

A monkey model of auditory scene analysis: How does the brain solve the 'cocktail party problem'?

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Importance

- More than half the world's population develop age related hearing loss.
- They have difficulty understanding speech in background noise like in a café or in a party. This difficulty is known as 'cocktail party problem'.

Questions

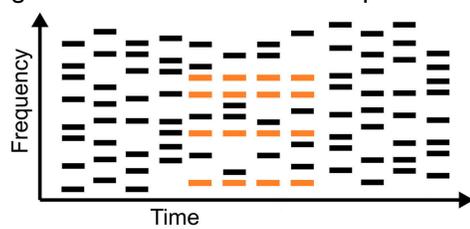
- Auditory scene analysis is the process by which a brain transforms an acoustic signal into object based representation. So which brain regions are involved in segregating auditory objects from background scene?
- How do the results compare in rhesus macaques and humans?

Why Monkeys?

- Animal model allow use of techniques not suitable to perform in humans
- Unlike in humans, systematic single neuron recordings is possible in animals which enable us to understand how neurons accomplish a task
- Monkeys are best suited as models due to their similar auditory abilities and similarity in the organization of their auditory brain with humans.

Figure Ground Stimulus

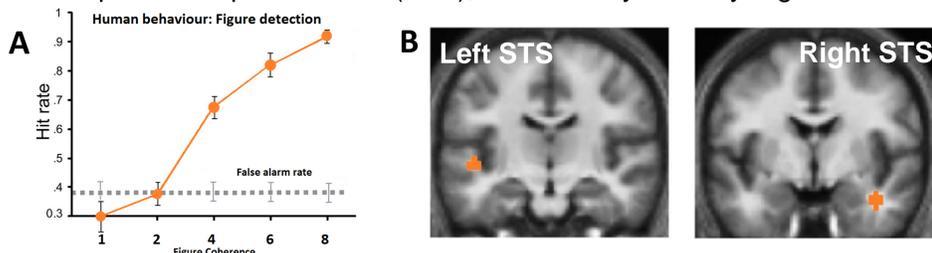
- Synthetic stimuli allow systematic manipulation of its parameters and do not have semantic confounds, enabling development of animal models.
- We have developed a new synthetic stimulus for understanding auditory segregation, where figure and ground overlap in frequency and time.
- Stochastic Figure-Ground (SFG) stimuli has a "figure" made of 'temporally coherent' spectral elements that repeat in time against a "ground" composed of randomly varying spectral elements.
- Coherence is the number of temporally coherent elements that form the figure. Saliency of a figure increases with increasing figure coherence.
- So coherence was varied to infer if monkeys can segregate SFG stimuli & identify brain regions involved from their responses that should co-vary



Spectrogram of SFG stimuli for auditory scene analysis

Humans behaviour & fMRI

- fMRI in humans showed bilateral activations for figure-ground analysis in Superior Temporal Sulcus (STS), a secondary auditory region.



Conclusions

- In macaques, I observed that auditory segregation based on temporal coherence occurs in secondary auditory regions, similar to humans.
- Thus macaques are a good model of human auditory scene analysis.
- My study is the first investigation to show such evidence in any animal.

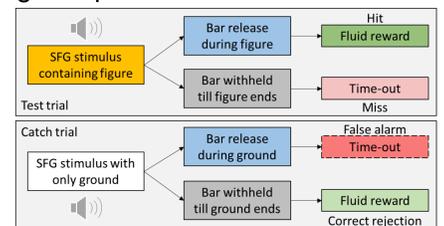
Reference

- Felix Schneider*, Pradeep Dheerendra*, Fabien Balezeau, Michael Ortiz-Rios, Yukiko Kikuchi, Christopher I. Petkov, Alexander Thiele, Timothy D. Griffiths. "Auditory figure-ground analysis in rostral belt and parabelt of the macaque monkey." *Scientific reports* 8 (2018).
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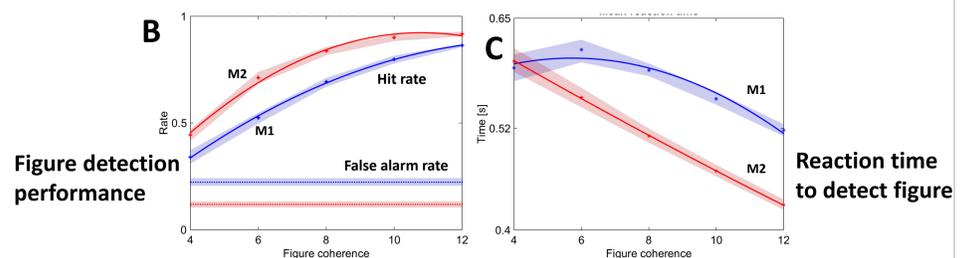
Monkey behaviour

- Two macaques were trained on a 'Go No-Go' paradigm to elucidate whether they were able to perceive figures present in SFG stimuli

(A) Schematic of the behavioural task



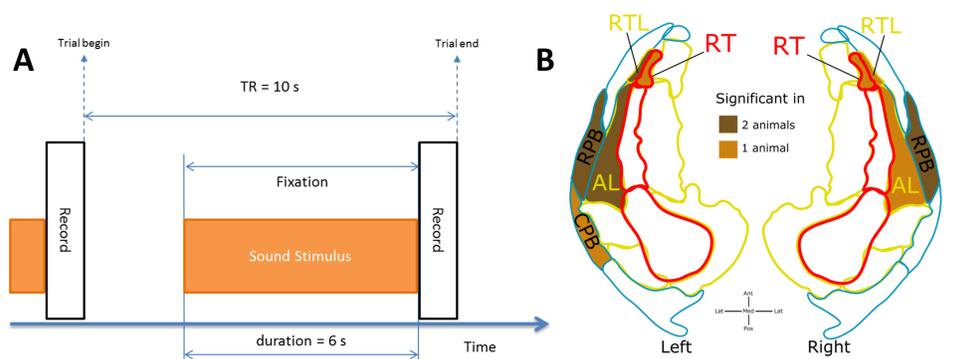
Behavioural results from 2 monkeys (B) Figure detection (C) Reaction time



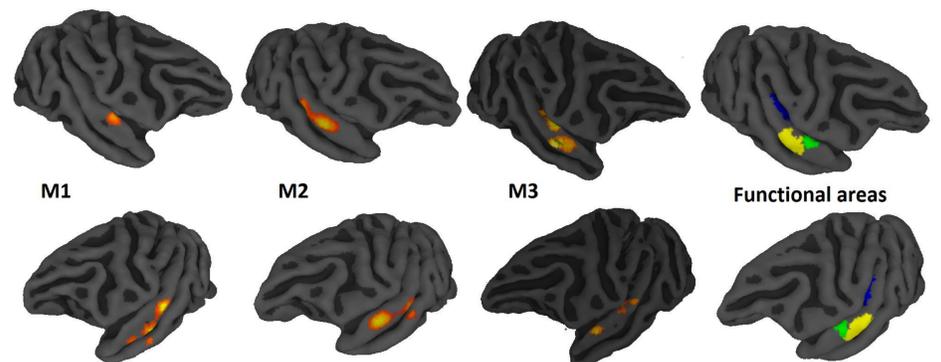
- Detection rate increased with coherence while reaction time decreased
- Thus, macaques are able to segregate figures from this SFG stimuli

Monkey fMRI

- Three macaques carried out visual fixation inside a 4.7T MRI scanner. SFG and control stimuli were randomized and passively presented.
- Sparse temporal paradigm used for acquisition. (A) Schematic below
- General Linear Model was used to partition brain responses and identify brain regions whose response systematically co-varied with coherence.



- Areas involved in auditory figure-ground analysis for each macaque are shown in reddish-yellow hue rendered on a standard macaque brain
- Functional areas: Yellow = Rostral Parabelt; Green = Rostro-lateral belt
- Parcellation (B) shows bilateral activation of rostral belt & parabelt areas



Future Directions

- I have provided spatial priors for recording from single neurons in macaques that allows both system-level and neuronal characterisation.
- We are evaluating relationship between SFG and speech-in-noise segregation in normal hearing subjects and hearing impaired patients.

Sponsors

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