The use of noise reduction at the upper limits of the fitting range

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Introduction

The maximum power output (MPO) of a hearing aid is the maximum sound pressure level (SPL) that the hearing aid can produce before saturation or compression limiting is reached. A high MPO results in higher output and less distortion resulting in the wearer's perception of sounds as being more natural and louder. Noise reduction algorithms attempt to reduce gain in specific bands when steady-state signals are detected. This will avoid reaching the ceiling of the hearing aid to minimize the saturation distortion at least for some patients. This could potentially result in better sound quality or improved speech understanding in noise. The current study examined the interaction of noise reduction algorithm and the maximum power output of the hearing aid. Results using a SII based noise reduction algorithm in high-input environments will be discussed with emphasis on patients having moderate-to-severe hearing losses.

Subjects

- 10 subjects (5 males and 5 females).
- All subjects with moderate-to-severe and severe-to-profound gently-sloping and flat hearing losses.
- All subjects were experienced hearing aid wearers.
- Age from 33 to 88 years with a mean age of 58 years.
- All participants were native English speakers.

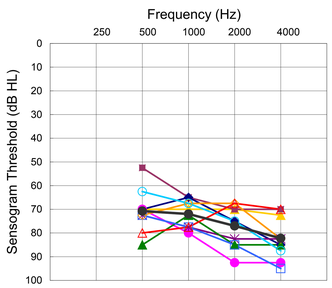


Figure 1: Sensogram thresholds averaged for left and right ears plotted for all participants.

Procedures

HINT (Hearing In Noise Test)

- Noise was fixed to 68 dB SPL and 75 dB SPL.
- A practice HINT test was provided to familiarize participants with the task.
- Speech and noise were both presented from 0° azimuth.
- Test conditions were counterbalanced.

ANL (Accetable Noise Level)

- Test was completed using Connected Speech Test (CST) passages.
- Appropriate MCL was measured for each MPO condition.
- BNL was determined with Babble noise was used as the background noise starting 20 dB below the MCL.
- Speech and noise were both presented from 0° azimuth.
- Test conditions were counterbalanced.

Methods

Hearing Instrument

- Widex Mind440-19 Digital Power BTEs were used in the study. This model contains a 15-channel fully adaptive directional microphone, speech intelligibility index based noise reduction, active feedback cancellation. The directional microphone was deactivated during testing.
- Each subject was fit binaurally using in-situ thresholds.
- Coupling was done using foam inserts with #13 tubing.
- The measurements on the acoustic performance of these hearing aids were completed with the Audioscan Verifit system.
- Three noise reduction algorithms:
- No noise reduction
- Speech Intelligibility Index (SII) based noise reduction algorithm called SpeechEnhancer (SE)
- Classic Noise Reduction

MPO Conditions

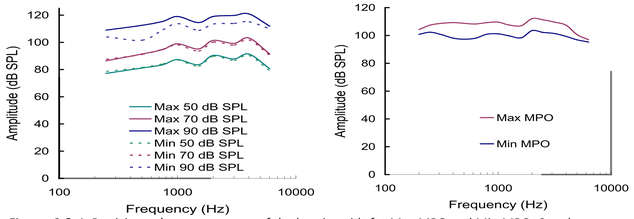
Default MPO is based on Pascoe's formula. MPO is hearing loss dependent. Two different MPO conditions were used in the study:

Max MPO:

- The gain of the aids remained at default. MPO values were increased to maximum. This was considered the Max MPO condition.

Min MPO:

- In-situ hearing thresholds were decreased to 40 dB HL (or remained at threshold for those with thresholds below 40 dB HL) and the MPO values were decreased to minimum values. Gain values were then increased to match those of the Max MPO condition. This was considered the Min MPO condition.



Figures 3 & 4: Participants' average output of the hearing aids for Max MPO and Min MPO. Coupler curves were obtained with Audioscan Verifit test box using a 2 cc coupler and an input of 50 and 70 dB SPL pink noise and 90 dB SPL tone burst signal (of 1/3 octave frequencies)(left) and an ANSI 90 dB SPL tone sweep (right) with the hearing aids in test mode 2.

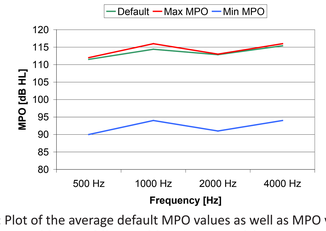


Figure 5: Plot of the average default MPO values as well as MPO values for Max and Min conditions for all participants.

Results

Hearing In Noise

Conversational level (68 dB SPL)

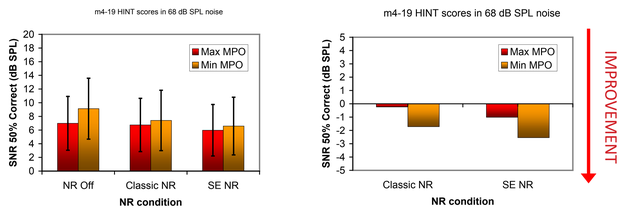


Figure 5 (left): HINT scores for 68 dB SPL level for the three NR conditions used in the study.
Figure 6 (right): Difference in HINT scores between no NR and the two NR algorithms.

- HINT scores for 68 dB SPL level are shown in Figure 5. Participants required lower SNR level when using higher MPO setting with all NR conditions. The difference between the two MPO conditions was largest (2.1 dB) when no noise reduction was used. The smallest difference (0.6 dB) was seen when using SII based NR.

- The benefit of using the two different NR algorithms in comparison of using no NR is shown in Figure 6. The use of noise reduction algorithm did not result in changes in SNR in the Max MPO condition. However, in the Min MPO condition both Classic NR and SII based NR reduced the required SNR by 1.7 dB and 2.5 dB respectively.

Louder level (75 dB SPL)

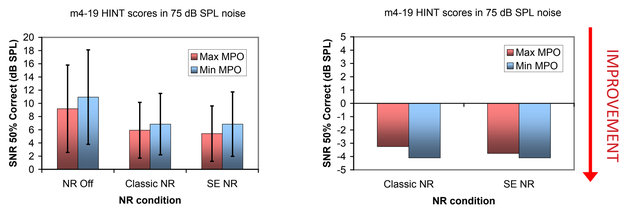


Figure 7 (left): HINT scores for 75 dB SPL level for the three NR conditions used in the study.
Figure 8 (right): Difference in HINT scores between no NR and the two NR algorithms.

- HINT scores for 75 dB SPL level are shown in Figure 7. As was seen with conversational 68 dB SPL level, participants required lower SNR level when using higher MPO setting with all NR conditions. The difference between the two MPO conditions was largest (1.7 dB) when no noise reduction was used.

- The benefit of using the two different NR algorithms in comparison of using no NR is shown in Figure 8. Unlike with the conversational 68 dB SPL level the use of noise reduction algorithm resulted in changes in SNR in both Min and Max MPO conditions. The benefit was greater in the Min MPO condition for which the benefit was the same 4.1 dB with Classic NR and the SII based NR algorithms.

Results (cont.)

Noise tolerance

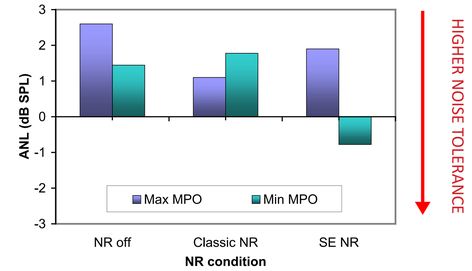


Figure 9: Average ANL scores in dB SPL for all participants for each hearing aid MPO condition with NR off, classic NR, and SE NR. (Note: One participants was not able to complete ANL testing as the words in the sentences mecame unclear in the Min MPO condition)

Subjective measures of MCL, BNL and ANL were not significantly affected by MPO. The power analysis suggested that N > 80 would have been needed for statistical significance.

Figure 9 shows the averaged ANL scores for all participants. A lower ANL score indicates more noise tolerance. In Max MPO condition listeners tolerated more noise when using noise reduction (classic NR or SE NR) than when noise reduction was deactivated. This benefit was 1.5 dB when using Classic NR and 0.7 dB when using SE NR.

In the Min MPO condition listeners had similar noise tolerance between NR off and classic NR conditions. SE NR provided 2.2 dB benefit on average in Min MPO condition compared to no NR condition.

Conclusions

The use of noise reduction algorithm resulted in improved speech-in-noise performance. The Min MPO condition provided more benefit from the use of noise reduction, but the Max MPO condition also benefited from the noise reduction algorithm when the signal level was higher. The benefit was greater with SII based noise reduction than with classic noise reduction. These results suggest that the use of a SII based noise reduction algorithm should be considered even for patients at the limits of the fitting range. Also, the results showed that for the group of subjects selected for this study, the higher MPO resulted in better performance with or without using noise reduction algorithm. This demonstrates that in addition to the use of noise reduction algorithm to improve speech understanding in noise, it is important to select a hearing aid with a high enough MPO.

References

- Kuk, F. 1998. Using the I/O curve to help solve subjective complaints with WDRC hearing instruments. Hear Rev 5, no. 1: 8-16; 59.
- Kuk F, Korhonen P, Baekgaard L, Jessen A. MPO: A forgotten parameter in hearing aid fitting. Hearing Review. 2008,14(6):34-40.
- Peeters H, Kuk F, Lau C, and Keenan D. (2009) Subjective and objective evaluation of noise management algorithms. JAAA, 20, no. 2:89-98.