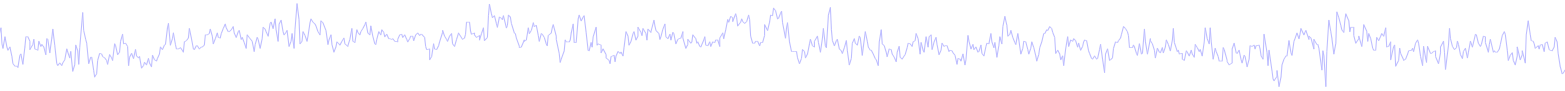
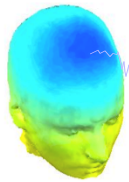


Artifact rejection and running ICA



Task 1

Reject noisy data

Task 2

Run ICA

Task 3

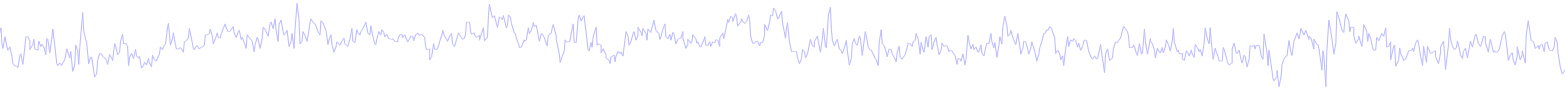
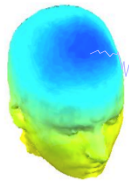
Plot components

Task 4

Remove components
(i.e. back-projection)

Exercise...

Artifact rejection and running ICA



Task 1

Reject noisy data

Task 2

Run ICA

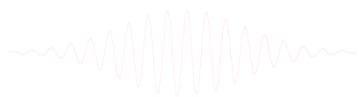
Task 3

Plot components

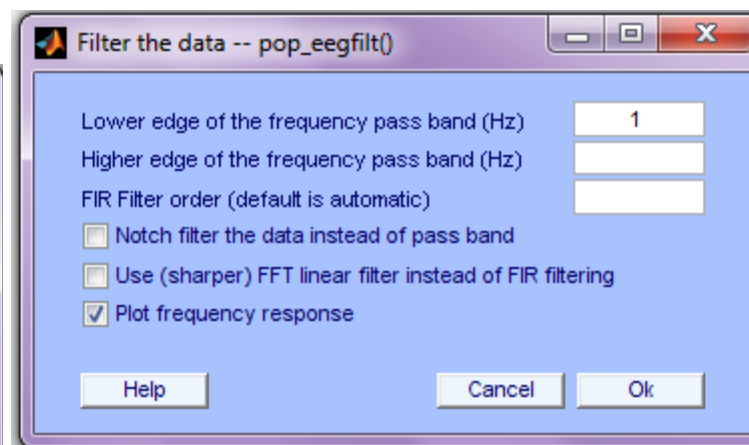
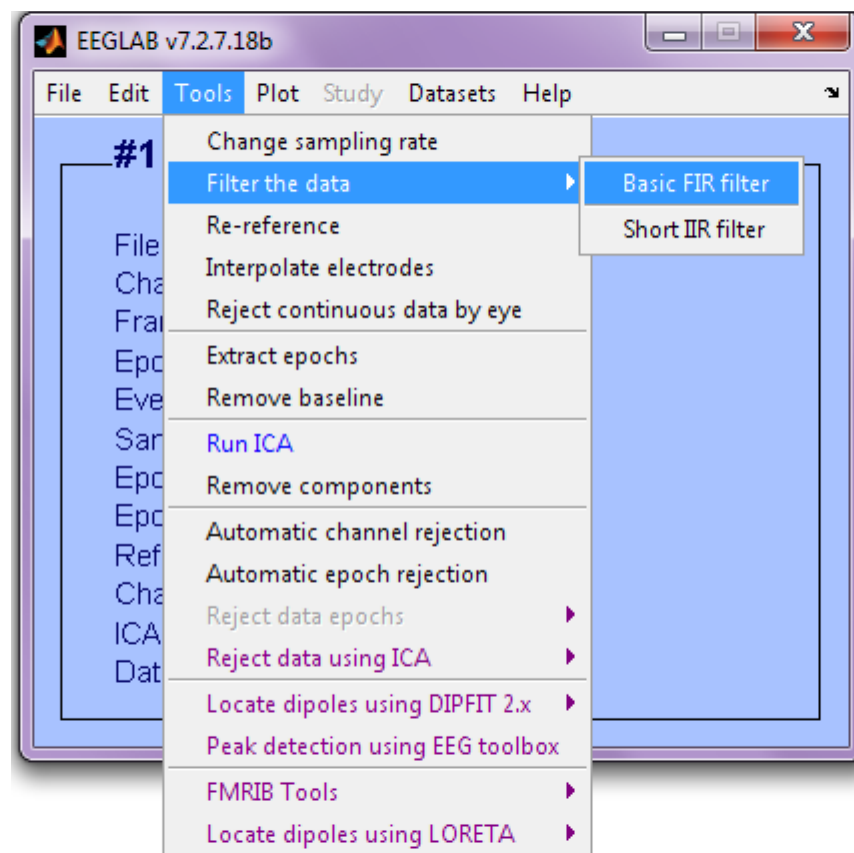
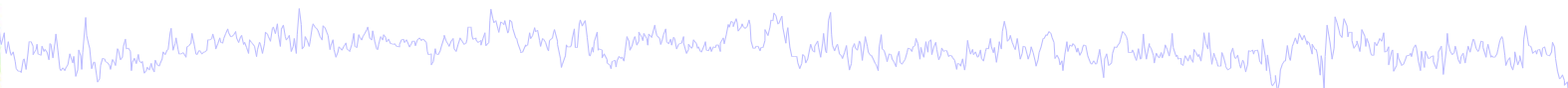
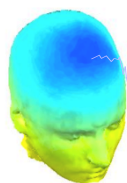
Task 4

Remove components
(i.e. back-projection)

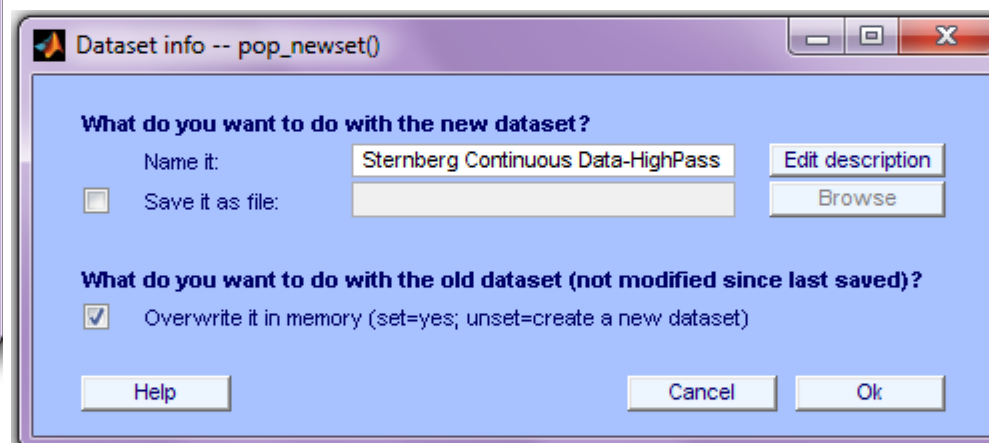
Exercise...



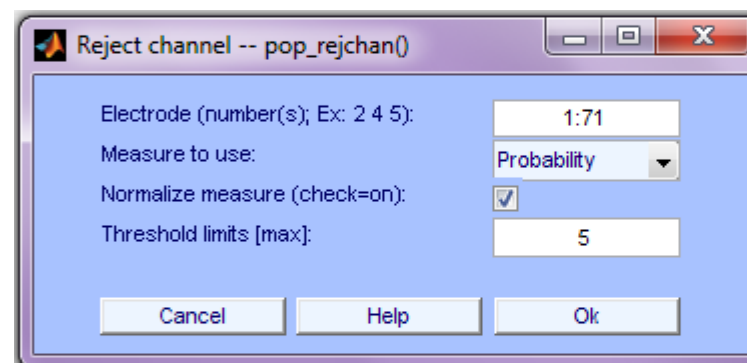
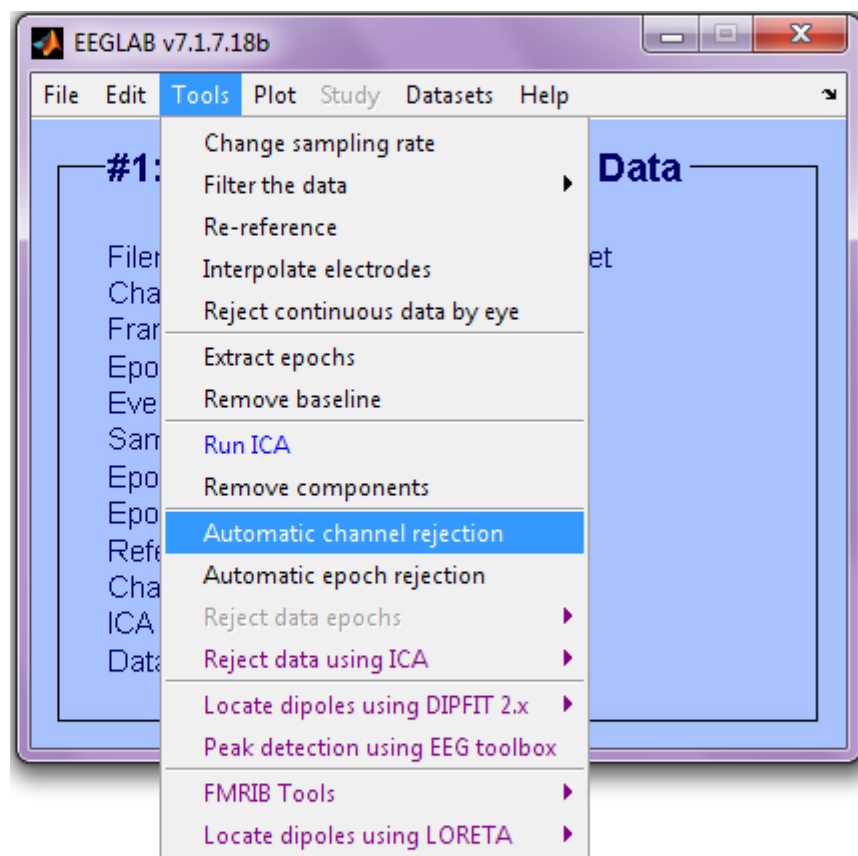
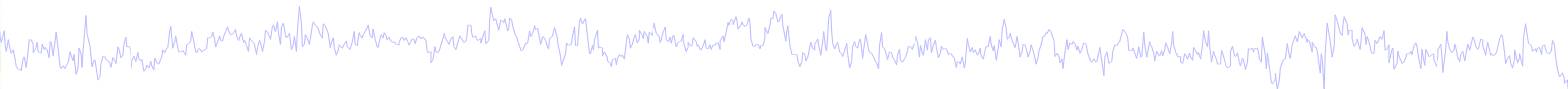
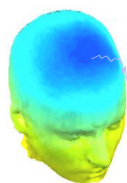
Filter the data (if necessary/desired)



High-pass
recommended

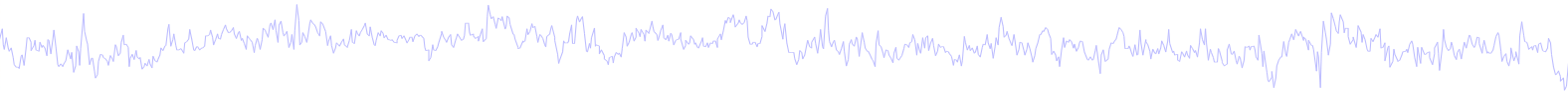
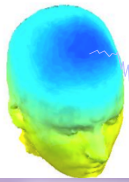


Auto-detection of noisy channels



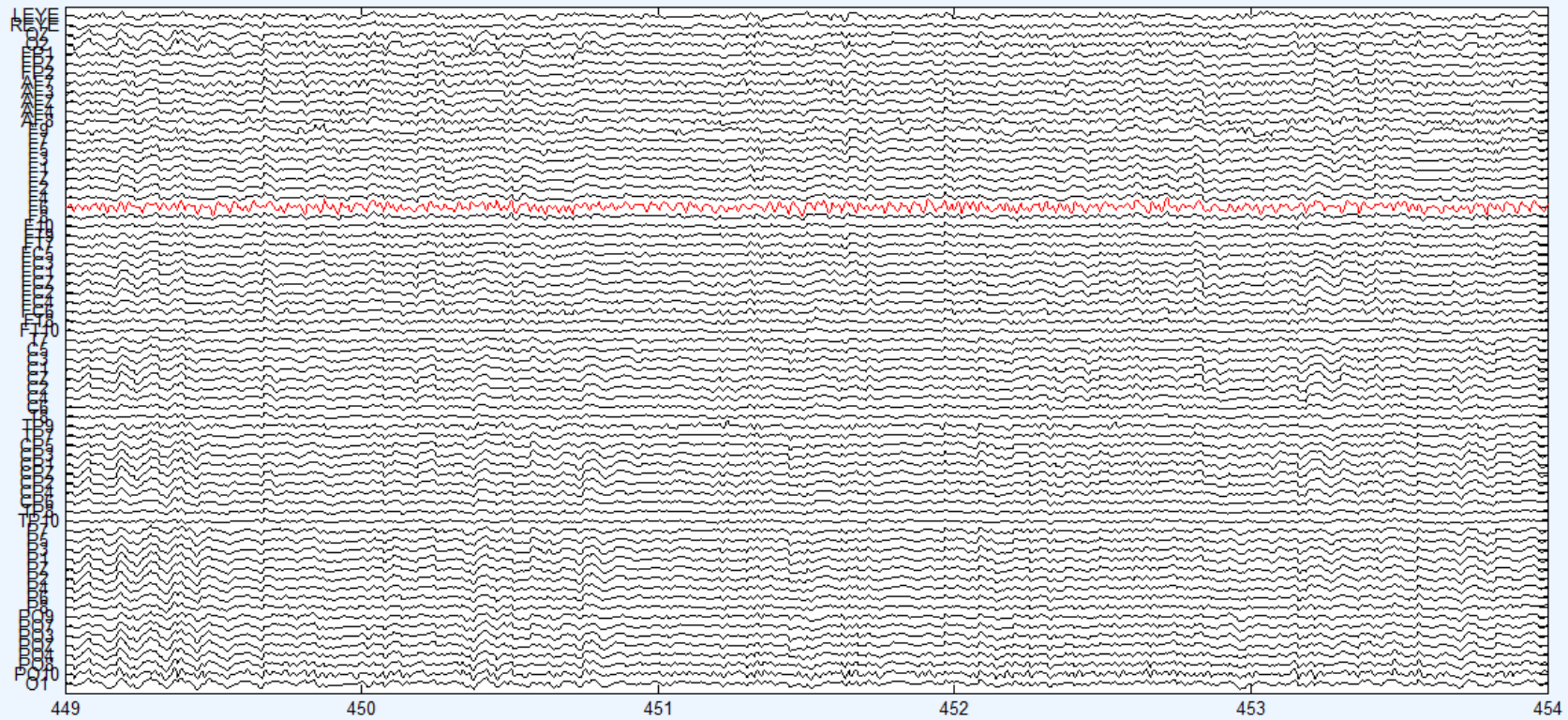
```
>> EEG = pop_rejchan(EEG, 'elec',[1:71] , 'threshold',5,...  
    'norm', 'on', 'measure', 'prob');
```


Auto-detected noisy channel



Scroll component activities -- eegplot()

Figure Display Settings Help



CANCEL

<<

<

449

>

>>

Chan.

Time

Value

TP8

452.1146

-2.6647

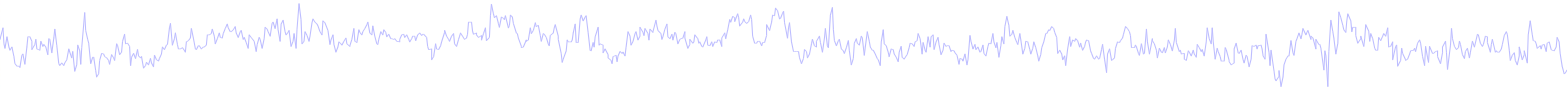
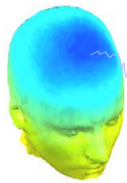
35

+

-

REJECT

Reject continuous data



Equivalent

EEGLAB v7.1.7.18b

File Edit **Tools** Plot Study Datasets Help

- Change sampling rate
- Filter the data
- Re-reference
- Interpolate electrodes
- Reject continuous data by eye**
- Extract epochs
- Remove baseline
- Run ICA
- Remove components
- Automatic channel rejection
- Automatic epoch rejection
- Reject data epochs
- Reject data using ICA
- Locate dipoles using DIPFIT 2.x
- Peak detection using EEG toolbox

Warning

Mark stretches of continuous data for rejection by dragging the left mouse button. Click on marked stretches to unmark. When done, press "REJECT" to excise marked stretches (Note: Leaves rejection boundary markers in the event table).

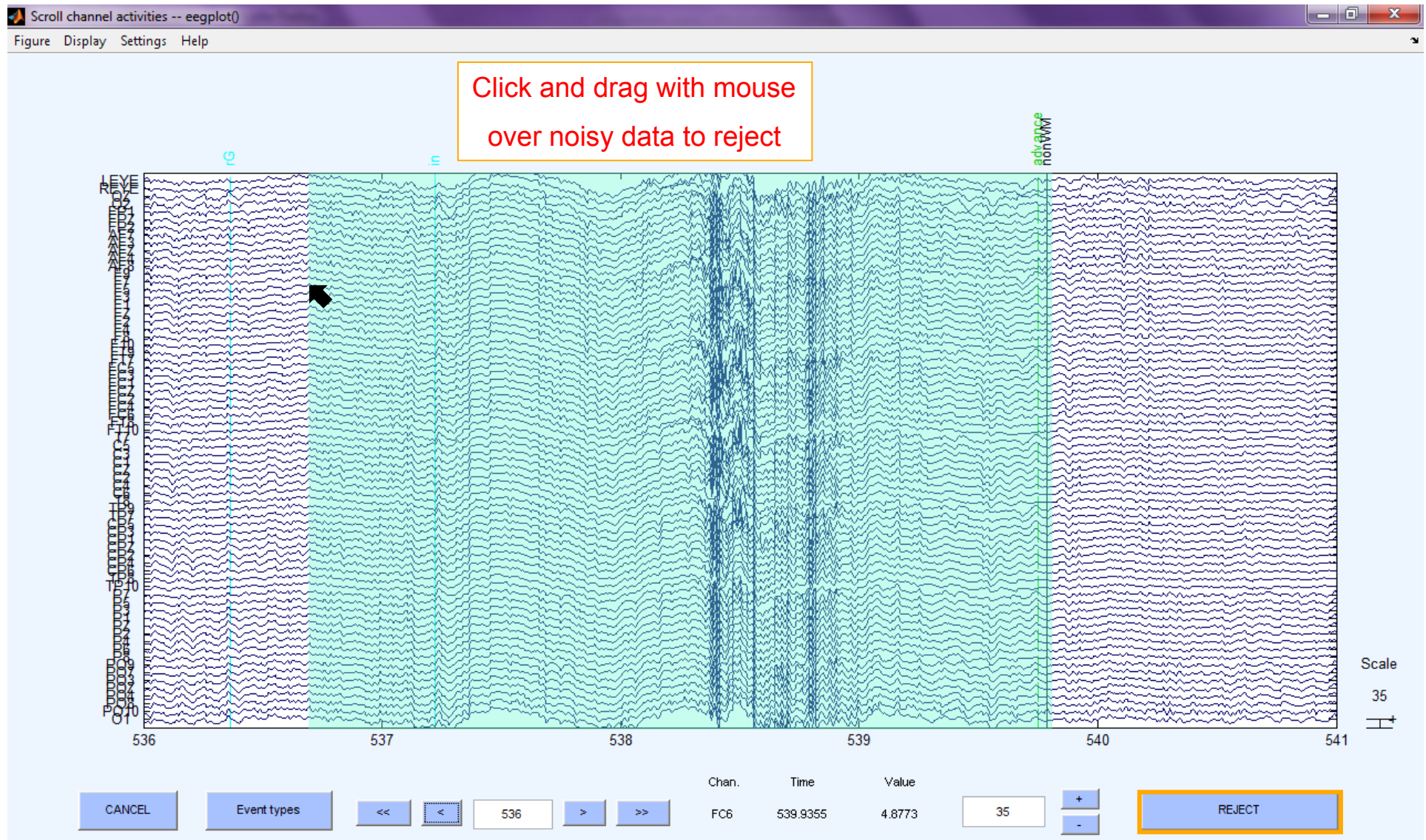
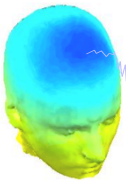
Cancel Continue

EEGLAB v7.1.7.18b

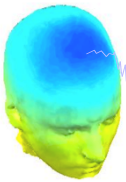
File Edit Tools **Plot** Study Datasets Help

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

Reject continuous data



Rejecting data for ICA



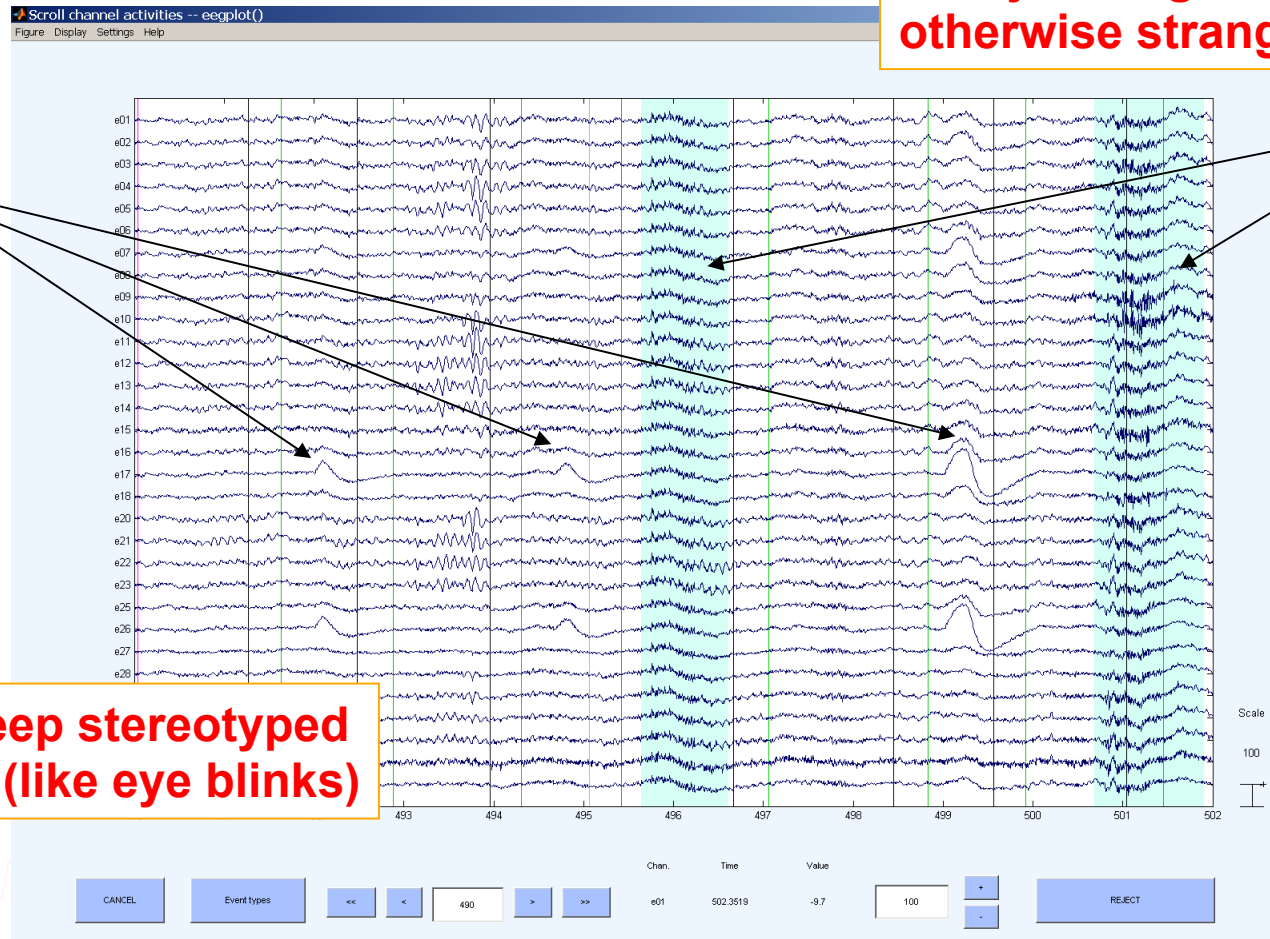
To prepare data for ICA:

Reject large muscle or otherwise strange events...

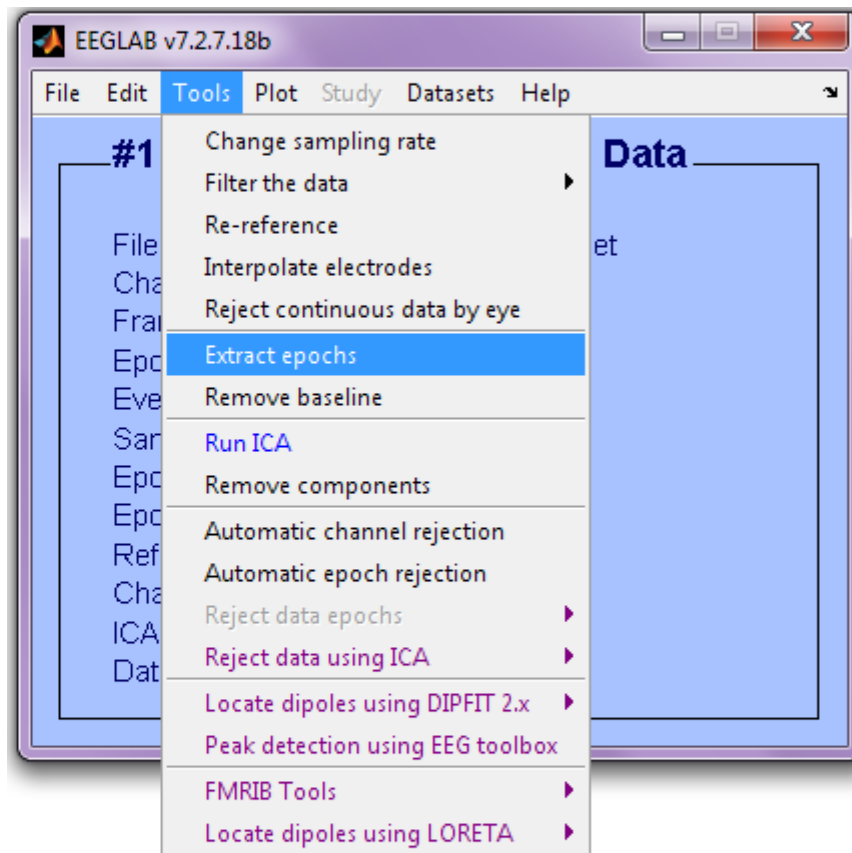
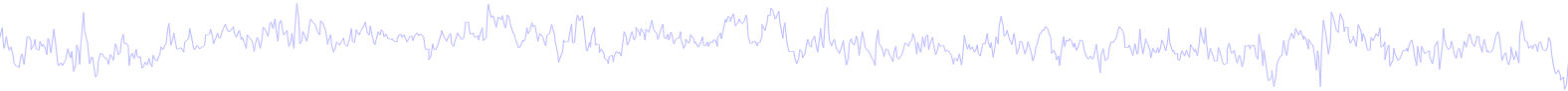
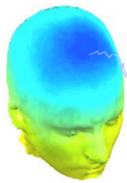
Keep

Reject

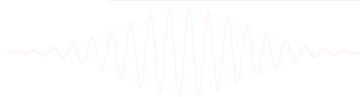
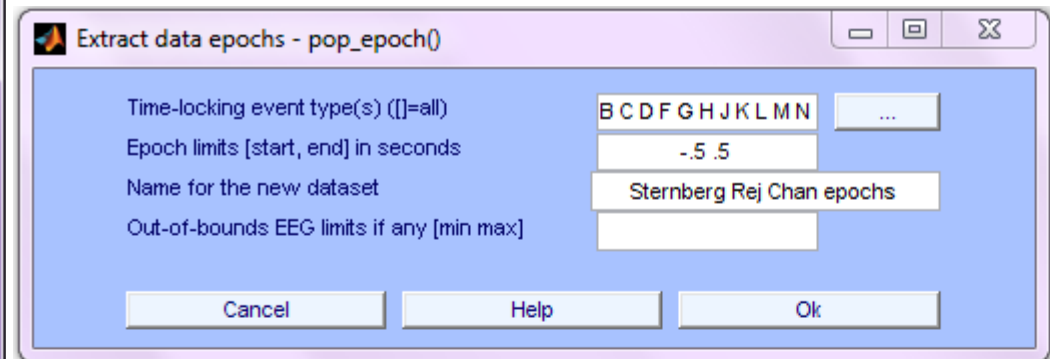
... but keep stereotyped artifacts (like eye blinks)



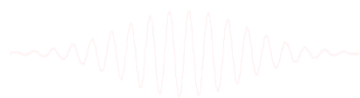
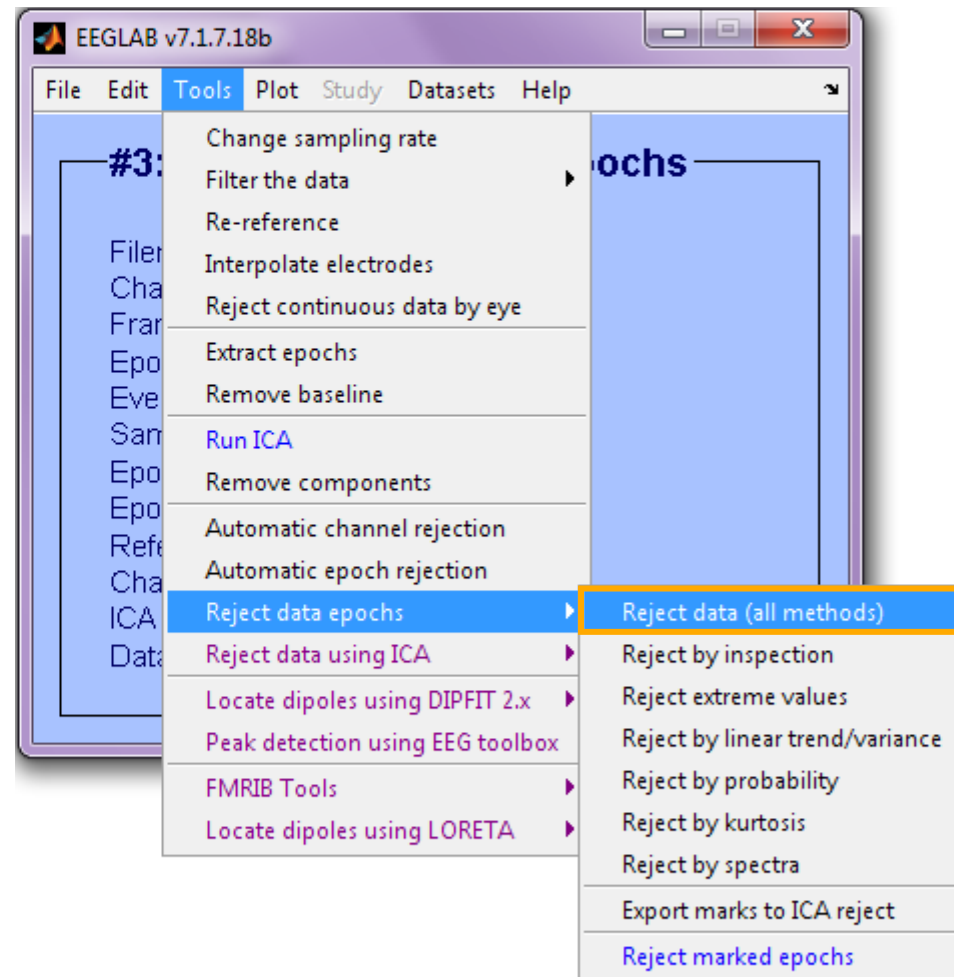
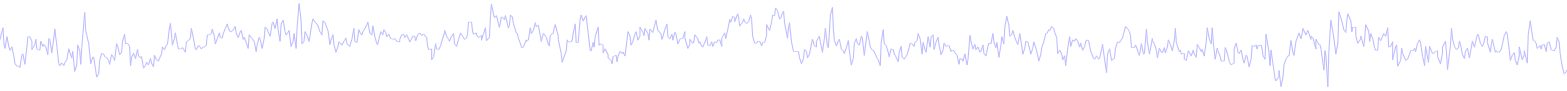
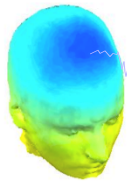
OR... Extract short epochs



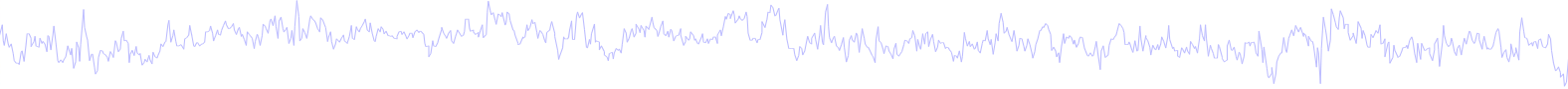
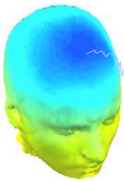
Choose all events



Auto-reject data epochs



Reject data epochs



visual
inspection

Reject trials using data statistics - pop_rejmenu()

Mark trials by appearance ☐ Marked trials 0

Find abnormal values ☐

Upper limit(s) (uV) 25 Lower limit(s) (uV) -25
Start time(s) (ms) -500 Ending time(s) (ms) 496
Electrode(s) 1:70 Currently marked trials 0

Find abnormal trends ☐

Max slope (uV/epoch) 50 R-squared limit (0 to 1) 0.3
Electrode(s) 1:70 Currently marked trials 0

Find improbable data ☐

Single-channel limit (std. dev.) 5 All channels limit (std. dev.) 5
Electrode(s) 1:70 Currently marked trials 0

Find abnormal distributions ☐

Single-channel limit (std. dev.) 5 All channels limit (std. dev.) 5
Electrode(s) 1:70 Currently marked trials 0

Find abnormal spectra (slow) ☐

Upper limit(s) (dB) 25 Lower limit(s) (dB) -25
Low frequency(s) (Hz) 0 High frequency(s) (Hz) 50
Electrode(s) 1:70 Currently marked trials 0

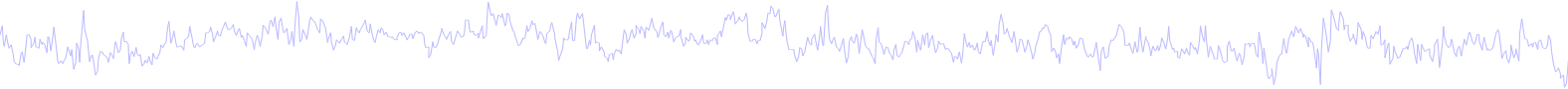
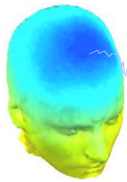
Plotting options

Show all trials marked for rejection by the measure selected above or checked below

☒ Abnormal appearance ☒ Abnormal values ☒ Abnormal trends
☒ Improbable epochs ☒ Abnormal distributions ☒ Abnormal spectra

probability

Reject data epochs



Reject trials using data statistics - pop_rejmenu()

Mark trials by appearance ☐ Marked trials 0

Find abnormal values ☐

Upper limit(s) (uV) 25 Lower limit(s) (uV) -25
Start time(s) (ms) -500 Ending time(s) (ms) 496
Electrode(s) 1:70 Currently marked trials 0

Find abnormal trends ☐

Max slope (uV/epoch) 50 R-squared limit (0 to 1) 0.3
Electrode(s) 1:70 Currently marked trials 0

Find improbable data ☐

Single-channel limit (std. dev.) 5 All channels limit (std. dev.) 5
Electrode(s) 1:70 Currently marked trials 32

Find abnormal distributions ☐

Single-channel limit (std. dev.) 5 All channels limit (std. dev.) 5
Electrode(s) 1:70 Currently marked trials 0

Find abnormal spectra (slow) ☐

Upper limit(s) (dB) 25 Lower limit(s) (dB) -25
Low frequency(s) (Hz) 0 High frequency(s) (Hz) 50
Electrode(s) 1:70 Currently marked trials 0

Plotting options

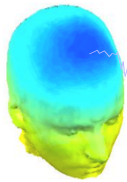
Show all trials marked for rejection by the measure selected above or checked below

☒ Abnormal appearance ☒ Abnormal values ☒ Abnormal trends
☒ Improbable epochs ☒ Abnormal distributions ☒ Abnormal spectra

Start by clicking
Calculate:

Number of epochs
above threshold
indicated here

Reject or retain marked epochs



Reject trials using data statistics - pop_rejmenu()

Mark trials by appearance ☐ Marked trials 0

Find abnormal values ☐

Upper limit(s) (uV)	25	Lower limit(s) (uV)	-25
Start time(s) (ms)	-500	Ending time(s) (ms)	496
Electrode(s)	1:70	Currently marked trials	0

Find abnormal trends ☐

Max slope (uV/epoch)	50	R-squared limit (0 to 1)	0.3
Electrode(s)	1:70	Currently marked trials	0

Find improbable data ☐

Single-channel limit (std. dev.)	5	All channels limit (std. dev.)	5
Electrode(s)	1:70	Currently marked trials	32

Find abnormal distributions ☐

Single-channel limit (std. dev.)	5	All channels limit (std. dev.)	5
Electrode(s)	1:70	Currently marked trials	0

Find abnormal spectra (slow) ☐

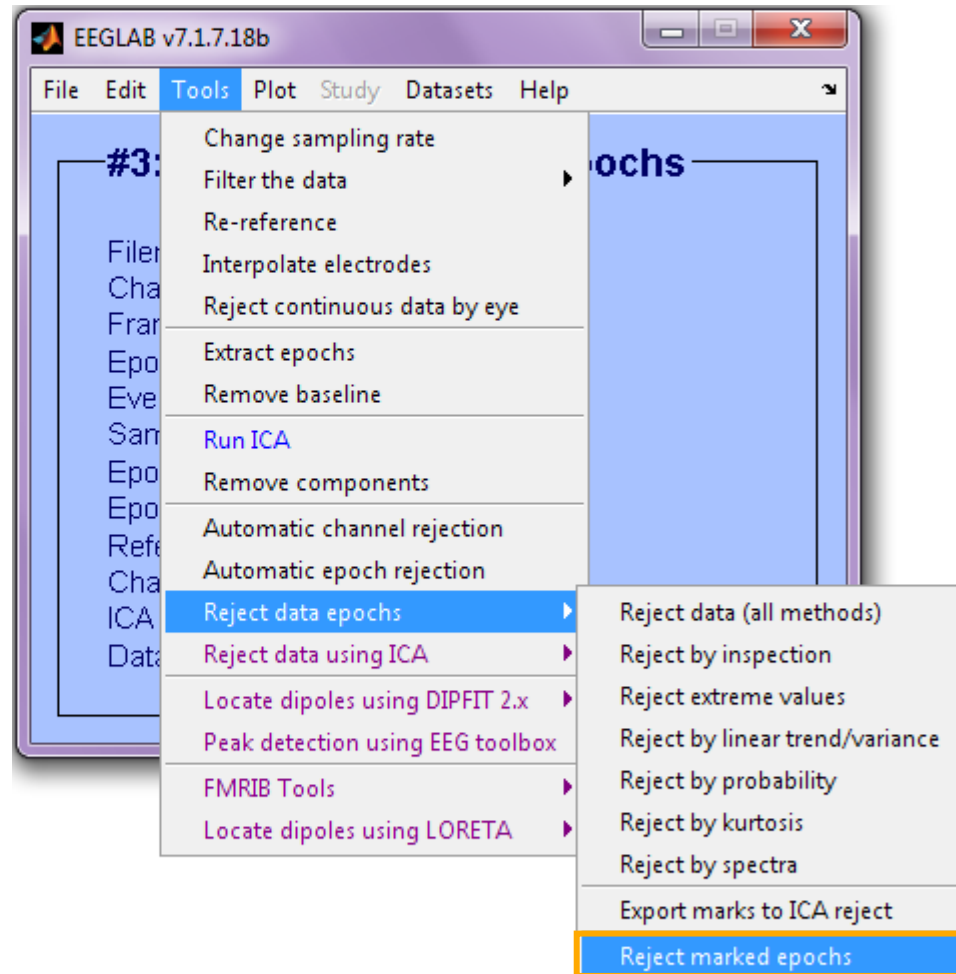
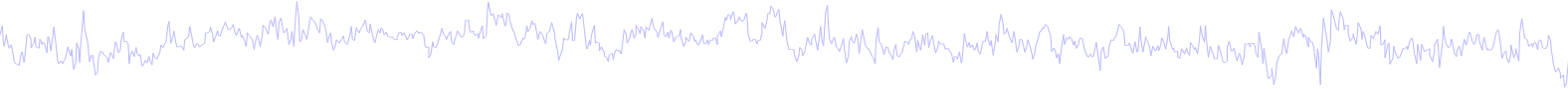
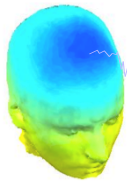
Upper limit(s) (dB)	25	Lower limit(s) (dB)	-25
Low frequency(s) (Hz)	0	High frequency(s) (Hz)	50
Electrode(s)	1:70	Currently marked trials	0

Plotting options

Show all trials marked for rejection by the measure selected above or checked below

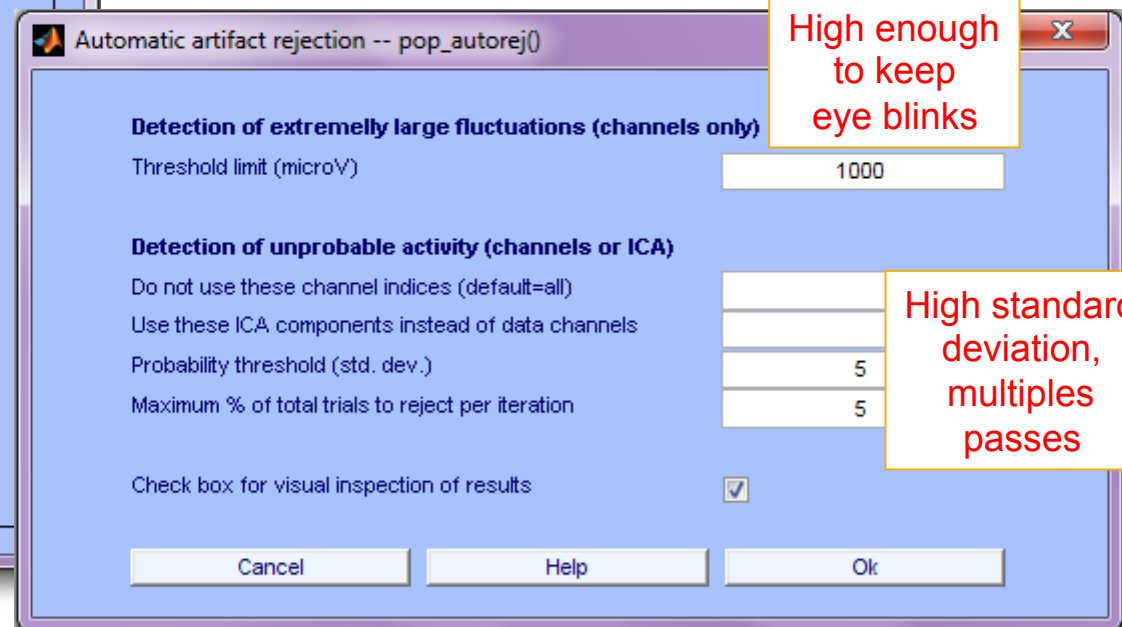
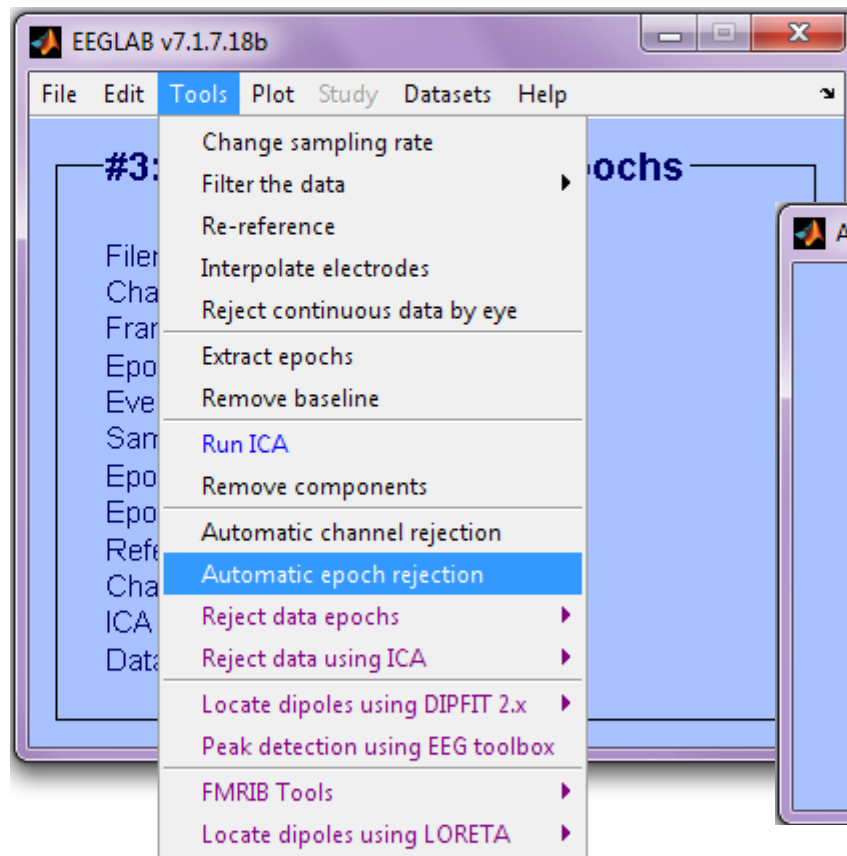
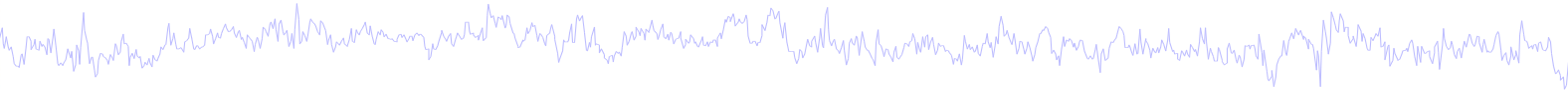
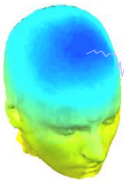
<input checked="" type="checkbox"/> Abnormal appearance	<input checked="" type="checkbox"/> Abnormal values	<input checked="" type="checkbox"/> Abnormal trends
<input checked="" type="checkbox"/> Improbable epochs	<input checked="" type="checkbox"/> Abnormal distributions	<input checked="" type="checkbox"/> Abnormal spectra

Reject marked epochs



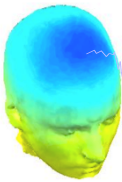
```
>> EEG = pop_jointprob(EEG,1,[1:70],5,5,0,0);  
>> EEG = pop_rejepoch(EEG,find(EEG.reject.rejglobal),0);
```

Reject data epochs (automatic)



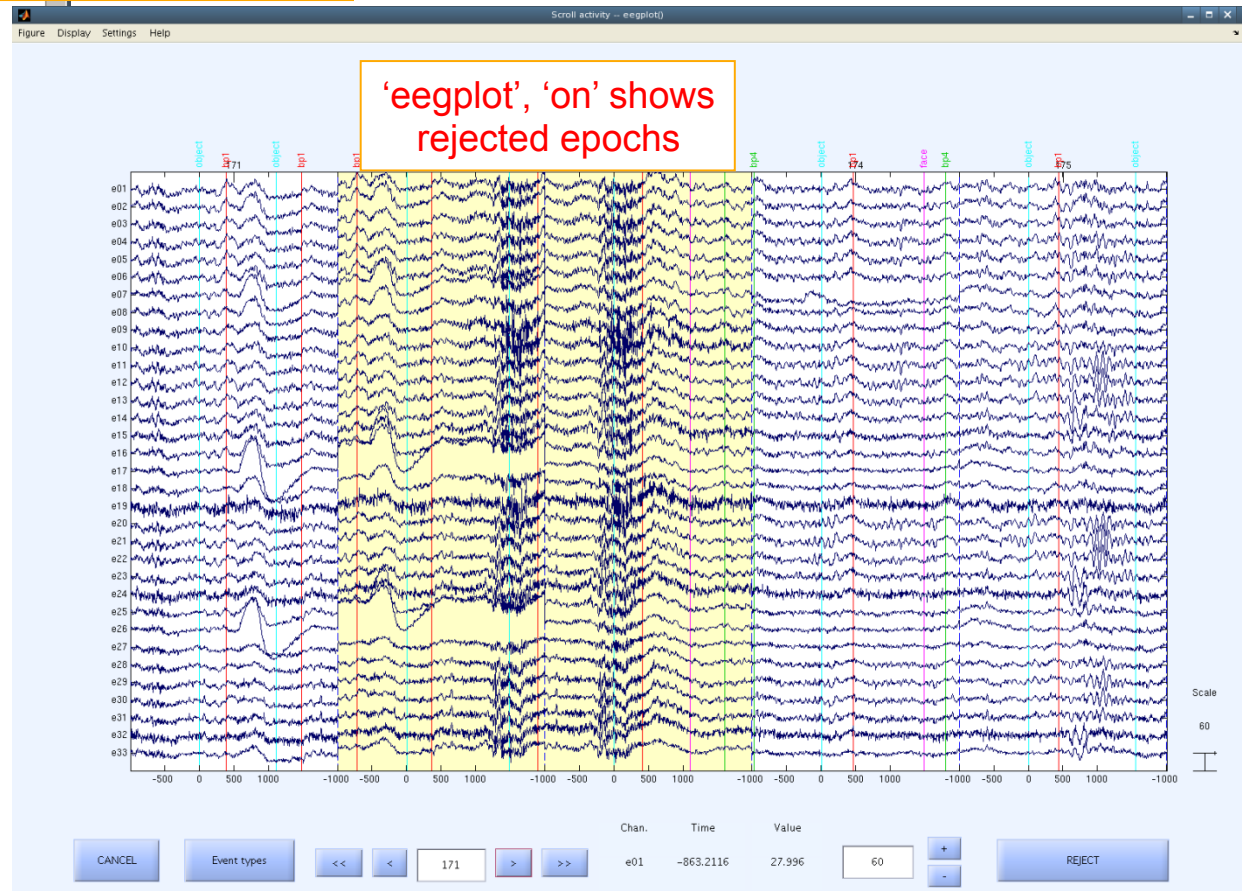
```
>> EEG = pop_autorej(EEG, 'nogui', 'on', 'eegplot', 'on');
```

Reject data epochs (automatic)

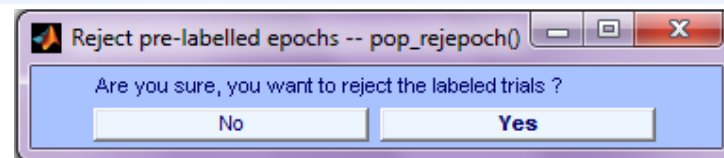


```
julie@doing/home/julie
File Edit View Terminal Tabs Help
>>
Running auto-rejection protocol...
33 channel selected
0/182 trials marked for rejection
Computing joint probability for channels...
Computing all-channel probability...
5/182 trials marked for rejection
5 trials marked for rejection
5/182 trials rejected
Removing 5 trial(s)...
Pop_select: removing 22 unreferenced events
Computing joint probability for channels...
Computing all-channel probability...
3/177 trials marked for rejection
3 trials marked for rejection
3/177 trials rejected
Removing 3 trial(s)...
Pop_select: removing 14 unreferenced events
Computing joint probability for channels...
Computing all-channel probability...
4/174 trials marked for rejection
4 trials marked for rejection
4/174 trials rejected
Removing 4 trial(s)...
Pop_select: removing 16 unreferenced events
Computing joint probability for channels...
Computing all-channel probability...
3/170 trials marked for rejection
3 trials marked for rejection
3/170 trials rejected
Removing 3 trial(s)...
Pop_select: removing 14 unreferenced events
Computing joint probability for channels...
Computing all-channel probability...
3/167 trials marked for rejection
3 trials marked for rejection
3/167 trials rejected
Removing 3 trial(s)...
Pop_select: removing 12 unreferenced events
Computing joint probability for channels...
Computing all-channel probability...
1/164 trials marked for rejection
1 trials marked for rejection
1/164 trials rejected
Removing 1 trial(s)...
Pop_select: removing 4 unreferenced events
Computing joint probability for channels...
Computing all-channel probability...
0/163 trials marked for rejection
0 trials marked for rejection
0/163 trials rejected
Final kurtosis reject...
Computing kurtosis for channels...
Computing all-channel kurtosis...
3/163 trials marked for rejection
3 trials marked for rejection
>>
```

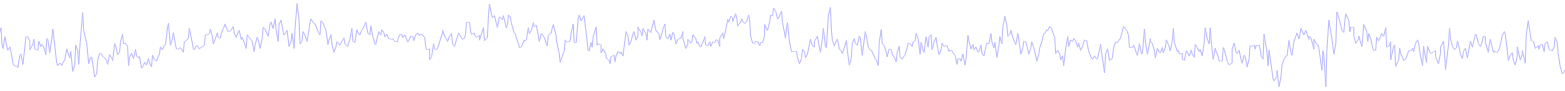
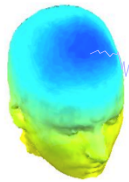
Iterative rejection
based on probability



'eegplot', 'on' shows
rejected epochs



Artifact rejection and running ICA



Task 1

Reject noisy data

Task 2

Run ICA

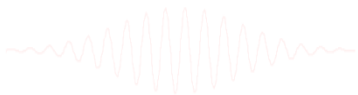
Task 3

Plot components

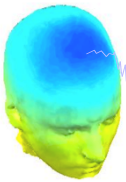
Task 4

Remove components
(i.e. back-projection)

Exercise...



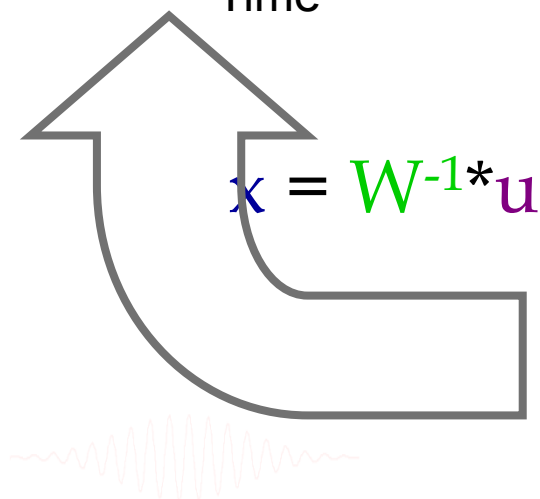
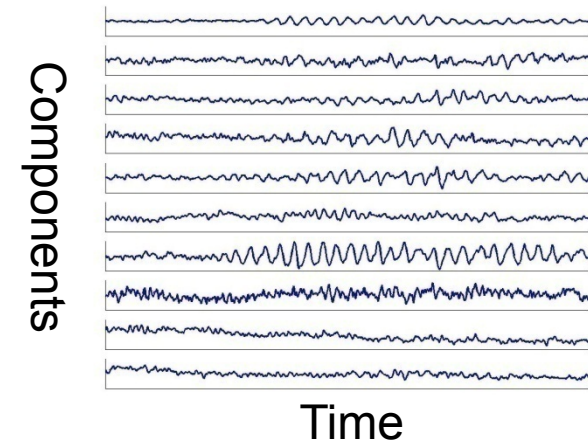
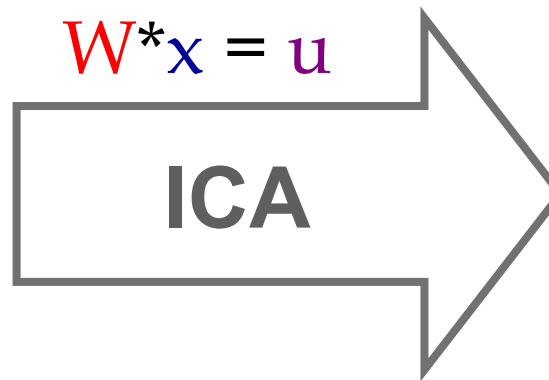
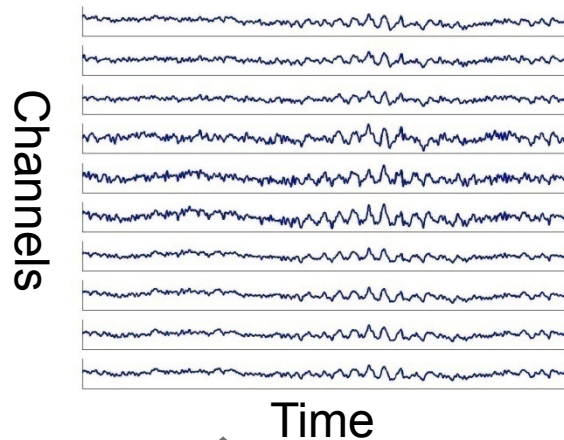
Independent Component Analysis



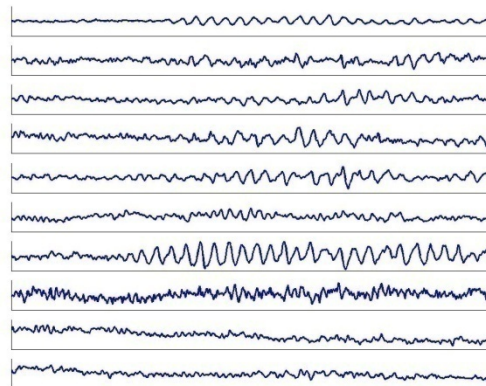
x = scalp EEG

W = unmixing matrix

u = sources

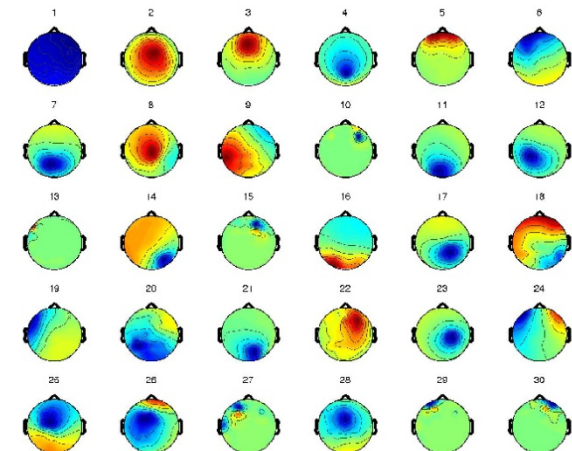


u = sources



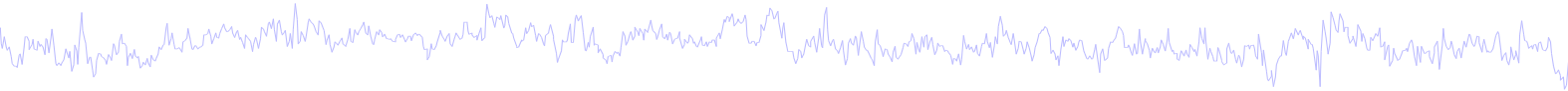
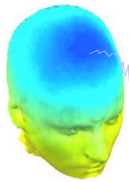
W^{-1} (scalp projections)

*



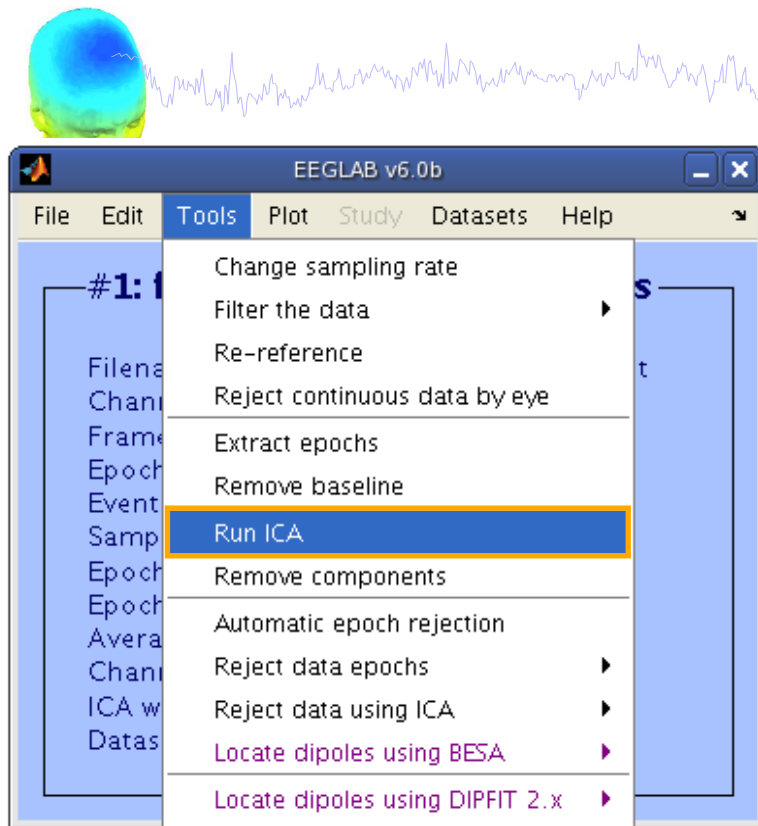
ICA Components

“Secrets” to a good ICA decomposition



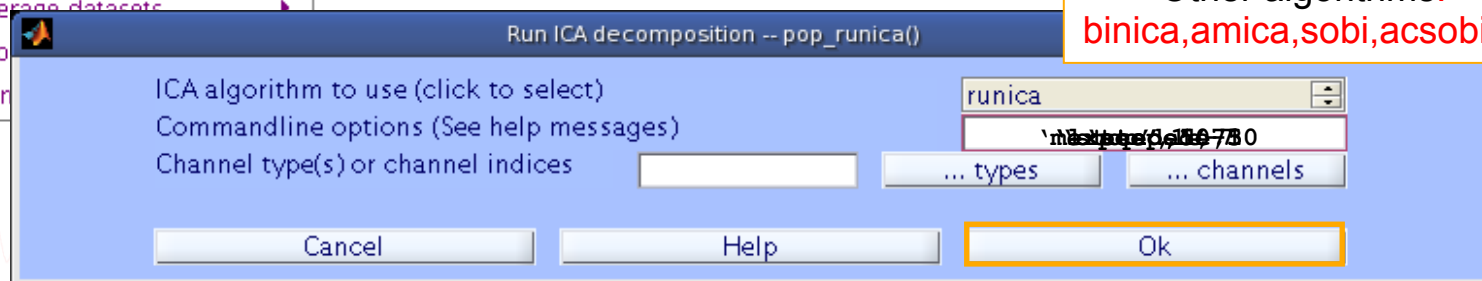
- Garbage in... garbage out (it's not magic)
- Remove large, non-stereotyped artifacts
- Do you have enough data? (based mostly on time, not frames)
- High-pass filter to remove slow drifts (no low-pass filter needed)
- Remove bad channels
- Data must be in double precision (not single)

Runica options

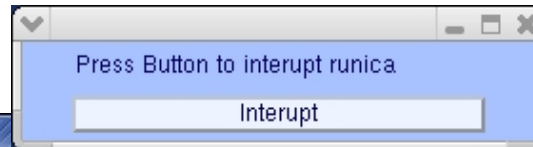
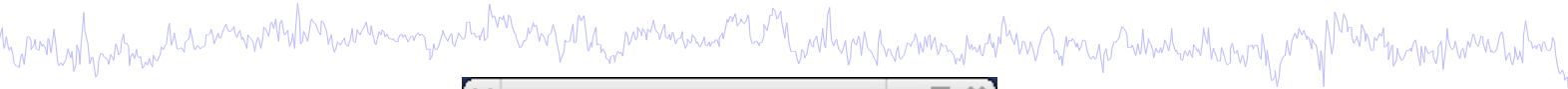
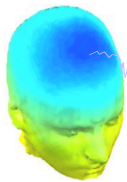


Option	Default	Comments
'extended'	0	1 is recommended to find sub-gaussians
'stop'	1e-7	final weight change → stop
'lrate'	determined from data	too small → too long... too large → wts blow up
'maxsteps'	512	more channels → more steps
'pca'	0 or EEG.nbchan	Decompose only a principal data subspace

Other algorithms:
binica, amica, sobi, acsobi, ro



Runica progress...



```

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

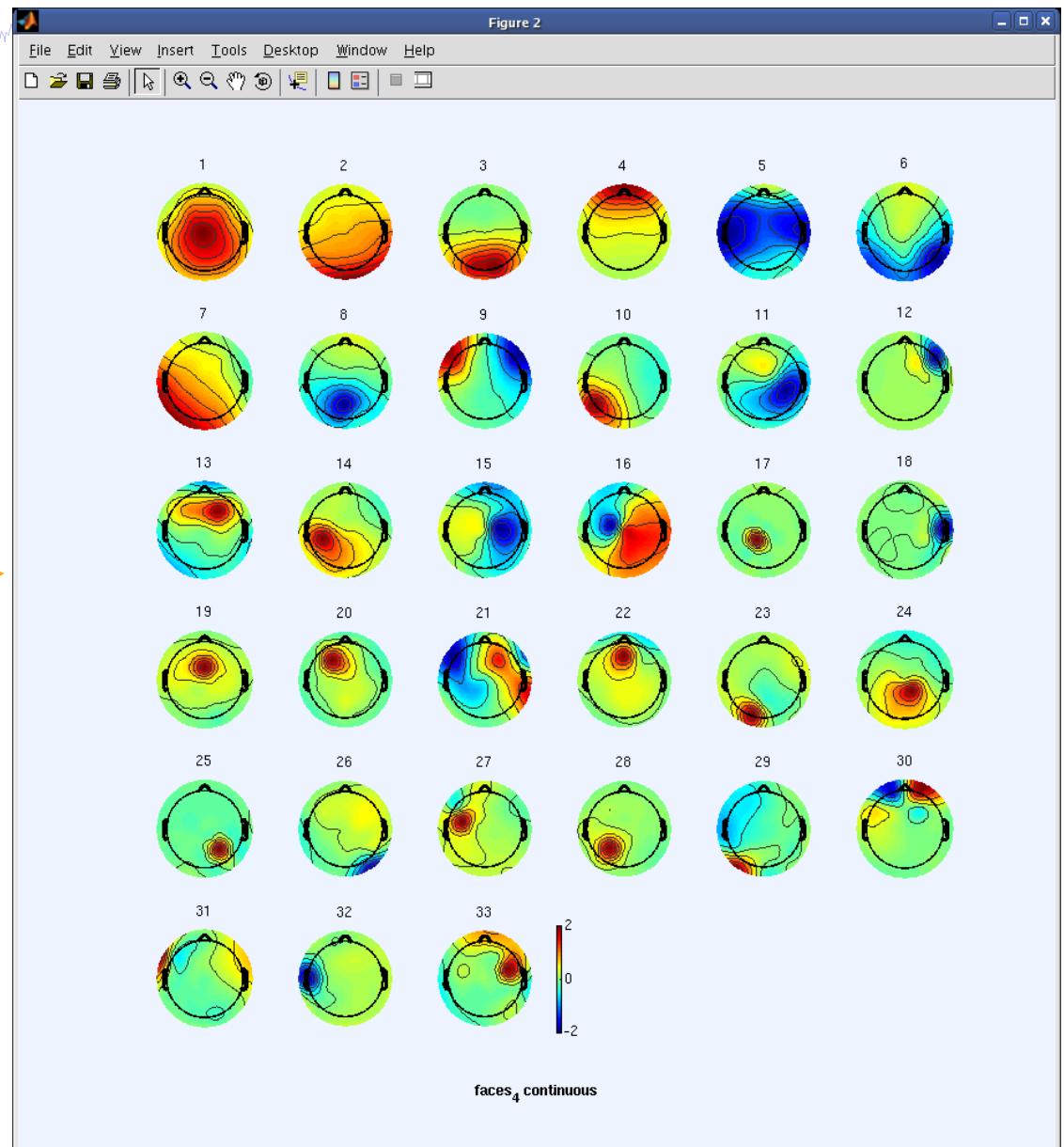
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Terminal
File Edit View Terminal Tabs Help

>> EEG

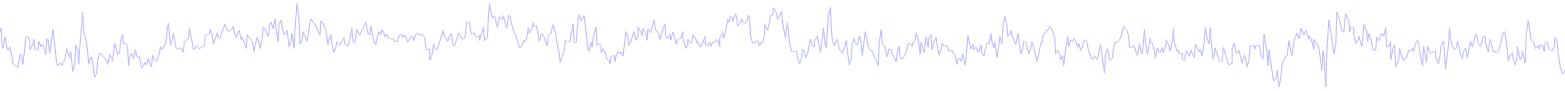
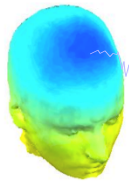
EEG =

    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]
    ica chansind: [1x33 double]
    chanlocs: [1x33 struct]
    urchanlocs: []
    chaninfo: [1x1 struct]
        ref: 'common'
    event: [1x731 struct]
    urevent: [1x731 struct]
    eventdescription: {[} {}]
    epoch: []
    epochdescription: {}
    reject: [1x1 struct]
    states: [1x1 struct]
    specdata: []
    specicaact: []
    splinefile: ''
    icasplinefile: ''
    dipfit: [1x1 struct]
    history: [1x1633 char]
    saved: 'no'
    etc: []

>>
```



Artifact rejection and running ICA



Task 1

Reject noisy data

Task 2

Run ICA

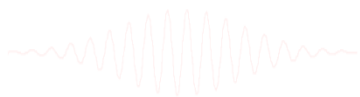
Task 3

Plot components

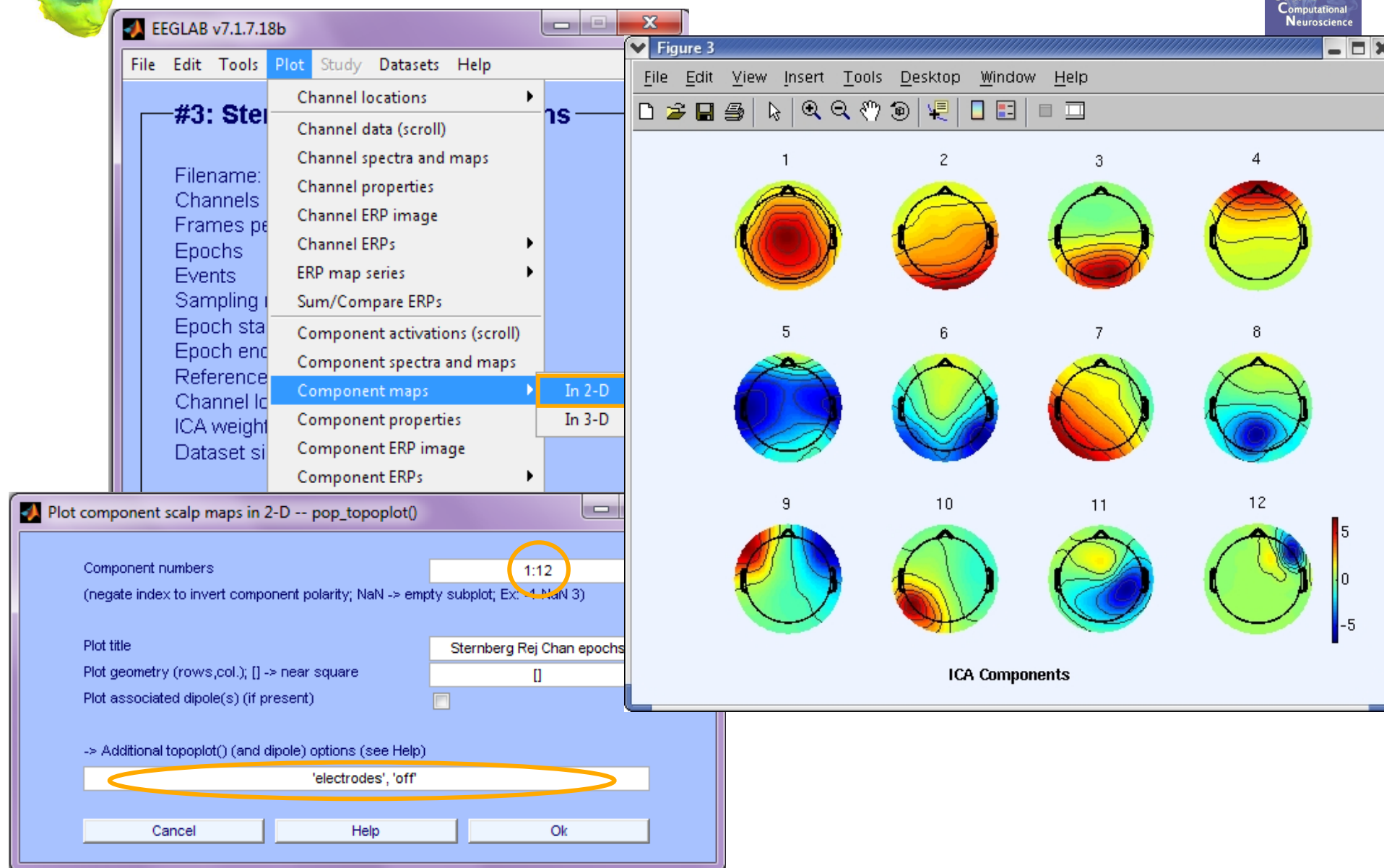
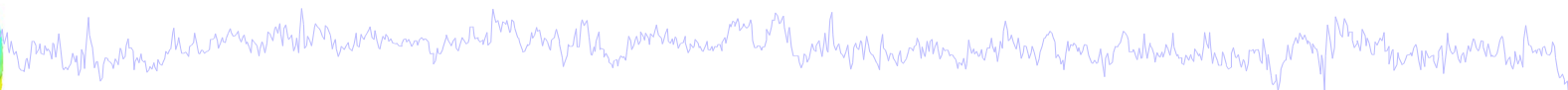
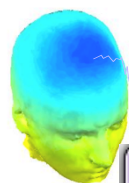
Task 4

Remove components
(i.e. back-projection)

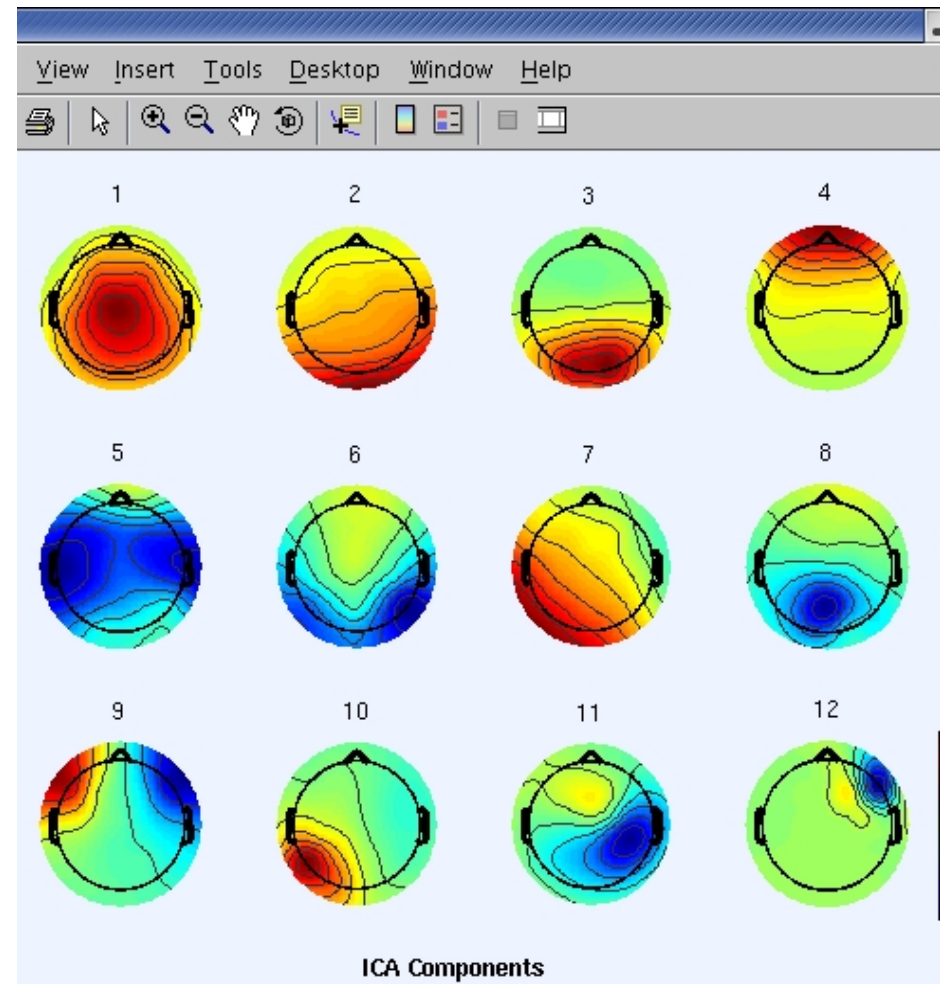
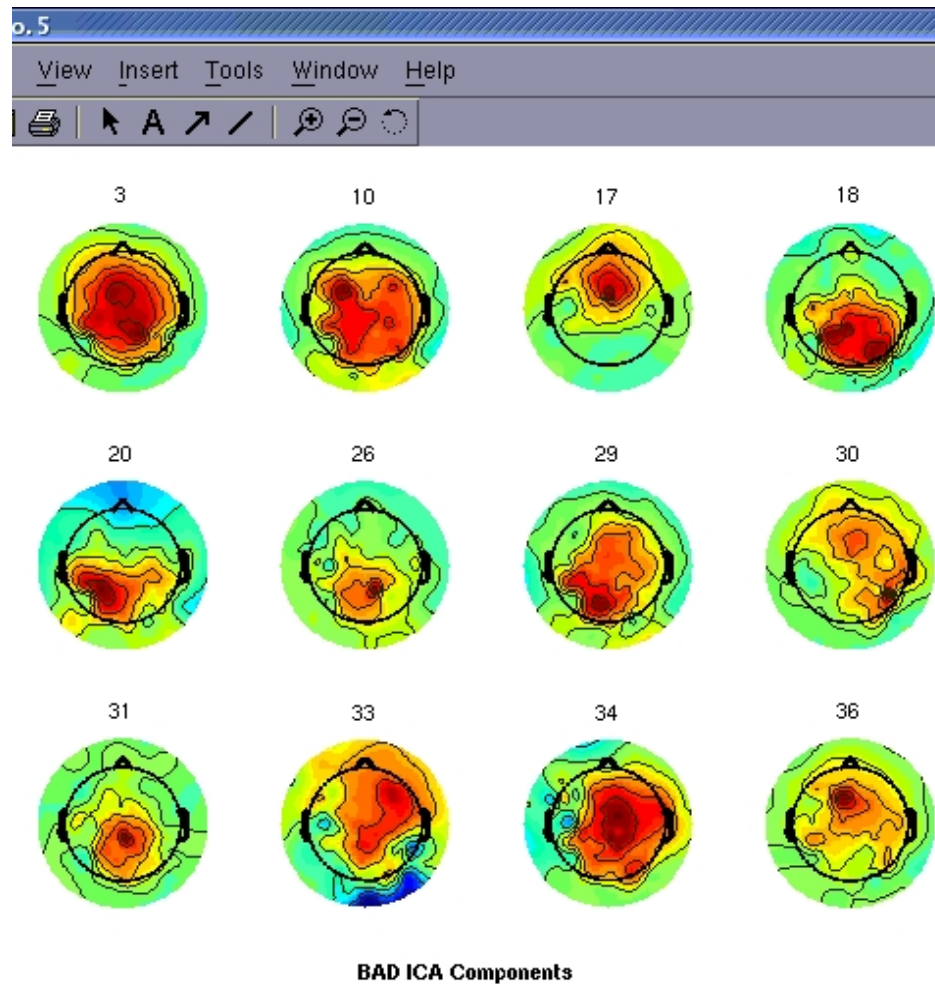
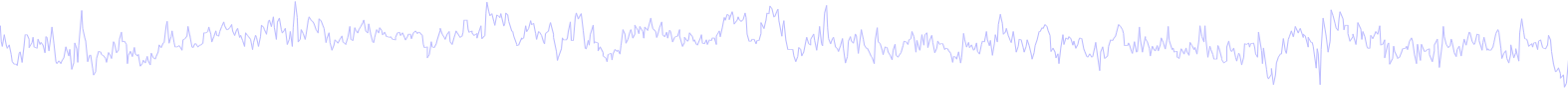
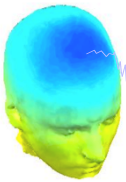
Exercise...



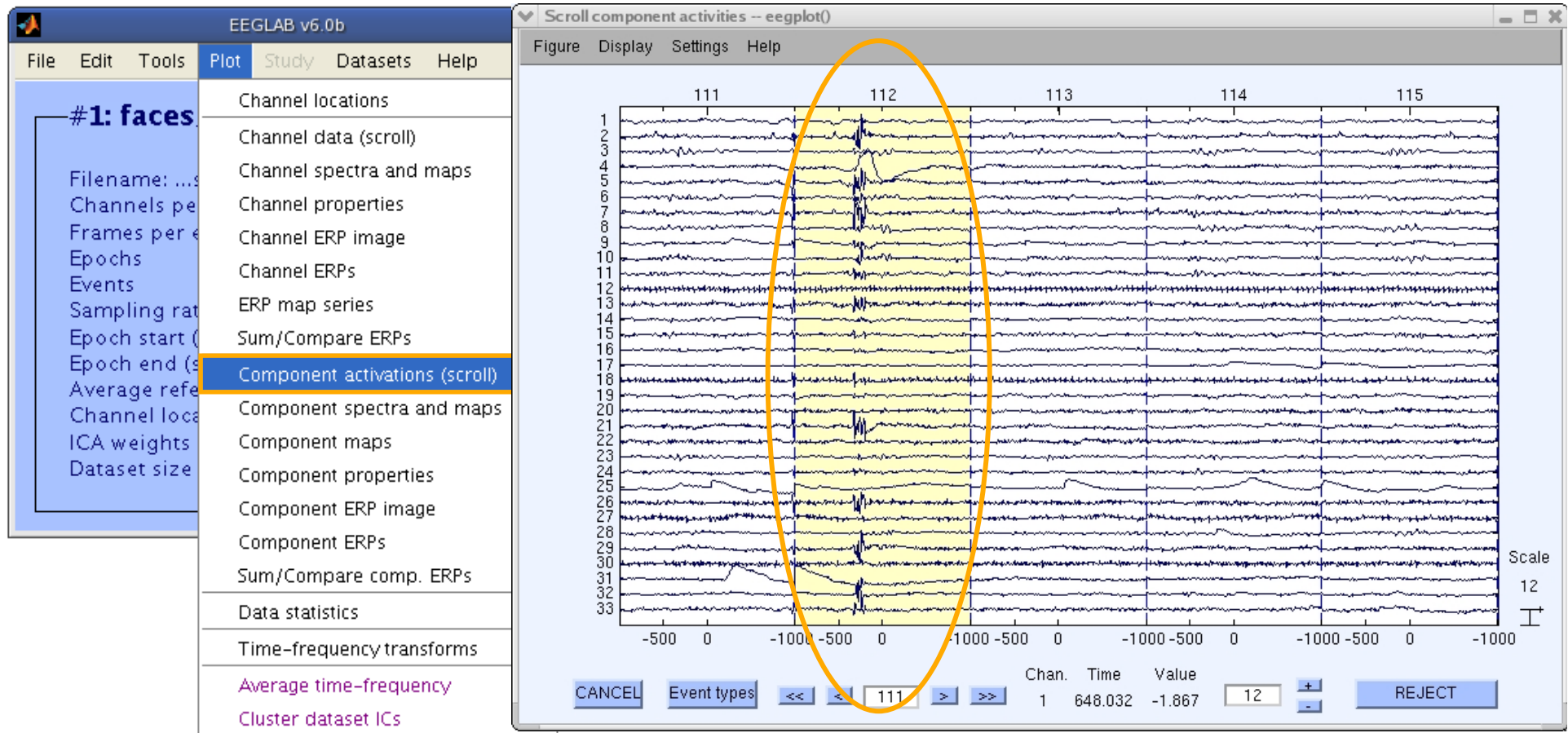
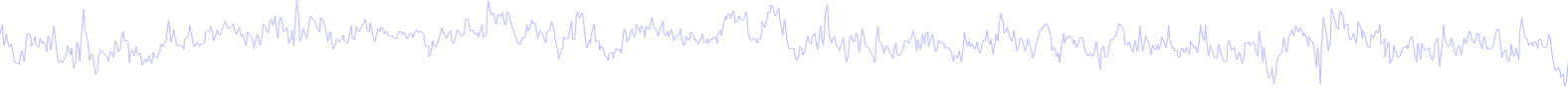
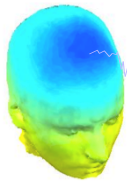
Plot ICA scalp maps



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**

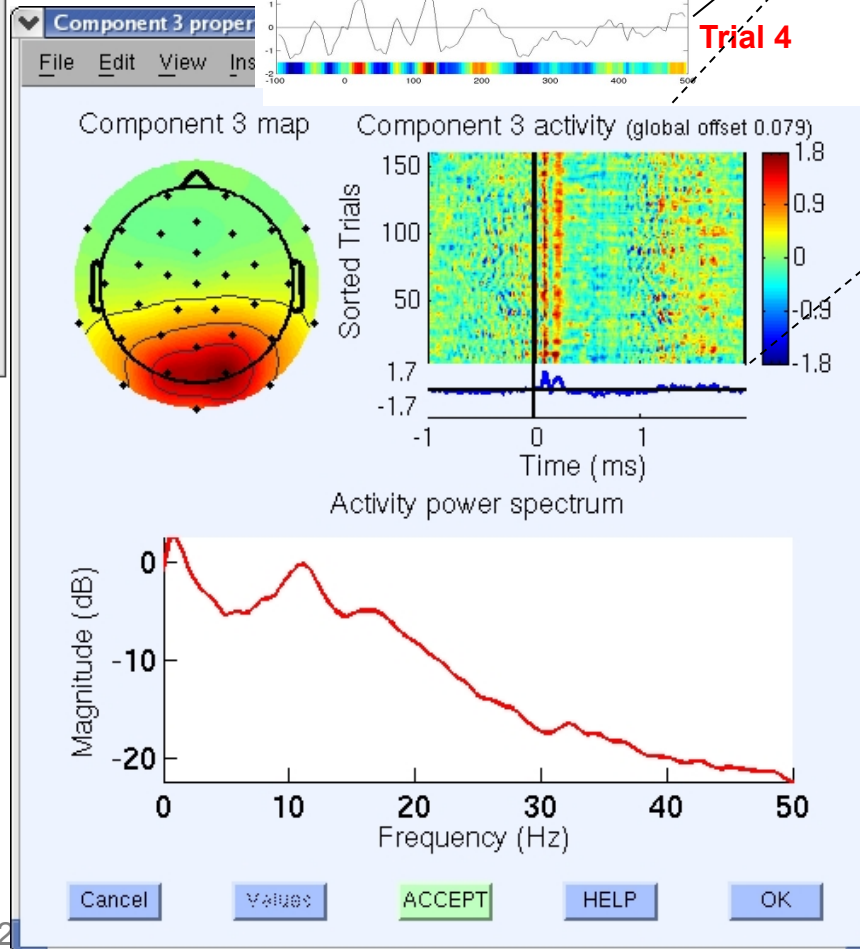
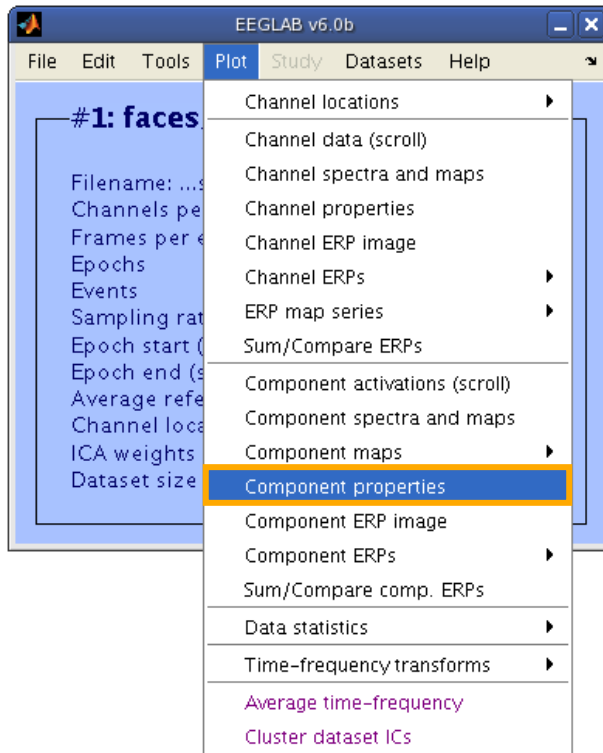
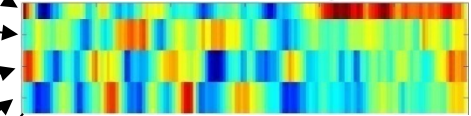


Trial 2

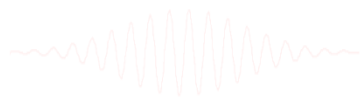
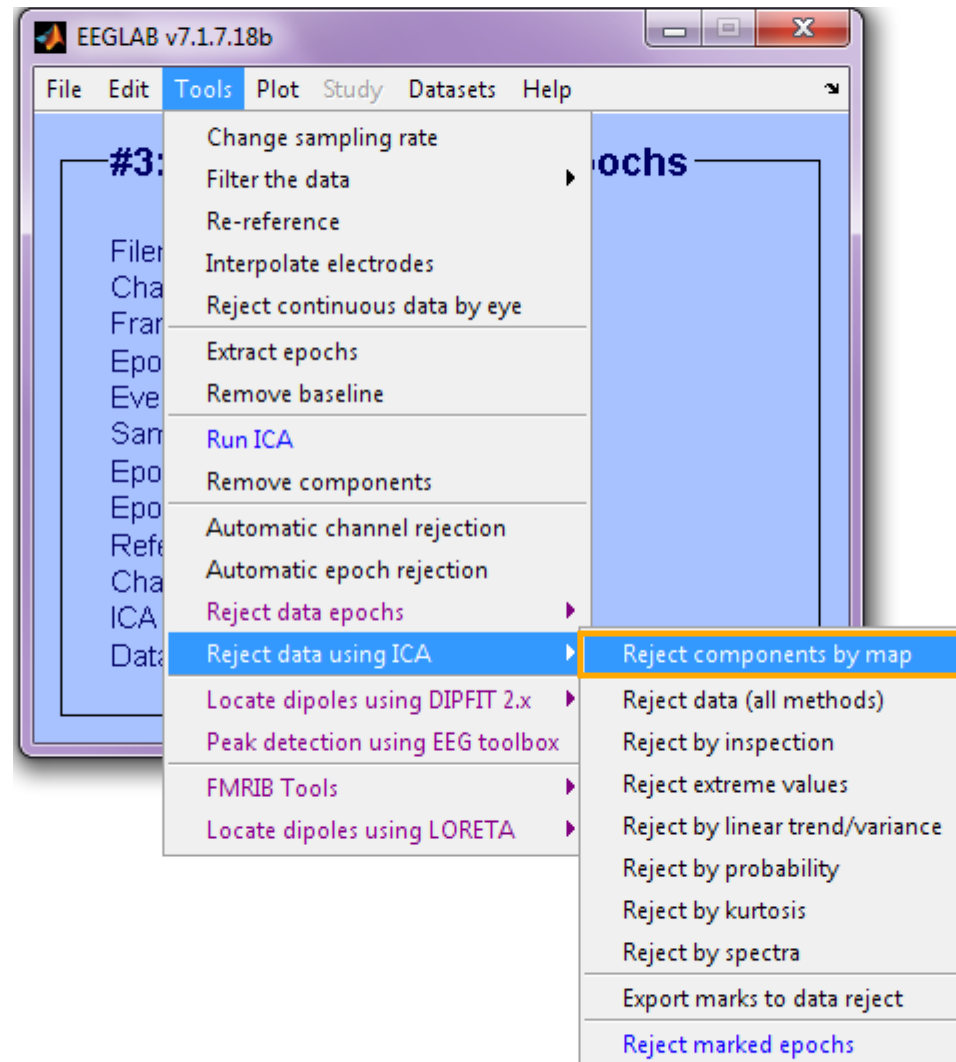
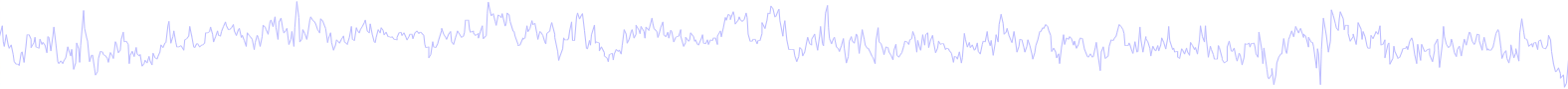
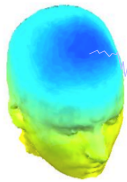
Trial 3

Trial 4

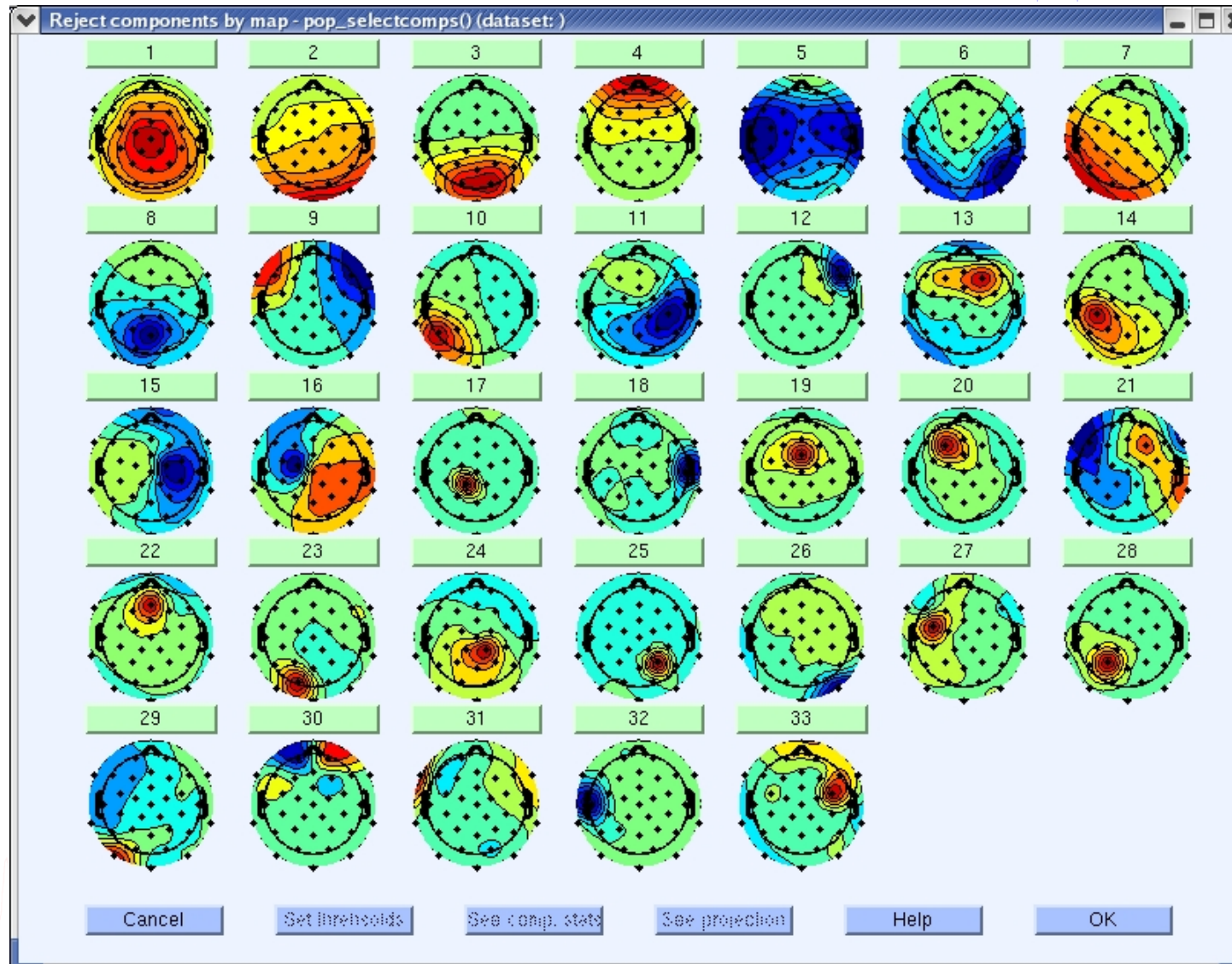
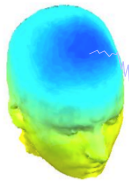
ERP Image

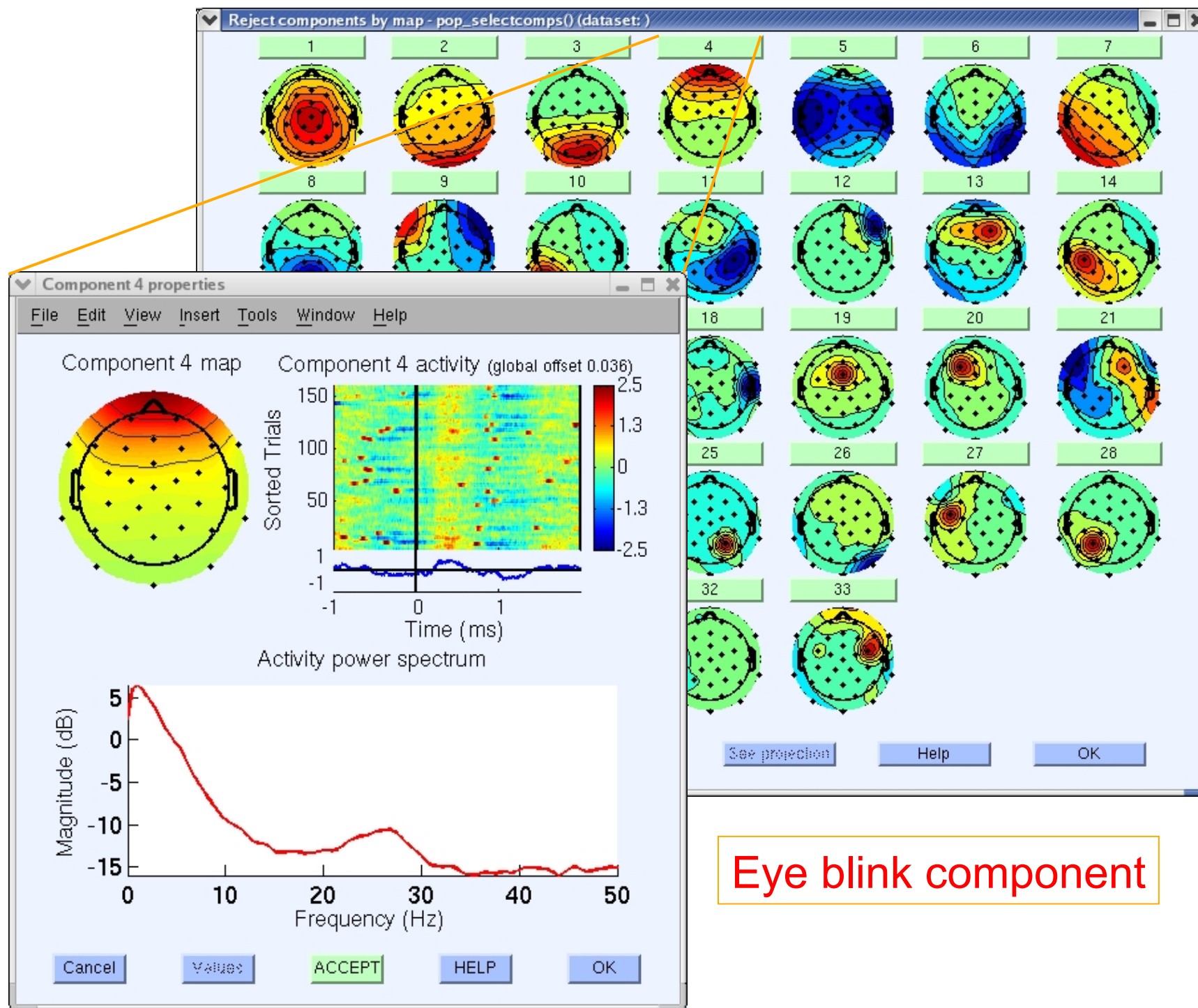


Reviewing component properties

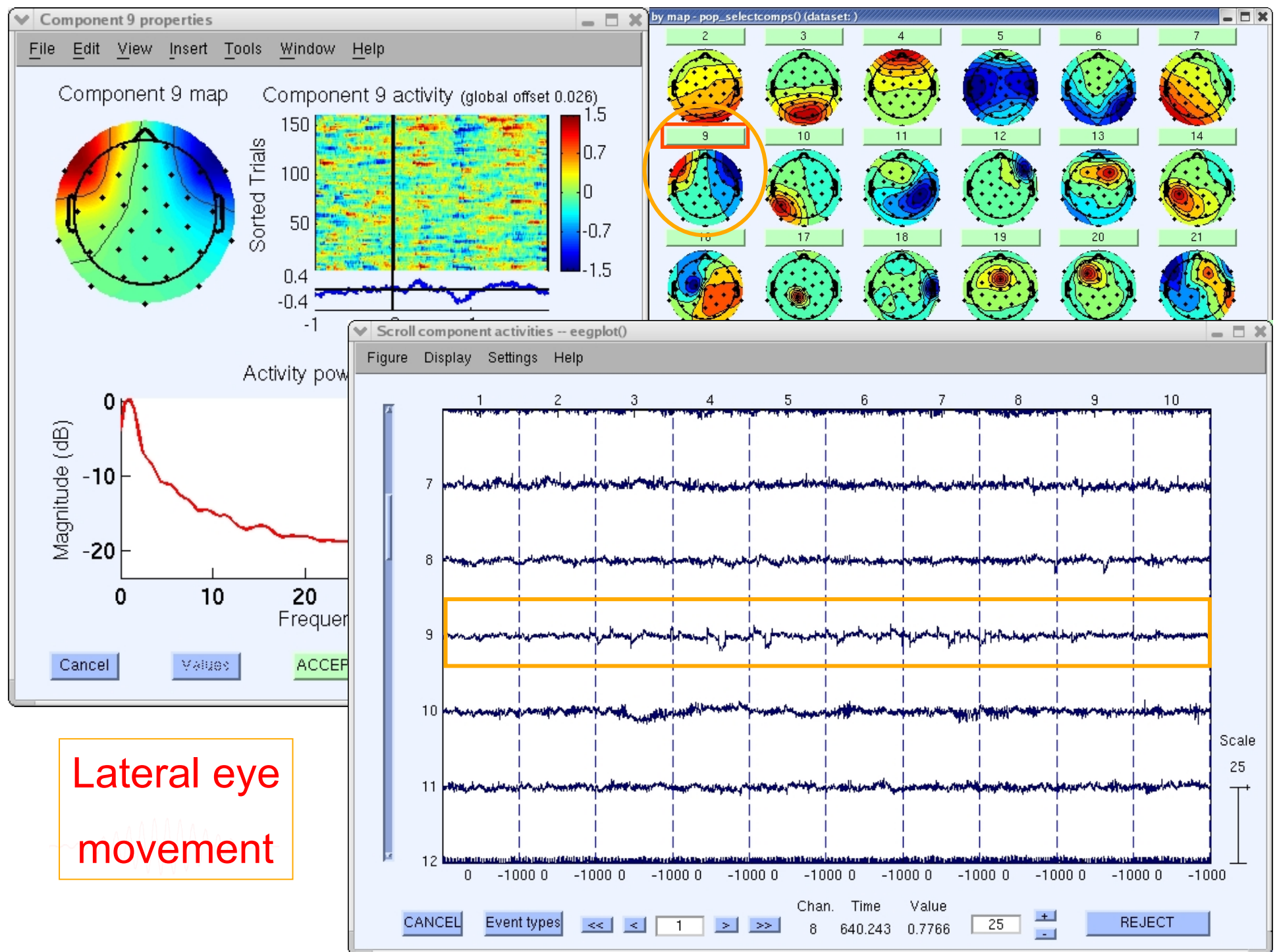


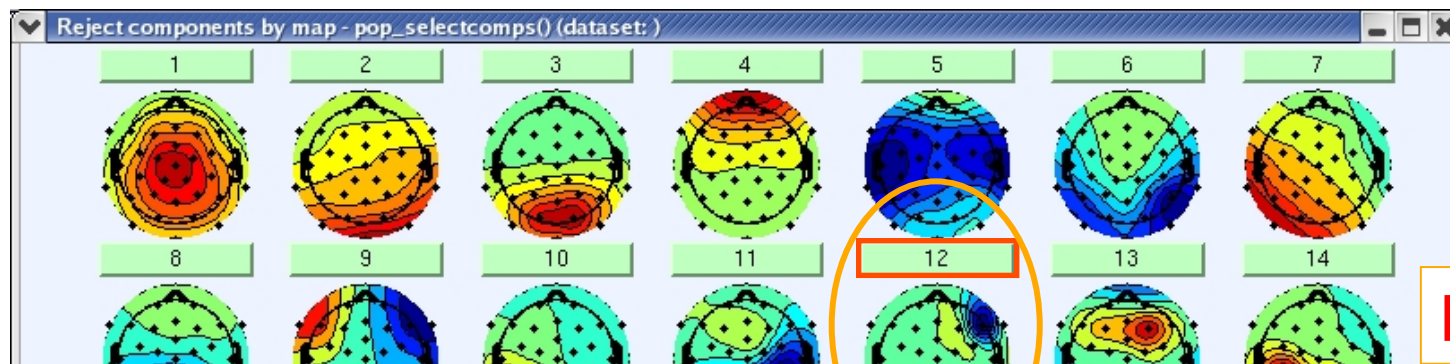
Component scalp maps/properties



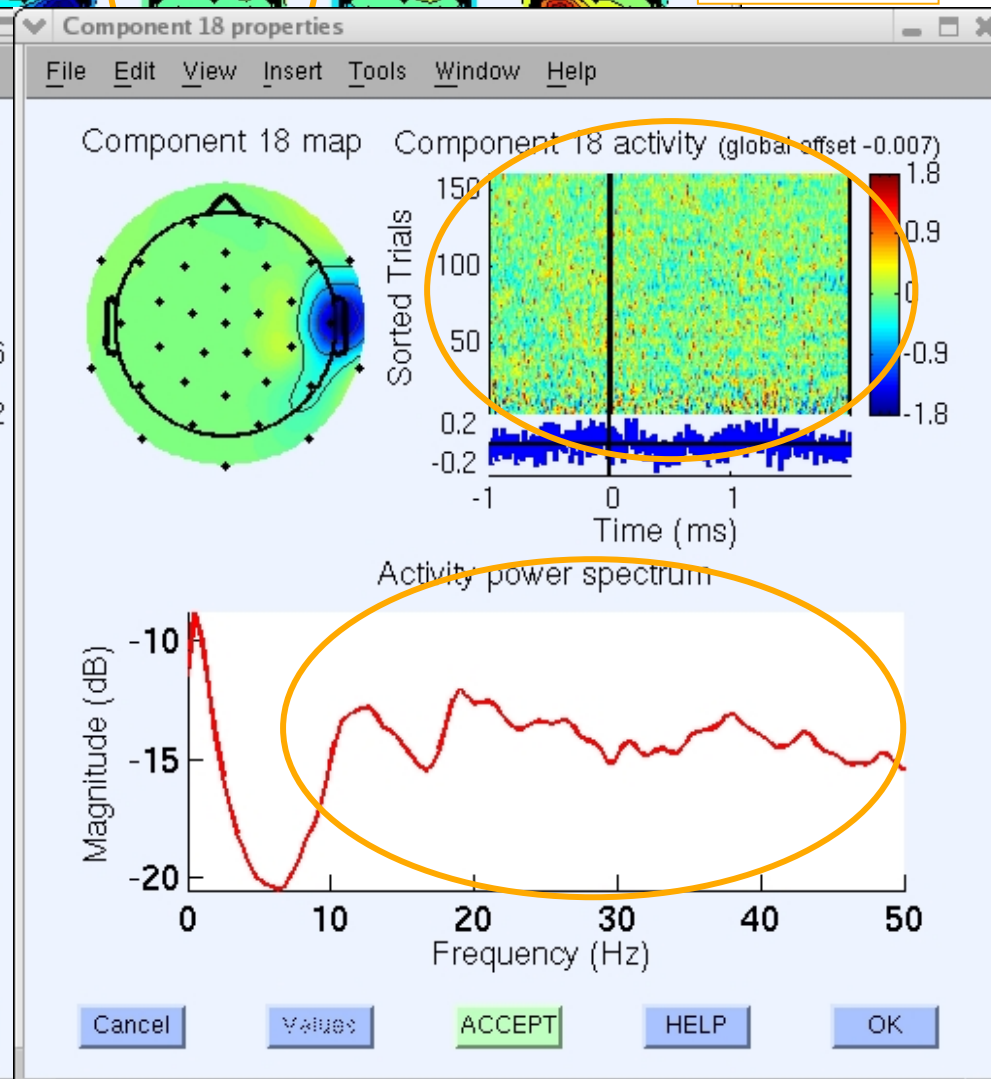
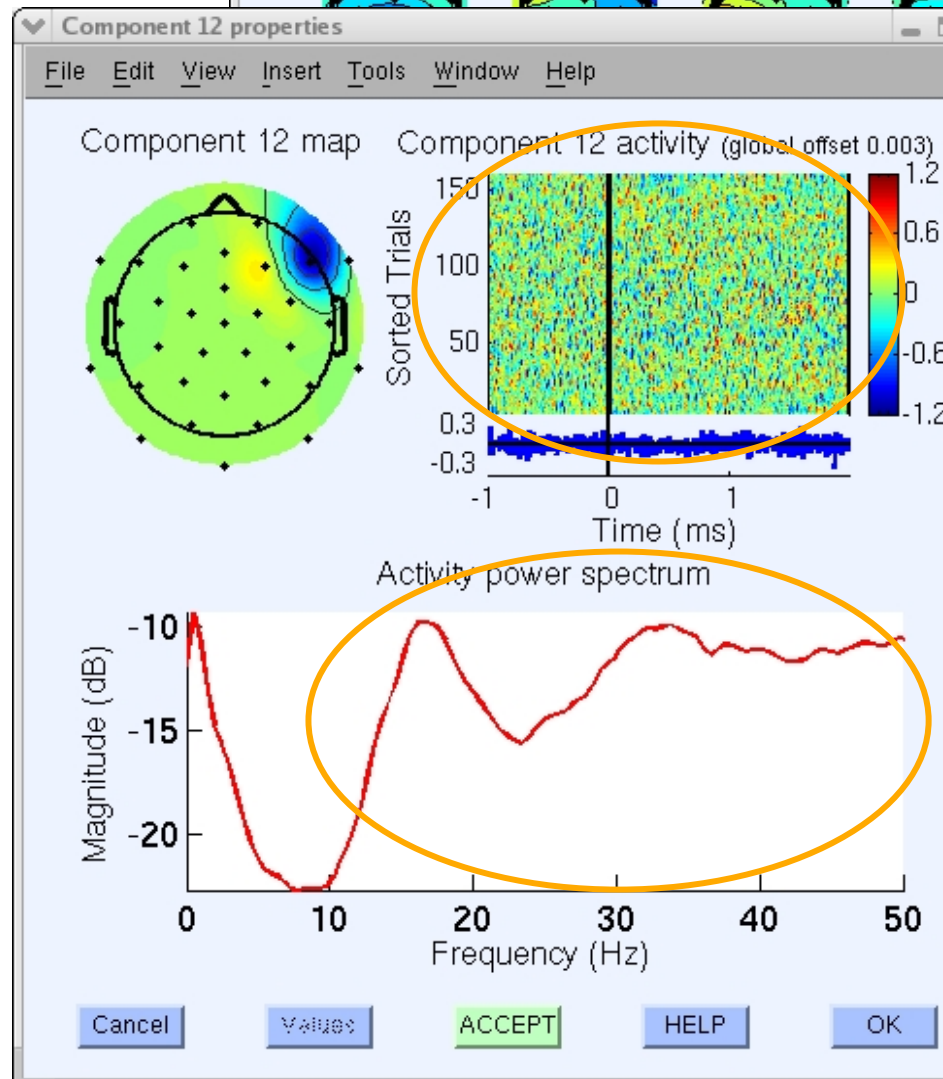


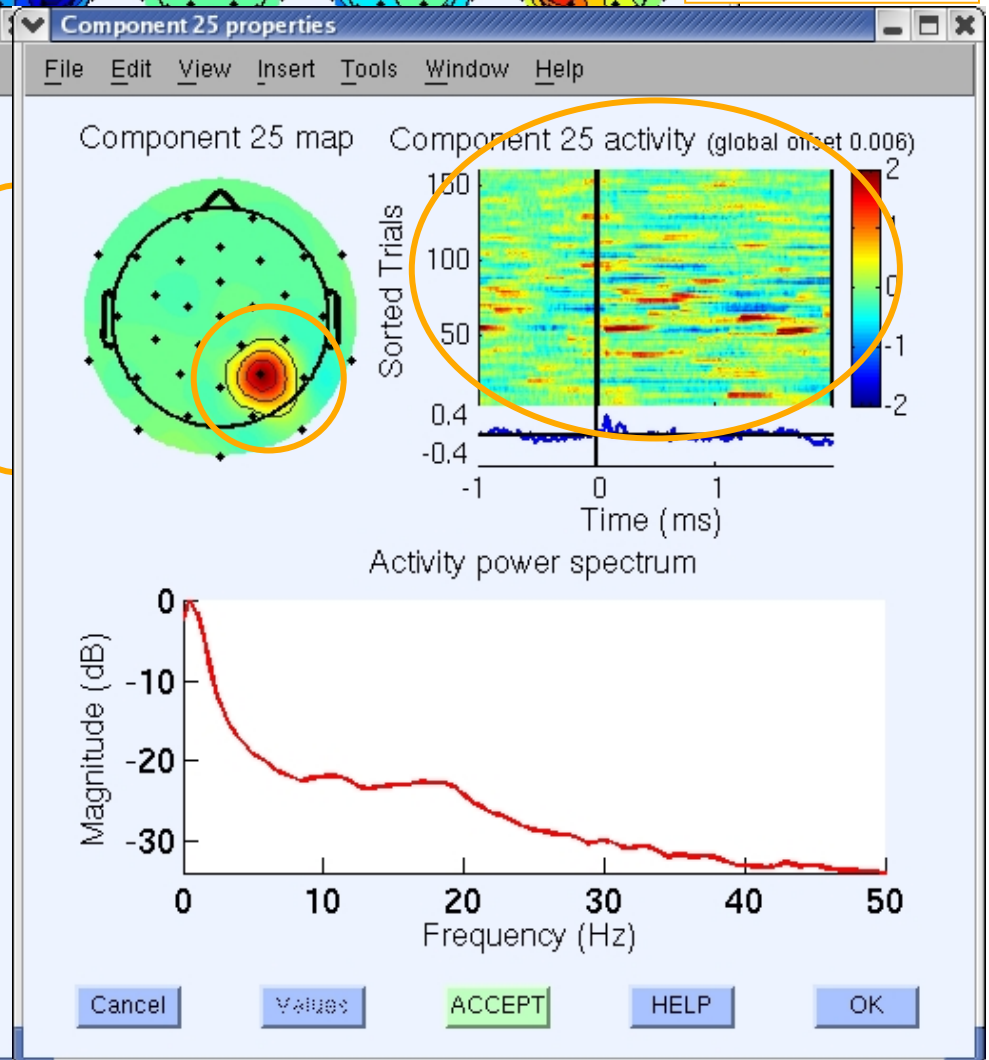
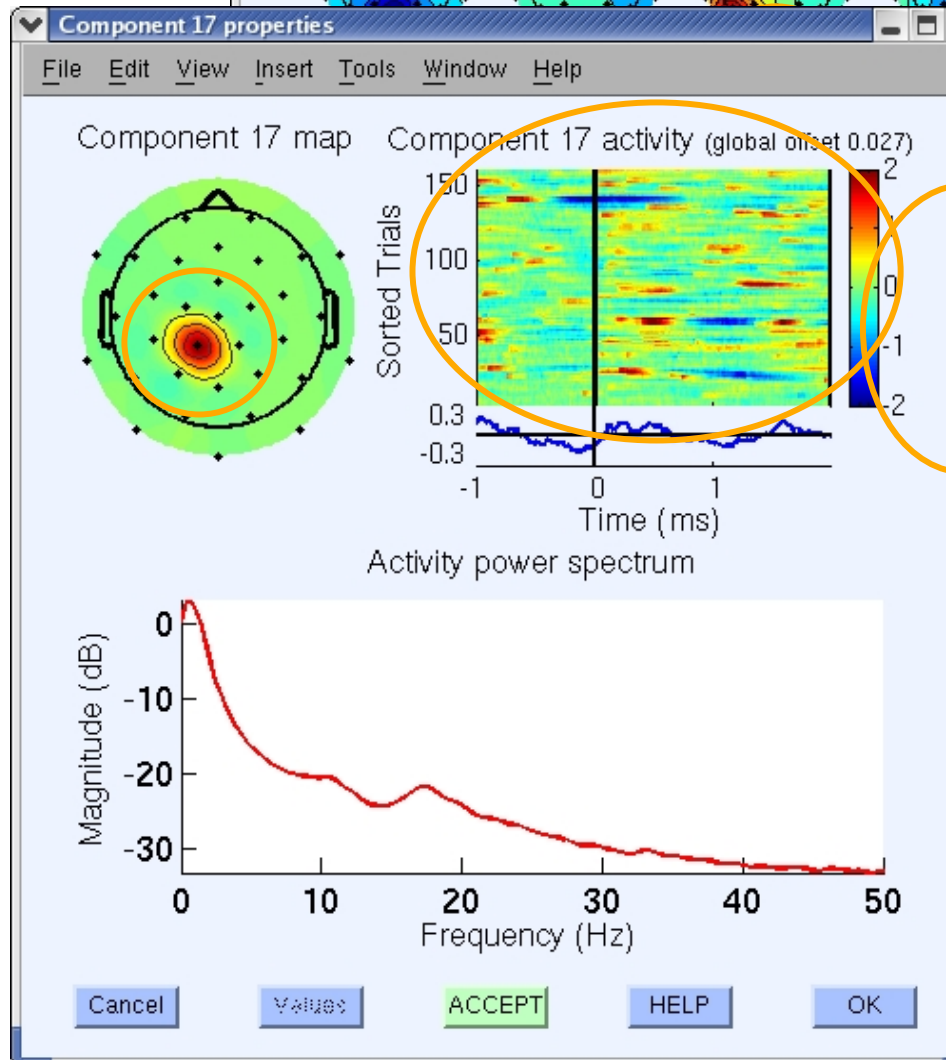
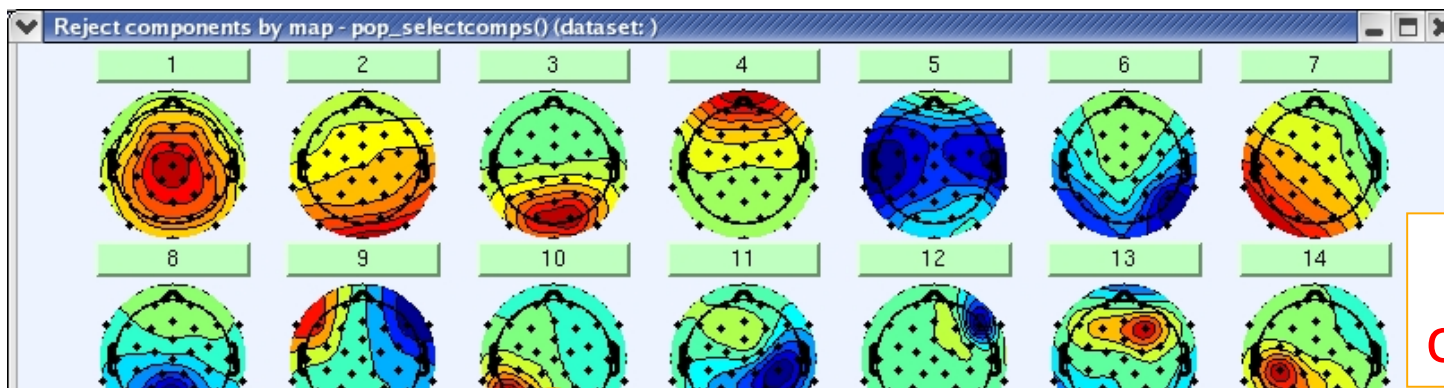
Eye blink component

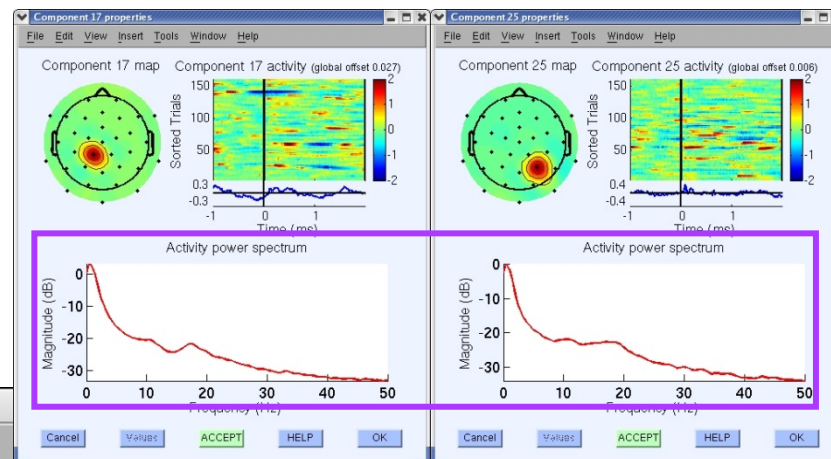
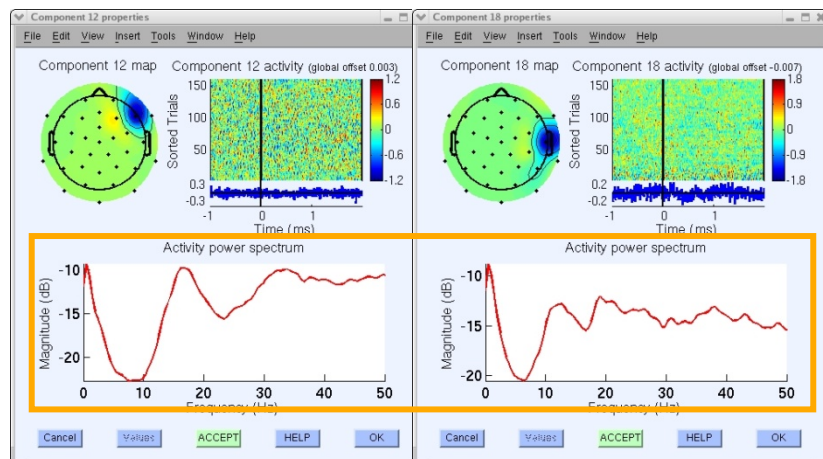




Muscle







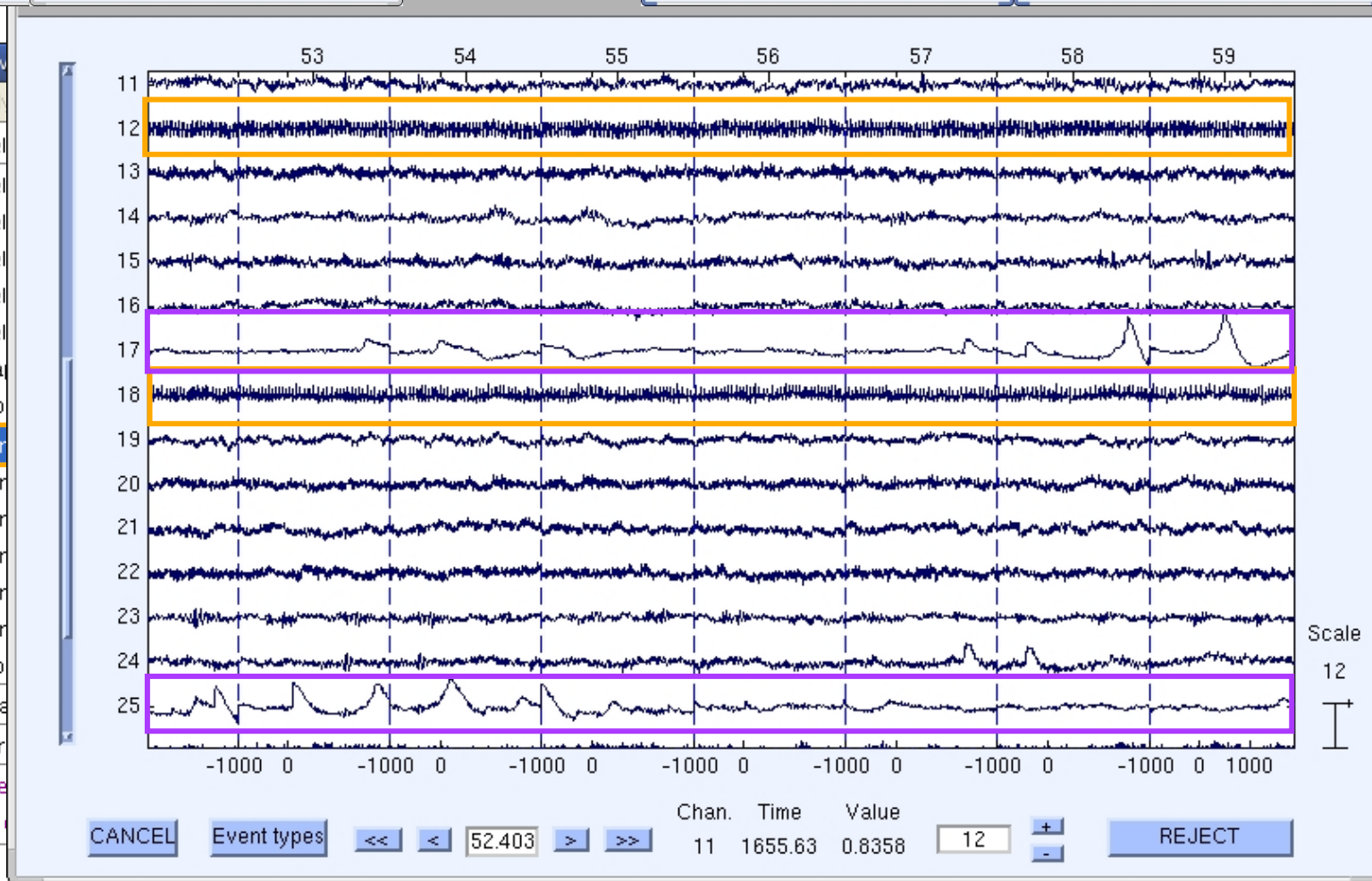
EEGLAB v.2012.0.1.10

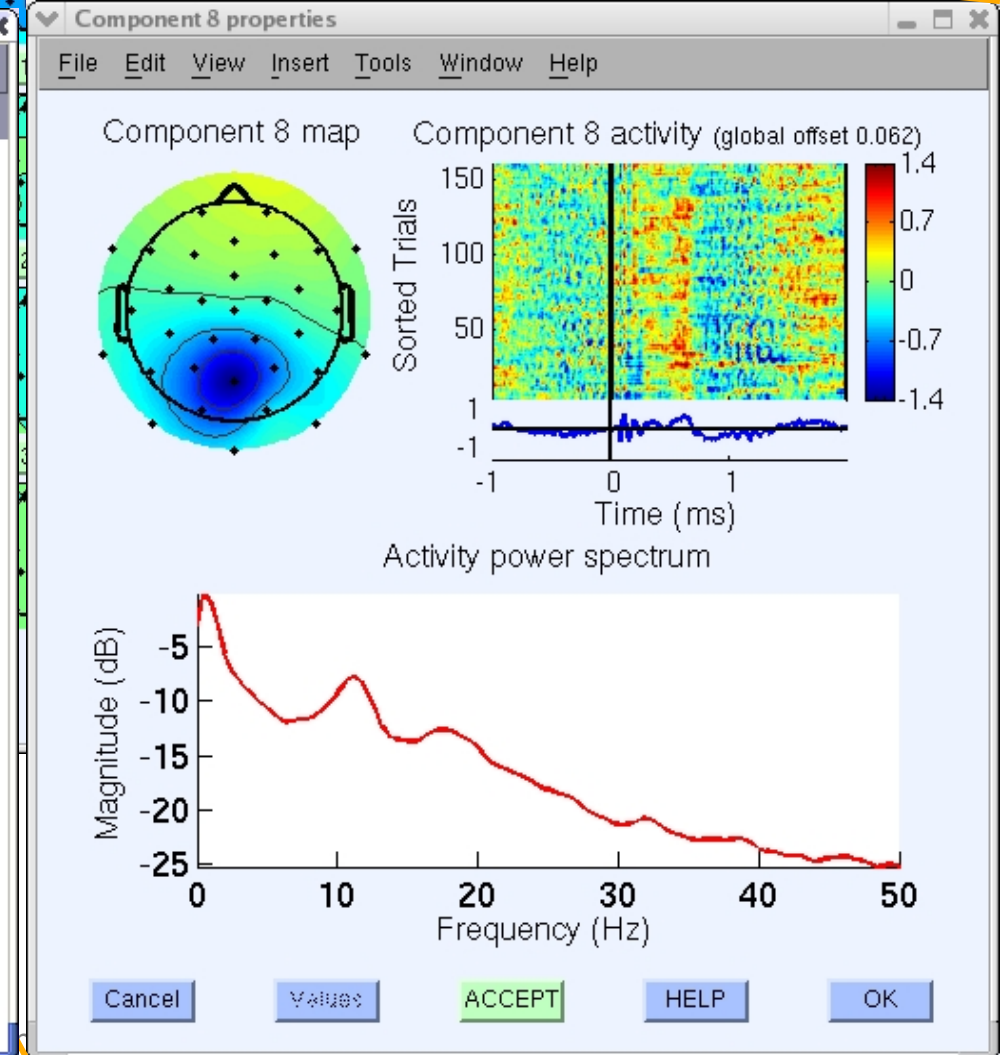
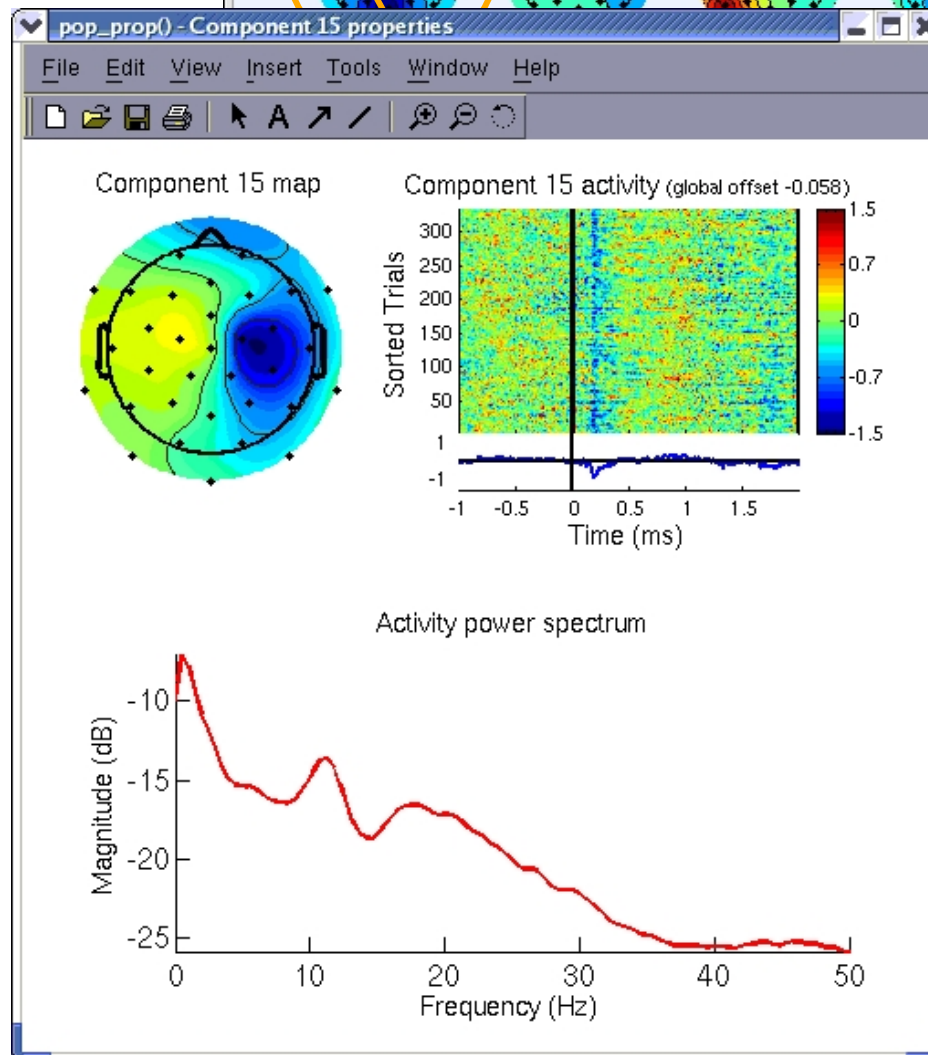
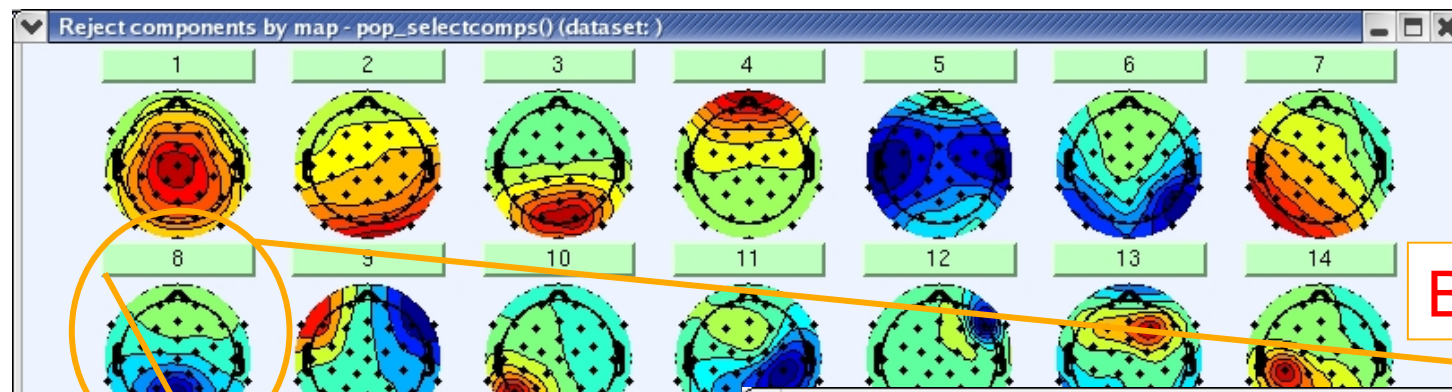
File Edit Tools Plot Study

#1: faces

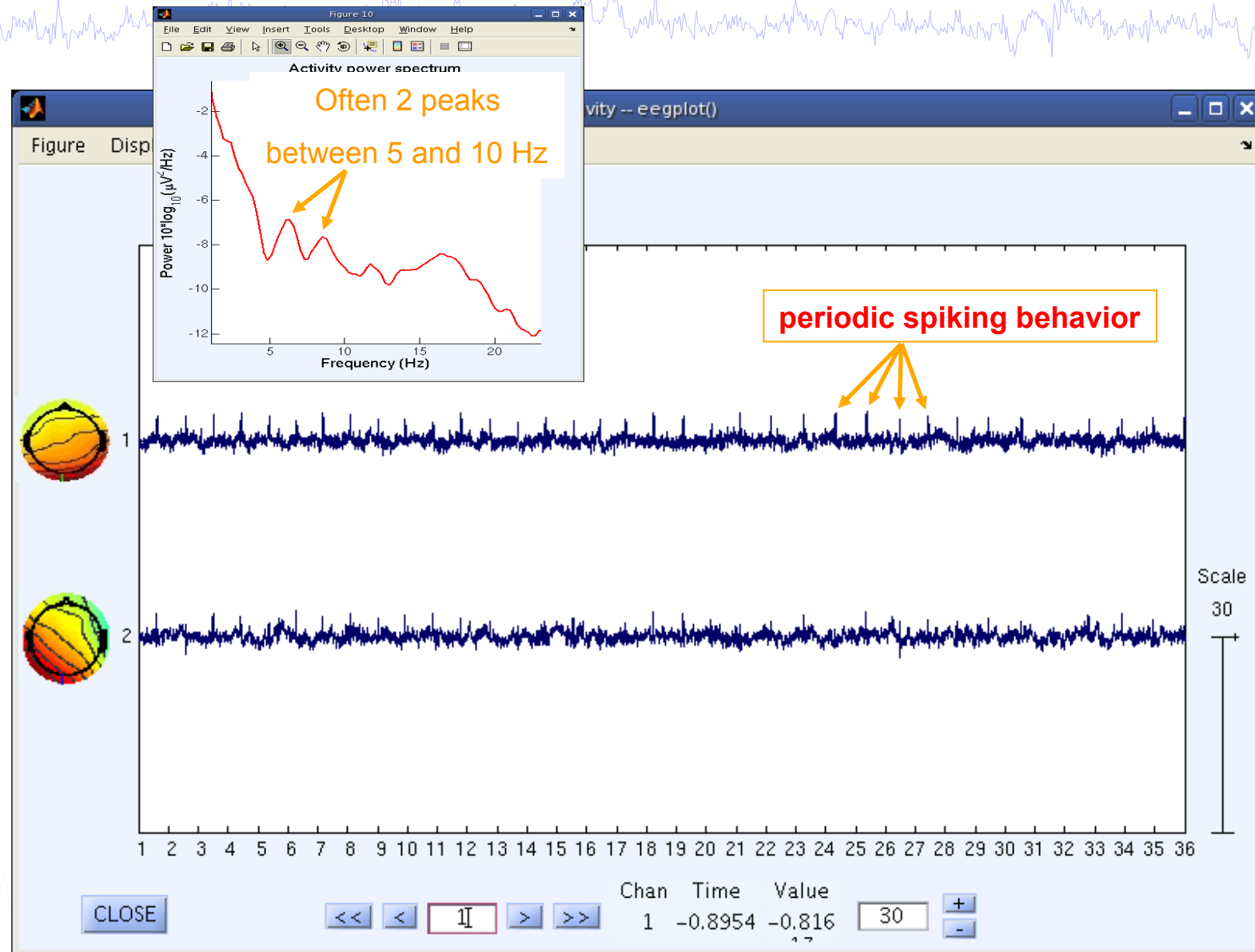
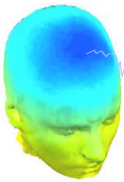
Filename: ...
 Channels per ...
 Frames per e ...
 Epochs
 Events
 Sampling rat ...
 Epoch start (...
 Epoch end (s ...
 Average refe ...
 Channel loca ...
 ICA weights ...
 Dataset size

Channel ...
 Channel ...
 Channel ...
 Channel ...
 Channel ...
 Channel ...
 ERP ma ...
 Sum/Co ...
Compor ...
 Compor ...
 Compor ...
 Compor ...
 Compor ...
 Compor ...
 Sum/Co ...
 Data sta ...
 Time-fr ...
 Average ...
 Cluster ...

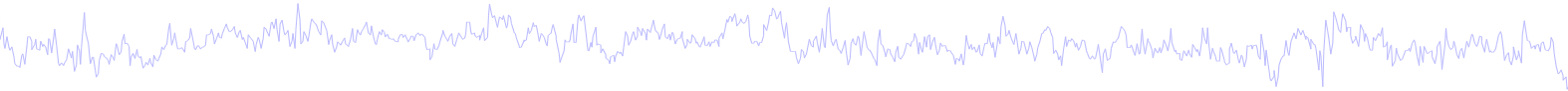
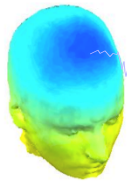




Pulse artifacts



Artifact rejection and running ICA



Task 1

Reject noisy data

Task 2

Run ICA

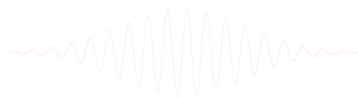
Task 3

Plot components

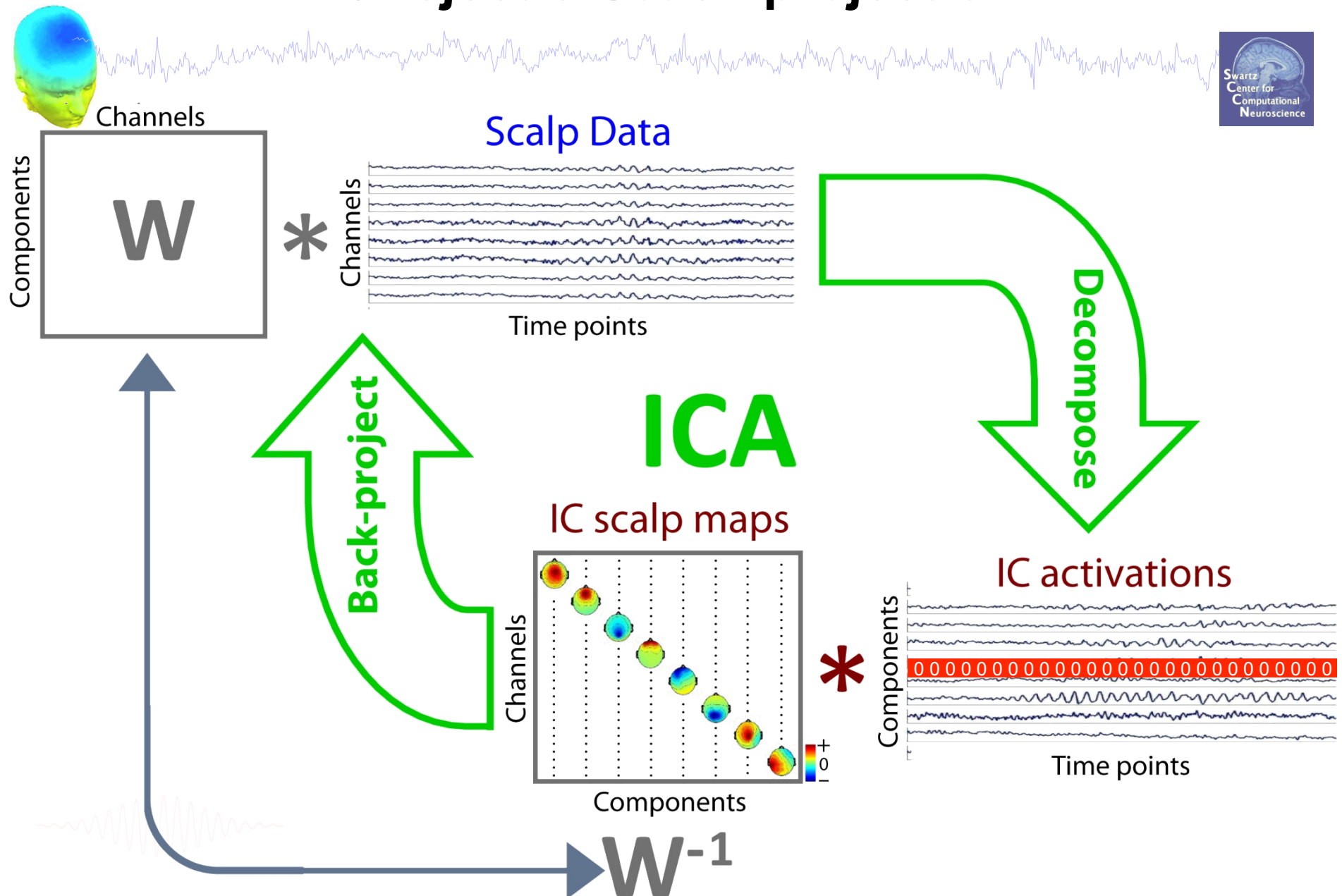
Task 4

Remove components
(i.e. back-projection)

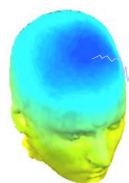
Exercise...



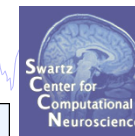
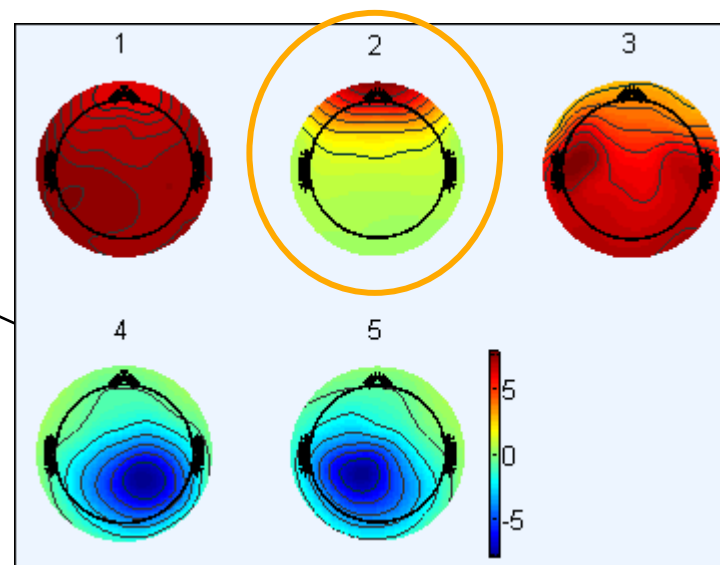
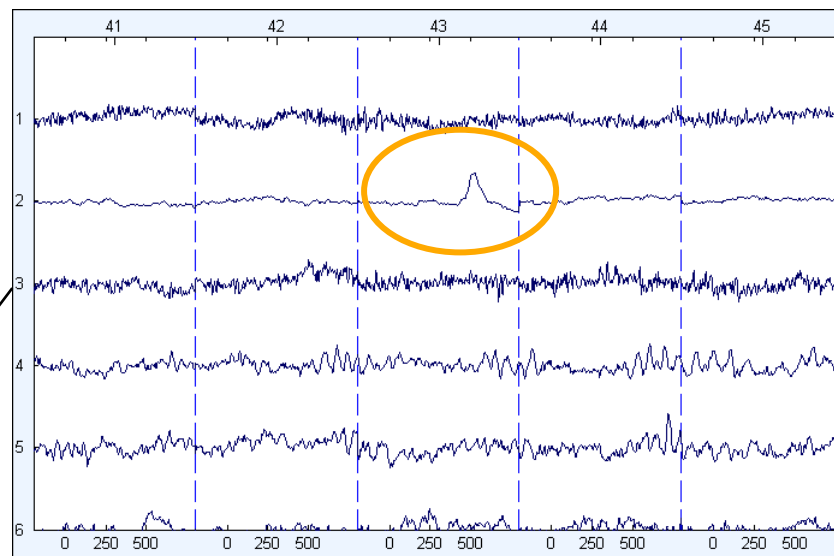
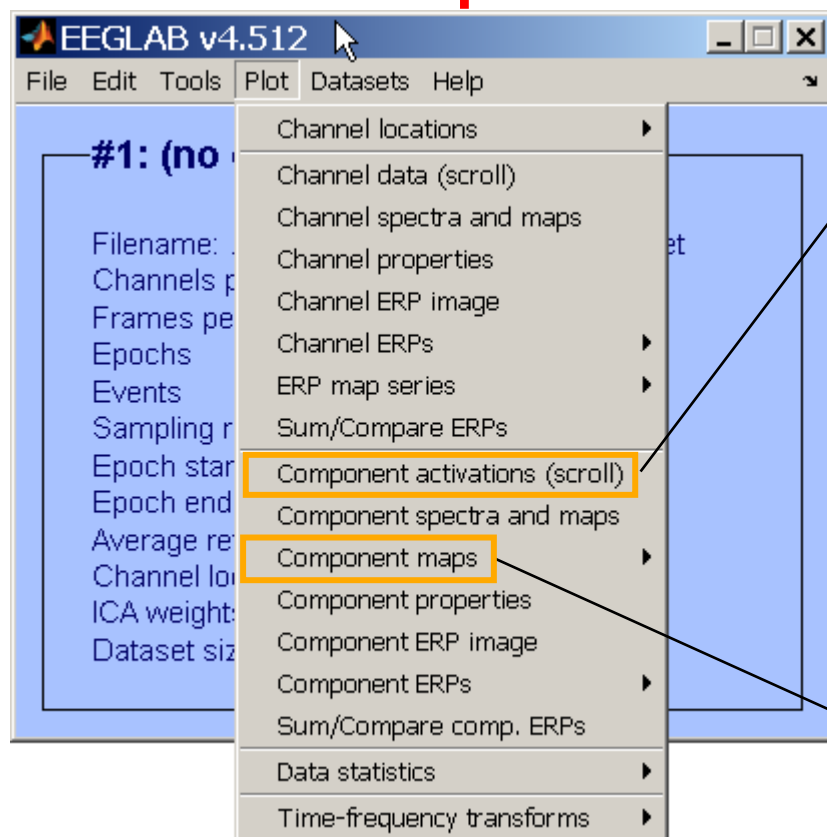
IC rejection/back-projection



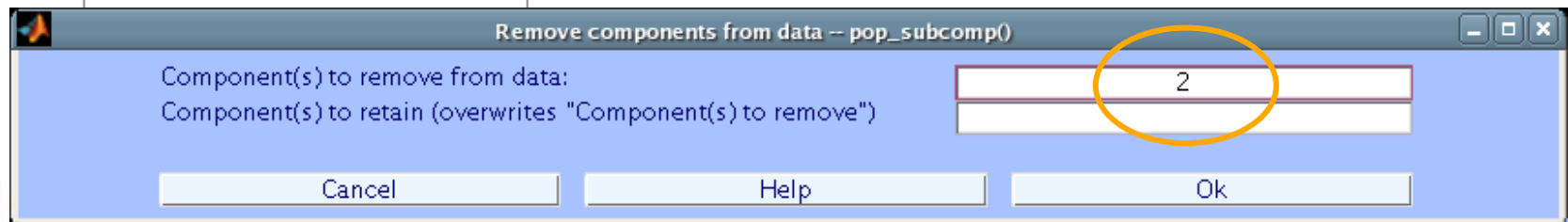
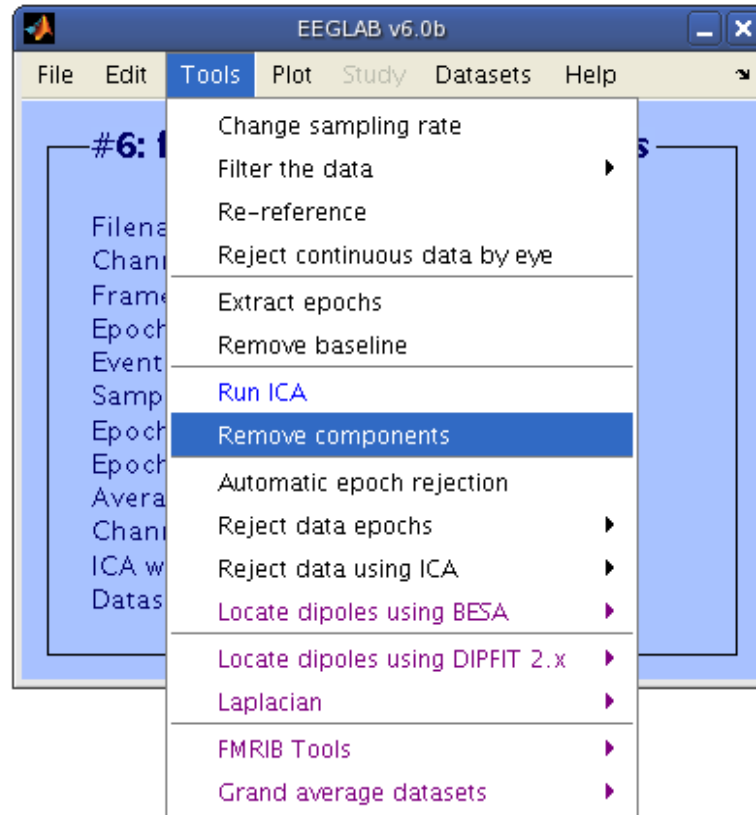
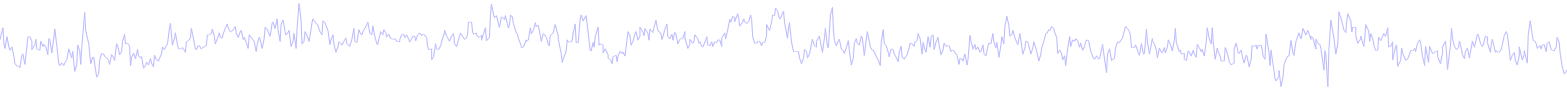
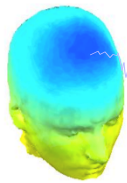
Eye blink correction



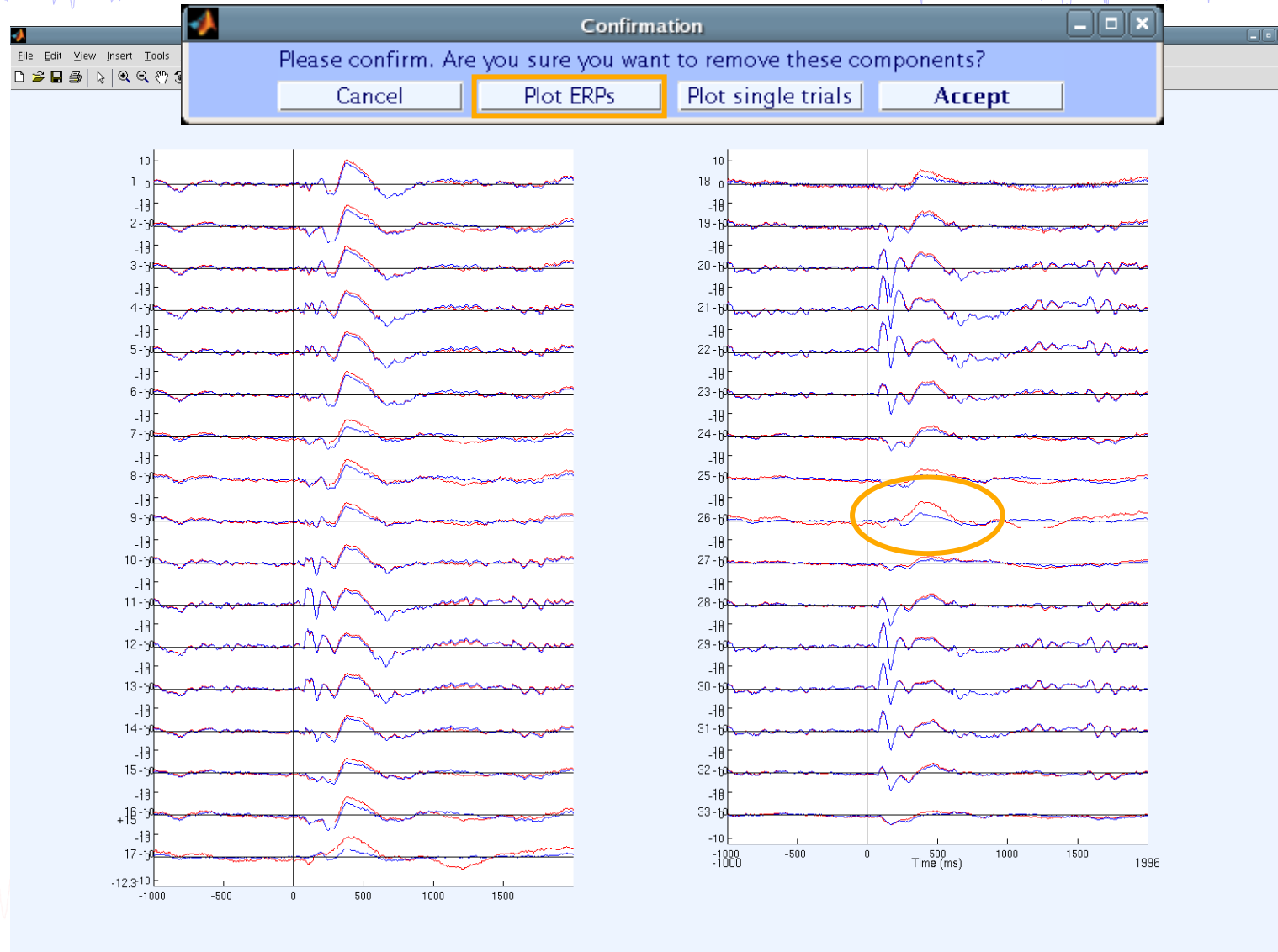
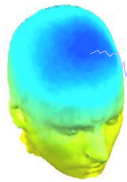
**Identify eye-blink
components:**



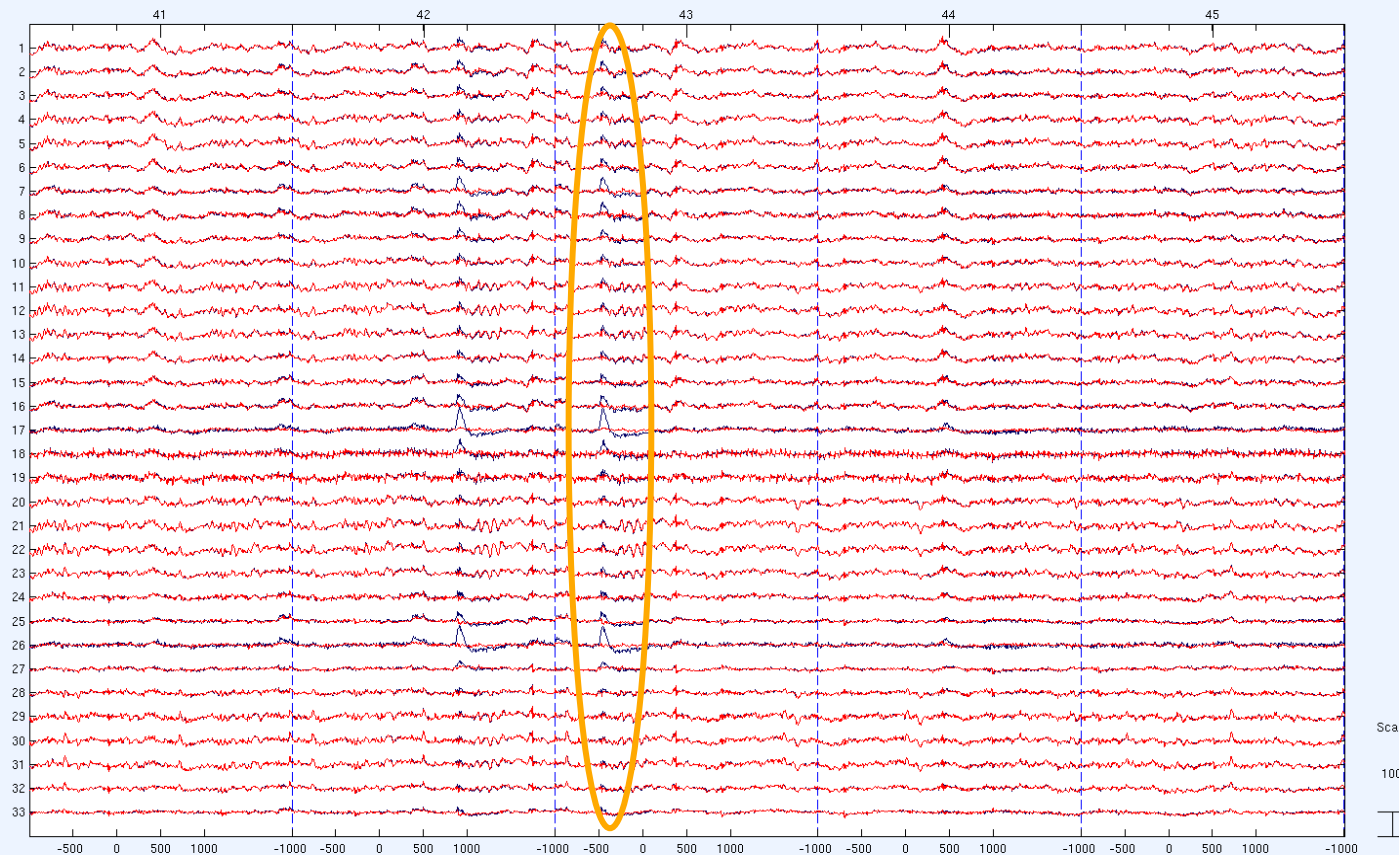
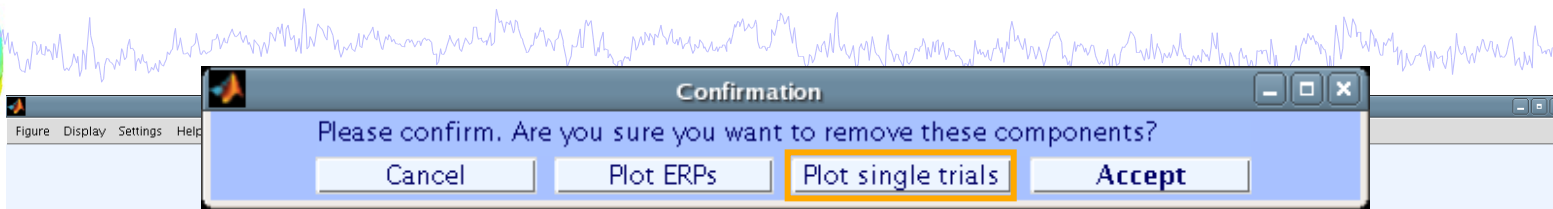
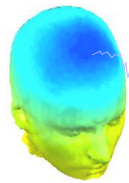
Eye blink correction



Eye blink correction



Eye blink correction

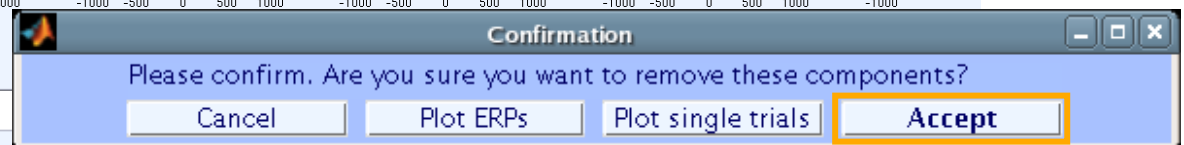


CLOSE

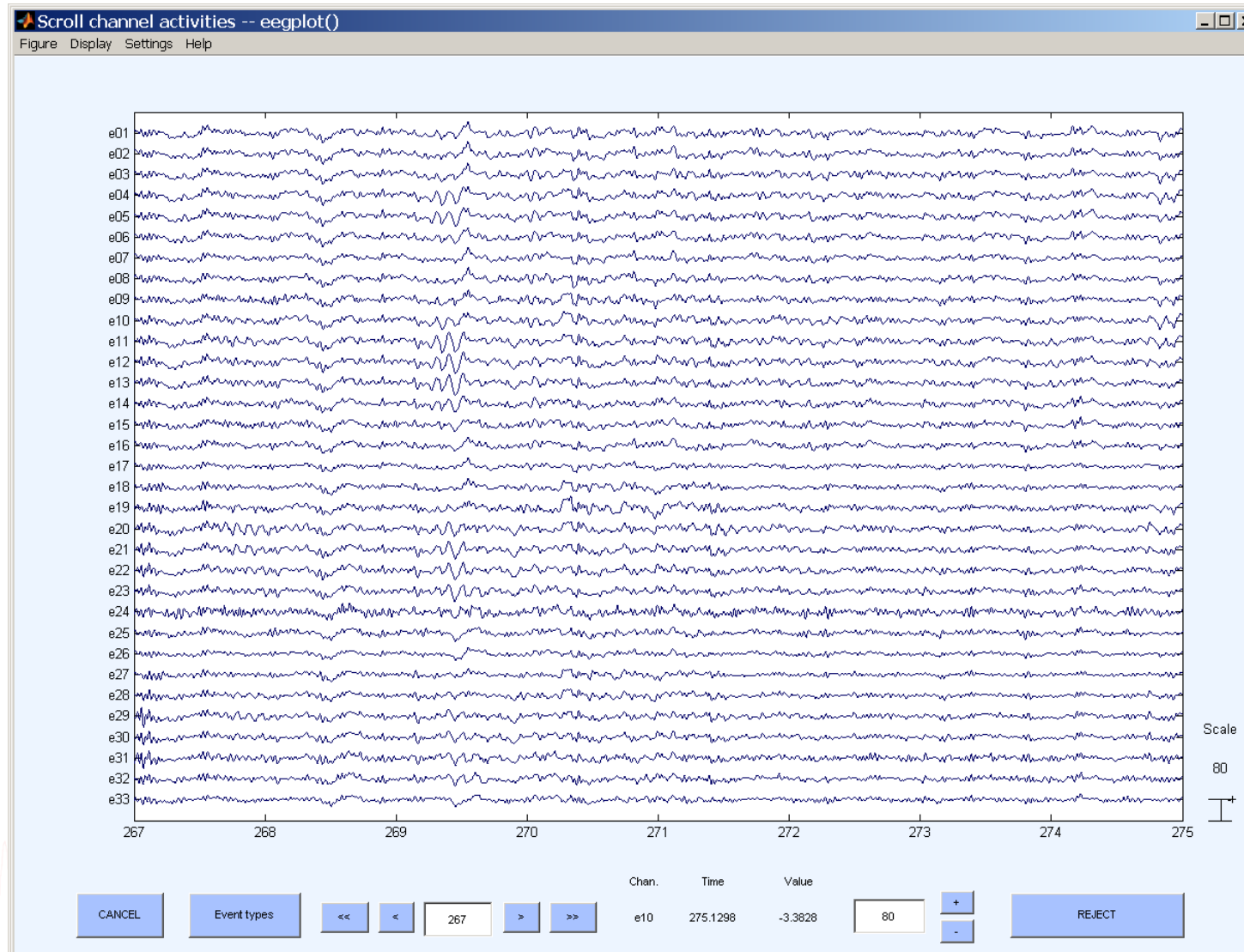
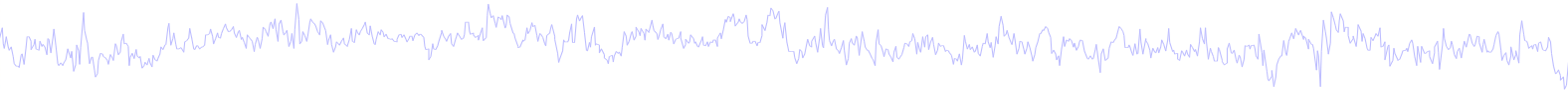
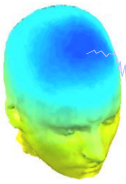
<<

<

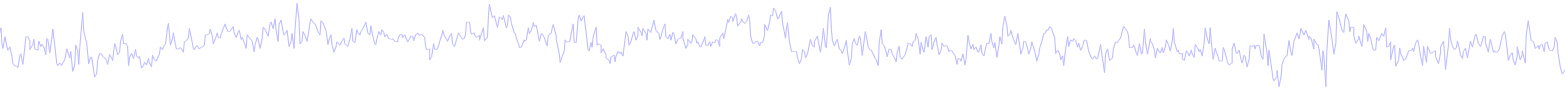
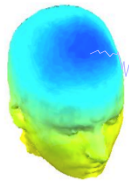
41



Eye blink correction



Exercise



- **ALL**
 - Load stern_125Hz.set
 - Epoch the data on **memorize** and **ignore** letters
 - Scroll the data and perform visual rejection
 - Try auto-rejection function and compare to visual inspection
 - Find and identify “artifact” ICs
 - How can you be sure that an IC is artifact?
 - Practice removing 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?

