Predicting speech understanding from EEG recordings: effect of attention
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1. Introduction

Objective correlate of speech understanding
- Speech envelope is a primary cue for speech understanding (Shannon et al., 1995).
- Cortical neural activity tracks the neural envelope of running speech (Probst and Davis, 2012)
- Reconstruction of speech envelope from cortical activity is possible (Ding and Simon, 2011).
- Quality of this reconstruction correlates with behaviorally measured speech understanding (Vanthornhout et al., 2018).

Research question
Question 1: Does the reconstruction quality of the speech envelope depend on how much attention the subject paid to the stimulus? Hypothesis: attention(subject) = SNR (EEG) = reconstruction quality.
Question 2: Can we reverse the effect of attention by choosing optimal signal processing parameters?

2. Methods

Participants
3 experiments:
1. 33 young normal hearing subjects, aged 19-23 years
2. 5 young normal hearing subjects, aged 22-26 years
3. 8 young normal hearing subjects, aged 18-23 years

EEG
BioSemi system with 64 electrodes

3. EEG conditions
1. Maximal attention: answering questions about the speech stimuli
2. Watching an animated movie
3. Playing Tetris

Signal processing

Figure 1: Example of simulated SNR = -9 dB. The red line is a simulated envelope with an integration window ranging from 0-75 ms, and a standard deviation of 0.14 dB and 1 Hz. The green line is a simulated envelope with a temporal integration window from 0-175 ms. The correlation is 0.25. The grey band is the 95% confidence interval (ρ = 0.25 ± 0.05).

4. Results

Experiment 1: effect of integration window (baseline)

The entrainment of the stimulus at multiple SNRs with and without watching a movie. The integration window 0-75 ms shows both conditions a quasi-monotonic trend suggesting the effect of attention was less prominent compared to the other integration windows.

Visually, we see that the increase in reconstruction quality is more monotonic compared to the other integration windows, this is supported by the correlation between the reconstruction quality and the SNR for the movie condition. (Spearman ρ = 0.4 for 0-75 ms, and ρ = 0.6 for 0-250 ms using a confidence interval).

Experiment 2: effect of watching a movie

The entrainment of the stimulus at multiple SNRs with and without watching a movie. The integration window 0-75 ms shows both conditions a quasi-monotonic trend suggesting the effect of attention was less prominent compared to the other integration windows.

Task: reading, listening, or watching a movie. Other integration windows did not show a monotonic increase.

Experiment 3: effect of playing Tetris

The entrainment of the stimulus at multiple SNRs with and without playing Tetris. The integration window 0-75 ms shows both conditions a quasi-monotonic trend suggesting the effect of attention was less prominent compared to the other integration windows.

Task: reading, listening, or playing Tetris. Other integration windows did not show a monotonic increase.

5. Conclusion

We found that entrainment of the speech envelope increases with stimulus SNR when choosing an integration window of 0-75 ms. Our hypothesis is that this results from having less effect of attention which can influence the level of entrainment (Pavanada and Simon, 2015; O’Donnell et al., 2014).

When subjects were watching a movie while listening to the speech stimuli, we found monotonically increasing entrainment with stimulus SNR in the 0-75 ms integration window. Other integration windows did not show a monotonic increase.

When subjects were playing Tetris while listening to the speech stimuli, we did not find this monotonic increase. We found the monotonic increase when the same subjects attentively listened to the speech stimuli. While this can be the result of failing to remove the effect of attention, it can also be due to motor artefacts.

Research question 1: When the attention of the subject was diverted to a movie or a Tetris game, we found a decrease in reconstruction quality at some SNRs.

Research question 2: By choosing an integration window from 0-75 ms we were able to reduce the effect of attention in the movie condition but not in the Tetris condition.

References

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