

The Dynamics of the Vocal Fold Oscillation

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The dynamics of the vocal fold oscillation for phonation in the chest register is investigated analytically, considering the general case of large amplitude oscillations.

A simple dynamical model of the vocal folds is first introduced, where they are represented by a rigid plank to capture the characteristic oscillation pattern with convergent and divergent glottal shapes. The capability of the model to reproduce the oscillation is demonstrated through numerical computations.

The equilibria and bifurcation phenomena in the oscillation are then examined. A bifurcation diagram is derived, which provides a general picture of the oscillation dynamics. Besides a threshold value of the subglottal pressure, a second condition for the oscillation is found, which requires a higher stiffness at the lower edge of the vocal folds than at the upper edge.

The action of the airflow in the oscillation is analyzed next, showing that it may be expressed as an element with a negative viscous damping plus a positive stiffness. The first term causes the oscillation when it overcomes the vocal fold positive damping. It increases with the oscillation amplitude, which explains the observed decrease of the minimum subglottal pressure required to sustain the oscillation after its onset. The second term is responsible for the observed increase of the oscillation frequency with the subglottal pressure.

Further, it is shown that there is a transfer of energy from the airflow to the vocal folds as a result of the glottal shape pattern. The oscillation is then explained as a balancing condition between the energies transferred from the airflow and dissipated in the tissues.

It is finally demonstrated that the cause of the oscillation can not be attributed to the existence of a negative semitransglottal differential resistance, questioning thus a previous theory based on the collapsible tube analogy.