The Search for Efficient Voice Production: Where Is It Leading Us?

Ingo R. Titze

This short essay is written to shed a little light on the ongoing efforts to define what is meant by efficient voice production, that which gives the most output for the least effort. Most pedagogues, clinicians, and voice scientists have wrestled somewhat with this problem because voices are often not big enough or enduring enough for a given vocal task. Amplification has been the single most important factor in alleviating the problem, but amplification is not yet acceptable or convenient for every venue of vocal performance. Furthermore, it is not clear that amplification maintains the same level of vocal skill and variety that can be achieved from a voice trained for optimum output.

Efficiency can be dealt with at various levels of energy conversion in the human body. Our muscles can be efficient in changing chemical energy to mechanical energy, our motor system in the brain and spinal cord can be efficient in organizing these muscles to do a task (e.g., change pitch, increase loudness), or our habitual positioning of our vocal folds and articulators may be efficient, especially when combined with the use of airflow from the lungs. To consider all of these levels of efficiency simultaneously is a daunting task for scientists. For this reason, the focus has been on acoustic efficiency, the ease in which glottal airflow is converted to acoustic pressure at the mouth.

Much has been learned from musical instrument makers. For hundreds of years, string, brass, and woodwind instruments have been designed and redesigned to improve ease of play, quality of sound, and amount of sound produced. What is nearly universal about musical instruments is that they have many resonances. The sound source is reinforced by these resonances, but most of the energy is kept inside of the instrument, and the small amount that is allowed to radiate out to the listener carries the signature of the instrument in its spectrum of frequencies. Violin makers, for example, spend much time shaping the top and bottom plates to the right thickness and curvatures, tapping the plates repeatedly to listen to the resonances in the wood. Prior to assembly of the plates, they predict the air volume resonance inside the body of the instrument. The location and dimensions of the bridge are varied to get the optimum coupling of energy between the strings and the top plate. Even the glue and the varnish matter in the sound quality of the instrument.

But why are many resonances important, and why is most of the energy kept inside? Doesn't that make the instrument inefficient by its very design? Yes, it does, and no, it doesn't. Most sound sources by themselves are poor radiators of sound. Strings by themselves do not drive much air, and buzzing lips, reeds, or vocal folds by themselves do not deliver much sound. They need a secondary structure, a resonator, to get their sound effectively into free space. Thus, even though the resonator keeps most of the energy inside, the amount it releases is still more than what the source by itself can release. One of the reasons that multiple resonances are needed is so the energy can be released over a wide spectrum of frequencies. This colors the sound and gives the instrument its unique characteristic. If the sound is single pitch and sustained (rather than percussive), its frequency spectrum is harmonic, or nearly harmonic. For reinforcement of all the harmonics, the resonances of the instrument have to be harmonically spaced for every note played, which is not a simple task in the design of an instrument. A compromise often is reached between the source and the resonator so that source harmonics can be "pulled" toward the resonance frequencies, and enough resonances are built in so that the "pulling" requirement is not too severe. This is the main reason for many resonances.

How does this apply to the vocal instrument? As singers, we have two major problems: 1) our resonator (the vocal tract) is too small to provide many resonances where we need them; and 2) the resonances are already spoken for by the fact that we want to speak while we sing. The res-

Journal of Singing, March/April 2004
Volume 60, No. 4, pp. 377–378
Copyright 2004
National Association of Teachers of Singing

onances are spread 1000 Hz apart, on average, whereas our resource harmonics are spaced much closer for most pitches we sing. Thus, "pulling" source harmonics and vocal tract resonances (formants) together for every pitch is an impossible task, especially in light of the already existing requirement that the first two formants must be placed for the intended vowel.

We are left with an alternate strategy, which is to use the vocal tract to change the nature of the airflow in the glottis. To achieve high intensity of sound, the glottal flow can be made to change very abruptly (from a high value to zero) by using the vocal tract as a kind of suction device. Similar to the Bernoulli Effect, which says that the walls of a tube can be sucked together by a rapid airflow through a constricted section of the tube, this is an "inertial suction effect" by the air column in the vocal tract. It says that flow can be maintained through the glottis a little longer (before glottal closure) in the wake of a forward-moving air column in the vocal tract. The key is not to raise the amount of flow, but to delay the reduction of glottal flow. This gives more vocal output for the same amount of vocal fold vibration, and average flow during phonation is conserved. Hence, we are beginning to get a clue to vocal efficiency.

Ingo R. Titze is Distinguished Professor of Speech Science and Voice at the University of Iowa and Executive Director of the Wilbur James Gould Voice Research Center at the Denver Center for the Performing Arts. His formal education is in physics and electrical engineering, but he has devoted much of his studies to vocal music and speech. Dr. Titze has published more than 150 articles in scientific and educational journals, coedited two books titled Vocal Fold Physiology, *and has authored a book called* Principles of Voice Production. *He has lectured throughout the world and has appeared on such educational television series as* Innovation, Quantum, *and* Beyond 2000. *He is a recipient of the William and Harriott Gould Award for laryngeal physiology, the Jacob Javits Neuroscience Investigation Award, the Claude Pepper Award, the Quintana Award, and the American Laryngological Association Award. He is a Fellow of the Acoustical Society of America and the American Speech-Language-Hearing Association. Dr. Titze has served on a number of national advisory boards and scientific review groups, including the Scientific Advisory Board of the Voice Foundation and the Division of Research Grants of the National Institutes of Health. He is Director of the National Center for Voice and Speech, a multi-instructional consortium. In addition to his scientific endeavors, Dr. Titze continues to be active as a singer. He is married to Kathy Titze and has four children. Mail should be addressed to Ingo R. Titze, National Center for Voice and Speech, 330 WJSHC, Iowa City, IA 52242. Telephone (319) 335-6600.*

Master of Arts in Music ◆ Master of Music

The Greatbatch School of Music
HOUGHTON COLLEGE

Musically Excellent ◆ Academically Engaging ◆ Profoundly Christian

A center for serious music students in the Christian world, the Greatbatch School of Music at Houghton College inaugurates graduate programs in music beginning fall 2004.
Degrees offered include the master of arts in music and the master of music in performance, conducting, composition, and collaborative performance.

The Greatbatch School of Music offers full tuition assistantships, including stipend, and provides opportunities for professional and artistic development under an outstanding faculty.

The new graduate degrees grow out of the college's distinguished and comprehensive undergraduate music program, which is embedded in Houghton's strong liberal arts tradition and clear Christian mission.

Houghton, New York 14744-0128 ◆ 800.777.2556 or 585.567.9400 ◆ Fax: 585.567.9517 ◆ music@houghton.edu

www.houghton.edu