Ingo Titze, Associate Editor

Pitch Accuracy With and Without Vibrato

Ingo R. Titze

Ingo Titze

Is the pitch of a straight tone more accurate than the pitch of tone sung with vibrato? The intuitive answer would probably be in favor of the straight tone, given that there is less variation in the fundamental frequency and all its harmonics. An answer based on some research on the perception of pitch is not straightforward, however. It requires parsing out two factors, (1) the psychophysics of pitch perception with and without frequency modulation, and (2) the motor control for producing a constant fundamental frequency (F_0).

Factor 1 has been studied with string instrument playing.[1] A virtuoso violist played tones with and without vibrato (D_4, $C^{\#}_5$, A_5, and G_6). If the intent of the performer playing with vibrato was to be in tune with a specific pitch (i.e., not intending to be sharp or flat), listeners judged his average pitch with the same degree of accuracy as if he played a straight tone. His average vibrato extent was a little less than a quarter tone up and down from the center frequency, similar to vocal vibrato. The authors drew the conclusion that pitch perception with vibrato is based on the average pitch in a vibrato cycle and that the frequency modulation does not mask the ability to perceive this average pitch.

This bring us to factor 2, the motor control for producing a constant fundamental frequency. Figure 1 shows an example of a jazz-like straight tone changing to a tone with vibrato. The singer was a well trained amateur who sings multiple styles. The mean (average) F_0 per individual vibrato cycle is shown superimposed with dots on the vibrato portion. Several observations are noteworthy. First, the straight tone is a little sharper relative to the vibrato portion. Second, the straight tone is not straight. Variations on the order of 1–2 Hz are present. For a mean frequency of 191 Hz, this is an approximate 0.5% jitter, which is quite normal in voice production and can be attributed to irregularity in muscle contraction. The variation of the vibrato-cycle average F_0 is slightly greater, attributable to the fact that the singer had not settled into a steady vibrato, perhaps by choice. In lieder or operatic productions, the same singer generally has less variability in the vibrato extent. Figure 2 shows a spectrographic example of a classically sung steady tone by the same singer.

A hypothesis may be in development here. Vibrato may have a stabilizing effect on combined cricothyroid (CT) and thyroarytenoid (TA) muscle contraction. Rather than relying on random motor unit firing of each muscle to produce a steady tonus (a tetanic contraction in which repeated muscle twitches are smoothed out by random activation), a more phasic contraction between the muscles may allow for less variability of the average vocal fold

Journal of Singing, November/December 2014
Volume 71, No. 2, pp. 207–208

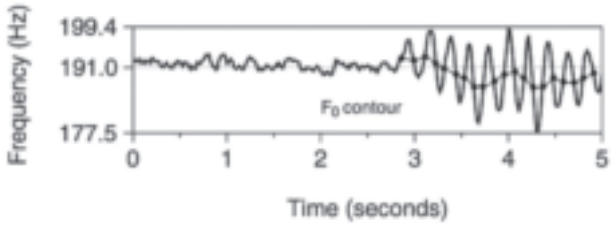

Figure 1. Fundamental frequency contour of a 5 s straight tone changing into a 2 s tone with vibrato.

length, and therewith the average F_0. It is possible that the synchronization of some low-frequency motor units (or perhaps a reflexive or mechanical phase-locking at the periphery) may reduce variability in the average F_0, even though the extent of frequency modulation in the vibrato swing is quite high.

This topic of pitch perception with and without vibrato raises many new questions on the production side. Do singers use vibrato to stabilize their central pitch? If so, what is the ideal vibrato extent and rate for this stabilization? What is the exact nature of reflex or muscle twitch synchronization, if it in fact exists?

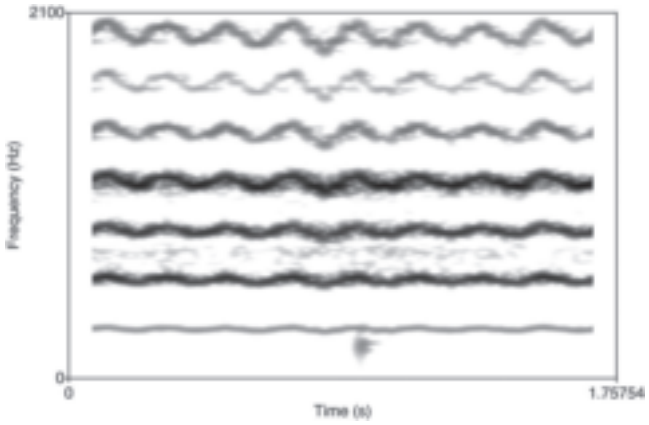

Figure 2. Spectrogram display of a constant pitch tone (D_4) sung with vibrato (same singer as in Figure 1).

Whatever the underlying mechanisms might be, it is impossible to claim, at this point, that there is a categorical advantage for pitch accuracy based on either presence or absence of vibrato. Studies similar to the viola vibrato study should be done for vocal vibrato. These studies should include expert/amateur differences on both the production and the perception side of the investigation.

NOTE

1. Judith C. Brown and Kathryn V. Vaughn, "Pitch Center of Stringed Instrument Vibrato Tones," *The Journal of the Acoustical Society of America* 100, no. 3 (1996): 1728–1735.

Stell auf den Tisch die duftenden Reseden,
Die letzten roten Astern trag herbei,
Und laßt uns wieder von der Liebe reden,
Wie einst im Mai.

Gib mir die Hand, daß ich sie heimlich drücke,
Und wenn man's sieht, mir ist es einerlei,
Gib mir nur eine deiner süßen Blicke,
Wie einst im Mai.

Hermann von Gilm
"Allerseelen," Richard Strauss