Effect of informational content of noise on neural speech representations, with and without peripheral hearing loss

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Background

- Older adults report difficulty understanding speech in noisy environments, even when signal-to-noise ratio is normal.
- Older adults may rely on cognitive resources to compensate for presbycusis in a similar degree than younger adults.
- Speech-language performance improves in the presence of a meaningful distractor.
- Activation of cortical areas during attention and memory is more pronounced in older listeners.
- Temporal processing deficits in the middle [3] and superior [4] auditory areas may account for the deficits experienced by older adults in processing simultaneous information.
- Informational content may affect older adults’ cortical but not subcortical response.
- We compared the effects of meaningful and meaningless noise (one-talker babble) on different temporal regions of noise for all the listeners.
- The informational content of noise affects older adults’ cortical, but not subcortical response.

Method

Participants

- Participants with normal hearing (N=30).
- 15 normal hearing young adults (N=30; 19 – 24 years old, mean 21.5, 18.2 ± 1.7 years).
- 15 normal hearing older adults (N=15; 65 – 75 years old, mean 70.7, 68.0 ± 1.6 years).
- 14 hearing impaired older adults (N=14; 75 – 86 years old, mean 82.3, 80.0 ± 1.6 years).

Audiogram and speech intelligibility score

- The mean of the speech reception thresholds of the better ear was 42.2 dB HL in both conditions.
- The mean of the speech discrimination score of the better ear was 95.6%.

Cognitive assessment

- Visual Memory: 41% of the listeners scored 80% or higher.
- Attention: 41% of the listeners scored 80% or higher.
- Working Memory: 41% of the listeners scored 80% or higher.

Auditory Midbrain EEG recordings

- 178-ms speech stimuli, presented diotically with alternating pitches at 70 dB (HL) at a rate of 16 Hz through monaural headphones (LH).
- 1000 Hz white noise stimulus (N=5) in 4 different conditions: presented in quiet and mixed noise (LH 80.0, 70.0, 60.0, 50.0) and with noise (N=5) where noise was monaural (female native English speaker) or meaningless (female Native Dutch speaker).
- 208 epochs per condition recorded from the 68 electrodes (64 Biosemi Active 2-Channel, 4 Biosemi Net2-Channel).
- 408 epochs by averaging the two productions to reduce any stimulus artifact.

Statistical analysis

- Significance levels: * p < 0.05, ** p < 0.01, *** p < 0.001.
- Results fromwinsorized ANOVA applied to study differences across groups. Non-parametric Mann-Whitney U test and Wilcoxon Signed Rank test were not selected.
- Post-hoc ANOVA was used to study attention across age groups. For the cortical analysis, the condition to quiet was used as a reference.
- The false discovery rate (FDR) procedure (Benjamini et al. 1996) was applied to control for multiple comparisons.

Auditory Midbrain EEG analysis

- Data analyzed using Three-Tiered Principal Components Analysis (PCA).
- Results were obtained using Three-Tiered Principal Components Analysis (PCA).
- The first 50 components were retained and then filtered between 2 - 8 Hz.
- In a group model, the first three filters were not retained.
- Correlations with performance on attention tests.

Auditory Cortex MEG analysis

- Data were analyzed using Three-Tiered Principal Components Analysis (PCA).
- Grand averages for each condition calculated for the 9 conditions in quiet and noise.
- Grand averages of the speech of younger and older adults calculated for the 9 conditions in quiet and noise.
- Correlation of the speech envelope to young adults showed higher rates than either group.

Results - Midbrain

- Grand averages show higher reconstruction accuracy for meaningful noise than for meaningless noise.
- Increased temporal precision leads to higher reconstruction accuracy.
- Differences between normal hearing and impaired older listeners.

Results - Cognitive

- Greater inhibitory control relates to better reconstruction accuracy, but only for the older normal hearing listeners.
- Increased temporal precision, greater noise degradations to both groups of older adults.

Discussion

Auditory midbrain

- The response of normal hearing young listeners was more resistant to the effects of background noise than those of older groups of older listeners.
- Increased temporal precision associated with less noise degradations to either group of older adults.

Auditory cortex

- Both normal hearing and hearing impaired older listeners had lower scores in the speech recognition tests than young adults, suggesting difficulties.
- Differences in noise degradation as a function of age, severity, and hearing loss.
- Increased temporal precision leads to higher reconstruction accuracy in older adults.
- The neural representation of the target speech stream is degraded by meaningful noise more in older adults with and without hearing loss.

Results - Correlation

- Correlation between the response in quiet and noise.
- Neural hearing impairment and hearing-impaired older listeners.
- Correlations with performance on attention tests.
- The neural representation of the target speech stream is degraded by meaningful noise more in older adults with and without hearing loss.

Summary

- All results indicate that factors other than peripheral hearing loss, such as age-related cognitive function, may significantly contribute to cortical encoding deficits.
- The results of the current analysis emphasize the importance of studying auditory temporal processing in different levels of the auditory system. Different levels of the auditory system, such as MEG, may reflect the neural processing of speech in the cortex.
- The neural representation of the target speech stream is degraded by meaningful noise more in older adults with and without hearing loss.

References

- Fitzgibbons and Gordon-Salant (2001)
- Bidelman et al. (2004)
- Presacco et al. (2016)
- Finegan et al. (2008).