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Distinguishing the Male and Female Voices

The human vocal tract is the oldest and the most perplexing musical instrument of which human beings are in possession. Because researchers cannot directly view the vocal organ, studies on human voice have been masked in both idealistic assumptions and variable results. The vocal tract, unlike most man-made instruments, is susceptible to numerous variations, as demonstrated when consonants or vowels are sung or spoken. Along with these variations, human beings are still able to control pitch and resonances through vocal training. If two male vocalists were to sing the same pitch, there are certain resonant differences that exist to distinguish each voice. Additionally, these upper resonances exist in the female voice, however the emphases are more unique to each sex.

The physical construction of the human vocal tract is an integral aspect of the human voice. The most important source components in the human vocal tract are the larynx and the vocal cords (Rossing 338). The vocal cords are comprised of numerous ligament folds that form a V-shaped opening through which sound can emanate. The vocal cords vibrate, rapidly opening and closing, to create a buzzing sound that forms the basis of voiced consonants and vowels (Rossing 339). Using the sub-glottal pressure created by air from the lungs, singers are able to better control the amplitude and frequency with which the vocal cords vibrate. Additionally, he rate at which the vocal folds vibrate relies largely on their mass and tension (Rossing 339).

The structure of the vocal tract is similar to that of a closed-open tube. If it were uniform along the entire tube, the vocal tract would exhibit distinct, idealized formants at "odd numbered multiples" of its first formant (Bozeman 61). If the average vocal tract length in an adult male is 17cm, the closed-open tube formant equations can be applied to the vocal tract: (*Where c = 340m/s)*

$$F1 = f_1 = c/4L \qquad F2 = f_2 = 3c/4L \qquad F3 = f_3 = 5c/4L$$

Using these equations, an adult male vocal tract should ideally produce formants, natural resonating frequencies, at "500 Hz, 1500 Hz, 2500 Hz and 3500 Hz," however since its structure is less consistent and more variable, these formants are spaced at different increments.

The most significant formant of the male voice is called "The Singer's Formant," a strong resonance at around 2600-3600 Hz (Bozeman 62). The singer's formant contributes "carrying power" and tone clarity and is present in most classically trained male singers. Because of the singer's formant around 3 kHz, male singers have the ability to project over symphony orchestras where the orchestral sound is weak (Mendes 530). When professionally trained singers perform with a choir, the singer's formant is less pronounced because projection is not a priority. The singer's formant requires a wide pharynx, is characteristic of "good singing" in chest voice, and more present when singers perform as a soloist. According to Bozeman, tones with a "pleasing balance" between the first formant and singer's formant creates the "ideal timbral balance of depth and brilliance," called *chiaroscuro* (Bozeman 62). Female voices also occasionally have a formant in the range of the singer's formant, though it is usually not as strong as that in male voices. Perhaps it is this resonating frequency that also helps distinguish a male voice from a female voice.

Besides the fact that male voices typically fall in a range lower than that of female voices, there are certain features that help differentiate male and female voice. The most significant factors used to distinguish voices are the fundamental frequency and the formant frequencies. In a test of six trained vocalists, three male and three female, singers were asked to sing different scales and different vowels. The vocalists all were recorded in the same room singing the same pitch, an A4, on "ah" in order to compare the frequency spectrums. For this experiment, each of the male singers was recorded having a singer's formant within the proper frequency range. The female singers, however, were less consistent regarding the singer's formant. Female #1 seemed to exhibit a formant within the proper range for a singer's formant, however the strength was not as significant as those of the male singers. Female #2 happened to have a singer's formant comparable to the male voice. Female #3 had two formants in the range —one at the lower boundary and one at the higher boundary—of the singer's formant in addition to the higher partials throughout the upper frequency spectrum. The commonality amongst the three trained female singers was the existence of significant higher formants in the range of 8 kHz to 11 kHz, which were more intense than those registered in the male vocal recordings.

Vocalist	Description
Male #1	Singer's Formant at 2875 Hz
Male #2	Singer's Formant at 3015 Hz

Male #3	Singer’s Formant at 3454 Hz
Female #1	Weak Singer’s Formant, but more significant higher formants at 8 kHz and 11 kHz
Female #2	Has a Singer’s Formant, but also more significant higher formants at 8 kHz and 10 kHz
Female #3	Two formants in range of Singer’s Formant and has more significant higher formant at 8 kHz

The female voices appeared to have frequencies throughout the range above 10 kHz, whereas male voices only had certain higher frequencies. The consistency at this range could be another factor contributing to the determinacy of voice. Through analyzing the vocals of these trained singers, it is reasonable to infer that both the fundamental frequency, and its partials, and the singer’s formant are significant factors that can help determine which person from which a sound is created.

Works Cited

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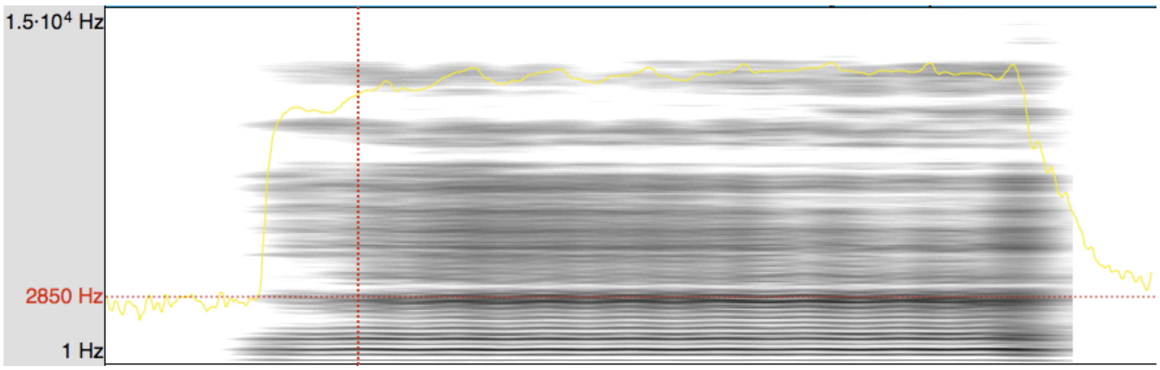
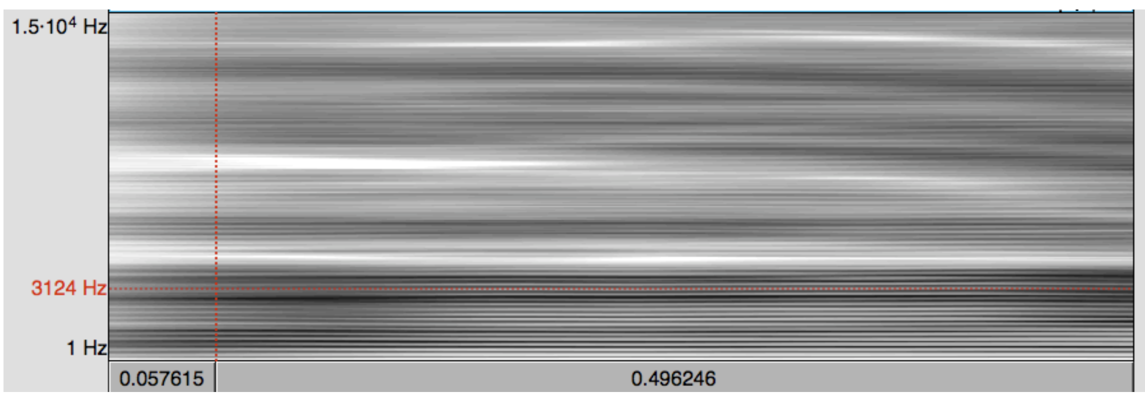
Mendes, Ana P., Howard B. Rothman, Christine Sapienza, and W.S. Brown Jr. "Effects of Vocal Training on the Acoustic Parameters of the Singing Voice." *Journal of Voice* 529th ser. 17.4 (2003): 529-43. Print.

Rossing, Thomas D., Paul A. Wheeler, and F. Richard Moore. *The Science of Sound*. 3rd ed. San Francisco: Addison Wesley, 2002. Print.

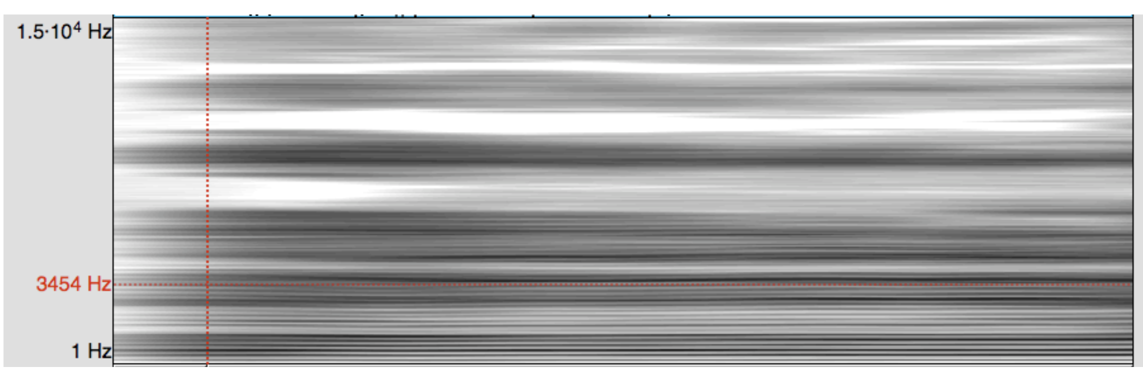
Male #1:



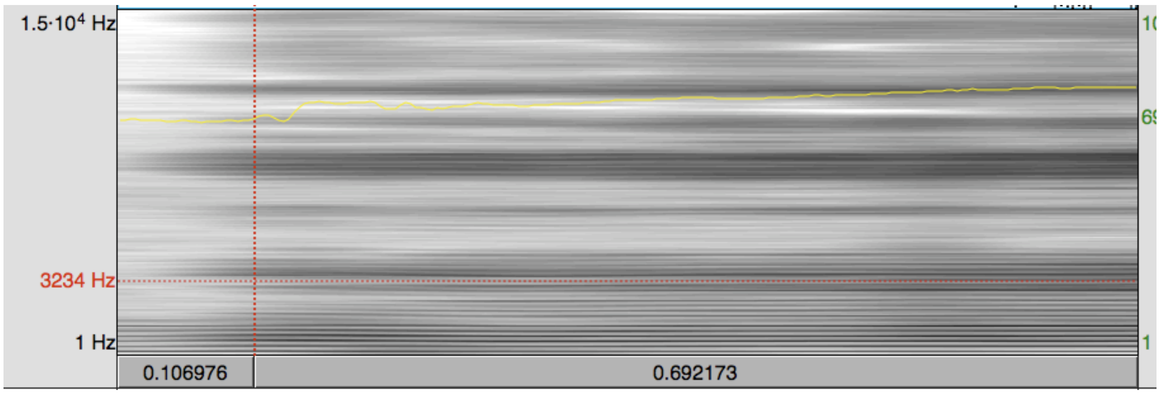
Male #2:



Male #3:



Female #1:



Female #2:

Female #3: