Hearing aid algorithm stability: Hagerman's phase-inversion technique

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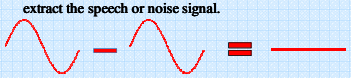
Introduction

- The phase-inversion technique (Hagerman and Olofsson, 2004) is a methodology used to estimate the signal-to-noise ratio (SNR) of hearing aid output.
- This technique sequentially presents two controlled signals to the hearing aid. The two recorded hearing aid outputs are then time-aligned and mixed to extract the speech or noise signal.

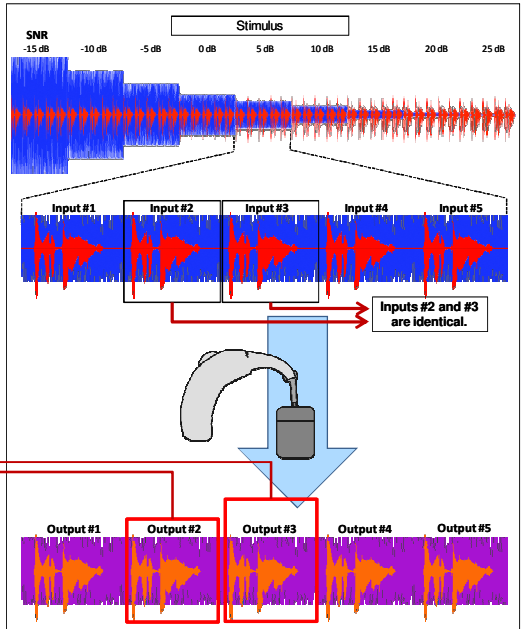


- The accuracy of the Hagerman technique depends on the stability of the hearing aid algorithm: If the algorithm processes sound differently for the same input presented at different times, the Hagerman technique will not accurately separate speech and noise signals.

- The objectives of this study:
  - To investigate the stability of hearing aid algorithms.
  - To demonstrate the importance of quantifying and reporting hearing aid stability when using the Hagerman technique.

Methods

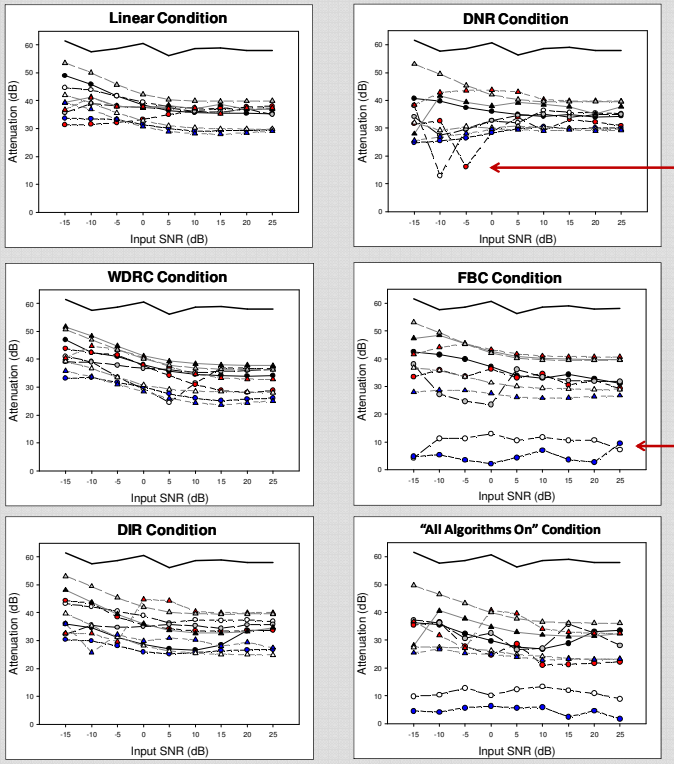
- Ten hearing aids (5 advanced and 5 older models) from 5 manufacturers were tested.
- Sound field recordings were made in a sound-treated booth.
- Stimuli (9 SNR conditions):
  - Speech: *HINT* sentences - fixed level of 65 dB(A)
  - Noise: *HINT* noise – descending from 80 dB(A) to 40 dB(A) in 5 dB steps.



- Six conditions: Linear, WDRC (wide dynamic range compression), DIR (directional microphone), DNR (digital noise reduction), FBC (feedback cancellation algorithm), and All Algorithms On.
- Hearing aid stability was quantified by examining the ***attenuation*** at each input SNR for each algorithm condition.
- ***Residuals*** from each input SNR were calculated by subtracting the waveform of **output #3** from **output #2.**
- **Attenuation** was quantified by subtracting the RMS of the ***Residual*** from the RMS of **output #2.**
- The larger the attenuation, the greater the stability.

Results

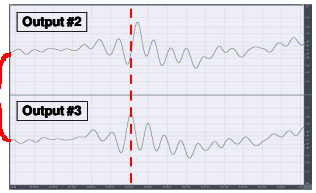
- The attenuation was high (25-50 dB) for the Linear, WDRC, and DIR conditions.
- For some hearing aids at certain SNRs, the attenuation decreased considerably when the DNR and FBC was turned on.



Discussions

- The amount of gain reduction of the ***DNR*** was not consistent over time, which reduced attenuation.

- ***Feedback cancellation*** caused a shift in phase, increasing the residual, and reducing attenuation.



Conclusions

- Results revealed that noise reduction and feedback cancellation are the most unstable algorithms that could compromise the Hagerman technique's accuracy.
- This study suggests the importance of quantifying and reporting hearing aid stability when using the Hagerman technique.

References

❖ Hagerman, B., Olofsson, A. (2004) A Method to Measure the Effect of Noise Reduction Algorithms Using Simultaneous Speech and Noise. *Acta Acustica United with Acustica.* 90, 356-361.

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