Outline

- ❑ Running ICA in EEGLAB
- ❑ Evaluate ICA results:
  - ✓ Scalp maps
  - ✓ Activations
  - ✓ Power
  - ✓ ERP images
  - ✓ ERSP (time/freq)
  - ✓ Cross coherence
- ❑ Exercise...

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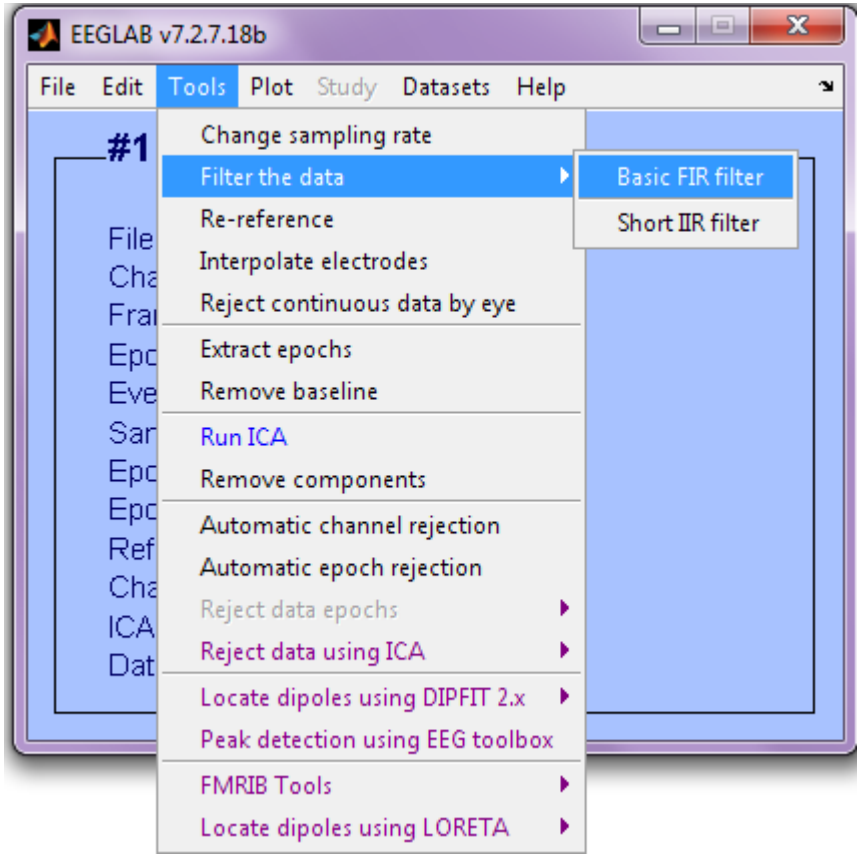
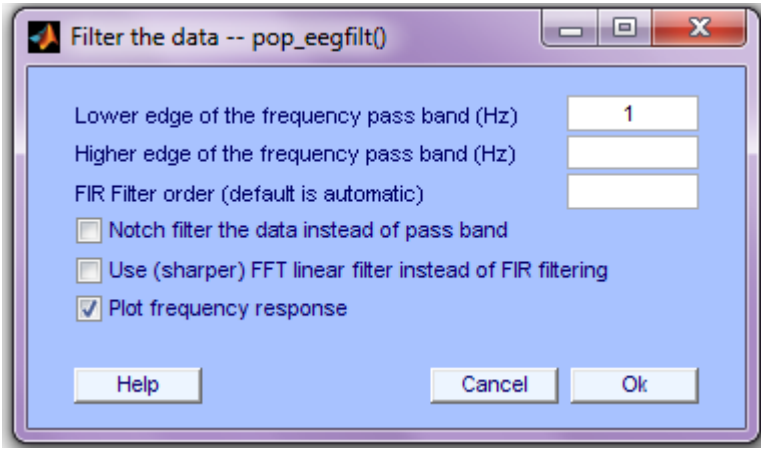
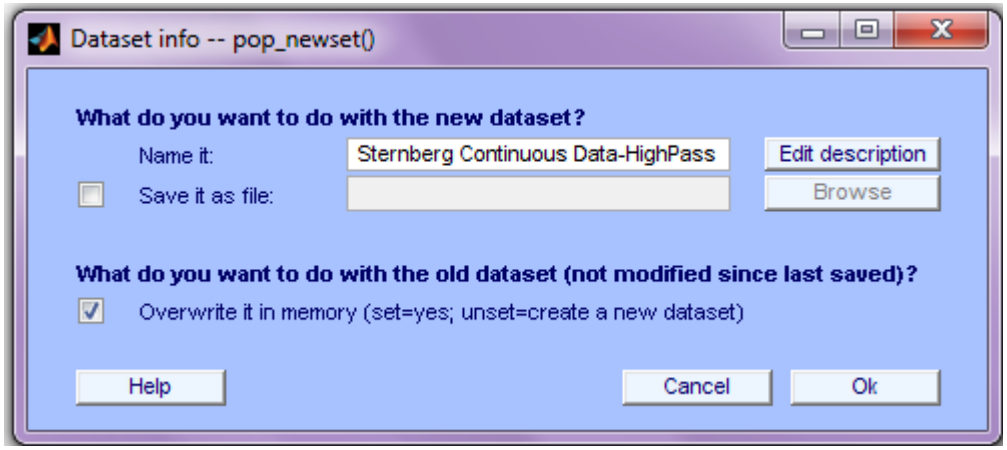
- Exercise...

Filter the data (if necessary/desired)

High-pass recommended

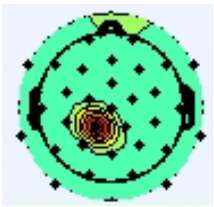






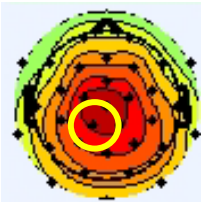
Remove channel(s)

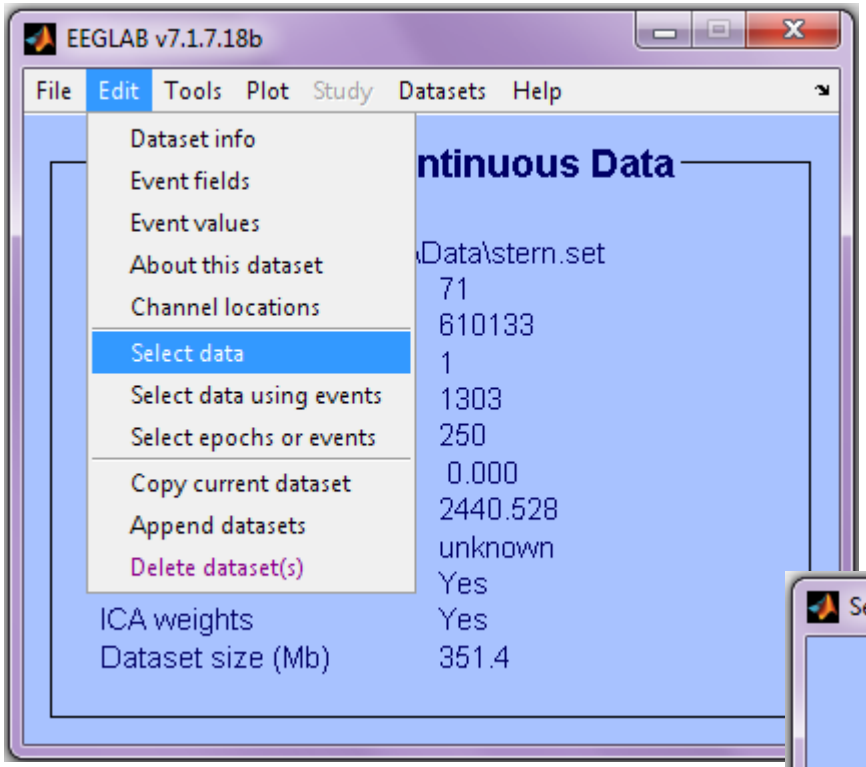
Why?

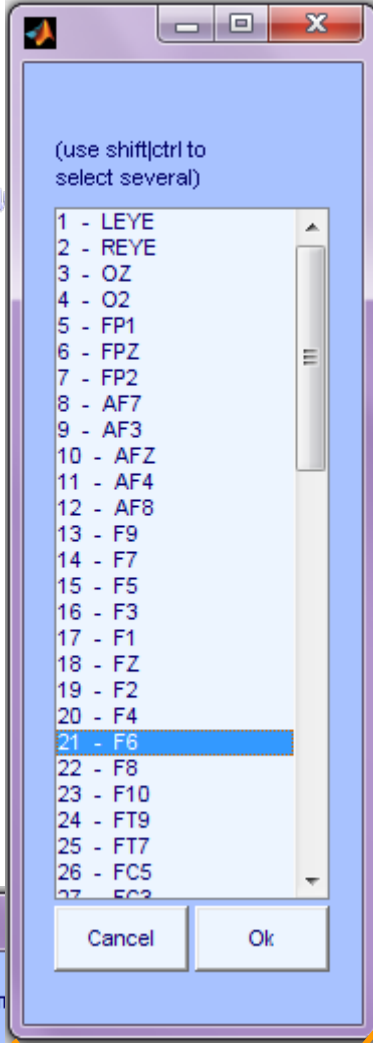


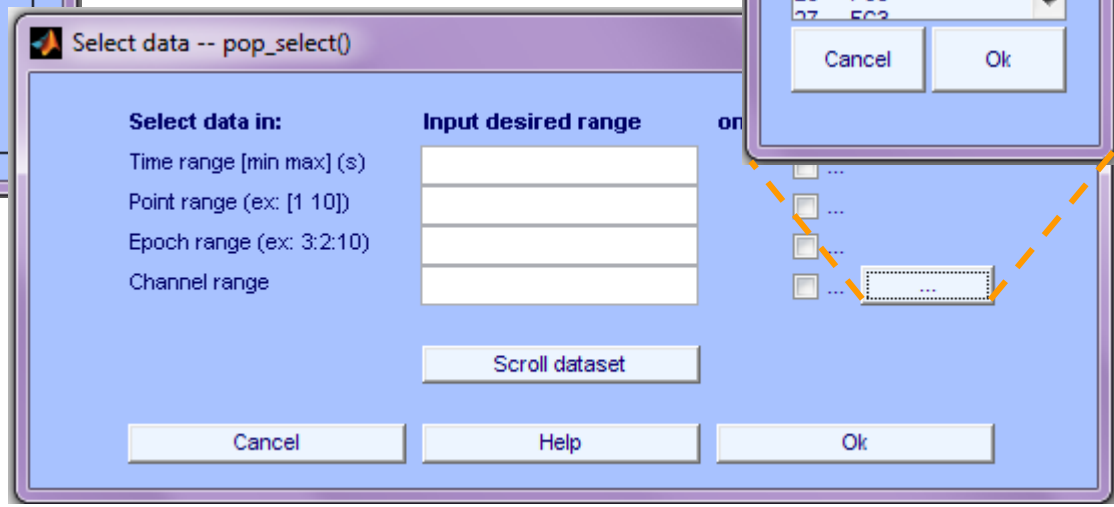
If this channel is unstable,

this IC may sometimes be compromised…

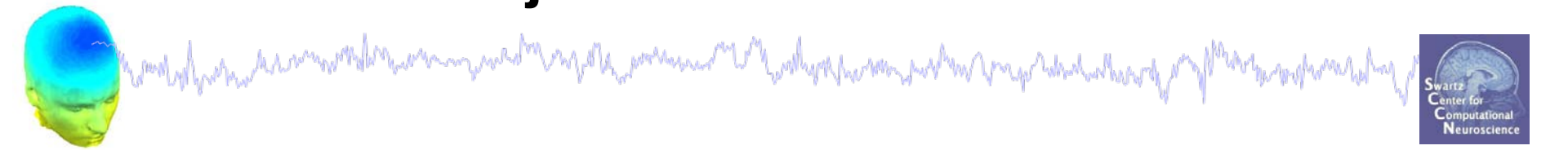








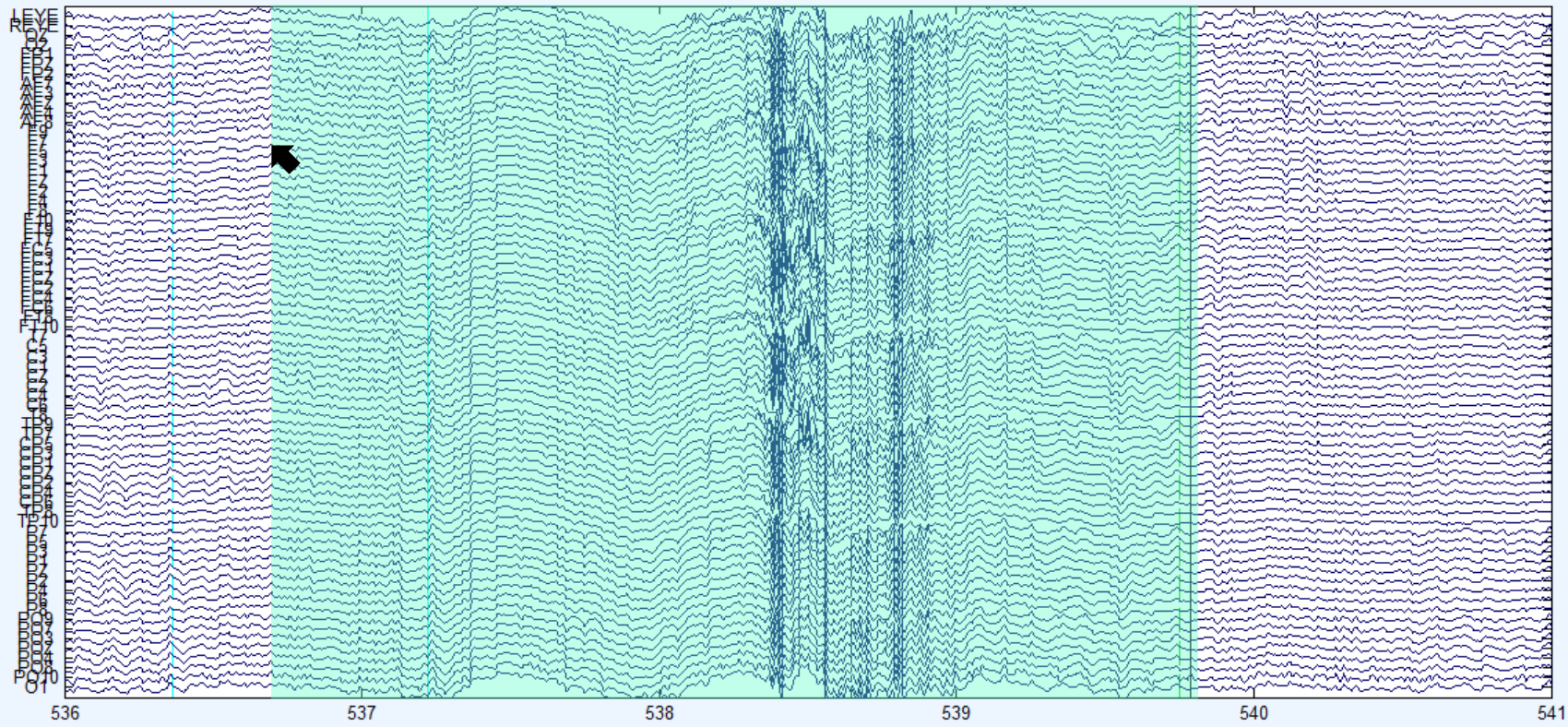
Reject continuous data



Scroll channel activities -- eegplot()

Figure Display Settings Help

Click and drag with mouse over noisy data to reject



CANCEL | Event types | << | < | 536 | > | >>

Chan. FC6 | Time 539.9355 | Value 4.8773

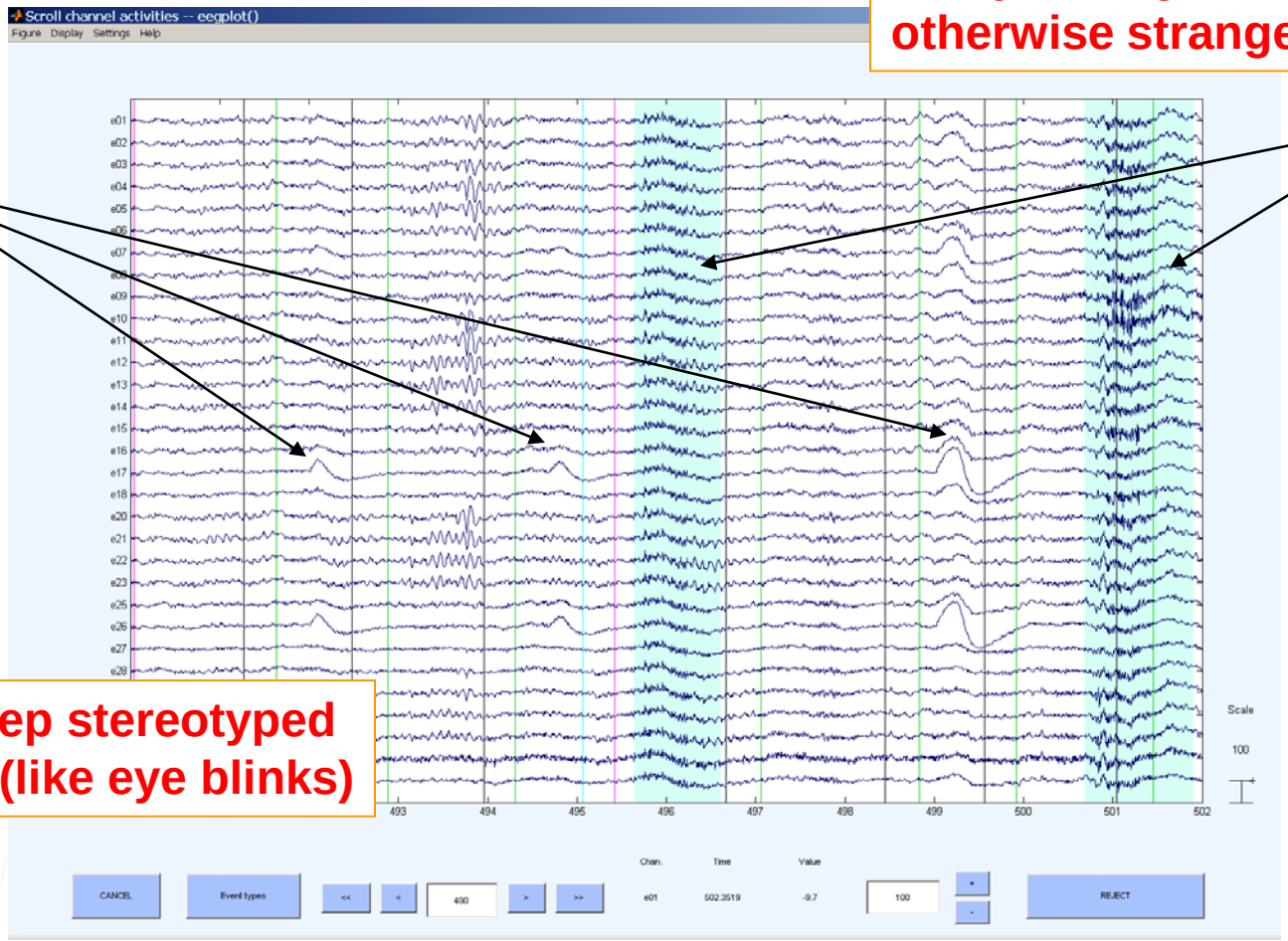
35 | + | -

REJECT

Rejecting data for ICA

To prepare data for ICA:

Reject large muscle or otherwise strange events...

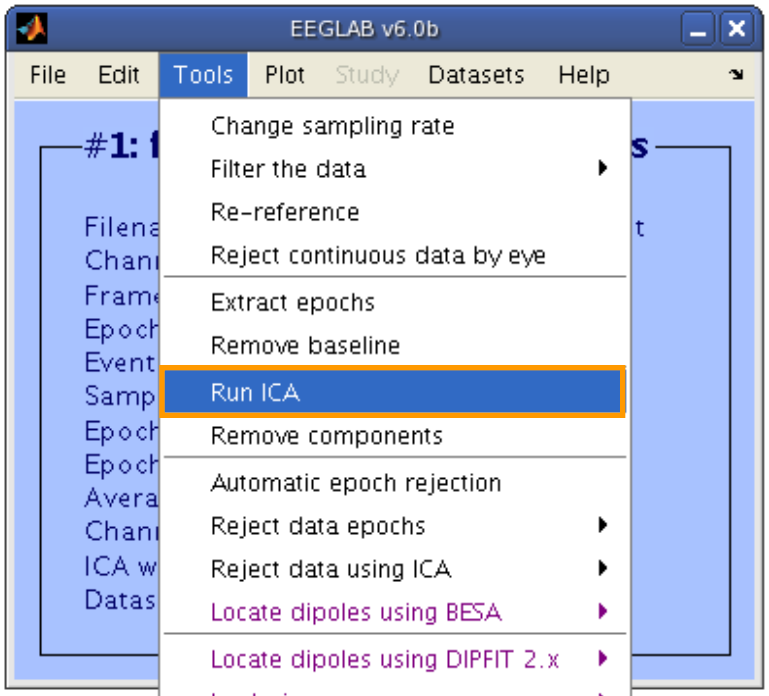


... but keep stereotyped artifacts (like eye blinks)

“Secrets” to a good ICA decomposition

- Garbage in… garbage out (it’s not magic)
- Remove large, non-stereotyped artifacts
- Do you have enough data? (based mostly on time, not frames)
- High-pass filter to remove slow drifts (no low-pass filter needed)
- Remove bad channels
- Data must be in double precision (not single)

Runica options



Option	Default	Comments
'extended'	0	1 is recommended to find sub-gaussians
'stop'	1e-7	final weight change → stop
'pca'	0 or EEG.nbchan	Decompose only a principal data subspace

Other algorithms:
binica,amica,sobi,etc…

Runica progress…

Swartz Center for Computational Neuroscience

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

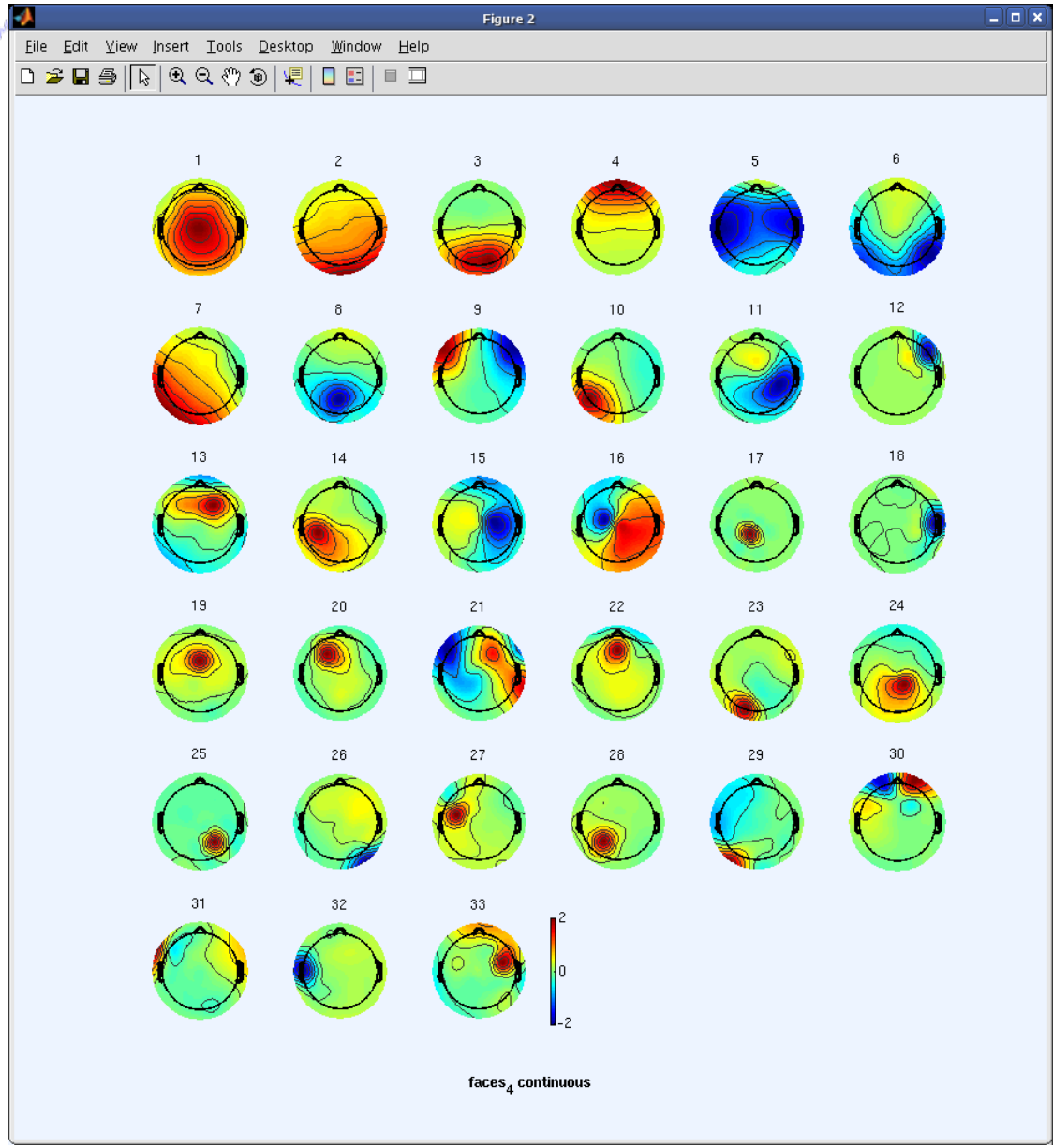
```
step 241 - lrate 0.000002, wchange 0.00000082, angledelta 101.5 deg
step 242 - lrate 0.000001, wchange 0.00000061, angledelta 96.1 deg
step 243 - lrate 0.000001, wchange 0.00000057, angledelta 97.5 deg
step 244 - lrate 0.000001, wchange 0.00000054, angledelta 93.7 deg
step 245 - lrate 0.000001, wchange 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 ...
>>
>>
```

ICA weights in EEG structure

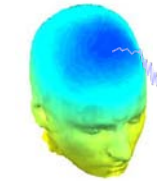
Terminal

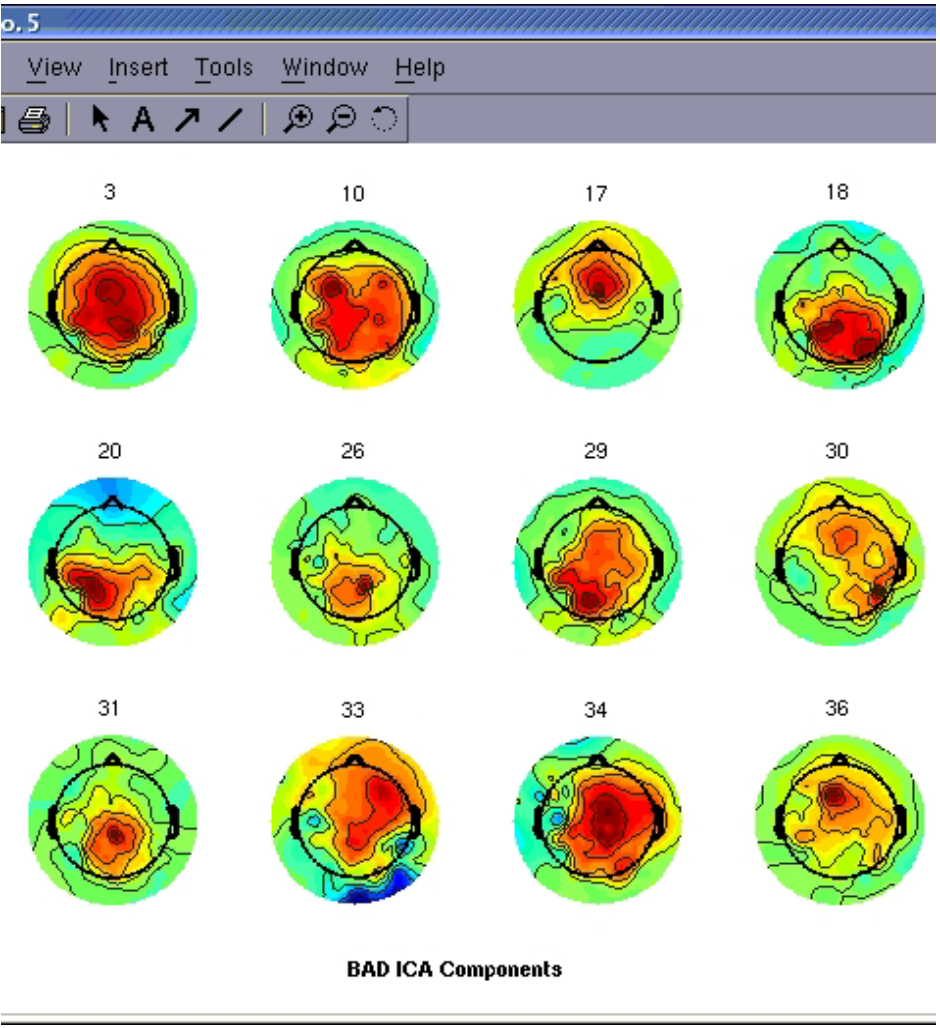
File Edit View Terminal Tabs Help

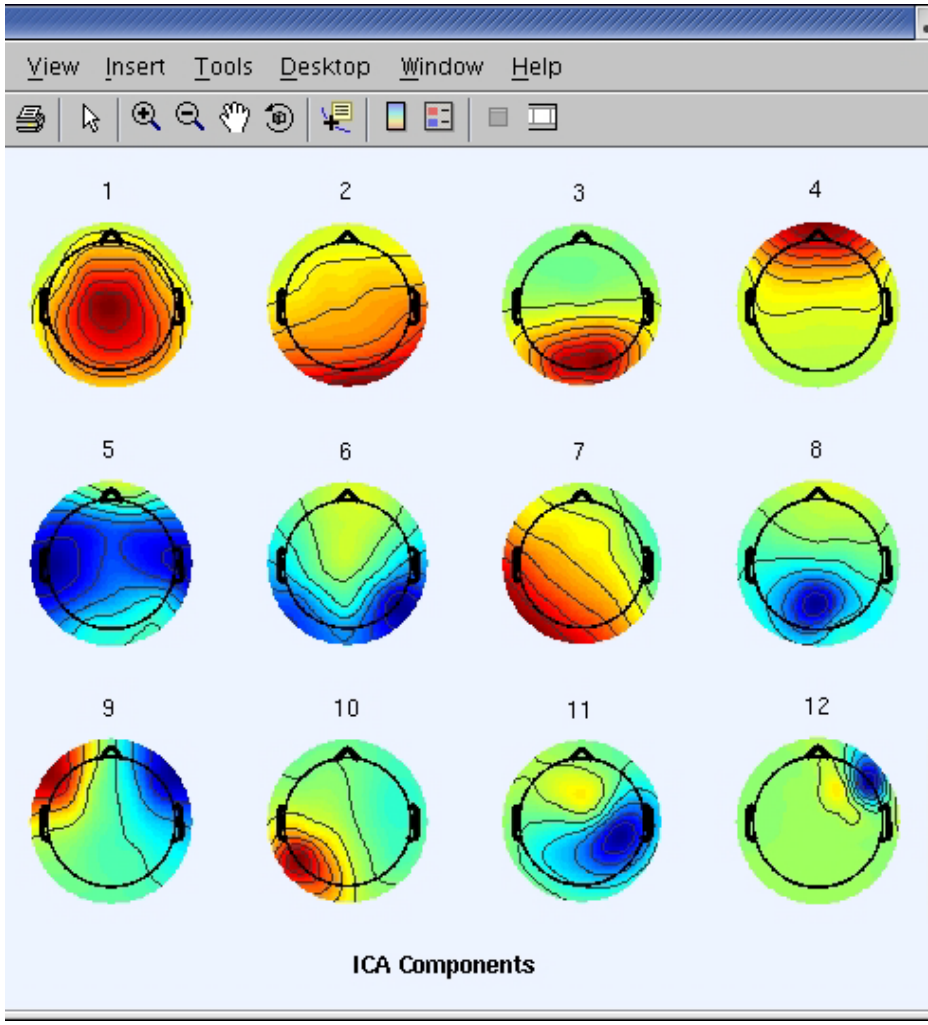
```
>> EEG

EEG =

            setname: 'faces_4 continuous'
           filename: 'faces_4.set'
           filepath: '/home/julie/workshop06/'
            subject: ''
              group: ''
          condition: ''
            session: []
           comments: [15x48 char]
             nbchan: 33
             trials: 1
               pnts: 133175
              srate: 250
               xmin: 0
               xmax: 532.6960
              times: []
               data: [33x133175 single]
            icaact: [33x133175 single]
          * icawinv: [33x33 double]
         icasphere: [33x33 double]
        icaweights: [33x33 double]
      icachansind: [1x33 double]
        chanlocs: [1x33 struct]
      urchanlocs: []
        chaninfo: [1x1 struct]
             ref: 'common'
           event: [1x731 struct]
          urevent: [1x731 struct]
  eventdescription: {[]  []}
           epoch: []
  epochdescription: {}
          reject: [1x1 struct]
           stats: [1x1 struct]
        specdata: []
      specicaact: []
      splinefile: ''
    icasplinefile: ''
          dipfit: [1x1 struct]
         history: [1x1633 char]
           saved: 'no'
             etc: []

>>
```



Compare 'good' and 'bad' scalp maps







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  - ✓ Scalp maps
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  - ✓ Power
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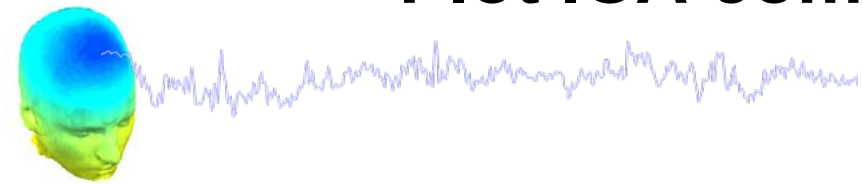
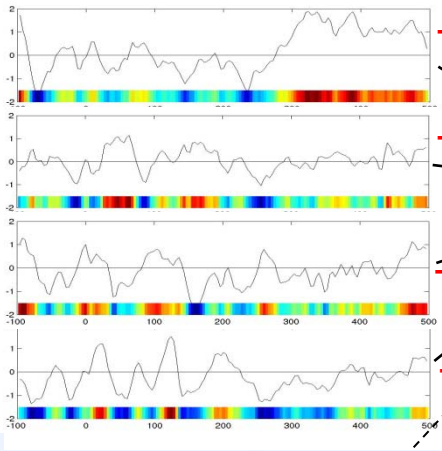
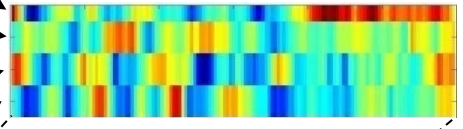
  - ✓ ERSP (time/freq)
  - ✓ Cross coherence
- ☐ Exercise...

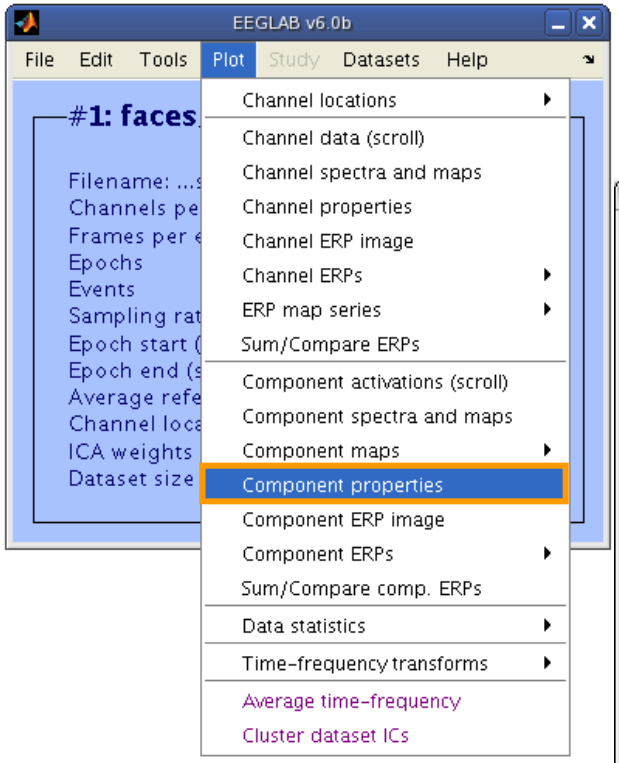
Plot ICA component properties

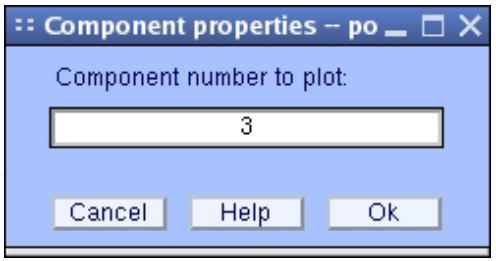


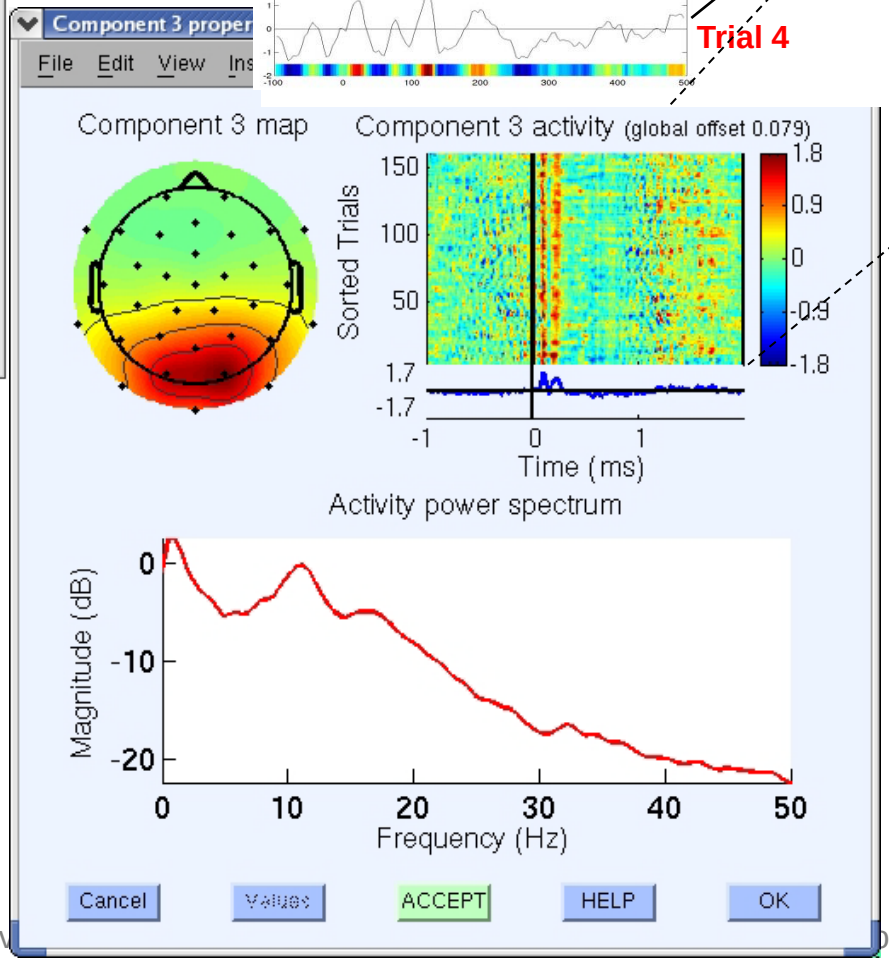


ERP Image

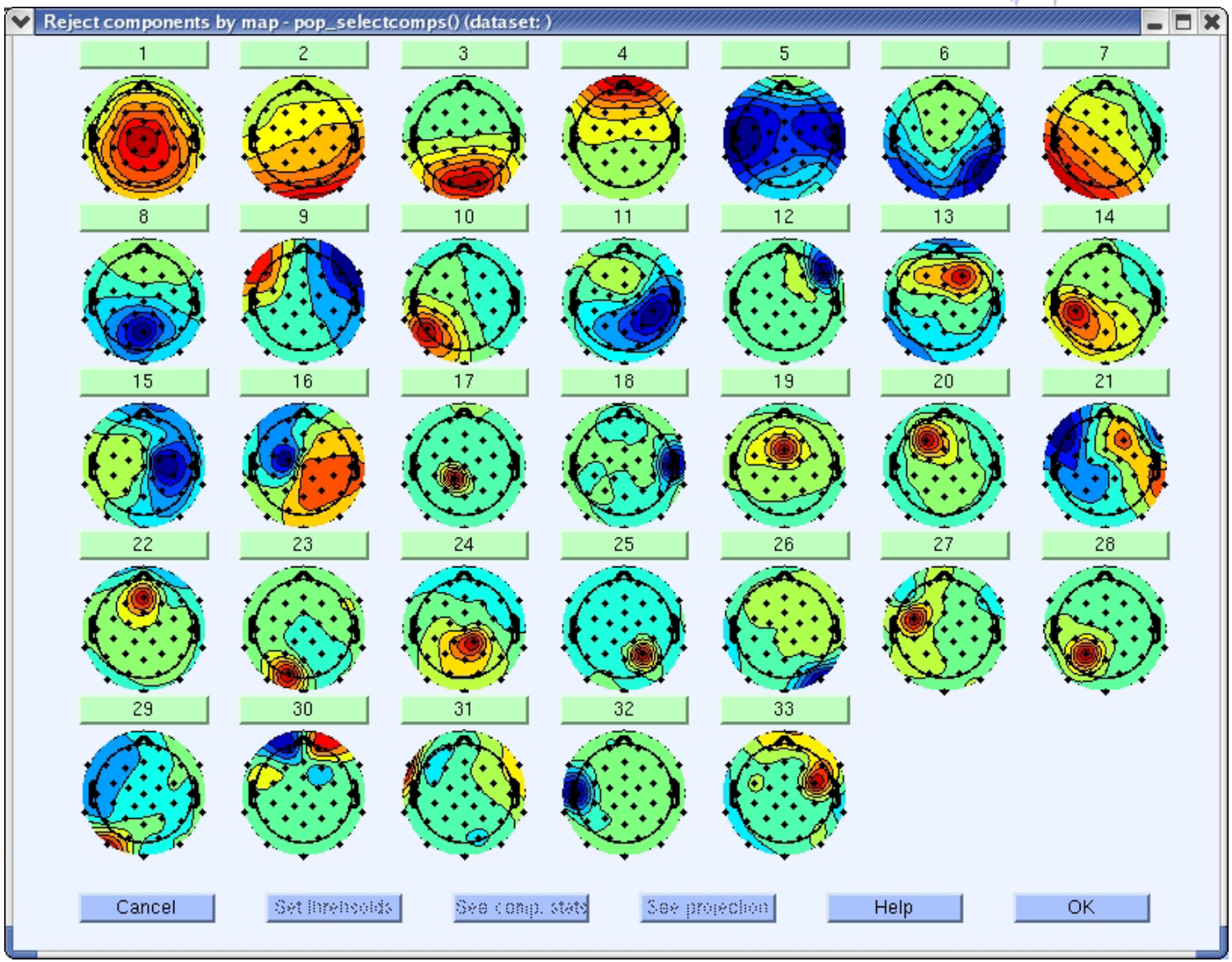


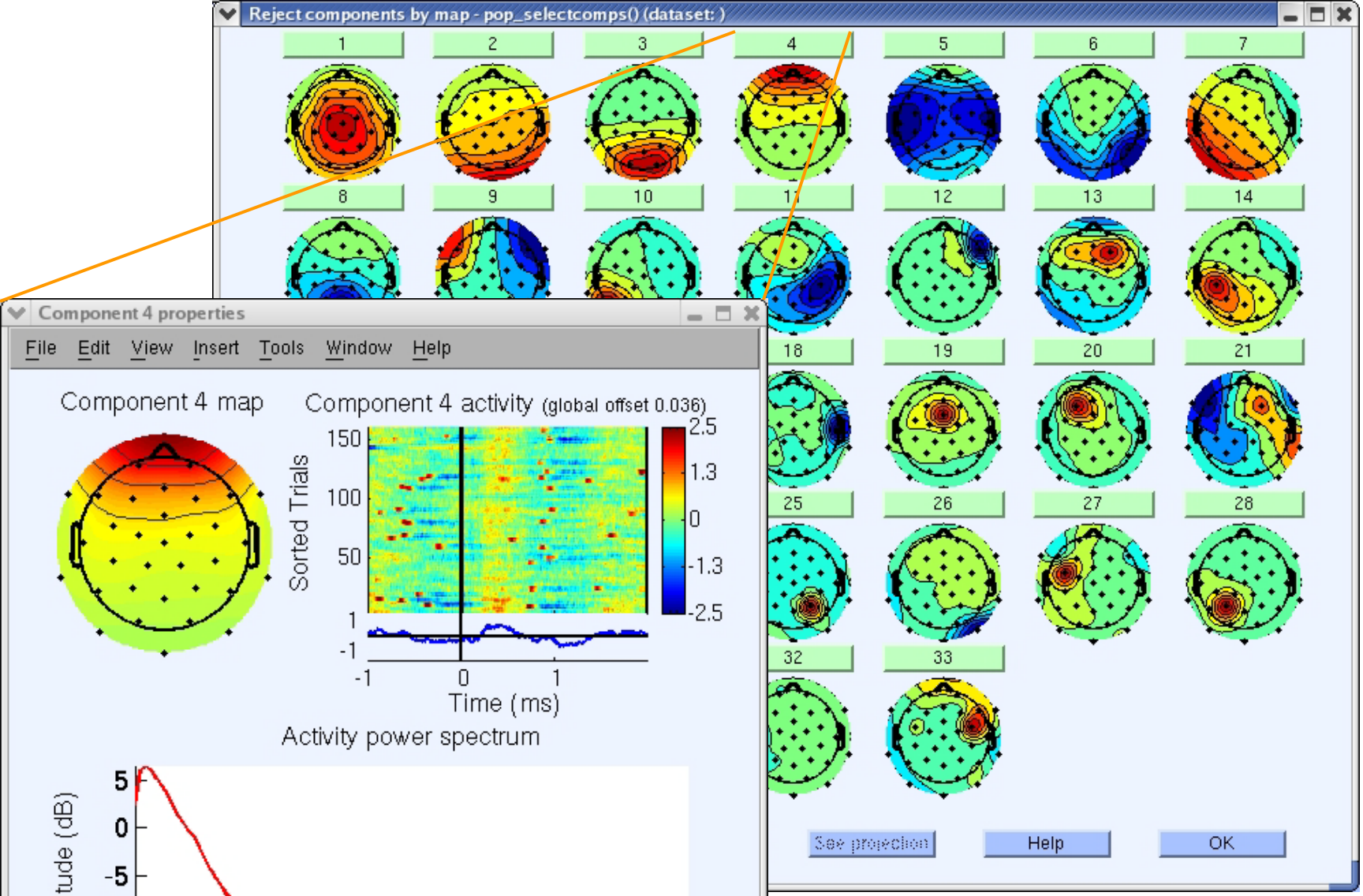




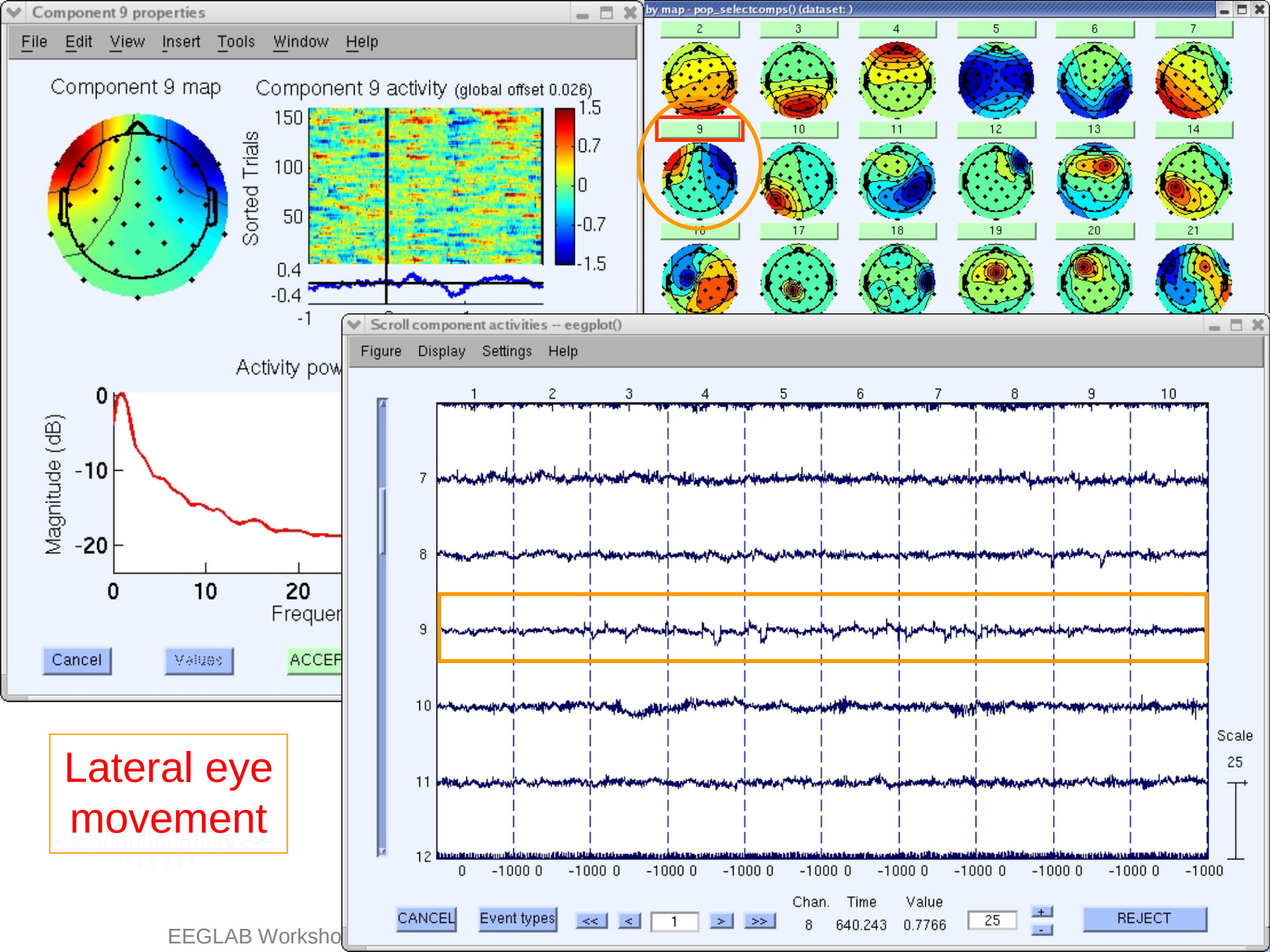


Component scalp maps/properties

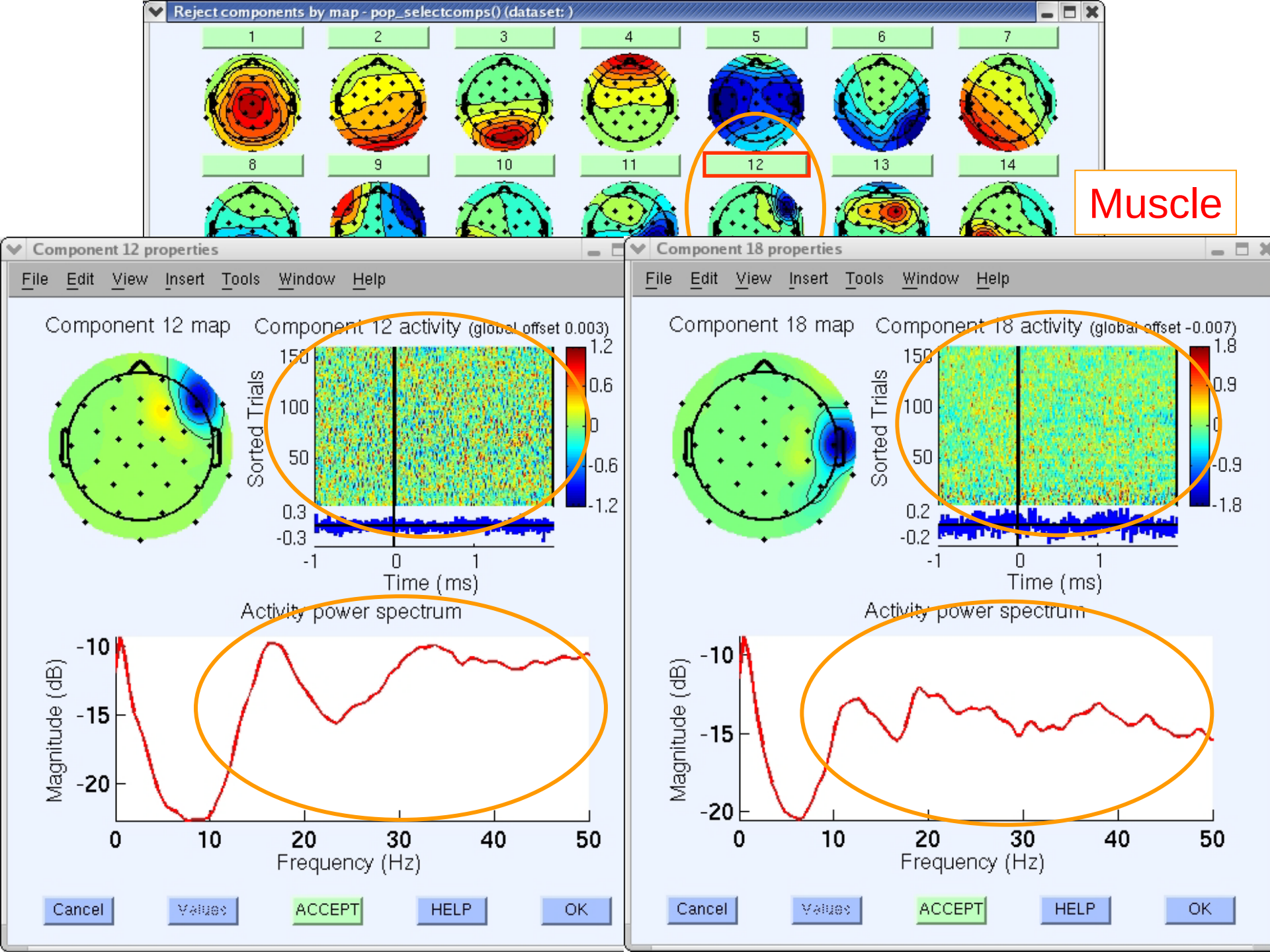


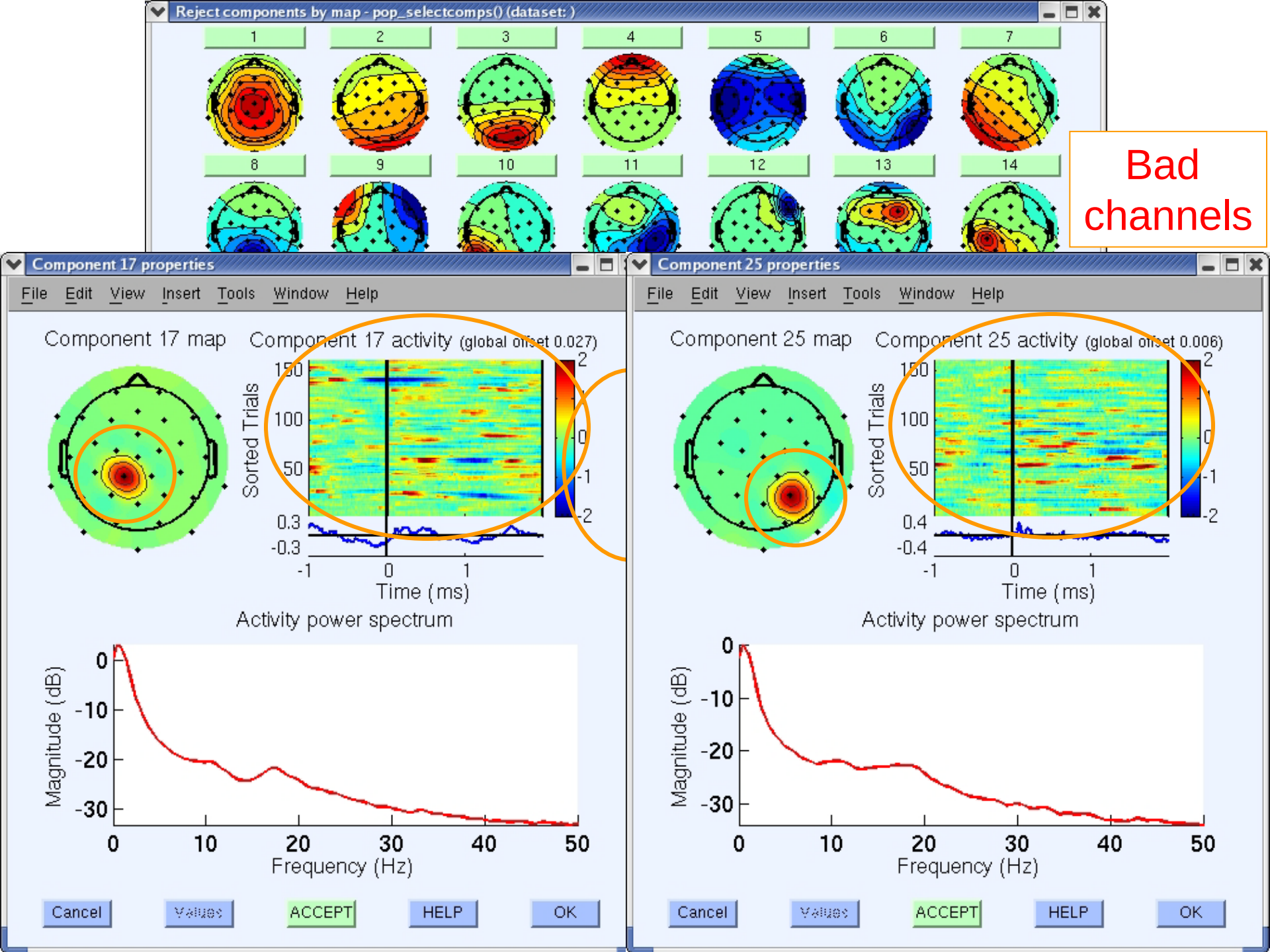


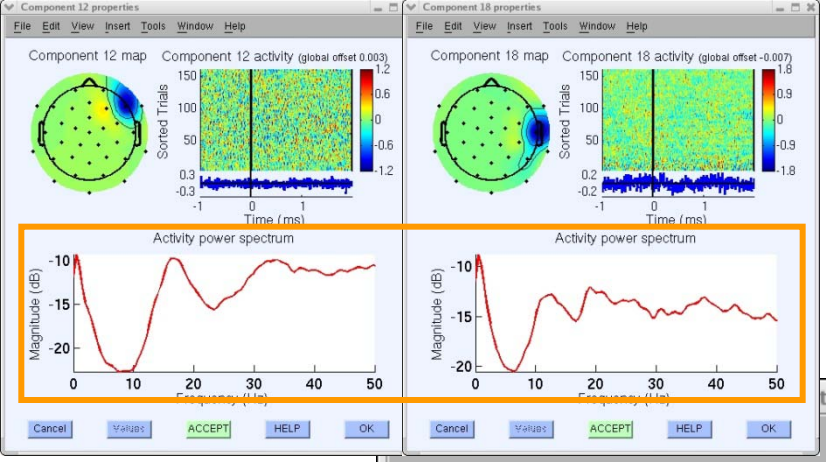
Eye blink component



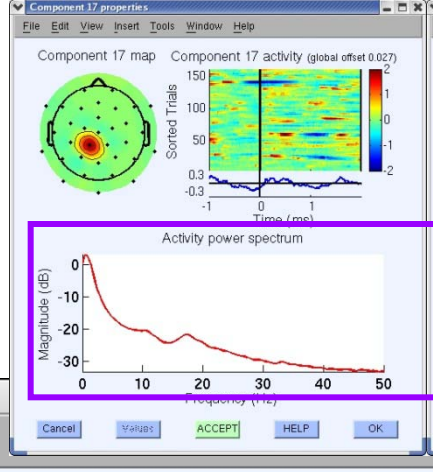
Lateral eye movement

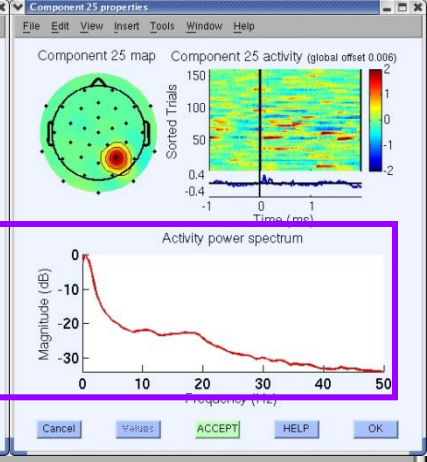

Reject components by map - pop_selectcomps() (dataset:)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Muscle
Component 12 properties
File Edit View Insert Tools Window Help
Component 12 map
Component 12 activity (global offset 0.003)
Sorted Trials
Time (ms)
Activity power spectrum
Magnitude (dB)
Frequency (Hz)
Cancel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

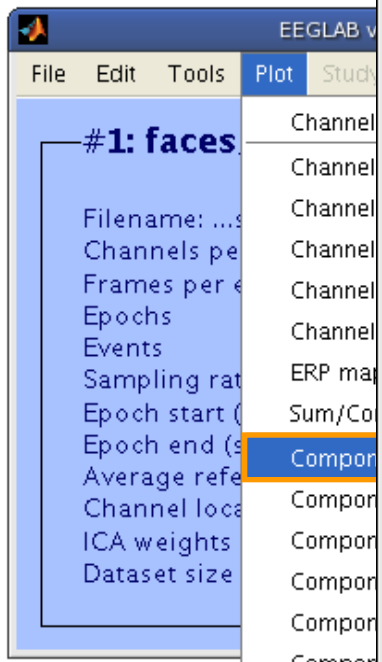

Reject components by map - pop_selectcomps() (dataset:)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Bad channels
Component 17 properties
File Edit View Insert Tools Window Help
Component 17 map
Component 17 activity (global offset 0.027)
Sorted Trials
Time (ms)
Activity power spectrum
Magnitude (dB)
Frequency (Hz)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


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


EEGLAB v
File Edit Tools Plot Study
#1: faces
Filename: ...s
Channels pe
Frames per e
Epochs
Events
Sampling rat
Epoch start (
Epoch end (s
Average refe
Channel loca
ICA weights
Dataset size
Channel
Channel
Channel
Channel
Channel
Channel
ERP map
Sum/Co
Compon
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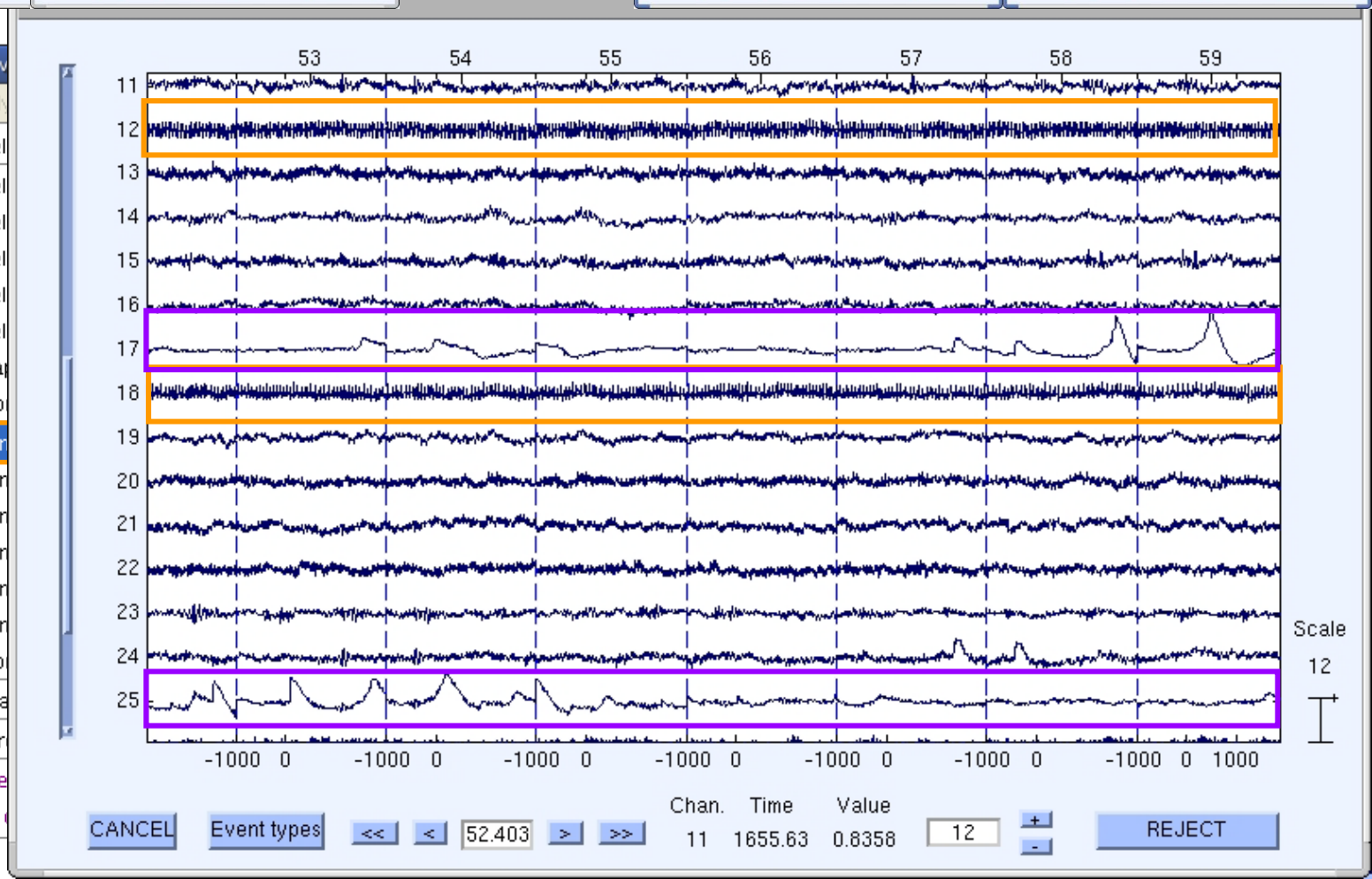
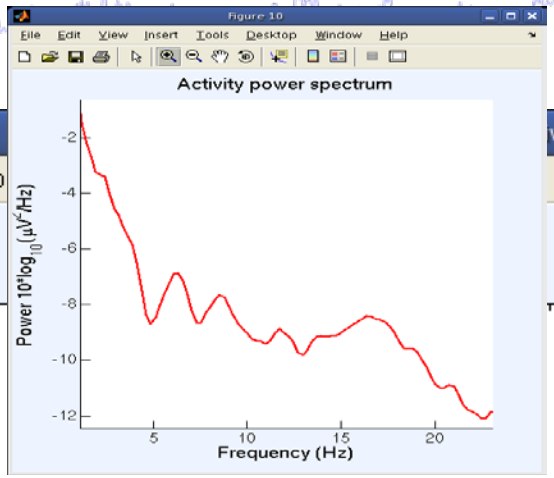
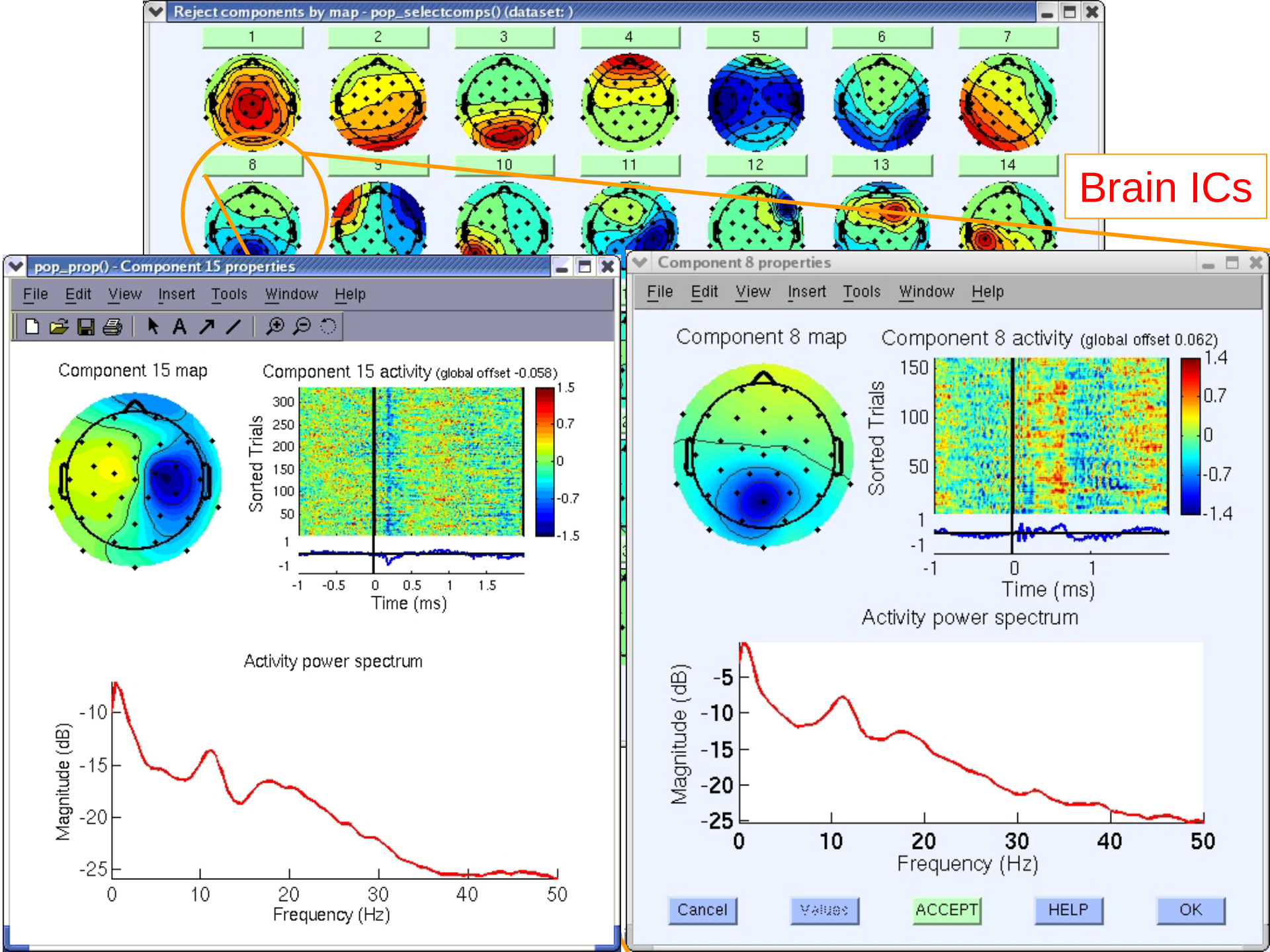
Compon
Compon
Compon
Compon
Compon
Sum/Co
Data sta
Time-fr
Average
Cluster

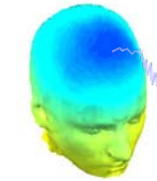

53 54 55 56 57 58 59
11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
-1000 0 -1000 0 -1000 0 -1000 0 -1000 0 -1000 0 -1000 0 1000
Scale
12
CANCEL
Event types
<<
<
52.403
>
>>
Chan. Time Value
11 1655.63 0.8358
12
+
-
REJECT

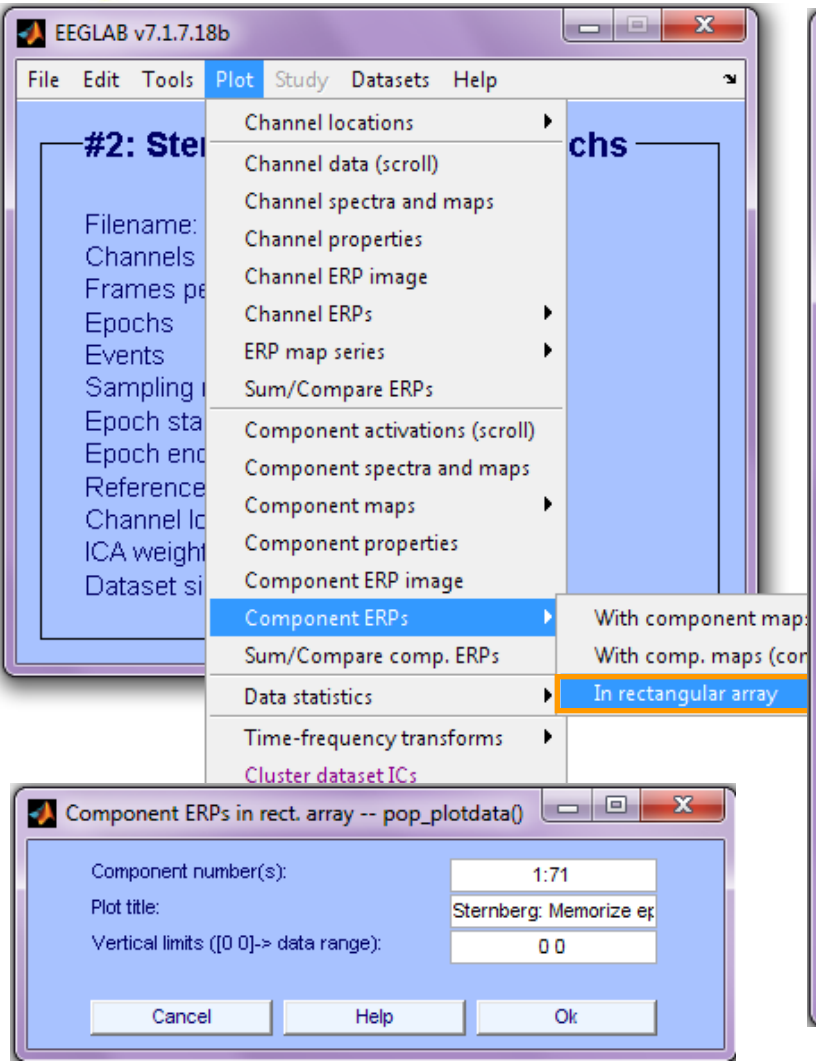
Pulse artifacts

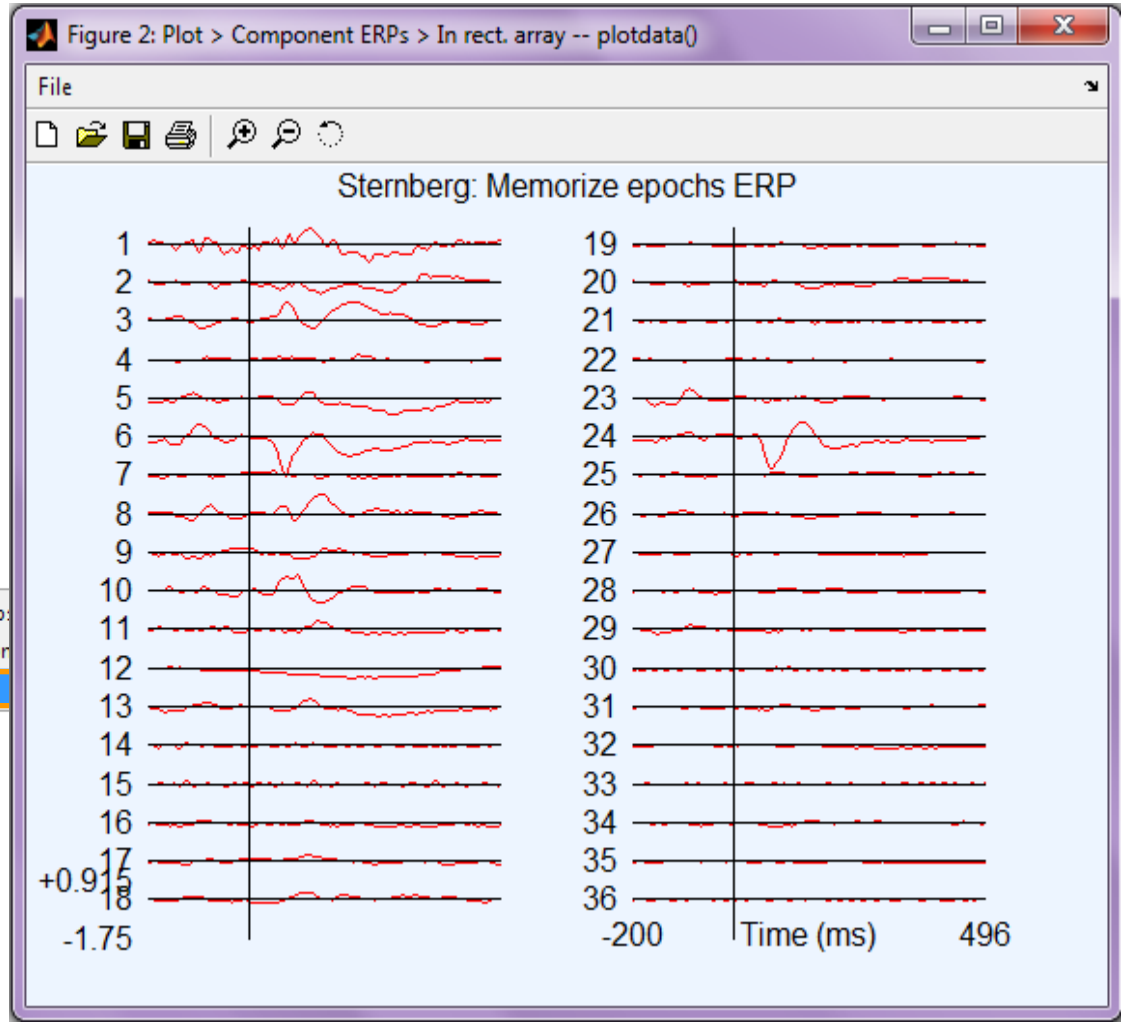



Reject components by map - pop_selectcomps() (dataset:)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Brain ICs
pop_prop() - Component 15 properties
File Edit View Insert Tools Window Help
Component 15 map
Component 15 activity (global offset -0.058)
Sorted Trials
Time (ms)
Activity power spectrum
Magnitude (dB)
Frequency (Hz)
Component 8 properties
File Edit View Insert Tools Window Help
Component 8 map
Component 8 activity (global offset 0.062)
Sorted Trials
Time (ms)
Activity power spectrum
Magnitude (dB)
Frequency (Hz)
Cancel
Values
ACCEPT
HELP
OK

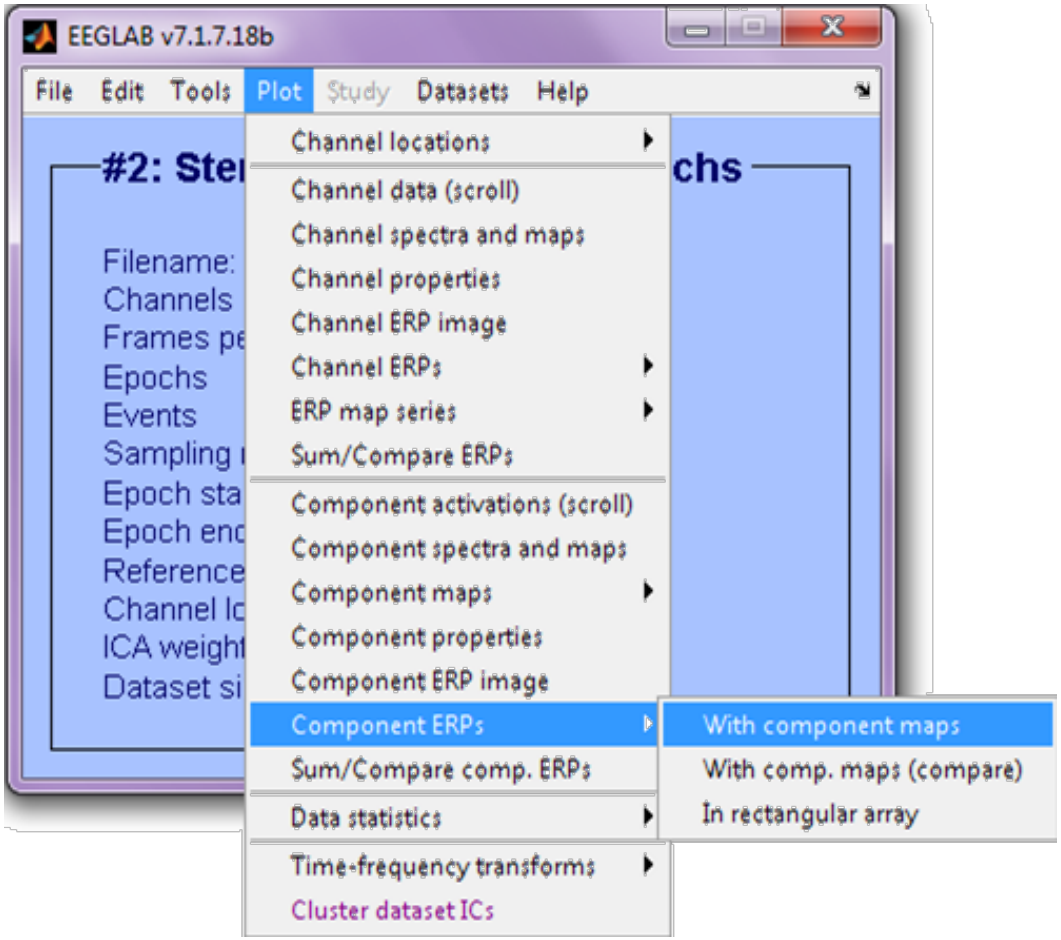
Component ERPs



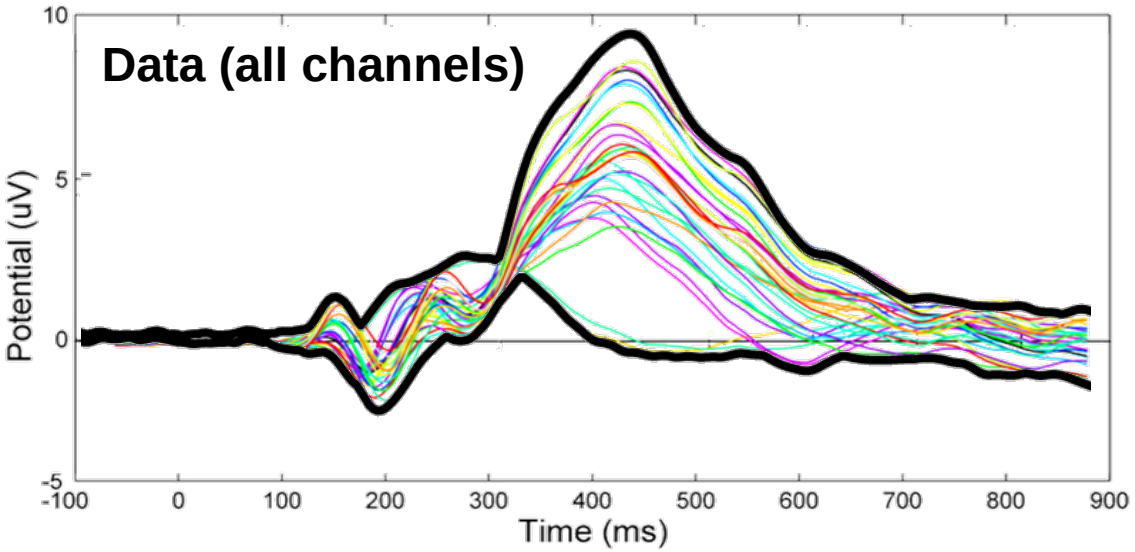


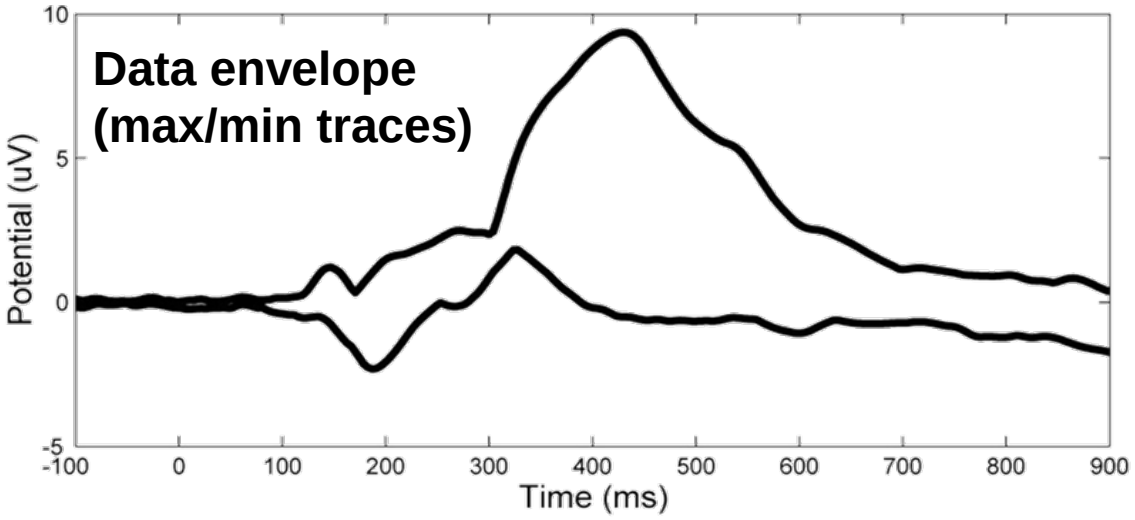


Component ERP envelope

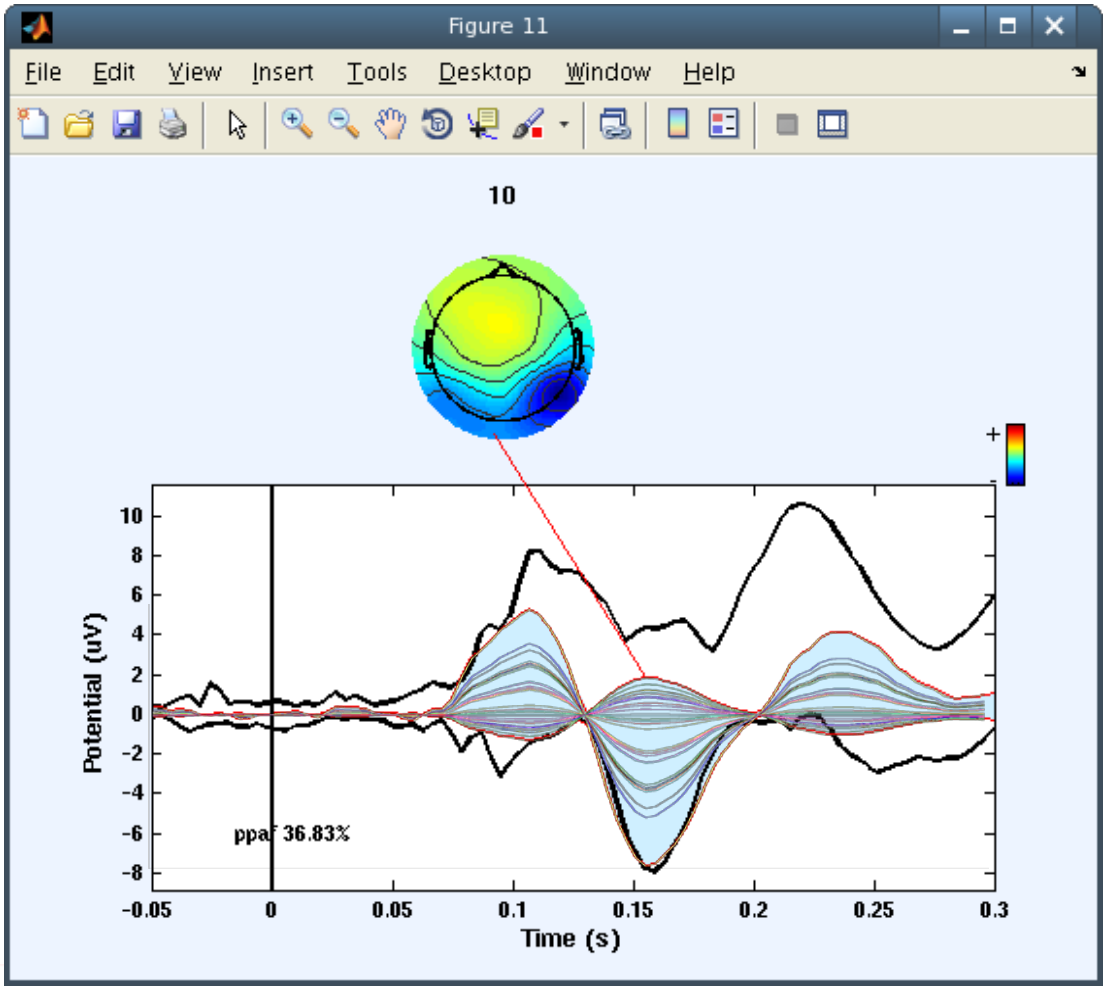


Definition: The data envelope

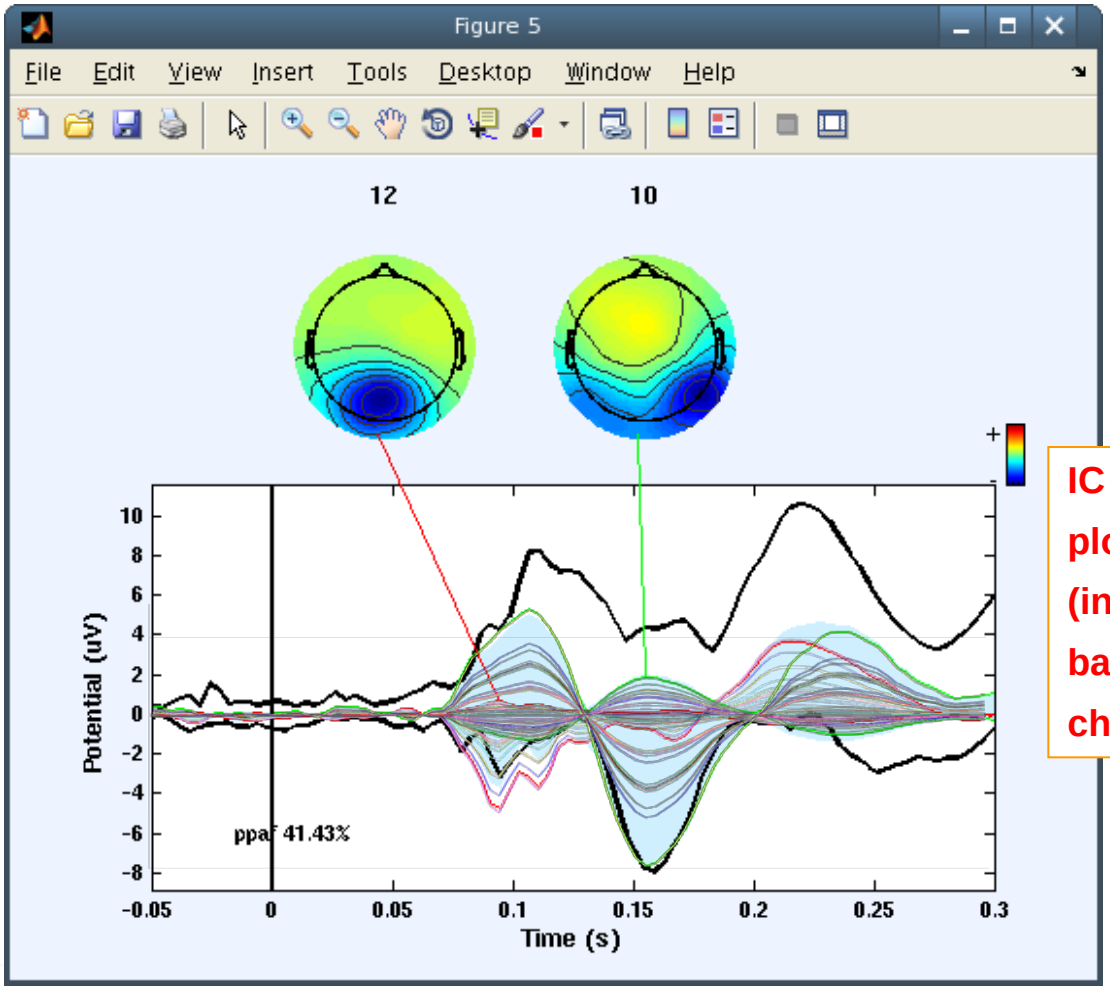




IC back-projection envelope

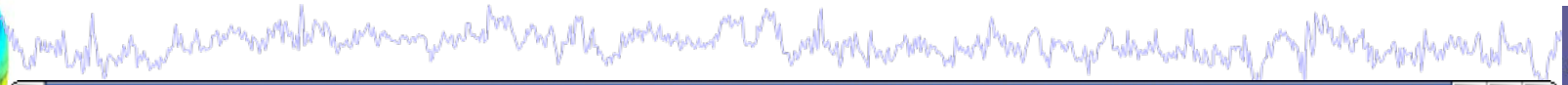


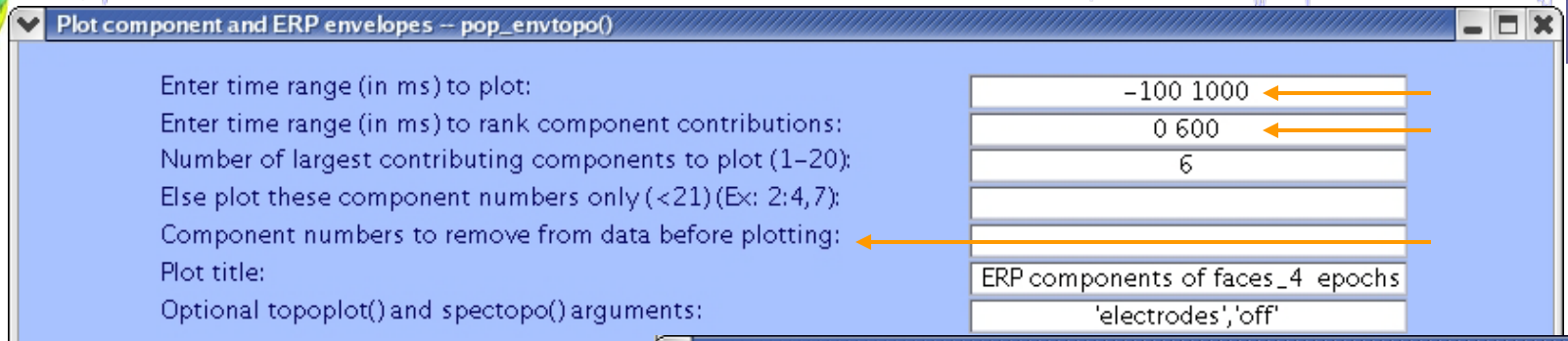
IC back-projection envelope

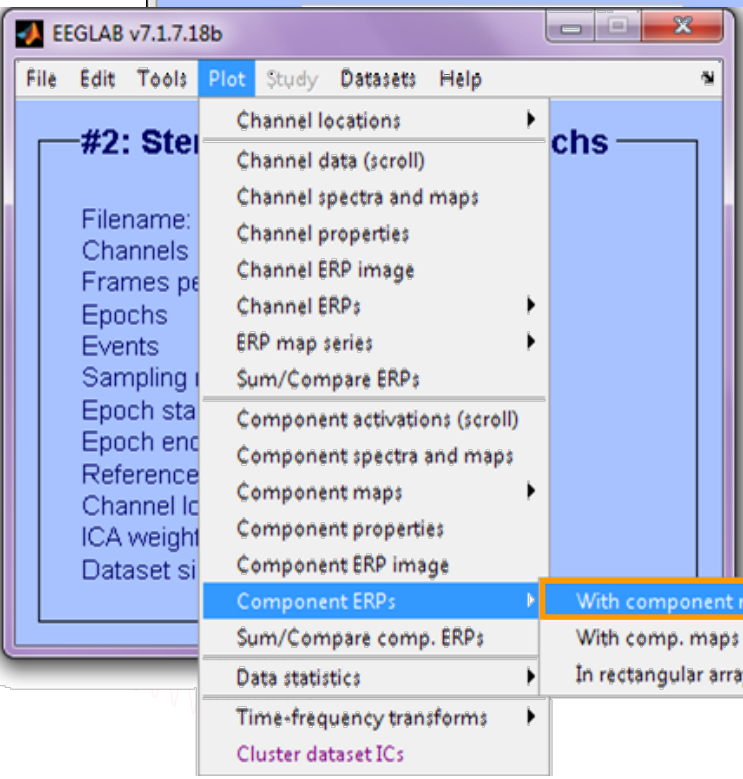


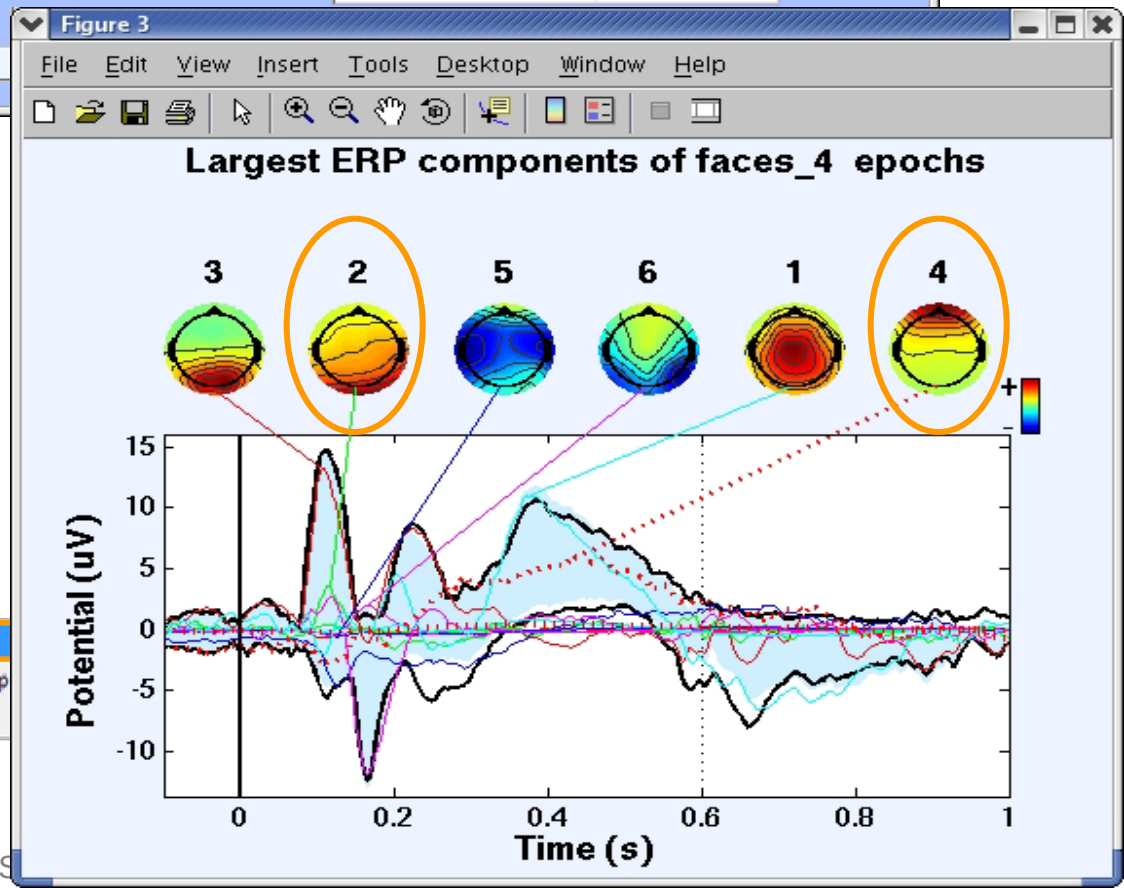
IC envelopes plotted for simplicity (instead of all back-projected channels)

IC contributions to ERP envelope

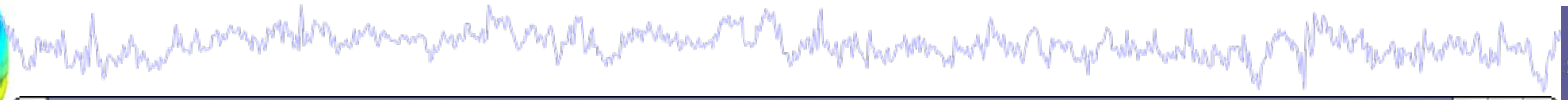








Component contribution to the dataset ERP



Swartz Center for Computational Neuroscience

Plot component and ERP envelopes -- pop_envtopo()

Enter time range (in ms) to plot:	-100 1000
Enter time range (in ms) to rank component contributions:	0 600
Number of largest contributing components to plot (1-20):	6
Else plot these component numbers only (<21) (Ex: 2:4,7):	
Component numbers to remove from data before plotting:	2, 4, 7, 9, 12, 17,18,25
Plot title:	ERP components of faces_4 epochs
Optional topoplot() and spectopo() arguments:	'electrodes','off'

Cancel

Artifact Components

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File Edit Tools Plot Study Datasets Help

#1: faces

Filename: ...
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Epochs
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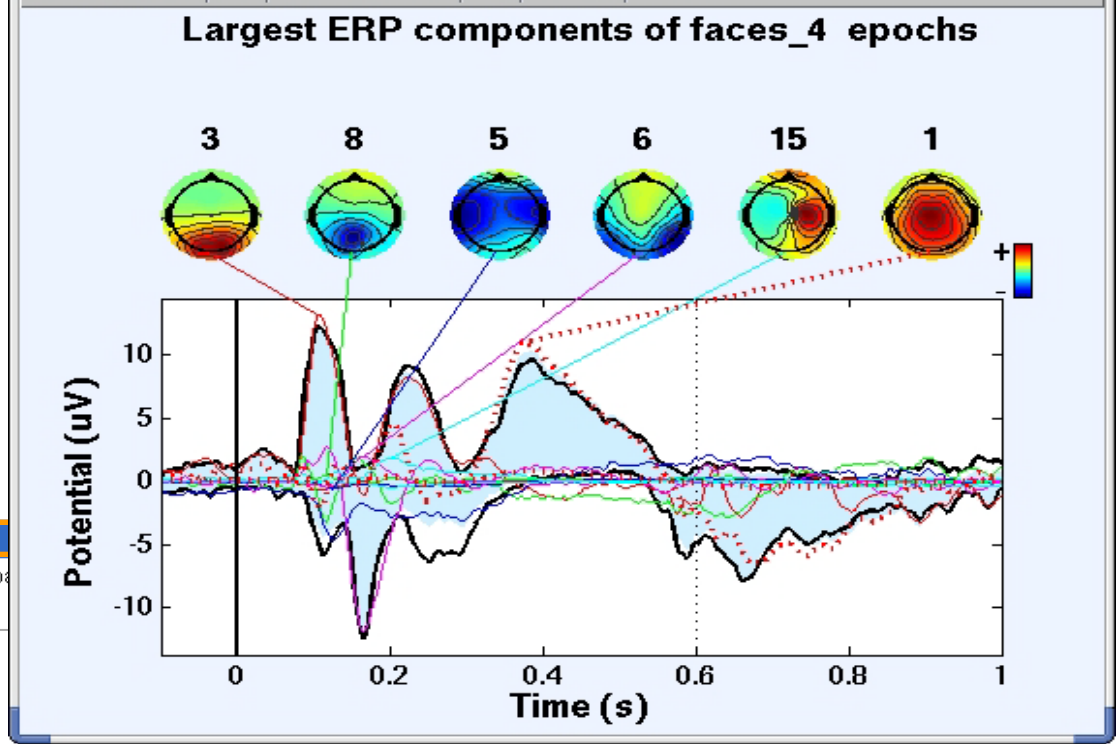
ICA weights
Dataset size

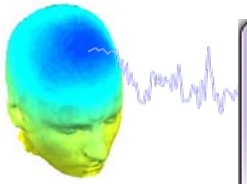
- Channel locations
- Channel data (scroll)
- Channel spectra and maps
- Channel properties
- Channel ERP image
- Channel ERPs
- ERP map series
- Sum/Compare ERPs
- Component activations (scroll)
- Component spectra and maps
- Component maps
- Component properties
- Component ERP image
- Component ERPs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

Figure 5

File Edit View Insert Tools Desktop Window Help



Plot component power



Component spectra and maps -- pop_spectopo()

Epoch time range to analyze [min_ms max_ms]:	0 2440528
Frequency (Hz) to analyze:	10
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:	1:71
Number of largest-contributing components to map:	5
Else, map only these component numbers:	
[Checked] Compute comp spectra; [Unchecked] (data-comp) spectra:	☑
Plotting frequency range ([min max] Hz):	2 25
Spectral and scalp map options (see topoplot):	'electrodes','off'

Cancel Help

EEGLAB v7.1.7.18b

File Edit Tools Pl

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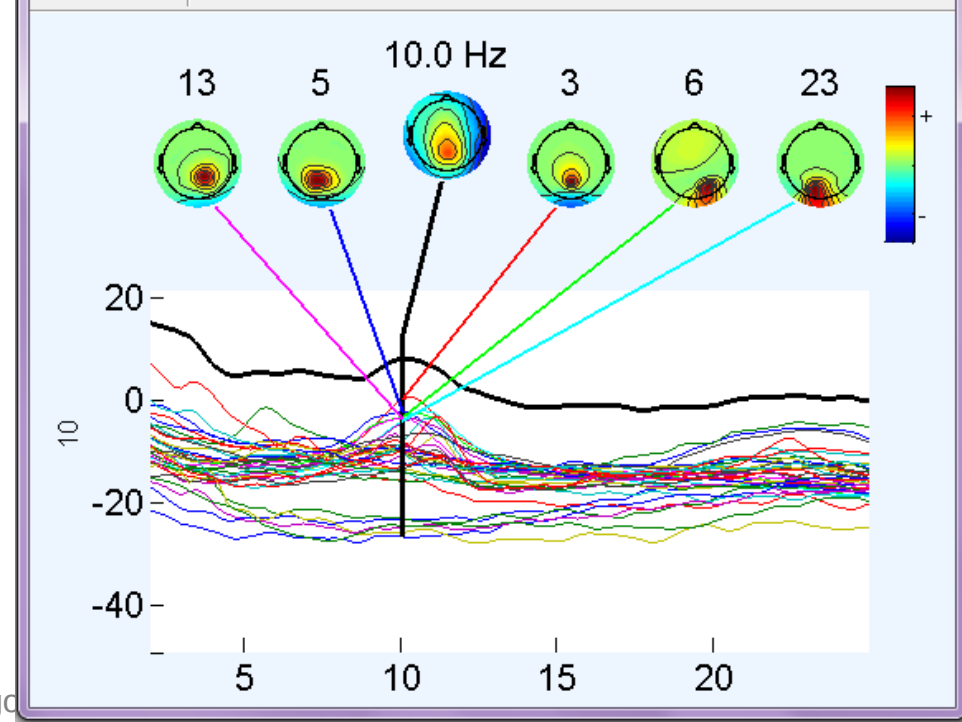
- Channel locations ▸
- Channel data (scroll)
- Channel spectra and maps
- Channel properties
- Channel ERP image
- Channel ERPs ▸
- ERP map series ▸
- Sum/Compare ERPs
- Component activations (scroll)
- Component spectra and maps
- Component maps ▸
- Component properties
- Component ERP image
- Component ERPs ▸
- Sum/Compare comp. ERPs
- Data statistics ▸

Figure 2: spectopo()

File



Plot component power

Component spectra and maps -- pop_spectopo()

Epoch time range to analyze [min_ms max_ms]:	0 2440528
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:	1:71
Number of largest-contributing components to map:	5
Else, map only these component numbers:	
[Checked] Compute comp spectra; [Unchecked] (data-comp) spectra:	☑
Plotting frequency range ([min max] Hz):	2 25
Spectral and scalp map options (see topoplot):	

Cancel

EEGLAB v7.1.7.18b

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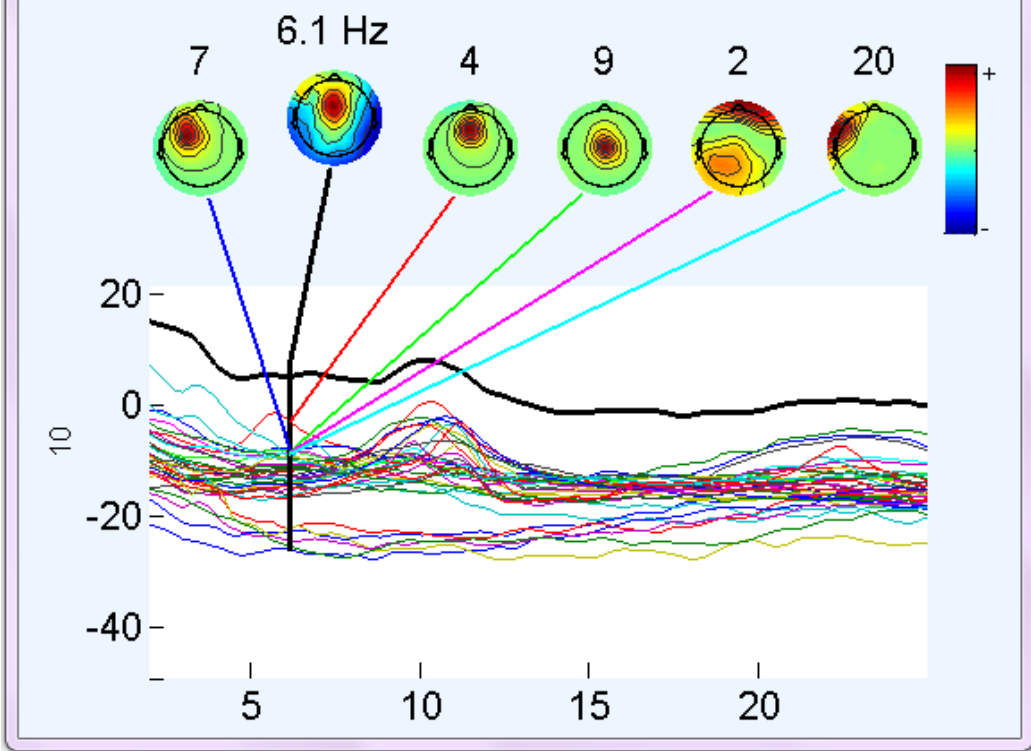
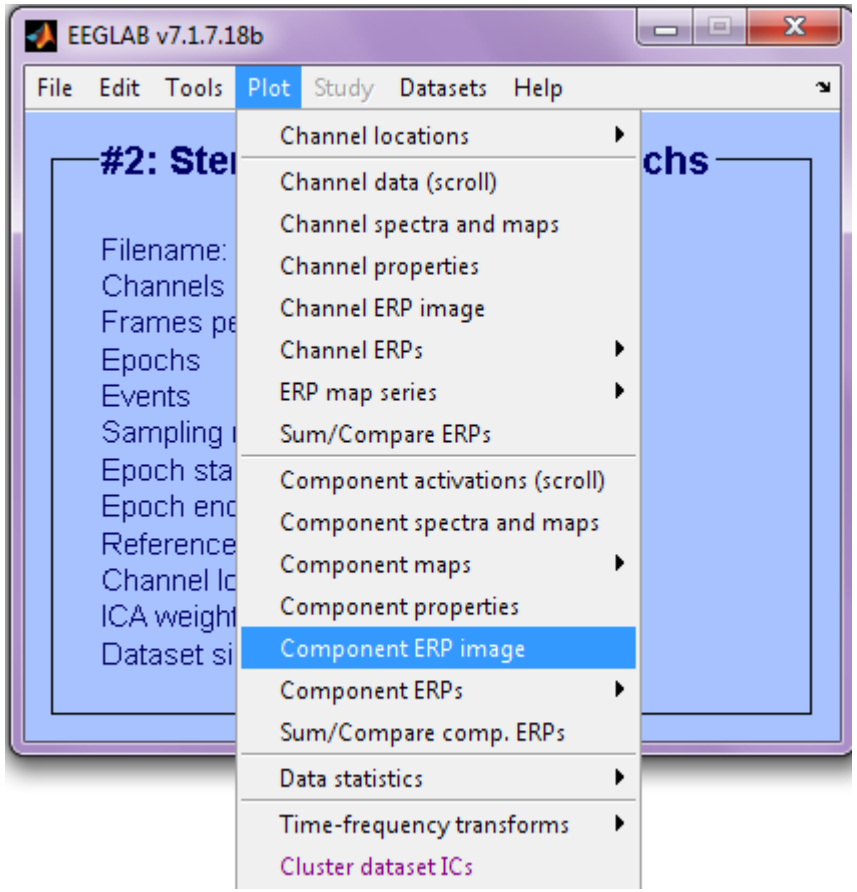
- Channel spectra and maps
- Channel properties
- Channel ERP image
- Channel ERPs
- ERP map series
- Sum/Compare ERPs
- Component activations (scroll)
- Component spectra and maps
- Component maps
- Component properties
- Component ERP image
- Component ERPs
- Sum/Compare comp. ERPs
- Data statistics

Figure 2: spectopo()

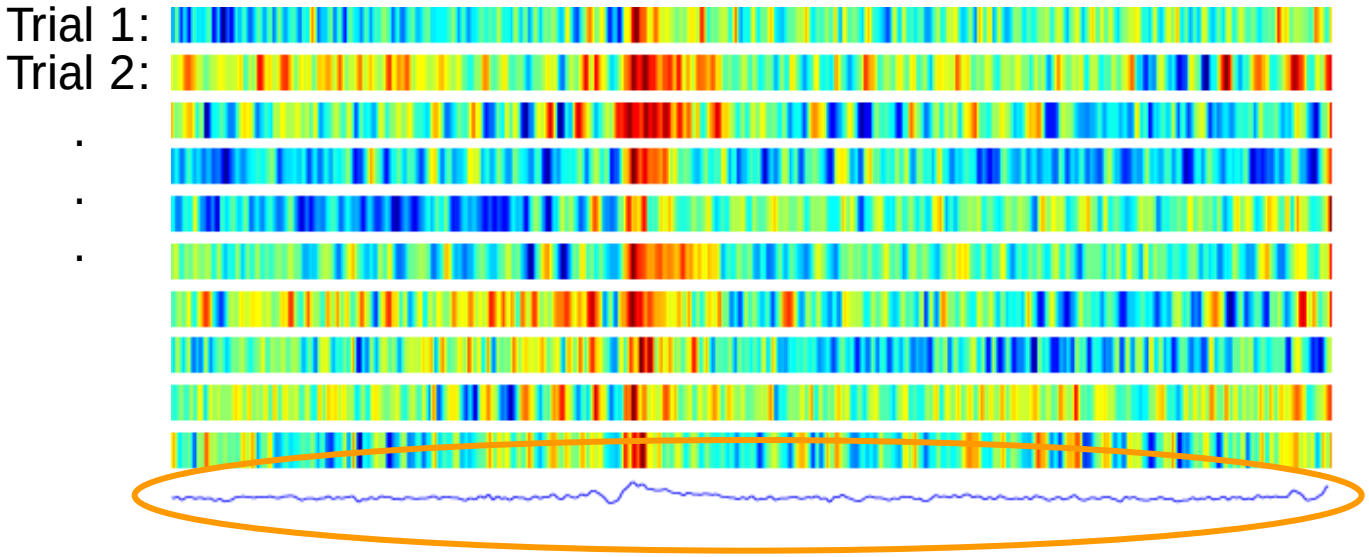
File

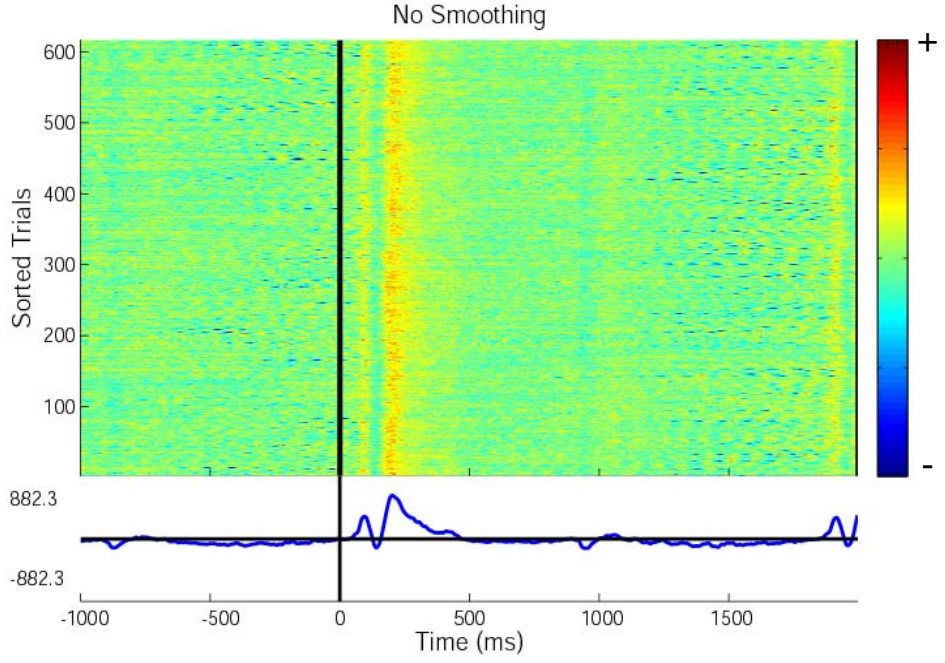


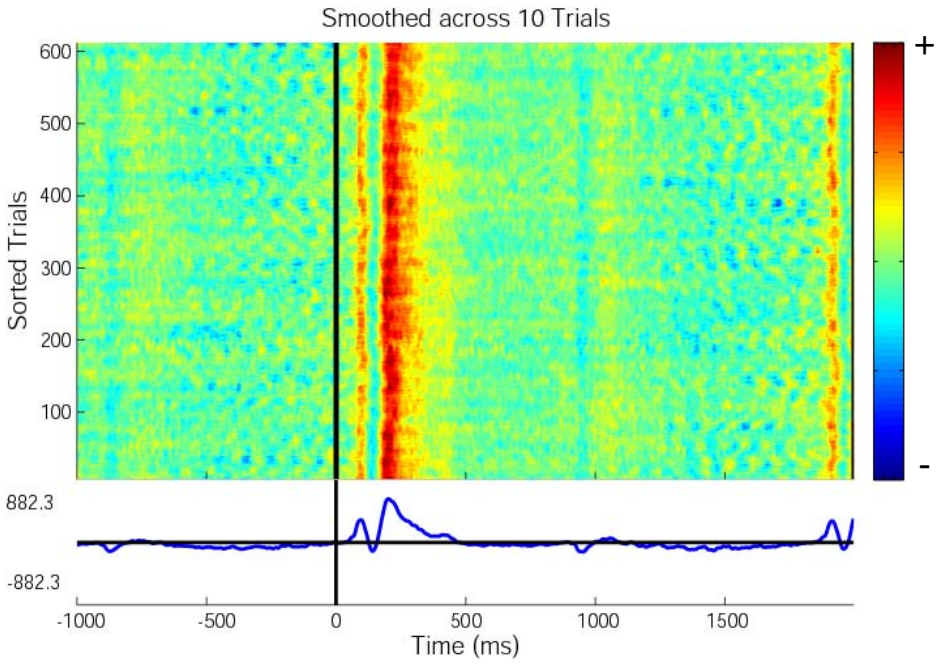
Component ERP image



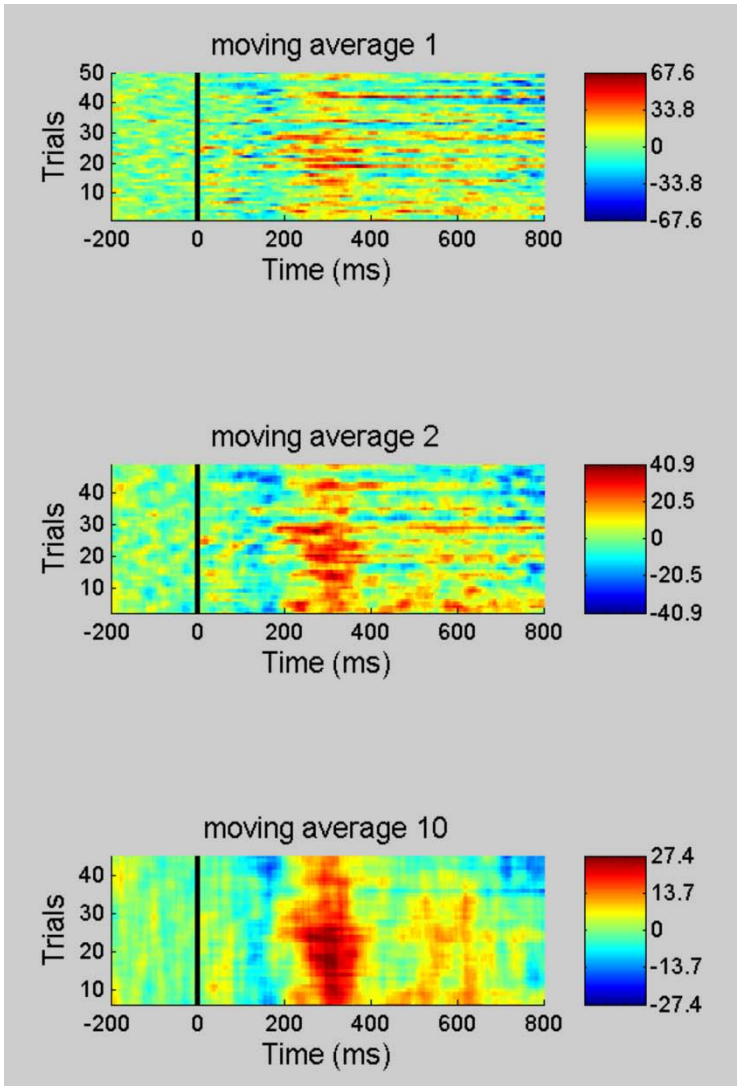
ERP Image basics



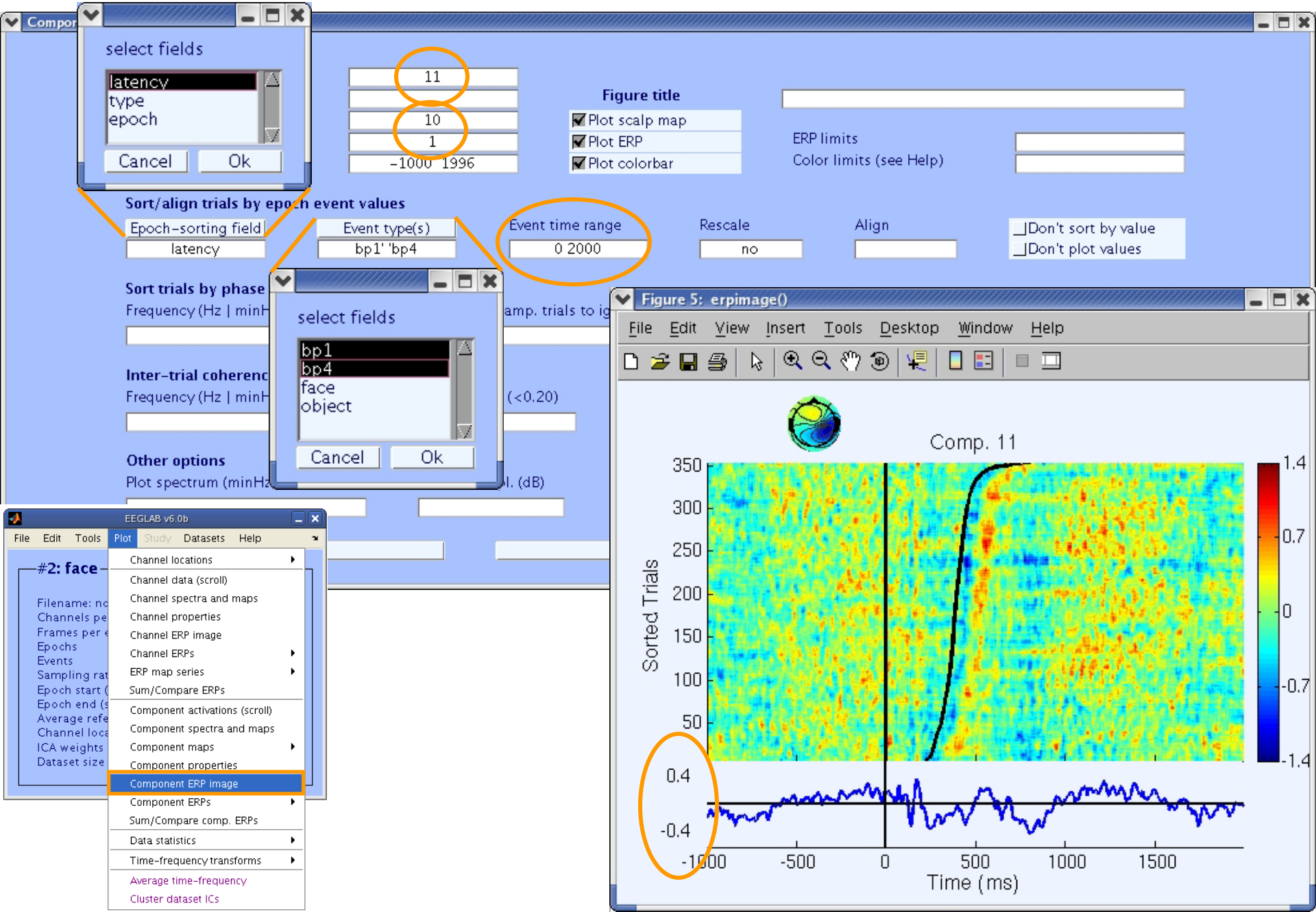




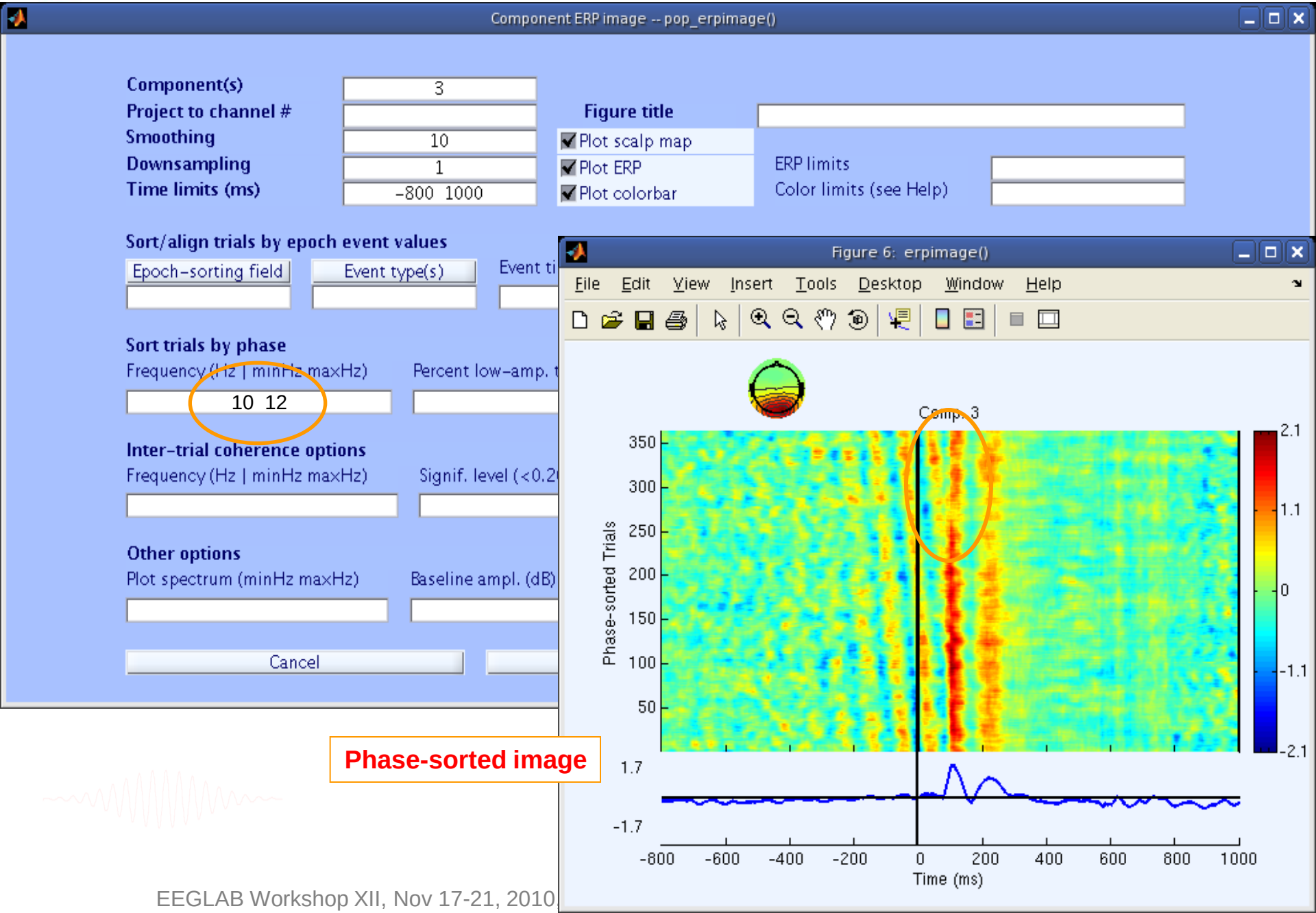
ERP Images: smoothing across trials



Component ERP Images

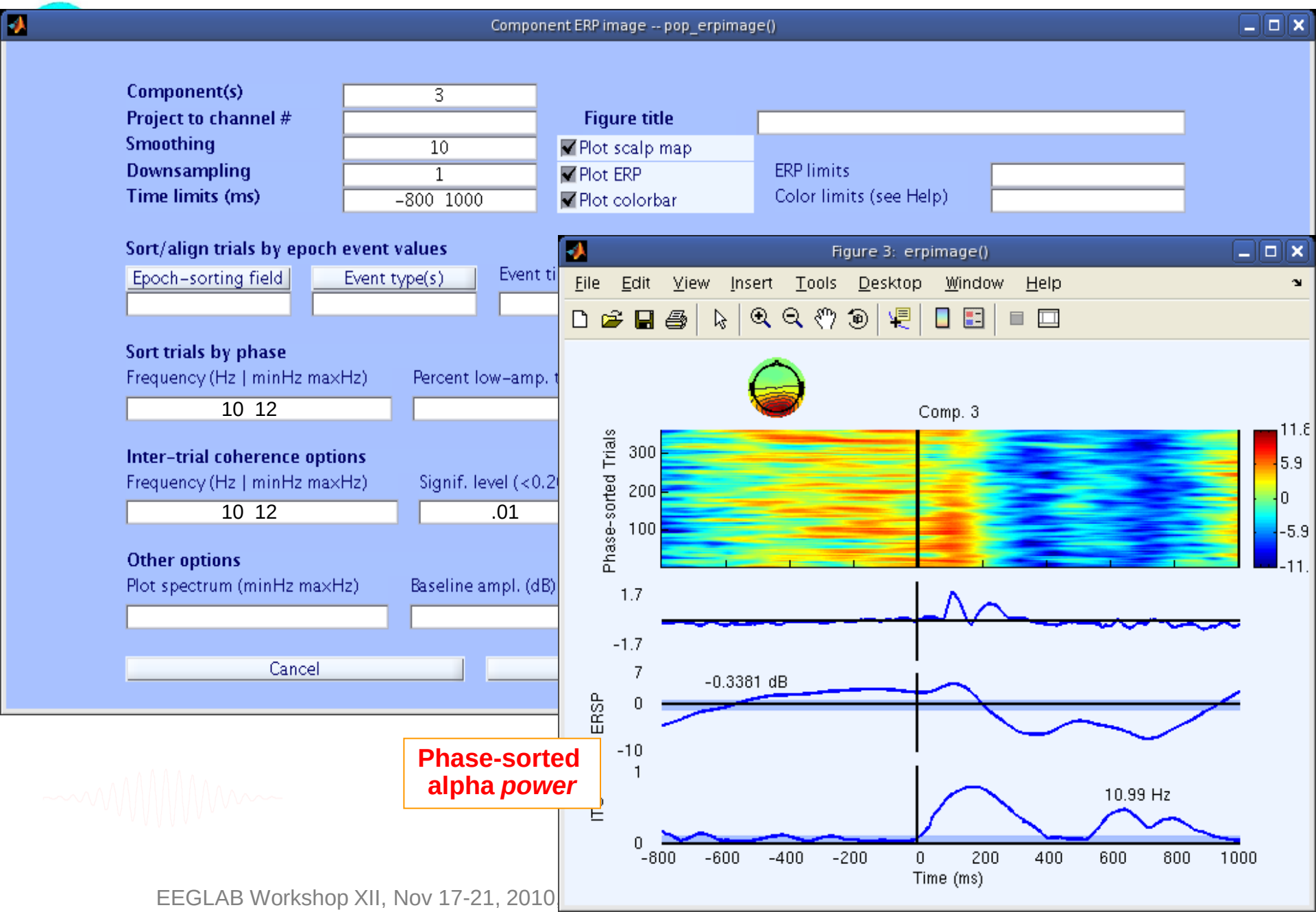


Component ERP Images



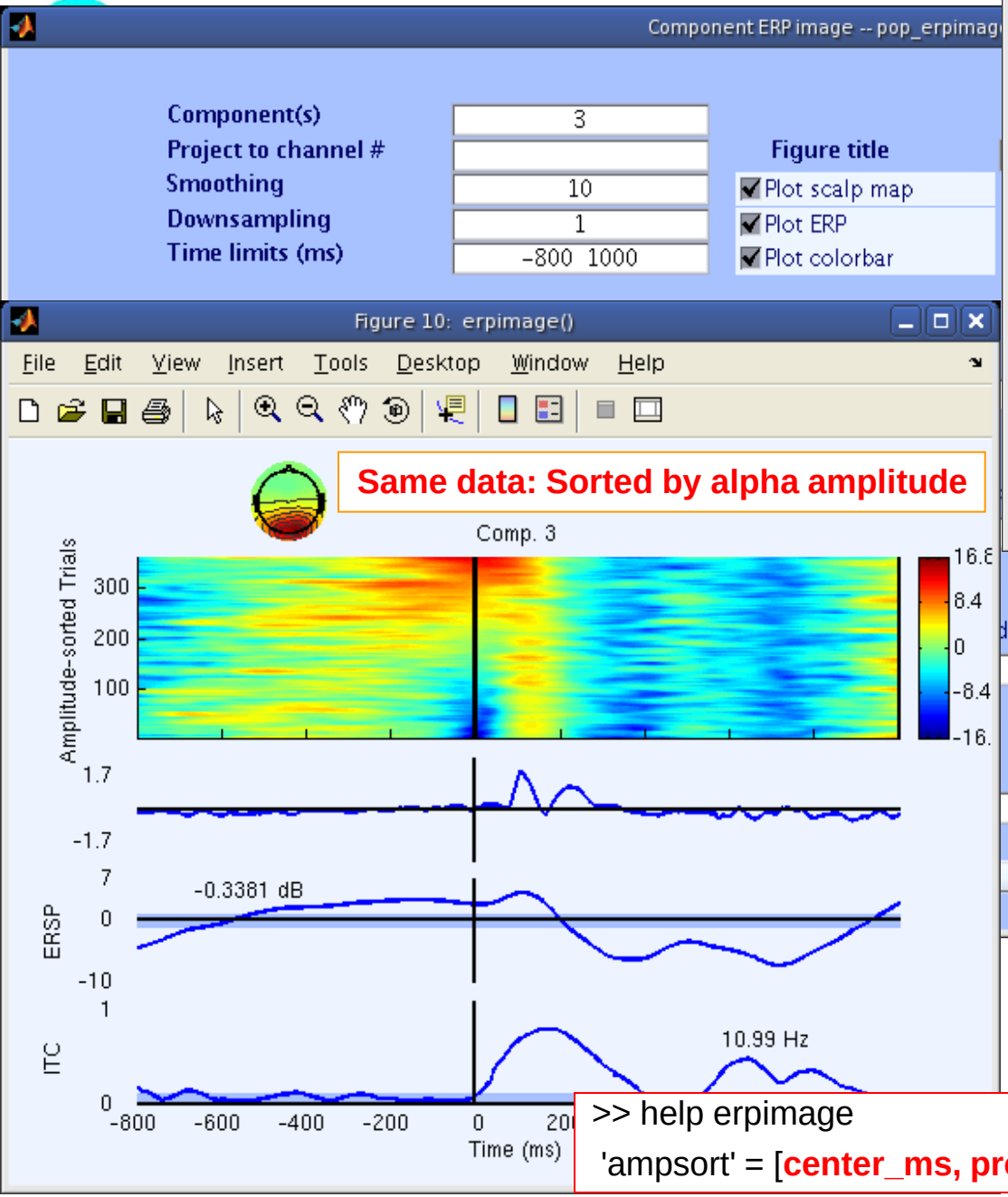
Phase-sorted image

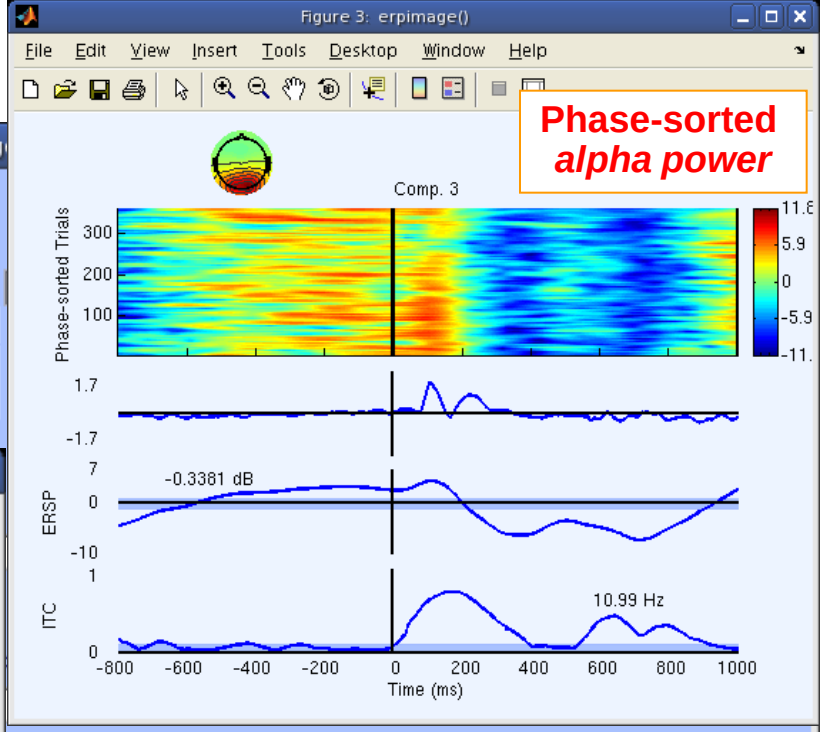
Component ERP Images

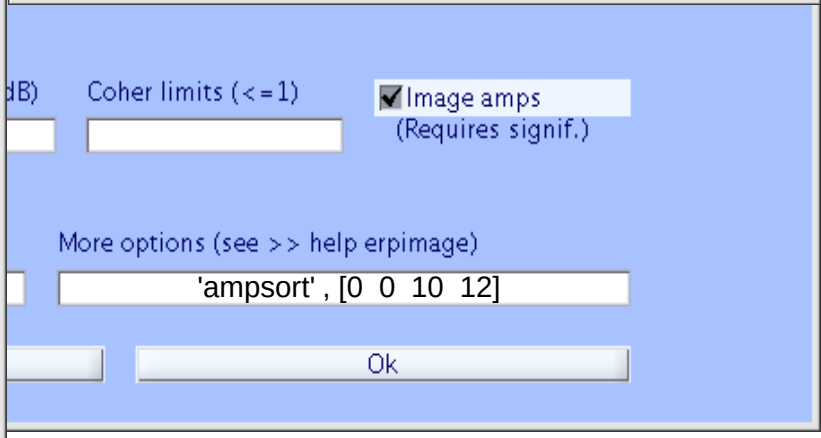


Phase-sorted alpha *power*

Component ERP



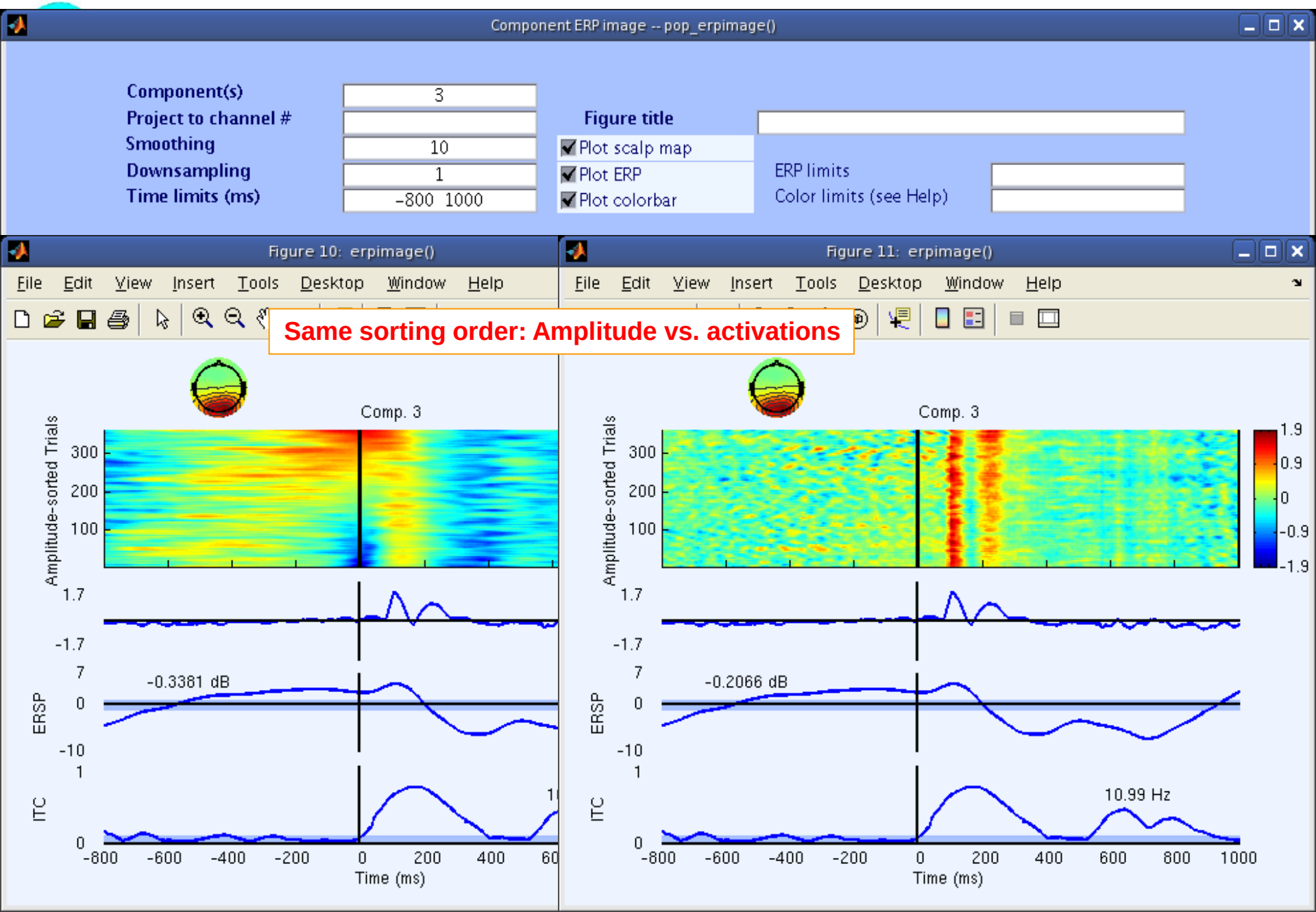




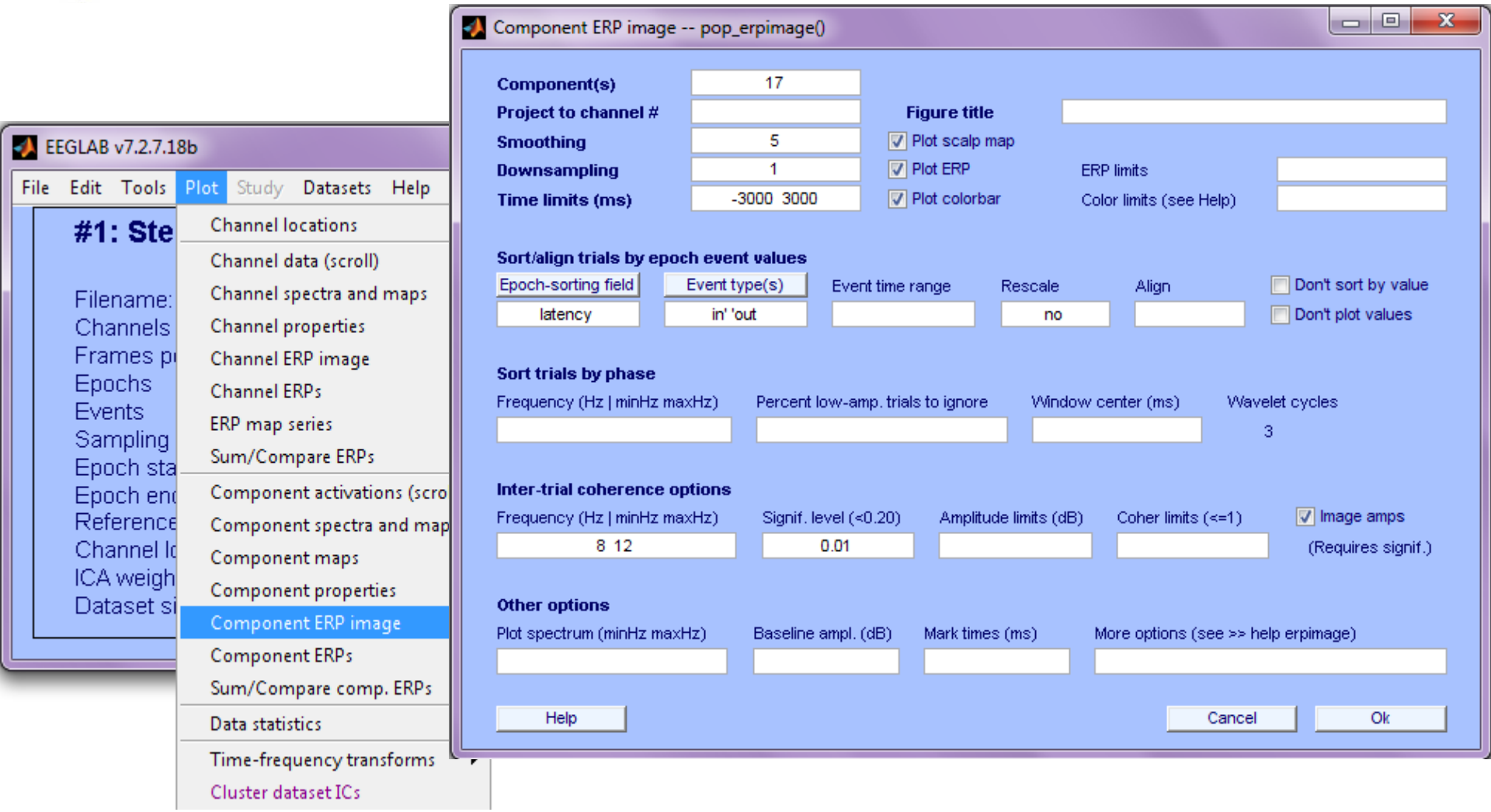
>> help erpimage

'ampsort' = [**center_ms, prcnt, freq, maxfreq**] Sort epochs by amplitude.

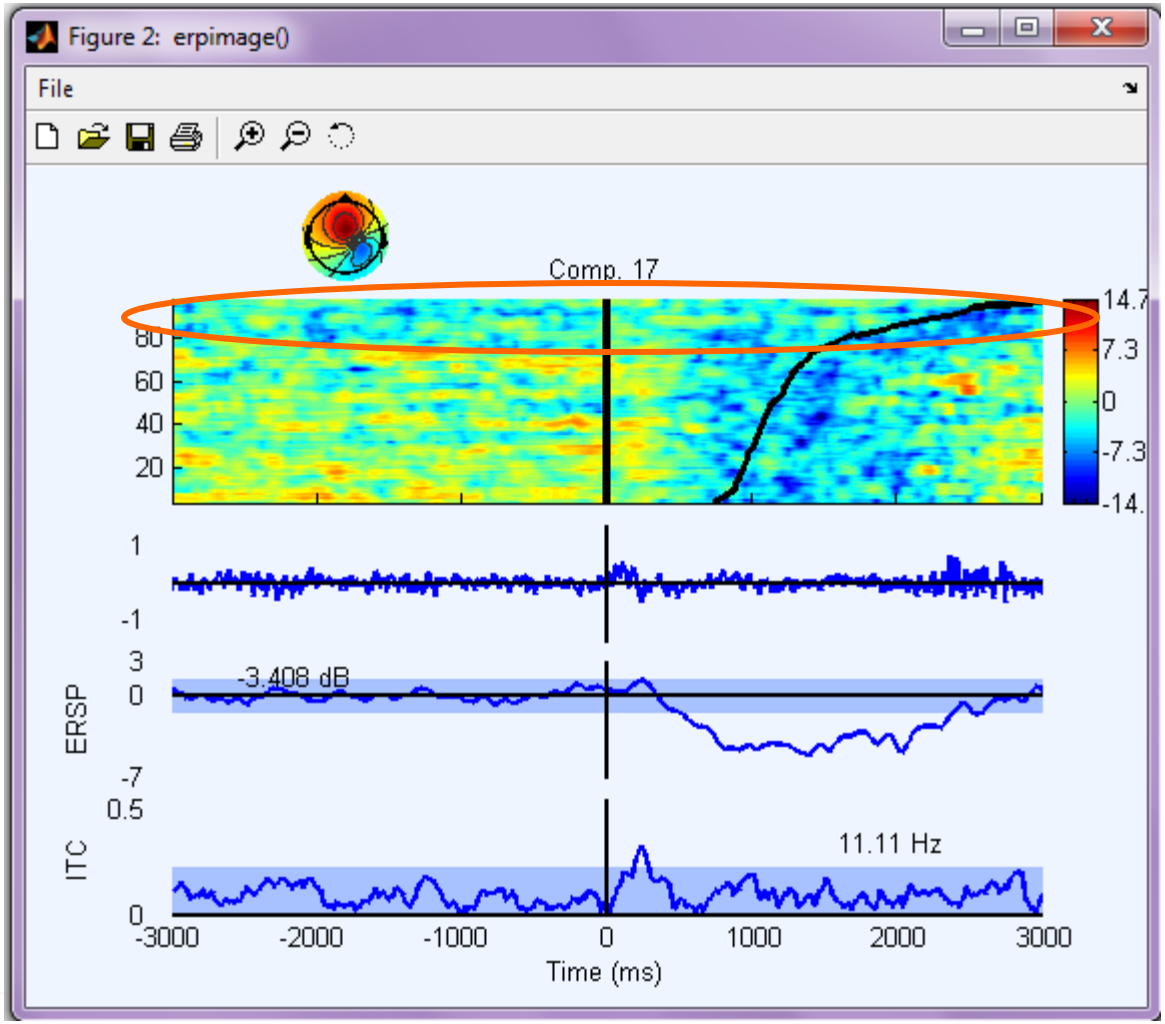
Component ERP Images



Sorting options in ERP image: RT

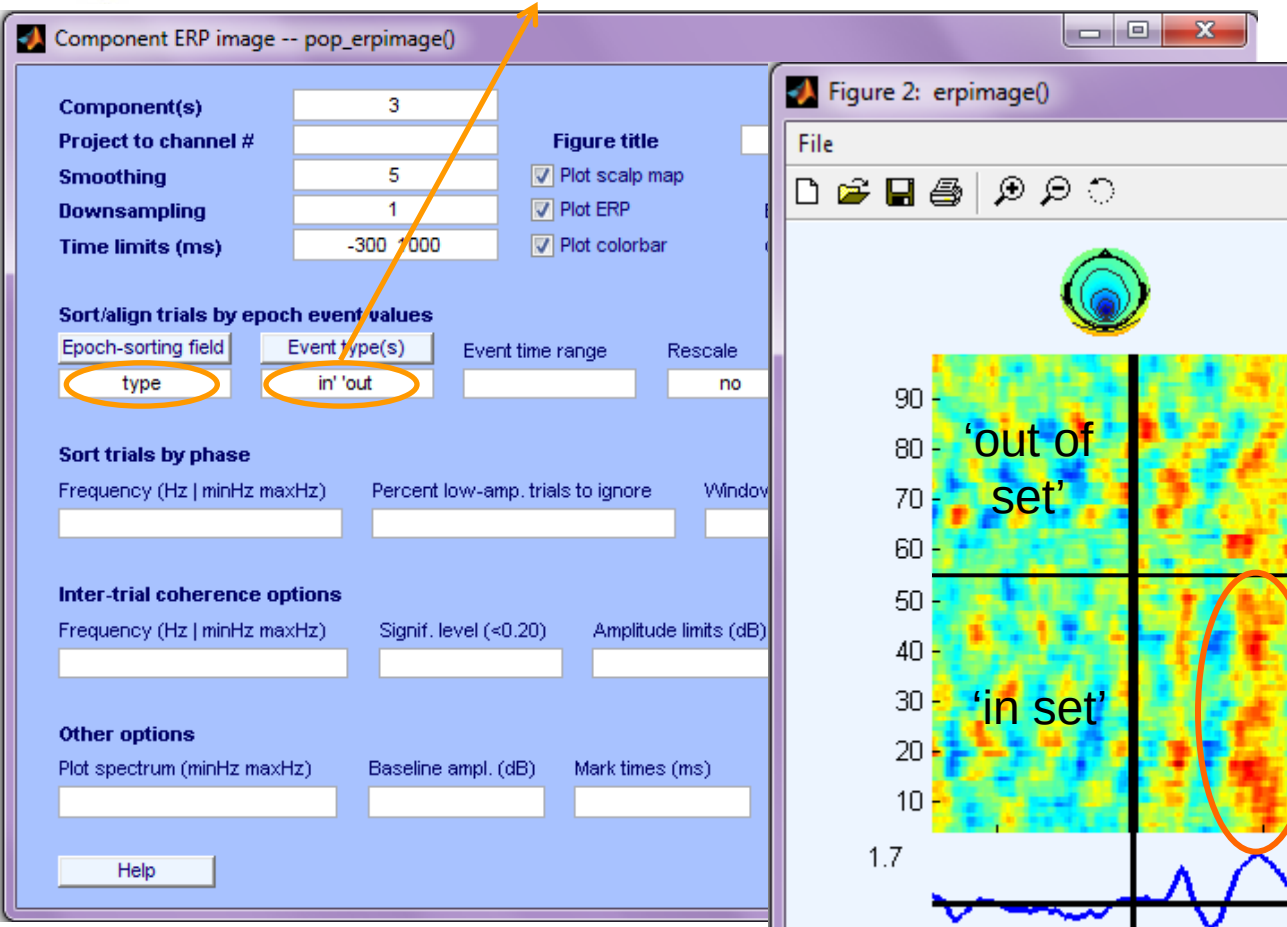


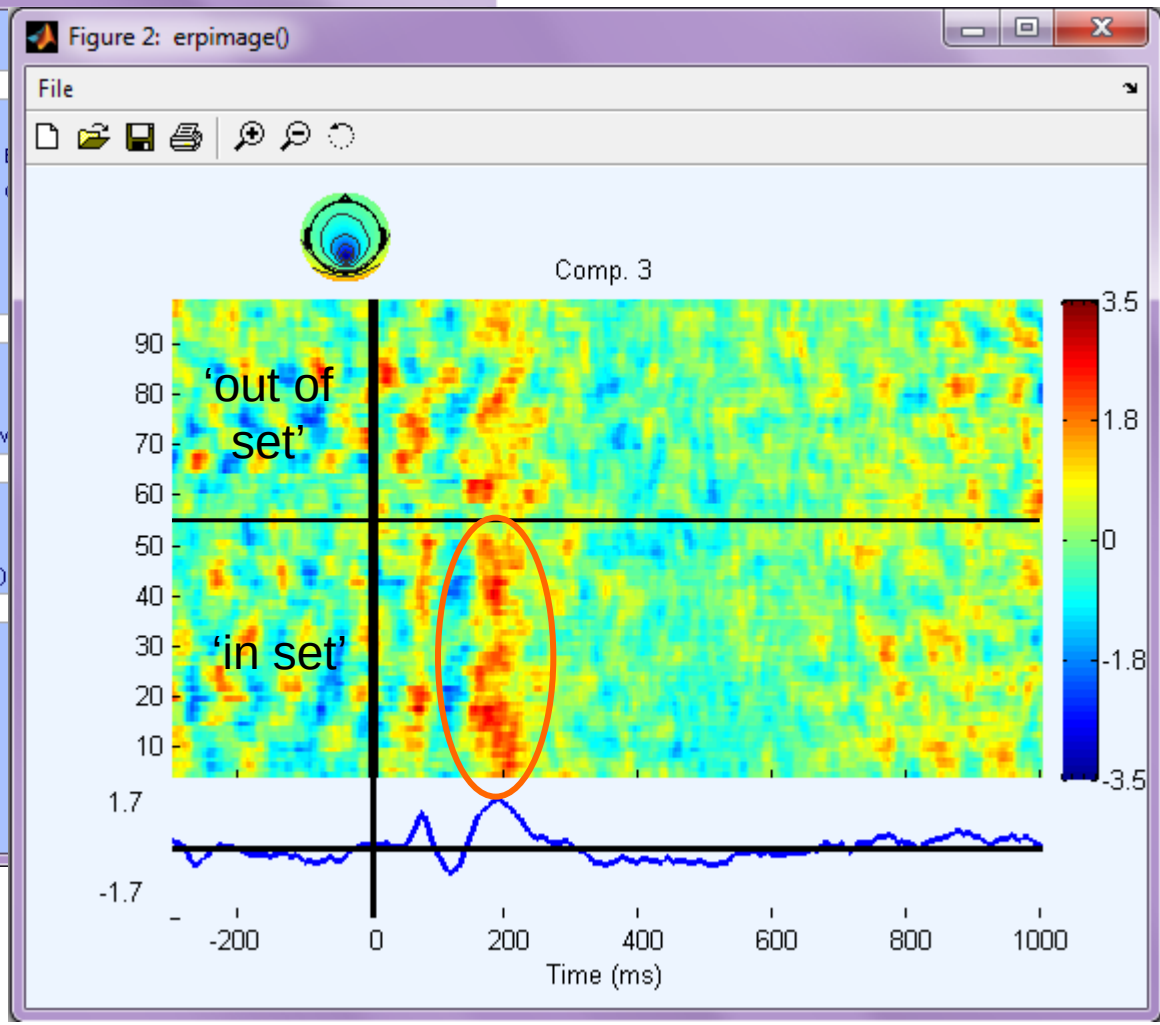
Sorting options in ERP image: RT



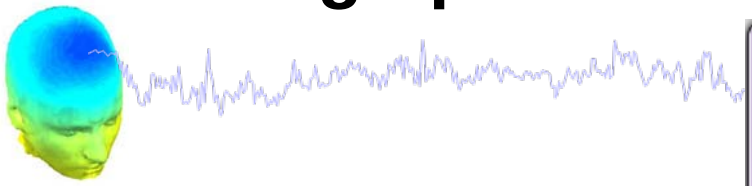
Sorting options in ERP image: type

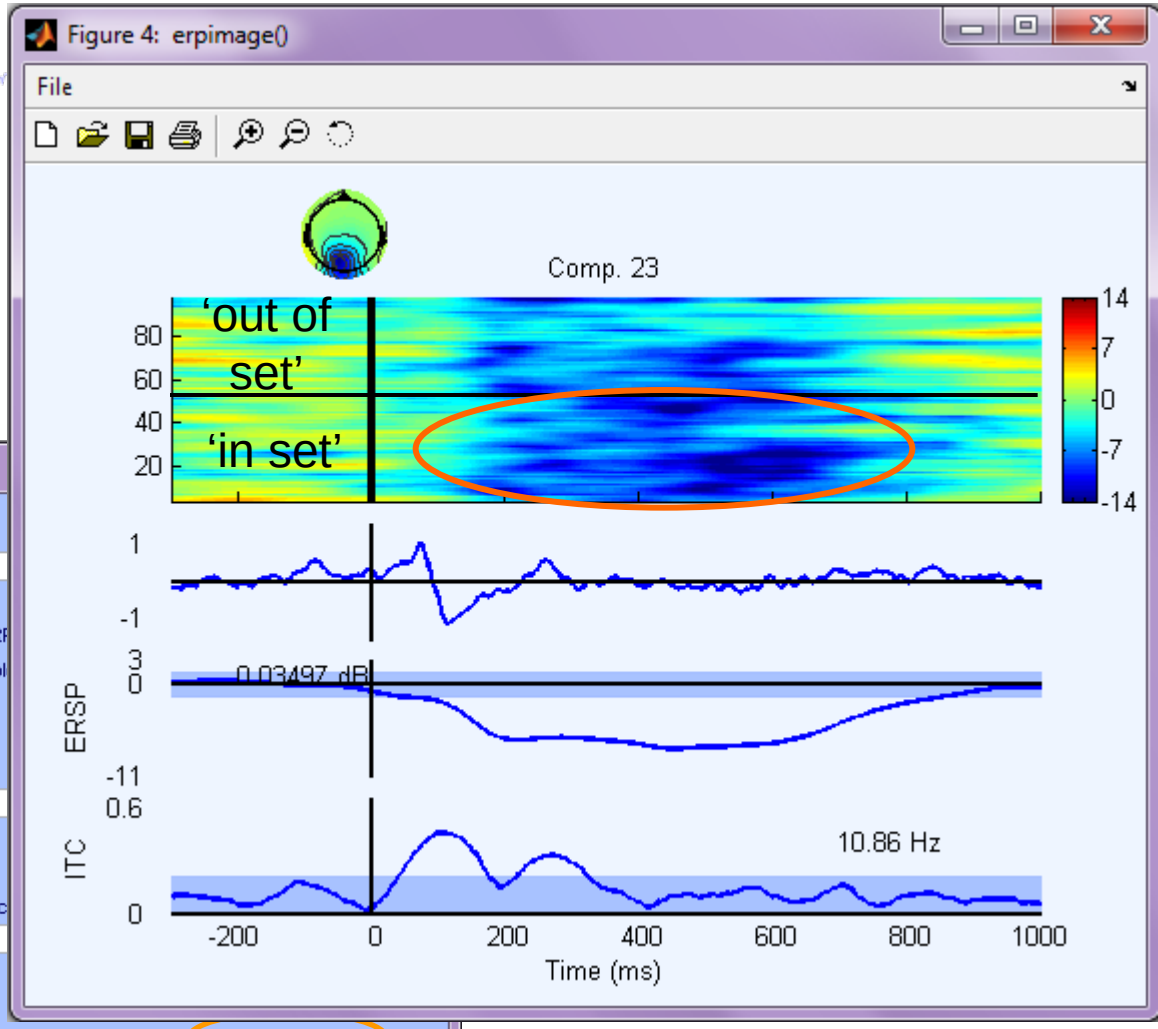
(ie, “was the probe letter in memorized set or not?”)

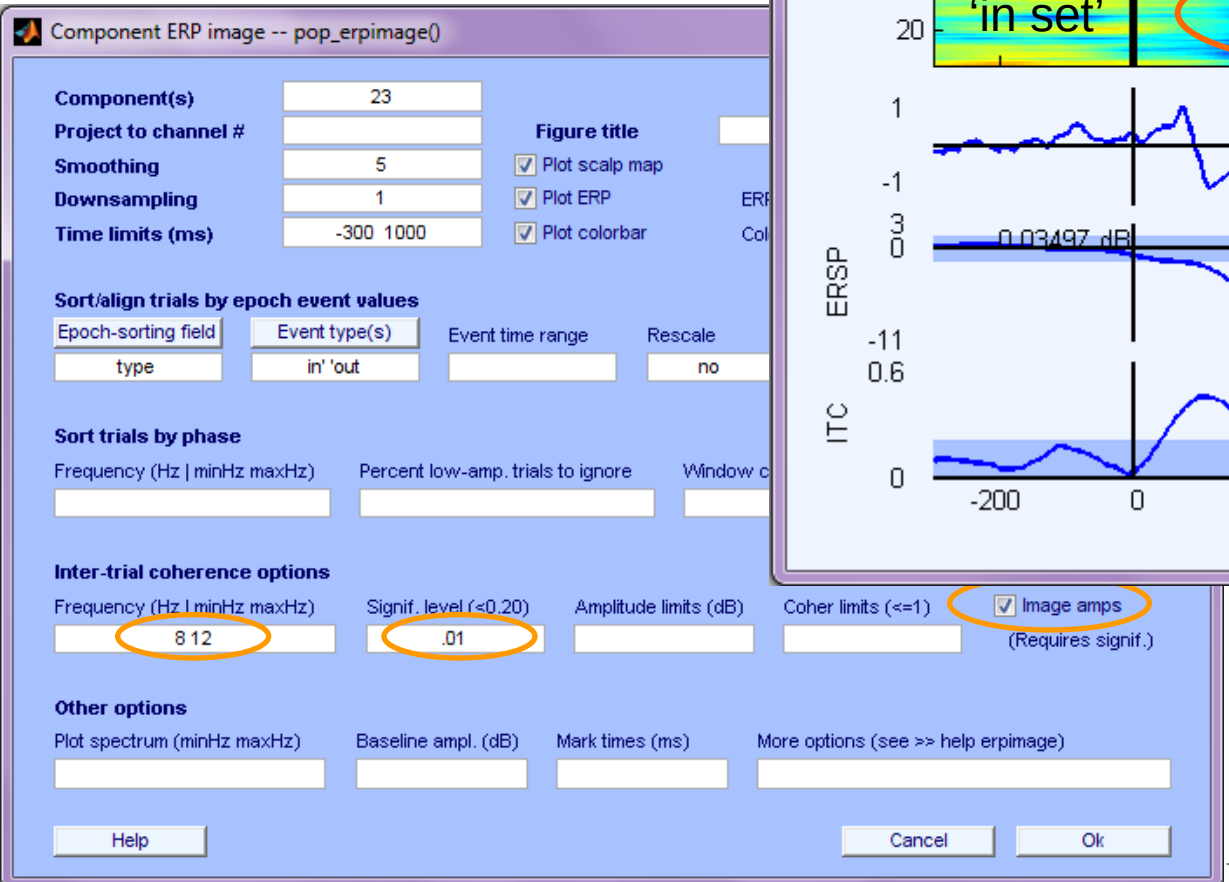




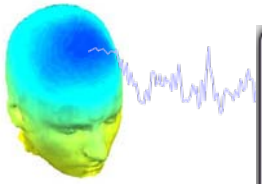
Sorting options in ERP image: type (img amps)







Plot IC ERSP



Plot component time frequency -- pop_newtimef()

Component number: 3
Sub epoch time limits [min max] (msec): -1000 1996
Use 200 time points
Frequency limits [min max] (Hz) or sequence:
Use limits, padding 1
Log spaced
Baseline limits [min max] (msec) (0->pre-stim.): 0
Use divisive baseline
No baseline
Wavelet cycles [min max/fact] or sequence: 3 0.5
Use limits
Use FFT
ERSP color limits [max] (min=
ITC color limits [max]
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EEGLAB v7.1.7.18b

File Edit Tools Plot

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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
Cluster dataset ICs

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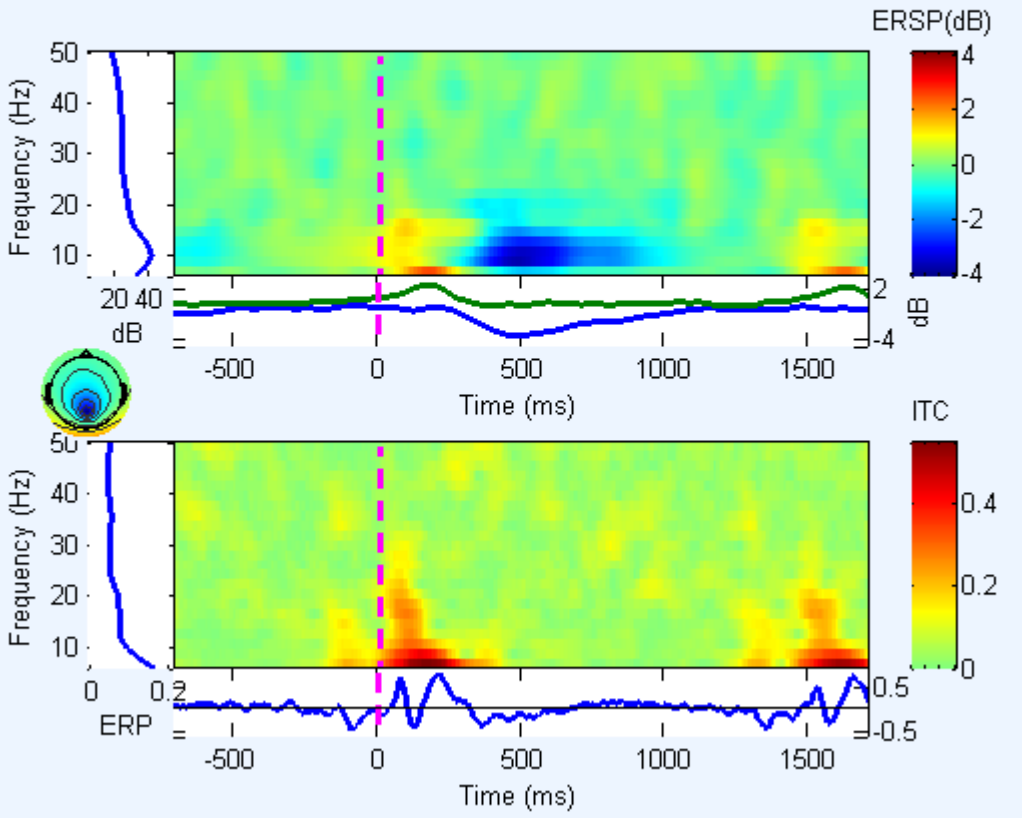
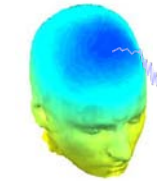
Figure 3

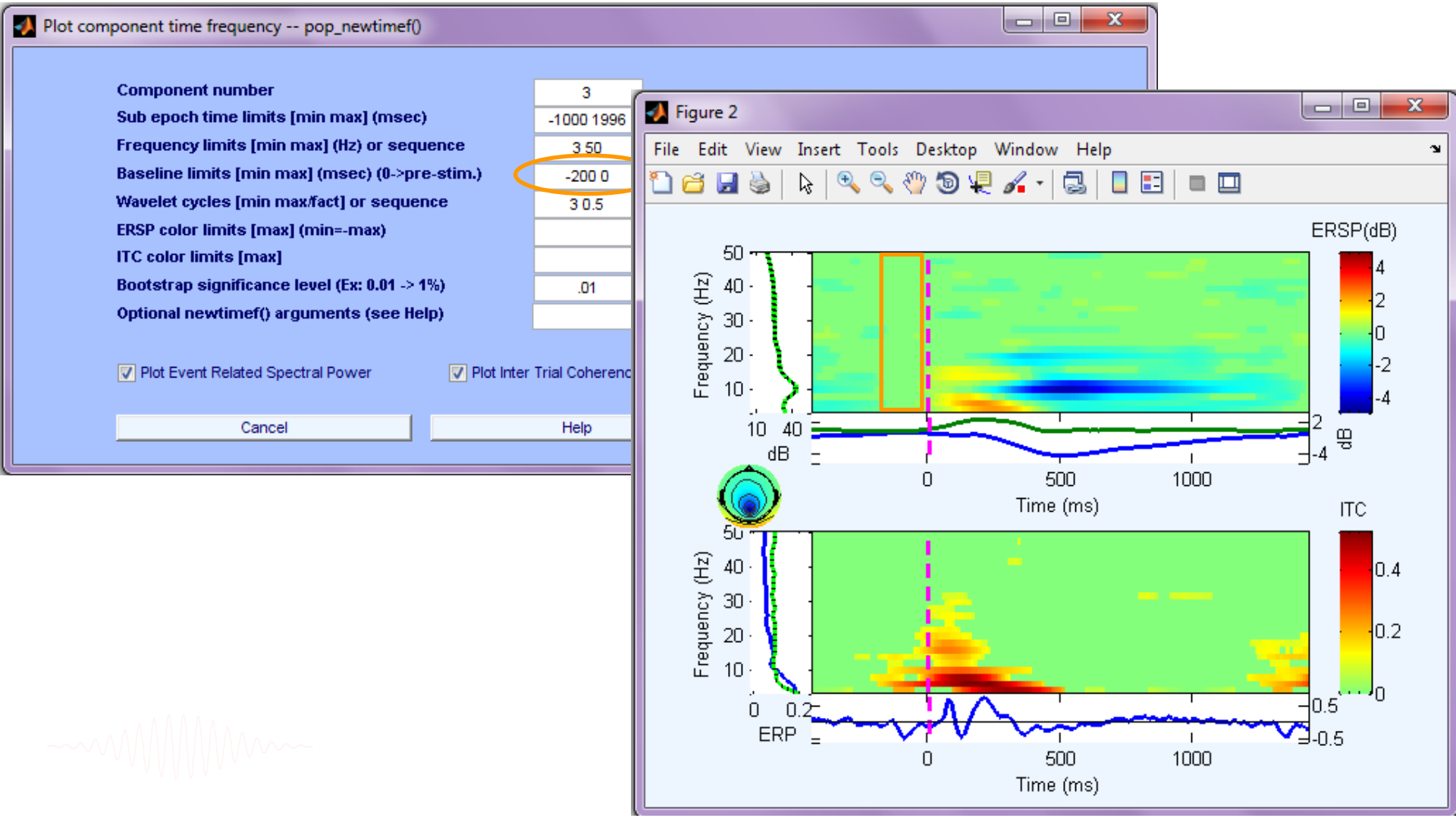
File

Time points lost at beginning and end of epoch

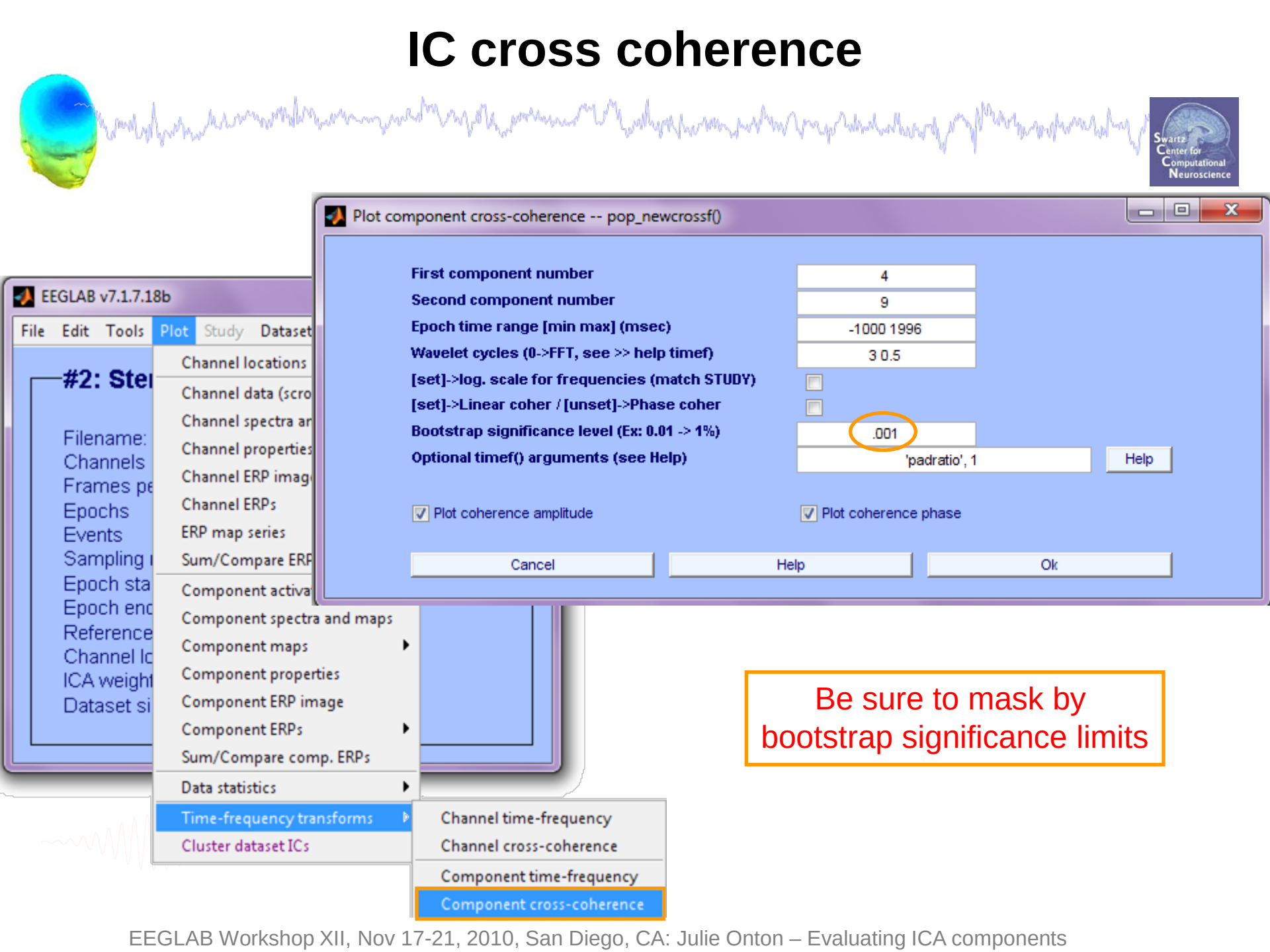


Plot IC ERSP



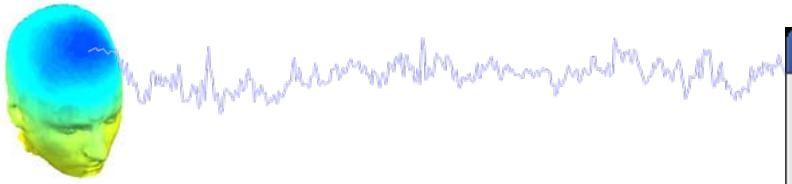

Plot component time frequency -- pop_newtimef()
Component number
3
Sub epoch time limits [min max] (msec)
-1000 1996
Frequency limits [min max] (Hz) or sequence
3 50
Baseline limits [min max] (msec) (0->pre-stim.)
-200 0
Wavelet cycles [min max/fact] or sequence
3 0.5
ERSP color limits [max] (min=-max)
ITC color limits [max]
Bootstrap significance level (Ex: 0.01 -> 1%)
.01
Optional newtimef() arguments (see Help)
Plot Event Related Spectral Power
Plot Inter Trial Coherenc
Cancel
Help
Figure 2
File Edit View Insert Tools Desktop Window Help
ERSP(dB)
Frequency (Hz)
dB
Time (ms)
ITC
ERP

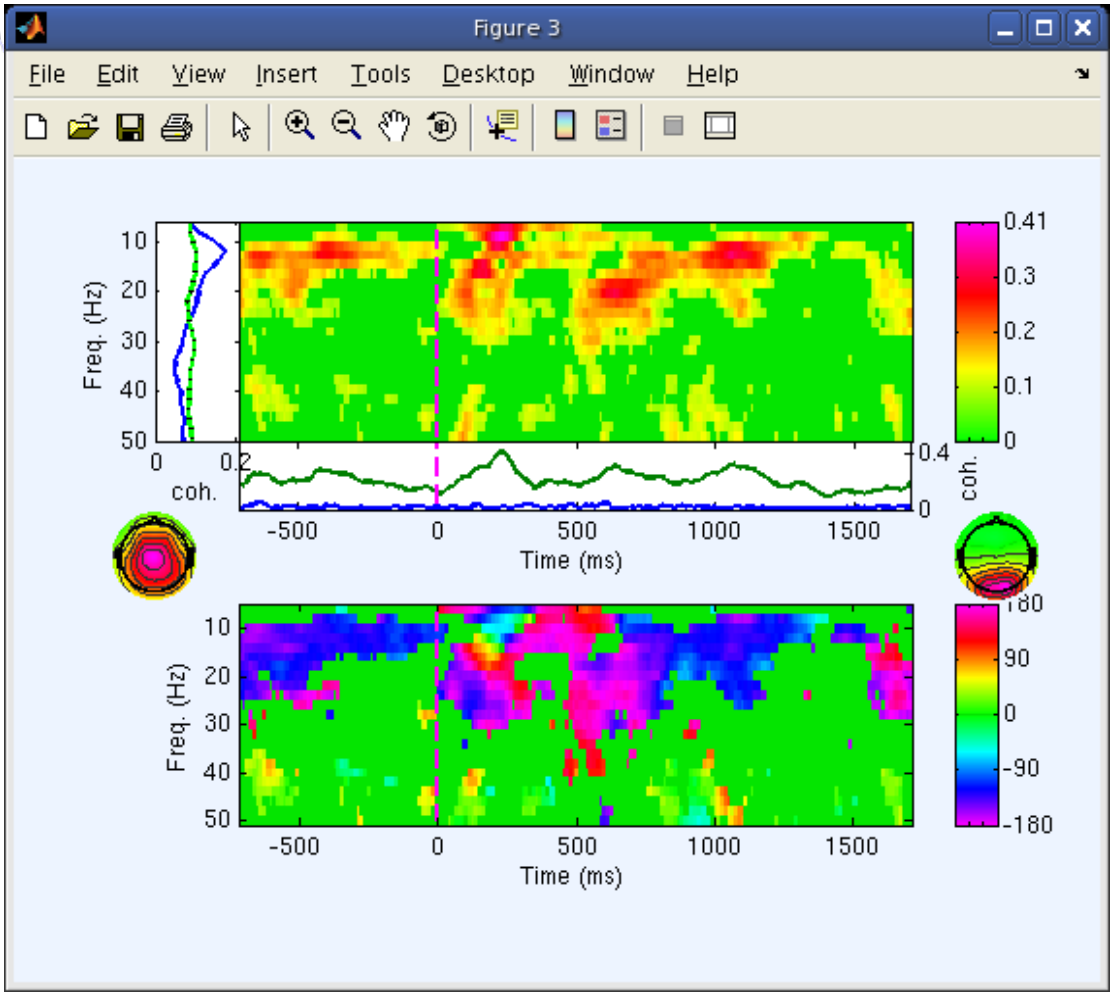
IC cross coherence

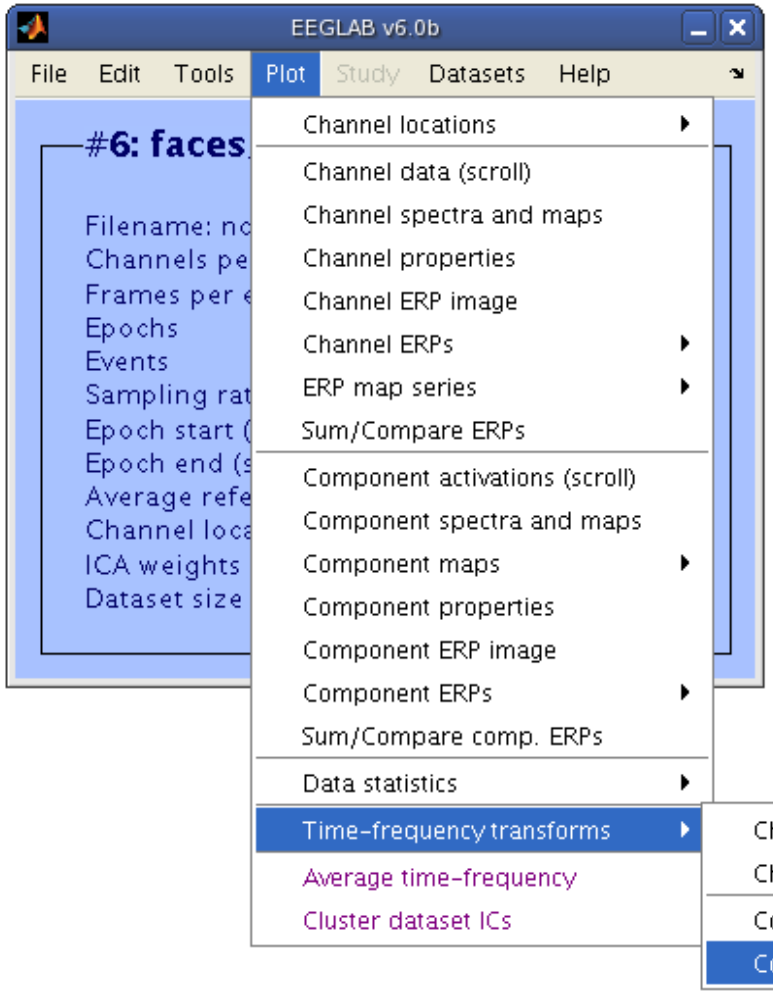


Be sure to mask by bootstrap significance limits

IC cross coherence







Exercise

- **ALL**
  - Load stern.set, epoch on **Memorize** letters, reject noise

- **Novice**
  - From the GUI, plot component ERPs with maps
  - Pick an interesting IC and plot an ERP image of it
  - Try sorting by RT or phase
  - Plot power and activations with same sorting order
    > is there any relationship?

- **Intermediate**
  - Plot ERSPs for selected IC
    > Compare FFT, wavelet(s), and multi-taper methods for ERSP
  - Plot cross coherence between two selected ICs
    > Compare this result with cross coherence between two channels that are highly weighted in the respective ICs