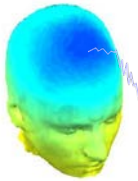
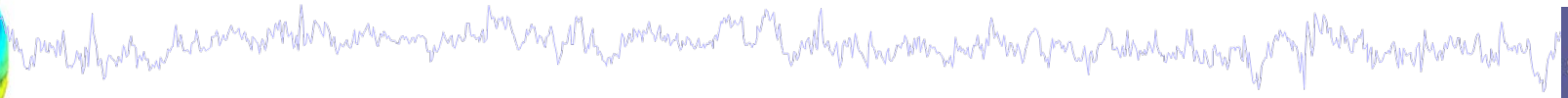
Evaluating ICs





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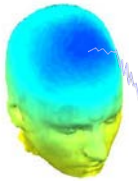
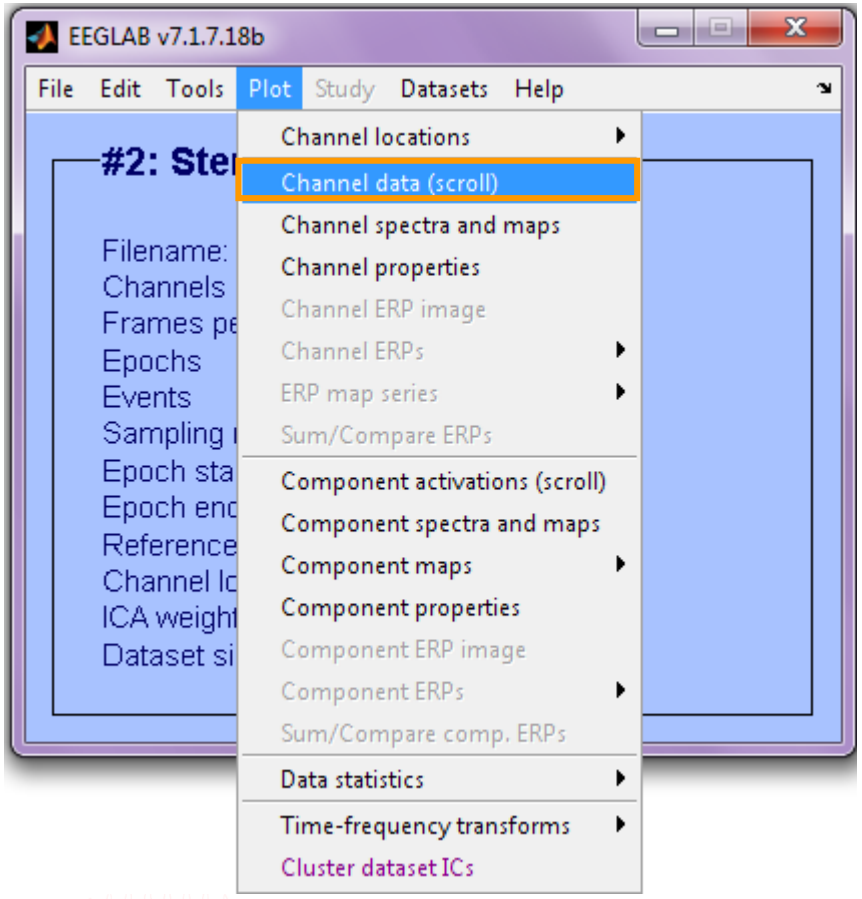
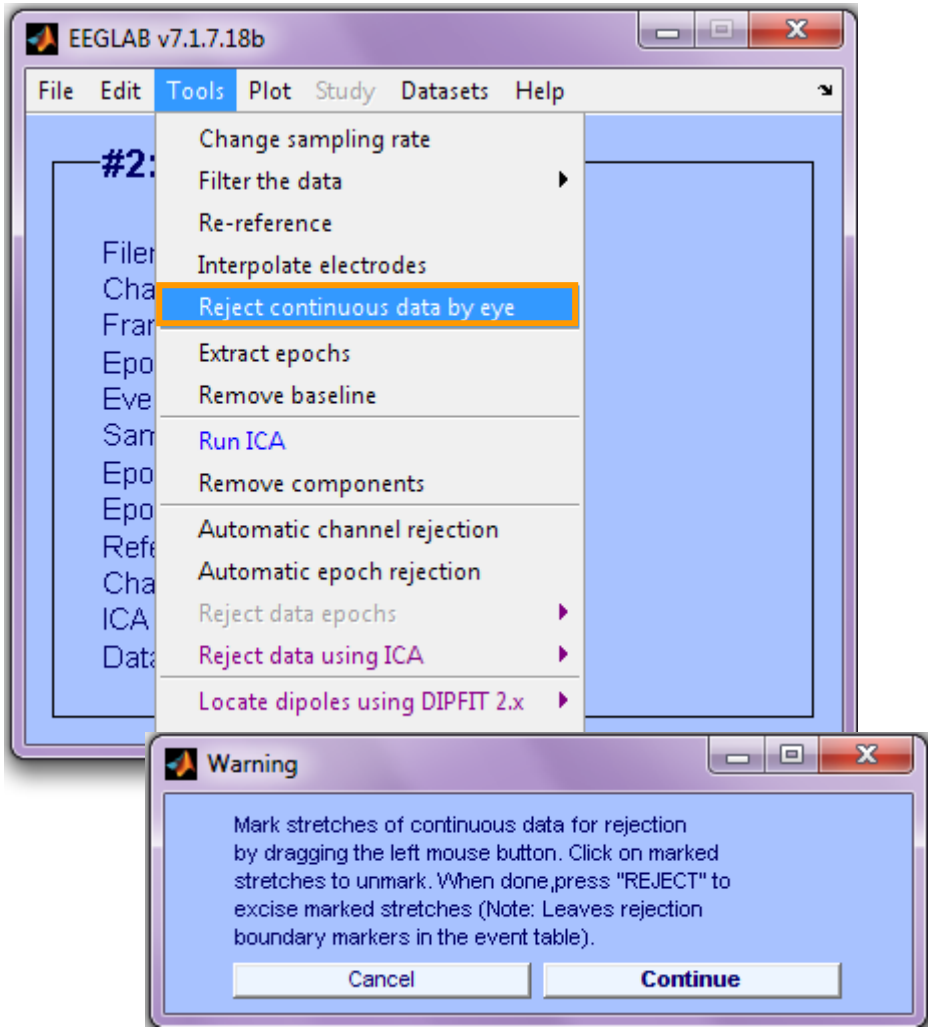
1. Run ICA
2. Apply ICA weights
3. IC scalp map interpretation
4. Basic IC evaluation
5. Identify IC artifacts

Reject continuous data

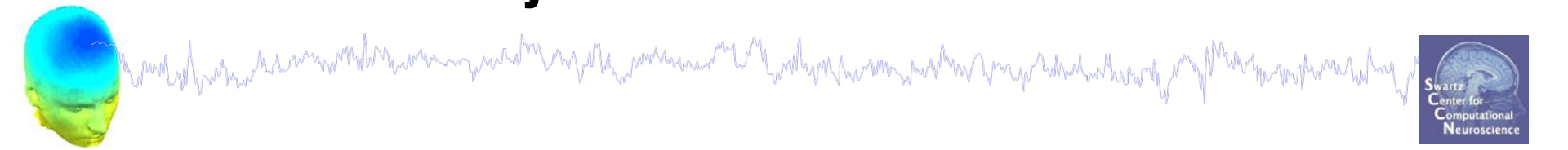


Equivalent





Reject continuous data



Scroll channel activities -- eegplot()

Figure Display Settings Help

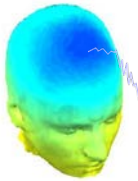
Click and drag with mouse over noisy data to reject

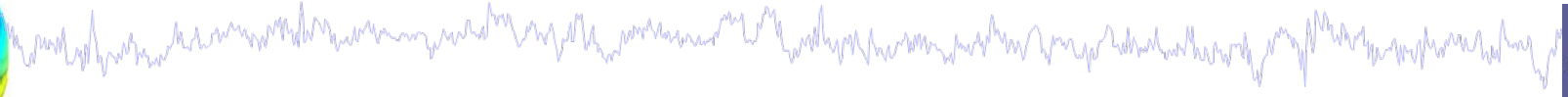
Scale 35

536 537 538 539 540 541

CANCEL | Event types | << | < | 536 | > | >> | Chan. FC6 | Time 539.9355 | Value 4.8773 | 35 | + | - | REJECT

Rejecting data for ICA





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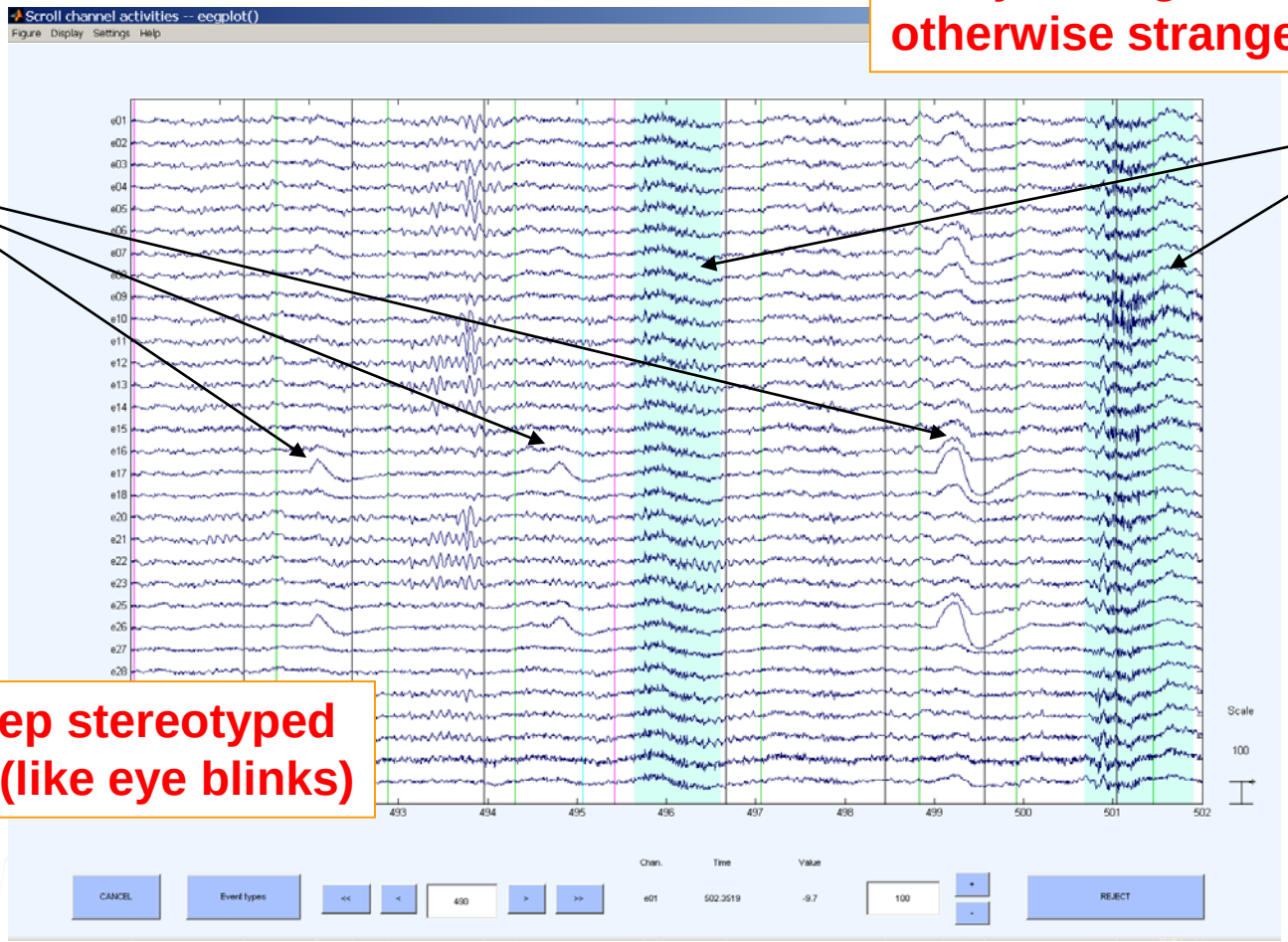
To prepare data for ICA:

Reject large muscle or otherwise strange events...

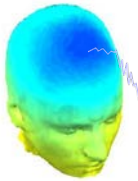
Keep

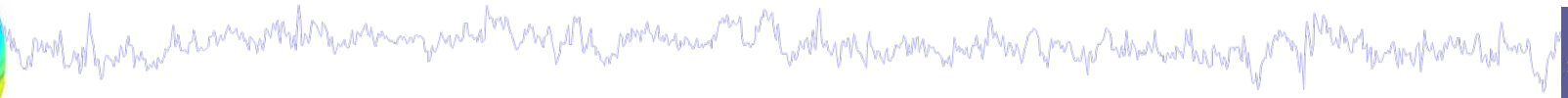
Reject



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

Independent Component Analysis





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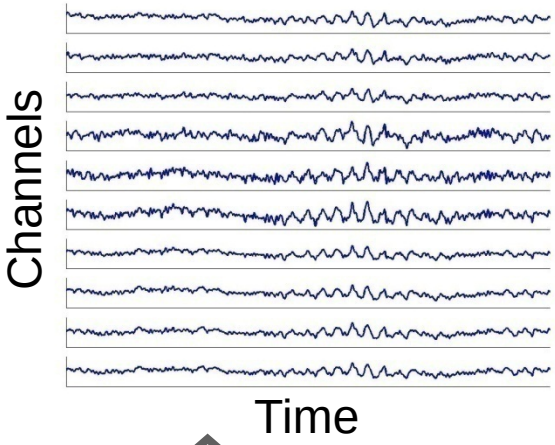
x = scalp EEG

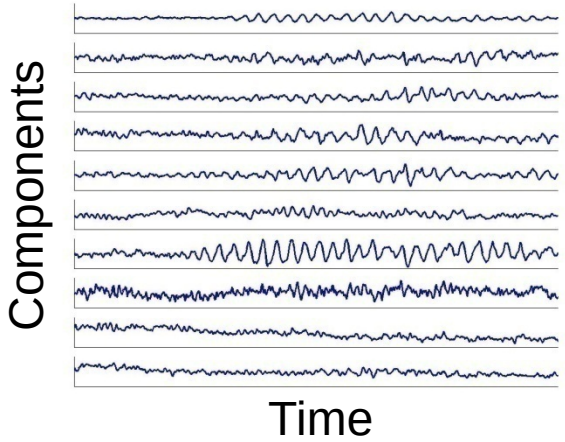
W = unmixing matrix

u = sources



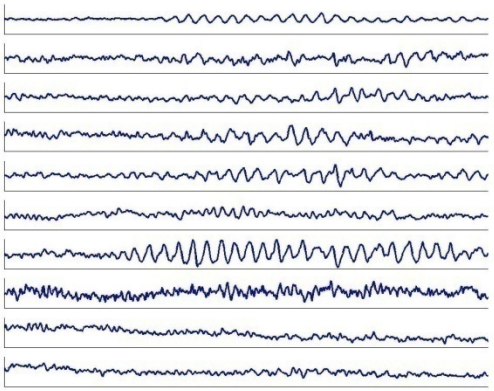
W*x = u

ICA



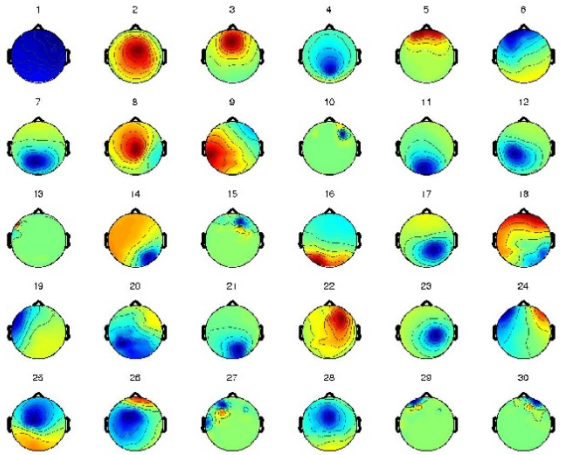
x = W^{-1}*u

u = sources

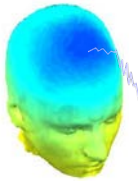


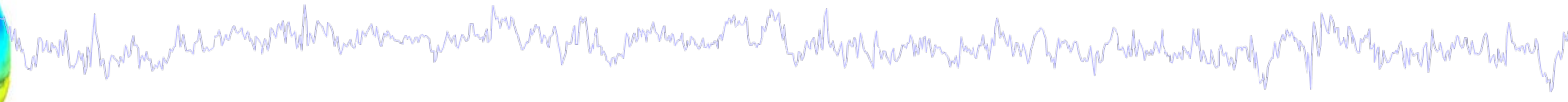
*

W^{-1} (scalp projections)



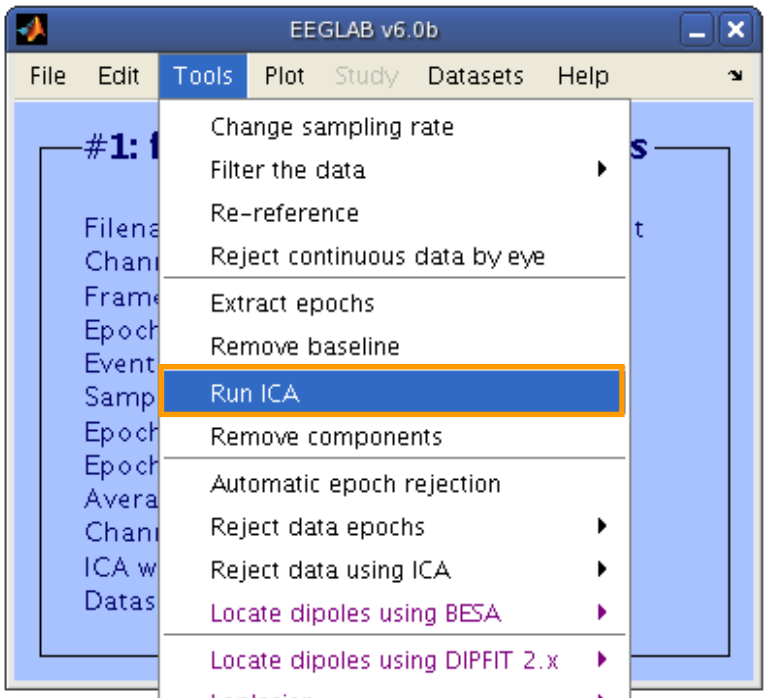
“Secrets” to a good ICA decomposition





- Garbage in… garbage out (it’s not magic)
- Remove large, non-stereotyped artifacts
- Do you have enough data? (based mostly on time, not frames)
  - * ~30 min of data for 60-70 channels, ~60 min for > 200 channels
- High-pass filter to remove slow drifts
  - * low-pass/ notch filters usually unnecessary
- Remove bad channels
- Data must be in double precision (not single)

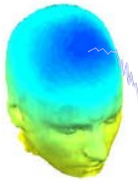
Runica options



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,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

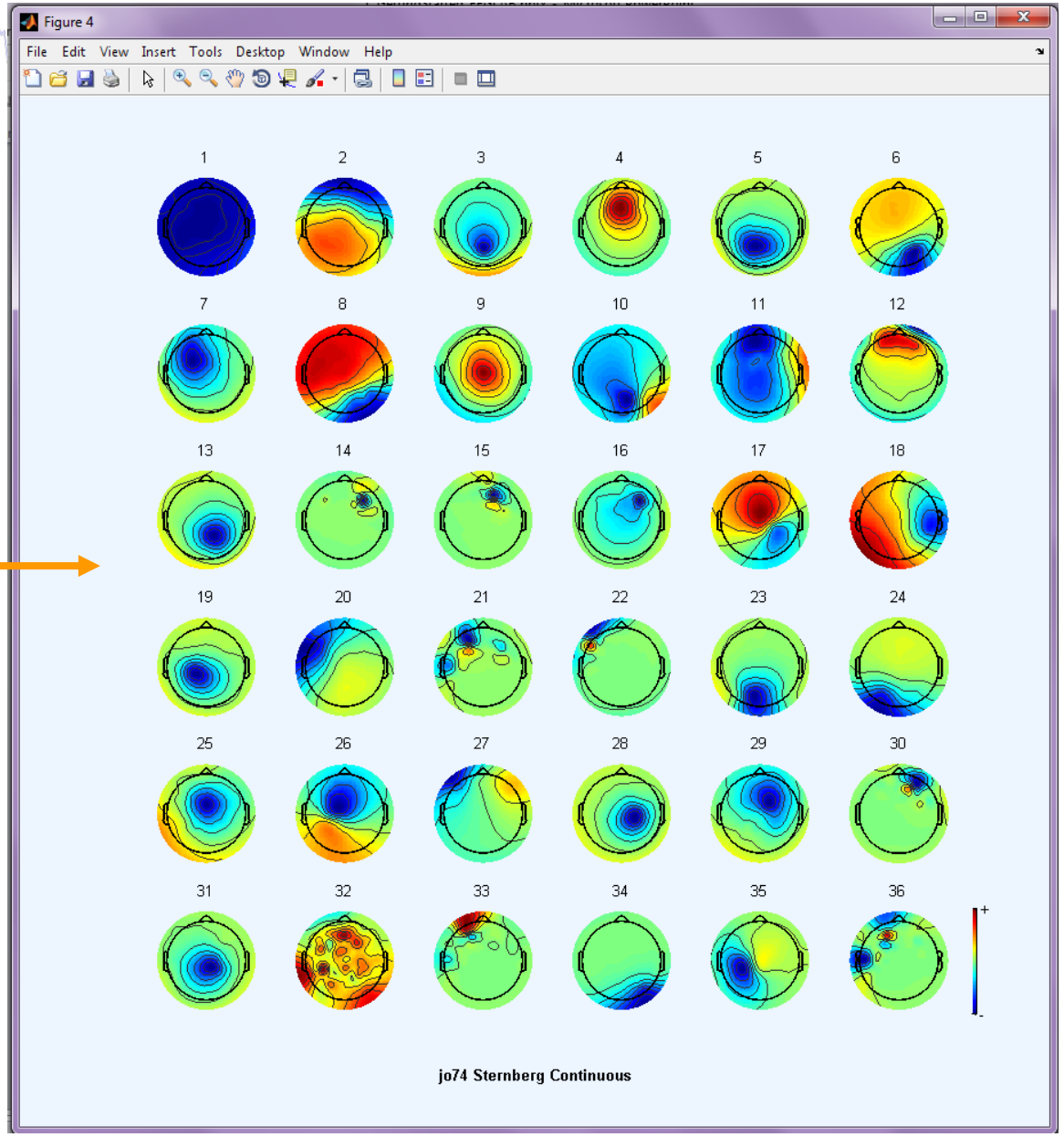
File Edit View Terminal Tabs Help

```
>> 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: []

>>
```



ICA weights in EEG structure

MATLAB 7.6.0 (R2008a)

File Edit Debug Parallel Desktop Window Help

Shortcuts How to Add What's New

New to MATLAB? Watch this Video, see Demos, or read Getting Started.

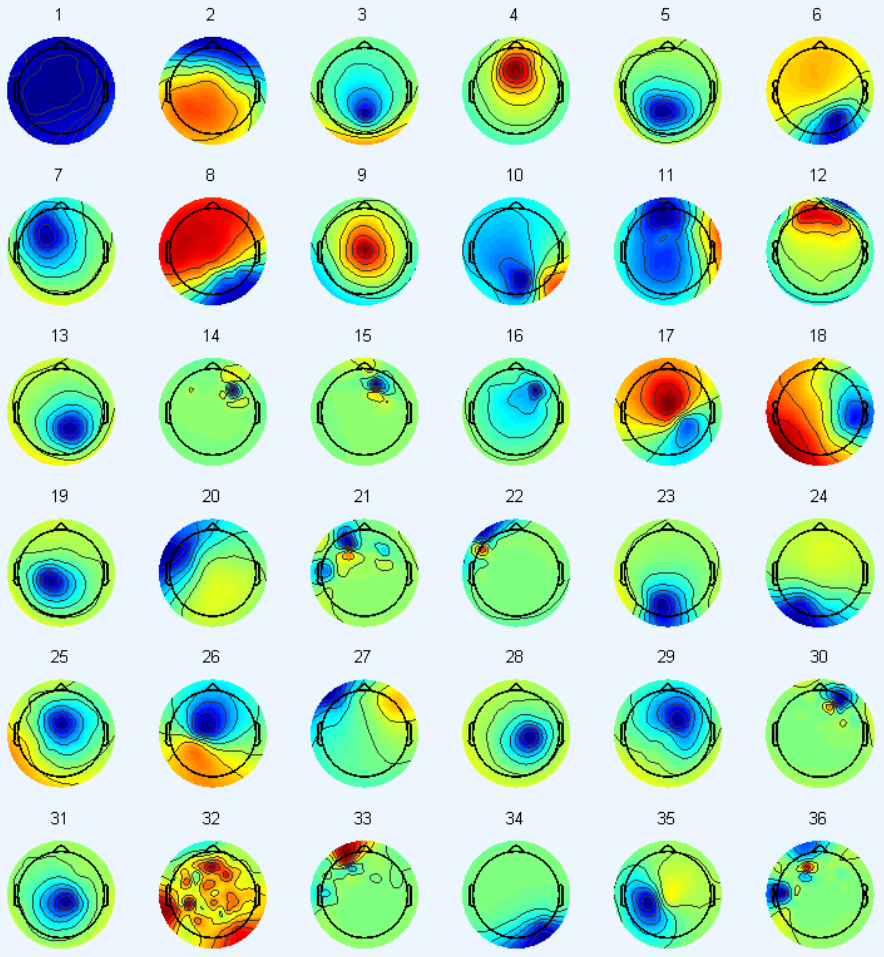
```
EEG =

            setname: 'Sternberg Continuous Data'
           filename: 'stern.set'
           filepath: [1x50 char]
            subject: ''
              group: ''
          condition: ''
            session: []
           comments: [22x108 char]
             nbchan: 71
             trials: 1
               pnts: 610133
              srate: 250
               xmin: 0
               xmax: 2.4405e+003
              times: []
               data: [71x610133 double]
            icaact: [71x610133 double]
          * icawinv: [71x71 double]
         icasphere: [71x71 double]
       icaweights: [71x71 double]
     icachansind: [1x71 double]
        chanlocs: []
      urchanlocs: []
        chaninfo: [1x1 struct]
             ref: 'common'
           event: [1x1303 struct]
         urevent: [1x1303 struct]
eventdescription: {1x15 cell}
```

Start OVR

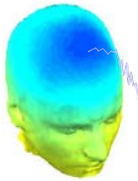
Figure 4

Edit View Insert Tools Desktop Window Help



EEG.icawinv = inv(EEG.icaweights * EEG.icasphere)

Applying ICA weights to EEG data



matrix

multiplication

EEG.data

frames

channels

channels

EEG.icaweights

*

EEG.icasphere

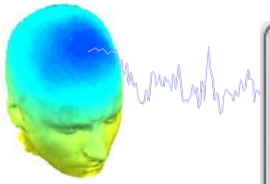
channels

channels

EEG.icaact

frames

Applying ICA weights to EEG data



Edit dataset information - pop_editset()

Dataset name jo74 Sternberg Data

Data sampling rate (Hz)	250	Subject code	
Time points per epoch (0->continuous)	750	Task condition	
Start time (sec) (only for data epochs)	-1	Session number	
Number of channels (0->set from data)	71	Subject group	
Ref. channel indices or mode (see help)	common	About this dataset	Enter comments

Channel location file or info From other dataset Browse

Note: The file format may be auto-detected from its file extension. See menu "Edit > Channel locations" for other options.

ICA weights array or text/binary file (if any): From other dataset Browse

ICA sphere array or text/binary file (if any): From other dataset Browse

ICA channel indices (by default all): From other dataset

Help

EEGLAB v10.2.2.1b

File Edit Tools Plot

Dataset info
Event fields
Event values
About this data
Channel locations
Select data
Select data using events
Select epochs or events
Copy current dataset
Append datasets

Select a text file

Look in: StemSubj

Recent Places
Desktop
Libraries
Computer
Network

NewICA71.sph
NewICA71.wts

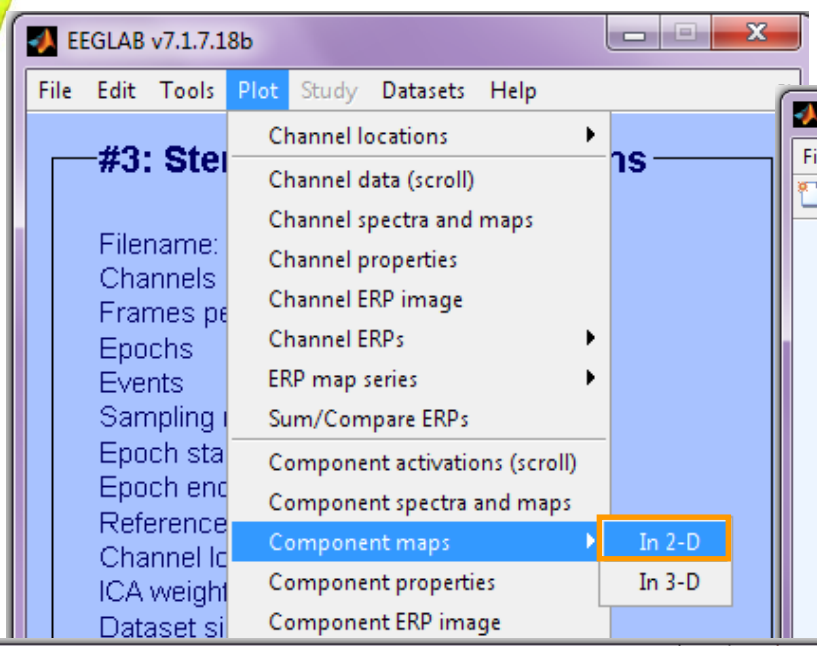
Same for sphering matrix

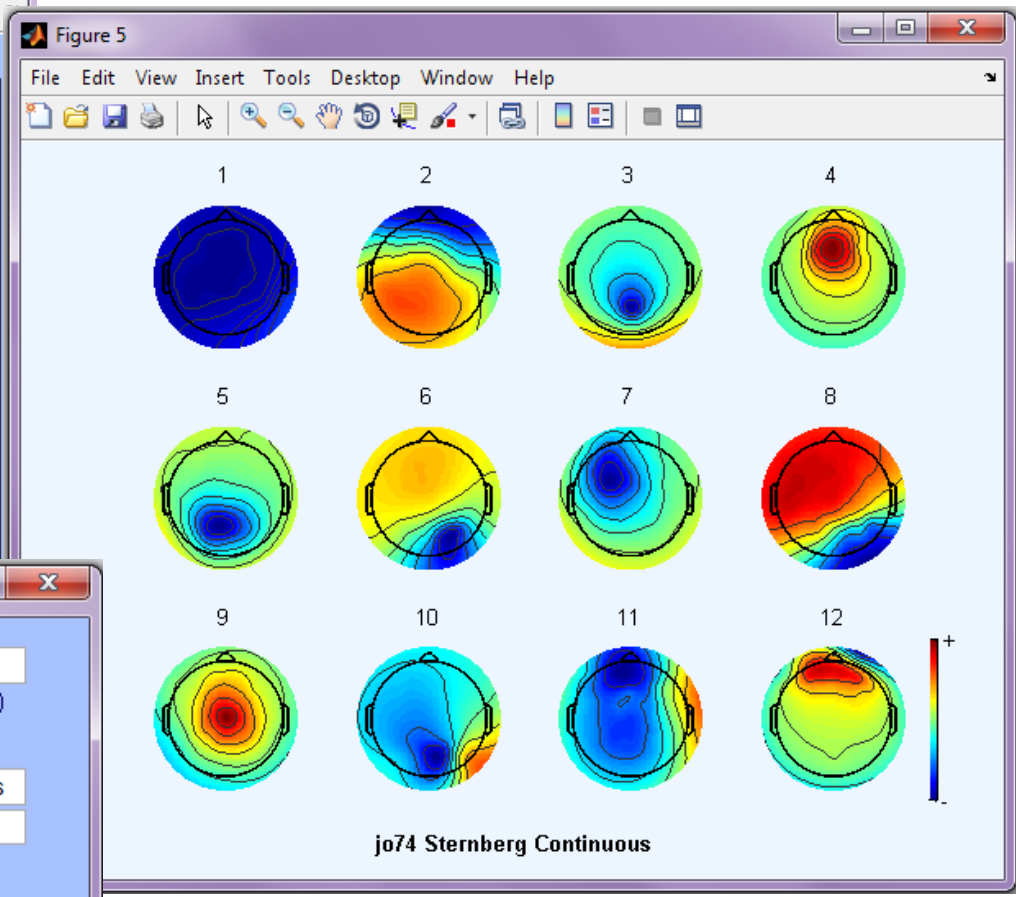
File name: NewICA71.wts Open

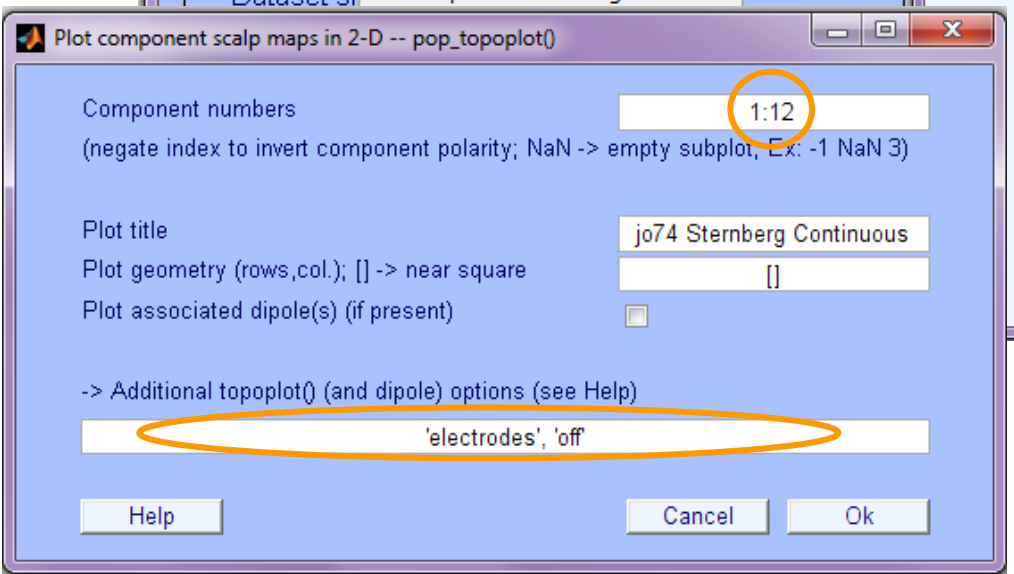
Files of type: All Files Cancel

Note: .wts and .sph not saved as separate files by EEGLAB, you must save them yourself:
floatwrite(EEG.icaweights,'C:\MyDirectory\ICA.wts');

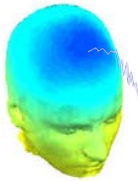
Plot ICA scalp maps

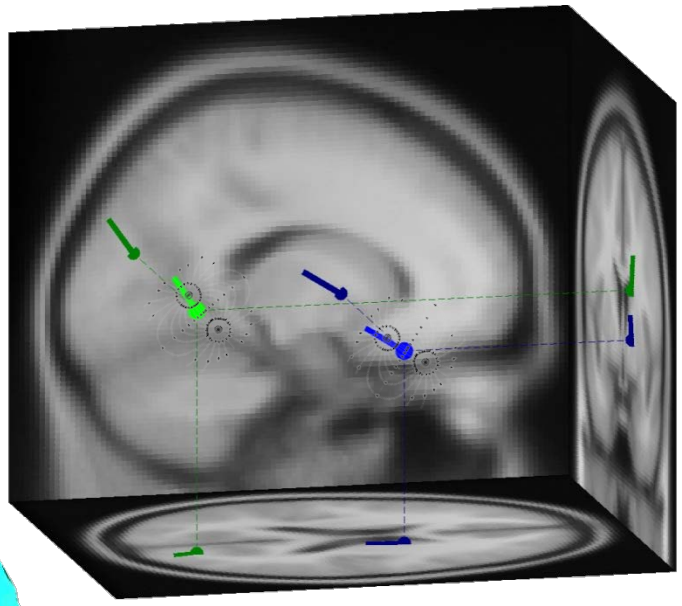


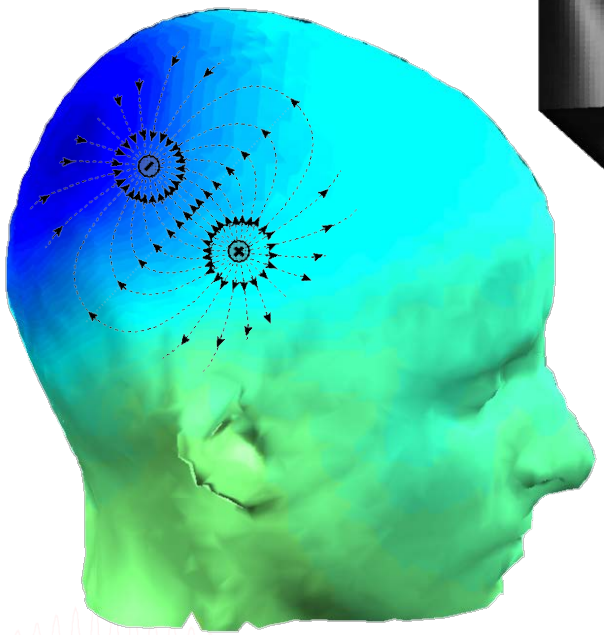


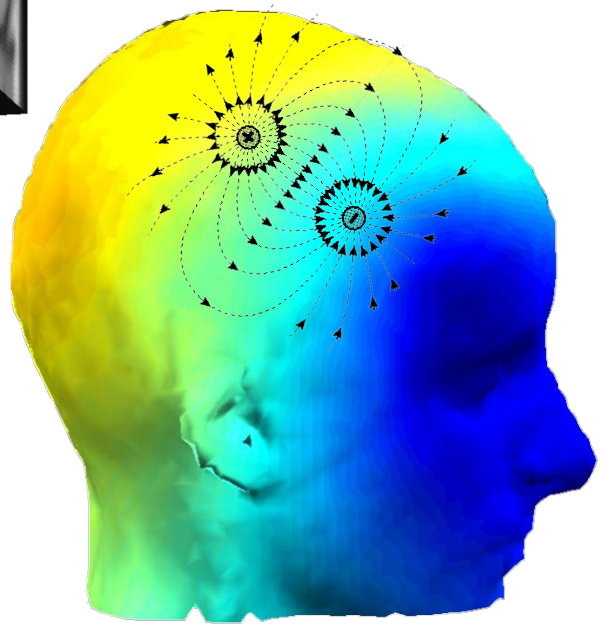


Single-dipole projections

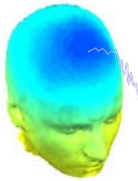


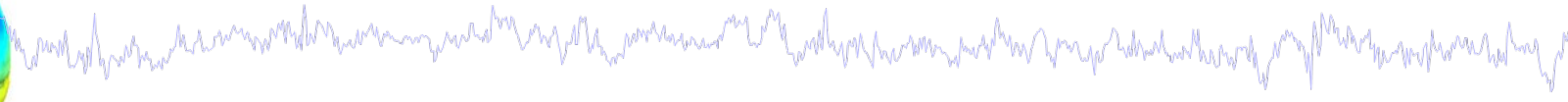






Compare 'good' and 'bad' scalp maps

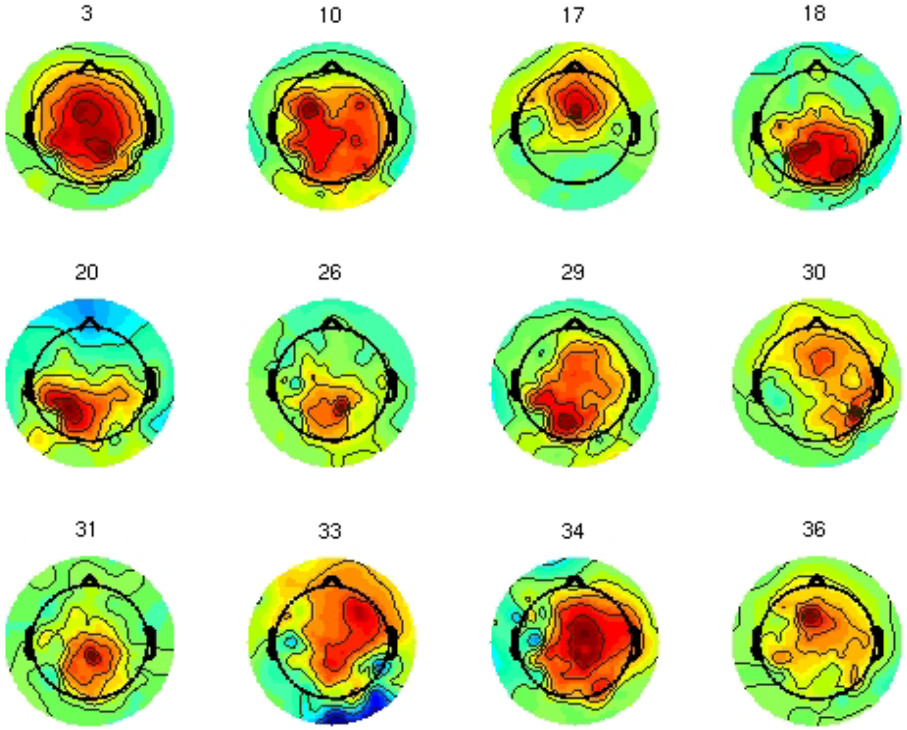




chaotic gradients

no clear patterns

INconsistent with single dipoles

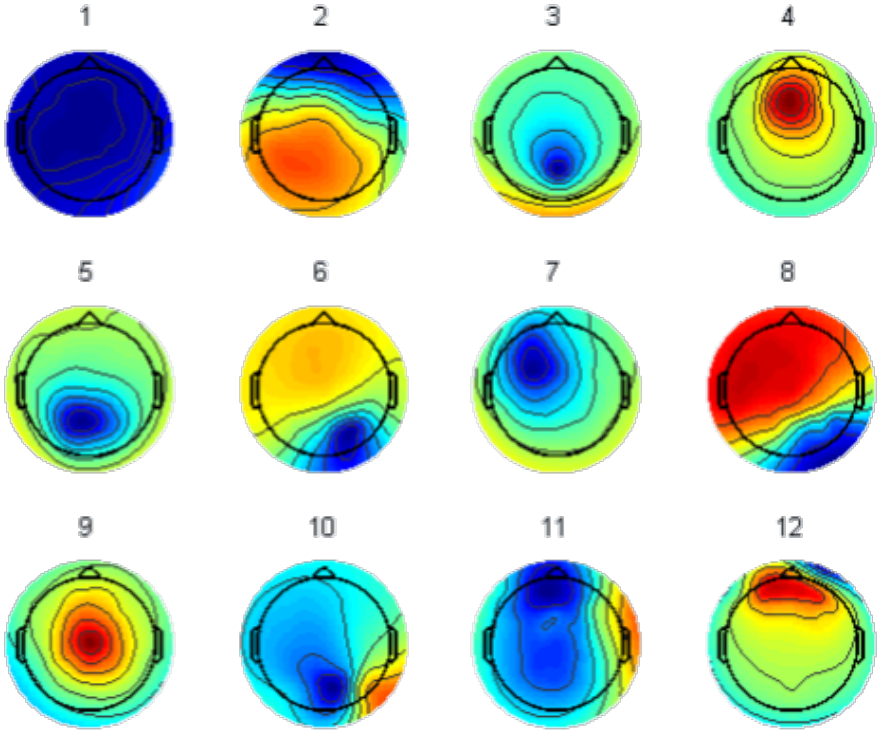


BAD ICA Components

smooth gradients

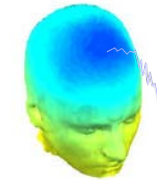
concentric rings (when radial)

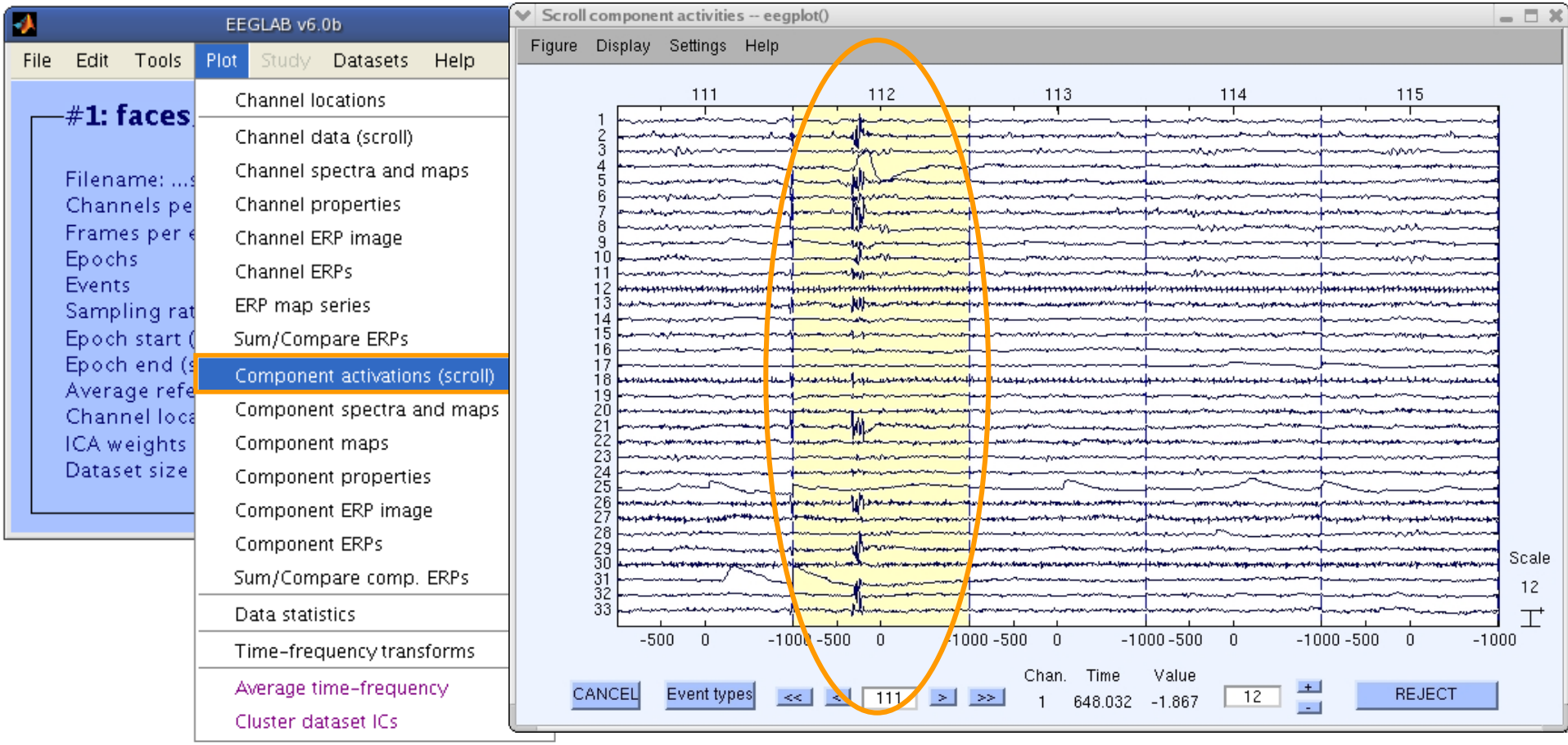
consistent with single dipoles



jo74 Sternberg Continuous

Scroll component activities

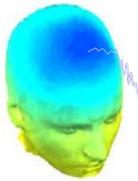




Time periods that are not independent across ICs

should be removed and ICA run again for better decomposition

Plot component power



Component spectra and maps -- pop_spectopo()

Epoch time range to analyze [min_ms max_ms]:	0 2440528
Frequency (Hz) to analyze:	10
Electrode number to analyze ([]=elec with max power; 0=whole scalp):	0
Percent data to sample (1 to 100):	20
Components to include in the analysis:	1:71
Number of largest-contributing components to map:	5
Else, map only these component numbers:	
[Checked] Compute comp spectra; [Unchecked] (data-comp) spectra:	☑
Plotting frequency range ([min max] Hz):	2 25
Spectral and scalp map options (see topoplot):	'electrodes','off'

Cancel Help

EEGLAB v7.1.7.18b

File Edit Tools Pl

#1: Ste ta

Filename:
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Frames pe
Epochs
Events
Sampling
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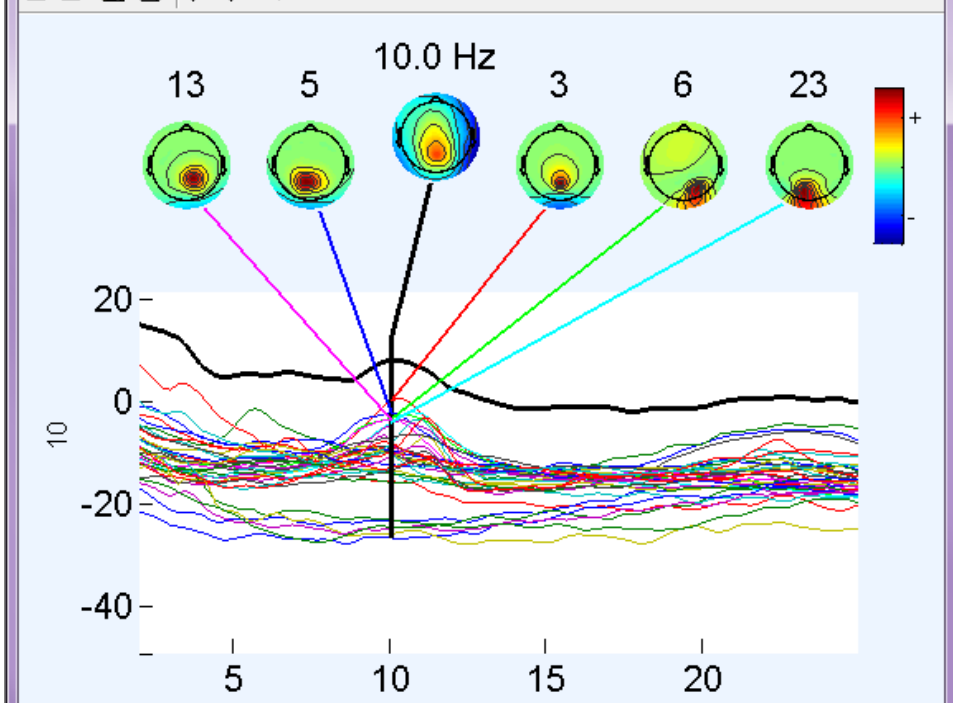
Reference
Channel lo
ICA weight
Dataset si

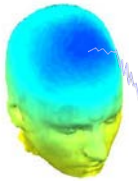
- Channel locations
- Channel data (scroll)
- Channel spectra and maps
- Channel properties
- Channel ERP image
- Channel ERPs
- ERP map series
- Sum/Compare ERPs
- Component activations (scroll)
- Component spectra and maps
- Component maps
- Component properties
- Component ERP image
- Component ERPs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

Figure 2: spectopo()

File



Plot component power



Component spectra and maps -- pop_spectopo()

Epoch time range to analyze [min_ms max_ms]:	0 2440528
Frequency (Hz) to analyze:	6
Electrode number to analyze ([]=elec with max power; 0=whole scalp):	0
Percent data to sample (1 to 100):	20
Components to include in the analysis:	1:71
Number of largest-contributing components to map:	5
Else, map only these component numbers:	
[Checked] Compute comp spectra; [Unchecked] (data-comp) spectra:	☑
Plotting frequency range ([min max] Hz):	2 25
Spectral and scalp map options (see topoplot):	

Cancel

EEGLAB v7.1.7.18b

File Edit Tools Plo

#1: Ste ta

Filename:
Channels
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Dataset si

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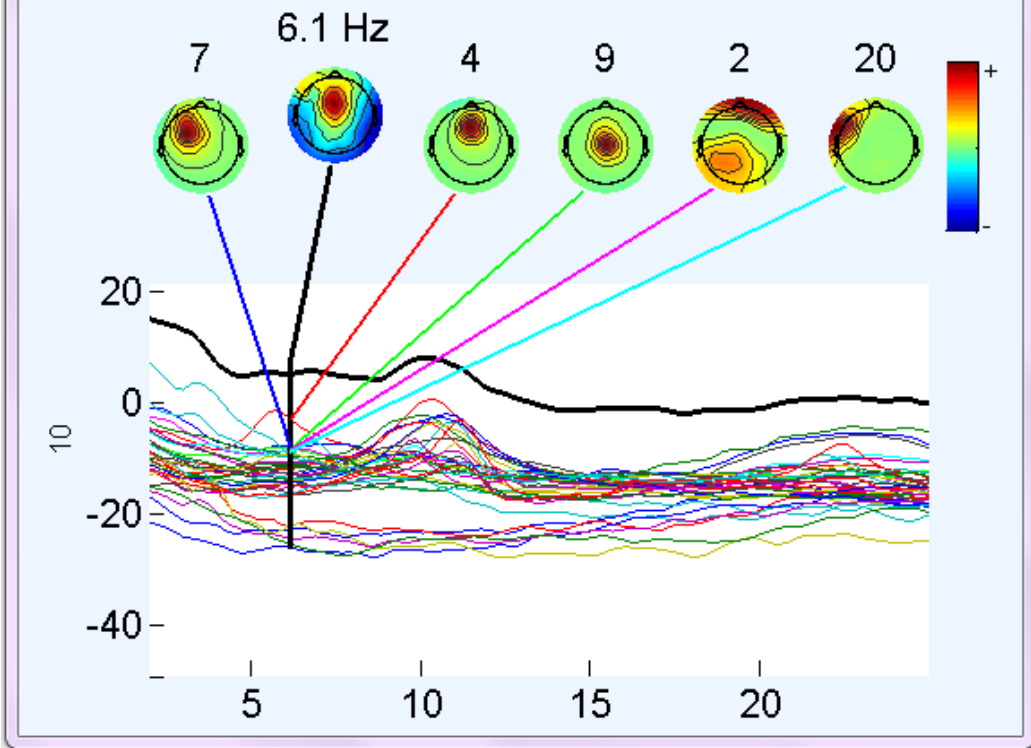
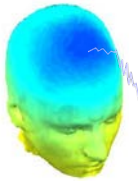
- Channel properties
- Channel ERP image
- Channel ERPs
- ERP map series
- Sum/Compare ERPs
- Component activations (scroll)
- Component spectra and maps
- Component maps
- Component properties
- Component ERP image
- Component ERPs
- Sum/Compare comp. ERPs
- Data statistics

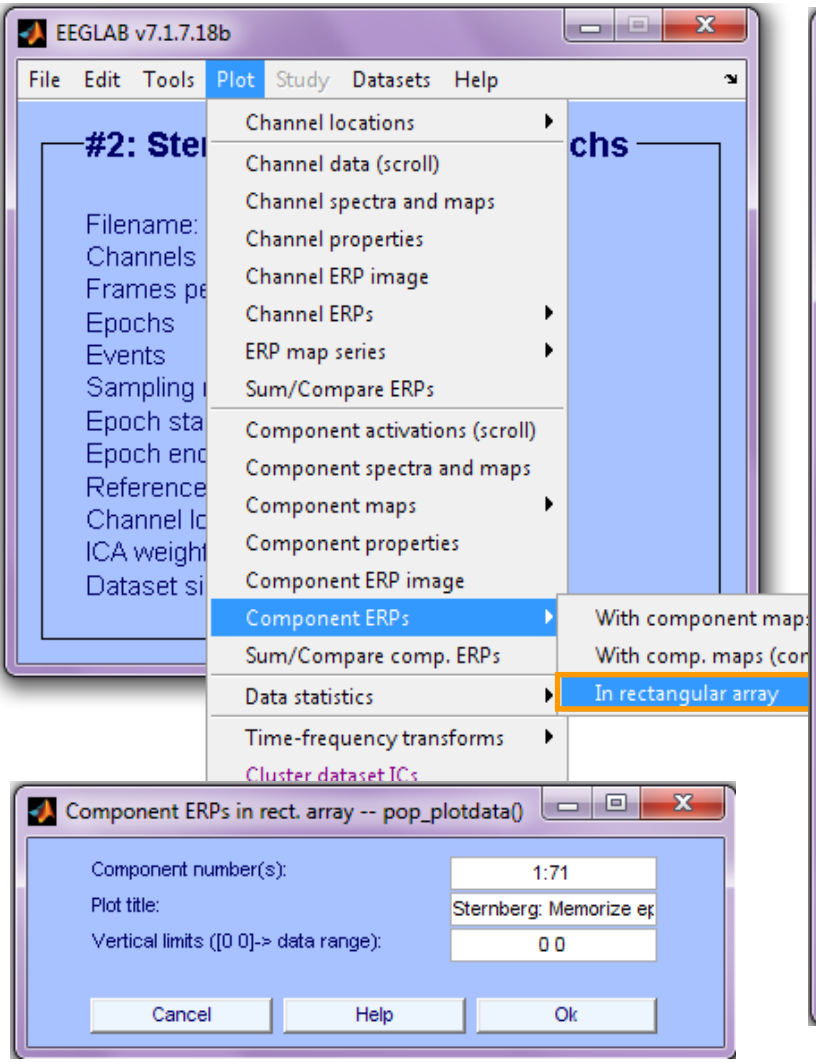
Figure 2: spectopo()

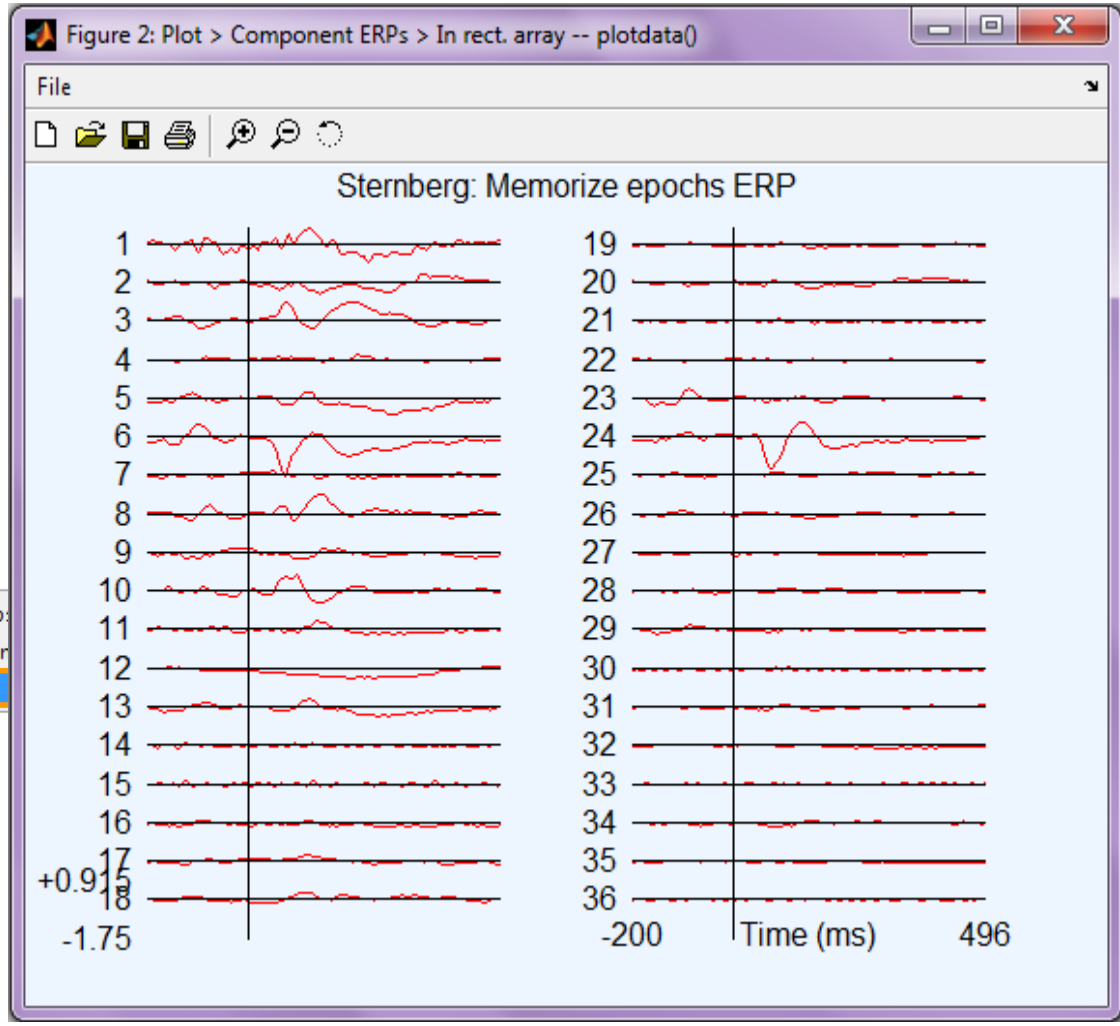
File



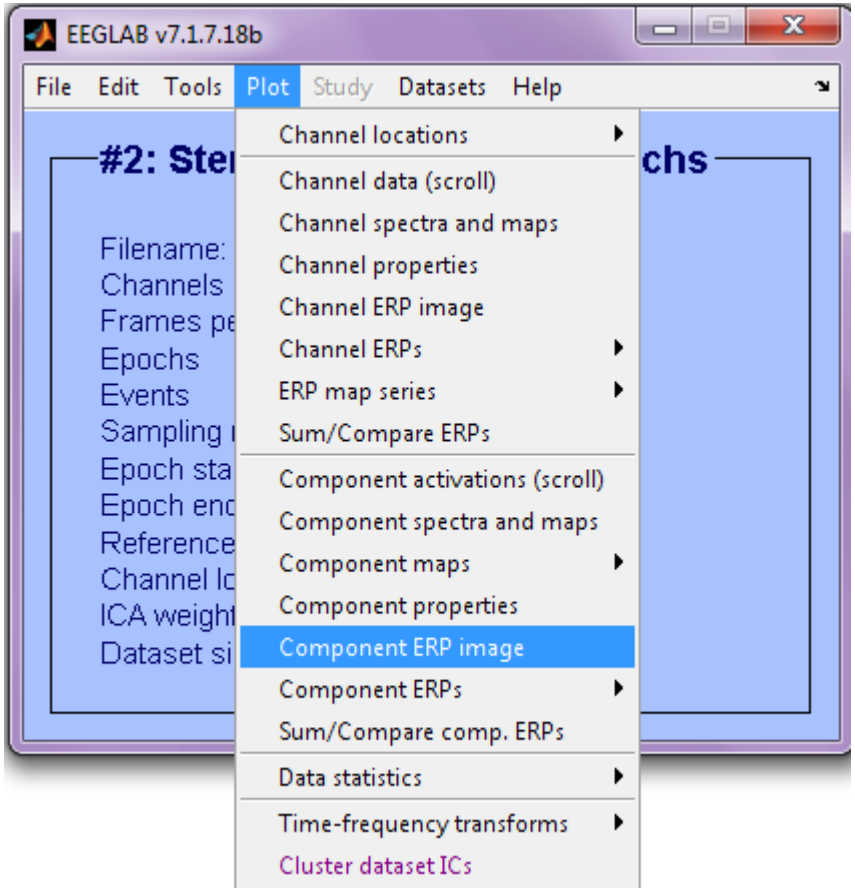
Component ERPs



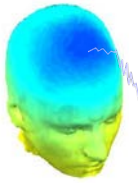




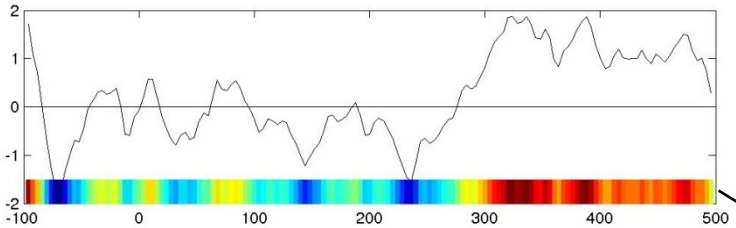
Component ERP image



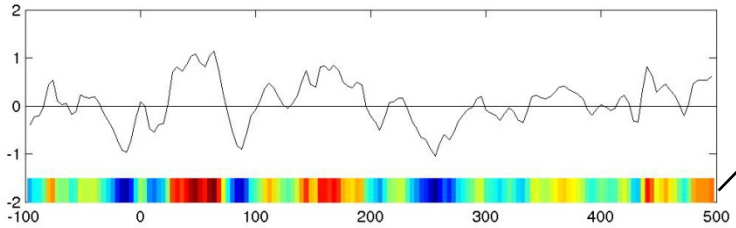
ERP Image basics



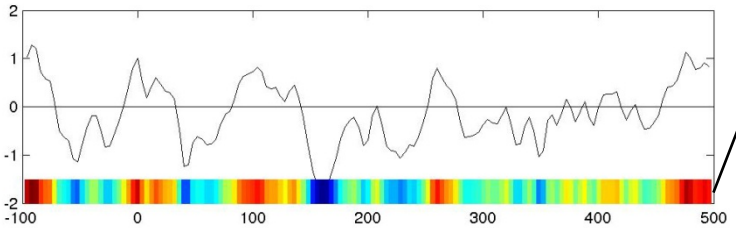
Trial 1



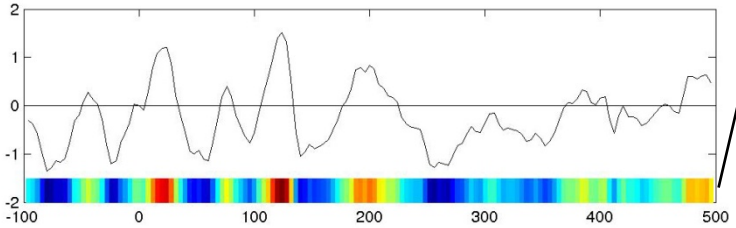
Trial 2



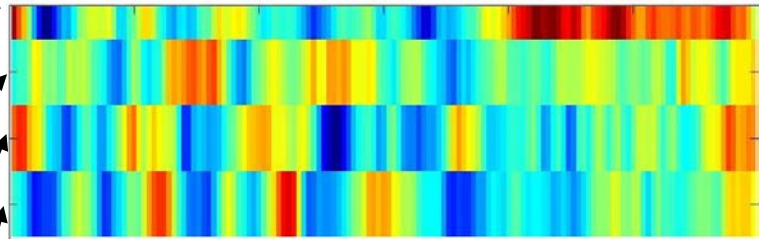
Trial 3



Trial 4

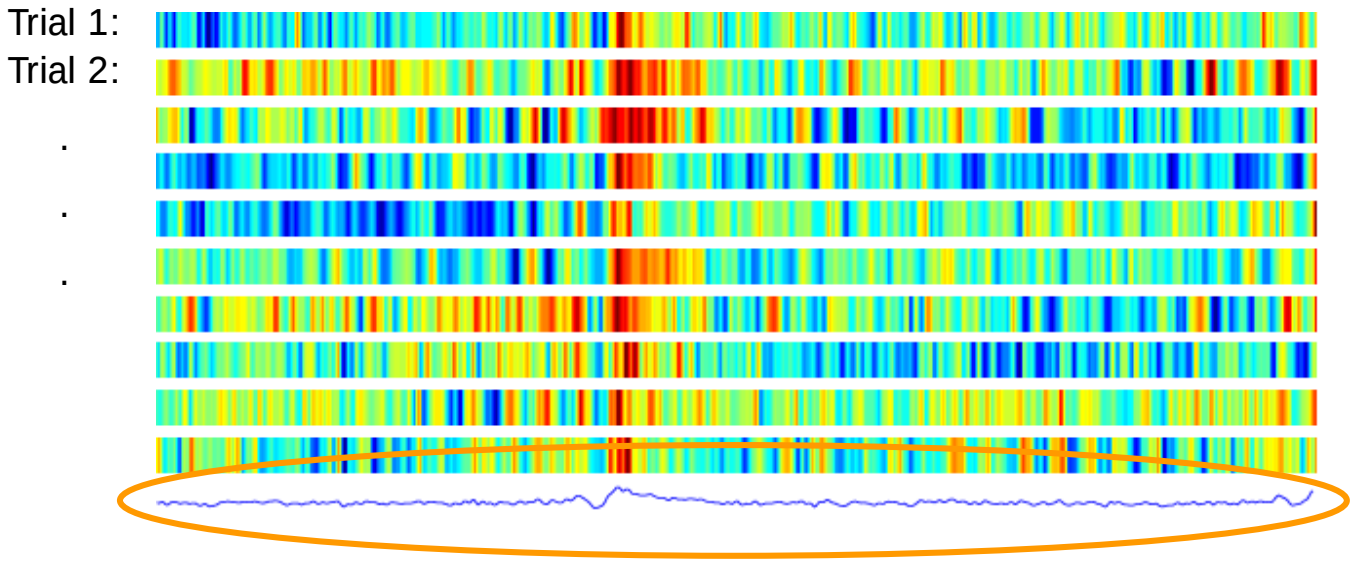


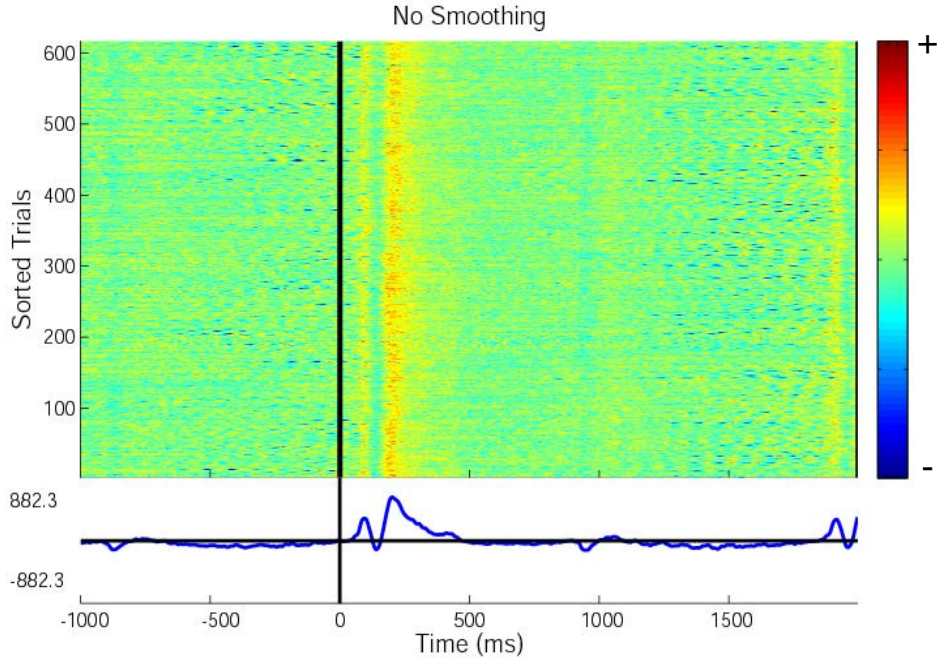
ERP Image

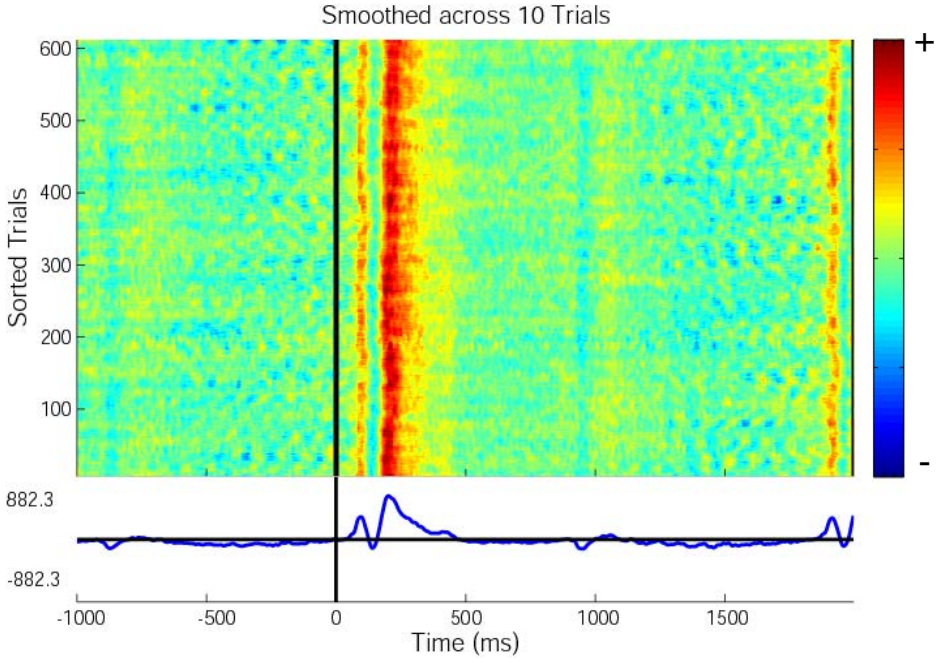


by default, sorted by time-on-task
(1st trial, 2nd trial, ...)

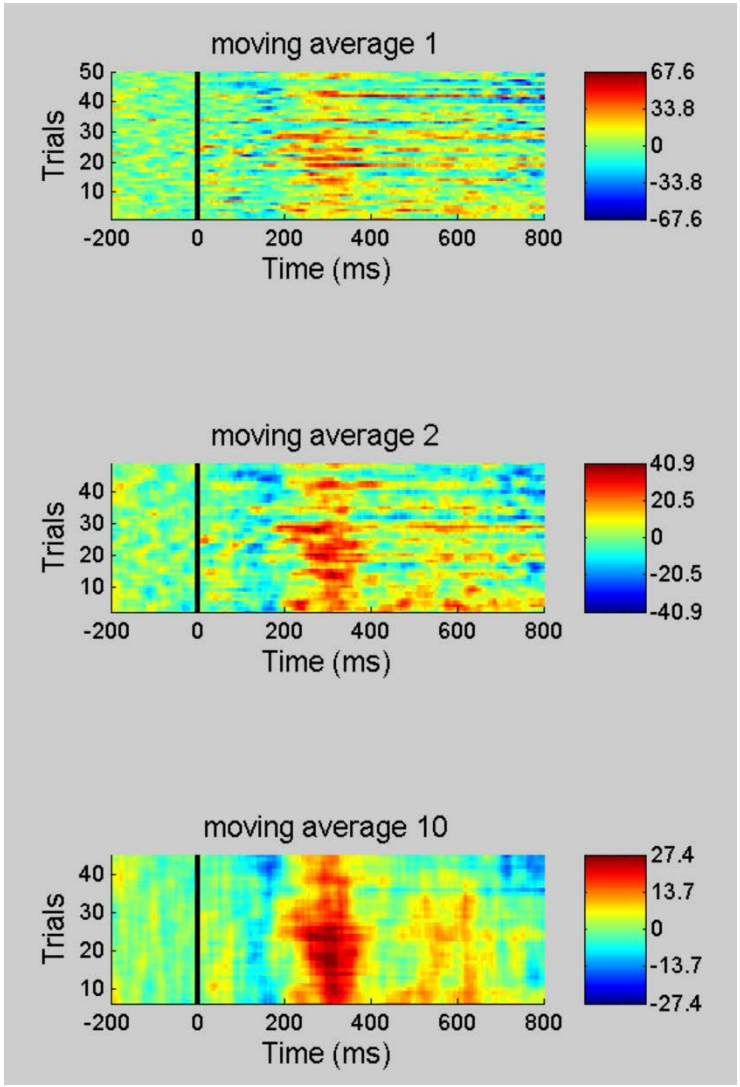
ERP Image basics



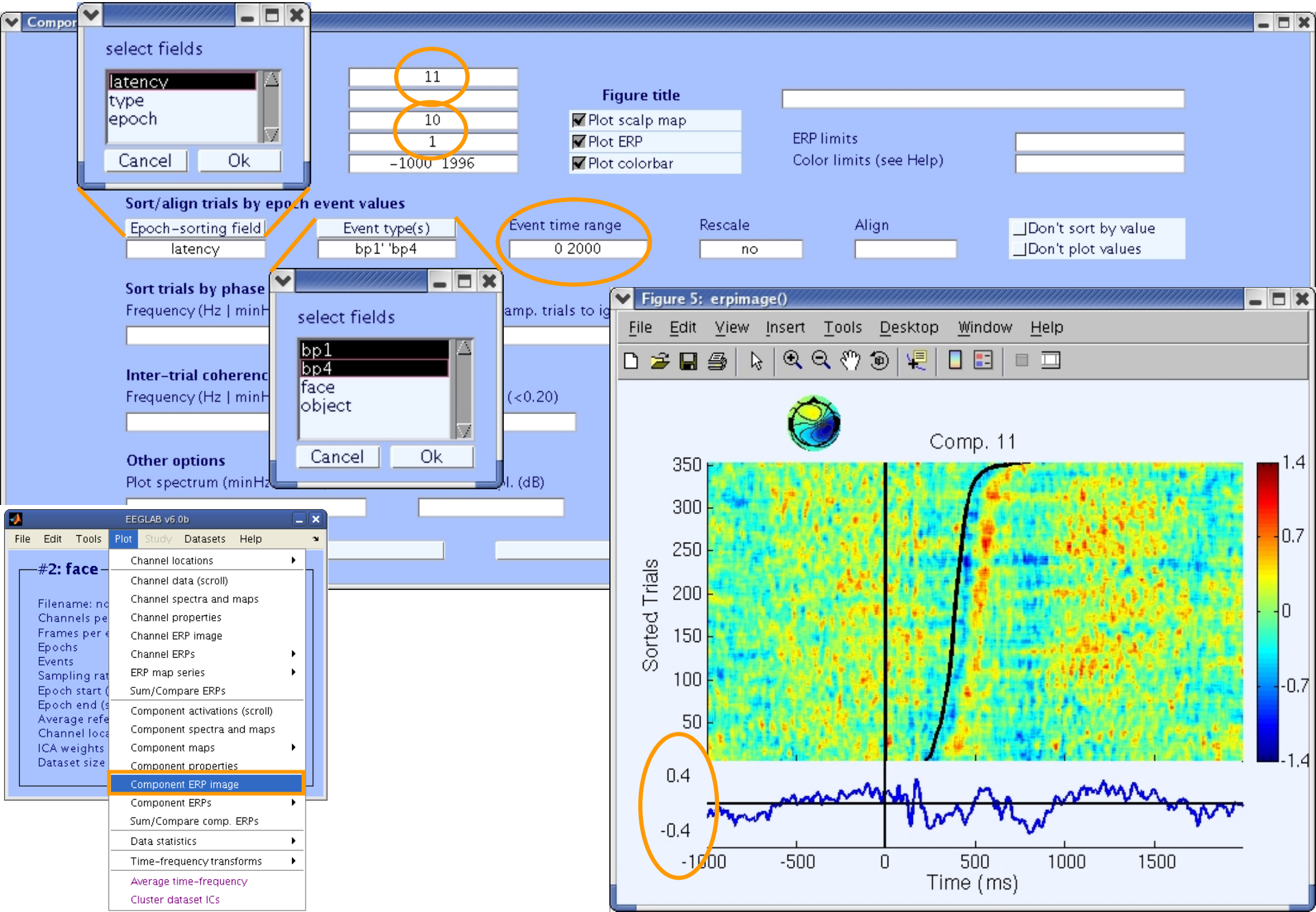




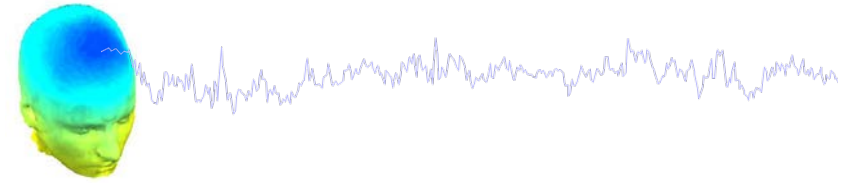
ERP Images: smoothing across trials

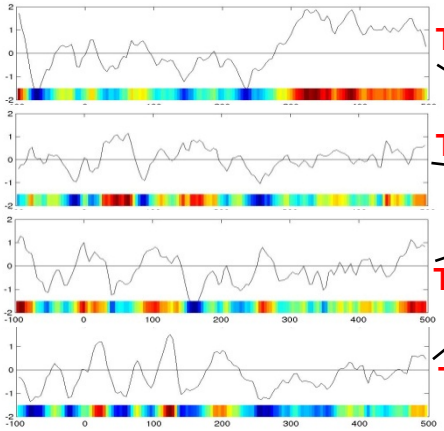


Component ERP Images

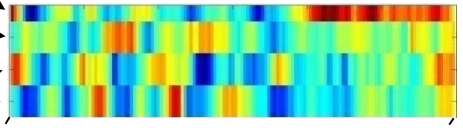


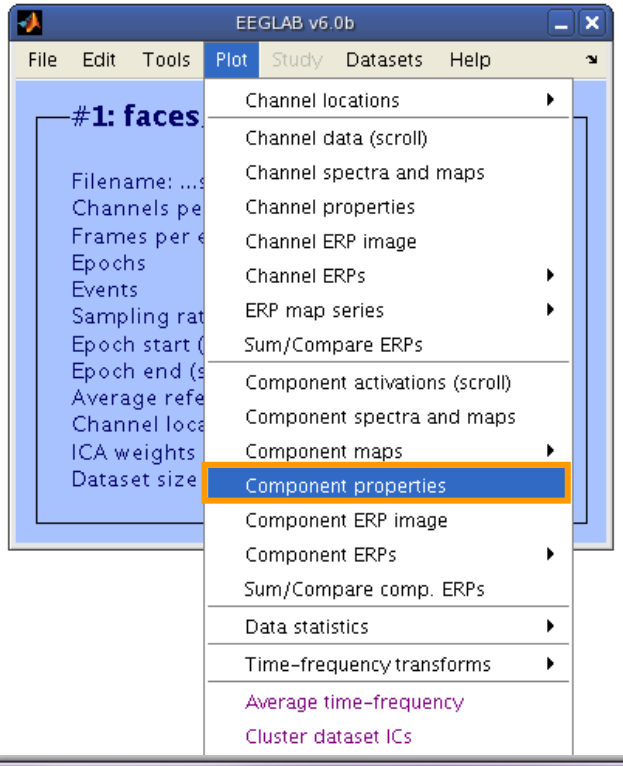
Plot ICA component properties

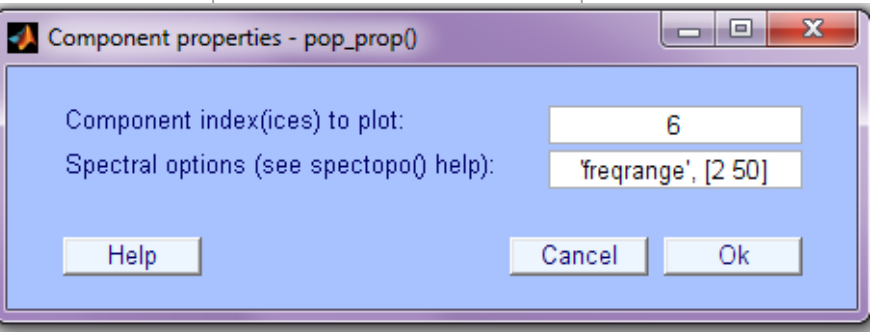


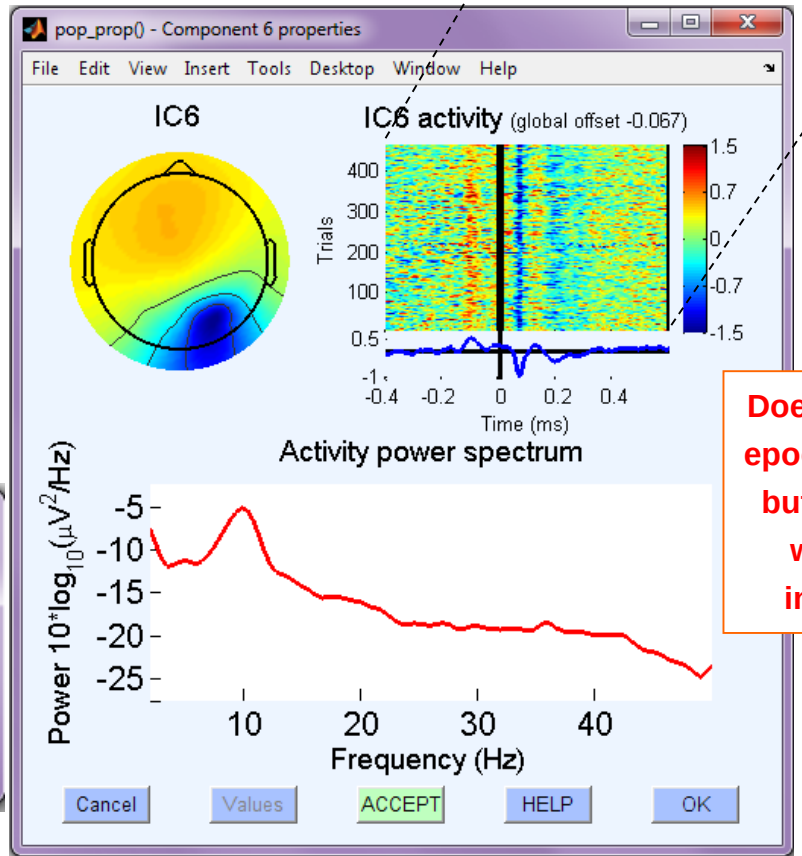


ERP Image



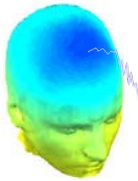






Does not require epoched dataset, but ERP image will be less informative

Exercise



- **ALL**

  - Load stern_125Hz.set

- **Novice**

  - Plot IC scalp maps

  - Scroll the IC activations and compare to channel data scroll

- **Intermediate**

  - Plot IC power, try different parameters from the GUI

  - Plot IC ERP images, try different parameters

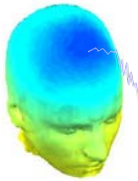
  - Plot IC properties

- **Advanced**

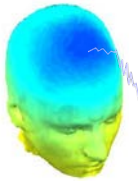
  - Practice saving EEG.icaweights and EEG.icasphere as .wts and .sph files and re-apply the weights again to stern.set

  - Try removing channels and run ICA again, how is the decomposition affected when there are very few channels?

Supplementary lessons

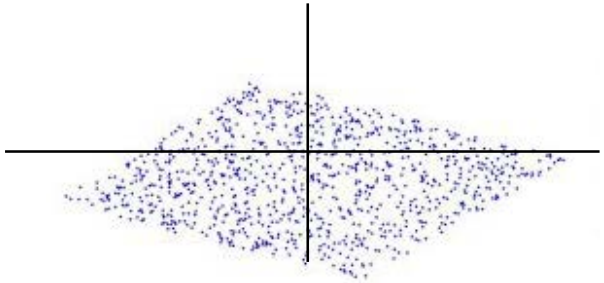


Explanation of "sphering"

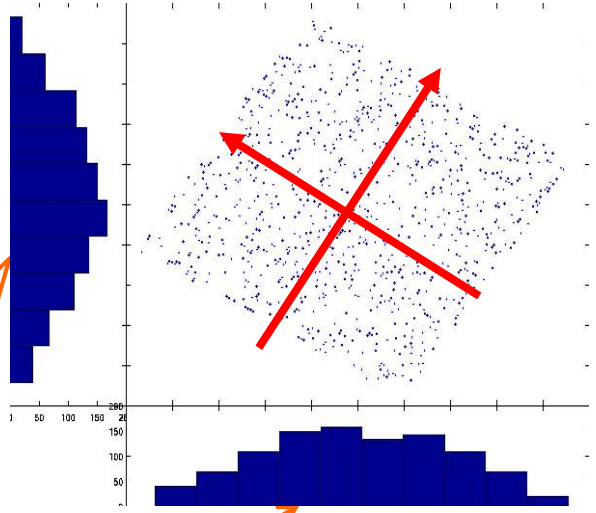


Sphered data

Original data



"Sphering":
Remove channel correlations



Like ICA, sphering is also a linear operation, so re-projecting to original space simply requires multiplying with weight matrix

Equal variance on both (all) axes

For more explanation, see:

http://sccn.ucsd.edu/~arno/indexica.html

and http://sccn.ucsd.edu/wiki/Linear_Representations_and_Basis_Vectors