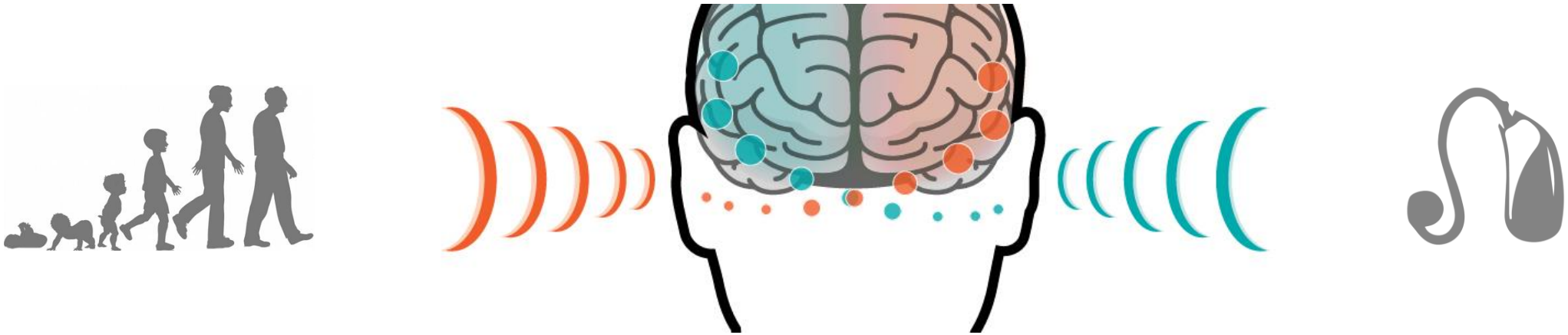

Neural tracking of continuous speech is exaggerated in healthy aging and hearing impaired adults

The neural mechanisms underlying speech-in-noise problems

Lien Decruy, Jonas Vanthornhout, Stefanie E. Kuchinsky, Samira Anderson, Jonathan Z. Simon, Tom Francart

Contact: liendecruy@gmail.com

Speech-in-noise difficulties

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Main cause = Age-Related Hearing Loss, **BUT** these problems are not fully resolved for:

- people with hearing aids
- people with clinically normal hearing thresholds

(Dillon 2001 (Hearing Aids); Humes et al. 2013 (Front Syst Neurosci))

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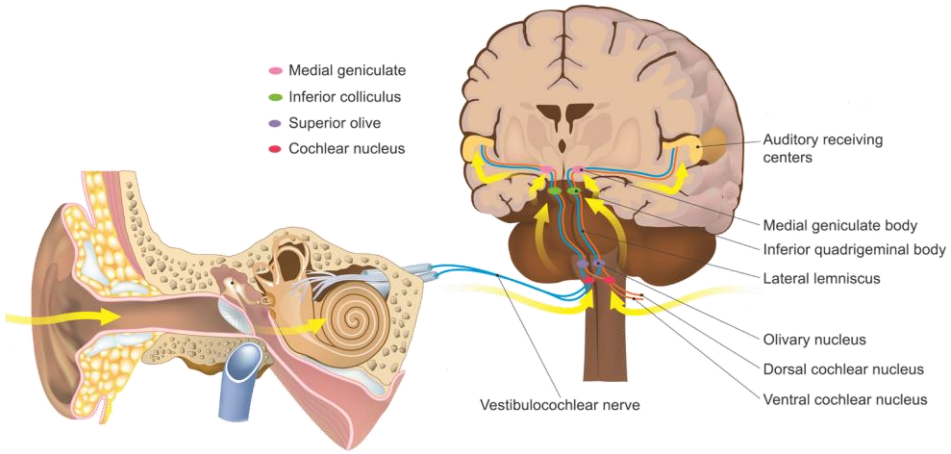

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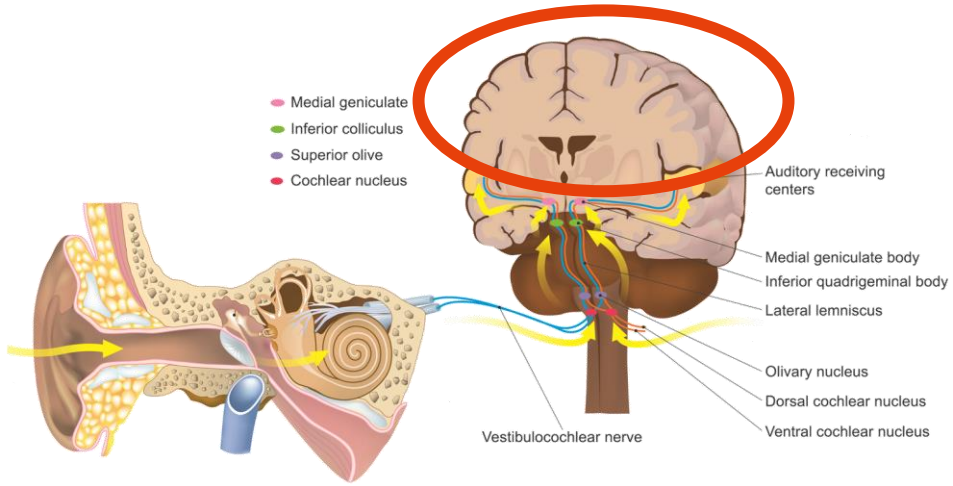

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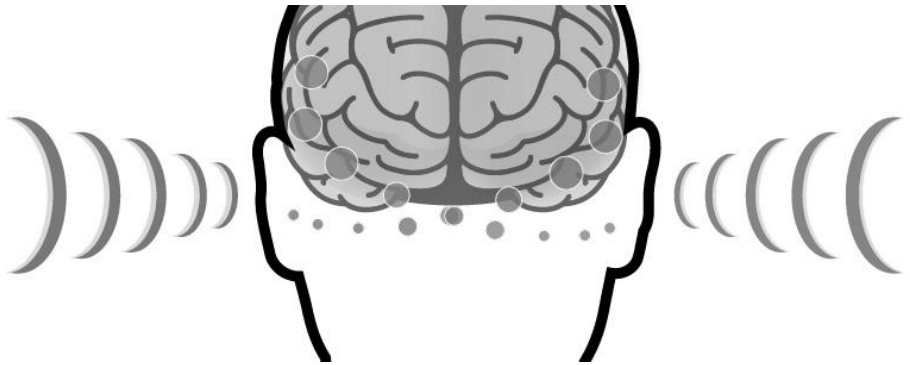

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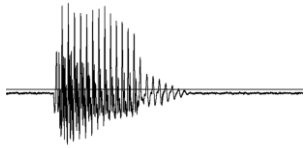

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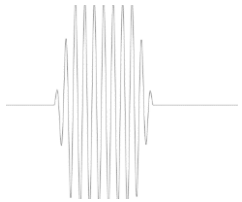

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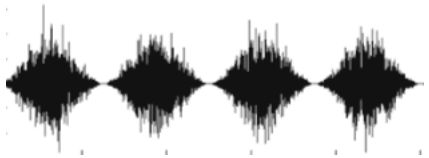

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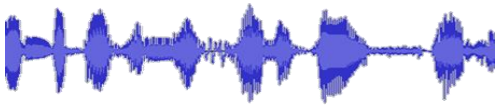

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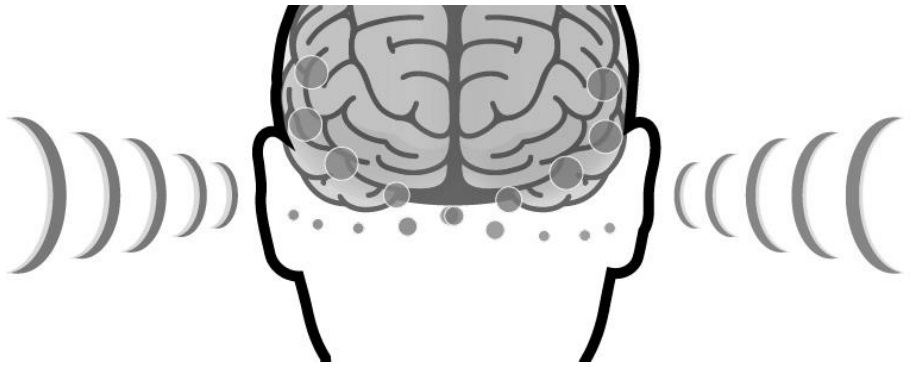

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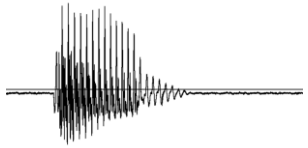

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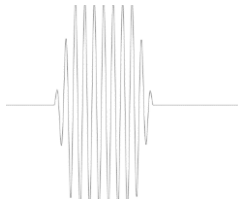

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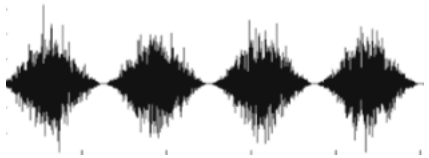

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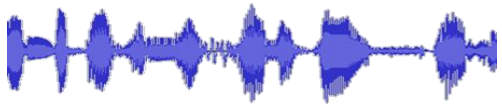

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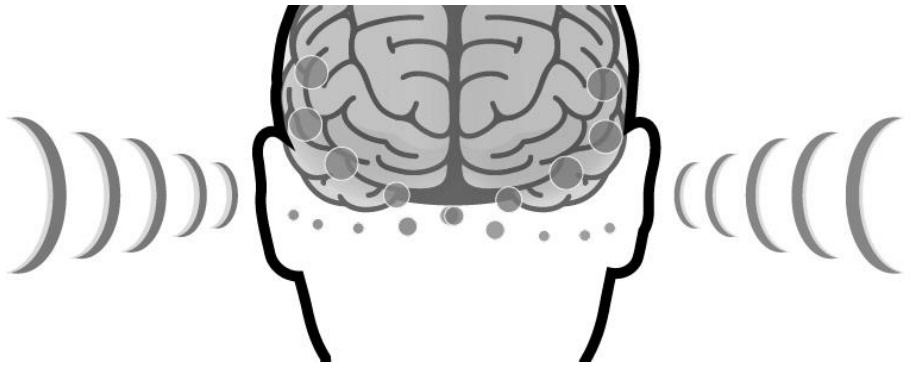

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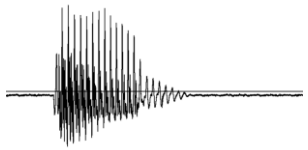

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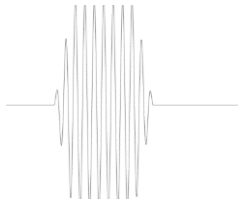

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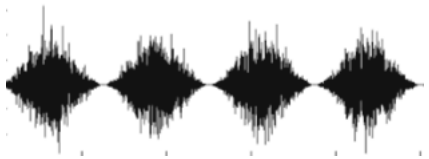

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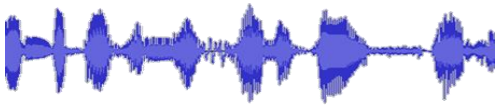

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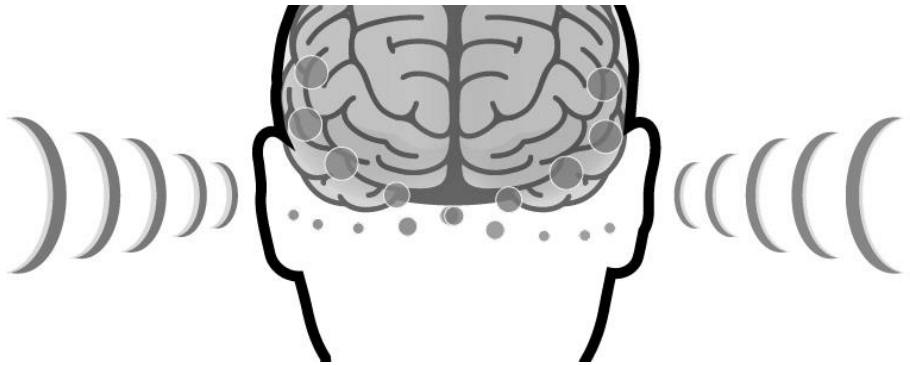

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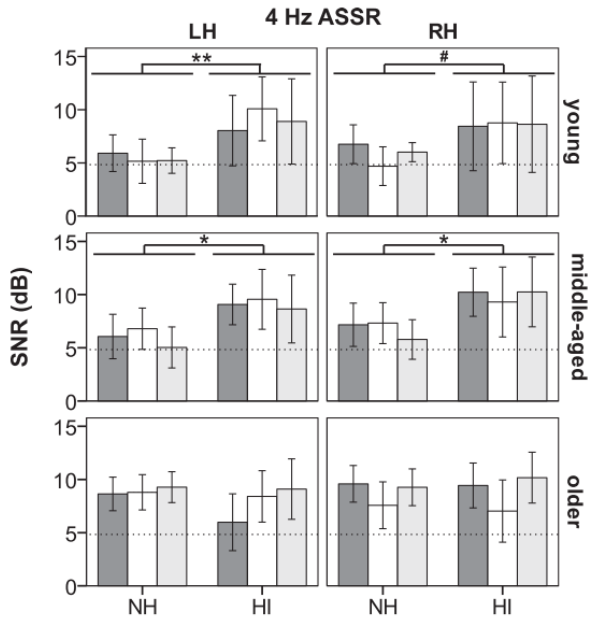

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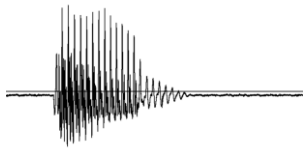

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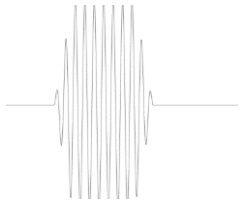

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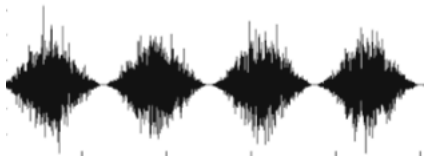

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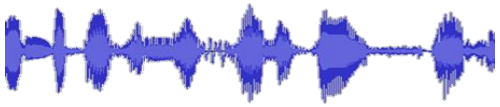

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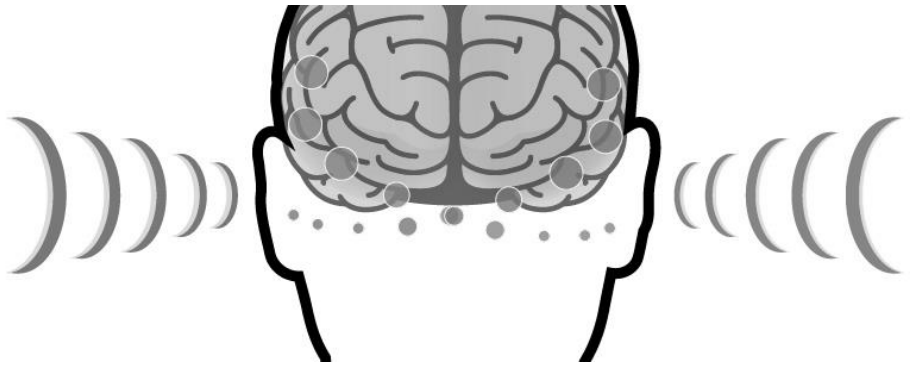

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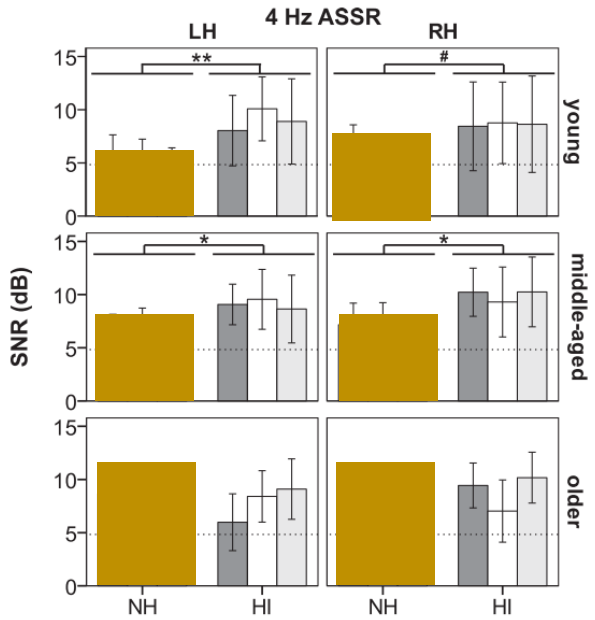

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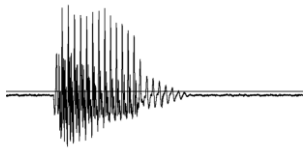

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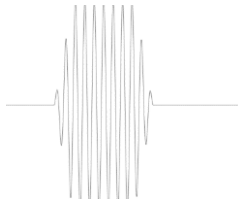

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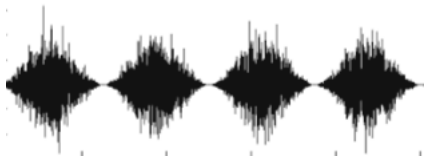

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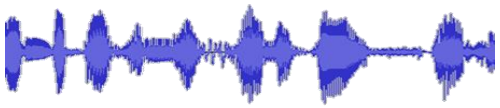

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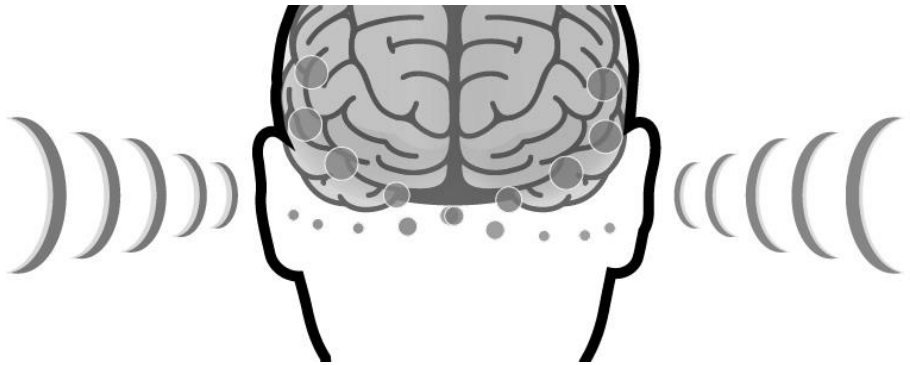

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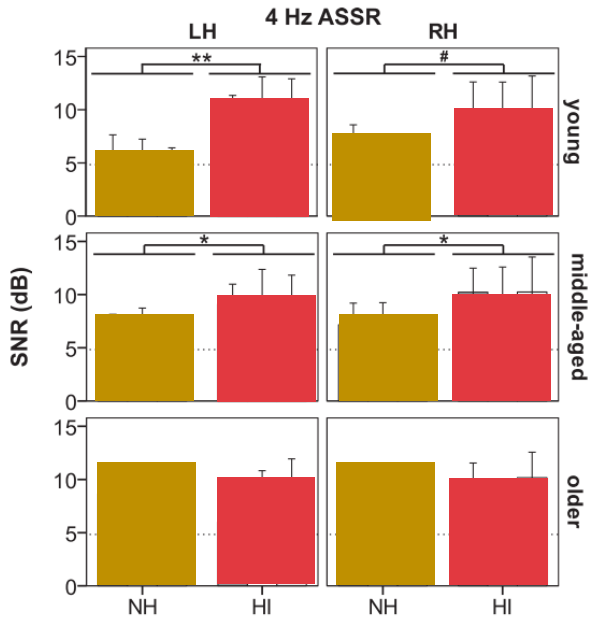

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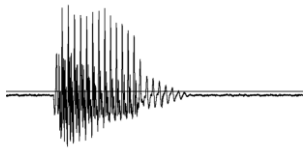

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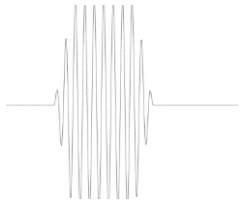

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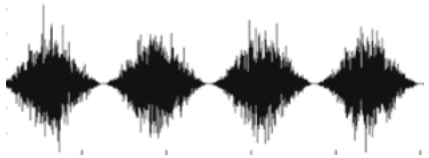

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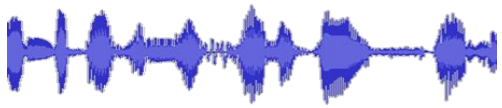

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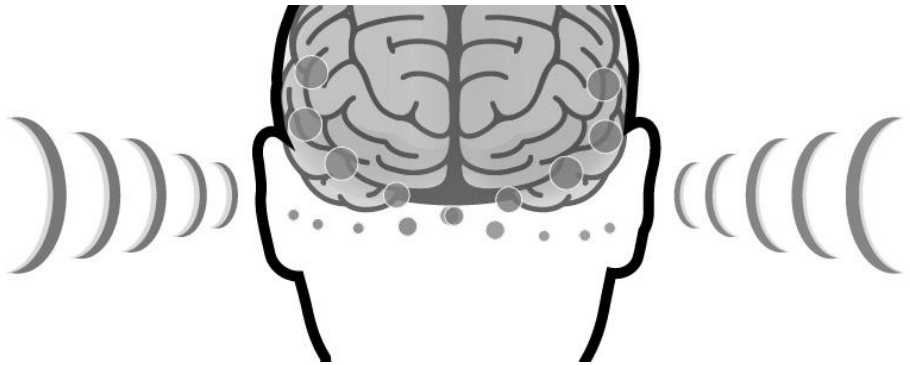

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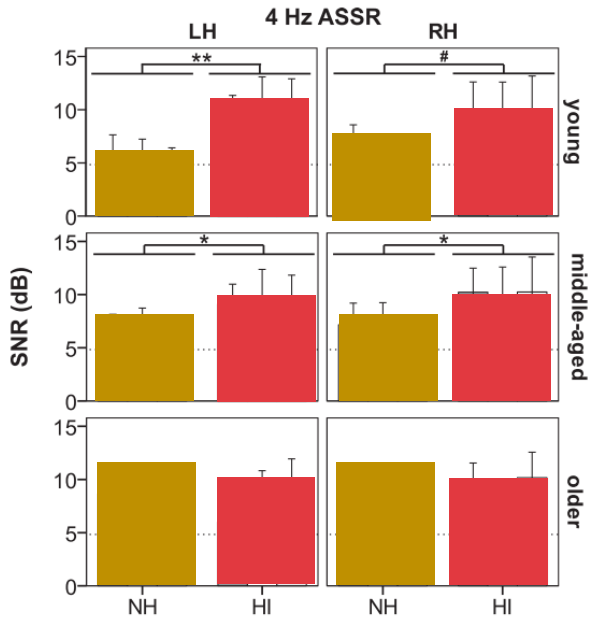
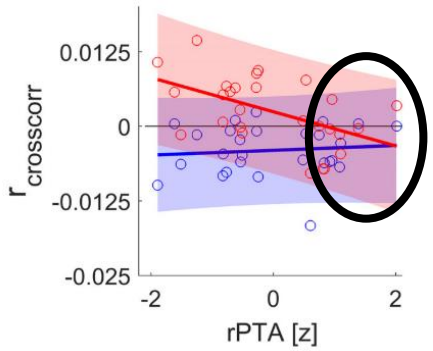




Petersen et al. 2017 (J. Neurophysiol)

- Higher degree of hearing loss => FG ~ BG.
- HI adults cannot ignore the BG speaker

RESEARCH DESIGN / METHODS

KU Leuven

54 NH adults (17-82 years)
14 HI adults (21-82 years)

Listen to two competing audiobooks (monaural)

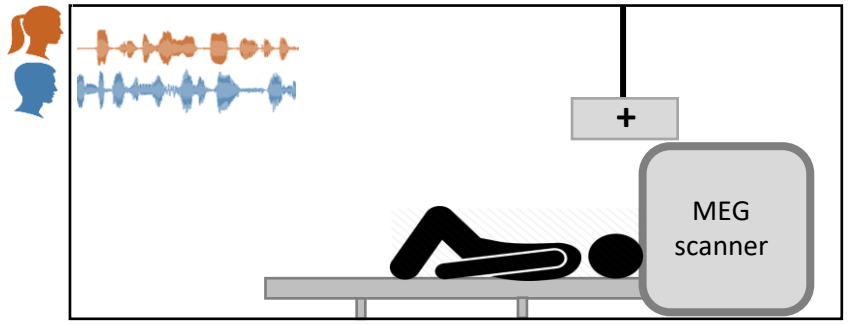
SNRs:
- Quiet, **0 dB**, SRT + 4 dB, SRT, SRT - 4 dB

Data collection & Analysis:
- EEG
- Backward and Forward Model
- PCA (dimensionality reduction)

University of Maryland

14 YNH (17-26 years) & 15 ONH (65+) adults
14 OHI (62-86 years) adults

Listen to two competing audiobooks (diotic)



SNRs:
- Quiet, **0 dB**, -6 dB

Data collection & Analysis:
- MEG
- Backward and Forward Model
- DSS (noise and dimensionality reduction)

Neural responses to the envelope of continuous speech:

Backward (stimulus reconstruction / decoder) and Forward (M/EEG prediction / TRF) model

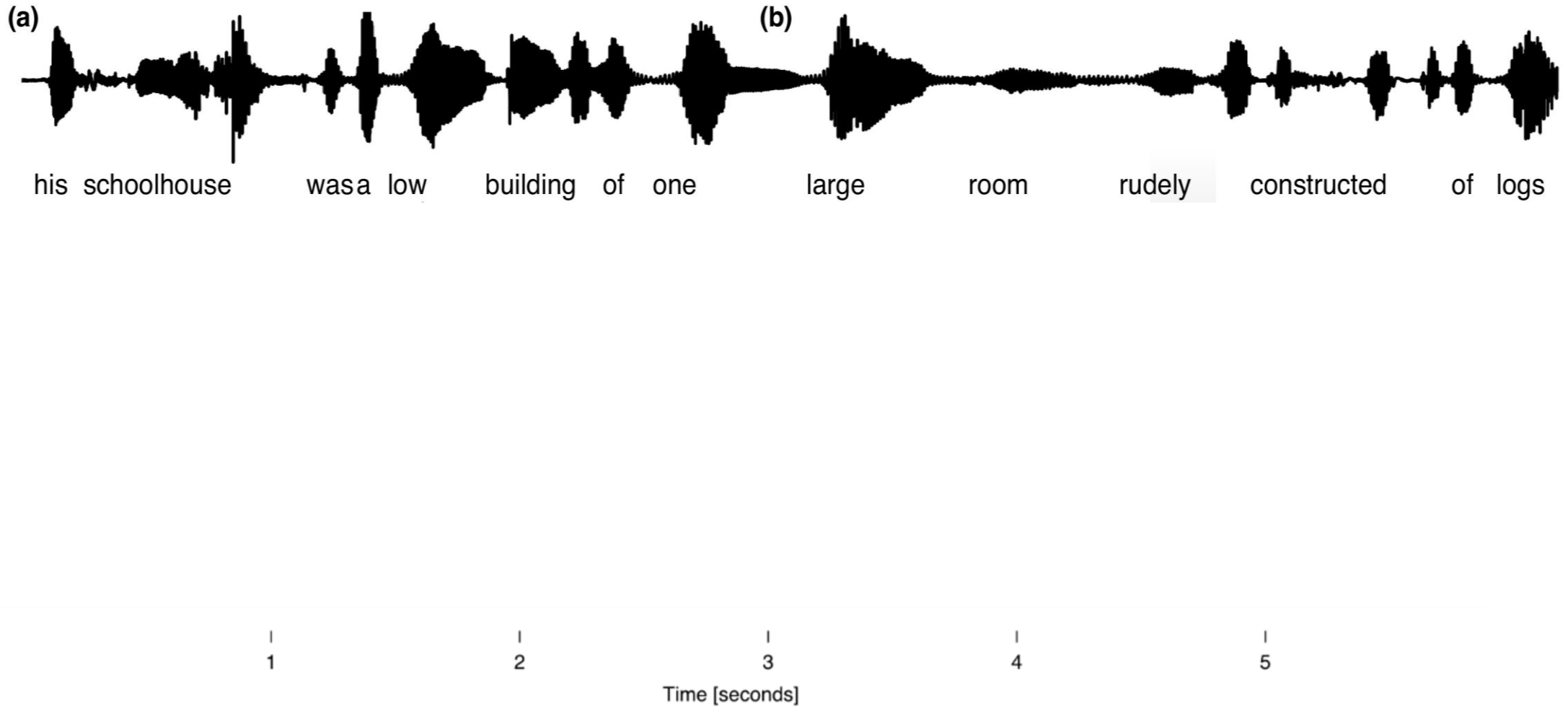


Figure “Models for analyzing speech tracking” by Brodbeck & Simon 2020 (Current Opinion in Physiology https://doi.org/10.1016/j.cophys.2020.07.014)

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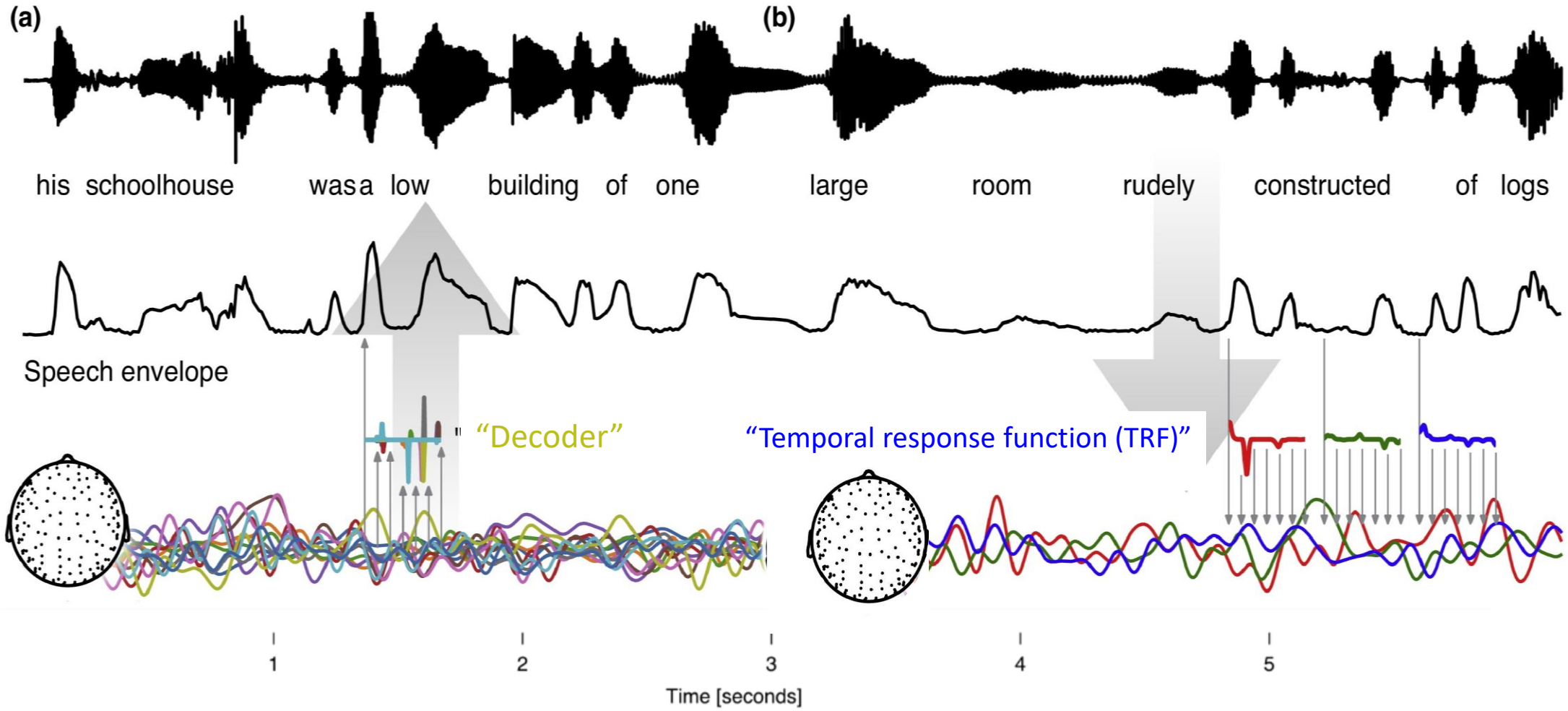

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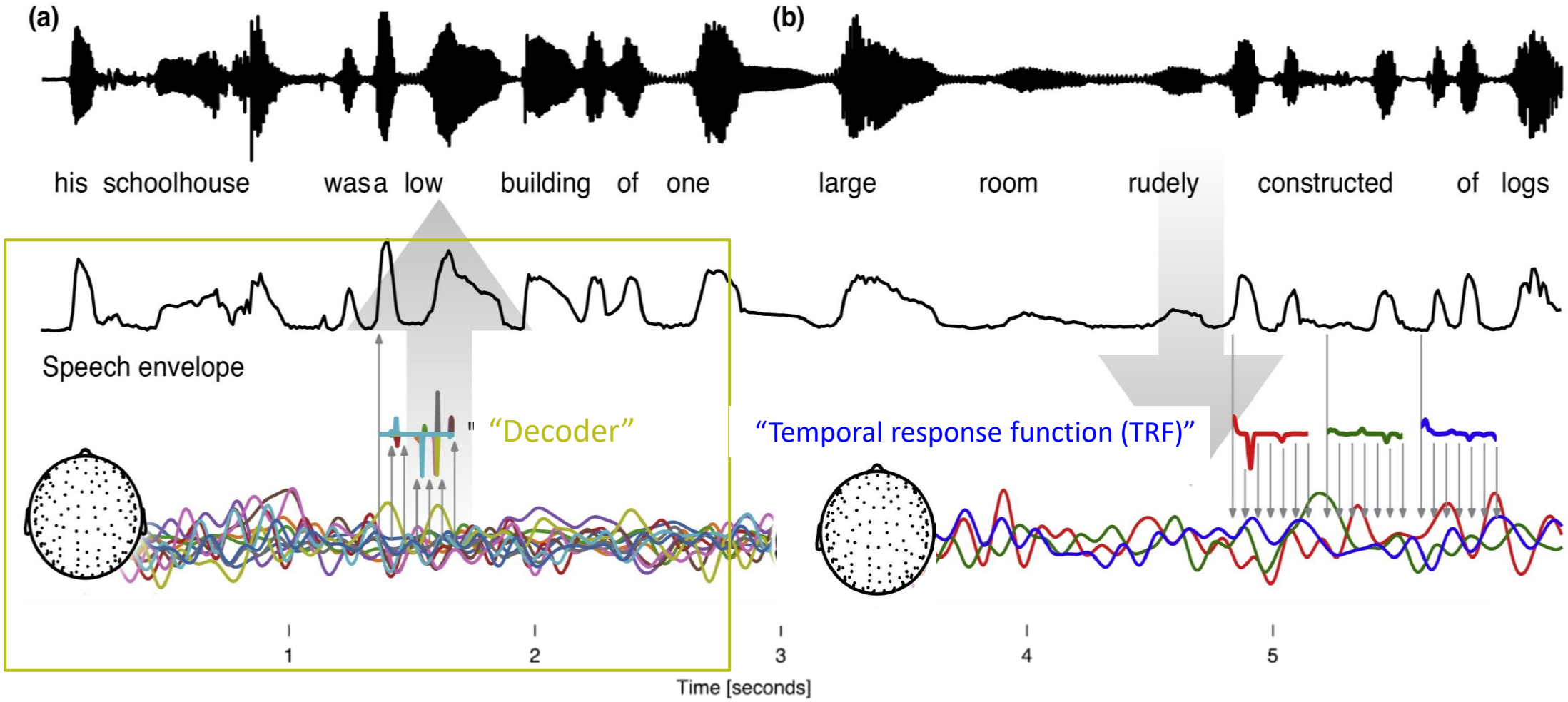

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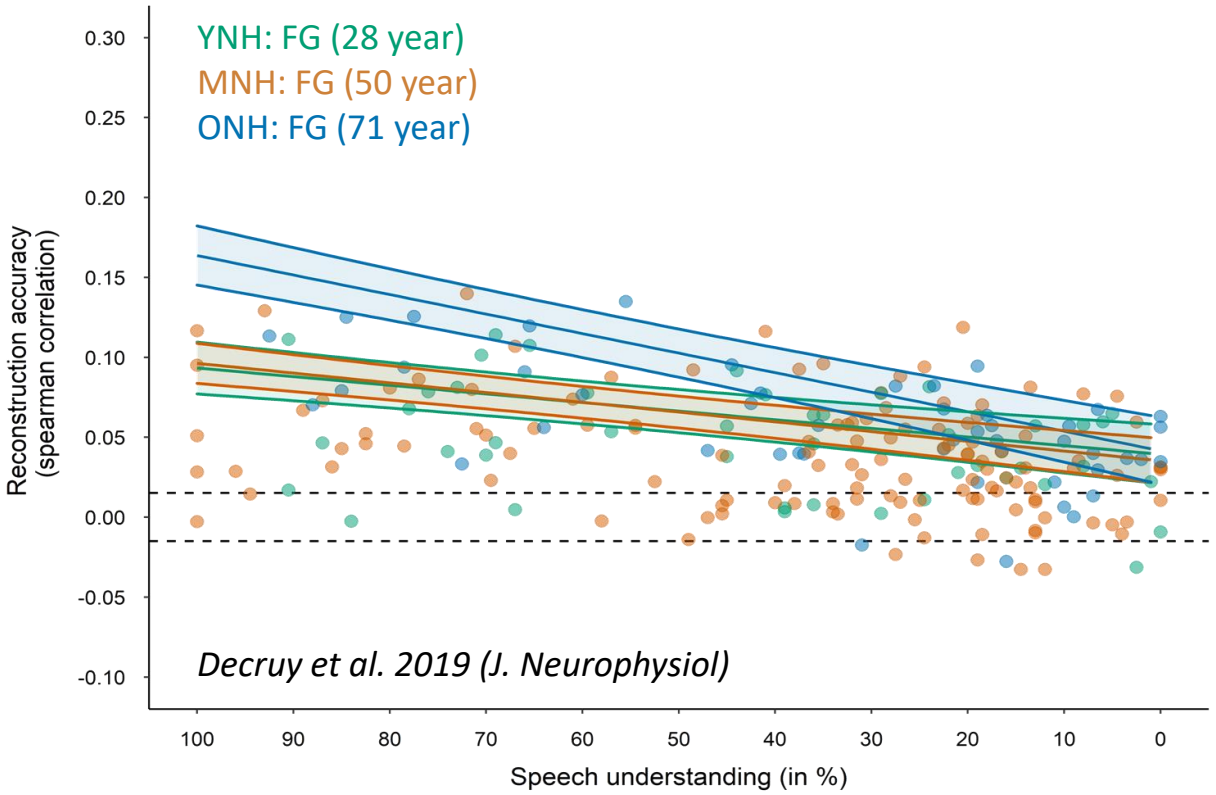
RESULTS: Effect of aging, SNR and attention on envelope tracking

KU Leuven (EEG)



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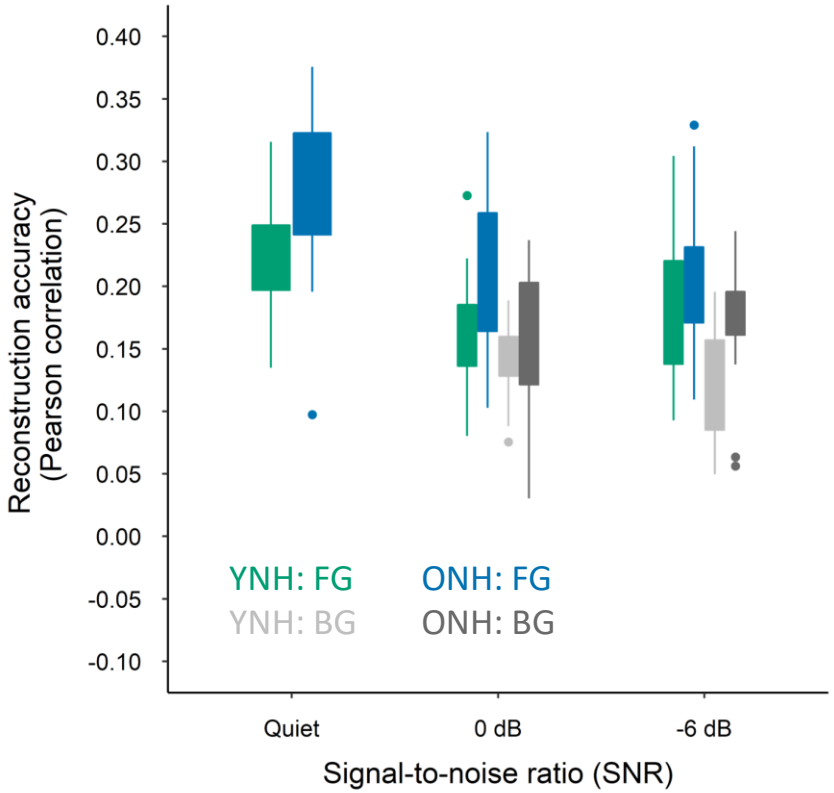

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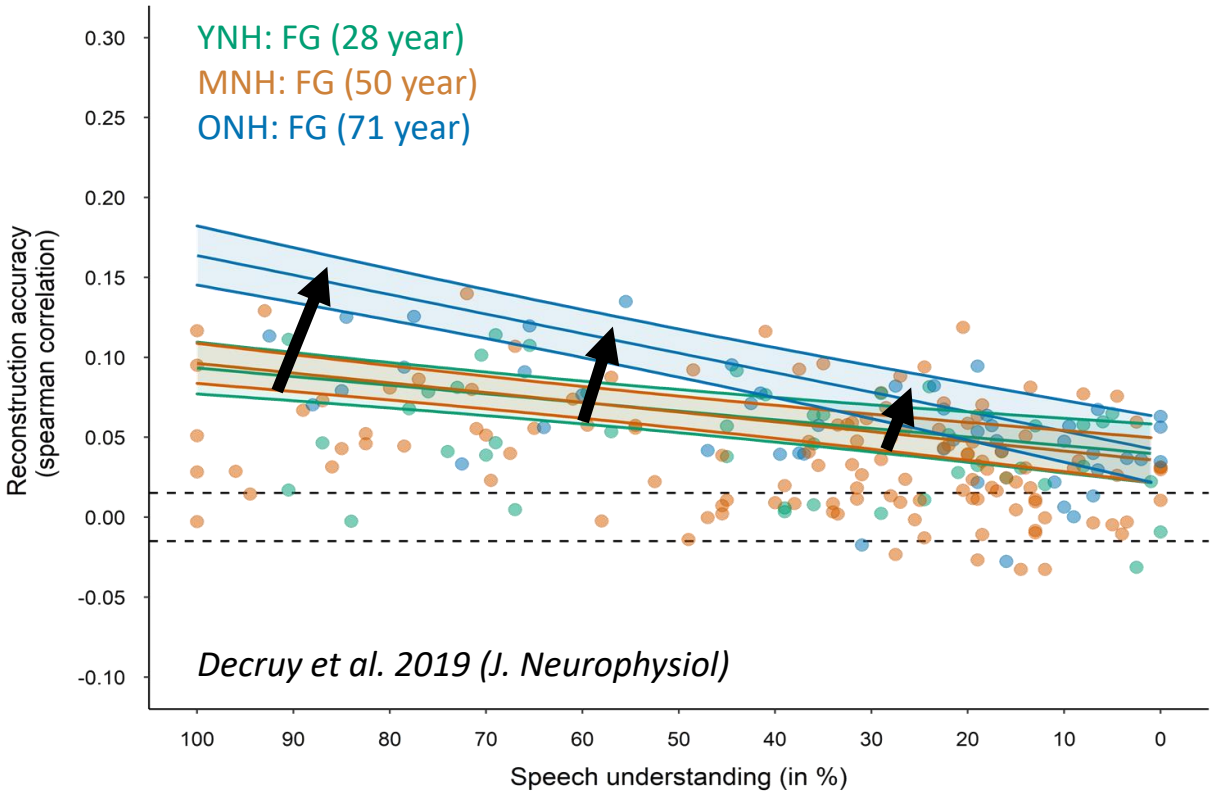

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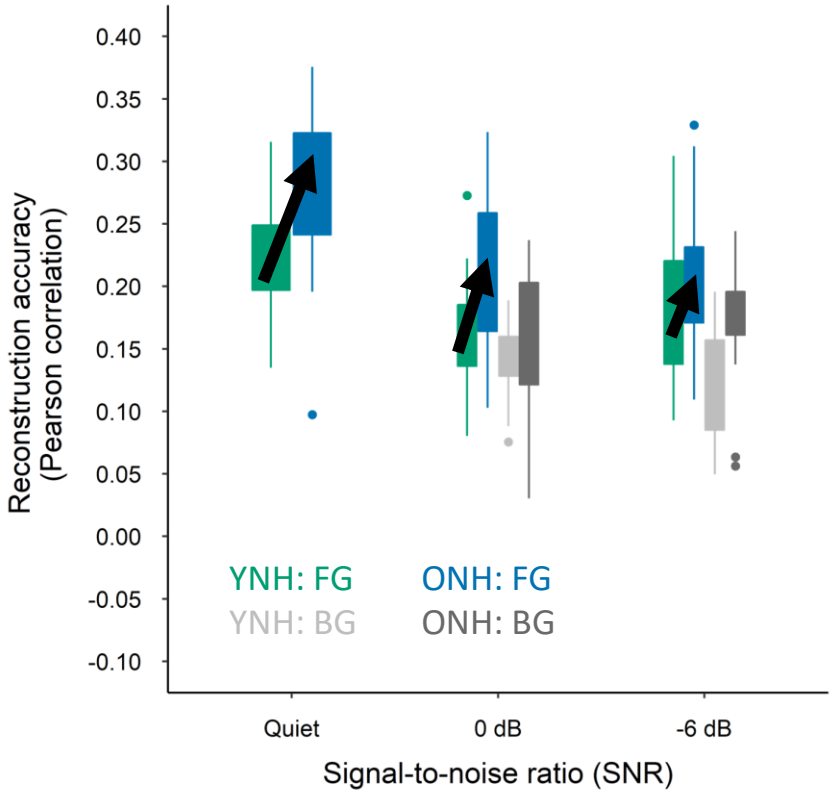

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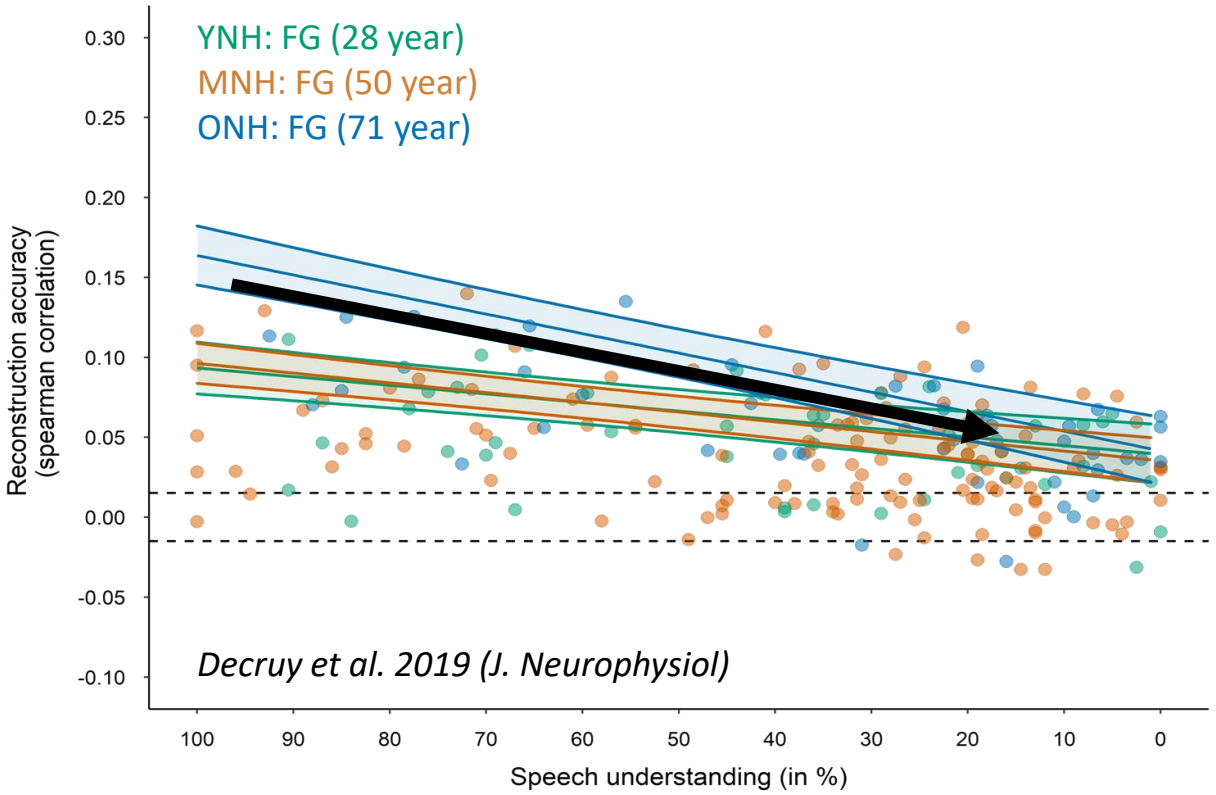

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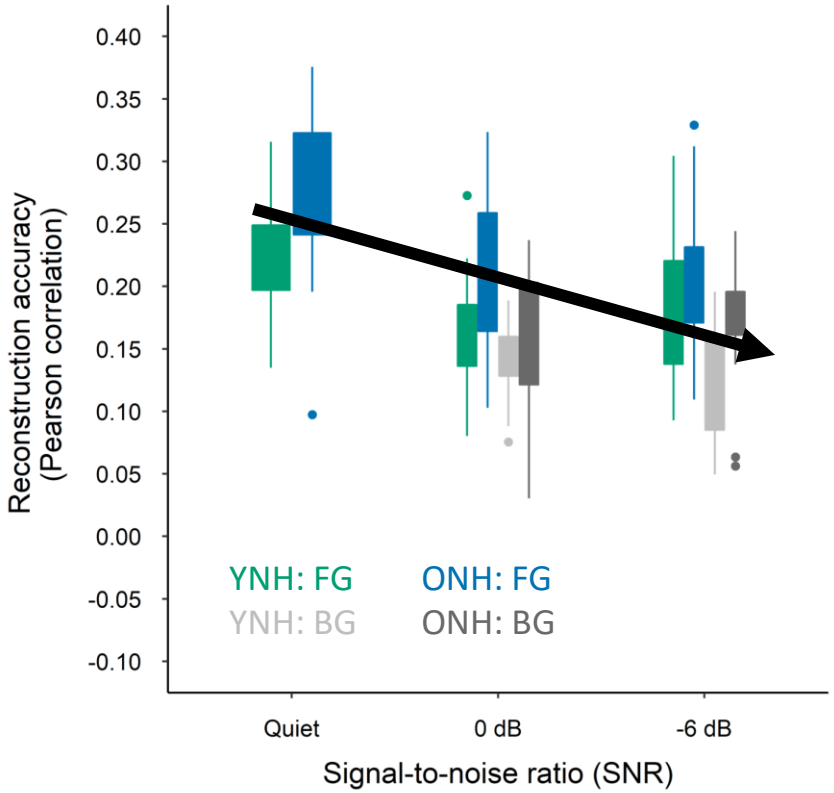

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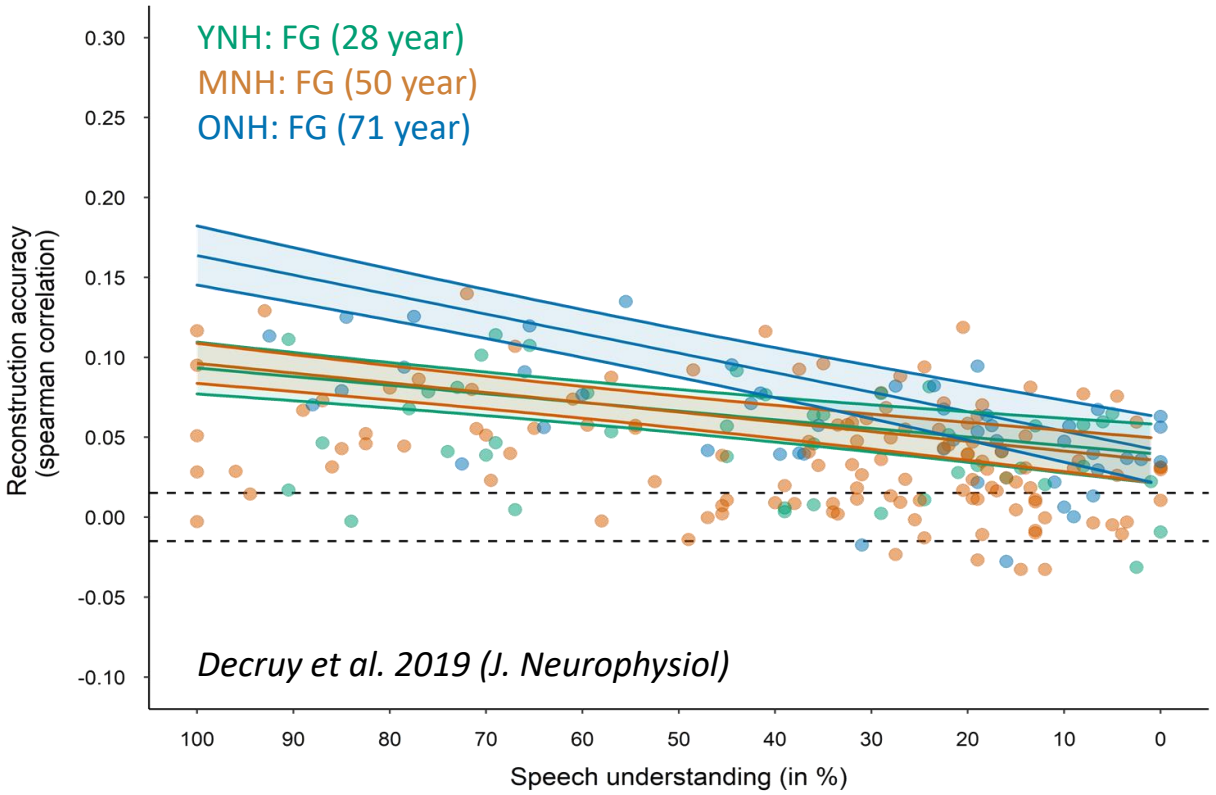
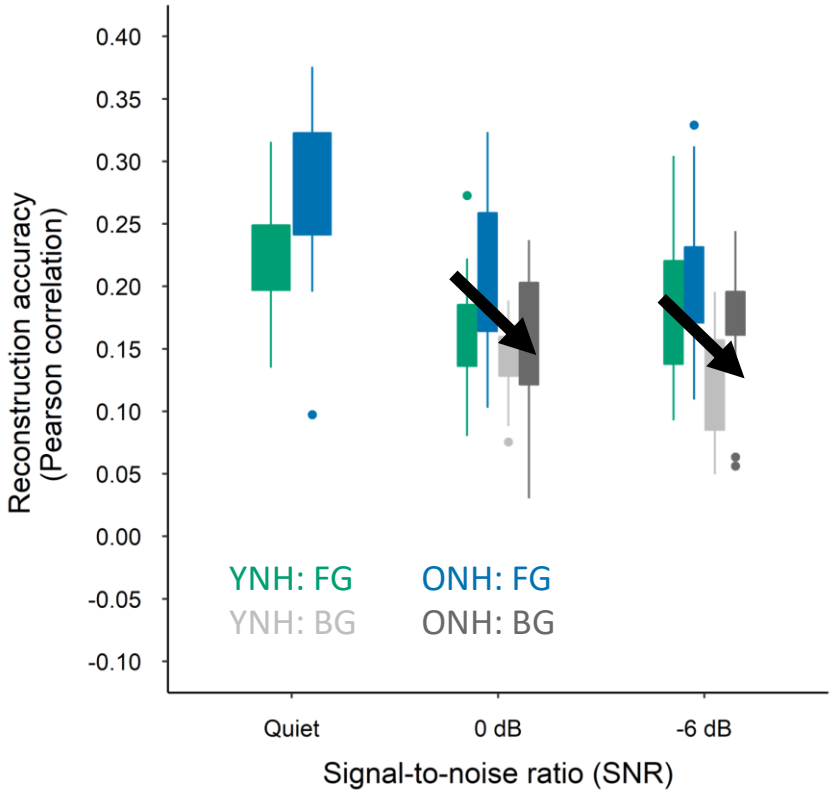
- Reconstruction accuracy ↓ with decreasing speech understanding / SNR

RESULTS: Effect of aging, SNR and attention on envelope tracking

KU Leuven (EEG)



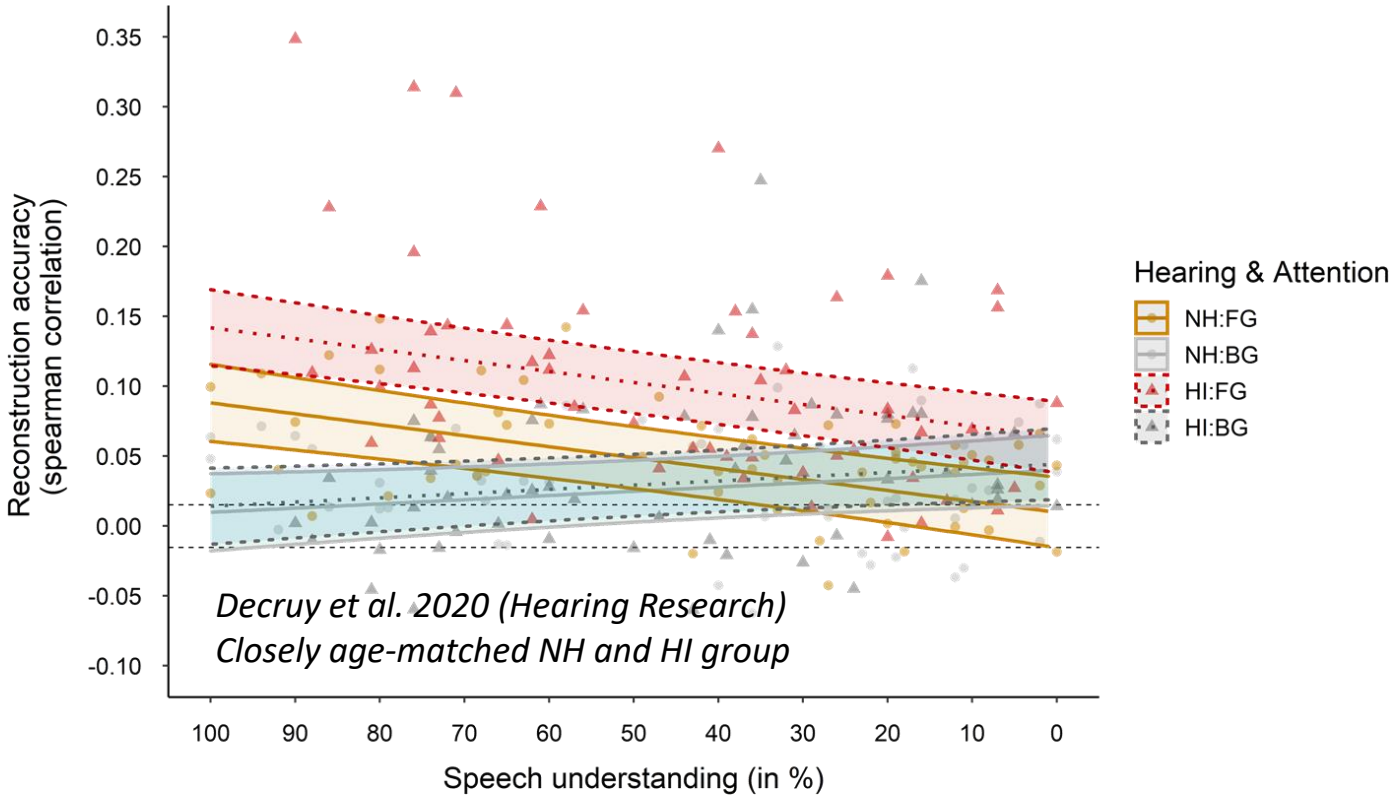
University of Maryland (MEG)



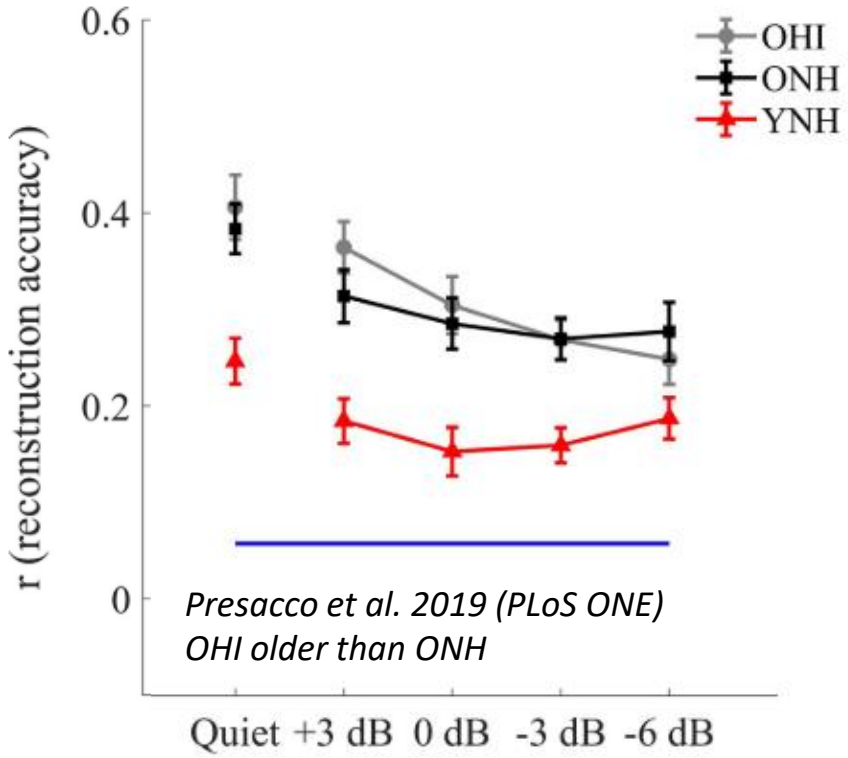
- Reconstruction accuracy for ONH > YNH (and MNH)
  but this exaggeration diminishes with decreasing SNR
- Reconstruction accuracy ↓ with decreasing speech understanding / SNR
- All groups show a better representation of Foreground (FG) versus Background (BG)

RESULTS: Effect of hearing loss, SNR and attention on envelope tracking

KU Leuven (EEG)



University of Maryland (MEG)



RESULTS: Effect of hearing loss, SNR and attention on envelope tracking

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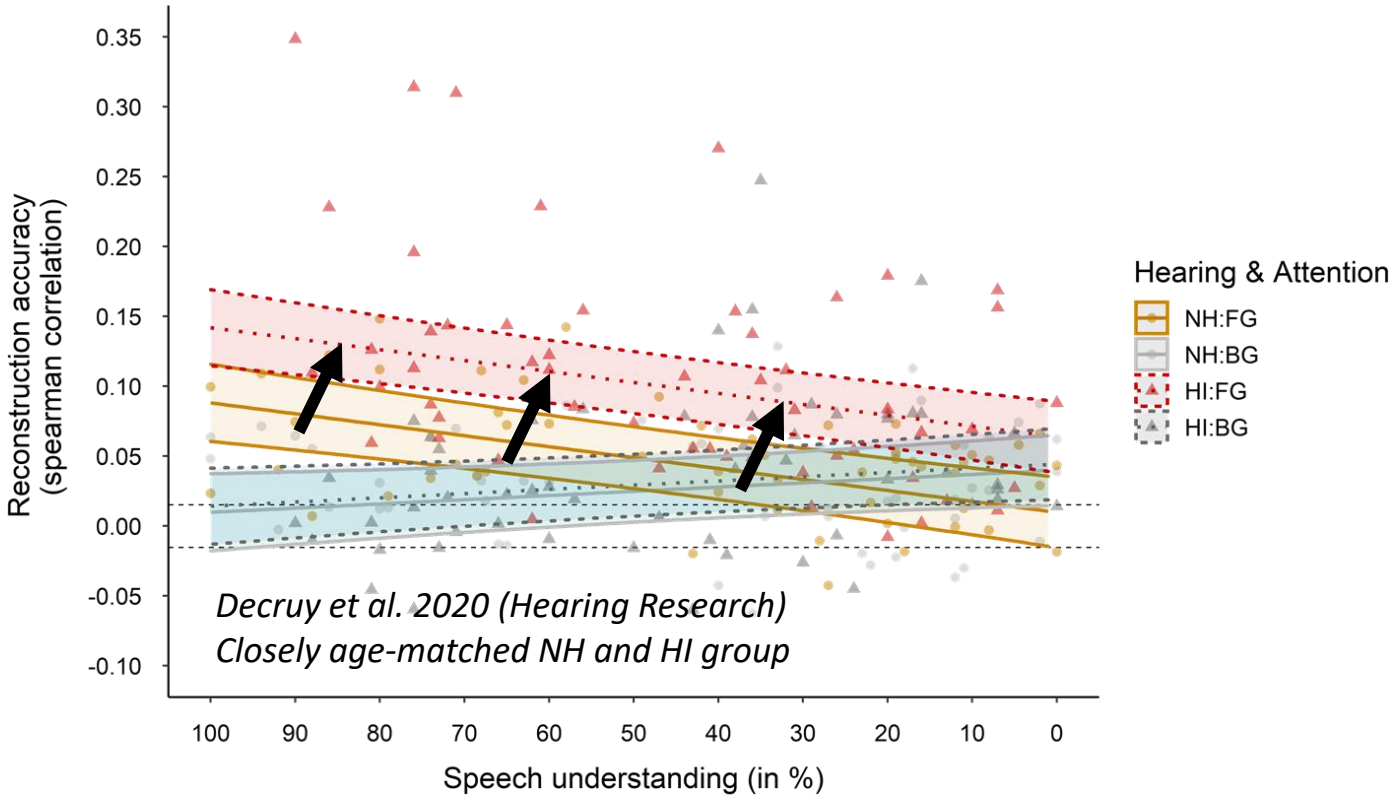

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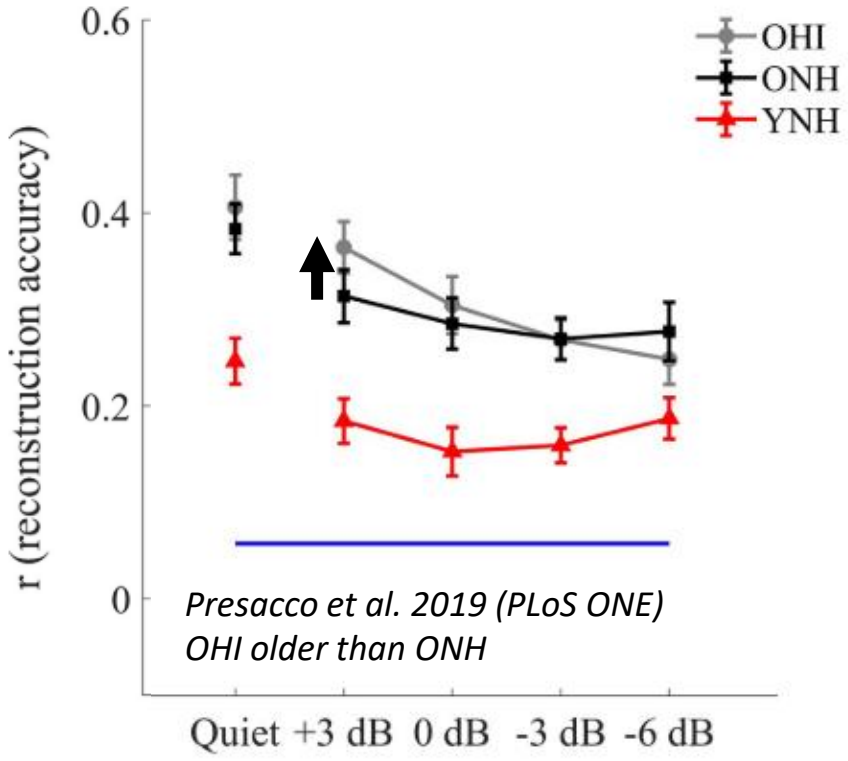
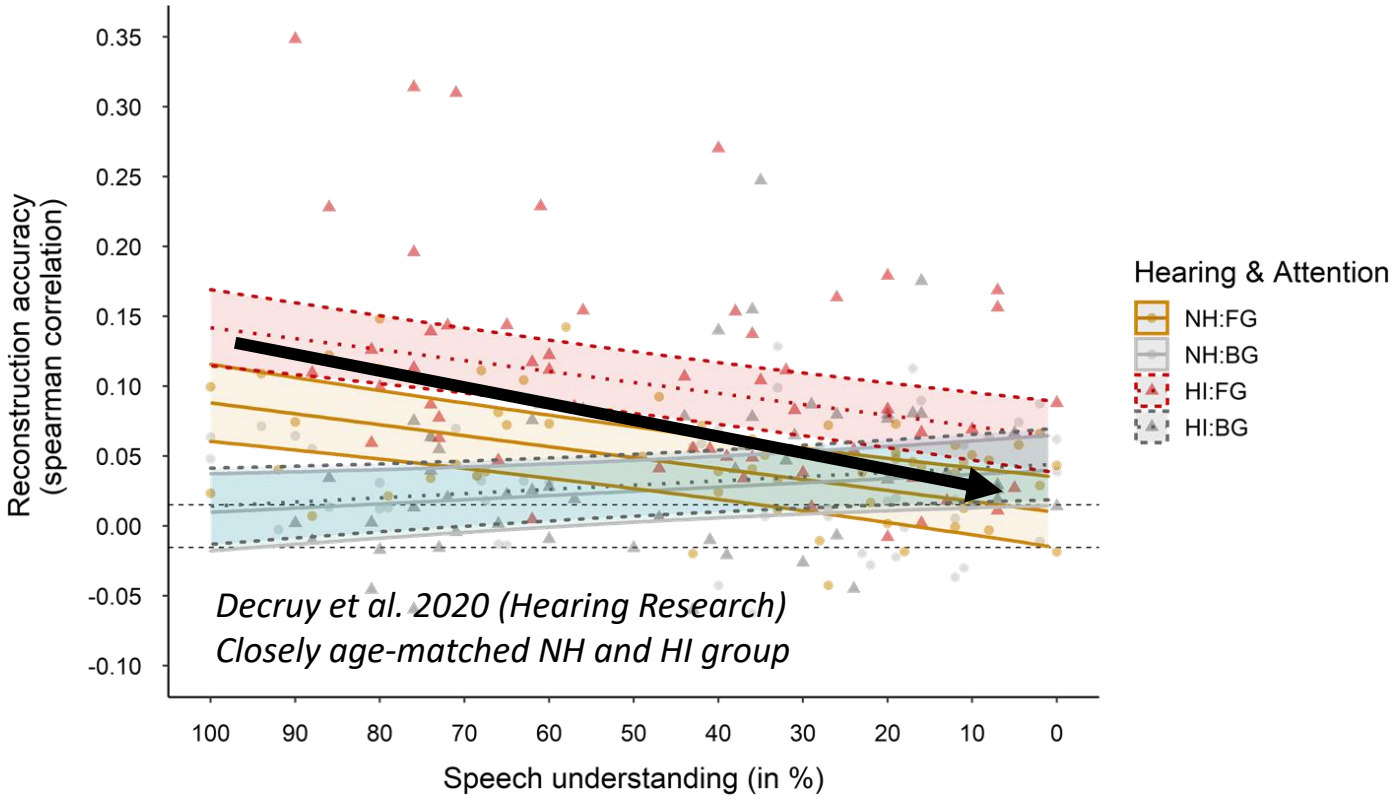


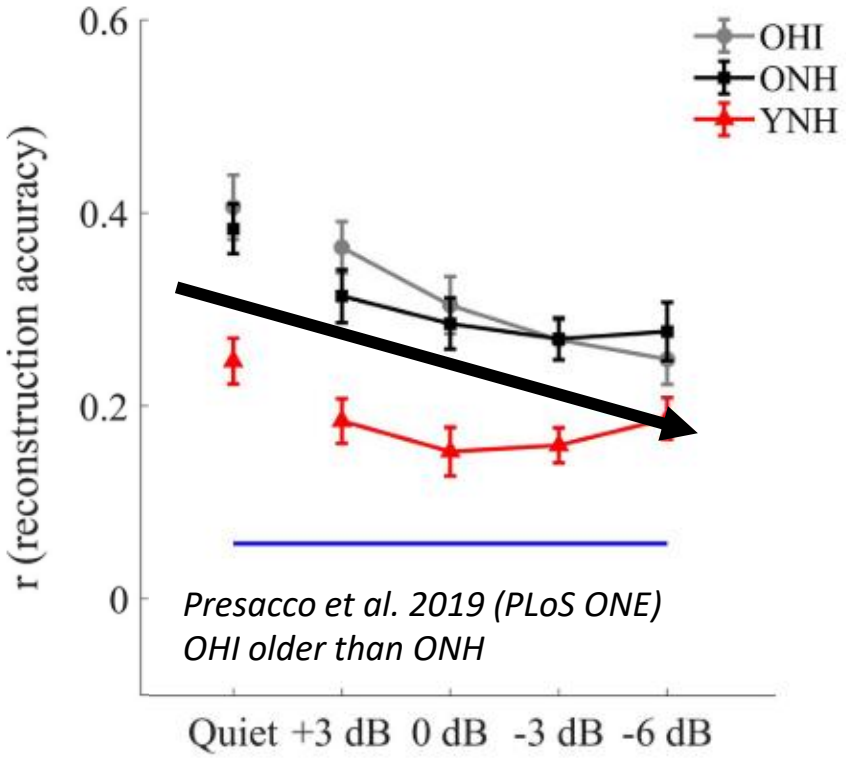
- Reconstruction accuracy for HI > NH (independent of SNR)

RESULTS: Effect of hearing loss, SNR and attention on envelope tracking

KU Leuven (EEG)



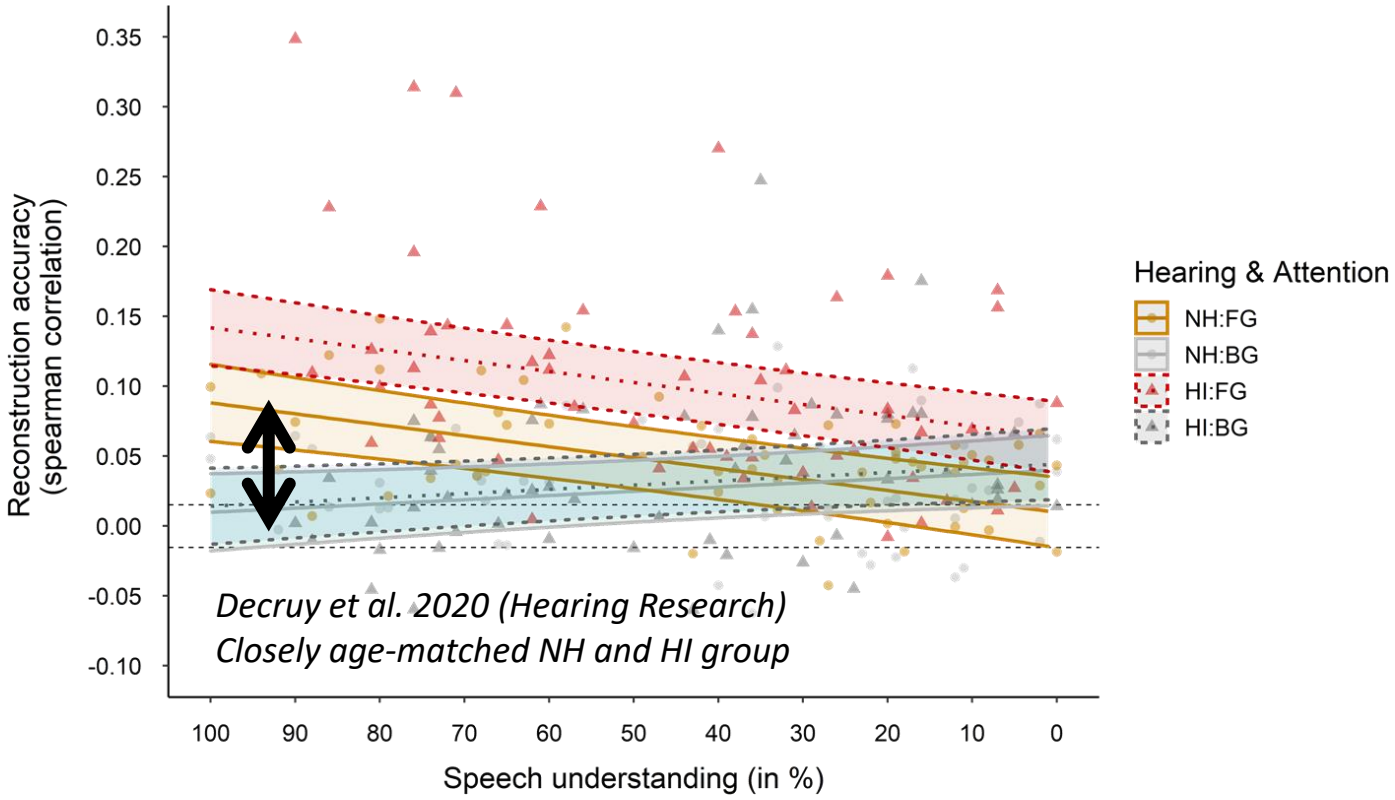
University of Maryland (MEG)



- Reconstruction accuracy for HI > NH (independent of SNR)
- Reconstruction accuracy for Foreground ↓ with decreasing SNR

RESULTS: Effect of hearing loss, SNR and attention on envelope tracking

KU Leuven (EEG)



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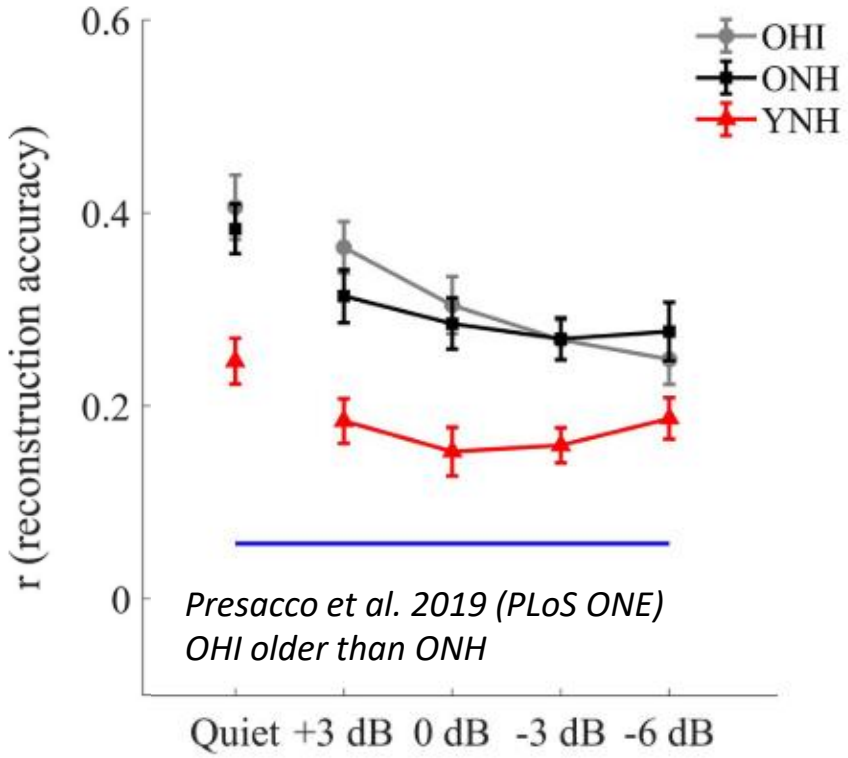


- Reconstruction accuracy for HI > NH (independent of SNR)
- Reconstruction accuracy for Foreground ↓ with decreasing SNR
- Both NH and HI show a better representation of Foreground (FG) versus Background (BG)

Neural responses to the envelope of continuous speech:

Backward (stimulus reconstruction / decoder) and Forward (M/EEG prediction / TRF) model

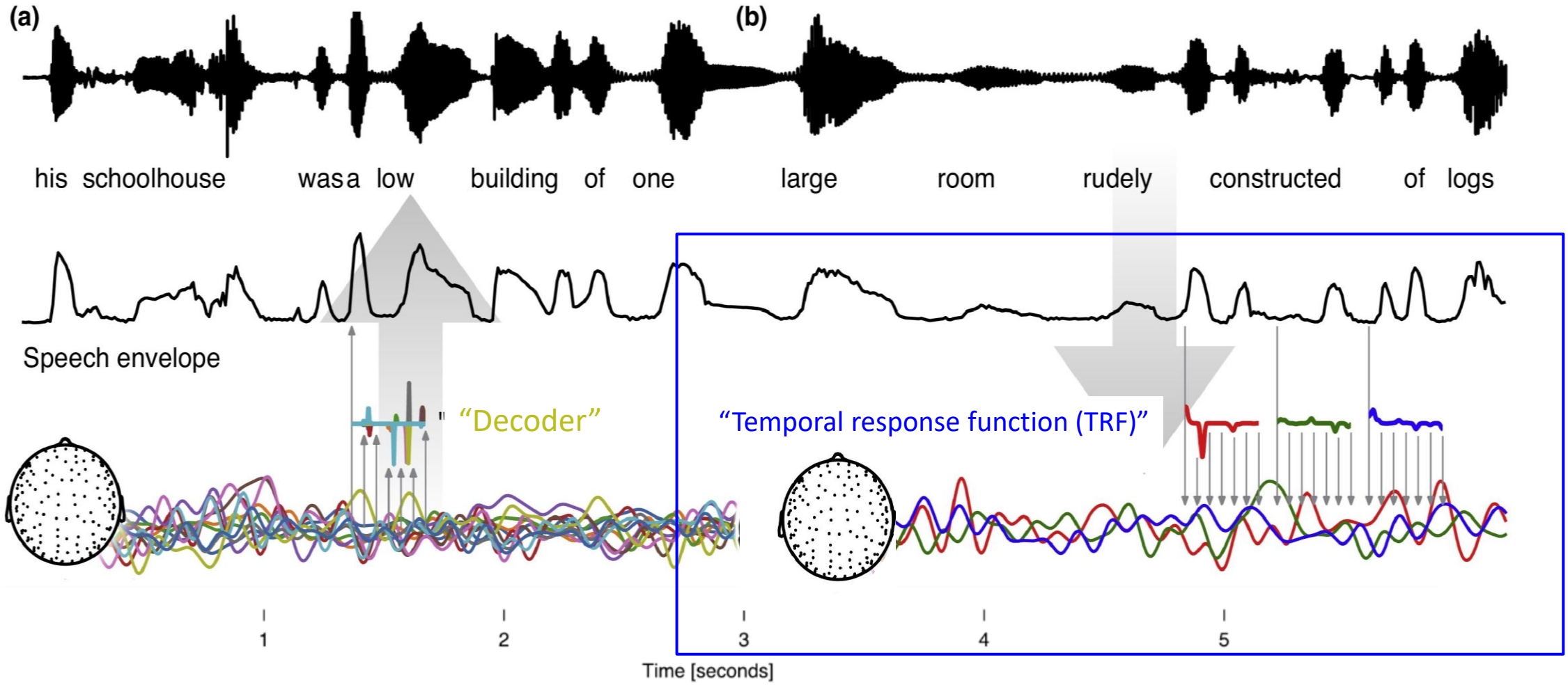
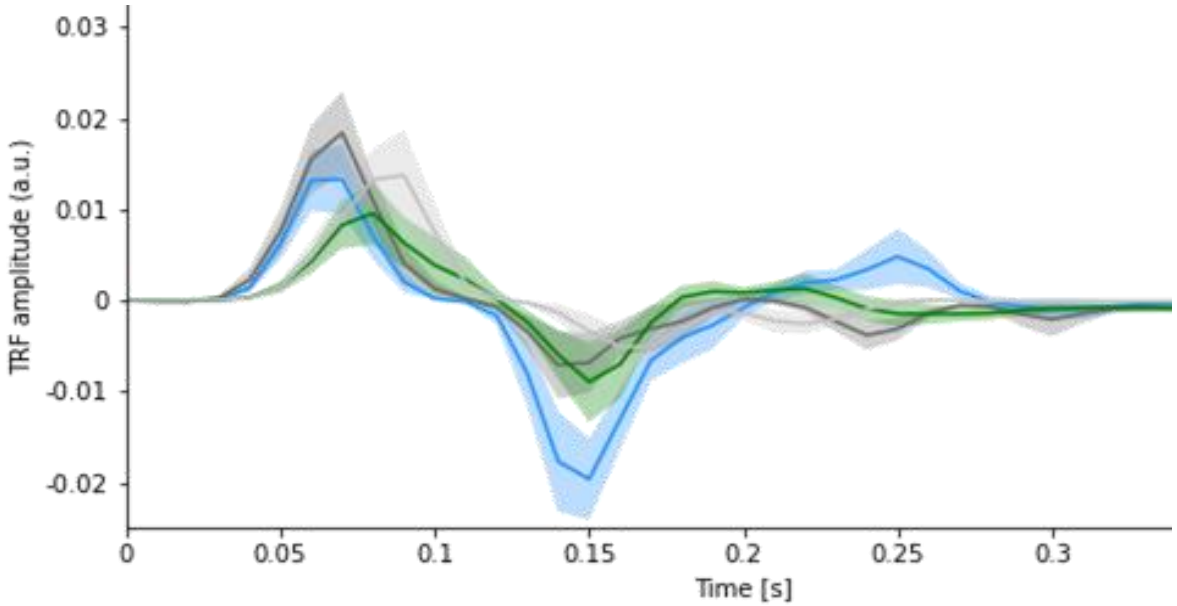


Figure "Models for analyzing speech tracking" by Brodbeck & Simon 2020 (Current Opinion in Physiology https://doi.org/10.1016/j.cophys.2020.07.014)

RESULTS: Effect of aging and attention on envelope tracking

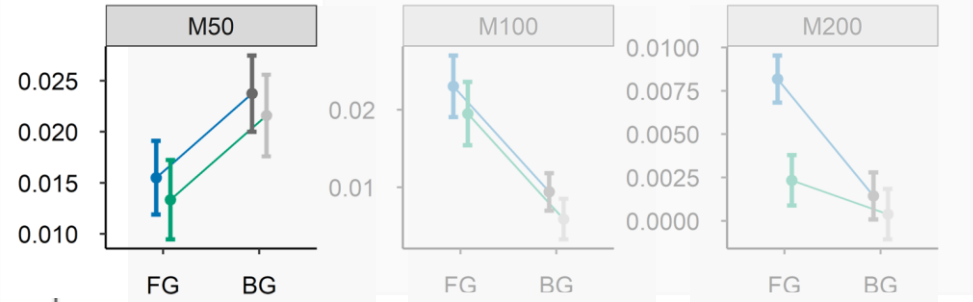
ONH: FG
YNH: FG

ONH: BG
YNH: BG



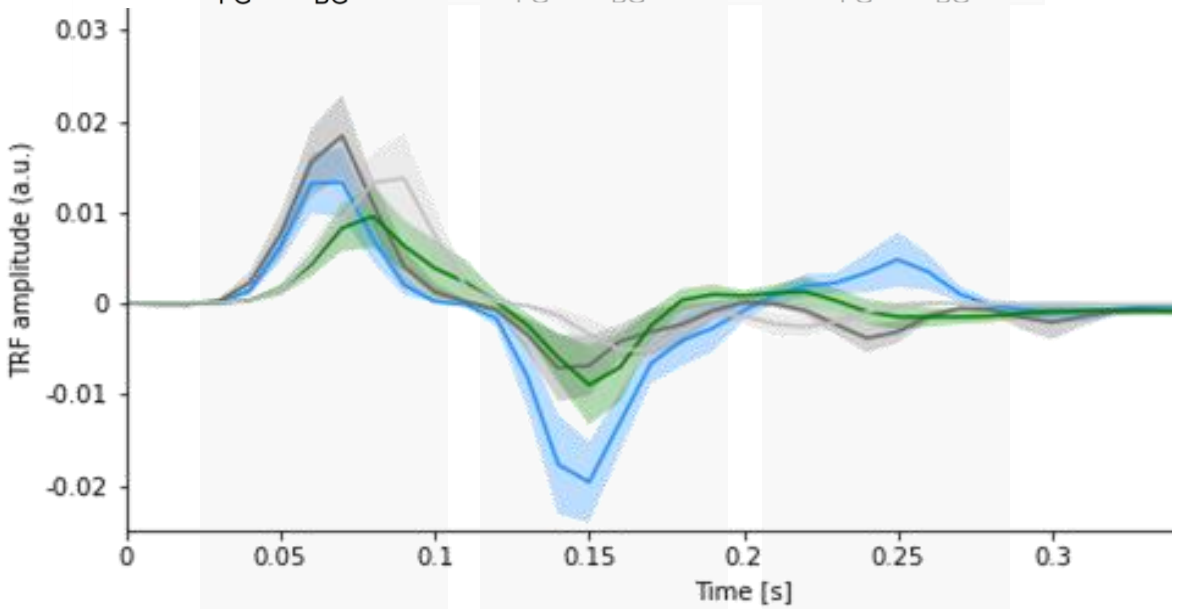
RESULTS: Effect of aging and attention on envelope tracking

TRF Amplitude
absolute value (a.u.)



ONH: FG
YNH: FG

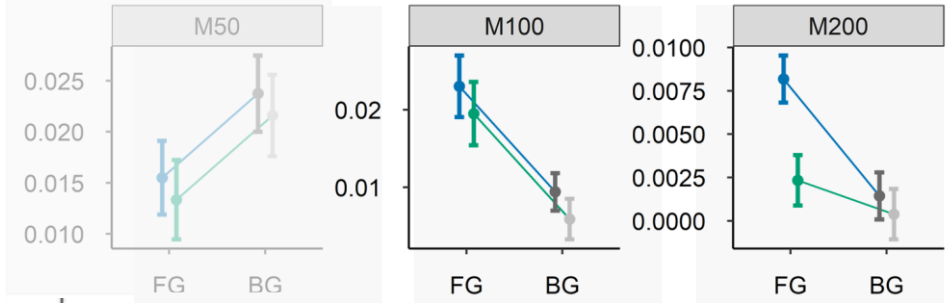
ONH: BG
YNH: BG



- M50: FG < BG (no significant effect of age)

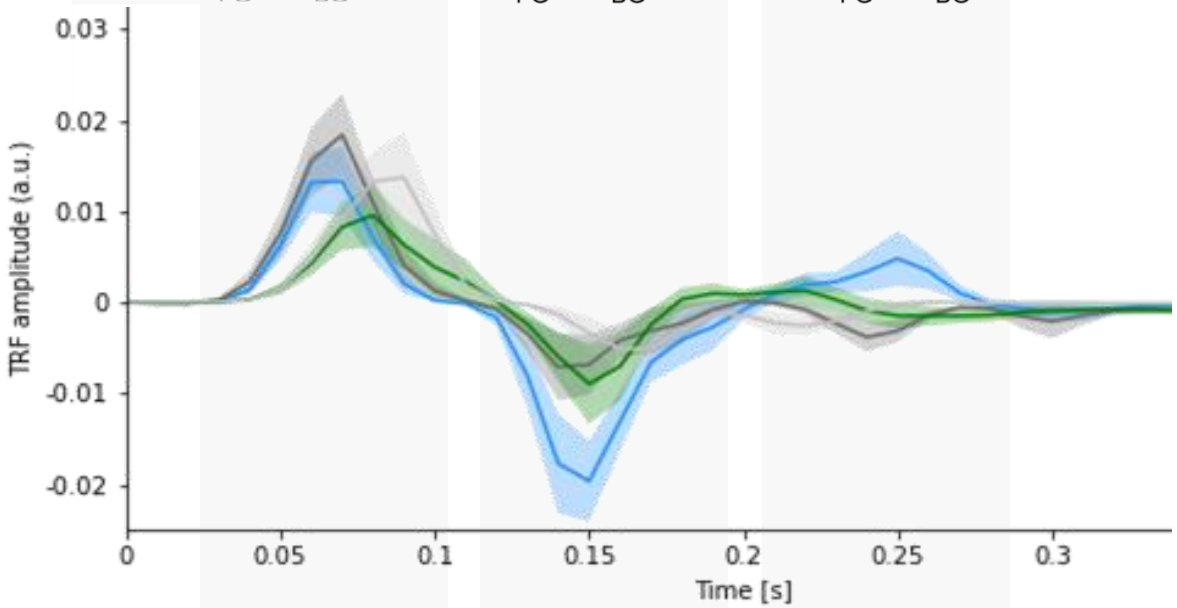
RESULTS: Effect of aging and attention on envelope tracking

TRF Amplitude
absolute value (a.u.)



ONH: FG
YNH: FG

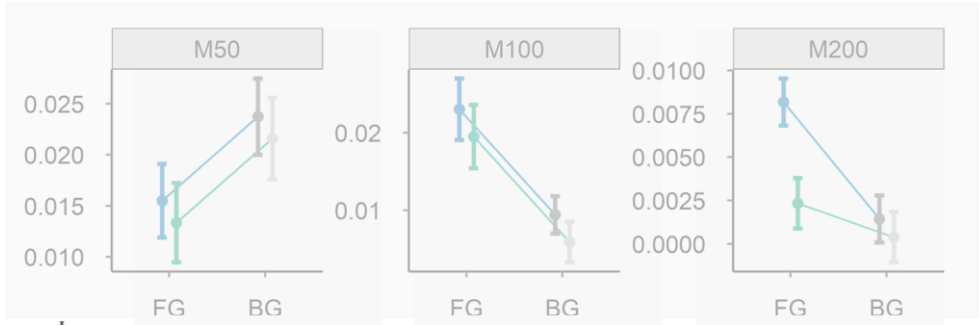
ONH: BG
YNH: BG



- M50: FG < BG (no significant effect of age)
- M100 and M200: FG > BG
- M200 FG: older > younger adults (exaggeration)

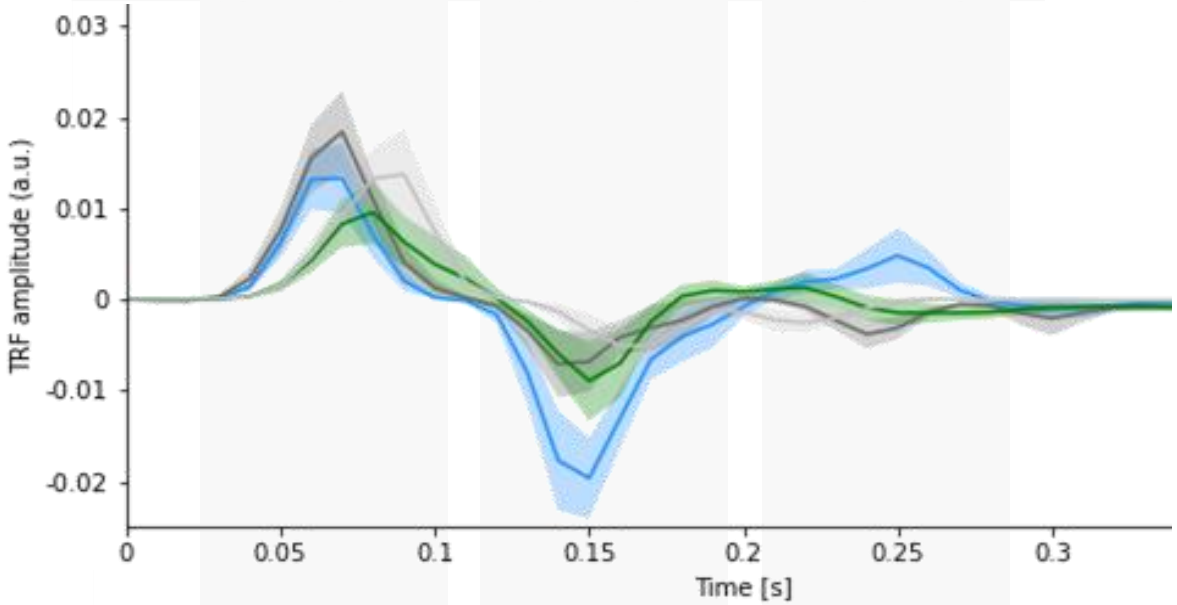
RESULTS: Effect of aging and attention on envelope tracking

TRF Amplitude
absolute value (a.u.)



ONH: FG
YNH: FG

ONH: BG
YNH: BG



- M50: FG < BG (no significant effect of age)
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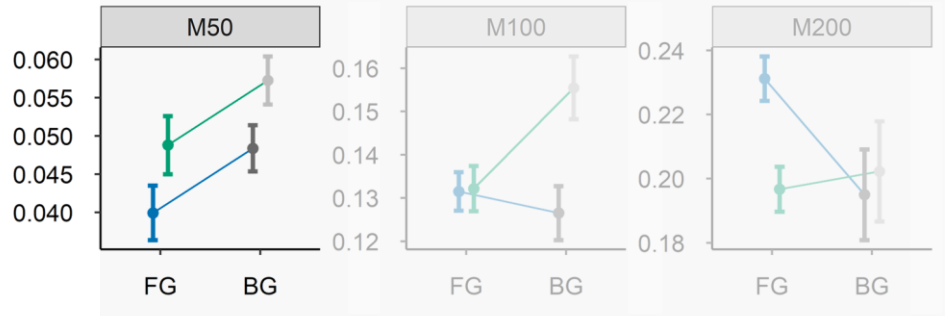
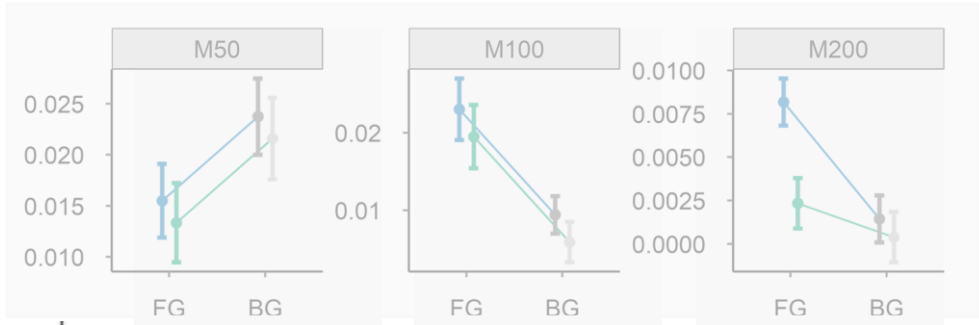
TRF Latency (s)



- M50 and YNH M100 : FG earlier than BG
- M50: earlier for ONH than YNH

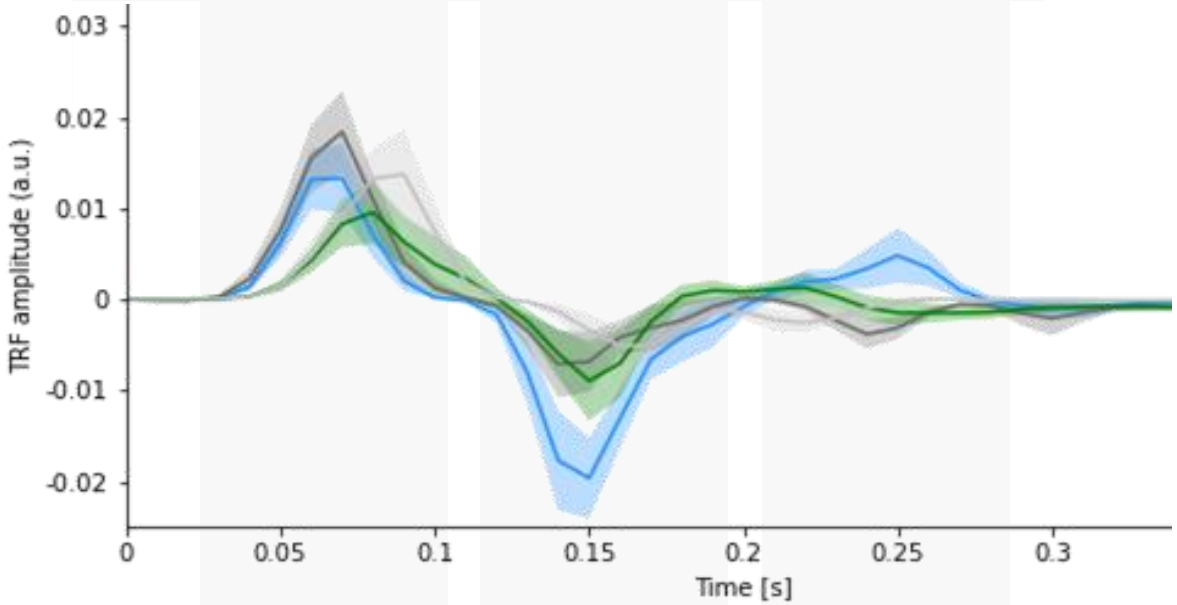
RESULTS: Effect of aging and attention on envelope tracking

TRF Amplitude
absolute value (a.u.)

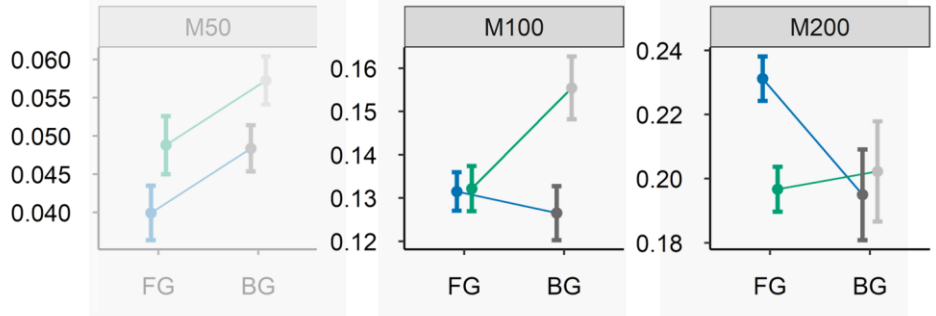


ONH: FG
YNH: FG

ONH: BG
YNH: BG



TRF Latency (s)



- M50: FG < BG (no significant effect of age)
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- M200 FG: older > younger adults (exaggeration)

- M50 and YNH M100 : FG earlier than BG
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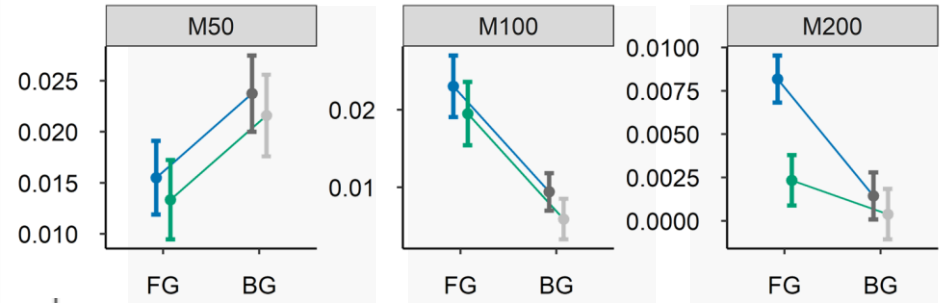
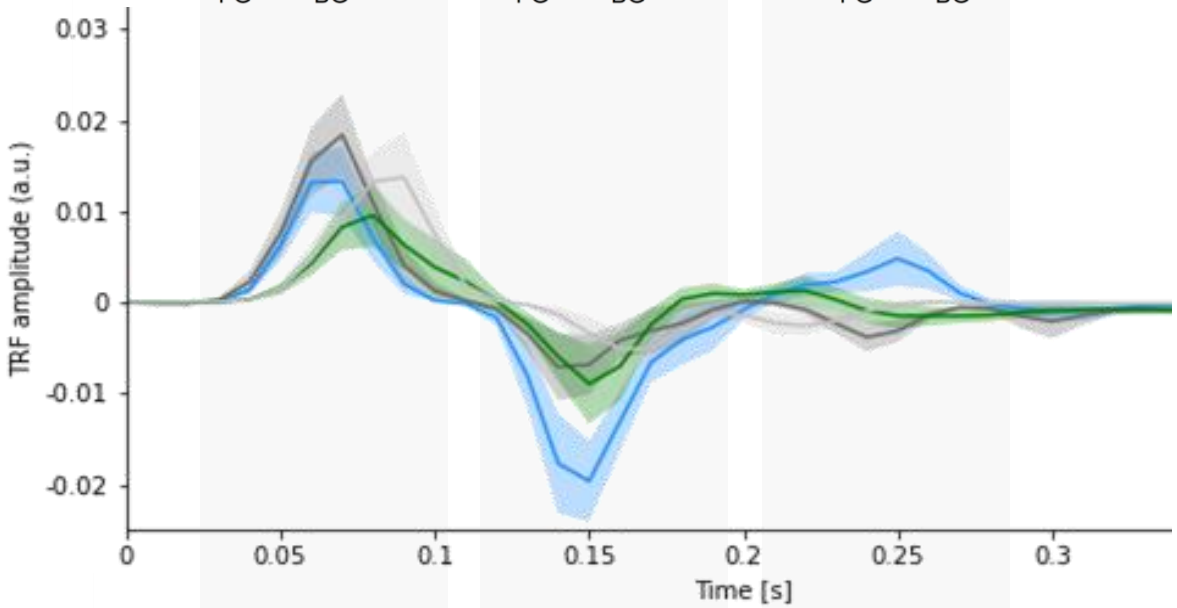
RESULTS: Effect of aging and attention on envelope tracking

TRF Amplitude
absolute value (a.u.)

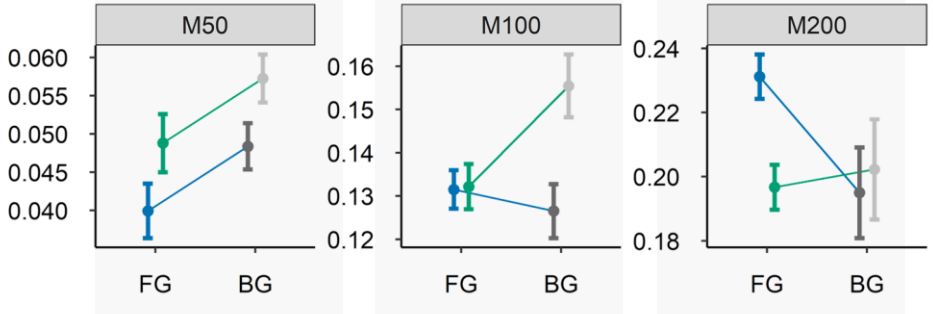


ONH: FG
YNH: FG

ONH: BG
YNH: BG



TRF Latency (s)



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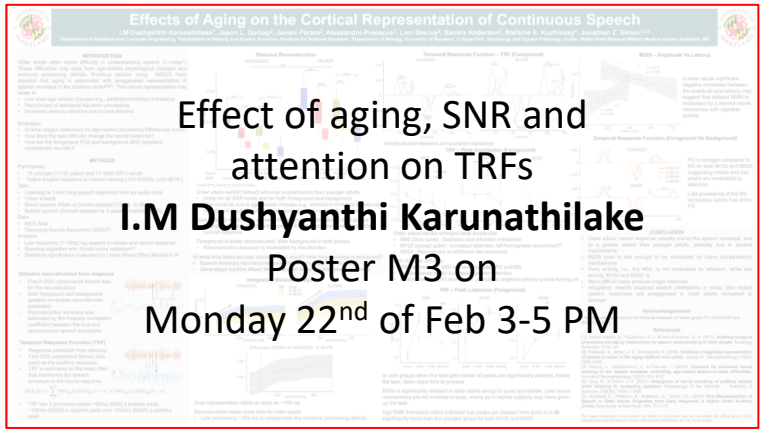


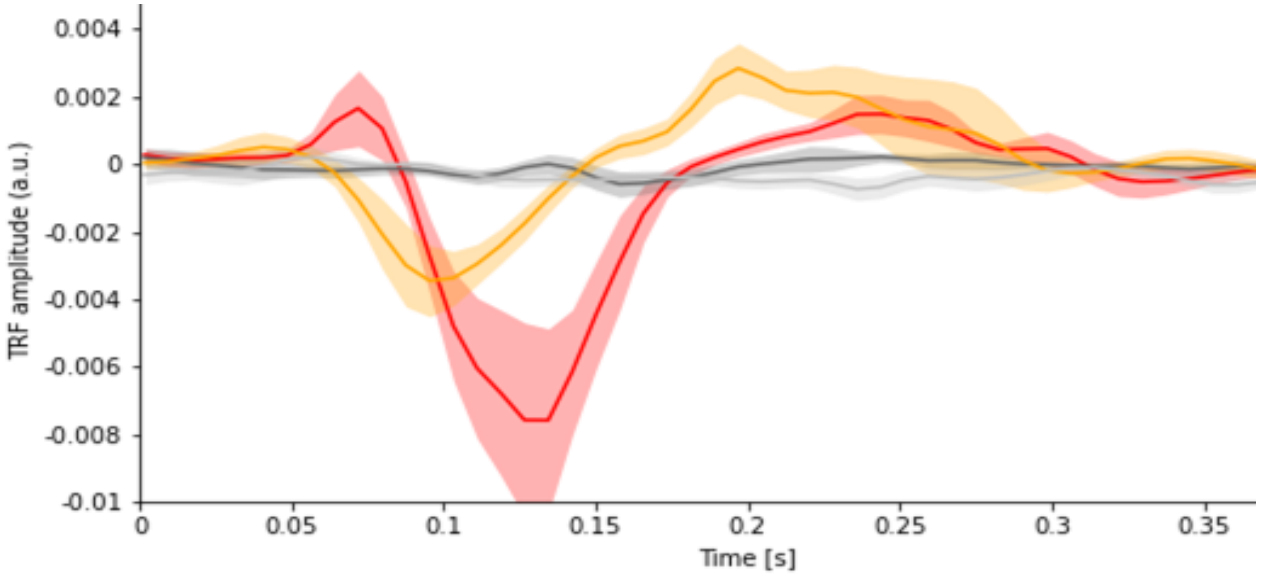
Effect of aging, SNR and attention on TRFs
I.M Dushyanthi Karunathilake
Poster M3 on
Monday 22nd of Feb 3-5 PM

- M50 and YNH M100 : FG earlier than BG
- M50: earlier for ONH than YNH
- ONH: M200 FG much later than BG => need longer processing time to segregate speakers

RESULTS: Effect of hearing loss and attention on envelope tracking

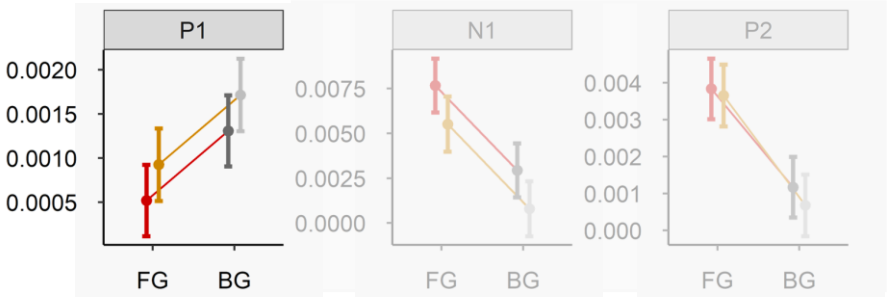
NH: FG
HI: FG

NH: BG
HI: BG



RESULTS: Effect of hearing loss and attention on envelope tracking

TRF Amplitude
absolute value (a.u.)



NH: FG
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NH: BG
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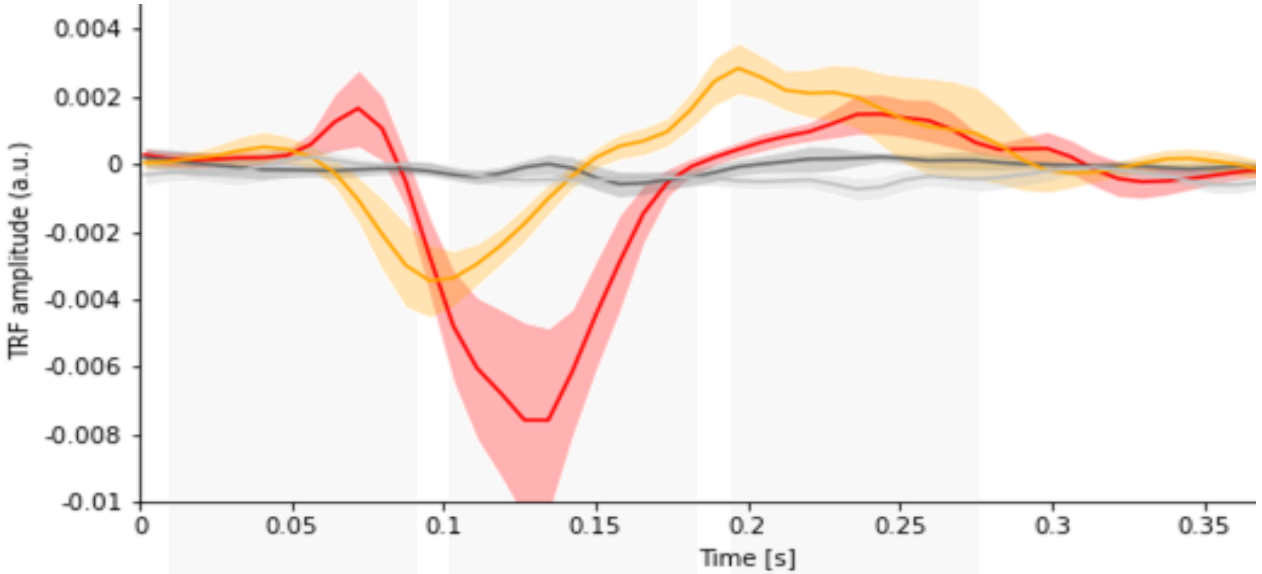
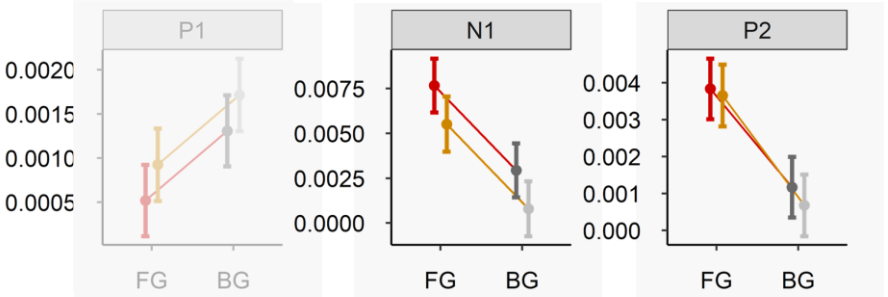


- P1: FG < BG (border significant)

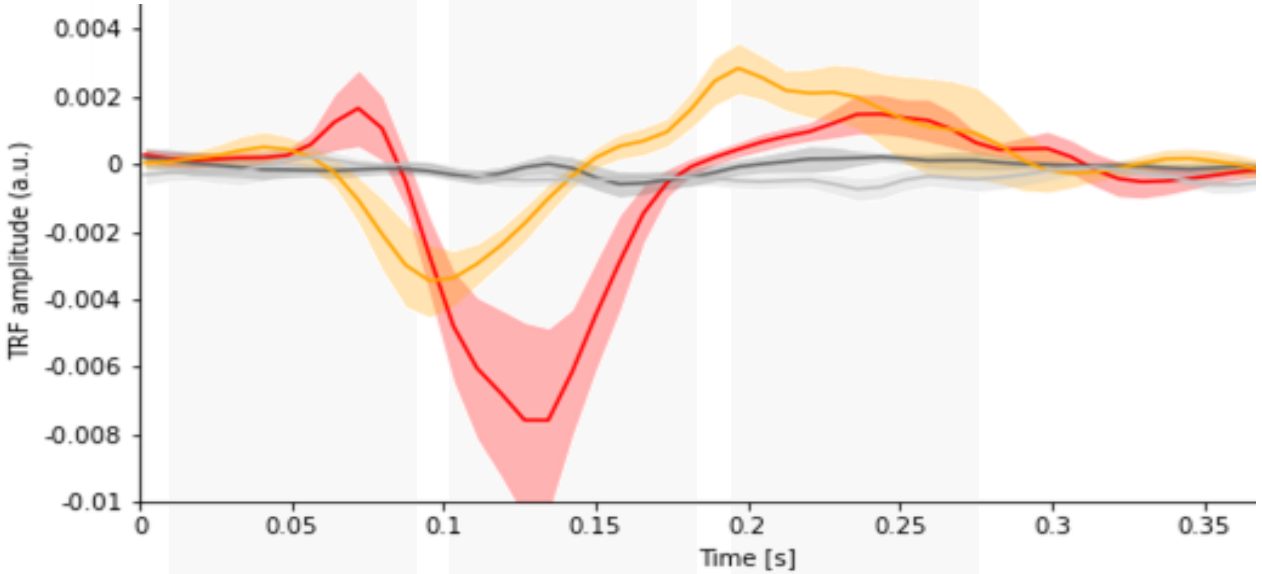
RESULTS: Effect of hearing loss and attention on envelope tracking

TRF Amplitude
absolute value (a.u.)



NH: FG
HI: FG

NH: BG
HI: BG



- P1: FG < BG (border significant)
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RESULTS: Effect of hearing loss and attention on envelope tracking

TRF Amplitude
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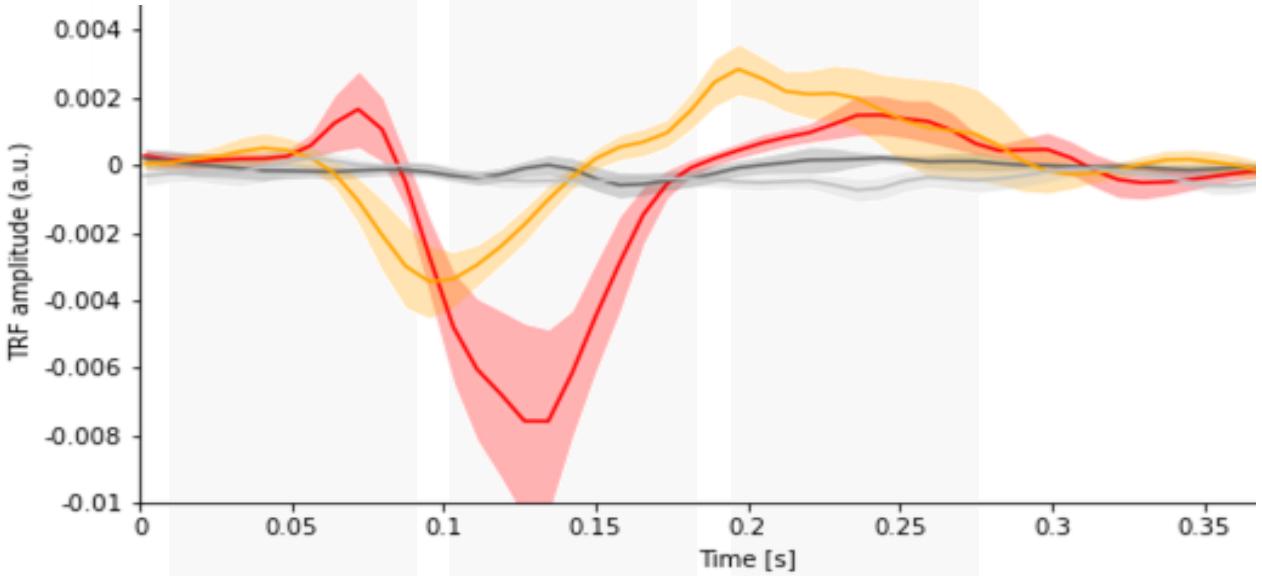

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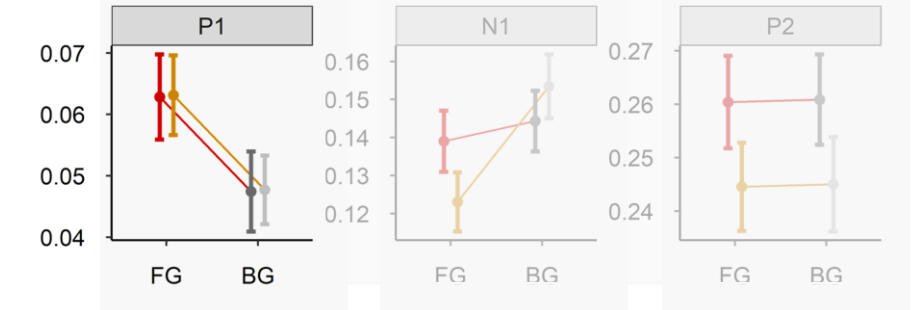
TRF Latency (s)



- P1 FG later than BG for both NH and HI

RESULTS: Effect of hearing loss and attention on envelope tracking

TRF Amplitude
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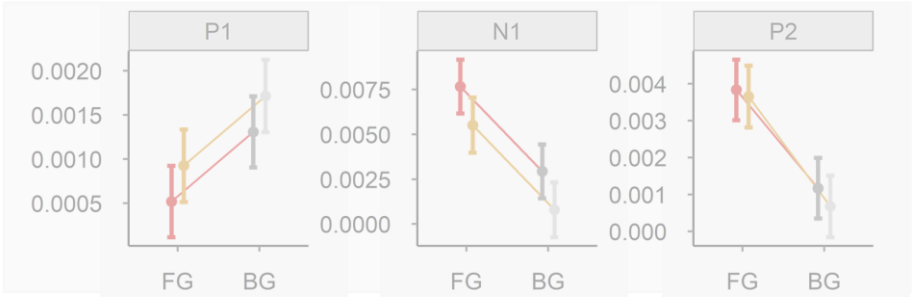

NH: FG
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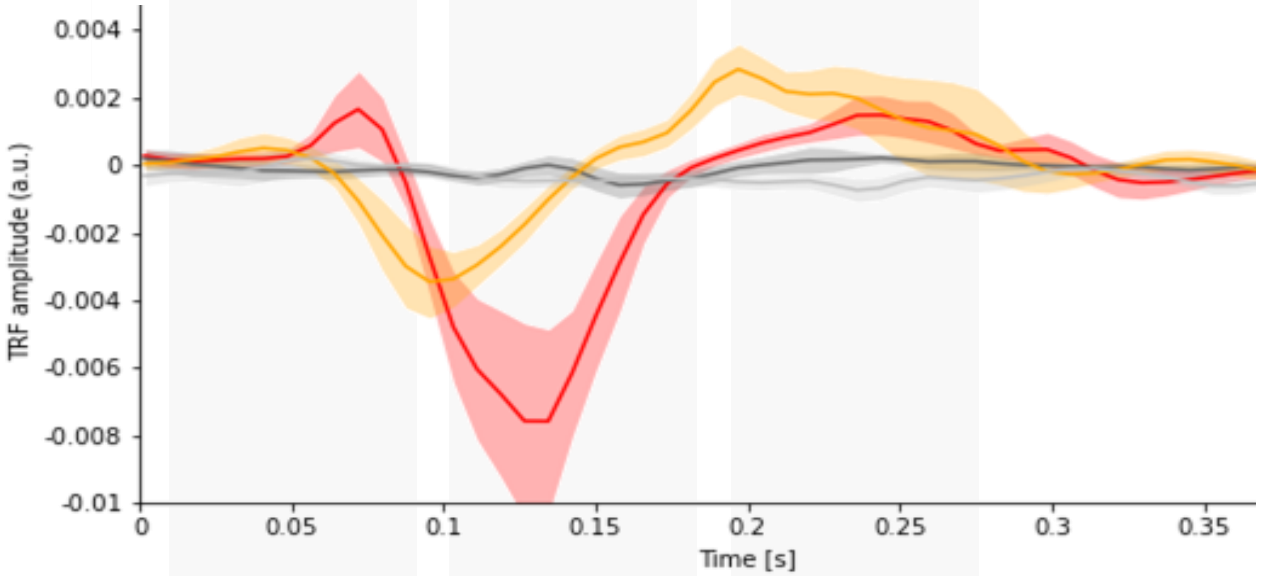

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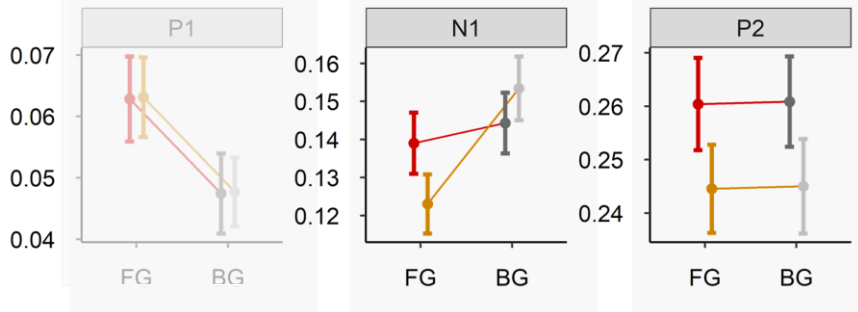
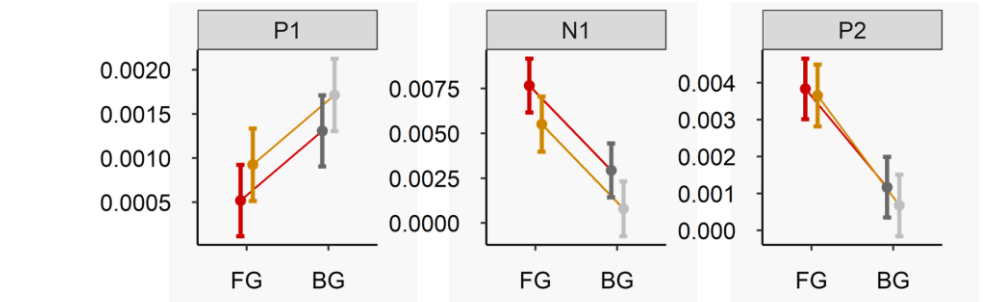


- P1 FG later than BG for both NH and HI
- HI delayed responses compared to NH for both N1 FG and P2 FG & BG (border significant)

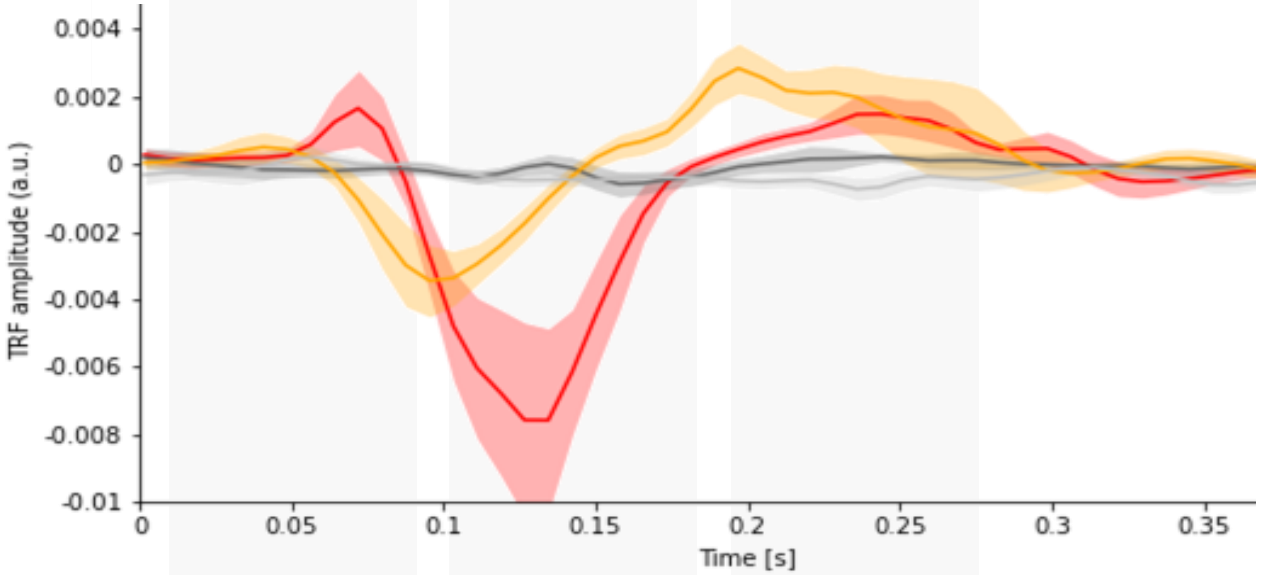
RESULTS: Effect of hearing loss and attention on envelope tracking

TRF Amplitude
absolute value (a.u.)



NH: FG
HI: FG

NH: BG
HI: BG



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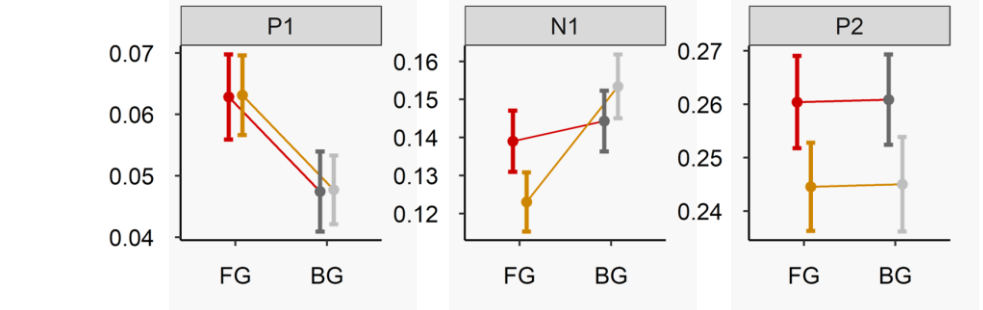
TRF Latency (s)



- P1 FG later than BG for both NH and HI
- HI delayed responses compared to NH for both N1 FG and P2 FG & BG (border significant)

SUMMARY: Neural responses to the envelope of continuous speech

- **Aging** is associated with **exaggerated** neural responses to speech
  (Presacco et al. 2016 (J. Neurophysiol); Decruy et al. 2019 (J. Neurophysiol))
  - Excitation/inhibition imbalance
  - Recruitment of additional brain regions / top-down resources
  - Inefficient connectivity between brain networks (redundant local processing)
- **Segregation** between competing speakers is **present for both younger and older adults**
- Older adults show **longer processing time** (delayed M200)

SUMMARY: Neural responses to the envelope of continuous speech

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  - Inefficient connectivity between brain networks (redundant local processing)
- **Segregation** between competing speakers is **present for both younger and older adults**
- Older adults show **longer processing time** (delayed M200)

- **Hearing loss** is associated with an **additional exaggeration** of the neural responses to speech
  (Decruy et al. 2020 (Hearing Research), Fuglsang et al. 2020 (J. Neurosci); Gillis et al. 2021 (bioRxiv))
  - Compensatory mechanisms for degraded input
  - Recruitment of additional brain regions / top-down resources to process speech
- **Segregation** of speakers is **present for both normal-hearing and hearing impaired adults**
- Neural responses are **delayed** for hearing impaired adults

Take home message & Future Work

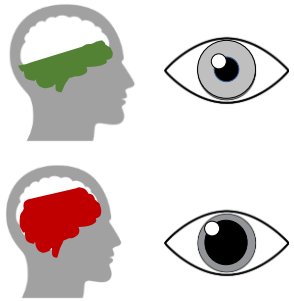
On top of age-effects, hearing impaired adults show an additional **exaggeration** and **delay** of their neural responses when processing continuous speech in noise

Take home message & Future Work

On top of age-effects, hearing impaired adults show an <u>additional</u> **exaggeration** and **delay** of their neural responses when processing continuous speech in noise

Features beyond the envelope
(Marlies Gillis: Podium 17 on Monday 22nd of Feb 3-5 PM)

Relate to behavioral measures:
- Speech-in-noise performance
- Cognitive skills (Presacco et al. 2016 (J. Neurophysiol); Decruy et al. 2019 (J. Neurophysiol))
- Effort (Lien Decruy: Poster W80 on Wednesday 24th of Feb 3-5 PM)



Use this knowledge to develop:
- new training paradigms (Dr. Sandra Gordon-Salant, Symposium 33 on Wednesday 24th of Feb 12:30 – 2:30 PM)
- self-fitting hearing aids (Mirkovic et al. 2019 (Hearing Research))

Thank you for listening!

Special thanks to

- **Marlies Gillis** (Podium 17, Monday 22th of Feb 3-5 PM)
- **I.M Dushyanthi Karunathilake** (Poster M3 on Monday 22th of Feb 3-5 PM)

- Participants
- CSSL & HESP lab (http://cansl.isr.umd.edu/simonlab/Publications.html)
  - Christian Brodbeck , Joshua Pranjeevan Kulasingham, Dushyanthi Karunathilake, Regina Calloway, Theo Dutcher, Kevin Hu, Alex Presacco, Jason L. Dunlap, Janani Perera
- ExpORL lab, ISIFIT team (https://gbiomed.kuleuven.be/english/research/50000666/50000672)
- Funding
- Melissa & Brandon

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