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Publication date:
2017

Document version:
Final published version

Citation for pulished version (APA):
Fischer, R-L., Neher, T., & Wagener, K. C. (2017). *Hearing aid noise suppression and working memory function*. Poster session presented at International Symposium on Auditory and Audiological Research 2017, Nyborg, Denmark.

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Hearing aid noise suppression and working memory function

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Motivation

- Speech understanding in noise (SiN) is an important but demanding daily-life situation
- Manufacturers' point of view: What is best processing strategy in such situations?
- There is a relation between speech perception, esp. SiN, 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 talker in spatially diffuse cafeteria noise:
 - Listening span test (LST): final word recognition and recall; Speech material: Basle sentence test (Tschopp & Züst, 1994)
 - N-back test: %-correct; Speech material: German Digit Triplets Test (Buschermöhle et al., 2014)

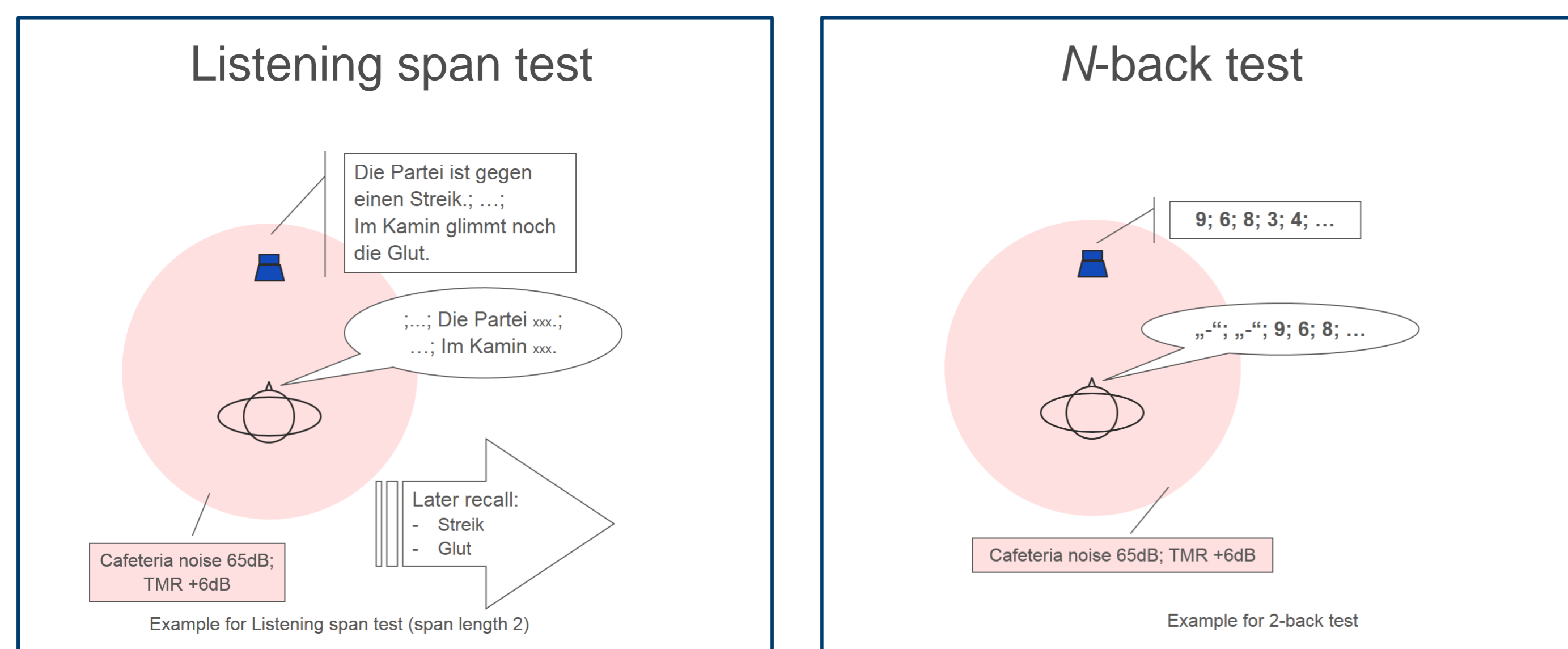


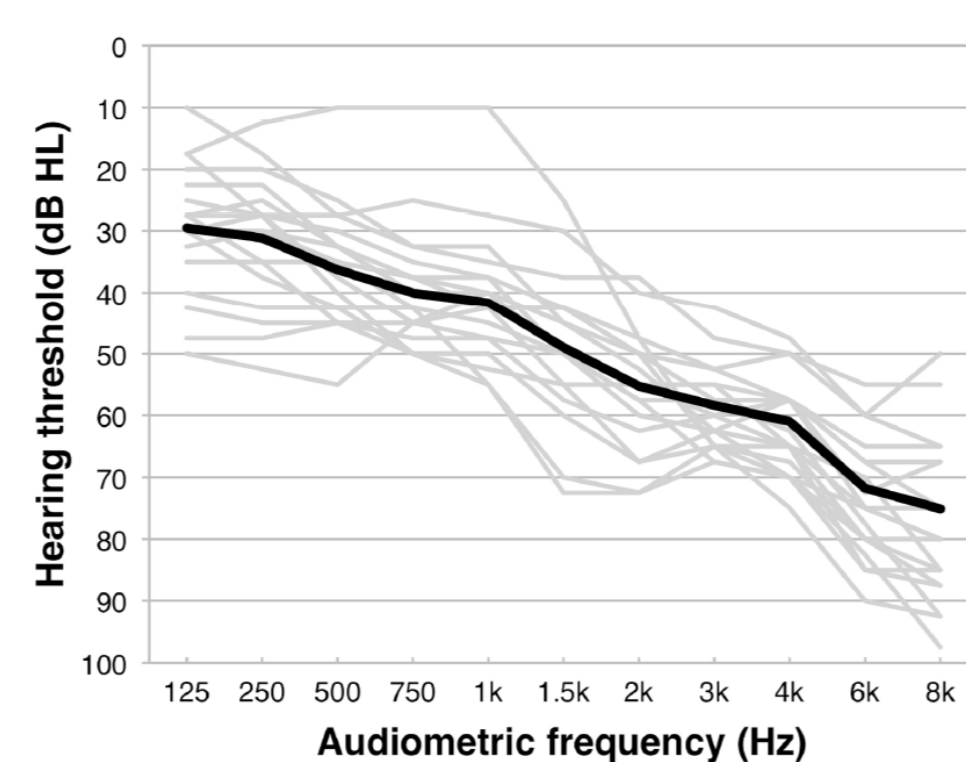
Fig 1: Illustration of the experimental setup for LST and N-back test.

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*)



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 Rönnberg, J., Rudner, M., Lunner, T. & Zekveld, A.A. (2010). When cognition kicks in: Working memory and speech understanding in noise. *Noise Health*, 12, 263 – 269.
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Results

Screening results

Tab 1: Speech intelligibility for both speech materials measured in SNR +6 dB.

Measure	M	Min	Max
LST	94 %	83 %	100 %
N-back	97 %	88 %	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

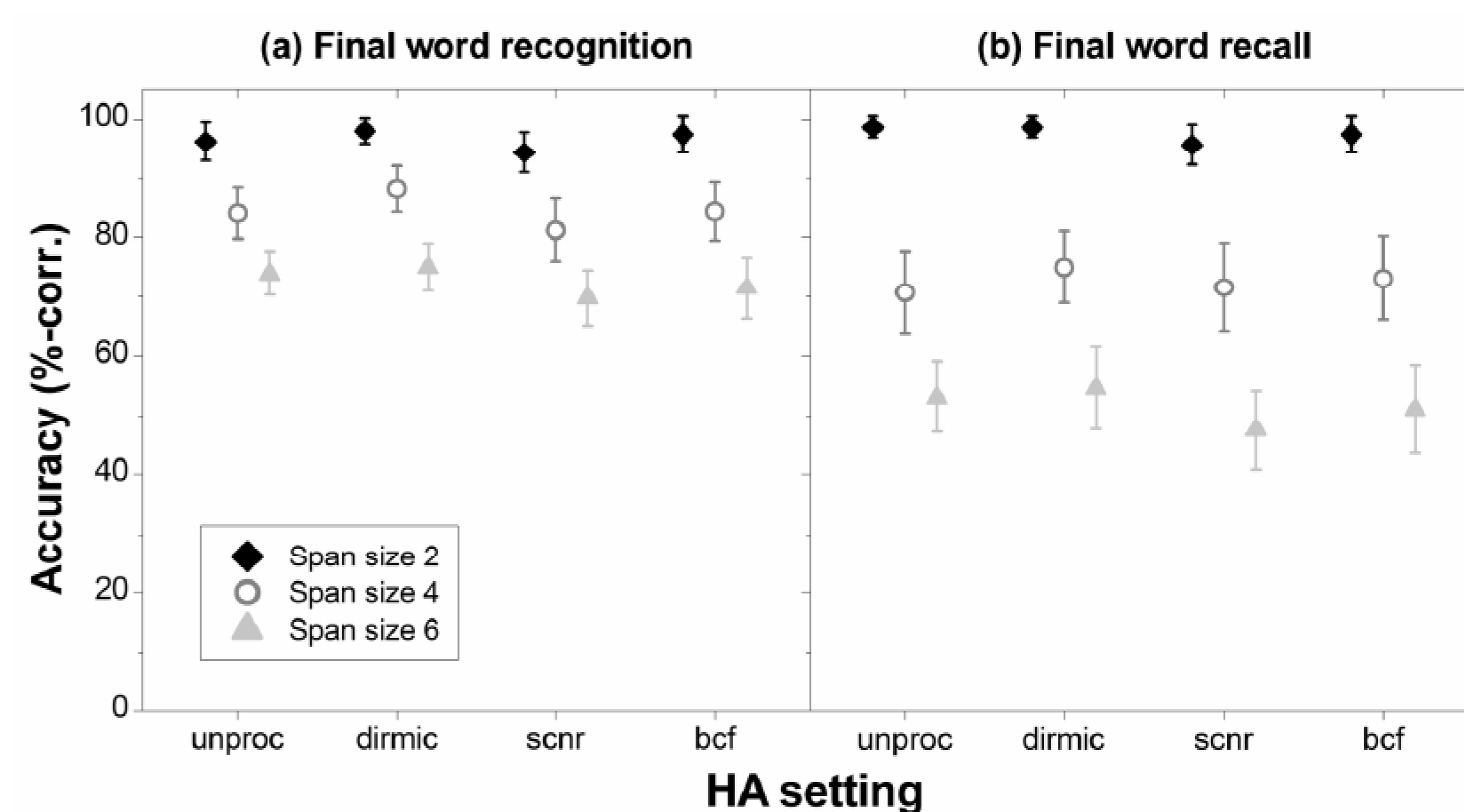


Fig 2: Means and 95% confidence intervals of (a) final word recognition scores and (b) final word recall scores from the LST measurements for three different span sizes and four HA settings.

- ❖ 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) $F_{(1,17)} = 222.3$, $p < .001$)
 - 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

Tab 2: Pearson's r correlation coefficients for LST, RST and PTA4 (* indicates $p < .05$; ** $p < .01$; *** $p < .001$).

	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)

