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An Appreciation of the Bozeman and Miller Descriptions of Formant-Harmonic Relations in Singing

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AS SEMINARS AND WORKSHOPS on singing styles and singing pedagogy grow in number around the world, there appear to be only minor differences about pedagogic explanations of vowel, pitch, and voice quality interactions. Everyone agrees that choices of pitch, vowel, and voice quality are not independent over wide ranges of vocal output. The differences are about the definitions and nature of source-filter interaction and formant-harmonic tuning.

In a lucid description in this journal a couple of years ago,¹ and in an earlier article in the *Choral Journal*,² it is illustrated how the first and second harmonics of the source are reinforced (or not reinforced) by the first formant of the vocal tract. Bozeman acknowledges generously the work of Donald Miller, who has contributed widely to the topic of individual harmonics being reinforced by F1 or F2.³ In Bozeman's articles, the perceptual nature of a "yell-like" production is contrasted with the perception of a "whoop" or "hoot" on the basis of second harmonic strength provided by the first formant. A key perception is that the voice "turns over" when the second harmonic passes through F1. The importance of the observation is that this change in percept can happen without any register adjustment in the source and without any change in the vocal tract on an upward or downward gliding pitch. This perceived "register change" is purely an acoustic phenomenon. It results from a sudden decrease in amplitude of 2F0 relative to F0 in the filtering process by the vocal tract. Informally, I observed this with synthesis many years ago, as have others, but Bozeman's description puts it into a nice pedagogic framework. Miller has focused on the relation between F2 and the third harmonic 3F0 in the high male voice. Typically, as 2F0 loses energy when passing over F1, 3F0 gains energy on the upskirt of F2. In some cases, both 2F0 and 3F0 can benefit from proximity to F2. In this case, 3F0 is nearly tuned to F0 and 2F0 is riding on the upskirt of F2, a musical fifth lower.

The story would be complete if all singers had vocal folds in which vibration and airflow could not be affected (or disturbed) by acoustic pressures in the vocal tract. In other words, if for every vowel, on every pitch, the vocal folds could produce the same vibration pattern and the same source harmonics, no other explanations would be necessary. Then the filtering of harmonics, as described by Bozeman and Miller, would be the crux of voice pedagogy.

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Evidence is building, however, that source-filter interaction changes the picture slightly. In such interaction,⁴ the vocal tract can help or hinder vocal fold vibration, but this help or hindrance is experienced differently by a harmonic below a formant than above a formant. It explains the often induced “voice break” phenomenon when the second harmonic passes through F1. We might ask: If a yell or a belt can be produced on an entire range of pitches leading up to an octave below F1 (where the second harmonic 2F0 equals F1), then why does a similar range of pitches not also exist on the other side of F1? Let’s call the note on which the second harmonic is “tuned” to F1 the super-belt or super-yell. There should then be a gradual, symmetric transition *out of* the super-belt at higher pitches that mirrors the transition *into* the super-belt at lower pitches. This is not what is experienced by most singers, however. On a gliding upward pitch, the percept of yell or belt is gradually increasing, but then drops abruptly. The best explanation of this abrupt change so far is that vocal fold vibration is affected by acoustic reactance of the vocal tract, which exhibits exactly this abrupt asymmetry on opposite sides of a formant.⁵ Reactance is positive below a formant and negative above a formant. Exact “tuning” of a formant to a harmonic is not necessary. In fact, dead center on a formant the reactance is zero, which provides neither help nor hindrance to vocal fold vibration.

It is likely that discussions on this topic will continue for some time. Bozeman (personal communication) recognizes this asymmetry and teaches awareness of source changes that can be triggered by abrupt vocal tract changes. Part of our pedagogic problem is that interaction can only be inferred, not directly measured, on live humans. Thus, a slow process of fragmentary data gathering, combined with computer simulation, is likely to continue to provide useful results. Furthermore, interaction is variable. Not everyone needs it or uses it. Thus, in some singers, it is a subtle effect, while in others it is pivotal for their technique. Research is ongoing to design vocal exercises that tease out the level of interaction. A voice training approach tailored to the individual may then emerge.

NOTES

1. Kenneth W. Bozeman, “The Role of the First Formant in Training the Male Singing Voice,” *Journal of Singing* 66, no. 3 (January/February 2010): 291–297.
2. Kenneth W. Bozeman, “Registration Strategies for Training the Male *Passaggio*,” *Choral Journal* 48, no. 12 (June/July 2008): 59–72.
3. Donald Miller and James Doing, “Upper Extension in Light of Visual Feedback,” *Journal of Singing* 54, no. 4 (March/April 1998): 3–7; Donald G. Miller, *Resonance in Singing* (Princeton, NJ: Inside View Press, 2008).
4. Ingo R. Titze, “Nonlinear Source-Filter Coupling in Phonation: Theory,” *Journal of the Acoustical Society of America* 123, no. 5 (May 2008): 2733–2749; Ingo R. Titze, Tobias Riede, and Peter Popolo, “Nonlinear Source-Filter Coupling in Phonation: Vocal Exercises,” *Journal of the Acoustical Society of America* 123, no. 4 (April 2008): 1902–1915; Ingo R. Titze, Albert S. Worley, and Brad H. Story, “Source-Vocal Tract Interaction in Female Operatic Singing and Theater Belting,” *Journal of Singing* 67, no. 5 (May/June 2011): 561–572.
5. Titze, Worley, and Story.

There is sweet music here that softer falls
Than petals from blown roses on the grass,
Or night-dews on still waters
Between walls of shadowy granite in a gleaming
pass.

Music that gentler on the spirit lies,
Than tir’d eyelids upon tir’d eyes;
Music that brings sweet sleep down
From blissful skies.

Here are cool mosses deep,
And thro’ the moss the ivies creep,
And in the stream the long-leaved flowers weep,
And from the craggy ledge the poppy hands in
sleep.

From *The Lotus Eaters*,
Alfred Lord Tennyson