MODELING THE PHYSICS OF PHONATION

Ingo R Titze

Executive Director, National Center for Voice and Speech
The Denver Center for the Performing Arts

Distinguished Professor of Speech Science and Voice
Speech Pathology and Audiology and the School of Music
The University of Iowa

Stages of Modeling

- Flow Pulse Models
- Kinematic Models of Normal Modes of Vibration
- Low-Dimensional Self-Oscillating Models
- High-Dimensional Self-Oscillating Models

Flow Pulse Modeling

- F0, intensity, and open quotient under good control
- Pulse skewing is ambiguous
- Poor source-system interactivity – no realistic nonlinear dynamic effects

Kinematic Modeling of Normal Modes of Vibration

- F0, intensity, and adduction under good control
- Good data base from which to model
- Source-tract interaction is with flow and pressures, but not with tissue movement
- Rules are needed for mode amplitudes and mode coupling

Low-Dimensional Self-Oscillating Models

- F0 and intensity are not under direct control
- Poorer data base from which to model
- Source-tract interaction is with flow, pressure, and with tissue movement
- Many rules are needed to control biomechanical parameters consistent with continuum mechanics
- Bifurcations and chaotic behavior is only phenomenologically, but not quantitatively, meaningful

High-Dimensional Self-Oscillating Models

- F0 and intensity are not under direct control
- Poorer data base from which to model
- Source-tract interaction is with flow, pressure, and with tissue movement
- Fewer rules are needed to control biomechanical parameters consistent with continuum mechanics
- Bifurcations and chaotic behavior is quantitatively meaningful
- Physics is difficult, computation is lengthy

Where Should More Effort Be Spent?

- Aerodynamics of contiguous flow channels in glottis to excite higher modes of vibration
- Aerodynamics of left-right asymmetry with vertical modes of vibration
- Pros and cons of finite-element versus finite-difference modeling of mixed boundary conditions
- Rule development for low-D models to control masses, springs, dampers, and geometry
- Simple rules for transition from incompressible flow in glottis to compressible (acoustic) flow in vocal tract
- More data sets on gender, age, species differences in morphology

Where Should Less Effort Be Spent?

- Flow pulse modeling (it is basically finished)
- Modeling nonlinear phenomena with model parameters that have little physiological or physical validity. (We know the phenomena now, but the applications need to be more predictive).