Effects of hearing aid signal processing on cognitive outcome measurements

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Introduction
It has been demonstrated that the benefit of signal processing intended for hearing aids is not limited to improvement in speech perception. Sarampalis et al. (2009) show that the Ephrath-Mallah noise reduction algorithm improves cognitive performance and reduces listening effort for people with normal hearing. However, better performance on the word-memory task for hearing-impaired listeners has not been reported.

This study examines how signal processing intended for hearing aids affects the cognitive demands of speech recognition and the remaining cognitive capacity in people with a hearing impairment. Binary time-frequency masking (BM) (Wang et al., 2009), which is a noise-reducing signal processing technique, was employed.

Method
Participants
Twenty experienced hearing aid users of 32 to 65 years of age (mean=54, SD=8) with symmetrical sensorineural hearing loss of 43 to 60 dB HL (mean=48, SD=4.9) were tested.

Procedure
A) Dual task – an assessment of cognitive demands
Each participant listened to 35 lists of 8 sentences in 7 background conditions and completed the dual task: 1) Perceptual speech recognition task: Repeat the final word immediately after listening to each sentence. 2) Free recall memory task: Report back, in any order and as many as possible, the final words that have previously repeated in a list.
B) Cognitive tests – assessing different cognitive abilities
- Physical matching / Lexical / Rhyme / Reading span / Word span / Semantic / Non-word span
Test conditions
- Seven conditions; 5 repetitions per condition
- No processing (NoP) vs. Realistic BM (NR) vs. Ideal BM (IBM)

Sentence material
- Dual task: 35 lists of 8 Swedish HINT sentences
- E.g. Pappa ska laga min fطالب
- Tanten handlar om gäng av Сова
- Rekstorn tog fram kastrullen
- Farfar skall visa balken.

Test set-up
- Speech: 65 dB A
- Noise: 4T, TNR, TNR/IBM, NR, NoP
- 4-talker babble (RT):
- Background noise:
- Same individualized SNR across noise conditions

Preliminary results

Table 1 shows correlations between cognitive tests and the results of the memory task (in terms of percentage of words that were recalled correctly). Reading span test, which measures working memory capacity, correlates with memory performance in most of the background conditions.

ANOVA shows significant main effects of noise type (SSN vs 4T) and noise reduction (NoP/NR/IBM). The 2-way interaction (noise type x noise reduction) indicates that in the 4T background, noise reduction improves memory performance; while in the SSN background, there is no improvement with the use of noise reduction (Figure 2).

The position of the final words in each of the 8-sentence lists in the memory task was also analyzed. Figure 3 shows mean memory performance as a function of position.

Preliminary conclusions
- Binary masking noise reduction technique helped freeing up cognitive resources and hence enhanced memory task performance in the 4T background. Such enhancement occurred in both long-term storage (primacy) and short-term storage (recency).
- In individuals with better working memory capacity, memory performance was more disturbed in the competing background speech than steady-state noise when there was no noise reduction.