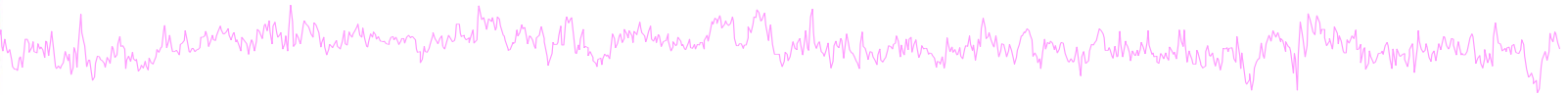


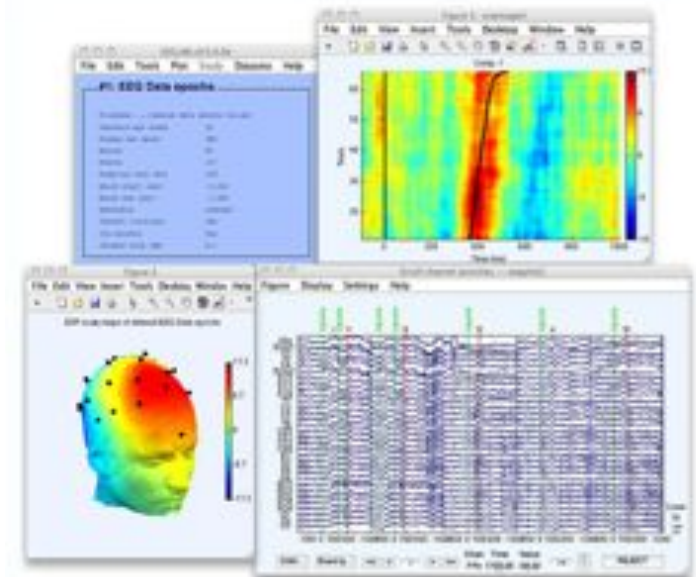
EEGLAB overview



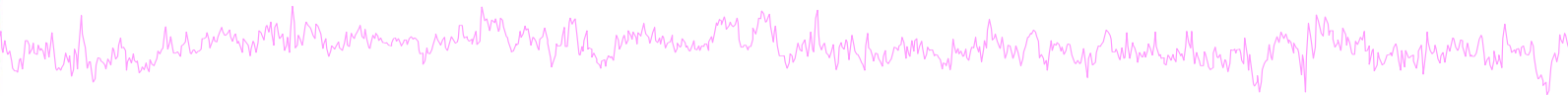
- Collection of about 600 functions (70 000 lines of code)
- About 100 000 download over the past 10 years
- 6 500 users on the discussion list and 10 500 on the diffusion list
- NIH funding since 2003

<http://sccn.ucsd.edu/eeglab>

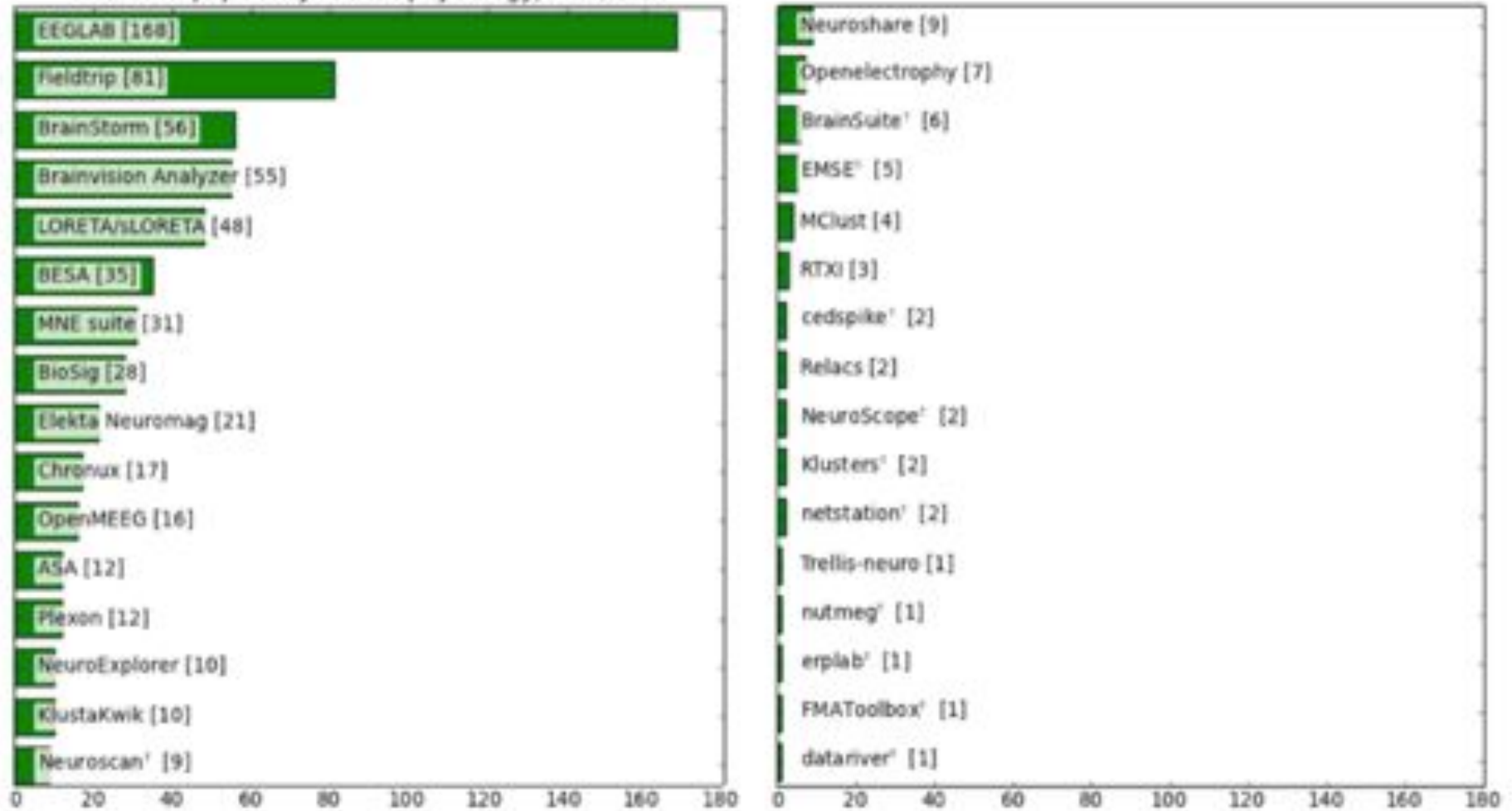
<http://sccn.ucsd.edu/wiki/eeglab>



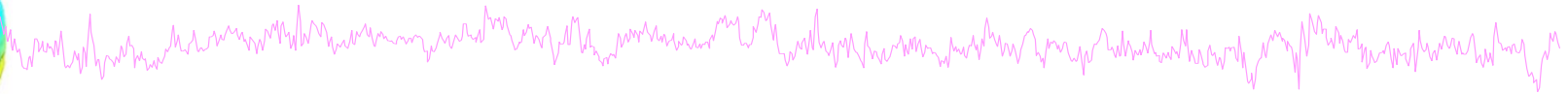
Hanke & Helcencko, 2011, Frontier in Neuroinformatics



Software popularity: Electrophysiology, MEG/EEG



EEGLAB standard processing pipeline



Single subject

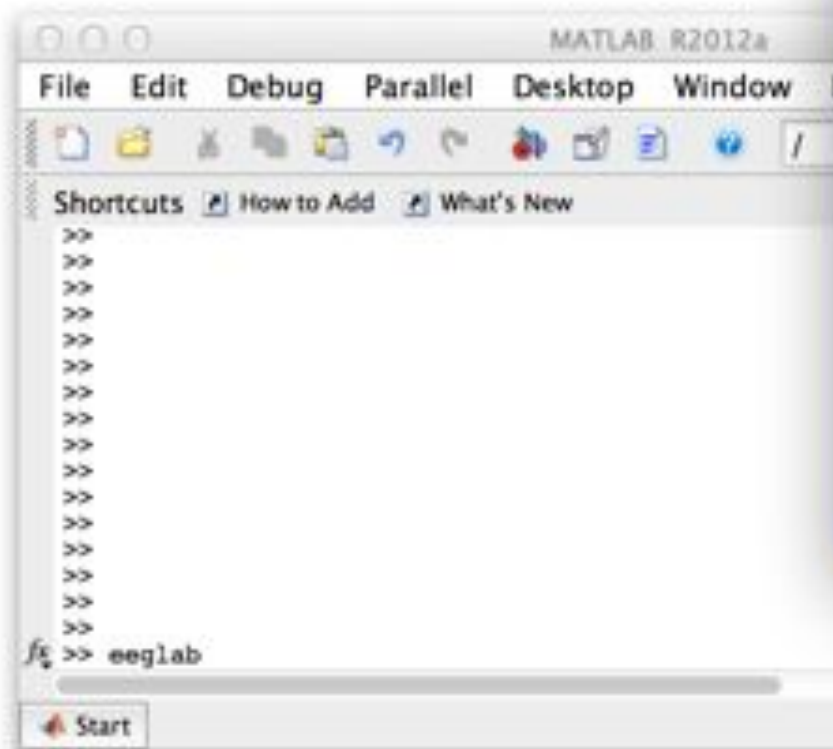
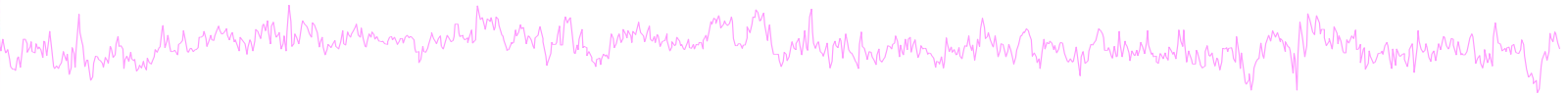
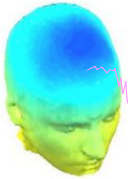
1. Import binary data, events and channel location
2. Edit, Re-reference, Resample, High pass filter data
3. Reject artifacts in continuous data by visual inspection
4. Extract epochs from data & reject artifactual epochs
5. Visualize data measures
6. Perform ICA decomposition
 - Perform source localization of components
 - Analyze components contribution to ERP
 - Analyze components contribution to spectrum

Multi-subjects

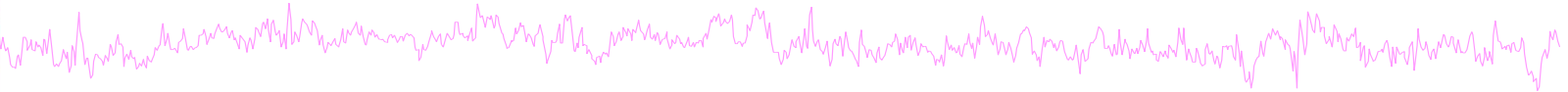
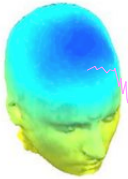
1. Build study and STUDY design
2. Pre-compute measures
3. Cluster components
4. Analyze clusters

Advanced analysis using scripting and EEGLAB command line functions

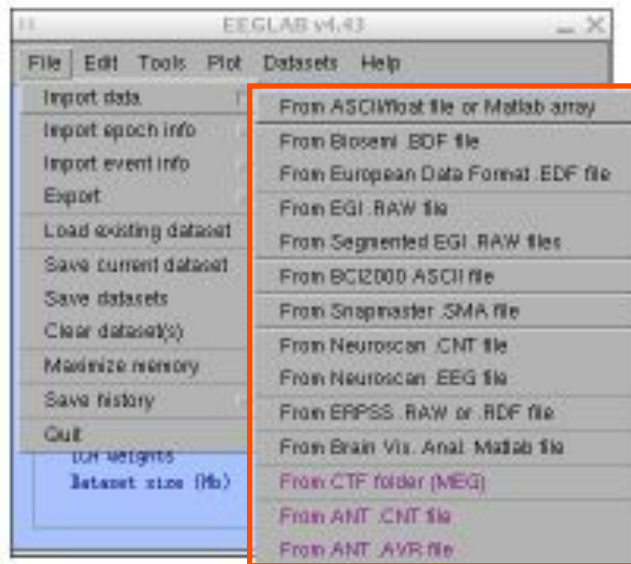
The EEGLAB Matlab software



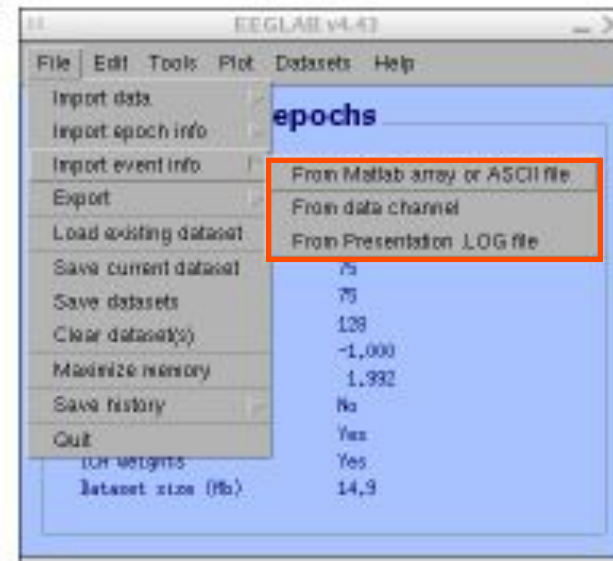
1. Importing data



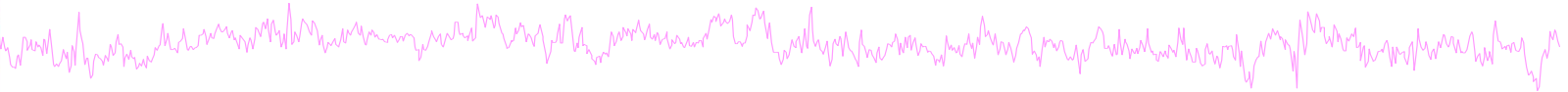
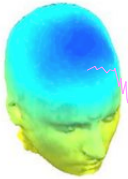
Import/load data



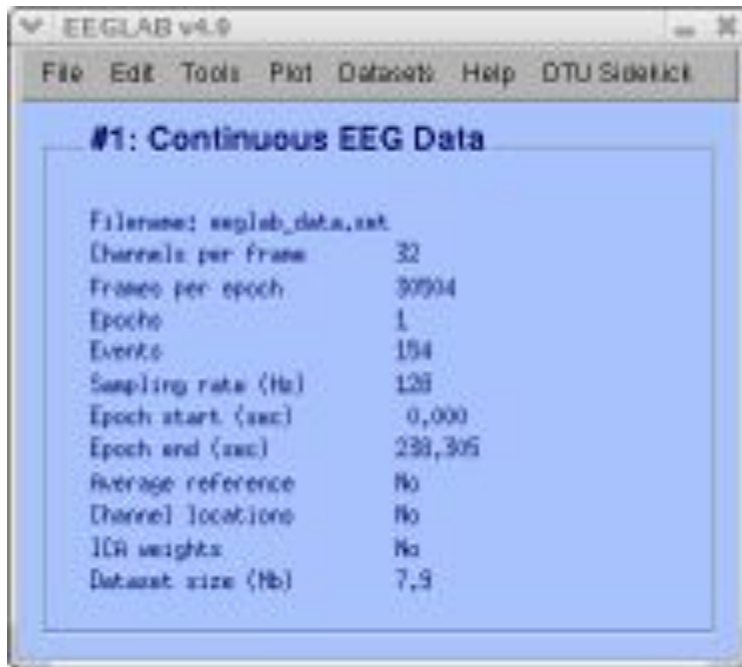
Import events



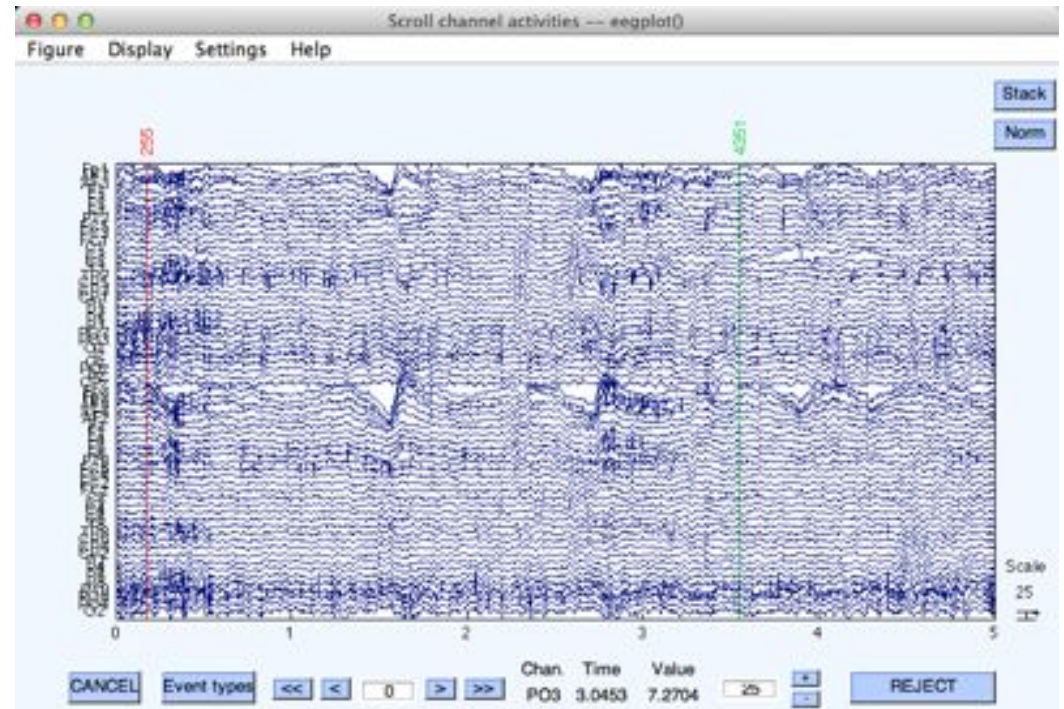
1. Importing data



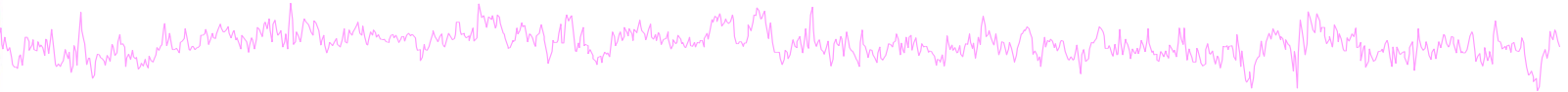
Data info



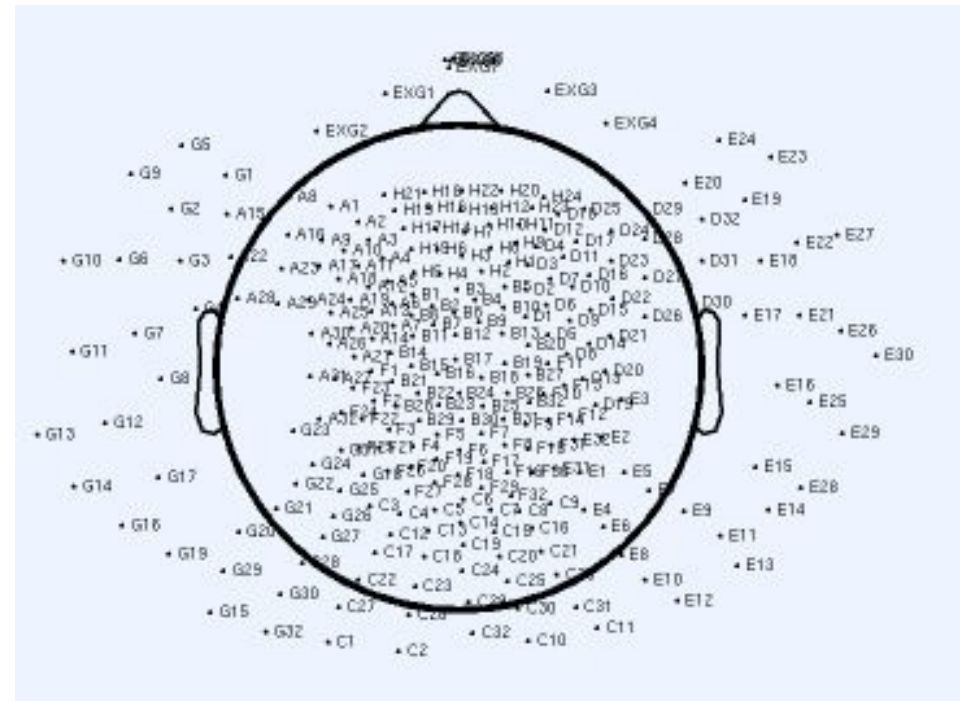
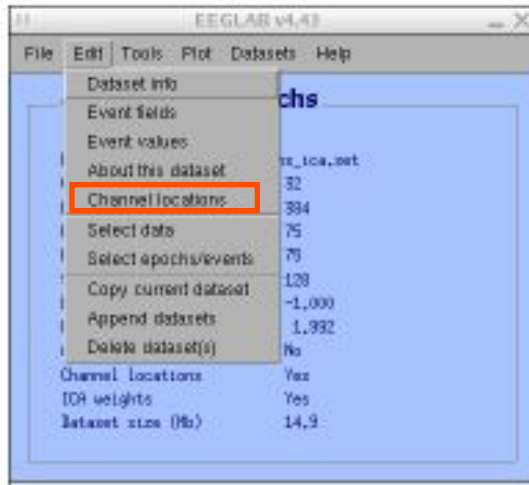
Scrolling data



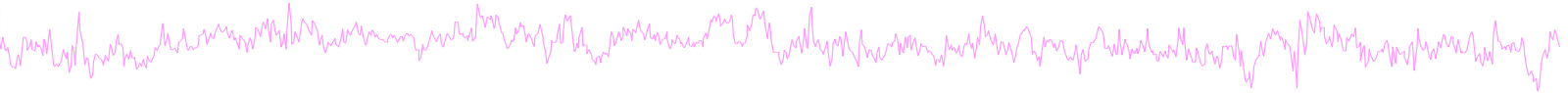
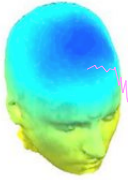
1. Importing channel location



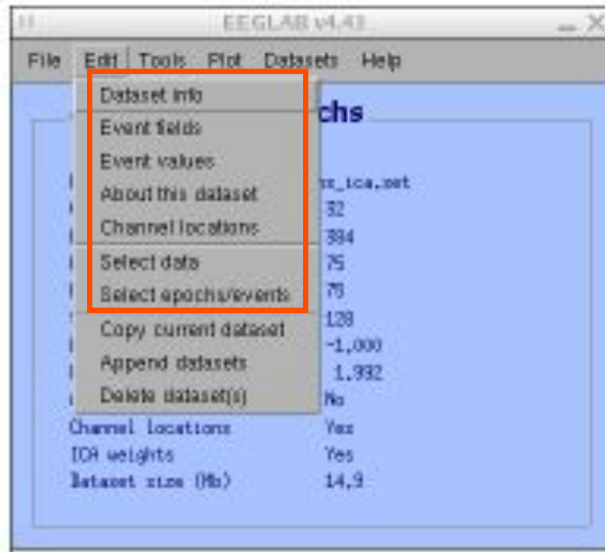
Import channel location



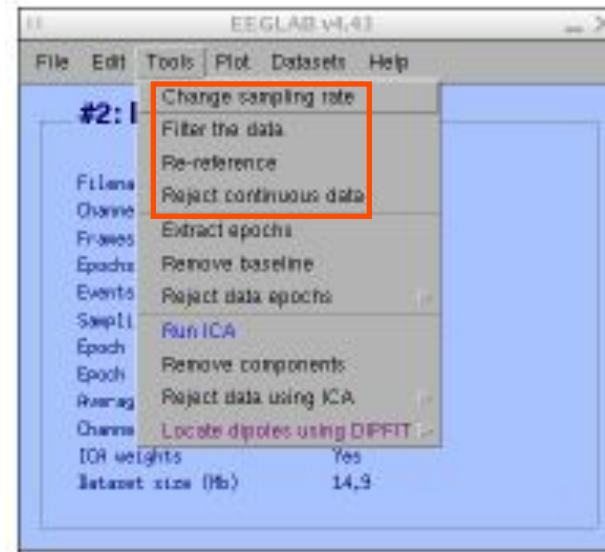
2. Edit, Re-reference, Resample, High pass filter data



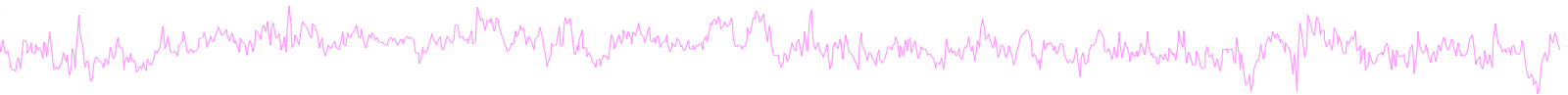
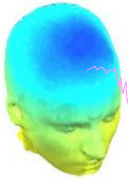
Edit/select data



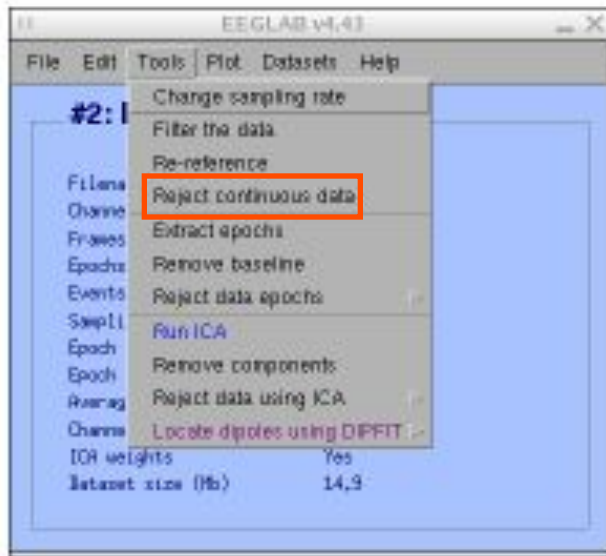
Preprocessing data



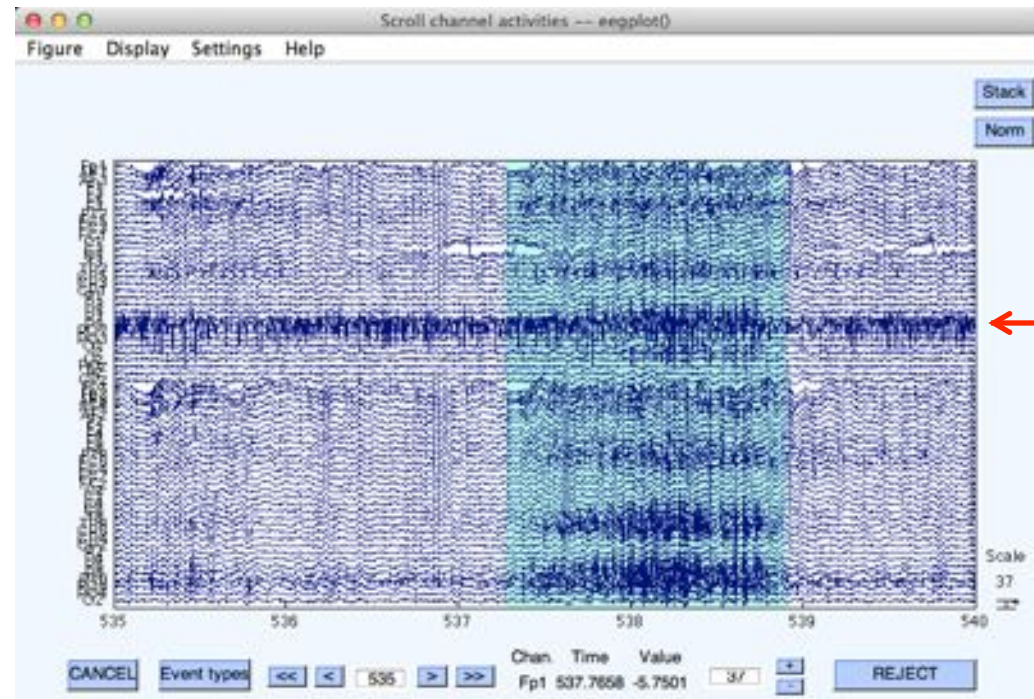
3. Reject artifacts in continuous data by visual inspection



Data info



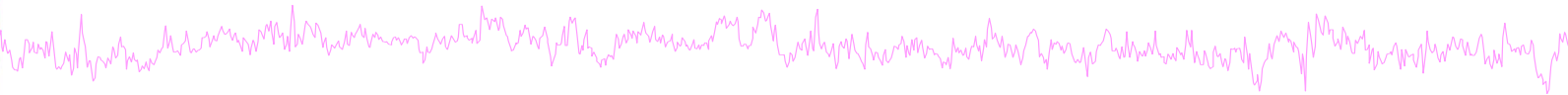
Reject portions of continuous data



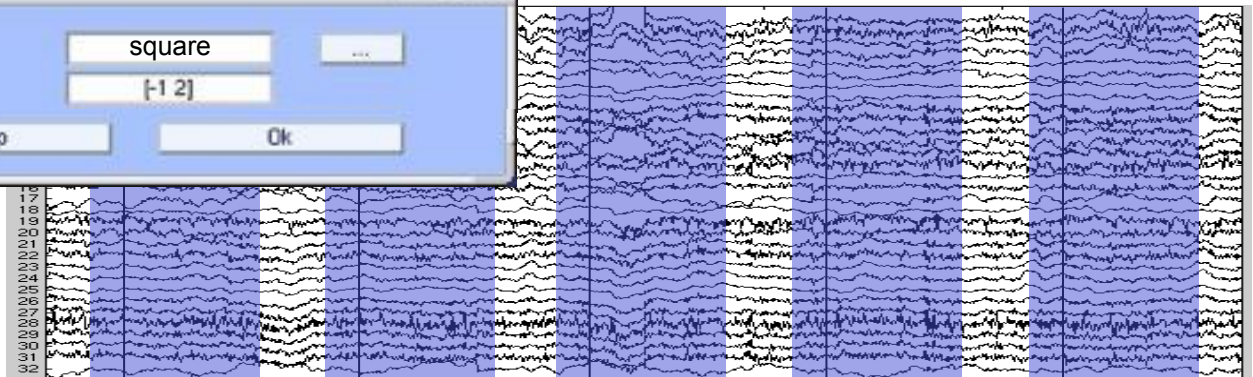
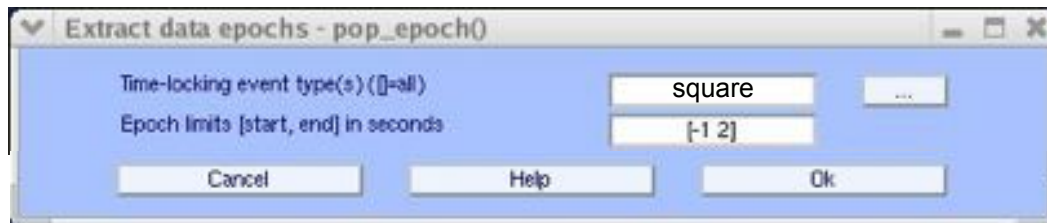
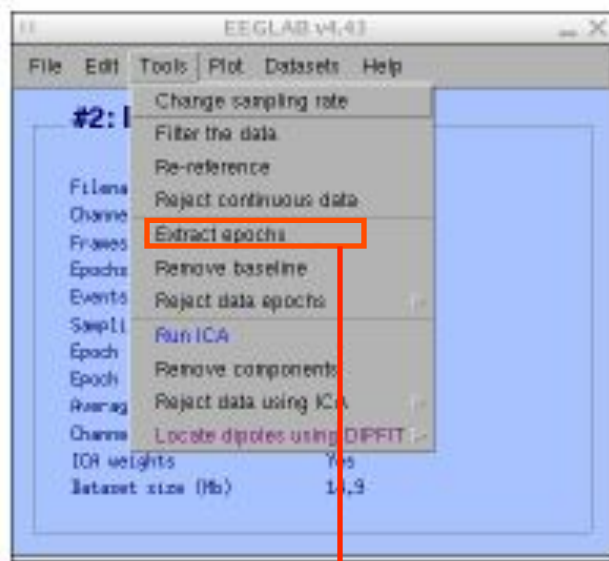
Bad channel

Bad portion of data

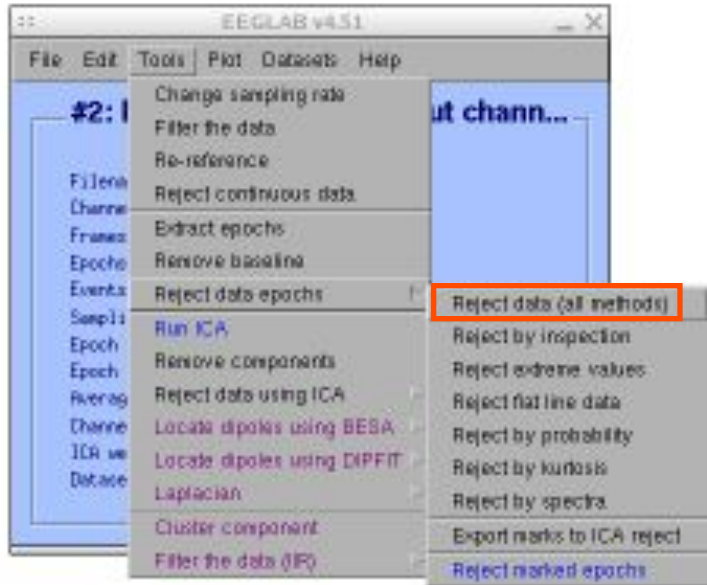
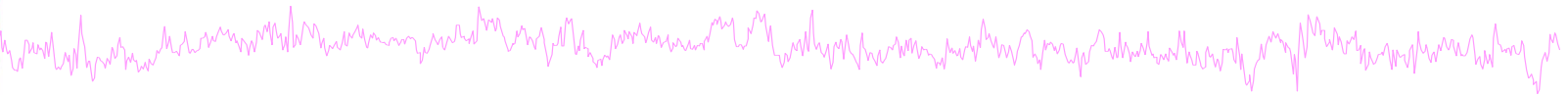
4. Extract epochs from data & reject artifactual epochs



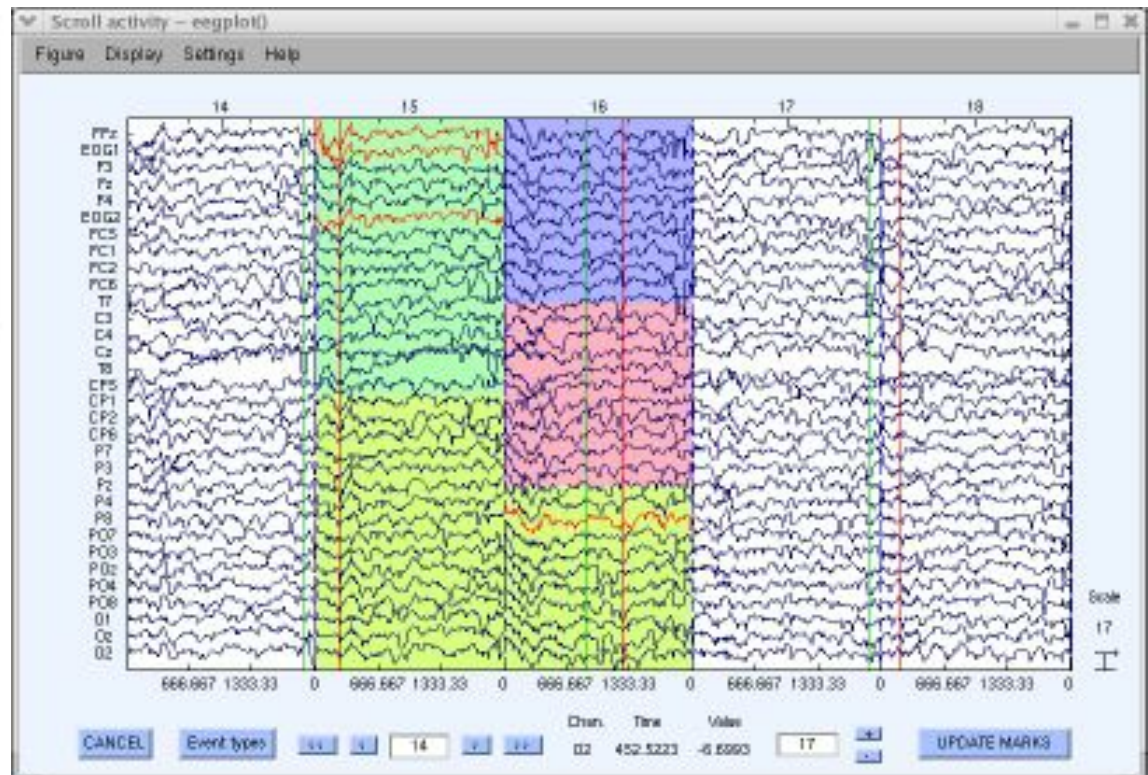
Preprocessing data



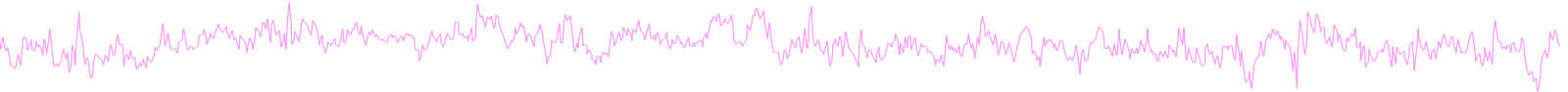
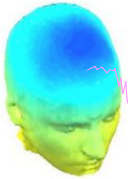
4. Extract epochs from data & reject artifactual epochs



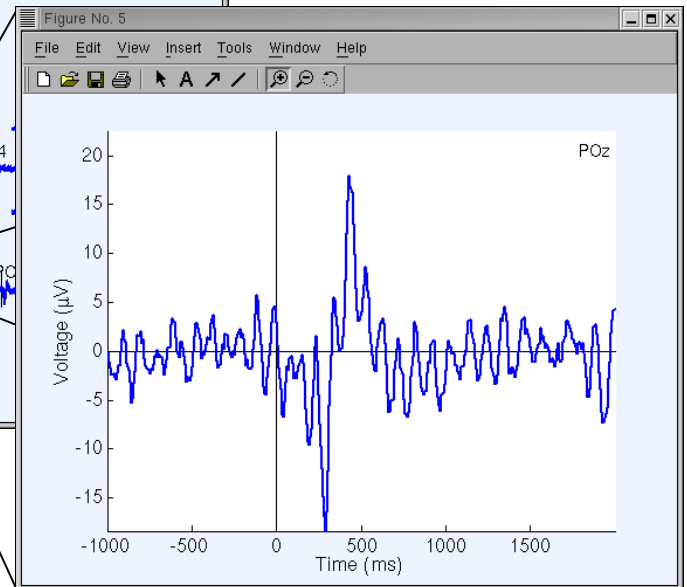
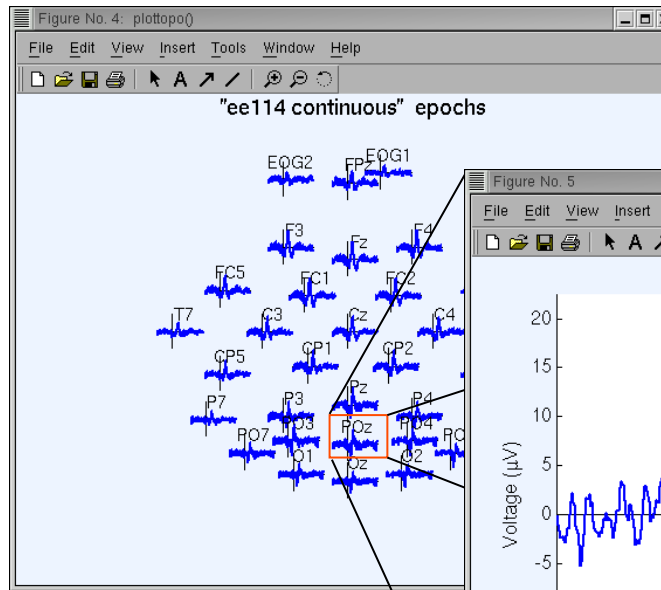
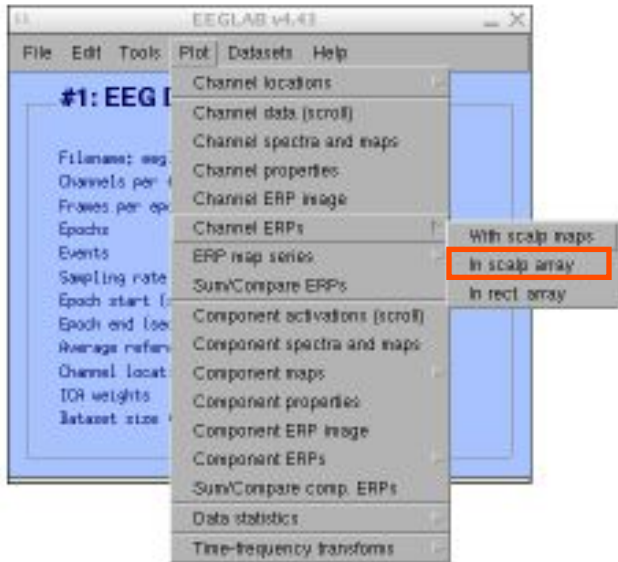
Different color = different rejection methods



5. Visualize data measures

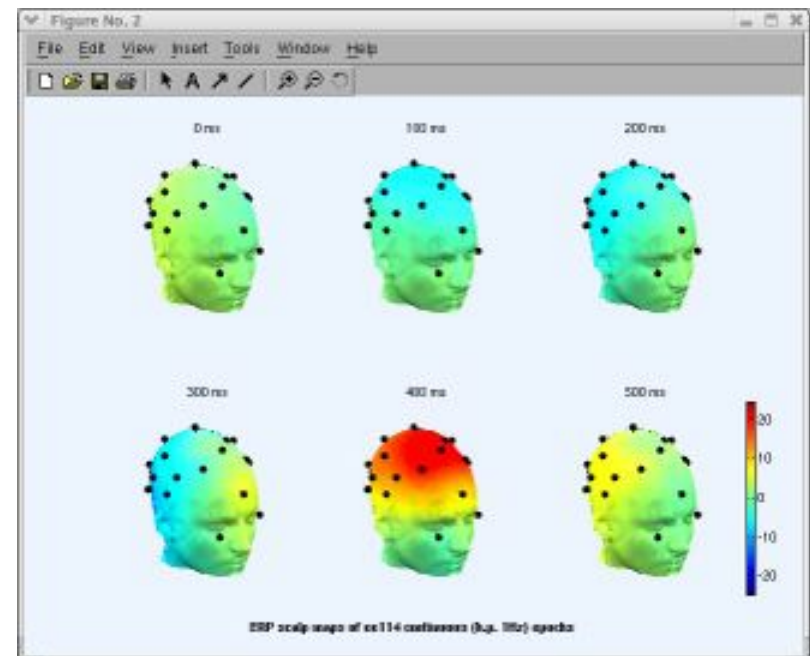
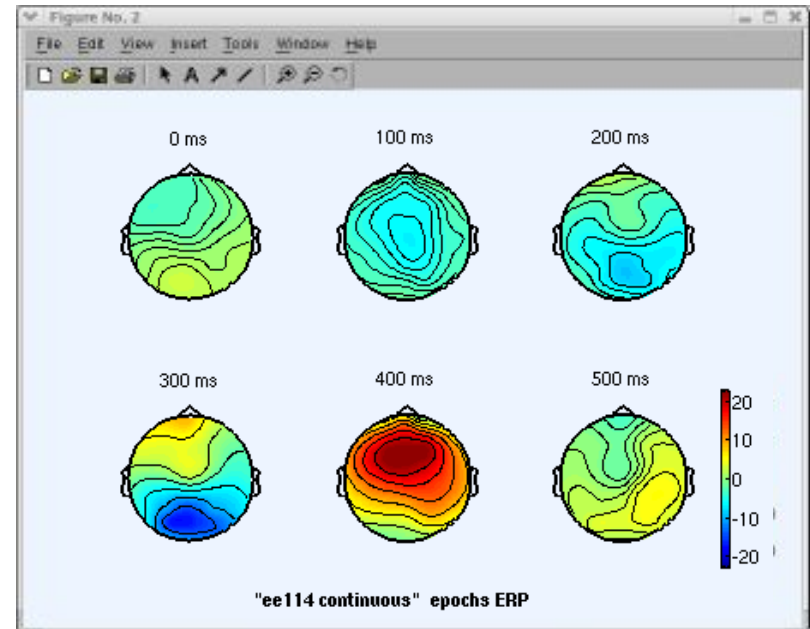
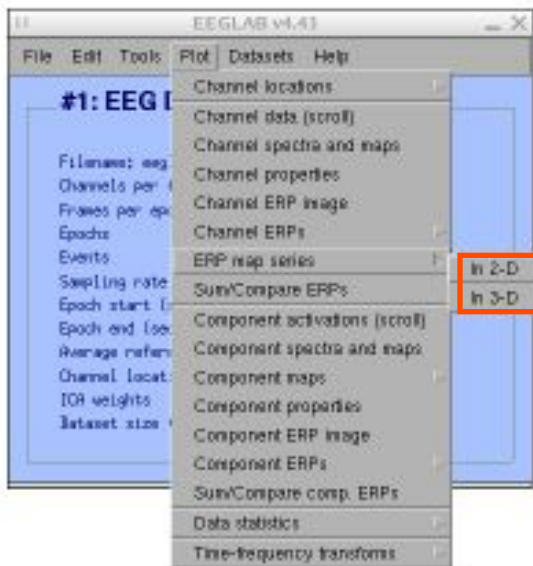


Plot ERP

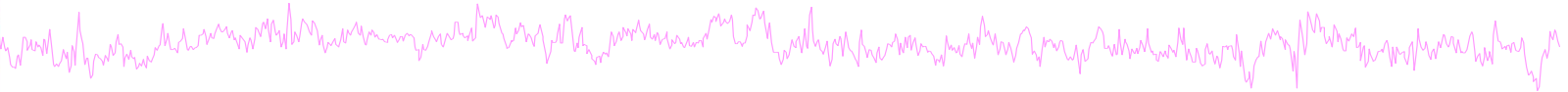
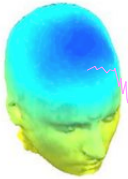


5. Visualize data measures

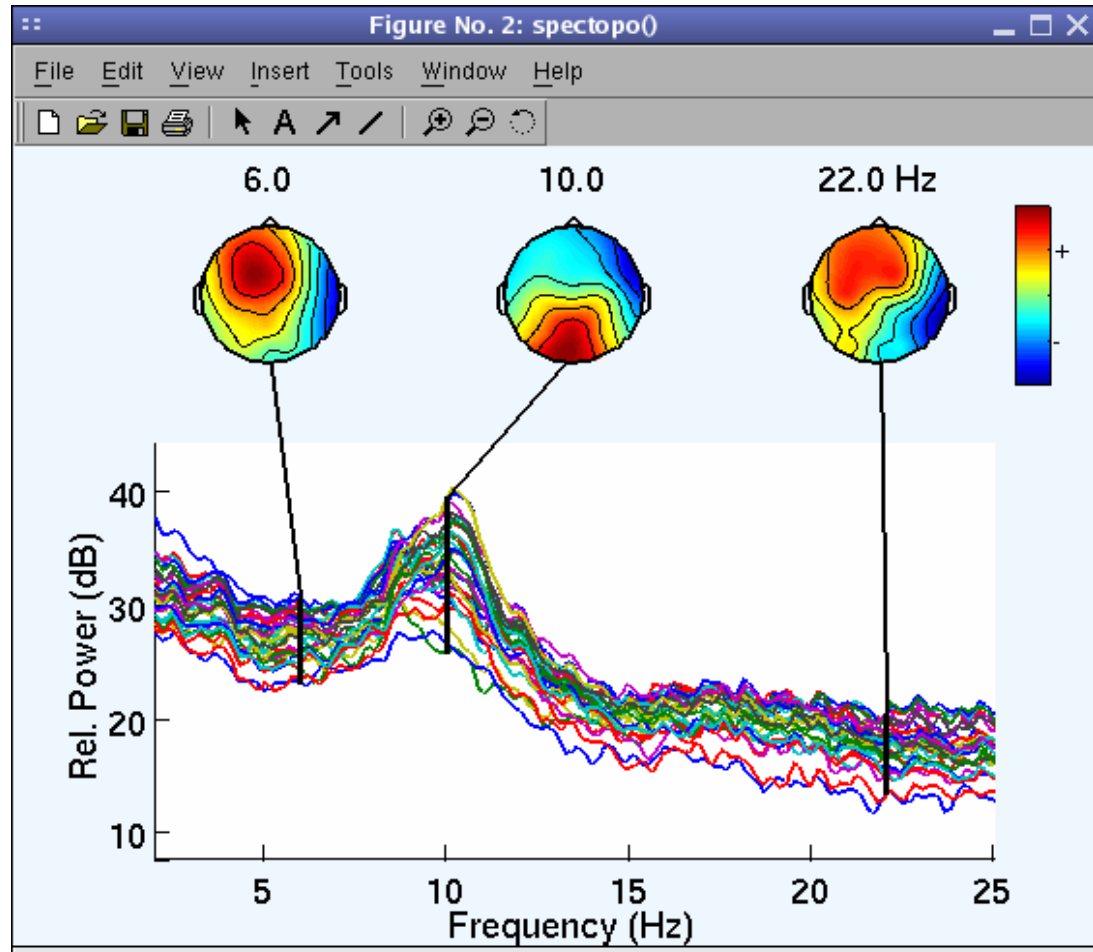
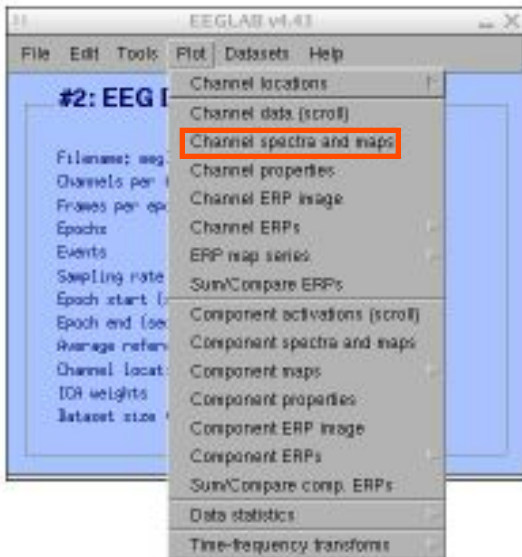
Plot ERP
map series



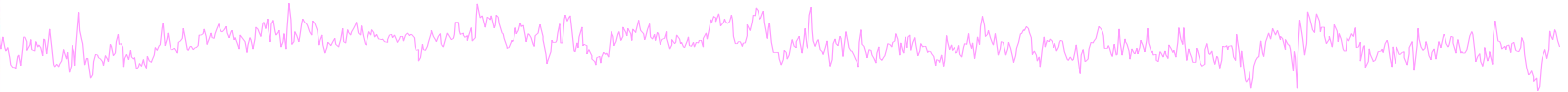
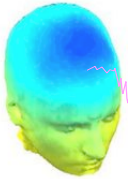
5. Visualize data measures



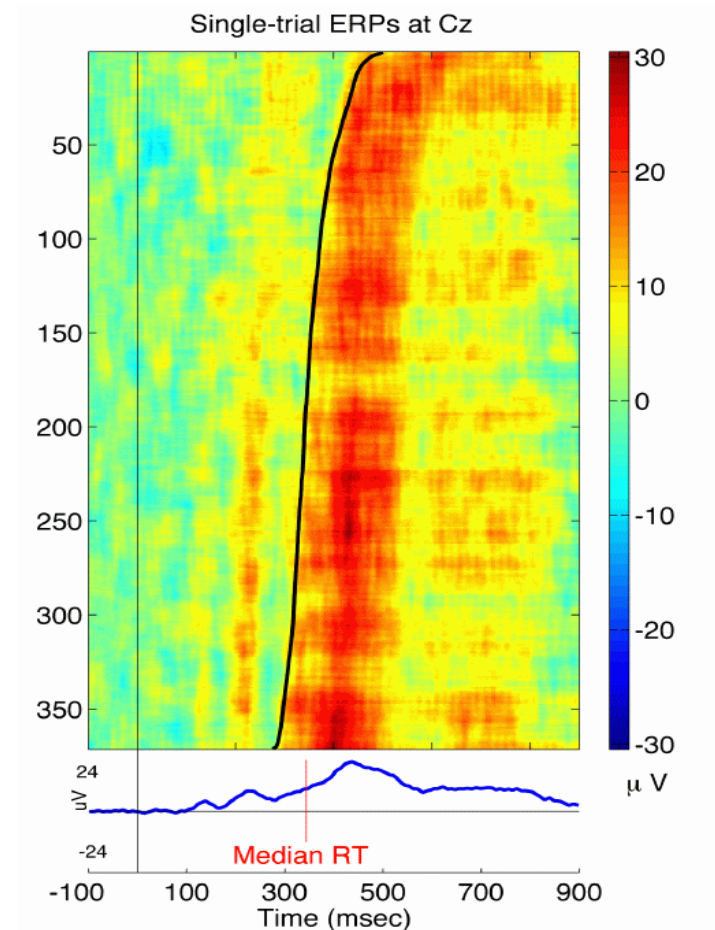
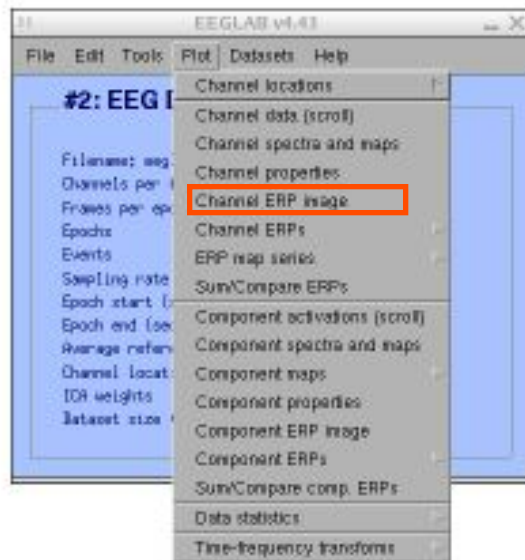
Plot data spectrum and maps



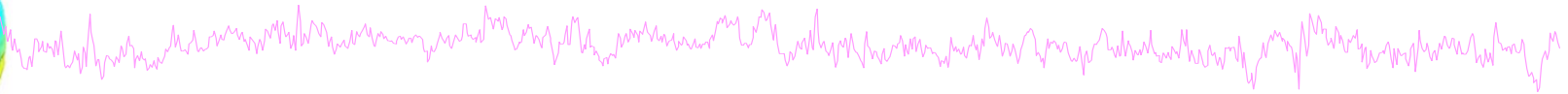
5. Visualize data measures



Plot channel ERP image



EEGLAB standard processing pipeline



Single subject

1. Import binary data, events and channel location
2. Edit, Re-reference, Resample, High pass filter data
3. Reject artifacts in continuous data by visual inspection
4. Extract epochs from data & reject artifactual epochs
5. Visualize data measures
6. Perform ICA decomposition
 - Perform source localization of components
 - Analyze components contribution to ERP
 - Analyze components contribution to spectrum

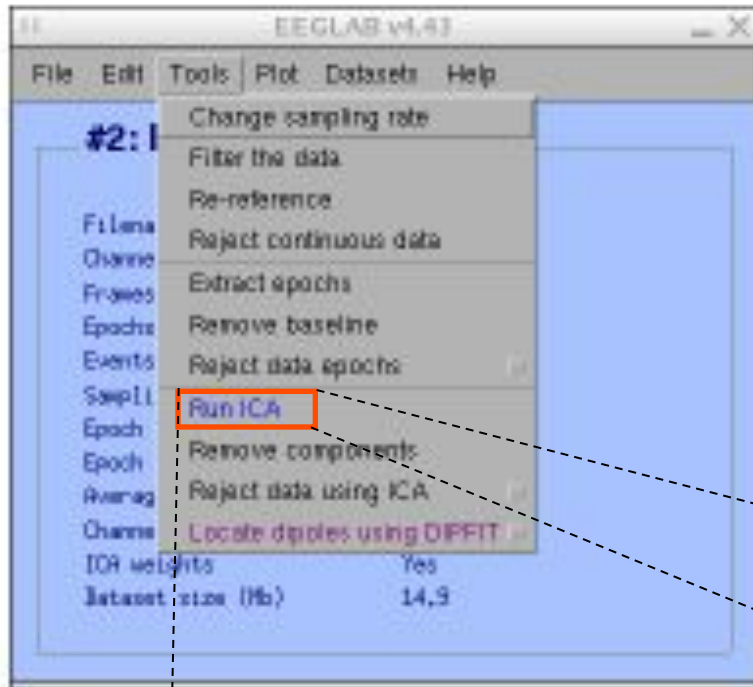
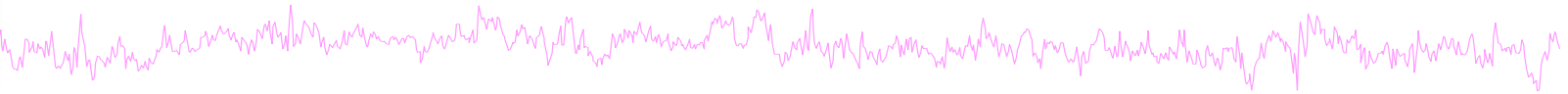
Multi-subjects

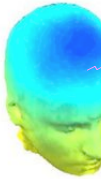
1. Build study
2. Pre-compute measures
3. Cluster components
4. Analyze clusters



Advanced analysis using scripting and EEGLAB command line functions

6. Perform ICA decomposition





Reject components by map - pop_selectcomps0 (dataset: Continuous EEG Data epochs)

1 2 3 4 5 6 7

8 9

15 16

22 23

29 30

Cancel Set threshold

Component 3 properties

File Edit View Insert Tools Window Help

Component 3 map

Component 3 activity (global offset 0.010)

Sorted Trials

Time (ms)

Activity power spectrum

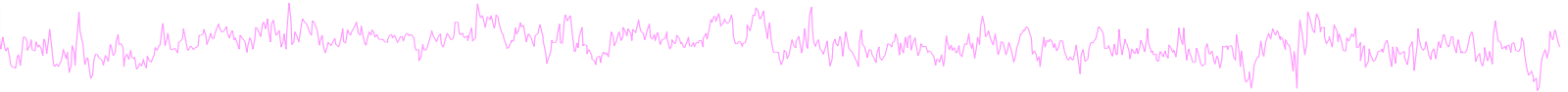
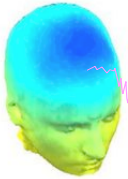
Magnitude (dB)

Frequency (Hz)

Cancel VIEW **ACCEPT** HELP OK

Detailed description: The image shows a software interface for EEG component selection. The main window displays a grid of 30 topographic maps of the scalp, numbered 1 to 30. A dialog box titled 'Component 3 properties' is open, showing a detailed view of 'Component 3'. This dialog includes a topographic map of Component 3, a time-frequency heatmap of 'Component 3 activity' (with a global offset of 0.010) showing sorted trials (0 to 60) over time (-1 to 1 ms), and an 'Activity power spectrum' plot showing magnitude in dB (from -40 to 0) versus frequency in Hz (from 0 to 50). The 'ACCEPT' button in the dialog is highlighted with a red circle.

Localizing components



EEGLAB v4.43

File	Edit	Tools	Plot	Datasets	Help
#1: 1					
File	Change sampling rate				
Online	Filter the data				
Frames	Re-reference				
Epochs	Reject continuous data				
Events	Extract epochs				
Sweep1	Remove baseline				
Epoch	Reject data epochs				
Averag	Run ICA				
Channe	Remove components				
ICR weights	Reject data using ICA				
Dataset size (Hb)	Locate dipoles using DIPFIT				
	Autofit components				
	Head model and settings				
	Coarse fit (grid scan)				
	Fine fit (iterative)				
	Plot component dipoles				

Figure No. 2

File Edit View Insert Tools Window Help

41 dipoles:

Plot All

Plot one

C 1 (7.55)

Keep/Next

Next

Prev

Keep/Prev

No controls

Display:

Motion on

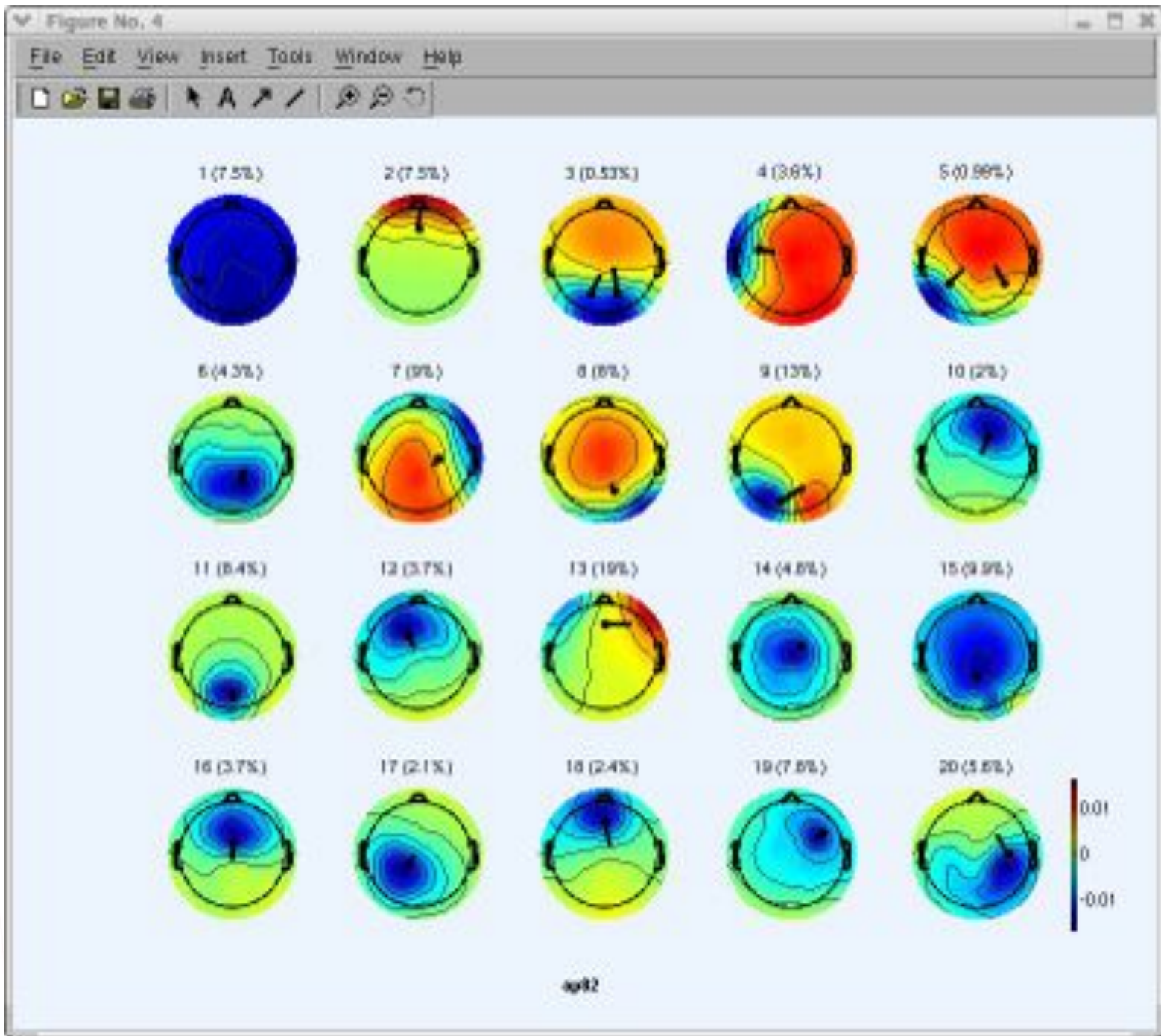
Tight view

Sagittal view

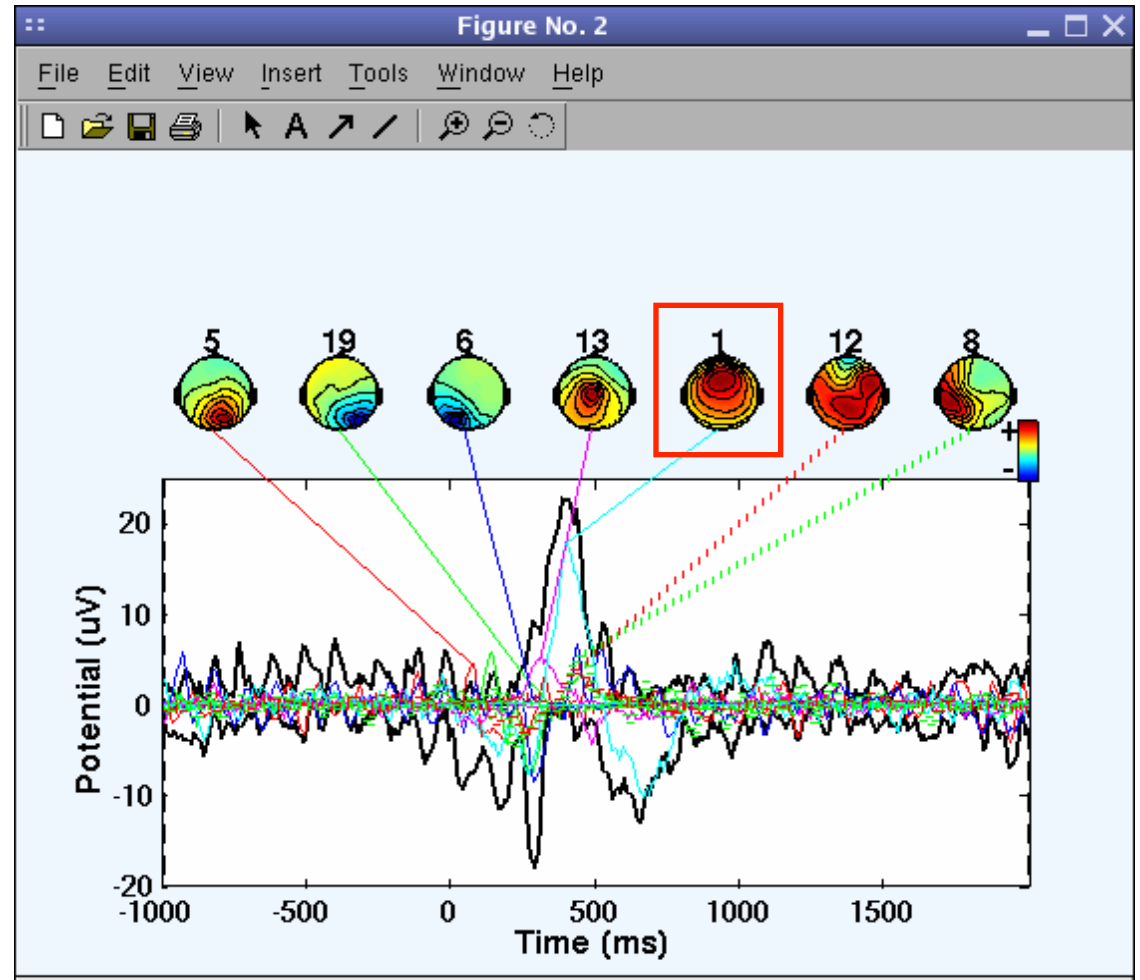
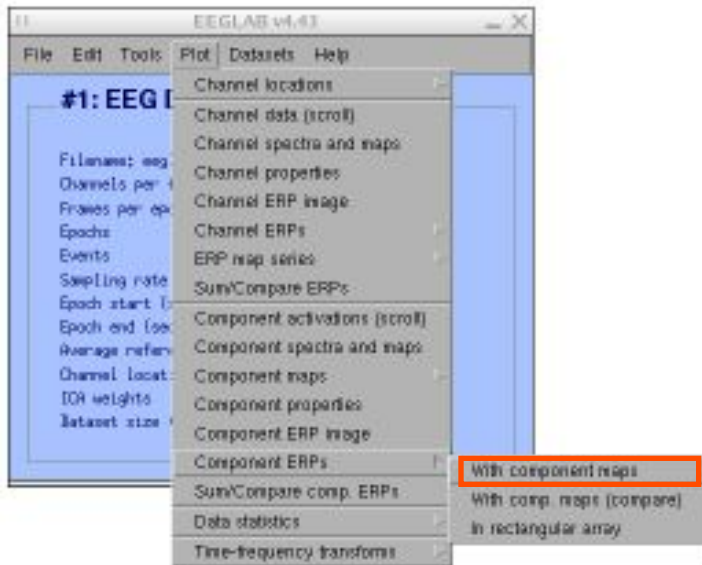
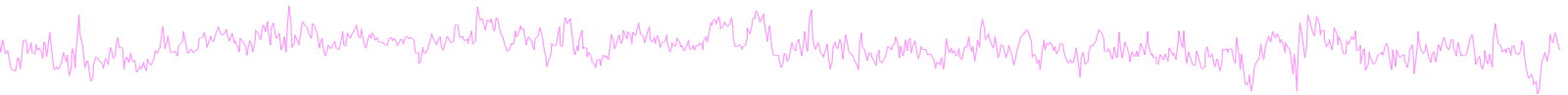
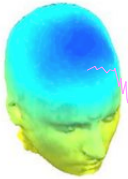
Coronal view

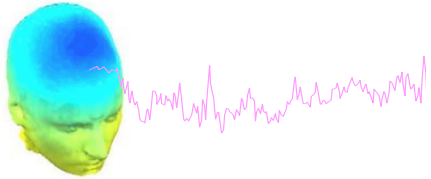
Top view



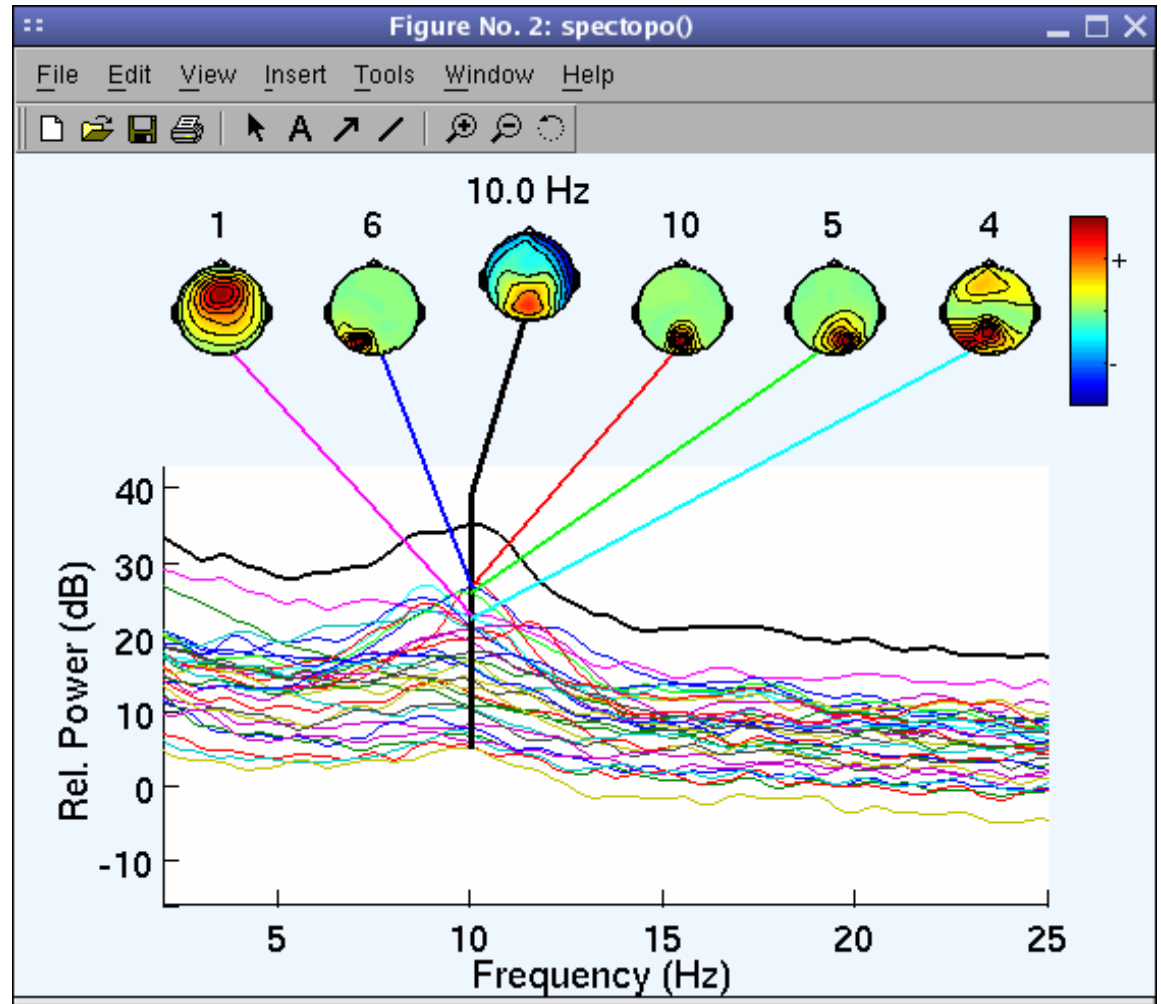
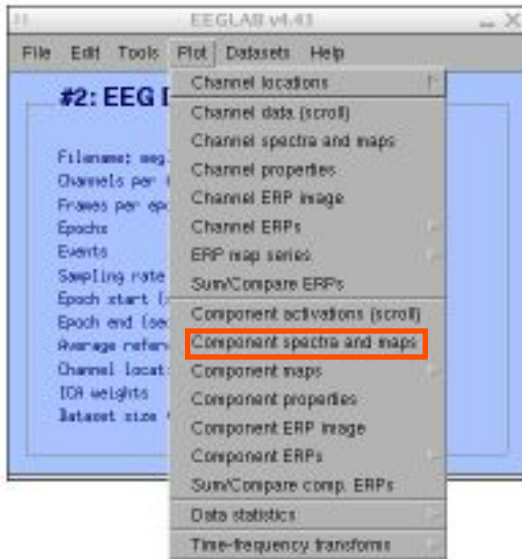
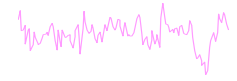


Component contribution to the ERP

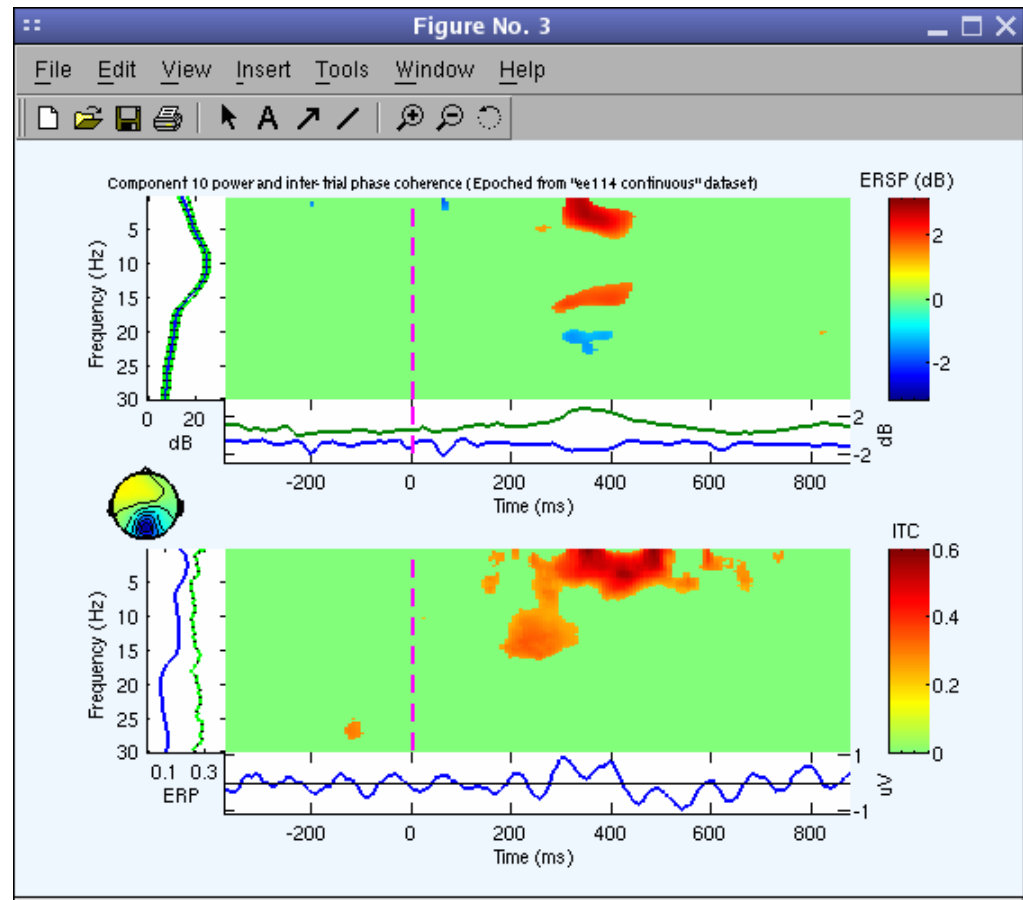
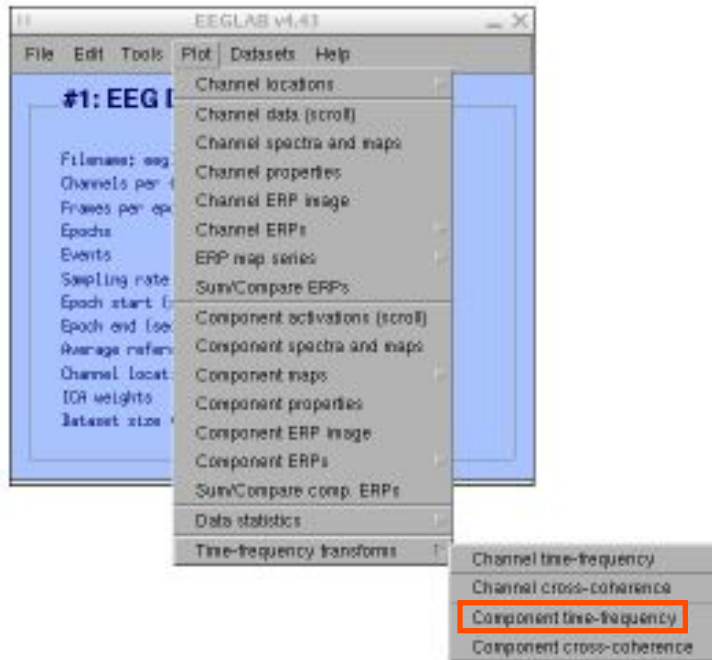
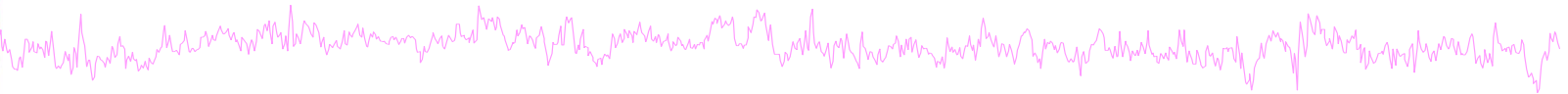




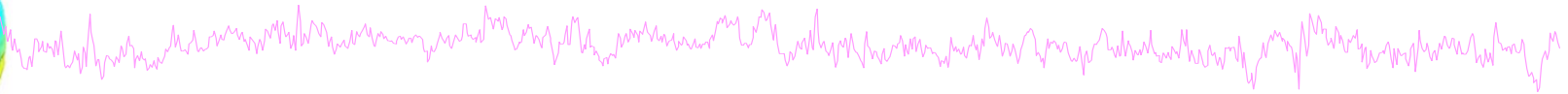
Component contribution to the EEG spectrum



Component time-frequency



EEGLAB standard processing pipeline



Single subject

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2. Edit, Re-reference, Resample, High pass filter data
3. Reject artifacts in continuous data by visual inspection
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5. Visualize data measures
6. Perform ICA decomposition
 - Perform source localization of components
 - Analyze components contribution to ERP
 - Analyze components contribution to spectrum

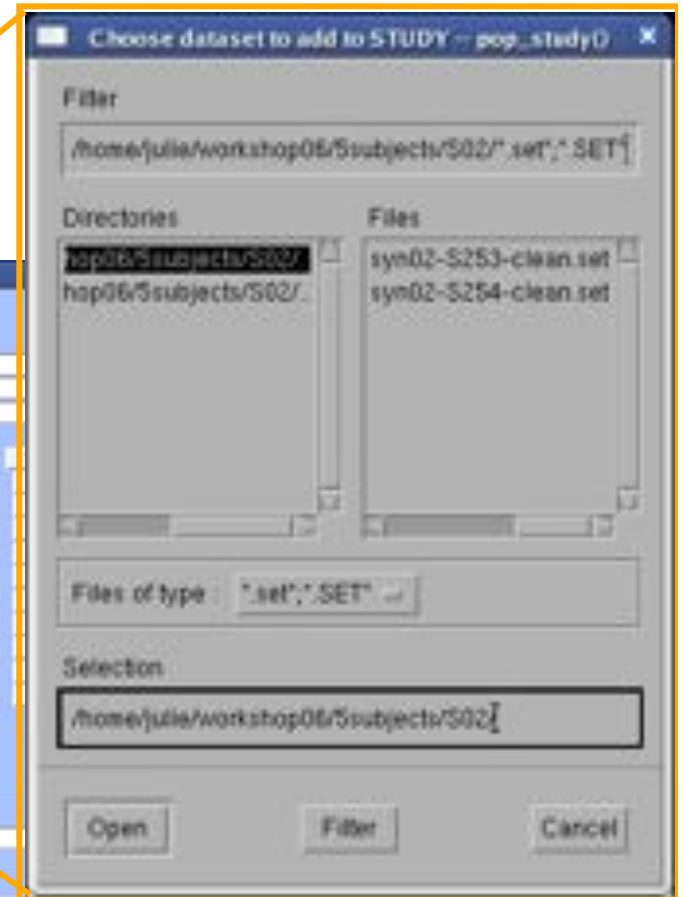
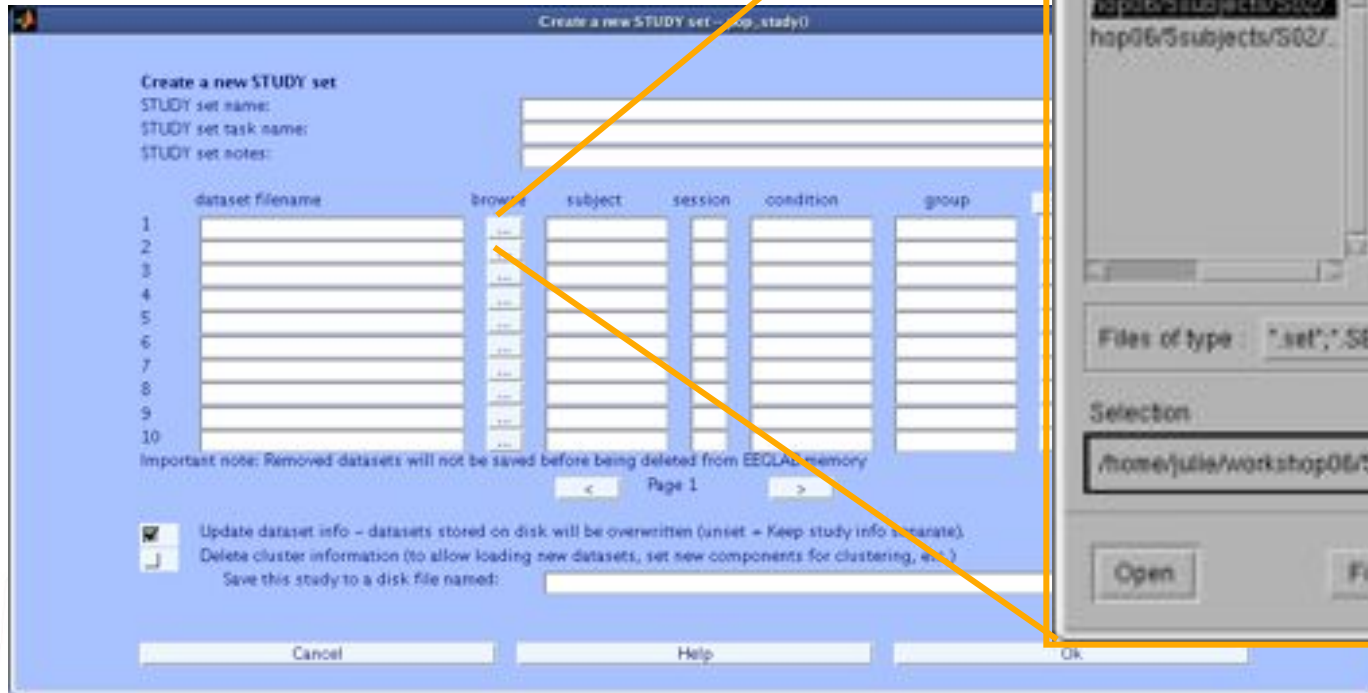
Multi-subjects

1. Build study and STUDY design
2. Pre-compute measures
3. Cluster components
4. Analyze clusters

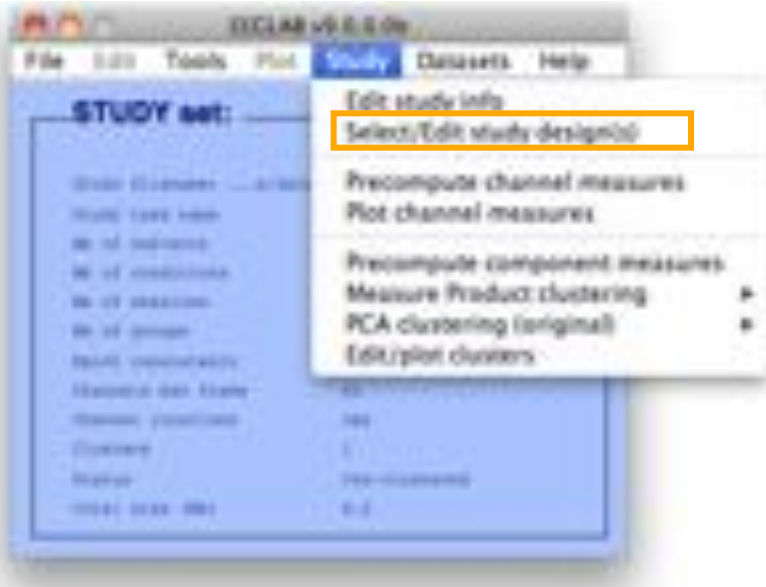
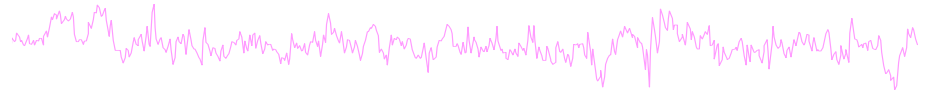


Advanced analysis using scripting and EEGLAB command line functions

1. Build a STUDY



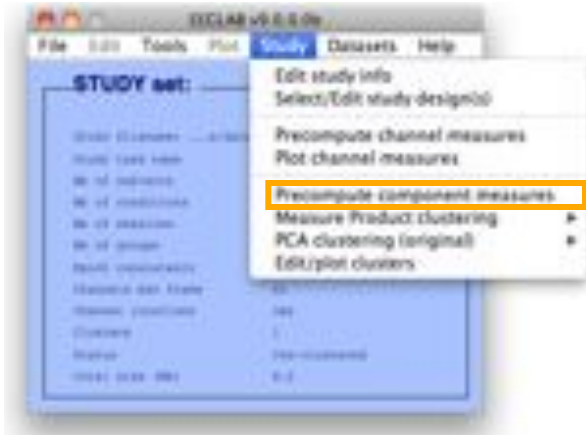
Edit STUDY design



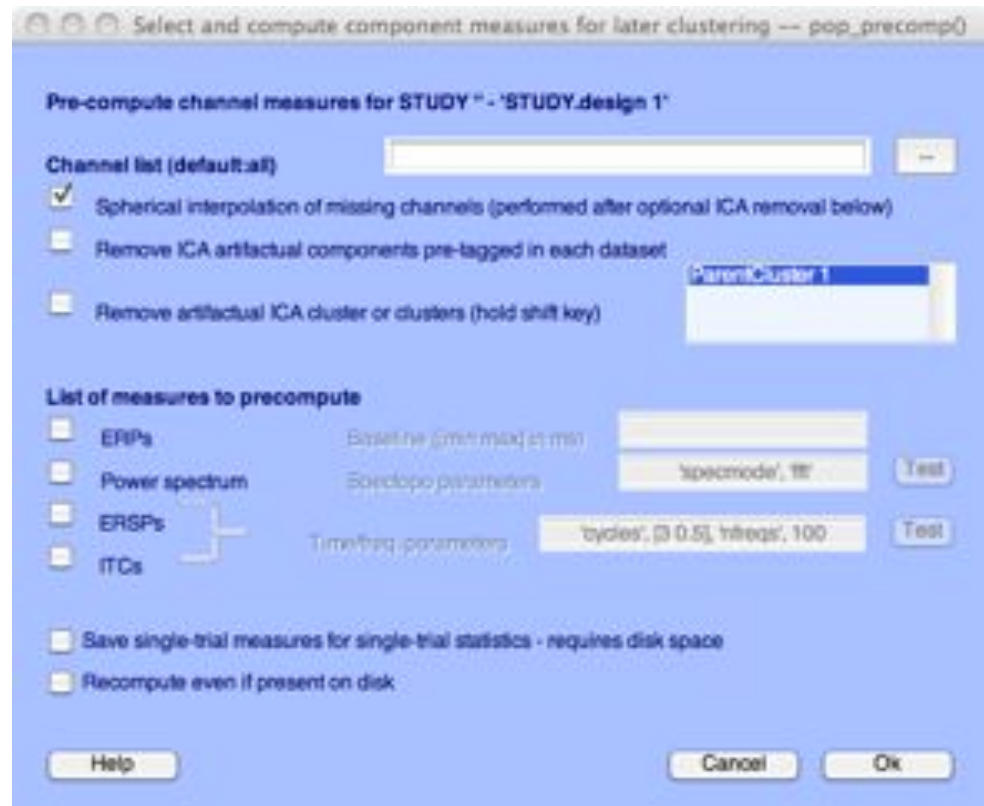
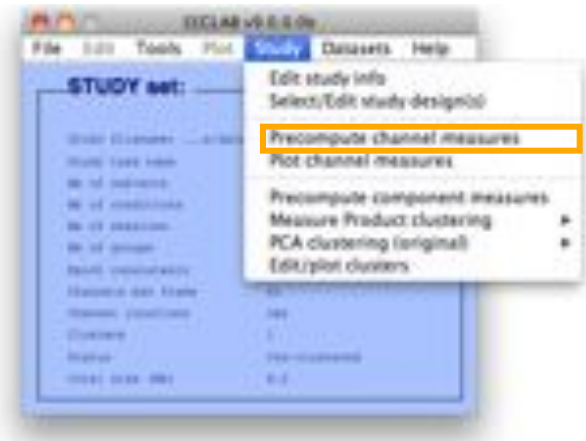
2. Pre-compute measures



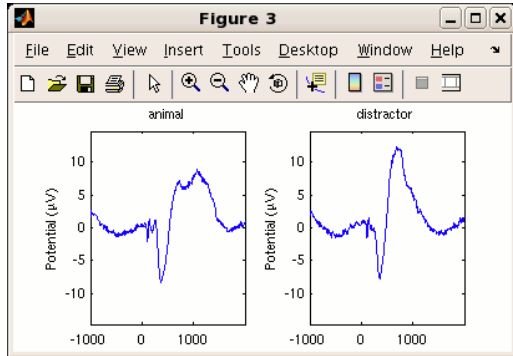
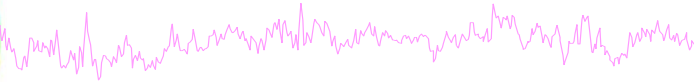
Components



Channels



Channel plotting



Study "

Select channel to plot

- All FP1
- All FP2
- All F3
- All F4
- All C3
- All C4
- All P2

Select subject(s) to plot

- All subjects
- cba FP1
- clm FP1
- ega FP1
- fsa FP1
- gro FP1
- kbb FP1

Plot ERPs Params

Plot spectra Params

Plot ERSPs Params

Plot ITCs Params

Plot channel properties

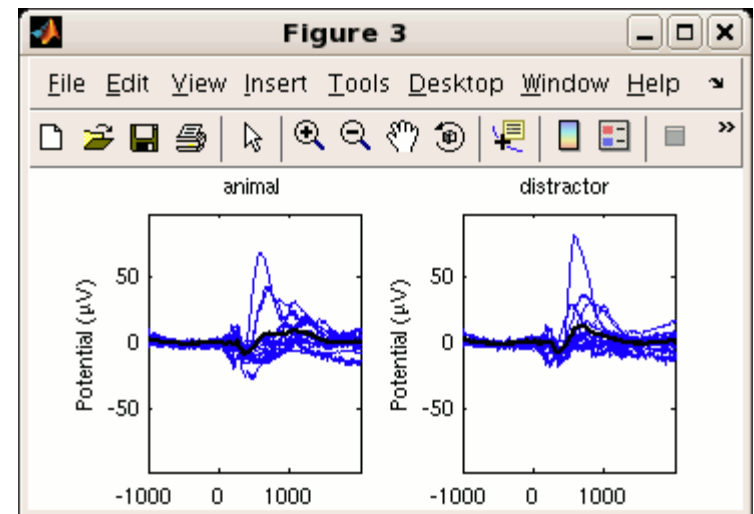
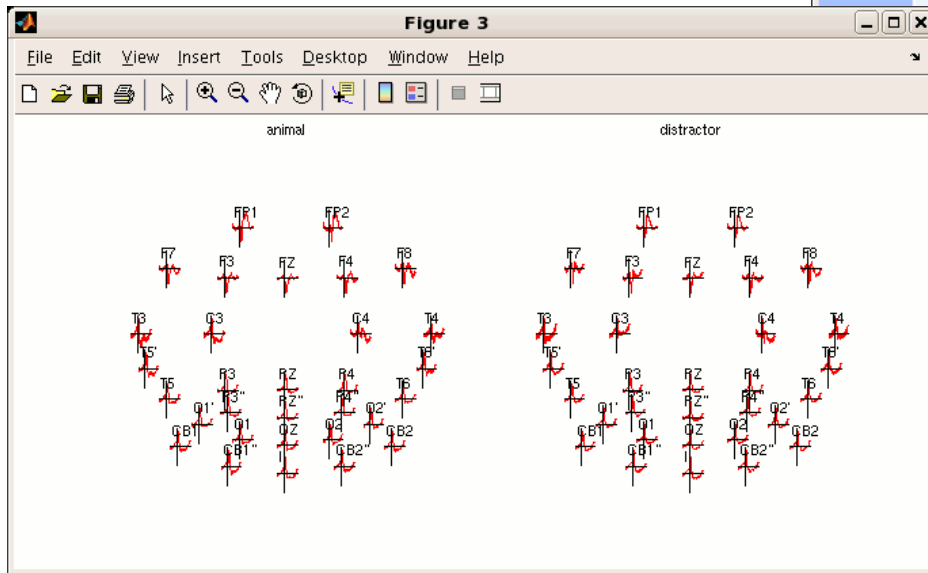
Create channel group (soon)

Edit channel group (soon)

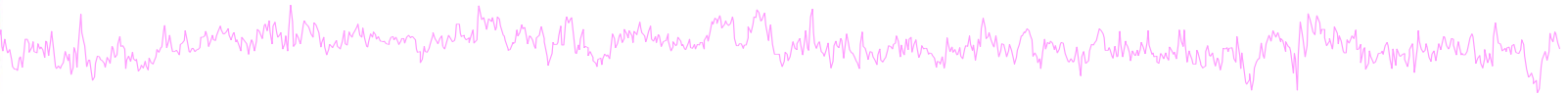
Delete channel group (soon)

Save STUDY set to disk /home/delorme/matlab/animal/animal.stu

Cancel Help Ok



3. Cluster components



STUDY set: Attention

Study filename	
Study task name	
Id. of subjects	
Id. of conditions	
Id. of sessions	
Id. of groups	
Epoch consistency	yes
Channels per frame	11
Channel locations	yes
Clusters	1
Status	Pre-clustered
Total size (Mb)	12.4

- Edit study info
- Precompute channel measures
- Plot channel measures
- Precompute component measures
- Build pre-clustering matrix**
- Cluster components
- Edit plot clusters

Select and compute component measures for later clustering -- pop_preclust()

Build pre-clustering matrix for STUDY 'Attention'

Select the cluster to refine during sub-clustering (any existing sub-hierarchy will be overwritten)

ParentCluster 1 (181 ICs)

(note: only measures that have been precomputed may be used)

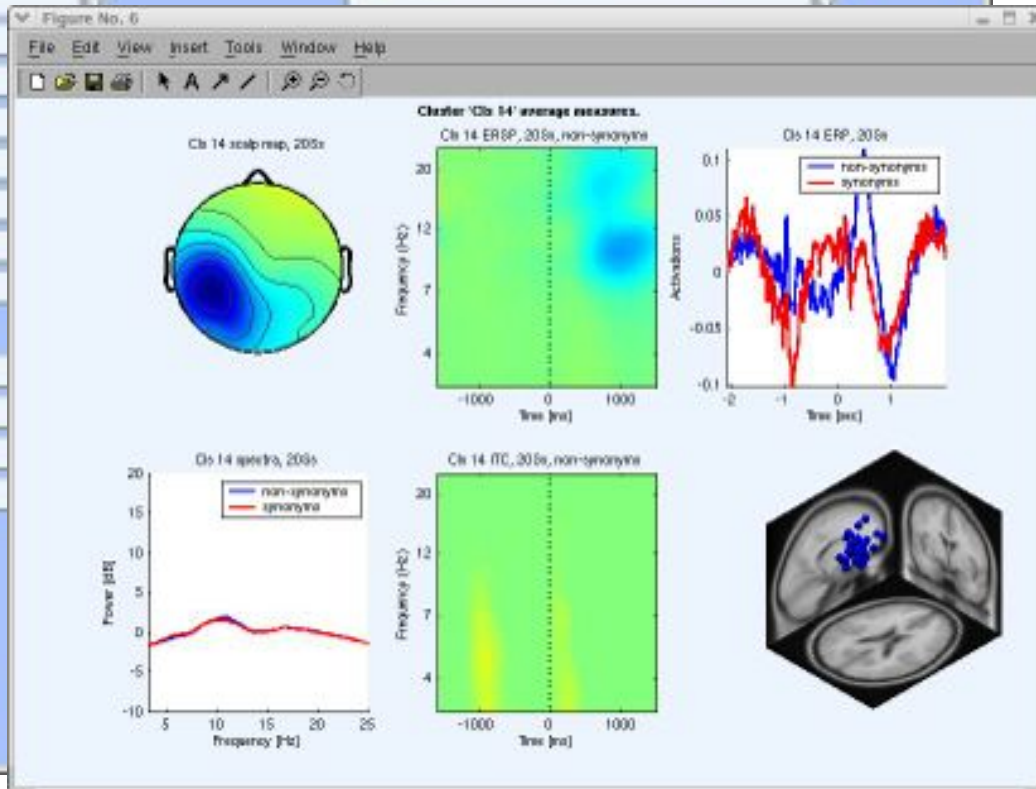
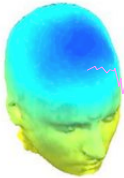
Load	Dims.	Norms	Rel. Wt.		
<input checked="" type="checkbox"/> spectra	10	<input checked="" type="checkbox"/>	1	Freq. range [Hz]	3 25
<input checked="" type="checkbox"/> ERPs	10	<input checked="" type="checkbox"/>	1	Time range [ms]	0 600
<input checked="" type="checkbox"/> dipoles	3	<input checked="" type="checkbox"/>	10		
<input type="checkbox"/> scalp maps	10	<input checked="" type="checkbox"/>	1	Use channel values	<input checked="" type="checkbox"/> Absolute values
<input checked="" type="checkbox"/> ERSPs	20	<input checked="" type="checkbox"/>	1	Time range [ms]	0 1500
<input checked="" type="checkbox"/> ITCs	10	<input checked="" type="checkbox"/>	1	Time range [ms]	0 600
<input type="checkbox"/> Final dimensions	10			Freq. range [Hz]	3 45
				Freq. range [Hz]	2 30

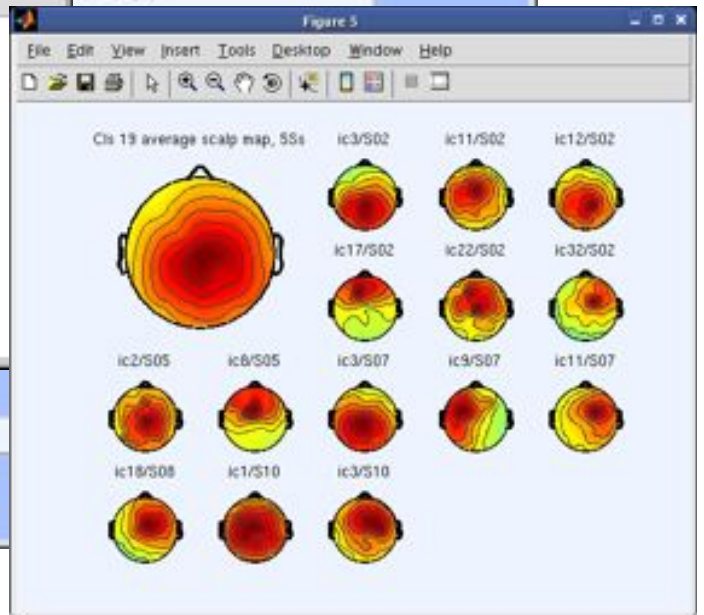
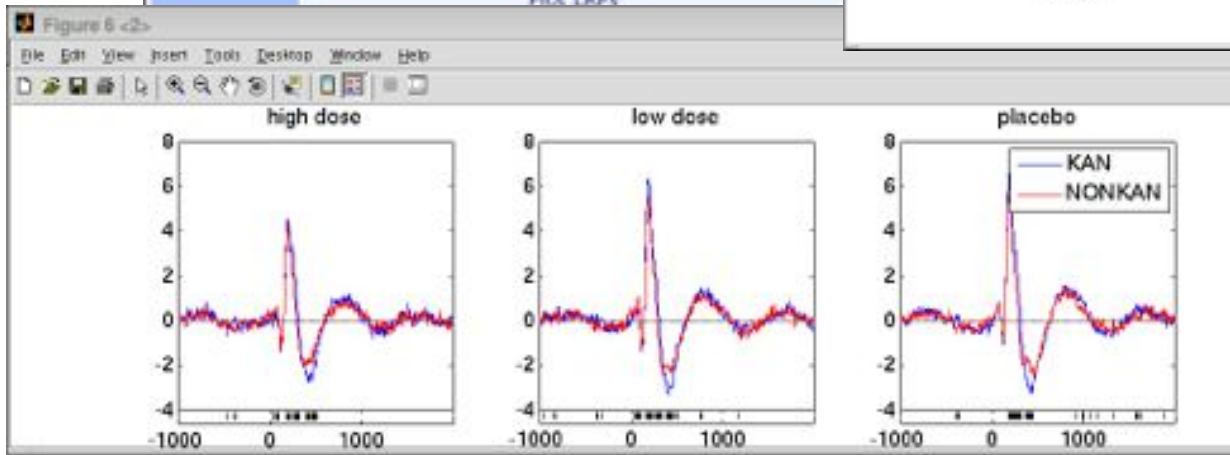
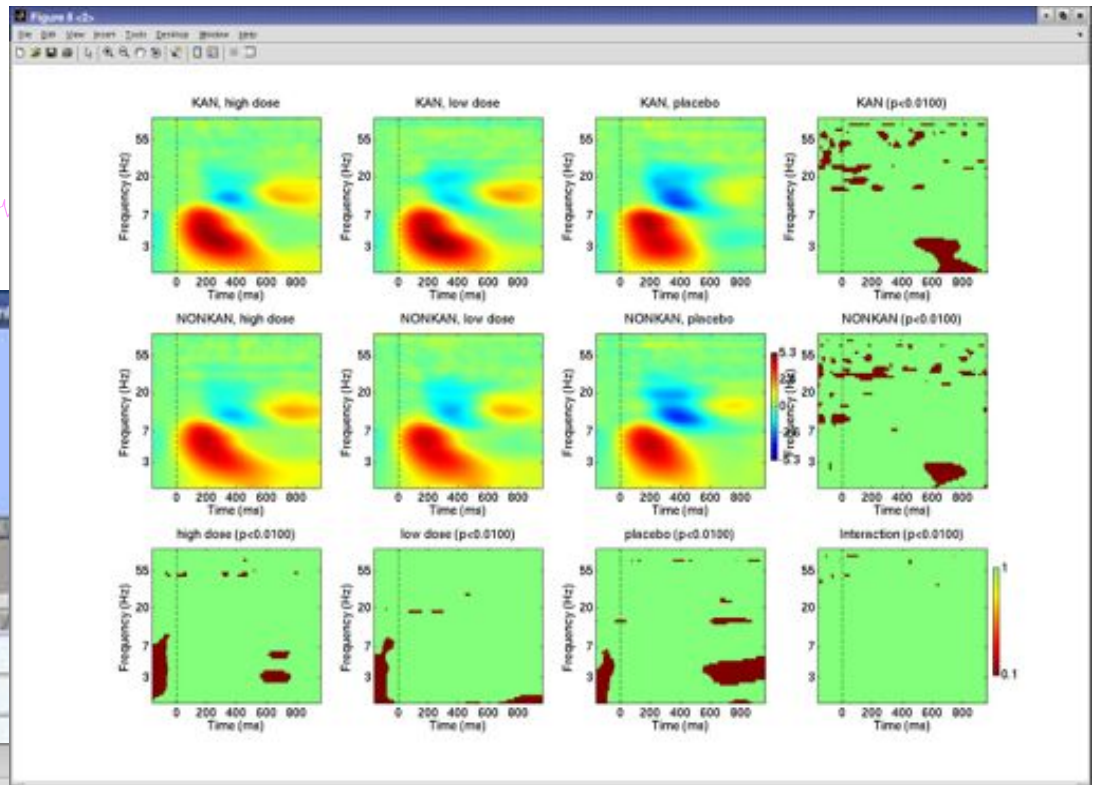
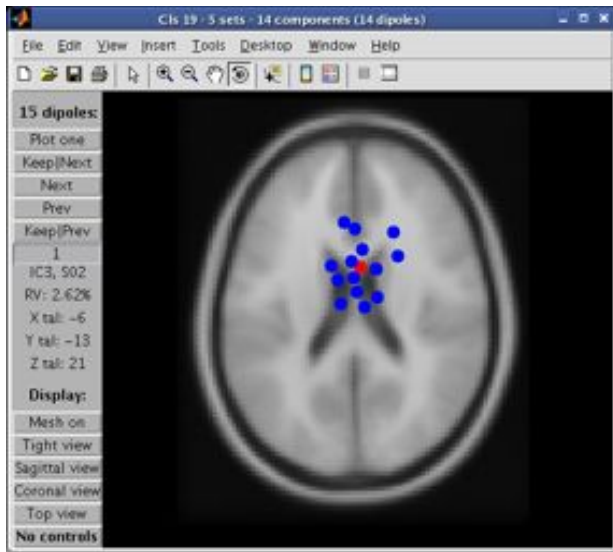
Save STUDY to file /home/julie/WorkshopSD2007/STUDY/attention.study

Cancel Help Ok



4. Analyze clusters

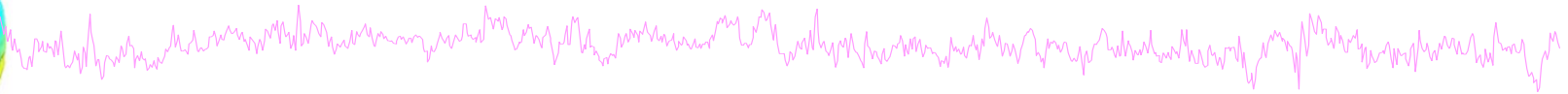




Cancel

Help

EEGLAB standard processing pipeline



Single subject

1. Import binary data, events and channel location
2. Edit, Re-reference, Resample, High pass filter data
3. Reject artifacts in continuous data by visual inspection
4. Extract epochs from data & reject artifactual epochs
5. Visualize data measures
6. Perform ICA decomposition
 - Perform source localization of components
 - Analyze components contribution to ERP
 - Analyze components contribution to spectrum

Multi-subjects

1. Build study and design
2. Pre-compute measures
3. Cluster components
4. Analyze clusters



Advanced analysis using scripting and EEGLAB command line functions

EEG structure

EEG =

```

setname: 'Epoched from "ee114 continuous"'
filename: 'ee114squaresepochs.mat'
filepath: 'home/amaise/ee114/'
pnts: 384
nbchan: 32
trials: 80
srate: 128
xmin: -1
xmax: 1.9922
data: [32x384x80 double]
icawinv: [32x32 double]
icasphere: [32x32 double]
icaweights: [32x32 double]
icaact: [32x384x80 double]
event: [1x157 struct]
epoch: [1x80 struct]
chanlocs: [1x32 struct]
comments: [2x150 char]
averf: 'no'
%
eventdescription: [1x5 cell]
epochdescription: []
specdata: []
specicaact: []
reject: [1x1 struct]
stats: [1x1 struct]
splinefile: []
ref: 'common'
history: [7x138 char]
unewent: [1x154 struct]
times: [1x384 double]
    
```

Number of data points per trial

Number of channels

Number of trials

Sampling rate

Time limits

Data

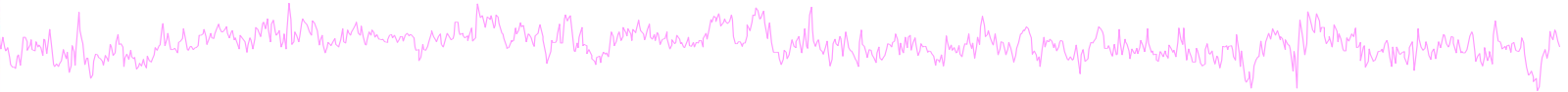
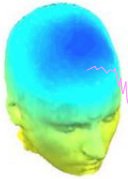
ICA scalp maps

ICA activity

Epoch/event information

Channel location

3 levels of functions



Administrative functions: handle EEG and ALLEEG structures

`eeglab()`, `eeg_checkset()`, `pop_delset()`, ...

Pop functions: interactive functions using EEG structure

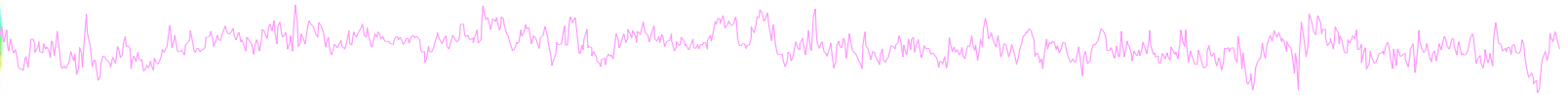
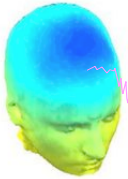
`pop_erpimage()`, `pop_topoplot()`, `pop_envtopo()`, ...

Signal processing functions: perform signal processing

`erpimage()`, `topoplot()`, `envtopo()`, ...



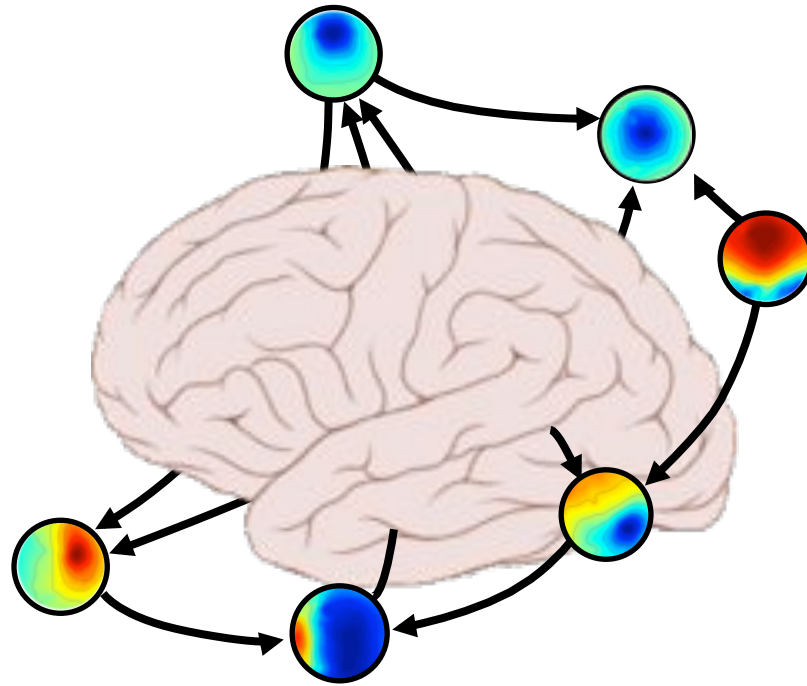
Command line tools



(“eegh” Menus write both dataset and global history)

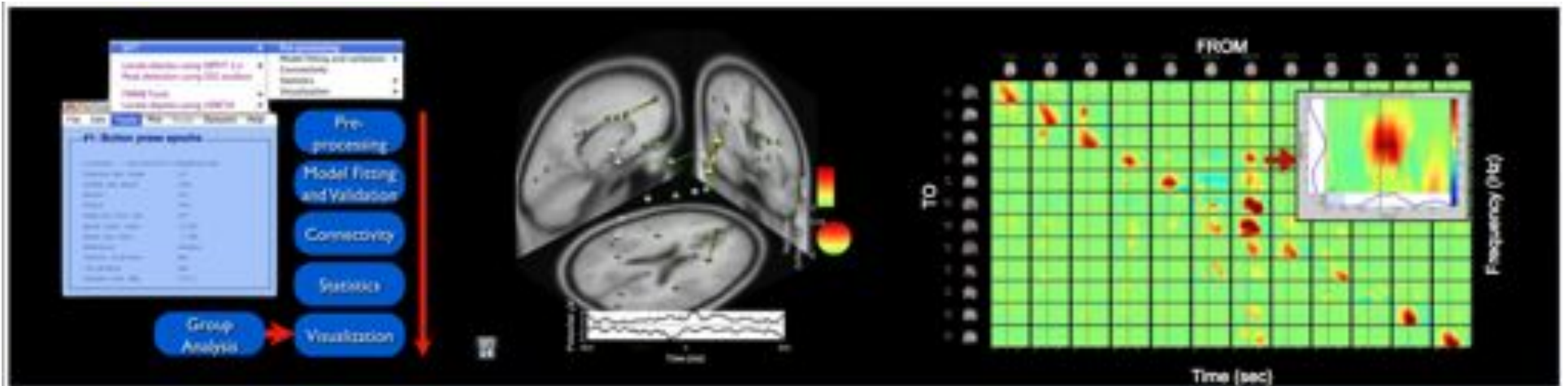
- Automated processing on groups of subjects (possibly on several processors).
- Richer options for plotting and processing functions (time-frequency decompositions, ...)
- Custom processing...





SIFT

Source Information Flow Toolbox



BCILAB - C. Kothe

The screenshot displays the BCILAB 0.9 software interface. The main window shows a menu with the option "Train now model..." selected. A "Parameter Search" dialog box is open, showing settings for the selected approach, calibration data source, loss/performance metric, cross-validation folds, and spacing around test trials. A "Spec-CSP" window is also open, displaying six topographic maps and line plots labeled "Spec-CSP Pattern 1" through "Spec-CSP Pattern 6".

Parameter Search Dialog:

- Selected approach: lastapproach ("Spectrally Weighted C...")
- Calibration data source: lastdata ("mag.vhd")
- Loss/Performance Metric: Automatically chosen
- Cross validation folds: 5
- Spacing around test trials: 5

Spec-CSP Window:

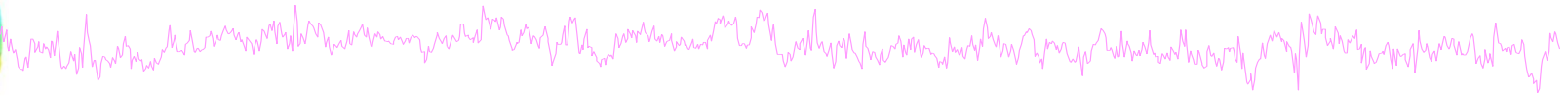
The window displays six topographic maps and line plots, labeled "Spec-CSP Pattern 1" through "Spec-CSP Pattern 6". Each plot shows a time series (x-axis: 0 to 40) and a corresponding topographic map (y-axis: 0 to 0.04 or 0.05). The topographic maps show spatial distributions of activity across the scalp, with colors ranging from blue (low) to red (high).

Pros/Cons of Matlab based open source



- Pros
 - Easy to program, highly modular and extendable
 - Not dependent on any platform (64-bit) and highly optimized
 - Large community of users (latest development in signal processing research)
 - Powerful scripting capabilities
- Cons
 - Matlab required for which you have to pay
 - Large memory requirements
 - Matlab bugs, possible version differences, cross-platform compatibility problems
 - Poor graphical interface

EEGLAB articles



Delorme, A., Makeig, S. (2004) EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. *Journal of Neuroscience Methods*, 134(1), 9-21.

Makeig, S., Debener, S., Onton, J., Delorme, A. (2004) Mining event related dynamics. *Trends in cognitive Neuroscience*, 8(5), 204-210.

Delorme, A., Mullen, T., Kothe, C., Bigdely-Shamlo, N., Akalin, Z., Vankov, A., Makeig, S. (2011) EEGLAB, MPT, NetSIFT, NFT, BCILAB, and ERICA: New tools for advanced EEG/MEG processing. *Computational Intelligence*, article ID 130714.

Delorme, A., Kothe, C., Bigdely, N., Vankov, A., Oostenveld, R., Makeig, S. (2010) Matlab Tools for BCI Research? In "human-computer interaction and brain-computer interfaces". Editors : Tan, D. and Nijholt, A. Springer Publishing.

Delorme, A., Makeig, S. (2009) Open Source Programming for Interpreted Language: Graphic Interface and Macro Bridging Interface. 2009 Fifth International Conference on Signal-Image Technology & Internet-Based Systems (SITIS, indexed in IEEE), Nov. 29 2009- Dec. 4 2009, 430-434.

Delorme A, Palmer J, Onton J, Oostenveld R, Makeig S. (2012) Independent EEG sources are dipolar. *PLoS One*, 7(2).

