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On Flow Phonation and Airflow Management

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Flow phonation is a term used in voice therapy and voice pedagogy to describe a production that feels effortless and efficient because ample airflow is passed through the glottis when the vocal folds vibrate. Using the analogy of water flowing from a reservoir, flow phonation is similar to opening the valve to release more water if valving is too tight. Some clinicians use the term *unpressing* because vocal folds can easily be pressed together in an attempt to make a stronger sound, which limits airflow. With flow phonation, the implication is that more airflow produces more sound output, but every singing teacher and speech-language pathologist knows that excessive flow makes the voice breathy and weak. It is therefore a question of optimizing the airflow, not maximizing it. But what is optimal, and what is the rationale behind it?

It must first be understood that there are two components of the glottal airflow, the steady component and the nonsteady (acoustic) component. The steady component is useless for sound production, except for some turbulent airflow noise created downstream from the glottis. The acoustic component is a flow that rises and falls as the glottis opens and closes (hundreds of times per second). This rise and fall creates a pressure against the vocal tract air column, which compresses the air and sets up the acoustic wave in the vocal tract. The key question becomes: Is this vocal tract input pressure dependent on the peak acoustic flow, or is it dependent on the rate of change of this acoustic flow? Therein lies the whole rationale for accepting or rejecting flow phonation as a tool for voice training.

The way in which an air column builds up an acoustic pressure depends on its *impedance*. This impedance, a ratio of acoustic pressure to acoustic flow, can be *resistive* or *reactive*. (For an in-depth description of these concepts, see Titze and Verdolini-Abbott, *Vocology: The Science and Practice of Voice Habilitation,* Chapter 10.)[1] A resistive impedance makes the pressure and flow rise and fall together, in phase. Flow phonation is therefore a perfect target for increasing acoustic output if the air column is resistive. Unfortunately, it rarely is. Inertive reactance usually dominates the impedance of the air column. The vocal tract input pressure is then determined by the *rate of change of the glottal airflow*, also known as the *flow derivative*. Typically, the maximum flow declination rate (MFDR) is the best measure of this flow derivative (Figure 1). To increase MFDR, we have two choices, either increase the peak flow or skew the waveshape so that the peak comes later in time. Delay of the peak

Journal of Singing, September/October 2015
Volume 72, No. 1, pp. 57–58

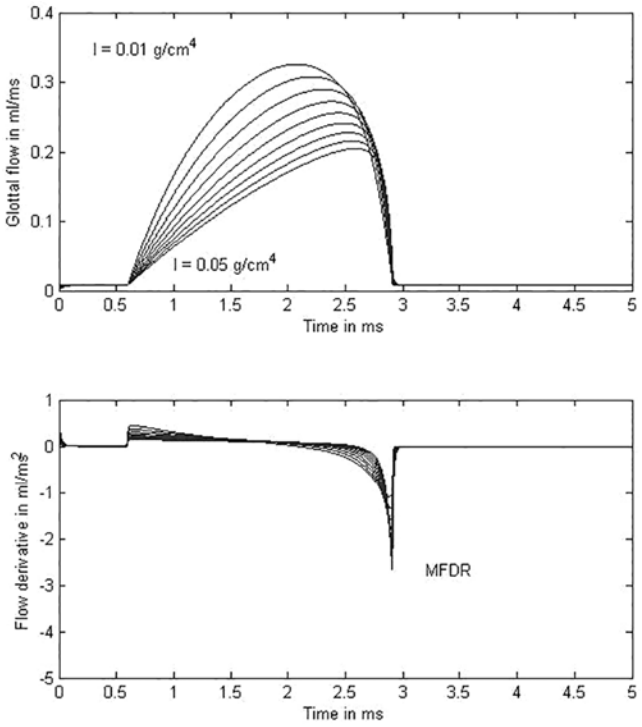

Figure 1. (Top) Nine glottal airflow pulses with different peak flows but similar flow declination rates. Values of vocal tract inertance I are indicated. Inertance is the inertive reactance divided by 2πf, where f is the frequency of interest (bottom). The rate of change of airflow for the same nine pulses, also known as the flow derivative. Maximum flow declination rate (MFDR) is the negative peak value as indicated.

flow is directly related to the inertive reactance of the air column. Figure 1 shows that the peak flow can actually decrease with increased inertance while MFDR stays constant. Efficient voice production is therefore regulated not only by vocal fold adduction and amplitude of vibration (which regulates peak flow), but by vocal tract inertance. A large peak flow can be effective if the vocal tract is not sufficiently inertive to skew the pulse and increase the MFDR. Nature has provided an impedance coupler (transformer) by way of the epilarynx tube. It is the narrow region of the vocal tract directly above the vocal folds. This epilarynx tube generally keeps the vocal tract inertive, but much variation occurs for different vocal tract shapes.

In summary, having an eye single to management of glottal airflow leaves out half of the picture. Singers who must produce long phrases on a single breath may in fact find flow-phonation counterproductive. Airflow conservation then invites vocal tract shapes that increase inertance, and therewith maximum flow declination rate, so that acoustic output power is increased.

NOTE

1. Ingo R. Titze and Katherine Verdolini-Abbott, *Vocology: The Science and Practice of Voice Habilitation* (Salt Lake City: National Center for Voice and Speech, 2012), 286–309.

Ingo R. Titze is Distinguished Professor of Speech Science and Voice at the University of Iowa and Executive Director of the National Center for Voice and Speech at the University of Utah. 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 400 articles in scientific and educational journals, coedited two books titled *Vocal Fold Physiology*, and now has three books in print: *Principles of Voice Production*, *The Myoelastic Aerodynamic Theory of Phonotion*, and *Fascinations with the Human Voice*. 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 and a Silver Medalist of the Acoustical Society of America, and a Fellow of 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. 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 and eight grandchildren. Mail should be addressed to Ingo R. Titze, National Center for Voice and Speech, 330 WJSHC, Iowa City, IA 52242. Telephone (319) 335-6600.

I bear the Scales, where hang in equipoise
The night and day; and when unto my lips
I put my trumpet, with its stress and noise
Fly the white clouds like tattered sails of ships;
The tree-tops lash the air with sounding whips;
Southward the clamorous sea-fowl wing their flight;
The hedges are all red with haws and hips,
The Hunter's Moon reigns empress of the night.

Oliver Wendell Holmes, "September"