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Filipino Women's Preferences for Male Voice Pitch: Intra-Individual, Life History, and Hormonal Predictors

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Abstract Prior work suggests that women's preferences for sexually dimorphic traits, such as preferences for masculine facial and vocal characteristics, may be modulated by a multitude of factors related to reproductive potential including breastfeeding status. In the present study, we investigated women's preferences for a highly sexually dimorphic vocal characteristic, voice pitch, across a sample of nulliparous ($n = 65$) and breastfeeding ($n = 63$) women in Manila, Philippines. We examined whether preferences for pitch were related to breastfeeding status, age, relationship status, self-rated attractiveness, or salivary steroid hormone concentrations. Both nulliparous and breastfeeding women displayed preferences for feminized, rather than masculinized, pitch. The strength of this preference was negatively associated with age and negatively associated with self-rated attractiveness, but was unrelated to breastfeeding and relationship status. Estradiol and progesterone positively interacted in predicting pitch preferences, such that estradiol tended to negatively predict preferences for masculinized pitch when progesterone was low, and to positively predict preferences when progesterone was high. Our findings reinforce the notion that reproductive potential predicts preferences for sexually dimorphic traits, and emphasize importance of assessing measures of reproductive potential when evaluating mate preferences.

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Many anthropoid primates exhibit sexually differentiated vocalizations, including sexually dimorphic vocal acoustic parameters (Puts et al. 2016). In humans, acoustic dimorphisms are due in part to the actions of pubertal androgens on vocal tract development (Fitch and Giedd 1999; Titze 1989). Testosterone causes vocal fold thickening and elongation, leading to a lower rate of vibration during phonation (fundamental frequency, F_0), which we perceive as a lower pitch. There is little overlap between the sexes in F_0; men's average speaking F_0 is more than 5 standard deviations (SD) below women's (Puts et al. 2012a; Titze 1989), a very large difference by conventional standards (Cohen 1988; Lakens 2013).

F_0 may indicate men's underlying condition to potential mates. For example, meta-analysis indicates a correlation between F_0 masculinity and height of 0.10 (Pisanski et al. 2014a), and F_0 may also predict strength (Hodges-Simeon et al. 2014; Puts et al. 2012a; but see Han et al. 2017). To the extent that F_0 is testosterone-dependent (Dabbs and Mallinger 1999; Puts et al. 2012a, 2016), it may also indicate underlying genetic quality (Folstad and Karter 1992; Puts et al. 2016; Thornhill and Gangestad 1999, 2006; Hodges-Simeon et al. 2015). Indeed, in two samples, Puts et al. (2016) found an interaction between cortisol and testosterone in predicting men's F_0, such that a low F_0 was more strongly related to higher testosterone levels in men whose cortisol was low. This result accords well with the stress-linked immunocompetence handicap hypothesis that both cortisol and testosterone will mediate relationships between immunocompetence and the expression of male secondary sex traits (Evans et al. 2000; Folstad and Karter 1992; see also Rantala et al. 2012).

Consonant with the proposal that a low F_0 indicates male condition, women have been found to prefer lower male F_0 (Collins 2000; Feinberg et al. 2011; Feinberg et al. 2005; Hodges-Simeon et al. 2010; Pisanski and Rendall 2011; Puts et al. 2016). The magnitude of women's preferences for F_0 may be moderated by a host of factors. Women's self-rated mate value or attractiveness may modulate masculinity preferences for sexually dimorphic faces (Little et al. 2001; Little and Mannion 2006; Penton-Voak et al. 2003) and voices (Feinberg et al. 2012; Vukovic et al. 2008), such that women with higher self-ratings exhibit stronger preferences for masculine features, as they may be able to better retain mates with masculine features than would women with low mate value.

At the intraindividual level, preferences for masculine features may be modulated by ovulatory cycle phase and mating context in a pattern consistent with a function in recruiting genetic benefits for offspring. Specifically, during the fertile phase of the ovulatory cycle, women have been found to prefer voices masculinized in both pitch and formants (Feinberg et al. 2006; Puts 2005, 2006), and this was particularly true of women's preferences for men in a short-term, purely sexual mating context, as opposed to a long-term, committed relationship (Puts 2005). The ovulatory shift hypothesis (reviewed in Gildersleeve et al. 2014; but see Harris 2011, 2013) posits that cyclic shifts in women's mate preferences evolved to recruit genes from males of high genetic quality during the fertile window when conception is possible. Such cyclic shifts in women's preferences may be driven by changes in estradiol (Pisanski et al. 2014b; Roney and Simmons 2008; Roney et al. 2011; but see Escasa-Dorne et al. 2016; Marcinkowska et al. 2016), testosterone (Bobst et al. 2014; Welling et al. 2007; but see Escasa-Dorne et al. 2016) and progesterone (Jones et al. 2006; Puts 2006).

However, the potential benefits of mating with masculine males may be offset by associated costs, including lower investment in mates and offspring and a greater risk of physical aggression and coercion from masculine males. For instance, some studies report negative relationships between testosterone and men's paternal investment (Alvergne et al. 2009; Gettler et al. 2015; Muller et al. 2009). Other studies report greater interest in uncommitted sex by men with higher testosterone levels (Edelstein et al. 2011; Puts et al. 2015; van Anders et al. 2007). To the extent that masculinized phenotypes such as voices and faces reflect androgen levels (Dabbs and Mallinger 1999; Evans et al. 2006; Penton-Voak and Chen 2004; Puts et al. 2016, 2012a), these phenotypes may also provide information about men's investment potential. Moreover, testosterone and testosterone-driven phenotypes have been linked to higher levels of dominance, aggression, and coercion (Archer 2006; Mazur and Booth 1998; Puts et al. 2006). Importantly, Li et al. (2014) found that viewing images of male-on-female violence disrupted women's preferences for both masculine faces and voices.

If women's preferences for masculine phenotypes function to recruit mates with genes that confer disease resistance, as theory suggests (Folstad and Karter 1992; Rantala et al. 2012), then women's preferences for masculine phenotypes may be stronger in environments where high genetic quality is more closely linked to survival. Across 30 countries with varying life expectancies, mortality rates, and impacts of communicable disease, women's preferences for masculinized faces increased as national health decreased (DeBruine et al. 2010). However, the converse has also been found: in countries ranking higher on United Nations indices of development and urbanization, women exhibited stronger preferences for masculinized faces (Scott et al. 2014). Thus, the environmental factors that influence the magnitude and direction of women's masculinity preferences require further study (for review of cross-cultural preferences for masculinity, see Pisanski and Feinberg 2013).

The potential costs of mating with masculine men may help explain why women may exhibit reduced masculinity preferences in the non-fertile phase of the ovulatory cycle when genetic benefits cannot offset these costs. Similarly, pregnant women and women with lactational amenorrhea would tend to experience a high cost/benefit ratio when mating with masculine men, as these women could not obtain genetic benefits. If ancestral women spent much of their reproductive years either pregnant or lactating, as do women in natural fertility populations today (Jasienska 2012), then women's preferences may have evolved to fluctuate not only across the ovulatory cycle, but also between episodes of cycling and episodes of pregnancy and lactational amenorrhea (Puts 2006; Roney and Simmons 2016).

Breastfeeding requires as much as 626 additional calories per day, exceeding the energetic requirements of pregnancy (Butte and King 2005). For approximately six months postpartum, breastfeeding women experience lactational amenorrhea (World Health Organization Task Force on Methods for the Natural Regulation of Fertility 1998), as breast stimulation by the infant suppresses GnRH secretion (Smith et al. 2010), decreasing LH levels below those needed for ovulation. GnRH is also required for the production of estradiol and testosterone, both of which are lower in breastfeeding women (McNeilly 2001). Decreased libido and sexual behavior during lactation (Avery et al. 2000; but see Tolor and DiGrazia 1976), along with energetic and hormonal changes, suggest decreased mating effort and increased parenting effort

(Vitzthum 2008). Consequently, like women in the non-fertile phase of the ovulatory cycle, breastfeeding women may exhibit heightened preferences for males with traits indicative of paternal investment and care (Puts 2006). Studies have shown that breastfeeding women show decreased preferences for facial masculinity (Cobey et al. 2015; Escasa-Dorne et al. 2016; Marcinkowska et al. 2017b) as well as voice pitch masculinity. Specifically, among Hadza foragers of Tanzania, breastfeeding women exhibited preferences for higher pitched male voices compared to women not currently breastfeeding (Apicella and Feinberg 2009); however, it is unknown whether this finding would replicate in other cultures, or whether the effect of breastfeeding status would remain when controlling for other important intra-individual modulators of voice pitch preferences such as self-rated attractiveness and hormone concentrations.

Thus, in the present study, we aimed to replicate and extend the findings of Apicella and Feinberg (2009) by exploring whether women's preferences for masculine voice pitch are modulated by breastfeeding status among nulliparous and breastfeeding women in Manila, Philippines. Further, we examined whether intra-individual differences in self-rated attractiveness and concentrations of estradiol, testosterone, and progesterone predict women's preferences for men's voices and mediate any effects of breastfeeding status.

Method

Study Site

All data were collected in the greater metropolitan Manila, Philippines area, including the cities Quezon City, Marakina, Taguig, and Mandaluyong. This area affords a large population with a high long-term lactation rate and low contraceptive use (Philippines National Statistics Office 2009). Participants were recruited from a number of breastfeeding support and teaching groups ("lactation centers") and neighborhood health centers ("barangays").

All materials (informed consent form, questionnaire, and audio instructions) were translated into Tagalog, but the option to complete forms in English was offered to all participants. Both English and Tagalog prompts were displayed during the voice preference task. The University of Nevada, Las Vegas (UNLV) Institutional Review Board approved all study materials and protocols, and the Marakina Health District provided on-site approval.

Participants

Participating women ($n = 128$) were between the ages of 18 and 38 (M = 24.5, SD = 5.2), heterosexual (per self-report), and not currently using hormonal contraceptives. Women provided self-reports of relationship status with the two options being currently in a relationship, or not currently in a relationship; 'relationship' was not further defined for participants. For the purposes of the present study, women with disorders shown to interact with sex steroid levels (e.g., thyroid disorders, polycystic ovary syndrome) were not recruited. All participants were given four kg of brown rice, a snack (either a vegetable/rice bowl or a pastry) and a drink (bottle of water, coconut juice, or fruit

juice) for participating. The approximate price of the compensation was US $10.00. The following groups of women were recruited to participate in this experiment.

Breastfeeding Group Sixty-three postpartum women with children between 1.5 to 18 months were recruited. The average age of the breastfed child was 9.7 months (SD = 5.2). All women were in a relationship and currently breastfeeding. Thirty-one women were amenorrheic, whereas 26 women had resumed menstrual cycles per self-report; this information was unavailable for three women.

Nulliparous Group Sixty-five cycling, nulliparous women were recruited to serve as a comparison group. Women were considered cycling if they had never given birth, were not currently on hormonal contraceptives, and did not have diagnosed medical conditions that influence sex steroid levels. Participants for the nulliparous cycling group were recruited from health centers, local schools, and churches.

Saliva Collection and Hormone Assays

Saliva samples were collected after participants provided informed consent. Each participant was first asked to drink a small amount of water to cleanse the mouth of any foreign particulates. Participants then provided a 1-ml saliva sample in a cryovial tube via passive drool, i.e., drooling through a straw placed in the cryovial tube rather than attempting to force the production of saliva. All samples were collected between 8 AM and 1 PM. Samples were immediately transported in a cooler to a − 20 º C freezer where they were stored until hormonal analysis. Samples were shipped overnight on dry ice to the UNLV Evolution and Human Behavior Lab, where they were analyzed using commercially available kits (Salimetrics LLC, State College, PA). Samples were assayed in batches and run in duplicate. Inter-assay coefficients of variation were 3.3% and 3.0% for testosterone, 7.8% and 4.3% for estradiol, and 11.7% and 14.7% for progesterone. The intra-assay coefficients of variation were 4.2% for testosterone, 7.3%, for estradiol, and 3.4% for progesterone. Hormone concentrations were skewed and thus natural log-transformed and z-scored for all analyses. Values greater than 3 SD from the mean were winsorized for analyses, which entails substituting these values with the highest observed value within 3 SD of the mean (Wilcox 2001). This was done for one progesterone and one estradiol value.

Voice Preferences

Participants completed a voice preference task by listening to male voices played on a Lenovo laptop computer using Sennheiser HD201 over-ear headphones. Samples of six male voices were obtained from a previous study (Puts et al. 2012a) in which men were recorded reading an excerpt from a standard voice passage, the Rainbow Passage (Fairbanks 1960). Participants heard the first sentence of the excerpt (approximately 4 s), as follows: "When the sunlight strikes raindrops in the air, they act as a prism and form a rainbow." Men were recorded reading the excerpt in an anechoic, soundproof booth using a Shure SM58 vocal cardioid microphone. A curved wire projection from the microphone stand kept the participant's mouth approximately 9.5 cm from the

microphone. Voices were recorded into a computer using Goldwave software in mono at a sampling rate of 44,100 Hz and 16-bit quantization, and saved as uncompressed ".wav" files.

Voice files were then manipulated to produce stimuli that were feminized or masculinized in pitch compared to the original voices in Praat 5.1.17. This resulted in voice pairs averaging a masculinized pitch of 99.67 (SD = 14.12) Hz and a feminized pitch of 141.31 (SD = 17.48) Hz, a difference corresponding to approximately five times the just-noticeable-difference (JND; Pisanski and Rendall 2011; Puts et al 2007). The entire sound spectrum was shifted up or down without affecting tempo, and any artefactual spectral changes were corrected by manipulating formant frequencies back via Praat's "gender shift" function until formant dispersion change was below the JND (Pisanski and Rendall 2011; Puts et al. 2007). Parameters were set to a pitch floor of 75 Hz, pitch ceiling of 300 Hz, and otherwise to default.

The resulting 12 manipulated voice files were presented in random order. Participants were instructed to rate how handsome or physically attractive they considered the individual speaking using a 5-point Likert scale, with endpoints labeled 1 (very unattractive) and 5 (very attractive).

Self-Rated Attractiveness

Women rated how attractive they considered their faces, bodies, and how attractive they considered themselves overall on 5-point Likert scales. Attractiveness self-ratings were strongly intercorrelated ($0.68 < r < 0.73$, Cronbach's $\alpha = 0.87$); consequently, we z-scored and summed them to create a composite self-rated attractiveness score used in analyses.

Statistical Analyses

All data were analyzed using SPSS v.23. Univariate analysis of variance (ANOVA) was used to test for group differences in age and hormone concentrations. To determine the effects of pitch manipulation, breastfeeding status, relationship status, age, self-rated attractiveness, and their interactions on ratings, we conducted a mixed-model repeated-measures ANOVA (see Results for a full description of the model). In cases where significant differences were found, post hoc tests were conducted to elucidate the nature of these differences. A second repeated-measures ANOVA was conducted with log-transformed estradiol and progesterone concentrations entered as covariates to elucidate the effect of hormones on pitch preferences. Mediation analyses (Preacher and Hayes 2004, 2007) were conducted using the PROCESS procedure in SPSS to determine whether any significant differences were mediated by estradiol, testosterone, and progesterone. More specifically, mediation analyses test whether a variable that is not the independent or dependent variable, when added to the model, diminishes the effect of the independent variable on the dependent variable. In such analyses, variables are considered to significantly mediate the relationship between the independent and dependent variable if the 95% confidence interval (CI) for the proposed mediator variable does not include zero. Estimates and 95% CIs for proposed mediator variables were calculated using bootstrap resamplings (b = 5000) of the data. Type 1 error rate

was set a priori to 0.05. Effect sizes from ANOVAs are reported as η^2 and are interpreted as 0.01, 0.06, and 0.14 being small, medium, and large, respectively (Cohen 1988).

Results

Individual Differences

Testosterone concentrations were higher in nulliparous women than in breastfeeding, cycling ($t(69) = 3.24$, $p < 0.01$) and breastfeeding, amenorrheic ($t(72) = 3.49$, $p < 0.01$) women. Likewise, estradiol levels were higher in nulliparous women than in breastfeeding, cycling ($t(72) = 2.31$, $p = 0.02$) and in breastfeeding, amenorrheic ($t(74) = 5.65$, $p < 0.01$) women. Progesterone levels were higher in nulliparous women than in breastfeeding, amenorrheic women ($t(85) = 2.87$, $p = 0.01$) but not breastfeeding, cycling women ($t(84) = 1.78$, $p = 0.08$). However, testosterone ($t(49) = -0.04$, $p = 0.98$), estradiol ($t(51) = 1.57$, $p = 0.12$), and progesterone ($t(50) = 1.25$, $p = 0.22$) concentrations did not differ between breastfeeding, cycling and breastfeeding, amenorrheic women; thus, breastfeeding, cycling and breastfeeding, amenorrheic women were combined into a single group for all analyses.

Breastfeeding women were older than nulliparous women ($F(1,125) = 26.8$, $p < 0.01$, $\eta^2 = 0.18$) and had lower testosterone ($F(1,101) = 21.0$, $p < 0.01$, $\eta^2 = 0.17$) and estradiol ($F(1,104) = 20.1$, $p < 0.01$, $\eta^2 = 0.16$) levels, as expected (Hendrick et al. 1998; Petrakis et al. 1987). Progesterone levels were also lower in breastfeeding women than in nulliparous women ($F(1,101) = 12.20$, $p < 0.01$, $\eta^2 = 0.09$). Breastfeeding women were more likely to report currently being in a relationship than were nulliparous women (100% vs. 28.33%, respectively; $\chi^2(1) = 67.87$, $p < 0.01$). There was no significant difference between nulliparous and breastfeeding women in self-rated attractiveness ($F(1,124) = 0.45$, $p = 0.50$, $\eta^2 < 0.01$) or in sexual desire ($F(1,115) = 3.2$, $p = 0.07$, $\eta^2 = 0.03$), as measured by the Female Sexual Functioning Index (FSFI; Rosen et al. 2000). Per self-report, nulliparous women were taller than breastfeeding women ($F(1,125) = 8.0$, $p = 0.01$, $\eta^2 = 0.06$), though body mass index (calculated by dividing weight in kilograms by height in meters^2) did not differ significantly between groups ($F(1,16) = 0.02$, $p = 0.88$, $\eta^2 < 0.01$). See Table 1 for sample demographic information.

Voice Ratings

To predict voice ratings, we used a mixed-model repeated-measures ANOVA, with voice manipulation as a within-subjects factor having two levels (feminized vs. masculinized pitch), breastfeeding status and relationship status as between-subjects factors, and age and self-rated attractiveness as covariates. There was a significant main effect of voice manipulation on women's ratings, such that feminized voices were rated as more attractive than masculinized voices ($F(1,110) = 24.99$, $p < 0.01$, $\eta^2 = 0.16$; Fig. 1). The main effect of breastfeeding group was almost significant ($F(1,110) = 3.51$, $p = 0.06$, $\eta^2 = 0.02$), such that breastfeeding women gave higher overall voice ratings (i.e., average ratings for both masculinized and feminized voices combined) than did nulliparous women; however, there was no significant interaction between group and

Table 1 Participant demographic information

	Nulliparous group ($n = 65$)	Breastfeeding group ($n = 63$)
Mean age in years (SD)*	22.51 (4.33)	26.94 (5.28)
Relationship Status*		
Currently in a relationship	28.3%	100%
Menstruation*		
Cycling	100%	48.3%
Not cycling (amenorrheic)	0%	51.7%
Testosterone pg/mL (SD)*	71.02 (28.48)	49.55 (18.70)
Estradiol pg/mL (SD)*	1.93 (0.75)	1.22 (1.04)
Progesterone pg/mL (SD)*	91.34 (90.13)	44.42 (50.66)
Mean number of children (SD)	n/a	2.74 (1.72)
Mean age of youngest child in months (SD)	n/a	9.61 (5.05)
Mean Female Sexual Function Index desire (SD)	4.20 (2.39)	4.84 (1.43)
Mean BMI (SD)	16.67 (6.95)	16.47 (7.18)
Mean height (SD)*	62.20 (2.36)	61.06 (2.15)

*Indicates significant ($p < 0.05$) difference between nulliparous and breastfeeding groups

pitch manipulation ($F(1,110) = 0.08$, $p = 0.78$, $\eta^2 < 0.01$), indicating that pitch preferences did not differ between groups. There were no main effects of relationship status ($F(1,110) = 0.78$, $p = 0.38$, $\eta^2 < 0.01$) or age ($F(1,110) = 1.77$, $p = 0.19$, $\eta^2 = 0.02$). There was a significant main effect of self-rated attractiveness ($F(1,110) = 4.38$, $p = 0.04$, $\eta^2 = 0.04$), such that self-rated attractiveness was positively correlated with mean voice ratings ($r = 0.19$, $p = 0.04$). There was a significant interaction between pitch manipulation and age ($F(1,110) = 3.91$, $p = 0.047$, $\eta^2 < 0.01$) and self-rated attractiveness ($F(1,110) = 5.85$, $p = 0.02$, $\eta^2 = 0.04$), but not relationship status ($F(1,110) = 0.33$, $p = 0.56$, $\eta^2 < 0.01$).

To elucidate the interactions between pitch manipulation and age and self-rated attractiveness, we calculated z-scores for women's ages and self-rated attractiveness scores, and graphed voice ratings for women ranking 1 SD above the mean and 1 SD below the mean for each variable (Fig. 2). Visual inspection indicates that a preference for feminized pitch was stronger in younger women, mainly because they exhibited an aversion to masculinized pitch. Visual inspection of the interaction between self-rated attractiveness and pitch preferences indicates that women self-rated as lower in attractiveness displayed a stronger preference for feminized pitch, again mainly because they rated masculinized voices less favorably.

We then examined the relationships between voice ratings and estradiol, testosterone, and progesterone. Estradiol, testosterone, progesterone, and estradiol × progesterone were entered as covariates into a mixed-model ANOVA, and ratings of masculinized and feminized pitch were entered as repeated measures. There were no main effects of estradiol ($F(1,86) = 1.67$, $p = 0.20$, $\eta^2 = 0.02$), testosterone ($F(1,86) = 0.06$, $p = 0.82$, $\eta^2 < 0.01$), or progesterone ($F(1,86) = 1.33$, $p = 0.25$, $\eta^2 = 0.02$) on overall ratings, nor were there significant interactions between pitch manipulation and estradiol ($F(1, 86) = 1.05$, $p = 0.31$, $\eta^2 = 0.01$), testosterone ($F(1,86) = 0.14$, $p = 0.71$, $\eta^2 < 0.01$),
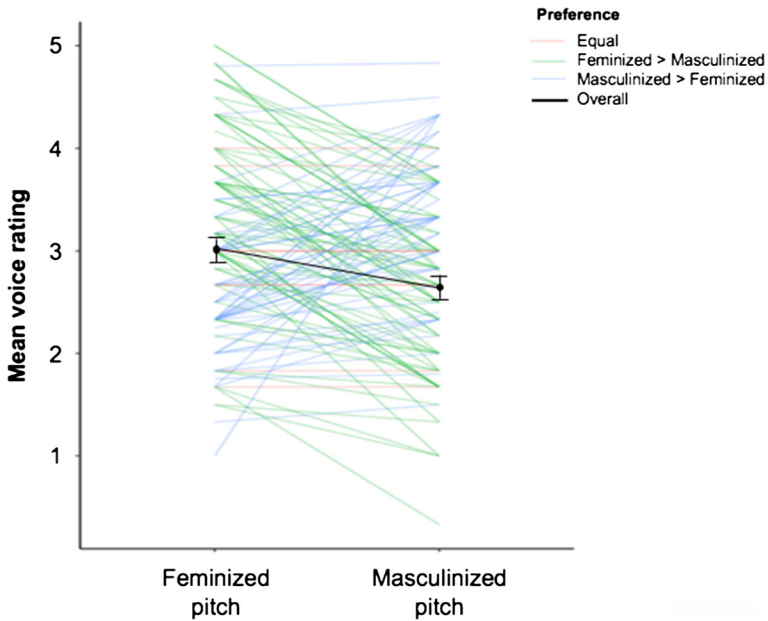
Fig. 1 Mean ratings of masculinized and feminized voices (*x*-axis). Each line represents one participant. Line color indicates preference for feminized pitch (green), masculinized pitch (blue), or no preference (red)

or progesterone ($F(1, 86) = 0.49$, $p = 0.48$, $\eta^2 < 0.01$). However, there was a significant estradiol × progesterone × pitch manipulation interaction ($F(1, 86) = 6.53$, $p = 0.01$, $\eta^2 = 0.08$). As estradiol × progesterone interactions are suggestive of ovulatory cycle effects, we explored whether this effect was present in all women, or only those experiencing regular menstrual cycles. Hence, we re-ran the above analysis, including participant group as a between-subjects factor. Only breastfeeding, amenorrheic and nulliparous women were included in this analysis, as the first several cycles after the cessation of lactational amenorrhea are often irregular and anovulatory (reviewed in Ellison 2003). The estradiol × progesterone × pitch manipulation interaction remained
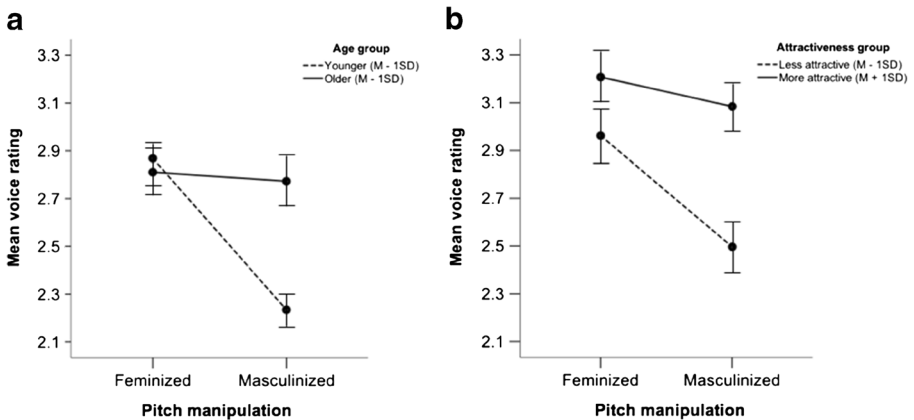

Fig. 2 Pitch preferences as a function of age (**a**) and self-rated attractiveness (**b**). Younger women and women who rated themselves lower in attractiveness showed a preference for feminine pitch in men's voices

statistically significant ($F(1, 59) = 4.38$, $p = 0.04$, $\eta^2 = 0.07$), but estradiol, progesterone, pitch manipulation, and participant group did not interact ($F(1, 59) = 0.16$, $p = 0.69$, $\eta^2 < 0.01$), indicating that the estradiol × progesterone interaction on pitch preferences did not differ as a function of whether women were cycling. We also ran this analysis with breastfeeding status (nulliparous versus both breastfeeding groups) as a between-subjects factor. Again, the estradiol × progesterone × pitch manipulation interaction remained statistically significant ($F(1, 86) = 7.30$, $p = 0.01$, $\eta^2 < 0.09$), and estradiol, progesterone, pitch manipulation, and participant group did not interact ($F(1, 86) = 0.66$, $p = 0.42$, $\eta^2 < 0.01$). Consequently, all women were combined for posthoc analyses. Posthoc regressions conducted to visualize this interaction suggested that estradiol tended to predict pitch preferences negatively among women with below-median progesterone and positively among women with above-median progesterone (Fig. 3).

Finally, we ran a series of mediation analyses to clarify the observed effects of group, attractiveness, and age. Estradiol, testosterone, and progesterone did not mediate the main effect of participant group; further, they did not mediate the interaction between attractiveness and formant manipulation, or the interaction between age and pitch manipulation. Age did not mediate the interaction between attractiveness and pitch manipulation, and attractiveness did not mediate the interaction between age and pitch manipulation; these results are summarized in Table 2.

Discussion

Recent work has examined women's preferences primarily for sexually dimorphic aspects of the voice, particularly fundamental frequency, as well as the inter-individual variables that modulate women's vocal preferences (for review, see Puts et al. 2012b). Apicella and Feinberg (2009) found in a hunter-gatherer population that breastfeeding women exhibited weaker preferences for masculinized voice pitch in long-term mating context than did nulliparous women. The authors interpreted this effect to indicate that breastfeeding women place a relatively high value on paternal investment and resource acquisition compared to genetic benefits (Gangestad et al. 2005; Jones et al. 2006). We were not able to replicate these findings in our sample of
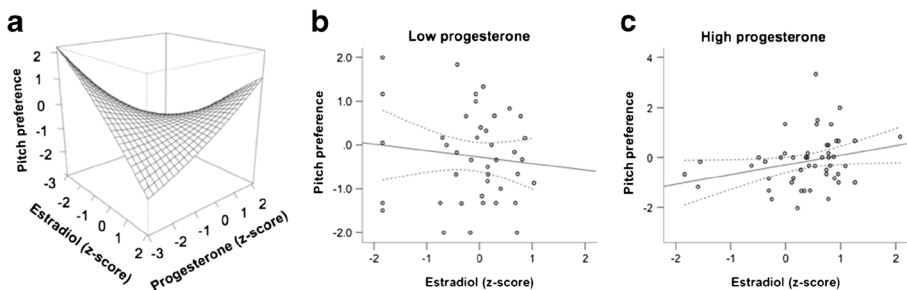

Fig. 3 Estradiol and progesterone positively interacted in predicting pitch preferences. Pitch preferences were calculated as ratings of masculinized pitch minus ratings of feminized pitch; hence, positive values indicate a greater preference for masculinized pitch. Panels (b) and (c) represent women with progesterone levels below and above, respectively, the sample median

Table 2 Summary of mediation analyses

Predictor	Proposed mediator	Outcome	Indirect effect	SE	95% CI
Group	Estradiol	Overall ratings	−0.06	0.07	−0.21 - 0.06
Group	Testosterone	Overall ratings	0.02	0.07	−0.16 – 0.11
Group	Progesterone	Overall ratings	0.001	0.03	−0.07 – 0.05
Attractiveness	Estradiol	Pitch pref	−0.001	0.006	−0.01 – 0.01
Attractiveness	Testosterone	Pitch pref	0.001	0.004	−0.01 – 0.01
Attractiveness	Progesterone	Pitch pref	0.002	0.004	−0.01 – 0.01
Age	Estradiol	Pitch pref	0.003	0.004	−0.01 – 0.01
Age	Testosterone	Pitch pref	−0.001	0.005	−0.07 – 0.005
Age	Progesterone	Pitch pref	0.001	0.003	−0.004 – 0.01
Attractiveness	Age	Pitch pref	0.001	0.03	−0.003 – 0.01
Age	Attractiveness	Pitch pref	0.001	0.006	−0.01 – 0.02

women from the Philippines; rather, we found that both nulliparous and breastfeeding women preferred feminized voice pitch over masculinized voice pitch, and that the extent to which feminized voice pitch was preferred did not differ between nulliparous and breastfeeding women.

Inter-individual and cross-cultural factors may modulate women's voice preferences, explaining some of the discrepancies in studies of women's vocal preferences. In prior work, women's self-rated attractiveness positively predicted their preferences for masculinized vocal pitch (Vukovic et al. 2008). Similarly, in the present study, women who rated themselves as more attractive rated voices masculinized in pitch more highly—and as a consequence, less strongly preferred feminized voices—than did women who rated themselves as less attractive. Age showed a similar pattern, such that older women exhibited a stronger preference for masculinized pitch relative to younger women (see also Pisanski et al. 2014b). This was driven by the fact that younger women exhibited a marked preference for feminized pitch, whereas older women rated voices with masculinized and feminized pitch similarly. This effect could be explained by the fact that pitch is negatively associated with biological age (Benjamin 1981) as well perceptions of age (Feinberg et al. 2005), and older women may prefer older-sounding voices. Alternatively, older women, and perhaps also more attractive women, may be less susceptible to coercion by masculine men if their age or attractiveness affords them social power and makes them less dependent on a particular mate. This may be indirectly supported by studies indicating higher levels of sexual coercion in cultures where women are granted low status (Sanday 1981), and empirical cross-cultural work finding a negative association between sexual coercion victimization and age (Hines 2007). We also found an almost significant effect of breastfeeding group, such that breastfeeding women tended to rate all voices overall as being more attractive than did nulliparous women. Though speculative, one explanation is that this effect is in part due to cultural expectations of women in the Philippines. Unmarried, nulliparous women in the Philippines are generally expected to be less interested in sexual behaviors, and therefore may exhibit less enthusiasm for mate selection and mating-related behaviors in general. Supporting this point, nulliparous women reported lower

sexual desire than did breastfeeding women (see Table 1). Thus, it is possible that the cultural expectation of nulliparous women to be virginal and less interested in mating-related behaviors contributed to their lower self-reported sexual functioning and ratings of men's voices compared to those of breastfeeding women; however, contrary to this point, there was no effect of relationship status on women's preferences. Further, when participants were collapsed across groups, post hoc analyses suggested no main effect of sexual desire as a significant modulator of overall voice ratings (see ESM).

We were unable to replicate previously reported effects of breastfeeding status on pitch preferences (Apicella and Feinberg 2009). Though the literature on women's mate preferences across different life history stages is growing (Cobey et al. 2015; Escasa-Dorne et al. 2016; Marcinkowska et al. 2017b), future work is required to elucidate to what extent various preferences change across life history stages, and what biological mechanisms and sociocultural factors modulate these changes. It is possible that our results diverge from those of Apicella and Feinberg (2009) due to sample differences in disease burden, morbidity and mortality rates, and indices of urbanization and development, among others. Studies have produced conflicting results as to the direction in which preferences are shifted based on these factors. Whereas indices of societal health negatively predicted women's preferences for masculinized faces across 30 nations (DeBruine et al. 2010), a second study found a positive association between indices of urbanization and development and preferences for masculinized faces (Scott et al. 2014), though neither study included a sample from the Philippines. The area from which participants were recruited ranks as medium and high, respectively, in indices of urbanization and development such as the Human Development Index (HDI) used in the analyses in Scott et al. (2014). As a whole, the Philippines has relatively low life expectancies and high infant mortality (UNICEF 2013), though life expectancies may be higher, and infant mortality lower, in highly urbanized areas, such as the Manila metropolitan area. Women exhibiting preferences for feminized pitch in a highly developed and urbanized area with relatively strong health indices is consistent with the hypotheses and findings of DeBruine et al. (2010), who proffer that as masculinized phenotypes may be associated with men's heritable disease resistance, women should exhibit stronger preferences for markers of genetic quality in environments with high disease burden. Indeed, in addition to the preference for feminized pitch, women in the Manila metropolitan area also exhibit a preference for feminized faces, regardless of breastfeeding status (Escasa-Dorne et al. 2016). Low disease burden and urbanization indices of Manila (Philippines National Statistics Office 2009) may in part explain why we did not observe a significant interaction between group and pitch manipulation. Though it has been suggested that women should exhibit stronger preferences for traits indicative of paternal investment and care when conception risk is low, and stronger preferences for traits indicative of men's health and genetic quality when conception risk is high, it may be that in urbanized areas with relatively low disease burden, preferences for traits indicative of paternal investment and care are more advantageous than traits indicative of health and genetic quality, regardless of women's conception risk.

Future research should explore other theoretically plausible cross-cultural variables that may also moderate women's preferences. For example, it is possible that levels of interpartner violence and coercion explain some of the cultural variability in women's preferences, such that in societies with higher levels of inter-partner violence and coercion, women exhibit preferences for more feminine phenotypes, as masculine

phenotypes may be perceived as more aggressive and violent. The effect of violence more generally on women's partner preferences is unclear; whereas exposure to violence was associated with decreases in women's preferences for facial (Borras-Guevara et al. 2017; Li et al. 2014) and vocal (Li et al. 2014) masculinity, other studies have reported the converse (Brooks et al. 2011). Further, there are no known studies investigating interpartner violence and aggression specifically and its relations to women's mate preferences.

Women's ratings of masculinized and feminized pitch were not associated with overall levels of estradiol, testosterone, or progesterone, but estradiol and progesterone interacted in predicting pitch preferences. Specifically, estradiol tended to positively predict preferences for masculine/less feminine pitch when progesterone levels were high, and to negatively predict preferences when progesterone levels were low. An interaction between estradiol and progesterone may suggest that pitch preferences are modulated by ovulatory cycle phase. However, estradiol × progesterone interactions did not differ by breastfeeding or cycling status. Though the present results point to an increased preference for pitch masculinity when both estradiol and progesterone are high, as during the mid-luteal phase, previous findings have suggested an increased preference for masculine vocal characteristics during the fertile phase of the cycle when estradiol is high and progesterone is low (Feinberg et al. 2006; Puts 2005, 2006). Initial studies assessing ovulatory cycle variation in women's preferences manipulated both pitch and formant frequencies (resonant frequencies influencing vocal timbre) simultaneously (Feinberg et al. 2006; Puts 2005, 2006), but pitch and formants may independently influence women's judgements of vocal attractiveness (Feinberg et al. 2005; Pisanski and Rendall 2011). When pitch and formants were manipulated separately (Pisanski et al. 2014b), estradiol predicted women's preferences for masculinized pitch and formants similarly, but progesterone tended to negatively predict preferences for masculinized formants and positively predict preferences for masculinized pitch. However, as cycle phase and ovulation were not assessed in the aforementioned study, it is unclear whether observed shifts were functions of shifts in cycle phase or unrelated shifts in hormone concentrations.

It is also important to note that we assessed hormonal variation only at the between-subjects level, whereas in previous work, women's mating psychology was modulated by hormone concentrations at a within-subjects (Pisanski et al. 2014b; Roney and Simmons 2013, 2017), but not between-subjects (Roney and Simmons 2013), level. Within-subject designs provide greater experimental power, requiring as few as 10% of the participants needed for a between-subjects study to detect an effect (Gangestad et al. 2016; Gonzales and Ferrer 2016). Further, as steroid hormones are released in a pulsatile manner (reviewed in Ellison 2003), a single hormone measurement from a participant may reflect a relatively acute peak or valley in the participant's hormone concentrations. Single hormone measurements are thus relatively "noisy" compared to repeated measures. This highlights the importance of repeat testing with human subjects, as it is otherwise impossible to disentangle the inter- versus intra-individual effects of hormones on behavior and psychology (Blake et al. 2016; Gangestad et al. 2016). Some recent work employing hormonal measurements and within-subjects designs has challenged the ovulatory shift hypothesis (Jones et al. 2017, 2018; Marcinkowska et al. 2017a; but see Roney and Simmons 2013, 2017); as such, it remains to be determined in which domains and to what extent ovulatory shifts are present.

The present study has several additional limitations. First, participants were not instructed to rate the attractiveness of vocal stimuli for short- or long-term relationship contexts, and were instead instructed to rate the attractiveness of vocal stimuli, with relationship context unspecified. Women's preferences for vocal masculinity have been found to be stronger in short-term than in long-term relationship contexts (Puts 2005; Saxton et al. 2016). It is possible that our findings would have differed if relationship context were specified. Second, analyses comparing breastfeeding, amenorrheic and breastfeeding, cycling women were limited by relatively modest samples of women in each group, though prior studies have detected differences between nulliparous and breastfeeding women with samples smaller than those of the present study (Apicella and Feinberg 2009). Additionally, it is possible that breastfeeding women were incorrectly categorized into amenorrheic and cycling groups. The resumption of menstruation in breastfeeding women is often marked by irregular and often anovulatory cycles; thus, it is possible that some of the women who categorized themselves as cycling had not yet experienced an ovulatory menstrual cycle. Future work comparing breastfeeding, cycling and breastfeeding, amenorrheic women would benefit from using luteinizing hormone tests to confirm ovulation. Third, Filipino women in the present study assessed voices of American men speaking English, and this may have influenced how voices were perceived. However, past research has shown that people can predictably evaluate mates from acoustic stimuli in another language (e.g., Apicella and Feinberg 2009; Wheatley et al. 2014), in their own language played backwards (Jones et al. 2008), and even from vowels alone (Feinberg et al. 2005). Moreover, because all stimuli were identical in this regard, and because individual voice stimuli were compared to themselves at two levels of masculinization/feminization, the language spoken is unlikely to have produced the observed pattern of results. Finally, given the recent emphasis on the advantages of within-subjects designs when examining hormonally-driven shifts in cognition and behavior highlighted in the paragraph above (Gangestad et al. 2016), future work should employ a longitudinal, rather than cross-sectional, design to assess changes in individual women's preferences across different life history stages.

Taken together, results of the present study accord with prior work suggesting that vocal pitch is a salient sexually dimorphic characteristic that influences women's mate preferences. Preferences for masculinized or feminized pitch may be modulated by measures of women's reproductive potential, including age, self-reported mate value, and estradiol and progesterone concentrations. Though changes in women's reproductive strategies have been studied by evaluating preferences across the ovulatory cycle, longitudinal analyses of women across different reproductive states (i.e., while normally cycling, pregnant, and breastfeeding) could provide a more complete and nuanced understanding of how women's mating strategies and preferences are influenced by conception risk and reproductive state.

Compliance with Ethical Standards

Conflicts of Interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

References

Alvergne, A., Faurie, C., & Raymond, M. (2009). Variation in testosterone levels and male reproductive effort: Insight from a polygynous human population. *Hormones and Behavior, 56*(5), 491–497. https://doi.org/10.1016/j.yhbeh.2009.07.013.

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

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

Archer, J. (2006). Testosterone and human aggression: An evaluation of the challenge hypothesis. *Neuroscience and Biobehavioral Reviews, 30*(3), 319–345. https://doi.org/10.1016/j.neubiorev.2004.12.007.

Avery, M. D., Duckett, L., & Roth Frantzich, C. (2000). The experience of sexuality during breastfeeding among primiparous women. *Journal of Midwifery & Women's Health, 45*(3), 227–237. https://doi.org/10.1016/S1526-9523(00)00020-9.

Benjamin, B. J. (1981). Frequency variability in the aged voice. *Journal of Gerontology, 36*(6), 722–726. https://doi.org/10.1093/geronj/36.6.722.

Blake, K. R., Dixson, B. J. W., O'Dean, S. M., & Denson, T. F. (2016). Standardized protocols for characterizing women's fertility: A data-driven approach. *Hormones and Behavior, 81*, 74–83. https://doi.org/10.1016/j.yhbeh.2016.03.004.

Bobst, C., Sauter, S., Foppa, A., & Lobmaier, J. S. (2014). Early follicular testosterone level predicts preference for masculinity in male faces - but not for women taking hormonal contraception. *Psychoneuroendocrinology, 41*, 142–150. https://doi.org/10.1016/j.psyneuen.2013.12.012.

Borras-Guevara, M. L., Batres, C., & Perrett, D. I. (2017). Aggressor or protector? Experiences and perceptions of violence predict preferences for masculinity. *Evolution and Human Behavior, 38*(4), 481–489. https://doi.org/10.1016/j.evolhumbehav.2017.03.004.

Brooks, R., Scott, I. M., Maklakov, A. A., Kasumovic, M. M., Clark, A. P., & Penton-Voak, I. S. (2011). National income inequality predicts women's preferences for masculinized faces better than health does. *Proceedings of the Royal Society B, 278*(1707), 810–812. https://doi.org/10.1098/rspb.2010.0964.

Butte, N. F., & King, J. C. (2005). Energy requirements during pregnancy and lactation. *Public Health Nutrition, 8*(7A), 1010–1027.

Cobey, K. D., Little, A. C., & Roberts, S. C. (2015). Hormonal effects on women's facial masculinity preferences: The influence of pregnancy, post-partum, and hormonal contraceptive use. *Biological Psychology, 104*, 35–40. https://doi.org/10.1016/j.biopsycho.2014.11.002.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. New York: Routledge Academic.

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

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., 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. *Proceedings of the Royal Society B, 277*(1692), 2405–2410. https://doi.org/10.1098/rspb.2009.2184.

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*(3), 248–255. https://doi.org/10.1016/j.yhbeh.2011.05.007.

Ellison, P. T. (2003). *On fertile ground: A natural history of human reproduction*. Boston: Harvard University Press.

Escasa-Dorne, M. J., Manlove, H., & Gray, P. B. (2016). Women express a preference for feminized male faces after giving birth. *Adaptive Human Behavior and Physiology*, 1–13. https://doi.org/10.1007/s40750-016-0048-6.

Evans, M. R., Goldsmith, A. R., & Norris, S. R. A. (2000). The effects of testosterone on antibody production and plumage coloration in male hose sparrows (Passer domesticus). *Behavioral Ecology and Sociobiology, 47*(3), 156–163. https://doi.org/10.1007/s002650050006.

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. *Biological Psychology, 72*(2), 160–163. https://doi.org/10.1016/j.biopsycho.2005.09.003.

Fairbanks, G. (1960). *Voice and articulation Drillbook* (2nd ed.). New York: Harper & Row.

Feinberg, D. R., Jones, B. C., Little, A. C., Burt, D. M., & Perrett, D. I. (2005). Manipulations of fundamental and formant frequencies influence the attractiveness of human male voices. *Animal Behaviour, 69*(3), 561–568. https://doi.org/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., … Perrett, D. I. (2006). Menstrual cycle, trait estrogen level, and masculinity preferences in the human voice. Hormones and Behavior, 49(2), 215–222. https://doi.org/10.1016/j.yhbeh.2005.07.004.

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. https://doi.org/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. https://doi.org/10.1007/s00265-011-1287-y.

Fitch, W. T., & Giedd, J. (1999). Morphology and development of the human vocal tract: A study using magnetic resonance imaging. *Journal of the Acoustical Society of America, 106*(3), 1511–1522. https://doi.org/10.1121/1.427148.

Folstad, I., & Karter, A. J. (1992). Parasites, bring males, and the immunocompetence handicap. *The American Naturalist, 139*(3), 603–622. https://doi.org/10.1086/285346.

Gangestad, S. W., Thornhill, R., & Garver-Apgar, C. E. (2005). Adaptations to ovulation. *Current Directions in Psychological Science, 14*(6), 312–316. https://doi.org/10.1111/j.0963-7214.2005.00388.x.

Gangestad, S. W., Haselton, M. G., Welling, L. L. M., Gildersleeve, K., Pillsworth, E. G., Burriss, R. P., … Puts, D. A. (2016). How valid are assessments of conception probability in ovulatory cycle research? Evaluations, recommendations, and theoretical implications. Evolution and Human Behavior, 37(2), 85–96. https://doi.org/10.1016/j.evolhumbehav.2015.09.001.

Gettler, L. T., McDade, T. W., Agustin, S. S., Feranil, A. B., & Kuzawa, C. W. (2015). Longitudinal perspectives on fathers' residence status, time allocation, and testosterone in the Philippines. *Adaptive Human Behavior and Physiology, 1*(2), 124–149. https://doi.org/10.1007/s40750-014-0018-9.

Gildersleeve, K. A., Haselton, M. G., & Fales, M. R. (2014). Do women's mate preferences change across the ovulatory cycle? A meta-analytic review. *Psychological Bulletin, 140*(5), 1205–1259. https://doi.org/10.1037/a0035438.

Gonzales, J. E., & Ferrer, E. (2016). Efficacy of methods for ovulation estimation and their effect on the statistical detection of ovulation-linked behavioral fluctuations. *Behavior Research Methods, 48*(3), 1125–1144. https://doi.org/10.3758/s13428-015-0638-4.

Han, C., Wang, H., Fasolt, V., Hahn, A. C., Holzleitner, I. J., DeBruine, L. M., … Jones, B. C. (2017). No evidence for correlations between handgrip strength and sexually dimorphic acoustic properties of voices. *bioRxiv.* https://doi.org/10.1101/227165.

Harris, C. R. (2011). Menstrual cycle and facial preferences reconsidered. *Sex Roles, 64*(9), 669–681. https://doi.org/10.1007/s11199-010-9772-8.

Harris, C. R. (2013). Shifts in masculinity preferences across the menstrual cycle: Still not there. *Sex Roles, 69*(9), 507–515. https://doi.org/10.1007/s11199-012-0229-0.

Hendrick, V., Altshuler, L. L., & Suri, R. (1998). Hormonal changes in the postpartum and implications for postpartum depression. *Psychosomatics, 39*(2), 93–101. https://doi.org/10.1016/S0033-3182(98)71355-6.

Hines, D. A. (2007). Predictors of sexual coercion against women and men: A multilevel, multinational study of university students. *Archives of Sexual Behavior, 36*(3), 403–422. https://doi.org/10.1007/s10508-006-9141-4.

Hodges-Simeon, C. R., Gaulin, S. J. C., & Puts, D. A. (2010). Different vocal parameters predict perceptions of dominance and attractiveness. *Human Nature, 21*(4), 406–427. https://doi.org/10.1007/s12110-010-9101-5.

Hodges-Simeon, C. R., Gurven, M., Puts, D. A., & Gaulin, S. J. C. (2014). Vocal fundamental and formant frequencies are honest signals of threat potential in peripubertal males. *Behavioral Ecology, 25*(4), 984–988. https://doi.org/10.1093/beheco/aru081.

Hodges-Simeon, C., Gurven, M., & Gaulin, S. (2015). The low male voice is a costly signal of phenotypic quality among Bolivian adolescents. *Evolution and Human Behavior, 36*(4), 294–302.

Jasienska, G. (2012). *The fragile wisdom: An evolutionary view on Women's biology and health*. Cambridge: Harvard University Press. https://doi.org/10.4159/harvard.9780674067196.

Jones, B. C., Little, A. C., Boothroyd, L. G., DeBruine, L. M., Feinberg, D. R., Smith, M. J. L., … Perrett, D. I. (2006). Commitment to relationships and preferences for femininity and apparent health in faces are strongest on days of the menstrual cycle when progesterone level is high. *Hormones and Behavior, 48*(3). https://doi.org/10.1016/j.yhbeh.2005.03.010.

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

Jones, B. C., Hahn, A. C., Fisher, C. I., Wang, H., Kandrik, M., Han, C., … DeBruine, L. M. (2017). No compelling evidence that preferences for facial masculinity track changes in women's hormonal status. *bioRxiv.* https://doi.org/10.1101/136549.

Jones, B. C., Hahn, A., Fisher, C., Wang, H., Kandrik, M., & DeBruine, L. M. (2018). General sexual desire, but not desire for uncommitted sexual relationships, tracks changes in women's hormonal status. *Psychoneuroendocrinology, 88*, 153–157. https://doi.org/10.1016/j.psyneuen.2017.12.015.

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for t-tests and ANOVAs. *Frontiers in Psychology, 4*, 1–12. https://doi.org/10.3389/fpsyg.2013.00863.

Li, Y., Bailey, D. H., Winegard, B., Puts, D. A., Welling, L. L. M., & Geary, D. C. (2014). Women's preference for masculine traits is disrupted by images of male-on-female aggression. *PLoS One, 9*(10), e110497. https://doi.org/10.1371/journal.pone.0110497.

Little, A. C., & Mannion, H. (2006). Viewing attractive or unattractive same-sex individuals changes self-rated attractiveness and face preferences in women. *Animal Behaviour, 72*(5), 981–987. https://doi.org/10.1016/j.anbehav.2006.01.026.

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, 268*(1462), 39–44. https://doi.org/10.1098/rspb.2000.1327.

Marcinkowska, U. M., Ellison, P. T., Galbarczyk, A., Milkowska, K., Pawlowski, B., Thune, I., & Jasienska, G. (2016). Lack of support for relation between woman's masculinity preference, estradiol level and mating context. *Hormones and Behavior, 78*, 1–7. https://doi.org/10.1016/j.yhbeh.2015.10.012.

Marcinkowska, U. M., Galbarczyk, A., & Jasienska, G. (2017a). La donna è mobile? Lack of cyclical shifts in facial symmetry, and facial and body masculinity preferences—A hormone based study. *Psychoneuroendocrinology, 88*, 47–53. https://doi.org/10.1016/j.psyneuen.2017.11.007.

Marcinkowska, U. M., Jasienska, G., & Prokop, P. (2017b). A comparison of masculinity facial preference among naturally cycling, pregnant, lactating, and post-menopausal women. *Archives of Sexual Behavior*, 1–8. https://doi.org/10.1007/s10508-017-1093-3.

Mazur, A., & Booth, A. (1998). Testosterone and dominance in men. *Behavioral and Brain Sciences, 21*(1998), 353–397. https://doi.org/10.1017/S0140525X98001228.

McNeilly, A. S. (2001). Neuroendocrine changes and fertility in breast-feeding women. *Progress in Brain Research, 133*, 207–214. https://doi.org/10.1016/S0079-6123(01)33015-7.

Muller, M. N., Marlowe, F. W., Bugumba, R., & Ellison, P. T. (2009). Testosterone and paternal care in East African foragers and pastoralists. *Proceedings of the Royal Society B: Biological Sciences, 276*(1655), 347–354. https://doi.org/10.1098/rspb.2008.1028.

Philippines National Statistics Office (2009). National Demographic and Health Survey – Preliminary Results for 2008. Retrieved from https://dhsprogram.com/pubs/pdf/FR224/FR224.pdf.

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. https://doi.org/10.1016/j.evolhumbehav.2004.04.003.

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. https://doi.org/10.1037/0735-7036.117.3.264.

Petrakis, N. L., Wrensch, M. R., Ernster, V. L., Midce, R., Murai, J., Simberg, N., & Sirreri, P. K. (1987). Influence of pregnancy and lactation on serum breast and fluid estrogen levels: Implications for breast cancer risk. *International Journal of Cancer, 40*(5), 587–591. https://doi.org/10.1002/ijc.2910400502.

Pisanski, K., & Feinberg, D. R. (2013). Cross-cultural variation in mate preferences for averageness, symmetry, body size, and masculinity. *Cross-Cultural Research, 47*(2), 162–197. https://doi.org/10.1177/1069397112471806.

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*(4), 2201–2212. https://doi.org/10.1121/1.3552866.

Pisanski, K., Fraccaro, P. J., Tigue, C. C., O'Connor, J. J. M., Röder, S., Andrews, P. W., … Feinberg, D. R. (2014a). Vocal indicators of body size in men and women: A meta-analysis. Animal Behaviour, 95, 89–99. https://doi.org/10.1016/j.anbehav.2014.06.011.

Pisanski, K., Hahn, A. C., Fisher, C. I., DeBruine, L. M., Feinberg, D. R., & Jones, B. C. (2014b). Changes in salivary estradiol predict changes in women's preferences for vocal masculinity. *Hormones and Behavior, 66*(3), 493–497. https://doi.org/10.1016/j.yhbeh.2014.07.006.

Preacher, K. J., & Hayes, A. F. (2004). SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behavior Research Methods, Instruments, and Computers, 36*(4), 717–731. https://doi.org/10.3758/BF03206553.

Preacher, K. J., & Hayes, A. F. (2007). Addressing moderated mediation hypotheses: Theory, methods, and prescriptions. *Multivariate Behavioral Research, 42*(1), 185–227. https://doi.org/10.1080/00273170701341316.

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. https://doi.org/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, 17*(1), 114–127. https://doi.org/10.1007/s12110-006-1023-x.

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. https://doi.org/10.1016/j.evolhumbehav.2005.11.003.

Puts, D. A., Hodges, C. R., Cárdenas, 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. https://doi.org/10.1016/j.evolhumbehav.2007.05.002.

Puts, D. A., Apicella, C. L., & Cardenas, R. A. (2012a). Masculine voices signal men's threat potential in forager and industrial societies. *Proceedings of the Royal Society B: Biological Sciences, 279*(1728), 601–609. https://doi.org/10.1098/rspb.2011.0829.

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. https://doi.org/10.1080/00224499.2012.658924.

Puts, D. A., Pope, L. E., Hill, A. K., Cárdenas, R. A., Welling, L. L. M., Wheatley, J. R., & Marc Breedlove, S. (2015). Fulfilling desire: Evidence for negative feedback between men's testosterone, sociosexual psychology, and sexual partner number. *Hormones and Behavior, 70*, 14–21. https://doi.org/10.1016/j.yhbeh.2015.01.006.

Puts, D. A., Hill, A. K., Bailey, D. H., Walker, R. S., Rendall, D., Wheatley, J. R., et al. (2016). Sexual selection on male vocal fundamental frequency in humans and other anthropoids. *Proceedings of the Royal Society B, 283*, 2–8.

Rantala, M. J., Moore, F. R., Skrinda, I., Krama, T., Kivleniece, I., Kecko, S., & Krams, I. (2012). Evidence for the stress-linked immunocompetence handicap hypothesis in humans. *Nature Communications, 3*(1), 694. https://doi.org/10.1038/ncomms1696.

Roney, J. R., & Simmons, Z. L. (2008). Women's estradiol predicts preference for facial cues of men's testosterone. *Hormones and Behavior, 53*(1), 14–19. https://doi.org/10.1016/j.yhbeh.2007.09.008.

Roney, J. R., & Simmons, Z. L. (2013). Hormonal predictors of sexual motivation in natural menstrual cycles. *Hormones and Behavior, 63*(4), 636–645. https://doi.org/10.1016/j.yhbeh.2013.02.013.

Roney, J. R., & Simmons, Z. L. (2016). Within-cycle fluctuations in progesterone negatively predict changes in both in-pair and extra-pair desire among partnered women. *Hormones and Behavior, 81*, 45–52. https://doi.org/10.1016/j.yhbeh.2016.03.008.

Roney, J. R., & Simmons, Z. L. (2017). Ovarian hormone fluctuations predict within-cycle shifts in women's food intake. *Hormones and Behavior, 90*, 8–14. https://doi.org/10.1016/j.yhbeh.2017.01.009.

Roney, J. R., Simmons, Z. L., & Gray, P. B. (2011). Changes in estradiol predict within-women shifts in attraction to facial cues of men's testosterone. *Psychoneuroendocrinology, 36*(5), 742–749. https://doi.org/10.1016/j.psyneuen.2010.10.010.

Rosen, R. C., Brown, C., Heiman, J. R., Leiblum, S. R., Meston, C. M., Shabsign, R., et al. (2000). The female sexual function index (FSFI): A multidimensional self-report instrument for the assessment of female sexual function. *Journal of Sex & Marital Therapy, 26*(2), 191–208. https://doi.org/10.1080/009262300278597.

Sanday, P. R. (1981). The socio-cultural context of rape: A cross-cultural study. *Journal of Social Issues, 37*(4), 5–27. https://doi.org/10.1111/j.1540-4560.1981.tb01068.x.

Saxton, T. K., Mackey, L. L., McCarty, K., & Neave, N. (2016). A lover or a fighter? Opposing sexual selection pressures on men's vocal pitch and facial hair. *Behavioral Ecology, 27*(2), 512–519. https://doi.org/10.1093/beheco/arv178.

Scott, I. M., Clark, A. P., Josephson, S. C., Boyette, A. H., Cuthill, I. C., Fried, R. L., Gibson, M. A., Hewlett, B. S., Jamieson, M., Jankowiak, W., Honey, P. L., Huang, Z., Liebert, M. A., Purzycki, B. G., Shaver, J. H., Snodgrass, J. J., Sosis, R., Sugiyama, L. S., Swami, V., Yu, D. W., Zhao, Y., & Penton-Voak, I. S. (2014). Human preferences for sexually dimorphic faces may be evolutionarily novel. *Proceedings of the National Academy of Sciences of the United States of America, 111*(40), 14388–14393. https://doi.org/10.1073/pnas.1409643111.

Smith, M. S., True, C., & Grove, K. L. (2010). The neuroendocrine basis of lactation-induced suppression of GnRH: Role of kisspeptin and leptin. *Brain Research, 1364*, 139–152. https://doi.org/10.1016/j.brainres.2010.08.038.

Thornhill, R., & Gangestad, S. W. (1999). Facial attractiveness. *Trends in Cognitive Science, 3*(12), 452–460. https://doi.org/10.1016/S1364-6613(99)01403-5.

Thornhill, R., & Gangestad, S. W. (2006). Facial sexual dimorphism, developmental stability, and susceptibility to disease in men and women. *Evolution and Human Behavior, 27*(2), 131–144. https://doi.org/10.1016/j.evolhumbehav.2005.06.001.

Titze, I. R. (1989). Physiologic and acoustic differences between male and female voices. *Journal of the Acoustical Society of America, 85*(4), 1699–1707. https://doi.org/10.1121/1.397959.

Tolor, A., & DiGrazia, P. V. (1976). Sexual attitudes and behavior patterns following pregnancy. *Archives of Sexual Behavior, 5*(6), 539–551. https://doi.org/10.1007/BF01541218.

UNICEF (2013). At a Glance: Philippines. Retrieved from https://www.unicef.org/infobycountry/philippines_statistics.html.

Vitzthum, V. J. (2008). Evolutionary models of women's reproductive functioning. *Annual Review of Anthropology, 37*(1), 53–73. https://doi.org/10.1146/annurev.anthro.37.081407.085112.

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. https://doi.org/10.1016/j.paid.2008.05.013.

Welling, L. L. M., Jones, B. C., DeBruine, L. M., Conway, C. A., Law Smith, M. J., Little, A. C., … Al-Dujaili, E. A. S. (2007). Raised salivary testosterone in women is associated with increased attraction to masculine faces. Hormones and Behavior, 52(2), 156–161. https://doi.org/10.1016/j.yhbeh.2007.01.010.

Wheatley, J. R., Apicella, C. L., Burriss, R. P., Cárdenas, R. A., Bailey, D. H., Welling, L. L. M., & Puts, D. A. (2014). Women's faces and voices are cues to reproductive potential in industrial and forager societies. *Evolution and Human Behavior, 35*(4), 264–271. https://doi.org/10.1016/j.evolhumbehav.2014.02.006.

Wilcox, R. R. (2001). *Fundamentals of modern statistical methods: Substantially improving power and accuracy.* New York: Springer-Verlag. https://doi.org/10.1007/978-1-4757-3522-2.

World Health Organization Task Force on Methods for the Natural Regulation of Fertility. (1998). The World Health Organization multinational study of breast-feeding and lactational amenorrhea. II. Factors associated with the length of amenorrhea. *Fertility and Sterility, 70*(3), 461–471.