From Insertion Gain to Speech Mapping: Benefits of an Output-Based Approach

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Traditional approaches to real-ear verification were developed when linear rationales and analogue technology were common. Those approaches typically involved adjustment of the hearing aid to match a Real-Ear Insertion Gain (REIG) target. Tonal frequency sweeps were the test signals of choice and there was a clear and predictable relationship between real-ear findings and functional gain measured in the soundfield. Today's hearing aids incorporate multi-channel compression, noise and feedback reduction algorithms and directionality as standard features, making it difficult to predict how the hearing aid will react to complex stimuli. Therefore, more advanced real-ear verification techniques are needed. To obtain more accurate representations of how hearing aids will react to real-world stimuli, complex test signals (such as speech and noise) are presented at multiple input levels. Complex test signals can prove valuable throughout the counselling process by facilitating realistic patient expectations and demonstrating the relative benefits and limits of advanced technology.

Complex test signals can prove valuable throughout the counselling process by facilitating realistic patient expectations

When conducting insertion gain measures, professionals must consider how the test signal interacts with the hearing aid signal processing scheme. For example, a 65 dB SPL frequency sweep stimulus consists of a series of narrow band tonal stimuli presented sequentially at the same intensity level. However, a 65 dB SPL speech signal consists of a broad band of low-mid frequency weighted energy presented simultaneously. At any moment in time, signal intensity is less than 65 dB in any frequency region. Assuming that the hearing aid incorporates multi-channel non-linear processing (i.e., more gain for softer signals), the hearing aid will provide more gain for the speech stimulus versus the frequency swept stimulus (see Figure 1). Therefore, the professional needs to choose a test signal that reflects the assumptions of the prescriptive target employed. Channel interaction and timing issues (i.e., attack and release times) can impact how the hearing aid reacts to narrow versus broadband stimuli.

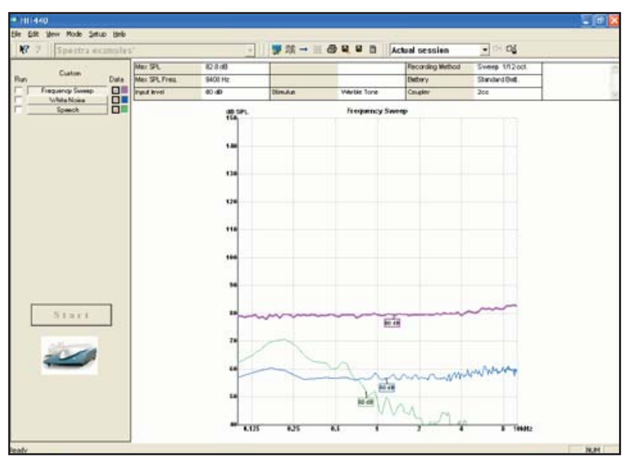

Figure 1. Differences in intensity level for frequency sweep (pink), white noise (blue) and speech (green), at 80 dB SPL.

Beyond differences related to bandwidth and intensity, temporal aspects of the test signal need to be considered. For example, pink noise would probably trigger the hearing aid's noise reduction algorithm. Unless the goal of the measurement was to demonstrate the noise reduction capabilities of the hearing aid, the noise reduction algorithm should be turned off during testing. When tonal stimuli are employed, the feedback reduction algorithm might be activated, reducing the accuracy of the results. Therefore, to get a true picture of how the hearing aid will react to speech, the best approach is to use speech as the test signal.

Recent hearing aid fitting guidelines from the American Academy of Audiology (see: Guidelines for the Audiological Management of Adult Hearing Impairment in Audiology Today Vol 18:5, 2006) recommended an output-based approach incorporating a speech or a speech-like test signal while conducting real-ear measures for verification purposes. With modern real-ear equipment it is relatively easy to incorporate these recommendations. Prescriptive targets derived assuming a speech stimulus can be employed as benchmarks regarding the appropriateness of the hearing aid settings. From a counselling standpoint, most patients find output-based data easier to understand and more meaningful than insertion gain curves. Figure 2 provides speech mapping data obtained using the Interacoustics Affinity system. The aided speech spectrum (red shaded region) is presented as an output measure in relation to the user's dynamic range (white region).

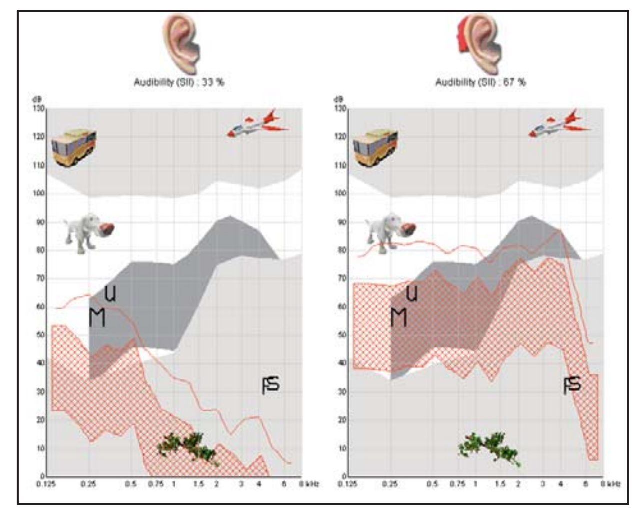

Figure 2. Speech mapping results obtained using conversational speech input.

Super-imposing the patient's aided speech signal over their dynamic range provides visual confirmation of improved audibility. In addition to pre-recorded speech sounds, some systems include "live" speech mapping. Signals of personal interest to the patient, such as a spouse's voice or music, can be presented and visualised and may be useful in demonstrating audibility differences among male, female and children's voices, or may prove beneficial in deriving an appropriate frequency response for a second memory (e.g., music program).

When comparing speech mapping data (see Figure 2) with insertion gain data (see Figure 3) the advantages of speech mapping are apparent. With the insertion gain graph, it is evident that additional high frequency gain would be required to meet the target; however, we have no indication of how much audibility we are providing nor any information related to the patient's dynamic range. Speech mapping results provide the same information (i.e., less than ideal audibility in the higher frequencies) with an easy-to-understand visualisation of the audibility and how much room is available should more gain be desired.

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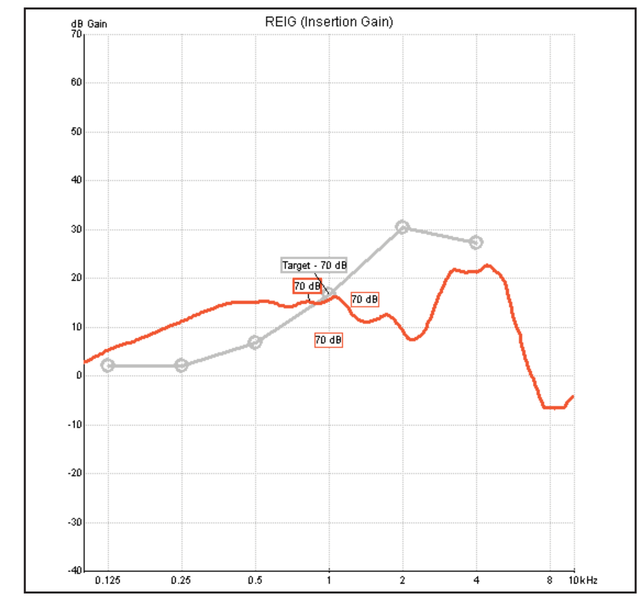

Figure 3. Insertion gain data obtained using the same hearing aid as in Figure 2.

In summary: Speech mapping is a valuable tool for the professional and the patient. Speech mapping data can be obtained quickly and easily. Using speech and speech-like stimuli provides the best approximation of hearing performance in the real-world, and removes the need to consider issues such as digital noise reduction during testing. Speech Mapping allows audibility to be clearly demonstrated, and targets can be employed (as desired) for benchmarking purposes. The professional can obtain a overall impression of the hearing aid fitting that provides useful data for fine tuning and counselling.