Friedrich-Alexander-Universität
Technische Fakultät
Department Artificial Intelligence in Biomedical Engineering (AIBE)

Analysis of Neural Responses to Continuous Speech Using MEG

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PhD candidate, *Sensory Neurotechnology* group

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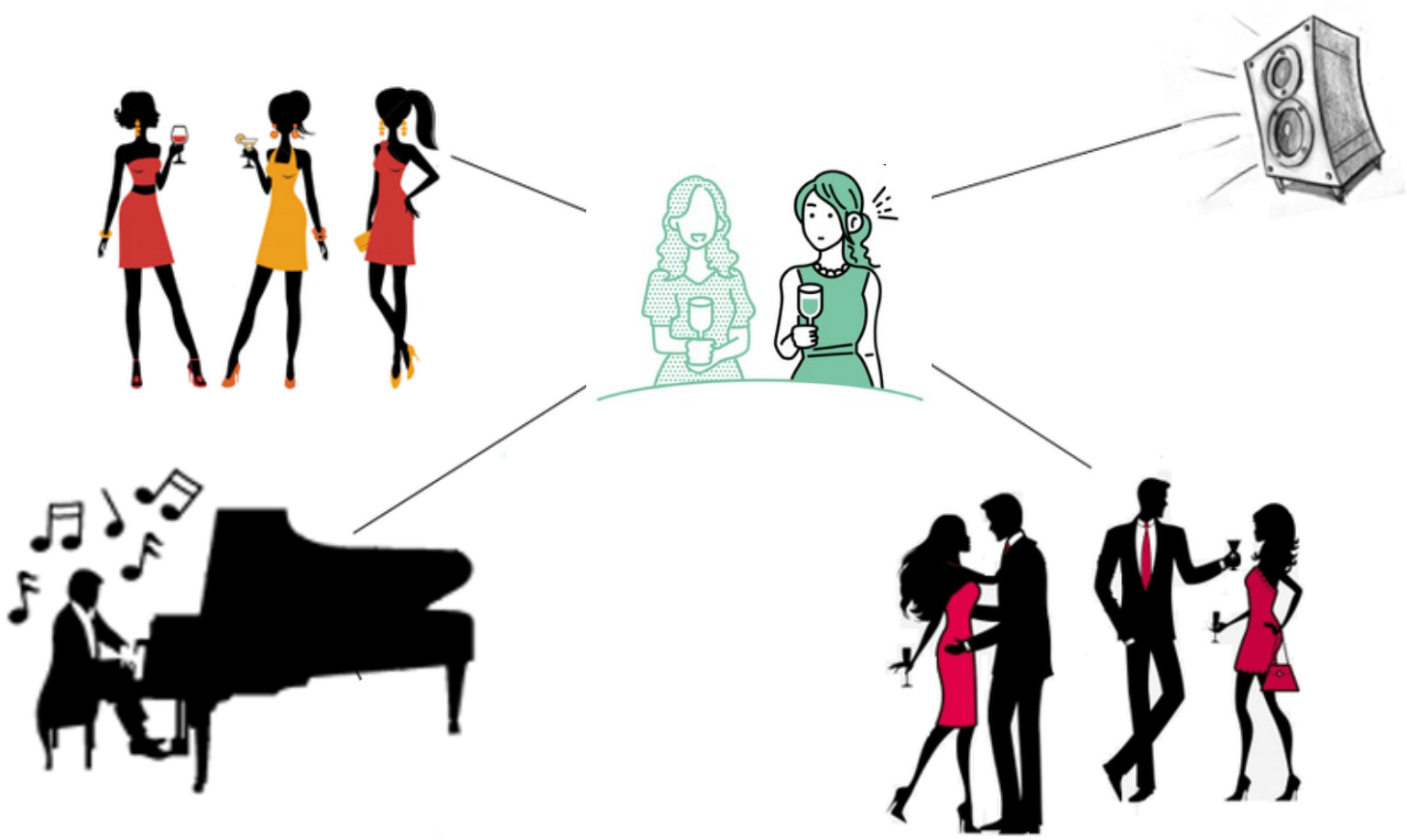
How is an audio signal processed in our brain?



Analysis of neural responses to continuous speech using Magnetoencephalography (MEG)

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Magnetoencephalography (MEG) and data acquisition

MEG:

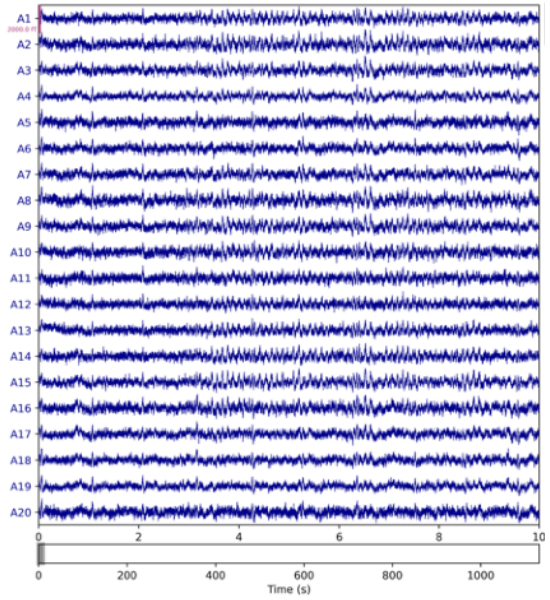
- functional neuroimaging technique

- sensory detection of magnetic fields, generated from active neurons in the brain

Experimental setup:

4D Neuroimaging, San Diego, 248 Magnetometers

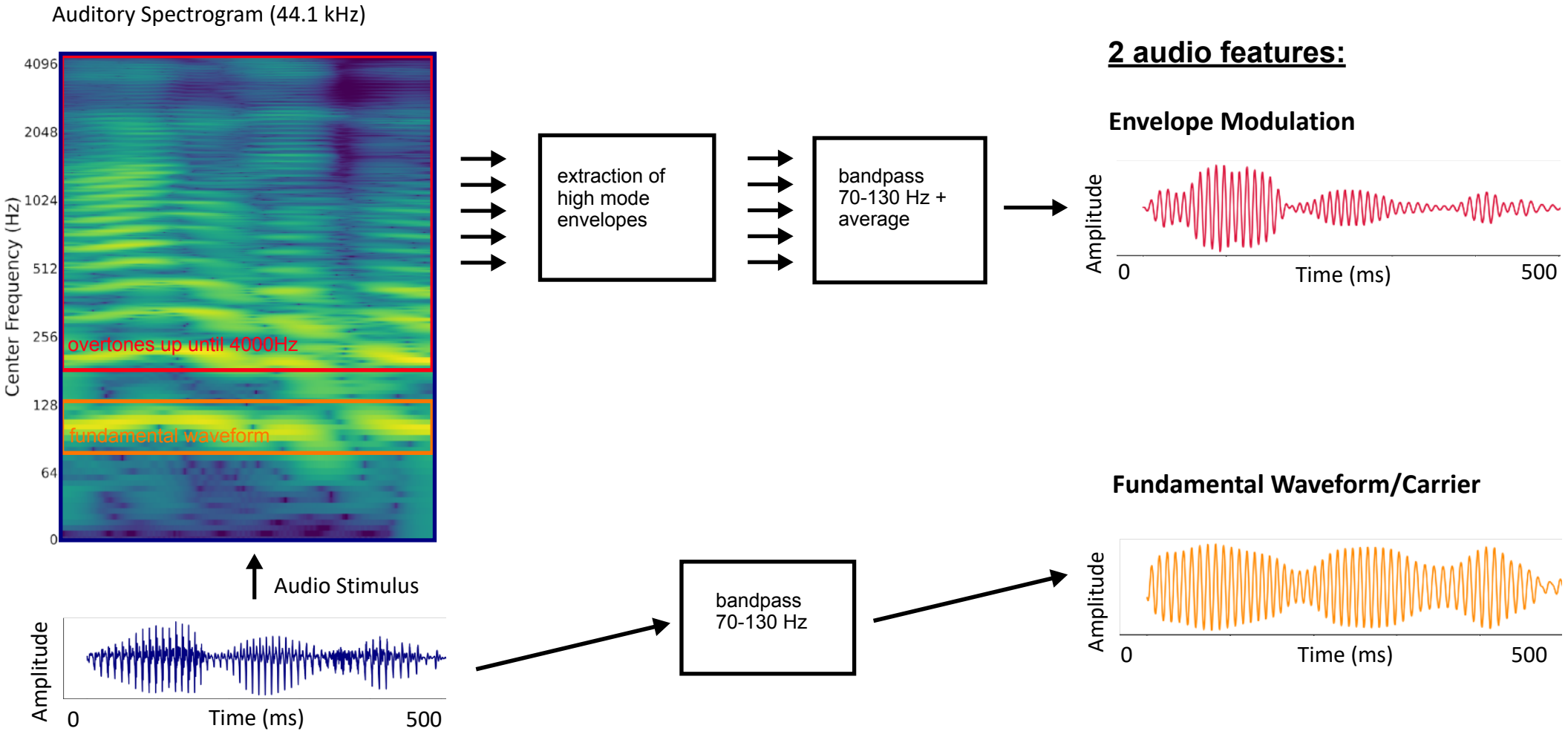
14 healthy, normal hearing participants attended 40 min audio book during MEG scan



MEG scanner at the centre for Epilepsy in Erlangen:

https://www.epilepsiezentrum.uk-erlangen.de/ueber-uns/rundgang/meg-biomagnetismus/

From audio book to acoustic stimulus



Temporal Response Functions

TRF: the set of time-dependent weights (α), of a linear combination of current and past samples of the predictor, that best predicts the current neural response at one MEG sensor

$$y_t = \sum_{\tau=1}^{T} (\alpha_{\tau,c} c_{t-\tau} + \alpha_{\tau,e} e_{t-\tau})$$

$c_{t-\tau}$: the delayed carrier predictor
$\alpha_{\tau,c}$: the corresponding carrier TRF
$e_{t-\tau}$: the delayed envelope modulation predictor
$\alpha_{\tau,e}$: the corresponding envelope modulation TRF

→ Here, the coefficients α describe the time course of the neural response y to the two stimulus audio features c and e (both features where fit simultaneously!)

Temporal Response Functions

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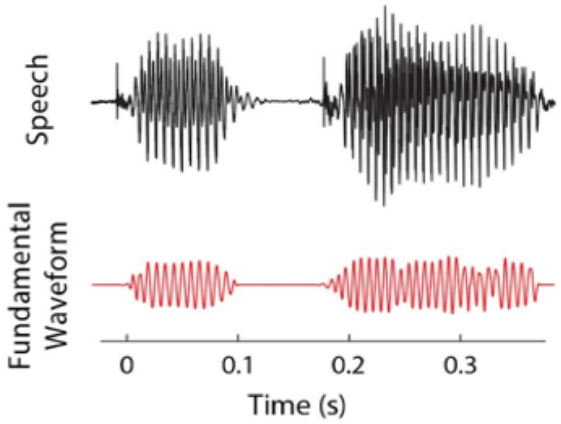
Acoustic stimulus



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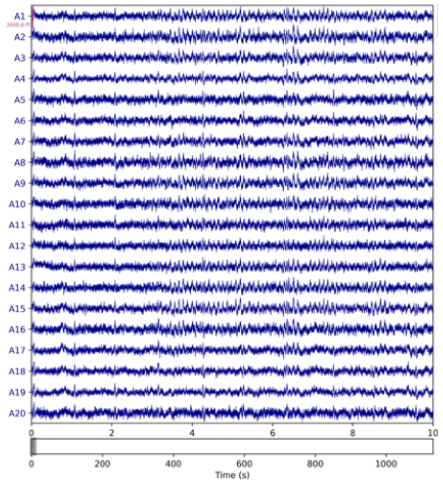
MEG recording



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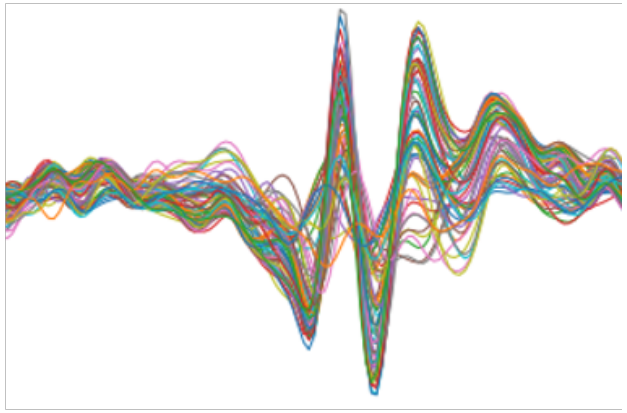
Temporal Response Functions (TRF)



Processing and source analysis of MEG responses to continuous speech

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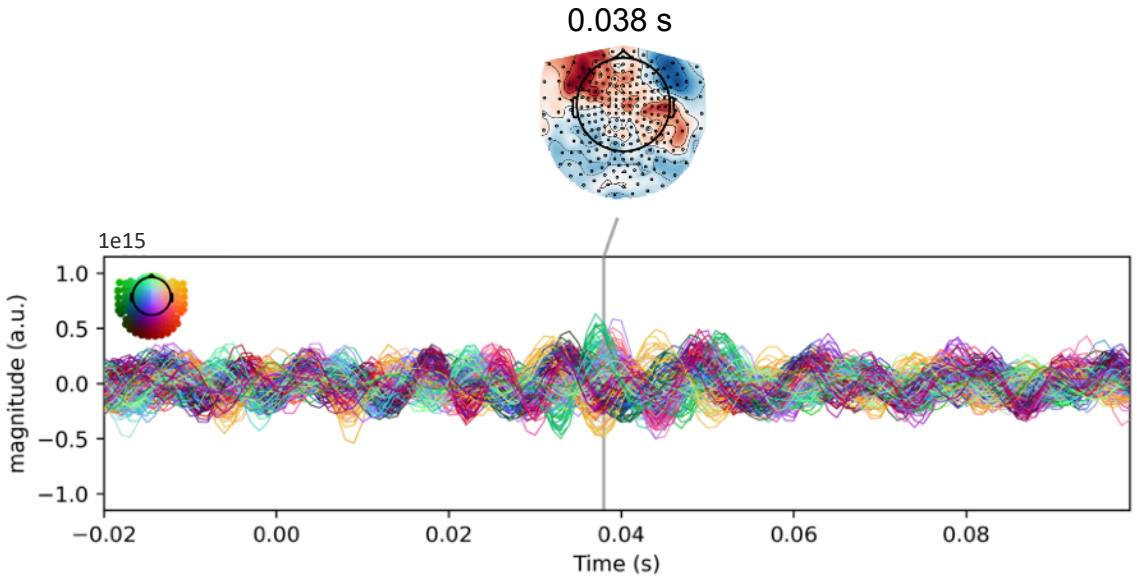
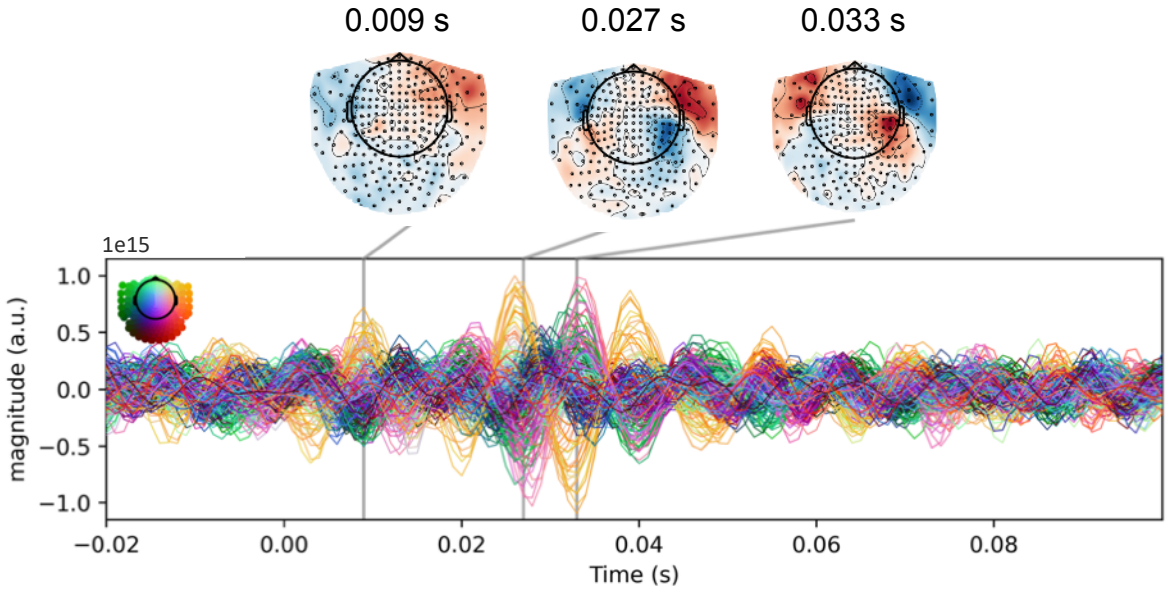
I. Fundamental waveform



II. Envelope modulations



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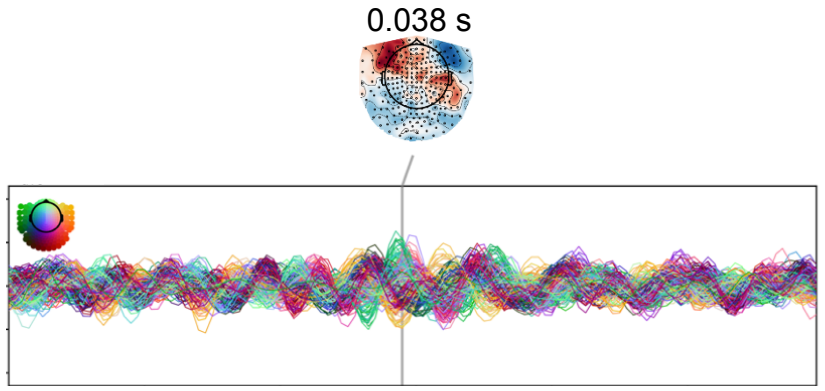

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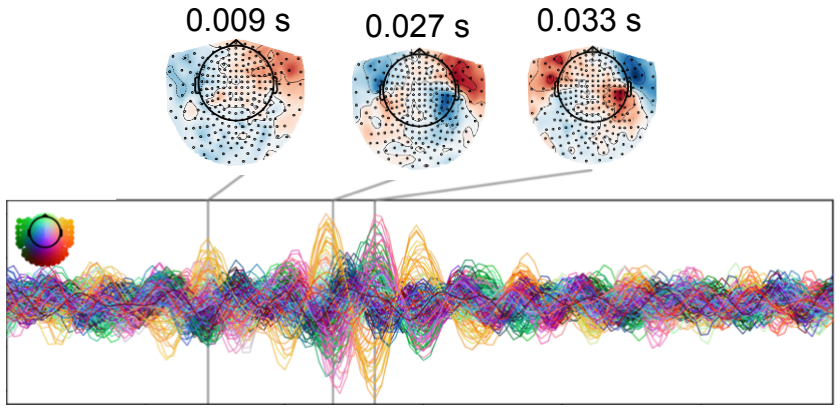
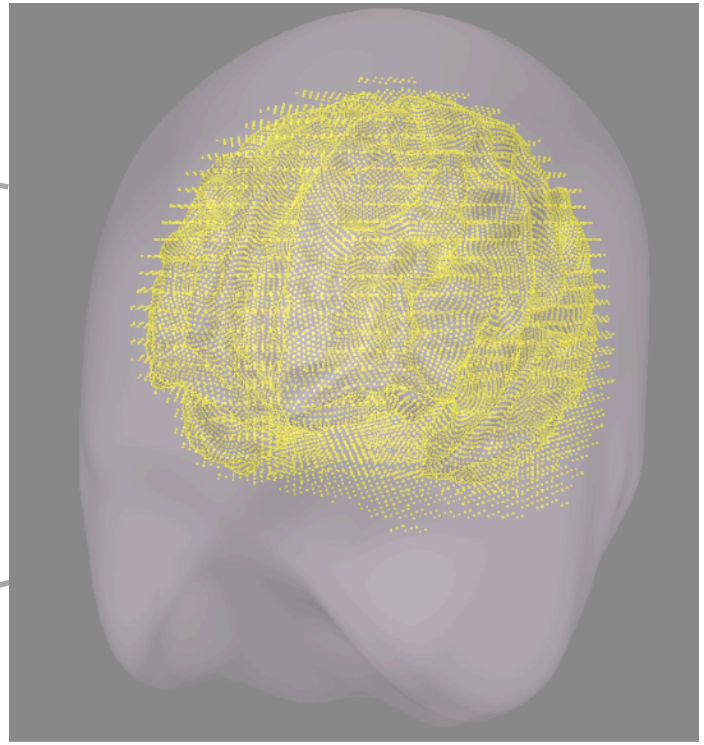


MRI volume + Boundary element model (BEM)



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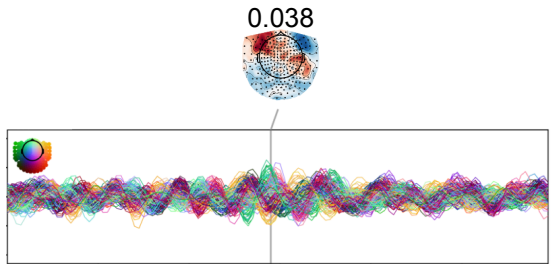

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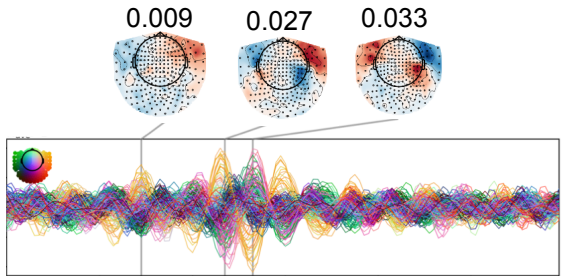

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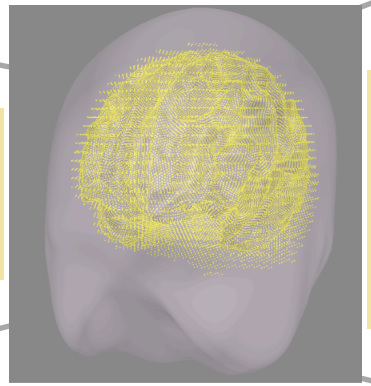
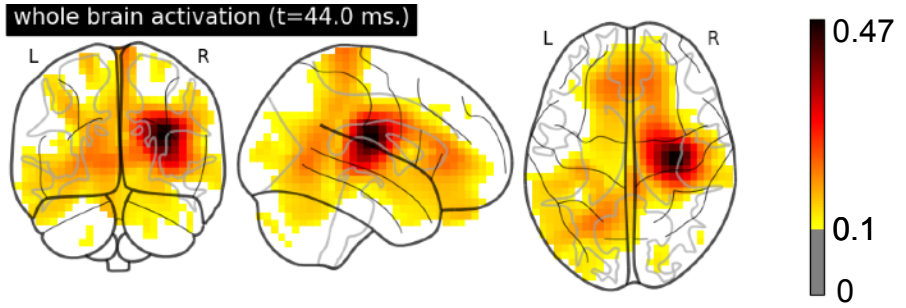
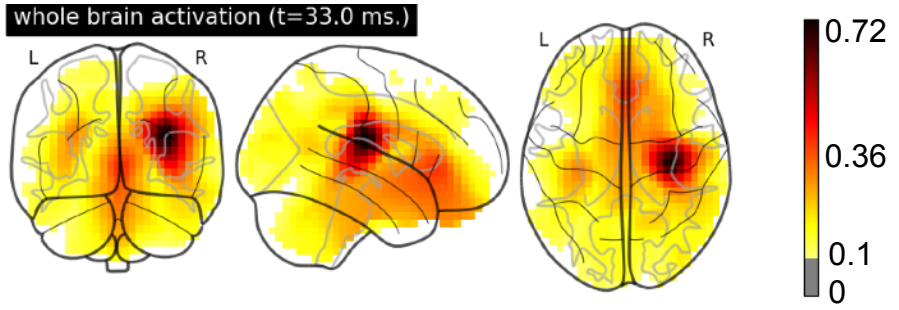


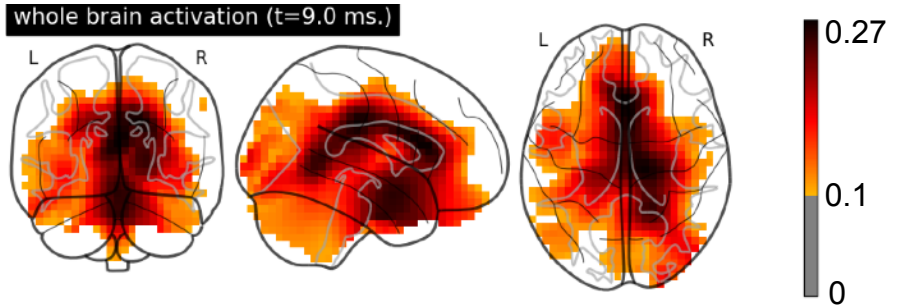
Forward modeling + inverse solution (dSPM)

I. Fundamental waveform



II. Envelope modulation





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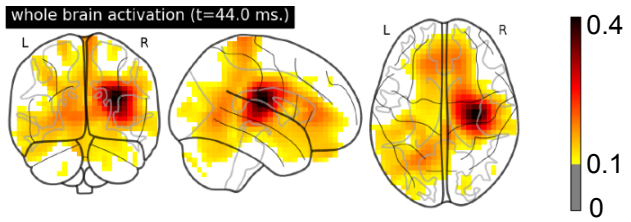

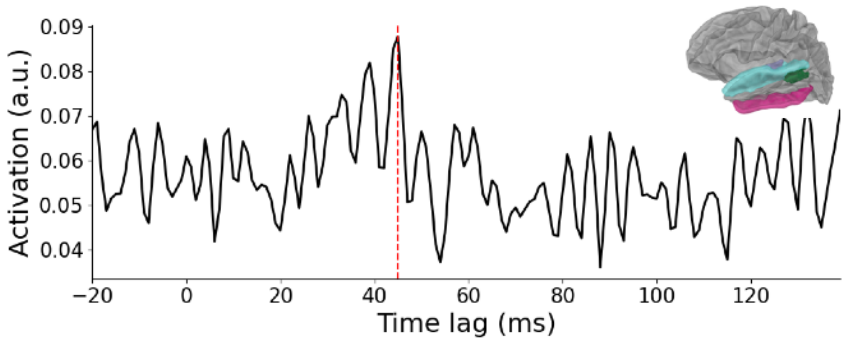

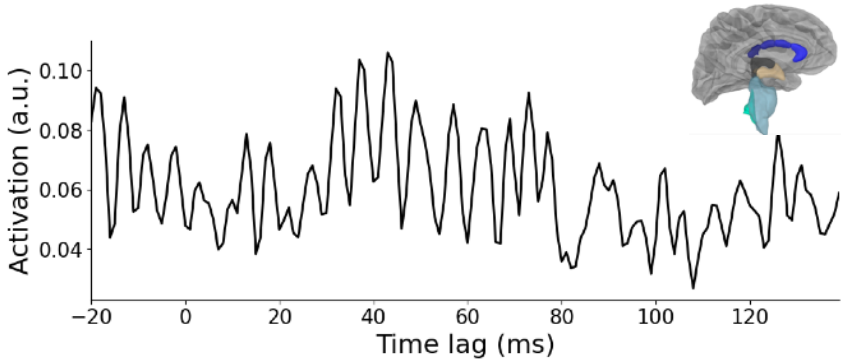

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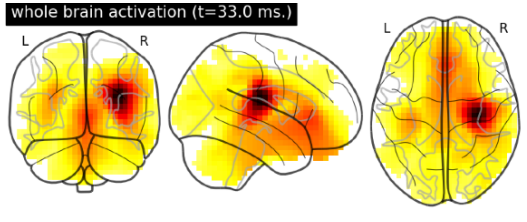

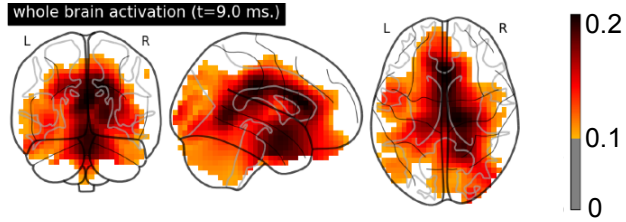

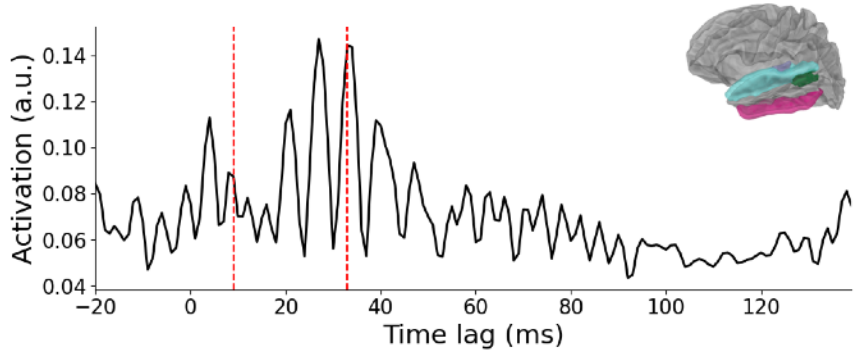

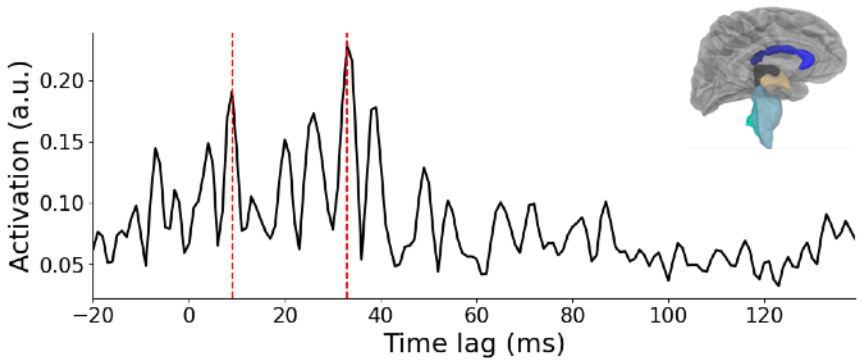

Towards smart hearing aids

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Vision of a smart hearing aid:

- Can detect focus of attention and reduce background noise
- Can be fitted to an individual hearing impairment and settings can be updated in real time, due to changing acoustic environment

➡ Allow a user to understand speech in all acoustic environments

- Measure brain activity to speech (in noise) from M/EEG
- Decode attention to one of several simultaneous speakers from the M/EEG in real time
- Include visual stimuli

➡ **Develop AI to make a hearing aid smart**

Thank you for your attention!

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