Effects of Aging on the Cortical Representation of Continuous Speech

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Background

Introduction

- Older adults often report **difficulty** in understanding speech in noise [1]
- These difficulties are not resolved for
  - people with ***clinically normal hearing***
  - people with ***hearing aids***
- Difficulties may arise from age-related physiological changes and temporal processing deficits

Speech-in-noise difficulties

Motivation

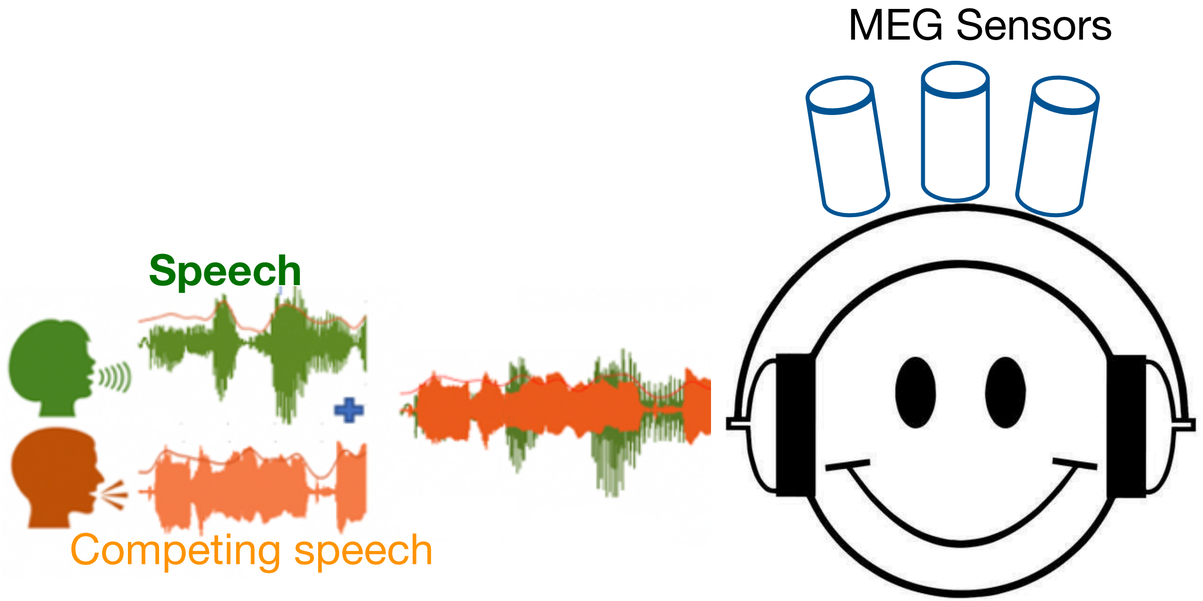
- To further investigate age-related neuro-physiological differences
  - At what stages (latencies), age-related processing differences occur?
  - How does the task difficulty change the neural response
  - How are the foreground (FG) and background (BG) speakers represented neurally?

1. Gordon-Salant, S., Fitzgibbons, P. J., & Yeni-Komshian, G. H. (2011). Auditory temporal processing and aging: Implications for speech understanding of older people. *Audiology Research*, *1*(1S), e4. https://doi.org/10.4081/audiores.2011.e4

Methods

Participants

- 18 Younger adults (age: 17-26 y)
- 17 Older adults (age: 65-78 y)
- **Normal Hearing** (125-4000 Hz , ≤25 dB HL)
- Native English Speakers



Task

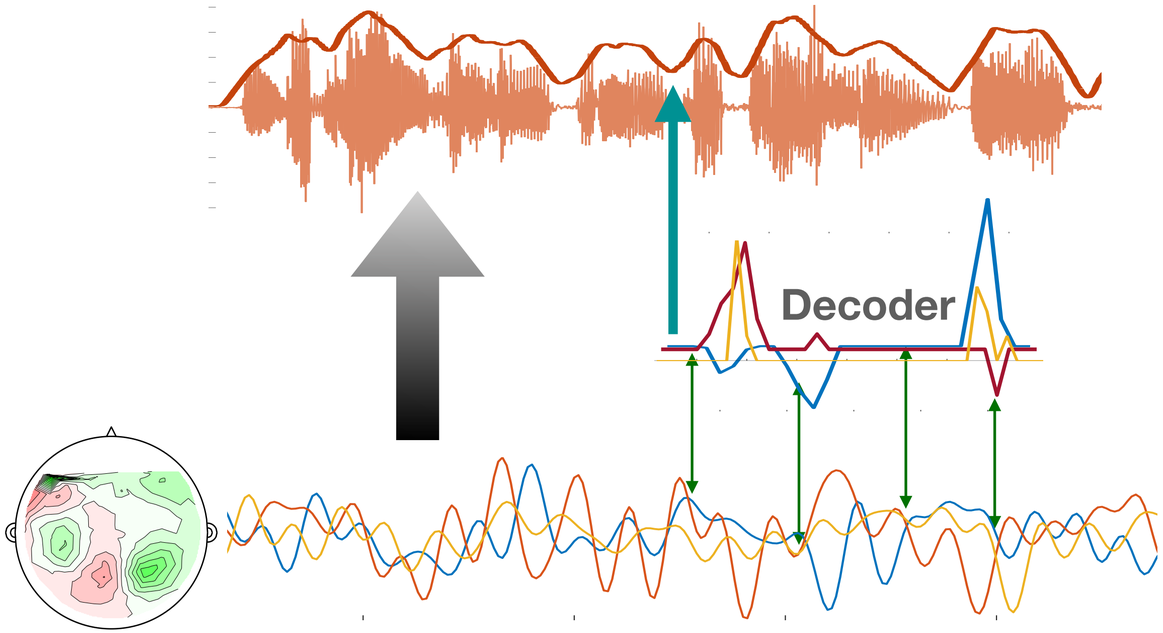
- Listening to **1 minute long** speech segments from an audio book
  - Clean speech
  - Mixed speech (Male speaker vs female speaker) [0 dB, -6 dB]
  - Babble speech

Data

- Magnetoencephalography (MEG) data
- Band pass filter 1-10 Hz

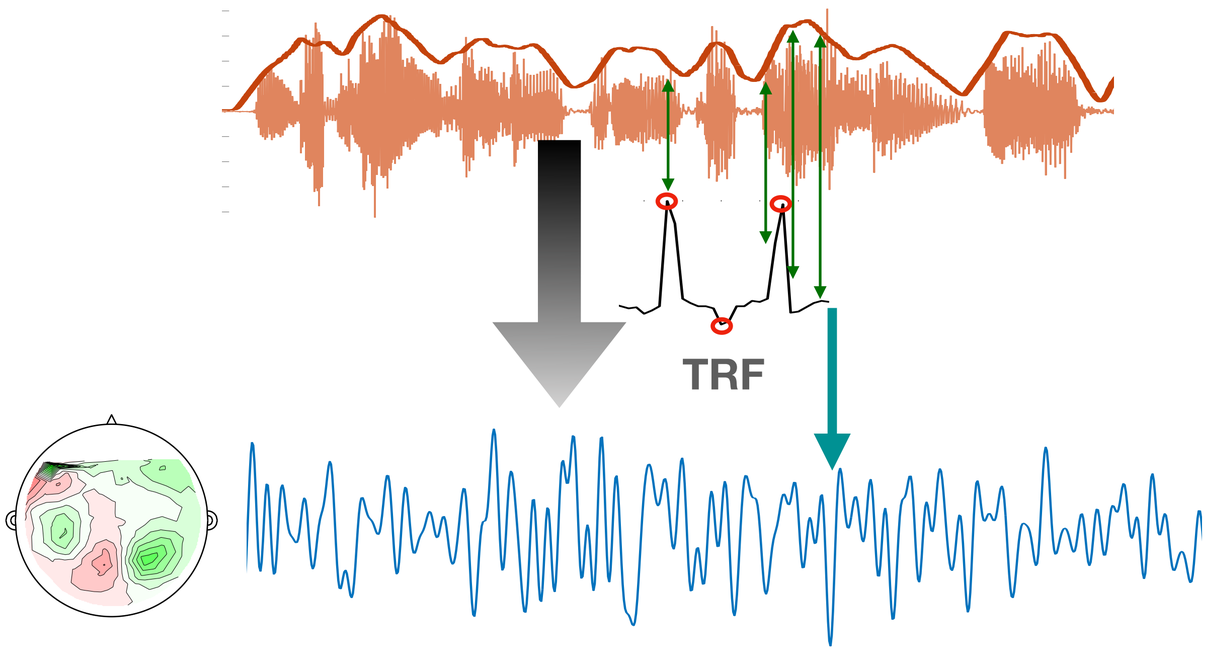
Analysis: Temporal Response Function(TRF)

Speech Envelope Reconstruction
(Decoder/ Backward model)



- Both foreground and background speaker envelopes reconstructed separately
- Reconstruction accuracy is measured by the Pearson correlation coefficient between the true and reconstructed speech envelopes

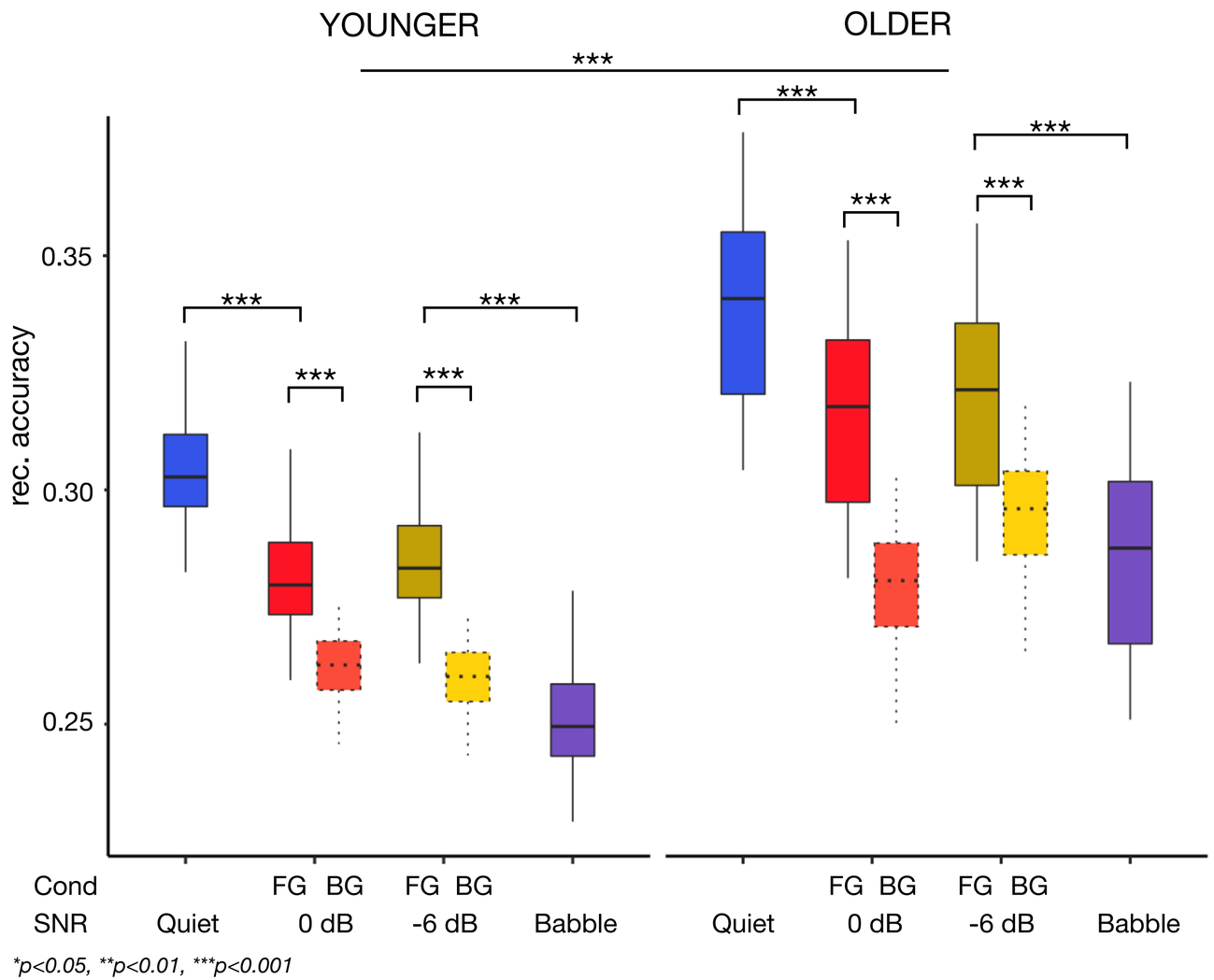
MEG prediction (Encoder/Forward model)
(Temporal Response Function)



- Foreground and background speaker TRFs estimated simultaneously
- TRF has 3 prominent peaks ~50 ms (M50) a positive peak, ~100 ms. (M100) a negative peak and ~200 ms. (M200) a positive peak

2. Ding, N., & Simon, J. Z. (2012). Emergence of neural encoding of auditory objects while listening to competing speakers. *Proceedings of the National Academy of Sciences*, *109*(29), 11854–11859. https://doi.org/10.1073/pnas.1205381109

Results : Stimulus Reconstruction



*p<0.05, **p<0.01, ***p<0.001

Younger vs Older

Older reconstruction **better** (!) than younger [3,4]

Hold for all SNR levels and for both foreground and background

- Age related changes e.g., excitation/ inhibition imbalance
- Recruitment of additional top-down resources
- Increased attention

Task Difficulty

Task difficulty worsens foreground reconstruction in both groups

- Background noise significantly worsens speech intelligibility in older listeners

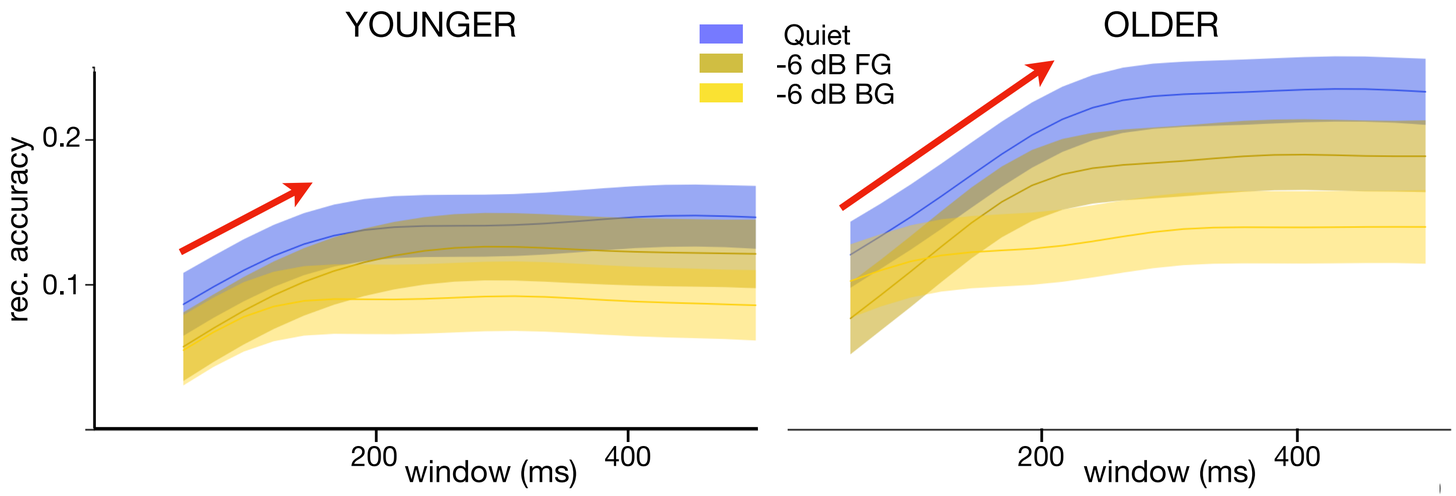
Foreground vs Background

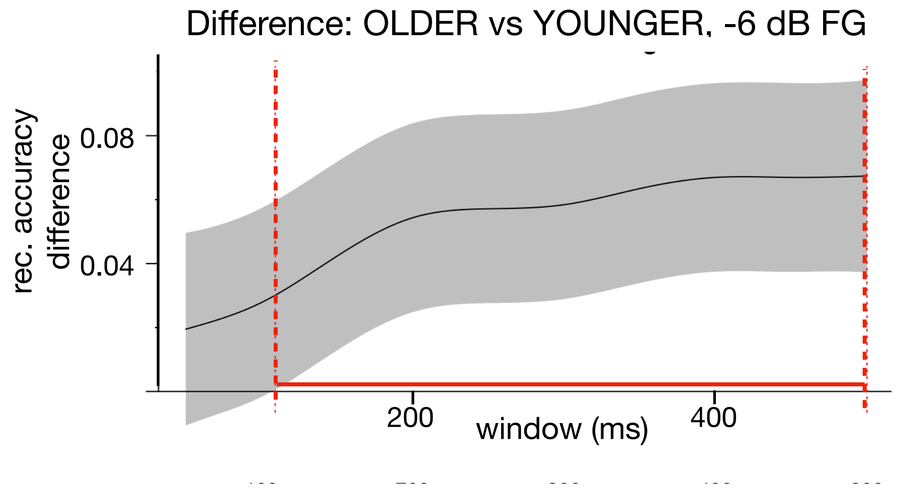
Foreground reconstruction better than Background for both groups

- Selective attention
- Separation into distinct sources

3. Presacco, A., Simon, J. Z., & Anderson, S. (2016). Evidence of degraded representation of speech in noise, in the aging midbrain and cortex. *Journal of Neurophysiology*, *116*(5), 2346–2355. https://doi.org/10.1152/jn.00372.2016
4. Decruy, L., Vanthornhout, J., & Francart, T. (2019). Evidence for enhanced neural tracking of the speech envelope underlying age-related speech-in-noise difficulties. *Journal of Neurophysiology*, *122*(2), 601–615. https://doi.org/10.1152/jn.00687.2018

Results : Integration Window Analysis





Younger vs Older

Reconstruction takes more time for older adults

- Additional processing ~200ms in older adults to compensate for the temporal processing deficits

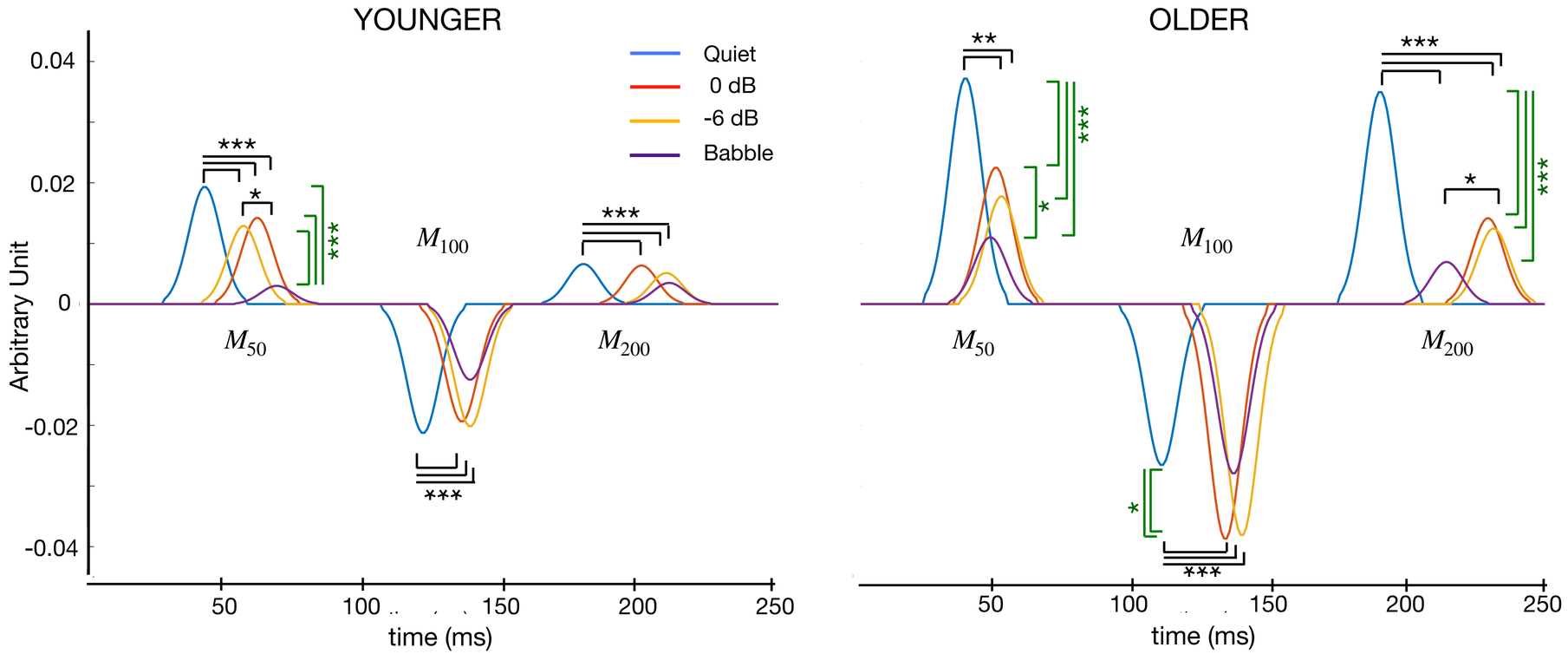
Over representation starts as early as ~100ms in older adults

- Excitation and inhibition imbalance

This motivates the TRF analysis

Results : Temporal Response Function (TRF)

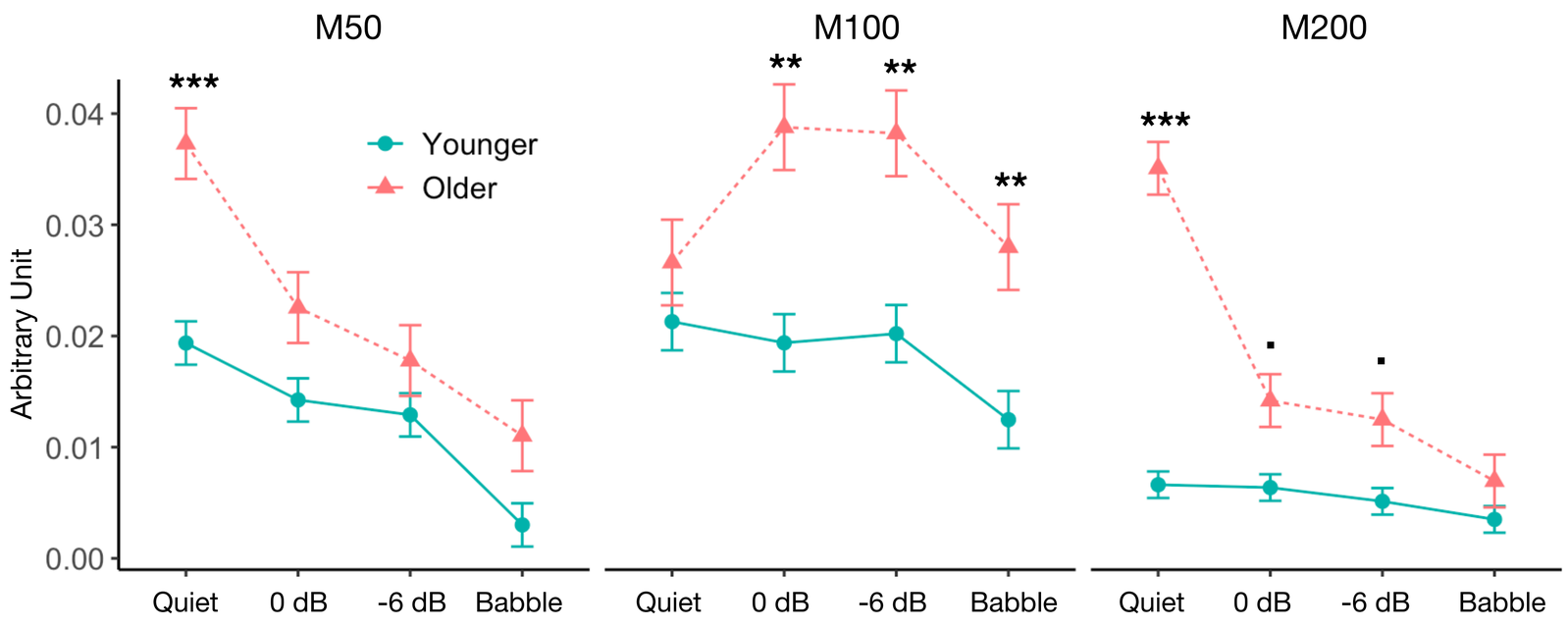
Foreground TRF



Plots contain illustrative TRFs

Results : TRF - Amplitudes

Foreground TRF



Younger vs Older

Older amplitudes bigger than younger amplitudes

- M50 : Excitation and inhibition imbalance
- M100 : Increased attention
- M200 : Recruitment of additional late resources

Task Difficulty

M50 decreases

- M50 is shared between foreground and background

M100 increases only in older adults

- Greater attention
- Listening asymmetry

M200 amplitude decreases

- Modulated by late neural mechanisms

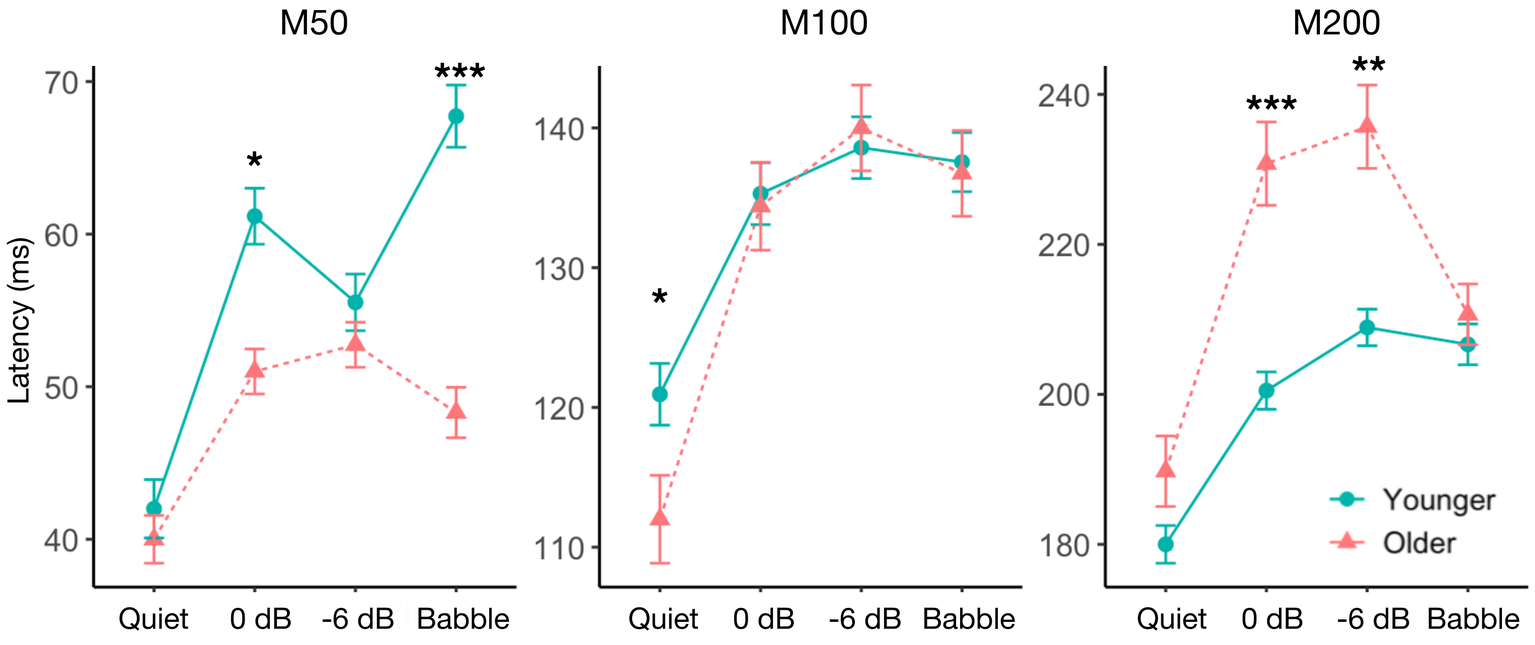
Foreground vs Background
(Not shown)

In both groups foreground is stronger than background for both M100 and M200

- M100 and M200 are modulated by attention

Results : TRF - Latencies

Foreground TRF



Younger vs Older

M200 is significantly delayed in older adults except in quiet and in babble.

- Late neural mechanisms are involved when the task gets harder

Age x SNR interaction effect indicated peaks are significantly delayed in older adults for M100 and M200

- Older adults processing time is adversely affected by noise

Task Difficulty

Quiet peaks early than 0 dB/-6 dB peaks

- Harder the task, takes more time to process

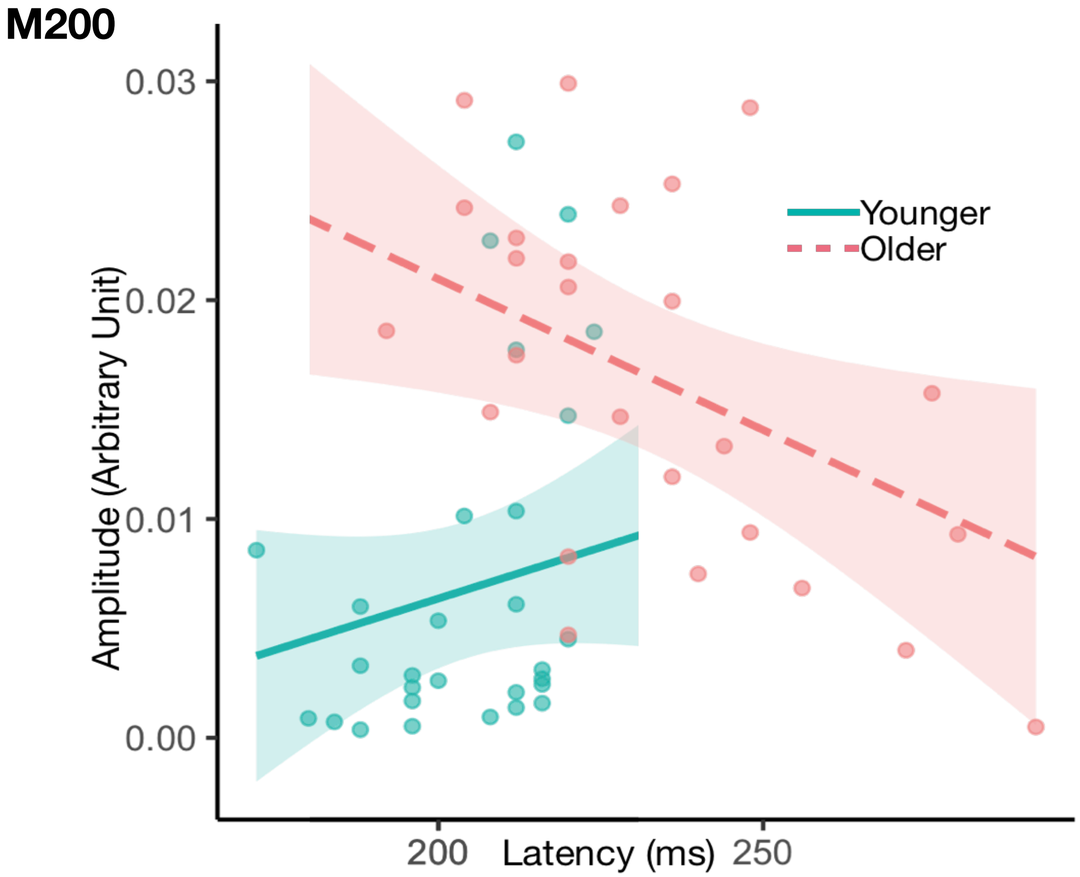
Foreground vs Background

(Not shown)

Late processing of background terminates before the foreground

- Foreground is processed for longer

Results : TRF - Amplitude Vs Latencies



Significant **negative relationship** between **M200** amplitude and latency in **older adults**

- Delayed M200 in older adults modulated by a second negative polarity peak?
- Other compensatory mechanism?

Conclusion

- Older adults' neural response robustly tracks the speech envelope, and to a greater extent than younger adults, possibly due to several mechanisms
- M200 peak is late enough to be modulated by many compensatory mechanisms
- Early activity, i.e., the M50, is not modulated by attention, while late activity, M100 and M200, is
- More difficult tasks produce longer latencies
- Altogether, despite impaired speech intelligibility in noise, time locked speech responses are exaggerated in older adults compared to younger

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