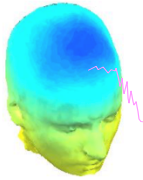
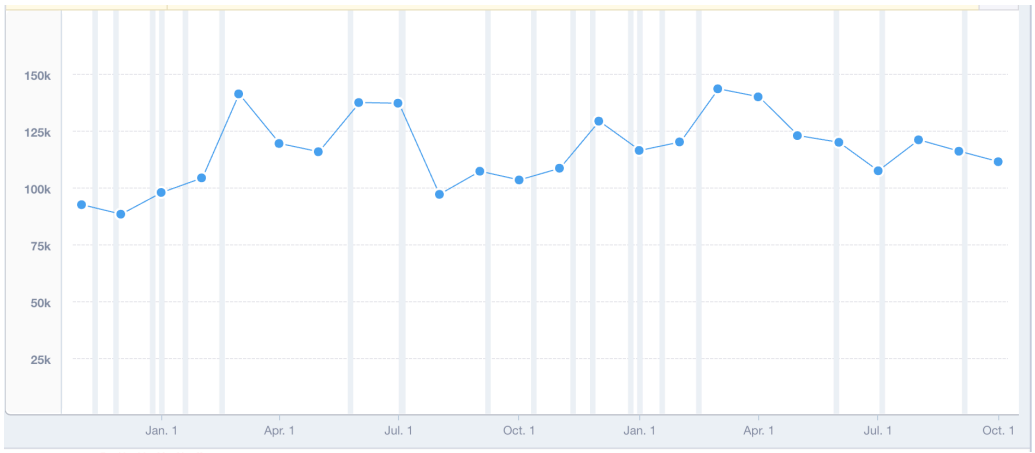
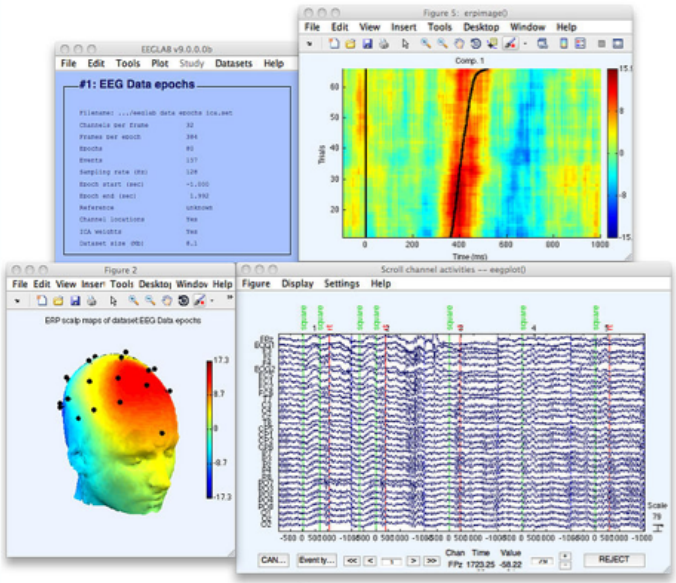
EEGLAB overview



- 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

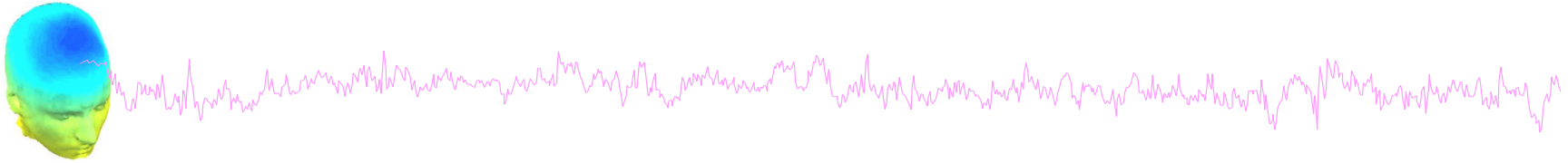


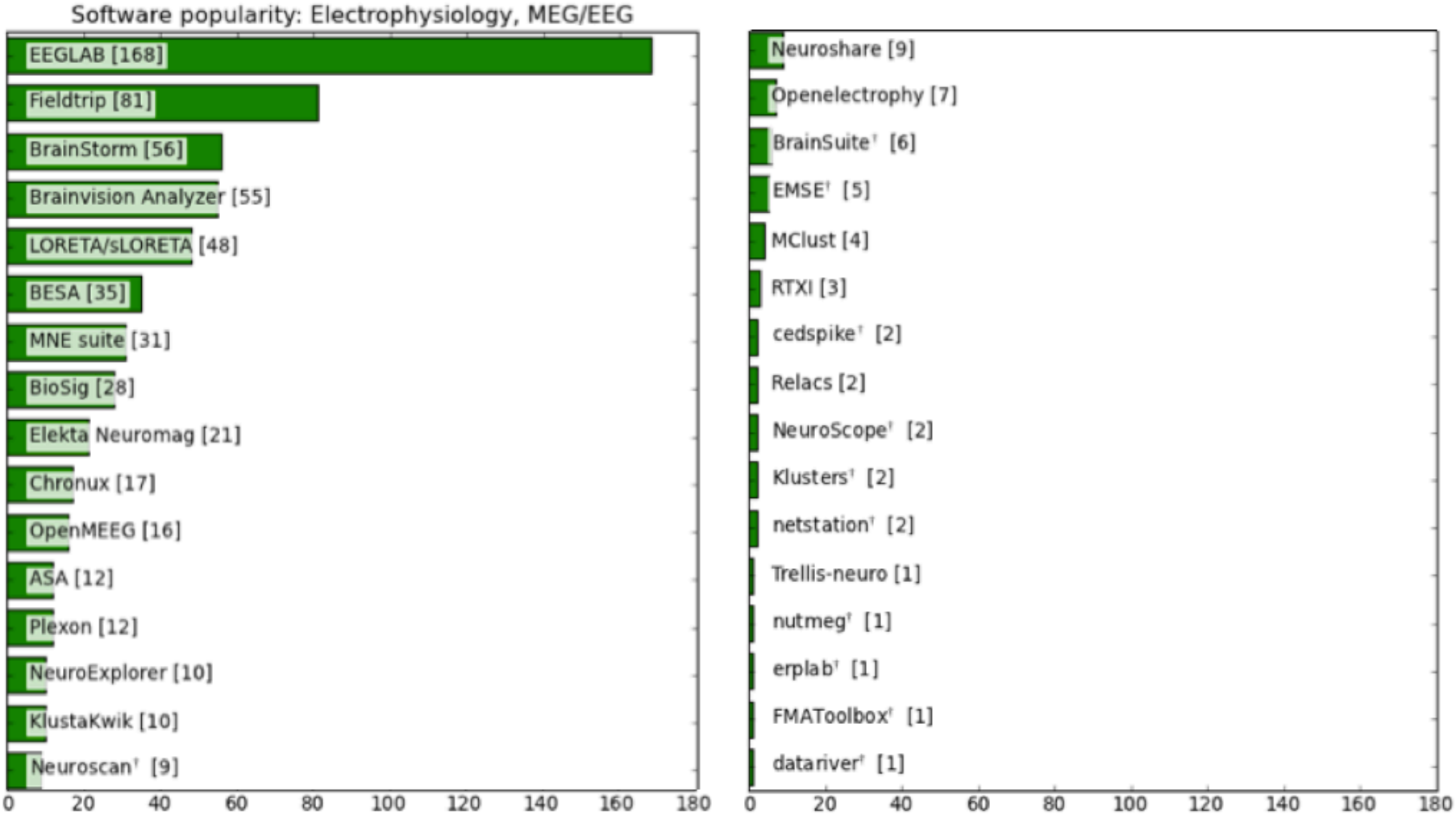


http://sccn.ucsd.edu/eeglab

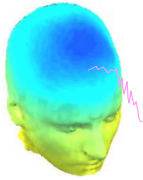
http://sccn.ucsd.edu/wiki/eeglab

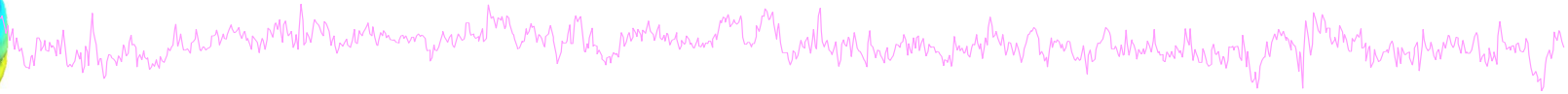
Hanke & Helcencko, 2011, Frontier in Neuroinformatics





EEGLAB standard processing pipeline





Single subject

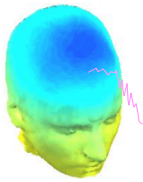
1. Import binary data, events and channel location
2. Edit, Re-reference, Resample, High pass filter data
3. Reject artifacts in continuous data by visual inspection
4. Extract epochs from data & reject artifactual epochs
5. Visualize data measures
6. Perform ICA decomposition
   - Perform source localization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

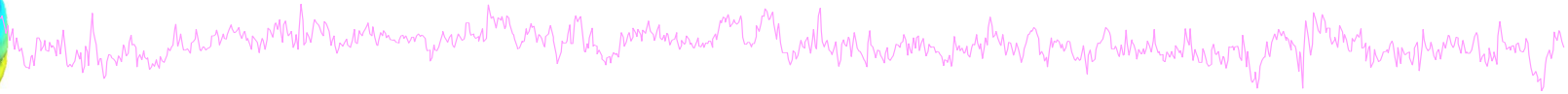
Multi-subjects

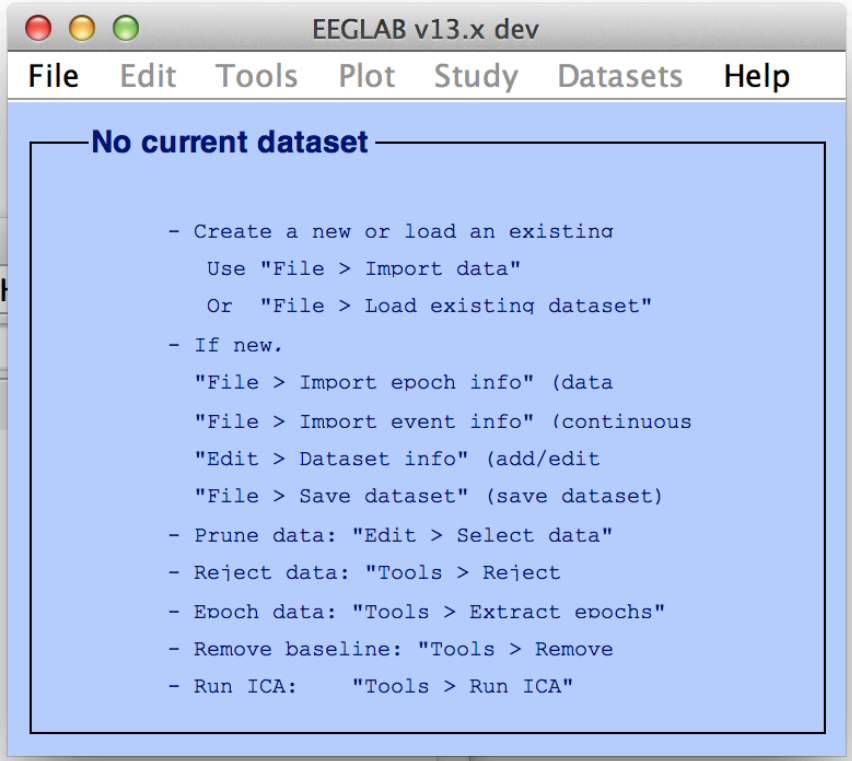
1. Build study and STUDY design
2. Pre-compute measures
3. Cluster components
4. Analyze clusters

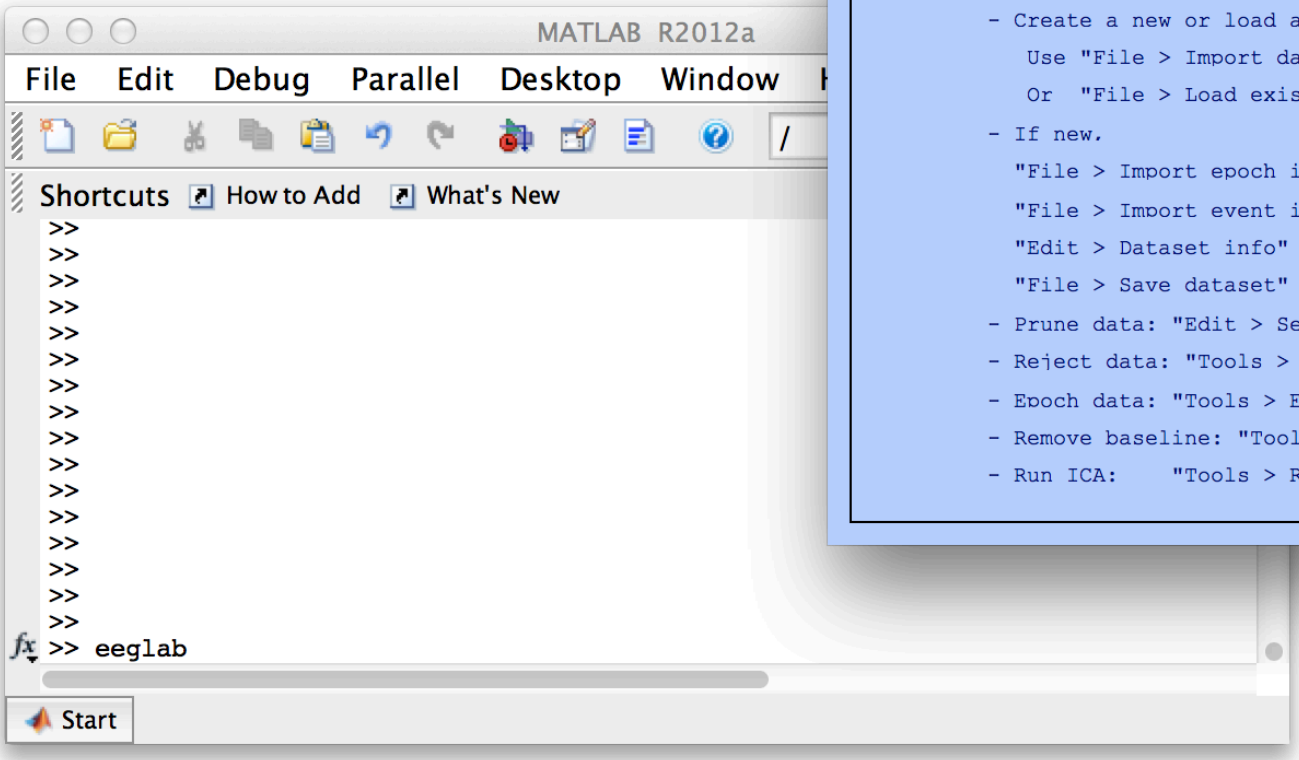
Advanced analysis using scripting and EEGLAB command line functions

The EEGLAB Matlab software



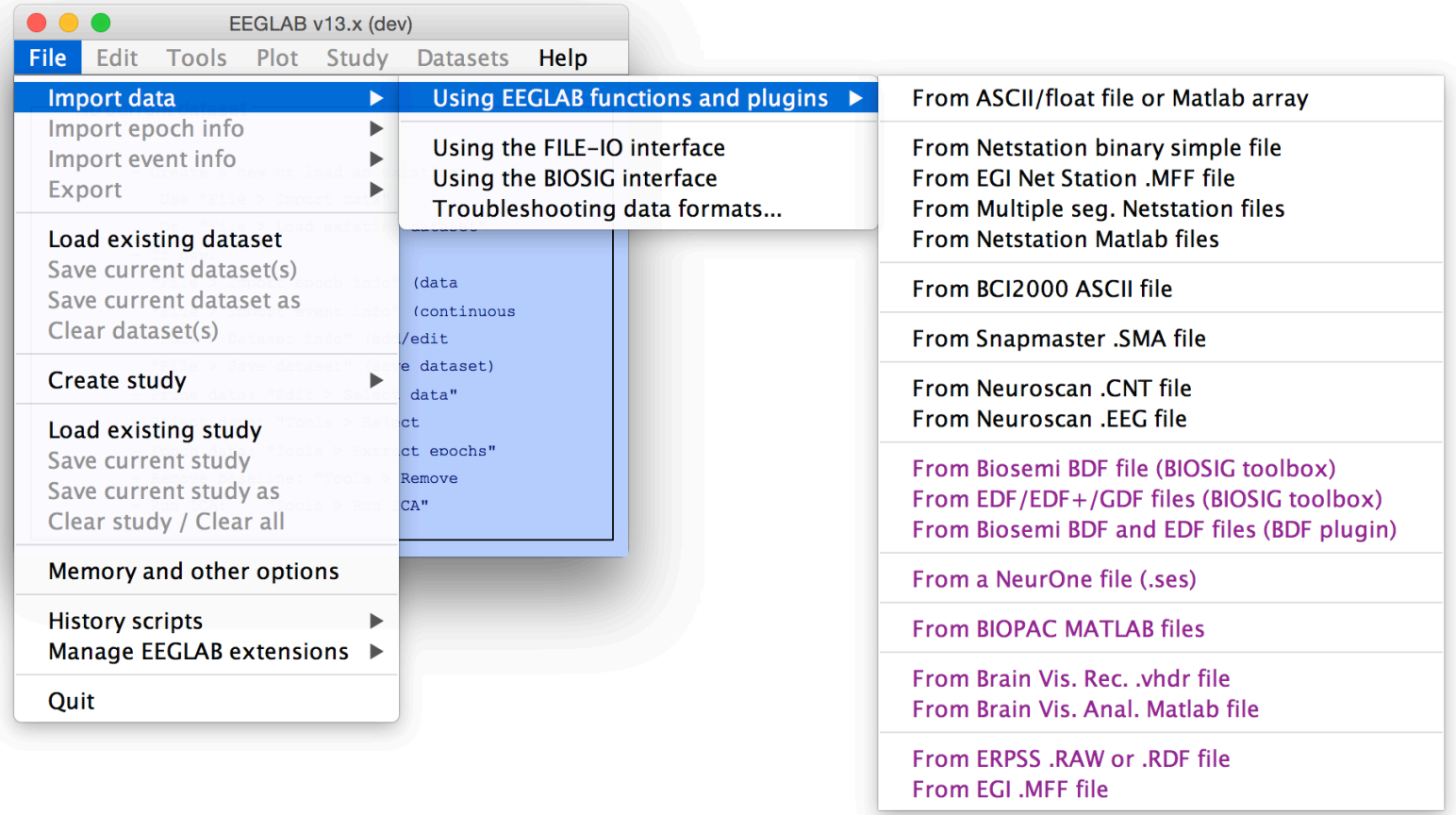






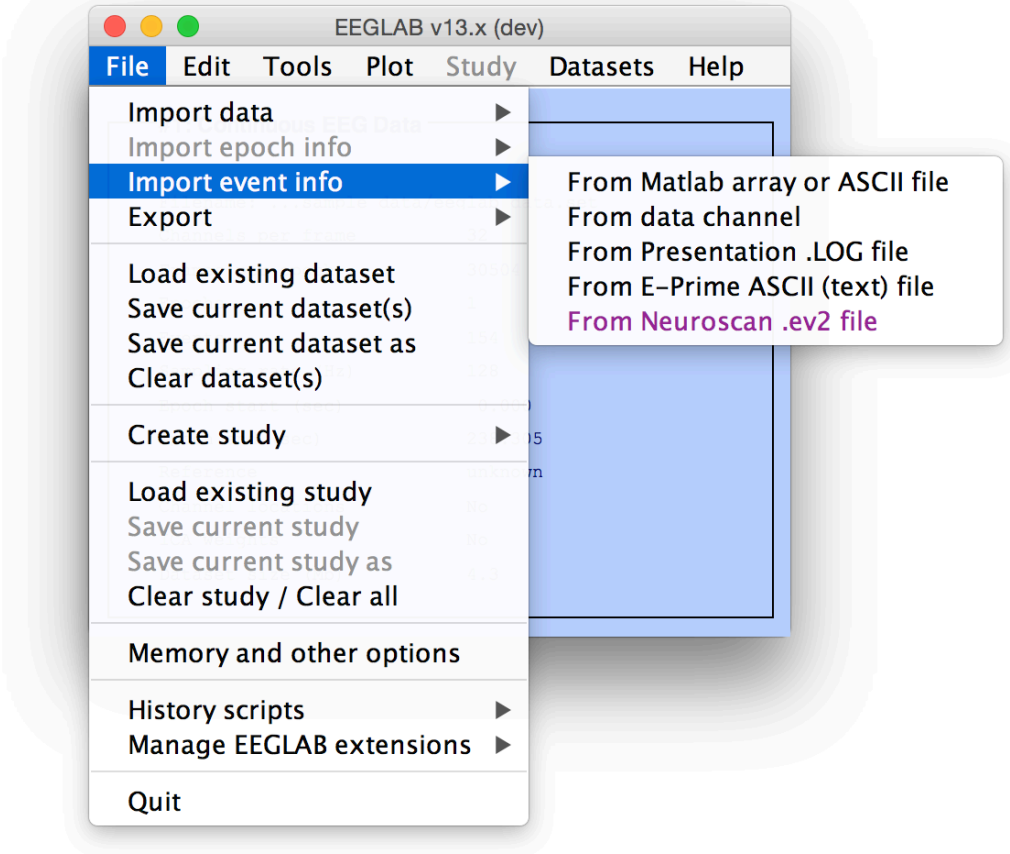
1. Importing data

Import/load data

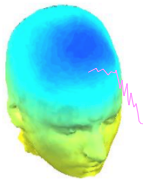


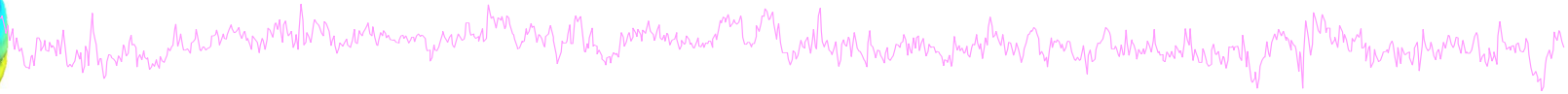
1. Importing data

Import events



1. Importing data





Data info

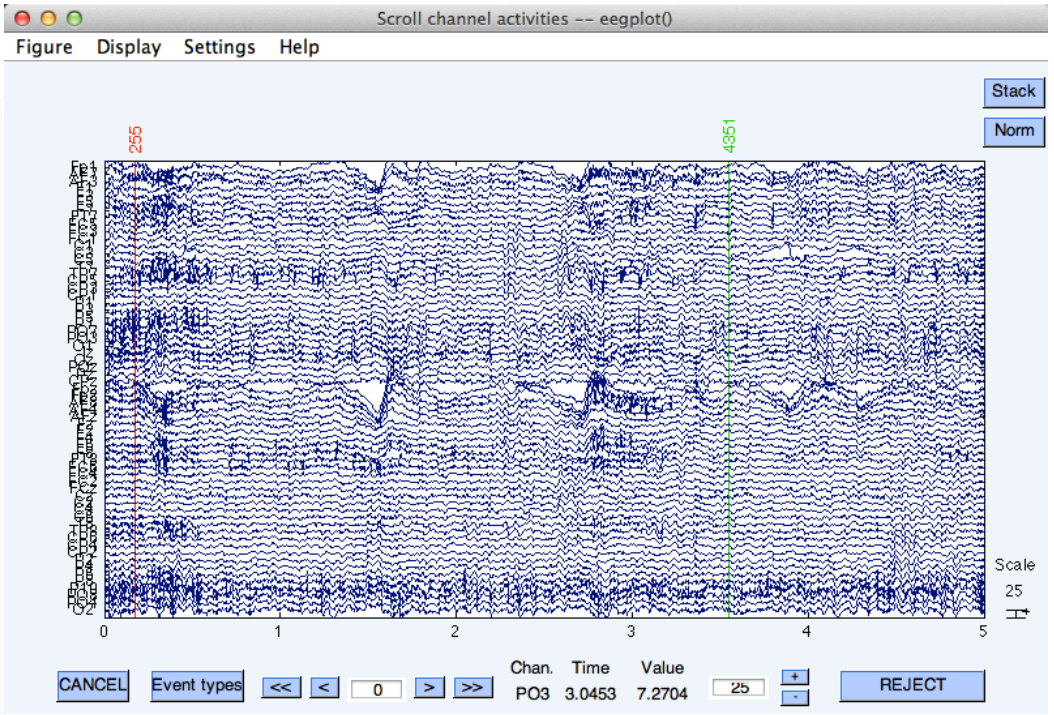
EEGLAB v13.x (dev)

File Edit Tools Plot Study Datasets Help

#1: Continuous EEG Data

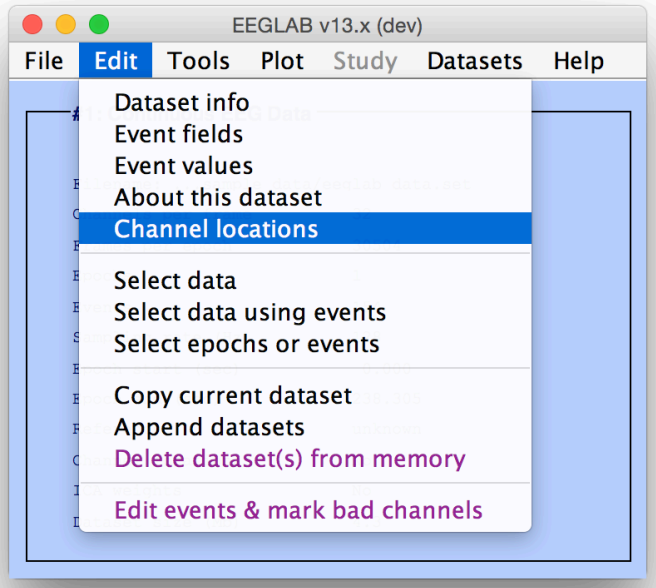
Filename: ...sample data/eeglab data.set	
Channels per frame	32
Frames per epoch	30504
Epochs	1
Events	154
Sampling rate (Hz)	128
Epoch start (sec)	0.000
Epoch end (sec)	238.305
Reference	unknown
Channel locations	No
ICA weights	No
Dataset size (Mb)	4.3

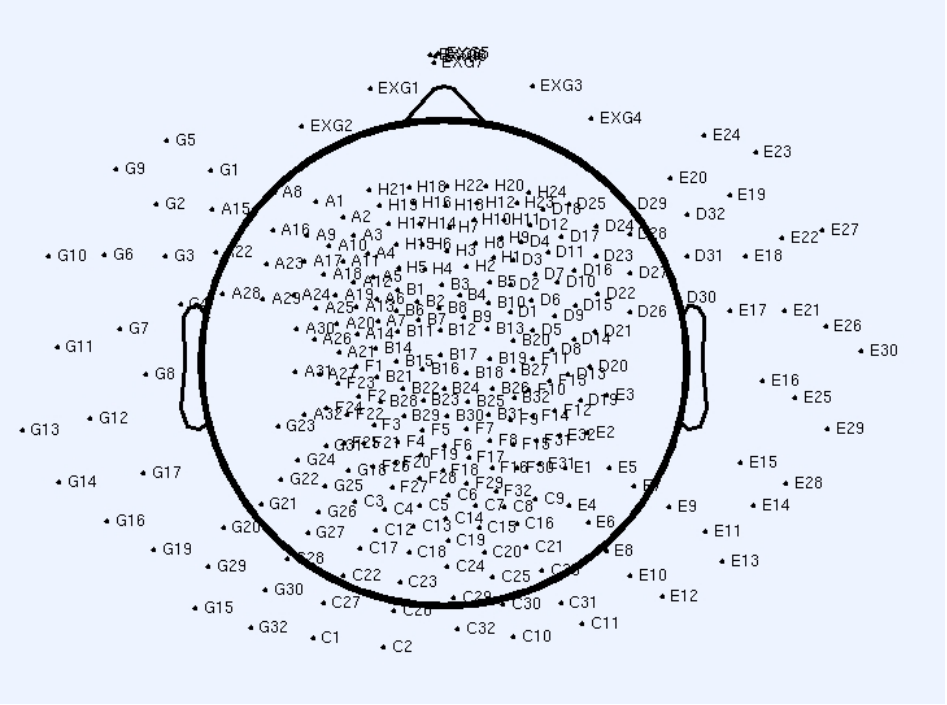
Scrolling data



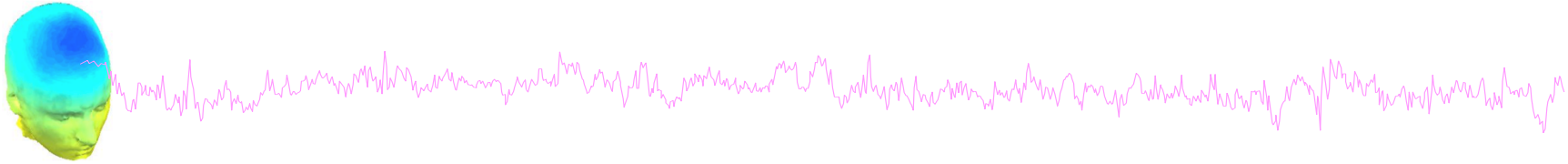
1. Importing channel location

Import channel location

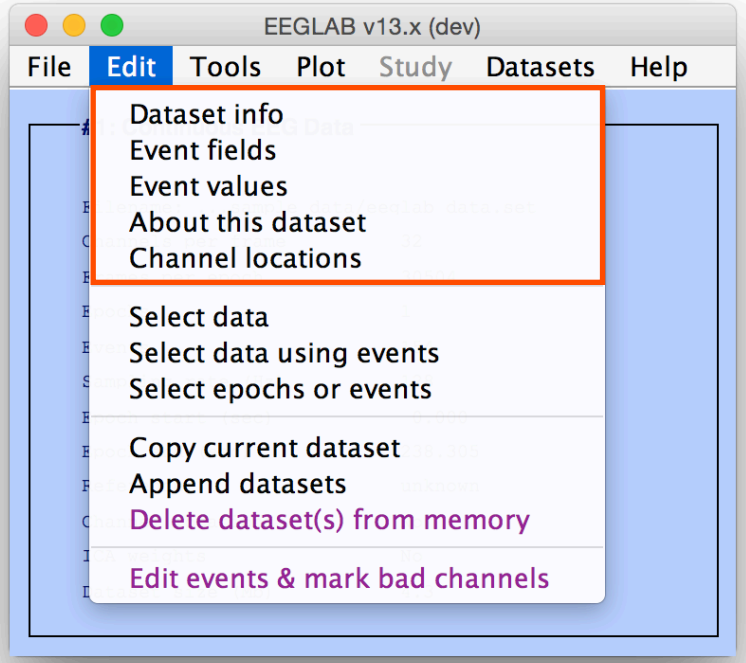




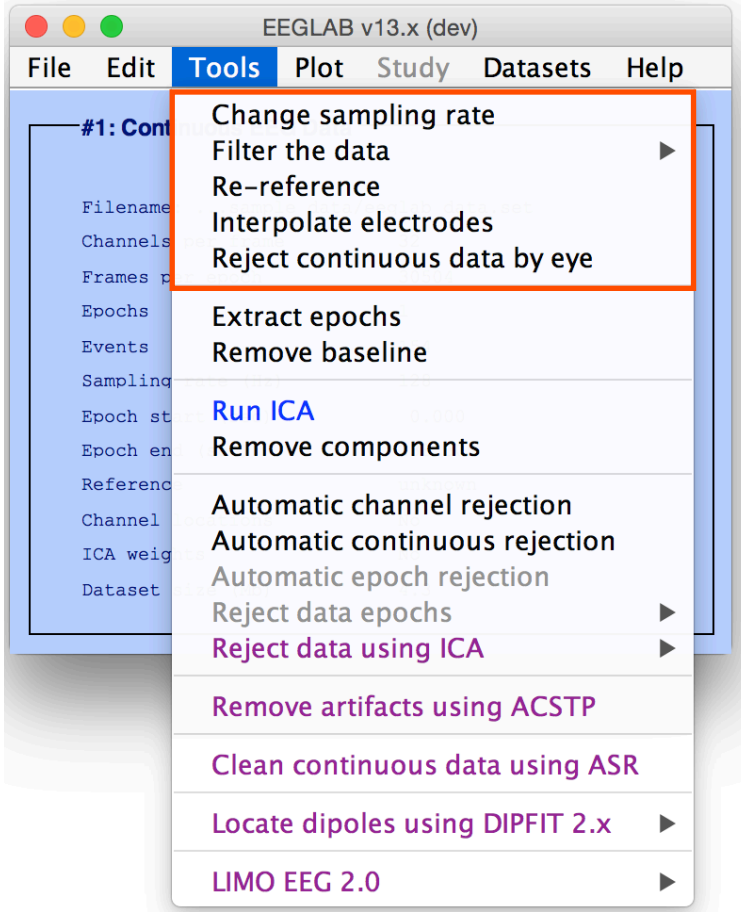
2. Edit, Re-reference, Resample, High pass filter data



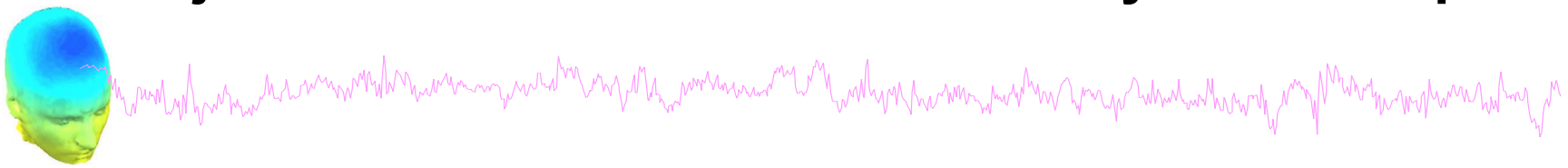
Edit/select data



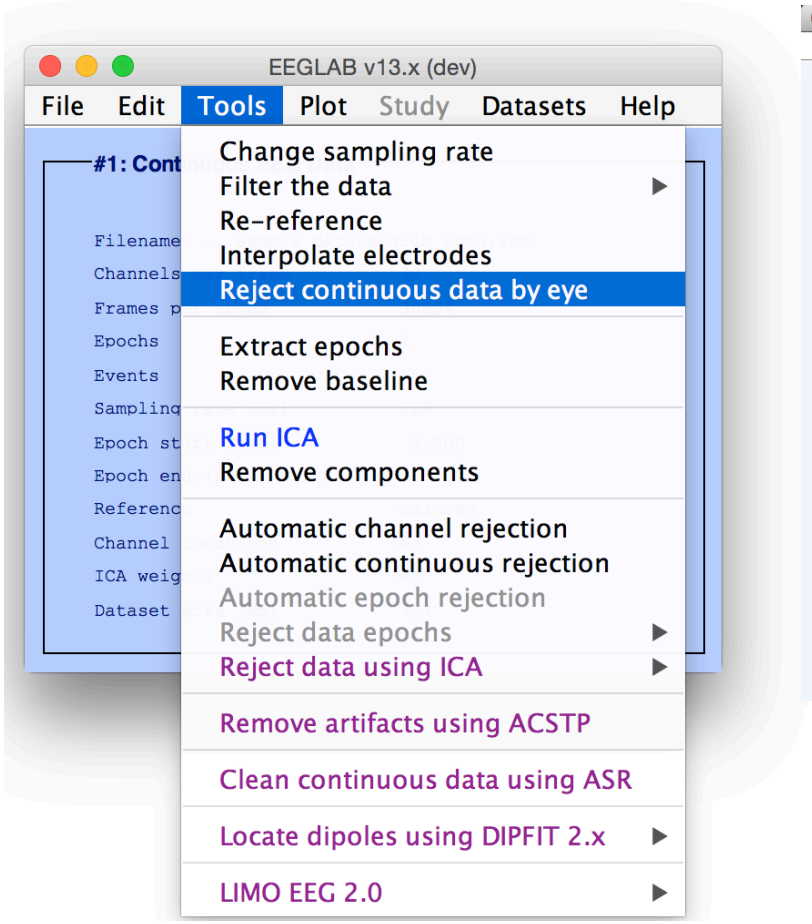
Preprocessing data

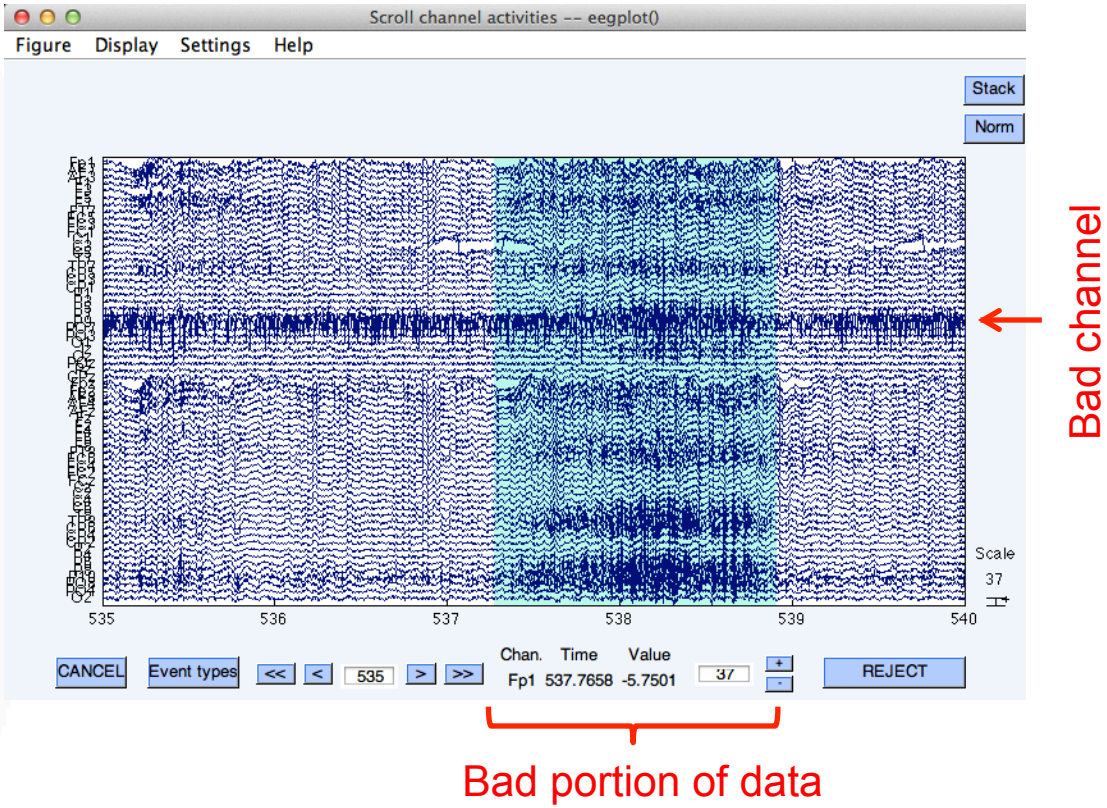


3. Reject artifacts in continuous data by visual inspection

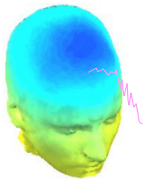


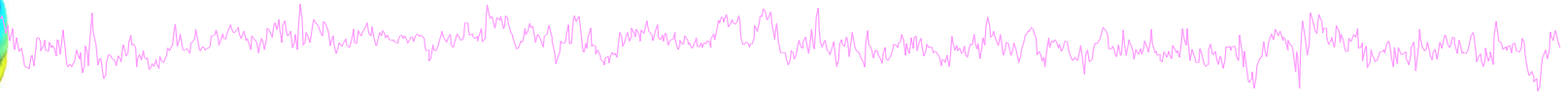
Reject portions of continuous data



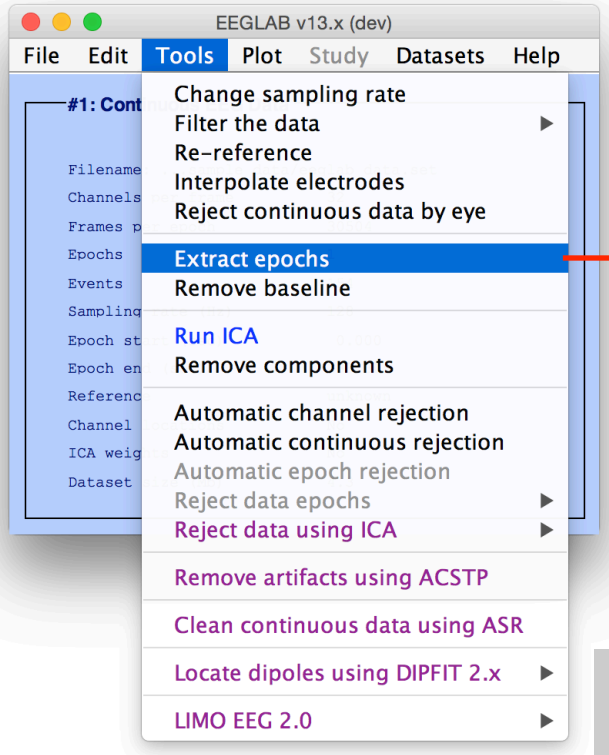


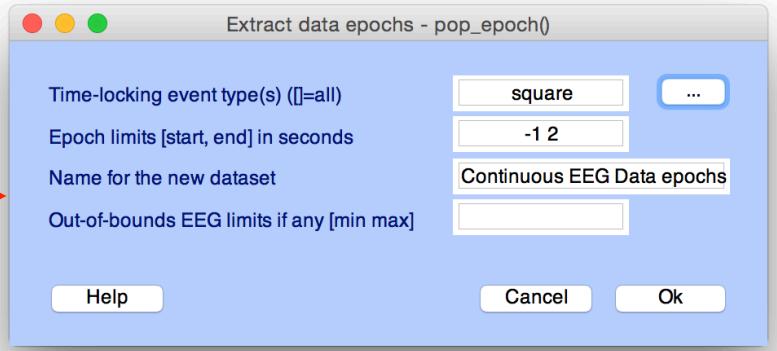
4. Extract epochs from data & reject artifactual epochs

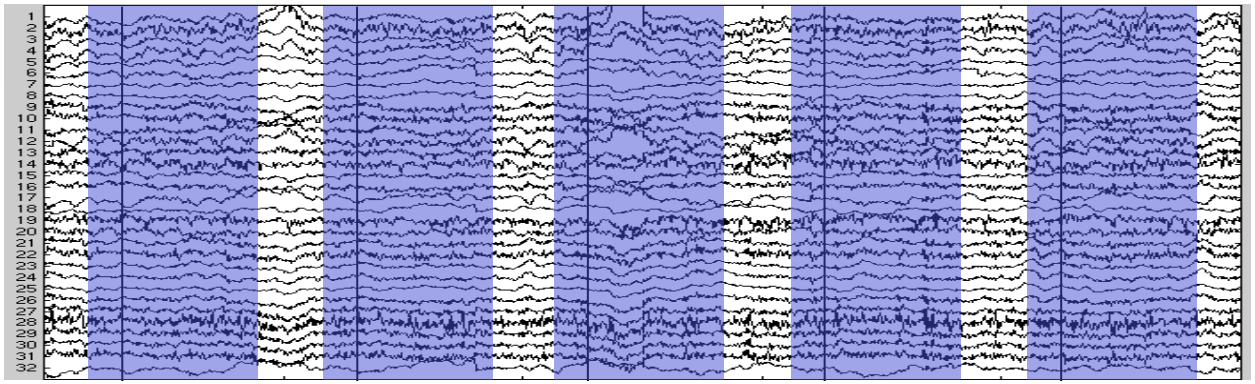




Preprocessing data







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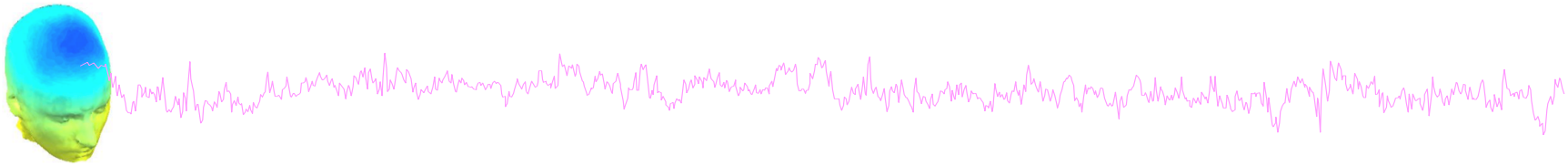
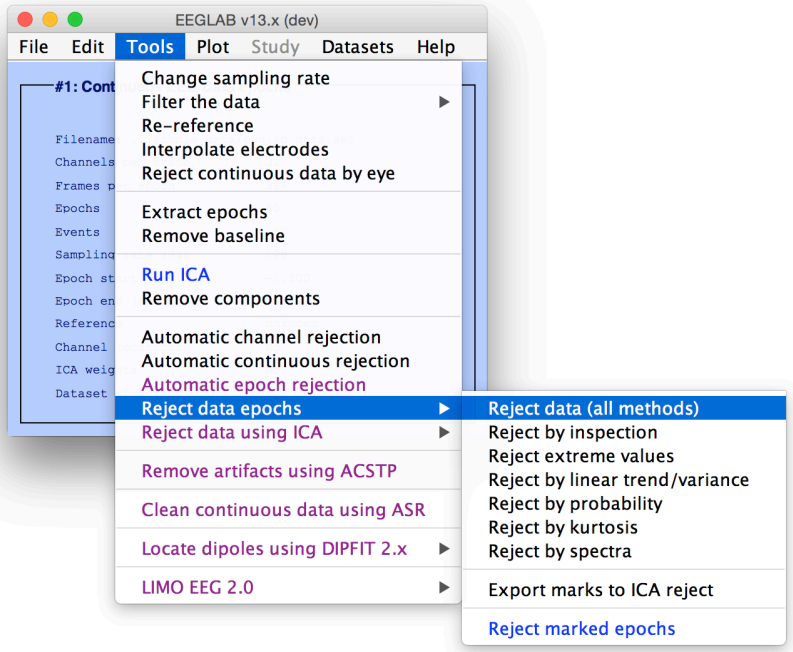
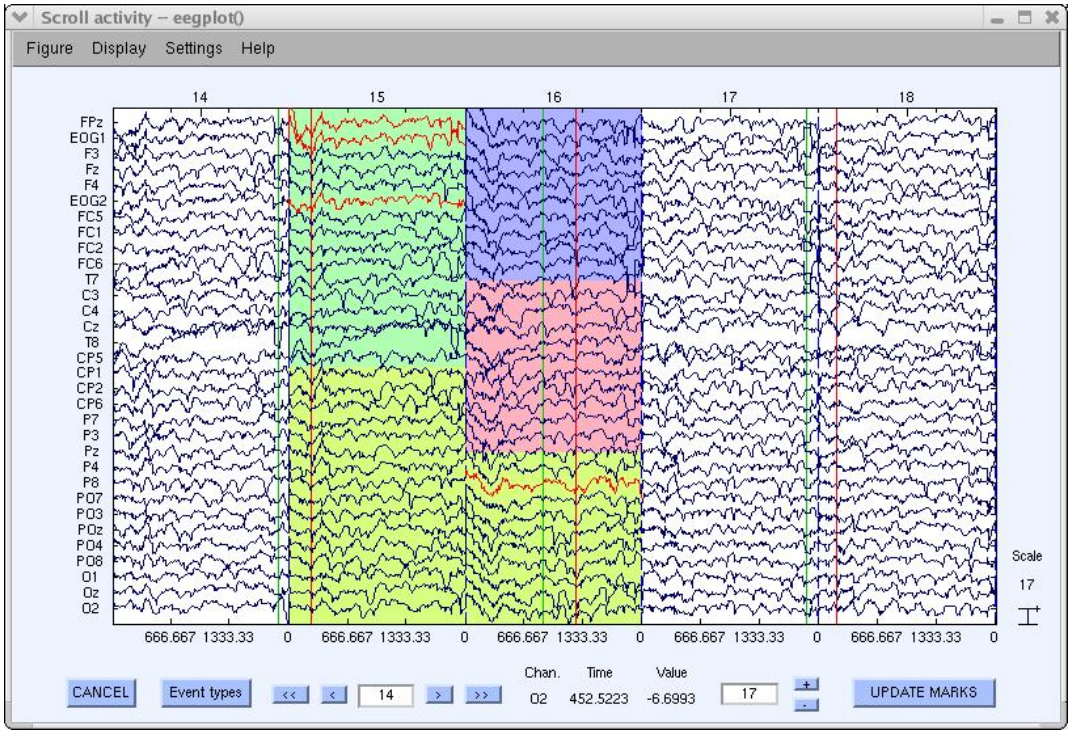
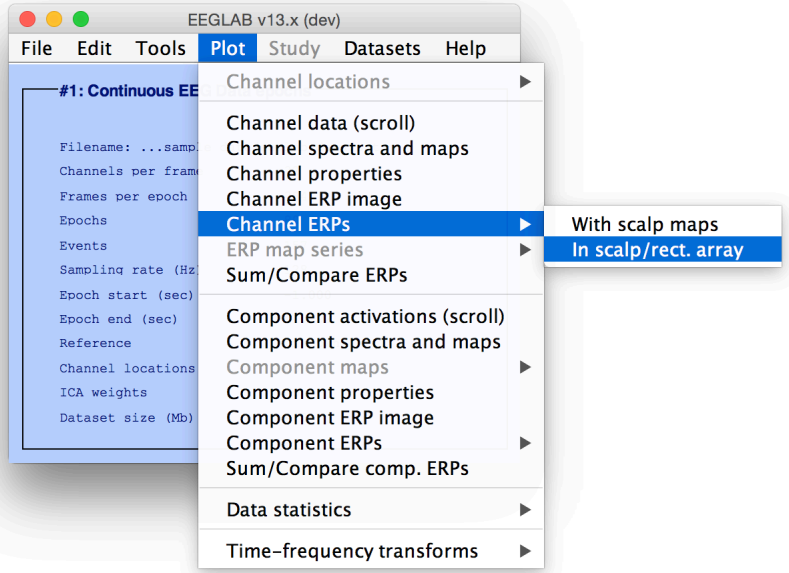




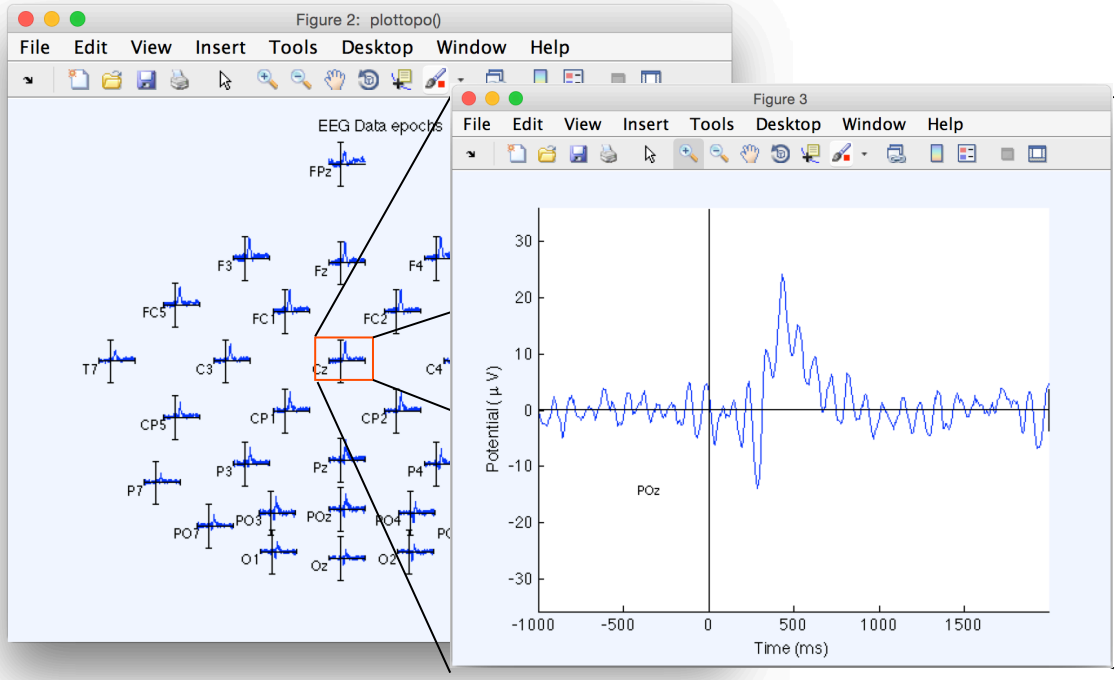
Different color = different rejection methods



5. Visualize data measures

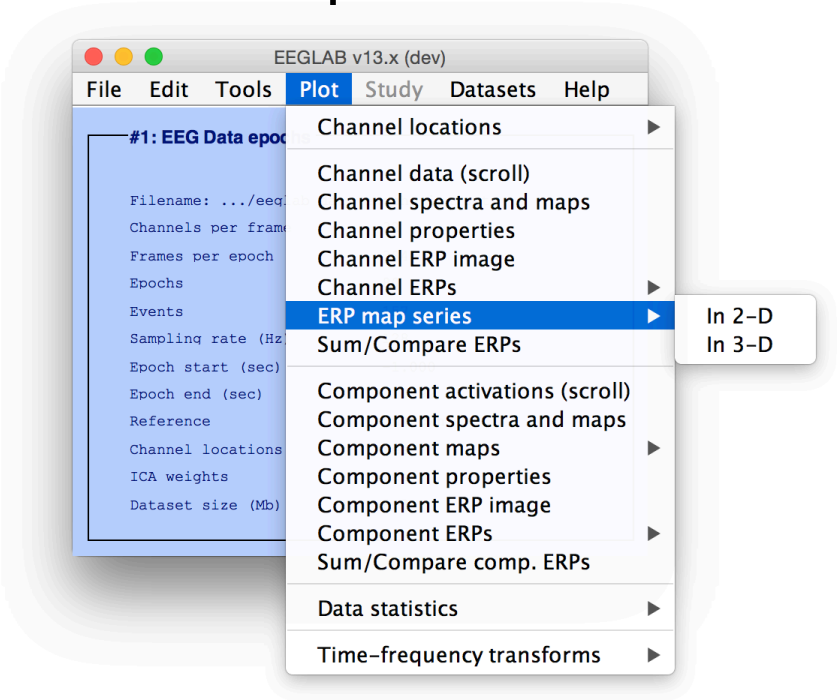


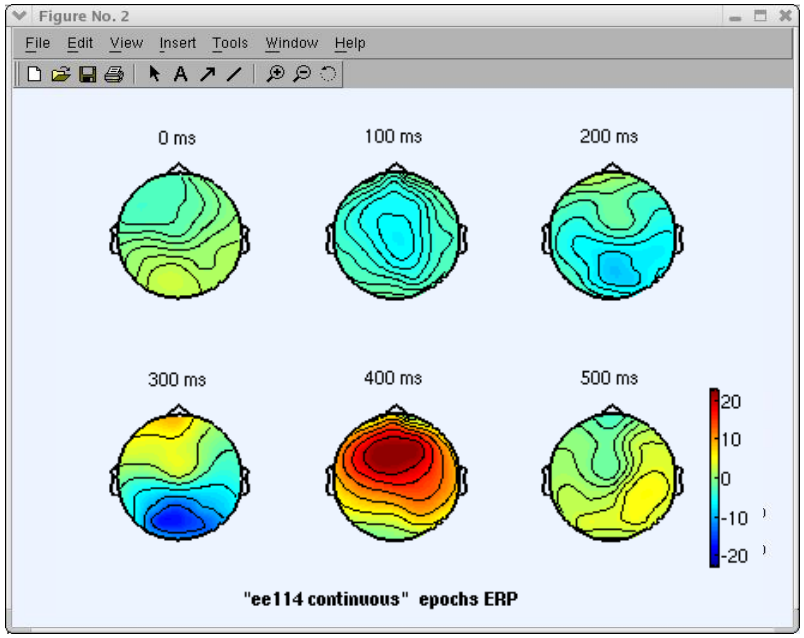
Plot ERP

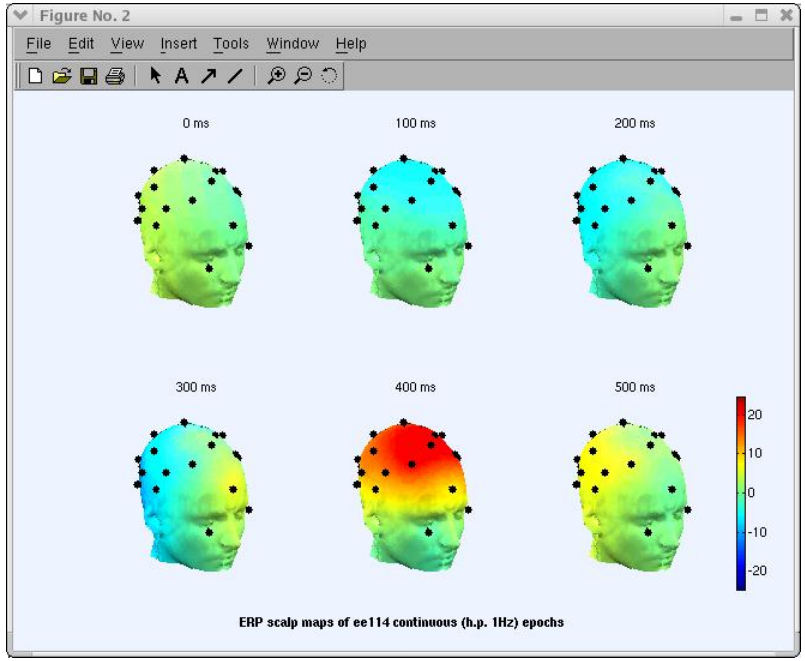


5. Visualize data measures

Plot ERP
map series







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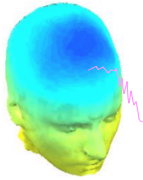
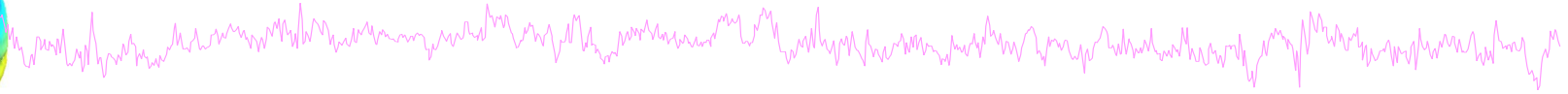
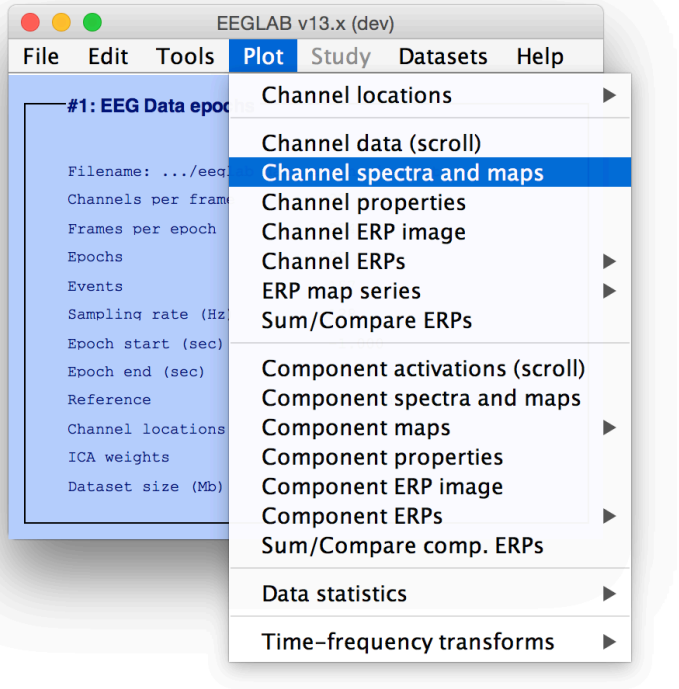
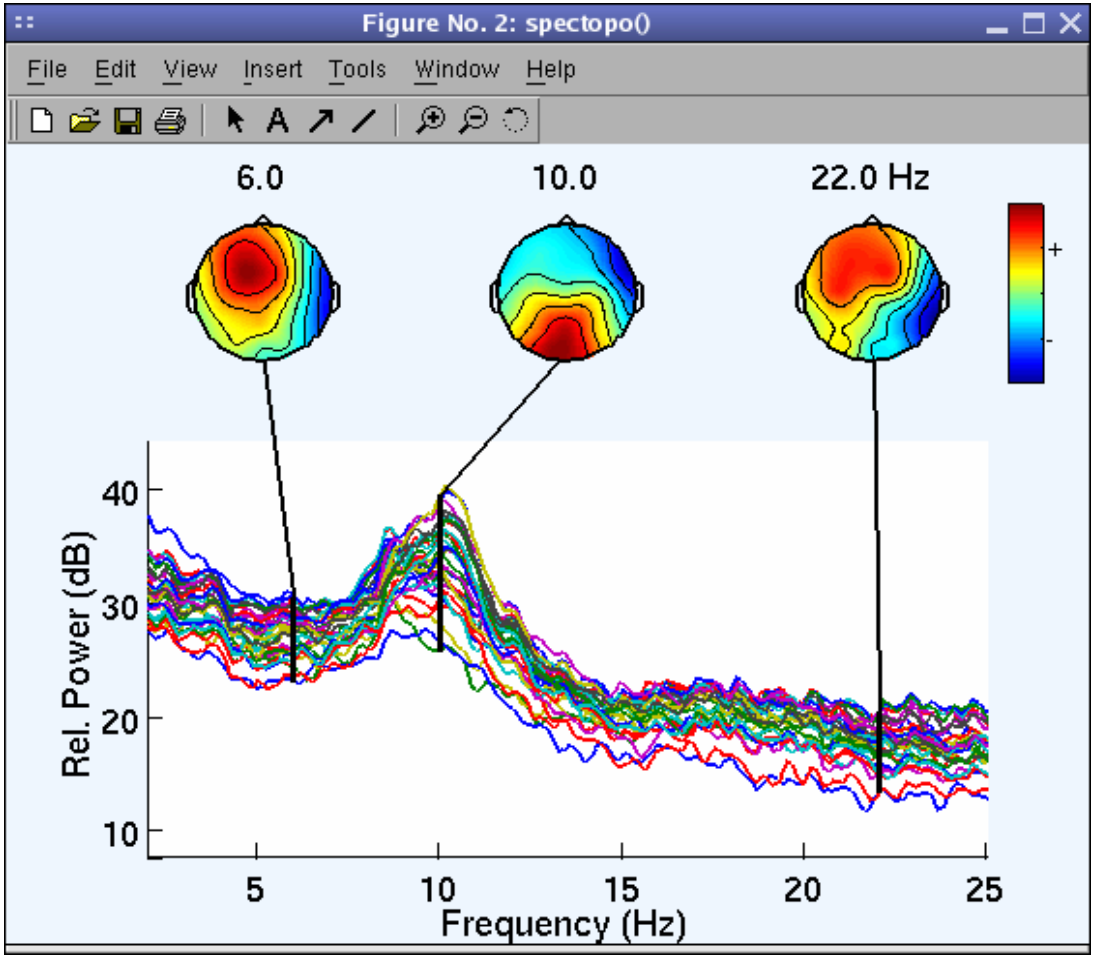




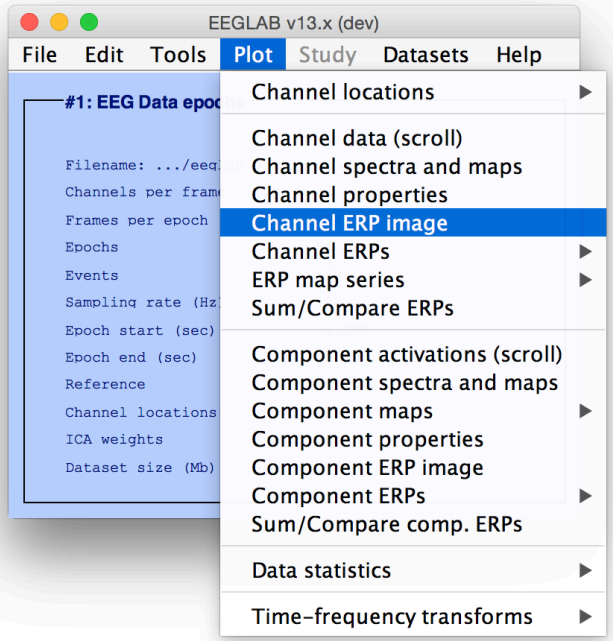
Plot data spectrum and maps

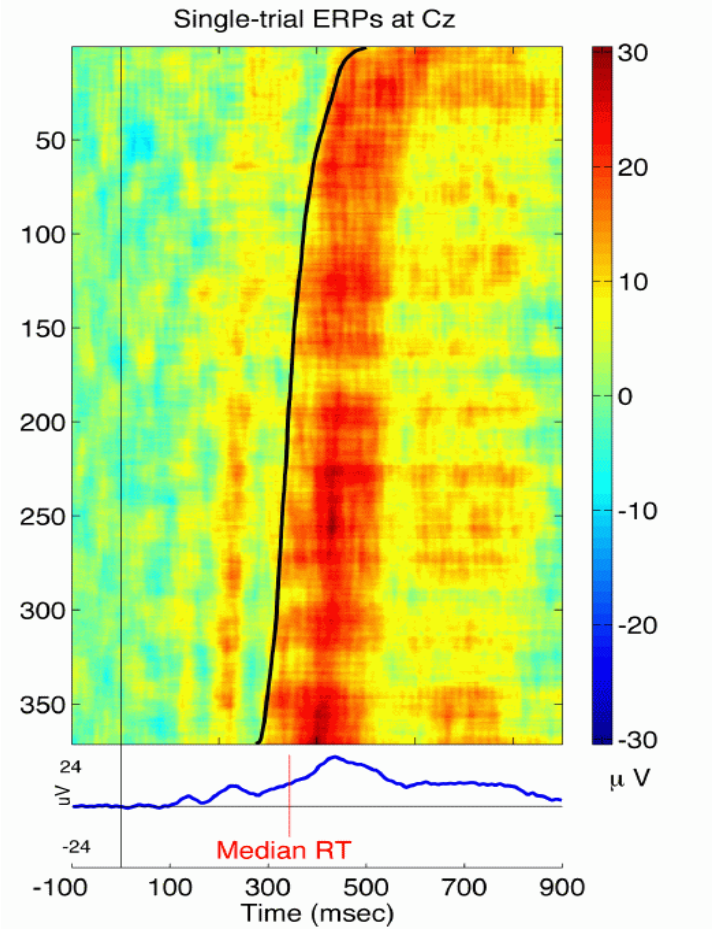




5. Visualize data measures

Plot channel ERPimage





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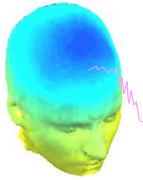

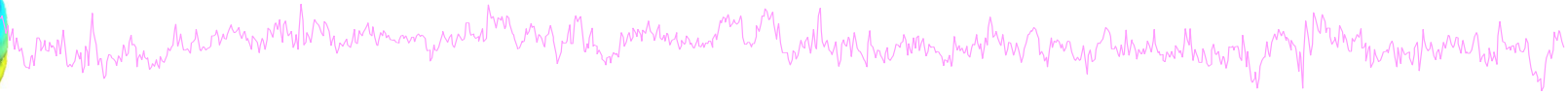

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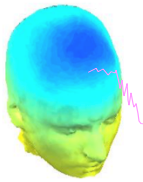
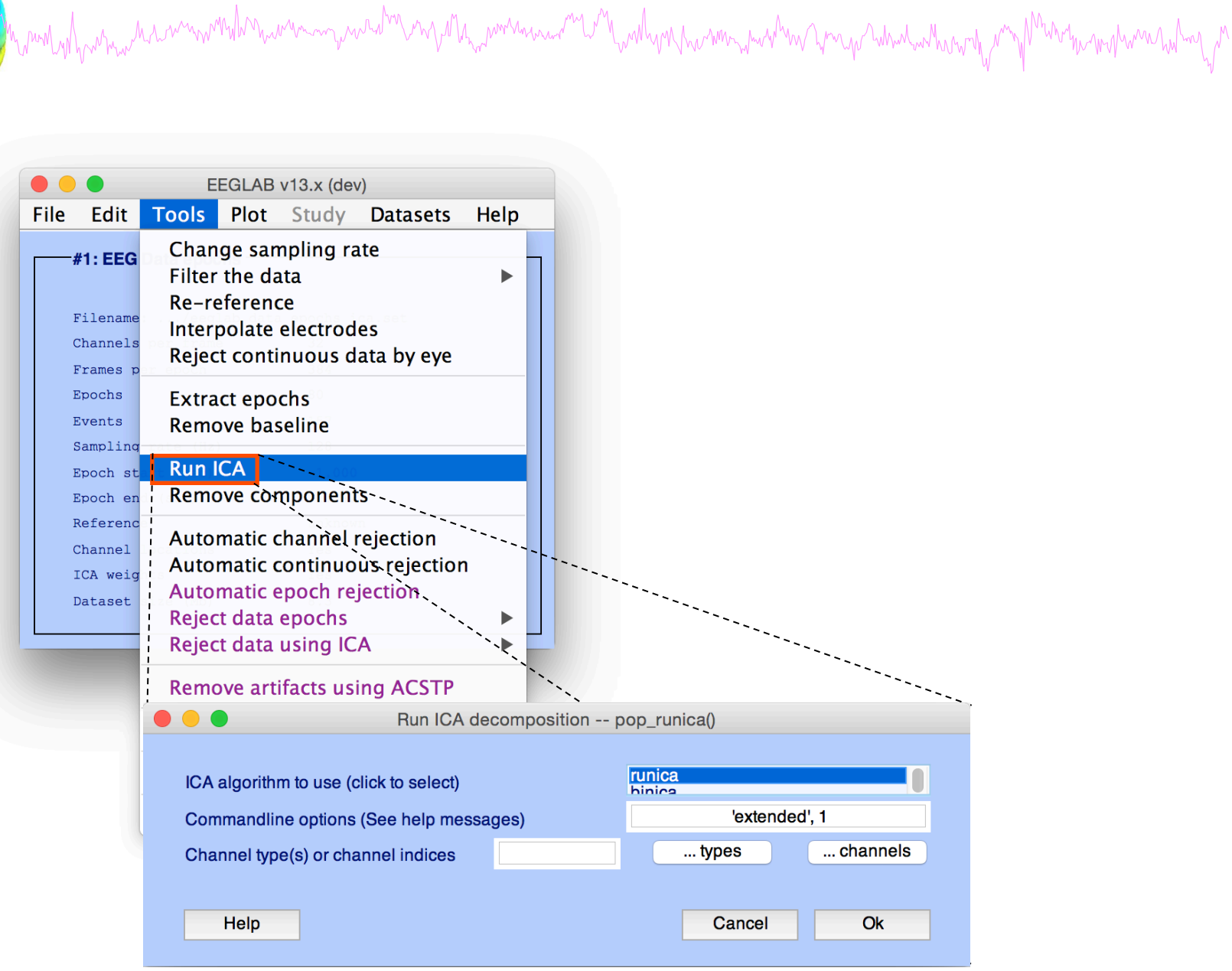
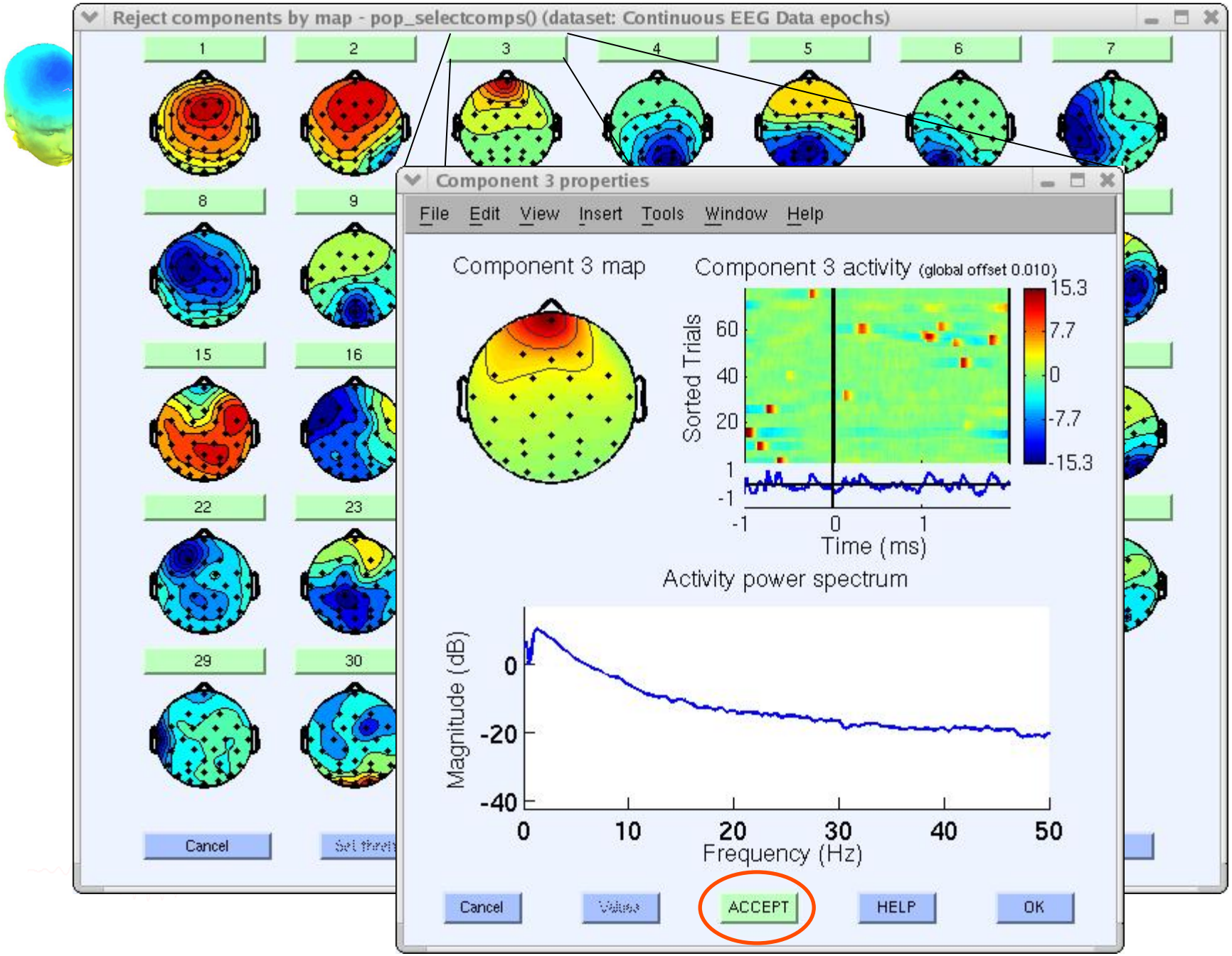
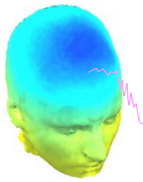
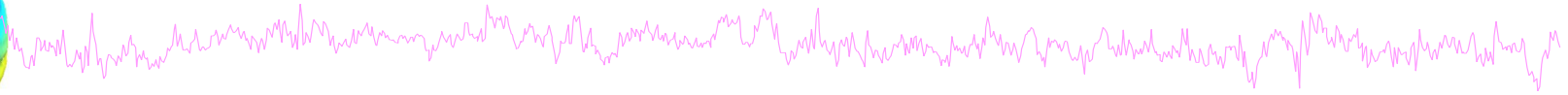


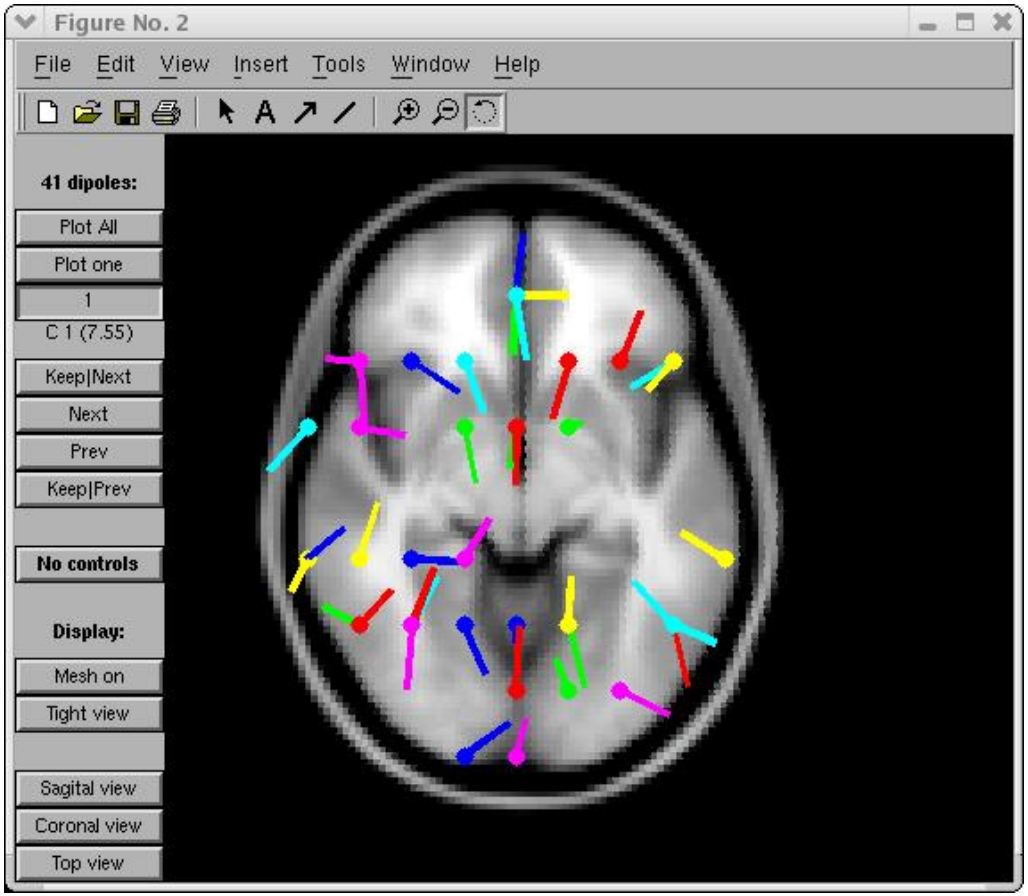


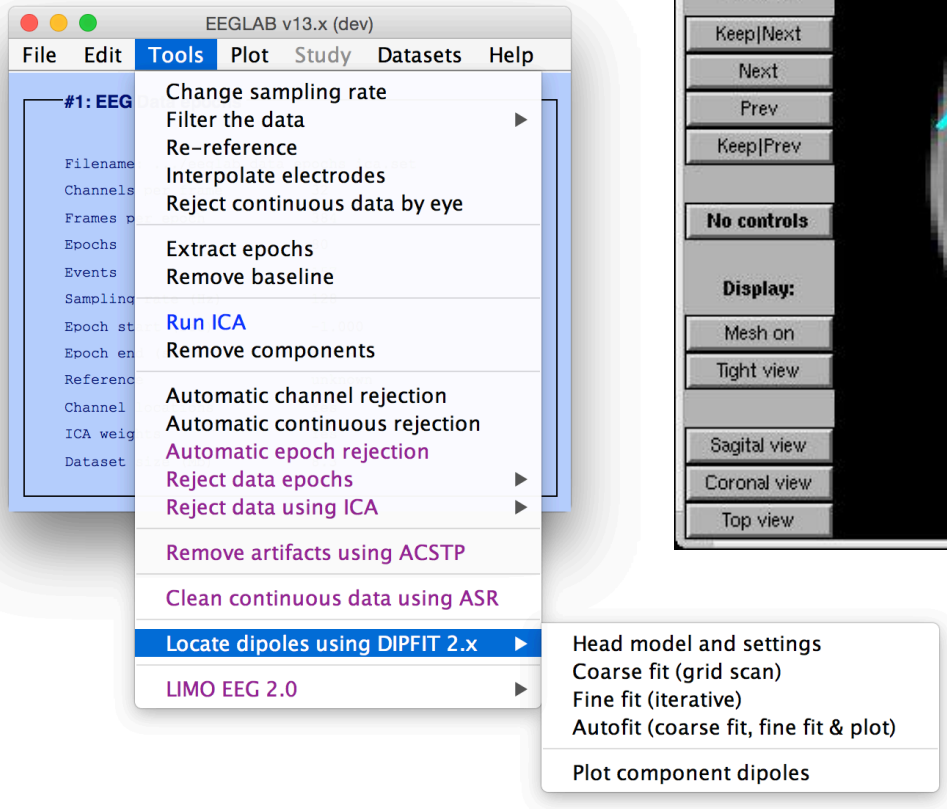

Reject components by map - pop_selectcomps() (dataset: Continuous EEG Data epochs)
1
2
3
4
5
6
7
8
9
15
16
22
23
29
30
Cancel
Component 3 properties
File Edit View Insert Tools Window Help
Component 3 map
Component 3 activity (global offset 0.010)
Sorted Trials
60
40
20
1
-1
15.3
7.7
0
-7.7
-15.3
-1
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









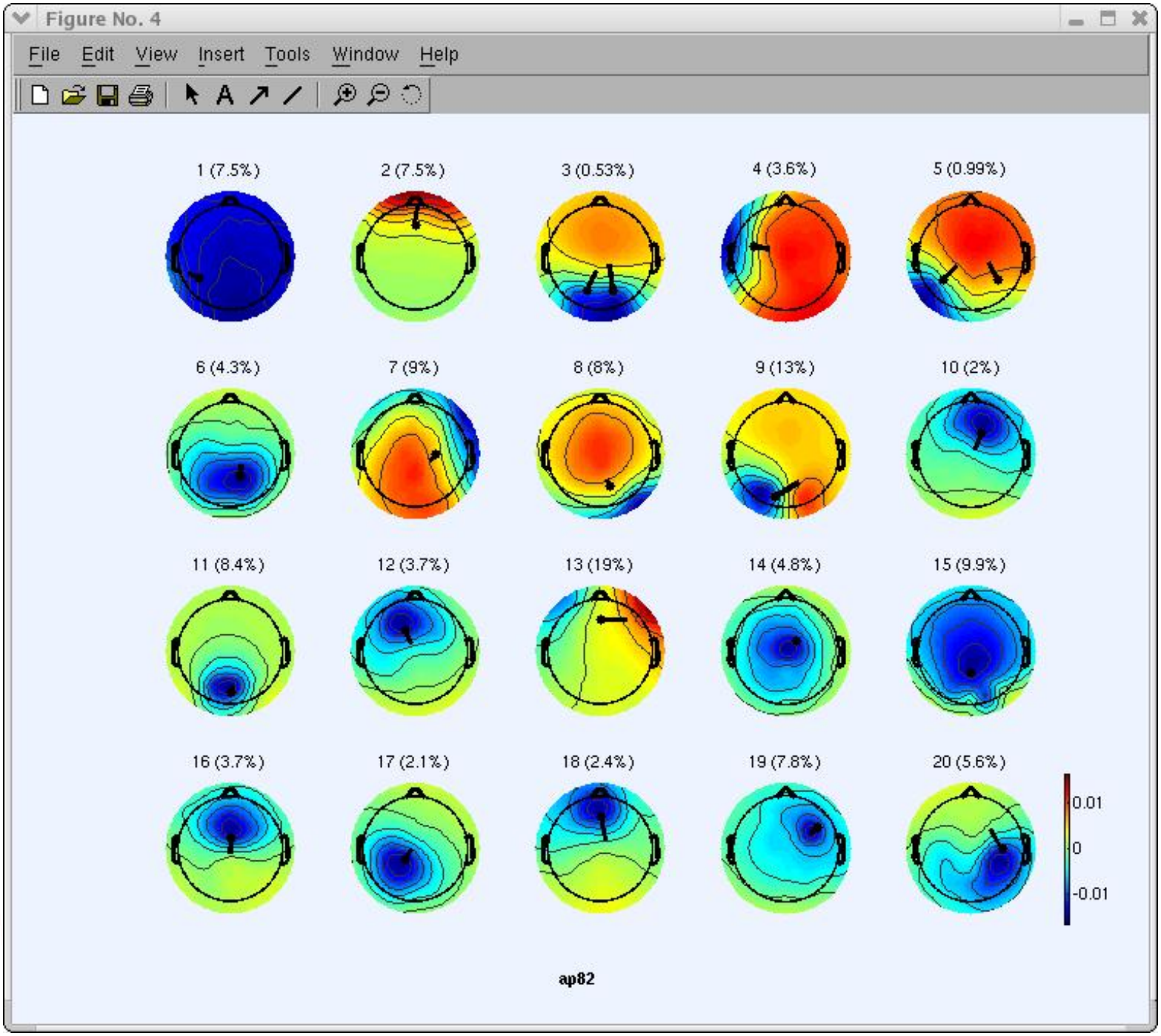
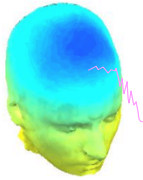
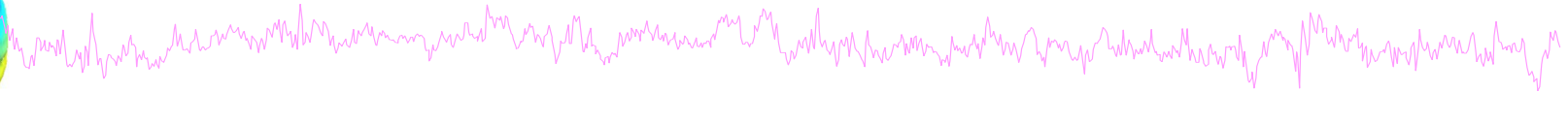
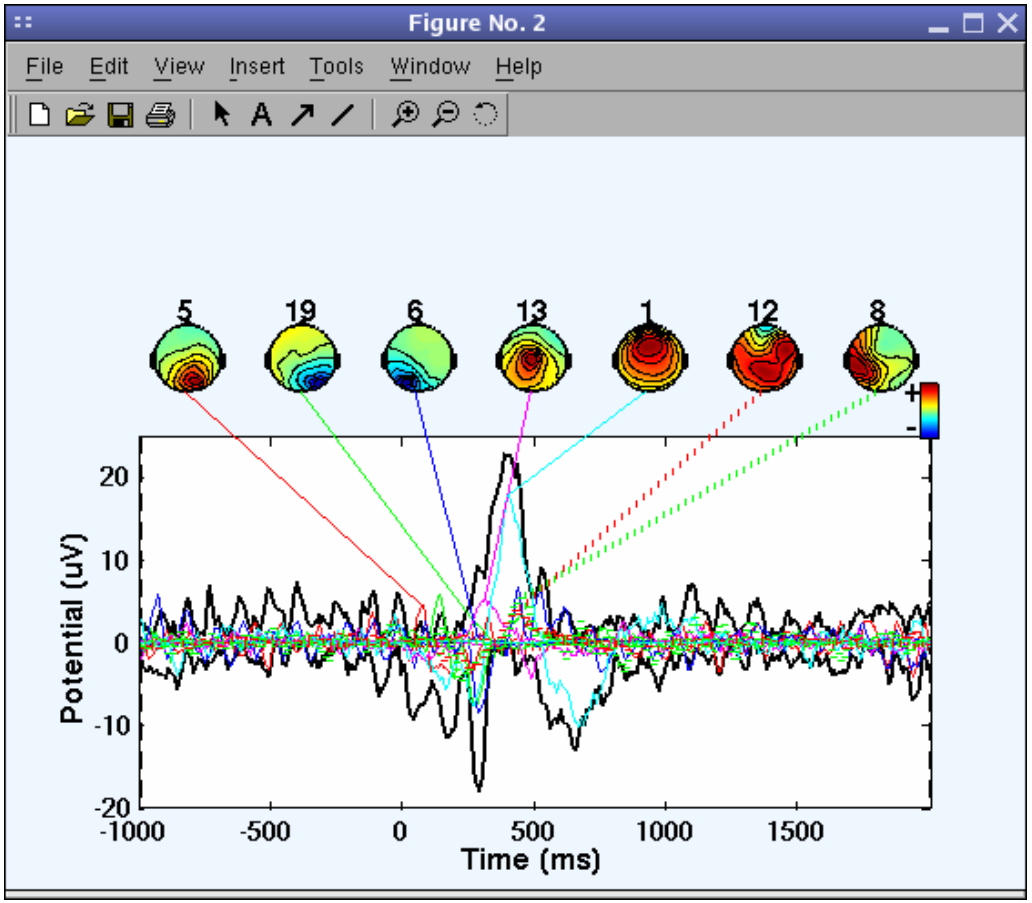


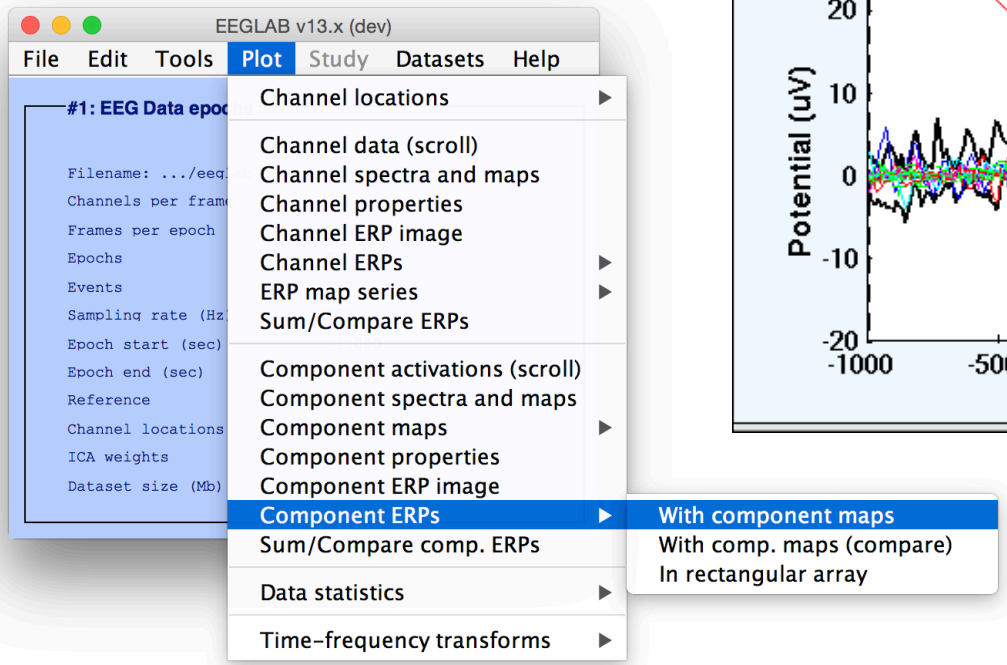
Figure No. 4
File Edit View Insert Tools Window Help
1 (7.5%)
2 (7.5%)
3 (0.53%)
4 (3.6%)
5 (0.99%)
6 (4.3%)
7 (9%)
8 (8%)
9 (13%)
10 (2%)
11 (8.4%)
12 (3.7%)
13 (19%)
14 (4.8%)
15 (9.9%)
16 (3.7%)
17 (2.1%)
18 (2.4%)
19 (7.8%)
20 (5.6%)
0.01
0
-0.01
ap82

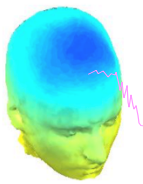
Component contribution to the ERP



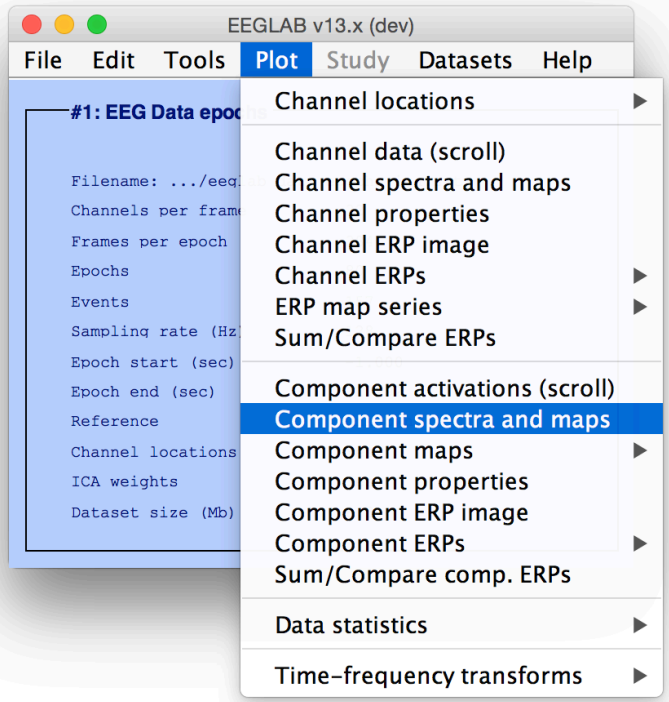


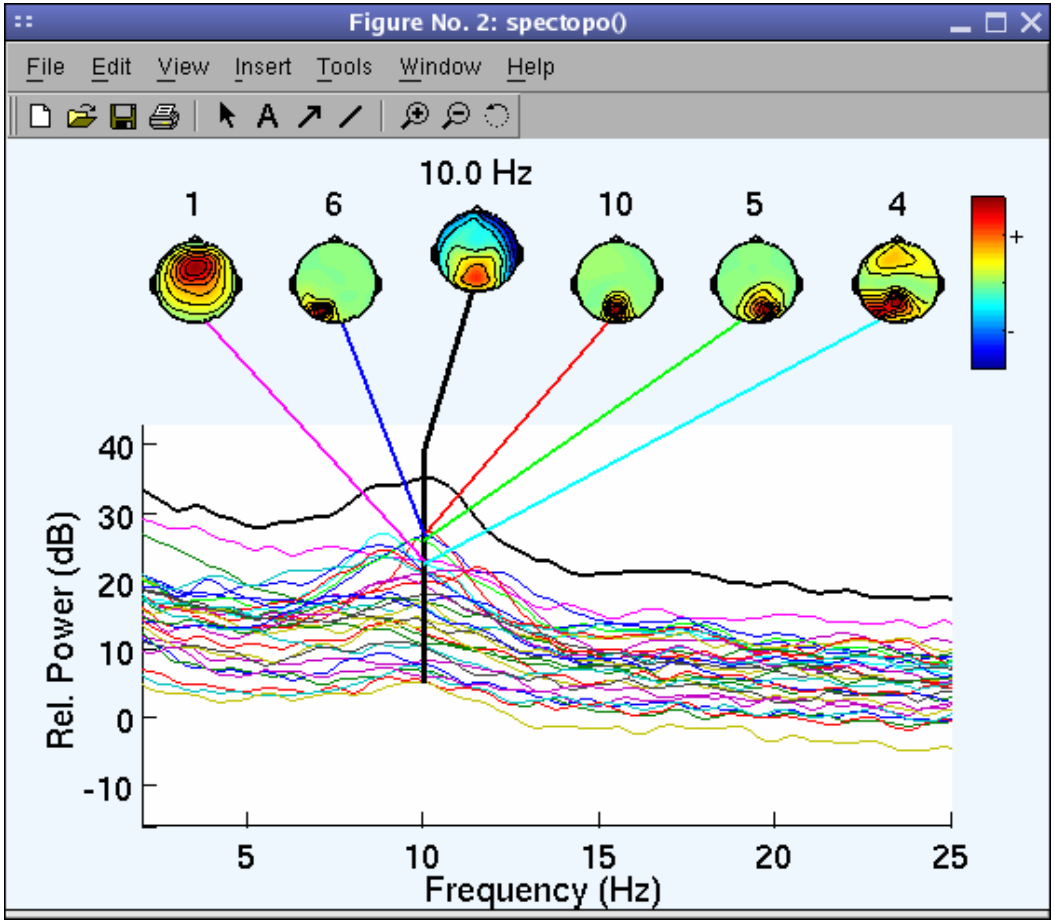




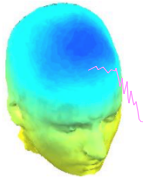


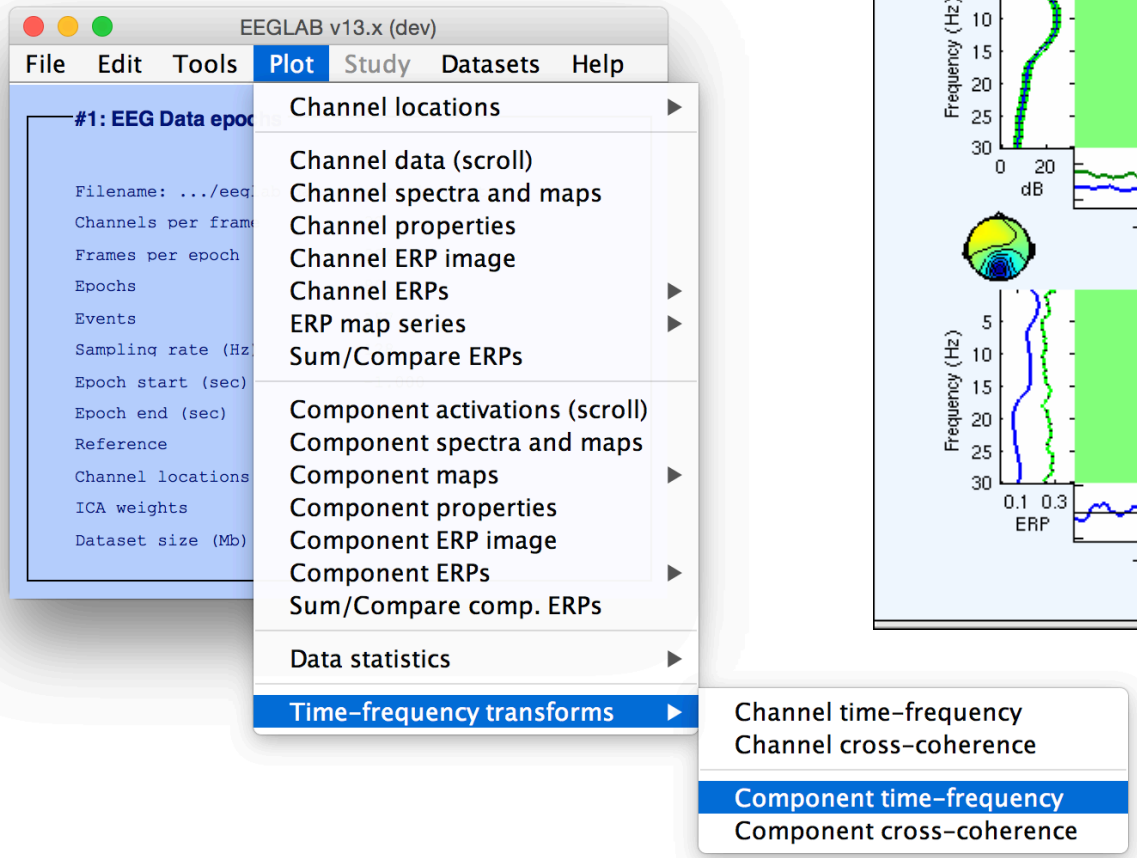
Component contribution to the EEG spectrum

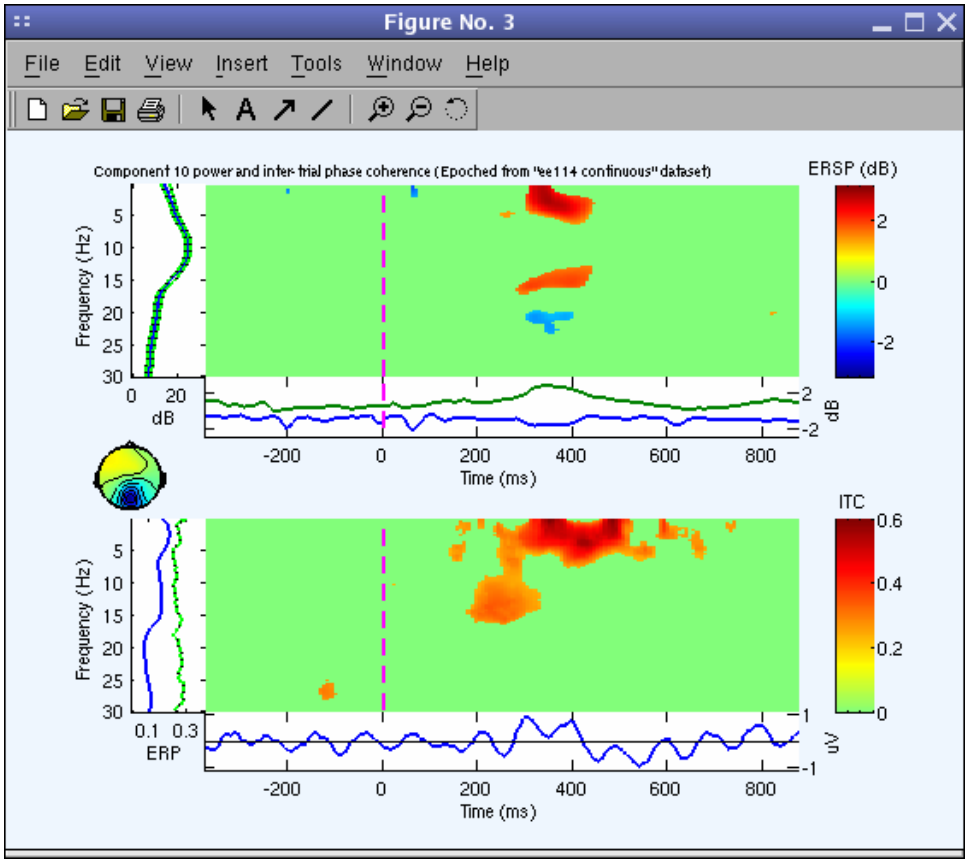




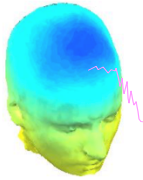
Component time-frequency

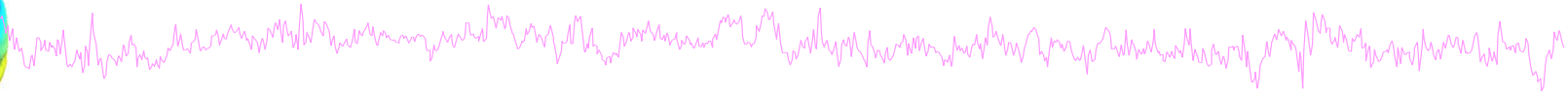






EEGLAB standard processing pipeline





Single subject

1. Import binary data, events and channel location
2. Edit, Re-reference, Resample, High pass filter data
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4. Extract epochs from data & reject artifactual epochs
5. Visualize data measures
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   - Perform source localization of components
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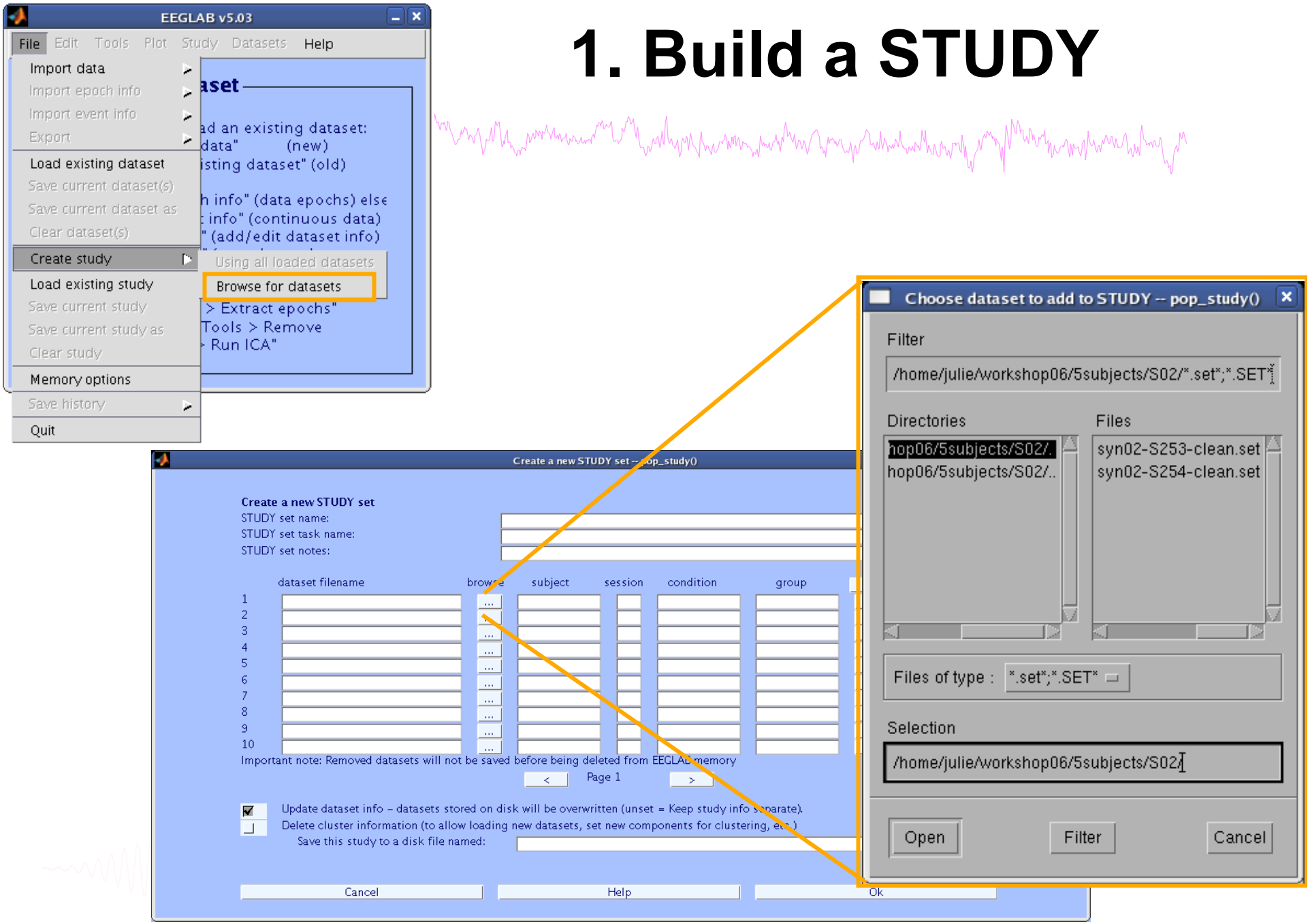
   - Analyze components contribution to spectrum

Multi-subjects

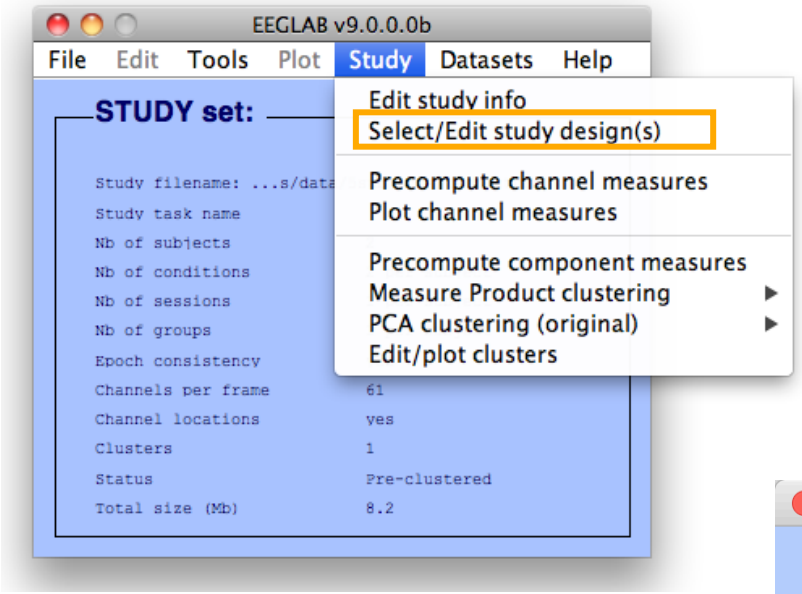
1. Build study and STUDY design
2. Pre-compute measures
3. Cluster components
4. Analyze clusters

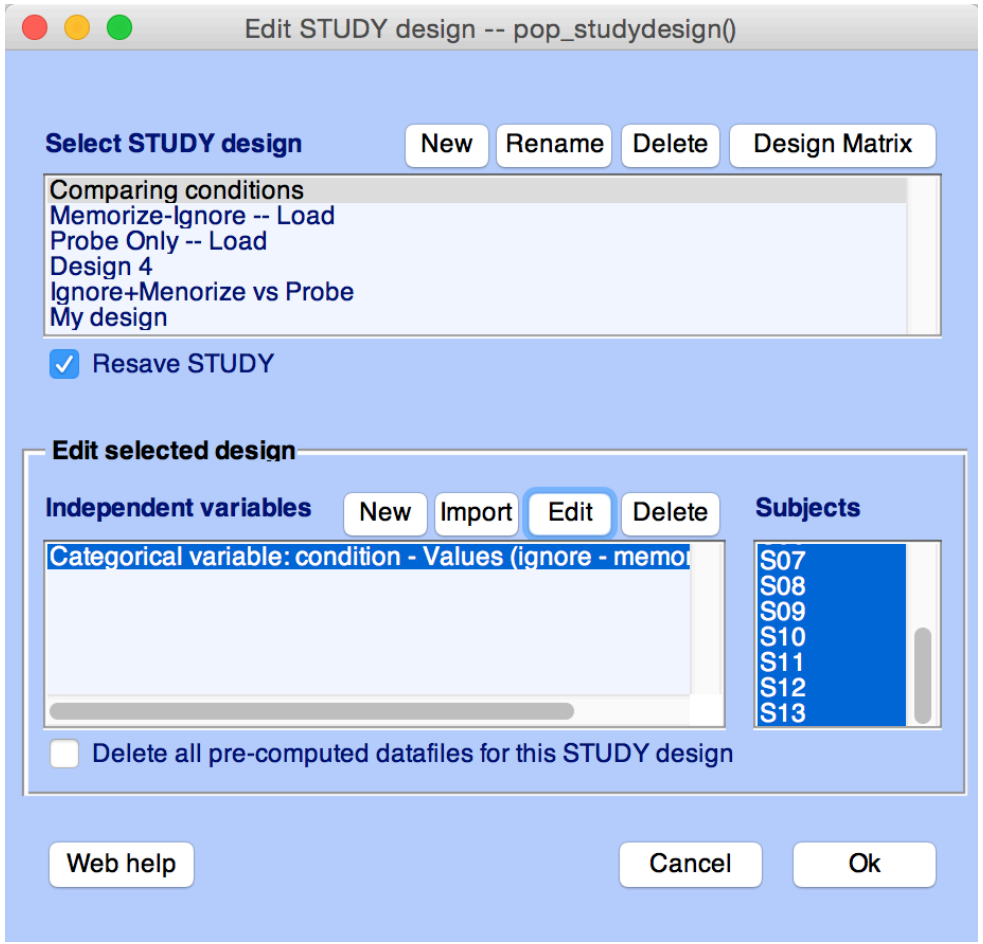
Advanced analysis using scripting and EEGLAB command line functions

1. Build a STUDY

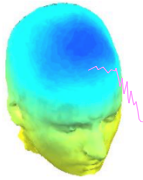


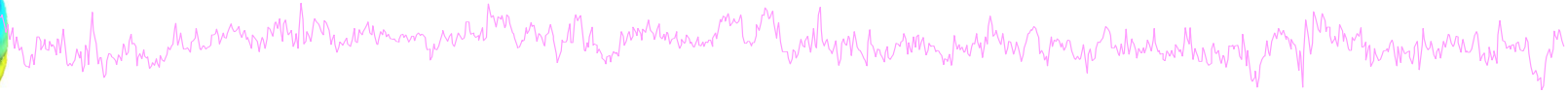
:dit STUDY design



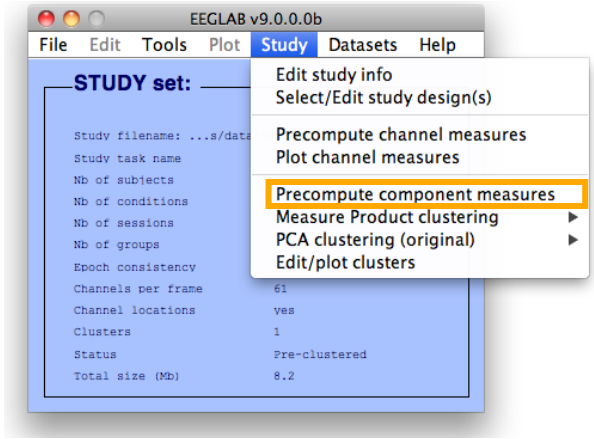


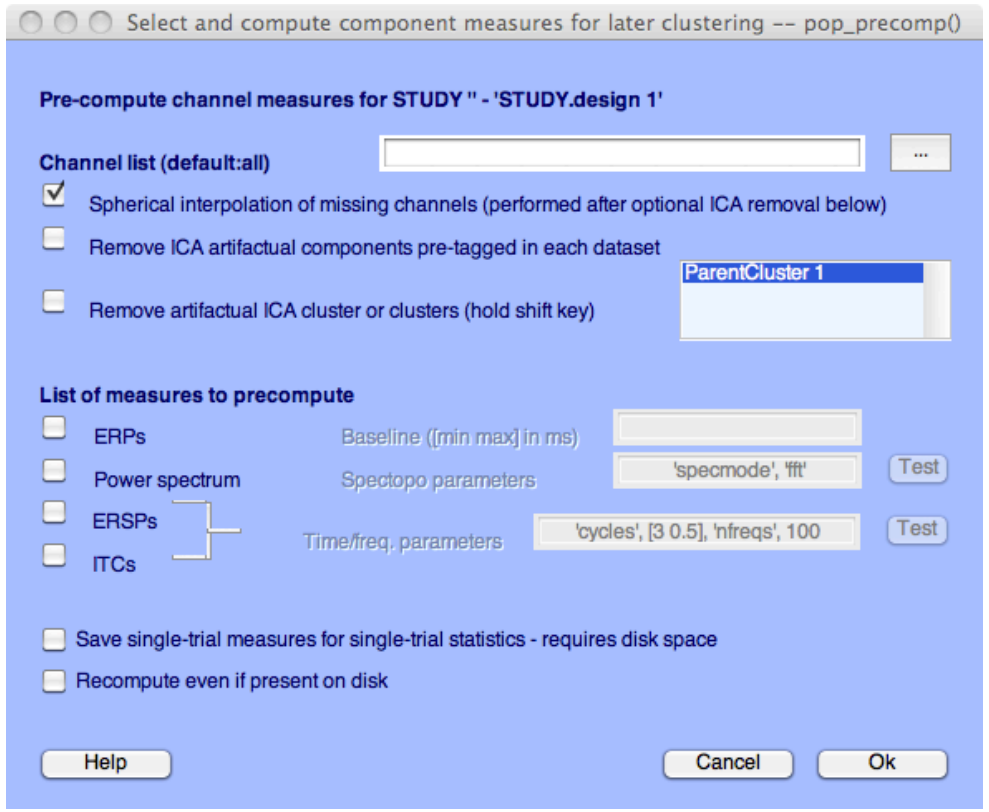
2. Pre-compute measures



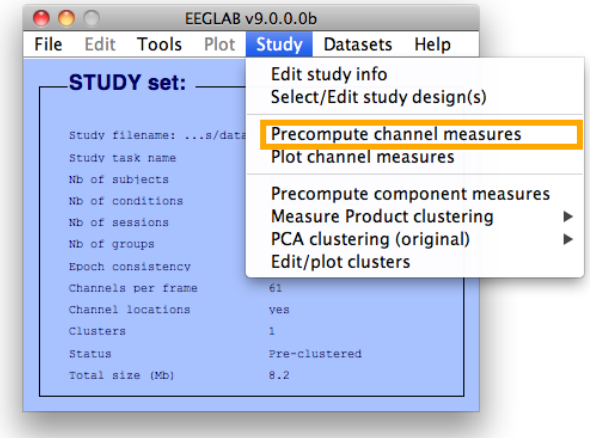


Components

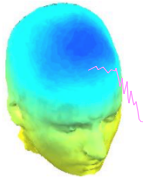


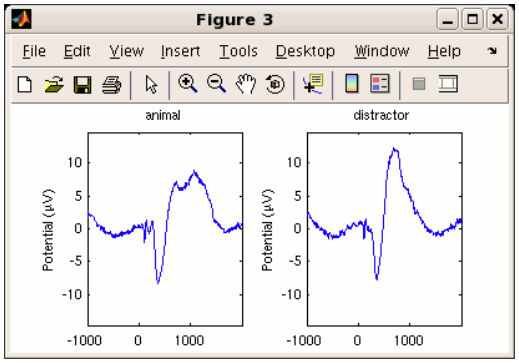


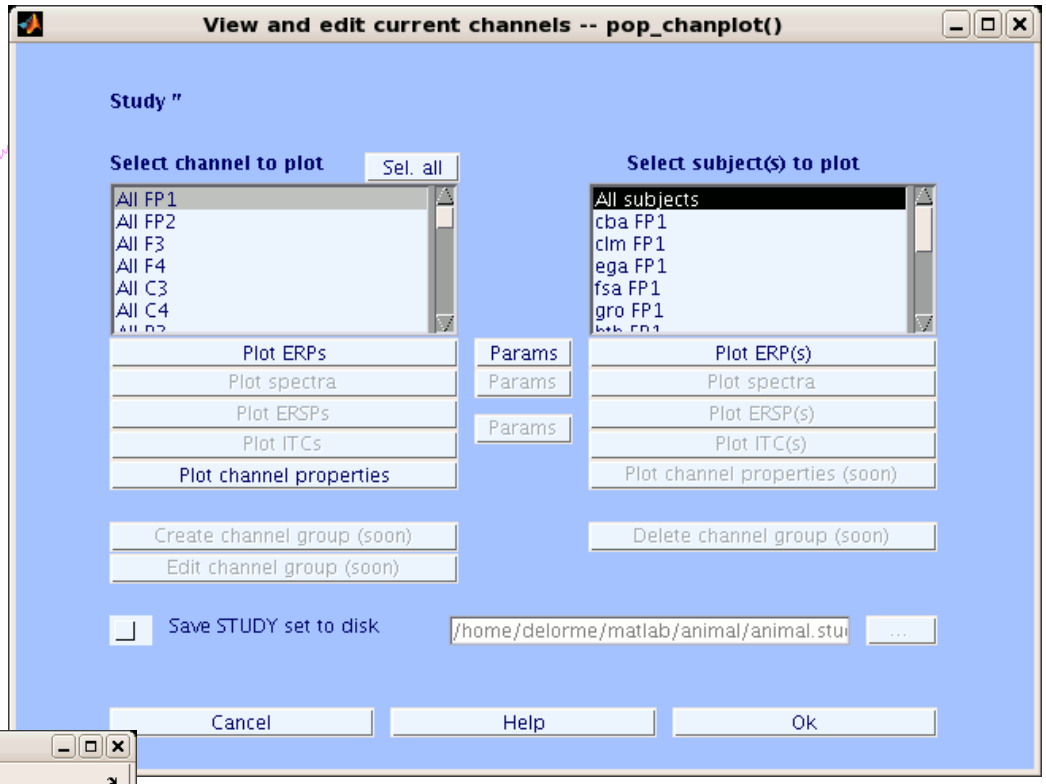
Channels

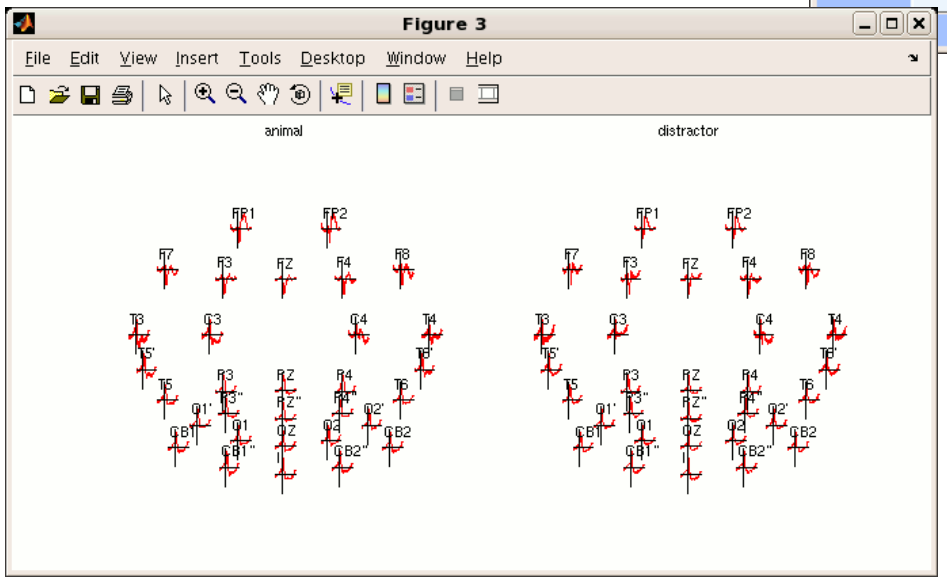


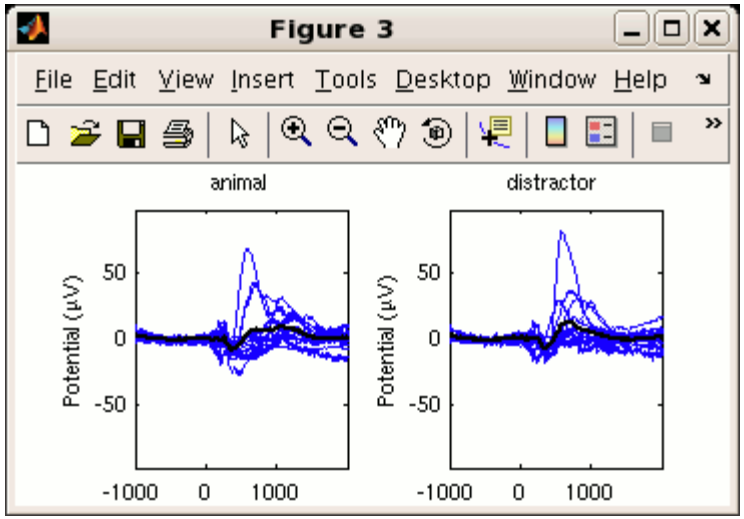
Channel plotting



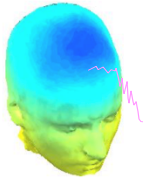


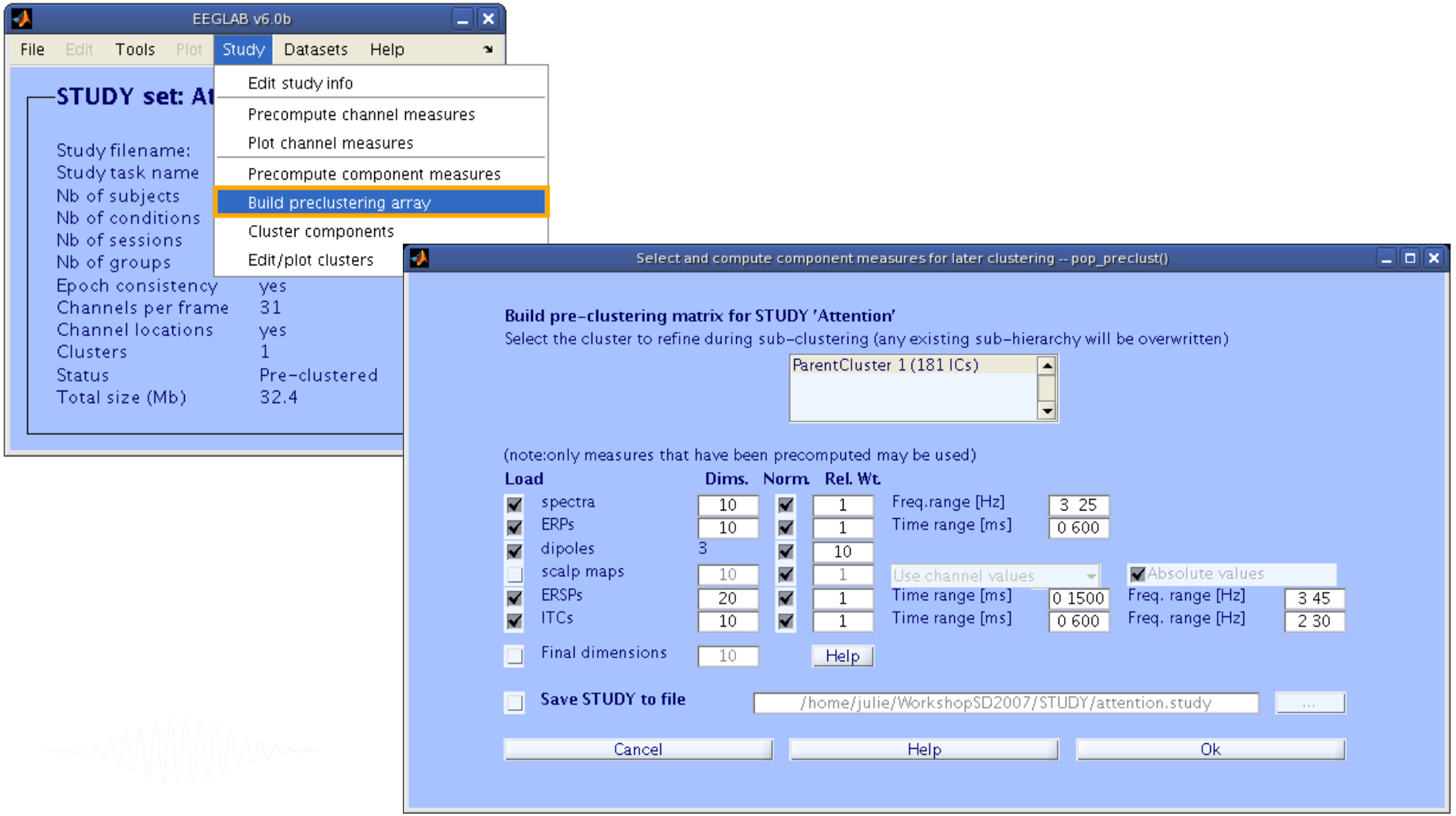




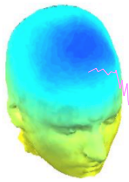


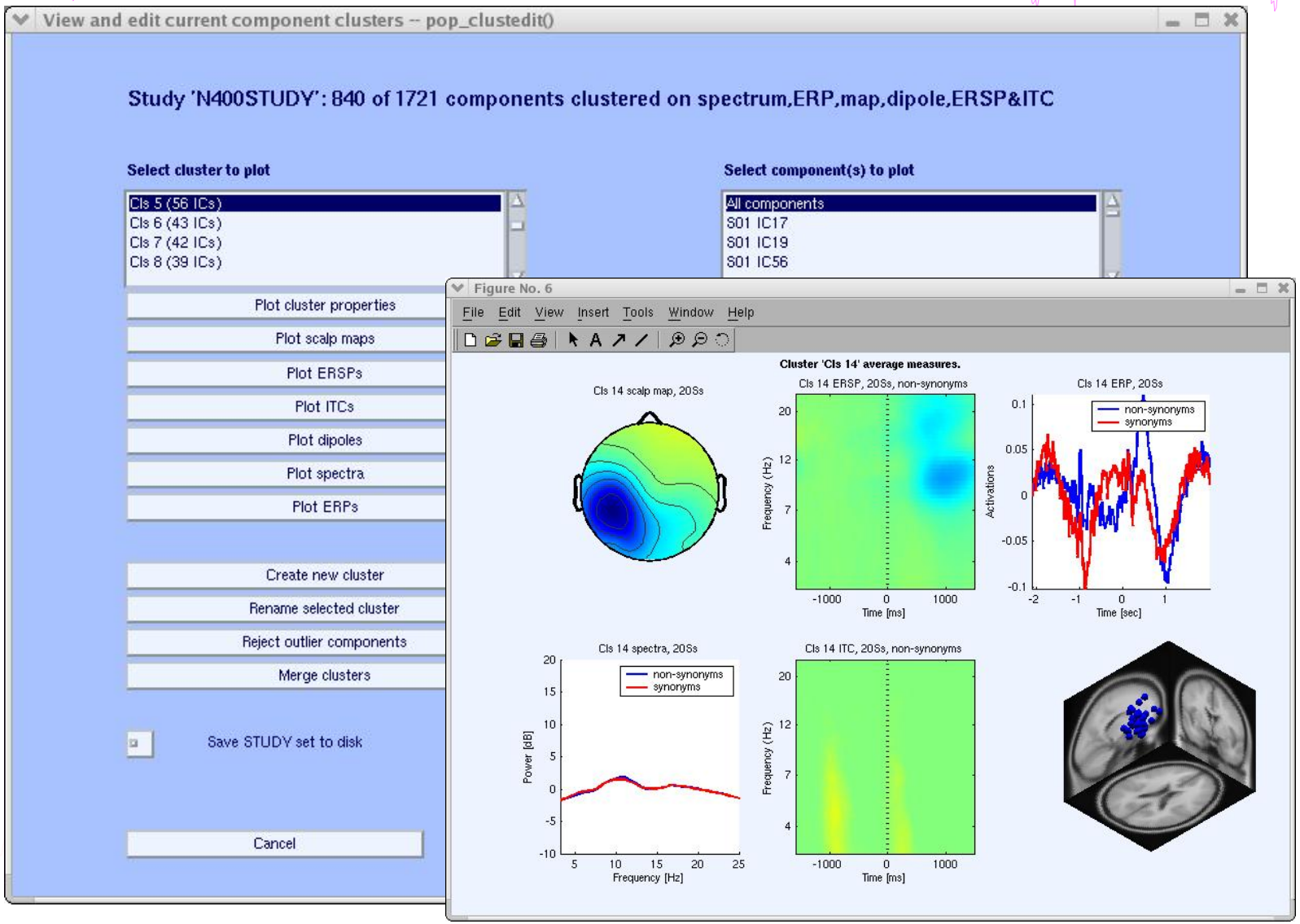
3. Cluster components

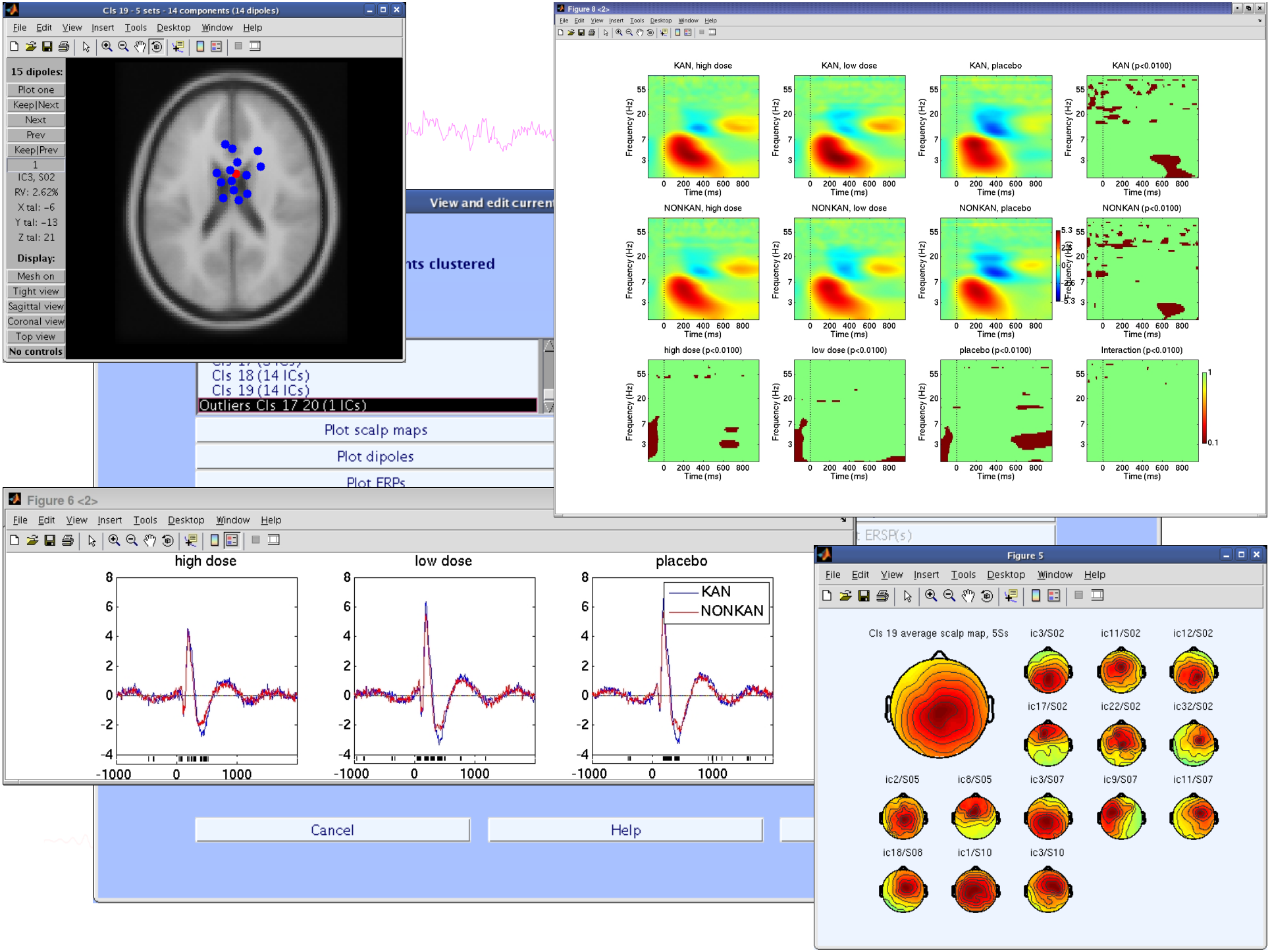




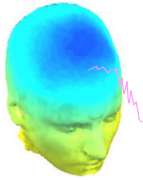
4. Analyze clusters

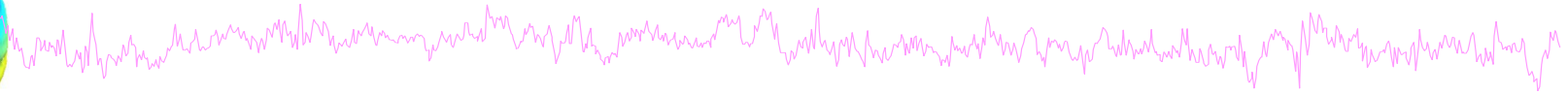





Cls 19 - 5 sets - 14 components (14 dipoles)
File Edit View Insert Tools Desktop Window Help
15 dipoles:
Plot one
Keep|Next
Next
Prev
Keep|Prev
1
IC3, S02
RV: 2.62%
X tal: -6
Y tal: -13
Z tal: 21
Display:
Mesh on
Tight view
Sagittal view
Coronal view
Top view
No controls
View and edit curren
nts clustered
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
Cancel
Help
ERSP(s)
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





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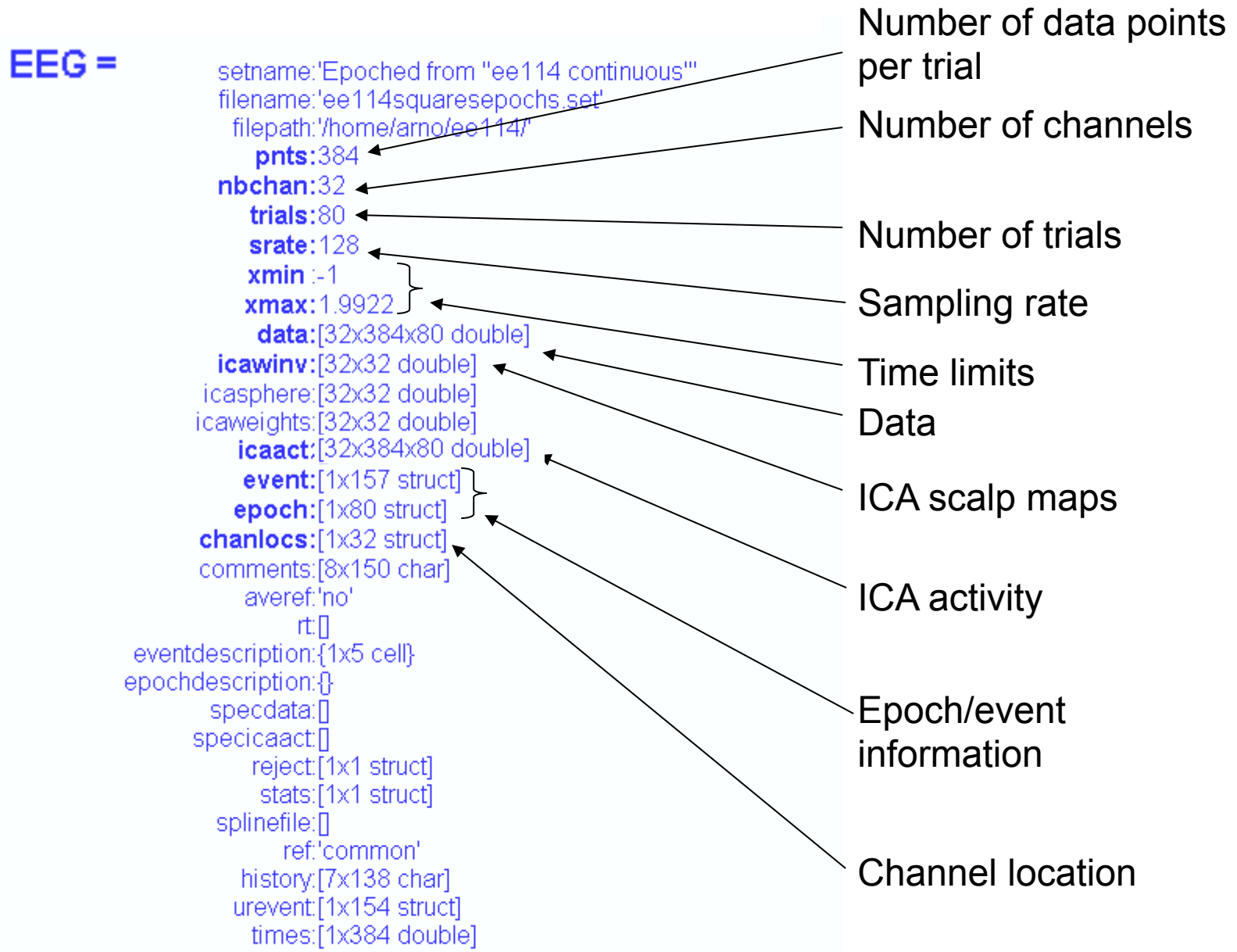
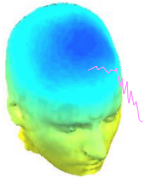
4. Analyze clusters

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(), …

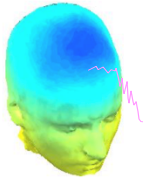
Pop functions: interactive functions using EEG structure

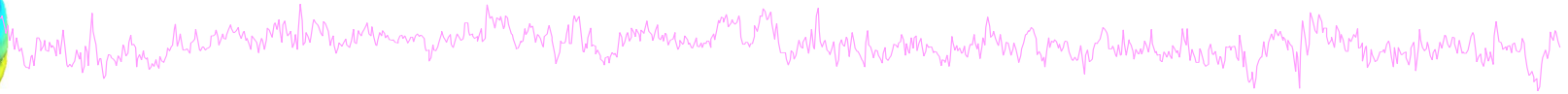
pop_erpimage(), pop_topoplot(), pop_envtopo(), …

Signal processing functions: perform signal processing

erpimage(), topoplot(), envtopo(), …

Command line tools



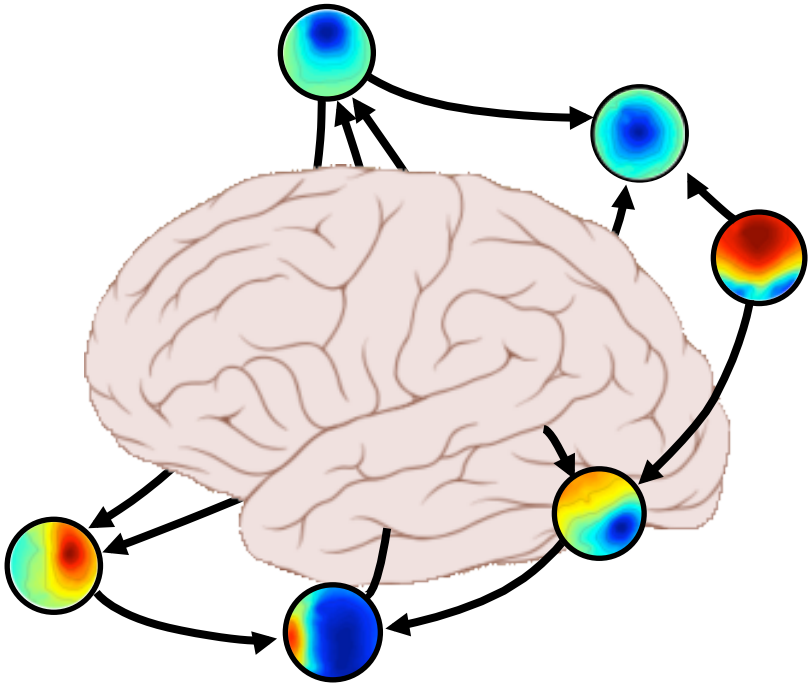


("eegh" Menus write both dataset and global history)

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

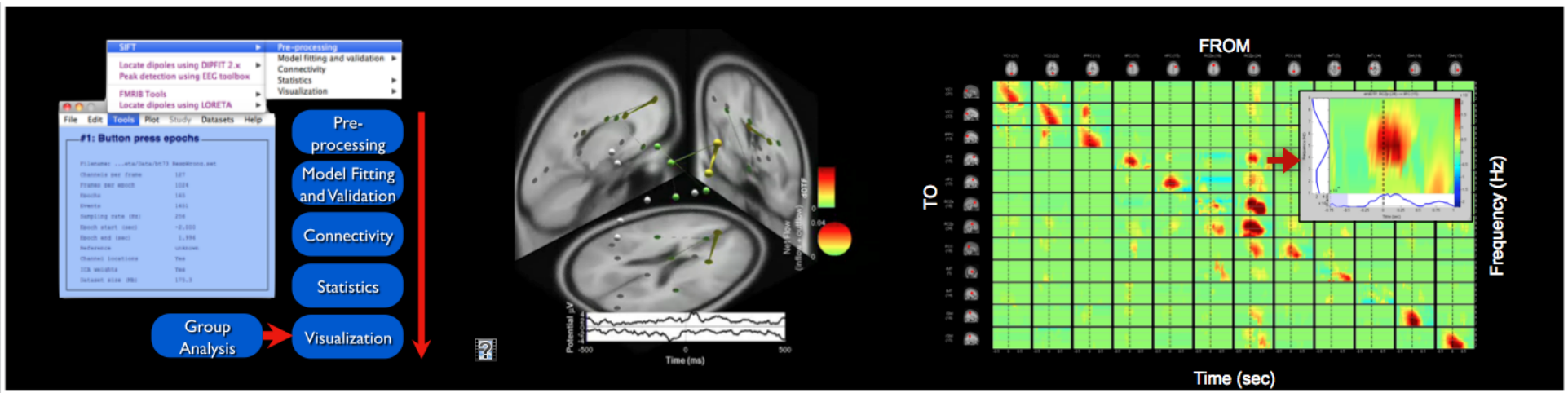
EEGLAB Scripting

```
% Create Stern STUDY
[ALLEEG EEG CURRENTSET ALLCOM] = eeglab;
pop_editoptions( 'option_storedisk', 1);
subjects = {'S01' 'S02' 'S03' 'S04' 'S05' 'S06' 'S07' 'S08' 'S09' 'S10' 'S11' 'S12'};
filepath = '/Users/arno/temp/STUDY'; % XXXXX Change path here XXXXX
if ~exist(filepath), error('You need to change the path to the STUDY'); end;
commands = {}; % initialize STUDY dataset list

% Loop through all of the subjects in the study to create the dataset
for loopnum = 1:length(subjects) %for each subject
    IgnoreFile   = fullfile(filepath, subjects{loopnum}, 'Ignore.set');
    MemorizeFile = fullfile(filepath, subjects{loopnum}, 'Memorize.set');
    ProbeFile    = fullfile(filepath, subjects{loopnum}, 'Probe.set');
    commands = {commands{:} ...
        {'index' 3*loopnum-2 'load' IgnoreFile   'subject' subjects{loopnum} 'condition' 'Ignore'} ...
        {'index' 3*loopnum-1 'load' MemorizeFile 'subject' subjects{loopnum} 'condition' 'Memorize'} ...
        {'index' 3*loopnum   'load' ProbeFile    'subject' subjects{loopnum} 'condition' 'Probe'}};
end;
% Uncomment the line below to select ICA components with less than 15% residual variance
% commands = {commands{:} {'dipselect', 0.15}};
[STUDY, ALLEEG] = std_editset(STUDY, ALLEEG, 'name','Sternberg','commands',commands,'updatedat','on');

% Update workspace variables and redraw EEGLAB
CURRENTSTUDY = 1; EEG = ALLEEG; CURRENTSET = [1:length(EEG)];
[STUDY, ALLEEG] = std_checkset(STUDY, ALLEEG);
eeglab redraw

[STUDY ALLEEG] = std_precomp(STUDY, ALLEEG, {},'rmicacomps','on','interp','on','recompute','on','erp','on');
STUDY = pop_erpparams(STUDY, 'topotime',[200 300] );
[STUDY erpdata] = std_erpplot(STUDY,ALLEEG,'channels',{'LEYE' 'REYE' 'OZ' 'O2' 'FP1' 'FPZ' 'FP2' 'AF7' ...
            'AF3' 'AFZ' 'AF4' 'AF8' 'F9' 'F7' 'F5' 'F3' 'F1' 'FZ' 'F2' 'F4' 'F6' 'F8' 'F10' 'FT9' ...
            'FT7' 'FC5' 'FC3' 'FC1' 'FCZ' 'FC2' 'FC4' 'FC6' 'FT8' 'FT10' 'T7' 'C5' 'C3' 'C1' 'CZ' ...
            'C2' 'C4' 'C6' 'T8' 'TP9' 'TP7' 'CP5' 'CP3' 'CP1' 'CPZ' 'CP2' 'CP4' 'CP6' 'TP8' 'TP10' ...
            'P7' 'P5' 'P3' 'P1' 'PZ' 'P2' 'P4' 'P6' 'P8' 'PO9' 'PO7' 'PO3' 'POZ' 'PO4' 'PO8' 'PO10' 'O1'});

dlmwrite('erpfile.txt',squeeze(erpdata{1}),'delimiter', '\t', 'precision', 2);
dlmwrite('erpfile.txt',squeeze(erpdata{2}),'-append', 'roffset', 1, 'delimiter', '\t', 'precision', 2);
dlmwrite('erpfile.txt',squeeze(erpdata{2}),'-append', 'roffset', 1, 'delimiter', '\t', 'precision', 2);
```

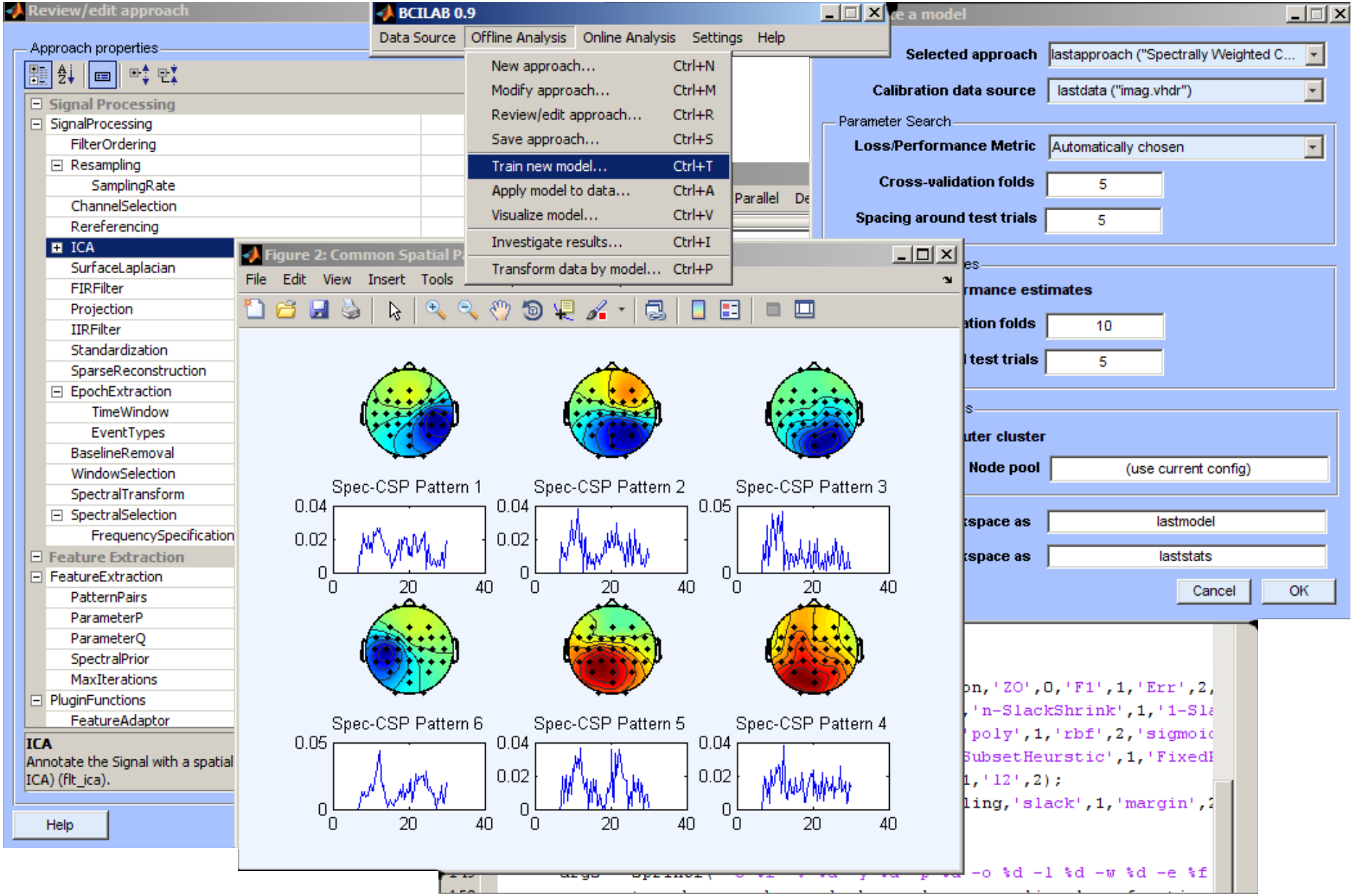


SIFT

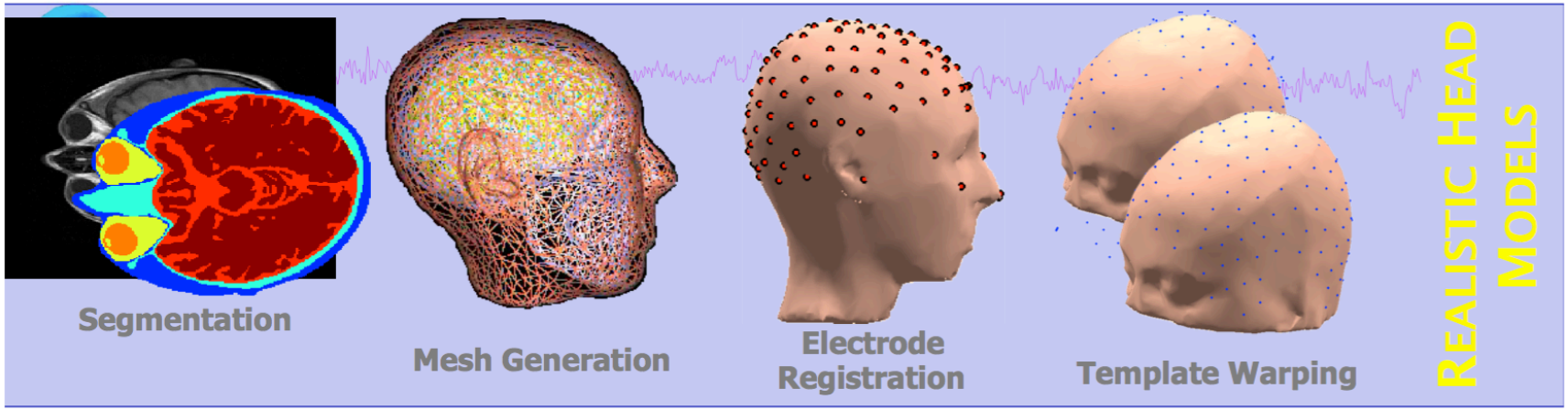
Source Information Flow Toolbox

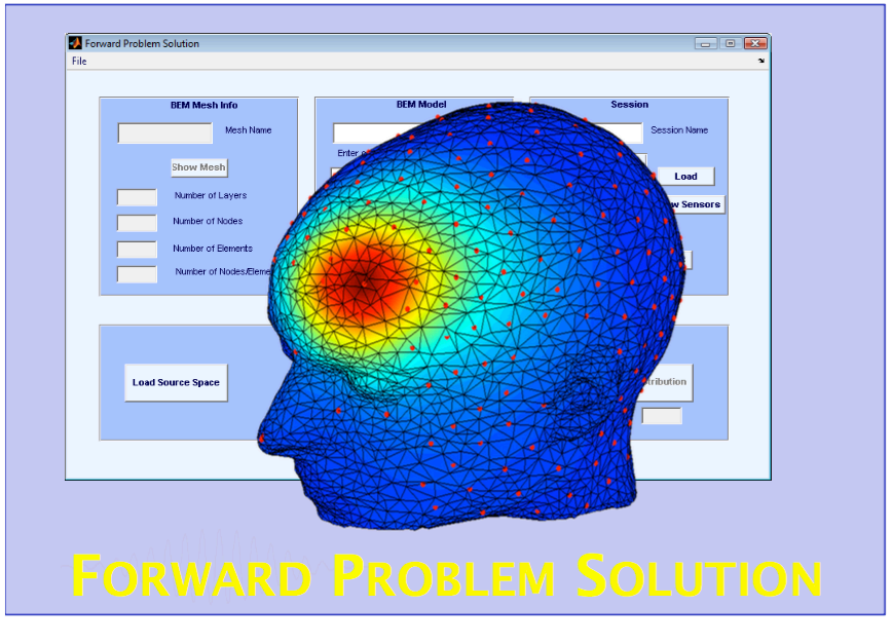


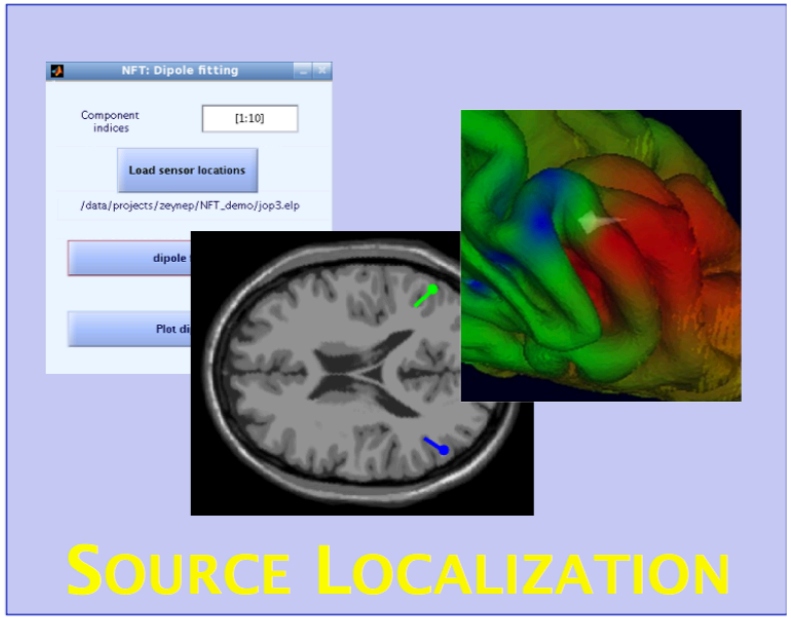
BCILAB - C. Kothe



NFT: Neuroelectromagnetic Forward Head Modeling Toolbox

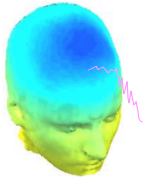






http://sccn.ucsd.edu/nft

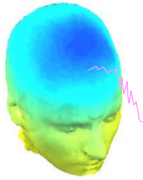
Pros/Cons of Matlab based open source

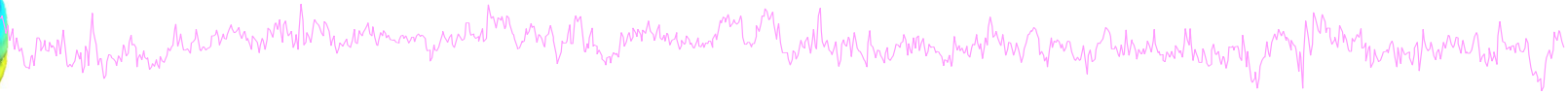


- Pros
  - Easy to program, highly modular and extendable
  - Not dependent on any platform (64-bit) and highly optimized
  - Large community of users (latest development in signal processing research)
  - Powerful scripting capabilities

- 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.

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Workshop Program (with corresponding PDFs)

Purple lettering = lecture
Orange lettering = tutorial

Monday, July 3rd

16:30 -- Train station shuttle bus pick up

17:00 -- Airport shuttle bus pick up

19:45 -- Dinner (included in registration)

20:45 – 21:30 -- Optional beginner Matlab course by Ramon Martinez

Tuesday, July 4th

7:00 - 8:30 Breakfast

Overview and ICA Theory/Practice

8:30 – 9:45 -- Mining event-related brain dynamics I (Scott Makeig)

9:45 – 10:15 -- EEGLAB overview (Arnaud Delorme)

-- Break--

10:30 – 11:30 -- ICA theory (Arnaud Delorme)

11:30 – 12:30 -- Data import, Artifact rejection (Tracy Brandmeyer)

12:30-13:45 Lunch --

ICA and time-frequency

13:45 – 14:30 -- ICA decomposition practicum (Arnaud Delorme)

14:30 – 15:15 -- Evaluating ICA components practicum (Arnaud Delorme)

15:15 – 15:45 -- Bootstraping ICA (Fiorenzo Artoni)

-- Break--

16:00 – 17:00 -- Time-frequency decompositions: Theory and practice (Tim Mullen)

19:45 -- Dinner

Wednesday, July 5th

7:30 - 8:30 Breakfast

Group analysis and ICA clustering in EEGLAB

8:30 - 9:00 -- Why cluster ICA components? (Scott Makeig)

9:00 - 9:30 -- Robust statistics and correction for multiple comparisons (Cyril Pernet)

9:30 - 10:30 -- Creating a STUDY and STUDY design (Arnaud Delorme)

-- Break--

10:45 - 11:45 -- Plotting and computing statistics in channels and components in STUDY (Arnaud Delorme)

11:45 - 12:45 -- Group analysis using EEGLAB studies: Methods to cluster ICA components (Arnaud Delorme)

12:45-13:45 Lunch --

13:45-18:00-- Hiking excursion

19:45 -- Dinner

Thursday, July 6th

7:30 - 8:30 Breakfast

Source Localization

8:30 – 9:30 -- Forward and inverse models - the Dipfit tools (Robert Oostenveld)

9:30 – 10:00 -- Using the Dipfit plugin of EEGLAB (Arnaud Delorme)

-- Break--

General Linear Modeling

10:15 – 12:00 -- Theory and practice of applying general linear models to EEG data using the LIMO EEGLAB plug-in (Cyril Pernet)

12:00 – 12:30 -- The future of LIMO and EEGLAB (Arnaud Delorme)

12:30-13:45 Lunch --

Source information flow

13:45 – 14:30 -- Source information flow and Granger-Causal modeling tools (Tim Mullen)

14:30 – 15:30 -- SIFT toolbox: Theory and live demo (Tim Mullen)

-- Break--

15:45 – 17:30 -- SIFT toolbox: practicum (Tim Mullen)

19:45 -- Dinner

20:00 - 23:00 -- SIFT hackathon, meet with Tim Mullen and his computer at the bar - ask anything you like

20:00 - 23:00 -- LIMO hackathon, meet with Cyril Pernet and his computer at the bar - ask anything you like

Friday, July 7th

7:30-8:30 -- Breakfast

8:30 – 9:30 -- Mining event-related brain dynamics II (Scott Makeig)

9:30 – 10:00 -- Using and building EEGLAB extensions/plug-ins (Arnaud Delorme)

-- Break--

10:15 – 11:30 -- Practicum, small group projects

11:30 – 12:00 -- Participant project presentations and general discussion

12:15 -- Lunch

13:00 -- Airport/train station shuttle bus leaves Bois Perche

14:30+ -- Airport/train station shuttle bus arrives in Toulouse