MEASURING THE TRANSFER FUNCTION OF PHYSICAL VOCAL TRACT MODELS - A COMPARATIVE STUDY

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3D-printed models of vocal tracts (VT) based on magnetic resonance imaging (MRI) and derived replicas are commonly used for education[1] and for detailed experimental analyses of the acoustical properties of the speech apparatus[2]. Therefore, exact knowledge of the acoustical transfer characteristics is needed.

To evaluate these transfer functions, two different experimental configurations were analyzed. First, excitation with an - assumed - broadband flow signal at the glottal region using an in-ear loudspeaker and simultaneous measurement of the acoustic pressure at the lips and the membrane motion via Laser Doppler velocimetry (LDV). Second, external excitation of the models using an ordinary loudspeaker and measurement of the pressure at the glottis and - in a further step - in front of the closed lips.

As a result, direct measurement of the moving membrane of the in-ear loudspeaker shows that it behaves not as frequency independent flow source. Moreover, the moving membrane is directly influenced by the VT input impedance and does not necessarily move in the first mode. Therefore, an in-ear loudspeaker is not an adequate acoustic excitation.

Further, the second procedure allows the exact calculation of the TF were the ratio of pressure at the glottis to the pressure at the (closed) lips is equivalent to the volume velocity transfer function which can be proved theoretically.

References:

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[2]Echternach et al. (2015) "Articulation and vocal tract acoustics at soprano subject's high fundamental frequencies", J Acoust Soc Am, Vol. 137, pp. 2586-2595