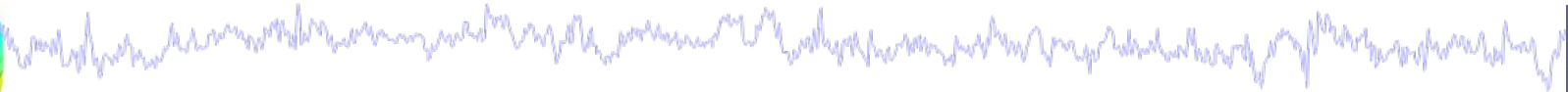


Artifact rejection and running ICA



Task 1

Reject noisy data

Task 2

Run ICA

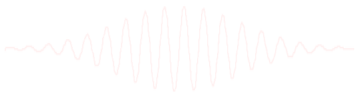
Task 3

Plot components

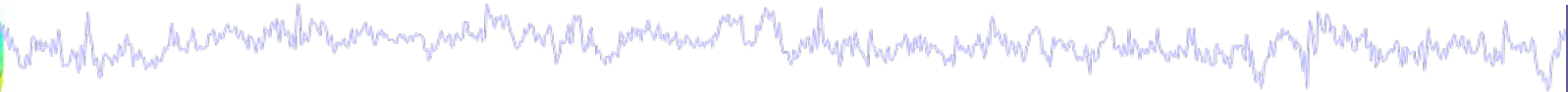
Task 4

Remove components
(i.e. back-projection)

Exercise...



Artifact rejection and running ICA



Task 1

Reject noisy data

Task 2

Run ICA

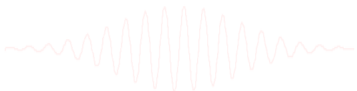
Task 3

Plot components

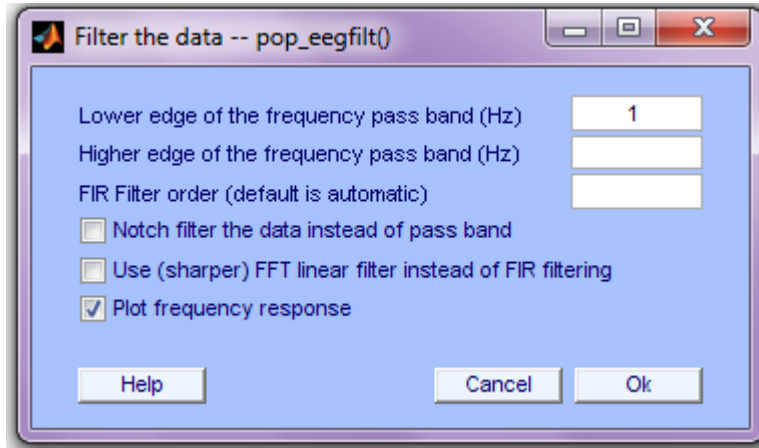
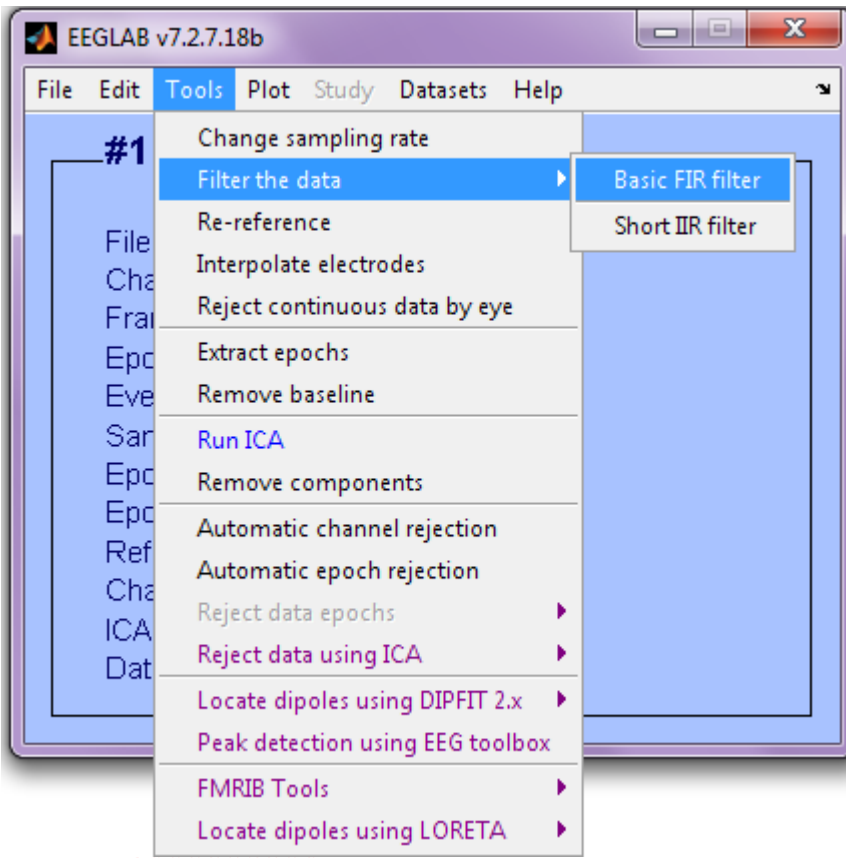
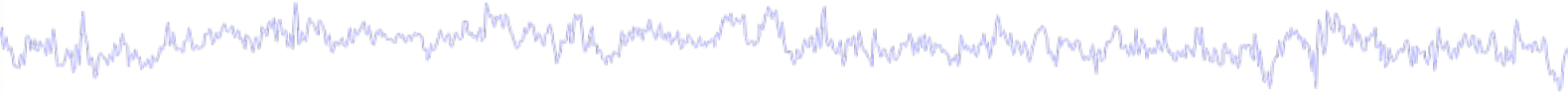
Task 4

Remove components
(i.e. back-projection)

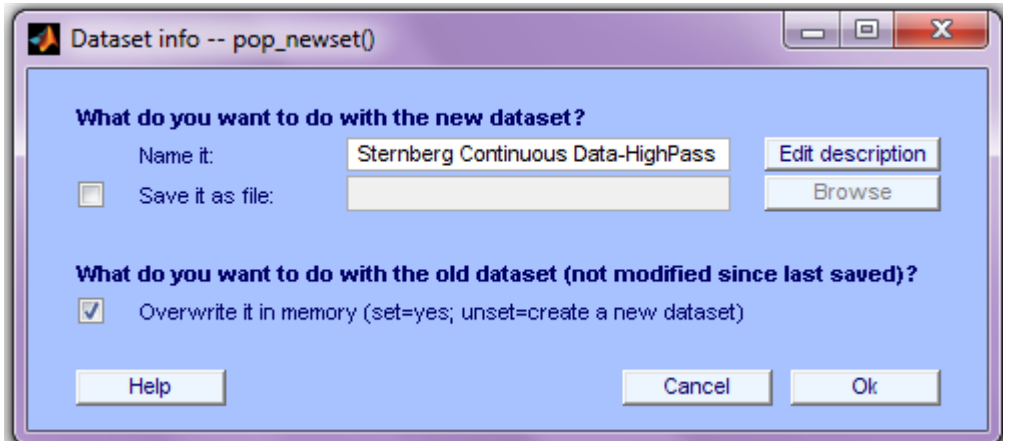
Exercise...



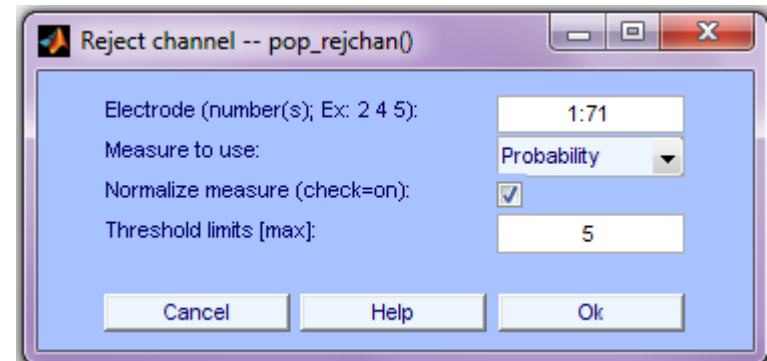
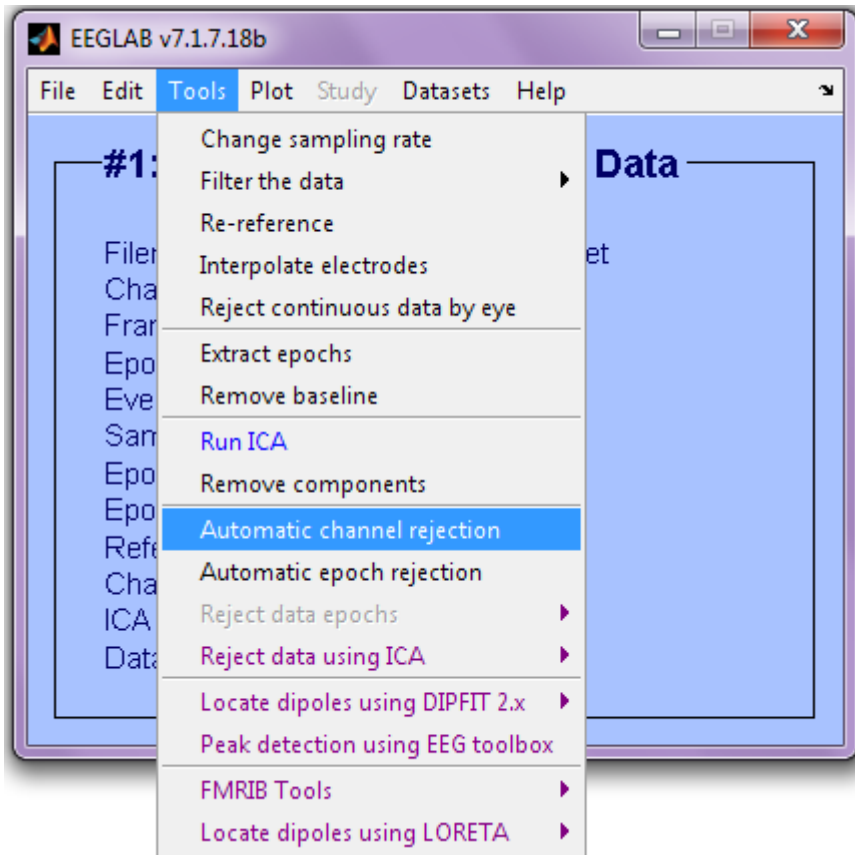
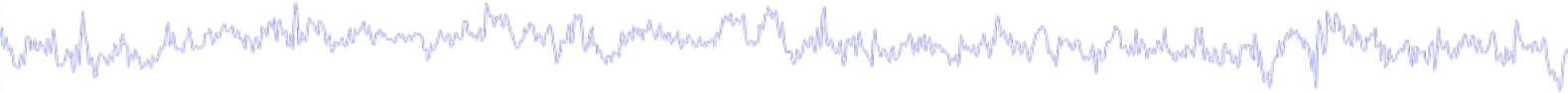
Filter the data (if necessary/desired)



High-pass recommended

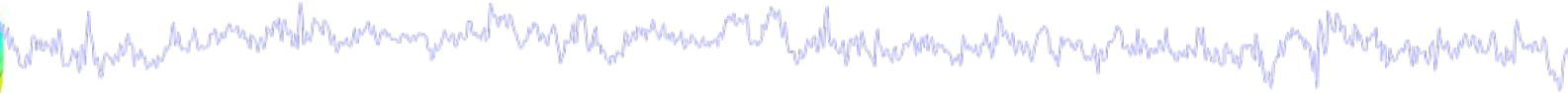


Auto-detection of noisy channels



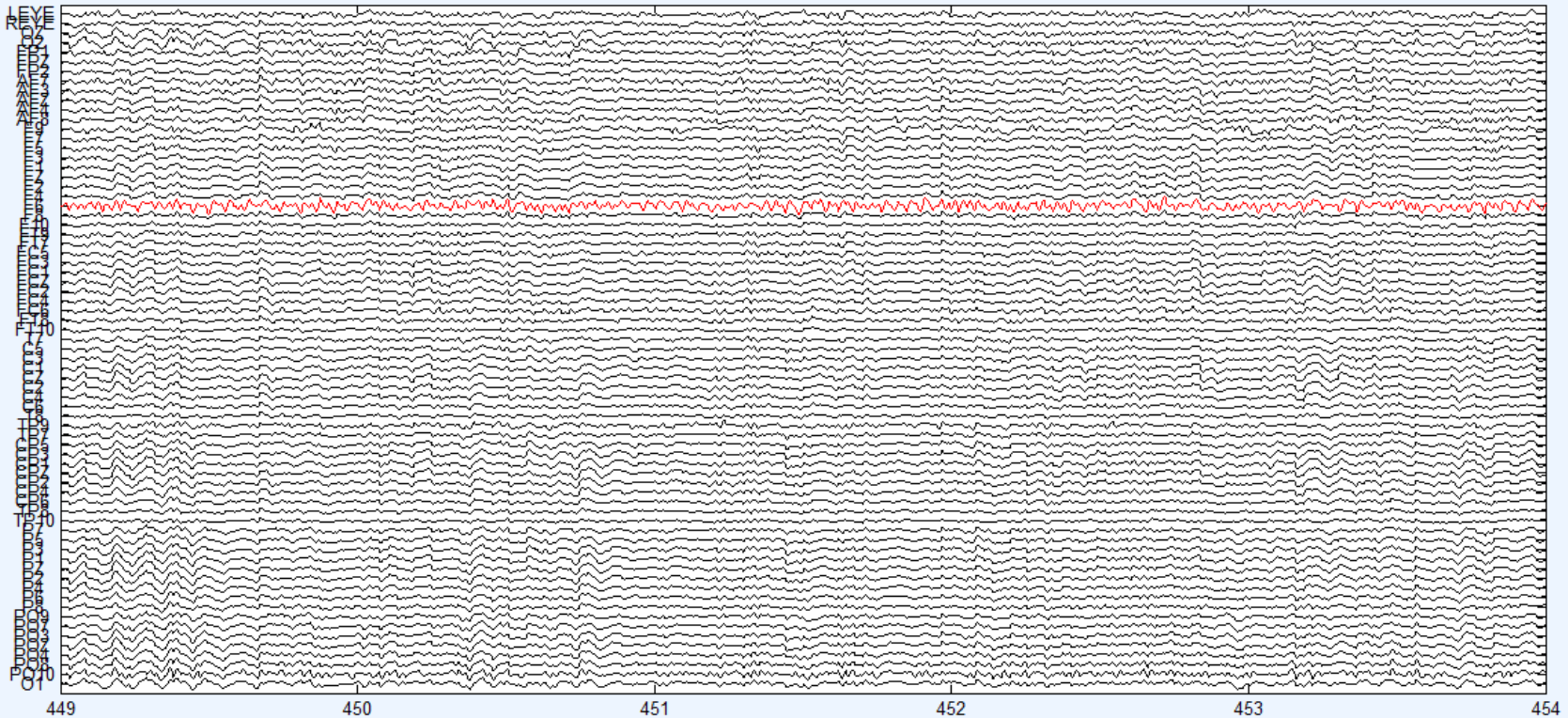
```
>> EEG = pop_rejchan(EEG, 'elec',[1:71] , 'threshold',5,...  
'norm', 'on', 'measure', 'prob');
```

Auto-detected noisy channel



Scroll component activities -- eegplot()

Figure Display Settings Help

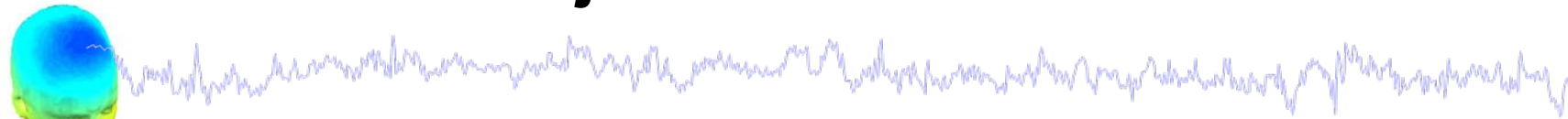


Scale
35
↑

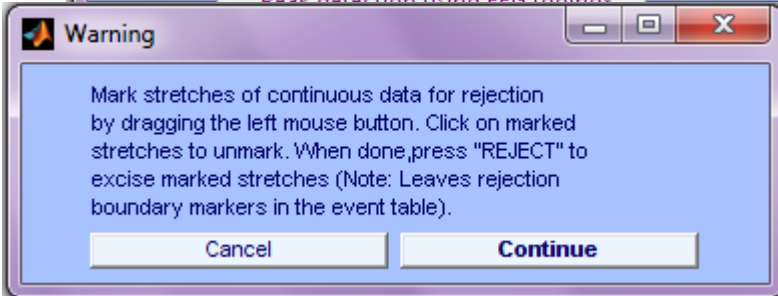
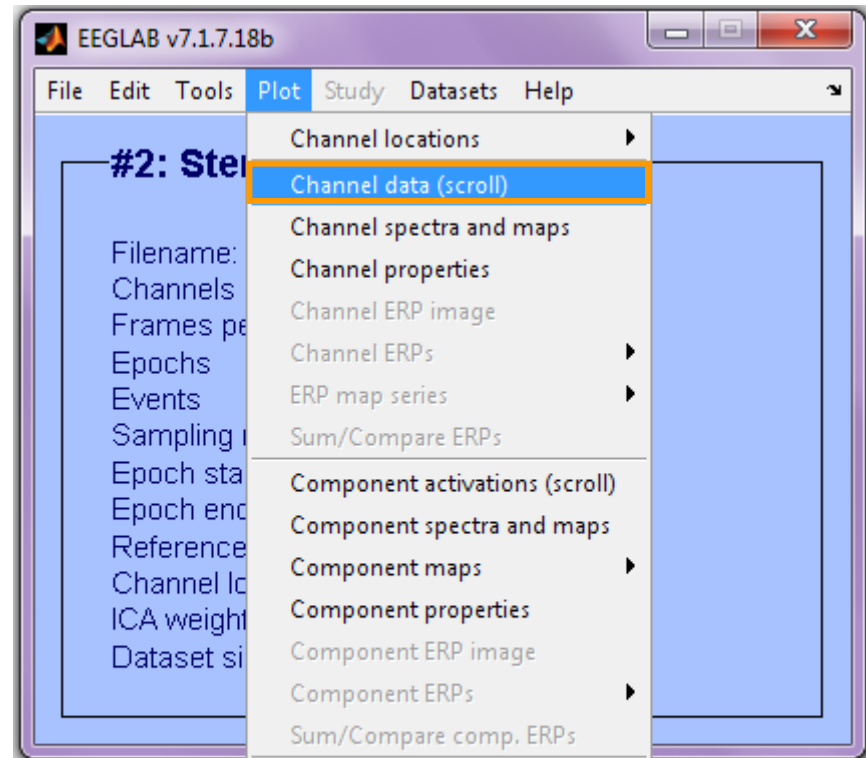
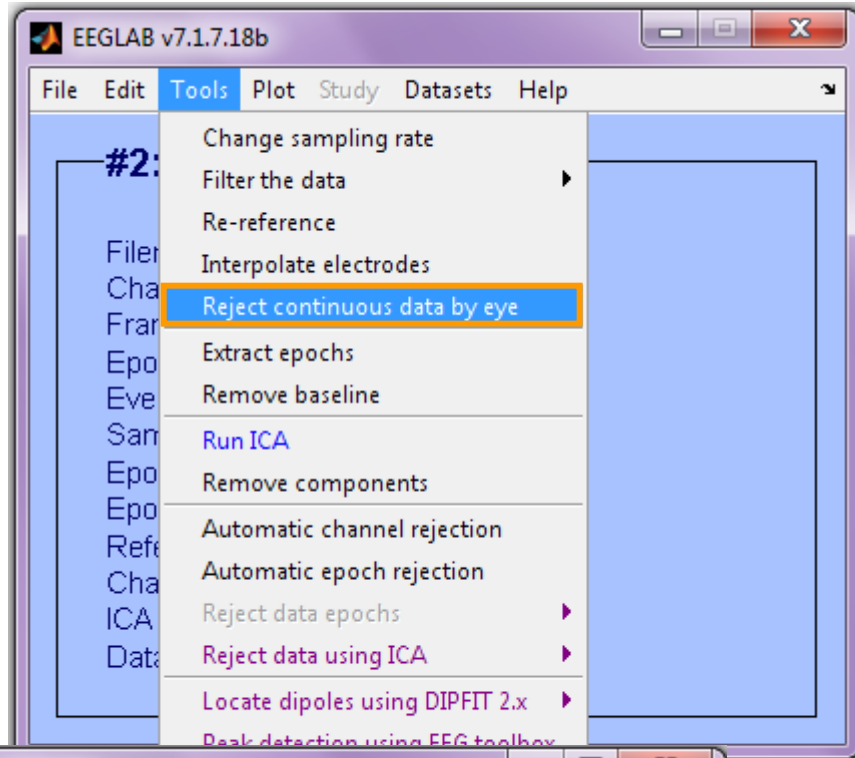
CANCEL << < 449 > >> Chan. Time Value 35 + - REJECT

Chan.	Time	Value
TP8	452.1146	-2.6647

Reject continuous data



Equivalent



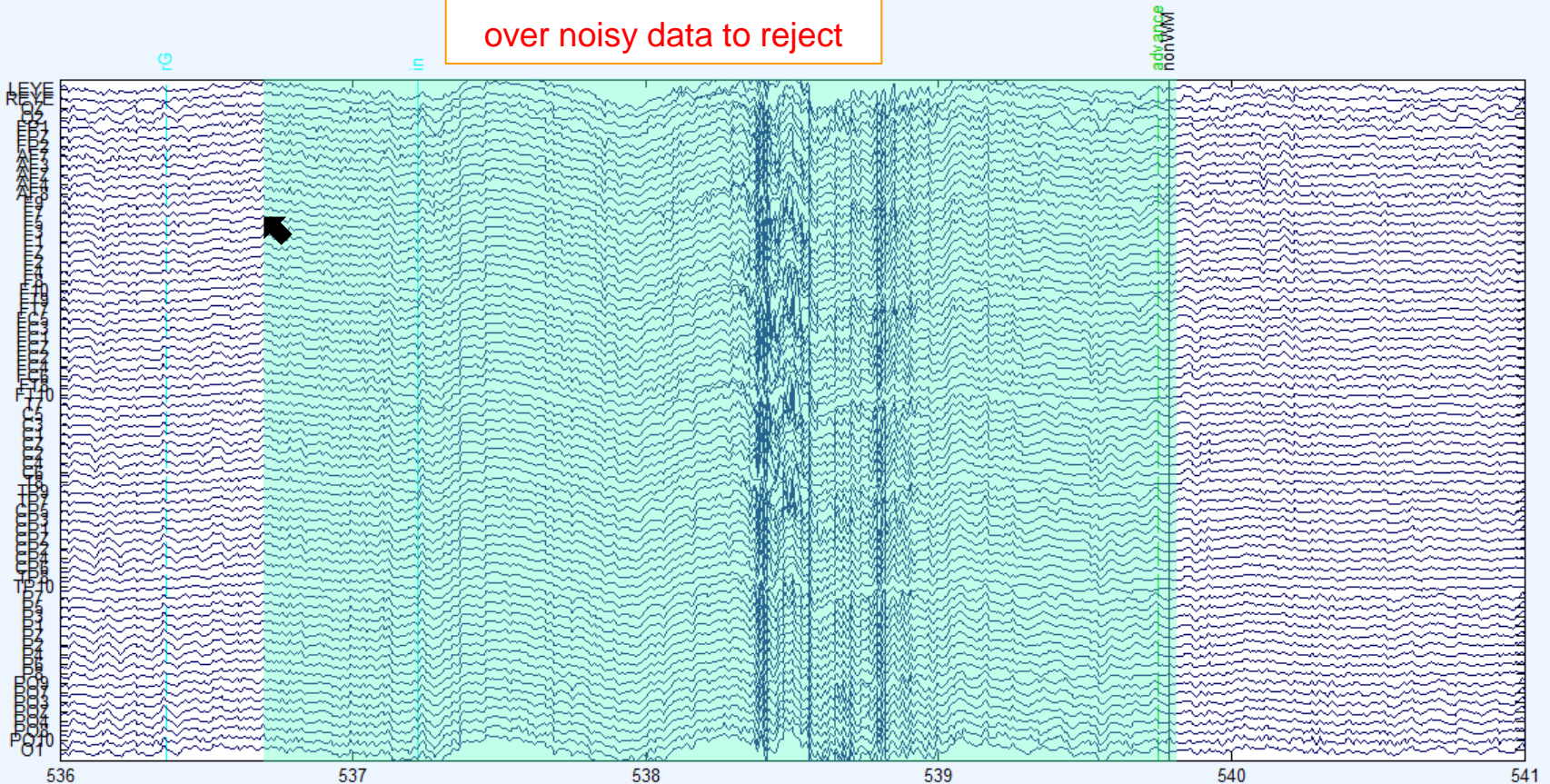
Reject continuous data



Scroll channel activities -- eegplot()

Figure Display Settings Help

Click and drag with mouse
over noisy data to reject



Scale

35



CANCEL

Event types

<<

<

536

>

>>

Chan.

Time

Value

FC6

539.9355

4.8773

35

+

-

REJECT

Rejecting data for ICA



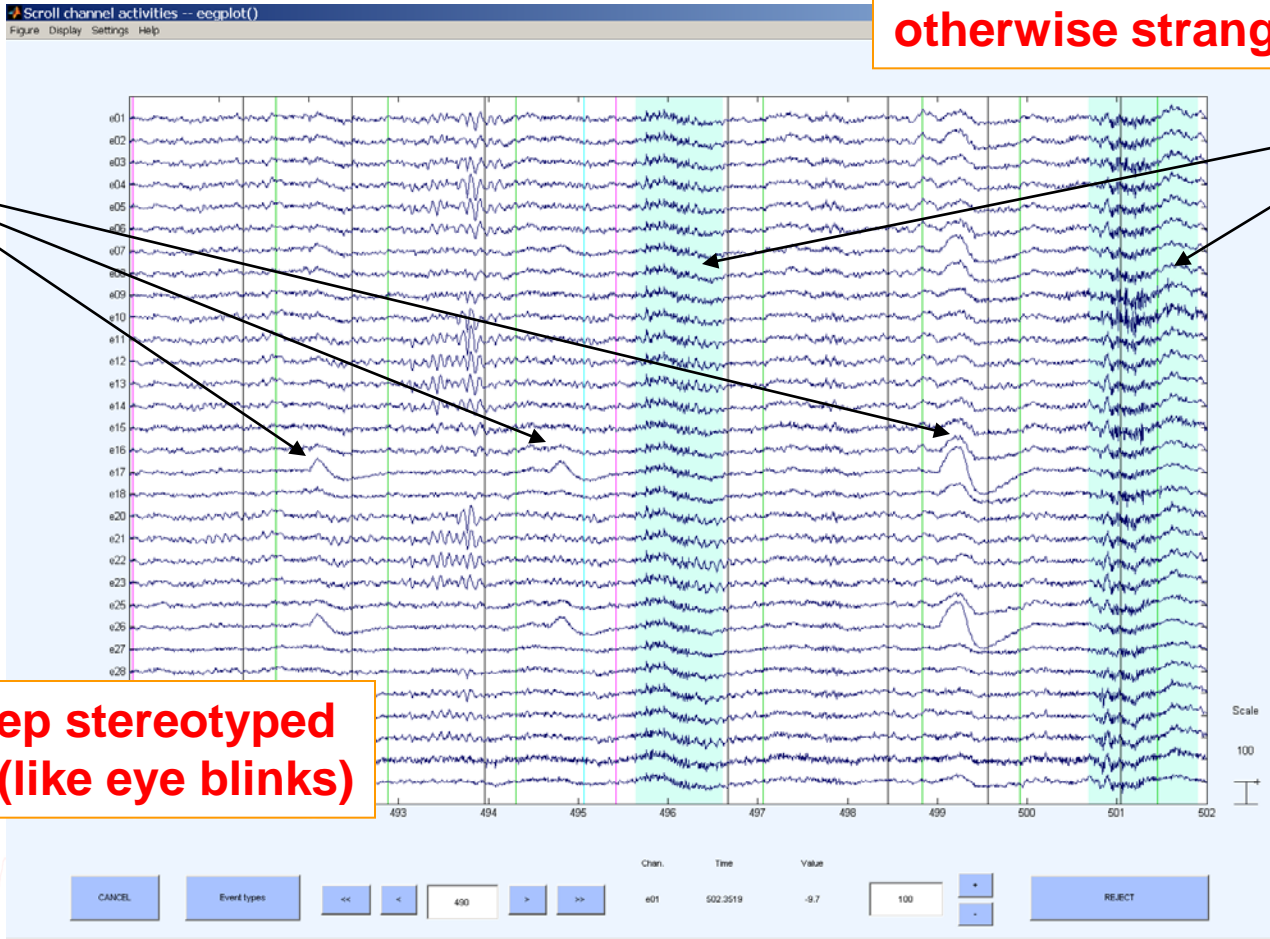
To prepare data for ICA:

Reject large muscle or otherwise strange events...

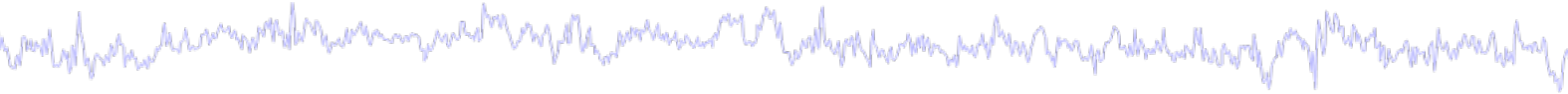
Keep

Reject

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



OR... Extract short epochs



Choose all events

EEGLAB v7.2.7.18b

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
- FMRIB Tools
- Locate dipoles using LORETA

#1

File

Cha

Fra

Epo

Eve

Sar

Epo

Epo

Ref

Cha

ICA

Dat

Data

Extract data epochs - pop_epoch()

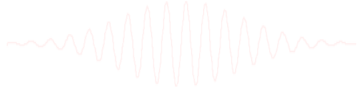
Time-locking event type(s) ([]=all)

Epoch limits [start, end] in seconds

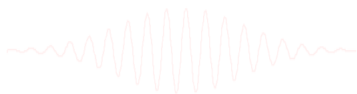
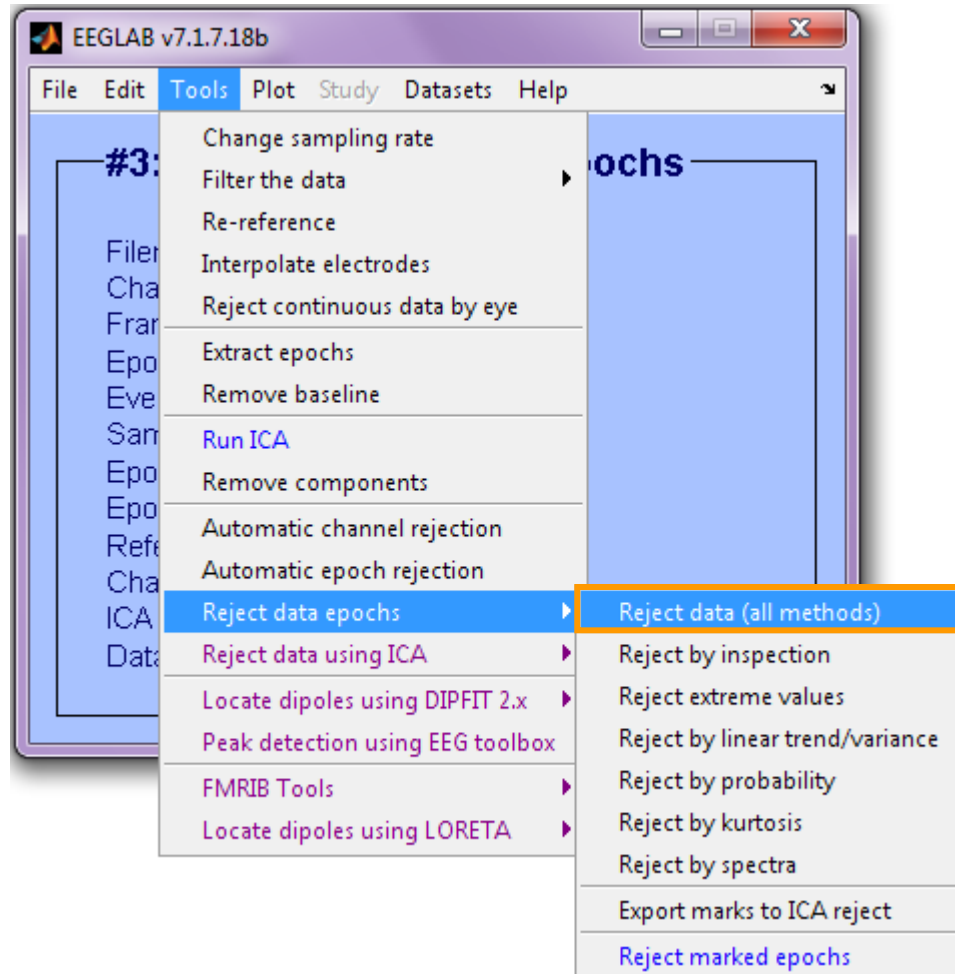
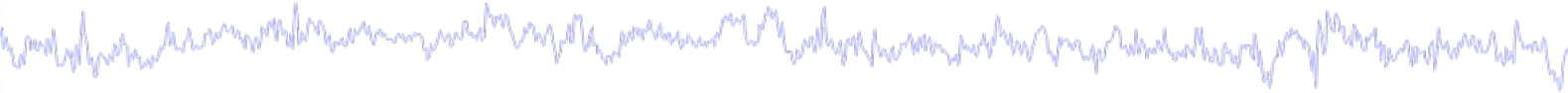
Name for the new dataset

Out-of-bounds EEG limits if any [min max]

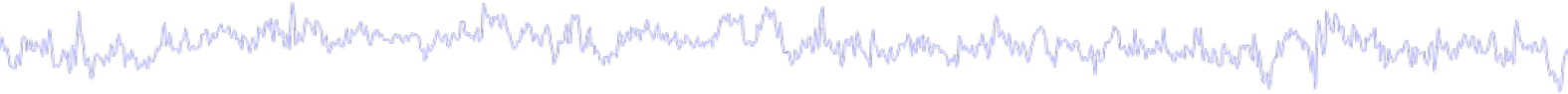
Cancel Help Ok



Auto-reject data epochs



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	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

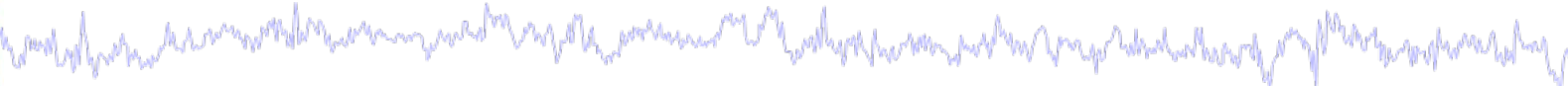
Show all trials marked for rejection by the measure selected above or checked below

<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

visual inspection

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)	<input type="text" value="25"/>	Lower limit(s) (uV)	<input type="text" value="-25"/>
Start time(s) (ms)	<input type="text" value="-500"/>	Ending time(s) (ms)	<input type="text" value="496"/>
Electrode(s)	<input type="text" value="1:70"/>	Currently marked trials	<input type="text" value="0"/>

Find abnormal trends

Max slope (uV/epoch)	<input type="text" value="50"/>	R-squared limit (0 to 1)	<input type="text" value="0.3"/>
Electrode(s)	<input type="text" value="1:70"/>	Currently marked trials	<input type="text" value="0"/>

Find improbable data

Single-channel limit (std. dev.)	<input type="text" value="5"/>	All channels limit (std. dev.)	<input type="text" value="5"/>
Electrode(s)	<input type="text" value="1:70"/>	Currently marked trials	<input type="text" value="32"/>

Find abnormal distributions

Single-channel limit (std. dev.)	<input type="text" value="5"/>	All channels limit (std. dev.)	<input type="text" value="5"/>
Electrode(s)	<input type="text" value="1:70"/>	Currently marked trials	<input type="text" value="0"/>

Find abnormal spectra (slow)

Upper limit(s) (dB)	<input type="text" value="25"/>	Lower limit(s) (dB)	<input type="text" value="-25"/>
Low frequency(s) (Hz)	<input type="text" value="0"/>	High frequency(s) (Hz)	<input type="text" value="50"/>
Electrode(s)	<input type="text" value="1:70"/>	Currently marked trials	<input type="text" value="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

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)	<input type="text" value="25"/>	Lower limit(s) (uV)	<input type="text" value="-25"/>
Start time(s) (ms)	<input type="text" value="-500"/>	Ending time(s) (ms)	<input type="text" value="496"/>
Electrode(s)	<input type="text" value="1:70"/>	Currently marked trials	0

Find abnormal trends

Max slope (uV/epoch)	<input type="text" value="50"/>	R-squared limit (0 to 1)	<input type="text" value="0.3"/>
Electrode(s)	<input type="text" value="1:70"/>	Currently marked trials	0

Find improbable data

Single-channel limit (std. dev.)	<input type="text" value="5"/>	All channels limit (std. dev.)	<input type="text" value="5"/>
Electrode(s)	<input type="text" value="1:70"/>	Currently marked trials	32

Find abnormal distributions

Single-channel limit (std. dev.)	<input type="text" value="5"/>	All channels limit (std. dev.)	<input type="text" value="5"/>
Electrode(s)	<input type="text" value="1:70"/>	Currently marked trials	0

Find abnormal spectra (slow)

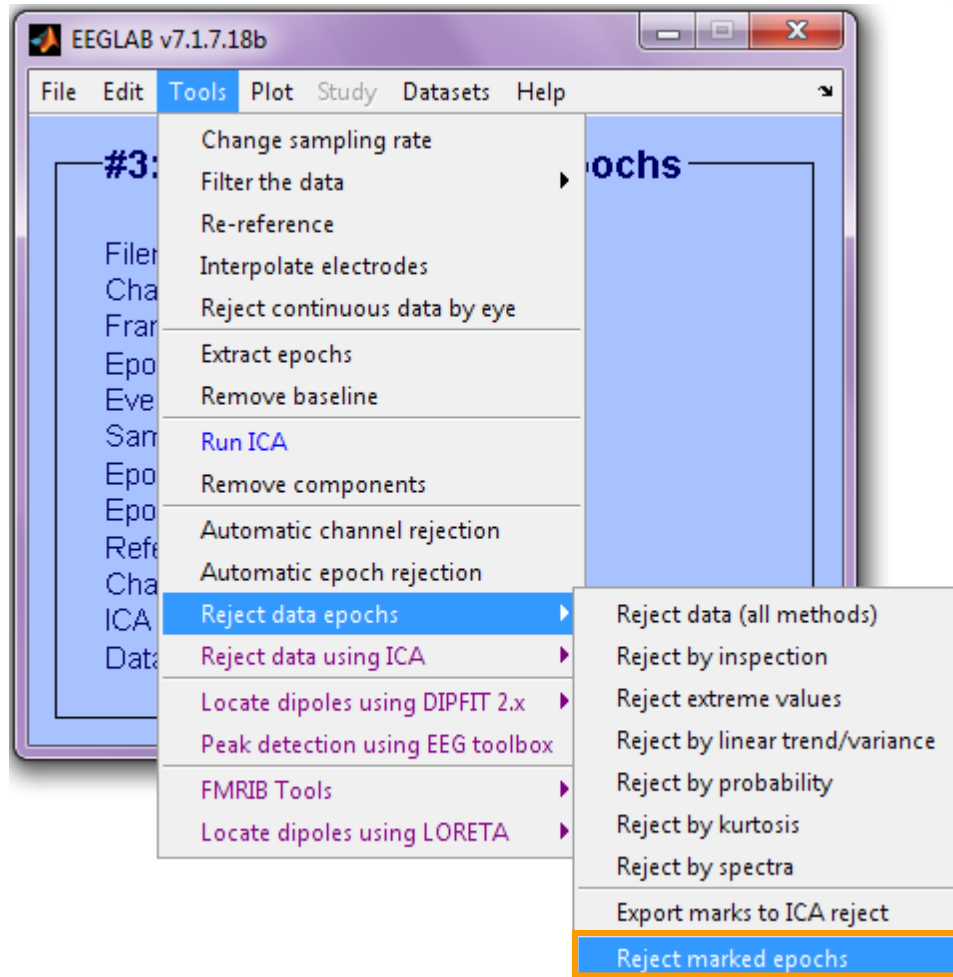
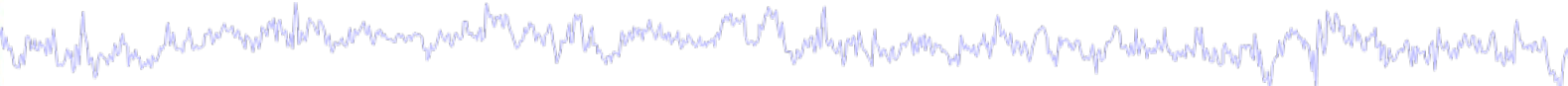
Upper limit(s) (dB)	<input type="text" value="25"/>	Lower limit(s) (dB)	<input type="text" value="-25"/>
Low frequency(s) (Hz)	<input type="text" value="0"/>	High frequency(s) (Hz)	<input type="text" value="50"/>
Electrode(s)	<input type="text" value="1:70"/>	Currently marked trials	0

Plotting options

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

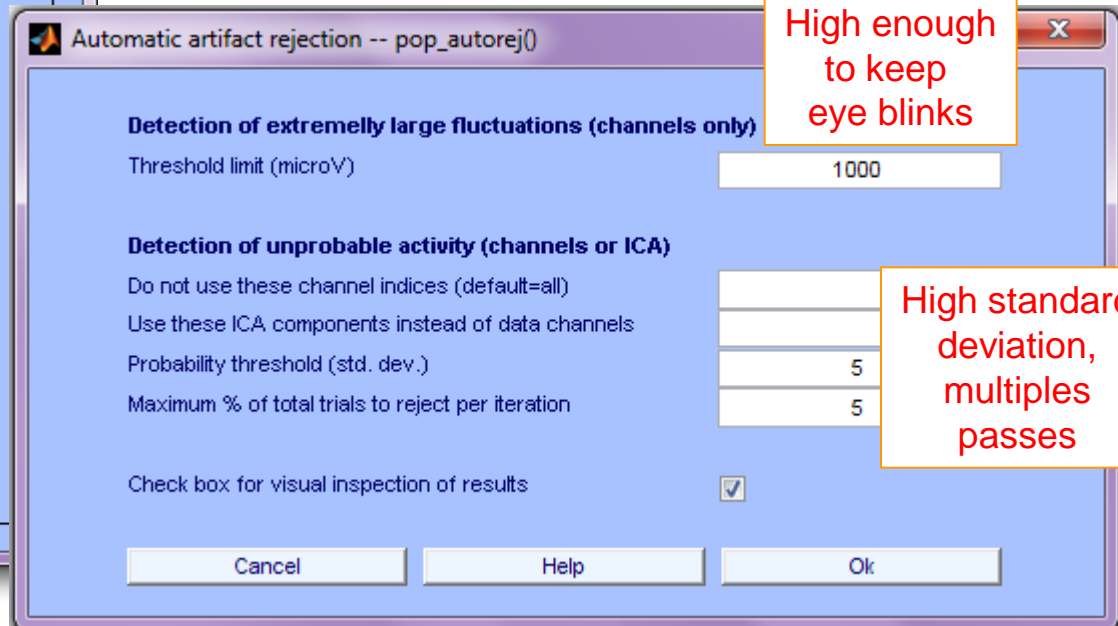
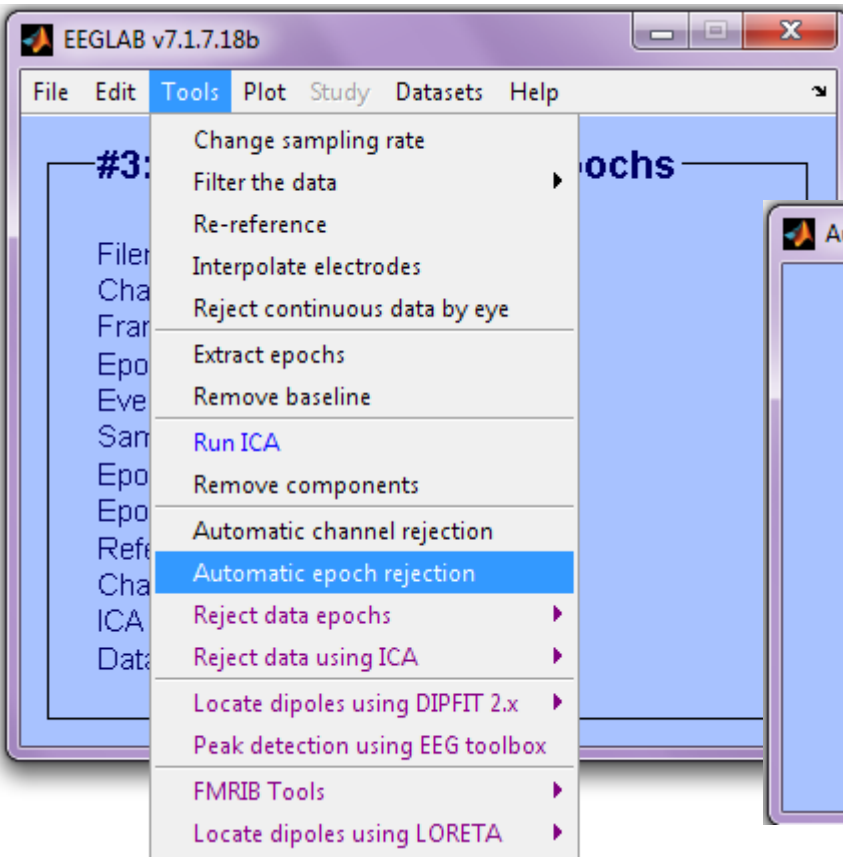
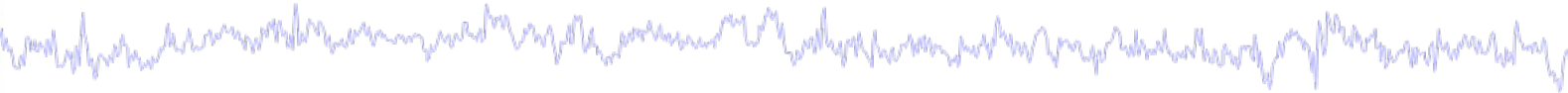
<input checked="" type="checkbox"/> Abnormal appearance	<input checked="" type="checkbox"/> Abnormal values	<input checked="" type="checkbox"/> Abnormal trends
<input checked="" type="checkbox"/> Improbable epochs	<input checked="" type="checkbox"/> Abnormal distributions	<input checked="" type="checkbox"/>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



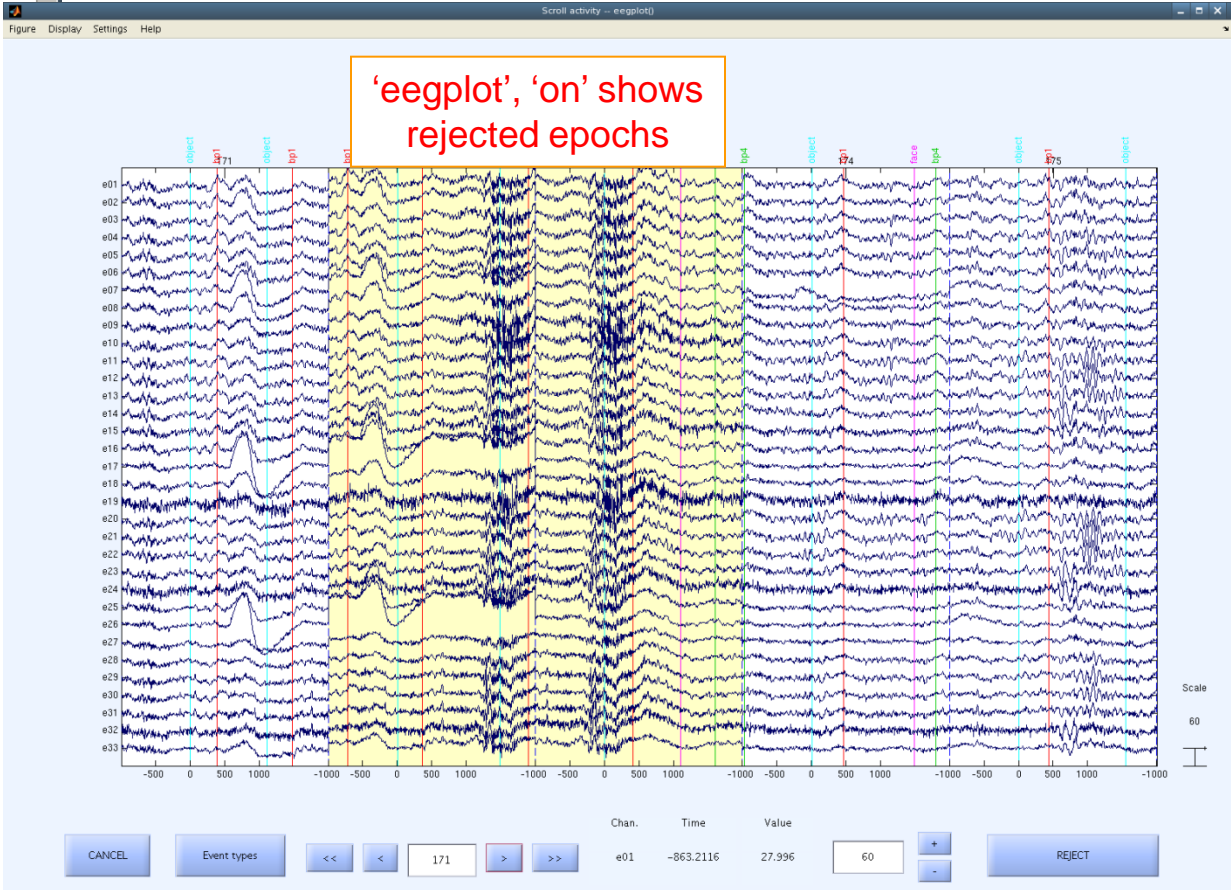
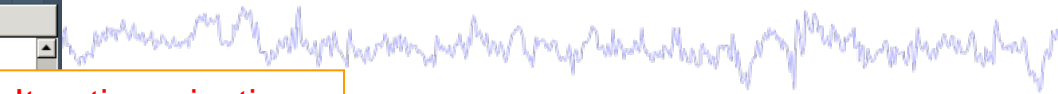
```
>> EEG = pop_autorej(EEG, 'nogui', 'on', 'eegplot', 'on');
```

Reject data epochs (automatic)



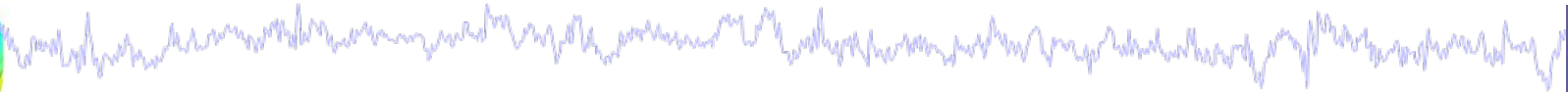
```
julie@doing:/home/julie
File Edit View Terminal Tabs Help
>>
Running auto-rejection protocol...
33 channel selected
0/182 trials marked for rejection
Computing joint probability for channels...
Computing all-channel probability...
5/182 trials marked for rejection
5 trials marked for rejection
5/182 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



Reject pre-labelled epochs -- pop_rejepoch()
Are you sure, you want to reject the labeled trials ?
No Yes

Artifact rejection and running ICA



Task 1

Reject noisy data

Task 2

Run ICA

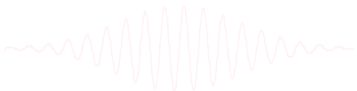
Task 3

Plot components

Task 4

Remove components
(i.e. back-projection)

Exercise...



Independent Component Analysis



x = scalp EEG

W = unmixing matrix

u = sources



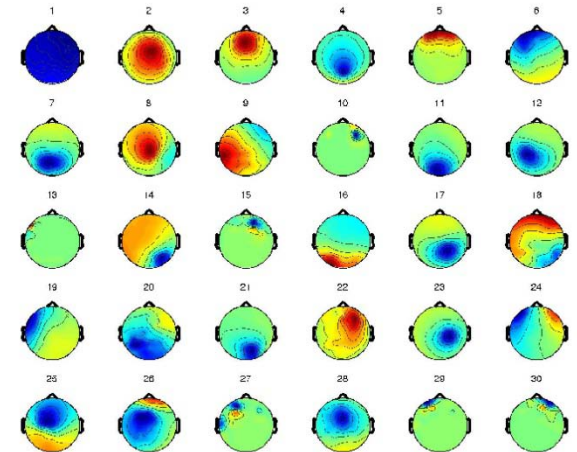
$$W * x = u$$

ICA

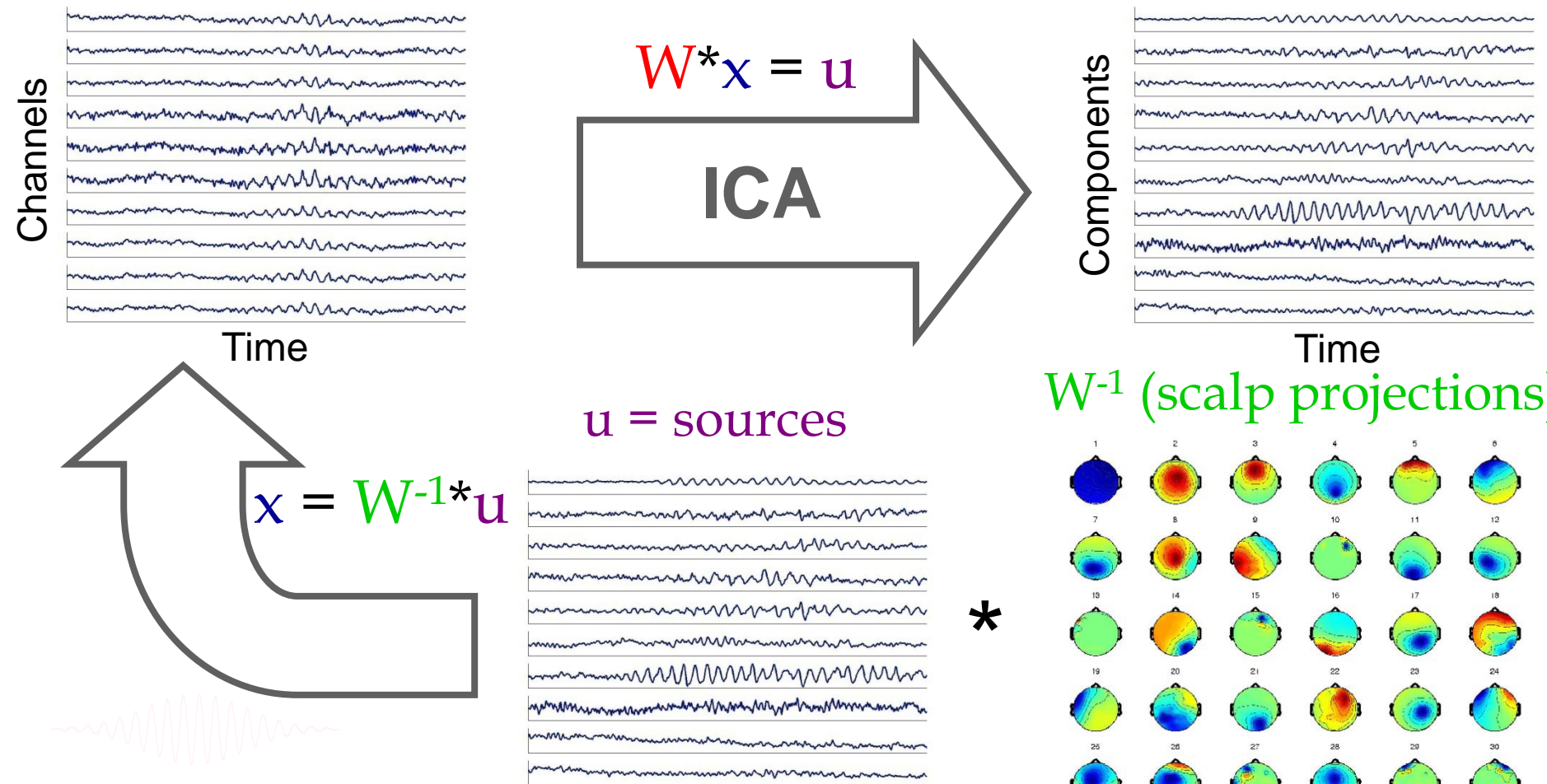
u = sources

$$x = W^{-1} * u$$

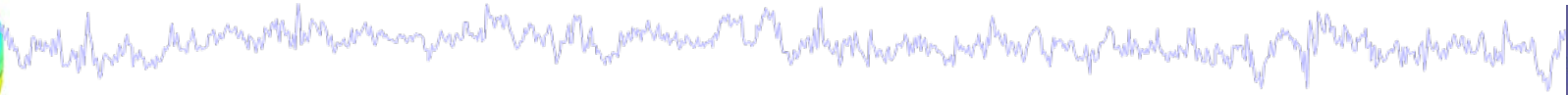
W^{-1} (scalp projections)



ICA Components

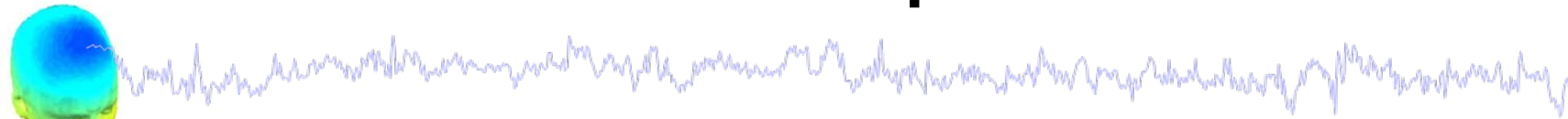


“Secrets” to a good ICA decomposition

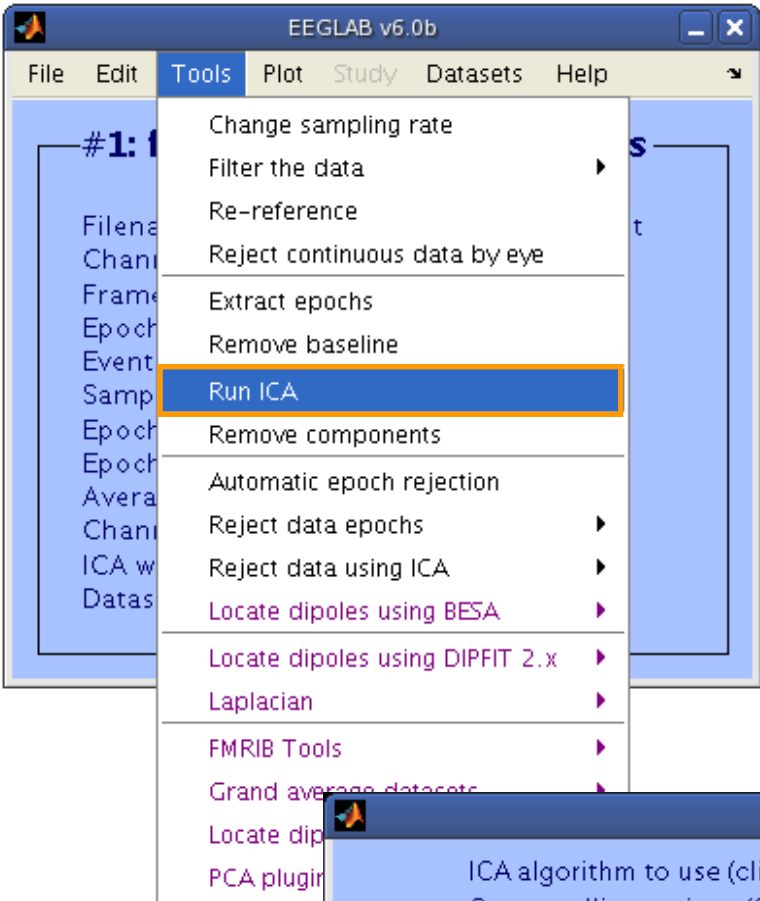


- Garbage in... garbage out (it's not magic)
- Remove large, non-stereotyped artifacts
- Do you have enough data? (based mostly on time, not frames)
- High-pass filter to remove slow drifts (no low-pass filter needed)
- Remove bad channels
- Data must be in double precision (not single)

Runica options



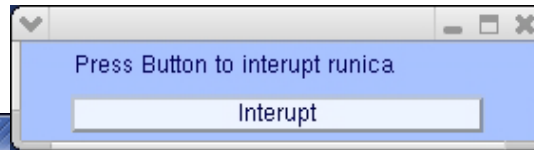
Option	Default	Comments
'extended'	0	1 is recommended to find sub-gaussians
'stop'	1e-7	final weight change → stop
'lrate'	determined from data	too small → too long... too large → wts blow up
'maxsteps'	512	more channels → more steps
'pca'	0 or EEG.nbchan	Decompose only a principal data subspace



Other algorithms:
binica, amica, sobi, acsobi



Runica progress...



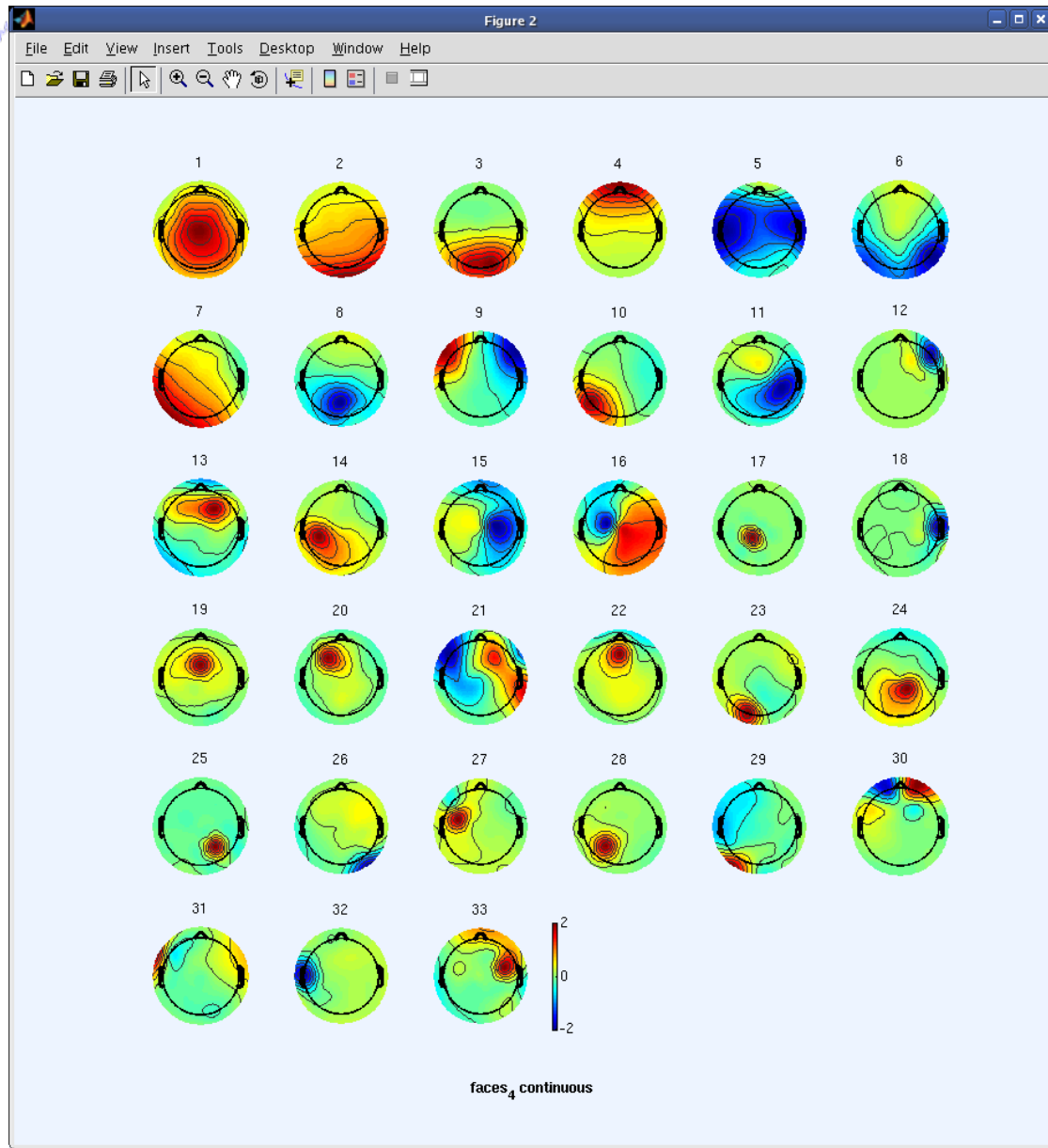
```
Input data size [33,133175] = 33 channels, 133175 frames/nFinding 33 ICA components using extended ICA.
Kurtosis will be calculated initially every 1 blocks using 6000 data points.
Decomposing 122 frames per ICA weight ((1089)^2 = 133175 weights, Initial learning rate will be 0.001, block size
Learning 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
```

```
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 ...
>>
>>
```

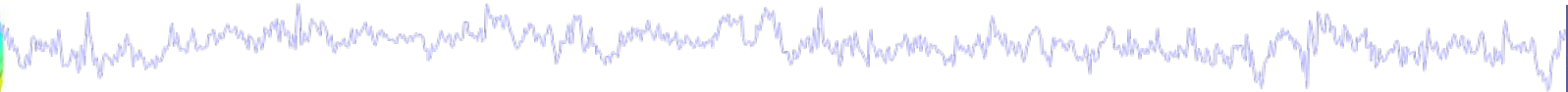
ICA weights in EEG structure

```
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: []
>>
```



Artifact rejection and running ICA



Task 1

Reject noisy data

Task 2

Run ICA

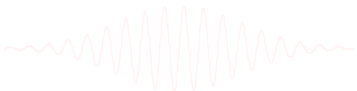
Task 3

Plot components

Task 4

Remove components
(i.e. back-projection)

Exercise...



Plot ICA scalp maps



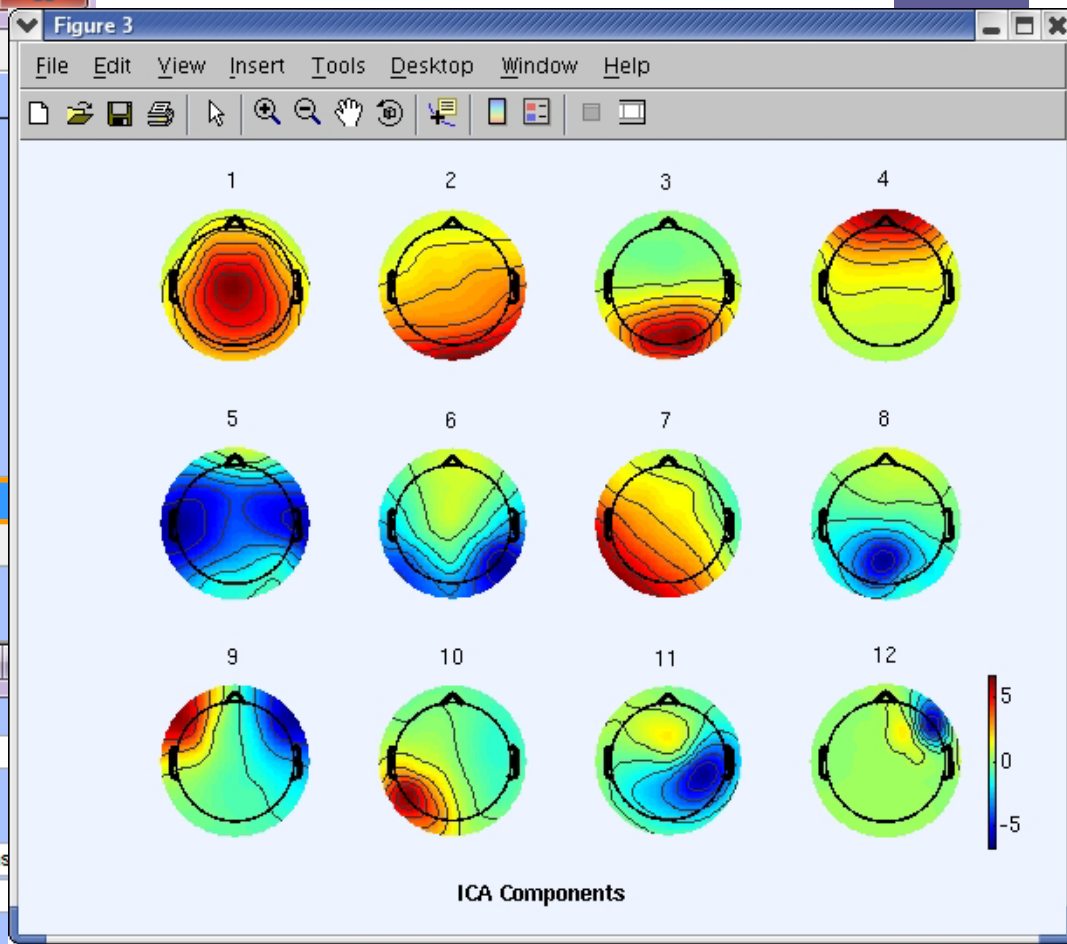
EEGLAB v7.1.7.18b

File Edit Tools **Plot** Study Datasets Help

#3: Sternberg Rej Chan epochs

Filename: ...
Channels ...
Frames per ...
Epochs ...
Events ...
Sampling rate ...
Epoch start ...
Epoch end ...
Reference ...
Channel locations ...
ICA weights ...
Dataset size ...

- Channel locations
- Channel data (scroll)
- Channel spectra and maps
- Channel properties
- Channel ERP image
- Channel ERPs
- ERP map series
- Sum/Compare ERPs
- Component activations (scroll)
- Component spectra and maps
- Component maps**
 - In 2-D
 - In 3-D
- Component properties
- Component ERP image
- Component ERPs



Plot component scalp maps in 2-D -- pop_topoplot()

Component numbers:

(negate index to invert component polarity; NaN -> empty subplot; Ex: -1 NaN 3)

Plot title:

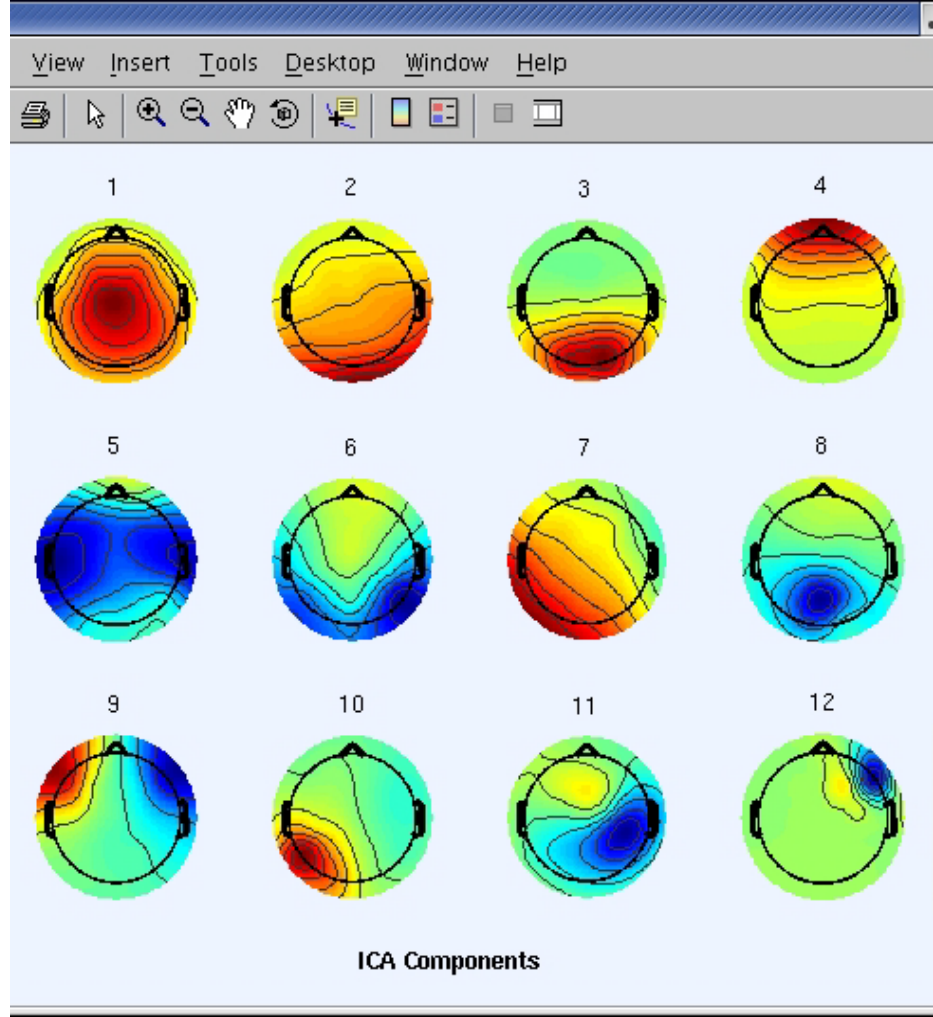
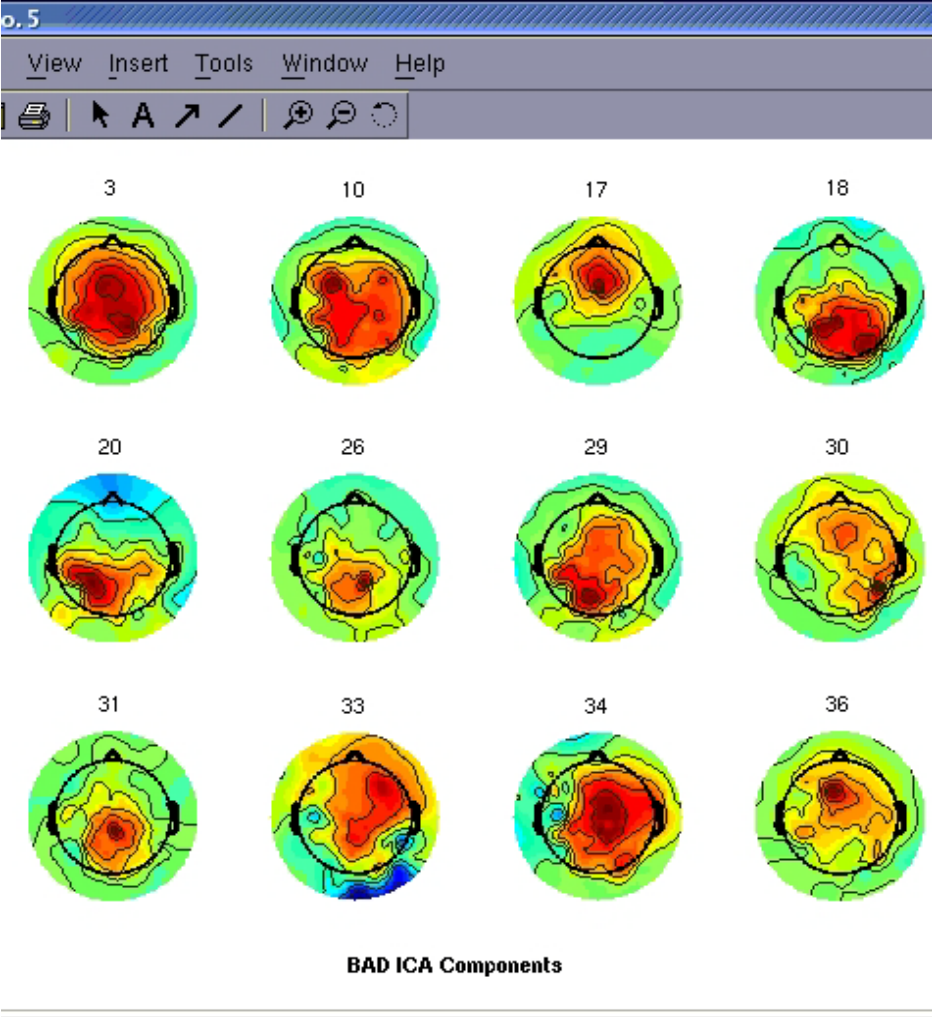
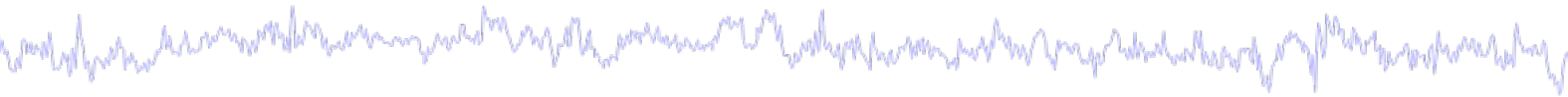
Plot geometry (rows,col.):

Plot associated dipole(s) (if present):

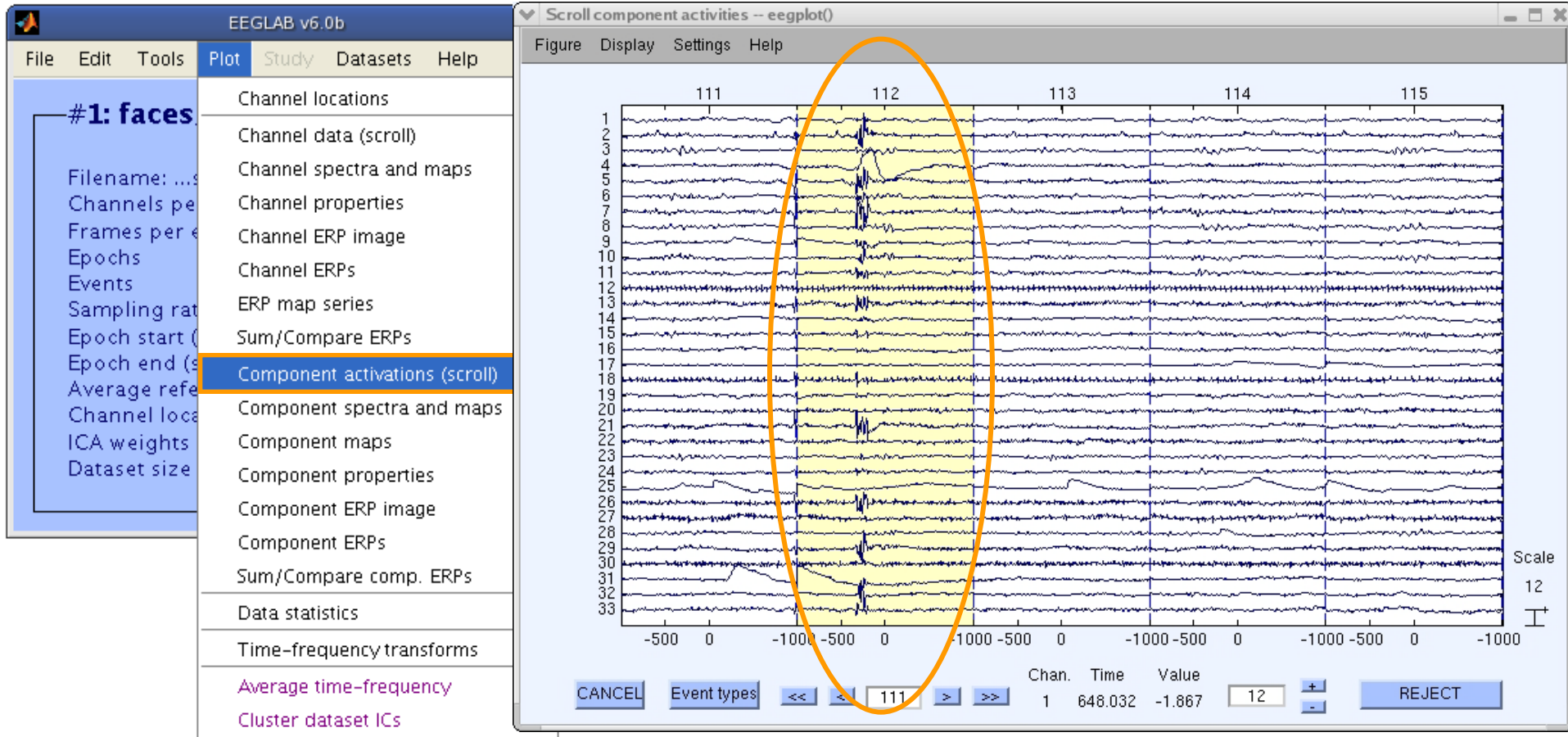
-> Additional topoplot() (and dipole) options (see Help)

Cancel Help Ok

Compare 'good' and 'bad' scalp maps

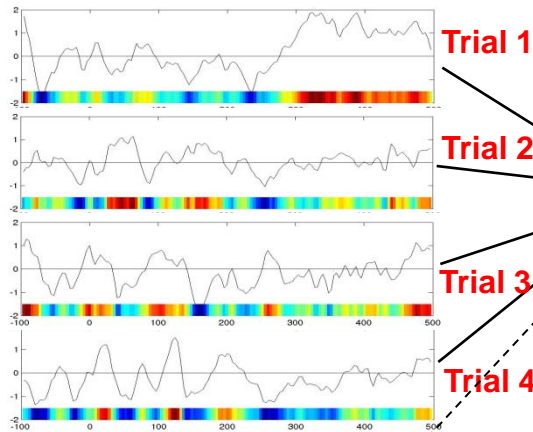
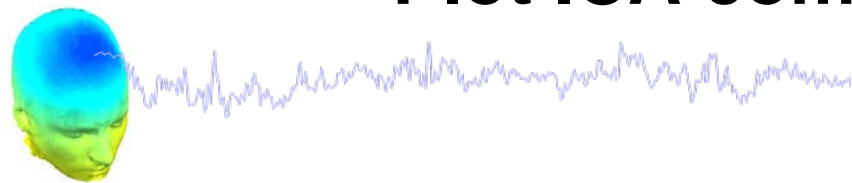


Scroll component activities

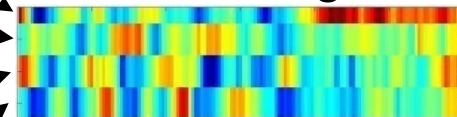


**Time periods that are not independent across ICs
should be removed and ICA run again for better decomposition**

Plot ICA component properties



ERP Image



EEGLAB v6.0b

File Edit Tools **Plot** Study Datasets Help

#1: faces

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

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

Component 3 properties

File Edit View Ins

Component 3 map

Component 3 activity (global offset 0.079)

Sorted Trials

Time (ms)

Activity power spectrum

Magnitude (dB)

Frequency (Hz)

Cancel Values ACCEPT HELP OK

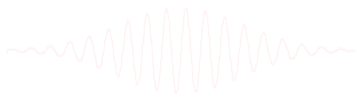
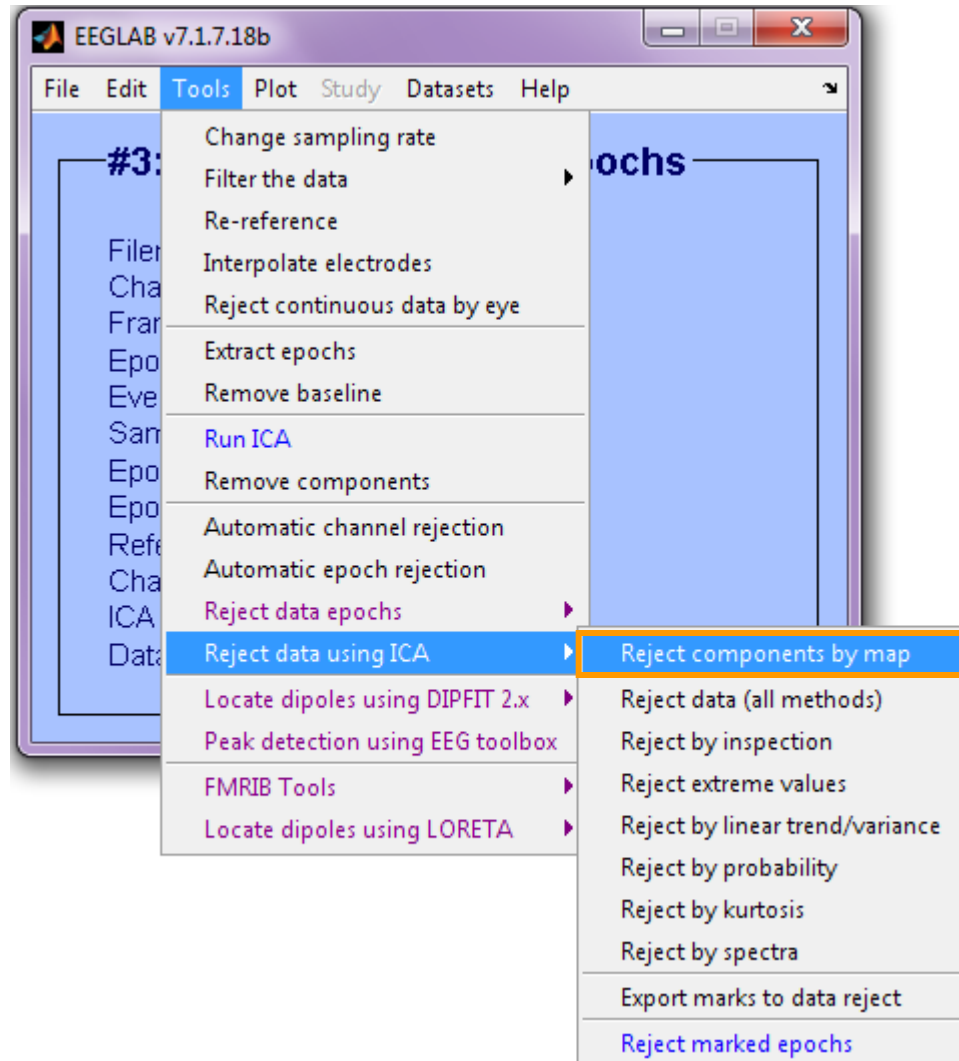
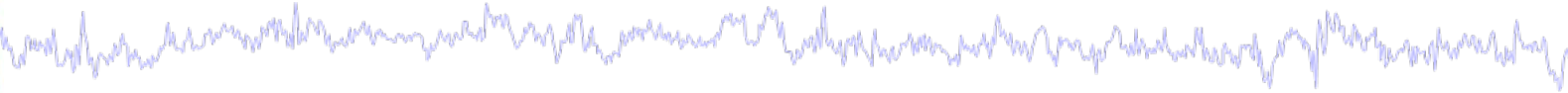
Component properties - po

Component number to plot:

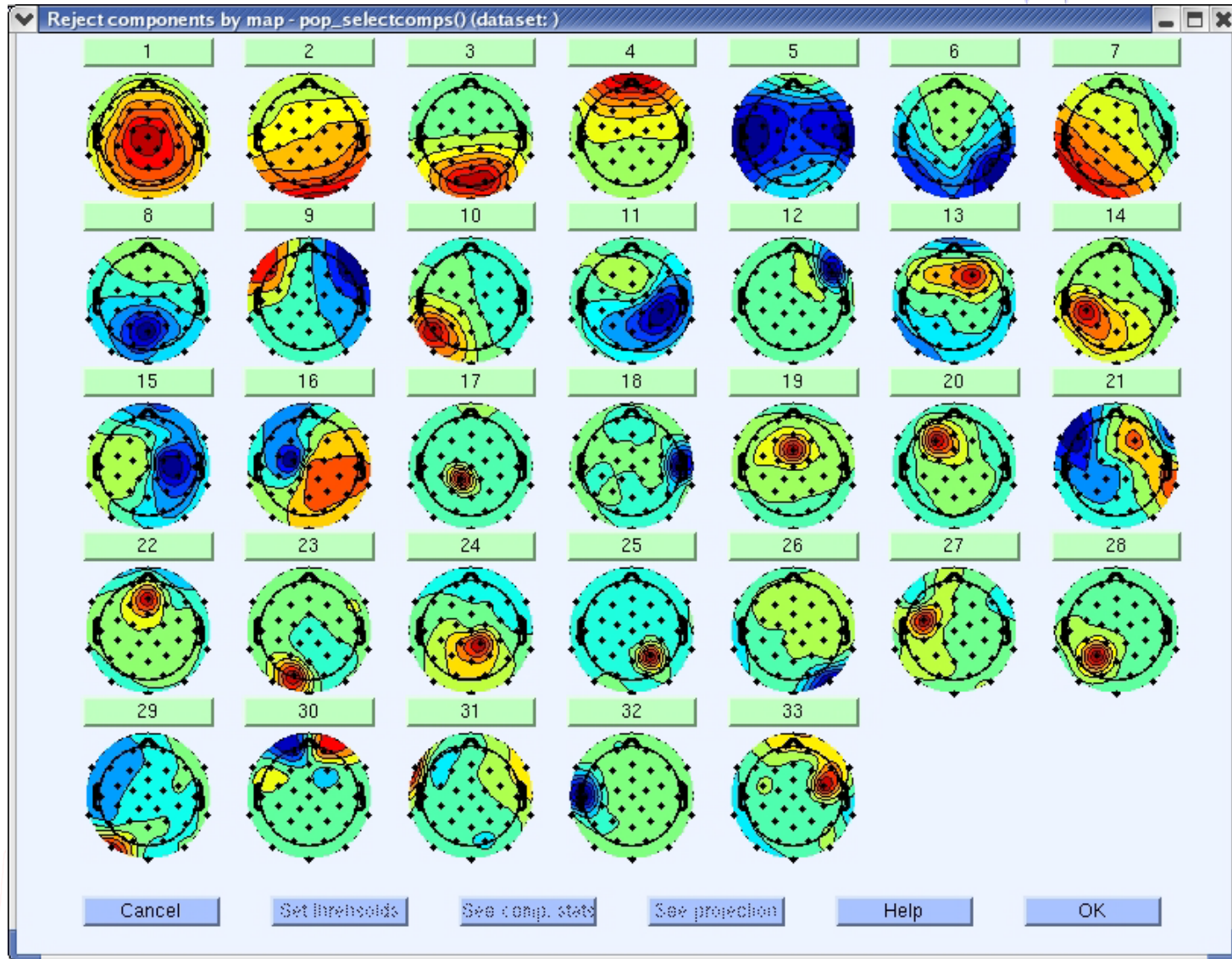
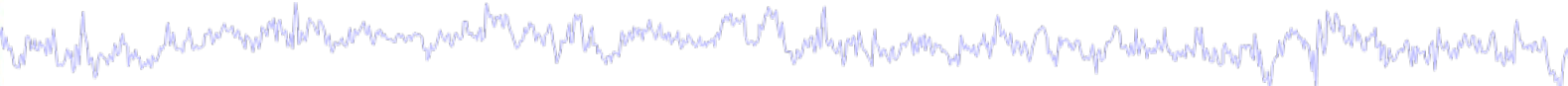
3

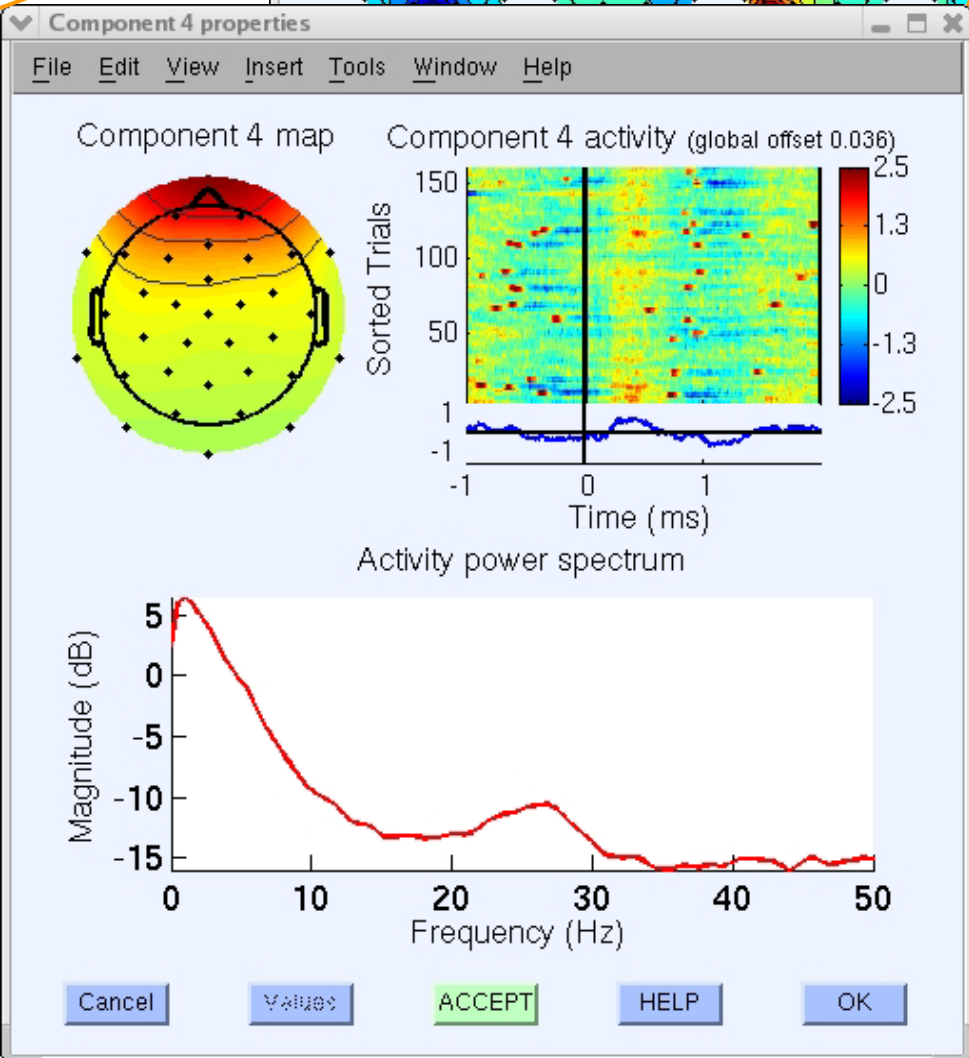
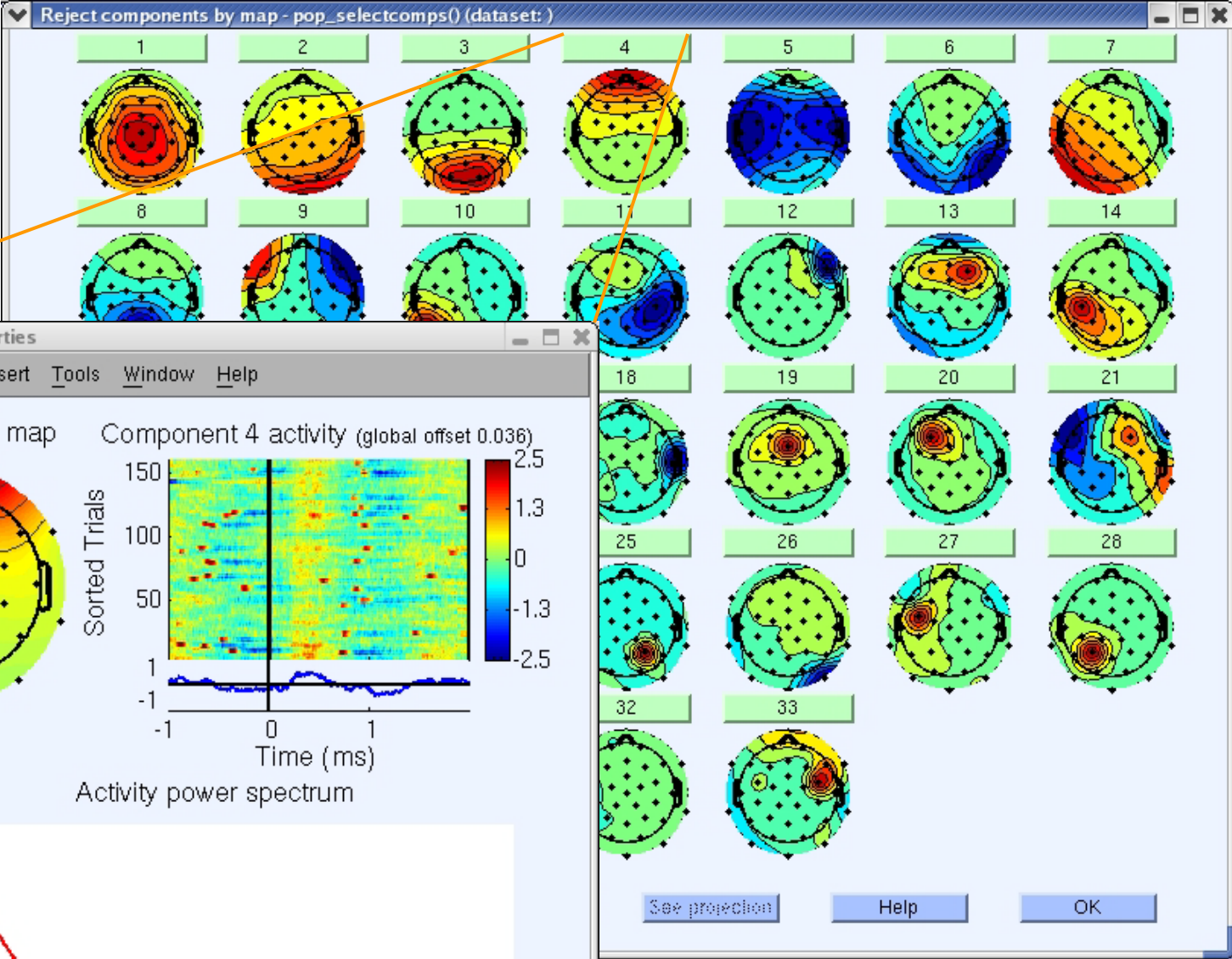
Cancel Help Ok

Reviewing component properties

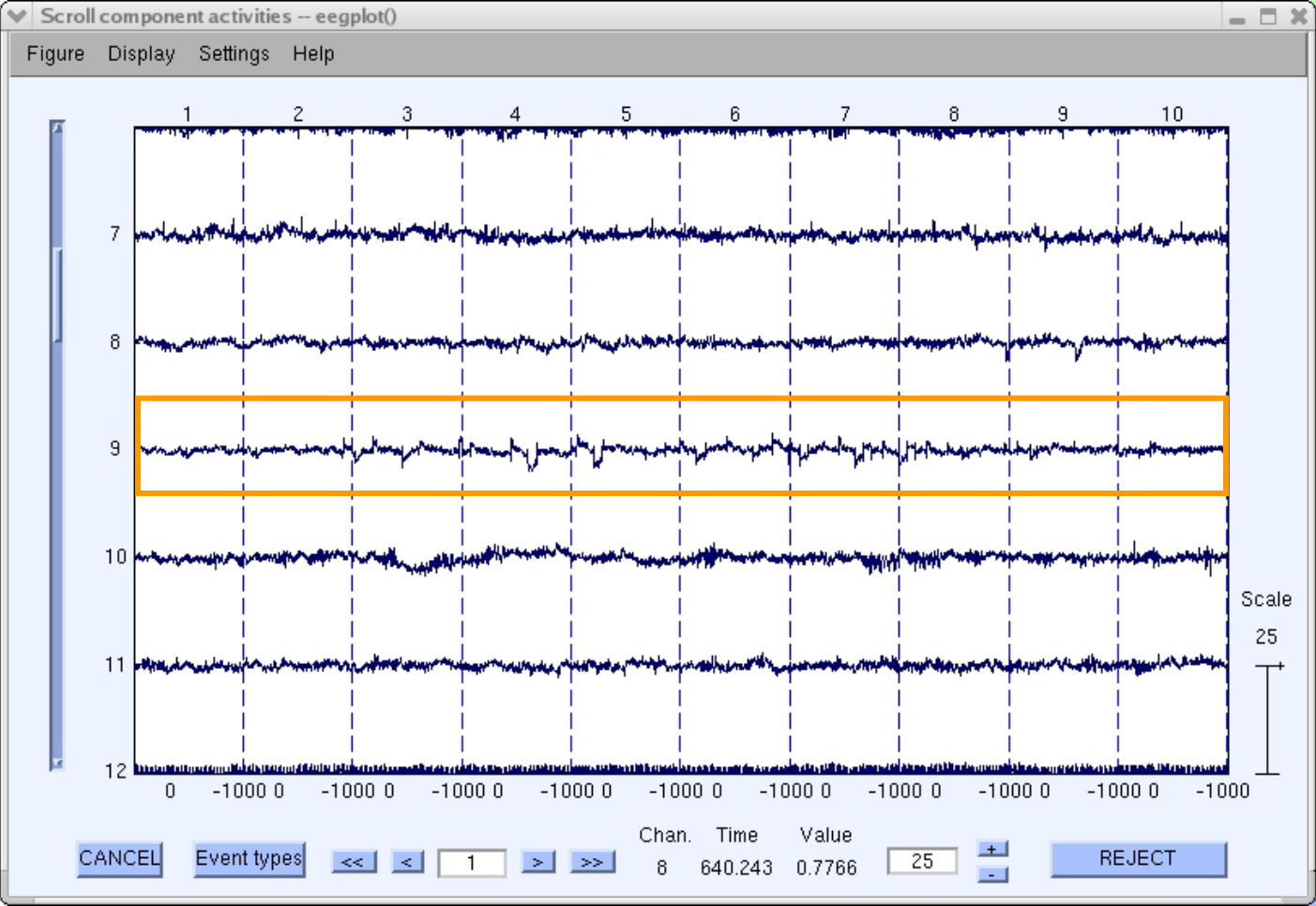
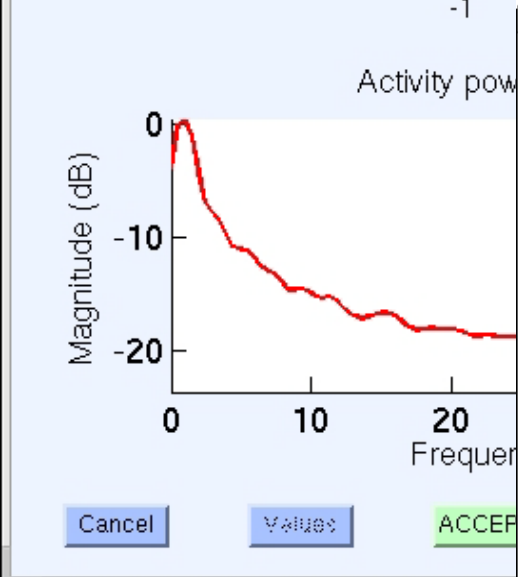
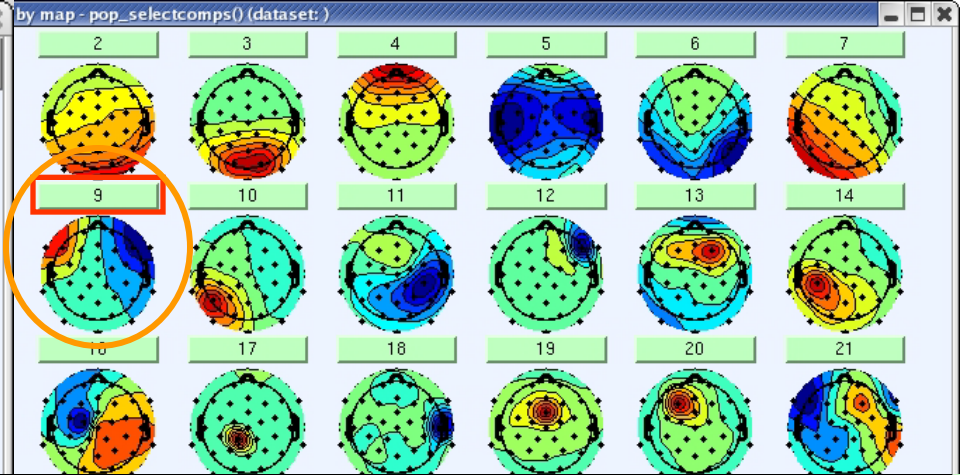
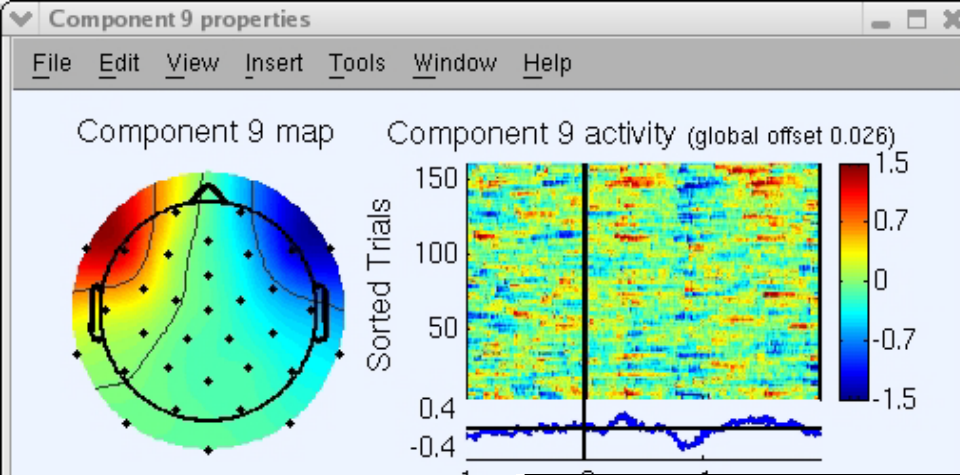


Component scalp maps/properties

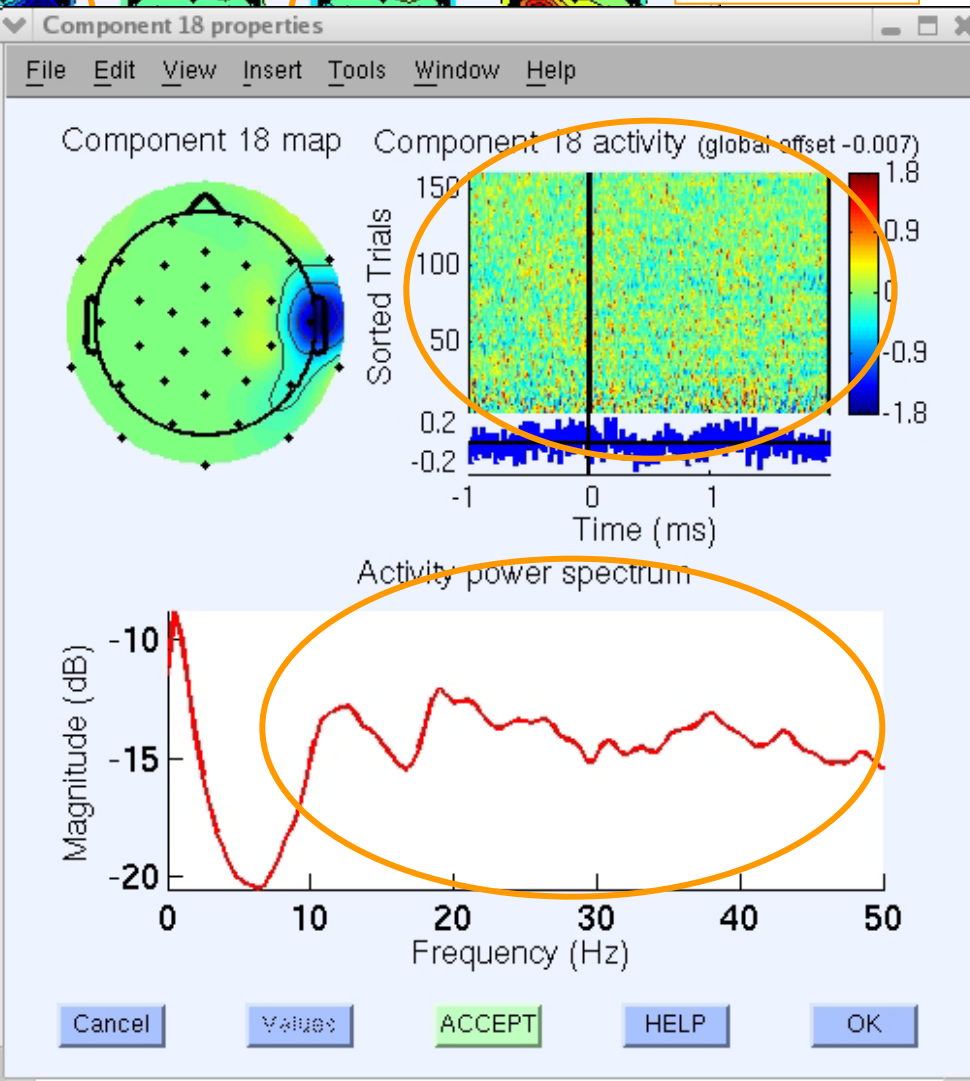
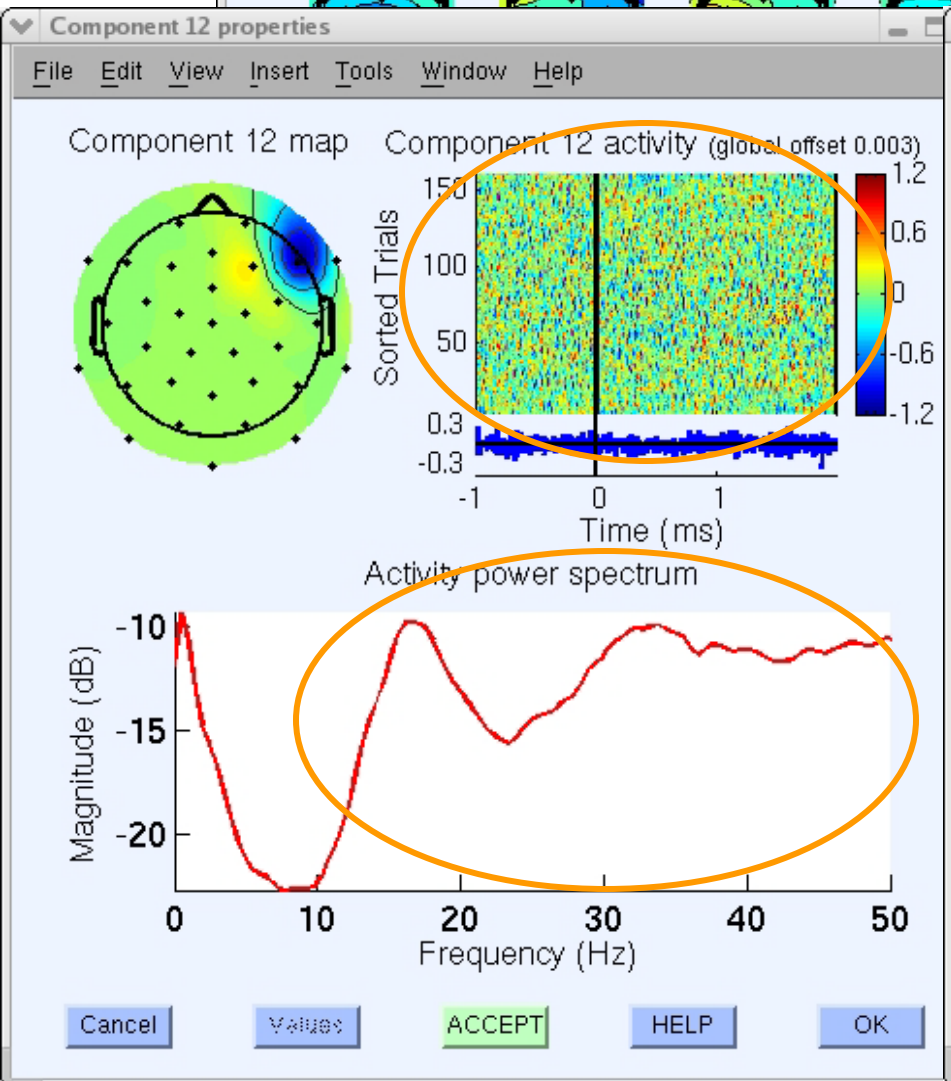
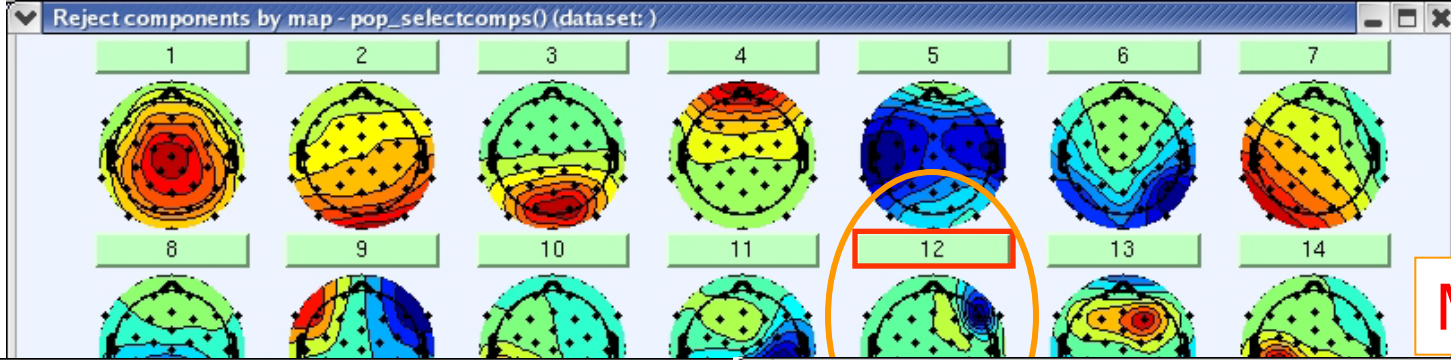


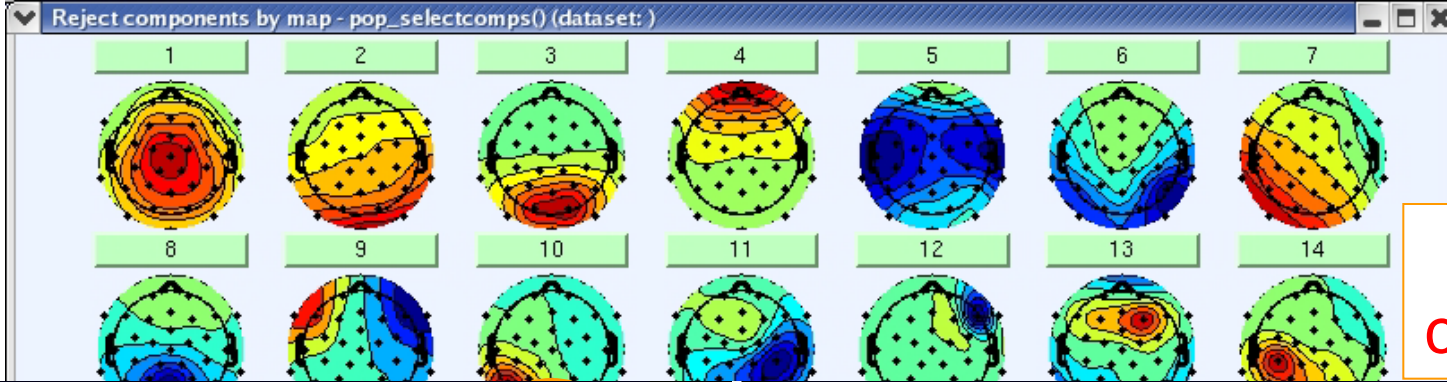


Eye blink component

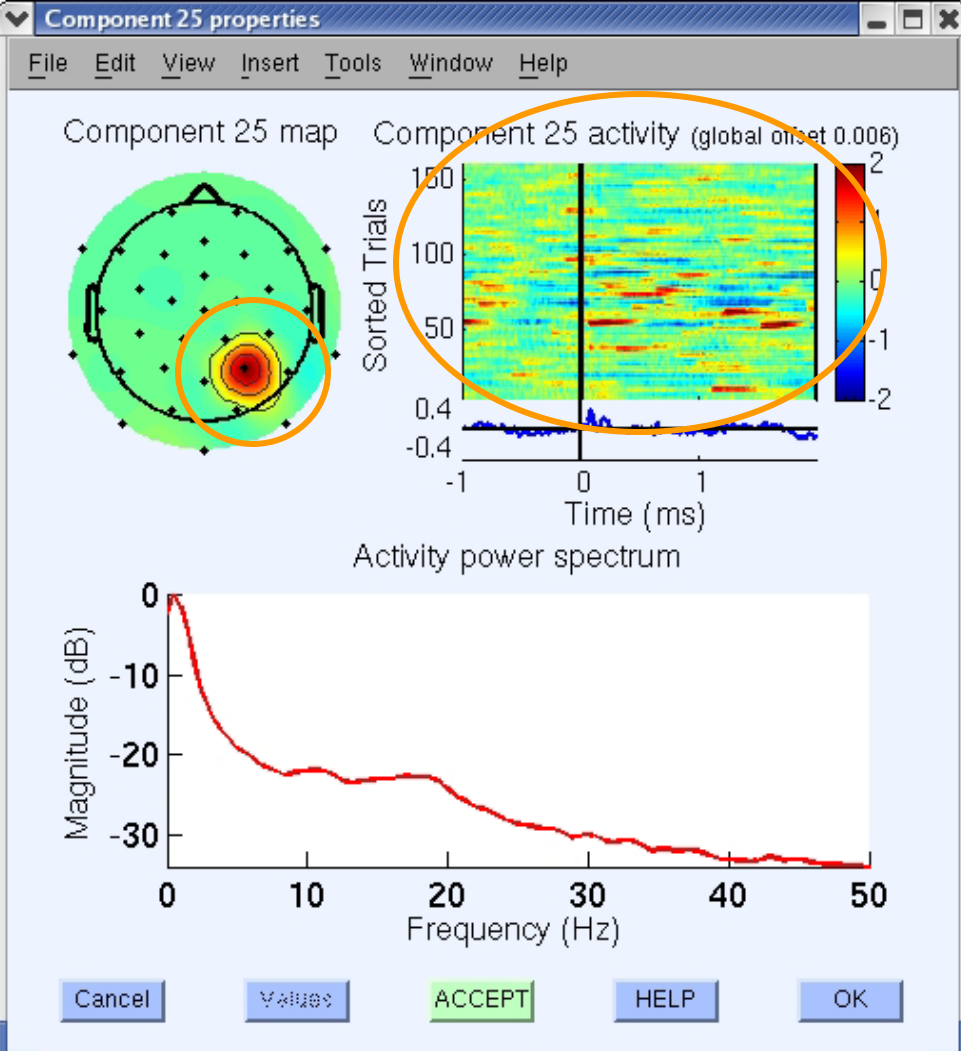
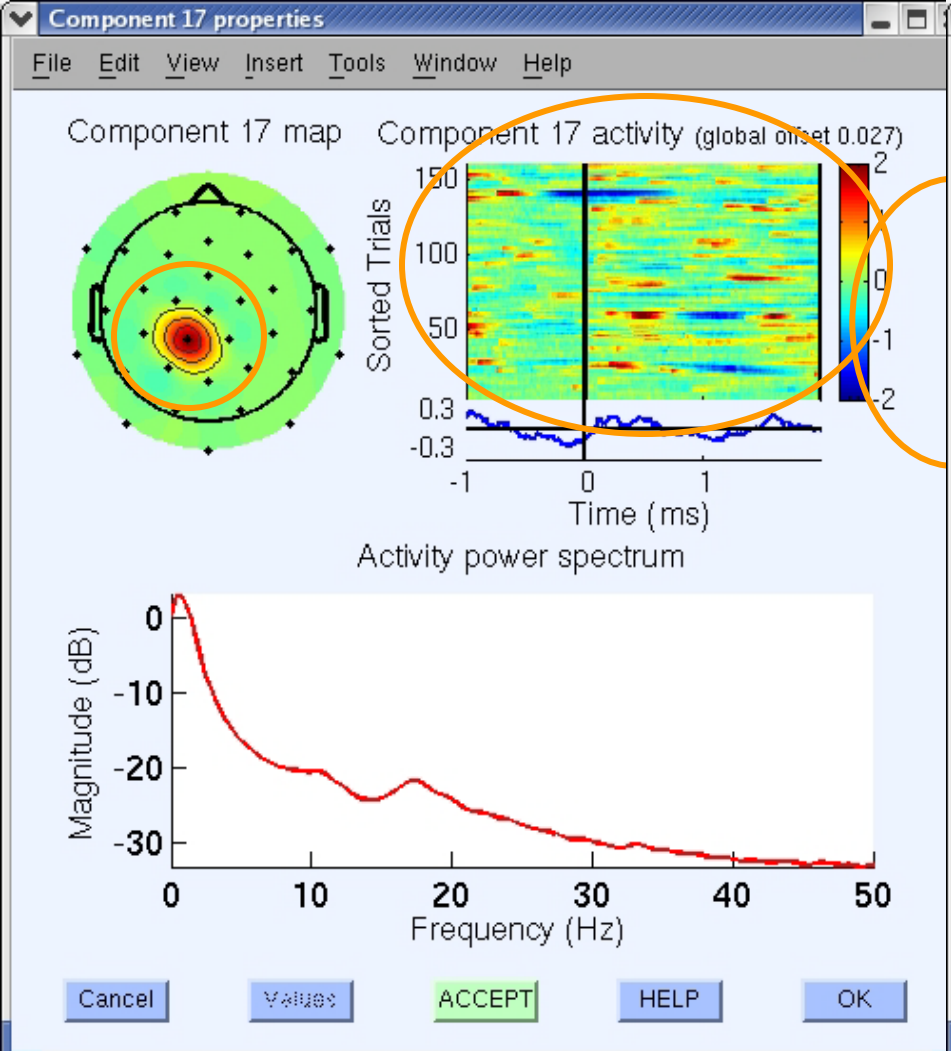


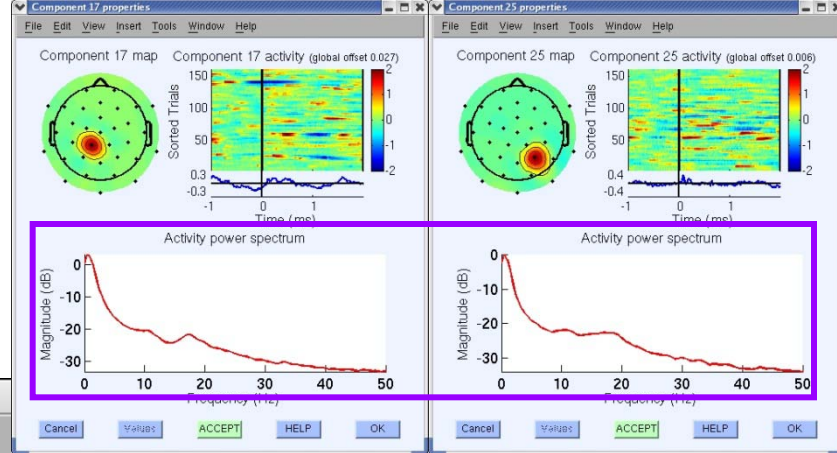
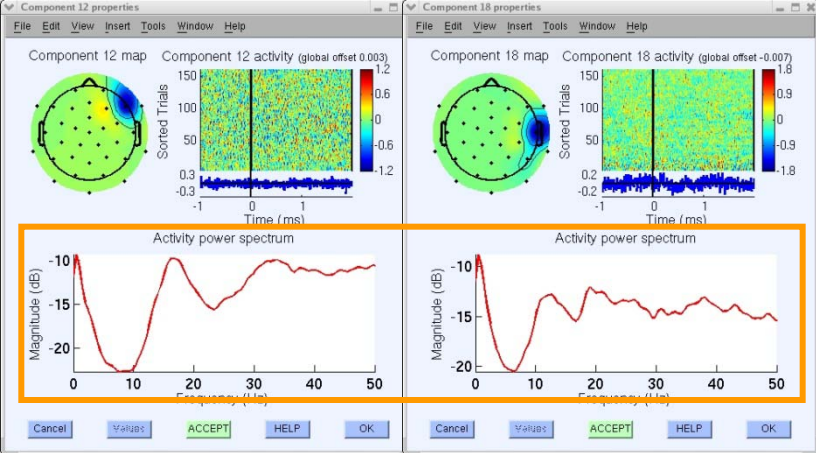
Lateral eye movement





Bad channels





EEGLAB v

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

Channel

ERP ma

Sum/Co

Compor

Compor

Compor

Compor

Compor

Compor

Compor

Compor

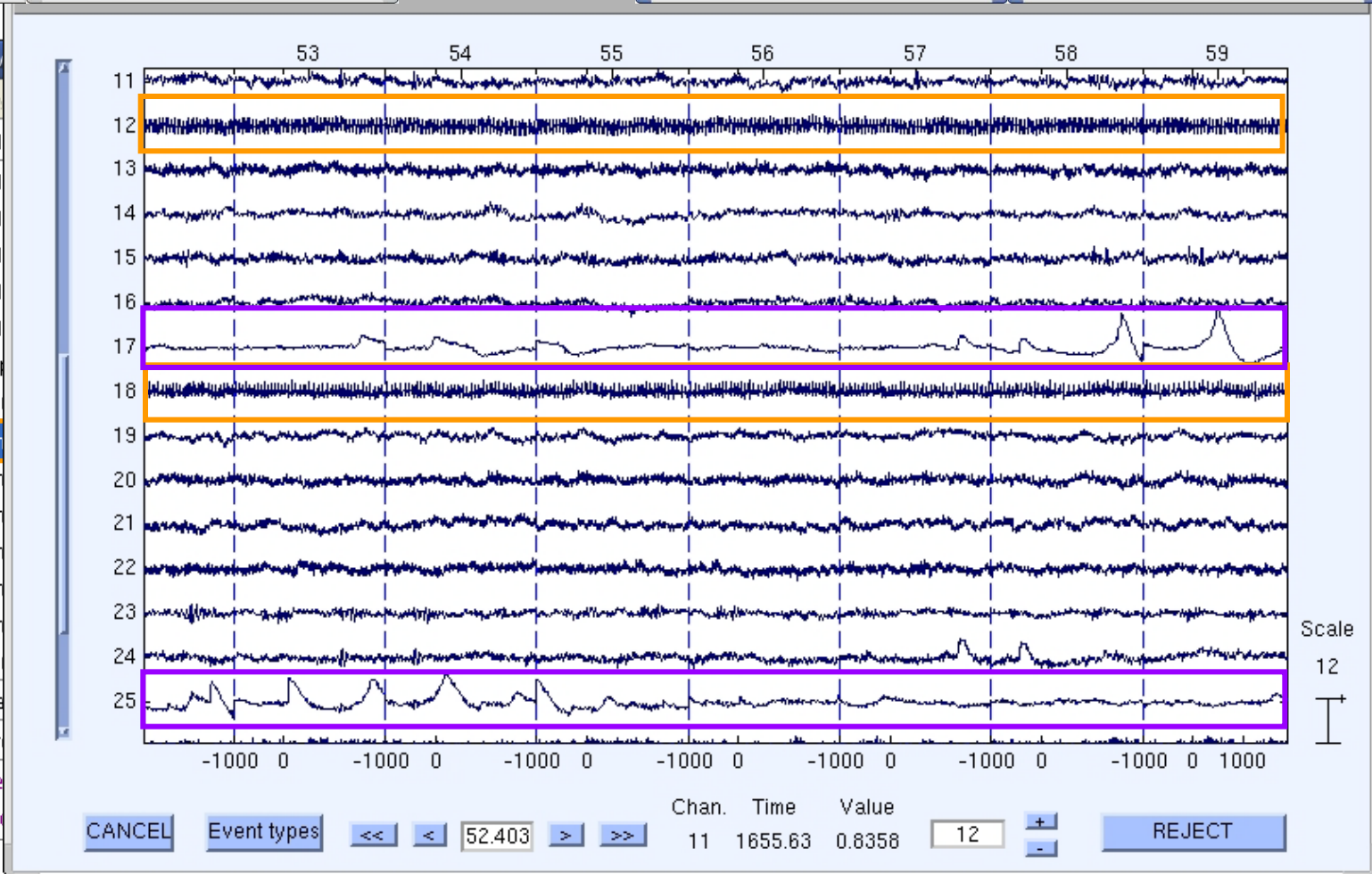
Sum/Co

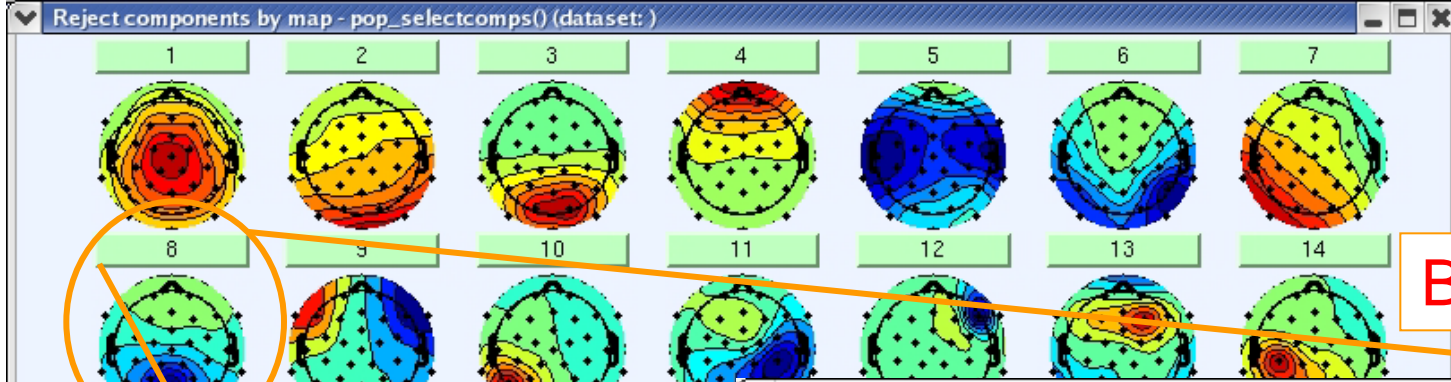
Data sta

Time-fr

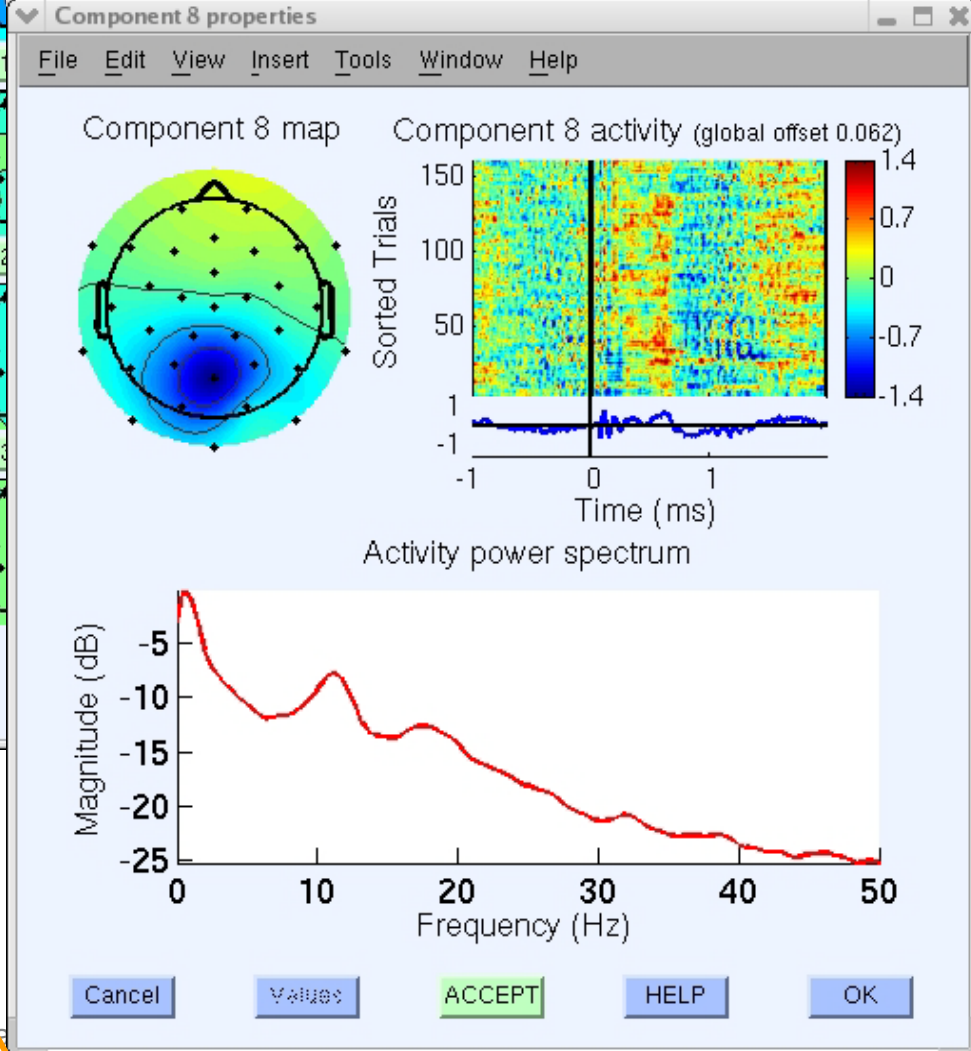
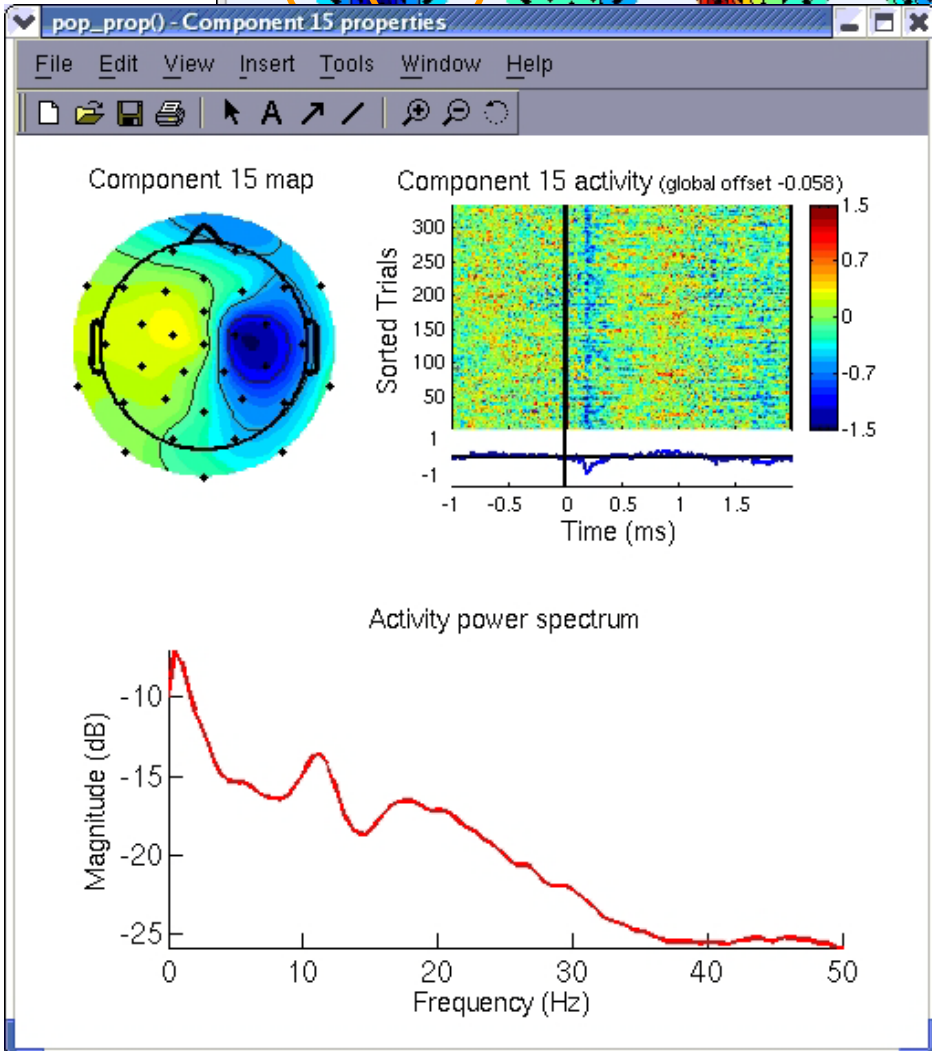
Average

Cluster

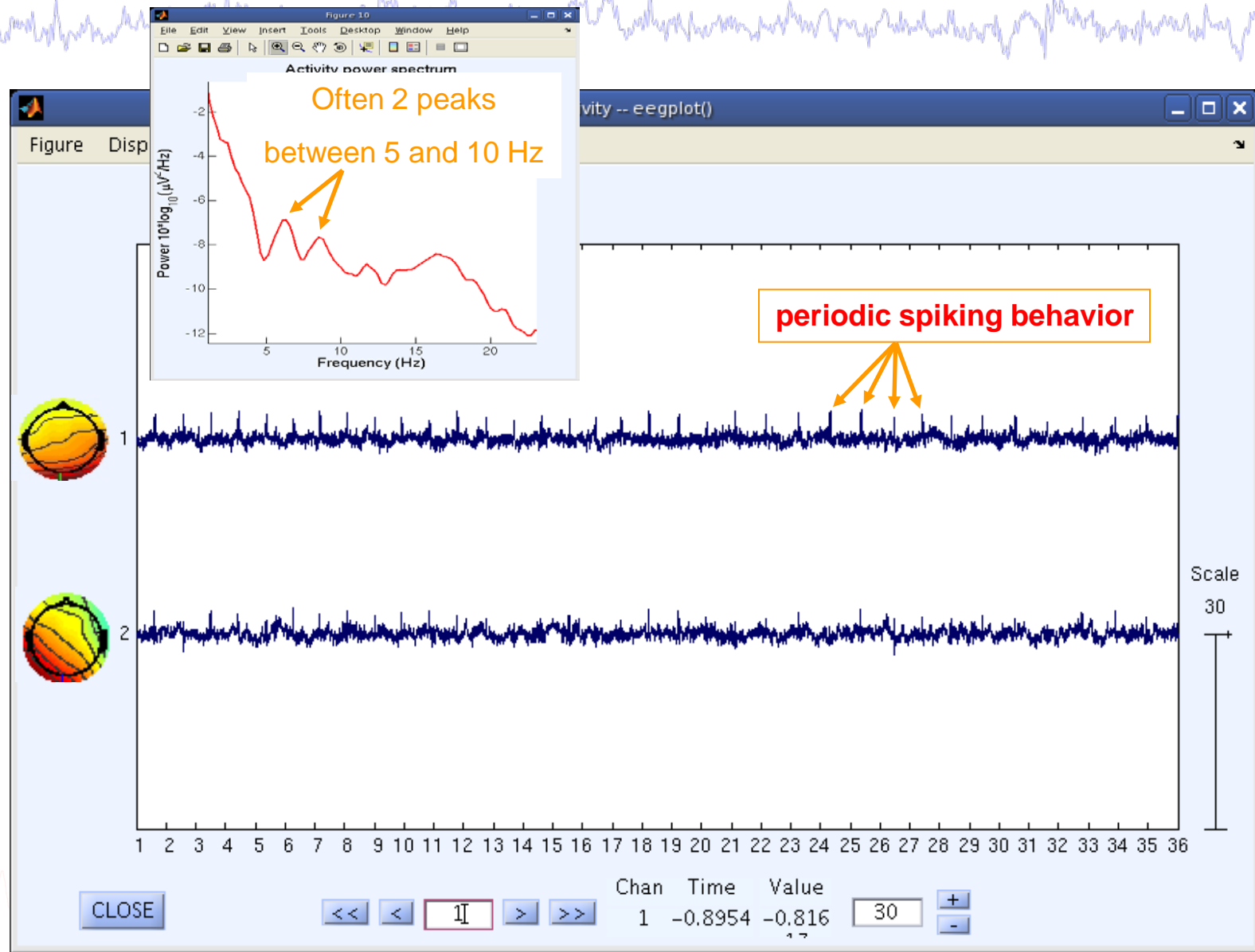




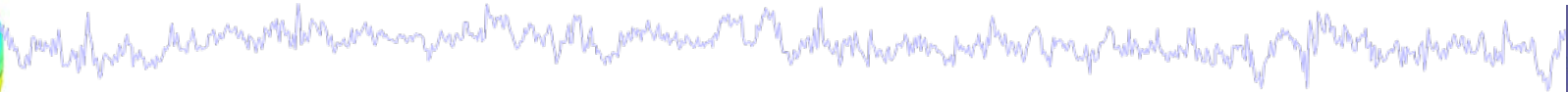
Brain ICs



Pulse artifacts



Artifact rejection and running ICA



Task 1

Reject noisy data

Task 2

Run ICA

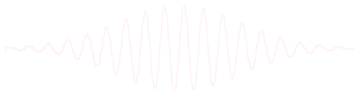
Task 3

Plot components

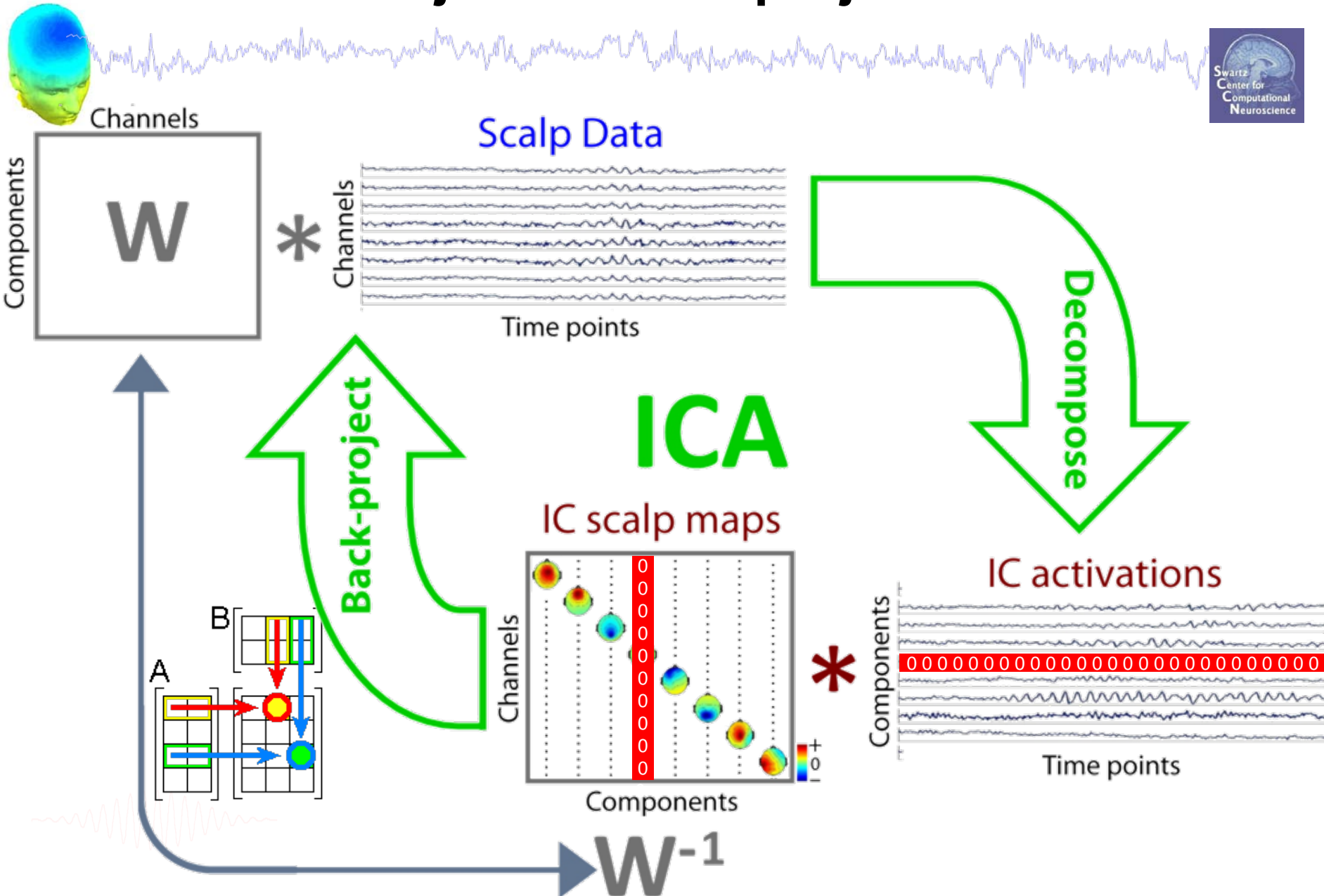
Task 4

Remove components
(i.e. back-projection)

Exercise...



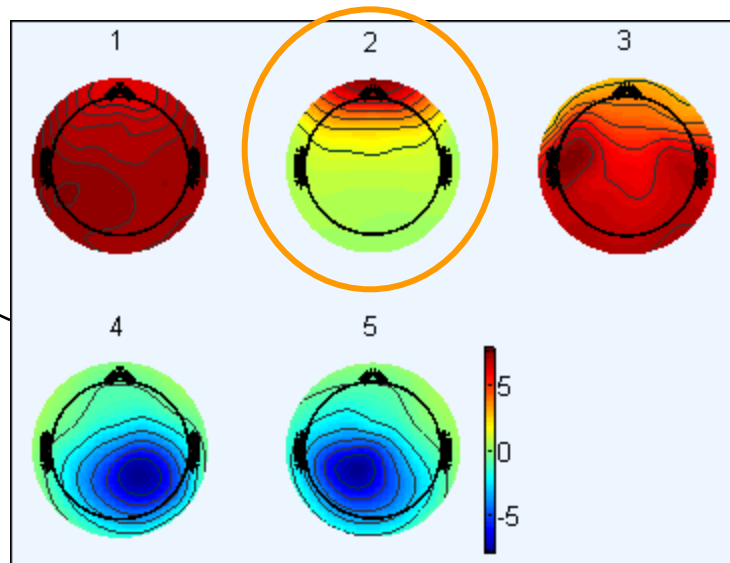
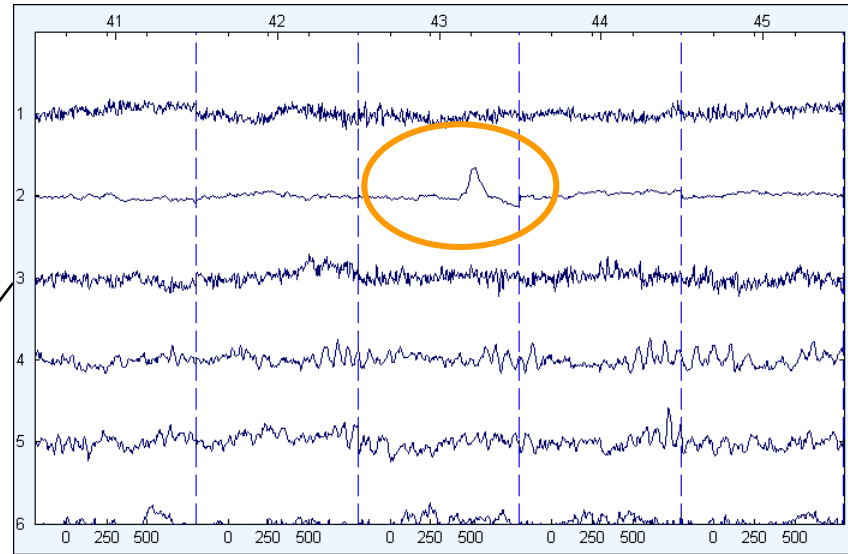
IC rejection/back-projection



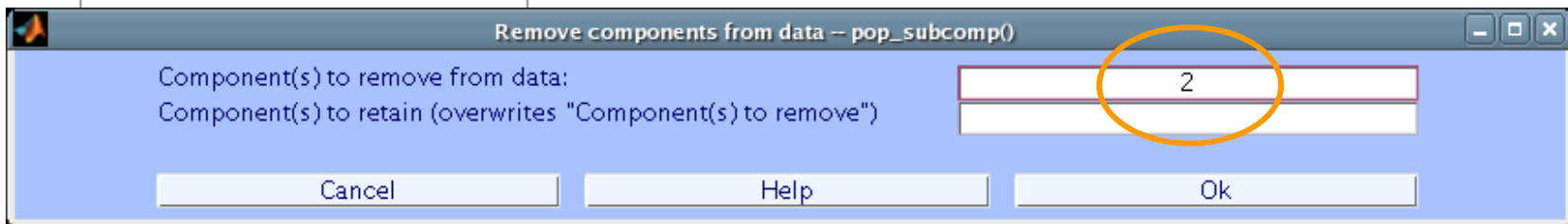
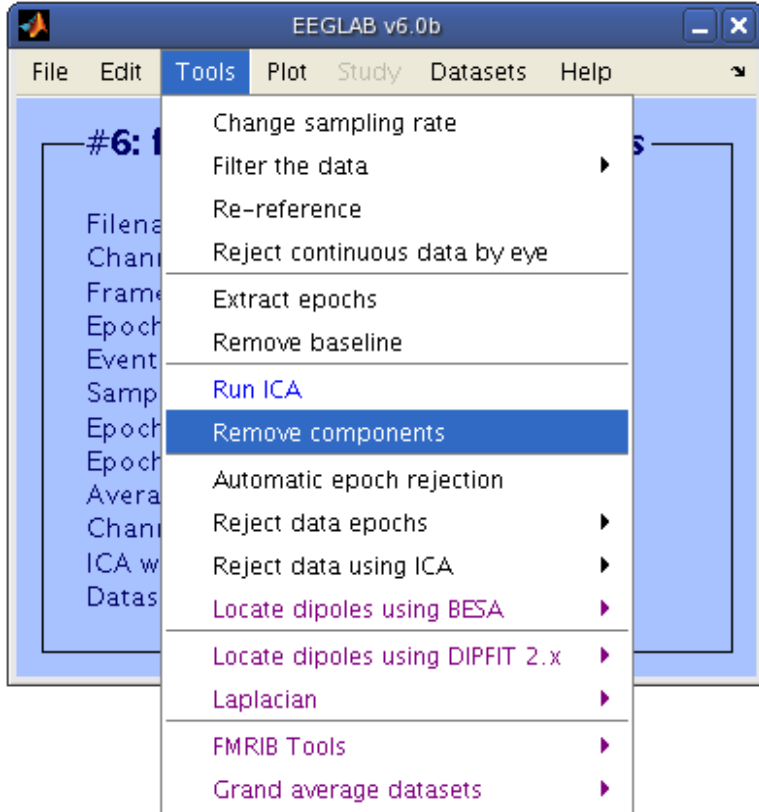
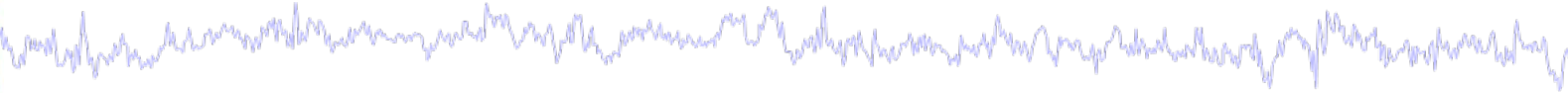
Eye blink correction



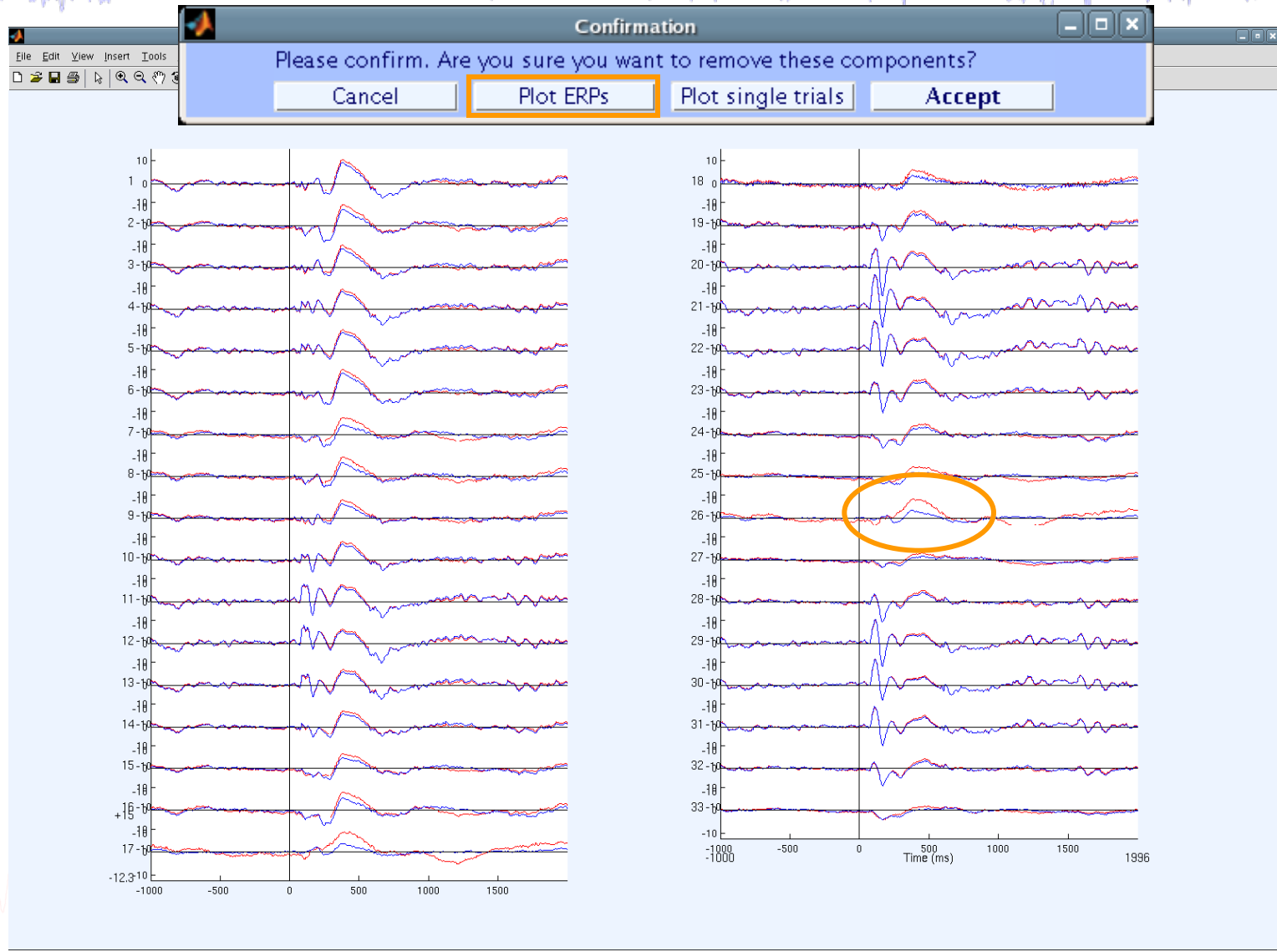
Identify eye-blink components:



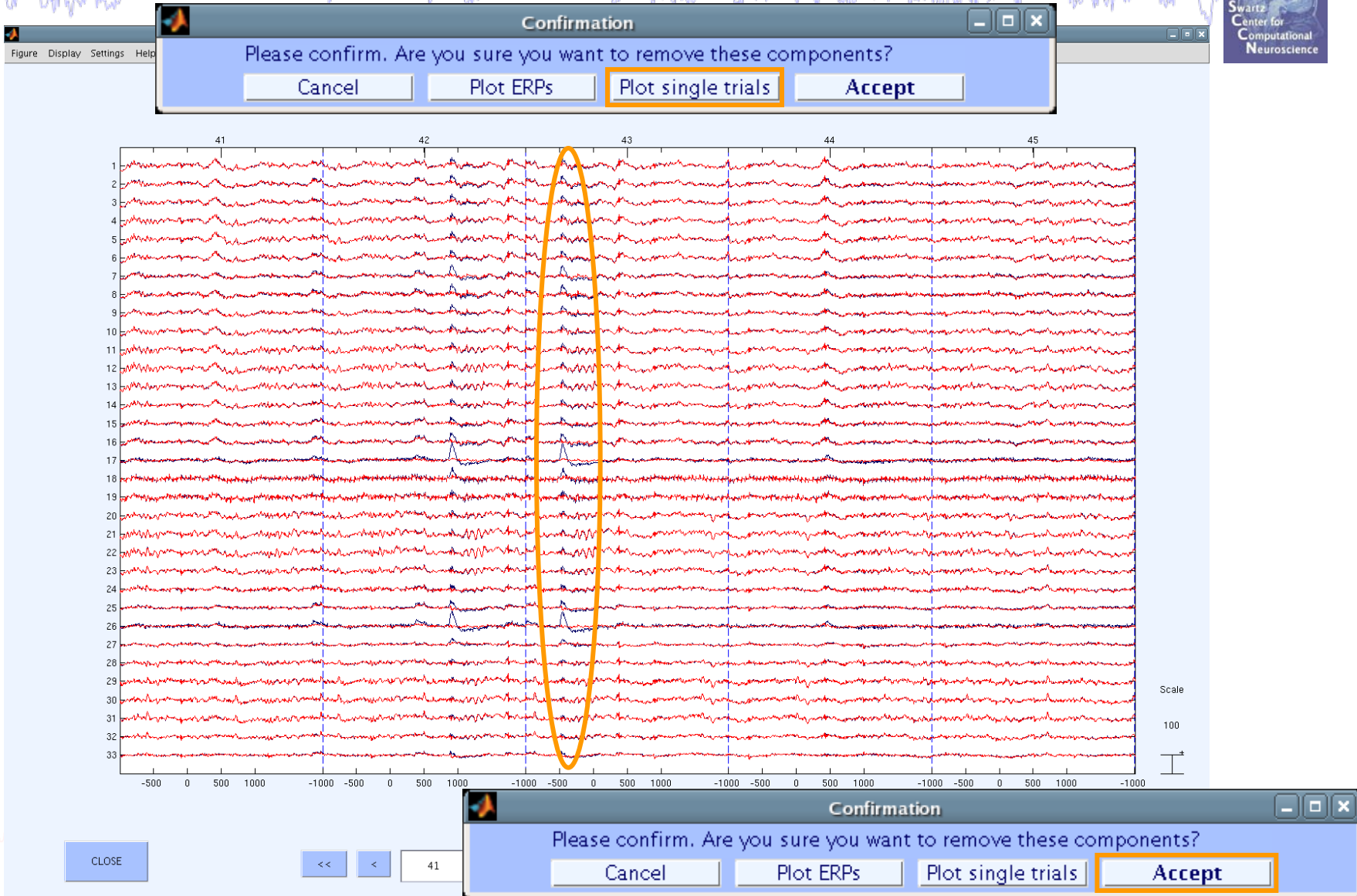
Eye blink correction



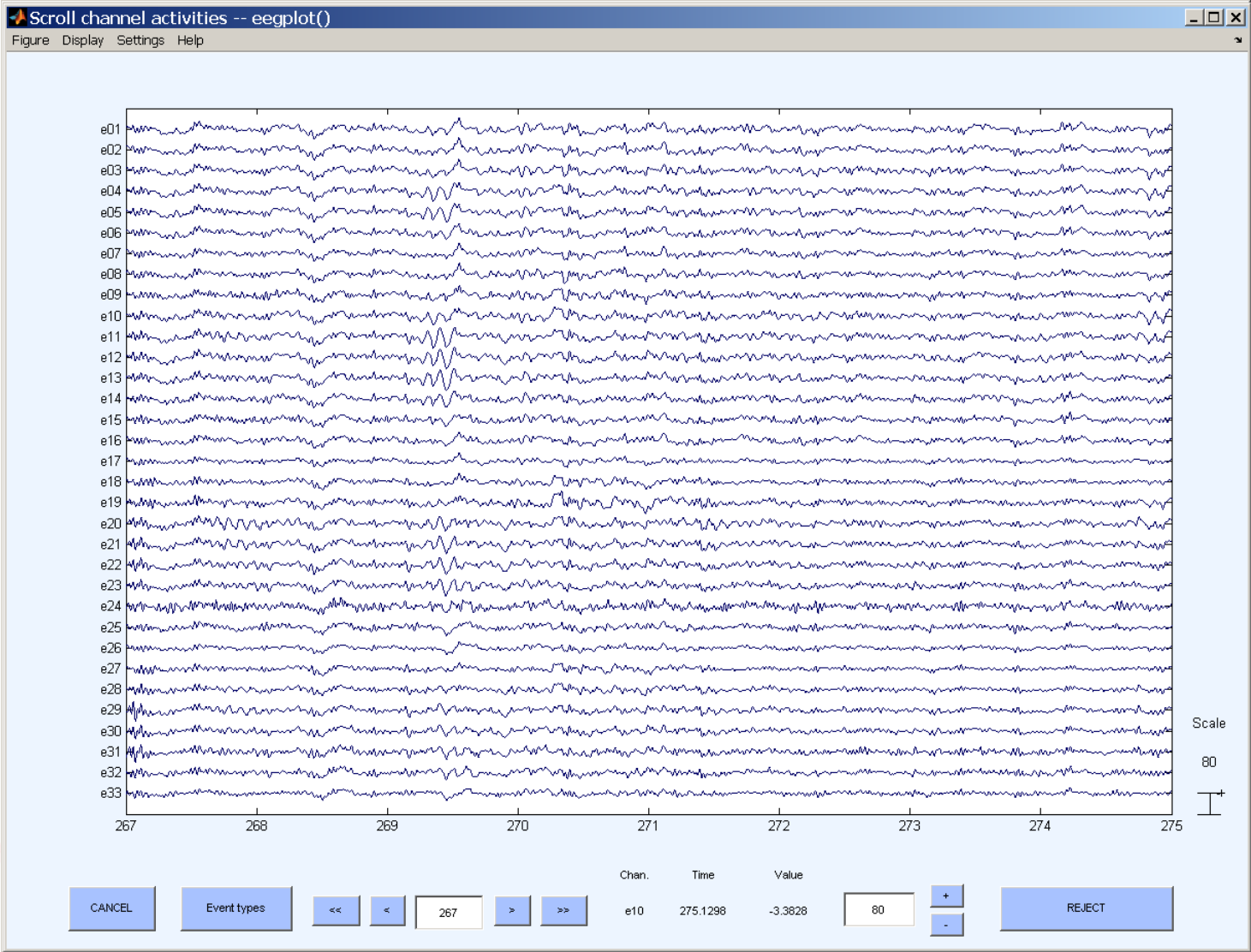
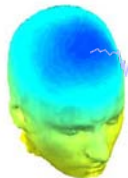
Eye blink correction



Eye blink correction



Eye blink correction



Exercise



- **ALL**
 - Load stern.set
 - 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?

