Ingo Titze, Associate Editor

Falsetto Register and Vowels

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THIS IS IN DIRECT RESPONSE to a question from Jeremy Silver, singer and singing teacher. He wrote the following question:

"Why can one only sing pure falsetto on the /i/ or /u/ vowel? Is this because of vocal tract tuning? I have been having a debate with other voice teachers about this phenomenon. I have been taught and found that even in approximated falsetto (where there is still not TA activity) you cannot produce any vowels but /i/ or /u/. If you bring in a bit of vocalis/TA, then you can start to sound /ɑ/ or /e/ or /o/. Is this correct? Also, Dr. Titze, is it possible to super-approximate the vocal cords while in pure falsetto so that you can get enough of the harmonic envelope to produce all the vowels clearly? It has been proposed to me that this is possible by the use of lateral cricoarytenoid (LCA) and interarytenoid (IA) muscles while keeping the larynx low. I don't believe it because I do not think you can keep the larynx low if you do this, and I'm not sure that you can produce all the vowels clearly without some TA involvement."

You raise some fascinating questions that are at the forefront of voice research at the moment. The interaction between vocal fold movement, glottal airflow, and specific vowels is what has been called the nonlinear source-filter theory of vowel production. Generally speaking, vibration of the vocal folds can be strengthened by acoustic pressures in the vocal tract when one or more of the lower harmonies is slightly below a formant frequency (to the left of the formant if you are looking at a frequency spectrum). In this region, the vocal tract provides what acousticians call "inertive reactance" to a frequency produced at the source. This inertive reactance assists the vocal folds in their vibration, producing greater amplitude, more collision, and the characteristics of modal (chest) register.

The vowels /i/ and /u/ both have a low first formant (F1 ≈ 250–300 Hz). That means that any pitch above C_4 (261 Hz) is likely to have its fundamental (first harmonic) above the first formant. It will not be reinforced by the vocal tract. Relative to other pitch-vowel combinations, the vibrational amplitude of the vocal folds will be reduced, resulting in less collision and likely a falsetto registration. For this reason, pure falsetto is easy to produce with /i/ and /u/. If we change the vowel to /ɑ/ or /æ/, the first formant rises and (for the same pitch) the vocal folds get more reinforcement from the vocal tract because the first harmonic is below F1. The larger amplitude and greater collision produces a chest-like quality. For this reason, yodelers will use the /i/–/æ/ and /u/–/ɑ/ vowel sequences with pitch jumps like C_4 to A_4 (261 Hz to 440 Hz). This accentuates the registration, which is the hallmark of good yodeling.

Journal of Singing, March/April 2007
Volume 63, No. 4, pp. 441–442

Your questions about muscle use in these cases are a bit more difficult to answer. Whenever more thyroarytenoid (TA) muscle contraction occurs, the lower part of the vocal folds adducts more, which also creates more collision and the perception of modal (chest) register. Likewise, lateral cricoarytenoid (LCA) and interarytenoid (IA) muscle contraction produces more adduction, but primarily on the upper part of the vocal fold, at the vocal processes. So, more adduction through muscle activation can make the registration go from falsetto to modal voice, but if carried too far the perception will become "pressed" voice. In many cases, it is better to produce the modal-falsetto distinction with vibrational amplitude changes rather than by adductory changes. The belief is that the tissues will remain healthier with less pressing, and the most recent (yet unpublished) results indicate that "apparent" glottal closure in the glottal flow waveform does not require much tissue collision when vowel-pitch combinations are favorable. Thus, modal-falsetto registrations can largely be regulated by vocal tract adjustments (vowel modifications) rather than vocal fold adjustments.

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 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 500 articles in scientific and educational journals, coedited two books titled *Vocal Fold Physiology*, and has authored two books called *Principles of Voice Production*, and *The Myoelastic Aerodynamic Theory of Phonotion*. 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. 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.