Quantifying Tessitura in a Song

Ingo R. Titze

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The term tessitura (Italian for texture) can be associated with a piece of music or with a singer. Often the concept of texture defaults to pitch, both range and average. Thus, the tessitura of a song tends to be associated with the distribution of pitches, measured in frequency of occurrence and duration of each occurrence. Similarly, the tessitura of a singer relates to the comfort level with a given distribution of pitches in a song.

Recent investigations on vocal dosimetry conducted on teachers in public schools[1] are based on four formal definitions of vocal doses: time dose, cycle dose, distance dose, and energy dose.[2] These doses can be calculated from daily and weekly measurements made with a portable device.[3] We have called the device the National Center for Voice and Speech (NCVS) dosimeter. Two of the doses calculated, the time dose and the cycle dose, appear to be useful for quantifying a singer's tessitura. We specify them here for each pitch in the song,

$$\text{Time dose} = t_p \quad , \quad (1)$$

$$\text{Cycle dose} = F_p\, t_p \quad , \quad (2)$$

where t_p is the duration of time accumulated on each pitch over the entire song and F_p is the fundamental frequency of a given pitch in the song. The time dose can be measured in seconds of actual performance or in equivalent whole notes presented in the score. The cycle dose is measured in cycles of vibration of the vocal folds.

Figure 1 shows a tessituragram for the aria "Il mio tesoro intanto" from Mozart's opera *Don Giovanni*, designated to be sung by a tenor in the role of Don Ottavio. It is notorious for its tessitura, hovering around the pitch F_4. The figure has five parts. At the bottom is a standard keyboard showing a range of pitches slightly larger than the typical tenor range. Above the keyboard is a voice range profile of a singer (the author in this case). In the middle is a distribution of the numbers of cycles of vocal fold vibration on each pitch. Second from the top is the equivalent number of whole notes sung on each pitch. The top shows the number of occurrences of each pitch.

Unless there are embellishments in the form of additional (unwritten) notes produced by the singer, the distributions of occurrences, equivalent whole note durations, and vibration cycles can be obtained from the written music (without performance). If there are unwritten notes and fermatas, the distributions can be obtained only with a dosimeter during performance.

In Figure 1, Mozart's written score was used. To give some specifics, this aria has 70 occurrences of the pitch C_4 (the supertonic in the key of $B^\flat$), 66 occurrences of the pitch $B^\flat_3$ (the tonic), and 49 occurrences of the pitch F_4

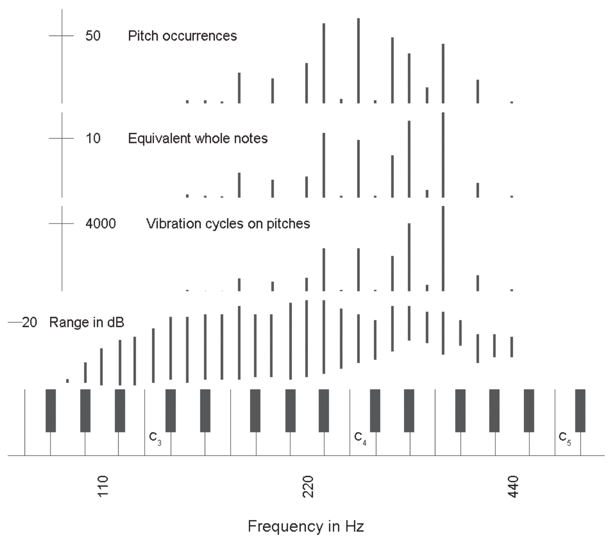

Figure 1. Tessituragram for the aria "Il mio tesoro intanto" from Mozart's opera *Don Giovanni*.

(the dominant). The supertonic leads in occurrences because of the frequent appoggiatura (leaning toward the tonic). There is only one occurrence of A_4, and one of E_3. There are two occurrences each of D_3, $E^\flat_3$, and $D^\flat_4$, and three occurrences of B_3. Other occurrences can be read off the scale to the left, which has a tic mark at 50 occurrences.

Although C_4 has the greatest number of occurrences, F_4 (the dominant) has the greatest accumulated duration (time dose), the equivalent of 16 full notes, or 4 full measures. This does not include two fermatas on this pitch, which are not quantifiable from the score. The subdominant ($E^\flat_4$) has the second greatest accumulated duration (14 3/8 whole notes) and the tonic ($B^\flat_3$) has the third greatest accumulated duration (12 1/8 whole notes). By converting the 4/4 meter to a metronome marking, the actual durations in seconds could be computed. For example, at 96 beats per minute, F_4 would accumulate 64 full beats, which is 2/3 of a minute or 40 seconds.

In terms of the cycle dose, the pitch F_4 encounters 5584 cycles of vibration, followed by 4471 cycles on $E^\flat_4$, 2825 cycles on $B^\flat_3$, and 2817 cycles on C_4. It is this cycle dose that gives the greatest clue to the tessitura for a singer. There are twice as many cycles of vibration on the dominant F_4 than on the tonic $B^\flat_3$, not counting fermatas.

To relate the tessitura of the song to the tessitura of the singer, the voice range profile needs to be considered. A voice range profile measures the range of intensities (in dB) available to the singer on every pitch. One could easily argue that the ideal tessitura for the singer would be centered around the pitch where the greatest dynamic range is available. This is where the singer can most easily crescendo and decrescendo, allowing for maximum interpretive skills. For the voice range profile shown in Figure 1 (directly above the keyboard), this would be around F_3–C_4. An approximate 30 dB of dynamic range is available, allowing for dynamic markings of *pp, p, mp, mf, f,* and *ff* to be differentiated by about 6 dB. In the D_4–G_4 range, only a 10–15 dB dynamic range is available to this singer, limiting the differentiation of dynamic marking to only about 3 dB. The pitches are all able to be sung by the singer, and the overall intensity on the high pitches may be acceptable, but the aria may lack luster due to restricted dynamics. Also, the singer may wear out (fatigue) because he is not able to take the pressure off and "coast" on some of the repeated long duration notes with lower dynamics.

We conclude that the tessitura of a singer may not match the tessitura of the song, even though the range is appropriately matched. Technology may provide some help in structuring tessituragrams to find the best matches. What is too often done is simply to change the key signature of the song, but unless the accumulated duration and cycle doses are quantified on various pitches within the song, singer-song adaptation still may not be complete.

NOTES

1. Ingo R.Titze, Eric J. Hunter, and Jan G. Švec, "Voicing and Silence Periods in Daily and Weekly Vocalizations of Teachers," *Journal of the Acoustical Society of America* 121, no. 1 (January 2007): 469–478.
2. Jan G. Švec, Ingo R.Titze, and Peter S. Popolo, "Measurement of Vocal Doses in Speech: Experimental Procedure and Signal Processing," *Logopedics Phoniatrics Vocology* 28, no. 4 (October 2003): 181–192.
3. Jan G. Švec, Ingo R.Titze, and Peter S. Popolo, "Estimation of Sound Pressure Levels of Voiced Speech from Skin Vibration of the Neck," *Journal of the Acoustical Society of America* 117, no. 3 (March 2005): 1386–1394.

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.