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Clinical Significance of the Two-Mass-Model

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The two mass model (2MM) as introduced by Ishizaka & Flanagan (1972) and simplified by Steinecke & Herzel (1995) describes many features of the vocal fold oscillation patterns [1,2]. Particularly, it was shown that a large variety of voice disorders may be explained by means of high-speed observations with subsequent interpretation by the 2MM. Laryngeal symmetry was identified as an important precondition for regular phonation [3]. Slight laryngeal asymmetries in vibrating masses or vocal fold tension may be compensated by the coupling of left and right vocal fold during collisions. However, when larger asymmetries are present, the voice may be hoarse. The purpose of this study was to identify critical values of asymmetry concerning mass and tension based on the 2MM.

Vocal fold oscillation patterns were determined numerically for different kinds and amounts of asymmetry and for different subglottal pressures (P_s) between 4 cm H_2O and 16 cm H_2O. The vocal fold trajectories were used to extract several parameters which provide information on voice quality. The parameter set is made up of open quotient (OQ), correlation coefficient (Xcorr), time corrected correlation ($Xcorr_{max}$), minimum and maximum glottal area during phonation ($area_{min}$, $area_{max}$) and a psychoacoustical roughness measure (70 Hz component) [4]. Additionally, subjective evaluation of the corresponding simulated voice samples were judged in terms of **r**oughness, **b**reathiness and **h**oarseness (RBH) by a group of experts.

Figure 1 shows six maps for the above mentioned parameters (represented by grey values) for different asymmetries and a subglottal pressure of P_s= 16 cm H_2O. Mass and spring constants for the left side were kept constant using the standard parameters [1]. Vibrating masses and spring constants for the right side were varied between Q=0.25 and 4.0 in steps of 0.05. Q_m and Q_k are plotted against the x-axis and y-axis, respectively. Values at $Q_m=Q_k=1$ correspond to complete symmetric phonation. Increased mass is represented by $Q_m>1$ etc. For example, the correlation coefficient is 1 for symmetric phonation. When both mass and tension is increased at one side, it remains large as indicated by the white area. With increasing distance from the $Q_m=Q_k$ -line correlation of left and right vocal fold oscillation decreases indicating vibratory irregularities. Glottal closure during phonation implies a minimum glottal area ($area_{min}$) of zero. Similar to the correlation coefficient, deviations from symmetric phonation occur primarily for $Q_m \neq Q_k$. However, even for large asymmetries $area_{min}$ becomes zero, indicating glottal closure.

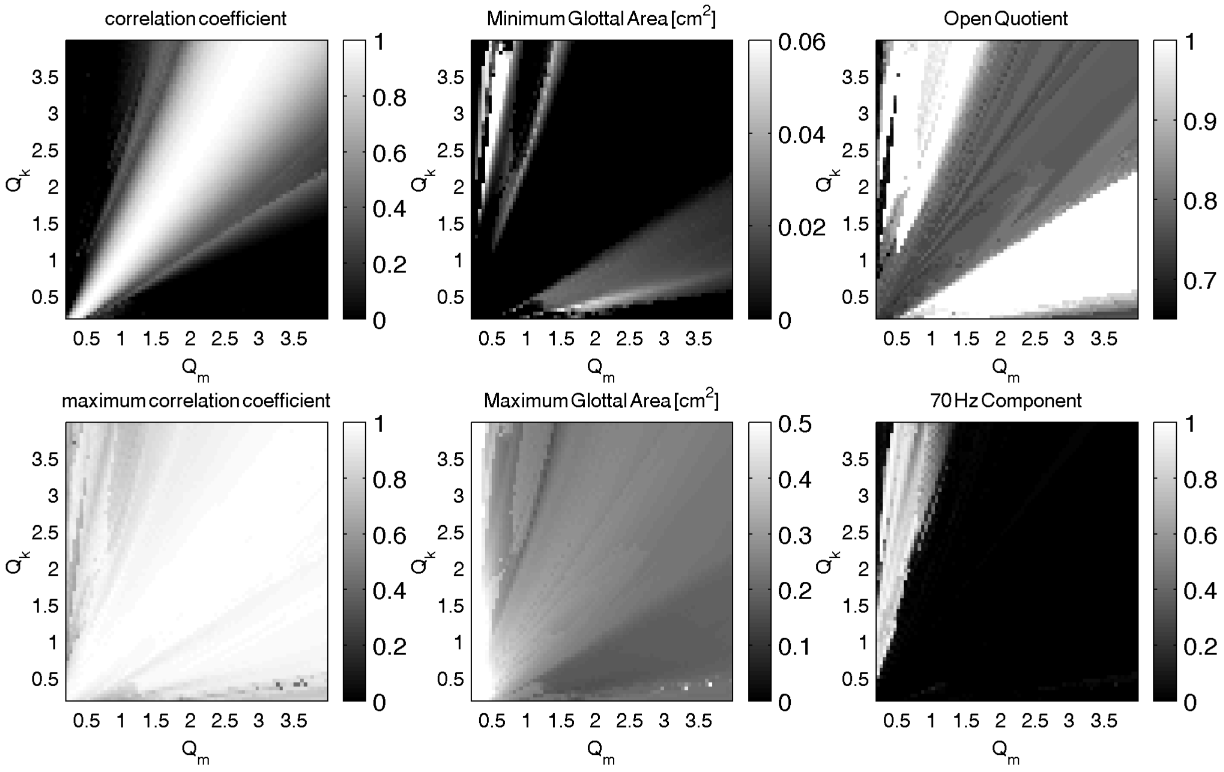

Figure 1: Several voice quality measures as a function of tension and mass for P_s=16 cm H_2O. Q_m and Q_k denote the quotient of the masses and spring constants on the right and left vocal fold, respectively. Mass quotient Q_m is plotted along the x-axis, spring constant quotient Q_k is plotted along the y-axis. The figures show six different voice quality parameters as correlation coefficient (left, top), maximum correlation coefficient (left, bottom), minimum and maximum glottal area (middle,top and middle, bottom), open quotient (right, top), and psychacoustical roughness measure (right, bottom).

The results indicate that hoarseness maps may be relevant for clinical use. They demonstrate the reasons of hoarseness and may help to choose therapy. In combination with high speed recordings the presented hoarseness maps allow evaluation of voice therapies.

References:

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