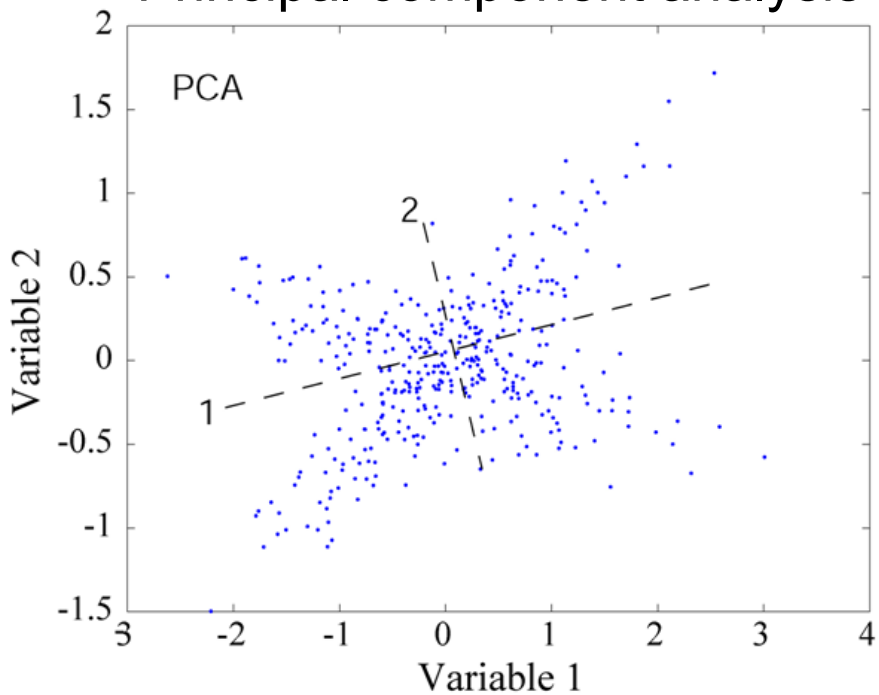
Independent component analysis applied to biophysical time series and EEG

Arnaud Delorme

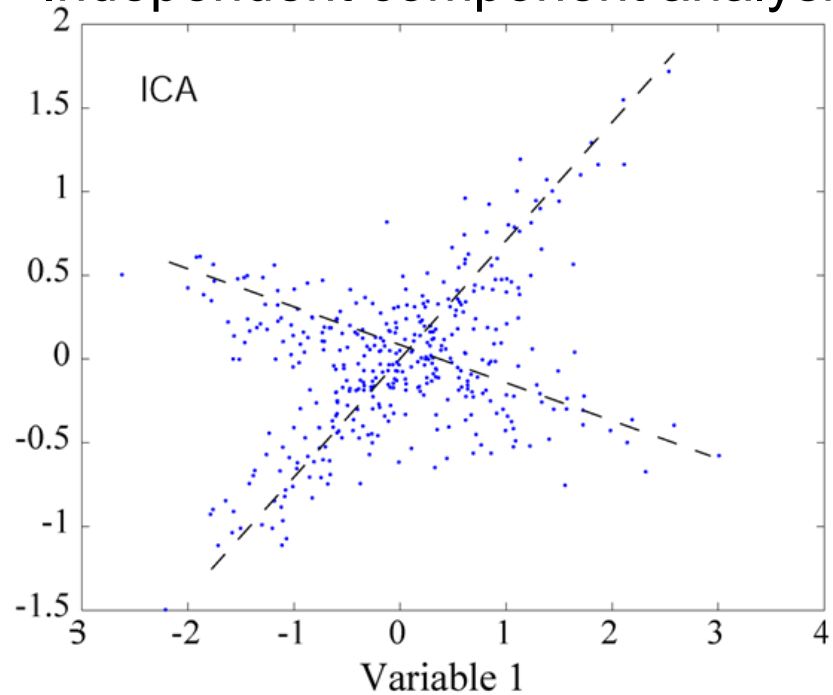
ICA and PCA

ICA is a method to recover a version, of the original sources by multiplying the data by a unmixing matrix,

Principal component analysis

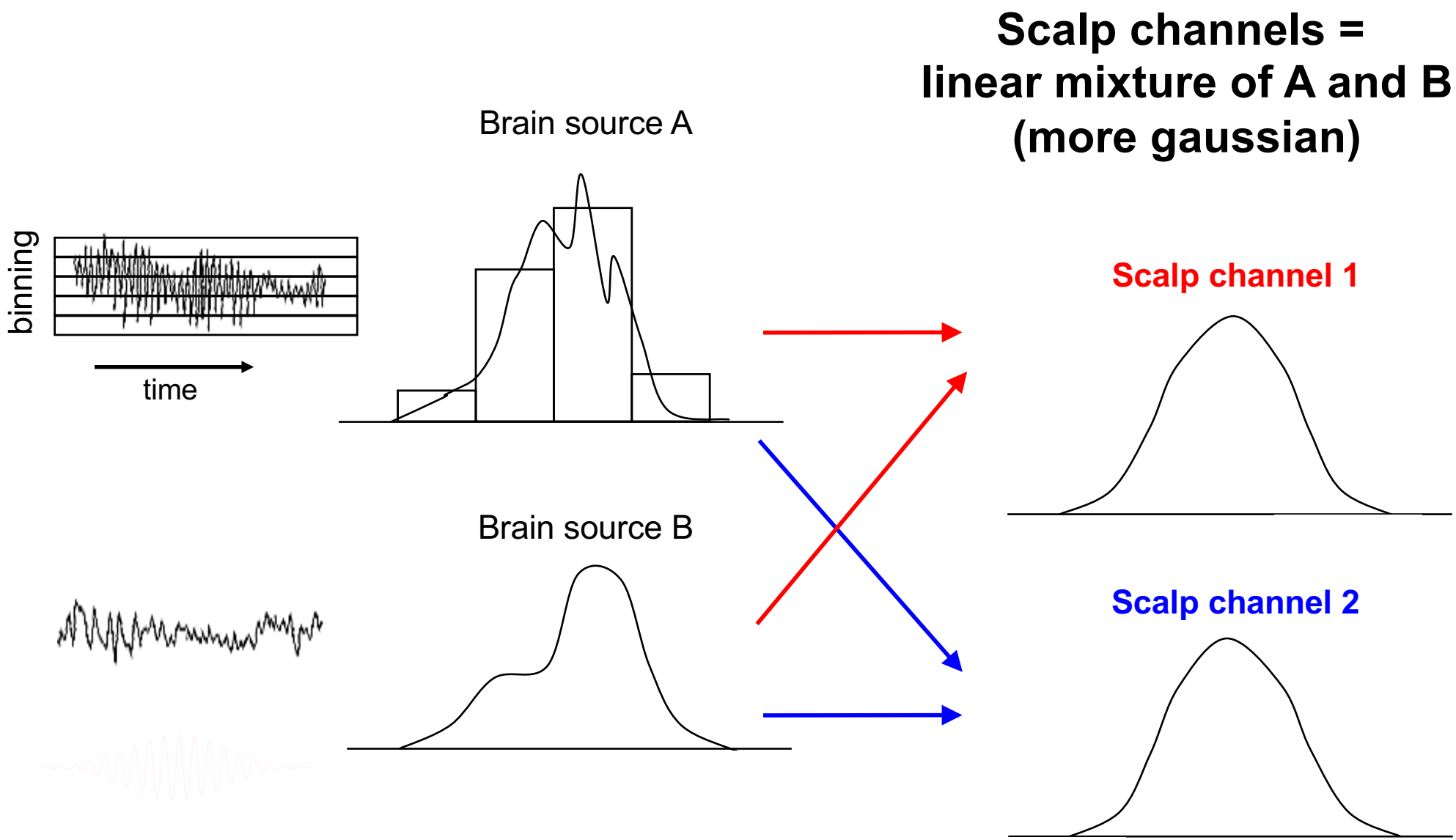


Independent component analysis

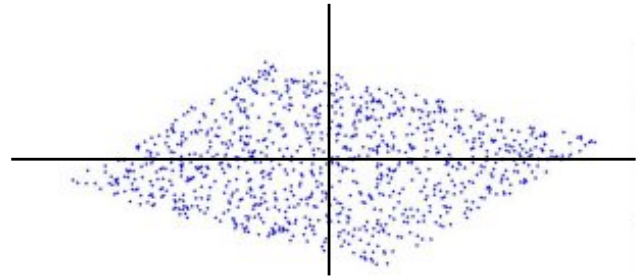


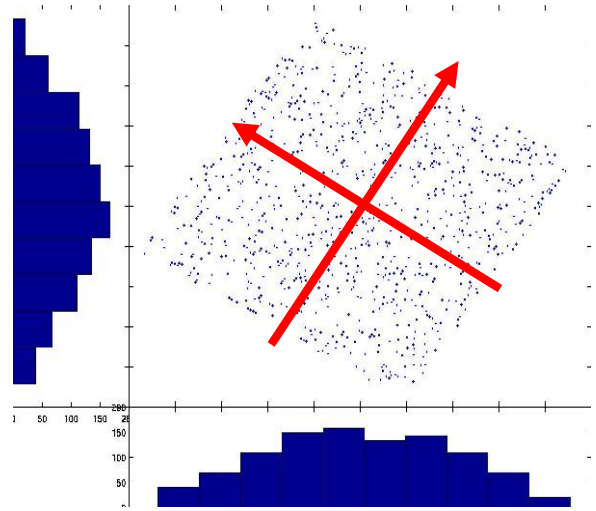
While PCA simply decorrelates the outputs (using an orthogonal mixing matrix), ICA attempts to make the outputs **statistically independent**, while placing no constraints on the minxing matrix.

Central limit theorem

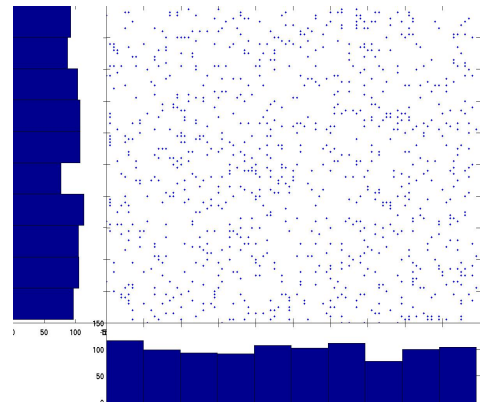


ICA Training Process





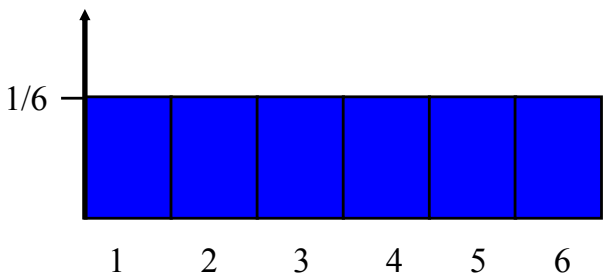
Central limit theorem



Entropy

$$H(X) = -\sum_{x \in \mathcal{X}} p(x) \log_b p(x).$$

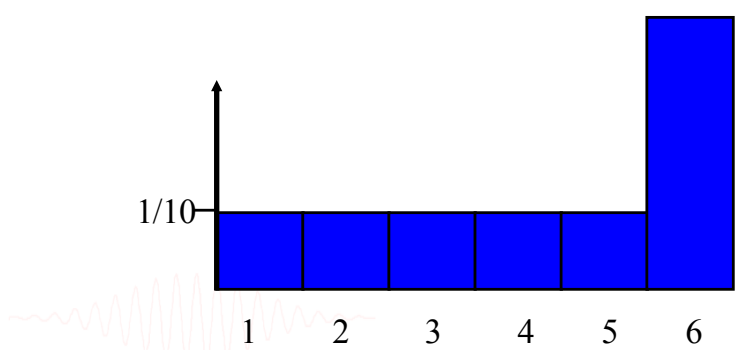
Dice: 1/6



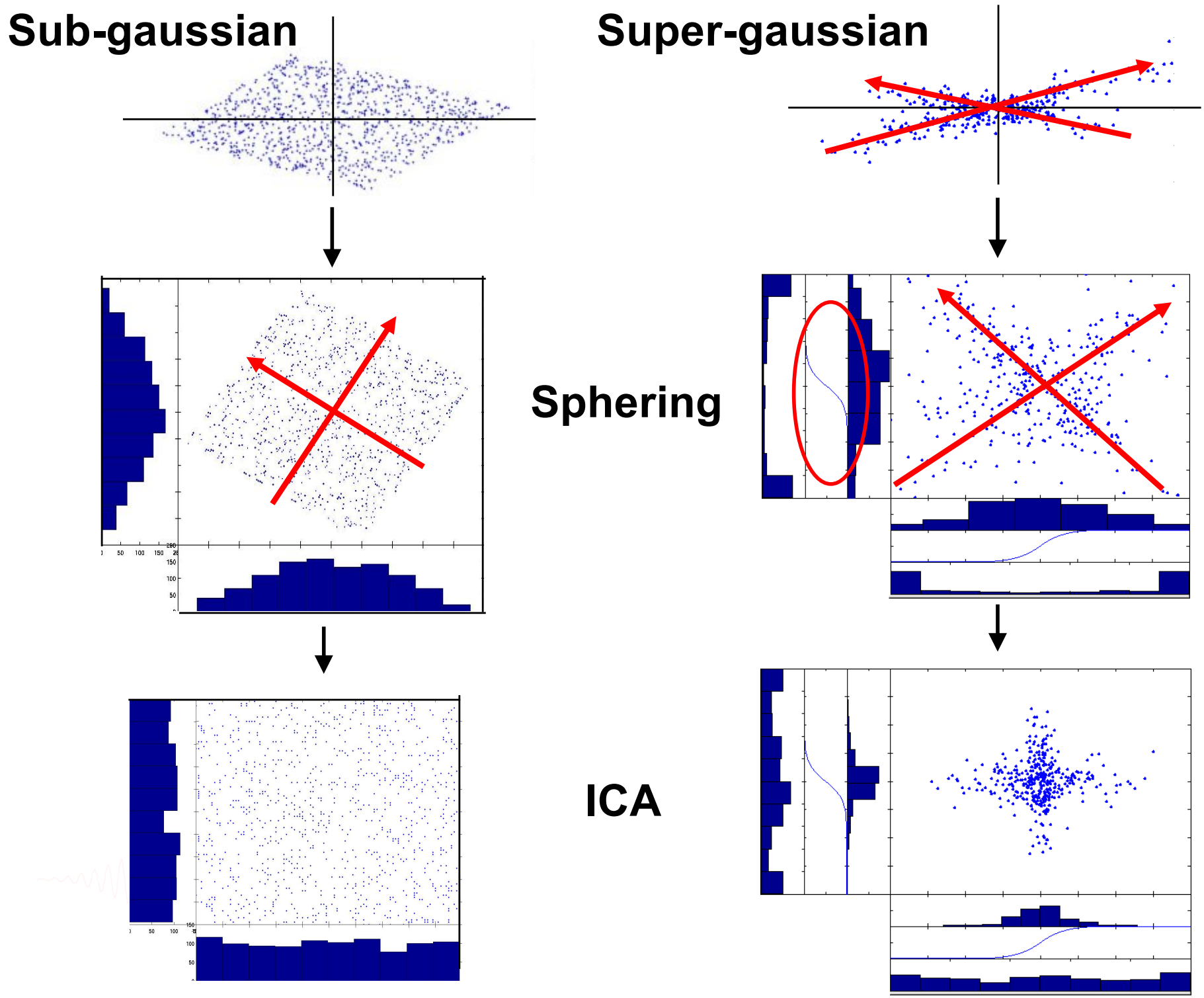
$$H = 6\left(-\frac{1}{6}\log_2\left(\frac{1}{6}\right)\right) = 2.58$$

Fake dice (make a 6 half of the time): entropy 2.16 (base 2)

less random



$$H = 5\left(-\frac{1}{10}\log_2\left(\frac{1}{10}\right)\right) - \frac{1}{2}\log_2\left(\frac{1}{2}\right) = 2.16$$


Sub-gaussian
Super-gaussian
Sphering
ICA

$$\mathbf{U} = \mathbf{W}\mathbf{X}$$

ICA activity

Data

Data X

$$\begin{array}{c} \\ \\ \\ \end{array}\begin{bmatrix} 3 & 2 & 5 & 4 & 3 & 2 & \\ 0 & -2 & -5 & -1 & 1 & -1 & \ldots \\ -1 & 2 & 0 & 1 & 0 & -3 & \end{bmatrix}\begin{array}{l} \leftarrow \text{Channel 1} \\ \leftarrow \text{Channel 2} \\ \leftarrow \text{Channel 3} \end{array}$$

$$\begin{bmatrix} 5 & 3 & -2 \\ 1 & 2 & 4 \\ 0 & -1 & 3 \end{bmatrix} \rightarrow \begin{bmatrix} 3*5+0*3-1*(-2) & 2*5+(-2)*3+2*(-2) & \\ 3*1+0*2-1*4 & 2*1+(-2)*2+2*4 & \ldots \\ 5*1-5*2+0*4 & 5*1-5*2+0*4 & \end{bmatrix}\begin{array}{l} \leftarrow \text{Comp. 1} \\ \leftarrow \text{Comp. 2} \\ \leftarrow \text{Comp. 3} \end{array}$$

Weight matrix W

ICA activity U

$$\mathbf{X} = \mathbf{W}^{-1}\mathbf{U}$$

Data

ICA activity U

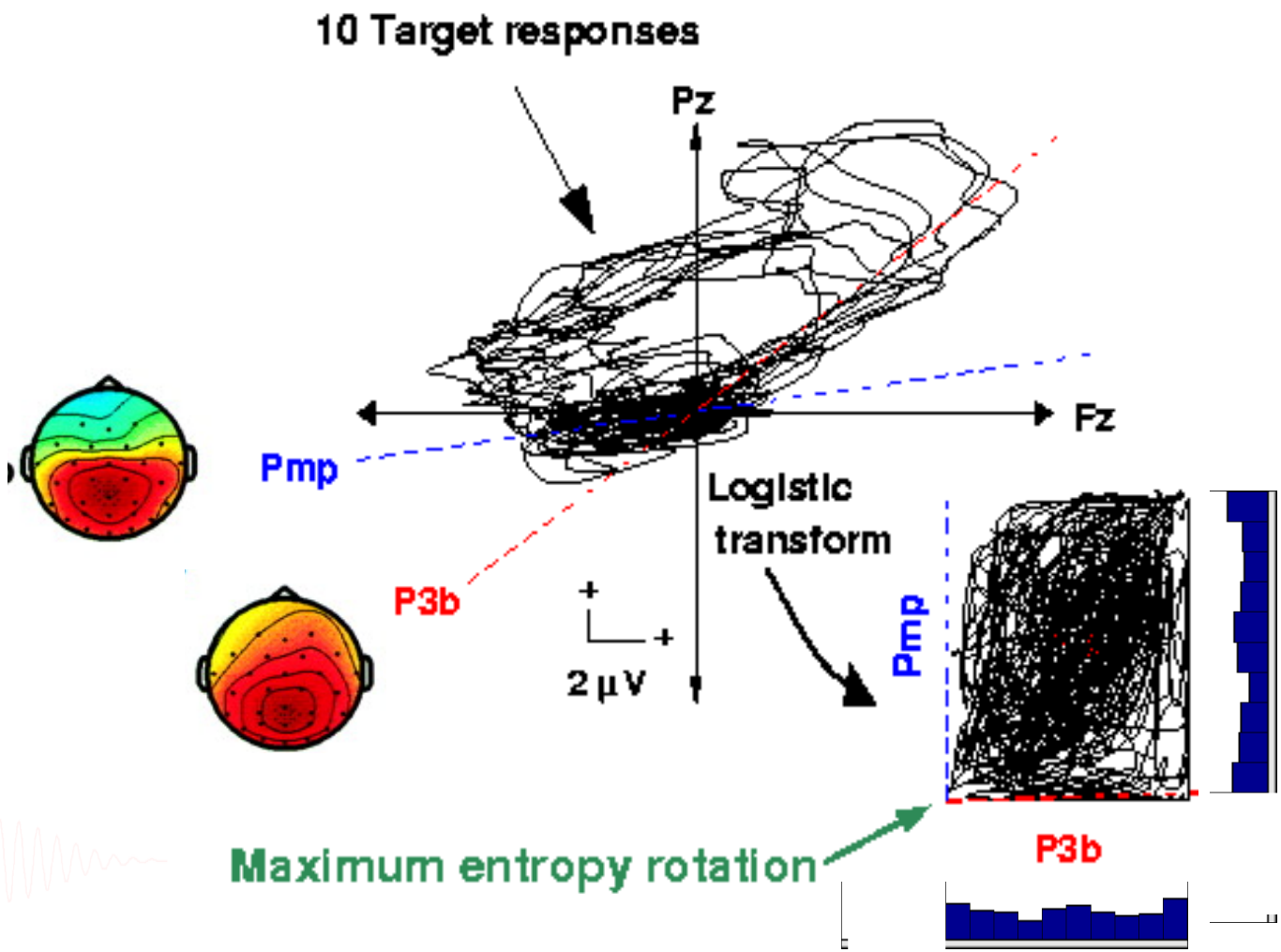
$$\begin{array}{cl} \begin{bmatrix} 3 & 2 & 5 & 4 & 3 & 2 & \\ 0 & -2 & -5 & -1 & 1 & -1 & \dots \\ -1 & 2 & 0 & 1 & 0 & -3 & \end{bmatrix} & \begin{array}{l} \leftarrow \text{Comp. 1} \\ \leftarrow \text{Comp. 2} \\ \leftarrow \text{Comp. 3} \end{array} \end{array}$$

$$\begin{bmatrix} 5 & 3 & -2 \\ 1 & 2 & 4 \\ 0 & -1 & 3 \end{bmatrix} \rightarrow \begin{array}{cl} \begin{bmatrix} 3*5+0*3-1*(-2) & 2*5+(-2)*3+2*(-2) & \\ 3*1+0*2-1*4 & 2*1+(-2)*2+2*4 & \dots \\ 5*1-5*2+0*4 & 5*1-5*2+0*4 & \end{bmatrix} & \begin{array}{l} \leftarrow \text{Chan 1} \\ \leftarrow \text{Chan 2} \\ \leftarrow \text{Chan 3} \end{array} \end{array}$$

Inverse weight matrix W^{-1}

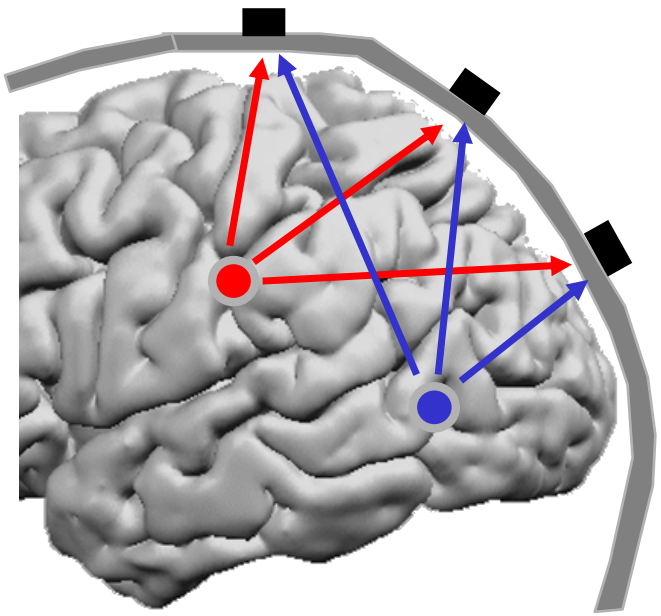
Data X

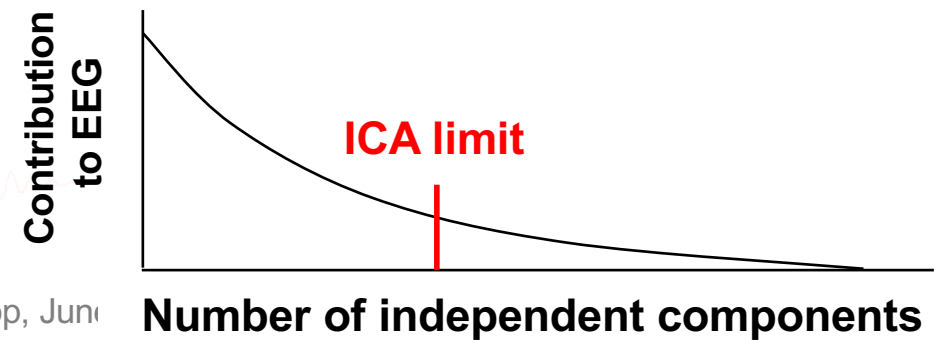
Independent components of EEG/ERP



ICA/EEG Assumptions

- Mixing is linear at electrodes **OK**
- Propagation delays are negligible **OK**
- Component time courses are independent **~**
- Number of components less than the number of channels.

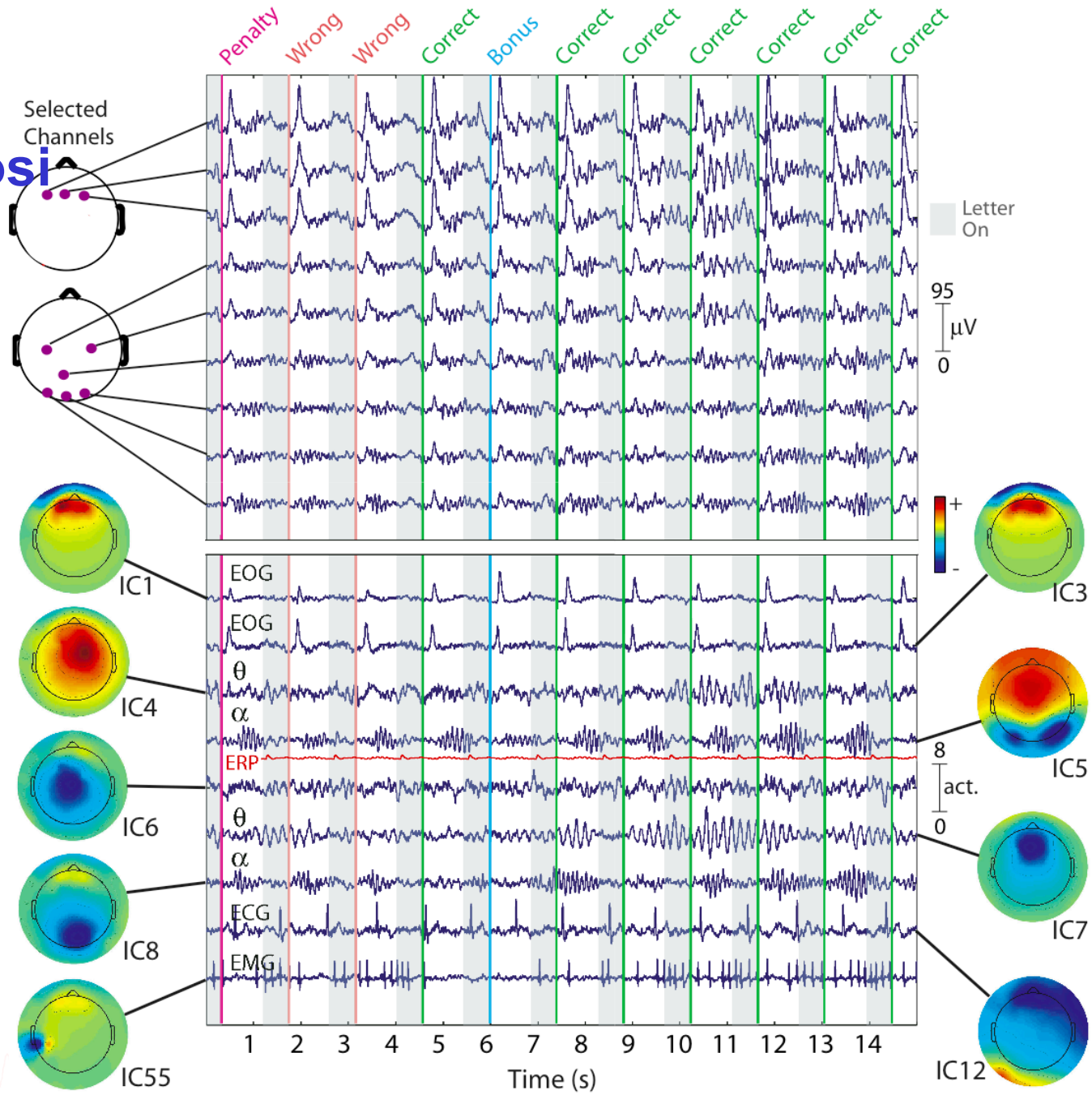




Characteristics of Independent Component of the EEG

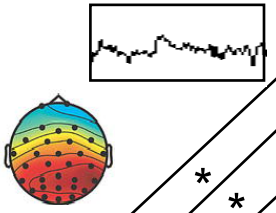
- Artifacts
- Stimulus-locked activity
- Response-locked activity
- Non-phase locked activity
- Event-modulated oscillatory activity
- Overlapping Maps and Spectra

Sample EEG Decomposition



Credit: J. Onton

Temporal ICA



ICA activity U

$$\begin{bmatrix} u_{1,1} & u_{1,2} & u_{1,3} & u_{1,4} & \\ u_{2,1} & u_{2,2} & u_{2,3} & u_{2,4} & \cdots \\ u_{3,1} & u_{3,2} & u_{3,3} & u_{3,4} & \end{bmatrix} \begin{array}{l} \leftarrow \text{Comp. 1} \\ \leftarrow \text{Comp. 2} \\ \leftarrow \text{Comp. 3} \end{array}$$

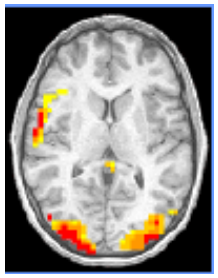
$$\mathbf{X}=\mathbf{W}^{-1}\mathbf{U}$$

$$\begin{bmatrix} w_{1,1}^{-1} & w_{1,2}^{-1} & w_{1,3}^{-1} \\ w_{2,1}^{-1} & w_{2,2}^{-1} & w_{2,3}^{-1} \\ w_{3,1}^{-1} & w_{3,2}^{-1} & w_{3,3}^{-1} \end{bmatrix} \rightarrow \begin{bmatrix} u_{1,1}w_{1,1}^{-1}+u_{2,1}w_{1,2}^{-1}+u_{3,1}w_{1,3}^{-1} & u_{1,2}w_{1,1}^{-1}+u_{2,2}w_{1,2}^{-1}+u_{3,2}w_{1,3}^{-1} & \\ u_{1,1}w_{2,1}^{-1}+u_{2,1}w_{2,2}^{-1}+u_{3,1}w_{2,3}^{-1} & u_{1,2}w_{2,1}^{-1}+u_{2,2}w_{2,2}^{-1}+u_{3,2}w_{2,3}^{-1} & \cdots \\ u_{1,1}w_{3,1}^{-1}+u_{2,1}w_{3,2}^{-1}+u_{3,1}w_{3,3}^{-1} & u_{1,2}w_{3,1}^{-1}+u_{2,2}w_{3,2}^{-1}+u_{3,2}w_{3,3}^{-1} & \end{bmatrix} \begin{array}{l} \leftarrow \text{Chan 1} \\ \leftarrow \text{Chan 2} \\ \leftarrow \text{Chan 3} \end{array}$$

Inverse weight matrix W^{-1}

Data X (EEG/MEG time series)

Spatial ICA



ICA activity U

$$\begin{bmatrix} u_{1,1} & u_{1,2} & u_{1,3} & u_{1,4} & \\ u_{2,1} & u_{2,2} & u_{2,3} & u_{2,4} & \cdots \\ u_{3,1} & u_{3,2} & u_{3,3} & u_{3,4} & \end{bmatrix} \begin{array}{l} \leftarrow \text{Comp. 1} \\ \leftarrow \text{Comp. 2} \\ \leftarrow \text{Comp. 3} \end{array}$$

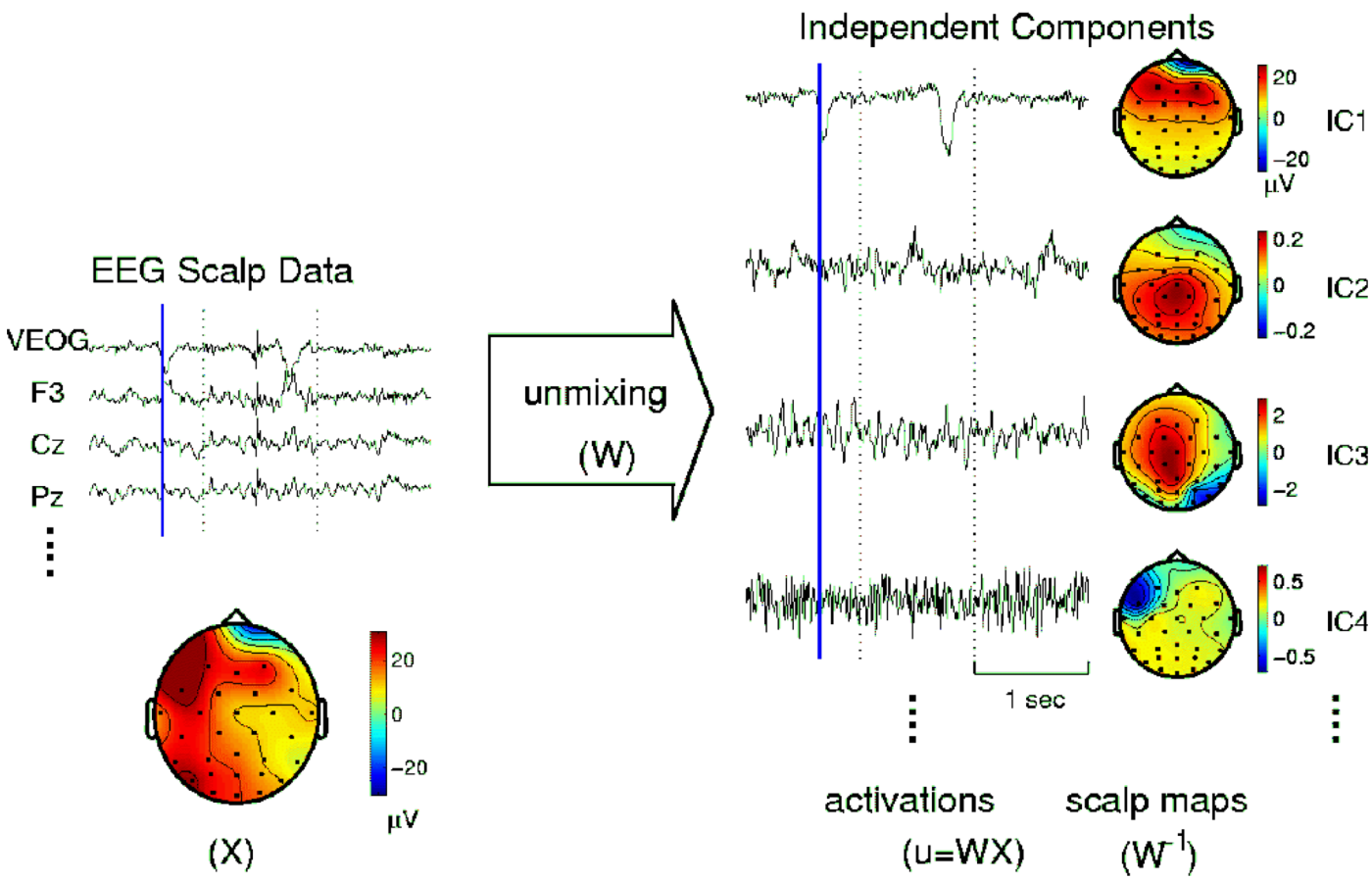
$$\mathbf{X}=\mathbf{W}^{-1}\mathbf{U}$$

$$\begin{bmatrix} w_{1,1}^{-1} & w_{1,2}^{-1} & w_{1,3}^{-1} \\ w_{2,1}^{-1} & w_{2,2}^{-1} & w_{2,3}^{-1} \\ w_{3,1}^{-1} & w_{3,2}^{-1} & w_{3,3}^{-1} \end{bmatrix} \rightarrow \begin{bmatrix} u_{1,1}w_{1,1}^{-1}+u_{2,1}w_{1,2}^{-1}+u_{3,1}w_{1,3}^{-1} & u_{1,2}w_{1,1}^{-1}+u_{2,2}w_{1,2}^{-1}+u_{3,2}w_{1,3}^{-1} & \\ u_{1,1}w_{2,1}^{-1}+u_{2,1}w_{2,2}^{-1}+u_{3,1}w_{2,3}^{-1} & u_{1,2}w_{2,1}^{-1}+u_{2,2}w_{2,2}^{-1}+u_{3,2}w_{2,3}^{-1} & \cdots \\ u_{1,1}w_{3,1}^{-1}+u_{2,1}w_{3,2}^{-1}+u_{3,1}w_{3,3}^{-1} & u_{1,2}w_{3,1}^{-1}+u_{2,2}w_{3,2}^{-1}+u_{3,2}w_{3,3}^{-1} & \end{bmatrix} \begin{array}{l} \leftarrow \text{Time 1} \\ \leftarrow \text{Time 2} \\ \leftarrow \text{Time 3} \end{array}$$

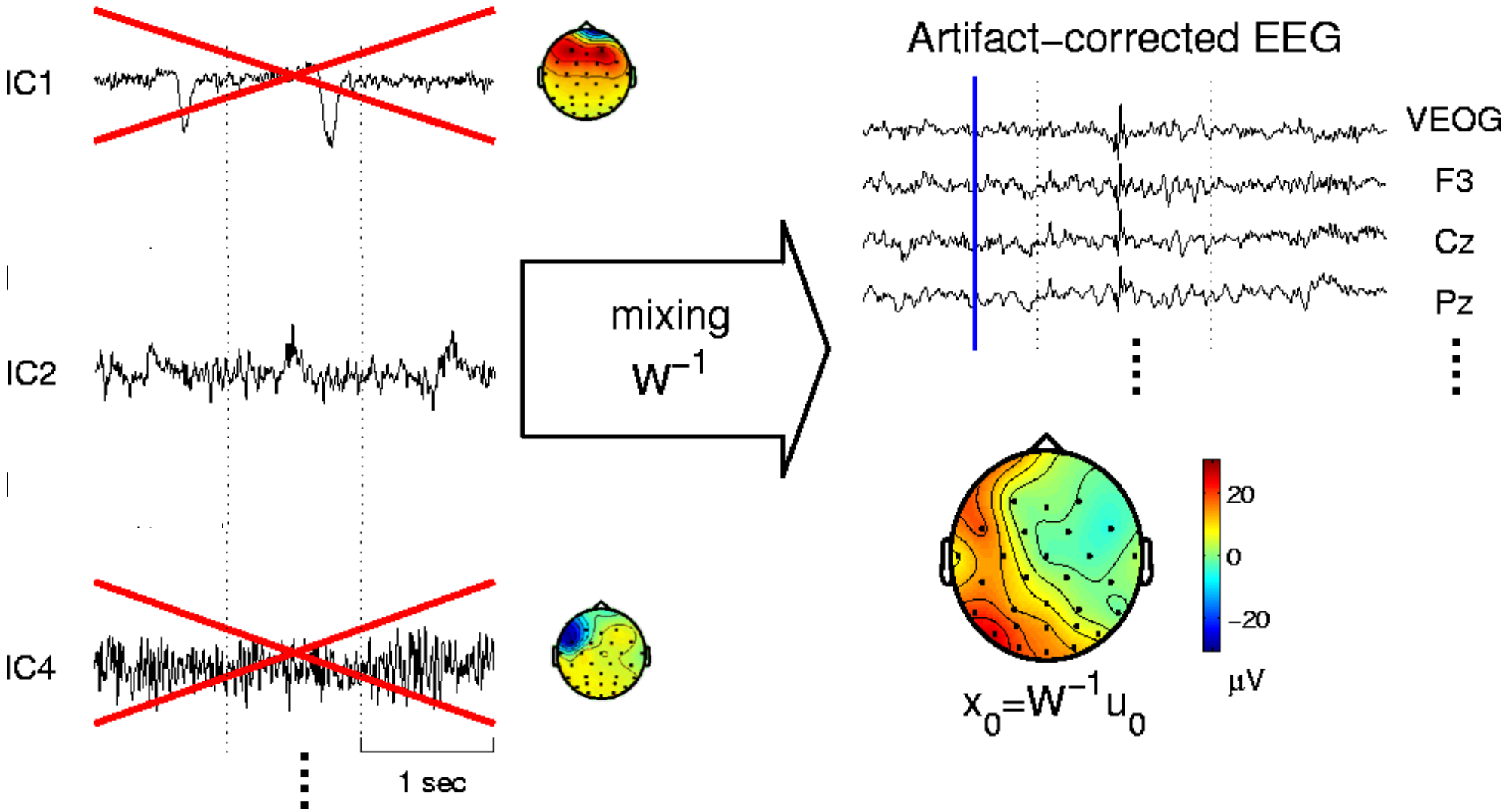
Inverse weight matrix W^{-1}

Data X (EEG/MEG voxel activities)

ICA Decomposition into Independent Components



Selective Projection onto Scalp Channels



$$\mathbf{X} = \mathbf{W}^{-1}\mathbf{U}$$

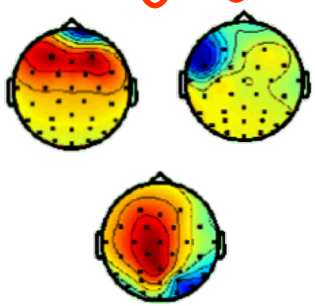
Data

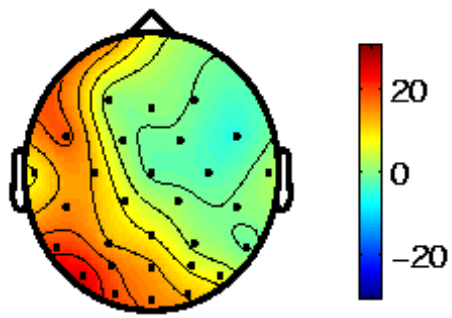
ICA activity U

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & \dots \\ 0 & -2 & -5 & -1 & 1 & -1 & \dots \\ 0 & 0 & 0 & 0 & 0 & 0 & \dots \\ \dots & & & & & & \end{bmatrix} \begin{array}{l} \leftarrow \text{Comp. 1} \\ \leftarrow \text{Comp. 2} \\ \leftarrow \text{Comp. 3} \\ \end{array}$$

$$\begin{bmatrix} 5 & 3 & -2 & \dots \\ 1 & 2 & 4 & \dots \\ 0 & -1 & 3 & \dots \\ \dots & & & \end{bmatrix} \rightarrow \begin{bmatrix} 3*5+0*3-1*(-2) & 2*5+(-2)*3+2*(-2) & \dots \\ 3*1+0*2-1*4 & 2*1+(-2)*2+2*4 & \dots \\ 5*1-5*2+0*4 & 5*1-5*2+0*4 & \dots \\ \dots & \dots & \end{bmatrix} \begin{array}{l} \leftarrow \text{Chan 1} \\ \leftarrow \text{Chan 2} \\ \leftarrow \text{Chan 3} \\ \end{array}$$

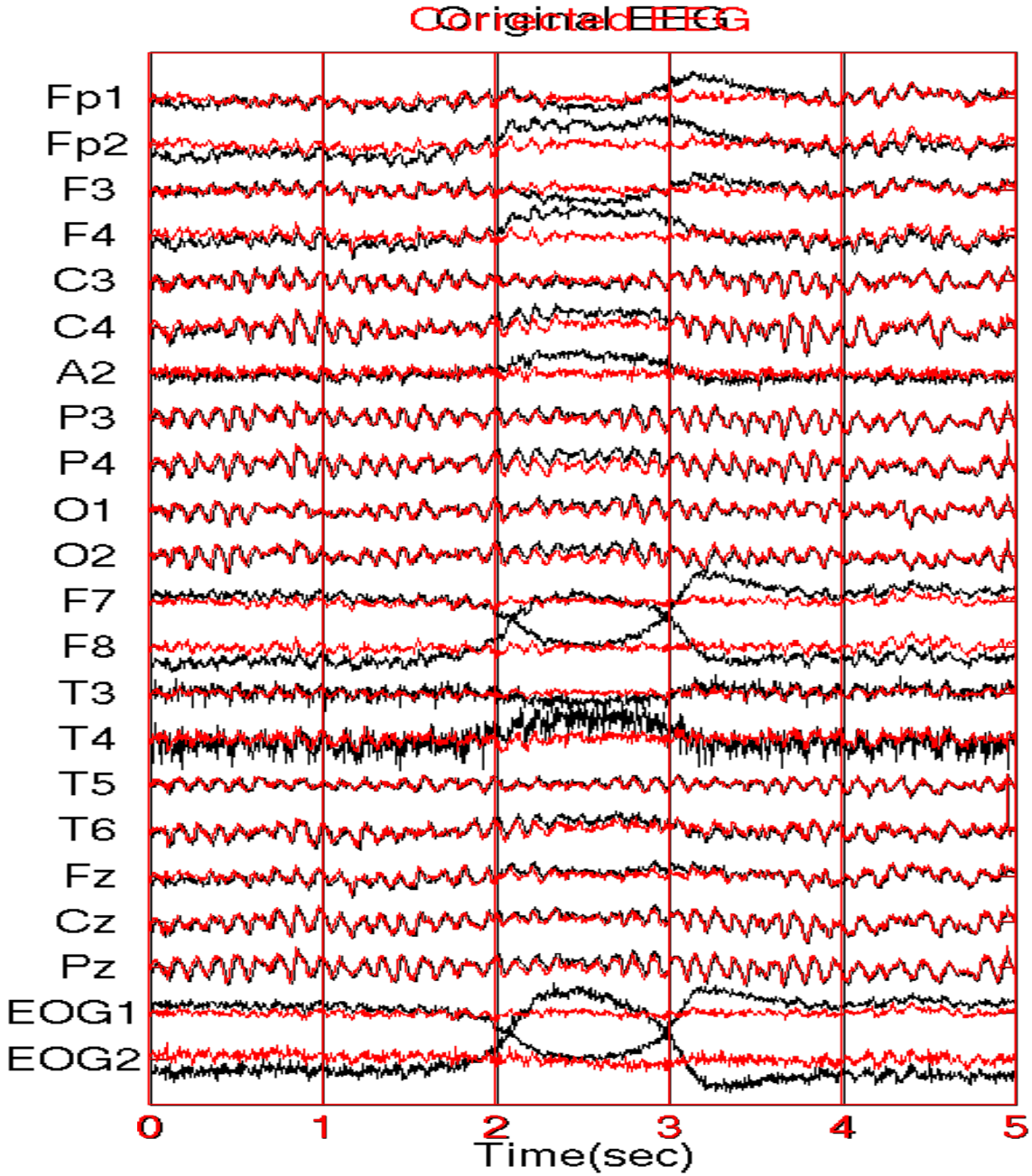
Data X



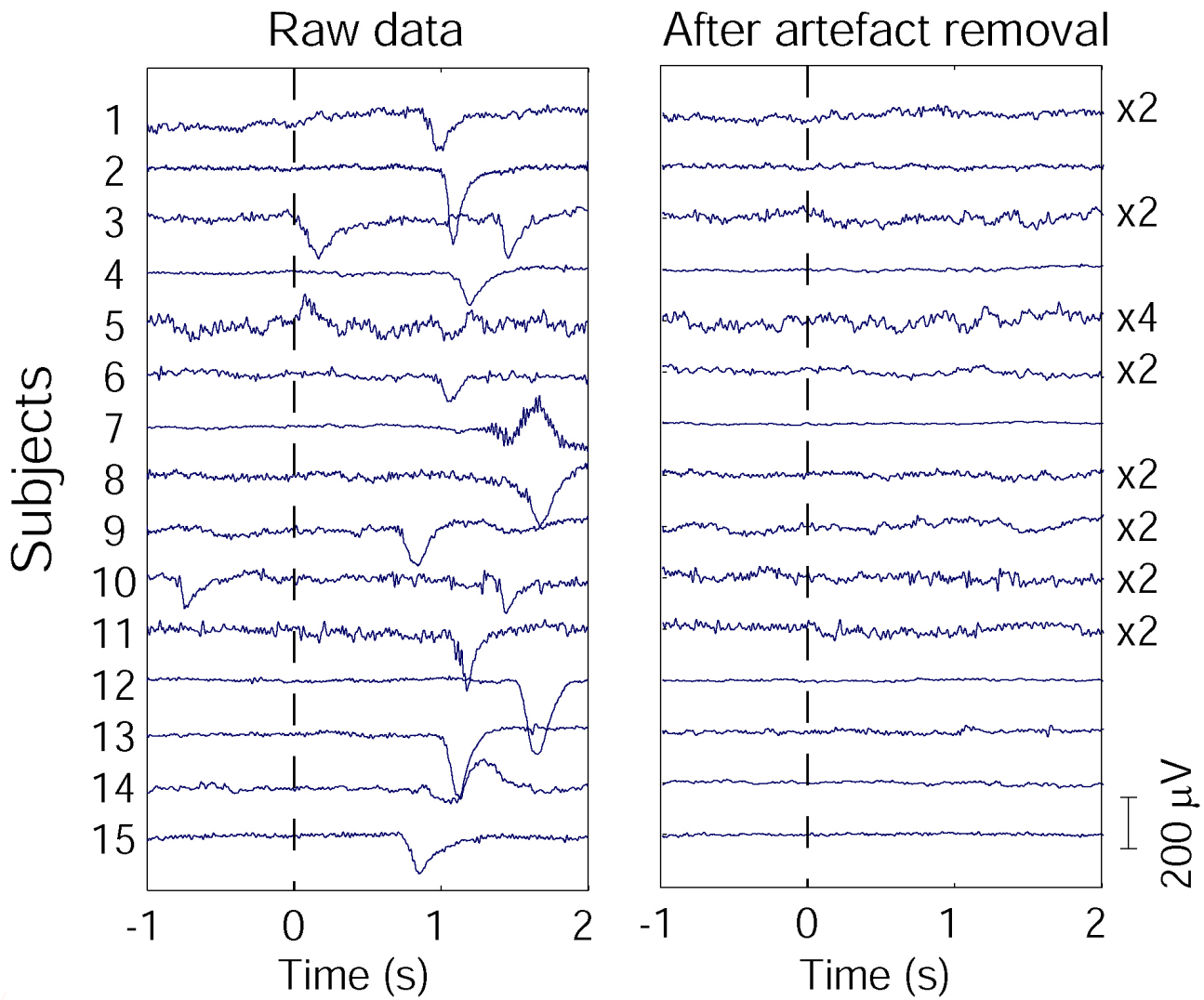


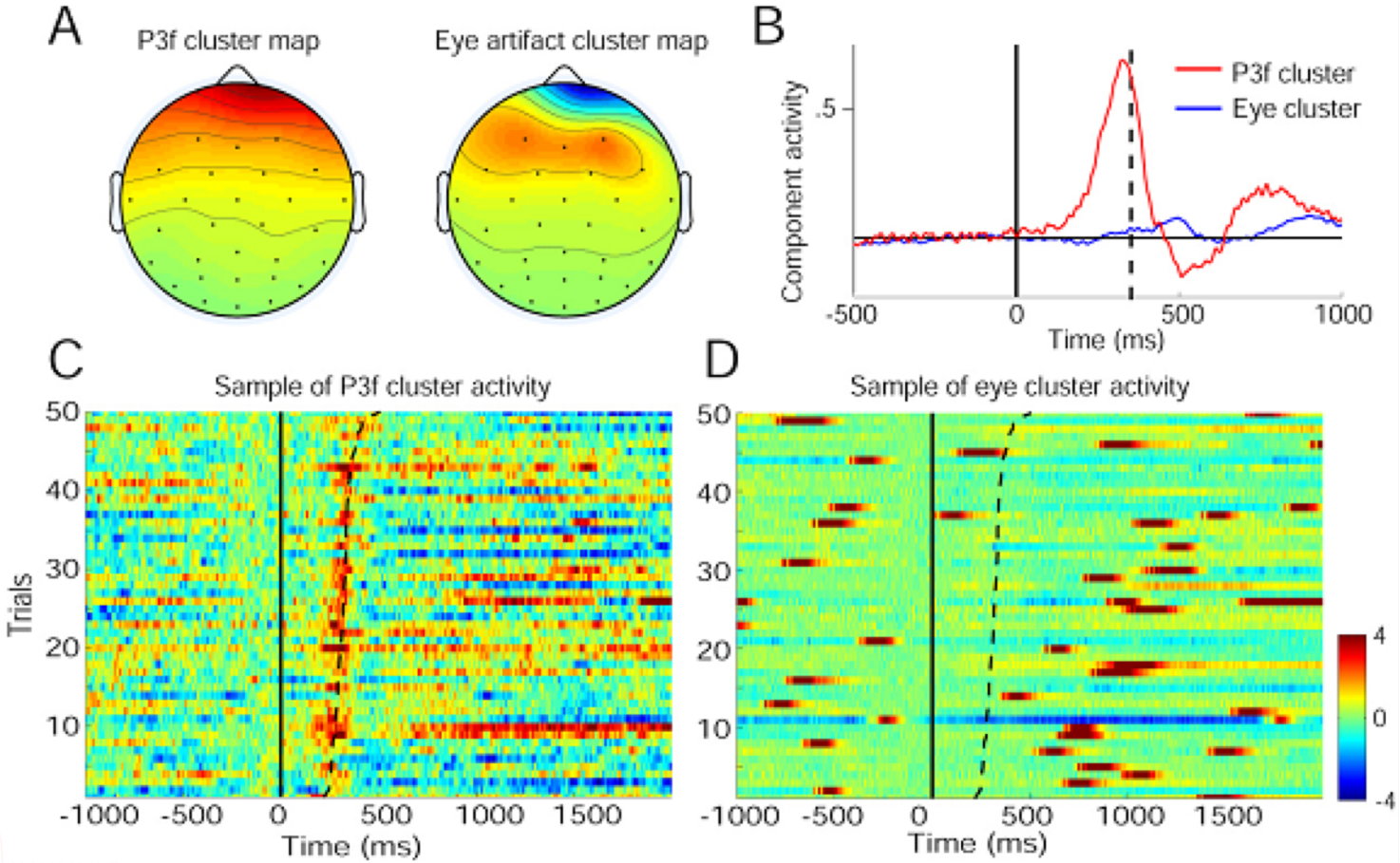
Inverse weight matrix W^{-1}

ICA-based Artifact Removal

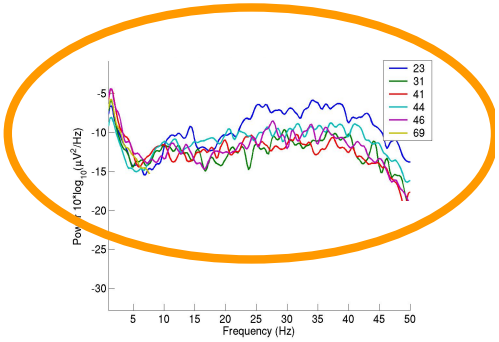


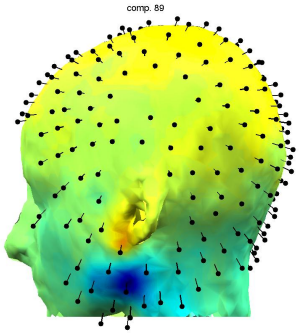
Artifact removal using ICA

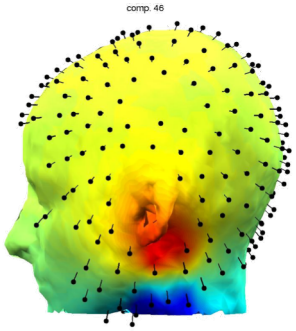


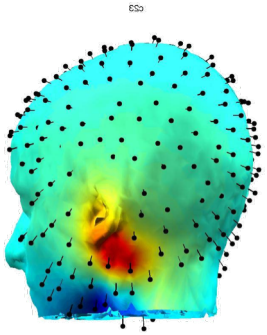

A
P3f cluster map
Eye artifact cluster map
B
P3f cluster
Eye cluster
Component activity
.5
-500
0
500
1000
Time (ms)
C
Sample of P3f cluster activity
Trials
50
40
30
20
10
-1000
-500
0
500
1000
1500
Time (ms)
D
Sample of eye cluster activity
50
40
30
20
10
-1000
-500
0
500
1000
1500
Time (ms)
4
0
-4

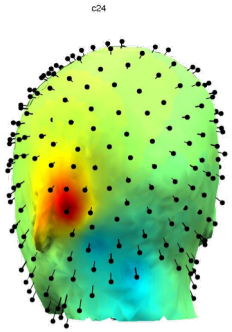
Some Independent EMG Components

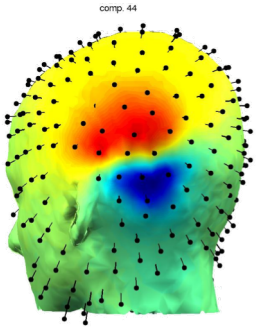


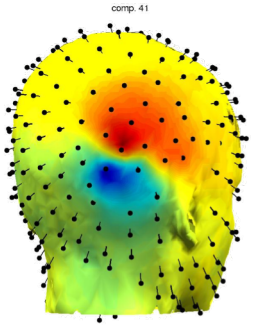


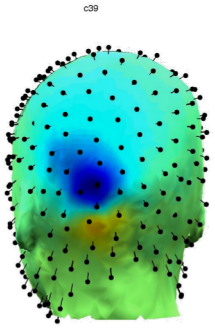


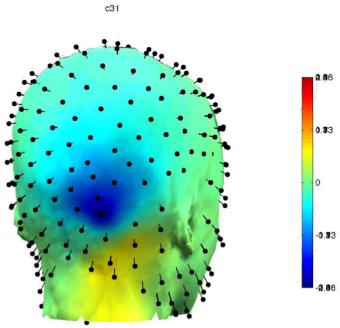


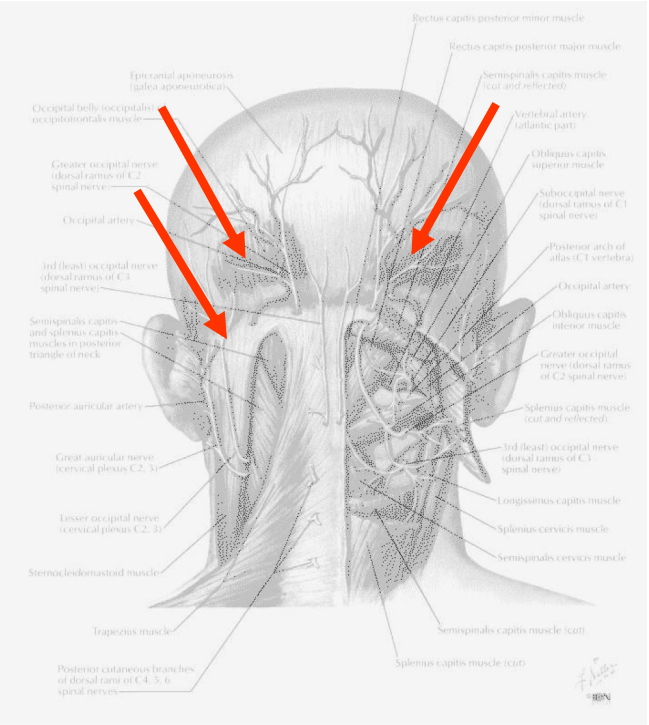




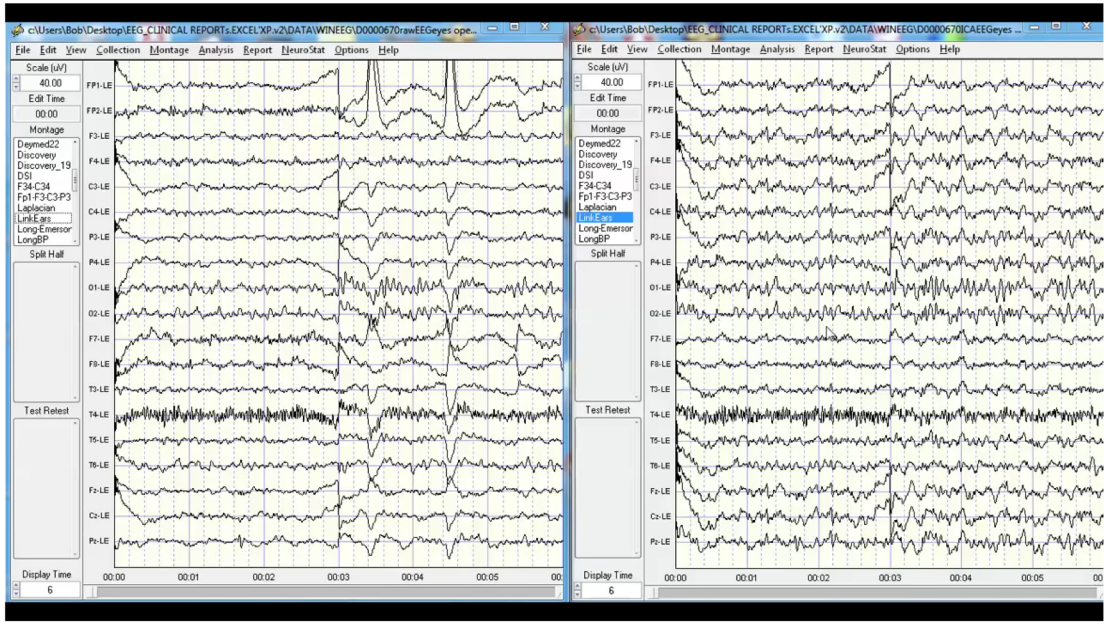








Does removing ICA adulterate the phase of the EEG signal?



ICA Reconstruction to Remove Artifact Adulterates EEG Phase & Coherence

3,817 views

16 25 SHARE

Robert Thatcher
Published on Nov 24, 2014

SUBSCRIBE 88

Independent Component Analysis (ICA) Reconstruction to remove artifact Adulterates EEG phase & Coherence & invalidates any subsequent analyses

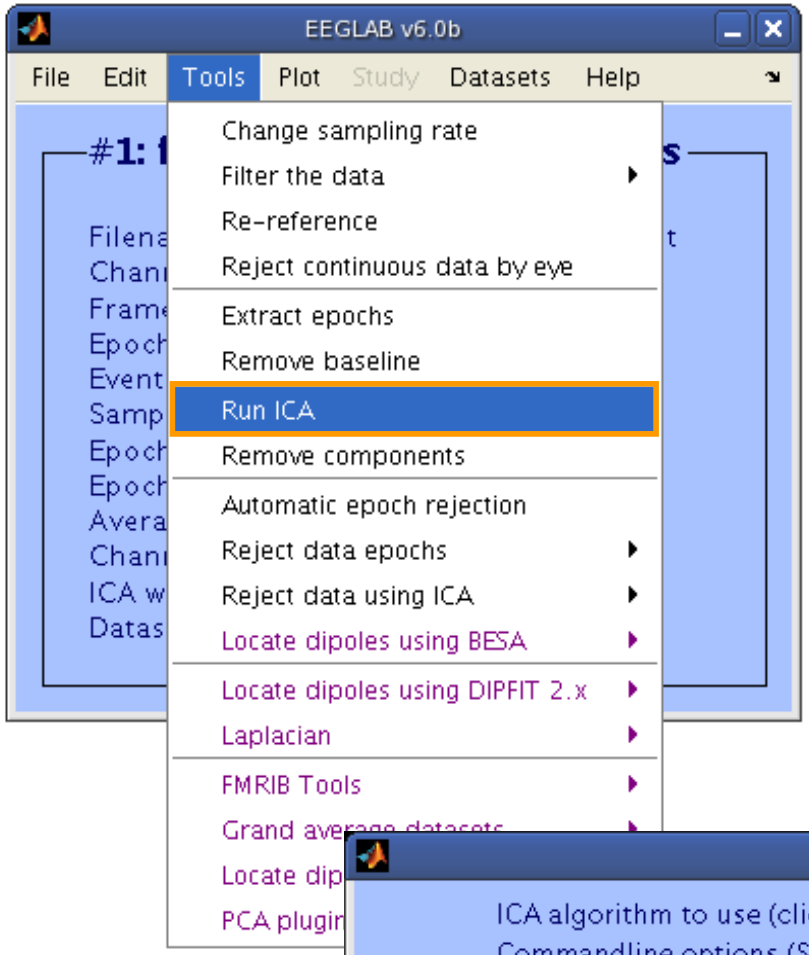
About 50 messages on EEGLABLIST
https://sccn.ucsd.edu/pipermail/eeglablist/2017/012642.html

- [Eeglablist] ICA misinformation *Arnaud Delorme*
  - [Eeglablist] ICA misinformation *Robert Thatcher*
    - [Eeglablist] ICA misinformation *Arnaud Delorme*
      - [Eeglablist] ICA misinformation *Robert Thatcher*
      - [Eeglablist] ICA misinformation *Arnaud Delorme*
      - [Eeglablist] ICA misinformation *robert lawson*
      - [Eeglablist] ICA misinformation *Tarik S Bel-Bahar*
      - [Eeglablist] ICA misinformation *Johanna Wagner*
      - [Eeglablist] FW: ICA misinformation *otte georges*
      - [Eeglablist] ICA misinformation *Arnaud Delorme*
- [Eeglablist] question regarding event marker's labels *Deepa Gupta*
- [Eeglablist] Emotiv device for BCI based on VEP *M Abul Hassan*
- [Eeglablist] ICA misinformation *Clemens Brunner*
  - [Eeglablist] ICA misinformation *drcoben*
- [Eeglablist] ICA Misinformation *Robert Thatcher*
  - [Eeglablist] ICA Misinformation *Ramesh Srinivasan*
    - [Eeglablist] ICA Misinformation *Robert Thatcher*
- [Eeglablist] How to Interpret Insignificant Coefficients of Regression Analysis *Iman Mohammad-Rezazadeh*
  - [Eeglablist] How to Interpret Insignificant Coefficients of Regression Analysis *Joaquin Rapela*
- [Eeglablist] ICA Misinformation *Arnaud Delorme*
  - [Eeglablist] ICA Misinformation *Robert Thatcher*
- [Eeglablist] How to Interpret Insignificant Coefficients of Regression Analysis *Iman Mohammad-Rezazadeh*
- [Eeglablist] ICA Misinformation *Arnaud Delorme*
  - [Eeglablist] ICA Misinformation *Robert Thatcher*
- [Eeglablist] ICA Misinformation *Arnaud Delorme*
  - [Eeglablist] ICA Misinformation *Robert Thatcher*
    - [Eeglablist] ICA Misinformation *Robert Thatcher*
- [Eeglablist] ICA Misinformation *Ramesh Srinivasan*
  - [Eeglablist] ICA Misinformation *Robert Thatcher*
- [Eeglablist] ICA Misinformation *Arnaud Delorme*
  - [Eeglablist] ICA Misinformation *Robert Thatcher*
    - [Eeglablist] ICA Misinformation *Robert Thatcher*
      - [Eeglablist] ICA Misinformation *otte georges*
      - [Eeglablist] ICA Misinformation *Arnaud Delorme*
      - [Eeglablist] ICA Misinformation *Arnaud Delorme*
      - [Eeglablist] ICA Misinformation *Stefan Debener*
      - [Eeglablist] ICA Misinformation *Robert Thatcher*
      - [Eeglablist] ICA Misinformation *Arnaud Delorme*
      - [Eeglablist] ICA Misinformation *Stefan Debener*
      - [Eeglablist] ICA Misinformation *Robert Thatcher*

“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
'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,amica,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

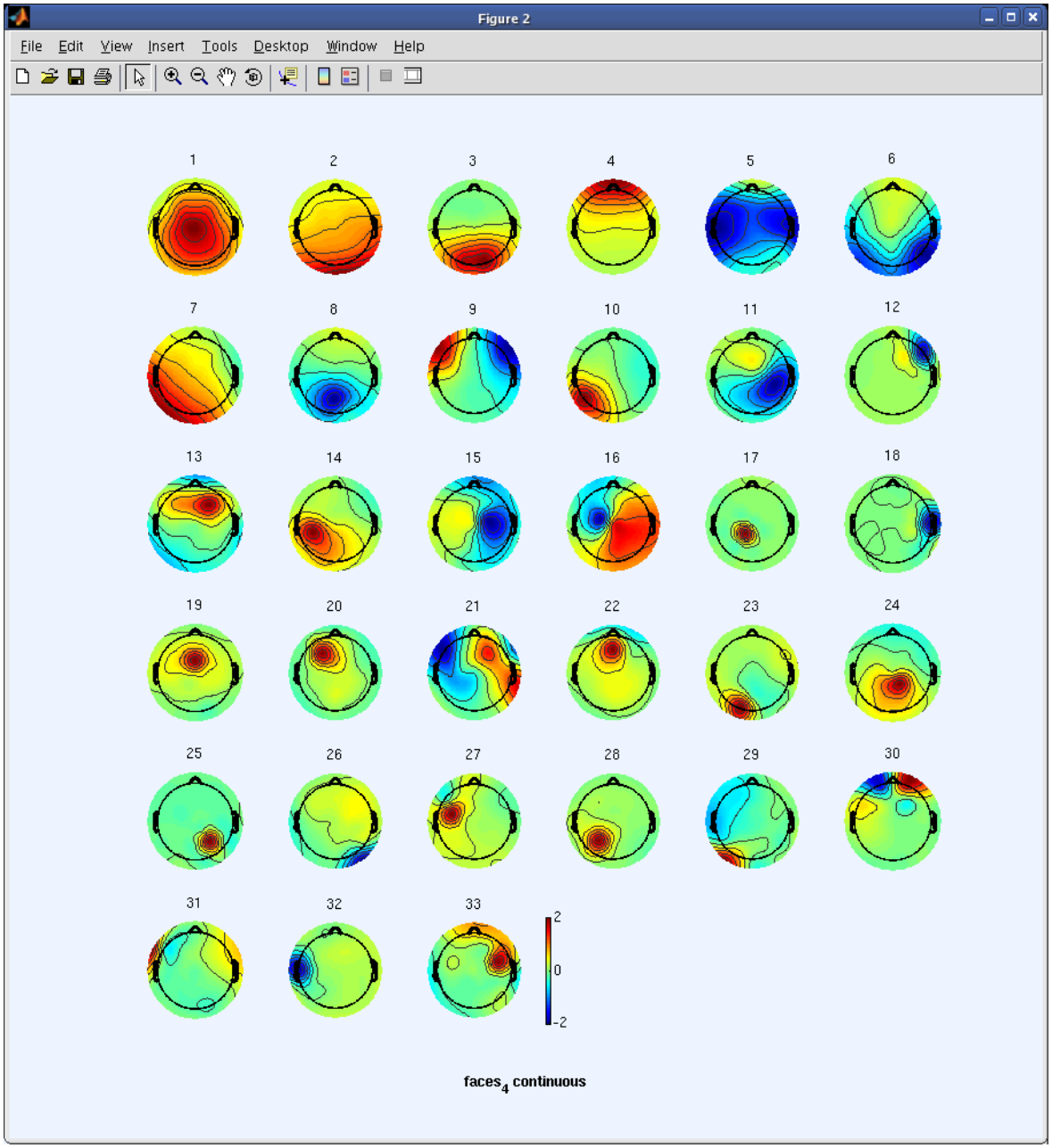
```
step 241 - lrate 0.000002, wchange 0.00000082, angledelta 101.5 deg
step 242 - lrate 0.000001, wchange 0.00000061, angledelta 96.1 deg
step 243 - lrate 0.000001, wchange 0.00000057, angledelta 97.5 deg
step 244 - lrate 0.000001, wchange 0.00000054, angledelta 93.7 deg
step 245 - lrate 0.000001, wchange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

ICA weights in EEG structure

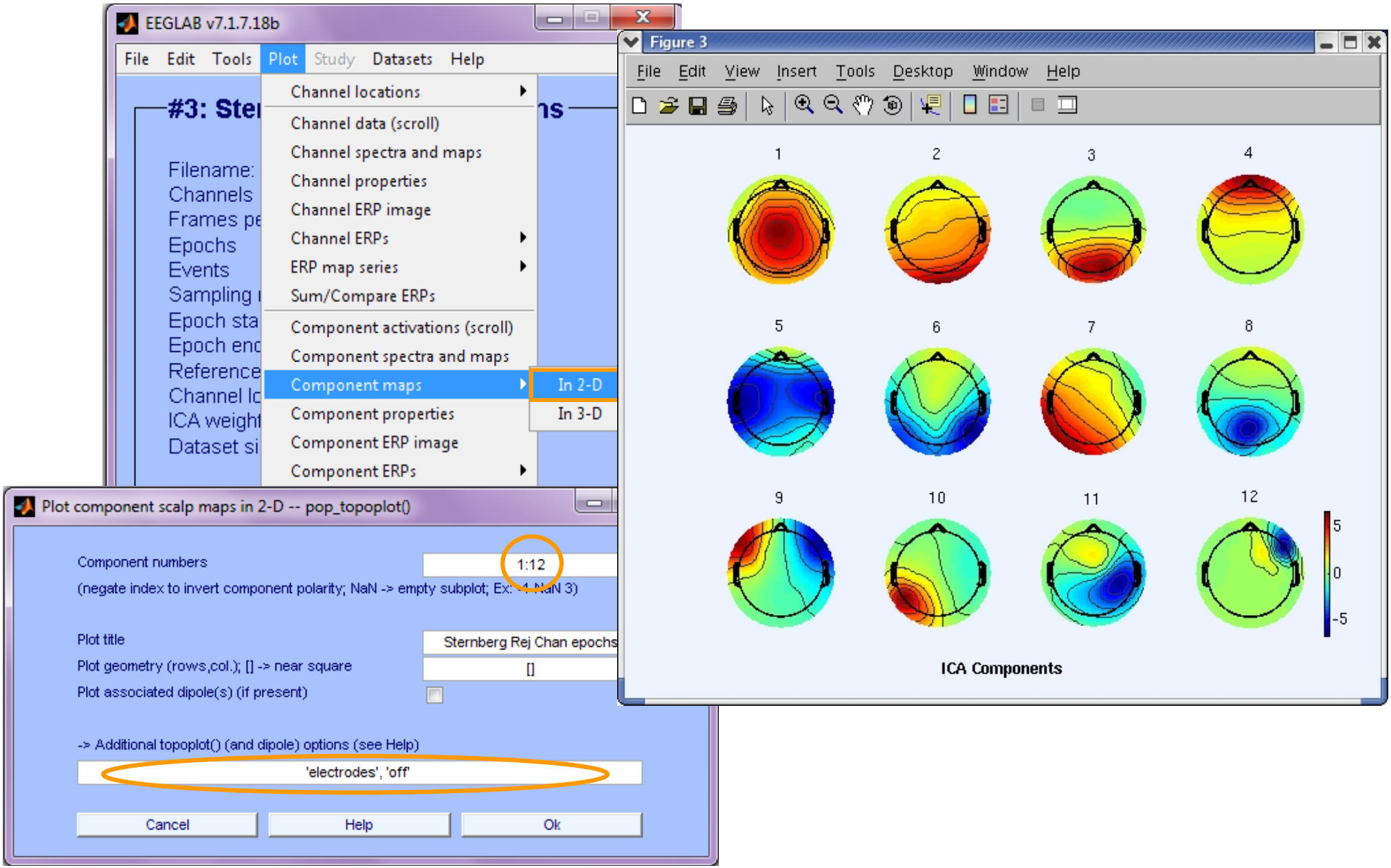
Terminal

File Edit View Terminal Tabs Help

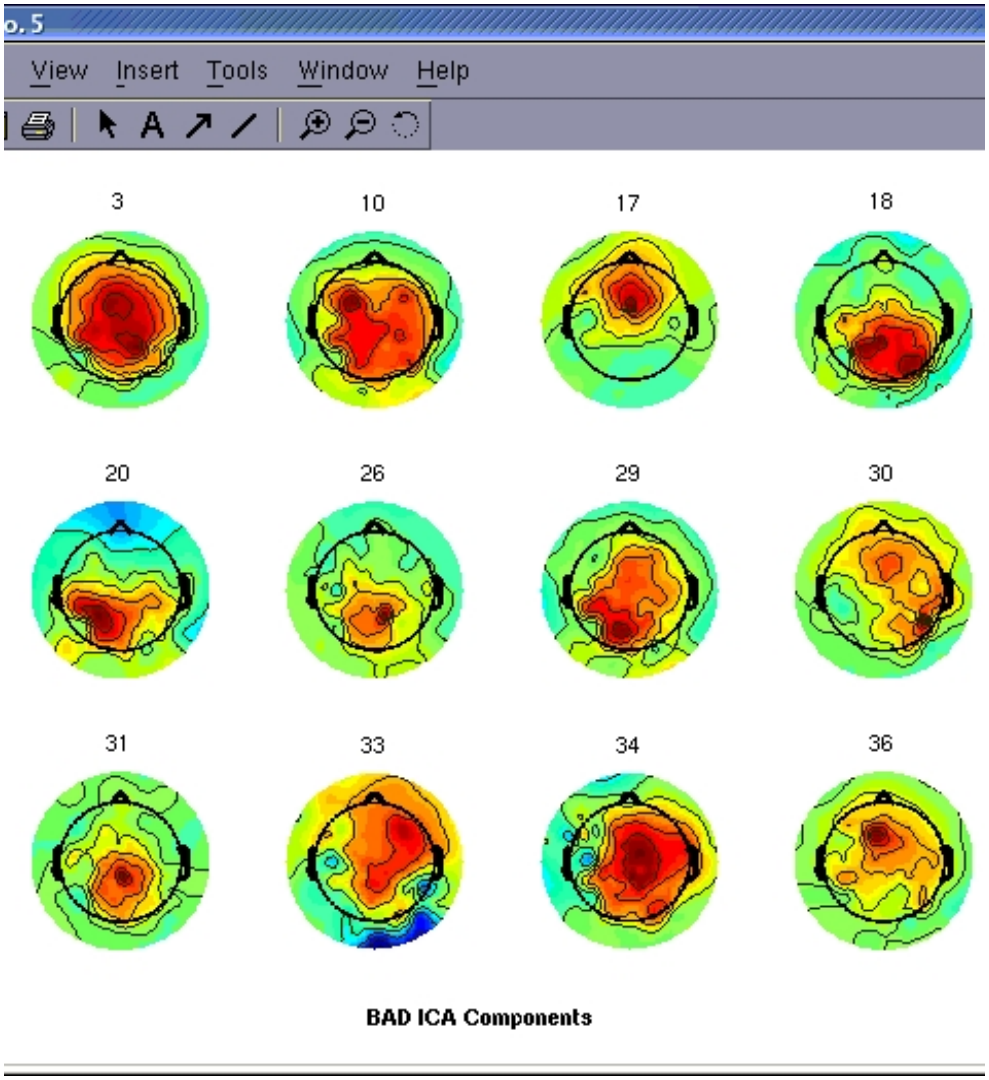
```
>> EEG

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: []

>>
```

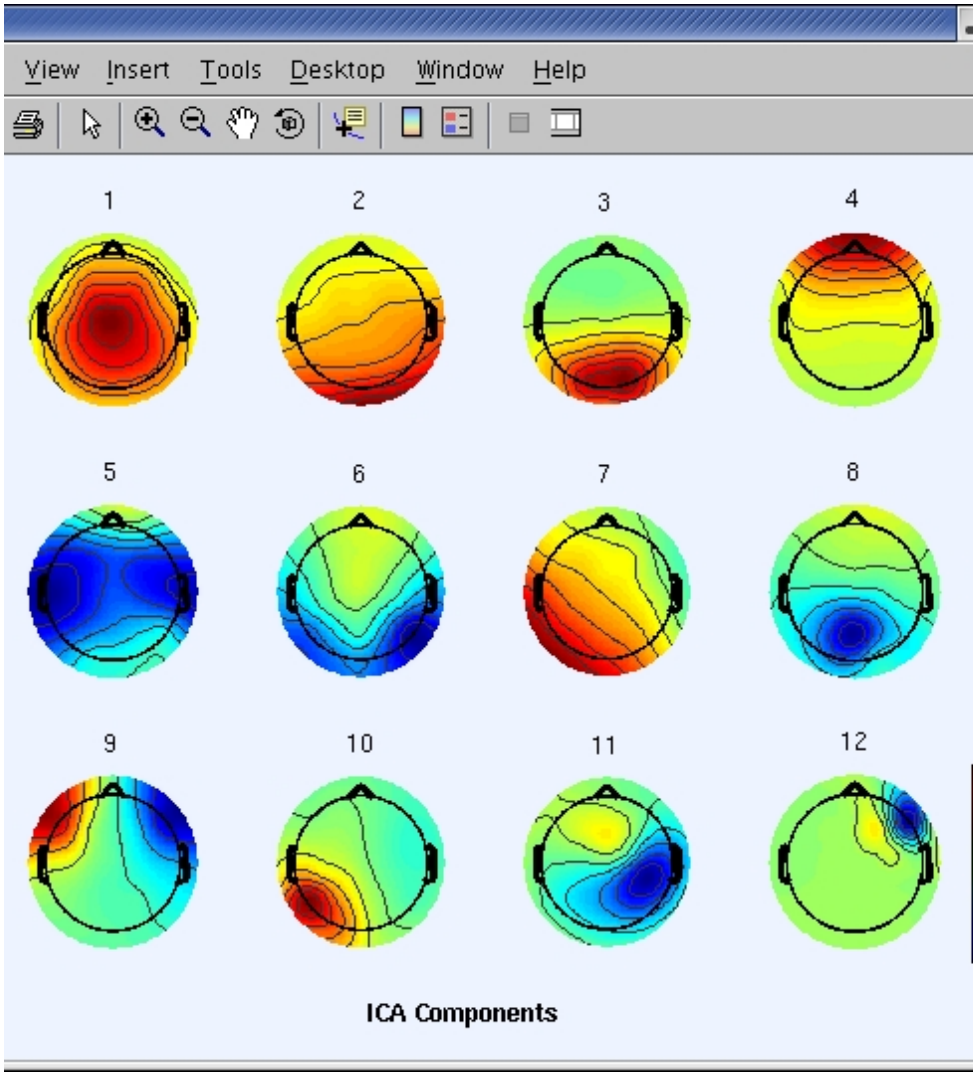


Plot ICA scalp maps

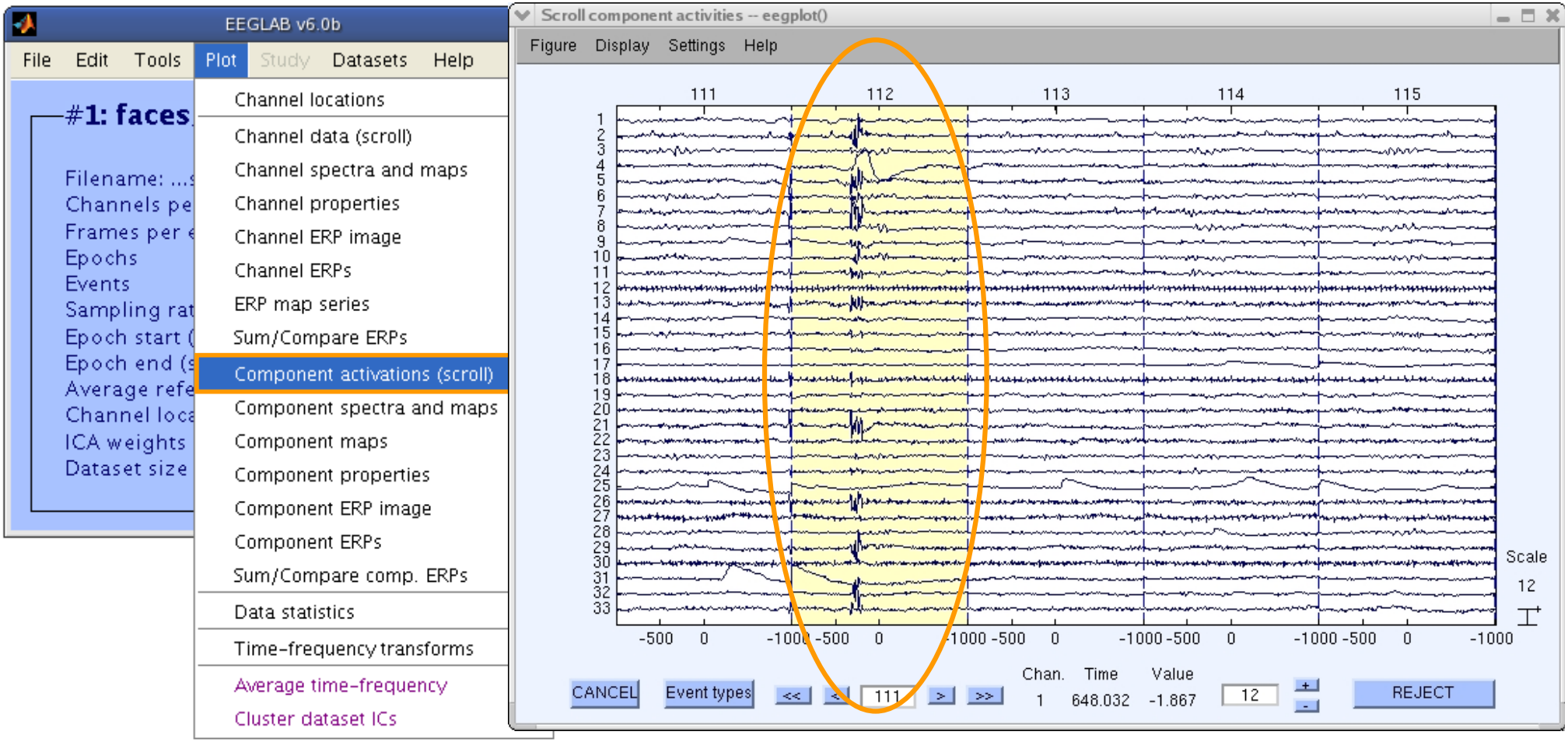


Compare 'good' and 'bad' scalp maps



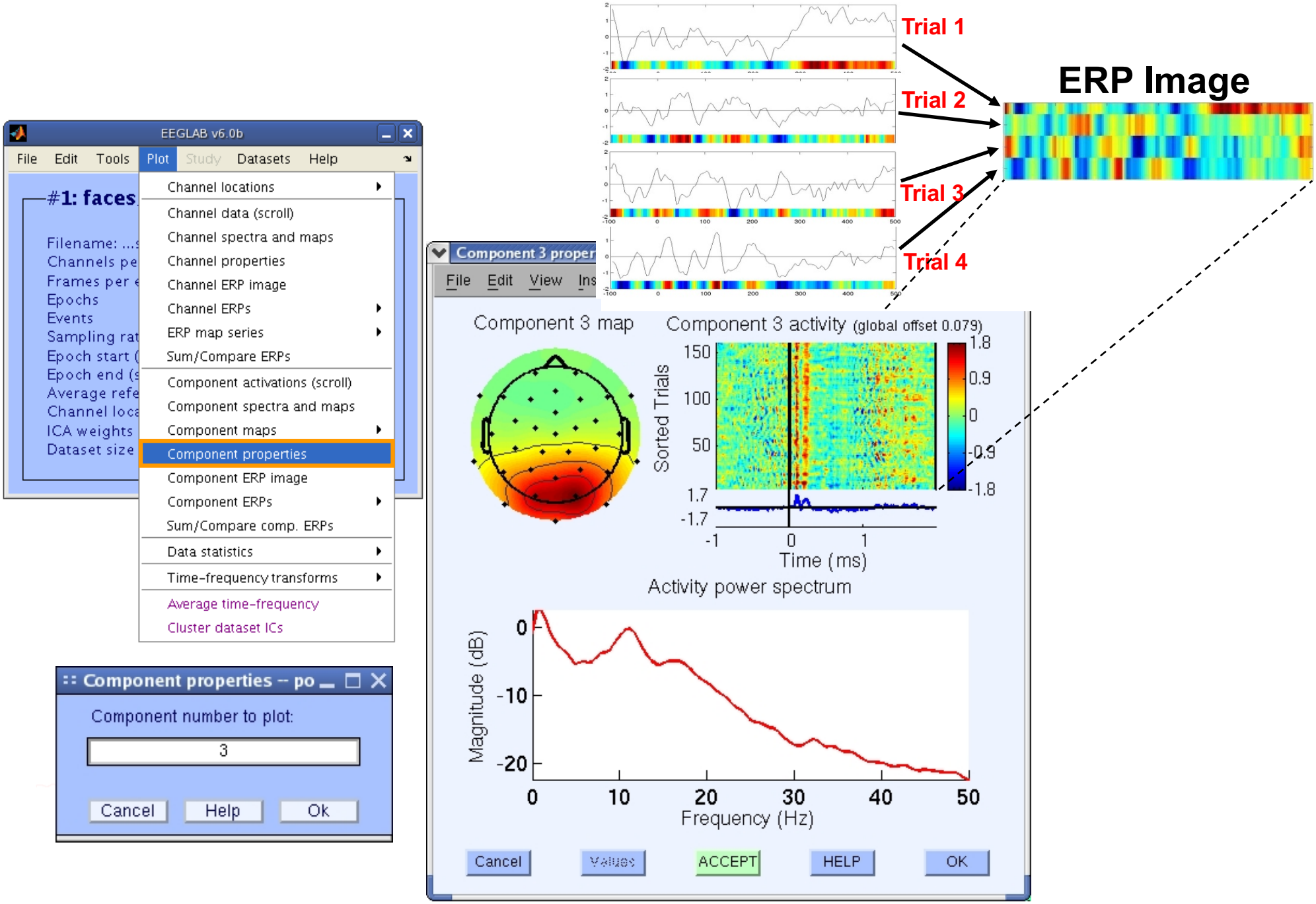


Scroll component activities



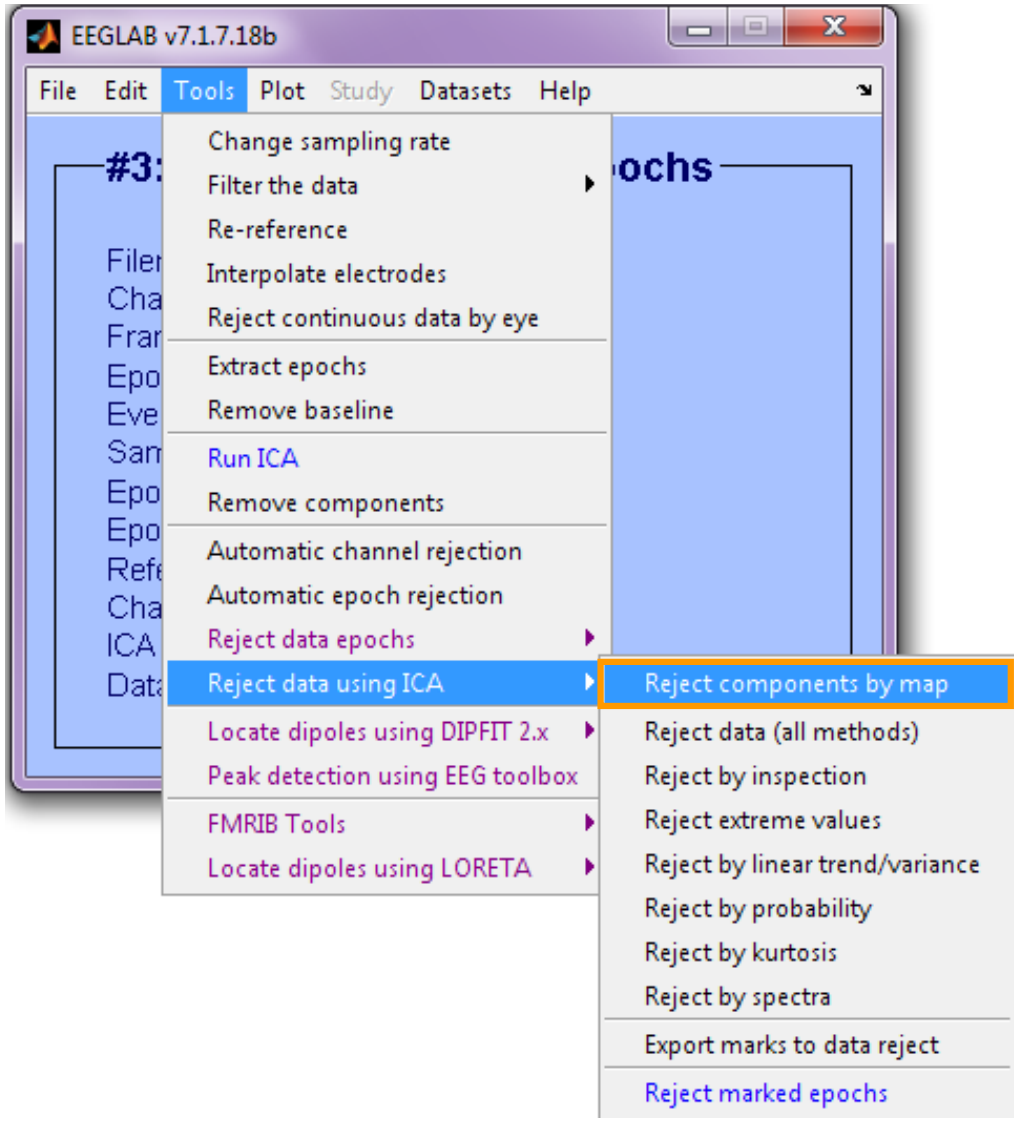
Time periods that are not independent across ICs should be removed and ICA run again for better decomposition

Plot ICA component properties

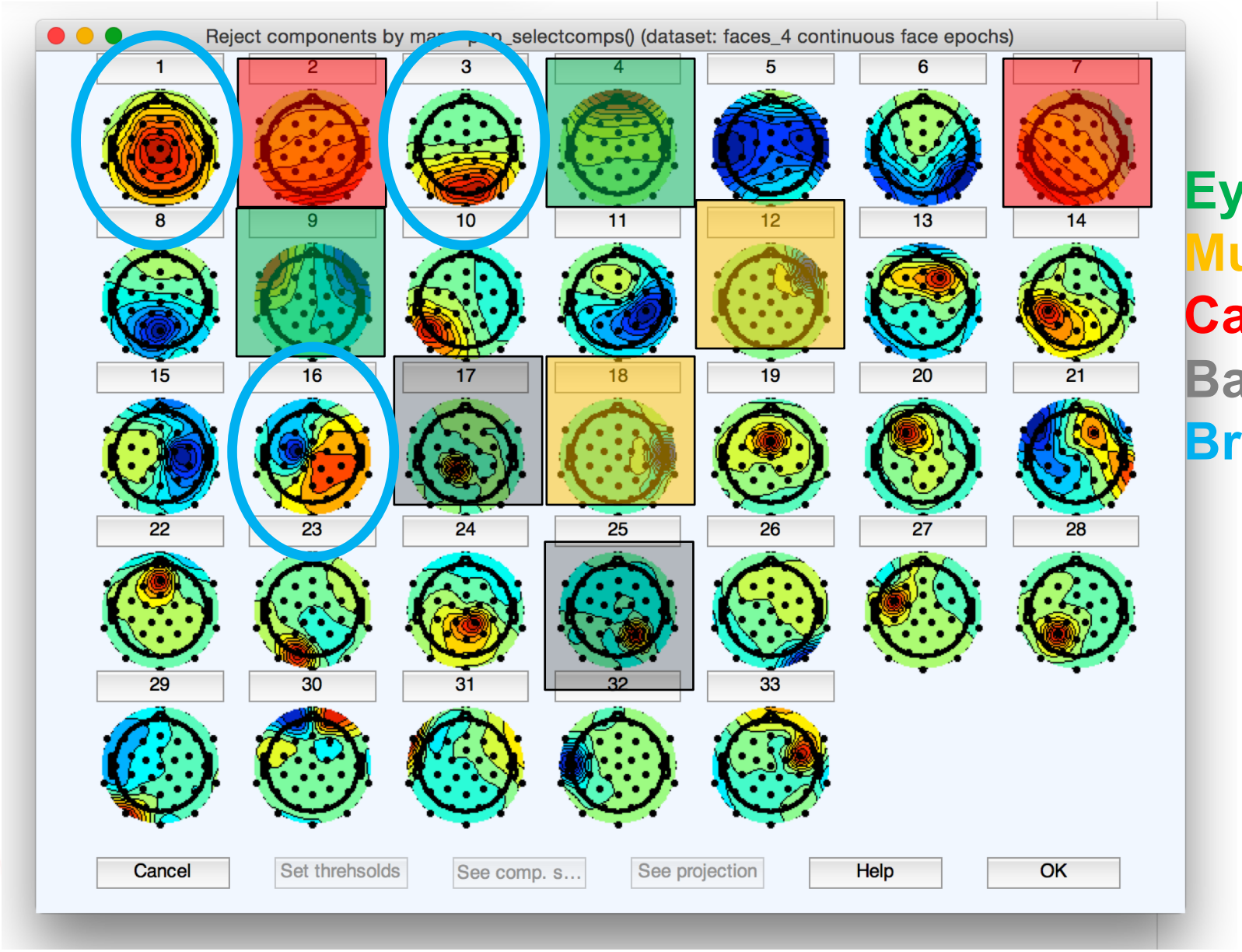


Removing Artifactual Components

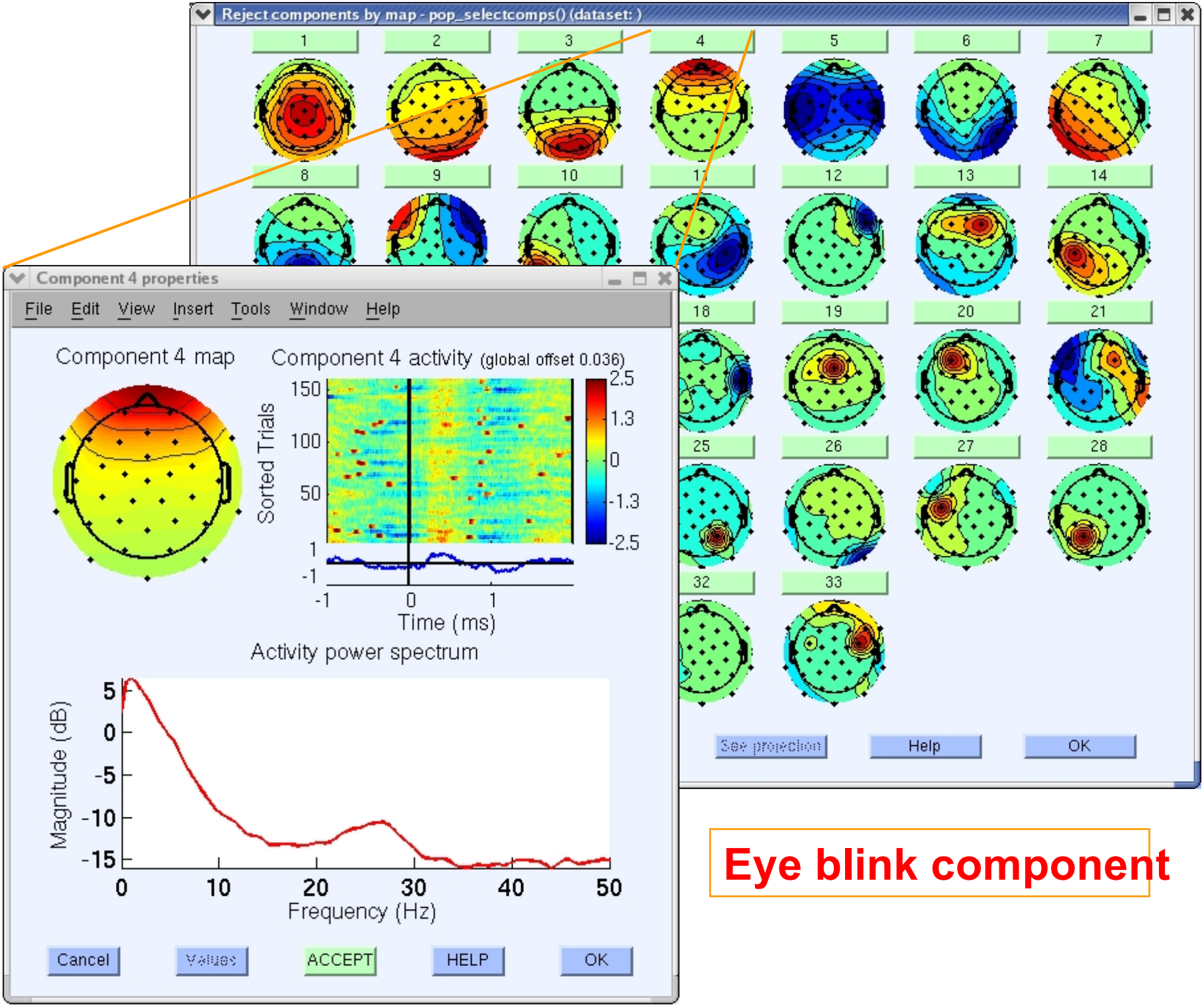
Reviewing component properties



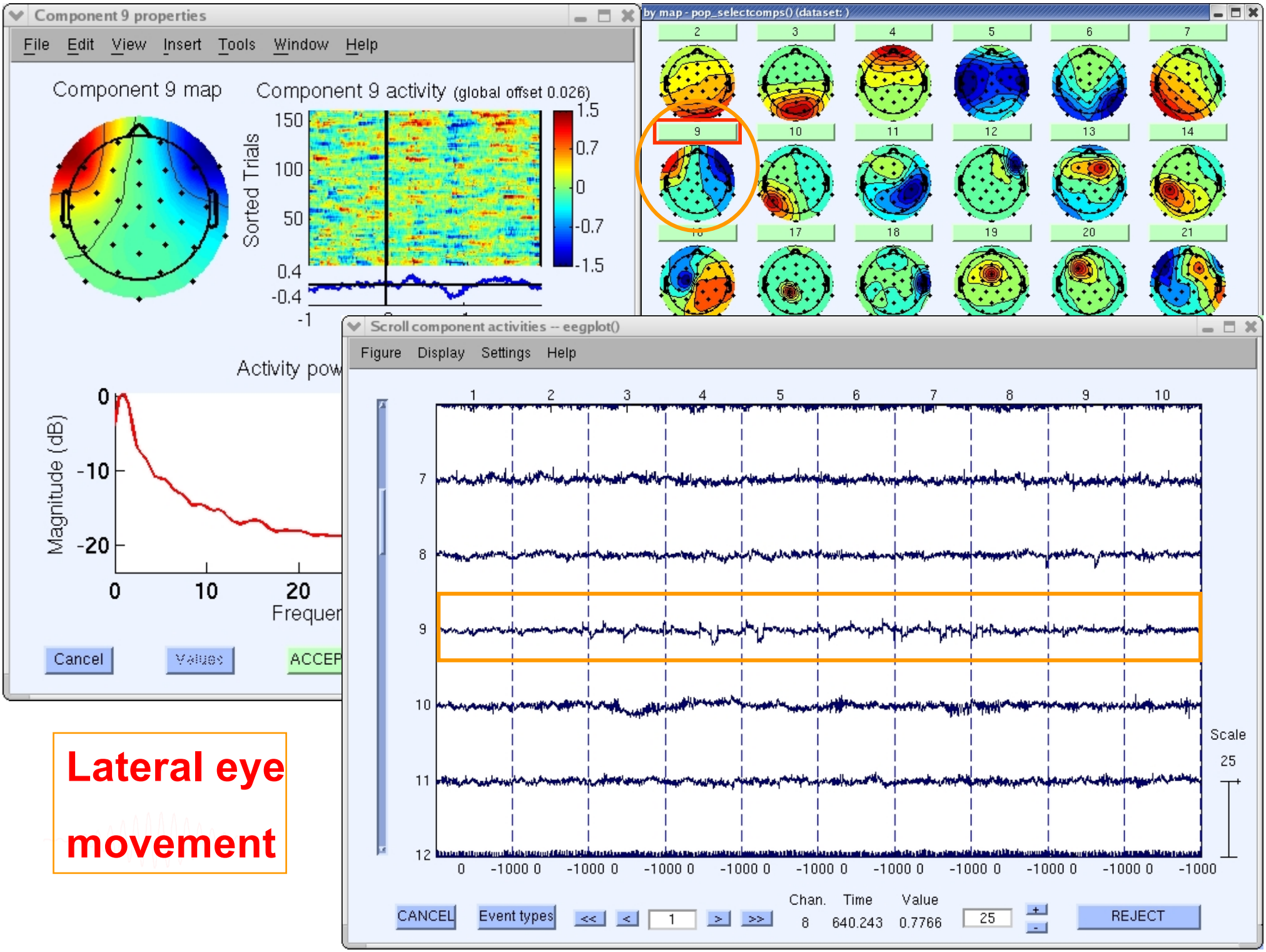
IC Classification…so far

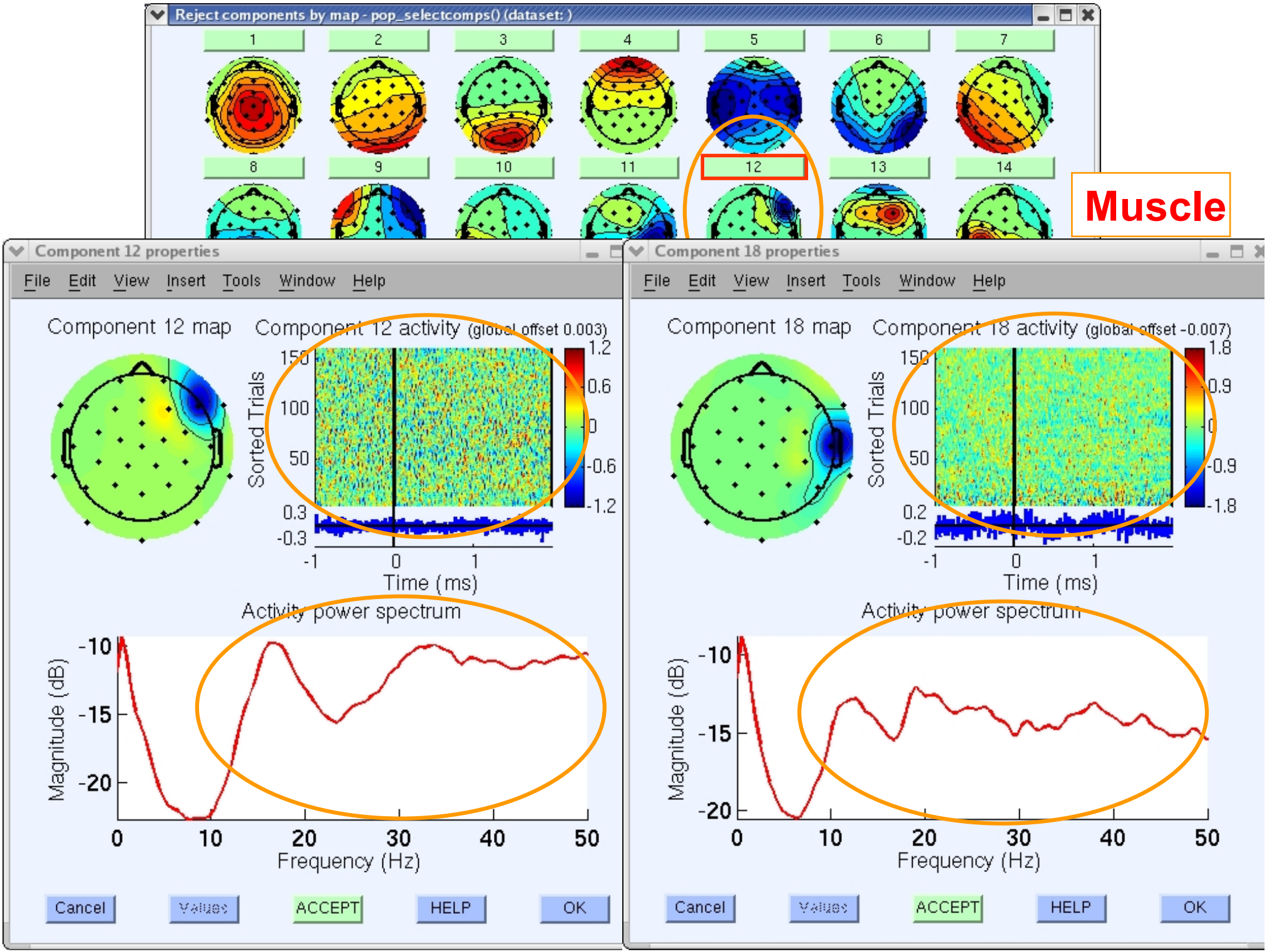


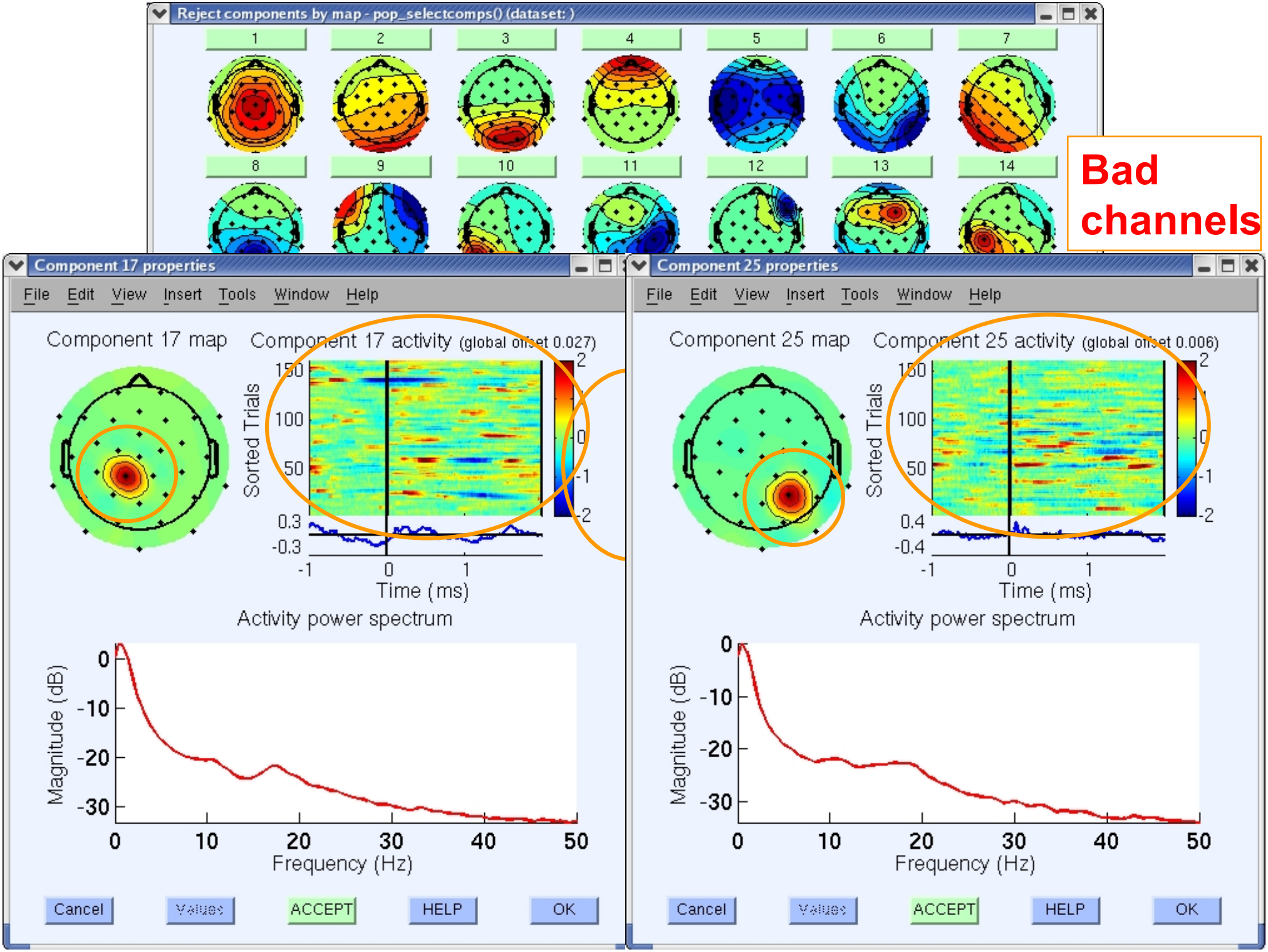
Eye
Muscle
Cardiac
Badchan
Brain

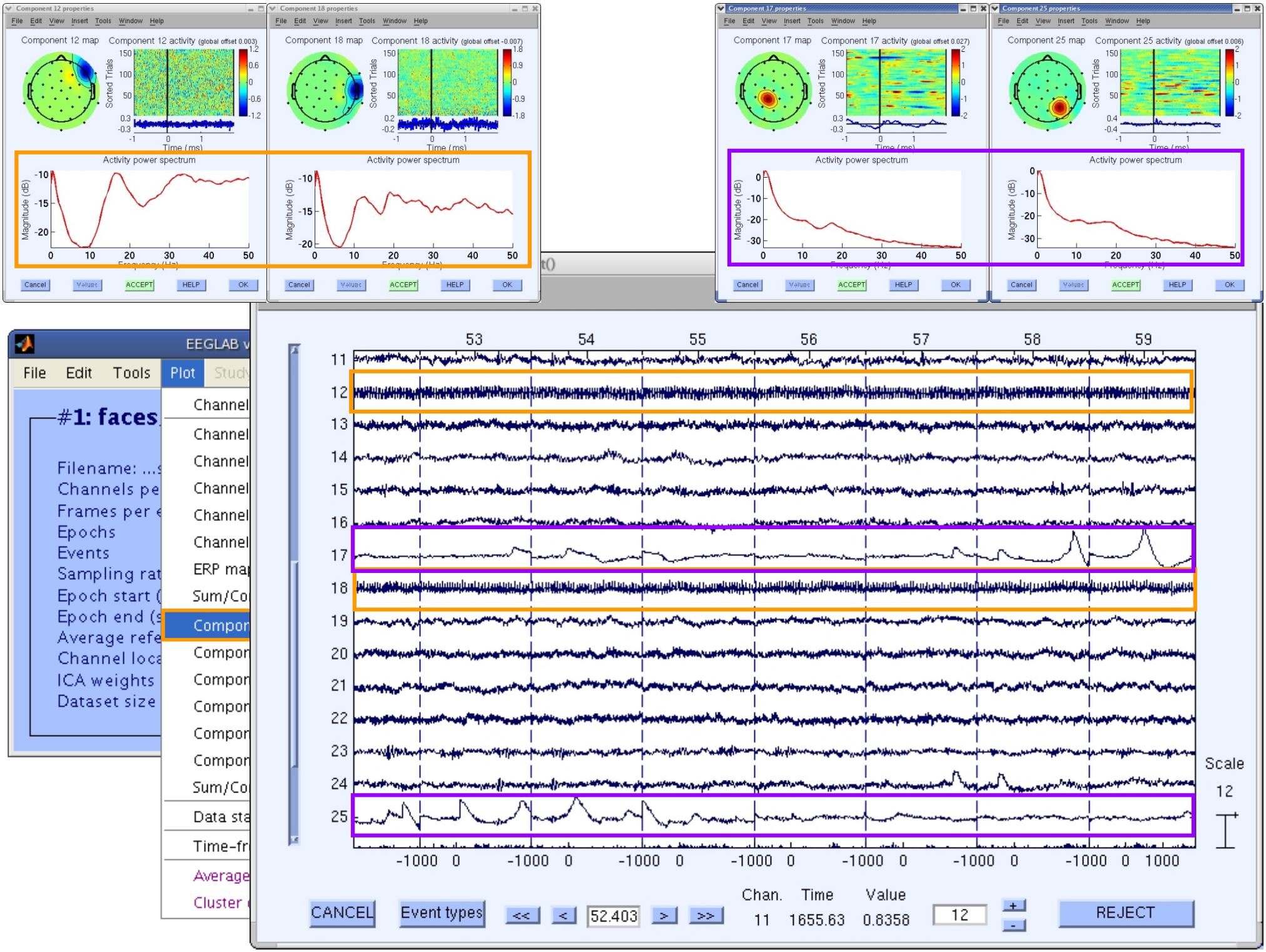


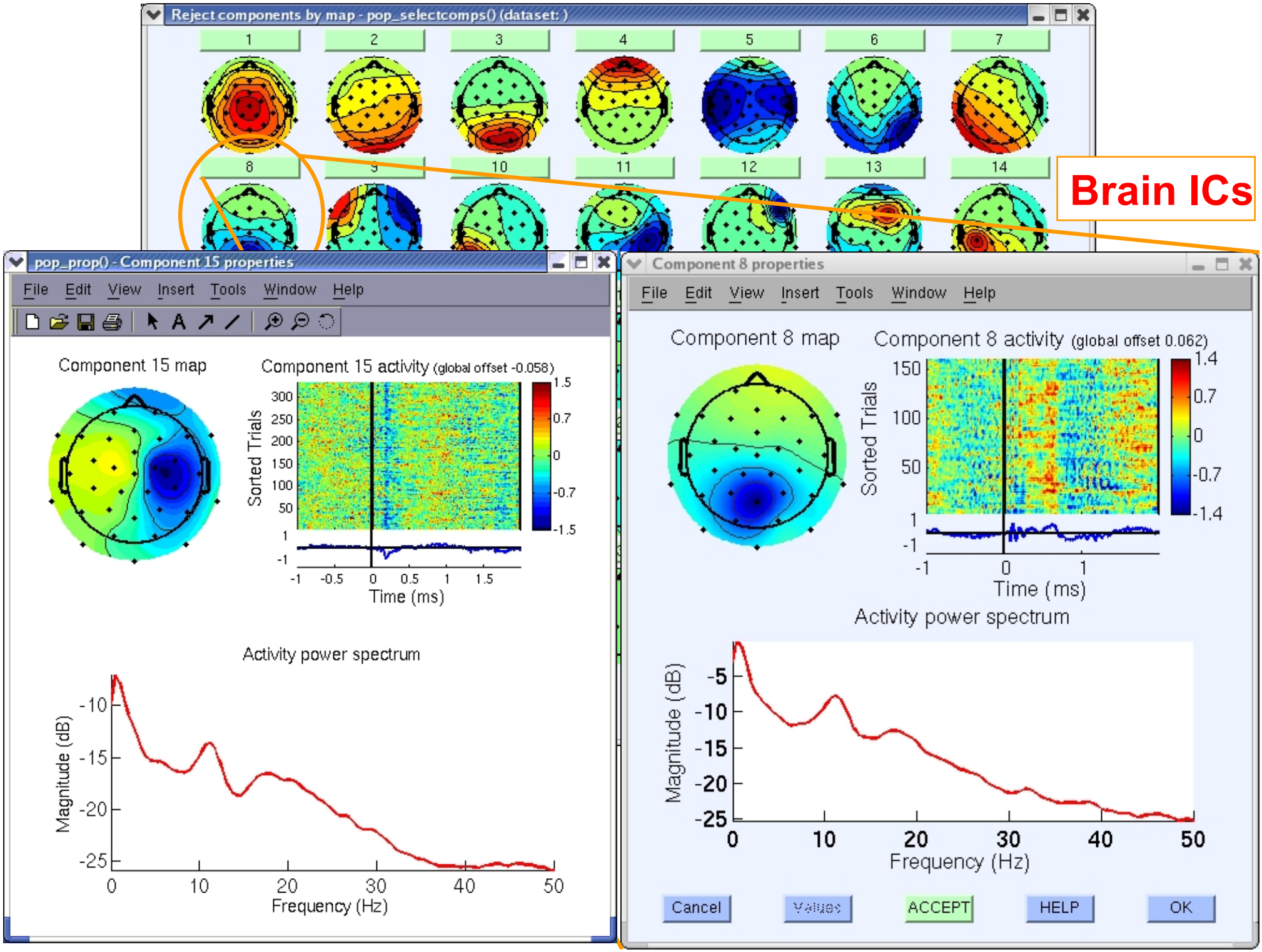
Eye blink component


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
Lateral eye movement

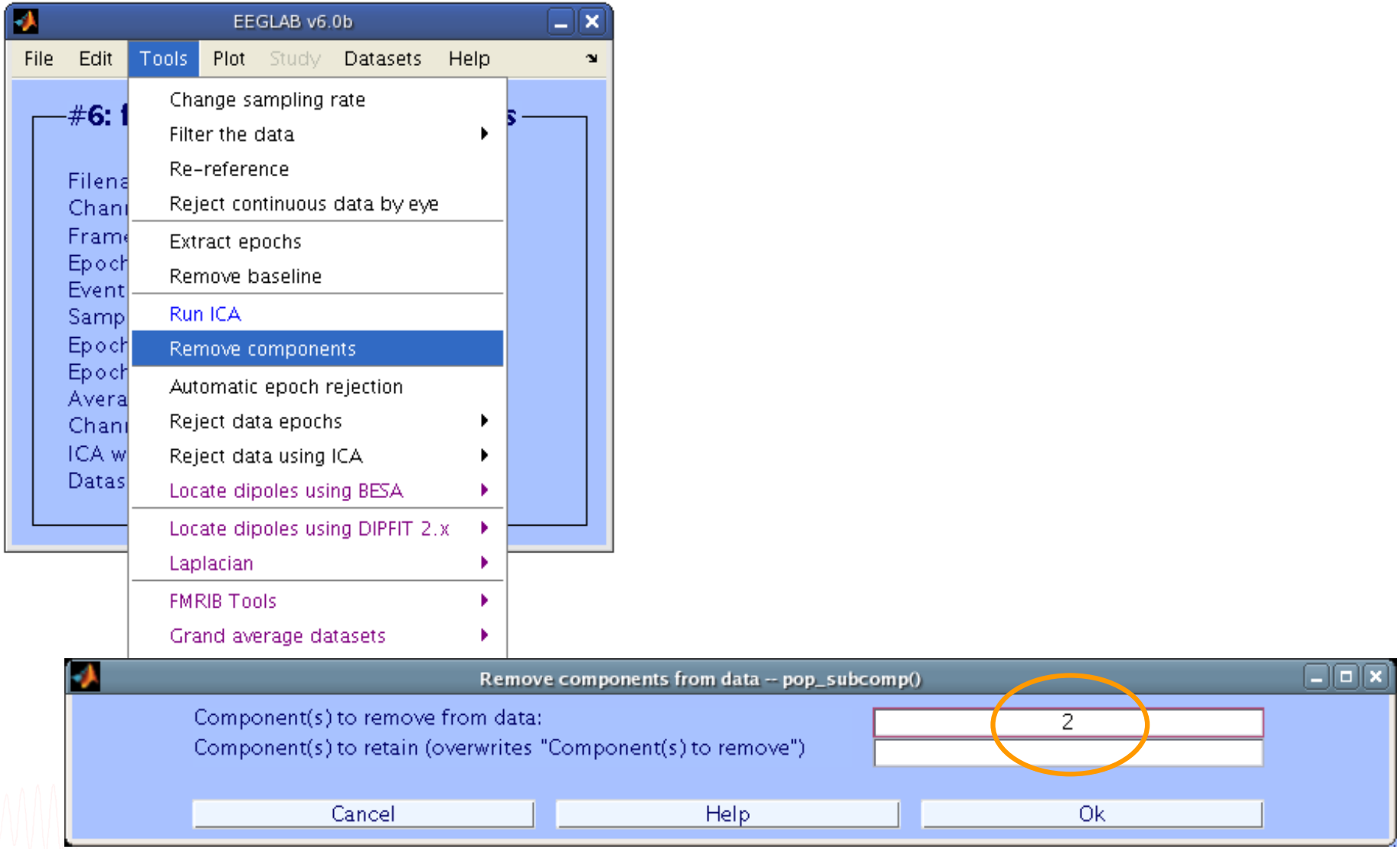

Reject components by map - pop_selectcomps() (dataset:)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Muscle
Component 12 properties
File Edit View Insert Tools Window Help
Component 12 map
Component 12 activity (global offset 0.003)
Sorted Trials
Time (ms)
Activity power spectrum
Magnitude (dB)
Frequency (Hz)
Cancel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

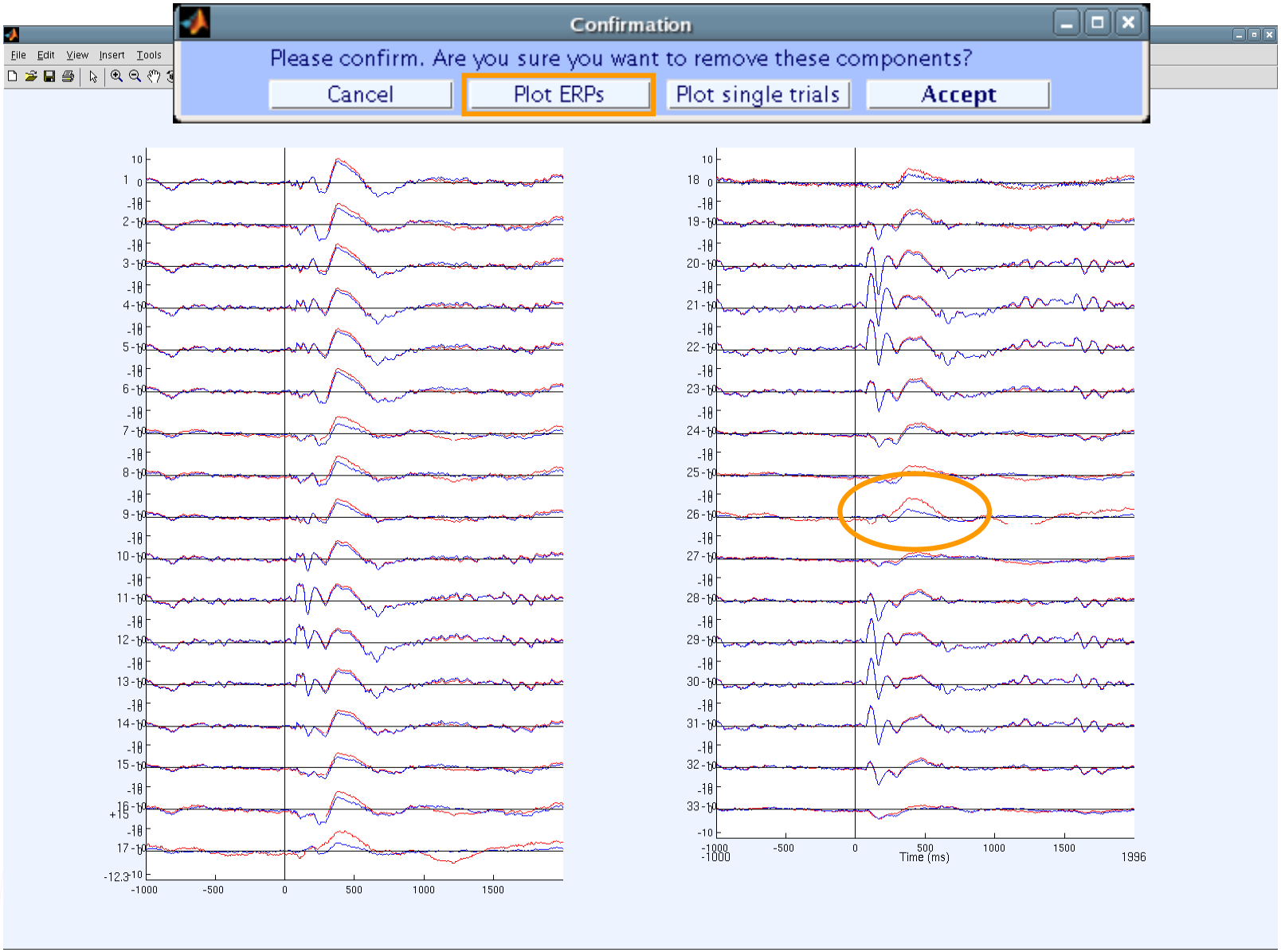

Component 12 properties
Component 12 map
Component 12 activity (global offset 0.003)
Activity power spectrum
Component 18 properties
Component 18 map
Component 18 activity (global offset -0.007)
Activity power spectrum
Component 17 properties
Component 17 map
Component 17 activity (global offset 0.027)
Activity power spectrum
Component 25 properties
Component 25 map
Component 25 activity (global offset 0.006)
Activity power spectrum
Magnitude (dB)
Sorted Trials
Time (ms)
Cancel
Values
ACCEPT
HELP
OK
EEGLAB
File
Edit
Tools
Plot
#1: faces
Filename:
Channels
Frames per
Epochs
Events
Sampling rat
Epoch start
Epoch end
Average refe
Channel loca
ICA weights
Dataset size
Channel
ERP ma
Sum/Co
Compon
Data sta
Time-fr
Average
Cluster
Scale
12
CANCEL
Event types
<<
<
52.403
>
>>
Chan.
Time
Value
11
1655.63
0.8358
12
REJECT


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

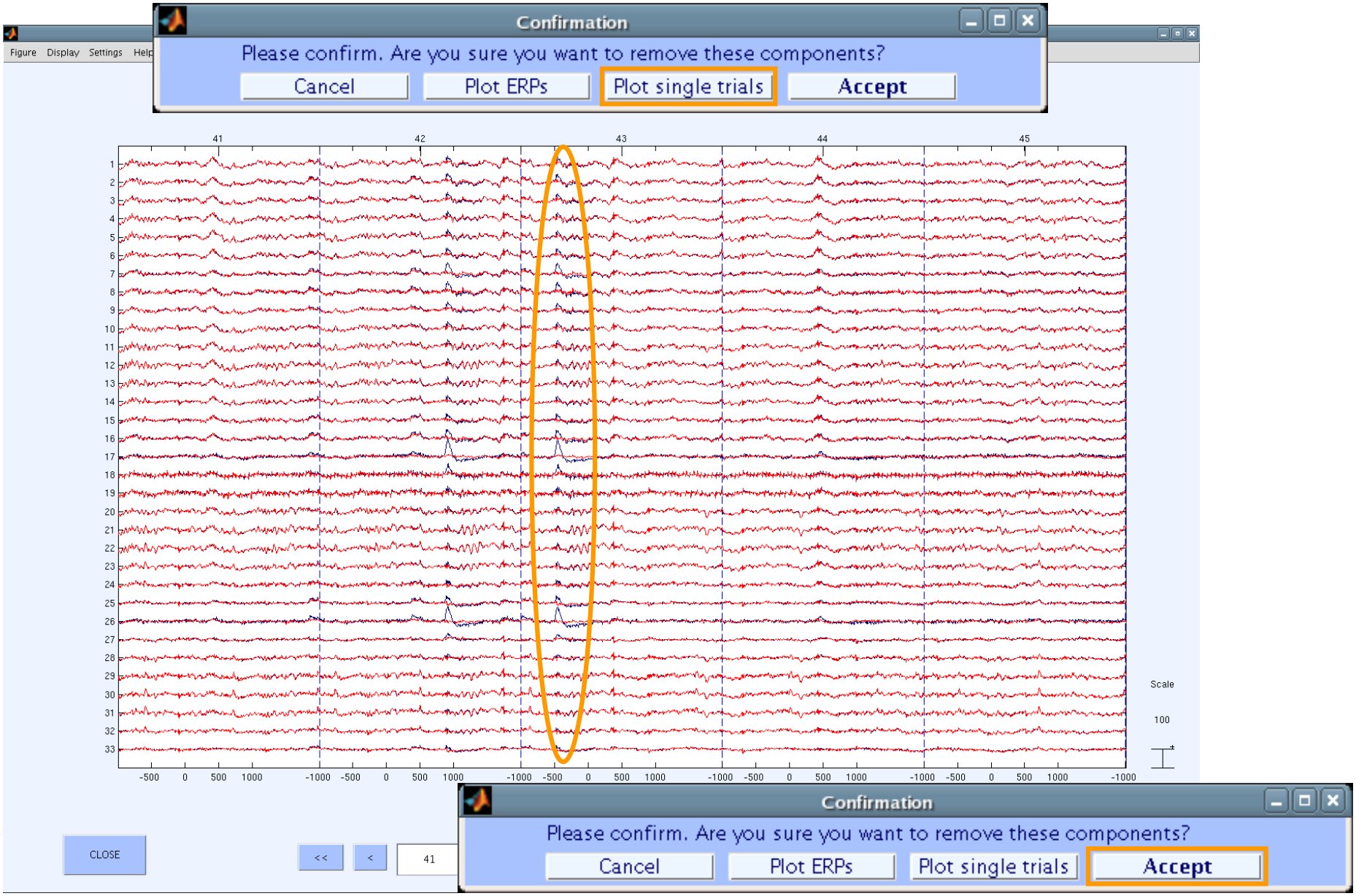
Eye blink correction



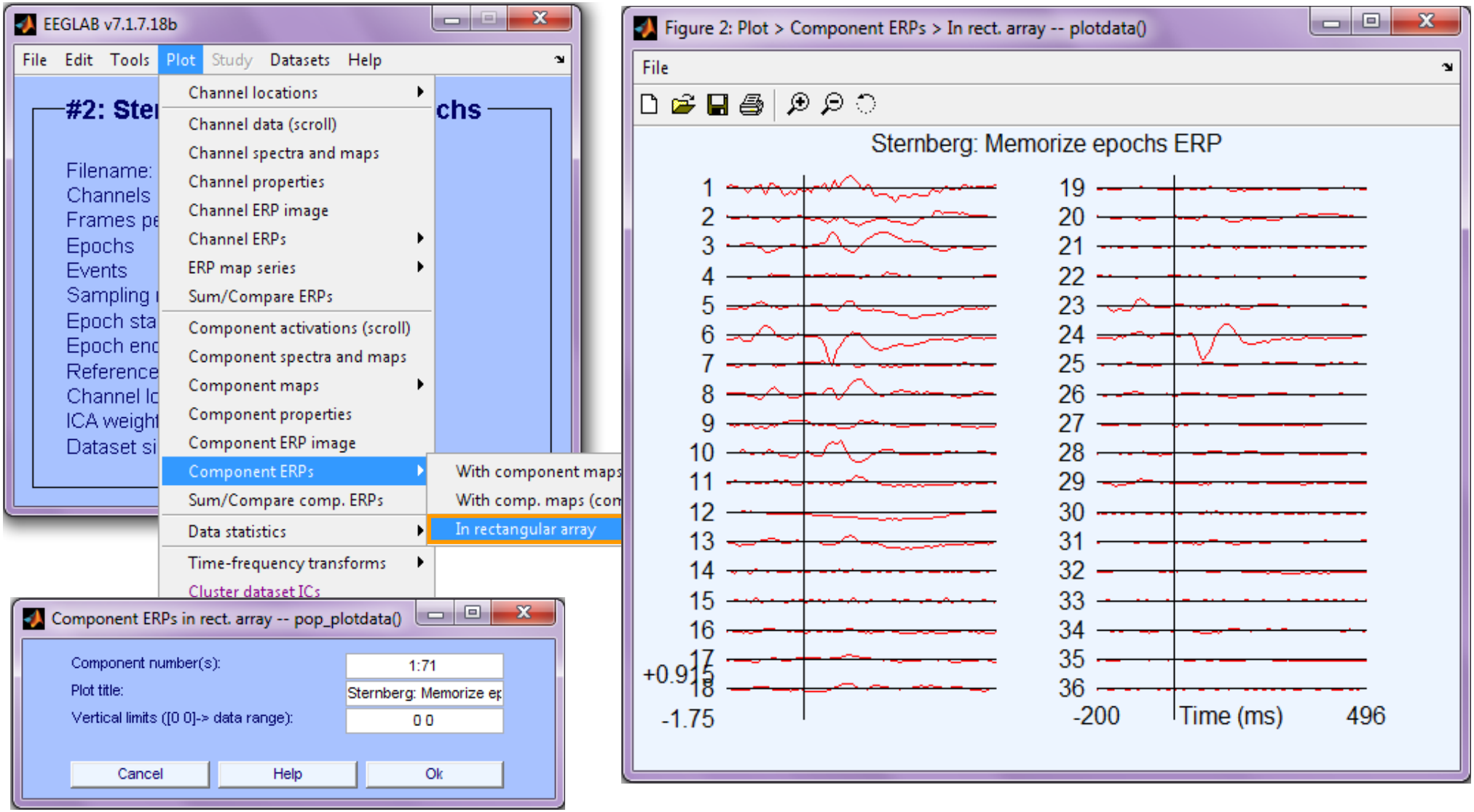
Eye blink correction



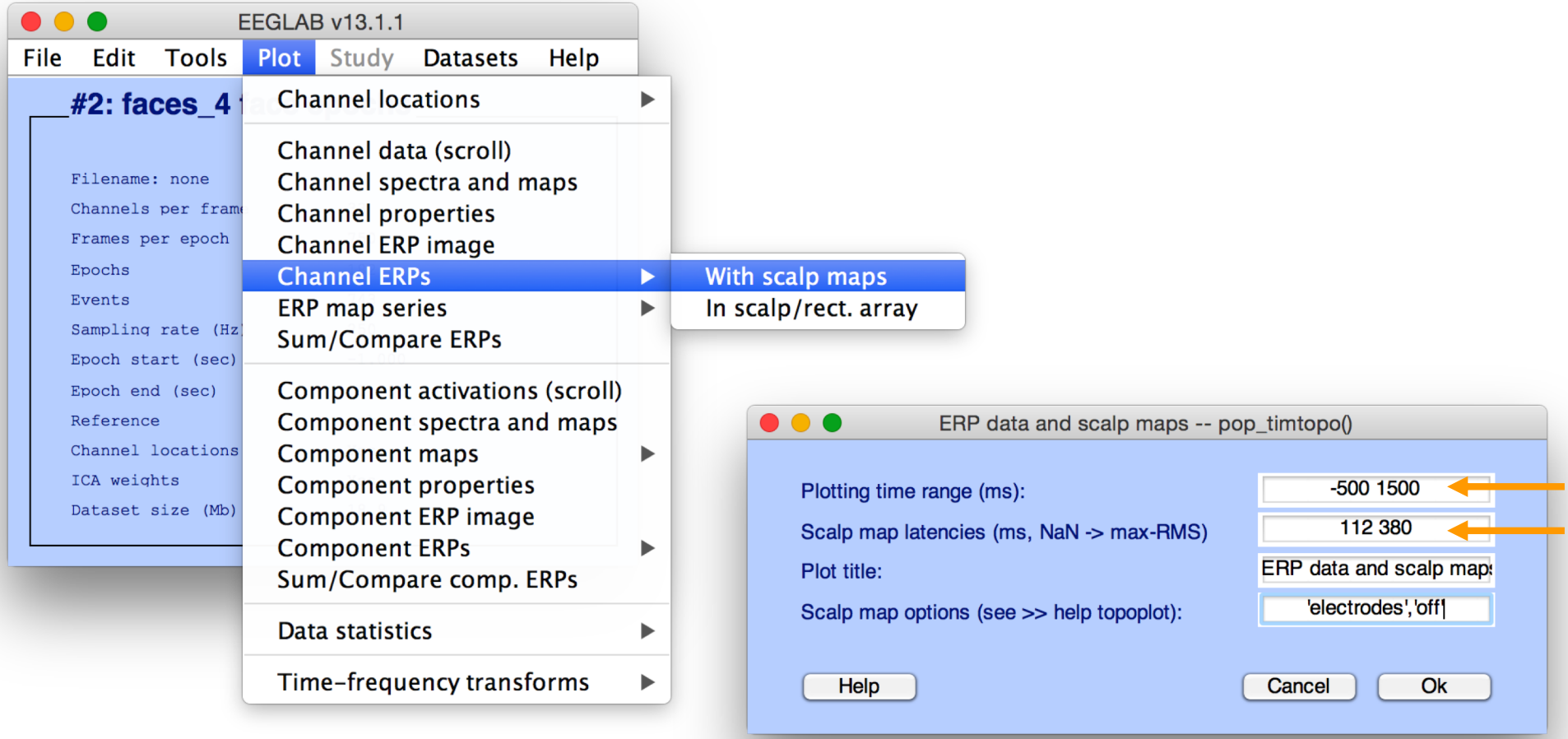
Eye blink correction



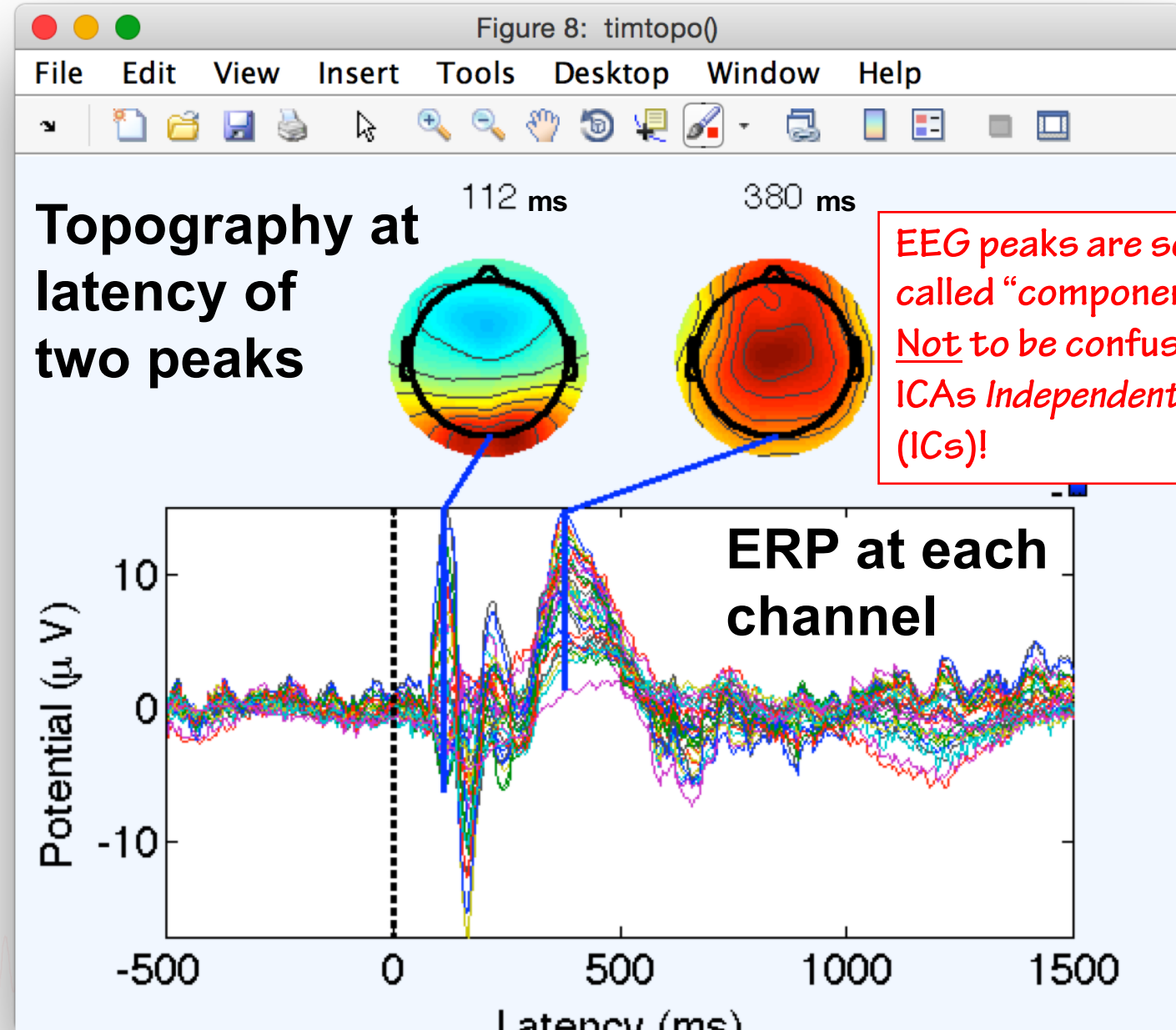
Component ERPs



A step back: Electrode-level ERP

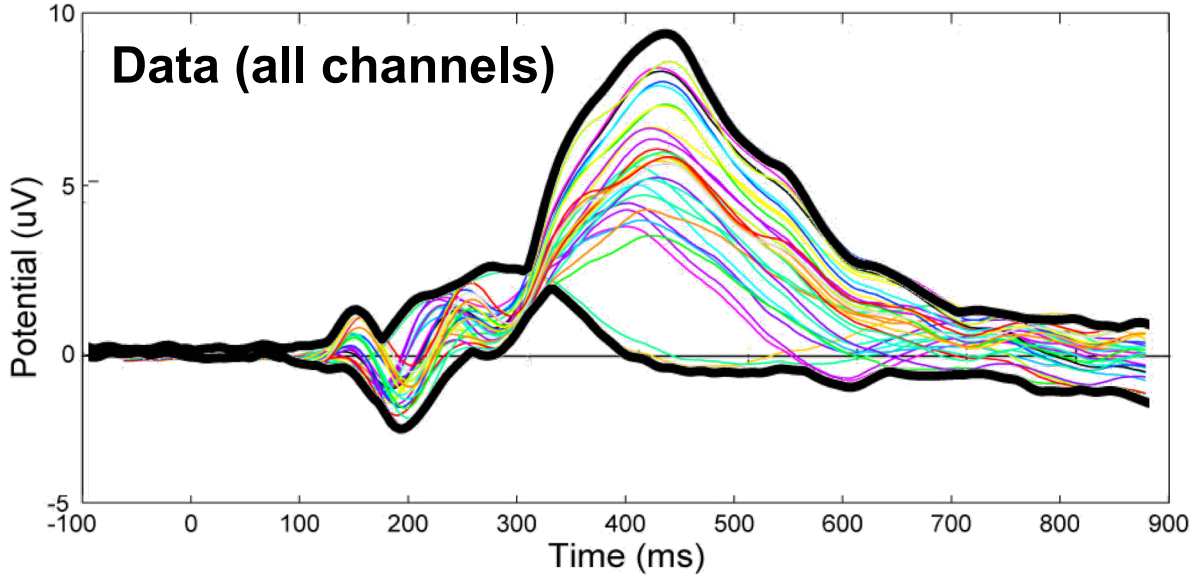


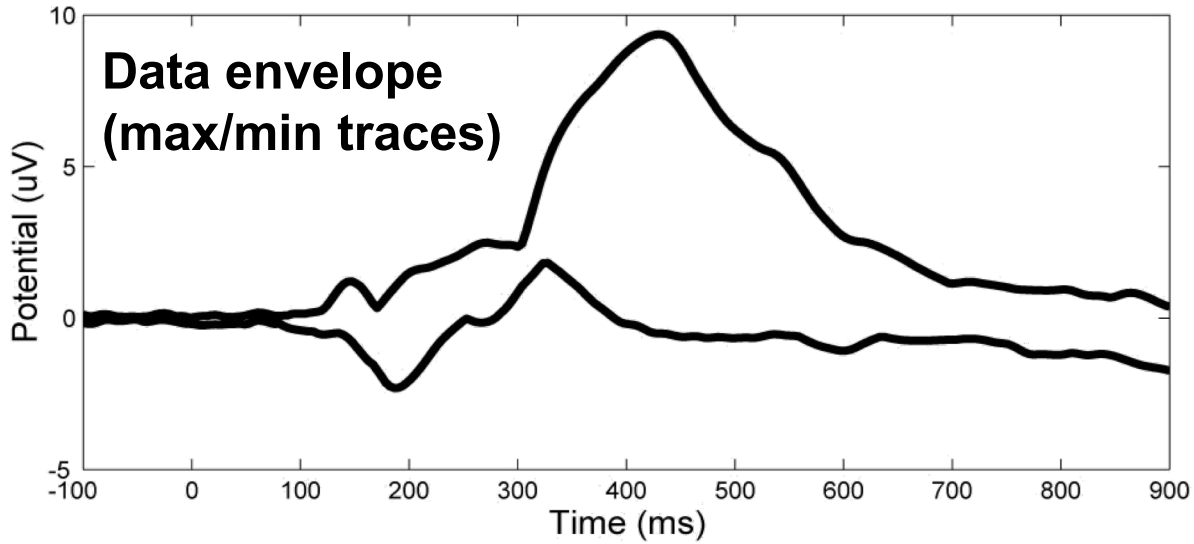
Traditional ERP: Time-locked activity at each channel



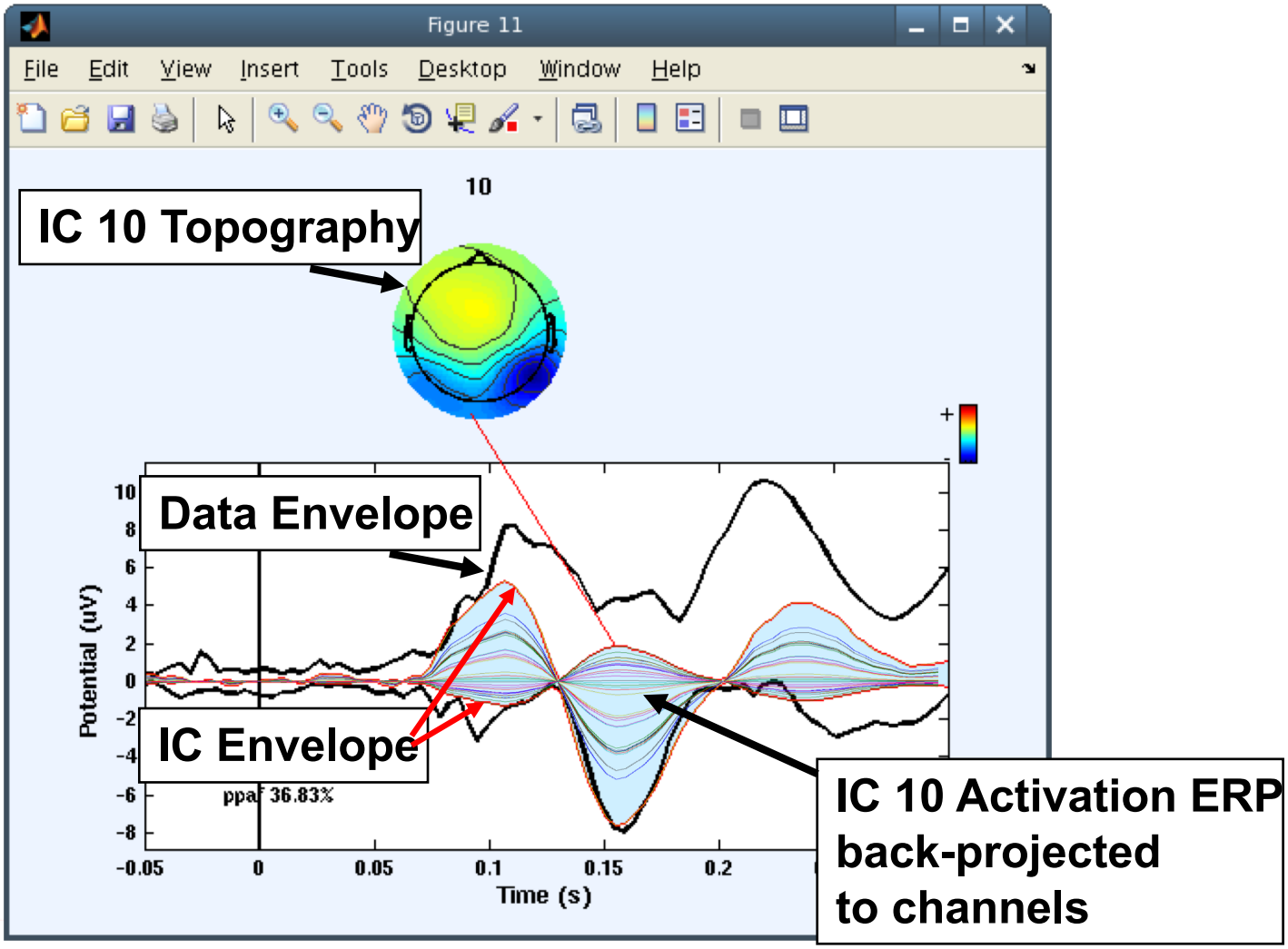
EEG peaks are sometimes called "components."
Not to be confused with ICAs *Independent Components* (ICs)!

Definition: The data envelope

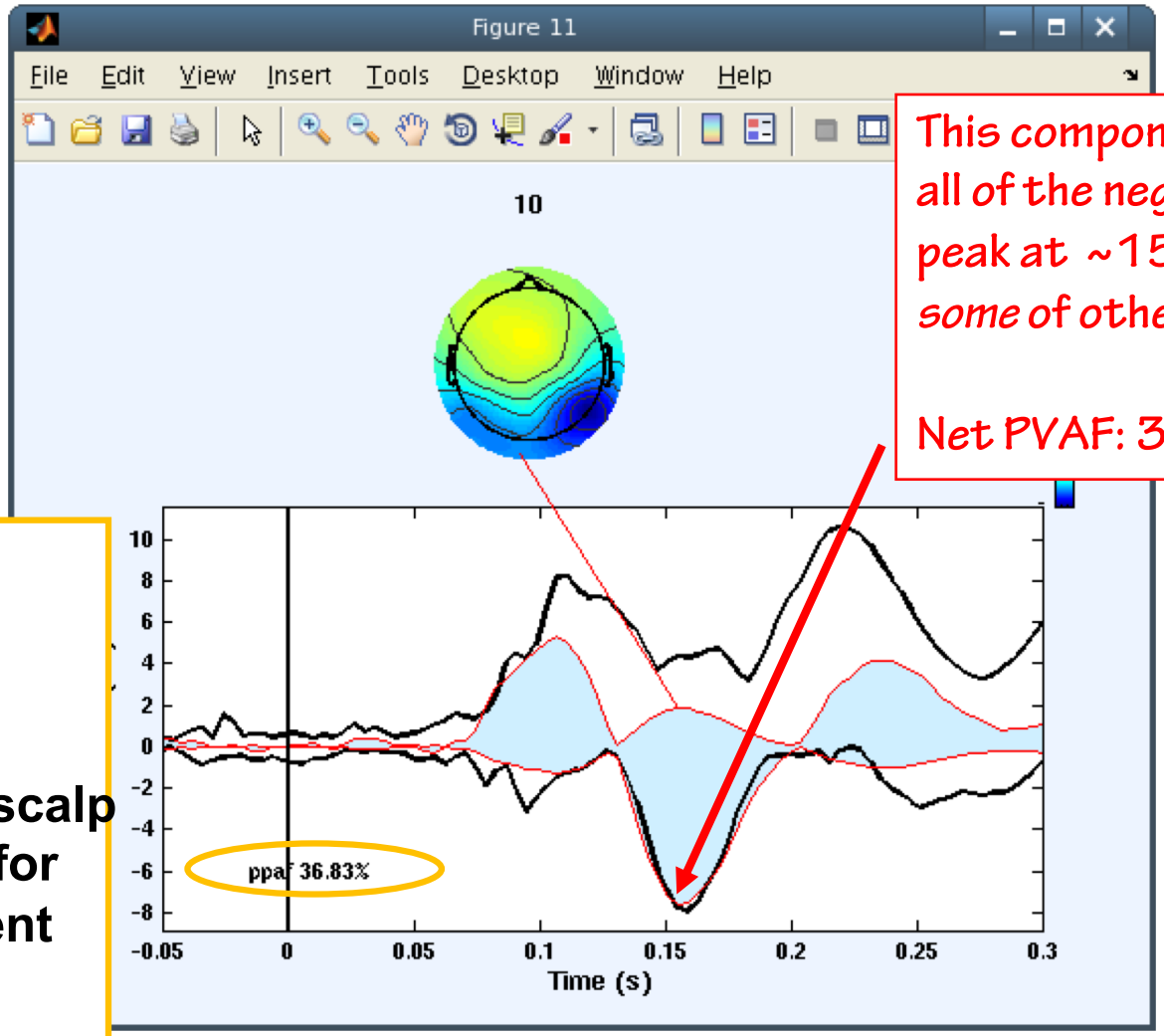




Definition: IC Envelope



Key: Scalp ERP peaks are often the sum of <u>multiple</u> independent source processes



This component accounts for all of the negative scalp ERP peak at ~150 ms, but *only some* of other ERP peaks

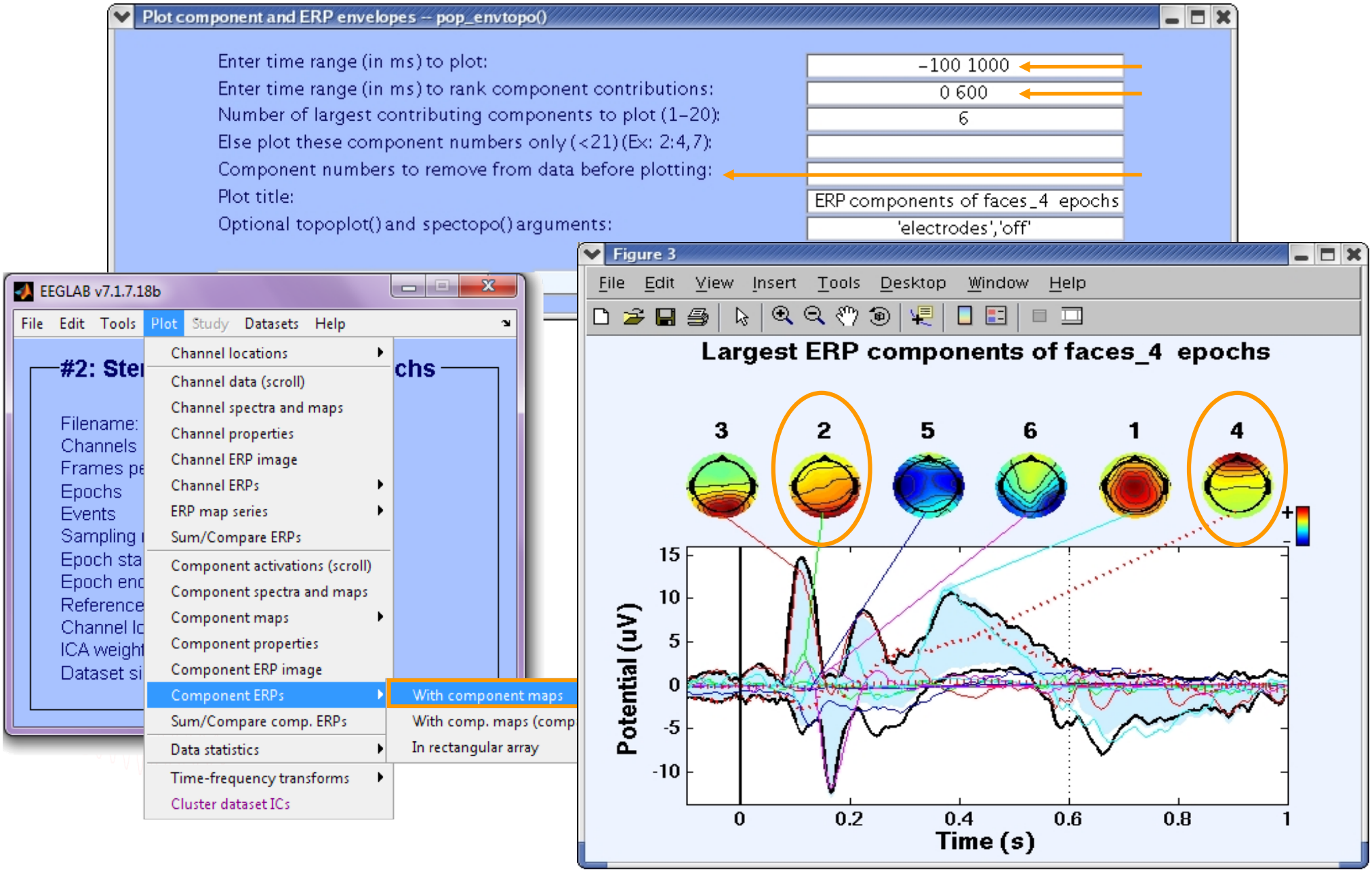
Net PVAF: 37%

PVAF
"% Variance Accounted For"

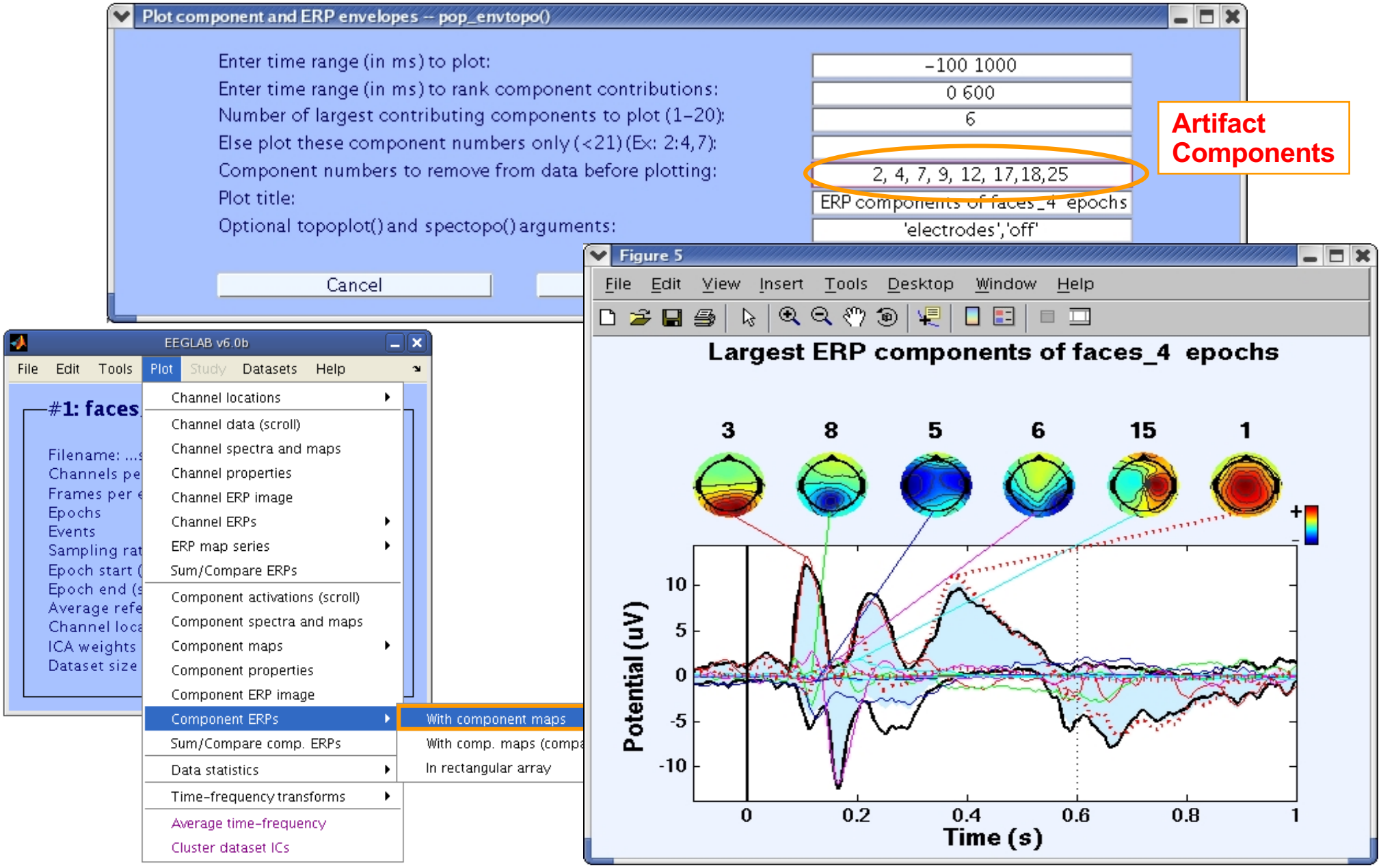
The variance of scalp EEG accounted for by this component

***ppaf**

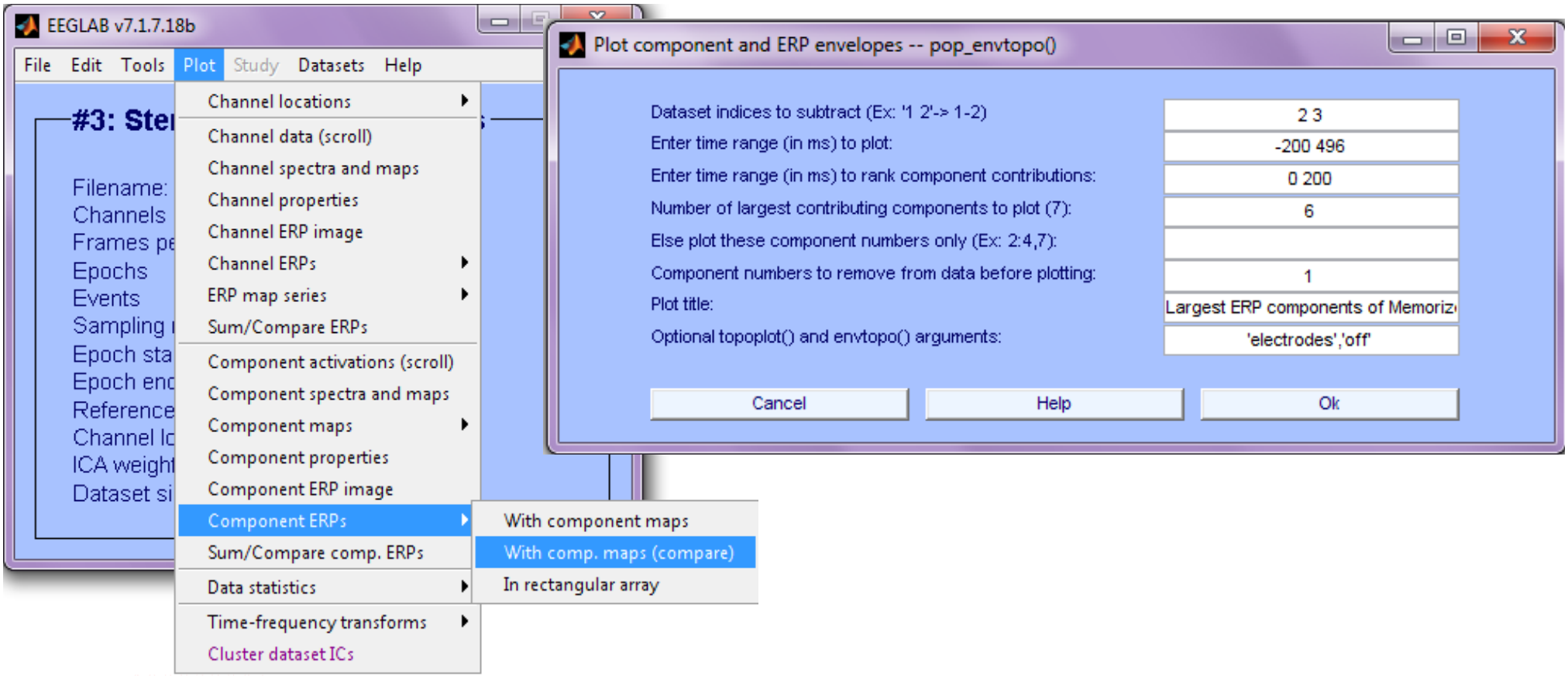
IC contributions to ERP envelope



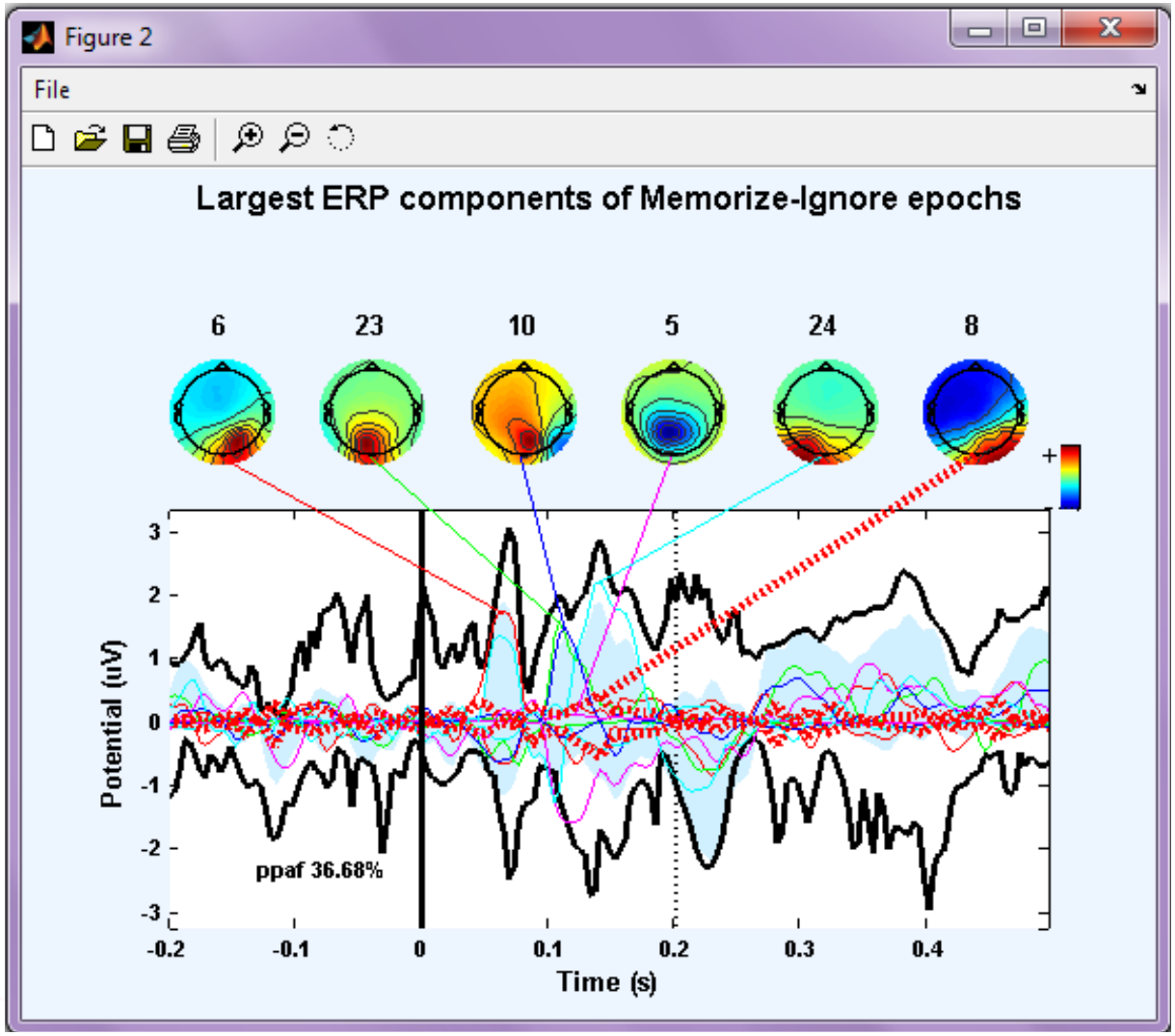
Component contribution to the dataset ERP



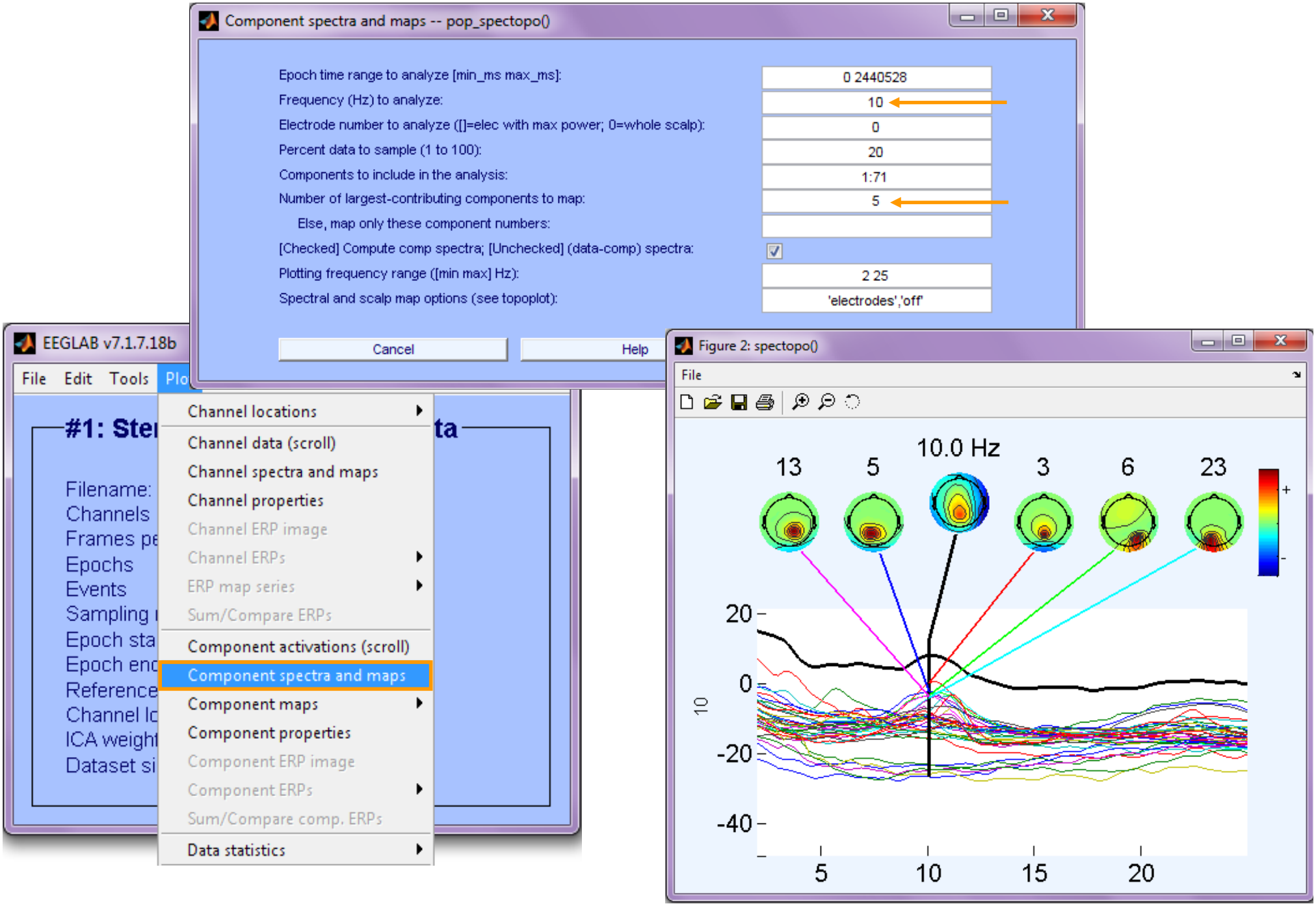
IC ERP difference



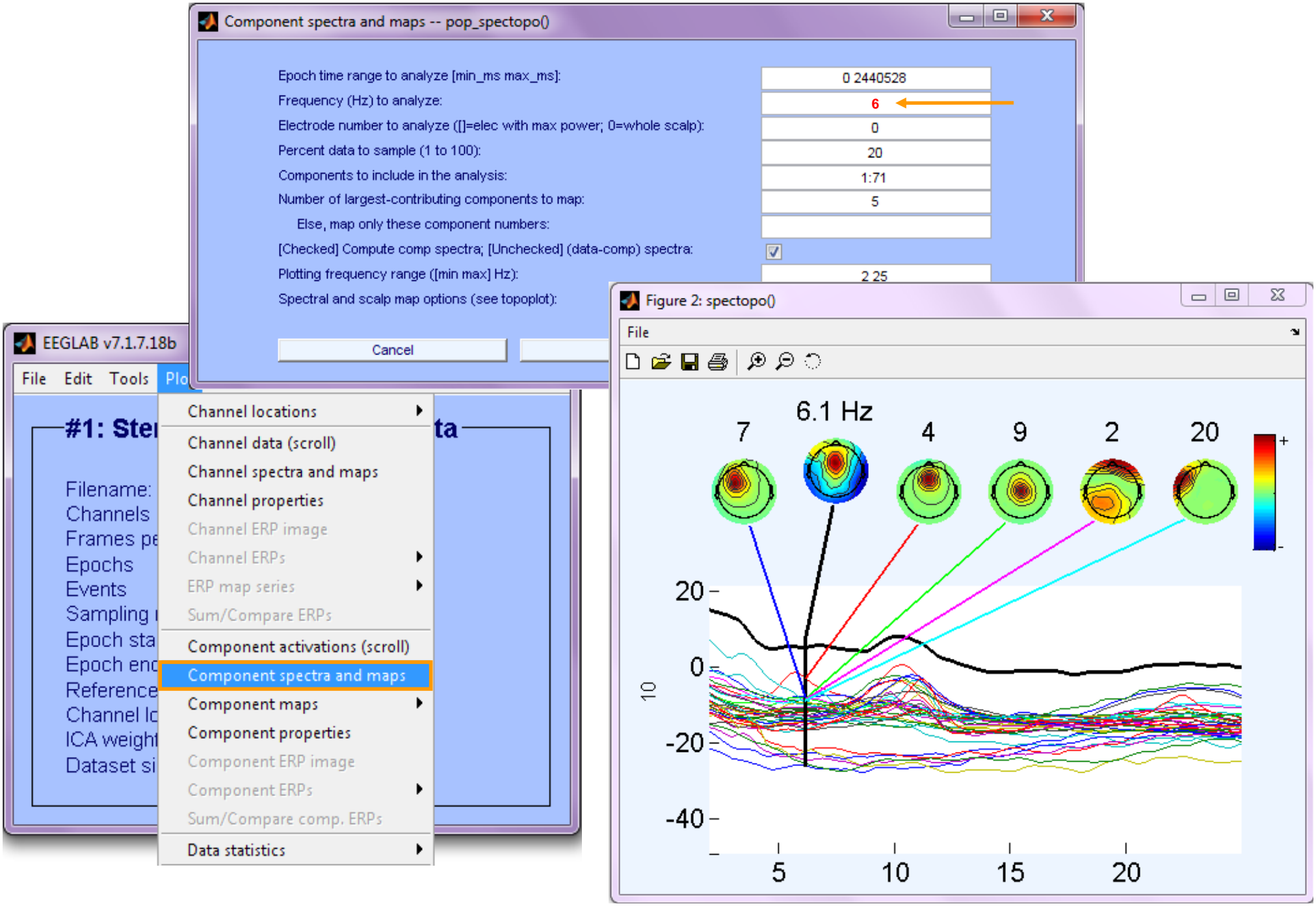
IC ERP difference



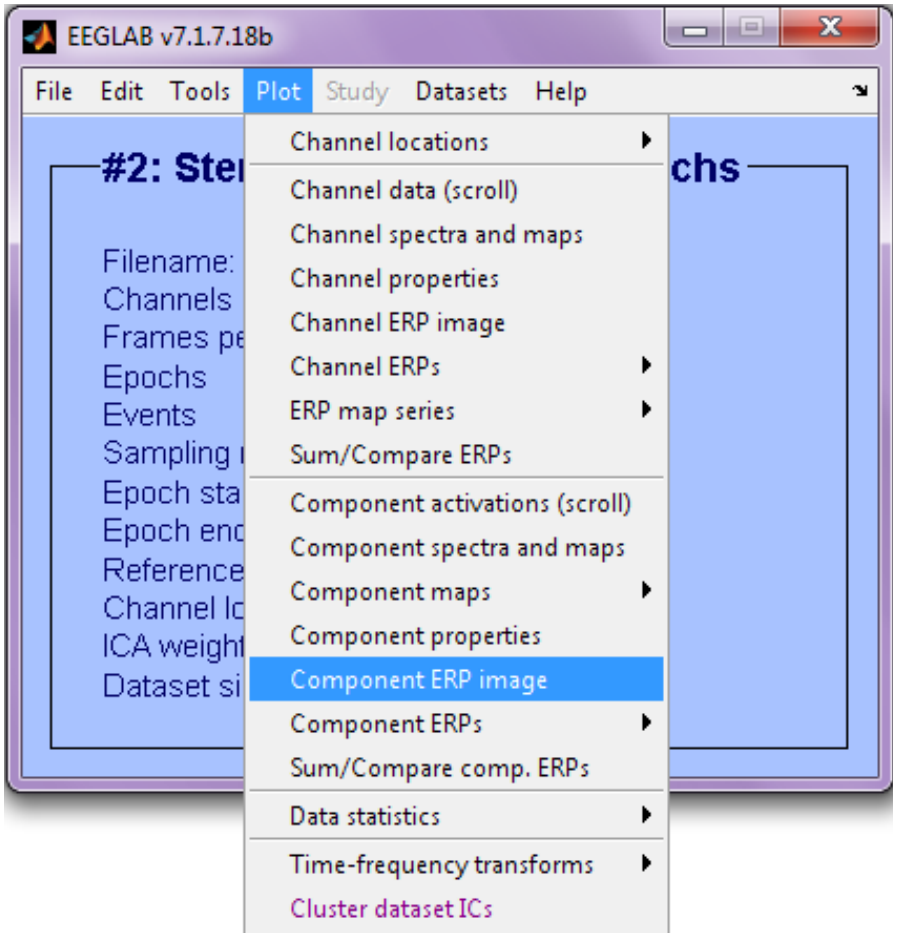
Plot component power



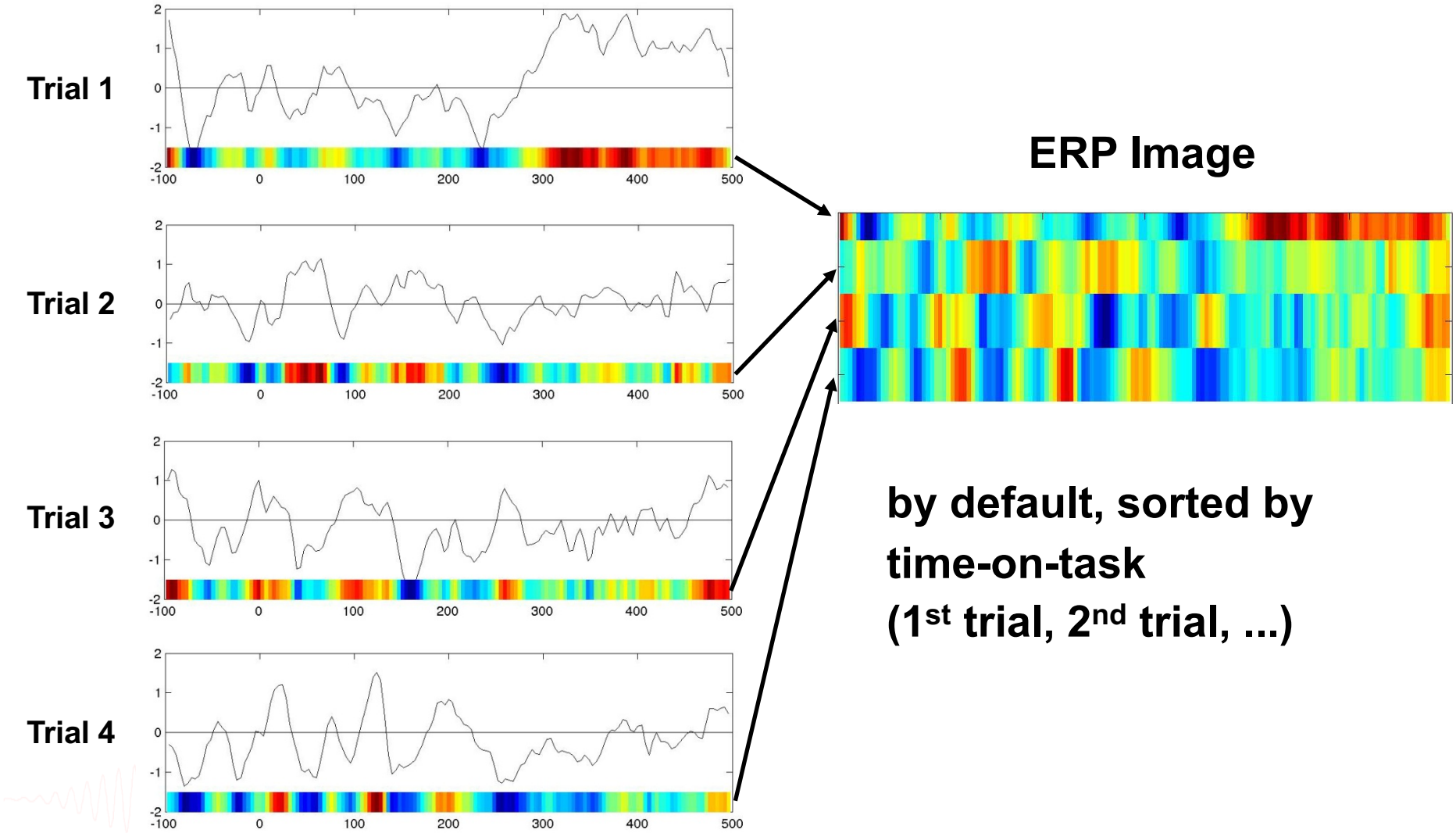
Plot component power



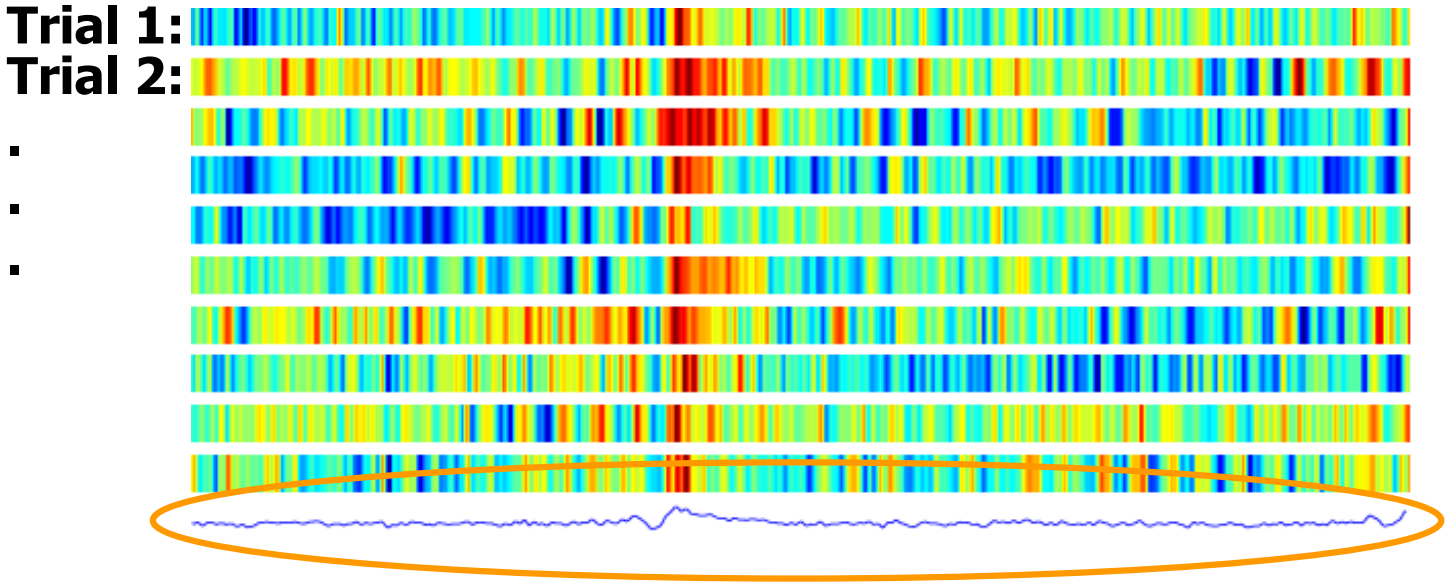
Component ERP image

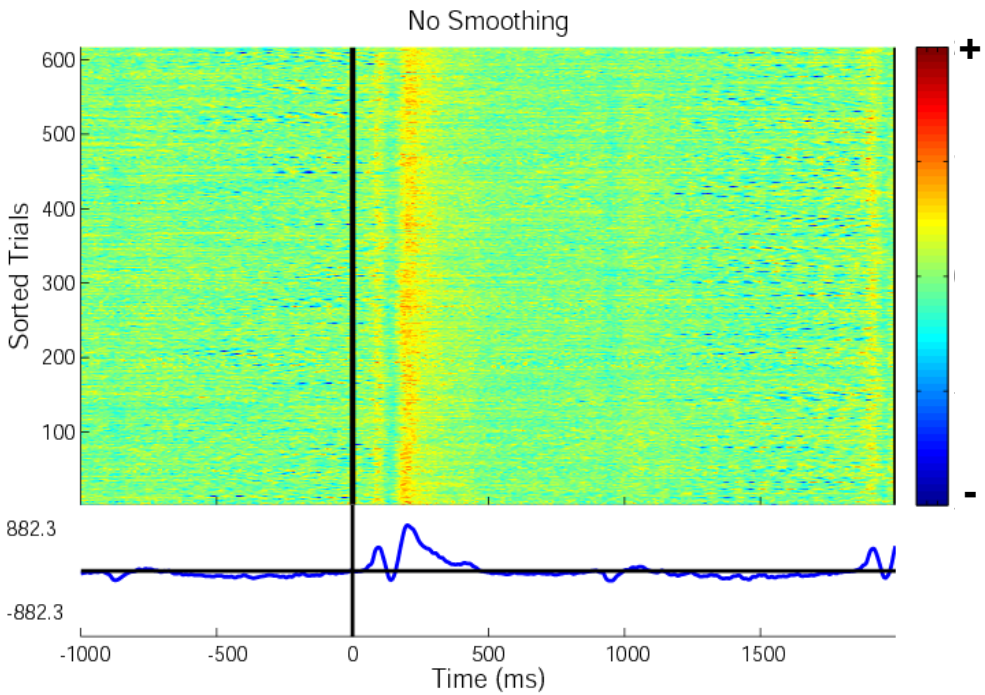


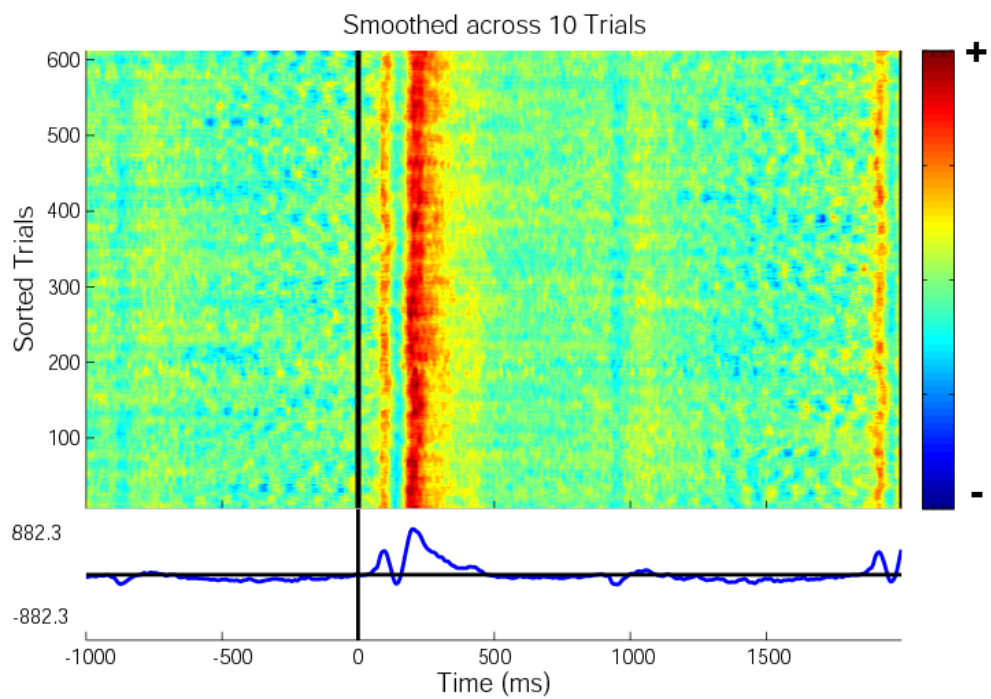
ERP Image basics



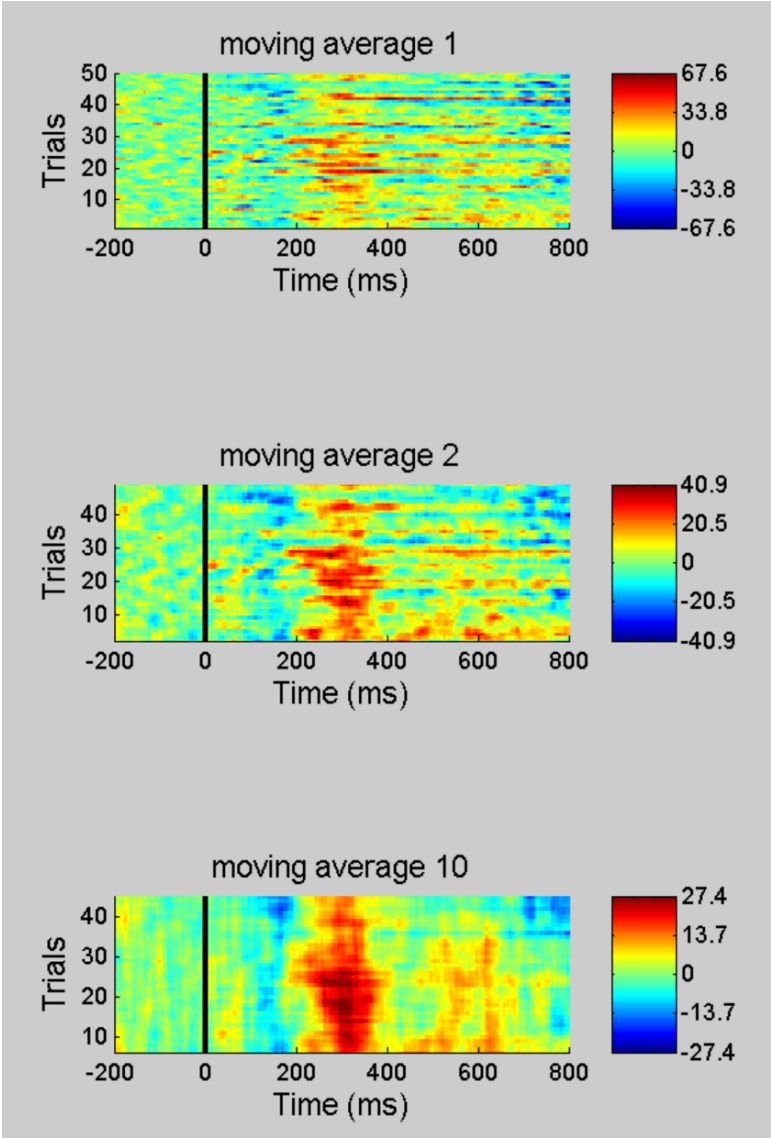
ERP Image basics



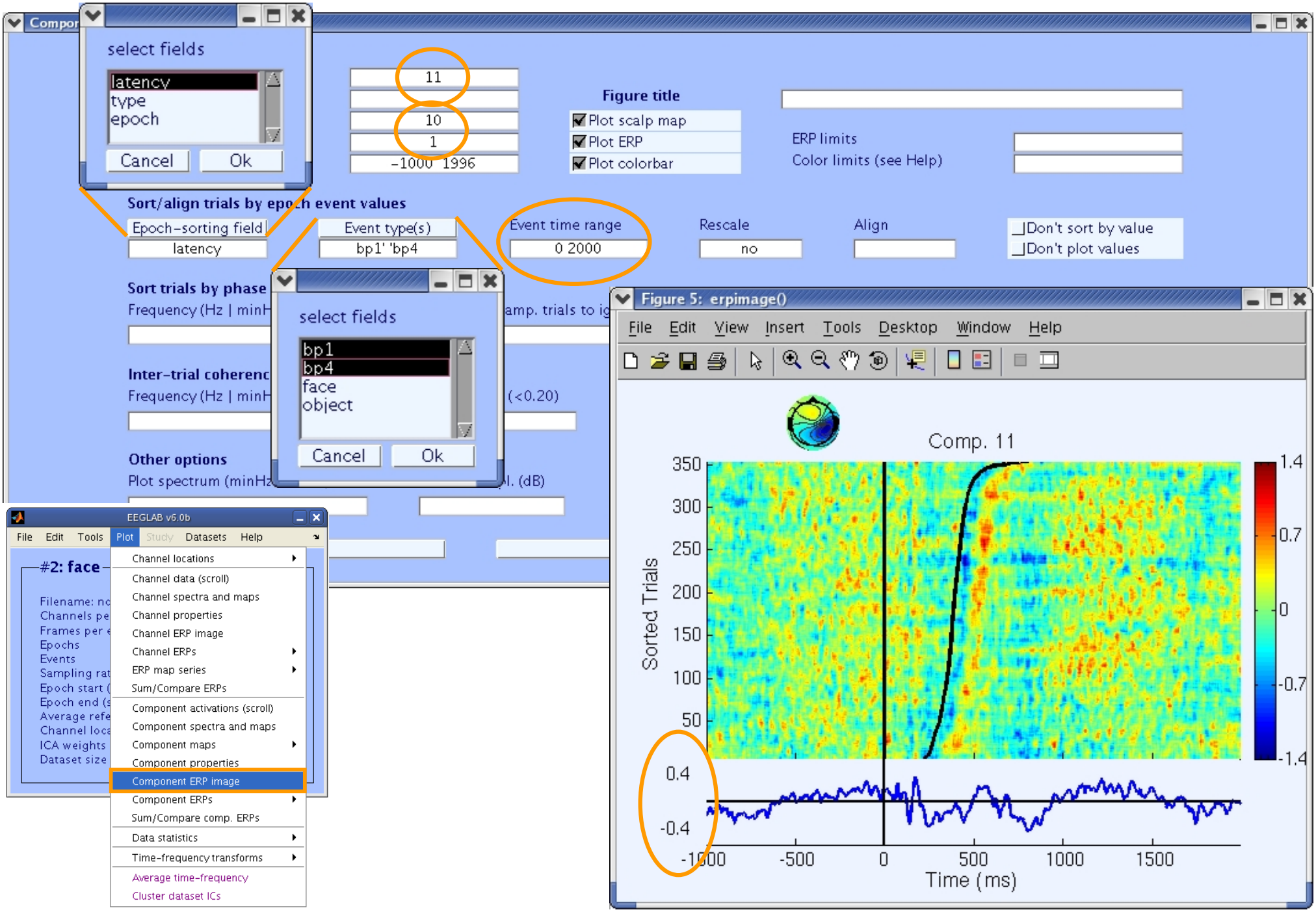




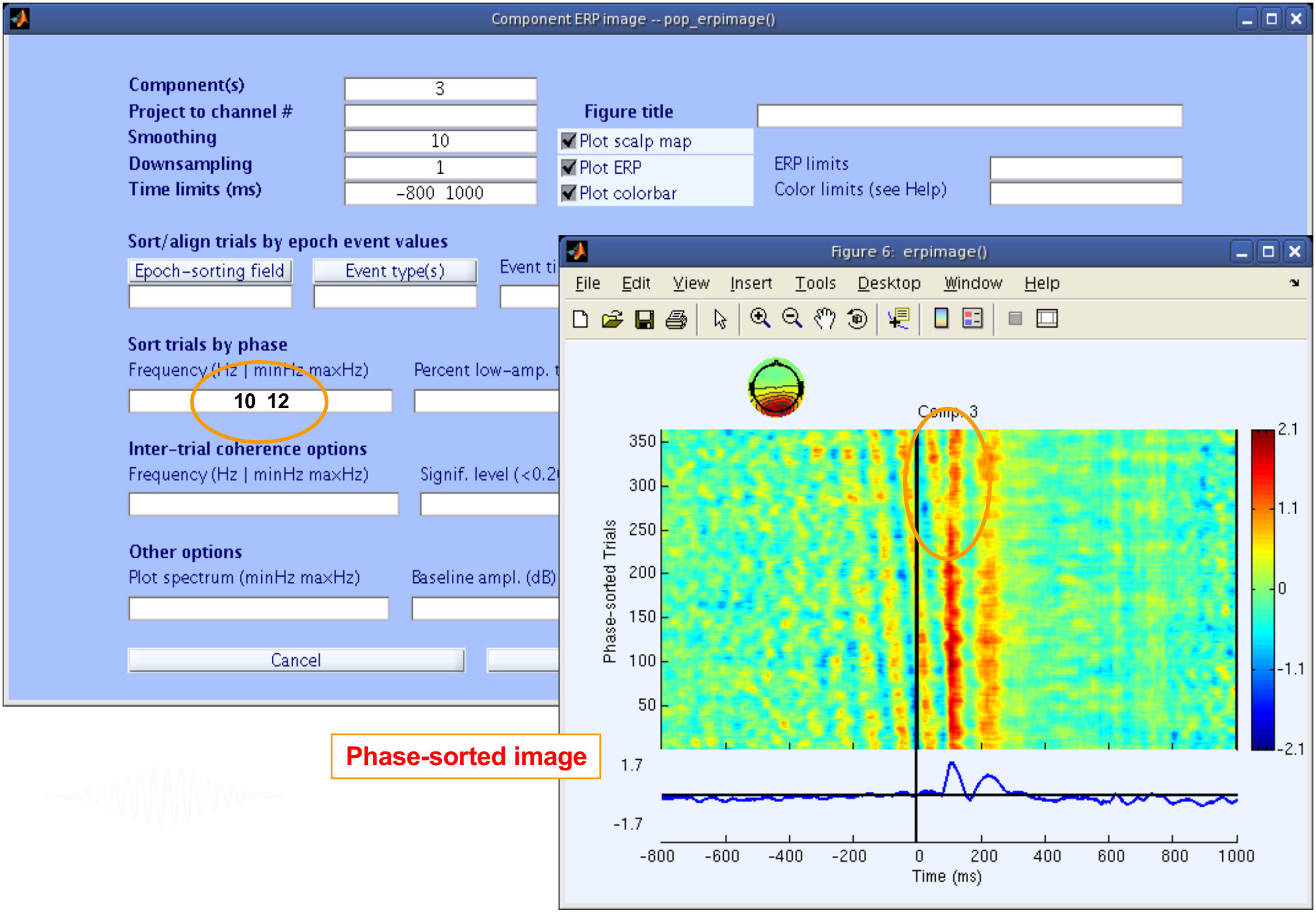
ERP Images: smoothing across trials



Component ERP Images

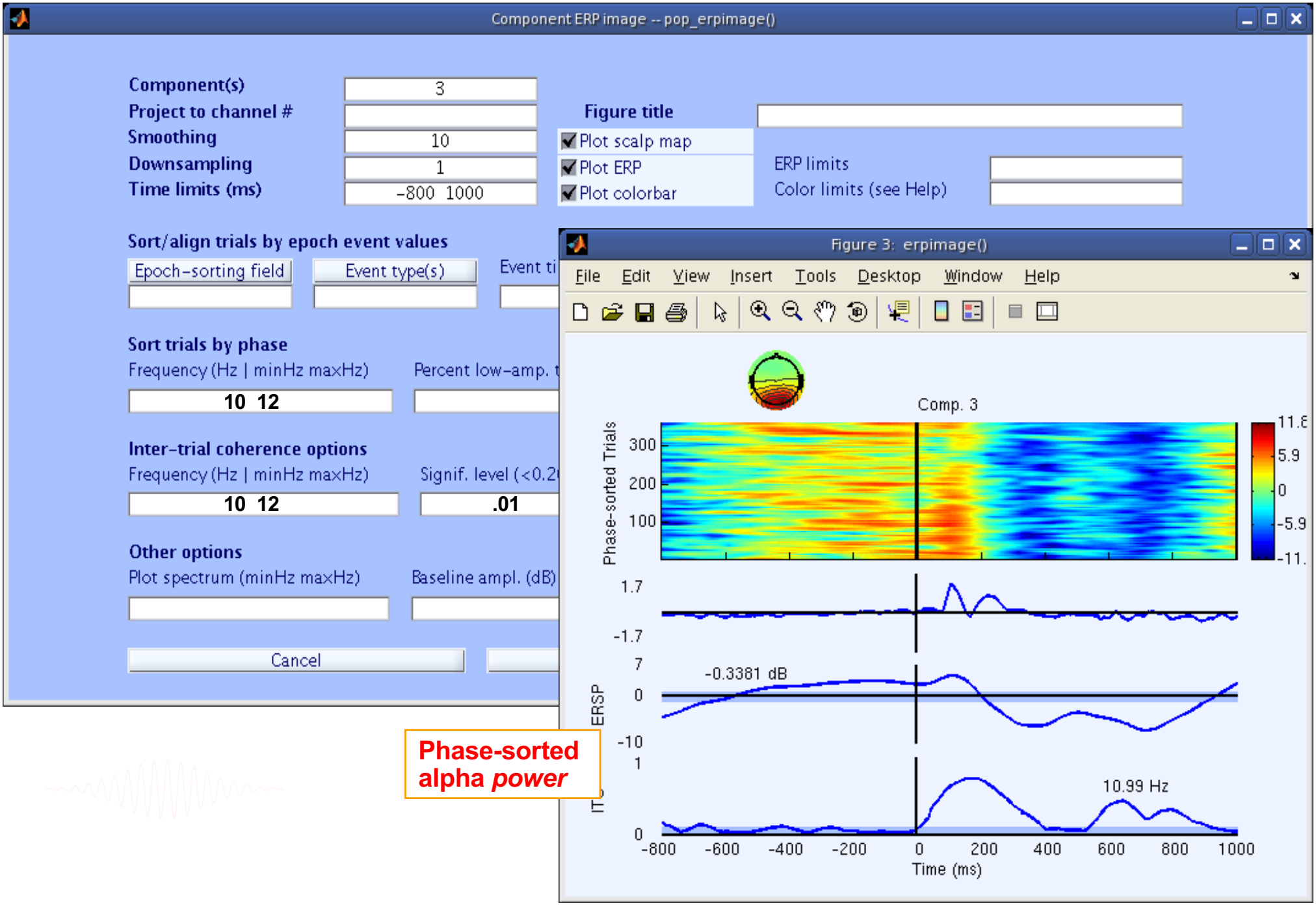


Component ERP Images

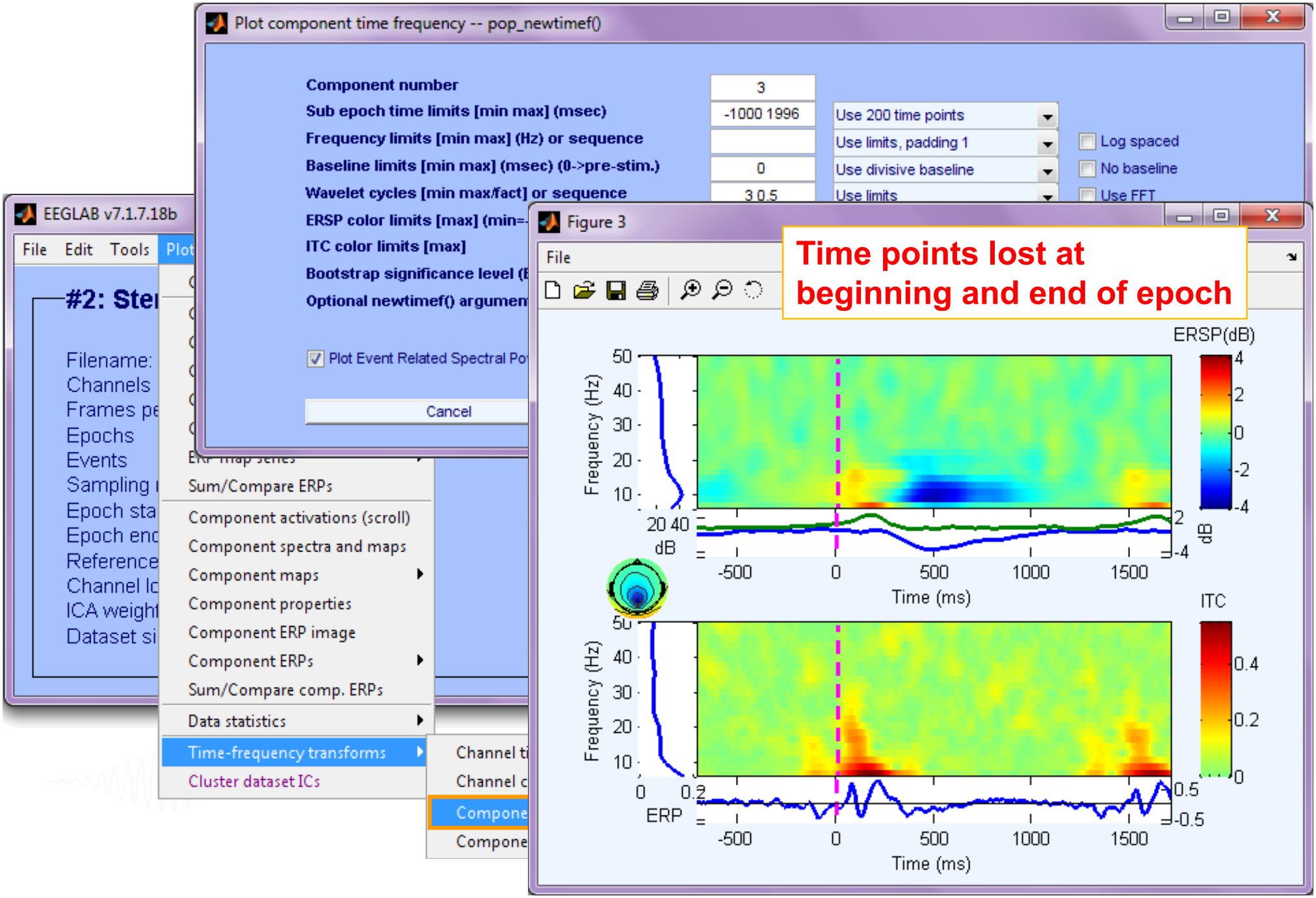


Phase-sorted image

Component ERP Images



Plot IC ERSP

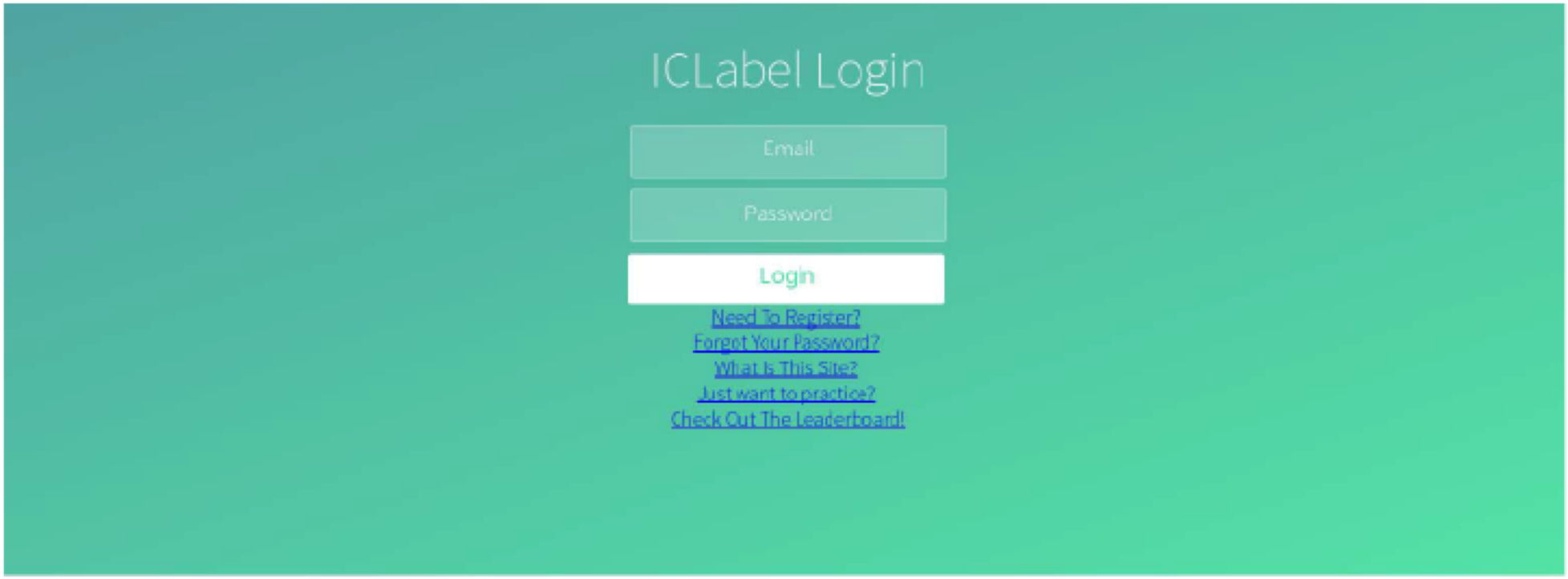

Plot component time frequency -- pop_newtimef()
Component number
3
Sub epoch time limits [min max] (msec)
-1000 1996
Use 200 time points
Frequency limits [min max] (Hz) or sequence
Use limits, padding 1
Log spaced
Baseline limits [min max] (msec) (0->pre-stim.)
0
Use divisive baseline
No baseline
Wavelet cycles [min max/fact] or sequence
3 0.5
Use limits
Use FFT
ERSP color limits [max] (min=
ITC color limits [max]
Bootstrap significance level (
Optional newtimef() argumen
Plot Event Related Spectral Po
Cancel
EEGLAB v7.1.7.18b
File Edit Tools Plot
#2: Ste
Filename:
Channels
Frames pe
Epochs
Events
Sampling
Epoch sta
Epoch end
Reference
Channel lo
ICA weight
Dataset si
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
Cluster dataset ICs
Channel ti
Channel c
Compone
Compone
Figure 3
File
Time points lost at beginning and end of epoch
ERSP(dB)
Frequency (Hz)
dB
Time (ms)
ITC
ERP

ICLabel website

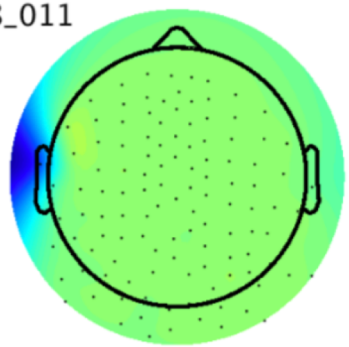
ICLabel project: create automated EEG IC classifier (labeler)

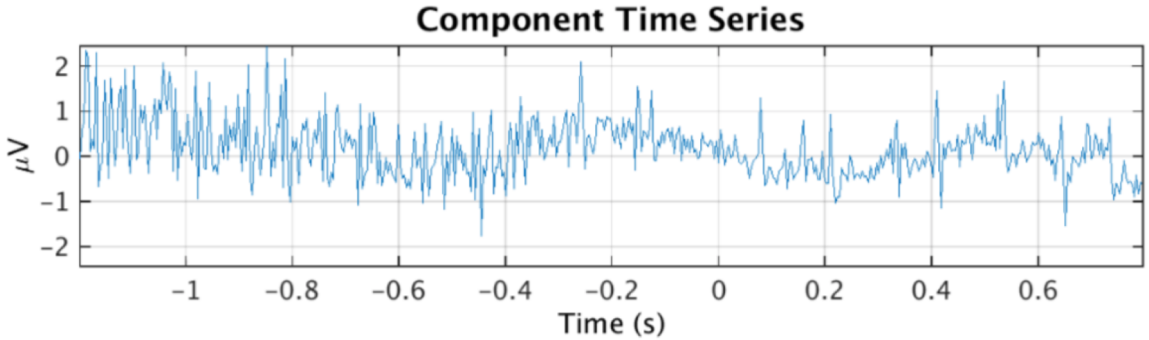
https://labeling.ucsd.edu/tutorial

vast collection of datasets.

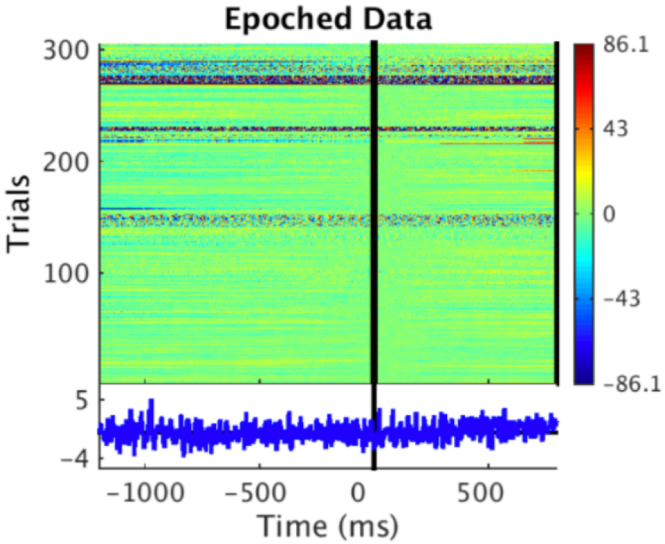


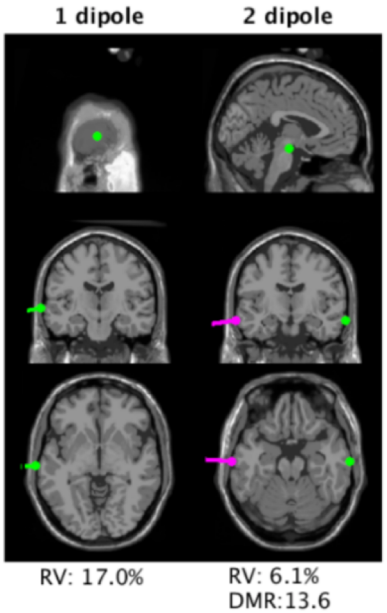
072188_011

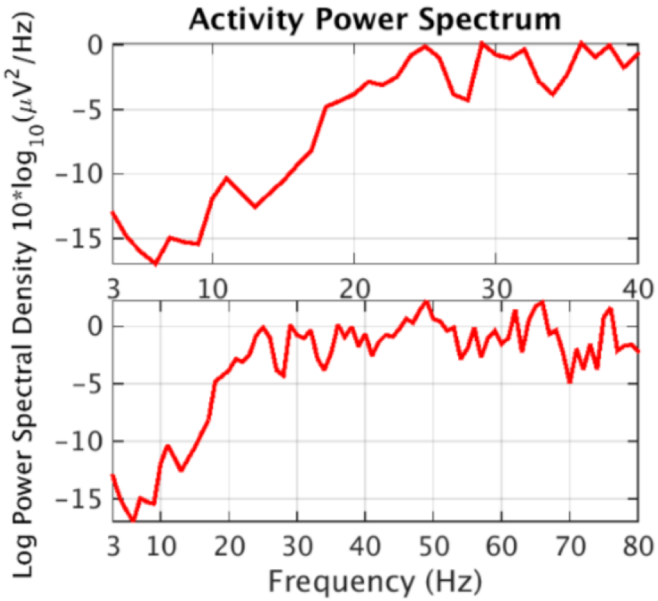




IC 11 of 30
Data Var. Accounted For:
15.96%

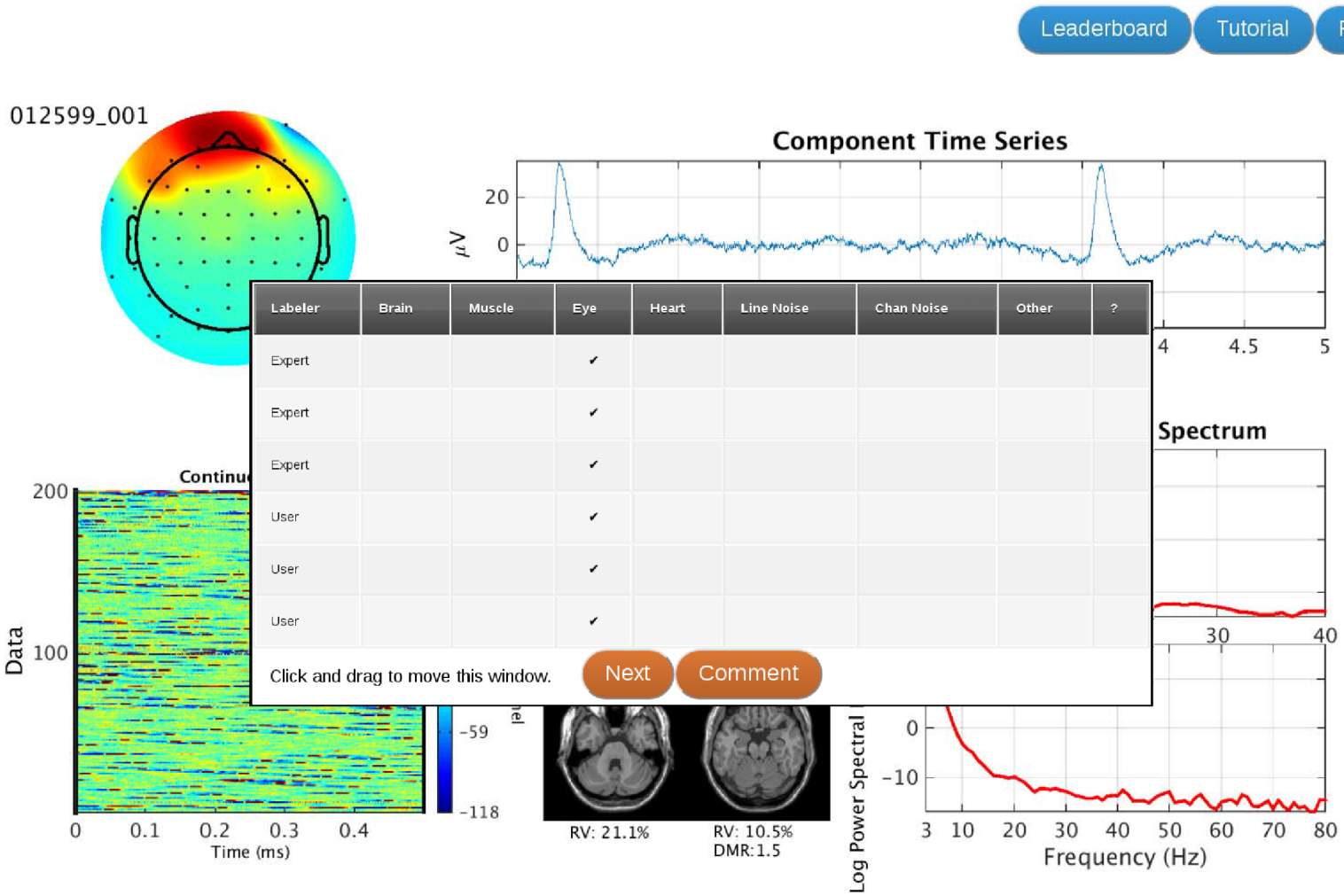




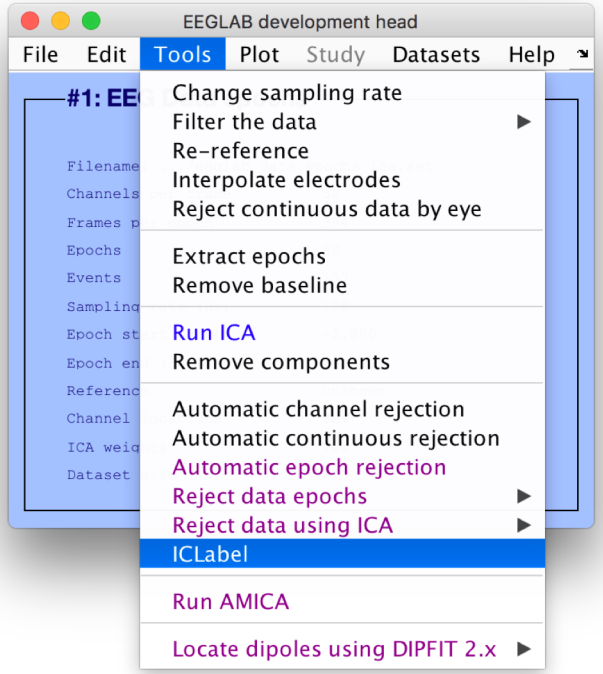


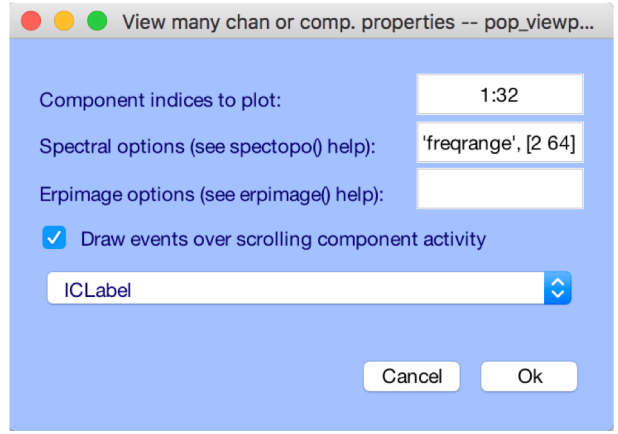
Brain | Muscle | Eye | Heart | Next | Line Noise | Chan Noise | Other | ?

ICLabel website – Label feedback



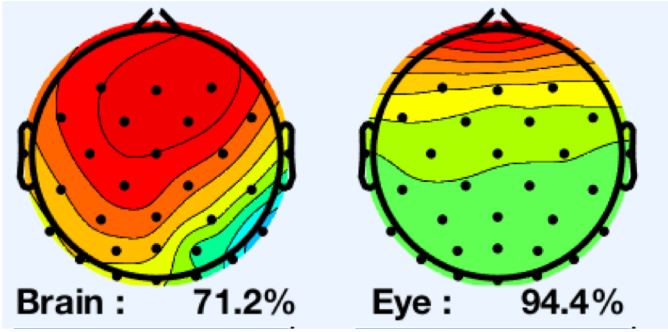
IC Label plugin (Luca Pion-Tonachini)

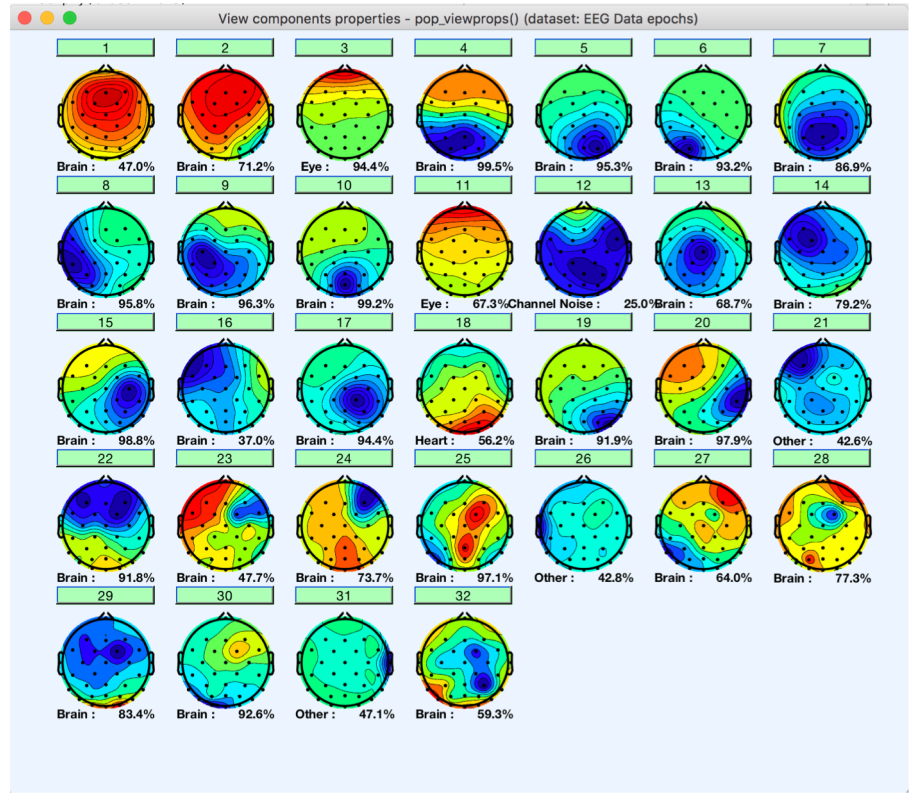




Component types

- Brain
- Muscle
- Eye
- Heart
- Line Noise
- Channel Noise
- Other





Exercise

- Start eeglab

- Load dataset stern_125.set (in EEG_data folder)

- Run ICA (already done for this dataset)

- From the GUI, plot component ERPs with maps

- Pick an interesting IC and plot an ERP image of it

- Try sorting by phase, is there any relationship to the IC activation pattern? What about power in a frequency band of choice?