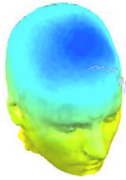
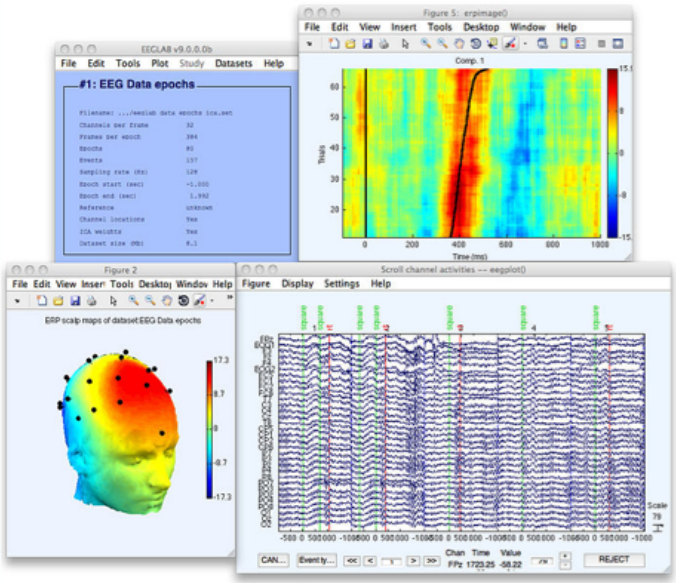
EEGLAB overview

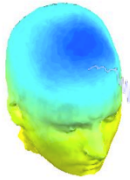


- Collection of over 300 functions (70000 lines of code)
- About 70 000 download over the past 8 years
- About 3500 users on the discussion list and 8500 on the diffusion list
- NIH funding since 2003



http://sccn.ucsd.edu/eeglab
http://sccn.ucsd.edu/wiki/eeglab
http://sccn.ucsd.edu/wiki/Workshop

EEGLAB standard processing pipeline



Single subject

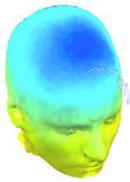
1. Import binary data, events and channel location
2. Edit, Re-reference, Resample, High pass filter data
3. Reject artifacts in continuous data by visual inspection
4. Extract epochs from data & reject artifactual epochs
5. Visualize data measures
6. Perform ICA decomposition
   - Perform source localization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

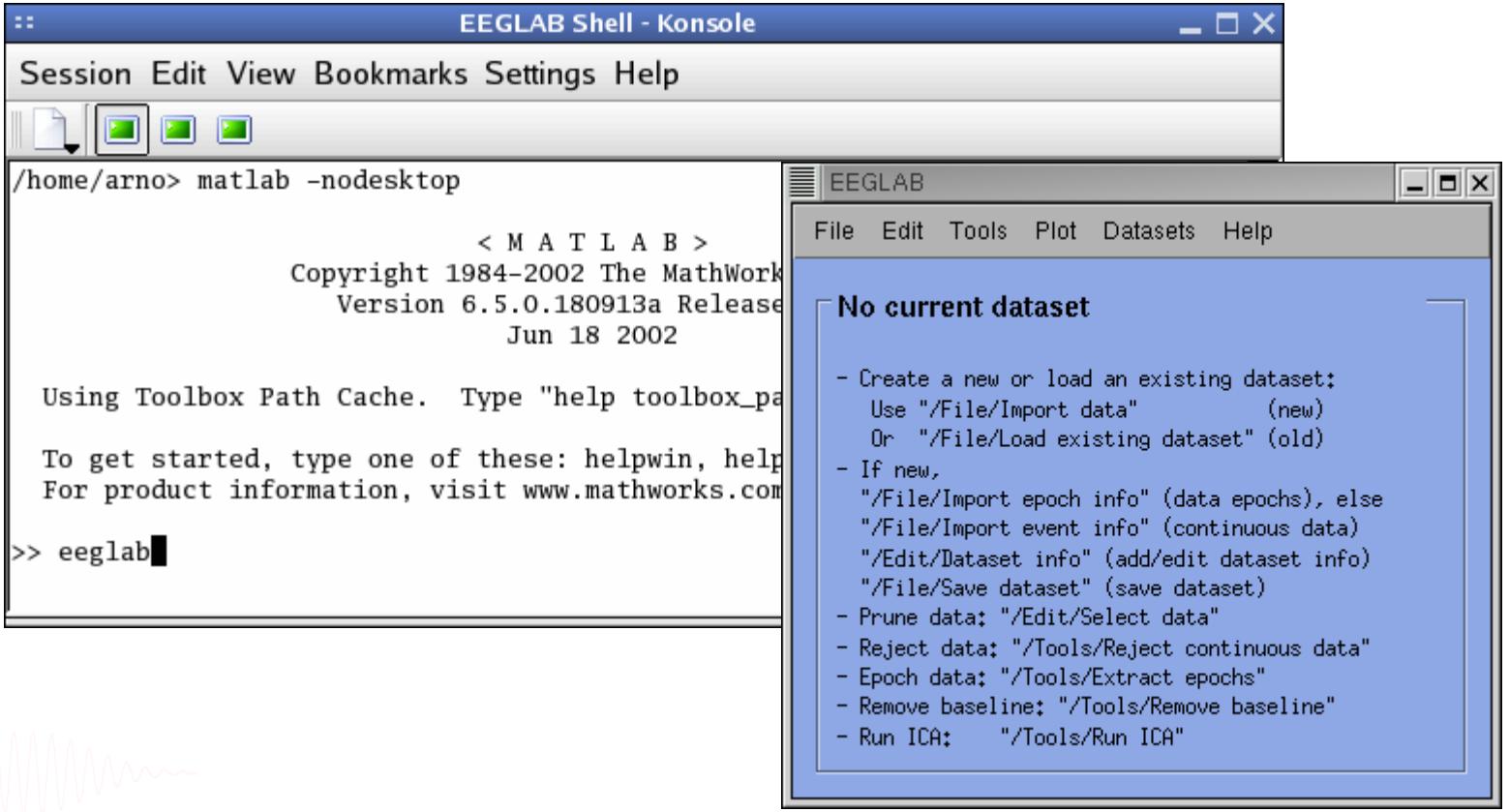
Multi-subjects

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

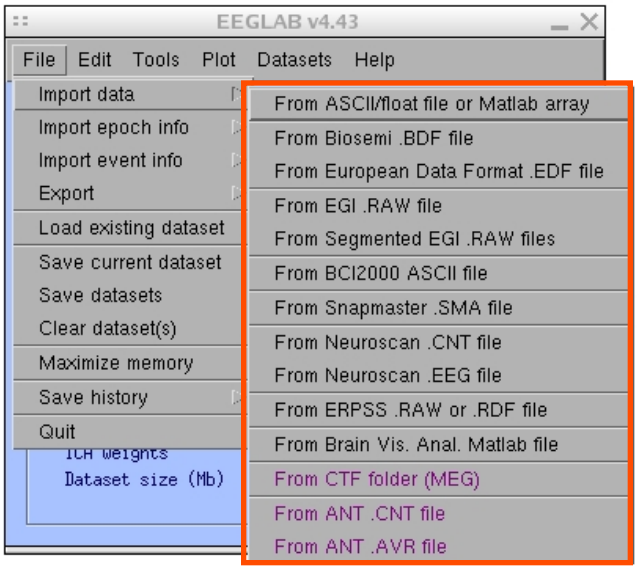
The EEGLAB Matlab software



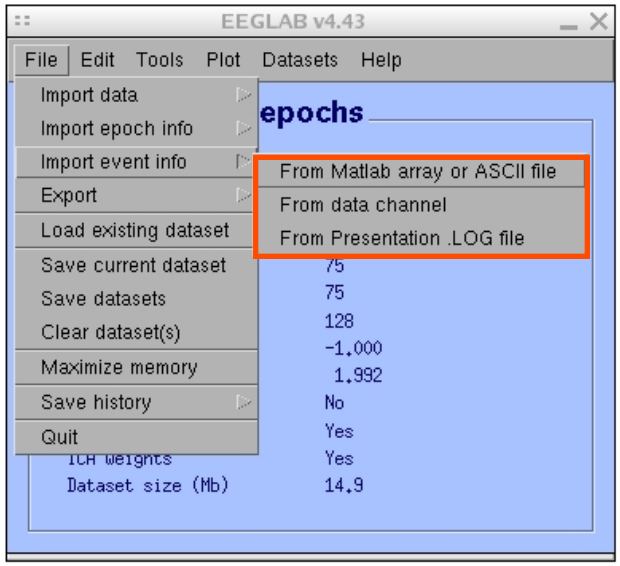


1. Importing data

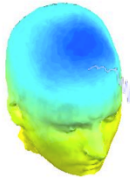
Import/load data



Import events



1. Importing data



Data info

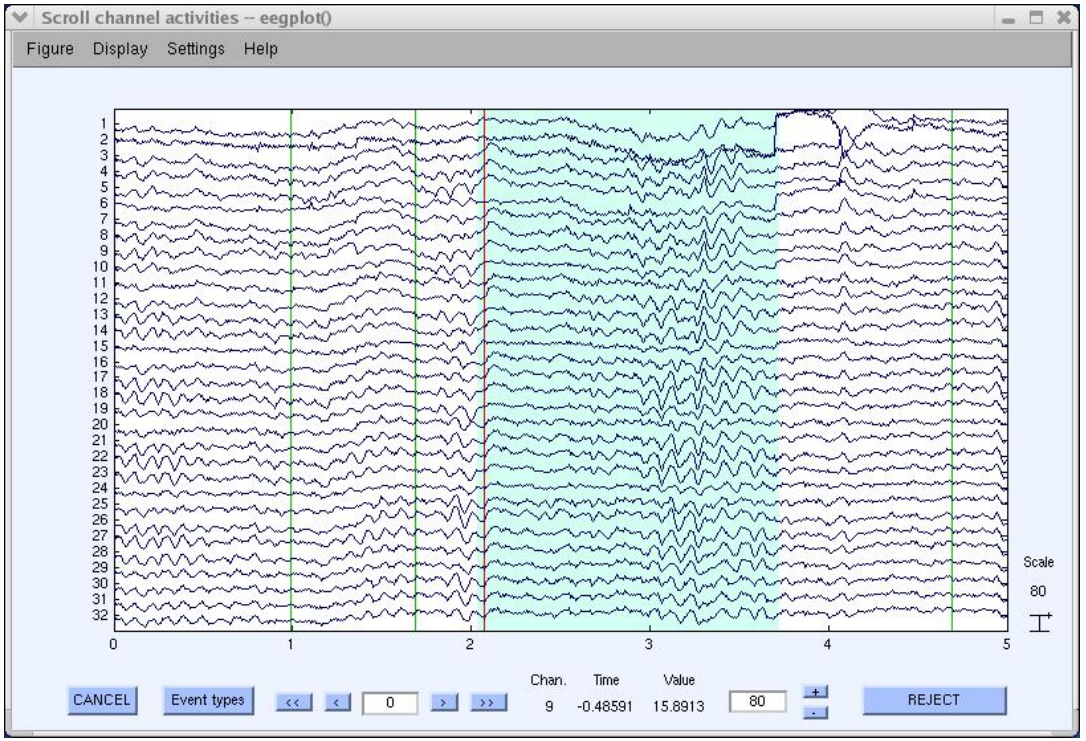
EEGLAB v4.0

File Edit Tools Plot Datasets Help DTU Sidekick

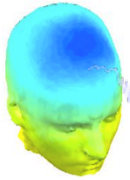
#1: Continuous EEG Data

Filename:	eeglab_data.set
Channels per frame	32
Frames per epoch	30504
Epochs	1
Events	154
Sampling rate (Hz)	128
Epoch start (sec)	0.000
Epoch end (sec)	238.305
Average reference	No
Channel locations	No
ICA weights	No
Dataset size (Mb)	7.9

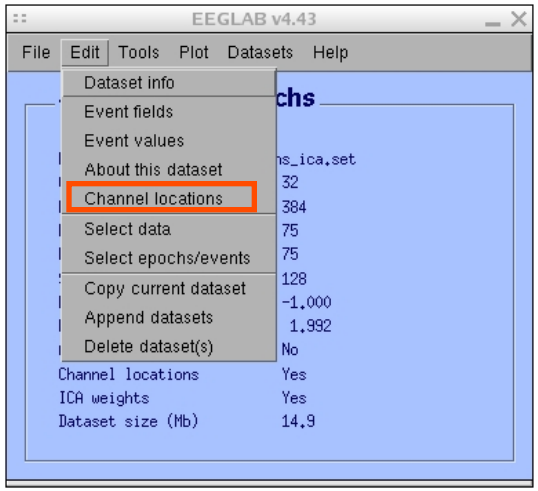
Scrolling data

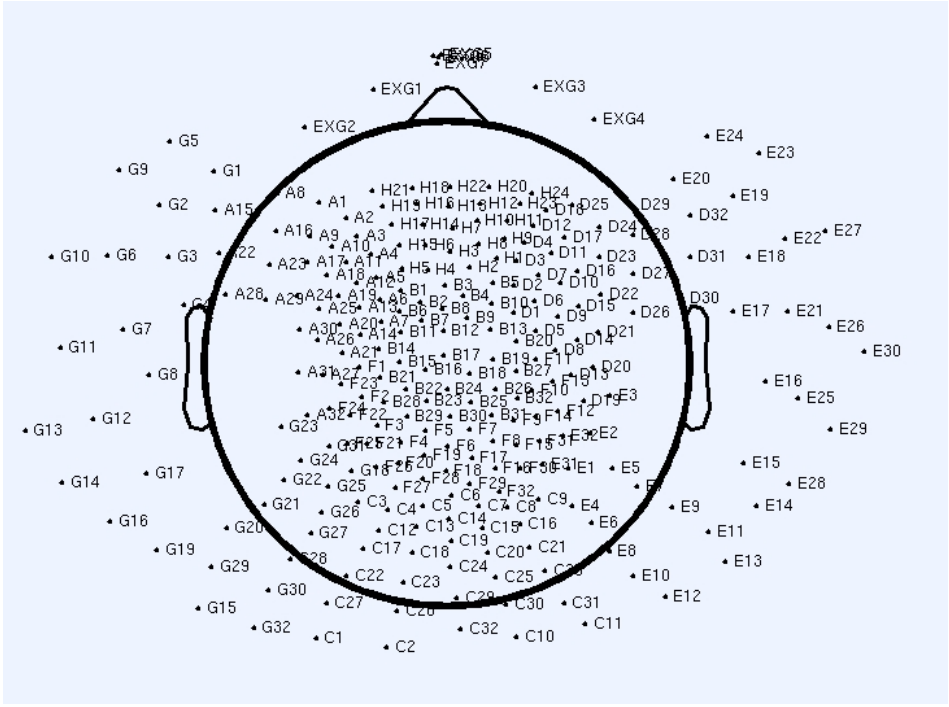


1. Importing channel location

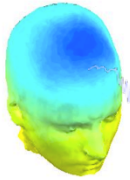


Import channel location

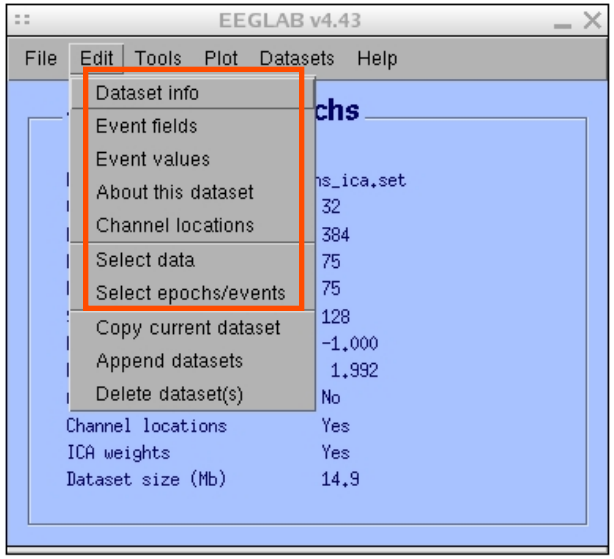




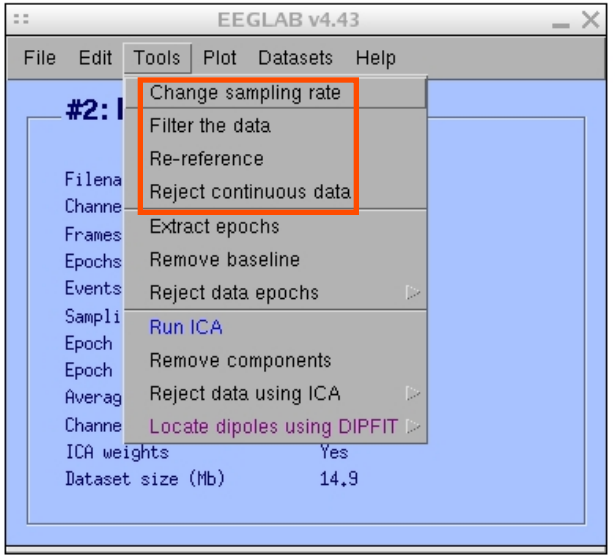
2. Edit, Re-reference, Resample, High pass filter data



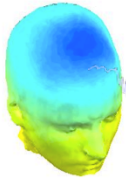
Edit/select data



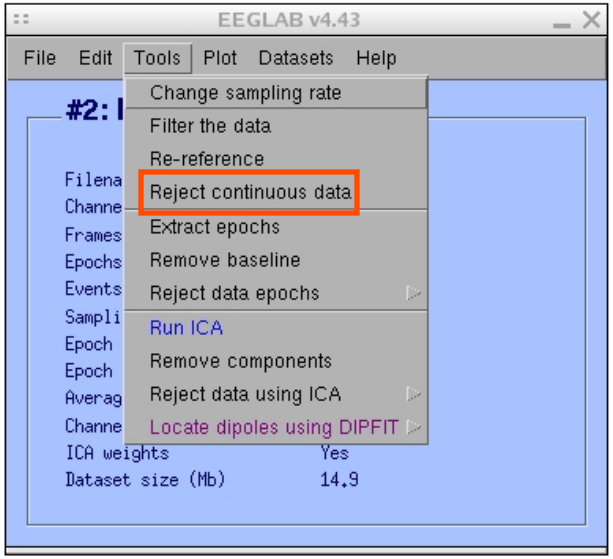
Preprocessing data



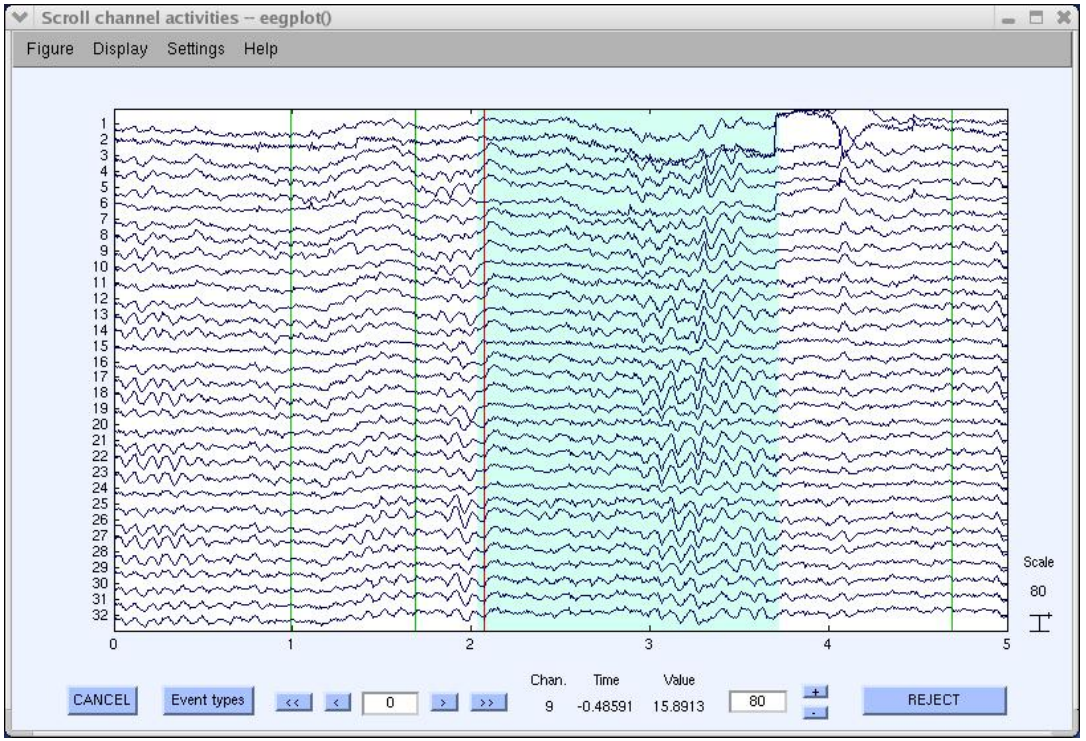
3. Reject artifacts in continuous data by visual inspection



Data info

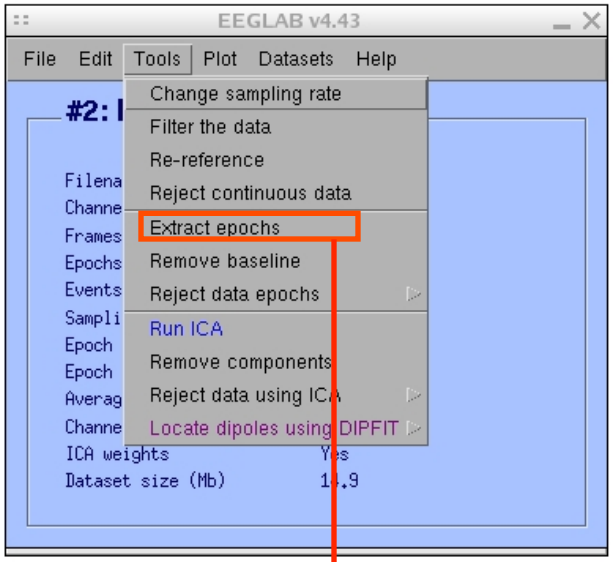


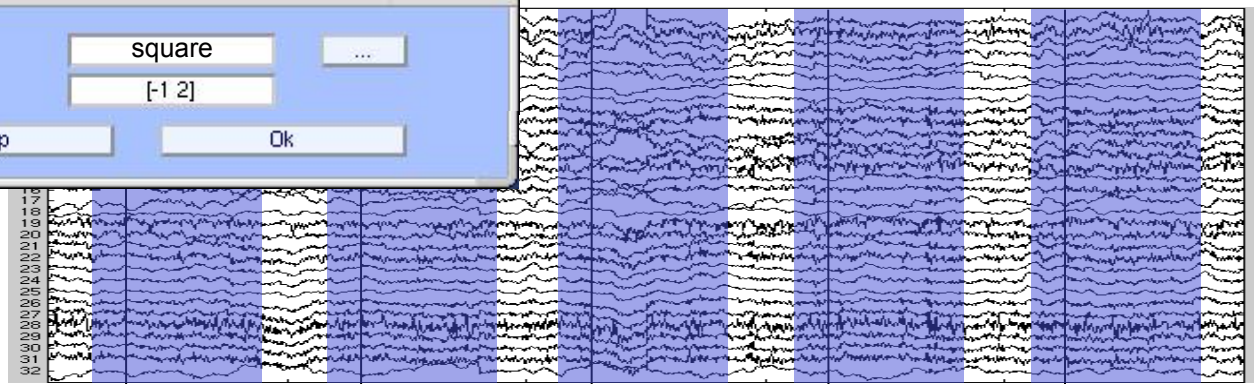
Reject portions of continuous data



4. Extract epochs from data & reject artifactual epochs

Preprocessing data





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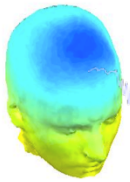
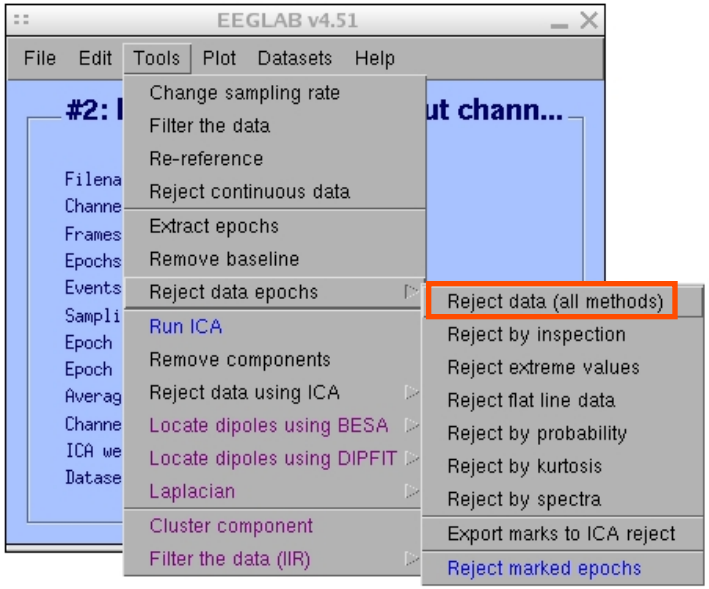
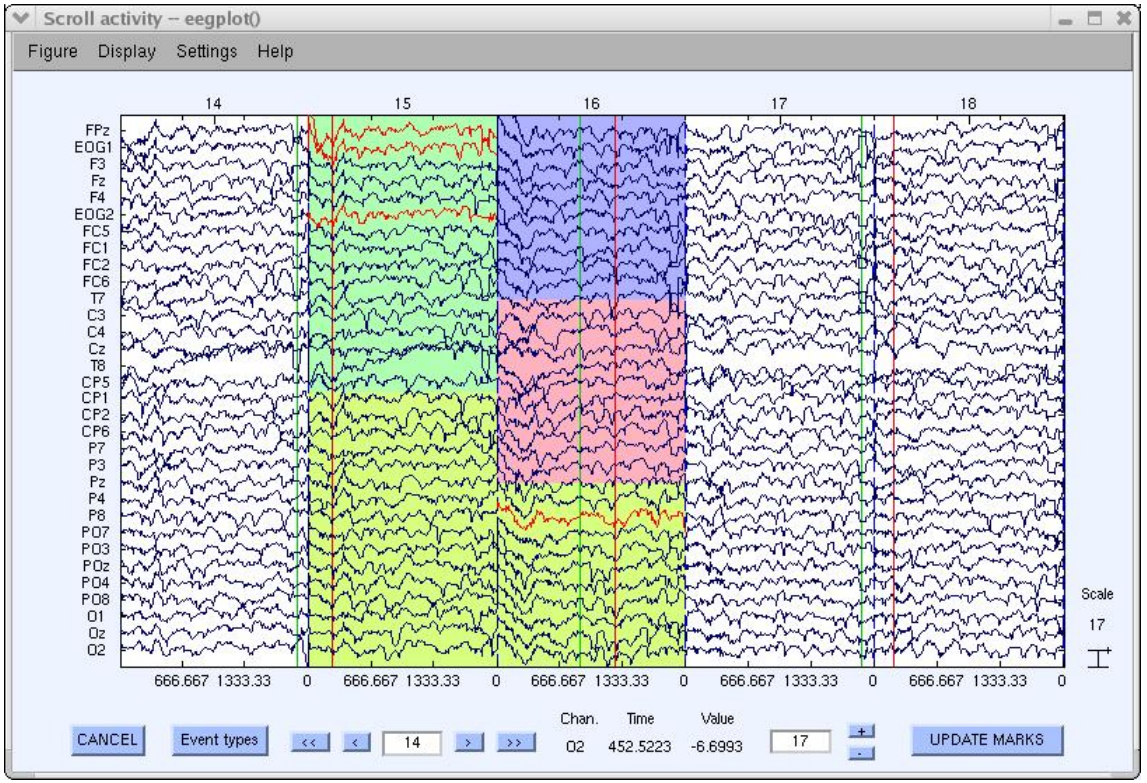
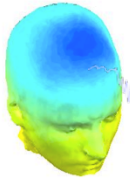




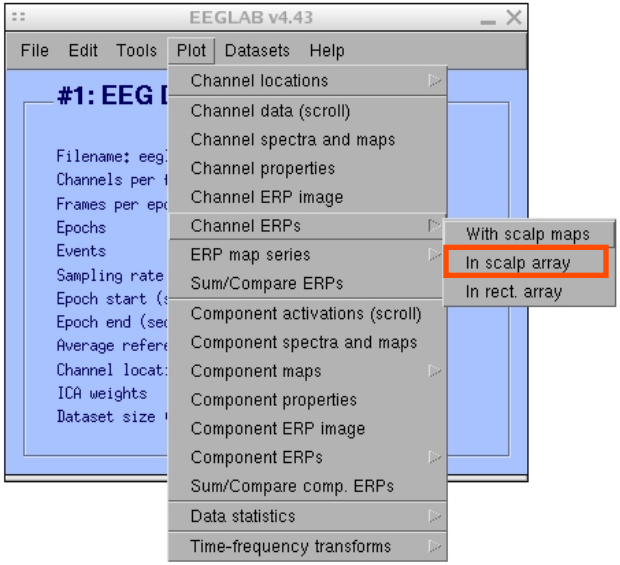
Different color = different rejection methods

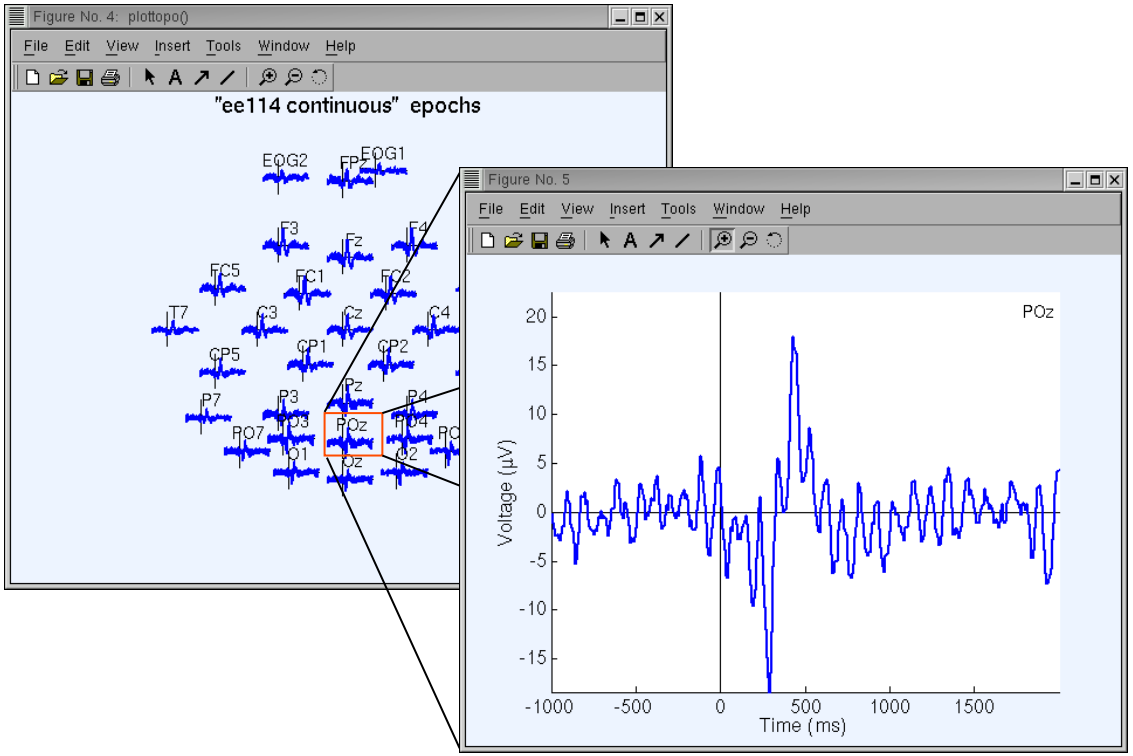


5. Visualize data measures



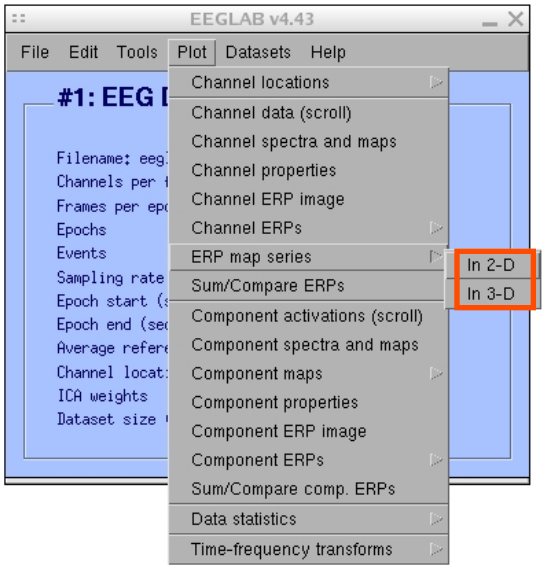
Plot ERP

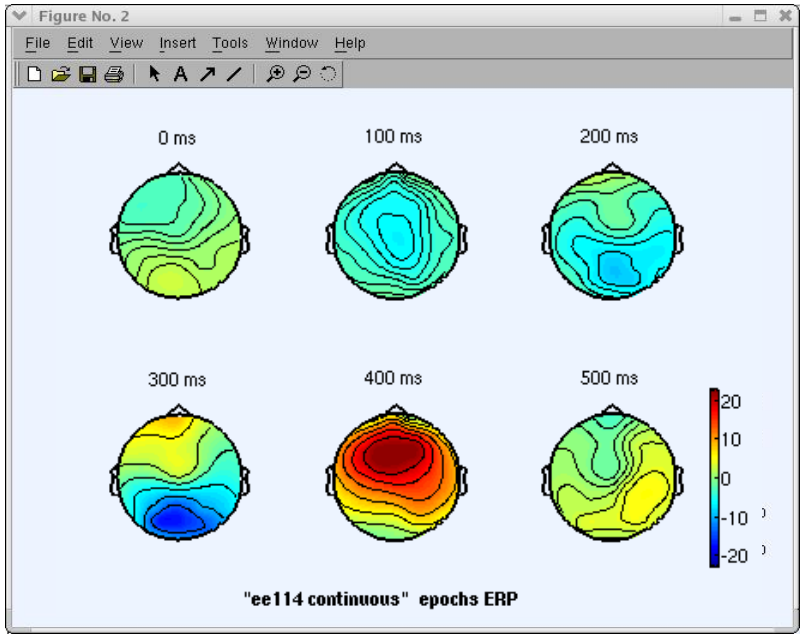


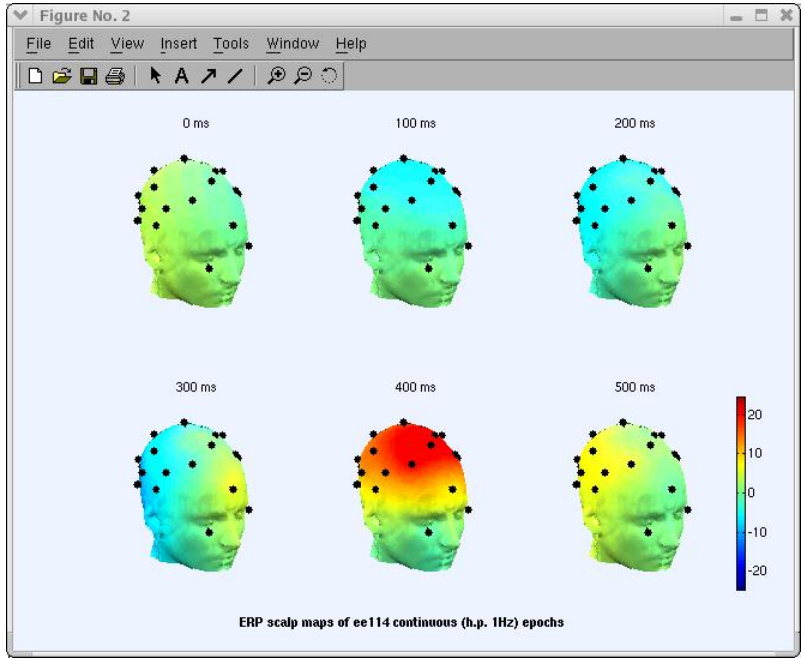


5. Visualize data measures

Plot ERP
map series







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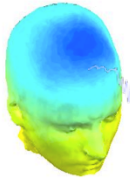
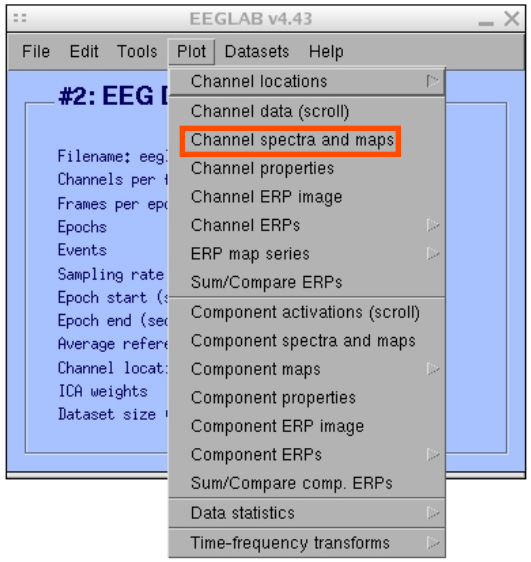
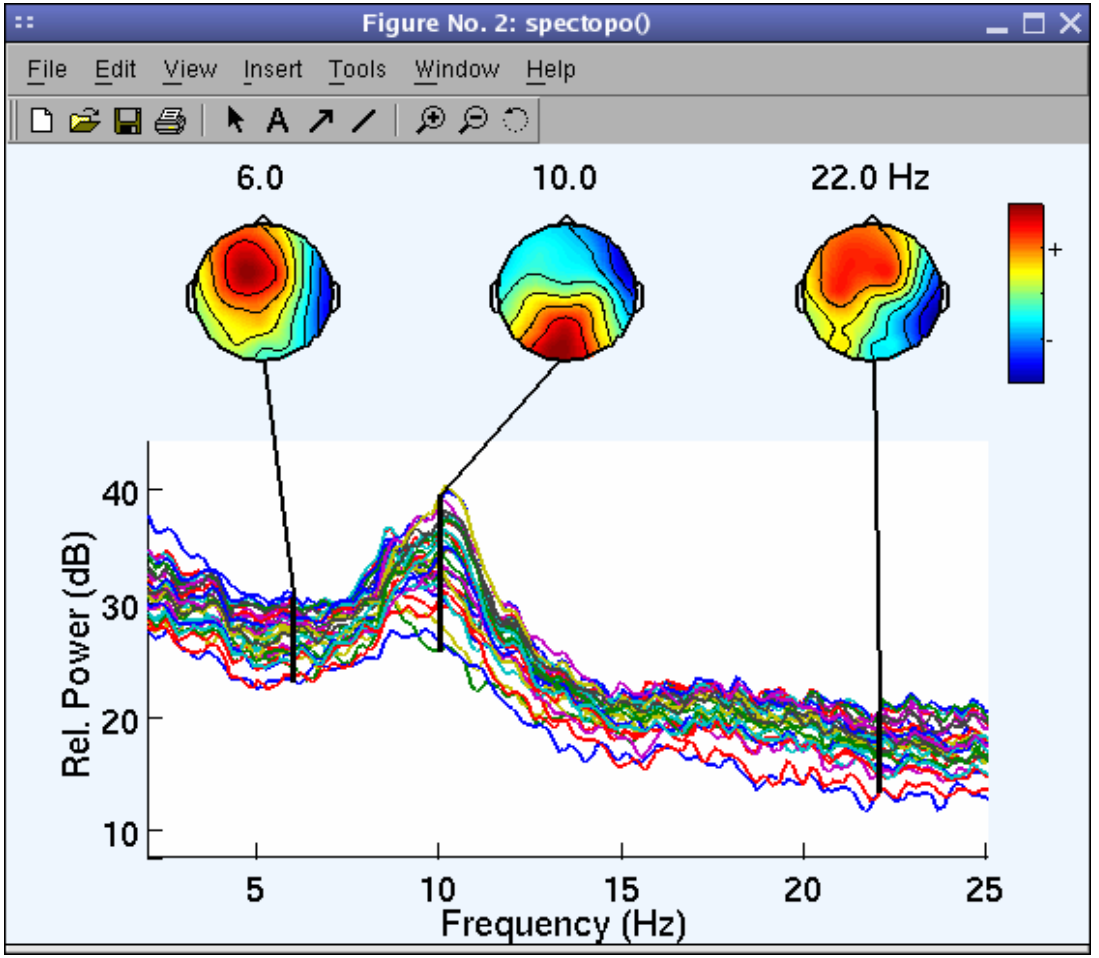


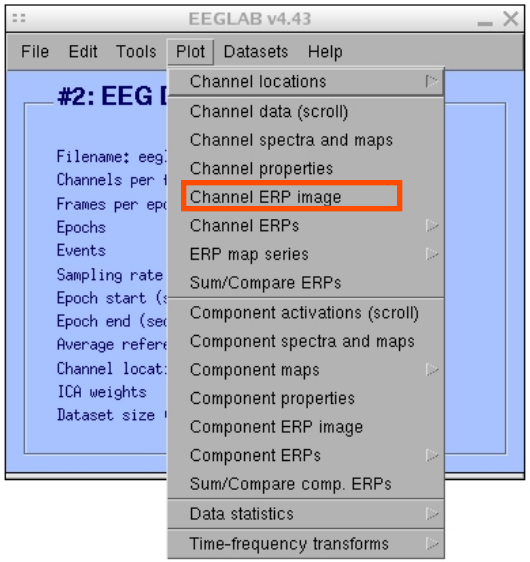
Plot data spectrum and maps

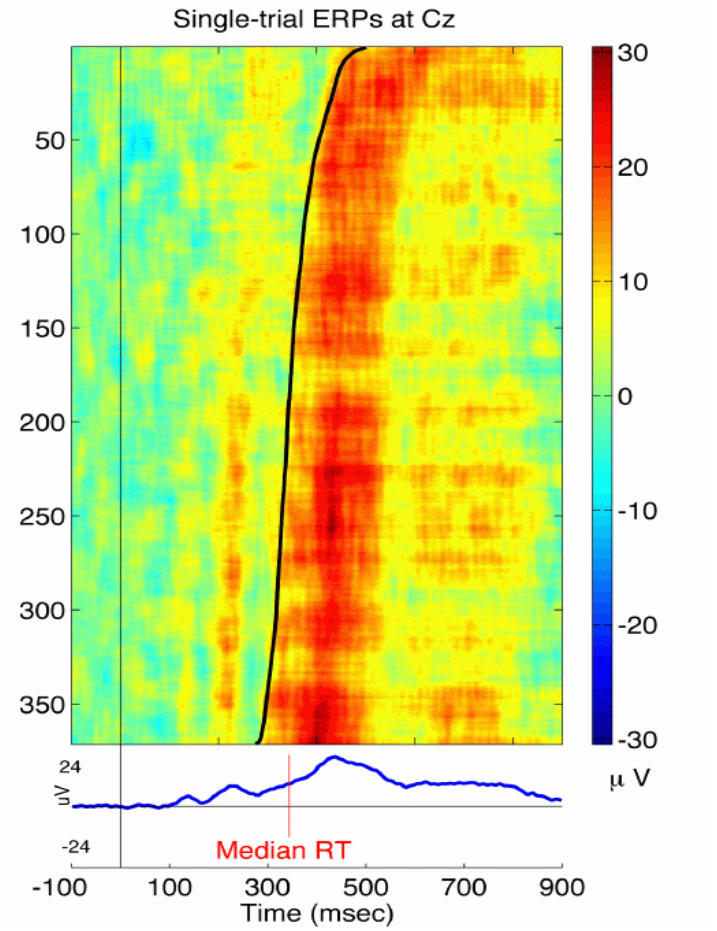




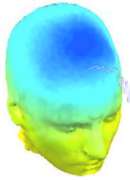
5. Visualize data measures

Plot channel ERPimage





EEGLAB standard processing pipeline



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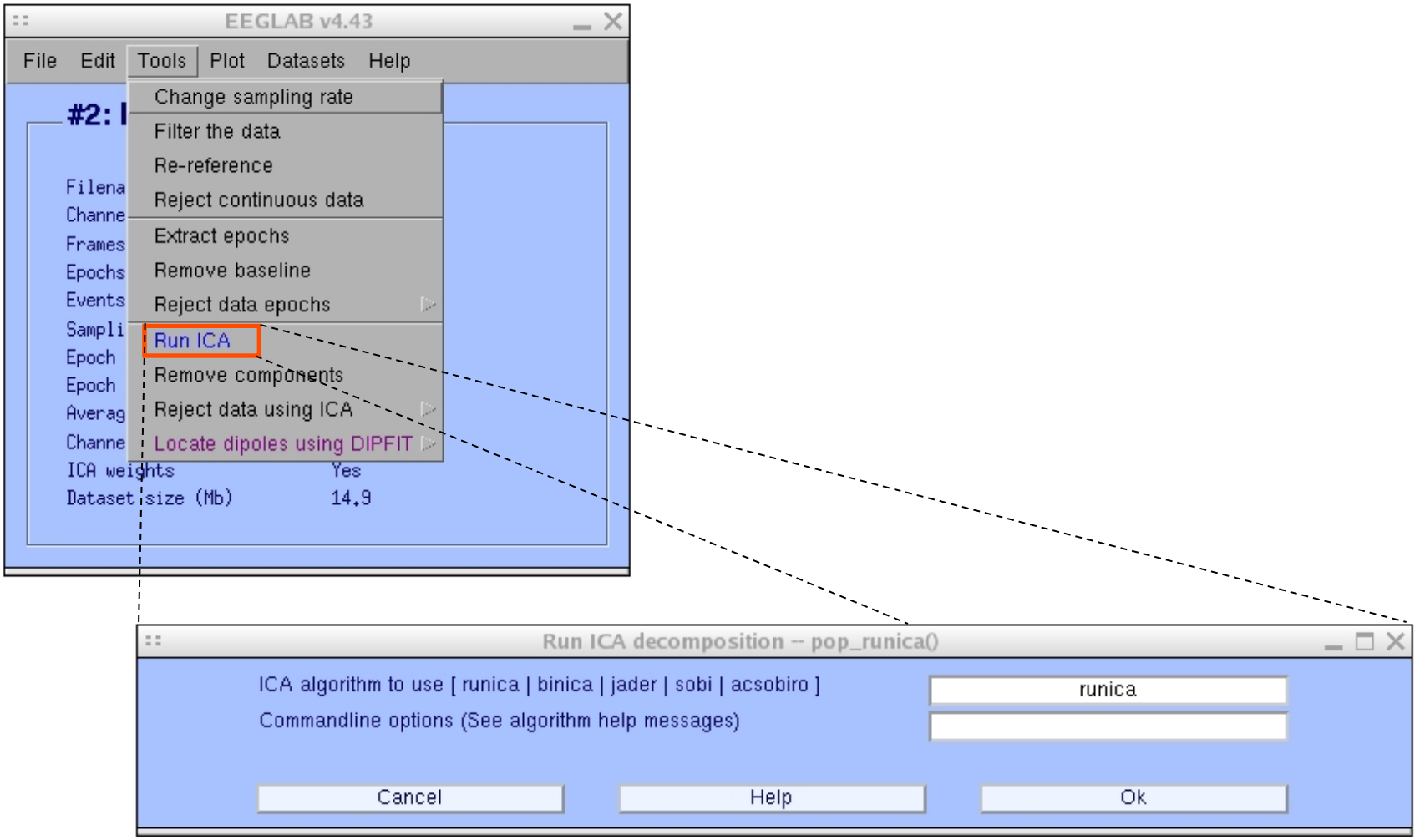
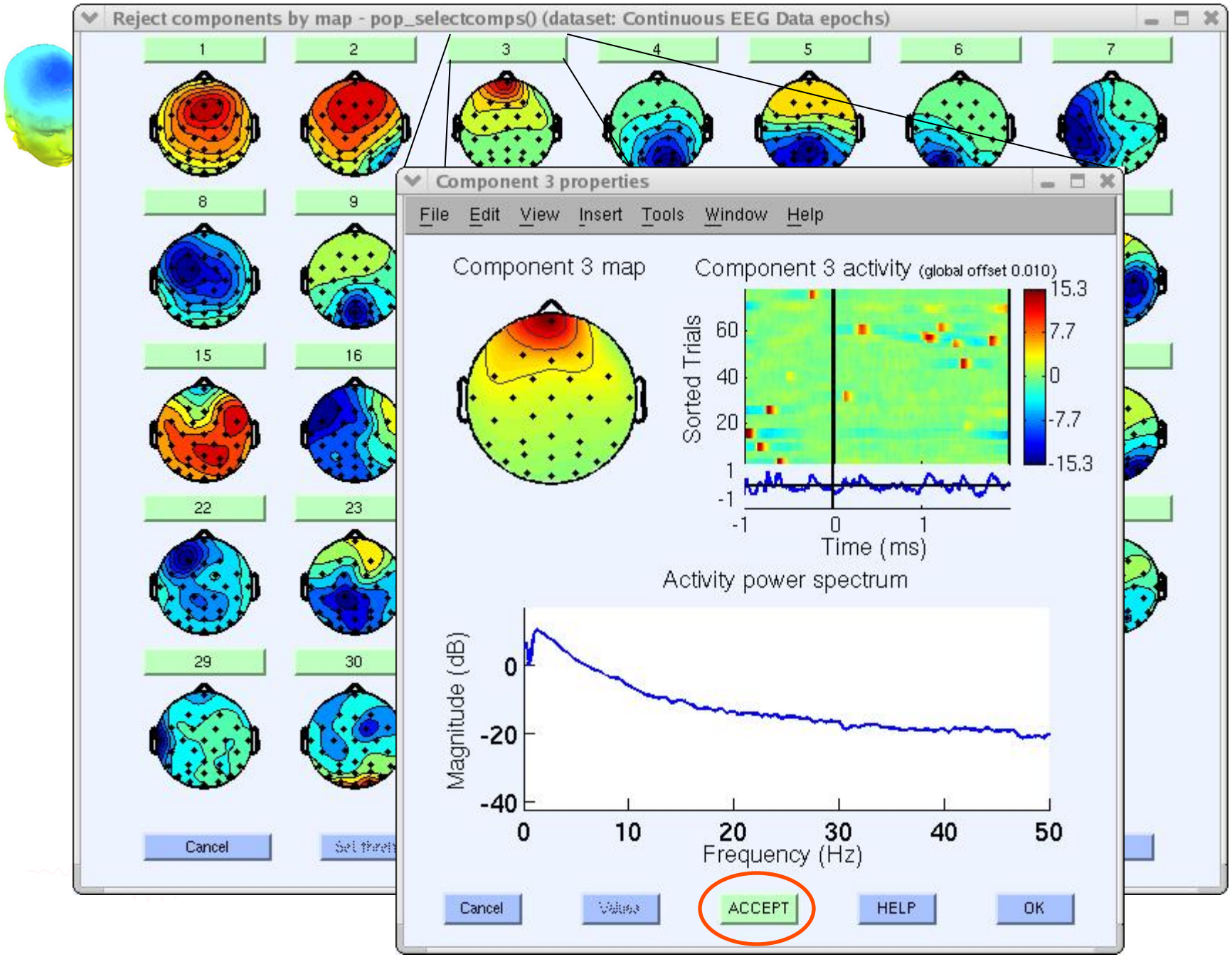
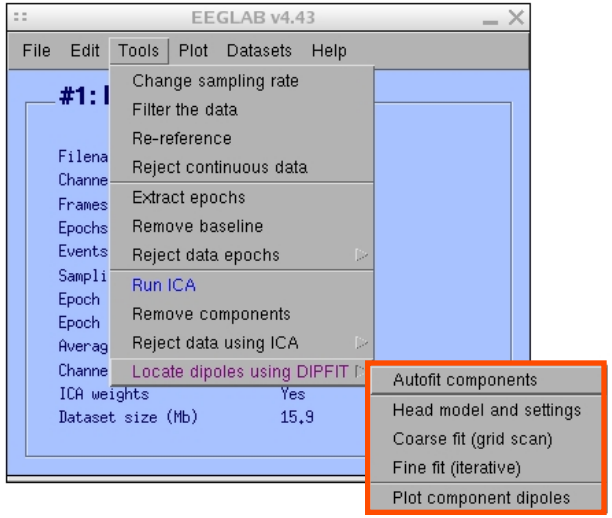
Advanced analysis using scripting and EEGLAB command line functions

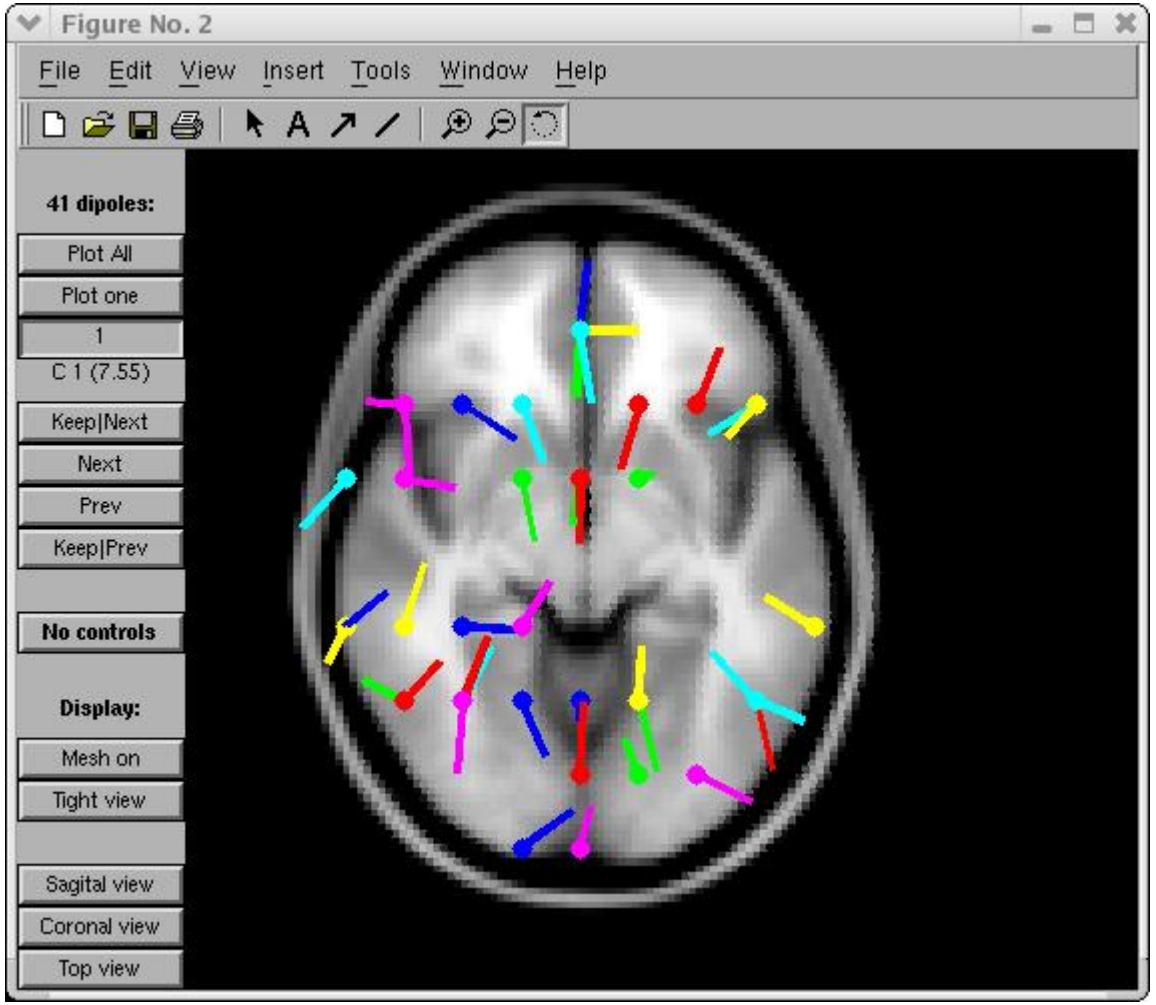
6. Perform ICA decomposition




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
Component 3 properties
File Edit View Insert Tools Window Help
Component 3 map
Component 3 activity (global offset 0.010)
Sorted Trials
60
40
20
1
-1
15.3
7.7
0
-7.7
-15.3
-1
0
1
Time (ms)
Activity power spectrum
Magnitude (dB)
0
-20
-40
0
10
20
30
40
50
Frequency (Hz)
Cancel
ACCEPT
HELP
OK

Localizing components





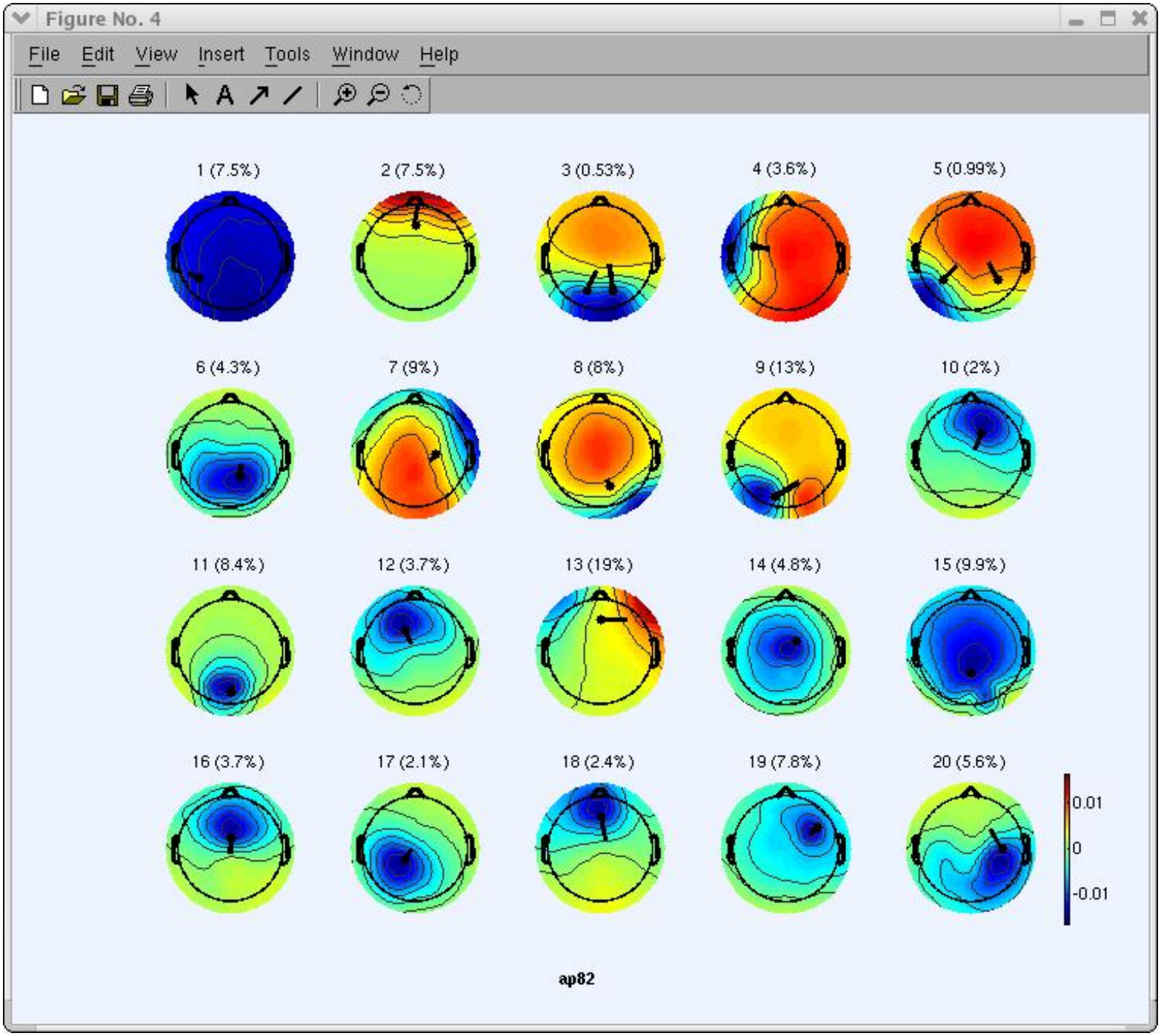
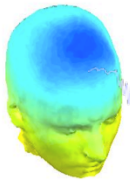
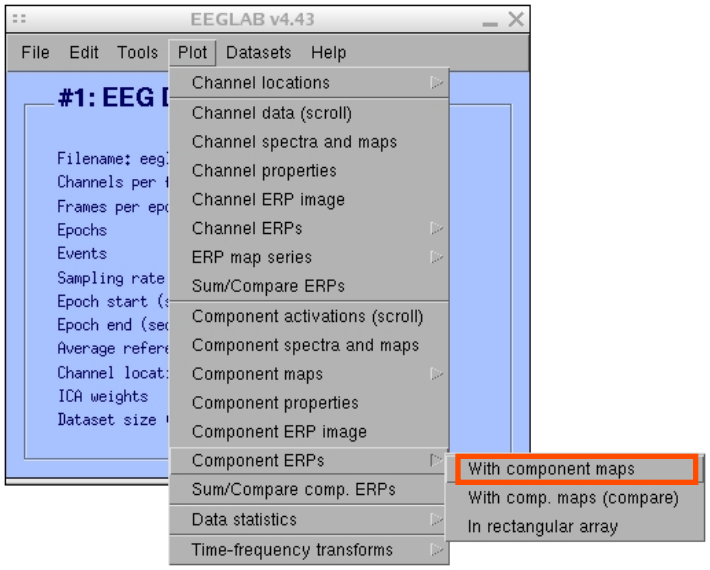
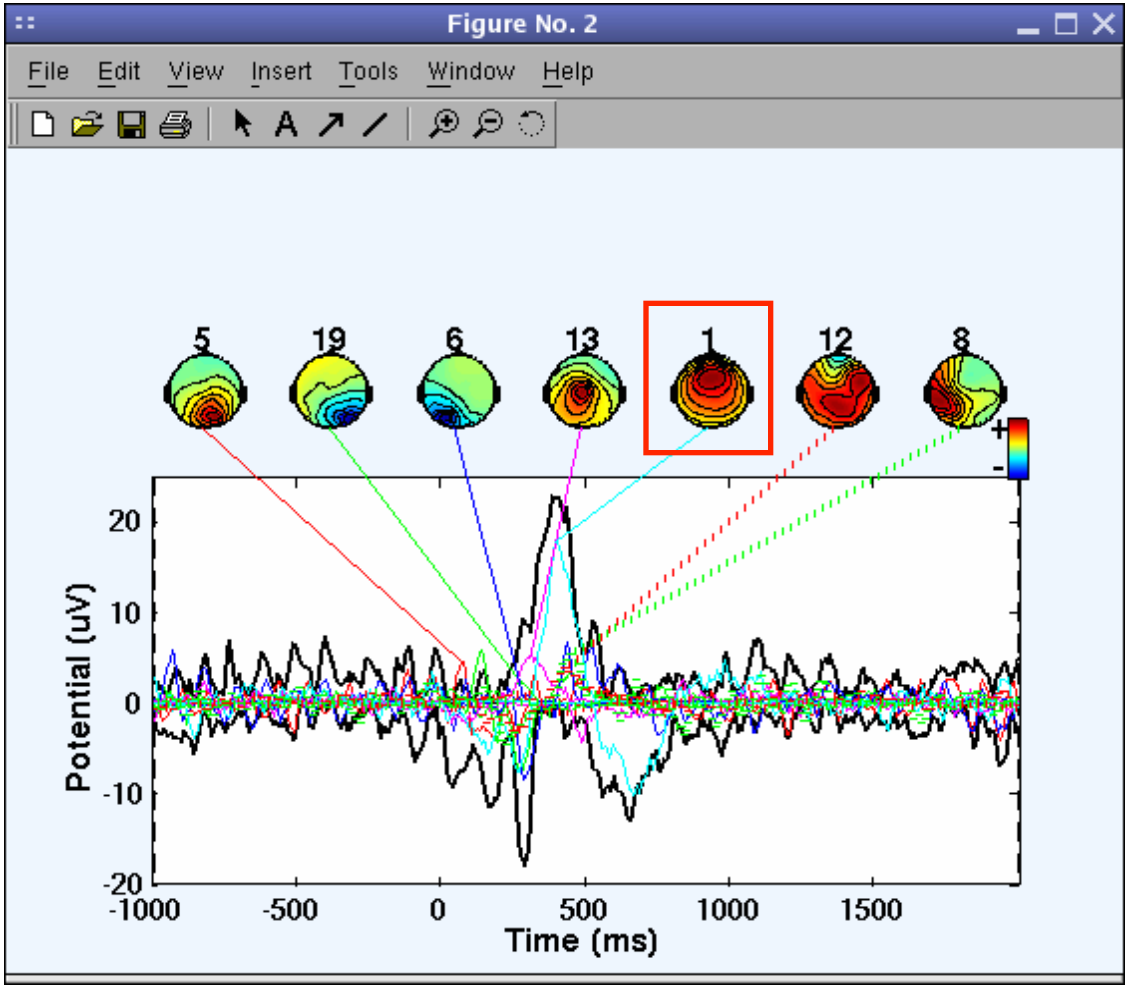


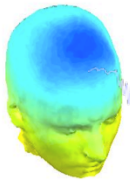
Figure No. 4
File Edit View Insert Tools Window Help
1 (7.5%)
2 (7.5%)
3 (0.53%)
4 (3.6%)
5 (0.99%)
6 (4.3%)
7 (9%)
8 (8%)
9 (13%)
10 (2%)
11 (8.4%)
12 (3.7%)
13 (19%)
14 (4.8%)
15 (9.9%)
16 (3.7%)
17 (2.1%)
18 (2.4%)
19 (7.8%)
20 (5.6%)
0.01
0
-0.01
ap82

Component contribution to the ERP

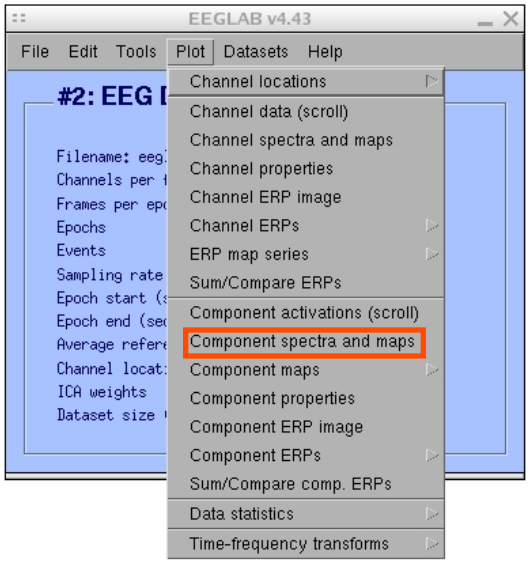


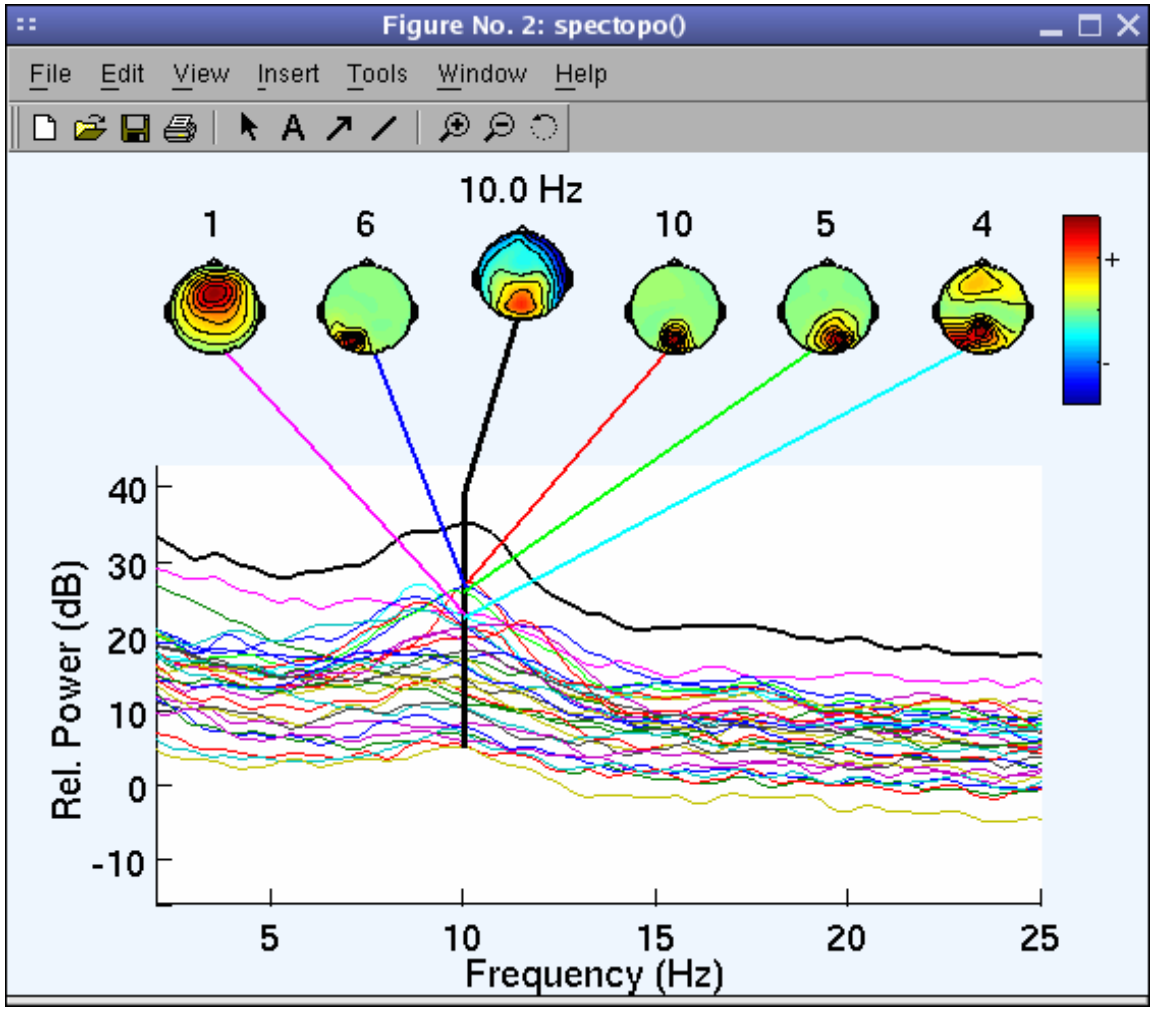




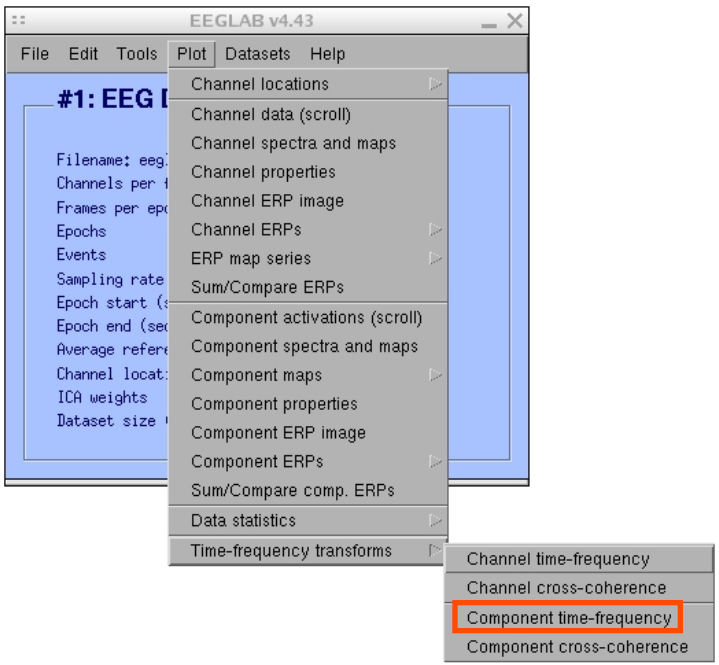


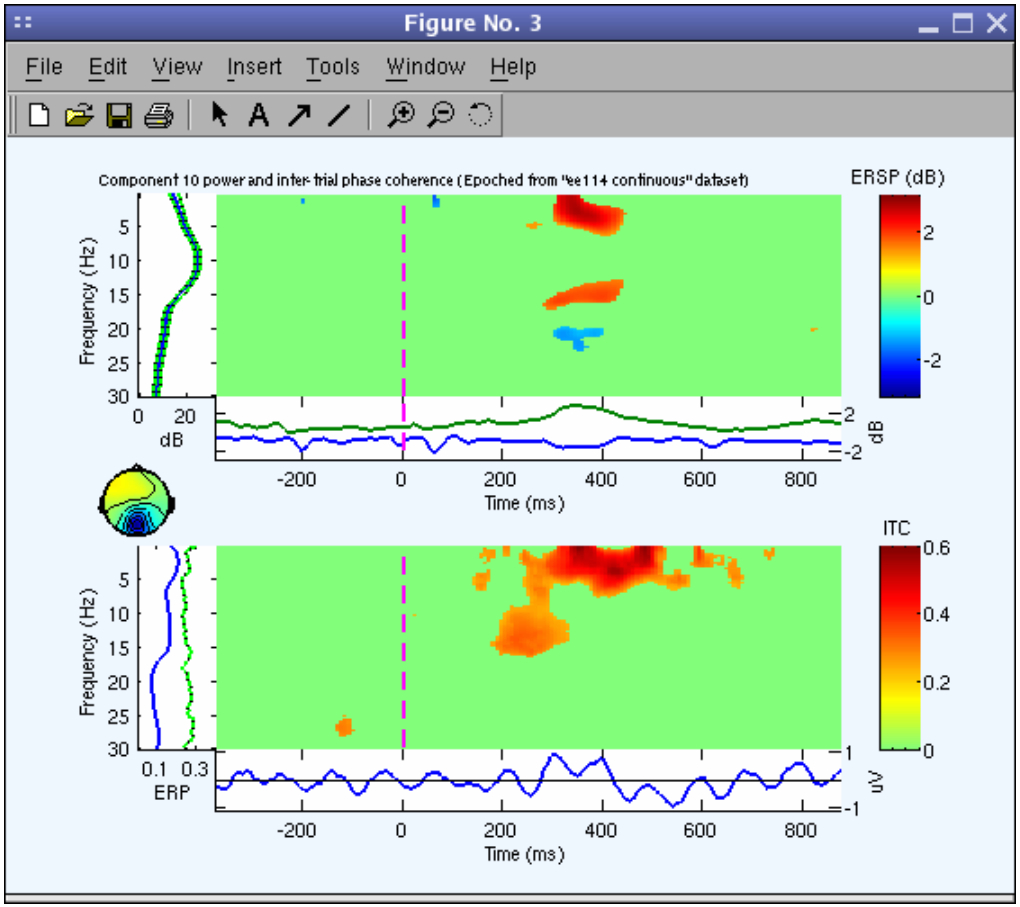
Component contribution to the EEG spectrum



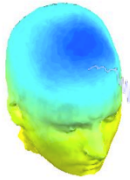


Component time-frequency





EEGLAB standard processing pipeline



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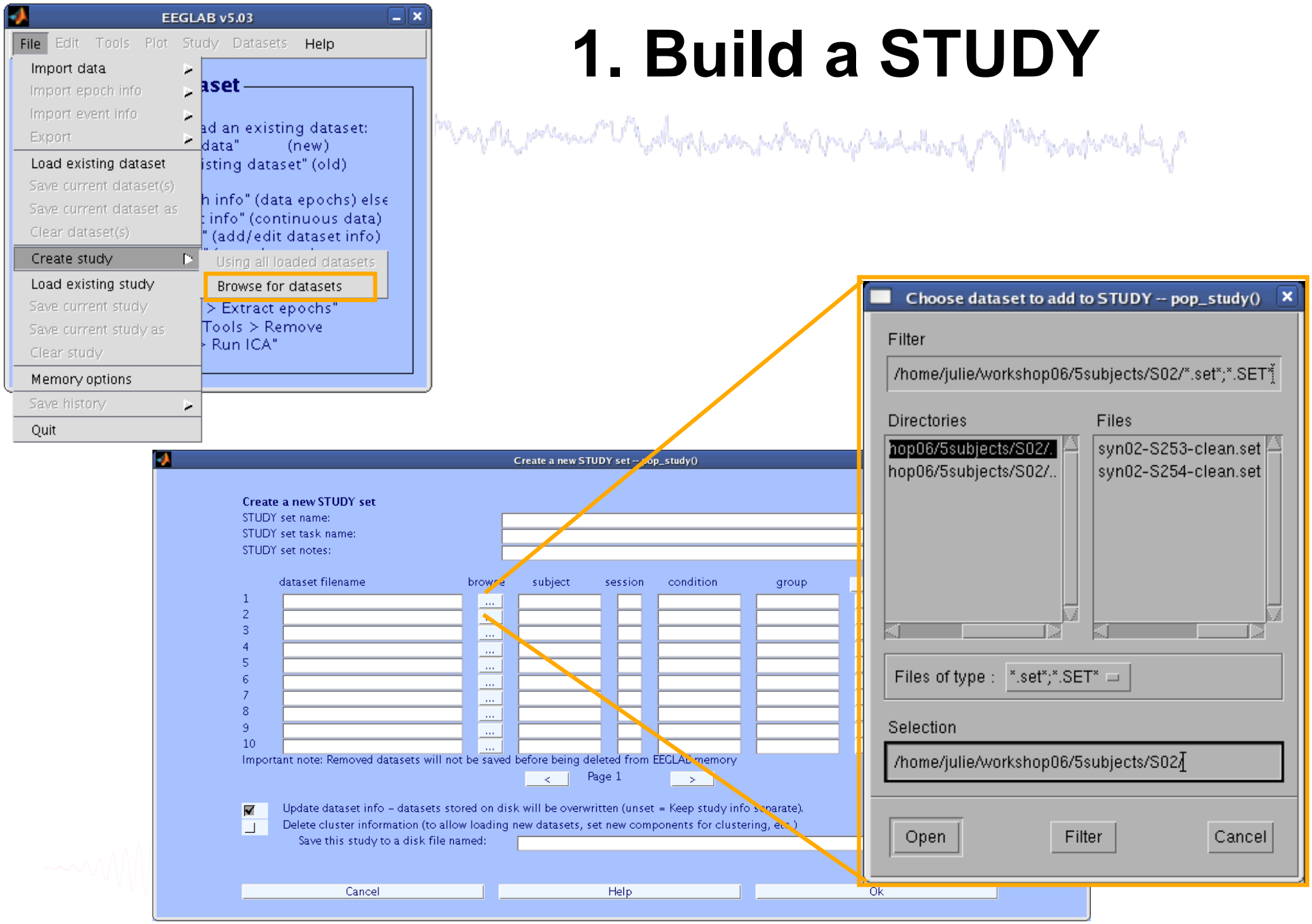
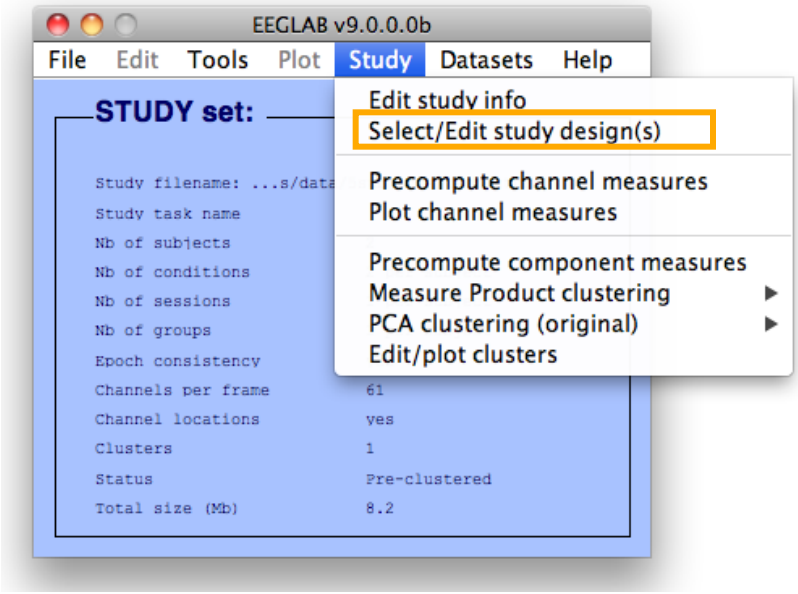
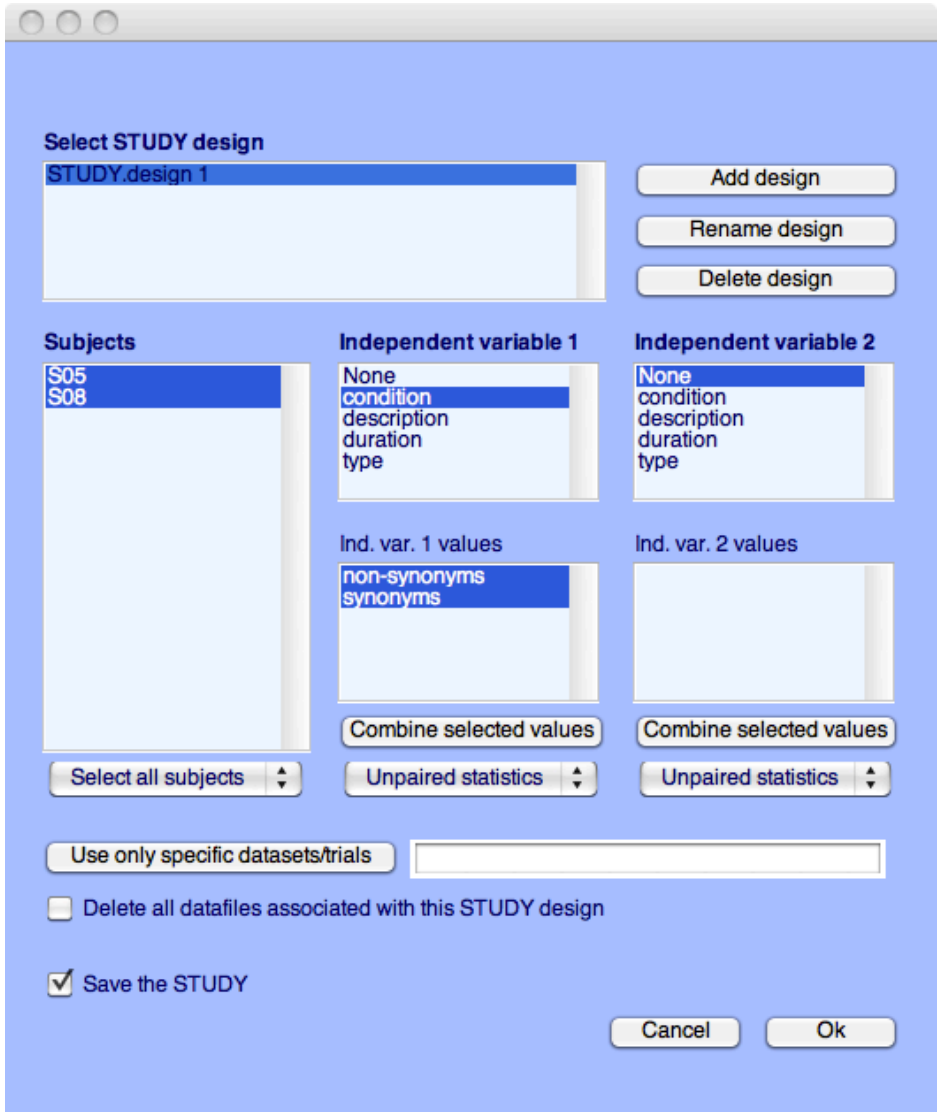
Advanced analysis using scripting and EEGLAB command line functions

1. Build a STUDY

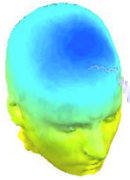


:dit STUDY design

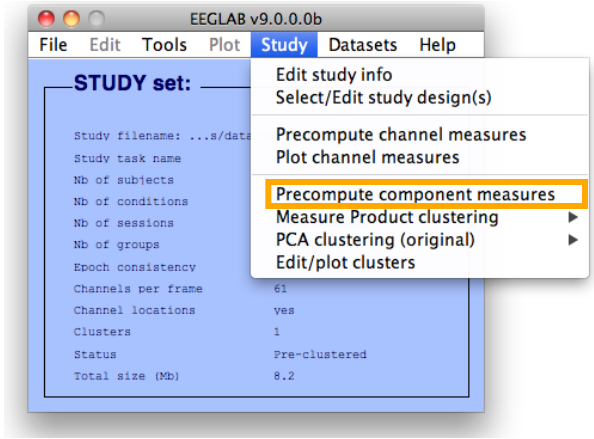




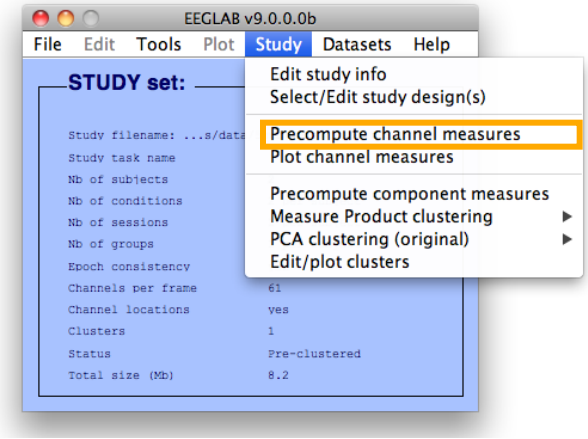
2. Pre-compute measures

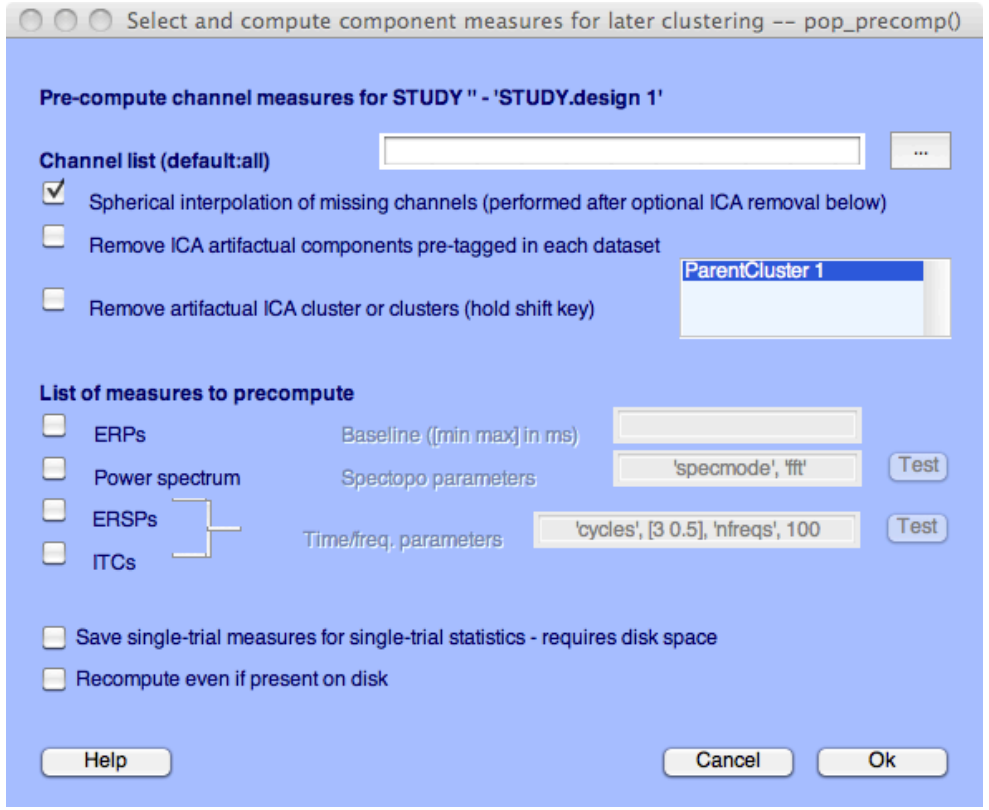


Components

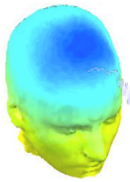


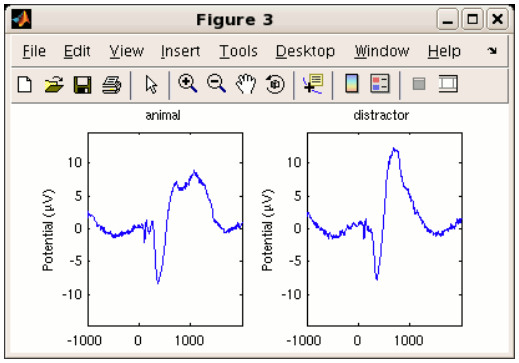
Channels

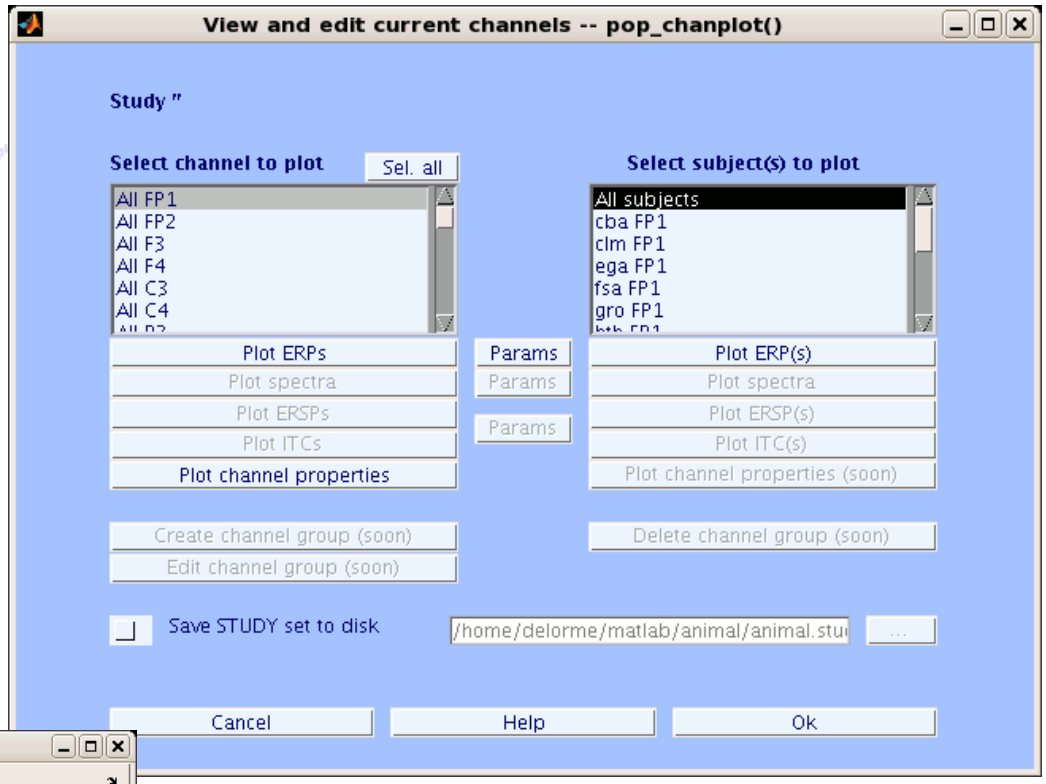


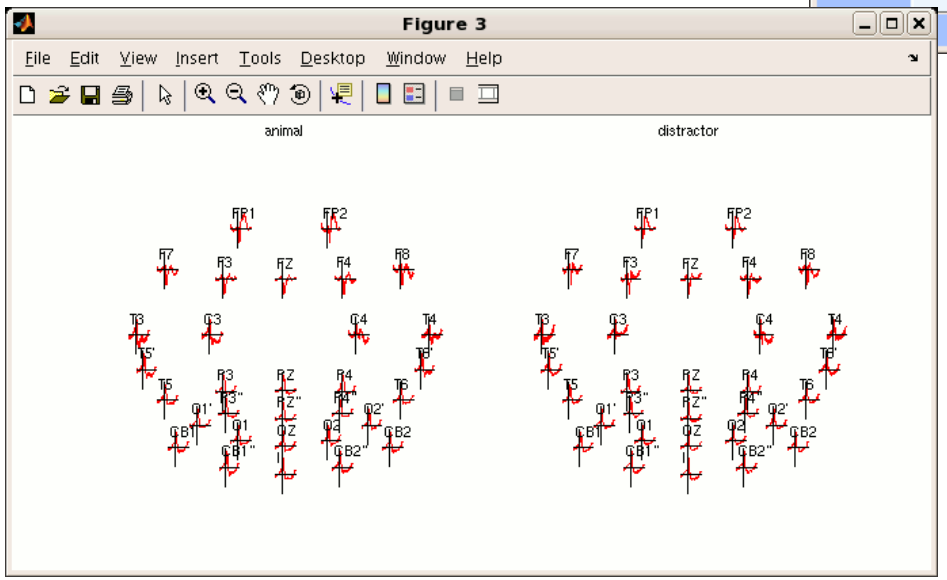


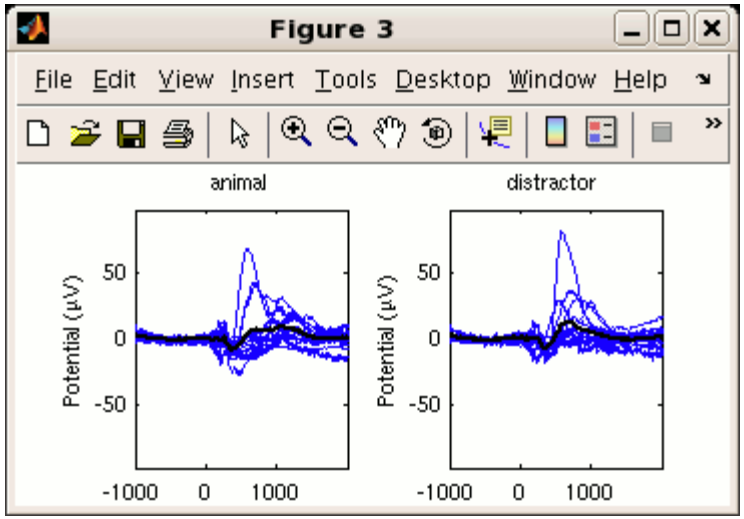
Channel plotting



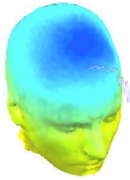


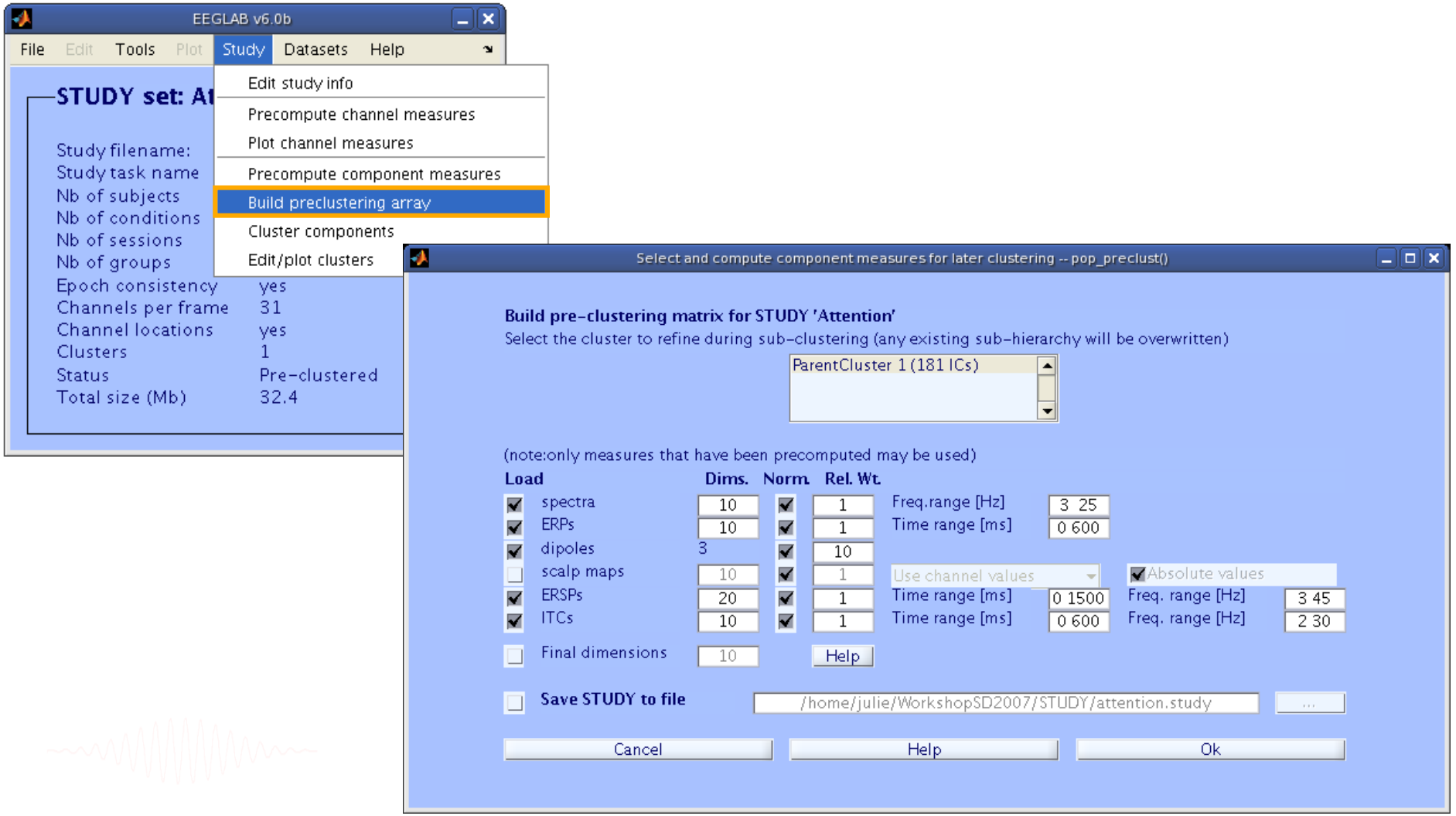




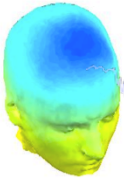


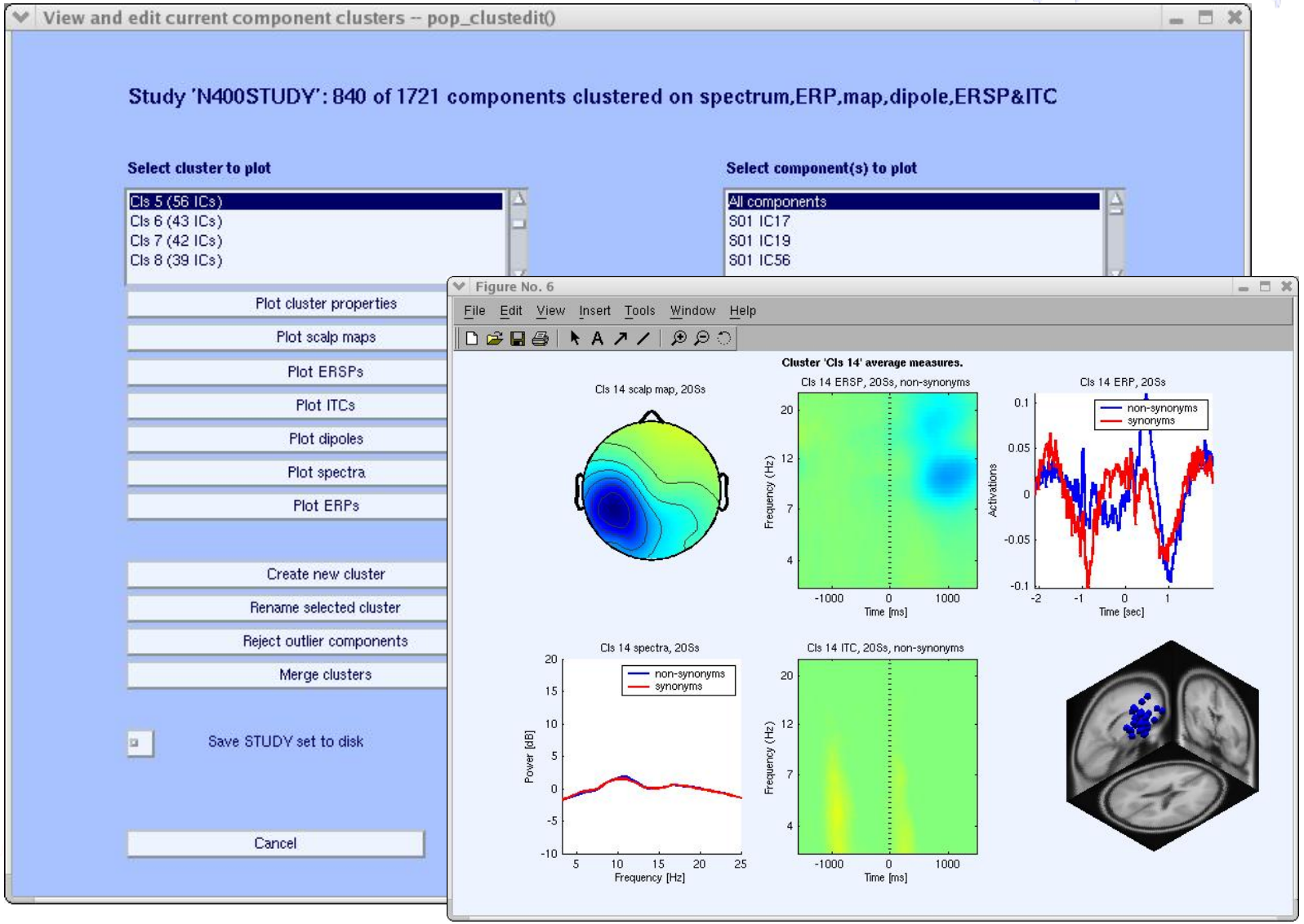
3. Cluster components

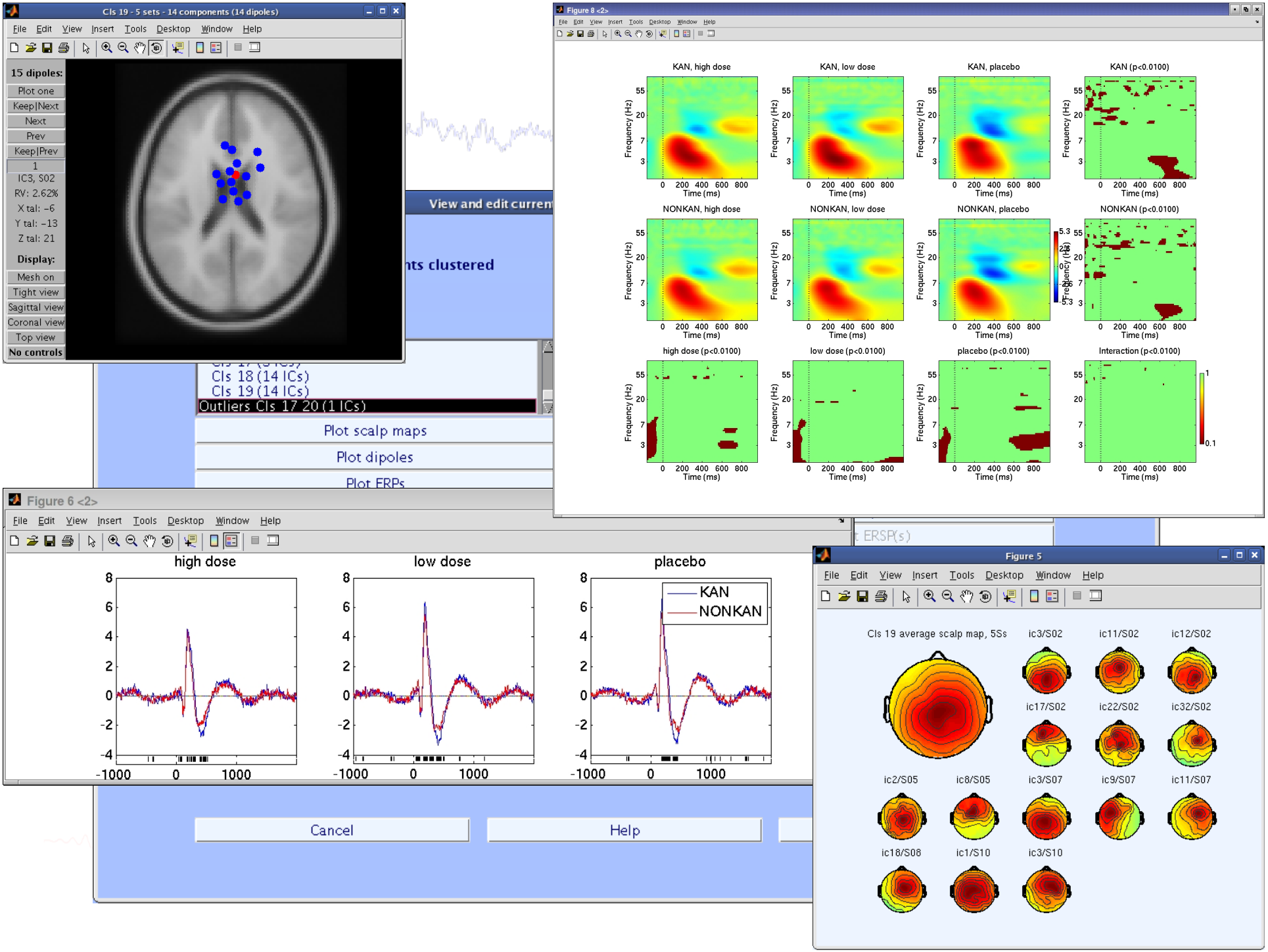




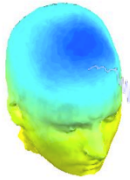
4. Analyze clusters






Cls 19 - 5 sets - 14 components (14 dipoles)
File Edit View Insert Tools Desktop Window Help
15 dipoles:
Plot one
Keep|Next
Next
Prev
Keep|Prev
1
IC3, S02
RV: 2.62%
X tal: -6
Y tal: -13
Z tal: 21
Display:
Mesh on
Tight view
Sagittal view
Coronal view
Top view
No controls
View and edit curren
nts clustered
Cls 18 (14 ICs)
Cls 19 (14 ICs)
Outliers Cls 17 20 (1 ICs)
Plot scalp maps
Plot dipoles
Plot ERPs
Figure 8 <2>
KAN, high dose
KAN, low dose
KAN, placebo
KAN (p<0.0100)
NONKAN, high dose
NONKAN, low dose
NONKAN, placebo
NONKAN (p<0.0100)
high dose (p<0.0100)
low dose (p<0.0100)
placebo (p<0.0100)
Interaction (p<0.0100)
Frequency (Hz)
Time (ms)
Figure 6 <2>
high dose
low dose
placebo
KAN
NONKAN
ERSP(s)
Cancel
Help
Figure 5
Cls 19 average scalp map, 5Ss
ic3/S02
ic11/S02
ic12/S02
ic17/S02
ic22/S02
ic32/S02
ic2/S05
ic8/S05
ic3/S07
ic9/S07
ic11/S07
ic18/S08
ic1/S10
ic3/S10

EEGLAB standard processing pipeline



Single subject

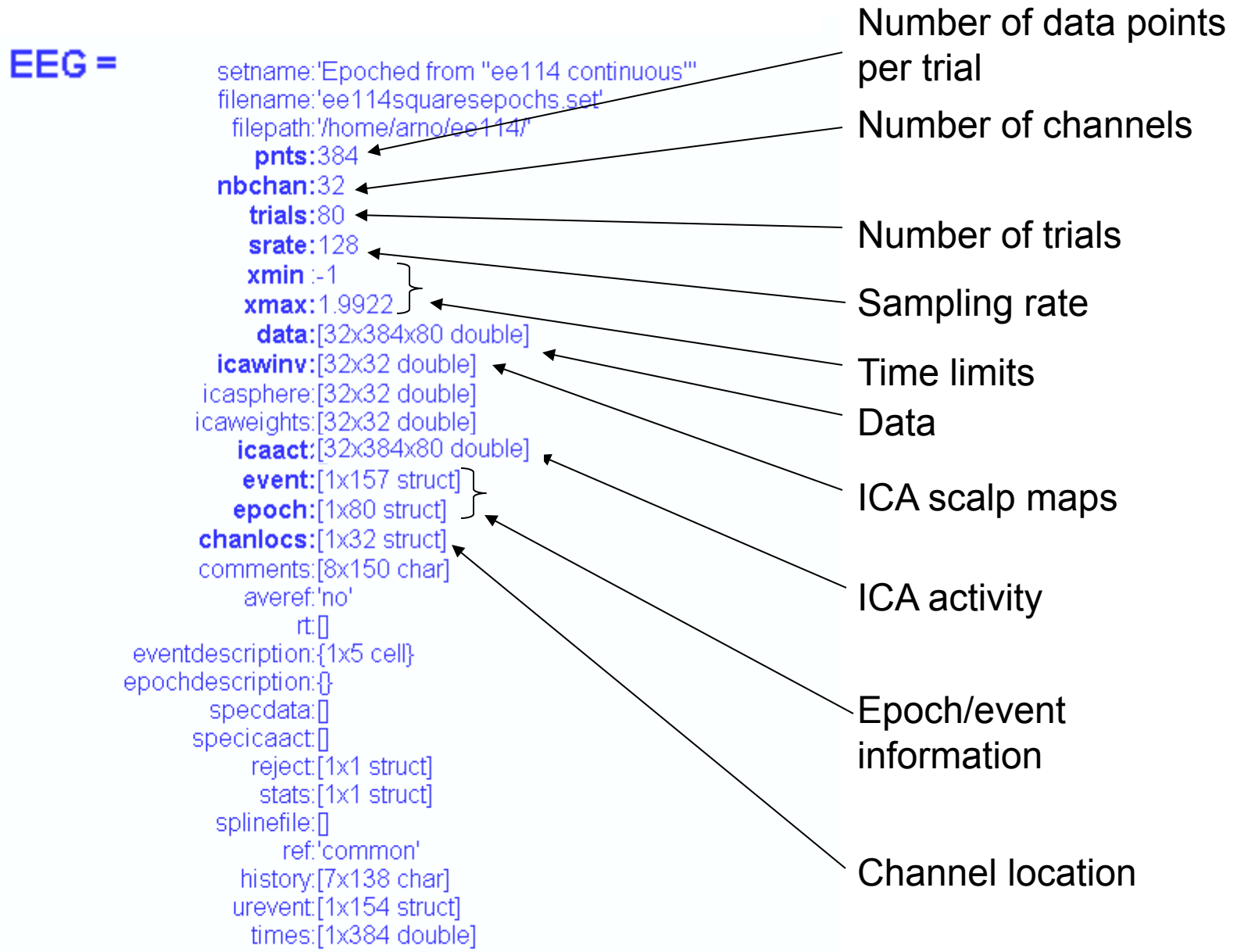
1. Import binary data, events and channel location
2. Edit, Re-reference, Resample, High pass filter data
3. Reject artifacts in continuous data by visual inspection
4. Extract epochs from data & reject artifactual epochs
5. Visualize data measures
6. Perform ICA decomposition
   - Perform source localization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

Multi-subjects

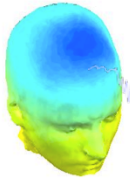
1. Build study and design
2. Pre-compute measures
3. Cluster components
4. Analyze clusters

Advanced analysis using scripting and EEGLAB command line functions

EEG structure



3 levels of functions



Administrative functions: handle EEG and ALLEEG structures

eeglab(), eeg_checkset(), pop_delset(), …

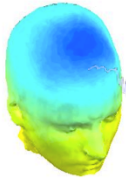
Pop functions: interactive functions using EEG structure

pop_erpimage(), pop_topoplot(), pop_envtopo(), …

Signal processing functions: perform signal processing

erpimage(), topoplot(), envtopo(), …

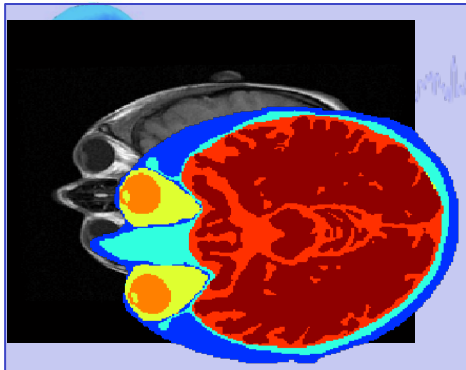
Command line tools



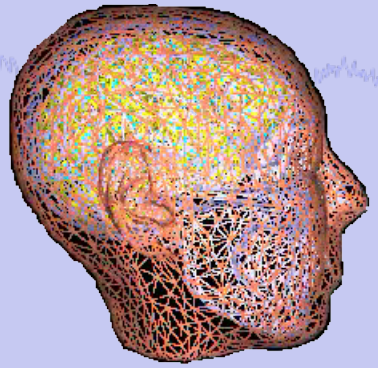
("eegh" Menus write both dataset and global history)

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

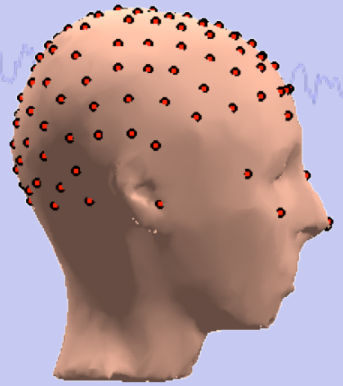
NFT: Neuroelectromagnetic Forward Head Modeling Toolbox



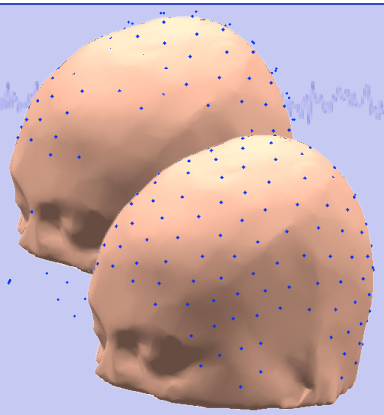
Segmentation



Mesh Generation

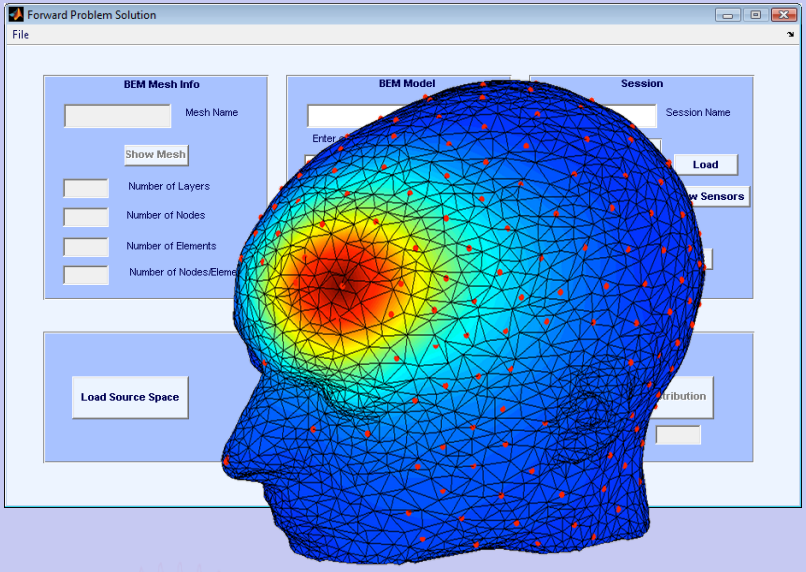


Electrode Registration

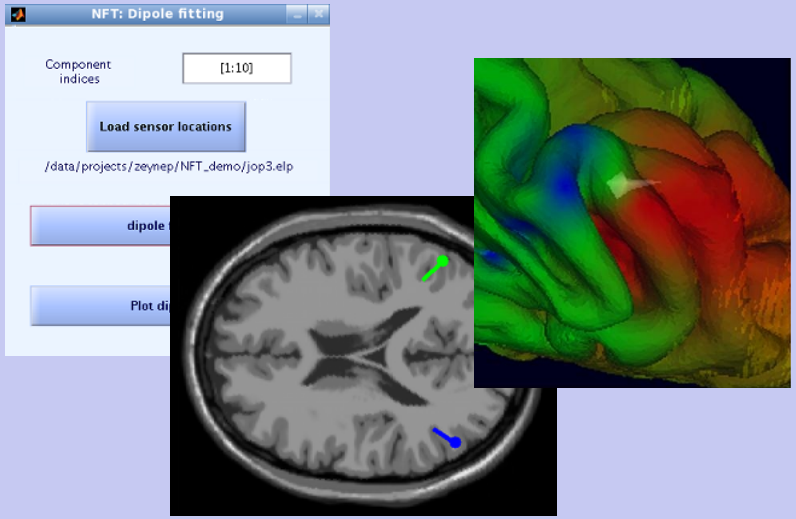


Template Warping

Realistic Head Models

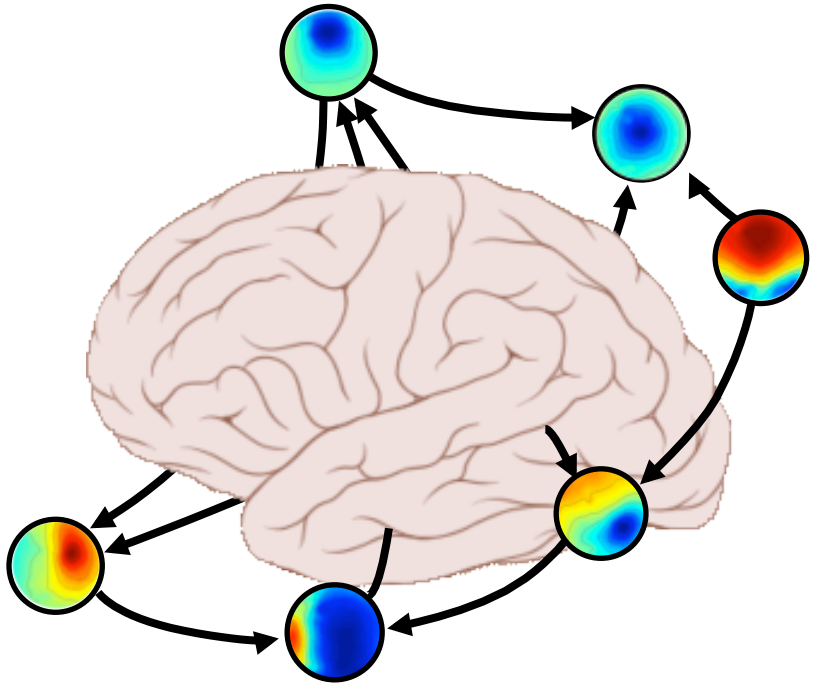


Forward Problem Solution



Source Localization

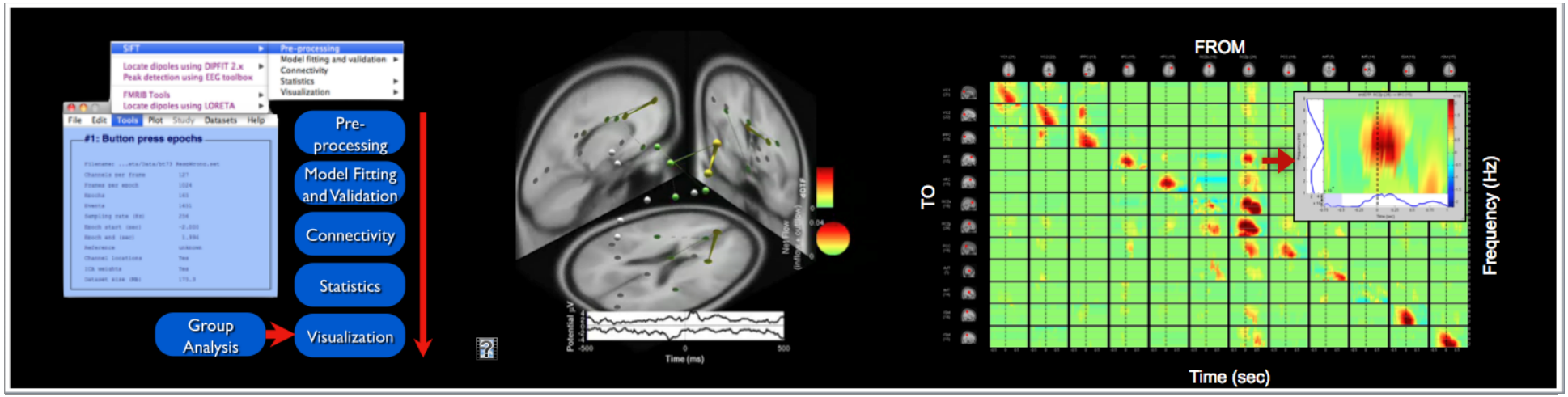
http://sccn.ucsd.edu/nft



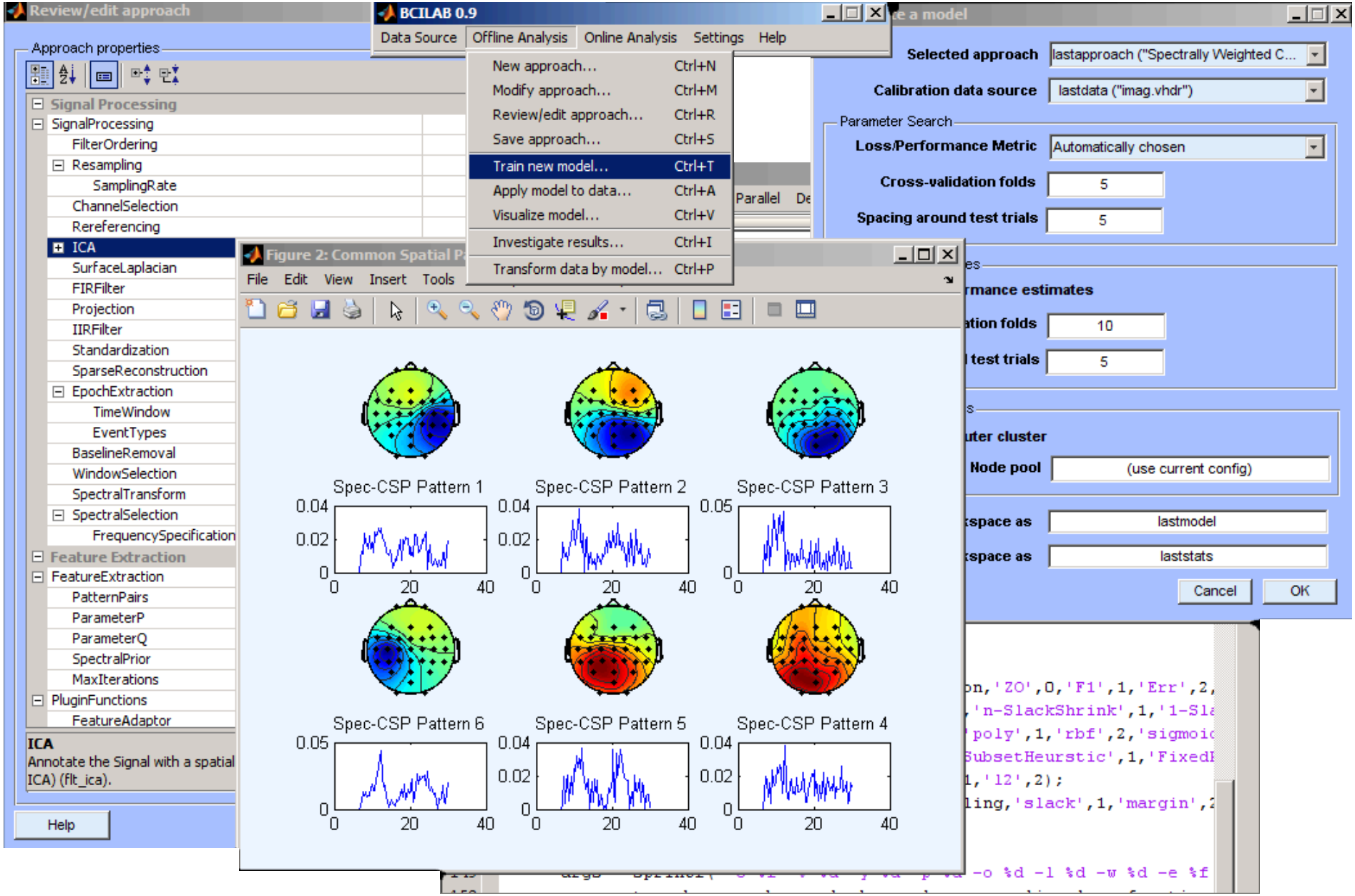
SIFT

Source Information Flow Toolbox

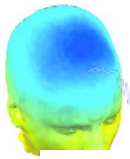
"It makes you cool"



BCILAB - C. Kothe



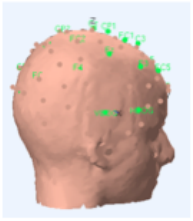
EEG database: HEAD-IT framework

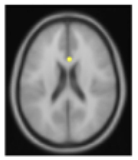


#1 EEG raw data files (+ECG, GSR, eye tracking, events, etc…)

#2

Subject information, questionnaires, anatomical MRI, DTI, channel locations





SRB/ Local

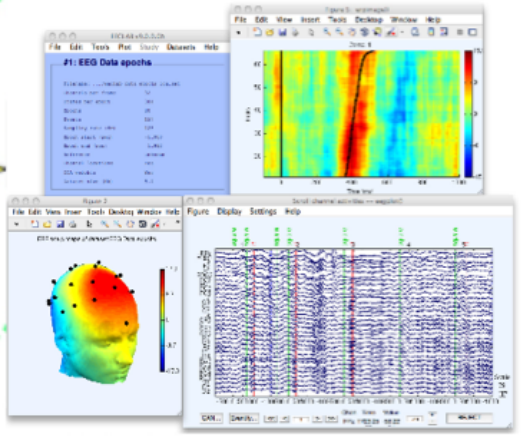
URL links

Head-IT

#3 Result images and files

Files and scripts

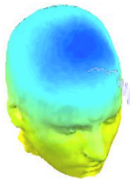
#5



#4 Database information for new files

Remote database access

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 Workshop Program Session I

Thursday, Nov. 18

8:00 - 8:30 am Check-in open (park early!)
8:30 – 10:00 am - Mining event-related brain dynamics I (Scott Makeig)
10:00 – 10:30 am - EEGLAB and Workshop overview (Arnaud Delorme)

Break (10:30-11:00)

11:00 am – 12:00 pm - Time-frequency decomposition (Arnaud Delorme)
12:00 pm – 12:30 pm - Independent component analysis (ICA) theory I (Jason Palmer)

12:30-1:30 Lunch on your own on campus

1:30 pm – 2:00 pm - ICA theory II (Jason Palmer)
2:00 – 3:00 pm - Data import and channel analysis (Klaus Gramann)

Break (3:00-3:30)

3:30– 4:30 pm - Evaluating ICA components (Julie Onton)
4:30– 5:30 pm - Basic scripting using EEGLAB "history" and the EEG structure (Julie Onton)
5:30 – 6:30 pm - Free time to explore EEGLAB using tutorial data and/or your own data

Friday, Nov 19

8:30 – 9:15 pm - Using bootstrap statistics (David Groppe)
9:15 – 10:30 am - The new 'STUDY.design' facility and multi-subject plotting (Arnaud Delorme)

Break (10:30-11:00)

11:00 – 11:45 am – Forward and inverse source modeling (Zeynep Akalin Acar)
11:45 – 12:30 am – Using the DIPFIT toolbox (Julie Onton)

12:30-3:00 Networking excursion: Picnic lunch and short hike in scenic Torrey Pines Reserve

4:00 – 4:30 am - STUDY component clustering (Arnaud Delorme)
4:30 – 5:30 pm - Advanced uses of 'STUDY.design' statistics (Arnaud Delorme)
5:30 – 6:30 pm - Free time to work on tutorial projects and/or own data

Saturday, Nov 20

8:30 – 9:30 am – Mining event-related dynamics II (Scott Makeig)
9:30 – 10:00 pm — Building EEGLAB plug-ins (Arnaud Delorme)
10:00 – 10:30 am - Small groups work on tutorial projects

Break (10:30-11:00)

11:00 – 11:45 am - Continued work on tutorial projects
11:45 – 12:30 am – Group project presentations and General Discussion (all)

12:30-1:30 Lunch on campus

EEGLAB Workshop Program Session II

Saturday, Nov 20

1:30 – 2:30 pm – Comparing EEG dynamics across subjects using the Measure Projection toolbox (Nima Bigdely Shamlo)
2:30 – 3:00 pm - Modeling effective connectivity by measuring source EEG information flow: theory (Tim Mullen)

Break (3:00-3:30)

3:30 – 5:00 pm - Modeling effective connectivity by measuring EEG information flow: practicum (Tim Mullen)
5:00 – 6:30 pm - Free time to work on tutorial projects and/or own data

Sunday, Nov 21

8:30 – 9:30 am – The NFT head modeling toolbox: overview (Zeynep Akalin Acar)
9:30 – 10:30 am – The NFT head modeling toolbox: practicum (Zeynep Akallin)

Break (10:30-11:00)

11:30 – 12:00 pm - Imaging human agency with Mobile brain/body imaging (MoBI) (Scott Makeig)
12:00 – 12:30 pm - The ERICA software environment for real-time, interactive experimental control and analysis (Andrey Vankov)

12:30-1:30 Lunch on campus

1:00 – 2:10 pm - MoBI Lab demos (Dev Sarma, Grace Leslie, Nima Bigdley-Shamlo)
2:10 – 2:30 pm - HeadIT: A resource for human electrophysiological data and tools (Jeff Grethe)
2:30 – 3:00 pm - EEG classification and cross-validation using the BCILAB toolbox: overview (Christian Kothe)

Break (3:00-3:30)

3:30 – 5:00 pm - EEG classification and cross-validation using the BCILAB toolbox: practicum (Christian Kothe)
5:00 – 6:30 pm - Free time to work on tutorial projects and/or own data

Monday, Nov 22

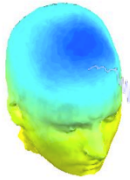
8:30 – 9:15 am - New directions in electrophysiology: Mobile brain monitoring by wearable/wireless EEG (Tzyy Ping Jung)
9:15 – 9:30 am - Mobile brain monitoring demo using 15-channel wireless dry electrode cap (TP Jung)
10:00 – 10:30 am - Small groups work on tutorial projects

Break (10:30-11:00)

11:00 am – 12:00 pm -- Continued work on tutorial projects
12:00 am – 12:30 pm -- Project results presentation and general discussion (all)

12:30 pm - Workshop close

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

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

Delorme, A., Makeig, S. Open Source Programming for Interpreted Language: Graphic Interface and Macro Bridging Interface. IEEE International Conference on Signal Image Technology and Internet Based Systems. In press.