Resonances of the human vocal tract and some of their uses

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The human vocal tract behaves approximately as an acoustical waveguide with a series of resonances whose frequencies may be varied by adjusting the position of tongue, lips and teeth. In voiced speech, these resonances interact with the harmonics of the lower frequency signal from the vibrating vocal folds to produce associated peaks, or formants, in the output spectrum. Such formants are characteristic of vowels in speech.

Singers sometimes use these resonances in musical rather than linguistic ways. For sopranos, the vibration frequency of their vocal folds may be much higher than the normal values for the lowest resonance, and consequently a reduced interaction would cause a loss of power. Direct measurements of the resonance frequencies of the vocal tract of classically-trained sopranos during singing show that they consistently increase them to match the frequency of their singing. This significantly increases the loudness and the uniformity of tone, at the expense of comprehensibility. The fundamental frequency of other singers is usually less than the value of the lowest resonance and so they would experience no advantage in tuning this resonance. However the power could be increased if the resonance frequency were tuned to a harmonic of the fundamental frequency. Our measurements indeed show that some altos, tenors and baritones use this strategy when appropriate.

The role of the vocal tract resonances is quite different when playing a wind instrument. The sound is then generated by the vibrating lip or reed valve rather than by the vibrating vocal folds. The frequency of vibration is then primarily determined by one of the strong resonances of the wind instrument itself. Our measurements show that varying the resonances of the vocal tract can then still slightly alter the vibration frequency and change the harmonic structure or timbre of the produced sound.

The research described has involved several members and associates of our Acoustics Laboratory. http://www.phys.unsw.edu.au/speech http://www.phys.unsw.edu.au/music