

The voice and face of woman: One ornament that signals quality?

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Abstract

The attractiveness of women's faces, voices, bodies, and odors appear to be interrelated, suggesting that they reflect a common trait such as femininity. We invoked novel approaches to test the interrelationships between female vocal and facial attractiveness and femininity. In Study 1, we examined the relationship between facial-metric femininity and voice pitch in two female populations. In both populations, facial-metric femininity correlated positively with pitch of voice. In Study 2, we constructed facial averages from two populations of women with low- and high-pitched voices and determined men's preferences for resulting prototypes. Men preferred averaged faces of women from both populations with higher pitched voices to those with lower pitched voices. In Study 3, we tested whether the findings from Study 2 also extended to the natural faces that made up the prototypes. Indeed, men and women preferred real faces of women with high-pitched voices to those with low-pitched voices. Because multiple cues to femininity are related, and feminine women may have greater reproductive fitness than do relatively masculine women, male preferences for multiple cues to femininity are potentially adaptive.

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1. Introduction

It is well documented that, in women, indices of mate quality are correlated across multiple modalities. Females with attractive faces have been shown to have attractive bodies (Thornhill & Grammer, 1999) and attractive voices (Collins & Missing, 2003). Body shape and vocal attractiveness are also intercorrelated (Collins & Missing, 2003; Hughes, Dispenza, & Gallup, 2004). Correlations between cross-modal indices of mate quality extend to facial attractiveness and attractiveness of body odor (Rikowski & Grammer, 1999). Furthermore, male preference strength for femininity in female faces was found to correlate with male preference strength for female-typical putative pheromones (Cornwell et al., 2004). It has been suggested that interrelationships between feminine characteristics reflect underlying reproductive health and hormonal profile (Thornhill & Gangestad, 1999) and age (Collins & Missing, 2003).

The pitch of voice (Abitbol, Abitbol, & Abitbol, 1999; Van Borsel, De Cuypere, Rubens, & Destaecke, 2000) and facial femininity (Thornhill & Gangestad, 1999) may both be related positively to estrogen and negatively to testosterone levels. Within the normal range, estrogen is positively linked to reproductive development, health, and the expression of femininity (Alonso & Rosenfield, 2002). If pitch of voice and facial femininity both reflect estrogen levels, pitch of voice and facial femininity may both be ornaments signalling the same underlying quality (see Thornhill & Grammer, 1999, for discussion). Study 1 tested whether correlations between facial and vocal attractiveness that exist at the subjective level (Collins & Missing, 2003) can be extended to objective measures of facial and vocal femininity. Here, we investigated the relationship between facial-metric femininity (sensu Penton-Voak et al., 2001) and pitch of voice. We predicted that if facial femininity and pitch of voice reflect sex hormone levels, females with feminine face shapes should also have higher pitched voices.

Femininity is attractive in women's faces (O'Toole et al., 1998; Perrett et al., 1998; Rhodes, Hickford, & Jeffery, 2000) and voices (Collins & Missing, 2003), and facial and vocal attractiveness correlate (Collins & Missing, 2003). Therefore, measures of vocal femininity should predict facial attractiveness. In Study 2, average facial prototypes (Benson & Perrett, 1993; Tiddeman, Burt, & Perrett, 2001) were constructed from women with relatively low-pitched voices and facial prototypes of women with relatively high-pitched voices. Two populations of women were studied. In Study 2, the attractiveness of these 'average' prototype images was evaluated by men in a forced-choice design where preference strength was also measured. The formulation of average faces is a useful tool to reduce noise prevalent in correlational studies as averaging highlights qualities common to the groups and suppresses those that are distinctive to individuals in the groups (see Benson & Perrett, 1993; Tiddeman et al., 2001). It was predicted that men would prefer the prototype faces of women with high-pitched voices to prototype faces of women with low-pitched voices. In Study 3, we tested if the relationship between voice pitch and facial attractiveness extended to the natural faces that made up the prototypes in Study 2.

2. Study 1

The aim of Study 1 was to determine the relationship between objective measures of femininity in face shape (facial-metric femininity, sensu Penton-Voak et al., 2001, who demonstrated that these measurements are sexually dimorphic) and femininity of voice (fundamental frequency). It was predicted that women with relatively feminine faces would also have relatively high-pitched voices. Collins and Missing (2003) proposed that the link between feminine facial and vocal qualities reflects chronological age. We examined this proposal by testing if age correlated with facial and vocal femininity, and by controlling for chronological age when analyzing the relationship between facial and vocal femininity.

2.1. Methods

2.1.1. Participants

This study comprised two independent samples. Participants included 52 White female undergraduate students (mean age=19.6, S.D.=2.1) from the University of St Andrews, Scotland, and 56 White female undergraduate students (mean age=18.4, S.D.=0.72) from the University of McMaster, Canada. One UK participant was removed from the analysis because her facial-metric femininity score was more than three standard errors away from the group's mean, leaving 51 UK participants as the final number of participants in the sample. One UK participant did not report her age and was excluded from analyses involving age.

2.1.2. Photographs

Images of women's faces were captured under diffuse lighting with neutral facial expression, in front of a standardized background. In the UK, a digital camera captured the images uncompressed, at a resolution of 1200×1000 pixels, with 24-bit RGB (red, green, and blue) color encoding. In Canada, images were captured under diffuse lighting at 1800×2400 pixel resolution, with a 32-bit RGB color encoding and 1:11 jpeg compression.

2.1.3. Facial-metric femininity measures

Facial-metric femininity was measured using an identical technique to Penton-Voak et al. (2001), but here, the scale was reversed such that high numbers indicate feminine face shapes and low numbers indicate masculine face shapes. From full color images, five measurements were taken (see Fig. 1). These measures were all *z* scored so that each trait would have the same scale. Consistent with Penton-Voak et al. (2001), an index of facial-metric femininity was calculated as $-[Z(\text{lower face height/face height})-Z(\text{face width/lower face height})-Z(\text{eye size})-Z(\text{mean height of eyebrow above top of eye})-Z(\text{cheekbone prominence})]$.

2.1.4. Voice recordings

In the UK, female participants were recorded speaking the English monophthong vowel sounds 'eh' as in the word 'bet' (International Phonetic Alphabet symbol: ε), 'ee' as in 'see' (i:), 'ah' as in 'father' (a:), 'oh' as in 'note' (o), 'oo' as in 'boot' (u:), with an Audio-Technica AT4041 condenser microphone (see <http://www.audio-technica.com>). The voices were

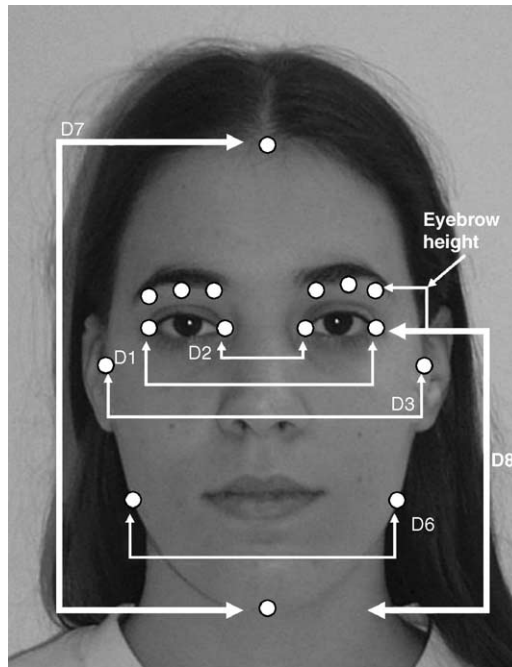


Fig. 1. Landmarks used in the facial-metric femininity measurement technique. Facial masculinity measurements: eye size $[(D1 - D2)/2]$, lower face/face height $(D8/D7)$, cheekbone prominence $(D3/D6)$, face width/lower face height $(D3/D8)$, and mean eyebrow height (mean distance from eyebrow to top of the eye).

recorded onto a computer hard disk using Sonic Foundry's SoundForge (see <http://www.soundforge.com>) at 44.1 kHz sampling rate and 16-bit quantization and saved as uncompressed "wav" files.

In Canada, methods of voice recording differed. A Labtec, Verse 504 microphone was used. Participants spoke two additional vowel sounds: 'uh' as in 'mud' (λ) and 'ih' as in 'his' (I). All sounds were included in averages.

2.1.5. Fundamental frequency measurement

Each vowel sound was analyzed separately using Praat software (www.praat.org). Fundamental frequency was measured using Praat's autocorrelation algorithm. Fundamental frequency measurement technique was identical to Feinberg et al. (2005), except fundamental frequency was searched for between 100 and 600 Hz (as recommended for women's voices by www.praat.org). Mean fundamental frequencies were measured by averaging the fundamental frequency of each voiced window across the entirety of each vowel sound. Subsequently, fundamental frequencies were averaged across vowels for each speaker.

2.1.6. Statistical analysis

The normal distribution for femininity, voice pitch, and age was examined in both samples (after removing the one UK participant whose facial-metric femininity score was a

statistical outlier). One-sample Kolmogorov–Smirnov tests indicated that only the distribution of participants' age from the Canadian sample differed from normal ($z=1.981$, $p=.001$; all other $z<1.23$, $p>.09$). Zero-order correlations were tested using Pearson's correlations in SPSS v11.0. Partial correlations were run to explore potential effects of chronological age.

2.2. Results

UK women with more feminine faces had higher pitched voices ($r_{52}=.340$, $p=.015$). Canadian women with more feminine faces also had higher voice pitches ($r_{56}=.363$, $p=.006$). Neither in Canada nor the UK did facial-metric femininity or pitch of voice correlate with age (all $|r|<.267$, all $p>.114$). In both samples (UK and Canada), Spearman's Rho correlations produced equivalent results. Furthermore, correlations between facial-metric femininity and pitch of voice remained significant after controlling for age (UK: $r_{47}=.317$, $p=.026$; Canada: $r_{53}=.358$, $p=.007$).

2.3. Discussion

In these studies, it was found that women with more feminine faces had higher pitched voices. This suggests that femininity of face and voice reflect a common underlying quality. This relationship was independent of age. Although age may be related to femininity in a population with a broader age spectrum (Deffenbacher, Johanson, & O'Toole, 1998; O'Toole, Price, Vetter, Bartlett, & Blanz, 1999), age cannot account for the findings reported here for populations of young adult females. Future studies could include wider age ranges to examine, with greater detail, the effects of age on the relationship between voice pitch and facial masculinity.

3. Study 2

The aim of Study 2 was to test if faces (Benson & Perrett, 1993; Tiddeman et al., 2001) of women with high-pitched voices differed in attractiveness than faces of women with low-pitched voices. Facial prototypes, constructed from many individual faces, were used as they highlight qualities common to groups and suppress distinctive qualities (Perrett, May, & Yoshikawa, 1994). It was hypothesized that men would prefer the average facial prototypes of women with high-pitched voices to those with low-pitched voices.

3.1. Methods

3.1.1. Participants

Female participants included 123 female students at the University of St Andrews and the Canadian participants from Study 2. UK female participants' ages were self-reported and ranged from 17 to 27 years ($M=20.6$, $S.D.=1.86$). Three hundred thirty-

eight male participants were recruited via the worldwide web. Male participants' age was also self-reported and ranged from 16 to 65 years ($M=26.59$, $S.D.=9.46$). Many published studies have used Internet-based tests to assess face preferences and other behaviors (Fessler & Navarrete, 2003; Jones et al., 2005; Little, Burt, Penton-Voak, & Perrett, 2001; Little & Jones, 2003; Little, Jones, Penton-Voak, Burt, & Perrett, 2002, 2003; Oates & Wilson, 2002), and the use of web-based methods has become common practice in psychology (Kraut et al., 2004). Studies have shown that laboratory and Internet-based tests of face preferences produce similar results (Buchanan, 2000; Jones et al., 2005; Wilson & Daly, 2004).

3.1.2. Image capture and voice recordings

Voices were recorded, and images were captured in an identical fashion to Study 2.

3.1.3. Stimuli manufacture

Using a computer graphics software (www.perceptionlab.com), digital images were delineated using 186 landmark points. Facial prototypes averaging shape, color, and texture information were constructed (Benson & Perrett, 1993; Tiddeman et al., 2001) out of the images of women from the UK with the 24 highest and 25 lowest pitched voices and Canadian women (from the sample in Study 2) with the 15 highest and 14 lowest pitched



Fig. 2. Facial prototypes constructed from women with high- and low-pitched voices. Top row: faces from Canadian sample; bottom row: faces from UK sample; left column: faces constructed from women with high-pitched voices; right column: faces constructed from women with low-pitched voices.

voices. Fig. 2 displays grayscale versions of the full color facial stimuli. Images were made symmetrical by first mirror flipping the image and, second, the averaging color, shape, and texture information with that of the original image (see Jones et al., 2004). Subsequently, these images were masked around the perimeter of the face to reduce cues from clothing and hairstyle.

3.1.4. Procedure

Image pairs were presented side by side via the Internet at size 397×499 pixels amongst filler items. Participants reported sex and age. Faces were rated in a forced-choice paradigm, in which raters could select strength of preference for either face. The eight-point scale was labelled “guess,” “slightly prefer,” “prefer,” and “strongly prefer” for each image. These scores were later converted to a numerical scale from 0 to 7 (0=highly prefer prototype faces of women with low-pitched voices, 7=highly prefer prototype faces of women with high-pitched voices). The side of presentation of face pairs was fully counterbalanced and order was randomized. Before analysis, potential repeat participants were removed by excluding repeat IP addresses (Kraut et al., 2004).

3.2. Results

In the Canadian sample, women making up the facial prototype of low-pitched voices had a mean voice pitch of 186.35 Hz (S.D.=8.39) and a mean age of 18.64 years (S.D.=0.84). Women making up the facial prototype of high-pitched voices had a mean voice pitch of 236.05 (S.D.=9.72) and a mean age of 18.13 (S.D.=0.64). An independent sample *t* test revealed that the two groups differed significantly in pitch of voice [$t(27)=-14.7, p<.0001$] but not in age [$t(27)=1.843, p=.076$].

In the UK sample, women making up the facial prototype of low-pitched voices had a mean pitch of 182.68 Hz (S.D.=5.9) and a mean age of 21.25 years (S.D.=2.23). UK women making up the facial prototype of high-pitched voices had a mean pitch of 236.01 Hz (S.D.=16.3) and a mean age of 20.32 years (S.D.=1.44). An independent-sample *t* test revealed that the two groups differed significantly in pitch of voice [equal variance not assumed: Levene’s test for equality of variances, $F(1,47)=15.412, p<.001$; Brown-Forsythe *t* test, $t(30.415)=-15.096, p<.0001$] but not age [$t(47)=1.692, p=.097$].

One-sample *t* tests showed that, for both Canadian and UK image pairs, men preferred the faces of women with high-pitched voices significantly above the chance value of 3.5 [Canada: $t(337)=12.1, M=4.71, S.E.=0.1, p<.0001$; UK: $t(337)=3.294, M=3.84, S.E.=0.103, p=.0001$].

4. Study 3

Study 3 tested whether men and women prefer faces of women with high-pitched voices to those with low-pitched voices. The stimuli used here were natural faces, to test if the findings from Study 2 extended to more ecologically valid stimuli.

Table 1
Mean and standard deviation of ages

Study number	Participants	Age mean (S.D.)
Study 1	UK	18.4 (0.72)
	Canada	19.6 (2.1)
Studies 2 and 3	UK stimuli	18.64 (0.84)
	Canada stimuli	19.6 (2.1)
	Raters (Study 2)	26.59 (9.46)

Standard deviation is in parentheses.

4.1. Methods

4.1.1. Participants

Participants included 41 students at the University of St Andrews (17 men and 24 women) and the faces that were used to construct the averages in Study 2. Ten men and 10 women rated Canadian faces. Seven men rated all UK faces, whilst two sets of 7 women rated each 1/2 of the UK faces. The age of the raters was not recorded (Table 1).

4.1.2. Stimuli

Facial stimuli were masked (as in Study 2) to reduce cues from hair and clothing.

4.1.3. Procedure

Faces were displayed on a screen in random orders. The attractiveness of each face was rated on a seven-point scale (1=*very unattractive*, 7=*very attractive*).

4.2. Results

Cronbach's alpha test showed that interrater agreement was high ($\alpha > .7$). Thus, all ratings were Z scored within group, and then ratings from men and women were averaged (as there was agreement between men and women as per which faces were attractive). A univariate ANOVA [dependent variable: facial attractiveness; between-groups factors: pitch of voice (high or low) and sample (UK or Canada); and covariate: age of face] tested the relationship between pitch of voice and facial attractiveness. The faces of women with high-pitched voices were found more attractive than the faces of women with low-pitched voices [$F(1,71)=88.6$, $p < .001$]. There were no other significant interactions [all $F(1,72) < 0.339$, $p > .562$].

5. Discussion

In Study 1, the femininity of women's face shapes correlated with pitch of voice in both the UK and Canadian samples. This effect was robust to different recording methods,

including microphone type and phonation, different photographic conditions, as well as phenotypic variation across continents. In populations with a wide age range, younger women may have more feminine facial and vocal features than older women do. The relationship between facial femininity and pitch of voice reported here, however, was not due to age. This suggests that although age contributes to female femininity (Deffenbacher et al., 1998; O'Toole et al., 1999), female femininity also independently reflects qualities such as hormonal status and reproductive health (Alonso & Rosenfield, 2002; Jasienska, Ziomkiewicz, Ellison, Lipson, & Thune, 2004; Moran et al., 1999; Zaadastra et al., 1993). The correlation between facial femininity and voice pitch supports the idea that cues to underlying quality are concordant in face and voice. Thus, findings by Collins and Missing (2003) that female facial and vocal attractiveness correlate may reflect that faces and voices signal common information about the degree to which femininity is expressed in an individual.

In two independent samples in Studies 2 and 3, it was found that the facial prototypes and natural faces (respectively) of women with high-pitched voices were more attractive than those with low-pitched voices. These findings extend those of Collins and Missing (2003); vocal femininity was a predictor of facial attractiveness. Male preferences for femininity, as indicated by face and voice, are potentially adaptive, as the expression of pitch of voice and facial femininity may be positively linked to estrogen (Abitbol et al., 1999; Alonso & Rosenfield, 2002; Thornhill & Gangestad, 1999), which is, in turn, positively linked to reproductive health and development (see Alonso & Rosenfield, 2002, for review). Although perceived age may contribute to attractiveness ratings in Studies 2 and 3, as perceived age is positively related to facial and vocal masculinity (see Deffenbacher et al., 1998; Feinberg et al., 2005; O'Toole et al., 1999), attributions of age will not have influenced our objective assessment of facial and vocal masculinity in Study 1. It is possible that when considering larger age ranges, age may have a greater effect on the relationship between vocal and facial masculinity.

In summary, we show that objective measures of vocal and facial femininity are correlated and that vocal femininity can predict facial attractiveness. If, in the ancestral environment, men who chose feminine partners enjoyed higher reproductive success, this evolutionary advantage could have shaped men's preferences for female femininity. Male preferences for femininity in women remain in modern society.

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