Electroacoustic correlates of subjective sound quality for hearing aid processed music

National Centre for Audiology, Western University, London, ON, Canada

Contact: jvaisber@uwo.ca

INTRODUCTION
Hearing aid design largely reflects speech acoustics—not music.1 Hearing aids may not amplify music as effectively as speech. Manufacturers often include dedicated music programs, although their programs’ efficiencies are not always fully understood. Listeners are often dissatisfied with hearing aid music SQ.2

Objective 1: Compare SQ of hearing aid processed music across a range of hearing aid models, music programs, and music genres (a version of the sound quality assessment has been published).3

Objective 2: Identify electroacoustic parameters associated with relative good and poor-SQ market-level hearing aids.

RESULTS: Sound Quality

A repeated measures ANOVA revealed that hearing aid model was a significant factor (F[2,19] = 19.7, p < 0.001). HA-2 and HA-4 were rated the highest and poorest, respectively.

Within the music program, HA-1 and -2 were rated significantly higher than HA-4 and -5, and HA-3 higher than HA-4.4

Within the universal program, HA-2 was rated significantly higher than HA-3, -4, and -5, and HA-1 higher than HA-4. There was a significant interaction of program by hearing aid (F[5,40] = 8.3, p < 0.001). The music program significantly improved SQ for HA-3 and HA-1.

METHODS: Sound Quality

Participants: Adult hearing aid users (n = 26, ages 20-84, μ17). Air conduction thresholds ranged from 35-40 DBHL in the low frequencies to 65-70 DBHL in the high frequencies.

Hearing aids: Five leading manufacturers’ hearing aids (2017), individually programmed to each participants’ thresholds. Participants listened to music clips processed through the music program and “first fit” (universal) program of each hearing aid.

Stimuli: Samples from five genres: classical, jazz, folk, pop, and favourite (chosen by participant). Randomized presentation by generating recordings on a Bruel & Kjaer Head & Torso 4128BC simulator. Stimuli were delivered to hearing aids mounted on the head & torso simulator at levels ranging from 60-78 dB SPL and played back via Etymotic Research 2 inserts headphones.

Electroacoustic measurements (related to SQ) were performed on HA-2 and -4 to determine if the measurements can be used to predict relative good- or poor-SQ market-level hearing aids.

METHODS: Electroacoustics

Figure 1: Software used to gather sound quality ratings of hearing aid processed samples. Clicking on each lettered button played the processed sample randomly assigned to it. Adjusting the slider indicated quality ratings.

Sound quality ratings: Obtained using the “multiple stimulus test with hidden references and anchors” (MUSHRA) task.2

RESULTS: Electroacoustics

Figure 2: Boxplots showing MUSHRA ratings for music recordings processed by both programs for each hearing aid across all genres.

Figure 3A (top) and 3B (bottom): 3A boxplots display comparisons of sensation levels between HA-2 and -4 across all genres. 3B horizontal boxplots display comparisons of the lower and upper limits of audibility (left and right, respectively) between HA-2 and -4 across all genres.

A discriminant function analysis (DFA) was performed using all electroacoustic measurements as predictors of HA-2 or HA-4. The analysis was significant (Wilk’s Λ) = 0.621, x²(8) = 199.6, p < 0.001. The canonical correlation coefficient was 0.62, suggesting relatively good predictability of hearing aid.

A repeated measures ANOVA revealed that hearing aid model was a significant factor (F[2,19] = 19.7, p < 0.001). HA-2 and HA-4 were rated the highest and poorest, respectively.

Within the music program, HA-1 and -2 were rated significantly higher than HA-4 and -5, and HA-3 higher than HA-4. Within the universal program, HA-2 was rated significantly higher than HA-3, -4, and -5, and HA-1 higher than HA-4. There was a significant interaction of program by hearing aid (F[5,40] = 8.3, p < 0.001). The music program significantly improved SQ for HA-3 and HA-1.

Table: Summary of electroacoustic measures and ANOVA results for HA-2 and HA-4. Significant effects are highlighted in bold.

CONCLUSIONS
Sound quality differences are most apparent between hearing aids. A music program improves ratings for two hearing aids, although less than the difference between a high- vs. low-rated hearing aid.

Electroacoustic measurements performed in this study can be used to classify a relative good- or poor-SQ market-level hearing aid.

The three most predictive measures for these hearing aids are sensation level in the ultra lows (50-200Hz), lows (250-500Hz) and lower limit of audibility.

Future Directions
Investigate potential sound quality interactions due to genre.

REFERENCE


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REFERENCES