Neural representations of Background speakers at the Cocktail Party

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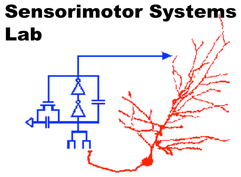
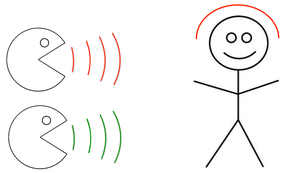
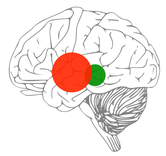


How are unattended background speakers represented neurally?

Stimulus world

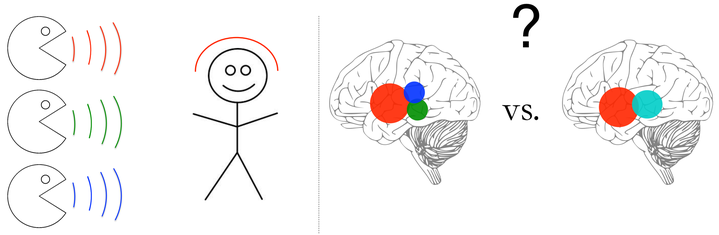


Neural world



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?

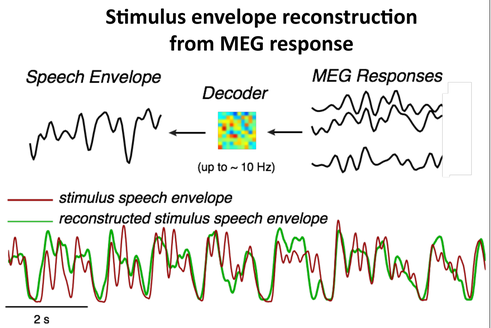
Experimental Design

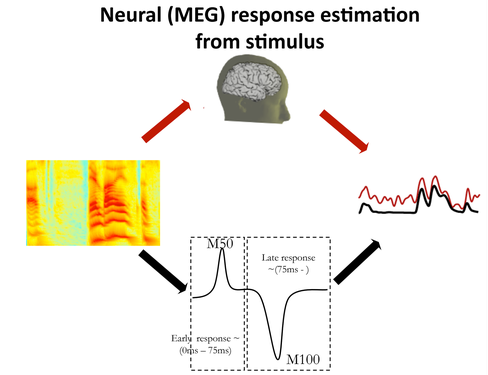
- 3 co-located speakers simultaneously narrating separate stories.
- 220 s stimulus duration, 3 attention conditions x 3 repetitions
- $N = 7$ Subjects.
- In each trial the subject counts the number of times a given keyword is heard in the attended story.
- At the end of 3 trials, the subject reports a summary of story.
- Magnetoencephalography (MEG), 157 channels.
- 1kHz sampling , Time-shifted PCA based de-noising.
- Spatial filtering used to reduce 157 channels to 8, more reliable, virtual channels.

Analysis & Results

Stimulus reconstruction

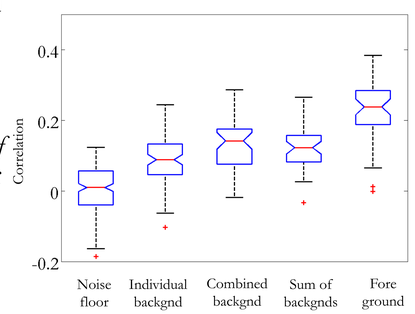
- Temporal envelope of stimulus is reconstructed from cortical responses using optimum linear filters.
- Reconstruction based on integrating neural responses over a temporal window.
- Differing latency ranges in the temporal integration window represent different neural areas, with different processing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



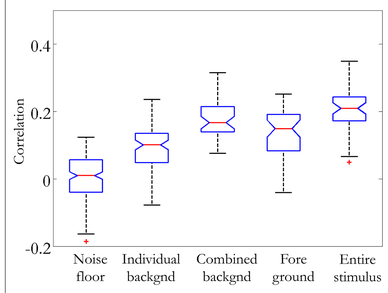


Stimulus reconstruction using only late responses

- *Foreground* is most accurately reconstructed of all.
- *Combined background* is more accurately reconstructed than *sum of individual backgrounds.* (for N=7, α=0.2, one-sided ttest)
- *Combined background* is more accurately reconstructed than any *individual background.*



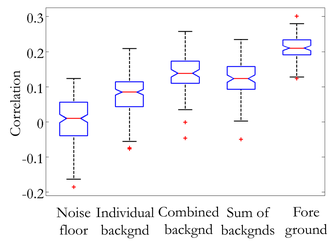
Stimulus reconstruction using only early responses

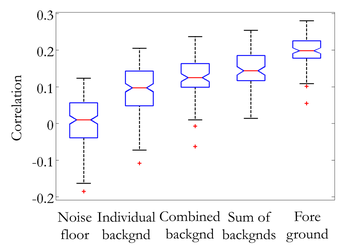


- *Physical stimulus* is most accurately reconstructed of all.
- *Combined background* is more accurately reconstructed than *any individual background.*
- *Combined background* is more accurately reconstructed than *foreground.*

Simulation Results

- Simulated neural response = 1.25*env(fgnd)+ env (bgnd1+bgnd2) +pink noise; *(N=14)*
- *Combined background* is more accurately reconstructed than *sum of individual backgrounds.*





- Simulated neural response = 1.25*env(fgnd)+ env (bgnd1)+env(bgnd2) +pink noise; *(N=14)*
- *Sum of individual backgrounds* is more accurately reconstructed than *combined background* .

Discussion

In a complex auditory scene with more than two sources

- Preliminary results indicate that 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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