Ingo Titze, Associate Editor

Can A Belt Or Call Timbre Be Achieved Without A Large Closed Quotient?

Ingo Titze

Ingo Titze

Journal of Singing, May/June 2016
Volume 72, No. 5, pp. 587–588

It is now well established that belting or calling is characterized acoustically by a strong second harmonic. In the sound emitted from the mouth, the dB level of the second harmonic frequency ($2f_o$) is greater than the dB level of the fundamental (first harmonic) frequency f_o. The symbols for these levels are chosen as L_1 for the first harmonic level and L_2 for the second harmonic level. If the difference L_2–L_1 is large, the timbre is rich and the pitch appears slightly higher because of the dominant second harmonic.

Harmonic frequencies in the source are created largely by vocal fold collision, which would suggest that the obvious way to boost the level of the second harmonic is to create greater collision, as measured by a large closed quotient. This strategy is not uncommon among belters or callers that have not been taught or explored other (perhaps safer) strategies based on vocal tract resonance. The obvious alternate strategy is to use the first formant to boost L_2. For notes G_4 and higher, the second harmonic frequency $2f_o$ is above 800 Hz, which means that the first resonance of only a few vowels (such as /a/ or /æ/) qualifies for boosting $2f_o$. These vowels have a first formant (resonance) frequency in the vicinity of 800 Hz. With the use of computer simulation, examples of both strategies are given here.

Figure 1 shows waveforms (left column) and frequency spectra (right column) for the first strategy, using ample vocal fold collision to increase the second harmonic. The vowel was an /Ü/ with a first formant frequency of 506 Hz, which lies between f_o (392 Hz for G_4) and $2f_o$ (784 Hz for G_4). Note that the closed quotient for glottal flow u_g is greater than 0.5 (middle left) and that the level of the second harmonic almost matches that of the fundamental (middle right). The same can be said for the glottal area a_g in the bottom row, except that the third harmonic is missing because the wave shape is very symmetric. The top row shows the radiated output pressure from the mouth p_o (left) and its spectrum (right). Here we see that the first three harmonics are all strong. The third harmonic is strong because it is near the second formant (around 1300 Hz for this vowel). It is clear that, with this strategy of firm adduction, the second harmonic is strong, but the choice of vowel does not raise its level higher than the levels of either of its neighboring harmonics.

Figure 2 shows waveforms and spectra for an alternative strategy, lightening the adduction and raising the first formant frequency with the vowel

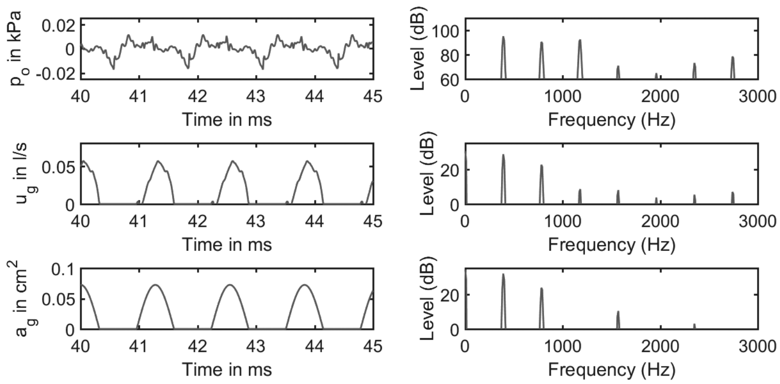

Figure 1. **Using vocal fold collision to increase the level of the second harmonic.**

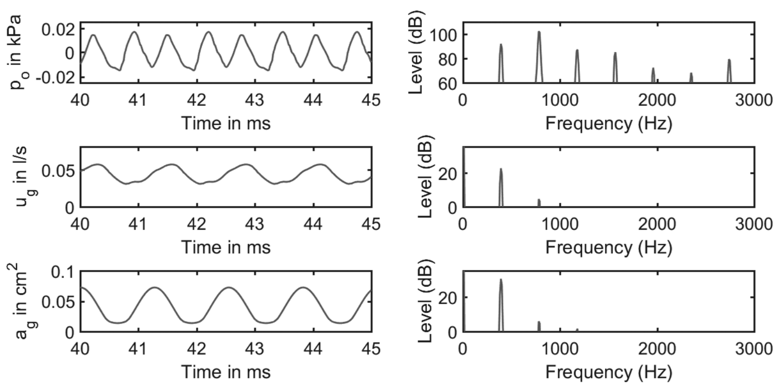

Figure 2. **Using vocal tract resonance to increase the level of the second harmonic.**

/a/. The picture is quite different. The closed quotient is zero (glottal flow u_g never shuts off and glottal area a_g is never zero), which means that harmonic production at the source is very weak. The second harmonic is barely visible (middle right). With a first formant frequency of the vowel /a/ set at 788 Hz, however, the second harmonic (784 Hz) is boosted by nearly 30 dB to rise 10 dB above the first harmonic level in the radiated output pressure (top right). The second harmonic is so strong that in the p_o waveform (top left) it looks like the period has doubled, which confirms the earlier suggestion of a higher pitch associated with a dominant $2f_o$.

In summary, the tendency of using a pressed voice for belting or calling is less effective than using a vowel with a high first formant. By giving two contrasting examples, it has been shown here (with simulation) that a very un-pressed source production, with a low level of second harmonic at the source, can produce a dominant second harmonic at the output with a vowel that has its first formant frequency slightly above $2f_o$