Hearing Brain Lab

Computational Sensorimotor Systems Lab

Effects of aging on temporal synchronization of speech in noise investigated in the cortex by using MEG and in the midbrain by using EEG techniques

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Background

"I can hear you, but I cannot understand you"

Problems in the auditory midbrain:

- Longer neural recovery (Walton et al., 1998)
- Lower number of available neurons capable of doing a specific task (i.e. gap detection) (Walton et al., 1998)
- Selective loss of high-threshold fibers (Furman et al., 2013)
- Decreased levels of inhibitory neurotransmitters (Caspary et al., 1995, 2005)
- Loss of temporal precision and time delays (Anderson et al., 2012)

Background (con't)

- Problems in the auditory cortex:
  - Age-related deficits in auditory temporal processing (de Villers-Sidani et al., 2010; Hughes et al., 2010; Juarez-Salinas et al., 2010)
- Psychoacoustics studies:
  - Age-related deficits in auditory temporal processing (Pichora-Fuller and Schneider, 1991; Fitzgibbons and Gordon-Salant, 1996; Frisina and Frisina, 1997)
- Hearing aids:
  - Speech understanding not improved in noise => increased audibility does not restore temporal precision degraded by aging (Tremblay et al., 2003)
- Relevance of this problem:
  - Strong correlations among hearing loss and depression (Kay et al., 1964; Herbst and Humphrey, 1980; Laforge et al., 1992; Carabellese et al., 1993) and cognitive impairment (Uhlmann et al., 1989; Gates et al., 1996; Lin et al., 2013)

Hypothesis

Age-related loss of temporal precision in the midbrain and in the cortex is an important factor in the older adult's difficulties when listening in noise

Neuroimaging techniques

Electroencephalography (EEG)

Electroencephalography (EEG) is the recording of electrical activity along the scalp

Excellent temporal resolution (~ms)

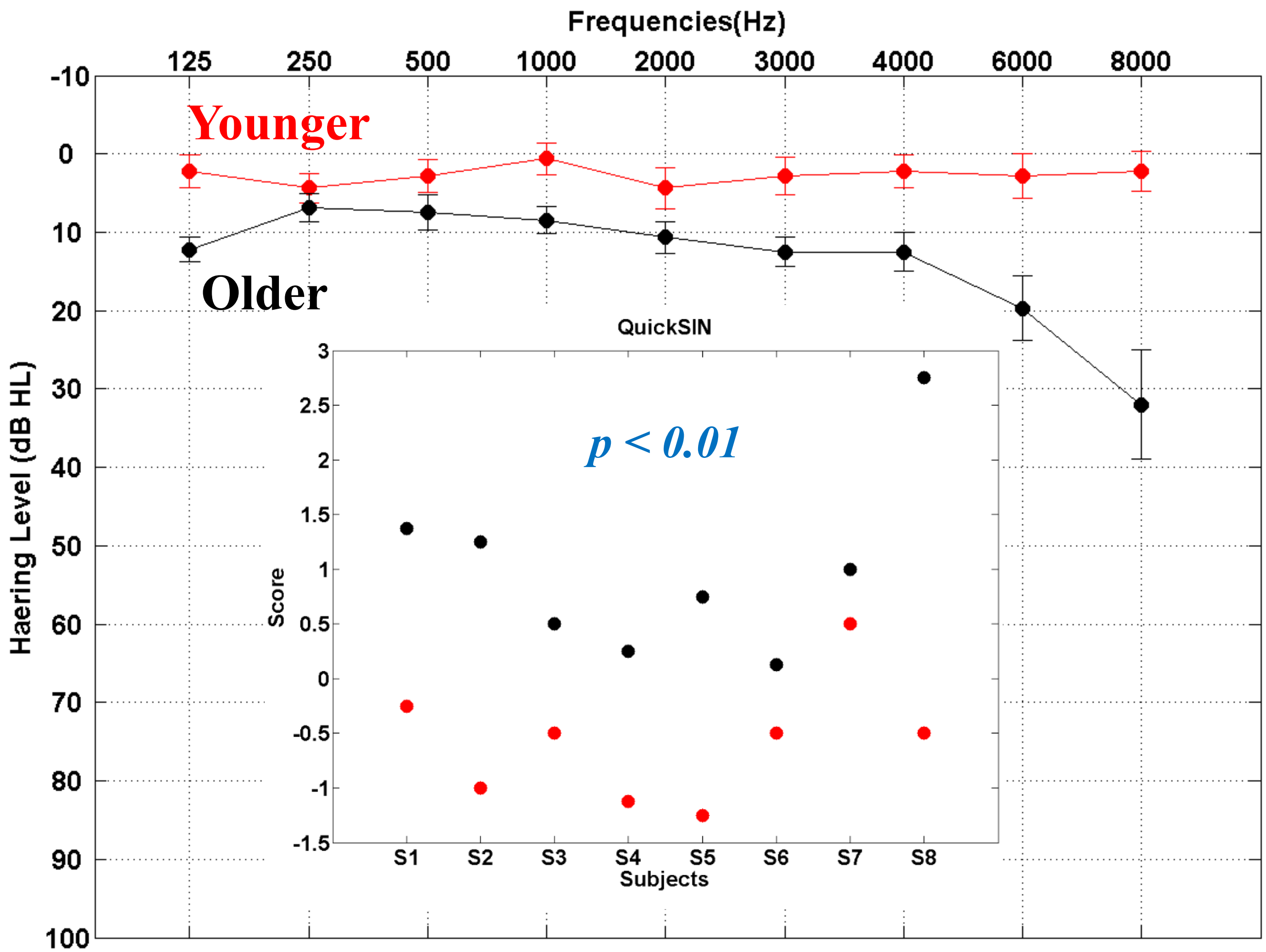
Magnetoencephalography (MEG)

The sensors detect weak magnetic fields from outside the head produced by brain activity

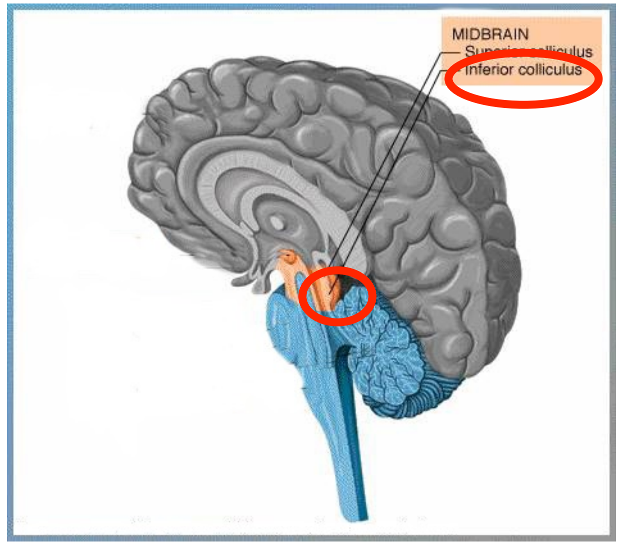
Well suited to measure slow temporal oscillations

Participants

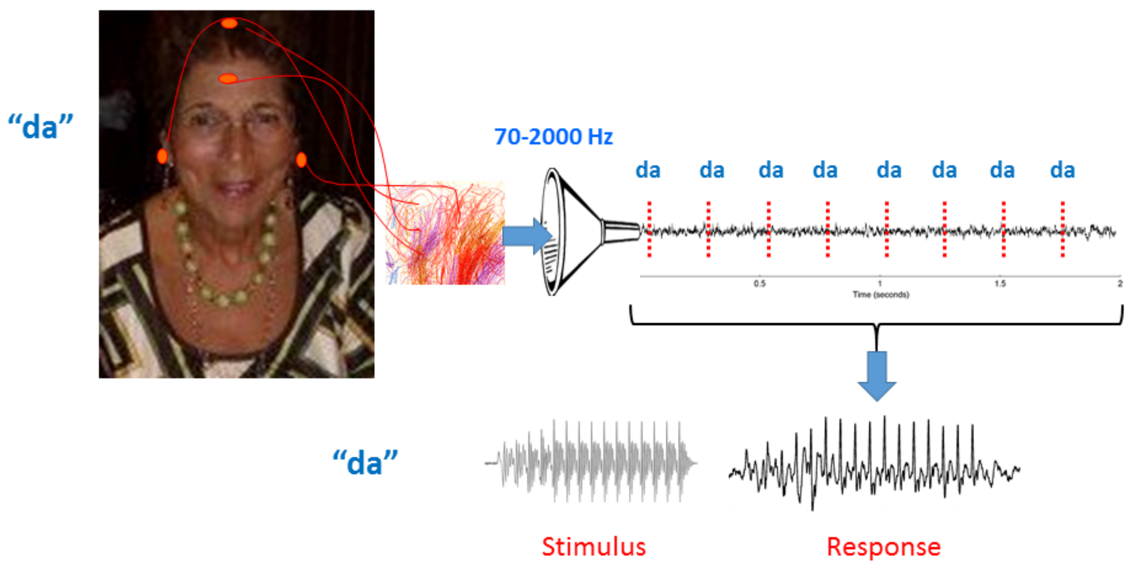
- Subjects: **8** younger adults (23.8 ± 3.18; 3 male), **8** older adults (63.3 ± 3.02; 3 male)
- Native English speakers, normal IQ scores (WASI test) and no signs of dementia (MOCA test)



MidBrain

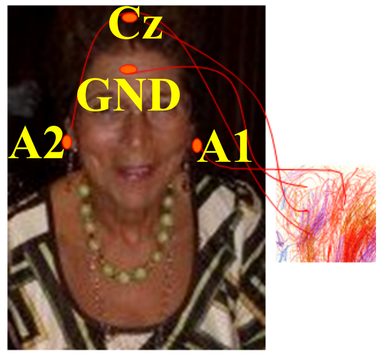


Frequency Following Response (FFR)



Experimental Set-up for EEG

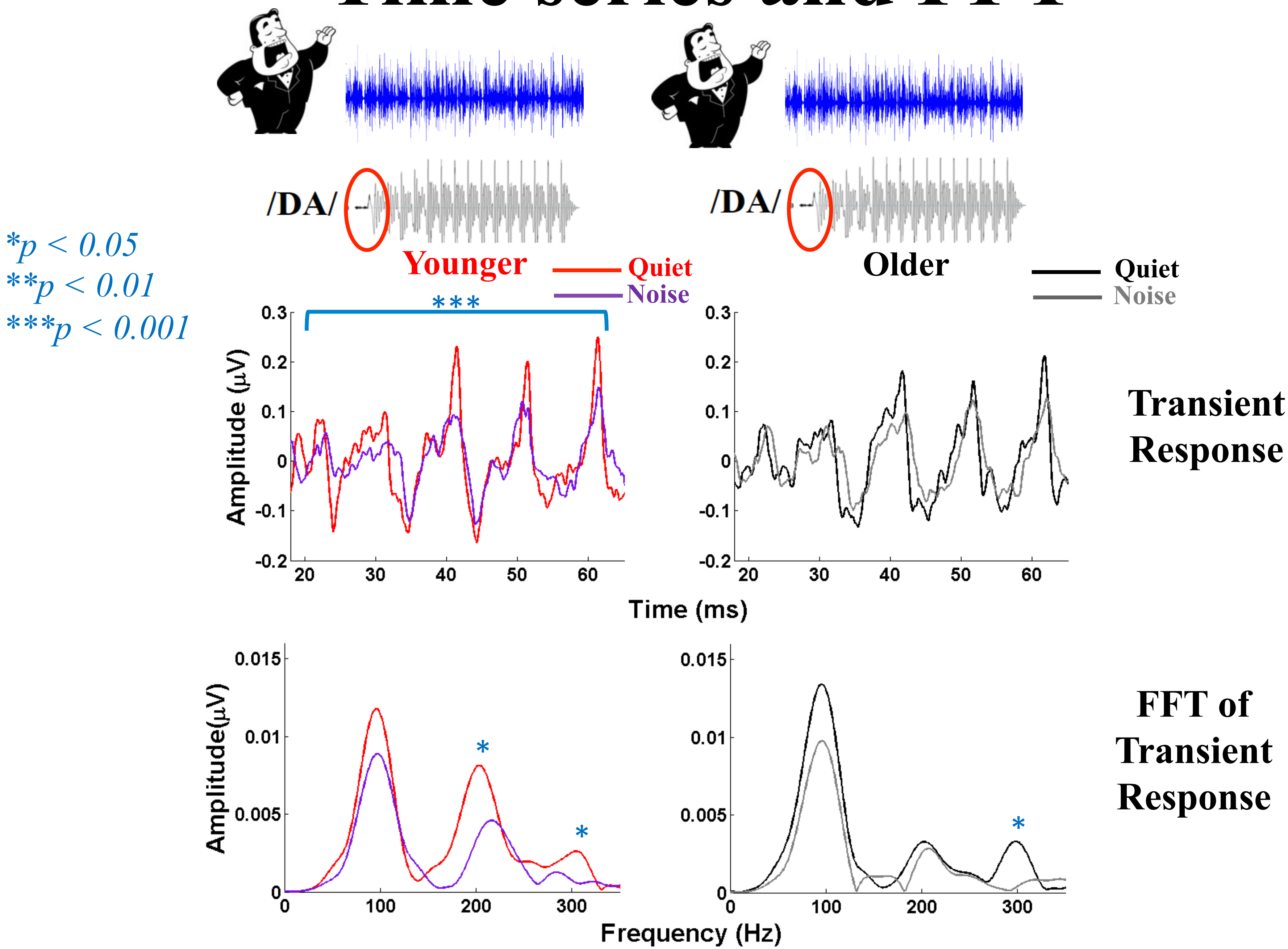
- FFR recorded from **EEG**
- Electrode montage:



- Speech syllables **/da/** synthesized at 100 Hz with Klatt and presented diotically at alternated polarity with single-talker competing speech (0 SNR)
- **3000** sweeps per conditions were averaged
- **250** ms (ISI = 80ms) per sweep
- **16384** kHz Sampling frequency

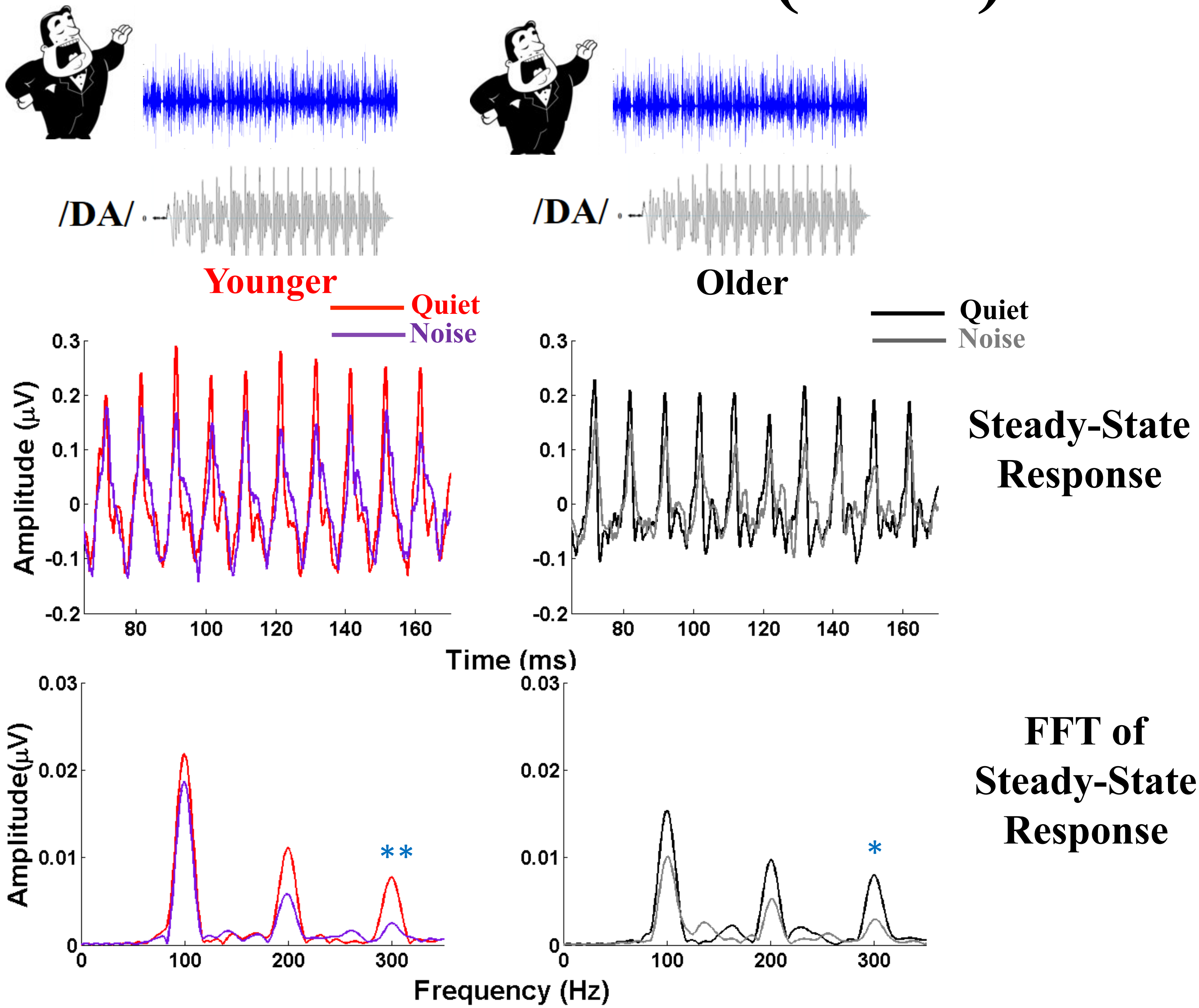
Task

Time series and FFT

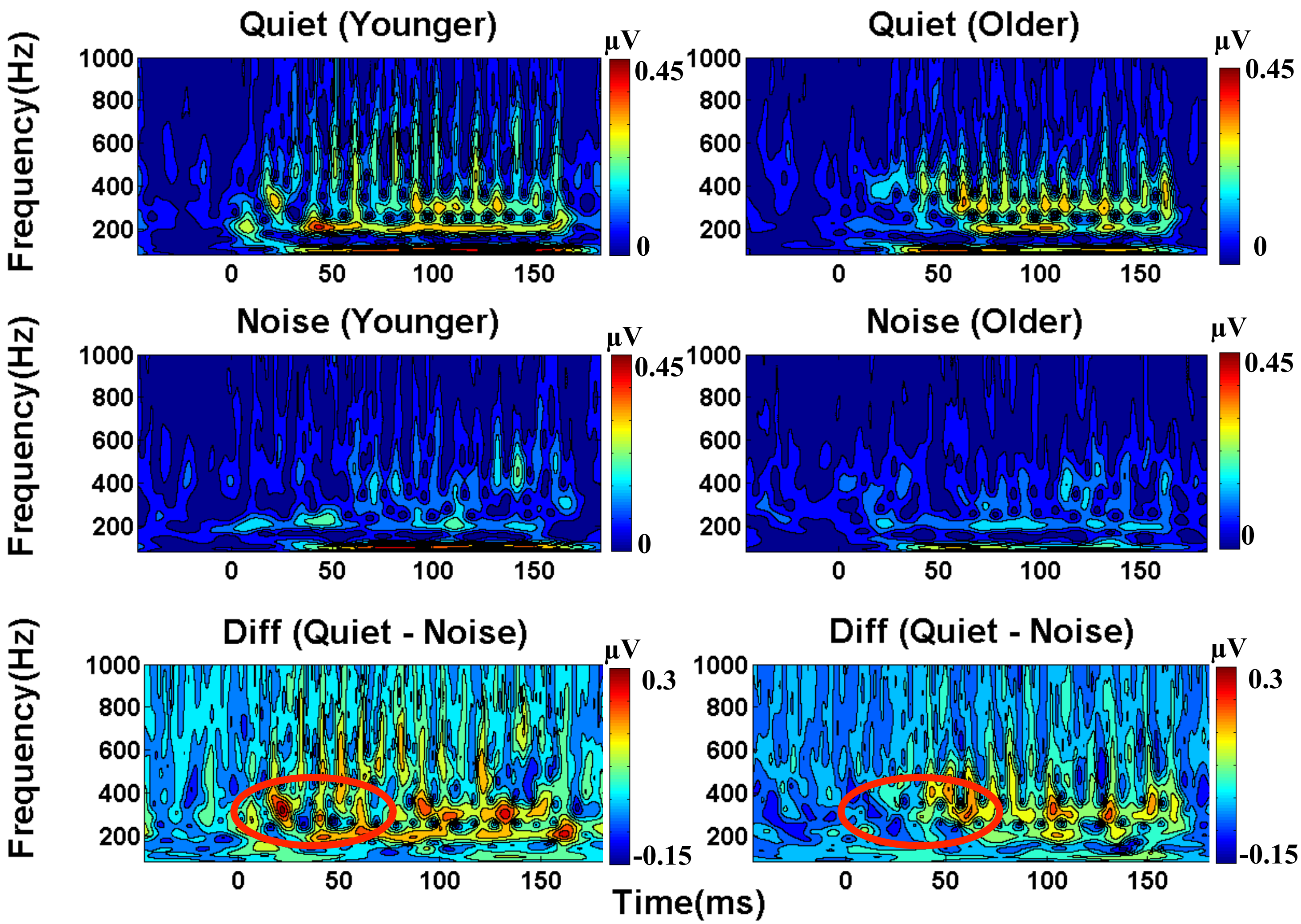


Time series and FFT(con't)

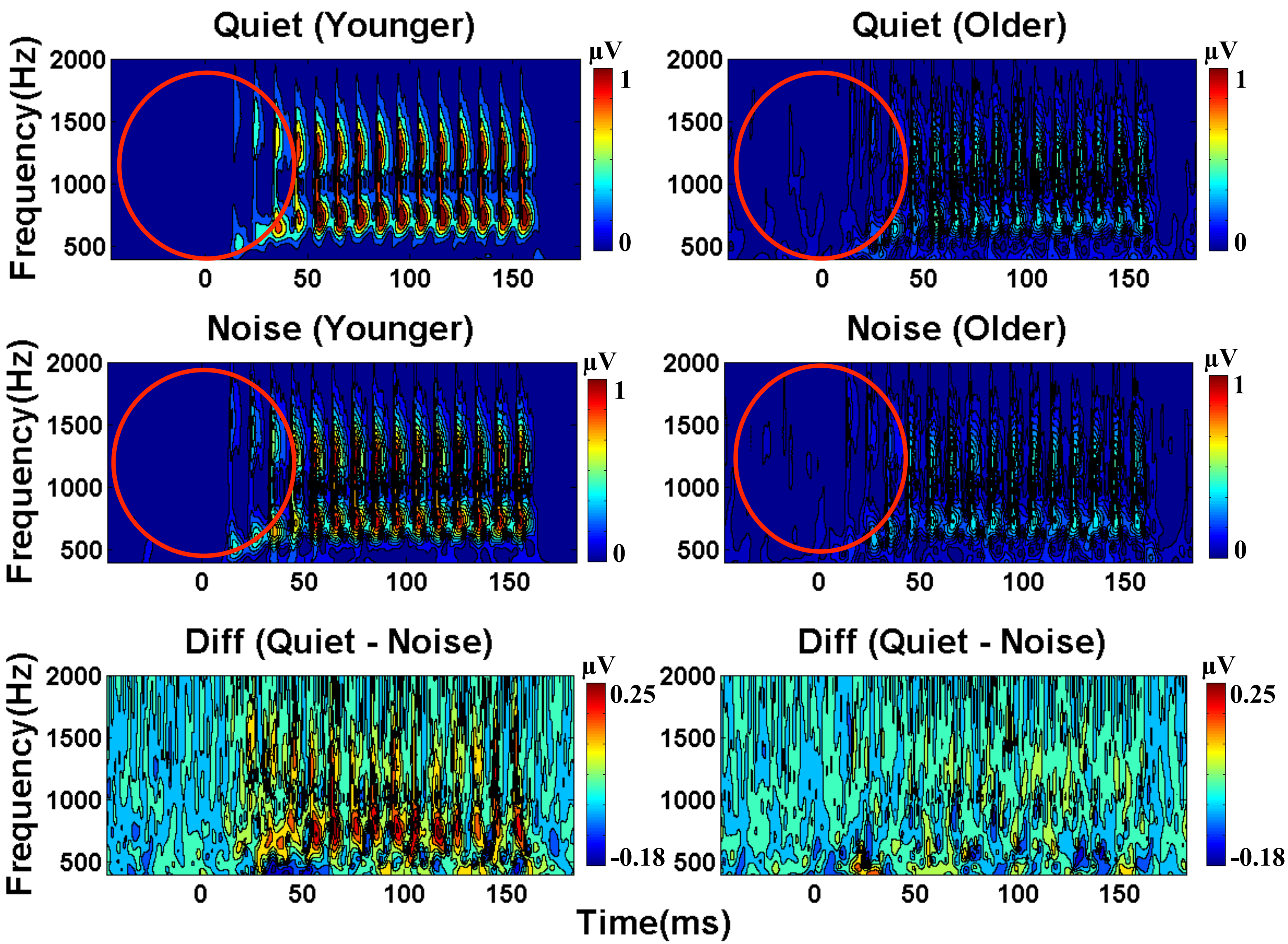
$*p < 0.05$
$**p < 0.01$
$***p < 0.001$



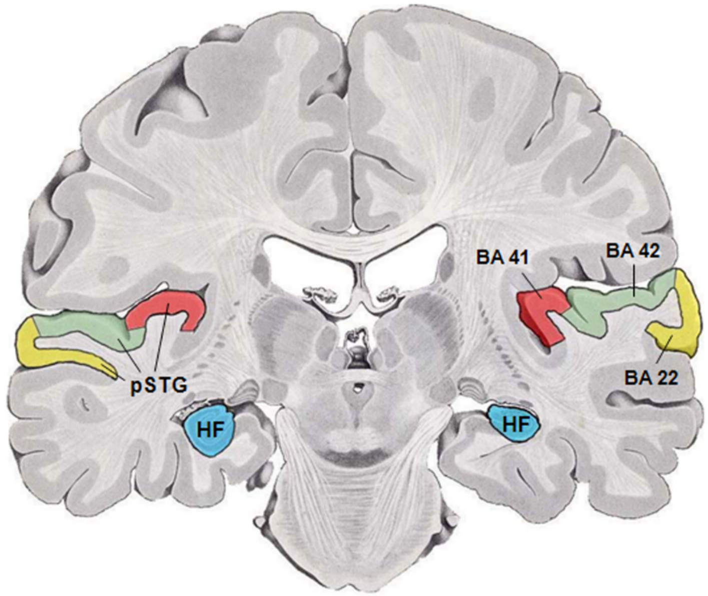
Time – Frequency Analysis (Envelope)



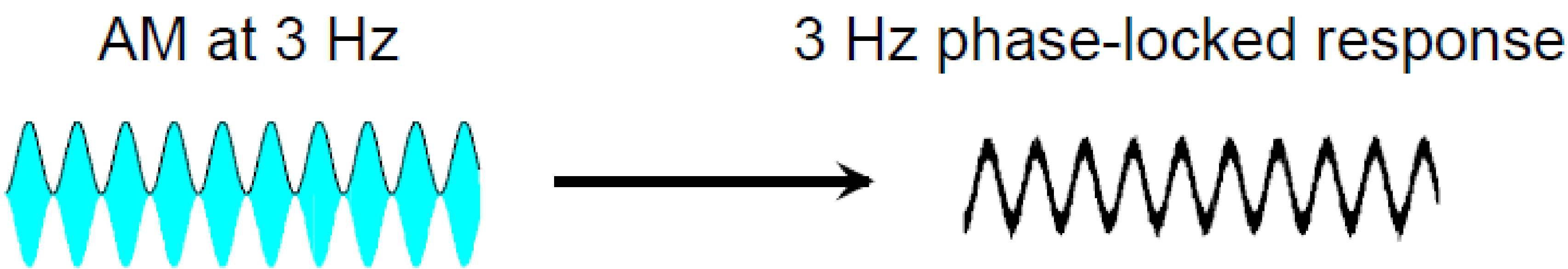
Time – Frequency Analysis (Temporal Fine Structure)



Auditory Cortex

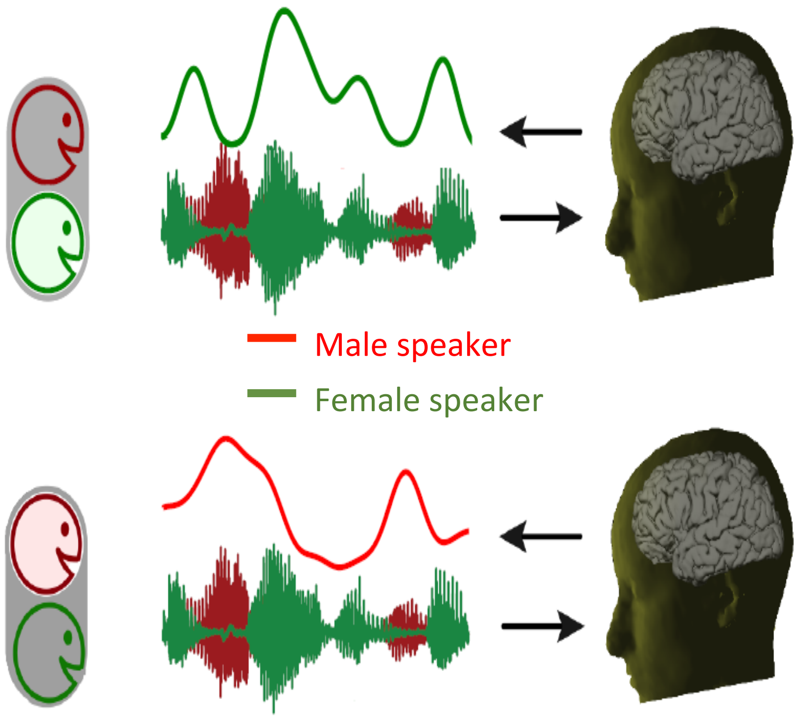


Slow temporal oscillations to decode speech envelope



Task

Selective Neural Encoding



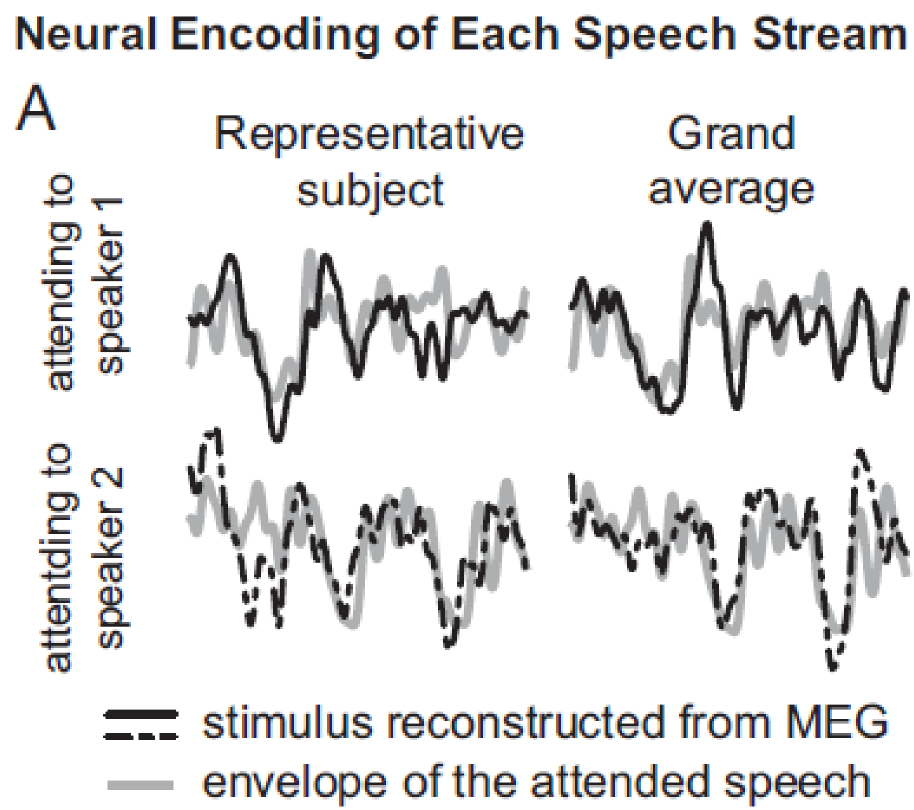


Figure adapted from "Simon, **2014, Int J Psychophysiol**"

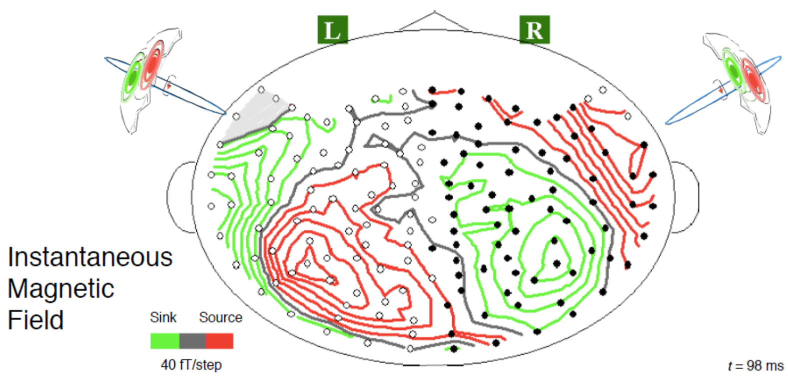
Ding and Simon, **2012, PNAS**

Experimental Set-up

- Subjects: **8** younger adults (23.8 ± 3.18; 3 male), **8** older adults (63.3 ± 3.02; 3 male)

- Cortical responses recorded from **MEG**

- MEG recorded from 157 sensors



- **3** trials (each one 1 minute long) recorded for each condition (attend male, attend female)

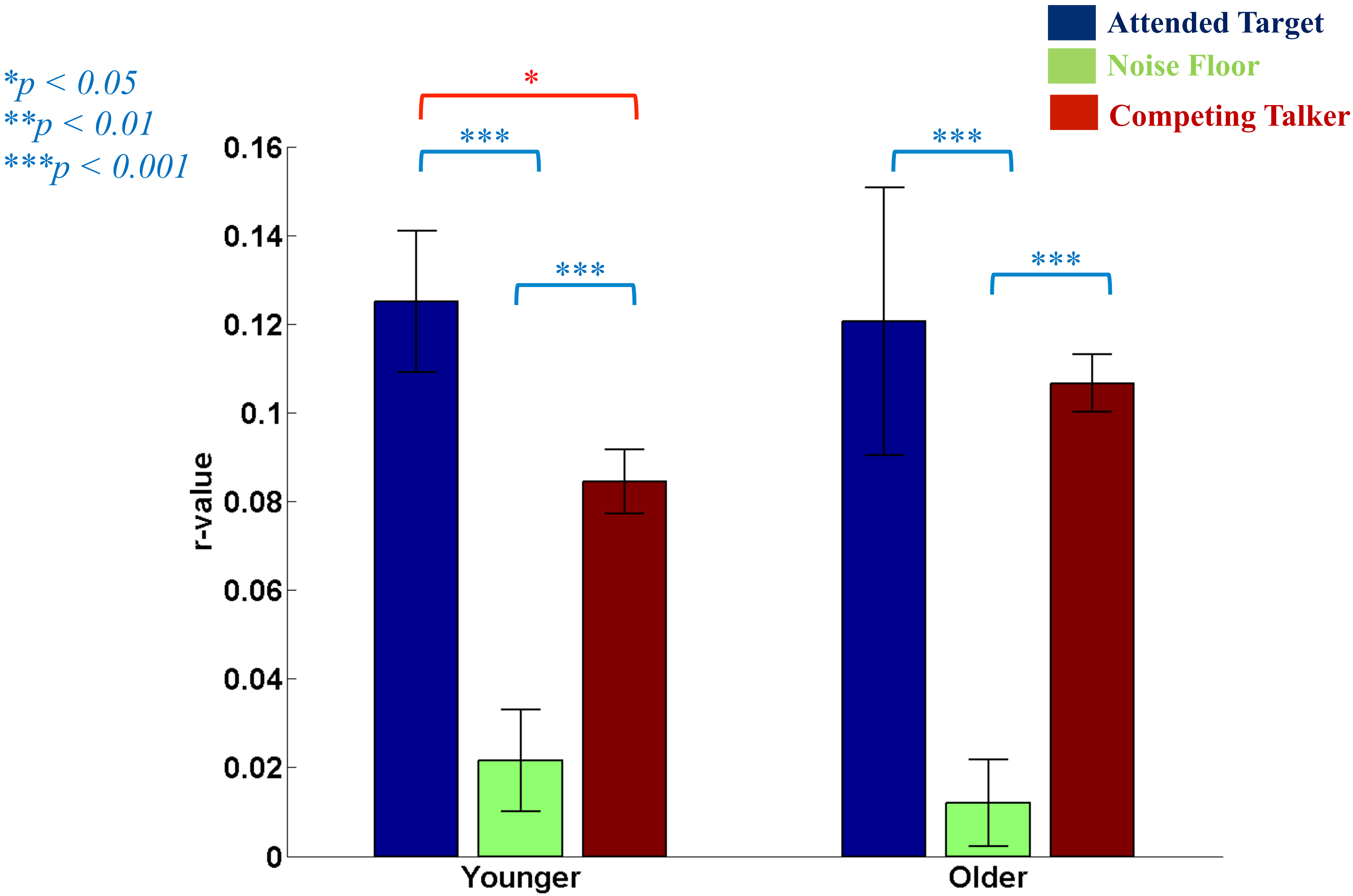
- **1** kHz Sampling frequency

Stimulus reconstruction

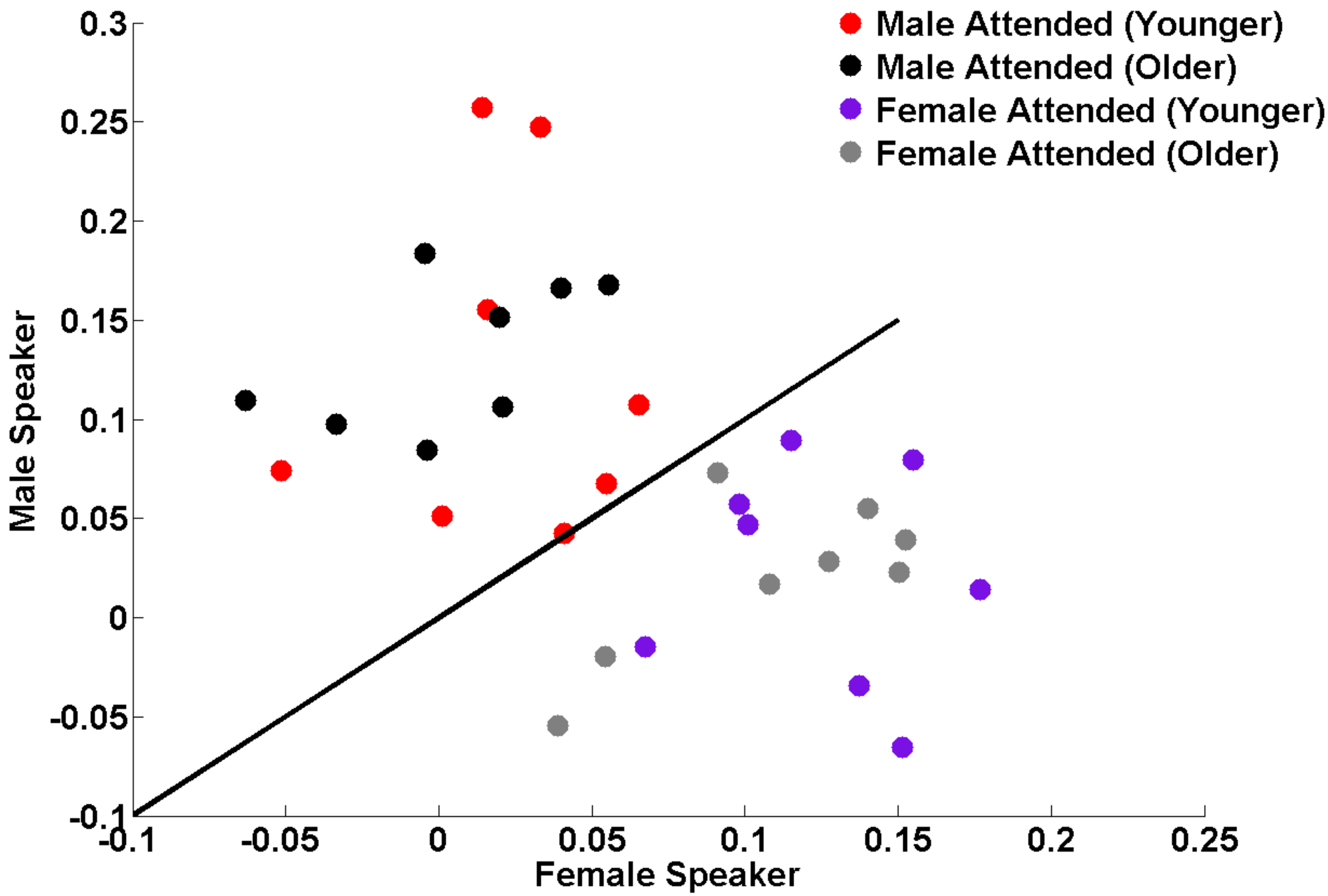
- Data were decomposed in the 1 - 8 Hz frequency band using the denoising source separation (DSS) algorithm (De Cheveigne and Simon, 2008)

- A linear model used the first 6 DSS components to reconstruct the envelope of the speech stimulus to which the subject was instructed to attend (Ding and Simon, 2012a)

Decoding Accuracy in Noise



Attended Speech Reconstruction



Summary of Results

- **Behavioral (QuickSIN)**
  - Showed a significant difference between younger and older adults in sentence recognition in noise

- **MidBrain (FFRs)**
  - Envelope shows significant differences between quiet and noise in the younger adults only
  - The time-frequency representation of the envelope and of the temporal fine structure shows minimal noise-related changes in older adults,
  - Younger adults show a significant reorganization of the envelope and of the temporal fine structure

Summary of Results (con’t)

- **<u>Cortex (Slow Temporal Oscillations)</u>**
  - Difference in decoding accuracy significantly different between target and background speech in younger adult only
  - In quiet differences in performance between younger and older adults are reduced

Conclusions

- Results suggest that aging affects subcortical and cortical encoding of speech in noise
- Temporal precision seems to be compromised in quiet in older adults already at the brainstem level
- Decreased temporal precision at the brainstem level in older adults might make the segregation of speeches harder to accomplish at the cortical level
- Decreased precision may lead to disadvantages in processing the rapid acoustic changes in speech that occur during a typical conversation
- This problem may be exacerbated in noisy conditions, when the target speech should be isolated from competing stimuli
- Possible role of attention at the cortical level?

Questions???

Hearing Brain Lab

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