Neural representations of Background speakers at the Cocktail Party

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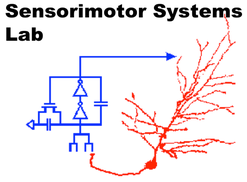
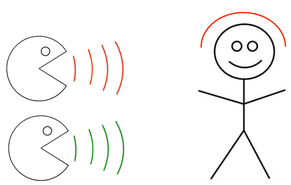
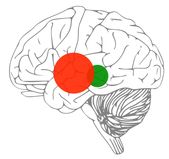


How are unattended background speakers represented neurally?

Stimulus world

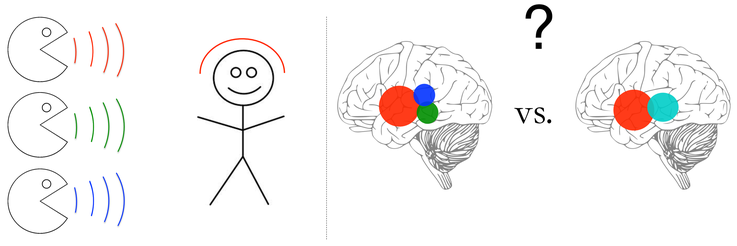


Neural world



With two auditory sources to choose from, attended (foreground) and unattended (background) have distinct neural representations (Ding & Simon, 2012).

But when there are more than two sources to choose from, are the background sources' representations *distinct* or *merged*?



Does selective attention work by selecting pre-formed auditory streams out of a complex auditory scene? Or by identifying only the attended (foreground) stream? Or a different mechanism?

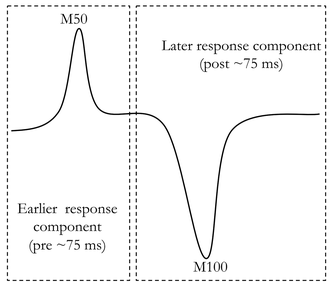
Experimental Design

- 3 co-located speakers simultaneously narrating separate stories.
- 220 s stimulus duration, 3 attention conditions x 3 repetitions
- $N = 7$ Subjects
- In each trial the subject counts the number of times a given keyword is heard in the attended story.
- At the end of 3 trials, the subject reports a summary of story.
- Magnetoencephalography (MEG) recordings, 157 channels.
- 1 kHz sampling , Time-shifted PCA based de-noising.
- Spatial filtering used to reduce 157 channels to fewer, more reliable virtual channels.

Analysis & Results

Stimulus reconstruction

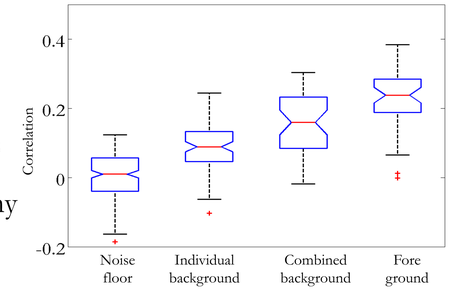
- Temporal envelope of stimulus is reconstructed from cortical responses using optimum linear filters.
- Correlation between reconstructed and actual envelope is used as metric as how faithfully the foreground or background is represented in cortical responses.
- Reconstruction is based on integrating neural responses over a temporal window.
- Different latency ranges in the temporal integration window represent different neural areas, with different processing specializations and representations.



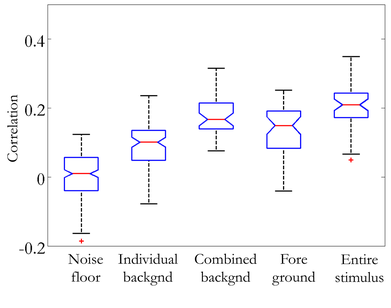
Stereotypical neural response

Stimulus reconstruction using only late responses

- *Foreground* is most accurately reconstructed of all.
- *Combined background* is more accurately reconstructed than any *individual background*.



Stimulus reconstruction using only early responses

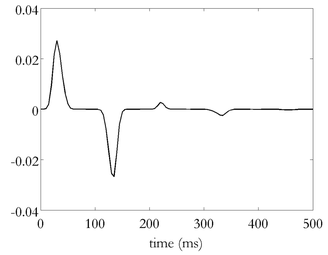


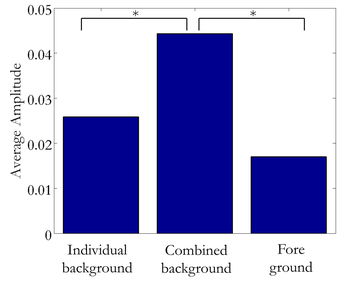
- *Physical stimulus* is most accurately reconstructed of all.
- *Combined background* is more accurately reconstructed than *any individual background*.
- *Combined background* is more accurately reconstructed than *foreground*.

Temporal Response function (TRF) analysis

- Neural response is modeled as linear (filtered) function of temporal envelope of speech stimulus.
- Optimum filters are derived using Boosting algorithm with 10-fold cross validation.

A representative TRF showing M50-like and M100-like responses for speech stimuli.



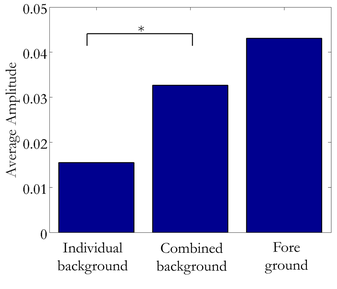


Average amplitudes for M50-like response

- Higher amplitudes observed for combined background than individual background or foreground.

Average amplitudes for M100-like response

- Higher amplitudes observed for combined background than any individual background.
- Highest amplitudes observed for Foreground but not significant.



Discussion

In a complex auditory scene with more than two sources:

- Longer latency cortical areas represent the auditory scene as a single foreground source but a merged background (everything other than foreground), not as having distinct neural representations for each source.
- Earlier latency cortical areas are consistent with representing the entire acoustic scene, without distinct neural representations for each source.

References: Ding N. and J. Z. Simon, (2012) *The Emergence of Neural Encoding of Auditory Objects While Listening to Competing Speakers*, PNAS, 109(29), 11854-11859.

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