Interaction of maximum power output and hearing loss

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Introduction

Maximum power output (MPO) represents the highest output level that a hearing aid can deliver. A low MPO means that the saturation or compression limiting of the hearing aid is reached easily with everyday sounds, including speech at a conversational level. MPO on a hearing aid can be regarded as "low" if the maximum output of the hearing aid is below the wearer's loudness expectation despite attempts to adjust the gain higher. This is especially true for those with a significant degree of hearing loss and when the input is above a conversational level. An adequately high MPO results in higher output and less distortion of the amplified speech. This may result in the wearer's perception of sounds as being more natural, sounding clearer, and louder. The appropriateness of the MPO depends on the output level available in a hearing aid and consequently on the severity of the hearing loss. The current study examined the interaction of MPO and the degree of hearing loss when listening to speech in a background noise.

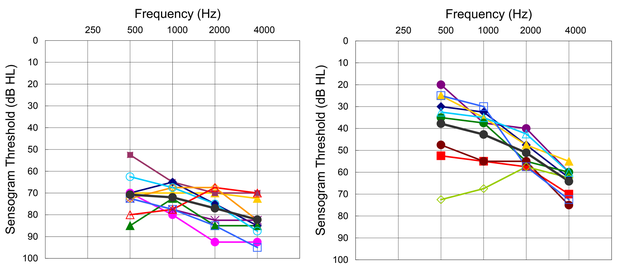
Subjects

- 19 subjects (10 females and 9 males).
- Participants were divided in two groups based on their hearing loss:

Group 1: Moderate-to-severe and severe-to-profound gently-sloping and flat hearing losses.
Age 33-88 years (mean 58 years).
Five females, five males.

Group 2: Six participants with mild to moderate sloping hearing losses.
Three participants with moderate flat hearing losses.
Age 60-84 years (mean 70 years).
Five females, four males.

- All subjects were experienced hearing aid wearers.
- All participants were native English speakers.



Figures 1 & 2: Sensogram thresholds averaged for left and right ears plotted for participants in Group 1 (left) and Group 2 (right).

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, and multi directional active feedback cancellation. The directional microphone and the noise reduction algorithm was deactivated during testing.
- Each subject was fit binaurally using in-situ thresholds.
- Coupling was done using foam inserts with #13 tubing.
- No noise reduction processing.

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.

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.

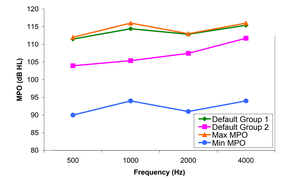
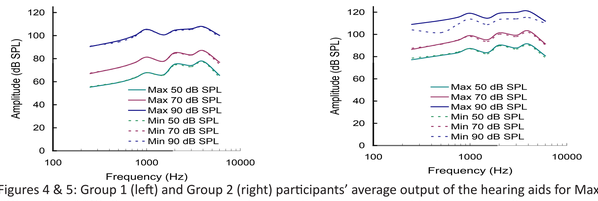


Figure 3: Plot of the average default MPO values for Groups 1 and 2 as well as MPO values for Max and Min conditions for all participants.



Figures 4 & 5: Group 1 (left) and Group 2 (right) 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) with the hearing aids in test mode 2.

Results

Conversational level (68 dB SPL)

Group 1

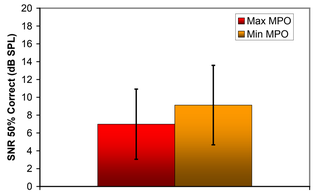


Figure 6: Average HINT SNR results for Group 1 in Max and Min MPO conditions when HINT noise was played at 68 dB SPL.

- On average, participants in Group 1 achieved better SNR scores with the Max MPO condition compared with the Min MPO condition (Figure 6).
- All participants except one had lower HINT scores in Max MPO than in Min MPO. The mean improvement was 2.14 dB with standard deviation of 1.49 dB.
- Paired-samples t-test Max MPO vs. Min MPO: $t(9) = 4.53$, $p=0.004$

Group 2

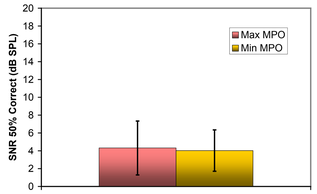


Figure 7: Average HINT SNR results for Group 2 in Max and Min MPO conditions when HINT noise was played at 68 dB SPL.

- The difference between Max and Min MPO conditions was not significant ($p > 0.05$)(Figure 7).
- For the Group 2 the two MPO conditions used in the study resulted in similar outputs for the same inputs. The coupler measurements (Figure 4) demonstrate that the response for signals at 50, 70 and 90 dB SPL was the same for Min and Max MPO conditions. Therefore for 68 dB noise level it is expected for participants to perform similarly in Min and Max MPO conditions.

Results (cont.)

Louder level (75 dB SPL)

Group 1

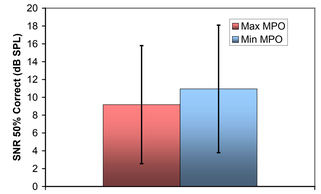


Figure 8: Average HINT SNR results for Group 1 in Max and Min MPO conditions when HINT noise was played at 75 dB SPL.

- Group 1 had better HINT scores with Max MPO compared with Min MPO (Figure 8).
- 7 subjects out of 10 performed better with Max MPO condition. Mean improvement was 1.8 dB.
- Paired-samples t-test Max MPO vs. Min MPO: NR Off ($p>0.05$).
- For 75 dB noise level is is expected that hearing aid reaches it ceiling for the loudest portions of the speech especially for the Min MPO condition (see Figure 5).

Group 2

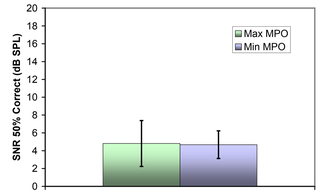


Figure 9: Average HINT SNR results for Group 2 in Max and Min MPO conditions when HINT noise was played at 75 dB SPL.

- HINT scores in Group 2 were not significantly different between Min and Max MPO conditions ($p > 0.05$) (Figure 9).
- The two MPO conditions provided sufficient head-room for the subjects in this hearing loss group even for louder sounds. The Max MPO condition even allowed more head-room than the default MPO would have (see Figure 3).

Conclusions

The results of this study demonstrated that speech-in-noise performance is compromised when a hearing aid with a low MPO is fit on a moderately-severe hearing loss. The mild-to-moderate group was not affected by the change in MPO as the lower MPO provided ample output in the test conditions. To maximize potential benefits of a hearing aid fitting it is important to select an aid with a sufficiently high MPO to ensure that the desired gain plus the input levels would not be limited. The same considerations should also be applied to setting the MPO on a hearing aid in order to ensure maximum audibility and optimal SNR.

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.