Artifact rejection and running ICA

Task 1

Reject noisy data

Task 2

Run ICA

Task 3

Plot components

Task 4

Remove components

(i.e. back-projection)

Exercise...

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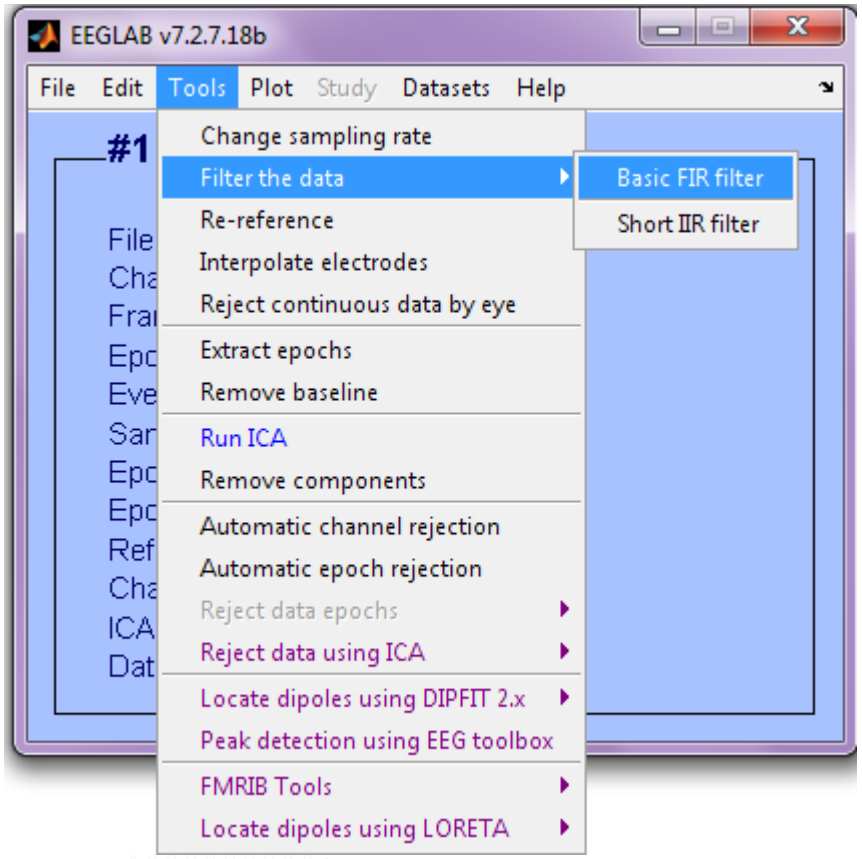
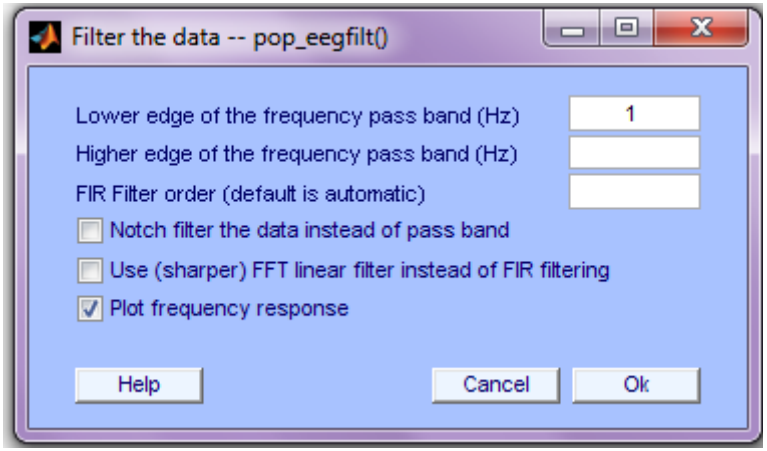
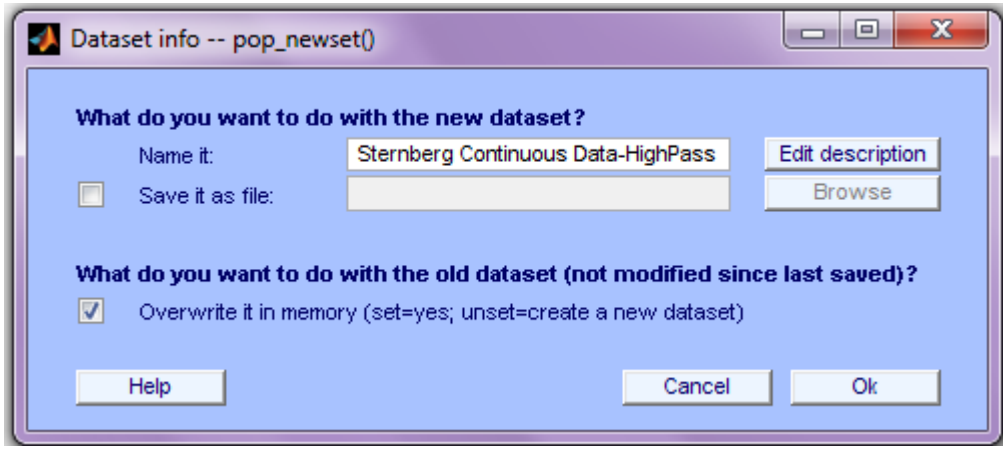
Exercise...

Filter the data (if necessary/desired)

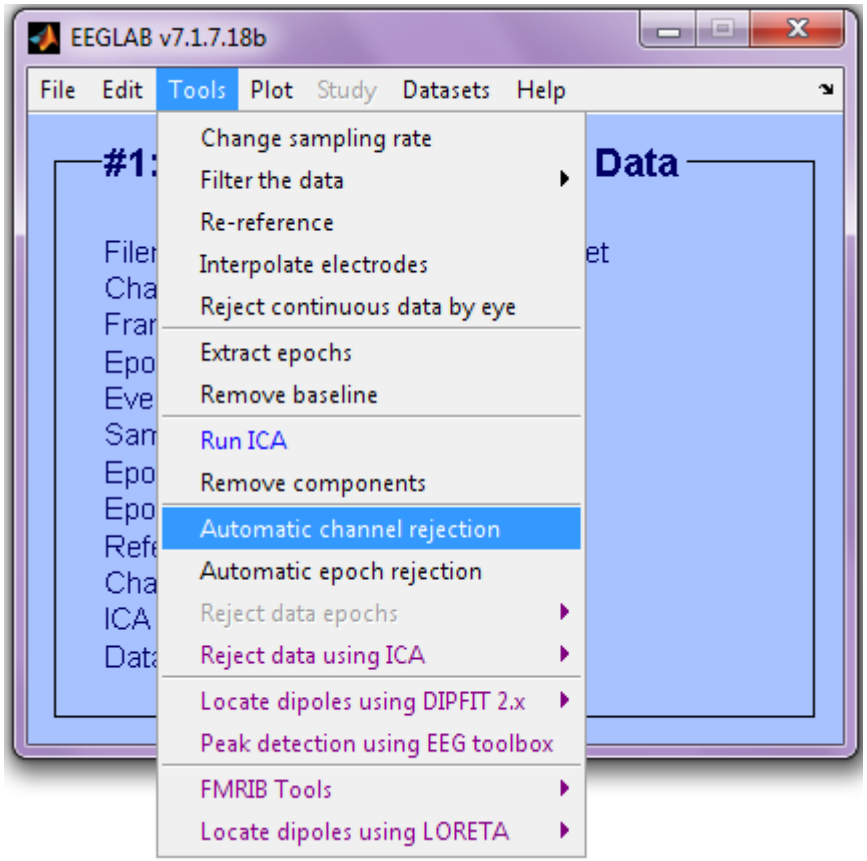


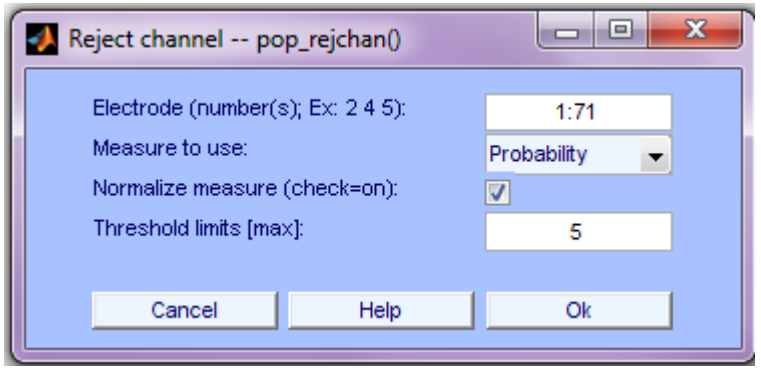


High-pass



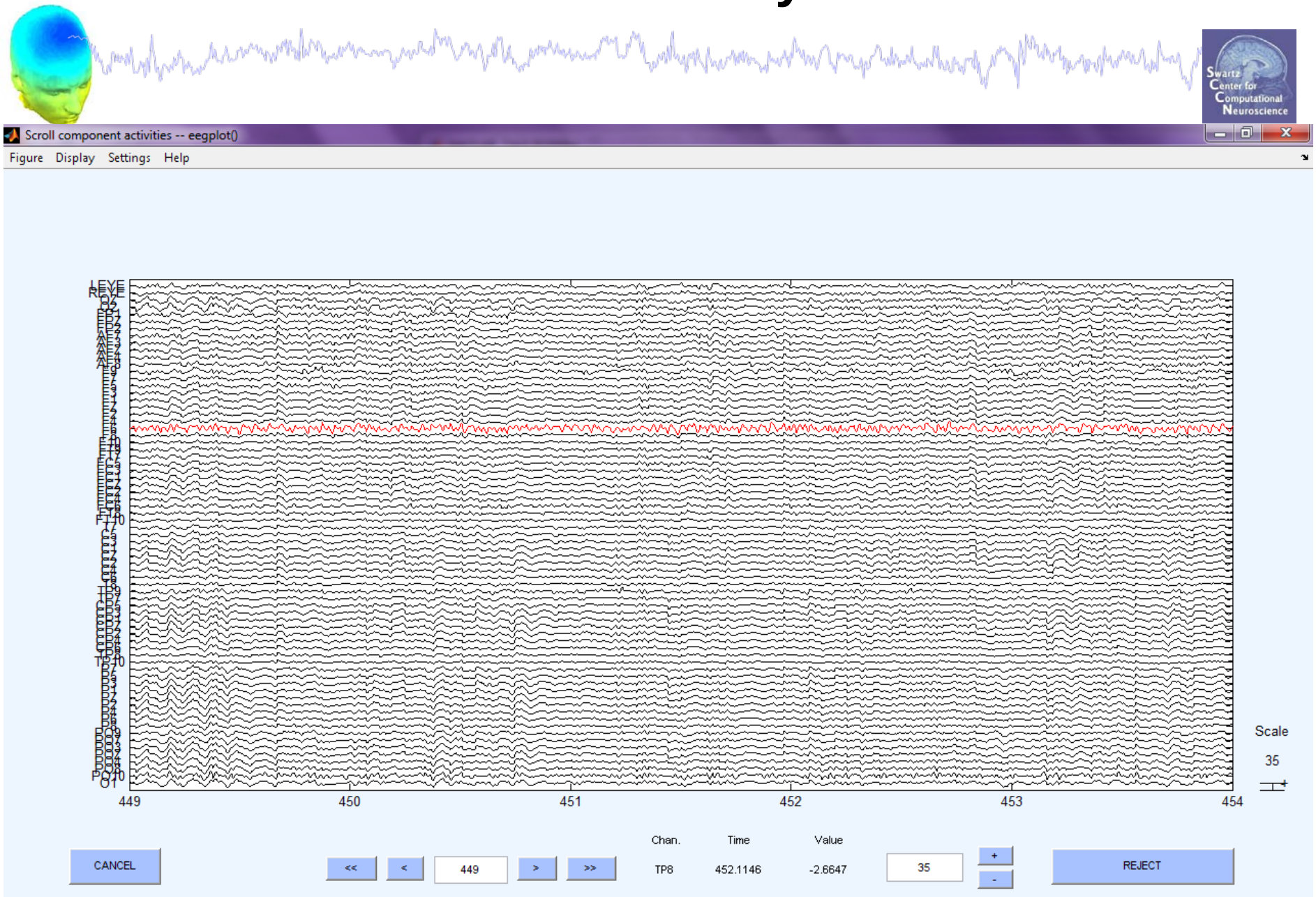
Auto-detection of noisy channels





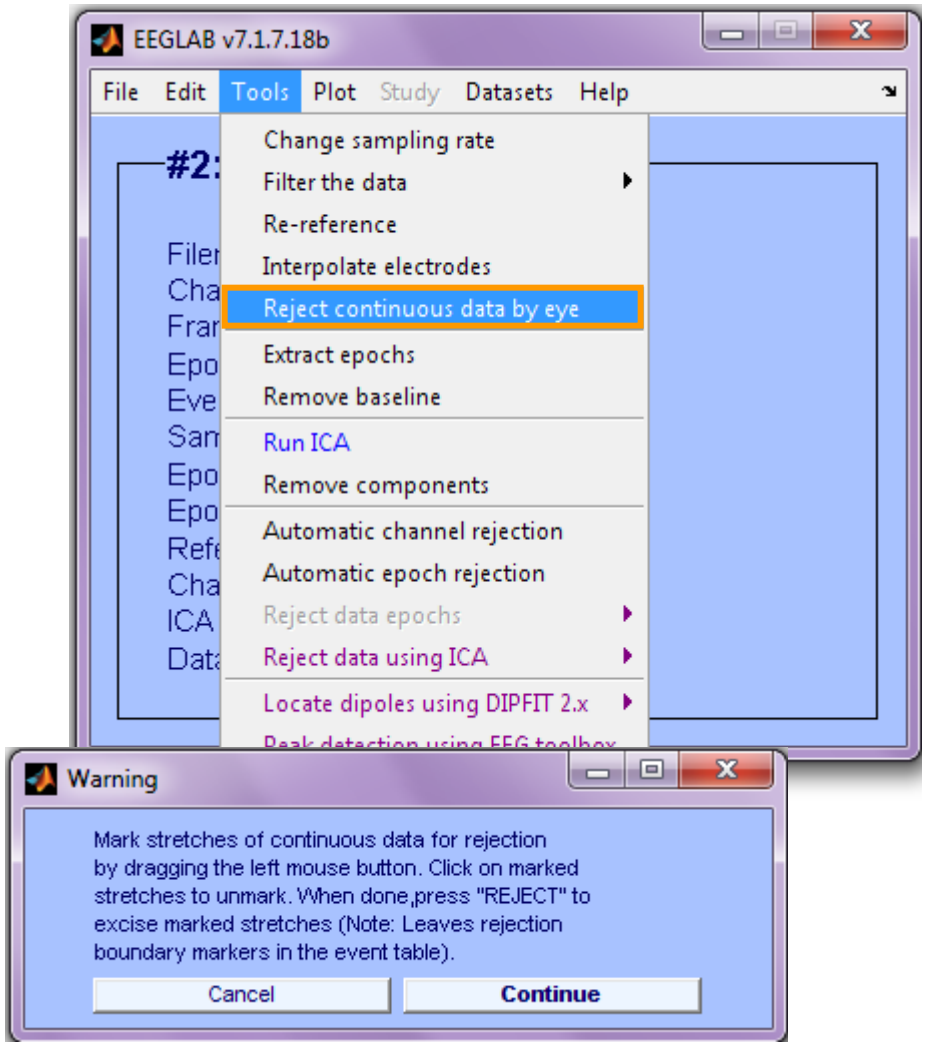

```
>> EEG = pop_rejchan(EEG,  'elec',[1:71] , 'threshold',5,...
 'norm', 'on', 'measure', 'prob');
```

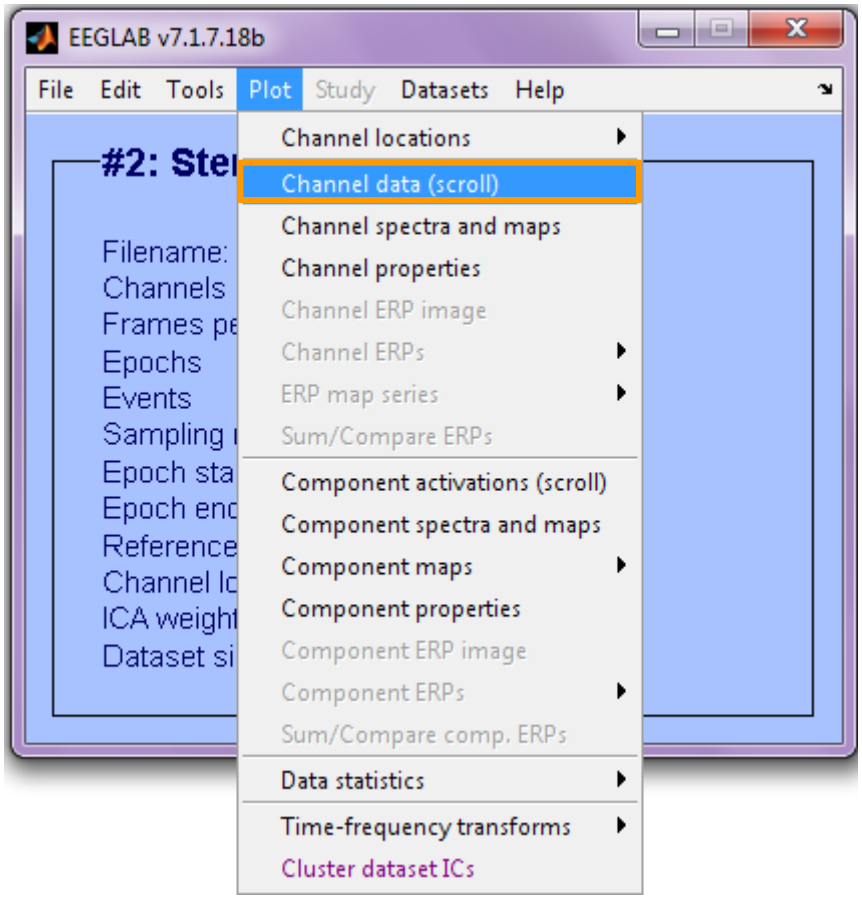
Auto-detected noisy channel



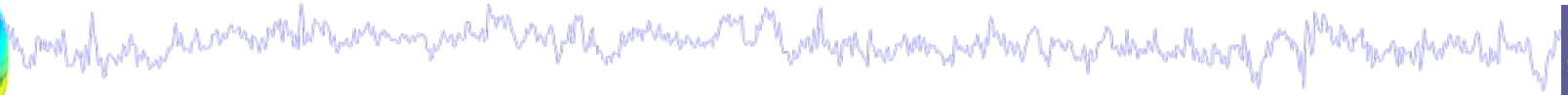
Reject continuous data

Equivalent





Reject continuous data



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Scroll channel activities -- eegplot()

Figure Display Settings Help

Click and drag with mouse over noisy data to reject

advance nonWM

536 537 538 539 540 541

Scale 35

CANCEL Event types << < 536 > >>

Chan. Time Value

FC6 539.9355 4.8773

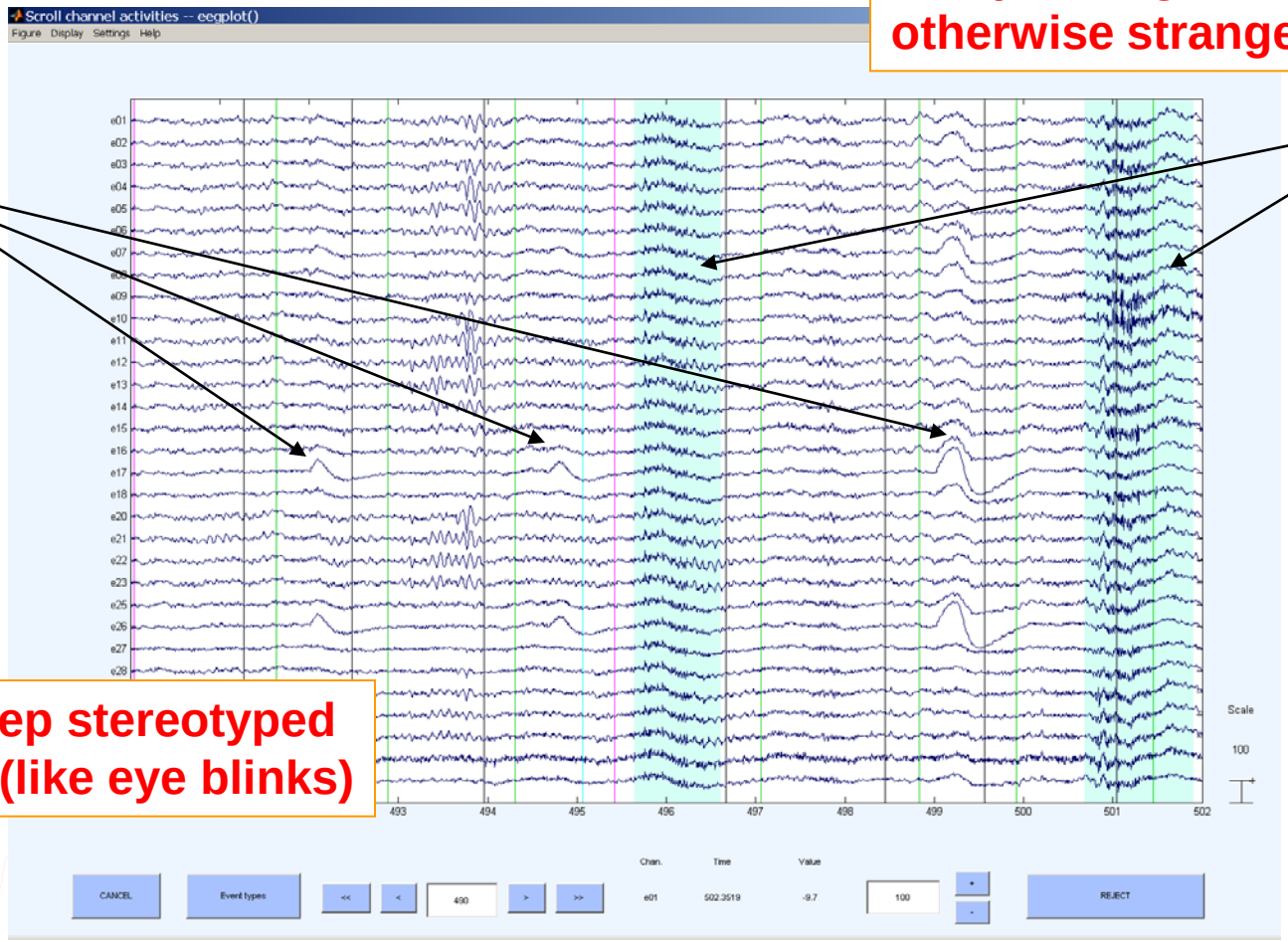
35 + -

REJECT

Rejecting data for ICA

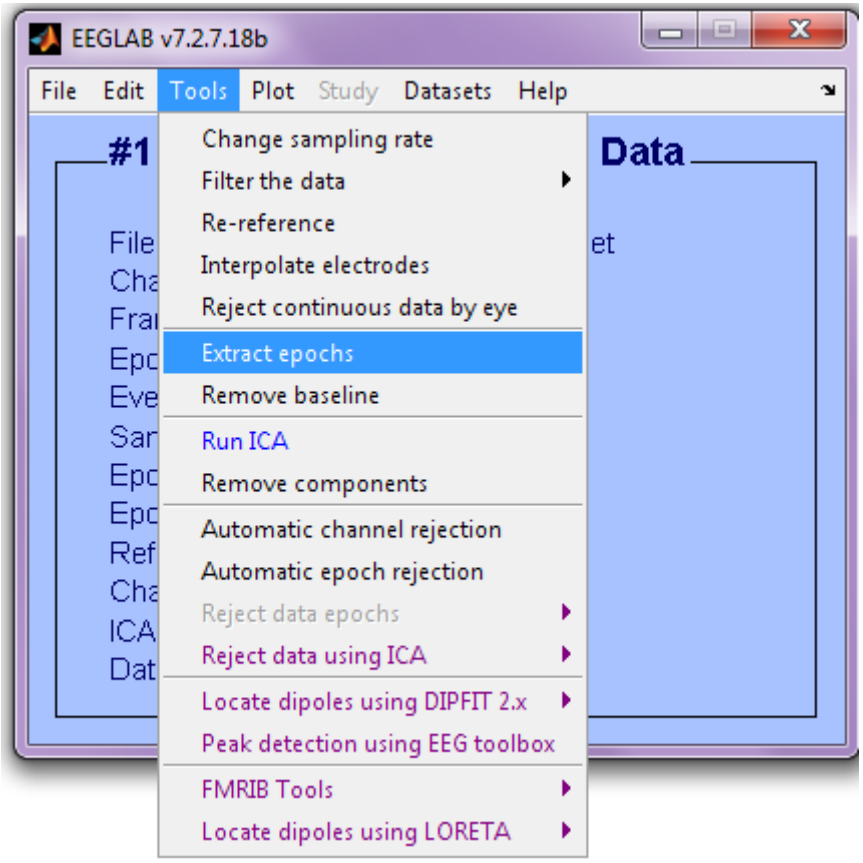
To prepare data for ICA:

Reject large muscle or otherwise strange events...

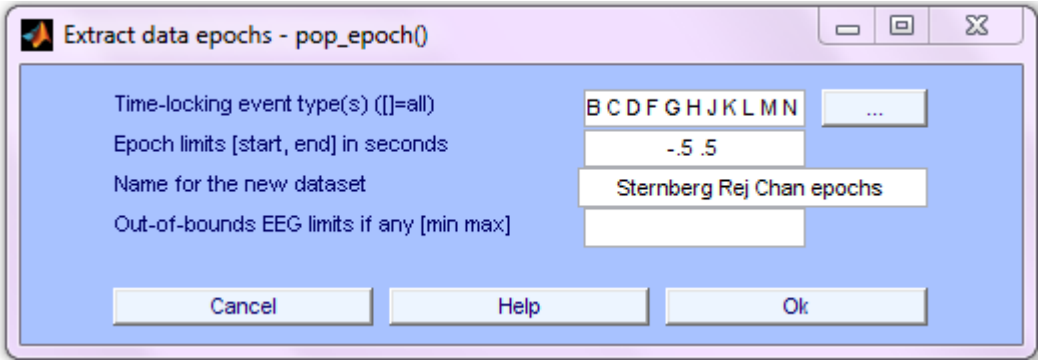


... but keep stereotyped artifacts (like eye blinks)

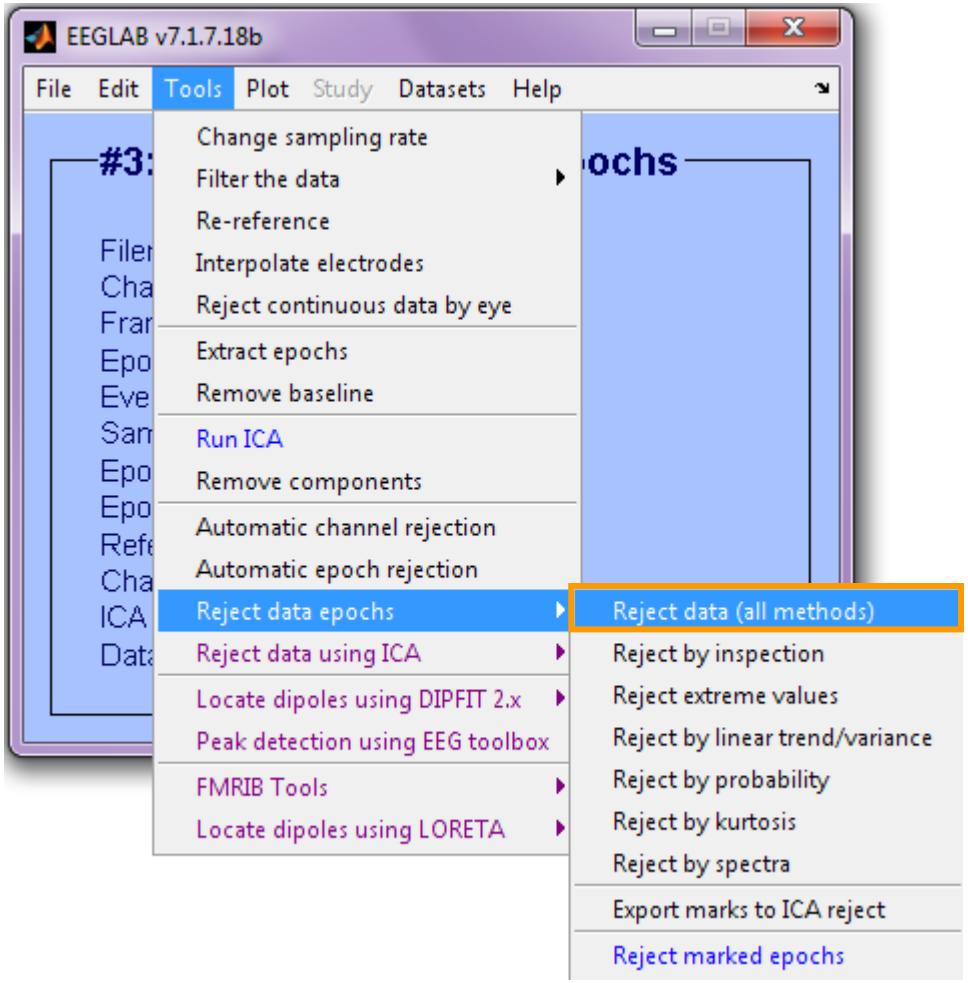
OR… Extract short epochs



Choose all events



Auto-reject data epochs

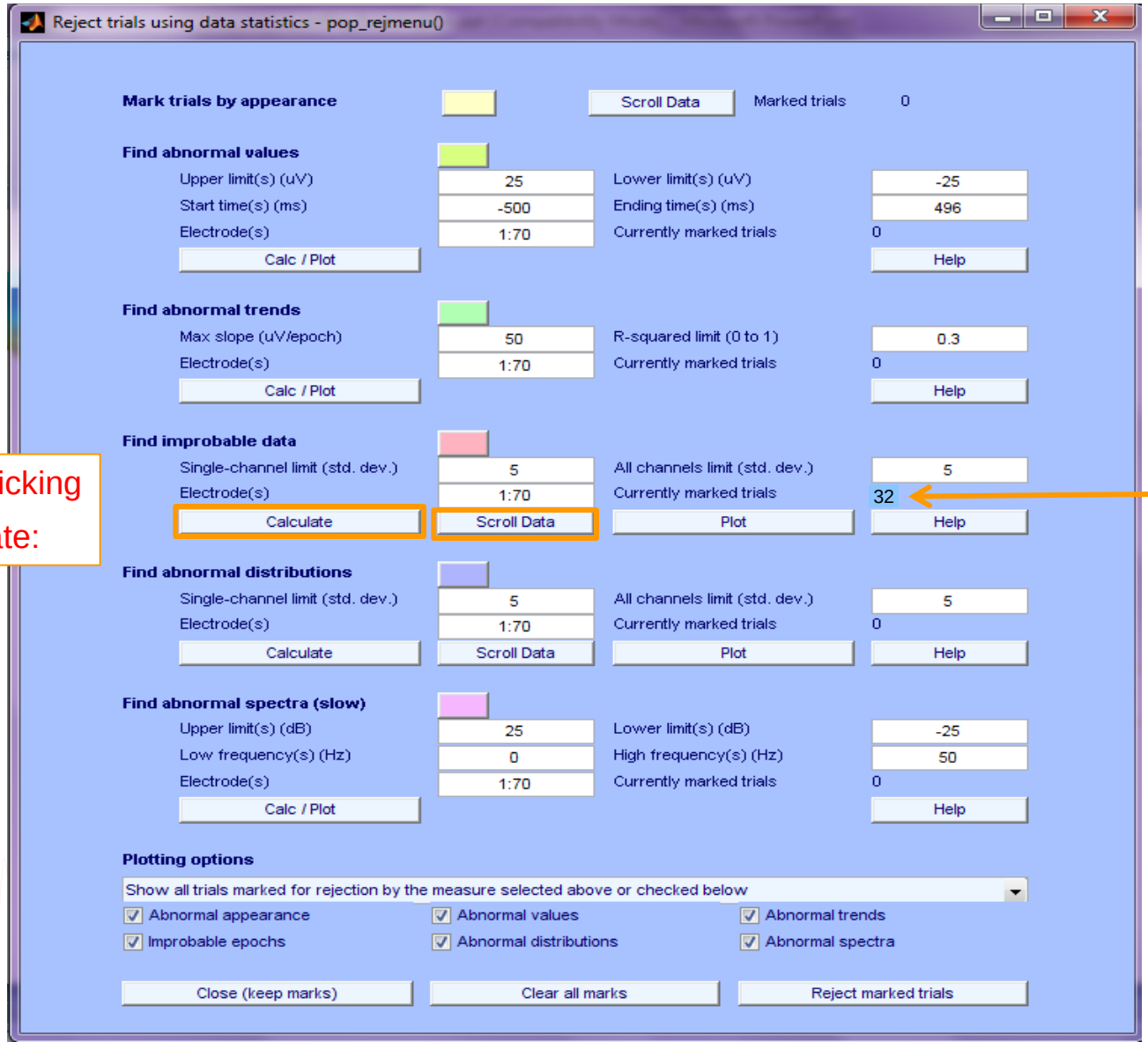


Reject data epochs

visual inspection

probability

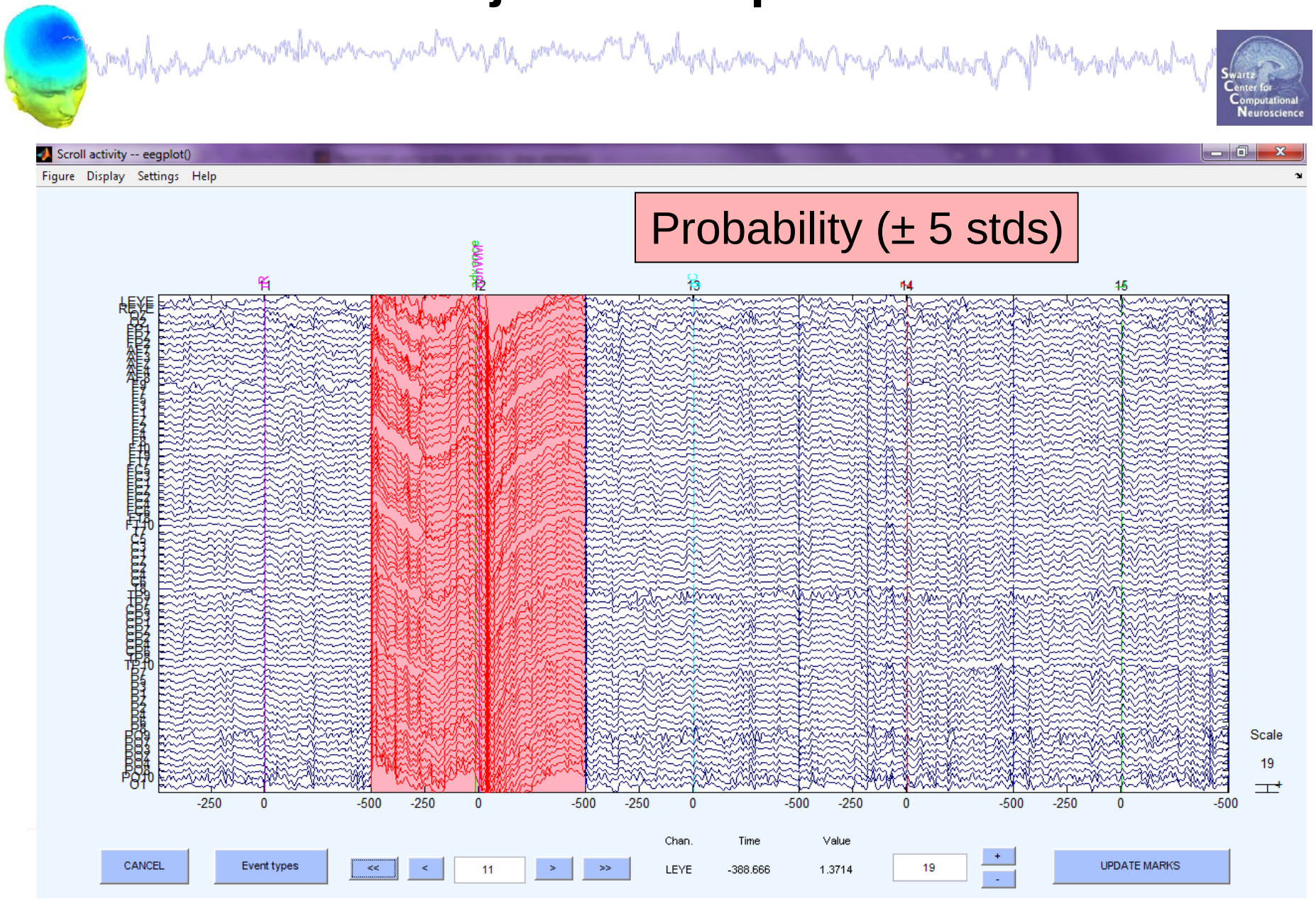
Reject data epochs



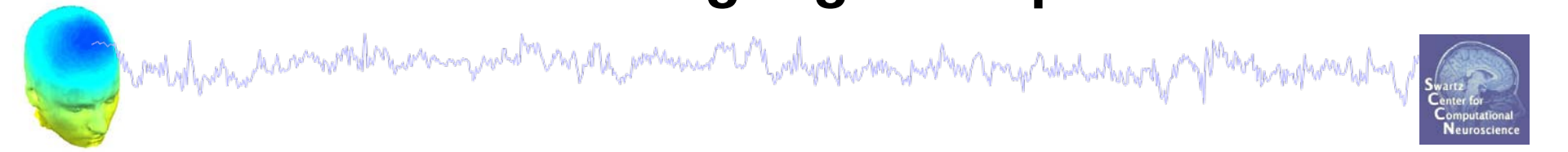
Start by clicking Calculate:

Number of epochs above threshold indicated here

Reject data epochs



Un-select highlighted epochs



Scroll activity -- eegplot()

Figure Display Settings Help

121 122 123 124 125

-250 0 -500 -250 0 -500 -250 0 -500 -250 0 -500 -250 0 -500

Scale 19

CANCEL Event types << < 121 > >>

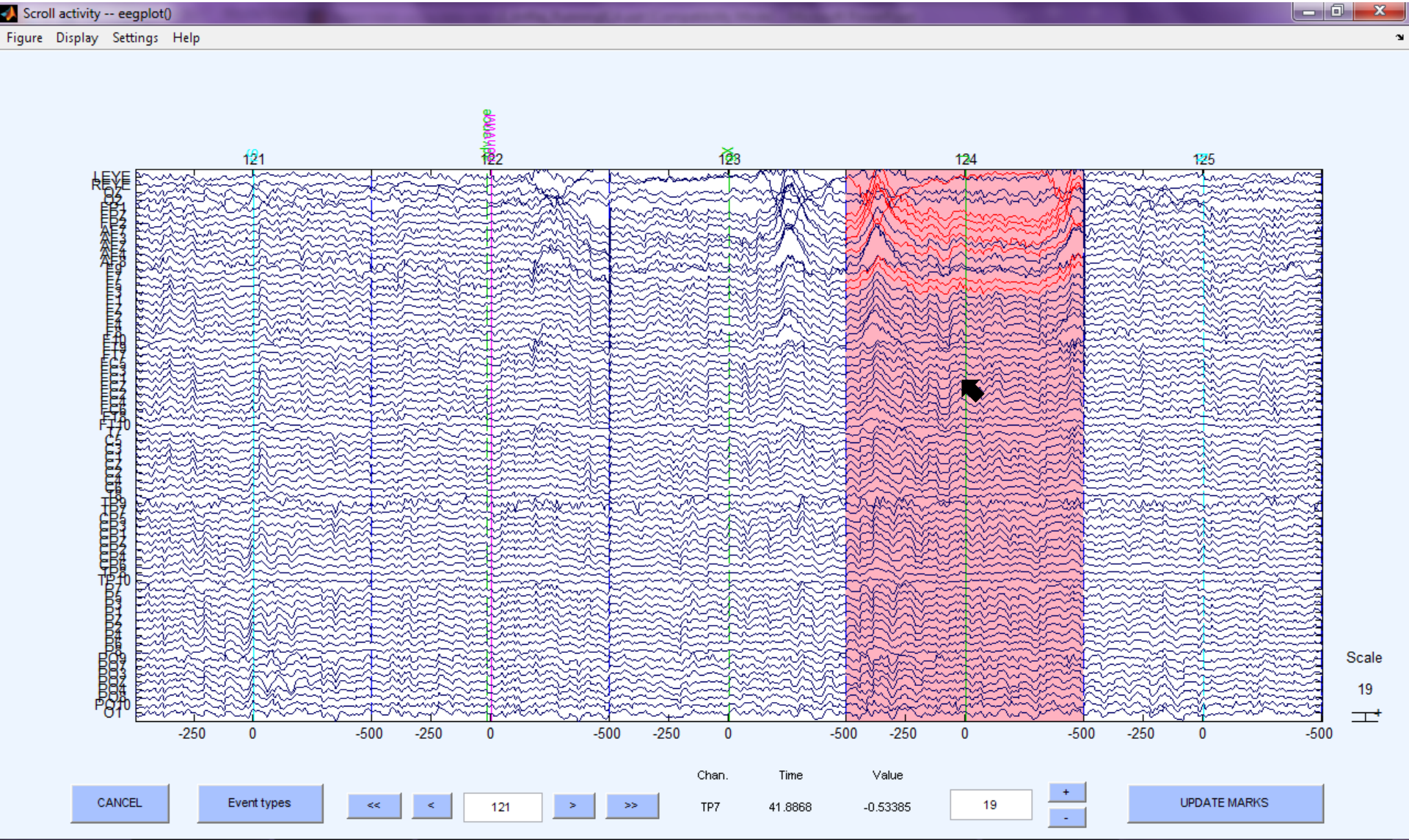
Chan. Time Value

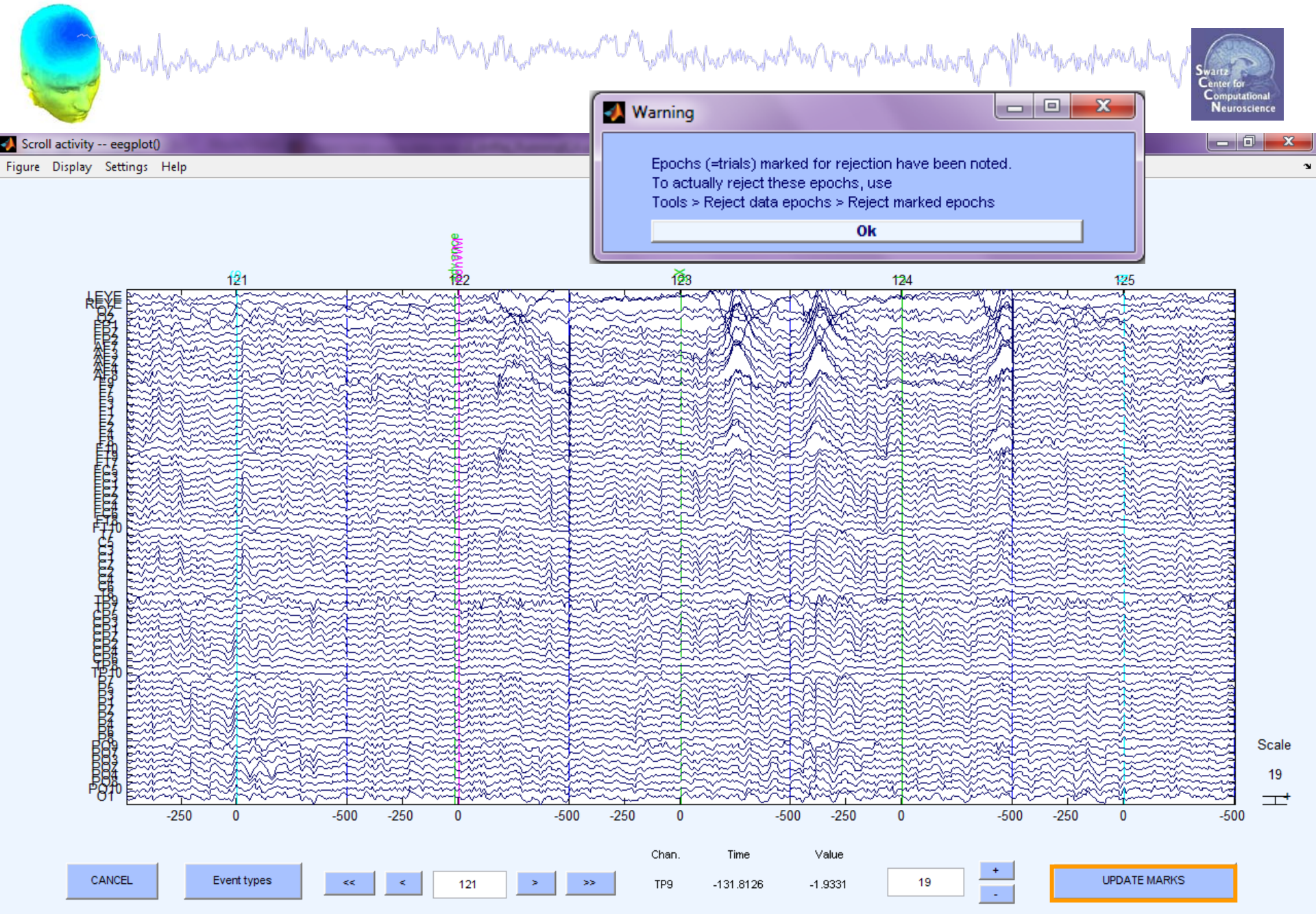
PO4 -68.9852 -0.77823

19 + -

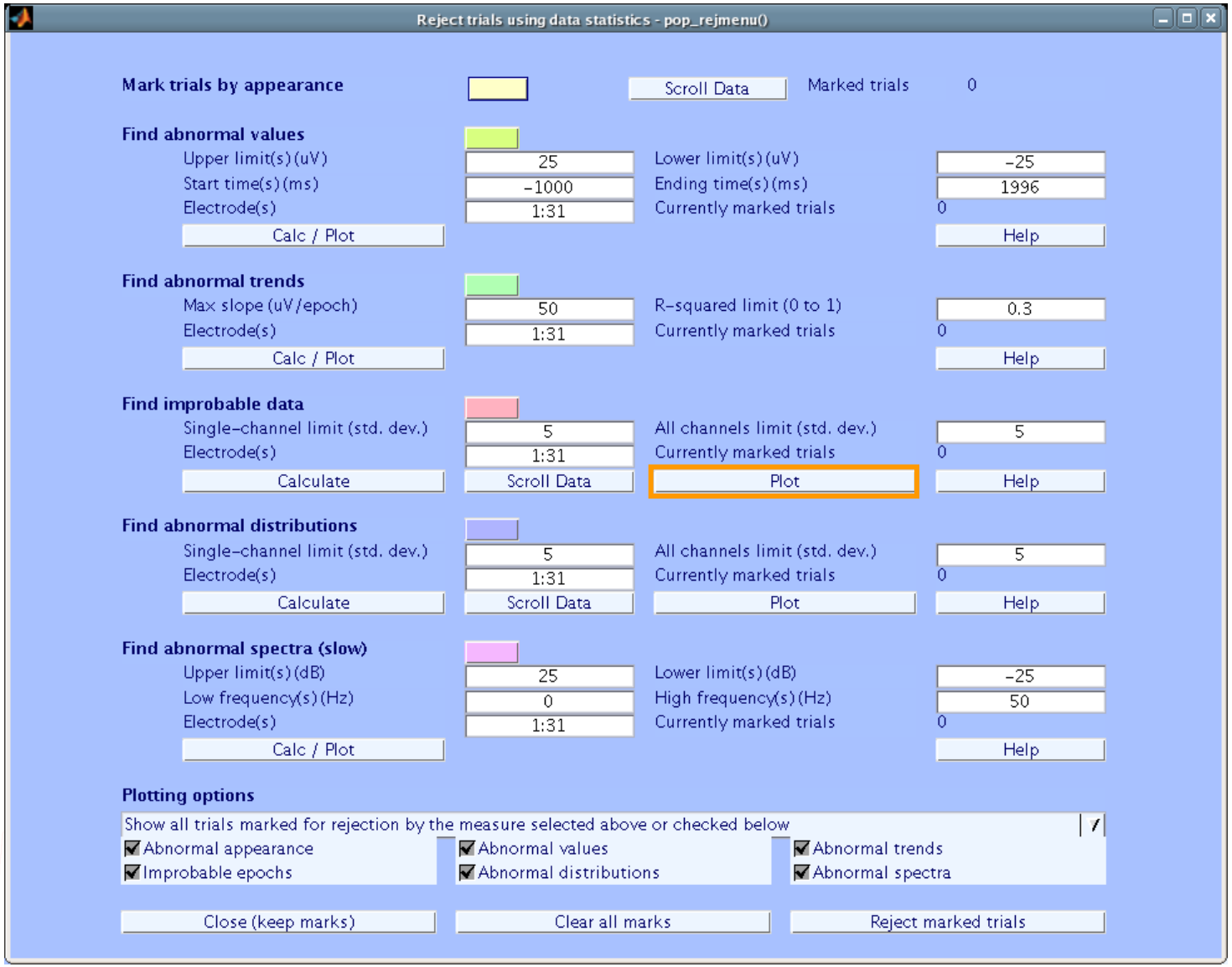
UPDATE MARKS

Un-select highlighted epochs

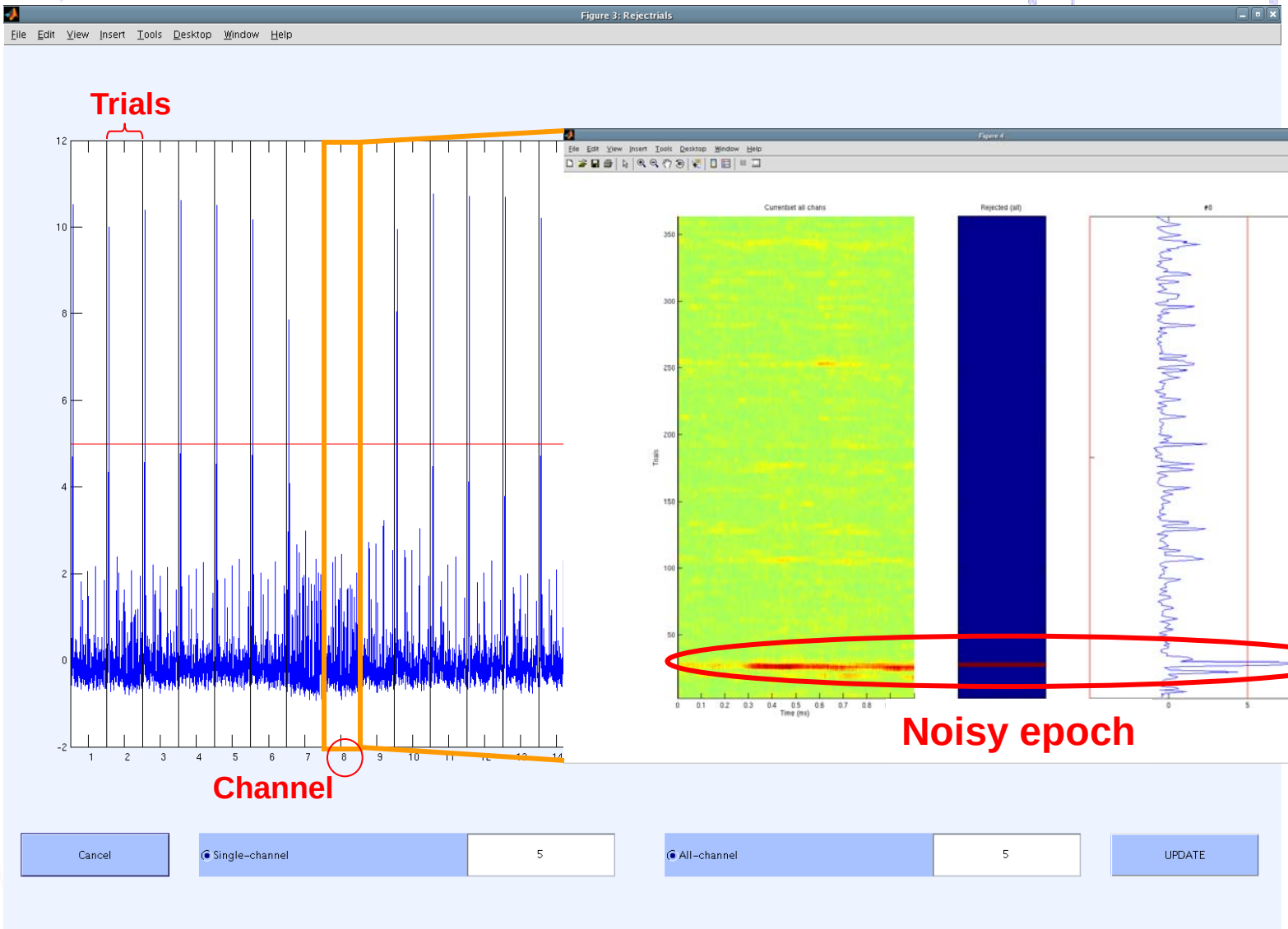



Warning
Epochs (=trials) marked for rejection have been noted.
To actually reject these epochs, use
Tools > Reject data epochs > Reject marked epochs
Ok
Scroll activity -- eegplot()
Figure Display Settings Help
121
122
123
124
125
Scale
19
CANCEL
Event types
<<
<
121
>
>>
Chan.
Time
Value
TP9
-131.8126
-1.9331
19
+
-
UPDATE MARKS

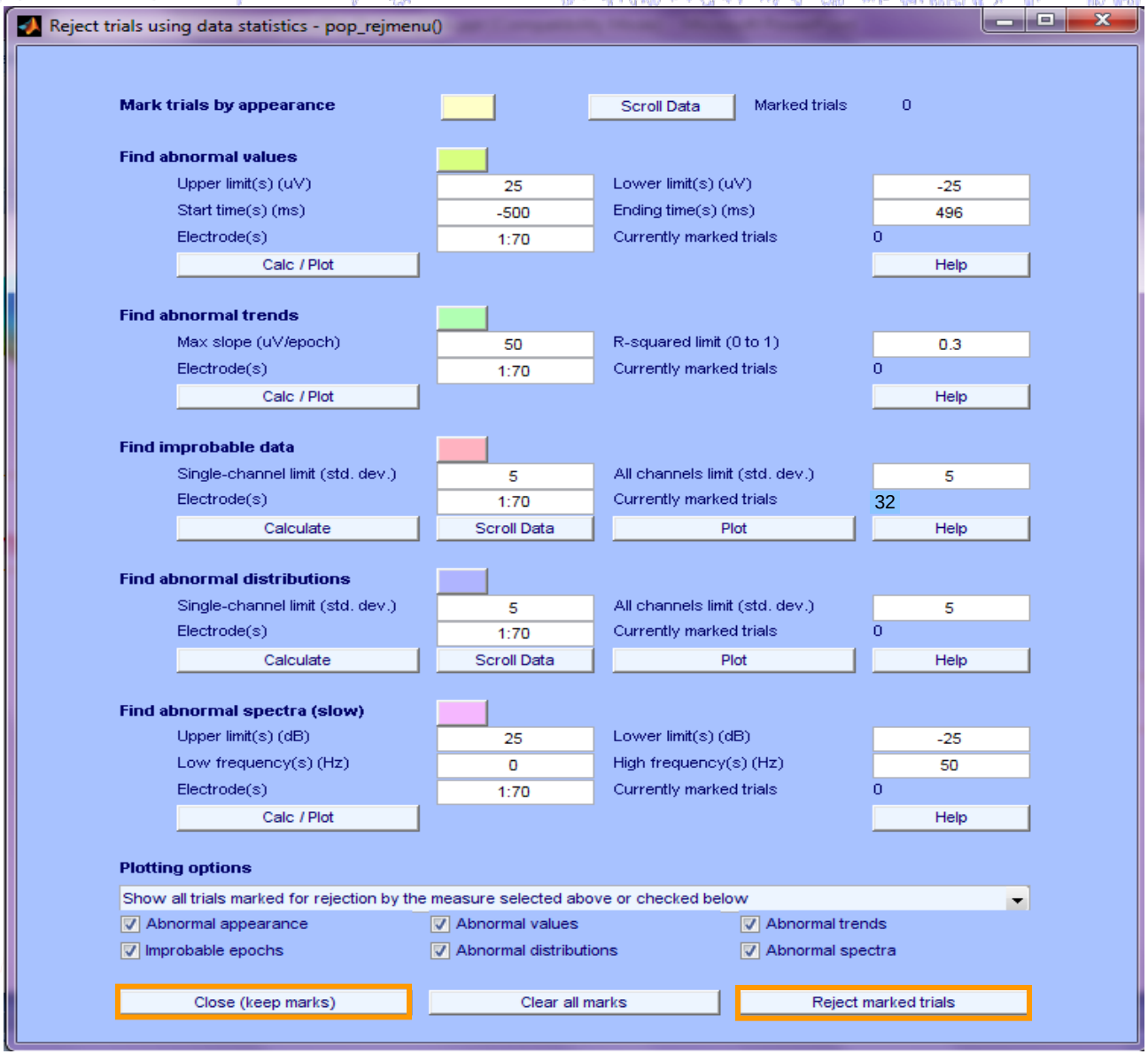
Plot channel measures over time



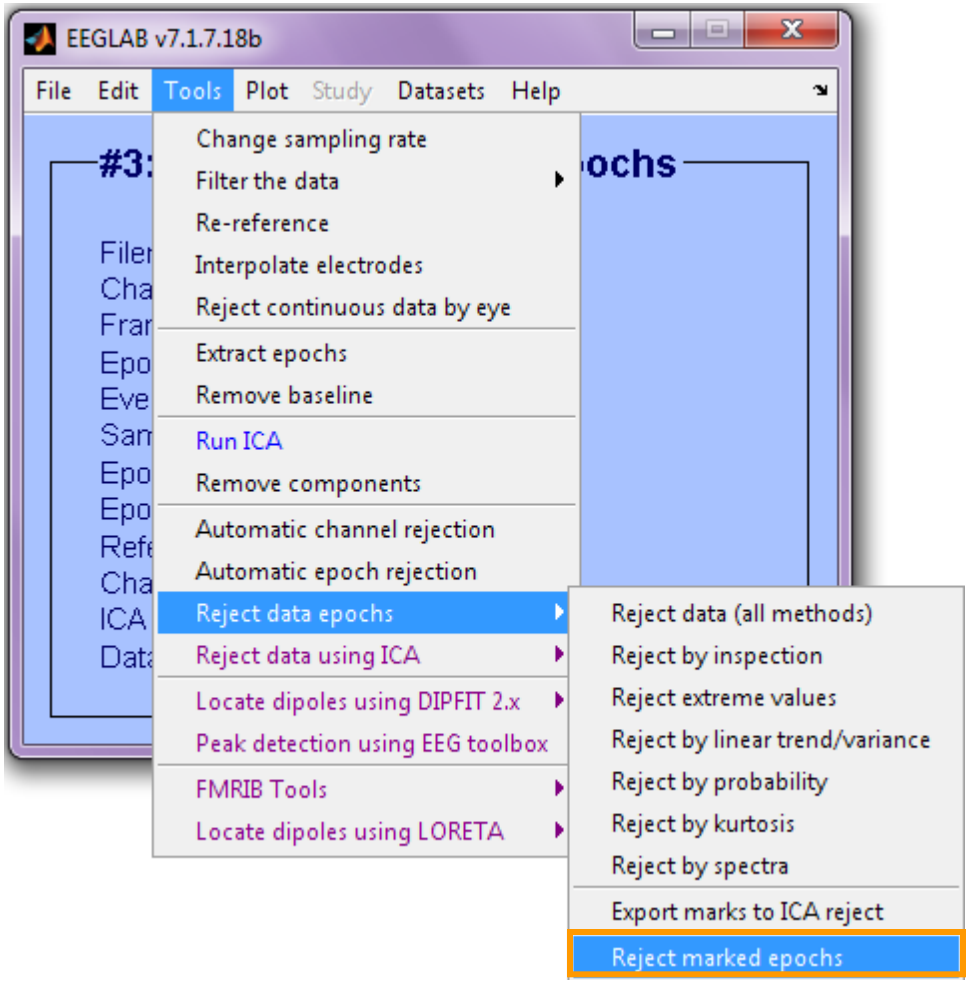
Reject data epochs



Reject or retain marked epochs

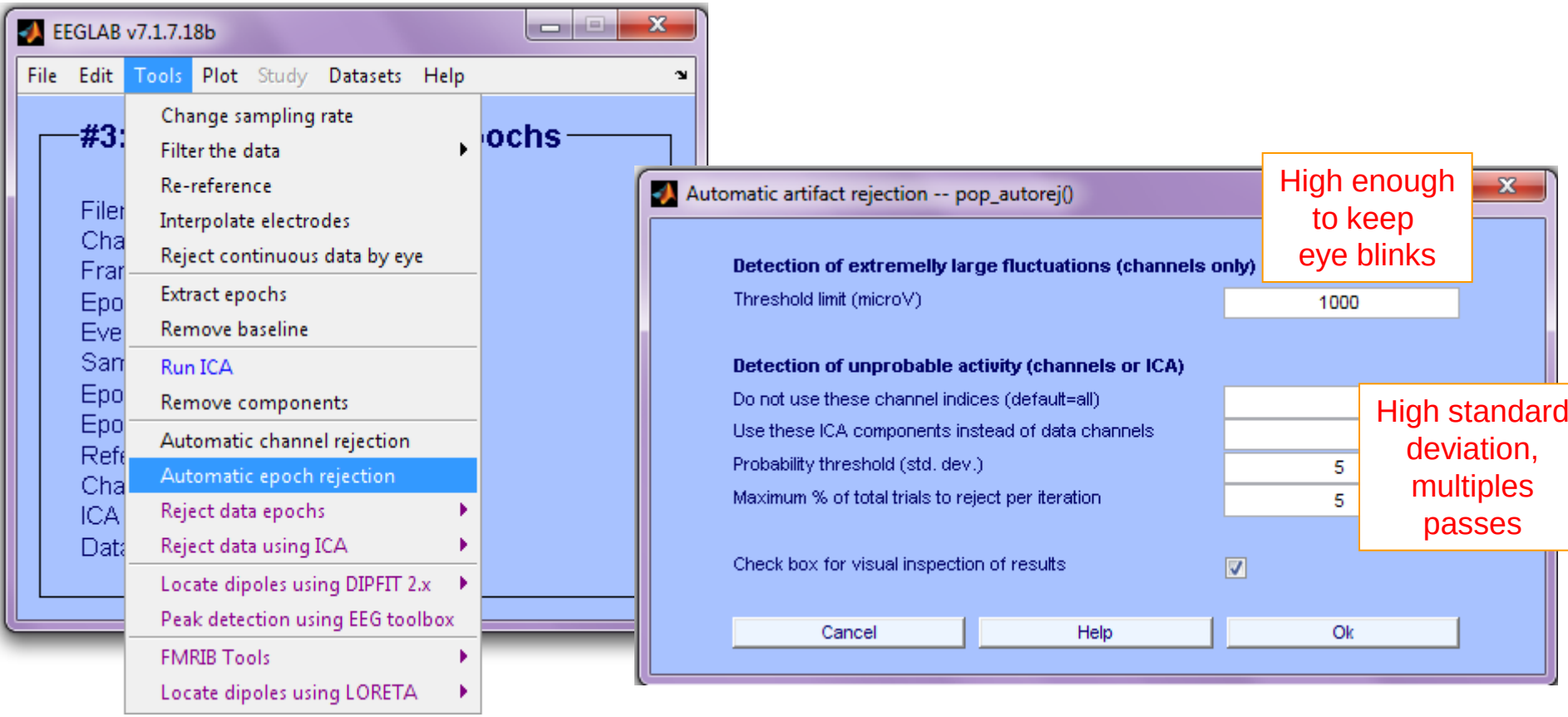


Reject marked epochs



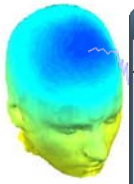

```
>> EEG = pop_jointprob(EEG,1,[1:70],5,5,0,0);
>> EEG = pop_rejepoch(EEG,find(EEG.reject.rejglobal),0);
```

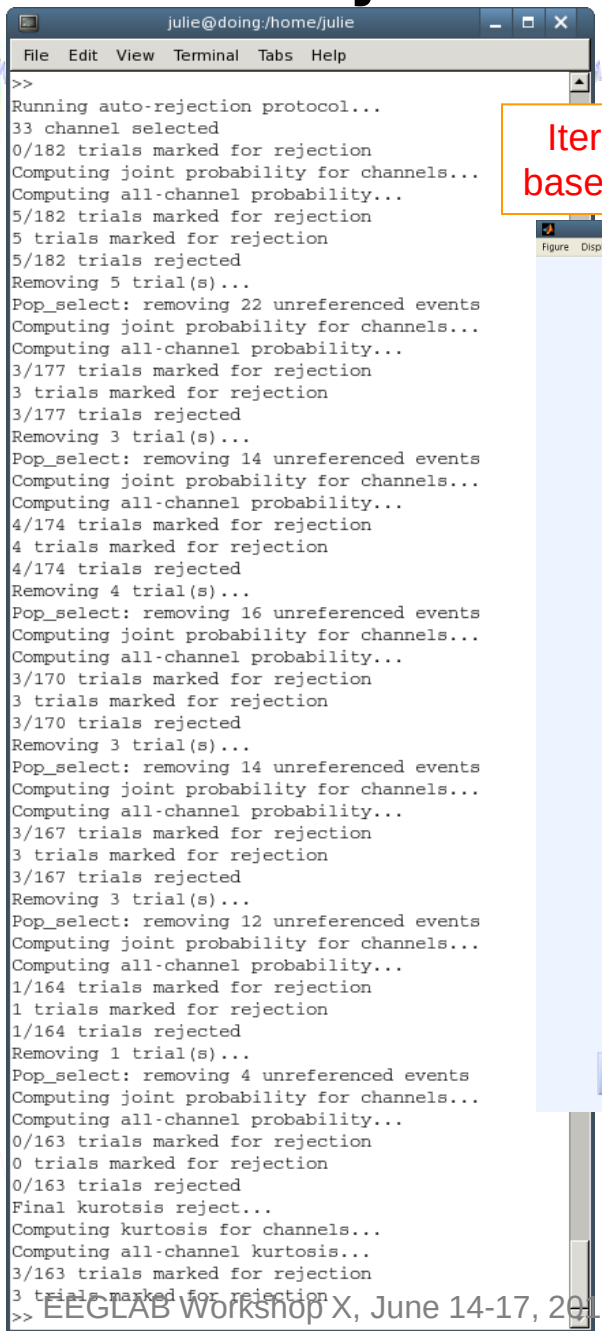
Reject data epochs (automatic)



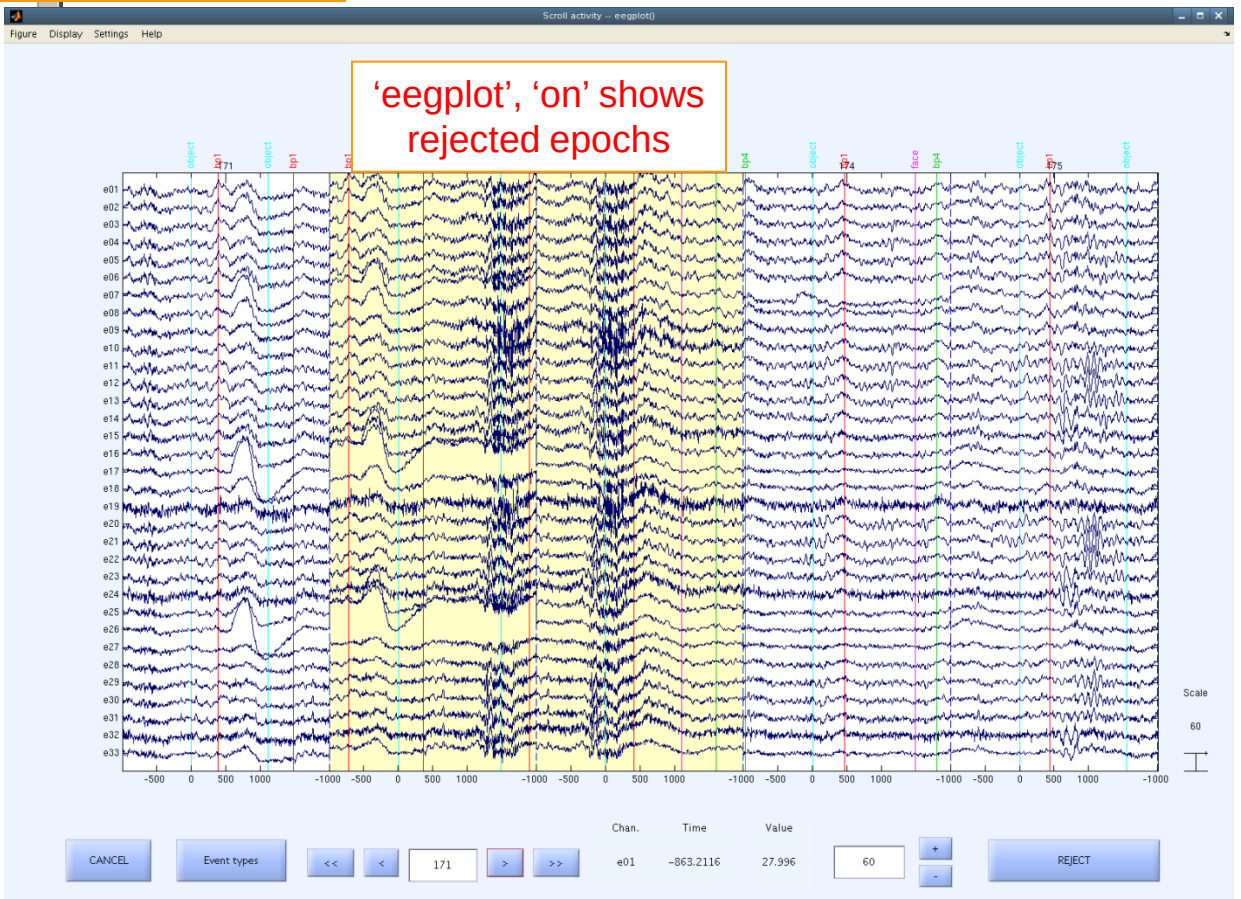

```
>> EEG = pop_autorej(EEG,  'nogui', 'on', 'eegplot', 'on');
```

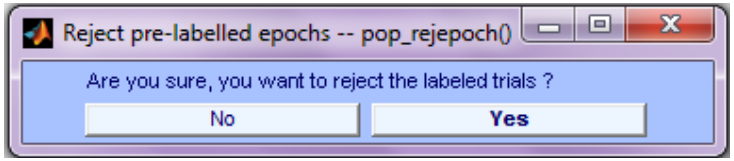
Reject data epochs (automatic)





Iterative rejection based on probability





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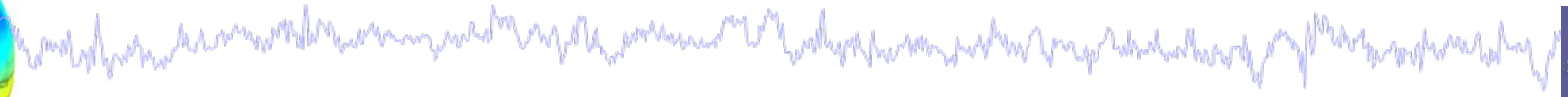
Exercise...

Independent Component Analysis



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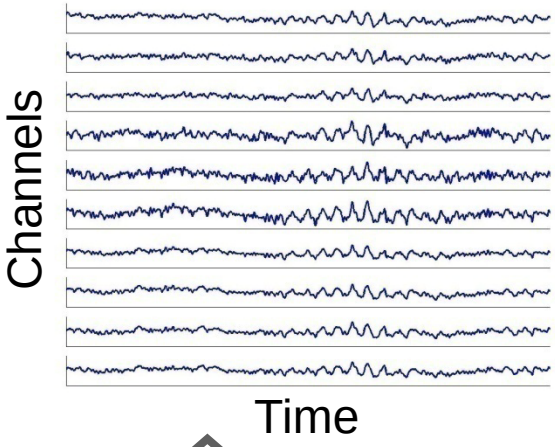
x = scalp EEG

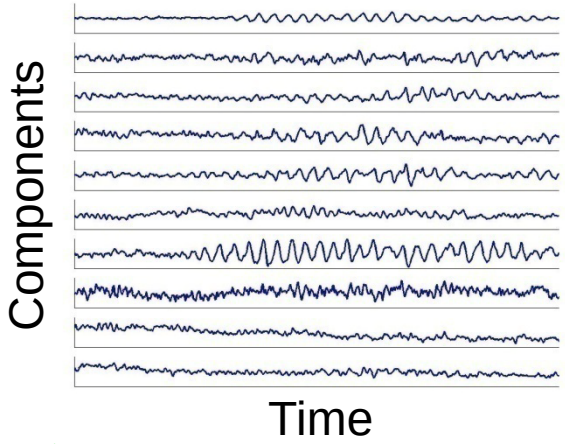
W = unmixing matrix

u = sources



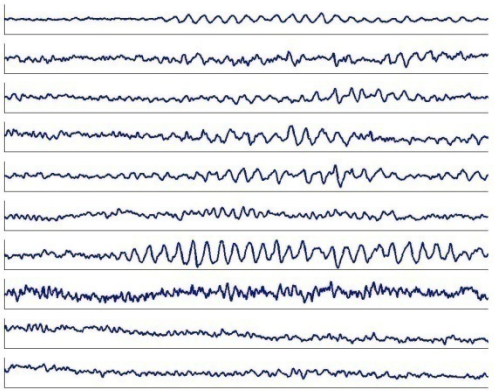
W*x = u

ICA



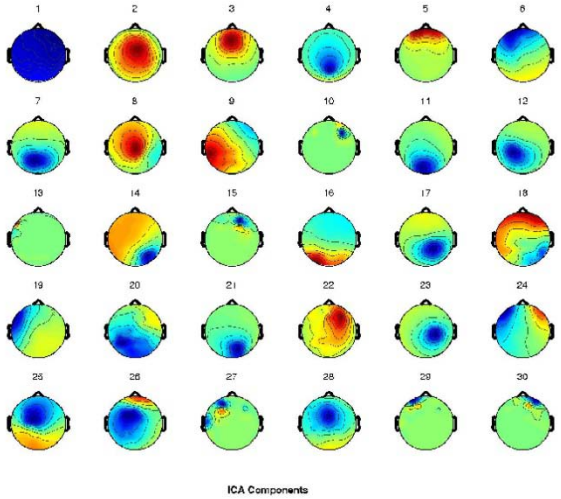
x = W^{-1}*u

u = sources



*

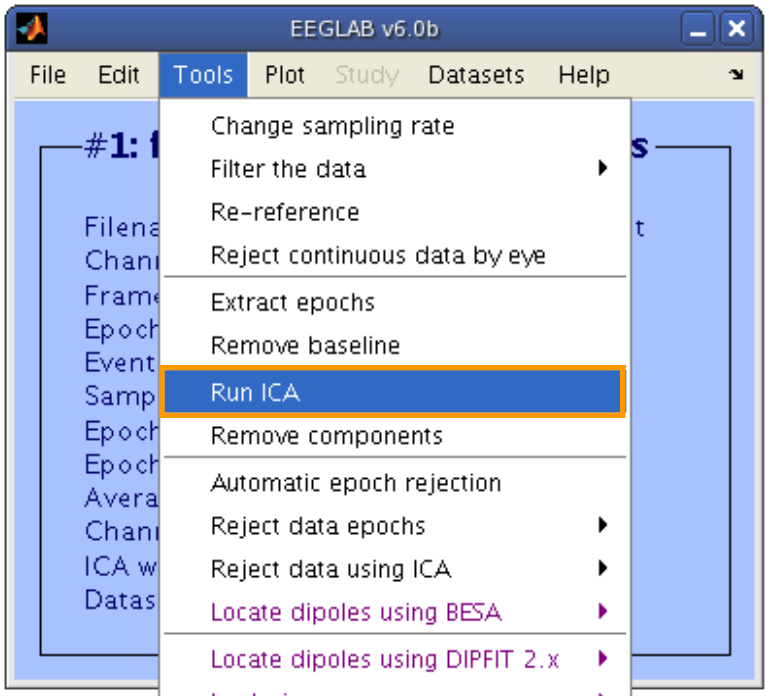
W^{-1} (scalp projections)



“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, jader,erica,sobi,acsobiro

Runica progress…

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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

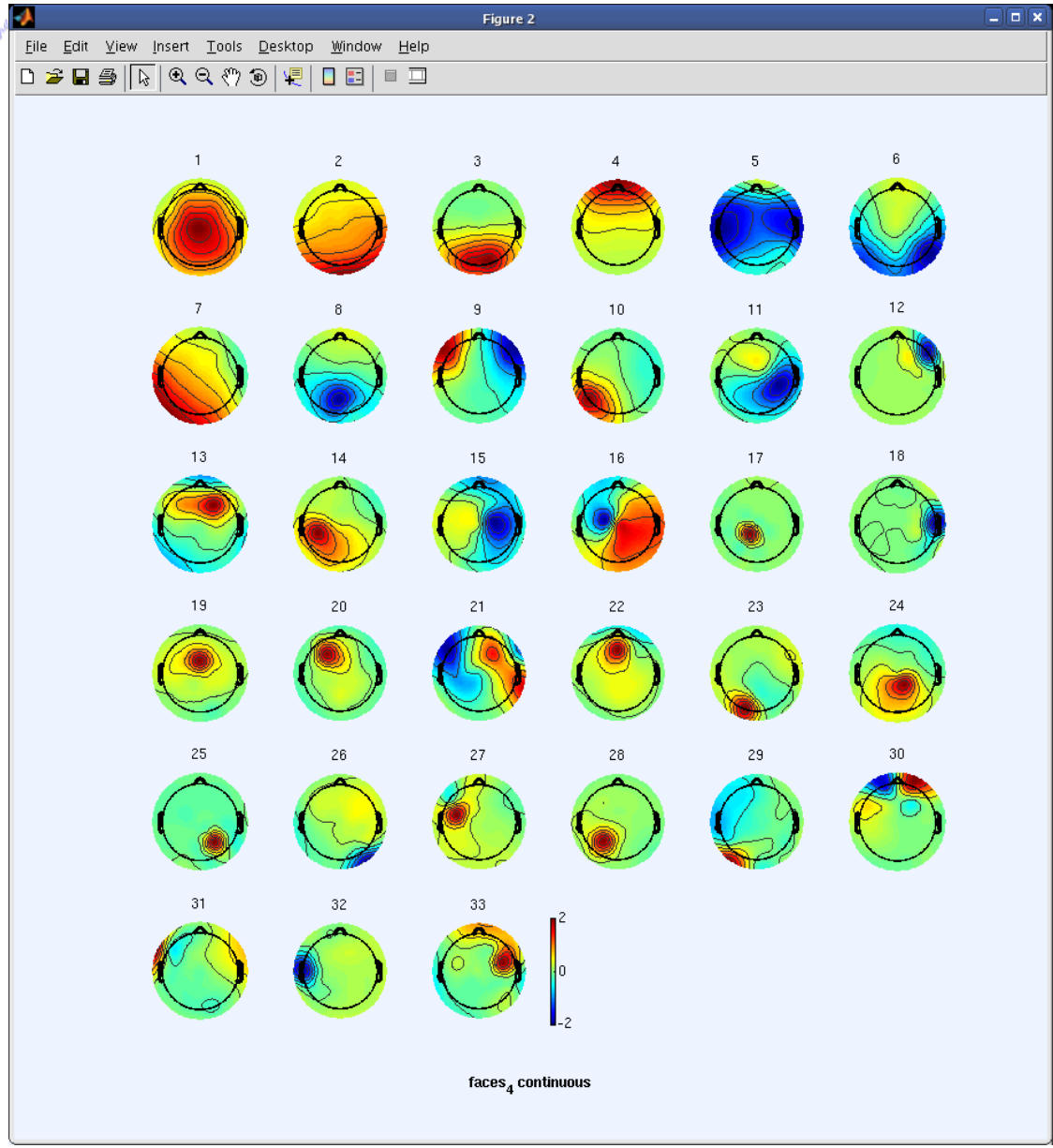
File Edit View Terminal Tabs Help

```
>> 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: []

>>
```



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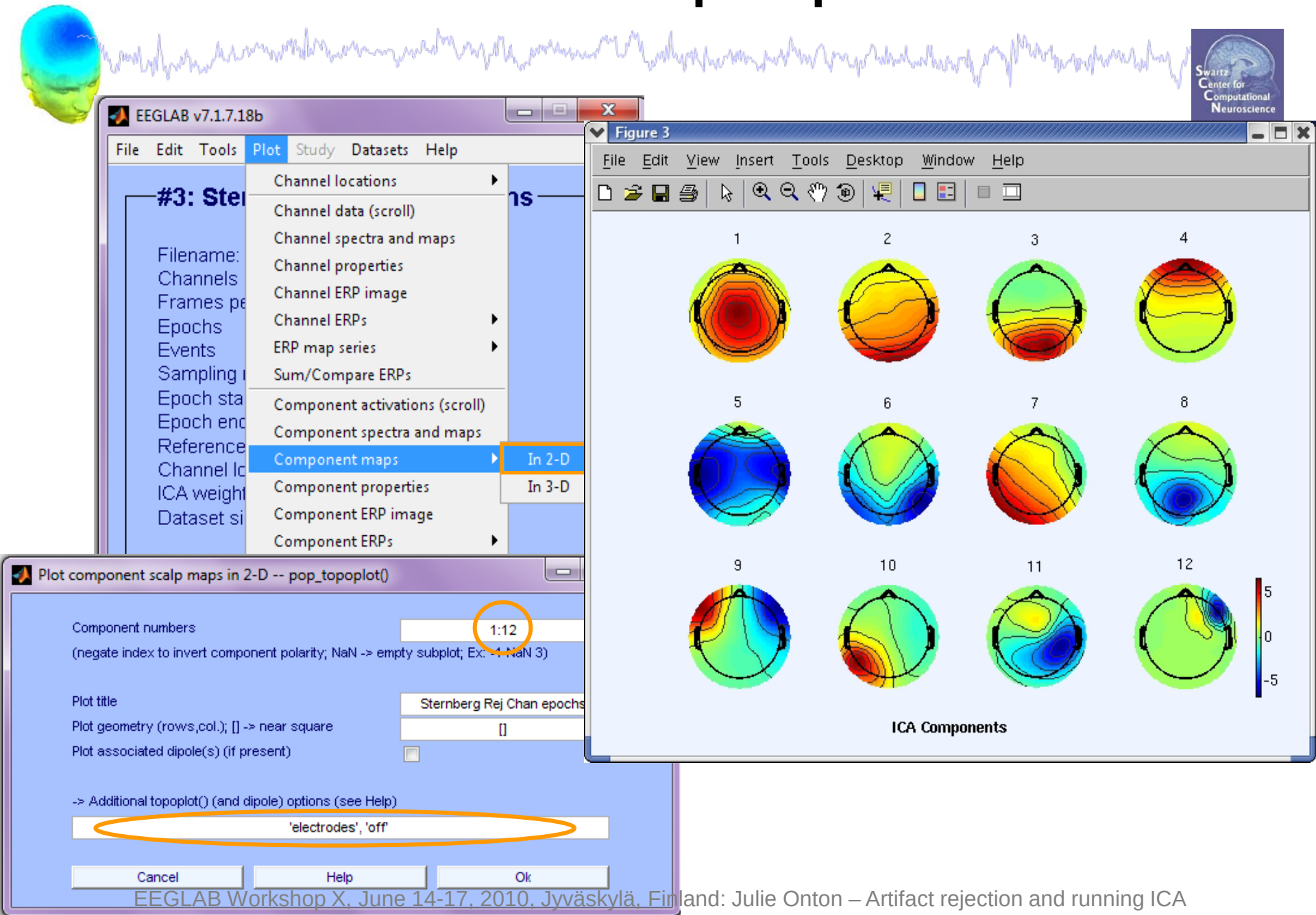
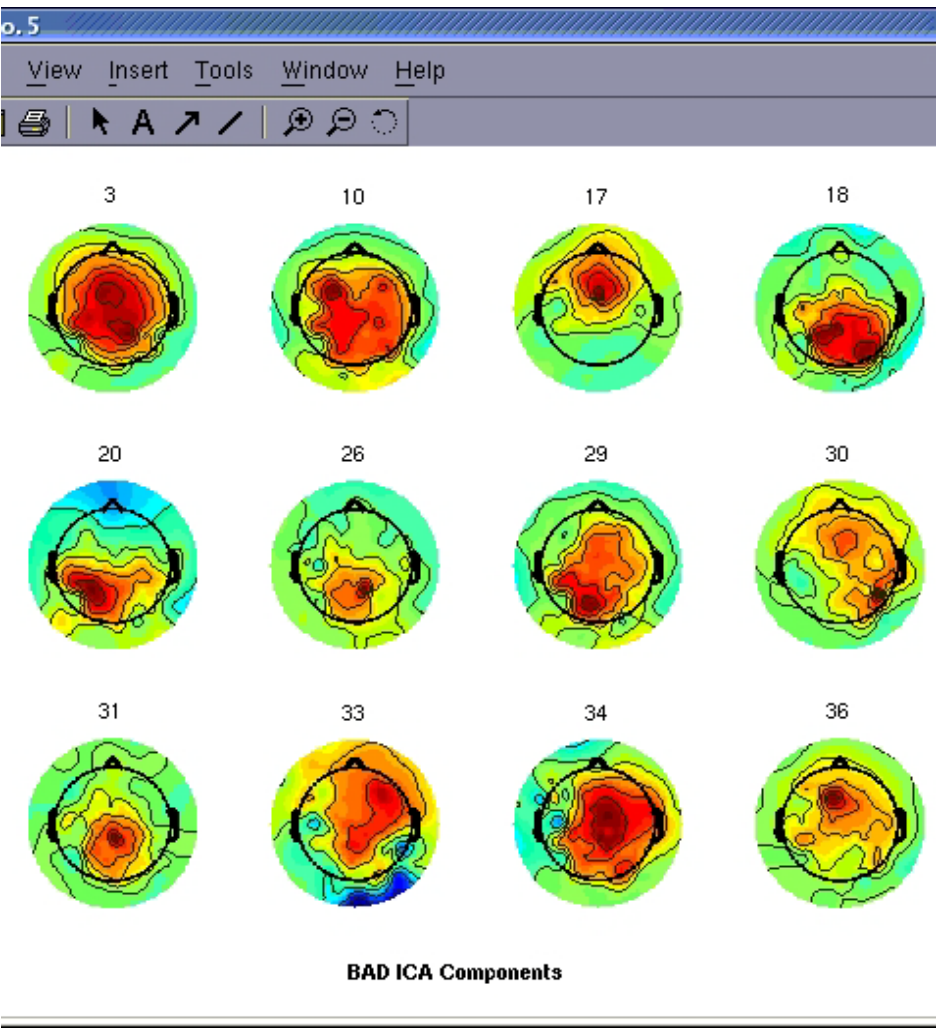
(i.e. back-projection)

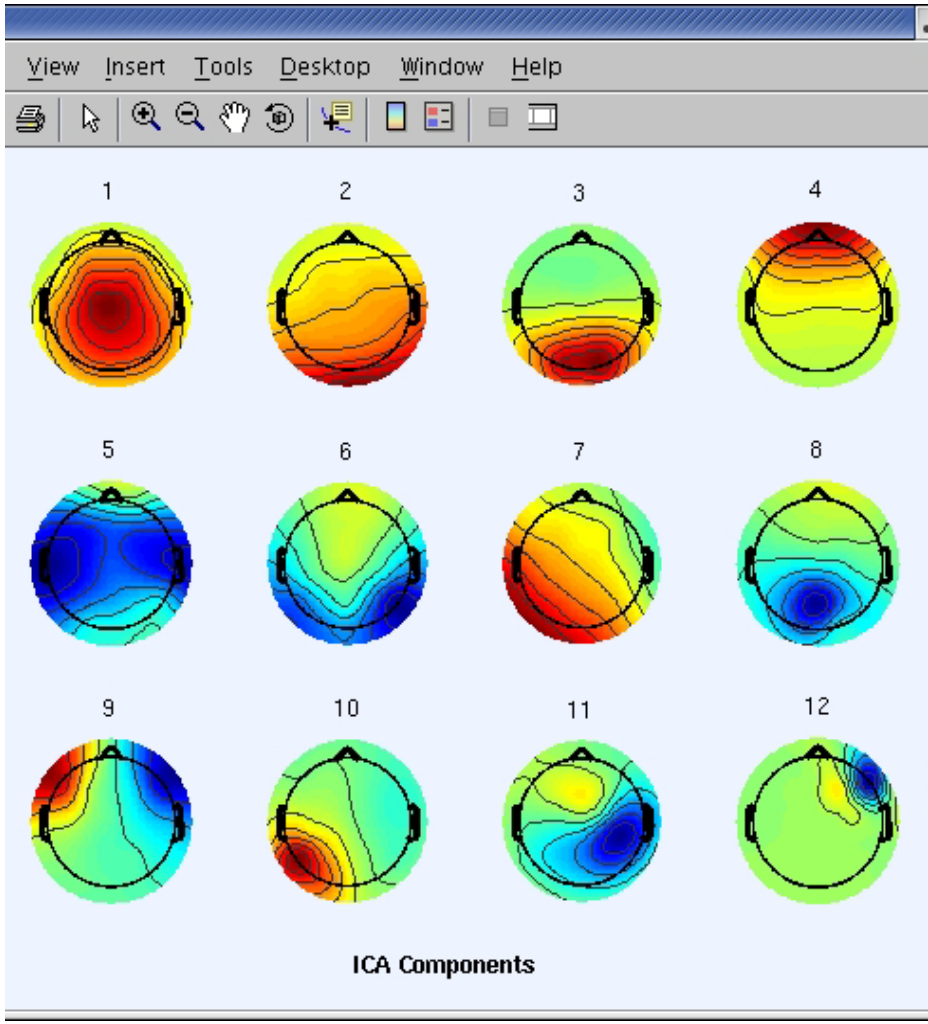
Exercise...

Plot ICA scalp maps

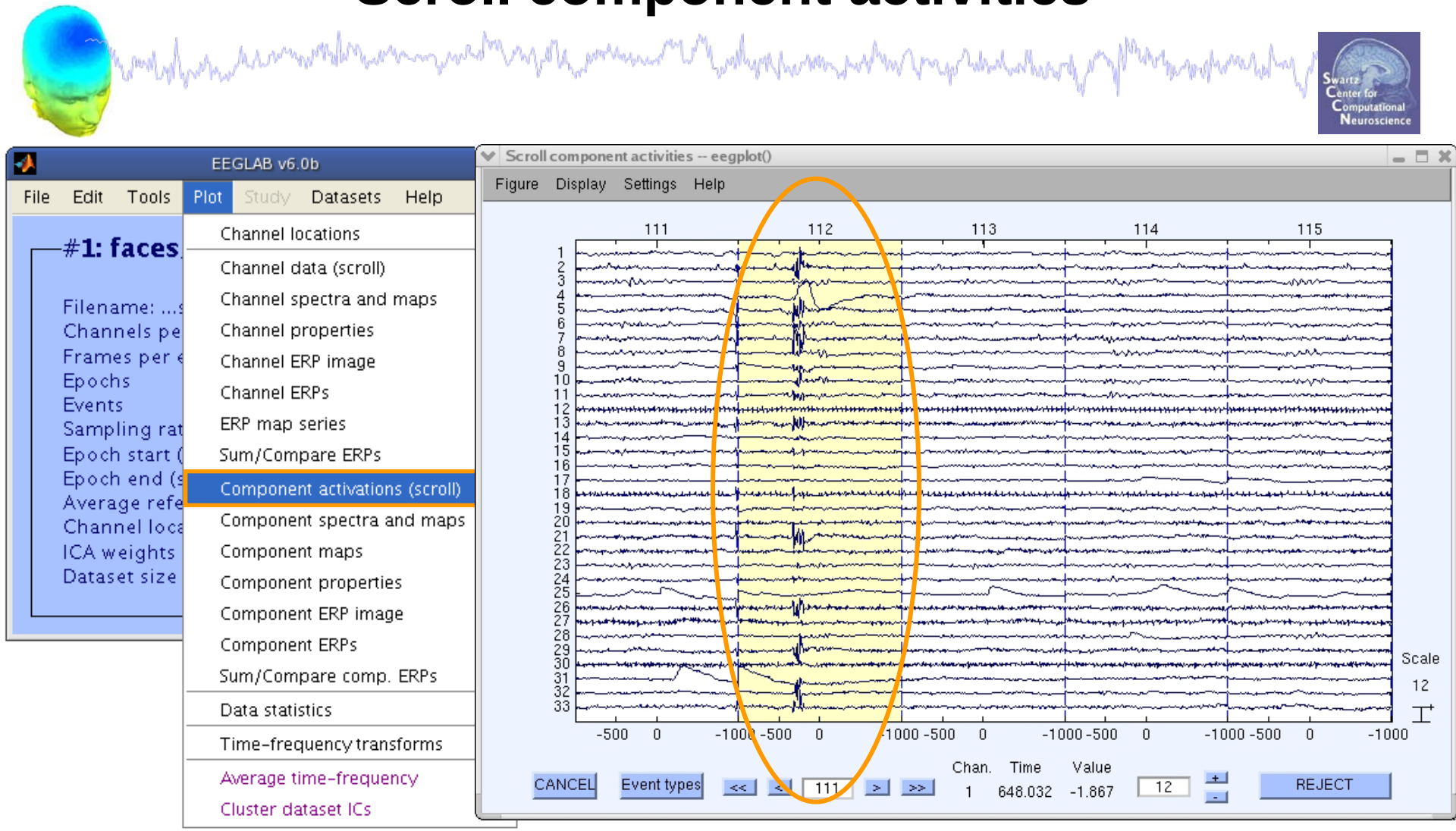


Compare 'good' and 'bad' scalp maps



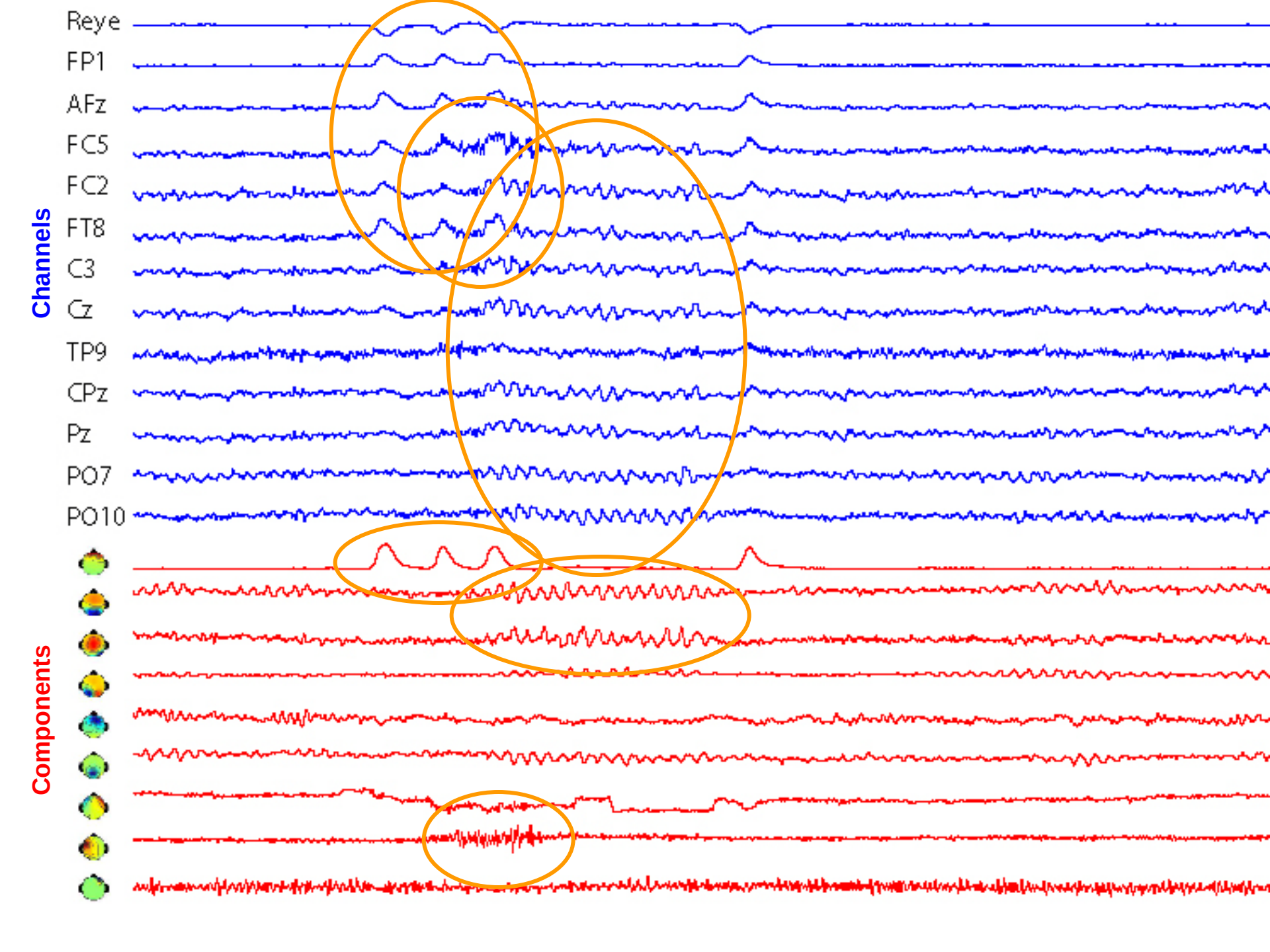


Scroll component activities

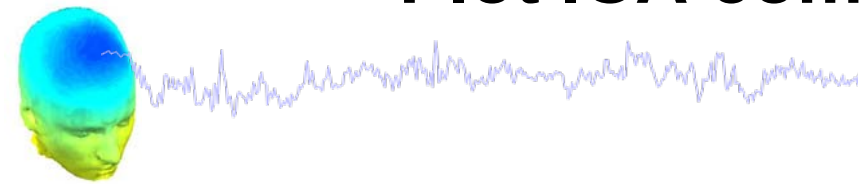


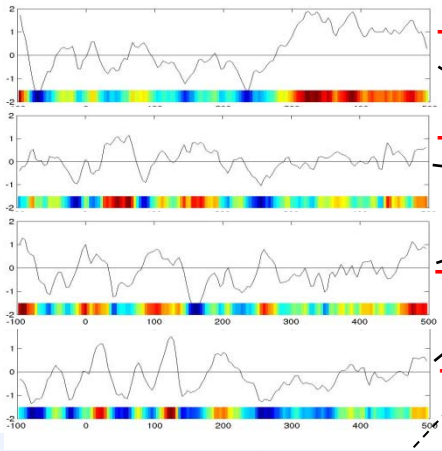
Time periods that are not independent across ICs

should be removed and ICA run again for better decomposition

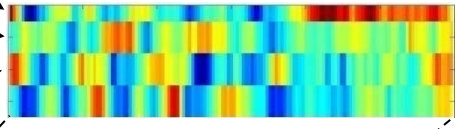

Channels
Components
Reye
FP1
AFz
FC5
FC2
FT8
C3
Cz
TP9
CPz
Pz
PO7
PO10

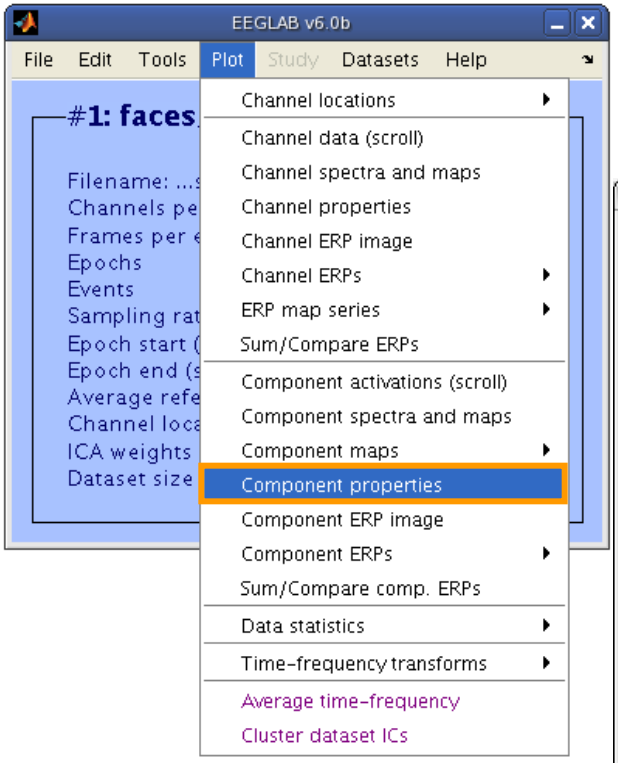
Plot ICA component properties

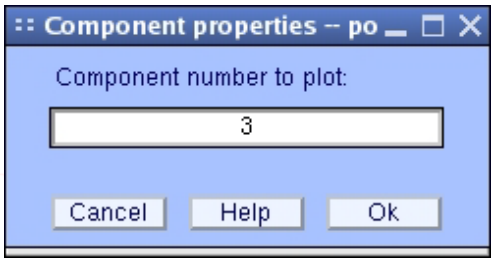


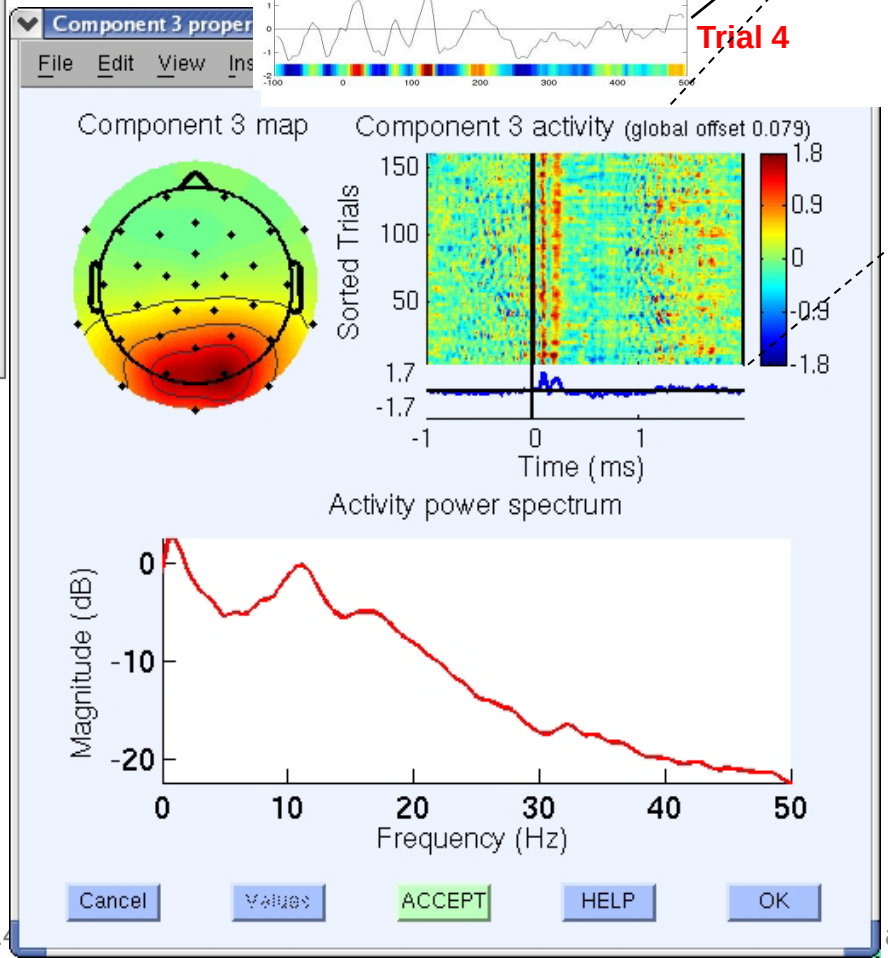


ERP Image

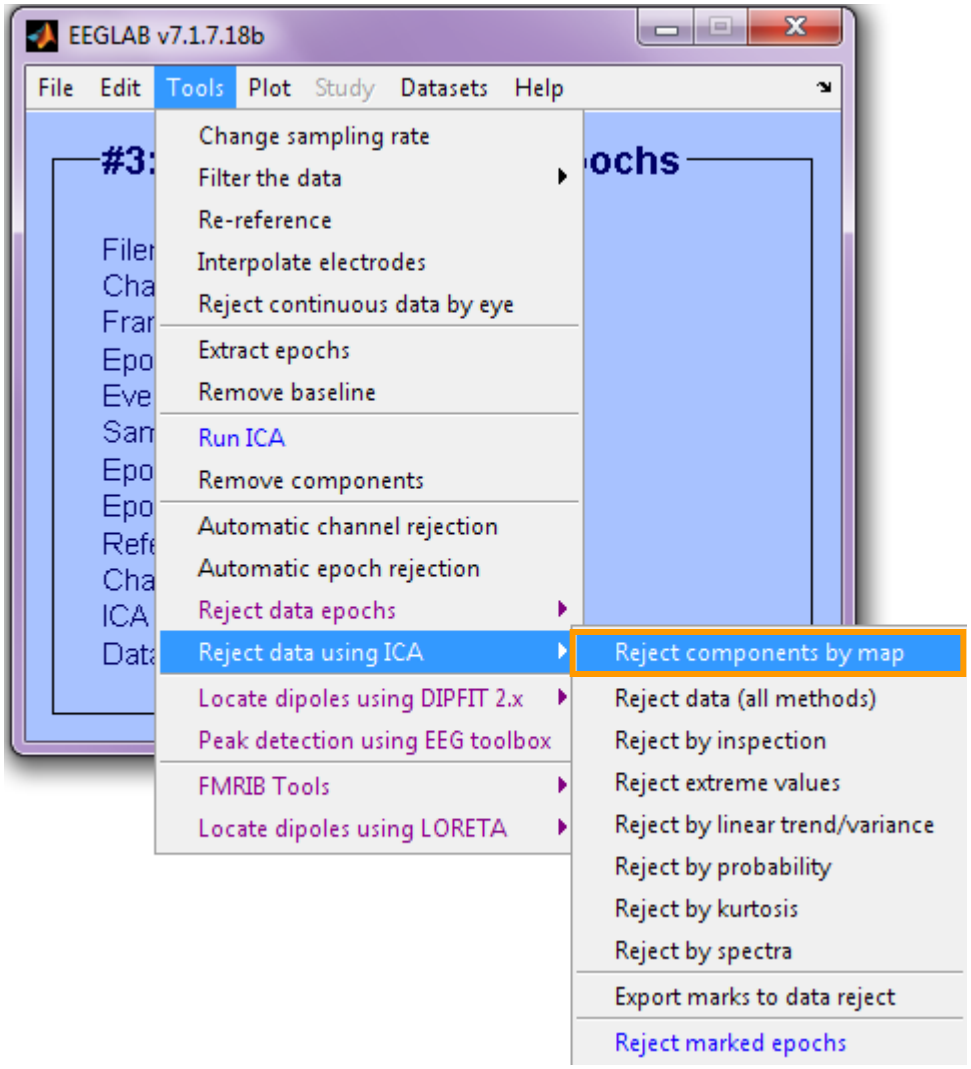




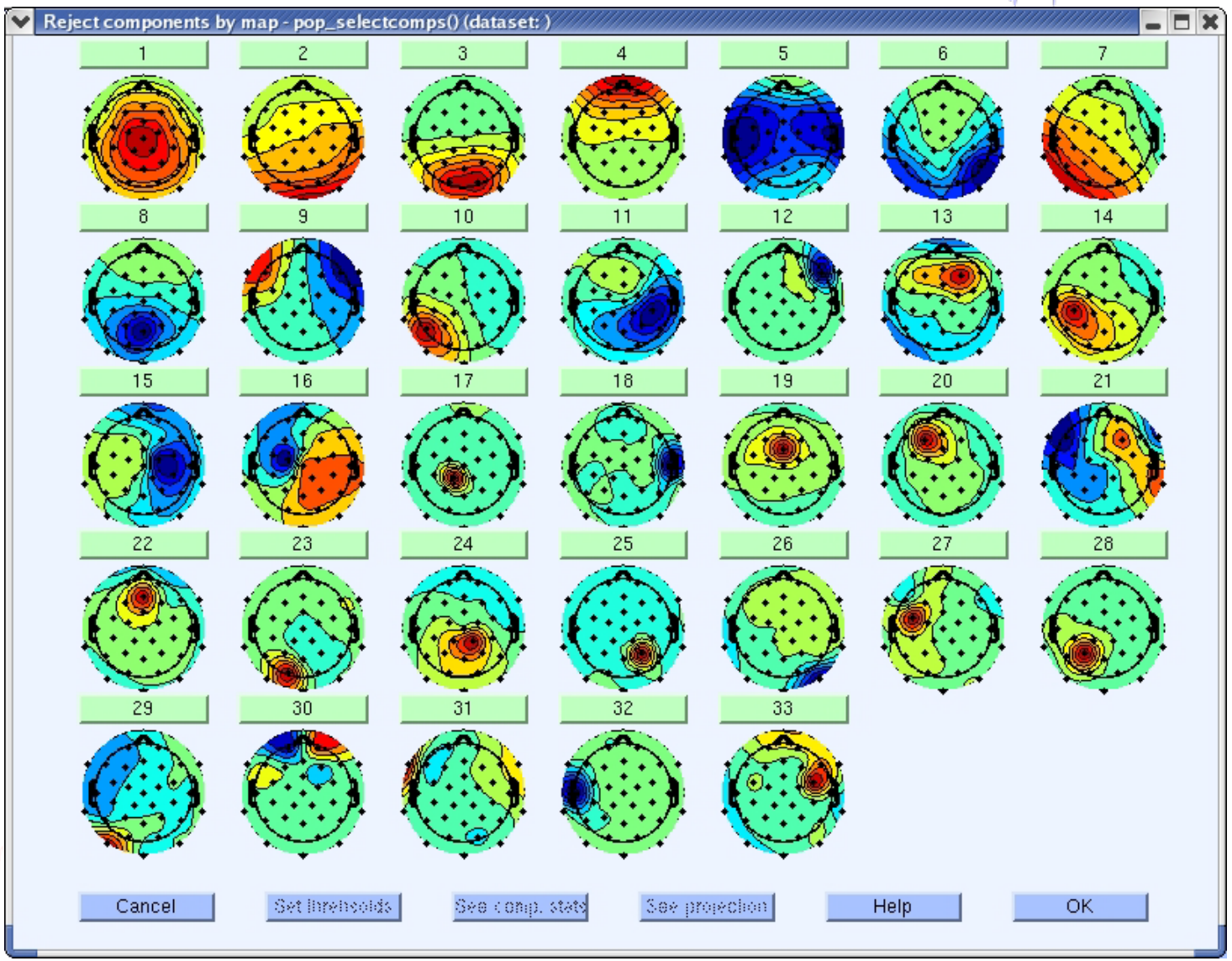


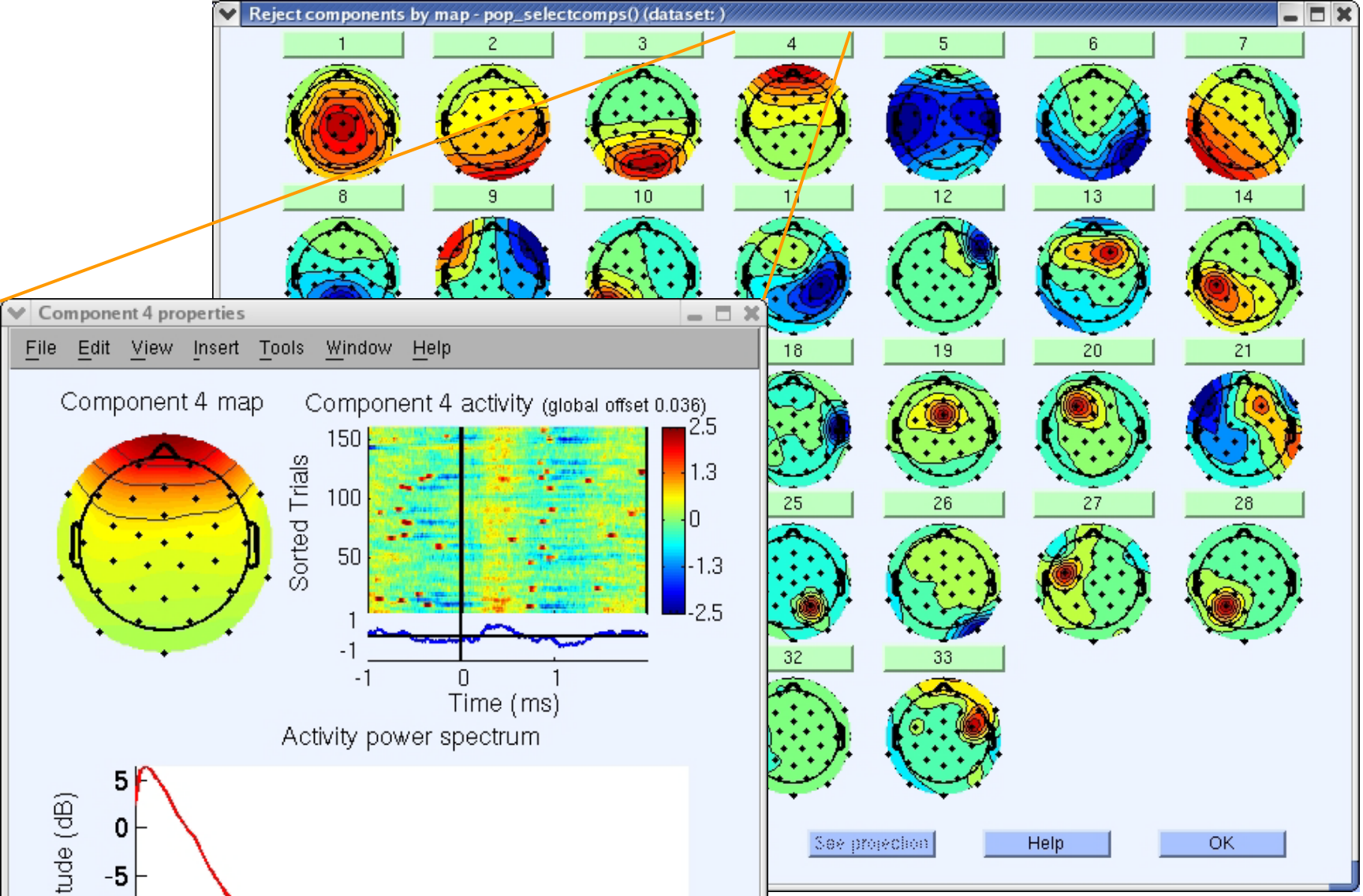


Reviewing component properties

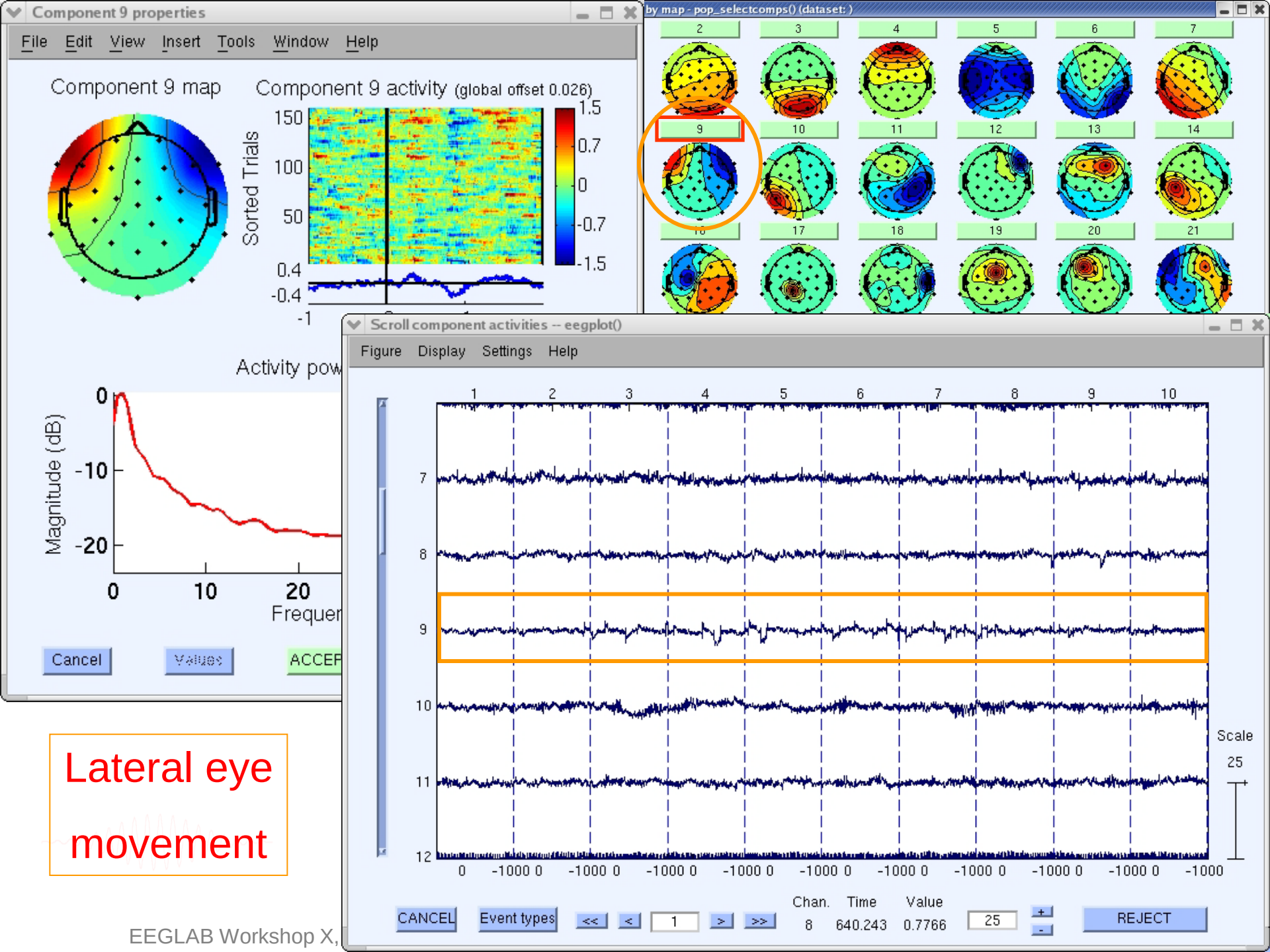


Component scalp maps/properties

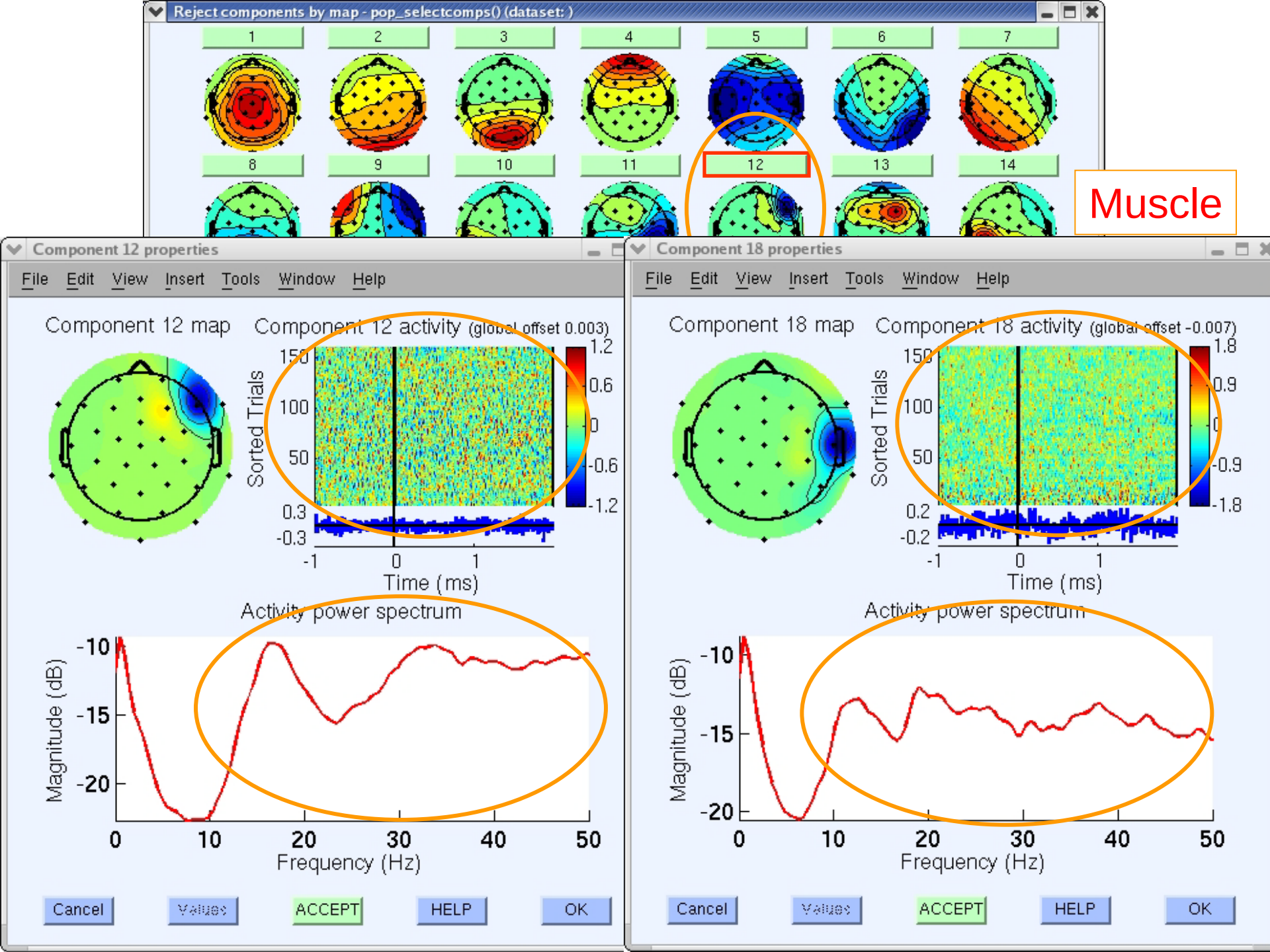


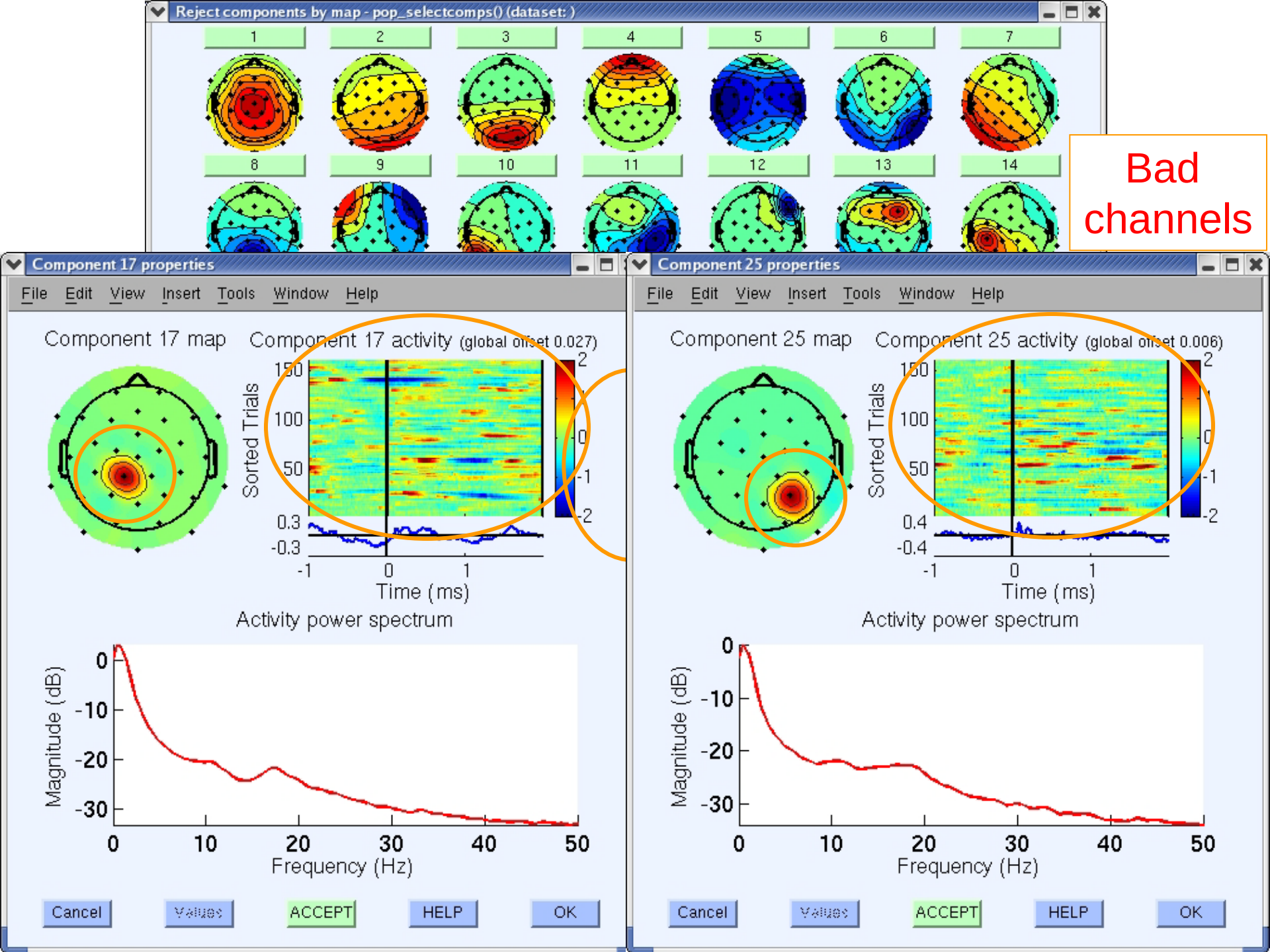


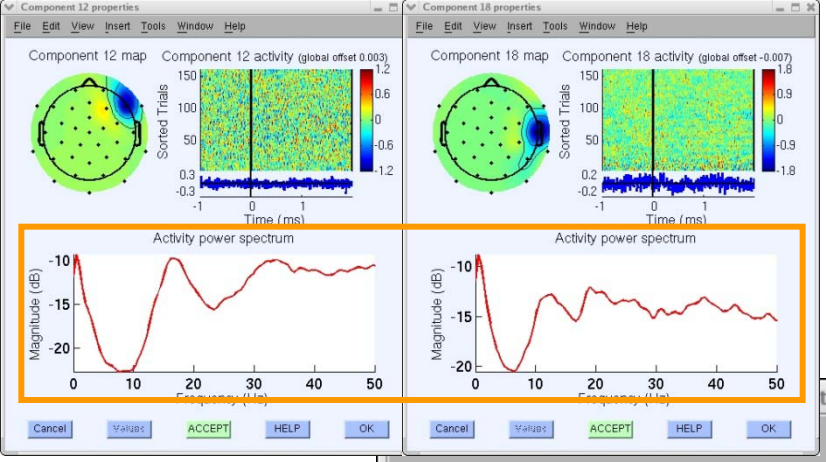
Eye blink component



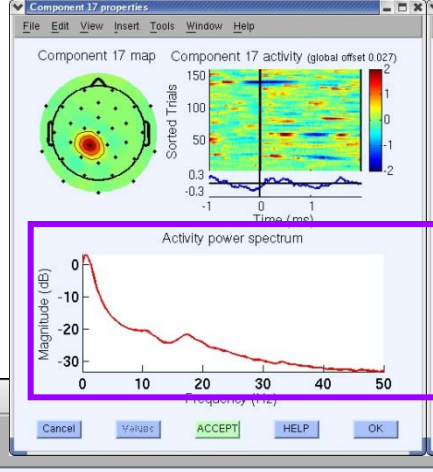
Lateral eye movement

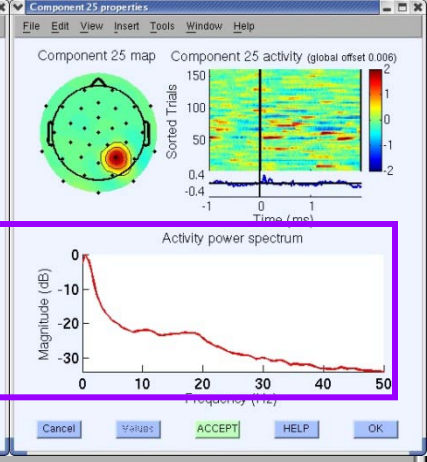

Reject components by map - pop_selectcomps() (dataset:)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Muscle
Component 12 properties
File Edit View Insert Tools Window Help
Component 12 map
Component 12 activity (global offset 0.003)
Sorted Trials
Time (ms)
Activity power spectrum
Magnitude (dB)
Frequency (Hz)
Cancel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

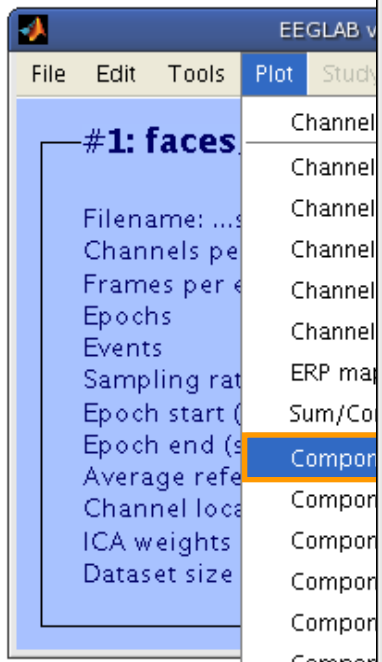

Reject components by map - pop_selectcomps() (dataset:)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Bad channels
Component 17 properties
File Edit View Insert Tools Window Help
Component 17 map
Component 17 activity (global offset 0.027)
Sorted Trials
150
100
50
0.3
-0.3
-1
0
1
Time (ms)
2
0
-1
-2
Activity power spectrum
Magnitude (dB)
0
-10
-20
-30
0
10
20
30
40
50
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
150
100
50
0.4
-0.4
-1
0
1
Time (ms)
2
0
-1
-2
Activity power spectrum
Magnitude (dB)
0
-10
-20
-30
0
10
20
30
40
50
Frequency (Hz)
Cancel
Values
ACCEPT
HELP
OK

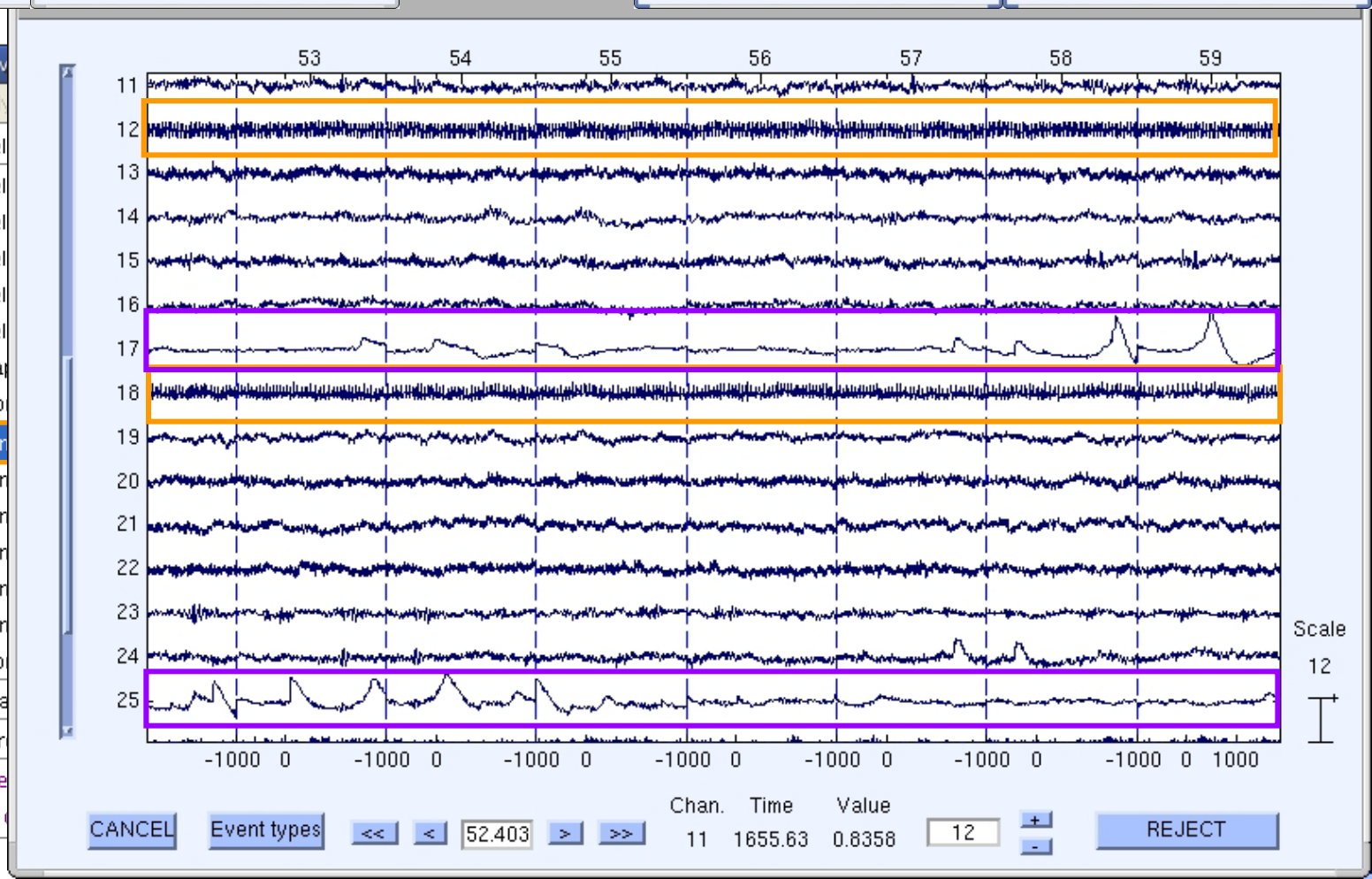

Component 12 properties
File Edit View Insert Tools Window Help
Component 12 map
Component 12 activity (global offset 0.003)
Sorted Trials
Time (ms)
Activity power spectrum
Magnitude (dB)
Frequency (Hz)
Cancel
Values
ACCEPT
HELP
OK

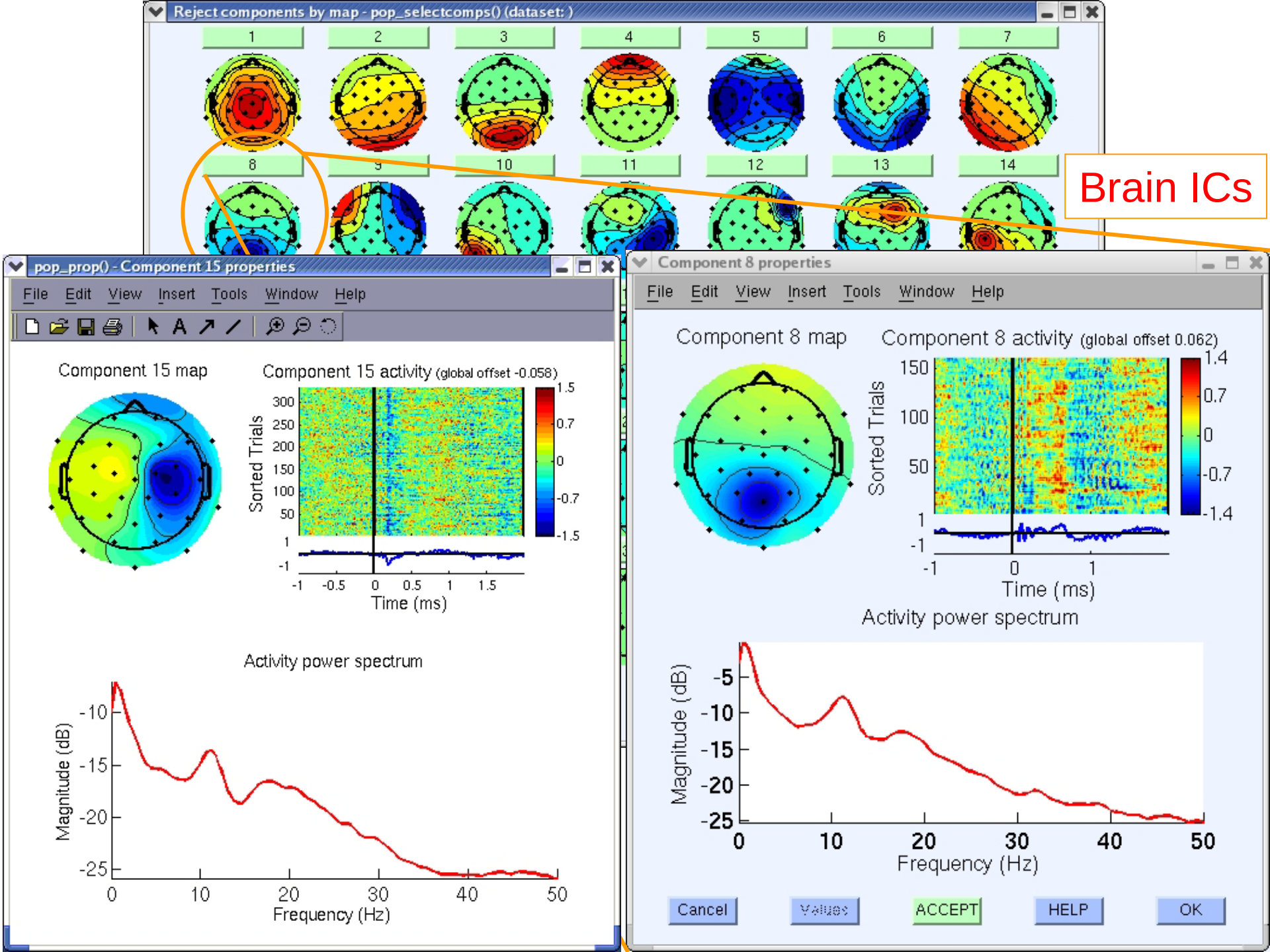
Component 18 properties
File Edit View Insert Tools Window Help
Component 18 map
Component 18 activity (global offset -0.007)
Sorted Trials
Time (ms)
Activity power spectrum
Magnitude (dB)
Frequency (Hz)
Cancel
Values
ACCEPT
HELP
OK


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

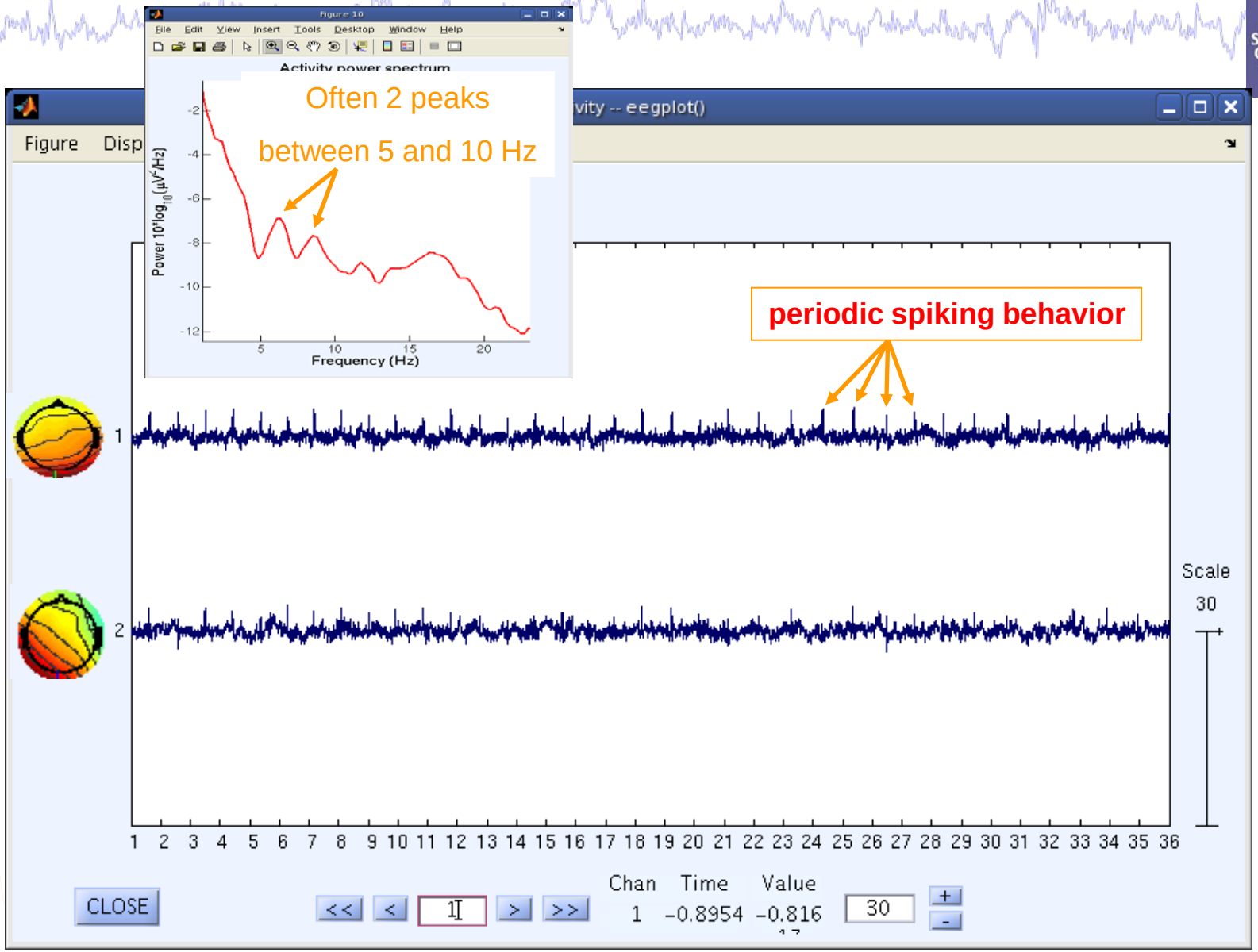

Component 25 properties
File Edit View Insert Tools Window Help
Component 25 map
Component 25 activity (global offset 0.006)
Sorted Trials
Time (ms)
Activity power spectrum
Magnitude (dB)
Frequency (Hz)
Cancel
Values
ACCEPT
HELP
OK


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
Compon
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


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

Pulse artifacts



Artifact rejection and running ICA

Task 1

Reject noisy data

Task 2

Run ICA

Task 3

Plot components

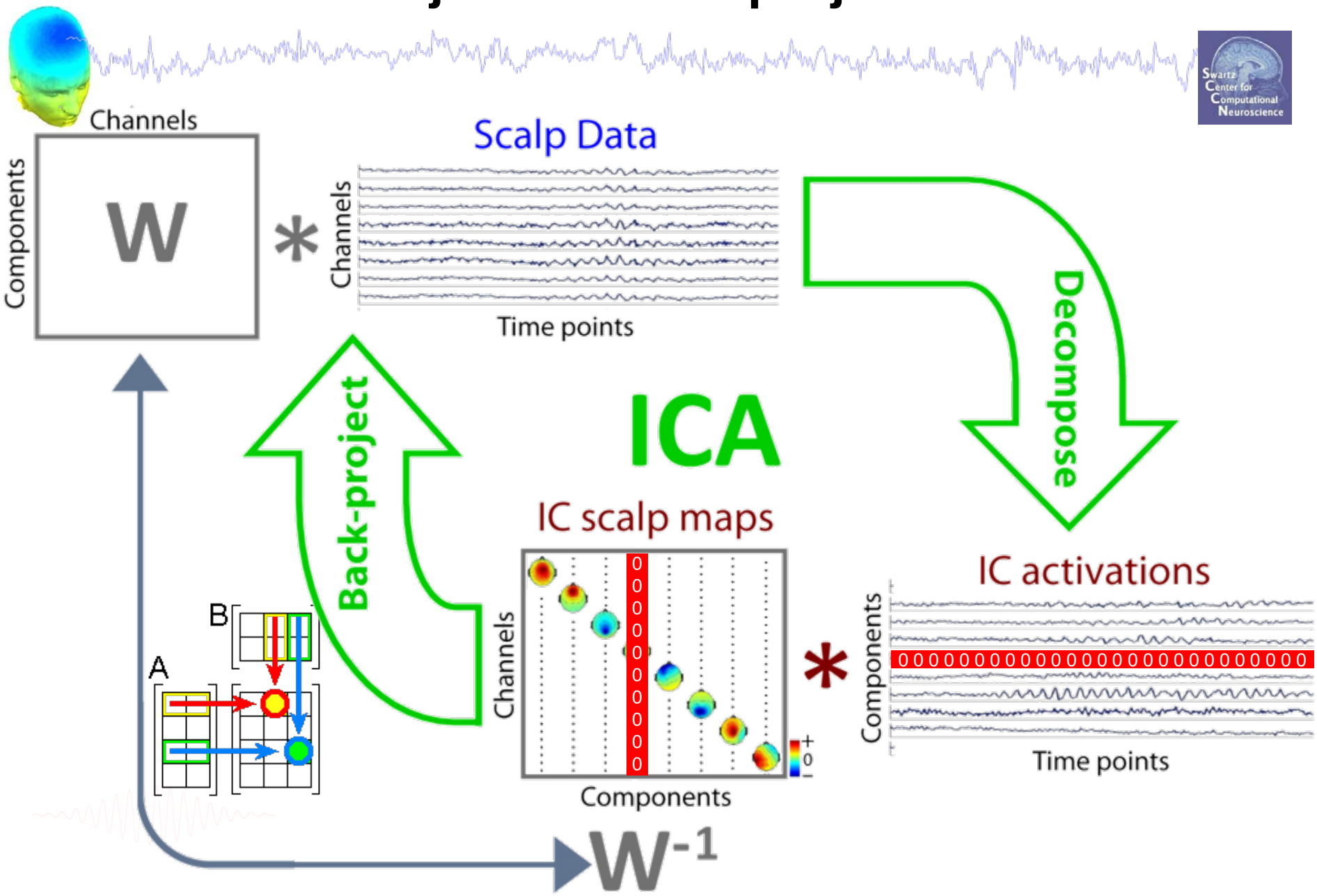
Task 4

Remove components

(i.e. back-projection)

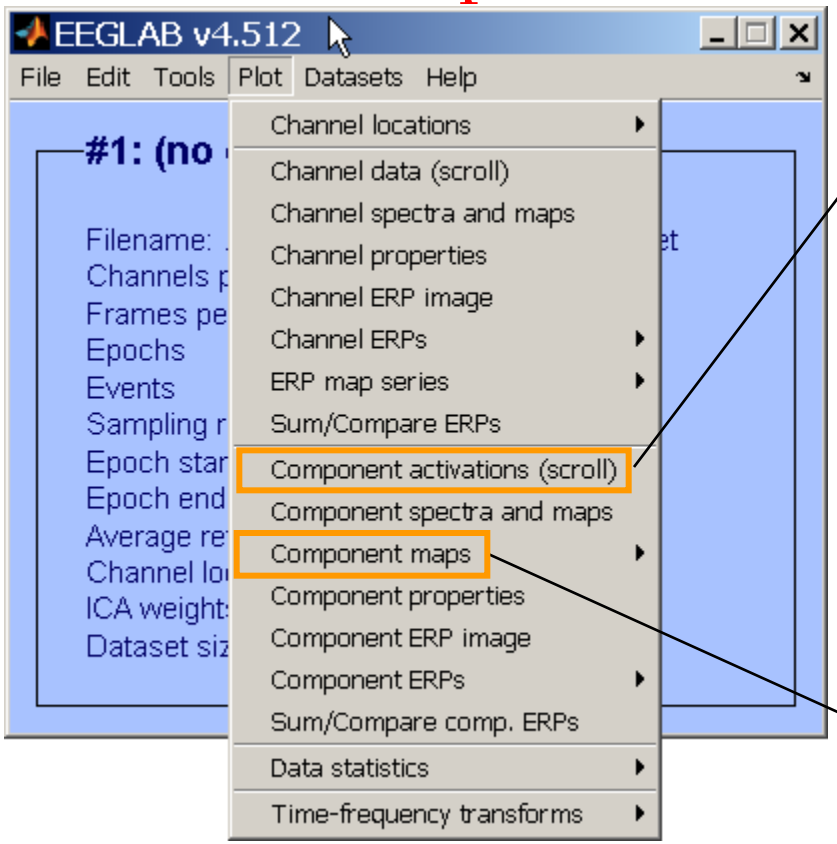
Exercise...

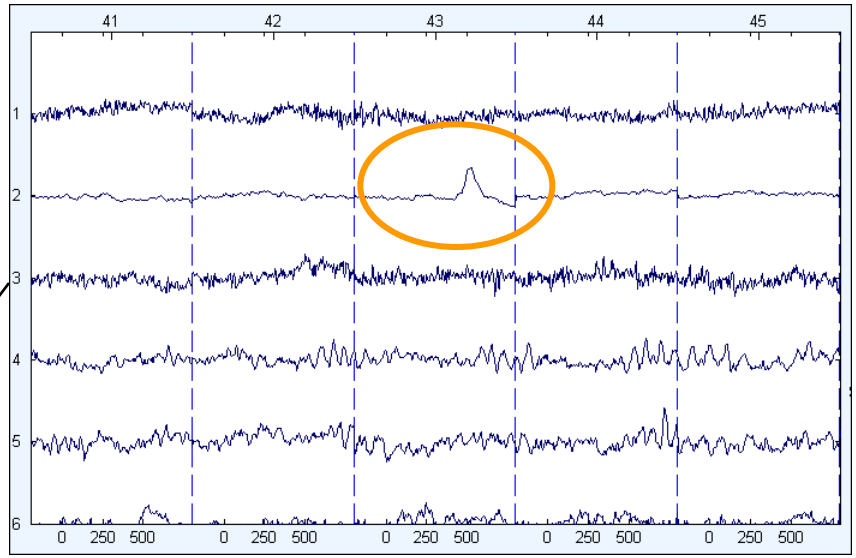
IC rejection/back-projection

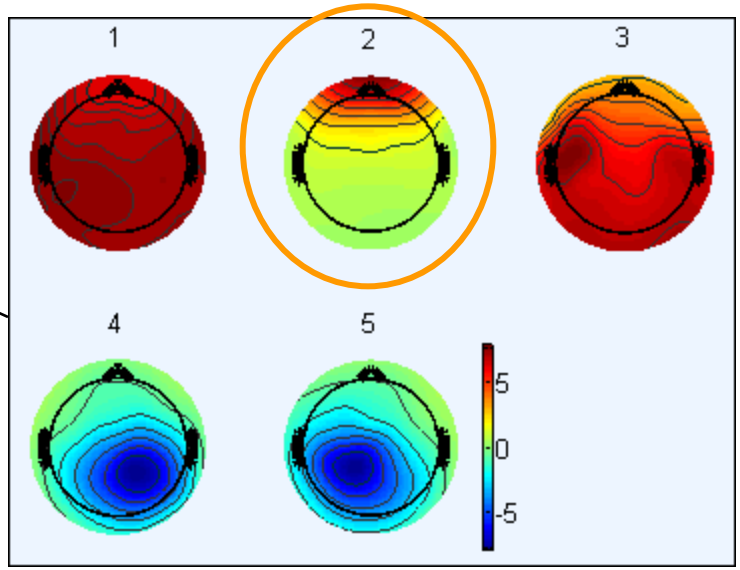


Eye blink correction

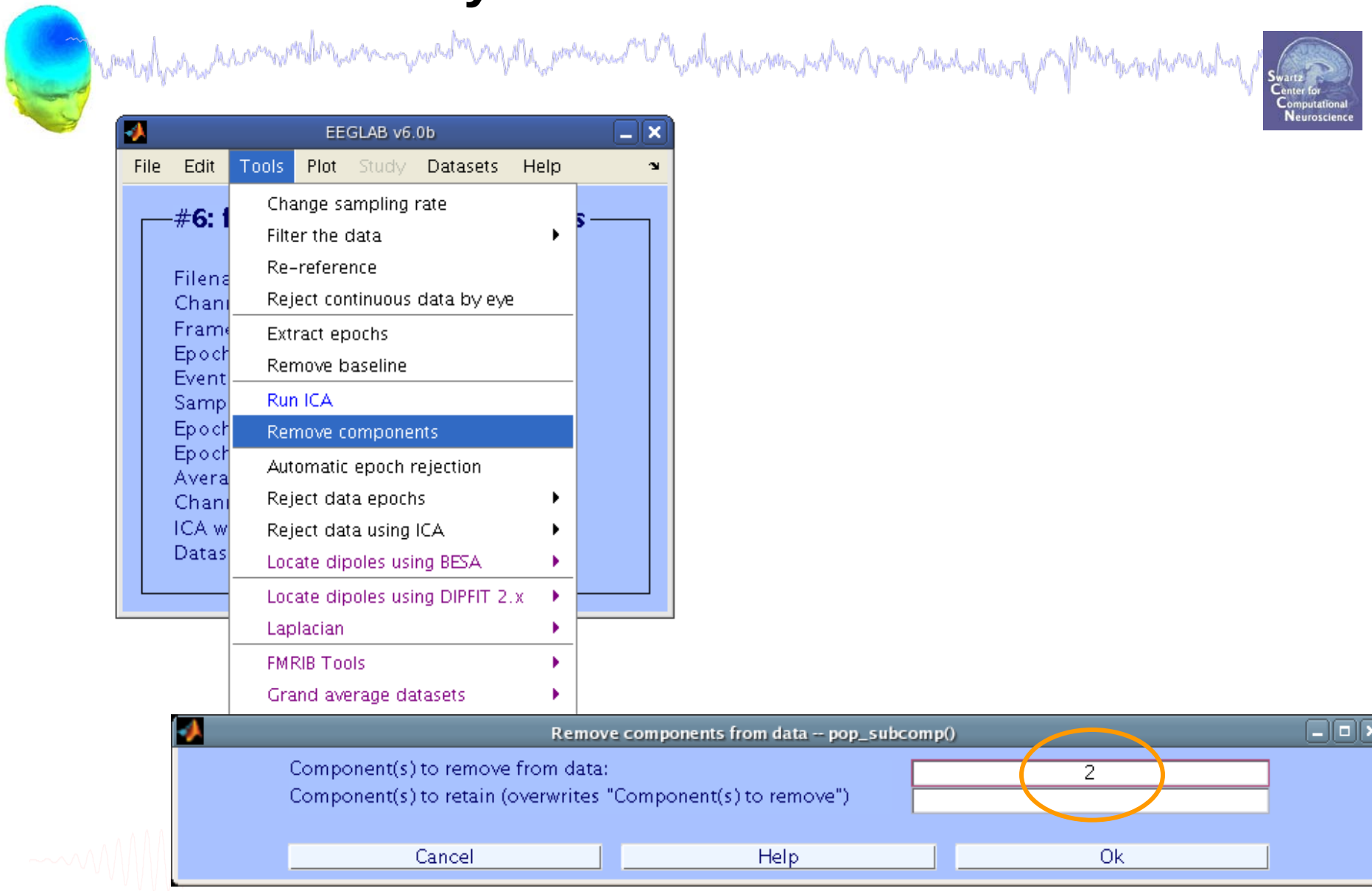
Identify eye-blink components:



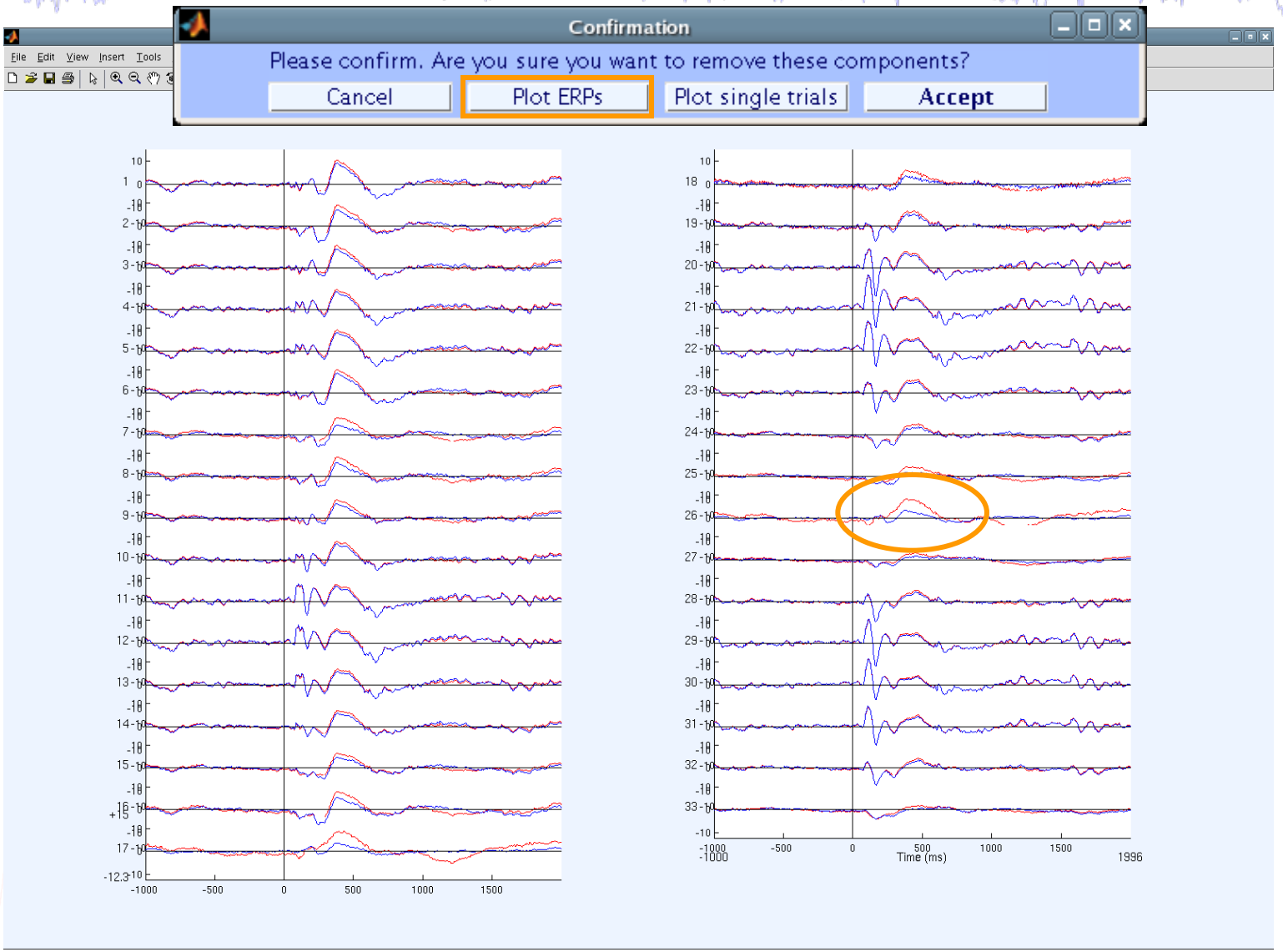




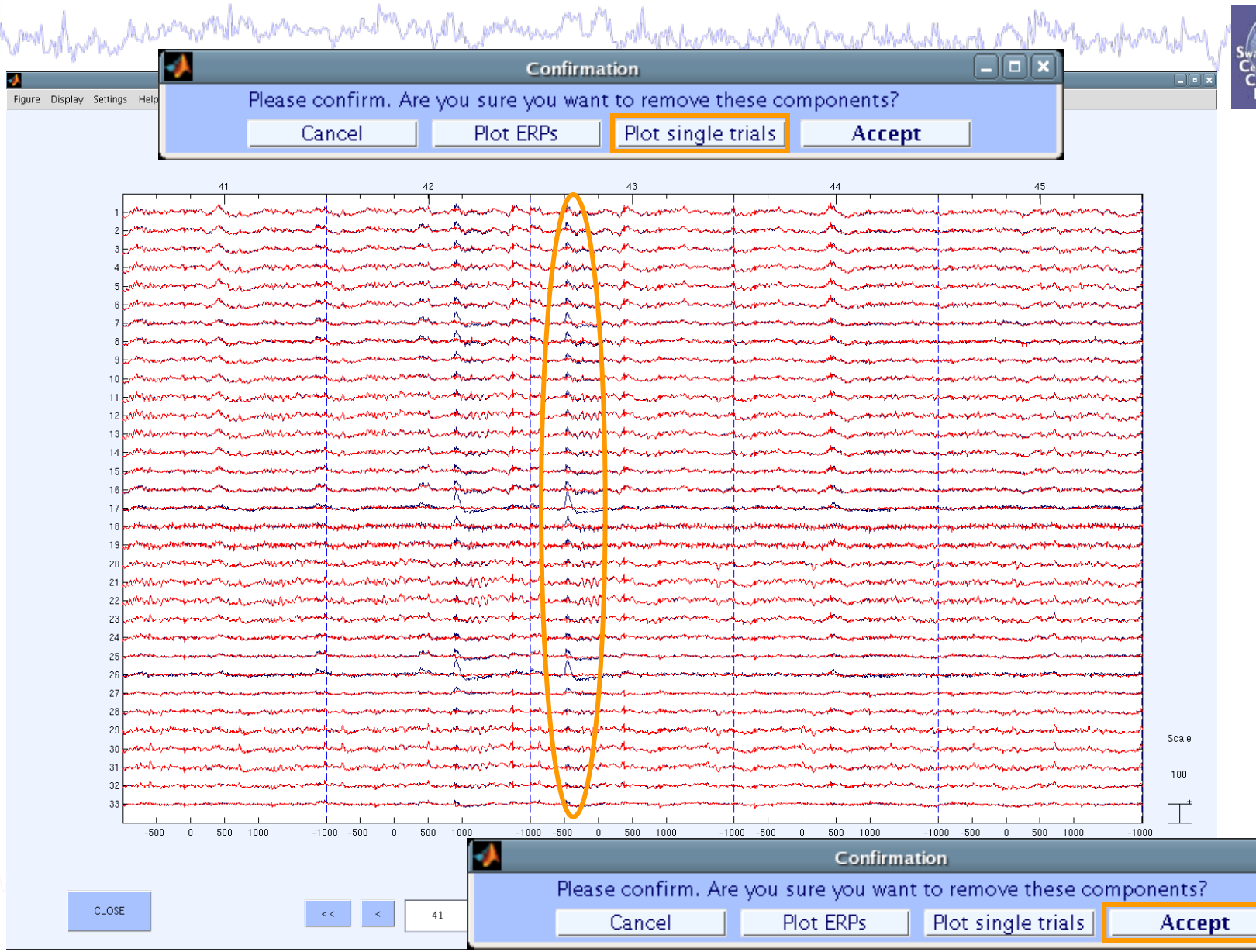
Eye blink correction



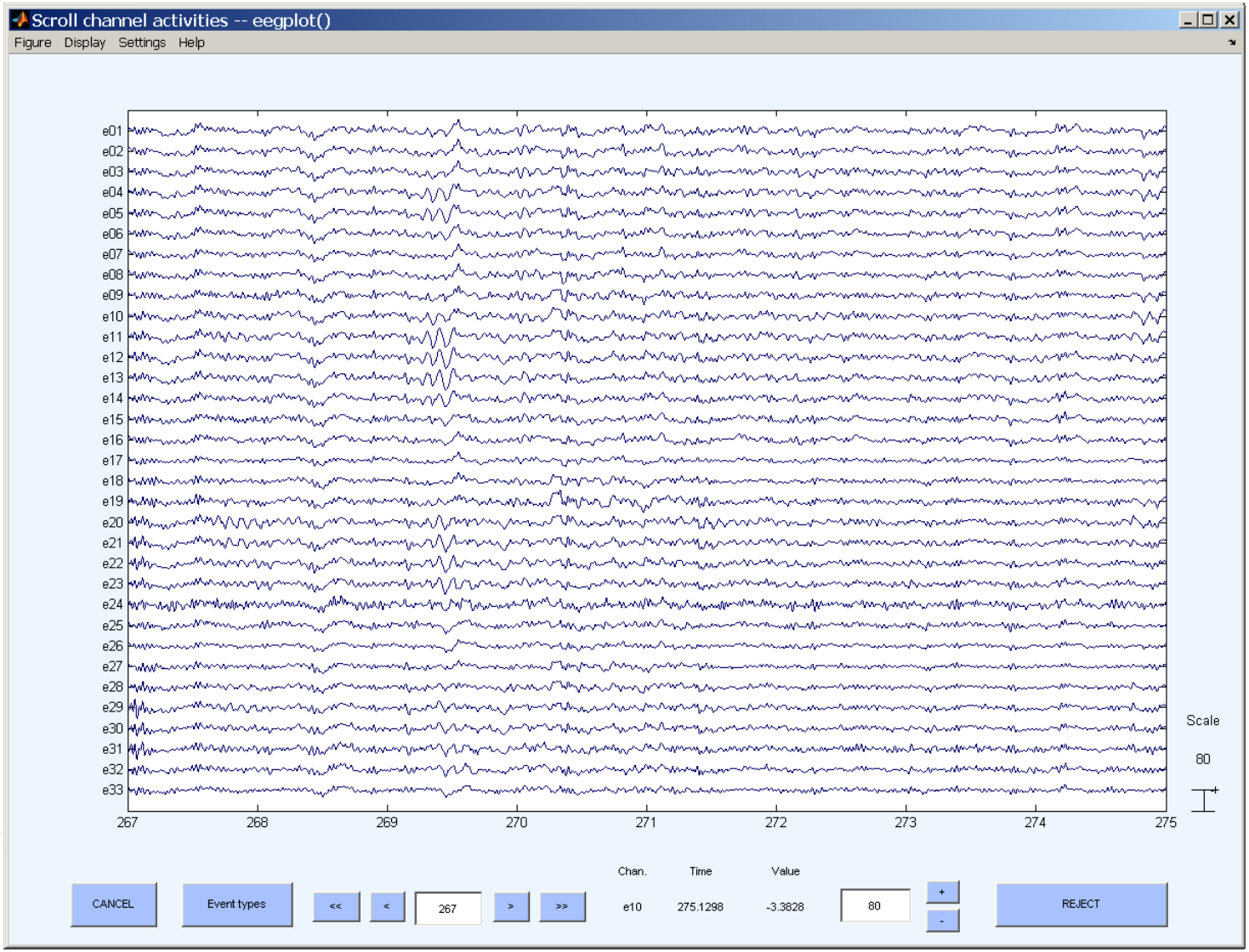
Eye blink correction



Eye blink correction



Eye blink correction



Exercise

- **ALL**

  - Load stern.set or stern_small.set

  - Epoch the data on memorize and ignore letters

  - From Reject data epochs->All methods menu

  - Scroll the data and perform visual rejection

  - Try other rejection protocols and compare

  - Explore channel probability and abnormal distribution plots

  - Find and identify artifact ICs

  - How can you be sure that an IC is artifact?

  - Remove a component from the EEG data (do not save this way!). Alternatively, try KEEPING just one component. What does the EEG.data scroll look like?