The "Big Five": Which Hearing Aid Manufacturers' Signal Processing is Most Preferred?

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Background

Ninety-nine percent of hearing aids sold worldwide are developed and distributed by only five manufacturers, commonly called "The Big Five" (Toward & Meyer, 2019). Although each hearing aid company makes claims about their devices being superior, no peer-reviewed articles could be found to support one company's signal processing being better than others. There was one manufacturer's study that demonstrated that their participants had a notable preference for the signal processing of their company's device compared to two other companies (Beck et al., 2021). However, there is inherently a risk of bias in proprietary research and these results should be interpreted with caution.

The goal of the current project was to determine if adults with normal hearing show systematic preferences for signal processing across the "Big Five" manufacturers. More specifically, we asked:

1. **Do participants show preferences for hearing aid signal processing from specific manufacturers?**
2. **What components of signal processing are important to listeners?**

Methodology

Primary analysis

Receiver-in-the-canal (RIC) hearing aids from each of the "Big Five" companies were programmed to manufacturer default settings for a fabricated patient with flat, moderate, sensorineural hearing loss. The hearing aids were placed on an acoustic manikin (KEMAR) and recordings were made in three different listening environments: non-speech sounds, speech-in-noise, and music.

Seventeen young adults with normal hearing abilities were recruited to satisfy a preliminary power analysis. Participants sat in an enclosed soundbooth and listened to counter-balanced, pairwise comparisons of the hearing aid recordings. For each comparison, they were asked to indicate their preferred recording and the strength of their preference on a sliding scale.

Post-hoc analysis

When programming the hearing aids, it was discovered that four out of five of the companies' default settings used adaptive directionality, but manufacturer 3 defaulted to omnidirectionality. While adaptive directionality scans the environment to amplify the primary speech signal, omnidirectionality prioritizes awareness of the environment from all sides.

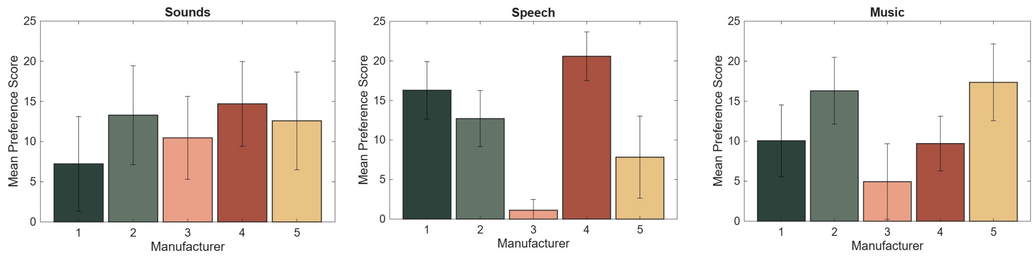
To determine if differences in preferences could be attributed primarily to directionality type, additional recordings were made for manufacturer 3 when it was re-programmed by the clinician to an alternative manufacturer pre-set that used more aggressive directionality.

Five young adults with normal hearing abilities were recruited to compare default-program recordings from all five hearing aid companies, plus the additional directional program from company #3. These comparisons were made for two listening environments: speech-in-noise and music.

Results

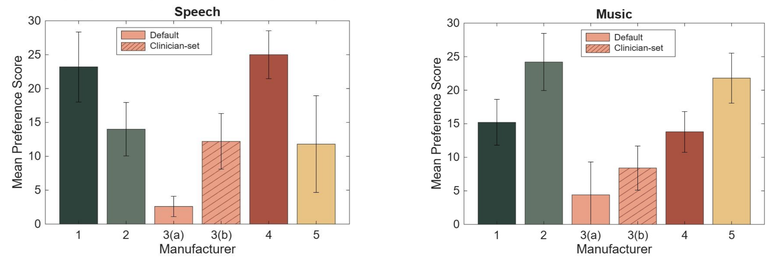
1. Do participants show preferences for hearing aid signal processing from specific manufacturers?

Each comparison was assigned a value to indicate wins (3 points), losses (0 points), and ties (1 point). Points were summed for each manufacturer for a value between 0-24 and averaged across participants. One-way repeated-measures analyses of variance (ANOVAs) were completed for each condition, revealing a significant effect of device on preference for non-speech sounds ($F(4, 64) = 3.51$, $p = .012$), speech-in-noise ($F(2.50, 102.14) = 60.75$, $p < .001$), and music ($F(4, 64) = 19.12$, $p < .001$). For non-speech sounds, all the manufacturers' signal processing were equally preferred except for manufacturer 1, which was least preferred. For speech-in-noise, manufacturer 4 was the most preferred and manufacturer 3 was the least preferred. For music, manufacturers 2 and 5 were the most preferred and manufacturer 3 was the least preferred.



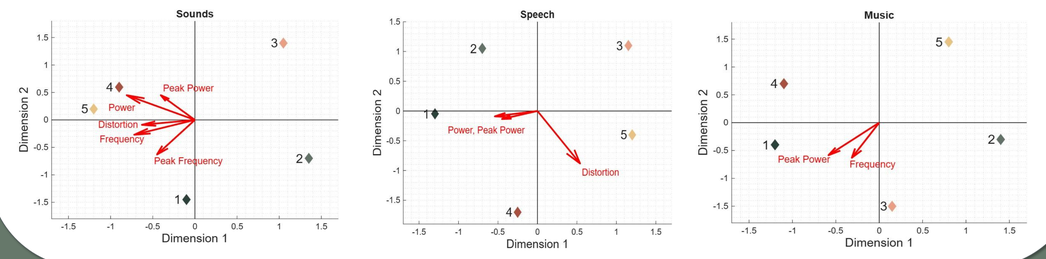
How do participants' preferences change when a hearing aid is set to clinician-set directionality versus default omnidirectional settings?

For speech-in-noise, manufacturers 1 and 4 were still preferred the most. Preference for Manufacturer 3 was more similar to other companies when in the clinician-set directionality mode. For music, manufacturers 2 and 5 were once again most preferred. Despite changing the signal processing settings, manufacturer 3 was still the least preferred in this condition.



2. What components of signal processing are important to listeners?

Multi-dimensional scaling (MDS) models were used to plot the perceptual differences between recordings based on degree of preference. These plots were correlated with measured acoustic parameters of the recordings to determine which aspects of sound drove decision-making. Spearman correlations stronger than .7 are shown below, demonstrating a strong relationship between the parameter and perceived differences among the devices. For the non-speech sounds condition, output level, distortion, and frequency emphasis influenced preference differences. For speech-in-noise, participants made decisions based on output level (dimension 1) and harmonic distortion (dimension 2). For music, both dimensions were influenced by output level and frequency emphasis.



References

Beck, D., Tryanski, D., & Man, B.K.L. (2021). Sound quality and hearing aids. *Hearing Review, 28*(8): 30-31.

Toward, L. & Meyer, S.R. (2019, April 11). Longer term investments – Medical devices. *UBS Chief Investment Office.*

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Discussion

1. **Did participants show preferences for hearing aid signal processing from specific manufacturers?**

Non-speech sounds: Although one company's signal processing was slightly less preferred, preferences were relatively equal across manufacturers, indicating that the companies all achieve similar noise reduction and comfort in this condition.

Speech-in-noise: The signal processing of manufacturer 3 was least preferred by all participants. This manufacturer's default programming set the hearing aids to omnidirectional processing, unlike the other companies that defaulted to adaptive directionality, which could explain why this manufacturer's default program performed poorly in an environment where background noises originated from multiple directions. While other signal processing strategies likely prioritized the signal-to-noise ratio of the speech, this company's default strategy seemed to prioritize sound awareness. When Manufacturer 3 was programmed to a clinician-set directional program, it was equally preferred to two of the other manufacturers. This suggests that hearing aid programming can have an important impact on how patients perceive sound. However, even after adjusting programming, Manufacturer 3 still did not perform to the level of the most-preferred devices, suggesting that there were inherent differences in the processing philosophies and capabilities of the different companies that were not overcome through programming changes alone.

Music: Music recordings were most preferred from the two companies that included an automatic classifier specifically designed to detect music in their default signal processing. Even after changing from the default, Manufacturer 3 was still the least-preferred. However, it should be noted that the clinician set program was intended for speech in noise. It is possible that this manufacturer may have been more preferred in this condition if it had been programmed specifically to a music setting.

2. What components of signal processing were important to listeners?

Non-speech sounds: Participants used acoustic characteristics consistent with loudness, spectral emphasis and distortion to make preference decisions. In this condition, devices that were louder, lower in spectral emphasis and with less distortion tended to be preferred.

Speech-in-noise: Participants tended to prefer signal processing that was louder and had more harmonic distortion, consistent with greater naturalness/fullness of sound.

Music: Participants seemed to prefer signal processing that was not as loud and had greater low-frequency emphasis in this condition.

Conclusion

Differences in signal processing across manufacturers resulted in meaningful differences in perceived sound quality, and no single device was preferred across all listening conditions. Listener preferences depended on the listening environment and the acoustic characteristics produced by each manufacturer's processing approach, indicating substantial individual variability in sound quality preference.

Programming adjustments influenced preference but did not eliminate differences across manufacturers, suggesting that clinicians can modify performance within a device but cannot fully change the overall processing approach. Because manufacturer signal processing strategies and priorities are not transparent, clinicians have limited guidance when selecting devices to match individual listener needs.

Future research should focus on identifying listener characteristics that predict preference for different processing approaches so that manufacturer selection and programming can be better individualized, leading to more efficient fittings and improved patient satisfaction.