Improving Speech Understanding and Listening Effort for Complex Communication Environments with a Novel Noise Reduction System

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Background & Present Study

Speech understanding in noise and the cognitive demands associated with it remain two key challenges for people with hearing impairment. Hearing aid manufacturers have invested significantly in signal processing that aims to address these needs by improving a listener's access to speech in complex communication environments. Directional microphones and digital noise reduction have been combined in modern hearing aids to provide significant improvements in signal-to-noise ratio (SNR), but these technologies involve trade-offs for the end-user's listening experience.

Noise reduction is a broad term with implementations well beyond hearing aids. Arguably, consumer applications such as Teams or Zoom have exceeded the noise reduction capabilities of hearing aids through the use of deep neural networks (DNN), which require significant processing power, unique architecture and power efficiency in order to run.

Phonak Audéo Sphere Infinio features two processors working in parallel: the ERA chip that provides traditional signal processing and other functions of the hearing aid, and the DEEPSONIC chip to run Spheric Speech Clarity (SSC), a DNN-based noise reduction system. DEEPSONIC has a unique architecture that allows for low latency DNN-based signal processing on a hearing aid to enhance speech and suppress noise. This is implemented in Sphere Infinio hearing aids in the Spheric Speech in Loud Noise (SSiLN) program, in combination with a static beamformer (Fixed Directional).

This technology was tested in a clinical investigation conducted at the Phonak Audiology Research Center (PARC). The benefits of this implementation of DNN-based signal processing for speech understanding in noise and listening effort were evaluated.

Methods

Participants

- 27 experienced adult hearing aid users with moderate to moderately severe bilateral hearing loss aged 58 to 93 years (*m*=75.1±8)

Hearing instruments

- Phonak Audéo Sphere Infinio 90 + two other premium hearing aids
- Proprietary fitting formulas at 100% of prescriptive gain
- Manual programs
- Custom acoustic coupling with 1mm vent

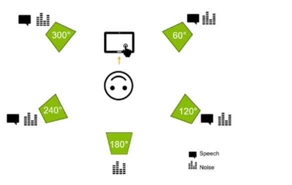
Methods continued

Task 1—Speech Understanding in Noise via modified Coordinate Response Measure (CRM)[1]

- Noise = speech-shaped noise from 5 speaker locations
- Speech = one CRM sentence presented individually from 1 of 4 possible speaker locations
- "Ready, Baron, go to [color] [number] now."
- Two female voices—Talker ID's 4 & 7
- SNR = -3 dB, with noise at 72 dB SPL
- Response = identification of both the color and number in the target sentence.

Comparisons

1. Phonak Sphere Infinio with SSC vs. without SSC in addition to a pinna effect microphone (Real Ear Sound)
2. SSiLN program vs. 2 competitor SiN programs

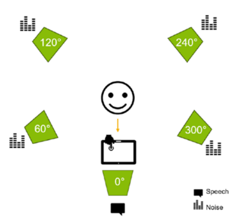


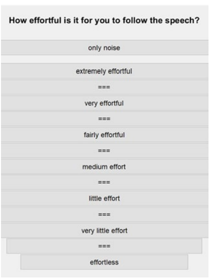
Task 2—Listening Effort via Adaptive Categorical Listening Effort Scaling (ACALES)[2]

- Noise = US Matrix speech-shaped noise at 72 dB SPL
- Speech = 3 sequential US Matrix sentences (female)
- Adaptive signal = speech presented from front
- Response = listening effort rating on a 13 pt. scale for each SNR presented

Comparison

1. Phonak Sphere Infinio with SSC vs. without SSC in addition to a pinna effect microphone (Real Ear Sound)





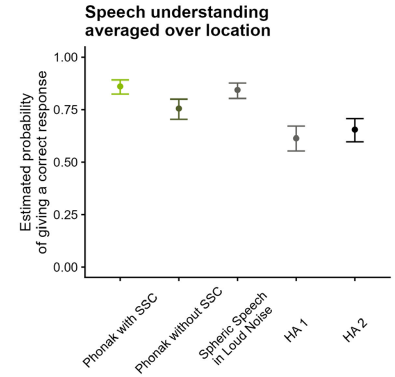
Results

Task 1—Speech Understanding in Noise

Participant responses were modelled using a generalized linear mixed-effects model with a logit link function. Hearing aid condition and sentence condition were treated as fixed effects with participant as random effects. The purpose of this model was to test whether the odds of providing a correct response significantly varied between different hearing aid processing conditions. The results can be interpreted as the ratio of the odds of providing a correct response under different hearing aid processing conditions.

Odds Ratio

- with SSC vs. without SSC = 2.01, asymptotic 95% CI: [1.6, 2.52], $p < 0.0001$
- SSiLN vs. competitor 1 = 2.86, asymptotic 95% CI: [2.15, 3.79], $p < 0.0001$
- SSiLN vs. competitor 2 = 3.41, asymptotic 95% CI: [2.54, 4.57], $p < 0.0001$

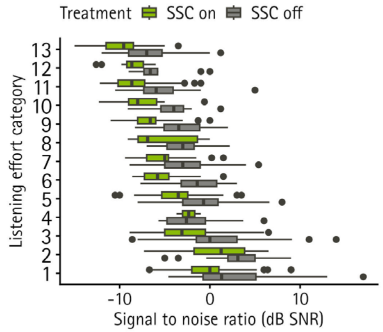


Task 2—Listening Effort

Effort ratings were modelled using linear mixed effects model with SNR as the dependent variable and including hearing aid processing as fixed effect and participant as random effects. Model results indicated that with SSC on participants could withstand an around 2.9 dB poorer SNR without a corresponding increase in subjective listening effort compared to without SSC.

Mean Difference

- with SSC vs. without SSC = -2.86 dB, 98% CI: [-3.32, -2.39], $p < 0.0001$



Conclusions

This investigation provides evidence that this implementation of DNN-based noise reduction improves speech understanding in complex noisy environments and reduces listening effort for adults, in isolation and in comparison, to two other premium hearing aids.

References

[1]**Bolia, R. S., Nelson, W. T., Ericson, M. A., & Simpson, B. D. (2000).** A speech corpus for multitalker communications research. *The Journal of the Acoustical Society of America, 107(2), 1065–1066.* https://doi.org/10.1121/1.428288 [2]**Krueger, M., Schulte, M., Brand, T., & Holube, I. (2017).** Development of an adaptive scaling method for subjective listening effort. *The Journal of the Acoustical Society of America, 141(6), 4680–4693. https://doi.org/10.1121/1.4986938*