High Frequency Time Locking in Human Auditory Cortex to Continuous Speech

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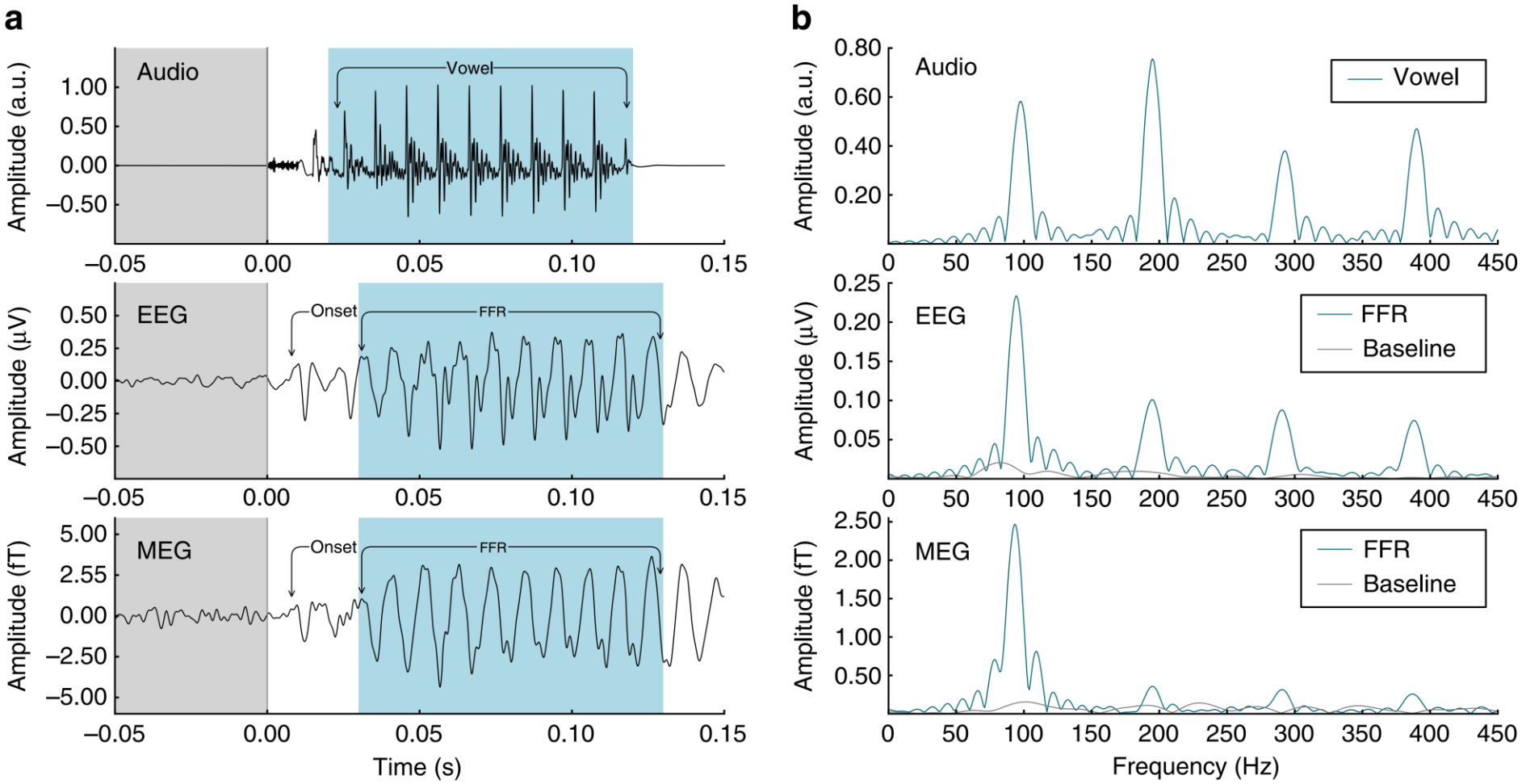
Background: Auditory Responses

- Complex sounds represented in brain using time-locked responses.
- Response **frequency decreases** up the auditory pathway
- **Fast EEG** Frequency Following Response (FFR)
  - Subcortical sources
  - Typically above 100 Hz
- **Slow MEG/EEG** responses to the speech envelope
  - Auditory cortex
  - Below 20 Hz

Background: Frequency Following Response (FFR)



Adapted from Coffey et al., Nat Commun (2016)

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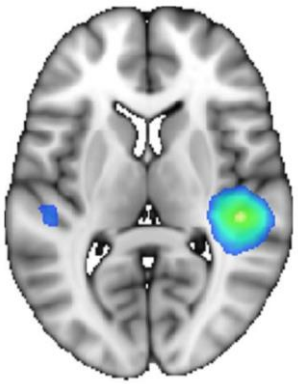
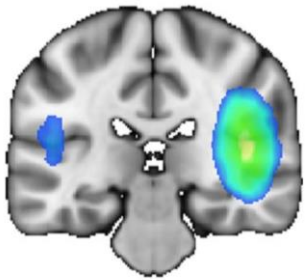
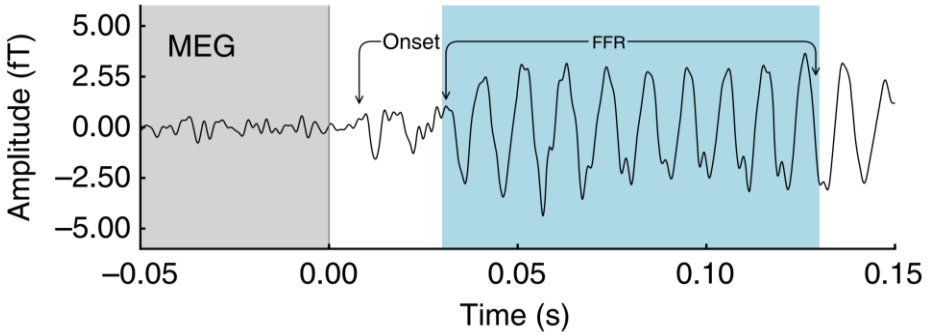
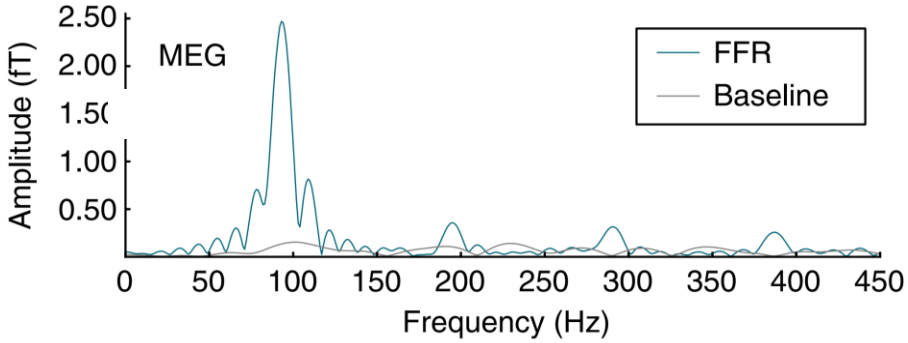




MEG responses dominated by cortical sources





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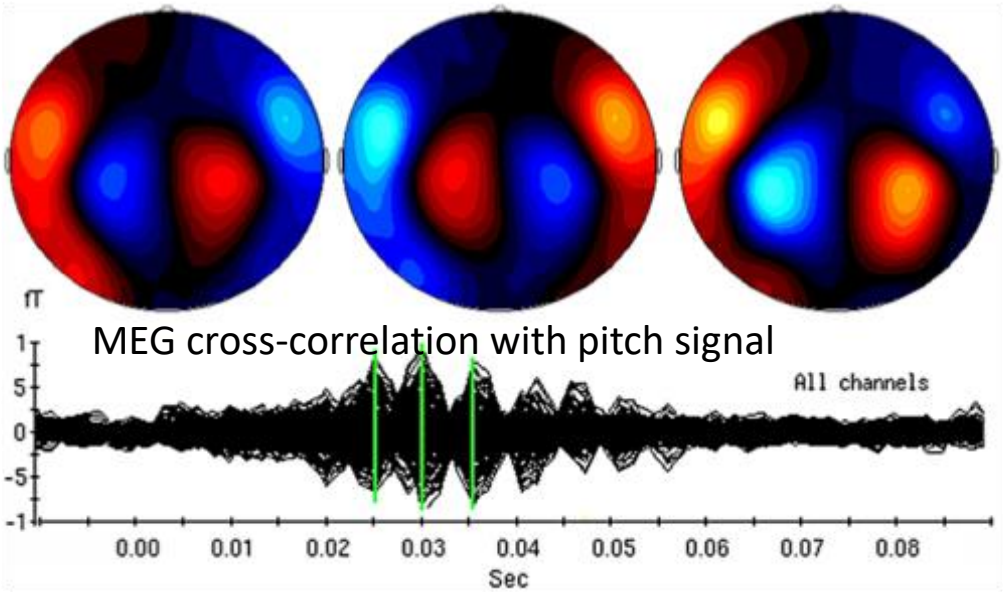
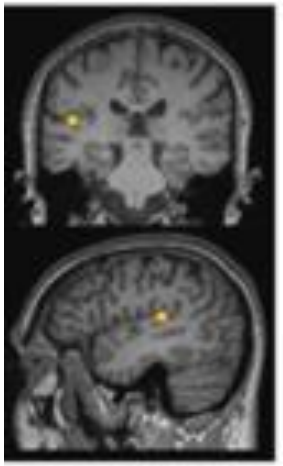
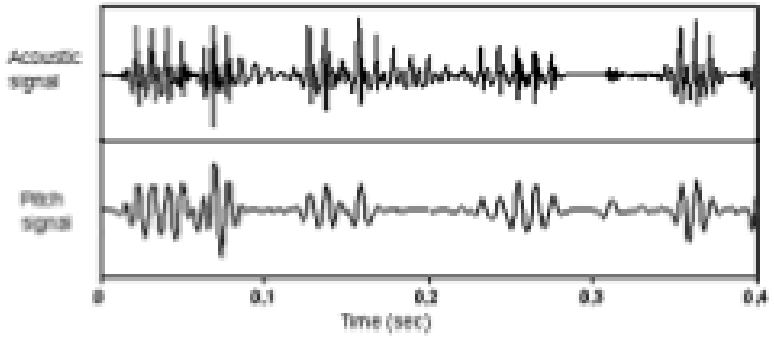
Fast MEG Responses to Continuous Speech



MEG cross-correlation with pitch signal





"pitch (ca. 100 Hz) elicited a neural resonance bound to a central auditory source at a latency of 30 ms"

Hertrich et al., Psychophysiology (2012)

Motivation

- Explore fast time-locked cortical responses to continuous speech
- Time-locking to the high frequency envelope or carrier of the speech?
- Hearing ability declines with aging
  - Subcortical fast EEG response: younger > older
  - Cortical slow MEG/EEG response: older > younger !!
  - **Cortical fast MEG?**

Methods

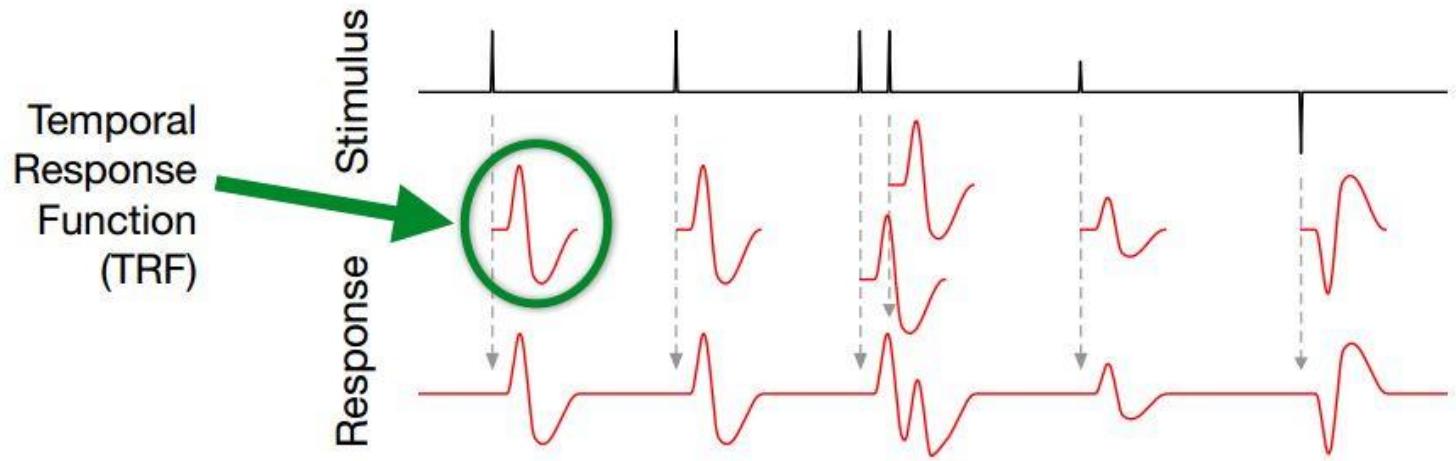
- MEG recorded from 17 younger (18-27 yrs), 23 older adults (61-78 yrs)
- Listening to male narration of an audiobook.

  1 minute x 6 trials

  Previously published data: Presacco et al., 2016a, b

- Regions of interest (ROIs)
  - cortical (temporal lobes)
  - subcortical (includes brainstem)

Methods: Temporal Response Function (TRF)



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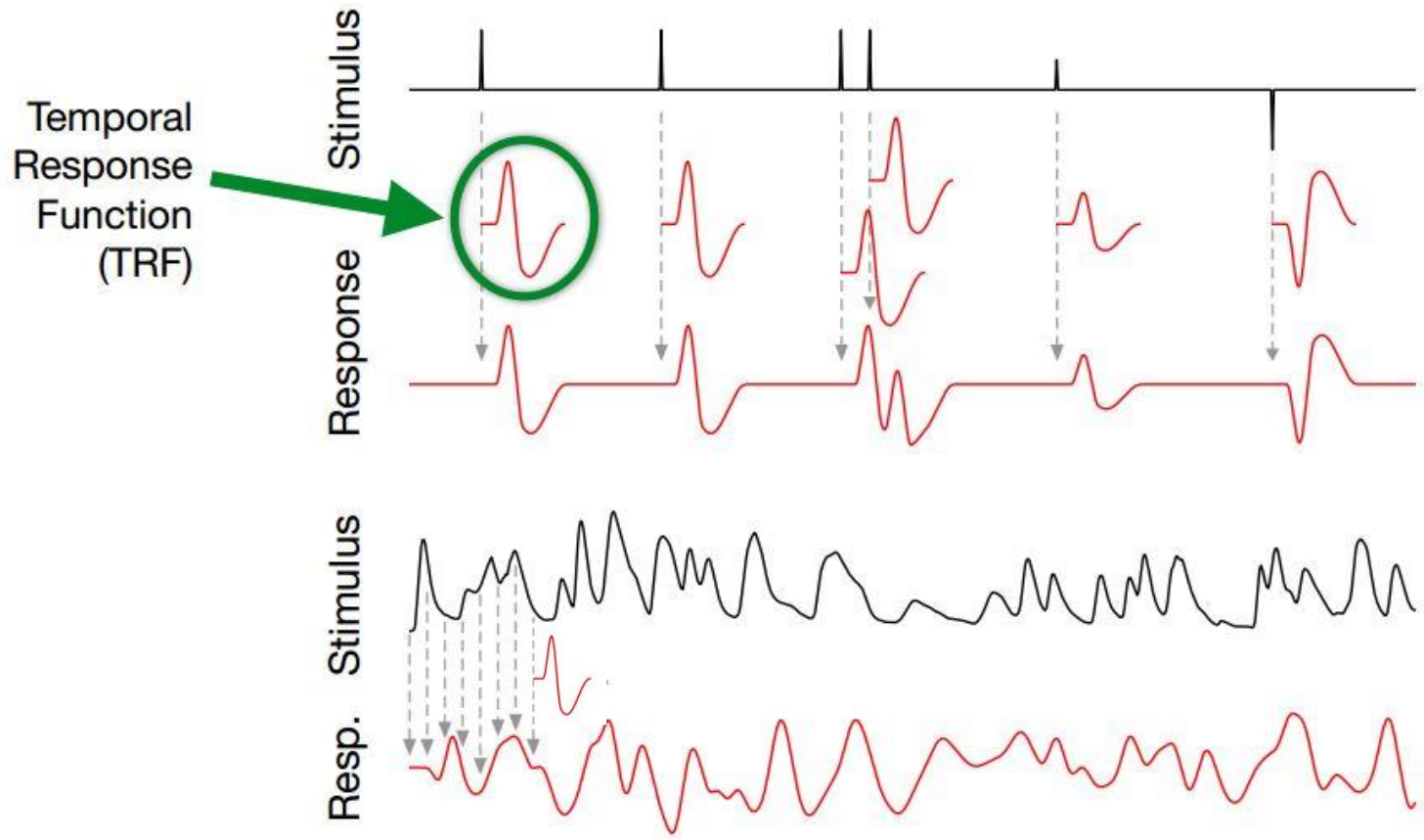

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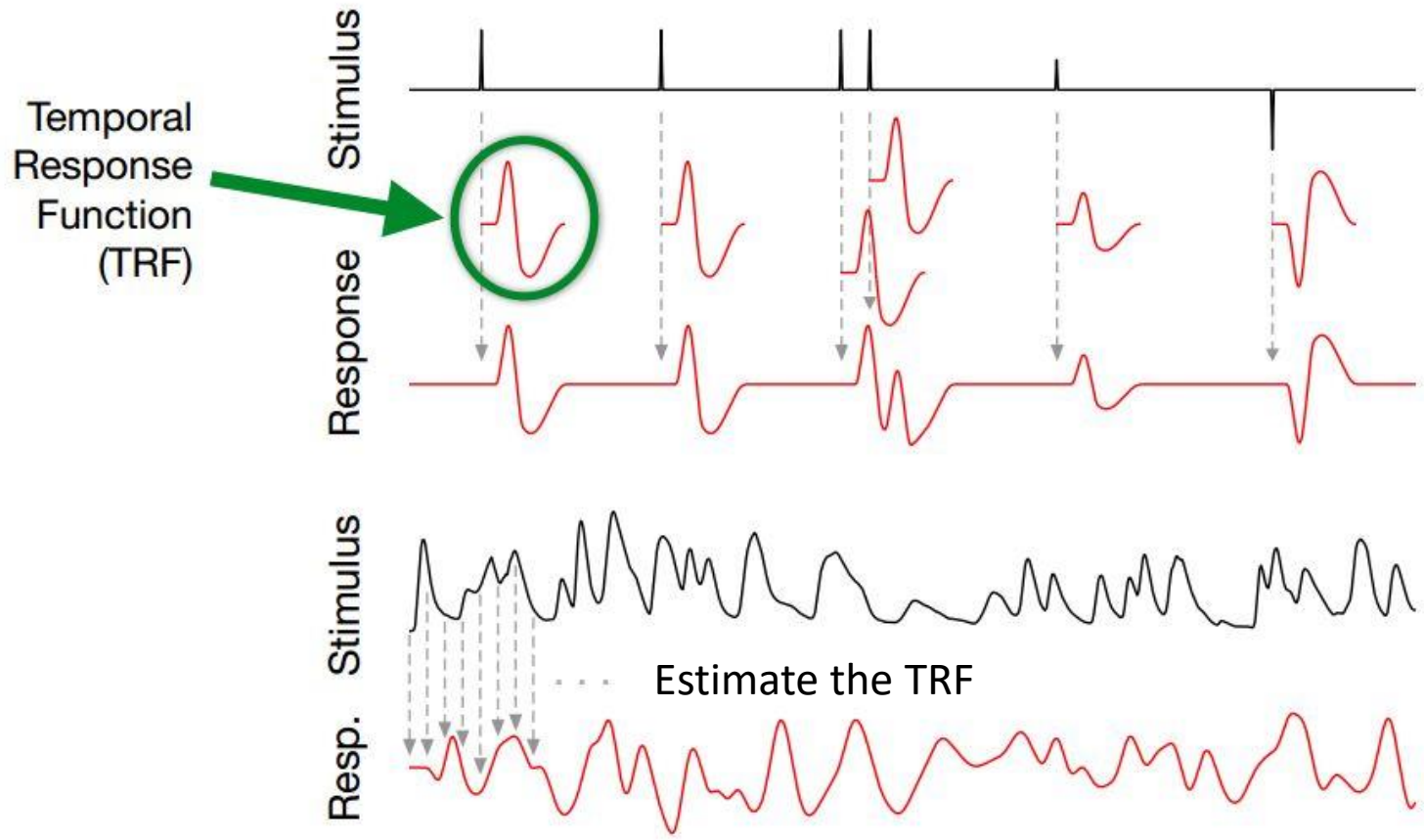
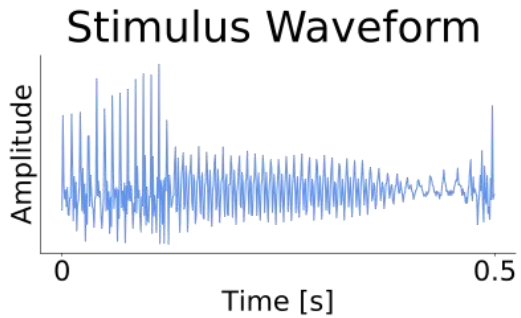


Methods:
Speech Representations (Predictors)



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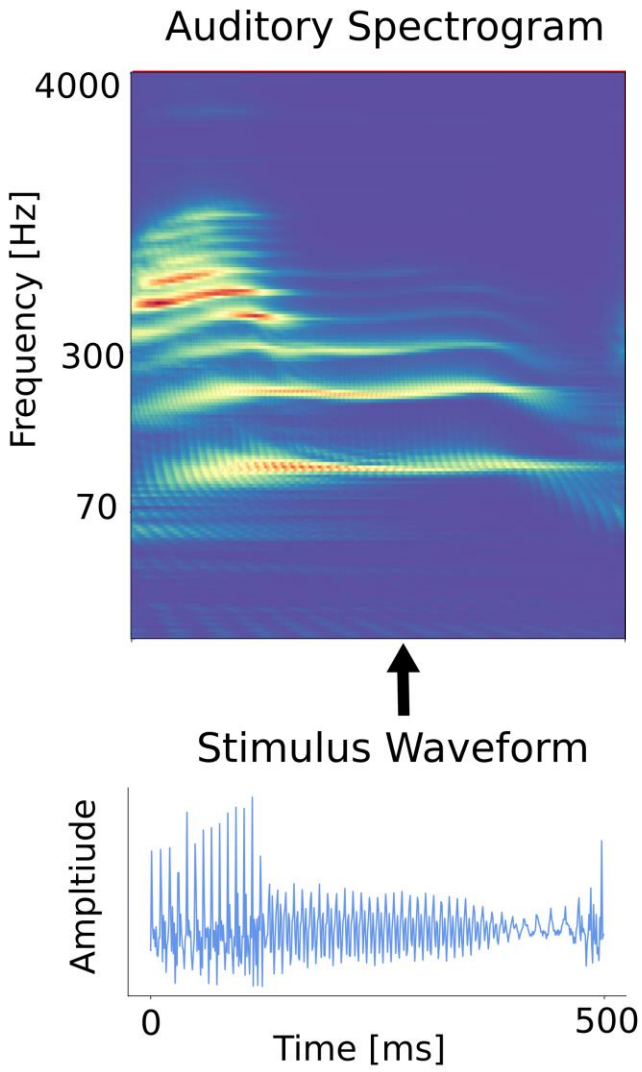

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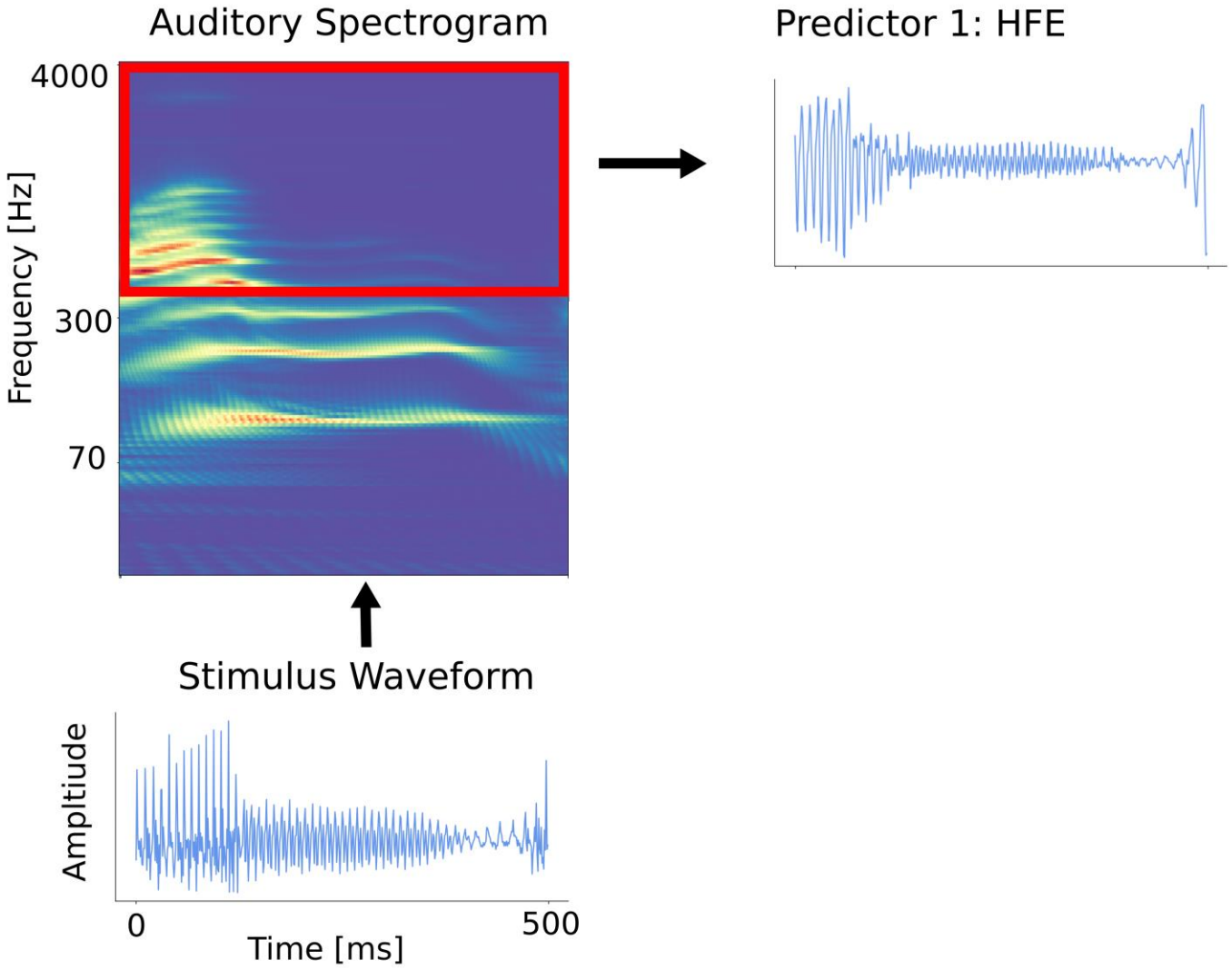

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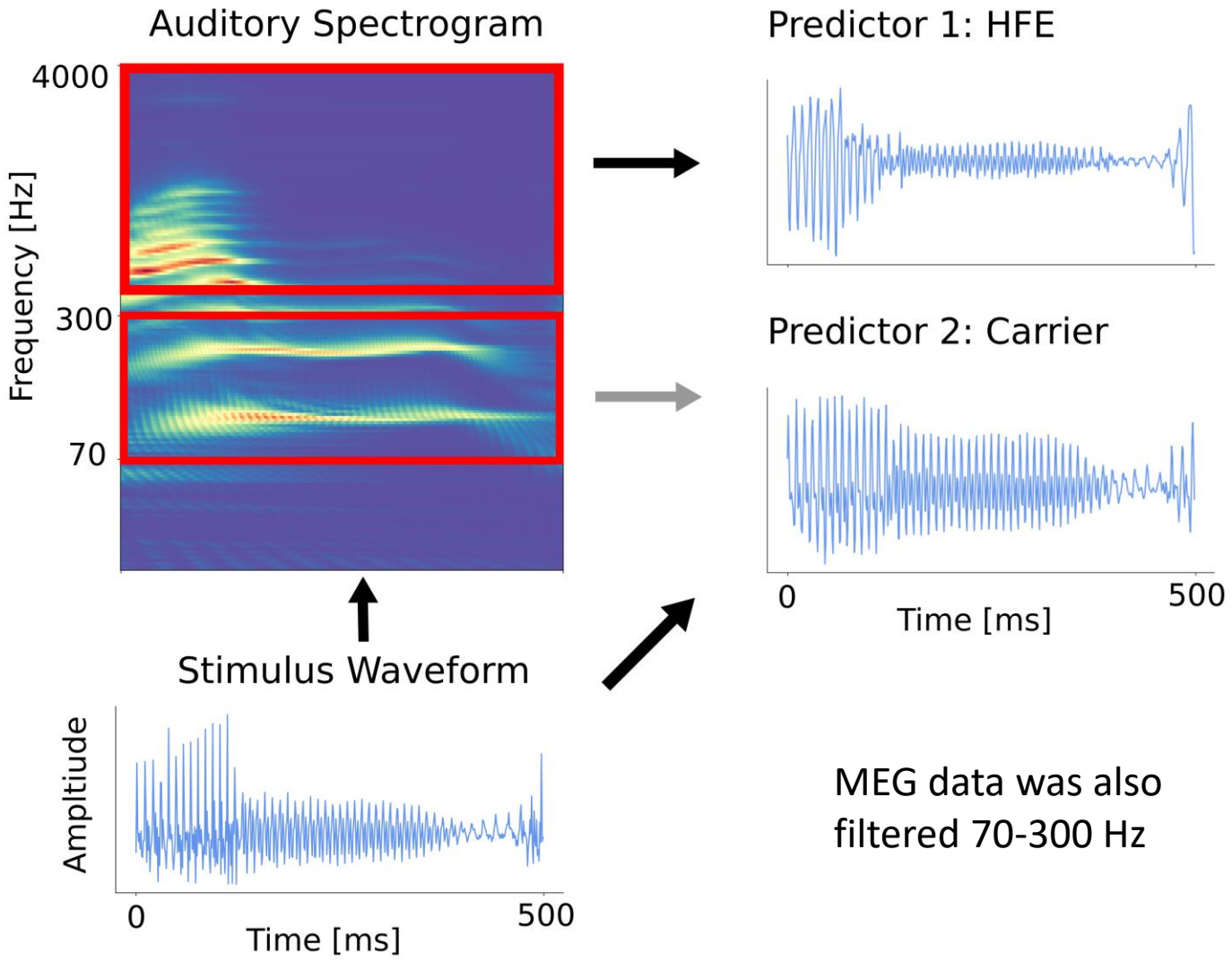
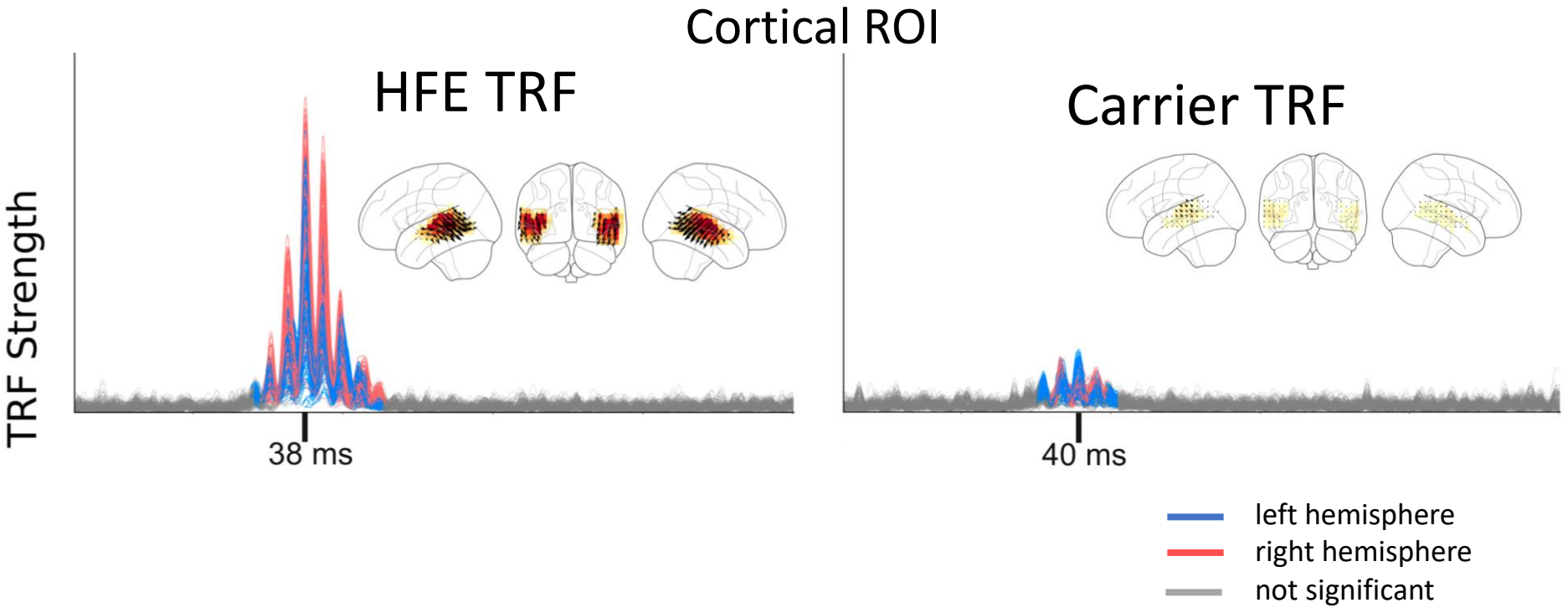


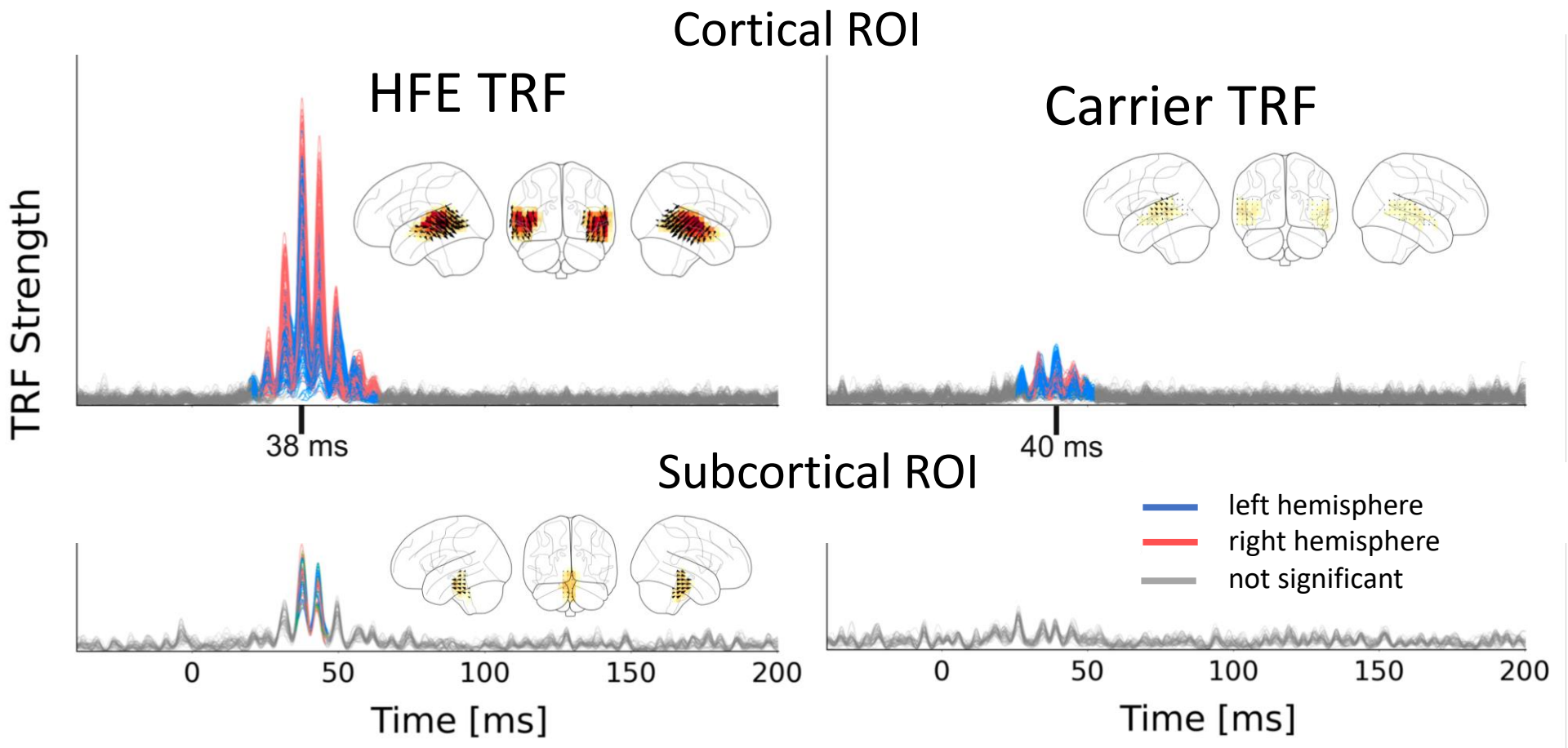
MEG data was also filtered 70-300 Hz

Results: HFE vs. Carrier



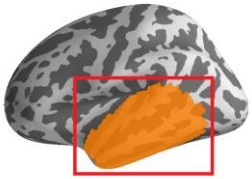
HFE TRF is stronger than Carrier TRF

Results: Cortical vs. Subcortical



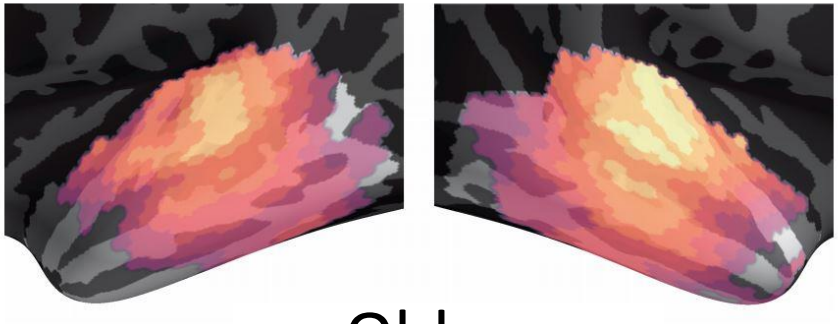
Peak latency of 38ms => Cortical origin

Results: Younger vs. Older



Response Model Fit

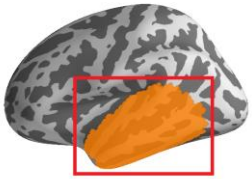
Younger



Older

No significant age related difference!

Results: Younger vs. Older



Response Model Fit

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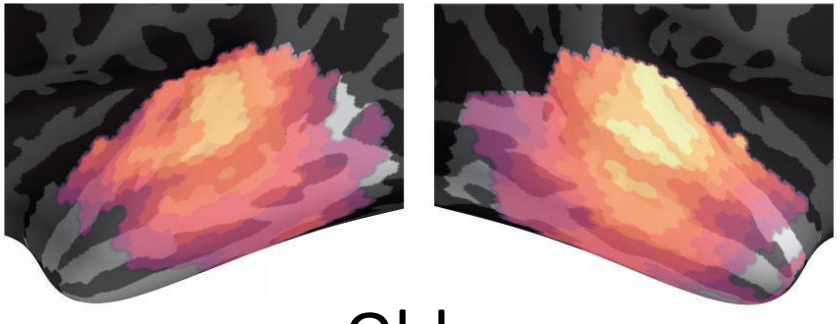
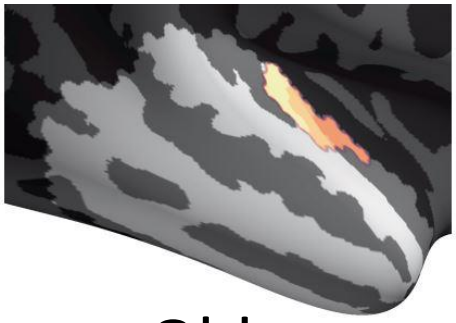


Older

No significant age related difference!

Lateralization

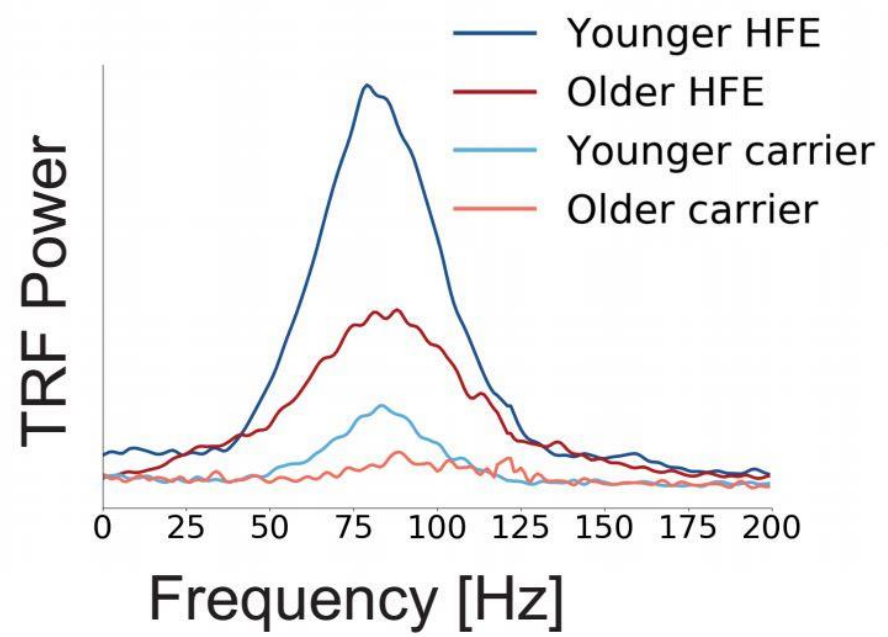
Younger



Older

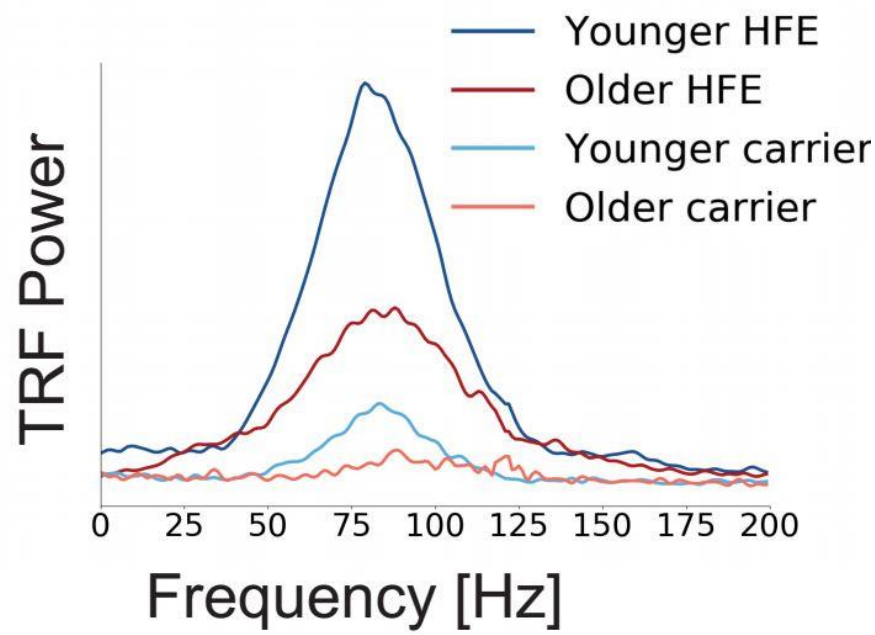
Right lateralized only in younger

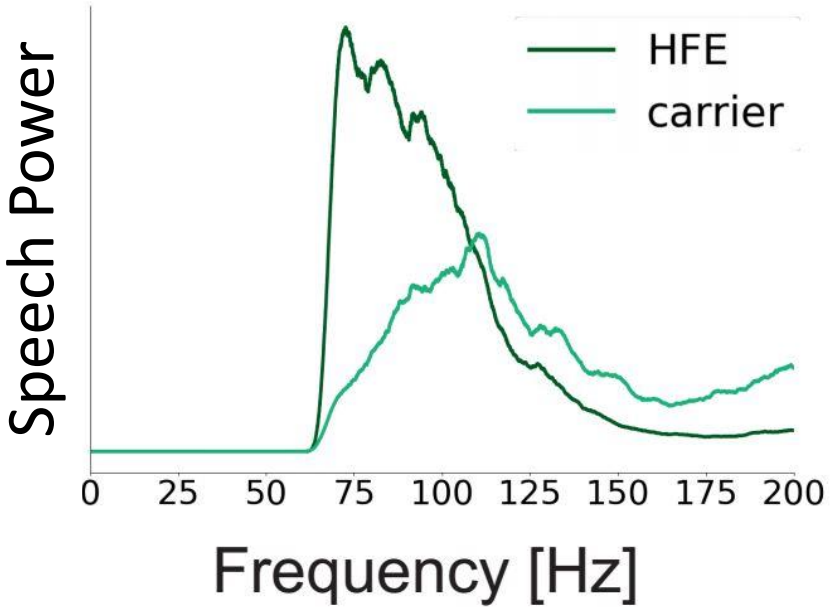
Results: Frequency Domain



TRF oscillation frequency around 80-90 Hz

Results: Frequency Domain





TRF oscillation frequency around 80-90 Hz

Speech power largest around 70-75 Hz (HFE) or 110-120 Hz (Carrier)

Where do these responses come from?

- Cortical neurons don’t phase lock at 80 - 90 Hz.
- But thalamic neurons can!
- Output of thalamic neurons are inputs to auditory cortex
- MEG can see dendritic inputs (LFP)

Summary

- Fast MEG cortical responses to continuous speech with latency 40 ms in auditory cortex.
- Mainly to the HFE and not carrier.
- Oscillation at 80-90 Hz, not driven by stimulus spectrum directly.
- Possibly thalamic inputs to cortex
- Right lateralized (in younger subjects)
- No significant age related differences! Unlike fast EEG FFR (younger > older) and slow cortical responses (older > younger)

Acknowledgements

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Poster available at
http://ter.ps/simonpubs

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Thank You!