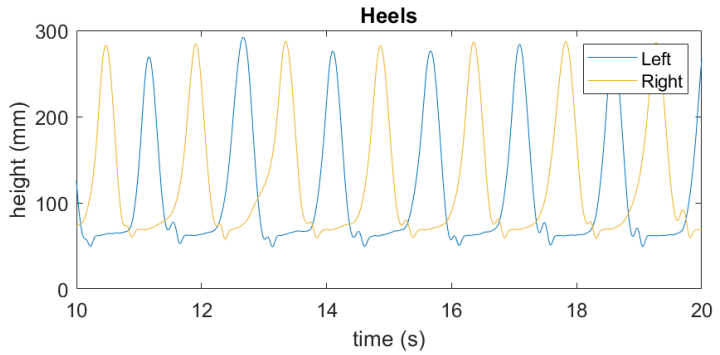
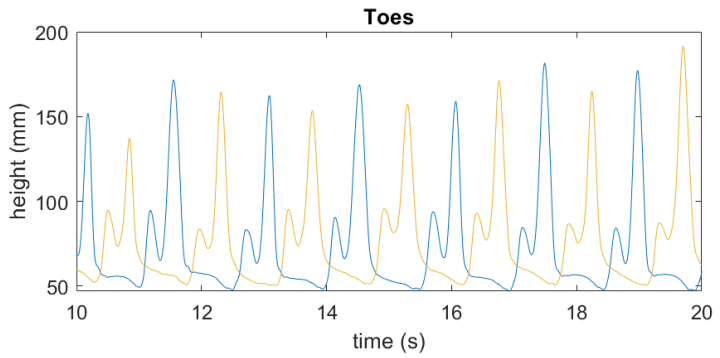
ISPGR WS
Bridging the Gap
Best Practices in Mobile Brain Imaging

Pre-processing EEG gait data

Differences between biomechanical and EEG data

- Heel and toe marker kinematics (low-pass filtered)





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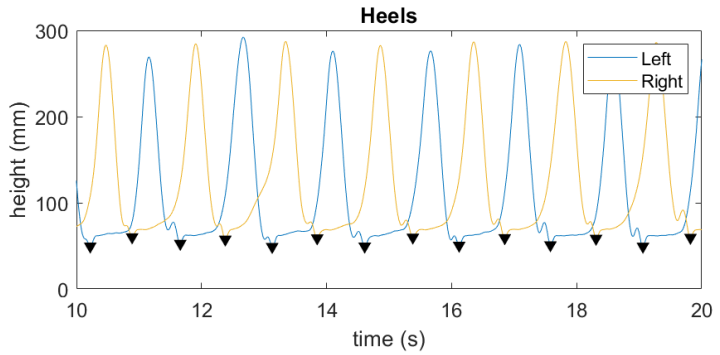

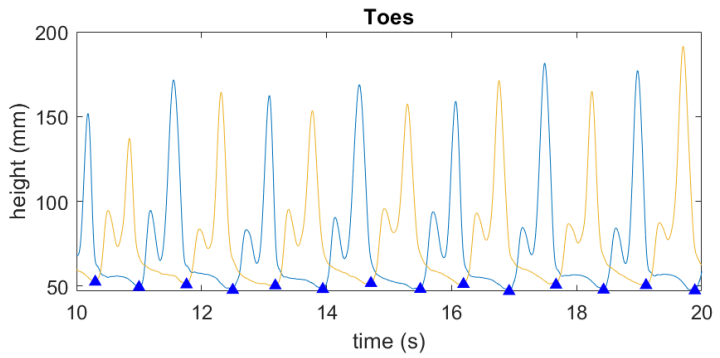

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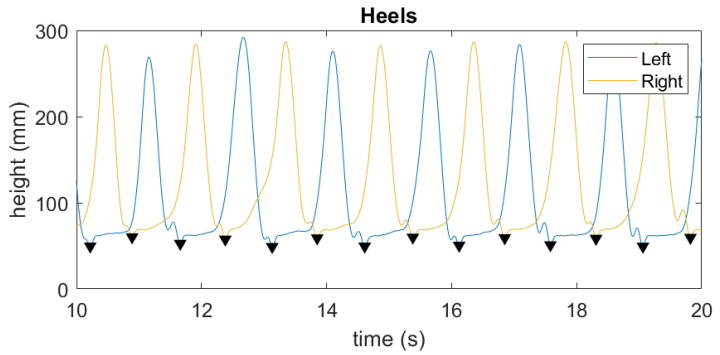
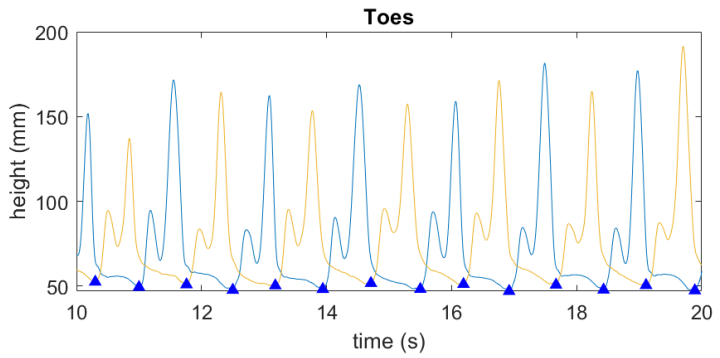
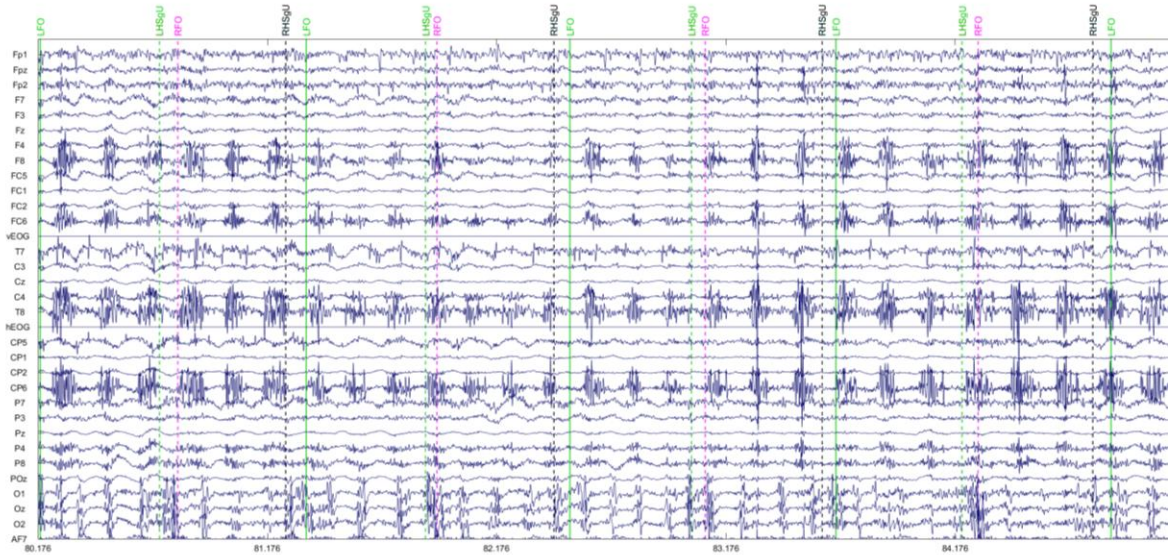




- Raw data



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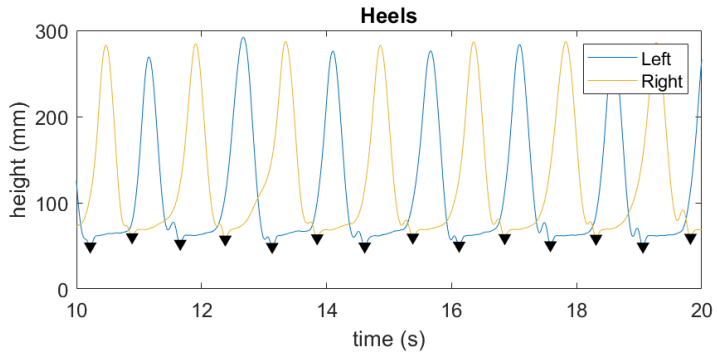

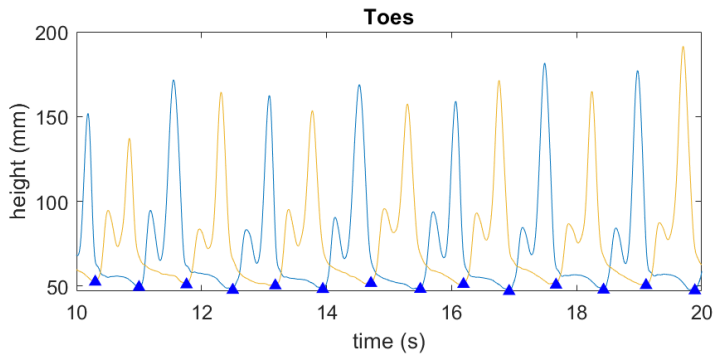

- Filtered data

Objectives of this session

After this session you will

- know the steps involved in EEG preprocessing
- know the different type of artefacts that occur during (mobile) EEG and,
- know how to determine the physiological origin of artefacts and brain data

What is preprocessing?

- All the steps required to convert the raw data to interpretable data
- Iterative process consisting of (at least) the following steps:
  - Visual inspection of the data
  - Band pass filtering
  - Removal of noisy data (and re-referencing)

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  - **Independent component analysis for artefact identification**

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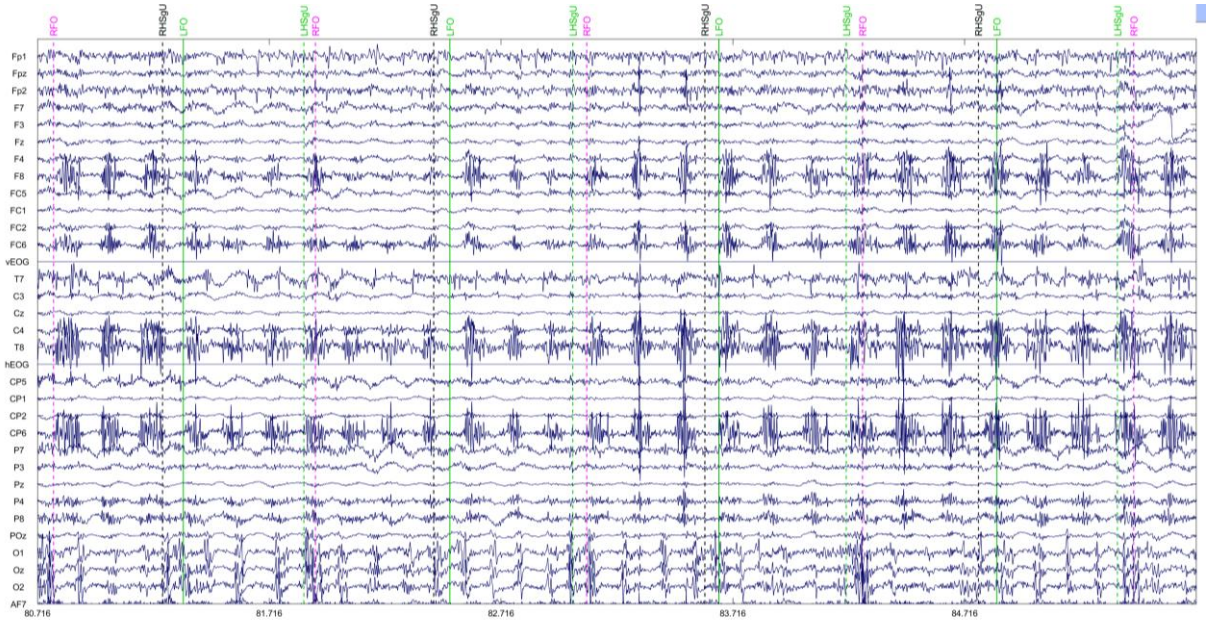
  - **Independent component analysis for artefact identification**

- Open-source toolboxes for Matlab (fieldtrip, eeglab) or Python (MNE-python)

Why preprocessing?

- Unavoidable artefacts during mobile brain imaging
  - Scalp and neck muscle activations
  - Eye movement and blinks
  - ECG artefact
  - Movement artefacts (i.e., time locked to gait events such as heel strikes)

- Environmental noise (i.e., line noise at 50 or 60 Hz and harmonics, WiFi, bluetooth)



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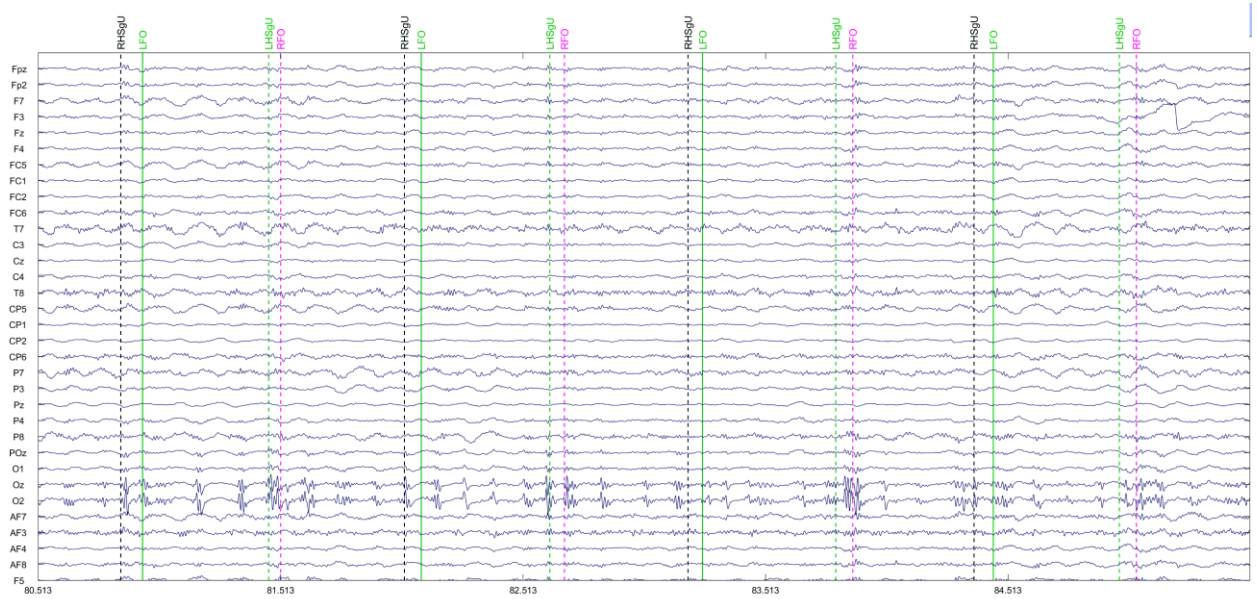

Step 1: visual inspection

- First step: visually inspection of the data to:
  - Get an impression about the data quality
  - Verify that all events/conditions are correctly specified in the recording
  - Remove irrelevant data segments (i.e., breaks between consecutive experimental tasks)

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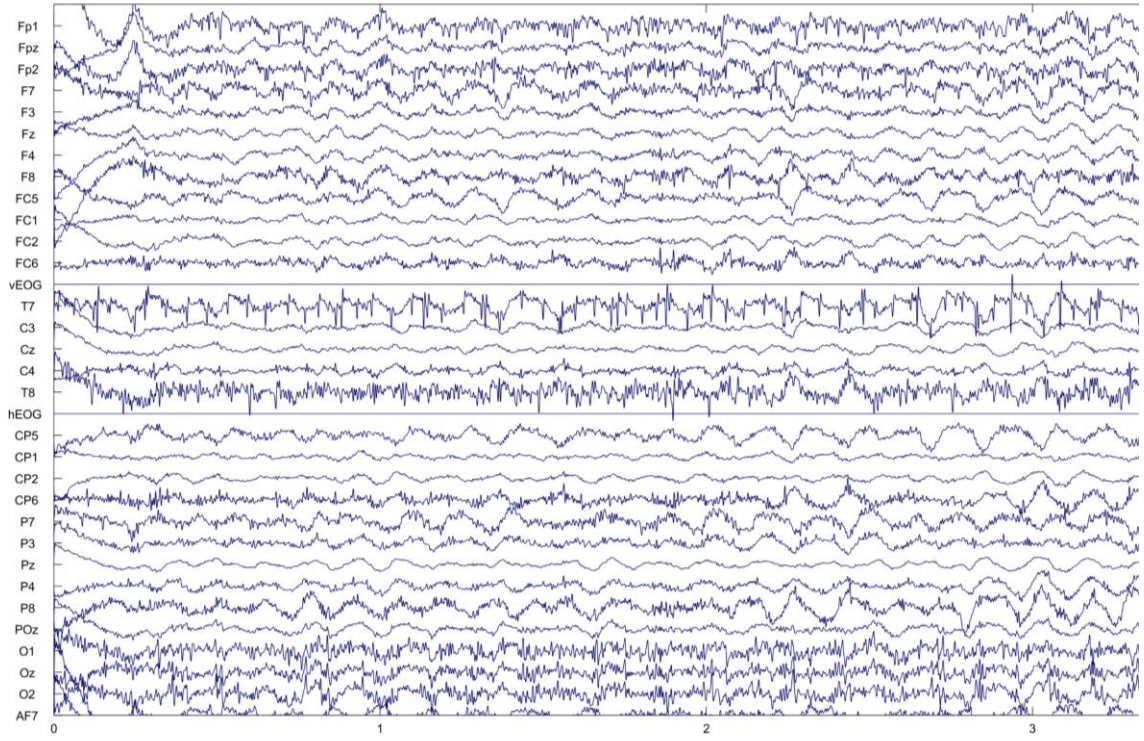
  - Get an impression about the data quality
  - Verify that all events/conditions are correctly specified in the recording
  - Remove irrelevant data segments (i.e., breaks between consecutive experimental tasks)
- Preprocessing will not be able to fix low quality data or recover relevant event information absent in the raw data

Step 2. Identification and removal of bad channels

- Visual inspection on data quality:
  - Are there any channels that are noisy/flat throughout the recording?



Step 2. Identification and removal of bad channels

- Visual inspection on data quality:
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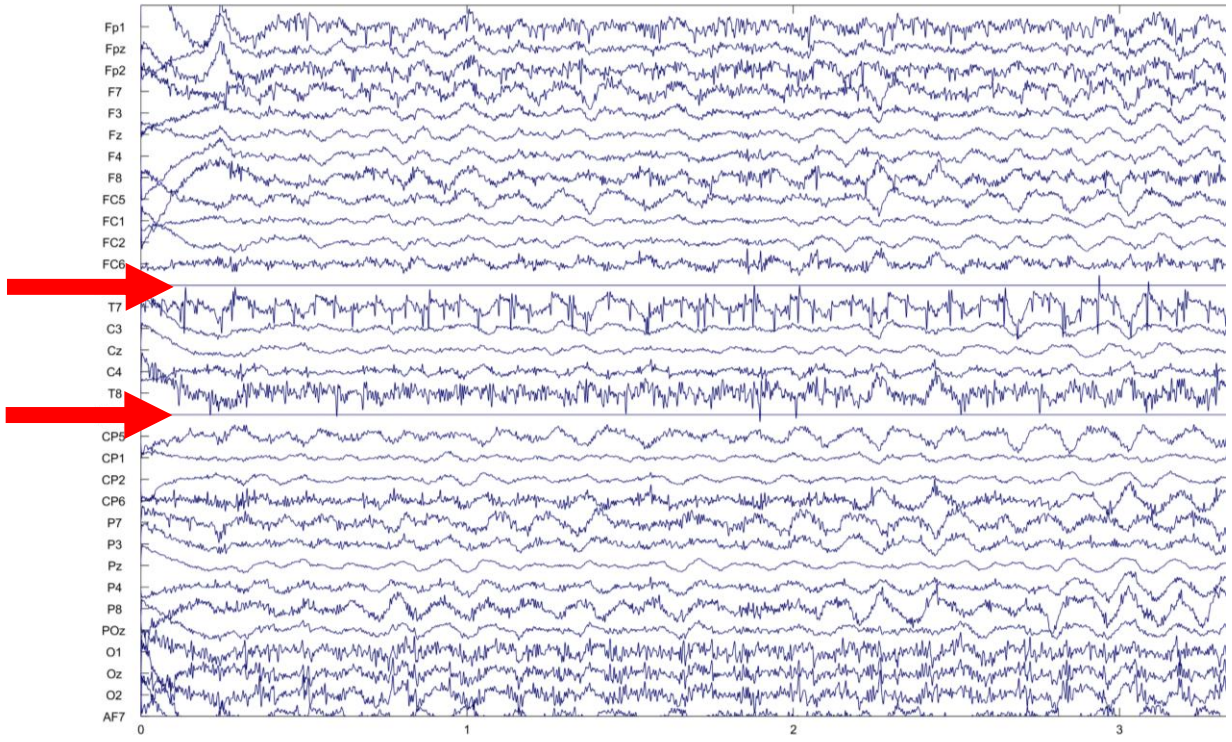
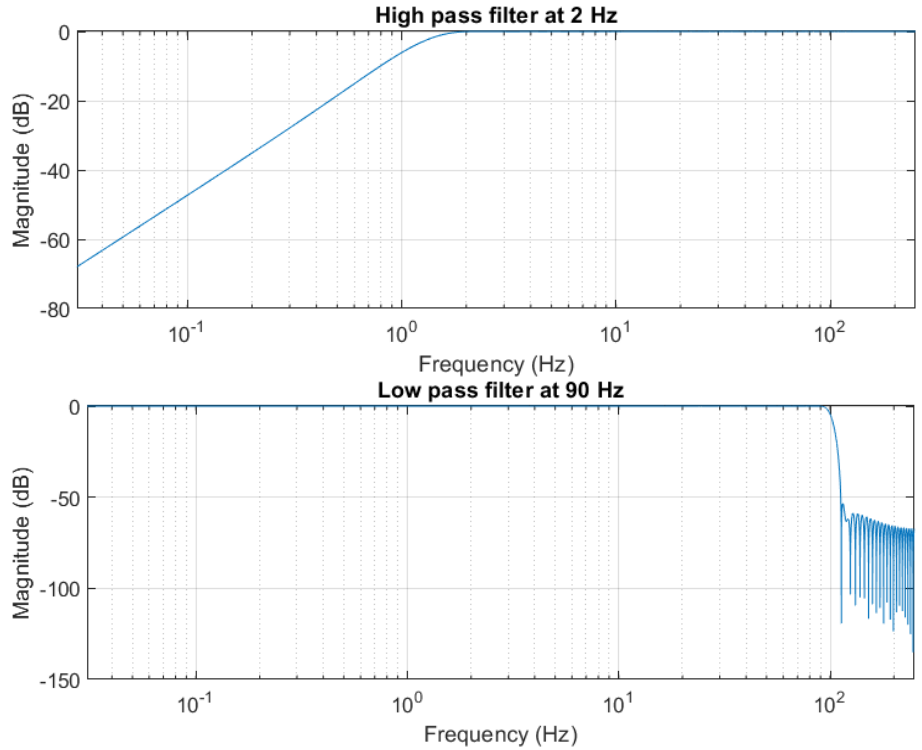
- If a channel is noisy/flat for the entire recording -> remove it
- If noise spreads over multiple channels for short time windows > remove the segment



Step 3. Filtering

- Why filter EEG data?
  - Remove low-frequency drift
  - Remove high-frequency noise



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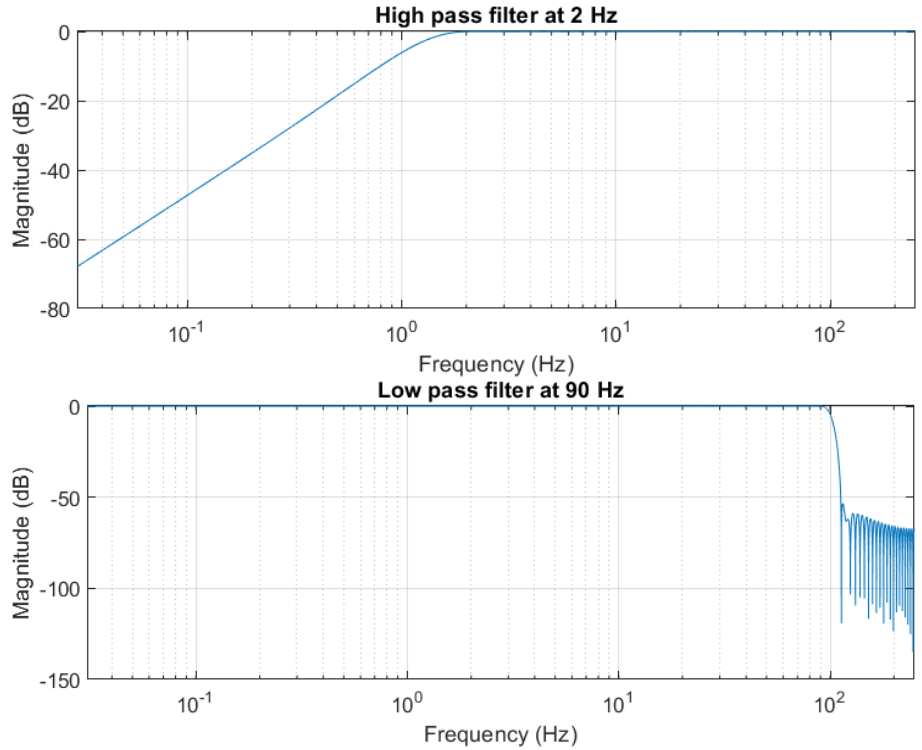

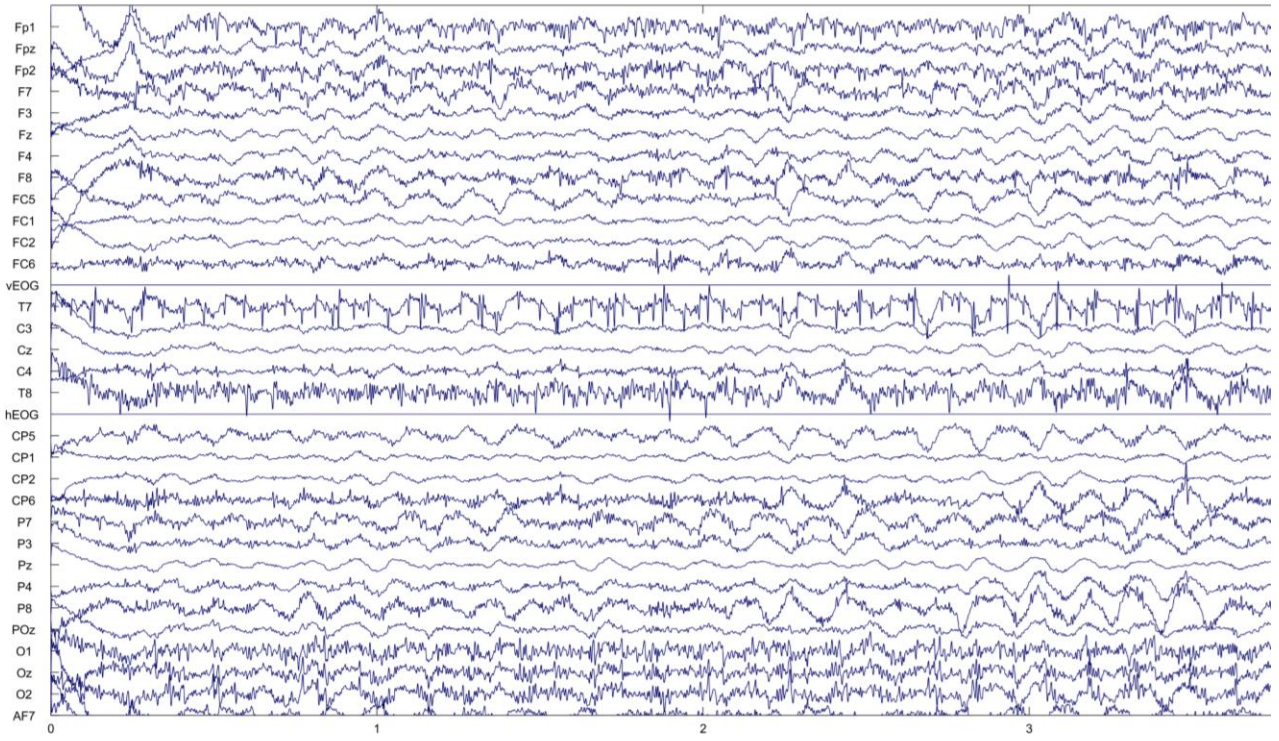

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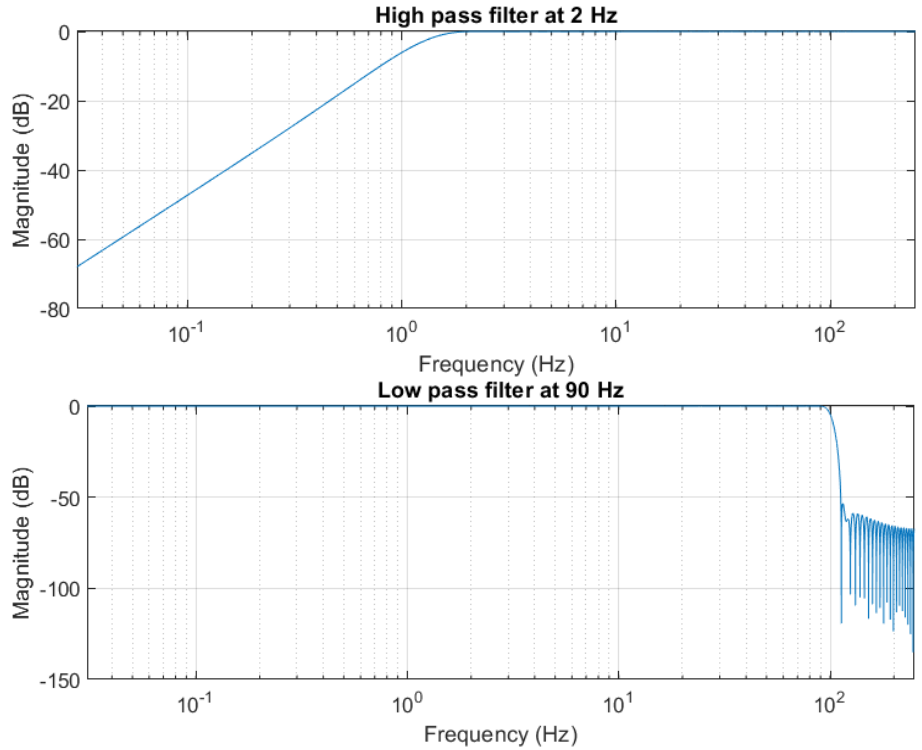
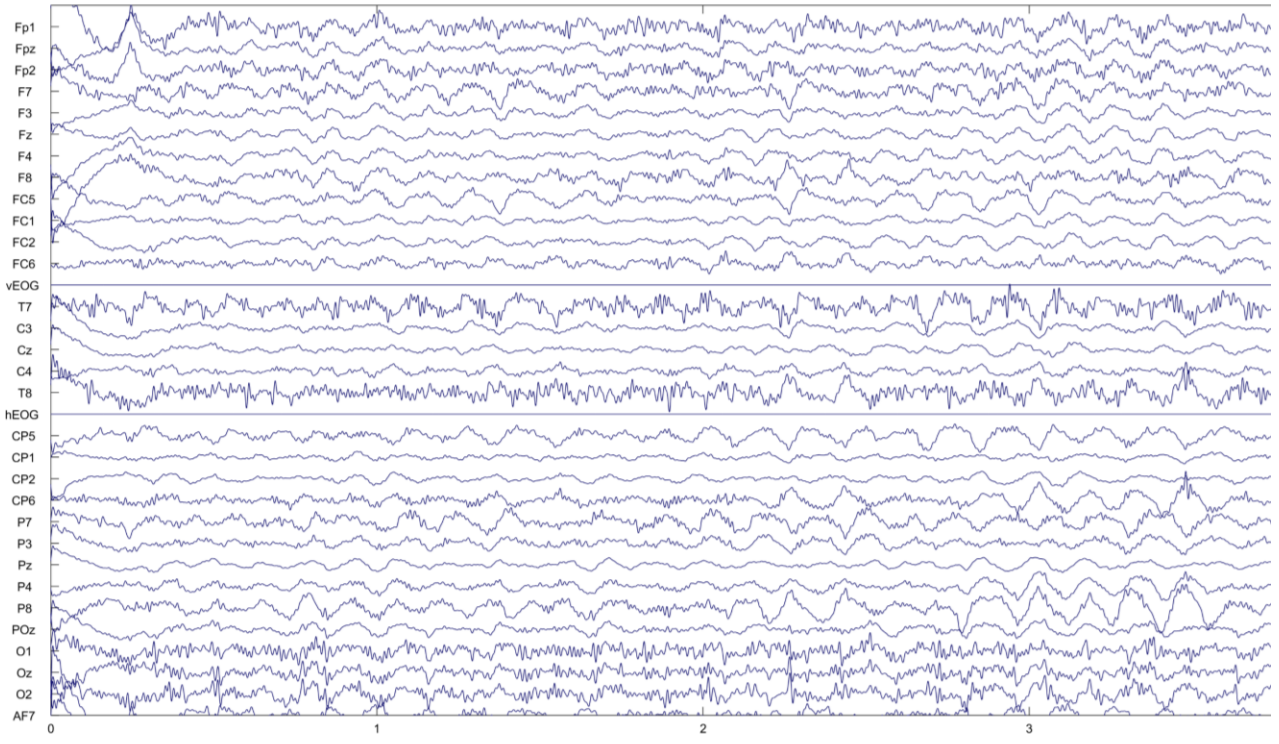
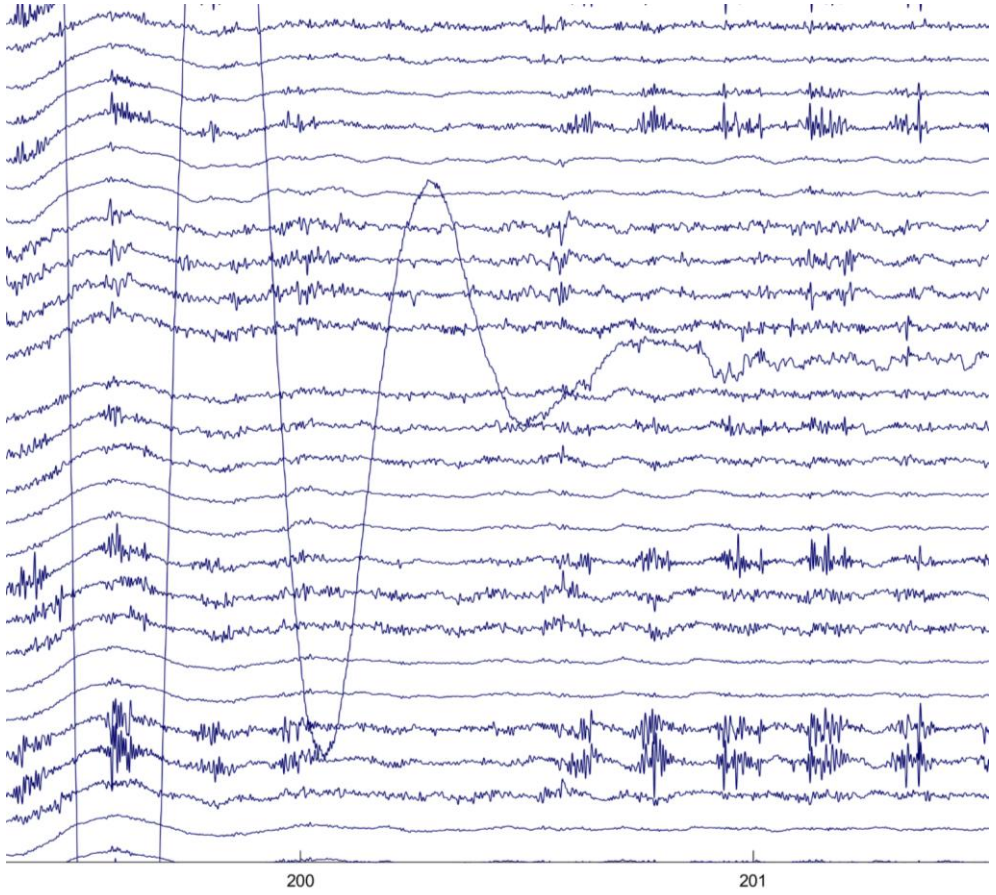




4. Re-referencing

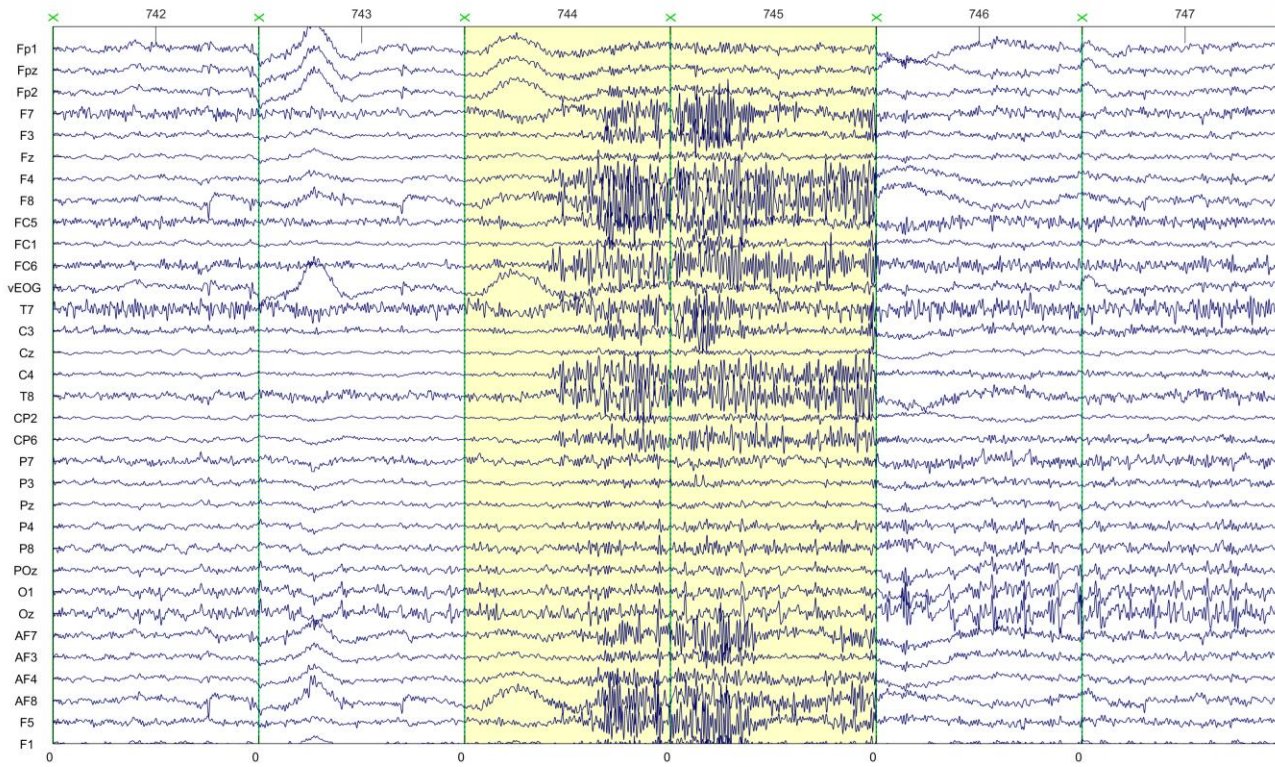
- EEG is recorded relative to a reference point
- The ‘common average’ reference is most frequently used in high density EEG recordings:
- $V_i = V_i - \frac{1}{N}\sum_{j=1}^{N} V_j$
- If a channel is removed from the data, re-reference the data

Average over all *N* EEG channels



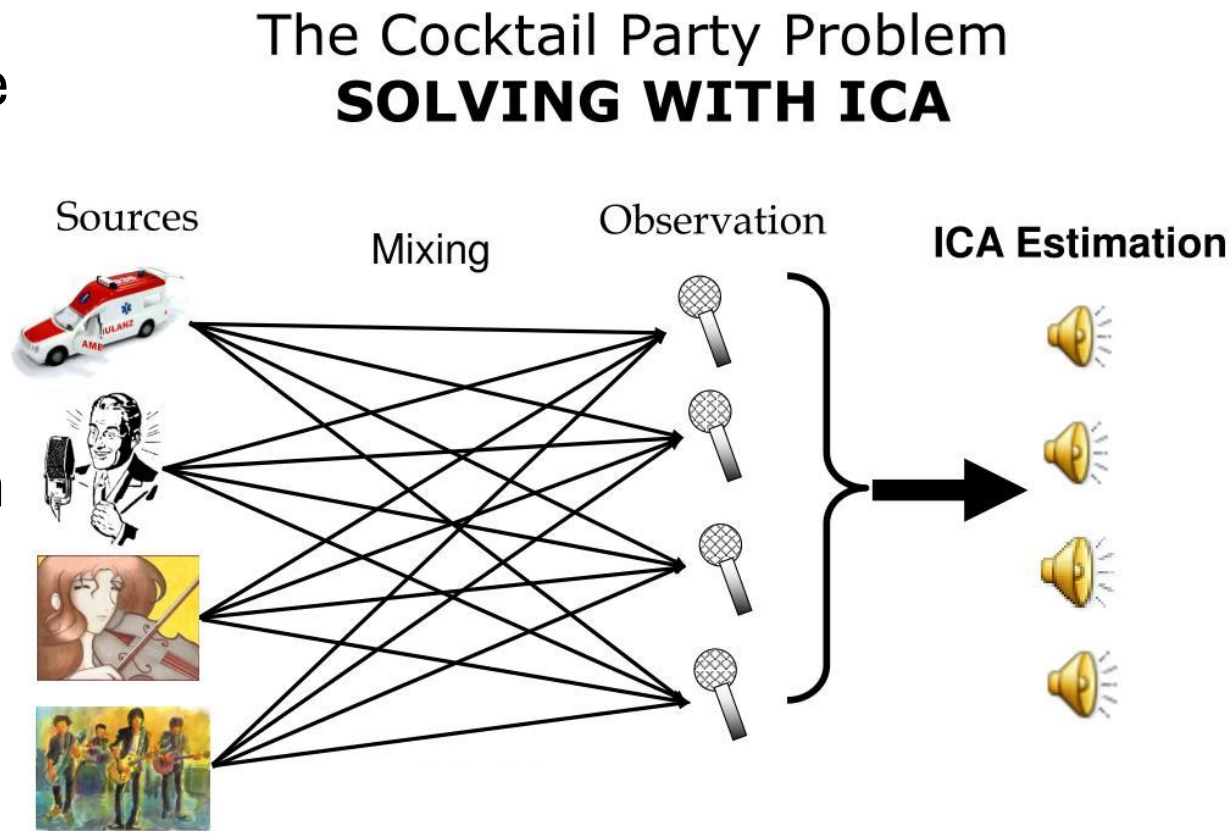
5. Remove noisy data segments

- Remove noisy segments of data
  - Noisy data during the experiment (muscle bursts/movement artefacts)
  - Prolonged periods of recorded EEG during breaks between experimental tasks
- Create short epochs of 1 second to avoid the unnecessary removal of clean data



6. Independent component analysis

- A statistical technique to separate multivariate mixture signals into **maximally independent** components(ICs) using higher-order statistics
- Solving the cocktail party problem



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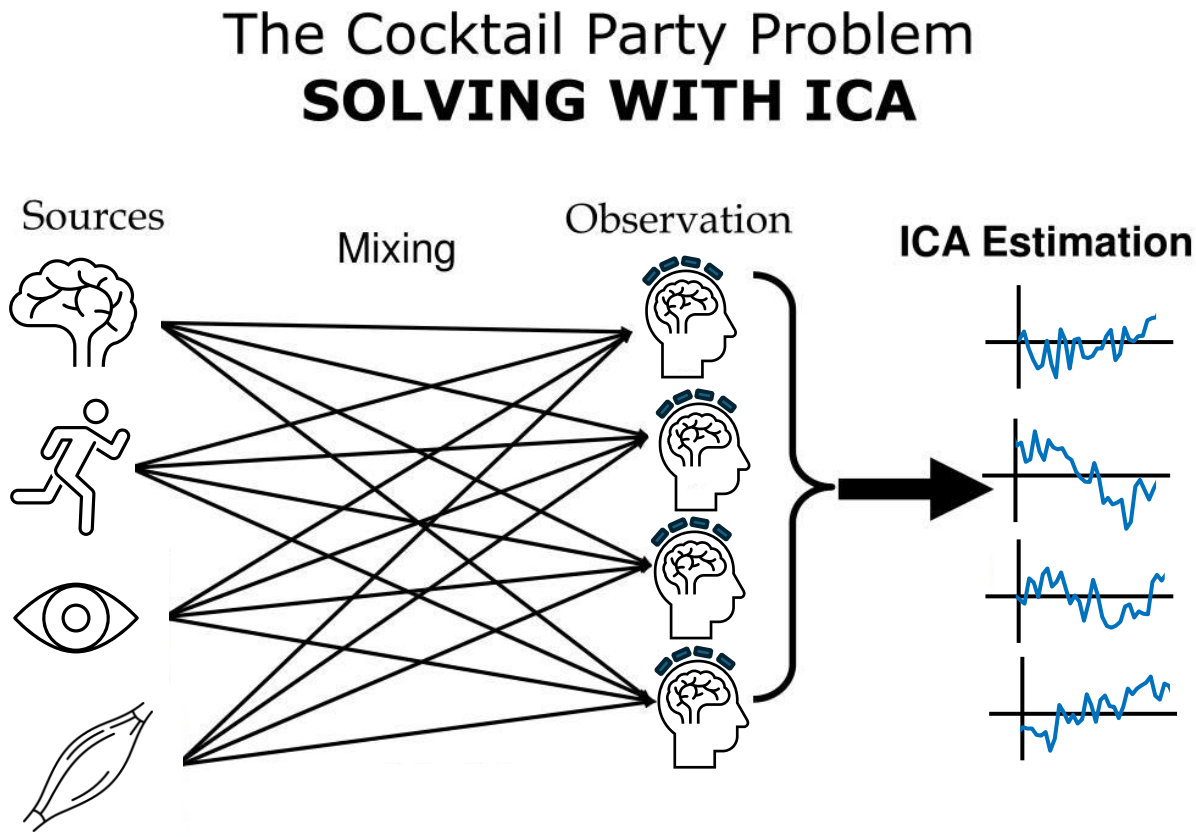
- **The brain as a cocktail party**

- Each electrode measures a linear combination of brain sources



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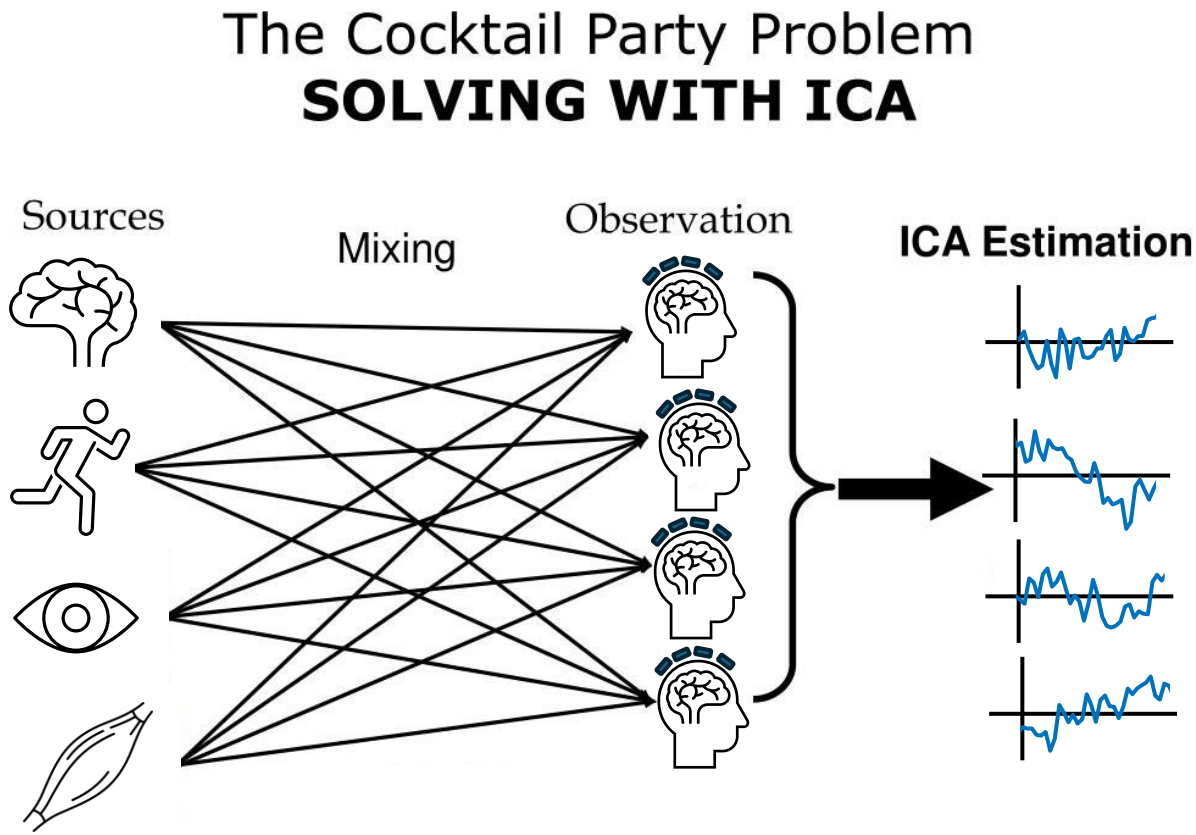
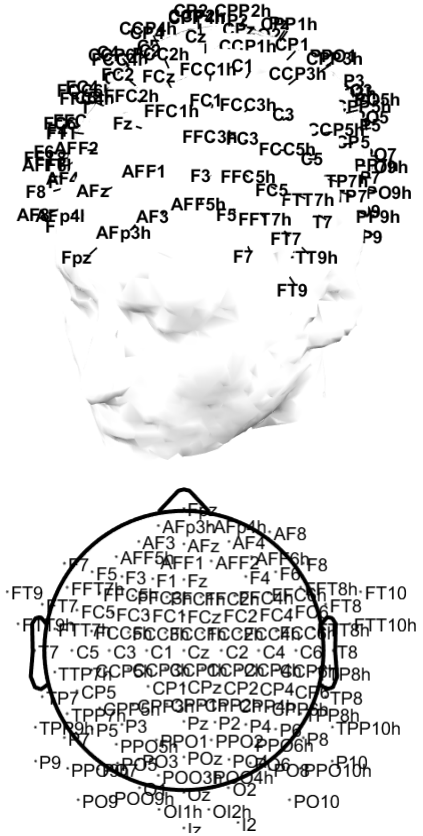


- Each electrode measures a linear combination of brain sources
- The mixing matrix describes how an ICs project to the scalp electrodes

Independent component characteristics

Electrode locations



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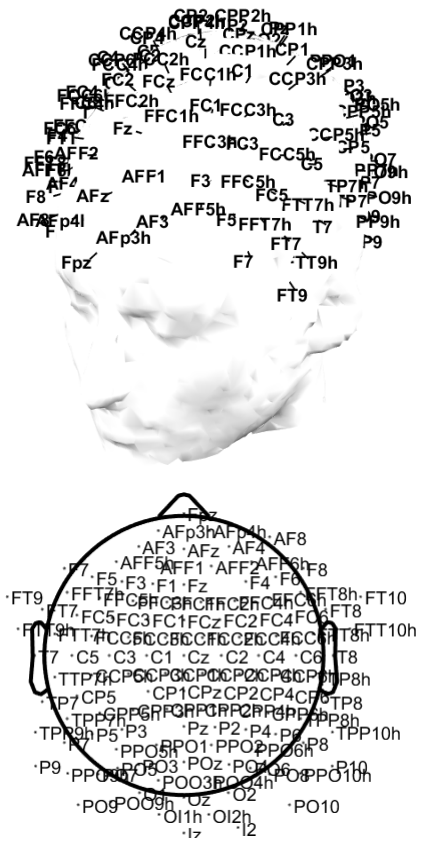
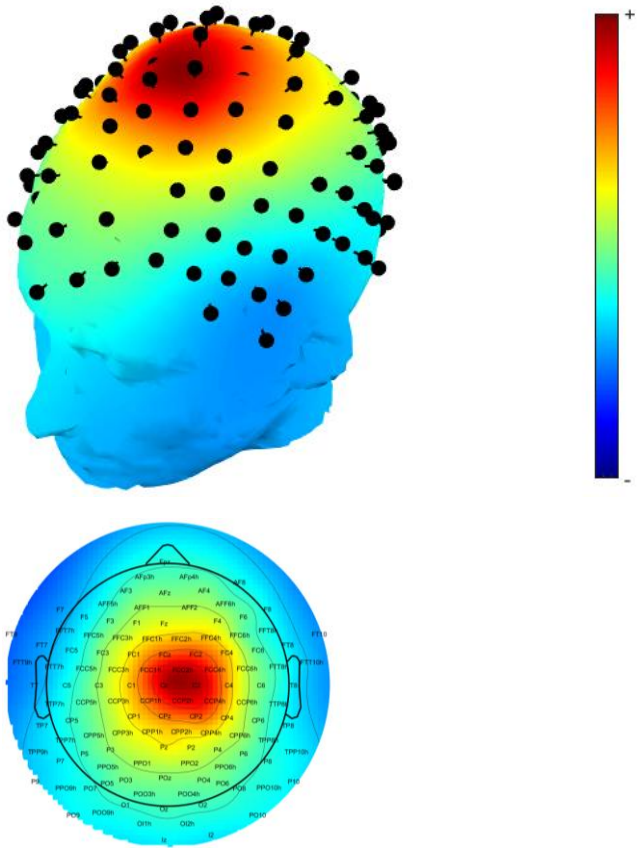


Projection of a single component



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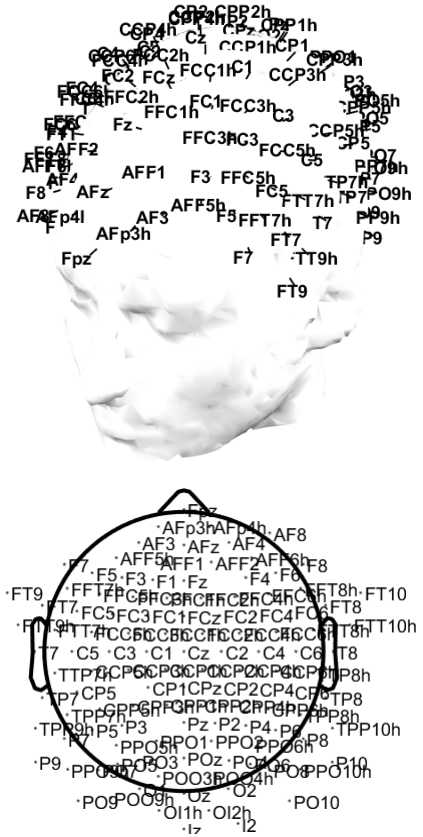

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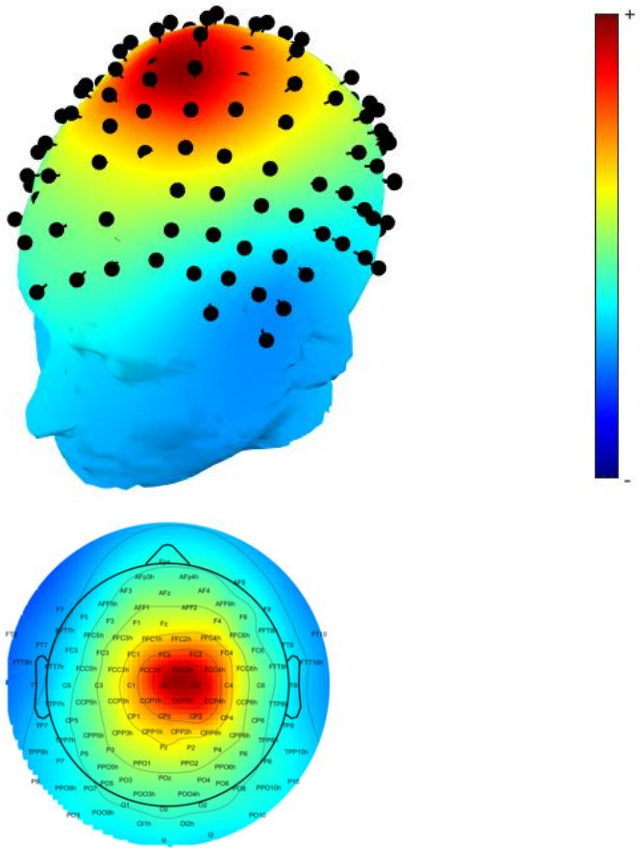
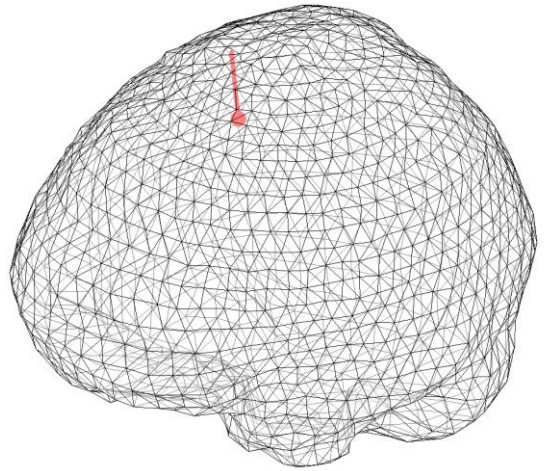


Modelling component as a single dipolar source



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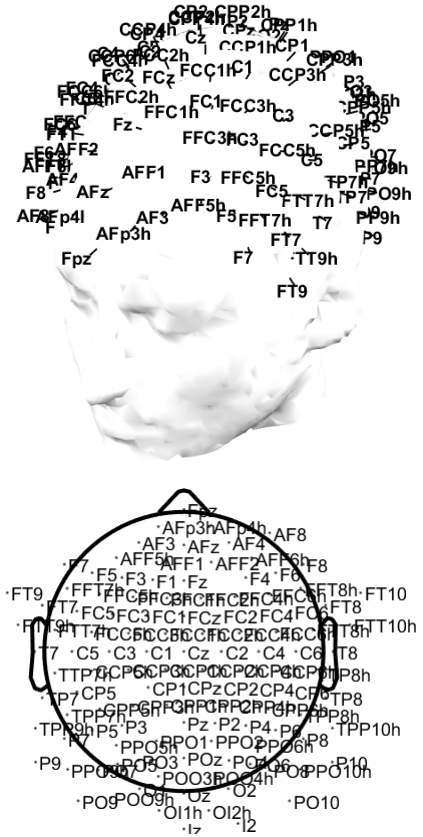

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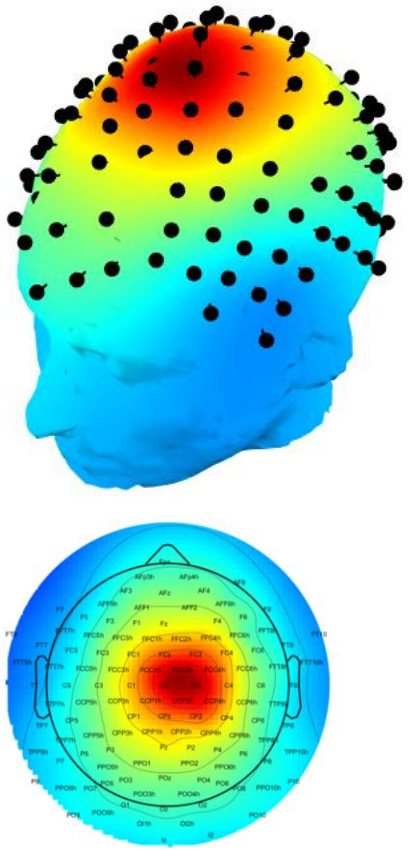

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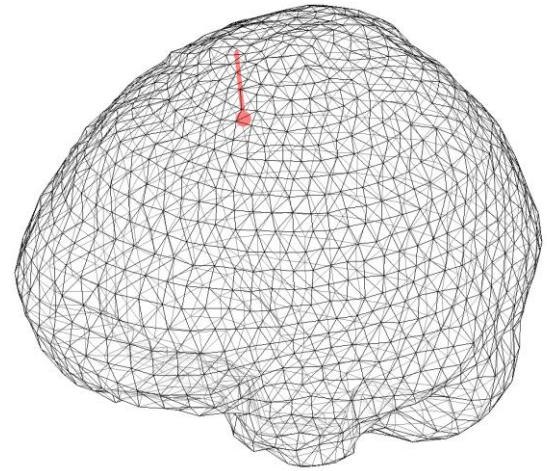

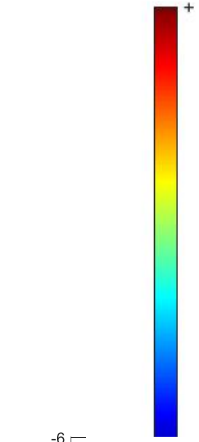

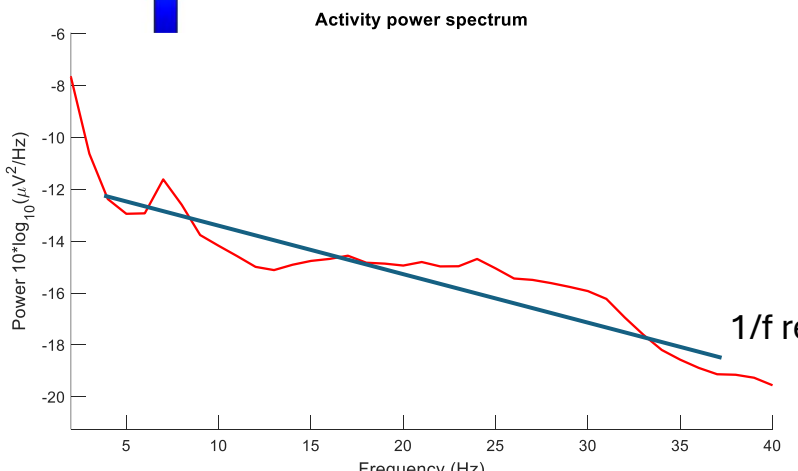

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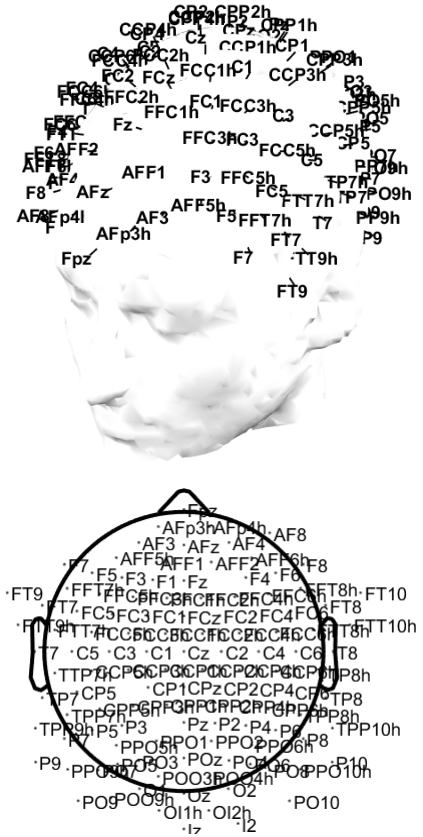

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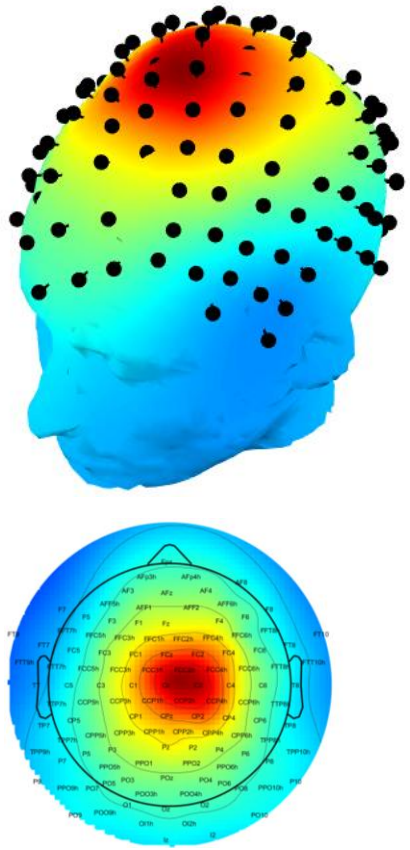

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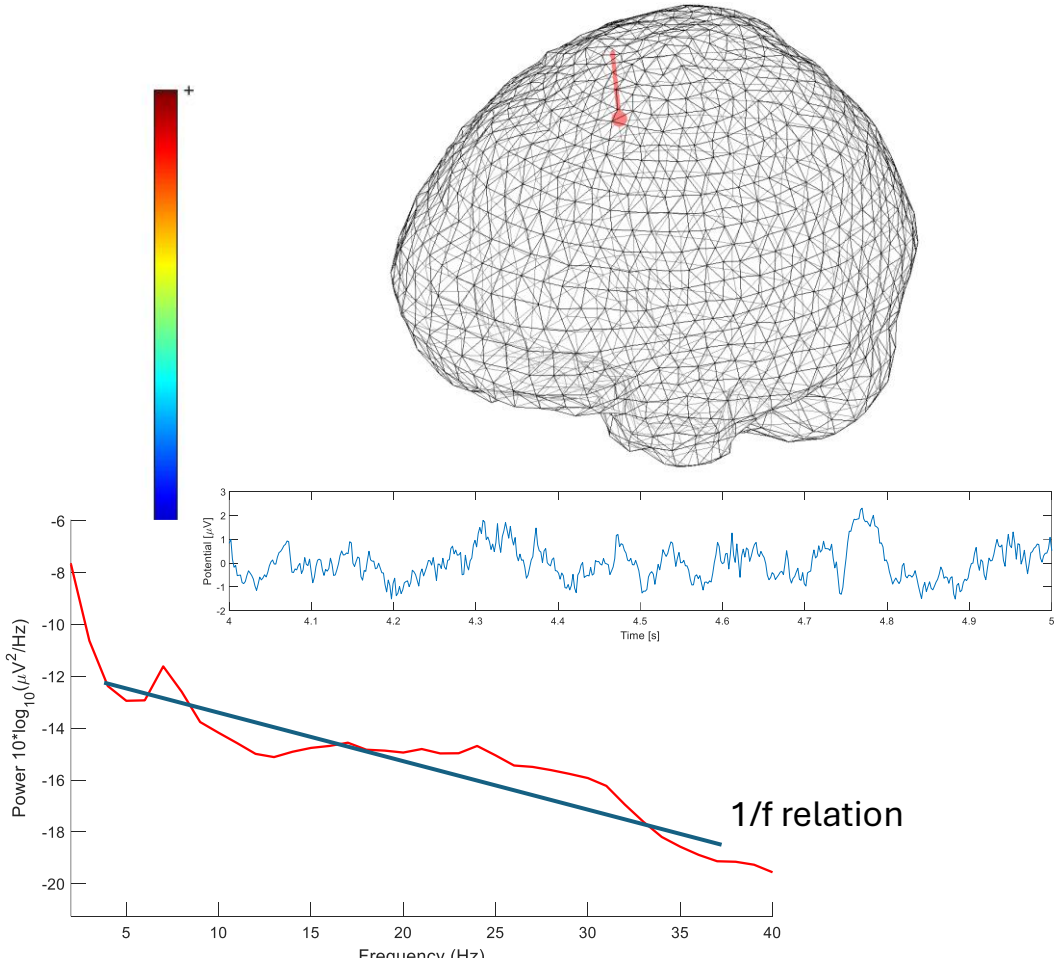
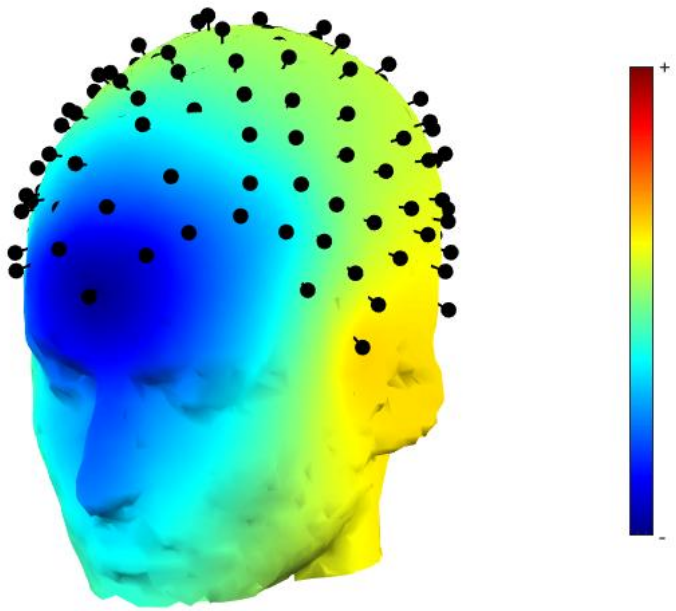
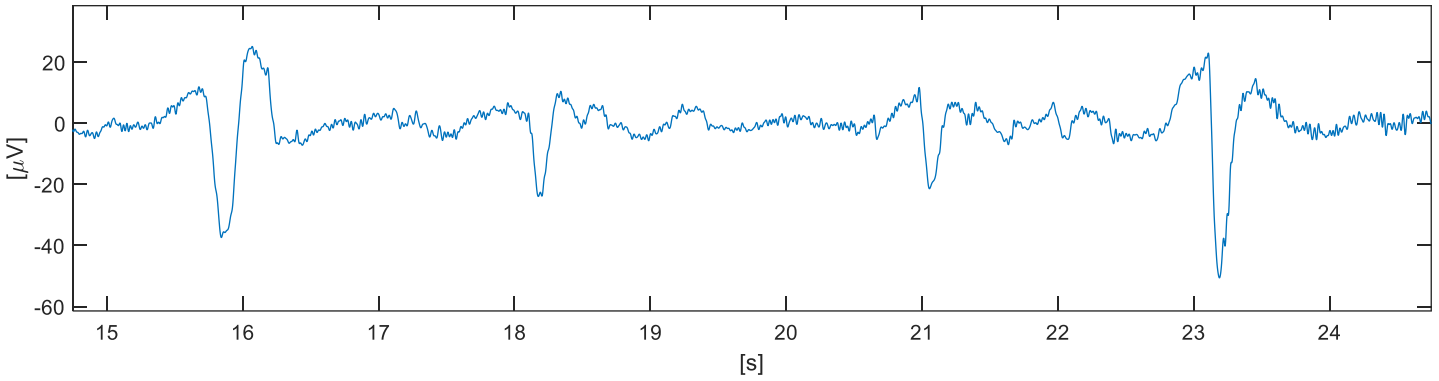


Artefact classification

- Based on:
  - Scalp map: describes how an independent component distributes to individual channels
  - Time- and frequency domain representation
  - Dipole location (inside or outside the head) and goodness of fit

Independent component classification (1)





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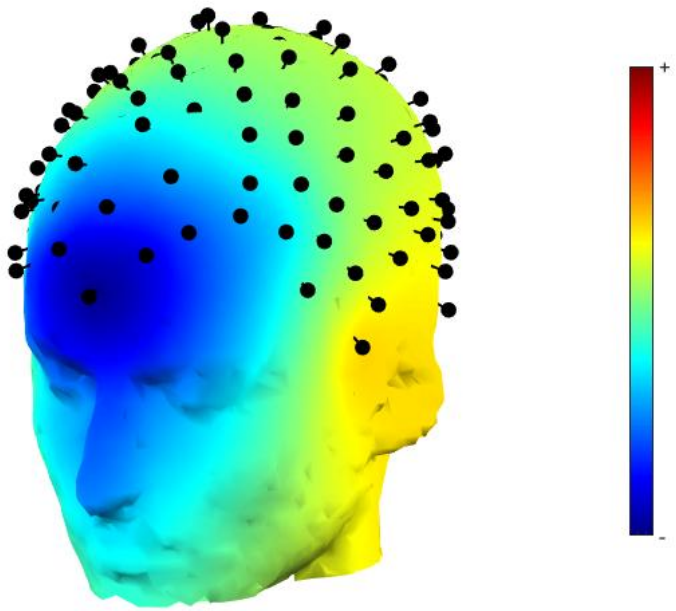
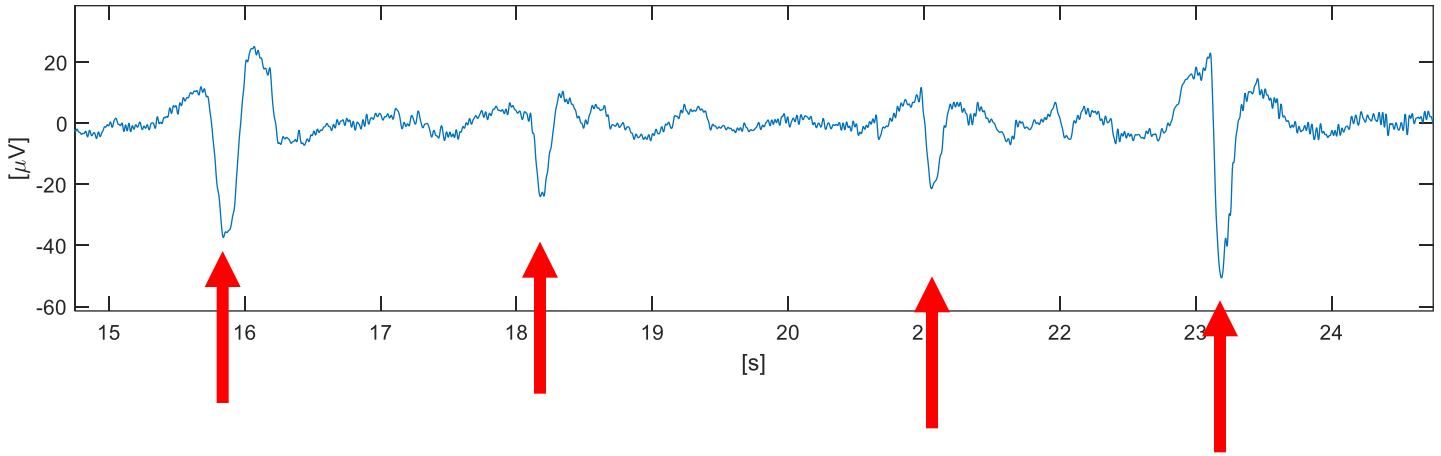
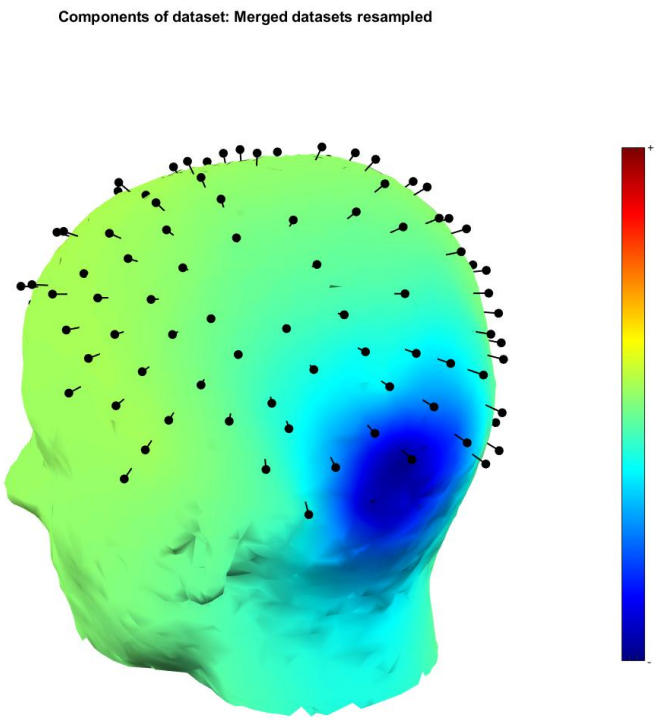
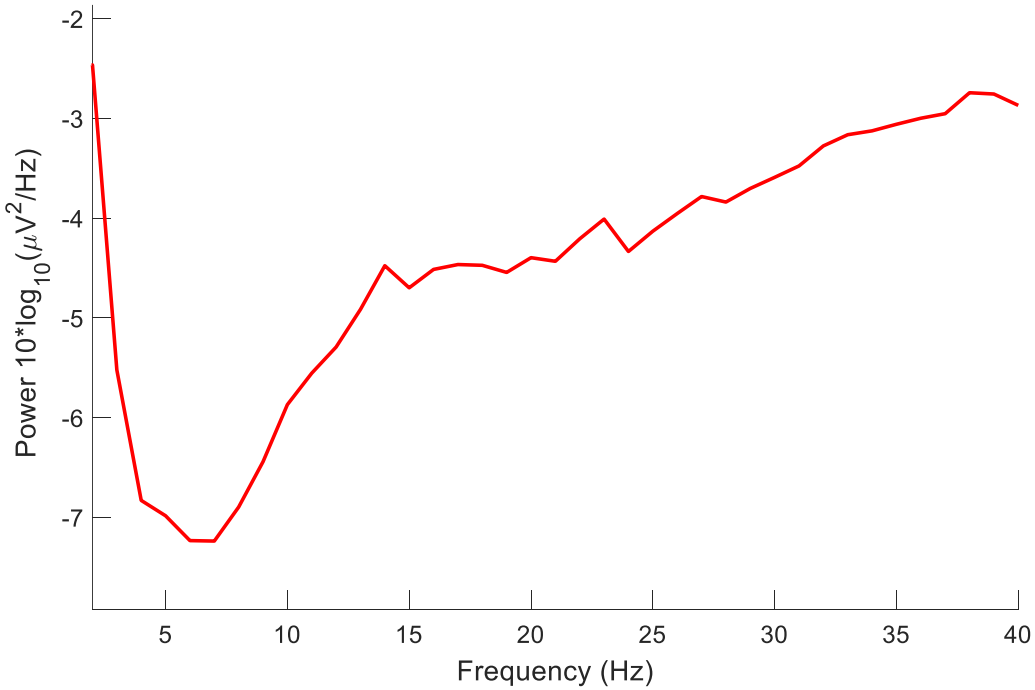




Independent component (2)





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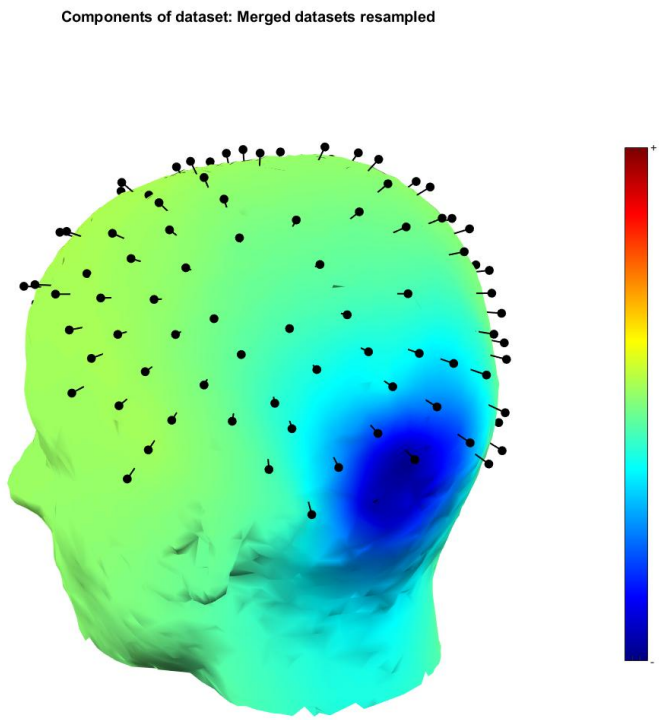

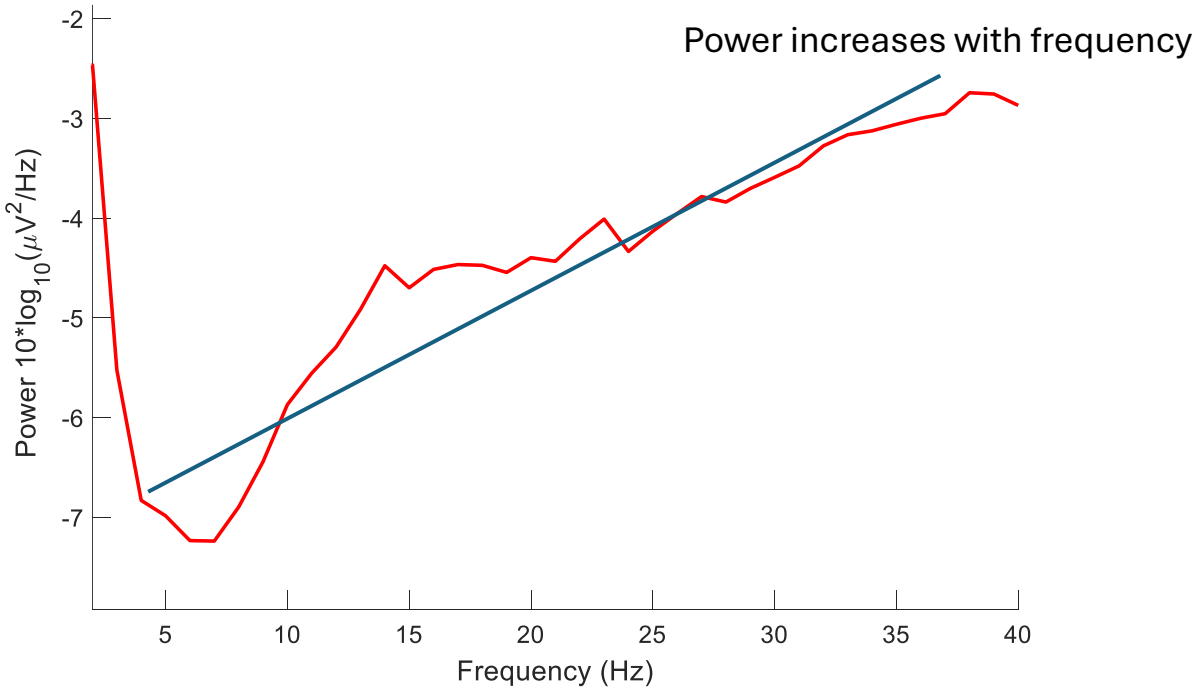

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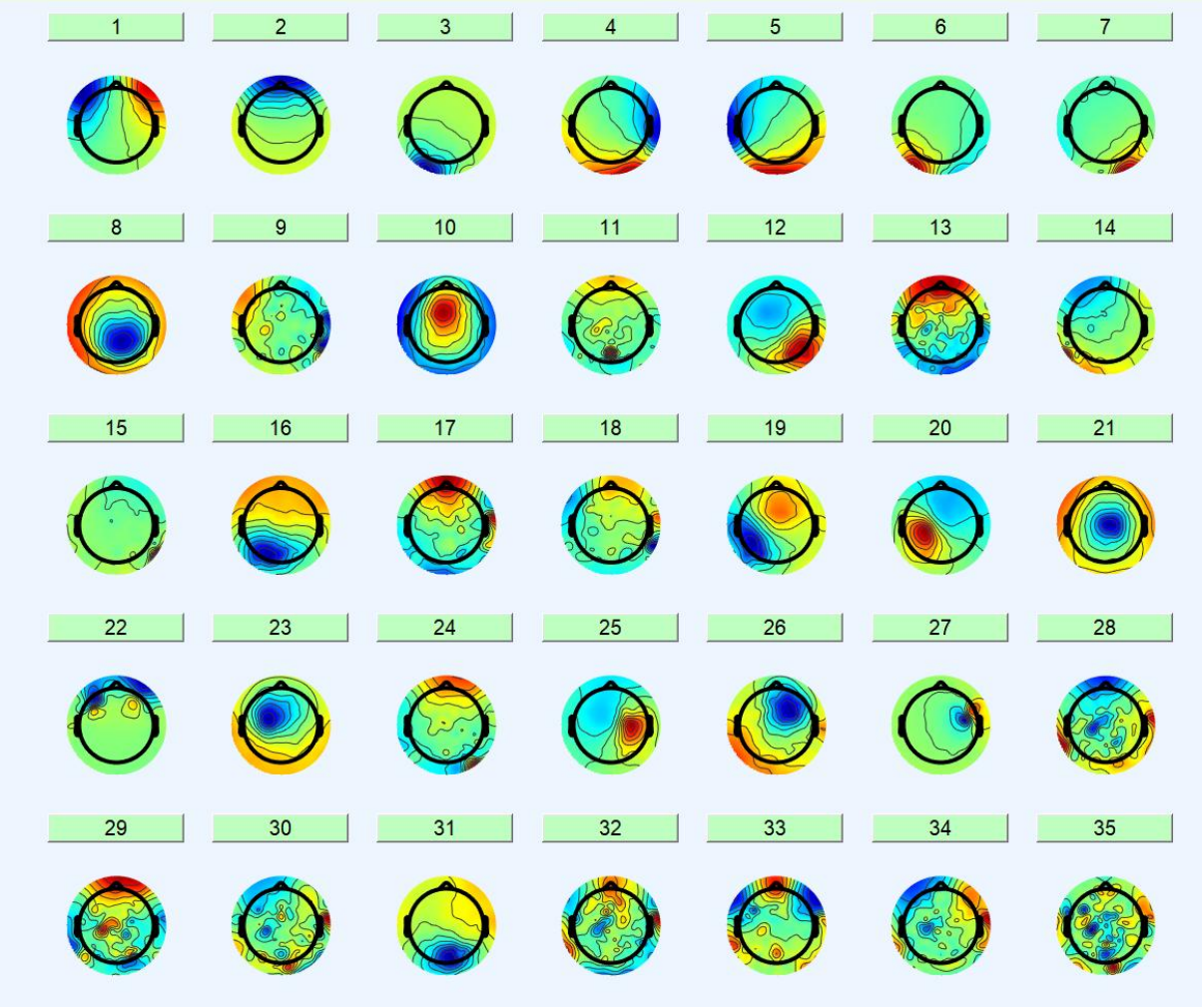

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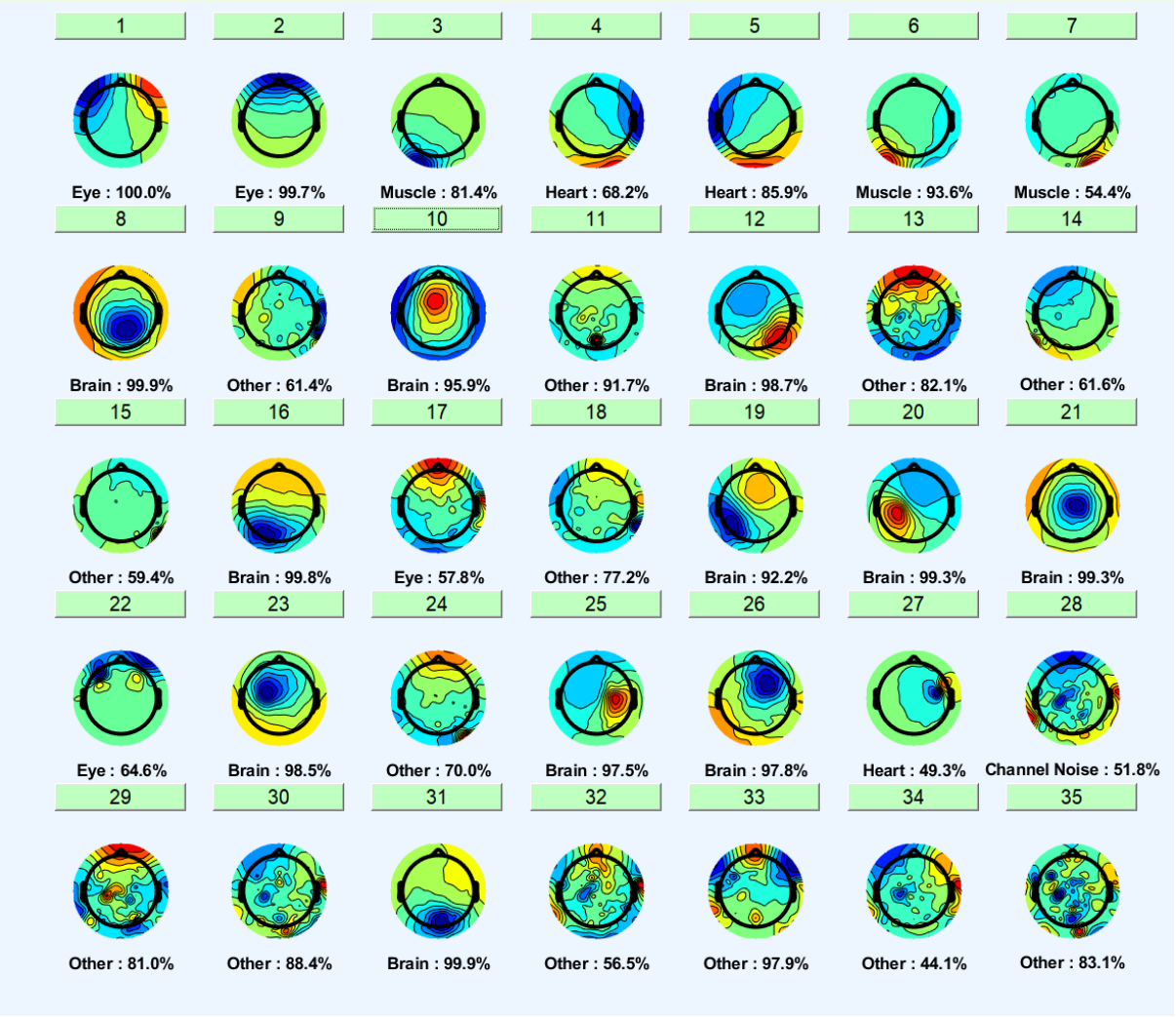
- **ICLabel plugin**



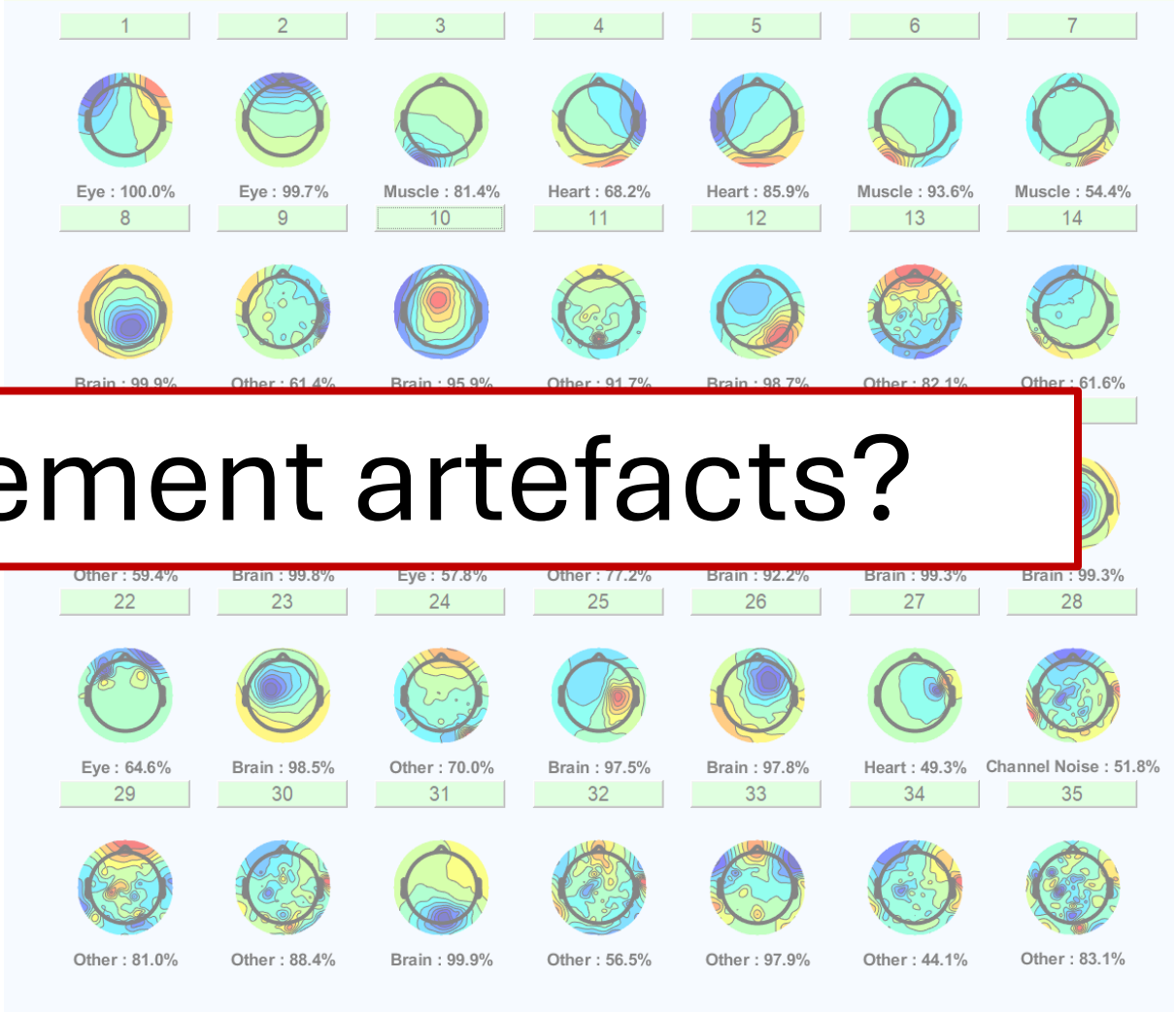
Artefact classification

- Scalp maps
- Time domain activity
- Power spectral density

What about movement artefacts?

of fit

- **Classify all components**
- **ICLabel plugin**



Movement artefact classification

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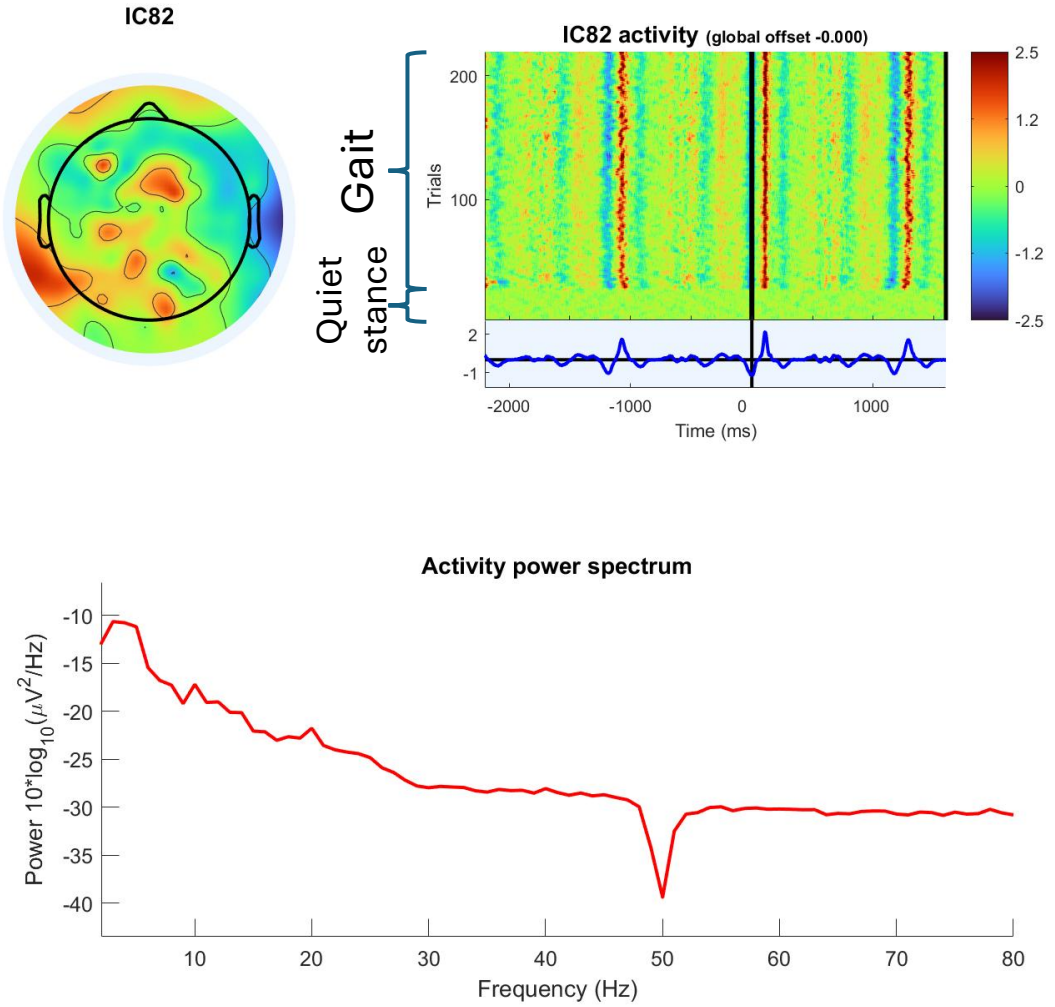
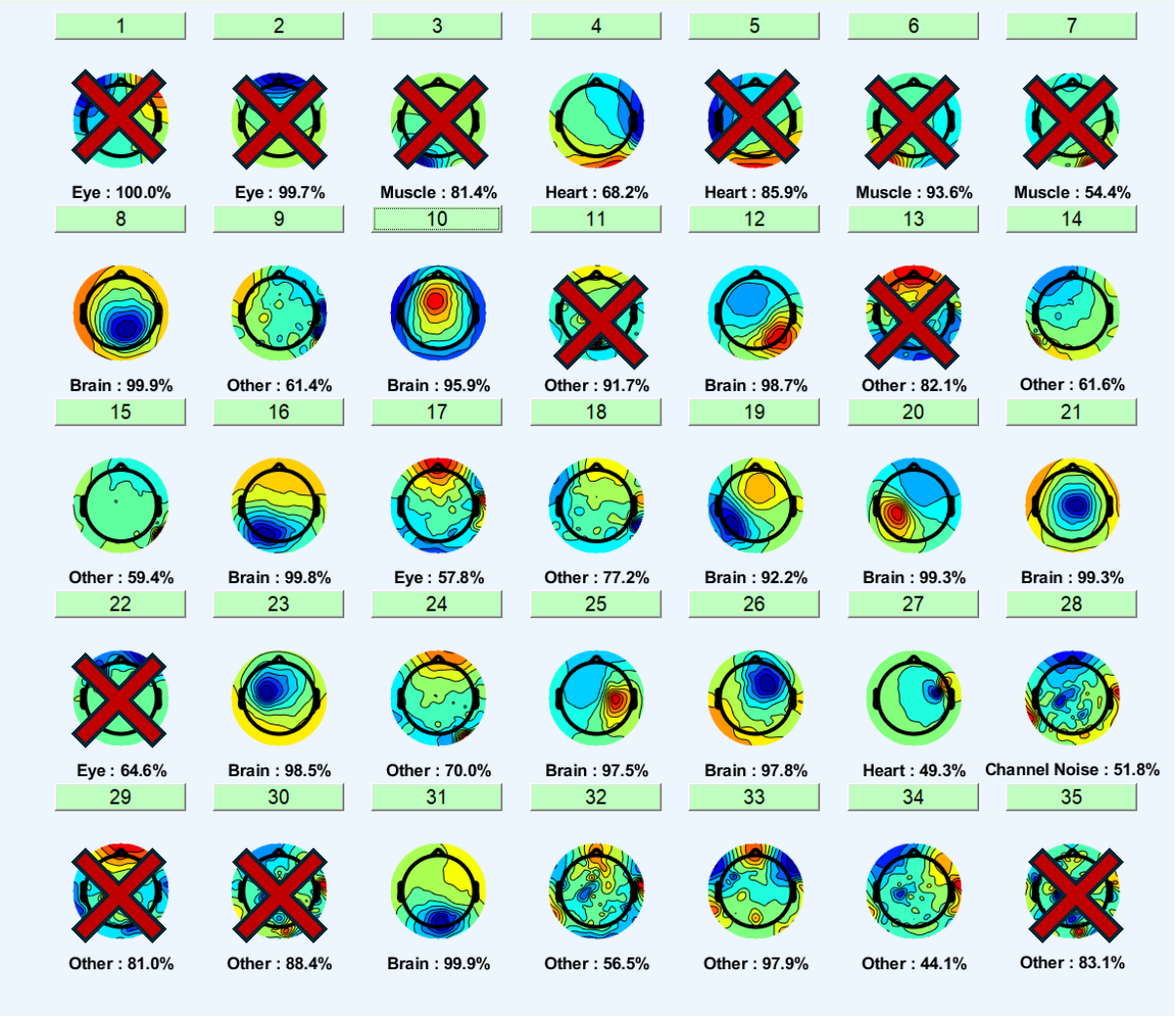
1) Define trials around a specific gait event of interest, i.e., heel strike
2) Calculate the consistency of independent components over trials (i.e., SNR)

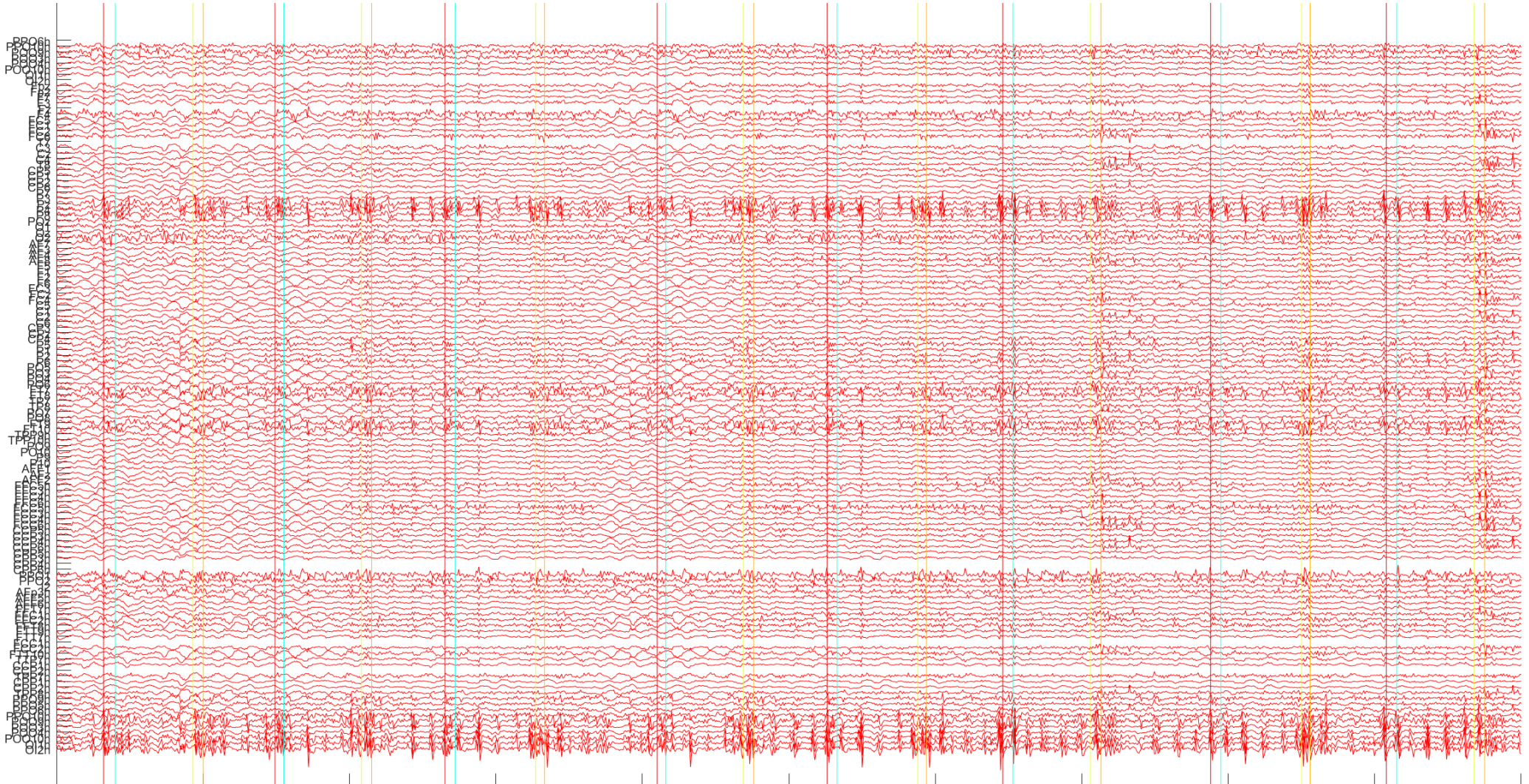


Artefact classification

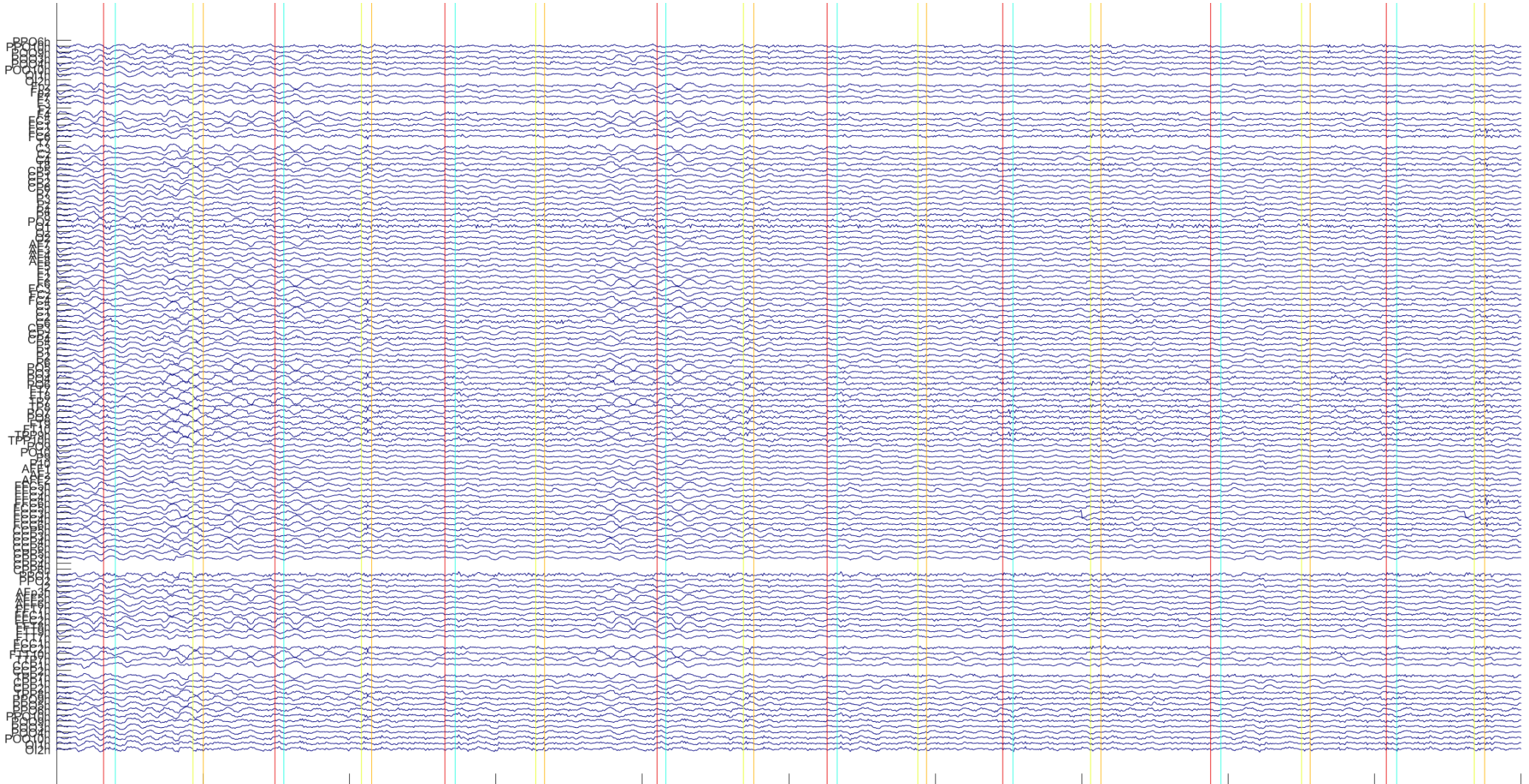
- Scalp maps
- Time domain activity
- Power spectral density (frequency domain)
- Dipole location and goodness of fit
- **(gait) event-related potential**



Preprocessing prepares data for analysis



Preprocessing prepares data for analysis



Next step: Processing of EEG data in relation to the gait cycle

Thank you for your attention!