Preserving the F0

By Dennis A. Colucci, AuD, MA

Human speech production—respiration, phonation, and articulation—relies on forcing air through intricately tuned and positioned vocal folds to produce the fundamental frequency (F0) and corresponding harmonics (H2-H12). This energy creates the formants through filtering or changes in the resonances of the vocal tract during speech, singing, and utterances, especially from the pharyngeal-oral-nasal cavities.

The F0 anchors sound contrast and functions as the carrier frequency for all subsequent related events. These low-frequency events are central to the understanding of speech, particularly in background noise. Verification tests to qualify the low-frequency response is an important part of achieving a better outcome when fitting hearing aids.

Voicing features such as pitch, timbre, and timing must be perceived to be successful at understanding speech, according to Anderson and Kraus.[1] It has been repeatedly shown that the F0, harmonics, and temporal characteristics (onset, offset, and phoneme transitions) are important for distinguishing an individual's speech patterns from others in background noise, especially for seniors.

Adding spatial filtering and digital noise cleaning make it possible for many patients to hear in noisy environments

Caroll, Tiaden, and Zeng also published an article that demonstrates the importance of low-frequency pitch-related tasks for patients with combined acoustic and electric hearing.[2] The results showed that the F0 cue and FM component were essential to improving speech in noise in simulated and patient studies.

The importance of preserving the low-frequency information in the fitting of amplification is vital for a variety of auditory processing events, not only for speech but also for music and tagging objects for identification.[3]

FREQUENCIES AT WORK

Modifying the cross-sectional area of the vocal tract alters the tubes' resonances, creating a variety of voiced consonants and vowels. Not only does the vocal tract filter sounds and alter formants, but the vocal folds can also increase the F0 by approximately an octave, even more for singers. All the signals differ by age and gender, with considerable variance within and among individuals.

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The mean F0 and the main formants (F1, F2, F3) for a newborn are 400 Hz, 1,094 Hz, 3,282 Hz, and 5,470 Hz (shrieks > 1,000 Hz; in children 3–10 years of age, the F0 is 300 Hz), according to Raymond Kent, PhD.[4] They are 225 Hz, 583 Hz, 1,749 Hz, and 2,915 Hz for women and 130 Hz, 500 Hz, 1,500 Hz, and 2,500 Hz for men.

The harmonics (timbre) are equal integer multiples of the F0, and are primarily lower-frequency energy events. A male voice with an F0 at 130 Hz, for example, would have harmonics at 260 Hz (H2), 390 Hz (H3), 520 Hz (H4), and so on.

LOW-FREQUENCY AIDED HEARING

Maximizing functional hearing while developing and maintaining long-term auditory skills is one of the goals when applying amplification. This requires a broad response to sound that is not easily obtained without the use of verification techniques, such as real-ear probe, aided sound-field thresholds, and most comfortable loudness (MCL) and uncomfortable loudness (UCL) level testing.

The primary issue when preserving low tones in the fitting is whether occlusion is needed to maintain the desired sound pressure level (SPL) at the eardrum. Depending on the level of hearing loss at 1,000 Hz and below, the choice between an open, closed, tulip, or power dome and a short or long earmold with various ventings should be examined carefully.

The goal is to ensure preservation of the lower tones by venting to allow low-frequency signals to enter the canal naturally while venting off the voiced sounds to ensure aided voice acceptance, as in the ski-slope configuration, or closing down the vent because of low-tone hearing loss to provide various degrees of occlusion to increase the gain at the desired tones.

When attempting to achieve the correct balance among audibility, loudness perception, feedback, aided voicing, and functional hearing needs, preserving the F0 in the prescription is important to hearing speech and speech in noise. The addition of spatial filtering and digital noise cleaning make it possible for many patients to hear in noisy environments and maximize their functional hearing.

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