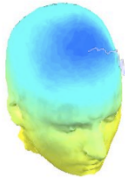
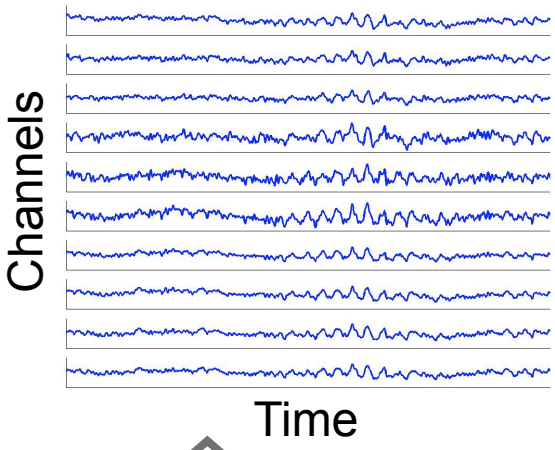
Independent Component Analysis



x = scalp EEG

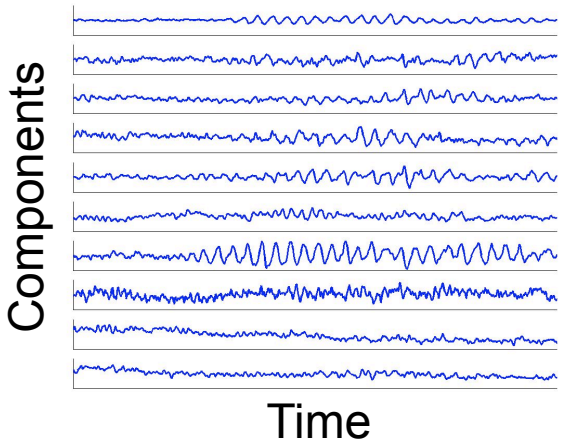
W = unmixing matrix

u = sources



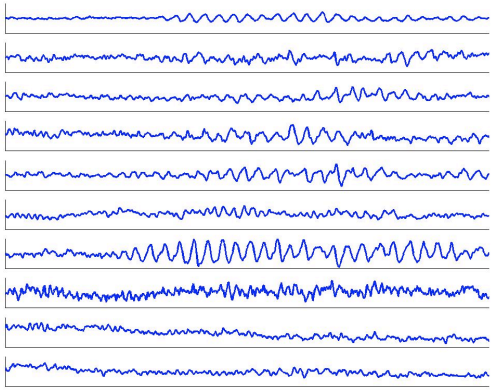
W*x = u

ICA



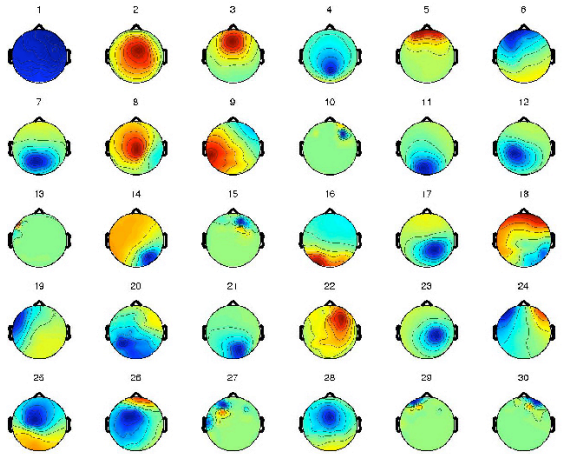
x = W^{-1}*u

u = sources

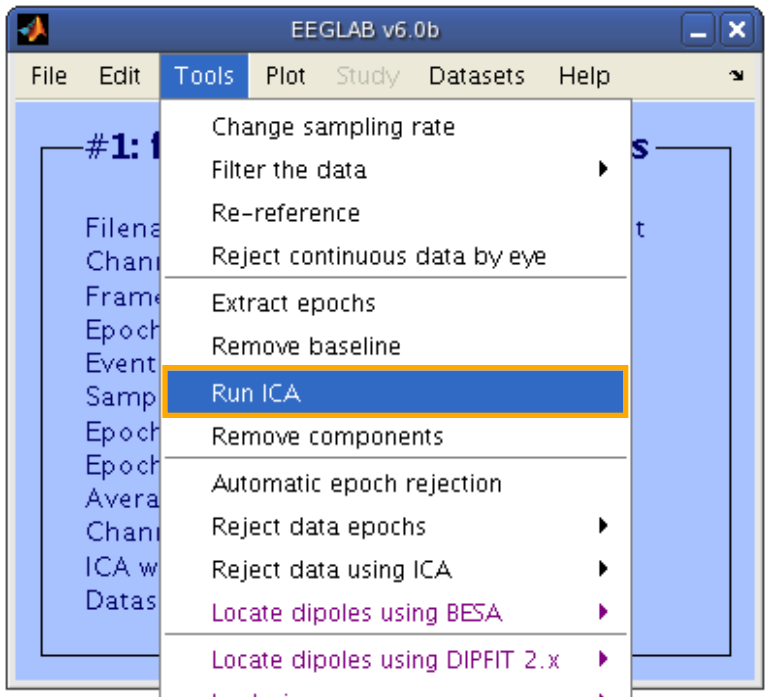


*

W^{-1} (scalp projections)



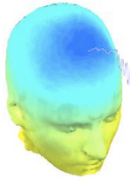
Runica options



Option	Default	Comments
'extended'	0	1 is recommended to find sub-gaussians
'stop'	1e-7	final weight change → stop
'lrate'	determined from data	too small → too long… too large → wts blow up
'maxsteps'	512	more channels → more steps
'pca'	0 or EEG.nbchan	Decompose only a principal data subspace

Other algorithms:
binica, jader,erica,sobi,acsobiro

Runica progress…



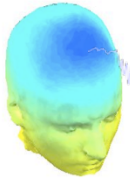
Press Button to interupt runica

Interupt

```
csh
Input data size [33,133175] = 33 channels, 133175 frames/nFinding 33 ICA components using extended ICA.
Kurtosis will be calculated initially every 1 blocks using 6000 data points.
Decomposing 122 frames per ICA weight ((1089)^2 = 133175 weights, Initial learning rate will be 0.001, block size
Learning rate will be multiplied by 0.98 whenever angledelta >= 60 deg.
More than 32 channels: default stopping weight change 1E-7
Training will end when wchange < 1e-07 or after 512 steps.
Online bias adjustment will be used.
Removing mean of each channel ...
Final training data range: -171.806 to 179.094
Computing the sphering matrix...
Starting weights are the identity matrix ...
Sphering the data ...
Beginning ICA training ... first training step may be slow ...
step 1 - lrate 0.001000, wchange 16.85061324, angledelta  0.0 deg
step 2 - lrate 0.001000, wchange 0.26760405, angledelta  0.0 deg
step 3 - lrate 0.001000, wchange 0.79058323, angledelta 104.0 deg
step 4 - lrate 0.000980, wchange 0.66700031, angledelta 147.2 deg
step 5 - lrate 0.000960, wchange 0.62849071, angledelta 146.5 deg
step 6 - lrate 0.000941, wchange 0.73967955, angledelta 150.7 deg
step 7 - lrate 0.000922, wchange 0.73727229, angledelta 151.6 deg
step 8 - lrate 0.000904, wchange 0.74051387, angledelta 137.9 deg
step 9 - lrate 0.000886, wchange 0.74536137, angledelta 156.0 deg
step 10 - lrate 0.000868, wchange 0.72101402, angledelta 143.7 deg
step 11 - lrate 0.000851, wchange 0.14690114, angledelta 102.5 deg
step 12 - lrate 0.000834, wchange 0.11822100, angledelta 114.3 deg
step 13 - lrate 0.000817, wchange 0.75552966, angledelta 100.6 deg
step 14 - lrate 0.000801, wchange 0.26739750, angledelta 109.1 deg
step 15 - lrate 0.000785, wchange 0.12123251, angledelta 94.2 deg
step 16 - lrate 0.000769, wchange 0.10285606, angledelta 110.7 deg
step 17 - lrate 0.000754, wchange 0.09770499, angledelta 118.6 deg
step 18 - lrate 0.000739, wchange 0.09544428, angledelta 117.1 deg
```

```
csh
step 241 - lrate 0.000002, wchange 0.00000082, angledelta 101.5 deg
step 242 - lrate 0.000001, wchange 0.00000061, angledelta 96.1 deg
step 243 - lrate 0.000001, wchange 0.00000057, angledelta 97.5 deg
step 244 - lrate 0.000001, wchange 0.00000054, angledelta 93.7 deg
step 245 - lrate 0.000001, wchange 0.00000055, angledelta 100.3 deg
step 246 - lrate 0.000001, wchange 0.00000047, angledelta 96.9 deg
step 247 - lrate 0.000001, wchange 0.00000046, angledelta 91.3 deg
step 248 - lrate 0.000001, wchange 0.00000045, angledelta 101.5 deg
step 249 - lrate 0.000001, wchange 0.00000041, angledelta 103.1 deg
step 250 - lrate 0.000001, wchange 0.00000036, angledelta 95.5 deg
step 251 - lrate 0.000001, wchange 0.00000033, angledelta 92.1 deg
step 252 - lrate 0.000001, wchange 0.00000029, angledelta 97.4 deg
step 253 - lrate 0.000001, wchange 0.00000030, angledelta 95.8 deg
step 254 - lrate 0.000001, wchange 0.00000023, angledelta 94.2 deg
step 255 - lrate 0.000001, wchange 0.00000023, angledelta 97.6 deg
step 256 - lrate 0.000001, wchange 0.00000023, angledelta 97.1 deg
step 257 - lrate 0.000001, wchange 0.00000021, angledelta 92.0 deg
step 258 - lrate 0.000001, wchange 0.00000020, angledelta 99.1 deg
step 259 - lrate 0.000001, wchange 0.00000019, angledelta 95.0 deg
step 260 - lrate 0.000001, wchange 0.00000015, angledelta 98.3 deg
step 261 - lrate 0.000001, wchange 0.00000014, angledelta 99.0 deg
step 262 - lrate 0.000001, wchange 0.00000014, angledelta 94.3 deg
step 263 - lrate 0.000001, wchange 0.00000013, angledelta 95.4 deg
step 264 - lrate 0.000001, wchange 0.00000012, angledelta 94.1 deg
step 265 - lrate 0.000001, wchange 0.00000011, angledelta 96.1 deg
step 266 - lrate 0.000001, wchange 0.00000010, angledelta 94.8 deg
step 267 - lrate 0.000001, wchange 0.00000010, angledelta 94.5 deg
step 268 - lrate 0.000001, wchange 0.00000010, angledelta 97.7 deg
step 269 - lrate 0.000001, wchange 0.00000008, angledelta 95.1 deg
Sorting components in descending order of mean projected variance ...
Permuting the activation wave forms ...
>>
>>
```

Evaluating ICA components



Component Scalp Maps & Activity

Component ERP

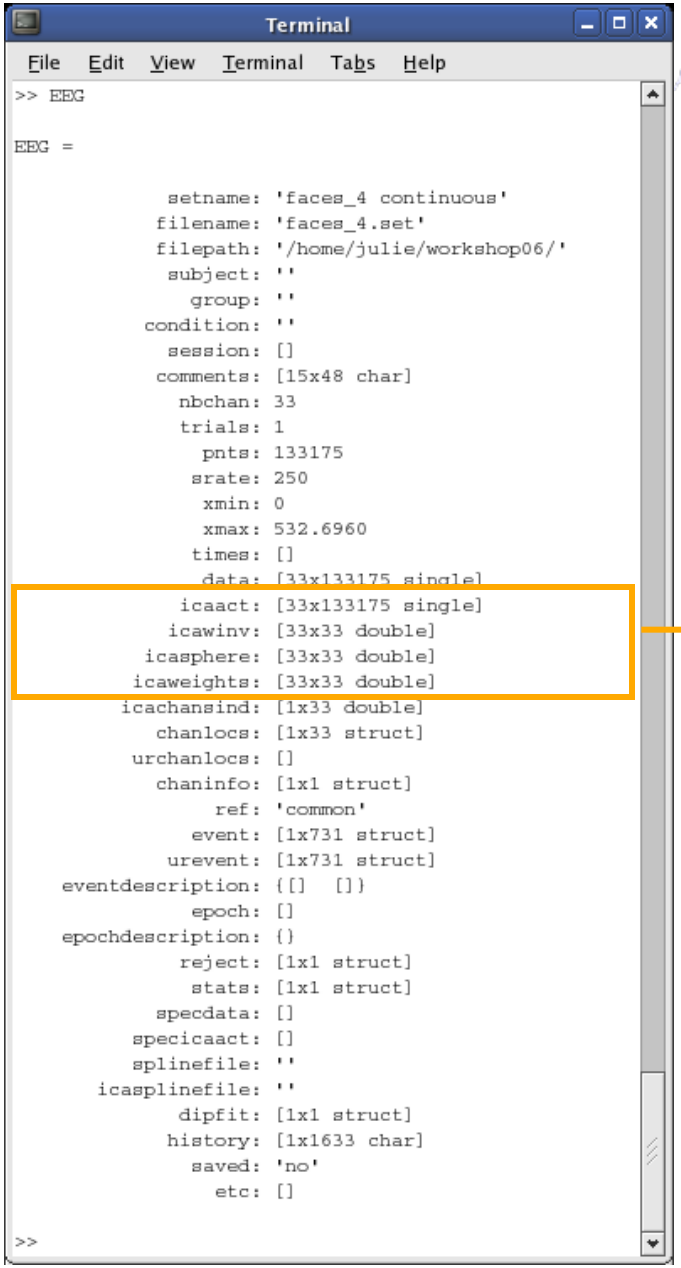
Component spectral power

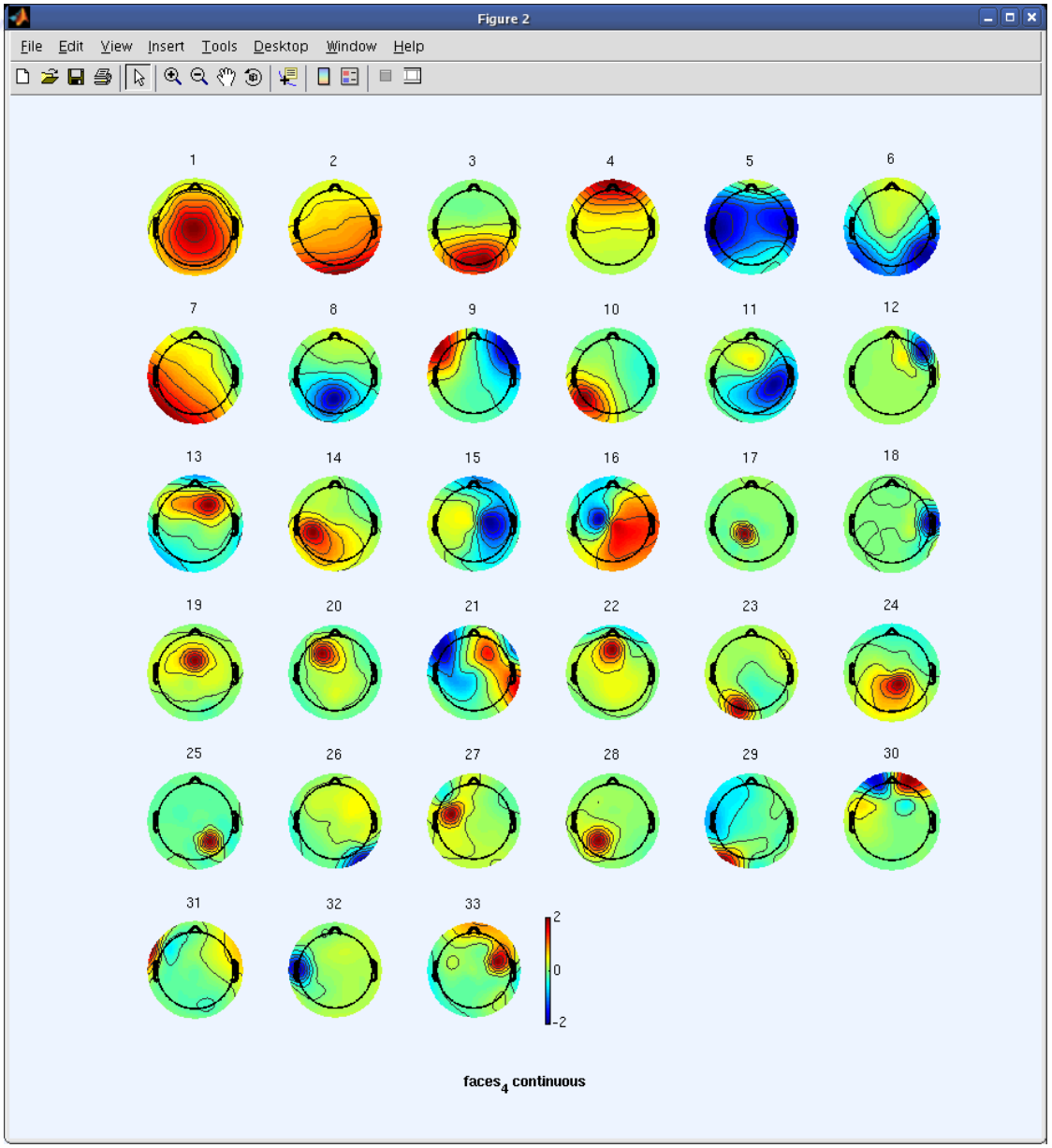
Component ERP images

Component ERSP & Coherence

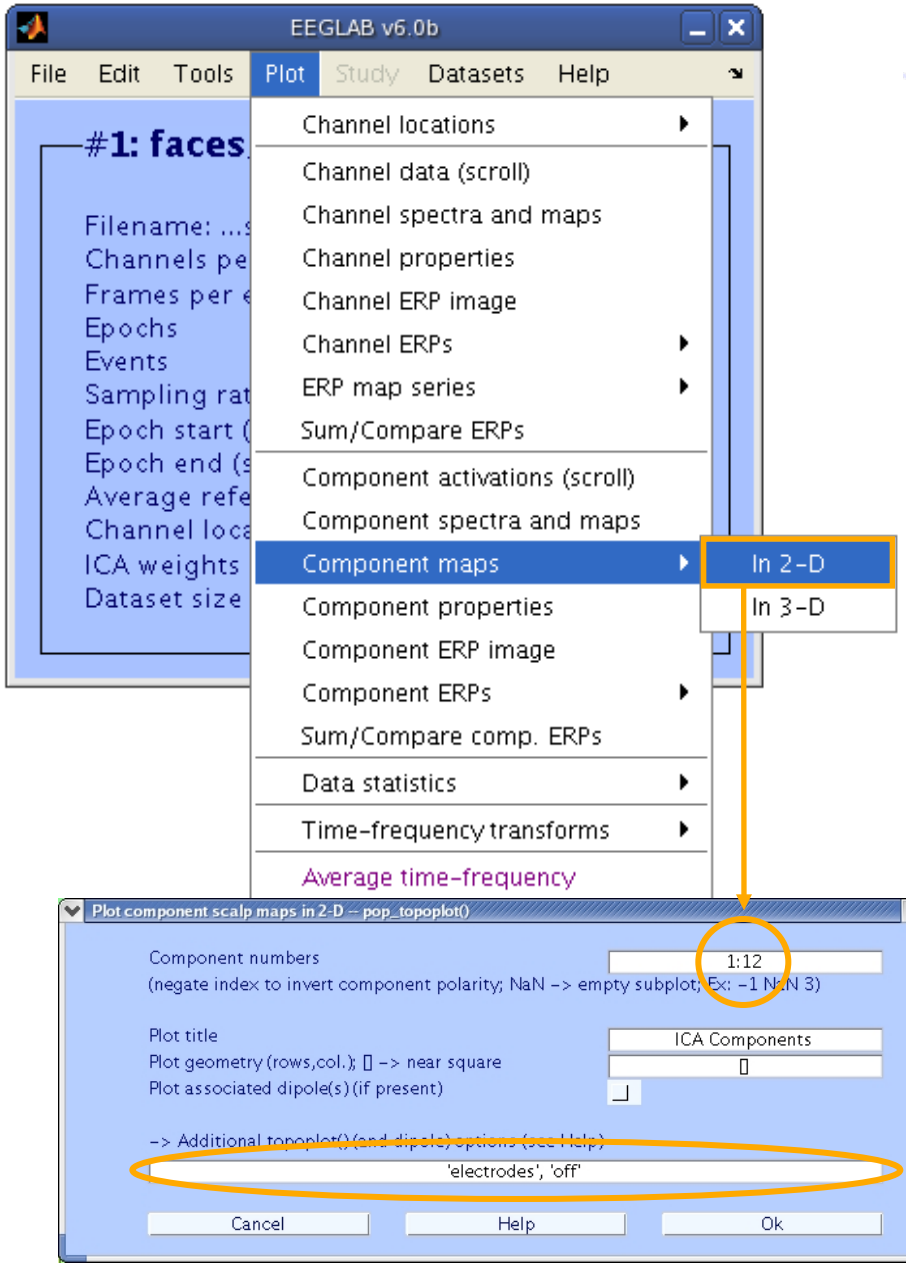
Exercise...

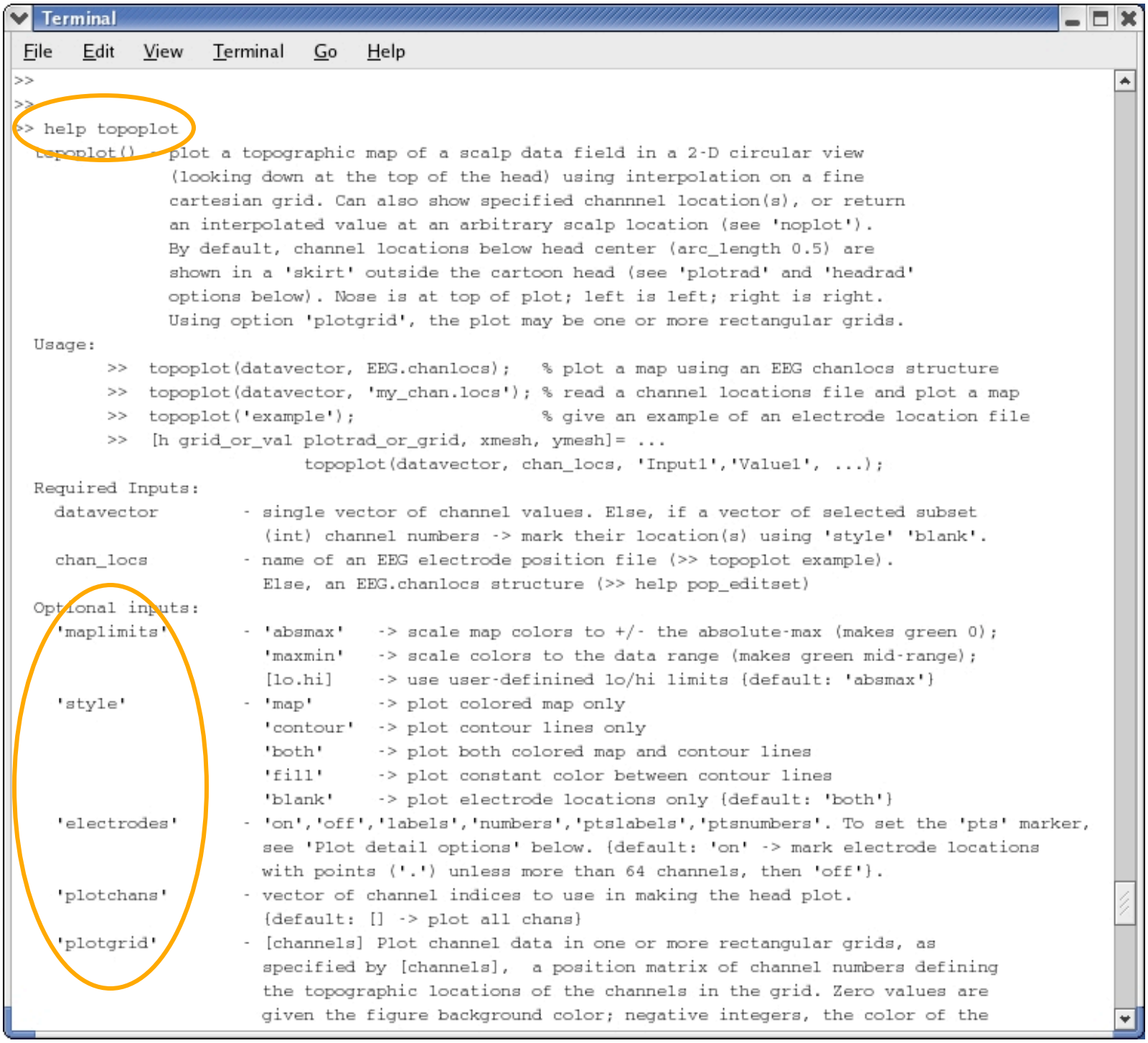
Where is the ICA decomp?



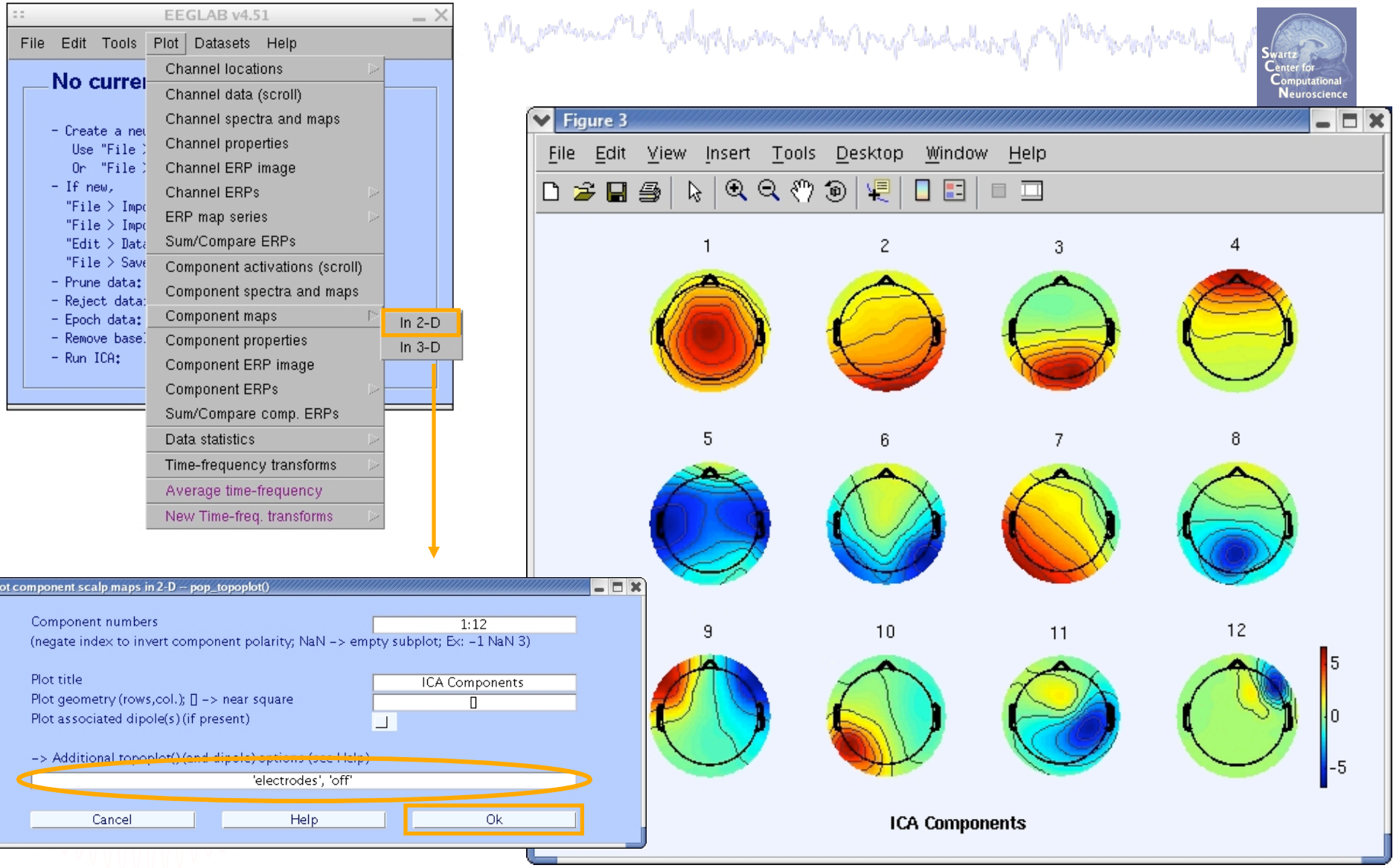


Plot ICA scalp maps

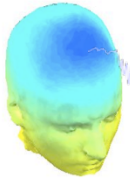


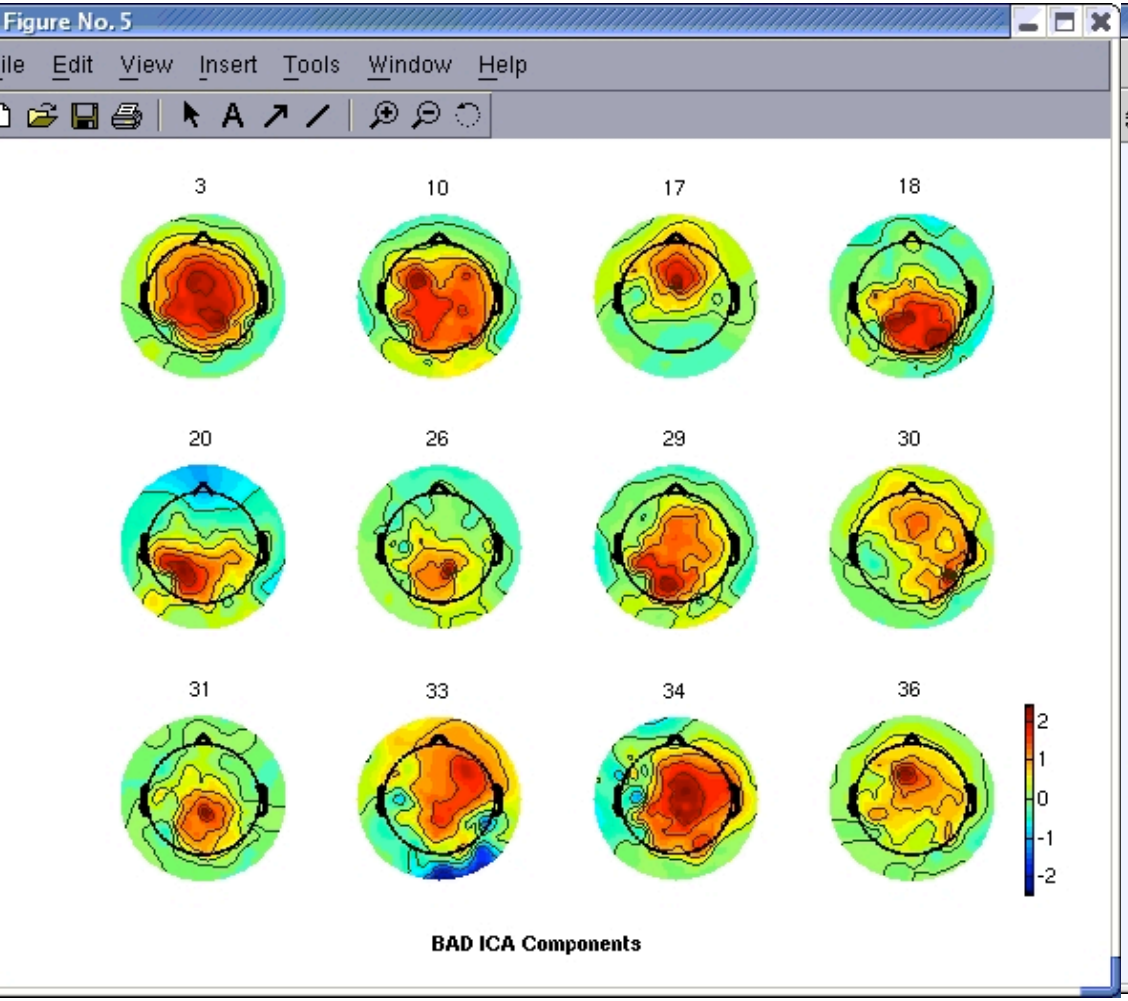

Terminal
File Edit View Terminal Go Help
>>
>>
>> help topoplot
topoplot() - plot a topographic map of a scalp data field in a 2-D circular view
(looking down at the top of the head) using interpolation on a fine
cartesian grid. Can also show specified channnel location(s), or return
an interpolated value at an arbitrary scalp location (see 'noplot').
By default, channel locations below head center (arc_length 0.5) are
shown in a 'skirt' outside the cartoon head (see 'plotrad' and 'headrad'
options below). Nose is at top of plot; left is left; right is right.
Using option 'plotgrid', the plot may be one or more rectangular grids.
Usage:
>> topoplot(datavector, EEG.chanlocs); % plot a map using an EEG chanlocs structure
>> topoplot(datavector, 'my_chan.locs'); % read a channel locations file and plot a map
>> topoplot('example'); % give an example of an electrode location file
>> [h grid_or_val plotrad_or_grid, xmesh, ymesh]= ...
topoplot(datavector, chan_locs, 'Input1','Value1', ...);
Required Inputs:
datavector - single vector of channel values. Else, if a vector of selected subset
(int) channel numbers -> mark their location(s) using 'style' 'blank'.
chan_locs - name of an EEG electrode position file (>> topoplot example).
Else, an EEG.chanlocs structure (>> help pop_editset)
Optional inputs:
'maplimits' - 'absmax' -> scale map colors to +/- the absolute-max (makes green 0);
'maxmin' -> scale colors to the data range (makes green mid-range);
[lo.hi] -> use user-definined lo/hi limits {default: 'absmax'}
'style' - 'map' -> plot colored map only
'contour' -> plot contour lines only
'both' -> plot both colored map and contour lines
'fill' -> plot constant color between contour lines
'blank' -> plot electrode locations only {default: 'both'}
'electrodes' - 'on','off','labels','numbers','ptslabels','ptsnumbers'. To set the 'pts' marker,
see 'Plot detail options' below. {default: 'on' -> mark electrode locations
with points ('.') unless more than 64 channels, then 'off'}.
'plotchans' - vector of channel indices to use in making the head plot.
{default: [] -> plot all chans}
'plotgrid' - [channels] Plot channel data in one or more rectangular grids, as
specified by [channels], a position matrix of channel numbers defining
the topographic locations of the channels in the grid. Zero values are
given the figure background color; negative integers, the color of the

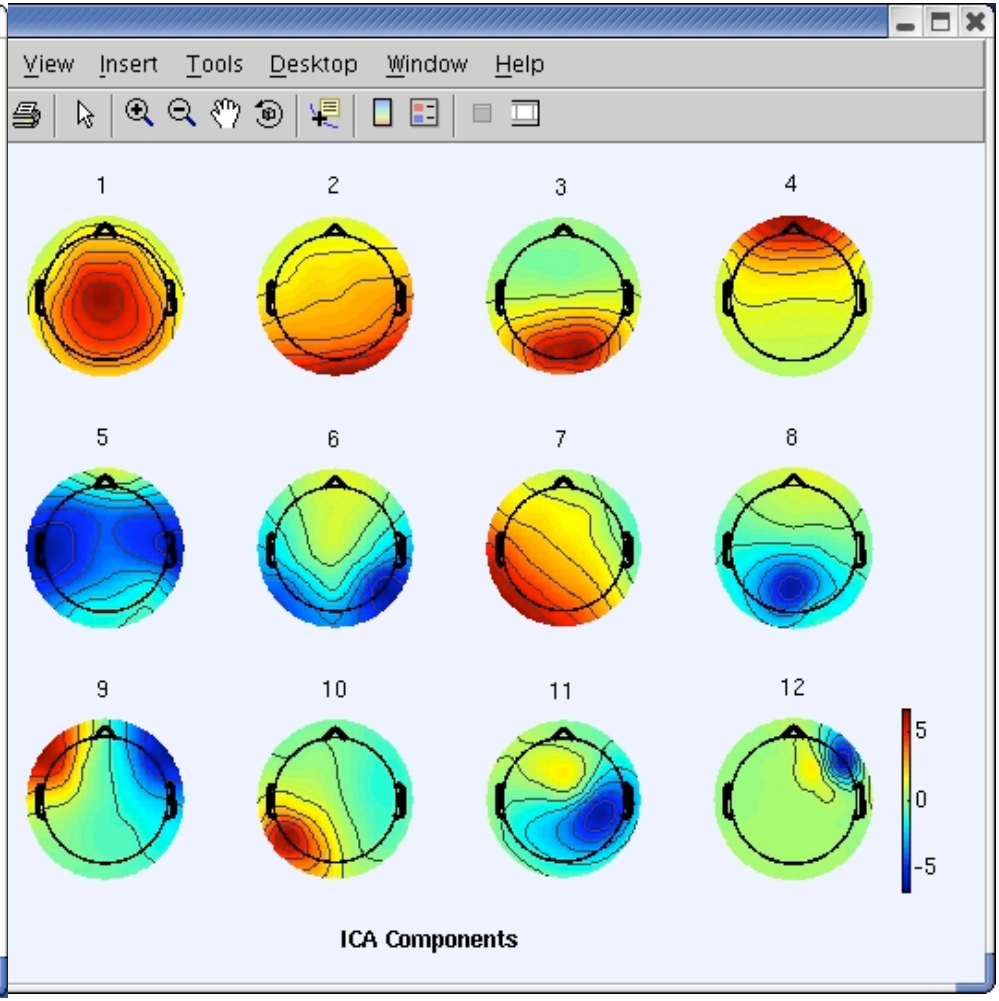
Plot ICA scalp maps



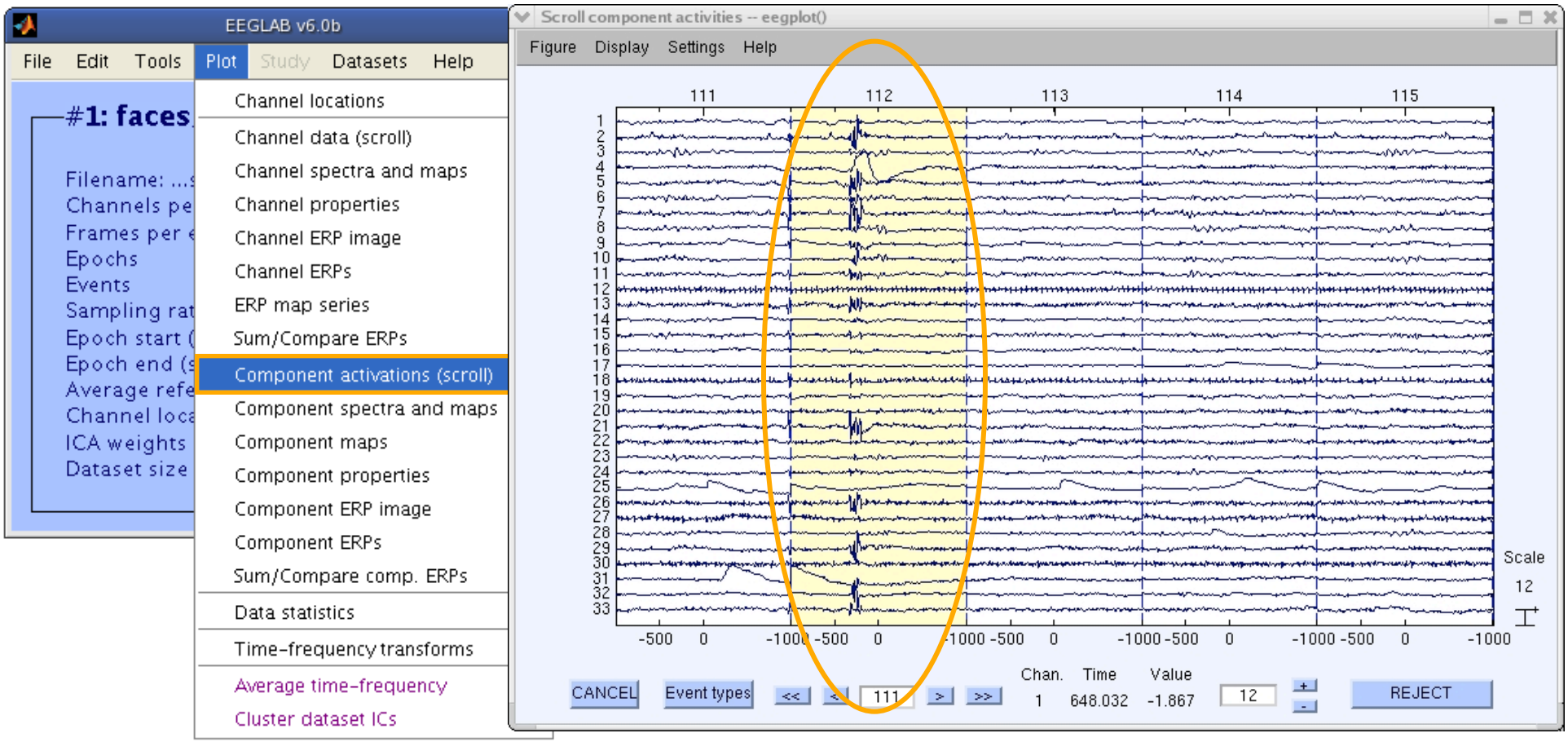
Compare 'good' and 'bad' scalp maps





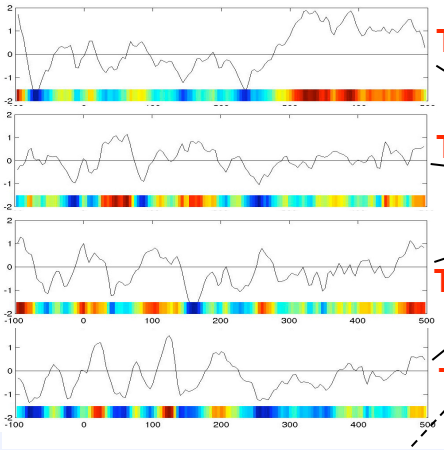


Scroll component activities

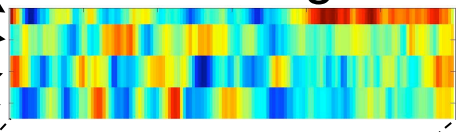


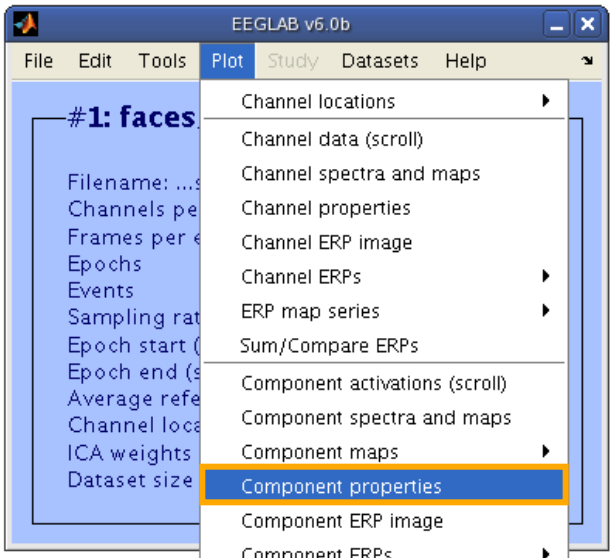
Activity like this that is *not* separated by ICA should be removed and ICA run again for better decomposition

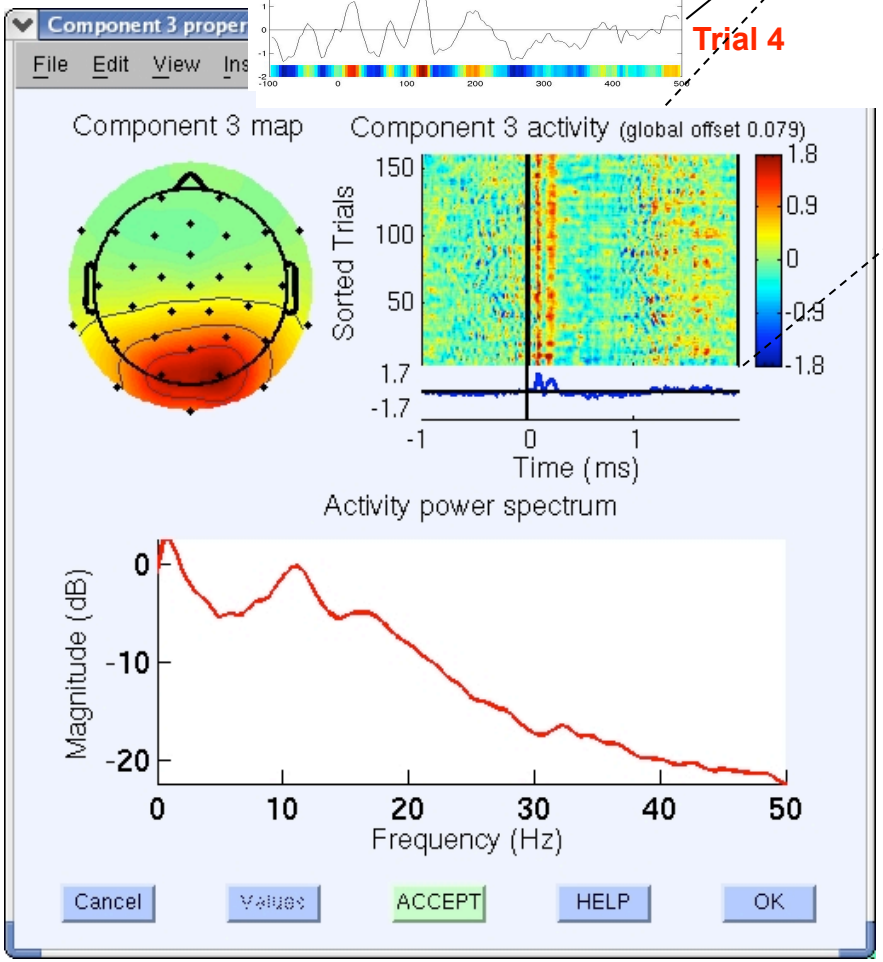
Plot ICA component properties



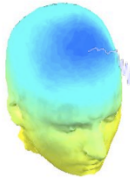
ERP Image

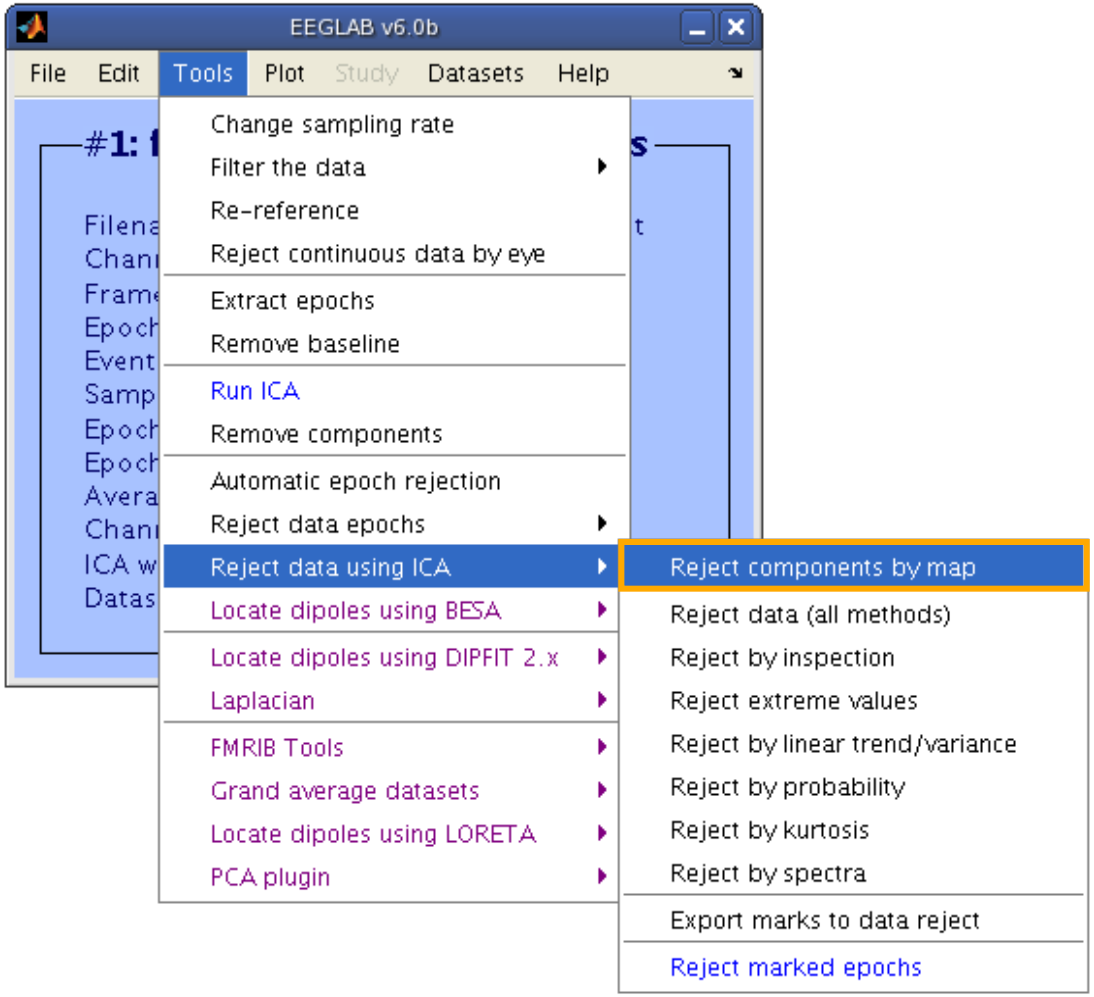




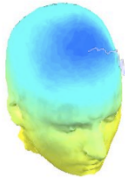


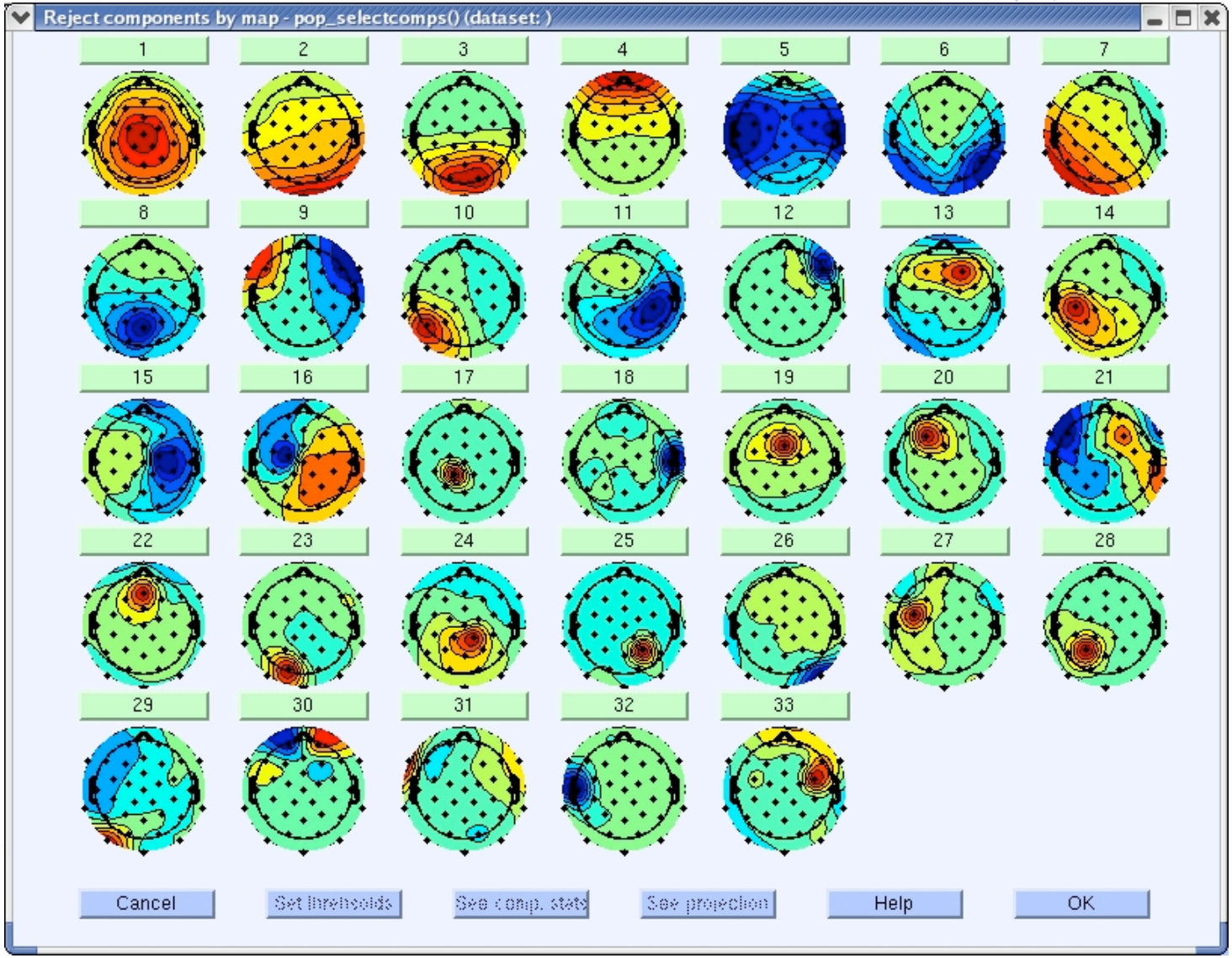
Reviewing component properties

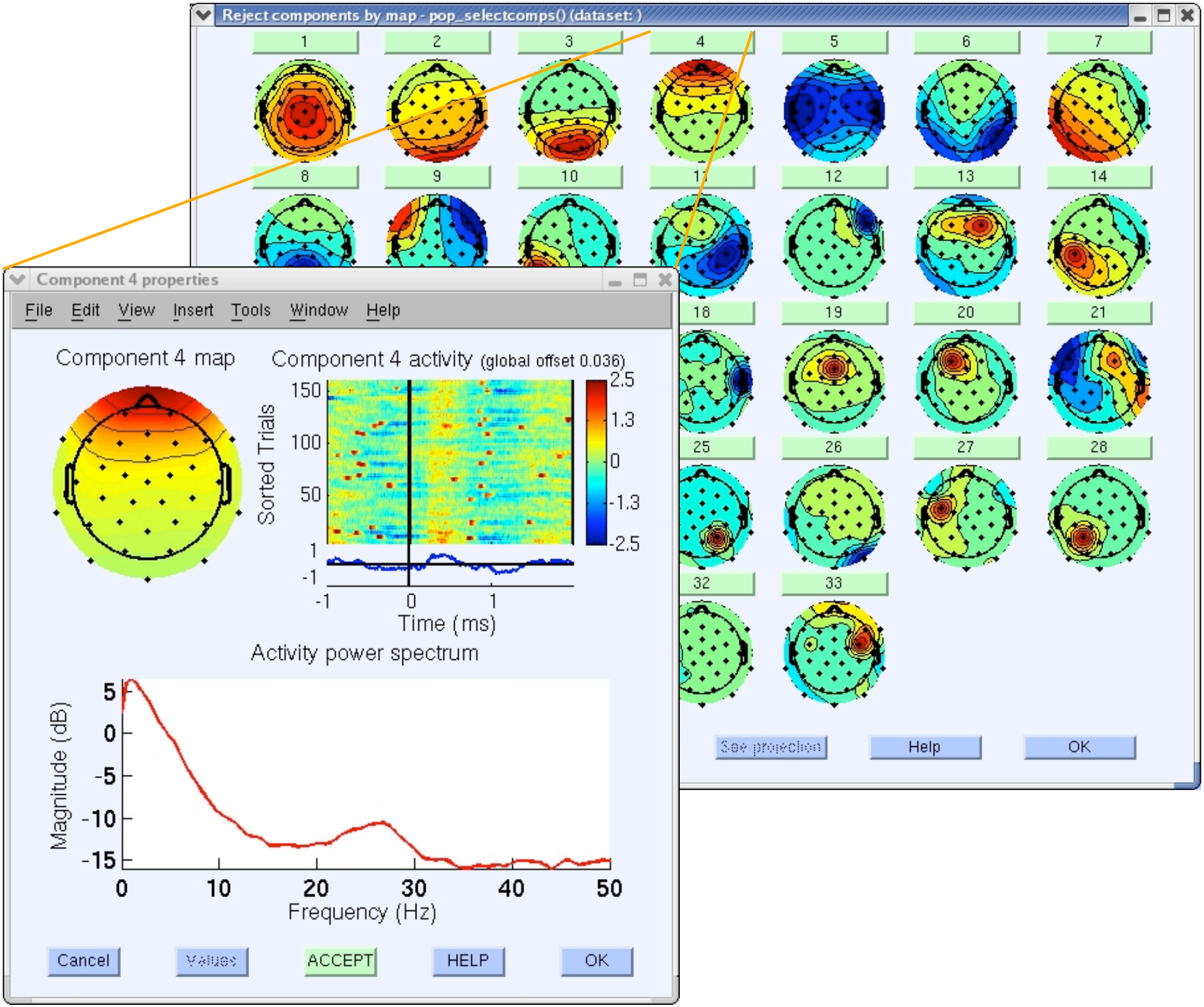


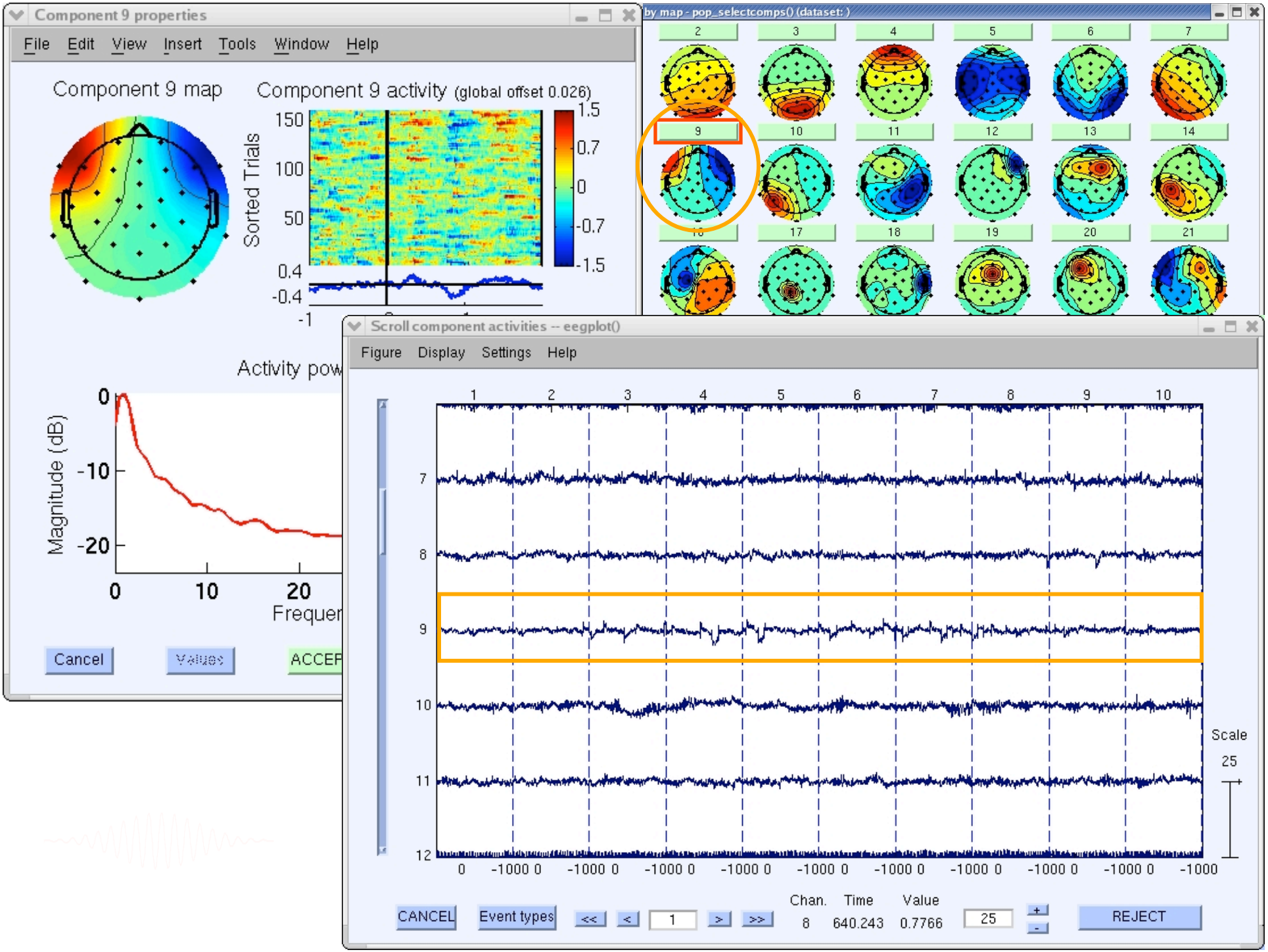


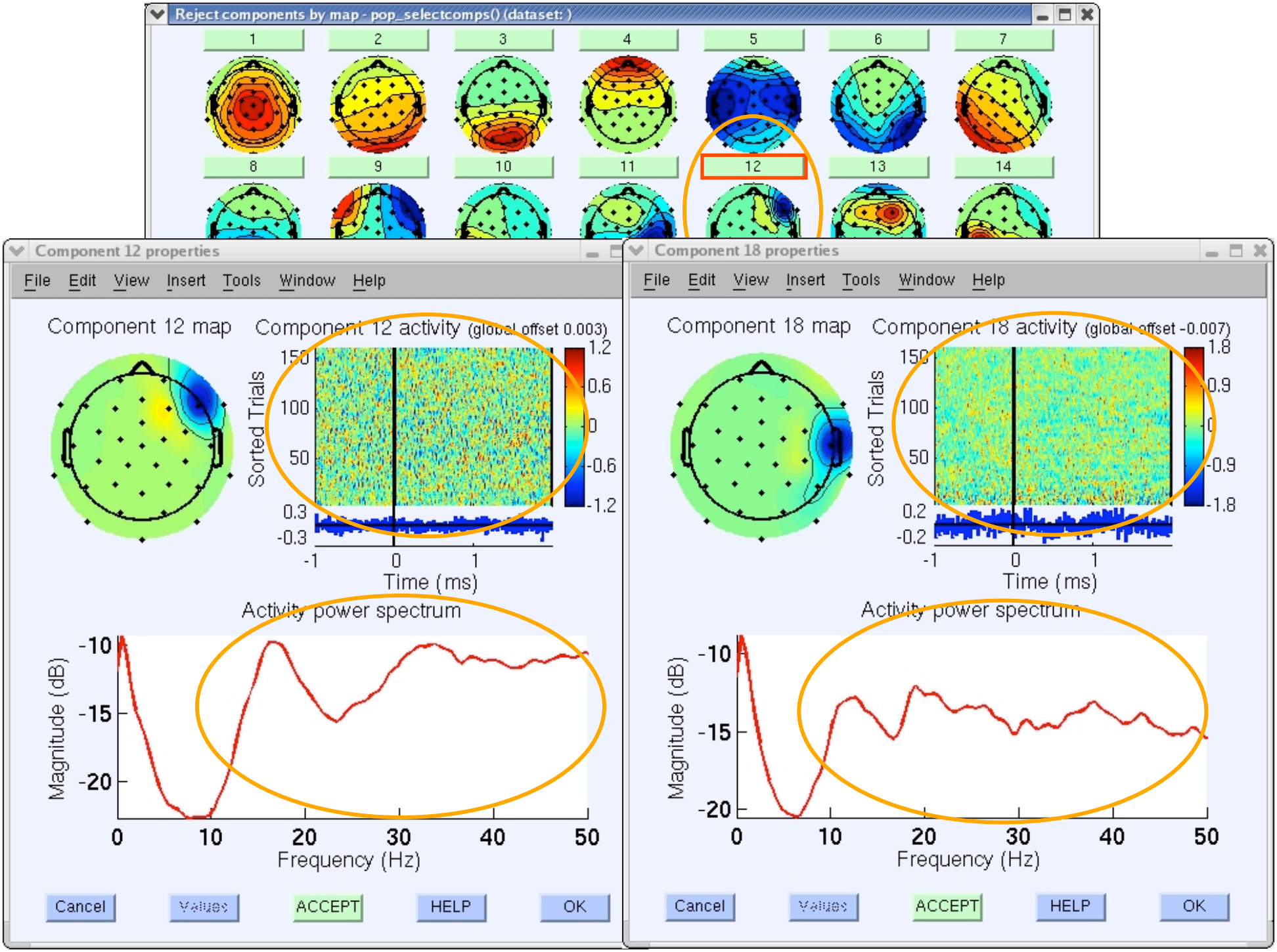
Component scalp maps/properties

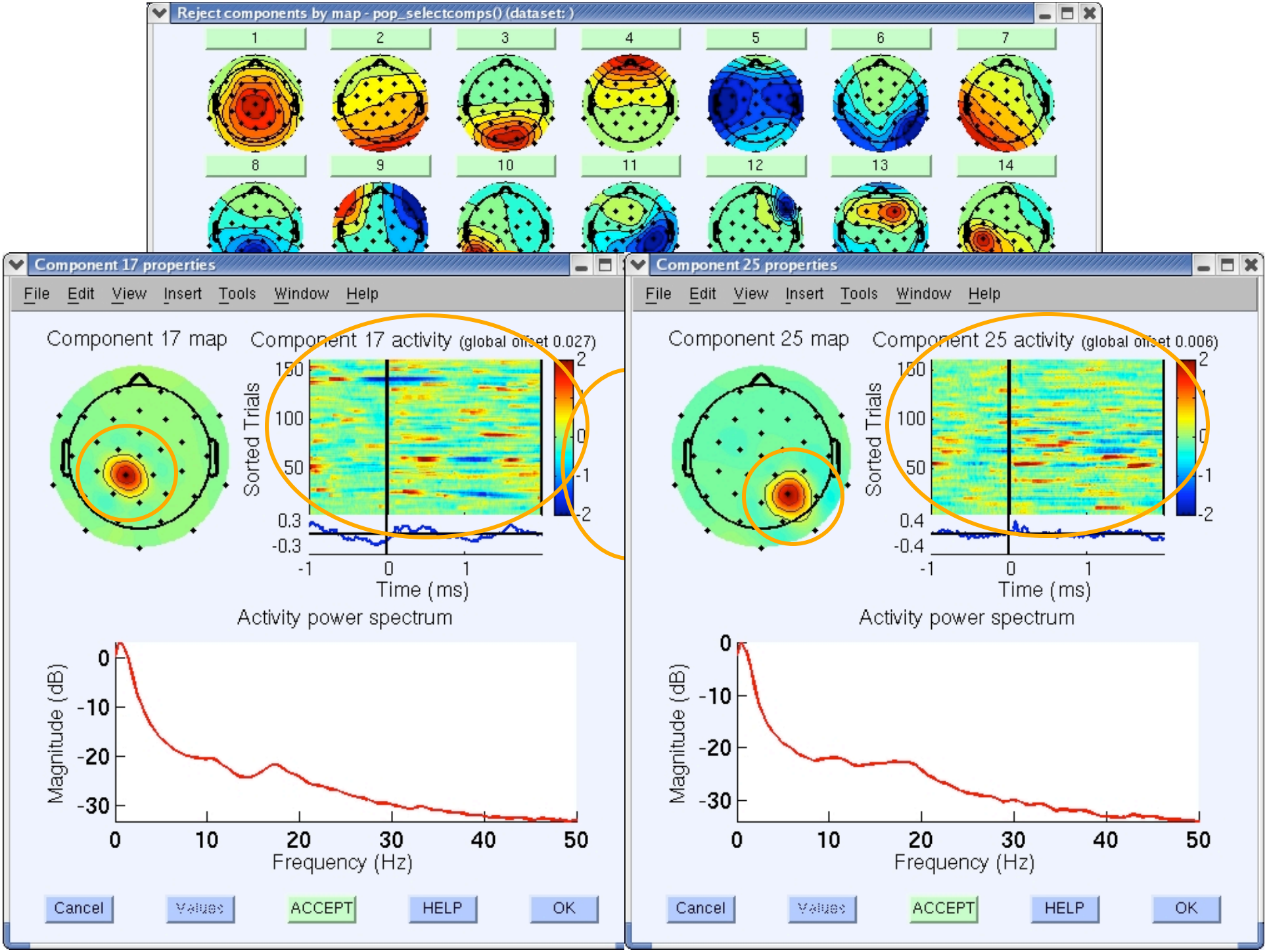


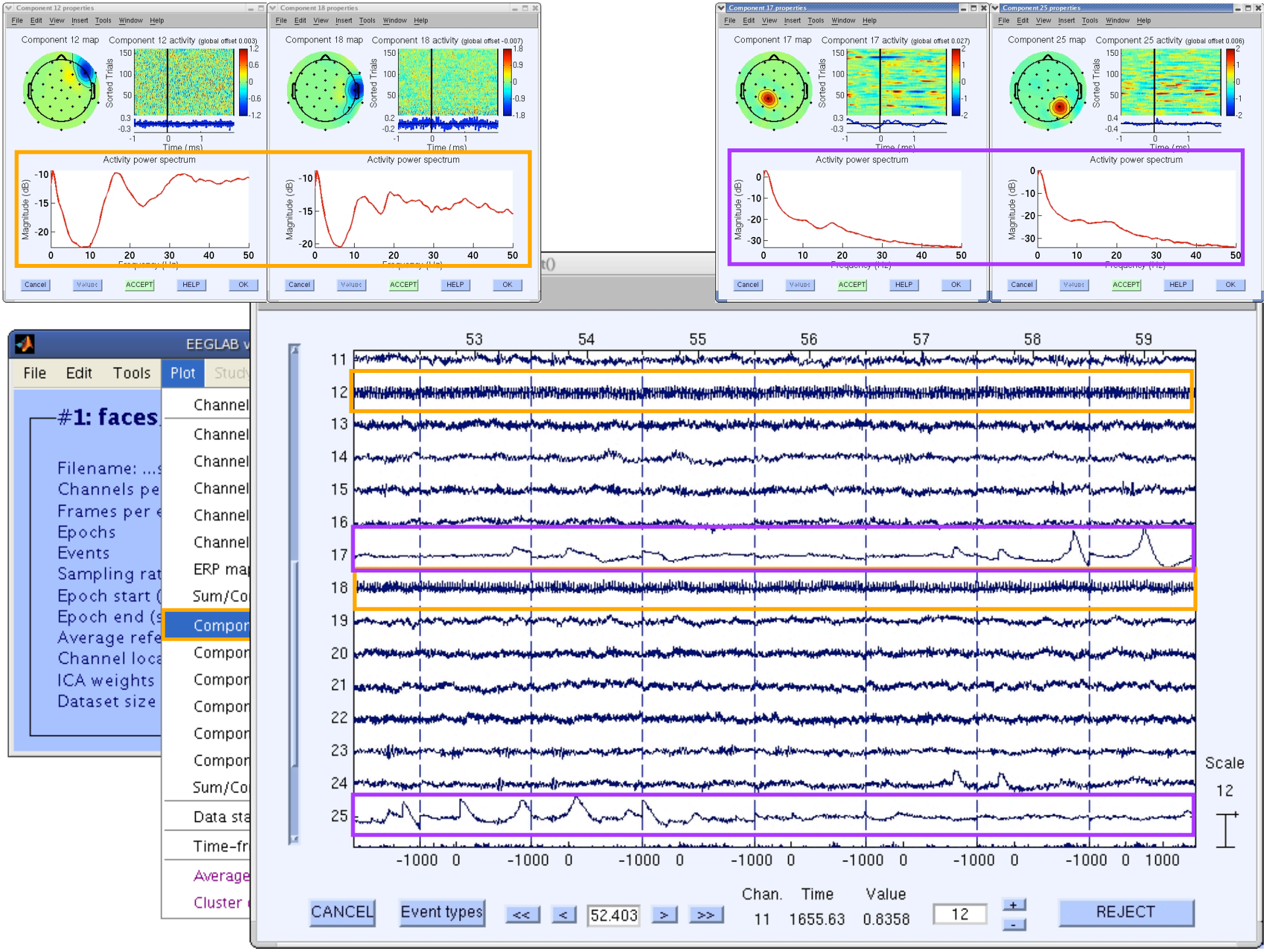



Reject components by map - pop_selectcomps() (dataset:)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
18
19
20
21
25
26
27
28
32
33
See projection
Help
OK
Component 4 properties
File Edit View Insert Tools Window Help
Component 4 map
Component 4 activity (global offset 0.036)
Sorted Trials
150
100
50
1
-1
2.5
1.3
0
-1.3
-2.5
-1
0
1
Time (ms)
Activity power spectrum
Magnitude (dB)
5
0
-5
-10
-15
0
10
20
30
40
50
Frequency (Hz)
Cancel
Values
ACCEPT
HELP
OK

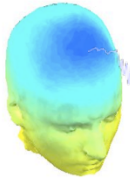

Component 9 properties
File Edit View Insert Tools Window Help
Component 9 map
Component 9 activity (global offset 0.026)
Sorted Trials
150
100
50
0.4
-0.4
-1
1.5
0.7
0
-0.7
-1.5
Activity pow
Magnitude (dB)
0
-10
-20
0
10
20
Frequer
Cancel
Values
ACCEP
by map - pop_selectcomps() (dataset:)
2 3 4 5 6 7
9 10 11 12 13 14
16 17 18 19 20 21
Scroll component activities -- eegplot()
Figure Display Settings Help
1 2 3 4 5 6 7 8 9 10
7
8
9
10
11
12
0 -1000 0 -1000 0 -1000 0 -1000 0 -1000 0 -1000 0 -1000 0 -1000 0 -1000 0 -1000
Scale
25
CANCEL
Event types
<<
<
1
>
>>
Chan. Time Value
8 640.243 0.7766
25
+
-
REJECT


Reject components by map - pop_selectcomps() (dataset:)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Component 12 properties
File Edit View Insert Tools Window Help
Component 12 map
Component 12 activity (global offset 0.003)
Sorted Trials
Time (ms)
Activity power spectrum
Magnitude (dB)
Frequency (Hz)
Cancel
Values
ACCEPT
HELP
OK
Component 18 properties
File Edit View Insert Tools Window Help
Component 18 map
Component 18 activity (global offset -0.007)
Sorted Trials
Time (ms)
Activity power spectrum
Magnitude (dB)
Frequency (Hz)
Cancel
Values
ACCEPT
HELP
OK

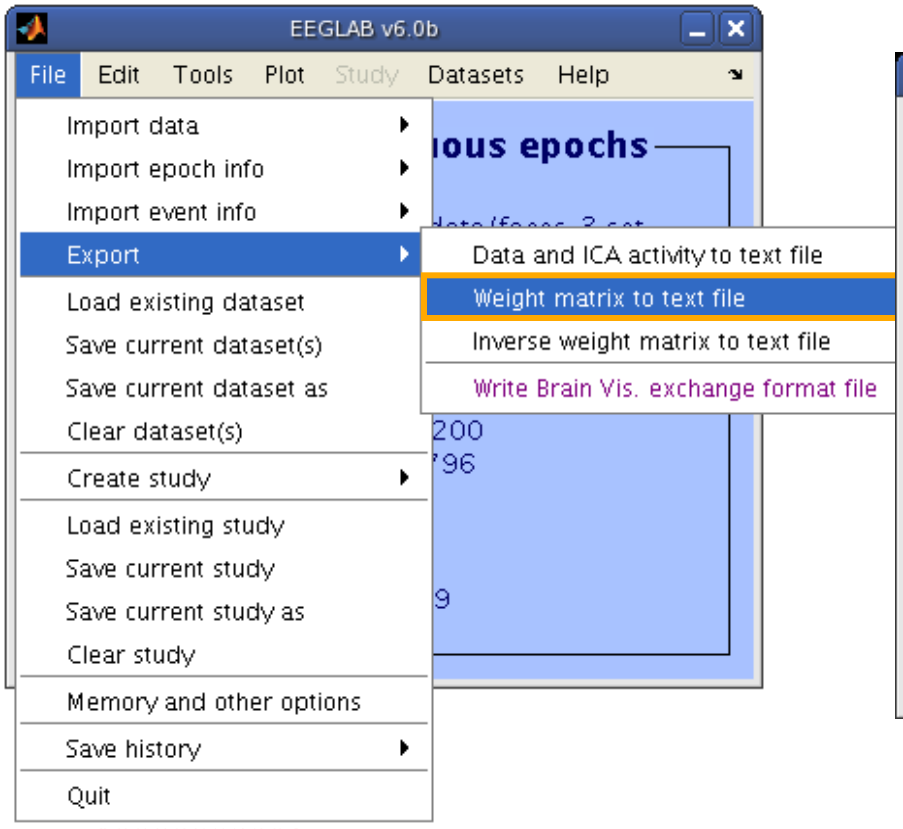

Reject components by map - pop_selectcomps() (dataset:)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Component 17 properties
File Edit View Insert Tools Window Help
Component 17 map
Component 17 activity (global offset 0.027)
Sorted Trials
Time (ms)
Activity power spectrum
Magnitude (dB)
Frequency (Hz)
Cancel
Values
ACCEPT
HELP
OK
Component 25 properties
File Edit View Insert Tools Window Help
Component 25 map
Component 25 activity (global offset 0.006)
Sorted Trials
Time (ms)
Activity power spectrum
Magnitude (dB)
Frequency (Hz)
Cancel
Values
ACCEPT
HELP
OK

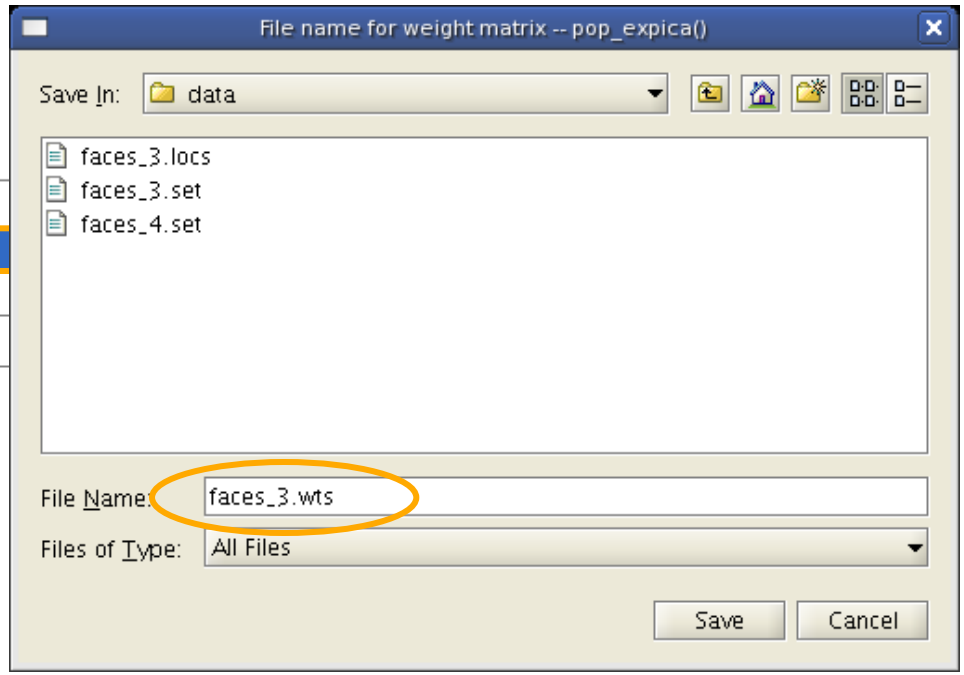

Component 12 properties
Component 12 map
Component 12 activity (global offset 0.003)
Activity power spectrum
Component 18 properties
Component 18 map
Component 18 activity (global offset -0.007)
Activity power spectrum
Component 17 properties
Component 17 map
Component 17 activity (global offset 0.027)
Activity power spectrum
Component 25 properties
Component 25 map
Component 25 activity (global offset 0.006)
Activity power spectrum
File Edit View Insert Tools Window Help
Sorted Trials
Time (ms)
Magnitude (dB)
Frequency (Hz)
Cancel
Values
ACCEPT
HELP
OK
EEGLAB
File Edit Tools Plot
#1: faces
Filename:
Channels pe
Frames per e
Epochs
Events
Sampling rat
Epoch start (
Epoch end (s
Average refe
Channel loca
ICA weights
Dataset size
Channel
ERP map
Sum/Co
Compon
Data sta
Time-fr
Average
Cluster
53 54 55 56 57 58 59
11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
-1000 0 1000
Scale
12
CANCEL
Event types
<< < 52.403 > >>
Chan. Time Value
11 1655.63 0.8358
12
+
-
REJECT

Export ICA weights

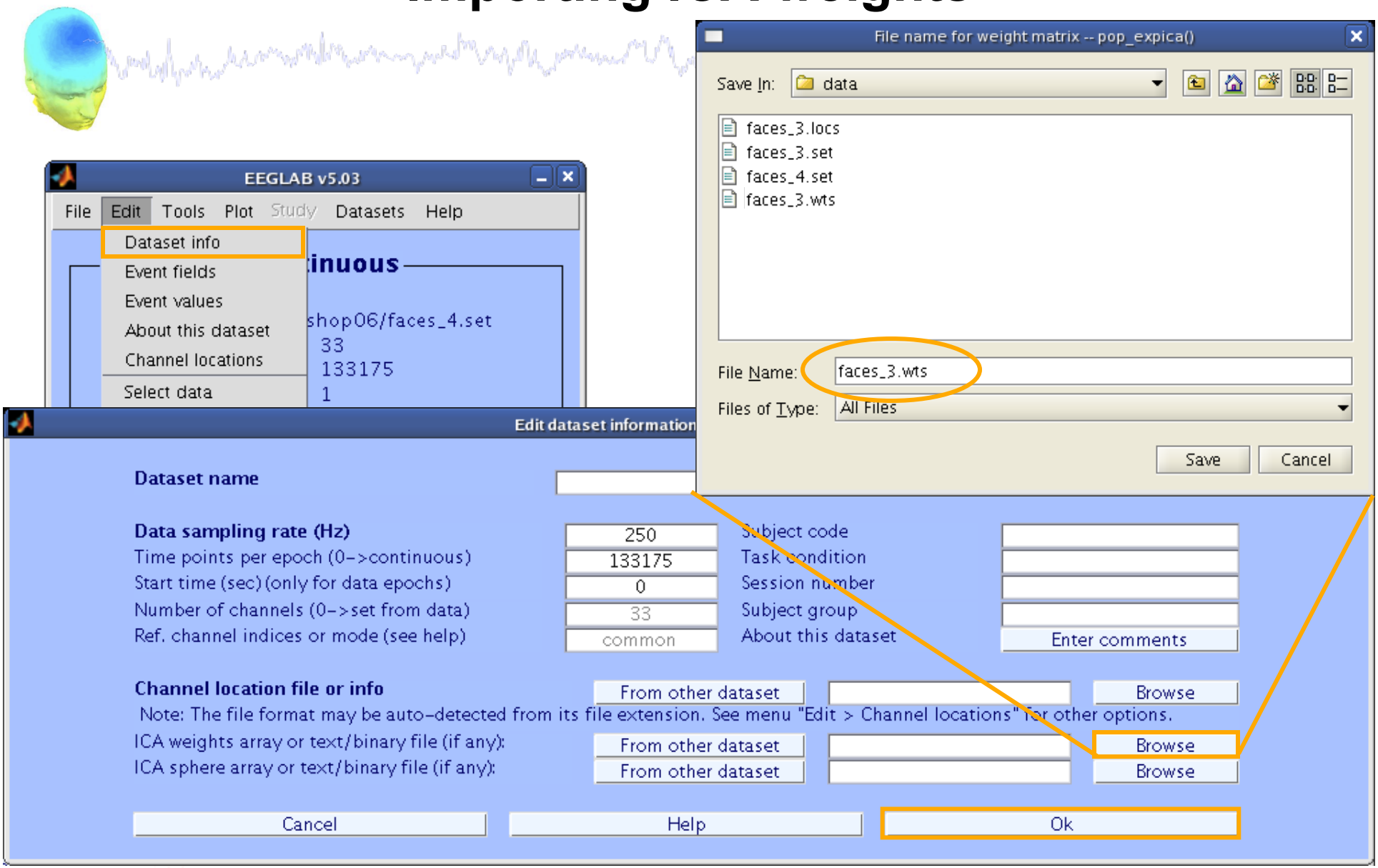


File will contain the weights*sphere matrix

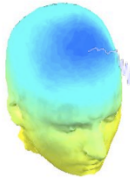




Importing ICA weights



Evaluating ICA components



Component Scalp Maps & Activity

Component ERP

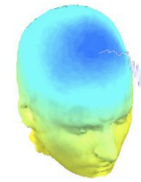
Component spectral power

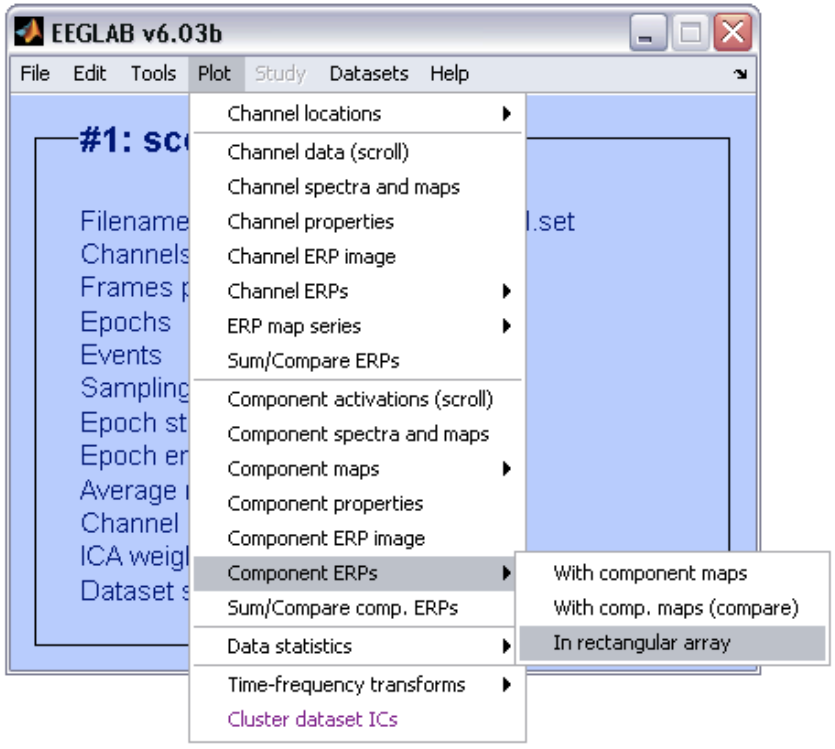
Component ERP images

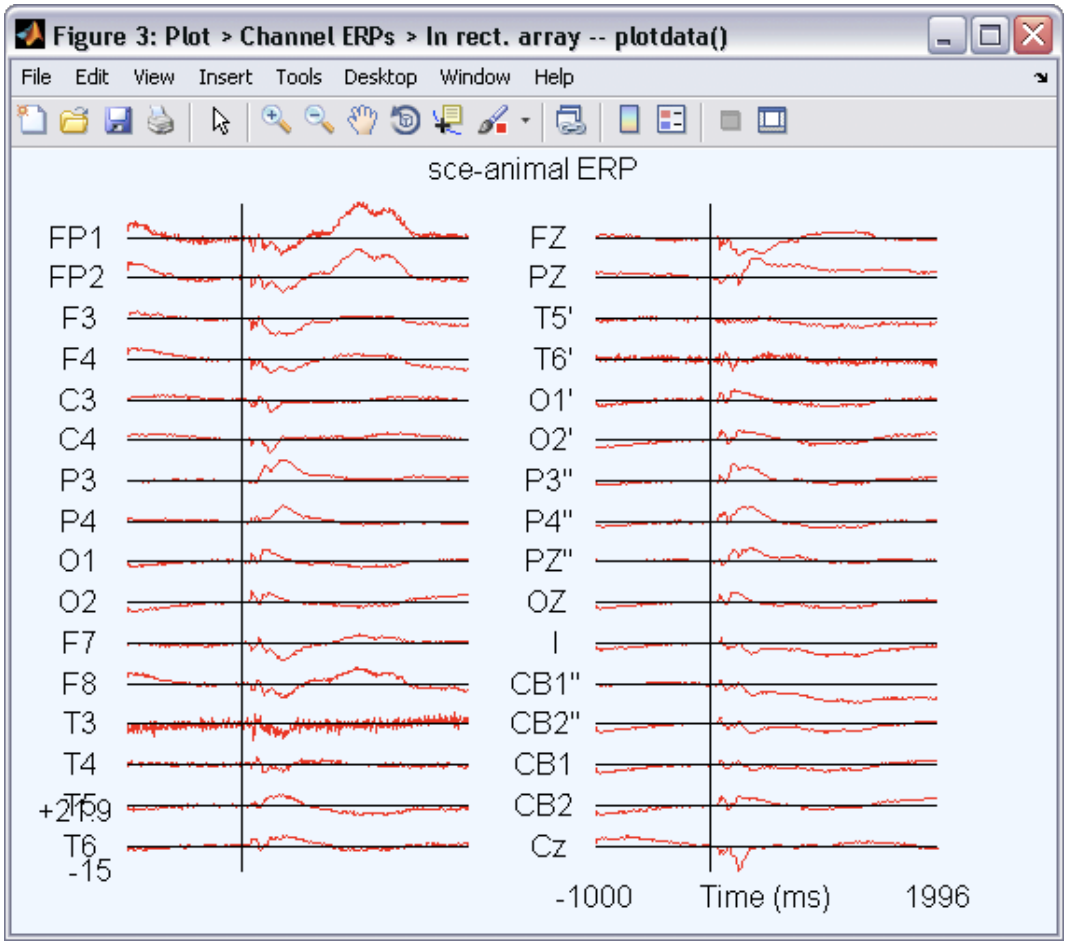
Component ERSP & Coherence

Exercise...

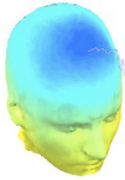
Component ERPs

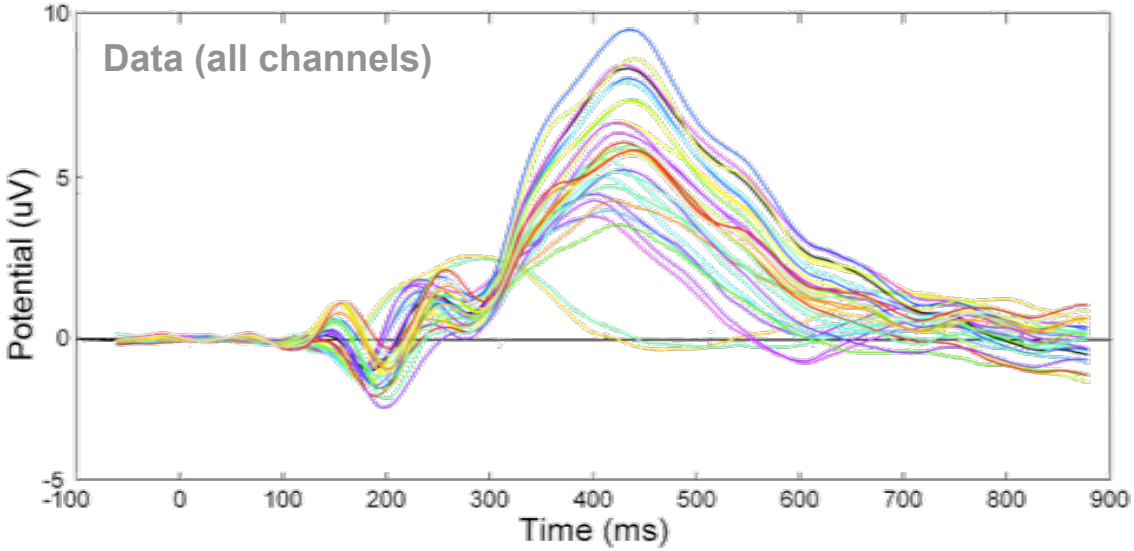


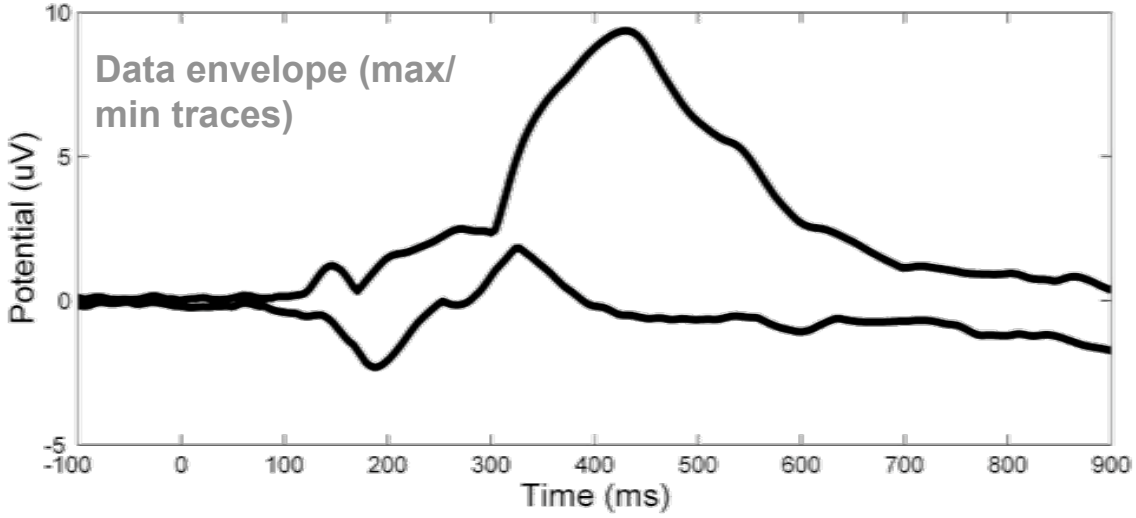




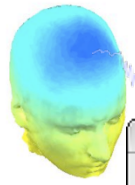
Definition: The data envelope

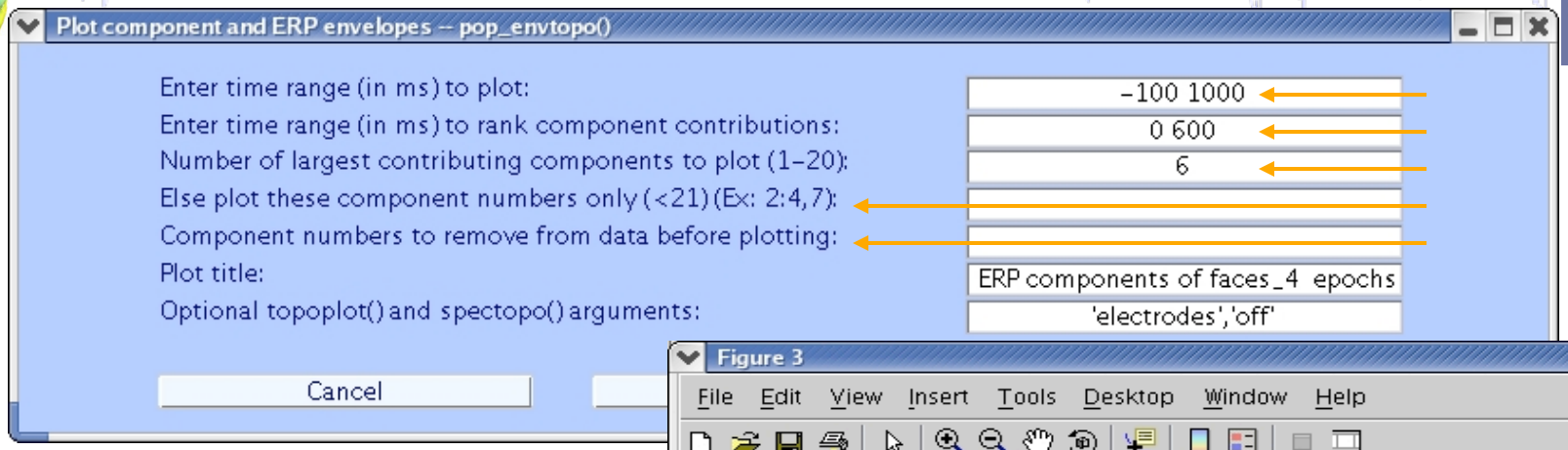


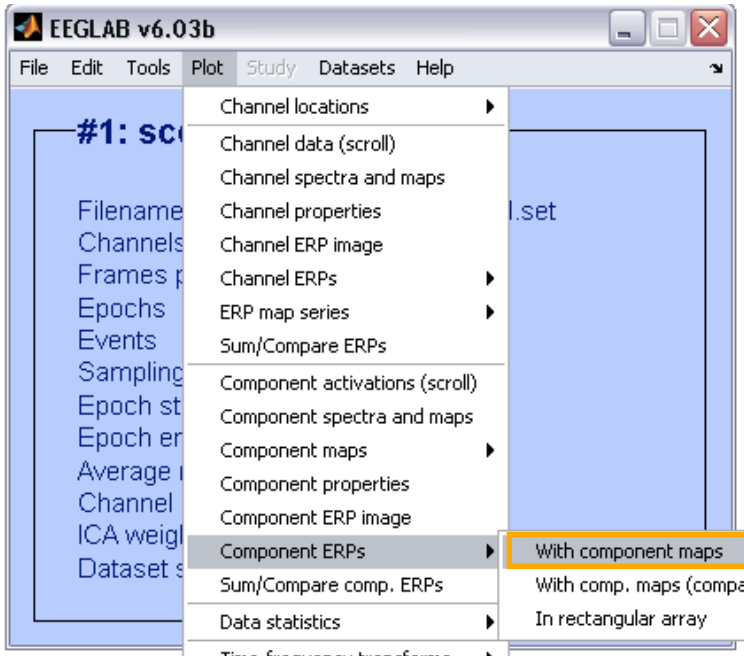


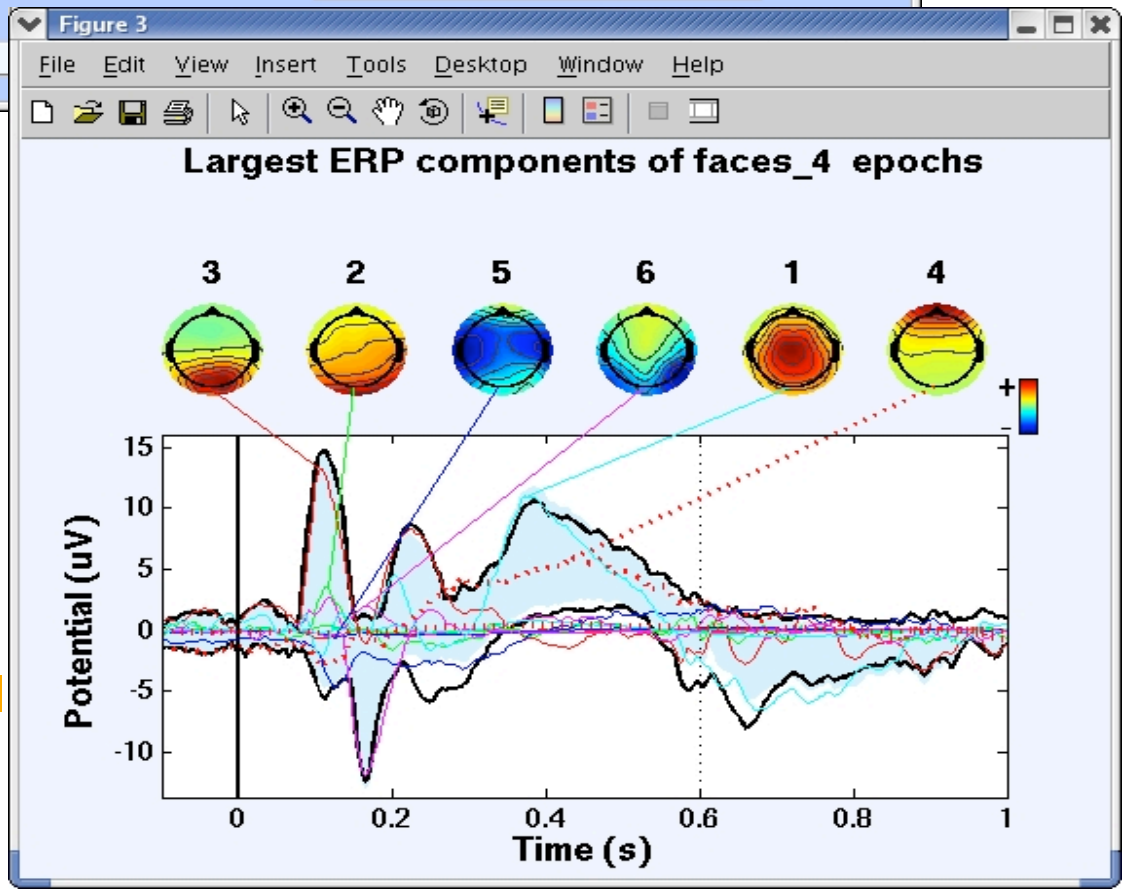


IC contributions to ERP envelope

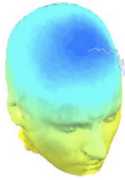








Evaluating ICA components



Component Scalp Maps & Activity

Component ERP

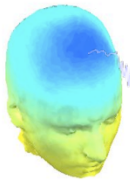
Component spectral power

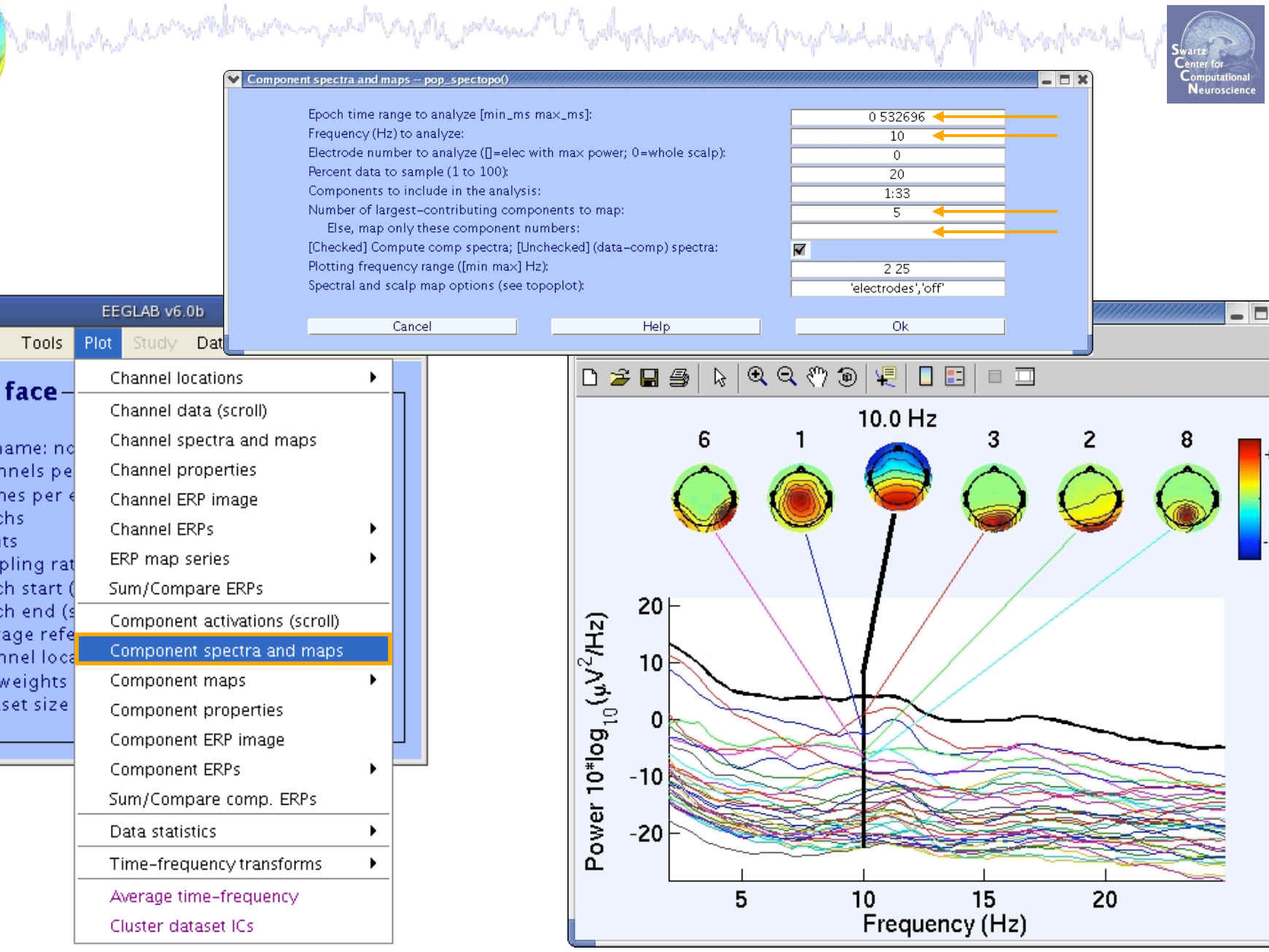
Component ERP images

Component ERSP & Coherence

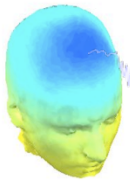
Exercise...

Plot component power





Plot component power



Component spectra and maps -- pop_spectopo()

Epoch time range to analyze [min_ms max_ms]: 0 532696
Frequency (Hz) to analyze: 6
Electrode number to analyze ([]=elec with max power; 0=whole scalp): 0
Percent data to sample (1 to 100): 20
Components to include in the analysis: 1:33
Number of largest-contributing components to map: 5
Else, map only these component numbers:
[Checked] Compute comp spec
Plotting frequency range ([min
Spectral and scalp map options
Cancel

EEGLAB v6.0b

File Edit Tools Plot Study Dat

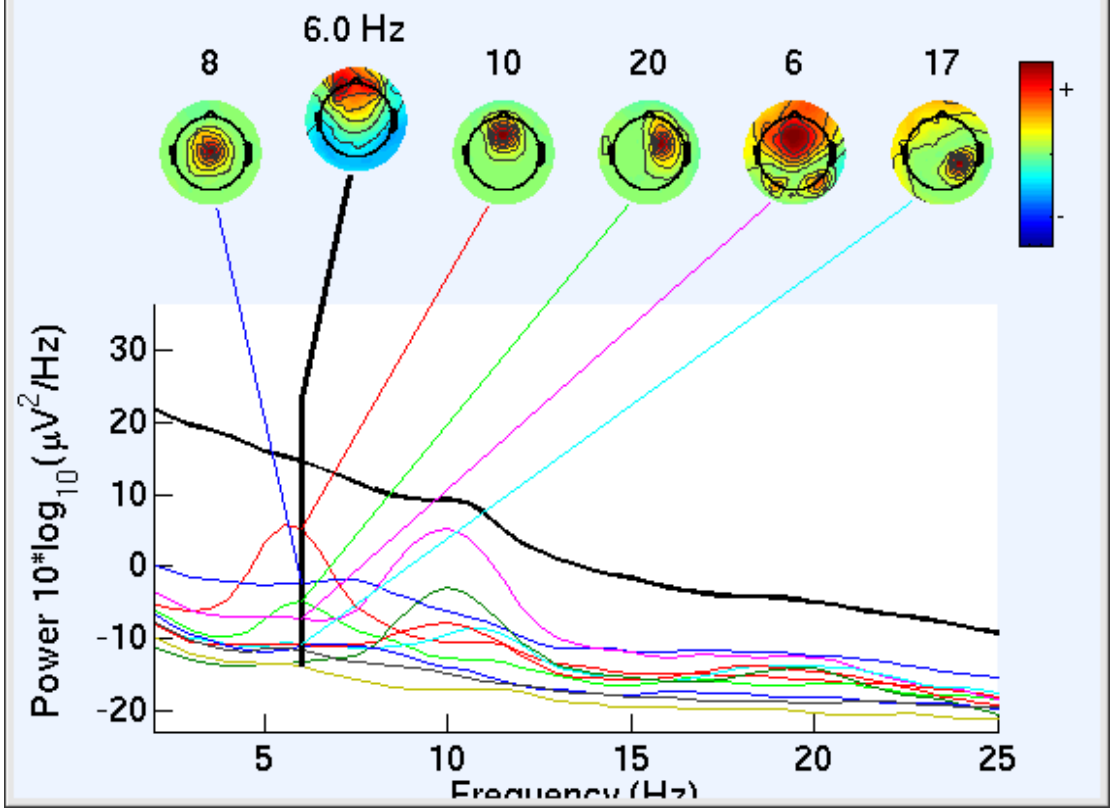
#2: face

Filename: nc
Channels pe
Frames per e
Epochs
Events
Sampling rat
Epoch start (
Epoch end (s
Average refe
Channel loca
ICA weights
Dataset size

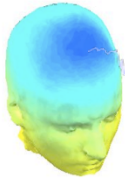
- Channel locations
- Channel data (scroll)
- Channel spectra and maps
- Channel properties
- Channel ERP image
- Channel ERPs
- ERP map series
- Sum/Compare ERPs
- Component activations (scroll)
- Component spectra and maps
- Component maps
- Component properties
- Component ERP image
- Component ERPs
- Sum/Compare comp. ERPs
- Data statistics
- Time-frequency transforms
- Average time-frequency
- Cluster dataset ICs

Figure 7: spectopo()

File Edit View Insert Tools Desktop Window Help



Evaluating ICA components



Component Scalp Maps & Activity

Component ERP

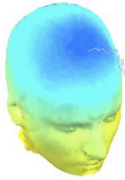
Component spectral power

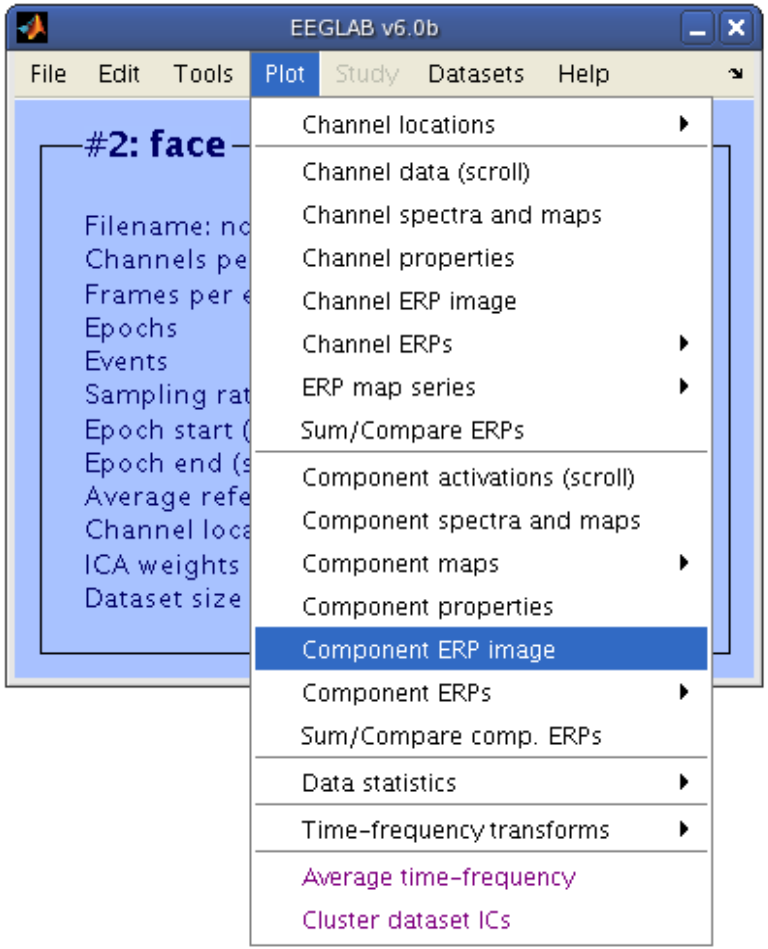
Component ERP images

Component ERSP & Coherence

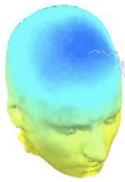
Exercise...

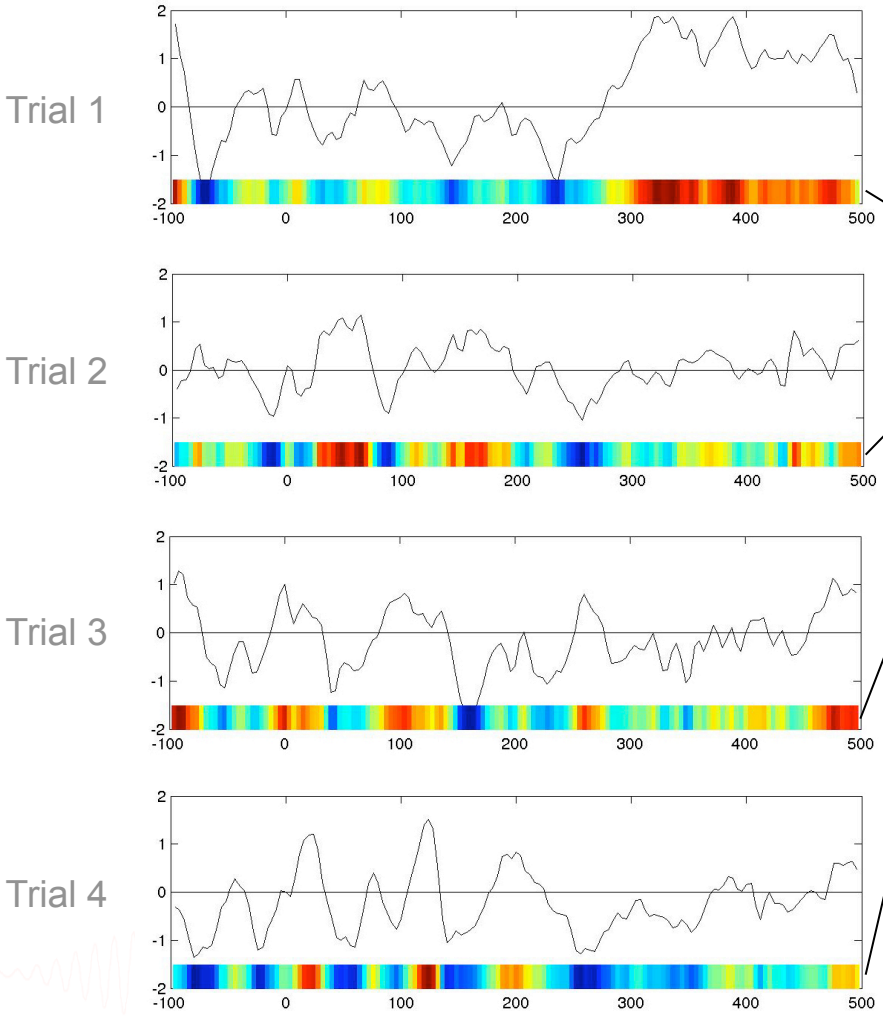
Component ERP image



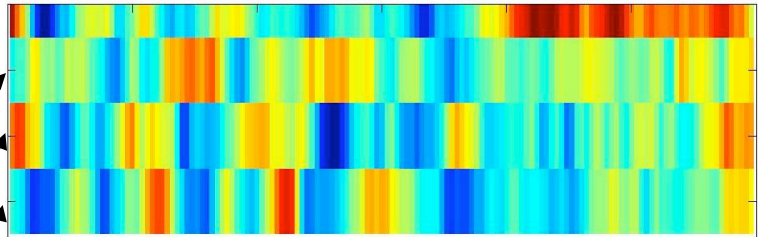


ERP Image basics



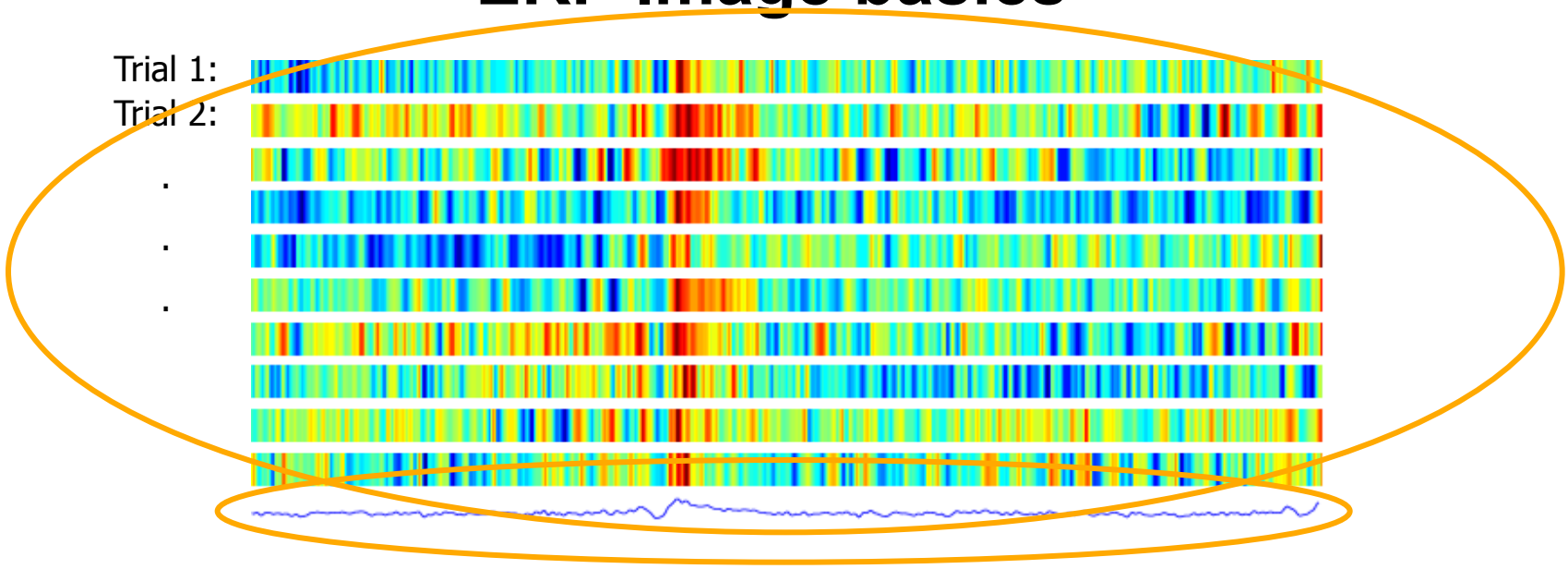


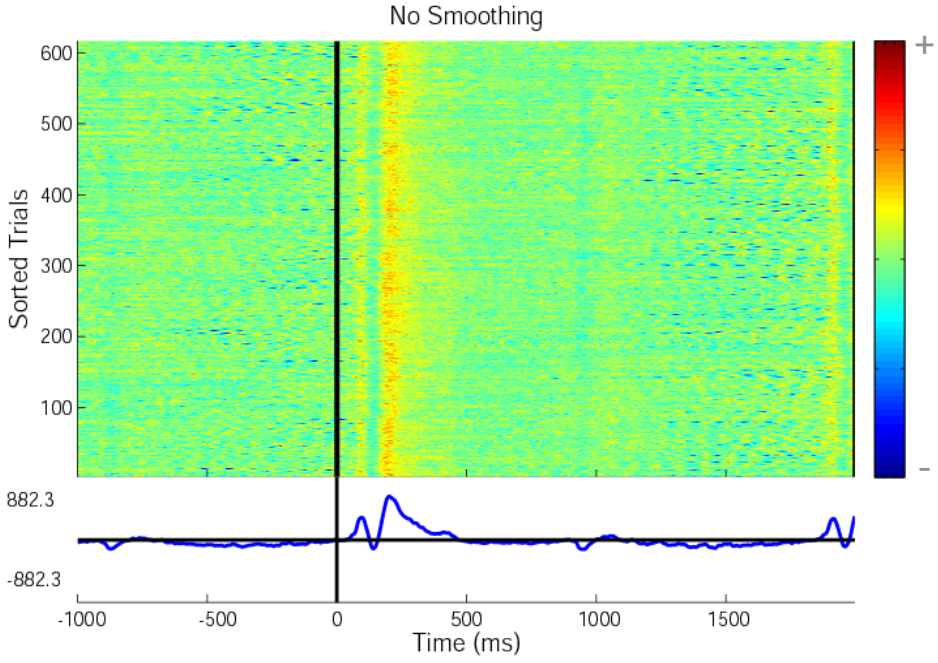
ERP Image

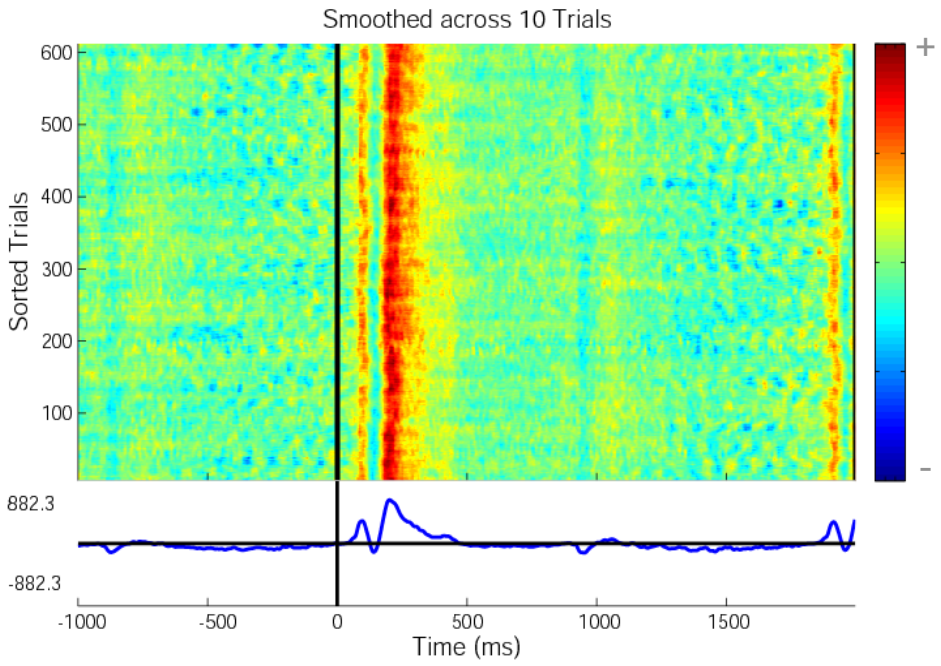


by default, sorted by time-on-task
(1st trial, 2nd trial, ...)

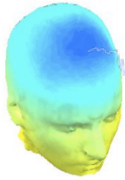
ERP Image basics

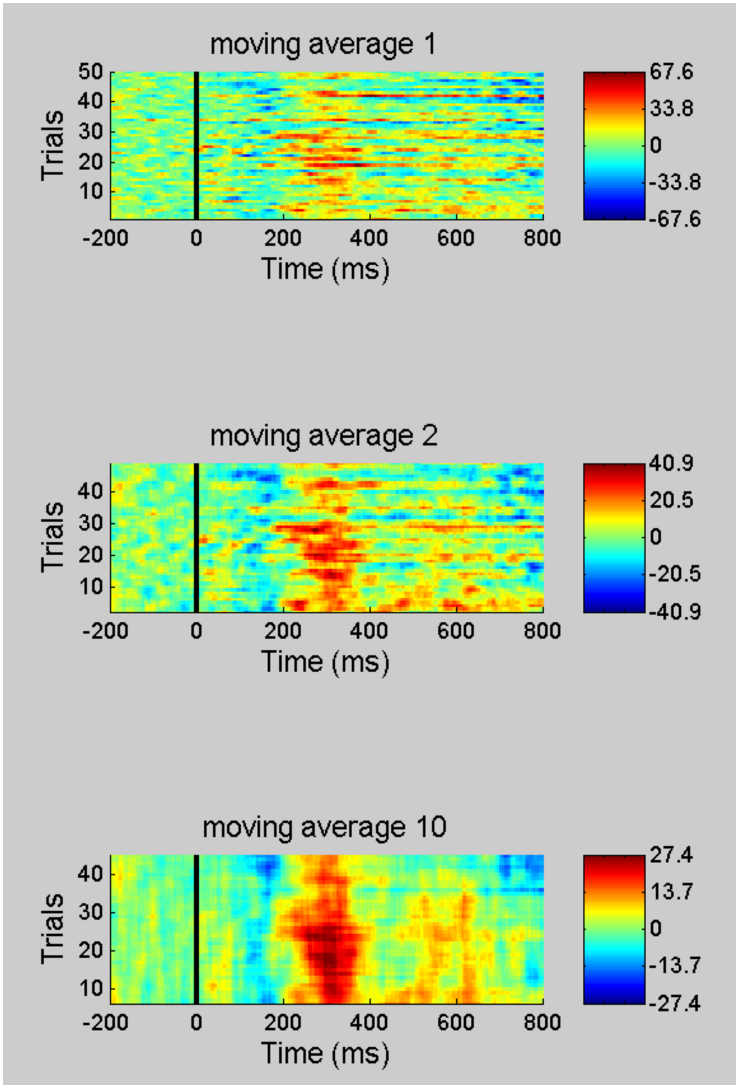




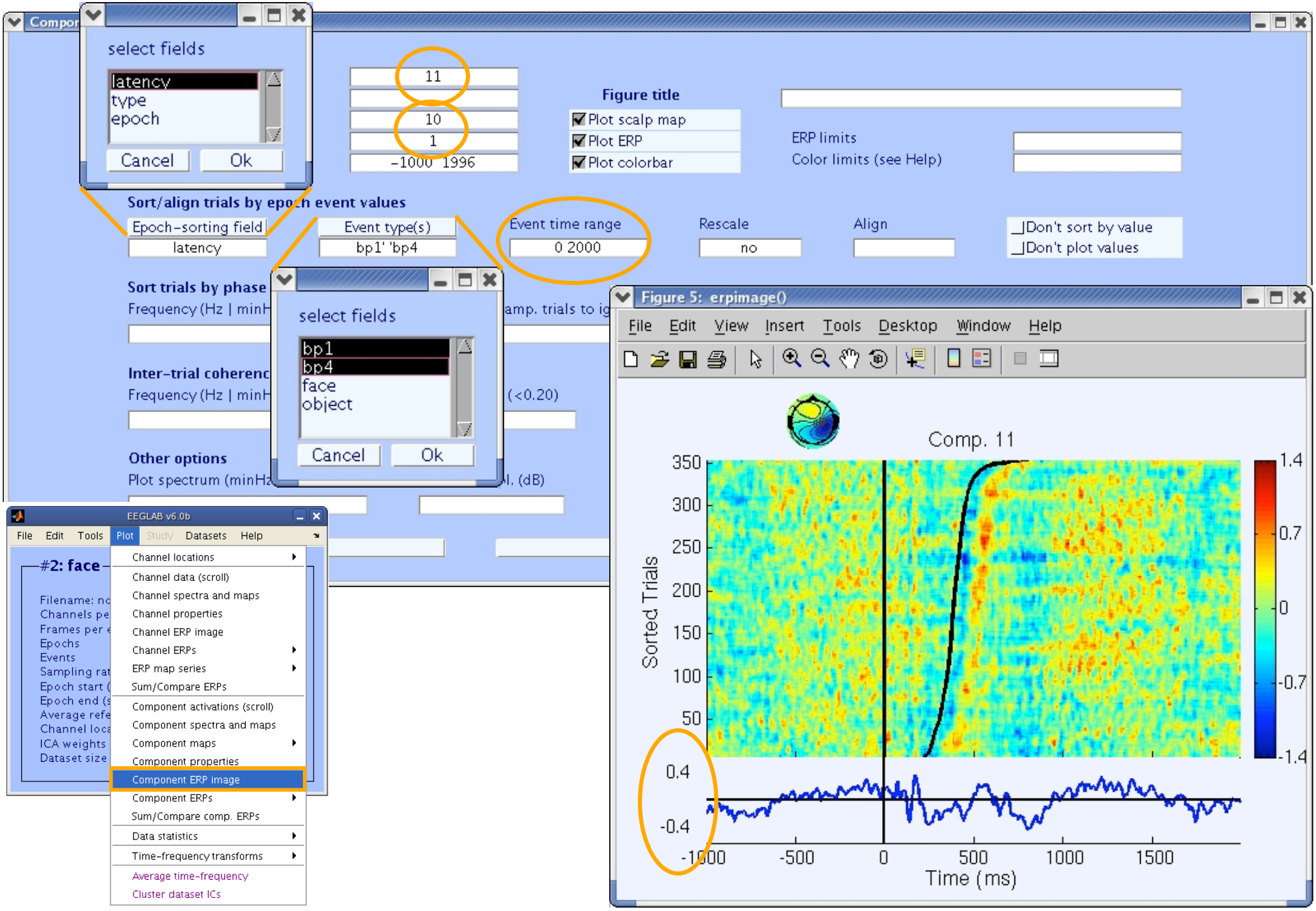


ERP Images: smoothing across trials

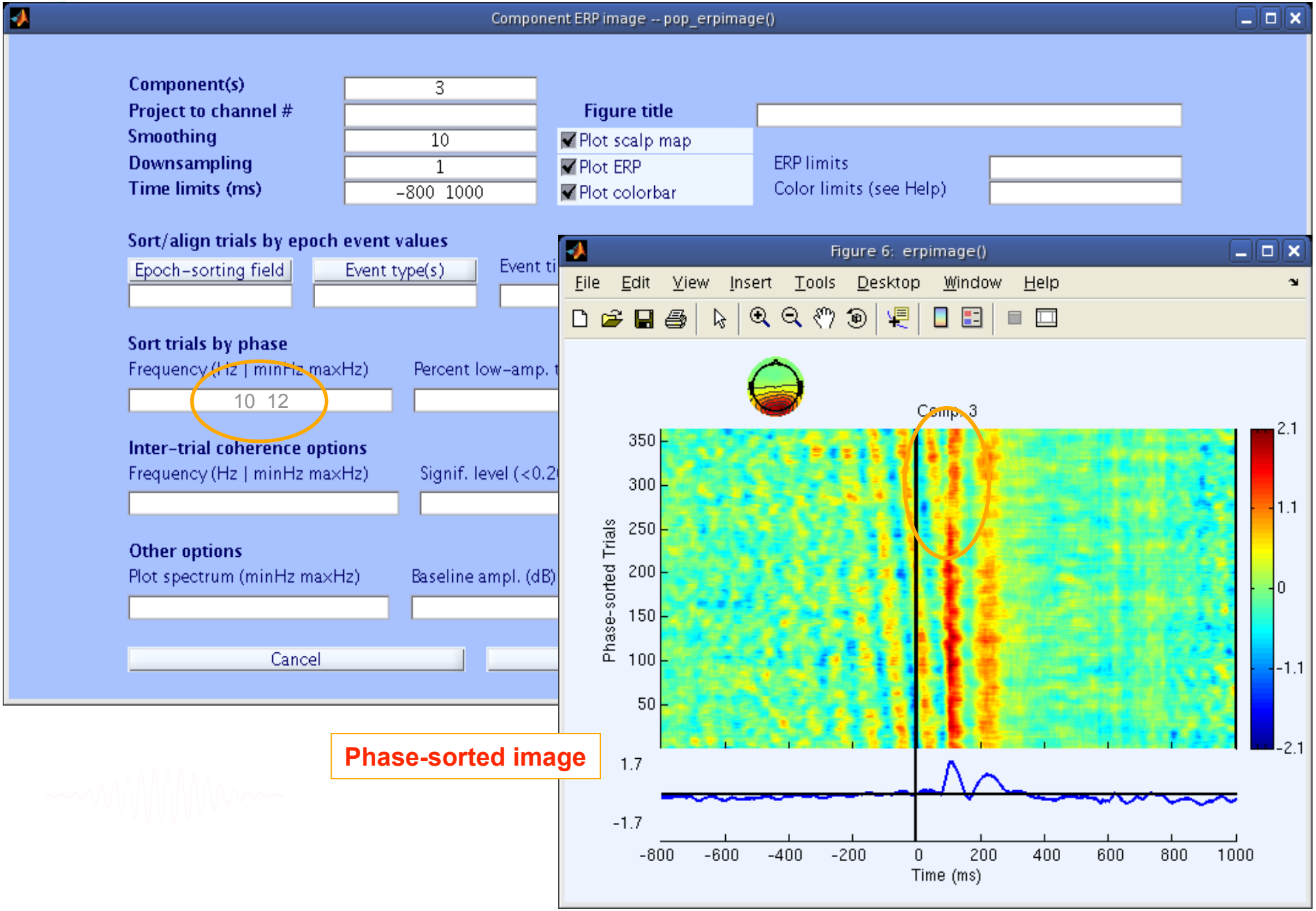




Component ERP Images

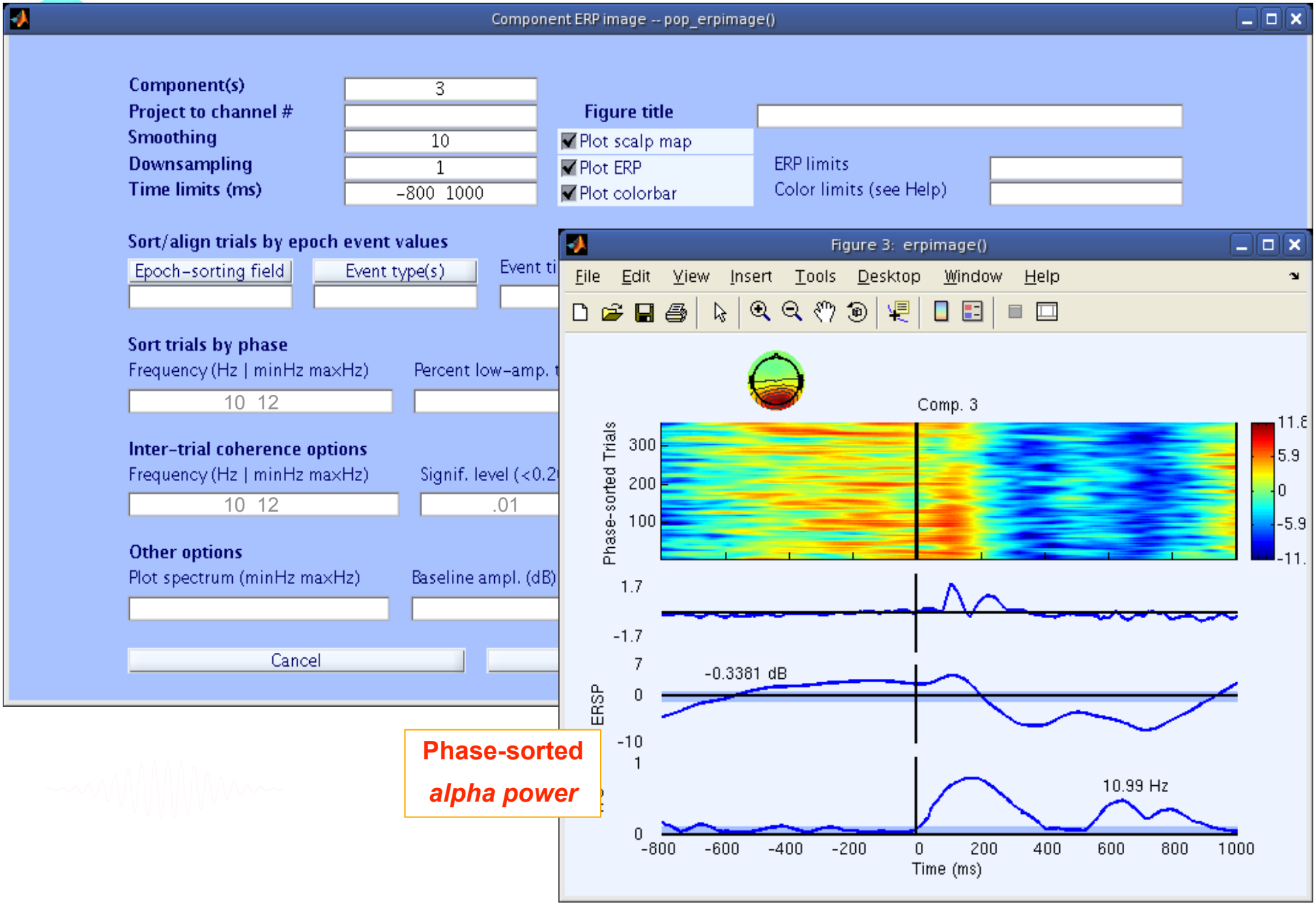


Component ERP Images



Phase-sorted image

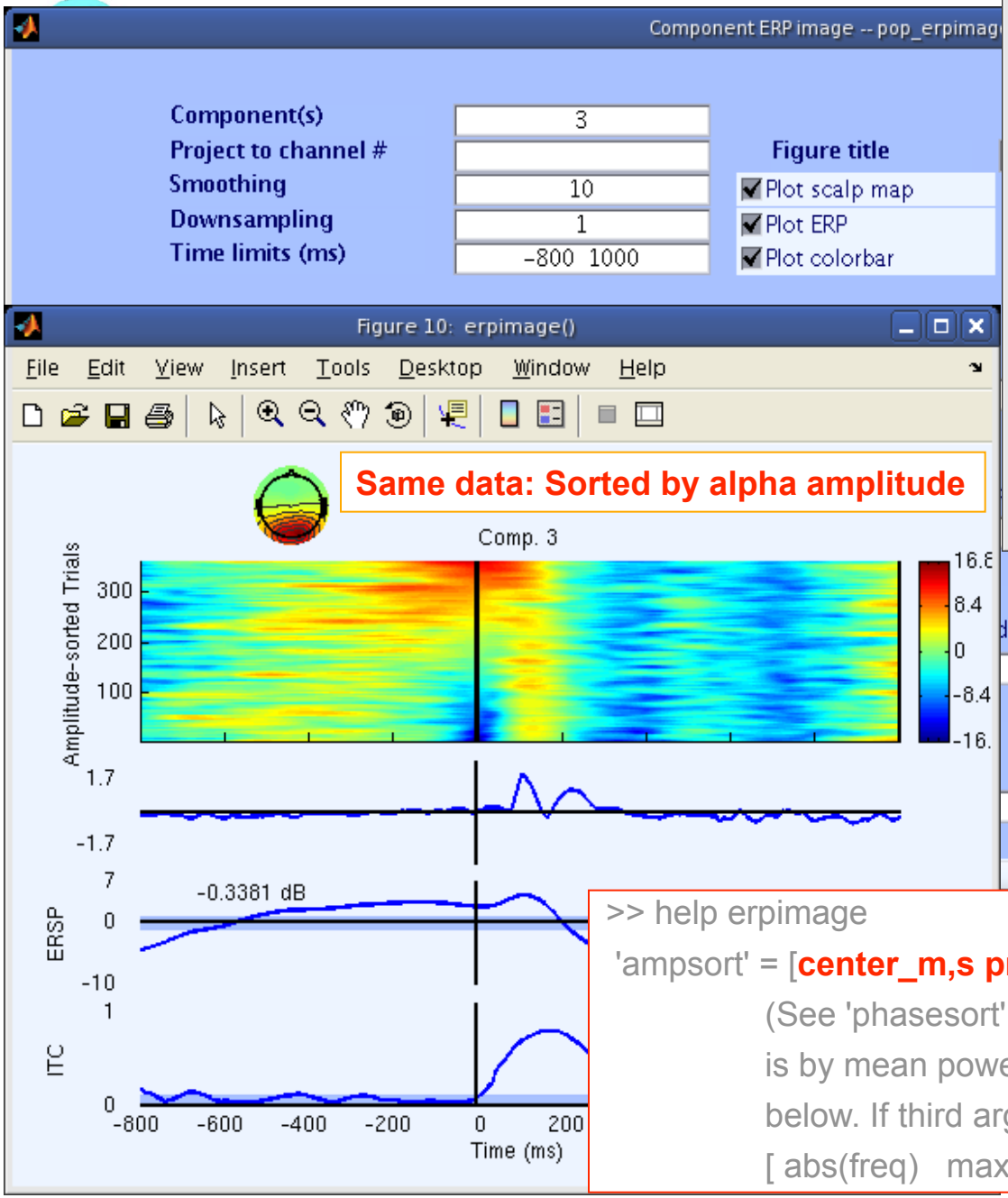
Component ERP Images

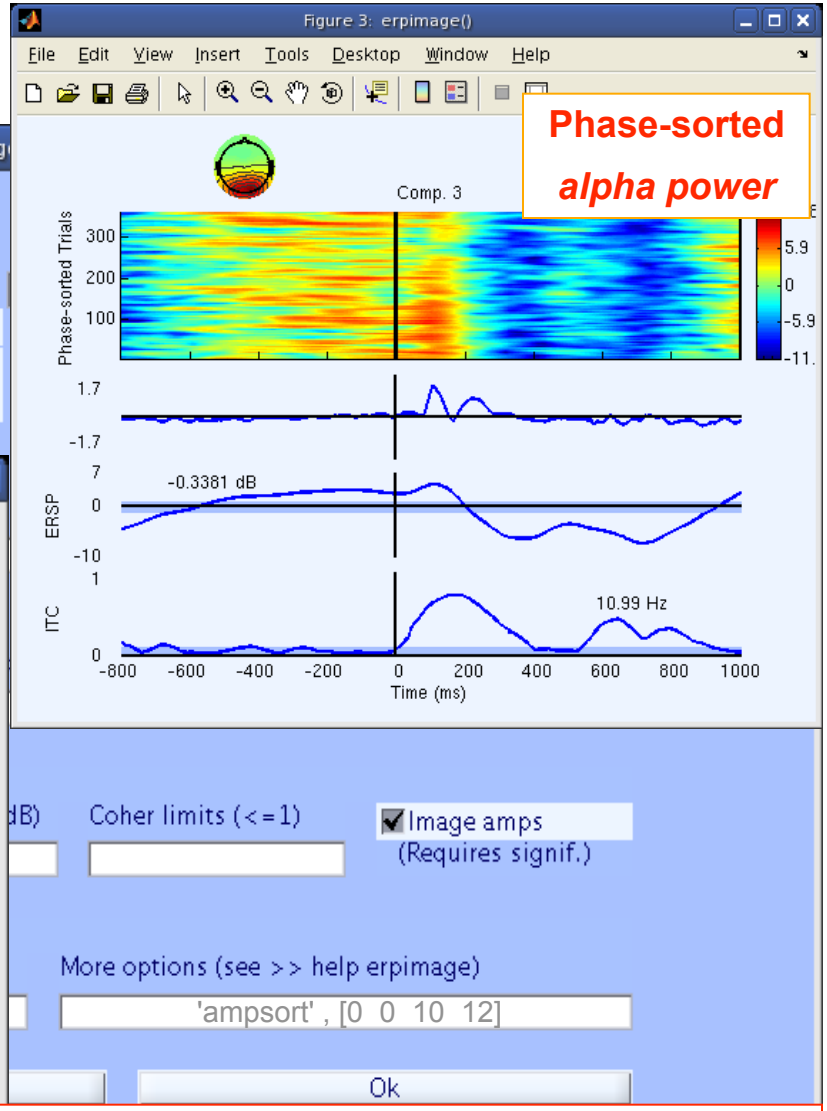


Phase-sorted

alpha power

Component ERP

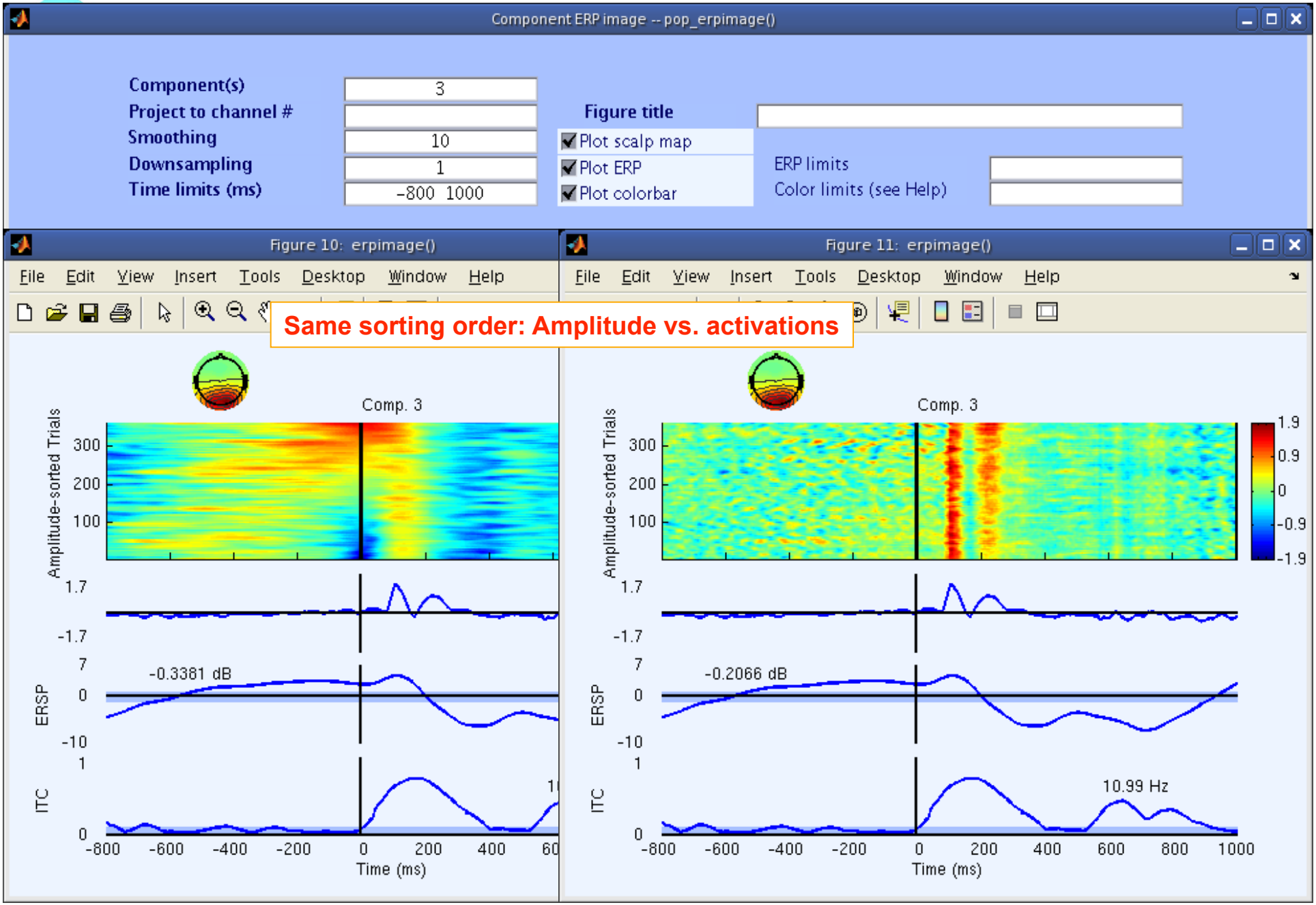




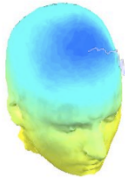
>> help erpimage

'ampsort' = [**center_m,s prcnt, freq, maxfreq**] Sort epochs by amplitude. (See 'phasesort' above). If ms_center is 'Inf', then sorting is by mean power across the time window specified by 'sortwin' below. If third arg, freq, is < 0, sort by mean power in the range [abs(freq) maxfreq].

Component ERP Images



Evaluating ICA components



Component Scalp Maps & Activity

Component ERP

Component spectral power

Component ERP images

Component ERSP & Coherence

Exercise...

Plot IC ERSP

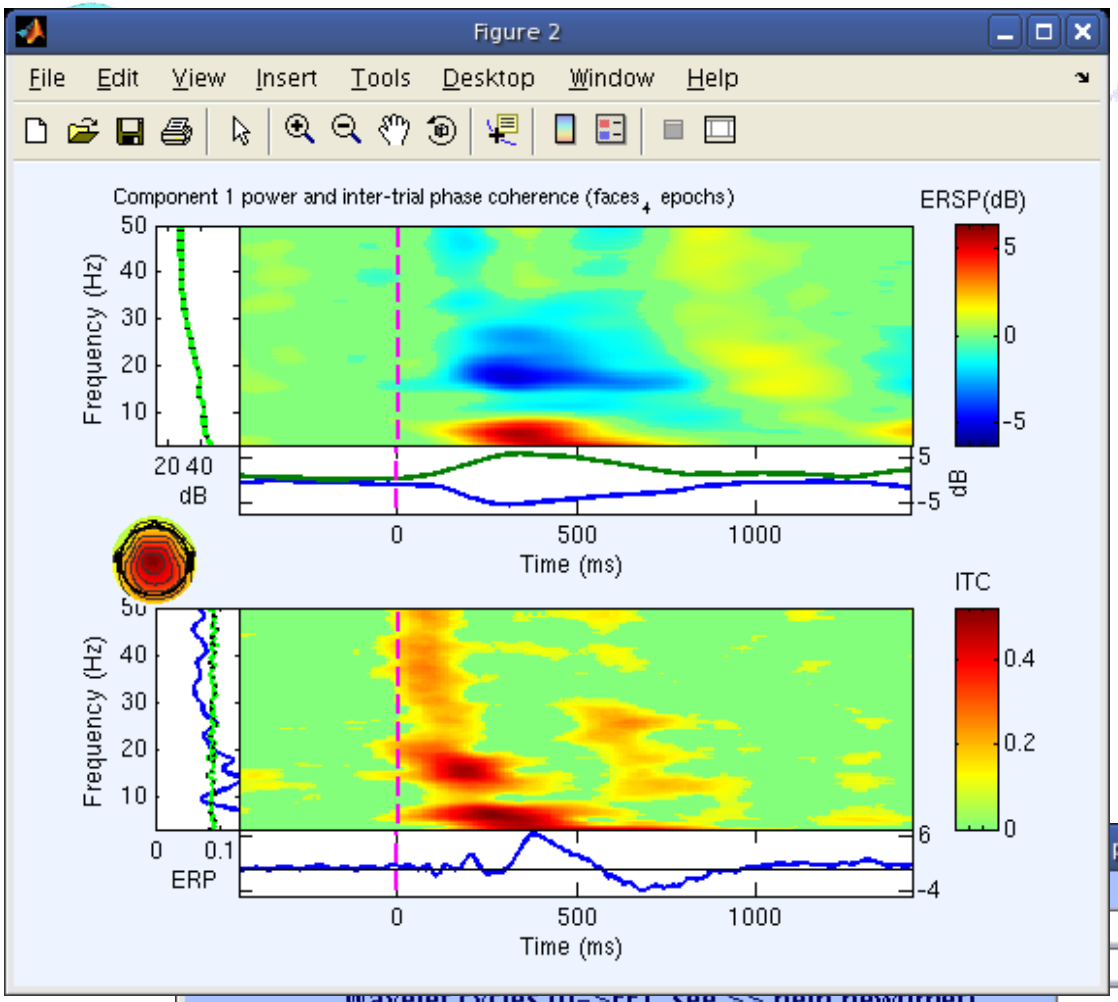
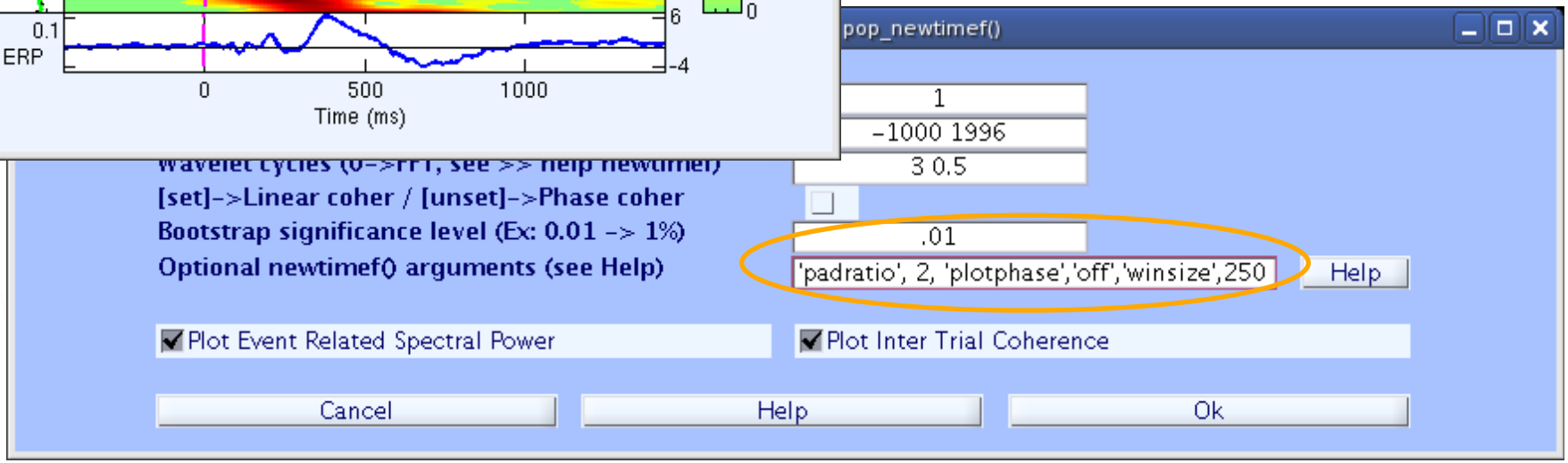
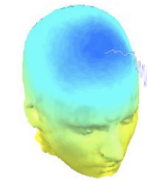
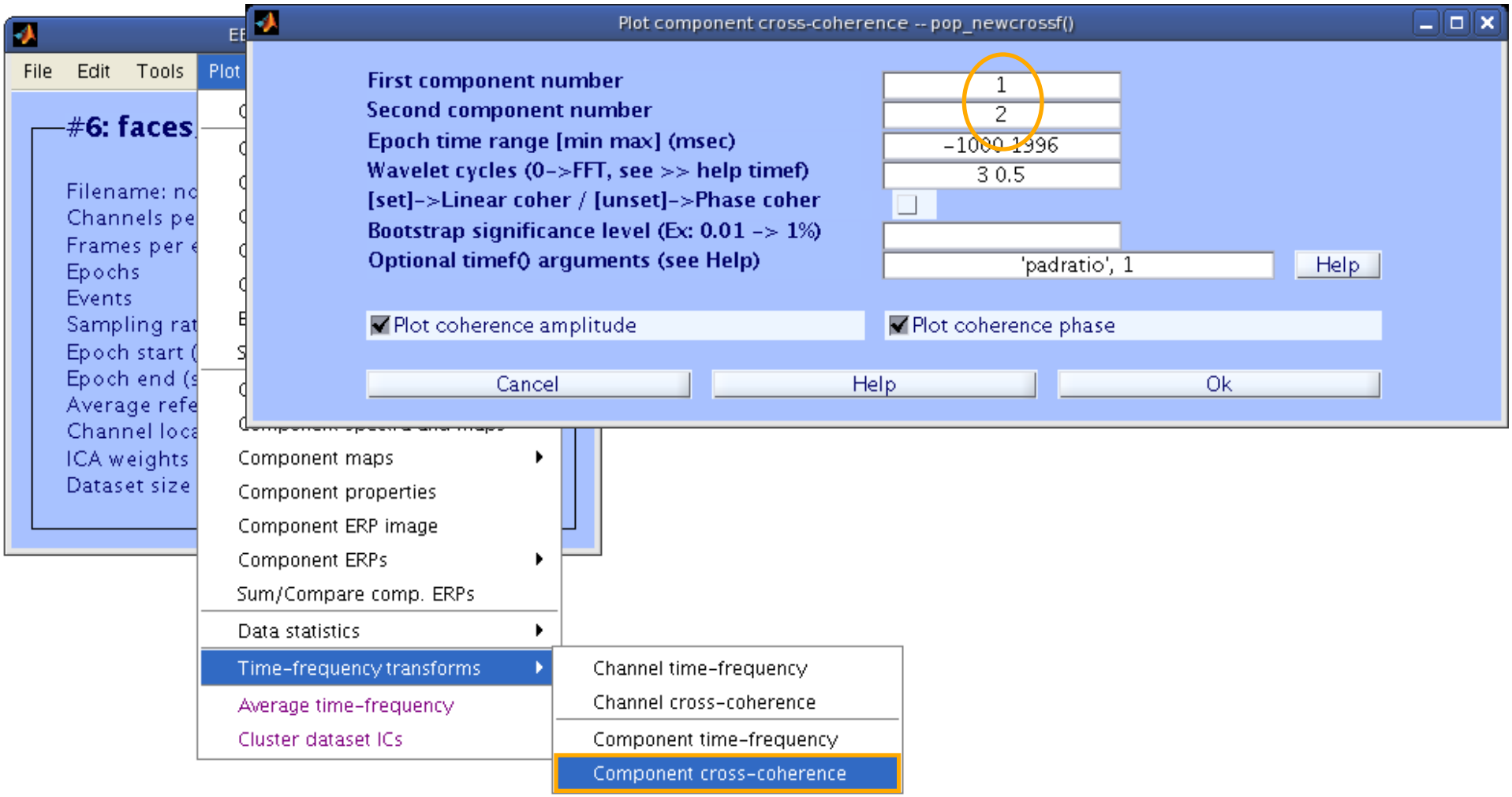


Figure 2
File Edit View Insert Tools Desktop Window Help
Component 1 power and inter-trial phase coherence (faces, epochs)
ERSP(dB)
Frequency (Hz)
50
40
30
20
10
20 40
dB
5
0
-5
dB
0
500
1000
Time (ms)
ITC
0.4
0.2
0
0
0.1
ERP
6
-4
0
500
1000
Time (ms)

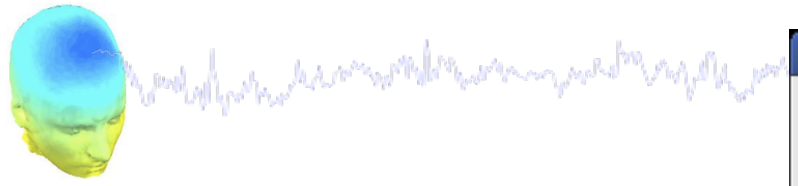

pop_newtimef()
1
-1000 1996
3 0.5
[set]->Linear coher / [unset]->Phase coher
Bootstrap significance level (Ex: 0.01 -> 1%)
.01
Optional newtimef() arguments (see Help)
'padratio', 2, 'plotphase','off','winsize',250
Help
Plot Event Related Spectral Power
Plot Inter Trial Coherence
Cancel
Help
Ok

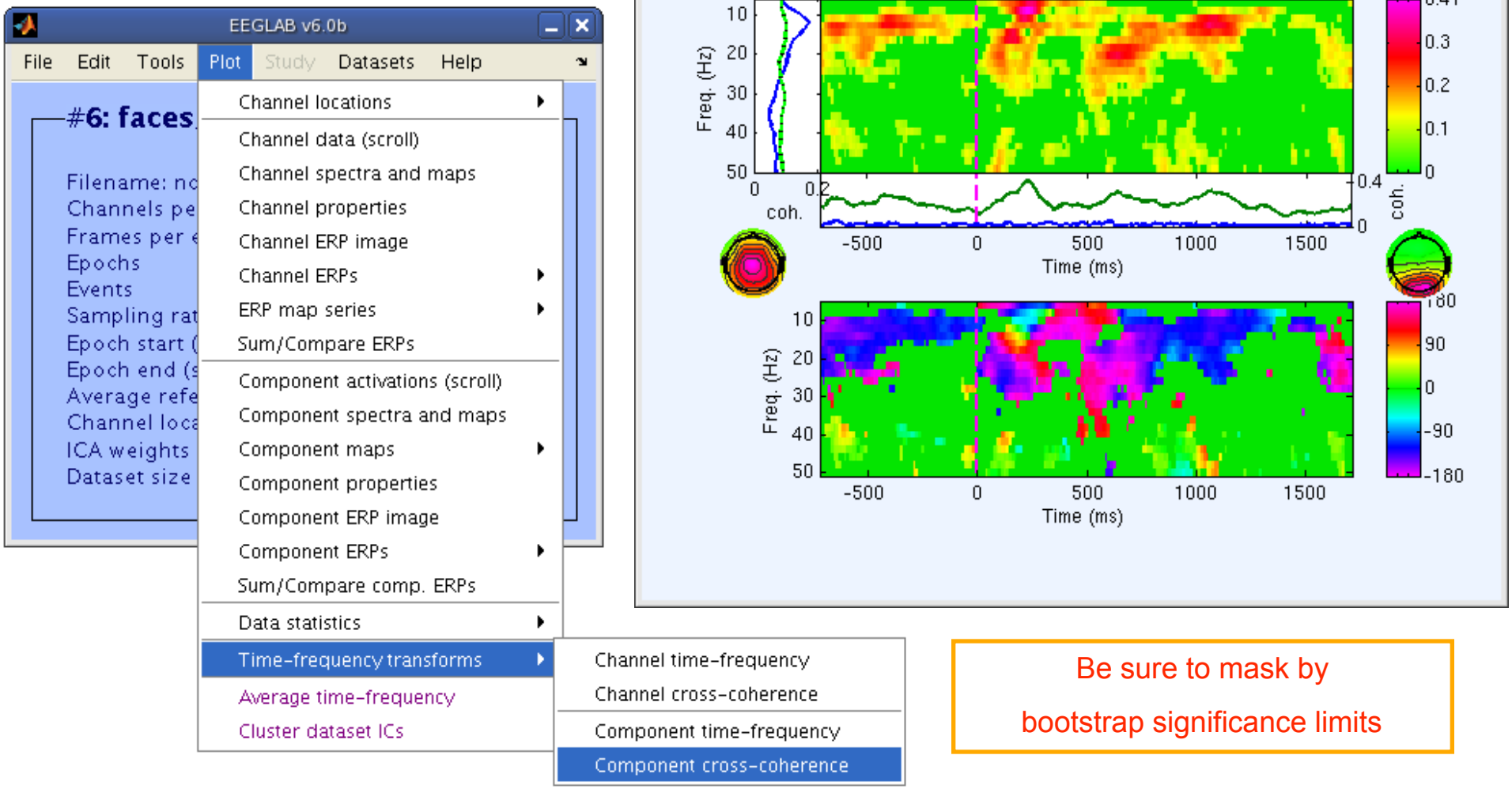
IC cross coherence





IC cross coherence

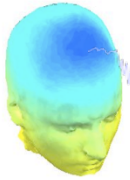




Be sure to mask by

bootstrap significance limits

Exercise



- **ALL**
  Load faces_3.set or faces_4.set, epoch, reject noise

- **ALL**
  -From the GUI, plot component ERPs with maps
  -Pick an interesting IC/ERP (e.g. component contributing to N170) and plot an ERP image of it
  -Try sorting by RT or phase, is there any relationship to the IC activation pattern? What about power in a frequency band of choice?

- **Advanced**
  -Plot cross coherence between two selected Ics studied above
  -Compare this result with cross coherence between two channels that are highly weighted in the respective ICs