



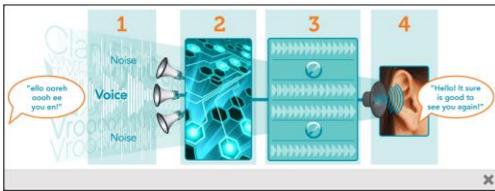
Cognition in Hearing Aid Users

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Hearing and cognition

- What are the factors affecting speech perception performance in people with hearing impairment?
- Hearing sensitivity
- Cognitive abilities (working memory)
- Age, and so on...

(Akeroyd, 2008)



Hearing and cognition

How does cognitive capacity influence speech perception?

a. Inter-individual differences in working memory capacity

Fred

Mary

b. Intra-individual differences in working memory span (WMS): Allocation of resources to processing vs storage varies with task



Lunner (2009), adapted from Pichora-Fuller (2007)



The empirical studies



Background

- Sarampalis et al. (2009) showed that Ephraim-Malah noise reduction algorithm improved cognitive performance and reduced listening effort for individuals with normal hearing.
- In the present studies
Effect of binary masking noise reduction on cognitive processing of speech for hearing aid users.



Study 1

Aims:

- Effects of noise (quiet, stationary noise and speech babble) and noise reduction on memory for speech.
- Role of individual differences in working memory capacity.

Participants:

- 26 experienced HA users
(mean age = 59 years; PTA: 43-61 dB HL)

Ng, Rudner, Lunner, Pedersen, & Rönnberg. (2013). *Int J Audiol*, 52(7), 433-441.



Test administration

A) Reading span test (Daneman & Carpenter, 1980; Rönnberg et al., 1989)

Instructions:

- Determine if the sentence makes sense or not (yes/no)
- After a number of sentences you will be asked to recall either **the first** or **the last** word from EACH sentence.

The train sang a song
The captain saw his boat
The bottle drank water
The priest drove a car



Test administration

A) Reading span test (Daneman & Carpenter, 1980; Rönnberg et al., 1989)

B) Free recall test

(Sentence-final Word Identification and Recall test; SWIR)

- Repeat the final word immediately after listening to each sentence.
- Report back the final words that have been previously repeated.



Test administration

A) Reading span test (Daneman & Carpenter, 1980; Rönnberg et al., 1989)

B) Free recall test

(Sentence-final Word Identification and Recall test; SWIR)

- Repeat the final word immediately after listening to each sentence.
- Report back the final words that have been previously repeated.

Example:

Pappa ska laga min fåtölj	
Tanten handlar en gång i veckan	primacy
Rektorn tog fram kastrullen	
Farmor åker till golfbanan	
Golvet täcktes av en vit matta	asymptote
Frukten packades i sex lådor	
Plänboken låg kvar på isen	
Farfar ska vaxa bilen	recency

All sentences are taken from the Swedish HINT test



Test conditions

- 5 test conditions (2 x2 +1)

- In quiet



- 4 test conditions in noise

	No Processing (NoP)	Noise reduction (NR)
Stationary noise (SSN)	(SSN/NoP)	(SSN/NR)
4-talker babble (4T)	(4T/NoP)	(4T/NR)

- 5 sentences lists per condition



Test conditions

- 5 test conditions (2 x2 +1)
 - In quiet
 - Speech at 65 dB A + linear amplification with individually prescribed frequency response
 - 4 test conditions in noise

	No Processing (NoP)	Noise reduction (NR)
Stationary noise (SSN)	SNR yielding 95% speech recognition in stationary noise + linear amplification with individually prescribed frequency response	
4-talker babble (4T)		

- Mean 95% SNR = 4.2 dB, SD = 1.9



Results

Free recall test

Comparing recall performance in 4-talker babble and in quiet:

- ANOVA: 3 x3 (x2)
- Within-subject factors
 - Background noise (NoP/NR/quiet)
 - Serial position (primacy/asymptote/recency)
- Between-subject factor
 - Reading span (High/Low)



Results

Free recall test

Comparing recall performance in 4-talker babble and in quiet:

- ANOVA: 3 x3 (x2)
- Within-subject factors
 - Background noise (quiet > NoP)
 - Serial position (recency > primacy > asymptote)
- Between-subject factor
 - Reading span (High > Low)



Results

Free recall test

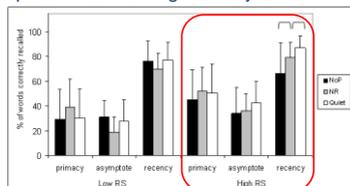
Comparing recall performance in 4-talker babble and in quiet:

- ANOVA: 3 x3 (x2)
- Within-subject factors
 - Background noise (quiet > NoP)
 - Serial position (recency > primacy > asymptote)
- Between-subject factor
 - Reading span (High > Low)
- Significant interactions:
 - Background noise x RS
 - Background noise x position
 - Background noise x position x RS



Results

- Binary masking noise reduction reduces the adverse effect of noise (in 4-talker babble only) on memory performance for words but only for individuals with high RS.
- Encoding of heard speech into working memory is facilitated by noise reduction.



Study 2

Aims:

- Effect of noise reduction on memory for speech heard in a competing speech background;
- Effect of masker language on memory for target native speech; and
- Role of individual differences in working memory capacity.

Participants:

- 26 experienced HA users (mean age = 62 years; PTA = 43-61 dB HL)

Ng, Rudner, Lunner & Rönnberg. (2015). *Ear Hear*, 36(1), 82-91.



Test administration

A) Reading span test

B) Free recall test (modified SWIR)

Report back, as many as possible, the final words of all sentences

Example:

Pappa ska laga min fåtöj	primacy
Tanten handlar en gång i veckan	
Rektorn tog fram kastrullen	asymptote
Farmor åker till golfbanan	
Golvet täcktes av en vit matta	
Frukten packades i sex lådor	recency
Planboken låg kvar på isen	



Test conditions

8 test conditions (2 x2 x2)

- 2 types of **noise reduction**

- 2 types of **competing speech**

	No Processing (NoP)	Noise reduction (NR)
4-talker babble in Swedish (Swe)	(Swe/NoP)	(Swe/NR)
4-talker babble in Chinese (Chi)	(Chi/NoP)	(Chi/NR)

- 2 types of **final word recognition**

Verbally repeat the final word / Not repeat any word in a list

5 sentence lists per condition



Test conditions

8 test conditions (2 x2 x2)

- 2 types of **noise reduction**

- 2 types of **competing speech**

	No Processing (NoP)	Noise reduction (NR)
4-talker babble in Swedish (Swe)	SNR yielding 95% speech recognition in Swedish 4-talker babble + linear amplification	
4-talker babble in Chinese (Chi)		

• Mean 95% SNR = 7.5 dB, SD = 2.0



Results

Free recall test

• ANOVA: 2 x2 x 2 x3 (x2)

• Within-subject factors

Noise reduction (NoP/NR)

Competing speech (Swe/Chi)

Final word recognition (repeat/not repeat)

Serial position (primacy/asymptote/recency)

• Between-subject factor

Reading span (High/Low)



Results

Free recall test

• ANOVA: 2 x2 x 2 x3 (x2)

• Within-subject factors

Noise reduction (NR > NoP)

Competing speech (Chi > Swe)

Final word recognition (repeat/not repeat)

Serial position (recency > primacy > asymptote)

• Between-subject factor

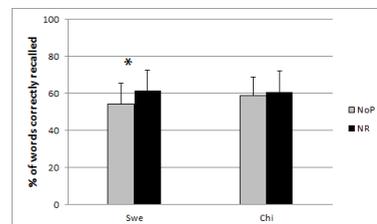
Reading span (High > Low)



Results

• Significant interactions

1) Noise reduction x competing speech

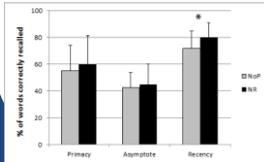




Results

- Significant interactions

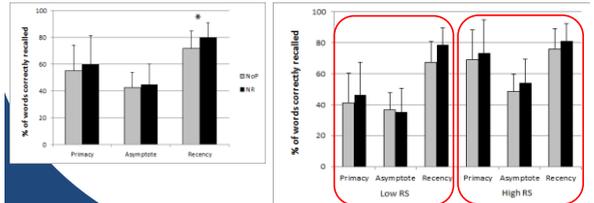
2) Noise reduction x serial position



Results

- Significant interactions

2) Noise reduction x serial position 3) Noise reduction x serial position



Conclusions

- Binary masking noise reduction improved memory for words heard in a competing speech background. In particular, such improvement occurred in the recency position. (Study 1 & 2)
- When noise reduction was applied, the effect of familiarity of language was no longer significant. (Study 2)
- In both studies, the effect of noise reduction on free recall performance were modulated by individual differences in working memory capacity.



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Thank you for your attention



Linköping University



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