Sensor Level Analysis ERP

EEGLAB

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Practical MEEG 2025, Aix-Marseille Université, France, October, 2025

Human Electrophysiology

Some EEG milestones

1926 ~1st first EEG recordings

1938 1st EEG spectral analysis

1962 1st computer for EP averaging (CAT)

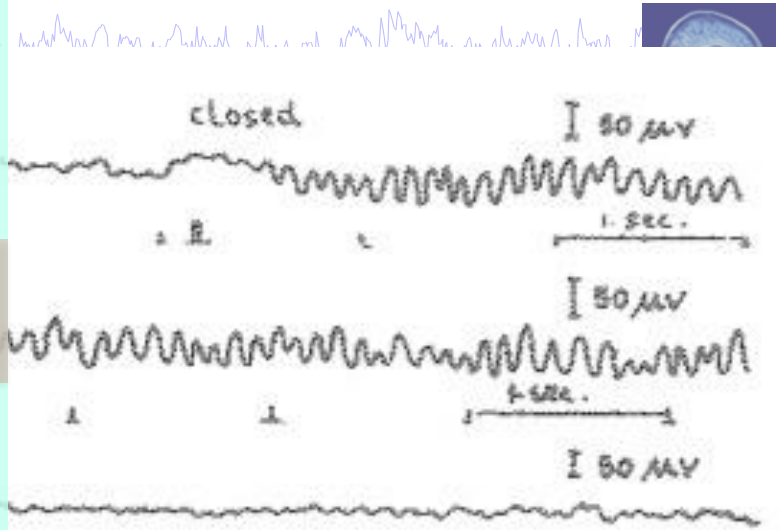
Event-related potential (ERP) averaging

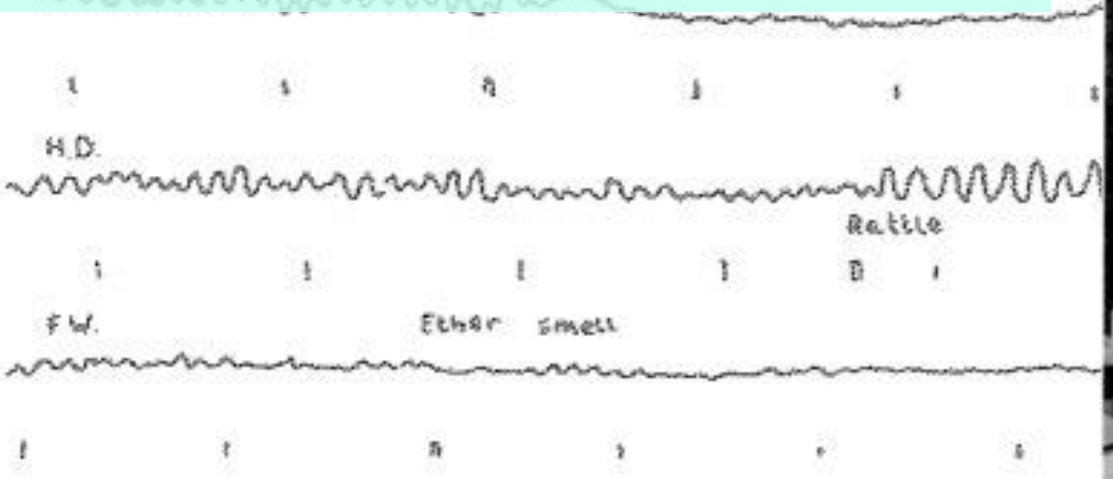
1979 1st source localization of EEG/MEG

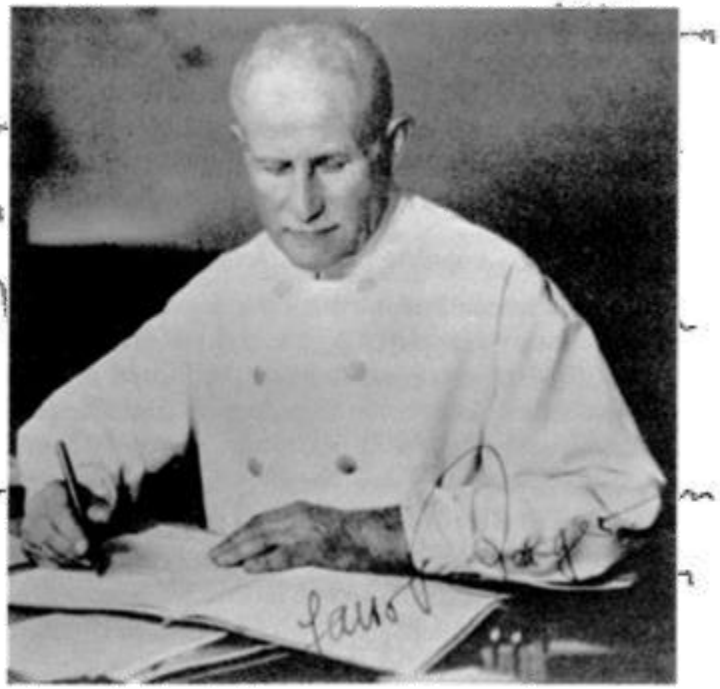
Functional EEG brain imaging

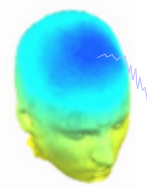
1995 1st multisource EEG filtering by ICA

2009 ~1st commercial dry electrode devices





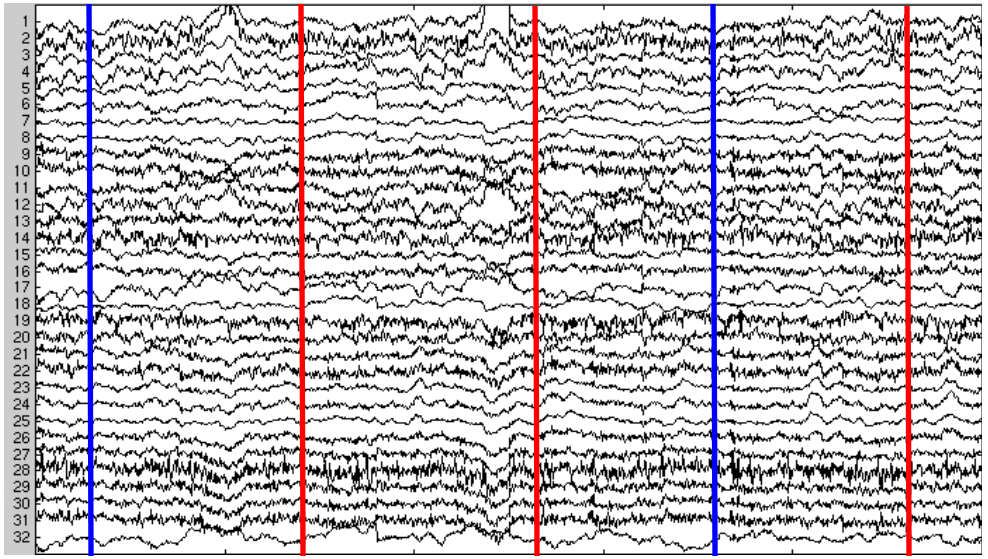




ERP Experiment

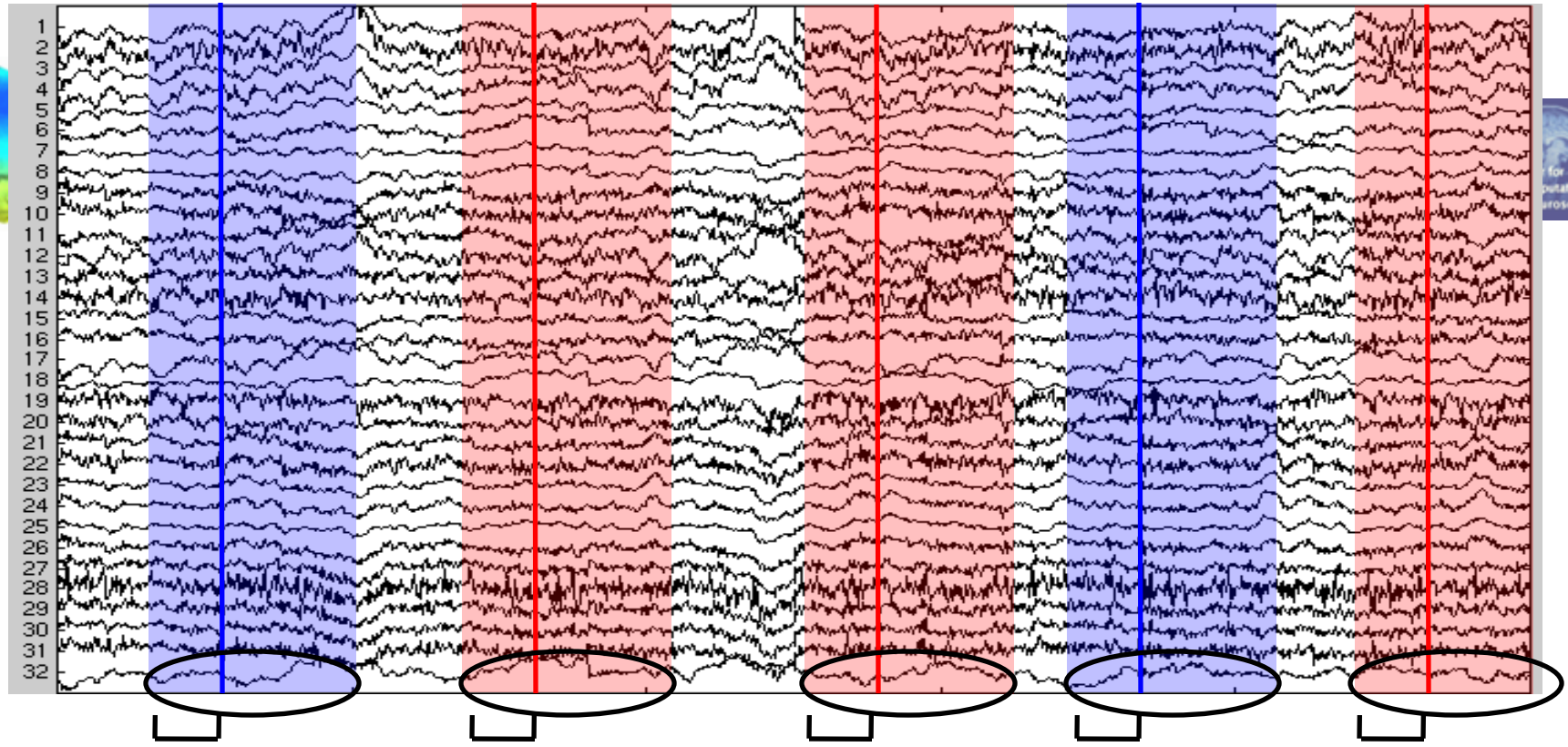
Recording

Electrodes



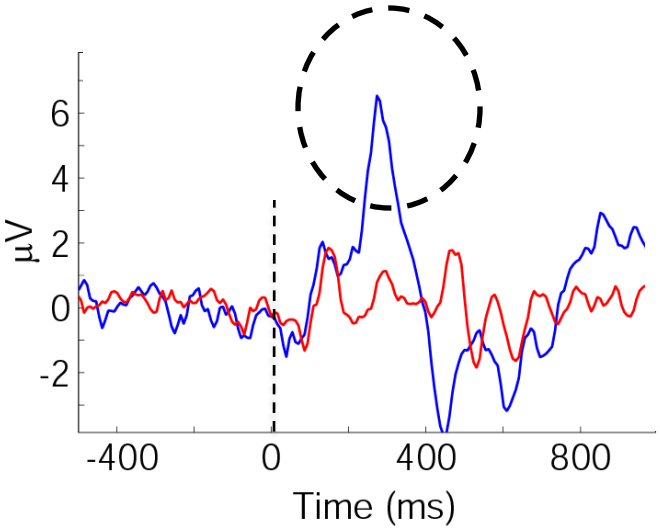
Time (ms)

Offline processing

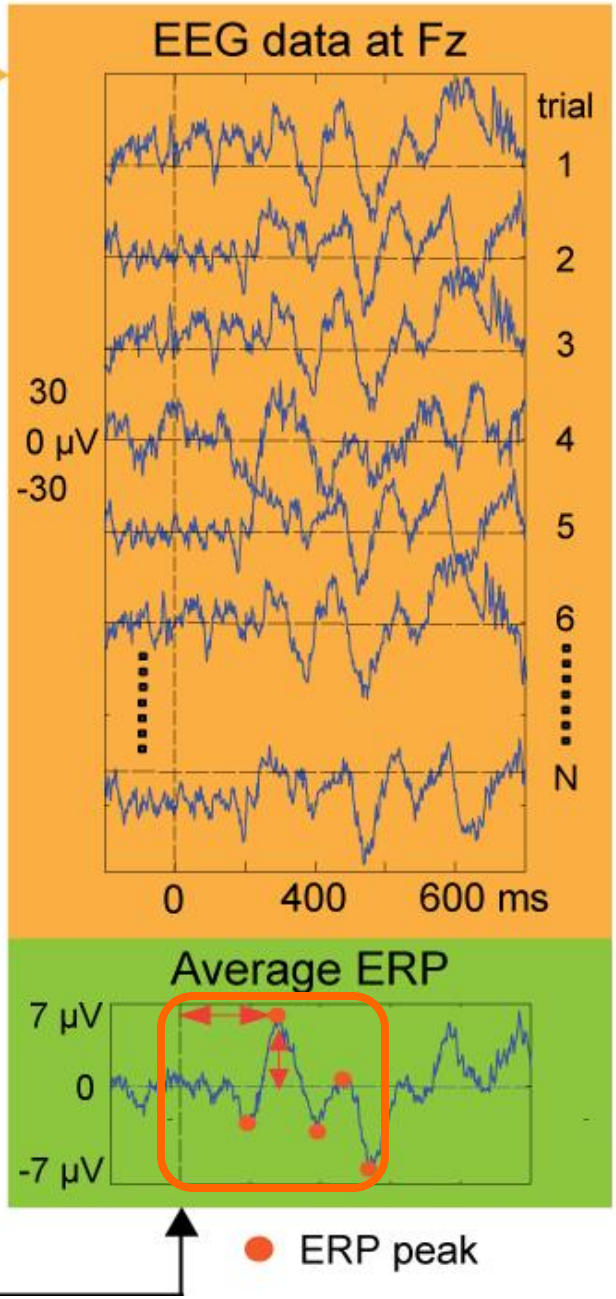


Electrode X

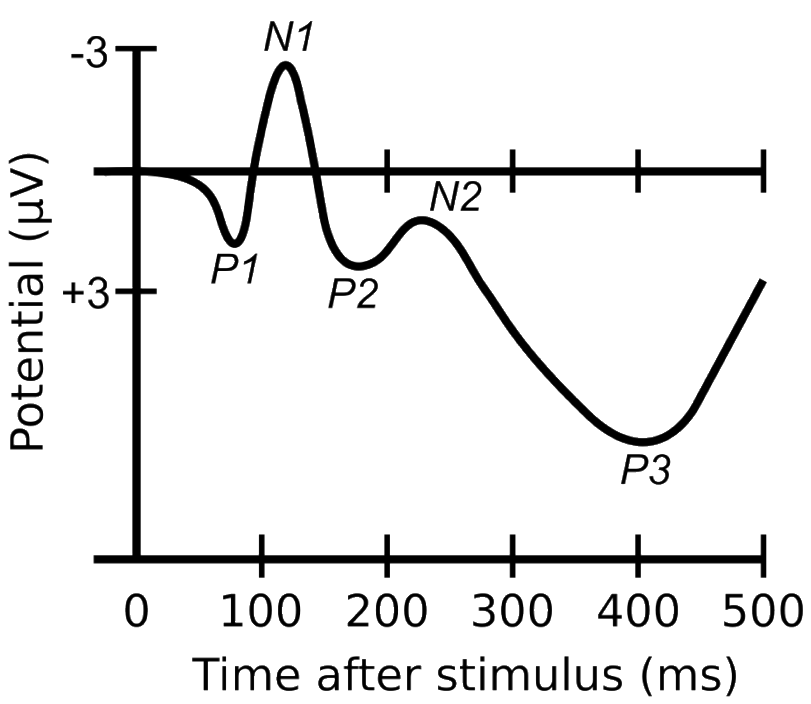
Baseline removal → Average

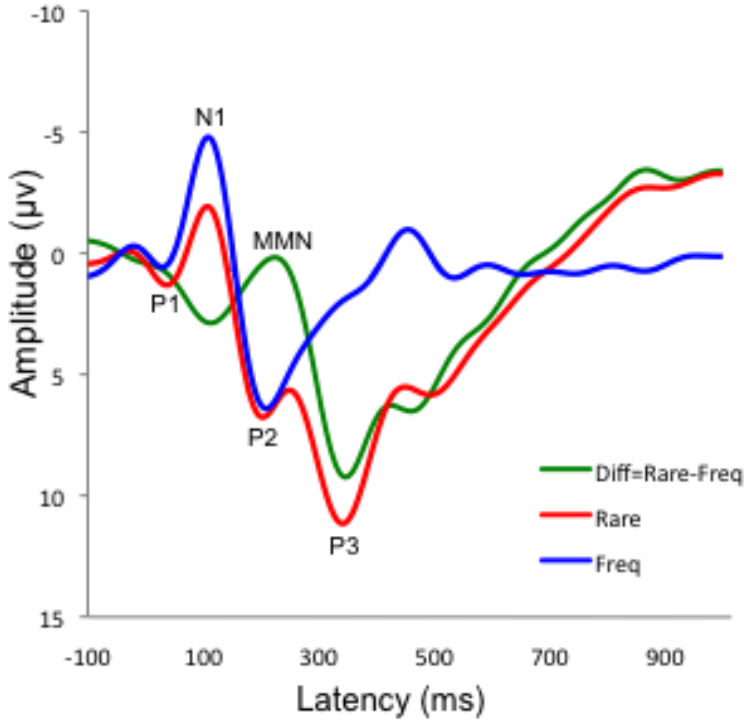


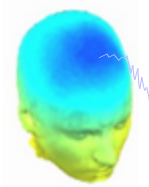
Typical EEG experiment



Examples of ERPs







Limitations of the ERP model

Data ≡ Average + "Background"

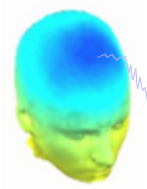
EEG ERP EEG "noise"

But, this linear decomposition is veridical if and only if:

1. The ***Average*** appears in each trial.

2. The ***Background*** is not perturbed in other ways by the time locking events.

ERP Image

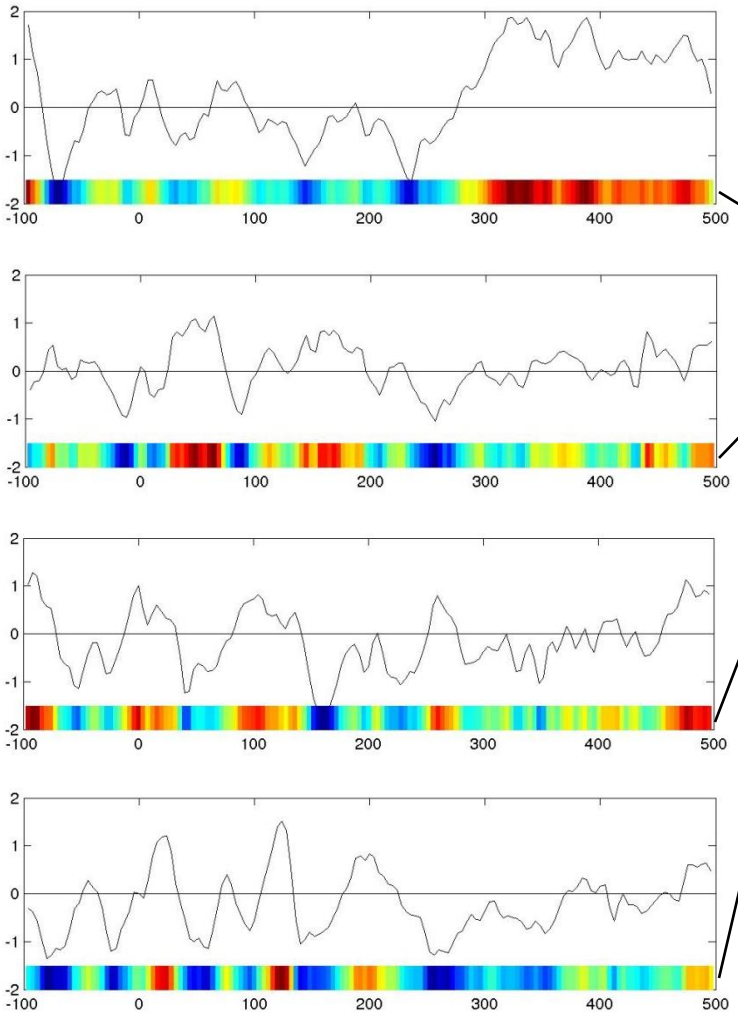


Trial 1

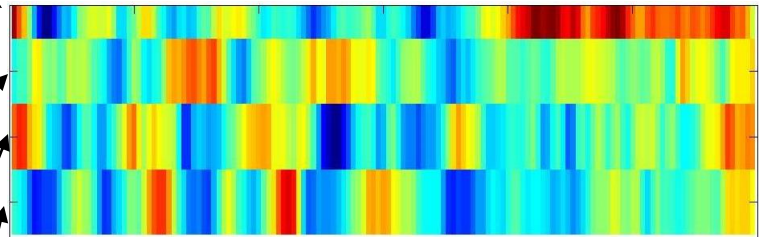
Trial 2

Trial 3

Trial 4

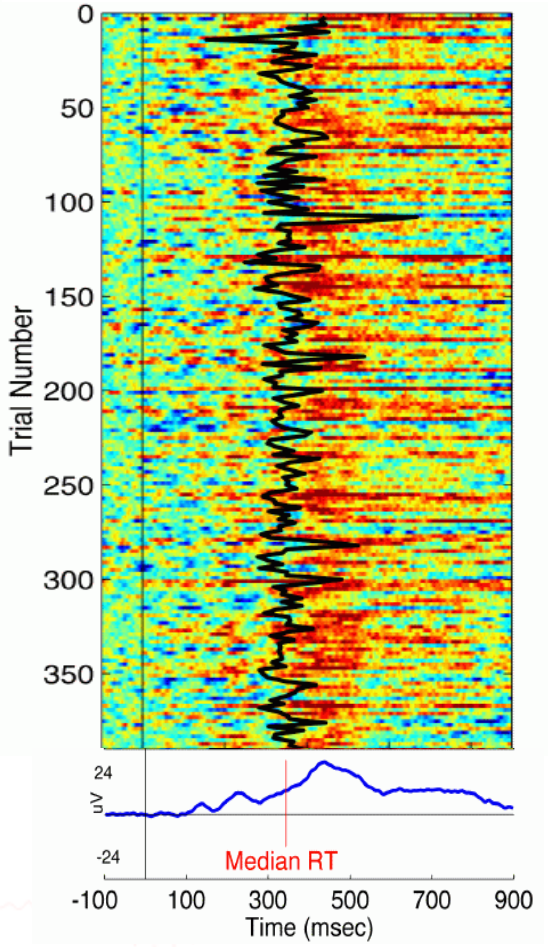


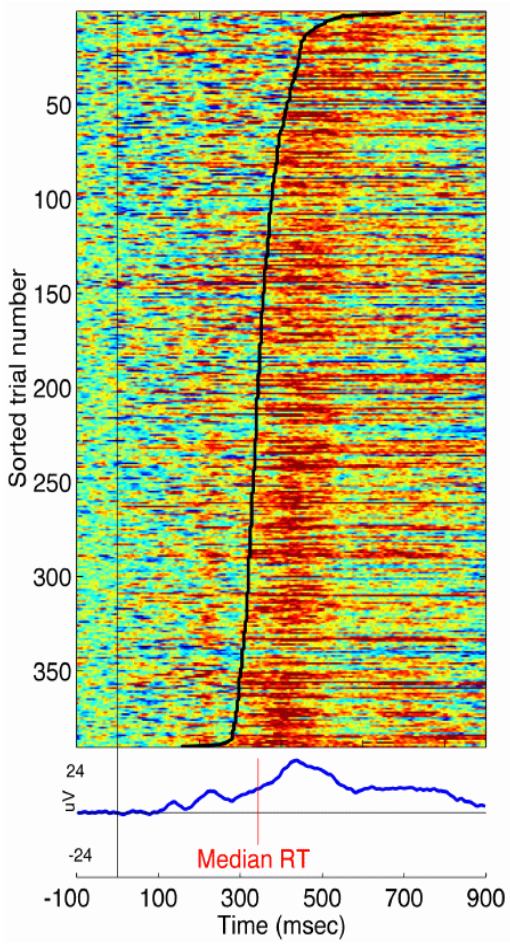
ERP Image

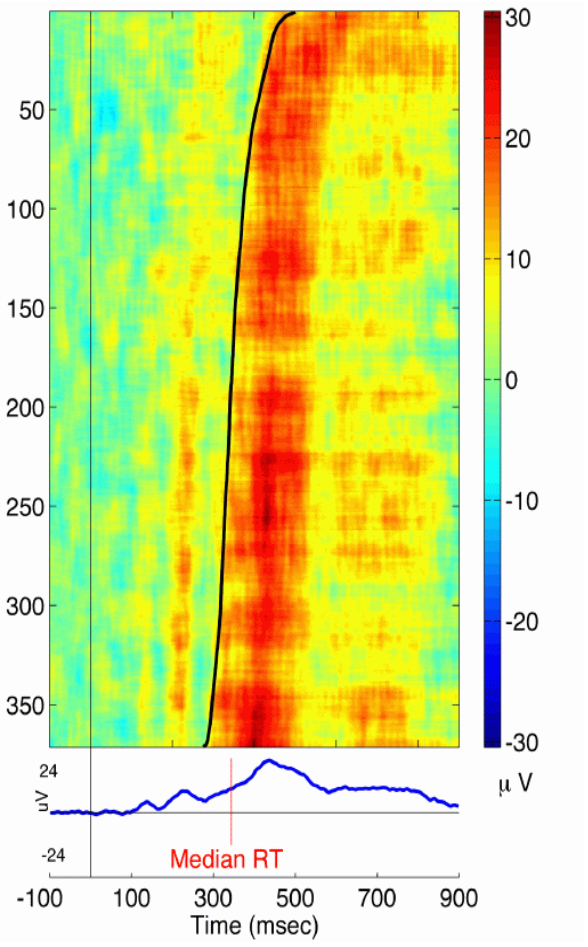


by default, sorted by time-on-task
(1st trial, 2nd trial, ...)

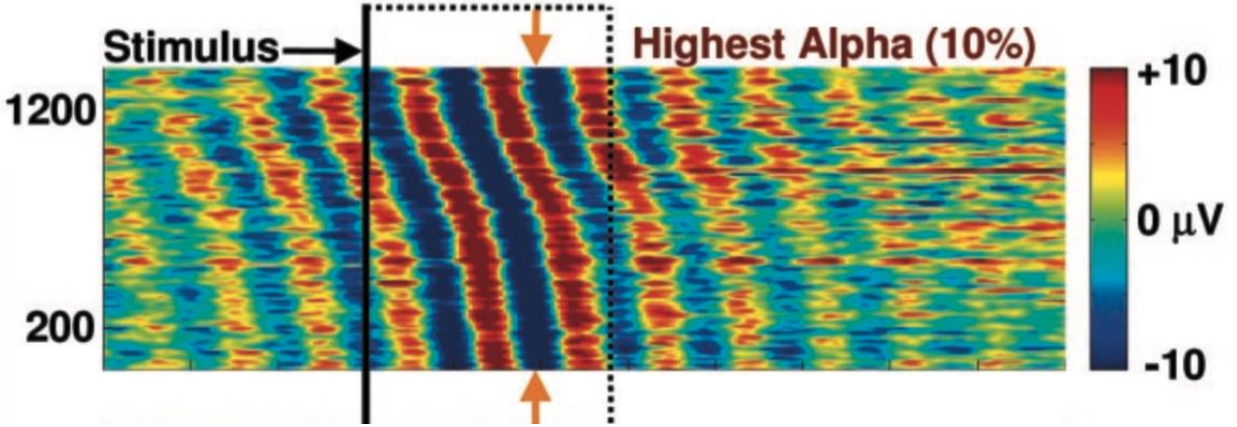
ERP Image


Trial Number
0
50
100
150
200
250
300
350
24
uV
-24
Median RT
-100
100
300
500
700
900
Time (msec)


Sorted trial number
50
100
150
200
250
300
350
24
uV
-24
Median RT
-100
100
300
500
700
900
Time (msec)

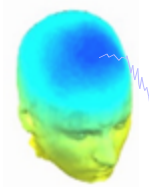

50
100
150
200
250
300
350
24
uV
-24
Median RT
-100
100
300
500
700
900
Time (msec)
30
20
10
0
-10
-20
-30
μ V

Phase synchronization and ERP



Makeig et al. (2001) *Science*, volume 295, Number 5555, pp. 690-694

EEG Analysis



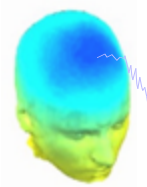
Goals

- Describe dynamic characteristics of brain activity
- Describe relation between different regions of brain

Approaches

- Time domain
- Frequency domain
- Time/Frequency

Load Example Dataset



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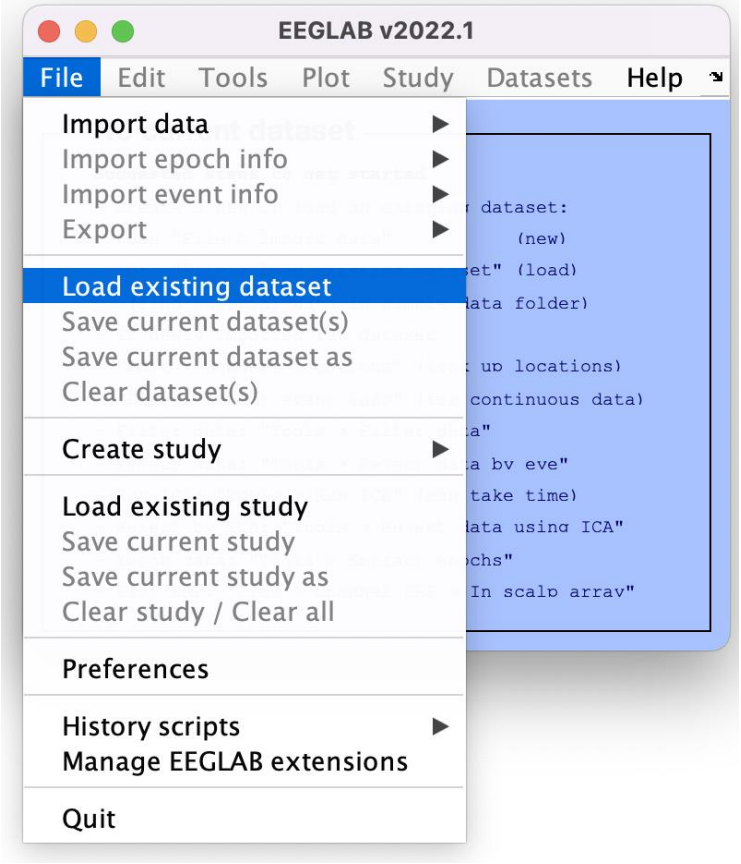
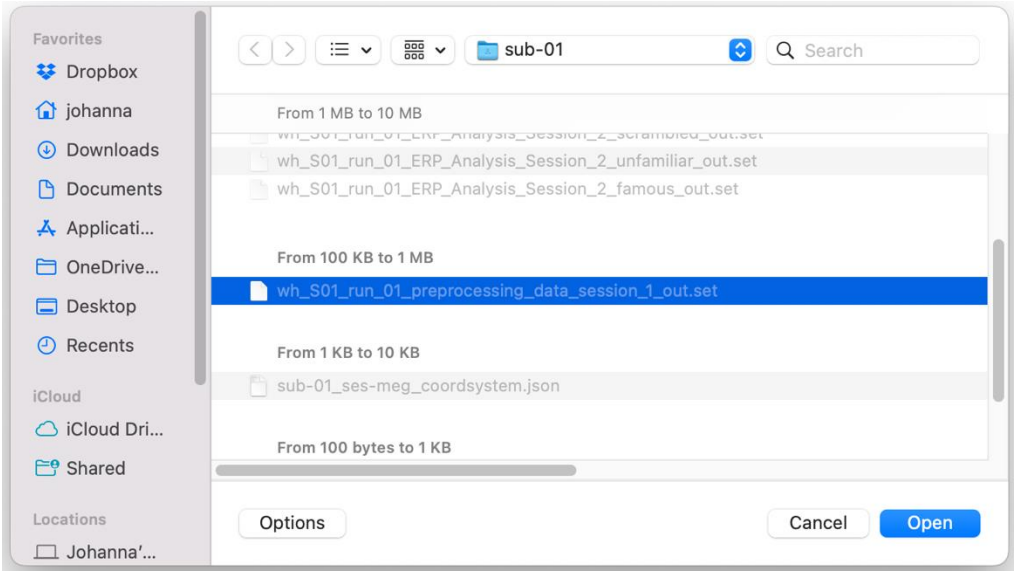
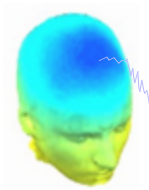
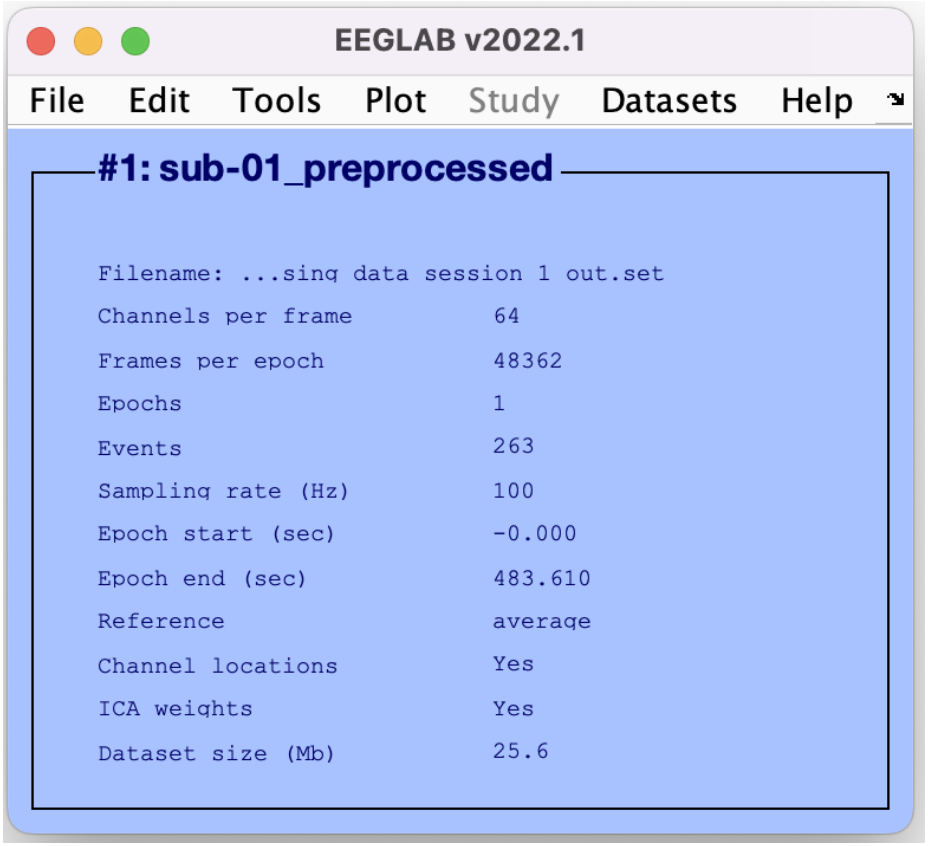
EEG = pop_loadset('filename', filename,'filepath',path2data)



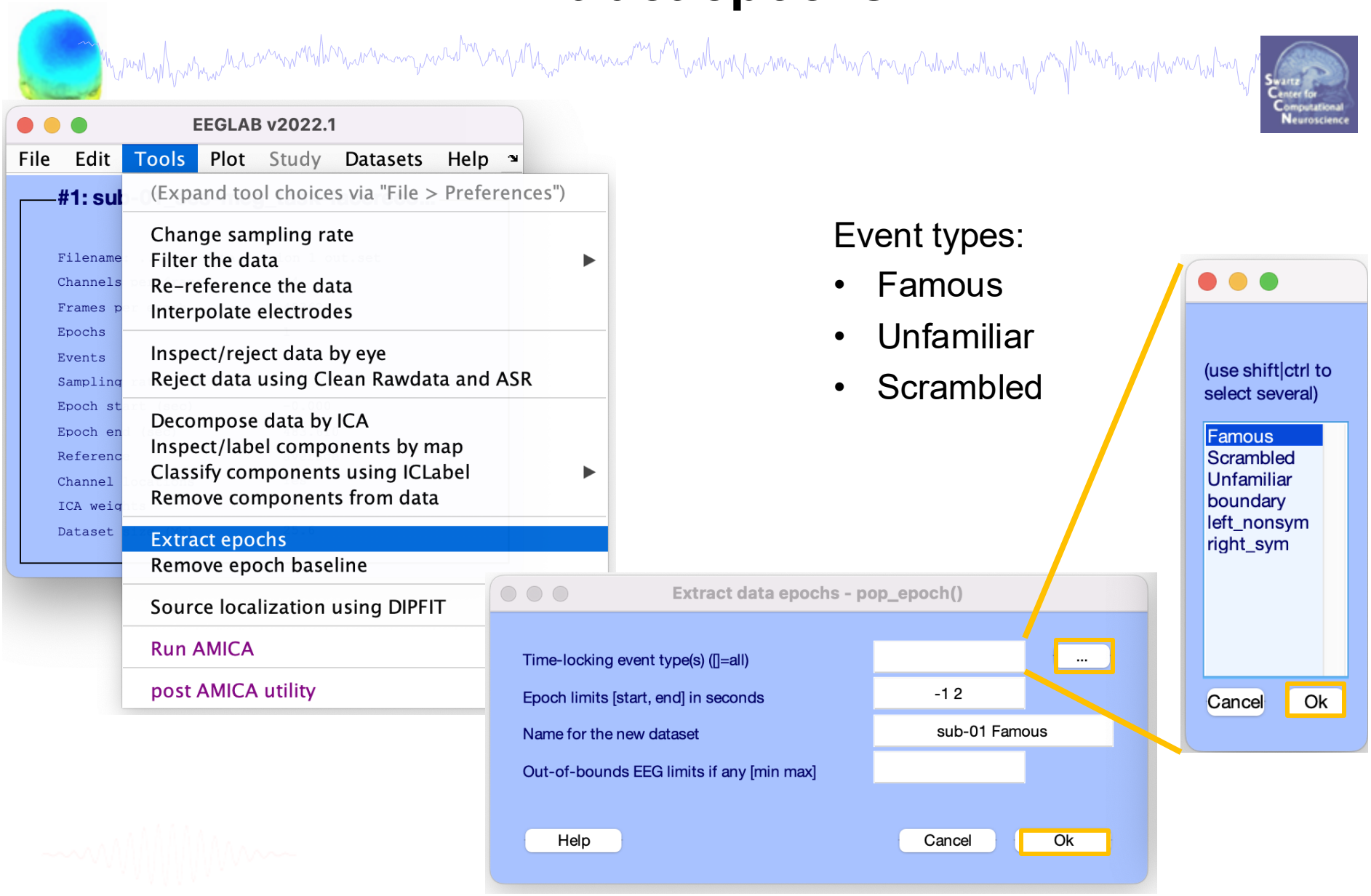


Load Example Dataset





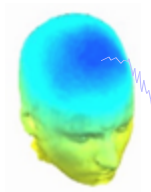
Extract epochs

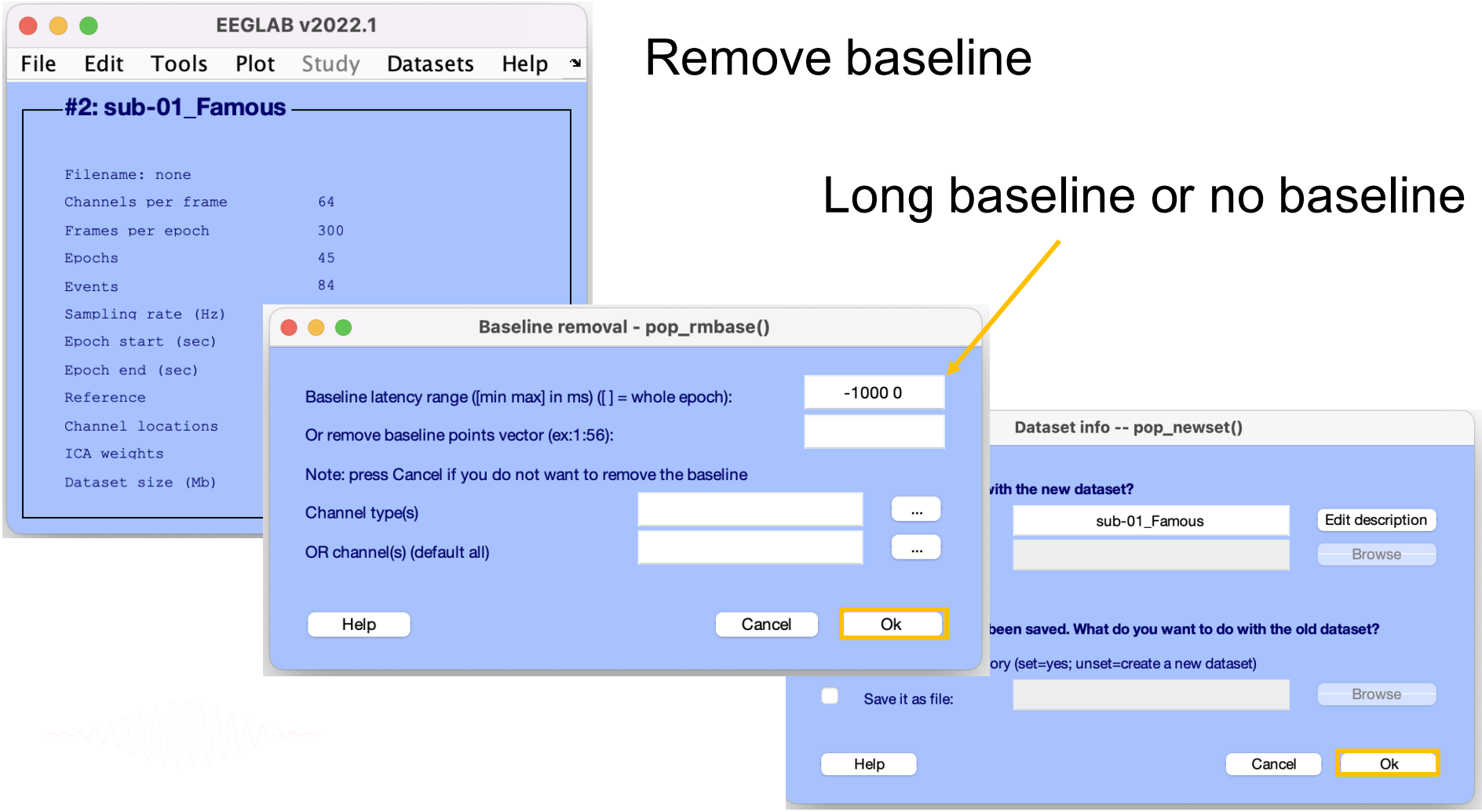


Event types:

- Famous
- Unfamiliar
- Scrambled

Extract epochs

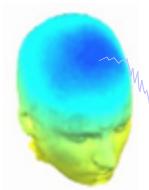


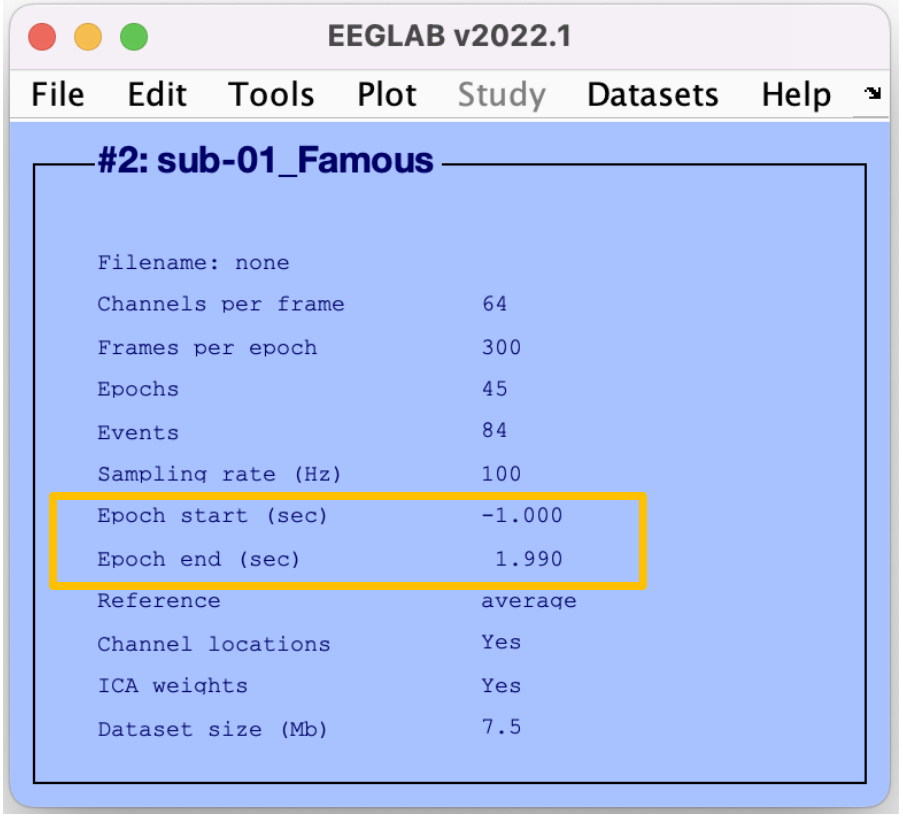


Remove baseline

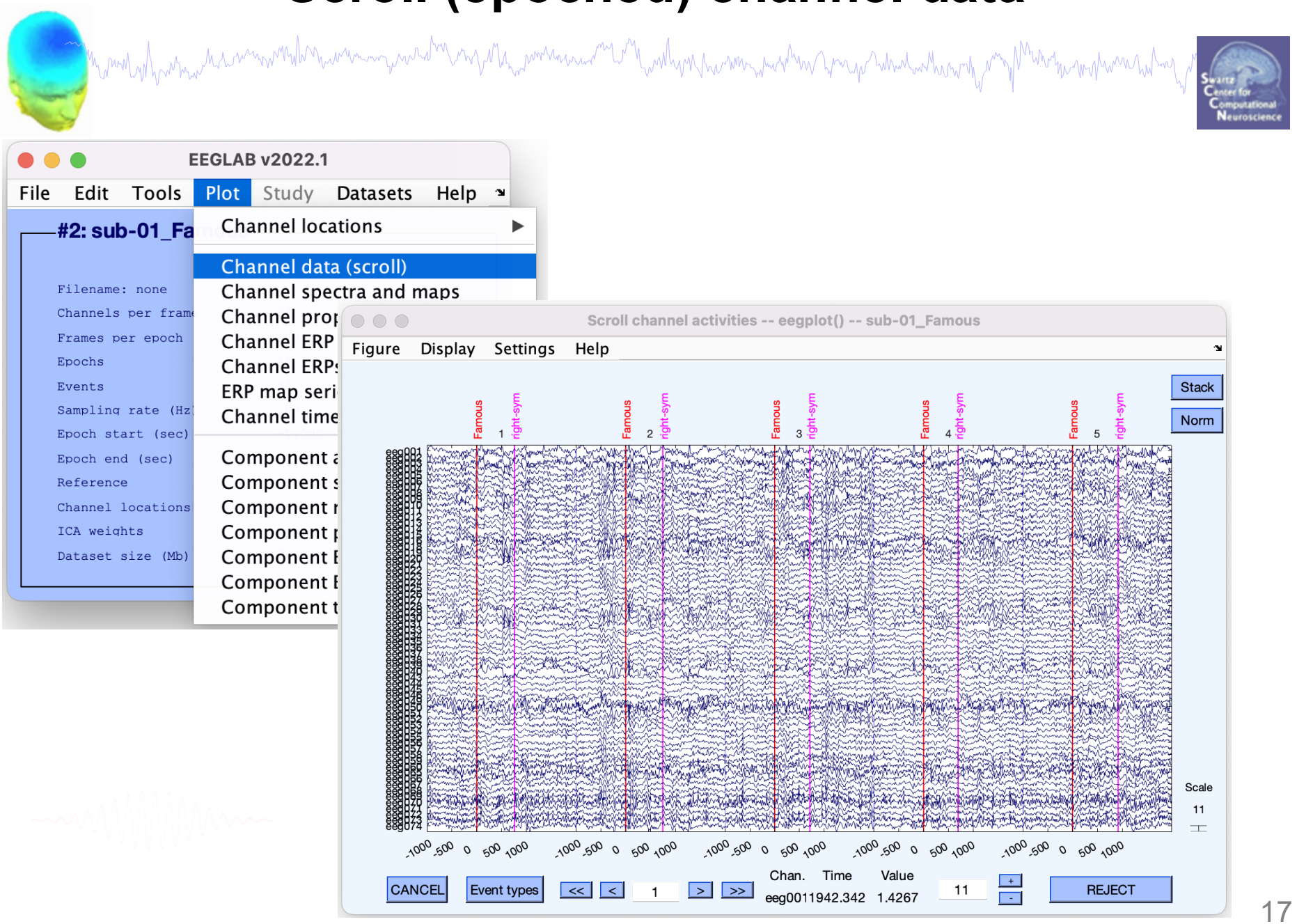
Long baseline or no baseline

Extract epochs

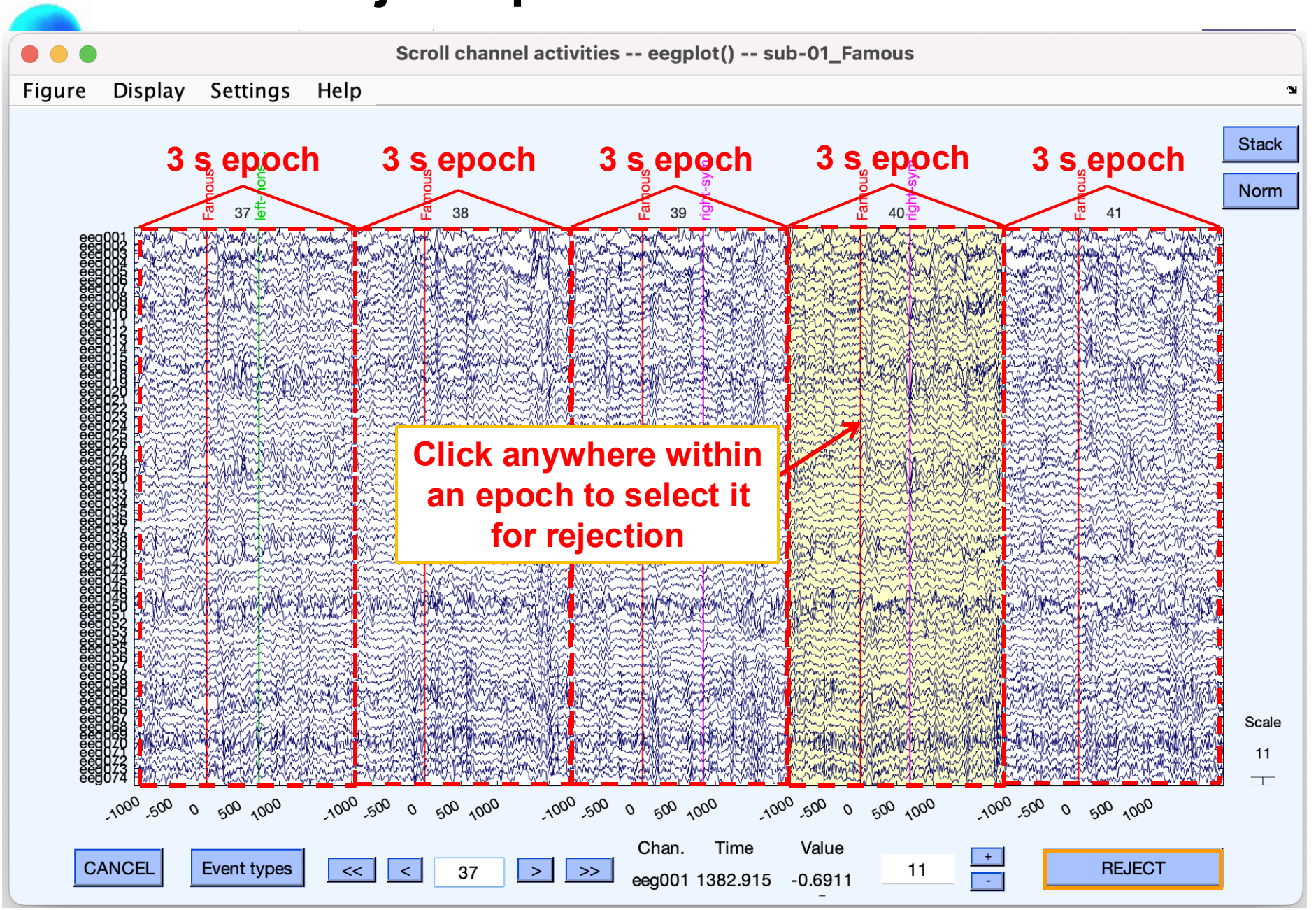




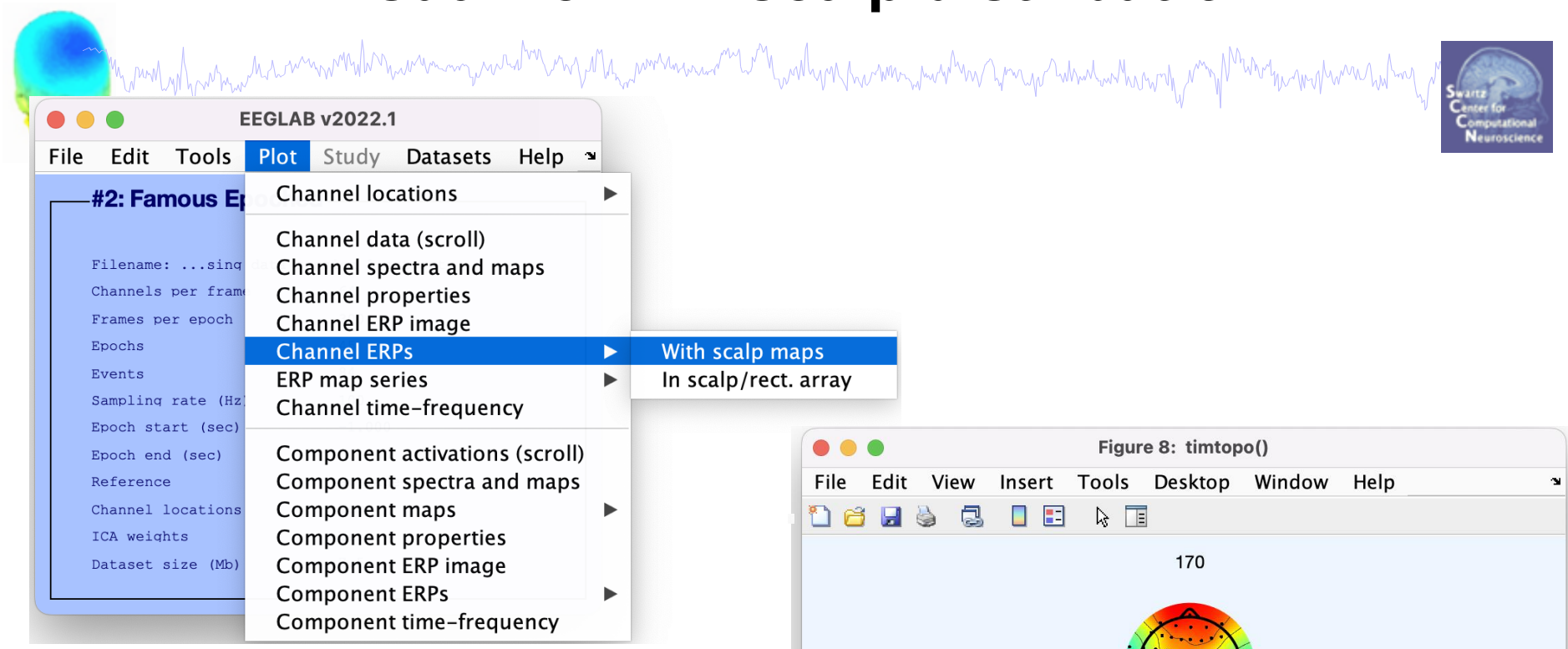
Scroll (epoched) channel data



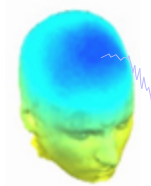
Reject epochs with artifacts



Visualize ERP scalp distribution

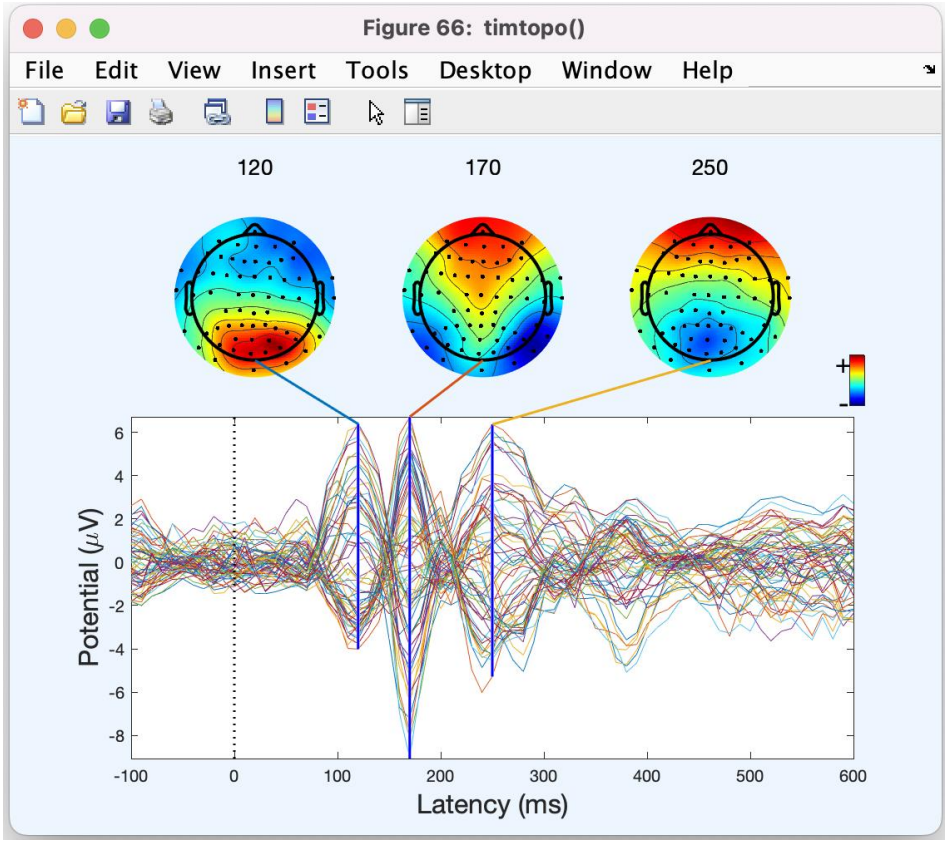


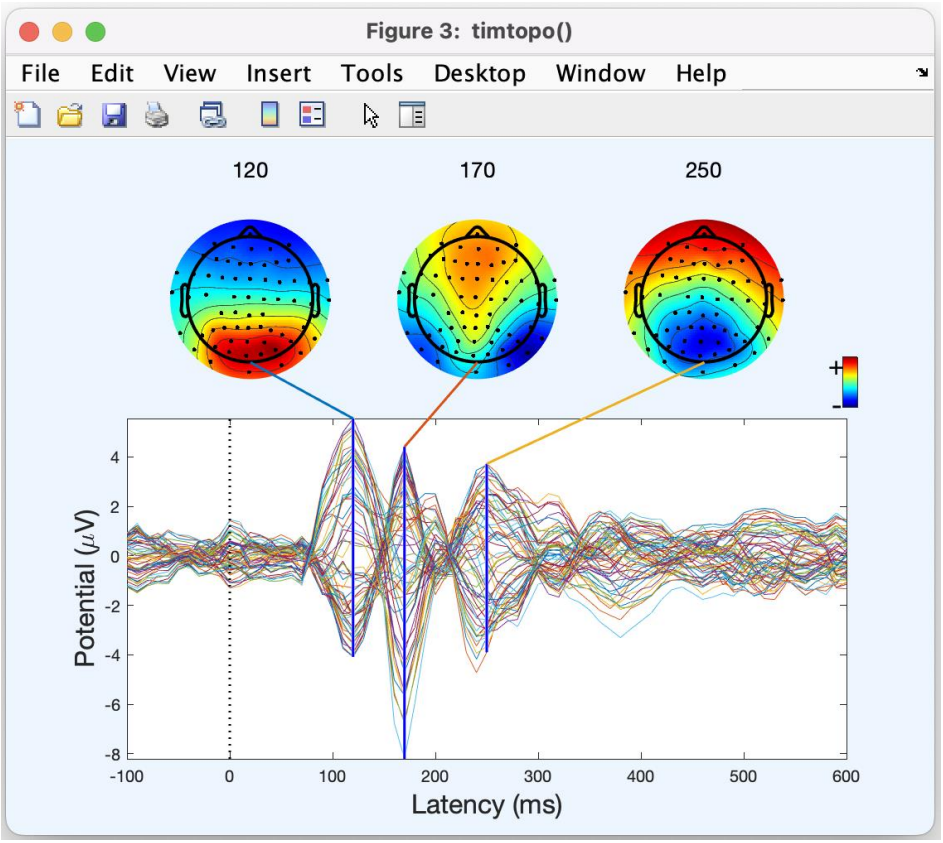
ERP scalp distribution



Before artefact IC removal

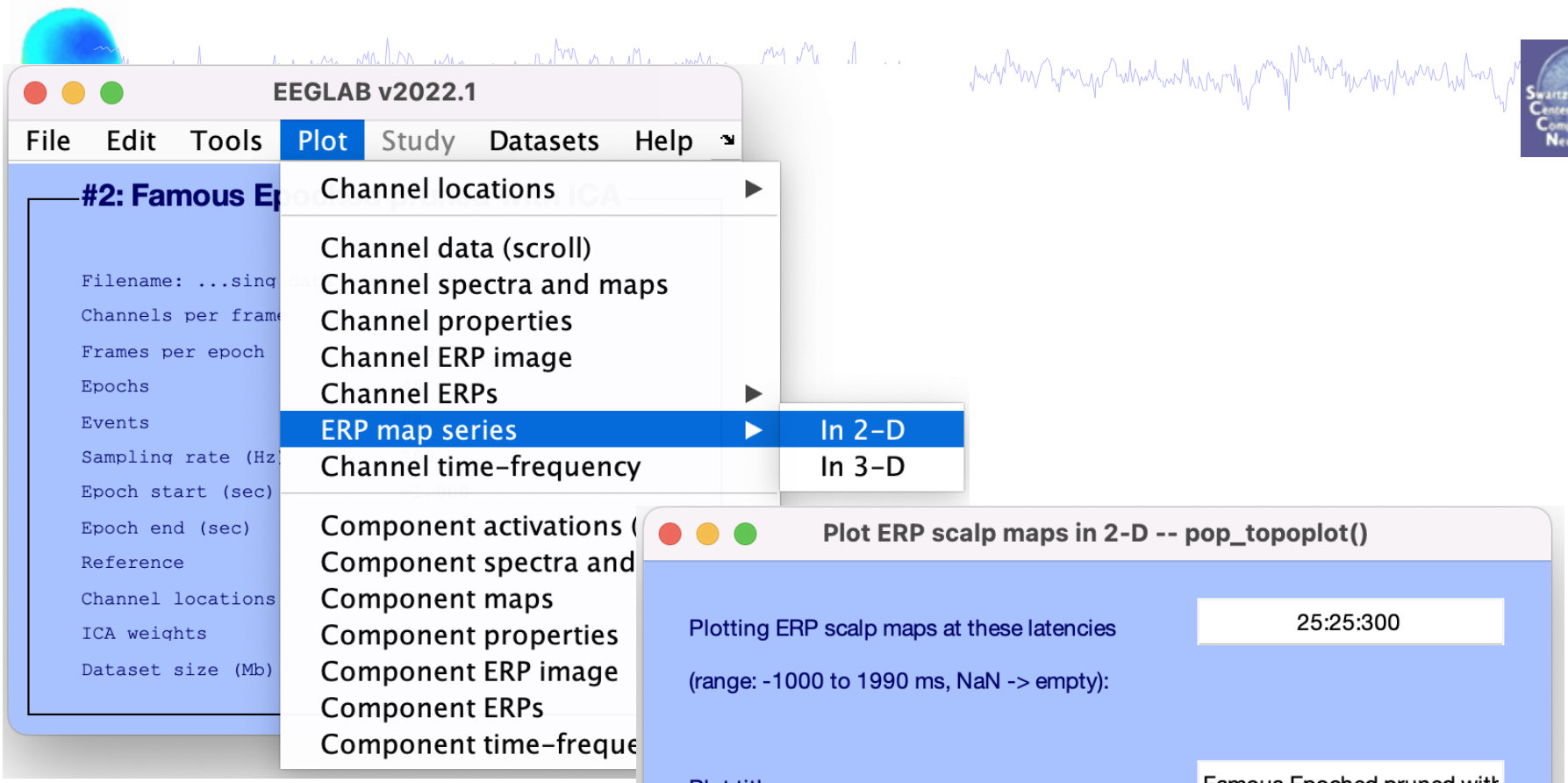
After artefact IC removal



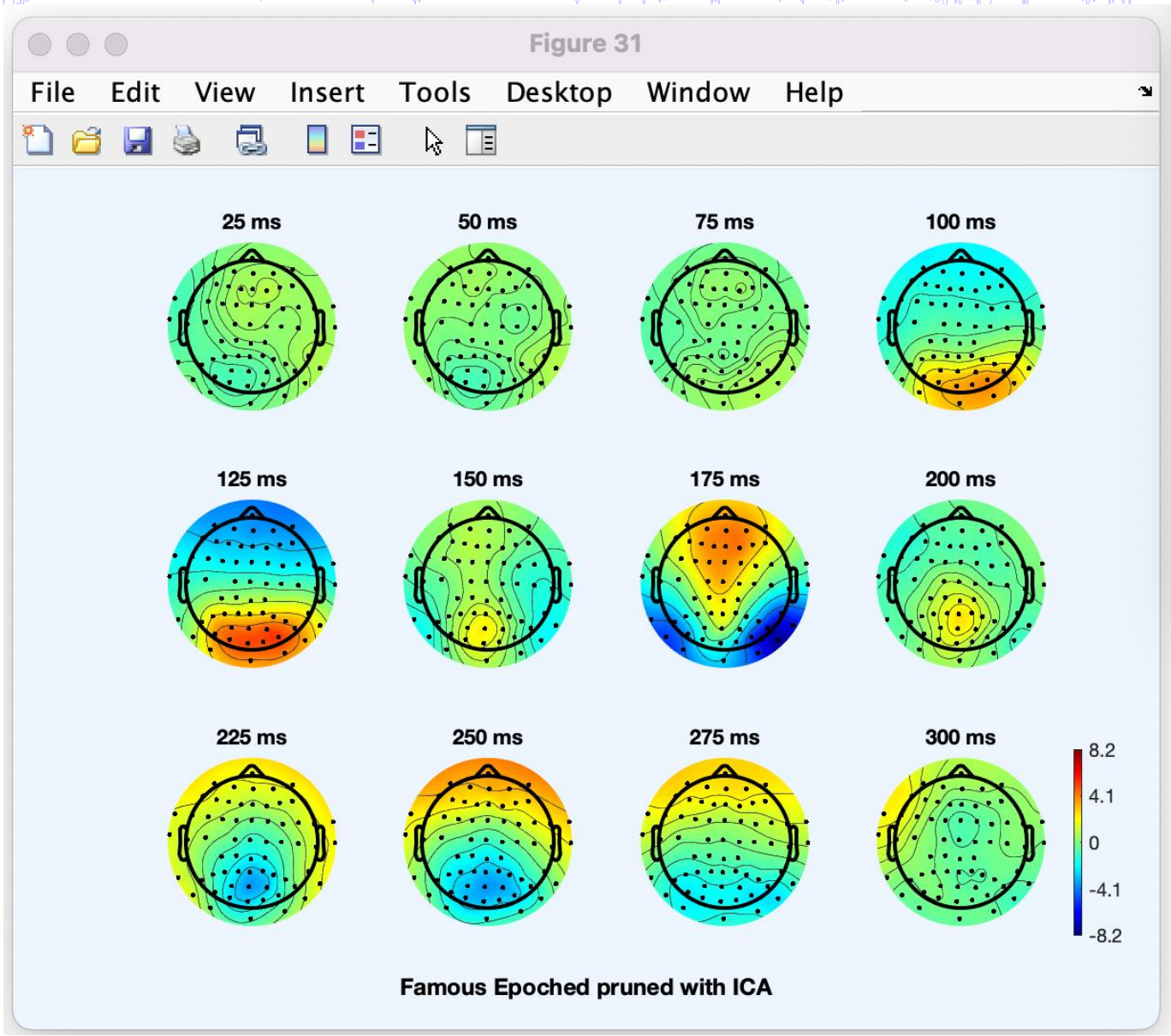


Note slightly decreased frontal activity after artefact removal, probably due to removed eye movements

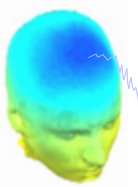
Visualize Channel ERPs in 2 D

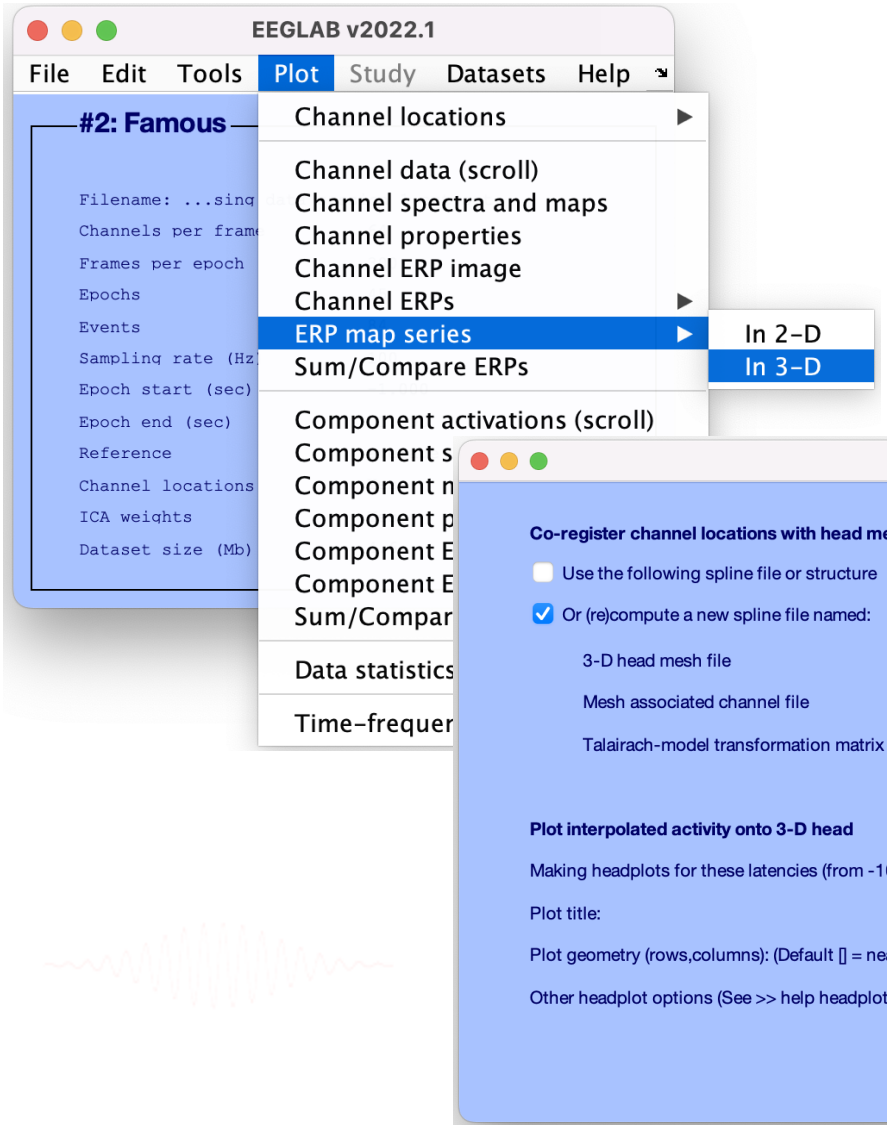


Visualize Channel ERPs in 2 D



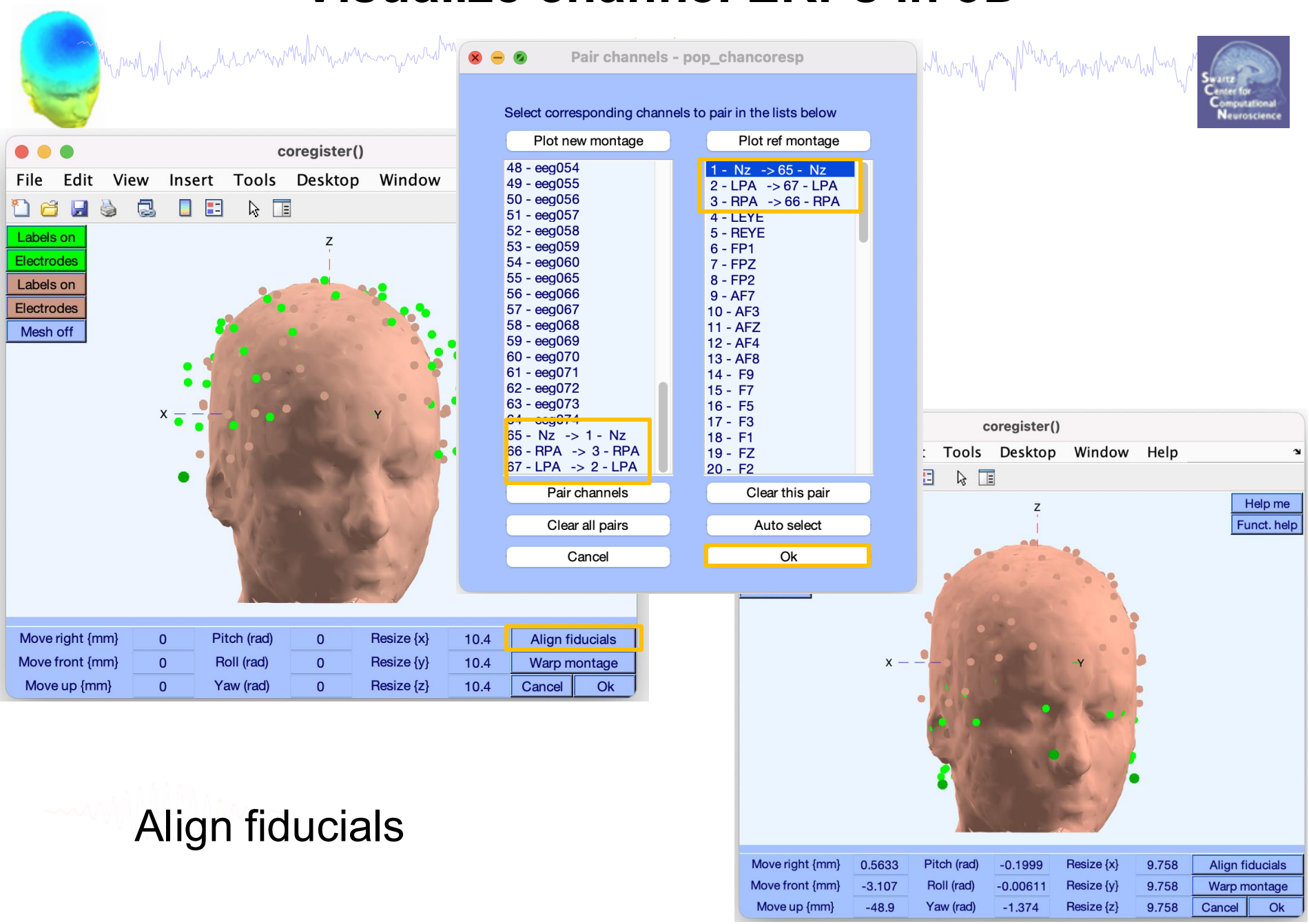
Visualize channel ERPs in 3D





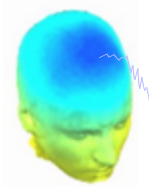
Co-register channels

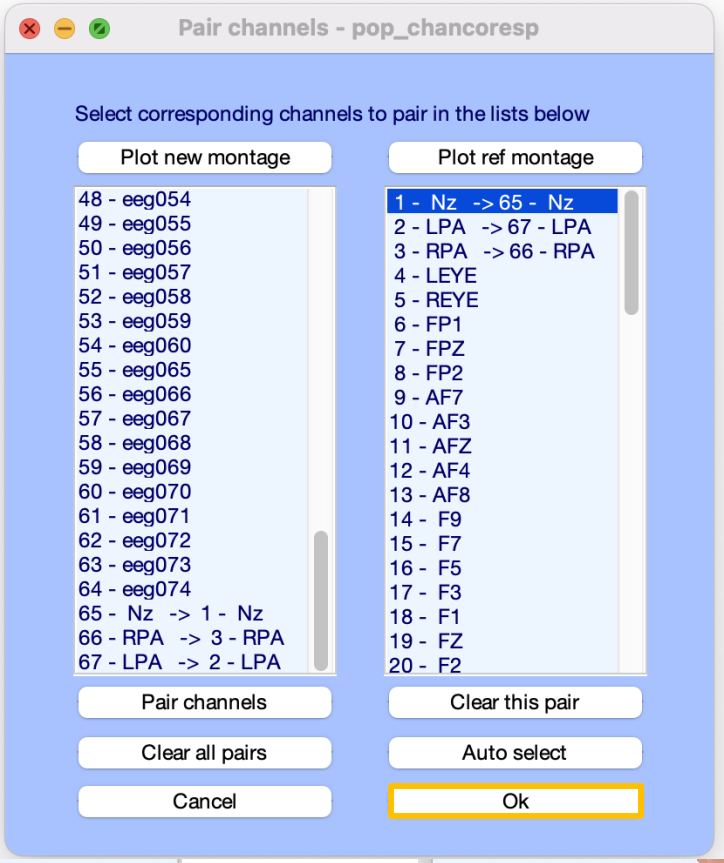
Visualize channel ERPs in 3D

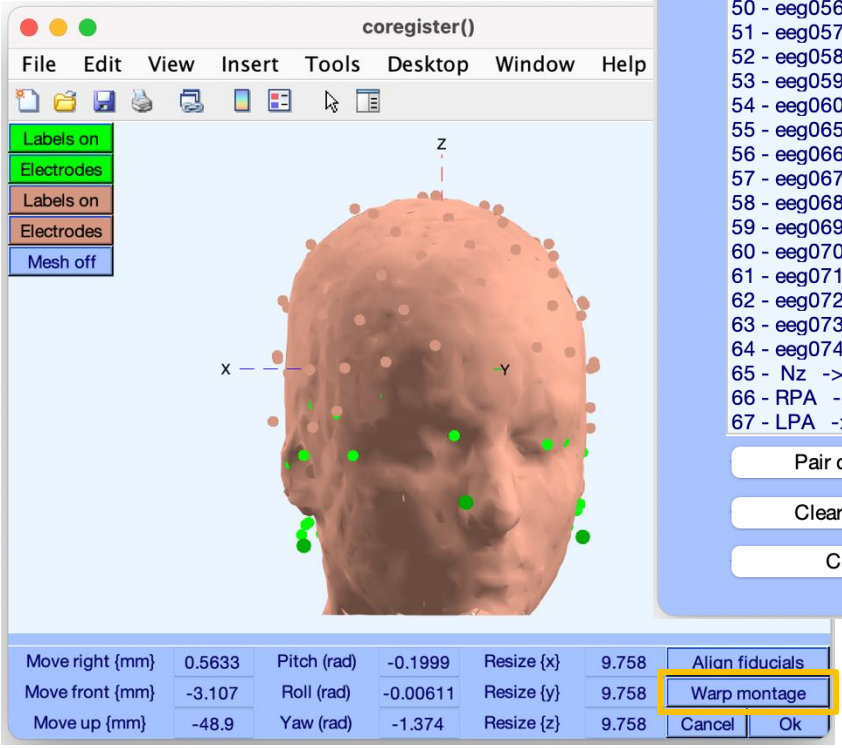


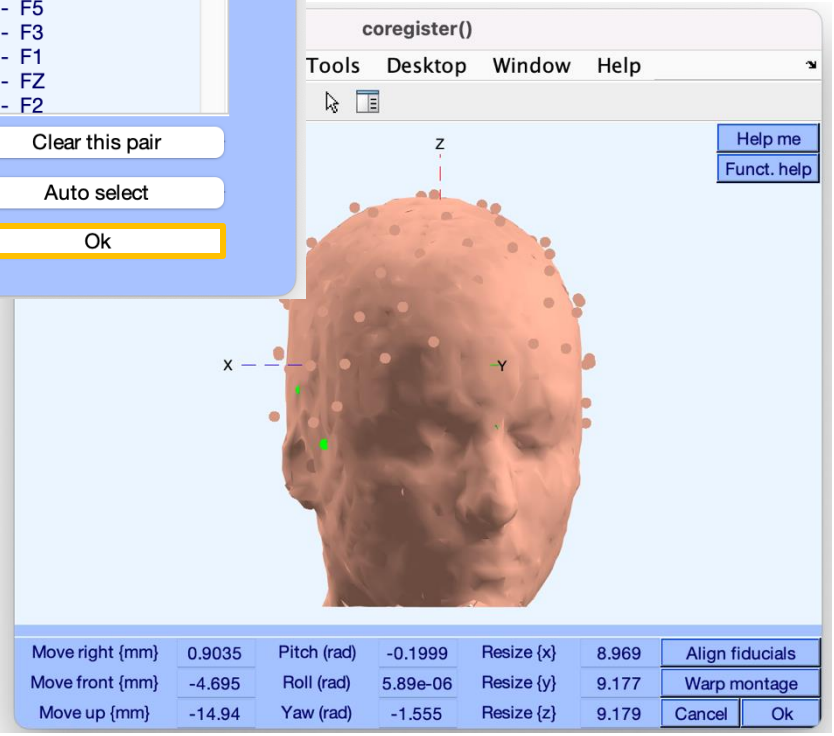
Align fiducials

Visualize channel ERPs in 3D



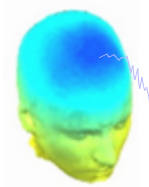


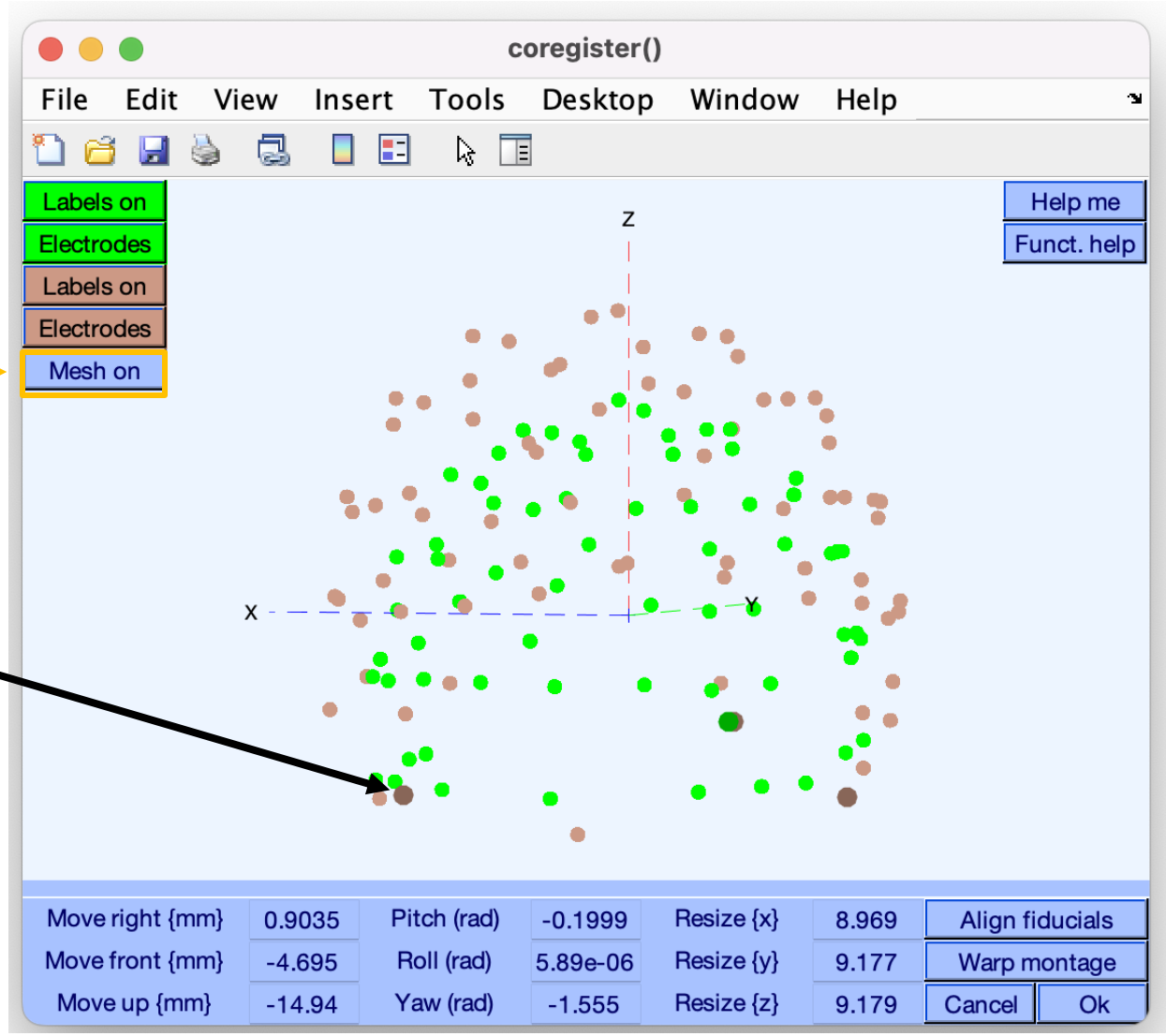




Warp montage

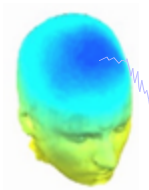
Visualize channel ERPs in 3D





Fiducials are aligned

Visualize channel ERPs in 3D



ERP head plot(s) -- pop_headplot()

Co-register channel locations with head mesh and compute a mesh spline file (each scalp montage needs a headplot() spline file)

- [ ] Use the following spline file or structure — /Users/johanna/Library/CloudStorage/GoogleDrive-joa.wagn@ — Browse — Help
- [x] Or (re)compute a new spline file named: — /Users/johanna/Library/CloudStorage/GoogleDrive-joa.wagn@ — Browse — Help

3-D head mesh file: mheadnew.mat — Browse other

Mesh associated channel file: mheadnew.xyz — Browse other

Talairach-model transformation matrix: 0.90355 -4.69459 -14.9446 -0.199874 5.88963e-06 — Manual coreg.

Plot interpolated activity onto 3-D head

Making headplots for these latencies (from -1000 to 1990 ms): 25:25:350

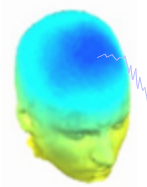
Plot title: ERP scalp maps of dataset:Famous

Plot geometry (rows,columns): (Default [] = near square)

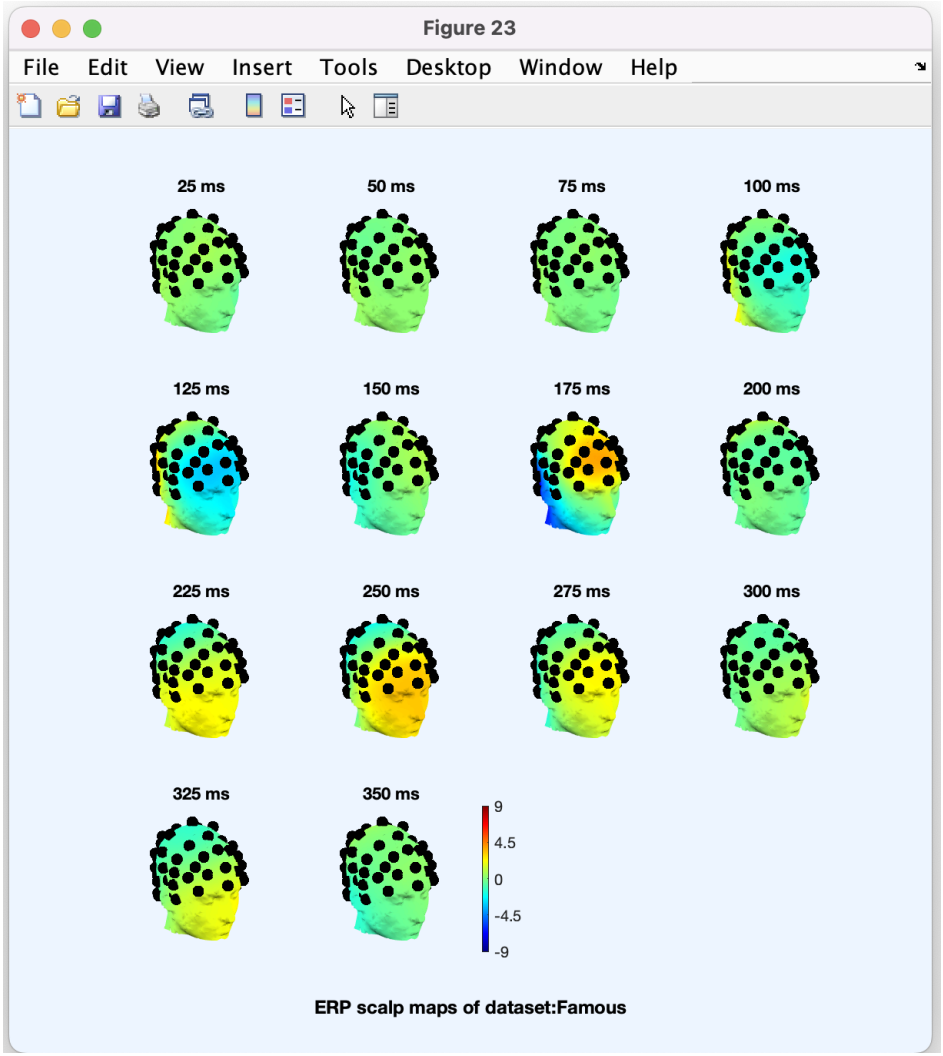
Other headplot options (See >> help headplot):

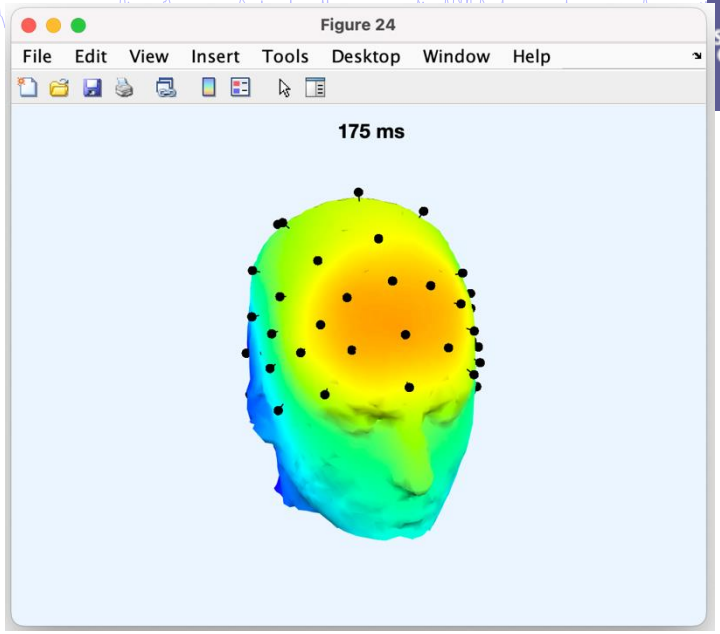
Cancel Ok

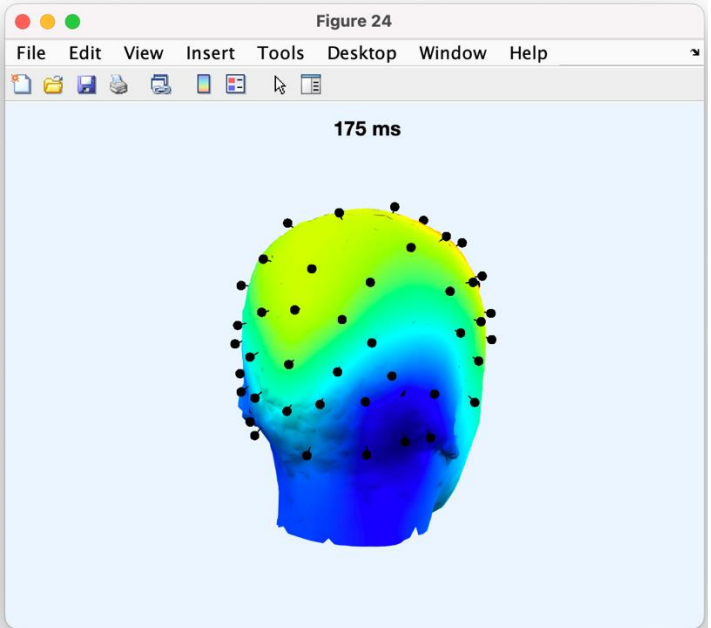
Visualize channel ERPs in 3D



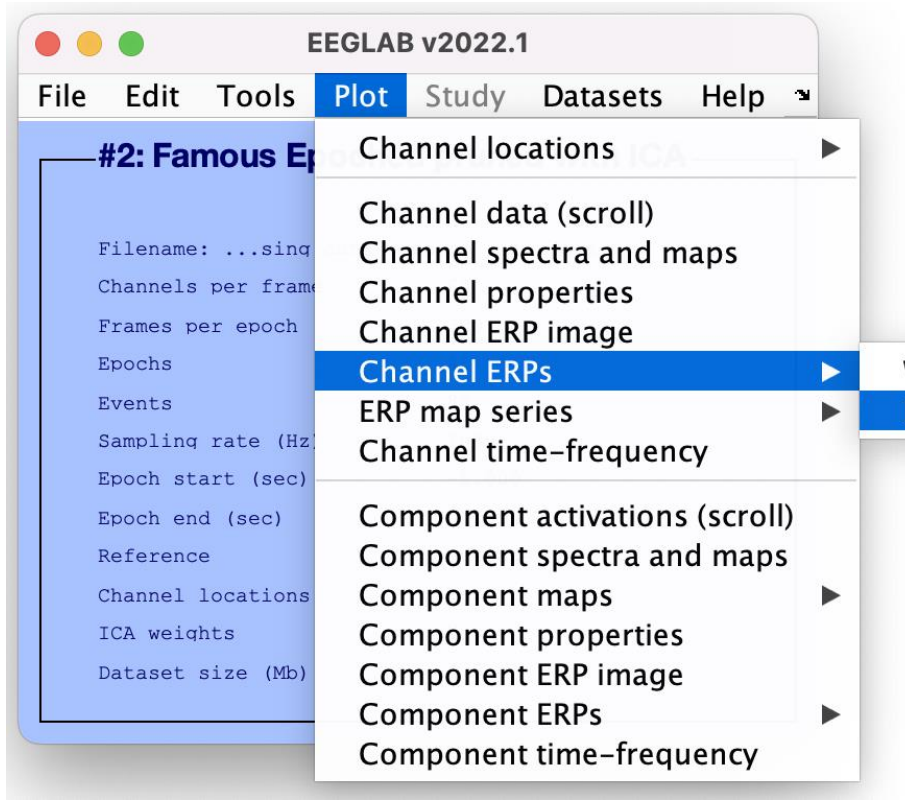
Click on the head

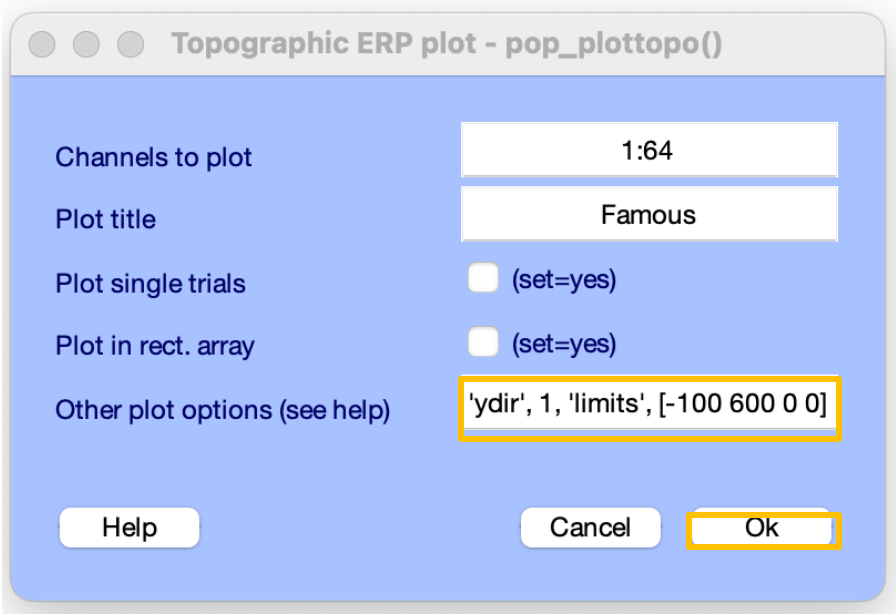




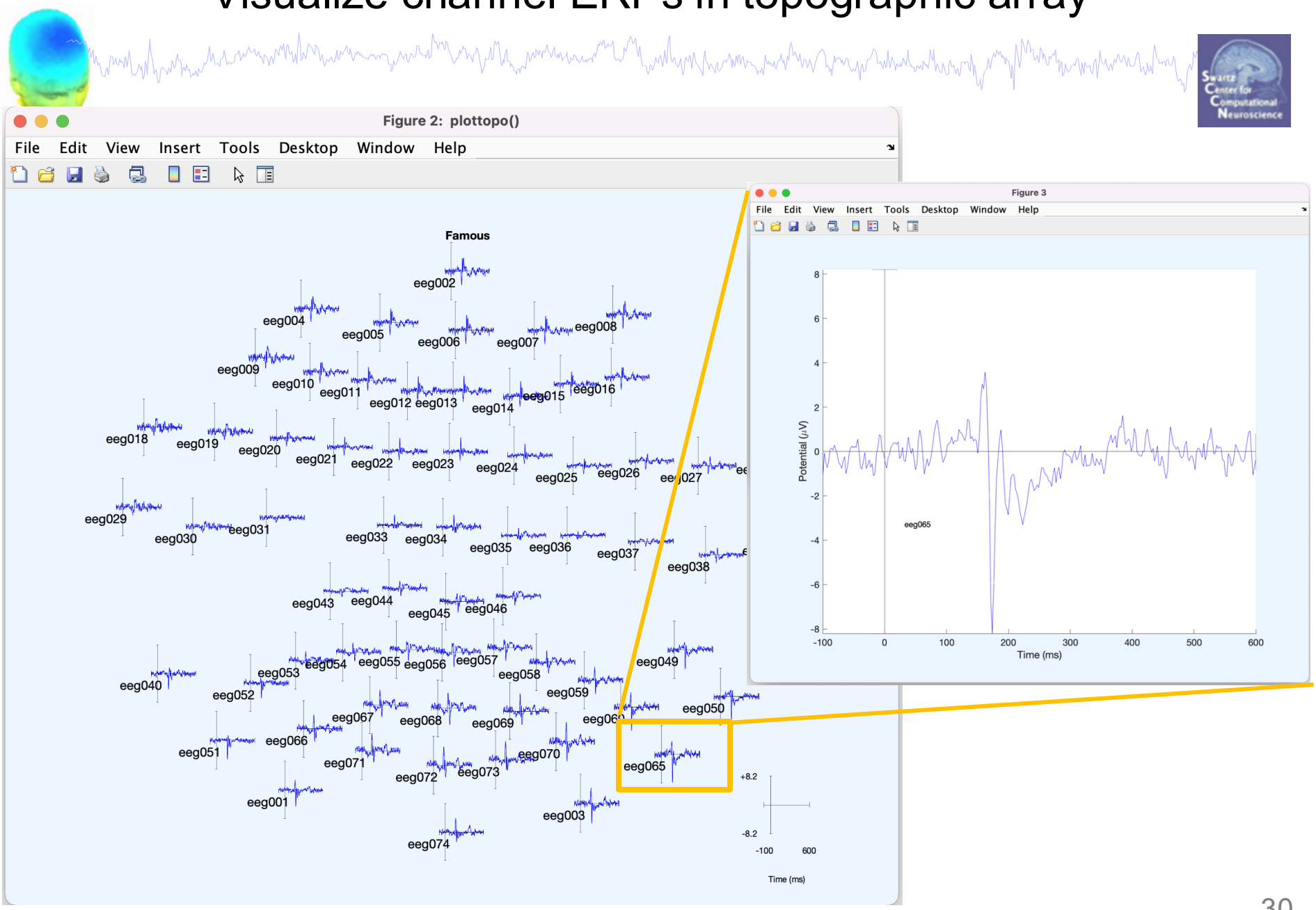


Visualize channel ERPs in topographic array

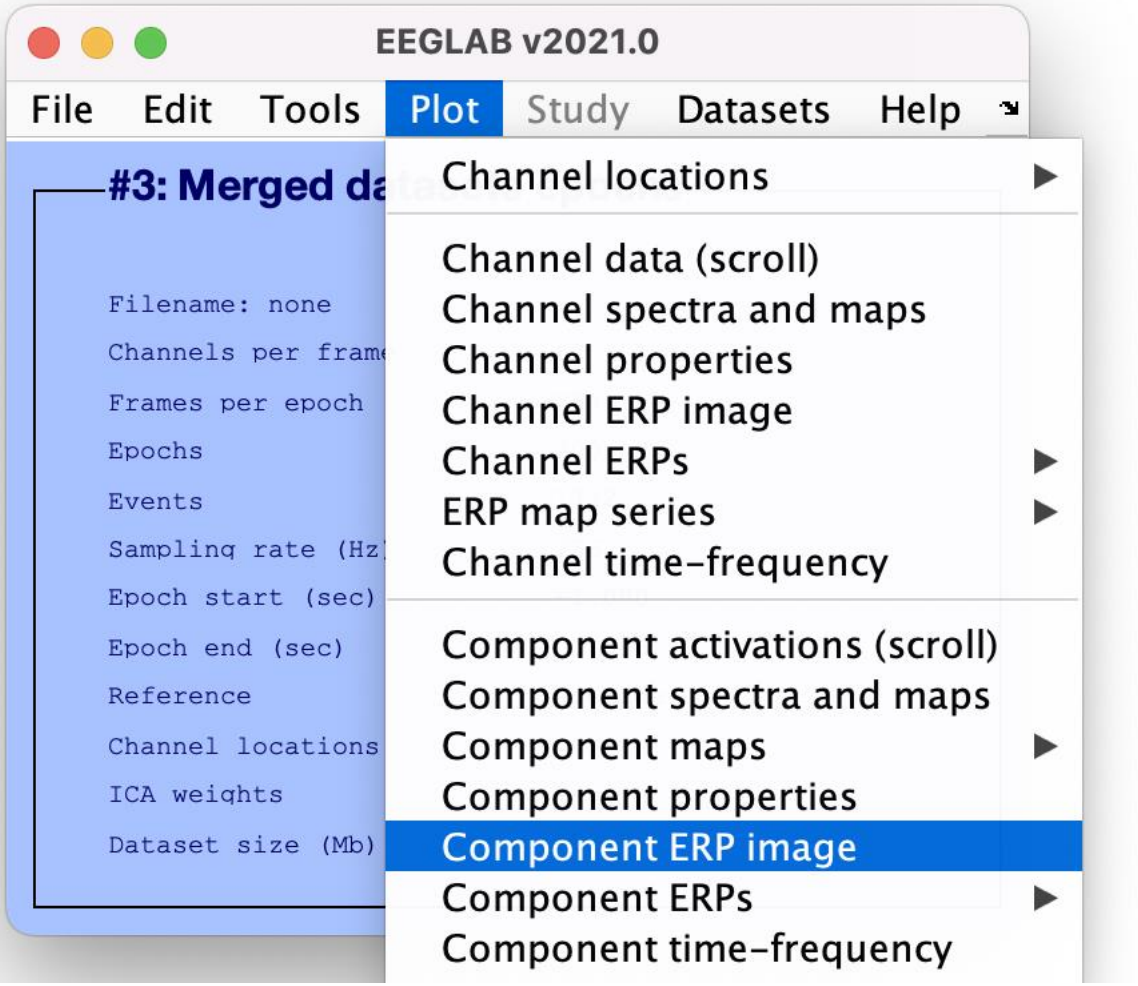




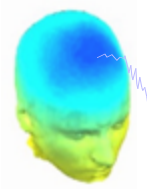
Visualize channel ERPs in topographic array

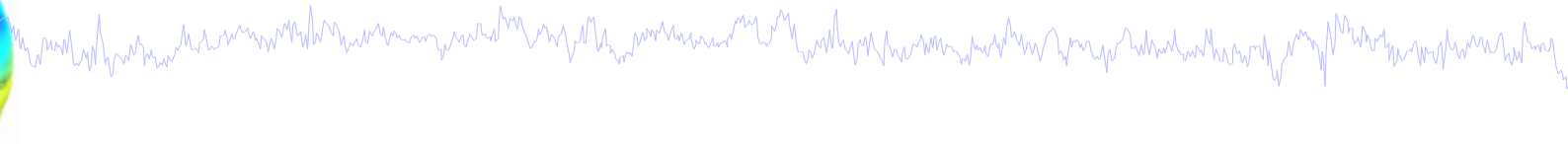


Component ERP image



ERP Image basics



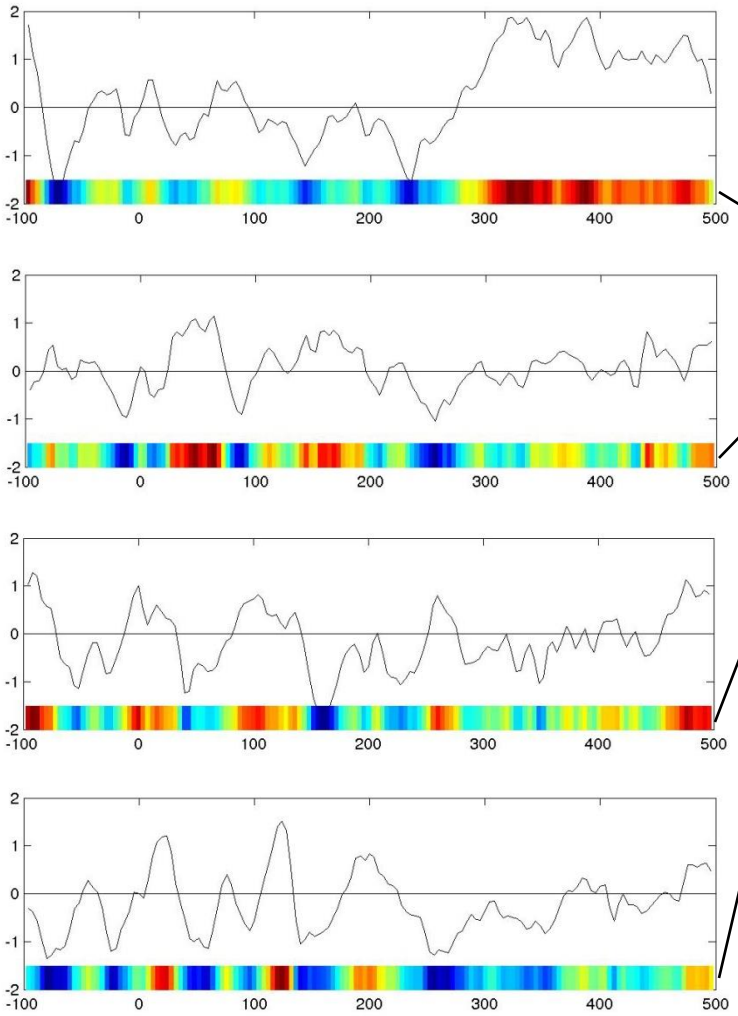


Trial 1

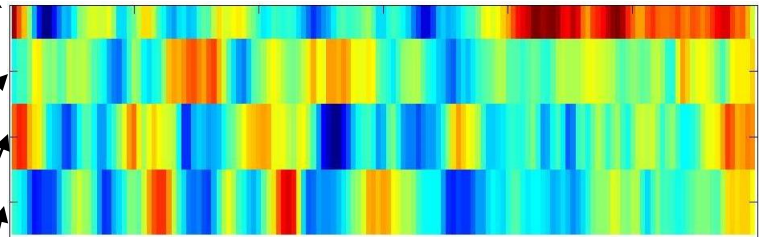
Trial 2

Trial 3

Trial 4

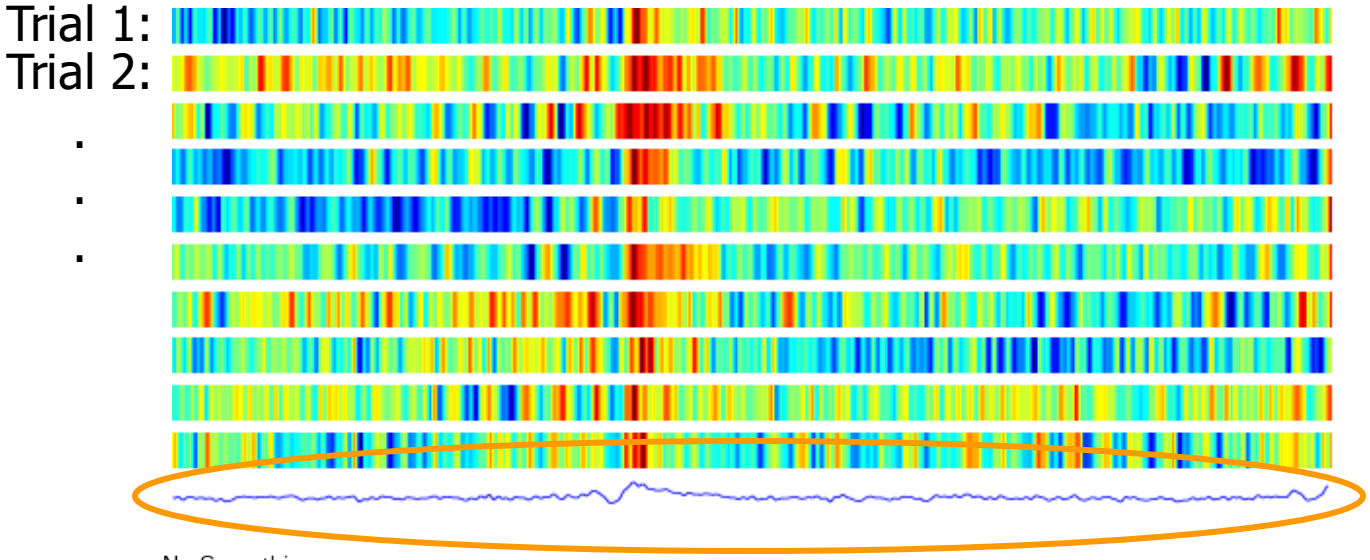


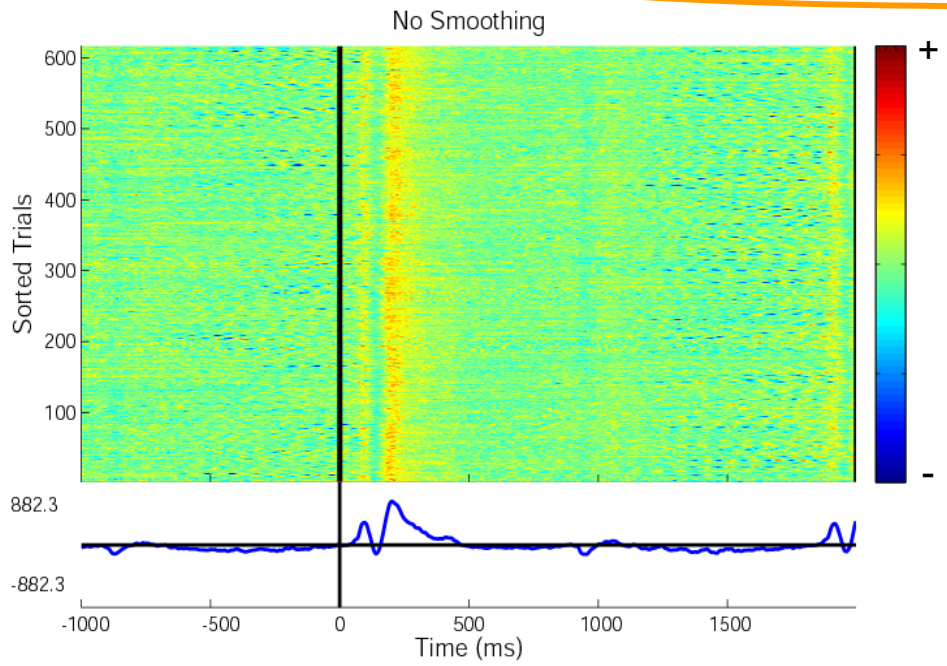
ERP Image

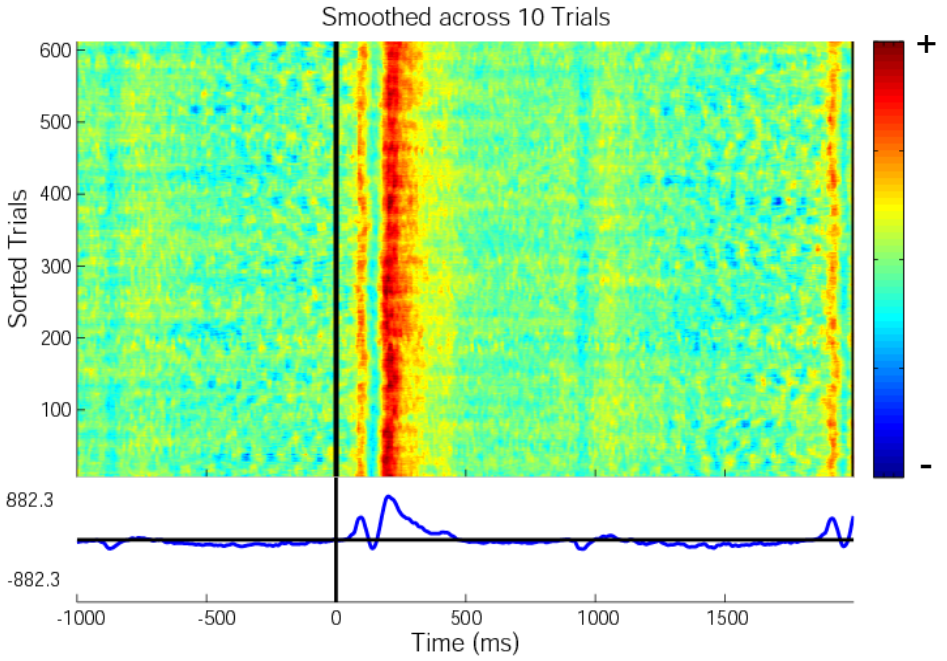


by default, sorted by time-on-task
(1st trial, 2nd trial, ...)

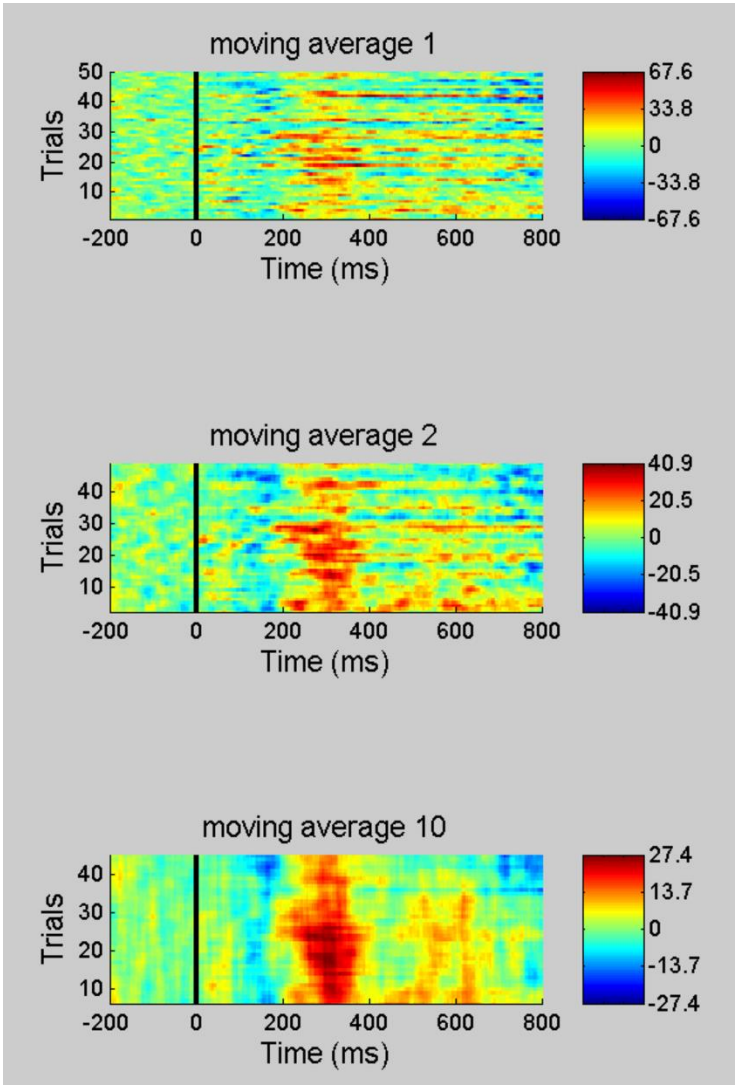
ERP Image basics



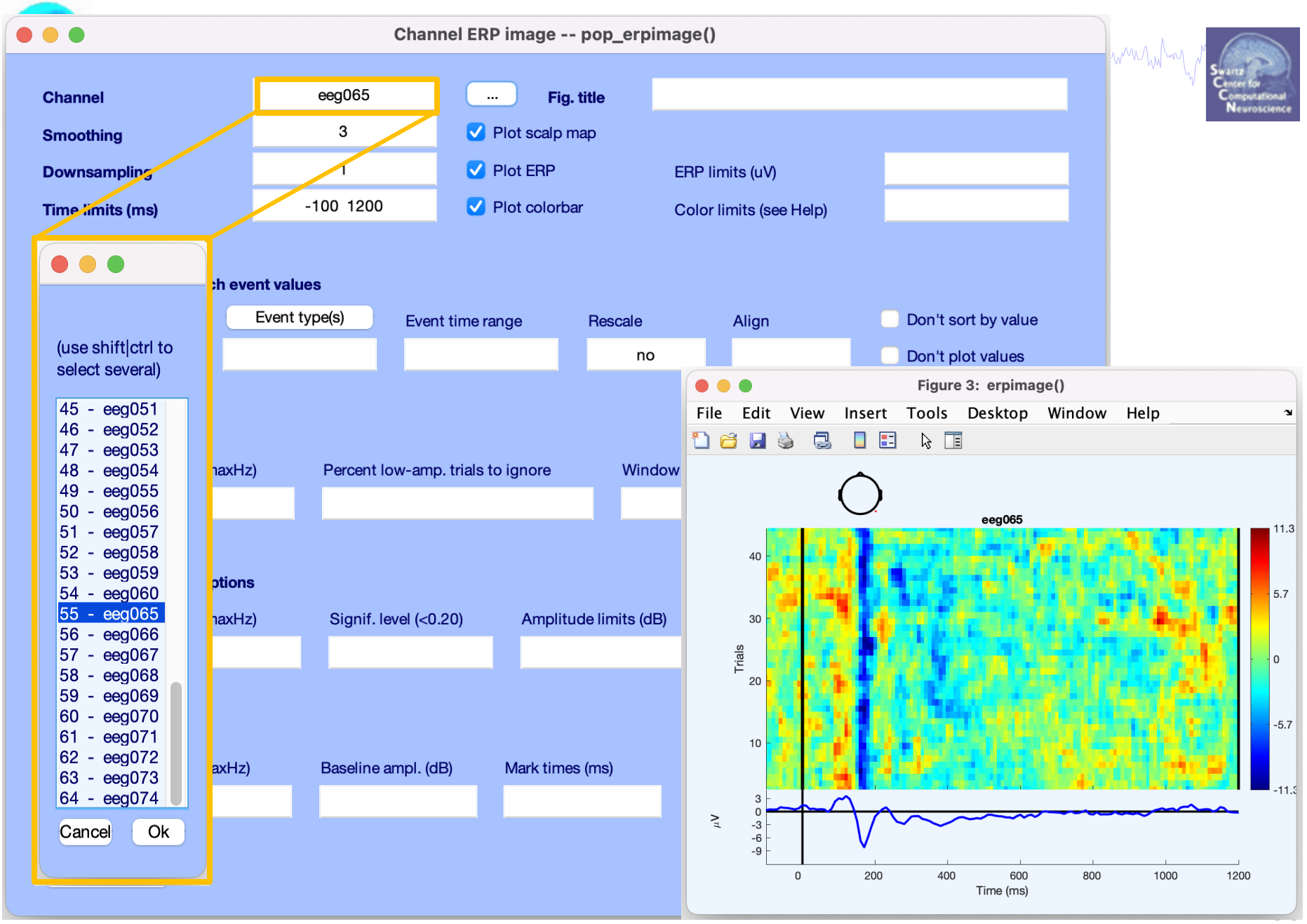




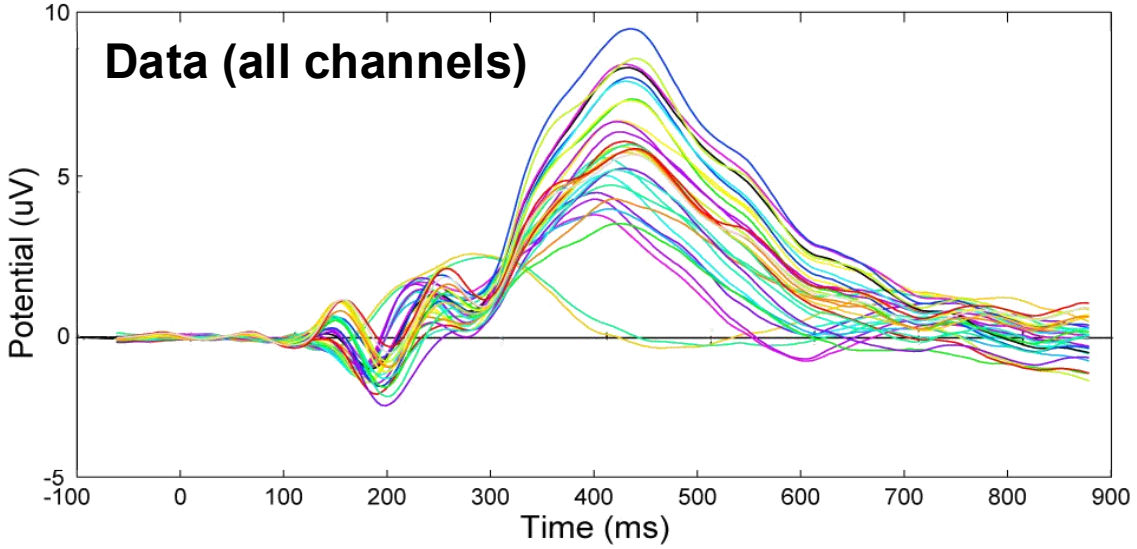
ERP Images: smoothing across trials

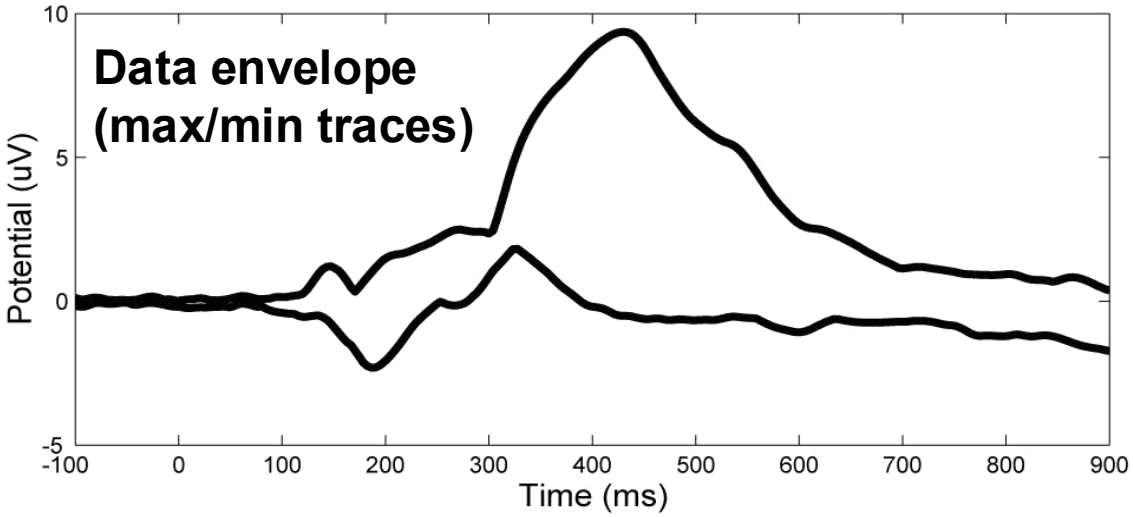


Channel ERP Image

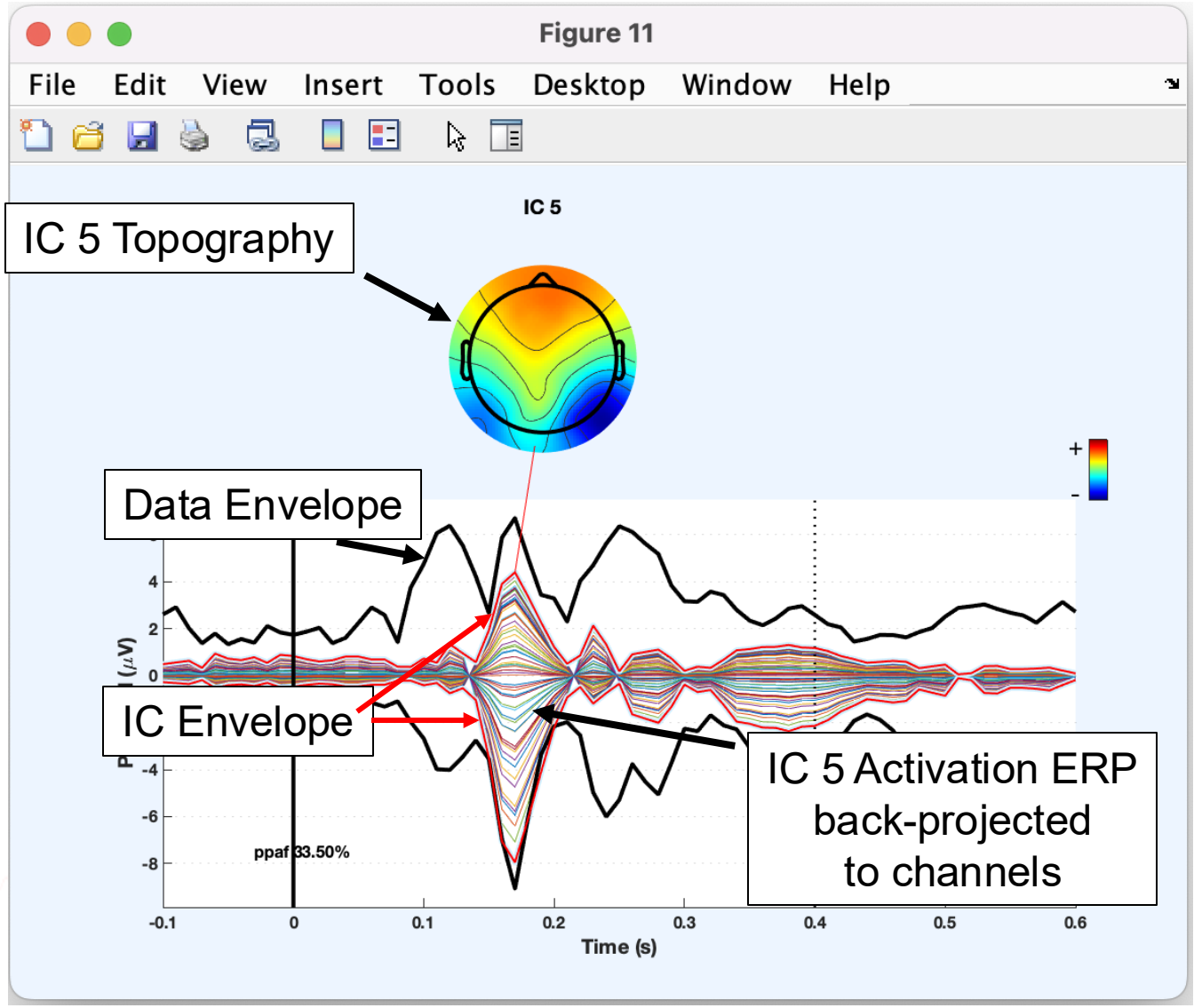


Definition: The data envelope

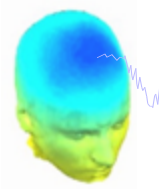


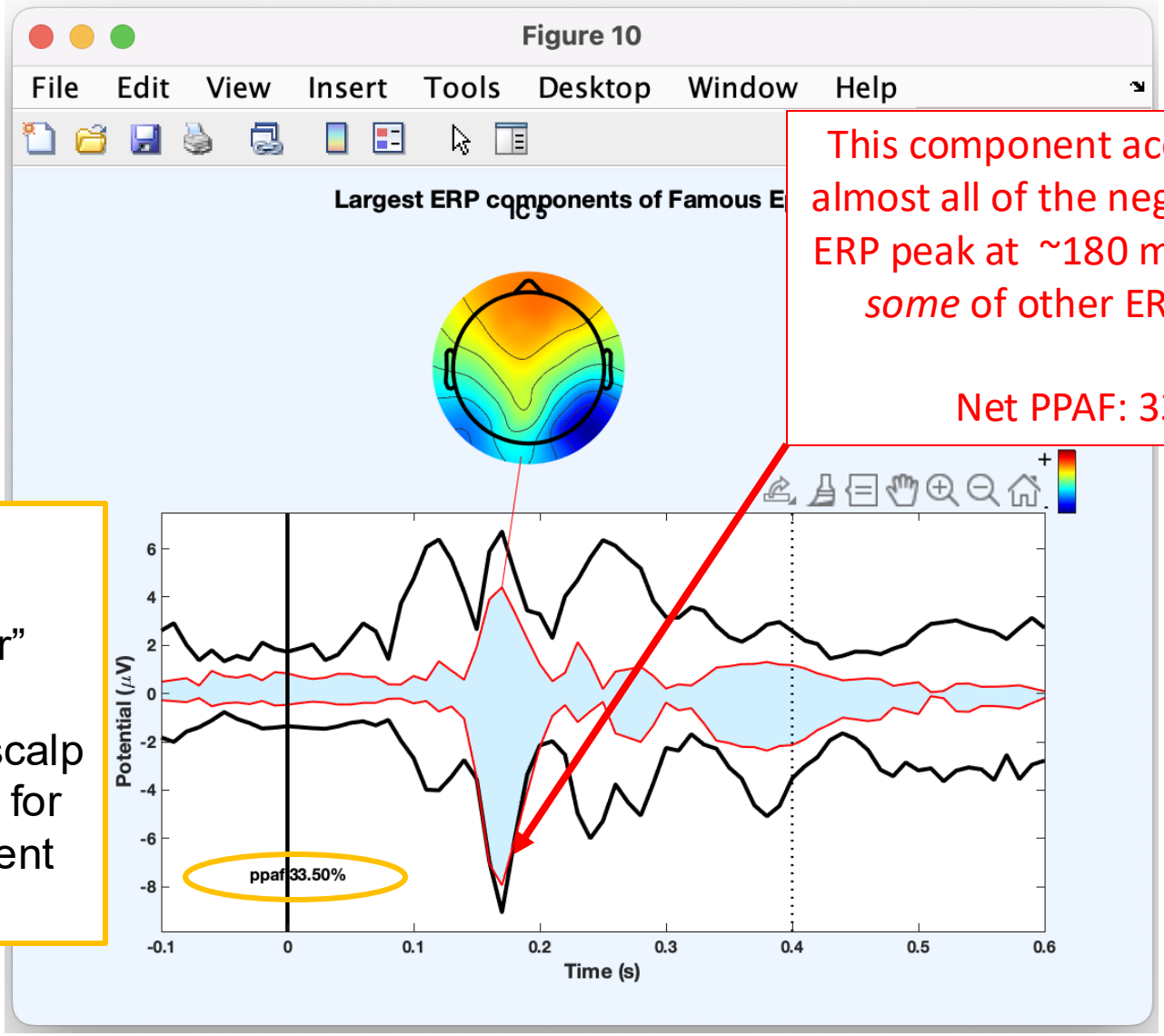


Definition: IC Envelope



Key: Scalp ERP peaks are often the sum of multiple independent source processes





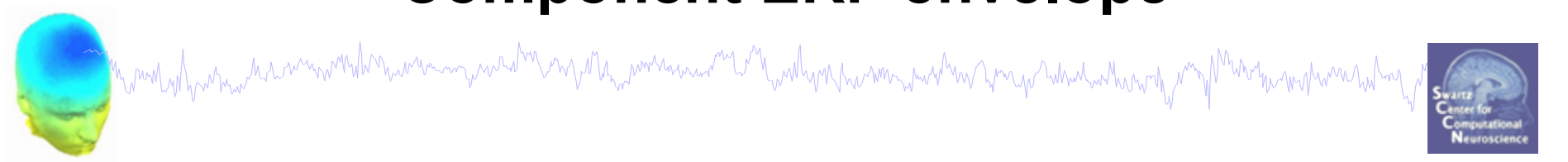
This component accounts for almost all of the negative scalp ERP peak at ~180 ms, but *only some* of other ERP peaks

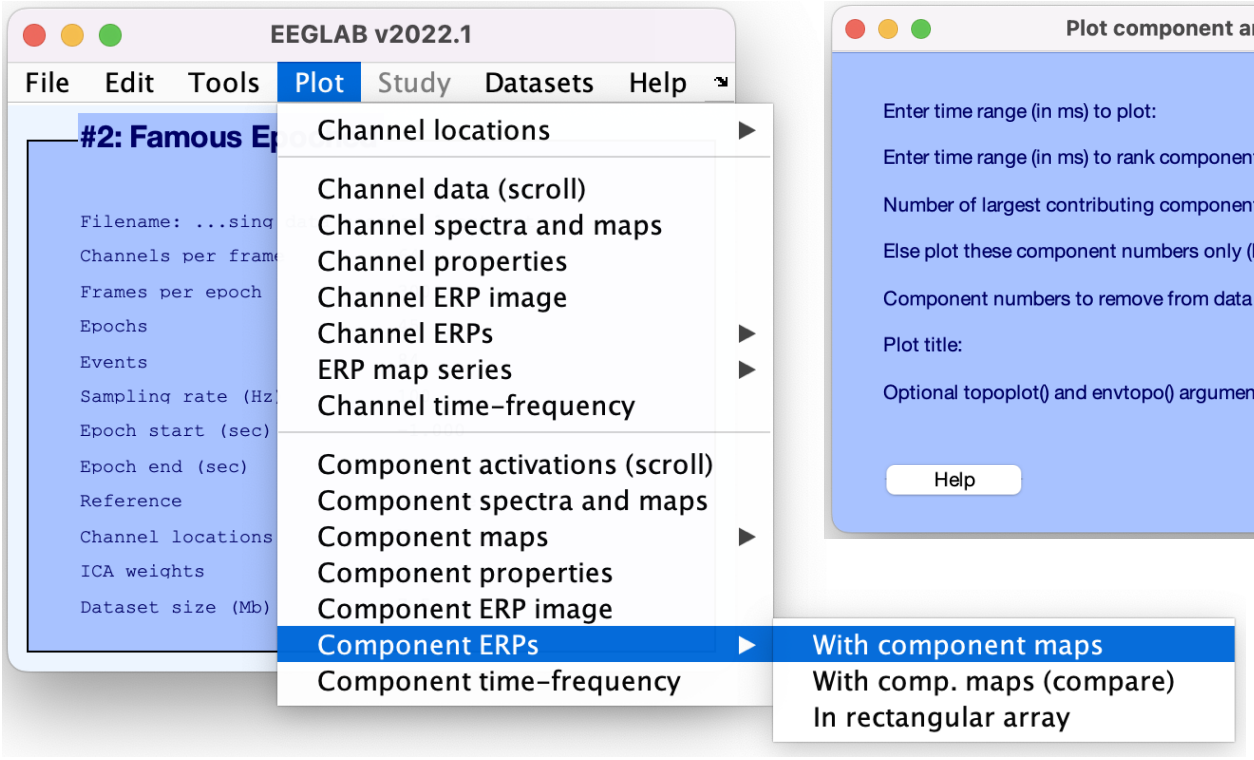
Net PPAF: 33%

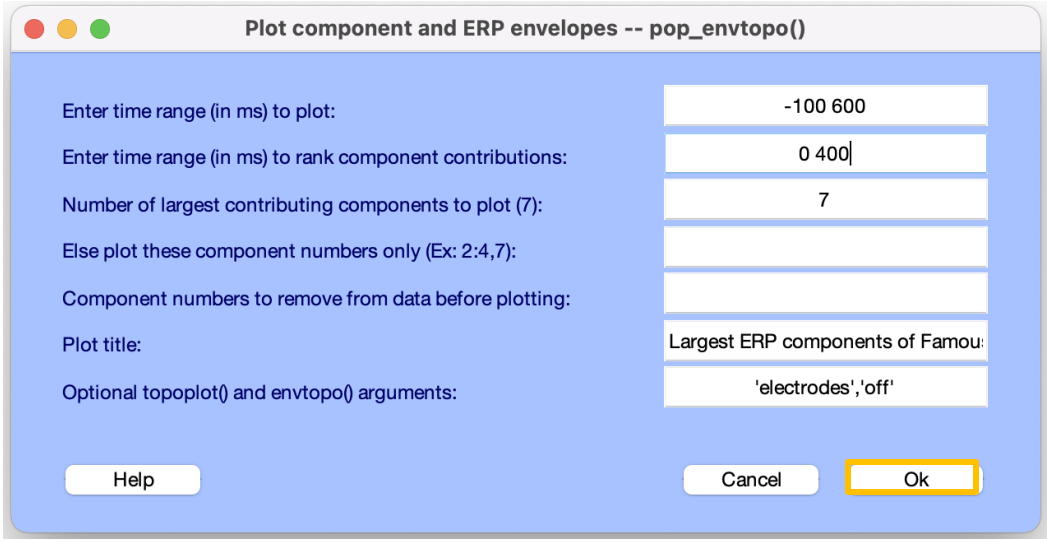
PPAF
"% Variance Accounted For"

The variance of scalp EEG accounted for by this component

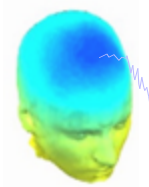
Component ERP envelope

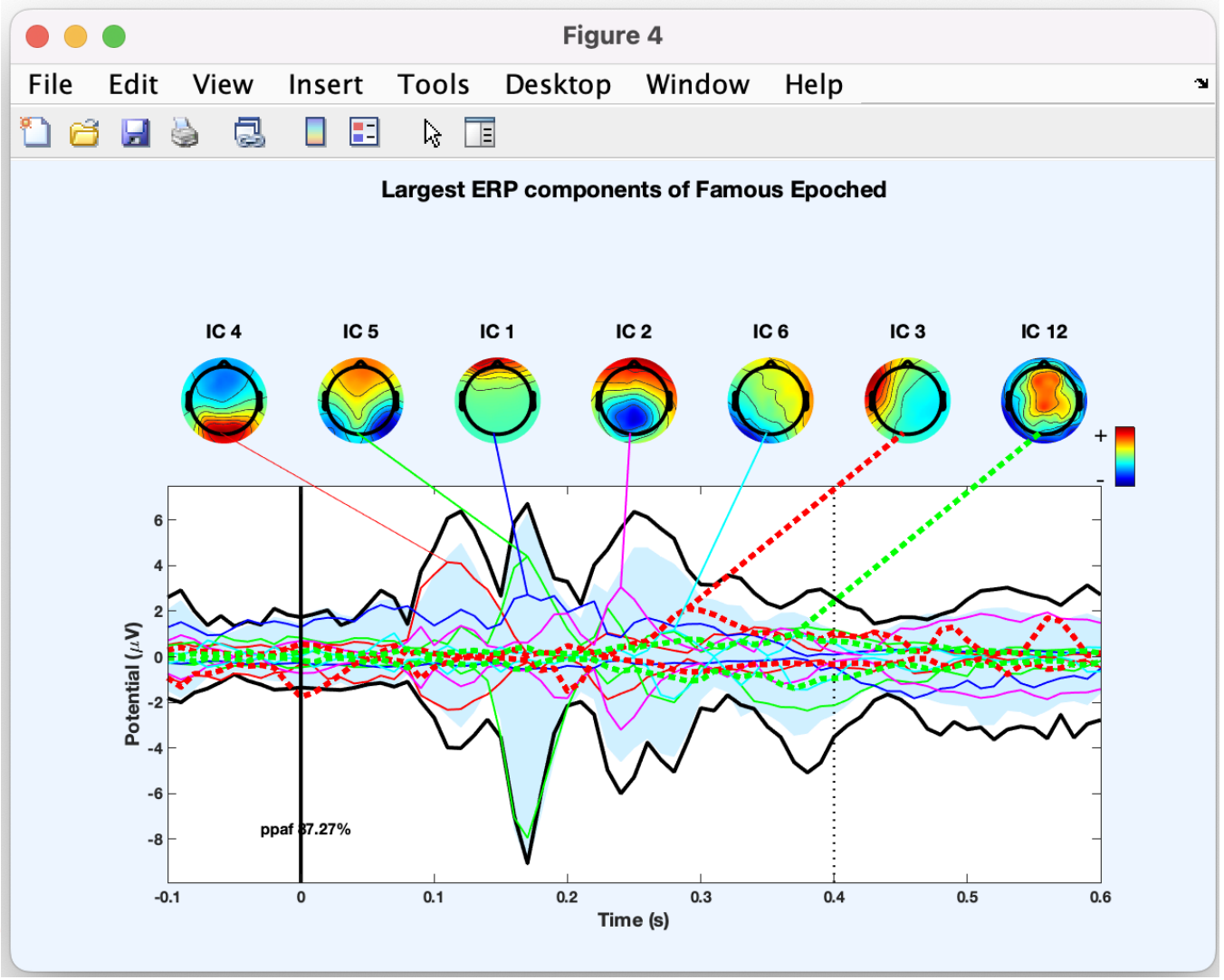




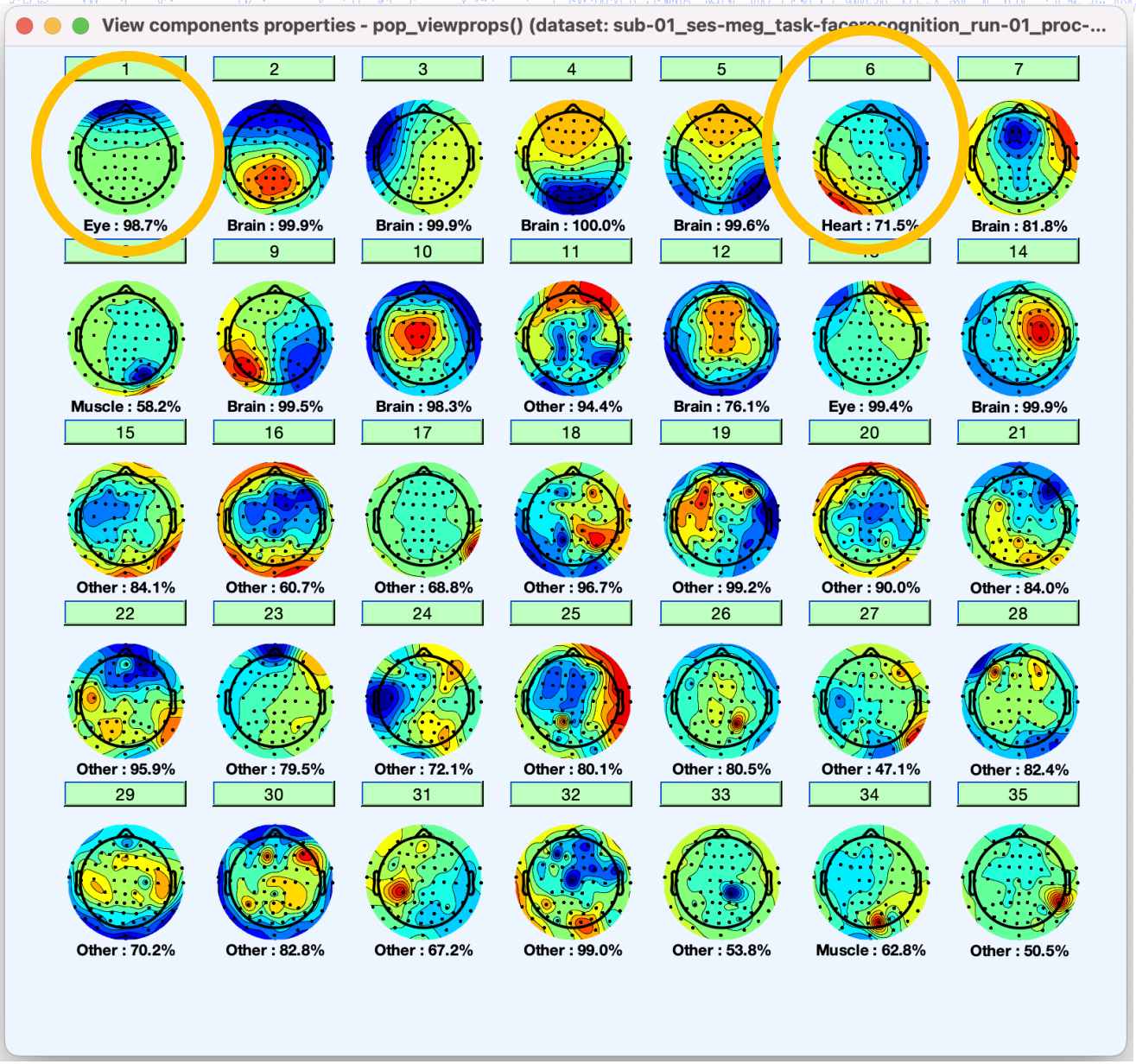


IC contributions to ERP envelope

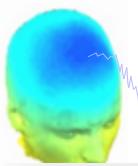


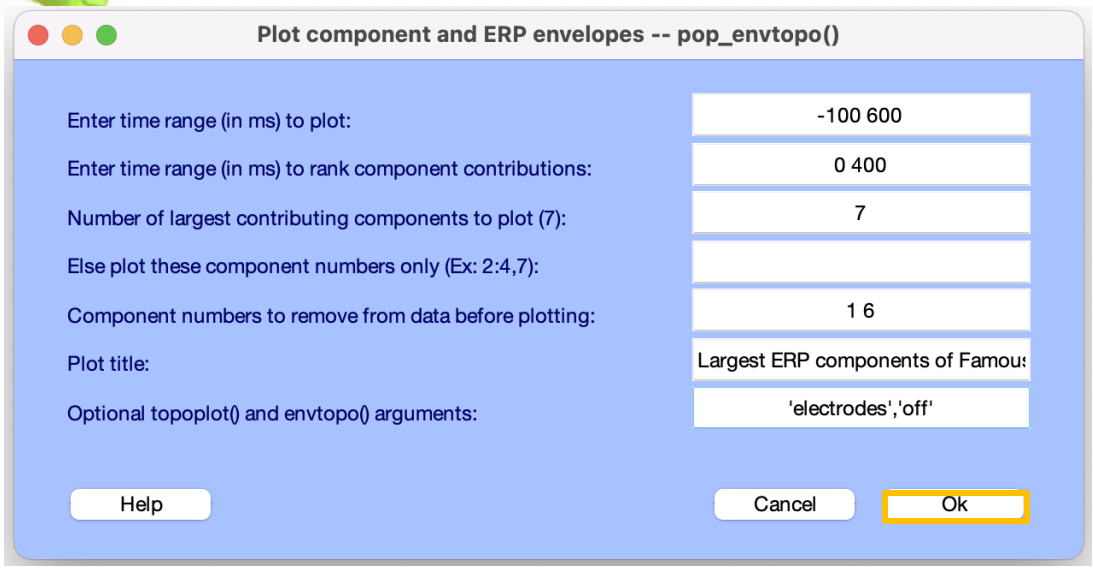


IC contributions to ERP envelope



IC contributions to ERP envelope

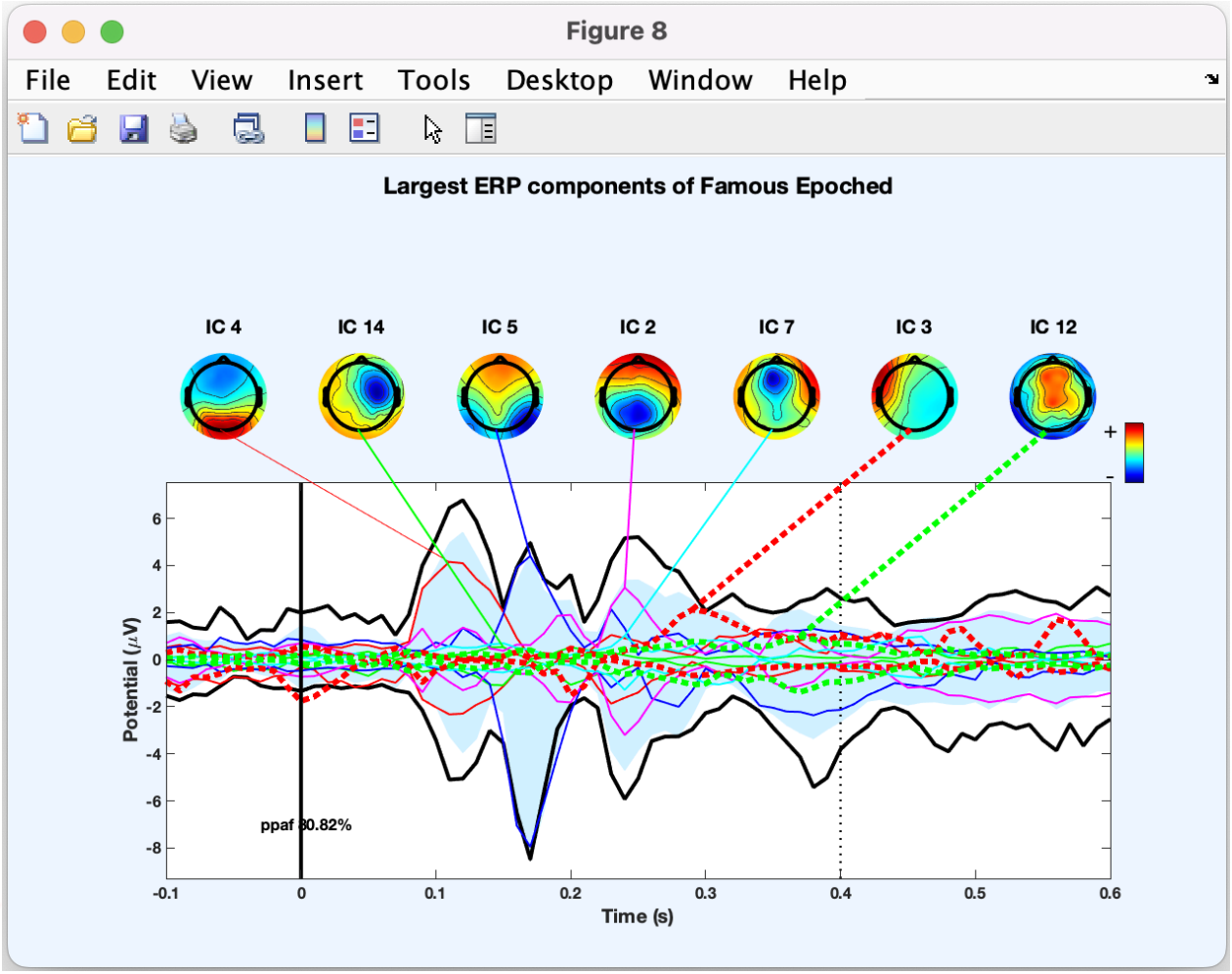




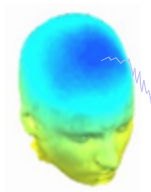
Removing artefact ICs

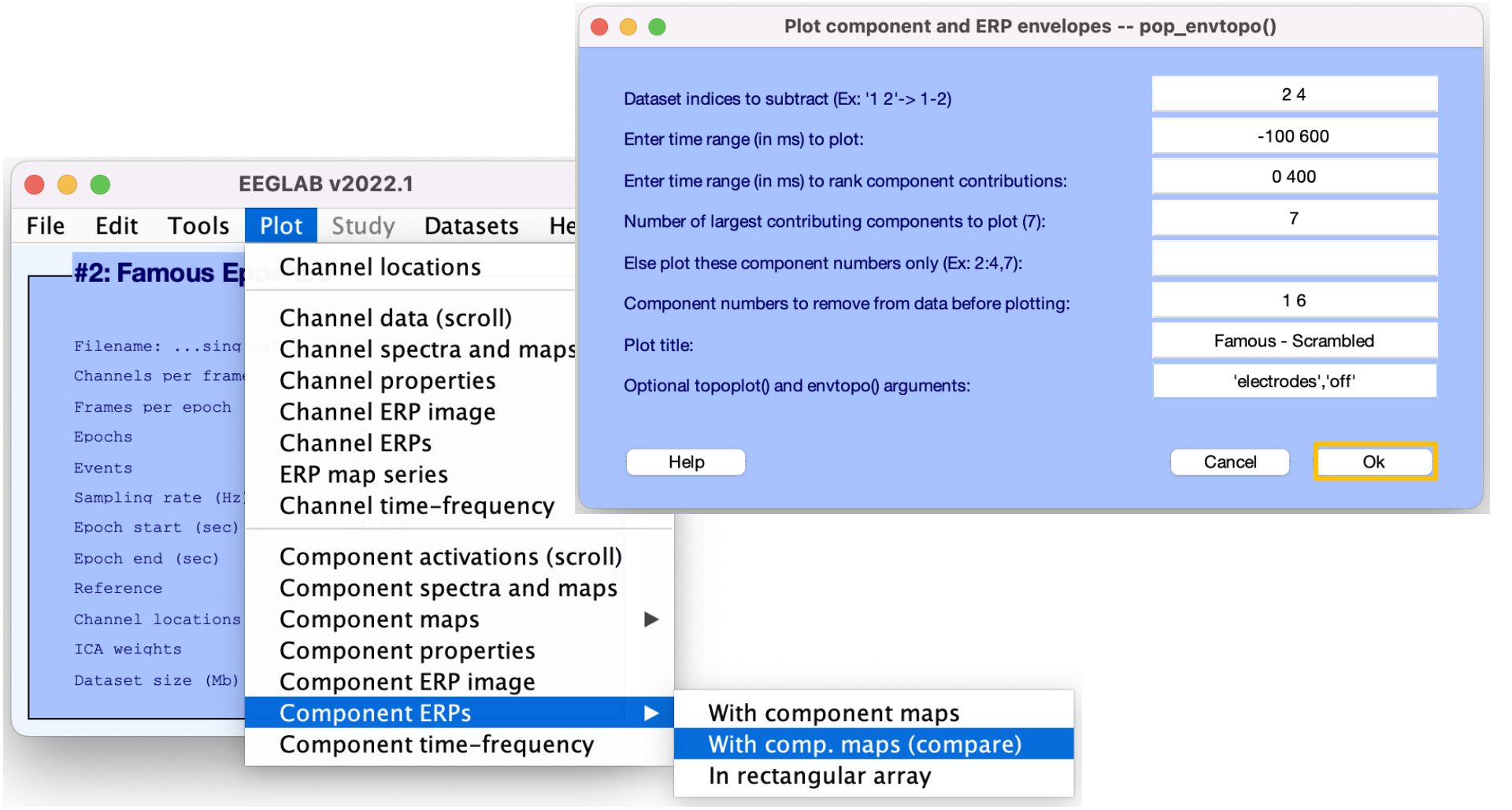
IC contributions to ERP envelope

Removing artefact ICs

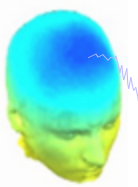


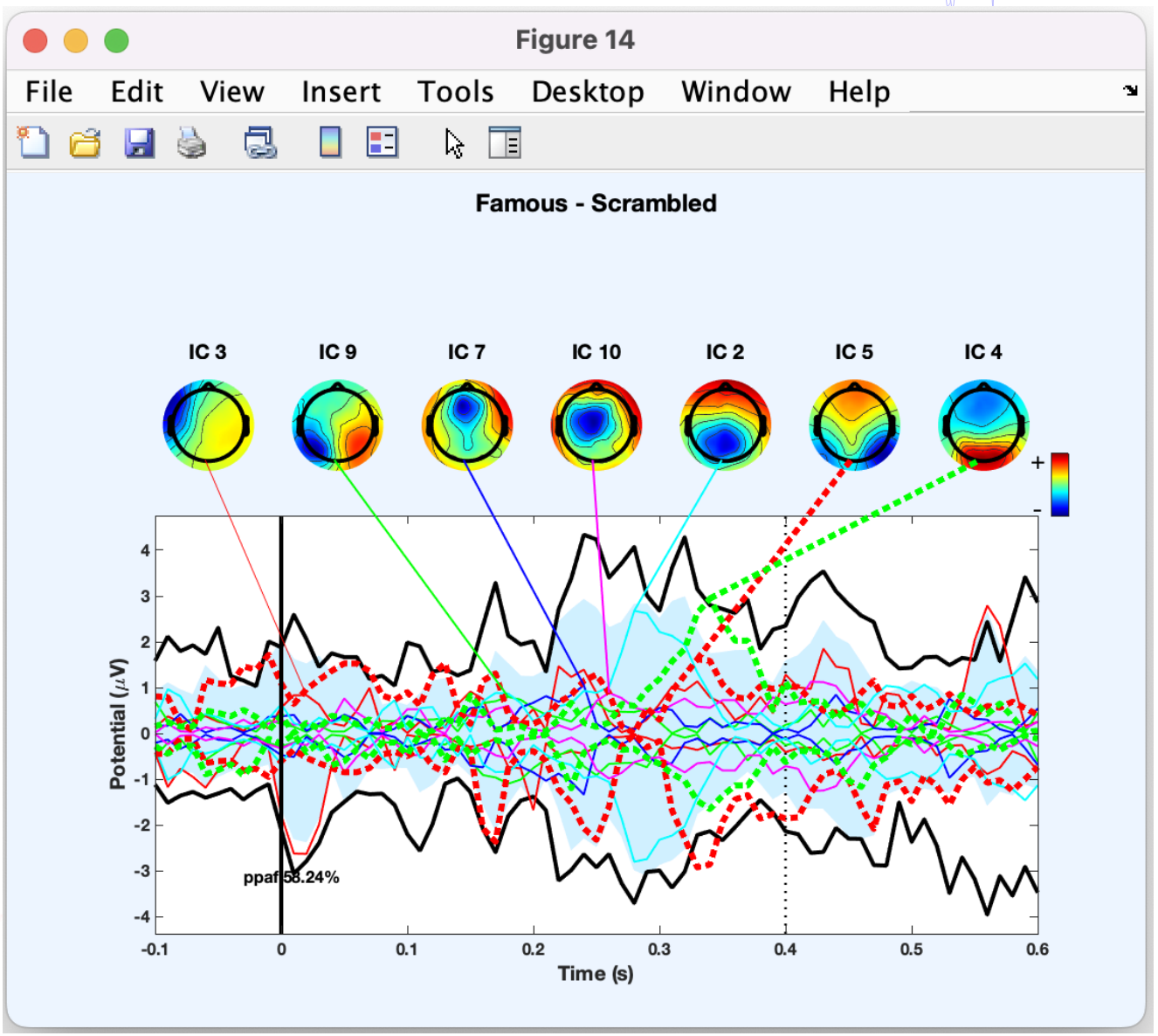
IC ERP difference between two conditions



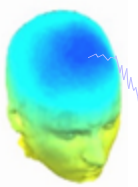


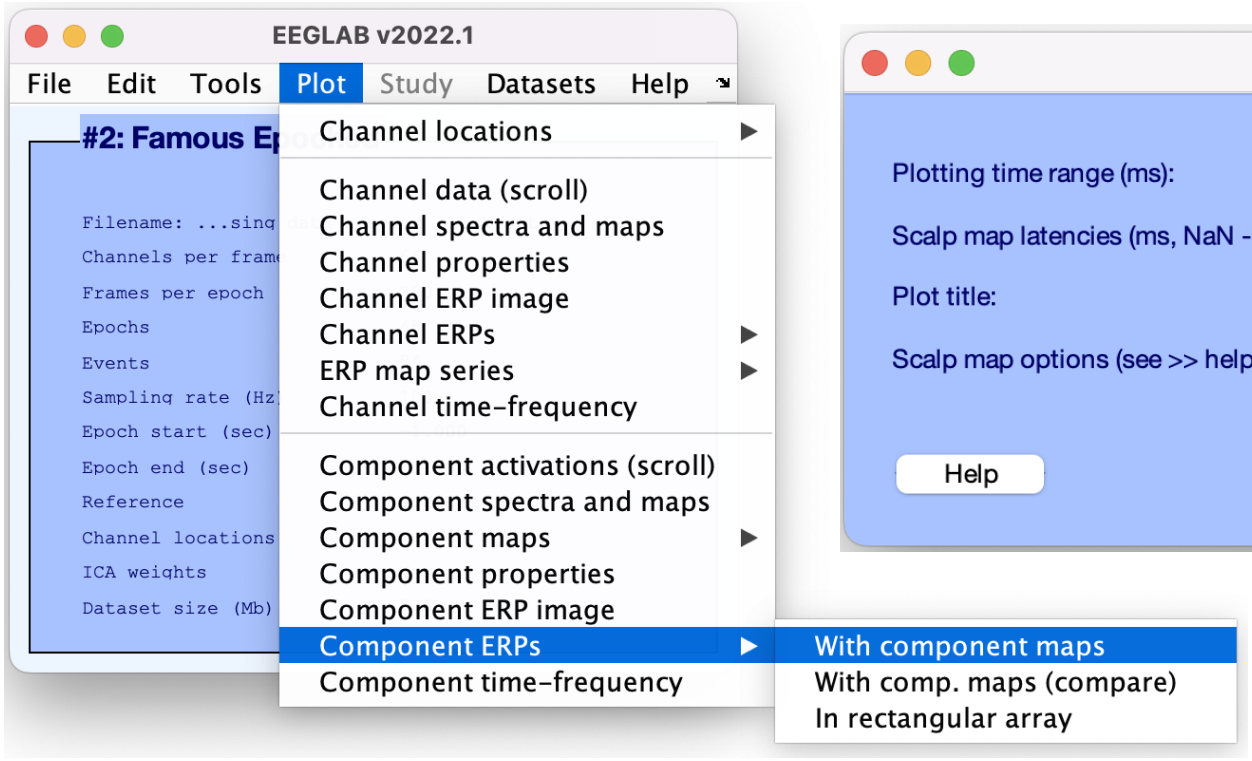
IC ERP difference between two conditions

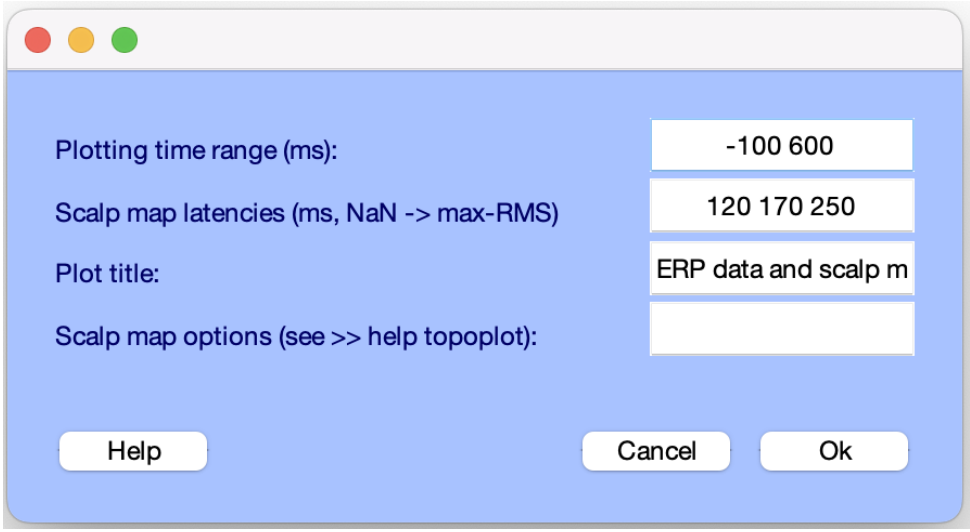




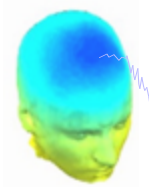
Plot maximum contributing components



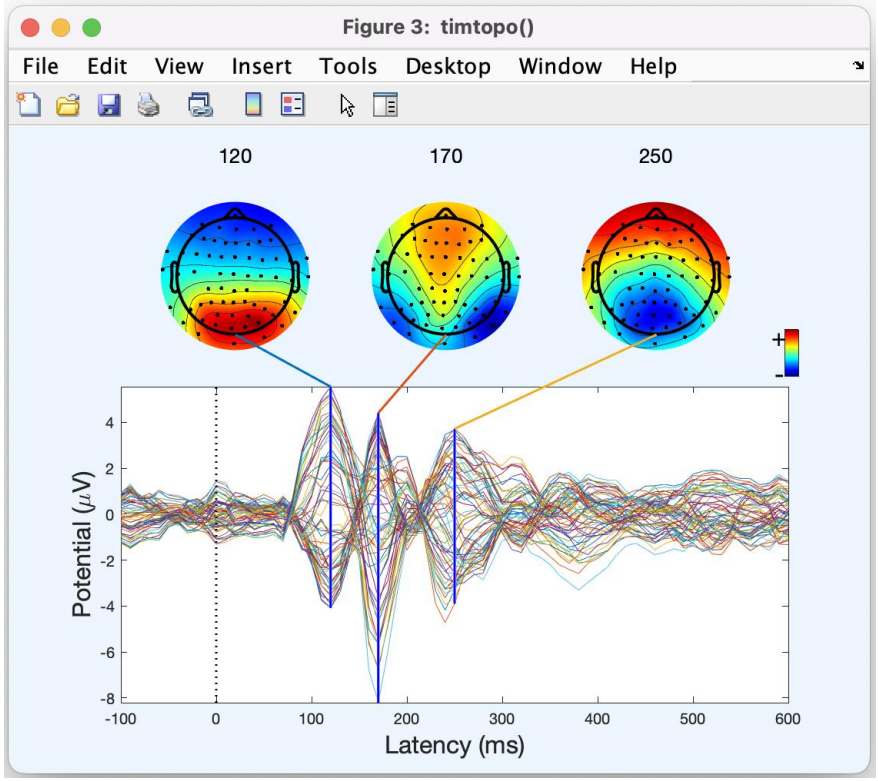




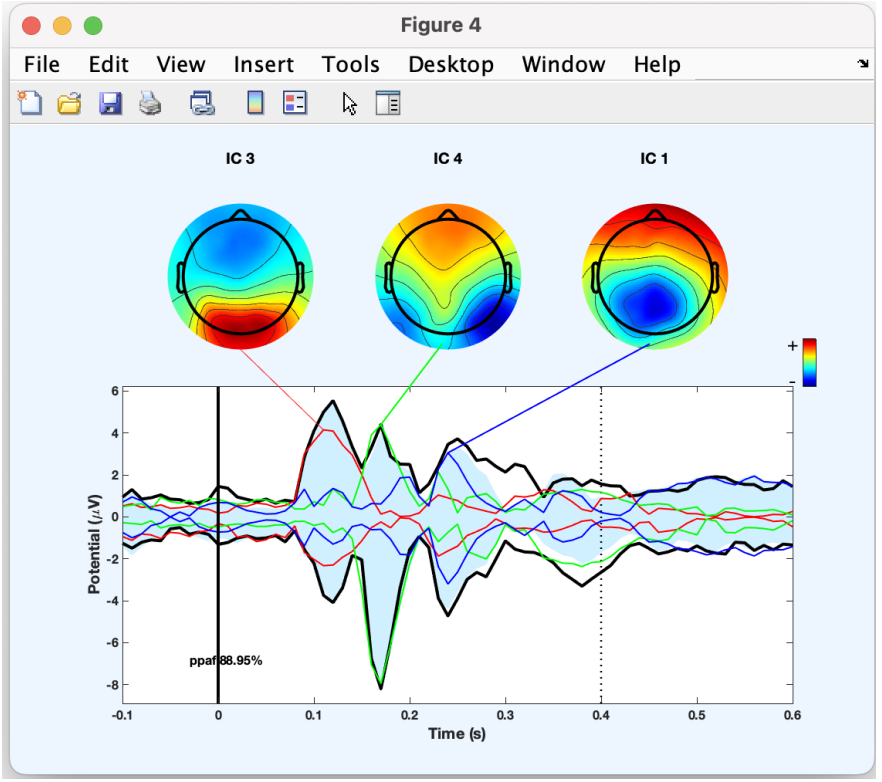
Plot maximum contributing components



Channel scalp distribution

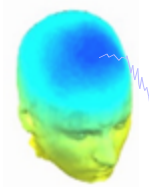


Maximum contributing ICs from 0 to 400ms



Note the similarity in channel scalp topography at the 3 ERP peaks and IC topography - ICA is able to separate the 3 distinct brain processes reflected in the 3 ERP peaks

Hands On!



Import preprocessed file using menu item **File > load existing dataset**

ds000117_pruned/derivatives/meg_derivatives/sub-01/ses-meg/meg/wh_S01_run_01_preprocessing_data_session_1_out.set

(run *script_01_import_data.m* and *script_02_preprocess_data.m* to generate this file)

Extract epochs for famous stimuli using menu **Tools > Extract epochs.** Leave all defaults (minus 1 to 2 seconds). Do not remove the baseline.

Plot envelope and look at scalp topography at 170 ms (face-related potential) using menu item **Plot > Plot channel ERPs > With scalp maps**

Plot ERPimage for channel 65 between -100 ms and 500 ms using menu item **Plot > Plot ERPimage**

Plot ICA component contribution to the ERP between 100 ms and 200 ms using menu item **Plot > Plot component ERPs > With component maps**

(run *script_03_epochs_and_erp.m* to generate data epochs files for famous, scrambled and unfamiliar stimuli – these files are used in subsequent lectures)