



# Sensor Level Analysis ERP

## EEGLAB

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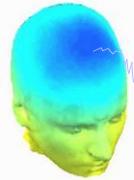
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# EEG Analysis



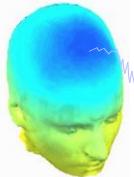
## Goals

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

## Approaches

- Time domain
- Frequency domain
- Time/Frequency

# Load Example Dataset



```
filename = 'wh_S01_run_01_preprocessing_data_session_1_out.set';
```

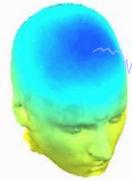
```
EEG = pop_loadset('filename', filename, 'filepath', path2data)
```

The screenshot shows the EEGLAB v2022.1 software interface. The main window has a menu bar with File, Edit, Tools, Plot, Study, Datasets, and Help. The 'File' menu is open, and the 'Load existing dataset' option is selected. To the right of the menu, there is a detailed description of what happens when the dataset is loaded. A file browser window is overlaid on the main window, showing a list of files in a folder named 'sub-01'. The files listed are:

- From 1 MB to 10 MB:
  - wh\_S01\_run\_01\_ERP\_Analysis\_Session\_2\_unfamiliar\_out.set
  - wh\_S01\_run\_01\_ERP\_Analysis\_Session\_2\_famous\_out.set
- From 100 KB to 1 MB:
  - wh\_S01\_run\_01\_preprocessing\_data\_session\_1\_out.set
- From 1 KB to 10 KB:
  - sub-01\_ses-meg\_coordsystem.json
- From 100 bytes to 1 KB:
  - Johanna'

The file 'wh\_S01\_run\_01\_preprocessing\_data\_session\_1\_out.set' is highlighted in blue. At the bottom right of the file browser window are 'Cancel' and 'Open' buttons.

# Load Example Dataset



EEGLAB v2022.1

File Edit Tools Plot Study Datasets Help

#1: sub-01\_preprocessed

Filename:	...sing data session 1 out.set
Channels per frame	64
Frames per epoch	48362
Epochs	1
Events	263
Sampling rate (Hz)	100
Epoch start (sec)	-0.000
Epoch end (sec)	483.610
Reference	average
Channel locations	Yes
ICA weights	Yes
Dataset size (Mb)	25.6



# Extract epochs

The image shows the EEGLAB v2022.1 software interface. At the top, there is a brain visualization and a logo for the Swartz Center for Computational Neuroscience. The main window has a menu bar with File, Edit, Tools, Plot, Study, Datasets, and Help. The Tools menu is open, showing various options like Change sampling rate, Filter the data, Re-reference the data, Interpolate electrodes, etc. The 'Extract epochs' option is highlighted with a blue selection bar. Below the menu is a list of tools: Remove epoch baseline, Source localization using DIPFIT, Run AMICA, and post AMICA utility. A sub-menu for 'Extract epochs' is shown, listing Famous, Scrambled, Unfamiliar, boundary, left\_nonsym, and right\_sym. A yellow arrow points from the 'Famous' option in this list to the corresponding entry in the 'Time-locking event type(s)' field of the 'Extract data epochs - pop\_epoch()' dialog box. The dialog box also includes fields for Epoch limits [-1 2], Name for the new dataset (sub-01 Famous), and Out-of-bounds EEG limits if any [min max]. Buttons for Help, Cancel, and Ok are at the bottom.

EEGLAB v2022.1

#1: sub

(Expand tool choices via "File > Preferences")

Tools

- Change sampling rate
- Filter the data
- Re-reference the data
- Interpolate electrodes
- Inspect/reject data by eye
- Reject data using Clean Rawdata and ASR
- Decompose data by ICA
- Inspect/label components by map
- Classify components using ICLabel
- Remove components from data
- Extract epochs**
- Remove epoch baseline

Source localization using DIPFIT

Run AMICA

post AMICA utility

Event types:

- Famous
- Unfamiliar
- Scrambled

Extract data epochs - pop\_epoch()

Time-locking event type(s) ([]=all)

Epoch limits [start, end] in seconds

Name for the new dataset

Out-of-bounds EEG limits if any [min max]

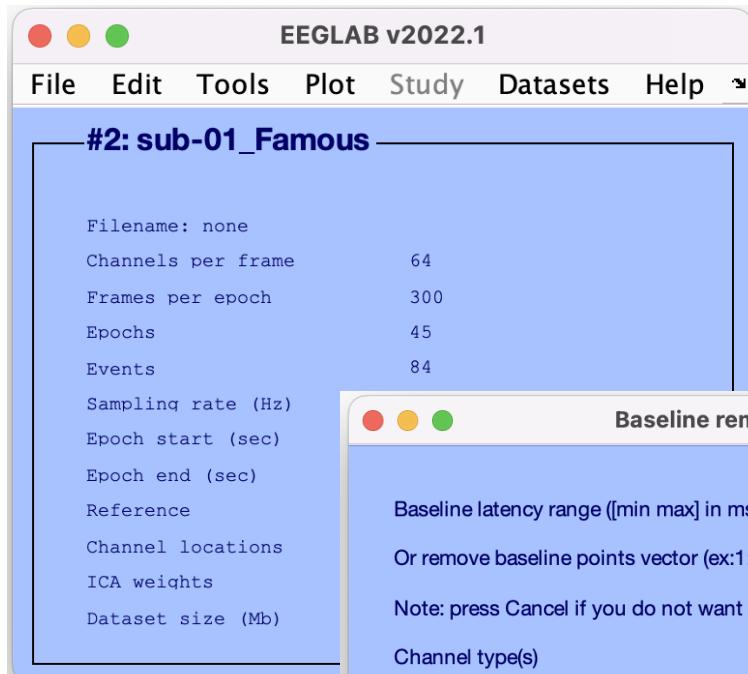
Help Cancel Ok

(use shift|ctrl to select several)

Famous  
Scrambled  
Unfamiliar  
boundary  
left\_nonsym  
right\_sym

Cancel Ok

# Extract epochs



Baseline removal - pop\_rmbase()

Baseline latency range ([min max] in ms) ([ ] = whole epoch):

Or remove baseline points vector (ex:1:56):

Note: press Cancel if you do not want to remove the baseline

Channel type(s)  ...  ...

OR channel(s) (default all)  ...  ...

Help Cancel Ok

## Remove baseline

Long baseline

Dataset info -- pop\_newset()

with the new dataset?

sub-01\_Famous

been saved. What do you want to do with the old dataset?

Save it as file:

Cancel Ok



# Extract epochs



EEGLAB v2022.1

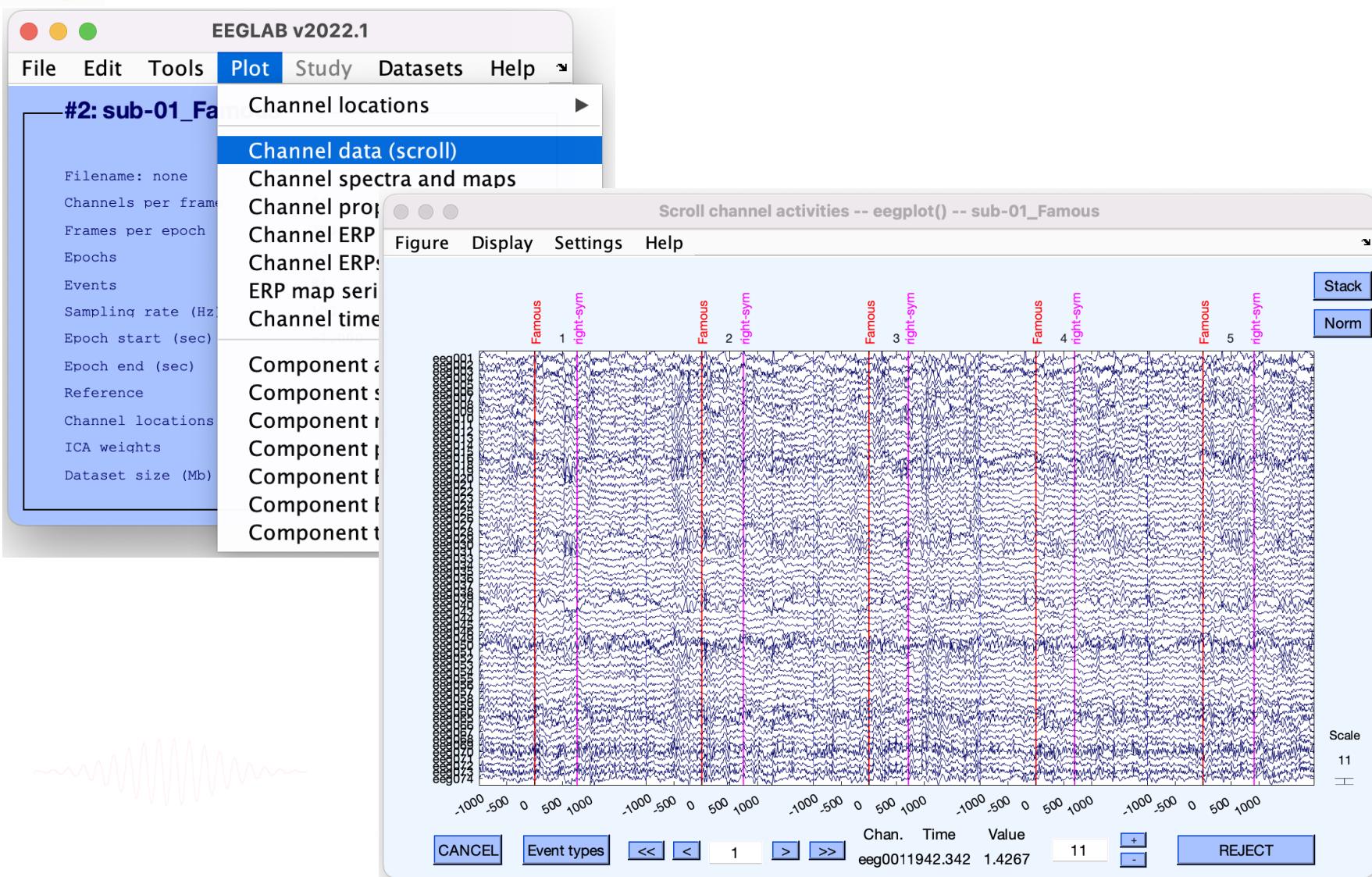
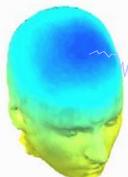
File Edit Tools Plot Study Datasets Help

#2: sub-01\_Famous

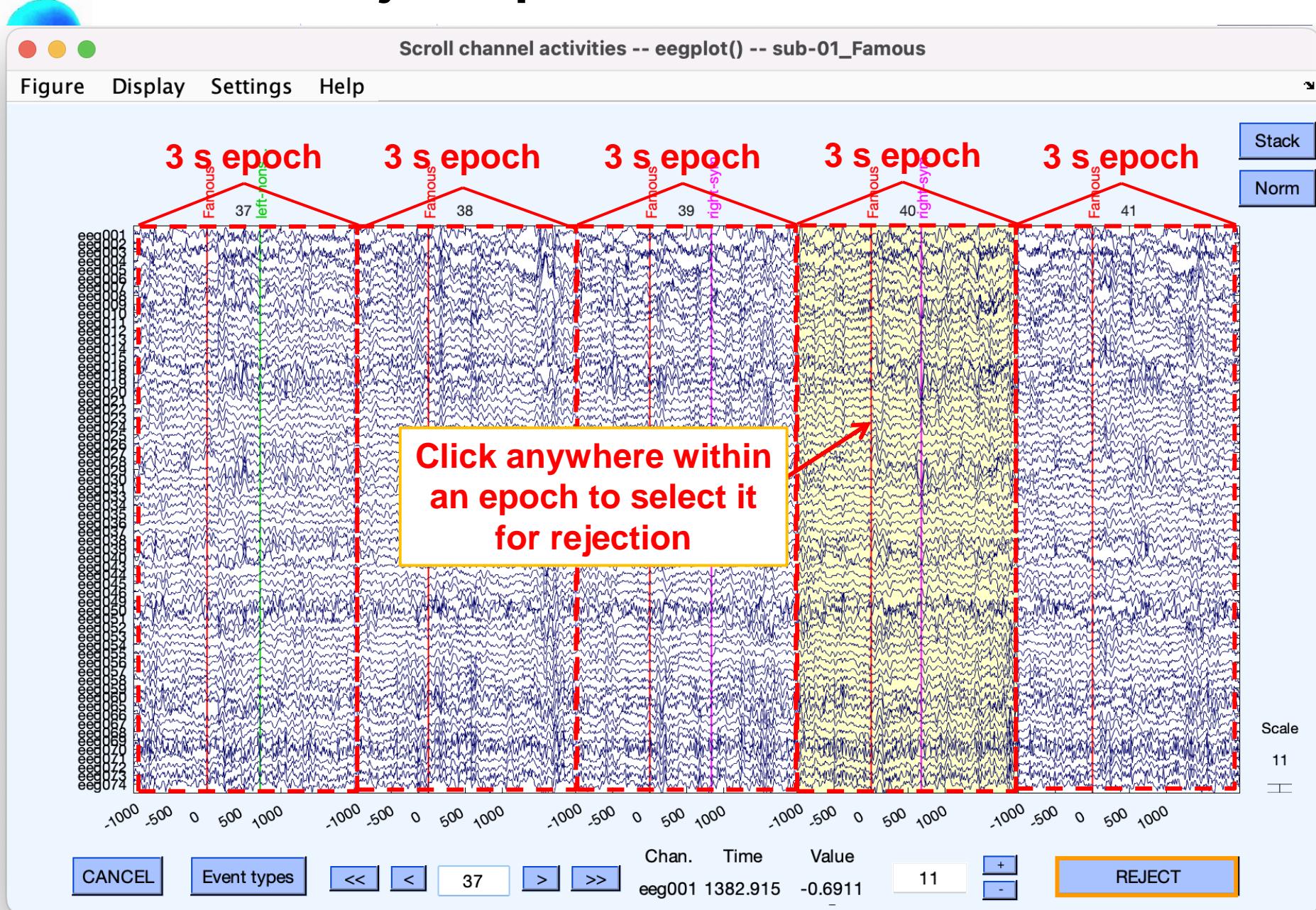
Filename:	none
Channels per frame	64
Frames per epoch	300
Epochs	45
Events	84
Sampling rate (Hz)	100
Epoch start (sec)	-1.000
Epoch end (sec)	1.990
Reference	average
Channel locations	Yes
ICA weights	Yes
Dataset size (Mb)	7.5



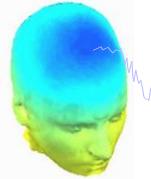
# Scroll (epoched) channel data



# Reject epochs with artifacts



# Reject epochs with artifacts

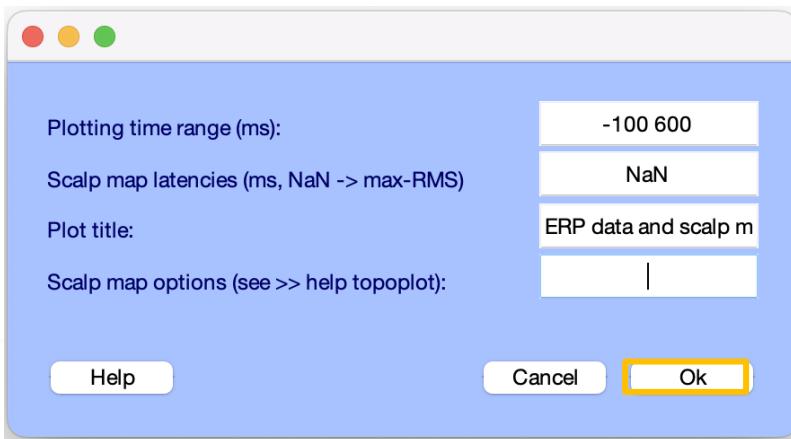
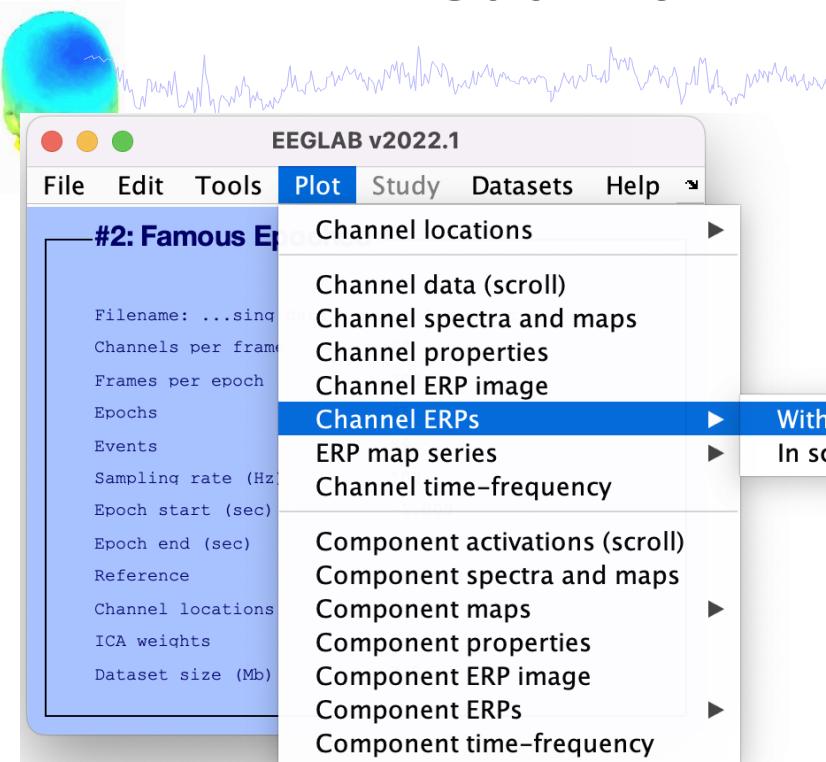


```
[EEG_famous, rejindx] = pop_eegthresh(...
```

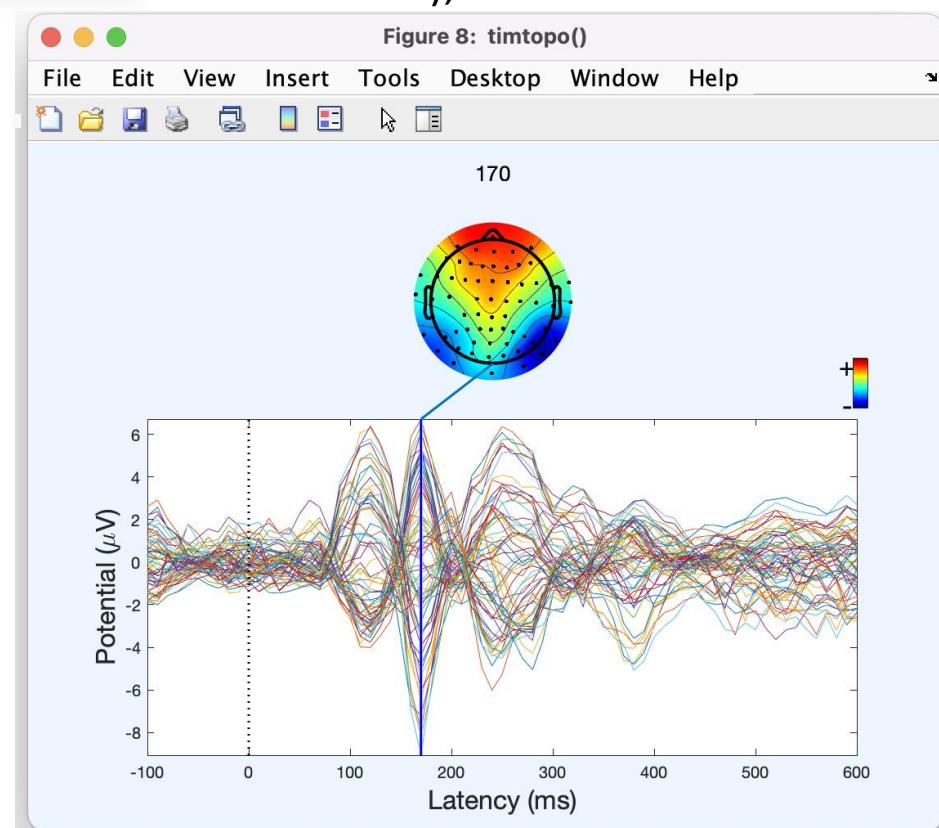
```
EEG_famous,...  
1,...  
1:EEG_famous.nbchan,...  
-400, 400,...  
EEG_famous.xmin,...  
EEG_famous.xmax,...  
0, 1);
```



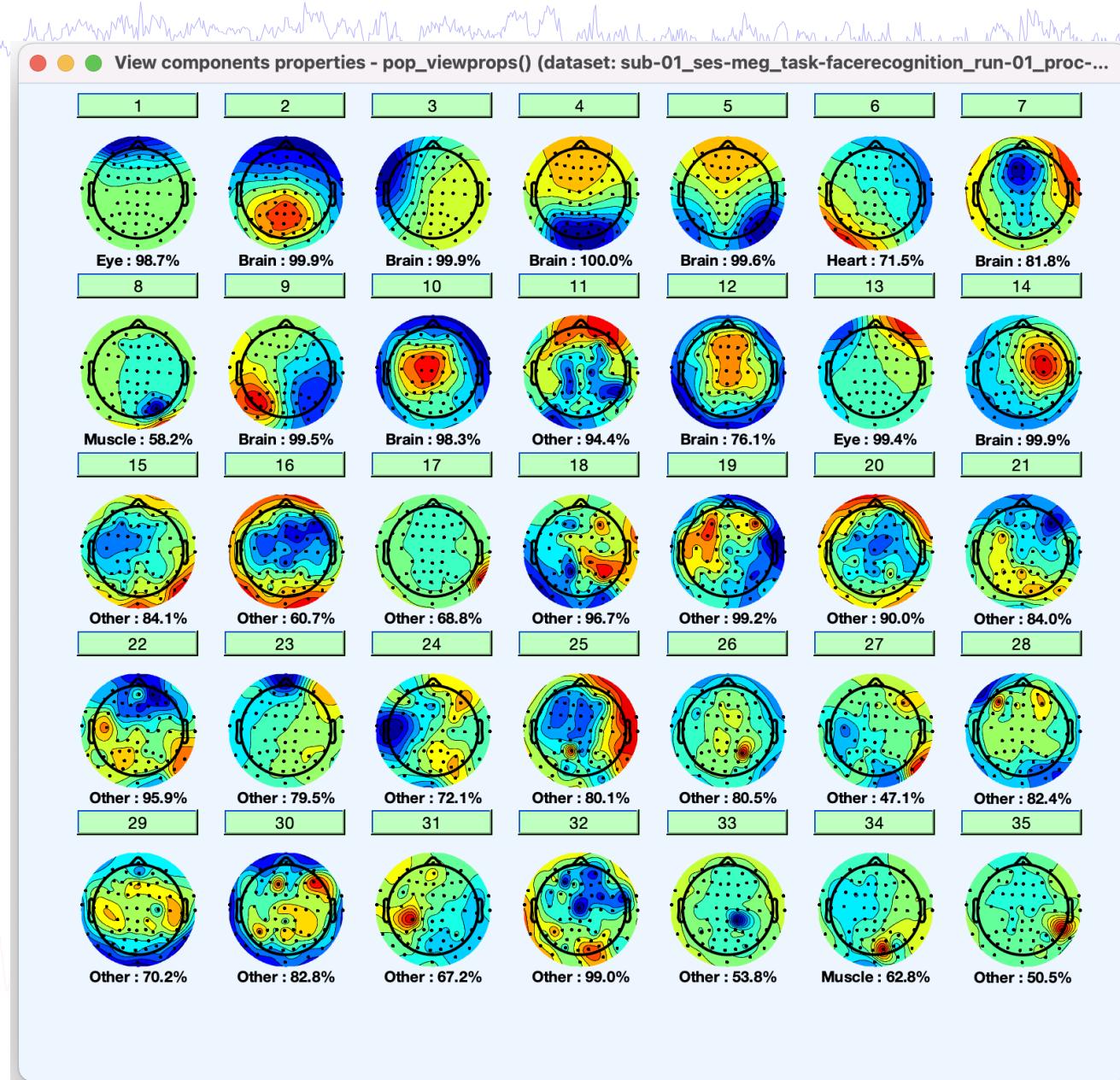
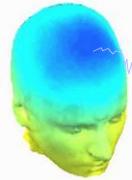
# Visualize ERP scalp distribution



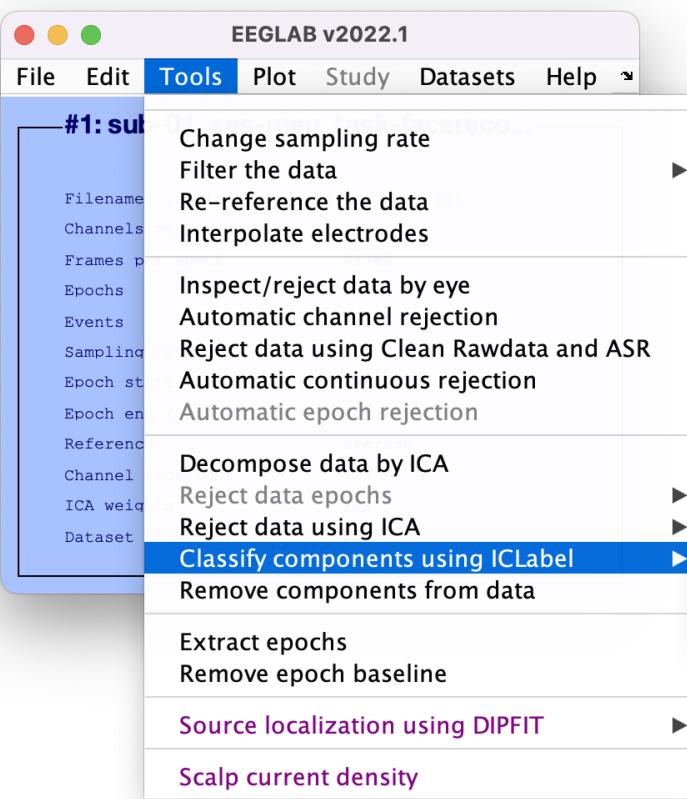
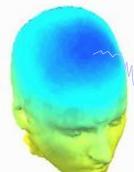
```
figure; pop_timtopo(...  
ALLEEG(2),...  
[-100 600],...  
[NaN],...  
'Famous');
```



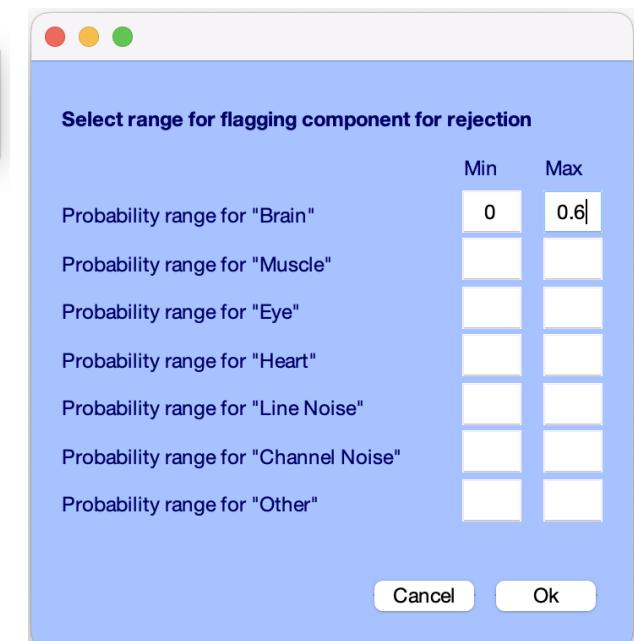
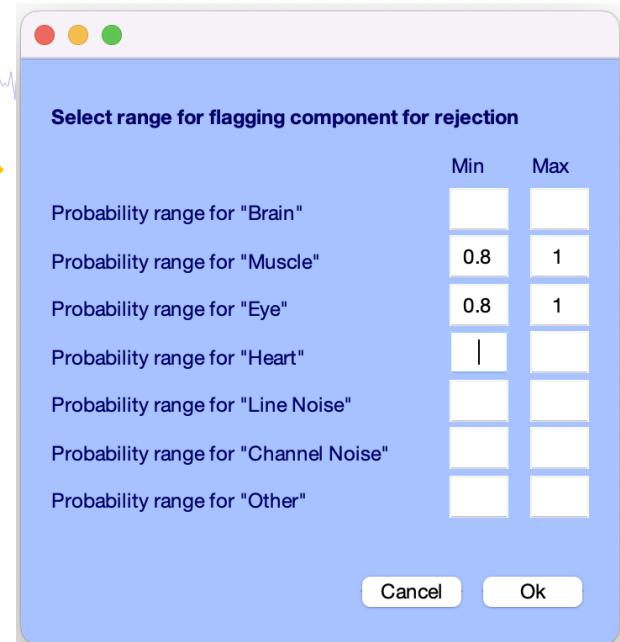
# Let's remove artifact ICs



# Let's remove artefact ICs using IC Label classification probabilities

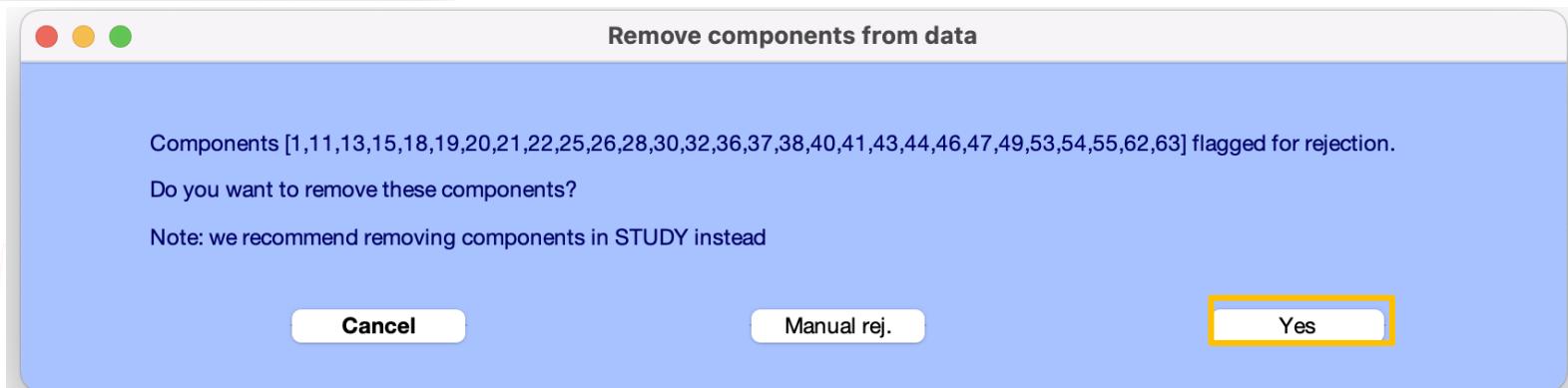
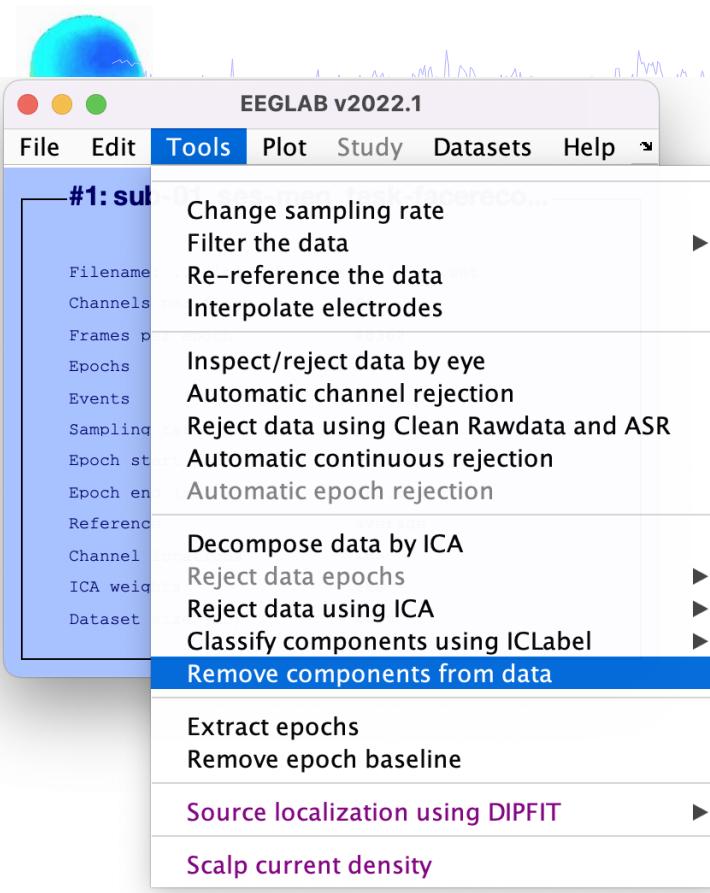


Either remove specific artefact ICs – here remove all ICs that have more than 80% probability to be muscle or eye components

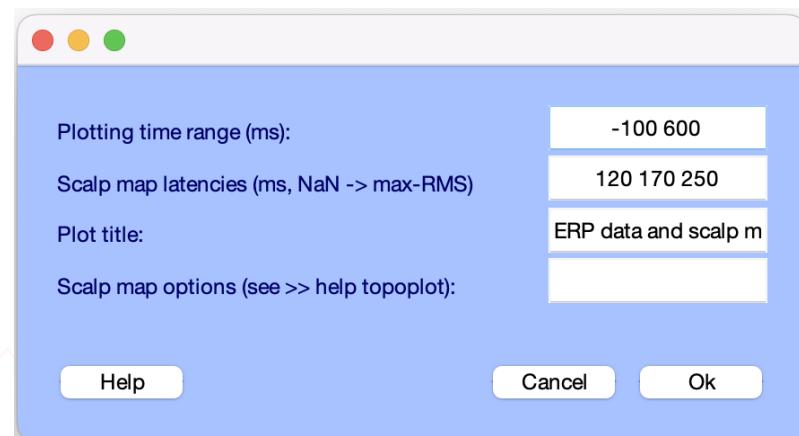
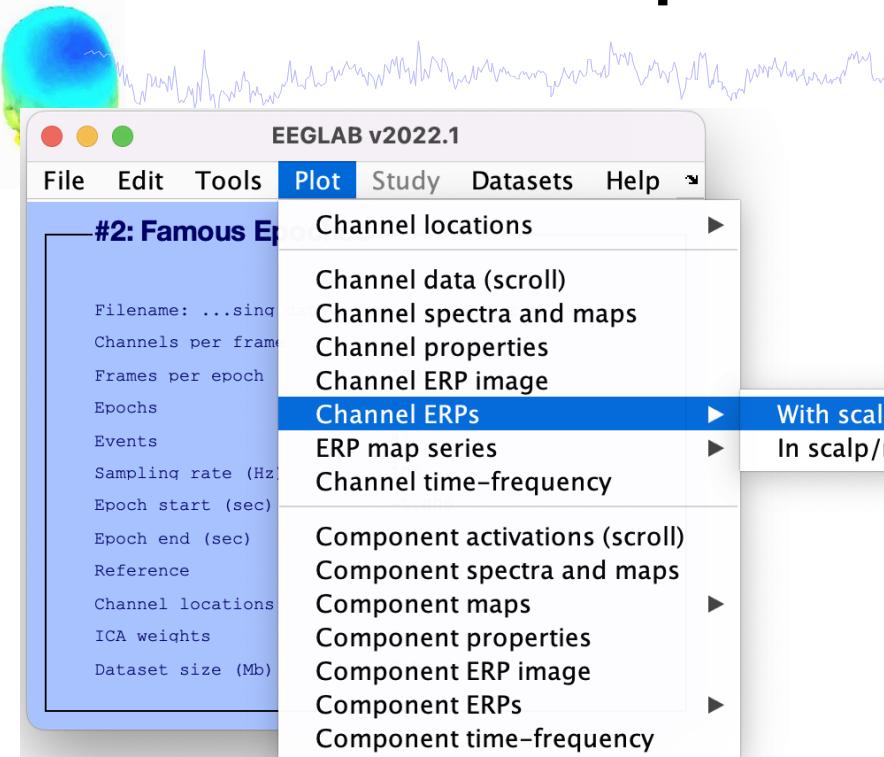


Or remove all ICs that have less than 60% probability to be brain components (you can also choose a different probability – i.e. 70%)

# Let's remove artefact ICs using IC Label classification probabilities



# Visualize ERP scalp distribution at different timepoints



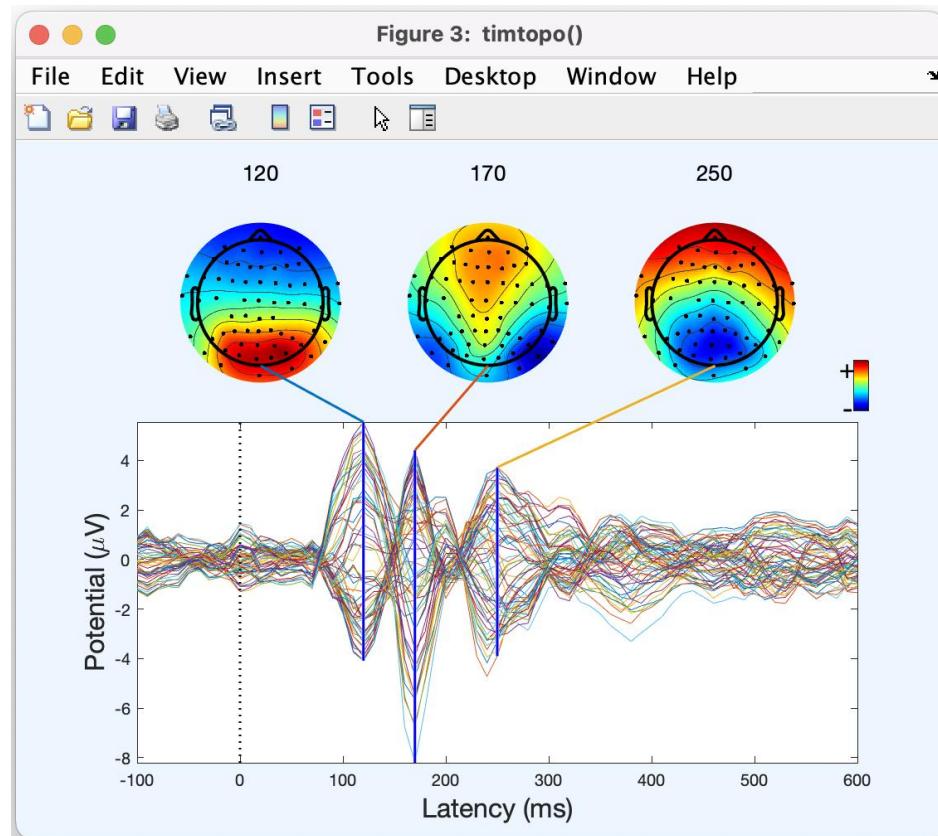
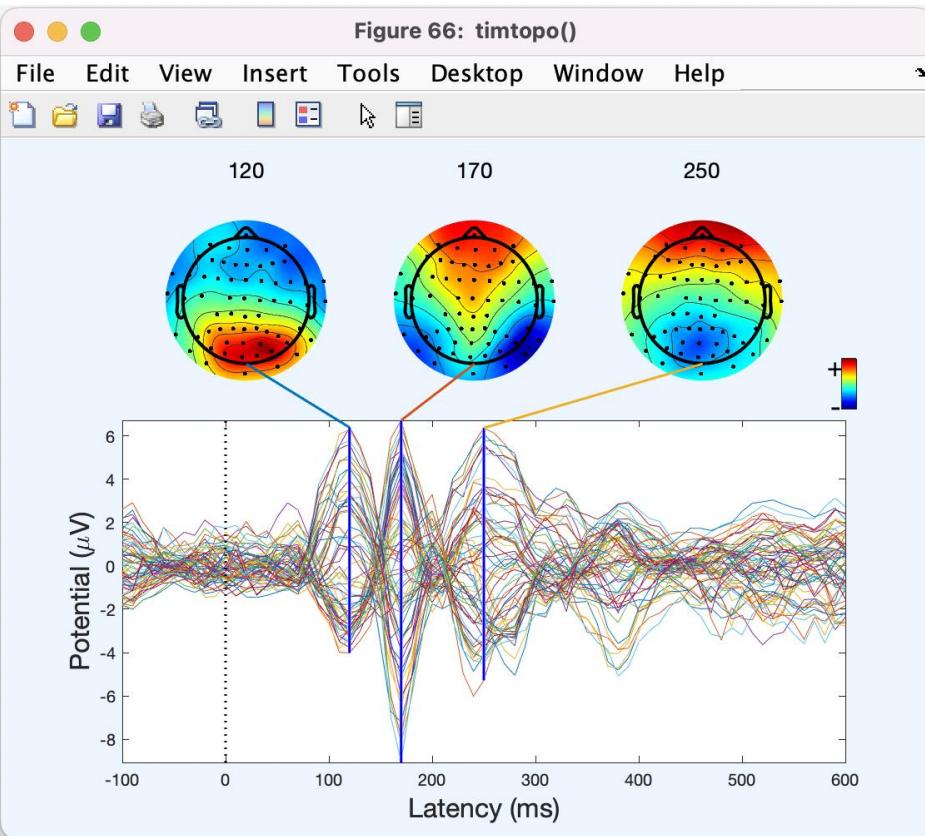
```
figure; pop_timtopo(...  
ALLEEG(2),...  
[-100 600],...  
[120 170 250],...  
'Famous');
```

# Visualize 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

The image shows the EEGLAB v2022.1 software interface. The main window has a blue header bar with the title "EEGLAB v2022.1" and a brain icon. Below the header is a menu bar with "File", "Edit", "Tools", "Plot" (which is highlighted in blue), "Study", "Datasets", and "Help". A sub-menu for "Plot" is open, showing the following options:

- Channel locations
- Channel data (scroll)
- Channel spectra and maps
- Channel properties
- Channel ERP image
- Channel ERPs
- ERP map series (this option is selected and highlighted in blue)
- Channel time-frequency

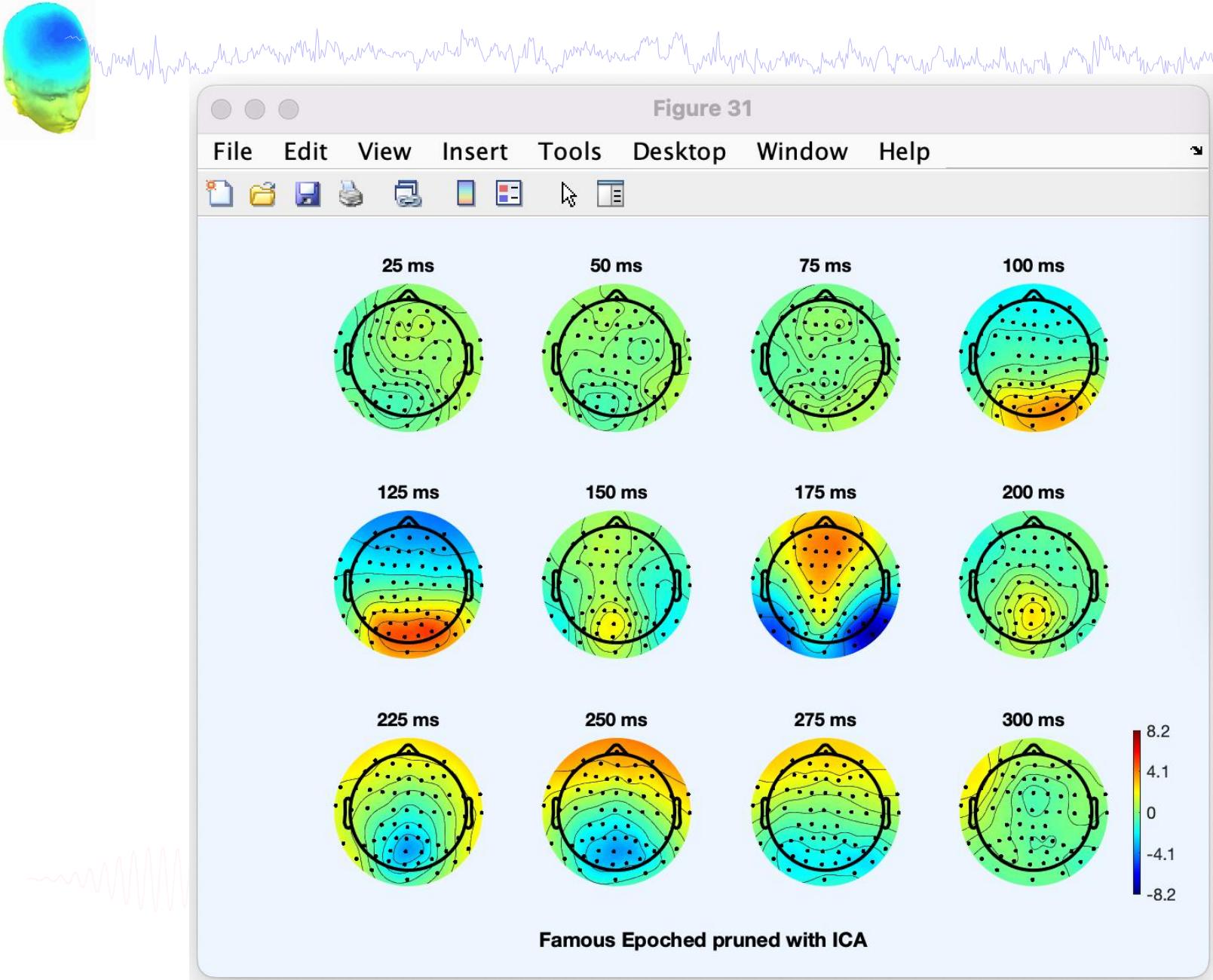
Under "ERP map series", there are two sub-options: "In 2-D" (selected) and "In 3-D".

A dialog box titled "Plot ERP scalp maps in 2-D -- pop\_topoplot()" is open in the foreground. It contains the following fields:

- Plotting ERP scalp maps at these latencies (range: -1000 to 1990 ms, NaN -> empty): 25:25:300
- Plot title: Famous Epoched pruned with
- Plot geometry (rows,col.); [] -> near square: []
- > Additional topoplot() options (see Help): 'electrodes', 'on'

At the bottom of the dialog box are three buttons: "Help", "Cancel", and "Ok".

# Visualize Channel ERPs in 2 D



# Visualize channel ERPs in 3D



EEGLAB v2022.1

File Edit Tools Plot Study Datasets Help

#2: Famous

Filename: ...sing

Channels per frame

Frames per epoch

Epochs

Events

Sampling rate (Hz)

Epoch start (sec)

Epoch end (sec)

Reference

Channel locations

ICA weights

Dataset size (Mb)

ERP map series

In 2-D

In 3-D

Sum/Compare ERPs

Component activations (scroll)

Component s

Component n

Component p

Component E

Component E

Sum/Compar

Data statistics

Time-frequen

## Co-register channels

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@  
 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 Manual coreg.

Plot interpolated activity onto 3-D head

Making headplots for these latencies (from -1000 to 1990 ms): 0

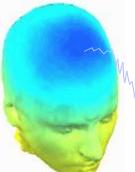
Plot title: ERP scalp maps of dataset:Famous

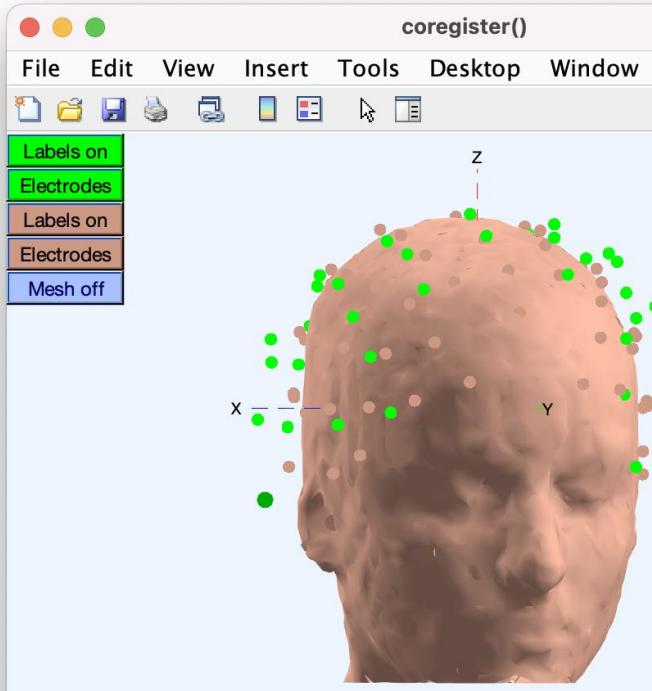
Plot geometry (rows,columns): (Default [] = near square)

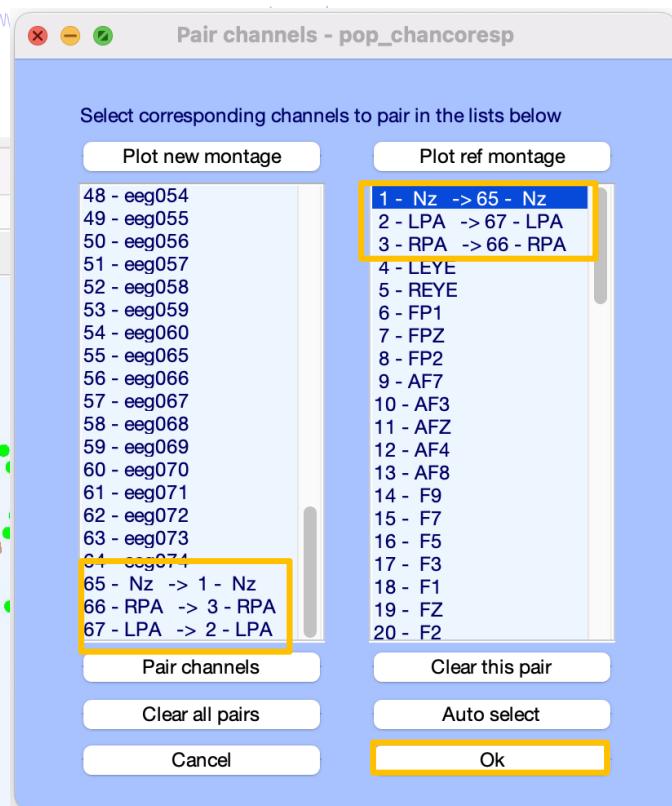
Other headplot options (See >> help headplot):

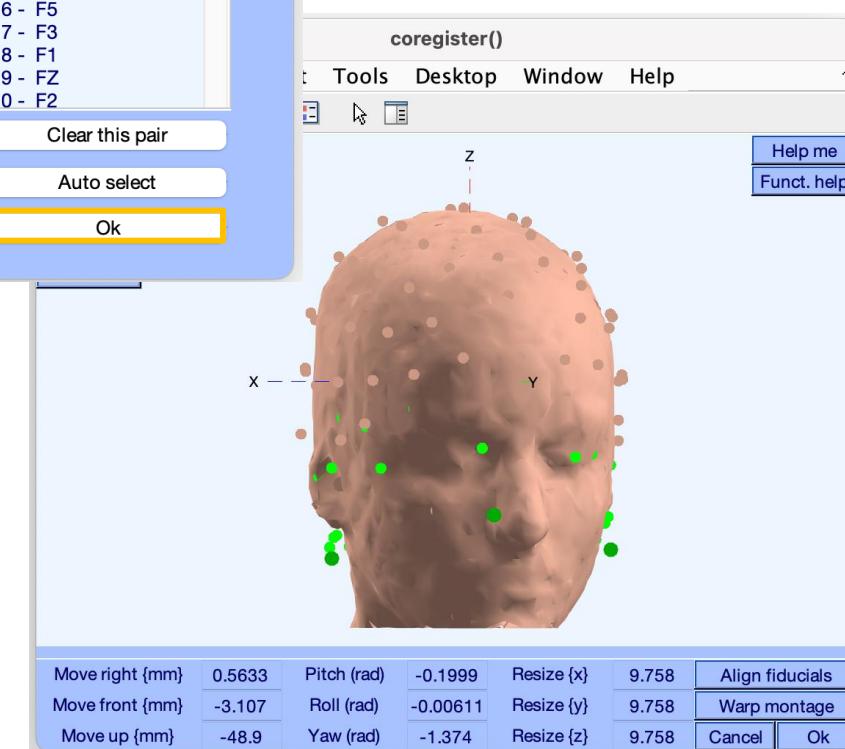
Cancel Ok

# Visualize channel ERPs in 3D

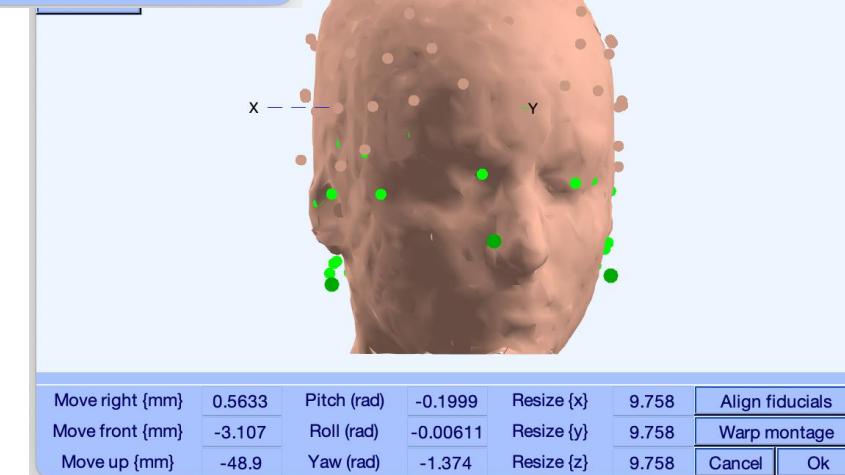
 







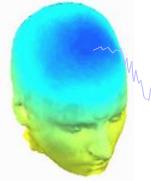
**Align fiducials**







# Visualize channel ERPs in 3D



**coregister()**

File Edit View Insert Tools Desktop Window Help

Labels on  
Electrodes  
Labels on  
Electrodes  
Mesh off

X Y Z

Move right {mm}	0.5633	Pitch (rad)	-0.1999	Resize {x}	9.758	Align fiducials
Move front {mm}	-3.107	Roll (rad)	-0.00611	Resize {y}	9.758	Warp montage
Move up {mm}	-48.9	Yaw (rad)	-1.374	Resize {z}	9.758	Cancel Ok

Pair channels - pop\_chancoresp

Select corresponding channels to pair in the lists below

Plot new montage      Plot ref montage

48 - eeg054	1 - Nz -> 65 - Nz
49 - eeg055	2 - LPA -> 67 - LPA
50 - eeg056	3 - RPA -> 66 - RPA
51 - eeg057	4 - LEYE
52 - eeg058	5 - REYE
53 - eeg059	6 - FP1
54 - eeg060	7 - FPZ
55 - eeg065	8 - FP2
56 - eeg066	9 - AF7
57 - eeg067	10 - AF3
58 - eeg068	11 - AFZ
59 - eeg069	12 - AF4
60 - eeg070	13 - AF8
61 - eeg071	14 - F9
62 - eeg072	15 - F7
63 - eeg073	16 - F5
64 - eeg074	17 - F3
65 - Nz -> 1 - Nz	18 - F1
66 - RPA -> 3 - RPA	19 - FZ
67 - LPA -> 2 - LPA	20 - F2

Pair channels      Clear this pair  
Clear all pairs      Auto select  
Cancel      Ok

Warp montage

coregister()

Tools Desktop Window Help

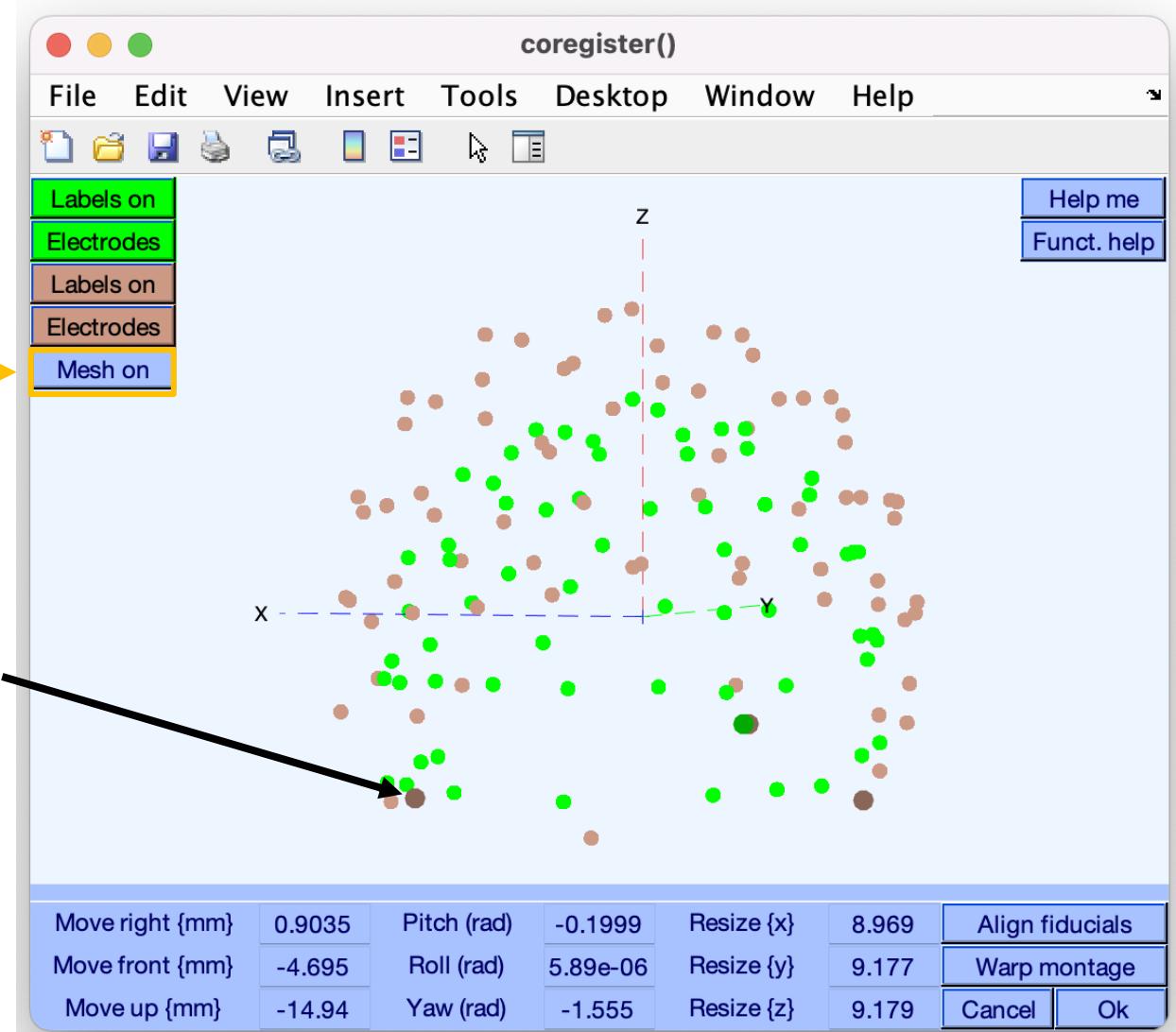
X Y Z

Move right {mm}	0.9035	Pitch (rad)	-0.1999	Resize {x}	8.969	Align fiducials
Move front {mm}	-4.695	Roll (rad)	5.89e-06	Resize {y}	9.177	Warp montage
Move up {mm}	-14.94	Yaw (rad)	-1.555	Resize {z}	9.179	Cancel Ok

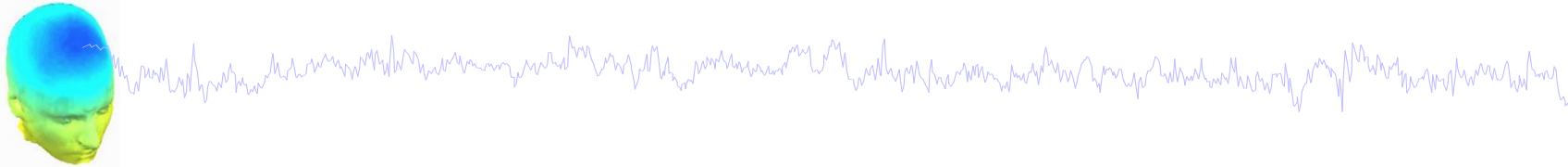
# Visualize channel ERPs in 3D



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@  
 Or (re)compute a new spline file named: /Users/johanna/Library/CloudStorage/GoogleDrive-joa.wagn@

3-D head mesh file mheadnew.mat  
Mesh associated channel file mheadnew.xyz  
Talairach-model transformation matrix 0.90355 -4.69459 -14.9446 -0.199874 5.88963e-06

Help Help Help Help

Browse Browse Browse other Browse other 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):

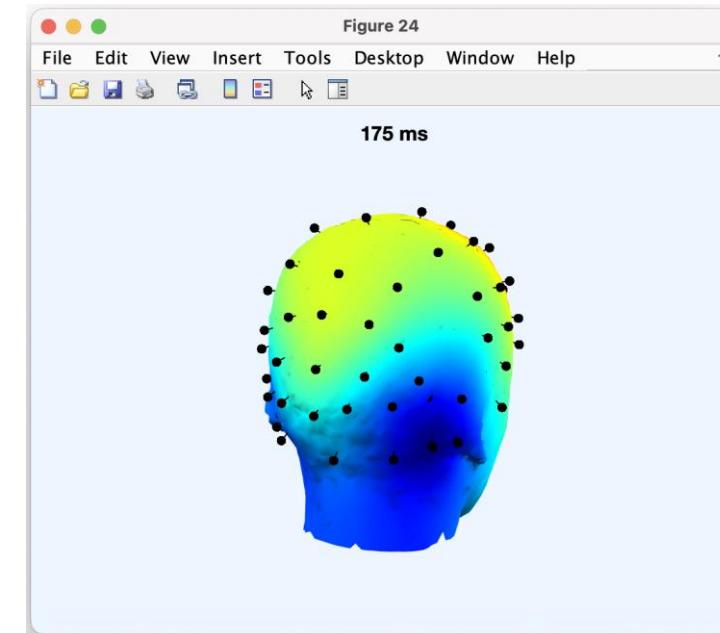
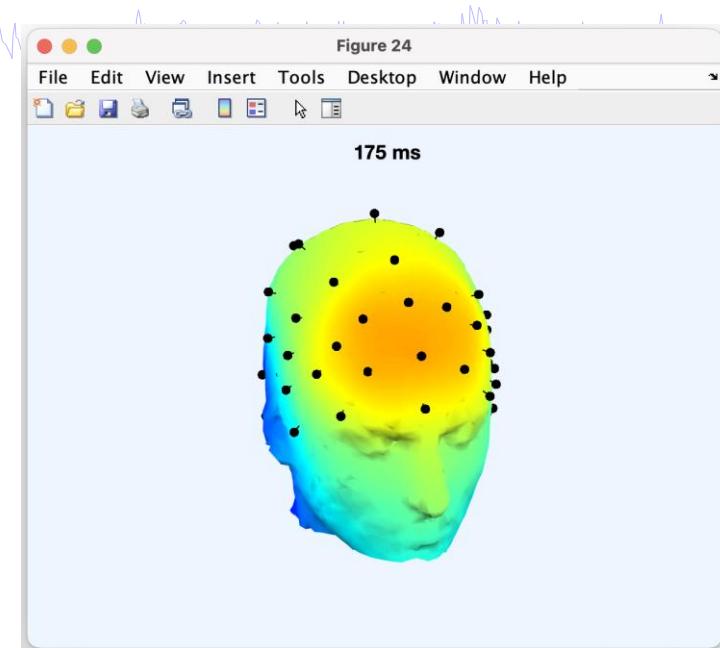
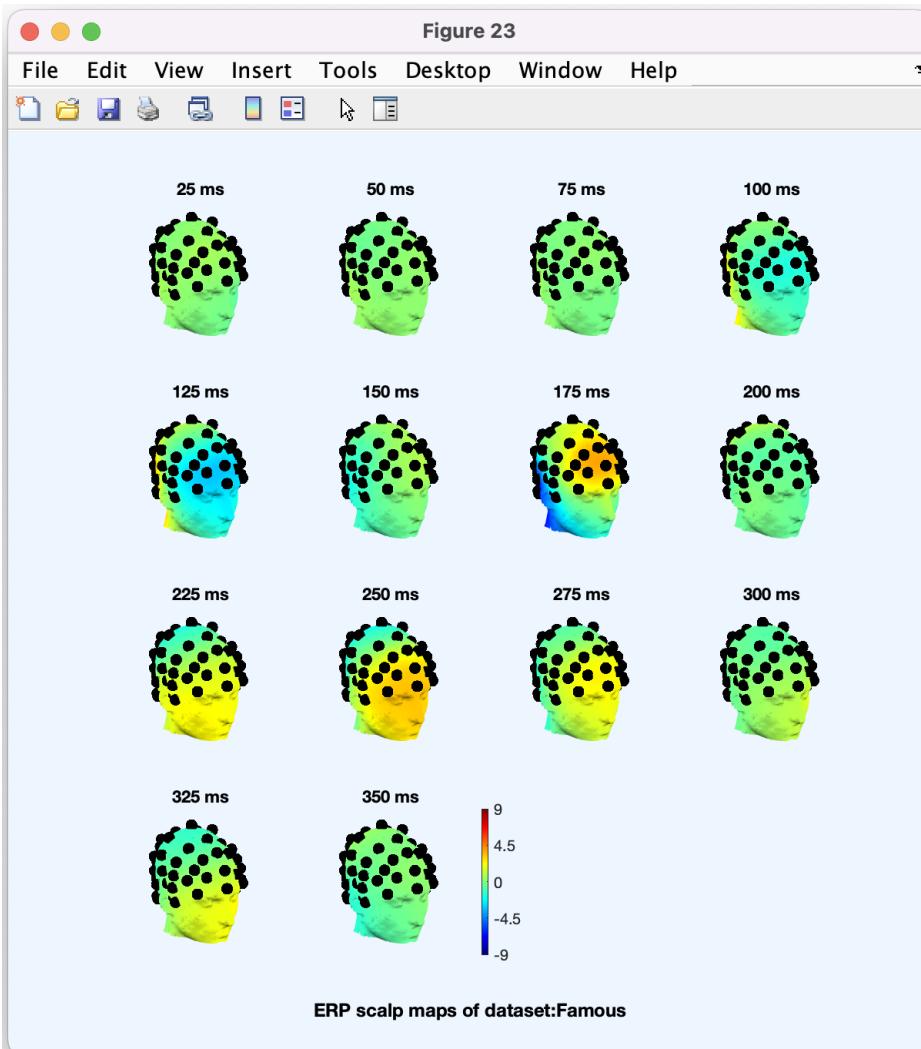
Cancel Ok



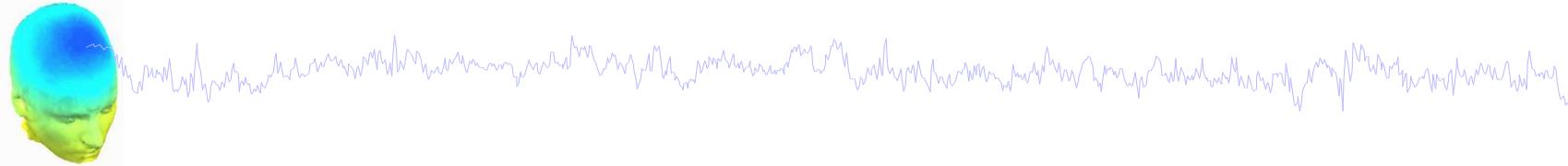
# Visualize channel ERPs in 3D



Click on the head



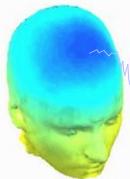
# Visualize channel ERPs in 3D



```
ALLEEG(2) = pop_headplot(...  
ALLEEG(2),... % EEG dataset  
1,... % plot channels  
[25:25:350],... % timepoints to plot  
'ERP scalp maps of dataset:Famous',... % plot title  
[4 4],... % rows and columns for plotting heads  
'setup',{[path2data 'wh_S01_run_01_preprocessing_data_session_1_out.spl'],...  
'meshfile','mheadnew.mat',... % mesh file  
'transform', ...  
[0.90355 -4.6946 -14.9446 -0.19987 5.8896e-06 -1.5545 8.969 9.1775 9.1785]});
```



# Visualize channel ERPs in topographic array



EEGLAB v2022.1

File Edit Tools Plot Study Datasets Help

#2: Famous Epochs

Filename: ...sing

Channels per frame

Frames per epoch

Epochs

Events

Sampling rate (Hz)

Epoch start (sec)

Epoch end (sec)

Reference

Channel locations

ICA weights

Dataset size (Mb)

Channel locations

Channel data (scroll)

Channel spectra and maps

Channel properties

Channel ERP image

Channel ERPs

ERP map series

Channel time-frequency

Component activations (scroll)

Component spectra and maps

Component maps

Component properties

Component ERP image

Component ERPs

Component time-frequency

With scalp maps

In scalp/rect. array

Topographic ERP plot - pop\_plottopo()

Channels to plot: 1:64

Plot title: Famous

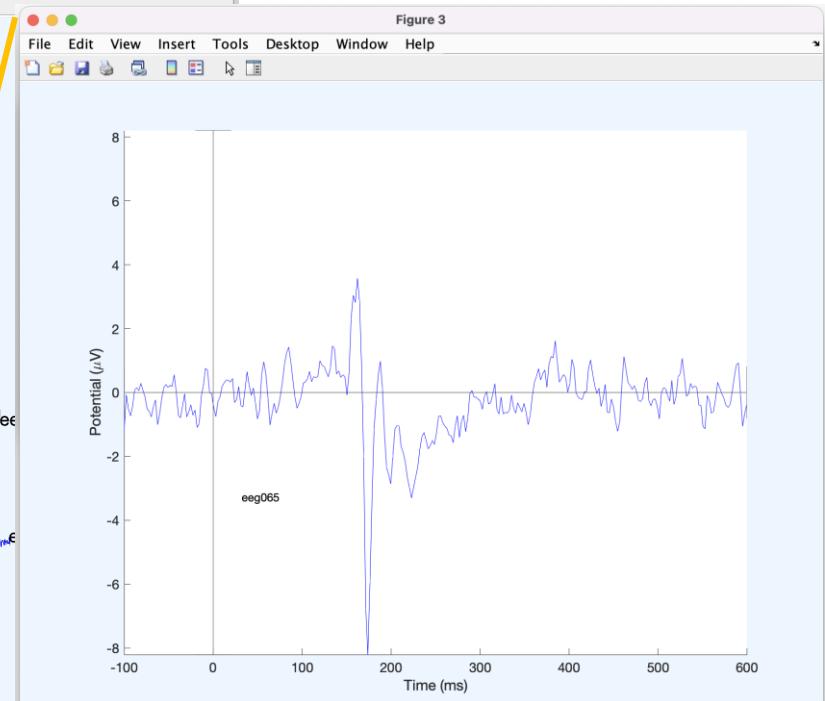
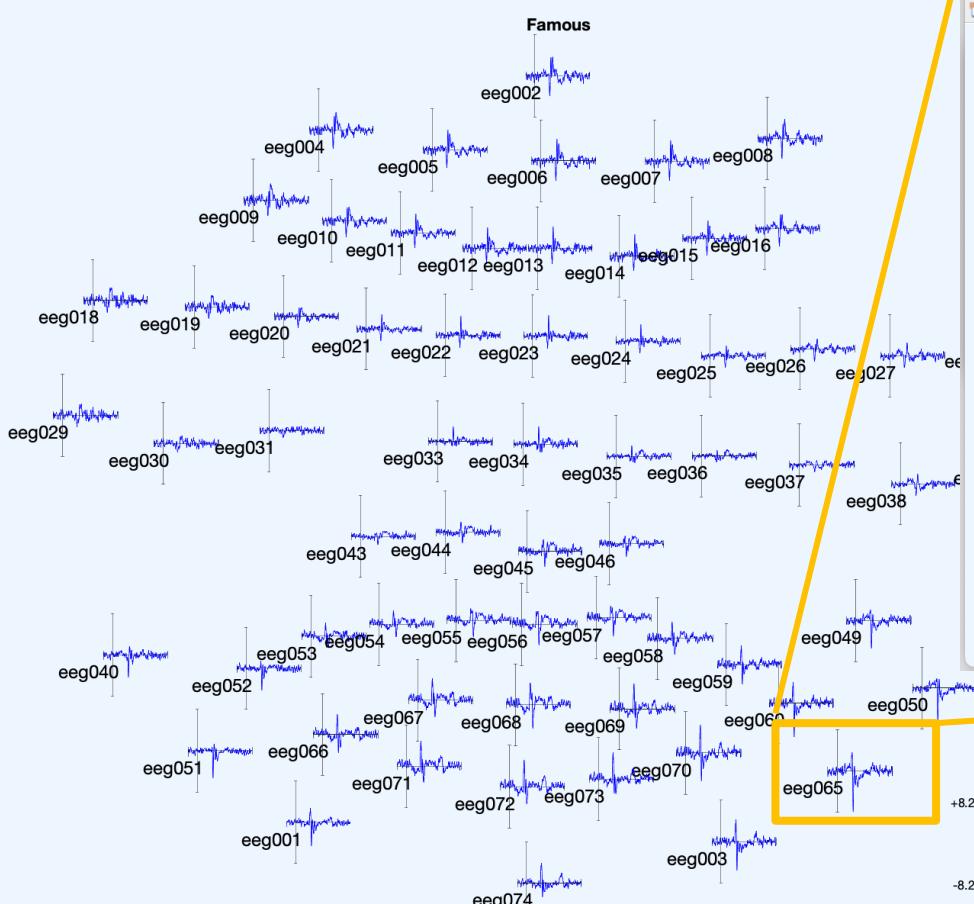
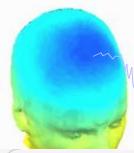
(set=yes) Plot single trials

(set=yes) Plot in rect. array

Other plot options (see help): 'ydir', 1, 'limits', [-100 600 0 0]

Help Cancel Ok

# Visualize channel ERPs in topographic array



# Component ERP image



EEGLAB v2021.0

File Edit Tools Plot Study Datasets Help ▾

#3: Merged data

Filename: none  
Channels per frame  
Frames per epoch  
Epochs  
Events  
Sampling rate (Hz)  
Epoch start (sec)  
Epoch end (sec)  
Reference  
Channel locations  
ICA weights  
Dataset size (Mb)

Channel locations ►

- Channel data (scroll)
- Channel spectra and maps
- Channel properties
- Channel ERP image
- Channel ERPs
- ERP map series
- Channel time-frequency

Component activations (scroll) ►

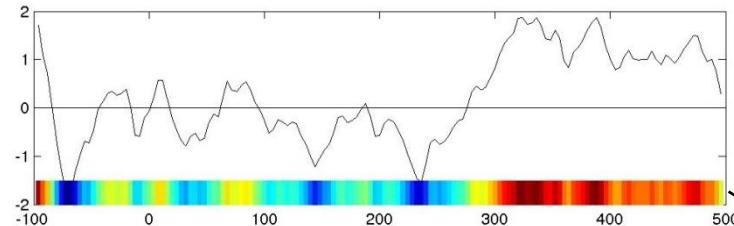
- Component spectra and maps
- Component maps
- Component properties
- Component ERP image
- Component ERPs
- Component time-frequency



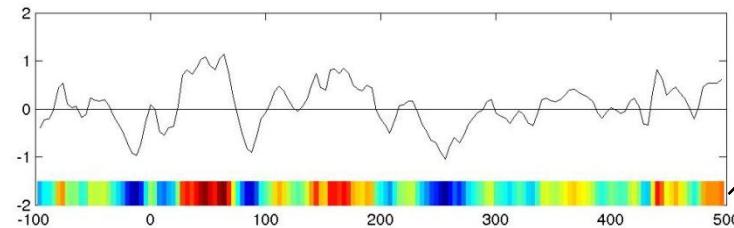
# ERP Image basics



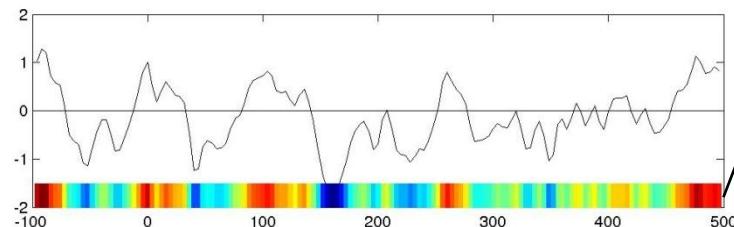
Trial 1



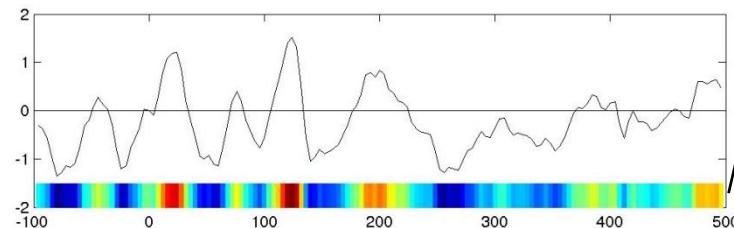
Trial 2



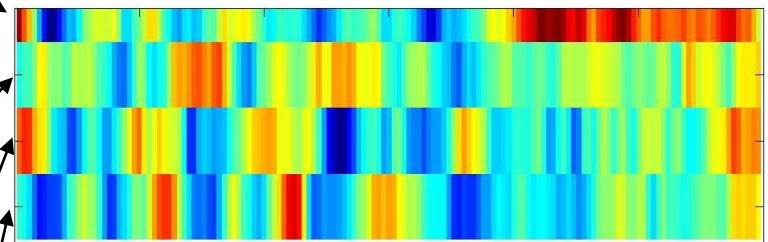
Trial 3



Trial 4



ERP Image



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

# ERP Image basics

Trial 1:



Trial 2:

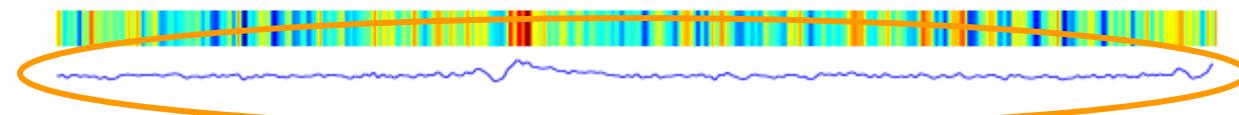


.

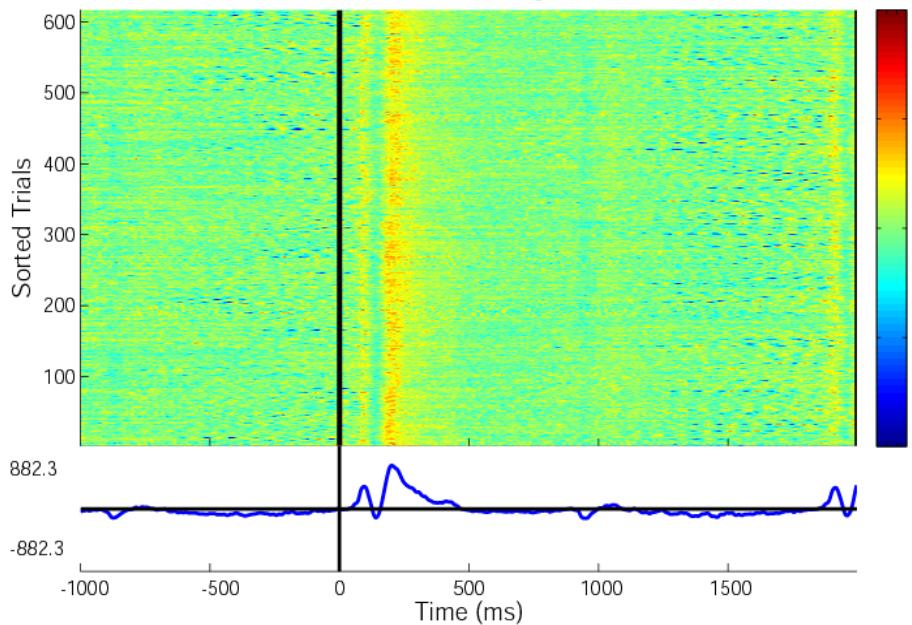
.

.

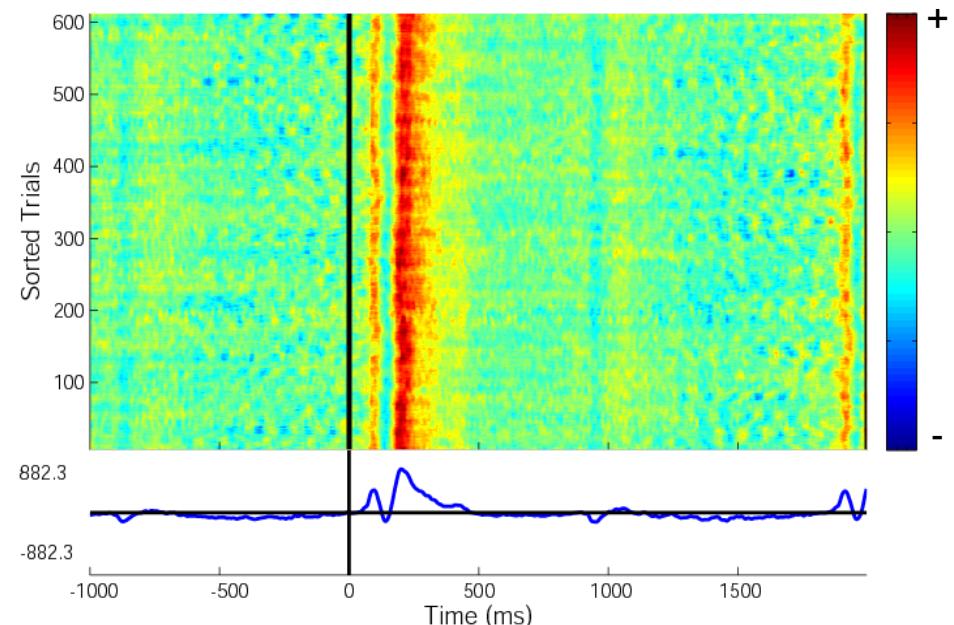
.



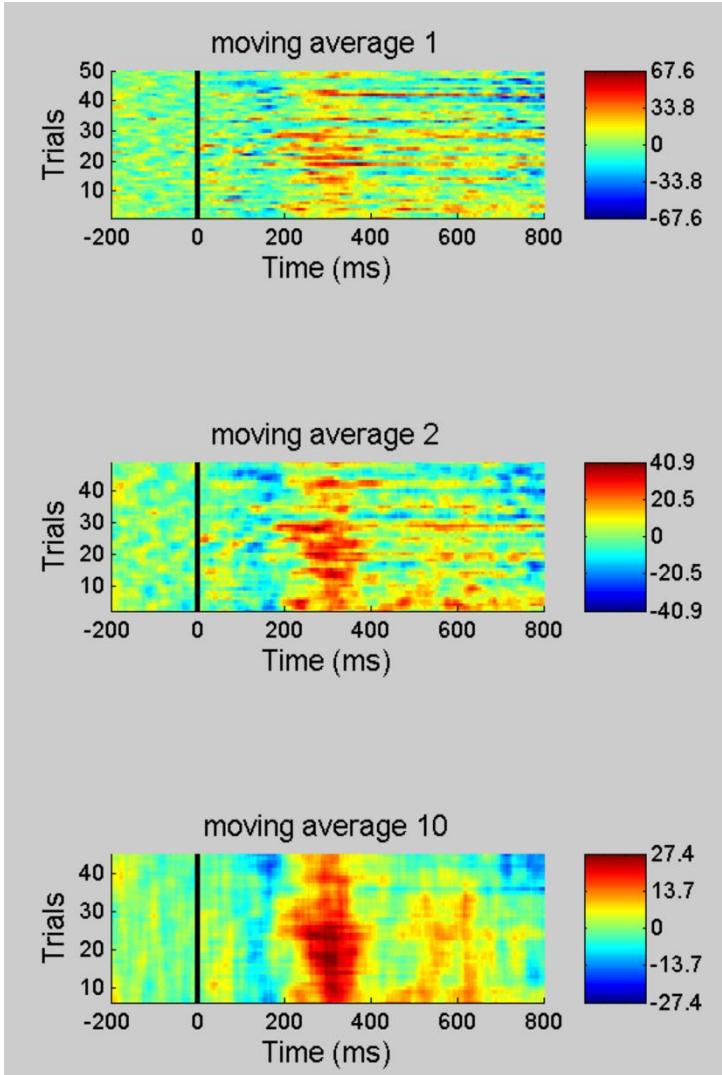
No Smoothing



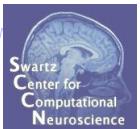
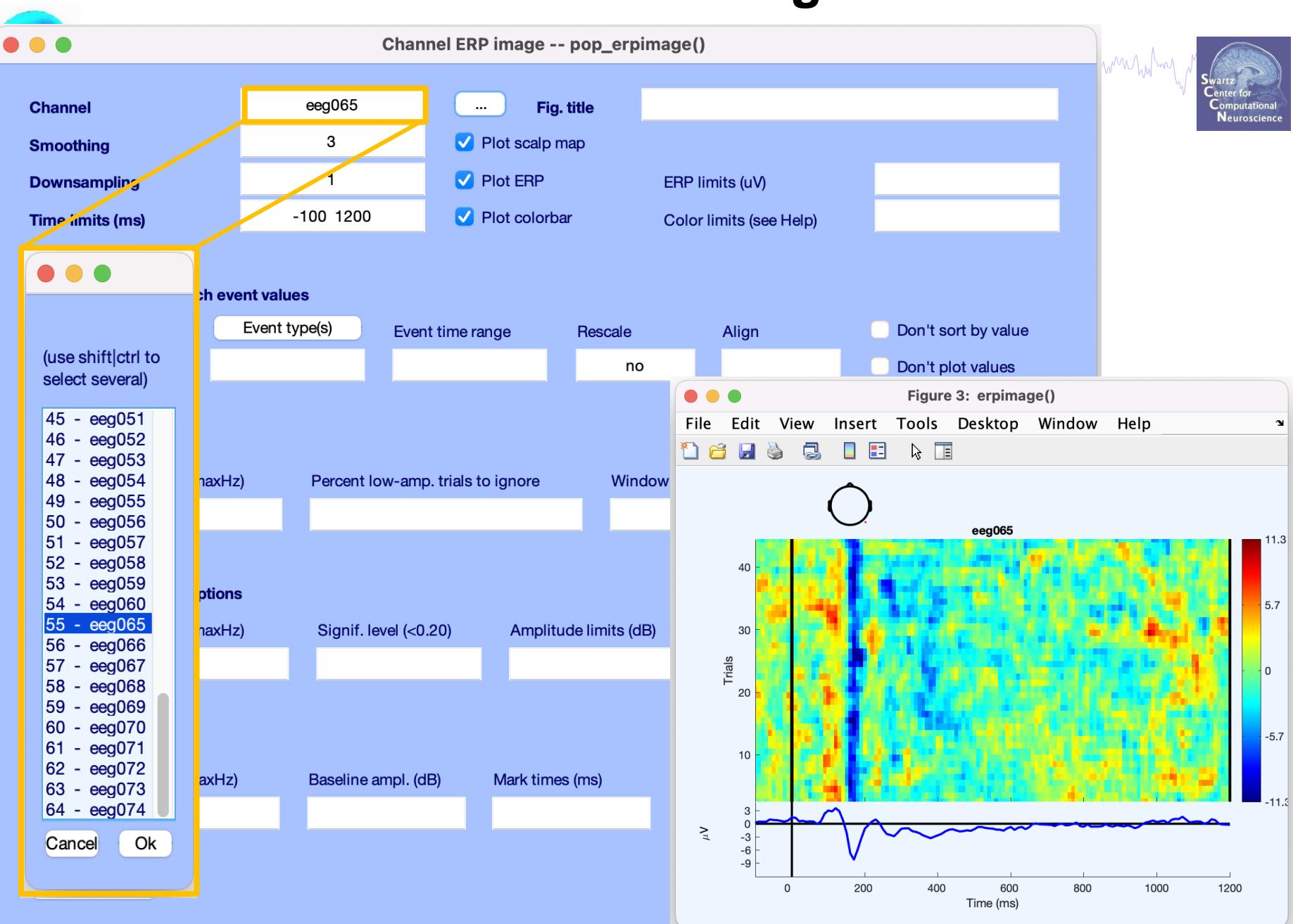
Smoothed across 10 Trials

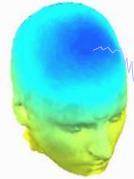


# ERP Images: smoothing across trials



# Channel ERP Image





# Hands On!

