

Acoustic tubes with maximal and minimal resonances

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This paper presents a theoretical derivation of acoustic tract shapes that minimize and maximize resonance frequencies. The derivation is based on a symmetry of Webster's horn equation and on Ehrenfest's adiabatic invariance hypothesis. It is shown that for minimizing formant frequencies, abrupt transitions are necessary, while for maximizing resonance frequencies, gradual transitions are needed. It is argued that this has implications for modeling human, animal and prehistoric vocal tracts. Such models should represent the anatomic (in)ability to produce abrupt and gradual transitions correctly, otherwise they would have biases towards different sets of formant frequencies than real vocal tracts.