Preferences for OTC vs. premium hearing aid processing

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Introduction

FDA-regulated Over-The-Counter (OTC) hearing aids (HAs) are a more affordable hearing care solution than traditional prescriptive devices. However, it is unclear whether OTC's limited programming flexibility and sound processing features might negatively impact listeners' benefit and satisfaction in different sound environments. Due to their recent arrival in the retail market, there is limited research comparing OTC and premium-level prescription devices. This study compared listeners' preferences for signals processed by these different levels of technology in conversational speech in noise, music, and everyday non-speech sounds and explored potential reasons for these preferences.

Research Questions:

When listening to conversational speech in noise, non-speech sounds, and music:

Q1. Do listeners prefer OTC or premium-level HA signal processing?

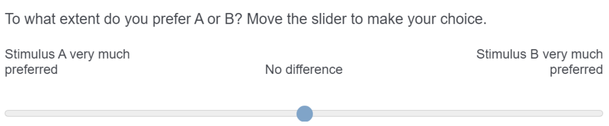
Q2. What acoustic parameters do listeners rely on when making decisions about these preferences?

Methods

Design: Within subjects, double-blinded, round robin comparison of recorded sounds.

Participants: 33 adults, ages 18-30, with typical hearing sensitivity.

Procedures: Listeners compared recordings made from the processed outputs of 2 OTC and 2 premium HAs, each from 2 different manufacturers. For each listening environment, recordings from each device were compared to each of the others, resulting in 12 comparisons per environment. The order of presentations was counterbalanced, and stimuli were presented using a custom MatLab program. For each type of stimulus, participants could switch between the 2 recordings, and then rated the degree of their preference for the first or second recording on a 100-point scale.



Devices and Recordings

The 4 devices were from among the most popular FDA-approved manufacturers on the market. All were RIC-style BTEs, with advanced signal processing capabilities. Premium devices had greater flexibility of adjustment, more sophisticated features, and were more adaptive, and retailed for approximately $4-5k more per pair than OTCs. Recordings were made in a sound-treated room. HAs were programmed for a moderate flat loss, fitted to a KEMAR manikin with closed acoustic couplings, and presented 3 types of everyday sounds: complex speech in noise, non-speech sounds, and music stimuli.

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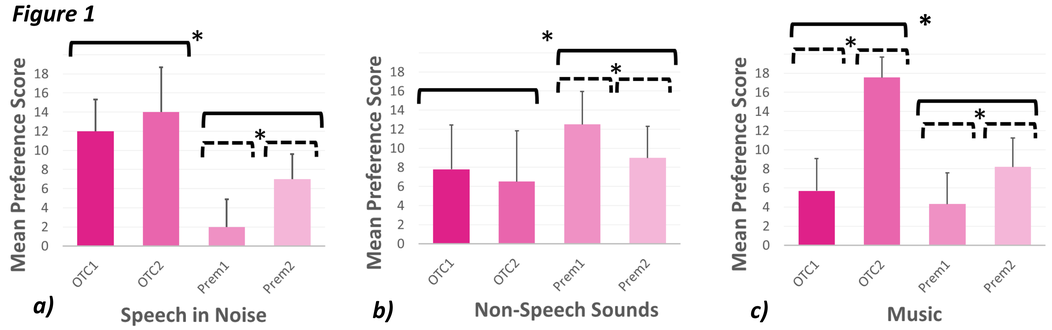
Results

1. Preferences for OTC and Premium HA processing

Preference scores are based on the total number of comparison wins, ties, and losses. Values were assigned as follows: Win:3, Tie:1, Loss:0. Scores were computed for each participant, with each device, in each listening condition (potential range 0-18). Figures 1a-c show average preferences per participant (error bars are 1 SD). Repeated measures ANOVAs, with *a priori* OTC vs Premium contrasts, and *post-hoc* Bonferroni-corrected pairwise comparisons were conducted. Statistically significant comparisons (* $p < .001$) are indicated with brackets/asterisks.

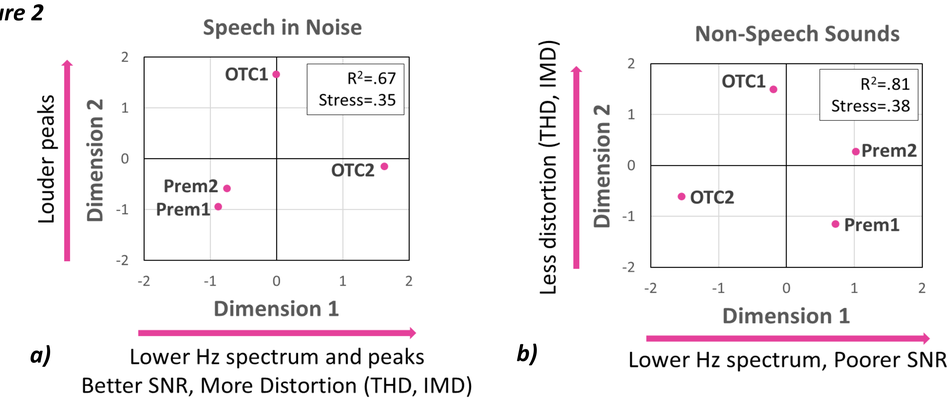
Figure 1



2. Acoustic-perceptual dimensions underlying preference judgements

Multi-dimensional scaling (MDS) analyses were conducted to uncover important factors behind listeners' preferences. Standard stress measures (Kruskal's) and R^2 Correlations demonstrated that the resulting MDS models were a reasonably good fit for the data. MDS models were compared against acoustic measures of the recorded signals to explore our hypothesis that preference was at least partially determined by acoustic characteristics.

Figure 2



Figures 2a-c show the perceptual distances between preferences for the sound recordings. For these maps, closer points indicate similarities in preference ratings in each dimension. These spatial plots were compared against the recordings' acoustic characteristics to highlight the acoustic sound features listeners used when making preference judgements. Characteristics that followed the same patterns as the dimensional plots are presented on the axes of Figures 2a-c.

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Q&As:

Q. Did listeners prefer OTC or premium-level signal processing?

A. Preferences varied in different environments. On average, OTC processing was preferred when listening to speech in noise and music, but Premium processing was preferred when listening to non-speech sounds. It was noted that preferences also varied between the device exemplars for a given class of HAs in several conditions.

Q. Which, if any, acoustic parameters did listeners use to make decisions about their preferences?

A. Perceptual dimensions were identified that were strongly related to strengths of preferences. Several acoustic characteristics of the processed sounds were directly related to these underlying dimensions. Differences in spectral content, SNR, and loudness were most important for listeners' preferences in speech in noise; spectral content and distortion were most important for preferences of processed non-speech sounds; and SNR, distortion, and peak loudness were most important when determining preferences for processed music.

Discussion:

Listening needs vary depending on the situation. When listening to speech in noise, understanding the signal is prioritized. This requires audibility and clarity of high Hz sound. In non-speech environments a balanced Hz response and adaptable dynamic range of loudness are most important for optimal sound quality and comfort. For the 4 devices used, manufacturers' general signal processing priorities impacted the processed sounds across environments. OTCs generally had a lower Hz emphasis, louder peaks, and were less effective at removing noise coming from varying locations. Subjectively, these devices sounded less full and natural than the premium devices. Although the premium HAs also more effectively reduced unwanted sounds, these also removed some important high Hz speech information and reduced loudness peaks. As a result, OTC processing was preferred for speech in noise and music, and Premium-level prescription HAs were preferred for nonspeech sounds. Expectedly, the OTCs maintained similar processing across all environments; however, it was surprising that the premium-feature devices did not adapt processing in a manner that was preferred in all listening conditions.

Conclusions: For OTC HA candidates wanting help understanding speech-in-noise, OTCs like the ones used here are highly recommended. However, sound quality characteristics desirable for understanding speech might be less favorable in non-speech environments. Manufacturers should continue to improve the effectiveness of adaptive algorithms to better reflect preferred acoustic characteristics in different environments. High variability in acoustic outputs, even within a class of devices, emphasizes the need for systematic evaluation of device outputs, regardless of the level of technology, when making recommendations based on patient needs and preferences.

Limitations: Listeners were young adults with typical hearing sensitivity, recordings were created in a controlled environment, and device exemplars do not represent all on the market.