Evidence of Age-Related Temporal Processing Deficits in EEG and MEG Recordings

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Background
Older adults often report that during a conversation they can hear what is said, but cannot understand the meaning, particularly when the conversation is in a noisy environment. These deficits may be due to deficits in auditory temporal processing [1]. A long time since auditory processing may be a key factor underlining shortened listening delays and decreased in response consistency and magnitude in older adults [2]. The frequency following response (FFR), an index of temporal sensitivity, reflects the neural response for predicting self-generated speech in noise. Processing deficits in older adults [3]. Recent results in magnetoencephalography (MEG) [4,5] have shown the feasibility of reconstructing the envelope of speech in noisy conditions by using long term-frequencies of the brain in younger adults. Although the effects of aging on neural speech processing has been investigated in quiet conditions [6,7], little is known about neural responses in temporal processing in younger vs. older adults.

Hypotheses
We hypothesize the effect of aging on neural and cortical responses in younger and older adults with normal hearing. Hypothesizing that the neural response of younger adults will be more robust to noise than the one of older adults. Specifically, we hypothesize a higher correlation between neural encoding of speech in quiet and noise conditions and a higher reconstruction (higher coding) reliability of the envelope of the attended speech envelope in the cortical level in younger adults than in older adults.

Materials and Methods
Participants
 Participants were native speakers of English (91 young adults, 20 - 25 years old: 43 females, 48 males; 34 older adults, 60+ years: 16 females, 18 males). All participants had normal hearing and no history of neurological or audio-visual disorder.

Auditory Midbrain EEG Analysis
Raw data were recorded and analyzed through bilateral Auditory Midbrain (1 kHz sampling rate, 200 ms latency window from 0 to 1 kHz). 

Auditory Cortex MEG analysis
Data were recorded using three 128-channel MEGs. 

Correlations between Speech Intelligibility, HT, midbrain and cortex

Results

Auditory Cortex MEG recordings
Speech was presented at 40 dB SPL and six noise levels below 1 kHz.
Participants were asked to attend to one of two tones presented flanking while ignoring the other one and to report the side of the louder. Three trials, each one approximately 1 minute in duration were recorded.

Non-negative sparse time recorded FFR signals were labeled as midbrain MEG system (Katharina Institute of Technology, Konstanz). Expectation was maximized with a L1/L2 sampling rate. A 200 Hz low-pass filter and a 20 Hz filter at 500 ms were applied.

Figure 1: Time-frequency map of all MEG channels. The lines represent the spectral magnitude of the midbrain activity observed over the frequency range. The red box shows the core temporal processing region.

Auditory Cortex MEG recordings
A score test at 40 dB SPL and six noise levels below 1 kHz.
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Figure 2: Averaged FFRs of younger adults (red) and older adults (green). The noise conditions were 0, 5, 10, 15, 20, 30 dB SPL. The error bars show the standard error (SE).

Neural enhancement in younger and older adults

Table 1: Correlations between Hearing Threshold (HT), midbrain and cortex.

Neural enhancement in younger and older adults

Subcortical and cortical responses significantly correlated: midbrain temporal processing may strongly influence cortical speech encoding.

Can Neural Measures Account for Speech Intelligibility?
High correlations between speech intelligibility and HT, and subcortical activity: possible compensation of temporal processing problems at the cortical level.

Conclusions

Auditory Midbrain
A significant positive effect found between age, sex, sex, and age differences in midbrain and cortical responses in older adults. Older adults’ ability to encode speech information in the auditory midbrain is already compromised in quiet.

The score correlation between the response of younger adults at a noise level is higher in older adults than in the whole group, suggesting that younger adults are more resistant to noise.

Overall, younger adults show stronger resistance to noise (higher cross-correlation values and lower auto-correlation values) than older adults.

Auditory Cortex MEG

Reconstruction of the correct envelope of the noise signal to speech envelope

Statistical analysis
A power test was used to compare difference within subjects, while LDA ANOVA was applied to study differences across groups.

The 4 taps (t values) were used to calculate the correlation between perceived hearing threshold - speech intelligibility score, auditory midbrain MEG and auditory cortex MEG variables.

Discussion
A MEG group analysis on effect found between age, gender, sex, and age differences in midbrain and cortical responses in older adults. Older adults’ ability to encode speech information in the auditory midbrain is already compromised in quiet.

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Figures

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References