Effect of Meaningful vs. Meaningless Noise on Speech Representations in the Aging Midbrain and Cortex

Alessandro Pressacco1,2, Jonathan Z. Simon2,3,4, Samira Anderson1,2
1Hearing and Speech Sciences Department, 2Neurosciences and Cognitive Science Program, 3Biology Department, 4Institute for Systems Research, 5Department of Electrical & Computer Engineering

University of Maryland, College Park, MD
apressacco@umd.edu

Background

- Older adults often report that they have difficulty understanding speech in noisy environments.
- Older adults may rely on cognitive strategies to compensate for these perceptual deficits to a greater degree than younger adults.
- Speech-processing performance improves in the presence of a meaningful stimulus (foreign language words) compared to an uninformative stimulus (speech-like noise).
- Inhibition of motor cortical area responses to stimuli and memory is increased in older adults during active suppression versus suppression alone.
- Differences in the ability to process meaningful versus meaningless stimuli in the presence of noise are related to age differences in cognitive function.
- Memory and processing speed are reduced in older adults.

We compared the effects of meaningful and meaningless noise on subcortical (FFR) and cortical responses (MEG) in normal hearing younger and older adults.

Hypotheses

- We hypothesized that older adults would show enhanced speech processing in the presence of meaningful noise compared to meaningless noise.
- We predicted that meaningful noise would enhance speech processing in the midbrain and cortex of older adults.

Method

Participants

- Participants with normal hearing, ages 21-35 (M = 25.2; SD = 2.5).
- Male: Female = 1:1.
- Participants were matched on their native language.
- Mean IQ scores: 116.26 ± 17.12.

Auditory MEG recordings

- Speech presented at 75 dB SPL and five different levels (1, 2, 3, 4, 5 dB SNR).
- Participants were asked to listen to either meaningful or meaningless noise while listening to speech.
- Target vs. non-target stimuli were used to elicit speech-locked potentials.
- Neural responses were recorded using 157-channel whole head MEG system.
- The MEG signals were analyzed using the FFR method.

Results - Midbrain

- Auditory MEG analysis

Auditory Midbrain EEG Analysis

- Data averaged and filtered 1-300 Hz. EEG analyses were conducted in quiet and speech conditions.
- Correlations between responses in quiet and high and low context noise were calculated.

Auditory Cortex MEG Analysis

- Mean responses were obtained in meaningful (10 conditions, 2 SNR) and meaningless (10 conditions, 2 SNR) conditions.
- Statistical analysis of the mean responses was performed with MANOVA (alpha correction).

Results - Cortex

- Neural reconstruction of speech envelope

Cognitive assessment

- Conners Continuous Performance Test (Conners CPT) was used to assess attention. Reaction times (ms), and number of omissions were assessed.
- Stroop task was used to assess cognitive interference.

Auditory Midbrain EEG recordings

- A 175 ms syllable was presented at 100 dB with a bilateral white noise presented daisically with alternating polarity (50% white noise, 50% silence) through earphones (2.0 kHz).
- EEG from same subjects at two different conditions:
  1. Auditory stimulus
  2. Auditory stimulus + Binaural Noise

Results - Correlation

- Statistical analysis

Correlation of response amplitudes in quiet vs. noise conditions

- Quiet-to-noise correlations in the steady-state region for meaningful and meaningless noise for all the conditions tested.

Discussion

- The results show that older adults are more resistant to the effects of background noise than younger adults.
- Effects of type of background noise did not differ at the level of midbrain.
- The effects of noise on speech processing did not differ significantly between groups for different background noise levels.

Auditory midbrain

- Both ONH and OHI make use of favorable conditions and engage cognitive resources to enhance speech processing.
- The midbrain is affected by both types of noise.
- Absence of correlation between midbrain and cortex suggests the existence of a central neuroplasticity related to speech processing.

Cortex

- Auditory cortex in ONH and OHI is more resistant to the effects of background noise than younger adults.
- Differences in the balance of excitatory and inhibitory neurotransmission, or changes in the neural mechanisms underlying speech processing may explain the differences observed.

Acknowledgements

- This study was funded by UMD ADVANCE Program for Inclusive Excellence, MCM Fund for Student Research Excellence, NSF HRD1008117, the T32DC000046 and the NIH R01DC014085.