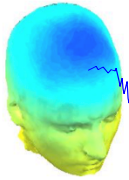
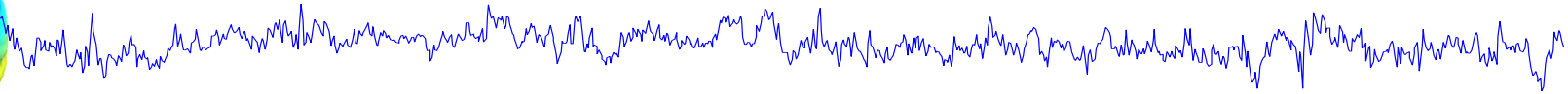
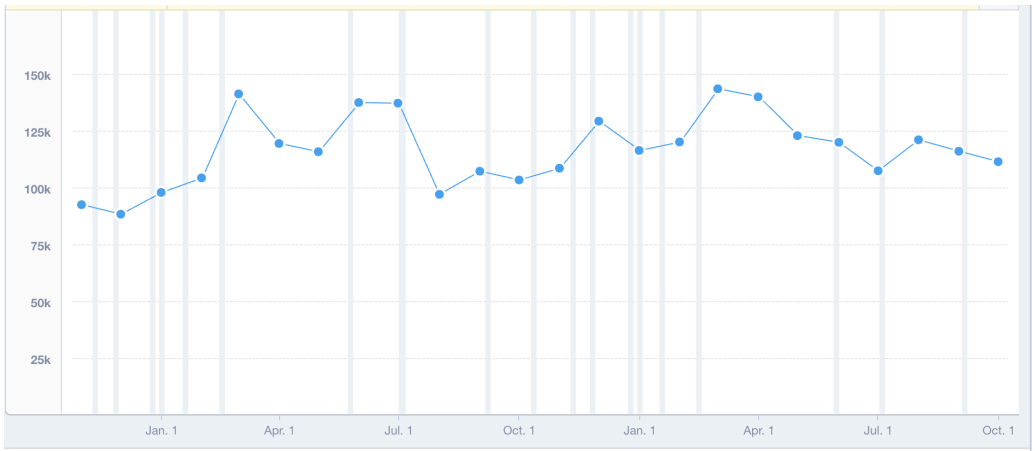
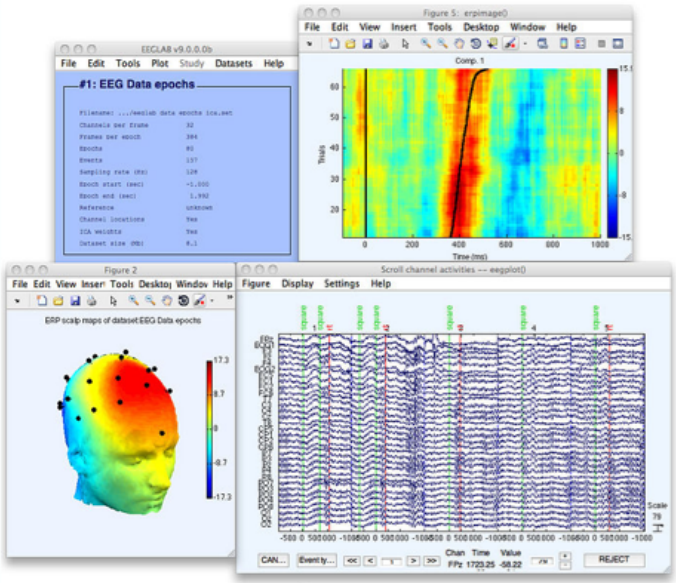
EEGLAB overview





- Collection of about 600 functions (70 000 lines of code)
- About 250 000 download over the past 10 years
- 6 500 users on the discussion list and 10 500 on the diffusion list
- NIH funding since 2003

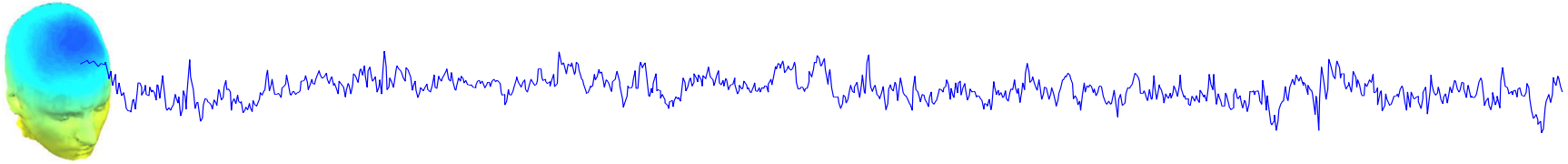


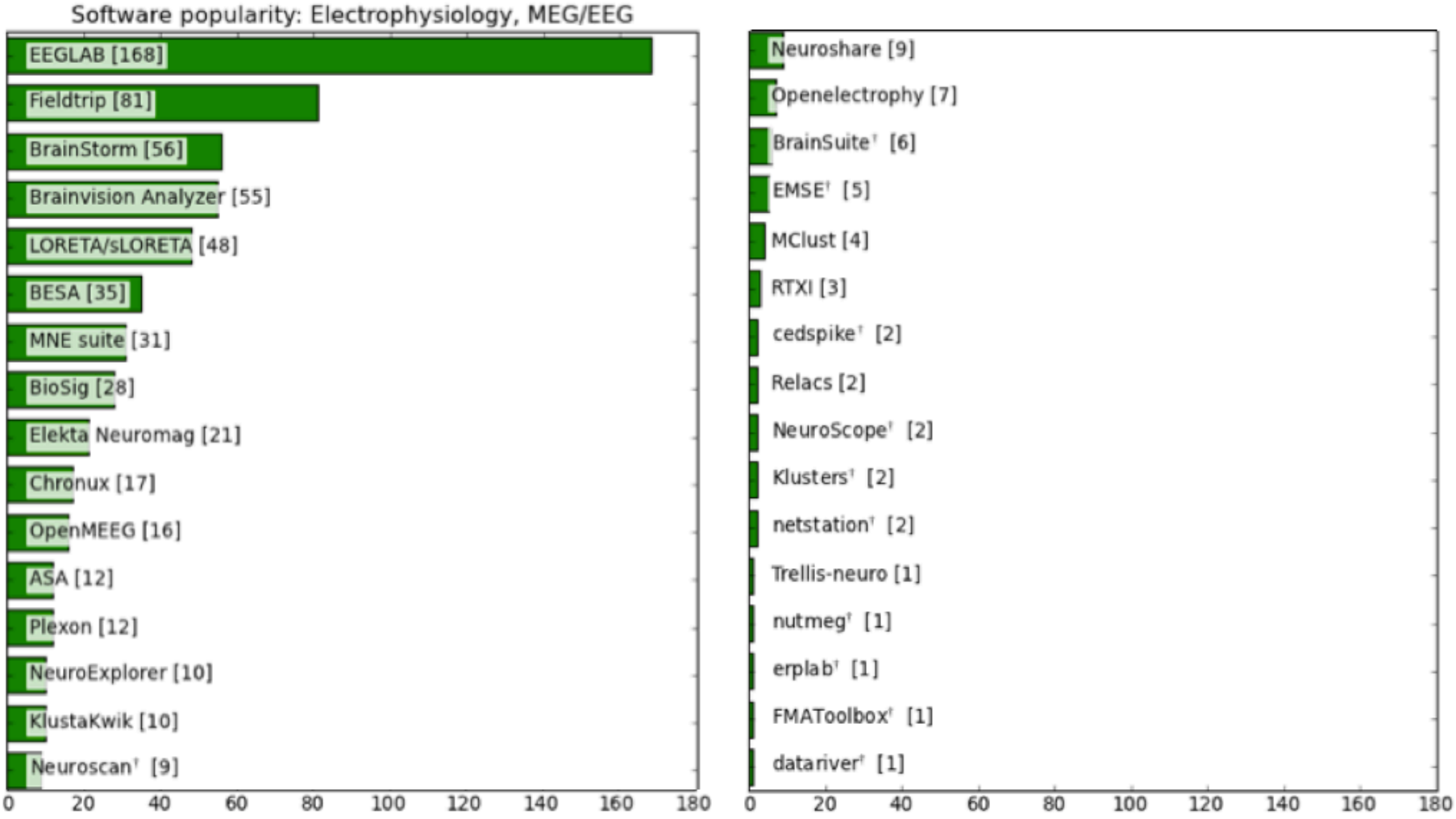


http://sccn.ucsd.edu/eeglab

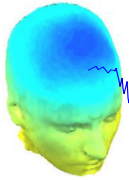
http://sccn.ucsd.edu/wiki/eeglab

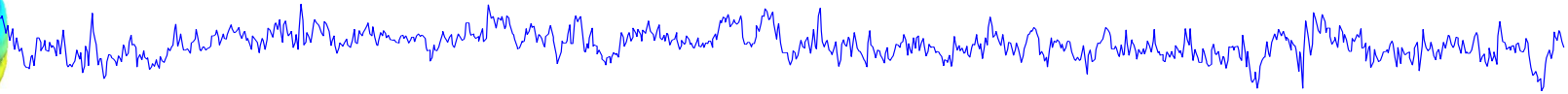
Hanke & Helcencko, 2011, Frontier in Neuroinformatics





EEGLAB standard processing pipeline





Single subject

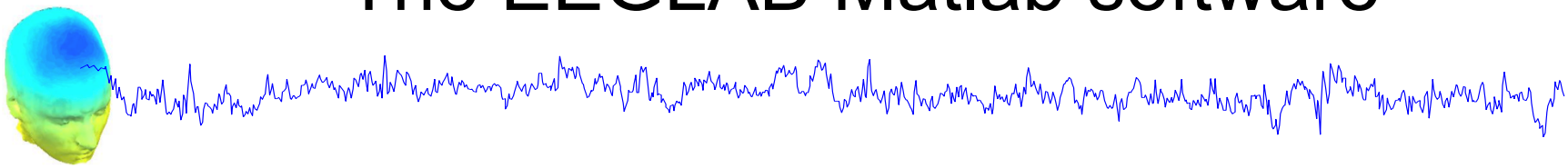
1. Import binary data, events and channel location
2. Edit, Re-reference, Resample, High pass filter data
3. Reject artifacts in continuous data by visual inspection
4. Extract epochs from data & reject artifactual epochs
5. Visualize data measures
6. Perform ICA decomposition
   - Perform source localization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

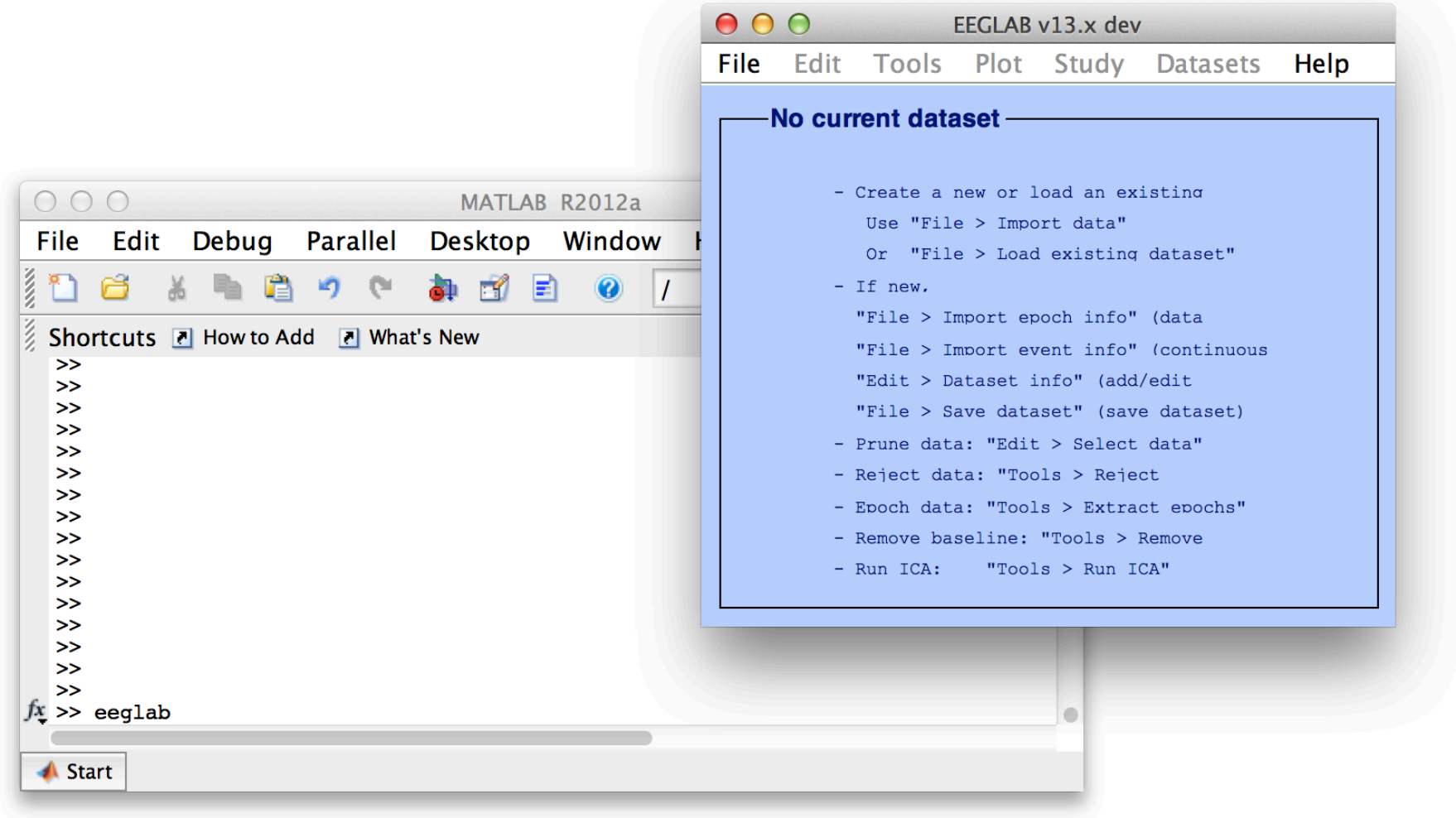
Multi-subjects

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

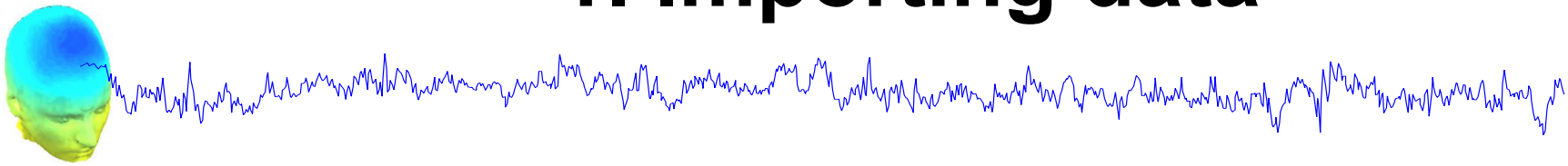
Advanced analysis using scripting and EEGLAB command line functions

The EEGLAB Matlab software

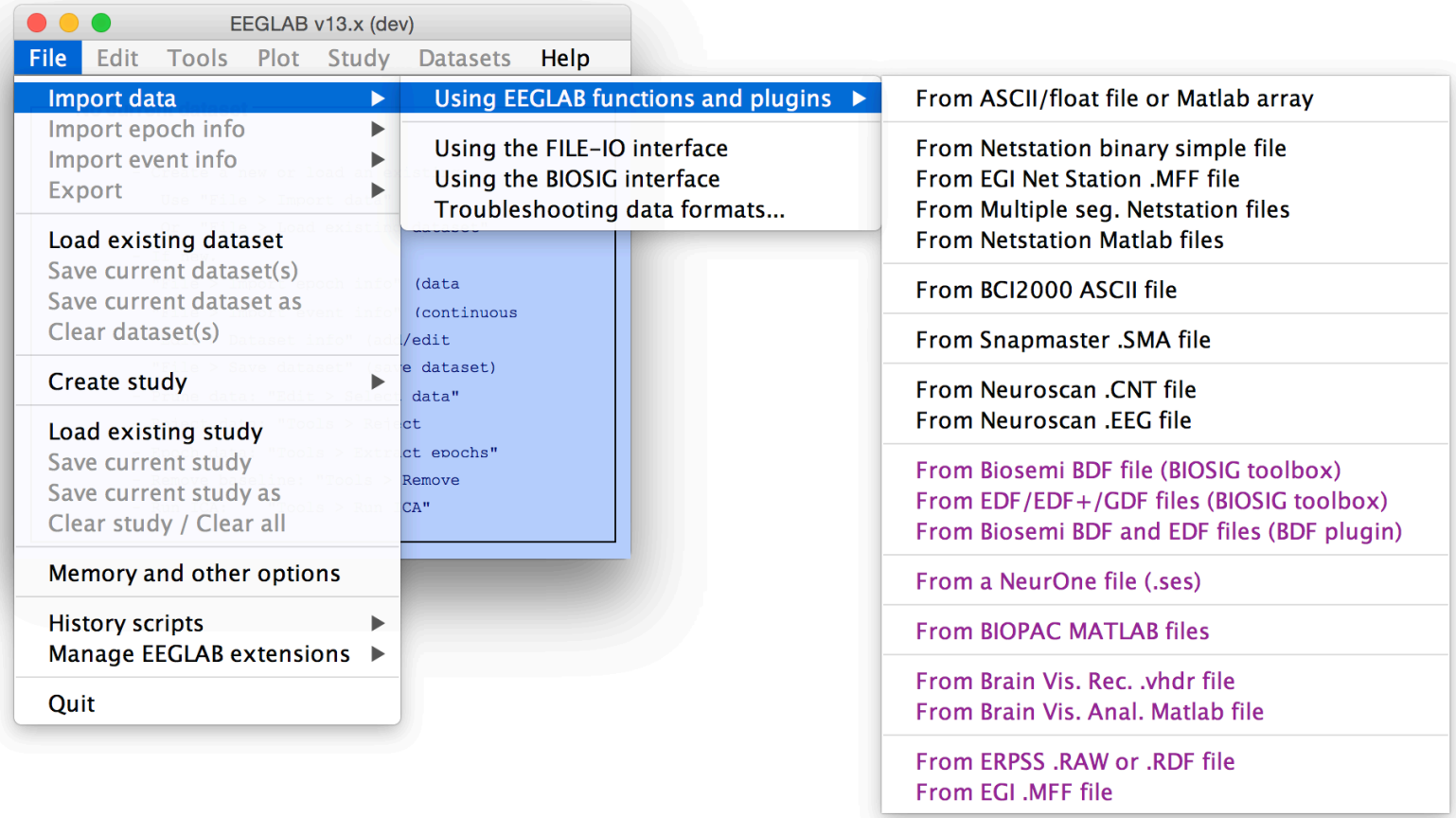




1. Importing data

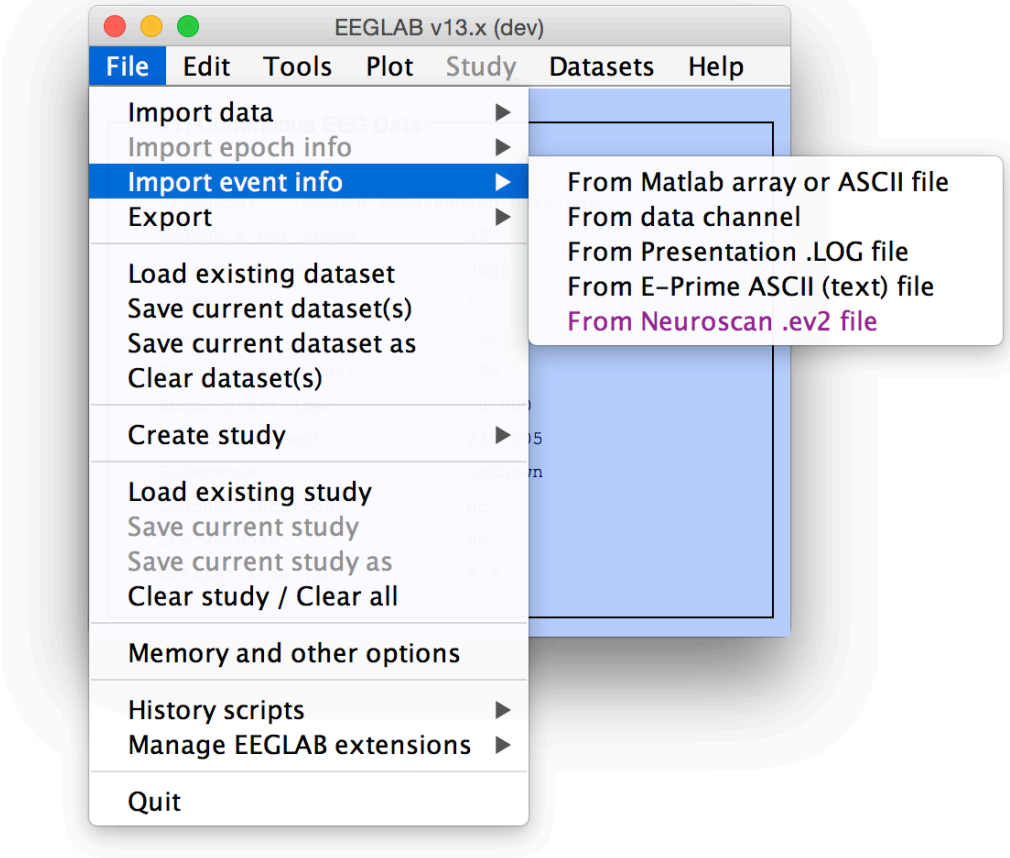


Import/load data

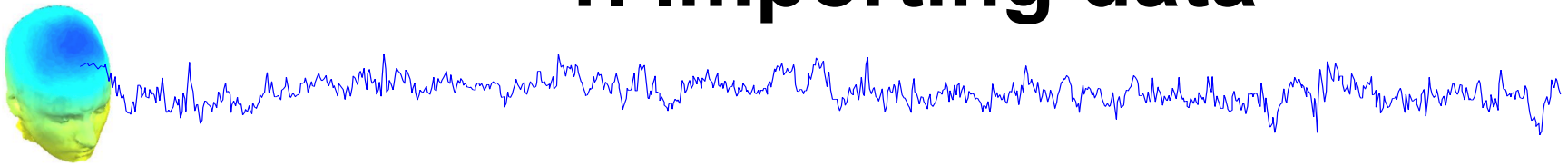


1. Importing data

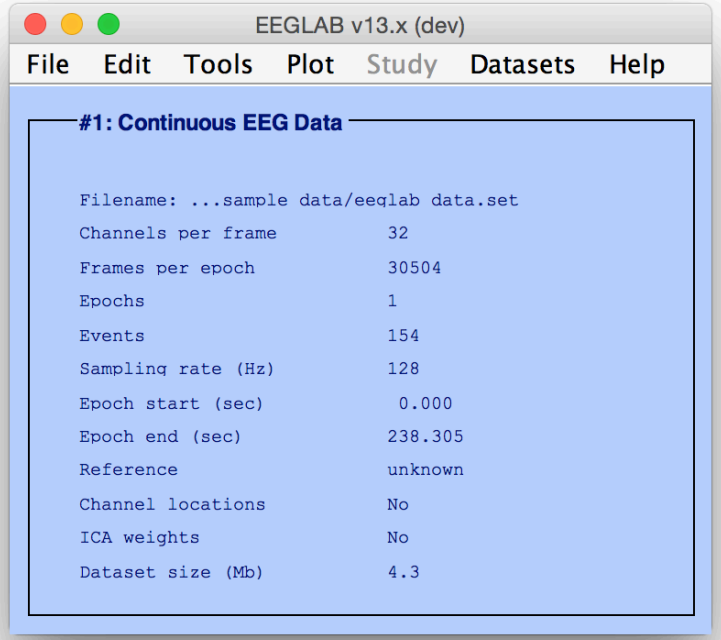
Import events



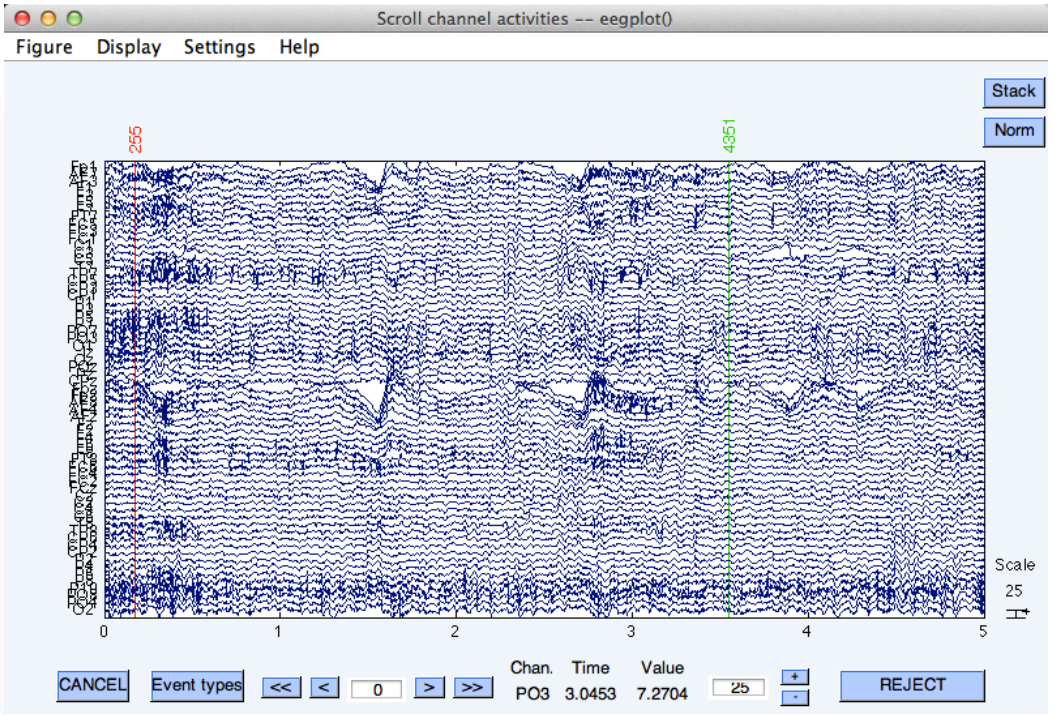
1. Importing data



Data info

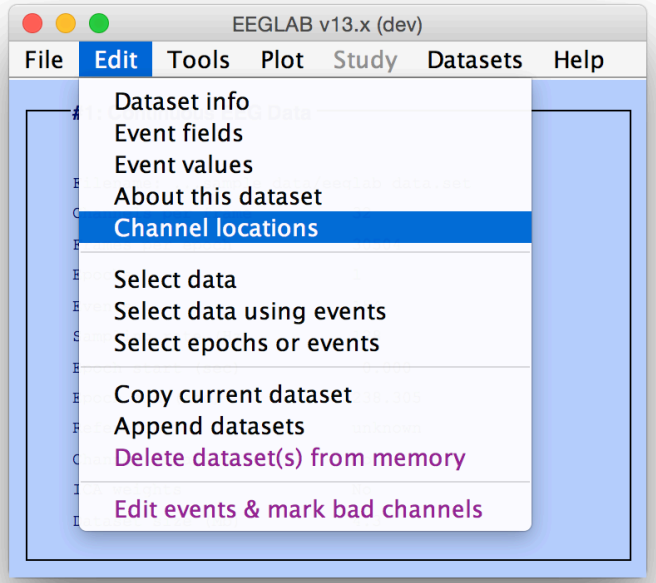


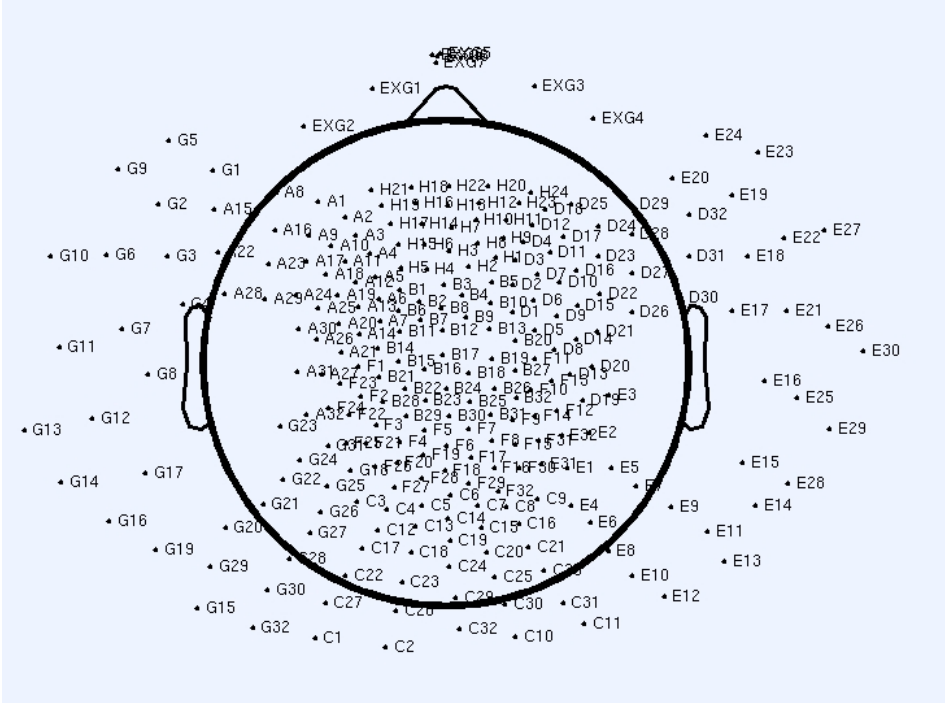
Scrolling data



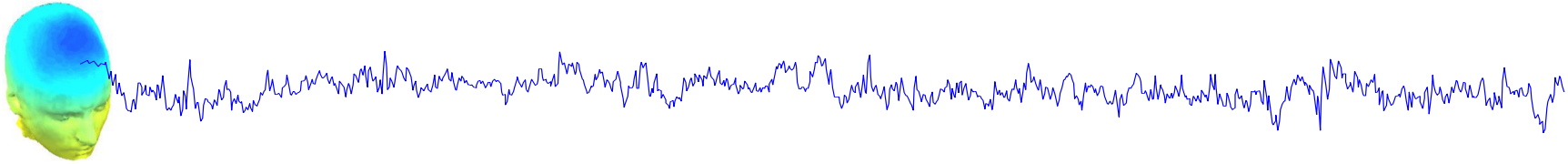
1. Importing channel location

Import channel location

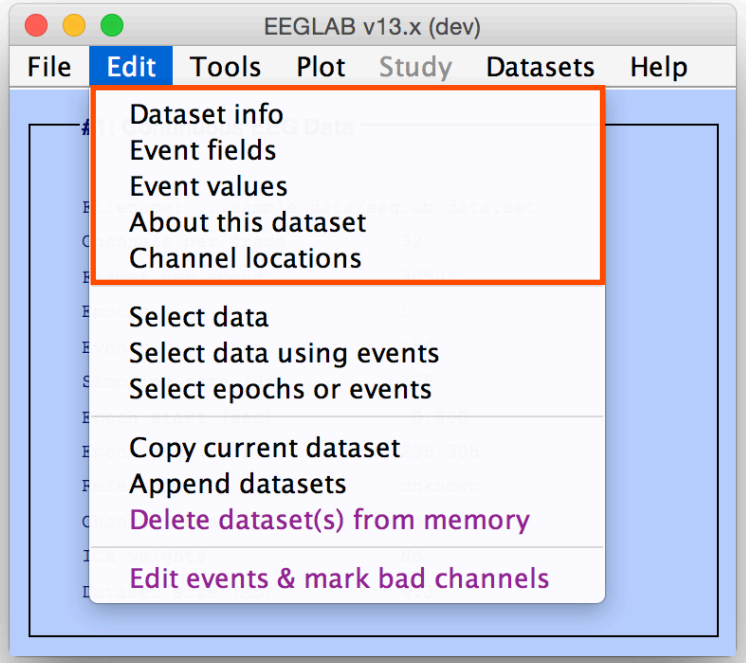




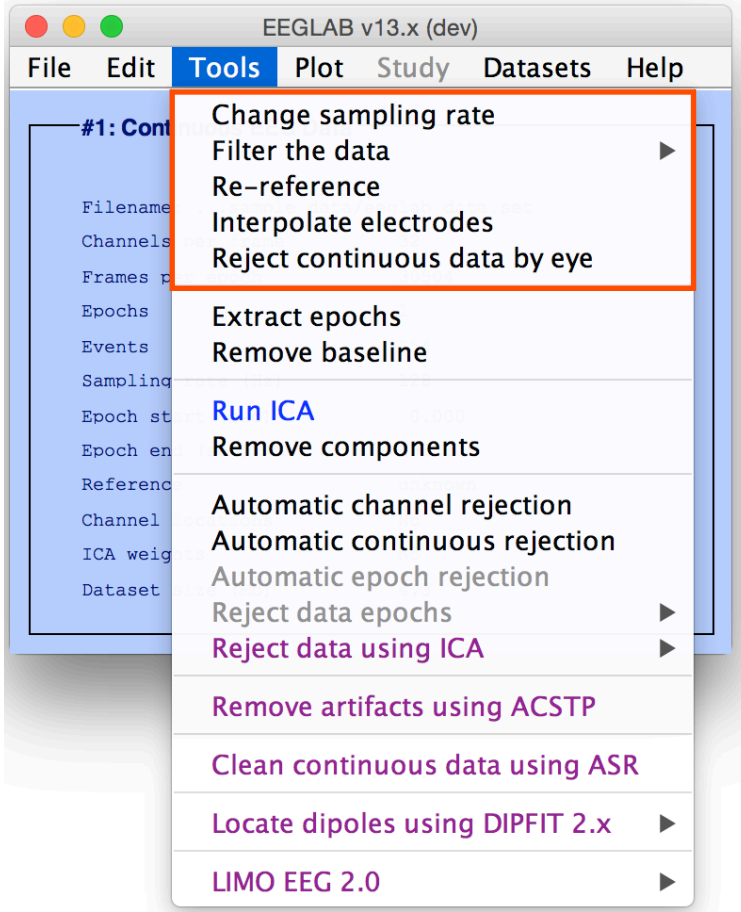
2. Edit, Re-reference, Resample, High pass filter data



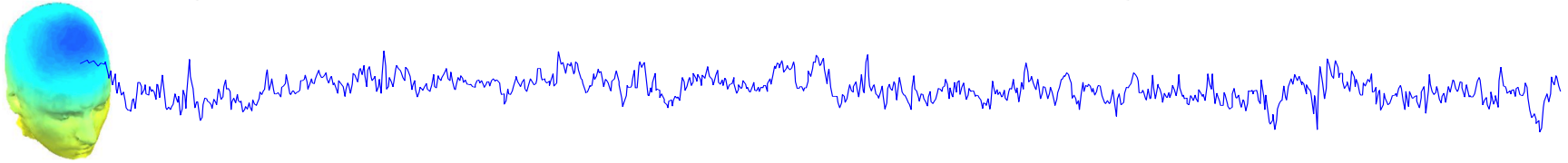
Edit/select data



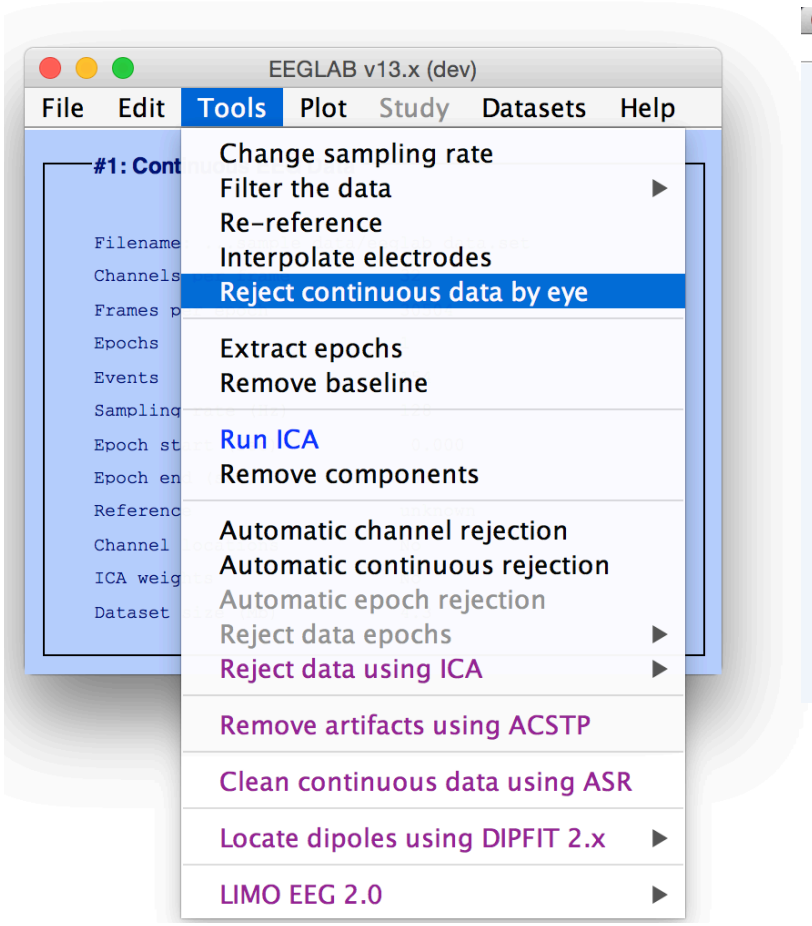
Preprocessing data

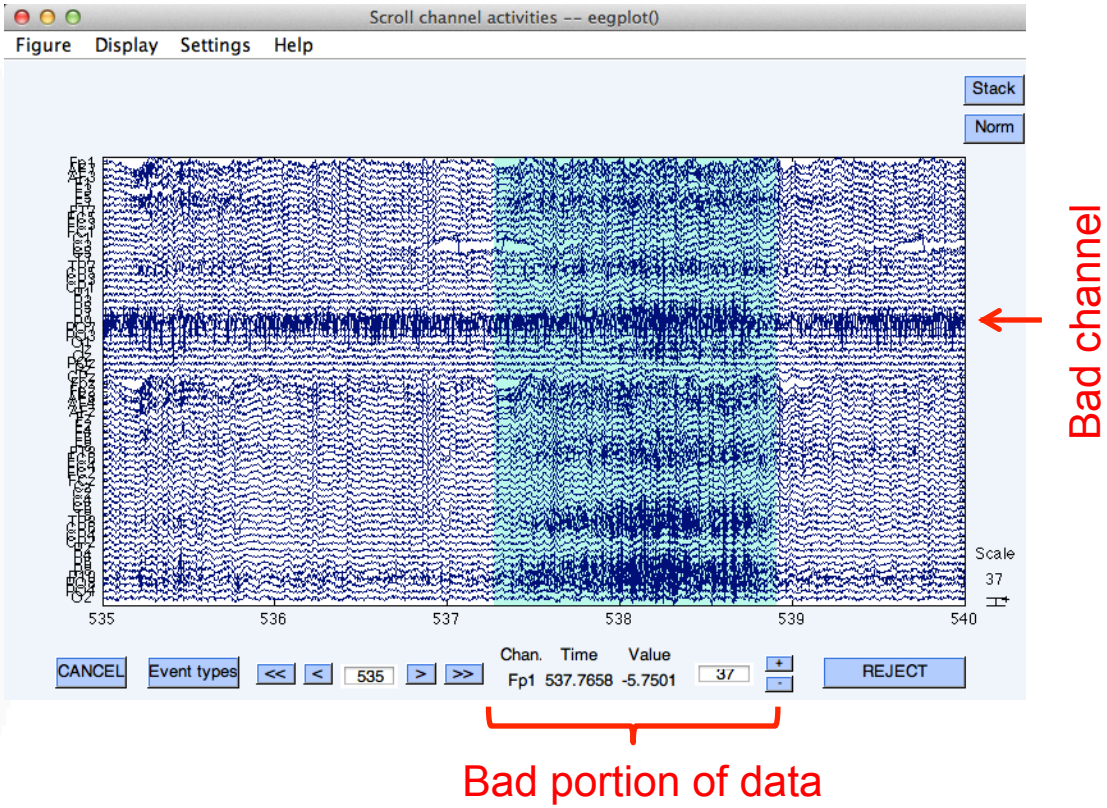


3. Reject artifacts in continuous data by visual inspection

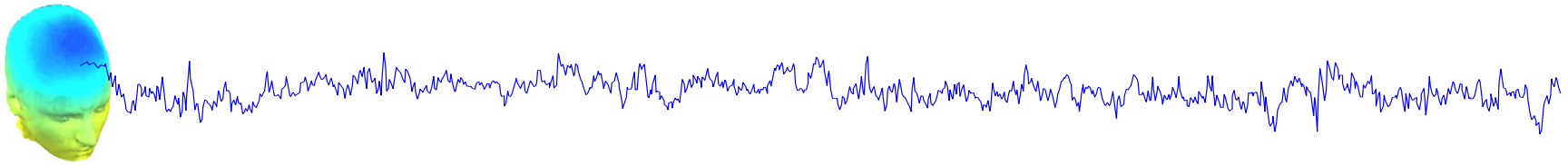


Reject portions of continuous data

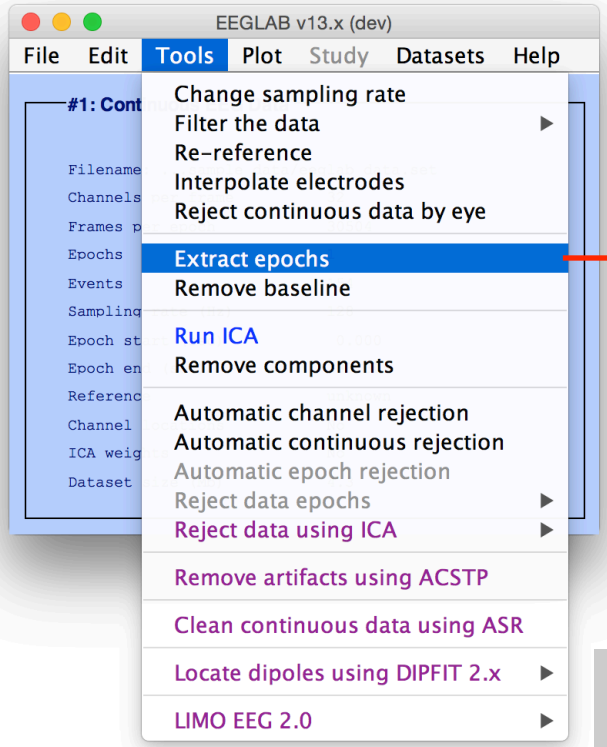


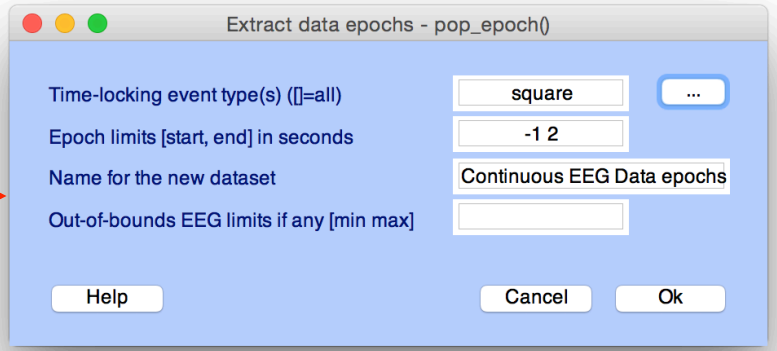


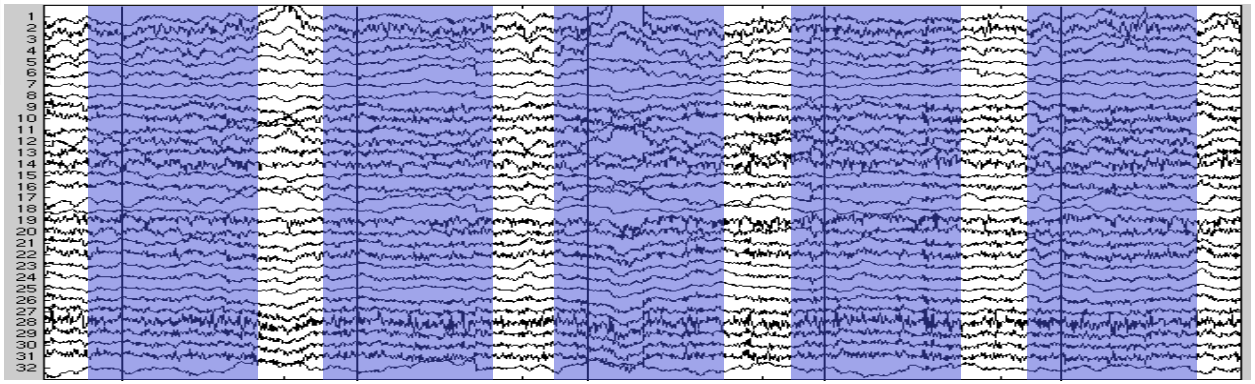
4. Extract epochs from data & reject artifactual epochs



Preprocessing data







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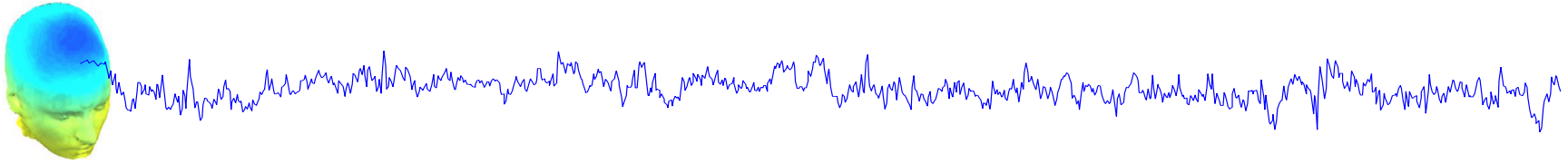
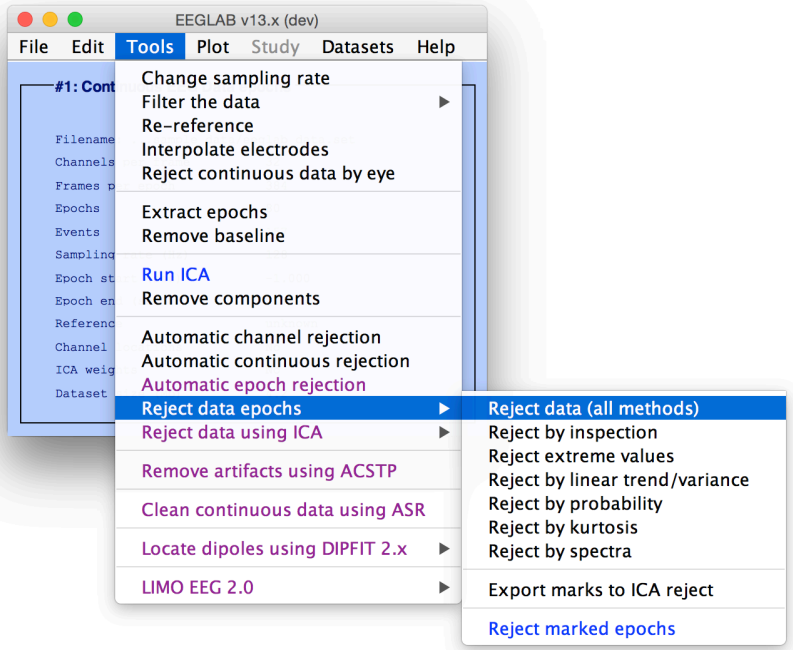
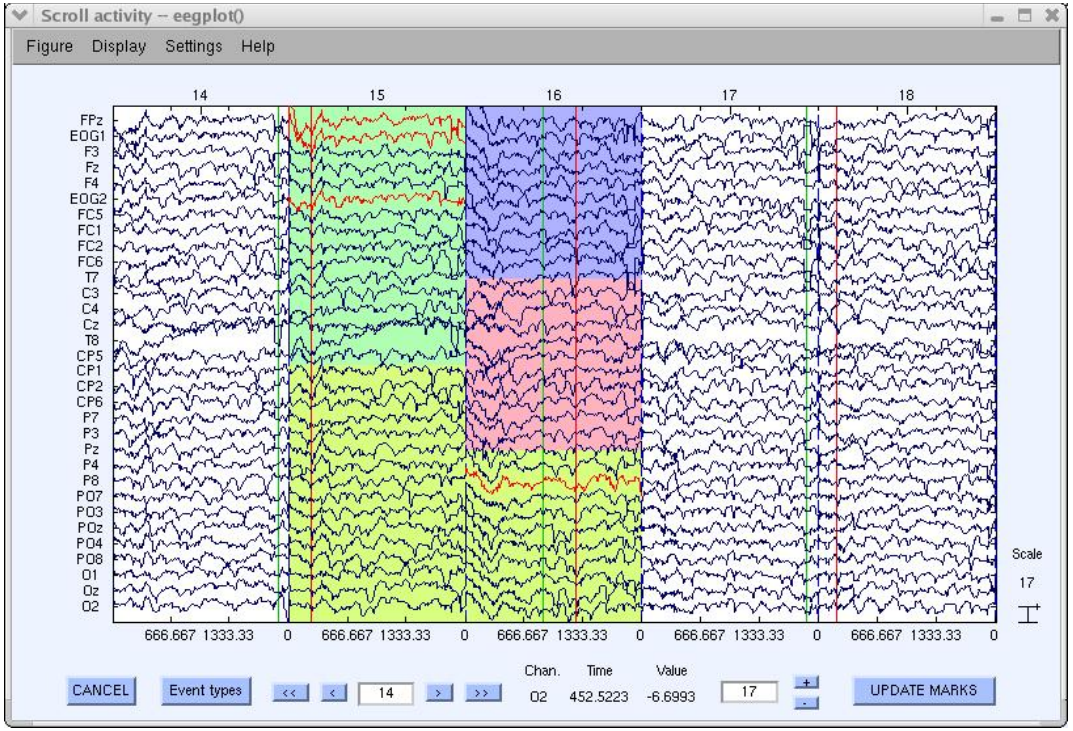
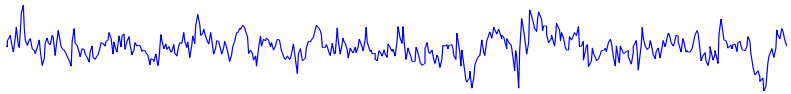


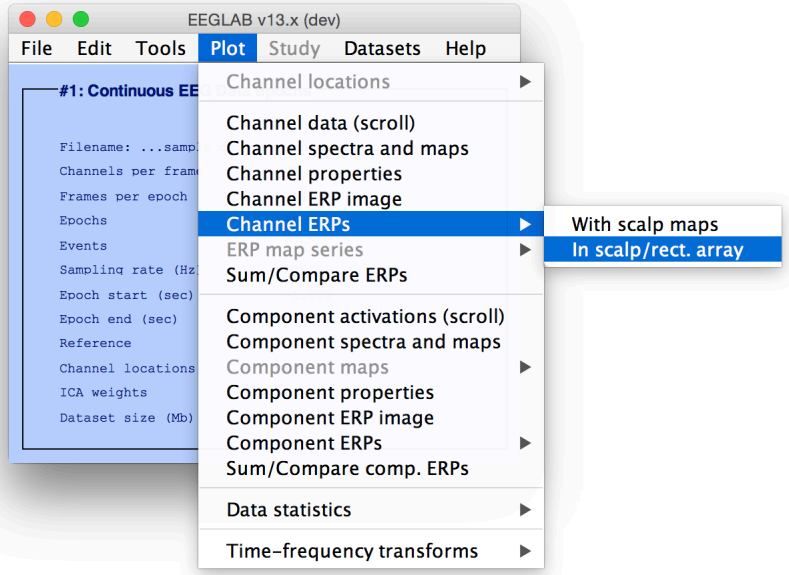


Different color = different rejection methods

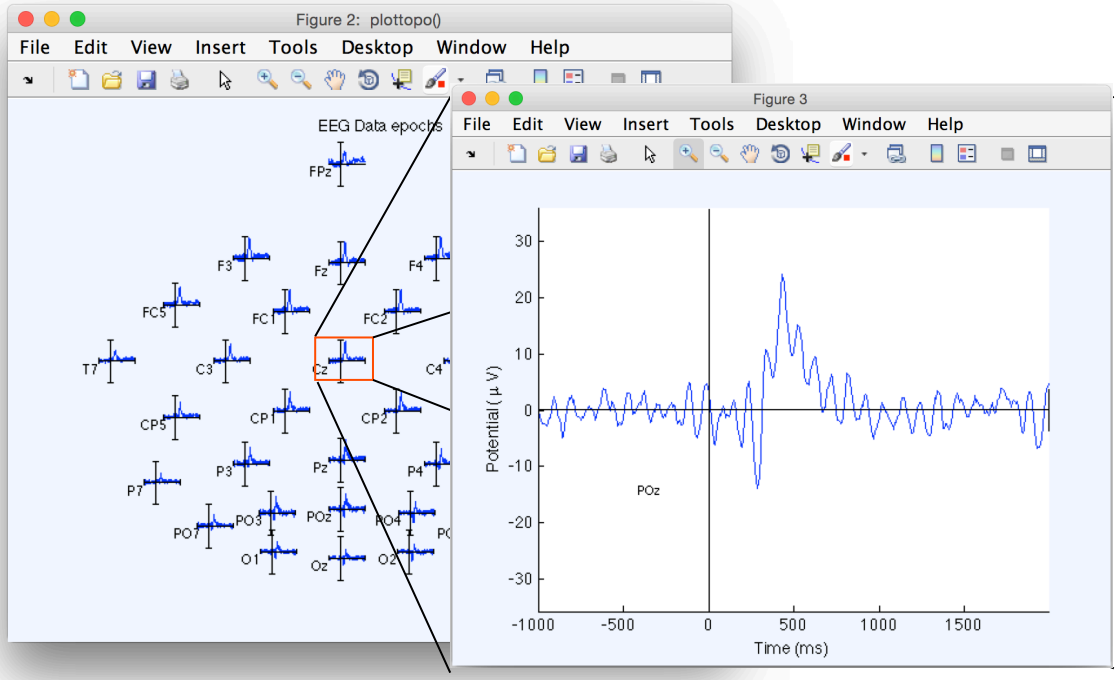


5. Visualize data measures



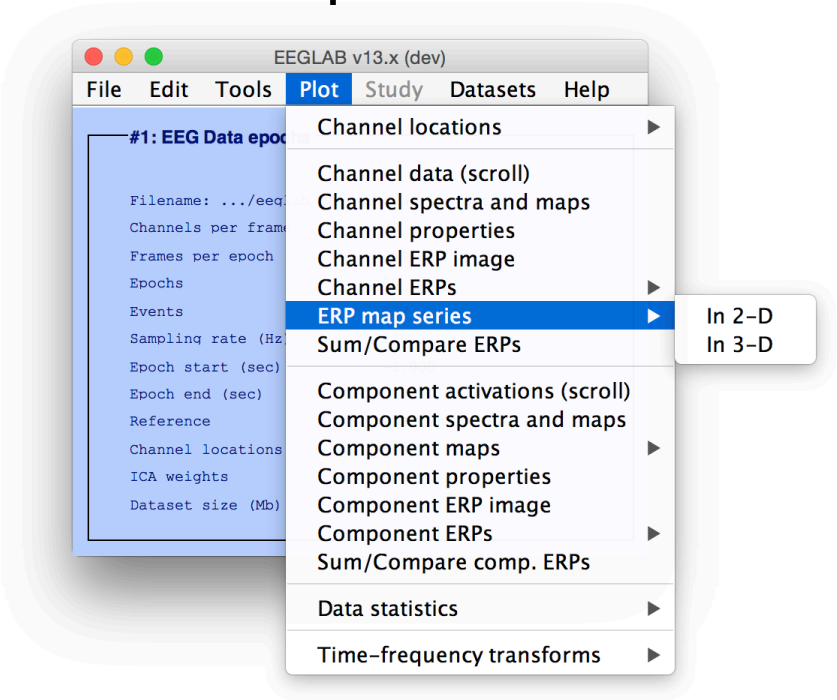


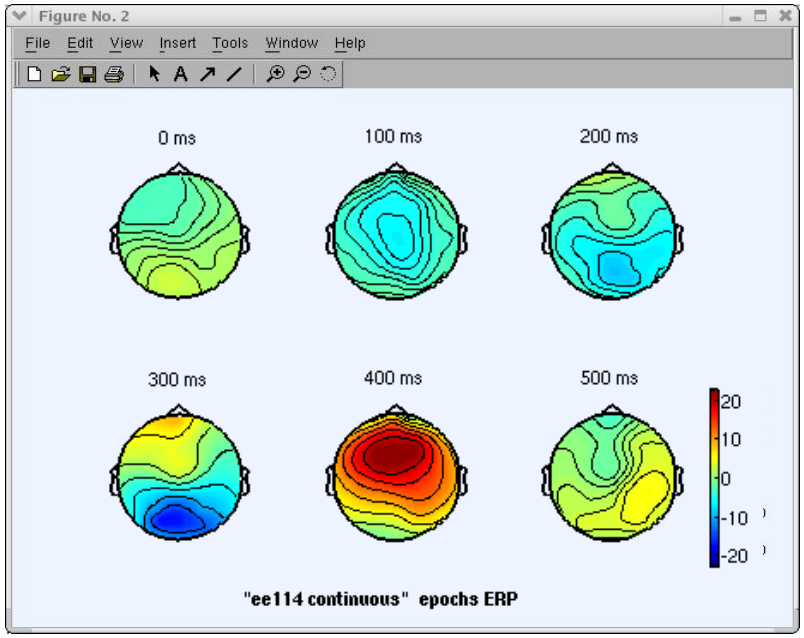
Plot ERP

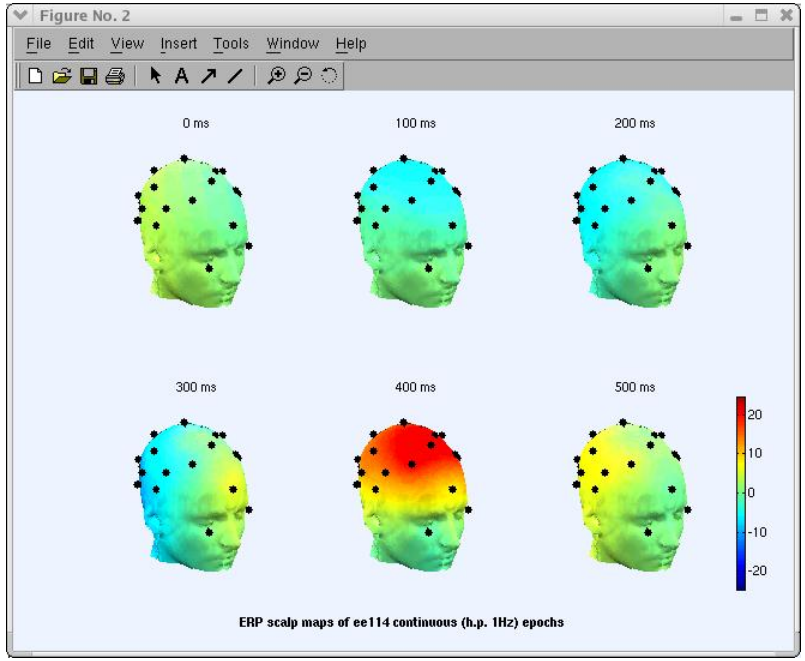


5. Visualize data measures

Plot ERP
map series







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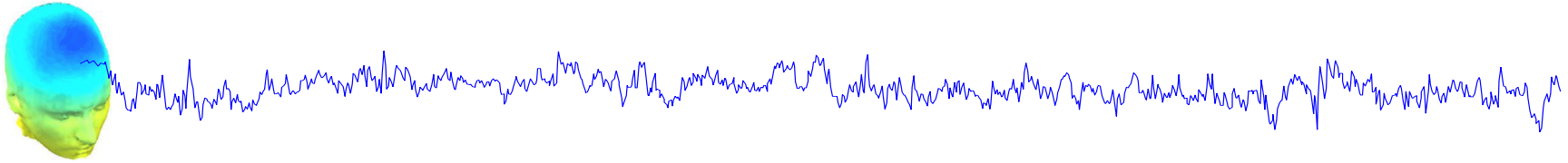
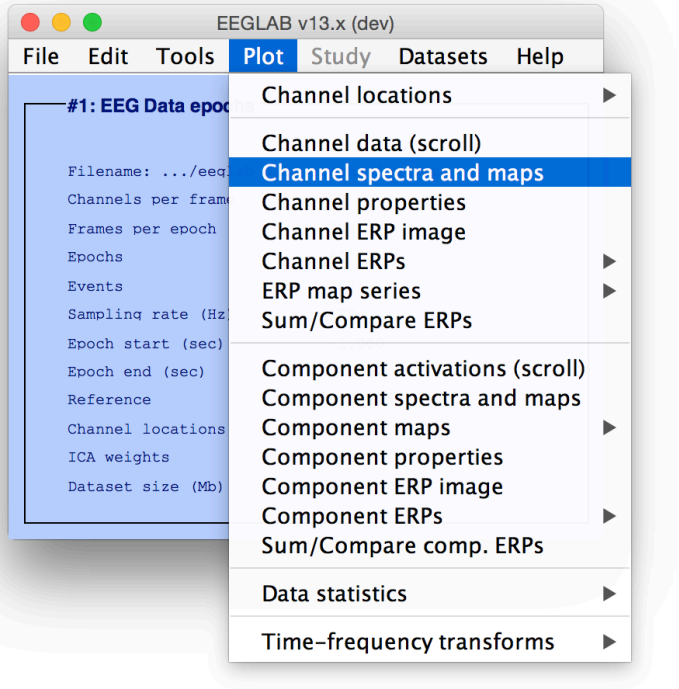
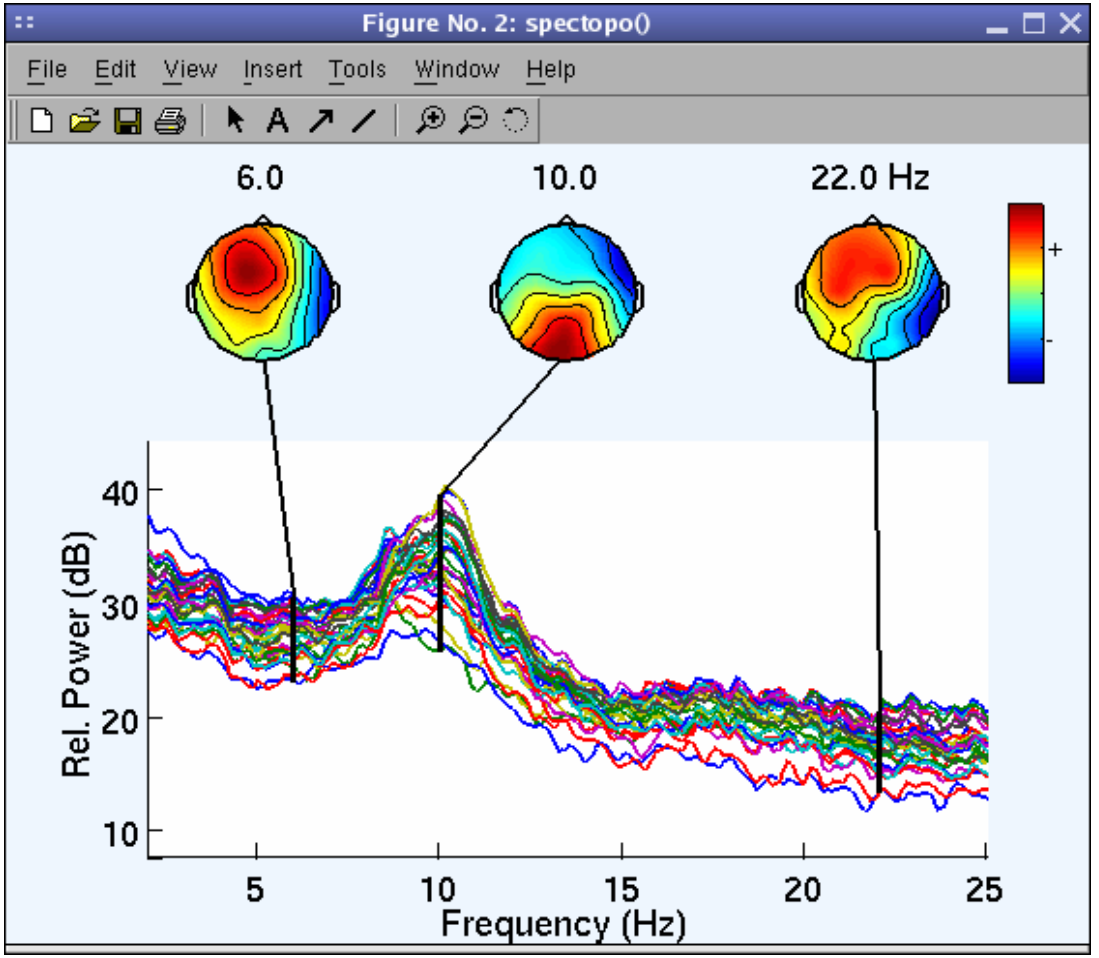


Plot data spectrum and maps





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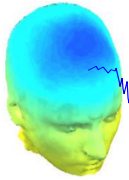
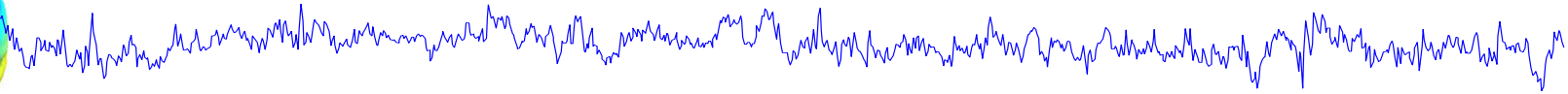
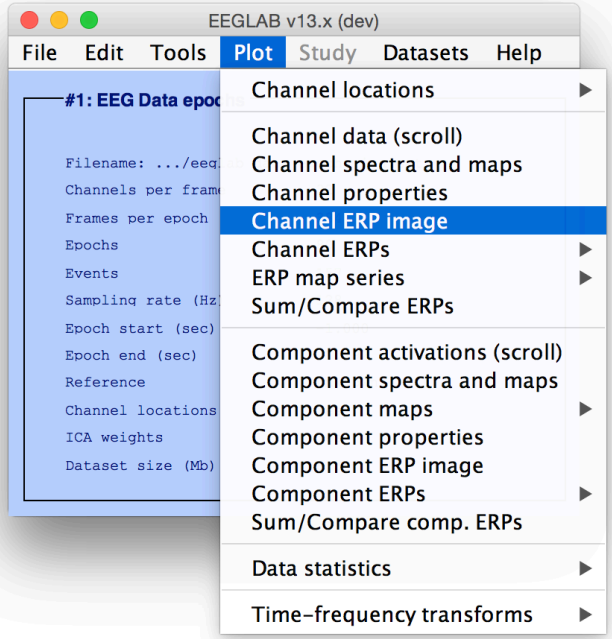
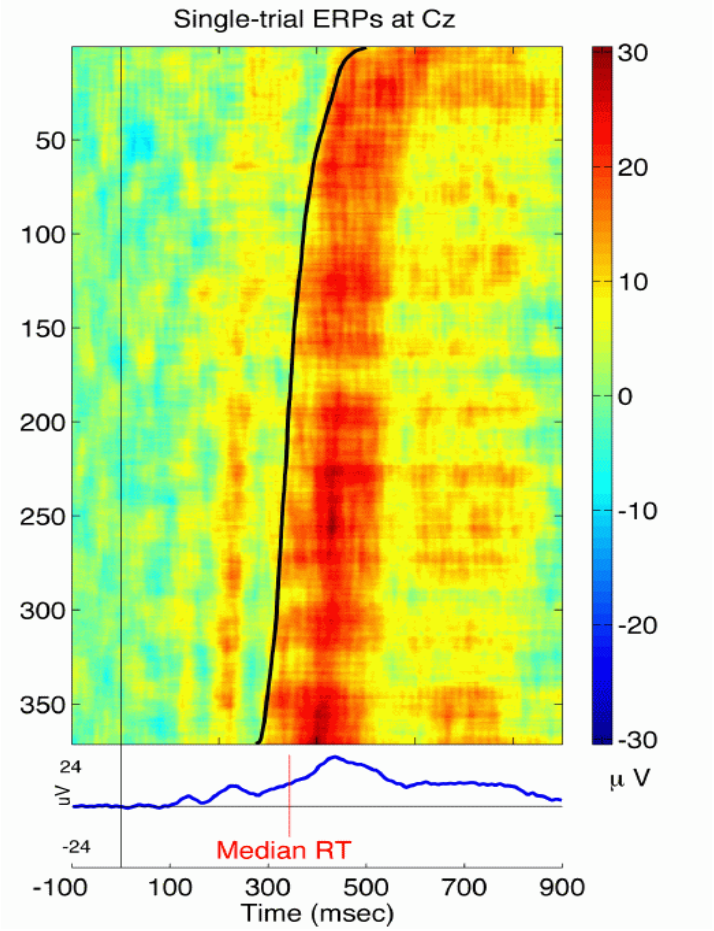


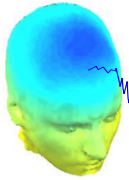


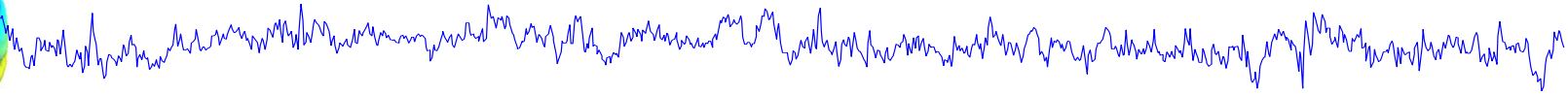
Plot channel ERPimage





EEGLAB standard processing pipeline





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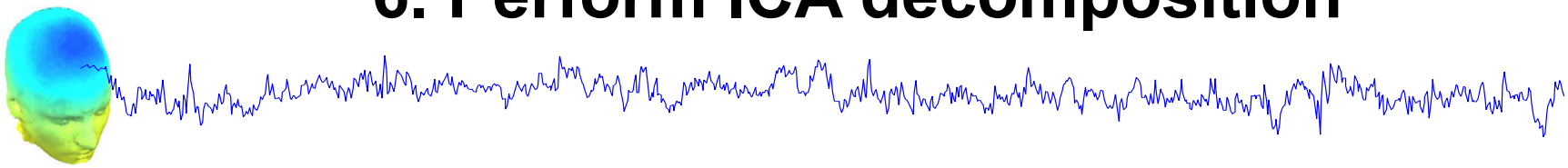
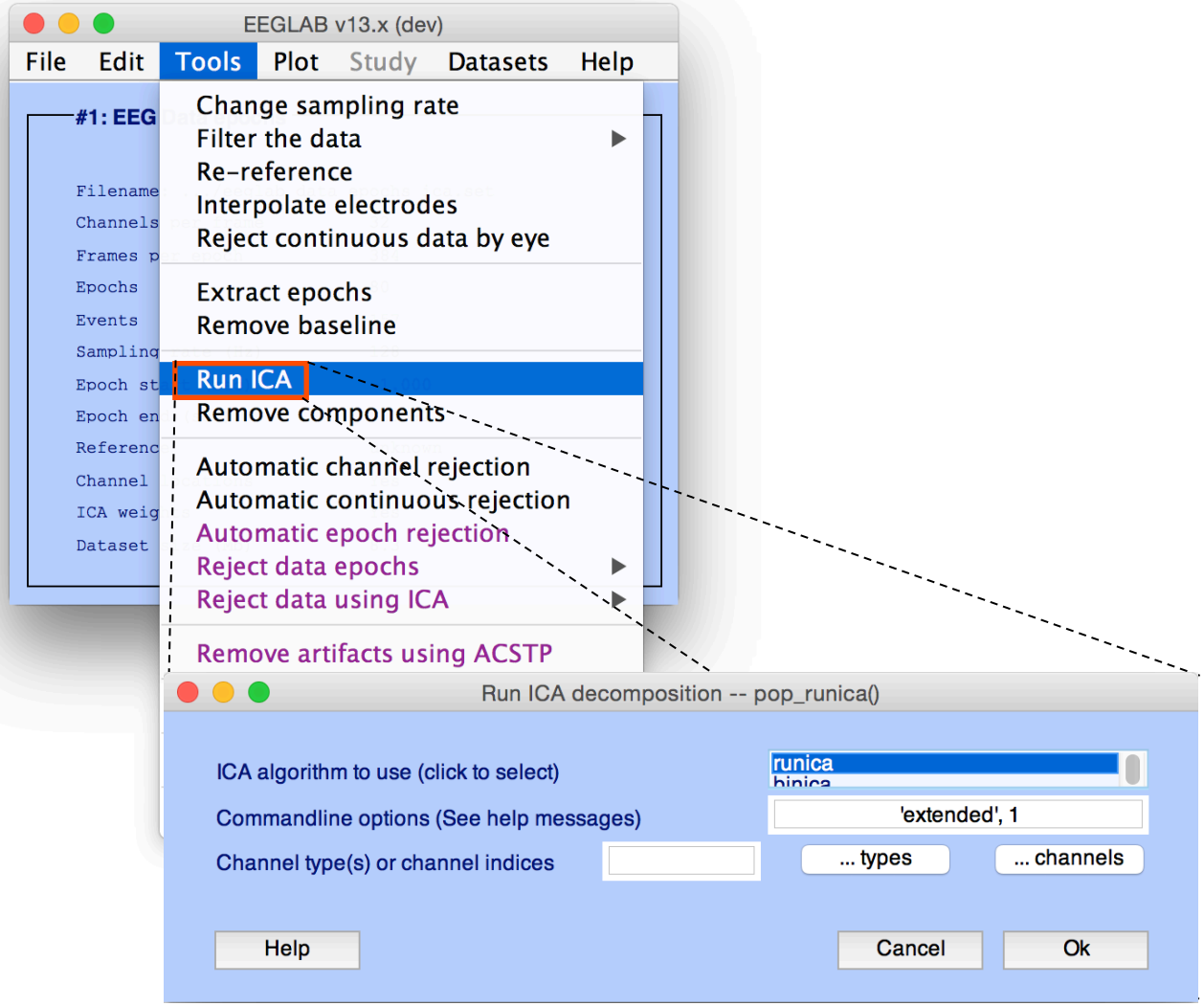
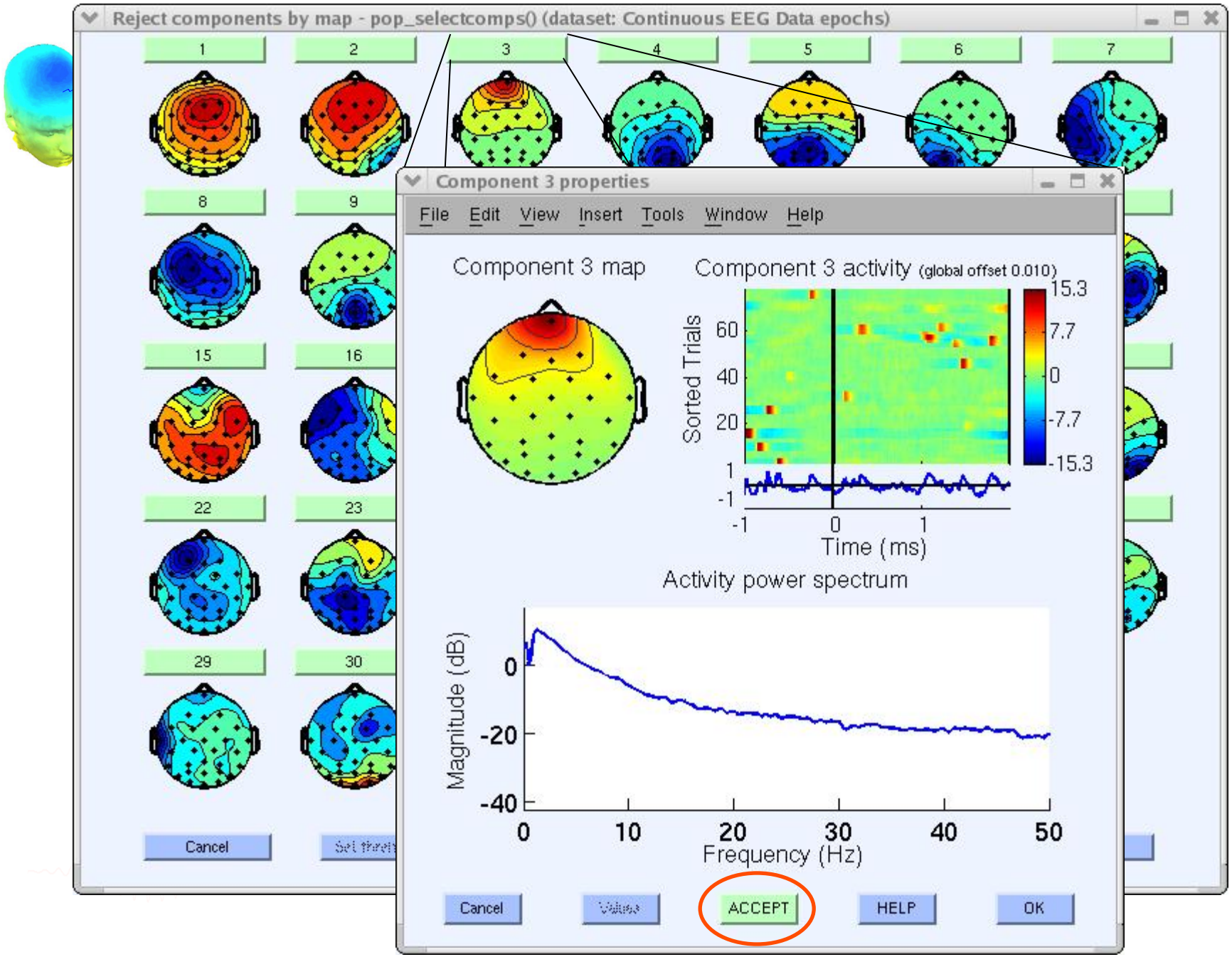
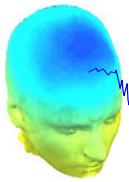
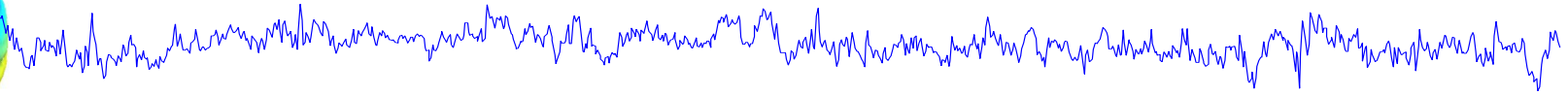


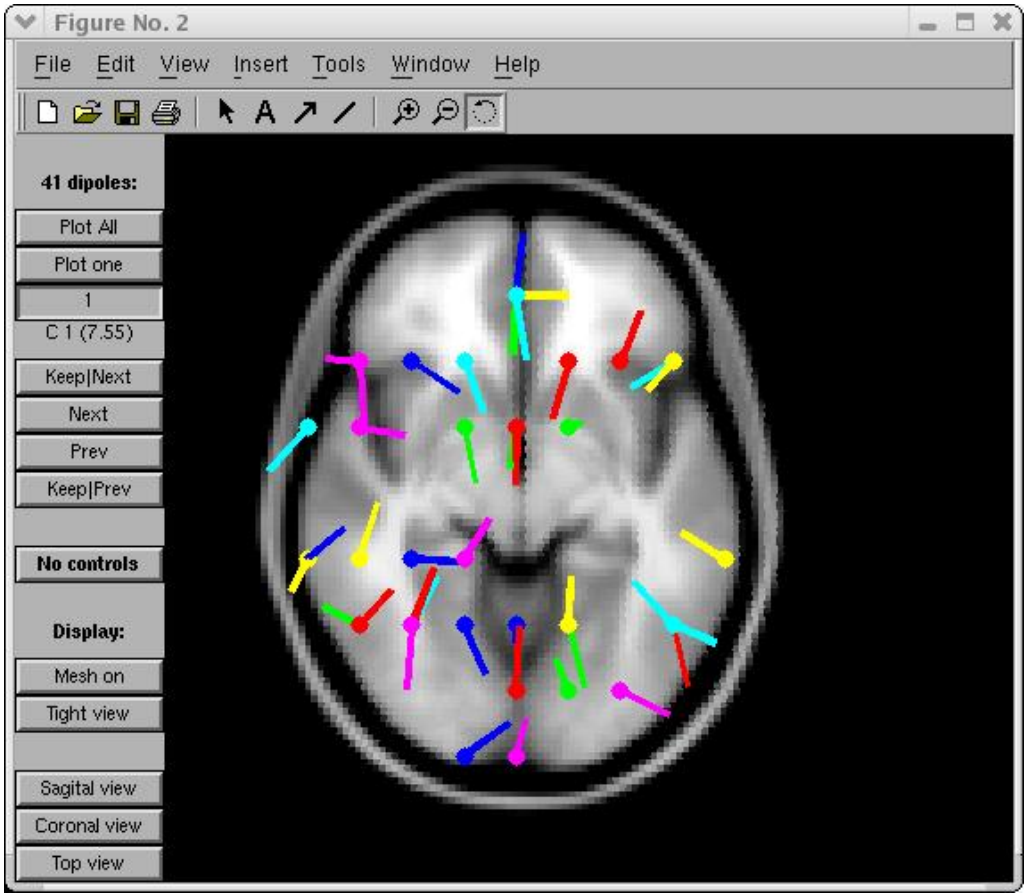


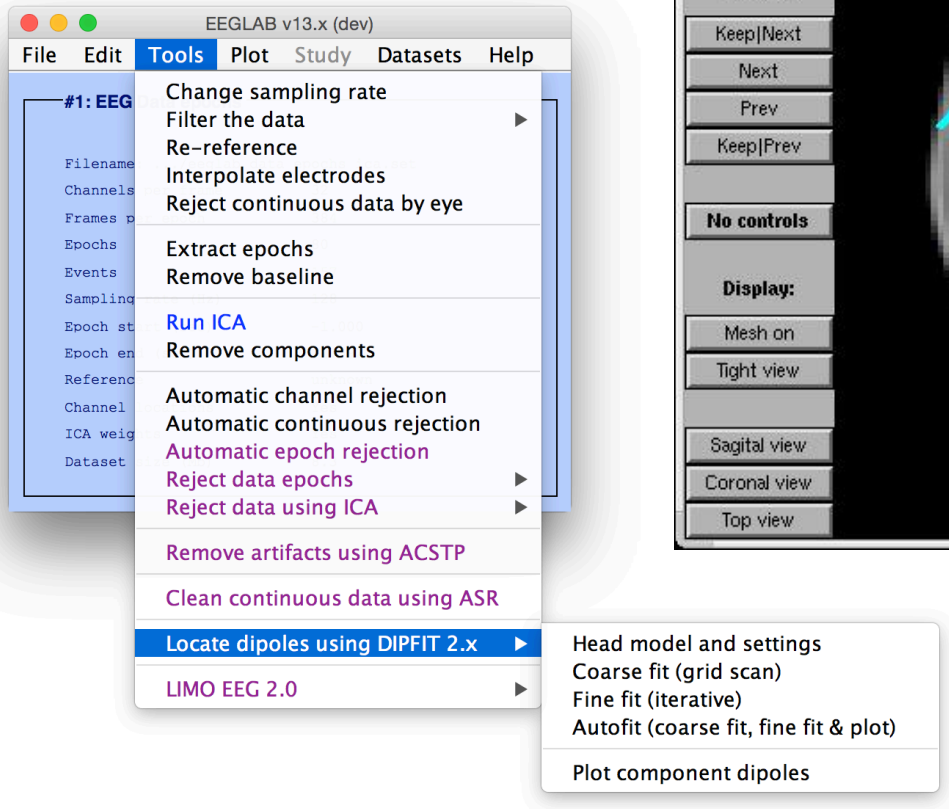

Reject components by map - pop_selectcomps() (dataset: Continuous EEG Data epochs)
1
2
3
4
5
6
7
8
9
15
16
22
23
29
30
Cancel
Component 3 properties
File Edit View Insert Tools Window Help
Component 3 map
Component 3 activity (global offset 0.010)
Sorted Trials
60
40
20
1
-1
15.3
7.7
0
-7.7
-15.3
-1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









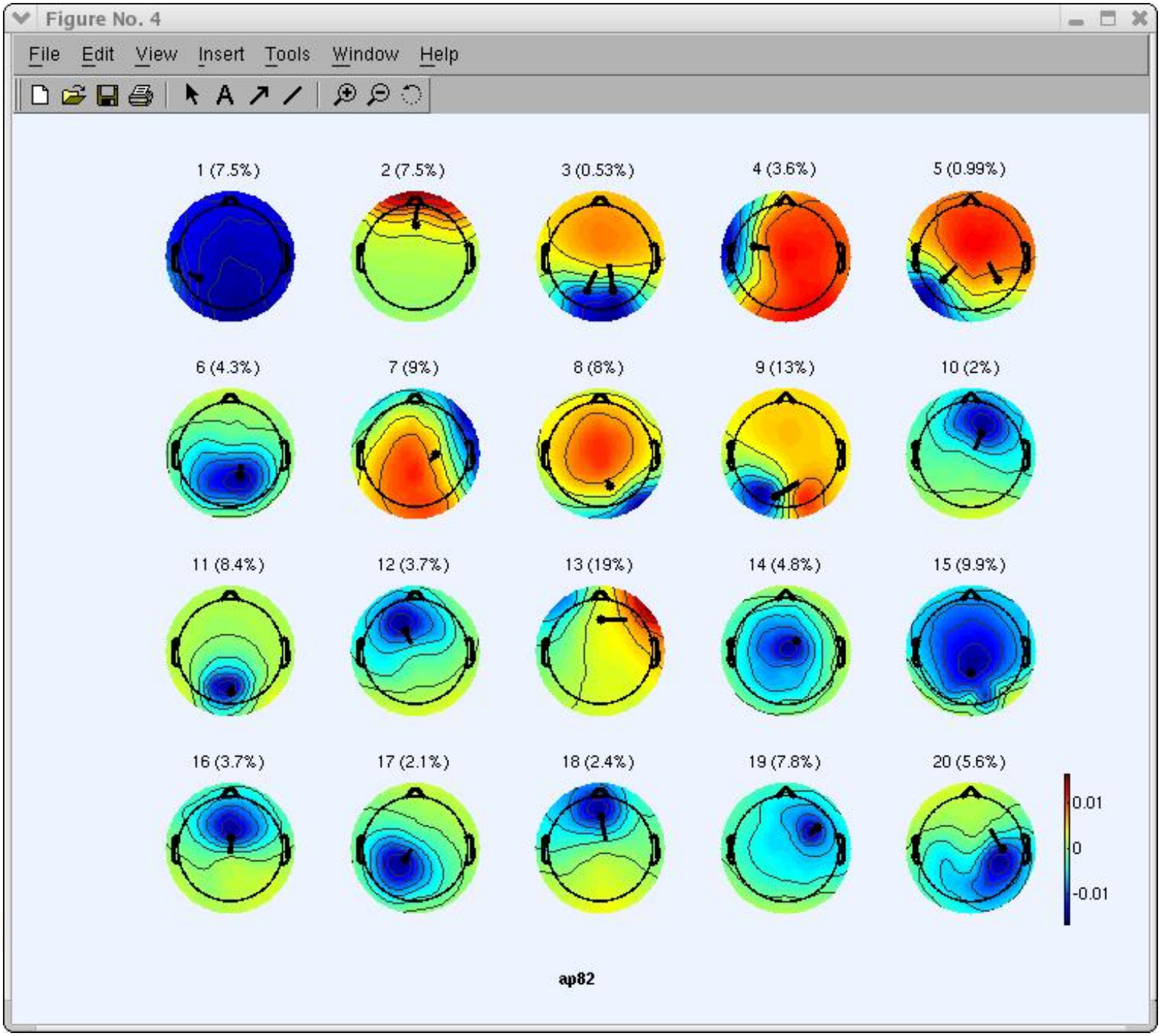


Figure No. 4
File Edit View Insert Tools Window Help
1 (7.5%)
2 (7.5%)
3 (0.53%)
4 (3.6%)
5 (0.99%)
6 (4.3%)
7 (9%)
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9 (13%)
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11 (8.4%)
12 (3.7%)
13 (19%)
14 (4.8%)
15 (9.9%)
16 (3.7%)
17 (2.1%)
18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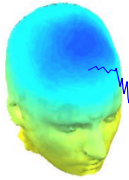
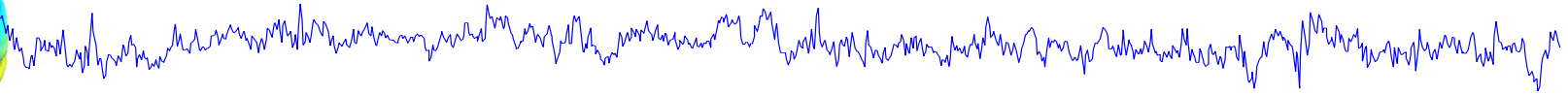
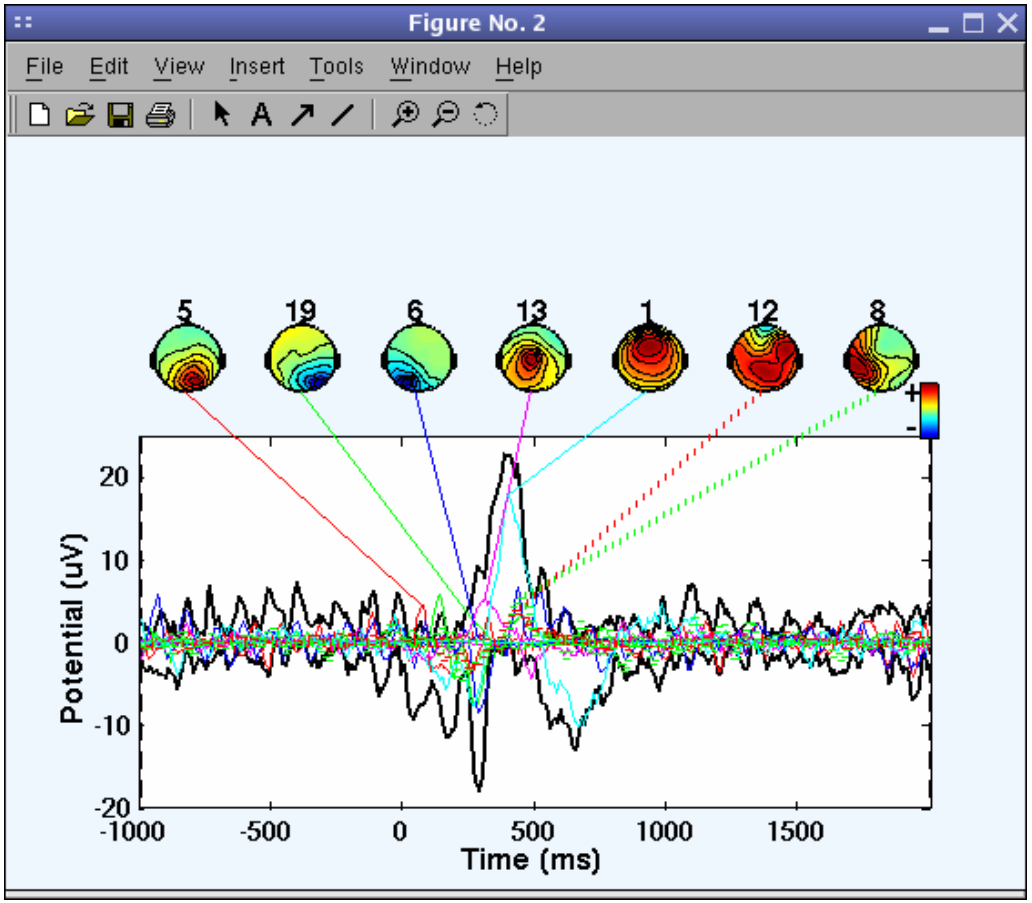
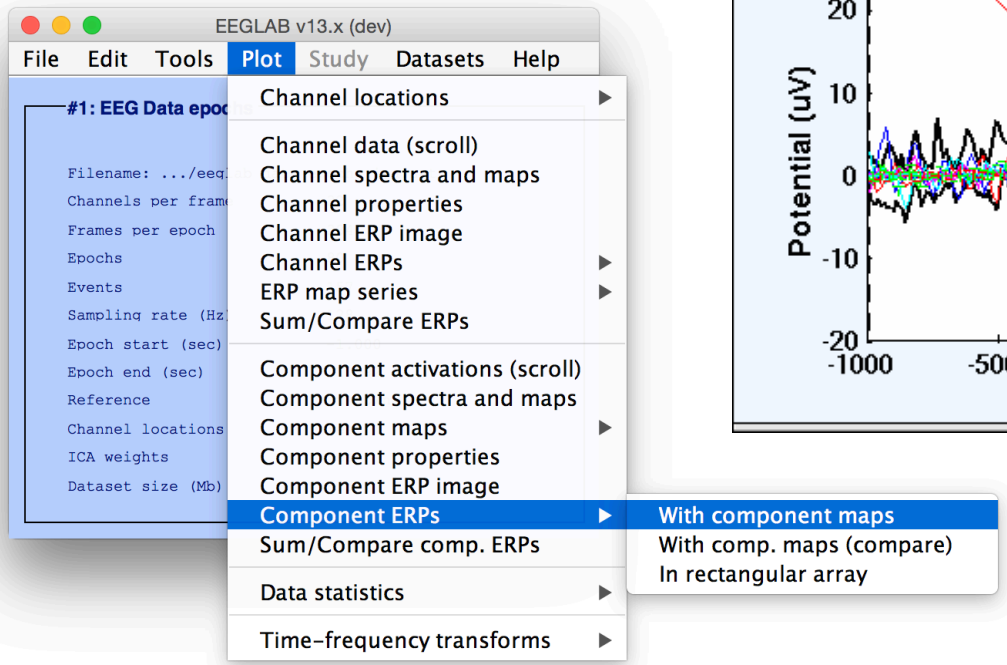
ap82

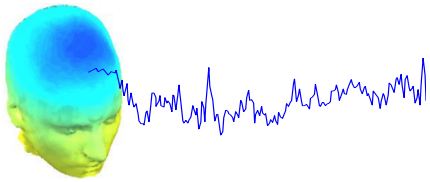
Component contribution to the ERP



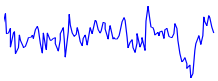


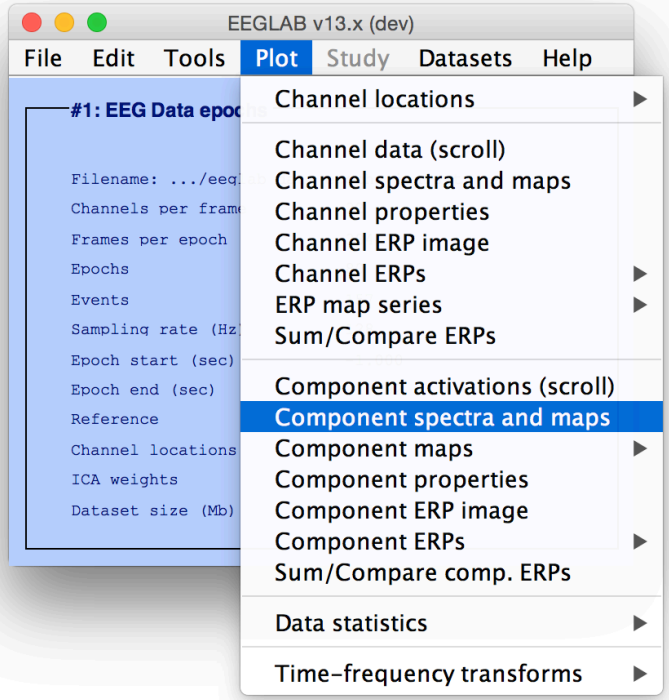


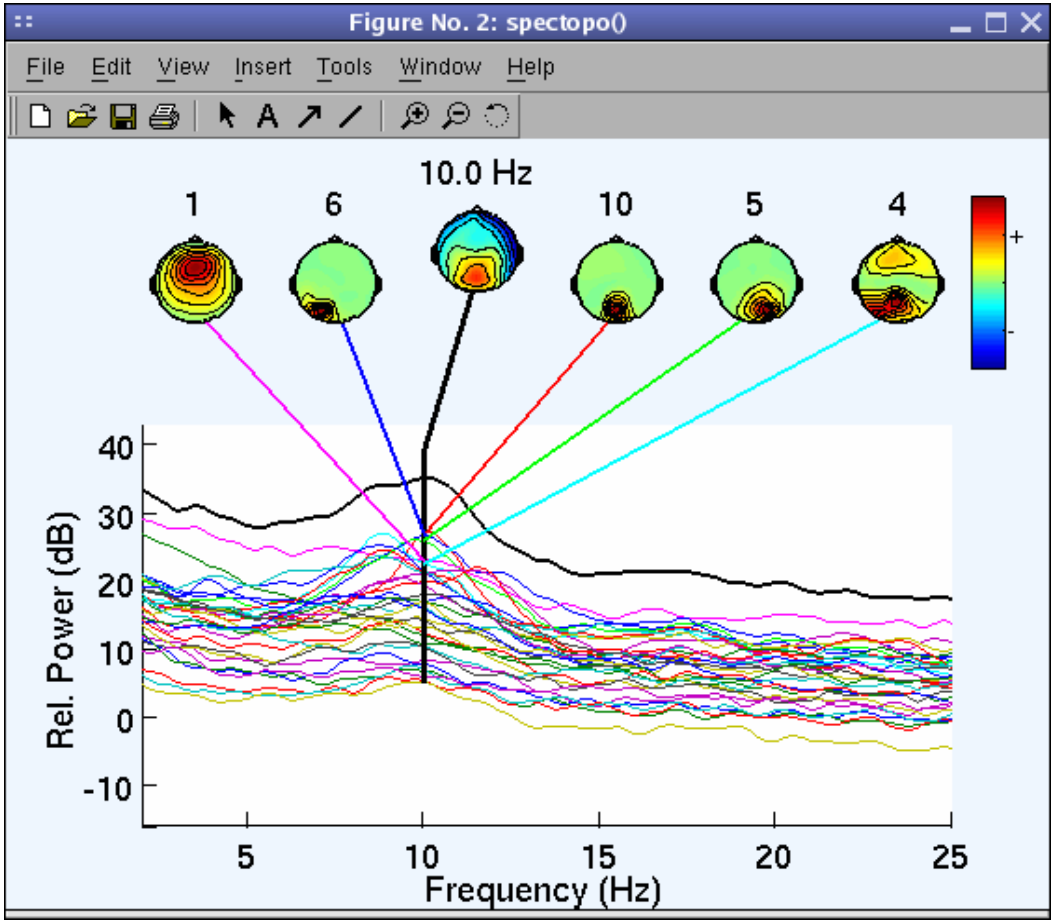




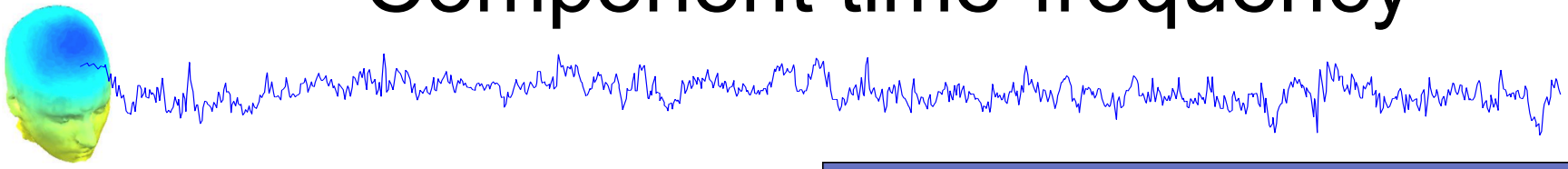
Component contribution to the EEG spectrum

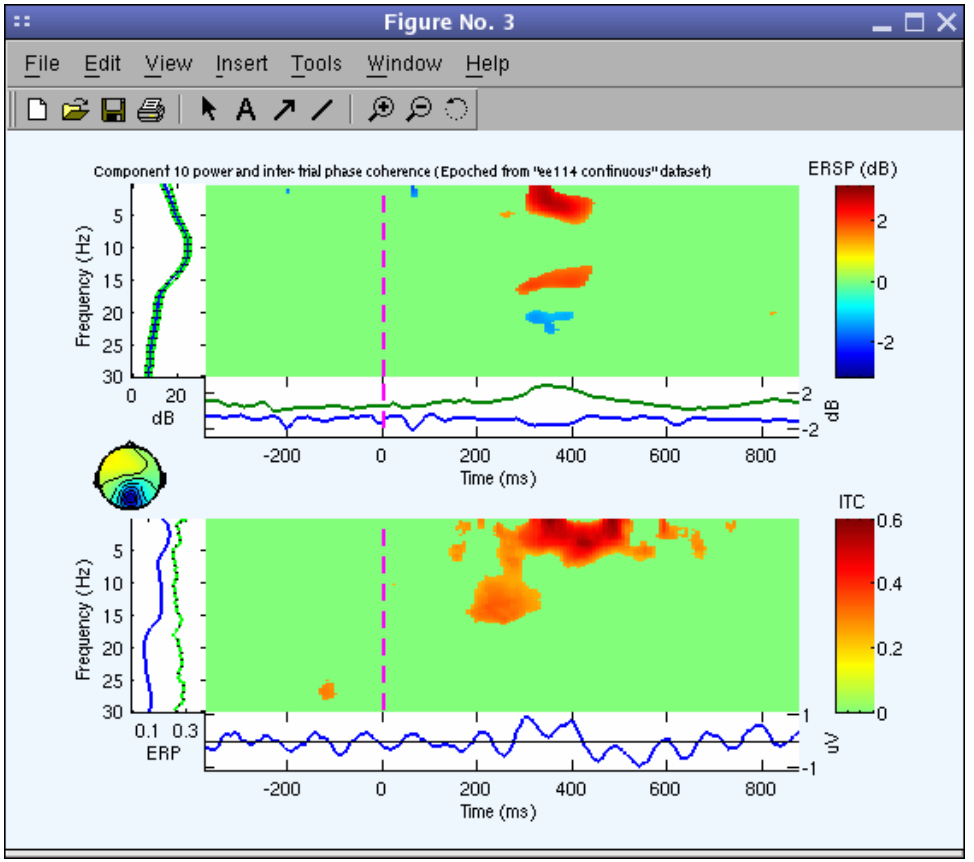


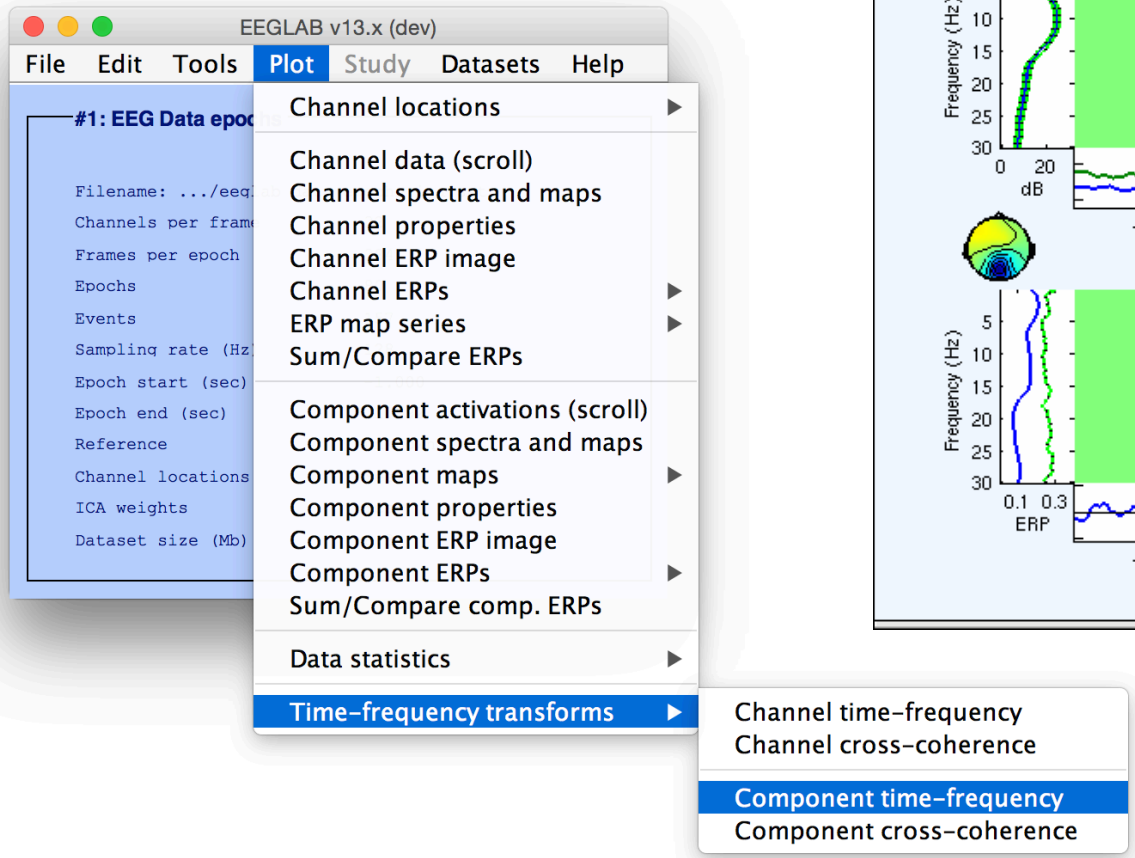




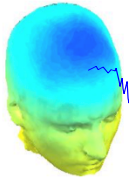
Component time-frequency

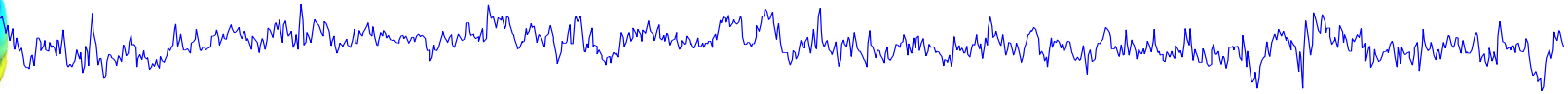






EEGLAB standard processing pipeline





Single subject

1. Import binary data, events and channel location
2. Edit, Re-reference, Resample, High pass filter data
3. Reject artifacts in continuous data by visual inspection
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   - Perform source localization of components
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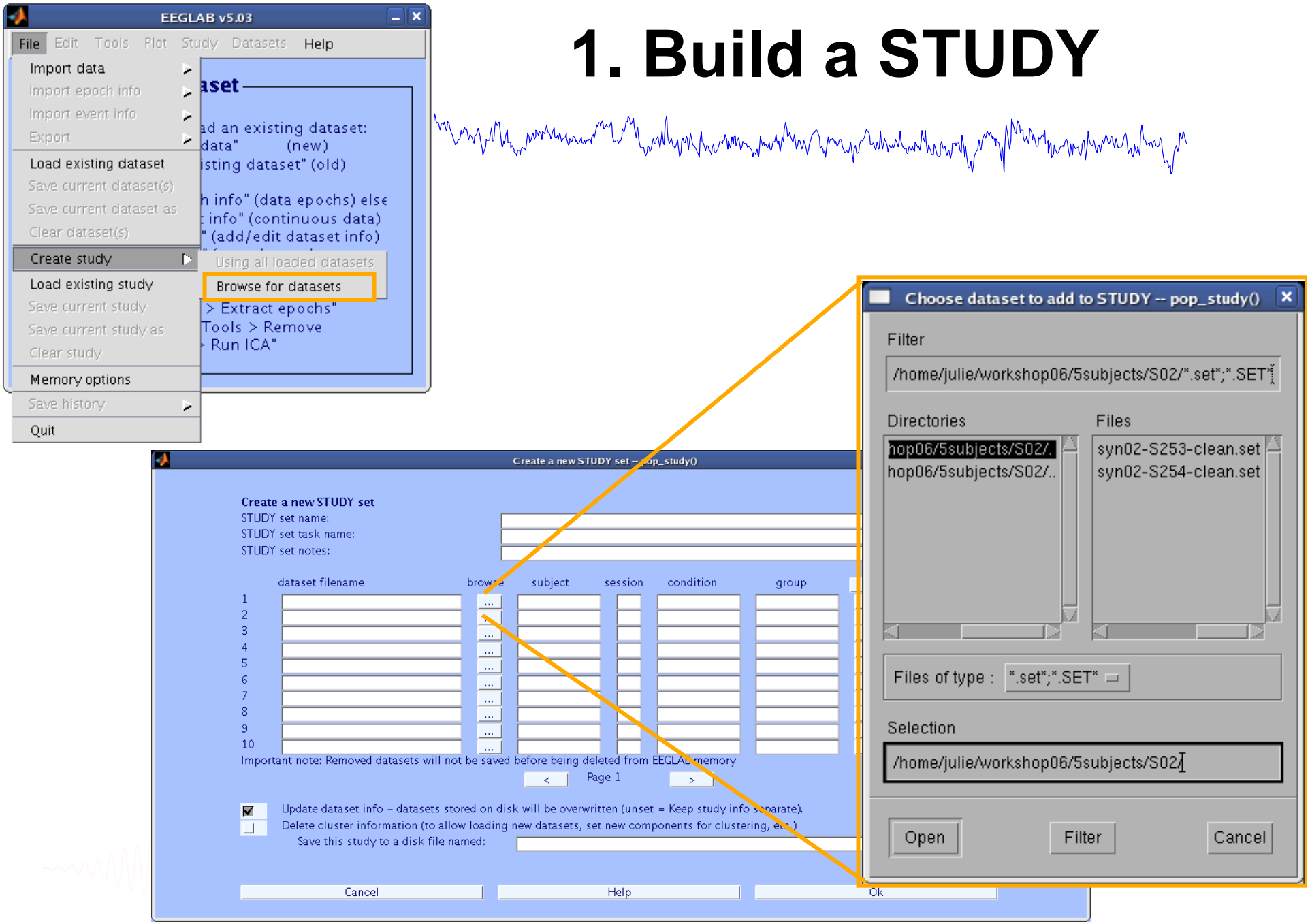
Multi-subjects

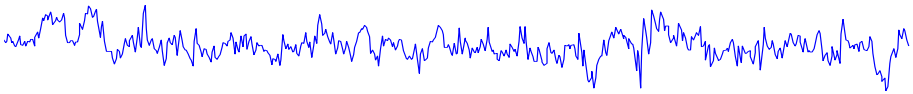
1. Build study and STUDY design
2. Pre-compute measures
3. Cluster components
4. Analyze clusters

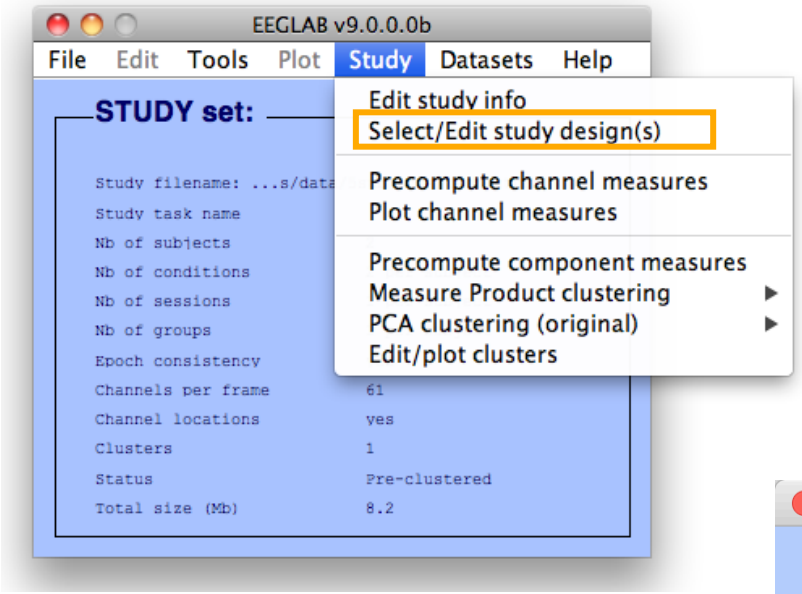
Advanced analysis using scripting and EEGLAB command line functions

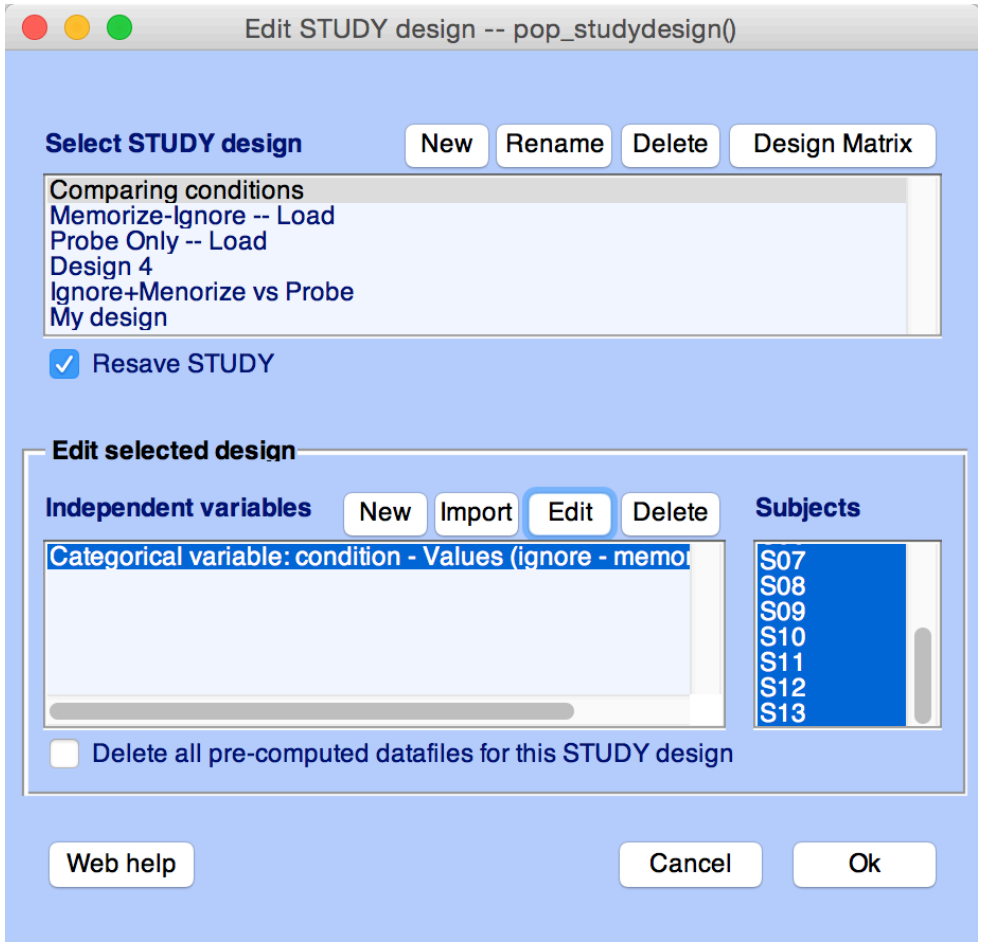
1. Build a STUDY



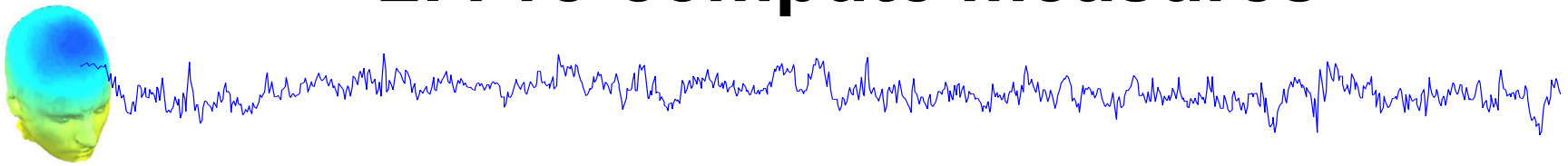
:dit STUDY design



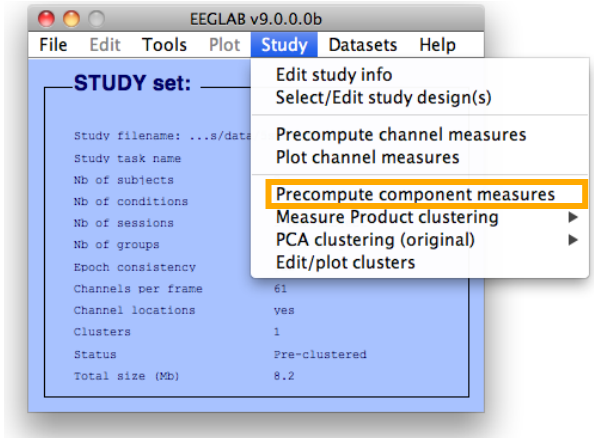




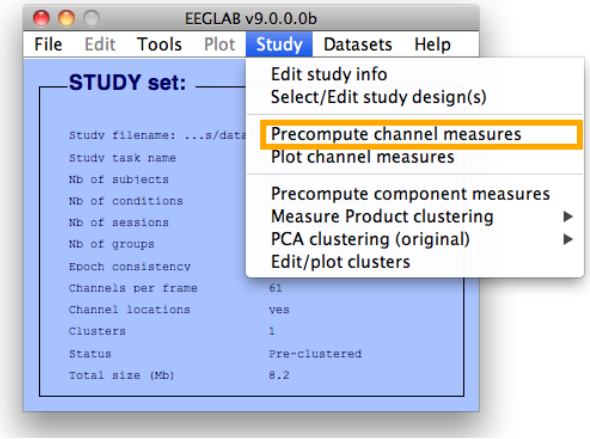
2. Pre-compute measures

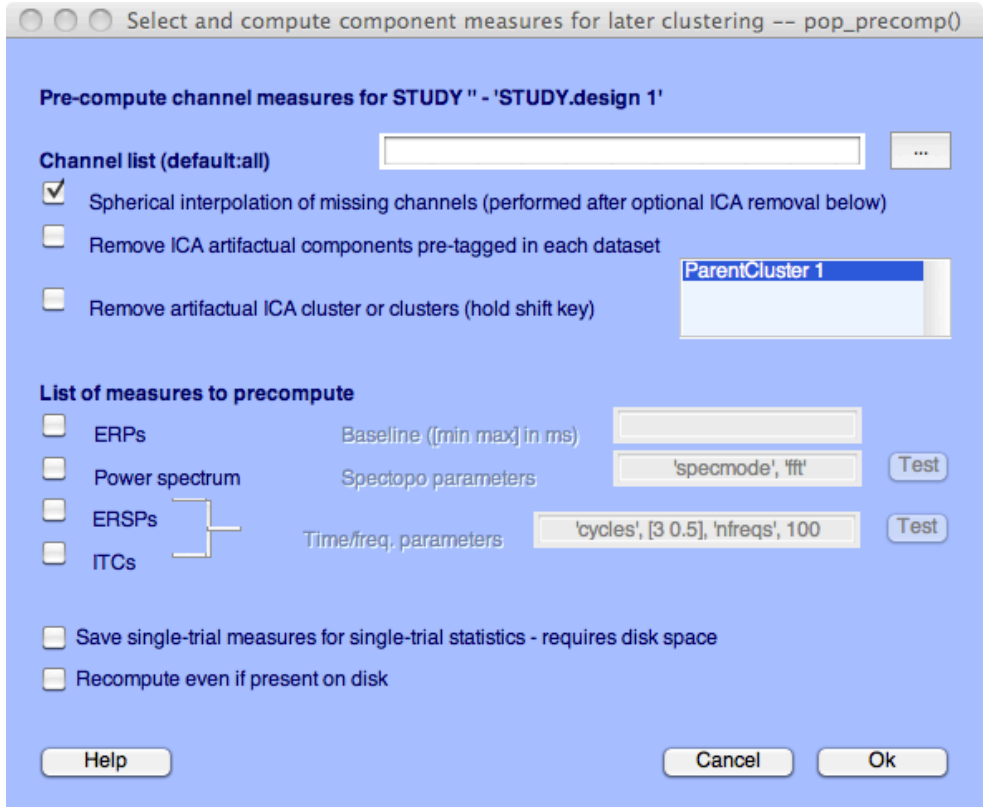


Components

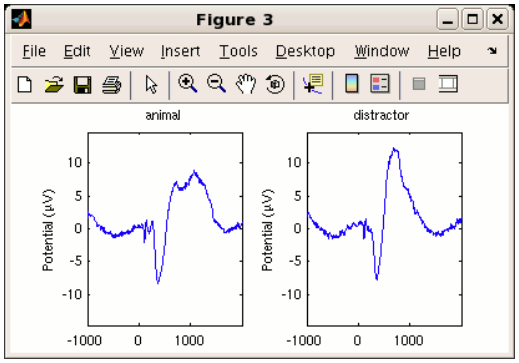


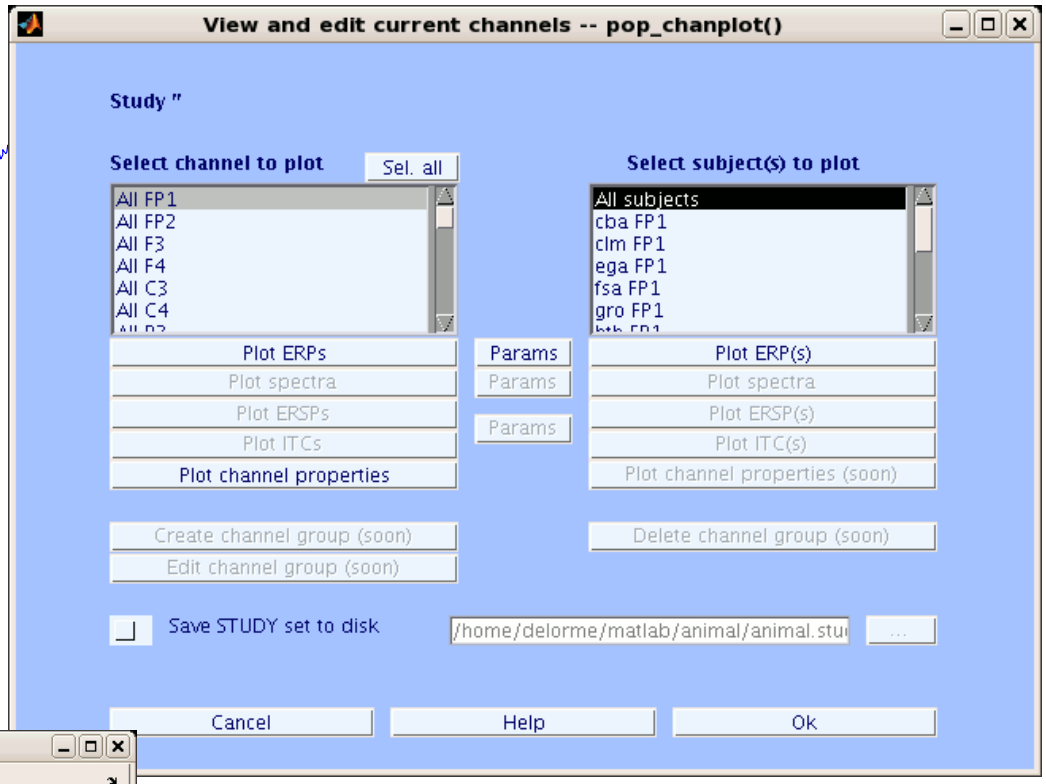
Channels

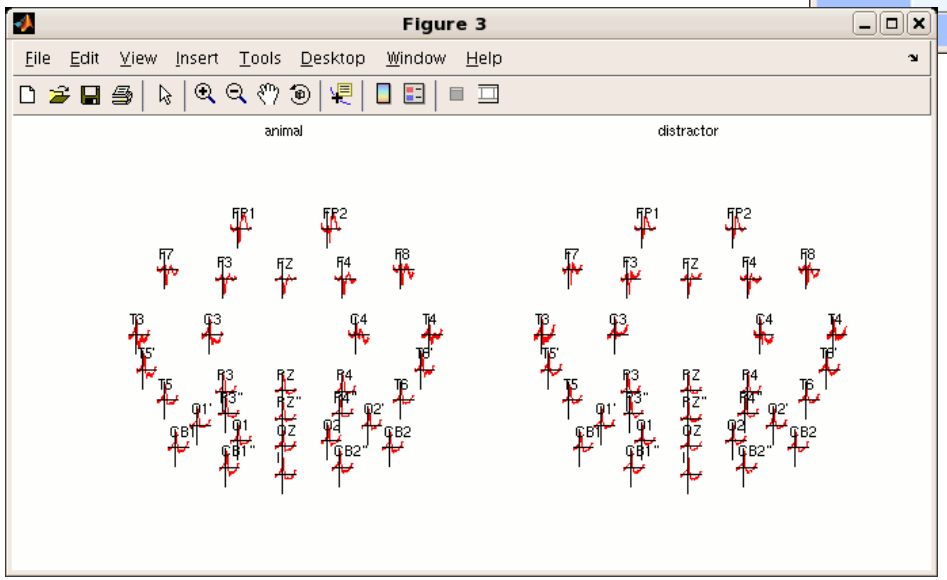


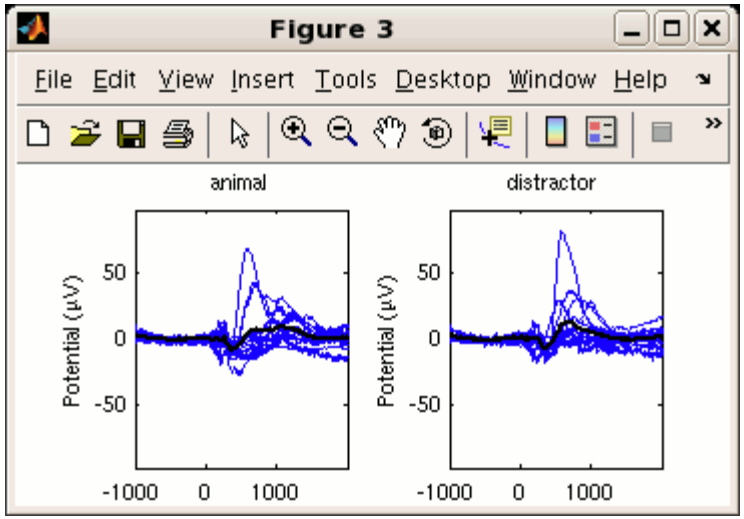


Channel plotting









3. Cluster components

EEGLAB v6.0b

File Edit Tools Plot Study Datasets Help

- Edit study info
- Precompute channel measures
- Plot channel measures
- Precompute component measures
- Build preclustering array
- Cluster components
- Edit/plot clusters

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

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)

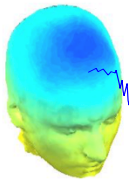
Load	Dims.	Norm.	Rel. Wt.		
spectra	10	1	Freq.range [Hz]	3 25	
ERPs	10	1	Time range [ms]	0 600	
dipoles	3	10			
scalp maps	10	1	Use channel values	Absolute values	
ERSPs	20	1	Time range [ms]	0 1500	Freq. range [Hz] 3 45
ITCs	10	1	Time range [ms]	0 600	Freq. range [Hz] 2 30
Final dimensions	10				

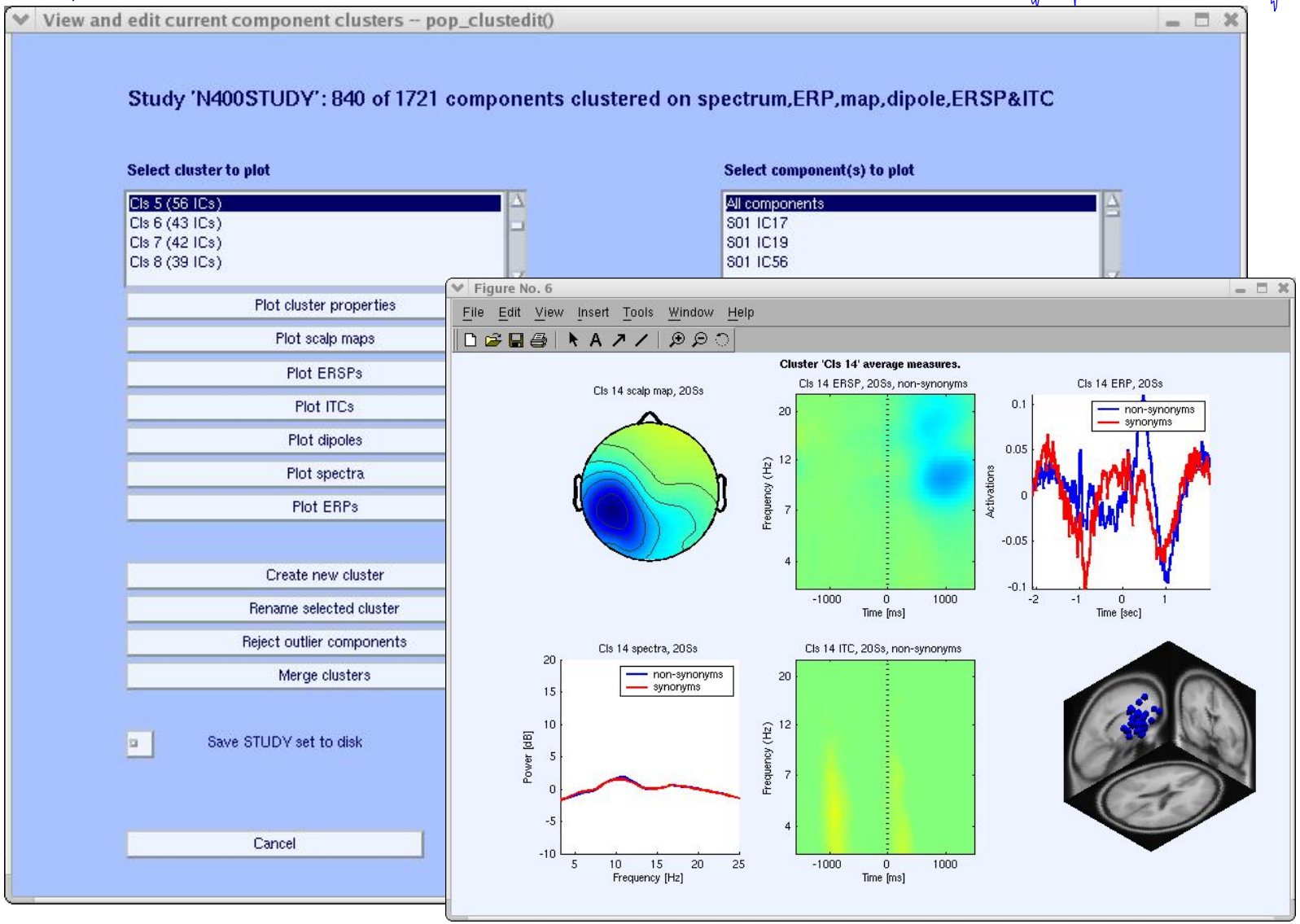
Help

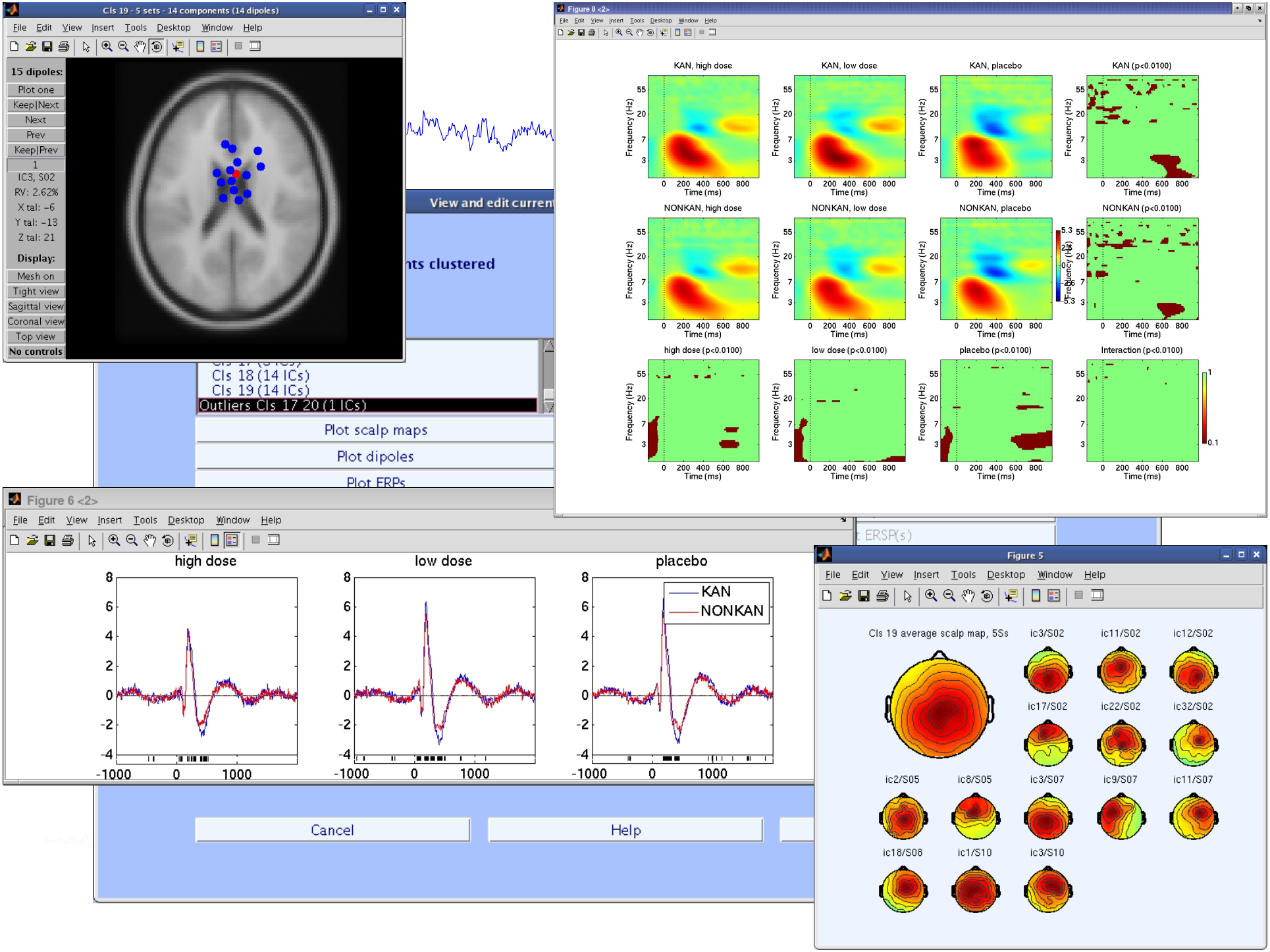
Save STUDY to file /home/julie/WorkshopSD2007/STUDY/attention.study ...

Cancel Help Ok

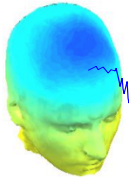
4. Analyze clusters

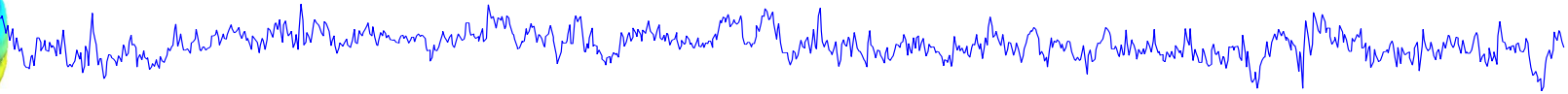





Cls 19 - 5 sets - 14 components (14 dipoles)
File Edit View Insert Tools Desktop Window Help
15 dipoles:
Plot one
Keep|Next
Next
Prev
Keep|Prev
1
IC3, S02
RV: 2.62%
X tal: -6
Y tal: -13
Z tal: 21
Display:
Mesh on
Tight view
Sagittal view
Coronal view
Top view
No controls
View and edit curren
nts clustered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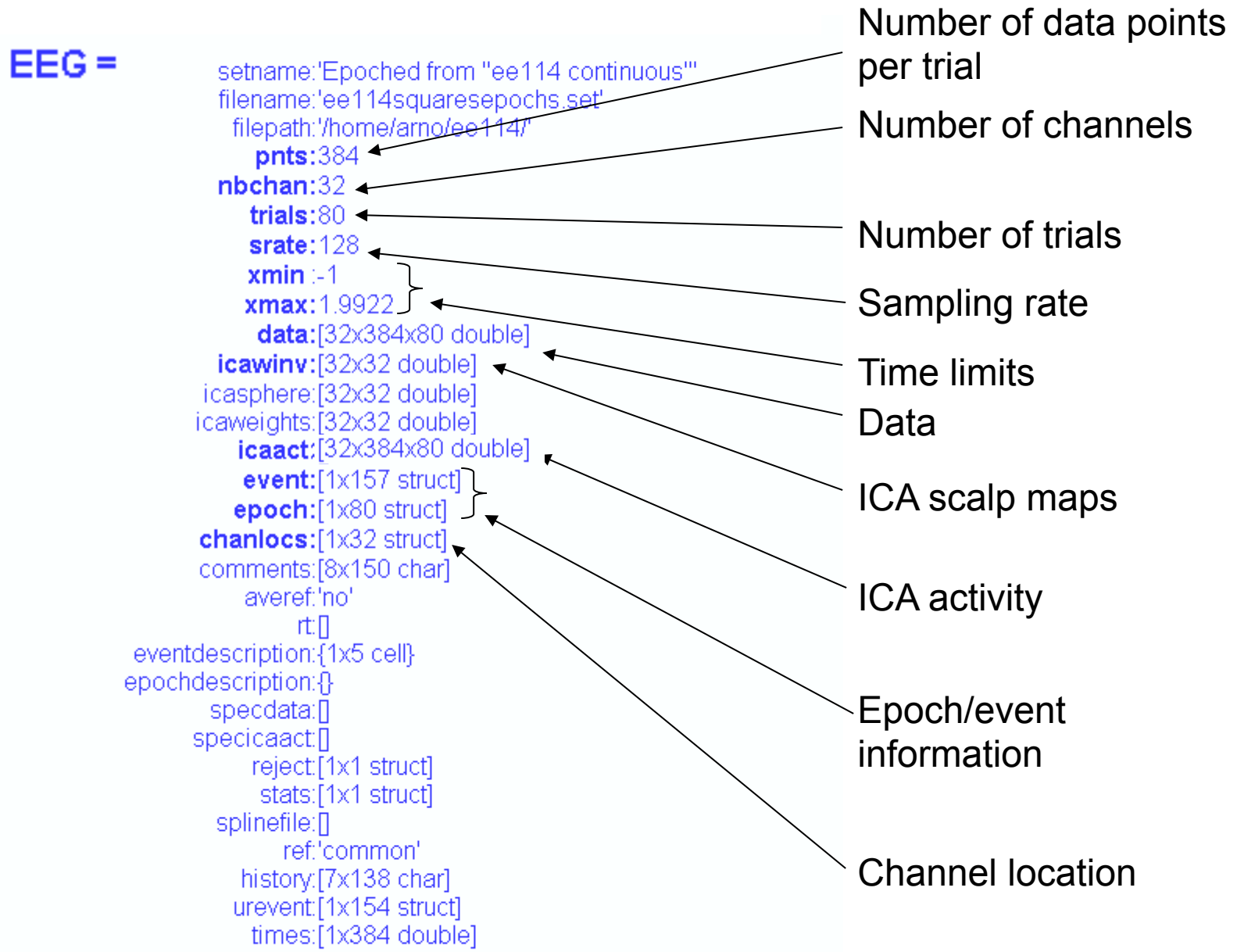
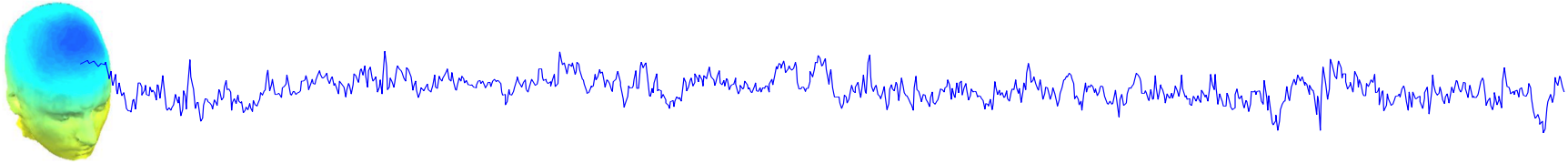
Advanced analysis using scripting and EEGLAB command line functions

EEG structure



3 levels of functions



Administrative functions: handle EEG and ALLEEG structures

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

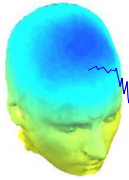
Pop functions: interactive functions using EEG structure

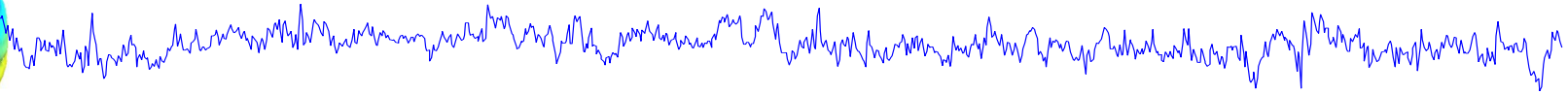
pop_erpimage(), pop_topoplot(), pop_envtopo(), …

Signal processing functions: perform signal processing

erpimage(), topoplot(), envtopo(), …

Command line tools



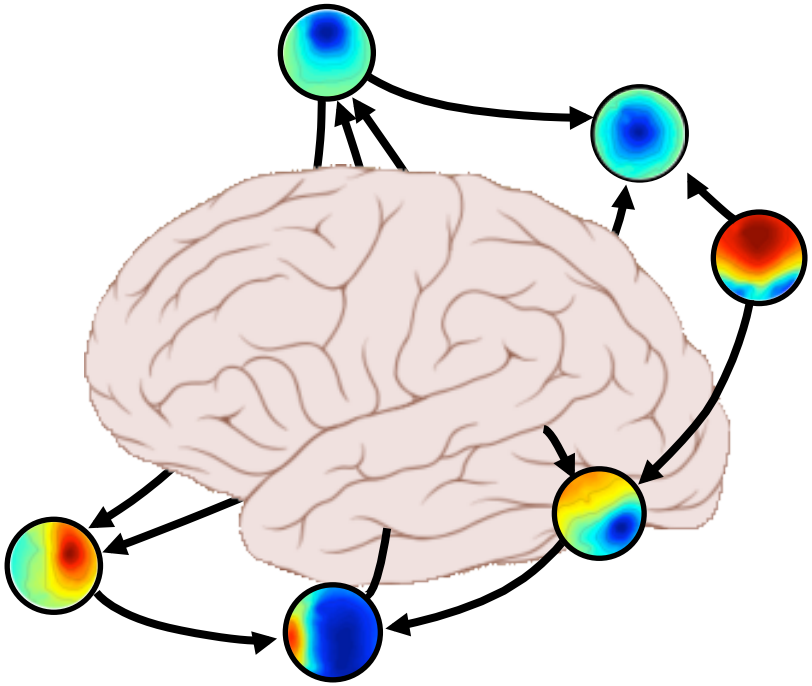


("eegh" Menus write both dataset and global history)

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

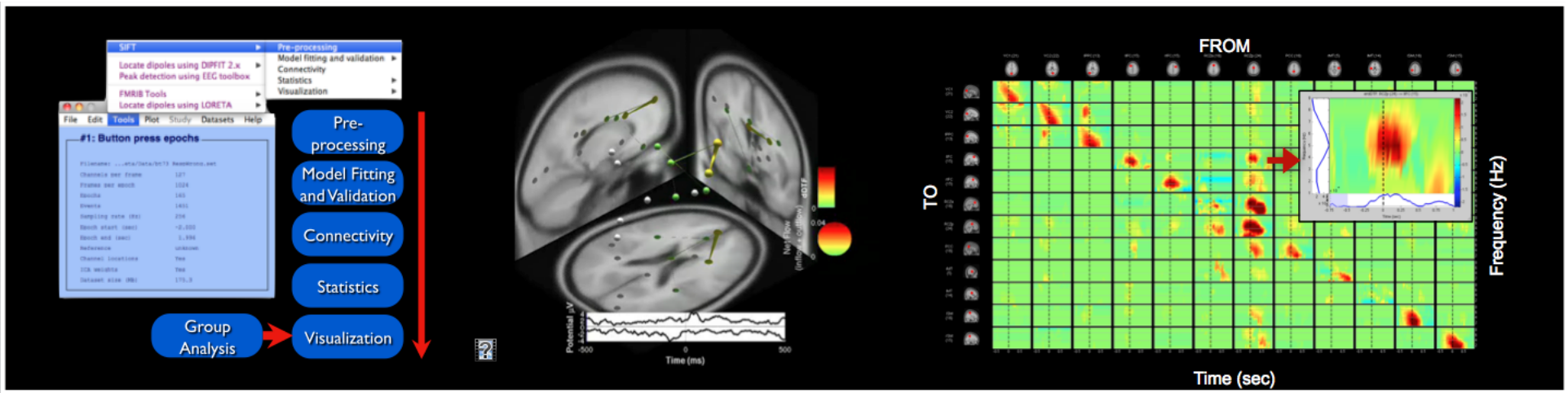
EEGLAB Scripting

```
% 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);
```

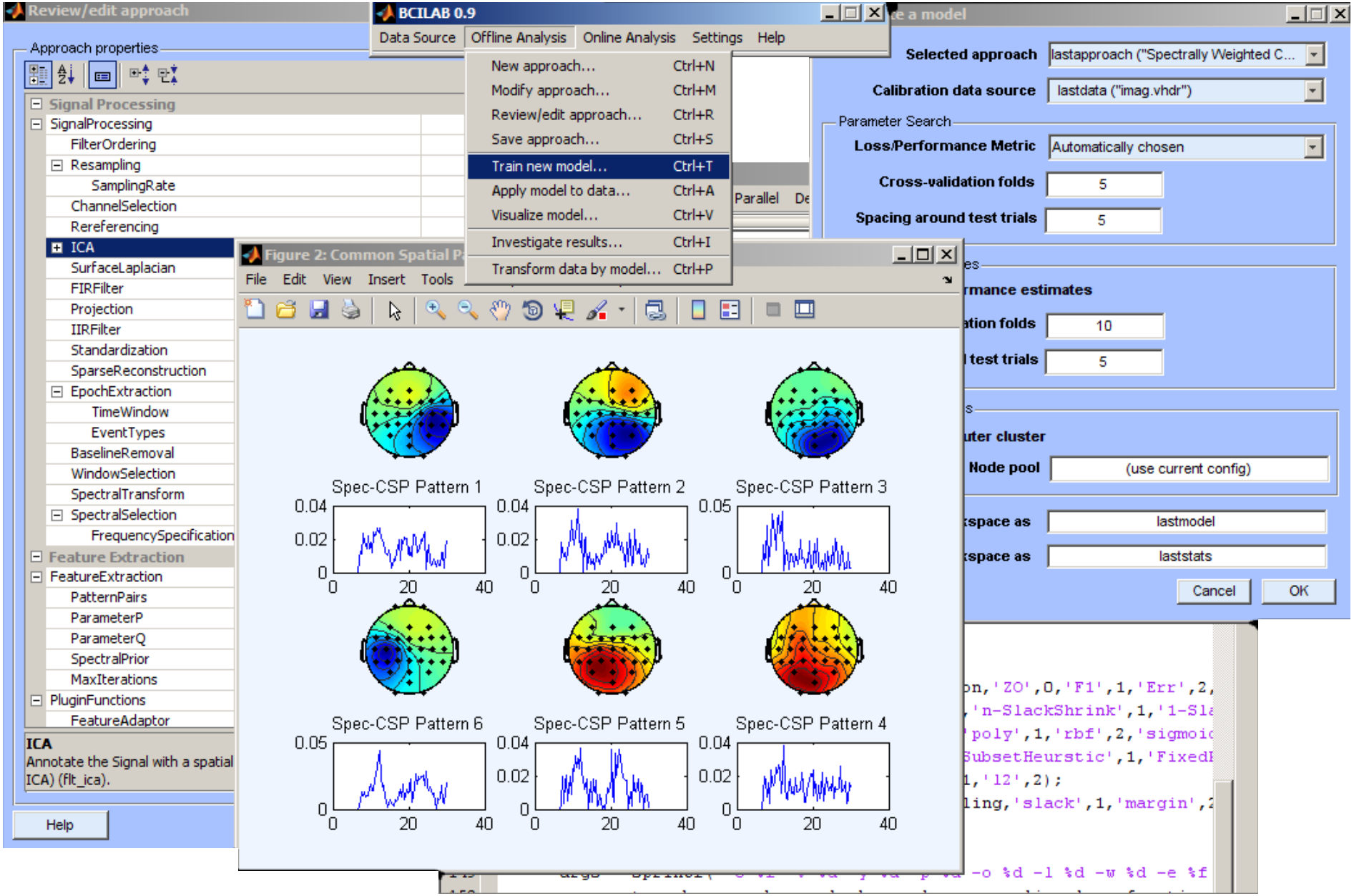


SIFT

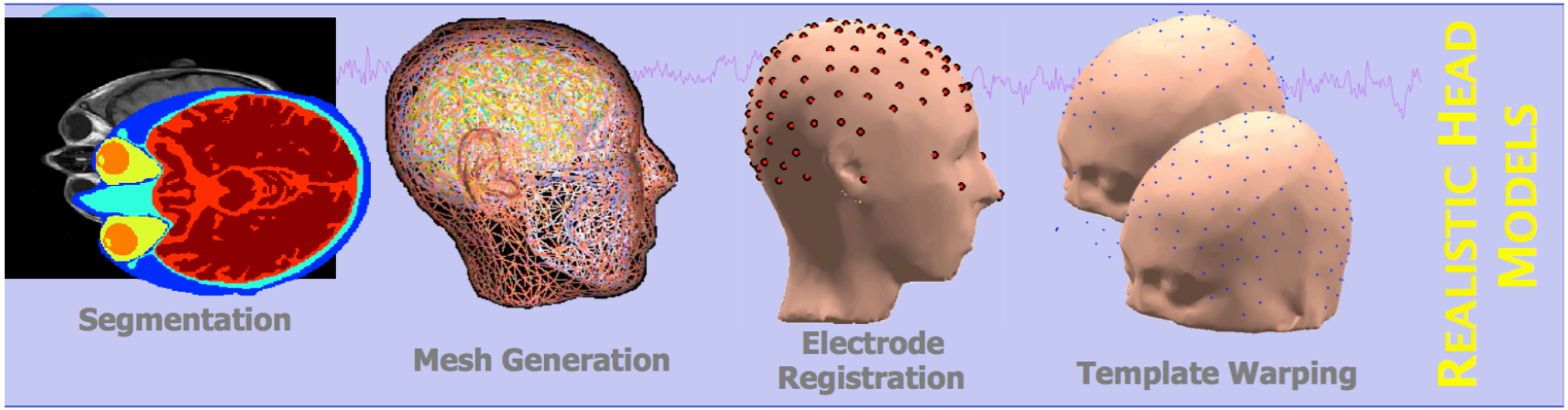
Source Information Flow Toolbox

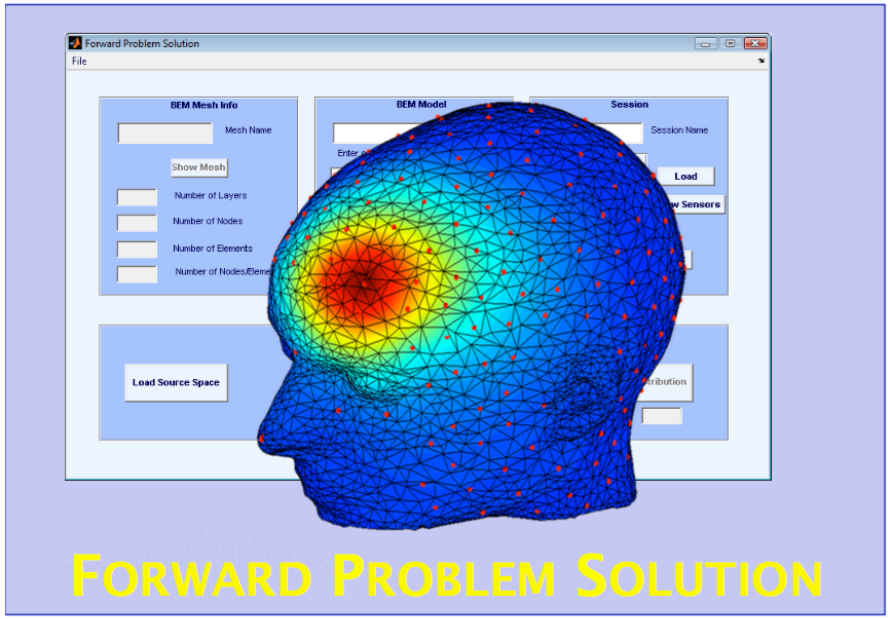


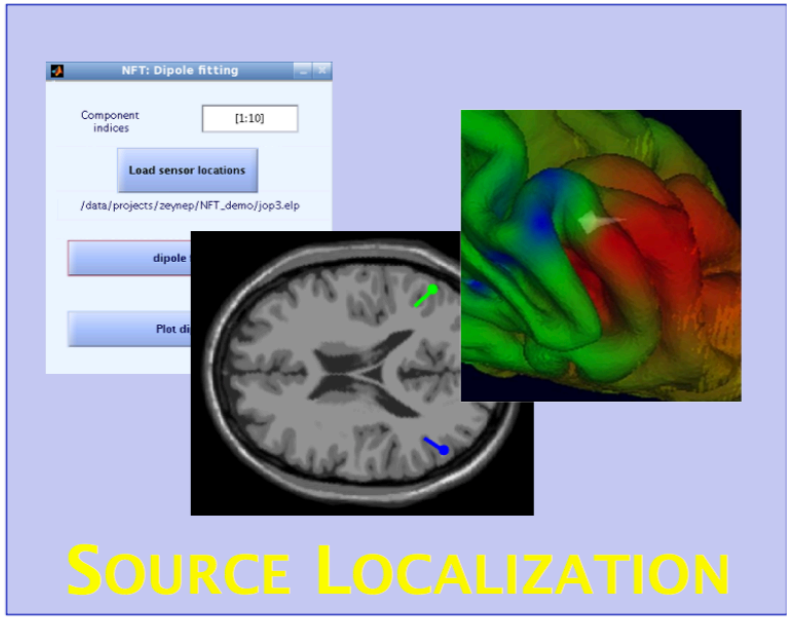
BCILAB - C. Kothe



NFT: Neuroelectromagnetic Forward Head Modeling Toolbox

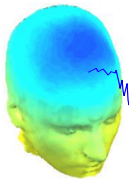


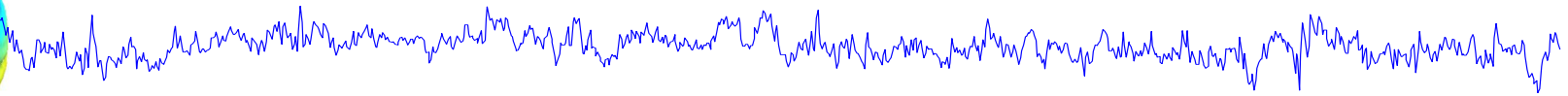




http://sccn.ucsd.edu/nft

Pros/Cons of Matlab based open source

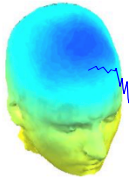


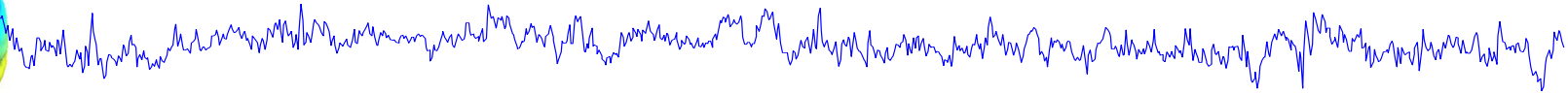


- Pros
  - Easy to program, highly modular and extendable
  - Not dependent on any platform (64-bit) and highly optimized
  - Large community of users (latest development in signal processing research)
  - Powerful scripting capabilities

- 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





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Workshop Program (with corresponding PDFs) [edit]

Purple lettering = lecture
Orange lettering = tutorial

Monday, September 25th

17:00 – 19:00 -- On-site registration

Tuesday, September 26th

9:20 – 10:00 -- On-site registration

Overview and ICA Theory/Practice

10:00 – 11:15 -- Mining event-related brain dynamics I (Scott Makeig) PDF
11:15 – 11:45 -- EEGLAB overview (Arnaud Delorme)

-- Break--

12:00 – 13:00 -- ICA theory (Jason Palmer) PDF

13:00-14:15 Lunch

ICA and time-frequency

14:15 – 15:15 -- Data import, Artifact rejection (John Iversen)
15:15 – 16:00 -- ICA decomposition practicum (John Iversen)

-- Break--

16:15 – 17:00 -- Evaluating ICA components practicum (Makoto Miyakoshi)
17:00 – 18:00 -- Time-frequency decompositions: Theory and practice (John Iversen)

Wednesday, September 27th

Group analysis and ICA clustering in EEGLAB

10:00 - 11:00 -- Why cluster ICA components? (Scott Makeig)

11:00 - 15:30 -- Excursion (Open-air Experiment and Hiking at Shinjuku-gyoen). Wearable EEG measurement system demonstration and discussion (Noriaki Kanayama, Hiroshima University, Shusuke Yoshimoto, Osaka University ; supported by the COI Next Generation Researchers Collaborative Research Fund (H29W03) from Japan Science and Technology Agency, JST). Picnic lunch and hiking.

16:00 - 16:45 -- Creating a STUDY and STUDY design (Arnaud Delorme)

-- Break--

17:00 - 17:45 -- Plotting and computing statistics in channels and components in STUDY (Arnaud Delorme)
17:45 - 18:30 -- Group analysis using EEGLAB studies: Methods to cluster ICA components (Arnaud Delorme)

Thursday, September 28th

Source Localization

10:00 – 11:30 -- The Neuroelectromagnetic Forward Head Modeling (NFT) and NIST (Inverse Source Imaging) toolkits (Scott Makeig)

11:30 – 12:00 -- Forward and inverse models - the Dipfit tools (Arnaud Delorme)

-- Break--

General Linear Modeling and statistics

12:15 - 13:00 -- Robust statistics and correction for multiple comparisons (Arnaud Delorme)

13:00-14:15 Lunch --

General Linear Modeling and statistics continued

14:15 – 15:15 -- Theory and practice of applying general linear models to EEG data using the LIMO EEGLAB plug-in (Arnaud Delorme)

15:15 – 15:45 -- LIMO and EEGLAB practicum (Arnaud Delorme)

-- Break--

Source information flow

16:00 – 17:00 -- Source information flow and Granger-Causal modeling tools (Tim Mullen)

17:00 – 18:00 -- SIFT toolbox: Theory, live demo, and practicum (Tim Mullen)

Friday, September 29th

10:00 – 11:00 -- Mining event-related brain dynamics II (Scott Makeig)

11:00 – 11:30 -- Using and building EEGLAB extensions/plug-ins (Arnaud Delorme)

-- Break--

Advanced plugins

11:45 – 12:30 -- Scripting using EEGLAB (Arnaud Delorme)

12:30 – 13:00 -- Preprocessing pipelines and utility tools (Makoto Miyakoshi) PDF

xx:xx – xx:xx -- groupSIFT: Solution for post-SIFT group-level statistics (Makoto Miyakoshi) PDF Supplementary movie1

13:00-14:15 Lunch --

14:15 – 15:45 -- Practicum, small group projects

-- Break--

16:00 – 17:00 -- Practicum, small group projects

17:00 – 17:30 -- Participant project presentations and general discussion

17:30 – 18:00 -- Workshop closes