Benefit of Linear and Non-Linear Amplification with Time-Varying Maskers

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Introduction

- Hearing aids with fast-acting, wide-dynamic range compression (WDRC) can process rapid fluctuations in speech, which may maximize effective moment-to-moment speech audibility.
- This processing may also distort the speech temporal envelope, which may be particularly detrimental for older adults with reduced cognitive abilities.
- Given that speech recognition relies on precise timing for accurate coding of temporal information, the benefits of compression amplification with rapid time constants may be limited for some older adults, especially for maskers with abrupt temporal fluctuations.
- The purpose of this study was to determine the extent to which aided speech recognition in noise by older adults varies with the temporal characteristics of the masker, hearing-aid compression processing, and listeners' cognitive abilities.
- Subjective ratings of task workload, listening effort, and hearing-aid benefit were also obtained to assess benefits of amplification beyond conventional measures of speech recognition in noise.

Methods

Participants (N=18, see audiogram)
- Bilateral mild-to-severe sloping sensorineural hearing loss
- Ages 62-82 years (Mean = 71.6 years; 8 Females)
- No previous hearing-aid use

Hearing Aids
- Bilateral experimental Starkey Wi Series i110 RIC
- Programmed according to NAL-NL2 with:
  - Fast-acting multi-channel
  - WDRC (AT=10 msec, RT=40 msec)
- Linear processing with output limiting
- Noise reduction, compression, and directionality not engaged
- Differences between measured and target real-ear gain < 5 dB from 0.25-3.0 kHz and < 10 dB from 4.0-6.0 kHz

Objective and Subjective Outcome Measures

- **Unaided and Aided Sentence Recognition in Noise (word scoring):**
  - IEEE sentences (0): 62 SPL, 2 lists per condition for 100 key words per score
  - Speech-shaped maskers (+60°): -3, 0, +3 dB SNR

- **Perceived Workload, Listening Effort, Difficulty:**
  - NASA Task Load Index
  - Abbreviated Profile of Hearing Aid Benefit (APHAB)∞
  - Measures of Working Memory and Processing Speed:
    - Reading Span
    - Connections (Simple & Complex)∞
    - Purdue Pegboard (Left, Right, Both & Assemblies)∞

Conclusions

- In the highly fluctuating square-wave masker only, hearing aids provided significant improvements in speech recognition, and this benefit was equivalent for WDRC and linear processing.
- As compared to performance in steady-state maskers, unaided and aided speech recognition improved in a babble-envelope masker and further improved in a square-wave masker. Significant aided modulation benefit was seen at the poorest SNR in the square-wave masker.
- Linear hearing aids reduced listening effort and WDRC hearing aids increased perceived performance during speech recognition tasks as compared to unaided listening.
- In contrast to previous findings, working memory and processing speed were not significant predictors of aided speech recognition, effects of compression processing, or effects of masker temporal characteristics.
- Reasons for differences from earlier results include (1) use of real hearing aids rather than laboratory-based signal processing, (2) minimal hearing-aid benefit for some conditions, and (3) participants with generally average-to-high cognitive function. Nevertheless, knowledge of certain cognitive abilities may ultimately provide useful information for selecting hearing-aid parameters for a subset of users.