The Effect of Noise on the Selective Attention

AUTHORS: Emina Alickovic[1,2], Carina Graversen[1], Dorothea Wendt[1,3], Patrycja Książek[1], Renskje K. Hietkamp[1], Thomas Lunner[1,2,3,4]

[1]Eriksholm Research Centre, Denmark, [2]Department of Electrical Engineering, Linkoping University, Sweden, [3]Department of Health Technology, Technical University of Denmark, Denmark, [4]Department of Behavioral Sciences and Learning, Linkoping University, Sweden

Introduction

Background

Recent research investigating selective attention has demonstrated that neural responses can be decoded in order to identify the attended sound source in everyday listening environments [1].

Auditory attention decoding (AAD) methods [2] from EEG data enable the decoding of the attentional selection.

Motivation

This study investigates the **effect of different signal to noise ratios (SNRs)** [3] on selective attention, quantified by decoding accuracy.

Research question

*Can AAD methods be used to examine the **effect SNR in hearing-aid (HA) users**?*

Experiment

Participants

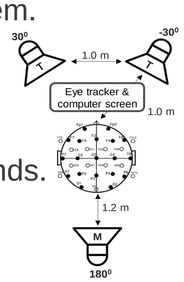
8 hearing impaired subjects with mild sensorineural, symmetrical hearing loss hearing loss (avg. age of 70 ± 12 years).

EEG data Acquisition

64 channels of scalp EEG data (10/20 system) were recorded using the Biosemi ActiveTwo system.

Stimuli

- **30s of Danish** non-dramatic news clips.
- 30° azimuth via loudspeakers.
- **Target (T)**: attended (A) & ignored (I) sounds.
- **Masker (M)**: 4-talker babble noise.

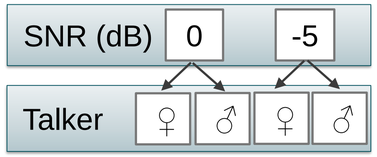


Hearing Aid settings

Subjects were fitted with 2 Oticon Opn1 mRITE HAs. Amplification was provided using the Voice Aligned Compression (VAC) rationale

Experiment design

Test design:

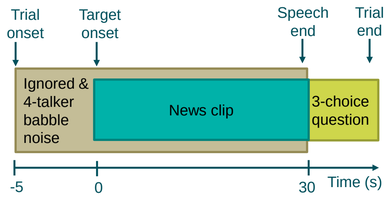


$$\mathrm{SNR} = \frac{\text{Signal power of A}}{\text{Signal power of I}}$$

Attended sound presented at either:

- 0 dB SNR (high SNR),
- -5 dB SNR (low SNR).

Task design:



- 27 trials per conditions.
- 4 conditions: 2SNRs (0 &-5dB) vs 2 target positions (-/+ 30 degree)

Data analysis method

Preprocessing

- Envelopes (env): abs(hilbert(speech))
- EEG & env:
  - Band-pass filter [1-8 Hz],
  - Down-sampled to 128Hz.

Per-trial TRF calculation

- mTRF toolbox [4]
- Decoder (D) properties:
  - Trained on A speech,
  - Time lags: 250ms post-stimulus.

Leave-one-out cross validation

- Averaged D (AD) = average of 107 Ds.
- 108 ADs calculated.

Speech reconstruction

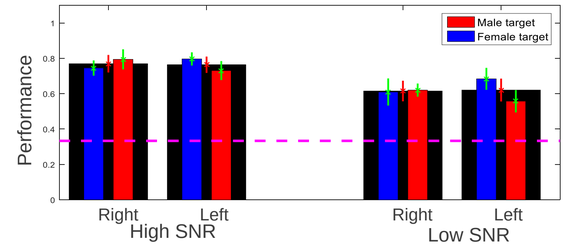
- Reconstructed A ($\hat{A}$): AD & *unseen* EEG

Classification

- Pearson *r:*
  - $r_A = \mathrm{corr}(\hat{A}, A)$
  - $r_I = \mathrm{corr}(\hat{A}, I)$
- Correct: $r_A > r_I$

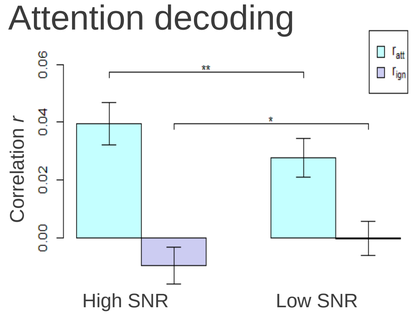
Results

Behavioral performance



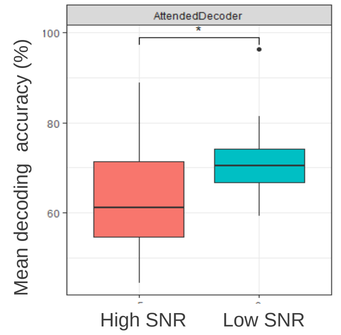
Averaged behavioral performance data. Sig effect of SNR (p=0.0028)

Attention decoding



Sig effect of SNR on:

- reconstructed A envelopes (p=0.0095).
- reconstructed I envelopes (p=0.0344).



Sig effect of SNR (p=0.0291).

Conclusion

Data analysis showed that SNR had a significant effect on AAD, demonstrating the potential of the AAD methods to reveal the impact of SNR on selective attention in individuals with hearing impairment.

Information
Emina Alickovic
Eriksholm Research Centre
eali@eriksholm.com

Read more at:
www.eriksholm.com:

References [1] O'sullivan, James A., et al. "Attentional selection in a cocktail party environment can be decoded from single-trial EEG." Cerebral Cortex 25.7 (2014): 1697-1706. [2] Das, Neetha, Alexander Bertrand, and Tom Francart. "EEG-based auditory attention detection: boundary conditions for background noise and speaker positions." Journal of neural engineering 15.6 (2018): 066017. [3] Alickovic, Emina, et al. "A Tutorial on Auditory Attention Identification Methods." Frontiers in Neuroscience 13 (2019): 153. [4] Crosse, Michael J., et al. "The multivariate temporal response function (mTRF) toolbox: a MATLAB toolbox for relating neural signals to continuous stimuli." Frontiers in human neuroscience 10 (2016): 604.

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