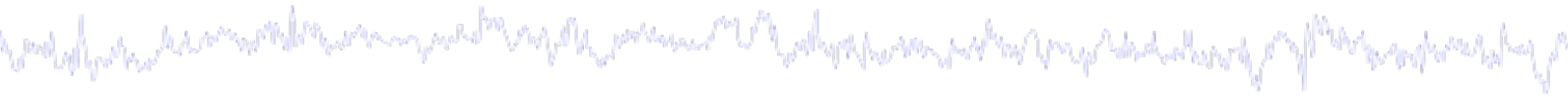
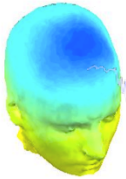
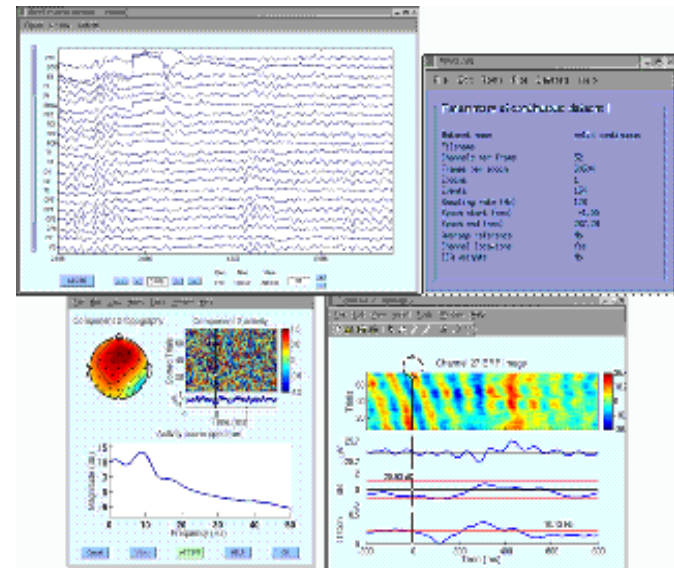


EEGLAB overview



- Collection of over 300 functions (70000 lines of code)
- About 70 000 download over the past 8 years
- About 3500 users on the discussion list and 8500 on the diffusion list
- NIH funding since 2003

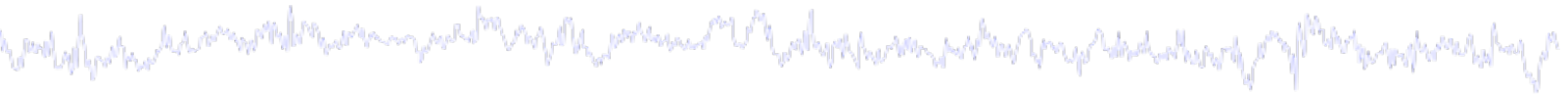
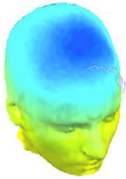


<http://sccn.ucsd.edu/eeglab>

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

http://sccn.ucsd.edu/wiki/Eleventh_EEGLAB_Workshop_Taiwan

Pros/Cons of Matlab based open source



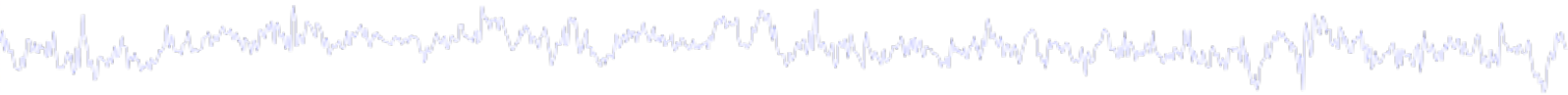
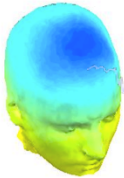
- Pros

- Easy to program, highly modular and extendable
- Not dependent on any platform (64-bit)
- Large community of users (latest development in signal processing research)
- Cannot imagine more powerful scripting capabilities

- Cons

- Matlab required for which you have to pay
- Large memory requirements
- Matlab bugs, possible version differences, cross-platform compatibility problems

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

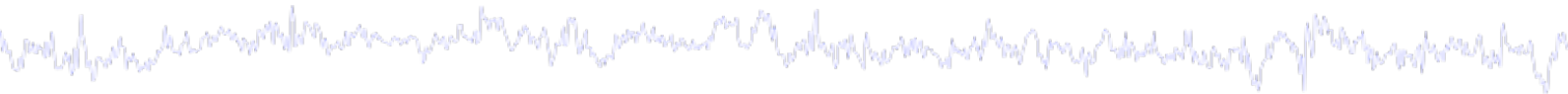
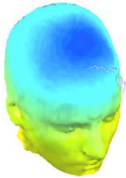
Multi-subjects

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



The screenshot displays the EEGLAB Matlab software interface. On the left is a terminal window titled "EEGLAB Shell - Konsole" with a menu bar containing "Session Edit View Bookmarks Settings Help". The terminal shows the command `matlab -nodesktop` being executed, resulting in the following output:

```
< M A T L A B >  
Copyright 1984-2002 The MathWorks  
Version 6.5.0.180913a Release  
Jun 18 2002  
  
Using Toolbox Path Cache. Type "help toolbox_path" for more information.  
  
To get started, type one of these: helpwin, helpdesk, or help  
For product information, visit www.mathworks.com  
  
>> eeglab
```

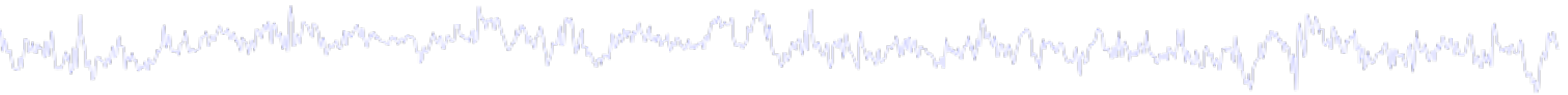
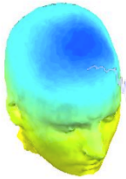
On the right is a help window titled "EEGLAB" with a menu bar containing "File Edit Tools Plot Datasets Help". The help window displays the following text:

No current dataset

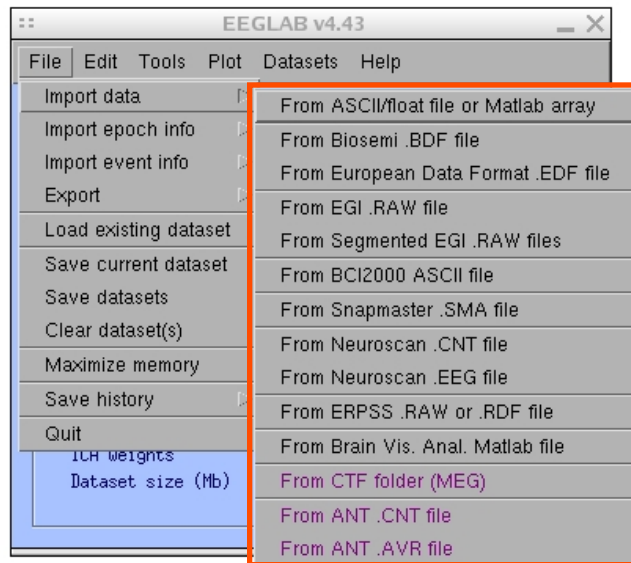
- Create a new or load an existing dataset:
Use `"/File/Import data"` (new)
Or `"/File/Load existing dataset"` (old)
- If new,
`"/File/Import epoch info"` (data epochs), else
`"/File/Import event info"` (continuous data)
`"/Edit/Dataset info"` (add/edit dataset info)
`"/File/Save dataset"` (save dataset)
- Prune data: `"/Edit/Select data"`
- Reject data: `"/Tools/Reject continuous data"`
- Epoch data: `"/Tools/Extract epochs"`
- Remove baseline: `"/Tools/Remove baseline"`
- Run ICA: `"/Tools/Run ICA"`



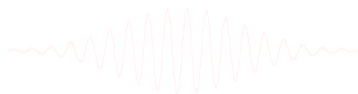
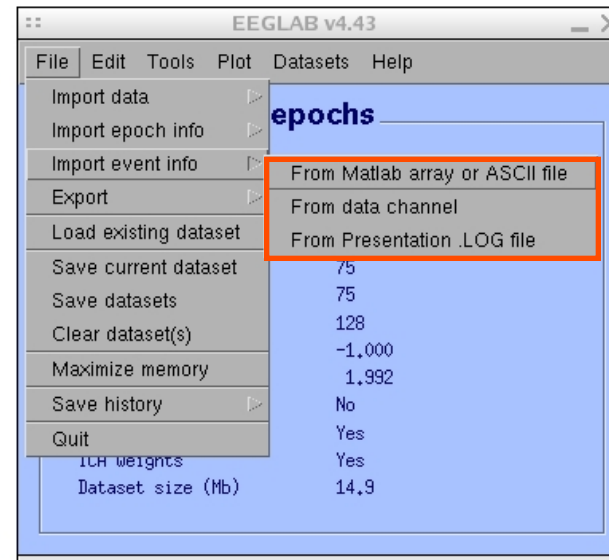
1. Importing data



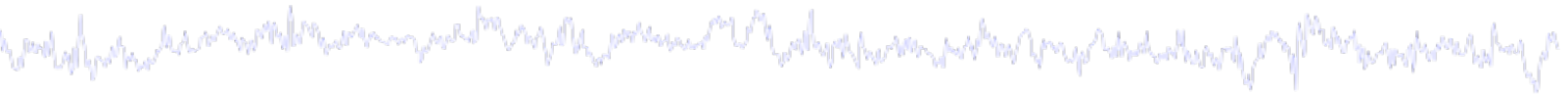
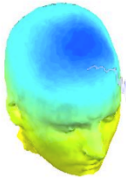
Import/load data



Import events



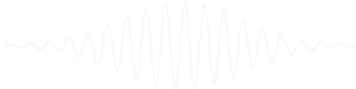
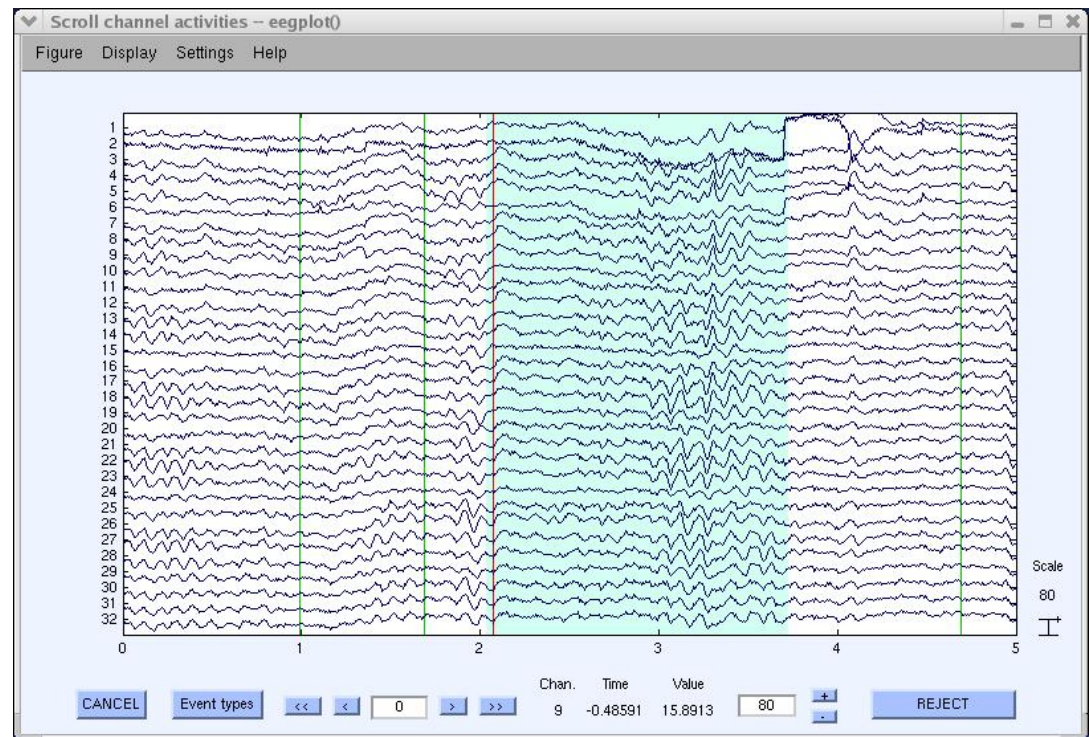
1. Importing data



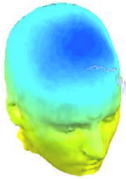
Data info



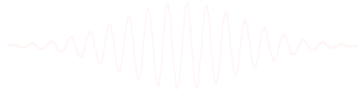
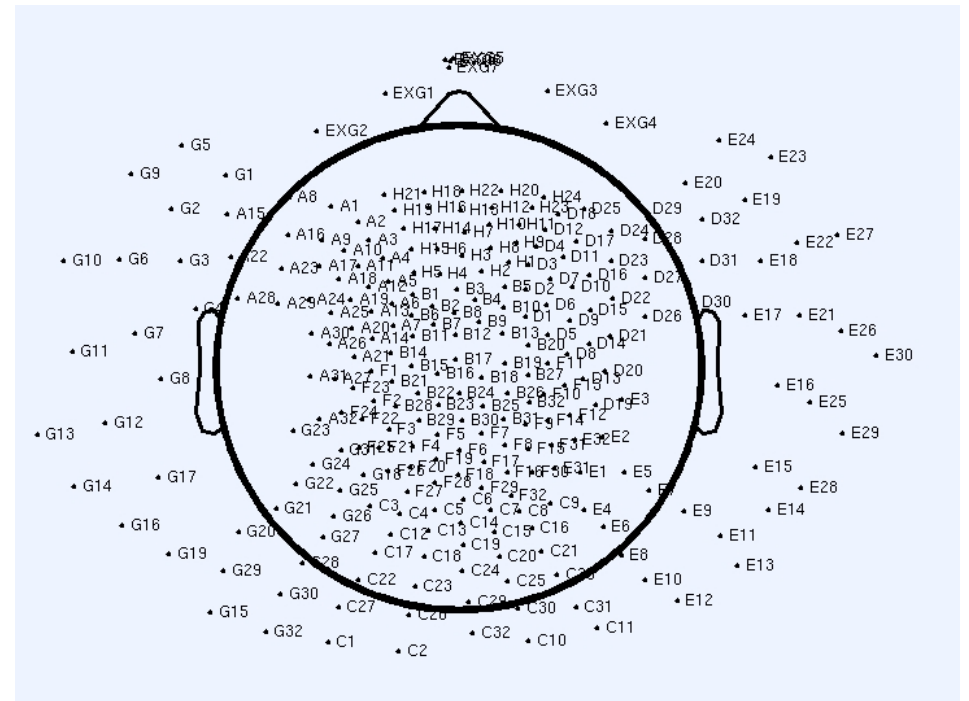
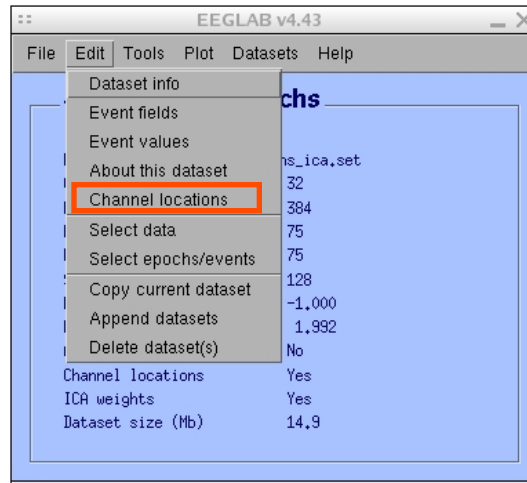
Scrolling data



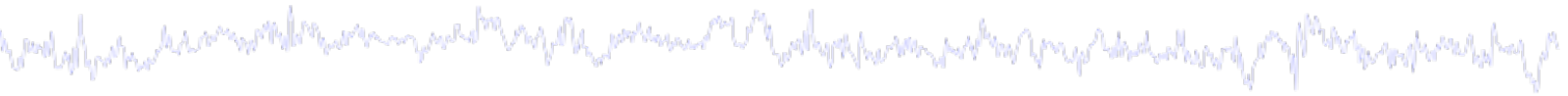
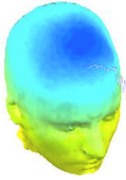
1. Importing channel location



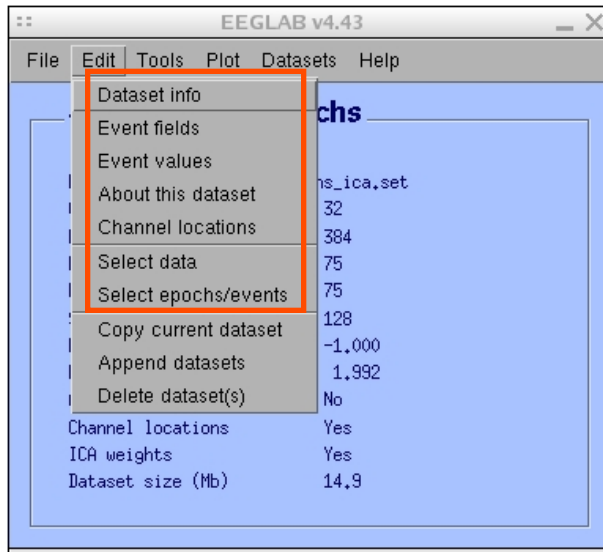
Import channel location



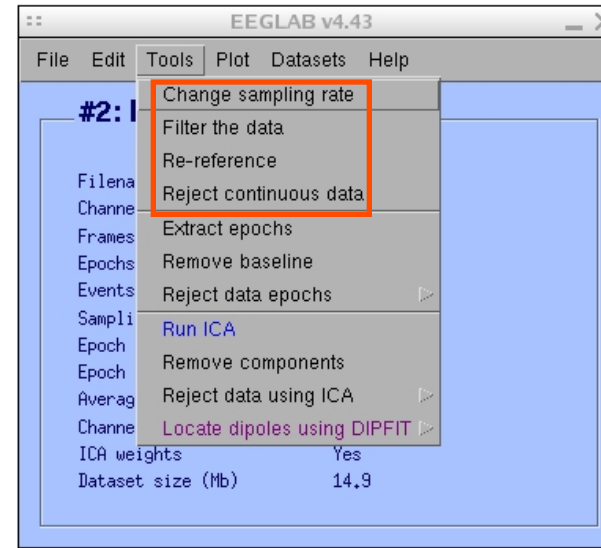
2. Edit, Re-reference, Resample, High pass filter data



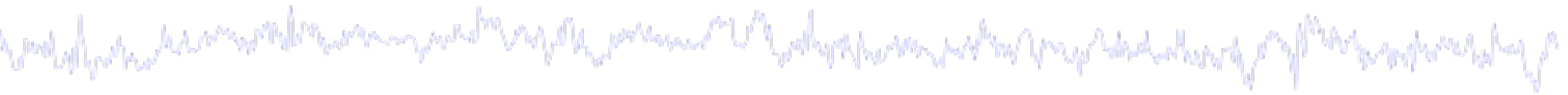
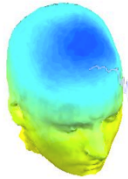
Edit/select data



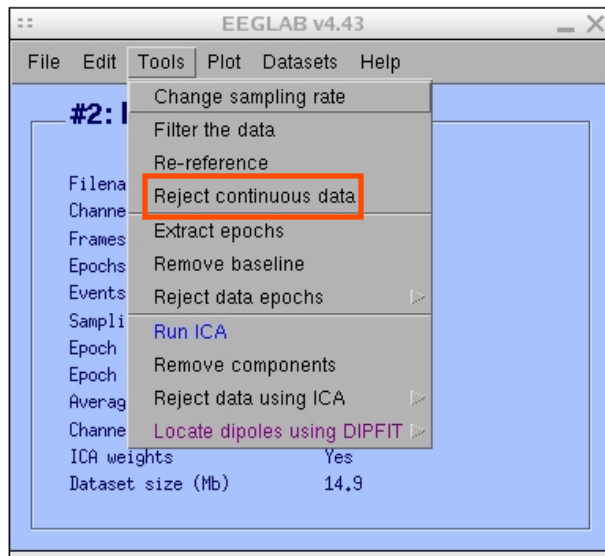
Preprocessing data



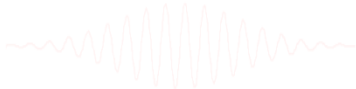
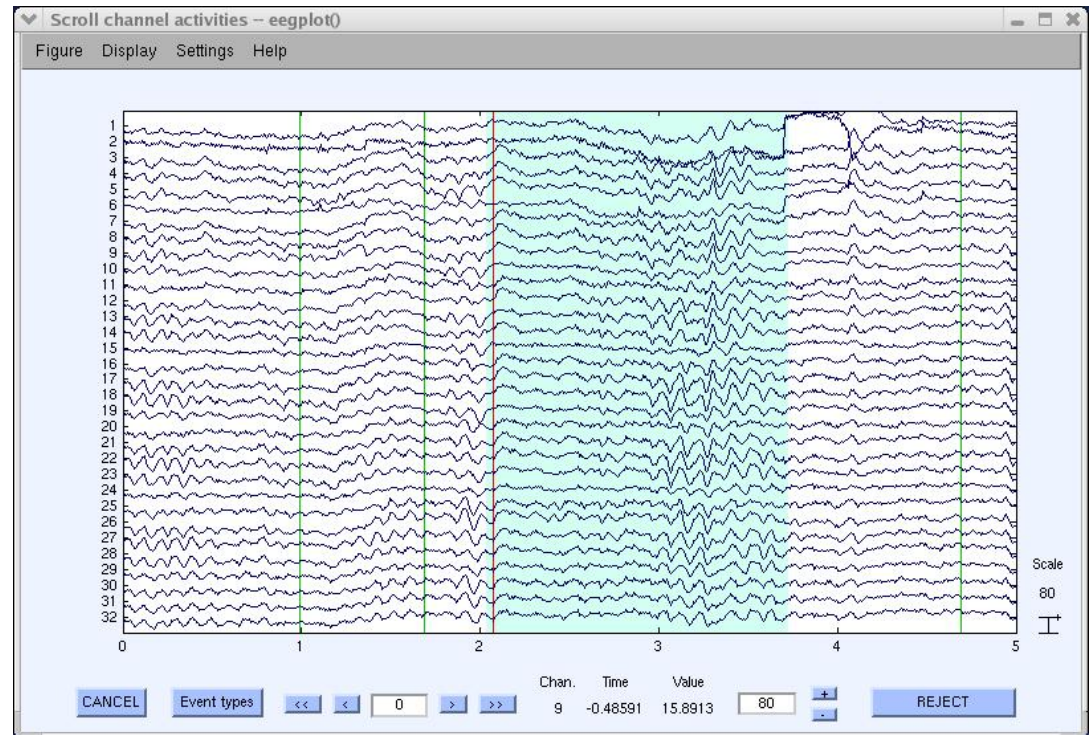
3. Reject artifacts in continuous data by visual inspection



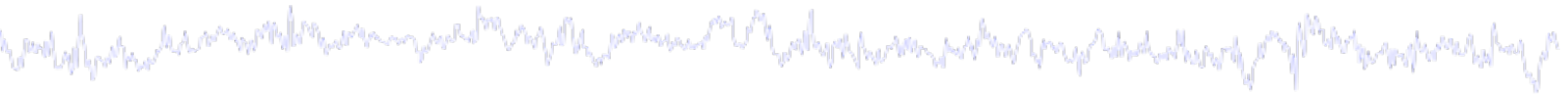
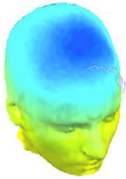
Data info



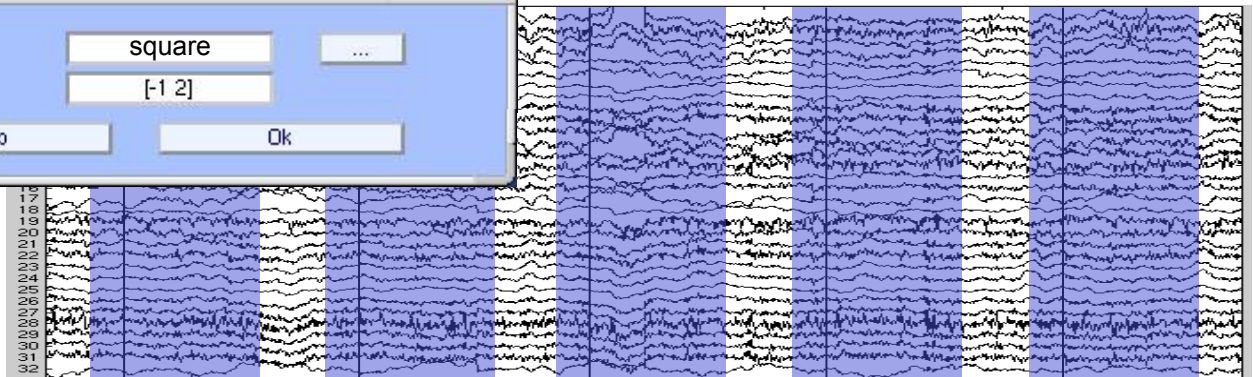
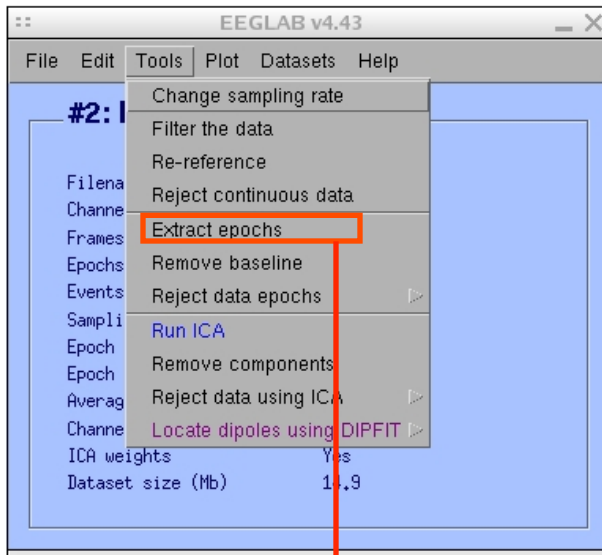
Reject portions of continuous data



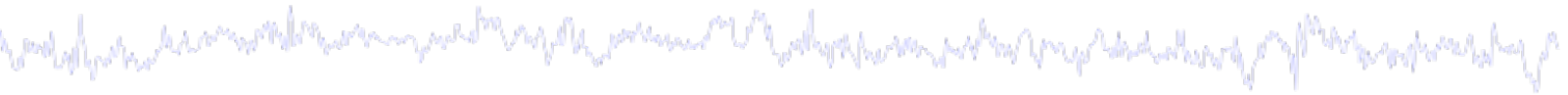
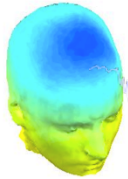
4. Extract epochs from data & reject artifactual epochs



Preprocessing data



4. Extract epochs from data & reject artifactual epochs



EEGLAB v4.51

File Edit Tools Plot Datasets Help

#2: I

Change sampling rate

Filter the data

Re-reference

Reject continuous data

Extract epochs

Remove baseline

Reject data epochs

Reject data (all methods)

Run ICA

Reject by inspection

Reject extreme values

Reject flat line data

Reject by probability

Reject by kurtosis

Reject by spectra

Export marks to ICA reject

Reject marked epochs

Locate dipoles using BESA

Locate dipoles using DIPFIT

Laplacian

Cluster component

Filter the data (IIR)

File name

Channel

Frames

Epochs

Events

Sampling

Epoch

Epoch

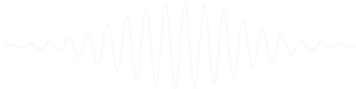
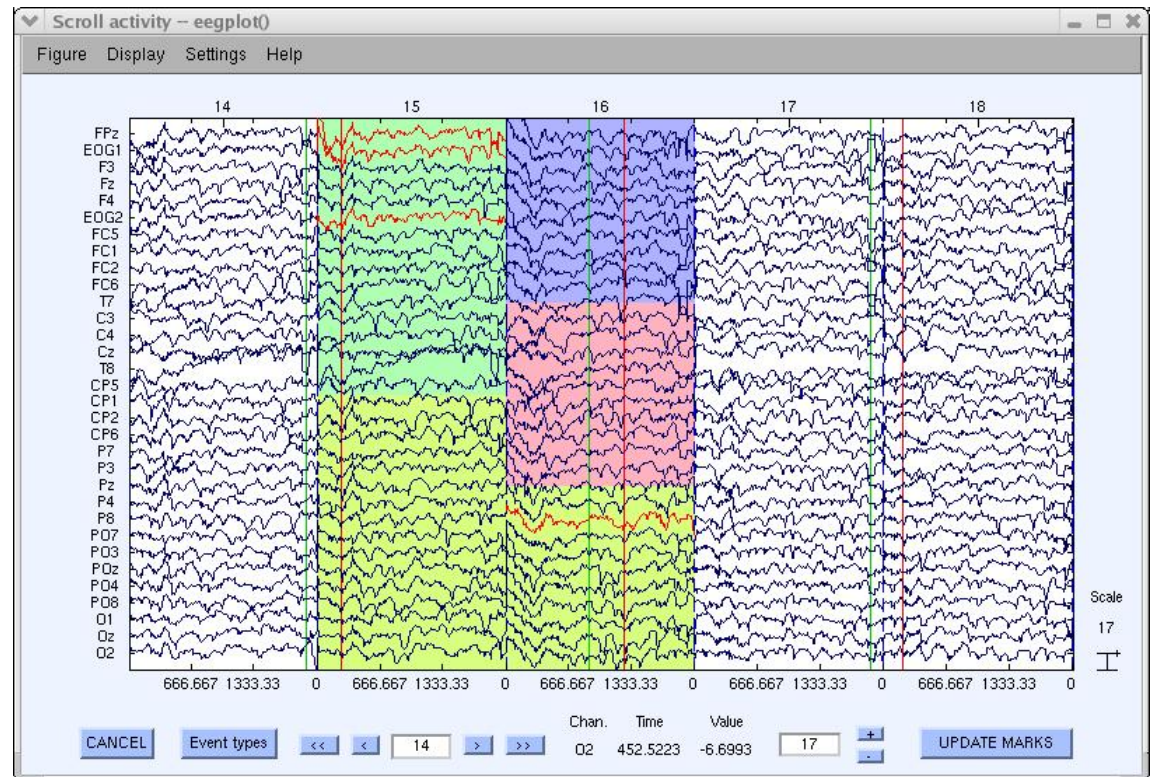
Average

Channel

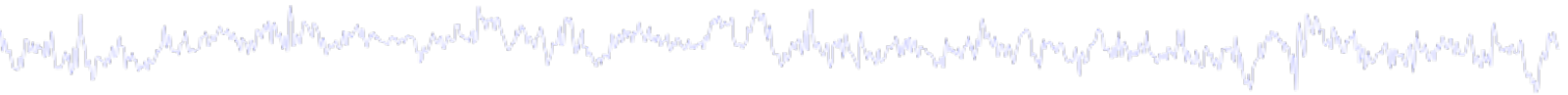
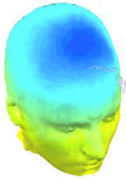
ICA weights

Dataset

Different color = different rejection methods

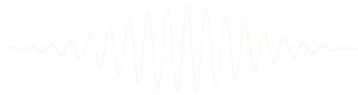
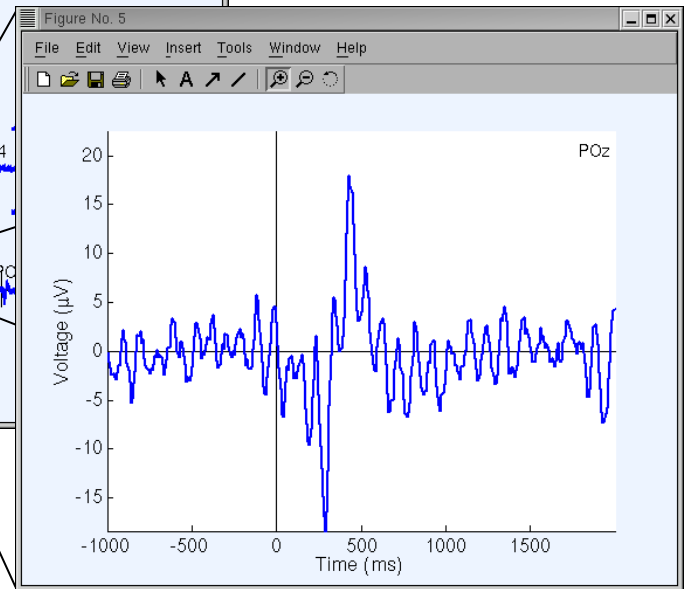
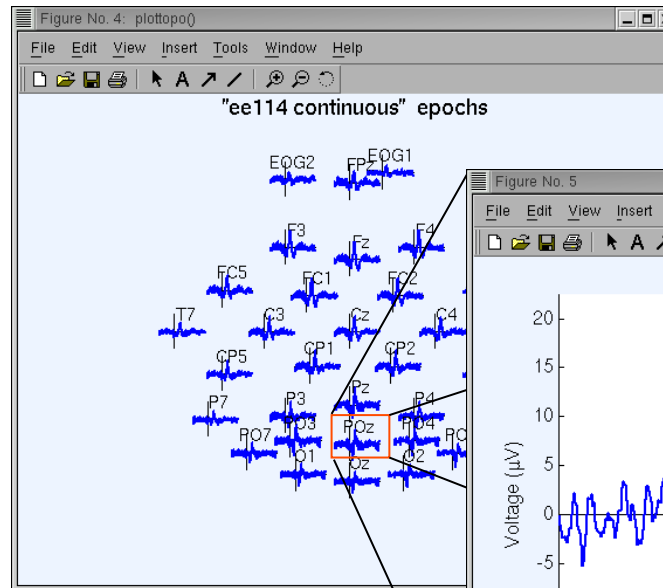


5. Visualize data measures



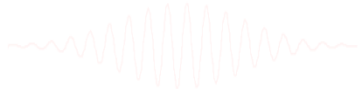
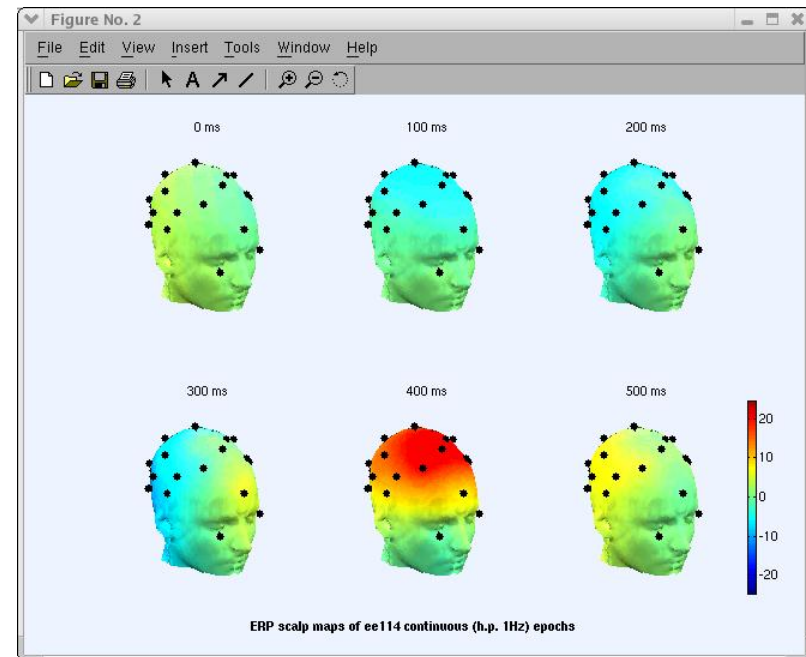
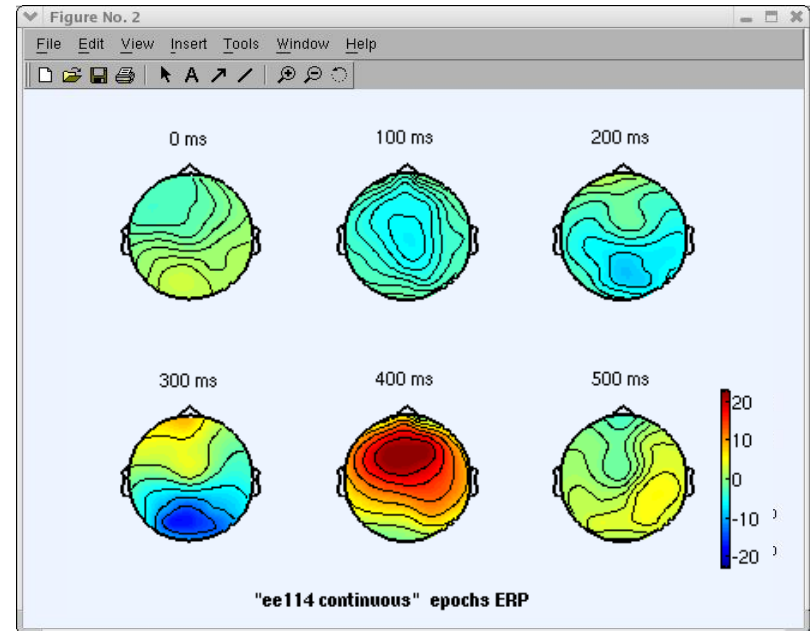
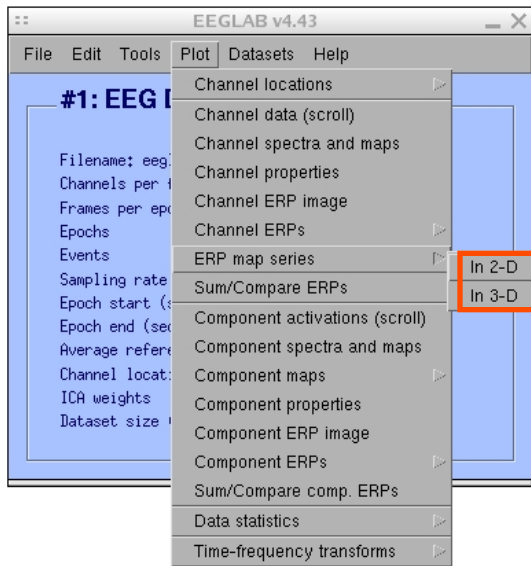
Plot ERP

- Channel locations
- Channel data (scroll)
- Channel spectra and maps
- Channel properties
- Channel ERP image
- Channel ERPs
 - With scalp maps
 - In scalp array**
 - In rect. array
- 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

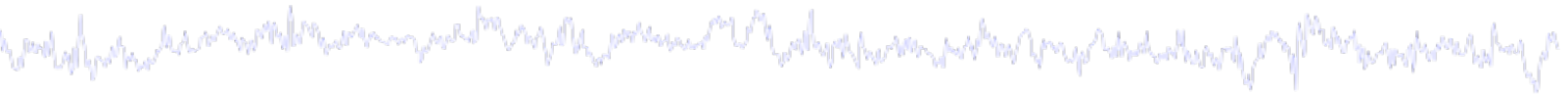
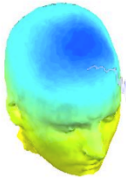


5. Visualize data measures

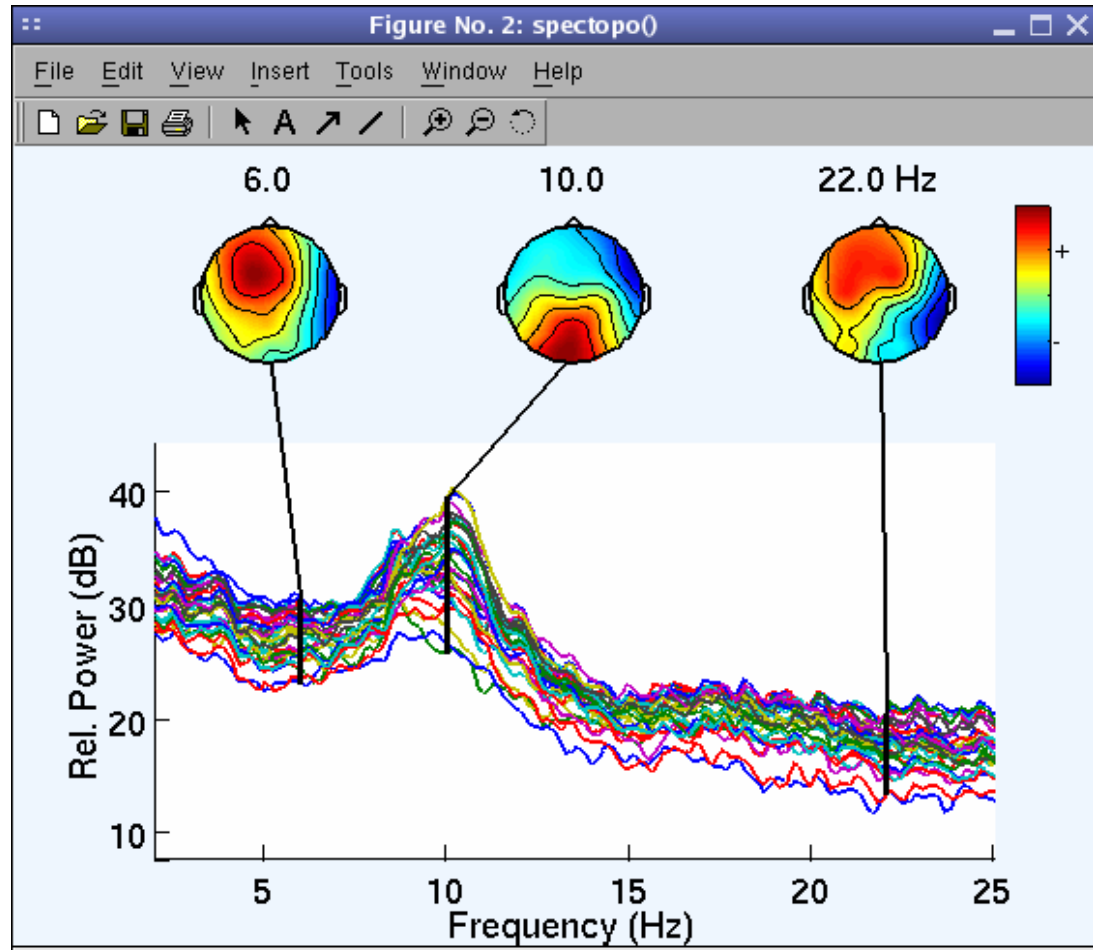
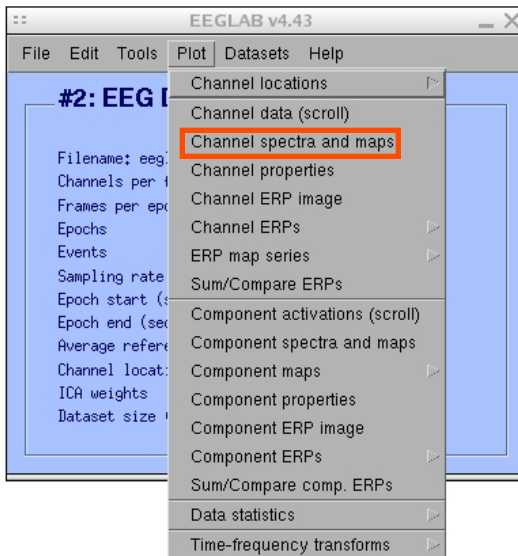
Plot ERP
map series



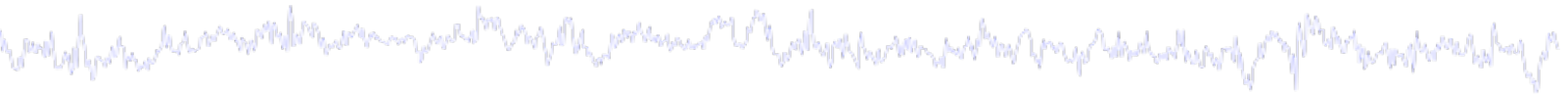
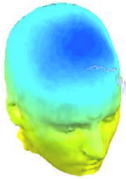
5. Visualize data measures



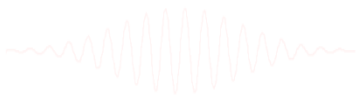
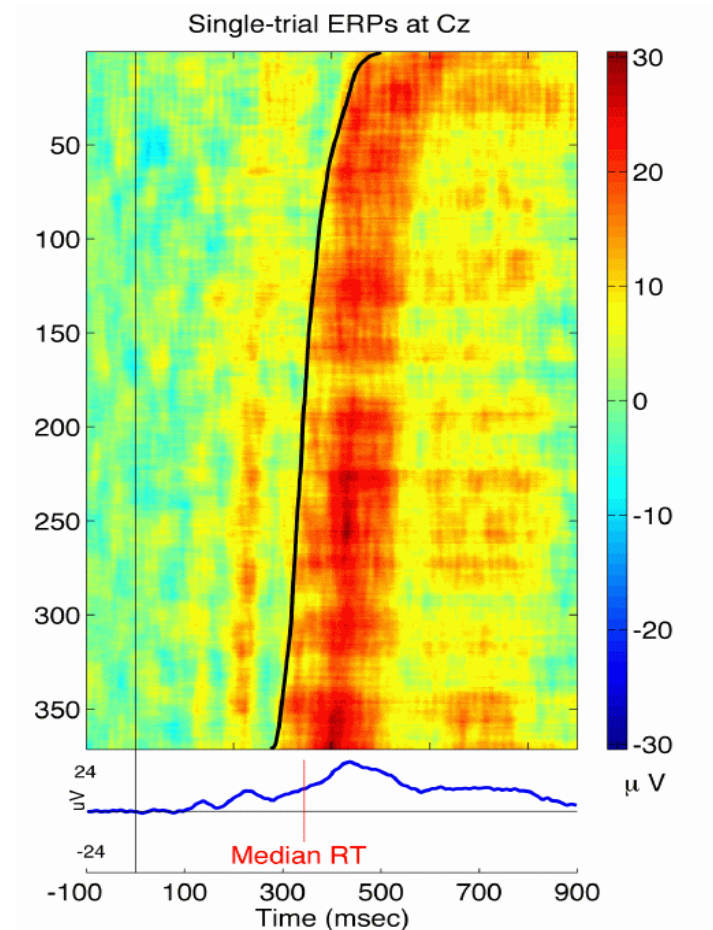
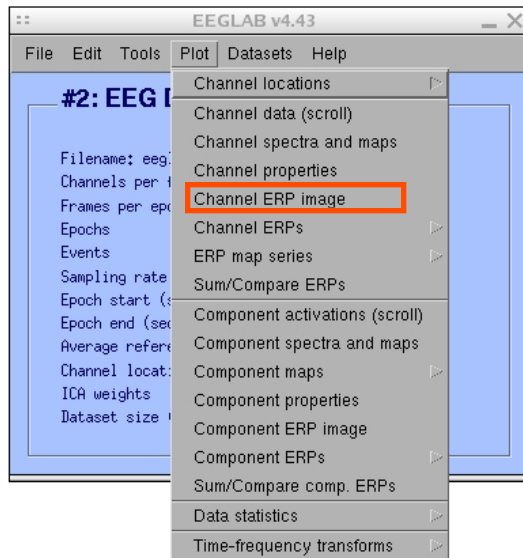
Plot data
spectrum and
maps



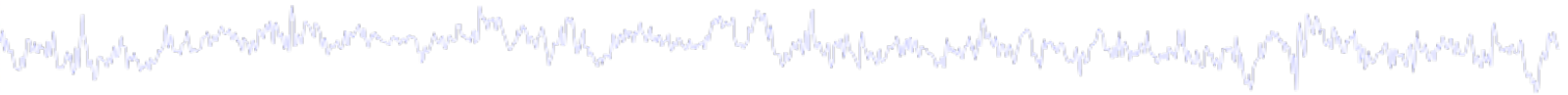
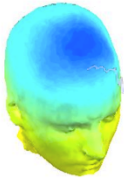
5. Visualize data measures



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

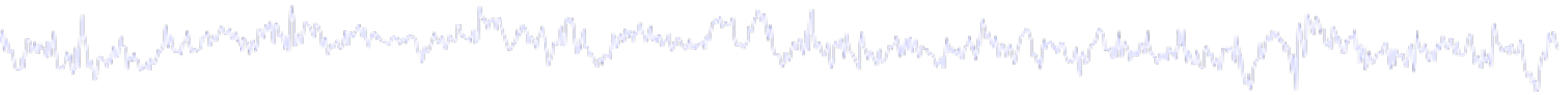
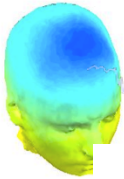
Multi-subjects

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



EEGLAB v4.43

File Edit Tools Plot Datasets Help

#2: I

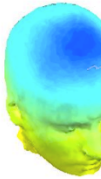
- Change sampling rate
- Filter the data
- Re-reference
- Reject continuous data
- Extract epochs
- Remove baseline
- Reject data epochs
- Run ICA**
- Remove components
- Reject data using ICA
- Locate dipoles using DIPFIT

File name:
Channel:
Frames:
Epochs:
Events:
Sampling rate:
Epoch:
Epoch:
Average:
Channel:
ICA weights: Yes
Dataset size (Mb): 14.9

Run ICA decomposition - pop_runica()

ICA algorithm to use [runica | binica | jader | sobi | acsobi]

Commandline options (See algorithm help messages)



Reject components by map - pop_selectcomps() (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

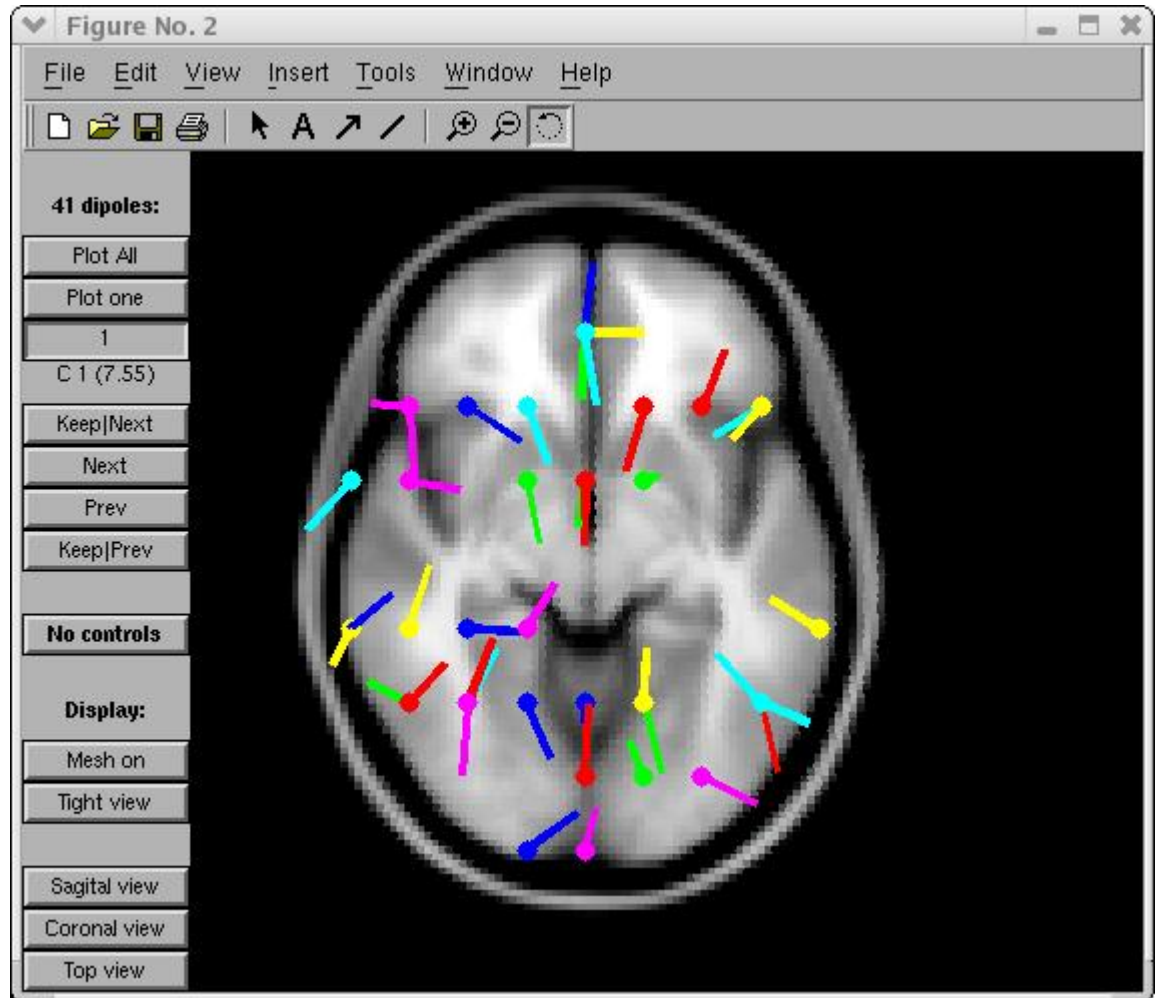
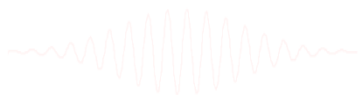
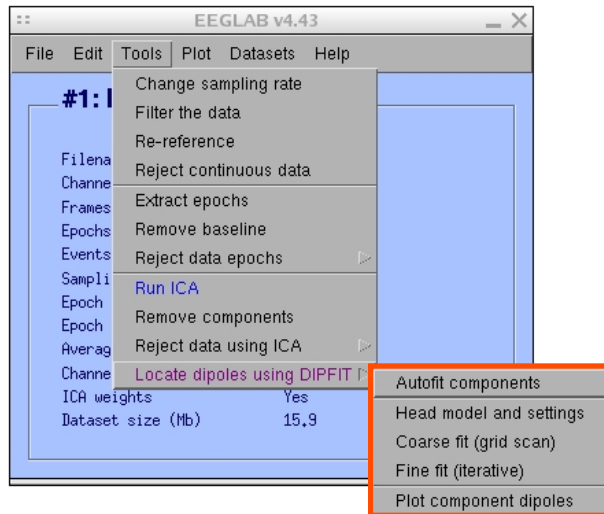
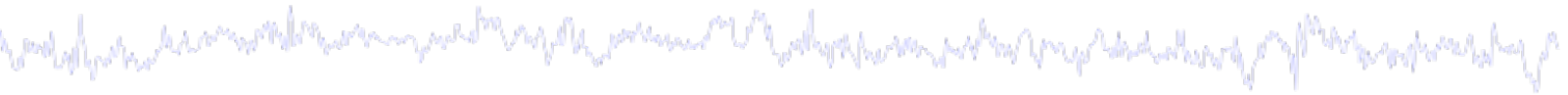
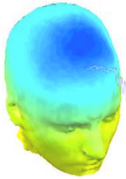
Magnitude (dB)

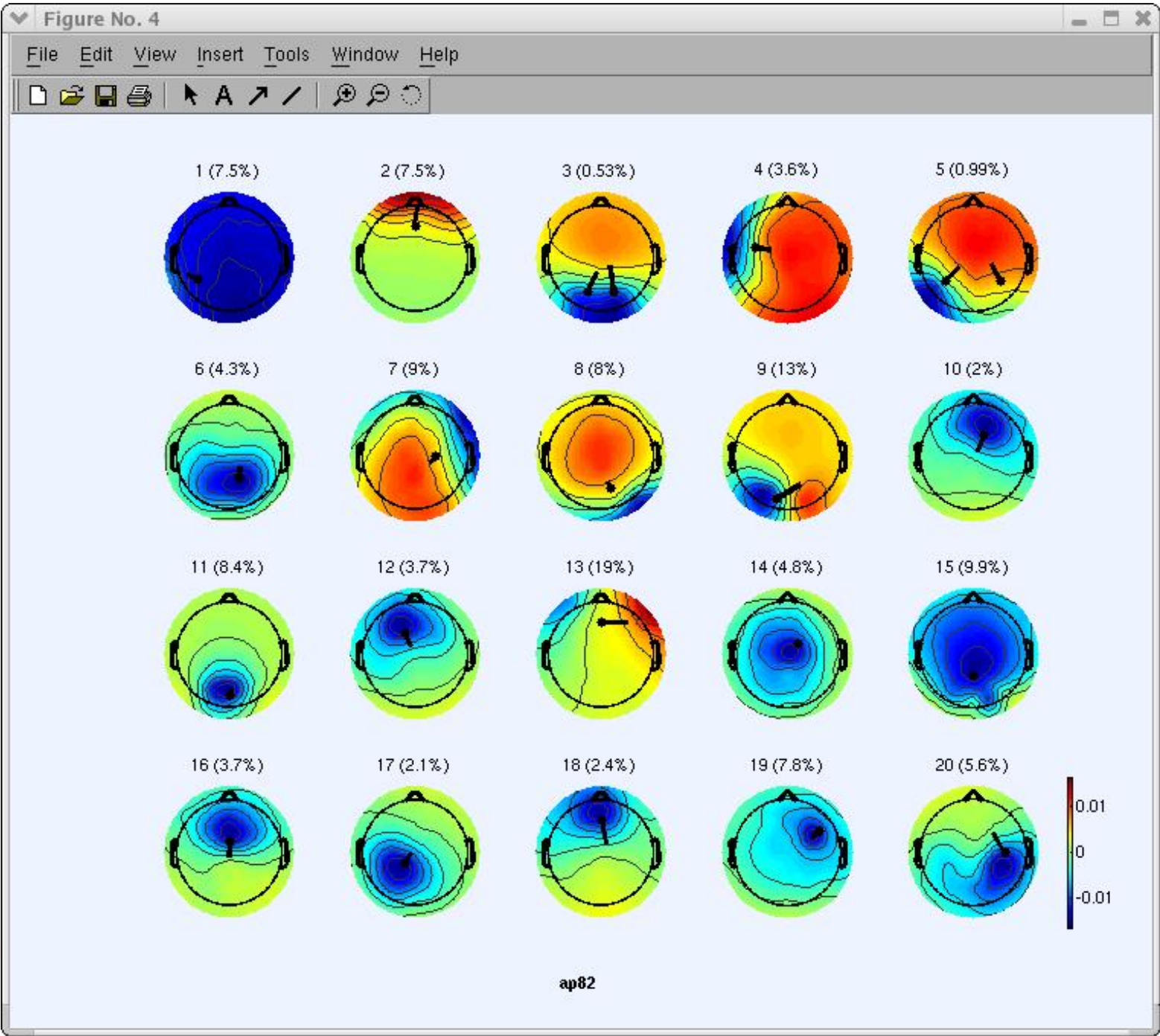
Frequency (Hz)

Cancel Values **ACCEPT** HELP OK

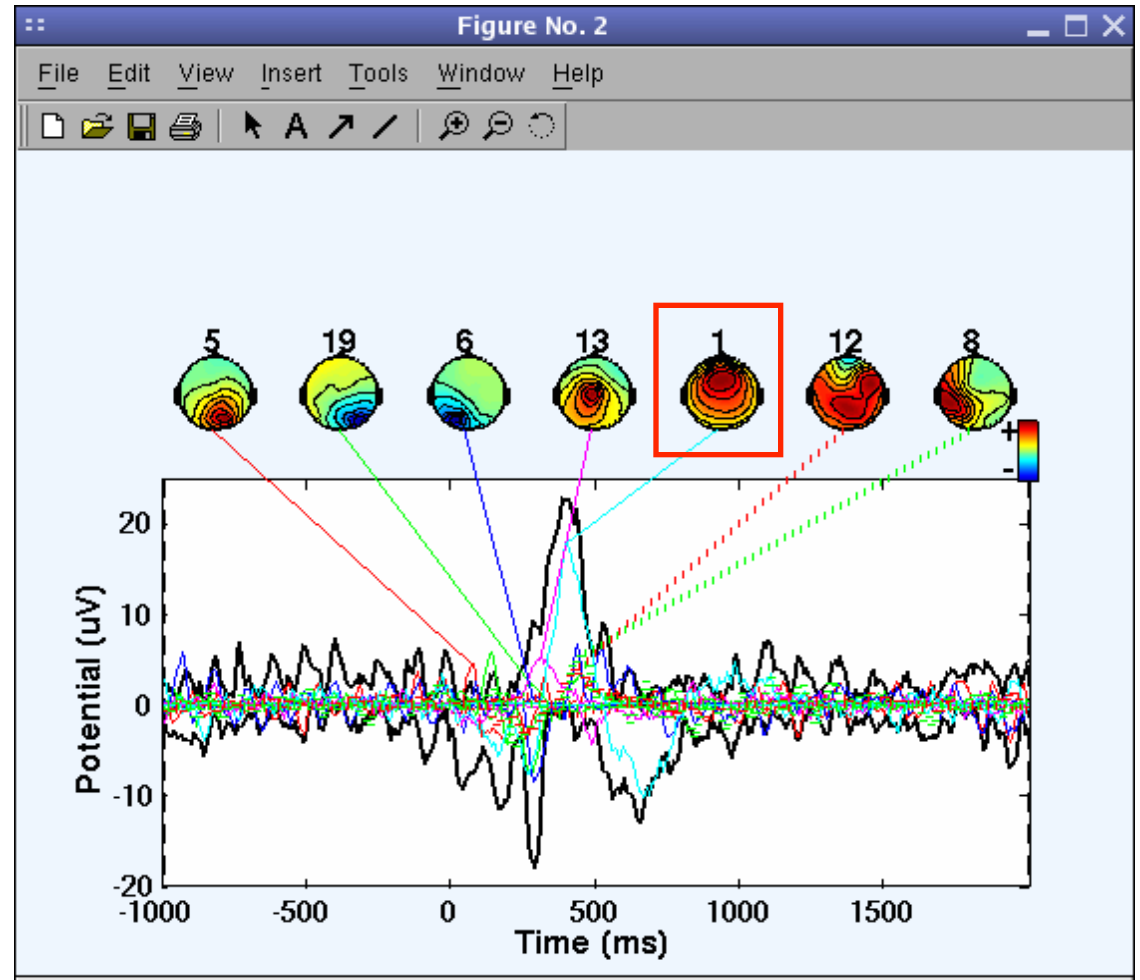
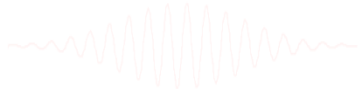
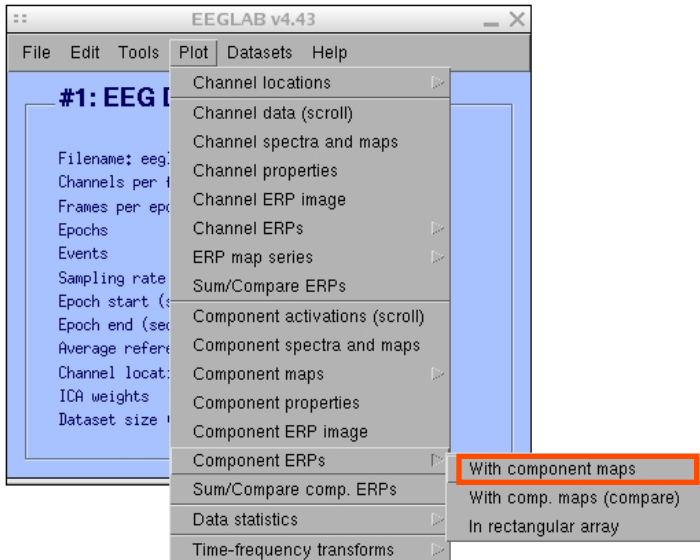
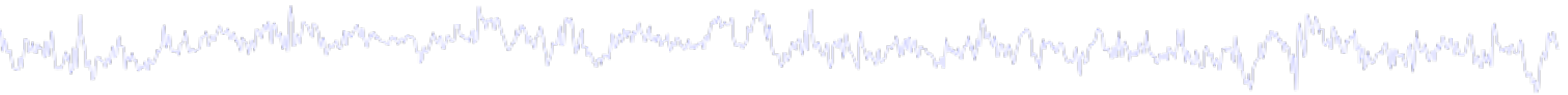
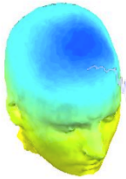
Detailed description: The image shows a software interface for EEG component selection. The main window displays a grid of 30 topographic maps of the scalp, numbered 1 to 30. Map 3 is highlighted with a green border. A 'Component 3 properties' dialog box is open, showing a detailed view of map 3. This dialog includes a topographic map, a heatmap of activity across sorted trials (y-axis 0-60, x-axis -1 to 1 ms), and a power spectrum plot (y-axis 0 to -40 dB, x-axis 0 to 50 Hz). The 'ACCEPT' button in the dialog is circled in red.

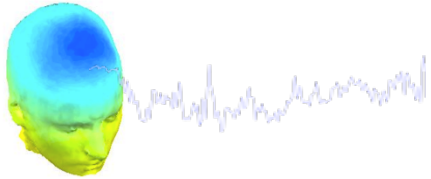
Localizing components



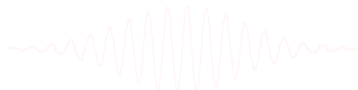
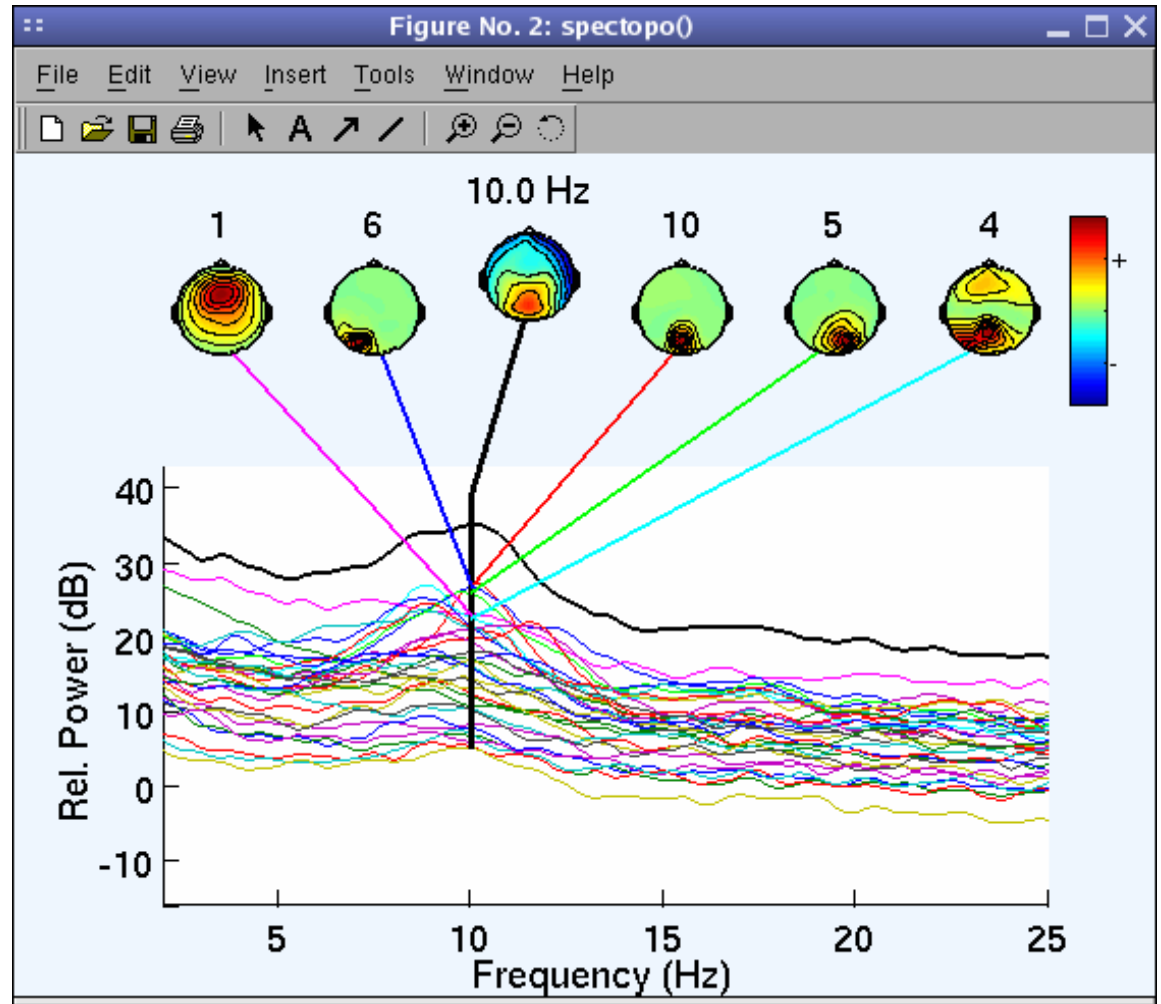
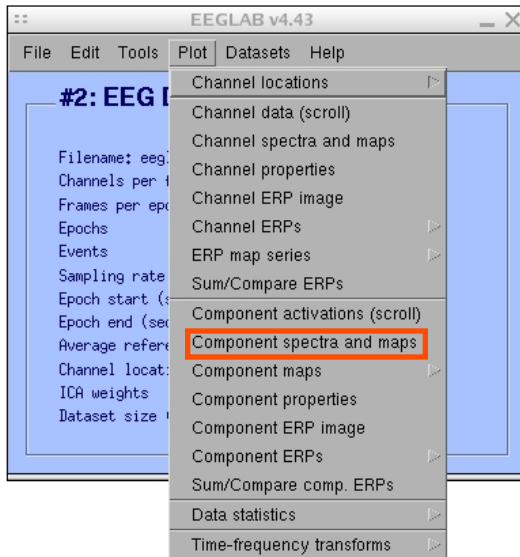


Component contribution to the ERP

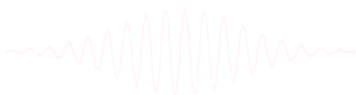
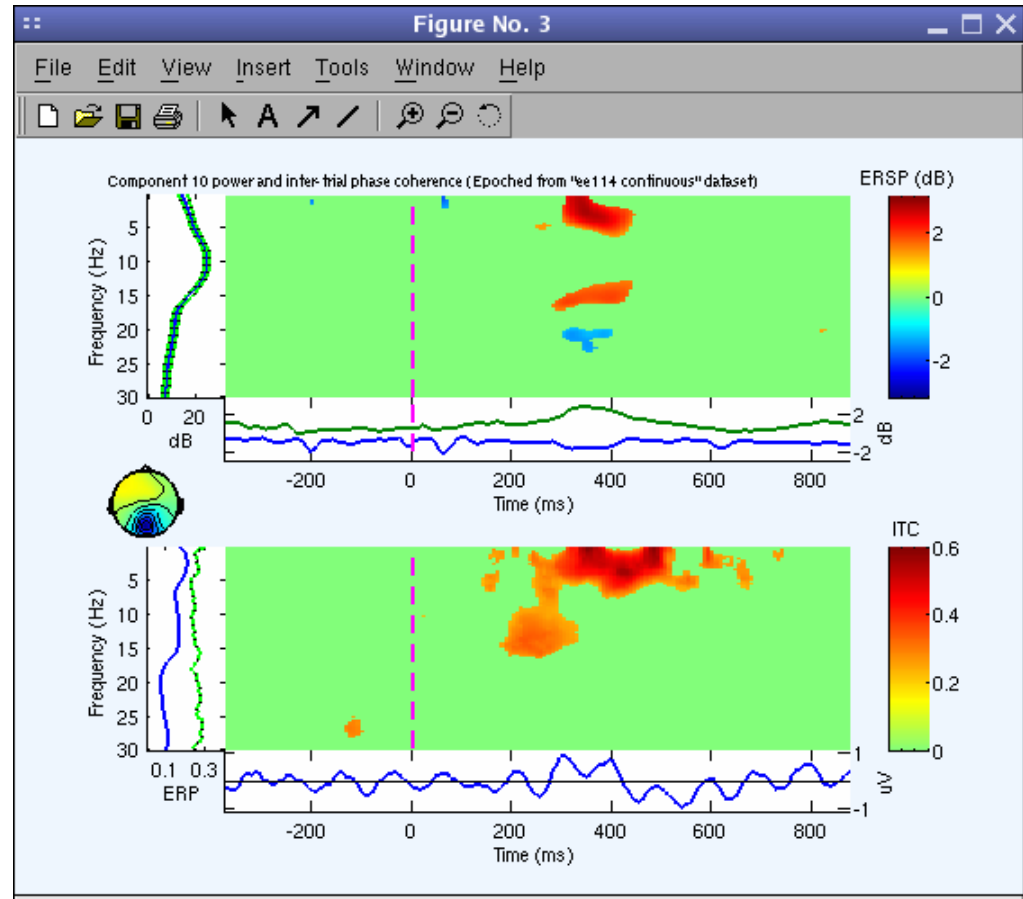
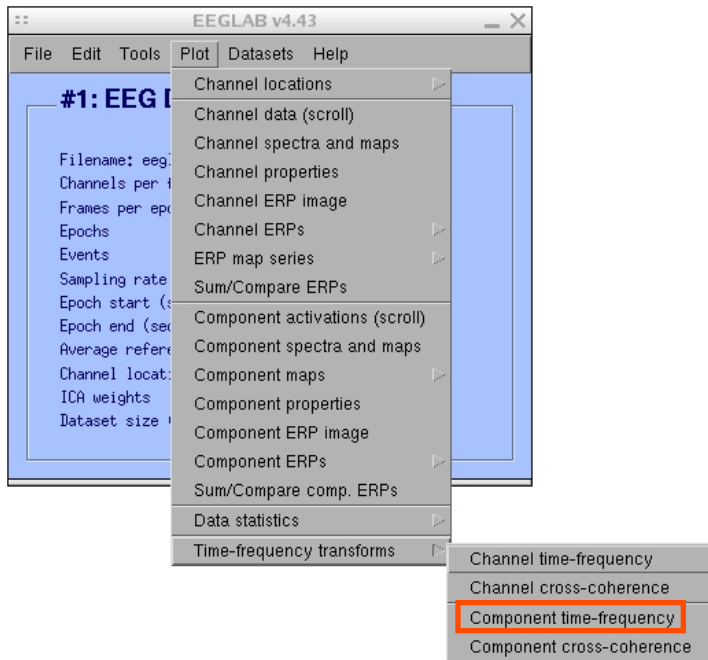
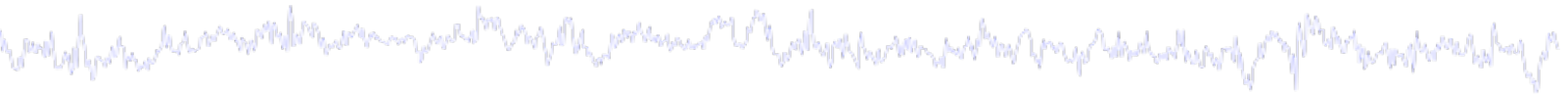
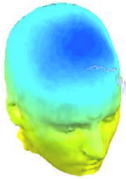




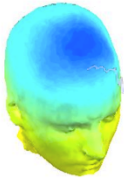
Component contribution to the EEG spectrum



Component time-frequency



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

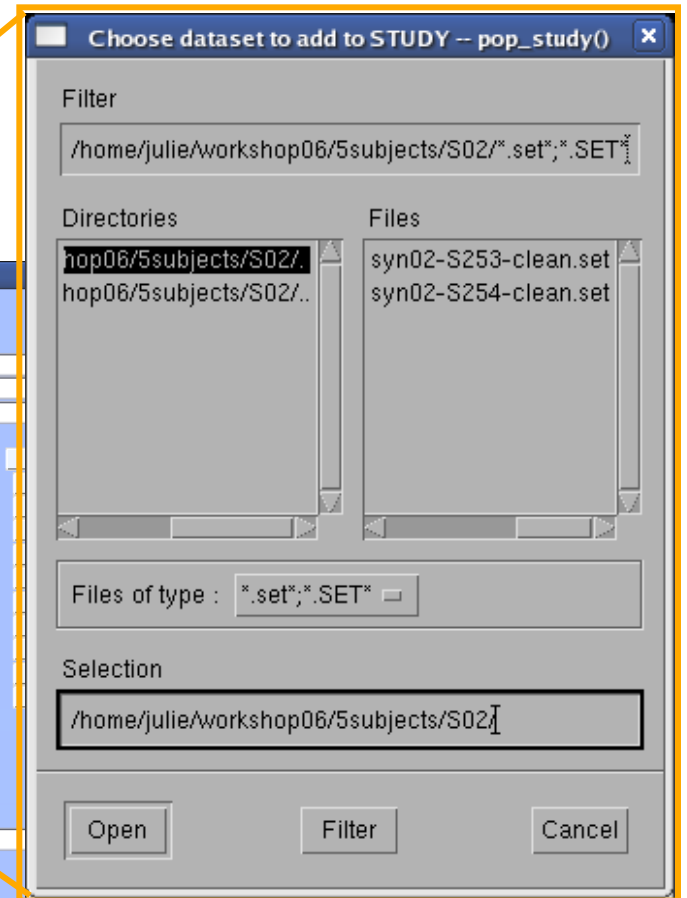
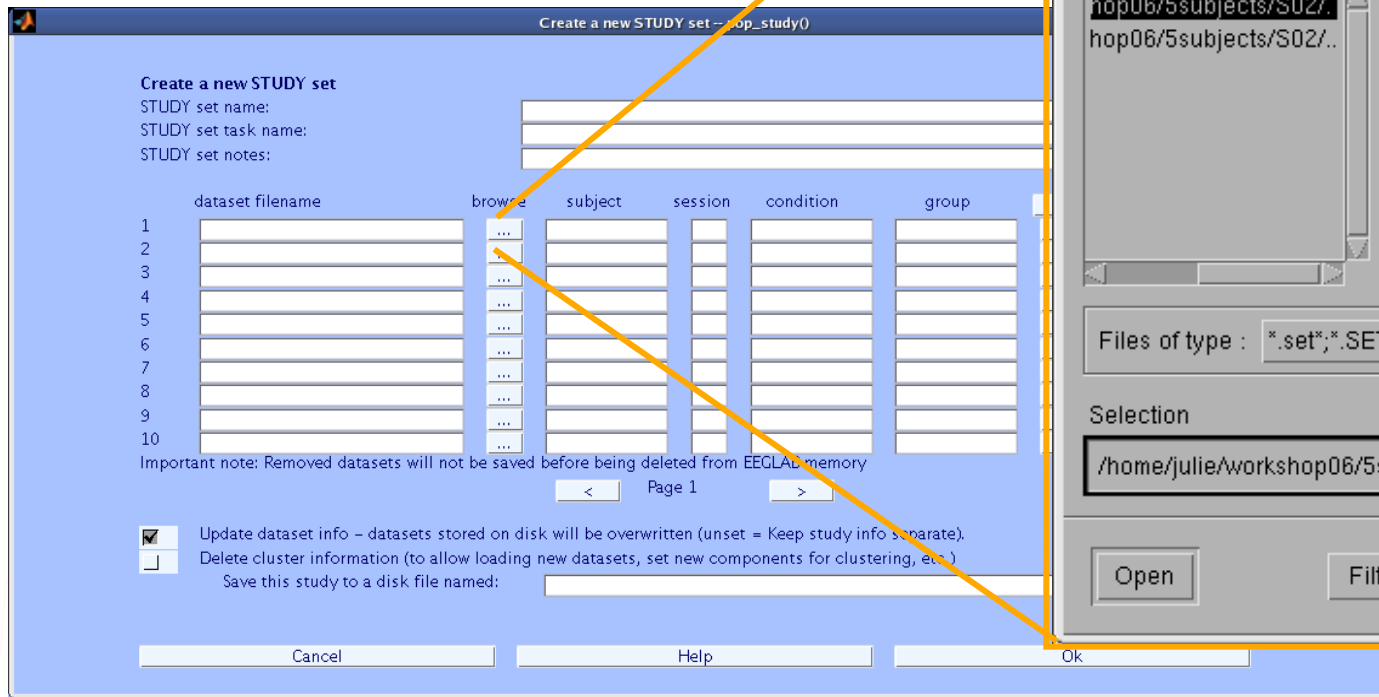
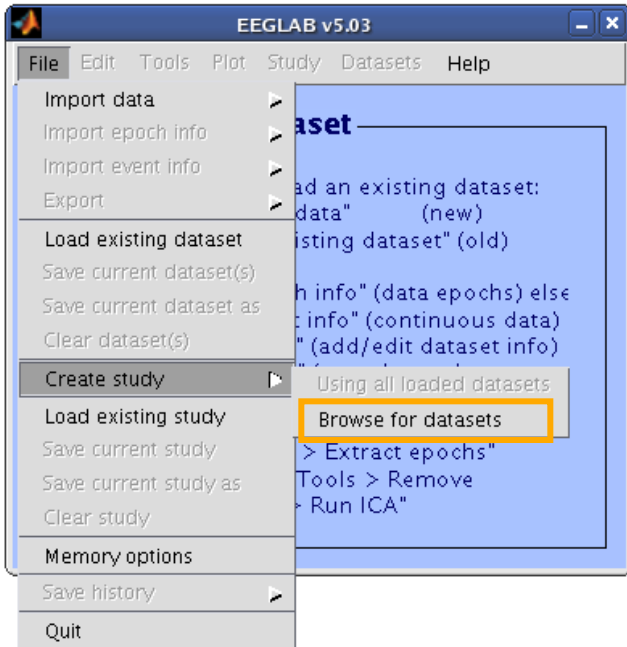
Multi-subjects

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

1. Build a STUDY



EEGLAB v9.0.0.0b

File Edit Tools Plot **Study** Datasets Help

STUDY set:

Study filename: ...s/data
 Study task name
 Nb of subjects
 Nb of conditions
 Nb of sessions
 Nb of groups
 Epoch consistency
 Channels per frame 61
 Channel locations yes
 Clusters 1
 Status Pre-clustered
 Total size (Mb) 8.2

Edit study info
Select/Edit study design(s)
 Precompute channel measures
 Plot channel measures
 Precompute component measures
 Measure Product clustering ▶
 PCA clustering (original) ▶
 Edit/plot clusters

Edit STUDY design



Select STUDY design

STUDY.design 1

Add design
 Rename design
 Delete design

Subjects

S05
 S08

Select all subjects

Independent variable 1

None
 condition
 description
 duration
 type

Ind. var. 1 values

non-synonyms
 synonyms

Combine selected values
 Unpaired statistics

Independent variable 2

None
 condition
 description
 duration
 type

Ind. var. 2 values

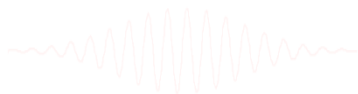
Combine selected values
 Unpaired statistics

Use only specific datasets/trials

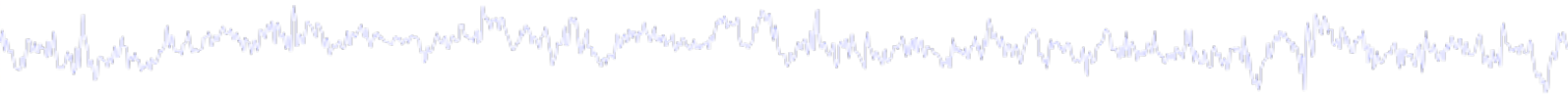
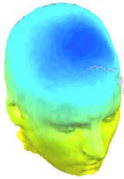
Delete all datafiles associated with this STUDY design

Save the STUDY

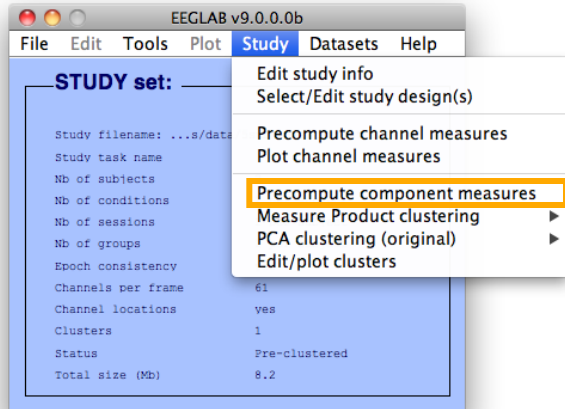
Cancel Ok



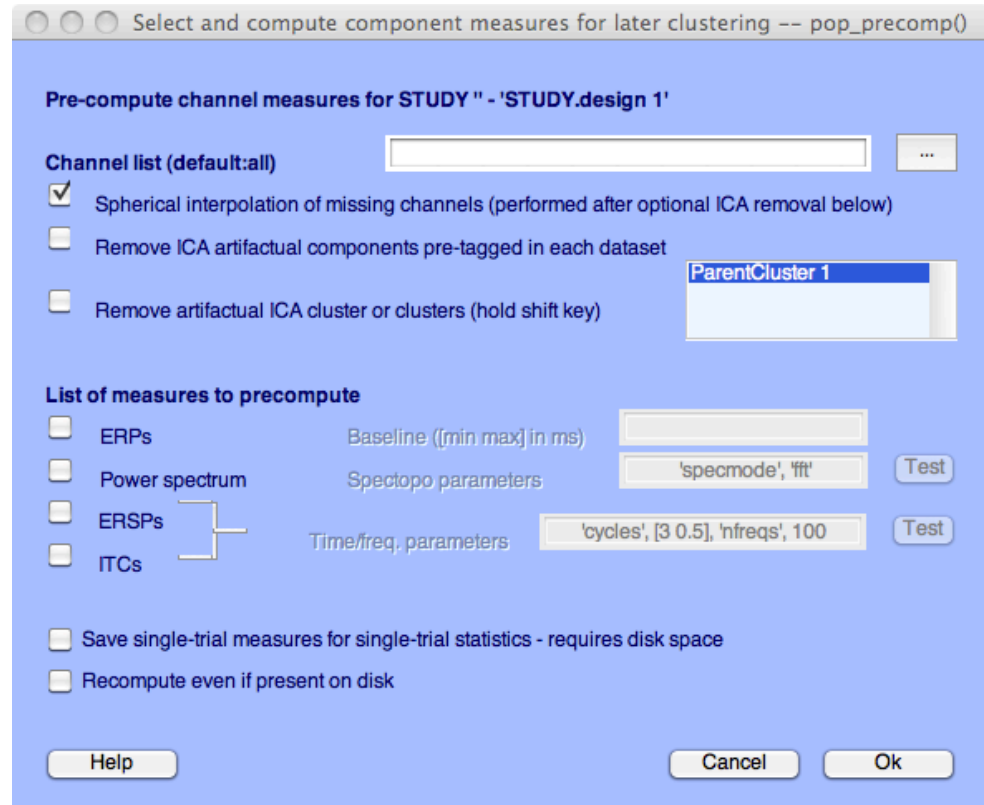
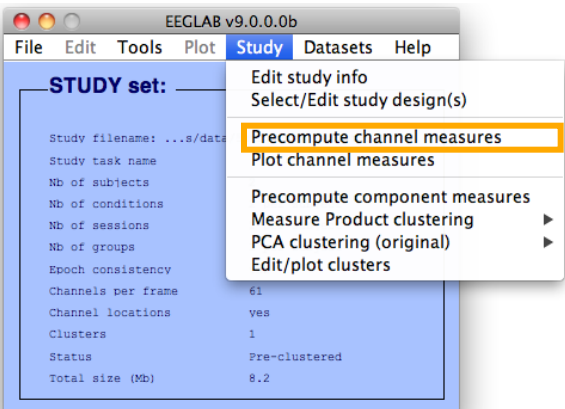
2. Pre-compute measures



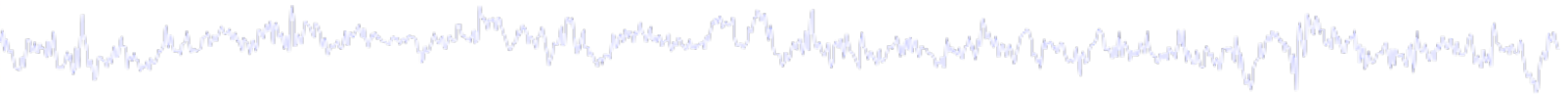
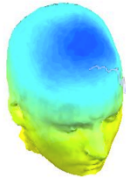
Components



Channels



3. Cluster components



EEGLAB v6.0b

File Edit Tools Plot **Study** Datasets Help

STUDY set: At

Study filename:
Study task name
Nb of subjects
Nb of conditions
Nb of sessions
Nb of groups
Epoch consistency yes
Channels per frame 31
Channel locations yes
Clusters 1
Status Pre-clustered
Total size (Mb) 32.4

- Edit study info
- Precompute channel measures
- Plot channel measures
- Precompute component measures
- Build preclustering array**
- 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)

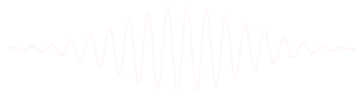
ParentCluster 1 (181 ICs)

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

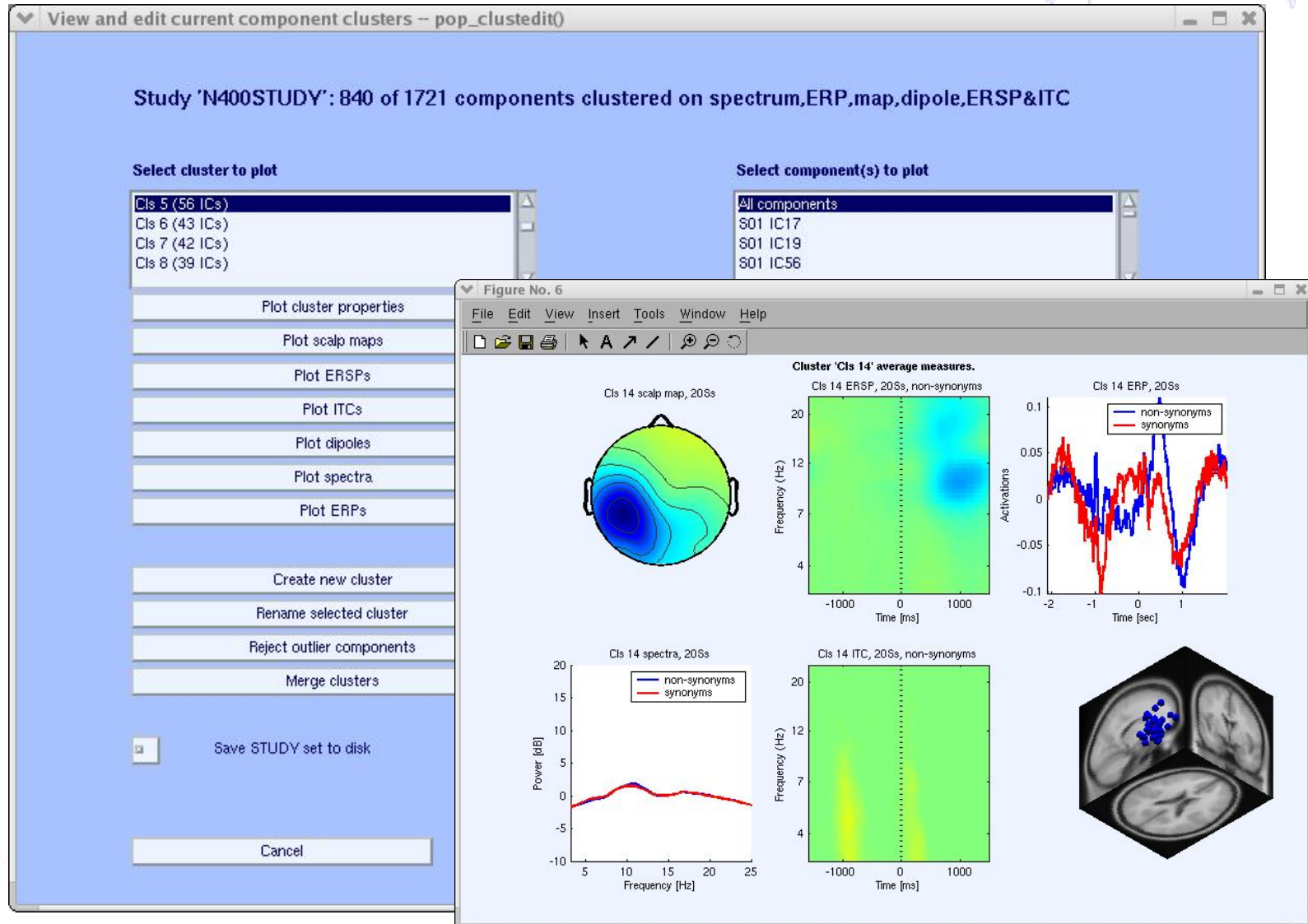
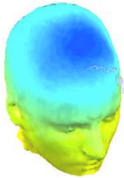
Load	Dims.	Norm.	Rel. Wt.	
<input checked="" type="checkbox"/> spectra	10	<input checked="" type="checkbox"/>	1	Freq. range [Hz] 3 25
<input checked="" type="checkbox"/> ERPs	10	<input checked="" type="checkbox"/>	1	Time range [ms] 0 600
<input checked="" type="checkbox"/> dipoles	3	<input checked="" 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 Freq. range [Hz] 3 45
<input checked="" type="checkbox"/> ITCs	10	<input checked="" type="checkbox"/>	1	Time range [ms] 0 600 Freq. range [Hz] 2 30
<input type="checkbox"/> Final dimensions	10			

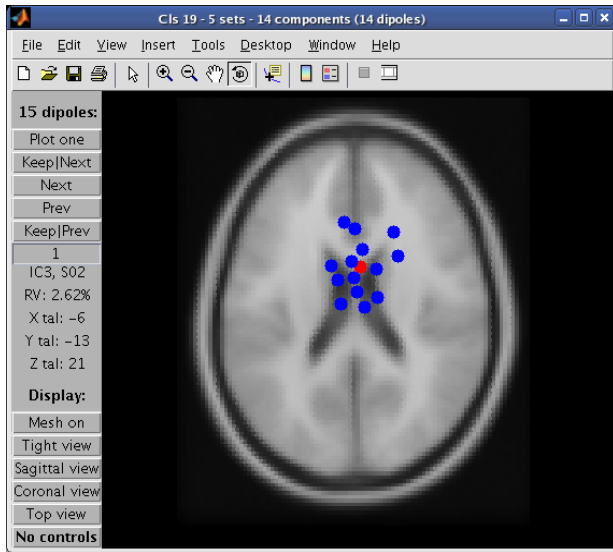
Save STUDY to file /home/julie/WorkshopSD2007/STUDY/attention.study ...

Cancel Help Ok



4. Analyze clusters

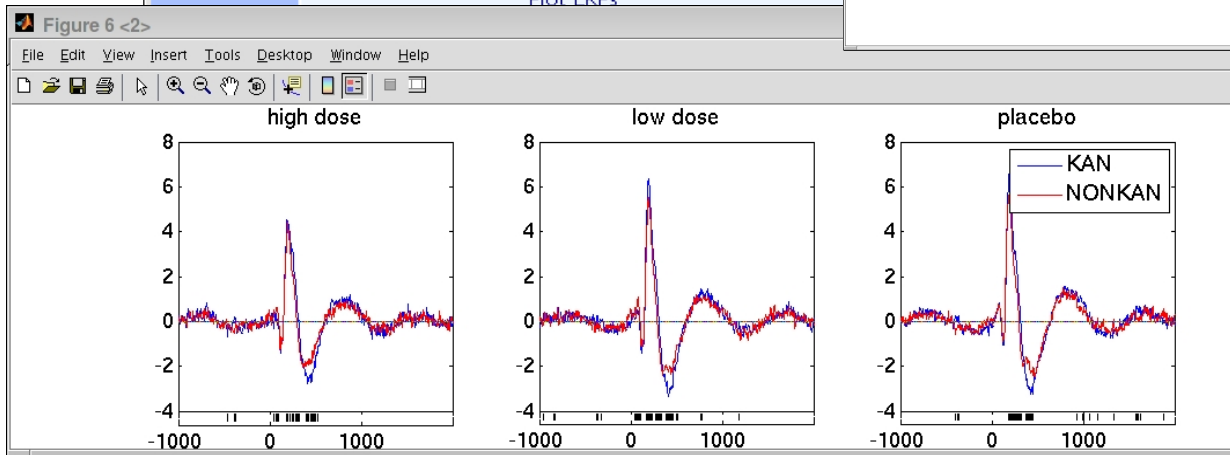
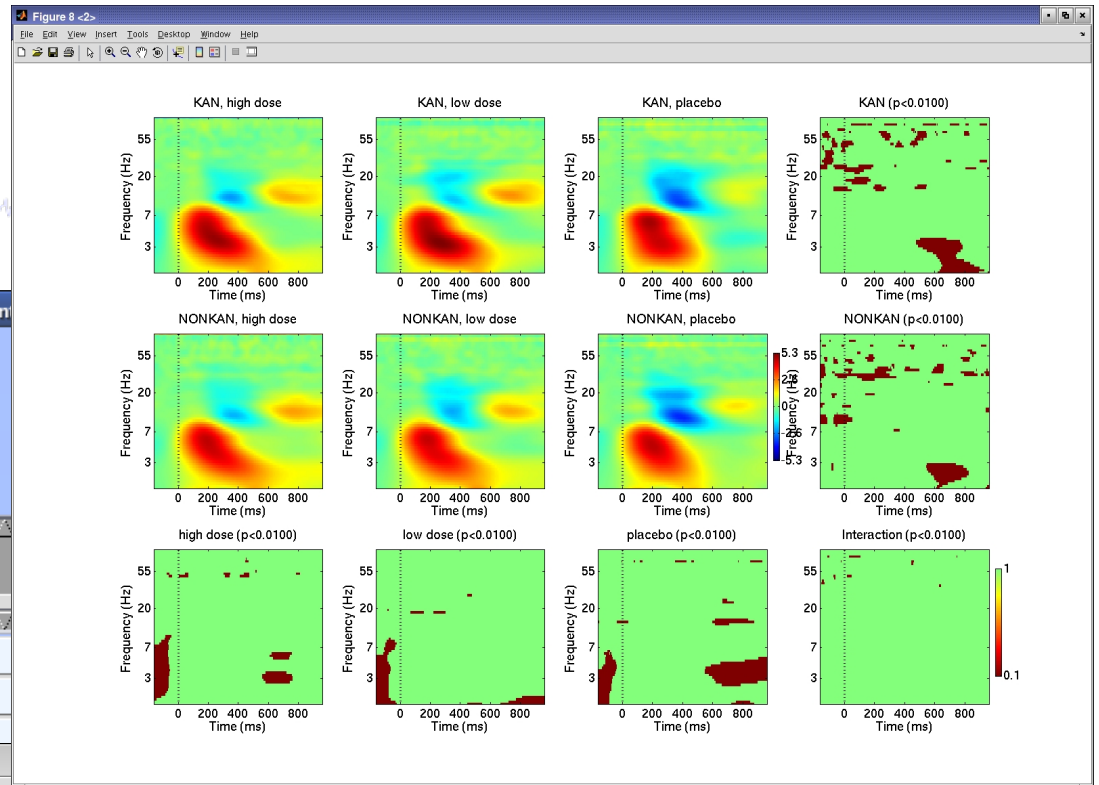




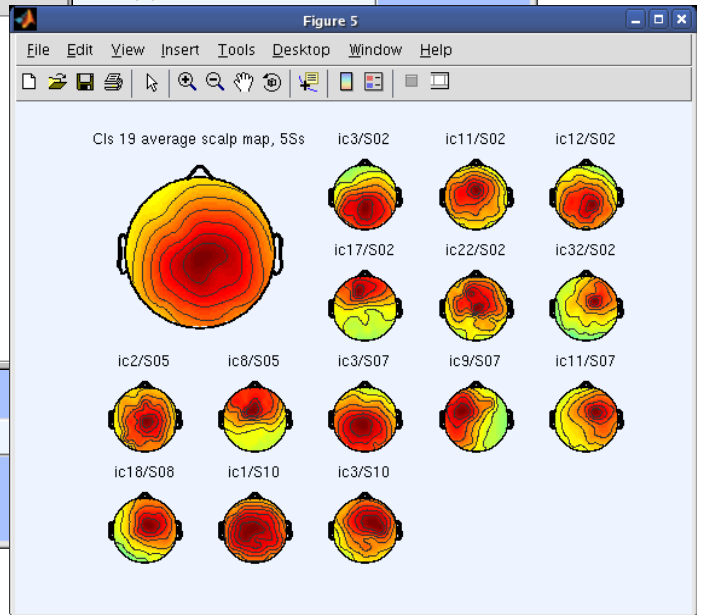
View and edit current
nts clustered

Cls 17 (S02)
Cls 18 (14 ICs)
Cls 19 (14 ICs)
Outliers Cls 17 20 (1 ICs)

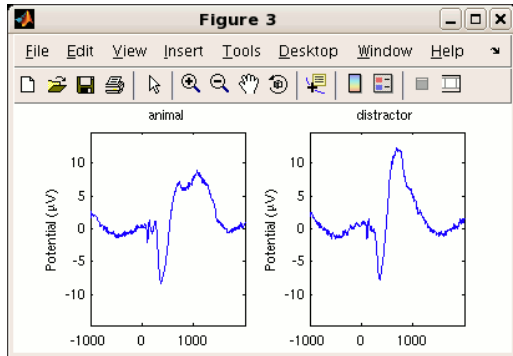
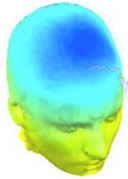
Plot scalp maps
Plot dipoles
Plot FRPs



Cancel Help



Channel plotting



View and edit current channels -- pop_chanplot()

Study "

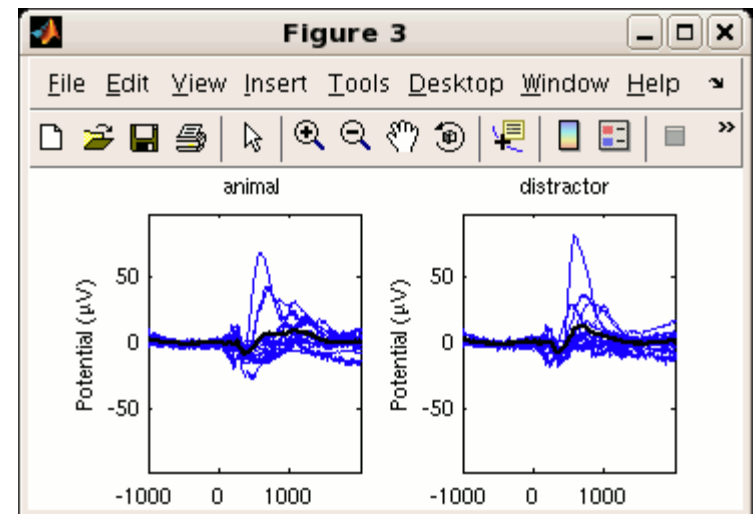
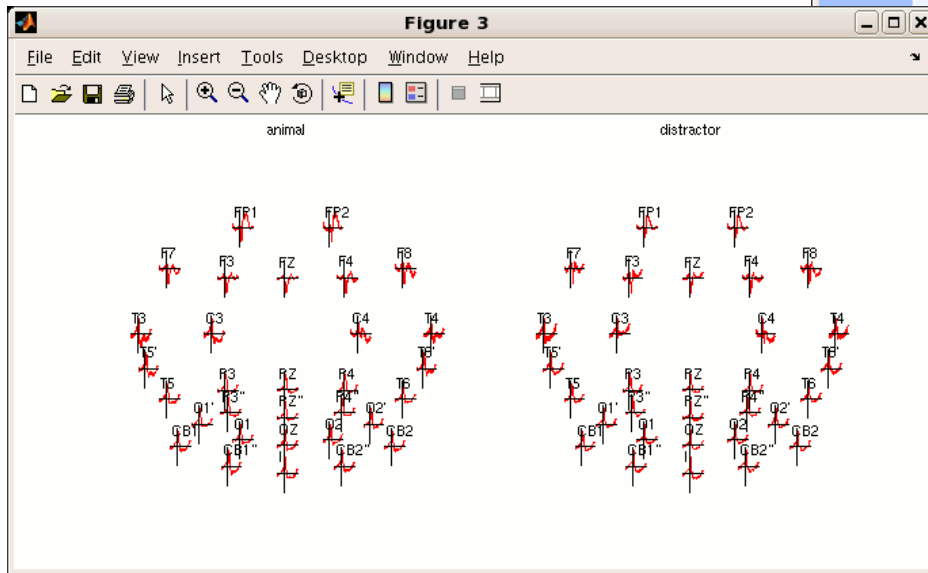
Select channel to plot

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

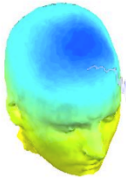
Select subject(s) to plot

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

Save STUDY set to disk



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:'ee114squareepochs.set'
filepath:'/home/arno/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:[8x150 char]
averef:'no'
rt:[]
eventdescription:{1x5 cell}
epochdescription:{}
specdata:[]
specicaact:[]
reject:[1x1 struct]
stats:[1x1 struct]
splinefile:[]
ref:'common'
history:[7x138 char]
urevent:[1x154 struct]
times:[1x384 double]
    
```

Number of data points per trial

Number of channels

Number of trials

Sampling rate

Time limits

Data

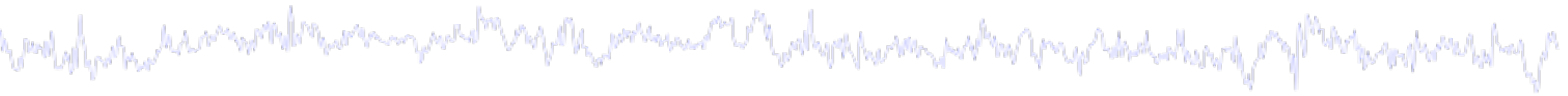
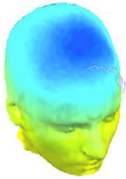
ICA scalp maps

ICA activity

Epoch/event information

Channel location

3 levels of functions



Administrative functions: handle EEG and ALLEEG structures

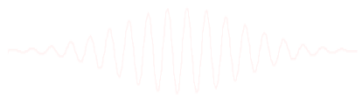
`eeglab()`, `eeg_checkset()`, `pop_delset()`, ...

Pop functions: interactive functions using EEG structure

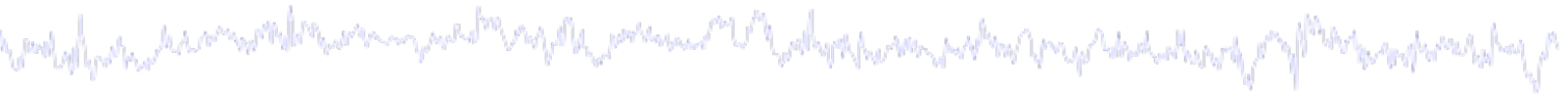
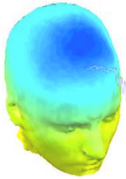
`pop_erpimage()`, `pop_topoplot()`, `pop_envtopo()`, ...

Signal processing functions: perform signal processing

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

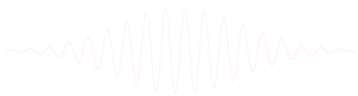


Command line tools

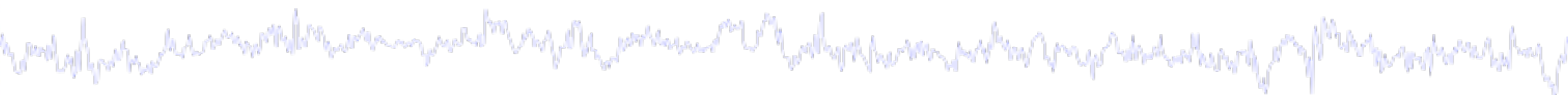
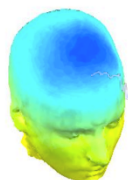


(Menus write both dataset and global history)

- Automated processing on groups of subjects (possibly on several processors).
- Richer options for plotting and processing functions (time-frequency decompositions, ...)
- Selecting data/epoch based on event context
- Custom processing...

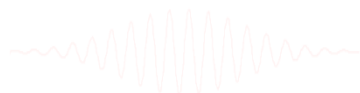


Current and future directions

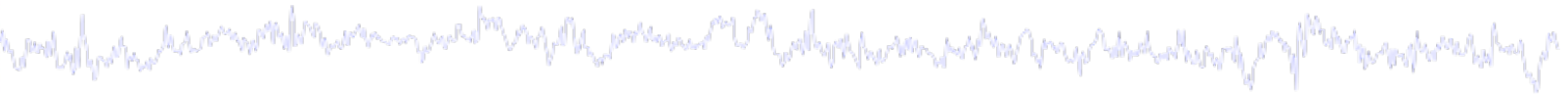
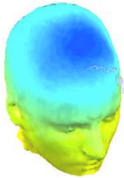


- Source localization (NFT – Zeynep Akalin)
- Connectivity toolbox (Tim Mullen)
- Analysis of large studies and parallel processing
- Study design
- Multi-modality imaging

- Improved memory mapping features
- Improved plug-in facility and script library
- Shared data resource (HEAD-IT)
- Open source community development (SVN server)

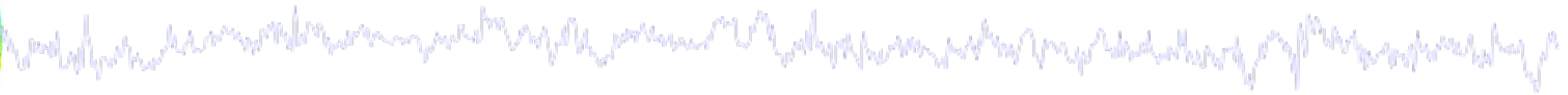
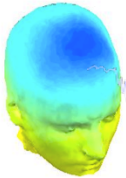


Workshop program



September 9 (Thursday)	
Time	Agenda
09:00~11:00	Workshop 1 : EEGLAB methods I <ul style="list-style-type: none">■ Klaus Gramann- Data import and channel analysis■ Julie Onton - Artifact rejection and running ICA■ Julie Onton - Evaluating ICA components Part 1
11:00~11:10	Break
11:10~12:30	Workshop 2 : EEGLAB methods I <ul style="list-style-type: none">■ Arnaud Delorme - Time-frequency decompositions■ Julie Onton - Using EEGLAB history for basic scripting
12:30-13:30	Lunch
13:30~15:10	Workshop 3 : EEGLAB methods II <ul style="list-style-type: none">■ Tzyy-Ping Jung - ICA theory and applications■ Julie Onton - Evaluating ICA components Part 2
15:10~15:20	Tea Break
15:20~16:30	Workshop 4 : EEGLAB methods II <ul style="list-style-type: none">■ Scott Makeig - Inverse models■ Arnaud Delorme - Dipole modeling with DIPFIT plugin
16:30~18:00	Group research

Workshop program



September 10 (Fri.)	
Time	Agenda
09:00~11:00	Workshop 5 : EEGLAB methods III <ul style="list-style-type: none">■ Scott Makeig - IC clustering and introduction to the STUDY■ Julie Onton - Build an EEGLAB STUDY■ Arnaud Delorme - Bootstrap statistics
11:00~11:10	Tea Break
11:10~12:30	Workshop 6 : EEGLAB methods IV <ul style="list-style-type: none">■ Arnaud Delorme - Plot and edit STUDY clusters from menu■ Julie Onton - STUDY analysis part I
12:30-13:30	Lunch
13:30~15:20	Workshop 7 : EEGLAB methods V <ul style="list-style-type: none">■ Julie Onton - STUDY analysis part II■ Arnaud Delorme - Extending EEGLAB with plug-ins
15:20~17:00	Group research continued
17:00~18:00	Group research reports and discussion

First EEGLAB Workshop

University of California San Diego
La Jolla, California,
Oct. 28-30, 2004
following the Society for
Neuroscience meeting
in San Diego



Workshops

Third EEGLAB Workshop
Singapore, Nov. 15-18, 2006



Second EEGLAB Workshop

Porto, Portugal, Sept. 17-19, 2004
preceeding the SPR meeting in Lisbon



Fourth EEGLAB Workshop

Aspet (pyrénées), France, June 26-29, 2007



....

11th EEGLAB Workshop

NCTU, Taiwan, Sept. 8-10, 2010