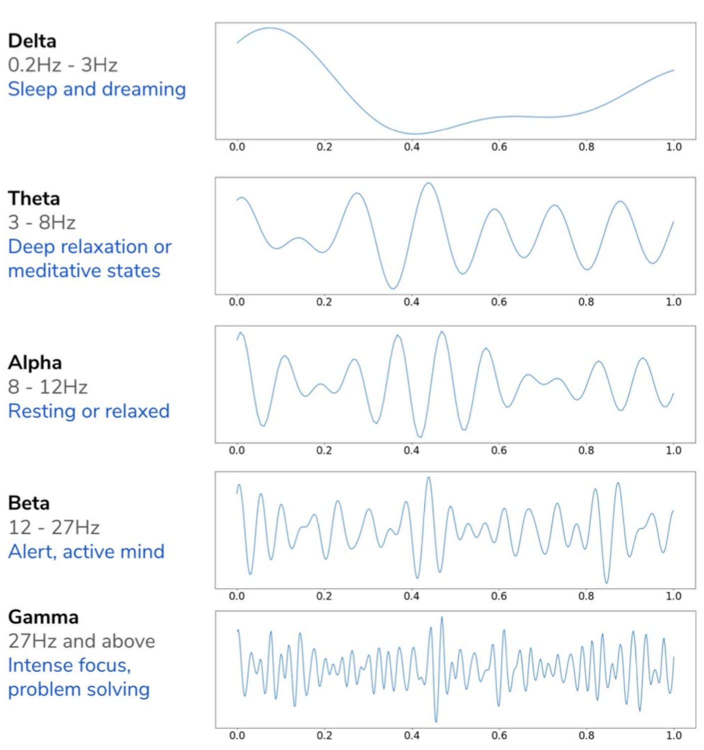
# Decoding executive functions from MEG neural oscillations in childhood

Giulio Benedetti, Jan Kujala and Tiina Parviainen
email: giulio.x.benedetti@student.jyu.fi

## Research Question

**Executive Functions** (EFs) represent a set of cognitive top-down processes involved in self-regulation and goal-oriented behaviour. These processes typically recruit the prefrontal cortex and secondary subcortical areas [1]. Previous research has found that **neural oscillations** may encode information about EF performance. However, it is unclear whether neural activity at specific frequency bands could drive the development of EFs and if **sex** or **age** play a modulatory role in such processes. Thus, we aim to study the contributions of neural oscillations to EF performance in children.

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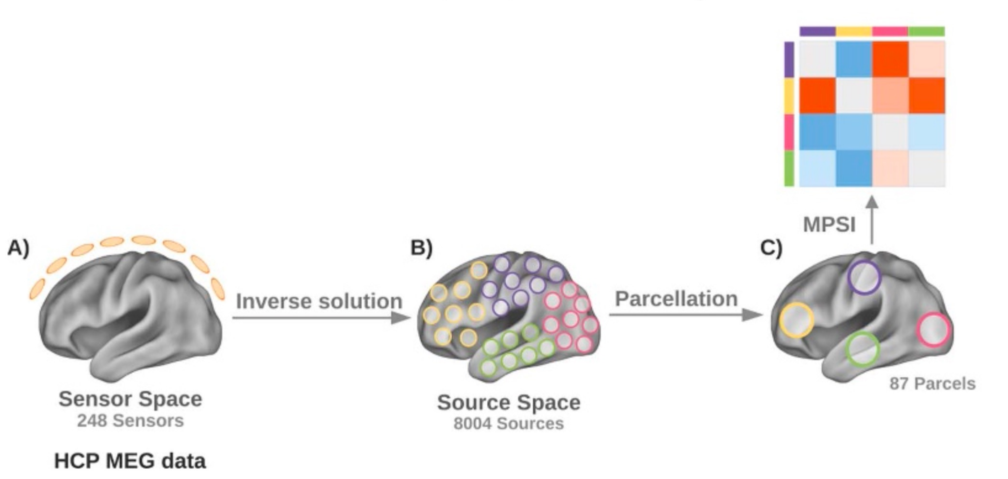
## Analysis and Modelling

The decoding task involves predicting EF performance from MEG-derived neural oscillations. A machine-learning approach will likely be adopted to ensure results interpretability. Feature importance will be assessed for each sex and age group.

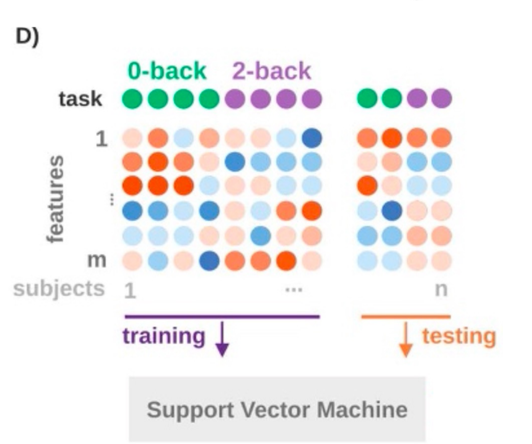
Our current analytical plans include:

- Train on **task-related recordings** and use resting state as baseline
- Conduct analyses in the **sensor space**, leaving source space for the future
- Predict **multiple EF scores**, such as working memory and inhibition control
- Perform a **regression task**, as opposed to classifying high vs low EF performance

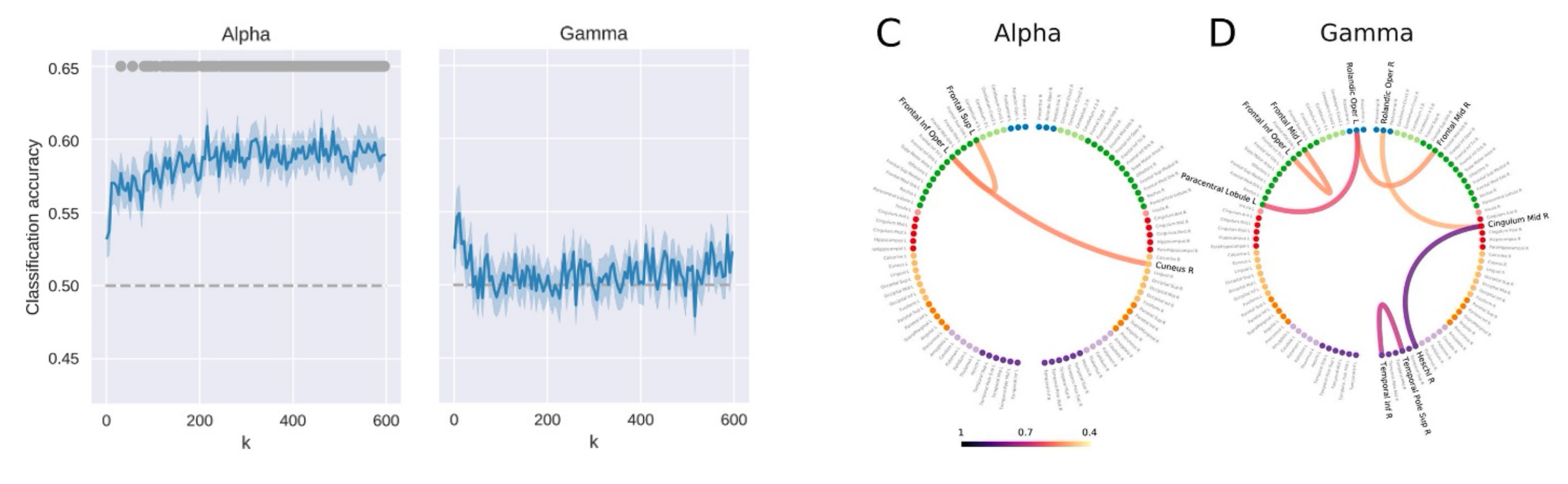
### 1. Data preprocessing




### 2. Model training




### 3. Feature Interpretation

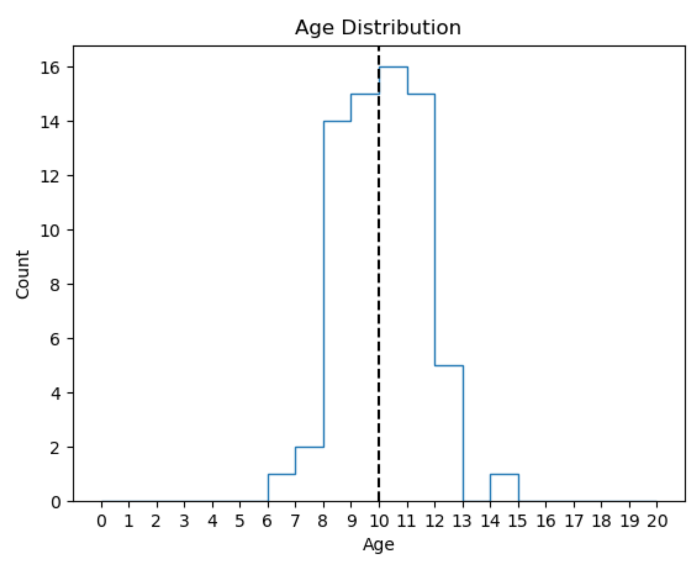



Adapted from [3].

## Participants and Experiment

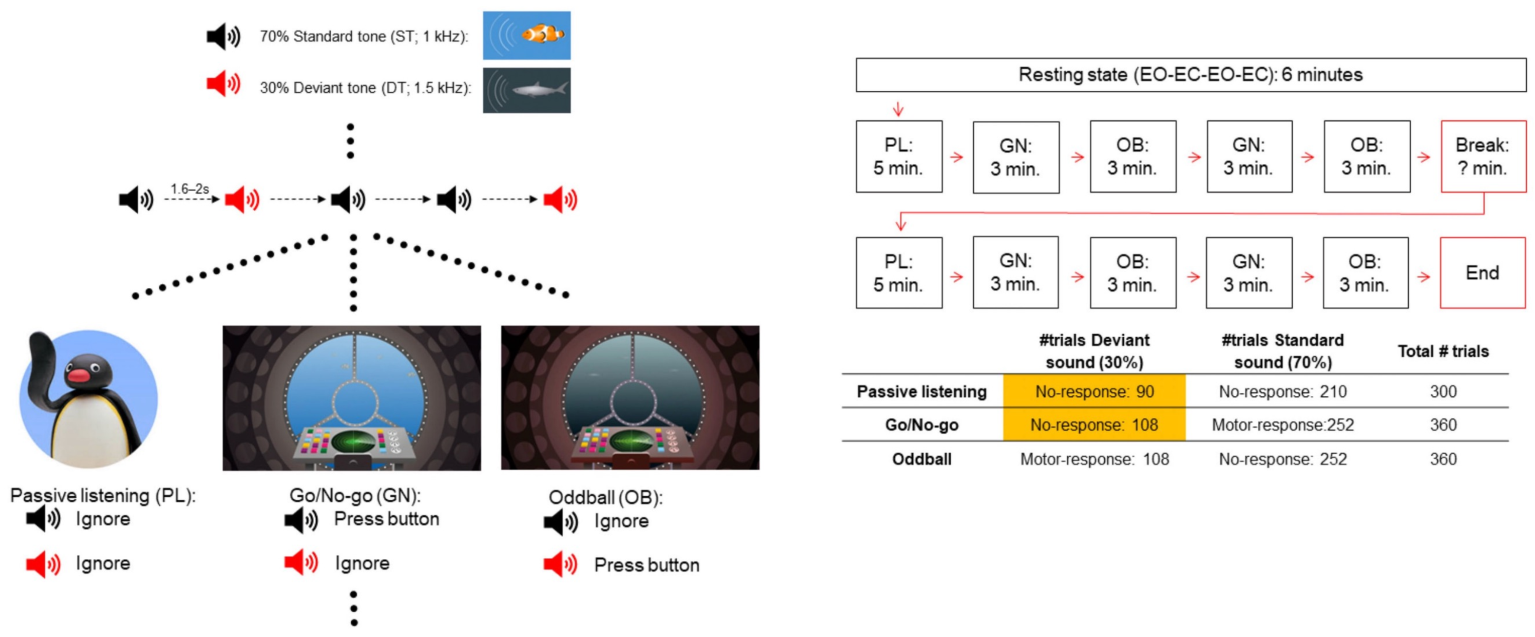
67 children (36 males and 31 females) between 6 and 14 years were drawn from the SAM cohort study [2]. Participants underwent resting-state and task-related MEG recordings (Go/No-go and Oddball paradigms). Additionally, they responded to a battery of cognitive tests to assess EF. We aim to conduct analyses for two age groups and both sexes.

### Participants statistics




| | Children N = 67, 36 males | | |
|---|---|---|---|
| | Mean | SD | Range |
| Age (years) | 10.17 | 1.44 | 6–14 |
| M/EEG experiment | | | |
| GN RT (ms) | 484.20 | 82.74 | 328–693 |
| GN ICV | 0.4 | 0.09 | 0.19–0.56 |
| GN RA (√% correct) | 2.54 | 1 | 0.53–4.87 |
| Behavioral assessment | | | |
| SSRT (ms) | 205.94 | 56.20 | 87–351 |
| Digit span[a,b] | 10.55 | 2.65 | 5–17 |
| Symbol search[a] | 12 | 2.58 | 5–18 |
| Codinga[a] | 10.88 | 2.98 | 4–19 |
| Block design[a] | 11.61 | 2.97 | 4–17 |
| Similarities[a] | 10.39 | 2.63 | 2–16 |

### Experimental design



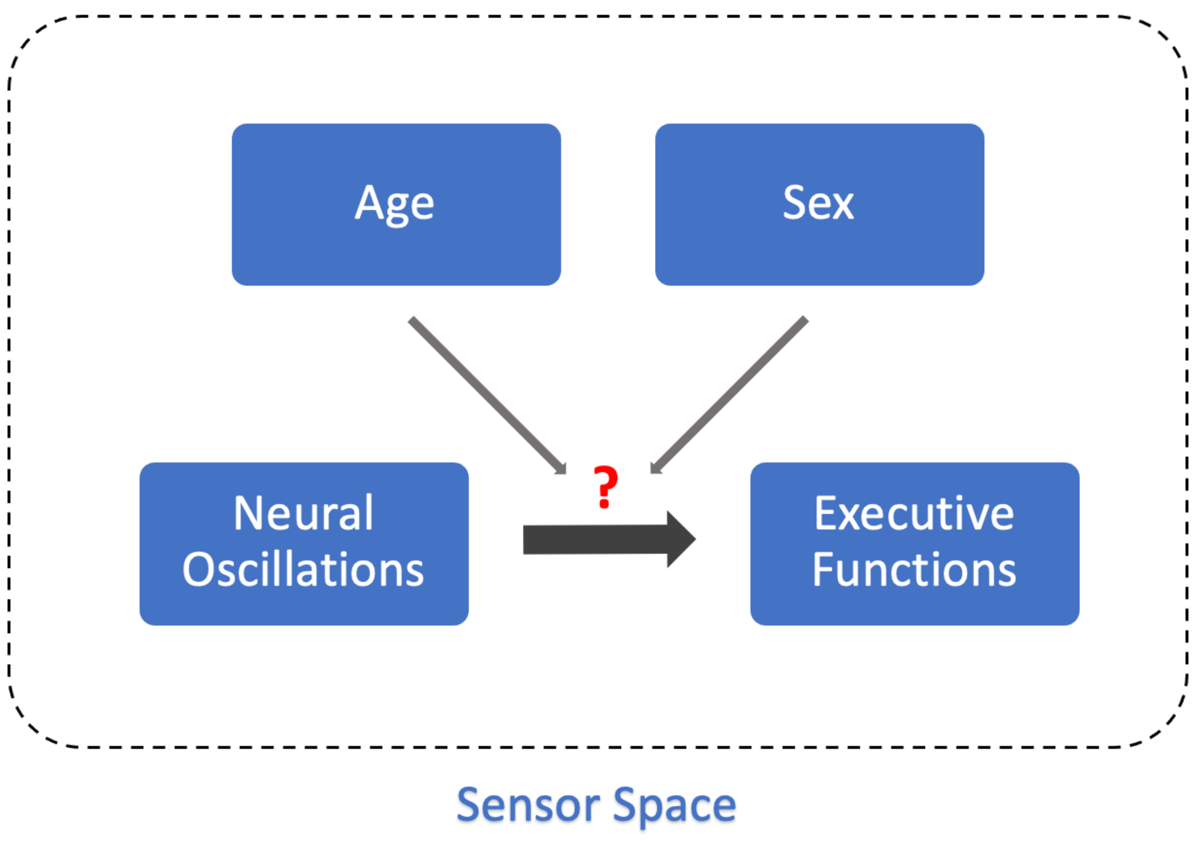

Adapted from [2].

## Study Objectives

It is unclear yet whether certain neural oscillations drive the development of EFs and whether sex plays a modulatory role in such processes. Results will help identify critical contributors of EF development and clarify their role in different sex and age groups.

This study targets the following long-term goals:

- Determine whether and to what extent **EF is decodable from neural activity**
- Identify **neural oscillations** important for EF across sex and age
- Determine if **inhibitory network** is more informative than resting-state network
- Identify **brain regions** important for EF across sex and age (if source space used)




References:
1. De Luca, C.R. and R.J. Leventer, *Developmental trajectories of executive functions across the lifespan, in Executive functions and the frontal lobes*. 2010, Psychology Press. p. 57-90.
2. van Bijnen, S., L. Parkkonen, and T. Parviainen, *Activity level in left auditory cortex predicts behavioral performance in inhibition tasks in children*. NeuroImage, 2022. 258: p. 119371.
3. Syrjälä, J., et al., *Decoding working memory task condition using magnetoencephalography source level long-range phase coupling patterns*. Journal of Neural Engineering, 2021. 18(1): p. 016027.