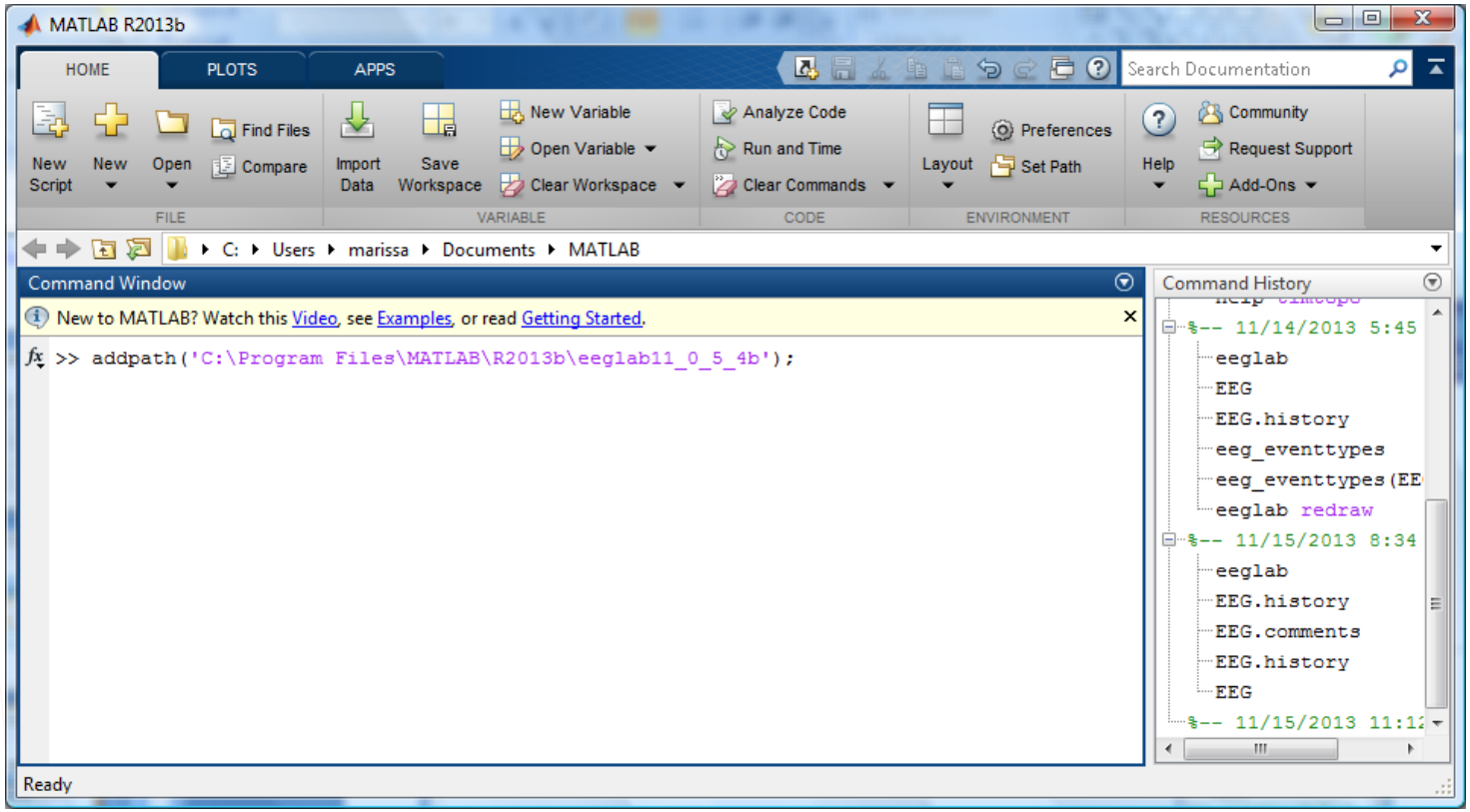
EEGLAB Processing

Data import/Preprocessing

Basic ERP visualization

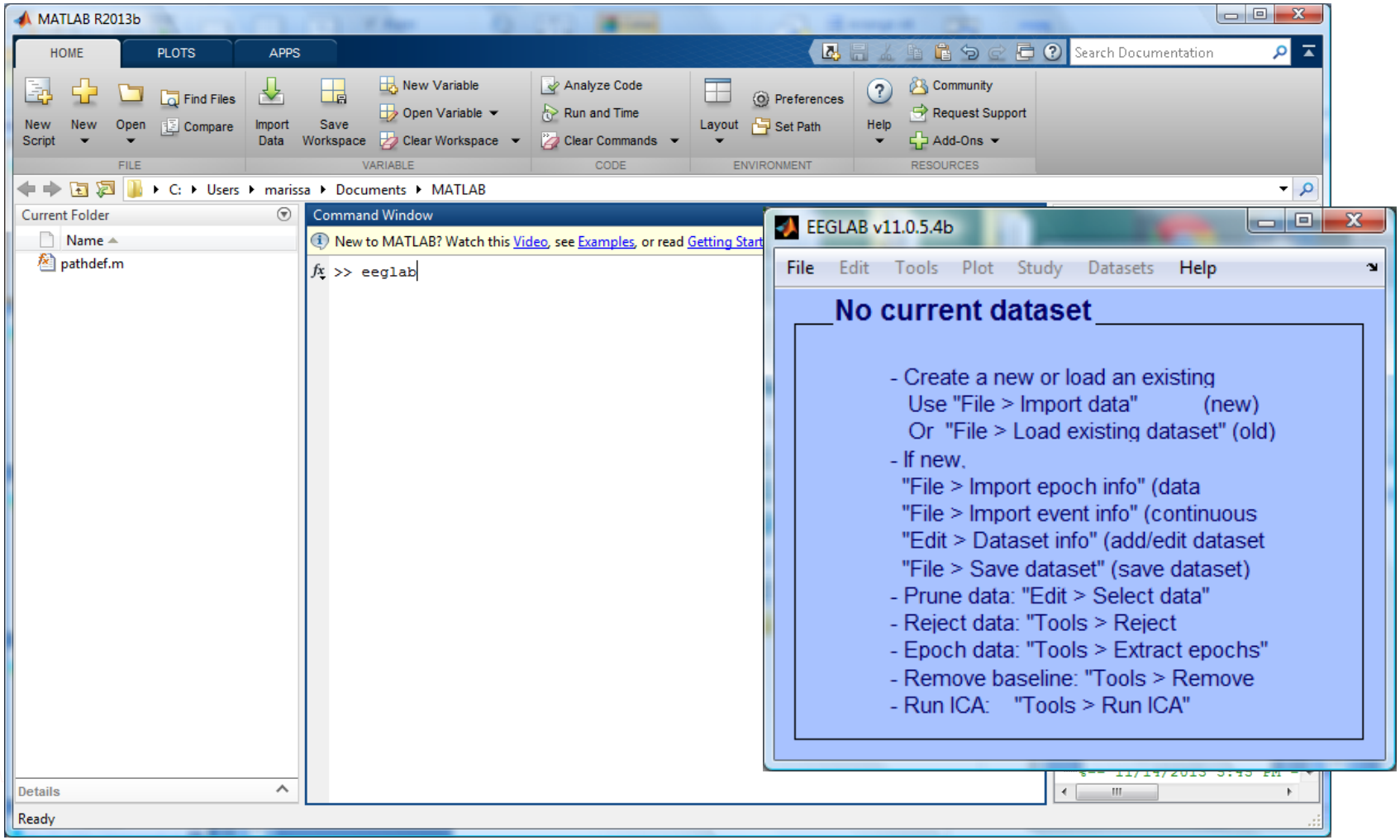
Installing EEGLAB and data folder

- Start Matlab
- Add the EEGLAB folder to your Matlab path:



The EEGLAB Matlab software

main graphic interface



Sample data: basic P300 paradigm

File

SimpleOddball.set

Data

68 channel EEG, 256 Hz sampling rate, Biosemi system, re-referenced during import to averaged left and right mastoid electrodes

Task

speeded button press response to star shape (no response to circle shape), 100 ms presentation duration, 200 trials

Pre-processing pipeline

Collect high-density EEG data (>30 chan)

Import into EEGLAB

Import event markers and channel locations

Re-reference/ down-sample (if necessary)

High pass filter (~.5 – 1 Hz)

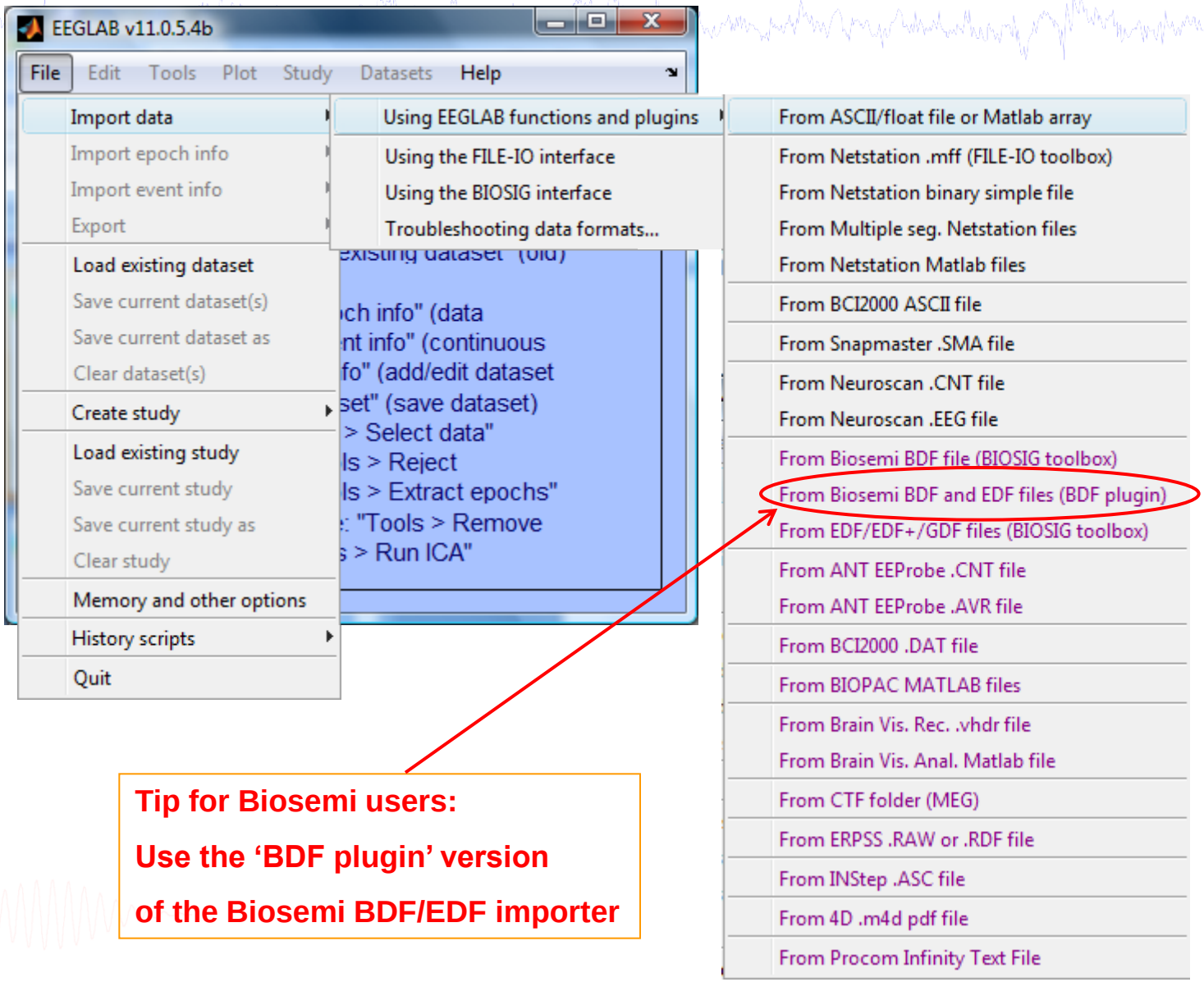
Examine raw data

Identify/reject bad channels

Reject large artifact time points

Run ICA

Importing a dataset

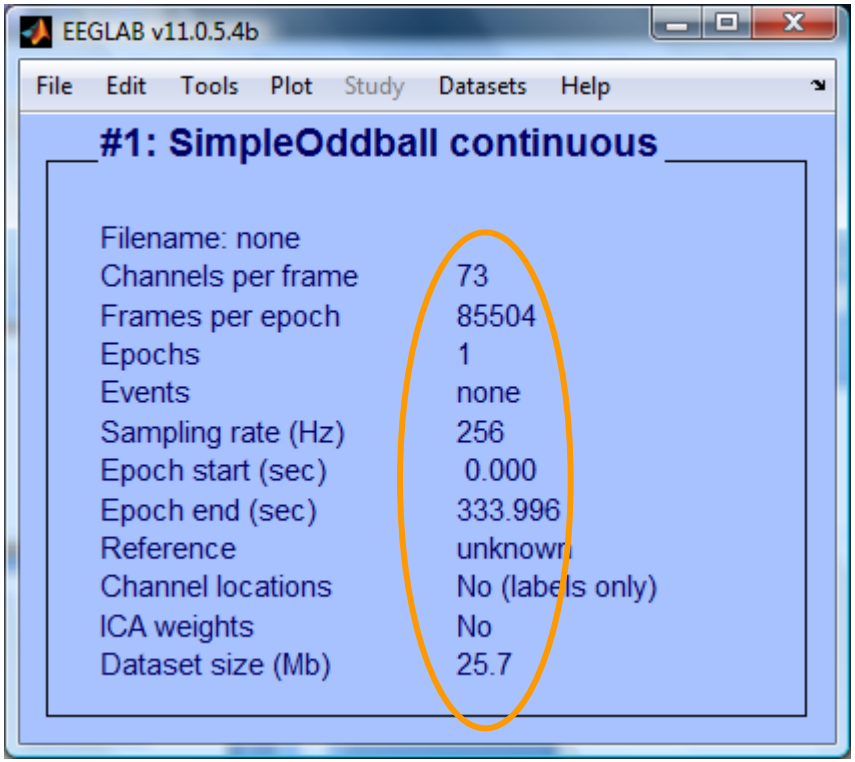


Tip for Biosemi users:

Use the 'BDF plugin' version

of the Biosemi BDF/EDF importer

Imported EEG data



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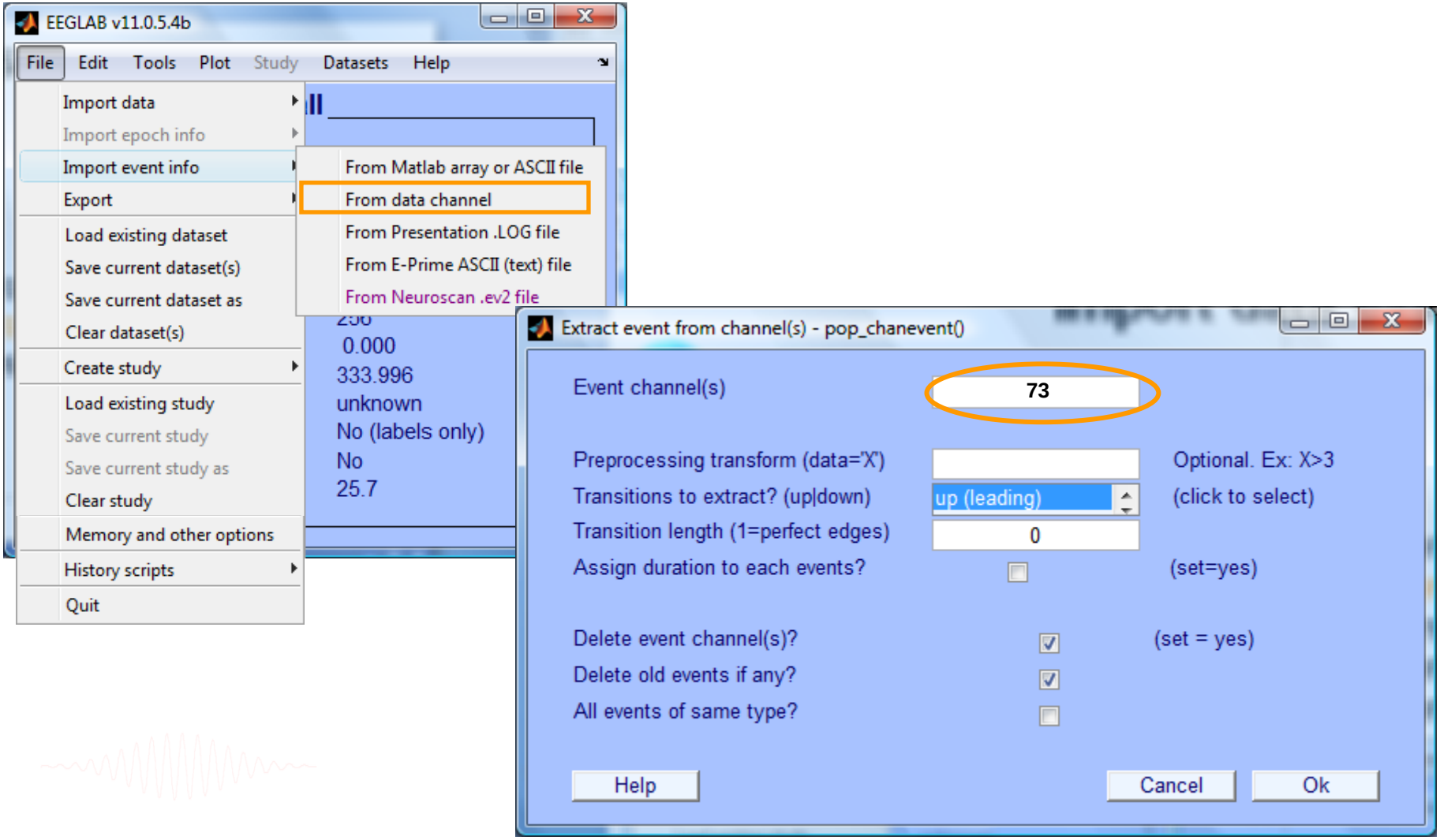
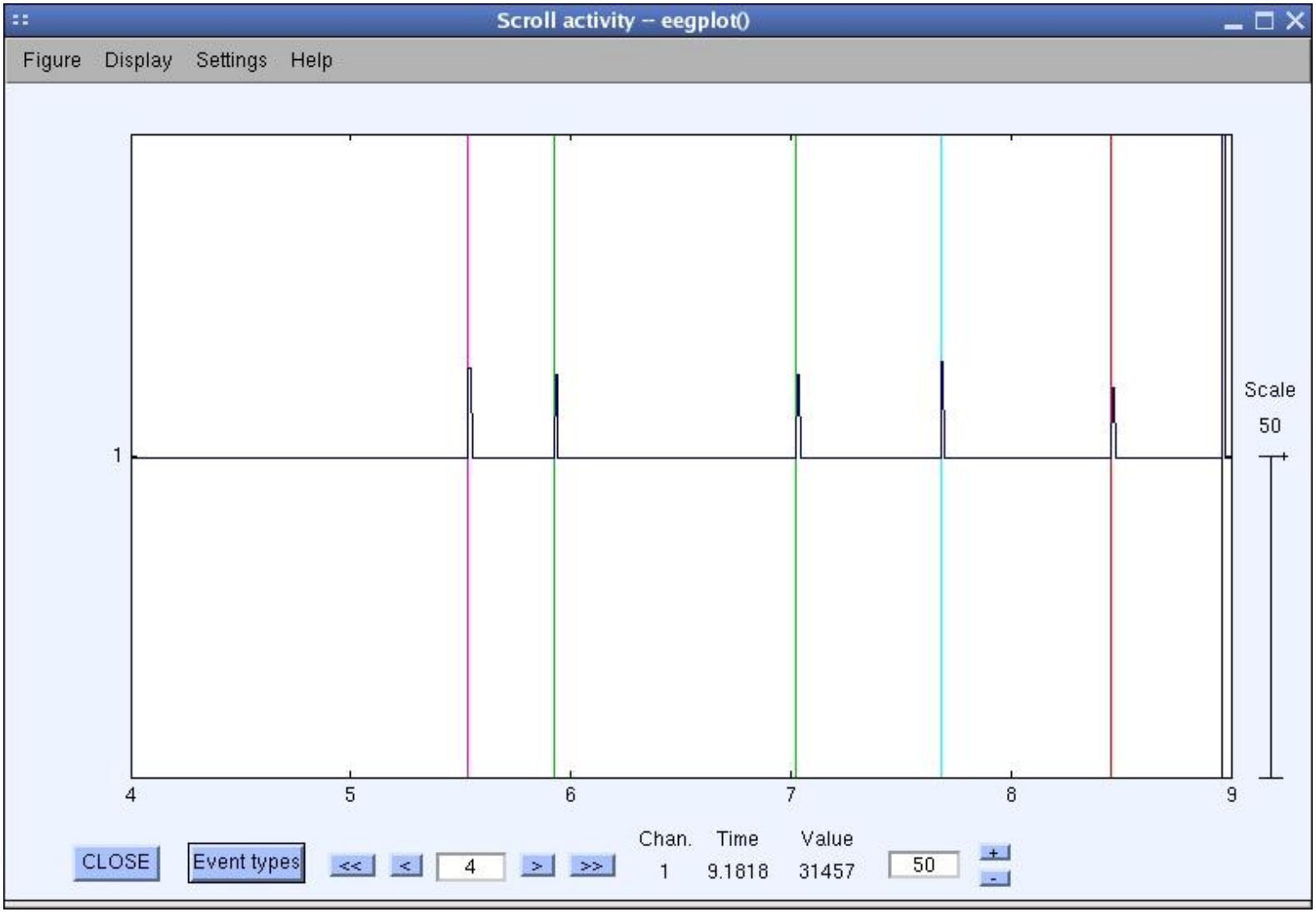
Run ICA

Import data events

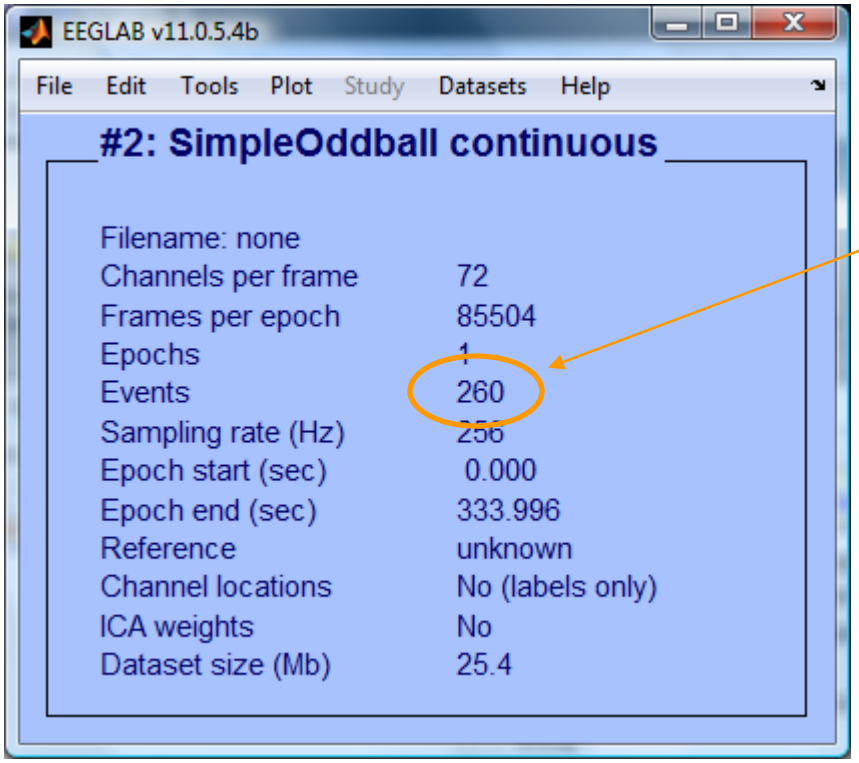
(Often imported automatically during data import)



Appearance of an event channel in raw data

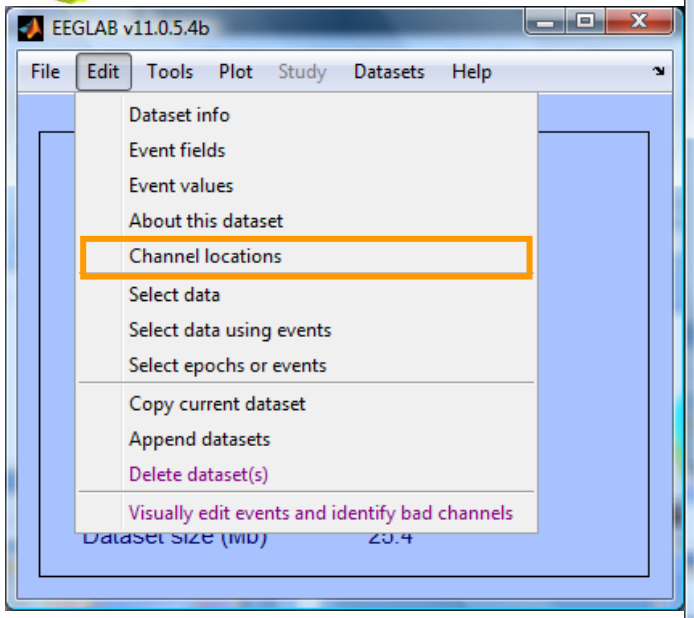


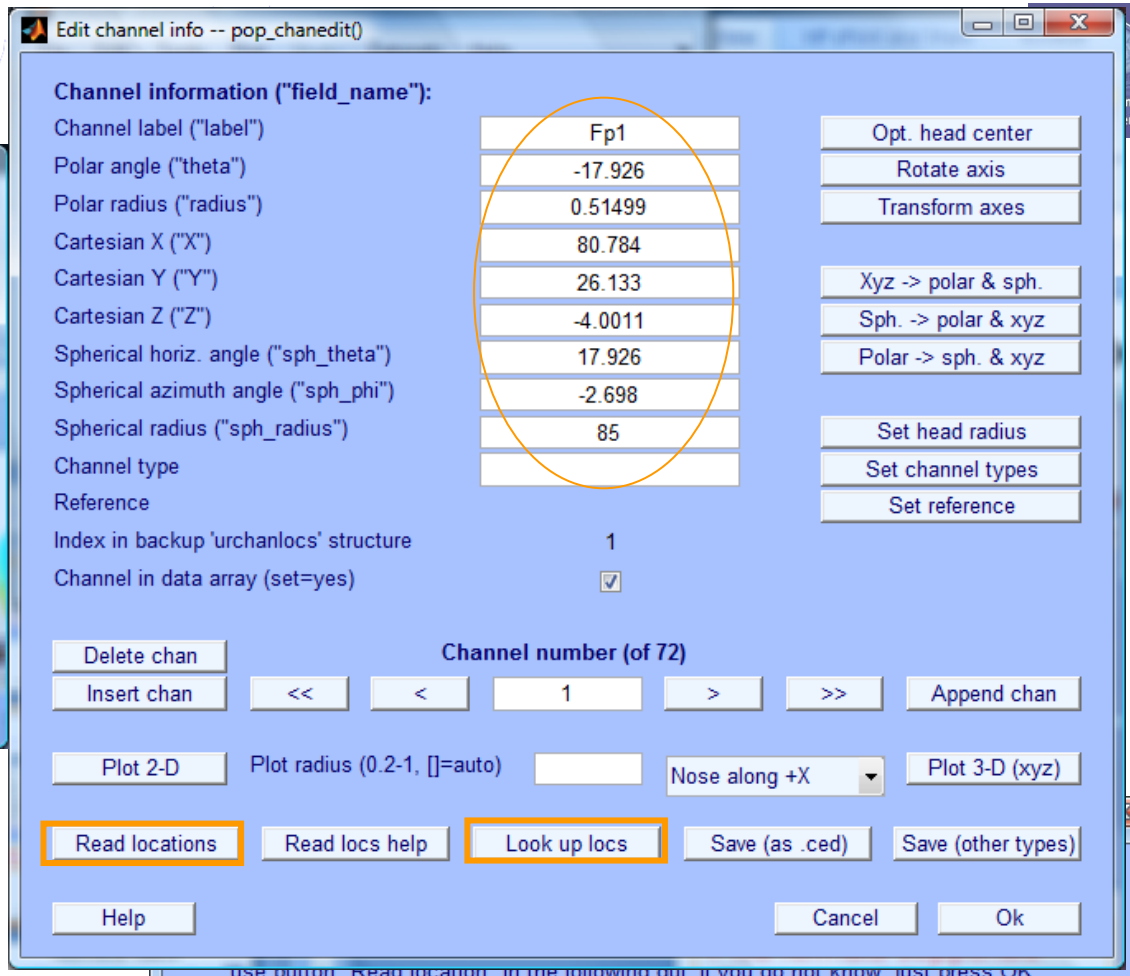
Imported data events

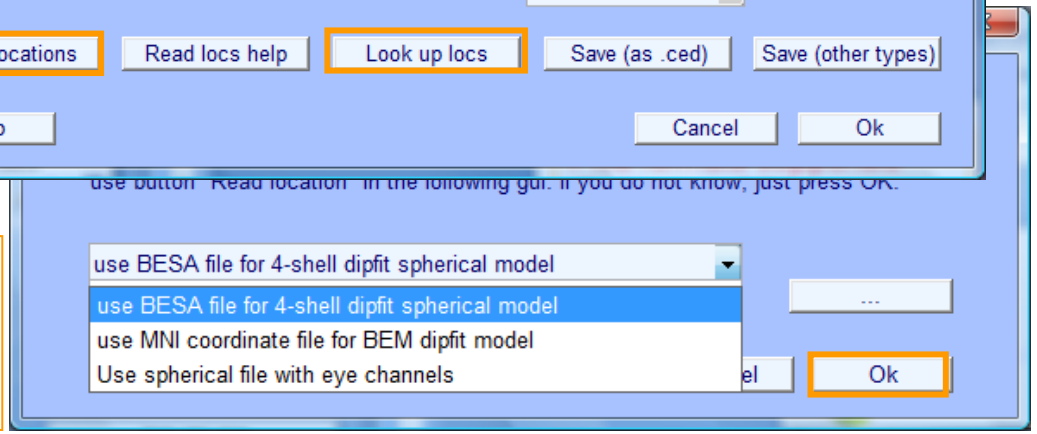


If event import was successful, you will see an appropriate number here

Import channel locations



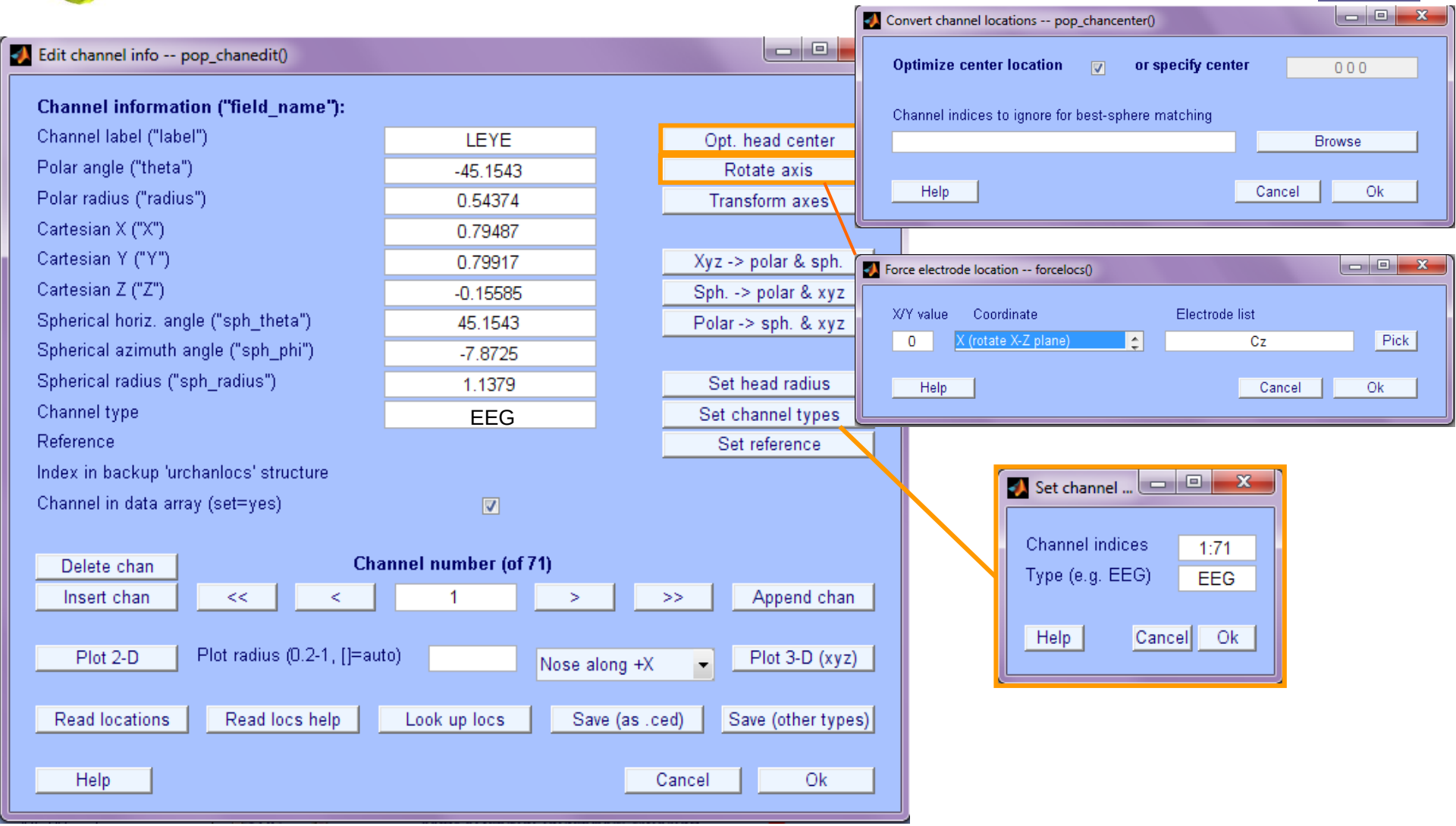




7 file formats supported (Polhemus, BESA, …)

Standard locations offered if you do not have locations and labels are standard

Import channel locations



Edit channel info -- pop_chanedit()

Channel information ("field_name"):

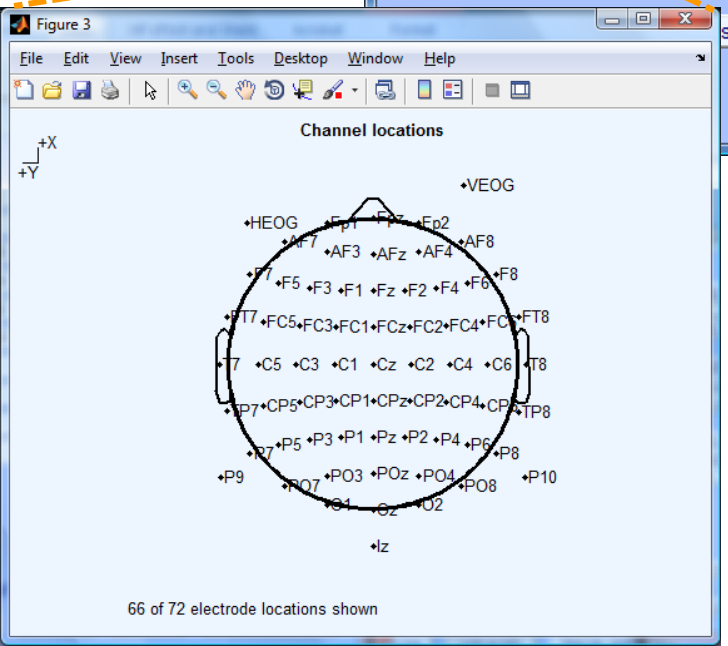
Channel label ("label")	HEOG	Opt. head center
Polar angle ("theta")	-42	Rotate axis
Polar radius ("radius")	0.65556	Transform axes
Cartesian X ("X")	55.7734	
Cartesian Y ("Y")	50.2186	Xyz -> polar & sph.
Cartesian Z ("Z")	-39.9051	Sph. -> polar & xyz
Spherical horiz. angle ("sph_theta")	42	Polar -> sph. & xyz
Spherical azimuth angle ("sph_phi")	-28	
Spherical radius ("sph_radius")	85	Set head radius
Channel type		Set channel types
Reference		Set reference
Index in backup 'urchanlocs' structure	68	
Channel in data array (set=yes)	☑	

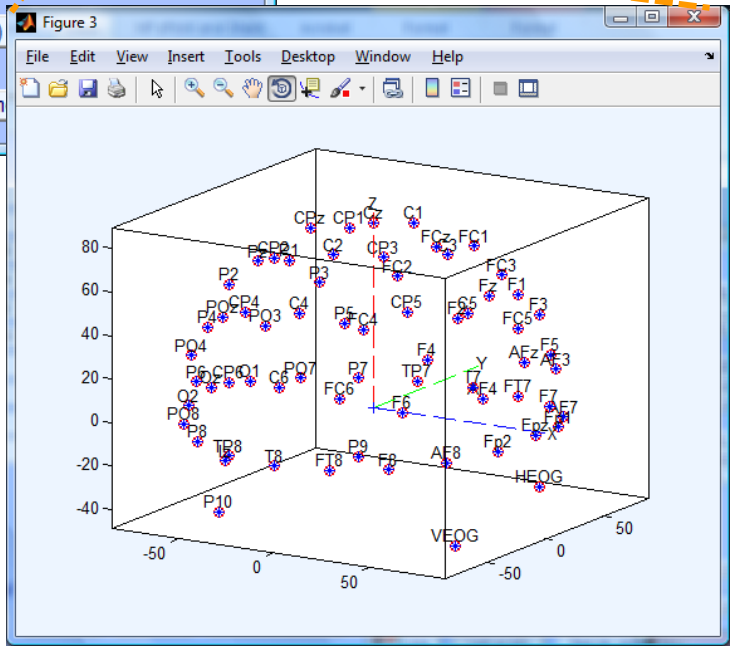
Delete chan | Insert chan | << | < | **Channel number (of 72)** 68 | > | >> | Append chan

Plot 2-D | Plot radius (0.2-1, []=auto) | Nose along +X | Plot 3-D (xyz)

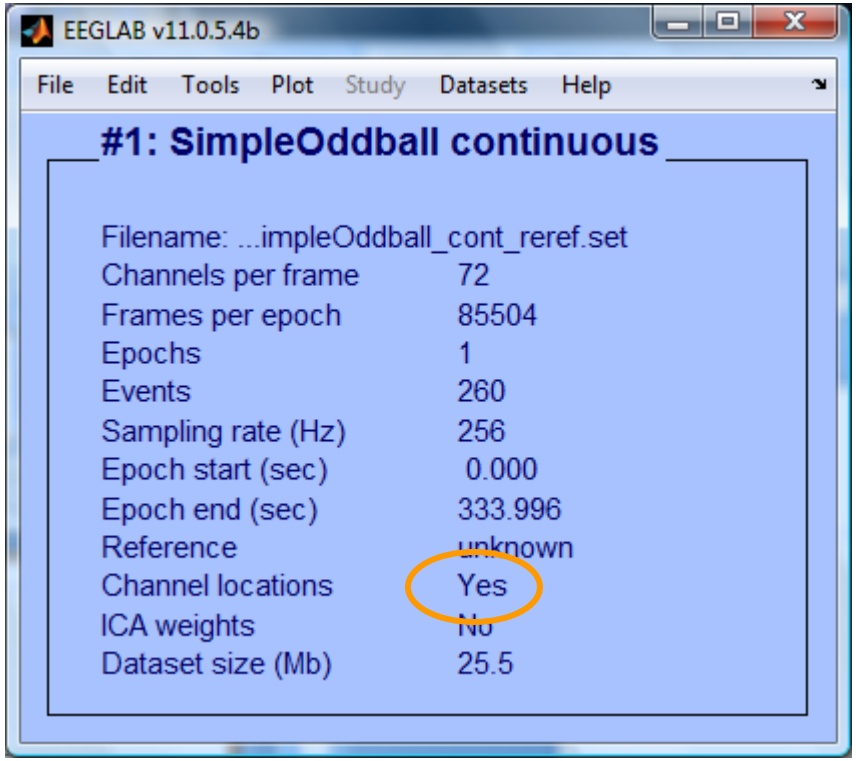
s help | Look up locs | Save (as .ced)

Can





Imported channel locations



Pre-processing pipeline

Collect high-density EEG data (>30 chan)

Import into EEGLAB

Import event markers and channel locations

Re-reference/ down-sample (if necessary)

High pass filter (~.5 – 1 Hz)

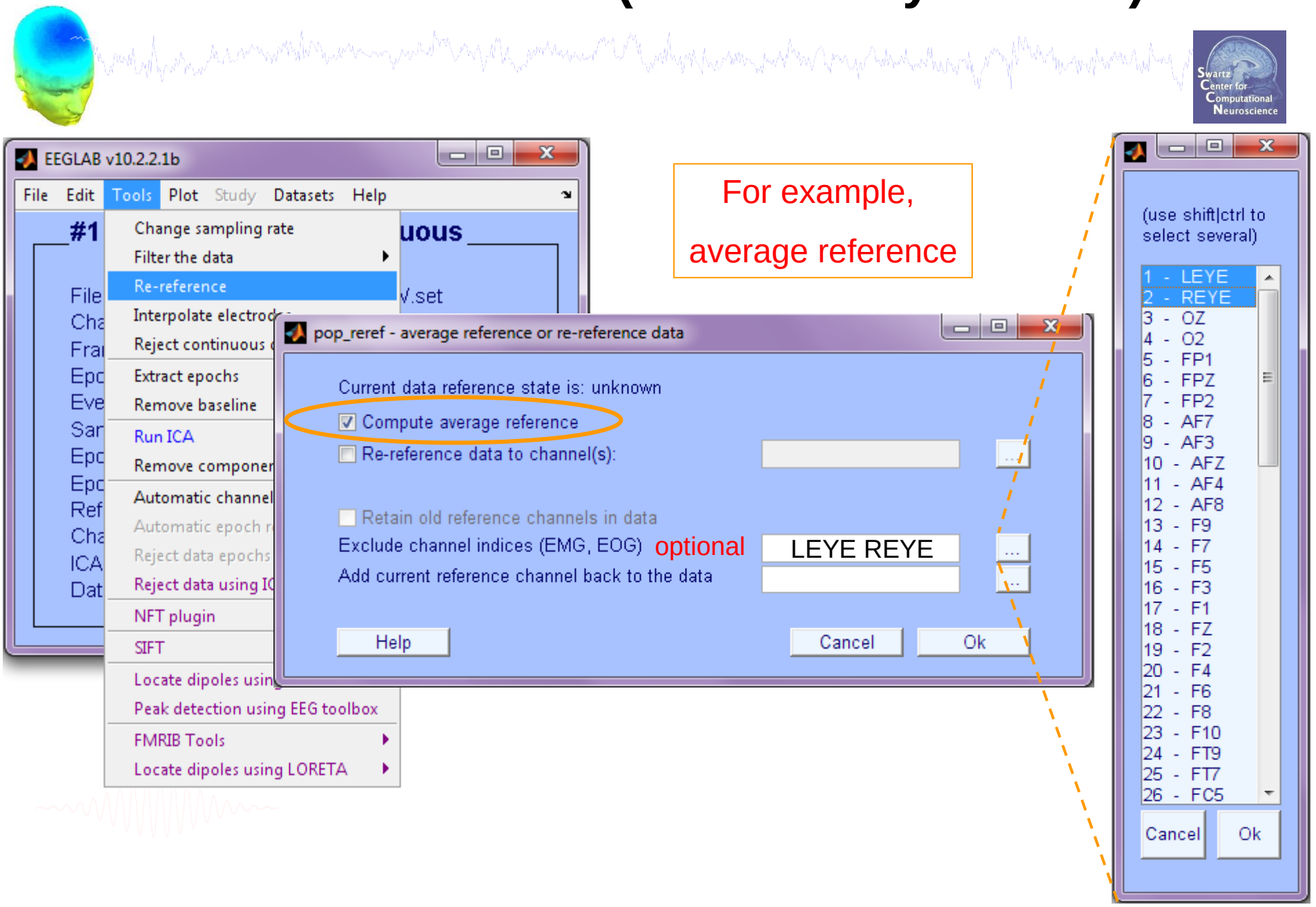
Remove line noise (if necessary)

Identify/reject bad channels

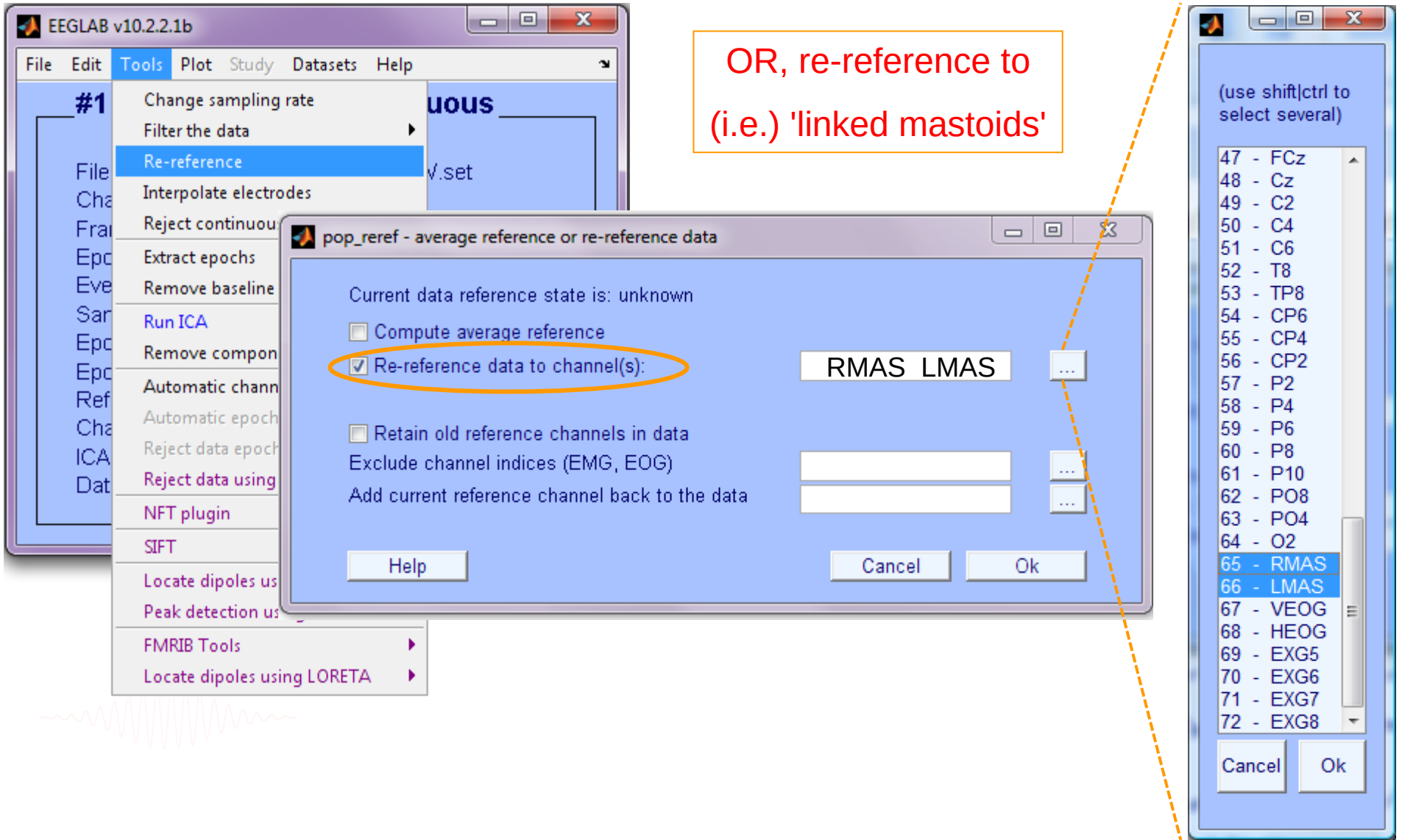
Reject large artifact time points

Run ICA

Re-reference data (if necessary/desired)



Re-reference data (if necessary/desired)



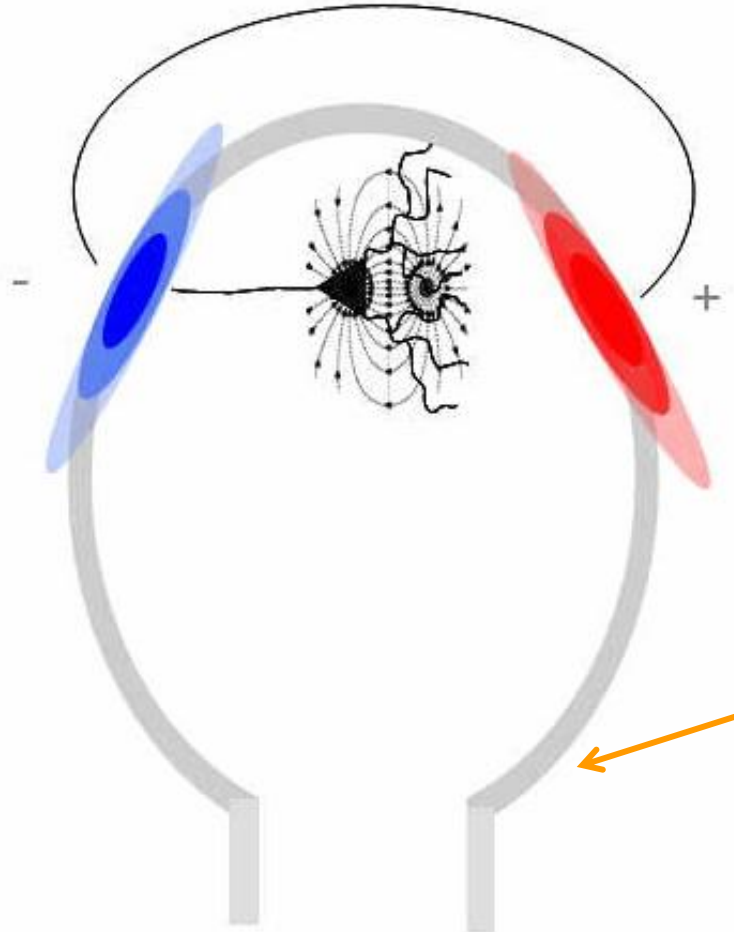
OR, re-reference to

(i.e.) 'linked mastoids'

Choice of reference

The "perfect" reference is probably impossible to find

True average reference requires **even electrode distribution over the head**



Typical montages have **fewer (if any) on the lower half of the head surface**

Rationale for average reference: outward positive and negative currents, summed across an entire (electrically isolated) sphere, will sum to 0 (by Ohm's law)

Save new dataset, keep old one

Dataset info -- pop_newset()

What do you want to do with the new dataset?

Name it: SimpleOddball continuous reref — Edit description

Save it as file: — Browse

Some changes have not been saved. What do you want to do with the old dataset?

Overwrite it in memory (set=yes; unset=create a new dataset)

Save it as file: C:\Users\marissa\Desktop\EEGLABwork — Browse

Help — Cancel — Ok

Enter filename

Save in: MATLAB

Name	Date modified	Type
external	11/10/2009 5:54 AM	File folder
functions	11/10/2009 5:50 AM	File folder
plugins	11/10/2009 5:52 AM	File folder
sample_data	11/10/2009 5:52 AM	File folder
sample_locs	11/10/2009 5:52 AM	File folder

Recent Places, Desktop, Libraries, Computer, Network

File name: — Save

Save as type: (*.set) — Cancel

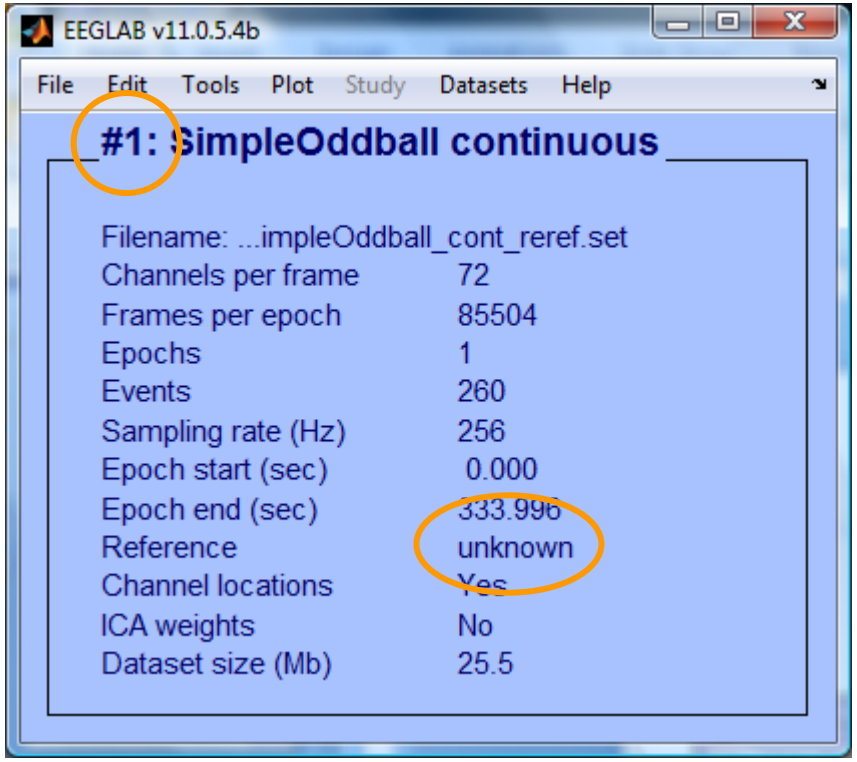
EEGLAB v11.0.5.4b

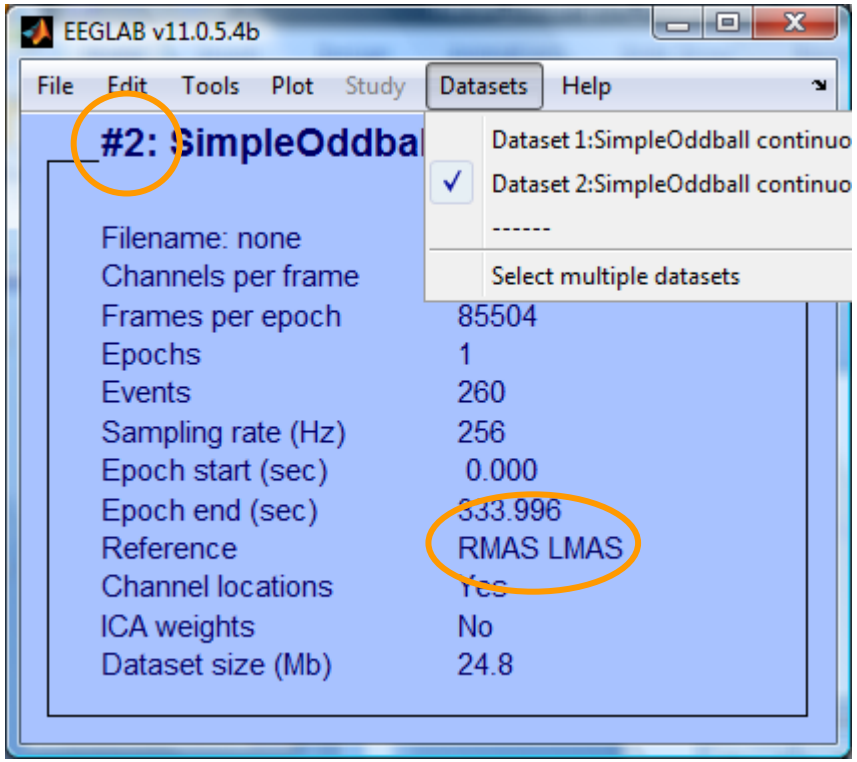
File Edit Tools Plot Study Datasets Help

#2: SimpleOddball continuous reref

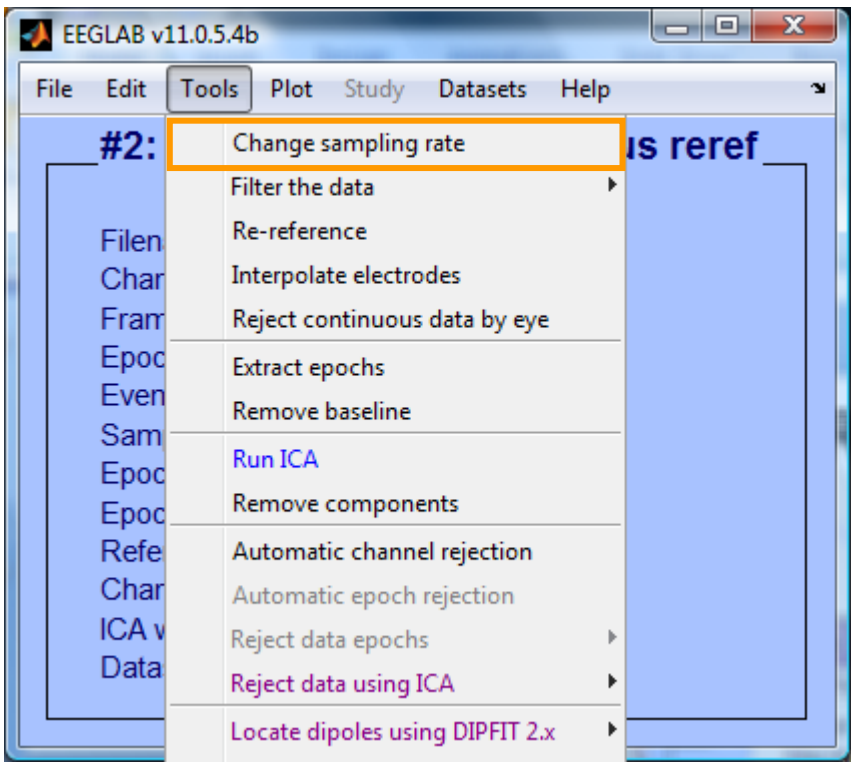
Filename: none	
Channels per frame	70
Frames per epoch	85504
Epochs	1
Events	260
Sampling rate (Hz)	256
Epoch start (sec)	0.000
Epoch end (sec)	333.996
Reference	RMAS LMAS
Channel locations	Yes
ICA weights	No
Dataset size (Mb)	24.8

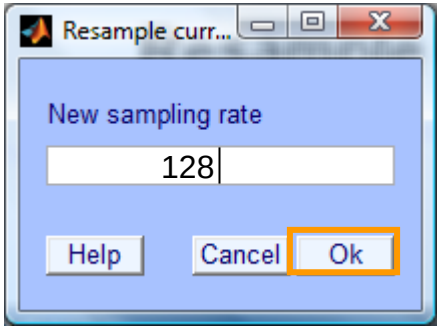
Multiple active datasets (ALLEEG)





Resample data (if necessary)





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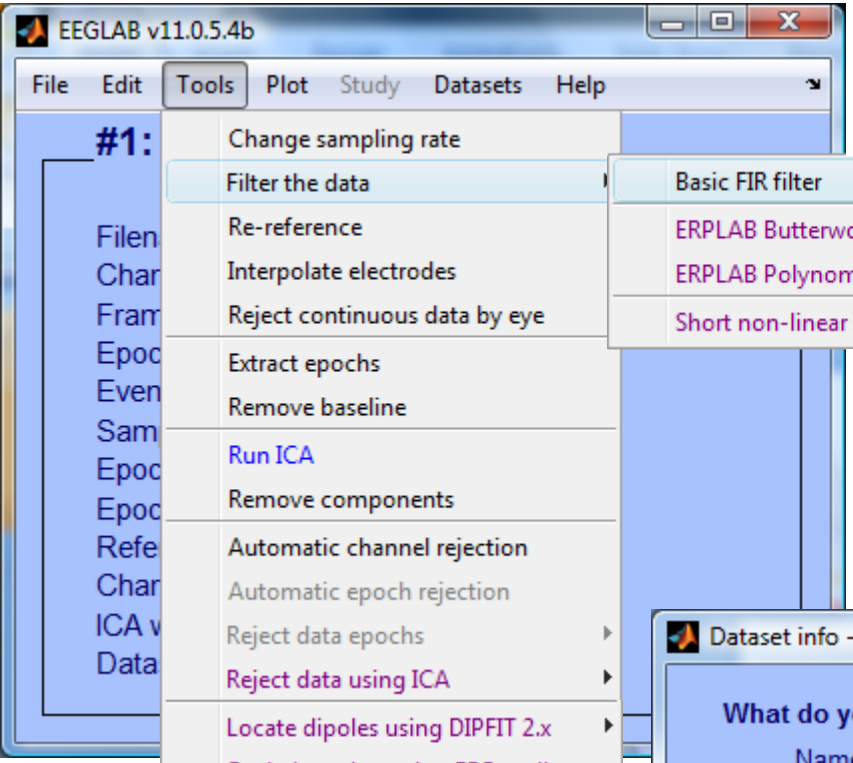
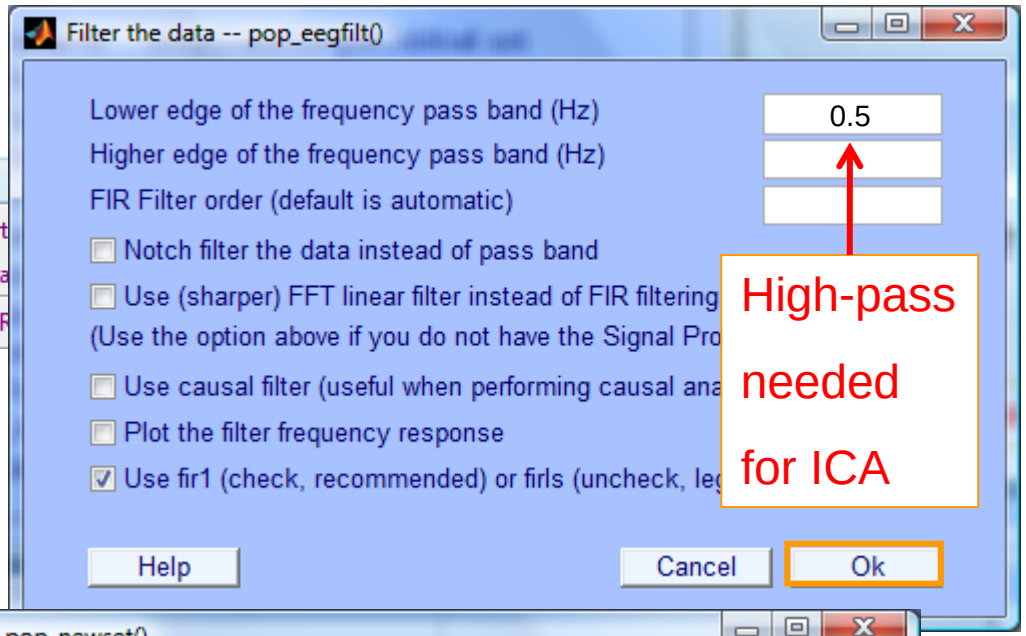
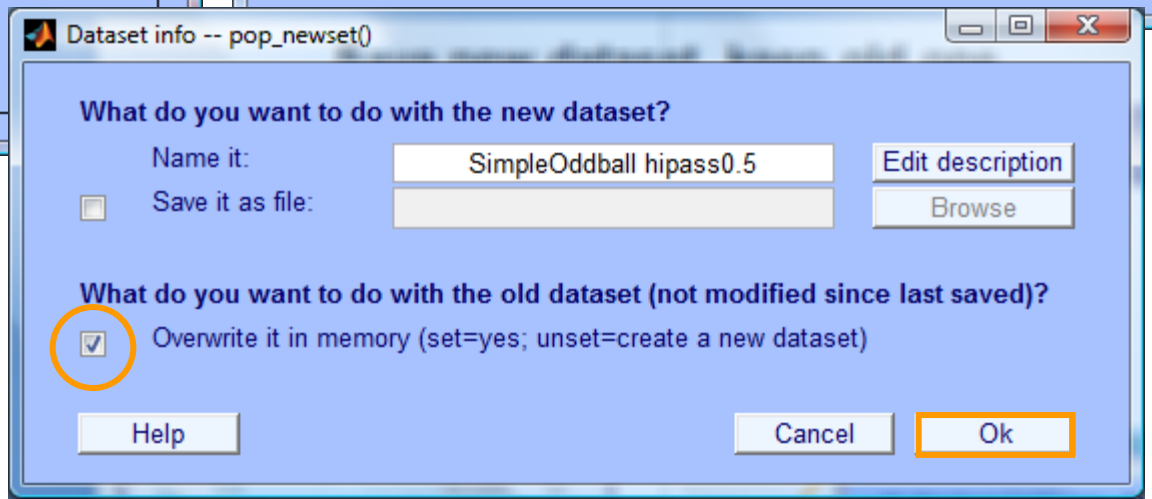
Run ICA

Filter the data (if necessary/desired)

Lower cut off frequencies require longer stretches of continuous data







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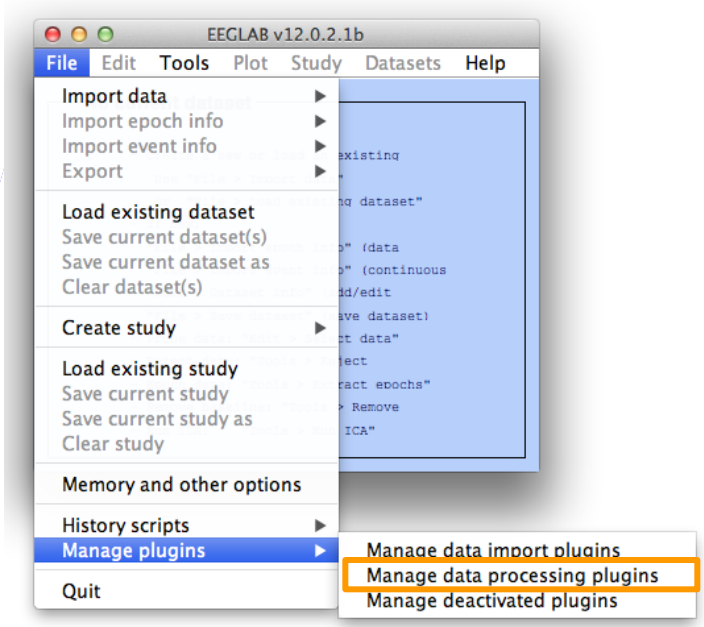
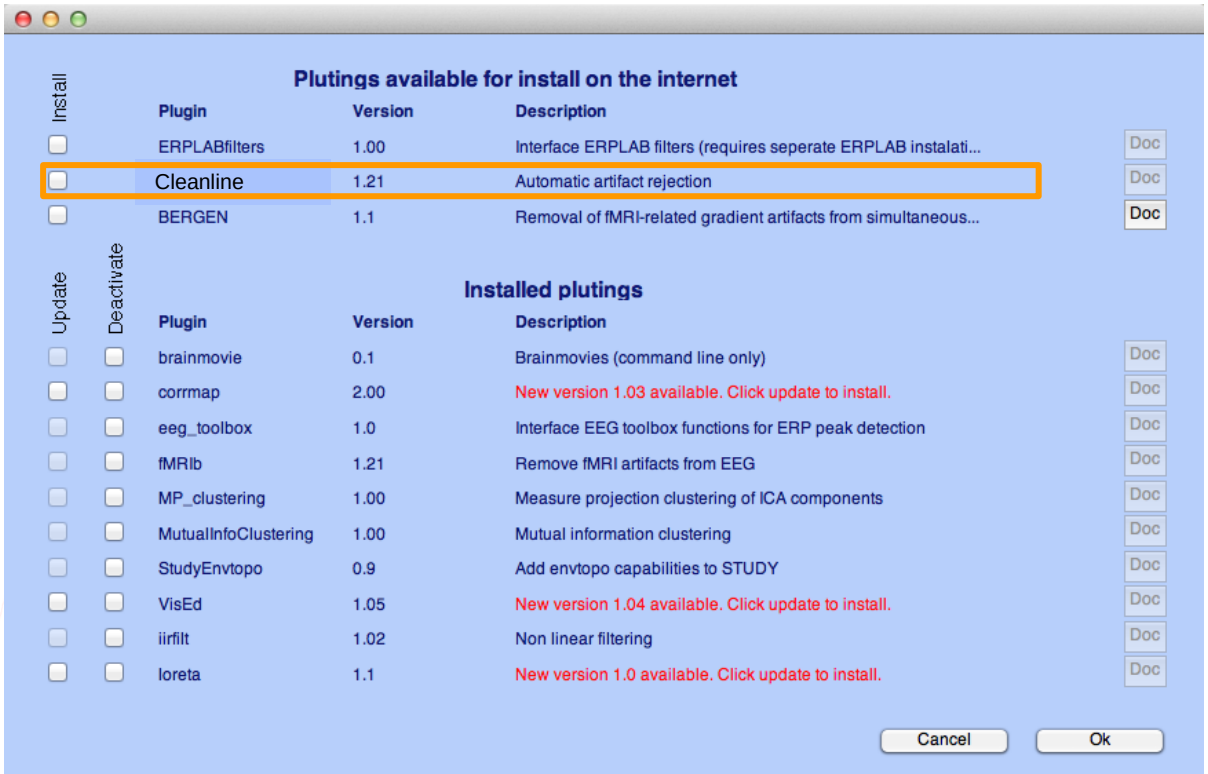
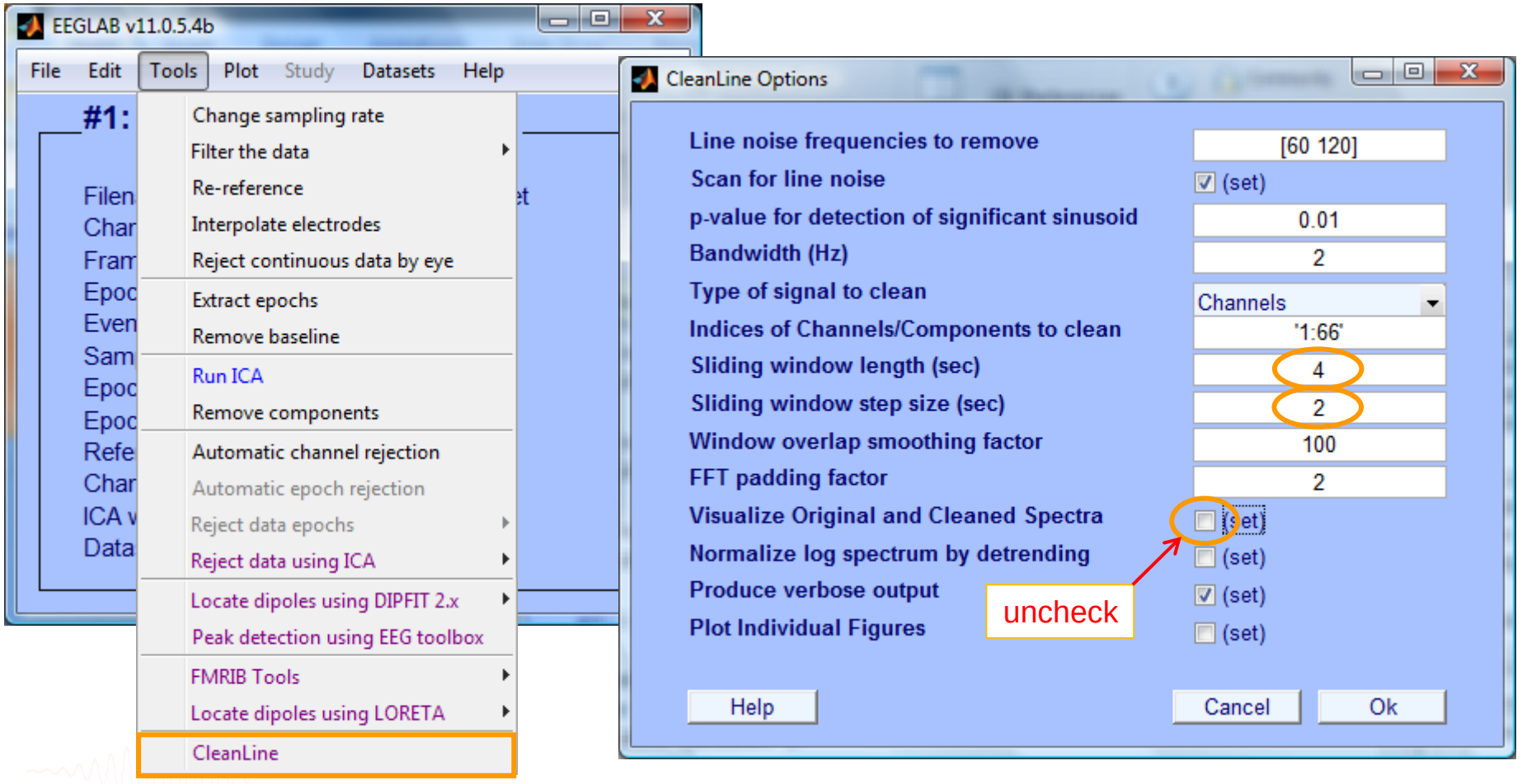
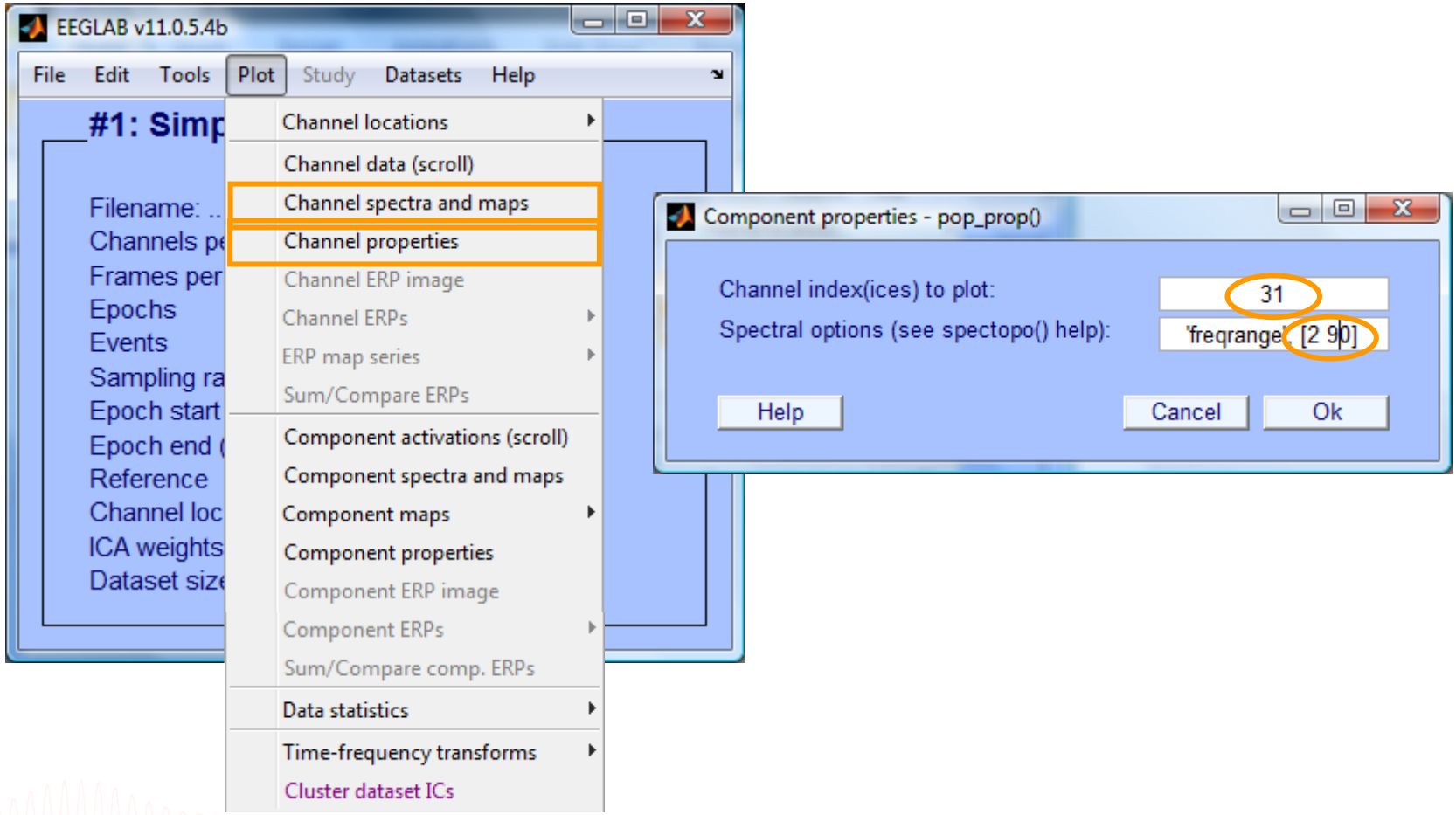

EEGLAB v12.0.2.1b
File Edit Tools Plot Study Datasets Help
Import data
Import epoch info
Import event info
Export
Load existing dataset
Save current dataset(s)
Save current dataset as
Clear dataset(s)
Create study
Load existing study
Save current study
Save current study as
Clear study
Memory and other options
History scripts
Manage plugins
Quit
Manage data import plugins
Manage data processing plugins
Manage deactivated plugins


Plutings available for install on the internet
Install
Plugin
Version
Description
ERPLABfilters 1.00 Interface ERPLAB filters (requires seperate ERPLAB instalati... Doc
Cleanline 1.21 Automatic artifact rejection Doc
BERGEN 1.1 Removal of fMRI-related gradient artifacts from simultaneous... Doc
Update
Deactivate
Installed plutings
Plugin
Version
Description
brainmovie 0.1 Brainmovies (command line only) Doc
corrmap 2.00 New version 1.03 available. Click update to install. Doc
eeg_toolbox 1.0 Interface EEG toolbox functions for ERP peak detection Doc
fMRIb 1.21 Remove fMRI artifacts from EEG Doc
MP_clustering 1.00 Measure projection clustering of ICA components Doc
MutualInfoClustering 1.00 Mutual information clustering Doc
StudyEnvtopo 0.9 Add envtopo capabilities to STUDY Doc
VisEd 1.05 New version 1.04 available. Click update to install. Doc
iirfilt 1.02 Non linear filtering Doc
loreta 1.1 New version 1.0 available. Click update to install. Doc
Cancel
Ok

Remove line noise (Cleanline)

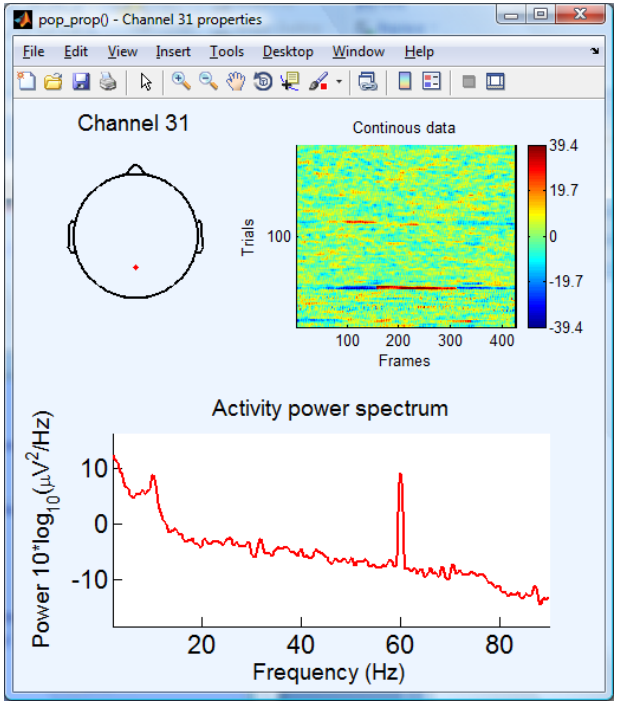


Plot channel spectra

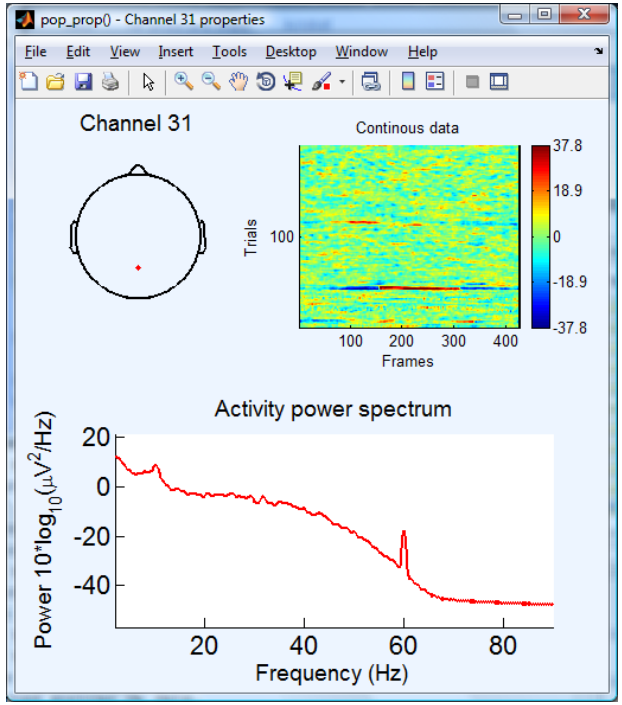


Filter comparisons

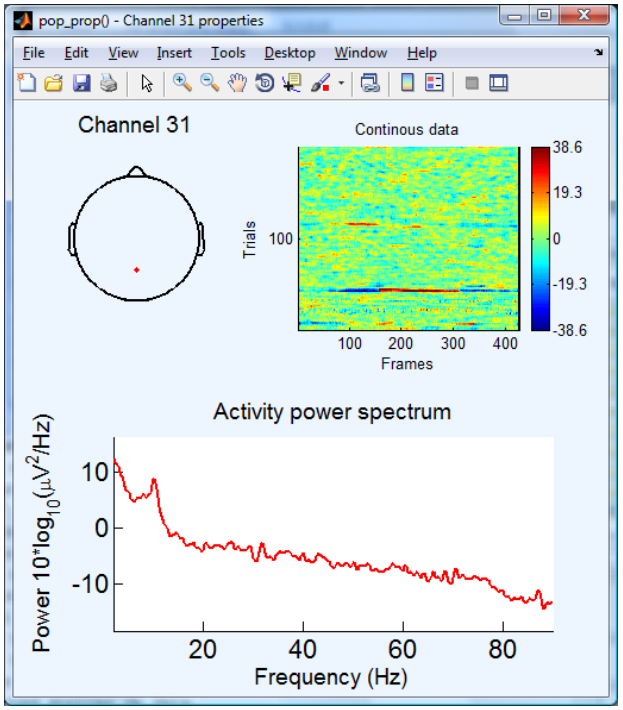
0.5 Hz high-pass filter



0.5 Hz high-pass filter
50 Hz low-pass filter



0.5 Hz high-pass filter
Cleanline: 60 Hz



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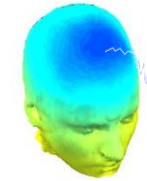
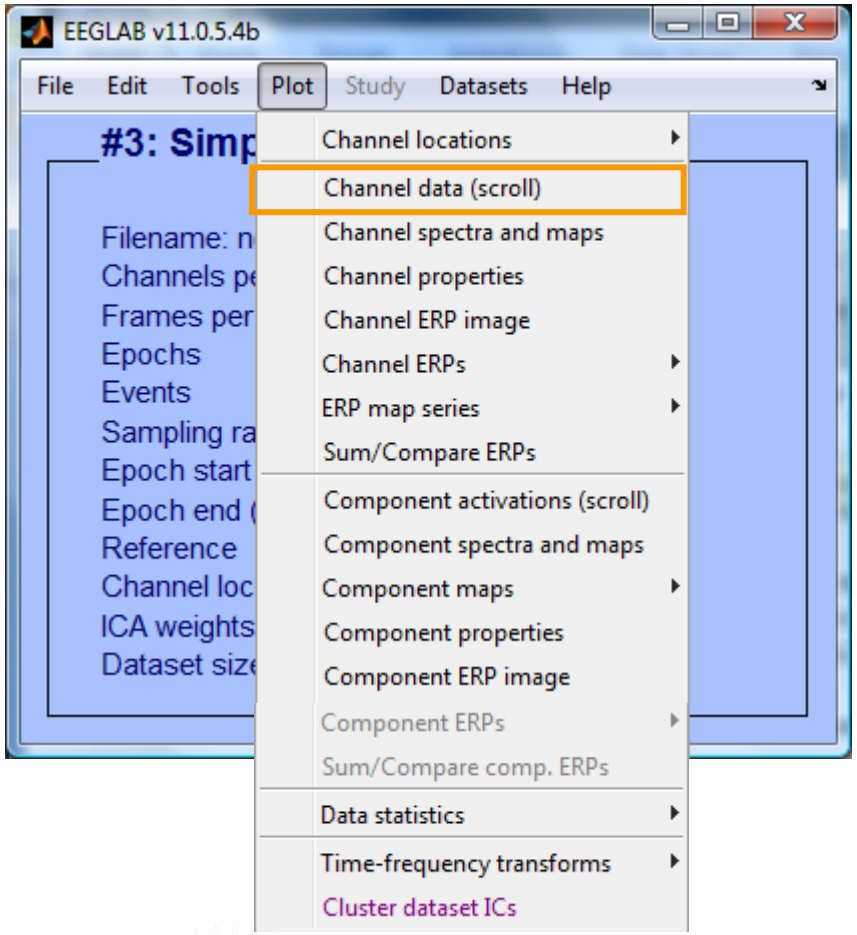
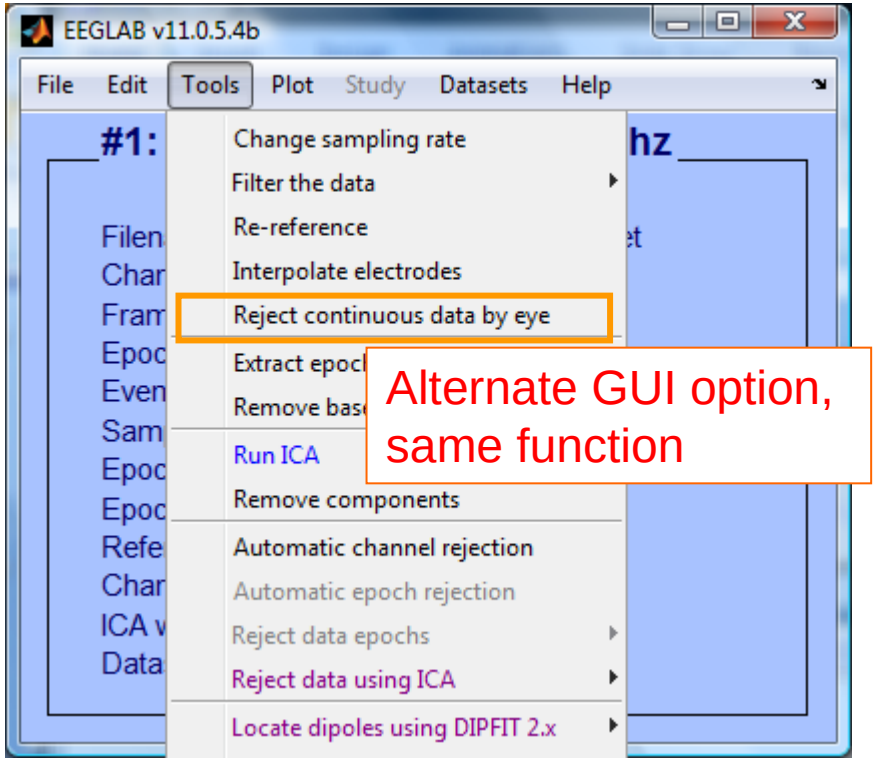
Run ICA

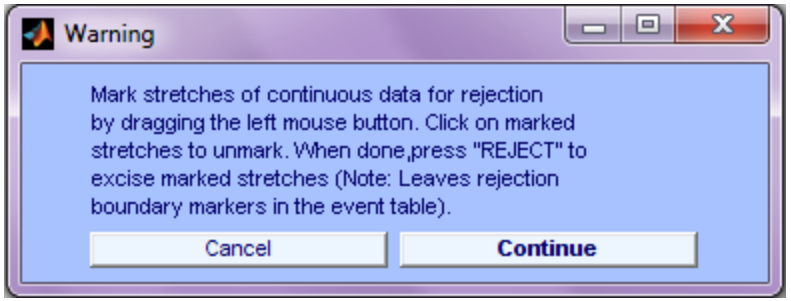
Scroll channel data



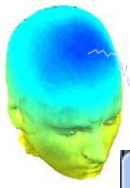


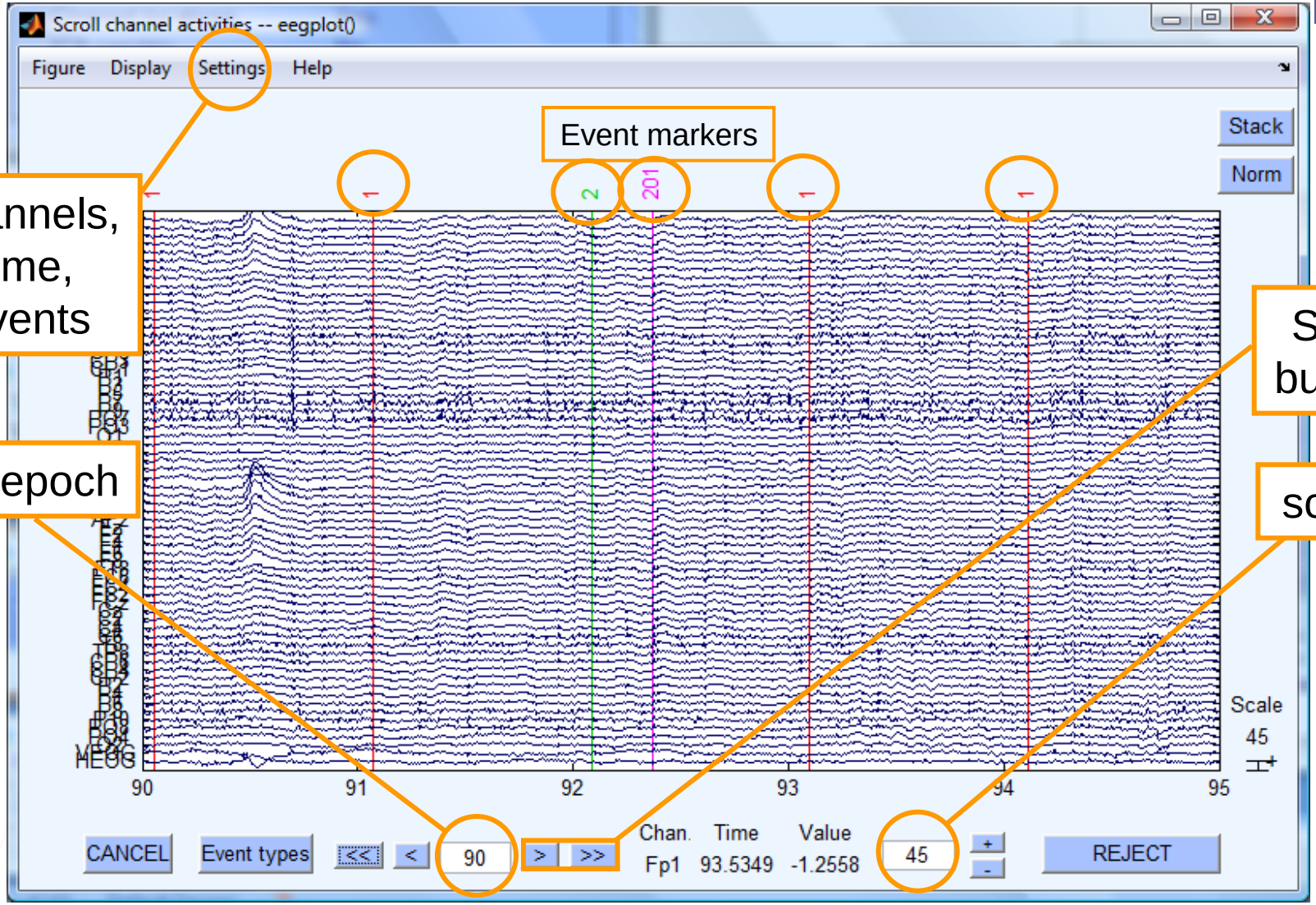


Alternate GUI option, same function

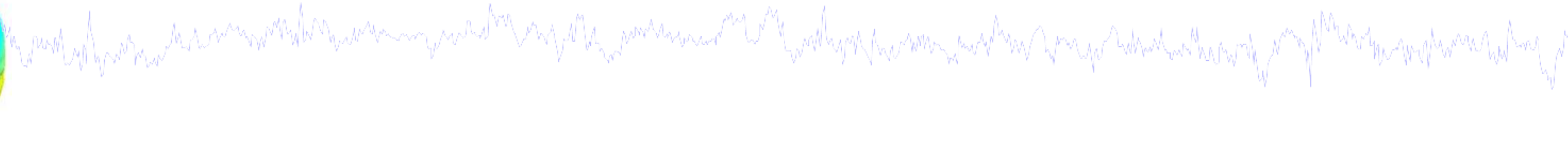


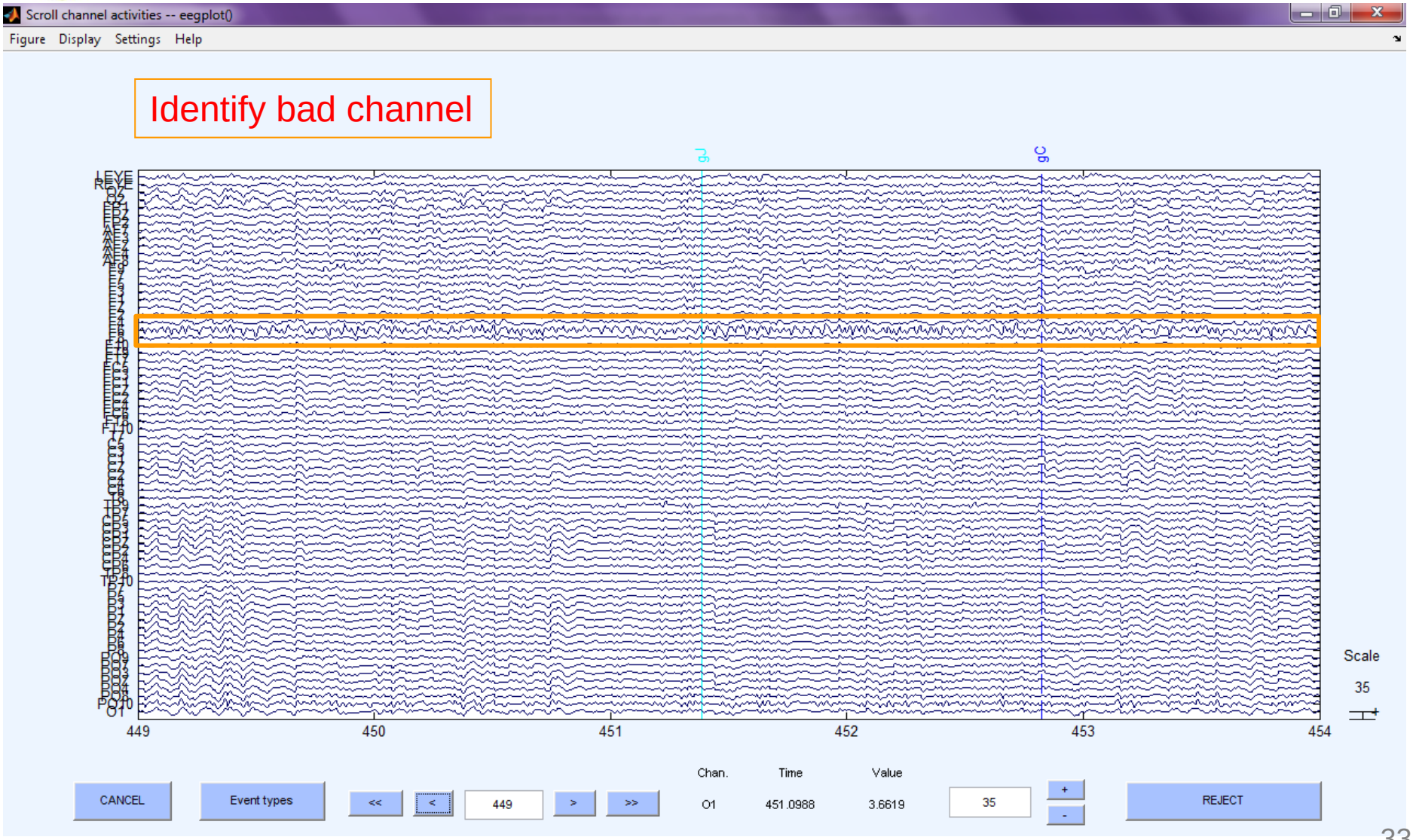
Scroll channel data



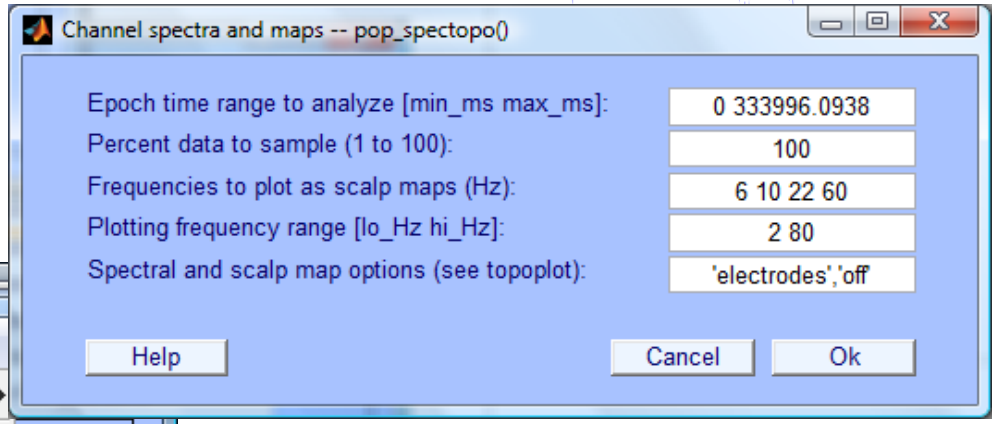


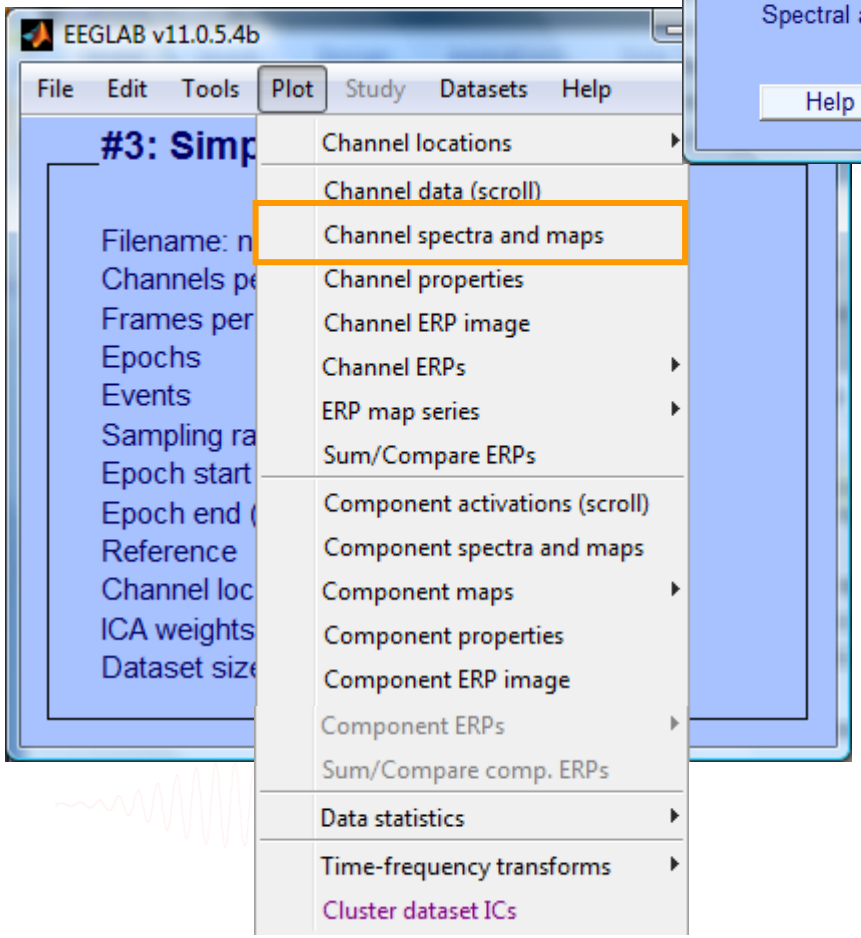
Manually identifying bad channels

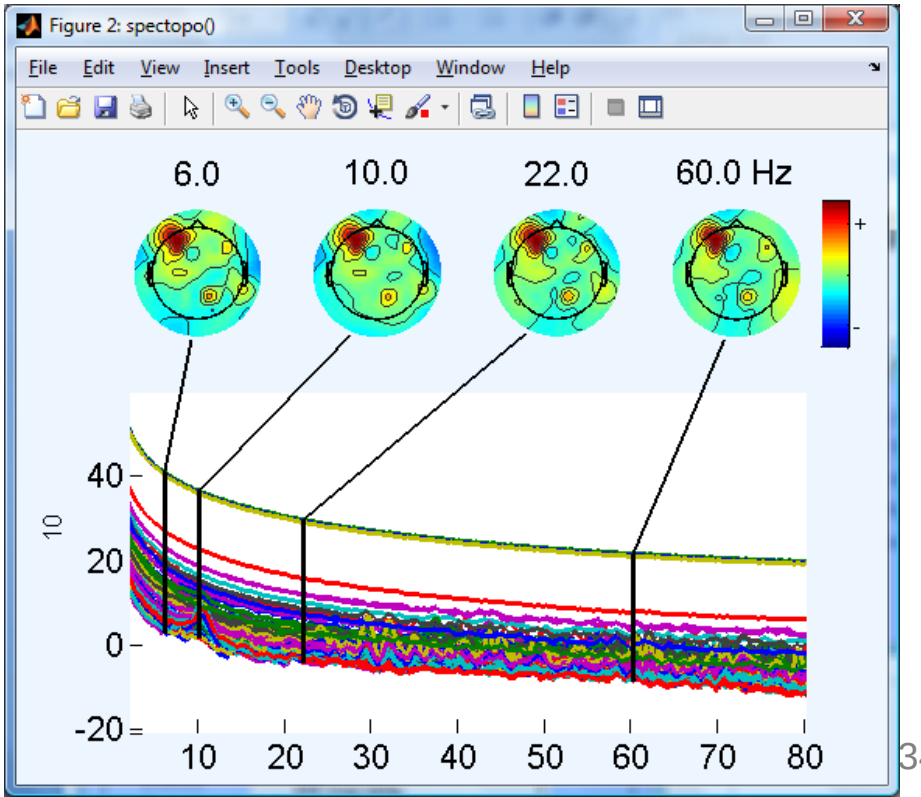




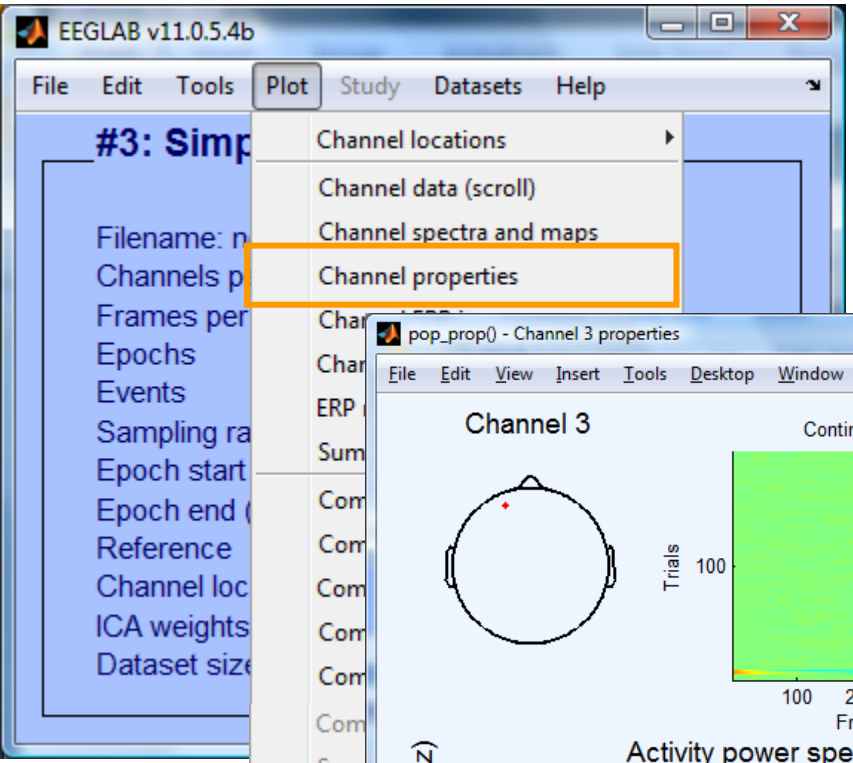
Manually identifying bad channels

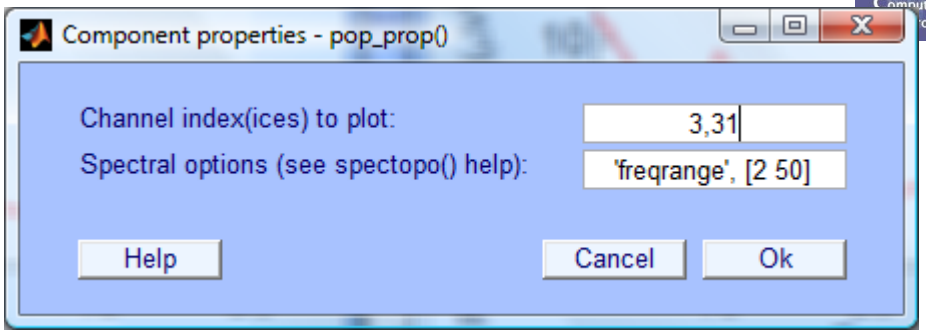


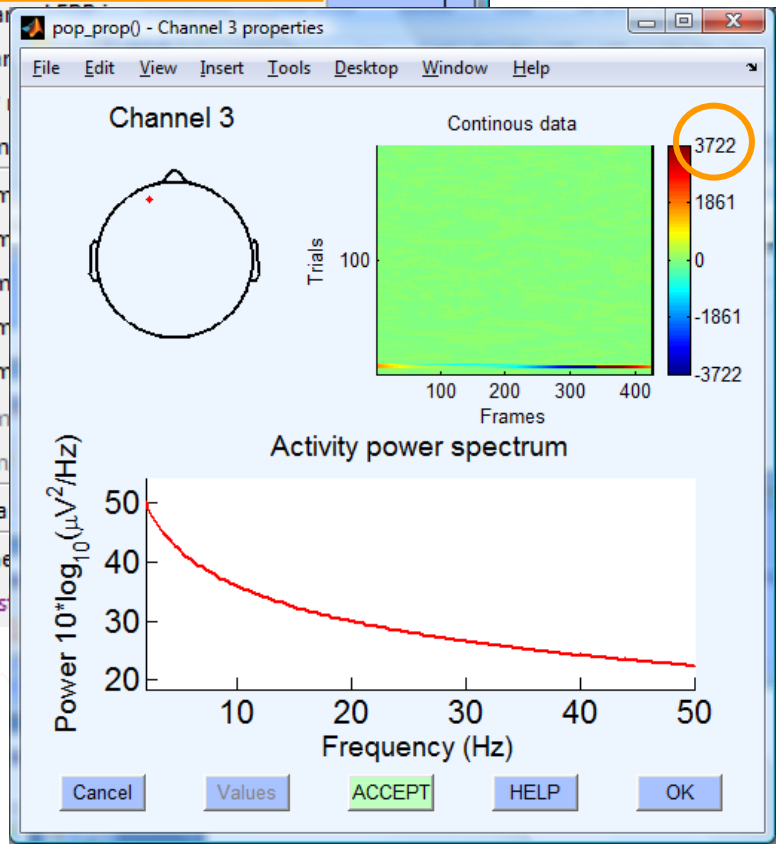


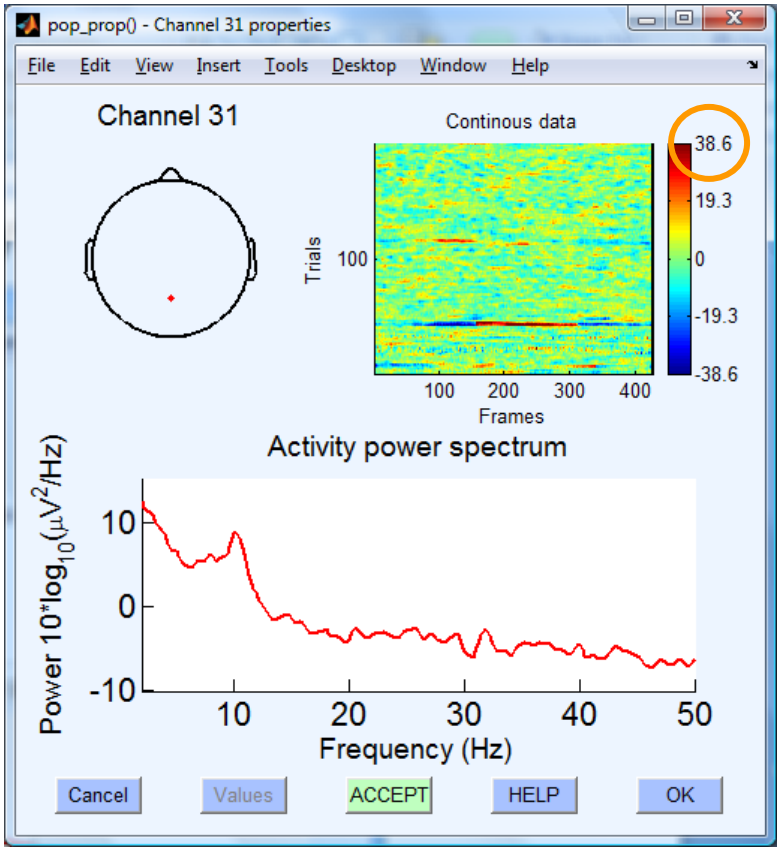


Manually identifying bad channels

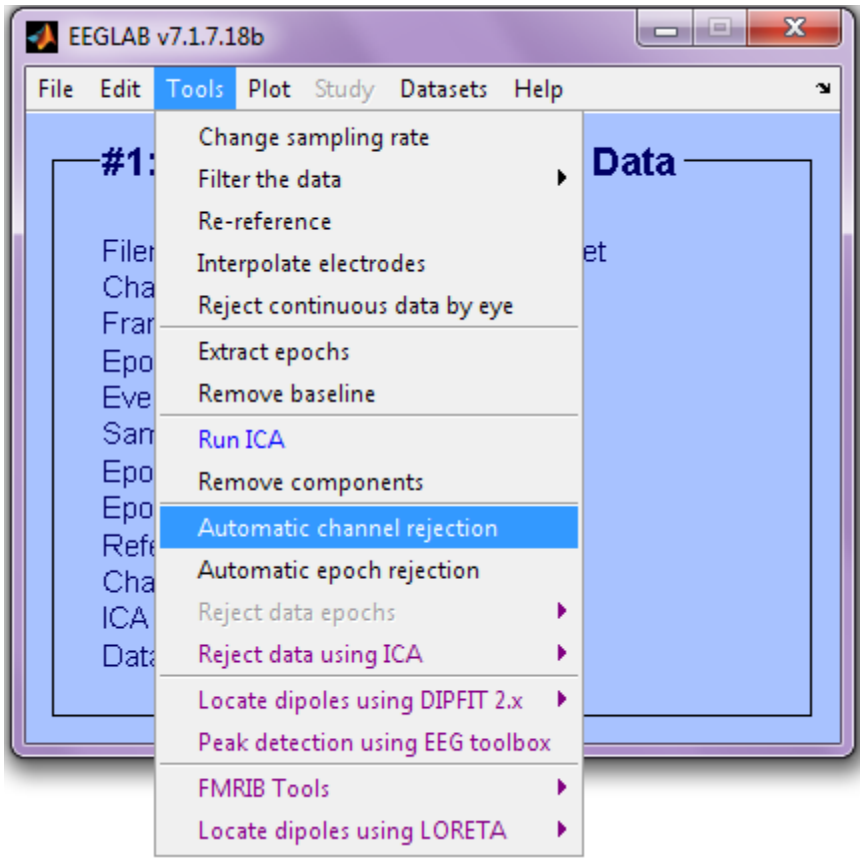


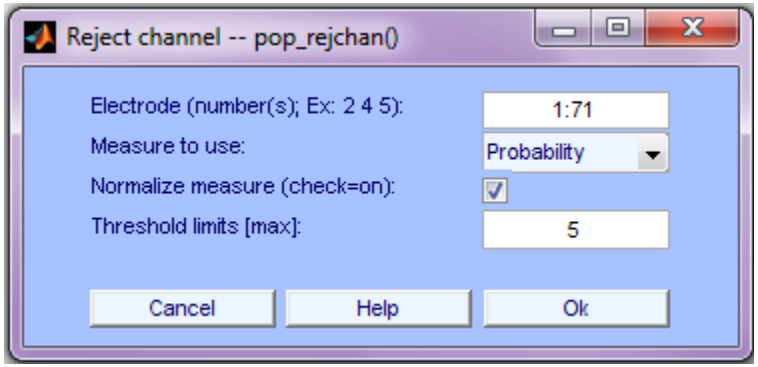




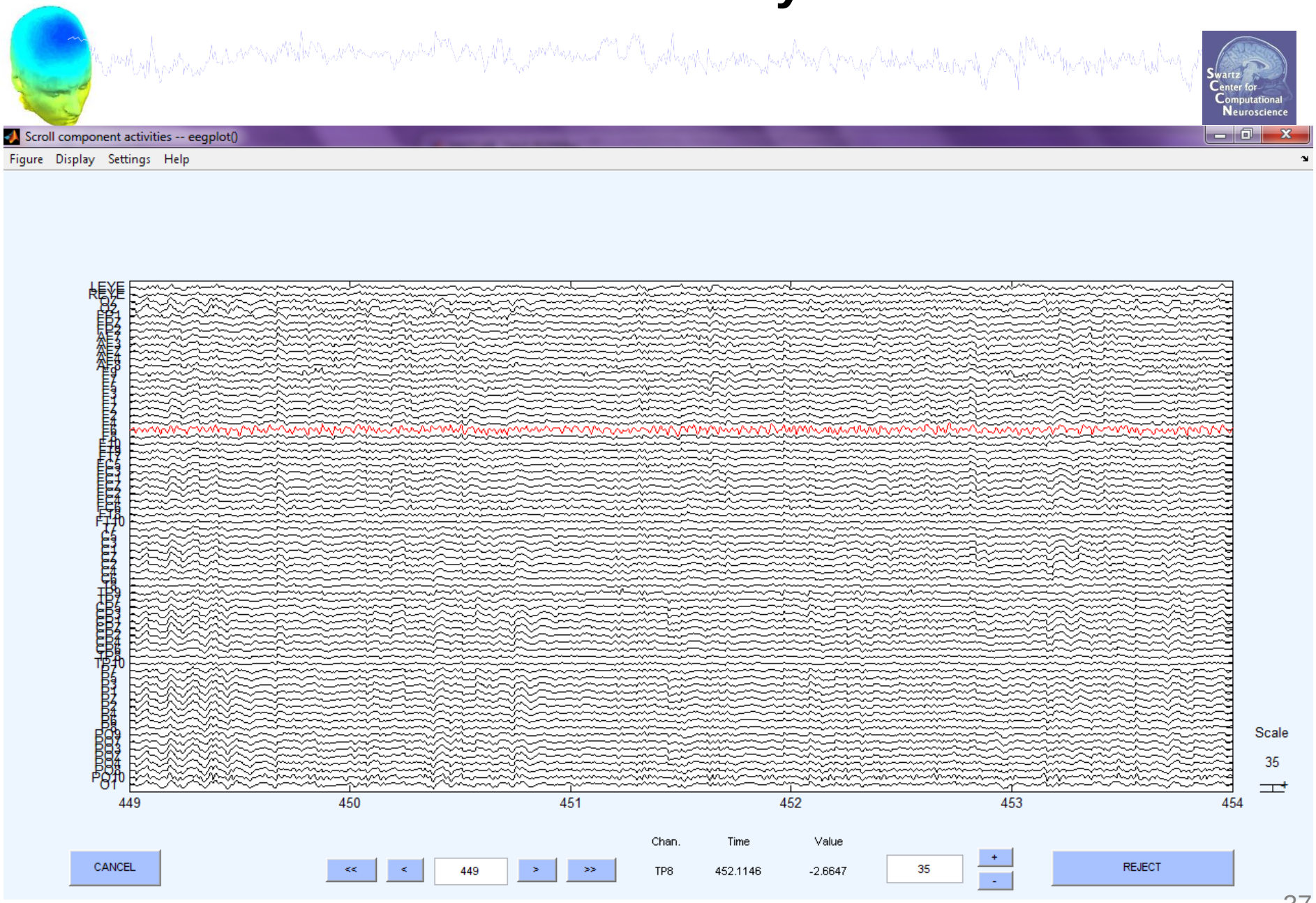


Auto-detection of noisy channels





Auto-detected noisy channel



Removing channel(s)

If not checked, will result

in dataset with one channel

EEGLAB v11.0.5.4b

File Edit Tools Plot Study Datasets Help

Dataset info
Event fields
Event values
About this dataset
Channel locations
Select data
Select data using e
Select epochs or ev
Copy current datas
Append datasets
Delete dataset(s)
Visually edit events

reref

Dataset size (MB)

Select data -- pop_select()

Select data in: | Input desired range | on->remove these

Time range [min max] (s)
Point range (ex: [1 10])
Epoch range (ex: 3:2:10)
Channel range — F6

...

Scroll dataset

Cancel

(use shift|ctrl to select several)

45 - FC4
46 - FC2
47 - FCz
48 - Cz
49 - C2
50 - C4
51 - C6
52 - T8
53 - TP8
54 - CP6
55 - CP4
56 - CP2
57 - P2
58 - P4
59 - P6
60 - P8
61 - P10
62 - PO8
63 - PO4

Dataset info -- pop_newset()

What do you want to do with the new dataset?

Name it: SimpleOddball hipass0.5 CL - F6 — Edit description

Save it as file: — Browse

What do you want to do with the old dataset (not modified since last saved)?

Overwrite it in memory (set=yes; unset=create a new dataset)

Help Cancel Ok

Pre-processing pipeline

Collect high-density EEG data (>30 chan)

Import into EEGLAB

Import event markers and channel locations

Re-reference/ down-sample (if necess

High pass filter (~ 5 – 1 Hz)

Remove line noise (if necessary)

STOP!

Save your dataset here; you will import ICA weights to this dataset later

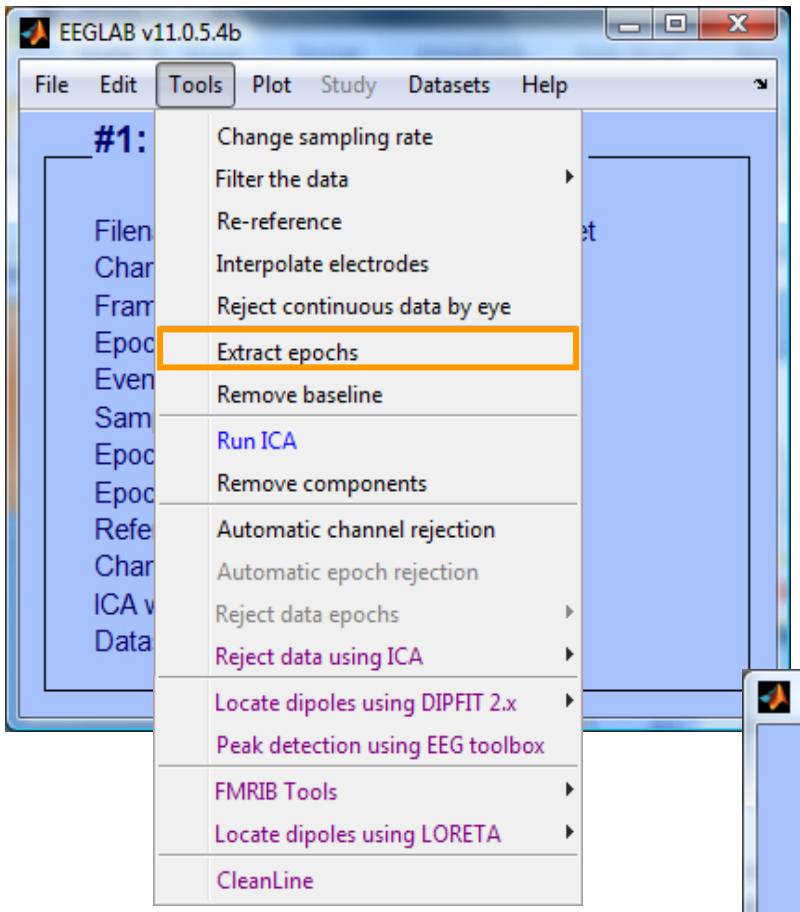
Identify/reject bad channels

Reject large artifact time points

Plot data

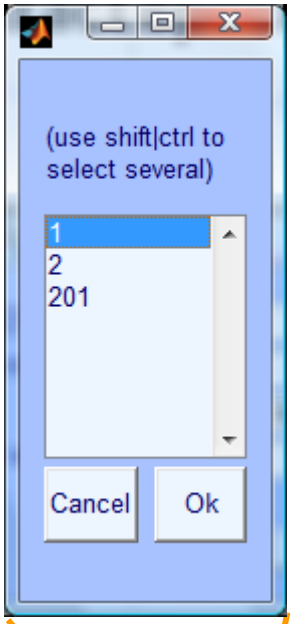
Run ICA

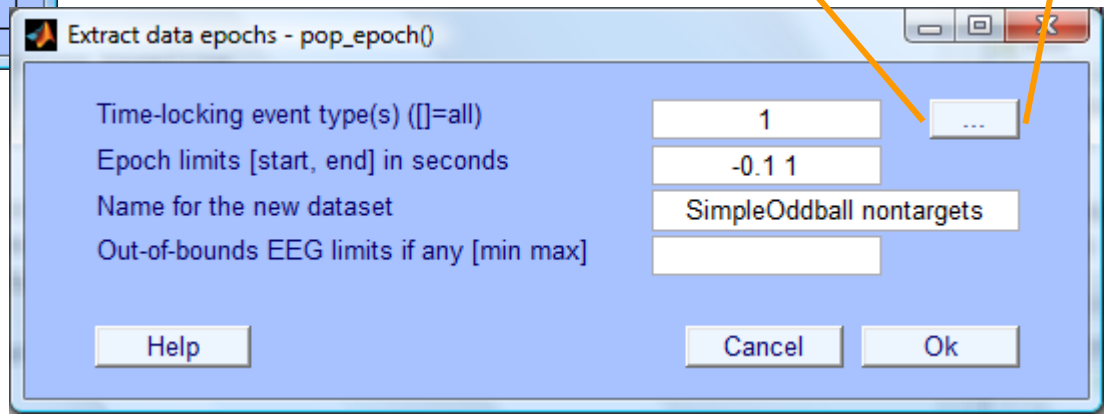
Extract epochs



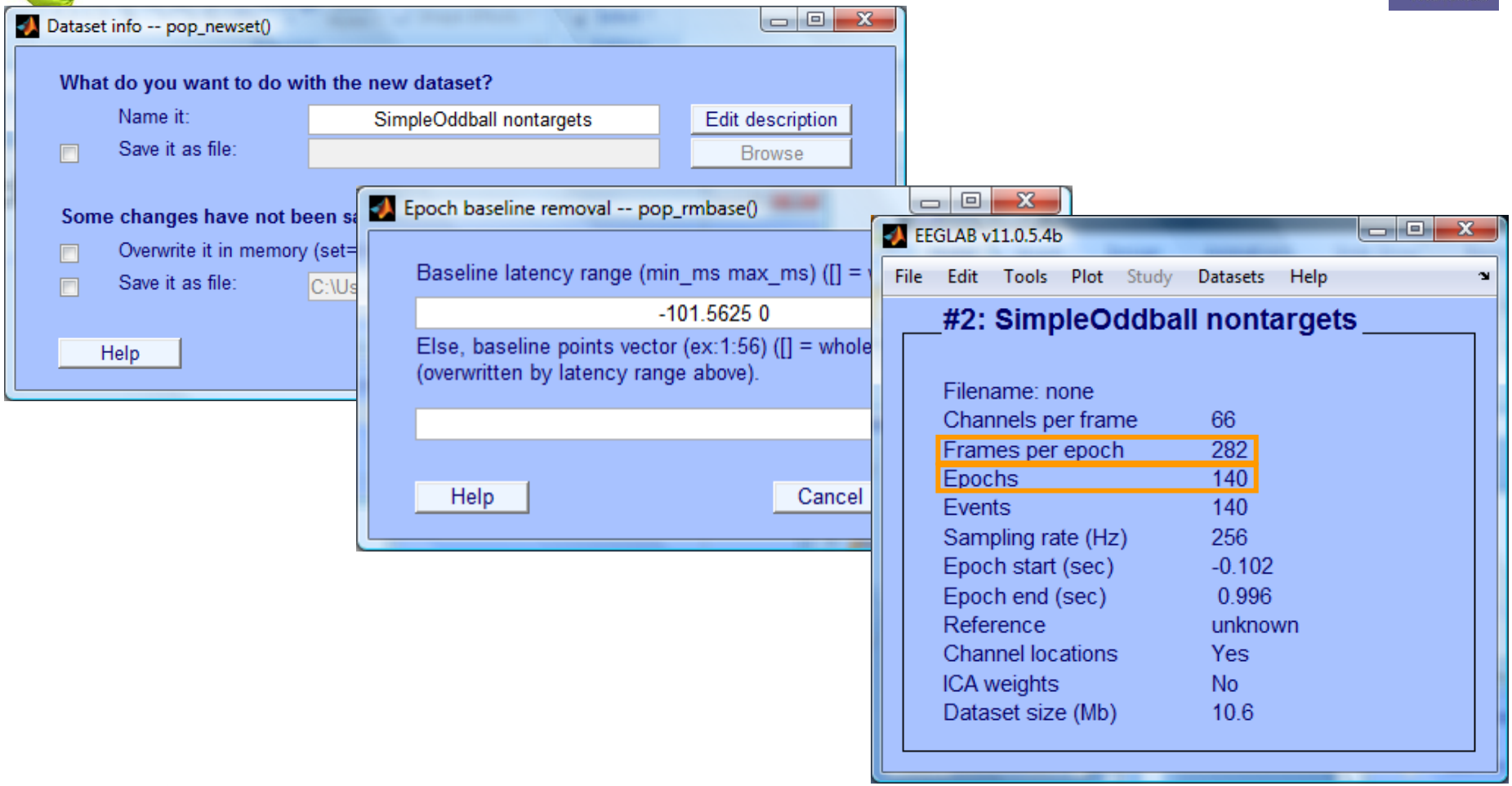

```
>> eeg_eventtypes(EEG)
```

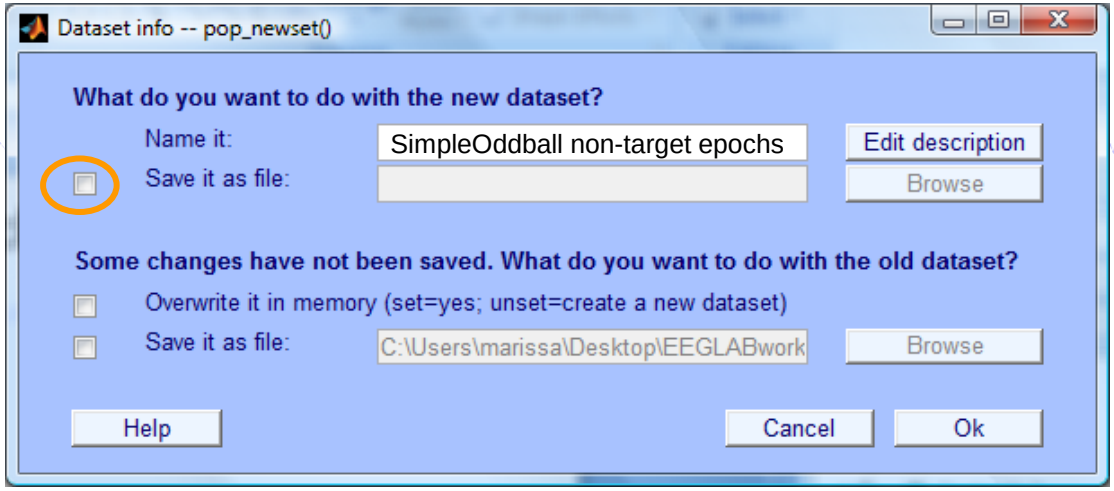
1	140	star
2	60	circle
201	60	button press



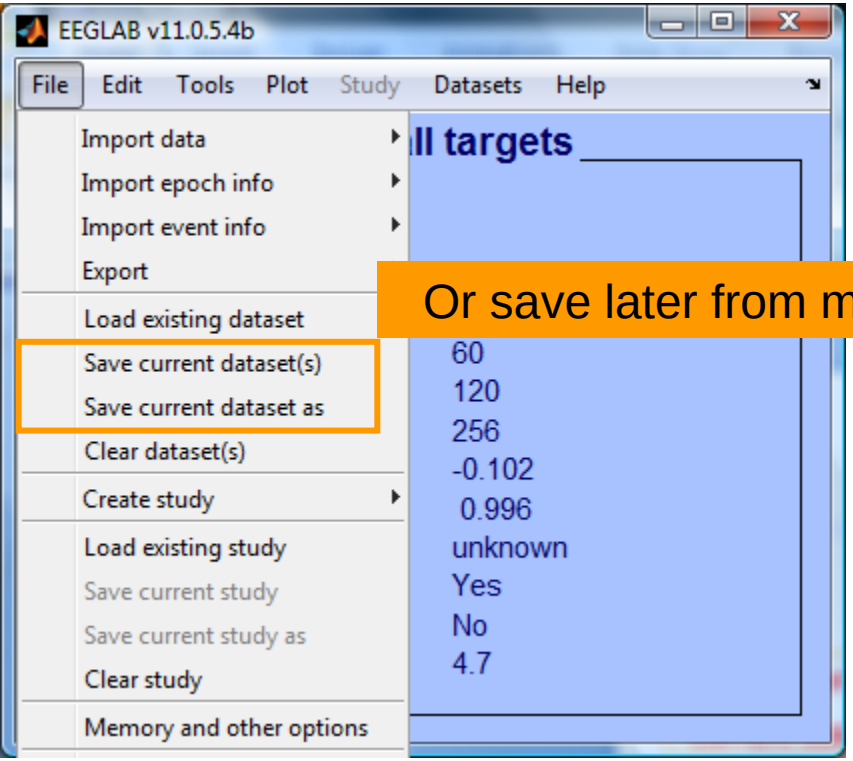


Extract epochs

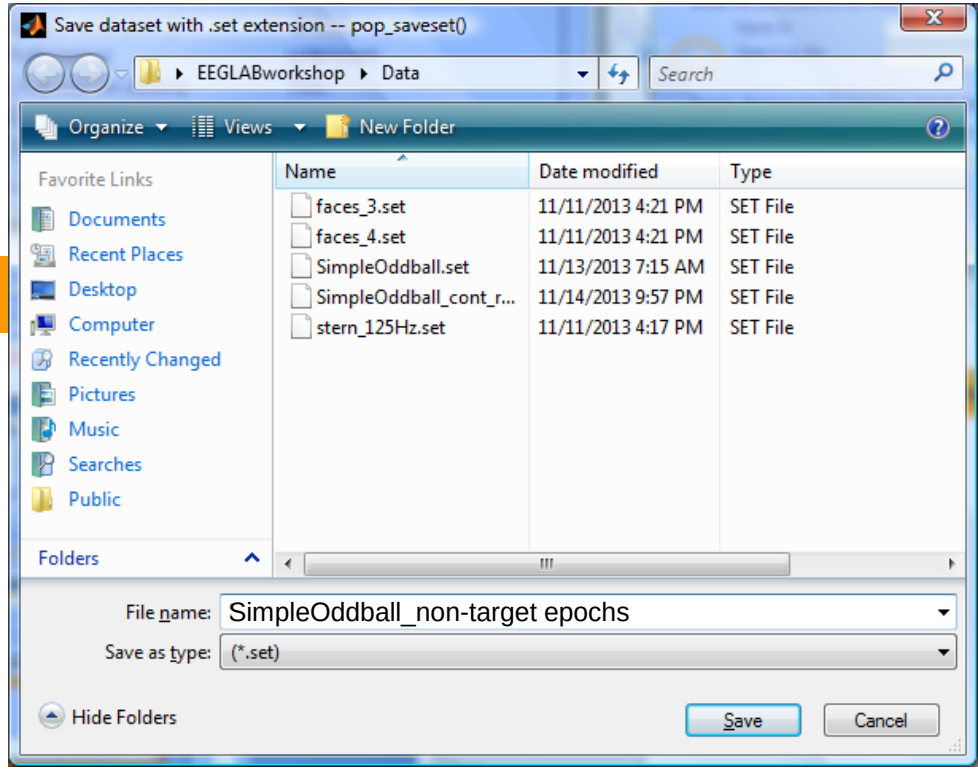




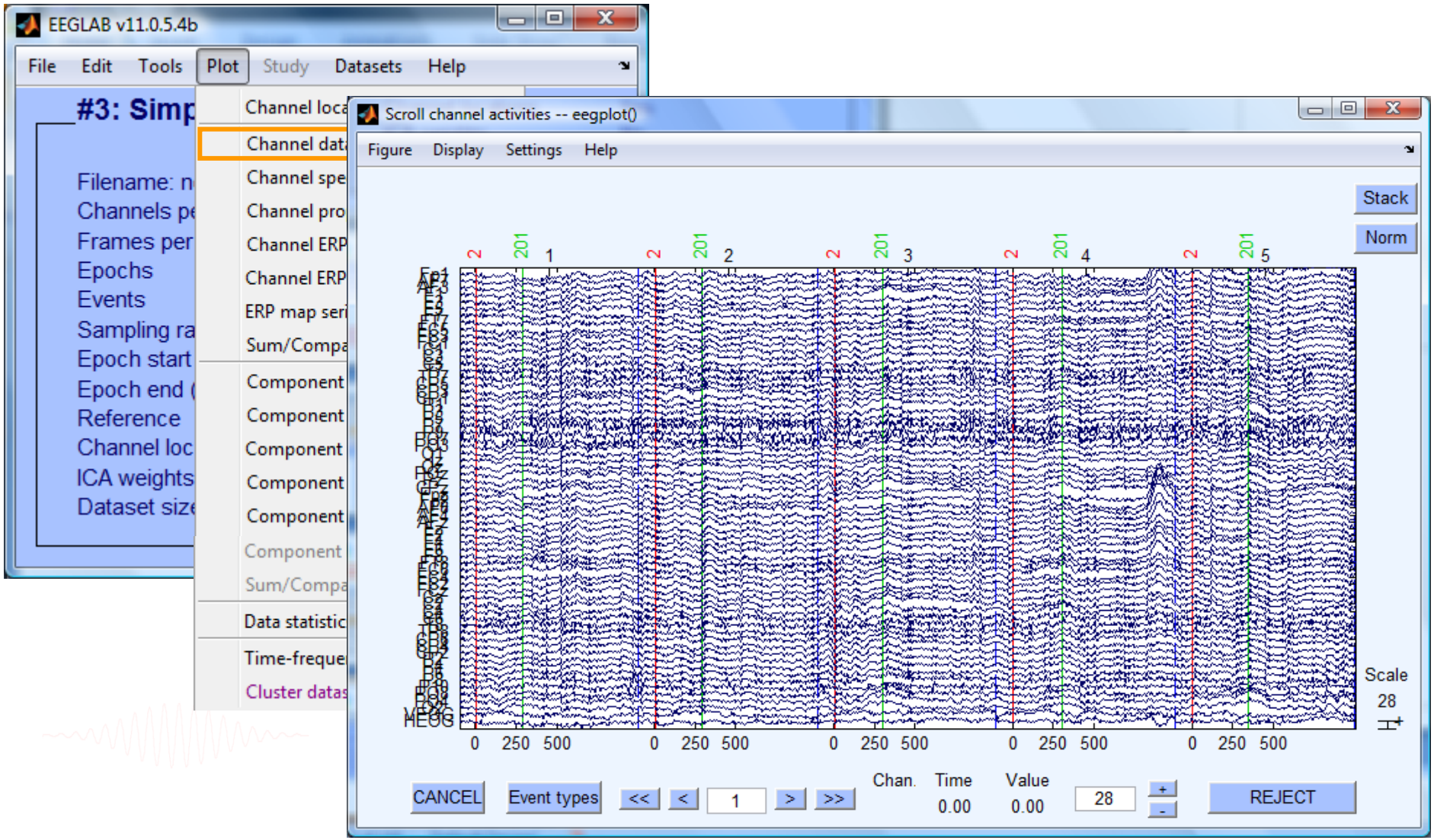
Save dataset (optional)



Or save later from menu

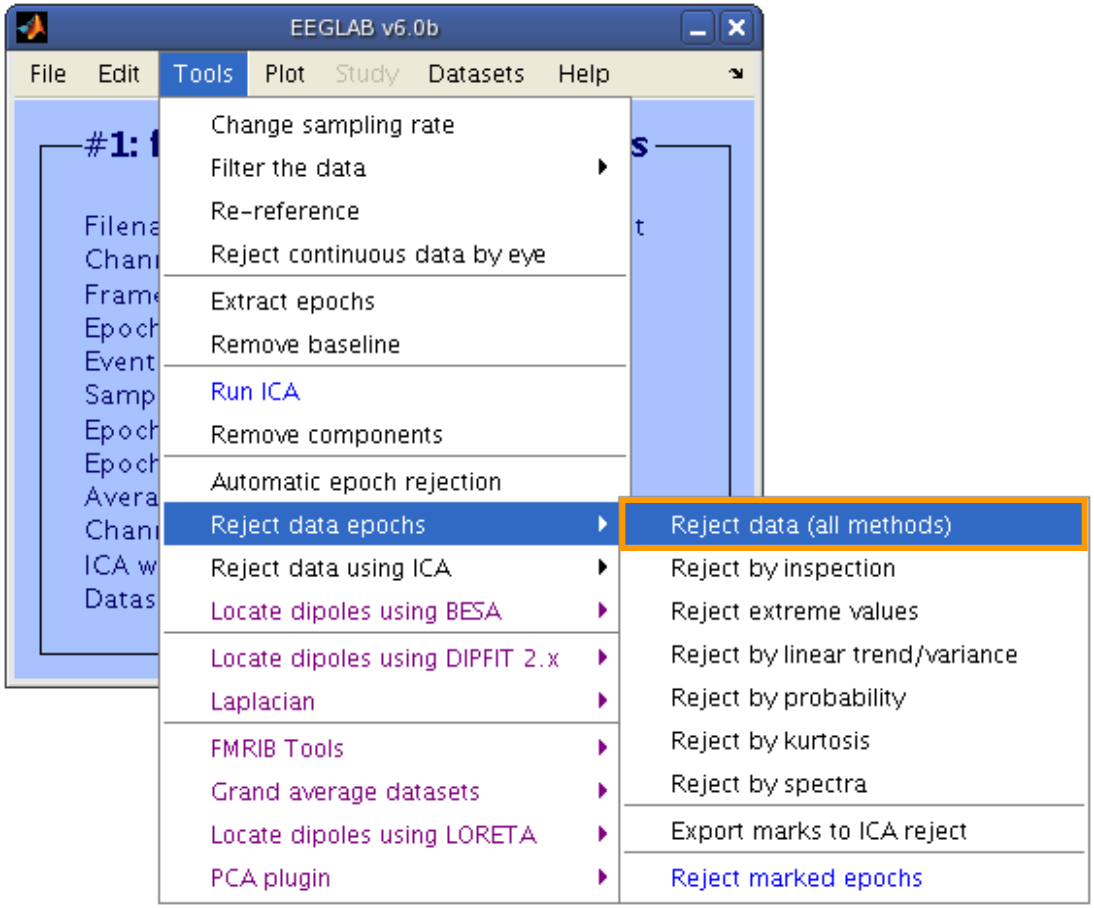


Scroll (epoched) channel data



Reject epochs with artifact

Reject data epochs



Reject data epochs

visual inspection

probability

Reject trials using data statistics - pop_rejmenu()

Mark trials by appearance

Scroll Data | Marked trials 0

Find abnormal values

Upper limit(s) (uV)	25	Lower limit(s) (uV)	-25
Start time(s) (ms)	-1000	Ending time(s) (ms)	1996
Electrode(s)	1:31	Currently marked trials	0

Calc / Plot | Help

Find abnormal trends

Max slope (uV/epoch)	50	R-squared limit (0 to 1)	0.3
Electrode(s)	1:31	Currently marked trials	0

Calc / Plot | Help

Find improbable data

Single-channel limit (std. dev.)	5	All channels limit (std. dev.)	5
Electrode(s)	1:31	Currently marked trials	0

Calculate | Scroll Data | Plot | Help

Find abnormal distributions

Single-channel limit (std. dev.)	5	All channels limit (std. dev.)	5
Electrode(s)	1:31	Currently marked trials	0

Calculate | Scroll Data | Plot | Help

Find abnormal spectra (slow)

Upper limit(s) (dB)	25	Lower limit(s) (dB)	-25
Low frequency(s) (Hz)	0	High frequency(s) (Hz)	50
Electrode(s)	1:31	Currently marked trials	0

Calc / Plot | Help

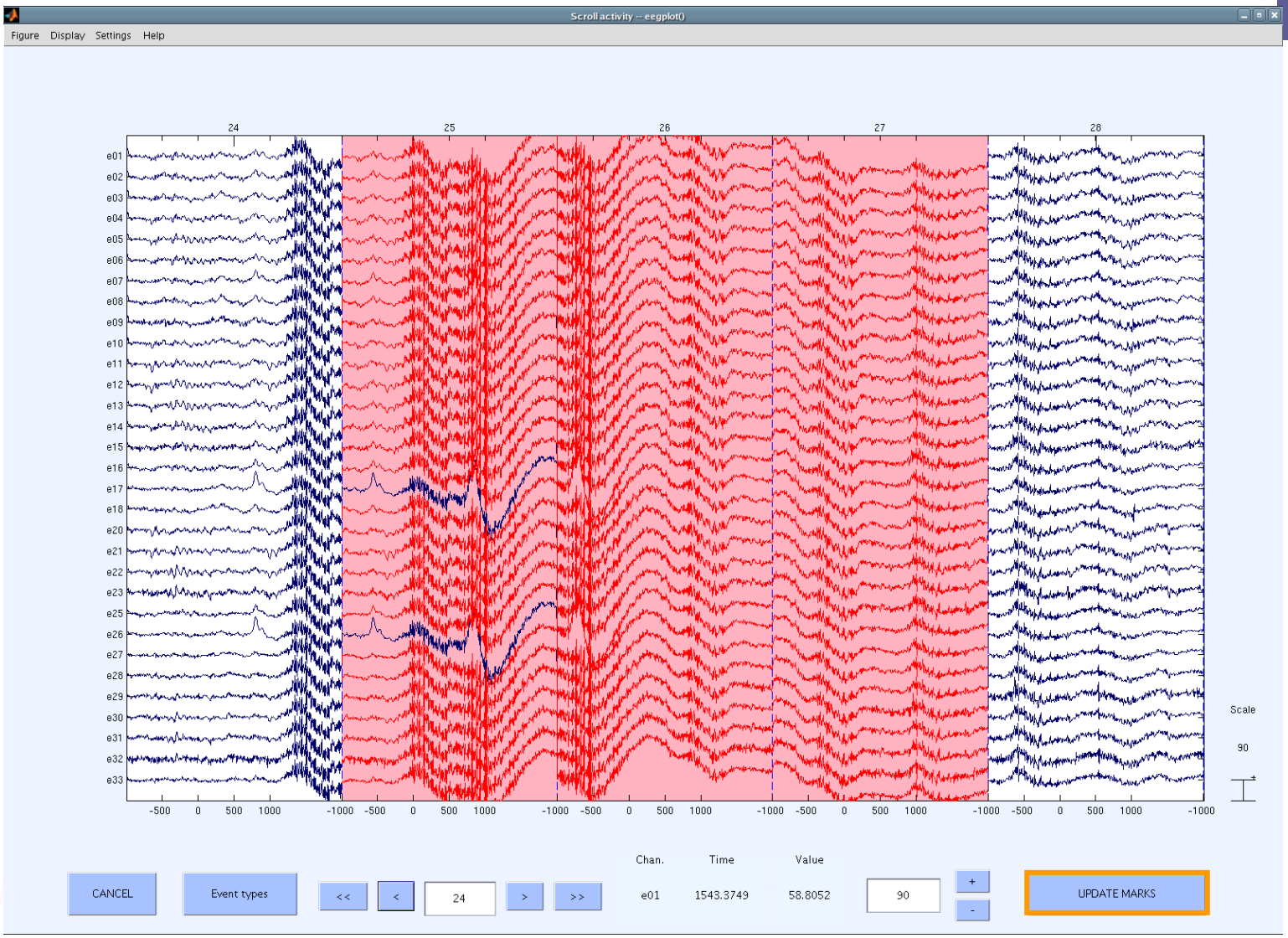
Plotting options

Show all trials marked for rejection by the measure selected above or checked below

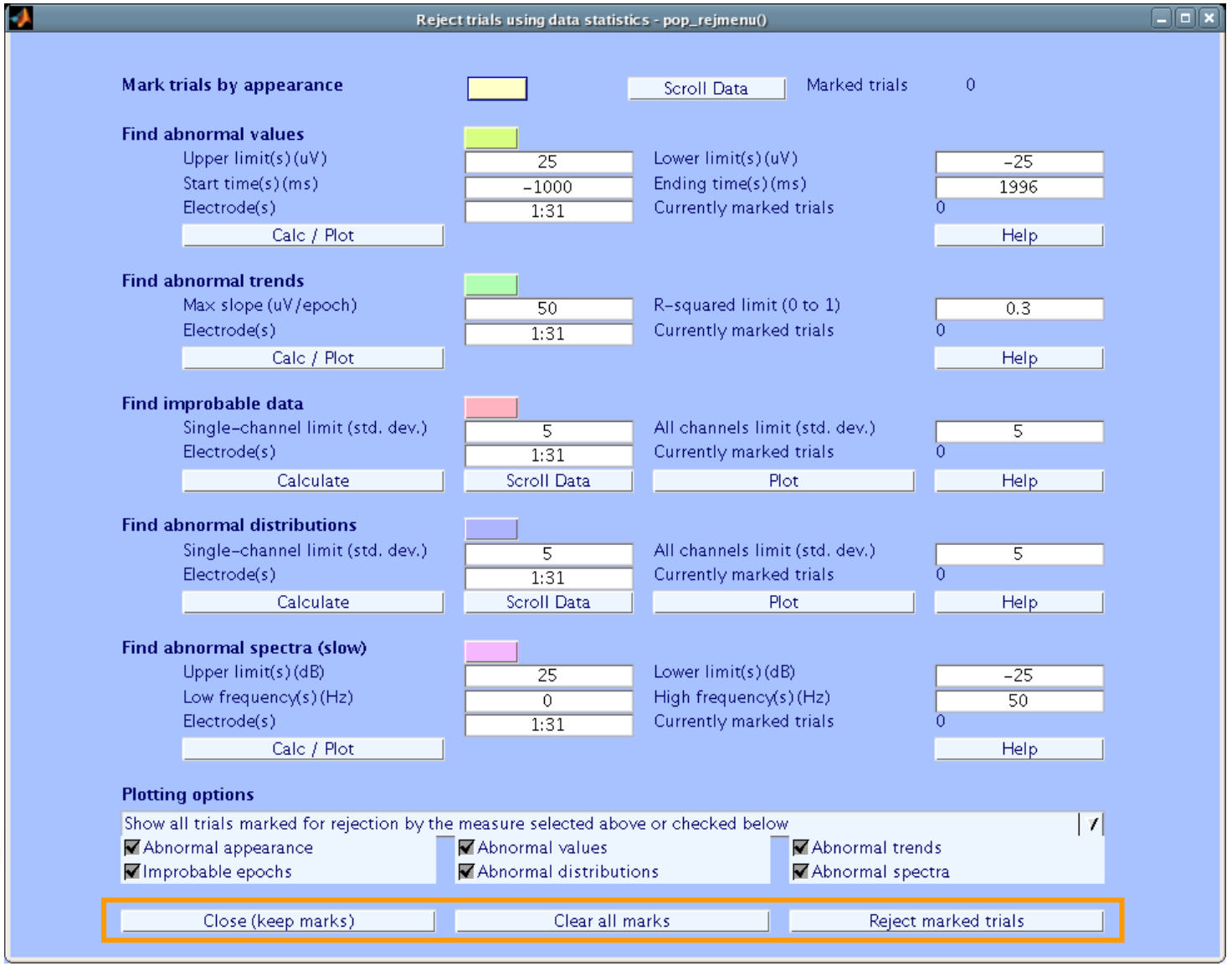
- [x] Abnormal appearance
- [x] Abnormal values
- [x] Abnormal trends
- [x] Improbable epochs
- [x] Abnormal distributions
- [x] Abnormal spectra

Close (keep marks) | Clear all marks | Reject marked trials

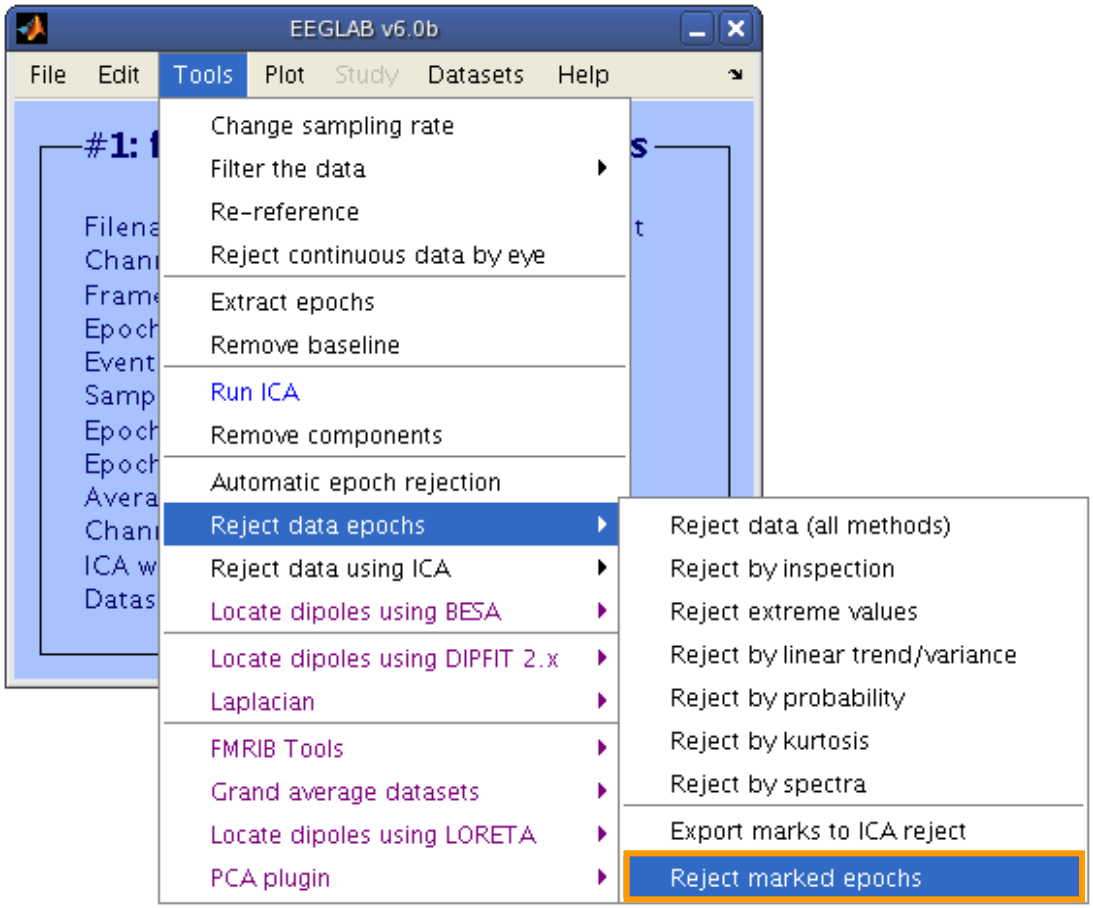
Reject data epochs



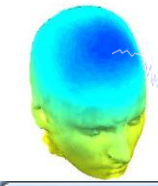
Reject data epochs

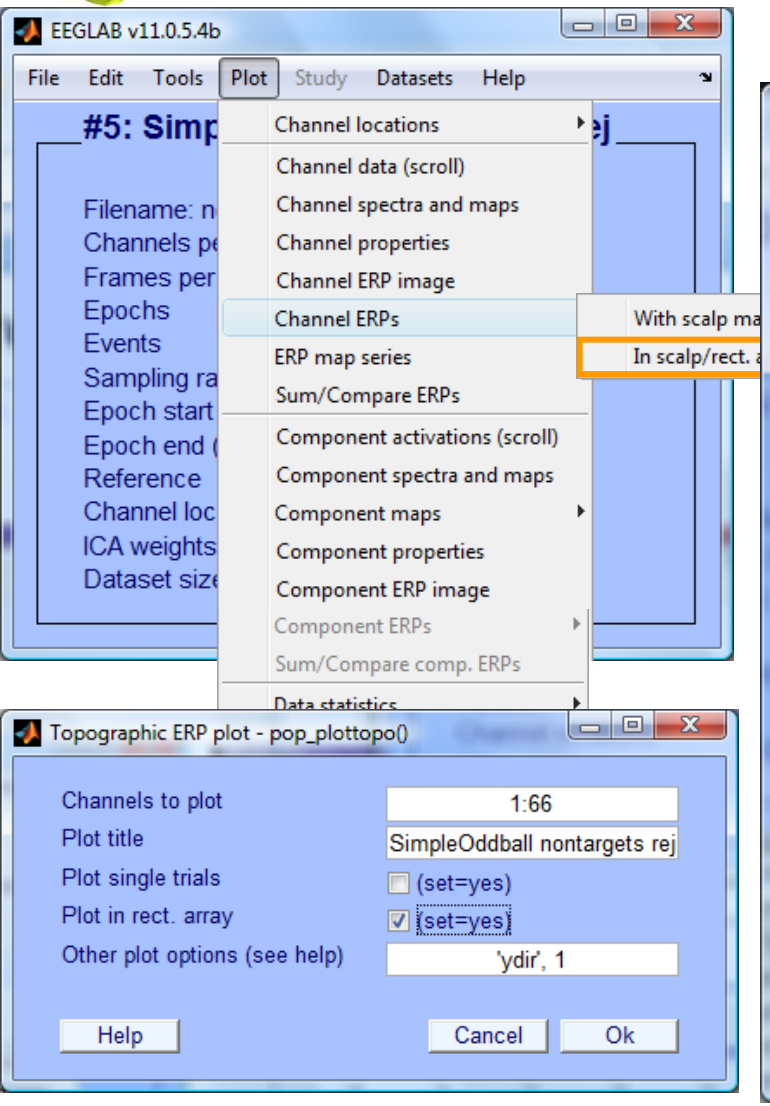


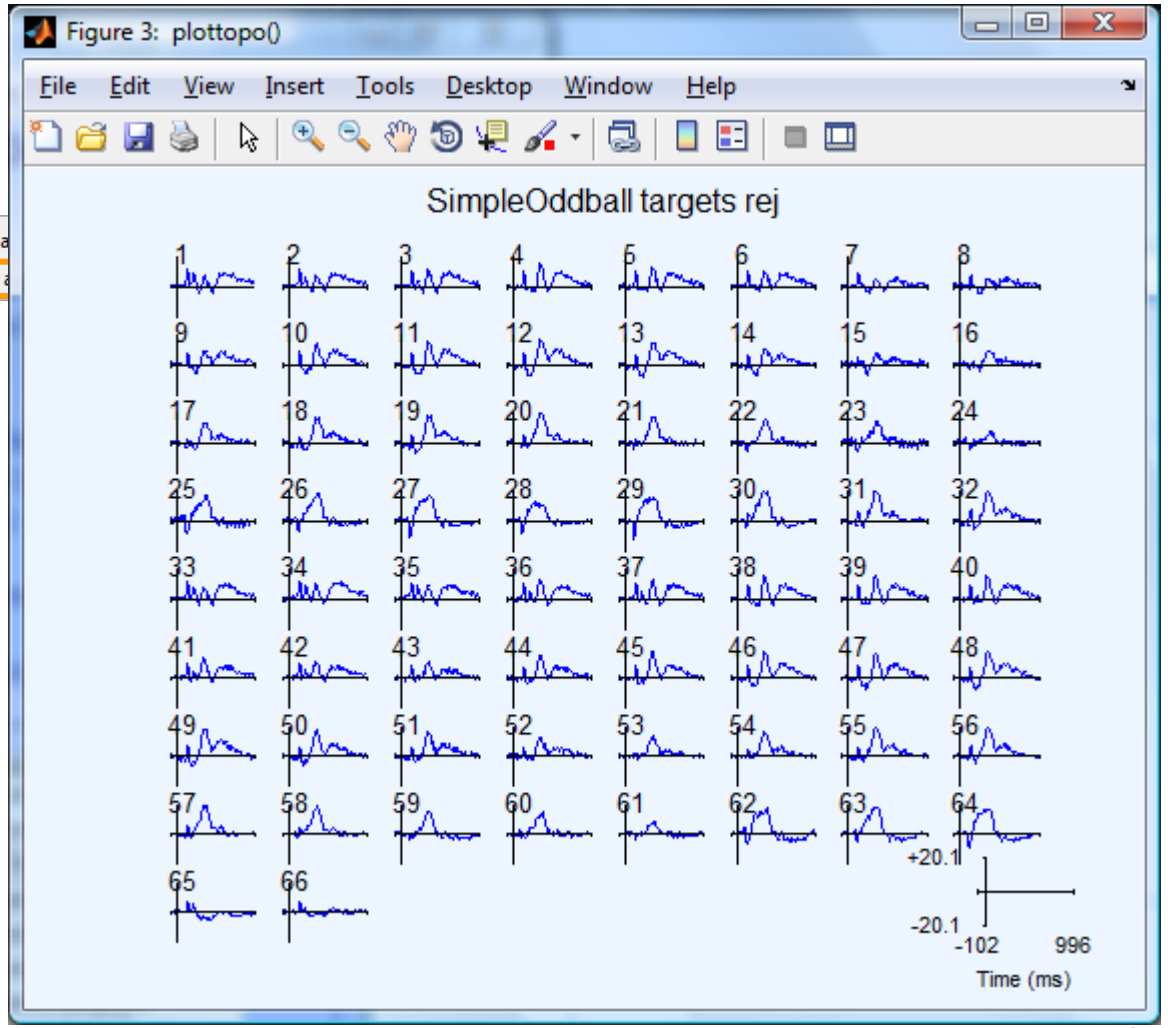
Reject data epochs



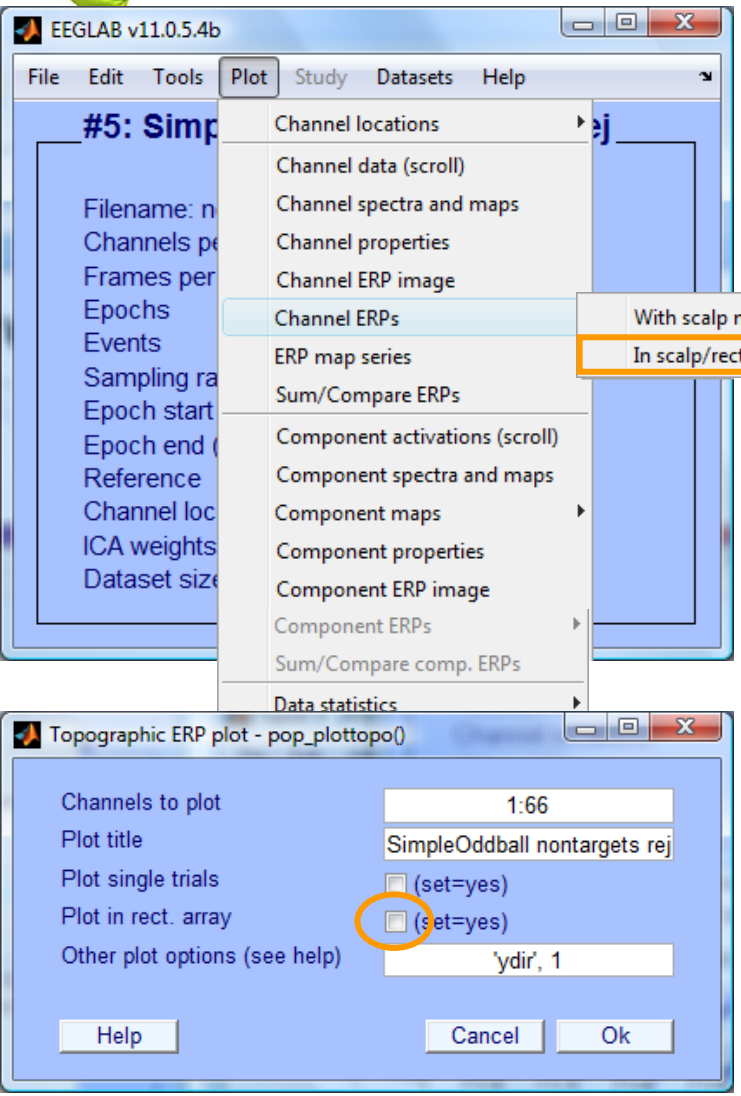
Visualize ERP in rectangular array

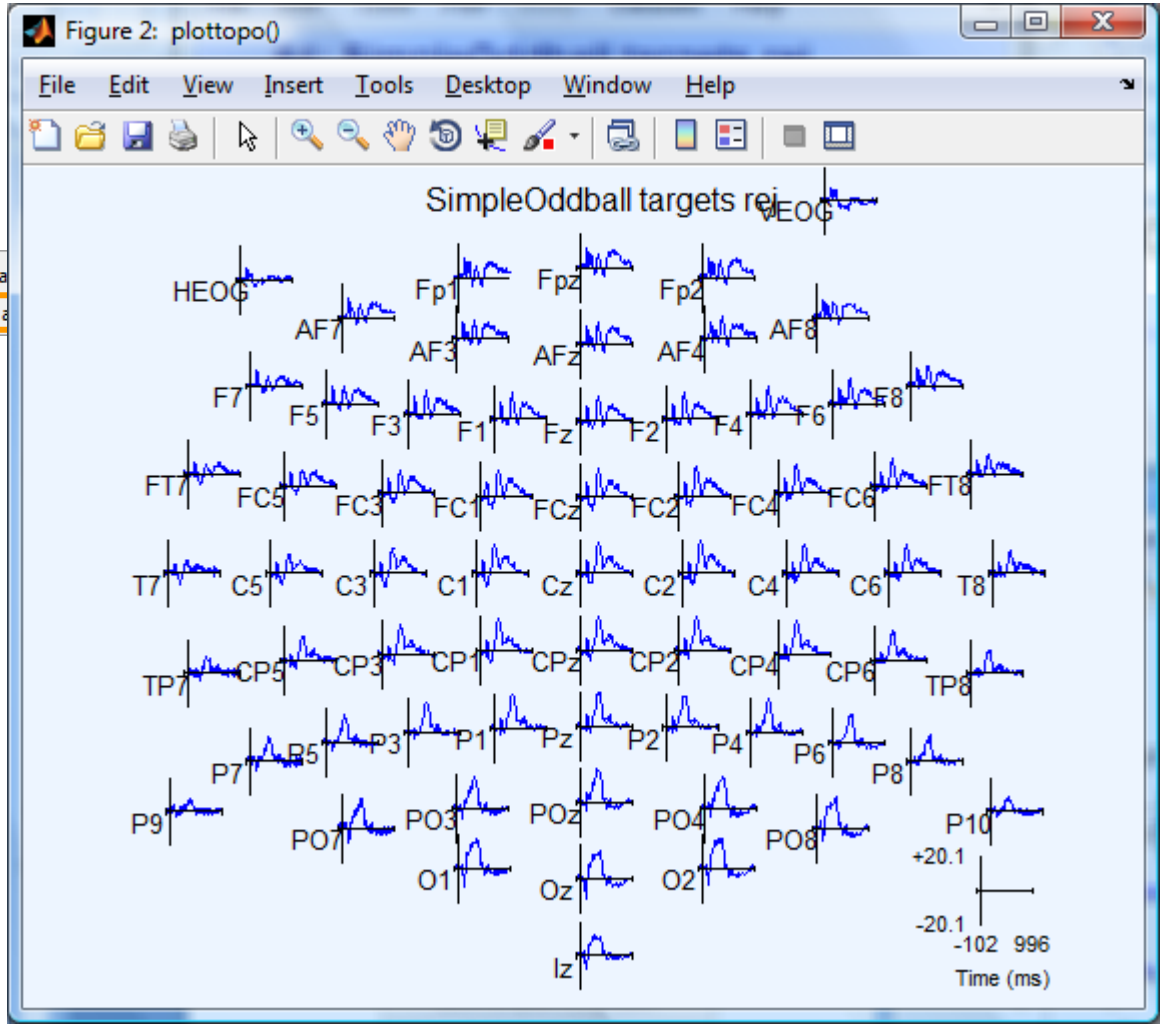




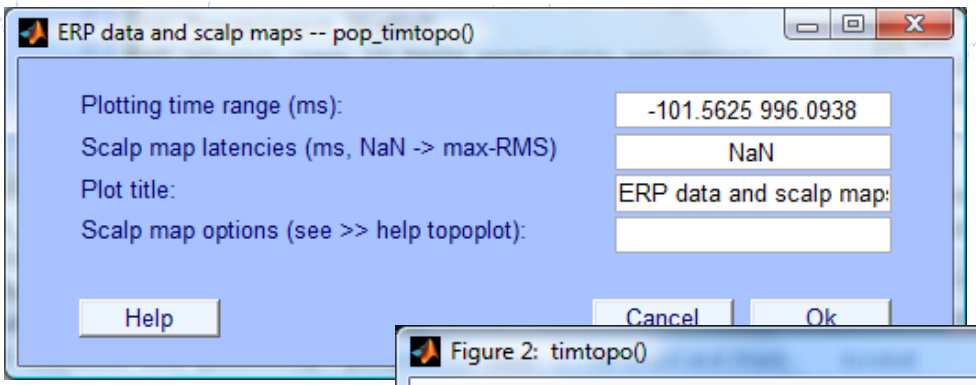


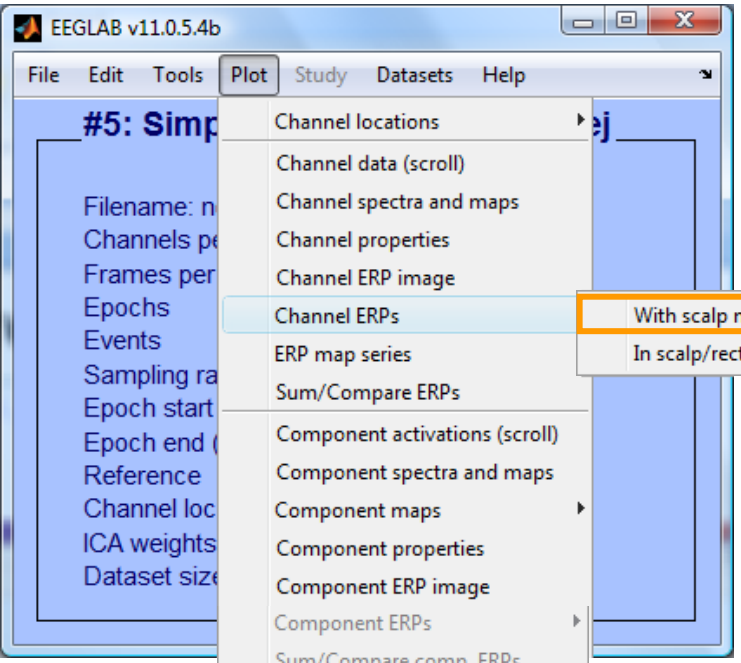
Visualize ERP in topographic array

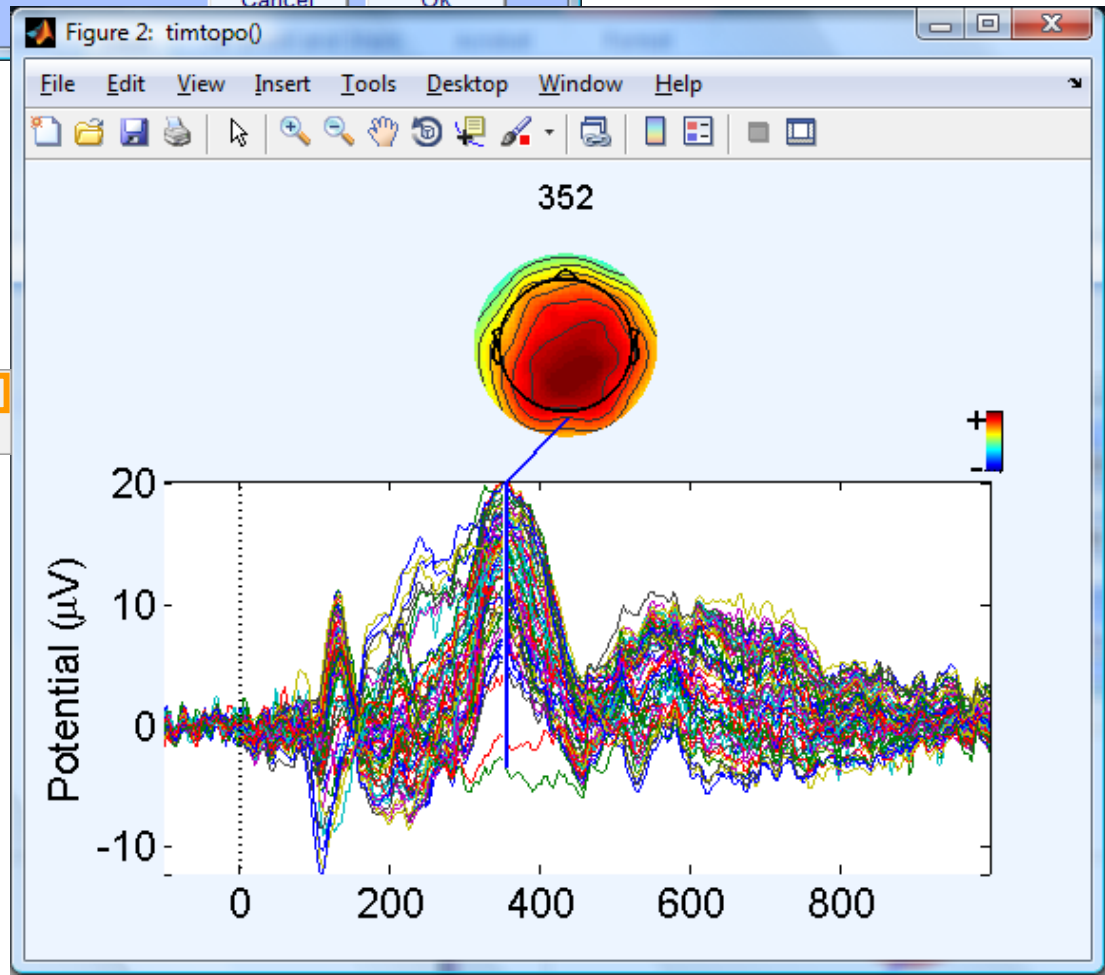




Visualize ERP scalp distribution







Visualize channel ERPs in 2D

Swartz Center for Computational Neuroscience

Plot ERP scalp maps in 2-D -- pop_topoplot()

Plotting ERP scalp maps at these latencies (range: -102 to 996 ms, NaN -> empty): 25:25:300

Plot title

Plot geomet

-> Additiona

Help

EEGLAB v11.0.5.4b

File Edit Tools Plot Study Data

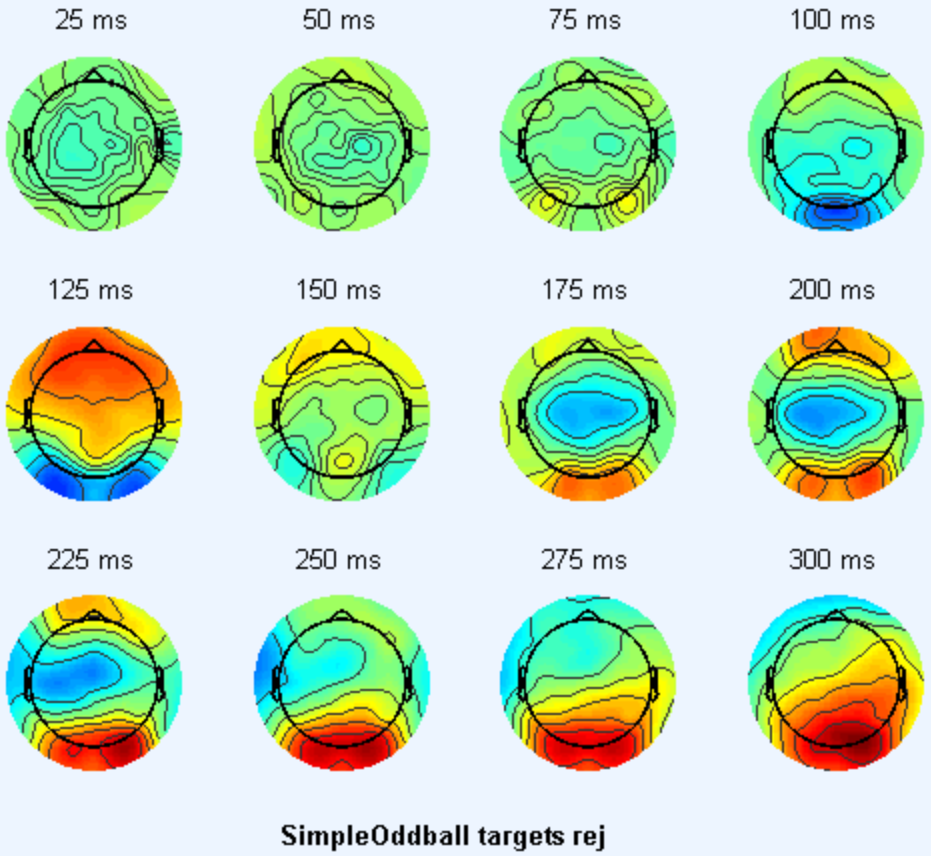
#4: Simp

Filename: n
Channels pe
Frames per
Epochs
Events
Sampling ra
Epoch start
Epoch end (
Reference
Channel loc
ICA weights
Dataset size

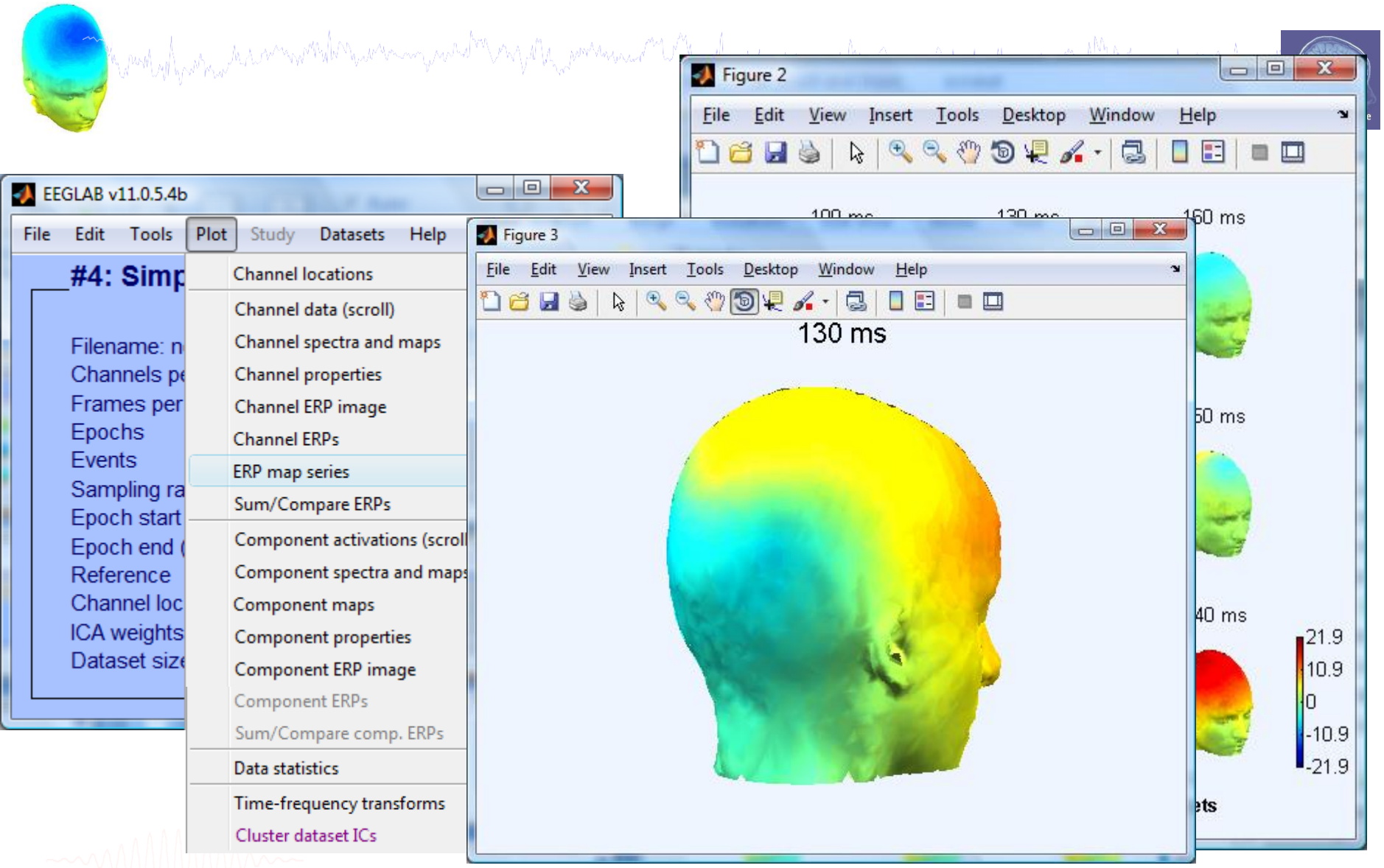
Channel locatio
Channel data (s
Channel spectr
Channel prope
Channel ERP in
Channel ERPs
ERP map series
Sum/Compare ERPs
Component activations (scroll)
Component spectra and maps
Component maps
Component properties
Component ERP image
Component ERPs
Sum/Compare comp. ERPs
Data statistics
Time-frequency transforms
Cluster dataset ICs

Figure 2

File Edit View Insert Tools Desktop Window Help



Visualize channel ERPs in 3D

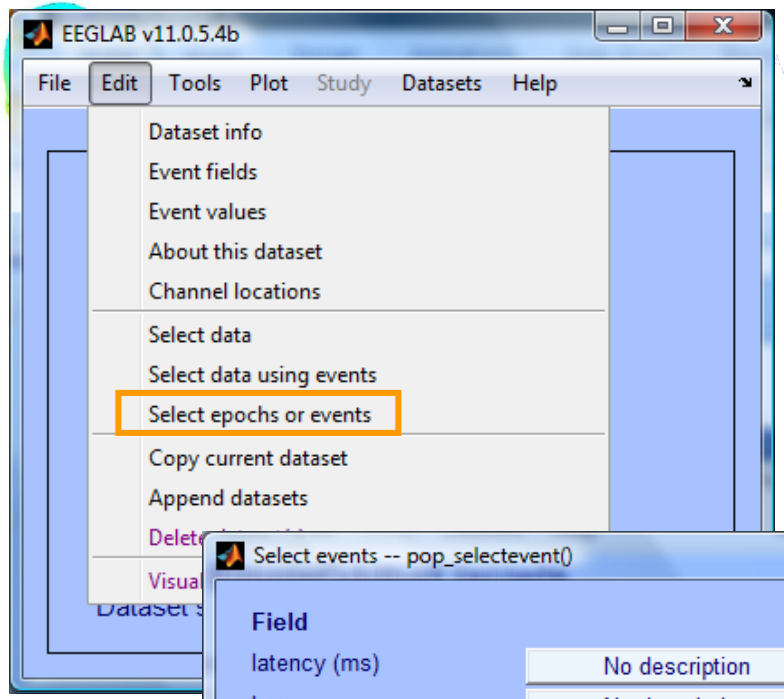


Exercises (continuous data)

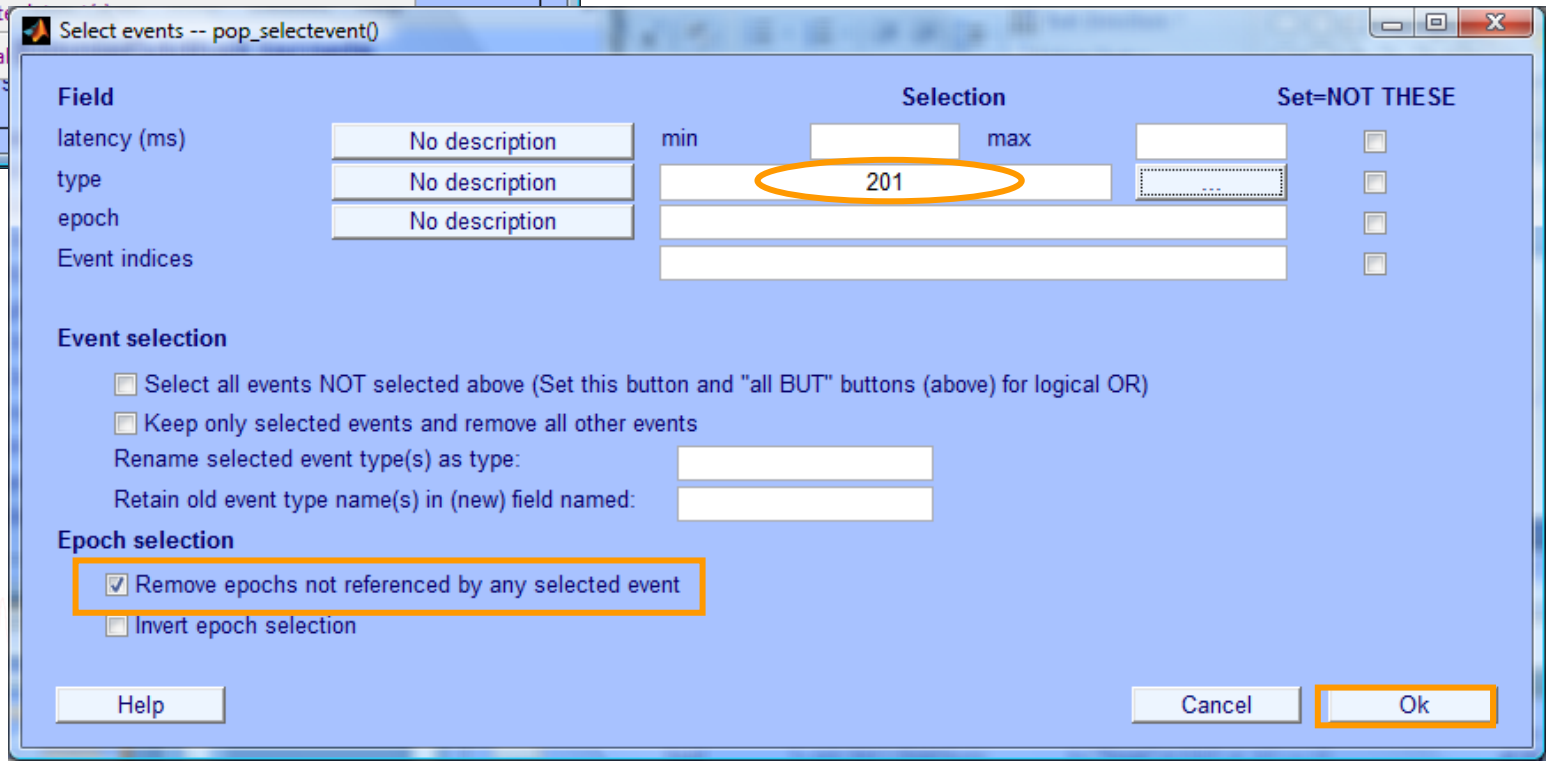
- Load SimpleOddball.set
- Re-reference data to average reference
- Hi-pass filter the continuous data, then save
- Epoch the data on circles (event type 1)
- Scroll the epoched data and perform visual rejection of epochs
- Explore the automated artifact rejection tools
- Save ‘clean’ epoched datasets for circles (targets)

Supplementary material

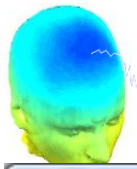
Select a subset of epochs

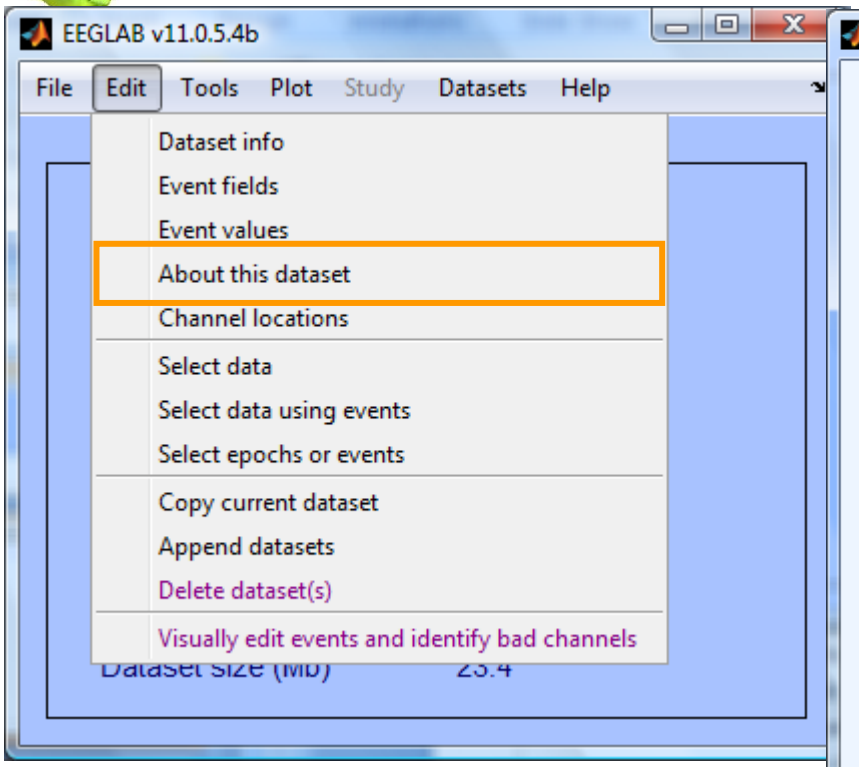


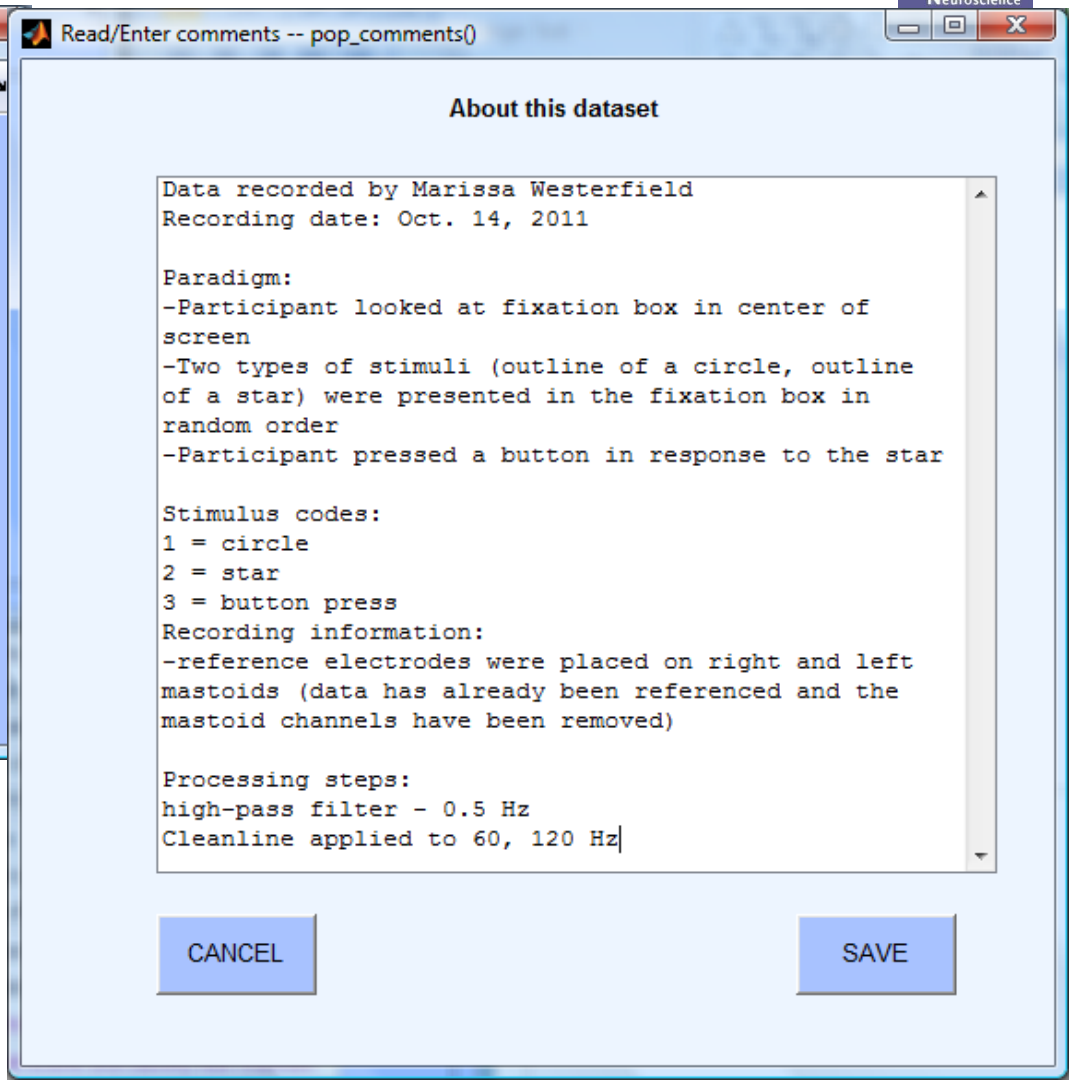
Keep only epochs with a 201 (button press) event



Comments and dataset history







Also:
>> EEG.comments

or
>> EEG.history

Removing channel(s)

- You may prefer to interpolate bad channels rather than remove them altogether
- The loss in dimensionality will affect the ICA decomposition
- Usual solution:
  - Delete the bad channels before running ICA
  - STUDY tools will do much of this automatically (interpolate missing channels, etc)