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Using reverse correlation to study individual perception: Including an auditory model in the experimental design loop

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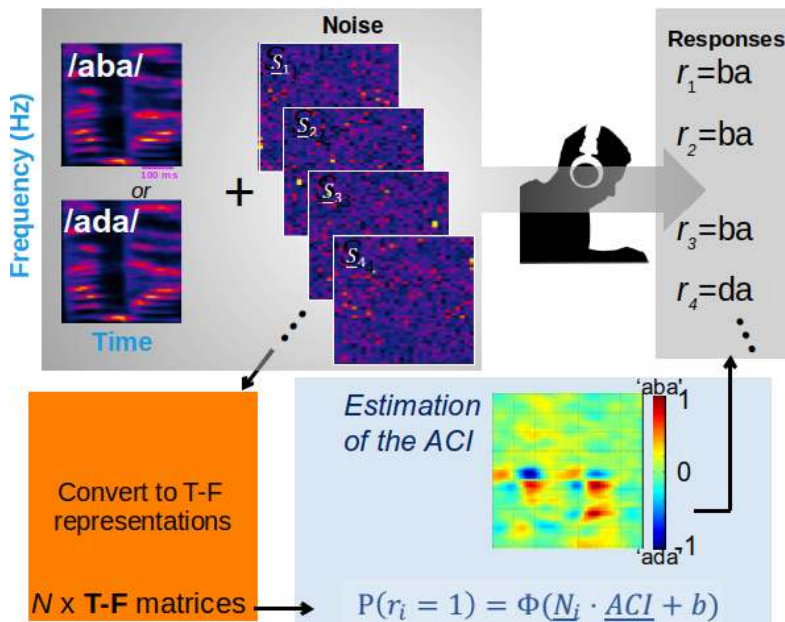
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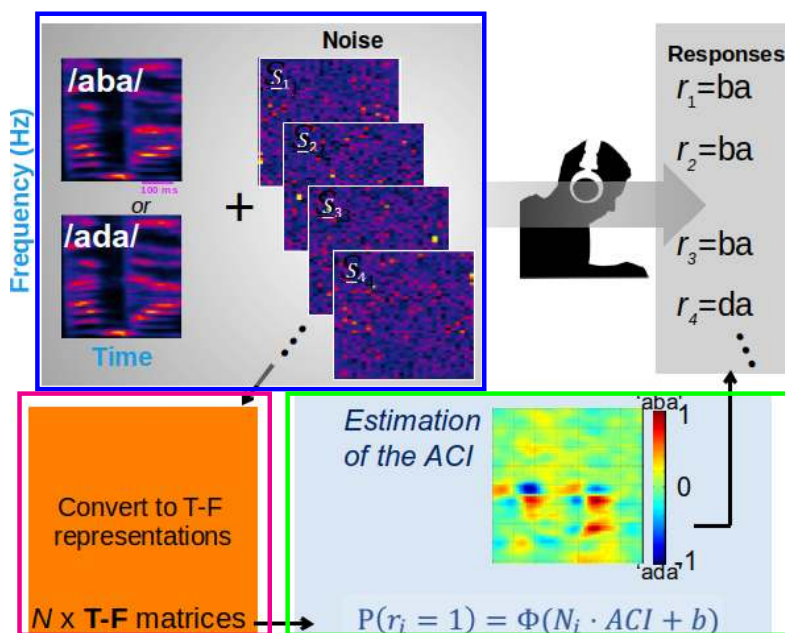
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Phoneme discrimination using the ACI method



- N trials needed
- N is too high (> 4000)

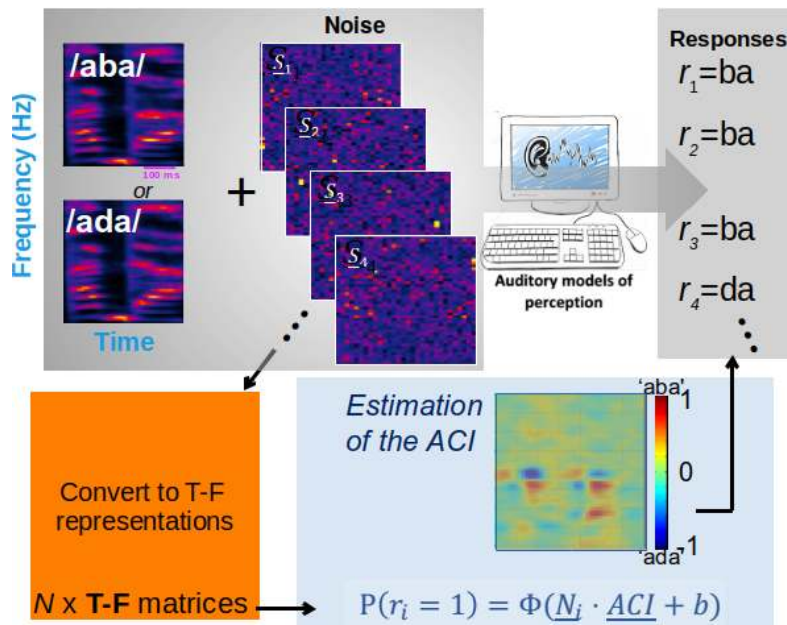
Phoneme discrimination using the ACI method: Optimisation?



- Other speech samples
- Other noises
- Another T-F transformation
- Another statistical fitting scheme

- Reviewed and unified for all our previous studies
[Osses et al. (2022, ICA)]

Phoneme discrimination using the ACI method: Optimisation?



- Other speech samples
- Other noises
- Another T-F transformation
- Another statistical fitting scheme
- Previous studies: White noise
- We wanted other noises

Outline

- 1 Introduction
- 2 Algorithm for noise generation
- 3 Results
- 4 Discussion & conclusions
- 5 (Supplementary)

Rationale: speeding up the ACI assessment

Fig. 1

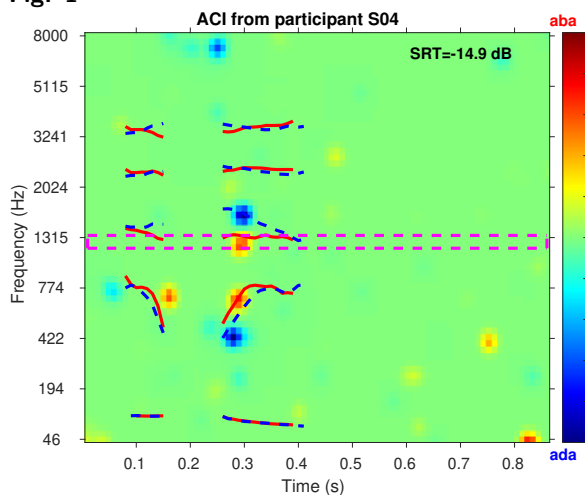
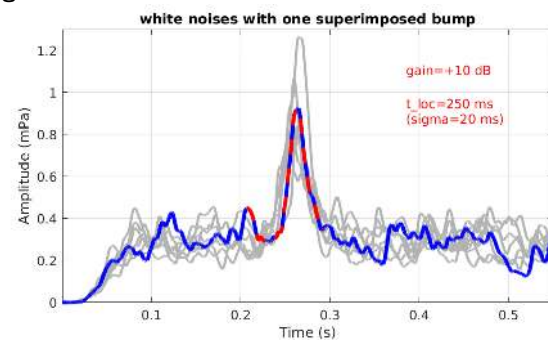


Fig. 2



- In the end: 30 bumps for each noise
- Random locations along time and frequency

Rationale: Hypotheses

Using bump noises:

- H1: We will be able to obtain clean ACIs: [pilots with one participant](#)
- H2: Different sets of noises will lead to the same ACIs: [to be checked by the model](#)

Experimental design:

- Baseline: White noises
- Data collection from 12 participants (4000 trials \approx 4h sessions x noise type x participant)



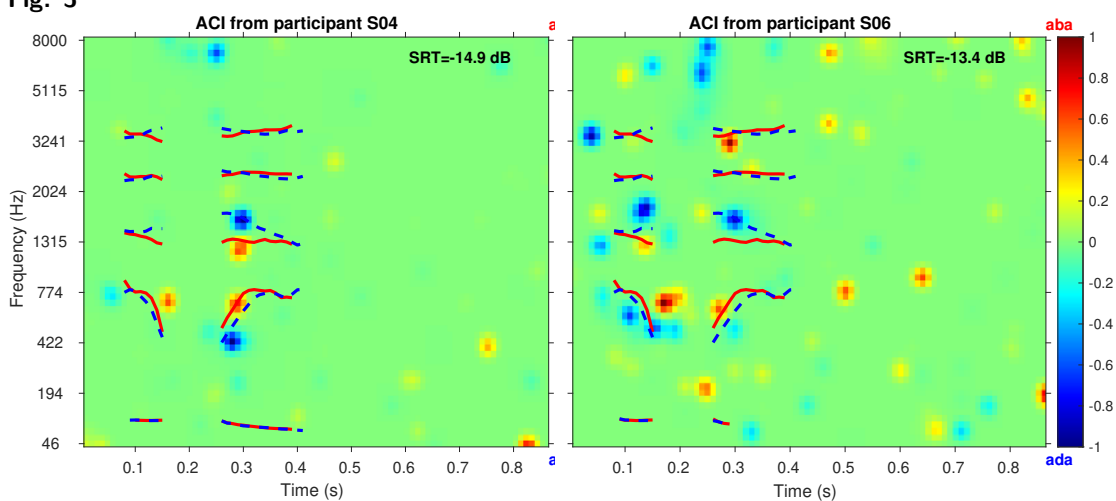
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H1 – Experiments

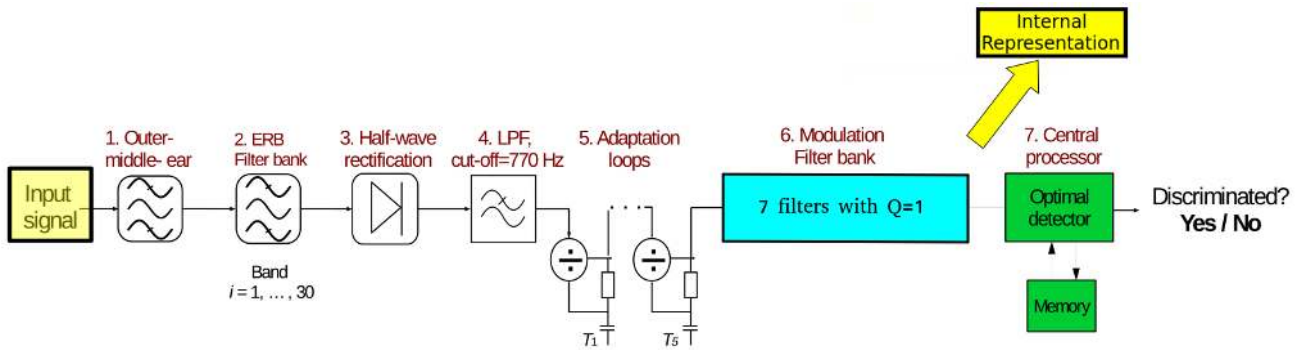
- H1: Yes, we were able to obtain clean ACIs, but...

Fig. 3



Maybe: Individual differences related to the specific set of bump noises (H2)?

H2 – ACIs from simulations: The auditory model

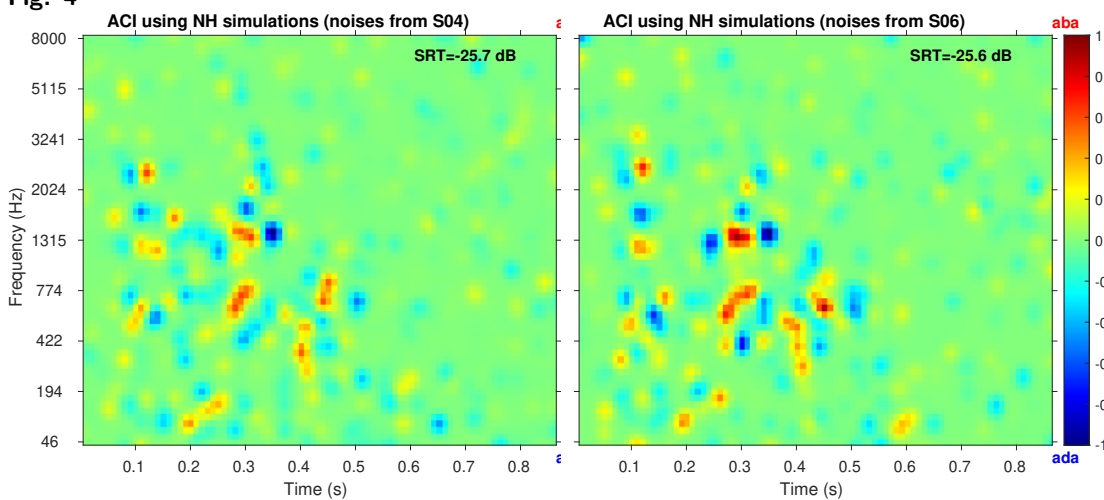


- Perceptual model based on the modulation-filter-bank model by *Dau et al. (1997)*
- Updated parameters, updated modulation filter bank
- Two template-approach as detailed by *Osses & Kohlrausch (2021)*, here:
 - Template 1: /aba/; Template 2: /ada/. Obtained from 1000 noisy samples
 - Supra-threshold level: SNR= -6 dB

H2 – ACIs from simulations

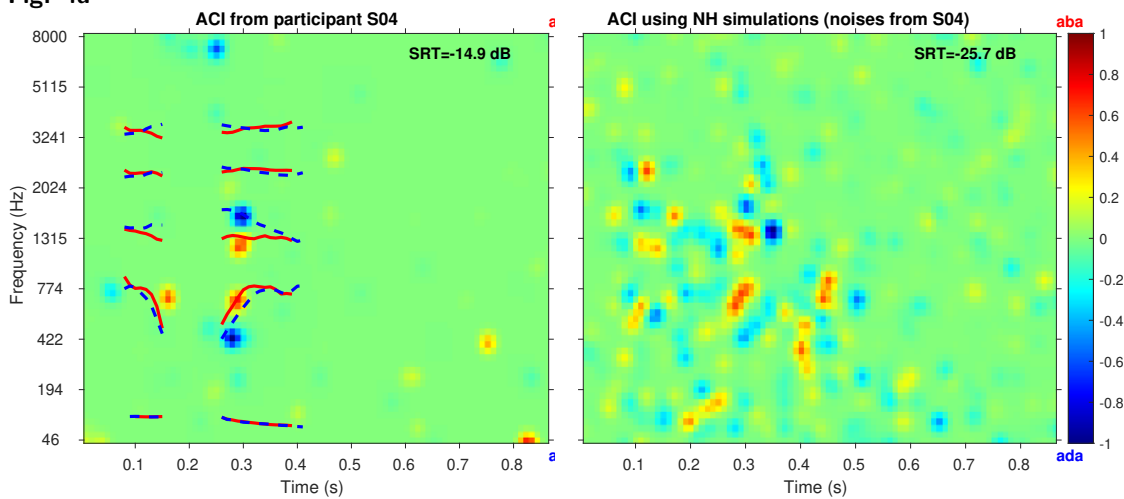
- H2: Yes, the ACIs were independent from the set of bump noises

Fig. 4



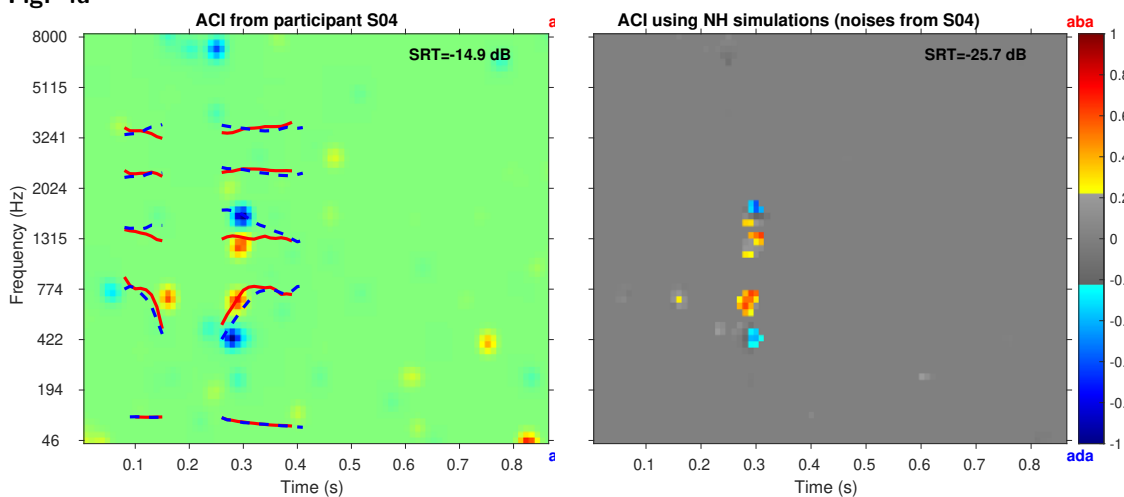
Comparing ACIs from experiments/simulations (1 of 2)

Fig. 4a



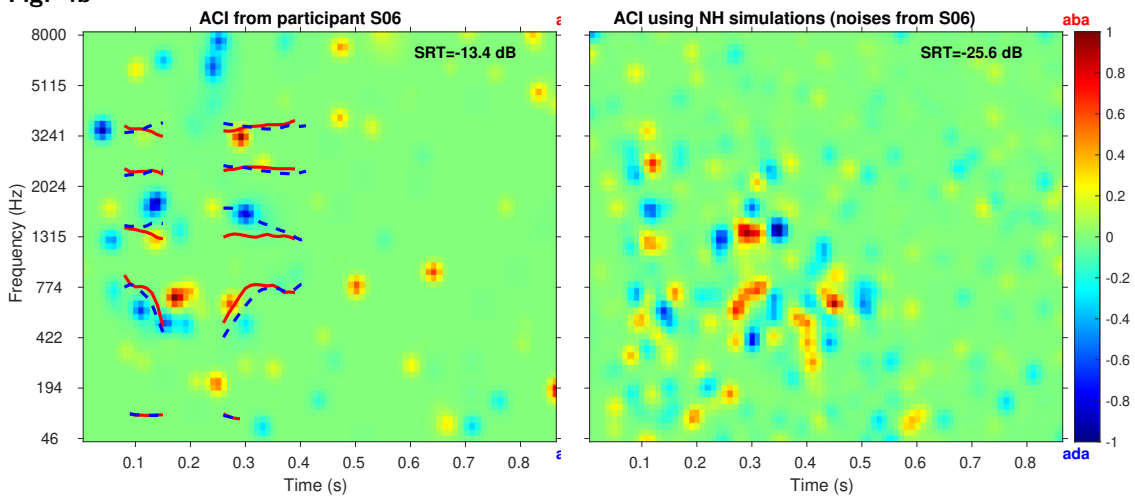
Comparing ACIs from experiments/simulations (1 of 2)

Fig. 4a



Comparing ACIs from experiments/simulations (2 of 2)

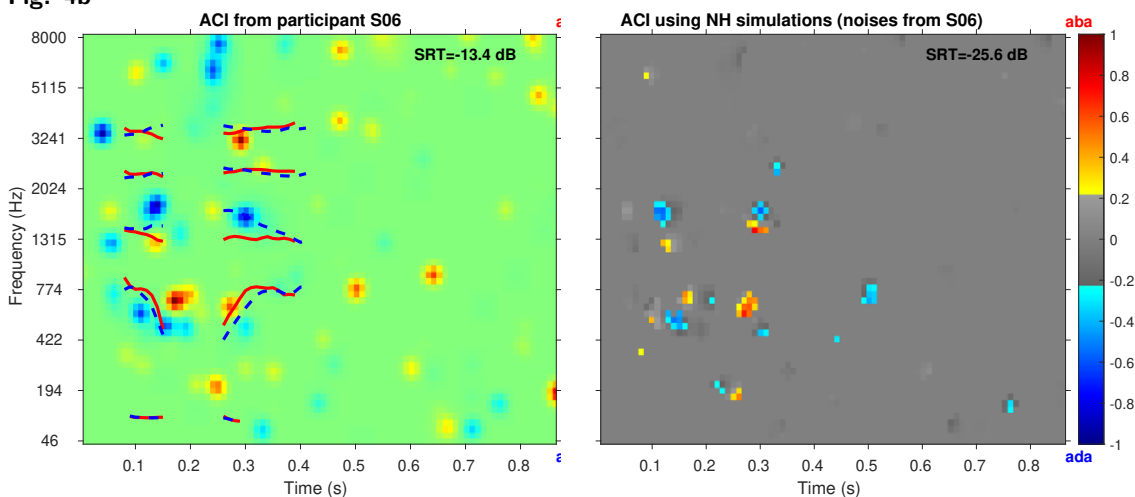
Fig. 4b



This means that all the cues in the experimental ACIs are a subgroup of the cues from ACIsim

Comparing ACIs from experiments/simulations (2 of 2)

Fig. 4b



This means that all the cues in the experimental ACIs are a subgroup of the cues from ACIsim

Outline

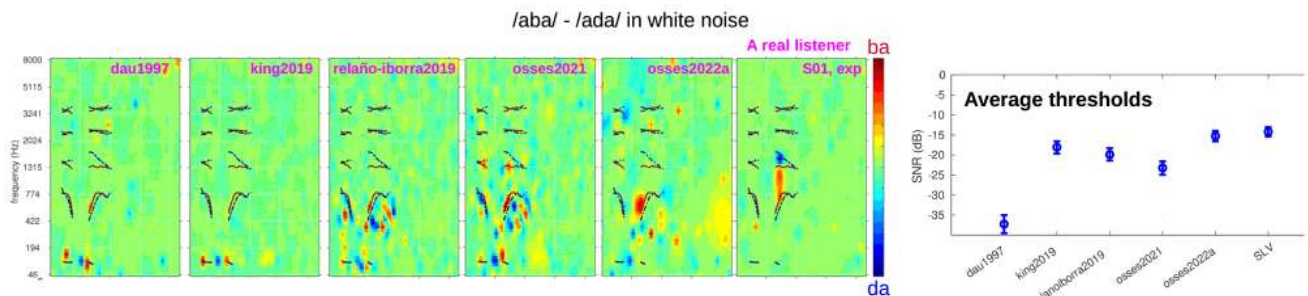
- 1 Introduction
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Using the auditory model: possibilities and limitations

- Template matching: based on the idea of “optimal detection” (*Green & Swets, 1966*)
- A very simple top-down decision back-end
- The auditory model as shown here: simulates a normal-hearing listener

Using the auditory model: possibilities and limitations

- Template matching: based on the idea of “optimal detection” (*Green & Swets, 1966*)
- A very simple top-down decision back-end
- The auditory model as shown here: simulates a normal-hearing listener
- **Are these results related to the specific auditory model (front end)?**



AMT models using the two-template matching (Figure taken from *Osses et al. 2022 (AABBA)*)

Using the auditory model: possibilities and limitations

- Template matching: based on the idea of “optimal detection” (*Green & Swets, 1966*)
- A very simple top-down decision back-end
- The auditory model as shown here: simulates a normal-hearing listener
- **Are these results related to the specific decision (back end)?**

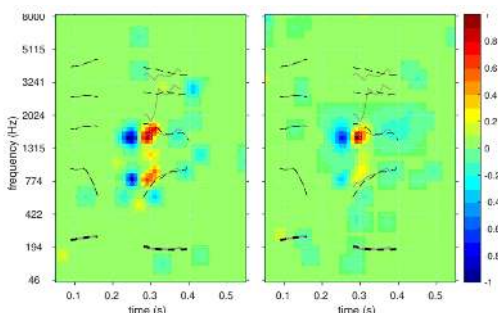


Figure 3: (Colour online) ACIs for the artificial listeners, i.e., the auditory model using the decision device 1 with $K=0.39$ MU (left panel) and using the decision device 2 (right panel). The colour codes and axis legends are as in Fig. 1.

osses2021.m model using cross correlations (left) or two-dim Pearson correlations (right)
 [Figure taken *Osses & Varnet (2021, DAGA)*]

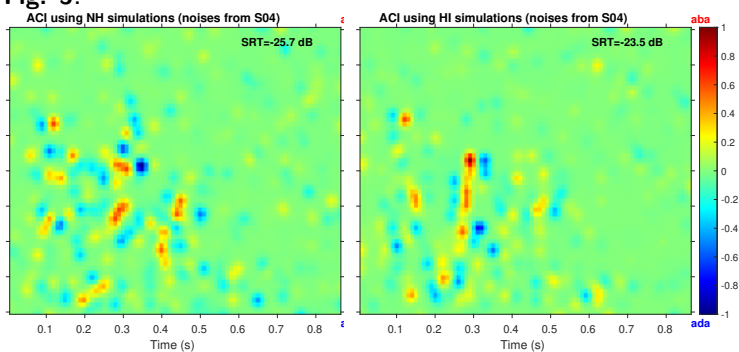
Using the auditory model: possibilities and limitations

- Individualisation of the model?
- This model was developed to simulate psychoacoustic tasks
- Hearing impairment can be introduced, but it is not straightforward:
 - 1 We cannot introduce an audiogram as in other models (e.g., from AMT [Majdak et al. (2022)]: zilany2014, bruce2018)
 - 2 Impairment can be introduced by this requires a careful understanding of the model stages and their expected effect (Holube & Kollmeier (1996))

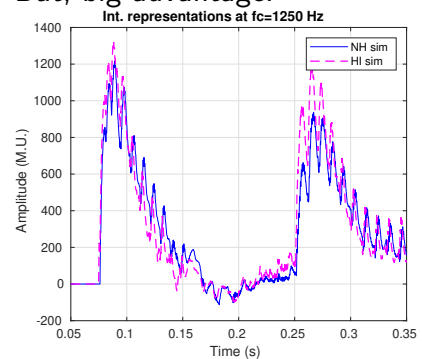
Using the auditory model: possibilities and limitations

- Individualisation of the model?
- **HI model:** Model with wider auditory filters and modified time constants in the adaptation loops (inspired by Holube1996)

Fig. 5:



But, big advantage:



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