Hearing Loss and Singing Sharp

Ingo R. Titze

Inasmuch as this column is in part dedicated to answering questions from the readership, permit me to share this recent correspondence:

Dear Dr. Titze,

My name is Marty Nevdahl and I'm a clinical instructor and supervisor in voice at the University of Washington Speech and Hearing Sciences department and clinic. I've been asked by one of our UW Music Department voice instructors whether or not a hearing loss could cause a singer to sing sharp? I'm still in the process of gathering more information on this singer, as I'm not clear that this person has a documented hearing loss. But I thought I would ask you if you knew of a connection between the two, or of any literature about this. Thanks.

This is an interesting question. The first point to make is that pitch perception is not only a function of the fundamental frequency of a sound, but also of the timbre (the collection of harmonics) and the intensity of the sound. But fundamental frequency is the dominant factor. The perception of this fundamental is sometimes referred to as the "low pitch."[1] Interestingly, the lower harmonics ($2F_0$ to $5F_0$) are more important for determining this "low pitch" than the fundamental (F_0) itself. The fundamental may be absent, as it often is in telephone speech, yet the "low pitch" is clearly perceived. The auditory system senses this pitch by extrapolating downward from the regular spacings between the harmonics in the lower part of the spectrum. A second pitch, related to higher frequency energy in the sound, is sometimes called "residue pitch." Consider a low frequency tone combined with a cluster of high frequency harmonics, around 2000 Hz. When the cluster is lowered to 1000 Hz, the sensation is a slightly flattened pitch, when the cluster is raised to 4000 Hz, the sensation is a slightly higher pitch.[2] This may apply to the perception of pitch in singing when there is a vocal ring (or a singer's formant). The presence of the singer's formant, and specifically raising the center frequency of this cluster of energy, may sharpen the perceived pitch. Can we argue from this that, if a person has high frequency hearing loss, he will try to raise his own pitch to compensate for the lack of "residue pitch"? We cannot say for sure, because over time of acquired deafness the entire pitch perception mechanism in the auditory system of the hearing-impaired person may have been recalibrated.

My colleague Dr. Christopher Turner at the University of Iowa has looked at pitch perception in people with hearing loss. He wrote to me in a personal communication.

In general, hearing loss could make someone sing "off key." However, the direction of this change would be highly variable across patients. For just pure tones, I'd guess most people (maybe 70%) tend to have the perceived pitch of a sound shift away from the region of hearing loss (i.e., downward if there is high frequency loss). However the other approximately 30% go the other way. These pitch shifts can be as large as 20% for some hearing losses. But for complex tones, the answer is even more complicated.

Since voicing involves complex tones, there doesn't seem to be a reliable answer.

Since pitch is also related to sound intensity (louder tones usually being judged higher in pitch), the hearing loss may compel singers to actually sing louder. Then the pitch change may actually be related to production rather than perception. In other words, F_0 may increase. It is well known that people tend to raise their pitch when they raise their loudness. This has to do with nonlinear tissue stretching in the vocal folds when vibrational amplitudes increase.

A related question, which wasn't asked by Marty Nevdahl, is whether or not a singing teacher with high frequency hearing loss can encourage a student with normal hearing to sing off pitch. Singing teachers often teach well into their 80s and 90s. Do they still perceive the same subtleties in voice pitch that they perceived earlier? I will not pretend to answer this question here and now, but would love to have some response from the readers.

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ENDNOTES

1. R. Plomp, *Aspects of Tone Sensation* (New York: Academic Press, 1976).

2. Ibid.

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