# Evidence of Noise Management Preference for Starkey Hearing Aids

**Dave Fabry, Ph.D., Krishna Rodemark, Au.D., Søren Vase Legarth, Jeff Crukley, Ph.D., Andrea Pociecha, Au.D., Kevin Seitz-Paquette, Au.D.**

## SUMMARY:

A benchmark test of seven sets of premium hearing aids was performed with the purpose of comparing noise management (directional microphone plus noise reduction algorithm(s)) performance for speech sound quality and preference in noisy listening situations.

In the evaluation, the new Starkey® hearing aid model, 'Livio® AI', was tested against Starkey Muse™ iQ, as well as direct competitor premium products from each of the major hearing aid manufacturers ("A" -"E"). Each hearing aid was evaluated in a multiple stimuli comparison method under four speech in babble conditions.

FORCE Technology SenseLab recruited 20 participants with hearing impairment from their expert listener panel. Each participant performed the sound quality evaluation in a double-blind, randomized experiment, based on KEMAR recordings of the hearing aids. The receiver-in-the-canal (RIC) hearing aids were individually programmed according to the NAL-NL2 rationale for each participant's hearing with a power dome coupling.

The attributes used for the evaluation were defined during a single two-hour attribute consensus session with five assessors from SenseLab's N3 (standard audiogram) panel.

Starkey Livio AI and Muse iQ devices were preferred over all competitive devices by participants who preferred low background noise levels and low distortion in challenging noisy listening environments for both male and female talkers.

## INTRODUCTION:

Modern hearing aids provide unparalleled flexibility for adjustment of hearing aid gain and output to meet specific fitting targets. Many manufacturers have developed proprietary formulae that optimize settings for their specific technology for quiet listening conditions. Speech sound quality and intelligibility in background noise, however, remains the biggest challenges for new and experienced hearing aid users (Aazh, Prasher, Nanchahal, & Moore, 2015; Abrams & Kihm, 2015; Johnson & Cox, 2016). Hearing aid manufacturers have employed a variety of monaural and binaural noise management systems, incorporating symmetric or asymmetric directional and beamforming microphone arrays, in combination with monaural or binaural noise reduction to tackle these challenges. Starkey hearing aids reduce background noise with a noise management system that uses dual high-frequency directionality together with fast-acting single microphone noise reduction (FSMNR; Muse iQ) or a binaural noise reduction (Livio) algorithm to improve the performance of noise reduction over FSMNR for non-stationary noise sources. At a high level, both systems use information from both hearing aids to provide:

- Greater perceived noise suppressions especially for non-stationary noise
- Faster adaptation to changing noise backgrounds
- Successful noise reduction in a wider range of environmental conditions

In the present study, both Starkey devices were compared to premium competitive devices fitted to an independently validated fitting formula (NAL-NL2). Though it is possible that use of proprietary formulae might have provided different results, this approach reflects current common clinical practice.

## METHODS:

Twenty experienced hearing aid wearers (five females), with mild-to-moderate hearing loss were selected for this laboratory study carried out at SenseLab in Copenhagen, Denmark. The age range of participants was 61-83 years (mean 72 years). All participants were native Danish speakers and selected based on their audiometric thresholds and previous experience assessing sound quality.

Participants listened to and rated seven bilateral sets of commercially-available RIC 312 products coupled to their respective power domes and programmed for each listener's audiogram using the NAL-NL2 fitting rationale. Feedback cancellation was initialized across all test devices for each participant. All settings were the default/manufacturer recommended settings for speech in noisy environments apart from frequency lowering, which was disabled across all manufacturers.

Hearing aids recording were made with a Knowles Electronics Mannequin for Acoustic Research (KEMAR) in four conditions (sound scenes) for each individual:

1. On-axis Danish male speech presented from 0 degrees at 75 dBA with diffuse Danish café babble noise presented at 72 dBA and an additional Danish female talker presented at 72 dBA from 90 degrees (+3 dB SNR).
2. On-axis Danish male speech presented from 0 degrees at 75 dBA with diffuse Danish café babble noise presented at 75 dBA and an additional female talker presented at 75 dBA from 90 degrees (0 dB SNR).
3. Off-axis Danish male speech presented from 235 degrees at 75 dBA with diffuse Danish café babble noise presented at 72 dBA and an additional Danish female talker presented at 72 dBA from 90 degrees (+3 dB SNR).
4. Off-axis Danish male speech presented from 235 degrees at 75 dBA with diffuse Danish café babble noise presented at 75 dBA and an additional Danish female talker presented at 75 dBA from 90 degrees (0 dB SNR).

Participants were provided instructions and listened to their individual, compensated recordings via calibrated Sennheiser HD650 headphones while seated in a quiet room. Participants were asked to rate their preference as well as assess several sound attributes including loudness, background noise, and reverberation using a visual analog scale. Data were collected with SenseLabOnline, a web-based listening test tool. Conditions and presentations were randomized in a double-blind fashion.

Overall loudness of the hearing aids was evaluated using a continuous scale ranging from 0 to 15 (Weak to Strong). Figure 1 shows the graphic user interface of the loudness evaluation.

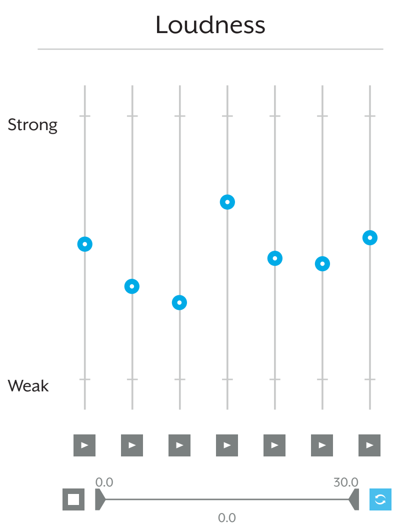


*Figure 1: The interface used to rate loudness. Participants could replay the recordings as many times as they liked and did not have a time limit.*

An overall evaluation of preference was rated across the 7 sets of hearing aids under each condition. Figure 2 shows the interface for preference rating, a continuous, hybrid, hedonic scale ranging from 0 = Dislike Extremely to 15 = Like Extremely.

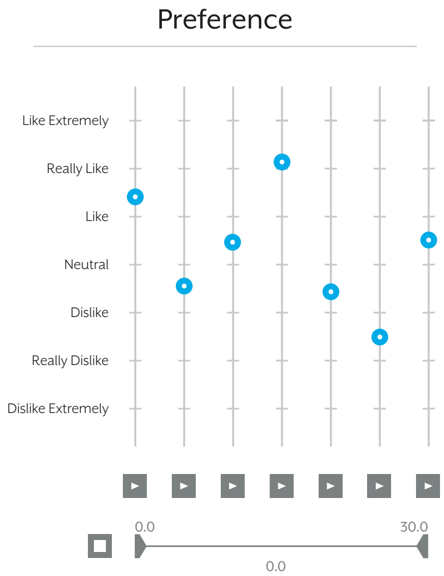


*Figure 2: The interface for the preference test provided by the SenseLabOnline tool.*

In addition to loudness and preference ratings, participants were also asked to rate the attributes developed by a small subset of SenseLab's expert listening panel. Five key attributes were identified:

1. Background Noise
2. Speech Clarity (Female)
3. Speech Clarity (Male)
4. Timbre Balance
5. Reverberation

The results reported in the present paper will focus on background noise and reverberation, with additional publications focused in the additional attribute areas.

## RESULTS:

We hypothesized that the different noise management systems used by different manufacturers would yield differences in loudness and overall preference for the four conditions under test, which simulated very challenging noisy listening environments.

**Overall Loudness.** Figure 3 illustrates overall loudness ratings across the seven hearing aids under evaluation, averaged across all four sound scenes. Starkey's Livio AI, Muse iQ and Manufacturer B were judged to be lower in overall loudness than for the remaining four competitive devices.

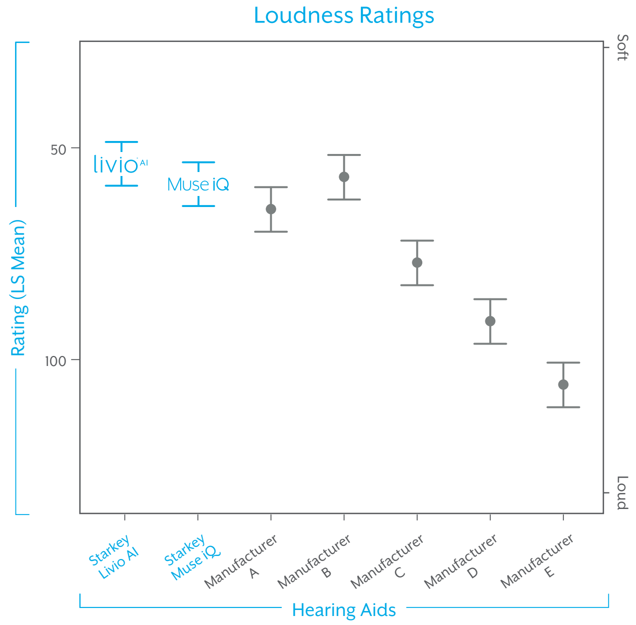


*Figure 3: Loudness ratings and standard deviations across the seven competitive devices*

**Background Noise.** Subjects were asked to rate the level of background noise present through each of the hearing aids, ranging from "dominating" to "inaudible". Figure 4 illustrates that Starkey Livio AI and Muse iQ received the lowest background noise ratings across all four sound scenes, with Manufacturer E being rated as having the most dominating background noise.

**Reverberation.** In addition to background noise, subjects were asked to rate distortion, in terms of reverberation, through each of the hearing aid systems in each condition. Figure 5 illustrates average distortion/reverberation ratings, ranging from "a lot" to "a little" across the seven test devices. Again, Starkey's Livio AI and Muse iQ received the lowest reverberation ratings across all acoustic scenes, and Manufacturer E was rated as having the highest reverberation/distortion.

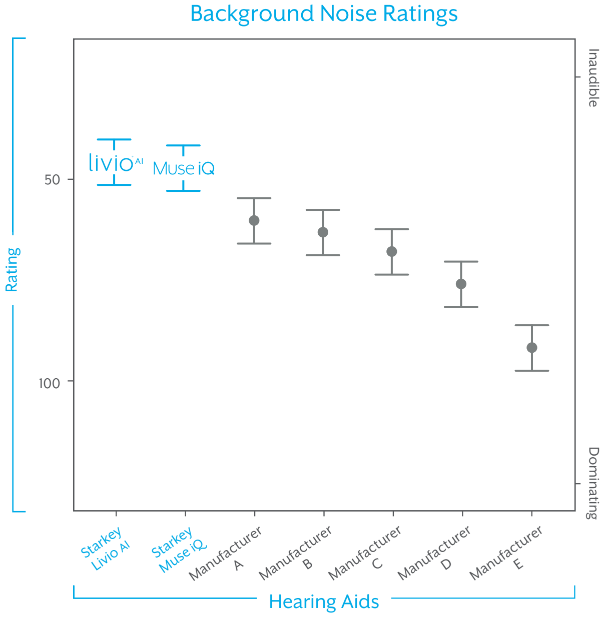


*Figure 4: Background noise ratings across all seven devices*

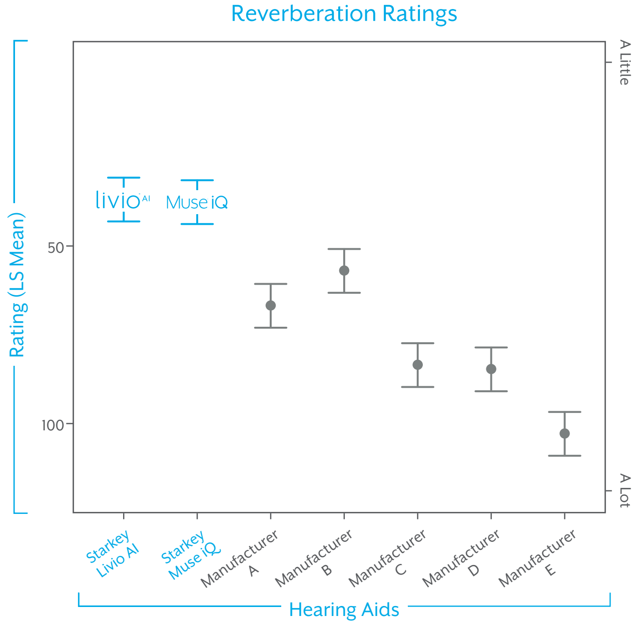


*Figure 5: Reverberation ratings across all seven test devices*

## CONCLUSIONS

Twenty participants with hearing impairment completed a double-blind, randomized perceptual evaluation of seven commercially-available hearing aids at FORCE Technology, SenseLab, an independent perceptual assessment company. The evaluation was based on KEMAR recordings of the hearing aids placed in four loud speech-in-noise conditions.

The findings indicated that both Starkey hearing aids were judged to be lower in overall loudness when compared to other manufacturers' premium products over all four noisy listening environments. In addition to background noise, Starkey Livio AI and Muse iQ were judged to have the lowest distortion, in terms of expressed reverberation, across all acoustic scenes.

In summary, both Starkey devices were preferred over all competitive devices by participants who preferred low background noise levels and low distortion in challenging noisy listening environments for both male and female talkers.

## REFERENCES


1. Aazh, H., Prasher, D., Nanchahal, K., & Moore, B. C. (2015). Hearing-aid use and its determinants in the UK National Health Service: a cross-sectional study at the Royal Surrey County Hospital. International journal of audiology, 54(3), 152-161.
2. Abrams HB, Kihm J. An Introduction to MarkeTrak IX: A New Baseline for the Hearing Aid Market. Hearing Review. 2015;22(6):16.
3. Johnson, J. A., Xu, J., & Cox, R. M. (2016). Impact of hearing aid technology on outcomes in daily life II: Speech understanding and listening effort. Ear and hearing, 37(5), 529.