

EEG Preprocessing in EEGLAB

Virtual EEGLAB workshop 2021
University of California San Diego
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Why preprocess data?



EEG data out of the recording device is a continuous unprocessed signal. It is like measuring a difference of potential on an oscilloscope.

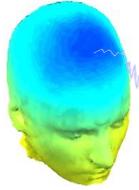


To make sense of the data, we need to:

- Extract meaningful measures from it (such as brain oscillations; brain source activations)
- Compare brain data in different conditions
- Assess reliable changes due to external stimuli (event-related potentials)

Before we do all that, we apply a series of transformations to the data

Pre-processing pipeline



Collect
EEG data

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

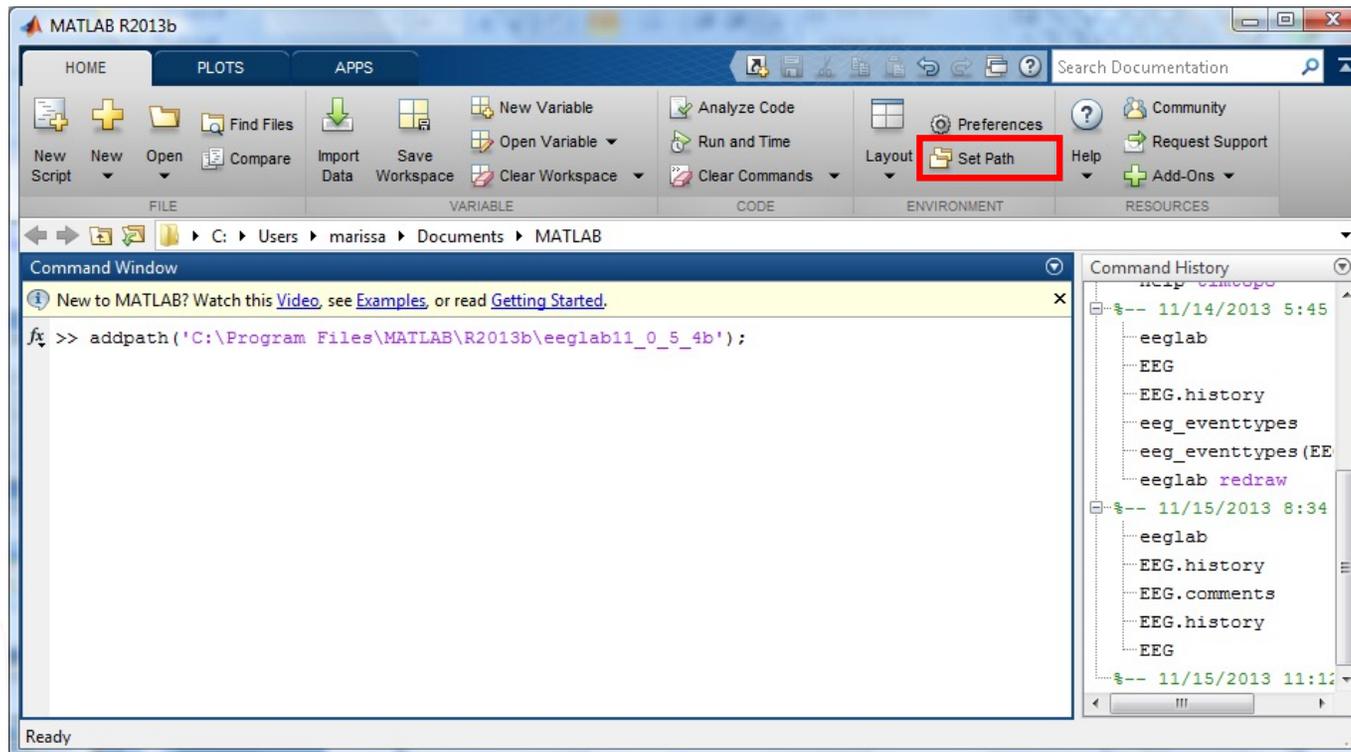
Run ICA and
reject components

Done

Installing EEGLAB and data folder



- Download and install Matlab (2008b or later)
- Download EEGLAB (<http://www.sccn.ucsd.edu/eeglab>)
- Unzip EEGLAB
- Add the EEGLAB folder to your Matlab path:



The EEGLAB Matlab software



main graphic interface

The screenshot shows the MATLAB R2013b environment. The Command Window contains the command `f>> eeglab`. The EEGLAB v11.0.5.4b window is open, displaying the following text:

No current dataset

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

Importing a dataset

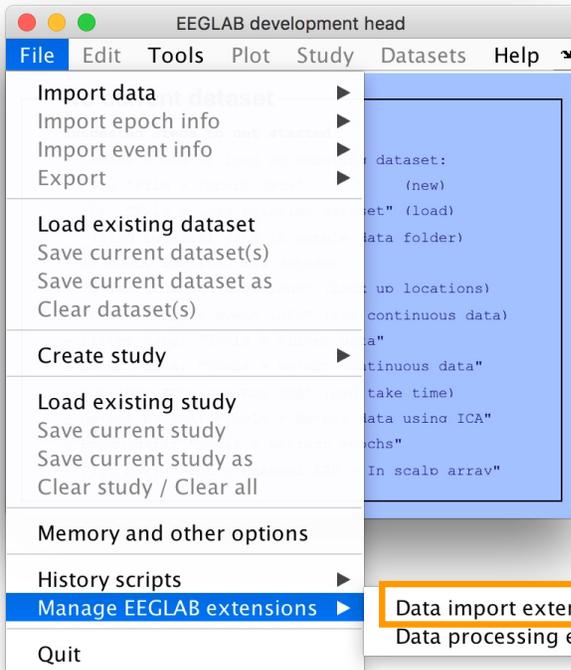


The screenshot displays the EEGLAB v11.0.5.4b software window. The 'File' menu is open, showing options like 'Import data', 'Load existing dataset', and 'Create study'. The 'Import data' submenu is also open, listing various data sources such as 'From ASCII/float file or Matlab array', 'From Netstation .mff', and 'From Biosemi BDF file'. A secondary window titled 'existing dataset (old)' is visible in the background, showing a list of operations like '> Select data' and '> Reject'.

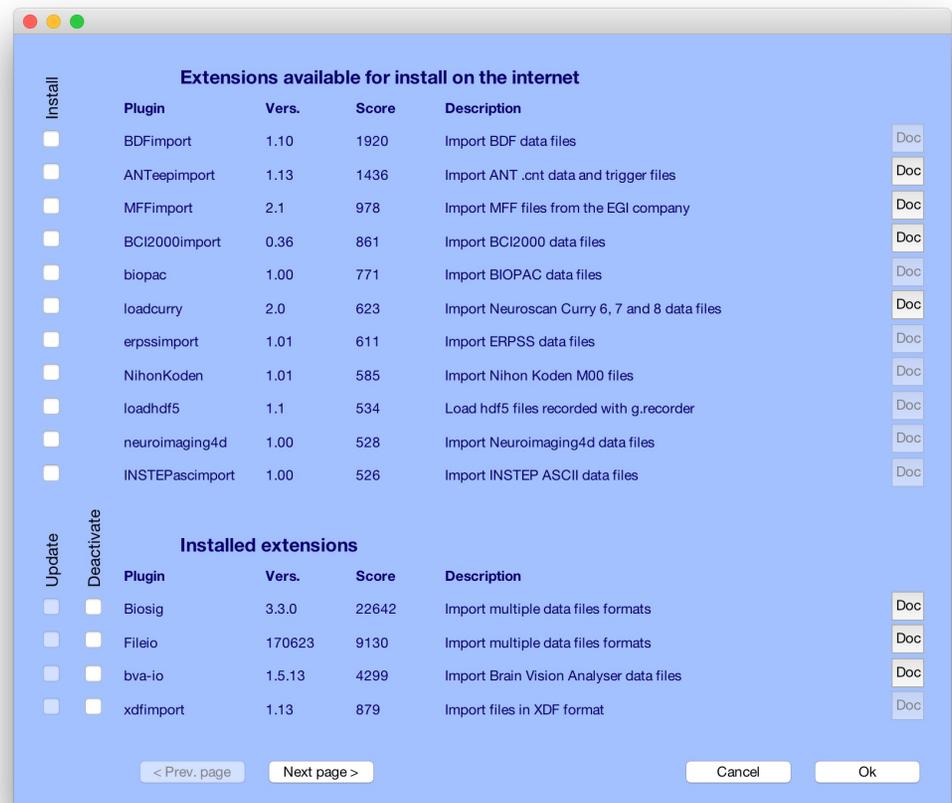
File	Import data	Using EEGLAB functions and plugins	From ASCII/float file or Matlab array
File	Import data	Using EEGLAB functions and plugins	From ASCII/float file or Matlab array
Edit	Import epoch info	Using the FILE-IO interface	From Netstation .mff (FILE-IO toolbox)
Tools	Import event info	Using the BIOSIG interface	From Netstation binary simple file
Plot	Export	Troubleshooting data formats...	From Multiple seg. Netstation files
Study	Load existing dataset	existing dataset (old)	From Netstation Matlab files
Datasets	Save current dataset(s)	ch info" (data	From BCI2000 ASCII file
Help	Save current dataset as	nt info" (continuous	From Snapmaster .SMA file
	Clear dataset(s)	fo" (add/edit dataset	From Neuroscan .CNT file
	Create study	set" (save dataset	From Neuroscan .EEG file
	Load existing study	> Select data"	From Biosemi BDF file (BIOSIG toolbox)
	Save current study	ls > Reject	From Biosemi BDF and EDF files (BDF plugin)
	Save current study as	ls > Extract epochs"	From EDF/EDF+/GDF files (BIOSIG toolbox)
	Clear study	: "Tools > Remove	From ANT EEProbe .CNT file
	Memory and other options	s > Run ICA"	From ANT EEProbe .AVR file
	History scripts		From BCI2000 .DAT file
	Quit		From BIOPAC MATLAB files



Install extension for importing data files



Data import extensions
Data processing extensions



Supported data formats



EEGLAB tutorial: <https://sccn.ucsd.edu/wiki/A01: Importing Continuous and Epoched Data>

Supported Data Formats

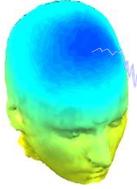
File Format	File Extension	File type	Events	Channel Labels	EEGLAB	Biosig	File IO	Support
ANT EEProbe	.avr	-	-	-	-	-	-	Comments
ANT EEProbe	.cnt	-	-	-	y	y	y	Comments
ASCII	.txt	-	-	-	y	y	-	Comments
BCI2000	.bci2000	continuous	-	-	p	-	-	Comments
BCI2000	.gdf	continuous	-	-	p	-	-	Comments
Biologic	.eeg	-	-	-	-	-	-	Comments
Biopac	.mat/.acq	-	-	-	p (see comments)	-	-	Comments
Biosemi	.bdf	continuous	Channel	-	y	y	y	Comments
Blackrock	.NEV .NSx	-	-	-	see comments	-	-	Comments
Brain Vision Analyzer	.mat	continuous & segmented	Embedded	-	y	y	n	Comments
Brain Vision Analyzer	.vhdr	-	file	-	y	y	n	Comments
BrainStorm	.vsm	-	-	-	-	-	-	Comments
Cogniscan	-	-	-	-	p	-	-	Comments
Compumedics Profusion	.raw	-	-	-	see comments	-	-	Comments
CTF/BrainStorm	.ctf	-	-	-	y	y	y	Comments
EGI/Netstation	.RAW	continuous & segmented	Channel	-	y	y	y	Comments
Elektra (MEG)	.fif	-	-	-	n (see comments)	y	n	Comments
Emotiv	.edf	-	-	-	y (see comments)	y (see comments)	y (see comments)	Comments
ERPSS	.raw	-	-	-	y	n	n	Comments
ERPSS	.rdf	-	-	-	y	n	n	Comments
European Data Format (16-bit)	.edf	-	Channel	-	y	y	n	Comments
EDF+	.edf	-	Channel	-	y	y	n	Comments
INSTEP	.asc	-	-	-	y	n	n	Comments
Matlab Array	.mat	-	Channel	-	y	y	n	Comments
Micromed	-	-	-	-	p	-	-	Comments
Neuroimaging4D	.m4d	-	-	-	y	n	n	Comments
Neuromag	.fif	-	-	-	see comments	n	see comments	Comments
Neuroscan	.avg	-	-	-	-	-	-	Comments
Neuroscan	.CNT	-	Embedded (see comments)	-	y	y	y	Comments
Neuroscan	.eeg	continuous	-	-	y	y	y	Comments
Nihon Kodhen	.eeg	continuous	-	-	-	y (see comments)	-	Comments
Profusion	.slp	-	-	-	-	-	-	Comments
Snapmaster	.SMA	-	Channel	-	y	y	n	Comments
Spike2	.mat	-	-	-	y (see comments)	n	n	Comments
Tucker-Davis Technology	.tdt	-	-	-	p	-	-	Comments



BIOSIG: <http://pub.ist.ac.at/~schloegl/biosig/TESTED>

File-IO: <https://www.fieldtriptoolbox.org/development/module/fileio/>

Sample data: basic P300 paradigm



File

SimpleOddball.set

Data

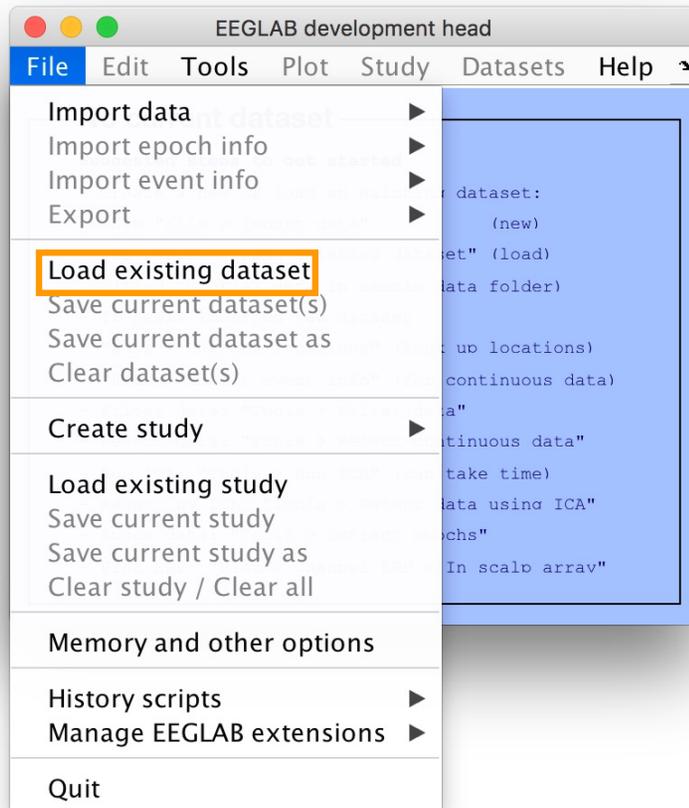
68 channel EEG, 256 Hz sampling rate, Biosemi system, re-referenced during import to averaged left and right mastoid electrodes

Task

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



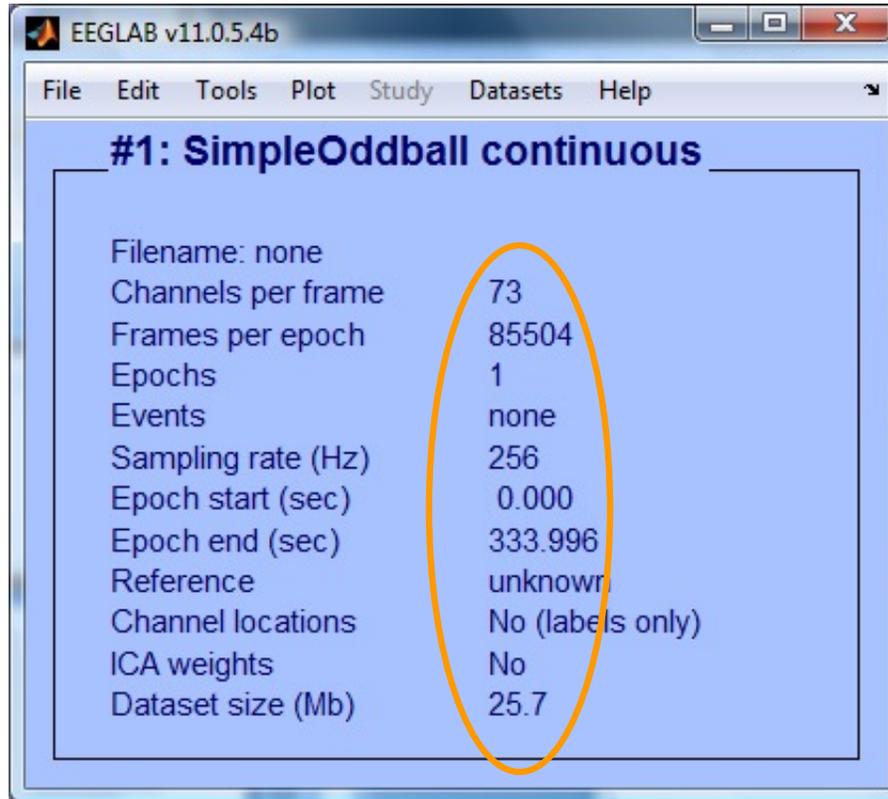
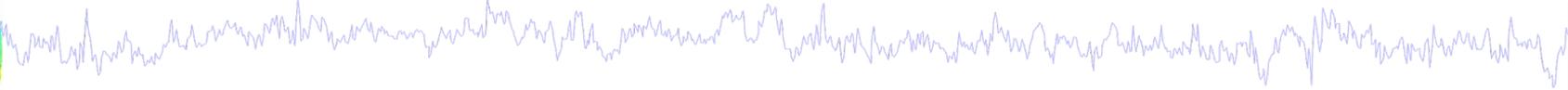
Load a dataset



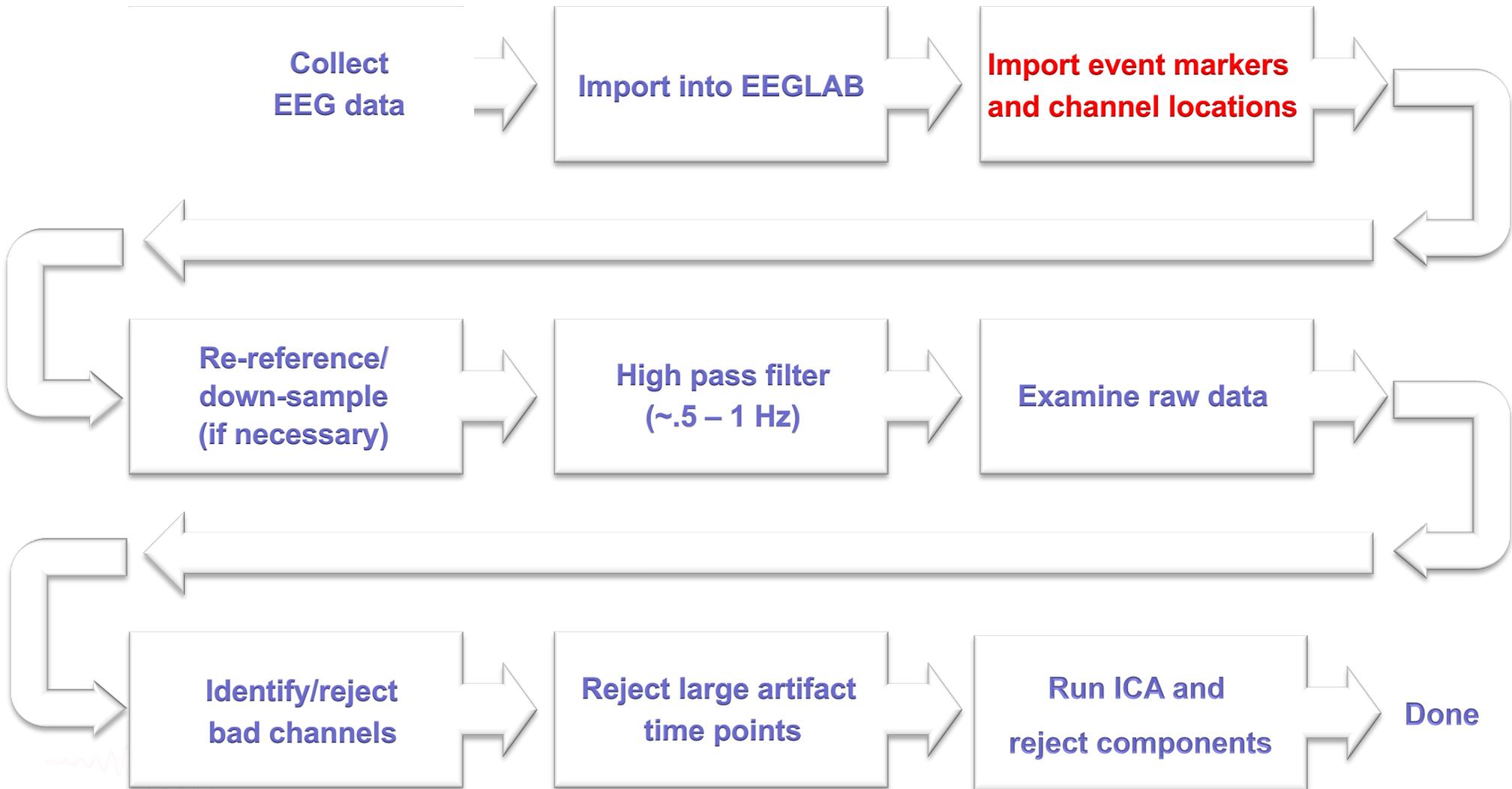
Load "SimpleOddball.set"



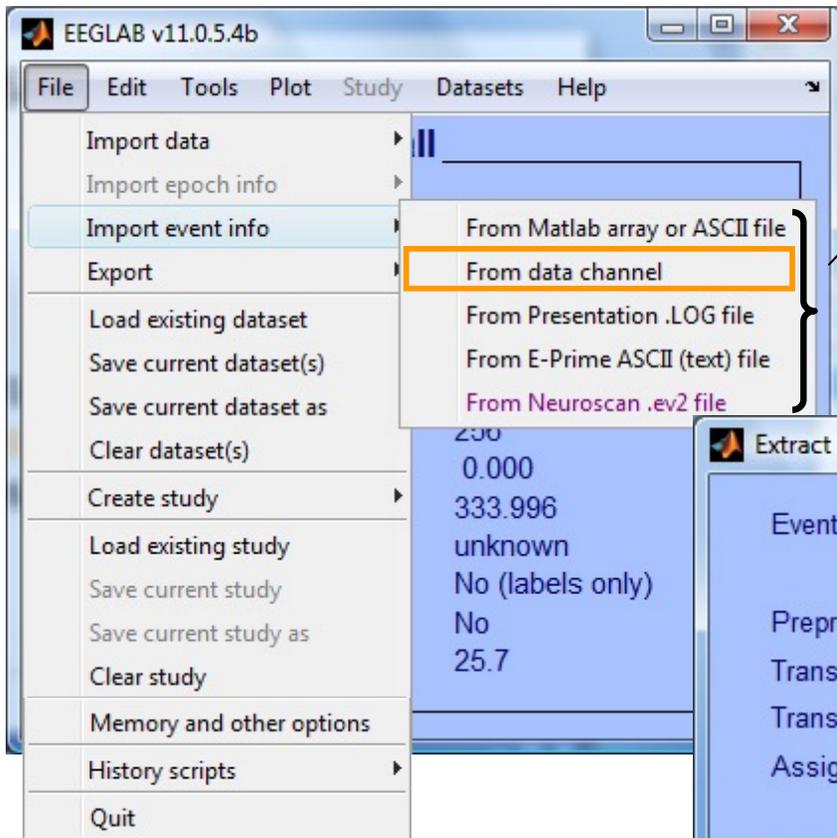
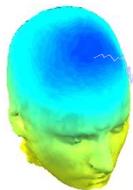
Imported EEG data



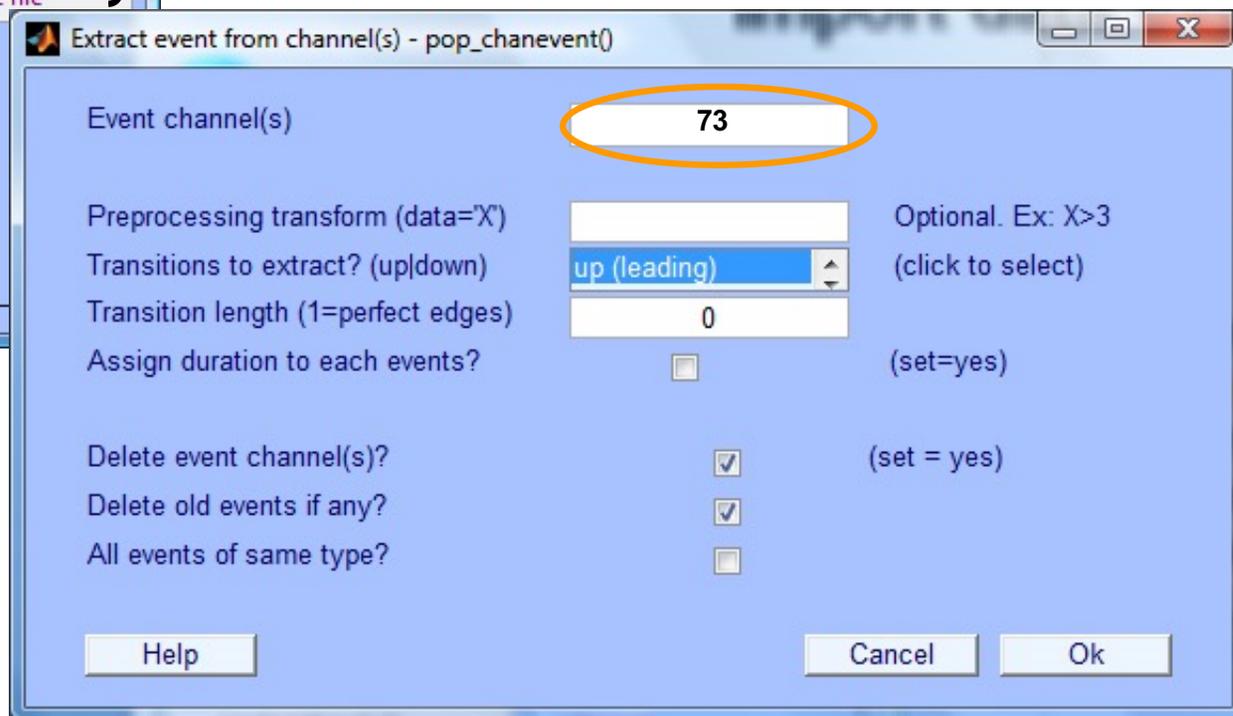
Pre-processing pipeline



Import data events

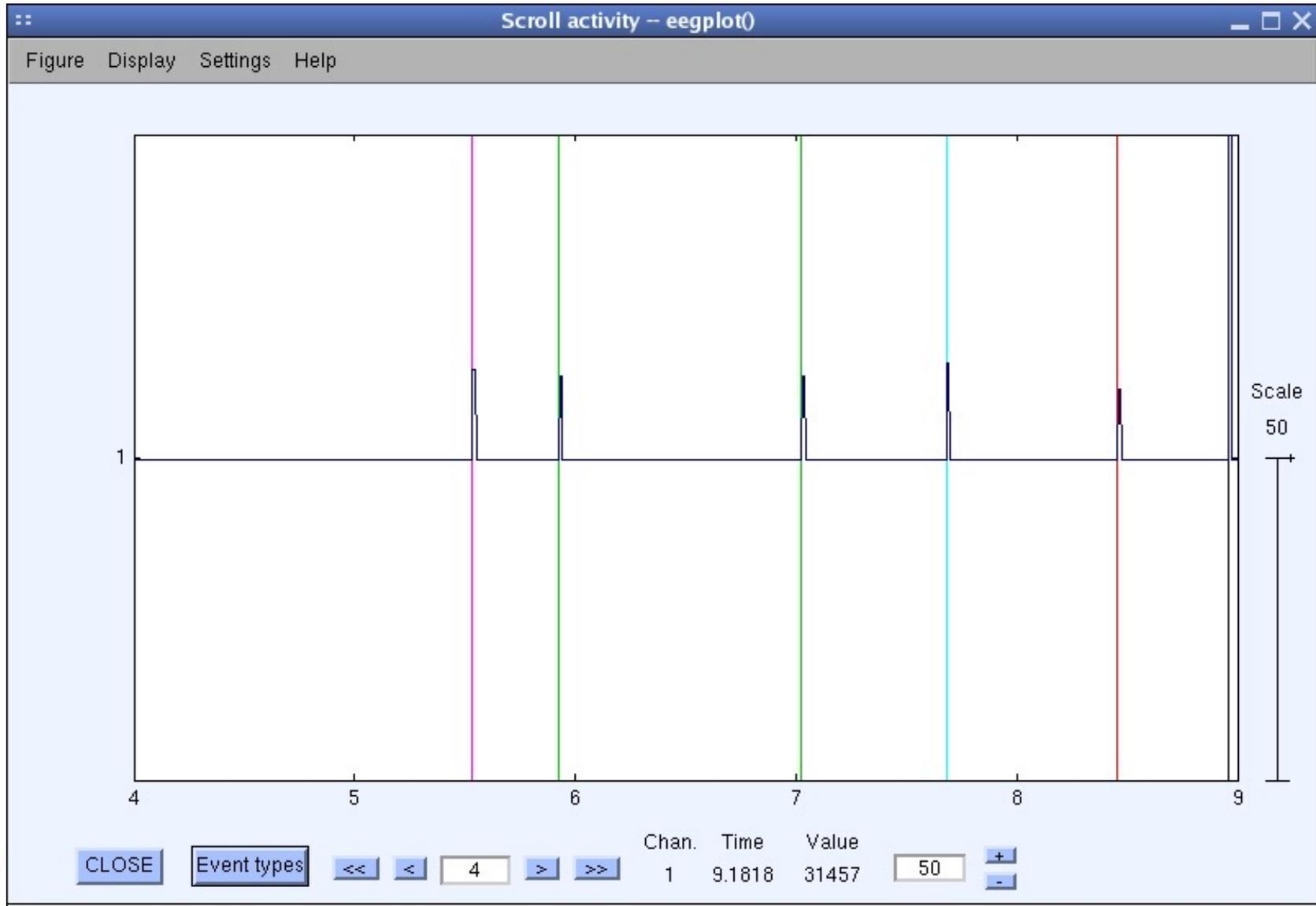


- Import events from Matlab array or ASCII file
- **Import events from data channel**
- Import from Presentation event file
- Import events from E-Prime event file
- Import events from Neuroscan event file

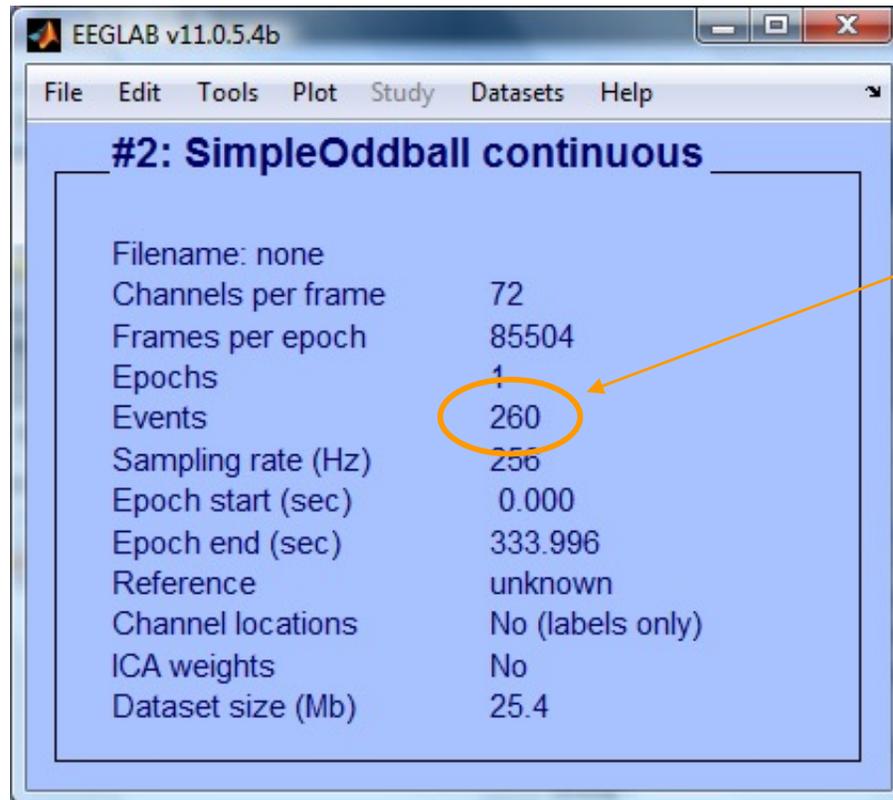


(Often imported automatically
during data import)

Appearance of an event channel in raw data



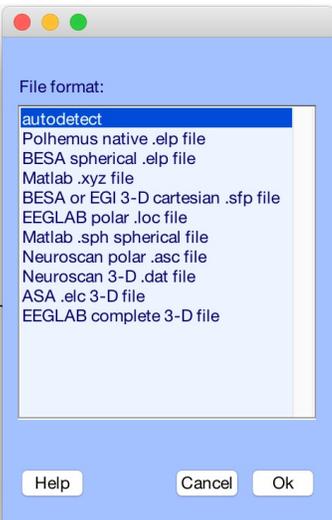
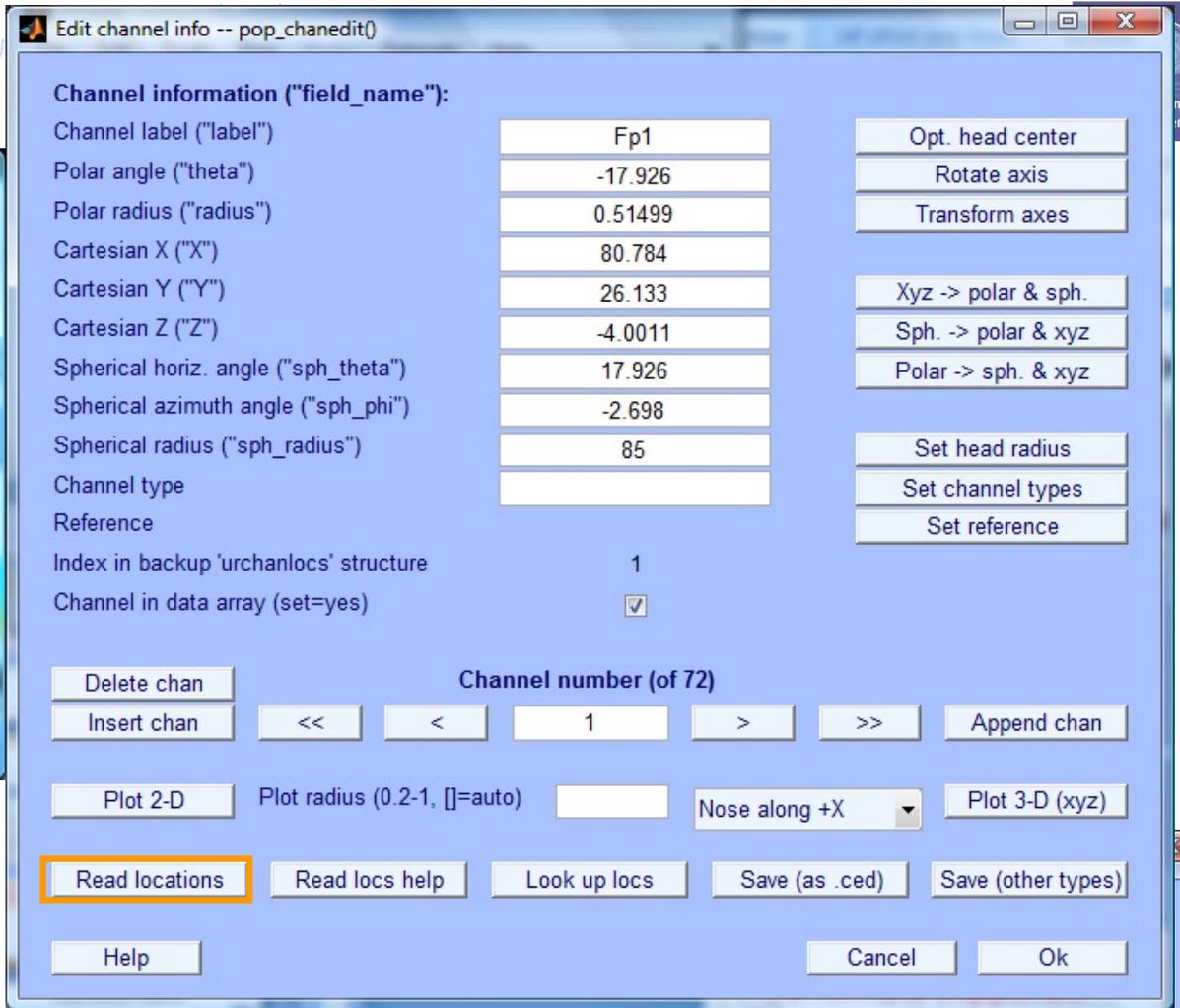
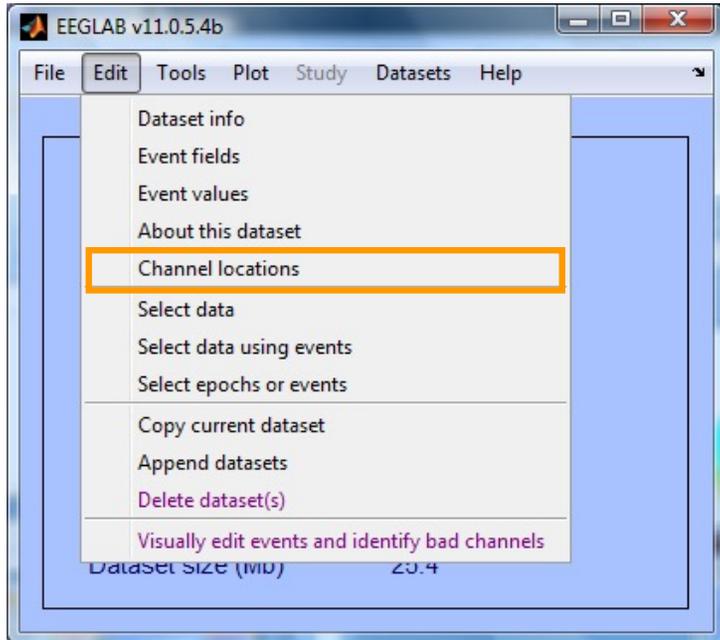
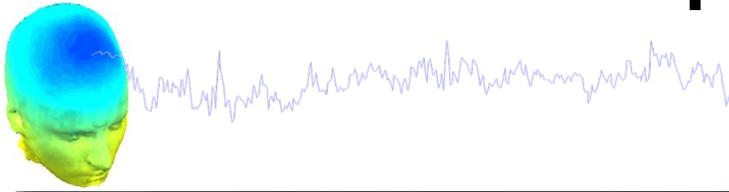
Imported data events



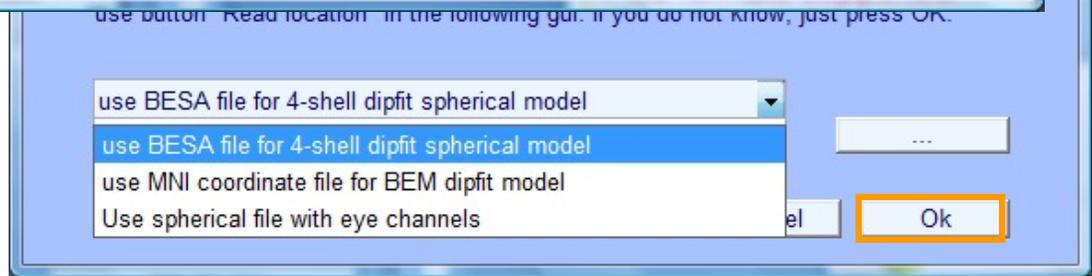
If event import was successful, you will see an appropriate number here

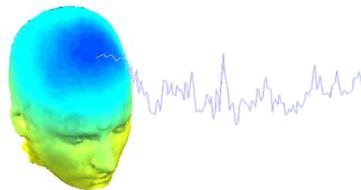


Import channel locations



10 file formats supported (Polhemus, BESA, ...)





Edit channel info -- pop_chanedit()

Channel information ("field_name"):

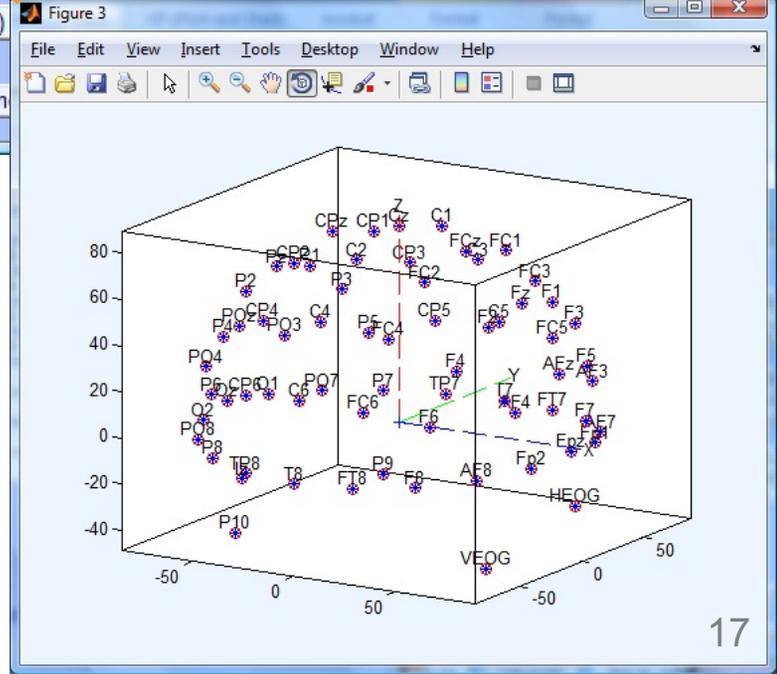
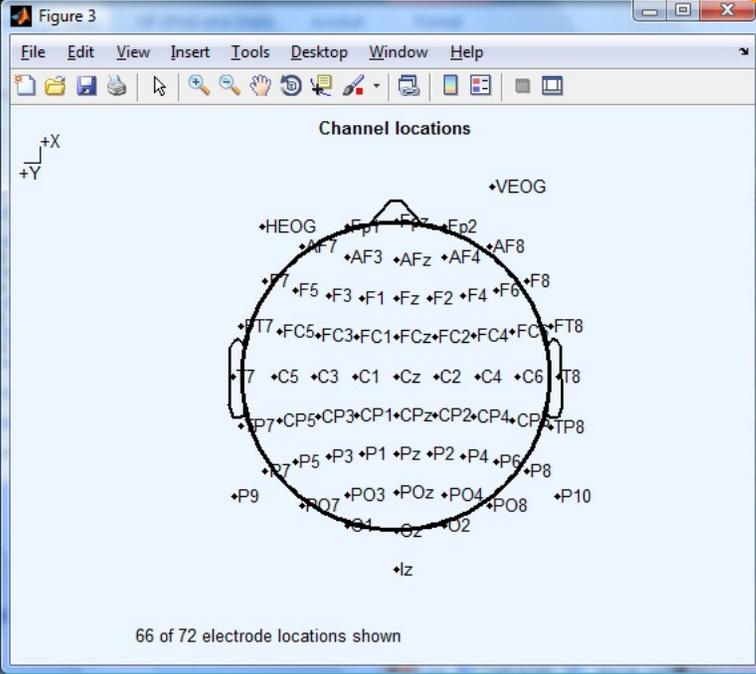
Channel label ("label")	HEOG
Polar angle ("theta")	-42
Polar radius ("radius")	0.65556
Cartesian X ("X")	55.7734
Cartesian Y ("Y")	50.2186
Cartesian Z ("Z")	-39.9051
Spherical horiz. angle ("sph_theta")	42
Spherical azimuth angle ("sph_phi")	-28
Spherical radius ("sph_radius")	85
Channel type	
Reference	
Index in backup 'urchanlocs' structure	68
Channel in data array (set=yes)	<input checked="" type="checkbox"/>

Buttons: Opt. head center, Rotate axis, Transform axes, Xyz -> polar & sph., Sph. -> polar & xyz, Polar -> sph. & xyz, Set head radius, Set channel types, Set reference

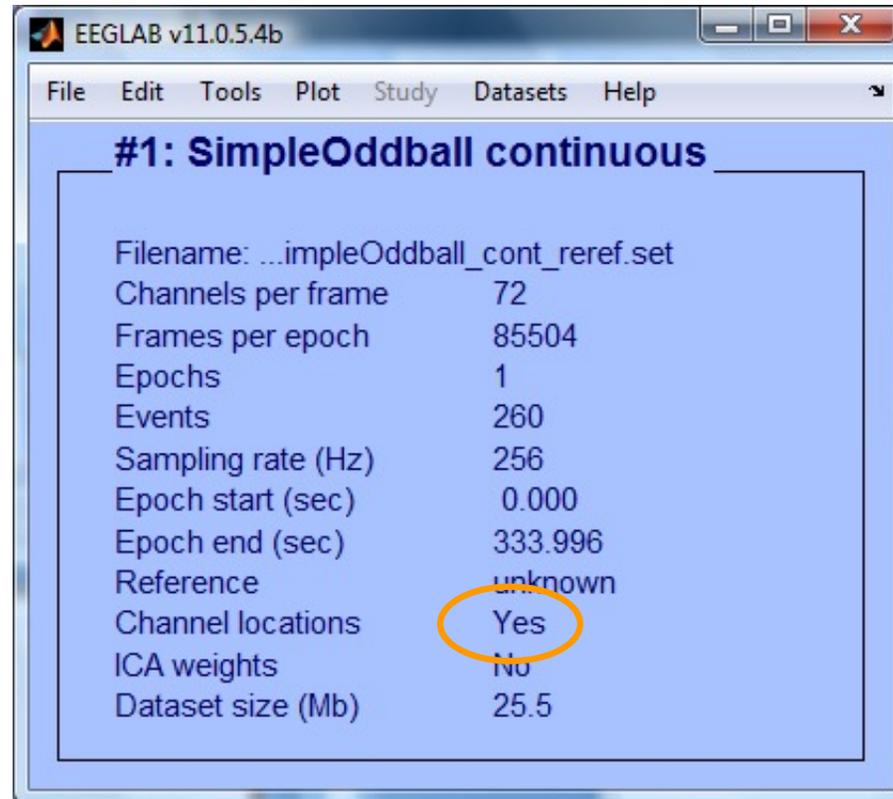
Channel number (of 72): 68

Buttons: Delete chan, Insert chan, <<, <, >, >>, Append chan

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



Imported channel locations



Comments and dataset history



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 events
Select epochs or events

Copy current dataset
Append datasets
Delete dataset(s)
Visually edit events and identify bad channels

Dataset size (MB) 23.4

Read/Enter comments -- pop_comments()

About this dataset

Data recorded by Marissa Westerfield
Recording date: Oct. 14, 2011

Paradigm:
-Participant looked at fixation box in center of screen
-Two types of stimuli (outline of a circle, outline of a star) were presented in the fixation box in random order
-Participant pressed a button in response to the star

Stimulus codes:
1 = circle
2 = star
3 = button press

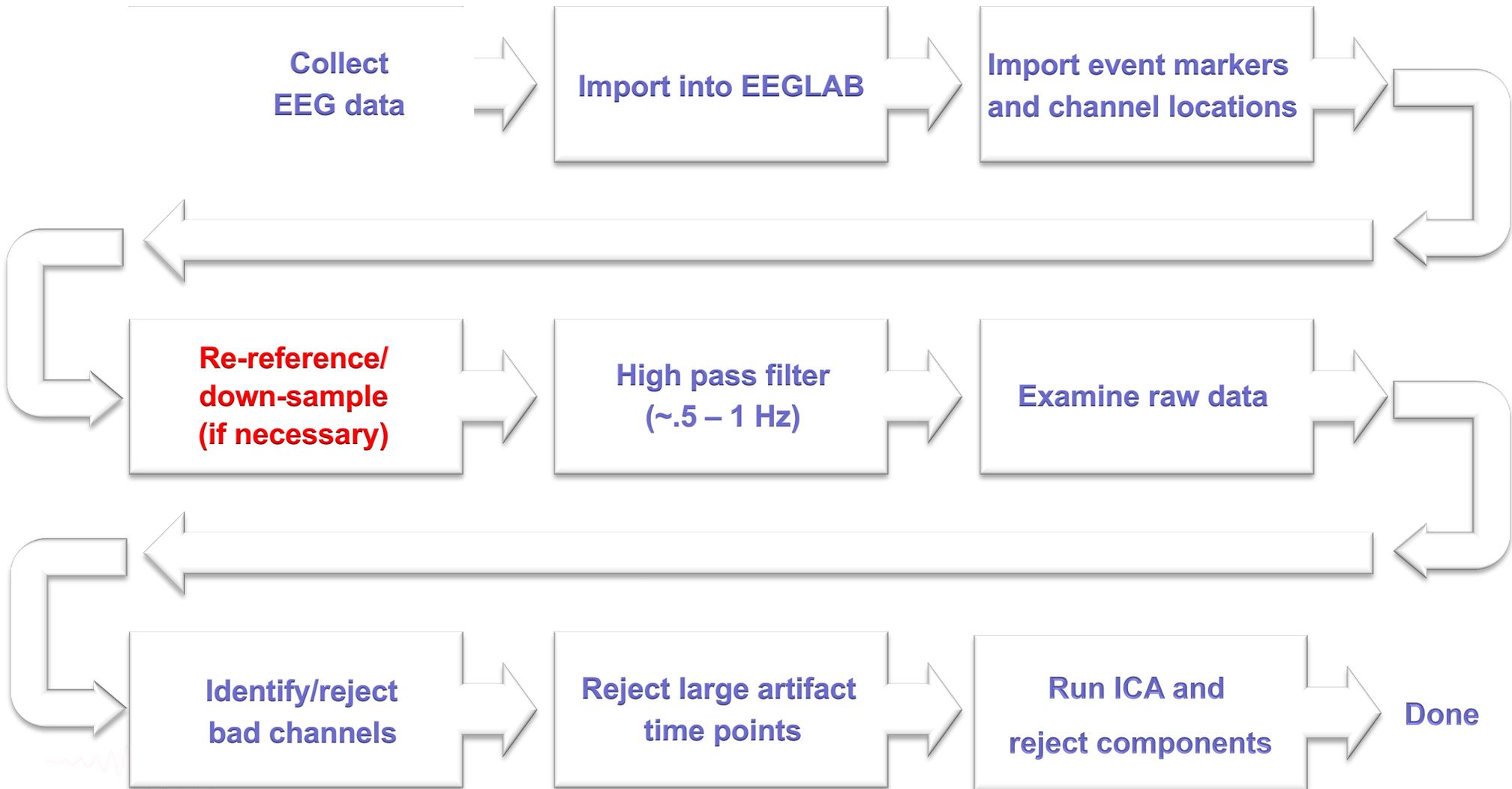
Recording information:
-reference electrodes were placed on right and left mastoids (data has already been referenced and the mastoid channels have been removed)

Processing steps:
high-pass filter - 0.5 Hz
Cleanline applied to 60, 120 Hz

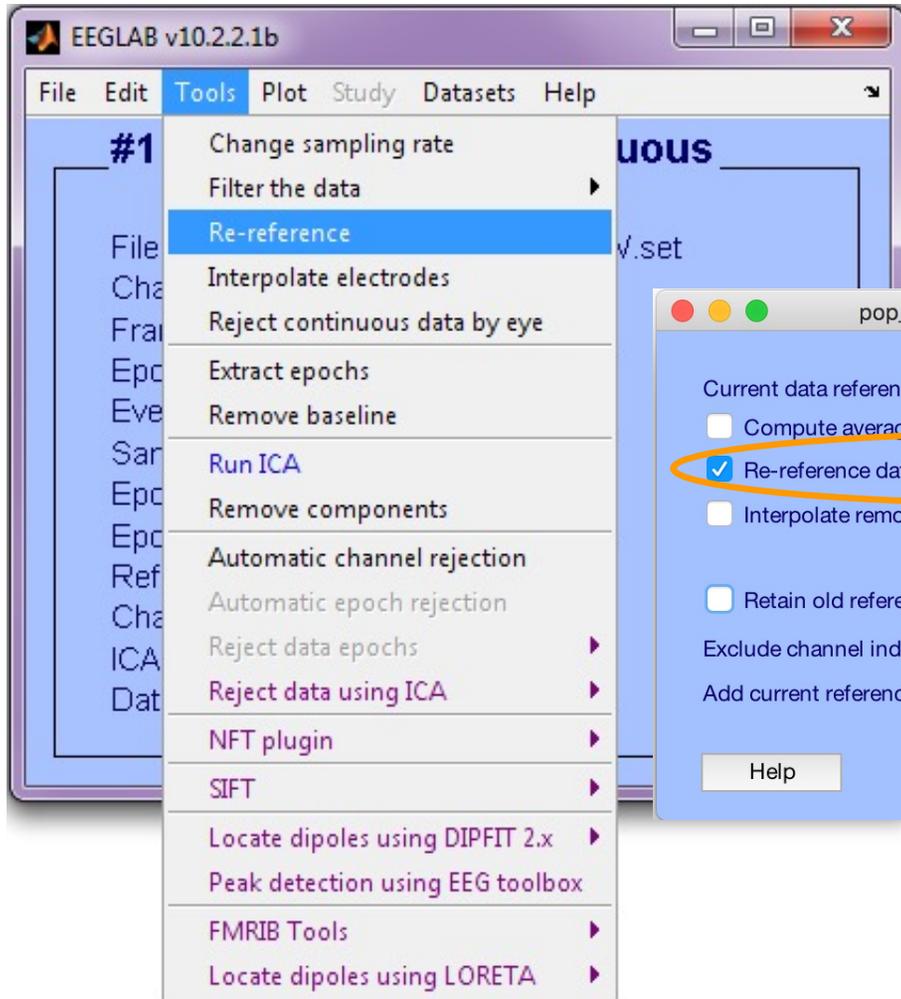
CANCEL SAVE



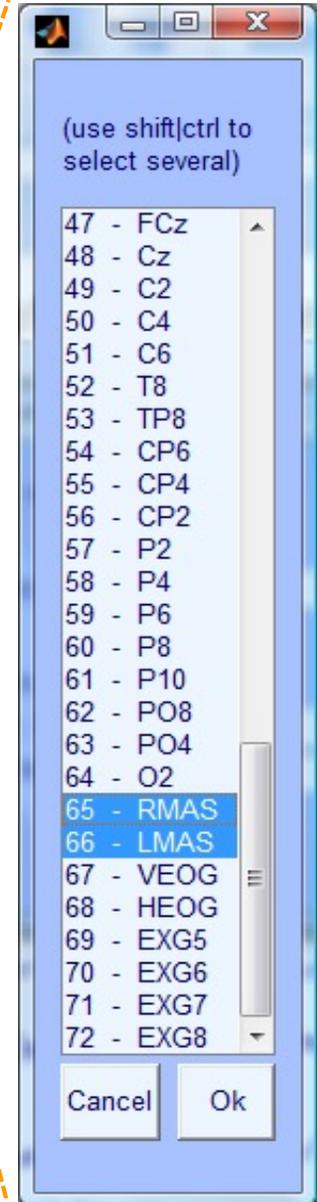
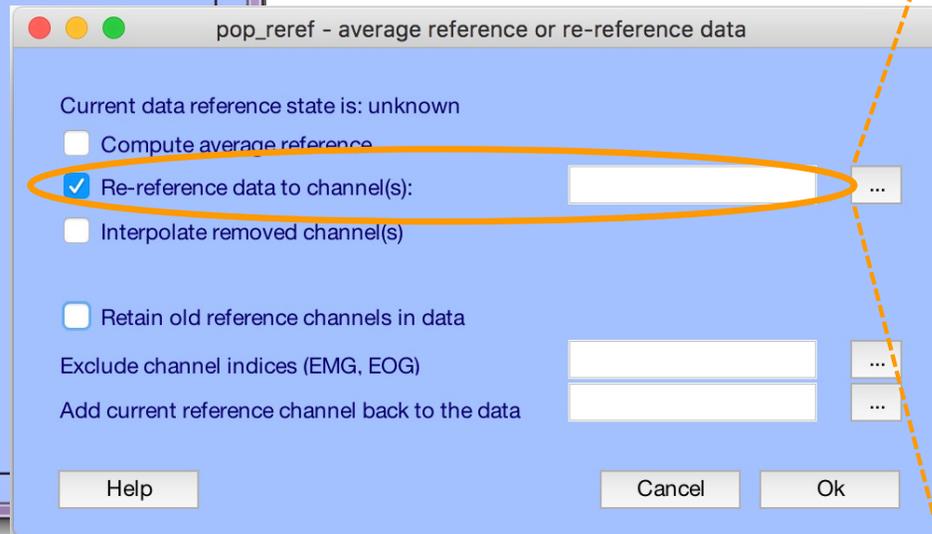
Pre-processing pipeline



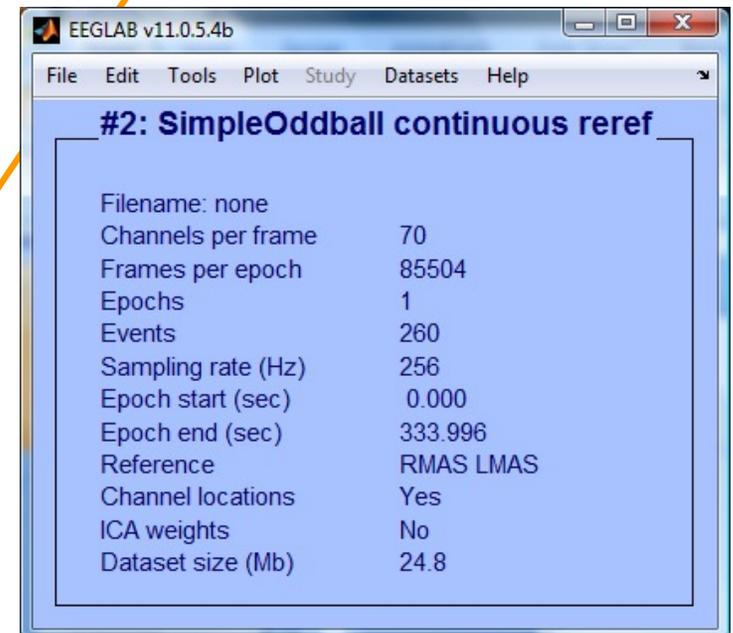
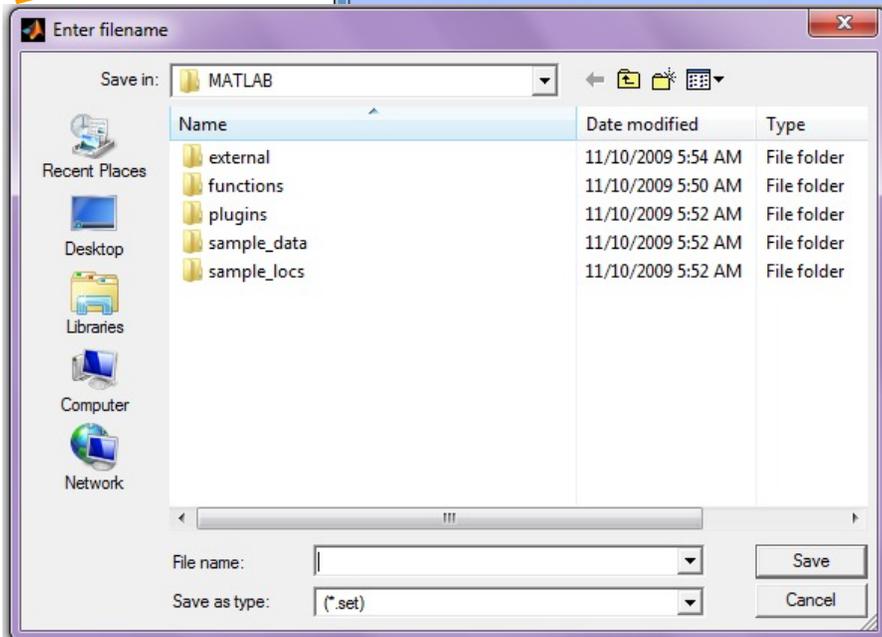
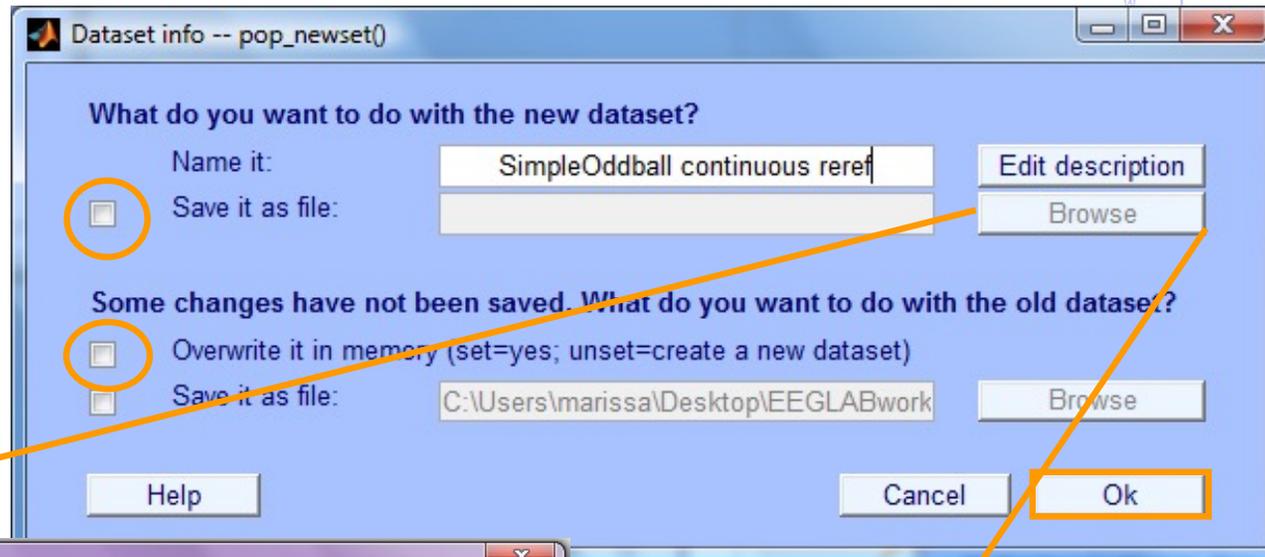
Re-reference data (if necessary/desired)



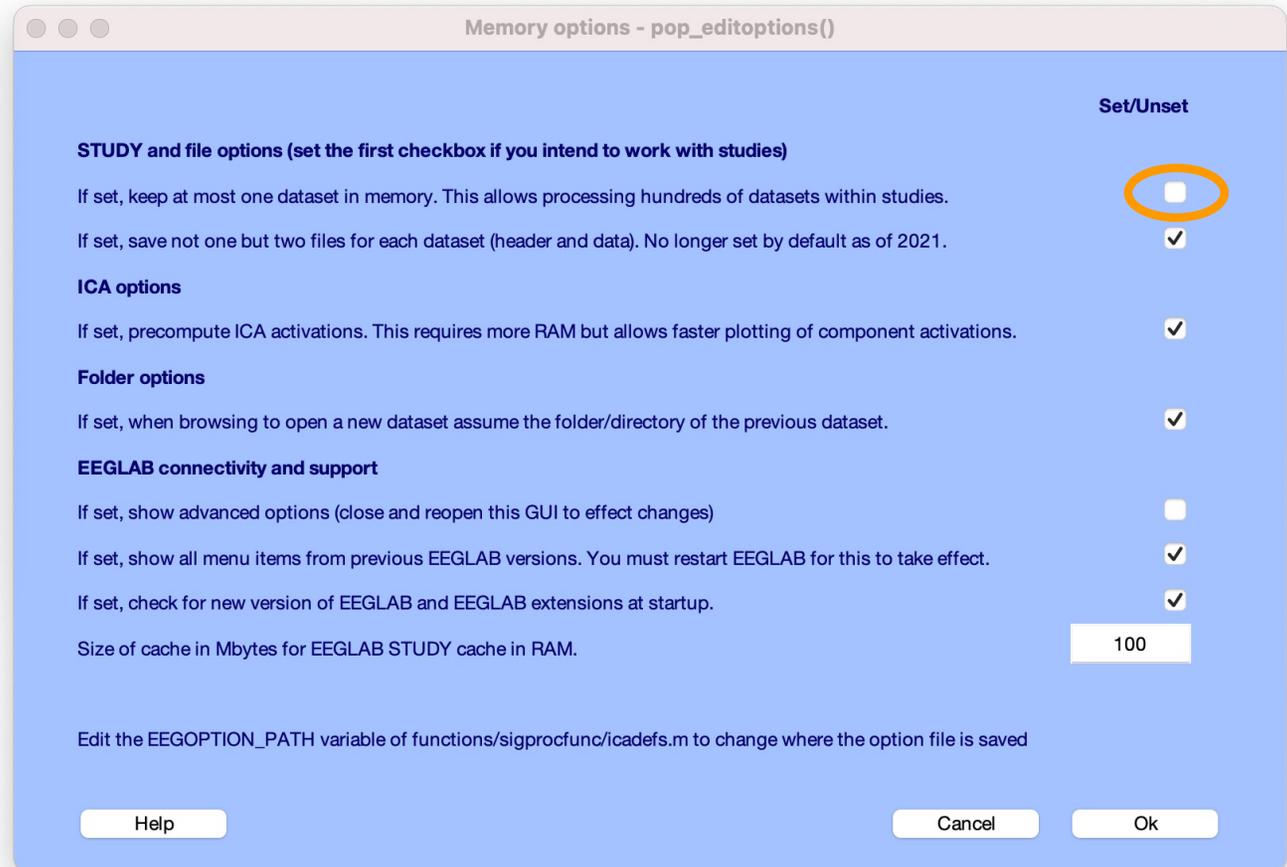
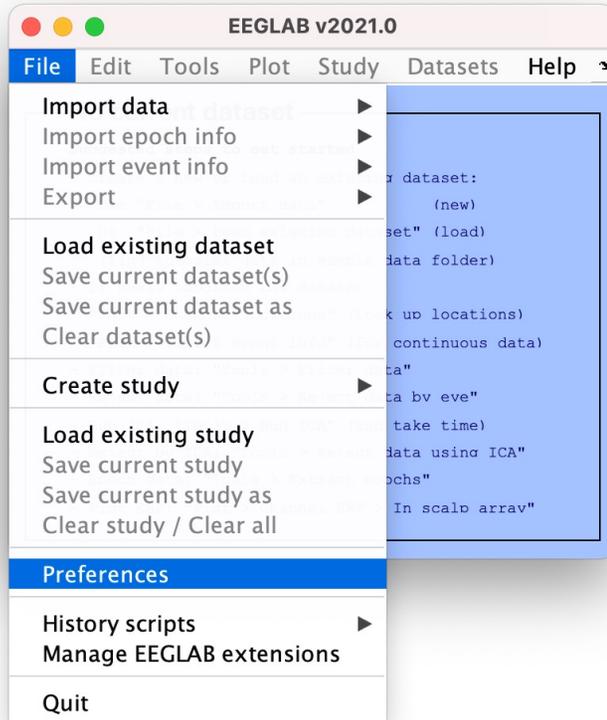
Re-reference to
(e.g.) 'linked mastoids'



Save new dataset, keep old one



Change preferences to keep multiple datasets in memory



Multiple active datasets



EEGLAB v11.0.5.4b

File Edit Tools Plot Study Datasets Help

#1: SimpleOddball continuous

Filename:	...impleOddball_cont_reref.set
Channels per frame	72
Frames per epoch	85504
Epochs	1
Events	260
Sampling rate (Hz)	256
Epoch start (sec)	0.000
Epoch end (sec)	333.996
Reference	unknown
Channel locations	Yes
ICA weights	No
Dataset size (Mb)	25.5

EEGLAB v11.0.5.4b

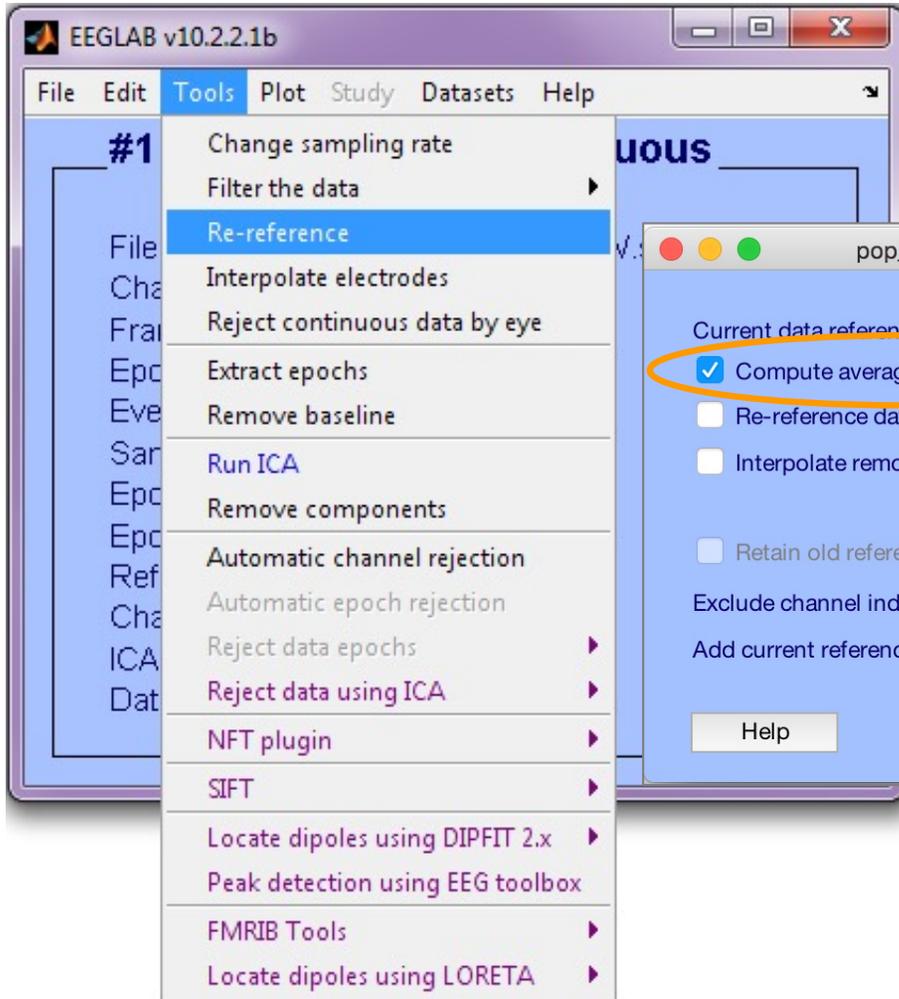
File Edit Tools Plot Study Datasets Help

#2: SimpleOddball continuous

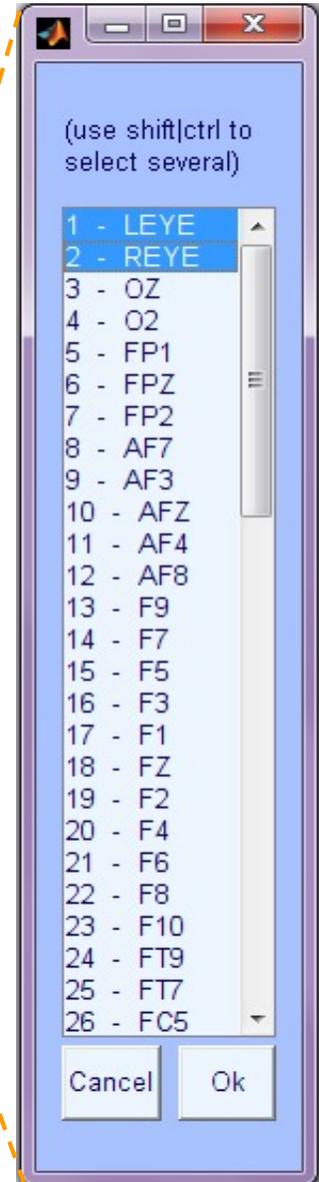
Filename:	none
Channels per frame	
Frames per epoch	85504
Epochs	1
Events	260
Sampling rate (Hz)	256
Epoch start (sec)	0.000
Epoch end (sec)	333.996
Reference	RMAS LMAS
Channel locations	Yes
ICA weights	No
Dataset size (Mb)	24.8



Re-reference data (if necessary/desired)



Or,
average reference

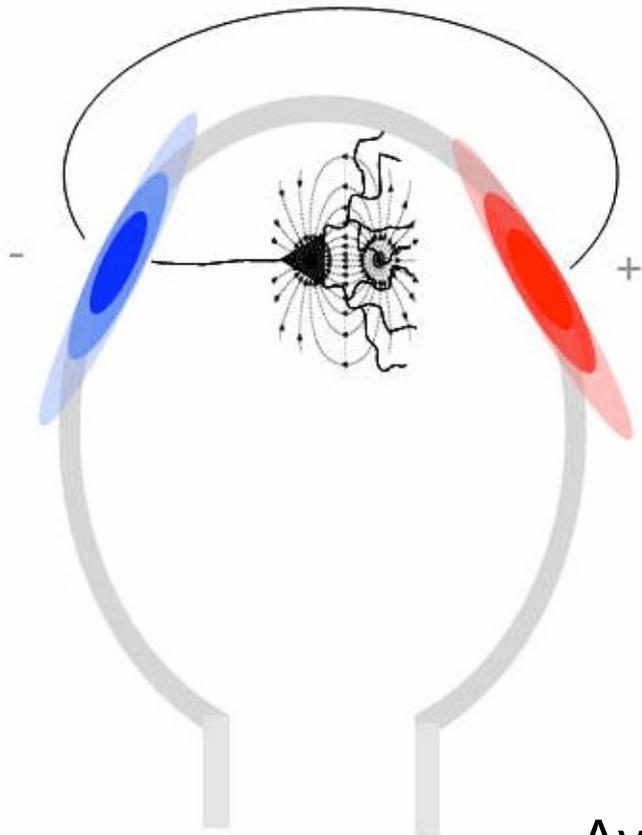


On Average Referencing



In theory, positive and negative current across entire head should balance—no net current source or sink: Average referencing enforces this.

In practice, depends on distribution of electrodes.



Average Reference assumption

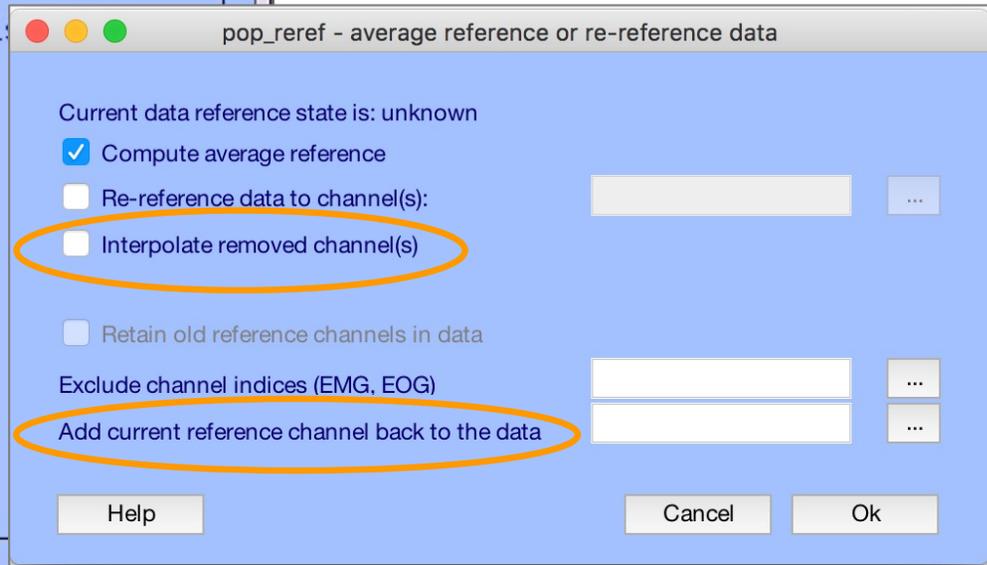
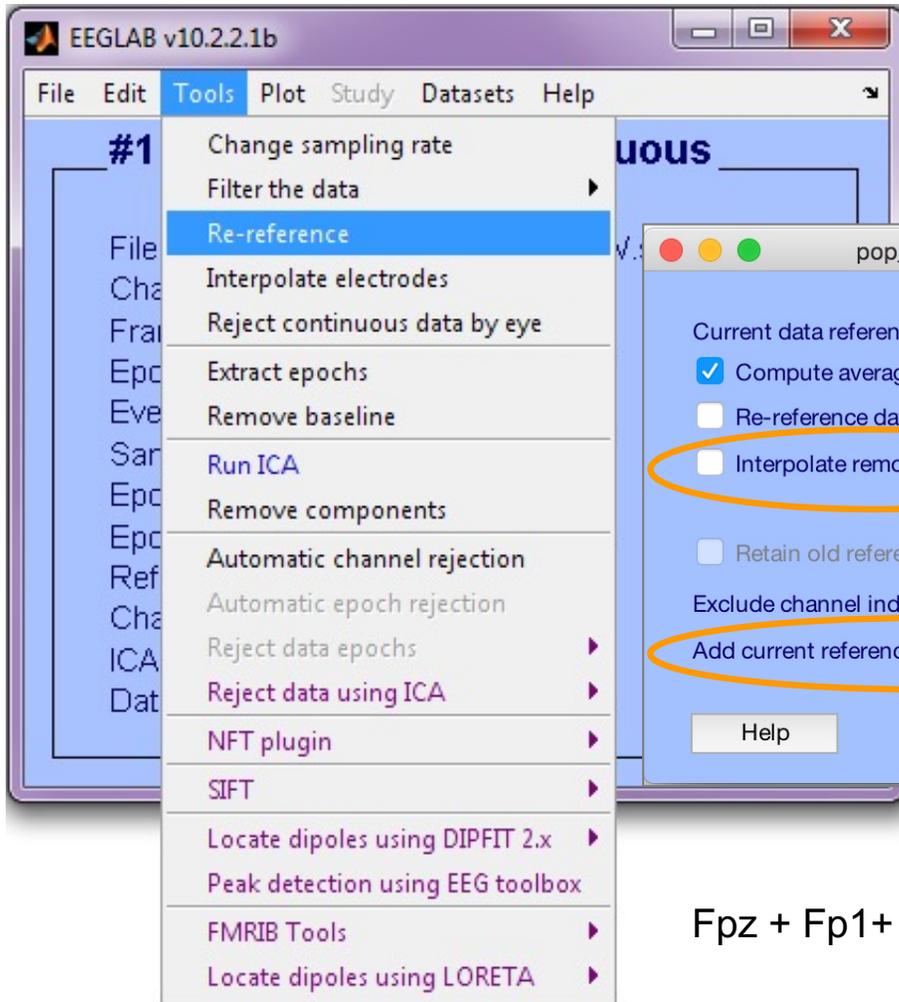
$$Fpz + Fp1 + AF3 + F8 + FT8 + \dots + TP10 = 0$$



Re-reference data (if necessary/desired)



average reference



$$Fpz + Fp1 + AF3 + F8 + FT8 + \dots + REF = 0 \text{ (REF is a scalp channel)}$$

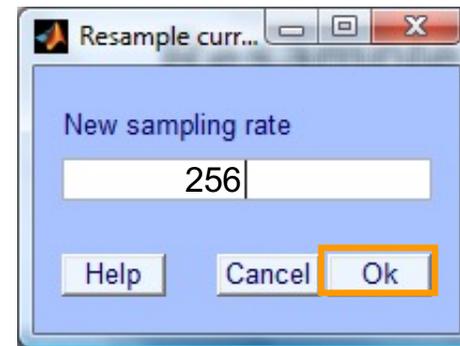
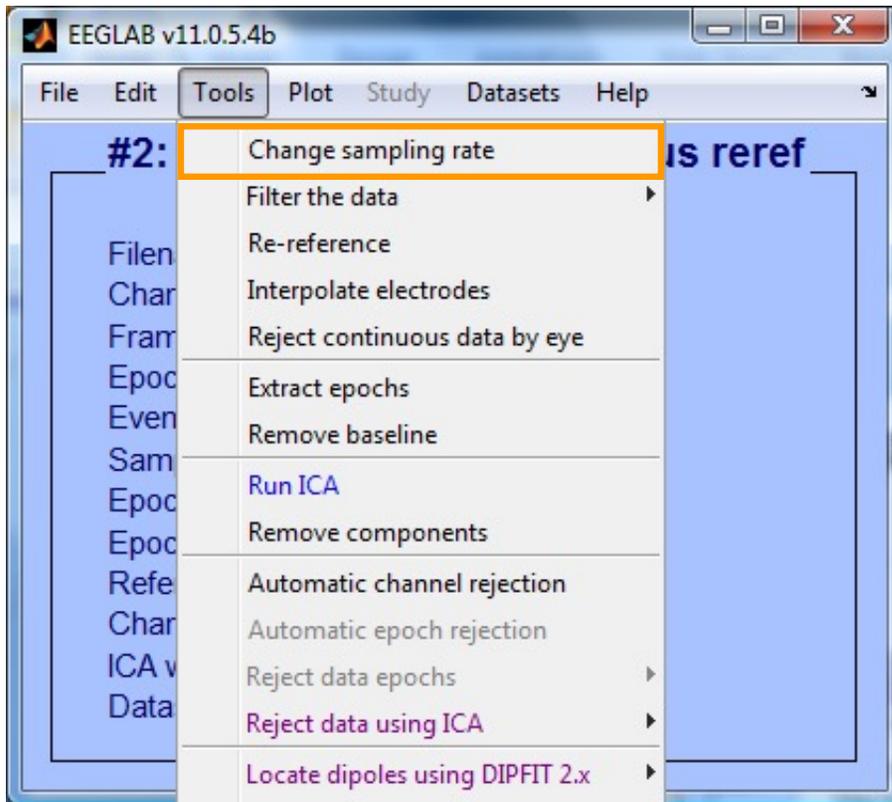
OR

$$Fpz + Fp1 + AF3 + F8 + FT8 + \dots = 0 \text{ (REF is not on the scalp, ear reference, ...)}$$

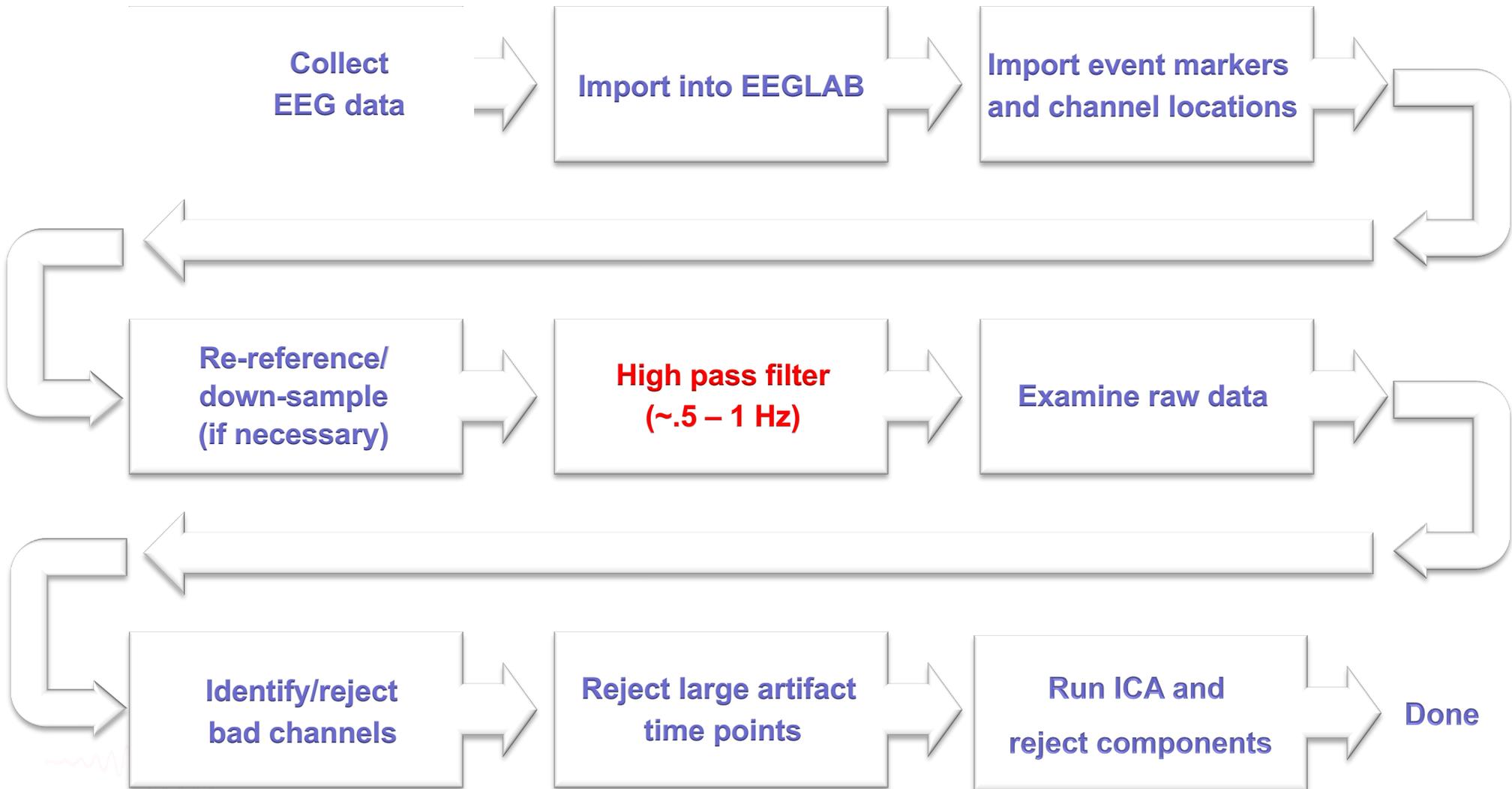
Resample data (if desired)



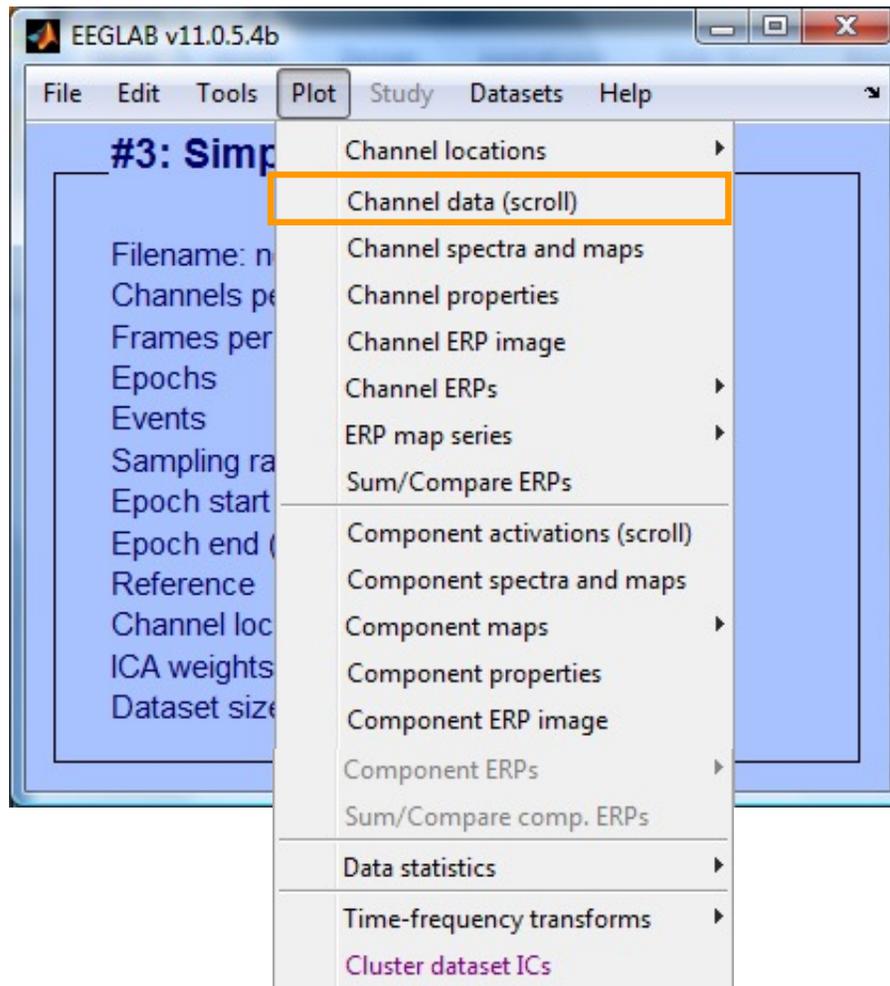
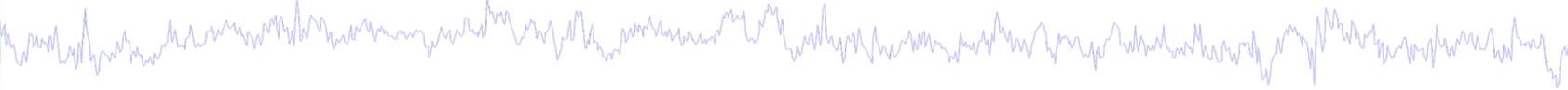
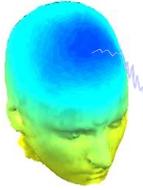
Reason: Reduce space, time.

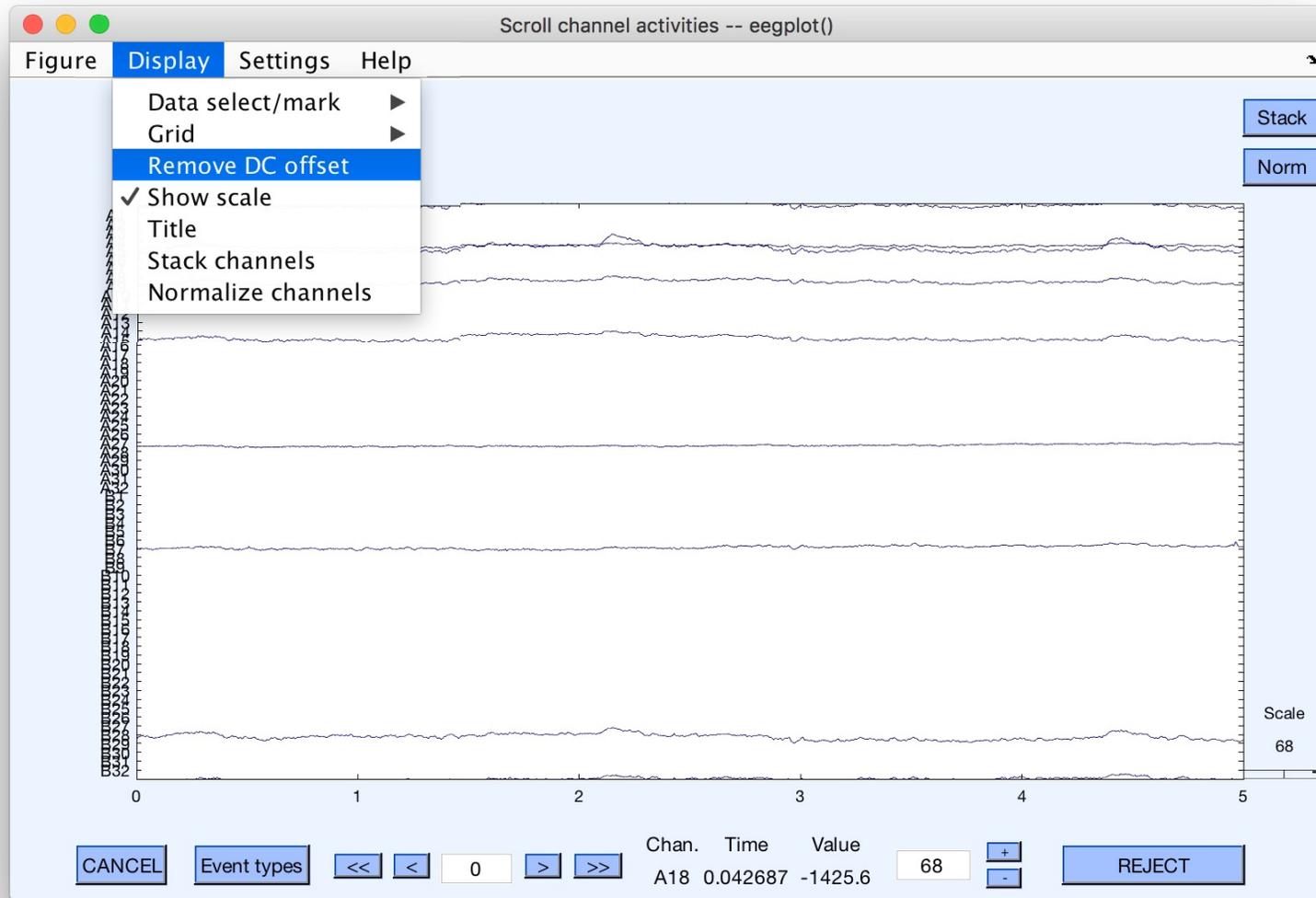
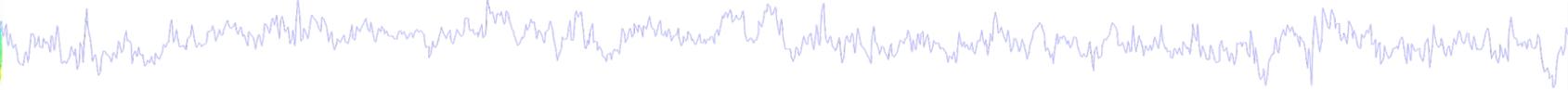


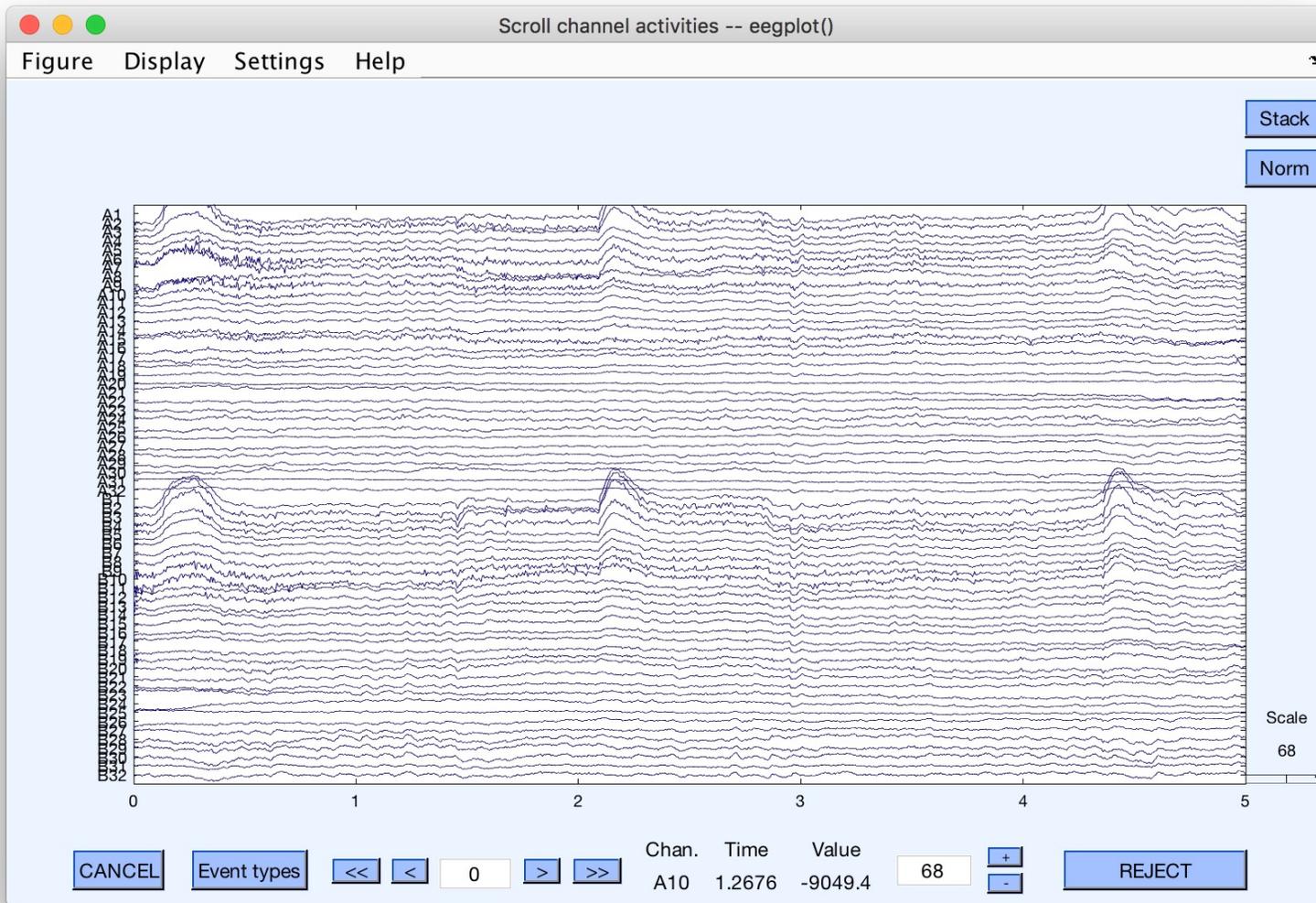
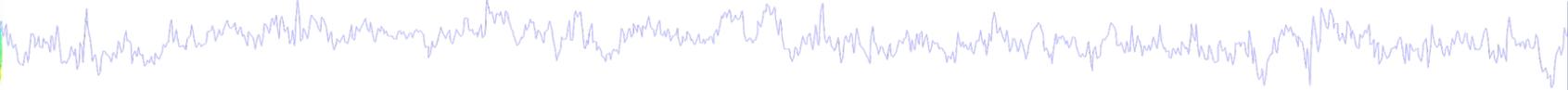
Pre-processing pipeline



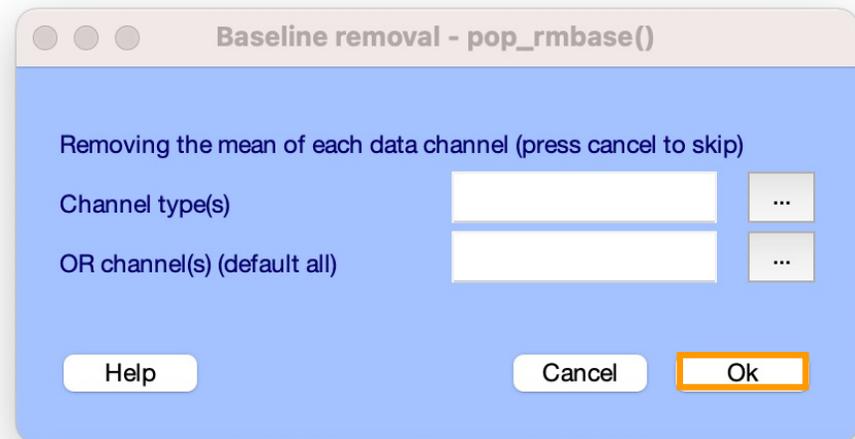
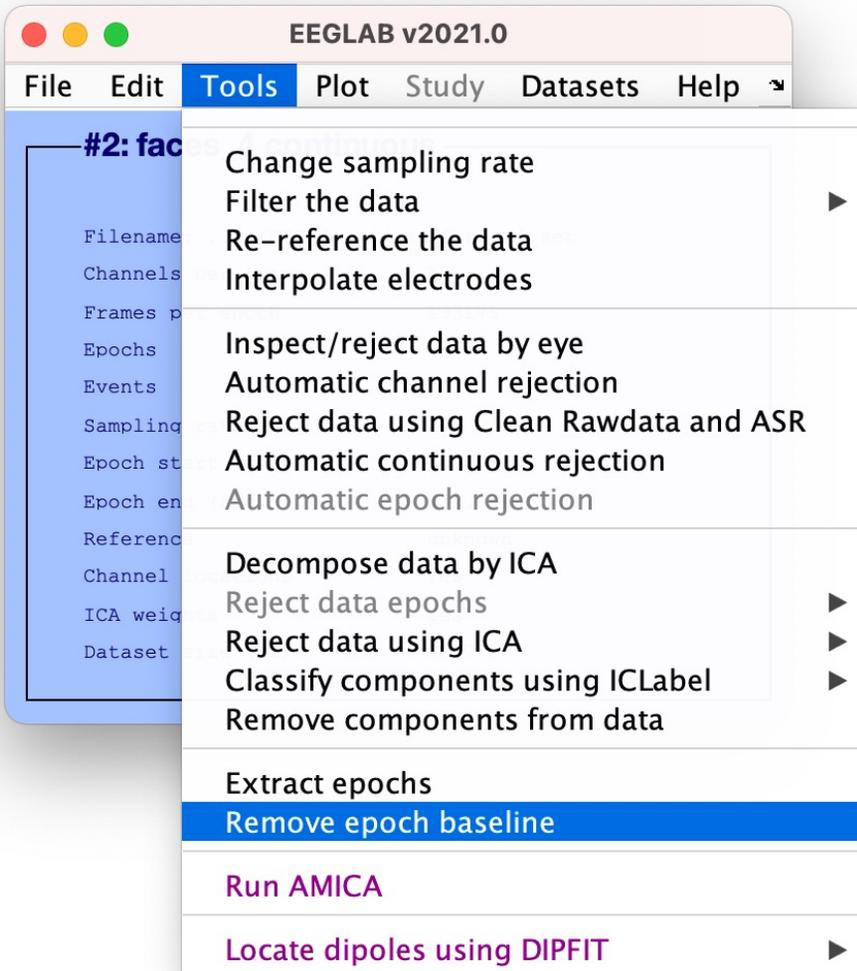
Scroll channel data







Remove DC offset

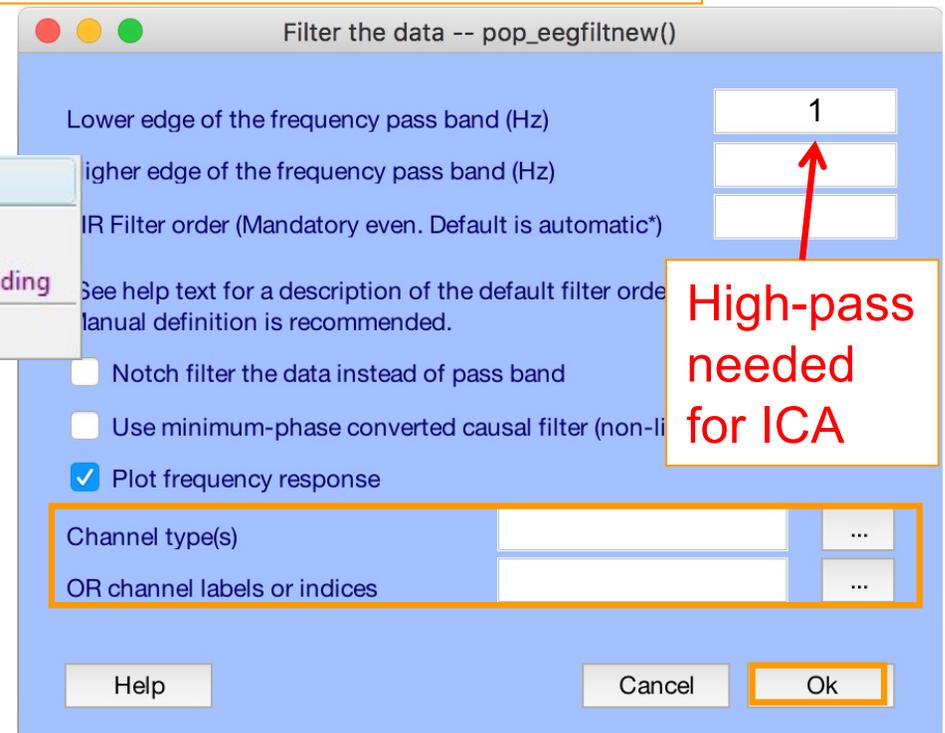
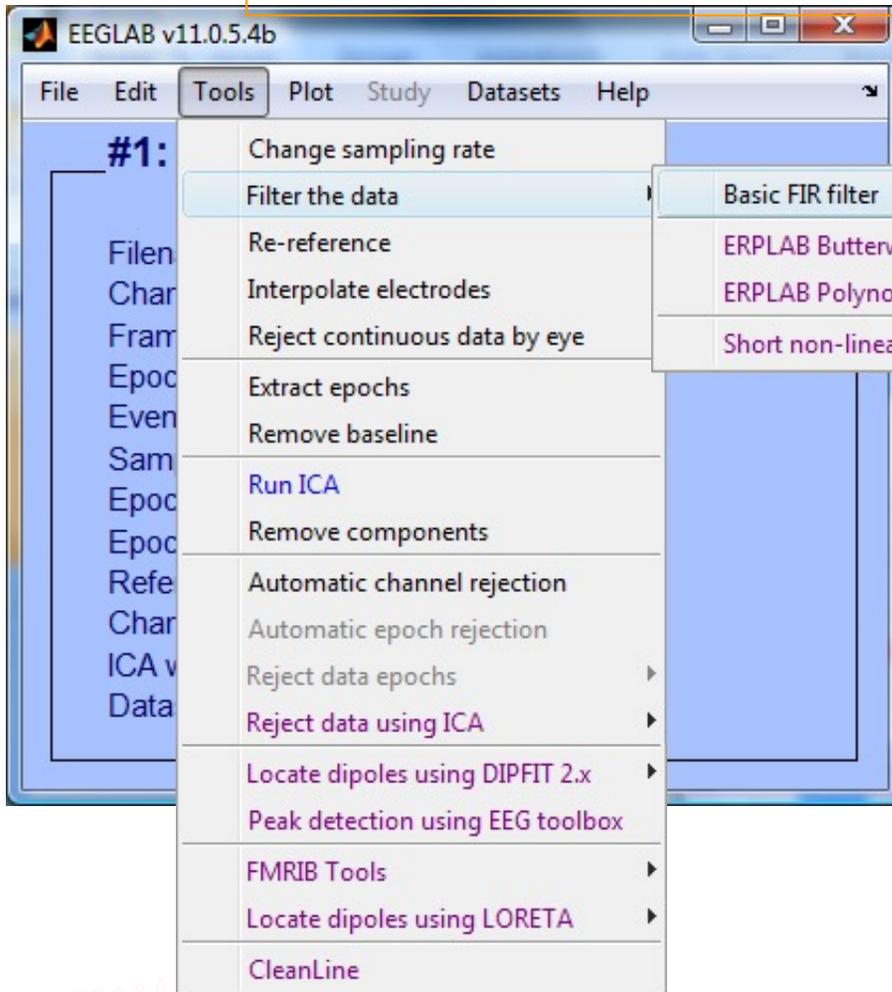


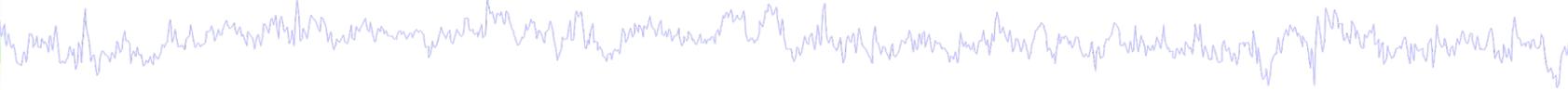
DC offsets introduce large filter artifact at signal boundaries, so it is better to remove them prior to filter the signal.

High-Pass Filter the data

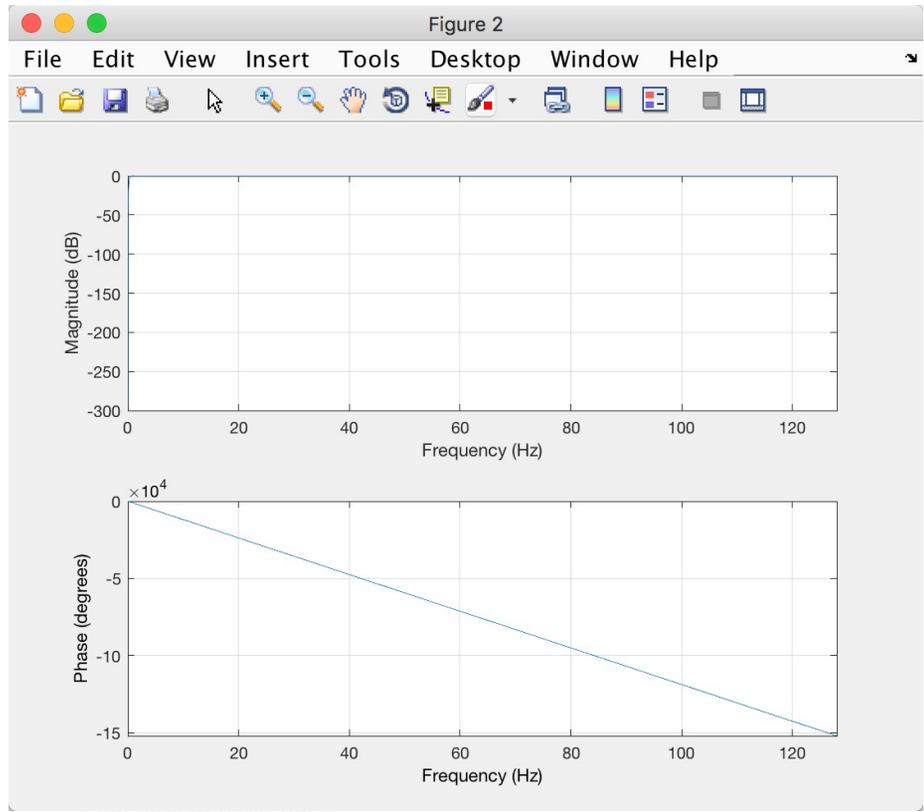


Reason: remove slow, possibly large amplitude, drift

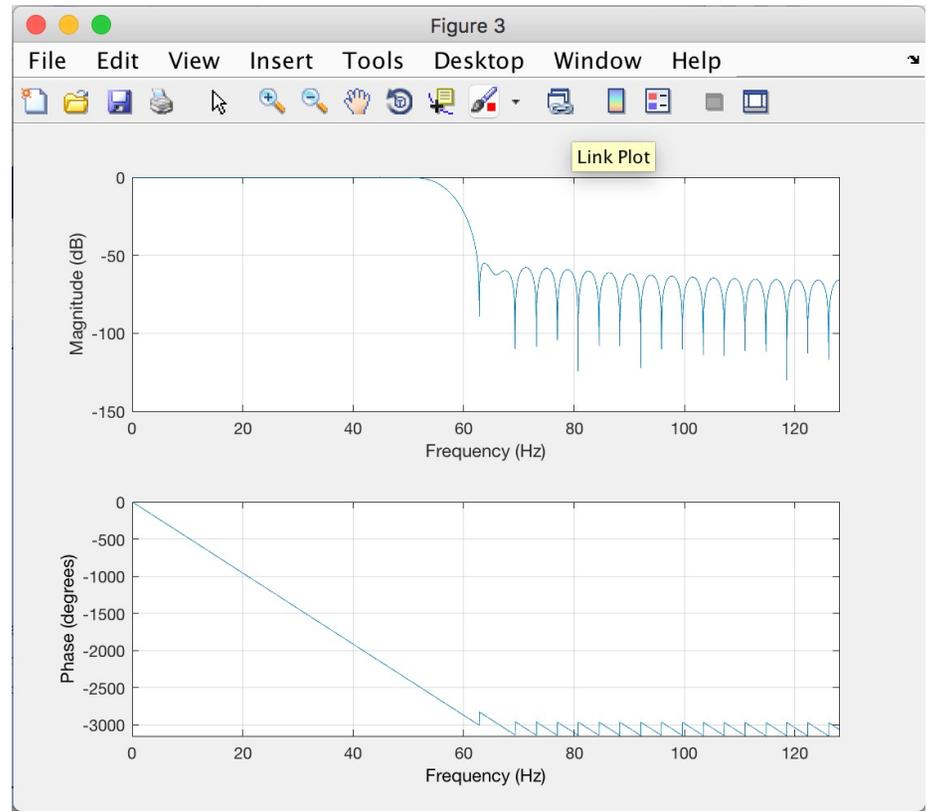




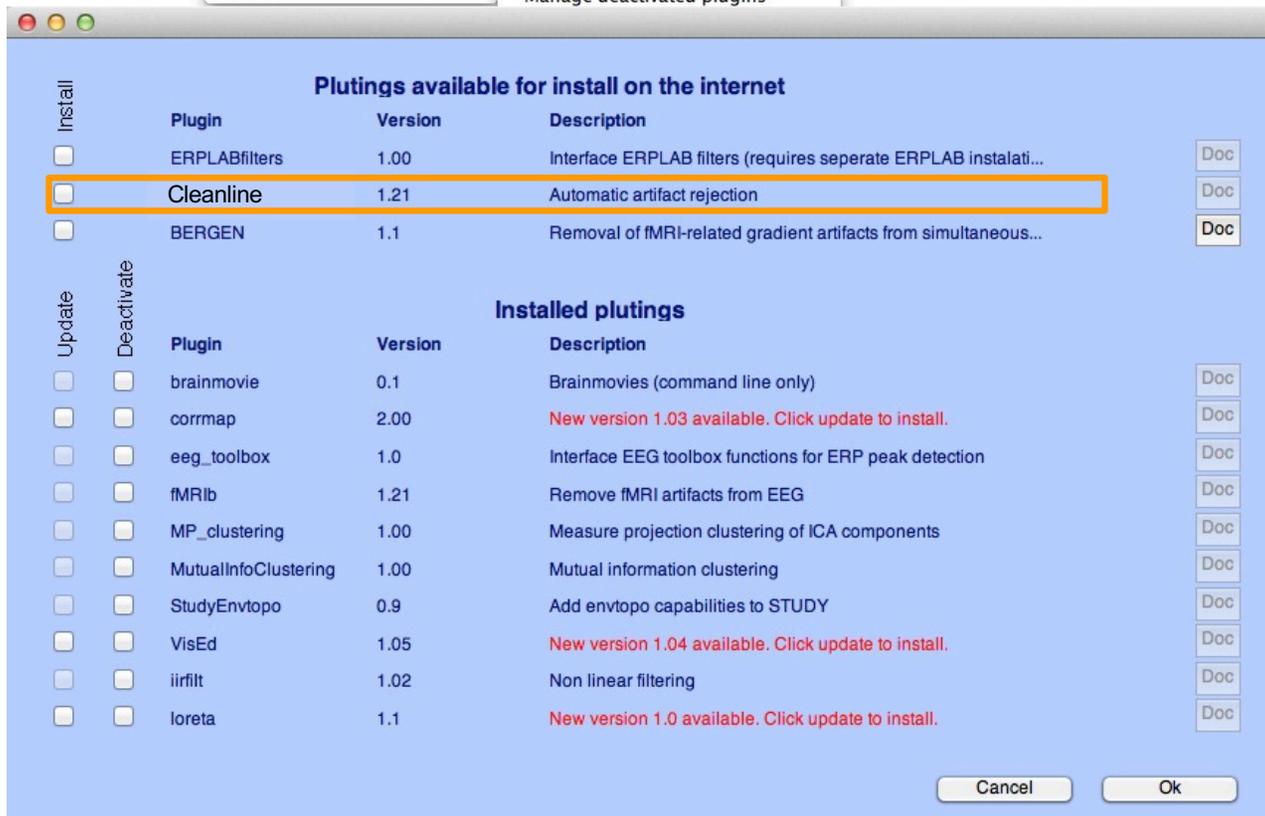
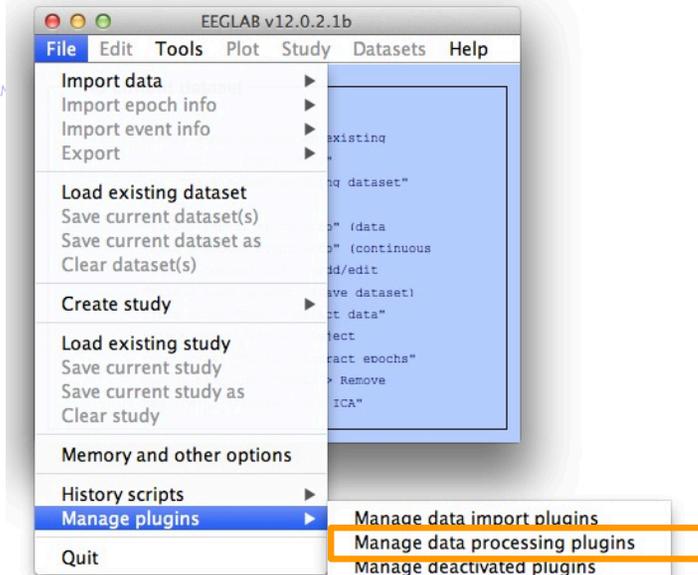
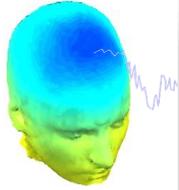
High pass (1 Hz)



Low pass (50 Hz)



Remove line noise (Cleanline)



CleanLine uses an approach for line noise removal advocated by Partha Mitra and Hemant Bokil in "Observed Brain Dynamics" (2007), Chapter 7.3.4.

Remove line noise (Cleanline)



EEGLAB v11.0.5.4b

File Edit **Tools** Plot Study Datasets Help

#1: Change sampling rate
Filter the data
Re-reference
Interpolate electrodes
Reject continuous data by eye

Extract epochs
Remove baseline

Run ICA
Remove components

Automatic channel rejection
Automatic epoch rejection
Reject data epochs
Reject data using ICA

Locate dipoles using DIPFIT 2.x
Peak detection using EEG toolbox

FMRIB Tools
Locate dipoles using LORETA

CleanLine

CleanLine Options

Line noise frequencies to remove [60 120]

Scan for line noise (set)

p-value for detection of significant sinusoid 0.01

Bandwidth (Hz) 2

Type of signal to clean Channels

Indices of Channels/Components to clean '1:66'

Sliding window length (sec) 4

Sliding window step size (sec) 2

Window overlap smoothing factor 100

FFT padding factor 2

Visualize Original and Cleaned Spectra (set)

Normalize log spectrum by detrending (set)

Produce verbose output (set)

Plot Individual Figures (set)

check

Help Cancel Ok

Plot channel properties



EEGLAB v11.0.5.4b

File Edit Tools **Plot** Study Datasets Help

#1: Simple

Filename: ...

Channels per

Frames per

Epochs

Events

Sampling rate

Epoch start

Epoch end (

Reference

Channel locations

ICA weights

Dataset size

Channel locations

Channel data (scroll)

Channel spectra and maps

Channel properties

Channel ERP image

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

Component properties - pop_prop()

Channel index(ices) to plot: 31

Spectral options (see spectopo() help): 'freqrange' [2 90]

Help Cancel Ok

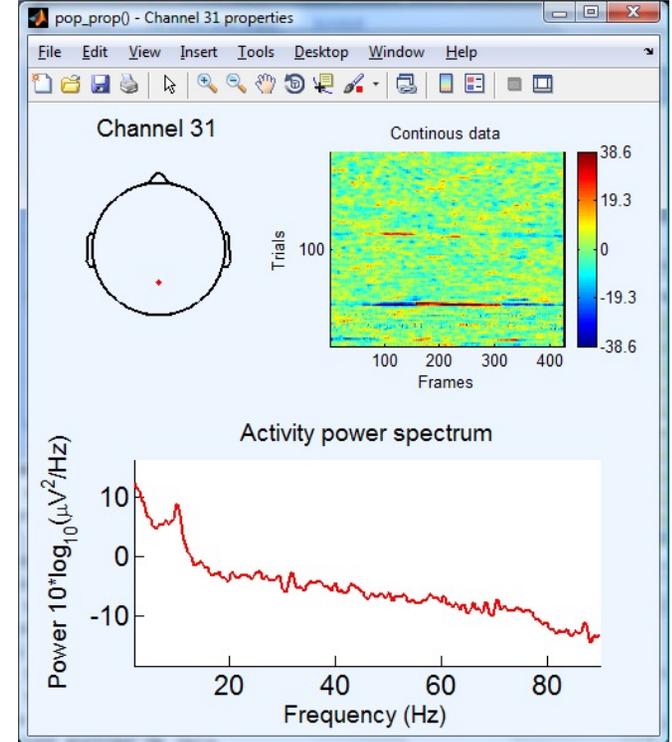
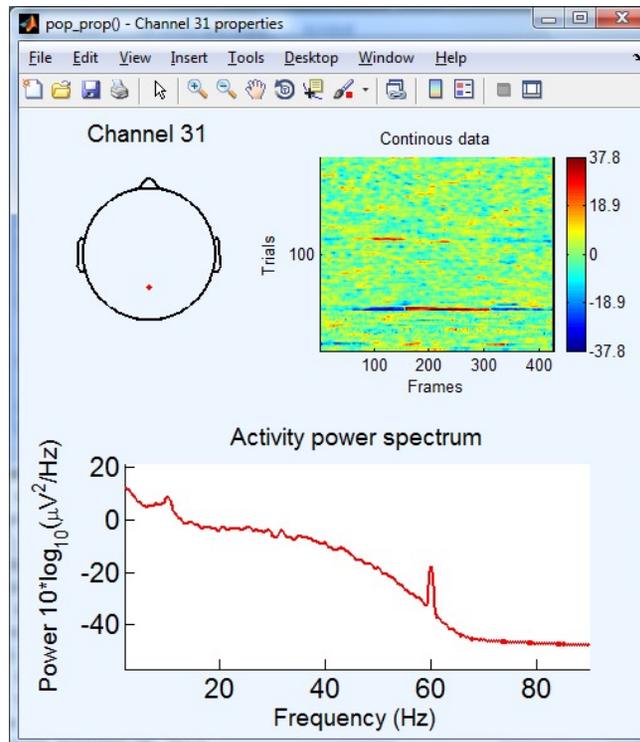
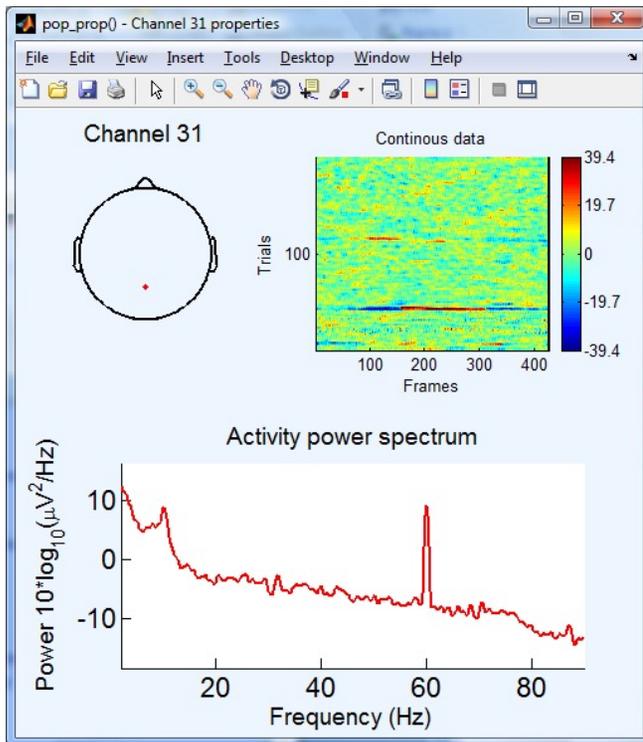
Filter comparisons



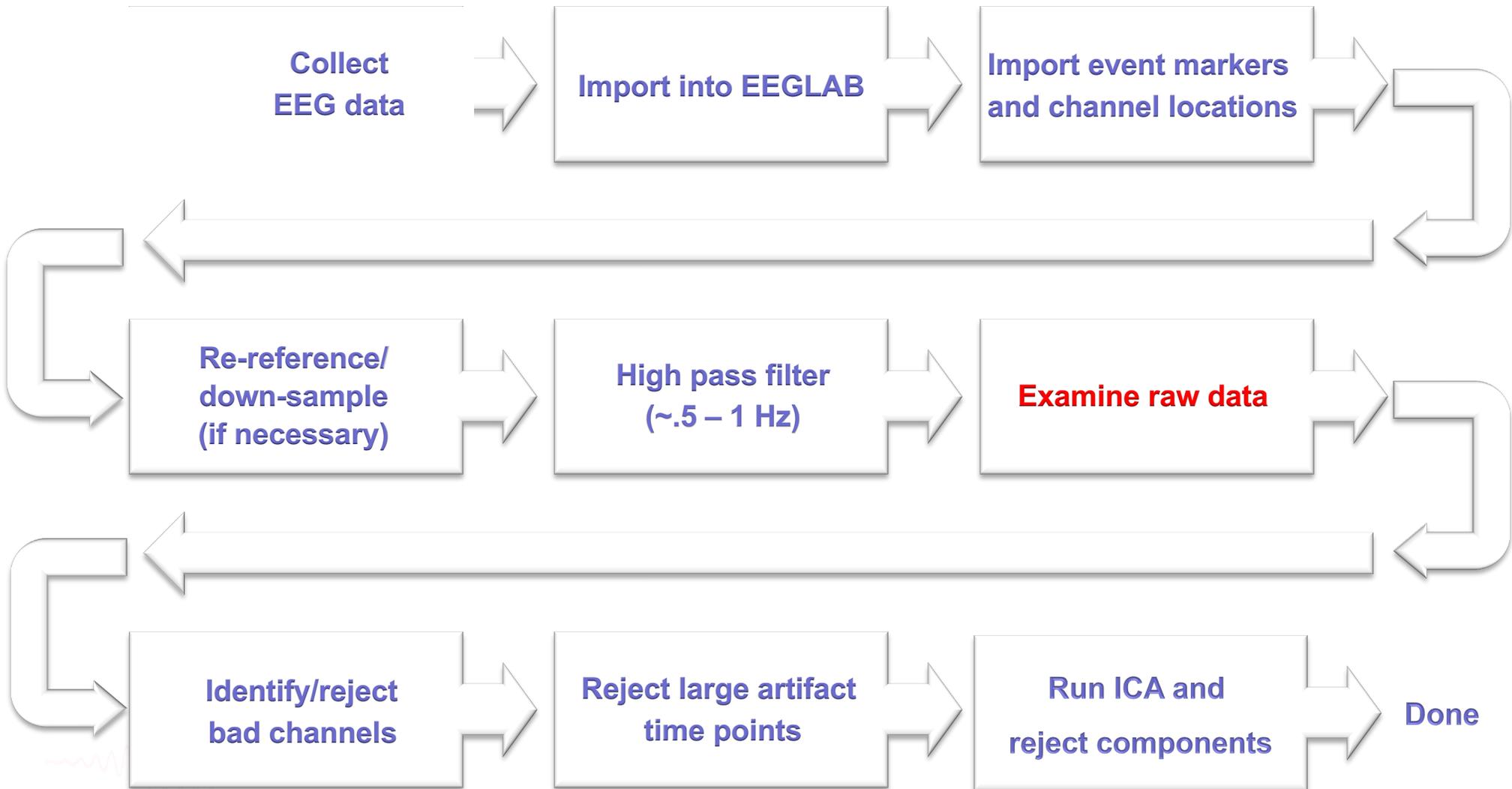
1 Hz high-pass filter

1 Hz high-pass filter
50 Hz low-pass filter

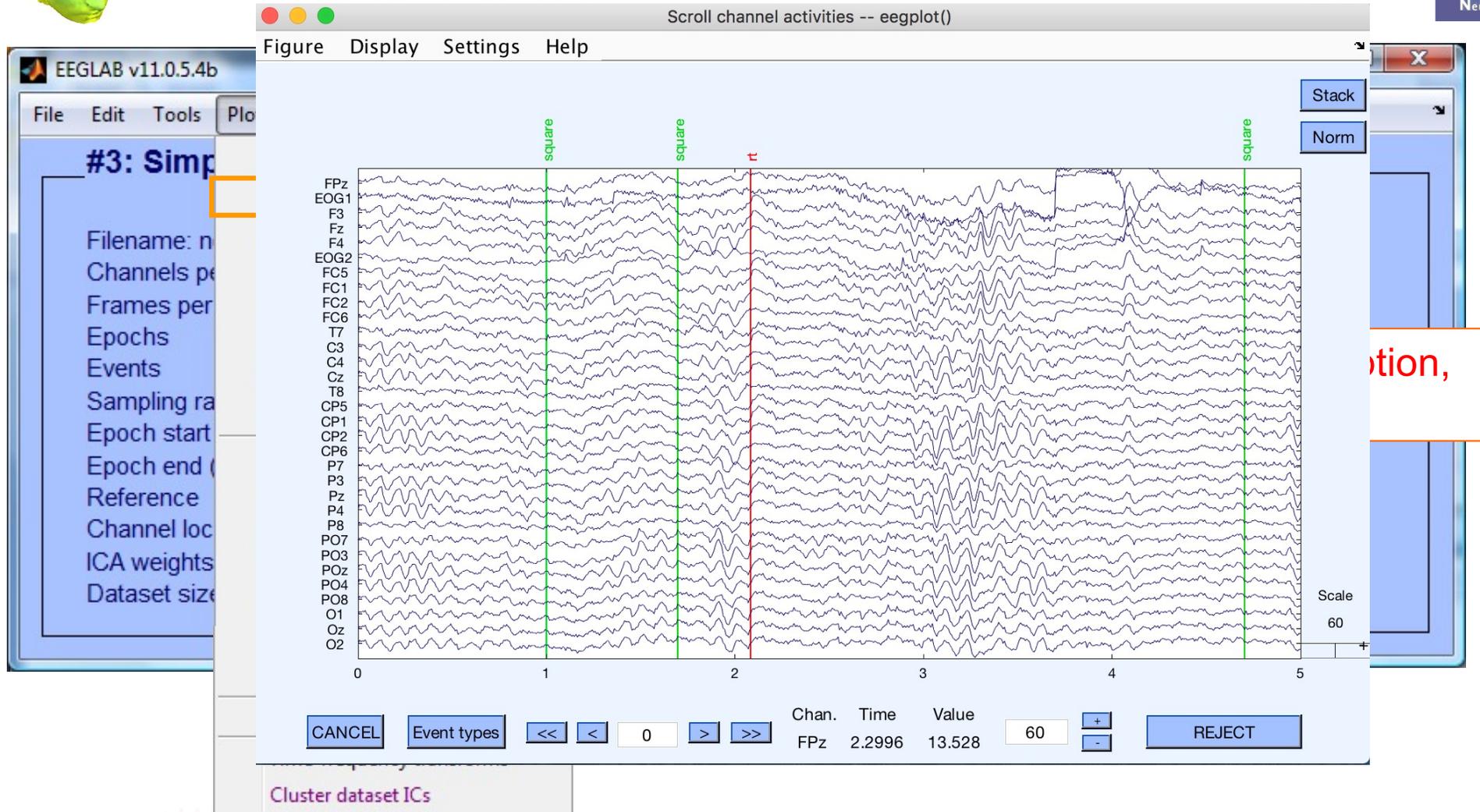
1 Hz high-pass filter
Cleanline



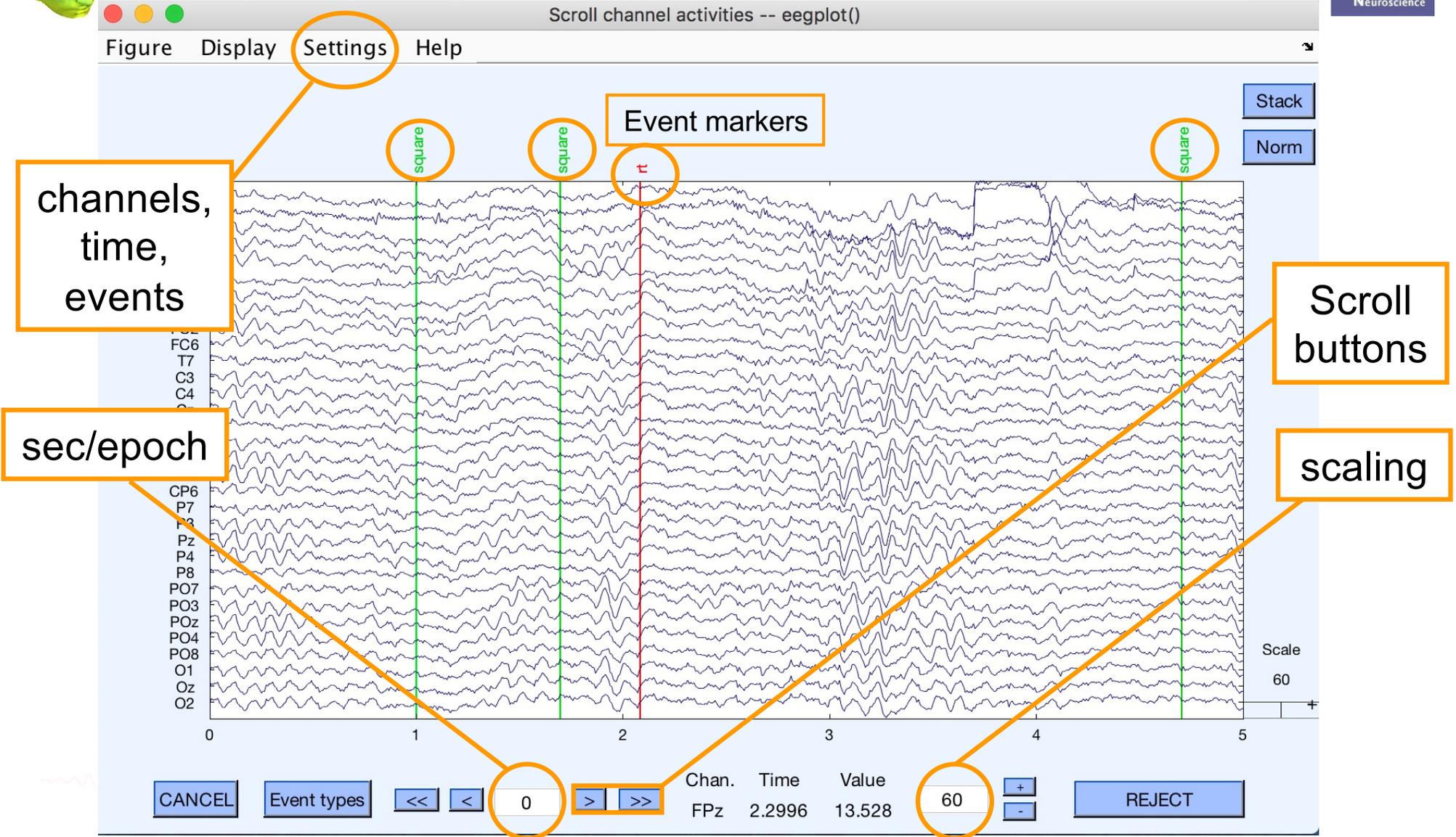
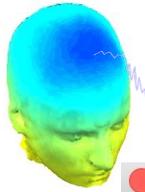
Pre-processing pipeline



Scroll channel data



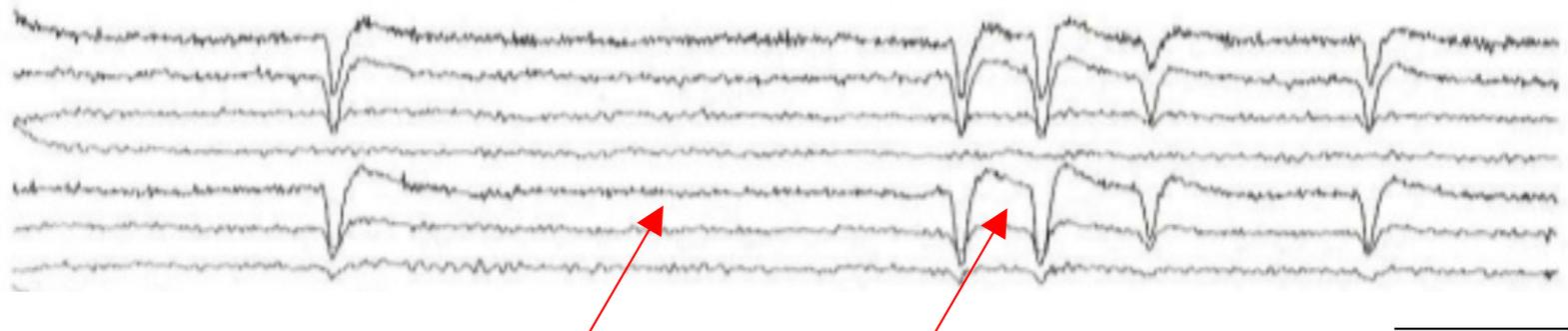
Scroll channel data



EEG artifacts



The amplitude of artifacts (such as eye movements) is often larger than the amplitude of brain data which potentially decrease signal/noise ratio, bias data analysis and potential results



EEG activity containing
potential brain data

Blink

1s

Type of artifacts



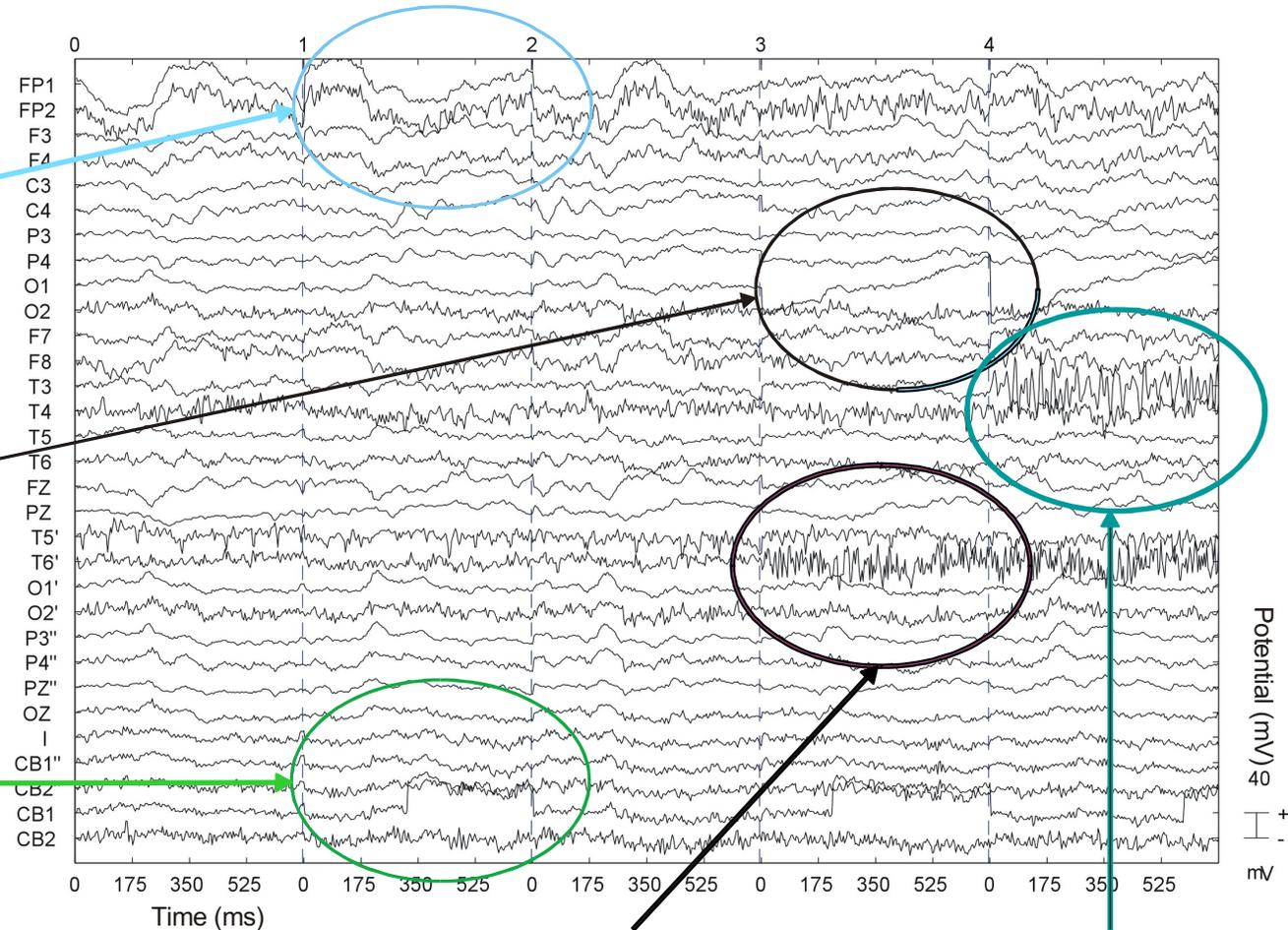
2 - Low frequency event (eye movements)

5 - Linear trend

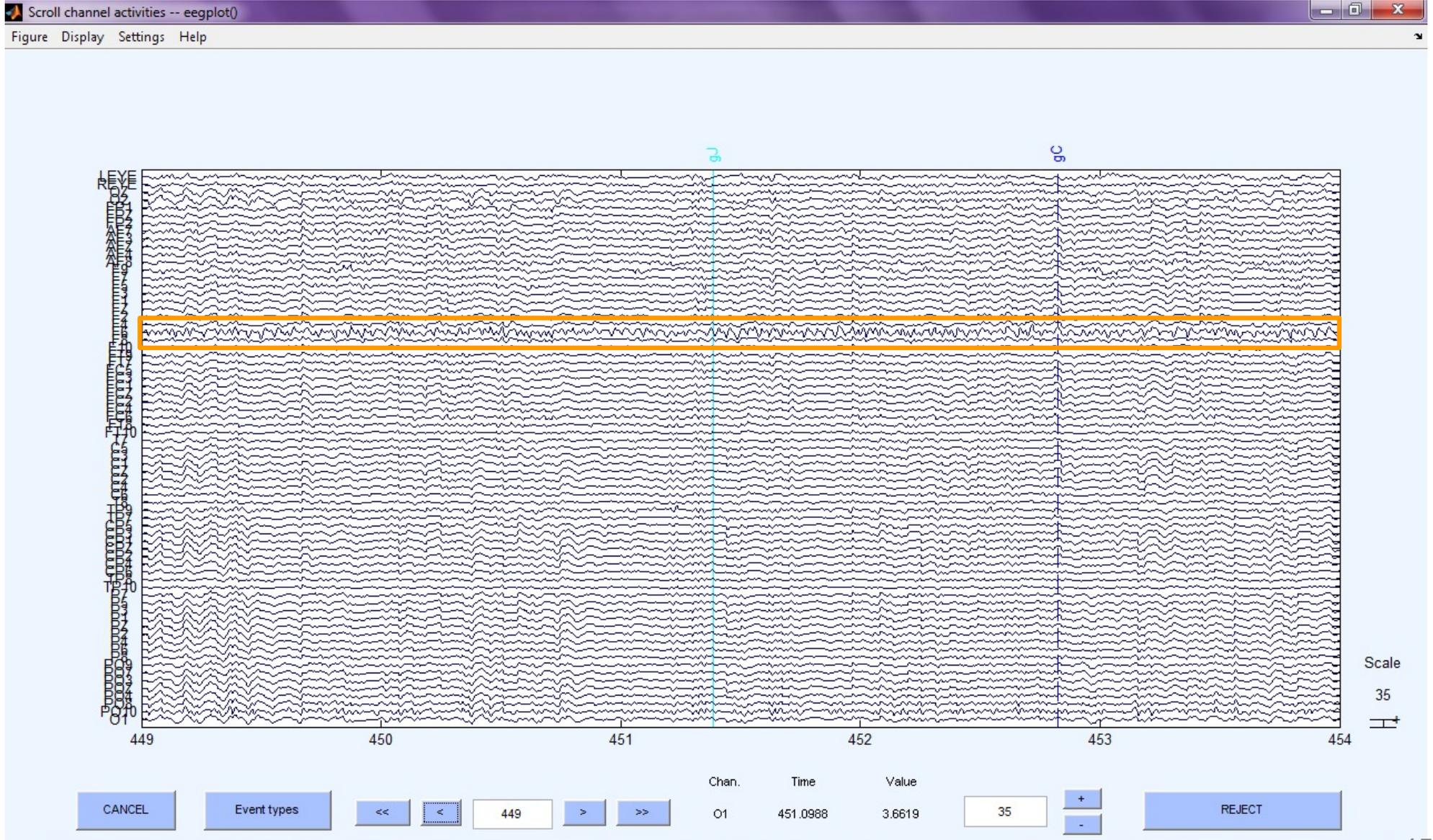
3 - Discontinuity

4 - High noise

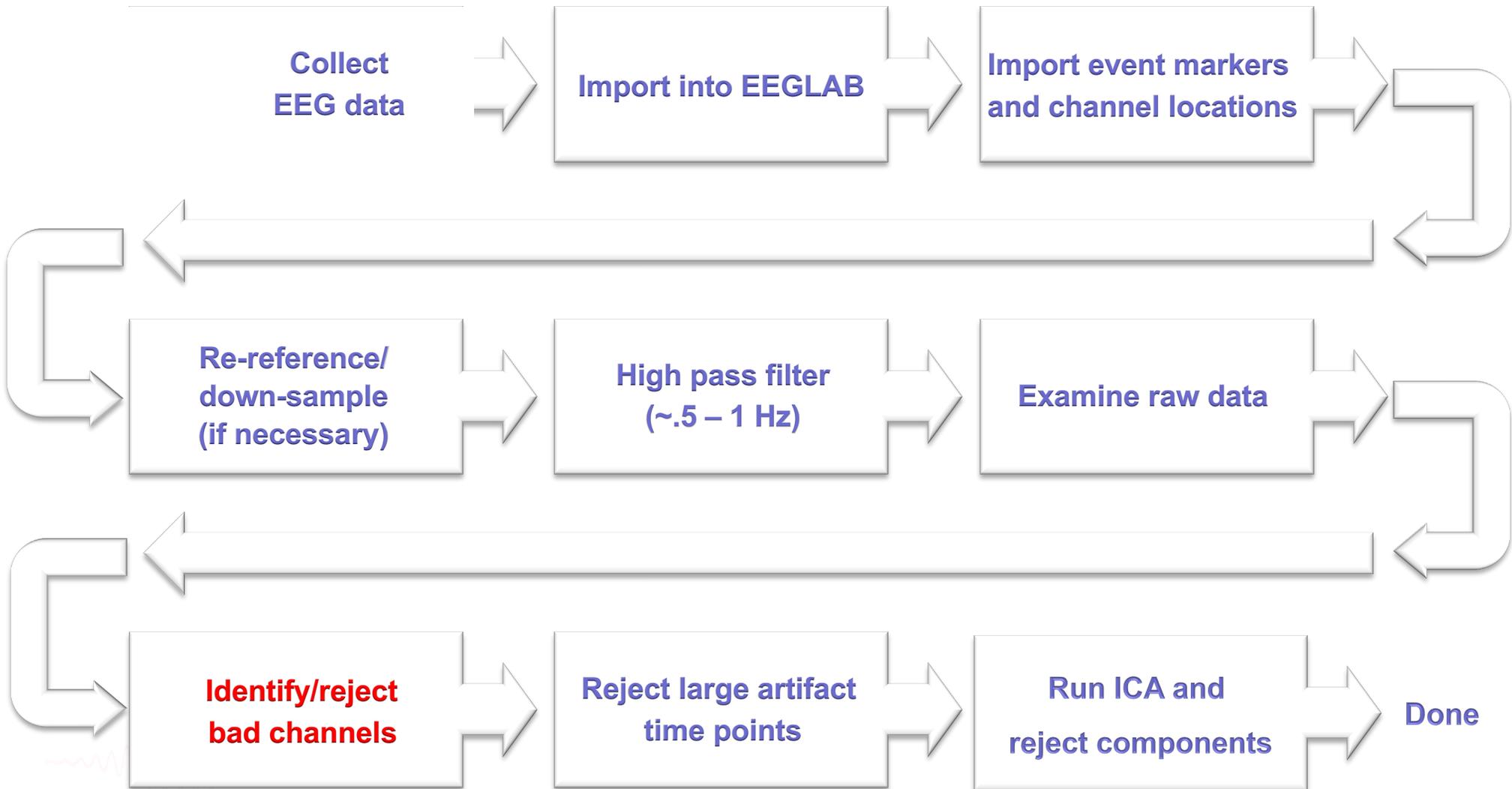
1 - Transient high frequency event (muscle)



Looking for bad channels



Pre-processing pipeline



Remove unwanted channels



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 events
- Select epochs of data
- Copy current data
- Append dataset
- Delete dataset(s)
- Visually edit event
- Dataset size (MB)

reref

Select data -- pop_select()

Select data in:	Input desired range	on->remove these
Time range [min max] (s)		<input type="checkbox"/> .
Point range (ex: [1 10])		<input type="checkbox"/> .
Epoch range (ex: 3:2:10)		<input type="checkbox"/> .
Channel range	EXG5 EXG6 EXG7 EXG8	<input checked="" type="checkbox"/> .

Scroll dataset

Help Cancel Ok

(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
- 64 - O2
- 65 - VEOG
- 66 - HEOG
- 67 - EXG5
- 68 - EXG6
- 69 - EXG7
- 70 - EXG8

Cancel Ok

Manually identifying bad channels



EEGLAB v11.0.5.4b

File Edit Tools **Plot** Study Datasets Help

#3: Simp

Filename: n

Channels pe

Frames per

Epochs

Events

Sampling ra

Epoch start

Epoch end

Reference

Channel loc

ICA weights

Dataset size

- Channel locations
- Channel data (scroll)
- Channel spectra and maps**
- Channel properties
- Channel ERP image
- 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

Channel spectra and maps -- pop_spectopo()

Epoch time range to analyze [min_ms max_ms]: 0 333996.0938

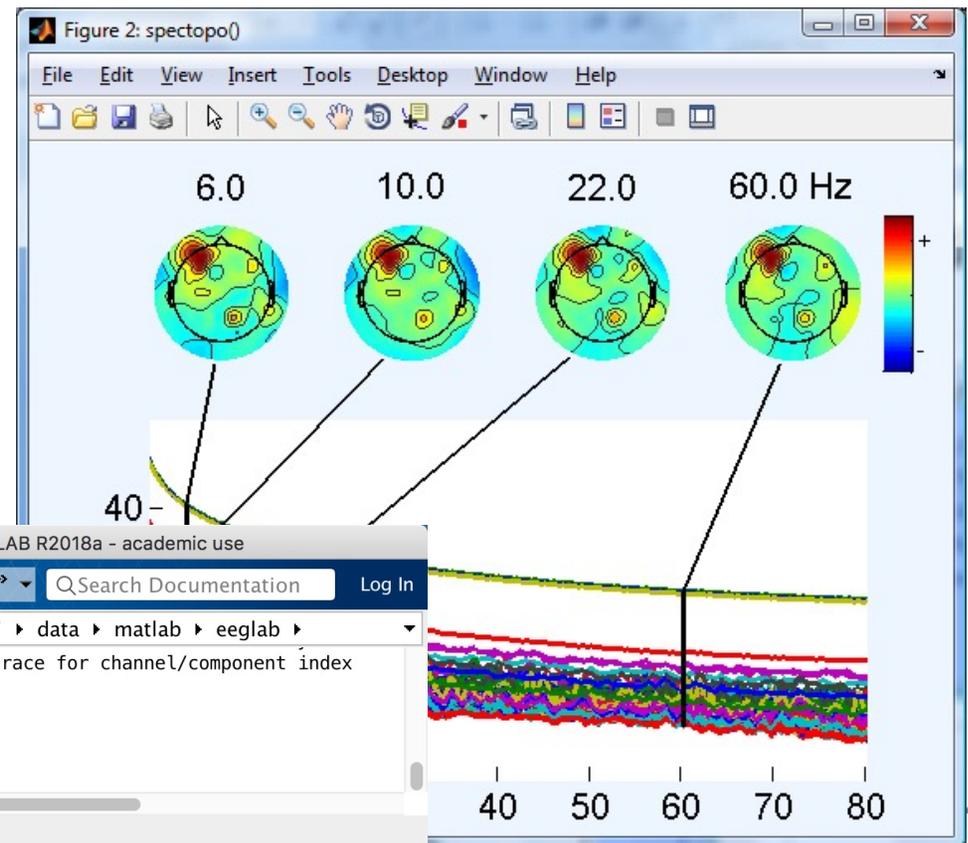
Percent data to sample (1 to 100): 100

Frequencies to plot as scalp maps (Hz): 6 10 22 60

Plotting frequency range [lo_Hz hi_Hz]: 2 80

Spectral and scalp map options (see topoplot): 'electrodes','off'

Help Cancel Ok



MATLAB R2018a - academic use

H... P... A... Q Search Documentation Log In

/ > data > matlab > eeglab >

Click on each trace for channel/component index

Channel 24

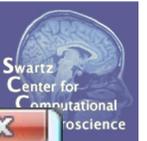
Channel 15

Channel 32

Channel 30

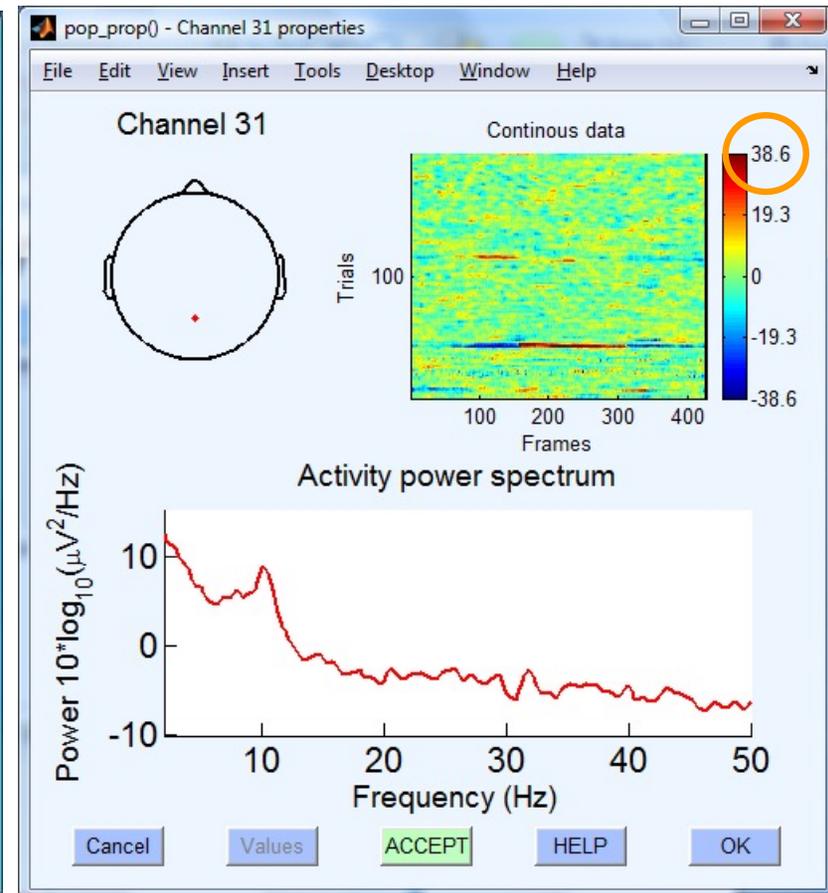
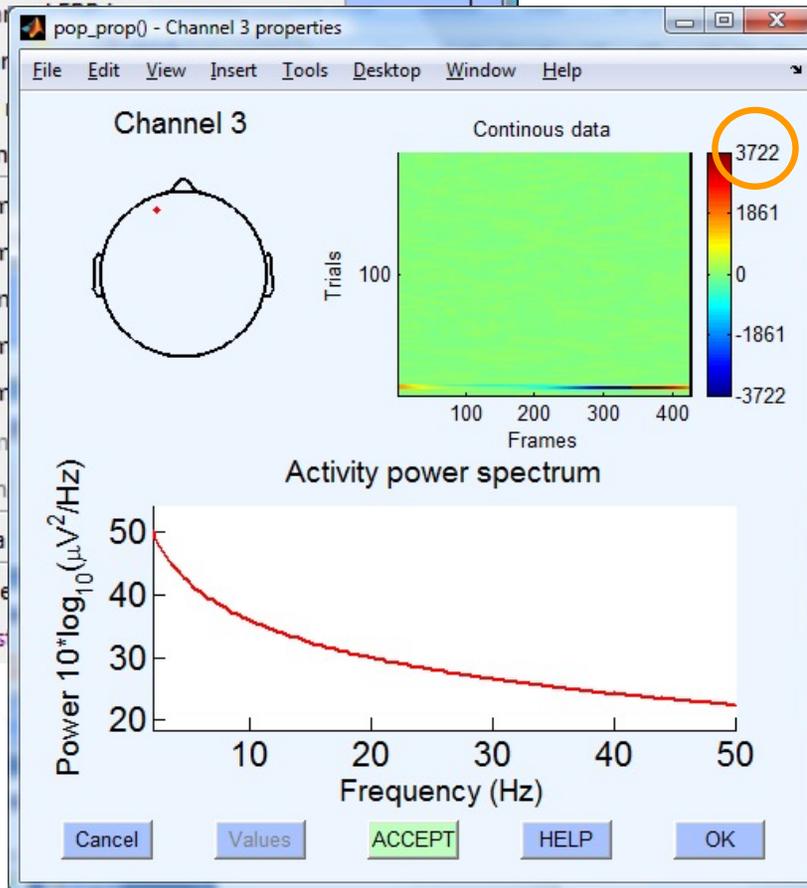
Command >>

Manually identifying bad channels

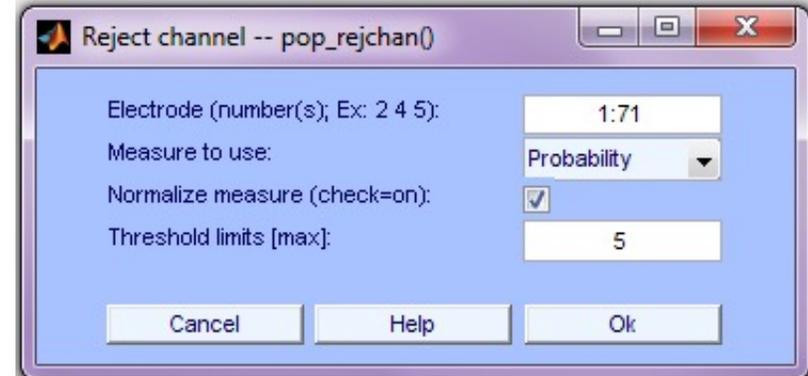
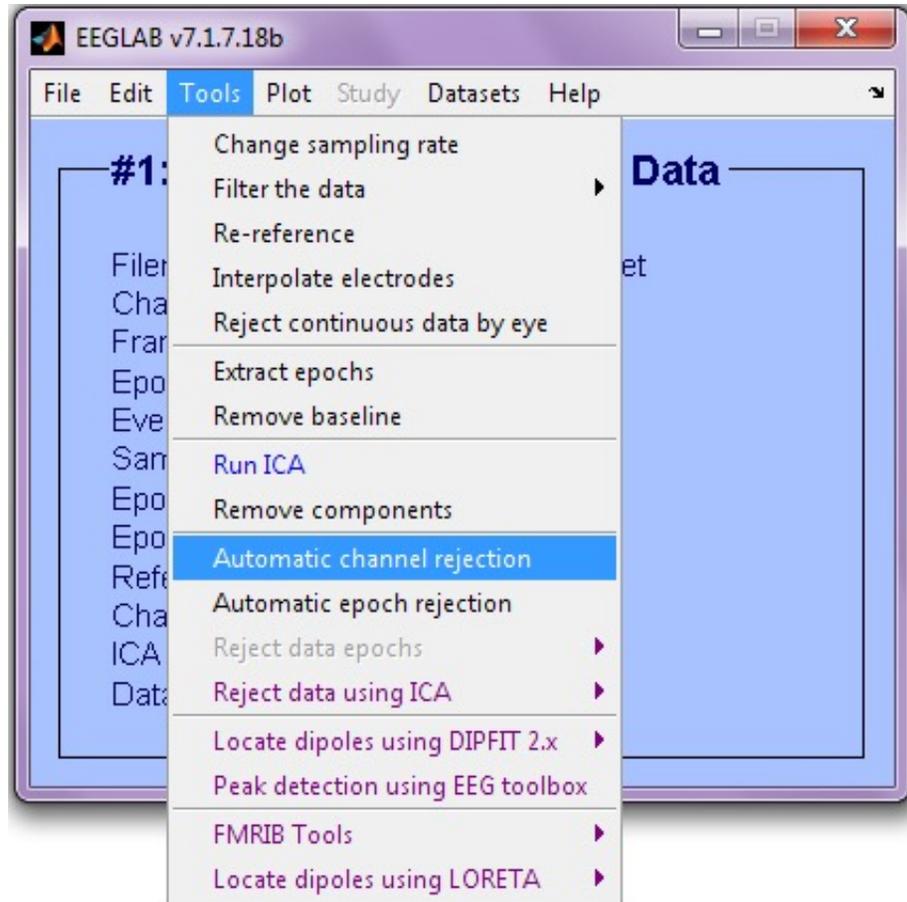


The main window of EEGLAB v11.0.5.4b. The "Plot" menu is open, and "Channel properties" is highlighted with an orange box. The left sidebar shows various parameters like "Filename: n", "Channels p", "Frames per", "Epochs", "Events", "Sampling ra", "Epoch start", "Epoch end", "Reference", "Channel loc", "ICA weights", and "Dataset size".

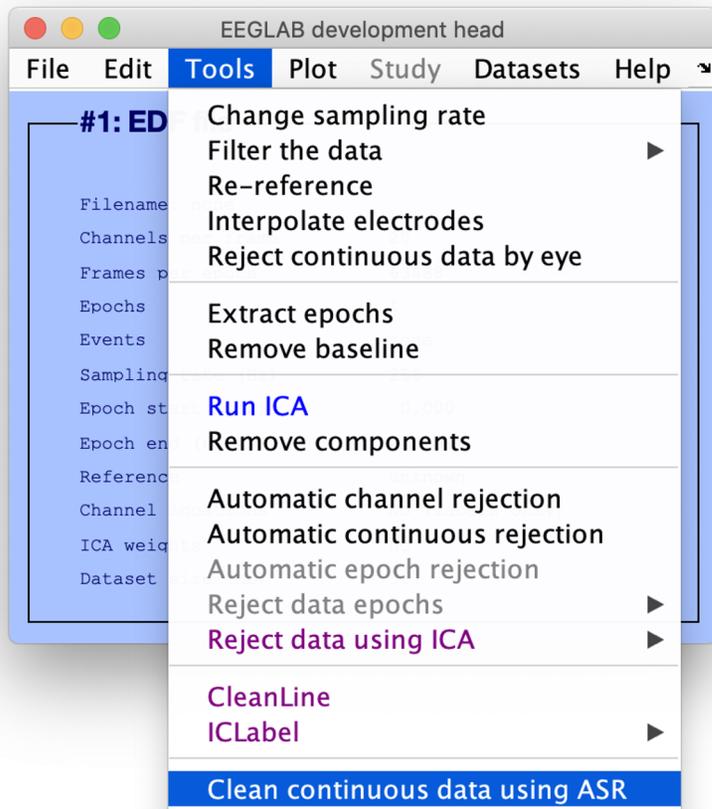
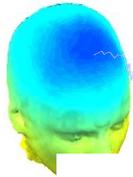
A dialog box titled "Component properties - pop_prop()". It has two input fields: "Channel index(ices) to plot:" with the value "3,31" and "Spectral options (see spectopo() help):" with the value "'freqrange', [2 50]". There are "Help", "Cancel", and "Ok" buttons.



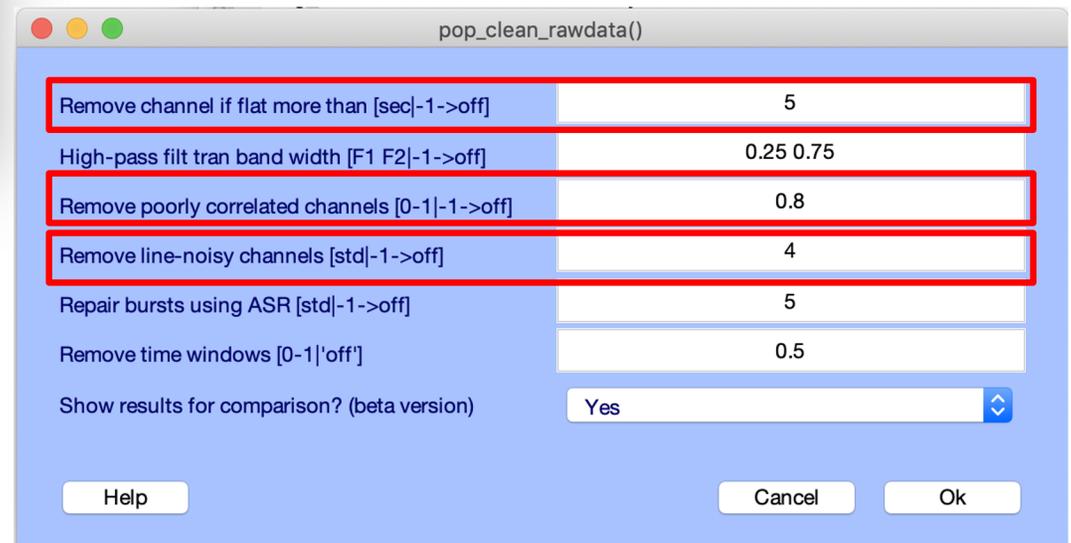
Auto-detection of noisy channels



Auto-detection of noisy channels



Clean_rawdata plugin of EEGLAB

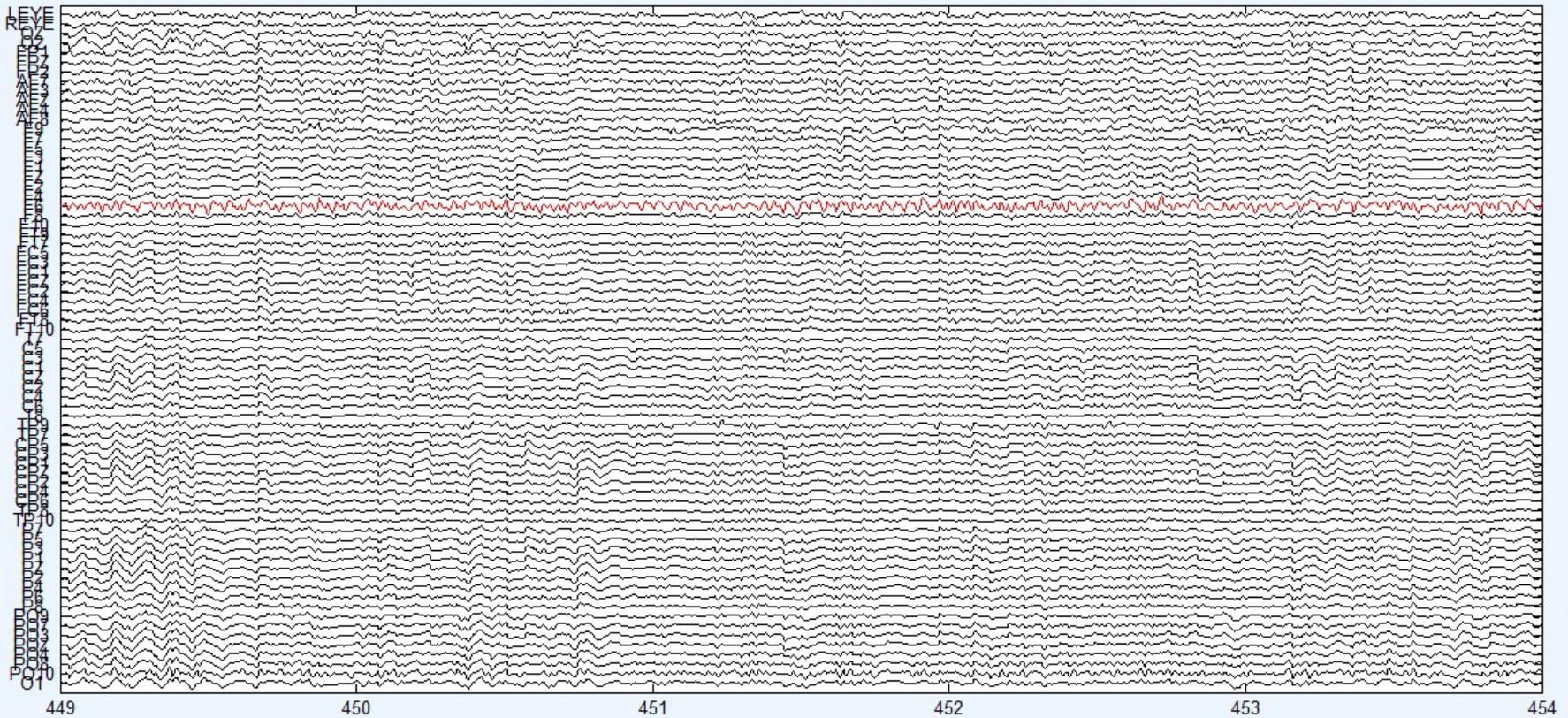


Auto-detected noisy channel



Scroll component activities -- eegplot()

Figure Display Settings Help



Scale
35

CANCEL

<< <

449

> >>

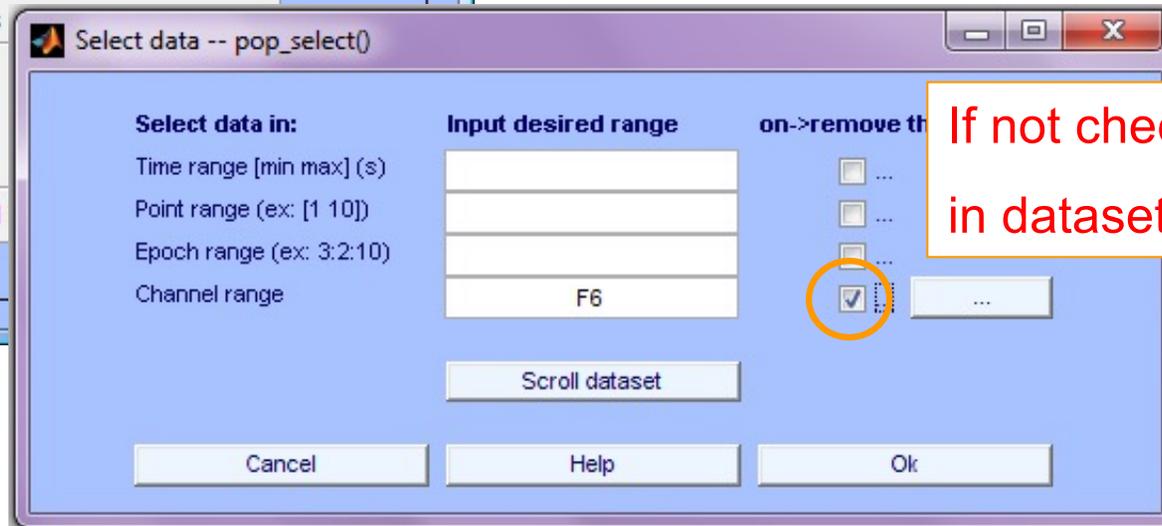
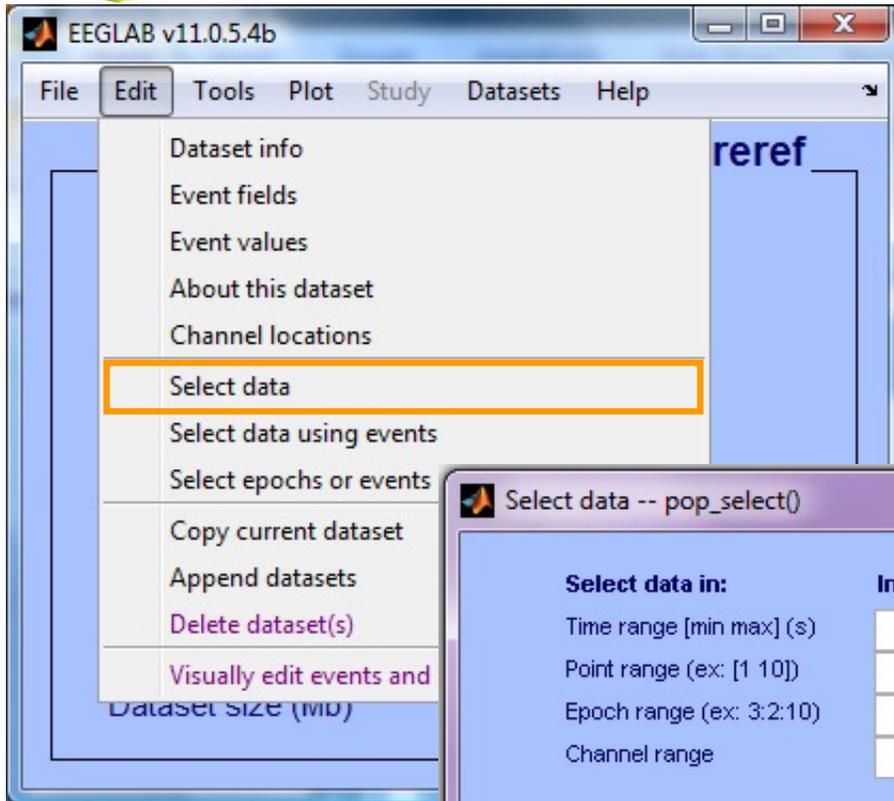
Chan.	Time	Value
TP8	452.1146	-2.6647

35

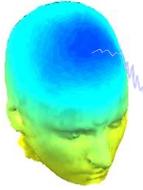
+
-

REJECT

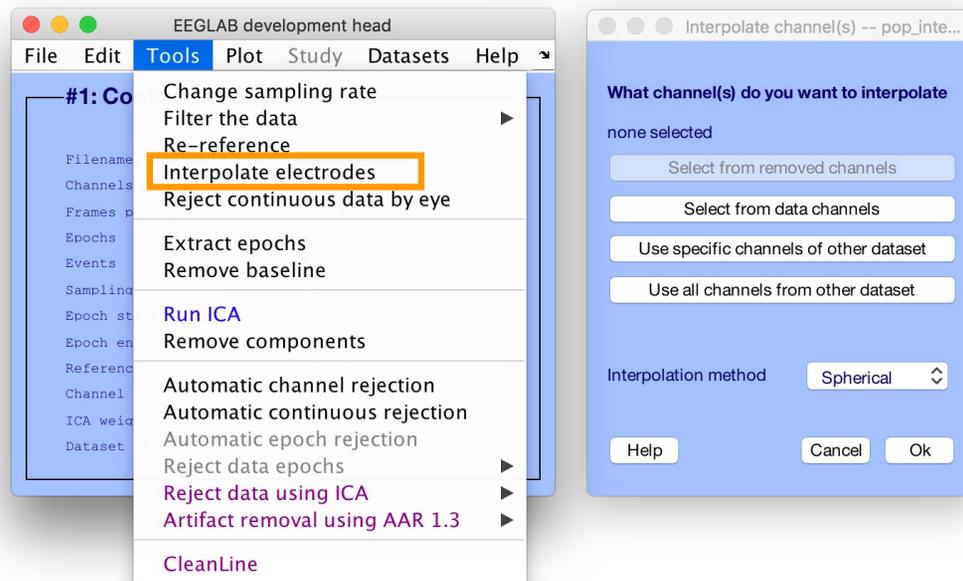
Removing channel(s)



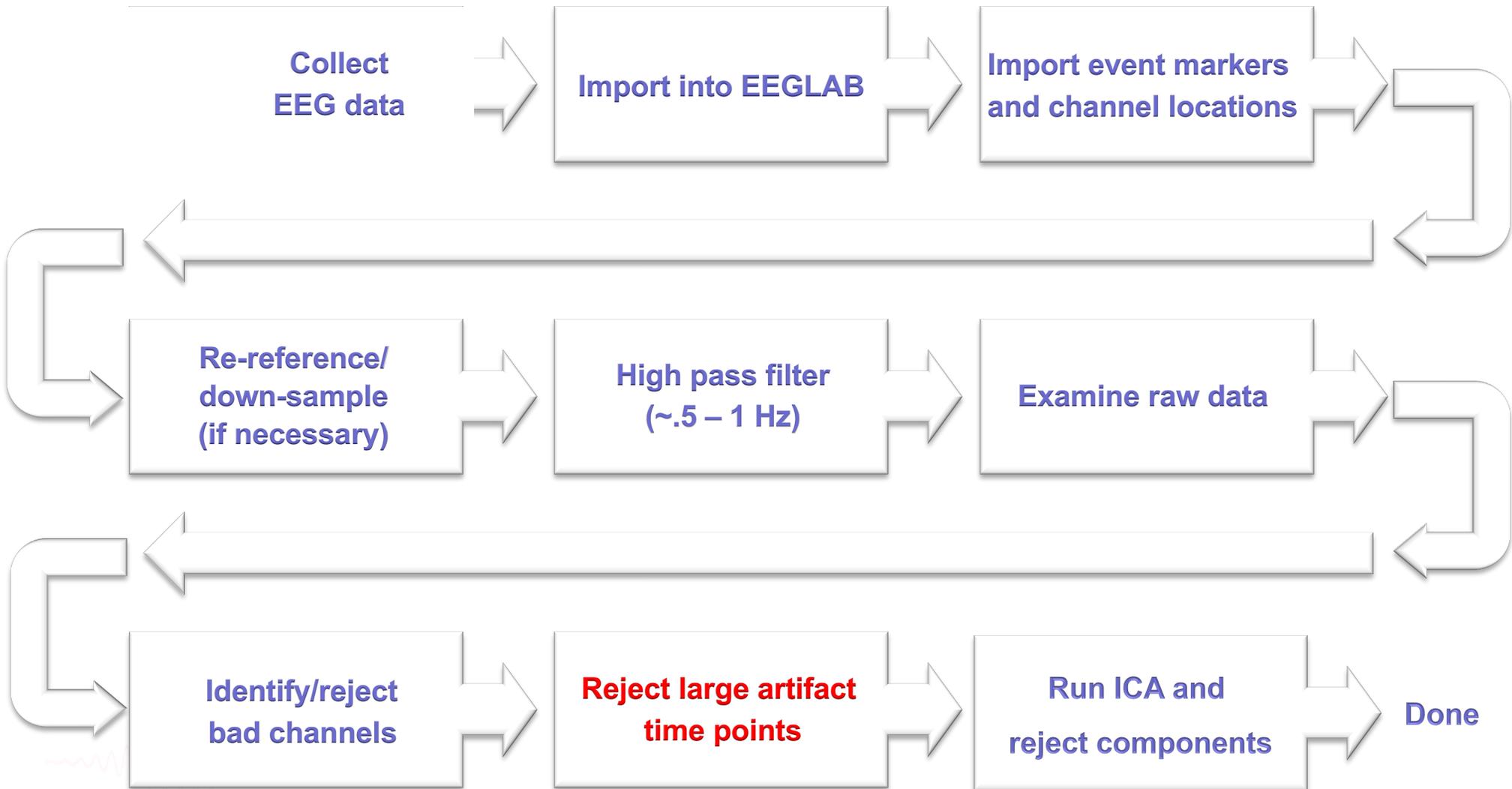
Removed channel(s)

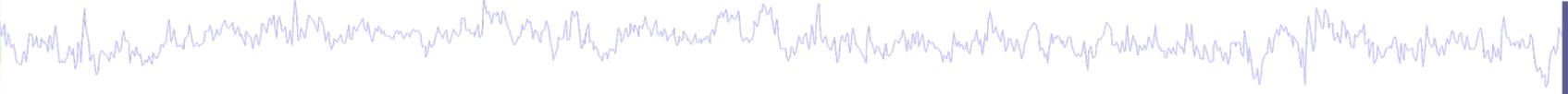


- In EEGLAB, removed channels are not only labeled for rejection, they are actually removed from the data.
- Interpolating channels instead of removing them?



Pre-processing pipeline



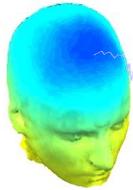


Data Cleaning for ICA

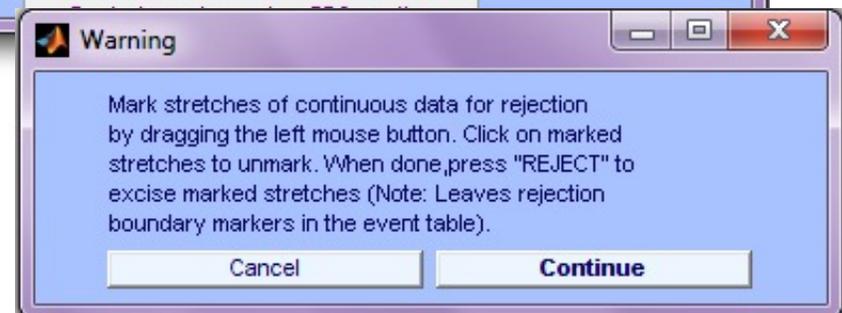
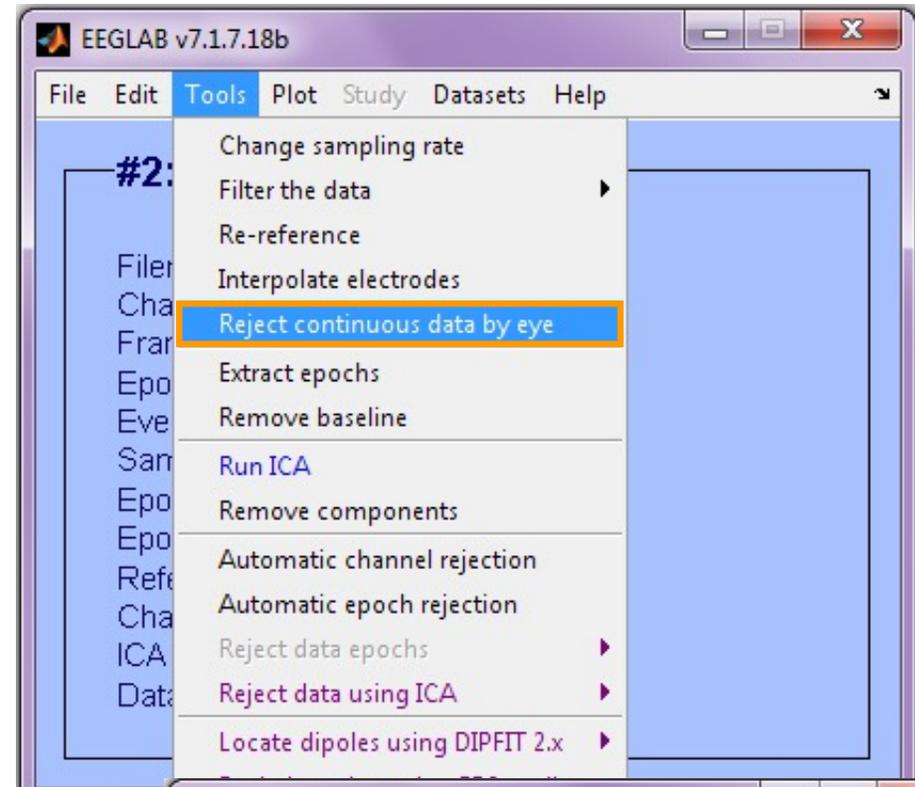
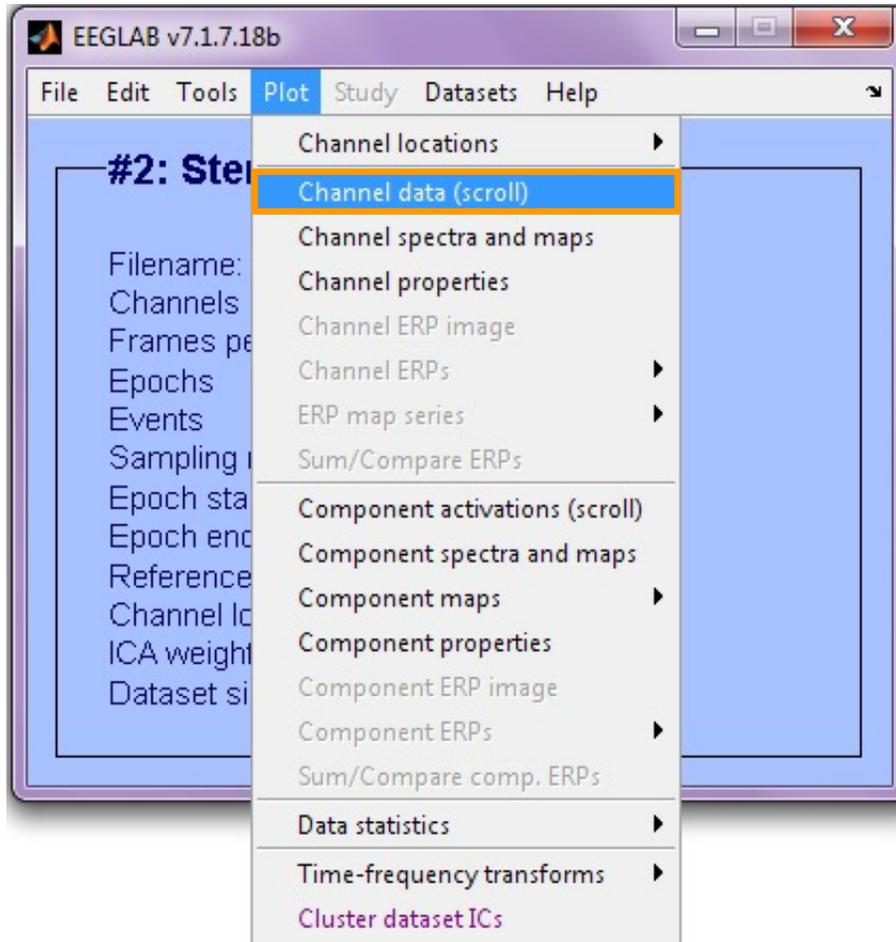
Variant 1: Continuous Data



Reject continuous data



Equivalent

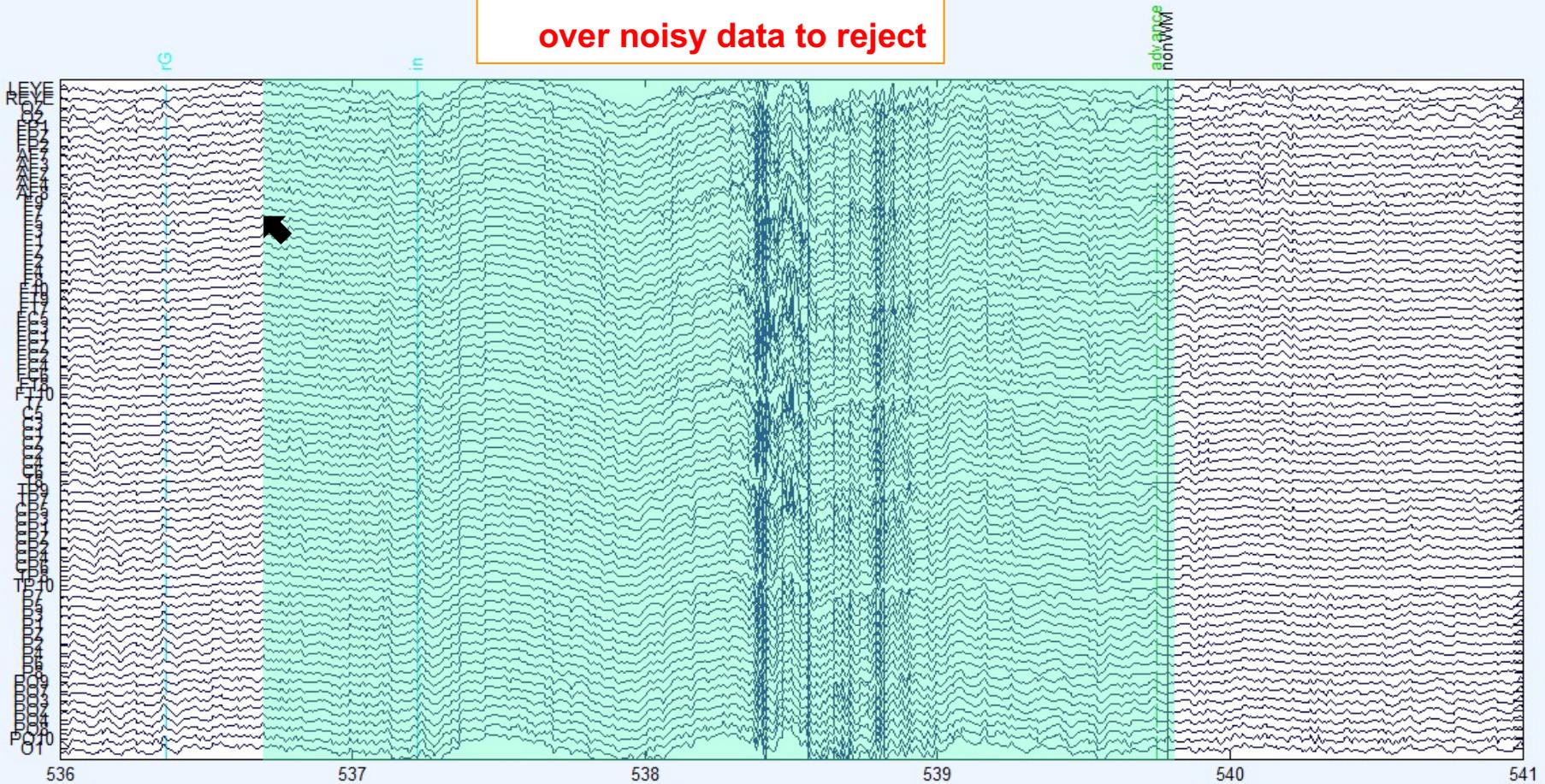


Reject continuous data



Scroll channel activities -- eegplot() Figure Display Settings Help

Click and drag with mouse over noisy data to reject



Scale 35

Control panel for the EEG plot interface. It includes a 'CANCEL' button, an 'Event types' dropdown menu, navigation buttons for time (double left arrow, left arrow, right arrow, double right arrow), a time input field showing '536', a channel input field showing 'FC6', a value input field showing '4.8773', a scale input field showing '35', and a 'REJECT' button. The 'REJECT' button is highlighted with an orange border.

Rejecting data for ICA



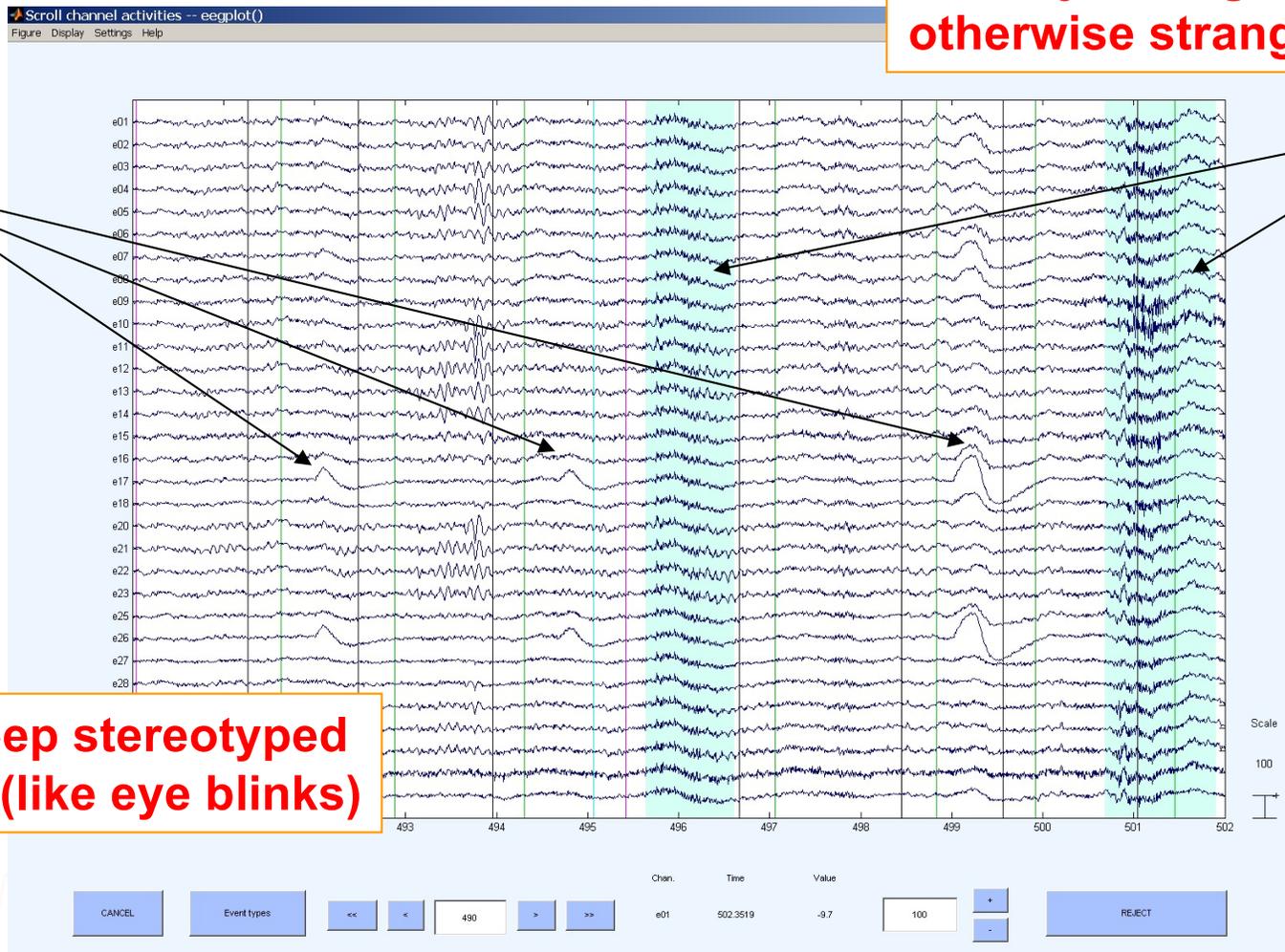
To prepare data for ICA:

Reject large muscle or otherwise strange events...

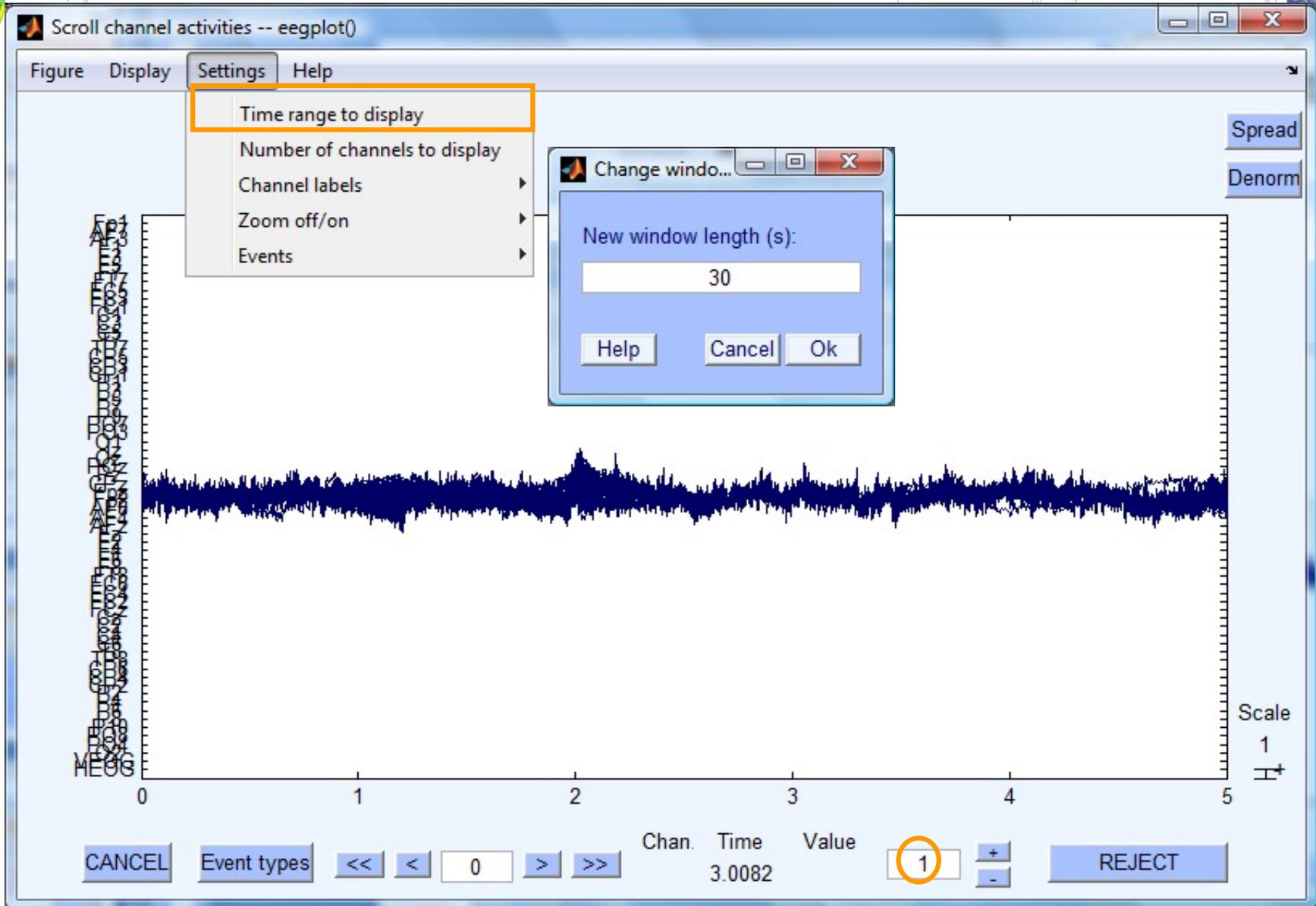
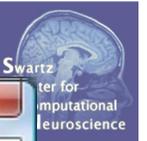
Reject

Keep

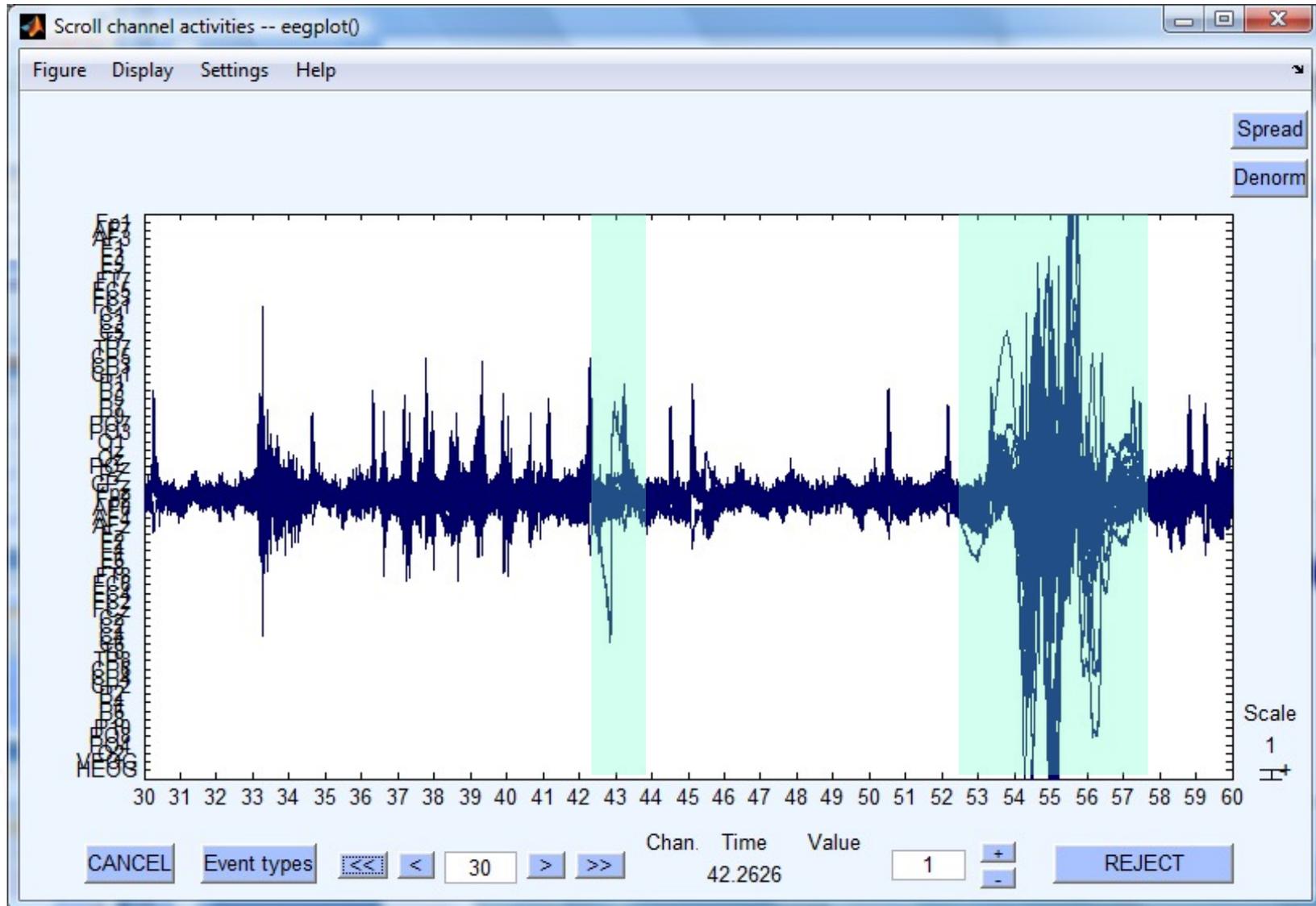
... but keep stereotyped artifacts (like eye blinks)



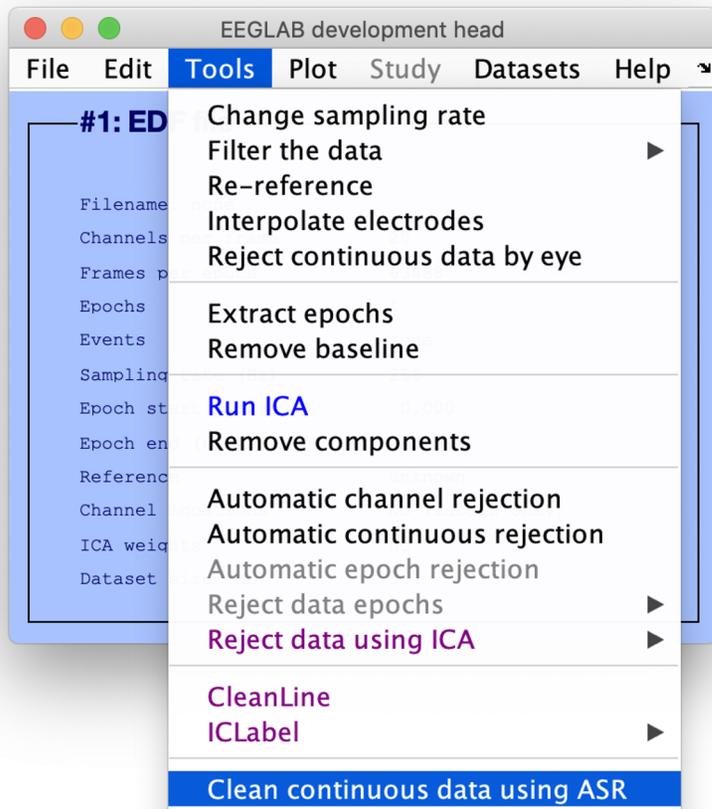
Fast manual artifact rejection



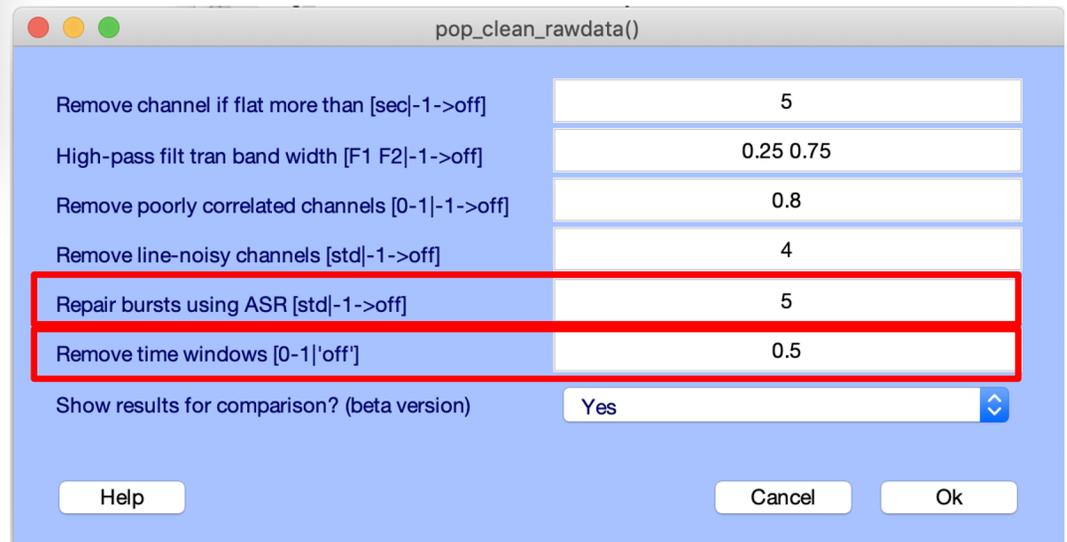
Fast manual artifact rejection

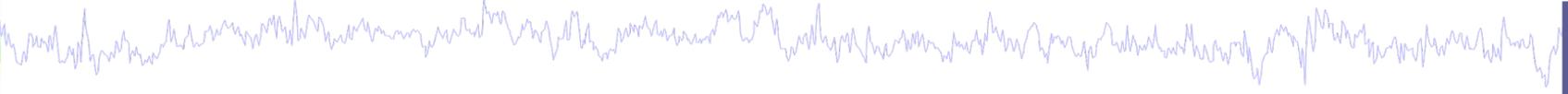


Automatic rejection of continuous data



Clean_rawdata plugin of EEGLAB



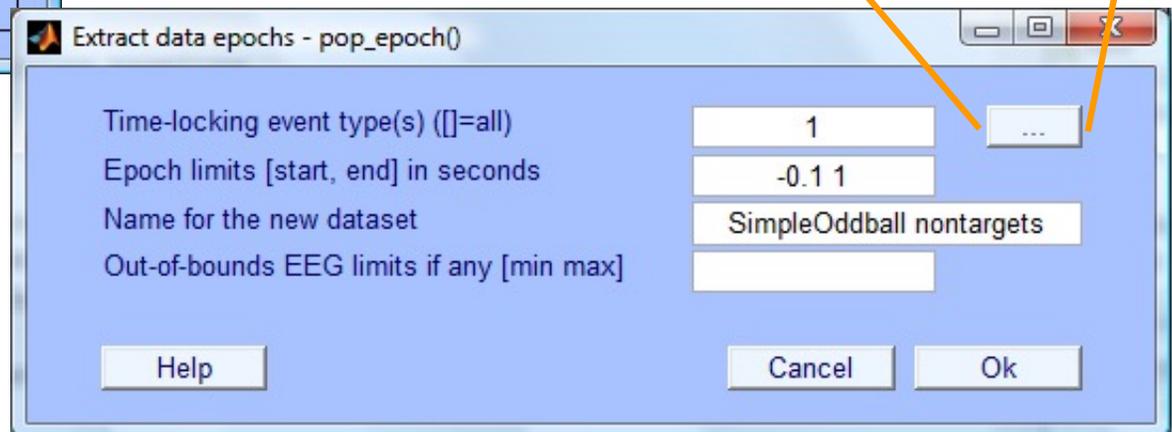
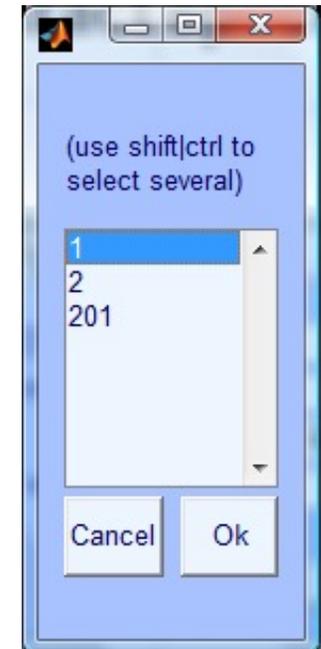
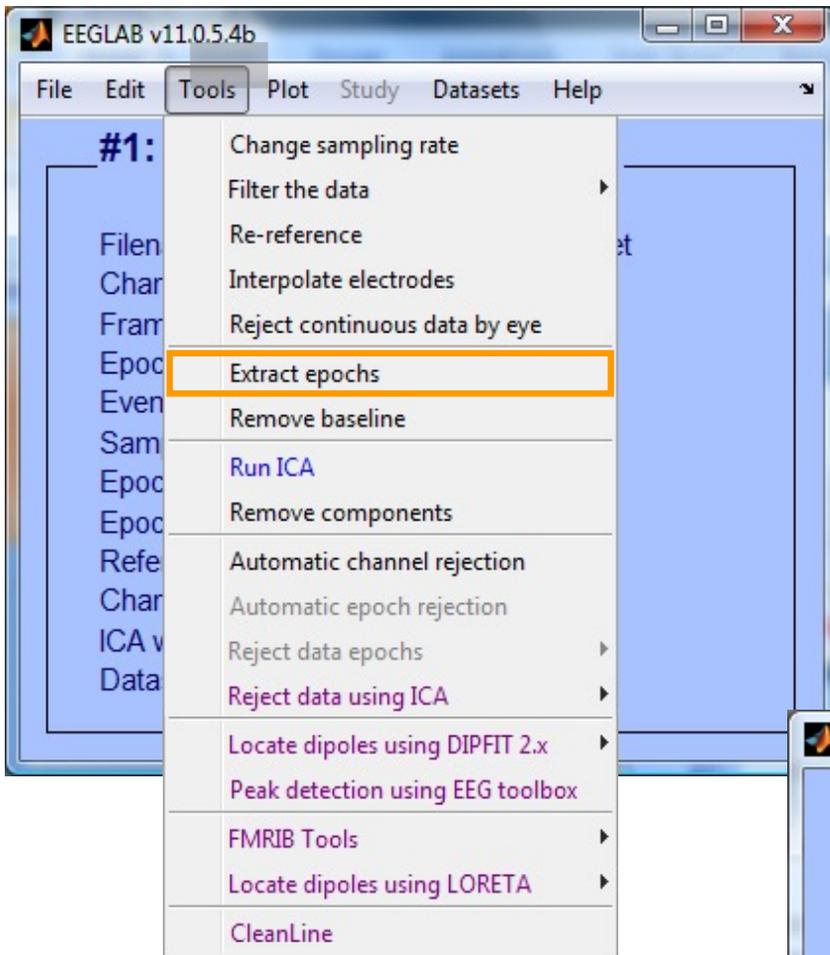


Data Cleaning for ICA

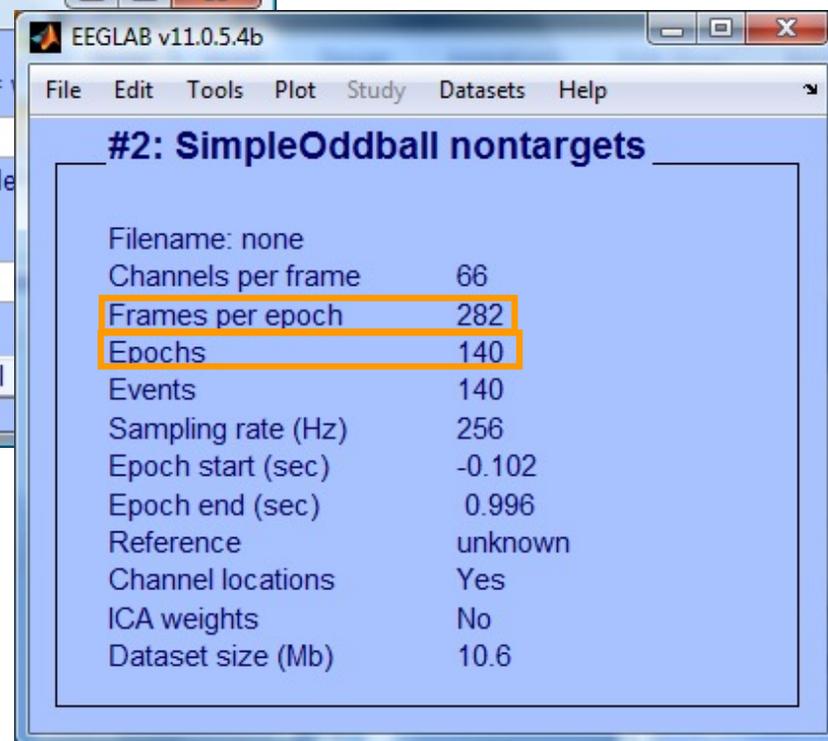
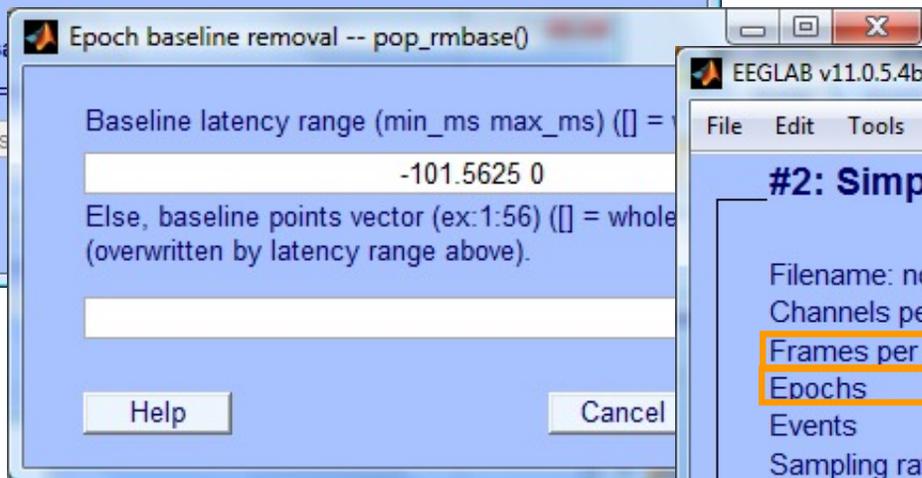
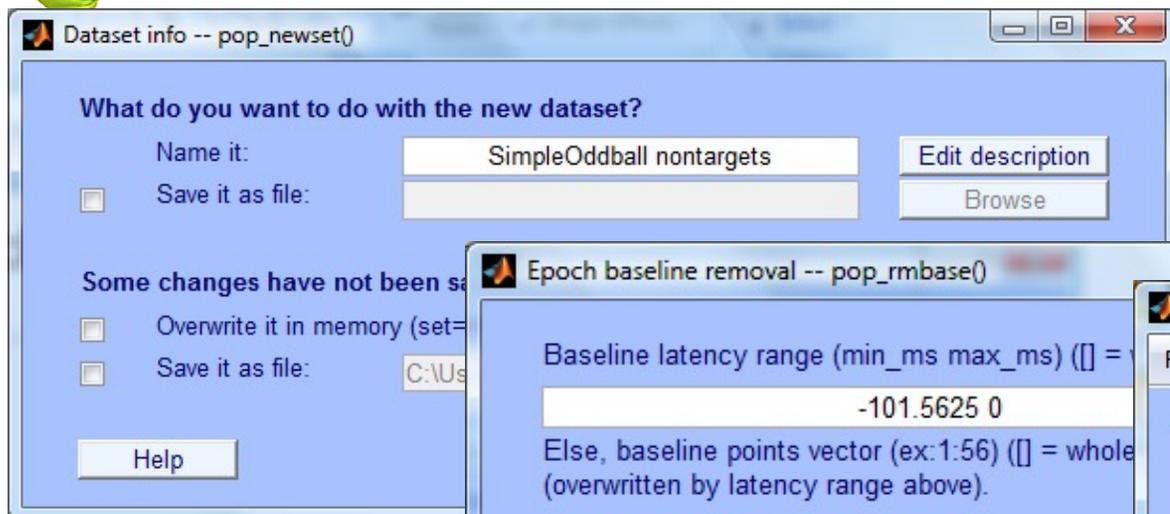
Variant 2: Epoched Data



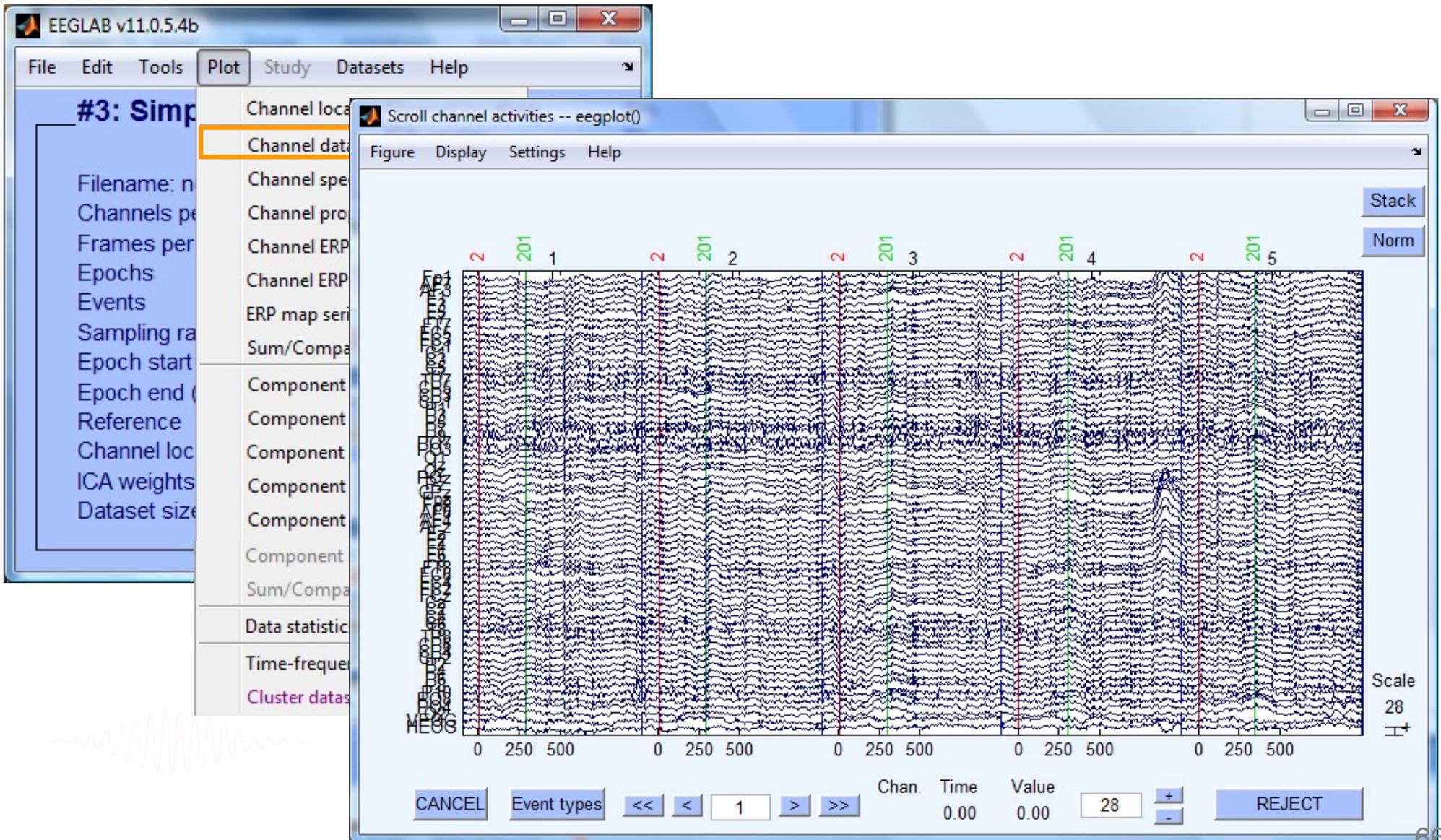
Extract epochs



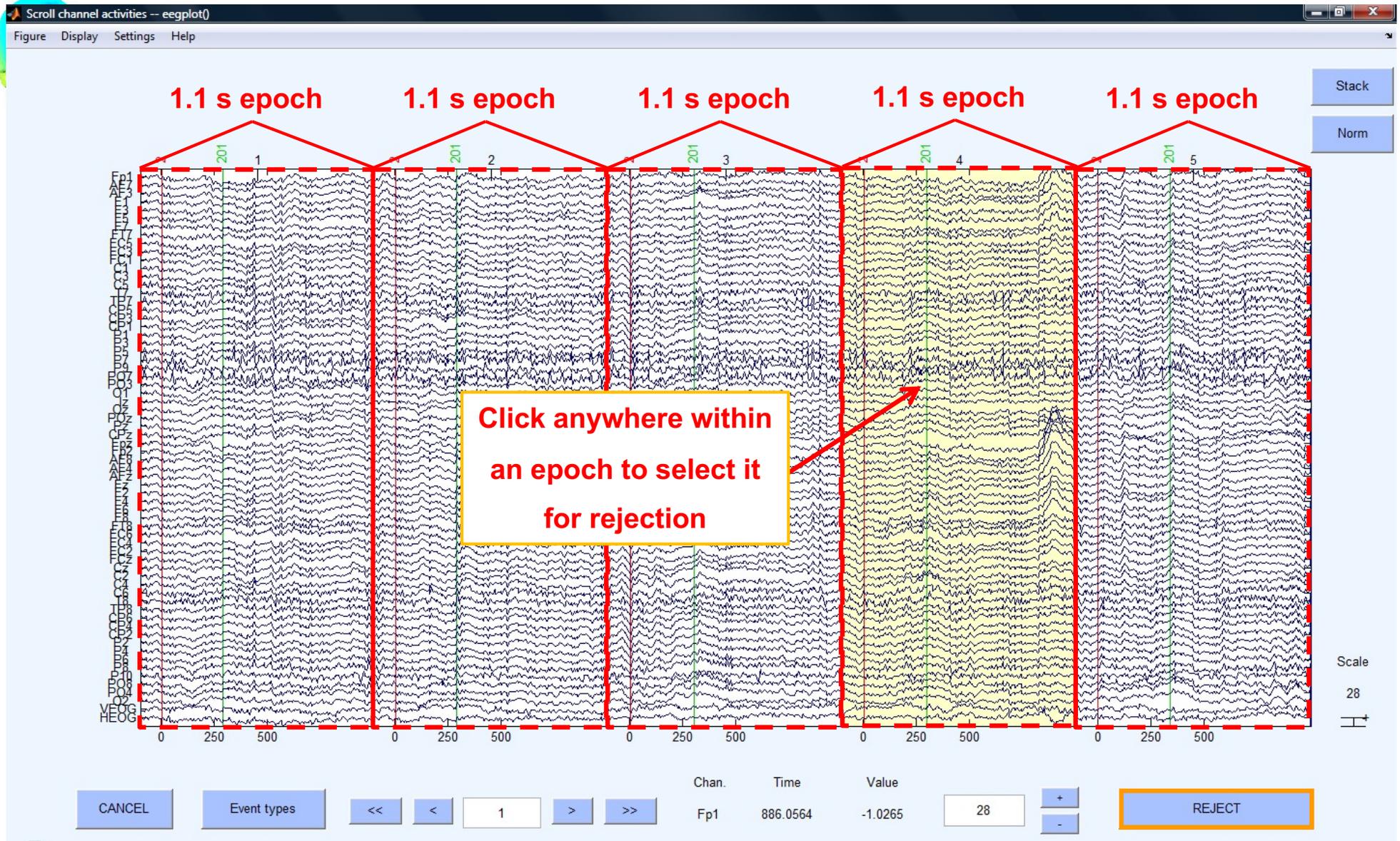
Extract epochs



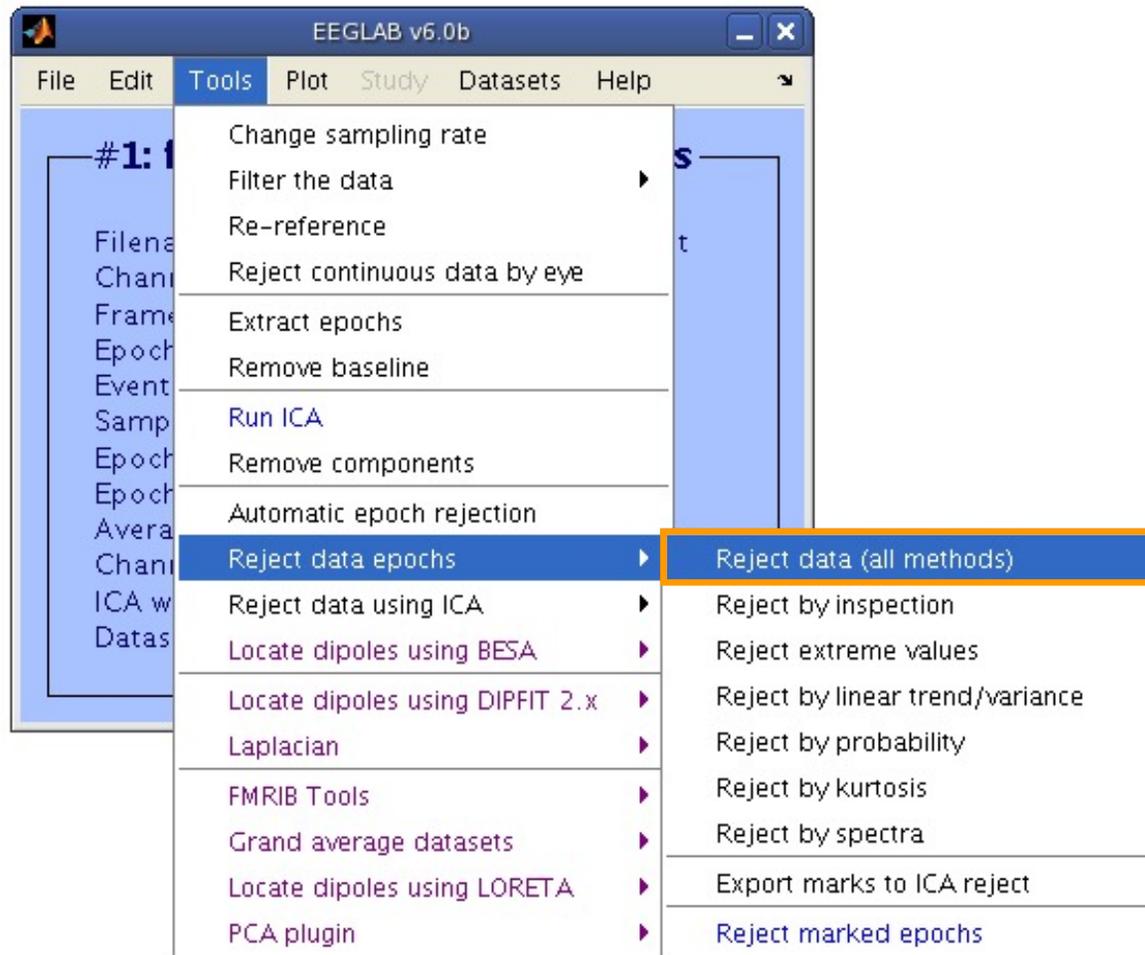
Scroll (epoched) channel data



Reject epochs with artifact



Automatic epoch rejection



Reject data epochs



Reject trials using data statistics - pop_rejmenu()

Mark trials by appearance Marked trials 0

Find abnormal values

Upper limit(s) (uV)	<input type="text" value="25"/>	Lower limit(s) (uV)	<input type="text" value="-25"/>
Start time(s) (ms)	<input type="text" value="-1000"/>	Ending time(s) (ms)	<input type="text" value="1996"/>
Electrode(s)	<input type="text" value="1:31"/>	Currently marked trials	<input type="text" value="0"/>

Find abnormal trends

Max slope (uV/epoch)	<input type="text" value="50"/>	R-squared limit (0 to 1)	<input type="text" value="0.3"/>
Electrode(s)	<input type="text" value="1:31"/>	Currently marked trials	<input type="text" value="0"/>

Find improbable data

Single-channel limit (std. dev.)	<input type="text" value="5"/>	All channels limit (std. dev.)	<input type="text" value="5"/>
Electrode(s)	<input type="text" value="1:31"/>	Currently marked trials	<input type="text" value="0"/>

Find abnormal distributions

Single-channel limit (std. dev.)	<input type="text" value="5"/>	All channels limit (std. dev.)	<input type="text" value="5"/>
Electrode(s)	<input type="text" value="1:31"/>	Currently marked trials	<input type="text" value="0"/>

Find abnormal spectra (slow)

Upper limit(s) (dB)	<input type="text" value="25"/>	Lower limit(s) (dB)	<input type="text" value="-25"/>
Low frequency(s) (Hz)	<input type="text" value="0"/>	High frequency(s) (Hz)	<input type="text" value="50"/>
Electrode(s)	<input type="text" value="1:31"/>	Currently marked trials	<input type="text" value="0"/>

Plotting options

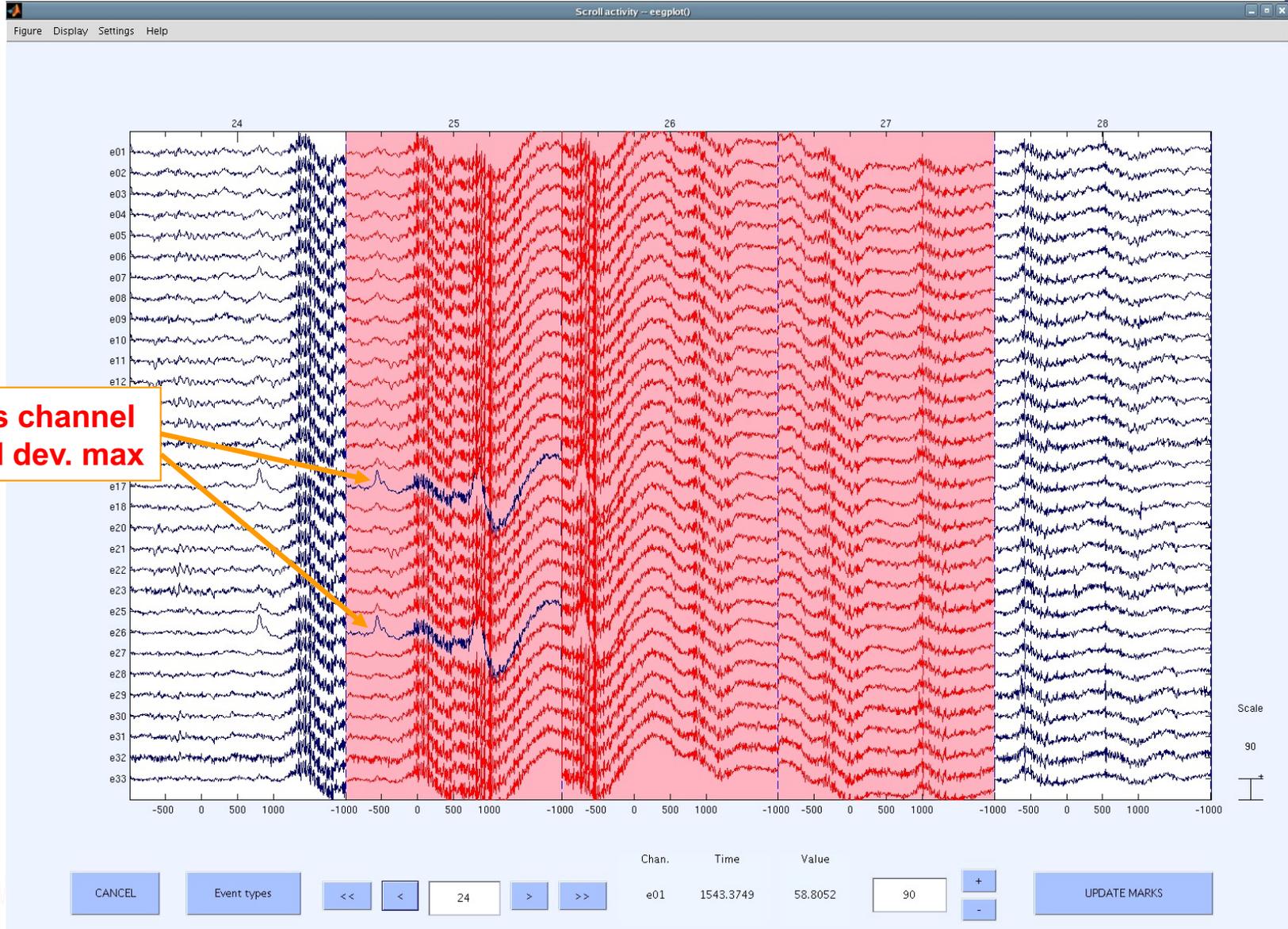
Show all trials marked for rejection by the measure selected above or checked below | /

<input checked="" type="checkbox"/> Abnormal appearance	<input checked="" type="checkbox"/> Abnormal values	<input checked="" type="checkbox"/> Abnormal trends
<input checked="" type="checkbox"/> Improbable epochs	<input checked="" type="checkbox"/> Abnormal distributions	<input checked="" type="checkbox"/> Abnormal spectra

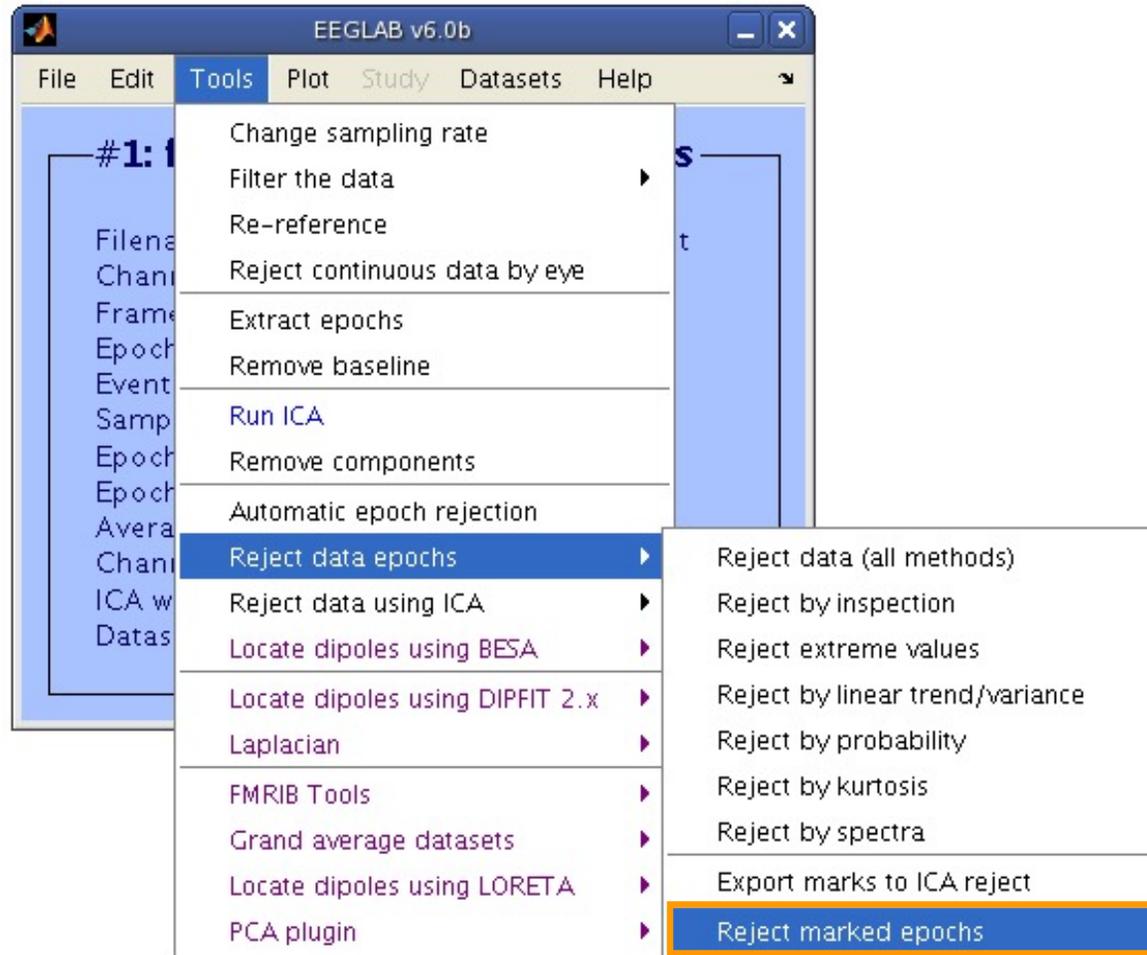
visual inspection

probability

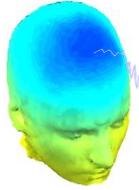
Reject data epochs



Reject data epochs



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

Many Preprocessing Variants



- Resources

- EEGLAB wiki “Quick Tutorial on Rejection”

https://eeglab.org/tutorials/misc/Quick_Tutorial_on_Rejection.html

- Makoto’s Preprocessing Pipeline

https://sccn.ucsd.edu/wiki/Makoto's_preprocessing_pipeline

- EEGLAB Plugins:

- Christian Kothe’s clean_rawdata plugin (ASR)
- Makoto Miyakoshi’s trimOutlier plugin

- Bigdely-Shamlo et al (2015): PREP Pipeline

- <http://dx.doi.org/10.3389/fninf.2015.00016>

Exercises (optional homework)



- Preprocess data of your choice or load a previously filtered dataset e.g. faces_4.set
- Identify bad channel(s) using auto-detection tool; plot channel properties of flagged channels
- Identify and remove non-task portions of continuous data; see if the previously flagged channels are still identified as bad
- Epoch on event of interest. Scroll the epoched data and perform visual rejection of epochs
- Explore the automated artifact rejection tools
- Run ICA