SWEDISH INSTITUTE FOR DISABILITY RESEARCH

LINNAEUS CENTRE HEAD GRADUATE SCHOOL

Linköping University

ÖREBRO UNIVERSITY

Cognitive hearing science: Ease of Language Understanding (ELU) in old age

Jerker Rönnberg and Mary Rudner

Linnaeus Centre HEAD, Linköping University
The Swedish Institute for Disability Research, Linköping University
Department of Behavioral Sciences and Learning, Linköping University

SWEDISH INSTITUTE FOR DISABILITY RESEARCH
LINNAEUS CENTRE HEAD GRADUATE SCHOOL

Cognitive hearing science

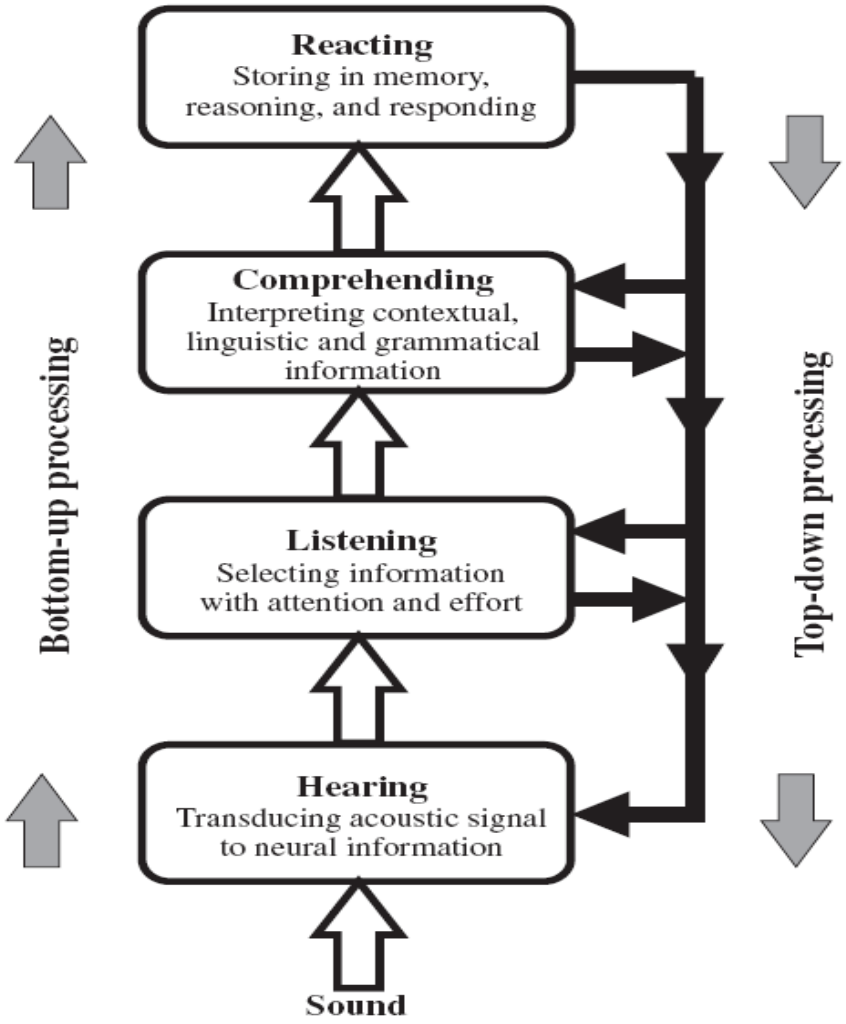
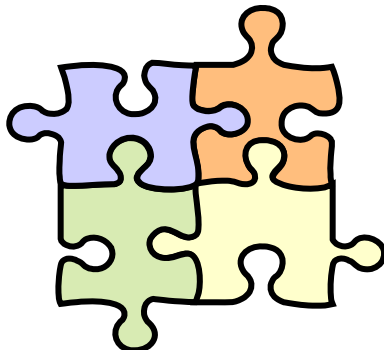


Fig. 1. A generalized model for bottom-up and top-down processing of auditory input (adapted from Edwards, 2007).

General behavioral findings across sensory modes in speech understanding tasks

Across visual/auditory/audiovisual/ speech understanding tasks, skilled performance is typically predicted by

- fast lexical/semantic access (for a review, see Rönnberg, 2003a).
- unlocking of the lexicon via phonological representations at the syllable level (rhyme tests) (Rönnberg, 2003b).

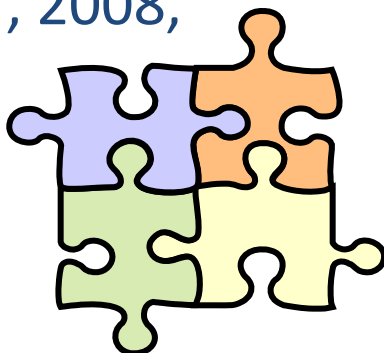


General behavioral findings across sensory modes..

Further

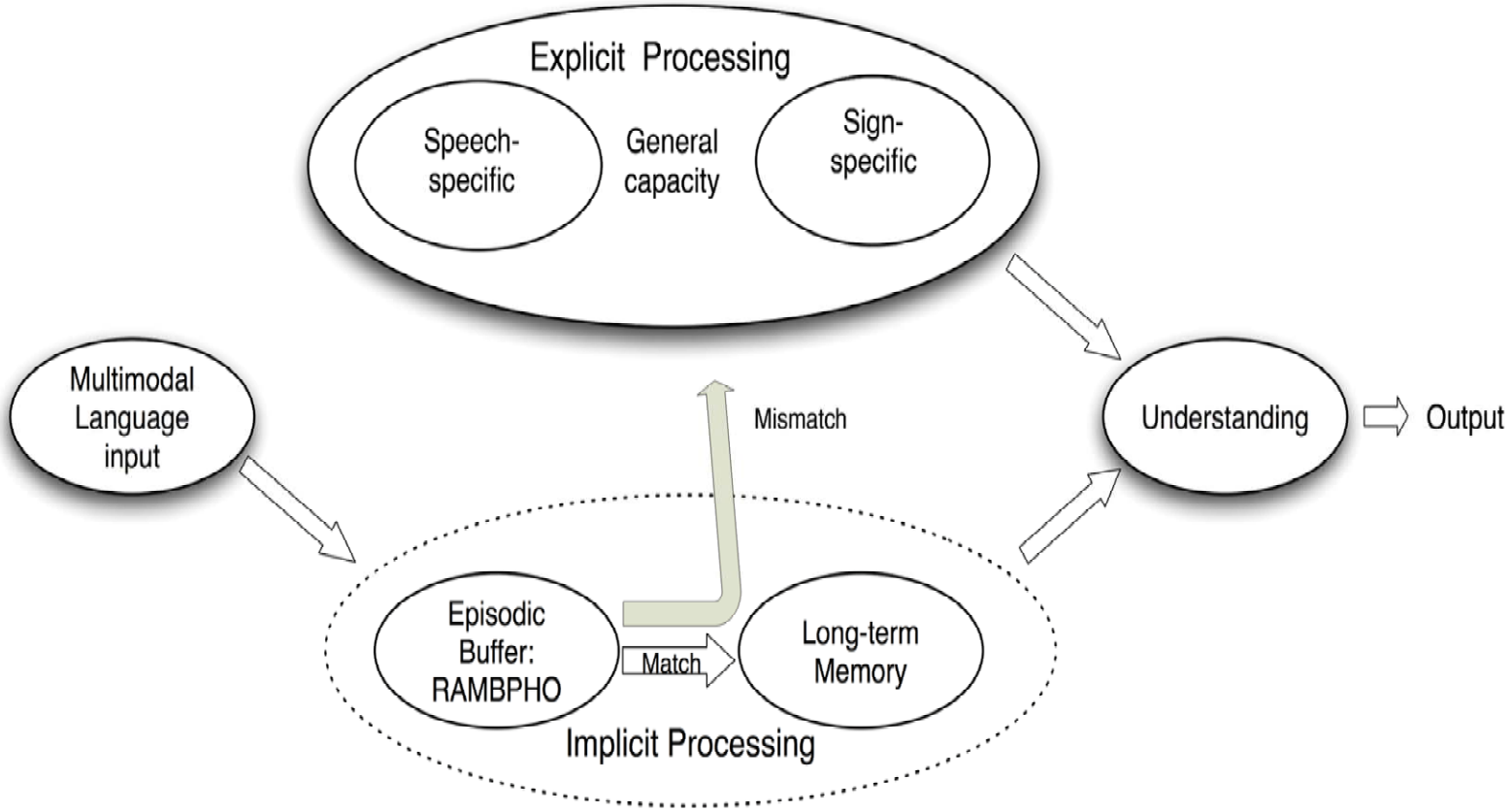
Complex Working Memory capacity (WM, measured by e.g., dual tasks such as listening/ reading span, visual letter monitoring), representing *simultaneous storage and processing capacities*

- predicts speech understanding (visual, audiovisual, tactile) in situations with low contextual support
- supports aggressive signal processing (e.g. with fast compression in modulated noise), especially in mismatch conditions (Gatehouse et al. 2003; 2006; Lunner, 2003; Rudner, Rönnberg et al., 2007, 2008, 2009)

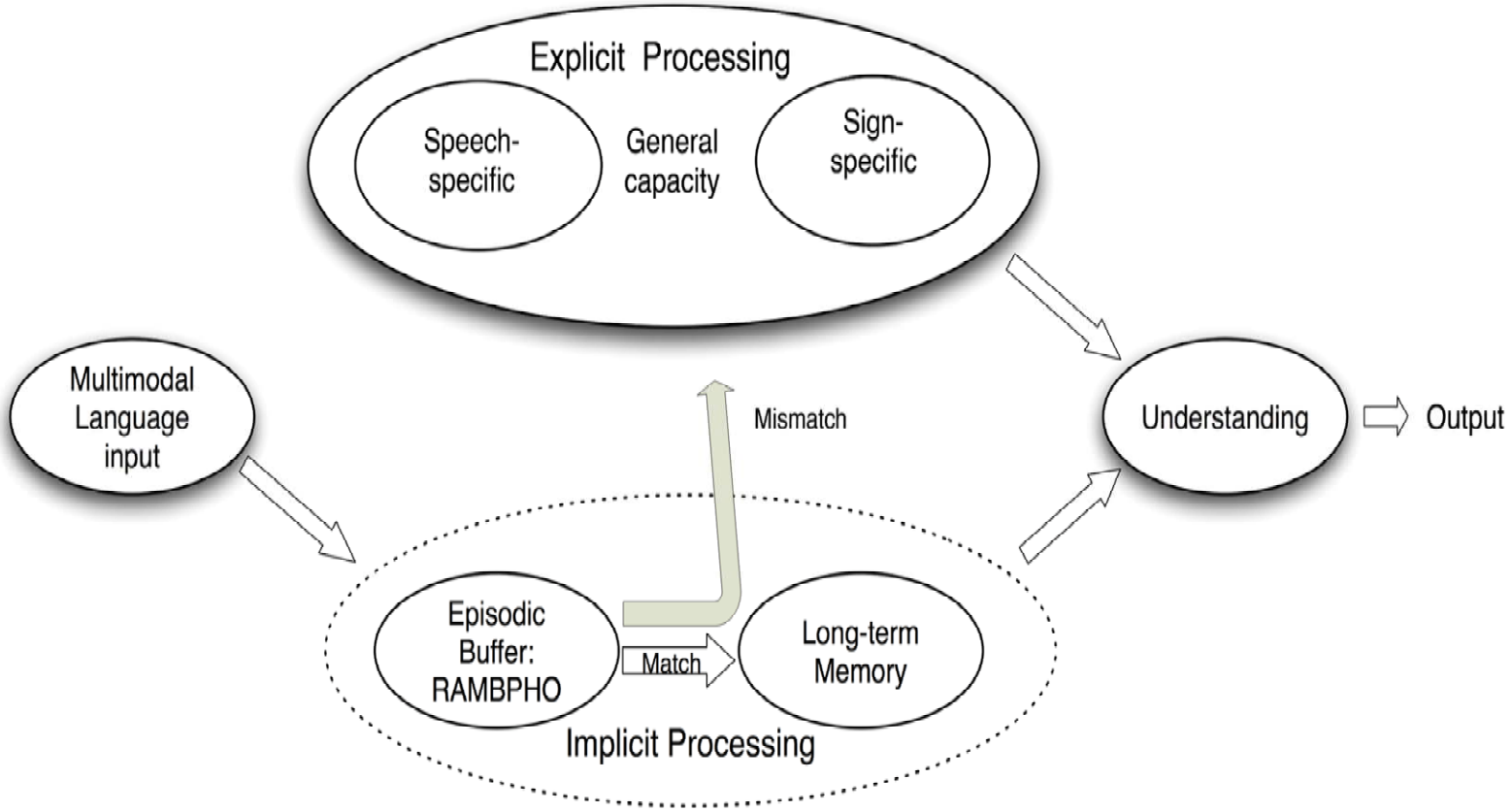


Working memory system for ELU

Rönnberg, Rudner, Foo & Lunner; *Int J Audiol*, 2008

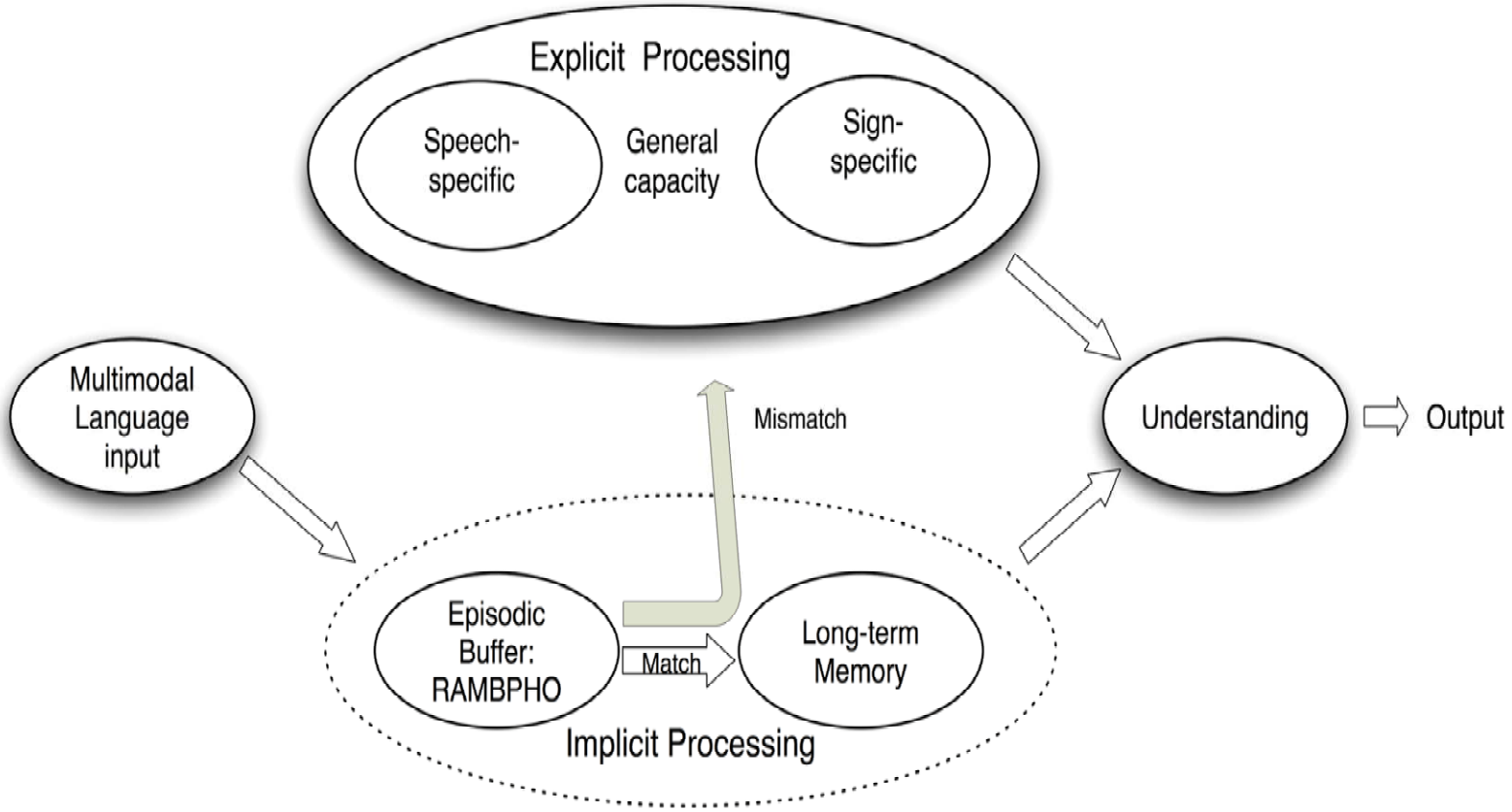


Time window: RAMBPHO to LTM, 150-400 ms; Stenfelt & Rönnberg (2009). *Scand J of Psychology, 50*, 385-393.



Time window: Explicit processing - repair, in seconds. Stenfelt & Rönnberg (2009).

Scand J of Psychology, 50, 385-393.



Assumptions/predictions tested

1. **Phonological, syllabic mismatch**
2. RAMBPHO
3. Disuse hypothesis
4. Cognitive aging does not affect mismatch and disuse, whereas all other components in the model are more affected
5. WM compensation and WM training

Test of mismatch assumption

Phonological mismatch for speech

We have shown in several studies that performance on complex **WM tasks (e.g. reading span) predicts speech understanding** in noise when **mismatch** has been manipulated:

When pre-experimental compression release settings in the hearing aid mismatch with the settings in the experimental aid (Foo et al. 2007, *JAAA*) see next slide

Test of mismatch assumption

Phonological mismatch for speech

Table 3. Correlations between Cognitive Measures and Speech Perception, Pearson's r

Speech recognition test	Hagerman				HINT			
Compression release setting	Fast		Slow		Fast		Slow	
Noise	Unmod	Mod	Unmod	Mod	Unmod	Mod	Unmod	Mod
Reading span	-0.67**	-0.65**	-0.41*	-0.61**	-0.53**	-0.47**	-0.60**	-0.65**
Letter monitoring	-0.19	-0.27	-0.41*	-0.36*	-0.51	-0.38	-0.31	-0.29

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

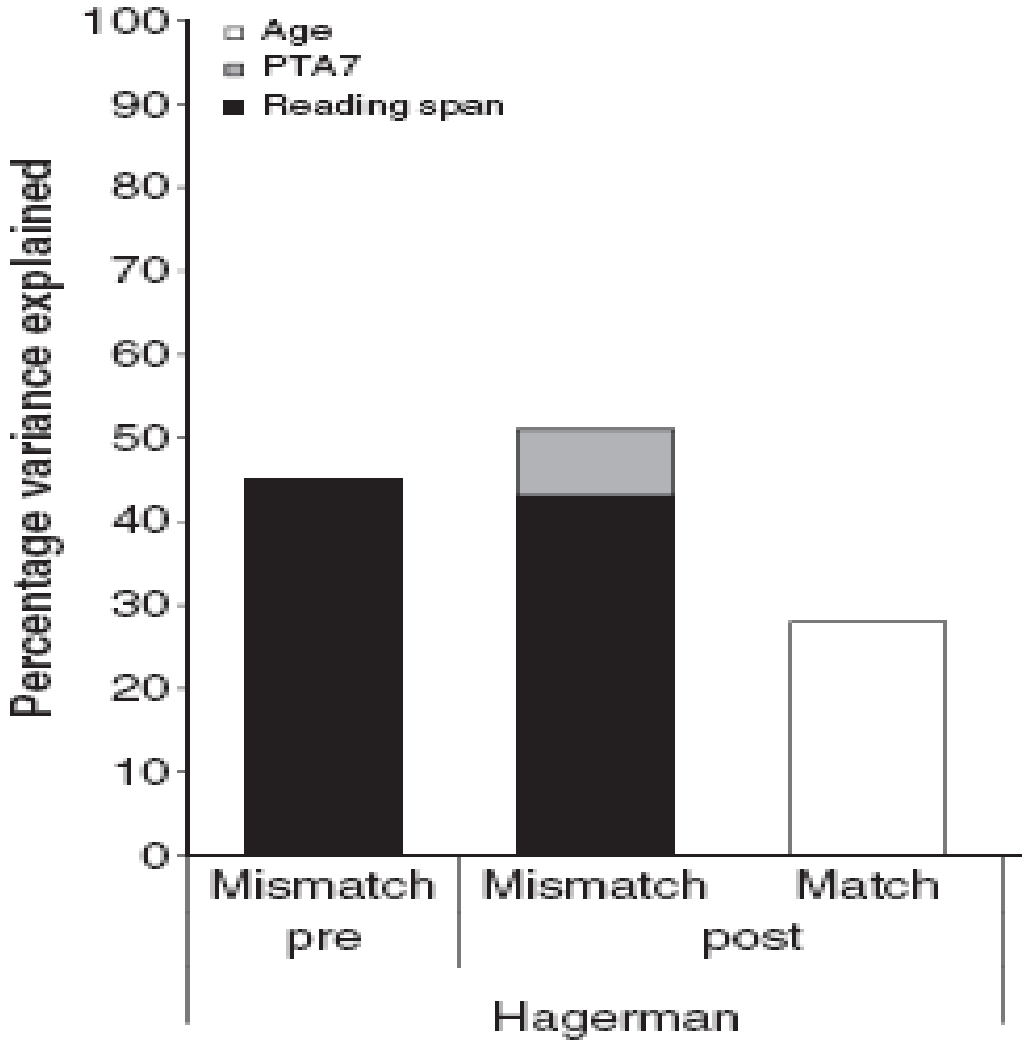
J Am Acad Audiol 18:618–631 (2007)

Recognition of Speech in Noise with New Hearing Instrument Compression Release Settings Requires Explicit Cognitive Storage and Processing Capacity

Catharina Foo*
Mary Rudner*†
Jerker Rönnberg*†
Thomas Lunner†‡§

Fig. 1. Percentage variance explained by reading span, PTA7 and age for match and mismatch conditions.

Rudner, M., Foo, C., Rönnberg, J. & Lunner, T. (2009). Cognition and aided speech recognition in noise: specific role for cognitive factors following nine-week experience with adjusted compression settings in hearing aids. *Scandinavian Journal of Psycholog* DOI: 10.1111/j.1467-9450.2008.00652.x



Assumptions/predictions tested

1. Phonological, syllabic mismatch
2. **RAMBPHO**
3. Disuse hypothesis
4. Cognitive aging does not affect mismatch and disuse, whereas all other components in the model are more affected
5. WM compensation and WM training

Binding: RAMBPHO

Rudner, Fransson, Nyberg, Ingvar & Rönnberg:
Neuropsychologia (2007, *45*, 2258-2276)

13 native bilinguals

Spoken and signed events were **mixed,**

2-back working memory task: Is binding via semantic representations necessarily explicit, or can it be implicit?

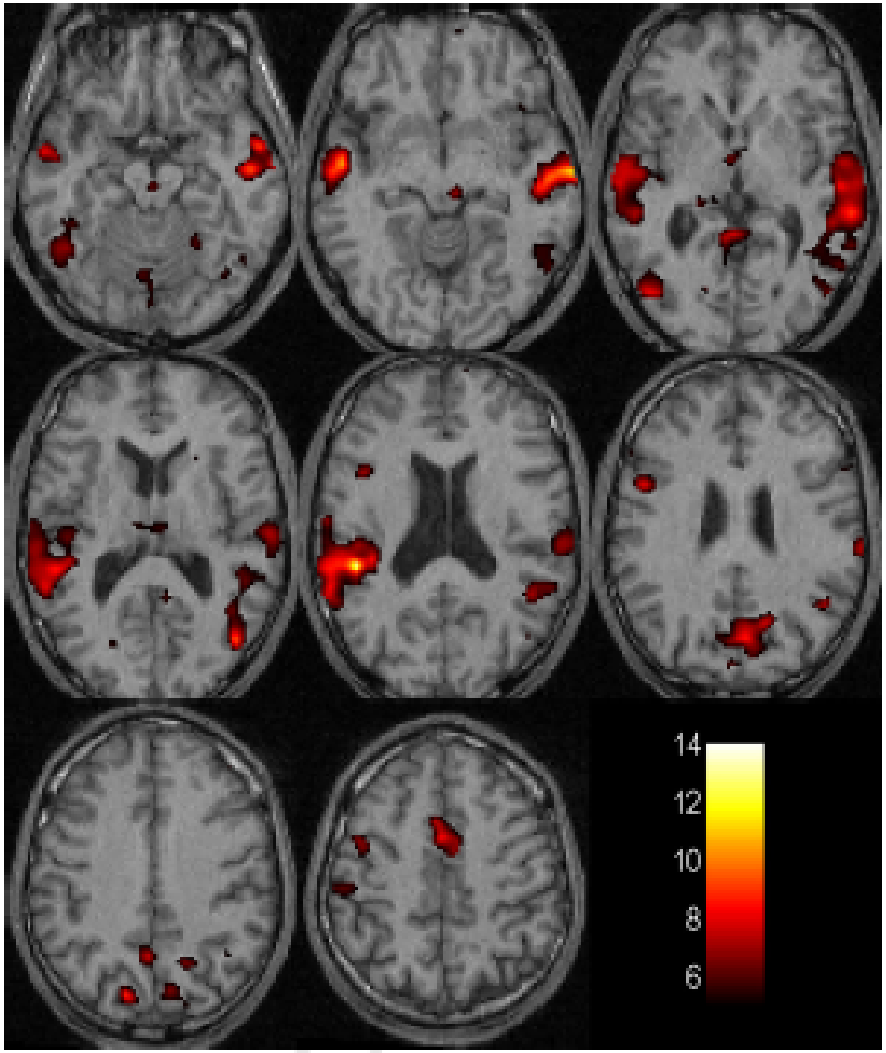


Fig. 3. Transient task component for 2Binding > Sign + Speech. The scale indicates *t*-scores above the common FDR threshold $p < 0.001$. Z-coordinates of slices in ascending order: −20, −10, 0, +10, +20, +30, +40, +50.

Assumptions/predictions tested

1. Phonological, syllabic mismatch
2. RAMBPHO
3. **Disuse hypothesis**
4. Cognitive aging does not affect mismatch and disuse, whereas all other components in the model are more affected
5. WM compensation and WM training

Hearing loss and cognition: Disuse and age-related hypotheses

- Sensory decline goes hand in hand with cognitive decline (i.e. common cause) (Baltes & Lindenberger)

- Impoverished auditory input (i.e., information degradation) predicts worse cognitive performance (this is not equated for in speech in noise testing; Gallacher, 2005)

> Hearing loss predicts verbal, episodic long-term memory decline – cognitive disuse hypothesis (Rönnberg et al)

Disuse hypothesis builds on ELU

When mismatch occurs –due to hearing impairment -, explicit STM/WM resources are taken into account but successful encoding and storage in, and retrieval from LTM, is assumed to decrease, hence resulting in a relative disuse of LTM, but not of STM.

The conservative test of the hypothesis is when the participants have acclimatized to a hearing aid.

Disuse

- Main result: **Episodic LTM**, not WM is predicted by degree of hearing impairment- supports ELU. Holds for both ears analysed separately.
- is not related to visual acuity, or any **combination** with the auditory impairment – is at variance with the *common cause* account
- holds for **auditorily** , motorically and textually based verbal recall tasks, not for face recognition – is at variance with an *information degradation* account

Assumptions/predictions tested

1. Phonological, syllabic mismatch
2. RAMBPHO
3. Disuse hypothesis
4. **Cognitive aging does not affect mismatch and disuse, whereas all other components in the model are more affected**
5. WM compensation and WM training

Assumptions/predictions tested

1. Phonological, syllabic mismatch
2. RAMBPHO
3. Disuse hypothesis
4. Cognitive aging does not eliminate mismatch and disuse effects
5. **WM compensation and WM training**

Hagerman lists: SNRs for WM capacity by age interactions

	50%			80%		
	High *Cap*	Low *Cap*	Pairwise-comp's	High *cap*	Low *cap*	Pairwise comp's
VERY OLD (76)	-4.90	***-1.85***	*Bold is sign diff;*	-0.65	***3.38***	*Bold is sign diff*;
OLD (64)	-5.77	-5.99	*No other contrasts*	-1.91	-1.40	*No other contrasts*

A link ?

Is there a possible link between intensive visuospatial WM training and the development of relevant storage and processing capacities in old listeners such that speech understanding is improved?

Conclusions

The *mechanisms* of the ELU model, i.e. *mismatch* and *disuse seem to be relatively unaffected by age, whereas the* explicit and implicit components per se are affected by age

Mismatch, RAMBPHO and language specificity predictions/assumptions, in their turn, are supported by published data from our labs.

Future challenges

- Training of WM for old persons such that it taps into abilities measured by reading/ listening span. Does this lead to improved speech understanding in adverse conditions?
- Describing the cognitive component processes of the explicit part of the ELU, how they relate, and how they interact with different kinds of signal processing.
- Describing the neural correlates of the consequences of mismatch, phonological and semantic.

Thank you for your attention!