

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

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

Alejandro Osses & Léo Varnet

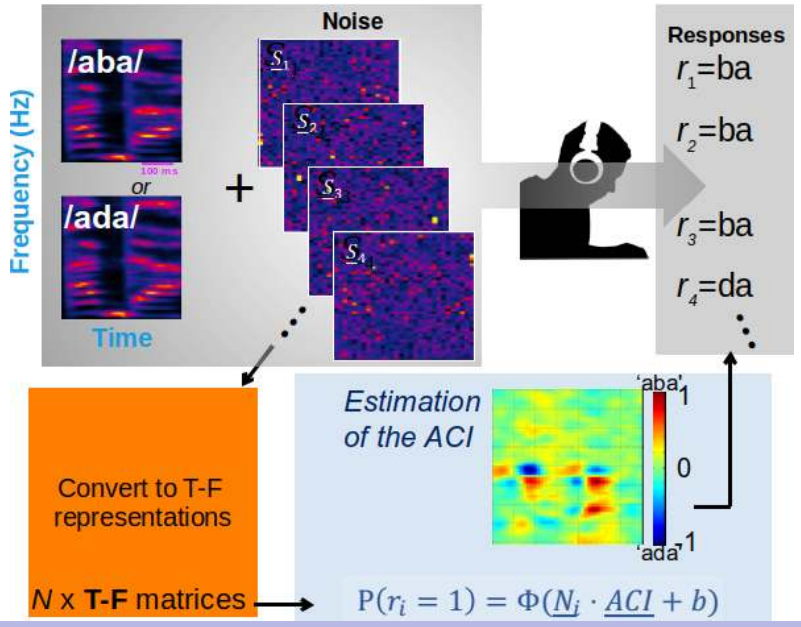
Laboratoire des systèmes perceptifs, ENS Paris, PSL University, France

ARCHES Oldenburg, 21-22 November 2022

Outline

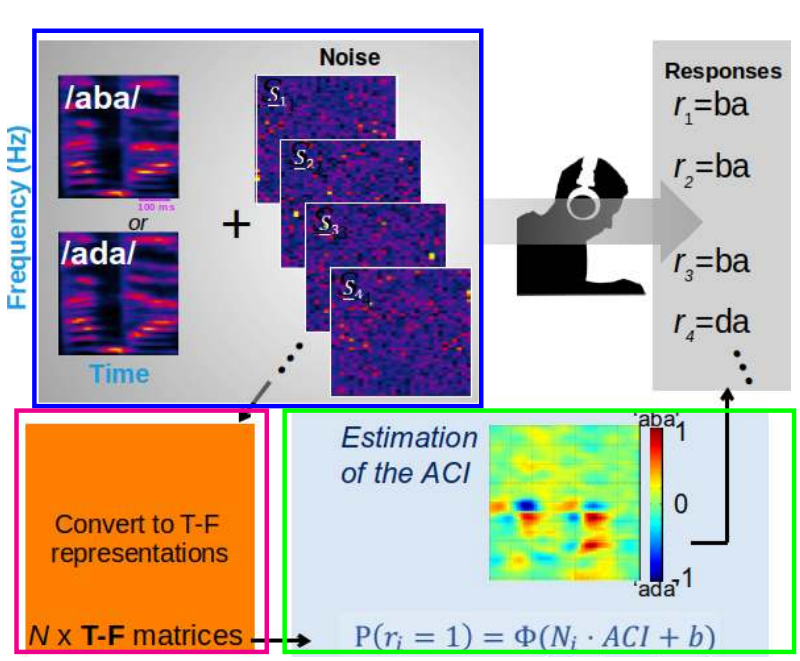
1. Introduction
2. Algorithm for noise generation
3. Results
4. Discussion & conclusions
5. (Supplementary)

Phoneme discrimination using the ACI method



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

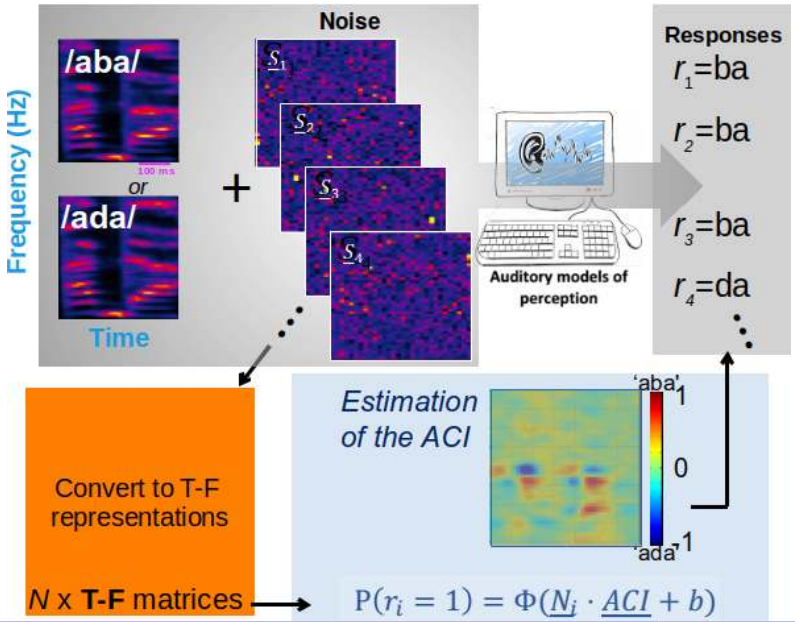
Phoneme discrimination using the ACI method: Optimisation?



- 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
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Rationale: speeding up the ACI assessment

Fig. 1

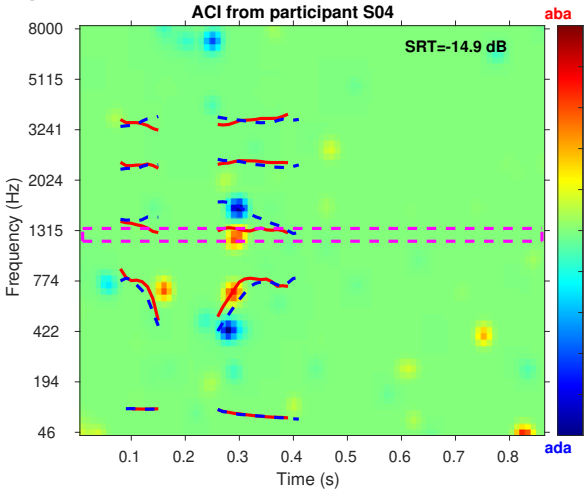
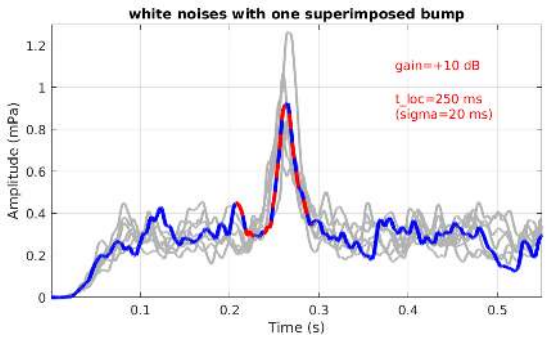


Fig. 2



- 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 ≈ 4h sessions x noise type x participant)



Outline

1 Introduction

2 Algorithm for noise generation

3 Results

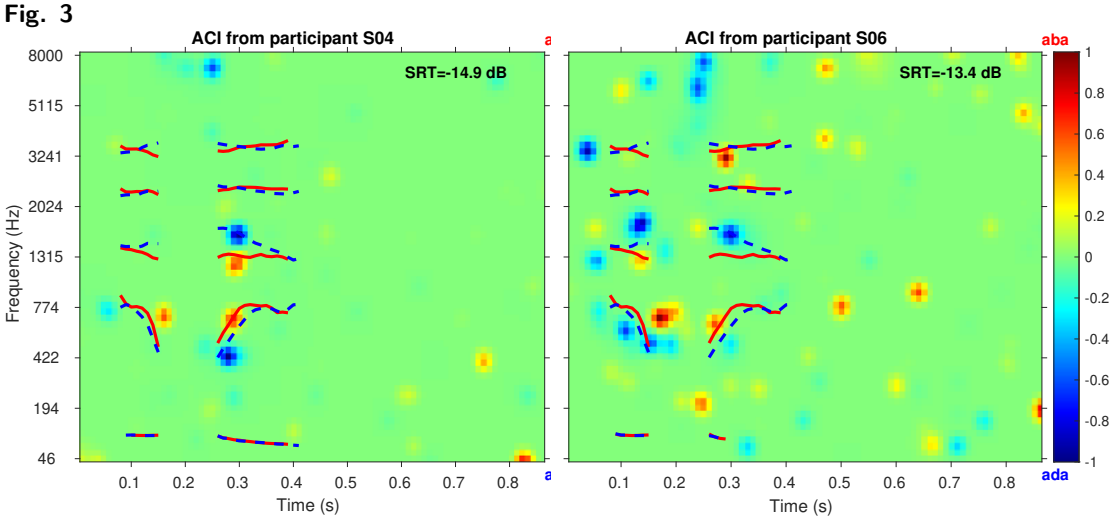
4 Discussion & conclusions

5 (Supplementary)

H1 – Experiments

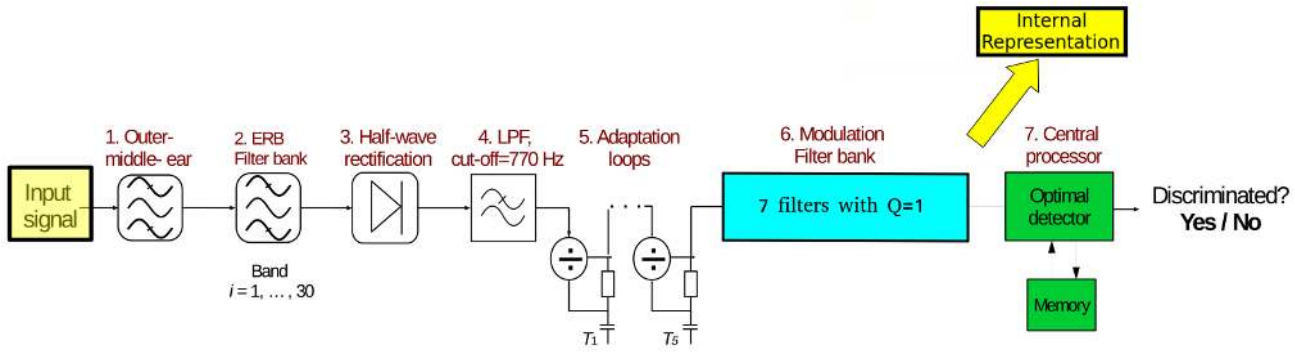
- H1: Yes, we were able to obtain clean ACIs, but...

Fig. 3



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

H2 – ACIs from simulations: The auditory model

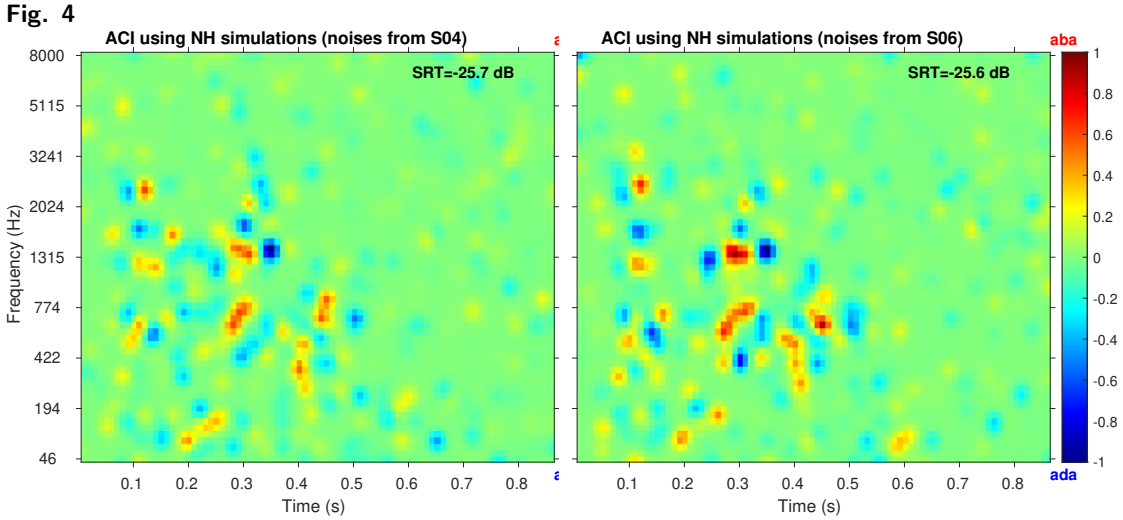


- Perceptual model based on the modulation-filter-bank model by *Dau et al. (1997)*
- Updated parameters, updated modulation filter bank
- Two template-approach as detailed by *Osses & Kohlrausch (2021)*, here:
  - Template 1: /aba/; Template 2: /ada/. Obtained from 1000 noisy samples
  - Supra-threshold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

H2 – ACIs from simulations

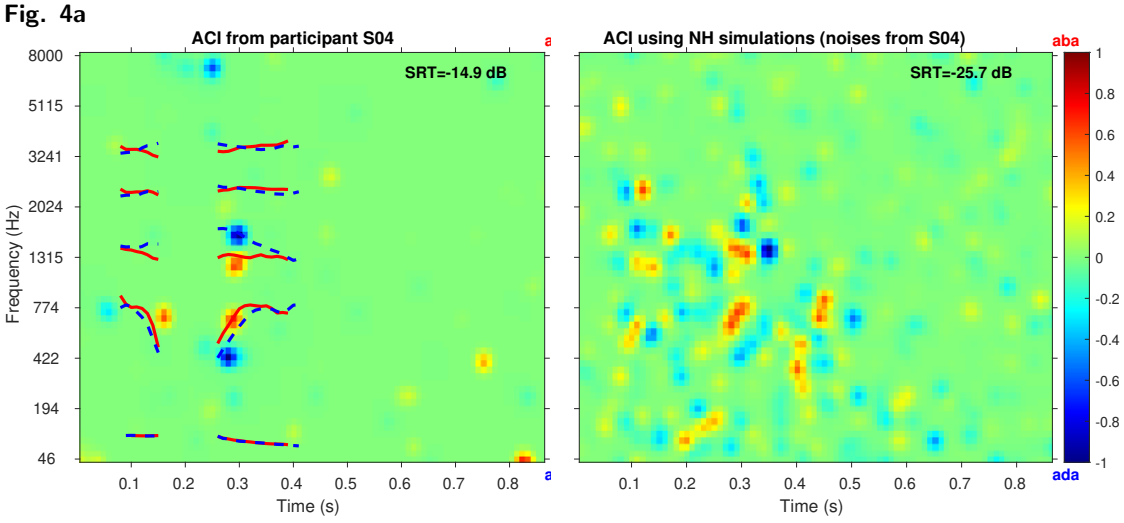
- H2: Yes, the ACIs were independent from the set of bump noises

Fig. 4



Comparing ACIs from experiments/simulations (1 of 2)

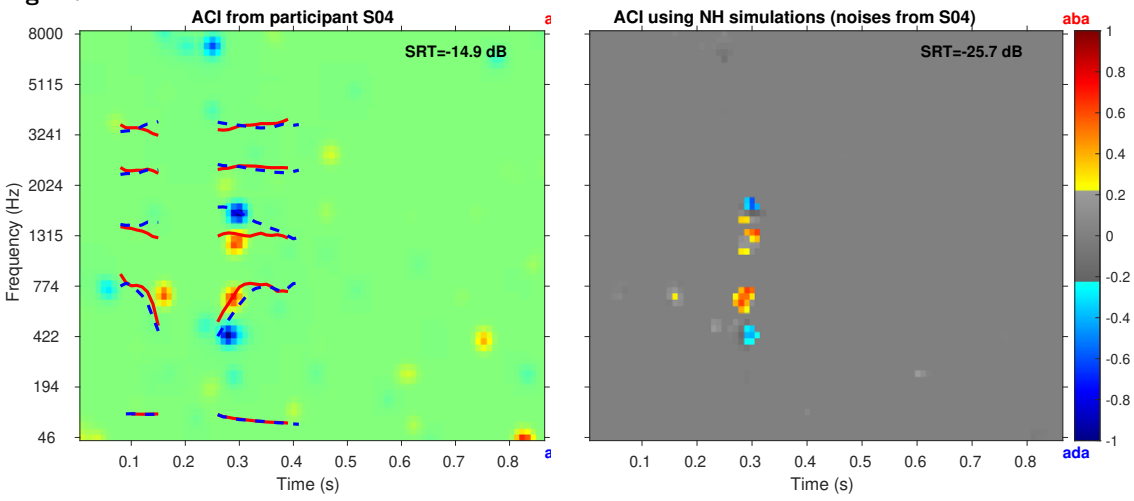
Fig. 4a



Introduction Algorithm for noise generation Results Discussion & conclusions (Supplementary)

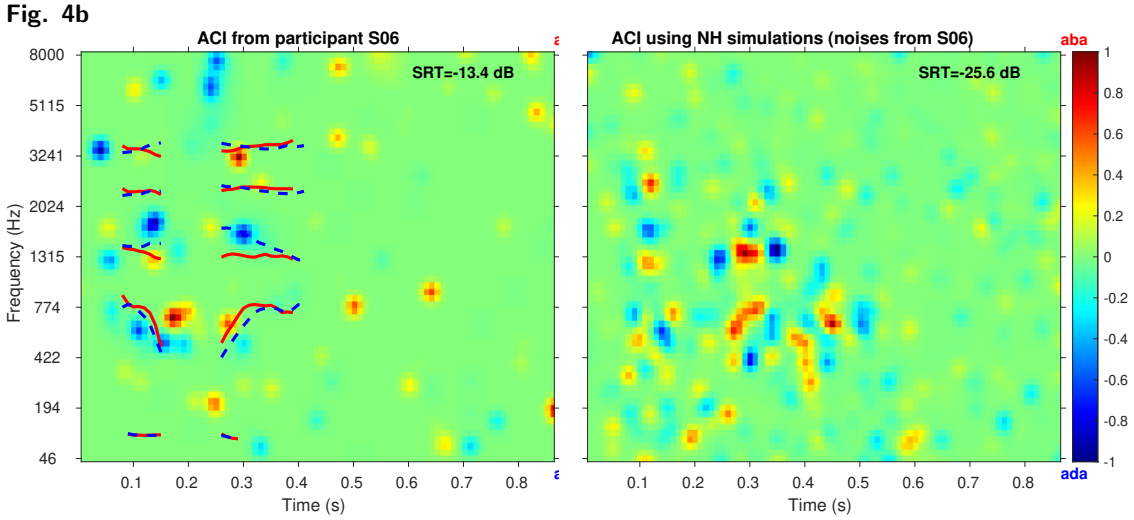
Comparing ACIs from experiments/simulations (1 of 2)

Fig. 4a



Comparing ACIs from experiments/simulations (2 of 2)

Fig. 4b

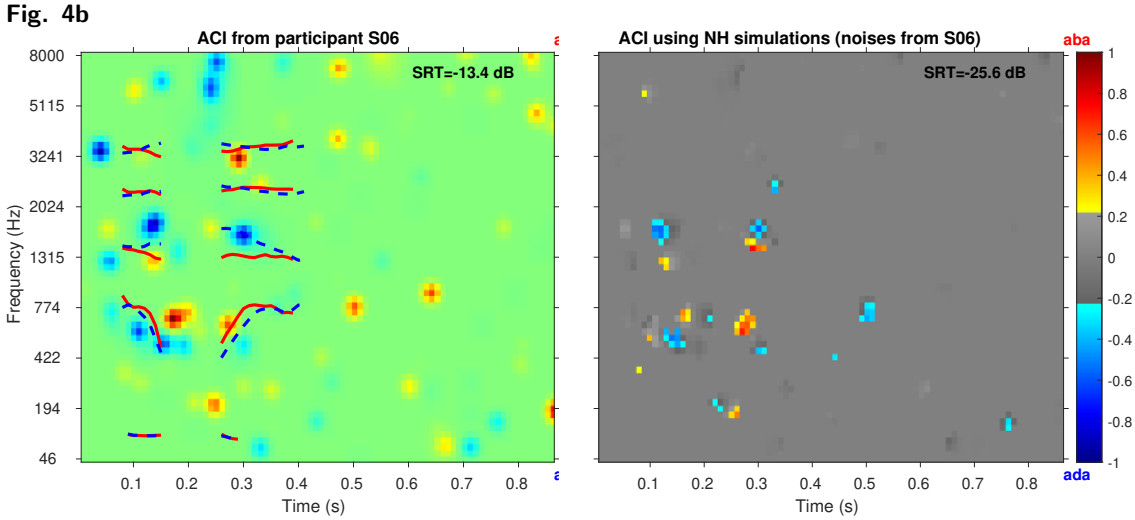


This means that all the cues in the experimental ACIs are a subgroup of the cues from ACIsim

Introduction Algorithm for noise generation Results Discussion & conclusions (Supplementary)

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

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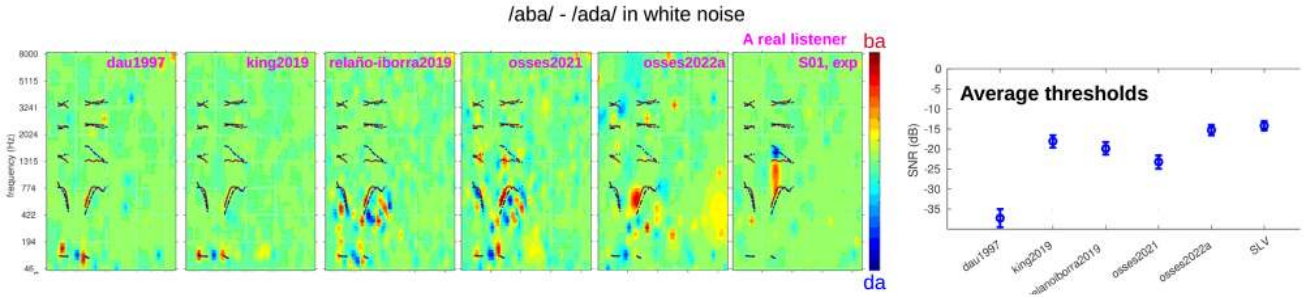
5 (Supplementary)

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)?**

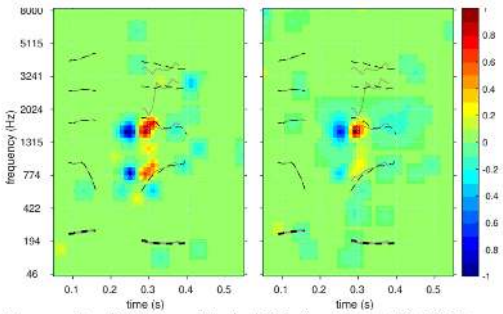


Figure 3: (Colour online) ACIs for the artificial listeners, i.e., the auditory model using the decision device 1 with K=0.39 MU (left panel) and using the decision device 2 (right panel). The colour codes and axis legends are as in Fig. 1.

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

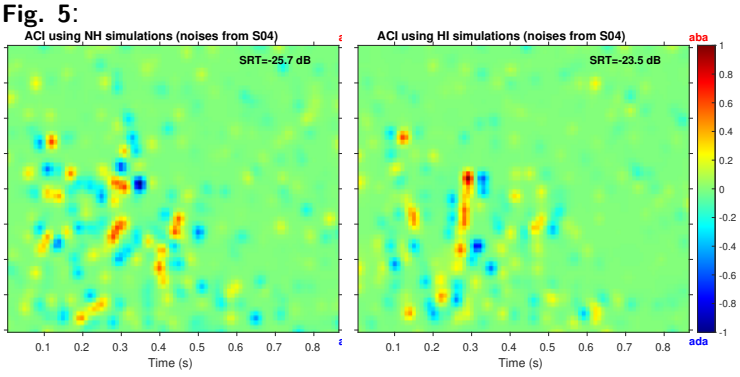
Using the auditory model: possibilities and limitations

- 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)*)

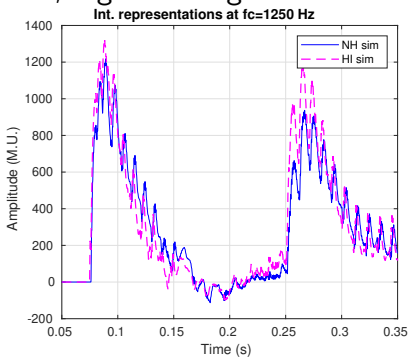
Using the auditory model: possibilities and limitations

- 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:



Conclusions

ACI method

- Assessment of individual listening strategies
- Interesting tool to obtain T-F cues for both models and participants

Use of auditory models (my main focus today)

- "Optimal integration of cues"
- Can be used to support/reject hypotheses
- Careful: T-F cues may not reflect the actual (but candidate) cues
- Careful: There might be results that are model dependent

I still believe that much can be learned from auditory models and the estimated internal representations

Thank you for your attention

- Questions or comments?



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