Ingo Titze, Associate Editor

Formant Frequency Shifts for Classical and Theater Belt Vowel Modification

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An informal study was conducted as a classroom exercise at the 2010 Summer Vocology Institute in Salt Lake City. Eleven students, each with five years or more of classical voice training, had been instructed in belt technique by a faculty member of the Brigham Young University music theater and dance department. A sequence of five speech vowels, phonetically written as /i/-/e/-/a/-/o/-/u/, was produced with the vocal fry (pulse register) technique to provide formant frequencies on a spectrum display (Voce Vista™). Four formant frequencies were measured for each vowel in the sequence, and entire sequence was repeated three times to determine the reliability of the measures.

The singers then were asked to modify the vowels to approximate an inverted megaphone mouth shape (wide in the back of the mouth and pharynx with only a moderate lip opening, as often taught in classical singing in the G_4–D_5 pitch range). The modification resulted in an approximate phonetic description of /I/-/ɛ/-/ʌ/-/ɔ/-/U/ for the vowels. Three repetitions of each sequence were produced. A megaphone mouth shape (wide open at the lips with no attempt to widen the back of the mouth or pharynx) was then produced by each singer. This modification is typical for belt production around G_4–D_5. The phonetic description was /i/-/e/-/æ/-/a/-/ɔ/, although the /i/ was not deemed a belt vowel by the instructor. There was little lip rounding for the /ɔ/, the belt modification for an /u/.

Figure 1 shows the first formant frequency (F1) across vowels for a male singer. The speech vowels showed the greatest F1 range, from around C_4 for /i/ to around E_5 for /ɑ/ and back to E_4 for /u/. The classical singing first formant frequencies had a much smaller variation across vowels. In fact, except for the /ɑ/ vowel, they all clustered around C_5, suggesting that the modification is used to strengthen the fundamental (first harmonic) frequency of the source for notes in the G_4–C_5 range. These are high notes for males and mid-range notes for females.

For the belt vowels, mainly /æ/,/a/, and a very bright /ɔ/, the first formant frequency approached C_6, suggesting that the second harmonic (2F0) from the source can be reinforced for notes in the G_4–C_5 range. In other words, F1 is raised nearly by an octave to resonate the second harmonic instead of the fundamental.

Figure 2 shows similar data for a female singer. The same pattern is seen, except that on average the formant frequencies are about 3–4 semitones higher.

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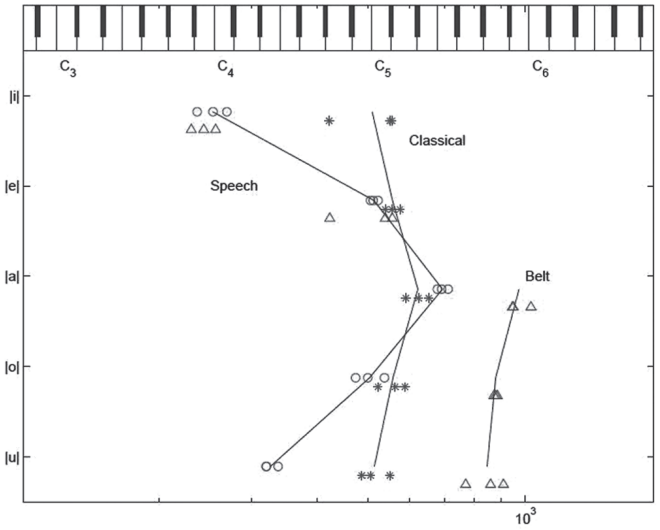

Figure 1. First formant frequency (F1) modifications from speech to classical singing and belt production. Data are for a male singer.

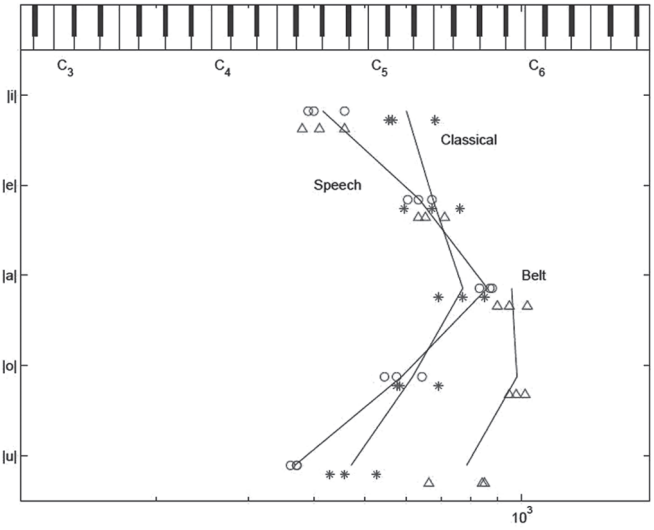

Figure 2. First formant frequency (F1) modifications from speech to classical singing and belt production. Data are for a female singer.

The full data set for all eleven singers will be published later. A preliminary observation here is that there is little difference in the way males and females approach vowel modification in the G_4–D_5 range, but the modifications are highly dependent on singing styles. The fundamental frequency (F0) appears to be reinforced by F1 for classical singing, whereas the second harmonic (2F0) appears to be reinforced by F1 for belting.

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.

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