law Smith et al., 2012). While Puts et al. (2013) failed to find a relationship between women's estrogen levels and their facial or vocal attractiveness, it should be noted that this study did not include an analysis of the relationship between women's estrogen levels and their facial femininity or their voice pitch. Therefore, while previous research has demonstrated a positive relationship between women's estrogen levels and facial femininity and attractiveness (Law Smith et al., 2006), and between facial and vocal femininity (Feinberg et al., 2005a) and attractiveness (Collins & Missing, 2003), the evidence for a direct relationship between women's vocal and facial attractiveness and women's estrogen levels requires further investigation.

Women with higher levels of trait estrogen express a desire for a higher number of offspring than do women with lower levels of trait estrogen (Law Smith et al., 2012). Such women are also more likely to be able to conceive, given that estrogen levels are positively associated with the probability of conception (Venners et al., 2006). Indeed, within the traditional nomadic Himba of Namibia, women with higher pitched-voices have a greater number of living children and grandchildren than do women with lower-pitched voices (Atkinson et al., 2012). Therefore, men's preferences for women with feminine faces and voices may be due to the increased reproductive success steming from mating with feminine women.

Within-individual differences in fertililty.

Voice pitch has also been hypothesized to communicate within-individual varitions in fertility. Pipitone and Gallup (2008) found that women's vocal attractiveness increased positively with conception risk as quantified by temporal proximity to ovulation. Fischer et al. (2011) found a similar effect of conception risk on women's vocal attractiveness, although only for free speech and not for attractiveness ratings of isolated vowels sounds. Voice pitch may also increase during times of increased conception risk, although only for speech with semantic content and not for vowel sounds (Bryant & Haselton, 2009). However, other research has not replicated this finding (Fischer et al., 2011). The occurrence of voice pitch modulation in socially meaningful speech, but not in content-

free speech, suggests that increases in women's voice pitch and attractiveness may be a result of behavioural modification in mating-relevant contexts (Fraccaro et al., 2011).

Youth.

Women's voice pitch decreases with increasing age (Awan, 2006; Nishio & Niimi, 2008), and higher pitched women's voices are perceived as belonging to women who are younger (Collins & Missing, 2003; Feinberg et al., 2008b). The voices of young girls and young adult women are perceived to be more attractive and feminine than are the voices of peri- and post-menopausal women (Röder, Fink, Feinberg, & Neave, 2013). The relationship between voice pitch, perceived age, and actual age is relevant to the adaptive function of men's preferences for women's voice pitch because, in comparison to older women, younger women are more likely to conceive (Dunson, Colombo, & Baird, 2002) and have relatively higher lifetime reproductive potentials (Fitzgerald, Zimon, & Jones, 1998). Among post-pubertal women, indices of fertility such as oocyte quality and quantity decrease with increasing age (Fitzgerald et al., 1998). Therefore, men may prefer higher-pitched women's voices, which sound younger, because youth is positively associated with fertility and/or higher future reproductive potential.

Health.

Feminine characteristics may also be preferred by men on the basis of associations among femininity, estrogen levels, and health. The faces of women with relatively higher estrogen levels, as well as the facial composites of women with relatively higher estrogen levels, are rated as more feminine, attractive, and healthy than are the faces of women with relatively lower estrogen levels (Law Smith et al., 2006). There are also positive associations amongst femininity, attractiveness, and health ratings of individual women's faces (Gray & Boothroyd, 2012; Law Smith et al., 2006). Women with relatively feminine faces report fewer respiratory illnesses (Gray & Boothroyd, 2012; Thornhill & Gangestad, 2006) and less antibiotic use (Gray & Boothroyd, 2012) than do women with relatively more masculine faces. Female vocal femininity is also negatively associated with other indices of health such as body weight, body mass, and hip circumference (Collins & Missing, 2003; Vukovic et al., 2010a). If feminine women are healthier than are relatively masculine women, offspring may benefit from increased maternal provisioning and/or heritable immunity. Importantly, when women's faces are manipulated to be more feminine while controlling for perceived health, preferences for femininity are weaker but still statistically significant (Moore et al., 2011b). Therefore, while evidence suggests that men's preferences for femininity are associated with men's preferences for health, preferences for such characteristics as youth and fertility are additional contributing factors (Moore et al., 2011b).

Fitness Risks Associated with Mating with Feminine Women

Men who mate with relatively feminine women may benefit from increased reproductive success, but may also be subject to increased fitness costs in the form of cuckoldry. Women with relatively higher levels of estrogen report a greater likelihood of flirting, kissing, and having a serious affair with someone other than their primary partner than do women with relatively lower levels of estrogen (Durante & Li, 2009). These women are also more likely to adopt a mating strategy of serial monogamy rather than a short-term mating strategy (Durante & Li, 2009). Furthermore, feminine female body shape is associated with relatively higher estrogen levels (Jasienska, Ziomkiewicz, Ellison, Lipson, & Thune, 2004). Women with more feminine bodies report a higher number of sex partners, extra-pair partners, and frequency of acting as an extra-pair partner than do other women (Hughes & Gallup, 2003; Hughes, Dispenza, & Gallup, 2004). Therefore, both women's estrogen levels and the expression of traits associated with higher levels of estrogen are positively associated with an increased risk of infidelity.

Individual Differences in Men's Preferences for Femininity

While men generally prefer women with feminine traits over women with masculine traits, variation in men's preferences for femininity is predicted by relationship context and individual differences in mate choice relevant traits.

Relationship context.

First, men's femininity preferences may be influenced by relationship context. Short-term relationship contexts are temporally brief, such as "a single date accepted on the spur of the moment, an affair within a long-term relationship, and the possibility of a one-night stand" (Penton-Voak et al., 2003). Long-term relationship contexts are of lengthier durations, and would "include someone you may want to move in with, someone you may consider leaving a current partner to be with, and someone you may, at some point, wish to marry (or enter into a relationship on similar grounds as marriage)" (Penton-Voak et al., 2003).

Puts et al. (2011) investigated men's preferences for women's voices in short-term and long-term relationship contexts. Here, men listened to women's voices that were manipulated to be higher or lower in pitch, and then rated the voices for attractiveness as a short-term or long-term mate. Puts et al. (2011) found that men rated higher pitched women's voices as more attractive than lower pitched women's voices in the context of a short-term, but not long-term, relationship. However, the voice stimuli used by Puts et al. (2011) differed in pitch and formant frequencies (i.e., apparent vocal tract length), suggesting that men's preferences for voice pitch are influenced by both relationship context and by other vocal characteristics.

Little et al. (2011a) found that men preferred feminine female faces and voices more in short-term than in long-term relationship contexts. By contrast, Burriss et al. (2011) found that men preferred feminized over masculinized women's faces for both short-term

and long-term relationships. Fraccaro et al. (2010) also found that women's vocal and facial femininity positively influenced men's mate preferences for both short-term and long-term relationship contexts. Here, men who preferred feminine women's faces also preferred feminine women's voices, although only when rating stimuli for long-term, and not short-term, relationships. The interaction between perceiver traits and relationship context also supports the findings that femininity influences men's preferences for long-term mates. For example, healthier men have stronger preferences for facial femininity than do less healthy men, although only for long-term relationships (Scott, Swami, Josephson, & Penton-Voak, 2008). Furthermore, men prefer relatively feminine women's faces for a long-term relationship when cued to safer social and economic conditions than when cued to harsher social and economic conditions (Little et al., 2007a). This may be because when social support and resources are highly available, men may be better able to accrue resources that are attractive to women. Thus, men themselves become more attractive as mates, and may be better able to attract and retain relatively feminine women as long-term mates. Hence, context-dependent femininity preferences may be particularly salient when considering individual differences in men's preferences for feminine mates.

Health.

The relationship between men's preferences for femininity and aspects related to men's own health suggests that men may prefer women with feminine traits on the basis of potential fitness benefits relating to health. For example, when primed with cues to the

presence of environmental pathogens, men have stronger preferences for feminine female faces than before priming or when primed with neutral visual stimuli (Little, DeBruine, & Jones, 2011b). Also, men's pathogen disgust, but not moral or sexual disgust, is positively associated with their preferences for feminine women's faces (Jones et al., In press). Cortisol levels increase in response to stress, and elevations in cortisol may subsequently suppress the immune system (Jones et al., In press). Jones et al. (In press) found that preferences for feminine women's faces were stronger amongst men with elevated cortisol levels. Hence, men who are currently less healthy, and/or are more concerned about disease, appear to have stronger preferences for feminine women's faces than do other men. Given findings that relatively feminine women are likely to be healthier than less feminine women (see subsection *Health* in *Fitness Benefits of Mating with Feminine Women*), men who mate with relatively feminine women may gain fitness benefits in the form of heritable health for offspring.

Correlates of mate value.

Men's own attractiveness may also predict their preferences for feminine women's faces. For example, both self- and other-rated attractiveness are positively correlated with men's preferences for facial femininity in the context of short-term, but not long-term, relationships (Burriss et al., 2011). Other research, however, has not found a significant relationship between men's attractiveness and their facial femininity preferences (Fraccaro et al., 2010; Moore et al., 2011b). Since attractiveness is a relative term that

may describe males with either masculine or feminine traits, the nature of the relationship amongst men's attractiveness, mate value, and their mate preferences may be clarified by future studies. However, trait testosterone (see section *Fitness benefits of Mating with Masculine Men*) is positively associated with preferences for feminized women's faces (Welling et al., 2008). Other traits such as higher sexual desire (Jones et al., 2011a), openness to uncommitted sex (Glassenberg et al., 2010), and sensation seeking (Jones et al., 2007) are also positively related to men's preferences for feminine women's faces. These findings suggest that while men generally prefer women with feminine traits over women with masculine traits, there are also individual differences in the degree to which men prefer femininity in potential mates.

Masculinity and Men's Mate Quality

Women's Preferences for Masculine Male Faces

Facial masculinity/femininity also influences women's perceptions of men's facial attractiveness. Previous research has shown that women are attracted to masculine men's faces (DeBruine et al., 2006; Feinberg, DeBruine, Jones, & Little, 2008a; Johnston, Hagel, Franklin, Fink, & Grammer, 2001; Penton-Voak et al., 2001; Scheib, Gangestad, & Thornhill, 1999) and feminine men's faces (Little & Hancock, 2002; Perrett et al., 1998; Rhodes & Hickford, 2000), whereas other research has not found a significant influence of masculinity or femininity on women's preferences for men's faces

(Glassenberg et al., 2010). However, women's preferences for masculinity are predicted under specific circumstances (see *Individual Differences in Women's Preferences for Masculinity* for further discussion).

Women's Preferences for Masculine Male Voices

Across studies, women prefer lower-pitched over higher-pitched men's voices (Collins, 2000; Feinberg, Jones, Little, Burt, & Perrett, 2005b; Feinberg et al., 2006; Feinberg et al., 2011). Women's preferences for lower-pitched over higher-pitched men's voices has been demonstrated using both unmanipulated (Bruckert, Lienard, Lacroix, Kreutzer, & Leboucher, 2006; Collins, 2000; Saxton, Caryl, & Roberts, 2006; Zuckerman & Miyake, 1993) and manipulated voices (Feinberg et al., 2005b; Feinberg et al., 2006; Feinberg et al., 2008a; Hodges-Simeon, Gaulin, & Puts, 2010; Jones et al., 2010b; Riding, Lonsdale, & Brown, 2006). However, when men's voices are lowered below 96 Hz (near the natural boundary of low-voice pitch in men), women prefer the raised-pitched over lowered-pitched verison of a voice (Re et al., 2012).

Women's preferences for masculine male voices are further evidenced by findings that men with lower-pitched voices tend to report higher numbers of past sex partners (Puts, Gaulin, & Verdolini, 2006) and have significantly more surviving offspring than do men with higher-pitched voices (Apicella, Feinberg, & Marlowe, 2007). Greater reproductive success amongst men with lower versus higher pitched voices may be due to

either differences in men's ability to acquire sexual access or differences in men's ability to successfully fertilize ovum during copulation. Because previous research has failed to find a significant relationship between voice pitch and sperm quality (Simmons, Peters, & Rhodes, 2011), pre-copulatory female mate selection likely explains higher reproductive success amongst men with lower pitched voices. When taken together, the above findings suggest that men with lower-pitched voices may have preferential access to willing female sex partners.

Fitness Benefits of Mating with Masculine Men

Health.

Morphological correlates of testosterone, such as facial and vocal masculinity, are hypothesized to communicate underlying mate quality because testosterone is associated with indices of health. Testosterone levels amongst men have been found to be negatively associated with such health risks as atherosclerosis, metabolic syndrome, type 2 diabetes mellitus, cardiovascular disease, insulin resistance, and erectile dysfunction (De Maddalena, Vodo, Petroni, & Aloisi, 2012; Feely, Saad, Guay, & Traish, 2009). Male facial masculinity is also positively associated with self-reported health (Thornhill & Gangestad, 2006) and with health as quantified by the examination of health records (Rhodes, Chan, Zebrowitz, & Simmons, 2003). Furthermore, men with a relatively masculine appearance have relatively lower levels of oxidative stress, which occurs when

the body's ability to counter free radicals is exceeded, and may result in DNA mutation, and hence disease (Gangestad, Merriman, & Thompson, 2010). However, the relationship between testosterone levels and health is controversial (Little, 2013; Scott, Clark, Boothroyd, & Penton-Voak, In press)**,** as some research has not found significant associations between men's testosterone levels and some health measures (Gangestad et al., 2010; van Anders, 2010). The failure to detect a significant relationship between indices of health and men's testosterone levels may be due to the moderating role of cortisol. The positive relationship between men's testosterone levels and their immune responses to a vaccine was stronger amongst men with lower cortisol levels than amongst men with higher cortisol levels (Rantala et al., 2012b). This suggests that environmental stressors may mediate the relationship between testosterone and health. Regardless of some null findings, any relationship between men's health and their testosterone suggests that women who mate with relatively masculine men may gain fitness benefits for offspring in the form of heritable immunity and/or reduced proximate exposure to pathogens.

Dominance.

Women may also gain fitness benefits relating to dominance by mating with relatively masculine men. Testosterone levels are positively associated with dominant behavior (Mazur and Booth, 1998). Masculine male voices and faces are perceived as more dominant than are feminine men's voices (Feinberg et al., 2006; Jones et al., 2010b;

Ohala, 1982; Puts et al., 2006; Puts, Hodges, Cardenas, & Gaulin, 2007; Tusing & Dillard, 2000; Wolff & Puts, 2010) and faces (Boothroyd, Jones, Burt, & Perrett, 2007; Burriss, Little, & Nelson, 2007; Perrett et al., 1998). Although men's voice pitch is not directly associated with their self-rated dominance scores, men will lower their voice pitch when speaking to a less physically dominant romantic competitor (Puts et al., 2006; Puts et al., 2007). Furthermore, male facial masculinity is associated with increased physical strength (Fink, Neave, & Seydel, 2007), and lower-pitched voices are perceived as belonging to stronger men than are higher-pitched voices (Sell et al., 2010). Physical strength is likely an important predictor in the initiation and outcome of male dominance competitions. Although low voice pitch may also be an important factor in men's dominance competitions for access to willing mates (Puts, Jones, & DeBruine, 2012b), women's selection of relatively masculine men as mates is hypothesized to be due to the potential fitness benefits of health and/or dominance that women gain for their offspring by mating with relatively more masculine men.

Fitness Risks Associated with Mating with Masculine Men

Men's testosterone levels are thought to be associated with increased mating effort at the cost of parental investment. For example, in comparison to other men, men with higher testosterone levels are less likely to invest in relationships and offspring (Booth & Dabbs, 1993; Roney, Hanson, Durante, & Maestripieri, 2006; Gray, Parkin, & Sammsvaughan, 2007; van Anders, Hamilton, & Watson, 2007; van Anders & Goldey,

2010). When men with relatively higher levels of testosterone are in relationships, they typically report lower levels of relationship commitment to their romantic partner in comparison to men with lower levels of testosterone (Caldwell Hooper, Gangestad, Thompson, & Bryan, 2011). Men with higher levels of testosterone are less likely to marry than are other men (Booth & Dabbs 1993). The marriages of men with relatively higher levels of testosterone are more likely to be characterized by domestic violence, marital instability, separation, and divorce than are the marriages of men with relatively lower levels of testosterone (Booth & Dabbs 1993). Whether women perceive relatively masculine men as less likely to invest resources, time, and effort into relationships is examined in Chapter 4.

Relatively masculine men may also present an increased risk of infidelity. When men with relatively higher levels of testosterone are in relationships, they report sustained interest in extra-pair sex (McIntyre et al., 2006). Furthermore, men's testosterone levels are positively associated with their reported number of sex partners (Peters et al., 2008; Pollet, van der Meij, Cobey, & Buunk, 2011) and extra-marital affairs (Fisher et al., 2009; Booth & Dabbs, 1993). In comparison to other men, men with relatively masculine bodies and attractive voices report higher numbers of sex partners, extra-pair partners, and frequency of acting as an extra-pair partner (Hughes & Gallup, 2003; Hughes et al., 2004). Therefore, women who prefer to mate with relatively masculine men may experience increased fitness costs stemming from the loss of protection and provisioning.

Whether women perceive relatively masculine men to be less likely to be sexually faithful than relatively feminine men is examined in Chapter 3.

Individual Differences in Women's Preferences for Masculinity

Individual differences in women's preferences for masculinity suggest that, for some women, mate choice decisions are influenced by a potential trade-off between obtaining parental investment versus heritable benefits for offspring, whereas other women may be able to obtain both parental investment and heritable benefits for offspring.

Menstrual cycle.

Women's preferences for vocal masculinity are greater in the fertile than infertile phase of the menstrual cycle (Feinberg et al., 2006), particularly when rating men's voices varying in masculinity for short-term relationships (Puts, 2005). Women's preferences for facial masculinity are also greater during the fertile versus infertile phase of the menstrual cycle (Johnston et al., 2001; Little, Jones, & DeBruine, 2008; Penton-Voak et al., 1999; Penton-Voak & Perrett, 2000). This pattern of menstrual cycle shifts in preferences for facial masculinity are greater when men are rated for short-term than for long-term relationships (Johnston et al., 2001; Little & Jones, 2012; Penton-Voak et al., 1999) and amongst women who are currently partnered than amongst single women (Penton-Voak

et al., 1999). These findings suggest that relatively masculine men may be preferred as short-term and/or extra-pair mates from whom heritable fitness benefits may be gained for offspring when protection and provisioning can be obtained from alternate sources, such as a current in-pair partner. While not all research has found evidence for variation in women's preferences for masculine traits across the menstrual cycle (Harris 2011, 2012), there is substantial evidence for menstrual cycle variation in women's preferences for a variety of masculine traits (for review see DeBruine et al., 2010b), such as voice pitch (Feinberg et al., 2006; Puts, 2005), body shape (Little, Jones, & Burriss, 2007b), behaviour (Gangestad, Simpson, Cousins, Garver-Apgar, & Christensen, 2004; Gangestad, Garver-Apgar, Simpson, & Cousins, 2007), and body movement (Provost, Troje, & Quinsey, 2008).

Fertility.

The hypothesis that women prefer masculine men on the basis of potential heritable benefits is underscored by the influence of hormonal birth control use on women's preferences for masculinity. Women who are currently using hormonal contraceptives have significantly weaker vocal and facial masculinity preferences than women who are not using hormonal contraceptives (Feinberg et al., 2008a). Furthermore, women who are not using hormonal birth control have stronger preferences for male facial masculinity in short-term than in long-term relationship contexts, but this context-dependent preference is not observed in women using hormonal birth control (Little,

Jones, Penton-Voak, Burt, & Perrett, 2002; Smith et al., 2009). Other factors relating to decreased fertility, such as breast feeding, are associated with weaker preferences for vocal masculinity (Apicella & Feinberg, 2009). Peri-pubescent and post-menopausal women also have weaker preferences for facial masculinity than do reproductive-age women (Jones, Vukovic, Little, Roberts, & DeBruine, 2011b; Little et al., 2010). Adolescents and adults, but not children, rate lower pitched men's voices as more attractive than higher pitched men's voices (Saxton et al., 2006), whereas infants prefer higher pitched over lower pitched speaking and singing, characteristic of infant-directed speech (Fernald & Kuhl, 1987; Trainor & Zacharias, 1998). This may be because lower pitched sounds are associated with perceptions of potential threat (Bolinger, 1964; Huron, Kinney, & Precoda, 2006). Moreover, it is not only the physiological capability to conceive that is positively associated with preferences for masculinity. Facial masculinity preferences are greater amongst partnered women who report desiring children than amongst partnered women who do not desire children (Watkins, 2011). Therefore, preferences for masculine male traits are stronger amongst women who are relatively more able and willing to conceive than amongst other women. Indeed, in comparison to women who were using hormonal birth control when selecting their mates, women who were not using hormonal birth control have significantly more masculine male mates and have stronger preferences for manipulated masculinity in male faces (Little, Burris, Petrie, Jones, & Roberts, In press).

Correlates of mate value.

Female mate selection may involve a trade-off between obtaining parental investment and obtaining heritable benefits for offspring. Some women may resolve this trade-off by selecting relatively masculine men as short-term and/or extra-pair mates, while selecting relatively feminine men as long-term mates. Other women may be able to obtain both heritable benefits and investment from relatively masculine men. This is suggested by findings that women's preferences for masculinity are predicted by variation in traits associated with women's underlying mate quality. Women's self-perceived attractiveness is positively related to their vocal and facial masculinity preferences (Feinberg et al., 2012; Little, Burt, Penton-Voak, & Perrett, 2001; Vukovic et al., 2008). Women with more attractive faces as rated by others, and women who have more feminine bodies, also have stronger preferences for masculinity in men's faces than do other women (Penton-Voak et al., 2003). Whether women's facial attractiveness as rated by others is also associated with their preferences for low voice pitch is examined in Chapter 2.

Women with higher pitched voices, a trait associated with female mate quality (see section *Fitness Benefits of Mating with Feminine Women)*, also prefer more masculine men's voices (Vukovic et al., 2010b). Trait estrogen levels (i.e. estrogen levels averaged across the menstrual cycle) may also indicate female mate quality (see section *Fitness Benefits of Mating with Feminine Women*). Women with higher trait estrogen levels demonstrate less menstrual cycle variation in vocal masculinity preferences,

whereas women with lower trait estrogen levels have stronger preferences for lower pitched men's voices during the late follicular versus the luteal menstrual cycle phase (Feinberg et al., 2006). This finding suggests that cyclic variation in women's preferences for low male voice pitch may be moderated by correlates of their own underlying mate quality. Moreover, women with relatively attractive faces and feminine bodies do not vary significantly in their preferences for facial masculinity across long and short-term mating contexts, whereas women with less feminine waist-to-hip ratios prefer relatively feminine men's faces more in long-term than in short-term relationship contexts (Penton-Voak et al., 2003). Therefore, women who are relatively higher in mate value themselves, as indicated by attractive and feminine traits, may be better able to obtain and/or retain relatively masculine men as mates in comparison to women who are relatively lower in mate value (Feinberg et al., 2006; Penton-Voak et al., 2003; Vukovic et al., 2010b).

Relationship context.

Women's preferences for vocal masculinity are observed in both short-term and long-term relationship contexts (Feinberg et al., 2012; Hodges-Simeon et al., 2010; Vukovic et al., 2011). Women's preferences for vocal masculinity are also relatively stronger in short-term than in long-term relationship contexts (Feinberg et al., 2012; Puts, 2005). In general, women tend to prefer relatively masculine male faces more in a short-term than in a long-term relationship context (Little et al., 2011a; Penton-Voak et al., 2003; Scott et al., 2008). However, individual differences interact with relationship

context to influence masculinity preferences. For example, women who perceive masculine men's voices as more dominant prefer vocal masculinity more in short-term than in long-term mating contexts (Vukovic et al., 2011). Women who perceive masculine men's voices as relatively more trustworthy also prefer masculine men's voices more as long-term than as short-term mates (Vukovic et al., 2011). When women are cued to a hypothetical safe versus harsh environment (in terms of the availability of social and economic support), women's preferences shift towards facial masculinity in long-term mates (Little et al., 2007a). This suggests that when social support and resources are readily available, women may perceive relatively masculine men as less risky long terms mates. Therefore, the nature of the interaction between relationship context and masculinity preferences can be influenced by other factors.

Health.

Factors relating to health are also associated with variation in women's preferences for masculinity. For example, women's self-rated health is negatively associated with their preferences for vocal masculinity in short-term, but not long-term relationships (Feinberg et al., 2012). Women who are higher in pathogen disgust have stronger preferences for masculine men's bodies, voices, and faces than do women who are lower in pathogen disgust (DeBruine, Jones, Tybur, Lieberman, & Griskevicius, 2010d; Jones et al., In press). Cueing the presence of environmental pathogens with

images of potentially infectious materials results in relatively stronger preferences for masculinity in comparison to before priming or to neutral images (Little et al., 2011b).

On a societal level, women from countries with indices of relatively poor health also have stronger masculinity preferences than do other women (DeBruine, Jones, Crawford, Welling, & Little, 2010a). In the United States, women from states with indices of relatively poor health have stronger masculinity preferences than do women from states with indices of relatively good health (DeBruine, Jones, Little, Crawford, & Welling, 2011). It has been suggested that income inequality may better account for variation in women's preferences for facial masculinity than do indices of national health, as these two factors covary (Brooks et al., 2010). Brooks et al. (2010) found that women from countries with higher levels of income inequality had stronger preferences for male facial masculinity than did women from countries with less income inequality. Nonetheless, subsequent research suggests that indices of national health predict preferences for male facial masculinity better than do indices of income inequality (DeBruine et al., 2011). Whether indices of national health or indices income inequality better predict societal-level variation in women's preferences for male facial masculinity are beyond the scope of this dissertation. Nevertheless, the relationship between societal- and individual-level health factors and women's preferences for male facial masculinity suggests that women's preferences for masculinity could potentially benefit offspring either directly, by reducing proximate exposure to pathogens, or indirectly, in the form of heritable immunity (for review see Tybur & Gangestad, 2011).

The Current Dissertation

The Influence of Masculinity/Femininity on Perceptions of Attractiveness

Vocal and facial masculinity are both positively associated with testosterone levels (Dabbs & Mallinger, 1999; Evans et al., 2008; Penton-Voak & Chen, 2004; Roney et al., 2006). Women tend to prefer male vocal masculinity over vocal femininity, (Collins, 2000; Feinberg et al., 2005b; Feinberg et al., 2006; Feinberg et al., 2011), but vary in their preferences for male facial masculinity or femininity (DeBruine et al., 2006; Glassenberg et al., 2010; Perrett et al., 1998; Rhodes & Hickford, 2000). Moreover, women who prefer facial masculinity also prefer vocal masculinity (Feinberg et al., 2008a) and putative masculine pheromones (Cornwell et al., 2004). Therefore, vocal and facial masculinity are both related to the same underlying physiological characteristics (i.e. testosterone) and are assessed by potential mates in similar fashions. This research examined women's preferences by presenting still images of faces separately from recordings of men's voices (Feinberg et al., 2008a). However, women's preferences for masculinity have not yet been examined by presenting men's faces and voices simultaneously. It is important to investigate how male vocal and facial masculinity influence perceptions of attractiveness when both traits are present because we typically encounter faces and voices together, rather than in isolation. In chapter 2, I investigate whether male facial and vocal masculinity have interactive or independent effects on women's perceptions of men's attractiveness.

Women who possess traits indicative of relatively higher mate value appear to have stronger preferences for masculine male traits (see section *Individual Differences in Women's Preferences for Masculinity*). Correlates of mate value, e.g. relatively high self-rated attractiveness, predict women's preferences for both facial and vocal masculinity across separate samples of women (Feinberg et al., 2012; Little et al., 2001; Vukovic et al., 2008). Facial attractiveness, as rated by others, is another correlate of women's mate value that has been demonstrated to positively influence women's preferences for male facial masculinity (Penton-Voak et al., 2003), but has not yet been shown to predict women's preferences for male vocal masculinity. In chapter 2, I examine whether women who have more attractive faces, as rated by others, have stronger preferences for both male facial and vocal masculinity than do women with less attractive faces.

The Influence of Masculinity/Femininity on Perceptions of Fitness Risks

Women prefer masculine men's voices over feminine men's voices (Collins, 2000; Feinberg et al., 2011; Feinberg et al., 2006; Feinberg, Jones, Little, Burt, & Perrett, 2005) and men prefer feminine women's voices over masculine women's voices (Feinberg et al., 2008b; Fraccaro et al., 2010; Jones et al., 2010b). Women with feminine voices and men with masculine voices are thought to be preferred due to relatively higher underlying mate value (*see* sections *Fitness Benefits of Mating with Feminine Women*, *Fitness Benefits of Mating with Masculine Men*). However, there are fitness risks associated with mating with relatively high mate value individuals. Relatively feminine

women and relatively masculine men may be more likely to commit infidelity than are other women and men (see sections *Fitness Risks Associated with Mating with Masculine Men, Fitness Risks Associated with Mating with Feminine Women*). Yet, men and women possessing traits associated with relatively higher infidelity risk are preferred as potential mates. In chapter 3, I examine whether voice pitch influences men's and women's perceptions of potential infidelity.

Relatively masculine men may also be less likely to invest in relationships and offspring in comparison to relatively feminine men (see section *Fitness Risks Associated with Mating with Masculine Men*), but whether or not masculine male traits (i.e. lower voice pitch) influence women's perceptions of relationship investment has yet to be determined. In chapter 4, I test whether women perceive men with lower pitched voices to be less likely than men with higher pitched voices to invest resources, time, and effort into romantic relationships.

Women's preferences for masculinity are greater when men are rated as potential short-term than as potential long-term mates (see section Individual *Differences in Women's Preferences for Masculinity*). Protection and provisioning for offspring may be niether expected nor required in short-term or extra-pair mating contexts. Hence, the extent to which women perceive men with masculine voices as investing and generous mates may predict women's preferences for lower pitched male voices in long-term more than in short-term relationship contexts. In chapter 4, I test whether men's voice pitch influences women's perceptions of relationship investment. I also test whether

perceptions of investment are related to women's vocal masculinity preferences in long-term more than in short-term relationship contexts.

The Influence of Masculinity/Femininity on Perceptions of Intrasexual Competition

The same traits that are valued in potential mates are also likely to be arenas of intrasexual competition (Dijkstra & Buunk, 1998; Dijkstra & Buunk, 2001). Both men's and women's jealousy responses to potential intrasexual competitors are influenced by the physical characteristics of same-sex rivals. Women with relatively feminine bodies evoke more jealousy in other women than do women with relatively less feminine bodies (Buunk & Dijkstra, 2005; Dijkstra & Buunk, 2001; Massar & Buunk, 2009). Whether the influence of female body femininity on women's jealousy extends to femininity in female voices and faces has yet to be tested. Also, men are more jealous towards rivals with relatively masculine bodies (Dijkstra & Buunk, 2001) and faces (Kruger, 2006), but is it unknown whether male vocal masculinity also influences men's jealousy. The assessment of relative intrasexual threat could potentially benefit perceivers if it aids in the allocation of mate guarding or mate retention efforts. In chapter 5, I examine whether vocal and facial masculinity/femininity influences men's and women's perceptions relating to intrasexual competition.

CHAPTER 2: FEMALE PREFERENCES FOR MALE VOCAL AND FACIAL MASCULINITY IN VIDEOS

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Preface

Vocal and facial masculinity are both testosterone-related traits (Dabbs & Mallinger, 1999; Evans et al., 2008; Penton-Voak & Chen, 2004; Roney et al., 2006). While women generally prefer male vocal masculinity over male vocal femininity (Collins, 2000; Feinberg et al., 2005b; Feinberg et al., 2006; Feinberg et al., 2011), women do not generally prefer either male facial masculinity or femininity (DeBruine et al., 2006; Glassenberg et al., 2010; Perrett et al., 1998; Rhodes & Hickford, 2000). However, women who do prefer facial masculinity tend to also prefer vocal masculinity (Feinberg et al., 2008a) and putative masculine pheromones (Cornwell et al., 2004). Therefore, vocal and facial masculinity are related to the same underlying physiological characteristics (i.e. testosterone) and are assessed by potential mates in similar fashions. However, no study of vocal and facial masculinity preferences has used the simultaneous presentation of dynamic cross-modal stimuli. Given that our primary experience is to encounter faces and voices together rather than in isolation, it is critical to demonstrate

that the observed influence of masculinity on women's mate preferences is not restricted to instances where faces or voices are separated from each other.

In the following study, I investigate women's preferences for masculinity by using videos of men speaking. Here, the use of dynamic audiovisual stimuli allowed for vocal and facial masculinity to be simultaneously manipulated. To determine whether individual differences influence women's preferences for masculinity in simultaneously presented faces and voices as it does when women assess men's faces in the absence of voices (Penton-Voak et al., 2003), we collected the facial attractiveness ratings of female raters. If women's facial attractiveness ratings are positively related to facial masculinity preferences (Penton-Voak et al., 2003), and if vocal and facial masculinity are common cues of underlying testosterone, then women's facial attractiveness may be positively associated with their preferences for male vocal masculinity and their preferences for male facial masculinity.

Abstract

Vocal and facial masculinity are cues to underlying testosterone in men and influence women's mate preferences. Consistent with the proposal that facial and vocal masculinity signal common information about men, prior work has revealed correlated female preferences for male facial and vocal masculinity. Previous studies have assessed women's preferences for male facial and vocal masculinity by presenting faces and voices independently and using static face stimuli. By contrast, here we presented women with short video clips in which male faces and voices were simultaneously manipulated in masculinity. We found that women who preferred masculine faces also preferred masculine voices. Furthermore, women whose faces were rated as relatively more attractive preferred both facial and vocal masculinity more than did women whose faces were rated as less attractive. These findings complement other evidence for cross-modal masculinity preferences among women, and demonstrate that preferences observed in studies using still images and/or independently presented vocal stimuli are also observed when dynamic faces and voices are displayed simultaneously in video format.

Introduction

Adult male vocal and facial masculinity are testosterone dependent traits that develop at puberty (Hollien 1960; Verdonck et al. 1999), and continue to be positively related to adult testosterone levels (Dabbs & Mallinger 1999; Penton-Voak & Chen 2004; Bruckert et al. 2006; Roney et al. 2006; Evans et al. 2008; Puts et al. In press; but see also Peters et al. 2008). Men's testosterone levels are also positively associated with dominance (Mazur & Booth 1998). Furthermore, masculinized men's voices (Tusing & Dillard 2000; Feinberg et al. 2006; Puts et al. 2006, 2007; Jones et al. 2010a) and faces (Perrett et al. 1998; Swaddle & Reierson 2002; Boothroyd et al. 2007; Jones et al. 2010b) are perceived as more dominant than are feminized voices and faces. Vocal masculinity is also associated with measures of dominance, such as body size (Evans et al. 2006; Puts et al. 2011) and physical strength (Puts et al. 2011). Facial masculinity among males has been observed to positively correlate with other objective indices of mate value, such as symmetry (Little et al. 2008; Gangestad & Thornhill 2003), physical strength (Fink et al. 2007), and disease resistance (Thornhill & Gangestad 2006; Rhodes et al. 2003). Since testosterone can have immunosuppressant effects (Folstad & Karter 1992; Wichmann et al. 1997; Chen & Parker 2004), vocal and facial masculinity may be cues to heritable immunocompetence and/or dominance (Zahavi 1975; Folstad & Karter 1992; Fink & Penton-Voak 2002; Feinberg 2008).

Among men, testosterone is positively related to mating effort (Booth & Dabbs 1993; McIntyre et al. 2006; Peters et al. 2008), dominant behaviour and social status

(Mazur & Booth 1998), while it is negatively related to measures of relationship and offspring investment (Booth & Dabbs 1993; Storey et al. 2000; Roney et al. 2006; Gray et al. 2007; Van Anders et al. 2007; Gettler et al. 2011). Although women prefer masculine, low-pitched men's voices (here we refer to pitch as the perception of fundamental frequency and/or its harmonics), preferences for facial masculinity are relatively more variable (reviewed in Feinberg 2008).

While not all women prefer masculinity to the same degree, those women who prefer masculine men's faces also tend to prefer masculine men's voices (Feinberg et al. 2008a), and individual differences among women influence vocal and facial masculinity preferences in similar ways. Women's facial and vocal masculinity preferences are strongest during the late-follicular menstrual cycle phase (Penton-Voak et al. 1999; Penton-Voak & Perrett 2000; Puts 2005; Feinberg et al. 2006), among women not using hormonal contraception (Feinberg et al. 2008a) and who experienced puberty at an earlier age (Jones et al. 2010c), and when women rate men as potential short-term partners (Little et al. 2002; Puts 2005). Furthermore, vocal and facial masculinity preferences are positively related to women's self-perceived attractiveness (Little et al. 2001; Vukovic et al. 2008). Other indices of a women's mate value, such as a feminine waist-to-hip ratio (Penton-Voak et al. 2003; Smith et al. 2009), and third party attractiveness ratings (Penton-Voak et al. 2003) are also associated with increased facial masculinity preferences. Women with feminine, higher pitched voices also have stronger vocal masculinity preferences than do women with masculine, lower pitched voices (Vukovic et

al. 2010). Increased masculinity preferences amongst women with relatively higher mate value may reflect a greater ability among these women to procure parental and/or relationship investment from more masculine men (Little et al. 2001; Penton-Voak et al. 2003; Feinberg et al. 2006; Vukovic et al. 2008; Smith et al. 2009).

Vocal and facial masculinity are both related to the same underlying physiological processes (i.e. testosterone expression), and are assessed by potential mates in similar fashions. To date, however, no study of vocal and facial masculinity preferences has used simultaneous presentation of dynamic cross-modal stimuli.

Studies using video stimuli have typically focused on comparing preferences for images of unmanipulated still and dynamic faces, and while some research has found evidence for a positive relationship between the attractiveness of male faces presented in videos and photographs (Roberts et al. 2009a, 2009b), others have not (Rubenstein 2005; Lander 2008; Penton-Voak & Chang 2008). Nevertheless, recent work suggests that the attractiveness ratings of men's voices and faces, presented independently (but from the same video recording), were positively correlated (Lander 2008). Surprisingly, Roberts et al. (2009a) found no significant difference in attractiveness ratings between videos presented with or without sound. Importantly, these studies did not specifically investigate preferences for vocal and facial masculinity; therefore, participants' attractiveness ratings may have been influenced by multiple characteristics. For instance, while perceptions of vocal and facial attractiveness are influenced by masculinity, vocal and facial attractiveness are also positively correlated with bilateral symmetry (Scheib et

al. 1999; Little et al. 2001; Hughes et al. 2008). Furthermore, by averaging attractiveness ratings across observers, Roberts et al. (2009a) and Lander (2008) were unable to address whether the relationships between vocal and facial attractiveness were influenced by individual differences between raters (Feinberg et al. 2008a). To address the aforementioned issues, we independently manipulated the masculinity of video and audio tracks of short video clips of men speaking, and had these stimuli rated for attractiveness. If vocal and facial masculinity function as cues to testosterone, then preferences for vocal and facial masculinity may be positively related across manipulations.

To our knowledge, only one study thus far has investigated preferences for masculine facial structure using photorealistic dynamic stimuli. Morrison et al. (2010) manipulated the facial masculinity of male faces in soundless videos and found that preferences for male facial sexual dimorphism were not significantly different from chance. It is unclear, however, whether the findings from Morrison et al. (2010) are attributable to the dynamic aspect of video as opposed to static images, or whether women's preferences for facial masculinity in dynamic videos are related to individual differences in preferences, as is observed in experiments using static images. Given that our primary experience with faces is dynamic in nature, it is critical to demonstrate that the observed influence of masculinity on women's mate preferences is not restricted to instances where faces are static. In order to determine if individual differences influence women's preferences for male masculinity in dynamic stimuli, we collected attractiveness ratings of the female viewers (Penton-Voak et al. 2003). If women's facial attractiveness

ratings are positively related to facial masculinity preferences (Penton-Voak et al. 2003), and if vocal and facial masculinity are common cues of testosterone, then women's facial attractiveness may also be positively associated with vocal masculinity preferences.

Methods

Participants.

Protocols for this study were approved by the McMaster Research Ethics Board. Female participants (n = 63; mean age = 18.71 years, SD = 1.71) were recruited from McMaster University and compensated with course credit for participation. Participant age and ethnicity were self-reported. All participants were heterosexual as assessed via the Kinsey Scale of Sexual Orientation (Kinsey et al. 1948). All participants were naïve to the experimental hypotheses.

Stimuli.

Participant Attractiveness.

Female participants were photographed with a FujiFilm FinePix S5 Pro digital camera with a Nikkor 60mm 2.8AF lens. Photographs were taken in colour, under standardized lighting conditions. Images were captured in RAW and exported to uncompressed TIFF format with FinePix 5.3 software. We standardized inter-pupillary distance to control for image size, and images were masked to reduce visual cues, such as

hairstyle, that have been shown to influence masculinity preferences (DeBruine et al. 2009).

Masculinity Preferences.

Stimuli were collected from male undergraduates (n= 4; mean age = 17.75 years, SD = 0.50) filmed in an anechoic sound attenuated booth (Whisper Room SE 2000) under standardized lighting conditions speaking the word "one". We selected the identities used in the current study at random from a larger set of stimuli. Post-manipulation voice pitch was similar to the normal male range after manipulation (111 – 159 Hz). Furthermore, we used 4 original voices here because many other studies of mate-choice relevant responses to manipulated vocal cues in human (Feinberg et al. In press; 2008a; 2008b; 2006; 2005; Jones et al. 2010b; O'Connor et al. 2011; Vukovic et al. 2008) and non-human (i.e. red deer, Charlton et al. 2008) studies have used similar numbers of voices. Furthermore, in human studies, research using 4-6 voices (Feinberg et al. In press; 2008a; 2008b; 2006; 2005; Jones et al. 2010b; O'Connor et al. 2011; Vukovic et al. 2008) found equivalent effects to many studies using identities ranging from dozens to hundreds of stimuli (Collins 2000; Collins & Missing 2003; DeBruine et al. 2010; Feinberg et al. 2008b; Puts 2005; Welling et al. 2007), suggesting that small numbers of stimuli, manipulated systematically, produce results that generalize to larger stimuli sets. Although the clips were short, previous work has established that 100ms exposure to a face is sufficient for attractiveness judgments to be formed that are indistinguishable from those formed following far longer exposure times (Willis & Todorov 2006). Furthermore, these

utterances are similar in length to a series of vowel sounds (for review, see Feinberg 2008) or a person saying the word "had", which have been shown to be sufficient to make consistent judgments of vocal attractiveness (Brukert et al. 2010).Videos were captured with a Panasonic AG-HVX200P video camera with a progressive scan rate of 23.98 frames per second, 24-bit colour depth and a 9x16 aspect ratio. Audio was captured using an external Sennheiser MKH 70 cardioid condenser microphone input to the video camera with a 48 kHz audio frequency sampling rate, and 16-bit amplitude quantization in Adobe On Location CS3 software. Both the still camera and video camera were white balanced using ExpoDisc.

We created our facial stimuli by manipulating the masculinity of still images from each frame of the video (Tiddeman & Perrett 2002). Still images were extracted from each uncompressed AVI file, and each frame was converted to a still image in TIFF format using Adobe Premier Pro.

We first created two prototypes to serve as endpoints when manipulating images in masculinity. One male and one female prototype were made by averaging together 32 facial images in colour, shape, and texture (Perrett et al. 1998). Prototypes were made symmetrical by averaging the shape, colour, and texture of each face with its mirror image (separately) (for details, see Perrett et al. 1998), and did not include the faces of any participants in this study.

Next, we manipulated facial masculinity to create a masculinized and feminized version of each frame (for example, see Figure 1). This was done by adding

(masculinized) or subtracting (feminized) 50% of the difference in shape between the male and female prototypes. We standardized inter-pupillary distance and masked the images in the same manner as above. Prototype-based image transformations were carried out using specialist computer graphics software (Tiddeman et al. 2001). This method of facial image transformation has been used successfully in face preference studies (see Feinberg 2008 for review) and has been shown to correlate positively with women's ideal or actual partner's masculinity (DeBruine et al. 2006) and with facial masculinity preferences observed using other facial image transformation methods (DeBruine et al. 2006, 2009).

Audio files were extracted as wav files using Adobe Premier Pro. We created a feminized (raised pitch) and masculinized (lowered pitch) version of each audio recording. We manipulated voice pitch using the pitch-synchronous overlap add (PSOLA France Telecom) method in Praat software (Boersma & Weenink 2009). This method of voice manipulation selectively manipulates fundamental frequency and related harmonics while controlling for other spectrotemporal features of the acoustic signal (Moulines & Charpentier 1990; Feinberg et al. 2005; Feinberg et al. 2008a).

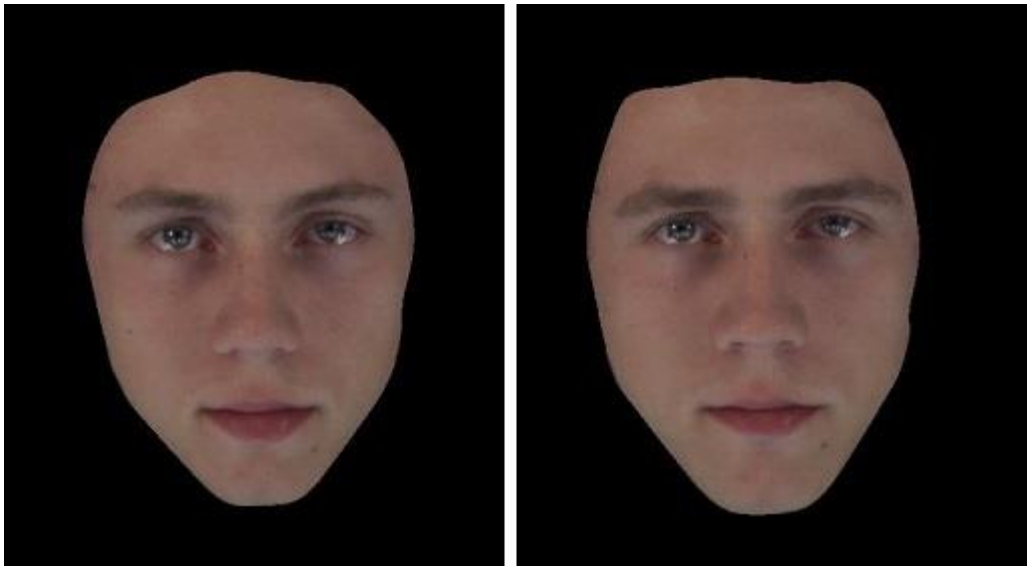

Figure 1. Example of feminized (left) and masculinized (right) facial stimuli.

Voice pitch was manipulated by raising or lowering voice pitch by +/- 0.5 equivalent rectangular bandwidths (ERBs) of the baseline frequency (see Figure 2 for spectrographic representation). This scale more precisely accounts for the difference between natural frequencies and pitch perception than do alternative scales (Tranmüller 1990). The resulting change in pitch is approximately equivalent to a 20 Hz manipulation for an average male voice pitch of 120 Hz. This level of pitch manipulation has been used in previous research on preferences for voice pitch (Feinberg et al. 2008a; Vukovic et al. 2008; Apicella & Feinberg 2009; Jones et al. 2010a), and has been shown to positively influence perceptions of masculinity (Feinberg et al. 2005) and dominance (Feinberg et al. 2006; Jones et al. 2010a8; Vukovic et al. 2011).

Masculinized and feminized audio and still images were re-compiled as AVI files in Adobe Premier Pro. Videos were then converted to MPEG-4 format at a resolution of

490x425 pixels, 24-bit colour, with a sampling rate of 44.1 kHz, and 16-bit amplitude quantization with the AAC audio codec using QuickTime Pro. This resulted in 4 videos per voice-face masculinity combination (masculine voice and face, masculine voice and feminine face, feminine voice and masculine face, feminine voice and face) for a total of 16 videos.

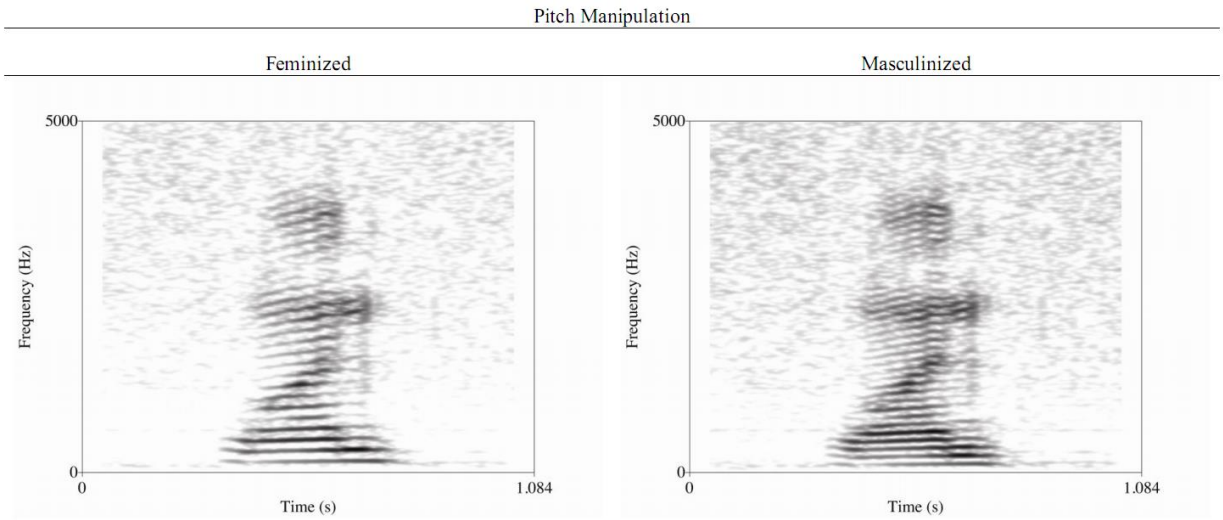

Figure 2. Spectrographic representation of one pair of male voices used in this study. All participants spoke the word "one".

Procedure.

Assessing Participant Attractiveness.

Male participants (n = 10; mean age = 19.40, SD = 1.35) were asked to rate each female face for attractiveness on a 7-point scale from 1 (very unattractive) to 7 (very

attractive). Faces were presented consecutively and fully randomized for order. Other studies have used similar numbers of participants to generate average ratings of traits such as health and masculinity (Feinberg et al. 2005; Jones et al. 2005). Facial attractiveness scores were calculated per female participant by averaging ratings across male participants. Inter-rater agreement among male participants on female participant facial attractiveness was extremely high (Cronbach's alpha = 0.97).

Masculinity Preferences.

Female participants were asked to rate each video for attractiveness on a 7-point scale from 1 (very unattractive) to 7 (very attractive). Participants initiated video playback on a computer monitor (30" Apple Cinema Display, monitor resolution 2560 x 1080, 24 bit colour). Dynamic video playback duration was approximately one second and videos were visible on-screen until participants entered their attractiveness rating. Videos were fully randomized for order of presentation and played sequentially.

Results

In order to investigate preferences for vocal and facial masculinity, we averaged the attractiveness ratings of each stimulus within each category to create an attractiveness score per voice-face combination for each participant (see Table 1 for descriptive statistics per voice-face combination). All analyses were carried out with SPSS 17, using

two-tailed probability estimates. Inter-rater agreement among female participants on video stimuli attractiveness was high (Cronbach's alpha = 0.88).

Table 1. Descriptive statistics of attractiveness ratings per voice-face combination.

Stimuli Manipulation		Mean	*SE*
Masculinized Face			
	Masculinized Voice	3.21	0.12
	Feminized Voice	2.92	0.10
Feminized Face			
	Masculinized Voice	3.31	0.10
	Feminized voice	2.98	0.09

Note. Judgements made on a 7-point scale (1 = very unattractive, 7 = very attractive)

To investigate the influence of masculinity manipulations on women's preferences, we used a repeated measures ANOVA [within-subject factors: facial masculinity (feminine, masculine) and vocal masculinity (feminine, masculine)]. We observed a main effect of vocal masculinity on preferences ($F_{1, 62} = 18.48$, $p < 0.001$) where across levels of facial masculinity, participants rated masculinized male voices (M = 3.25, SE = 0.10) as more attractive than feminized male voices (M = 2.95, SE = 0.09).

There were no other significant effects or interactions (all *F*-values < 2.38, all *p*-values > 0.128).

Individual Differences in Masculinity Preferences

To determine if there were differences in voice and face masculinity preferences among individuals, we used a mixed design ANOVA [within-subject factors: facial masculinity (feminine, masculine) and vocal masculinity (feminine, masculine); between subjects factor: ethnicity of rater (Caucasian, non-Caucasian), covariate: women's 3rd party facial attractiveness ratings]. We observed a main effect of facial masculinity on preferences ($F_{1, 60}$= 6.55, p = 0.013), where, across levels of vocal masculinity, participants rated feminized male faces (M = 3.16, SE = 0.09) as more attractive than masculinized male faces (M = 3.09, SE = 0.10). This was qualified by interactions between women's own facial attractiveness and both facial masculinity preferences ($F_{1, 60}$ = 4.78 p = 0.033). Here, preferences for facial masculinity were positively related to women participant's facial attractiveness (see below for statistical tests). Additionally, we found a significant interaction between women's own facial attractiveness and vocal masculinity preferences ($F_{1, 60}$ = 7.41, p = 0.008), where preferences for vocal masculinity were positively related to women participant's facial attractiveness (see below for statistical tests). There were no other significant effects or interactions (all *F*-values < 1.56, all *p*-values > 0.217).

To interpret the interaction described above, we investigated the relationship between facial masculinity preferences, vocal masculinity preferences, and 3rd party

attractiveness ratings. Vocal masculinity preferences were calculated by subtracting attractiveness ratings of feminized male voices from attractiveness ratings of masculinized male voices, for each level of facial manipulation. This resulted in two scores: preference for masculinized male voices paired with feminized faces, and preference of masculinized male voices paired with masculinized faces. We then averaged these two preference scores. Facial masculinity preferences were calculated by subtracting attractiveness ratings of feminized male faces from attractiveness ratings of masculinized male faces, for each level of pitch manipulation. This resulted in two scores: preference for masculinized male faces paired with feminized voices, and preference of masculinized male faces paired with masculinized voice. We then averaged these two preference scores. This resulted in a general vocal masculinity preference score and a general facial masculinity preference score, where higher numbers reflect higher average attractiveness ratings independent of the masculinity of the other modality.

Third party facial attractiveness ratings were significantly positively correlated with both vocal masculinity preferences (r =.303, n = 63, p = 0.016) and facial masculinity preferences (r =.264, n = 63, p = 0.036). Additionally, we found a significant positive correlation between facial masculinity and vocal masculinity preferences (r = .371, n = 63, p = 0.003). The positive correlation between vocal and facial masculinity preferences remained significant after controlling for women's facial attractiveness (r = .316, n = 60, p = 0.012).

Discussion

In the current study, we simultaneously manipulated the masculinity of voices and faces in short video clips of men speaking and examined women's preferences for the men in these videos. We found a positive correlation between women's preferences for male vocal and facial masculinity. We also found that women's own facial attractiveness positively predicted their preferences for vocal and facial masculinity. We found no evidence that preferences for masculinity in one modality were modulated by the level of masculinity in another modality (i.e. facial masculinity did not directly affect preferences for vocal masculinity, and vice versa). Preferences for both vocal and facial masculinity may be adaptive as the expression of masculinity in men's voices and faces is dependent upon testosterone levels (Hollien 1960; Verdonck et al. 1999), and therefore may cue heritable dominance and/or immunocompetence (Zahavi 1975; Folstad & Karter 1992; Fink & Penton-Voak 2002; Puts et al. 2007; Feinberg 2008; Jones et al. 2010a). Assessing multiple cues to the same underlying quality is potentially adaptive for the perceiver, as multiple cues may increase the fidelity of masculinity as a cue to testosterone, reduce the efficacy of potentially dishonest cues, and allow perceivers to focus on different modalities given noisy visual or auditory environments (Candolin 2003).

In the current study, we observed a main effect of facial masculinity, where across levels of voice pitch, women preferred feminized over masculinized faces. This is similar to findings from other studies of women's facial masculinity preferences (Welling et al. 2008; Little et al. 2002; Rhodes et al. 2000; Perrett et al. 1998). It is possible that women,

on average, prefer more feminine male faces because men with more masculine faces, and therefore more testosterone, are less likely to invest in relationships and offspring (for review see Feinberg 2008). Prior research has suggested that variation in women's masculinity preferences may be moderated by women's own mate value (see Feinberg 2008 for review). Indeed, this main effect was qualified by a significant interaction between women's own facial attractiveness and both facial and vocal masculinity preferences, where 3rd party attractiveness ratings positively predicted both vocal and facial masculinity preferences. This result supports previous findings that 3rd party attractiveness ratings predict facial masculinity preferences in facial photographs (Penton-Voak et al. 2003). Here we extend this finding to videos and voices manipulated in masculinity. These findings contribute to a growing body of evidence that indicates preferences for masculinity are greater among women of relatively higher mate value as indicated by a feminine voice and body (Penton-Voak et al. 2003; Smith et al. 2009; Vukovic et al. 2010), self-perceived attractiveness (Little et al. 2001; Vukovic et al. 2008), other-rated attractiveness (Penton-Voak et al. 2003), fertile menstrual-cycle phase (Penton-Voak et al. 1999; Penton-Voak & Perrett 2000; Puts 2005; Feinberg et al. 2006), abstention from hormonal contraceptives (Little et al. 2002; Feinberg et al. 2008), and breastfeeding (Apicella & Feinberg 2009). Increased masculinity preferences among women with relatively higher mate value, as suggested by the positive correlations between masculinity preferences and women's own attractiveness observed in the current study, may be due to these women's greater ability to attract masculine mates (Little et al. 2001; Penton-Voak et al. 2003; Feinberg et al. 2006; Vukovic et al. 2008, 2010).

Additionally, this behaviour may also be adaptive if it aids in the ability to retain investment from masculine mates (Little et al. 2001; Penton-Voak et al. 2003; Feinberg et al. 2006; Vukovic et al. 2008, 2010).

Similar to the methods of Morrison et al. (2010), we investigated preferences for facial masculinity using dynamic video stimuli. While Morrison et al. (2010) found that facial masculinity preferences were not significantly different from chance, we found significant preferences for femininity in men's faces. We also found significantly greater preferences for facial masculinity among more attractive women, which suggests that the influence of mate value on masculinity preferences is not limited to preferences assessed via static images and underlines the importance of accounting for individual differences when investigating masculinity preferences among women. It is possible that differences in stimuli, specifically facial motion, contributed to differences between Morrison et al. (2010) and the current study in the observed influence of facial masculinity on preferences. In comparison to the dynamic facial images used by Morrison et al. (2010), the facial stimuli in our study displayed less overall motion. Although previous work has indicated the importance of behavioural displays in women's mate preferences (Gangestad et al. 2004), Morrison et al. (2010) found that facial movement did not significantly affect attractiveness ratings. It is therefore unlikely that the observed differences in the influence of facial masculinity manipulations on attractiveness ratings between the current study and Morrison et al. (2010) are due to differences in degree of facial movement.

While women's facial attractiveness accounted for a small although significant proportion of the variance in facial and vocal masculinity preferences (9.2% and 6.9%, respectively), including this variable was enough to alter significance levels for main effects of both facial and vocal masculinity preferences, thus demonstrating the critical need to account for individual differences in studies of masculinity preferences.

In summary, we presented women with dynamic video stimuli manipulated to possess different combinations of masculinity across audiovisual modalities, and found that those women who prefer masculine voices also prefer masculine faces. These results are consistent with those from Feinberg et al. (2008), who also found correlated preferences for masculinity among women who rated still images of faces and voices independently. The positive relationship between women's preferences for masculinity in men's faces and voices remained significant when we controlled for the effects of women's own attractiveness, suggesting that correlated preferences for masculinity in different domains is not solely due to the effects of women's own attractiveness. Furthermore, these results complement other evidence for cross-modal preferences, such as women's preferences for putative male pheromones and facial masculinity (Cornwell et al. 2004), and men's preferences for female vocal and facial femininity (Fraccaro et al. 2010). We also found that 3rd party attractiveness ratings were positively correlated with both vocal and facial masculinity preferences. This result supports findings from Penton-Voak et al. (2003), who found that women whose faces were rated as more attractive by a 3rd party displayed greater preferences for masculinity when shown still images of men's

faces. Importantly, this demonstrates that the preferences observed in studies using still images and/or independently presented vocal stimuli are also observed when dynamic faces and voices are displayed simultaneously in video format. Therefore, masculinity preferences observed both here and in prior studies (Penton-Voak et al. 2003; Feinberg et al. 2008) are not likely attributable to the manner of stimuli presentation.

References

Apicella, C. L. & Feinberg, D. R. 2009: Voice pitch alters mate-choice-relevant perception in hunter-gatherers. P. Roy. Soc. B-Biol. Sci. 276, 1077-1082.

Boersma, P. & Weenink, D. 2009: Praat: Doing phonetics by computer Version 5.1.04 edn. pp. Computer program.

Booth, A. & Dabbs, J. M. 1993: Testosterone and men's marriages. Soc. Forces 72, 463-477.

Boothroyd, L., Jones, B., Burt, D. & Perrett, D. 2007: Partner characteristics associated with masculinity, health and maturity in male faces. Pers. Individ. Dif. 43, 1161-1173.

Bruckert, L., Bestelmeyer, P., Latinus, M., Rouger, J., Charest, I., Rousselet, G.A., Kawahara, I., Belin, P. 2010: Vocal attractiveness increases by averaging. Curr. Bio. 26, 116-120.

Bruckert, L., Lienard, J. S., Lacroix, A., Kreutzer, M. & Leboucher, G. 2006: Women use voice parameters to assess men's characteristics. P. Roy. Soc. B-Biol. Sci. 273, 83-89.

Candolin, U. 2003: The use of multiple cues in mate choice. Biol. Rev. 78, 575-595.

Charlton, B.D., Reby, D., McComb, K. 2008: Effect of combined source (F0) and filter (formant) variation on red deer hind responses to male roars. J. Acoust. Soc. Am. 123, 2936–2943.

Chen, C. C. G. & Parker, C. R. 2004: Adrenal androgens and the immune system. Semin. Reprod. Med. 22, 369-377.

Collins, S. A. 2000: Men's voices and women's choices. Anim. Behav. 60, 773–780.

Collins, S. A., & Missing, C. 2003: Vocal and visual attractiveness are related in women. Anim. Behav. 65, 997-1004.

Cornwell, R. E., Boothroyd, L., Burt, D. M., Feinberg, D. R., Jones, B. C., Little, A. C., Pitman, R., Whiten, S. & Perrett, D. I. 2004: Concordant preferences for opposite-sex signals? Human pheromones and facial characteristics. P. Roy. Soc. B-Biol. Sci. 271, 635-640.

Dabbs, J. M. & Mallinger, A. 1999: High testosterone levels predict low voice pitch among men. Pers. Individ. Dif. 27, 801-804.

DeBruine, L. M., Jones, B. C., Little, A. C., Boothroyd, L. G., Perret, D. I., Penton-Voak, I. S., Cooper, P. A., Penke, L., Feinberg, D. R., & Tiddeman, B. P. 2006: Correlated preferences for facial masculinity and ideal or actual partner's masculinity. P. Roy. Soc. B-Biol. Sci. 273, 1355-1360.

DeBruine, L. M., Jones, B. C., Smith, F. G. & Little, A. C. 2009: Are attractive men's faces masculine or feminine? The importance of controlling confounds in face stimuli. J. Exp. Psychol. Human. 363, 751-758.

DeBruine, L.M., Jones, B.C., Crawford, J.R., Welling, L.L.M., & Little, A.C. (2010). The health of a nation predicts their mate preferences: cross-cultural variation in women's preferences for masculinized male faces. P. Roy. Soc. B-Biol. Sci. 277, 2405-2410.

Evans, S., Neave, N., & Wakelin, D. (2006). Relationships between vocal characteristics and body size and shape in human males: an evolutionary explanation for a deep male voice. Biol. Psychol. 72, 160-163.

Evans, S., Neave, N., Wakelin, D. & Hamilton, C. 2008: The relationship between testosterone and vocal frequencies in human males. Physiol. Behav. 93, 783-788.

Feinberg, D. R., Jones, B. C., Little, A. C., Burt, D. & Perrett, D. I. 2005: Manipulations of fundamental and formant frequencies influence the attractiveness of human male voices. Anim. Behav. 69, 561-568.

Feinberg, D. R., Jones, B. C., Law Smith, M. J., Moore, F. R., DeBruine, L. M., Cornwell, R. E., Hillier, S. G., & Perrett, D. I. 2006: Menstrual cycle, trait estrogen level ,and masculinity preferences in the human voice. Horm. Behav. 49, 215 - 222

Feinberg, D. R. 2008: Are human faces and voices ornaments signaling common underlying cues to mate value? Evol. Anthropol. 17, 112-118.

Feinberg, D. R., DeBruine, L. M., Jones, B. C. & Little, A. C. 2008a: Correlated preferences for men's facial and vocal masculinity. Evol. Hum. Behav. 29, 233-241.

Feinberg, D. R., DeBruine, L. M., Jones, B.C., & Perrett, D. I. 2008b: The role of femininity and averageness in aesthetic judgments of women's voices. Perception. 37, 615-623

Feinberg, D. R., Jones, B. C., Law Smith, M. J., Moore, F. R., DeBruine, L. M., Cornwell, R. E., Hillier, S. G. & Perrett, D. I. 2006: Menstrual cycle, trait estrogen level, and masculinity preferences in the human voice. Horm. Behav. 49, 215-222.

Feinberg, D. R., Jones, B. C., DeBruine, L. M., O'Connor, J. J. M., Tigue, C. & Borak, D. J. In press: Integrating fundamental and formant frequencies in women's preferences for men's voices. Behav. Ecol.

Fink, B., Neave, N. & Seydel, H. 2007: Male facial appearance signals physical strength to women. Am. J. Hum. Biol. 19, 82-87.

Fink, B. & Penton-Voak, I. S. 2002: Evolutionary psychology of facial attractiveness. Curr. Dir. Psychol. Sci. 11, 154-158.

Folstad, I. & Karter, A. 1992: Parasite, bright males, and the immunocompetence handicap. Am. Nat. 139, 603-623.

Fraccaro, P. J., Feinberg, D. R., DeBruine, L. M., Little, A. C., Watkins, C. D. & Jones, B. C. 2010: Correlated male preferences for femininity in female faces and voices. Evol. Psychol. 8, 447-461.

Fraccaro, P.J., Jones, B.C., Vukovic, J., Smith, F.G., Watkins, C.D., Feinberg, D.R., Little, A.C., & DeBruine, L.M. (2011). Experimental evidence that women speak in a higher voice pitch to men they find attractive. J. Evol. Psychol. 9, 57-67.

Gangestad, S.W., & Thornhill, R. 2003: Facial masculinity and fluctuating asymmetry. Evol. Hum. Behav. 24, 231-241.

Gangestad, S.W., Simpson, J. A., Cousins, A. J.,Garver-Apgar, C. E., & Christensen, P. N. 2004: Women's preferences for male behavioral displays change across the menstrual cycle. Psychol. Sci. 15,203-207.

Gettler, L. T., McDade, T. W., Feranil, A. B., & Kuzawa, C. W. (2011). Longitudinal evidence that fatherhood decreases testosterone in human males. Proc. Natl. Acad. Sci. USA, 108, 16194-16199.

Gray, P., Parkin, J. & Sammsvaughan, M. 2007: Hormonal correlates of human paternal interactions: A hospital-based investigation in urban Jamaica. Horm. Behav. 52, 499-507.

Hollien, H. 1960: Some laryngeal correlates of vocal pitch. J. Speech. Hear. 3, 52-58.

Hughes, S. M., Pastizzo, M. J. & Gallup, G. G. 2008: The sound of symmetry revisited: Subjective and objective analyses of voice. J. Nonverbal. Behav. 32, 93-108.

Jones, B. C., Feinberg, D. R., DeBruine, L. M., Little, A. C. & Vukovic, J. 2010a: A domain-specific opposite-sex bias in human preferences for manipulated voice pitch. Anim. Behav. 79, 57-62.

Jones, B. C., DeBruine, L. M., Main, J. C., Little, A. C., Welling, L. L. M., Feinberg, D. R. & Tiddemann, B. P. 2010b: Facial cues of dominance modulate the short-term gaze-cuing effect in human observers. P. Roy. Soc. B-Biol. Sci. 277, 617-624.

Jones, B. C., Boothroyd, L., Feinberg, D. R., & DeBruine, L. M. 2010c: Age at menarche predicts individual differences in women's preferences for masculinized male voices in adulthood. Pers. Indiv. Differ. 48, 860-863.

Jones, B. C., Perrett, D. I., Little, A. C., Boothroyd, L., Cornwell, R. E., Feinberg, D. R., Tiddeman, B. P., Whiten, S., Pitman, R. M., Hillier, S. G., Burt, D. M., Stirrat, M. R., Law Smith, M. J. & Moore, F. R. 2005: Menstrual cycle, pregnancy and oral contraceptive use alter attraction to apparent health in faces. P. Roy. Soc. B-Biol. Sci. 272, 347-354.

Kinsey, A. C., Pomeroy, W. B. & Martin, C. E. 1948: Sexual behaviour in the human male. W.B. Saunders, Philadelphia.

Lander, K. 2008: Relating visual and vocal attractiveness for moving and static faces. Anim. Behav. 75, 817-822.

Little, A. C., Burt, D. M., Penton-Voak, I. S. & Perrett, D. I. 2001: Self-perceived attractiveness influences human female preferences for sexual dimorphism and symmetry in male faces. P. Roy. Soc. B-Biol. Sci. 268, 39-44.

Little, A. C., Jones, B. C., Penton-Voak, I. S., Burt, D. M. & Perrett, D. I. 2002: Partnership status and the temporal context of relationships influence human female preferences for sexual dimorphism in male face shape. P. Roy. Soc. B-Biol. Sci. 269, 1095-1100.

Little, A. C., Jones, B. C., Waitt, C., Tiddeman, B. P., Feinberg, D. R., Perrett, D. I., Apicella, C. L., Marlowe, F. W. & Reimchen, T. 2008: Symmetry Is Related to Sexual Dimorphism in Faces: Data Across Culture and Species. PLoS ONE 3, e2106.

Little, A.C., Connely, J., Feinberg, D.R., Jones, B.C., & Roberts, S.C. (2011). Human preference for masculinity differs according to context in faces, bodies, voices, and smell. Behav. Ecol. 22, 862-868.

Mazur, A. & Booth, A. 1998: Testosterone and dominance in men. Behav. Brain. Sci. 21, 353-397.

McIntyre, M., Gangestad, S. W., Gray, P. B., Chapman, J. F., Burnham, T. C., O'Rourke, M. T. & Thornhill, R. 2006: Romantic involvement often reduces men's

testosterone levels--but not always: The moderating role of extrapair sexual interest. J. Pers. Soc. Psychol. 91, 642-651.

Morrison, E. R., Clark, A. P., Tiddeman, B. P. & Penton-Voak, I. S. 2010: Manipulating shape cues in dynamic human faces: Sexual dimorphism is preferred in female but not male faces. Ethology 116, 1234-1243.

Moulines, E. & Charpentier, F. 1990: Pitch synchronous waveform processing techniques for text-to-speech synthesis using diphones. Speech Commun. 9, 453-467.

O'Connor, J.J.M., Re, D.E., & Feinberg, D.R. (2011). Voice pitch influences perceptions of sexual infidelity. Evol. Psychol. 9, 64-78.

Penton-Voak, I. & Chen, J. Y. 2004: High salivary testosterone is linked to masculine male facial appearance in humans. Evol. Hum.Behav. 25, 229-241.

Penton-Voak, I. S. & Chang, H. Y. 2008: Attractiveness judgements of individuals vary across emotional expression and movement conditions. J. Evol. Psych. 6, 89-100

Penton-Voak, I. S., Little, A. C., Jones, B. C., Burt, D. M., Tiddeman, B. P. & Perrett, D. I. 2003: Female condition influences preferences for sexual dimorphism in faces of male humans (Homo sapiens). J. Comp. Psychol. 117, 264-271.

Penton-Voak, I. S. & Perrett, D. I. 2000: Female preferences for male faces changes cyclically - further evidence. Evol. Hum. Behav. 21, 39-48.

Penton-Voak, I. S., Perrett, D. I., Castles, D. L., Kobayashi, T., Burt, D. M., Murray, L. K. & Minamisawa, R. 1999: Menstrual cycle alters face preference. Nature 399, 741-742.

Perrett, D. I., Lee, K. J., Penton-Voak, I., Rowland, D., Yoshikawa, S., Burt, D. M., Henzil, S. P., Castles, D. L. & Akamatsu, S. 1998: Effects of sexual dimorphism on facial attractiveness. Nature 34, 884-887.

Peters, M., Simmons, L. W. & Rhodes, G. 2008: Testosterone is associated with mating success but not attractiveness or masculinity in human males. Anim. Behav. 76, 297-303.

Puts, D. A. 2005: Mating context and menstrual phase affect women's preferences for male voice pitch. Evol. Hum. Behav. 26, 388-397.

Puts, D., Gaulin, S. & Verdolini, K. 2006: Dominance and the evolution of sexual dimorphism in human voice pitch. Evol. Hum. Behav. 27, 283-296.

Puts, D. A., Hodges, C. R., Cardenas, R. A. & Gaulin, S. J. C. 2007: Men's voices as dominance signals: vocal fundamental and formant frequencies influence dominance attributions among men. Evol. Hum. Behav. 28, 340-344.

Puts, D. A., Apicella, C. L., & Cardenas, R. A. (In press). Masculine voices signal men's threat potential in forager and industrial societies. P. Roy. Soc. B-Biol. Sci.

Rhodes, G., Hickford, C., & Jeffery. L. 2000: Sex-typicality and attractiveness: Are supermale and superfemale faces super-attractive? Br. J. Psych. 91, 125-140.

Rhodes, G., Chan, J., Zebrowitz, L. A., & Simmons, L. W. 2003: Does sexual dimorphism in human faces signal health? P. Roy. Soc. B-Biol. Sci. 270, S93-S95.

Roberts, S. C., Little, A. C., Lyndon, A., Roberts, J., Havlicek, J. & Wright, R. L. 2009a: Manipulation of body odour alters men's self-confidence and judgements of their visual attractiveness by women. Int. J. Cosmetic Sci. 31, 74-54.

Roberts, S. C., Saxton, T. K., Murray, A. K., Burriss, R. P., Rowland, H. M. & Little, A. C. 2009b: Static and dynamic facial images cue similar attractiveness judgements. Ethology 115, 588-595.

Roney, J. R., Hanson, K. N., Durante, K. M. & Maestripieri, D. 2006: Reading men's faces: women's mate attractiveness judgments track men's testosterone and interest in infants. P. Roy. Soc. B-Biol. Sci. 273, 2169-2175.

Rubenstein, A. J. 2005: Variation in perceived attractiveness: differences between dynamic and static faces. Psychol. Sci. 16, 759-762.

Scheib, J. E., Gangestad, S. W. & Thornhill, R. 1999: Facial attractiveness, symmetry and cues of good genes. P. Roy. Soc. B-Biol. Sci. 26, 1913-1917.

Smith, F.G., Jones, B.C., DeBruine, L.M., & Little, A.C. (2008). Interactions between masculinity-femininity and apparent health in face preferences. Behav. Ecol., 20, 441-445.

Smith, F. G., Jones, B. C., Welling, L. L. W., Little, A. C., Vukovic, J., Main, J. C. & DeBruine, L. M. 2009: Waist–hip ratio predicts women's preferences for masculine male faces, but not perceptions of men's trustworthiness. Pers. Individ. Dif. 47, 476-480.

Storey, A. E., Walsh, C. J., Quinton, R. L., & Wynne-Edwards, K. E. (2000). Hormonal correlates of paternal responsiveness in new and expectant fathers. Evol Hum Behav, 21, 79-95.

Swaddle, J. P. & Reierson, G. W. 2002: Testosterone increases perceived dominance but not attractiveness in human males. P. Roy. Soc. B-Biol. Sci. 269, 2285-2289.

Thornhill, R. & Gangestad, S. W. 2006: Facial sexual dimorphism, developmental stability and parasitic infections in men and women. Evol. Hum. Behav. 27, 131-144.

Tiddeman, B., Burt, D. M. & Perrett, D. I. 2001: Computer graphics in facial perception research. IEEE Comput. Graph. 21, 42-50.

Tiddeman, B. & Perrett, D. I. 2002: Transformation of dynamic facial image sequences using static 2D prototypes. Visual Comput. 18, 218-225.

Tranmüller, H. 1990: Analytical expressions for the tonotopic sensory scale. J. Acoust. Soc. Am. 88, 97-100.

Tusing, K. J. & Dillard, J. P. 2000: The Sound of Dominance: Vocal precursors of perceived dominance during interpersonal influence. Hum. Commun. Res. 26, 148-171.

Van Anders, S. M., Hamilton, L. D. & Watson, N. V. 2007: Multiple partners are associated with higher testosterone in North American men and women. Horm. Behav. 51, 454-459.

Verdonck, A., Gaethofs, M., Carels, C. & De Zegher, F. 1999: Effect of low-dose testosterone treatment on craniofacial growth in boys with delayed puberty. Eur. J. Orthodont. 21, 137-143.

Vukovic, J., Feinberg, D. R., Jones, B. C., DeBruine, L. M., Welling, L. L. M., Little, A. C. & Smith, F. G. 2008: Self-rated attractiveness predicts individual differences in women's preferences for masculine men's voices. Pers. Individ. Dif. 45, 451-456.

Vukovic, J., Jones, B. C., DeBruine, L., Feinberg, D. R., Smith, F. G., Little, A. C., Welling, L. L. M. & Main, J. 2010: Women's own voice pitch predicts their preferences for masculinity in men's voices. Behav. Ecol. 21, 767-772.

Vukovic, J., Jones, B. C., Feinberg, D. R., DeBruine, L., Smith, F. G., Welling, L. L. M. & Little, A. C. 2011: Variation in perceptions of physical dominnce and trustworthiness predicts individual differences in the effect of relaitonship context

on women's preferences for masculnie pitch in men's voices. Brit. J. Psychol. 102, 37-48.

Welling, L., Jones, B., Debruine, L., Conway, C., Lawsmith, M., Little, A., Feinberg, D., Sharp, M., & Aldujaili, E. (2007). Raised salivary testosterone in women is associated with increased attraction to masculine faces. Horm. Behav. 52, 156-161.

Welling, L. L. M., Jones, B. C., DeBruine, L. M., Little, A.C., Smith, F. G. 2008: Exposure to sexually attractive men decreases women's preferences for feminine faces. J. Ev. Psych. 6, 219-230.

Wichmann, M. W., Ayala, A. & Chaudry, I. H. 1997: Male sex steroids are responsible for depressing macrophage immune function after trauma-hemorrhage. Am. J. Physiol.-Cell Ph. 273, 1335-1340.

Willis, J., & Todorov, A. 2006: First Impressions: Making up your mind after 100-ms exposure to a face. Psych. Sci. 17, 592-598.

Zahavi, A. 1975: Mate selection - a selection for a handicap. J. Theor. Biol. 53, 205-214.

CHAPTER 3: VOICE PITCH INFLUENCES PERCEPTIONS OF SEXUAL INFIDELITY

O'Connor, J.J.M., Re, D.E., & Feinberg, D.R. (2011). *Evolutionary Psychology, 9,* 64-78.

Preface

In chapter 2, I established that women's preferences for vocal and facial masculinity were positively correlated when tested using simultaneously presented men's voices and faces. I also found that women's facial attractiveness positively predicted their preferences for masculine men's faces presented in videos, as it does when women's masculinity preferences are assessed using still images of men's faces, as previously found by Penton-Voak (2003). Furthermore, I found that women with relatively attractive faces had stronger preferences for male vocal masculinity than did women with relatively unattractive faces. This novel finding, together with the finding that women with relatively attractive faces have stronger preferences for male facial masculinity, suggests that individual differences in mate value predict women's mate preferences across modalities. I did not find evidence that women's preferences for vocal masculinity/ femininity interacted with the manipulated masculinity/ femininity of the simultaneously presented face (and vice versa).

Women prefer masculine men's voices (Chapter 2) and men prefer feminine women's voices (see section *Men's Preferences for Feminine Women's Voices*). Women

with feminine voices, and men with masculine voices, are thought to be preferred as mates because these characteristics are associated with relatively higher underlying mate value (*see* Chapter 1). Women with more feminine, higher pitched voices may be younger, healthier, and more fertile mates than women with more masculine, lower pitched voices (see section *Fitness Benefits of Mating with Feminine Women*). Men with masculine, lower pitched voices may confer fitness benefits to offspring in the form of heritable immunity to disease and/or dominance (see section *Fitness Benefits of Mating with Masculine Men*). However, there are potential fitness risks associated with mating with relatively high mate value individuals. Specifically, feminine women and masculine men may present an increased risk of future infidelity, which could result in cuckoldry or abandonment, respectively (see sections *Fitness Risks Associated with Mating with Masculine Men, Fitness Risks Associated with Mating with Feminine Women*). Yet, the very traits associated with an increased risk of infidelity are the same traits that are preferred in potential mates. In the following study, I examine whether individuals perceive masculine male and feminine female voices to be cues to infidelity risk.

Abstract

Sexual infidelity can be costly to members of both the extra-pair and the paired couple. Thus, detecting infidelity risk is potentially adaptive if it aids in avoiding cuckoldry or loss of parental and relationship investment. Among men, testosterone is inversely related to voice pitch, relationship and offspring investment, and is positively related to the pursuit of short-term relationships, including extra-pair sex. Among women, estrogen is positively related to voice pitch, attractiveness, and the likelihood of extra-pair involvement. Although prior work has demonstrated a positive relationship between men's testosterone levels and infidelity, this study is the first to investigate attributions of infidelity as a function of sexual dimorphism in male and female voices. We found that men attributed high infidelity risk to feminized women's voices, but not significantly more often than did women. Women attributed high infidelity risk to masculinized men's voices at significantly higher rates than did men. These data suggest that voice pitch is used as an indicator of sexual strategy in addition to underlying mate value. The aforementioned attributions may be adaptive if they prevent cuckoldry and/or loss of parental and relationship investment via avoidance of partners who may be more likely to be unfaithful.

Introduction

Sexual infidelity has associated fitness costs and benefits for both sexes. Males benefit from increased reproductive success by procreating with additional females, while females benefit by selectively reproducing with males that offer either greater indirect genetic benefits such as viable offspring (Gangestad and Thornhill, 1997; Symons, 1979), or greater direct benefits such as material resources (Greiling and Buss, 2000; Gray, 1997), than do their current mates. Extra-pair copulations carry potential fitness costs to both men and women, such as the risk of exposure to sexually transmitted infections (Geary and Byrd-Craven, 2004). If discovered, extra-pair mates risk retaliation from the in-pair partner (Daly and Wilson, 1988), and risk resource loss via devaluation as a long-term mate (Alatalo, Gottlander, and Lundverg, 1987). Detecting the risk of partner infidelity is potentially adaptive, as sexual infidelity is inherently costly to the in-pair mate. Men are subject to a loss in fitness if they are cuckolded by their mate, while women risk loss of resource investment to the extra-pair female and any of her subsequent offspring (Anderson, Kaplan, and Lancaster, 2007, 1999).

Individuals may infer infidelity risk among males by assessing testosterone-dependent traits. Indeed, converging evidence indicates that sexual strategy varies with men's testosterone levels. Testosterone levels are inversely related to relationship investment (Van Anders, Hamilton, and Watson, 2007; Gray, Campbell, Marlowe, Lipson, and Ellison, 2004; Booth and Dabbs, 1993) and parental investment (Gray, Parkin, and Samms-vaughan, 2007). Men with relatively high testosterone levels report

sustained interest in sex beyond their current committed relationship (McIntyre et al., 2006), a greater number of sex partners (Peters, Rhodes, and Simmons, 2008), and a higher number of extra-marital affairs (Fisher et al., 2009).

Men's testosterone levels are associated with mating strategy, and specifically with sexual infidelity. Therefore, individuals may evaluate morphological markers of hormonal status in order to infer the probability of sexual infidelity. The development of a masculine, low-pitched voice is dependent upon pubertal testosterone levels (Hollien, 1960). Voice pitch (the perception of fundamental frequency and/or corresponding harmonics), is tied to the rate of vocal fold vibration, which is influenced by vocal fold size, length, and thickness (Titze, 1994). Thicker and longer vocal folds are capable of producing lower frequencies than are thinner vocal folds (Titze, 1994). In males, pubertal testosterone levels cause an increase in vocal fold length and thickness, leading to an adult male voice pitch that is on average half that of the average adult female voice pitch (Abitbol, Abitbol, and Abitbol, 1999; Harries, 1998).

Voice pitch continues to be negatively correlated with testosterone levels into adulthood (Evans, Neave, Wakelin, and Hamilton, 2008; Dabbs and Mallinger, 1999). Testosterone can act as an immunosuppressant (Chen and Parker, 2004; Wichmann, Ayala, and Chaudry, 1997; Folstad and Karter, 1992), thus testosterone-dependent traits may serve as indicators of an immune system robust enough to withstand the adverse effects of testosterone (Feinberg, 2008; Fink and Penton-Voak, 2002; Folstad and Karter, 1992). Testosterone levels are also positively associated with dominant behavior and

social status (Mazur and Booth, 1998). Therefore, vocal masculinity communicates heritable immunity to contagion and dominance, and thus mate quality.

Lower-pitched men's voices are not only rated as more attractive (Feinberg, DeBruine, Jones, and Little, 2008a; Vukovic et al., 2008; Saxton, Caryl, and Roberts, 2006; Feinberg, Jones, Little, Burt, and Perrett, 2005a; Collins, 2000), but are associated with a greater number of reported sexual partners (Puts, Gaulin, and Verdolini, 2006), and greater reproductive success (Apicella, Feinberg, and Marlowe, 2007) than are higher pitched men's voices. Furthermore, men with attractive voices report more sex partners than do men with less attractive voices (Hughes, Dispenza, and Gallup, 2004). There is also evidence that suggests men with low-pitched voices are more likely to commit infidelity; men with attractive voices report a higher number of extra-pair sex partners and are chosen by women as an extra-pair partner more often (Hughes et al., 2004). The above suggests that men with relatively high testosterone levels may present a greater infidelity risk to their partners, though it is unclear whether observers assess infidelity risk via vocal cues to underlying testosterone levels.

Estimating the likelihood of a woman committing sexual infidelity may also rely on the evaluation of physiological markers of hormonal status. While there is substantial evidence for a positive relationship between testosterone and sexuality among men, the relationship between women's sexuality and testosterone is more complex (for review see Bancroft, 2005; Baumeister, Cantanese, and Vohs, 2001). Increases in women's testosterone levels during the fertile phase of the menstrual cycle are associated with

increased preferences for masculinity in men's faces (Welling et al., 2007). This may indicate increased infidelity risk due to women's desire to obtain heritable traits of immunocompetence and dominance for their offspring from men with higher testosterone, while maintaining parental and resource investment from their current mates (Welling et al., 2007). Additionally, increases in testosterone during the fertile menstrual cycle phase are positively related to intercourse frequency among couples (Morris, Udry, Khan-Dawood, and Dawood, 1987; Persky, Lief, Strauss, Miller, and O'Brien, 1978). Therefore, the relationship between cyclic variations in testosterone and sexuality may not solely reflect women's extra-pair interest.

Although there is a relationship between cyclic variations in testosterone and sexuality *within* women, the evidence for a positive relationship between trait levels of testosterone and sexuality *among* different women is equivocal (for review see Stuckey, 2008; Bancroft, 2005; Baumeister et al., 2001). Indeed, van Anders and Dunn (2009) found that among women, higher levels of sexual desire were related to higher trait levels of estrogen, but not to higher trait levels of testosterone.

While research suggests that women's trait levels of testosterone may be unrelated to infidelity risk, there is evidence to suggest that a feminine voice pitch is associated with increased infidelity risk. Among women, vocal femininity, i.e. relatively high voice pitch, is positively related to estrogen levels (Abitbol et al., 1999) and may indicate both fertility status and underlying reproductive capability (Bryant and Haselton, 2009; for review see Feinberg, 2008). Women with higher measured levels of estrogen report a greater number

of long-term relationships, yet also report a greater likelihood of adulterous behaviors (Durante and Li, 2009). Men judge women with higher-pitched voices as more attractive (Feinberg, DeBruine, Jones, and Perrett, 2008b; Jones, Feinberg, DeBruine, Little, and Vukovic, 2008; Collins and Missing, 2003), more feminine (Feinberg et al., 2008b), younger (Feinberg et al., 2008b; Collins and Missing, 2003), and as more desirable marriage partners (Apicella and Feinberg, 2009) than they judge women with lower-pitched voices. Additionally, women with attractive voices report more sex partners, more extra-pair sex, and are chosen more often by paired men as extra-pair partners (Hughes et al., 2004).

Like vocal femininity, a feminine (i.e. lower) waist-to-hip ratio is an indicator of estrogen levels (Jasienska, Ziomkiewicz, Ellison, Lipson, and Thune, 2004). Women with feminine waist-to-hip ratios are rated by men as relatively more attractive (Singh, Dixson, Jessop, Morgan, and Dixson, 2010; Singh, 1993), evoke jealousy from other women (Buunk and Dijkstra, 2005), score higher on assessments of sexual desire (van Anders, 2005) and report more extra-pair sex than do women with less feminine waist-to-hip ratios (Hughes and Gallup, 2003). Women with feminine bodies also have more attractive voices than do women with less feminine bodies (Hughes et al., 2004; Collins and Missing, 2003). Estrogen-dependent traits among women are not only associated with adulterous behavior, but may influence the perception of infidelity risk as well. Men who perceive their partners as more attractive are more likely to engage in frequent and multiple anti-cuckoldry tactics, indicating that men perceive infidelity risk to be higher

for partners that are more attractive (Kaighobadi and Shackelford, 2008). Therefore, women with attractive, feminine voices may be perceived are more likely to commit infidelity due to a greater opportunity for, or engagement in, extra-pair sex given their desirability as a mate.

Whether observers hold beliefs about the fidelity of potential mates based on vocal sexual dimorphism has yet to be investigated. Here we tested whether observers' attributions of sexual infidelity are influenced by manipulating the pitch of male and female voices. We predicted that men with relatively more masculine voices would be perceived as more likely to be unfaithful to their romantic partners than would men with relatively less masculine voices. We predicted that women with feminized voices would be perceived as more likely to cheat sexually on their partners than would women with masculinized voices.

It is potentially adaptive for individuals to be sensitive to cues of infidelity among potential mates due to the costs of infidelity to the in-pair partner (Anderson, Kaplan, and Lancaster, 2007, 1999); non-mates cannot inflict such costs. Therefore, we predict that pitch manipulations will influence attributions of infidelity to opposite sex but not same sex voices.

In order to determine if attributions of infidelity are related to voice pitch preferences, we also measured participants' attributions of attractiveness to male and female voices differing only in pitch. If participants' attributions of infidelity are determined by pitch

preferences, than there will be a positive relationship between vocal masculinity preferences and attributions of infidelity.

Materials and Methods

Participants.

Protocols for this study were approved by the McMaster University Research Ethics Board. Participants were 54 males (mean age = 18.31 years, S.D. = 0.95) and 61 females (mean age = 19.07 years, S.D. = 1.29), recruited from the McMaster University on-line subject pool and compensated with extra course credit for participation.

Participant age and sexual orientation were self-reported. We excluded participants indicating sexual orientation other than heterosexual (n = 7), and those that failed to indicate any sexual orientation (n= 4). This resulted in a final sample of 49 males (mean age = 18.29 years, S.D. = 0.91) and 55 females (mean age = 19.09 years, S.D. = 1.30).

Stimuli.

Voice clips were collected and manipulated in the same manner as Feinberg et al., (2008a; 2008b; 2006, 2005a, 2005b). Participants aged 18-24 (9 women, 9 men) were recorded speaking the English monopthong vowels (International Phonetic Alphabet Symbols in parentheses); 'ah' as in father (a), 'ee' as in see (i), 'eh' as in bet (ε), 'oh' as in note (o), 'oo' as in boot (u). Single channel recordings were made in a quiet room with

an Audio-Techica AT4041 microphone at a 44.1 kHz sampling rate, with 16-bit amplitude quantization in Sound Forge software (Sony Creative Software).

We created two versions of each recording, a feminized version with raised pitch, and a masculinized version with lowered pitch. Voice pitch was modified using the pitch-synchronous overlap add (PSOLA™ France Telecom) method in Praat software (Boersma and Weenink, 2009).The PSOLA method is a standard technique of voice manipulation as it selectively manipulates fundamental frequency, and related harmonics, while controlling for other spectrotemporal features of the signal (Feinberg et al., 2008b; Feinberg et al., 2005a, 2005b; Moulines and Charpentier, 1990).

Voice pitch was raised and lowered by adding or subtracting 0.5 equivalent rectangular bandwidths (ERBs) of the baseline frequency. The ERB scale accounts for the difference between pitch perception and natural frequencies more accurately than do alternative scales (Tranmüller, 1990). This manipulation is equivalent to an approximately 25 Hz manipulation at an average female voice pitch of 225 Hz, and a 20 Hz manipulation for an average male voice pitch of 120 Hz, while ensuring the degree of pitch manipulation is perceived equivalently regardless of the natural pitch of a given voice. See Table 1 for descriptive statistics of the vocal stimuli. This level of manipulation has been successful in previous research on voice pitch (Apicella and Feinberg, 2009; Feinberg et al., 2008b; Jones et al., 2008; Vukovic et al., 2008).

Table 1. Descriptive statistics of vocal stimuli.

	Sex of Voice			
Pitch Manipulation	Female		Male	
	Hz	ERB	Hz	ERB
Feminized	229.26	5.95	138.92	3.99
Masculinized	181.87	4.95	98.99	2.98

Procedure.

Male and female voices were presented in separate randomized blocks. Within blocks, stimuli pairs were randomized for order and side of screen presentation. The infidelity and attractiveness blocks were randomized for order and were interspersed with both auditory and non-auditory distracter tasks. Stimuli pairs were masculine and feminine versions of the same identity, presented in a two-alternative forced choice paradigm. Voices were played consecutively, prompted by the participant selecting the 'play' button for the individual voice.

Following Feinberg et al. (2008b), we presented all participants with the same 4 voice pairs, and verbally instructed participants to choose which one, from each pair, was more likely to cheat sexually on their romantic partner. The question "which person do

you think is more likely to cheat on their partner?" remained visible on-screen throughout the infidelity attribution block. In the attractiveness attribution block, we presented all participants with the same 6 voice pairs, and verbally instructed participants to choose which one, from each pair, was more attractive. The question "which is more attractive to you?" remained visible on-screen throughout the attractiveness attribution block.

Five of the voice pairs in the attractiveness attribution block were different from those voice pairs presented in the infidelity attribution block. The infidelity and attractiveness attribution blocks contained a different number of trials and different voice pairs in order to prevent participants from engaging in identity matching across tasks. Participants indicated their choice after listening to each voice pair, and could play voices clips multiple times (Feinberg et al., 2005a; Collins, 2000). Participant responses automatically loaded the next voice pair.

Results

We calculated the proportion of trials in which participants selected the masculinized versions of voice pairs as more likely to commit infidelity and as more attractive, separately. Shapiro-Wilk tests indicated significant deviation from normalcy for all variables (all $W > .851$, all $p < .005$); therefore, all analyses used non-parametric, two-tailed probability estimates. See Table 2 for descriptive statistics.

One-sample Wilcoxon signed rank tests were used to determine if pitch manipulations influenced the proportion of trials that masculinized voices were selected as more likely to be unfaithful, against what would be expected by chance alone (0.5). Women chose masculinized (i.e. low pitched) men's voices ($Z = 3.79$, $P < 0.001$) as more likely to be unfaithful on a significantly greater proportion of trials than they chose feminized (i.e. high *pitched*) men's voices. There was no influence of pitch manipulation on women's attributions of infidelity to female voices ($Z = -.978$, $P = 0.328$).

Table 2. Mean proportion of trials raters chose masculinized stimuli.

Stimuli		Sex of Rater	
Female		Women	Men
	Infidelity	0.46 (0.04)	0.40 (0.04)
	Attractiveness	0.27 (0.03)	0.21 (0.03)
Male			
	Infidelity	0.69 (0.04)	0.53 (0.05)
	Attractiveness	0.66 (0.03)	0.57 (0.04)

Note. Standard errors in parentheses.

Men chose feminized female voices as more likely to cheat on their partners more often than they chose masculinized female voices (Z = -2.26, P = 0.024). There was no effect of male voice pitch manipulation on men's attributions of infidelity (Z = 0.50, P = 0.615).

Both men (Z = -5.88, $P < 0.001$) and women (Z = - 5.49, $P < 0.001$) selected feminized female voices as more attractive than masculinized female voices. Women participants chose masculinized men's voices (Z = 3.65, $P < 0.001$) as more attractive than feminized men's voices, but male voice pitch manipulations did not influence men's attractiveness ratings (Z = 1.04, P= 0.301).

We used Mann-Whitney U tests to determine if there were sex differences in attributions of infidelity and attractiveness. Women chose masculinized male voices as more likely to commit infidelity on a significantly greater proportion of trials than did men (U= 956.00, Z = -2.62, P = 0.009). There was no significant difference between men's and women's attributions of infidelity to women's voices (U= 1214.00, Z = -0.90, P = 0.371). Furthermore, we did not find any significant sex differences in voice pitch preferences either male (U = 1120.50, Z = -1.50, P = 0.132) or female voices (U= 1133.00, Z = -1.44, P = 0.149).

We used Spearman's rank order correlations to determine the relationship between pitch preferences and attributions of infidelity. For male voices, there was no relationship between pitch preferences and attributions of infidelity among men (r = 0.111, N = 49, P = 0.447) or women participants (r = 0.148, N = 55, P = 0.282). Additionally, there was no

relationship between preferences for female voice pitch and attributions of infidelity among men (r = -0.061, N = 49, P = 0.677) or women (r = 0.222, n = 55, p = 0.104).

Repeating all analyses with parametric statistics yielded no qualitative differences from the aforementioned analyses.

Discussion

We hypothesized that masculinized men's voices and feminized women's voices would be perceived as more attractive and more likely to commit infidelity. We found that while women attributed infidelity to masculinized men's voices, men's attributions of infidelity were not related to male voice pitch manipulations. While men attributed infidelity to feminized women's voices, women did not. Thus, the results reported here cannot be due to a response bias to low or high pitched voices in general. Furthermore, there was no relationship between participants' preferences for voice pitch and their attributions of infidelity, suggesting that attributions of infidelity are not merely an artifact of preferences.

We found that women rated masculinized men's voices as more likely to commit infidelity than feminized men's voices. Considering that women rate lower-pitched men's voices as more attractive than higher-pitched men's voices, both here and in prior studies (Jones, Feinberg, DeBruine, Little, and Vukovic, 2010; Vukovic et al., 2010; Feinberg et al., 2008a; Jones et al., 2008; Saxton et al., 2006; Feinberg et al., 2005a; Collins, 2000),

these findings are consistent with Hughes et al. (2004), who found that men with attractive voices report engaging in more extra-pair sex than do men with less attractive voices. Men's vocal masculinity serves as an index of testosterone levels (Evans et al., 2008; Bruckert, Liénard, Lacroix, Kreutzer, and Leboucher, 2006; Dabbs and Mallinger, 1999; Hollien, 1960). Testosterone is positively associated with short-term mating effort (Peters, Simmons, and Rhodes, 2008; Gray, Kahlenberg, Barrett, Lipson, and Ellison, 2002), and negatively associated with parental investment (Gray et al., 2007) and relationship effort (van Anders, Hamilton, and Watson, 2007; Gray et al., 2004; Gray et al., 2002; Booth and Dabbs, 1993). Self-reported engagement in extra-pair copulation is significantly higher among men with more masculine bodies as rated by participants (Rhodes, Simmons, and Peters, 2005), and as measured by shoulder-to-hip ratio (Hughes and Gallup, 2003). Women also perceive masculinized male faces as more likely to commit infidelity and as more desirable extra-pair partners (Kruger, 2006). Furthermore, men with relatively high levels of testosterone are more likely to engage in risk-taking behaviors, such as drug use and sexual promiscuity, and are more likely to contract sexually transmitted infections (Booth, Johnson, and Granger, 1999). Therefore, relatively masculine men may be more likely to risk the costs associated with infidelity in favor of the potential reproductive gains, and women's attributions of infidelity risk to such men may aid in avoiding the investment loss and health costs associated with partner infidelity.

Male participants attributed greater infidelity risk to women with voices manipulated to be higher in pitch than those with voices manipulated to be lower in pitch.

These findings are consistent with those from Hughes et al. (2004), who found that women with attractive voices report engaging in more extra-pair sex than did women with less attractive voices. Both here and in prior studies, men rate higher-pitched women's voices as more attractive than lower-pitched women's voices (Apicella and Feinberg, 2009; Feinberg et al., 2008b; Jones et al., 2008; Collins and Missing, 2003). Women's vocal femininity is positively related to between-individual estrogen levels (Abitbol et al., 1999), and may also cue menstrual cycle phase (Bryant and Haselton, 2009; c.f. Chae, Choi, Kang, Choi, and Jin, 2001) and so may indicate both state and trait fecundity. Among women, estrogen is positively related to number of long-term relationships, likelihood of adulterous behavior (Durante and Li, 2009), and body femininity (Jasienska et al., 2004). In turn, body femininity is associated with higher sexual desire (van Anders, 2005), inducing same-sex jealousy, and engaging in extra-pair sex (Hughes et al., 2004; Hughes and Gallup, 2003). Puts et al. (2011) also found that women with more feminine voices are perceived by other women as more flirtatious and as more attractive to men. Furthermore, women with attractive, feminine voices also have attractive, feminine faces (Feinberg et al., 2005b; Collins and Missing, 2003). Among men, preferences for feminine female voices covary with preferences for feminine female faces, particularly in the context of a long-term relationship (Fraccaro et al., 2010). Women with relatively more feminine faces are more likely to be in long-term relationships (Rhodes et al., 2005), and therefore may have increased opportunities for extra-pair copulation given their desirability as a mate, regardless of relationship context (Scott, Swami, Josephson, and Penton-Voak, 2008). Indeed, increased perceived opportunity for extra-pair sex is a key

predictor of infidelity (Atkins, Baucom, and Jacobson, 2001; Treas and Giesen, 2000). Therefore, men's attributions of infidelity to feminine women are adaptive if it aids in avoiding the fitness costs of sexual transmitted infection and cuckoldry.

Our results evidence the influence of morphological indicators of hormonal status on attributions of infidelity risk, though only to opposite sex individuals. The absence of an effect of same-sex pitch manipulations on attributions of infidelity indicates that opposite-sex infidelity attributions were not due to general response biases, but were indicative of the influence of cues to underlying hormonal status on the perception of a potential mates' fidelity.

In the current study, we found a significant sex difference in attributions of infidelity to male, but not female voices; women chose masculinized male voices as more likely to commit infidelity on a significantly higher proportion of trials than did men. It is possible that this discrepancy is due to sex differences in the potential costs of male infidelity. It is potentially adaptive for individuals to be more sensitive to cues of infidelity among potential mates than among non-mates, due to the costs of infidelity to the in-pair partner, such as resource loss (Anderson, Kaplan, and Lancaster, 2007, 1999). If this were the case, we would also expect that men are more sensitive to cues of female infidelity than are other women. In the present study, however, we did not find a significant difference between men's and women's attributions of infidelity to female voices. Future studies may elucidate the disparately of sex differences in the influence of voice pitch on attributions of infidelity.

In the present study, and consistent with prior work (Jones et al., 2010; Vukovic et al., 2010, 2008; Feinberg et al., 2008a, 2005a; Saxton et al., 2006; Collins, 2000) we found that women, but not men, preferred lower-pitched men's voices. Nevertheless, we also found that both men and women preferred higher-pitched women's voices. Other studies have also found that women prefer higher-pitched women's voices (Feinberg et al., 2008b), though not all (Jones et al., 2010, 2008). Indeed, Feinberg et al. (2008b) demonstrated that women generally prefer high-pitched women's voices, but not those that are extremely high, suggesting that women may derogate potential competition (Fisher, 2004). In line with prior research (Jones et al., 2010; Feinberg et al., 2008b), we found that preferences for feminine female voices were greater among men than among women, and preferences for masculine male voices were greater among women than among men, although the differences reported here were non-significant, possibly due to our smaller sample size.

Importantly, we did not find a relationship between variations in preferences for masculinity or femininity and variations in attributions of infidelity. Therefore, individual differences in attributions of infidelity to masculine male and feminine female voices do not appear to reflect variation in preferences for these cues. We can also conclude that our findings are not likely due to a general "halo effect" (Feingold, 1998) where observers infer positive personality traits to individuals with attractive voices (Zuckerman and Driver, 1989). If our results were due to a halo effect, then masculinized male voices and feminized female voices would have been rated as less likely to cheat on their romantic

partners, as fidelity is a positive trait. Therefore, explaining the current results in terms of a "halo effect" would be inappropriate for both male and female stimuli.

Participants in our experiment attributed infidelity and attractiveness to different voices by choosing between two versions of a voice, which differed only in voice pitch. Although our results indicated that voice pitch influenced attributions of infidelity and attractiveness, the absence of a significant correlation between these two attributions indicates that voice pitch manipulations did not influence these two attributions to the same degree.

Voice pairs within the attractiveness attribution blocks were different from those voice pairs in the infidelity attribution blocks, except for one male and one female voice pair, which were present in both blocks. Due to the experimental procedure where participants chose between raised or lowered pitch versions of the same voice, any similarities or differences between different voice pairs are unlikely to influence the results. Other studies of voice preferences have produced equivalent results regardless of whether all participants listened to the same (Feinberg et al., 2006) or to different voices (Puts, 2005). While it is possible that some participants chose the raised or lowered version of a voice present in both blocks as both more attractive and as more likely to cheat, separate analyses on the two overlapping voices failed to detect such a relationship.

In summary, this was the first study to test for associations between vocal sexual dimorphism, preferences for voice pitch, and perceived infidelity. We found that observer's attributions of infidelity were influenced by manipulations of vocal pitch.

Women attributed infidelity to masculinized male voices, and men attributed infidelity to feminized women's voices. Infidelity poses potential fitness risks to both sexes, such as loss of resource investment, cuckoldry, sexually transmitted infections, retaliation, and devaluation as a mate (Geary and Byrd-Craven, 2004; Buss, 1994; Daly and Wilson, 1988; Alatalo et al., 1987; Fitch and Shugart, 1984). Infidelity attributions may be the function of an adaptive heuristic that aids in preventing reduced fitness. This type of heuristic may have been particularly crucial for our ancestors, who would have suffered considerable fitness costs if they lost paternity, resources, or parental investment to a same-sex competitor.

References

Abitbol, J., Abitbol, P., and Abitbol, B. (1999). Sex hormones and the female voice. *Journal of Voice, 13,* 424-446.

Alatalo, R. V., Gottlander, K., and Lundverg, A. (1987). Extra-pair copulations and mate guarding in the polyterritorial pied flycatcher, ficedula hypoleuca. *Behaviour, 101,* 139-155.

Anderson, K. G., Kaplan, H., and Lancaster, J. (2007). Confidence of paternity, divorce, and investment in children by Albuquerque men. *Evolution and Human Behavior, 28,* 1-10.

Anderson, K. G., Kaplan, H., and Lancaster, J. (1999). Paternal care by genetic fathers and stepfathers I: Reports from Albuquerque men. *Evolution and Human Behavior, 20,* 405-431.

Apicella, C. L., and Feinberg, D.R. (2009). Voice pitch alters mate-choice-relevant perception in hunter-gatherers. *Proceedings of the Royal Society B-Biological Sciences, 276,* 1077-1082.

Apicella, C. L., Feinberg, D. R., and Marlowe, F. W. (2007). Voice pitch predicts reproductive success in male hunter-gatherers. *Biology Letters, 3,* 682-684.

Atkins, D. C., Baucom, D. H., and Jacobson, N. S. (2001). Understanding infidelity: Correlates in a national random sample. *Journal of Family Psychology, 15,* 735-749.

Bancroft, J. (2005). The endocrinology of sexual arousal. *Journal of Endocrinology, 186,* 411-427.

Baumeister, R. F., Catanese, K. R., and Vohs, K. D. (2001). Is there a gender difference in strength of sex *drive? Theoretical views, conceptual distinctions, and a review of relevant evidence. Personality and Social Psychology Review, 5*, 242-273.

Boersma, P. & Weenink, D. (2009). Praat: doing phonetics by computer (Version 5.1.04) [Computer program]. Retrieved April 4, 2009, from http://www.praat.org/.

Booth, A., and Dabbs, J. M. (1993). Testosterone and men's marriages. *Social Forces, 72,* 463-477.

Booth, A., Johnson, D. R., and Granger, D. A. (1999). Testosterone and men's health. *Journal of Behavioral Medicine, 22,* 1-9.

Bruckert, L., Liénard, J., Lacroix, A., Kreutzer, M., and Leboucher, G. (2006). Women use voice parameters to assess men's characteristics. *Proceedings of the Royal Society B: Biological Sciences, 273,* 83-89.

Bryant, G. A., and Haselton, M. G. (2009). Vocal cues of ovulation in human females. *Biology Letters, 5*, 12-15.

Buss, D. M. (1994). *The evolution of desire.* New York: Basic Books.

Buunk, B. P., and Dijkstra, P. (2005). A narrow waist versus broad shoulders: Sex and age differences in the jealousy-evoking characteristics of a rival's body build. *Personality and Individual Differences, 39,* 379-389.

Chae, S. W., Choi, G., Kang, H. J., Choi, J. O., and Jin, S. M. (2001). Clinical Analysis of Voice Change as a Parameter of Premenstrual Syndrome. *Journal of Voice, 15,* 278-283.

Chen, C. C. G., and Parker, C. R. (2004). Adrenal androgens and the immune system. *Seminars in Reproductive Medicine, 22,* 369-377.

Collins, S. A. (2000). Men's voices and women's choices. *Animal Behaviour, 60,* 773-780.

Collins, S. A., and Missing, C. (2003). Vocal and visual attractiveness are related in women. *Animal Behaviour, 65,* 997-1004.

Dabbs, J. M., and Mallinger, A. (1999). High testosterone levels predict low voice pitch among men. *Personality and Individual Differences, 27,* 801-804.

Daly, M., and Wilson, M. (1988). *Homicide*. Hawthorne, NY: Adline de Gruyter.

Durante, K. M., and Li, N. P. (2009). Oestradiol level and opportunistic mating in women. *Biology Letters, 5,* 179-182.

Evans, S., Neave, N., Wakelin, D., and Hamilton, C. (2008). The relationship between testosterone and vocal frequencies in human males. *Physiology and Behavior, 93,* 783-788.

Feinberg, D. R. (2008). Are human faces and voices ornaments signaling common underlying cues to mate value? *Evolutionary Anthropology, 17,* 112-118.

Feinberg, D. R., DeBruine, L. M., Jones, B. C., and Little, A. C. (2008a). Correlated preferences for men's facial and vocal masculinity. *Evolution and Human Behavior, 29,* 233-241.

Feinberg, D. R., DeBruine, L. M., Jones, B. C., and Perrett, D. I. (2008b). The relative role of femininity and averageness of voice pitch in aesthetic judgments of women's voices. *Perception, 37,* 615-623.

Feinberg, D.R., Jones, B.C., Law Smith, M.J., Moore, F.R., DeBruine, L.M., Cornwell, R.E., Hillier, S.G., & Perrett, D.I. (2006). Menstrual cycle, trait estrogen level, and masculinity preferences in the human voice. *Hormones and Behaviour, 49,* 215-222.

Feinberg, D. R., Jones, B. C., Little, A. C., Burt, D. M., and Perrett, D. I. (2005a). Manipulations of fundamental and formant frequencies influence the attractiveness of human male voices. *Animal Behaviour, 69,* 561-568.

Feinberg, D. R., Jones, B. C., DeBruine, L. M., Moore, F. R., Law Smith, M. J., Cornwell, R. E., Tiddeman, B. P., Boothroyd, L. G., and Perrett, D. I. (2005b). The voice and face of woman: One ornament that signals quality? *Evolution and Human Behavior, 26,* 398-408.

Feingold, A. (1998). Good-looking people are not what we think. *Psychological Bulletin, 111,* 304-341.

Fink, B., and Penton-Voak, I. S. (2002). Evolutionary psychology of facial attractiveness. *Current Directions in Psychological Science, 11,* 154-158.

Fisher, A. D., Corona, G., Bandini, E., Mannucci, E., Lotti, F., Boddi, V., Forti, G., and Maggi, M. (2009). Psychobiological Correlates of Extramarital Affairs and

Differences between Stable and Occasional Infidelity among Men with Sexual Dysfunctions. Journal of Sexual Medicine, 6(3), 866-875.

Fisher, M. L. (2004). Female intrasexual competition decreases female facial attractiveness. *Proceedings of the Royal Society B: Biological Sciences (Suppl.), 271*, S283-S285.

Fitch, M. A., and Shugart, G. W. (1984). Requirements for a mixed-reproductive strategy in avian species. *The American Naturalist, 124*, 116-126.

Folstad, I., and Karter, A. (1992). Parasite, bright males, and the immunocompetence handicap. *American Naturalist, 139*, 603-623.

Gangestad, S. W., and Thornhill, R. (1997). The evolutionary psychology of extra-pair sex: The role of fluctuating asymmetry. *Evolution and Human Behavior, 18*, 69-88.

Geary, D. C., and Byrd-Craven, J. (2004). The evolution of human mate choice. The *Journal of Sex Research, 41*, 27-42.

Gray, E. M. (1997). Female red-winged blackbirds accrue material benefits from copulating with extra-pair males. *Animal Behavior, 53*, 625-693.

Gray, P. B., Campbell, B. C., Marlowe, F. W., Lipson, S. F., and Ellison, P. T. (2004). Social variables predict between-subject but not day-to-day variation in the testosterone of US men. *Psychoneuroendocrinology, 29*, 1153-1162.

Gray, P. B., Parkin, J. C., and Samms-vaughan, M. E. (2007). Hormonal correlates of human paternal interactions: A hospital-based investigation in urban Jamaica. *Hormones and Behavior, 52*, 499-507.

Gray, P. B., Kahlenberg, S. M., Barrett, E. S., Lipson, S. F., and Ellison, P. T. (2002). Marriage and fatherhood are associated with lower testosterone in males. *Evolution and Human Behavior, 23,* 193-201.

Greiling, H., and Buss, D. M. (2000). Women's sexual strategies: The hidden dimension of extra-pair mating. *Personality and Individual Differences, 28,* 929-963.

Harries, M., Hawkins, S., Hacking, J., and Hughes, I. (1998). Changes in the male voice at puberty: Vocal fold length and its relationship to the fundamental frequency of the voice. *The Journal of Laryngology and Otology, 112,* 451-454.

Hollien, H. (1960). Some laryngeal correlates of vocal pitch. *Journal of Speech and Hearing, 3,* 52-58.

Hughes, S. M., Dispenza, F., and Gallup, G. G. (2004). Ratings of voice attractiveness predict sexual behavior and body configuration. *Evolution and Human Behavior, 25,* 295-304.

Hughes, S. M., and Gallup, G. G. (2003). Sex differences in morphological predictors of sexual behavior Shoulder to hip and waist to hip ratios. *Evolution and Human Behavior, 24,* 173-178.

Jasienska, G., Ziomkiewicz, A., Ellison, P. T., Lipson, S. F., and Thune, I. (2004). Large breasts and narrow waists indicate high reproductive potential in women. *Proceedings of the Royal Society B: Biological Sciences, 271,* 1213-1217.

Jones, B. C., Feinberg, D. R., DeBruine, L. M., Little, A. C., and Vukovic, J. (2010). A domain-specific opposite-sex bias in human preferences for manipulated voice pitch. *Animal Behavior, 79,* 57-62.

Jones, B. C., Feinberg, D. R., DeBruine, L. M., Little, A. C., and Vukovic, J. (2008). Integrating cues of social interest and voice pitch in men's preferences for women's voices. *Biology Letters, 4,* 192-194.

Kaighobadi, F., and Shackelford, T. (2008). Female attractiveness mediates the relationship between in-pair copulation frequency and men's mate retention behaviors. *Personality and Individual Differences, 45,* 293-295.

Kruger, D.J. (2006). Male facial masculinity influences attributions of personality and reproductive strategy. *Personal Relationships, 13,* 451-463.

Mazur, A., and Booth, A. (1998). Testosterone and dominance in men. *Behavioral and Brain Sciences, 21,* 353-397.

McIntyre, M., Gangestad, S. W., Gray, P. B., Chapman, J. F., Burnham, T. C., O'Rourke, M. T., and Thornhill, R. (2006). Romantic involvement often reduces men's testosterone levels--but not always: The moderating role of extrapair sexual interest. *Journal of Personality and Social Psychology, 91,* 642-651.

Morris, N. M., Udry, J. R., Khan-Dawood, F., and Dawood, M. Y. (1987). Marital Frequency and midcycle female testosterone. *Archives of Sexual Behavior, 16,* 27-37.

Moulines, E., and Charpentier, F. (1990). Pitch synchronous waveform processing techniques for text-to-speech synthesis using diphones. *Speech Communication, 9,* 453-467.

Persky, H., Lief, H. I., Strauss, D., Miller, W. R., and O'Brien, C. P. (1978). Plasma testosterone level and sexual behavior of couples. *Archives of Sexual Behavior, 7,* 157-173.

Peters, M., Rhodes, G., and Simmons, L. W. (2008). Does attractiveness in men provide clues to semen quality? *Journal of Evolutionary Biology, 21,* 572-579.

Peters, M., Simmons, L., and Rhodes, G. (2008). Testosterone is associated with mating success but not attractiveness or masculinity in human males. *Animal Behavior, 76,* 297-303.

Puts, D.A., Barndt, J.L., Welling, L.L.M., Dawood, K., & Burriss, R.P. (2011). Intrasexual competition among women: Vocal femininity affects perceptions of attractiveness and flirtatiousness. *Personality and Individual Differences, 50,* 111-115.

Puts, D. A., Gaulin, S. J.C., and Verdolini, K. (2006). Dominance and the evolution of sexual dimorphism in human voice pitch. *Evolution and Human Behavior, 27,* 283-296.

Puts, D.A. (2005). Mating context and menstrual phase affect women's preferences for male voice pitch. *Evolution and Human Behavior, 26,* 388-397.

Rhodes, G., Simmons, L., and Peters, M. (2005). Attractiveness and sexual behavior: Does attractiveness enhance mating success? *Evolution and Human Behavior, 26,* 186-201.

Saxton, T. K., Caryl, P. G., and Roberts, S. C. (2006). Vocal and facial attractiveness judgments of children, adolescents and adults: The ontogeny of mate choice. *Ethology, 112,* 1179-1185.

Scott, I., Swami, V., Josephson, S. C., and Penton-Voak, I. S. (2008). Context-dependent preferences for facial dimorphism in a rural Malaysian population. *Evolution and Human Behavior, 29,* 289-296.

Singh, D. (1993). Adaptive significance of female physcial attractiveness: Role of waist-to-hip ratio. *Journal of Personality and Social Psychology, 65,* 293-307.

Singh, D., Dixson, B. J., Jessop, T. S., Morgan, B., and Dixson, A. F. (2010). Cross-cultural consensus for waist–hip ratio and women's attractiveness. *Evolution and Human Behavior, 31,* 176-181.

Sony Creative Software. Sound Forge Software (Version 6.0) [Computer Software].

Stuckey, B. G. A. (2008). Female Sexual Function and Dysfunction in the Reproductive Years: The Influence of Endogenous and Exogenous Sex Hormones. *Journal of Sexual Medicine, 5*, 2282-2290.

Symons, D. (1979). *The evolution of human sexuality.* Oxford: Oxford University Press.

Titze, I. R. (1994). *Principles of voice production.* Englewood Cliffs, NJ: Prentice Hall.

Tranmüller, H. (1990). Analytical expressions for the tonotopic sensory scale. *Journal of the Acoustical Society of America, 88,* 97-100.

Treas, J., and Giesen, D. (2000). Sexual infidelity among married and cohabiting Americans. *Journal of Marriage and the Family, 62,* 48-60.

van Anders, S. M., and Dunn, E. J. (2009). Are gonadal steroids linked with orgasm perceptions and sexual assertiveness in women and men? *Hormones and Behavior, 56,* 206-213.

van Anders, S., Hamilton, L., and Watson, N. (2007). Multiple partners are associated with higher testosterone in North American men and women. *Hormones and Behavior, 51,* 454-459.

van Anders, S. M., and Hampson, E. (2005). Waist-to-hip ratio is positively associated with bioavailable testosterone by negatively associated with sexual desire in healthy premenopausal women. *Psychosomatic Medicine, 67,* 246-250.

Vukovic, J., Jones, B. C., DeBruine, L., Feinberg, D. R., Smith, F. G., Little, A. C., Welling, L. L. M., and Main, J. (2010). Women's own voice pitch predicts their preferences for masculinity in men's voices. *Behavioral Ecology, 21,* 767-772.

Vukovic, J., Feinberg, D. R., Jones, B. C., DeBruine, L. M., Welling, L. L. M., Little, A. C., and Smith, F. G. (2008). Self-rated attractiveness predicts individual differences in women's preferences for masculine men's voices. *Personality and Individual Differences, 45,* 451-456.

Welling, L. L. M., Jones, B. C., Debruine, L. M., Conway, C. ., Law smith, M. j., Little, A. C., Feinberg, D. R., Sharp, M. A., and Aldujaili, E. A. S. (2007). Raised salivary testosterone in women is associated with increased attraction to masculine faces. *Hormones and Behavior, 52,* 156-161.

Wichmann, M. W., Ayala, A., and Chaudry, I. H. (1997). Male sex steroids are responsible for depressing macrophage immune function after trauma-hemorrhage. *American Journal of Physiology - Cell Physiology, 273,* 1335-1340.

Zuckerman, M. and Driver, R. E. (1989). What sounds beautiful is good: the vocal attractiveness stereotype. *Journal of Nonverbal Behavior, 13,* 67–82.

CHAPTER 4: THE INFLUENCE OF MALE VOICE PITCH ON WOMEN'S PERCEPTIONS OF RELATIONSHIP INVESTMENT

O'Connor, J.J.M., Fraccaro, P.J. & Feinberg, D.R. (2012). *Journal of Evolutionary Psychology, 10,* 1-13.

Preface

In the previous study, I found that women with higher pitched voices were perceived as presenting a signifcantly greater risk of infidelity than were women with lower pitched voices. Men with relatively lower pitched voices were perceived as presenting a greater risk of infidelity than were men with relatively higher pitched voices. Despite these negative personality attributions, lower pitched men's voices are prefered by women over relatively higher pitched men's voices (Chapter 2, Chapter 3). Infidelity poses a fitness risk to women in the form of the loss of male protection and provisisioning for themselves and offspring (Anderson, Kaplan, & Lancaster, 1999; Anderson, Kaplan, & Lancaster, 2007). If women are somewhat aware of the fitness costs associated with mating with relatively masculine men, then women's preferences for vocal masculinity may be influenced by the extent to which they perceive relatively masculine men as willing to invest in relationships and offspring. This potential relationship between women's perceptions of investment and their preferences for men's voices may be stronger in long-term than in short-term relationship contexts. This is because previous

research finds that women's preferences for masculinity are greater when masculine men are rated as short-term or potential extra-pair mates (see section Individual *Differences in Women's Preferences for Masculinity*). Under these conditions, women may prefer relatively masculine men as short-term and potentially extra-pair partners when protection and provisioning for offspring is available from other sources, such as the in-pair partner.

In the following study, I tested whether manipulations of men's voice pitch influenced women's perceptions of relationship investment. I examined whether investment-related perceptions differed according to the allocation of material resources versus non-resource based relationship invesment, i.e. time and effort. Furthermore, I tested whether perceptions of resource-based investment, i.e. financial generosity, were related to perceptions of general financial behaviour or to women's preferences for voice pitch. If women use men's voice pitch as an indicator of proclivity for relationship investment, then women will select feminized men's voices as more likely to invest time and effort, and be more financially generous within their romantic relationships.

Abstract

The degree to which men invest financial resources, time, and effort into pursuing and maintaining relationships may be perceived by women as a cue to that man's suitability as father and a mate. Women's mate preferences are also influenced by cues to underlying heritable mate quality, such as an attractive, masculine voice. Relatively more masculine men may be able to provide heritable benefits to offspring, but masculinity is associated with decreased investment in relationships and offspring. Both individual differences in women's preferences for masculine voices and women's attributions of negative personality traits to masculine men suggests that women may be somewhat aware of the negative associations between men's physical masculinity and relationship/parental investment. In the current study, we found that in general, women perceived feminized men's voices as significantly more likely to invest time and effort, and be financially generous with romantic partners. We also found that women's preferences for masculine voice pitch in a long-term, but not short-term relationship context, were positively related to perceptions of male financial generosity and investment of time and effort in romantic relationships. These perceptions may represent an adaptive heuristic that aids women in selecting long-term mates that are likely to invest in relationships and offspring.

Introduction

Female mate choice is influenced by both cues to direct benefits, such as provisioning and protection, and by cues to heritable indirect benefits, such as physical attractiveness (Andersson 1994; Gangestad and Simpson 2000; Geary and Byrd-Craven 2004). Women's preferences for men with status and economic potential represents women's desire for mates who possess resources to invest, while women's preferences for personality characteristics, such as dependability and stability, represent women's desire for mates who are likely to invest acquired resources in offspring (Buss 2008). Therefore, the degree to which men invest resources, time, and effort into pursuing and maintaining a relationship may be perceived by women as a cue to that man's suitability as a father, and therefore as a mate. Indeed, women's preferences for men possessing indicators of resource acquisition and propensity to invest resources in relationships and offspring are particularly evident in the context of a long-term relationship (Buunk, Dijkstra, Fetchenhauer, and Kenrick 2002; Greitemeyer, Hengmith, and Fischer 2005; Li and Kenrick 2006; Scheib 2001; Stewart, Stinnett, and Rosenfeld 2000).

Women's preferences for cues to heritable benefits are amplified in the context of a short-term relationship (Li and Kenrick 2006; Li, Valentine, and Patel 2011; Scheib 2001). Cues to indirect genetic benefits may include, but are not limited to, traits such as vocal and facial masculinity (Feinberg 2008; Jones et al. 2008; Thornhill and Gangestad 1999). Male vocal and facial masculinity are dependent upon adequate levels of pubertal testosterone (Hollien 1960). Testosterone levels among men are negatively associated

with health risks such as metabolic syndrome, cardiovascular disease, insulin resistance, type 2 diabetes mellitus, and erectile dysfunction (Feely, Saad, Guay, and Traish 2009). Furthermore, the perceived masculinity of adolescent male faces is positively correlated with both perceptions of health and with actual health as quantified by examination of health records (Rhodes, Chan, Zebrowitz, and Simmons 2003). Adult males with more masucline faces also report a lower number and shorter duration of respiratory infections than do men with less masculine faces (Thornhill and Gangestad 2006). Therefore, higher levels of testosterone among men are associated with indices of health which could potentially benefit offspring either directly by reducing proximate exposure to pathogens or indirectly in the form of heritable immunity (Tybur & Gangestad 2011). Testosterone may also further represent cues to direct resources; testosterone levels are positively associated with increased dominant behaviour and social status (Mazur and Booth 1998; Tremblay et al. 1998), and dominant, high status men are more likely to gain access to resources than are less dominant, lower status men (Geary and Byrd-Craven 2004; Mazur and Booth 1998).

Men possessing relatively more masculine traits may provide some benefits to offspring, but testosterone is also associated with decreased investment in relationships and offspring (Booth and Dabbs 1993; Gray, Parkin, and Sammsvaughan 2007; Roney, Hanson, Durante, and Maestripieri 2006; van Anders, Hamilton, and Watson 2007). Men with relatively high testosterone levels report sustained interest in sex beyond their current committed relationship (McIntyre et al. 2006), a greater number of sex partners

(Peters, Simmons, and Rhodes 2008), and a higher number of extra-marital affairs (Fisher et al. 2009). Men with relatively lower levels of testosterone are more likely to currently be in a long-term committed relationship than are men with relatively higher levels of testosterone (van Anders and Goldey 2010). Men with relatively higher testosterone levels are more likely to be single, have one or more uncommitted relationships, or be polyamorously partnered than are men with lower testosterone levels (van Anders and Goldey 2010; van Anders et al. 2007). Furthermore, there is a significant negative relationship between relationship commitment and partnered men's testosterone (Caldwell Hooper, Gangestad, Emery Thompson, and Bryan 2011). Men possessing testosterone-dependent traits such as facial masculinity are also more likely to be open to sex outside of a committed relationship than are men with less masculine faces (Boothroyd, Jones, Burt, DeBruine and Perrett 2008). Furthermore, men with lower-pitched voices report a higher number of sex partners (Puts 2005) and a higher number of surviving offspring (Apicella, Feinberg and Marlowe 2007) than do men with higher-pitched voices. Therefore, men who are likely to confer indirect benefits to offspring and have access to resources are less likely to provide relationship/parental investment.

Variation in preferences for testosterone-dependent traits suggests that women have the adaptive capacity to solve the problem of how to gain both heritable genetic benefits as well as investment from potential mates. First, women generally prefer low-pitched masculine male voices over higher-pitched male voices (Collins 2000; Feinberg, Jones, Little, Burt and Perrett 2005; Feinberg, DeBruine, Jones, and Little, 2008a; Jones,

Feinberg, DeBruine, Little, and Vukovic, 2010; Pisanski and Rendall 2011; Vukovic et al. 2010). However, women's preferences for masculine male voice pitch (defined here as the perception of fundamental frequency and/or corresponding harmonics) are heightened among women in the fertile menstrual cycle phase (Feinberg et al. 2006; Puts 2005) and among women not using hormonal contraception (Feinberg et al. 2008a). Vocal masculinity preferences are greater among fertile women when rated in the context of a short-term relationship (Hodges-Simeon, Gaulin, and Puts 2010; Puts 2005). Second, women's preferences for vocal masculinity are positively related to their mate value. Women with high self-rated attractiveness (Vukovic et al. 2008), or who possess traits related to mate value, such as vocal femininity (Vukovic et al. 2010), demonstrate stronger vocal masculinity preferences than do other women. Similarly, women with high self-rated (Little et al. 2001) and high other-rated attractiveness (Penton-Voak et al. 2003) have greater preferences for men's facial masculinity in long-term relationship contexts than do other women. Therefore, women of relatively higher quality may be better than others in attaining and/or retaining parental investment from relatively more masculine men. Women of lesser mate quality may pursue masculine men when heritable traits may benefit potential offspring, but long-term investment is available from alternate sources.

Variations in women's preferences for masculine male voices suggest that women may be somewhat aware of the negative associations between men's physical masculinity and relationship/parental investment. Facial masculinity is positively related to perceptions of mating effort and negatively related to perceptions of parental and

relationship investment (Kruger 2006). Masculine men's faces are also rated as less warm, less honest, less cooperative, and as lower quality parents (Perrett et al. 1998). If facial masculinity influences perceptions related to mate quality based on underlying relationships with testosterone, then other testosterone-dependent traits such as voice pitch may similarly influence mate-choice relevant perceptions.

Here we tested whether men's voice pitch influenced women's perceptions of resource based and non-resource based relationship investment, and if these perceptions of relationship investment are related to perceptions of general financial behaviour or are more specifically related to voice pitch preferences. We predicted that if women utilize men's voice pitch as a cue to proclivity for relationship (and hence, parental) investment, then women will select feminized men's voices as more likely to invest time and effort, and be more financially generous within their romantic relationships.

Methods

Participants.

Protocols for this study were approved by the McMaster Research Ethics Board. Heterosexual women (N = 138; mean age =18.60 years, SD = 1.19) were recruited from McMaster University and compensated with course credit for participation. Participant age and sexual orientation (Kinsey, Pomeroy, and Martin 1948) were self-reported.

Stimuli.

Voice stimuli were collected and manipulated in the same manner as Feinberg et al. (2005; 2008b; 2006). Men aged 18-24 (N = 6) were recorded speaking English monopthong vowels; 'ah' as in father, 'ee' as in see, 'eh' as in bet, 'oh' as in note, 'oo' as in boot. Single channel recordings were made in a quiet room with an Audio-Techica AT4041 microphone at a 44.1 kHz sampling rate, with 16-bit amplitude quantization in Sound Forge software (Sony Creative).

Voice pitch was modified using the pitch-synchronous overlap add (PSOLA® France Telecom) method in Praat software (Boersma and Weenink 2009). The PSOLA method is a standard technique of voice manipulation, which selectively manipulates fundamental frequency and related harmonics while controlling for other spectrotemporal features of the signal (Feinberg et al. 2005; 2008b; Moulines and Charpentier 1990).

Voice pitch was raised and lowered by adding or subtracting 0.5 equivalent rectangular bandwidths (ERBs) of the baseline frequency. The ERB scale accounts for the difference between pitch perception and natural frequencies more accurately than do alternative scales (Tranmüller 1990). This manipulation is approximately equivalent to a 20 Hz manipulation for an average male voice pitch of 120 Hz. This level of manipulation has been successful in previous research on voice pitch (Apicella and Feinberg 2009; Feinberg et al. 2008b; Jones, Feinberg, DeBruine, Little, and Vukovic 2008; Vukovic et al. 2008; 2010) and has been shown to influence perceptions of masculinity (Feinberg et

al. 2005). The resulting frequency of all manipulated voices spanned the normal range of adult male voice pitch (94.9 to 160.1 Hz).

Procedure.

Voice pairs were presented in 5 separate, randomized blocks representing 5 different rating contexts (saving money, invest, generous, short-term relationship, long-term relationship). Stimuli pairs were randomized for order and side of screen presentation within blocks, and blocks were interspersed with distracter tasks.

Stimuli pairs were masculine and feminine versions of the same voice, presented in a two-alternative forced choice paradigm. Voices were played consecutively, prompted by the participant selecting the 'play' button for the individual file. Participant responses automatically loaded the next trial.

Participants rated opposite sex voices within 5 different contexts. In the investment context, we asked participants to indicate which, from a pair of voices, invests more time and effort into their romantic relationships. This context served as a measure of perception of relationship investment that was not solely determined by resource investment. In the generous context, we asked participants to indicate which, from a pair of voices, is more likely to be financially generous with their partner. This context provided a measure of purely resource-based relationship investment. In the saving money context, we asked participants to indicate which, from a pair of voices, is more likely to save rather than spend their money. This context served as a control in

determining whether perceptions of relationship investment were a function of perceptions of general financial behaviour among men. Lastly, we gauged voice preferences among participants within both a short-term and a long-term relationship context. Following Penton-Voak et al. (2003), participants were instructed:

> Short-term: Choose the person you think is more attractive for a short-term relationship. Short-term implies that the relationship may not last a long time. Examples of this type of relationship would include a single date accepted on the spur of the moment, an affair within a long-term relationship, and possibility of a one-night stand.
>
> Long-term: Choose the person you think is more attractive for a long-term relationship. Examples of this type of relationship would include someone you may want to move in with, someone you may consider leaving a current partner to be with, and someone you may, at some point, wish to marry (or enter into a relationship on similar grounds as marriage).

Results

For all rating contexts, we calculated the proportion of trials in which participants selected the masculinized version of a voice from each voice pair. All analyses were done using two-tailed probability estimates ($\alpha = 0.05$).

We used one-sample t-tests against chance (0.5) to determine if voice pitch manipulations influenced the proportion of trials in which participants selected the

masculinized voices over the feminized voices (see Table 1 for descriptive statistics). Women selected masculinized men's voices as more attractive on a significantly greater proportion of trials than they selected feminized men's voices in the short-term (t_{137} = 7.77, P <0.001) and long-term relationship contexts (t_{137} = 6.64, P <0.001). Women selected feminized voices as more likely to invest time and effort into their romantic relationships (t_{137}= - 3. 96, P <0.001) and as more likely to be financially generous with their romantic partner (t_{137} = - 2.06, P = 0.042). Perceptions of saving versus spending money were not significantly influenced by voice pitch manipulations (t_{137} = 0.123, P = 0.902).

Table 1. The mean proportion of trials in which participants selected the masculinized version of a voice pair.

Context	Mean proportion of trials masculinity was chosen	SE
Save vs. spend money	0.50	0.03
Financially generous	0.44	0.03
Invest time and effort	0.40	0.02
Short-term relationship context	0.69	0.02
Long-term relationship context	0.67	0.03

We used an ANCOVA to investigate the relationship between voice pitch preferences and women's perceptions of generosity, investment, and saving money [within-subject factors: context (saving money, generous, invest), covariates: short-term voice preferences, long-term voice preferences]. Mauchly's test indicated that the assumption of sphericity had been violated for the variable context ($\chi 2_2 = 11.50$, $P = 0.003$), therefore degrees of freedom for that variable were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = 0.924$) (Girden, 1992). The results were not qualitatively influenced by using other methods of correcting for sphericity assumption violations, nor were they altered by using uncorrected degrees of freedom.

We found a significant effect of context on women's selection of masculinized voices ($F_{1.85,\ 249.48} = 11.04$, $P < 0.001$). Posthoc pairwise comparisons indicated that participants chose masculine voices on a greater proportion of trials in the saving money context ($M = 0.504$, $SE = 0.029$) than in the effort context ($M = 0.405$, $SE = 0.023$, $P = .010$). The proportion of trials in which participants chose masculinized voices was not significantly different between the saving money and the investment context ($M = 0.444$, $SE = 0.025$, $P = .304$), nor between the investment and the effort contexts ($P = 0.460$).

When holding short-term voice preferences constant, we found a significant between-subject effect of long-term voice preferences ($F_{1,135} = 13.93$, $P < 0.001$), where collapsed across rating contexts, the proportion of trials in which participants chose the more masculine voice was significantly positively correlated with preferences for masculine voices in the context of a long-term relationship ($R = 0.268$, $N = 138$, $P =$

0.002). When holding long-term voice preferences constant, the between-subjects effect of short-term voice preferences was a non-significant trend ($F_{1,135} = 3.26$, $P = 0.073$), and did not correlate significantly with the proportion of trials (across rating contexts) in which participants chose the more masculine voice ($R = 0.003$, $N = 138$, $P = 0.976$).

We found a significant interaction between long-term voice preferences and rating context ($F_{1.85, 249.45} = 4.03$, $P = 0.022$). Pearson correlations indicated that there was no significant relationship between long-term voice preferences and perceptions of saving money ($R = -0.035$, $N = 138$, $P = 0.680$). However, participants who chose masculinized men's voices as more attractive in the context of a long-term relationship also chose masculinized men's voices as more likely to invest time and effort into their romantic relationships ($R = 0.256$, $N = 138$, $P = 0.002$) and as more likely to be financially generous with their romantic partner ($R = 0.369$, $N = 138$, $P < 0.001$) (See *Figure 1*). Fisher's *r*-to-*z* comparison indicated that the strength of these two relationships was not significantly different ($r_1 - r_2 = 0.113$, $Z = -1.031$, $P = 0.303$) (Preacher, 2002). Preferences for masculine voices in the long-term were also positively correlated with preferences for masculine voices in the short-term ($R = 0.491$, $N = 138$, $p < 0.001$).

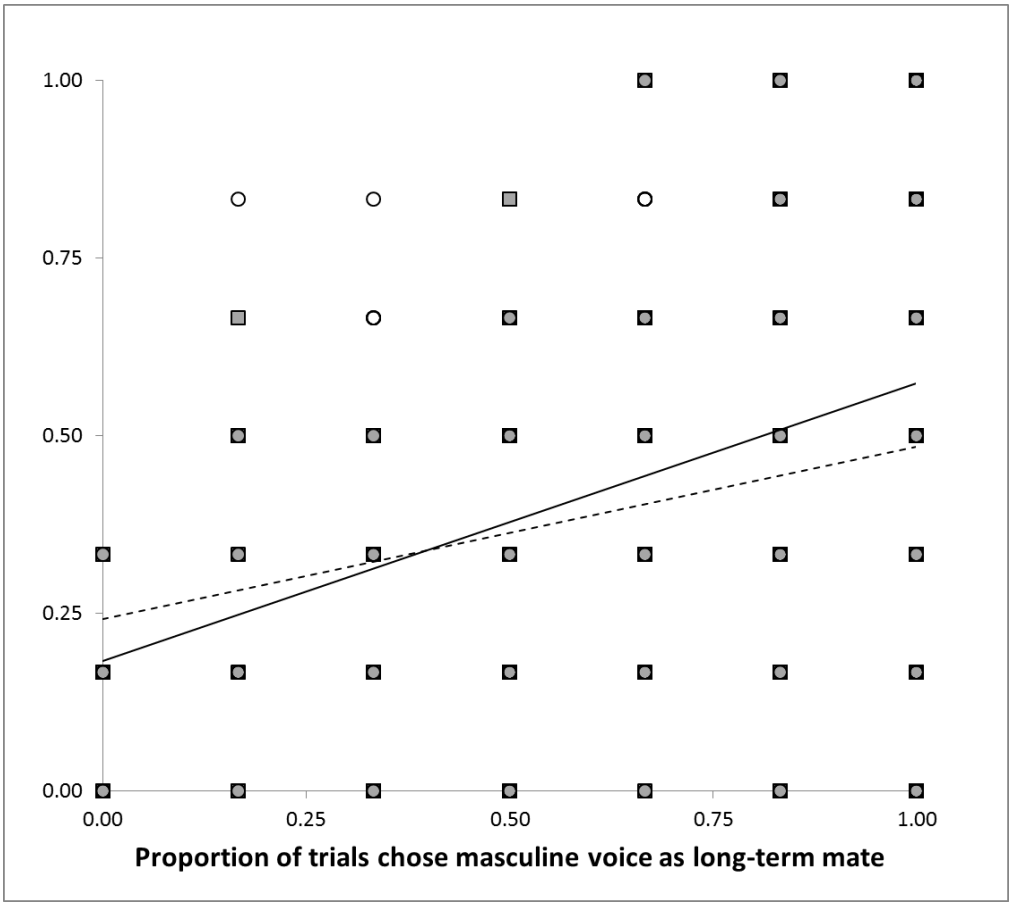

Figure 1. Interaction between long-term voice preferences and perceptions of investment.

Note. Graph depicts a significant positive relationship long-term voice preferences and perceptions of investment of time and effort (○) and financial generosity (□). Solid (investment) and dashed lines (generosity) are lines of best fit.

Discussion

In the current study we found that when asked to choose who is more likely to be financially generous with their romantic partner, and who is more likely to invest time and effort in their relationships, women generally chose feminized male voices. We also found that in comparison to women who preferred feminized voices for long-term relationships, women who preferred masculine voices in the context of a long-term relationship chose masculinized voices as more likely to be financially generous with their romantic partner and as more likely to invest time and effort in their relationships. Women's perceptions of whether a man was more likely to save versus spend his money were not significantly influenced by voice pitch manipulations, and were not significantly related to voice pitch preferences.

Our findings that women perceive relatively more feminine male voices as more likely to invest time and effort into their relationships and be more financially generous with their romantic partner indicates that women may be using testosterone-dependent traits to assess multiple aspects of mate quality. Testosterone is inversely related to both voice pitch (Dabbs and Mallinger, 1999; Evans, Neave, Wakelin, and Hamilton, 2008; Hollien, 1960) and propensity for relationship and parental investment (Booth and Dabbs, 1993; Caldwell Hooper, et al., 2011; Fisher, et al., 2009; Gray, et al., 2007; Roney, et al., 2006; van Anders, et al., 2007). Indeed, women perceive men with low-pitched voices as less likely to be faithful to their romantic partner than men with higher-pitched voices (O'Connor, Re, and Feinberg, 2011). Other testosterone-dependent traits such as facial

masculinity similarly influence mate-choice relevant perceptions; women perceive feminine men's faces as better marriage partners, as more likely to invest in relationships and offspring (Kruger, 2006), and as better quality parents (Perrett et al. 1998). First, this indicates that women's perceptions of masculine voiced males as less likely to invest or be generous within romantic relationships may be based on a kernel of truth. Such perceptions would be adaptive if women who avoided selecting more masculine men in favour of less masculine men as long-term mates garnered increased reproductive success via gains in relationship and offspring investment. Second, our findings indicate that perceptions relating to relationship and offspring investment are influenced in the same direction by both facial and vocal cues to underlying testosterone.

We also found that women who preferred more masculine voices in the context of a long-term relationship were more likely to choose masculinized voices as financially generous and as more likely to invest time and effort in their relationships than were women who preferred more feminized voices. Our findings suggest that those women who prefer relatively more masculine men for long-term relationships also perceive masculine men as suitable mates in terms of relationship and parental investment. Similarly, Vukovic et al. (2011) found that women who perceive masculine male voices as more trustworthy than feminine male voices showed greater preferences for masculine male voices in the long-term than in short-term relationship contexts. These findings underscore the importance of the relationship between personality attributions and mate preferences in women's selection of long-term romantic partners. While the direction of

the relationship between perceptions and preferences cannot be determined at present, these findings suggest that individual differences in the extent to which women prefer masculine men for short-term rather than long-term partners may be driven by variations in perceptions relating to relationship investment.

Importantly, voice pitch manipulations did not significantly influence women's selection of who was more likely to save versus spend their money, nor were women's preferences for masculinized voices in the context of a short-term or long-term relationship related to their perceptions of who would save versus spend their money. Therefore, the influence of male voice pitch is not likely a function of perceptions of general financial behaviour. Furthermore, preferences for voice pitch in the short-term were not significantly related to perceptions of investment and generosity, indicating that our results are not due to any halo effects. If our results were due to a halo effect, we would expect that perceptions of generosity and investment would be positively related to short-term voice pitch preferences, which was not the case. Here, only voice pitch preferences in the context of a long-term relationship were related to perceptions of generosity and investment, as would be predicted given that indicators of resource acquisition and propensity to invest resources in relationships and offspring are particularly important for long-term relationships (Buunk, et al., 2002; Greitemeyer, et al., 2005; Li and Kenrick, 2006; Scheib, 2001; Stewart, et al., 2000).

In summary, we found that overall, women perceived feminized male voices as more likely to be financially generous with their romantic partner and as more likely to invest

time and effort in their relationships. We also found that women who preferred masculine voices in the context of a long-term relationship also chose masculinized voices as more likely to be financially generous with their romantic partner and as more likely to invest time and effort in their relationships than were women who preferred more feminized voices. These perceptions may represent an adaptive heuristic that aids women in selecting long-term mates that are likely to invest in relationships and offspring.

References

Andersson, M. (1994): *Sexual Selection*. New Jersey: Princeton University Press.

Apicella, C. L., and Feinberg, D. R. (2009): Voice pitch alters mate-choice-relevant perception in hunter-gatherers. *Proceedings of the Royal Society B-Biological Sciences,* 276, 1077-1082.

Apicella, C. L., Feinberg, D. R., and Marlowe, F. W. (2007): Voice pitch predicts reproductive success in male hunter-gatherers. *Biology Letters,* 3, 682-684.

Boersma, P., and Weenink, D. (2009): Praat: Doing phonetics by computer (Version 5.1.04).

Booth, A., and Dabbs, J. M. (1993): Testosterone and men's marriages. *Social Forces,* 72, 463-477.

Boothroyd, L. G., Jones, B. C., Burt, D. M., DeBruine, L. M., and Perrett, D. I. (2008): Facial correlates of sociosexuality. *Evolution and Human Behavior,* 29, 211-218.

Buss, D. M. (2008): *Evolutionary psychology: The new science of the mind* (3rd ed.). Boston, MA: Allyn and Bacon.

Buunk, A. P., Dijkstra, P., Fetchenhauer, D., and Kenrick, D. T. (2002): Age and gender differences in mate selection criteria for various involvement levels. *Personal Relationships,* 9, 271-278.

Caldwell Hooper, A. E., Gangestad, S. W., Emery Thompson, M., and Bryan, A. D. (2011): Testosterone and romance: The association of testosterone with

relationship commitment and satisfaction in heterosexual men and women. *American Journal of Human Biology,* 23, 553-555.

Collins, S. A. (2000): Men's voices and women's choices. *Animal Behaviour,* 60, 773-780.

Creative, S. Sound Forge (Version 6.0).

Dabbs, J. M., and Mallinger, A. (1999): High testosterone levels predict low voice pitch among men. *Personality and Individual Differences,* 27, 801-804.

Evans, S., Neave, N., Wakelin, D., and Hamilton, C. (2008). The relationship between testosterone and vocal frequencies in human males. *Physiology & Behavior,* 93, 783-788.

Feely, R. J., Saad, F., Guay, A., and Traish, A. M. (2009). Testosterone in men's health: A new role for an old hormone. *Journal of Men's Health,* 6, 169-176.

Feinberg, D., Jones, B., Little, A., Burt, D., and Perrett, D. (2005). Manipulations of fundamental and formant frequencies influence the attractiveness of human male voices. *Animal Behaviour,* 69, 561-568.

Feinberg, D. R. (2008). Are human faces and voices ornaments signaling common underlying cues to mate value? *Evolutionary Anthropology,* 17, 112-118.

Feinberg, D. R., DeBruine, L. M., Jones, B. C., and Little, A. C. (2008a). Correlated preferences for men's facial and vocal masculinity. *Evolution and Human Behavior,* 29, 233-241.

Feinberg, D. R., DeBruine, L. M., Jones, B. C., and Perrett, D. I. (2008b). The relative role of femininity and averageness of voice pitch in aesthetic judgments of women's voices. *Perception,* 37, 615-623.

Feinberg, D. R., Jones, B. C., Law Smith, M. J., Moore, F. R., DeBruine, L. M., Cornwell, R. E., Hillier, S. G., and Perrett, D. I. (2006). Menstrual cycle, trait estrogen level, and masculinity preferences in the human voice. *Hormones and Behavior,* 49, 215-222.

Fisher, A. D., Corona, G., Bandini, E., Mannucci, E., Lotti, F., Boddi, V., Forti, G., and Maggi, M. (2009). Psychobiological Correlates of Extramarital Affairs and Differences between Stable and Occasional Infidelity among Men with Sexual Dysfunctions. *Journal of Sexual Medicine,* 6, 866-875.

Gangestad, S. W., and Simpson, J. A. (2000): The evolution of human mating: trade-offs and strategic pluralism. *Behavioral and Brain Sciences,* 23, 573-644.

Geary, D. C., and Byrd-Craven, J. (2004): The evolution of human mate choice. *The Journal of Sex Research,* 41, 27-42.

Girden, E. R. (1992): ANOVA: Repeated measures. *Sage University Papers Series on Quantitative Applications in the Social Sciences* (Vol. 84). Thousand Oaks, CA: Sage.

Gray, P., Parkin, J., and Sammsvaughan, M. (2007): Hormonal correlates of human paternal interactions: A hospital-based investigation in urban Jamaica. *Hormones and Behavior,* 52, 499-507.

Greitemeyer, T., Hengmith, S., and Fischer, P. (2005): Sex differences in the willingness to betray and switch romantic partners. *Swiss Journal of Psychology,* 64, 265-272.

Hodges-Simeon, C. R., Gaulin, S. J. C., and Puts, D. A. (2010): Different vocal parameters predict perceptions of dominance and attractiveness. *Human Nature,* 21, 406-427.

Hollien, H. (1960): Some laryngeal correlates of vocal pitch. *Journal of Speech and Hearing,* 3, 52-58.

Jones, B. C., DeBruine, L. M., Perrett, D. I., Little, A. C., Feinberg, D. R., and Law Smith, M. J. (2008): Effects of Menstrual Cycle Phase on Face Preferences. *Archives of Sexual Behavior,* 37, 78-84.

Jones, B. C., Feinberg, D. R., DeBruine, L. M., Little, A. C., and Vukovic, J. (2008): Integrating cues of social interest and voice pitch in men's preferences for women's voices. *Biology Letters,* 4, 192-194.

Jones, B. C., Feinberg, D. R., DeBruine, L. M., Littl.e, A. C., and Vukovic, J. (2010): A domain-specific opposite-sex bias in human preferences for manipulated voice pitch. *Animal Behaviour,* 79, 57-62.

Kinsey, A. C., Pomeroy, W. B., and Martin, C. E. (1948). *Sexual behaviour in the human male*. Philadelphia: W.B. Saunders.

Kruger, D. J. (2006): Male facial masculinity influences attributions of personality and reproductive strategy. *Personal Relationships,* 13, 451-463.

Li, N. P., and Kenrick, D. T. (2006): Sex similarities and differences in preferences for short-term mates: What, whether, and why. *Journal of Personality and Social Psychology*, 90, 468-489.

Li, N. P., Valentine, K. A., and Patel, L. (2011): Mate preferences in the US and Singapore: A cross-cultural test of the mate preference priority model. *Personality and Individual Differences,* 50, 291-294.

Little, A. C., Burt, D. M., Penton-Voak, I. S. & Perrett, D. I. (2001): Self-perceived attractiveness influences human female preferences for sexual dimorphism and symmetry in male faces. *Proceedings of the Royal Society B: Biological Sciences,* 268, 39-44.

Mazur, A., and Booth, A. (1998): Testosterone and dominance in men. *Behavioral and Brain Sciences,* 21, 353-397.

McIntyre, M., Gangestad, S. W., Gray, P. B., Chapman, J. F., Burnham, T. C., O'Rourke, M. T., and Thornhill, R. (2006): Romantic involvement often reduces men's testosterone levels-but not always: The moderating role of extrapair sexual interest. *Journal of Personality and Social Psychology,* 91, 642-651.

Moulines, E., and Charpentier, F. (1990): Pitch synchronous waveform processing techniques for text-to-speech synthesis using diphones. *Speech Communication,* 9, 453-467.

O'Connor, J. J. M., Re, D. E., and Feinberg, D. R. (2011): Voice pitch influences perceptions of sexual infidelity. *Evolutionary Psychology,* 9, 64-78.

Penton-Voak, I. S., Little, A. C., Jones, B. C., Burt, D. M., Tiddeman, B. P., and Perrett, D. I. (2003): Female condition influences preferences for sexual dimorphism in faces of male humans (Homo sapiens). *Journal of Comparative Psychology,* 117, 264-271.

Perrett, D. I., Lee, K. J., Penton-Voak, I. S, Rowland, D., Yoshikawa, S., Burt, D. M., Henzil, S. P., Castles, D. L., and Akamatsu, S. (1998): Effects of sexual dimorphism on facial attractiveness. *Nature,* 34, 884-887.

Peters, M., Simmons, L. W., and Rhodes, G. (2008): Testosterone is associated with mating success but not attractiveness or masculinity in human males. *Animal Behaviour*, 76, 297-303.

Pisanski, K., and Rendall, D. (2011): The prioritization of voice fundamental frequency or formants in listeners' assessments of speaker size, masculinity, and attractiveness. *Journal of the Acoustical Society of America,* 129, 2201-2212.

Preacher, K. J. (2002): Calculation for the test of the difference between two independent correlation coefficients. Retrieved from http://quantpsy.org

Puts, D. A. (2005). Mating context and menstrual phase affect women's preferences for male voice pitch. *Evolution and Human Behavior,* 26, 388-397.

Rhodes, G., Chan, J., Zebrowitz, L.A., and Simmons, L. W. (2003): Does sexual dimorphism in human faces signal health? *Proceedings of the Royal Society B: Biological Sciences,* 270, S93-S95.

Roney, J. R., Hanson, K. N., Durante, K. M., and Maestripieri, D. (2006): Reading men's faces: women's mate attractiveness judgments track men's testosterone and interest in infants. *Proceedings of the Royal Society B: Biological Sciences,* 273, 2169-2175.

Scheib, J.E. (2001): Context-specific mate choice criteria: Women's trade-offs in the context of long-term and extra-pair mateships. *Personal Relationships,* 8, 371-389.

Stewart, S., Stinnett, H., and Rosenfeld, L. B. (2000): Sex differences in desired characteristics of short-term and long-term partners. *Journal of Social and Personal Relationships,* 17, 843-853.

Thornhill, R., and Gangestad, S. W. (1999): Facial Attractiveness. *Trends in Cognitive Sciences,* 3, 452-460.

Thornhill, R., and Gangestad, S. W. (2006): Facial sexual dimorphism, developmental stability and parasitic infections in men and women. *Evolution and Human Behavior,* 27, 131-144.

Tranmüller, H. (1990): Analytical expressions for the tonotopic sensory scale. *Journal of the Acoustical Society of America,* 88, 97-100.

Tremblay, R. E., Schaal, B., Boulerice, B., Arsenault, L., Soussignan, R.G., Paquette, D., and Laurent, D. (1998): Testosterone, physical aggression, dominance, and physical development in early adolescence. *International Journal of Behavioral Development,* 22, 753-777.

Tybur, J. M., and Gangesad, S. W. (2011): Mate preferences and infectious disease: Theorectical consierations and evidence in humans. *Philisophical Transactions of the Royal Society B: Biological Sciences,* 366, 3375-3388.

van Anders, S. M., and Goldey, K. L. (2010): Testosterone and partnering are linked via relationship status for women and 'relationship orientation' for men. *Hormones and Behavior*, 58, 820-826.

van Anders, S. M., Hamilton, L. D., and Watson, N. V. (2007): Multiple partners are associated with higher testosterone in North American men and women. *Hormones and Behavior*, 51, 454-459.

Vukovic, J., Feinberg, D. R., Jones, B. C., DeBruine, L. M., Welling, L. L. M., Little, A. C., and Smith, F. G. (2008): Self-rated attractiveness predicts individual differences in women's preferences for masculine men's voices. *Personality and Individual Differences*, 45, 451-456.

Vukovic, J., Jones, B. C., DeBruine, L. M., Feinberg, D. R., Smith, F. G., Little, A. C., Welling, L. L. M., and Main, J. (2010): Women's own voice pitch predicts their preferences for masculinity in men's voices. *Behavioral Ecology*, 21,767-772.

Vukovic, J., Jones, B. C., Feinberg, D. R., DeBruine, L. M., Smith, F. G., Welling, L. L. M., and Little, A. C. (2011): Variation in perceptions of physical dominance and trustworthiness predicts individual differences in the effect of relationship context on women's preferences for masculine pitch in men's voices. *British Journal of Psychology*, *102*, 37-48.

CHAPTER 5: THE INFLUENCE OF FACIAL MASCULINITY AND VOICE PITCH ON JEALOUSY AND PERCEPTIONS OF INTRASEXUAL RIVALRY

O'Connor, J.J.M. & Feinberg, D.R. (2012). *Personality and Individual Differences, 52,* 369-373.

Preface

Men with lower pitched voices and women with higher pitched are perceived as presenting a greater infidelity risk than are men with higher pitched voices and women with lower pitched voices (Chapter 3). Surprisingly, this relationship between voice pitch and perceptions of infidelity risk were specific to opposite-sex voices (Chapter 3). This suggests that the influence of voice pitch on perceptions of infidelity is stronger for potential mates than it is for same-sex competitors. However, the assessment of infidelity risk presented by intrasexual competitors could potentially benefit perceivers if it aids in the allocation of mate guarding or mate retention efforts. Indeed, previous research has suggested that both men and women are influenced by the physical characteristics of potential same-sex rivals. For example, women with relatively feminine bodies evoke more jealousy in other women in comparison to women with relatively masculine bodies (Buunk & Dijkstra, 2005; Dijkstra & Buunk, 2001). Women subliminally primed with attractive versus unattractive same-sex faces responded with more jealousy, worry, hurt,

and anger in response to hypothetical jealousy-evoking scenarios (Massar & Buunk, 2010). Women also rate feminized women's voices as more flirtatious than masculinized women's voices (Puts et al., 2011). Men respond more jealously towards potential rivals with relatively more masculine bodies (Dijkstra & Buunk, 2001) and faces (Kruger, 2006). Given that body masculinity/femininity is associated with the same underlying hormones as vocal and facial masculinity/femininity, vocal and facial masculinity may also influence responses to potential sexual rivals. In the following experiment, I examined whether preferences for who should accompany romantic partners on a weekend trip and jealousy in response to imagined flirting were influenced by the vocal and facial masculinity/ femininity of same-sex individuals.

Abstract

The assessment of same-sex individuals as intrasexual competitors may depend in part on the perceived mate value of potential rivals. Men's and women's preferences for vocal and facial masculinity suggest that feminine women and masculine men may be perceived as more threatening intrasexual competitors. We tested the influence of men's and women's vocal and facial masculinity on preferences for who should accompany romantic partners on a weekend trip and on jealousy in response to imagined flirting. We found that men and women preferred their partners to be accompanied by people who had less masculine/feminine voices, and were more jealous in response to people who had relatively more masculine/feminine voices. Women, but not men, rated faces with exaggerated sex-typical characteristics as undesirable travel companions for their romantic partners and reported more jealousy in response to imagined flirting from such faces. We also found that participants who rated masculine male and feminine female stimuli as more attractive also perceived such stimuli as greater intrasexual threats, demonstrating individual differences in competition-related social perceptions. Our findings indicate that perceptions related to intrasexual competition are related to cues to underlying mate quality, which may aid in effective mate guarding.

Introduction

Jealousy may be an adaptive response to perceived pair-bond threats, though not all potential competitors will elicit equivalent jealous responses (Buss, Shackelford, Choe, Buunk, & Dijkstra, 2000). Individuals possessing traits indicating relatively high mate value may be perceived as greater threats to relationships than those without such traits (Dijkstra & Buunk, 1998; Dijkstra & Buunk, 2001).

Female characteristics such as a higher-pitched voice, feminine facial structure, and a feminine waist-to-hip ratio are traits preferred by men (for review see Feinberg 2008; Little, Jones, & DeBruine, 2011). Women also report more intense jealousy when rating attractive female faces (Massar & Buunk, 2010) and bodies (Dijkstra & Buunk, 2001; Massar & Buunk, 2009). Vocal (Abitbol, Abitbol, & Abitbol, 1999), facial (Law Smith et al., 2006), and body (Jasienska, Ziomkiewicz, Ellison, Lipson, & Thune, 2004) femininity communicate relatively higher estrogen levels, which are positively related to reproductive potential (Venners et al., 2006). Therefore, estrogen-dependent traits may cue underlying mate quality (for review see Feinberg, 2008; Little et al., 2011), and may elicit jealousy among other women.

Among men, lower-pitched, masculine voices (Dabbs & Mallinger, 1999; Hollien, 1960), masculine facial structure (Verdonck, Gaethofs, Carels, & De Zegher, 1999) and body configuration are testosterone-dependent traits (Kasperk et al., 1997).Testosterone levels are positively associated with indices of health (Feely, Saad, Guay, & Traish, 2009), dominant behaviour, and social status (Mazur & Booth, 1998). Also, facial

masculinity is positively correlated with measures of perceived and actual health (Rhodes, Chan, Zebrowitz, & Simmons, 2003; Thornhill & Gangestad, 2006). Furthermore, masculine men's faces and voices are perceived as relatively more dominant (Perrett et al., 1998; Feinberg et al., 2006; Jones, et al., 2010a). Indeed, men and women are more likely to follow the gaze of masculine faces, demonstrating that images of faces can influence dominance-related behaviours (Jones et al., 2010b). Therefore, testosterone-dependent traits may communicate health and/or dominance.

Women generally prefer relatively masculine men's voices and bodies (Collins, 2000; Feinberg, Jones, Little, Burt, & Perrett, 2005; Hodges-Simeon, Gaulin, & Puts, 2010; Jones, et al., 2010a). Both vocal and facial masculinity preferences increase with conception risk (Feinberg, et al., 2006; Penton-Voak et al., 1999; Puts, 2005) and for short-term relationships (Little, Jones, Penton-Voak, Burt, & Perrett, 2002; Puts, 2005). Women who are open to casual sex, as indicated by the sociosexual orientation inventory (Simpson & Gangestad, 1991), prefer relatively masculine men's faces (Waynforth, Delwadia, & Camm, 2005) and bodies (Provost, Kormos, Kosakoski, & Quinsey, 2006). As masculinity preferences are greater among women in seek of short-term and potentially extra-pair relationships, men possessing relatively more masculine traits may be perceived by other men as particularly threatening to pair-bond fidelity (Dijkstra & Buunk, 2001; Kruger, 2006; Massar & Buunk, 2009).

Men's jealous responses to imagined scenarios are elicited by traits such as body masculinity (Dijkstra & Buunk, 2001; Massar & Buunk, 2009). Similarly, Kruger (2006)

found that men chose feminized male faces more often than masculinized men's faces when asked to choose the man they would prefer accompany their girlfriend on a short trip to another city, suggesting that men perceive males with masculine faces as a greater threat to pair-bond fidelity than males with feminine faces. It is unknown if these perceptions of potential rivalry are tied to attractiveness, or alternatively, some knowledge of underlying mating strategies. Furthermore, it is unknown whether these attributions generalize to other testosterone-dependent traits, and whether prior findings extend to women's perceptions.

Here, we tested the influence of vocal and facial masculinity on perceptions of how jealous people would be if the person were flirting with their partner, or who they would prefer accompany their partner on a weekend trip, as well as the degree to which these perceptions are related to perceptions of attractiveness. If jealousy responses and/or preferences for partner accompaniment are influenced by cues to underlying mate quality, then jealousy responses and preferences for partner accompaniment may correlate with the degree to which they find masculinity/femininity attractive.

Methods

Participants.

This study was approved by the McMaster Research Ethics Board. Heterosexual men (N = 40; mean age =19.22 years, *SD* = 1.82) and women (N = 39; mean age =18.72

years, *SD* = 0.97) were recruited from McMaster University and compensated with course credit. Participant age, relationship status, and sexual orientation (Kinsey, Pomeroy, & Martin, 1948) were self-reported.

Stimuli.

Participants (6 women, 6 men) aged 18-24 were photographed in colour, with a neutral facial expression, under standardized lighting conditions. Computer graphics software (Tiddeman, Burt, & Perrett, 2001) was used to create a masculinized and feminized version of each face in the same manner as Perrett et al. (1998). Faces were masked to remove visual cues of hairstyle, facial jewellery, and clothing. This method of facial stimuli creation has been widely and successfully used in studies of face preferences (for review, see Feinberg, 2008), and has been validated in a number of studies (DeBruine et al., 2006; 2010).

Voice stimuli were collected from participants aged 18-24 (6 women, 6 men), speaking the English monopthong vowels; 'ah' as in father, 'ee' as in see, 'eh' as in bet, 'oh' as in note, 'oo' as in boot. Single channel recordings were made in a quiet room with an Audio-Techica AT4041 microphone at a 44.1 kHz sampling rate, with 16-bit amplitude quantization in Sound Forge software (Sony Creative Software)

We created two versions of each recording, a feminized version with raised pitch, and a masculinized version with lowered pitch. Pitch was modified using the pitch-

synchronous overlap add (PSOLA® *France Telecom*) method in Praat software (Boersma & Weenink, 2009). Pitch was raised and lowered by adding or subtracting 0.5 equivalent rectangular bandwidths (ERBs) of the baseline frequency. This level of manipulation has been successful in previous research on voice pitch (Apicella & Feinberg, 2009; Feinberg, DeBruine, Jones, & Perrett, 2008; Jones et al., 2010a).

Procedure.

Same-sex face and voice pairs were presented in separate, randomized blocks within 3 different rating contexts (jealousy, weekend trip, attractiveness). Within blocks, stimuli pairs were randomized for order and side of screen presentation.

Stimuli pairs were masculine and feminine versions of the same voice or face, presented in a two-alternative forced choice paradigm. Faces were presented simultaneously on either side of the screen. Voices were played consecutively, prompted by the participant selecting the 'play' button for the individual file. Participant responses automatically loaded the next trial.

Participants rated same-sex voices and faces within 3 contexts. First, following Kruger (2006), we asked participants to indicate which, from a pair of voices/faces, they would prefer to accompany their romantic partner on a weekend trip. Second, we asked participants to indicate which, from a pair of voices/faces, would make them more jealous if flirting with their romantic partner, which provided a measure of the degree to which

potential rivals induced jealousy. Third, participants were asked to indicate which, from a pair of voices/faces, was more attractive. All participants were instructed to imagine they had a partner if they were not currently in a relationship.

Results

We calculated the proportion of trials in which women selected feminized female stimuli and men selected masculinized male stimuli, per rating context. We reverse coded the weekend accompaniment variable (1-proportion of trials participant selected sex-typical voice/face) to reflect the proportion of trials in which participants chose sex-typical stimuli as *undesirable* travel companions for their romantic partner. All analyses were done using two-tailed probability estimates.

One-sample Wilcoxon signed-rank tests against chance (0.5) were used to determine if pitch manipulations influenced participant's selection of voices and faces, for each sex separately (see *Figure 1*). In the weekend context, women selected feminized female voices ($Z = 4.34$, $P < .001$) and faces ($Z = 3.42$, $P = .001$) as undesirable travel companions for their romantic partner on significantly greater proportion of trials than would be predicted by chance. In the jealousy and attractiveness contexts, women selected feminized female voices (jealousy: $Z = 4.91$, $P < .001$, attractiveness: $Z = 4.52$, $P < .001$) and faces (jealousy: $Z = 5.44$, $P < .001$, attractiveness $Z = 5.09$, $P < .001$) significantly more often than chance.

In the weekend context, men selected feminized men's voices ($Z = 4.09$, $P < .001$) as preferred travel companions for their romantic partner on a significantly greater proportion of trials than would be predicted by chance. Men reported jealousy in response to masculinized men's voices that was significantly greater than chance ($Z = 5.13$, $P < .001$). There was no significant effect of face manipulations on the proportion of trials in which men selected masculinized male faces for either the weekend ($Z = -0.17$, $P = .862$) or jealousy ($Z = -1.13$, $P = .257$) contexts. Men selected feminized male faces as more attractive ($Z = -3.80$, $P < .001$) significantly more often than chance. There was no significant effect of pitch manipulations on the proportion of trials in which men chose masculine male voices as more attractive ($Z = 1.26$, $P = .207$).

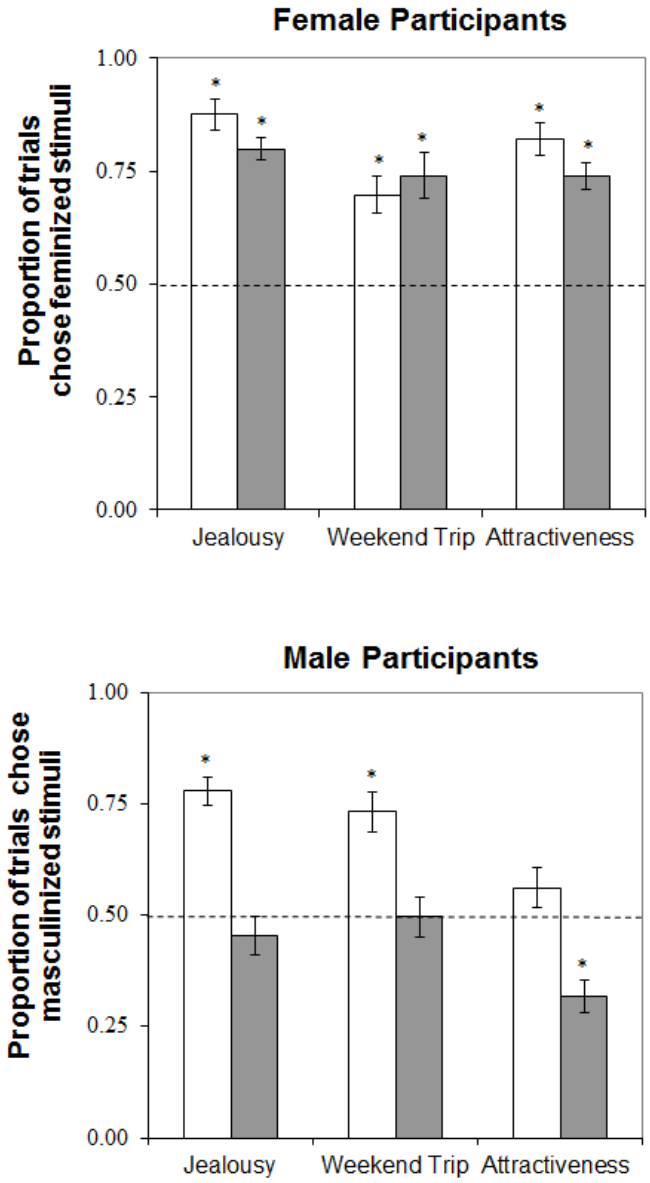

Figure 1. Mean and SEM of the proportion of trials female (top) and male (bottom) participants selected the feminized/masculinized version of a face ■ or voice □ pair, per rating context. Chance (0.5) is indicated by the dashed line, * indicates significant difference from chance ($p \leq .001$).

To test for individual differences in attributions we used two separate repeated measures ANOVAs [within-subject factors: rating context (weekend companionship, jealousy over flirting), between-subject factors: participant relationship status (partnered, unpartnered); sex of participant (male, female), covariate: preferences for sex typical faces (section 3.1) or voices (section 3.2)]. We conducted analyses for facial and vocal stimuli separately because manipulations were not perceptually equivalent across modalities. Thus, comparisons between the strength of preferences for masculinity in voices and faces would not be distinguishable from differences in the relative strengths of the manipulations across modalities. Separate analyses using the mean preference for vocal and facial masculinity as within-subject factors did not change the significance of any effects.

Facial Stimuli.

We found a significant between-subjects effect of face preferences on how often participants selected masculine male/feminine female faces for weekend accompaniment and jealousy (see Table 2). To investigate the direction of this effect, we averaged the proportion of trials in which participants selected masculine male/feminine female faces across both the weekend companionship and the jealousy over flirting rating contexts. A Pearson correlation indicated that participants who preferred more masculine male/feminine female also selected more masculine male/feminine female faces across both rating contexts ($r = 0.648$, $N = 79$, $P < 0.001$). There were no other significant main

effects or interactions. Furthermore, a partial correlation indicated that when controlling for face preferences, participants who selected masculine male/feminine female faces in the weekend companionship context also selected masculine male/feminine female faces in the jealousy over flirting context (pr = 0.323, N = 76, P = 0.004).

Table 1. Analysis of variance for face stimuli

Analysis of Variance for Face Stimuli

Source	*Df*	*F*	*η*	*P*
Within subjects				
Context	1	0.01	.000	.941
Context x face preference	1	0.57	.008	.425
Context x sex	1	2.00	.026	.161
Context x relationship status	1	1.60	.021	.210
Context x sex x relationship status	1	0.43	.006	.517
Error	74			
Between subjects				
Face preference	1	13.54	.155	<.001
Sex	1	2.19	.029	.144
Relationship status	1	2.93	.038	.091
Sex x relationship status	1	0.32	.004	.574
Error	74			

Vocal Stimuli.

The ANOVA indicated a significant between-subjects effect of voice preferences on participant selection of masculine male/feminine female voices for weekend accompaniment and jealousy (see Table 2). A Pearson correlation showed that participants who preferred more masculine male/feminine female voices also chose more masculine male/feminine female voices on average across both rating contexts ($r = 0.335$, $N = 79$, $P = 0.003$). There were no other significant main effects or interactions. Additionally, a partial correlation indicated that when controlling for voice preferences, participants who selected masculine male/feminine female voices in the weekend companionship context also selected masculine male/feminine female voices in the jealousy over flirting context ($pr = 0.348$, $N = 76$, $P = 0.002$).

Table 2. Analysis of variance for voice stimuli

Analysis of Variance for Voice Stimuli

Source	*Df*	*F*	*η*	*P*
Within subjects				
Context	1	0.14	.002	.711
Context x voice preference	1	1.31	.017	.257
Context x sex	1	0.00	.000	.987
Context x relationship status	1	0.85	.011	.360
Context x sex x relationship status	1	0.64	.009	.428
Error	74			
Between subjects				
Voice preference	1	10.07	.120	.002
Sex	1	0.62	.008	.435
Relationship status	1	0.19	.003	.662
Sex x relationship status	1	0.02	.000	.901
Error	74			

Discussion

Here we investigated the influence of vocal and facial masculinity on jealousy responses to imagined flirting and preferences for who should accompany romantic partners on a weekend trip. We found that women reported jealousy in response to feminine women, and preferred that their partners be accompanied by relatively more masculine women. This is consistent with research finding attractive female faces (Massar & Buunk, 2010) and feminine bodies (Dijkstra & Buunk, 2001; Massar & Buunk, 2009) elicit jealousy among other women. Women also perceive feminine women's voices as both more flirtatious and more attractive to men than masculine women's voices (Puts, et al., 2011). Among women, vocal attractiveness and body femininity is positively associated with higher frequencies of acting as an extra-pair partner (Hughes, Dispenza, & Gallup, 2004; Hughes & Gallup, 2003). Thus, women's perceptions of other women observed in the current study may reflect the greater intrasexual threat presented by such women.

Men preferred their partners to be accompanied by men with more feminine voices and reported greater jealousy in response to masculine voices. Men with more masculine voices report a higher number of sex partners (Puts, 2005) and a higher number of children than do men with higher-pitched voices (Apicella et al., 2007). Male body masculinity not only induces jealousy among males (Dijkstra & Buunk, 2001; Massar & Buunk, 2009), but is also associated with higher frequencies of acting as an extra-pair partner (Hughes & Gallup, 2003). Men's testosterone levels are also positively associated

with measures of mating effort and success (McIntyre et al., 2006; Peters, Simmons, & Rhodes, 2008; Fisher et al., 2009). Furthermore, male vocal masculinity is positively associated with perceptions of increased infidelity risk among opposite sex listeners (O'Connor et al., 2011). Consequently, men's jealous responses to male vocal masculinity in the current study may indicate that such men are perceived to be greater threats to pair bond fidelity due to testosterone as an underpinning of both voice pitch and sexual strategy.

Interestingly, men's jealousy and preferences for who should accompany romantic partners to masculine men's faces were not significantly different from chance. While on the surface this finding appears to contrast with Kruger (2006), who found that men perceived masculinized male faces as a greater pair-bond threat than feminized male faces when asking male participants a similar question regarding accompaniment on a weekend trip, we found that men's ratings of masculine male faces were related to how attractive men perceived these faces to be. This was also true among female participants, and was consistent across rating scales and modalities; men and women who rated masculine male/feminine female (respectively) as more attractive indicated increased jealousy to such stimuli, and preferred that their partner be accompanied by potential competitors with less exaggeratedly sex-typical faces and voices. Relatedly, Watkins et al. (2010; in press) found that participants scoring as relatively more dominant were less likely to rate masculinized same-sex faces as more dominant than feminized faces. Therefore, the above suggests that individual differences contribute to variation in perceptions related to

intrasexual competition. Furthermore, there were no significant sex differences in attributions to either faces or voices, indicating that the influence of morphological indicators of underlying hormonal status on perceptions of intrasexual competition is similar between the sexes. We also found that relationship status did not significantly influence participant's selection of sex-typical faces or voices, suggesting that responses to mate-choice relevant scenarios are not fully dependent on whether participants are envisioning a current or imaginary romantic partner.

In the current study we asked individuals to report jealousy and preferences for a travel partner in response to imagined scenarios. Although participant responses were reported in response to a hypothesized situation, the accuracy of participant's behavioural forecasts is unknown. Future studies may investigate the relationship between participant's predicted and actual behaviour in circumstances presenting intrasexual threat. Also, the age range of our sample was restricted to between 18 and 24 years. It is possible that perceptions of intersexual threat are influenced by exaggerated sex-typicality differently in other age groups. Future studies may examine whether the influence of vocal and facial masculinity interacts with perceiver age to influence perceptions of intrasexual rivalry.

In summary, we found that men and women reported jealousy in response to imagined flirting from masculine male and feminine female voices (respectively). Overall, women reported jealousy in response to imagined flirting from feminine female faces, but men's jealousy in response to imagined flirting was not significantly influenced by male facial

masculinity. We did however observe a significant influence of voice and face preferences, where jealousy was significantly and positively related to attractiveness ratings of voices and faces, among both male and female participants. Such perceptions may be adaptive, both currently and in our evolutionary past, if they aid individuals in allocating mate guarding efforts against potential interlopers more efficiently.

References

Abitbol, J., Abitbol, P., & Abitbol, B. (1999). Sex hormones and the female voice. *Journal of Voice, 13*, 424-446.

Apicella, C. L., Feinberg, D. R., & Marlowe, F. W. (2007). Voice pitch predicts reproductive success in male hunter-gatherers. *Biology Letters, 3*, 682-684.

Apicella, C. L., & Feinberg, D. R. (2009). Voice pitch alters mate-choice-relevant perception in hunter-gatherers. *Proceedings of the Royal Society B-Biological Sciences, 276*, 1077-1082.

Boersma, P., & Weenink, D. (2009). Praat: Doing phonetics by computer (Version 5.1.04).

Buss, D. M., Shackelford, T. K., Choe, J., Buunk, B. P., & Dijkstra, P. (2000). Distress about mating rivals. *Personal Relationships, 7*, 235-243.

Collins, S. A. (2000). Men's voices and women's choices. *Animal Behaviour, 60*, 773-780.

Dabbs, J. M., & Mallinger, A. (1999). High testosterone levels predict low voice pitch among men. *Personality and Individual Differences, 27*, 801-804.

DeBruine, L. M., Jones, B. C., Little, A. C., Boothroyd, L. G., Perrett, D. I., Penton-Voak, I. S., Cooper, P. A., Penke, L., Feinberg, D. R., & Tiddeman, B. P. (2006). Correlated preferences for facial masculinity and ideal or actual partner's masculinity. *Proceedings of the Royal Society B: Biological Sciences, 273*, 1355-1360.

DeBruine, L. M., Jones, B. C., Smith, F. G., & Little, A. C. (2010). Are attractive men's faces masculine or feminine? The importance of controlling confounds in face stimuli. *Journal of Experimental Psychology: Human Perception and Performance, 363*, 751-758.

Dijkstra, P., & Buunk, A. P. (1998). Jealousy as a function of rival characteristics: An evolutionary perspective. *Personality and Social Psychology Bulletin, 24*, 1158-1166.

Dijkstra, P., & Buunk, B. P. (2001). Sex differences in the jealousy-evoking nature of a rival's body build. *Evolution and Human Behavior, 22*, 335-341.

Feely, R. J., Saad, F., Guay, A., & Traish, A. M. (2009). Testosterone in men's health: A new role for an old hormone. *Journal of Men's Health, 6*, 169-176.

Feinberg, D. R., Jones, B. C., Little, A. C., Burt, D., & Perrett, D. I. (2005). Manipulations of fundamental and formant frequencies influence the attractiveness of human male voices. *Animal Behaviour, 69*, 561-568.

Feinberg, D. R. (2008). Are human faces and voices ornaments signaling common underlying cues to mate value? *Evolutionary Anthropology, 17*, 112-118.

Feinberg, D. R., DeBruine, L. M., Jones, B. C., & Little, A. C. (2008). Correlated preferences for men's facial and vocal masculinity. *Evolution and Human Behavior, 29*, 233-241.

Feinberg, D. R., Jones, B. C., Law Smith, M. J., Moore, F. R., DeBruine, L. M., Cornwell, R. E., Hillier, S. G., & Perrett, D. I. (2006). Menstrual cycle, trait

estrogen level, and masculinity preferences in the human voice. *Hormones and Behavior, 49*, 215-222.

Fisher, A. D., Corona, G., Bandini, E., Mannucci, E., Lotti, F., Boddi, V., Forti, G., & Maggi, M. (2009). Psychobiological correlates of extramarital affairs and differences between stable and occasional infidelity among men with sexual dysfunctions. *Journal of Sexual Medicine, 6*, 866-875.

Hodges-Simeon, C. R., Gaulin, S. J. C., & Puts, D. A. (2010). Different vocal parameters predict perceptions of dominance and attractiveness. *Human Nature, 21*, 406-427.

Hollien, H. (1960). Some laryngeal correlates of vocal pitch. *Journal of Speech and Hearing, 3*, 52-58.

Hughes, S. M., Dispenza, F., & Gallup, G. G. (2004). Ratings of voice attractiveness predict sexual behavior and body configuration. *Evolution and Human Behavior, 25*, 295-304.

Hughes, S. M., & Gallup, G. G. (2003). Sex differences in morphological predictors of sexual behavior Shoulder to hip and waist to hip ratios. *Evolution and Human Behavior, 24*, 173-178.

Jasienska, G., Ziomkiewicz, A., Ellison, P.T., Lipson, S.F., & Thune, I. (2004). Large breats and narrow waists indicate high reproductive potential in women. *Proceedings of the Royal Society B: Biological Sciences, 271*, 1213-1217.

Jones, B. C., Feinberg, D. R., DeBruine, L. M., Little, A. C., & Vukovic, J. (2008). Integrating cues of social interest and voice pitch in men's preferences for women's voices. *Biology Letters, 4*, 192-194.

Jones, B. C., Feinberg, D. R., DeBruine, L. M., Little, A. C., & Vukovic, J. (2010a). A domain-specific opposite-sex bias in human preferences for manipulated voice pitch. *Animal Behaviour, 79,* 57-62.

Jones, B. C., DeBruine, L. M., Main, J. C., Little, A. C., Welling, L. L. M., Feinberg, D. R., & Tiddeman, B. P. (2010b). Facial cues of dominance modulate the short-term gaze-cuing effect in human observers. *Proceedings of the Royal Society of London B, 277,* 617-624.

Kasperk, C., Helmboldt, A., Borcsok, I., Heuthe, S., Cloos, O., Niethard, F., & Ziegler, R. (1997). Skeletal site-dependent expression of the androgen receptor in human osteoblastic cell populations. *Calcified Tissue, 61,* 464-473.

Kinsey, A. C., Pomeroy, W. B., & Martin, C. E. (1948). *Sexual behaviour in the human male*. Philadelphia: W.B. Saunders.

Kruger, D. J. (2006). Male facial masculinity influences attributions of personality and reproductive strategy. *Personal Relationships, 13,* 451-463.

Law Smith, M. J., Perrett, D. I., Jones, B. C., Cornwell, R. E., Moore, F. R., Feinberg, D. R., Boothroyd, L. G., Durrani, S. J., Stirrat, M. R., Whiten, S., Pitman, R. M., & Hillier, S. G. (2006). Facial appearance is a cue to oestrogen levels in women. *Proceedings of the Royal Society B: Biological Sciences, 273,* 135-140.

Little, A. C., Jones, B. C., & DeBruine, L. M. (2011). Facial attractiveness: evolutionary based research. *Philosophical Transactions of the Royal Society B: Biological Sciences, 366,* 1638-1659.

Little, A. C., Jones, B. C., Penton-Voak, I. S., Burt, D. M., & Perrett, D. I. (2002). Partnership status and the temporal context of relationships influence human female preferences for sexual dimorphism in male face shape. *Proceedings of the Royal Society B: Biological Sciences, 269,* 1095-1100.

Massar, K., & Buunk, A. P. (2009). Rivals in the mind's eye: Jealous responses after subliminal exposure to body shapes. *Personality and Individual Differences, 46,* 129-134.

Massar, K., & Buunk, A. P. (2010). Judging a book by its cover: Jealousy after subliminal priming with attractive and unattractive faces. *Personality and Individual Differences, 49,* 634-638.

Mazur, A., & Booth, A. (1998). Testosterone and dominance in men. *Behavioral and Brain Sciences, 21,* 353-397.

McIntyre, M., Gangestad, S. W., Gray, P. B., Chapman, J. F., Burnham, T. C., O'Rourke, M. T., & Thornhill, R. (2006). Romantic involvement often reduces men's testosterone levels -but not always: The moderating role of extrapair sexual interest. *Journal of Personality and Social Psychology, 91,* 642-651.

O'Connor, J. J. M., Re, D. E., & Feinberg, D. R. (2011). Voice pitch influences perceptions of sexual infidelity. *Evolutionary Psychology, 9,* 64-78.

Penton-Voak, I. S., & Perrett, D. I. (2000). Female preferences for male faces changes cyclically - further evidence. *Evolution and Human Behavior, 21,* 39-48.

Penton-Voak, I. S., Perrett, D. I., Castles, D. L., Kobayashi, T., Burt, D. M., Murray, L. K., & Minamisawa, R. (1999). Menstrual cycle alters face preference. *Nature, 399*, 741-742.

Perrett, D. I., Lee, K. J., Penton-Voak, I. S., Rowland, D., Yoshikawa, S., Burt, D. M., Henzil, S. P., Castles, D. L., & Akamatsu, S. (1998). Effects of sexual dimorphism on facial attractiveness. *Nature, 34*, 884-887.

Peters, M., Simmons, L. W., & Rhodes, G. (2008). Testosterone is associated with mating success but not attractiveness or masculinity in human males. *Animal Behaviour, 76*, 297-303.

Provost, M. P., Kormos, C., Kosakoski, G., & Quinsey, V. L. (2006). Sociosexuality in women and preference for facial masculinization and somatotype in men. *Archives of Sexual Behavior, 35*, 305-312.

Puts, D. A. (2005). Mating context and menstrual phase affect women's preferences for male voice pitch. *Evolution and Human Behavior, 26*, 388-397.

Puts, D. A., Barndt, J. L., Welling, L. L. M., Dawood, K., & Burriss, R. P. (2011). Intrasexual competition among women: Vocal femininity affects perceptions of attractiveness and flirtatiousness. *Personality and Individual Differences, 50*, 111-115.

Rhodes, G., Chan, J., Zebrowitz, L. A., & Simmons, L. W. (2003). Does sexual dimorphism in human faces signal health? *Proceedings of the Royal Society B: Biological Sciences, 270*, S93-S95.

Simpson, J. A., & Gangestad, S. W. (1991). Individual differences in sociosexuality: Evidence for convergent and discriminant validity *Personality and Individual Differences, 60,* 870-883.

Thornhill, R., & Gangestad, S. W. (2006). Facial sexual dimorphism, developmental stability and parasitic infections in men and women. *Evolution and Human Behavior, 27,* 131-144.

Tiddeman, B., Burt, D. M., & Perrett, D. I. (2001). Computer graphics in facial perception research. *IEEE Computer Graphics and Applications, 21,* 42-50.

Venners, S. A., Liu, X., Perry, M. J., Korrick, S. A., Li, Z., Yang, F., Yang, J., Lasley, B. L., Xu, X., & Wang, X. (2006). Urinary estrogen and progesterone metabolite concentrations in menstrual cucles of fertile women with non-contraception, early pregnancy loss or clinical pregnancy. *Human Reproductions, 21,* 2272-2280.

Verdonck, A., Gaethofs, M., Carels, C., & De Zegher, F. (1999). Effect of low-dose testosterone treatment on craniofacial growth in boys with delayed puberty. *European Journal of Orthodontics, 21,* 137-143.

Watkins, C. D., Jones, B. C., & DeBruine, L. M. (2010). Individual differences in dominance perception: Dominant men are less sensitive to facial cues of male dominance. *Personality and Individual Differences, 49,* 967-971.

Watkins, C. D., Quist, M. C., Smith, F. G., DeBruine, L. M & Jones, B. C. (In press). Individual differences in women's perceptions of other women's dominance. *European Journal of Personality.*

Waynforth, D., Delwadia, S., & Camm, M. (2005). The influence of women's mating strategies on preference for masculine facial architecture. *Evolution and Human Behavior, 26*, 409-416.

CHAPTER 6: GENERAL DISCUSSION

In this dissertation I have examined the influence of vocal and facial sexual dimorphism on social perceptions in relation to mate choice. In chapter 2, I found that women's preferences for male vocal and facial masculinity were positively correlated when tested using simultaneously presented voices and faces. I also found that women with relatively attractive faces had stronger preferences for masculine male voices and faces than did women with relatively less attractive faces. In chapter 3, I found that voice pitch influenced perceptions of infidelity. Men perceived women with higher pitched voices as more likely to cheat on their romantic partners than women with lower pitched voices. Women perceived men with lower pitched voices as more likely to commit infidelity than men with higher pitched voices. In chapter 4, women perceived men with lower pitched voices as less likely to be generous and investing romantic partners than men with higher pitched voices. However, women who preferred men with lower pitched voices as long-term mates also perceived men with lower pitched voices as more likely to be generous, investing mates than did other women. In chapter 5, I found that vocal and facial masculinity also influenced perceptions relating to intrasexual competition. Women were more jealous towards hypothetical rivals with relatively feminine than with relatively masculine faces and voices. Men were more jealous of hypothetical rivals with relatively masculine voices than of rivals with relatively feminine voices, but there was no main effect of facial masculinity on men's jealousy. In the following, I discuss the

implications of the above findings, and identify potential future research directions and general limitations.

The Influence of Masculinity/Femininity on Perceptions of Attractiveness

In chapter 2, I examined whether women's perceptions of attractiveness were differently influenced by different combinations of male facial and vocal masculinity presented in videos. Here, women preferred lower pitched over higher pitched men's voices, and this preference did not depend on whether men's faces were manipulated to be more feminine or more masculine. This finding supports prior research that has found that women prefer lower pitched men's voices to higher pitched men's voices (see section *Women's Preferences for Masculine Male Voices).* I also found that women preferred feminine men's faces to masculine men's faces, and that this preference did not depend on whether men's voices were manipulated to be higher or lower in pitch. Previous research has also found that women prefer feminine men's faces to masculine men's faces (Little & Hancock, 2002; Perrett et al., 1998; Rhodes & Hickford, 2000). However, other research has found that women prefer masculine men's faces to feminine men's faces (DeBruine et al., 2006; Feinberg et al., 2008a; Johnston et al., 2001; Penton-Voak et al., 2001; Scheib et al., 1999) or has not found that manipulations of facial masculinity significantly influence women's preferences for men's faces (Glassenberg et al., 2010).

In chapter 2, I found that women whose faces were rated as more attractive had stronger preferences for both vocal and facial masculinity than did women whose faces

were rated as less attractive. Previous research found that women who are rated as more attractive have stronger preferences for male facial masculinity than do women who are rated as less attractive (Penton-Voak et al., 2003), but it was unknown whether relatively attractive women also had stronger preferences for male vocal masculinity. These findings suggest that women's mate value, as communicated by facial attractiveness, influences women's preferences for masculinity in a similar manner across modalities, i.e. voice pitch and facial masculinity. Other individual differences also have similar effects on women's voice and face preferences. For example, women who rate themselves as more attractive have greater preferences for both facial masculinity (Little et al., 2001) and vocal masculinity (Feinberg et al., 2012; Vukovic et al., 2008) than do women who rate themselves as less attractive. Therefore, women who are relatively higher in mate value may be better able to either obtain and/or retain relatively masculine men as long-term mates (Feinberg et al., 2006; Little et al., 2001; Penton-Voak et al., 2003; Vukovic et al., 2008; Vukovic et al., 2010b). Furthermore, women in the fertile phase of the menstrual cycle also have stronger preferences for masculinity in men's faces (for review see Jones et al., 2008a) and voices (Feinberg et al., 2006; Puts, 2006) than do other women. Hence, the adaptive function of women's preferences for masculinity in men's faces may be similar to the adaptive function of women's preferences for masculinity in men's voices (i.e. gaining heritable health and/or dominance for offspring).

Although the results presented in chapter 2 failed to demonstrate that vocal and facial masculinity have interactive effects on men's attractiveness, it is possible that this is

due to the levels of vocal and facial masculinity manipulations that were used. In this study only two levels of manipulated masculinity were used; faces were manipulated to be 50% more masculine and 50% more feminine, and voice pitch was raised and lowered by 0.5 ERBs. It is possible that using additional levels of facial and vocal masculinity manipulations could result in a significant interaction between vocal and facial masculinity on women's perceptions of men's attractiveness. Indeed, other research suggests that voices can influence the selection of faces. Röder et al. (2013) had raters listen to women's voices and then select the which face corresponded to the voice. Faces were selected from a continuum of 1200 frames ranging from extreme facial masculinity to extreme facial femininity. Röder et al. found that the faces that raters selected in response to younger women's voices were relatively more feminine than the faces selected in response to older women's voices. Hence, using a higher number of vocal and facial masculinity manipulations may be relatively more sensitive to any potential interactions between male vocal and facial masculinity. Future studies may examine women's ratings of men's attractiveness using a greater range of facial and vocal masculinity manipulations.

Previous research has investigated women's cross-modal masculinity preferences by presenting voices separately from faces, and by presenting still photographs of men's faces (Feinberg et al., 2008a). In chapter 2, I found that women who preferred masculinity in men's voices also preferred masculinity in men's faces when rating videos of men speaking for attractiveness. Therefore, although facial and vocal masculinity

manipulations in this study appeared to have independent effects on women's perceptions of attractiveness, women's preferences for male vocal and facial masculinity were positively related. When men's faces and voices are manipulated to be more exaggeratedly sex-typical, they are also perceived as more masculine than were faces and voices manipulated to be less exaggeratedly sex-typical (DeBruine, Jones, Smith, & Little, 2010c; Feinberg et al., 2005b). Masculinized men's faces and lower pitched voices are both perceived as relatively more dominant than are feminized men's faces and higher pitched voices (Boothroyd et al., 2007; Burriss et al., 2007; Feinberg et al., 2006; Jones et al., 2010b). Moreover, women who prefer masculine male faces also prefer putative male pheromones, which may be indicative of relatively higher testosterone levels (Cornwell et al., 2004). Both facial masculinity (Dabbs & Mallinger, 1999; Evans et al., 2008; Marečková et al., 2011; Penton-Voak & Chen, 2004) and vocal masculinity (Dabbs & Mallinger, 1999; Evans, Neave, Wakelin, & Hamilton, 2008) are associated with relatively greater levels of testosterone. Therefore, the above suggests that vocal and facial masculinity communicate similar information about underlying qualities in potential mates (Feinberg, 2008). The assessment of masculine traits across modalities is potentially adaptive if it decreases errors in the assessment of the suitability of potential mates (Candolin, 2003).

The study presented in chapter 2 is the first in which men's faces and voices are simultaneously manipulated in masculinity and thus established this methodology for future research on the interaction between vocal and facial masculinity on a wide variety

of perceptions. This study is also the first to demonstrate that an individual difference (i.e. other-rated facial attractiveness) is positively associated with both facial and vocal masculinity preferences within the same sample of women participants. Hence, this study provides converging evidence for the role of individual differences in women's cross-modal masculinity preferences and is a first step towards investigating preferences for multi-modal traits as we encounter them in the real world.

The Influence of Masculinity/Femininity on Perceptions of Fitness Risks

In chapter 3, I investigated whether perceptions of infidelity were influenced by voice pitch manipulations. I found that men perceived higher pitched women's voices as being associated with a relatively greater threat of infidelity than were lower pitched women's voices. Women perceived lower pitched men's voices as being associated with a relatively greater threat of infidelity than were higher pitched men's voices. Men's and women's perceptions of infidelity were unrelated to their preferences for voice pitch, suggesting that the selection of exaggeratedly sex-typical voices as more likely to commit infidelity was not driven by perceptions of these voices as attractive.

The influence of voice pitch manipulations on perceptions of infidelity observed in chapter 3 may be somewhat based on a kernel of truth. This is because relatively feminine women with higher levels of estrogen, and relatively masculine men with higher levels of testosterone, may present an increased risk of infidelity (Booth & Dabbs, 1993;

Durante & Li, 2009; Fisher et al., 2009; McIntyre et al., 2006). For instance, women with relatively feminine characteristics, such as a feminine body shape, report greater frequencies of extra-pair sex than do other women (Hughes & Gallup, 2003; Hughes et al., 2004). When asked to rate the future probability of flirting, kissing, and having a serious affair with someone other than their primary partner, women with relatively higher levels of estrogen predict a greater future likelihood of engaging in these behaviours than do women with relatively lower levels of estrogen (Durante & Li, 2009). A similar pattern is observed between men's masculinity and infidelity. Men with relatively higher levels of testosterone are less committed to their romantic partners (Caldwell Hooper, Gangestad, Emery Thompson, & Bryan, 2011), report greater interest in extra-pair sex (McIntyre et al., 2006), and engage in more extra-marital affairs than do men with relatively lower testosterone levels (Booth & Dabbs, 1993; Fisher et al., 2009). Men with relatively masculine bodies and more attractive voices report higher numbers of extra-pair partners than do other men (Hughes & Gallup, 2003; Hughes et al., 2004). Thus, these findings suggest that perceivers may be somewhat aware of the relationship between morphological indicators of underlying mate quality and sexual strategies.

Infidelity has potential fitness consequences for both males and females. Female infidelity may increase the risk of cuckoldry, whereas male infidelity may lead to the loss of male protection and provisioning (Geary & Byrd-Craven, 2004). Masculine men and feminine women may be more likely to commit infidelity than feminine men and masculine women (see sections *Fitness Risks Associated with Mating with Masculine*

Men, Fitness Risks Associated with Mating with Feminine Women). Men and women whose mate preferences are influenced by perceptions of infidelity may gain fitness benefits if they are better able to select long-term mates who are less likely to abandon relationships and/or offspring, or who are less likely to engage in cuckoldry. Infidelity risk presents potential fitness costs, thus the pre-emptive identification of potential infidelity may be adaptive.

In chapter 3, I found that men with lower pitched voices and women with higher pitched voices were perceived as presenting a greater risk of future infidelity than were men with higher pitched voices and women with lower pitched voices. However, it is unknown whether men with lower pitched voices and women with higher pitched voices engage in extra-pair sex at higher frequencies than do men and women with less exaggeratedly sexually dimorphic voices. Therefore, future research may investigate whether men with lower pitched voices and women with higher pitched voices engage in infidelity at greater frequencies than do other individuals.

Infidelity is not the only behaviour that may present potential fitness costs. Indeed, male investment in relationships and offspring is especially relevant to women's reproductive success as the loss of paternal investment can negatively impact offspring morbidity and mortality (for review see Geary, 2005). In chapter 4, I examined whether women's perceptions of who is more likely to invest time and effort into romantic relationships, and who is more likely to be financially generous with their mates, were influenced by male voice pitch. I found that women perceived higher pitched men's

voices as indicting a greater likelihood of investing time and effort into romantic relationships, and a greater likelihood of being financially generous with their romantic partners. Women's perception of lower pitched men's voices as less likely to be investing, generous mates reflects the negative relationship between men's testosterone levels and investment in relationships. Men with higher testosterone levels are less likely to be in long-term relationships (Booth & Dabbs, 1993; van Anders, Hamilton, & Watson, 2007; van Anders & Goldey, 2010). When men with higher levels of testosterone are in relationships, they report more extra-pair interest (Edelstein, Chopik, & Kean, 2011) and lower relationship commitment than do men with lower testosterone levels (Caldwell Hooper et al., 2011). Thus, the influence of voice pitch on these perceptions of resource-based and non-resource based investment may reflect observable differences in men's commitment-related behaviours within romantic relationships.

In chapters 3 and 4, I found that women perceived men with lower pitched voices to be more likely to commit infidelity and less likely to be generous, investing mates. However, women also prefer lower pitched over higher pitched men's voices. Therefore, there is a disparity between women's preferences for masculine men's voices and their perceptions of men with masculine voices as suitable mates. To address this issue, I examined the relationship between women's preferences for male voice pitch and their attributions of male investment in romantic relationships. I found that women's preferences for lower pitched men's voices were positively associated with their perceptions of men with lower pitched voices as generous, investing mates. Here, the

strength of women's preferences for men with lower pitched voices as long-term mates was positively associated with their perceptions of men with lower pitched voices as financially generous and investing mates. Whereas in chapters 3 and 4 I demonstrate that women are somewhat aware of the increased risk of infidelity and reduced relationship investment associated with pursuing masculine men as mates, the results presented in chapter 4 suggests that perceptions of relationship investment are associated with preferences for masculine men as long-term mates. Therefore, some women may prefer masculine men as mates because they perceive such men to be likely to invest in relationships. If women preferred masculine men despite perceptions of reduced relationship investment, then women who selected lower pitched men's voices as more attractive long-term mates would not also select lower-pitched men's voices as more likely to be investing, generous mates.

In chapter 4, I found that women perceived men with lower pitched voices to be less likely to be generous and investing mates than men with higher pitched voices. However, women who preferred lower pitched men's voices in the context of a long-term relationship perceived such men to be relatively more generous and investing mates. It is possible that perceptions of relationship investment may be related to variation in women's masculinity preferences across the menstrual cycle. Women's preferences for vocal (Feinberg et al., 2006; Puts, 2005) and facial masculinity (Johnston et al., 2001; Little et al., 2008; Penton-Voak et al., 1999; Penton-Voak & Perrett, 2000) are greater in the fertile than the infertile phase of the menstrual cycle. Women's perceptions of men's

relationship commitment and paternal quality also vary across the menstrual cycle. Durante et al. (2012) found that in comparison to women not in the ovulatory phase of the menstrual cycle, women who were in the ovulatory phase of the menstrual cycle perceived physically attractive and charismatic men to be relatively more committed romantic partners and more investing fathers. Whether variation in women's perceptions of male relationship investment also provides a proximate explanation for menstrual cycle related variation in women's preferences for male vocal and facial masculinity is an avenue for future research.

Chapter 3 is the first study to demonstrate that female vocal femininity and male vocal masculinity are associated with perceptions of increased infidelity risk. The results from chapter 3 also extend previous findings on the influence of male facial masculinity on perceptions of infidelity (Kruger, 2006) to men's vocal masculinity. Therefore, masculinity in men's faces and voices has similar effects on women's perceptions of infidelity risk, thus underscoring the redundant nature of multimodal masculinity on social perceptions relating to mate choice. Furthermore, findings from chapter 4 demonstrate that while vocal masculinity negatively impacts women's perceptions of relationship investment, women who have stronger preferences for men with lower pitched voices as long-term mates also have more positive perceptions of men with lower pitched voices as investing mates. Overall, the research presented here suggests that men's and women's perceptions of potential fitness risks are influenced by opposite-sex voice pitch.

The Influence of Masculinity/Femininity on Perceptions of Intrasexual Competition

Prior research has suggested that women's perceptions of intrasexual competition are influenced by the physical characteristics of potential same-sex rivals. For instance, women react more jealously towards women with relatively feminine bodies (Buunk & Dijkstra, 2005; Dijkstra & Buunk, 2001) and attractive faces than to other women (Massar & Buunk, 2010). In chapter 5, I examined whether manipulations of female vocal and facial femininity influenced women's perceptions relating to intrasexual competition. In this study, participants selected faces and voices in response to hypothetical scenarios: jealousy in response to flirting with their romantic partner, and preferred travel companion for their romantic partner. Women were more jealous in response to feminine female faces and voices, and preferred that their partners be accompanied by women with relatively masculine voices and faces. Women who rated feminine women's faces and voices as relatively attractive also indicated more jealousy in response to feminine women hypothetically flirting with their romantic partner, and preferred women with relatively masculine faces and voices as travel companions for their romantic partners. Women also rate feminized women's voices as both more flirtatious and more attractive to men than they rate masculinized women's voices (Puts et al., 2011). Men prefer women with feminine characteristics (see section *Fitness Benefits of Mating with Feminine Women*), and hence, women are more jealous and wary of women with feminine traits than women with masculine traits as intrasexual rivals. Given that women's vocal attractiveness and body femininity are positively associated with higher frequencies of reporting acting as an

extra-pair partner (Hughes & Gallup, 2003; Hughes et al., 2004), it is possible that female femininity is also associated with mate poaching. Hence, it may be adaptive for women to preferentially allocate mate guarding efforts towards relatively feminine and hence threatening same-sex rivals.

Although previous research has shown that men's jealousy is positively influenced by masculine male bodies (Dijkstra & Buunk, 2001) and faces (Kruger, 2006), whether the influence of masculinity on men's jealousy extends to other men's voices had not yet been examined. In chapter 5, I found that male participants were more jealous in response to men with lower pitched voices than men with higher pitched voices, and preferred that their partners be accompanied by men with relatively higher pitched than lower pitched voices. Male body masculinity also induces jealousy among males (Dijkstra & Buunk, 2001; Massar & Buunk, 2009). Male body masculinity and male vocal attractiveness are associated with higher frequencies of reporting acting as an extra-pair partner (Hughes & Gallup, 2003). If masculine men are more threatening intrasexual competitors, then mate guarding against men with lower pitched voices may be adaptive, as is the case for women's allocation of mate guarding efforts towards feminine women.

Although the above suggests that men's perceptions relating to intrasexual competition are influenced by morphological correlates of testosterone, i.e. voice pitch and body masculinity, in chapter 5 male facial masculinity did not influence men's jealousy or selection of travel companions at levels beyond chance. This pattern of results is of note because it may reflect the variability of women's masculinity preferences. For

instance, many studies have demonstrated that women select lower pitched male voices as generally more attractive than higher pitched male voices (Bruckert et al., 2006; Collins, 2000; Feinberg et al., 2005b; Feinberg et al., 2006; Feinberg et al., 2011; Jones, Boothroyd, Feinberg, & DeBruine, 2010a; Jones et al., In press; Saxton et al., 2006; Zuckerman & Miyake, 1993)[1] and here male vocal masculinity influenced men's jealousy and selection of travel companions. Previous research has found women's general preferences for masculine faces (DeBruine et al., 2006; Feinberg et al., 2008a; Johnston et al., 2001; Jones et al., In press; Penton-Voak et al., 2001; Scheib et al., 1999) and feminine faces (Little & Hancock, 2002; Perrett et al., 1998; Rhodes & Hickford, 2000), whereas other research has not found general preferences for either masculine or feminine men's faces (Glassenberg et al., 2010; Sacco, Jones, DeBruine, & Hugenberg, 2012). Although facial and vocal masculinity are hypothesized to communicate similar information about underlying health and dominance (Feinberg, 2008; Puts et al., 2012b), there may be differences in the strength or accuracy with which these traits are communicated (Candolin, 2003). This may result in somewhat more variation in women's general preferences for facial masculinity than in women's general preferences for vocal masculinity when not accounting for individual differences amongst women (Feinberg et al., 2006; Feinberg et al., 2012; Little et al., 2001; Vukovic et al., 2008; Vukovic et al., 2010b) or the relationship context in which masculine traits are rated or selected (Feinberg et al., 2012; Little et al., 2007a; Little et al., 2011a). This apparent disparity in

[1] These studies refer to those where female participants selected voices as attractive without specifying relationship context.

the main effect of masculinity on women's preferences for men's voices versus men's faces appears to be reflected in this study. Whereas the main effect of facial masculinity on men's jealousy and selection of travel companions was not significant, men's selection of masculine male faces as attractive predicted their jealousy in response to masculine male faces and the selection of male travel companions with feminine faces. Therefore, men's jealousy responses to masculine male faces may to some extent reflect variation in men's perceptions of women's facial masculinity preferences.

An alternate explanation for this pattern of results is that the manipulations of voice pitch and facial masculinity may not be perceptually equivalent. For instance, in chapter 5 voices were manipulated by increasing or decreasing the pitch of the voice by 0.5 ERBs, whereas faces were manipulated to be 50% more or less masculine relative to baseline. However, it is unknown whether this level of voice pitch manipulation is perceptually equivalent to this level of facial masculinity manipulation. This means that differences in the influence of vocal masculinity versus facial masculinity on any given perception cannot be dissociated from differences in the magnitude of manipulation between voices and faces. However, this is unlikely to be the case given that there was a significant effect of male facial masculinity on men's ratings of attractiveness, and if facial masculinity manipulations were not strong enough to influence men's perceptions, then facial masculinity would not have significantly influenced perceptions of attractiveness.

In chapter 5, I found that women who perceived women with feminine faces and voices as relatively more attractive were also relatively more jealous of women with feminine faces and voices. Men who perceived men with masculine faces and voices as relatively more attractive were relatively more jealous of men with masculine faces and voices. It is possible that other individual differences may also predict variation in the influence of facial or vocal masculinity/ femininity on perceptions related to intrasexual competition. This is illustrated by Buunk and Dijkstra (2005), who found that women with relatively feminine bodies were more jealous of potential rivals with relatively feminine versus relatively masculine bodies. Mating effort is a finite resource (Jones et al., 2008b; Mishra, Clark, & Daly, 2007) that requires the allocation of mate guarding efforts to be efficient. Individuals who are of relatively higher mate value themselves may allocate mate guarding efforts more efficiently towards situations in which potential interlopers are also relatively higher in mate value. For instance, women with higher pitched voices and/or feminine faces may be more jealous of other women who have relatively feminine traits than they are of women with relatively masculine traits. Future research may examine whether correlates of underlying mate value, such as vocal or facial femininity and masculinity, predict individual differences in the influence of vocal and facial masculinity manipulations on jealous responses to potential intrasexual rivals.

The study presented in chapter 5 is one of the first to explicitly investigate the influence of vocal and facial masculinity and femininity on hypothetical scenarios relating to intrasexual competition: jealousy in response to flirting and selection of romantic

partner's travel companion. These findings demonstrate that vocal and facial femininity and masculinity influence perceptions relating to intrasexual competition in a manner consistent with the influence of vocal and facial masculinity and femininity on mate preferences.

General Limitations

The four studies included in this dissertation share similar methodologies, and therefore similar limitations. First, these studies include somewhat homogenous participant samples: first-year university students with an average age of approximately 18.5 years. It is possible that the patterns of results presented here may be different in other age groups and levels of education. Participant age group may predict individual differences in mate-choice related social perceptions since age is related to mate value amongst reproductively-active adults, positively for men and negatively for women (Brase & Guy, 2004). Indeed, reproductive-aged women have stronger preferences for facial masculinity than do post-menopausal (Jones et al., 2011b; Little et al., 2010) or pre-pubertal females (Little et al., 2010). Although the studies included in this dissertation did not examine the influence of age on social perceptions of vocal and facial femininity/masculinity, future studies may investigate these perceptions across broader age ranges.

Educational background may also be associated with socioeconomic status and therefore access to material resources (Baum & Ma, 2007). Access to material resources may be an important predictor of men's attractiveness to women (Buss 2008), as well as an important factor in women's mate preferences (Moore et al., 2006). It is possible that men with relatively greater accumulated resources are more attractive to women, and hence, may have stronger preferences for feminine women's faces and voices than do other men. However, preliminary research has failed to find a significant relationship between women's self-rated socioeconomic status and women's preferences for lower pitched men's voices (O'Connor, Fraccaro, Tigue, & Feinberg, 2013). Future research may further investigate whether factors relating to resource accumulation, such as education and socioeconomic status, contribute to variation in the influence of vocal and facial masculinity/femininity on mate choice related social perceptions.

Second, the studies presented here asked participants to respond to hypothetical scenarios of mate choice and intrasexual competition. While the hypothetical nature of such scenarios is required in order to empirically examine the influence of masculinity manipulations on social perceptions, real life scenarios are often accompanied by rich social information and personal consequences that are absent from experimental environments. Nonetheless, other research indicates that women who prefer masculine to feminine men's faces in experimental settings also have stronger preferences for masculinity in their ideal mates and in their actual mates (DeBruine et al., 2006). Hence, women who report currently having or desiring relatively masculine mates also select

male faces manipulated to be relatively masculine as more attractive than male faces manipulated to relatively feminine. Furthermore, experimental studies of women's preferences for masculinity demonstrate that hormonal birth control use is associated with relatively weaker preferences for vocal and facial masculinity than are observed in women who do not use hormonal birth control (Feinberg et al., 2008a). Further examination of actual partner selection reveals that women who were using hormonal birth control when their relationship began had relatively more feminine-looking male partners than did women who were not using hormonal birth control (Little, Burriss, Petrie, Jones, & Roberts, In press). Therefore, while it is difficult to determine the extent to which social perceptions predict behavioural responses to mating-related scenarios in the real world, women's masculinity preferences observed in experimental settings do align with their desired and actual mate choices.

Conclusions

In this dissertation I have examined the influence of vocal and facial masculinity and femininity on social perceptions relating to mate choice. I have demonstrated that male vocal and facial masculinity influences women's perceptions of men's attractiveness in videos of men speaking. I have also shown that women and men are somewhat aware of the potential fitness risks associated with preferring mates with relatively masculine and feminine voices (respectively). Furthermore, I demonstrated that vocal and facial masculinity and femininity influence intrasexual competition in a manner consistent with

opposite-sex mate preferences. When taken together, these studies demonstrate the pervasive influence of masculinity and femininity on mate-choice relevant social perceptions.

References

Abitbol, J., Abitbol, P., & Abitbol, B. (1999). Sex hormones and the female voice. *Journal of Voice, 13*, 424-446. doi: 10.1016/S0892-1997(99)80048-4

Anderson, K. G., Kaplan, H., & Lancaster, J. (1999). Paternal care by genetic fathers and stepfathers I: Reports from Albuquerque men. *Evolution and Human Behavior, 20*, 405-431.

Anderson, K. G., Kaplan, H., & Lancaster, J. (2007). Confidence of paternity, divorce, and investment in children by Albuquerque men. *Evolution and Human Behavior, 28*, 1-10.

Apicella, C. L., Feinberg, D. R., & Marlowe, F. W. (2007). Voice pitch predicts reproductive success in male hunter-gatherers. *Biology Letters, 3*(6), 682-684. doi: 10.1098/rsbl.2007.0410

Apicella, C. L., & Feinberg, D. R. (2009). Voice pitch alters mate-choice-relevant perception in hunter-gatherers. *Proceedings of the Royal Society B-Biological Sciences, 276*(1659), 1077-1082. doi: 10.1098/rspb.2008.1542

Atkinson, J., Pipitone, R. N., Sorokowska, A., Sorokowski, P., Mberira, M., Bartels, A., & Gallup, G. G., Jr. (2012). Voice and handgrip strength predict reproductive success in a group of indigenous African females. *PLoS ONE, 7*(8), e41811. doi: 10.1371/journal.pone.0041811

Awan, S. N. (2006). The aging female voice: Acoustic and respiratory data. *Clinical Linguistics & Phonetics, 2*, 171-180.

Biever, D. M., & Bless, D. M. (1989). Vibratory Characteristics of the vocal folds in young adult and geriatric women. *Journal of Voice, 3*, 120-131.

Bolinger, H. R. (1964). Intonation across languages. In J. H. Greenberg, C. A. Ferguson & E. A. Moravcsik (Eds.), Universals of Human Language, Vol. 2: Phonology. (pp. 471-524). Standford, CA: Stanford University Press.

Booth, A., & Dabbs, J. M. (1993). Testosterone and men's marriages. *Social Forces, 72*, 463-477.

Booth, A., Granger, D. A., Mazur, A., & Kivlighan, K. T. (2006). Testosterone and social behavior. *Social Forces, 85*, 167-191.

Boothroyd, L., Jones, B., Burt, D., & Perrett, D. (2007). Partner characteristics associated with masculinity, health and maturity in male faces. *Personality and Individual Differences, 43*(5), 1161-1173. doi: 10.1016/j.paid.2007.03.008

Borkowska, B., & Pawlowski, B. (2011). Female voice frequency in the context of dominance and attractiveness perception. *Animal Behaviour, 82*(1), 55-59. doi: 10.1016/j.anbehav.2011.03.024

Brooks, R., Scott, I. M., Maklakov, A. A., Kasumovic, M. M., Clark, A. P., & Penton-voak, I. S. (2010). National income inequality predicts women's preferences for masculinized faces better than health does. *Proceedings of the Royal Society B: Biological Sciences, 278*, 810-812. doi: 10.1098/rspb.2010.0964

Bruckert, L., Lienard, J. S., Lacroix, A., Kreutzer, M., & Leboucher, G. (2006). Women use voice parameters to assess men's characteristics. *Proceedings of the Royal Society B: Biological Sciences, 273*(1582), 83-89. doi: 10.1098/rspb.2005.3265

Bryant, G. A., & Haselton, M. G. (2009). Vocal cues of ovulation in human females. *Biology Letters, 5*(1), 12-15. doi: 10.1098/rsbl.2008.0507

Burriss, R. P., Little, A. C., & Nelson, E. C. (2007). 2D:4D and Sexually Dimorphic Facial Characteristics. *Archives of Sexual Behavior, 36*(3), 377-384. doi: 10.1007/s10508-006-9136-1

Burriss, R. P., Welling, L. L. M., & Puts, D. A. (2011). Men's attractiveness predicts their preference for femal facial femininity when judging for short-term, but not long-term, partners. *Personality and Individual Differences, 50*, 542-546.

Buunk, B., & Dijkstra, P. (2005). A narrow waist versus broad shoulders: Sex and age differences in the jealousy-evoking characteristics of a rival's body build. *Personality and Individual Differences, 39*(2), 379-389. doi: 10.1016/j.paid.2005.01.020

Caldwell Hooper, A. E., Gangestad, S. W., Emery Thompson, M., & Bryan, A. D. (2011). Testosterone and Romance: The association of testosterone with relationship commitment and satisfaction in heterosexual men and women. *American Journal of Human Biology, 23*, 553-555. doi: doi: 10.1002/ajhb.21188

Candolin, U. (2003). The use of multiple cues in mate choice. *Biological Reviews, 78*(4), 575-595. doi: 10.1017/s1464793103006158

Childers, D. G., & Wu, K. (1991). Gender recognition from speech. Part II: Fine analysis. *Journal of the Acoustical Society of America, 90*, 1847-1856.

Collins, S. A. (2000). Men's voices and women's choices. *Animal Behaviour, 60*(6), 773-780. doi: 10.1006/anbe.2000.1523

Collins, S. A., & Missing, C. (2003). Vocal and visual attractiveness are related in women. *Animal Behaviour*, *65*(5), 997-1004. doi: 10.1006/anbe.2003.2123

Cornwell, R. E., Boothroyd, L., Burt, D. M., Feinberg, D. R., Jones, B. C., Little, A. C., Pitman, R., Whiten, S., & Perrett, D. I. (2004). Concordant preferences for opposite-sex signals? Human pheromones and facial characteristics. *Proceedings of the Royal Society B: Biological Sciences, 271*(1539), 635-640. doi: 10.1098/rspb.2003.2649

Cunningham, M. R. (1986). Measuring the physical in physical attractiveness: quasi-experiments on the sociobiology of female beauty. *Journal of Personality and Social Psychology, 50*, 925-935.

Dabbs, J. M., & Mallinger, A. (1999). High testosterone levels predict low voice pitch among men. *Personality and Individual Differences, 27*, 801-804.

De Maddalena, C., Vodo, S., Petroni, A., & Aloisi, A. M. (2012). Impact of testosterone on body fact composition. *Journal of Cellular Physiology, 227*, 3744-3748.

DeBruine, L. M., Jones, B. C., Little, A. C., Boothroyd, L. G., Perrett, D. I., Penton-Voak, I. S., Cooper, P. A., Penke, L., Feinberg, D. R., & Tiddeman, B. P. (2006). Correlated preferences for facial masculinity and ideal or actual partner's masculinity. *Proceedings of the Royal Society B: Biological Sciences, 273*(1592), 1355-1360. doi: 10.1098/rspb.2005.3445

DeBruine, L. M., Jones, B. C., Crawford, J. R., Welling, L. L. M., & Little, A. C. (2010a). The health of a nation predicts their mate preferences: cross-cultural variation in women's preferences for masculinized male faces. *Proceedings of the Royal*

Society B-Biological Sciences, 277(1692), 2405-2410. doi: 10.1098/rspb.2009.2184

DeBruine, L. M., Jones, B. C., Frederick, D. A., Haselton, M. G., Penton-Voak, I. S., & Perrett, D. I. (2010b). Evidence for menstrual cycle shifts in women's preferences for masculinity: A response to Harris (in press) "Menstrual cycle and facial preferences reconsidered". *Evolutionary Psychology, 8*, 768-775.

DeBruine, L. M., Jones, B. C., Smith, F. G., & Little, A. C. (2010c). Are attractive men's faces masculine or feminine? The importance of controlling confounds in face stimuli. *Journal of Experimental Psychology: Human Perception and Performance, 363*, 751-758.

DeBruine, L. M., Jones, B. C., Tybur, J. M., Lieberman, D., & Griskevicius, V. (2010d). Women's preferences for masculinity in male faces are predicted by pathogen disgust, but not by moral or sexual disgust. *Evolution and Human Behavior, 31*(1), 69-74. doi: 10.1016/j.evolhumbehav.2009.09.003

DeBruine, L. M., Jones, B. C., Little, A. C., Crawford, J. R., & Welling, L. L. M. (2011). Further evidence for regional variation in women's masculinity preferences. *Proceedings of the Royal Society B: Biological Sciences, 278*, 813-814.

Dijkstra, P., & Buunk, B. P. (2001). Sex differences in the jealousy-evoking nature of a rival's body build. *Evolution and Human Behavior, 22*, 335-341.

Dunson, D. B., Colombo, B., & Baird, D. D. (2002). Changes with age in the level and duration of fertility in the menstrual cycle. *Human Reproduction, 17*, 1399-1403.

Durante, K. M., & Li, N. P. (2009). Oestradiol level and opportunistic mating in women. *Biology Letters, 5*, 179-182.

Durante, K. M., Griskevicius, V., Simpson, J. A., Cantu´, S. M., & Li, N. P. (2012). Ovulation leads women to perceive sexy cads as good dads. *Journal of Personality and Social Psychology, 103*, 292-305.

Edelstein, R. S., Chopik, W. J., & Kean, E. L. (2011). Sociosexuality moderates the association between testosterone and relationship status in men and women. *Hormones and Behavior, 60*, 248-255.

Enlow, D. (1982). *Handbook of Facial Growth*. Philadelphia, PA: W B Saunders.

Evans, S., Neave, N., Wakelin, D., & Hamilton, C. (2008). The relationship between testosterone and vocal frequencies in human males. *Physiology & Behavior, 93*(4-5), 783-788. doi: 10.1016/j.physbeh.2007.11.033

Feely, R. J., Saad, F., Guay, A., & Traish, A. M. (2009). Testosterone in men's health: A new role for an old hormone. *Journal of Men's Health, 6*, 169-176. doi: 10.1016/j.jomh.2009.06.005

Feinberg, D. R., Jones, B. C., DeBruine, L. M., Moore, F. R., Law Smith, M. J., Cornwell, R. E., Tiddeman, B. P., Boothroyd, L. G., & Perrett, D. I. (2005a). The voice and face of woman: One ornament that signals quality? *Evolution and Human Behavior, 26*(5), 398-408. doi: 10.1016/j.evolhumbehav.2005.04.001

Feinberg, D. R., Jones, B. C., Little, A. C., Burt, D. M., & Perrett, D. I. (2005b). Manipulations of fundamental and formant frequencies influence the

attractiveness of human male voices. *Animal Behaviour, 69*, 561-568. doi: 10.1016/j.anbehav.2004.06.012

Feinberg, D. R., Jones, B. C., Law Smith, M. J., Moore, F. R., DeBruine, L. M., Cornwell, R. E., Hillier, S. G., & Perrett, D. I. (2006). Menstrual cycle, trait estrogen level, and masculinity preferences in the human voice. *Hormones and Behavior, 49*(2), 215-222. doi: 10.1016/j.yhbeh.2005.07.004

Feinberg, D. R. (2008). Are human faces and voices ornaments signaling common underlying cues to mate value? *Evolutionary Anthropology, 17*(2), 112-118. doi: 10.1002/evan.20166

Feinberg, D. R., DeBruine, L. M., Jones, B. C., & Little, A. C. (2008a). Correlated preferences for men's facial and vocal masculinity. *Evolution and Human Behavior, 29*(4), 233-241. doi: 10.1016/j.evolhumbehav.2007.12.008

Feinberg, D. R., DeBruine, L. M., Jones, B. C., & Perrett, D. I. (2008b). The relative role of femininity and averageness of voice pitch in aesthetic judgments of women's voices. *Perception, 37*(4), 615-623. doi: 10.1068/p5514

Feinberg, D. R., Jones, B. C., DeBruine, L. M., O'Connor, J. J. M., Tigue, C. C., & Borak, D. J. (2011). Integrating fundamental and formant frequencies in women's preferences for men's voices. *Behavioral Ecology, 22*(6), 1320-1325. doi: 10.1093/beheco/arr134

Feinberg, D. R., DeBruine, L. M., Jones, B. C., Little, A. C., O'Connor, J. J. M., & Tigue, C. C. (2012). Women's self-perceived health and attractiveness predict their male vocal masculinity preferences in different directions across short- and long-term

relationship contexts. *Behavioral Ecology and Sociobiology, 66*(3), 413-418. doi: 10.1007/s00265-011-1287-y

Fernald, A., & Kuhl, P. (1987). Acoustic determinants of infant preference for motherese speech. *Infant Behaviour and Development, 10*, 279-293.

Fink, B., Neave, N., & Seydel, H. (2007). Male facial appearance signals physical strength to women. *American Journal of Human Biology, 19*(1), 82-87. doi: 10.1002/ajhb.20583

Fischer, J., Semple, S., Fickenscher, G., Jurgens, R., JKruse, E., Heistermann, M., & Amir, O. (2011). Do women's voices provide cues of the likelihood of ovulation? The importance of sampling regime. *PLoS ONE, 6*, e24490-e24490.

Fisher, A. D., Corona, G., Bandini, E., Mannucci, E., Lotti, F., Boddi, V., Forti, G., & Maggi, M. (2009). Psychobiological Correlates of Extramarital Affairs and Differences between Stable and Occasional Infidelity among Men with Sexual Dysfunctions. *Journal of Sexual Medicine, 6*(3), 866-875. doi: 10.1111/j.1743-6109.2008.01140.x

Fitzgerald, C., Zimon, A. E., & Jones, E. E. (1998). Aging and reproductive potential in women. *Yale Journal of Biology and Medicine, 71*, 367-381.

Fraccaro, P. J., Feinberg, D. R., DeBruine, L. M., Little, A. C., Watkins, C. D., & Jones, B. C. (2010). Correlated male preferences for femininity in female faces and voices. *Evolutionary Psychology, 8*, 447-461.

Fraccaro, P. J., Jones, B. C., Vukovic, J., Smith, F. G., Watkins, C. D., Feinberg, D. R., Little, A. C., & DeBruine, L. M. (2011). Experimental evidence that women speak

in a higher voice pitch to men they find attractive. *Journal of Evolutionary Psychology*, *9*, 57-67.

Gangestad, S. W., Simpson, J. A., Cousins, A. J., Garver-Apgar, C. E., & Christensen, P. N. (2004). Women's preferences for male behavioral displays change across the menstrual cycle. *Psychological Science, 15*, 203-207.

Gangestad, S. W., Garver-Apgar, C. E., Simpson, J. A., & Cousins, A. J. (2007). Changes in women's mate preferences across the ovulatory cycle. *Journal of Personality and Social Psychology, 92*(1), 151-163. doi: 10.1037/0022-3514.92.1.151

Gangestad, S. W., Merriman, L. A., & Thompson, M. E. (2010). Men's oxidative stress, fluctuating asymmetry and physical attractiveness. *Animal Behavior, 80*, 1005-1013.

Geary, D. C., & Byrd-Craven, J. (2004). The evolution of human mate choice. *The Journal of Sex Research, 41*, 27-42.

Geary, D. C. (Ed.). (2005). *Evolution of paternal investment*. Hoboken: John Wiley & Sons.

Glassenberg, A. N., Feinberg, D. R., Jones, B. C., Little, A. C., & DeBruine, L. M. (2010). Sex-Dimorphic Face Shape Preference in Heterosexual and Homosexual Men and Women. *Archives of Sexual Behavior*. doi: 10.1007/s10508-009-9559-6

Gray, A. W., & Boothroyd, L. G. (2012). Female facial appearance and health. *Evolutionary Psychology, 10*, 66-77.

Harries, M., Hawkins, S., Hacking, J., & Hughes, I. (1998). Changes in the male voice at puberty: Vocal fold length and its relationship to the fundamental frequency of the voice. *The Journal of Laryngology and Otology, 112*, 451-454.

Hodges-Simeon, C. R., Gaulin, S. J. C., & Puts, D. A. (2010). Different vocal parameters predict perceptions of dominance and attractiveness. *Human Nature, 21*, 406-427.

Hughes, S. M., & Gallup, G. G. (2003). Sex differences in morphological predictors of sexual behavior Shoulder to hip and waist to hip ratios. *Evolution and Human Behavior, 24*(3), 173-178. doi: 10.1016/s1090-5138(02)00149-6

Hughes, S. M., Dispenza, F., & Gallup, G. G. (2004). Ratings of voice attractiveness predict sexual behavior and body configuration. *Evolution and Human Behavior, 25*(5), 295-304. doi: 10.1016/j.evolhumbehav.2004.06.001

Huron, D., Kinney, D., & Precoda, K. (2006). Influence of pitch height on the perception of submissiveness and threat in musical passages. *Empirical Musicology Review, 1*, 170-177.

Jasienska, G., Ziomkiewicz, A., Ellison, P. T., Lipson, S. F., & Thune, I. (2004). Large breasts and narrow waists indicate high reproductive potential in women. *Proceedings of the Royal Society B-Biological Sciences, 271*(1545), 1213-1217. doi: 10.1098/rspb.2004.2712

Johnston, V. S., Hagel, R., Franklin, M., Fink, B., & Grammer, K. (2001). Male facial attractiveness - Evidence for hormone-mediated adaptive design. *Evolution and Human Behavior, 22*(4), 251-267. doi: 10.1016/s1090-5138(01)00066-6

Jones, B., DeBruine, L., Little, A., Conway, C., Welling, L., & Smith, F. (2007). Sensation seeking and men's face preferences. *Evolution and Human Behavior, 28*(6), 439-446. doi: 10.1016/j.evolhumbehav.2007.07.006

Jones, B. C., DeBruine, L. M., Perrett, D. I., Little, A. C., Feinberg, D. R., & Smith, M. J. L. (2008a). Effects of menstrual cycle phase on face preferences. *Archives of Sexual Behavior, 37*(1), 78-84. doi: 10.1007/s10508-007-9268-y

Jones, B. C., Feinberg, D. R., DeBruine, L. M., Little, A. C., & Vukovic, J. (2008b). Integrating cues of social interest and voice pitch in men's preferences for women's voices. *Biology Letters, 4*(2), 192-194. doi: 10.1098/rsbl.2007.0626

Jones, B. C., Boothroyd, L., Feinberg, D. R., & DeBruine, L. M. (2010a). Age at menarche predicts individual differences in women's preferences for masculinized male voices in adulthood. *Personality and Individual Differences, 48*(7), 860-863. doi: 10.1016/j.paid.2010.02.007

Jones, B. C., Feinberg, D. R., DeBruine, L. M., Little, A. C., & Vukovic, J. (2010b). A domain-specific opposite-sex bias in human preferences for manipulated voice pitch. *Animal Behaviour, 79*(1), 57-62. doi: 10.1016/j.anbehav.2009.10.003

Jones, B. C., Little, A. C., Watkins, C. D., Welling, L. L. M., & DeBruine, L. M. (2011a). Reported sexual desire predicts men's preferences for sexually dimorphic cues in women's faces. *Archives of Sexual Behavior, 40,* 1281-1285.

Jones, B. C., Vukovic, J., Little, A. C., Roberts, S. C., & DeBruine, L. M. (2011b). Circum-menopausal changes in women's preferences for sexually dimorphic cues in peer-aged faces. *Biological Psychology, 87,* 453-455.

Jones, B. C., Feinberg, D. R., Watkins, C. D., Fincher, C. L., Little, A. C., & DeBruine, L. M. (In press). Pathogen disust predicts women's preferences for masculinity in men's voices, faces, and bodies. *Behavioral Ecology*.

Jones, B. C., Fincher, C. L., Welling, L. L. M., Little, A. C., Feinberg, D. R., Watkins, C. D., Al-Dujaili, E. A. S., & DeBruine, L. M. (In press). Salivary cortisol and pathogen disgust predict men's preferences for feminine shape cues in women's faces. *Biological Psychology*.

Jones, D., & Hill, K. (1993). Criteria of facial attractiveness in five populations. *Human Nature, 4*, 271-296.

Keating, C. F. (1985). Gender and the physiognomy of dominance and attractiveness. *Social Psychology Quarterly, 48*, 61-70.

Kruger, D. J. (2006). Male facial masculinity influences attributions of personality and reproductive strategy. *Personal Relationships, 13*, 451-463.

Law Smith, M. J., Perrett, D. I., Jones, B. C., Cornwell, R. E., Moore, F. R., Feinberg, D. R., Boothroyd, L. G., Durrani, S. J., Stirrat, M. R., Whiten, S., Pitman, R. M., & Hillier, S. G. (2006). Facial appearance is a cue to oestrogen levels in women. *Proceedings of the Royal Society B: Biological Sciences, 273*(1583), 135-140. doi: 10.1098/rspb.2005.3296

Law Smith, M. J., Deady, D. K., Moore, F. R., Jones, B. C., Cornwell, R. E., Stirrat, M., Lawson, J. F., Feinberg, D. R., & Perrett, D. I. (2012). Maternal tendencies in women are associated with estrogen levels and facial femininity. *Hormones and Behavior*.

Little, A. C., Burt, D. M., Penton-Voak, I. S., & Perrett, D. I. (2001). Self-perceived attractiveness influences human female preferences for sexual dimorphism and symmetry in male faces. *Proceedings of the Royal Society B: Biological Sciences, 268*(1462), 39-44. doi: 10.1098/rspb.2000.1327

Little, A. C., & Hancock, P. J. B. (2002). The role of masculinity and distinctiveness in judgments of human male facial attractiveness. *British Journal of Psychology, 93*, 451-464.

Little, A. C., Jones, B. C., Penton-Voak, I. S., Burt, D. M., & Perrett, D. I. (2002). Partnership status and the temporal context of relationships influence human female preferences for sexual dimorphism in male face shape. *Proceedings of the Royal Society B: Biological Sciences, 269*(1496), 1095-1100. doi: 10.1098/rspb.2002.1984

Little, A. C., Cohen, D. L., Jones, B. C., & Belsky, J. (2007a). Human preferences for facial masculinity change with relationship type and environmental harshness. *Behavioral Ecology and Sociobiology, 61*, 967-973.

Little, A. C., Jones, B. C., & Burriss, R. P. (2007b). Preferences for masculinity in male bodies change across the menstrual cycle. *Hormones and Behavior, 51*(5), 633-639. doi: 10.1016/j.yhbeh.2007.03.006

Little, A. C., Jones, B. C., & DeBruine, L. M. (2008). Preferences for variation in masculinity in real male faces change across the menstrual cycle: Women prefer more masculine faces when they are more fertile. *Personality and Individual Differences, 45*(6), 478-482. doi: 10.1016/j.paid.2008.05.024

Little, A. C., Saxton, T. K., Roberts, S. C., Jones, B. C., DeBruine, L. M., Vukovic, J., Perrett, D. I., Feinberg, D. R., & Chenore, T. (2010). Women's preferences for masculinity in male faces are highest during reproductive age range and lower around puberty and post-menopause. *Psychoneuroendocrinology, 35*(6), 912-920. doi: 10.1016/j.psyneuen.2009.12.006

Little, A. C., Connely, J., Feinberg, D. R., Jones, B. C., & Roberts, S. C. (2011a). Human preference for masculinity differs according to context in faces, bodies, voices, and smell. *Behavioral Ecology, 22*(4), 862-868. doi: 10.1093/beheco/arr061

Little, A. C., DeBruine, L. M., & Jones, B. C. (2011b). Exposure to visual cues of pathogen contagion changes preferences for masculinity and symmetry in opposite-sex faces. *Proceedings of the Royal Society B-Biological Sciences, 278*(1714), 2032-2039. doi: 10.1098/rspb.2010.1925

Little, A. C., & Jones, B. C. (2012). Variation in facial masculinity and symmetry preferences across the menstrual cycle is moderated by relationship context. *Psychoneuroendocrinology, 37*(7), 999-1008. doi: 10.1016/j.psyneuen.2011.11.007

Little, A. C. (2013). Multiple motives in women's preferences for masculine male faces: comment on Scott et al. *Behavioral Ecology*, *24*, 590-591.

Little, A. C., Burris, R. O., Petrie, M., Jones, B. C., & Roberts, C. S. (In press). Oral contraceptive use in women changes preferences for male facial masculinity and is associated with partner facial masculinity. *Psychoneuroendocrinology*.

Little, A. C., Burriss, R. P., Petrie, M., Jones, B. C., & Roberts, S. C. (In press). Oral contraceptive use in women changes preferences for male facial masculinity and is associated with partner facial masculinity *Psychoneuroendocrinology*, 1-9.

Marečková, K., Weinbrand, Z., Chakravarty, M. M., Lawrence, C., Aleong, R., Leonard, G., Perron, M., Pike, G. B., Veillette, S., Pausova, Z., & Paus, T. (2011). Testosterone-mediated sex differences in the face shape during adolescence: Subject impressions and objective features. *Hormones and Behavior, 60*, 681-690.

Massar, K., & Buunk, A. P. (2009). Rivals in the mind's eye: Jealous responses after subliminal exposure to body shapes. *Personality and Individual Differences, 46*(2), 129-134. doi: 10.1016/j.paid.2008.09.016

Massar, K., & Buunk, A. P. (2010). Judging a book by its cover: Jealousy after subliminal priming with attractive and unattractive faces. *Personality and Individual Differences, 49*(6), 634-638. doi: 10.1016/j.paid.2010.05.037

McIntyre, M., Gangestad, S. W., Gray, P. B., Chapman, J. F., Burnham, T. C., O'Rourke, M. T., & Thornhill, R. (2006). Romantic involvement often reduces men's testosterone levels--but not always: The moderating role of extrapair sexual interest. *Journal of Personality and Social Psychology, 91*(4), 642-651. doi: 10.1037/0022-3514.91.4.642

Mishra, S., Clark, A., & Daly, M. (2007). One woman's behavior affects the attractiveness of others. *Evolution and Human Behavior, 28*, 145-149.

Moore, F. R., Cornwell, R. E., Law Smith, M. J., Al Dujaili, E. A. S., Sharp, M., & Perrett, D. I. (2011a). Evidence for the stress-linked immunocompetence handicap

hypothesis in human male faces. *Proceedings of the Royal Society B: Biological Sciences, 278*, 774-780.

Moore, F. R., Law Smith, M. J., Taylor, V., & Perrett, D. I. (2011b). Sexual dimorphism in the female face is a cue to health and social status but not age. *Personality and Individual Differences, 50*, 1068-1073.

Nishio, M., & Niimi, S. (2008). Changes in speaking fundamental frequency characteristics with aging. *Folia Phoniatr Logop, 60*, 120-127.

O'Connor, J. J. M., Fraccaro, P. J., Tigue, C. C., & Feinberg, D. R. (2013). *Voice pitch, accent, and socioeconomic status: Multiple cues to mate value within a single modality.* . Manuscript in preparation. McMaster University. Hamilton, ON.

Ohala, J. J. (1982). The voice of dominance. *Journal of the Acoustical Society of America, 72*, S66.

Penton-Voak, I. S., Perrett, D. I., Castles, D. L., Kobayashi, T., Burt, D. M., Murray, L. K., & Minamisawa, R. (1999). Menstrual cycle alters face preference. *Nature, 399*, 741-742.

Penton-Voak, I. S., & Perrett, D. I. (2000). Female preference for male faces changes cyclically: Further evidence. *Evolution and Human Behavior, 21*(1), 39-48. doi: 10.1016/s1090-5138(99)00033-1

Penton-Voak, I. S., Jones, B. C., Little, A. C., Baker, S., Tiddeman, B., Burt, D. M., & Perrett, D. I. (2001). Symmetry, sexual dimorphism in facial proportions and male facial attractiveness. *Proceedings of the Royal Society B: Biological Sciences, 268*(1476), 1617-1623. doi: 10.1098/rspb.2001.1703

Penton-Voak, I. S., Little, A. C., Jones, B. C., Burt, D. M., Tiddeman, B. P., & Perrett, D. I. (2003). Female condition influences preferences for sexual dimorphism in faces of male humans (Homo sapiens). *Journal of Comparative Psychology, 117*(3), 264-271. doi: 10.1037/0735-7036.117.3.264

Penton-Voak, I. S., & Chen, J. Y. (2004). High salivary testosterone is linked to masculine male facial appearance in humans. *Evolution and Human Behavior, 25*(4), 229-241. doi: 10.1016/j.evolhumbehav.2004.04.003

Perrett, D. I., May, K. A., & Yoshikawa, S. (1994). Facial shape and judgements of female facial attractiveness. *Nature, 368*, 239-242.

Perrett, D. I., Lee, K. J., Penton-Voak, I., Rowland, D., Yoshikawa, S., Burt, D. M., Henzil, S. P., Castles, D. L., & Akamatsu, S. (1998). Effects of sexual dimorphism on facial attractiveness. *Nature, 34*, 884-887.

Peters, M., Simmons, L. W., & Rhodes, G. (2008). Testosterone is associated with mating success but not attractiveness or masculinity in human males. *Animal Behaviour, 76*(2), 297-303. doi: 10.1016/j.anbehav.2008.02.008

Pipitone, R. N., & Gallup, G. G., Jr. (2008). Women's voice attractiveness varies across the menstrual cycle. *Evolution and Human Behavior, 29*(4), 268-274. doi: 10.1016/j.evolhumbehav.2008.02.001

Pisanski, K., & Rendall, D. (2011). The prioritization of voice fundamental frequency or formants in listeners' assessments of speaker size, masculinity, and attractiveness. *Journal of the Acoustical Society of America, 129*, 2201-2212.

Pollet, T. V., van der Meij, L., Cobey, K. D., & Buunk, A. P. (2011). Testosterone levels and their associations with lifetime number of opposite sex partners and remarriage in a large sample of American elderly men and women. *Hormones and Behavior, 60*, 72-77.

Pound, N., Penton-Voak, I. S., & Surridge, A. K. (2009). Testosterone responses to competition in men are related to facial masculinity *Proceedings of the Royal Society B: Biological Sciences, 276*, 153-159.

Provost, M. P., Troje, N. F., & Quinsey, V. L. (2008). Short-term mating strategies and attraction to masculinity in point-light walkers. *Evolution and Human Behavior, 29*, 65-69.

Puts, D. A. (2005). Mating context and menstrual phase affect women's preferences for male voice pitch. *Evolution and Human Behavior, 26*(5), 388-397. doi: 10.1016/j.evolhumbehav.2005.03.001

Puts, D. A. (2006). Cyclic variation in women's preferences for masculine traits - Potential hormonal causes. *Human Nature-an Interdisciplinary Biosocial Perspective, 17*(1), 114-127.

Puts, D. A., Gaulin, S. J. C., & Verdolini, K. (2006). Dominance and the evolution of sexual dimorphism in human voice pitch. *Evolution and Human Behavior, 27*(4), 283-296. doi: 10.1016/j.evolhumbehav.2005.11.003

Puts, D. A., Hodges, C. R., Cardenas, R. A., & Gaulin, S. J. C. (2007). Men's voices as dominance signals: vocal fundamental and formant frequencies influence

dominance attributions among men. *Evolution and Human Behavior, 28*(5), 340-344. doi: 10.1016/j.evolhumbehav.2007.05.002

Puts, D. A., Barndt, J. L., Welling, L. L. M., Dawood, K., & Burriss, R. P. (2011). Intrasexual competition among women: Vocal femininity affects perceptions of attractiveness and flirtatiousness. *Personality and Individual Differences, 50,* 111-115.

Puts, D. A., Apicella, C. L., & Cárdenas, R. A. (2012a). Masculine voices signal men's threat potential in forager and industrial societies. . *Proceedings of the Royal Society B: Biological Sciences, 279,* 601-609.

Puts, D. A., Jones, B. C., & DeBruine, L. M. (2012b). Sexual selection on human faces and voices. *Journal of Sex Research, 49*(2-3), 227-243. doi: 10.1080/00224499.2012.658924

Puts, D. A., Bailey, D. H., Cárdenas, R. A., Burriss, R. P., Welling, L. L., Wheatley, J. R., & Dawood, K. (2013). Women's attractiveness changes with estradiol and progesterone across the menstrual cycle. *Hormones and Behavior, 63,* 13-19. doi: 10.1016/j.yhbeh.2012.11.007

Rantala, M. J., Coetzee, V., Moore, F. R., Skrinda, I., Kecko, S., Krama, T., Kivleniece, I., & Krams, I. (2012a). Adiposity, compared with masculinity, serves as a more valid cue to immunocompetence in human mate choice. *Proceedings of the Royal Society B: Biological Sciences, 280,* 1-6.

Rantala, M. J., Moore, F. R., Skrinda, I., Krama, T., Kivleniece, I., Kecko, S., & Krams, I. (2012b). Evidenc for the stress-linked immunocompetence handicap hypothesis in humans. *Nature Communications, 3,* 1-5.

Re, D. E., O'Connor, J. J. M., Bennett, P. J., & Feinberg, D. R. (2012). Preferences for very low and very high voice pitch in humans. *PLoS ONE, 7,* e32719.

Rhodes, G., & Hickford, C. J. L. (2000). Sex-typicality and attractiveness: Are supermale and superfemale faces super-attractive? *British Journal of Psychology, 91,* 125-140.

Rhodes, G., Chan, J., Zebrowitz, L. A., & Simmons, L. W. (2003). Does sexual dimorphism in human faces signal health? *Proceedings of the Royal Society B: Biological Sciences, 270,* S93-S95.

Riding, D., Lonsdale, D., & Brown, B. (2006). The effects of average fundamental frequency and variance of fundamental frequency on male vocal attractiveness to women. *Journal of Nonverbal Behavior, 30*(2), 55-61. doi: 10.1007/s10919-006-0005-3

Röder, S., Fink, B., Feinberg, D. R., & Neave, N. (2013). Facial visualizations of women's voices suggest a cross-modality preference for femininity *Evolutionary Psychology, 11,* 227-237.

Roney, J. R., Hanson, K. N., Durante, K. M., & Maestripieri, D. (2006). Reading men's faces: women's mate attractiveness judgments track men's testosterone and interest in infants. *Proceedings of the Royal Society B: Biological Sciences, 273*(1598), 2169-2175. doi: 10.1098/rspb.2006.3569

Sacco, D. F., Jones, B. C., DeBruine, L. M., & Hugenberg, K. (2012). The roles of sociosexual orientation and relationship status in women's face preferences. *Personality and Individual Differences, 53,* 1044-1047.

Saxton, T. K., Caryl, P. G., & Roberts, S. C. (2006). Vocal and facial attractiveness judgments of children, adolescents and adults: The ontogeny of mate choice. *Ethology, 112*(12), 1179-1185.

Scheib, J. E., Gangestad, S. W., & Thornhill, R. (1999). Facial attractiveness, symmetry and cues of good genes. *Proceedings of the Royal Society B: Biological Sciences, 26,* 1913-1917.

Scott, I., Swami, V., Josephson, S. C., & Penton-Voak, I. S. (2008). Context-dependent preferences for facial dimorphism in a rural Malaysian population. *Evolution and Human Behavior, 29*(4), 289-296. doi: 10.1016/j.evolhumbehav.2008.02.004

Scott, I. M. L., Clark, A. P., Boothroyd, L. G., & Penton-Voak, I. S. (In press). Do men's faces really signal heritable immunocompentence? *Behavioral Ecology*.

Sell, A., Bryant, G. A., Cosmides, L., Tooby, J., Sznycer, D., von Rueden, C., Krauss, A., & Gurven, M. (2010). Adaptations in humans for assessing physical strength from the voice. *Proceedings of the Royal Society B: Biological Sciences, 227*, 3509-3518.

Simmons, L. W., Peters, M., & Rhodes, G. (2011). Low pitched voices are perceived as masculine and attractive but do they predict semen quality in men? *PLoS ONE, 6*(12), e29271 doi: 10.1371/journal.pone.0029271

Smith, F. G., Jones, B. C., DeBruine, L. M., & Little, A. C. (2008). Interactions between masculinity-femininity and apparent health in face preferences. *Behavioral Ecology, 20,* 441-445.

Smith, F. G., Jones, B. C., LIttle, A. C., DeBruine, L. M., Welling, L. L. M., Vukovic, J., & Conway, C. A. (2009). Hormonal contraceptive use and perceptions of trust modulate the effect of relationship context on women's preferences for sexual dimorphism in male face shape. *Journal of Evolutionary Psychology, 7,* 195-210.

Stathopoulos, E. T., Huber, J. E., & Sussman, J. E. (2011). Changes in acoustic characteristics of the voice across the life span: Measures from individuals 4-93 years of age. *Journal of Speech, Language, and Hearing Research, 54,* 1011-1021.

Tanner, J. M. (1978). *Foetus into man: Physical growth from conception to maturity.* London: Open Books.

Thornhill, R., & Gangestad, S. W. (1996). The evolution of human sexuality. *Trends in Ecology & Evolution, 11*.

Thornhill, R., & Gangestad, S. W. (2006). Facial sexual dimorphism, developmental stability and parasitic infections in men and women. *Evolution and Human Behavior, 27,* 131-144.

Titze, I. R. (1994). *Principles of voice production*. Englewood Cliffs, NJ: Prentice Hall.

Trainor, L. J., & Zacharias, C. A. (1998). Infants prefer higher-pitched singing. *Infant Behaviour and Development, 21*(799-806).

Tusing, K. J., & Dillard, J. P. (2000). The Sound of Dominance: Vocal precursors of perceived dominance during interpersonal influence. . *Human Communication Research, 26,* 148-171.

Tybur, J. M., & Gangestad, S. W. (2011). Mate preferences and infectious disease: Theorectical considerations and evidence in humans. *Philosophical Transactions of the Royal Society B: Biological Sciences, 366,* 3375-3388.

van Anders, S. M., Hamilton, L. D., & Watson, N. V. (2007). Multiple partners are associated with higher testosterone in North American men and women. *Hormones and Behavior, 51*(3), 454-459. doi: 10.1016/j.yhbeh.2007.01.002

van Anders, S. M. (2010). Gonadal steroids and salivary IgA in healthy young women and men. *American Journal of Human Biology, 22,* 348-352.

van Anders, S. M., & Goldey, K. L. (2010). Testosterone and partnering are linked via relationship status for women and 'relationship orientation' for men. *Hormones and Behavior, 58,* 820-826.

Venners, S. A., Liu, X., Perry, M. J., Korrick, S. A., Li, Z., Yang, F., Yang, J., Lasley, B. L., Xu, X., & Wang, X. (2006). Urinary estrogen and progesterone metabolite concentrations in menstrual cucles of fertile women with non-contraception, early pregnancy loss or clinical pregnancy. *Human Reproductions, 21,* 2272-2280.

Verdonck, A., Gaethofs, M., Carels, C., & De Zegher, F. (1999). Effect of low-dose testosterone treatment on craniofacial growth in boys with delayed puberty. *European Journal of Orthodontics, 21,* 137-143.

Vukovic, J., Feinberg, D. R., Jones, B. C., DeBruine, L. M., Welling, L. L. M., Little, A. C., & Smith, F. G. (2008). Self-rated attractiveness predicts individual differences in women's preferences for masculine men's voices. *Personality and Individual Differences, 45*(6), 451-456. doi: 10.1016/j.paid.2008.05.013

Vukovic, J., Feinberg, D. R., DeBruine, L. M., Smith, F. G., & Jones, B. C. (2010a). Women's voice pitch is negatively correlated with health risk factors. *Journal of Evolutionary Psychology, 21*(4), 767-772.

Vukovic, J., Jones, B. C., DeBruine, L., Feinberg, D. R., Smith, F. G., Little, A. C., Welling, L. L. M., & Main, J. (2010b). Women's own voice pitch predicts their preferences for masculinity in men's voices. *Behavioral Ecology, 21*(4), 767-772. doi: 10.1093/beheco/arq051

Vukovic, J., Jones, B. C., Feinberg, D. R., DeBruine, L. M., Smith, F. G., Welling, L. L. M., & Little, A. C. (2011). Variation in perceptions of physical dominance and trustworthiness predicts individual differences in the effect of relationship context on women's preferences for masculine pitch in men's voices. *British Journal of Psychology, 102*(37-48). doi: 10.1348/000712610x498750

Watkins, C. D. (2011). Reproductive ambition predicts partnered, but not unpartnered, women's preferences for masculine men. *British Journal of Psychology, 103*, 317-329.

Welling, L. M., Jones, B. C., DeBruine, L. M., Smith, F. G., Feinberg, D. R., Little, A. C., & Al-Dujaili, E. A. S. (2008). Men report stronger attraction to femininity in

women's faces when their testosterone levels are high. *Hormones and Behavior, 54*, 703-708.

Wolff, S. E., & Puts, D. A. (2010). Vocal masculinity is a robust dominance signal in men. *Behavioral Ecology and Sociobiology, 64*, 1673-1683.

Zuckerman, M., & Miyake, K. (1993). The attractive voice - what makes it so. *Journal of Nonverbal Behavior, 17*(2), 119-135. doi: 10.1007/bf01001960