Beyond speech intelligibility testing: A memory test for assessment of signal processing interventions in ecologically valid listening situations

Background
Noise reduction schemes for hearing aids have their own 'ecology' in the sense that they should be tailored to work best where they are needed (and are able to deliver some noise reduction). This calls for investigations that focus on daily life situations where benefit of noise reduction can be shown.

Working memory (WM) is important for online language processing in a dialogue. We use WM to store, (re)listen to what was said, and to attend to things saliently. According to the Ease of Language Understanding (ELU) model (Rönnberg et al., 2013), a poor representation of a signal in the neural pathways will lead to activations of the (off)error WM system. We argue that hearing impaired persons may rely much more on effortful WM resources to understand what has been said, compared to normal hearing persons who can rely more on effortlessly highly over-learned automatic speech recognition systems. Therefore tests which probe the degree of load on WM resources may be useful for evaluating the benefit of hearing aids in terms of effort rather than performance.

Benefit of hearing aid signal processing is often assessed by speech intelligibility in noise tests. Usually these tests are most sensitive at a signal-to-noise ratio (SNR) below 0 dB. However, a recent study by Ng et al. (2012) showed that the SNRs in ecologically listening situations (e.g. kitchen, babble, and car) were typically well above 0 dB SNR. That is, SNRs needed that can show eventual benefits of hearing aid processing in the +5-15 dB range. Cognitive Spare Capacity (CSC) refers to the residual capacity after successful speech understanding in noise tests that is needed to perform other tasks. Therefore new measures are needed that can show eventual benefits of hearing aid processing in the +5-15 dB range.

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Methods
Participants
- Twenty-two native Danish speakers (11 women and 14 men).
- Symmetrical moderate to moderately-severe, acquired sensorineural hearing loss (see left-right average audiograms in the figure).
- Recruited from the Eriksholm test subject pool.
- Average age 70 years (SD = 7.7, range: 54-79 years).
- Average pure-tone thresholds (PTA) at 0.5, 1, 2, and 4 kHz in both ears was 49.7 ± 10.5 dB HL.
- All were hearing aid users.

No history of cognitive problems or psychological disorders was reported.

Memory recall test
1. Her går alle med [subtitles]
2. Han legger slappe [carousel]
3. Eleven skriver en lang [report]
4. Hele byen kom til [kiosk]
5. Hans datter vil på [filmmakers]
6. I går havde filmen [premieres]
7. Fabrikkens port var [library]

The task was to repeat the last word after each sentence followed by recalling as many words as possible after sentence #7 (Method inspired by Pichora-Fuller, 2005 and Sesayopoulos et al., 2009).

Procedure
Stimuli:
- Danish HINT sentences.
- Four-talker babble (Danish).
- Presented via earphones.

Prepare Experiment:
- Assure audiometry = No Processing condition (NoP). Linear gain with individually fitted frequency response.
- Prepare Experiment:
- Auditory processing hearing aids (e.g., Temporal Fine Structure Preservation, NRS).
- Adjust SNR to 95 % correct on average 9.6 dB (Range 6 - 15 dB).

Discussion & conclusion

SNR for 95 % correct on average 9.6 dB (Range 6 - 15 dB).

Possible to show improved recall for an experimental NR algorithm at ‘high’ SNRs.

Main effect of Aggressive noise reduction
- Regulated Ng et al. (in press) new language = robust effects.
- Long-term memory improved by Aggressive noise reduction
- Indicates better neural encoding.

Limitations
- only tested with one speech material (HINT).
- do not know if 7 items recall is optimal for all subjects.

Implications
Increased evidence for a useful method to evaluate noise reduction systems at ecological SNRs.

REFERENCE
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Results

Hearing aid assessment of speech intelligibility performance at high ecological signal-to-noise ratios is difficult due to ceiling effects. Here we suggest using working memory as an outcome measure in high SNR conditions. See also the companion poster Ng et al. (2014).

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