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The role of femininity and averageness of voice pitch in aesthetic judgments of women's voices

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Abstract. Although averageness is preferred in auditory stimuli (eg music) and non-face objects (eg wristwatches), exaggerated feminine characteristics are preferred to averageness in female faces. To establish whether or not men prefer femininity in female voices to average characteristics, we conducted a correlational study (study 1) to assess the relationship between voice pitch and attractiveness ratings. We found a positive linear relationship between voice pitch and attractiveness ratings. In study 2 we manipulated pitch in women's voices with low (lower than average), average, and high (higher than average) starting pitches and gauged men's preferences. Men preferred women's voices with raised pitch for all levels of starting pitch. These findings suggest that men prefer high voice pitch to average voice pitch in women's voices.

1 Introduction

Many researchers have hypothesised that averageness is an important component of attractiveness. Although people generally prefer average configurations in faces and non-face objects to non-average configurations (Halberstadt and Rhodes 2000, 2003; Langlois and Roggman 1990; Little and Hancock 2002; Penton-Voak and Perrett 2000), highly attractive women's faces deviate systematically from an average configuration (Perrett et al 1994). Indeed, shifting the shape of female faces *away* from average by exaggerating feminine shape characteristics increases their attractiveness (Perrett et al 1999).

Recent research has shown that women who have attractive voices tend to have attractive faces (Collins and Missing 2003). This relationship between vocal and facial attractiveness in women may reflect a positive relationship between female voice pitch and facial femininity (Feinberg et al 2005a). Although establishing the extent to which preferences for femininity exceed preferences for averageness has been an important feature of research on facial attractiveness (eg Perrett et al 1994, 1999), we know of no studies of the relative roles of femininity and averageness in judgments of the attractiveness of women's voices. This is particularly surprising given studies demonstrating preferences for averageness in other auditory stimuli, such as music (Repp 1997).

In light of the above, we undertook two studies of the relative contributions of feminine (ie high) voice pitch and averageness of voice pitch for the attractiveness of women's voices. First, we carried out a correlational analysis of over one hundred and twenty women's voices (study 1). In particular, we were interested in establishing whether or not the relationship between attractiveness and measured voice pitch was best explained by a positive linear relationship (indicating a preference for femininity of pitch) or by a quadratic function with the vertex centred on the average value for pitch (indicating a preference for averageness of pitch). Voices were measured for pitch and rated for attractiveness.

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In a second study, we tested if voice pitch alone is an auditory cue to female vocal attractiveness, by manipulating voice pitch alone in female voices. It is not clear from tests of correlations between voice pitch and attractiveness ratings of unmanipulated voices (Collins and Missing 2003) whether voice pitch is an auditory cue to female vocal attractiveness or if the correlation between attractiveness and voice pitch arises because of other characteristics of the voice that co-vary with pitch (Feinberg et al 2005b). In study 2, we therefore tested if lowering and raising pitch (Feinberg et al 2005b) independent of other vocal characteristics has the same effect on attraction to voices when the starting pitch (ie pitch before manipulation) of the voices was average, lower than average (ie masculine), and higher than average (ie feminine). If increasing pitch in female voices that are already more feminine than average increases their attractiveness, this would demonstrate that preferences for high pitch in female voices outweigh preferences for average pitch in vocal stimuli, as it would demonstrate that shifting voice pitch away from average can have a positive effect on attractiveness ratings.

2 Study 1

2.1 *Methods*

2.1.1 *Voice recording.* One hundred and twenty-three female undergraduates at the University of St Andrews [aged 17 – 27 years, mean (M) = 20.6 years, SD = 1.9 years] were recorded speaking the monopthong vowels: eh as in bet (e), ee as in see (iː), ah as in father (aː), oh as in note (ou), oo as in boot (ʊə) (symbols in parentheses are International Phonetic Alphabet symbols). Sounds were recorded with an Audio-Technica AT4041 cardioid condenser microphone (see http:///www.audio-technica.com) in a quiet room. Vowel sounds were recorded directly onto computer hard disk and were encoded at 44.1 kHz sampling rate, at 16 bit quantisation, and saved as uncompressed 'wav' files.

2.1.2 *Acoustic analysis.* Acoustic measurements were conducted at 11.025 kHz sampling rate to increase frequency resolution. Fundamental frequency (pitch) was measured with Praat's autocorrelation function with input parameters as defined elsewhere (Feinberg et al 2005a, 2006).

2.1.3 *Stimulus creation.* Voices were normalised to 500 ms in duration with the pitch-synchronous overlap add (PSOLA) algorithm (see section 3.1.2), which changes duration whilst holding all other acoustic properties of the voice constant (Boersma and Weenink 2001; Charpentier and Moulines 1989). Root-mean-square amplitude (RMS) of each sound was normalised to 87.5 dB spl.

2.1.4 *Playback.* For each vocaliser, vowels were always played back in the same order: 'ah', 'ee', 'eh', 'oh', and 'oo'. The order in which each speaker's entire set of vowels was played was randomised (ie the order of vocaliser was randomised). Therefore, order of stimuli could not have systematic effects on vocal attributions. Vowel sounds were played back to ten male raters. Using headphones, at a constant volume, voices were assessed in two equal-sized blocks by the same raters because of the large number of female voices. The order of blocks was also randomised. The age of raters ranged from 18 to 25 years. Playback sampling rate was 44.1 kHz. Participants rated attractiveness on a 7-point scale (1, very unattractive; 7, very attractive).

2.2 *Results*

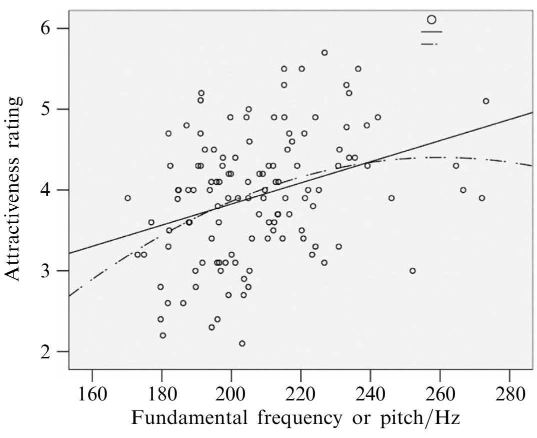
Table 1 shows descriptive statistics on voice pitch. Our sample had a lower average voice pitch than reported in other studies (Childers and Wu 1991).

For each vocaliser, we averaged the ten men's attractiveness ratings. There was a significant positive correlation (Pearson) between voice pitch and attractiveness ($r_{123} = 0.341$, $p < 0.0001$) indicating that men were attracted to women's voices with higher pitch.

Table 1. Descriptive statistics of voice pitch.

$N = 123$	Fundamental frequency (pitch)/Hz			
	minimum	maximum	mean	SD
	170.20	273.21	207.82	20.52

To investigate whether or not men prefer feminine voice pitch over average pitch, we ran two regression analyses: one linear and one quadratic. If averageness is preferred to femininity, then the quadratic model will be in the shape of inverted 'U', with the vertex of the 'U' centred around either our sample's average voice pitch (~207 Hz), or that which is reported for other samples (eg ~220 Hz—Childers and Wu 1991). If femininity is preferred to averageness, then the linear model will be a better fitting model than the quadratic model. Both the linear ($F_{1,121} = 15.93$, $p < 0.0001$) and quadratic ($F_{2,120} = 8.99$, $p < 0.0001$) models of the relationship between voice pitch and attractiveness were highly significant (see figure 1). We assessed which model was best fitting with Akaike's Information Criteria (Motulskey and Christopoulos 2004) test, which compares the sum of squares from each model, whilst taking into account the complexity of the model (degrees of freedom). Akaike's Information Criteria test revealed a difference in Akaike's Information Criteria of 16.11 (linear – quadratic), a 99.97% probability that the linear model was correct, and that the linear model was 3145.7 times more likely to be correct than the quadratic model. Thus, these analyses suggest that men's preferences for feminine pitch are greater than their preferences for average pitch in women's voices. Note that all of the aforementioned relationships would remain significant after Bonferroni correction for multiple comparisons ($n = 3$).



○ observed
— linear
-·- quadratic

Figure 1. The linear model of voice pitch and attractiveness (solid line) is a better fitting model than the quadratic model (dotted and dashed line). Here we find a positive association between voice pitch and attractiveness ratings, with the most attractive voices far higher in pitch than the average pitch of our sample.

3 Study 2

Our findings from study 1 complement those of Collins and Missing (2003), who also showed that men's attractiveness ratings of natural women's voices correlate positively with women's voice pitch. Although a quadratic model of pitch and voice attractiveness was significant, the linear model was a significantly better fitting model. Thus we found little evidence to support that averageness is the critical determinant of female voice attractiveness. To investigate further and to control for the effects of acoustic correlates of voice pitch on attractiveness ratings, in study 2 we tested men's and women's preferences for raised and lowered pitch in women's voices with low, average, or high starting pitch (see table 2). If men and women prefer average pitch in women's voices, then there will be a preference for raised pitch in the group with low starting pitch,

Table 2. Mean (in Hz) and standard deviation (in parentheses) of fundamental frequencies (pitch) of manipulated voices at each level of starting pitch.

Starting pitch	Lowered pitch	Raised pitch
Low (200)	180 (1.40)	220 (1.40)
Average (220)	200 (0.26)	240 (0.26)
High (241)	221 (0.95)	261 (0.95)

no preference in the group with average starting pitch, and preference for low pitch in the group with high starting pitch. If attractive voices are high in pitch as opposed to average, then raised pitch will be preferred in each group.

3.1 *Methods*

3.1.1 *Participants.* Protocols were approved by the University of St Andrews Ethics Committee. Female voices were taken from study 1 such that five would have a low starting pitch (ie pitch of unmanipulated voice) of 200 Hz, five have an average starting pitch of 220 Hz [average pitch equal to that reported by Childers and Wu (1991)], and five have a high starting pitch of 240 Hz. Participants who provided voices were aged 18–23 years (M = 20.00 years, SD = 1.69 years). Raters included two hundred and sixty-three women aged 17–63 years (M = 24.58 years, SD = 7.57 years) and three hundred and forty-two men aged 17–64 years (M = 26.23 years, SD = 8.44) who rated attractiveness, forty-seven men aged 17–55 years (M = 26.55 years, SD = 9.27 years) and fifty-six women aged 18–64 years (M = 27.05 years, SD = 10.27 years) who rated perceived age, and sixty-eight men aged 17–69 years (M = 28.87 years, SD = 11.20 years) and fifty women aged 17–62 years (M = 28.03 years, SD = 10.71 years) who rated perceived femininity. Voices were rated over the worldwide web and in the laboratory. Internet-based tests for attractiveness ratings have been widely used, and results from these studies are consistent with results from lab-based studies [see Feinberg et al (2005a) for a review of web-based attractiveness experiments and validation of methods]. The numbers of subjects reported above reflect rejection of data from duplicate IP addresses (Kraut et al 2004).

3.1.2 *Stimulus generation.* Each vowel sound was manipulated separately. Fundamental frequency was manipulated by using the pitch-synchronous overlap add (PSOLA) method (Boersma and Weenink 2001). The PSOLA method allows selective manipulation of pitch (fundamental frequency and corresponding harmonics) independently of formant frequencies (see Feinberg et al 2005b). To feminise voices, the fundamental frequency of each voice was raised by 20 Hz (see Feinberg et al 2005b). The converse was done to masculinise voices. The amplitude of each vowel was normalised to 87.3 dB RMS. Voices were then converted to MPEG layer 3 audio format (mp3) and uncompressed at 11.025 kHz sampling rate at 128 kbit s^{-1} bit-rate with the LAME 3.93 encoder (all spectrotemporal features were preserved exactly, within the Nyquist frequency of 22.05 Hz). Figure 2 shows the spectrograms of manipulated voices.

3.1.3 *Acoustical analysis.* After stimuli were manufactured, each vowel sound was analysed separately with the Praat software (www.praat.org). Absolute pitch (fundamental frequency in Hz) was measured by using Praat's autocorrelation algorithm. Pitch measurement technique was identical to that used in study 1. Formant frequencies were measured with a technique described elsewhere (Feinberg et al 2005b, 2006). Table 1 shows descriptive statistics for pitch in Hz of manipulated voices.

3.1.4 *Procedure.* Voices were presented with a forced-choice paradigm. Participants listened to fifteen pairs of manipulated voices (each pair consisting of pitch-lowered and

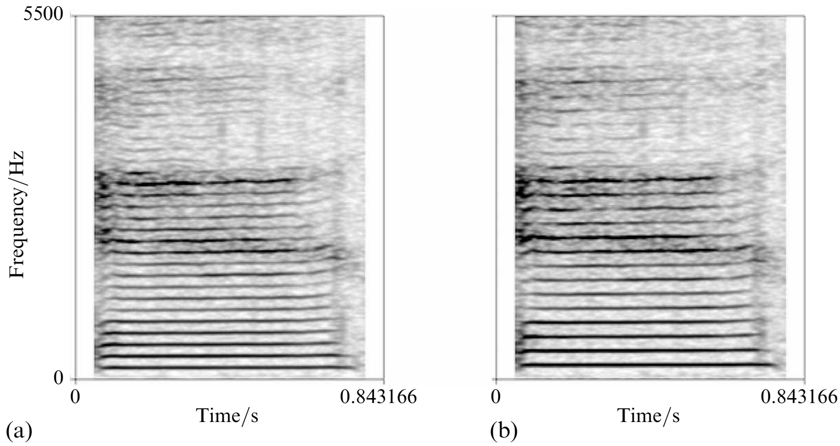


Figure 2. Spectrograms of manipulated vowel "ee" from a speaker with a starting fundamental frequency of 220 Hz (a) masculinised by lowering the frequency by 20 Hz, and (b) feminised by raising the frequency by 20 Hz. Harmonics are the horizontal lines ascending the two plots. Harmonic spacing is equal to the fundamental frequency (Ladefoged 1996). Thus the voice raised by 20 Hz has broader harmonic spacing than the voice lowered by 20 Hz.

pitch-raised versions of a single identity; see Feinberg et al 2005b). Side of presentation and order of stimulus presentation were fully randomised. Three different groups of raters chose which voice was either more attractive, older, or more feminine-sounding. Participants were instructed to listen to both voices (separately) through headphones and then select which voice was more attractive. Participants were allowed unmonitored ad-libitum stimulus repetitions (as in Feinberg et al 2005b, 2006).

3.2 *Results*

One-way ANOVAs showed that the pitch groups (high, average, and low) that women were divided into did not differ significantly in age ($F_{2,12} = 0.061$, $p = 0.941$) or formant qualities (ie formant frequencies 1–4 and formant dispersion: all $F_{2,12} < 1.659$, all $p > 0.230$; see table 3).

Table 3. Descriptive statistics of formant frequencies of unmanipulated voices. Mean and standard deviation of formant frequencies 1–4 (F1–F4) and their dispersion (Fdisp) = [(F4–F3) + (F3–F2) + (F2–F1)]/3 (Fitch 1997).

Acoustic measurement	Low starting pitch	Average starting pitch	High starting pitch
F1	584 (99.7)	530 (66.2)	534 (65.5)
F2	1725 (219.8)	1773 (86.1)	1840 (109.4)
F3	2848 (81.6)	2937 (207.4)	3004 (100.8)
F4	4008 (246.8)	4067 (162.2)	4122 (20.9)
Fdisp	1141 (64.1)	1179 (48.9)	1196 (26.2)

3.2.1 *Stimulus calibration.* Independent sample t-tests showed that men and women did not differ significantly in ratings of femininity or age at any level of starting pitch (all $|t| < 1.170$, all $p > 0.201$). Furthermore, age did not correlate with the percentage of voices chosen to be more feminine or younger at any level of starting pitch (all $|r| < 0.104$, all $p > 0.095$). Therefore, subsequent analyses were collapsed across sex and age groups.

One-sample t-tests (chance value = 50%) revealed that at each level of starting pitch, when pitch was raised, voices sounded more feminine (low: $t_{109} = 17.60$, $p < 0.0001$; average: $t_{109} = 16.84$, $p < 0.0001$; high: $t_{106} = 13.85$, $p = 0.0001$) and younger (low: $t_{96} = 23.77$,

$p < 0.0001$; average: $t_{96} = 17.748$, $p < 0.0001$; high: $t_{96} = 18.97$, $p < 0.0001$) than the same voices with lowered pitch.

To further test if starting pitch affected how much more feminine or younger voices with raised pitch sounded than the same voices with lowered pitch, paired-sample t-tests (comparing the percentage of raised pitch voices chosen at each level of starting pitch) were conducted. There was no effect of starting pitch on how each manipulation affected perceptions of age (all $t < 1.74$, all $p > 0.085$; df = 106, 108, and 105, respectively, for low, average, high starting pitch). However, there were significant differences when comparing ratings of femininity between the high-pitched, low-pitched, and average-pitched starting groups (high – average: $t_{106} = 2.48$, $p = 0.015$; average – low: $t_{108} = 1.42$, $p = 0.158$; high – low: $t_{105} = 3.09$, $p = 0.003$). Note that all of the aforementioned relationships remain significant after Bonferroni correction for multiple comparisons. Figure 3 illustrates these data.

3.2.2 *Attractiveness ratings.* Independent sample t-tests showed that, among all levels of starting pitch, men's attractiveness judgments were more affected by the pitch manipulation than women's attractiveness judgments were (all $t > 2.63$, all $p < 0.01$). Therefore, men's and women's ratings were analysed separately in subsequent analyses. Raters' age, however, did not correlate with the percentage of voices chosen to be more attractive at any level of starting pitch, when men's and women's ratings were considered separate groups or the same group (all $|r| < 0.104$, all $p > 0.096$). Note that the aforementioned significant relationships would remain significant after Bonferroni correction for multiple comparisons ($n = 3$).

For each sex and group of voices (low, average, and high) the percentage of feminine voices chosen was calculated. For men's ratings, one-sample t-tests (chance value = 50%) revealed that participants preferred femininity in voices with low starting pitch ($t_{341} = 18.34$, $p < 0.0001$), voices with average starting pitch ($t_{342} = 16.27$, $p < 0.0001$), and in voices with high starting pitch ($t_{339} = 8.54$, $p < 0.0001$). For women's ratings, one-sample t-tests (chance value = 50%) revealed that participants preferred femininity in voices with low starting pitch ($t_{254} = 11.432$, $p < 0.0001$), voices with average starting pitch ($t_{254} = 7.83$, $p < 0.0001$), but not voices with high starting pitch ($t_{255} = 0.99$, $p = 0.324$). Note that all of the aforementioned relationships remain significant after Bonferroni correction for multiple comparisons ($n = 6$).

To further analyse the effect of starting pitch on the extent to which each manipulation affected attractiveness ratings, paired-sample t-tests compared the percentage of raised-pitch voices chosen from each level of starting pitch, for each sex of raters separately. For male raters, the manipulation had a greater effect on voices from the group with low starting pitch than those from the average group ($t_{338} = 2.683$, $p = 0.0008$). The manipulation also had a greater effect on voices from the group with average starting pitch than the group with high starting pitch ($t_{338} = 5.72$, $p < 0.0001$). The effect of the manipulation on low starting pitch was greater than that on high starting pitch ($t_{335} = 8.05$, $p < 0.0001$). For women raters, the manipulation had a greater effect on voices from the group with low starting pitch than those from the average group ($t_{252} = 4.54$, $p < 0.0001$). The manipulation also had a greater effect on voices from the group with average starting pitch than the group with high starting pitch ($t_{253} = 6.03$, $p < 0.0001$). The effect of the manipulation on low starting pitch was greater than that on high starting pitch ($t_{253} = 8.94$, $p < 0.0001$). Note that all significant effects reported here are robust to Bonferroni correction for multiple comparisons ($n = 3$ for separate male and female comparisons). Figure 3 displays the aforementioned results.

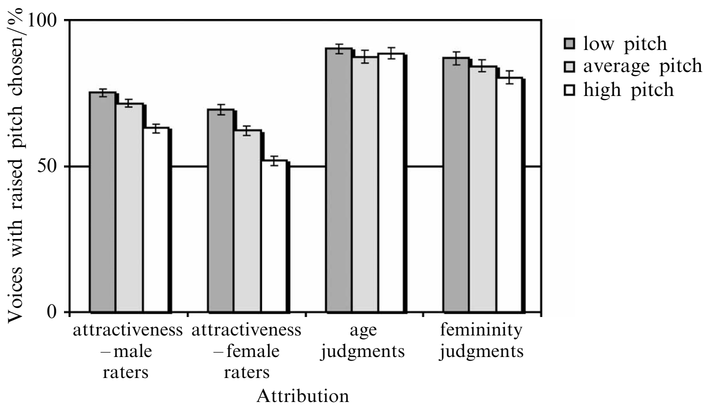


Figure 3. Voice pitch manipulations and attributions. At each starting pitch, men preferred voices with raised pitch to voices with lowered pitch above the chance value of 50%. The manipulation had a greater effect on the voices with the lowest starting pitch than those with the highest starting pitch, except for age ratings.

4 Discussion

In study 1 we found a positive correlation between voice pitch and attractiveness ratings of women's voices. A linear model was a better fit than a quadratic model. Thus, we found no support that the voices most average in pitch were the most attractive. Instead, voices with the highest pitch were the most attractive. Here, however, the mean pitch of our sample is 10 Hz lower than reported elsewhere (Childers and Wu 1991). This suggests that either there is cross-cultural variation in female voice pitch, or some other sample-related differences between the two studies. Thus, further research should be carried out to investigate such topics.

In study 2, we found that the pitch manipulation had the strongest effect on attractiveness ratings in the group with low starting pitch, and the weakest effect on the group with high starting pitch. At first glance, this may seem explainable by differences between actual and perceived pitch (Traunmüller 1990). If, however, differences in how manipulations altered ratings based on their starting pitch were solely due to differences in perceived pitch between manipulations, then all attributions should follow the same pattern because the stimuli will be differentially discriminable. This did not happen. Although starting pitch affected femininity attributions in the same way as attractiveness ratings did, there was a different effect of starting pitch on age ratings. Thus, differences between perceived pitch and physical pitch cannot be the only explanation for the aforementioned result.

For voices at each starting pitch, increasing pitch increased men's ratings of attractiveness of women's voices (although women had no preference for high or average voice pitch in the condition with the highest starting voice pitch). Our finding that increasing pitch enhances women's vocal attractiveness is also consistent with Collins and Missing (2003) who found a positive association with pitch and attractiveness in unmanipulated voices. The fact that increasing pitch enhanced the attractiveness of voices that were already higher pitched than average prior to the vocal manipulation indicates that men preferred voices with feminine characteristics to average characteristics. Therefore, our results do not support the idea that attractive voices are only average [as could be hypothesised on the basis of the findings of Langlois and Roggman (1990)]. Although averageness is attractive in faces (Langlois and Roggman 1990; Little and Hancock 2002), non-face objects (Halberstadt and Rhodes 2000, 2003), and music (Repp 1997), men's preferences for exaggerated feminine female traits in both faces and voice pitch appear to outweigh general preferences for averageness, at least for male raters.

Our results also suggest that women may have a lower threshold in their choice how high in pitch women's voices can be and remain attractive to men. In other words, there is a sex difference in the point at which raising voice pitch does not increase attractiveness. Whether or not this is because of sex differences in preferences, or due to generalised sex differences in task performance is yet to be determined.

In summary, we demonstrated that men prefer femininity of pitch over averageness of pitch in women's voices. Men may prefer women with high-pitched women's voices because high voice pitch in women is associated with pro-social stereotypes (Berry et al 1994; Zuckerman and Driver 1989), and hormonal markers of fertility (Abitbol et al 1999; Feinberg et al 2005a; Van Borsel et al 2000).

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