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Hearing aid noise suppression and working memory function

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Motivation

- Speech understanding in noise (SNR) is an important but demanding daily-life situation
- Manufacturers’ point of view: What is the best processing strategy in such situations?
- There is a relation between speech perception, esp. SNR, of hearing-impaired listeners, and the ability to manipulate and store sensory information (e.g. Akeroyd, 2008; Rönnberg et al., 2010)
- However, the relation between outcome from hearing aid (HA) noise suppression and working memory function is still unclear. This study thus addressed the following research questions:
  1. How do different noise suppression algorithms influence the working memory function of elderly HA users?
  2. Is there a relation with performance on a reading span test (RST)?
  3. How can the working memory function of elderly HA users be assessed reliably?

Methods

- Working memory measures
  - Predictor variable: RST (large spread)
  - Dependent variables: Auditory working memory in SNR +6 dB with a frontal target tasker in spatially diffuse cafeteria noise:
    - Listening span test (LST): final word recognition and recall
    - Speech material: Baseline sentence test (Tschopp & Züst, 1994)
    - N-back test: %-correct; Speech material: German Digit Triplets Test (Buschermöhle et al., 2014)

- HA conditions
  - Computer simulation of bilaterally fitted HAs (MHA, Grimm et al., 2006)
  - Individual linear amplification (NAL-RP)
  - Noise suppression settings
    1. Unprocessed (unproc)
    2. Directional microphone (dir)
    3. Single-channel noise reduction (scnr)
    4. Binaural coherence-based noise reduction (bcnr)
  - Setting 2: 4 matched in terms of speech-weighted SNR improvement (~3 dB re unprocessed)

- Participants
  - 20 experienced HA users (ages 55 – 80 years; M = 72 years)
  - Bilateral sloping sensorineural hearing loss (PTA4: 33 – 61; M = 49 dB HL)
  - RST scores 26 – 70; M = 44 %-corr.
  - Inclusion criteria for subjects: 80 %-corr for LST and N-back material; screening measurements (one training run per material with dirmic, followed by speech recognition measure 24 trials per material in unproc)

Reference:

Results

- Screening results
  - Table 1: Speech intelligibility for both speech materials measured in SNR +6 dB.
    | Measure | M | Min | Max |
    |---------|---|-----|-----|
    | LST     | 94 % | 83 % | 100 % |
    | N-back  | 97 % | 86 % | 100 % |
  - Note: The high SNR was chosen in order to ensure very good intelligibility throughout. However, statistical analyses revealed significant differences (see next section).
- LST results
  - ANOVA performed on this data revealed significant main effects for both recognition and recall:
    - Span size ((a) F(1,17) = 128.3, p < .001; (b) F(1,17) = 222.2, p < .001)
    - HA setting ((a) F(3,51) = 4.3, p < .001; (b) F(3,51) = 8, p < .05)
    - RST ((a) F(1,17) = 18.4, p < .001; (b) F(1,17) = 19.4, p < .001)
    - Post-hoc analyses indicated final word recognition and recall better for:
      - Span size 4 than span size 6
      - dir setting than scnr setting
- LST correlation analysis
  - Table 2: Pearson’s correlation coefficients for LST, RST, and PTA4 (~ indicates p < .05, *** p < .001, ** p < .01).
    |        | Reading Span | PTA4 |
    |--------|--------------|------|
    | Final word recognition | 0.74*** | -0.47* |
    | Final word recall | 0.63** | n.s. |
- N-back results
  - Almost 20 % of our participants were unable to perform the 2-back task, whereas all of them could perform the 1-back task
  - Test-retest reliability was low for 2-back task; ceiling effects for 1-back task
  - No influence of HA settings observable
- Conclusions
  - HA noise suppression can affect auditory memory (recognition and recall of speech) at clearly positive SNRs
    1) RST shows strong relation to SIN performance, unexplained variance points towards existence of additional influencing factors (beyond the ones included here)
    2) LST able to reveal differences in working memory function with different HA settings: N-back test unable to do so
    3) No support for the idea that reading span modulates working memory with noise suppression processing (at least not for the HA settings used here)