



EEG Preprocessing

Importing data, rejecting data, and performing ICA decomposition

EEGLAB Workshop XXVI

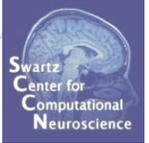
Ben-Gurion University, Be'er-Sheva, Israel

Day 1

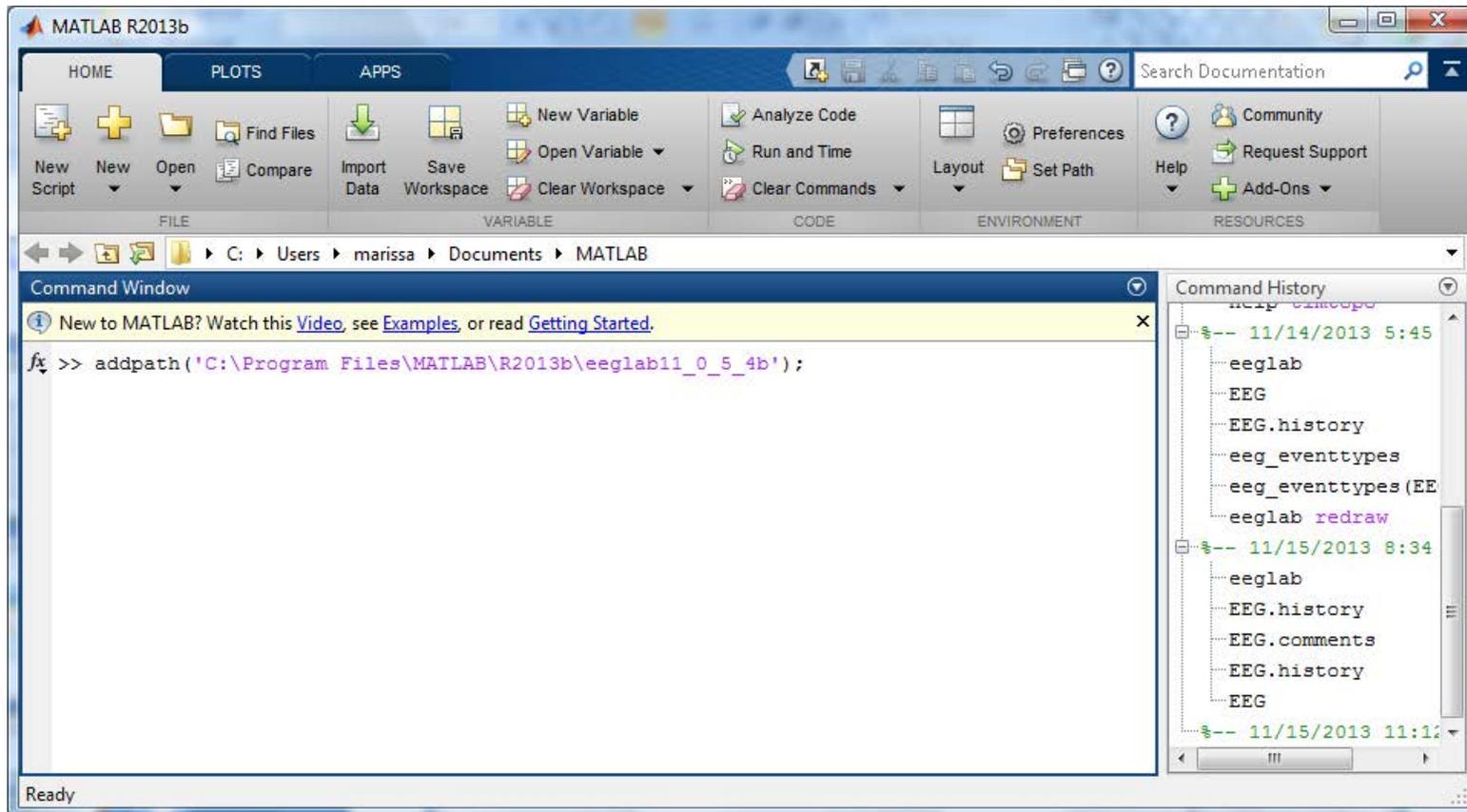
John Iversen



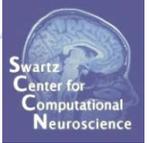
Installing EEGLAB and data folder



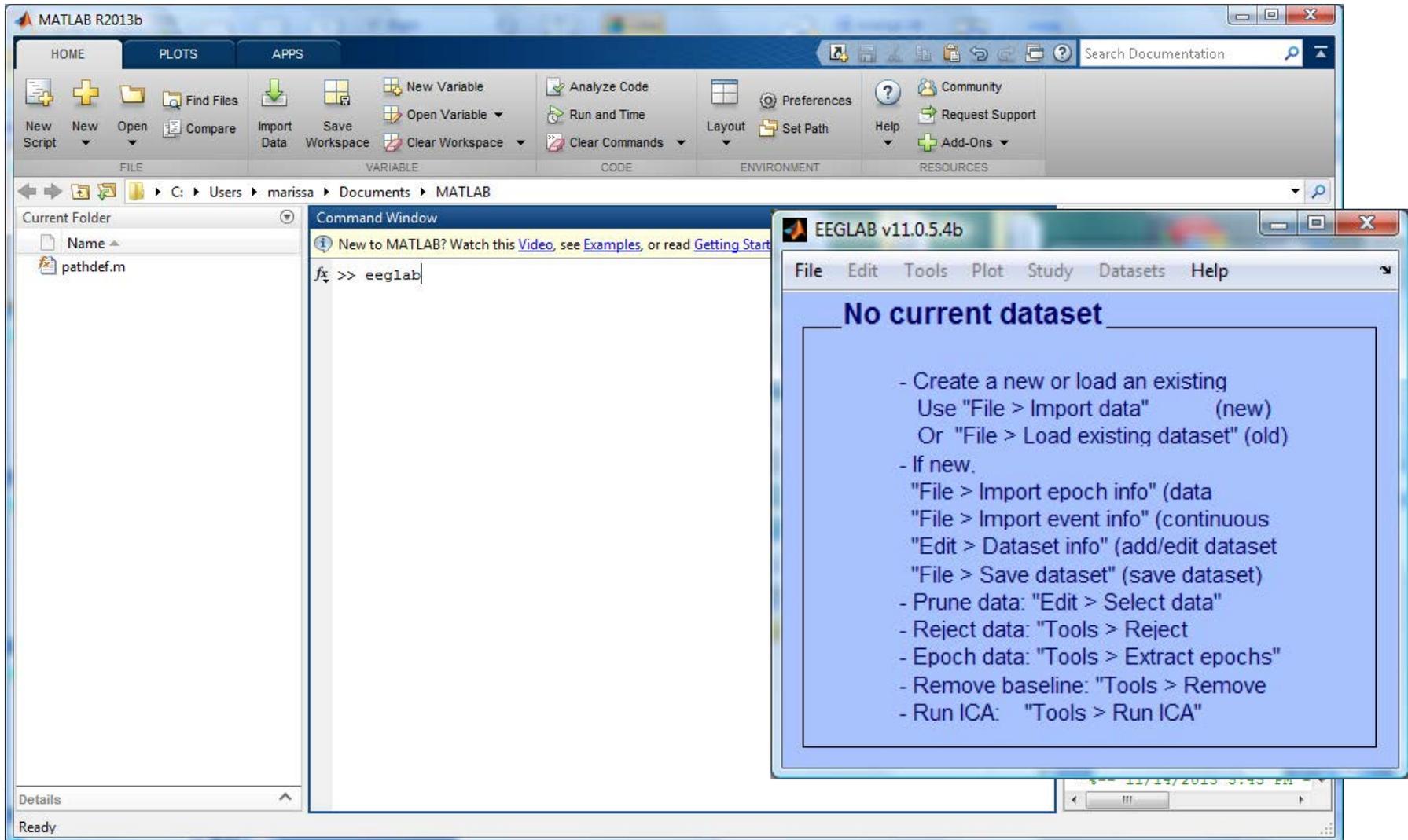
- Start Matlab
- Add **only** the top-level EEGLAB folder to your Matlab path:



The EEGLAB Matlab software



main graphic interface



The Goal of Preprocessing



- Create a complete EEGLAB data set with
 - EEG
 - Channel Locations
 - Events
- Preprocess the EEG data to yield optimal ICA decompositions
 - Rereferencing
 - High Pass Filtering
 - Remove bad channels, noisy segments of data
- Run ICA decomposition
 - See the next two lectures...



“Secrets” to a good ICA decomposition



- Garbage in... garbage out (it's not magic)
- Remove large, non-stereotyped artifacts
- Do you have enough data? (based mostly on time, not frames)
- High-pass filter to remove slow drifts (no low-pass filter needed)
- Remove bad channels
- Data must be in double precision (not single)

Many Preprocessing Options



- Resources

- EEGLAB wiki “Quick Tutorial on Rejection”

- http://sccn.ucsd.edu/wiki/Quick_Rejection_Tutorial

- Makoto’s Preprocessing Pipeline (Day 3, 12:30)

- http://sccn.ucsd.edu/wiki/Makoto%27s_preprocessing_pipeline

- EEGLAB Plugins:

- Miyakoshi’s `trimOutlier` plugin
- Mullen’s `cleanline` plugin
- Kothe’s `clean_rawdata` plugin (ASR)

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

- PREP plugin

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

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



EEGLAB v11.0.5.4b

File Edit Tools Plot Study Datasets Help

Import data

- Using EEGLAB functions and plugins
 - From ASCII/float file or Matlab array
 - From Netstation .mff (FILE-IO toolbox)
 - From Netstation binary simple file
 - From Multiple seg. Netstation files
 - From Netstation Matlab files
 - From BCI2000 ASCII file
 - From Snapmaster .SMA file
 - From Neuroscan .CNT file
 - From Neuroscan .EEG file
 - From Biosemi BDF file (BIOSIG toolbox)
 - From Biosemi BDF and EDF files (BDF plugin)**
 - From EDF/EDF+/GDF files (BIOSIG toolbox)
 - From ANT EEProbe .CNT file
 - From ANT EEProbe .AVR file
 - From BCI2000 .DAT file
 - From BIOPAC MATLAB files
 - From Brain Vis. Rec. .vhdr file
 - From Brain Vis. Anal. Matlab file
 - From CTF folder (MEG)
 - From ERPSS .RAW or .RDF file
 - From INStep .ASC file
 - From 4D .m4d pdf file
 - From Procom Infinity Text File

**Tip for Biosemi users:
Use the 'BDF plugin' version
of the Biosemi BDF/EDF importer**

Sample data: basic P300 paradigm



File

SimpleOddball.set

Data

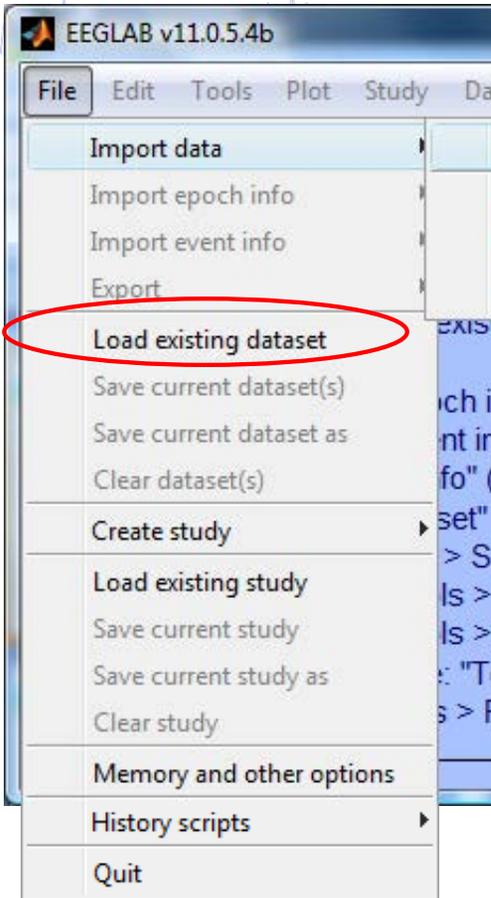
68 channel EEG, 256 Hz sampling rate, Biosemi system, re-referenced during import to averaged left and right mastoid electrodes

Task

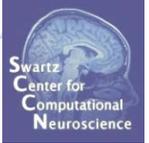
speeded button press response to star shape (no response to circle shape), 100 ms presentation duration, 200 trials



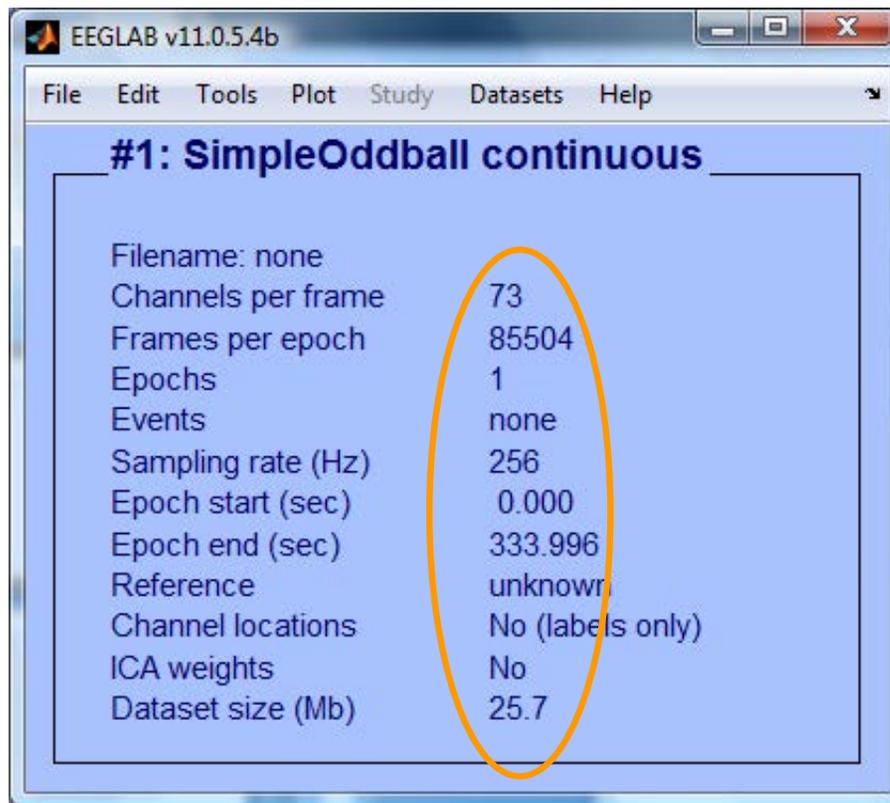
Load a dataset

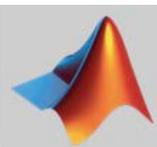


Load "SimpleOddball.set"



Imported EEG data





EEG structure



```
VARIABLE
/Users > jri > Documents > matlab > matlab >
>> EEG
EEG =
  struct with fields:
    setname: 'Simple Oddball'
    filename: 'SimpleOddball.set'
    filepath: '/Users/jri/Documents/ Research/Presentations/EEGLAB/2017 EEGLAB Israel/E...'
    subject: ''
    group: ''
    condition: ''
    session: []
    comments: [19x53 char]
    nbchan: 66
    trials: 1
    pnts: 85504
    srate: 256
    xmin: 0
    xmax: 334
    times: [1x85504 double]
    data: [66x85504 double]
    icaact: []
    icawinv: []
    icasphere: []
    icaweights: []
    icachansind: []
    chanlocs: [1x66 struct]
    urchanlocs: []
    chaninfo: [1x1 struct]
    ref: 'common'
    event: [1x260 struct]
    urevent: [1x261 struct]
    eventdescription: {'' '' ''}
    epoch: []
    epochdescription: {}
    reject: [1x1 struct]
    stats: [1x1 struct]
    specdata: []
    specicaact: []
    splinefile: ''
    icasplinefile: ''
    dipfit: []
    history: '...'
    saved: 'yes'
    etc: [1x1 struct]
    datfile: 'SimpleOddball.fdt'
```

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

Also:

>> EEG.comments

and

>> EEG.history

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)

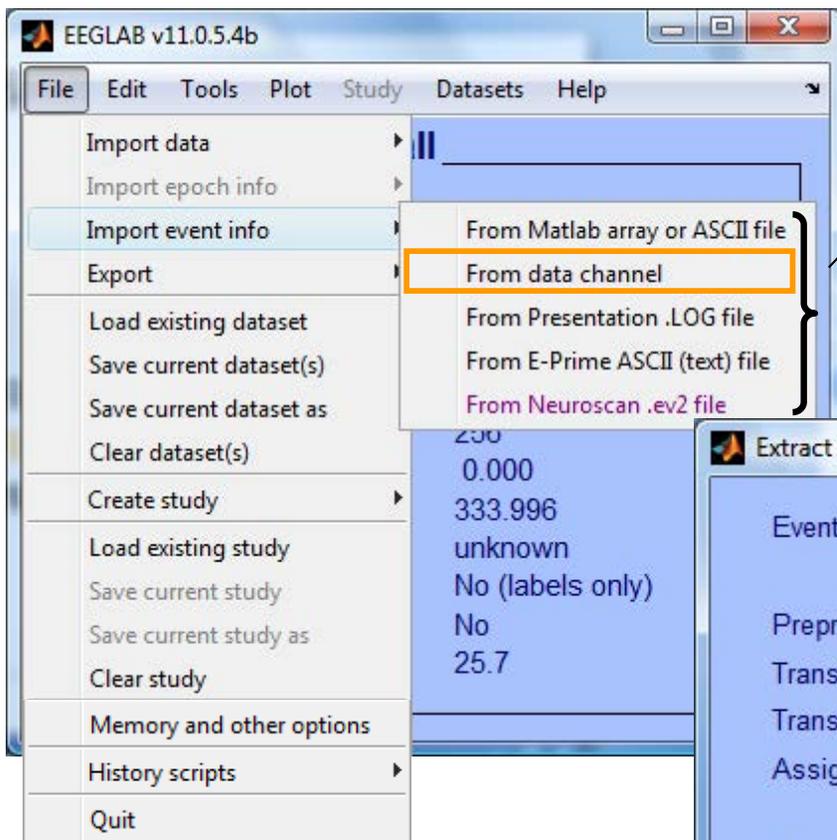
Remove line noise
(if necessary)

Identify/reject
bad channels

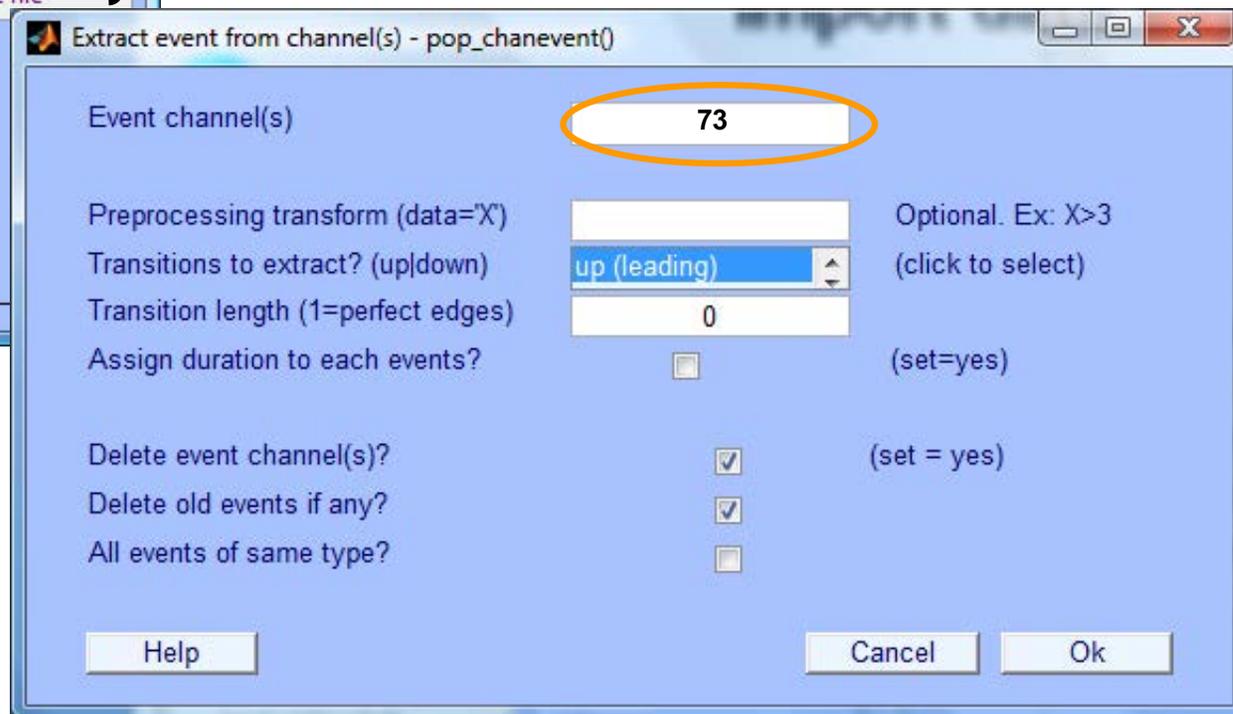
Reject large artifact
time points

Run ICA

Import data events

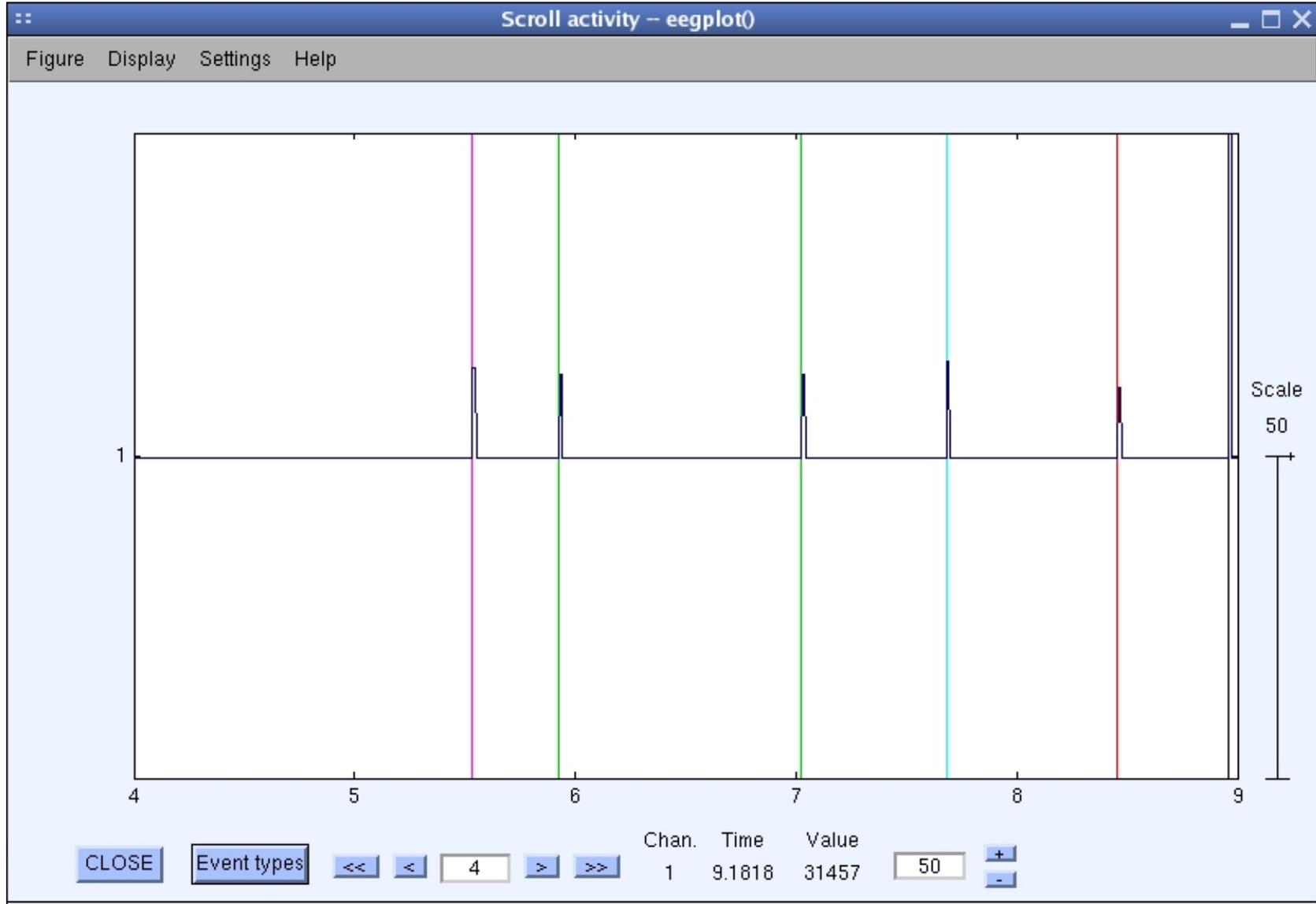


- Import events from Matlab array or ASCII file
- **Import events from data channel**
- Import from Presentation event file
- Import events from E-Prime event file
- Import events from Neuroscan event file

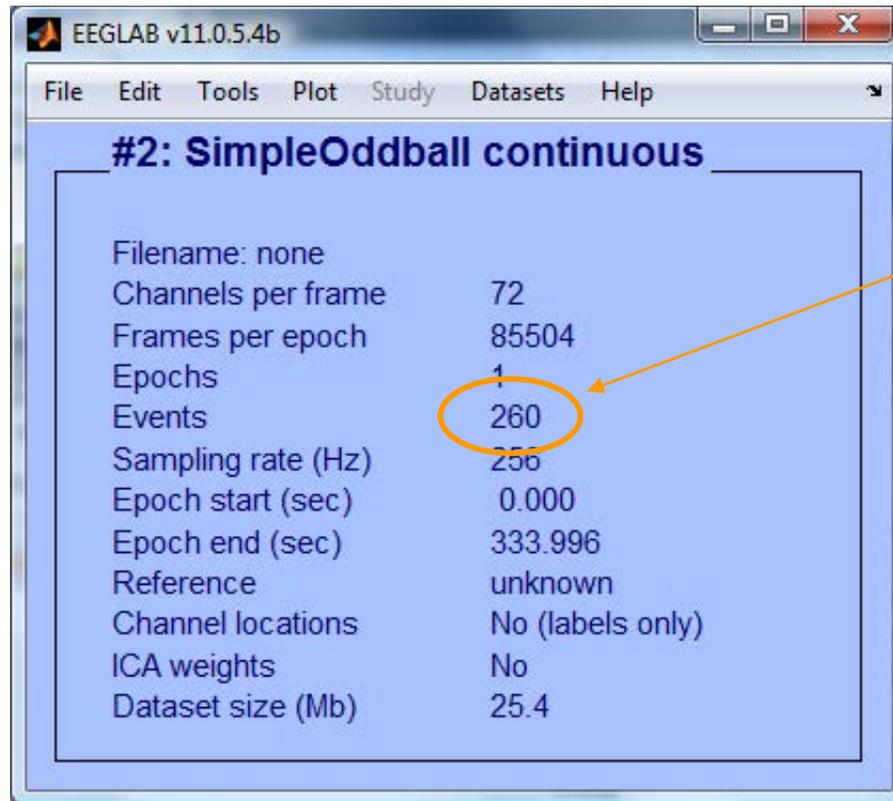
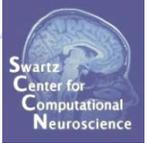


(Often imported automatically
during data import)

Appearance of an event channel in raw data



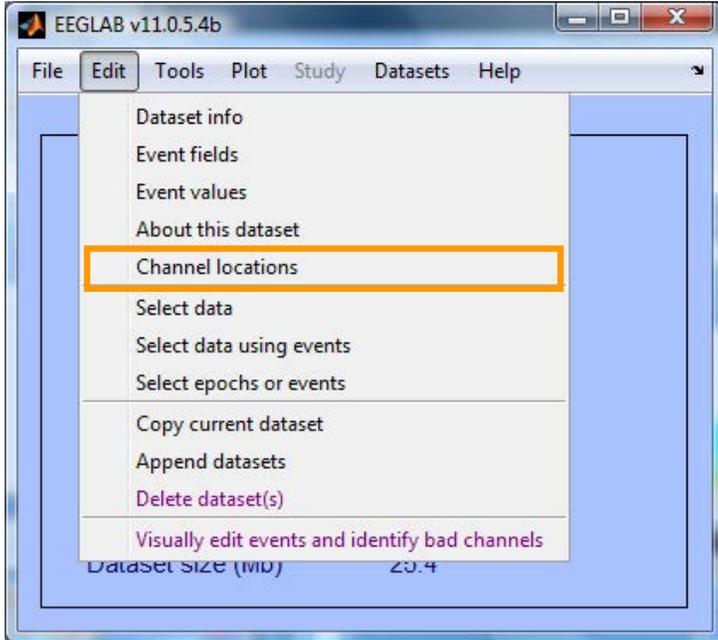
Imported data events



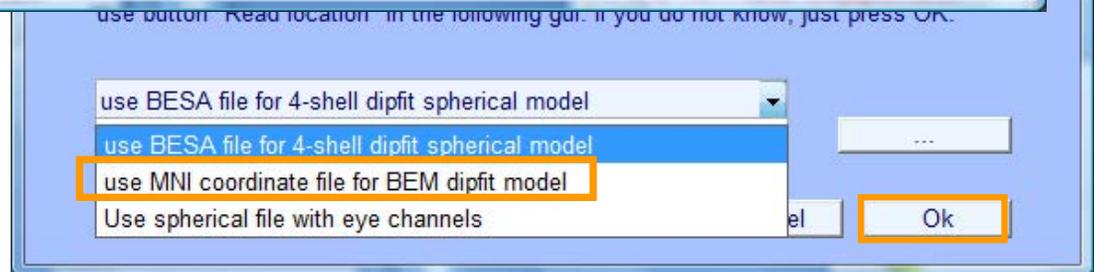
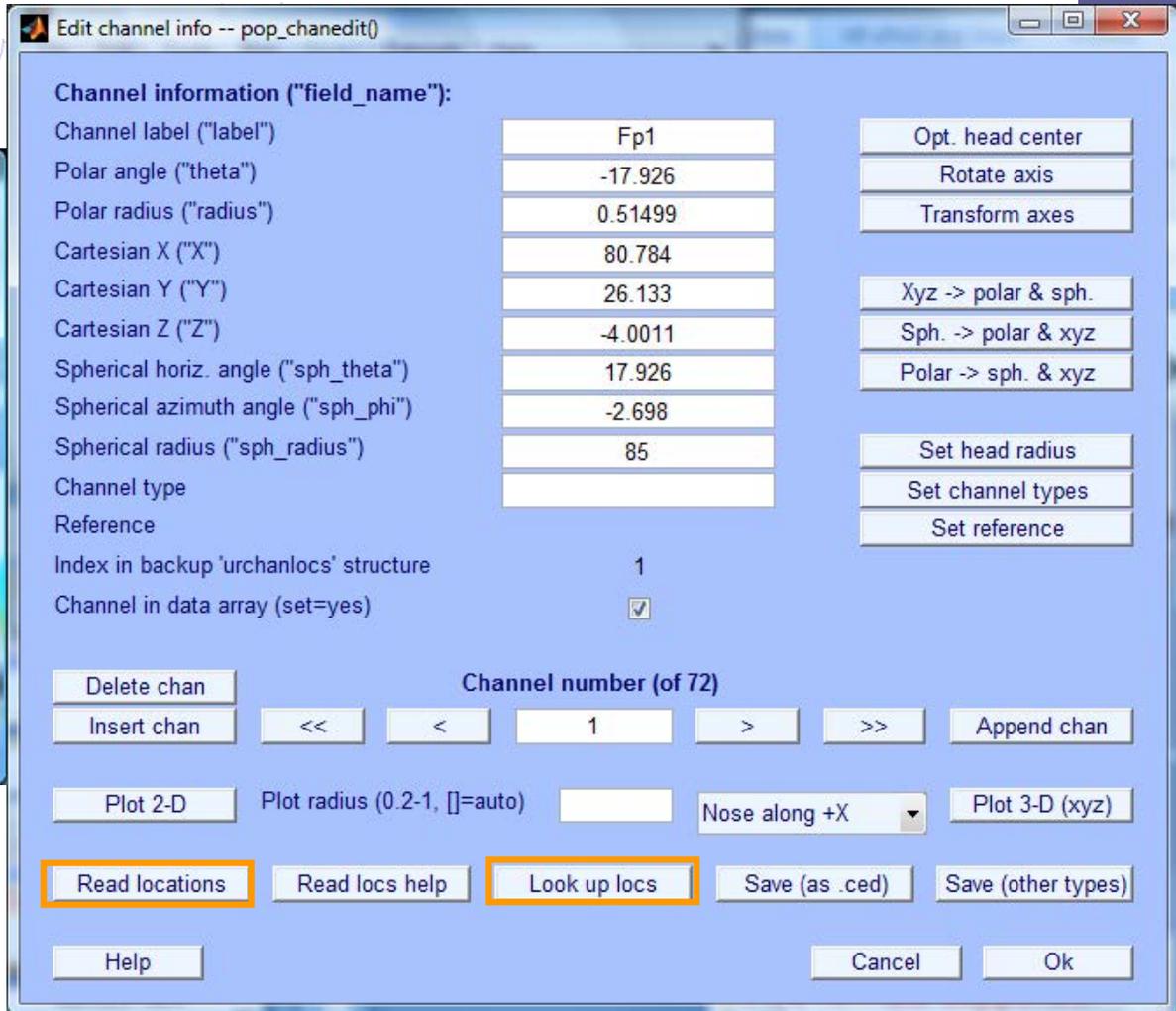
If event import was successful, you will see an appropriate number here



Import channel locations



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



Import channel locations



Edit channel info -- pop_chanedit()

Channel information ("field_name"):

Channel label ("label")	LEYE
Polar angle ("theta")	-45.1543
Polar radius ("radius")	0.54374
Cartesian X ("X")	0.79487
Cartesian Y ("Y")	0.79917
Cartesian Z ("Z")	-0.15585
Spherical horiz. angle ("sph_theta")	45.1543
Spherical azimuth angle ("sph_phi")	-7.8725
Spherical radius ("sph_radius")	1.1379
Channel type	EEG
Reference	
Index in backup 'urchanlocs' structure	
Channel in data array (set=yes)	<input checked="" type="checkbox"/>

Buttons: Delete chan, Insert chan, Plot 2-D, Read locations, Help

Channel number (of 71)

Buttons: <<, <, 1, >, >>, Append chan

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

Buttons: Read locs help, Look up locs, Save (as .ced), Save (other types), Cancel, Ok

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

Convert channel locations -- pop_chancenter()

Optimize center location or specify center

Channel indices to ignore for best-sphere matching

Buttons: Help, Browse, Cancel, Ok

Force electrode location -- forcelocs()

XY value	Coordinate	Electrode list
0	X (rotate X-Z plane)	Cz

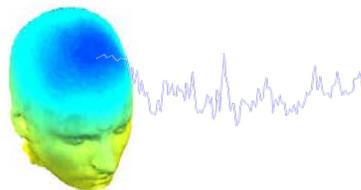
Buttons: Help, Pick, Cancel, Ok

Set channel ...

Channel indices

Type (e.g. EEG)

Buttons: Help, Cancel, Ok



Edit channel info -- pop_chanedit()

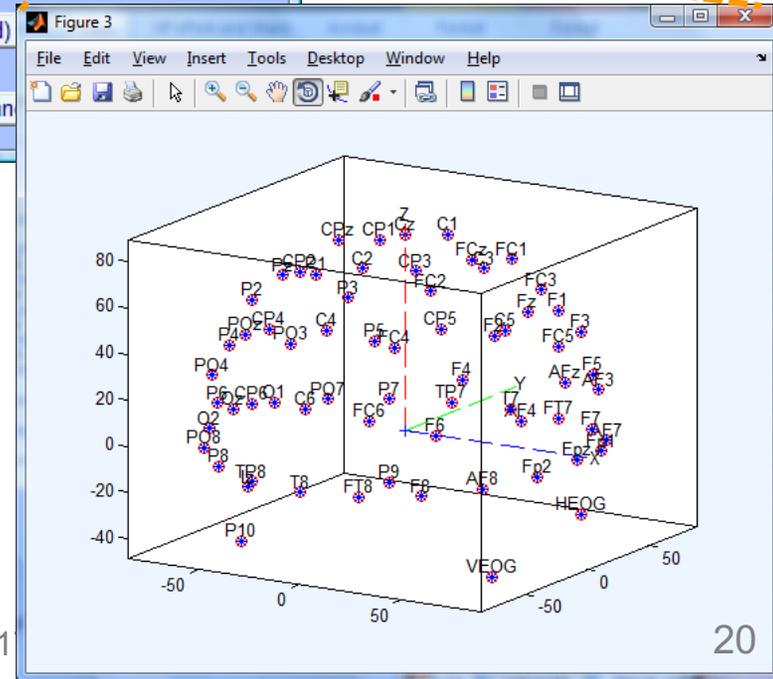
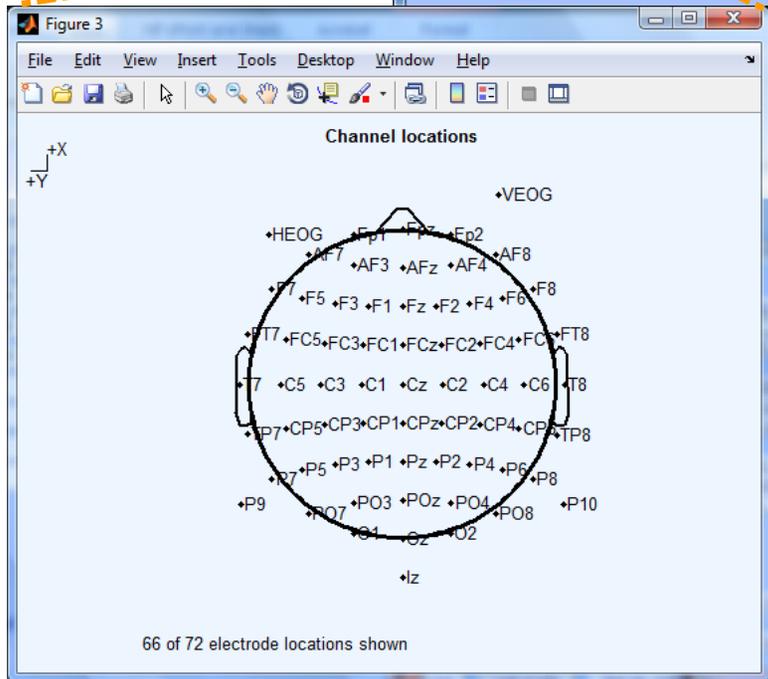
Channel information ("field_name"):

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)	<input checked="" type="checkbox"/>	

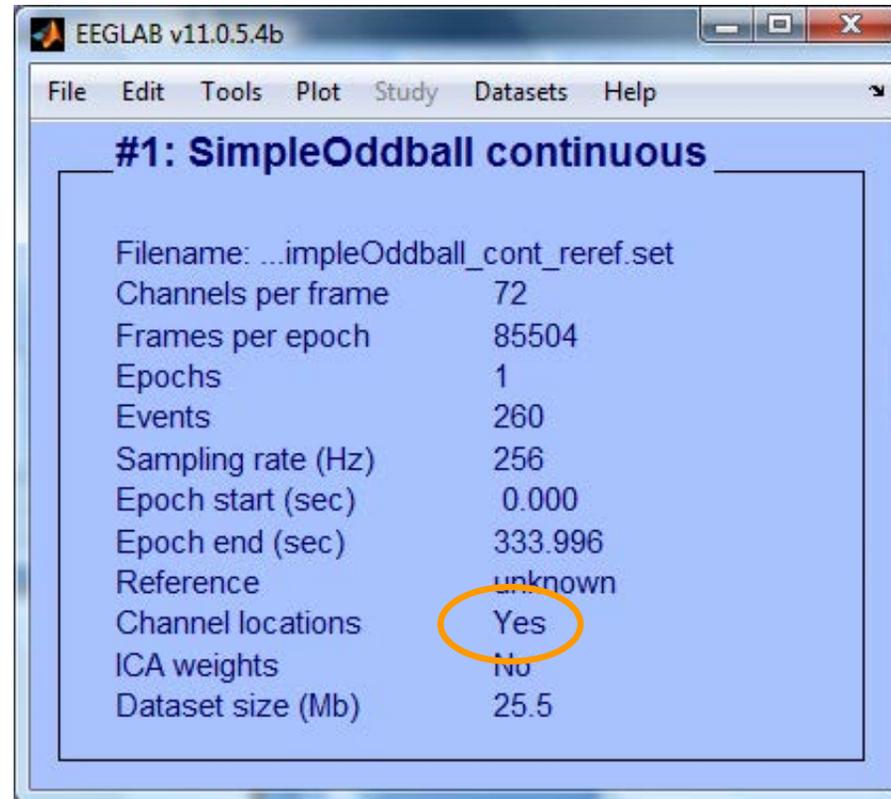
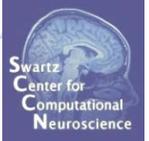
Channel number (of 72): 68

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



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)

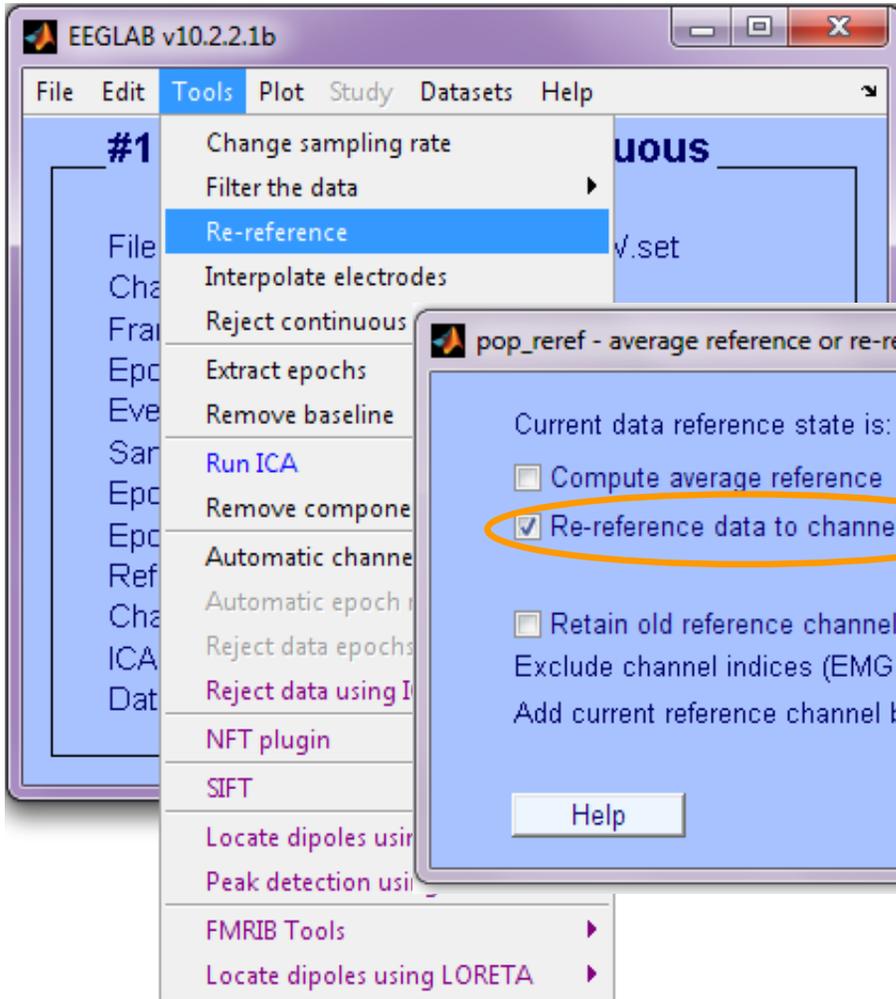
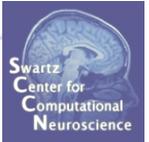
Remove line noise
(if necessary)

Identify/reject
bad channels

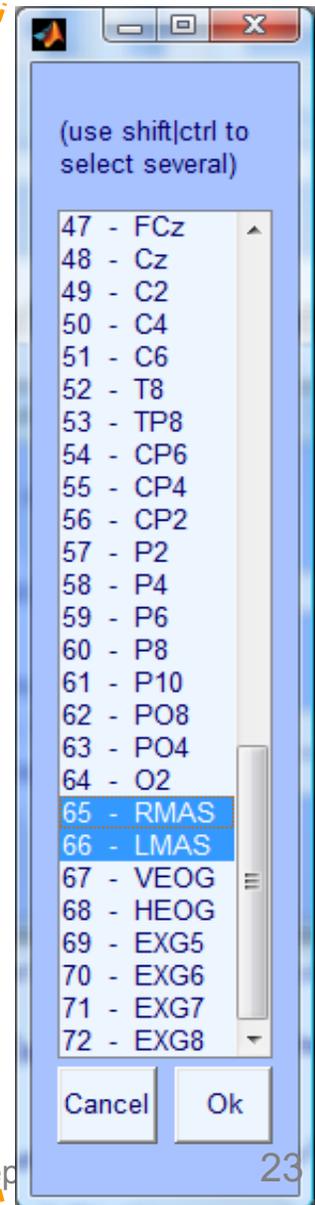
Reject large artifact
time points

Run ICA

Re-reference data (if necessary/desired)



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



Re-reference data (if necessary/desired)



EEGLAB v10.2.2.1b

File Edit **Tools** Plot Study Datasets Help

#1

Change sampling rate

Filter the data

Re-reference

Interpolate electrodes

Reject continuous data

Extract epochs

Remove baseline

Run ICA

Remove component

Automatic channel selection

Automatic epoch rejection

Reject data epochs

Reject data using ICA

NFT plugin

SIFT

Locate dipoles using MNE

Peak detection using EEG toolbox

FMRIB Tools

Locate dipoles using LORETA

Or,
average reference

pop_reref - average reference or re-reference data

Current data reference state is: unknown

Compute average reference

Re-reference data to channel(s):

Retain old reference channels in data

Exclude channel indices (EMG, EOG) optional VEOG HEOG

Add current reference channel back to the data

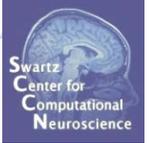
Help Cancel Ok

(use shift|ctrl to select several)

- 31 - Pz
- 32 - CPz
- 33 - Fpz
- 34 - Fp2
- 35 - AF8
- 36 - AF4
- 37 - AFz
- 38 - Fz
- 39 - F2
- 40 - F4
- 41 - F6
- 42 - F8
- 43 - FT8
- 44 - FC6
- 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**

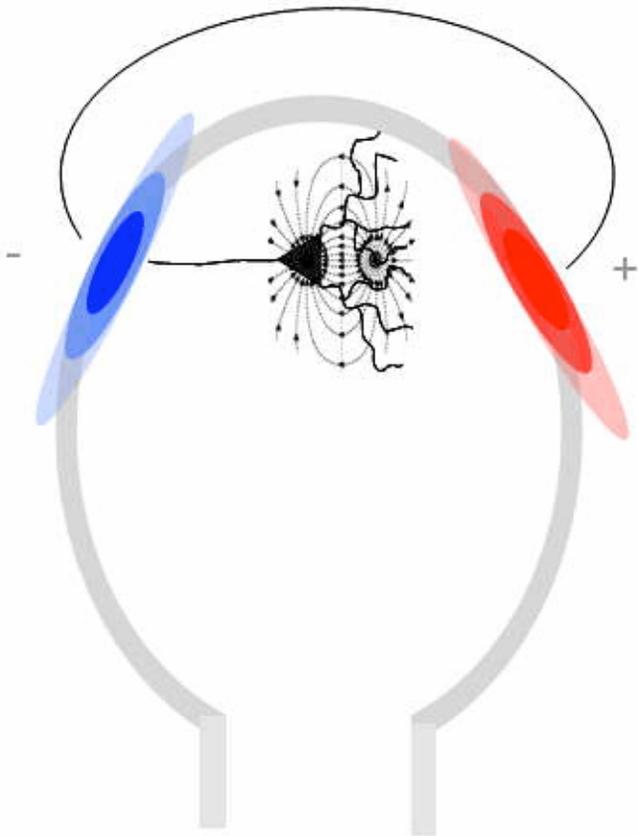
Cancel Ok

On Average Referencing

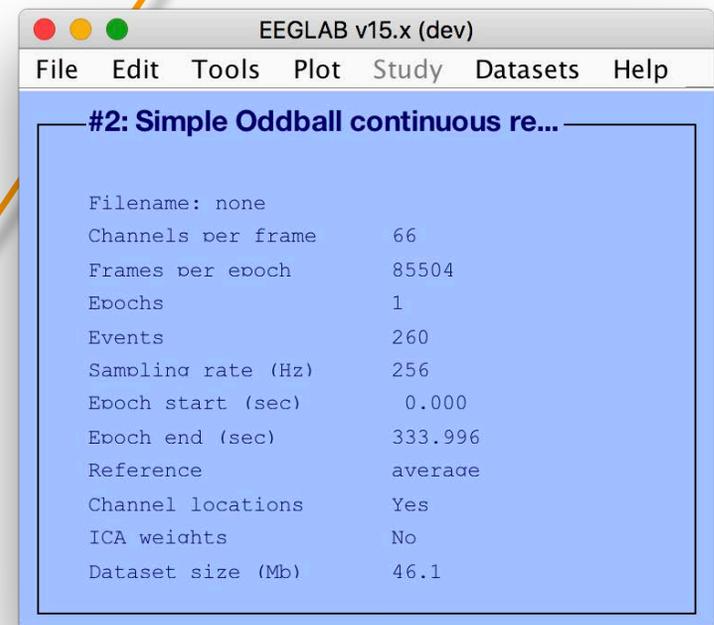
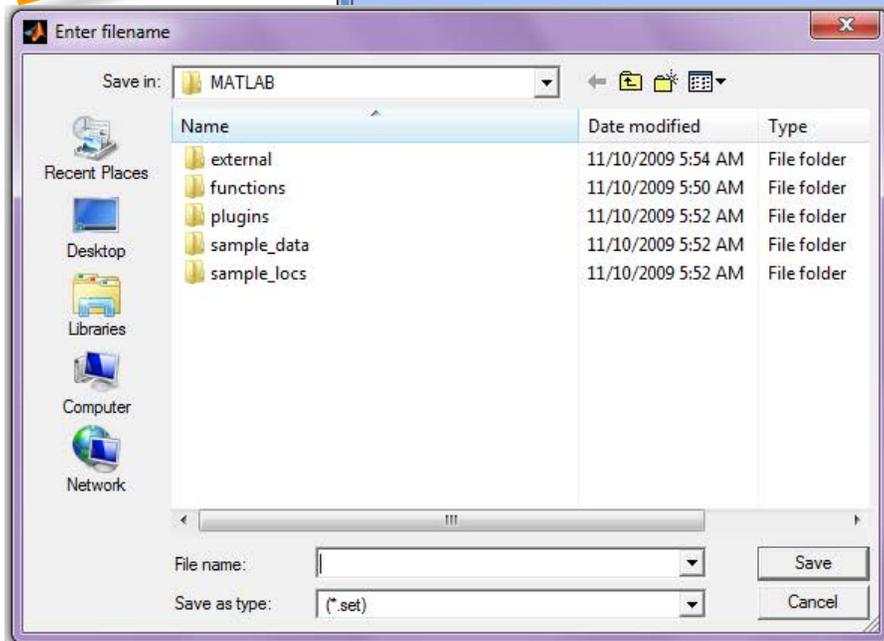
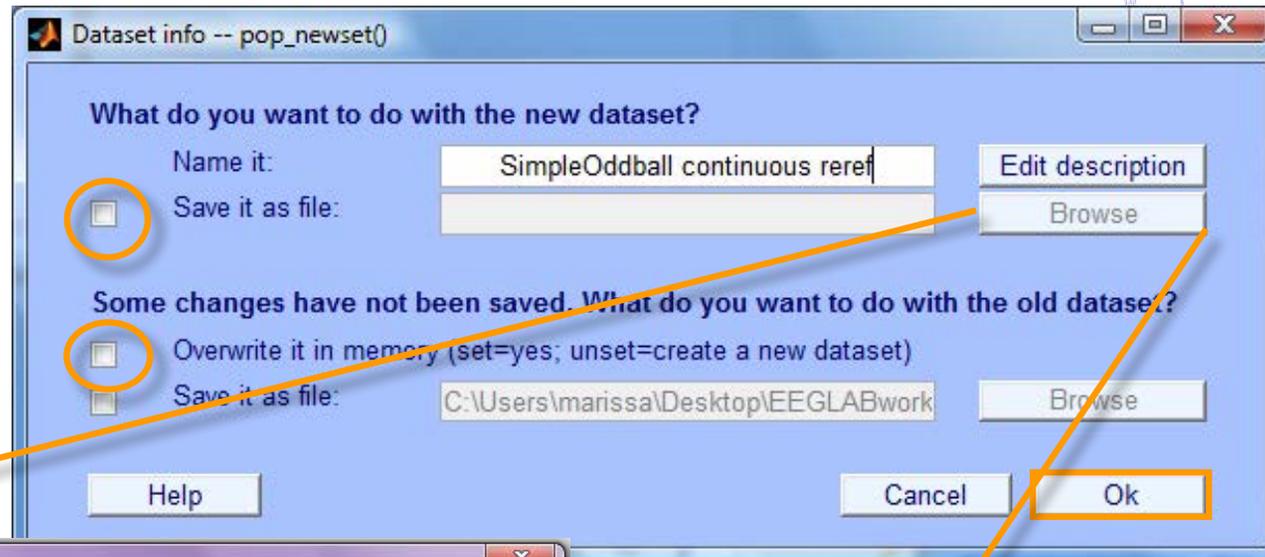


In theory, positive and negative current across entire head should balance—no net current source or sink: Average referencing enforces this.

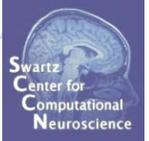
In practice, depends on distribution of electrodes.



Save new dataset, keep old one



Multiple active datasets (ALLEEG)



EEGLAB v15.x (dev)

File Edit Tools Plot Study **Datasets** Help

#2: Simple Oddball continuous reref

Dataset 1: Simple Oddball
✓ Dataset 2: Simple Oddball continuous reref

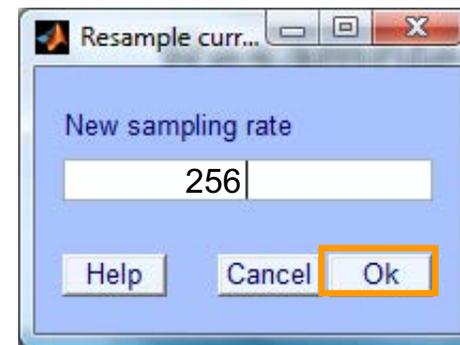
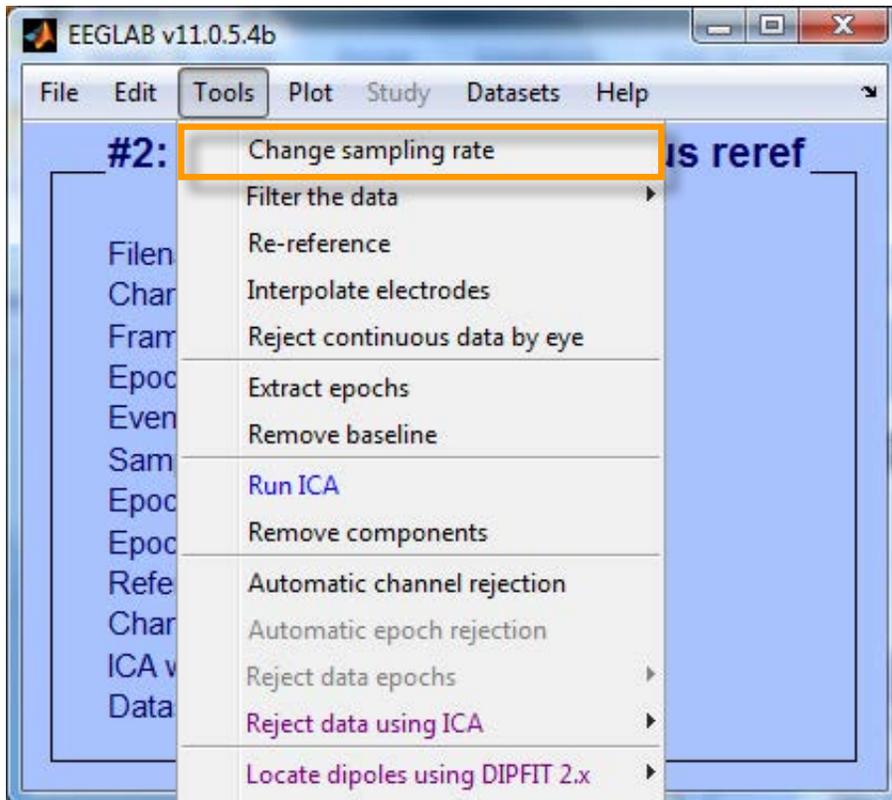
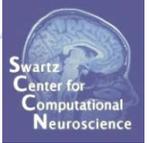
Select multiple datasets

Filename: none
Channels per frame 66
Frames per epoch 85504
Epochs 1
Events 260
Sampling rate (Hz) 256
Epoch start (sec) 0.000
Epoch end (sec) 333.996
Reference **average**
Channel locations Yes
ICA weights No
Dataset size (Mb) 46.1

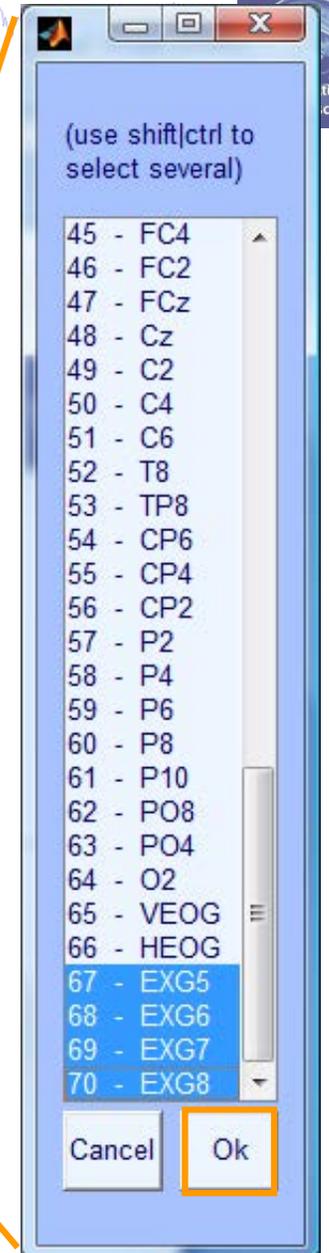
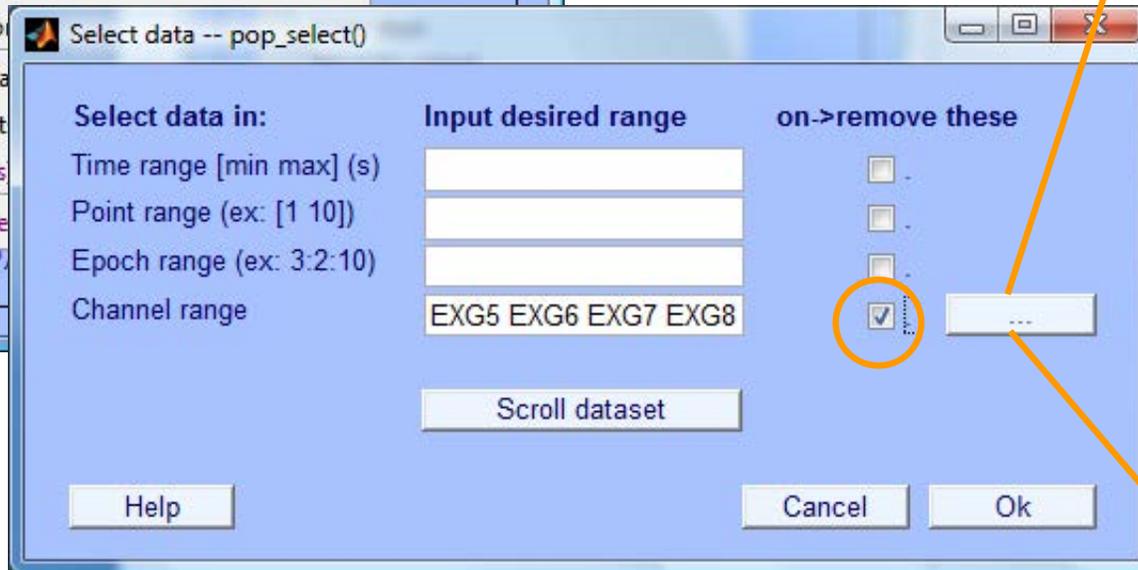
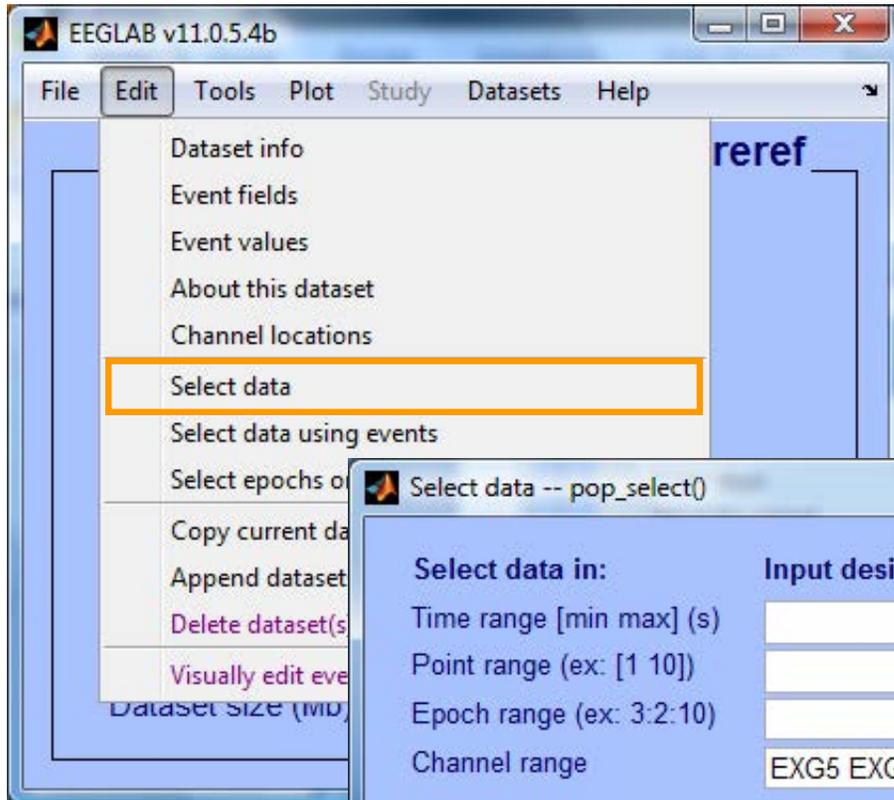
Resample data (if desired)



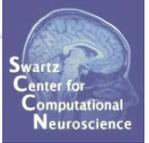
Reason: Reduce space, time. But keep nyquist and ICA data length requirements in mind...



Remove unwanted channels



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)

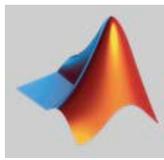
STOP!
*Save your continuous dataset here
(at least!)*

Remove line noise
(if necessary)

Identify/reject
bad channels

Reject large artifact
time points

Run ICA



EEG.history



- `EEG = pop_readbdf('C:\Users\...\tb_stars_199.bdf', [1 334] ,73,[65 66]);`
- `EEG.setname='Simple Oddball';`
- `EEG = pop_select(EEG, 'nochannel', {'EXG1' 'EXG2' 'EXG5' 'EXG6' 'EXG7' 'EXG8'});`
- `EEG = pop_chanedit(EEG, 'lookup', ...`
- `EEG=pop_loadset('filename','SimpleOddball.set','filepath','C:\\Users\\marissa\\Desktop\\EEGLABworkshop\\Data\\');`
- `EEG.comments = pop_comments('', '', strcat('Data recorded by Marissa Westerfield'...`
- `EEG = pop_selectevent(EEG, 'type',[1 2 201] , 'deleteevents','on');`
- Today
- `EEG = pop_loadset('filename','SimpleOddball.set',
'filepath','/Users/jri/Documents/ Research/Presentations/EEGLAB/2017 EEGLAB
Israel/EEG_data/');`

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)

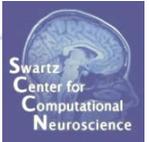
Remove line noise
(if necessary)

Identify/reject
bad channels

Reject large artifact
time points

Run ICA

High-Pass Filter the data



Reason: remove slow, possibly large amplitude, drift

The screenshot shows the EEGLAB v11.0.5.4b interface. The 'Tools' menu is open, and 'Filter the data' is selected. The 'Filter the data -- pop_eegfilt()' dialog box is open, showing the 'Lower edge of the frequency pass band (Hz)' set to 0.5. A red arrow points to the 0.5 value with the text 'High-pass needed for ICA'. The 'Dataset info -- pop_newset()' dialog box is also open, showing the 'Name it:' field set to 'SimpleOddball hipass0.5' and the 'Overwrite it in memory' checkbox checked. The 'Ok' button in the 'Dataset info' dialog is highlighted with an orange box.

Pre-processing pipeline



Collect high-density EEG data (>30 chan)

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(if necessary)

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(~.5 – 1 Hz)

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bad channels

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time points

Run ICA



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
 - Manage data import plugins
 - Manage data processing plugins
 - Manage deactivated plugins
- Quit

Plugins available for install on the internet

Install	Plugin	Version	Description	Doc
<input type="checkbox"/>	ERPLABfilters	1.00	Interface ERPLAB filters (requires separate ERPLAB instalati...	Doc
<input type="checkbox"/>	Cleanline	1.21	Automatic artifact rejection	Doc
<input type="checkbox"/>	BERGEN	1.1	Removal of fMRI-related gradient artifacts from simultaneous...	Doc

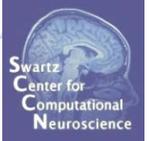
Update Deactivate

Installed plugins

Update	Deactivate	Plugin	Version	Description	Doc
<input type="checkbox"/>	<input type="checkbox"/>	brainmovie	0.1	Brainmovies (command line only)	Doc
<input type="checkbox"/>	<input type="checkbox"/>	corrmap	2.00	New version 1.03 available. Click update to install.	Doc
<input type="checkbox"/>	<input type="checkbox"/>	eeg_toolbox	1.0	Interface EEG toolbox functions for ERP peak detection	Doc
<input type="checkbox"/>	<input type="checkbox"/>	fMRlib	1.21	Remove fMRI artifacts from EEG	Doc
<input type="checkbox"/>	<input type="checkbox"/>	MP_clustering	1.00	Measure projection clustering of ICA components	Doc
<input type="checkbox"/>	<input type="checkbox"/>	MutualInfoClustering	1.00	Mutual information clustering	Doc
<input type="checkbox"/>	<input type="checkbox"/>	StudyEnvtopo	0.9	Add envtopo capabilities to STUDY	Doc
<input type="checkbox"/>	<input type="checkbox"/>	VisEd	1.05	New version 1.04 available. Click update to install.	Doc
<input type="checkbox"/>	<input type="checkbox"/>	iirfilt	1.02	Non linear filtering	Doc
<input type="checkbox"/>	<input type="checkbox"/>	loreta	1.1	New version 1.0 available. Click update to install.	Doc

Cancel Ok

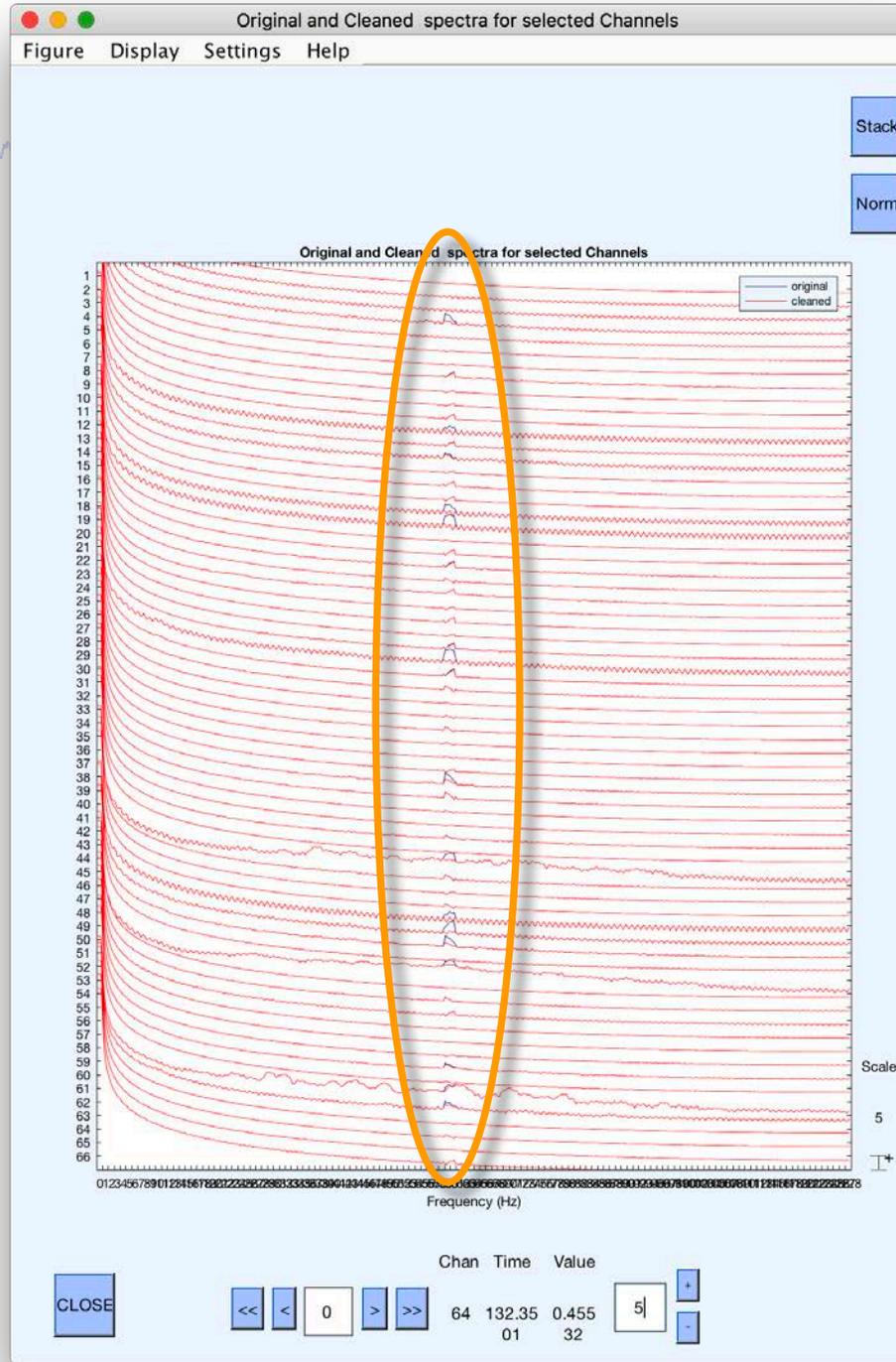
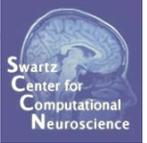
Remove line noise (Cleanline)



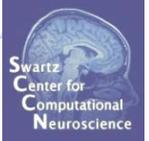
The screenshot shows the EEGLAB v11.0.5.4b interface. The 'Tools' menu is open, and 'CleanLine' is highlighted at the bottom. The 'CleanLine Options' dialog box is displayed, showing the following settings:

- 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)

A red arrow points to the 'Visualize Original and Cleaned Spectra' checkbox, which is labeled 'check' in a yellow box. The 'CleanLine' option in the menu and the 'Visualize Original and Cleaned Spectra' checkbox are also circled in orange.

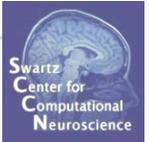


Plot channel spectra



The screenshot shows the EEGLAB v11.0.5.4b software interface. The 'Plot' menu is open, displaying various options. The 'Channel spectra and maps' and 'Channel properties' options are highlighted with orange boxes. A 'Component properties - pop_prop()' dialog box is overlaid on the right side of the screen. In this dialog box, the 'Channel index(ices) to plot' field contains the value '31', and the 'Spectral options (see spectopo() help):' field contains the value 'freqrange' with a range of '[2 90]'. Both the '31' and the range '[2 90]' are circled in orange. The dialog box also includes 'Help', 'Cancel', and 'Ok' buttons.

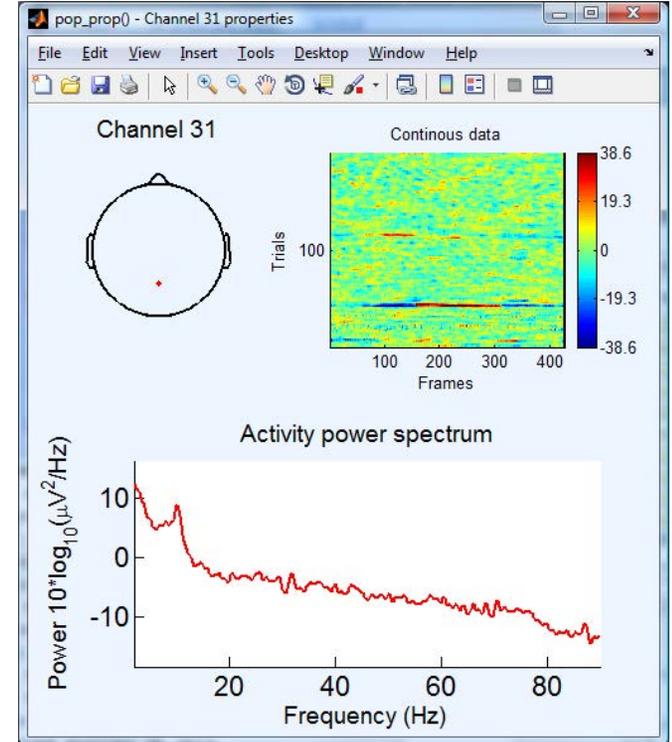
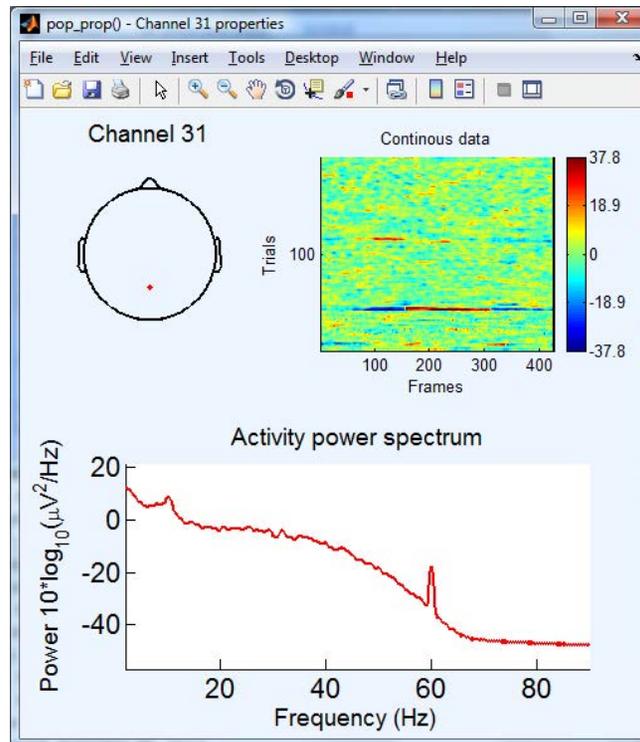
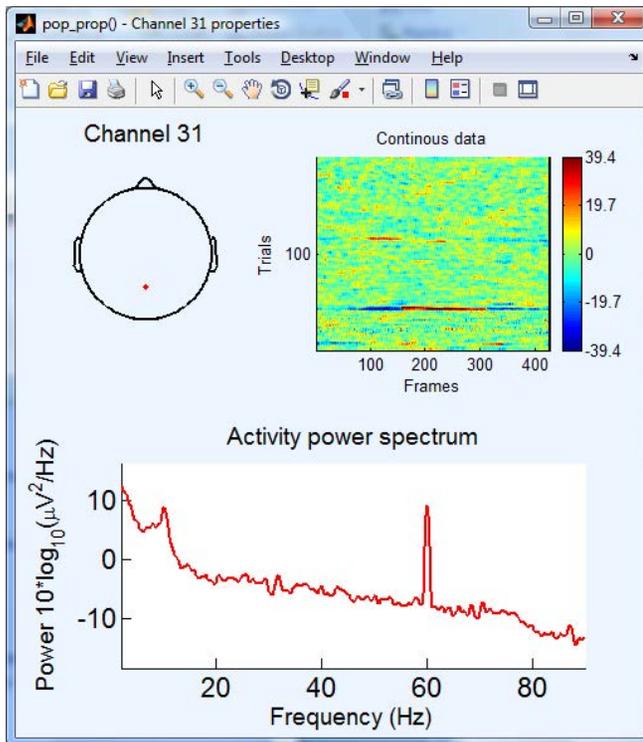
Filter comparisons



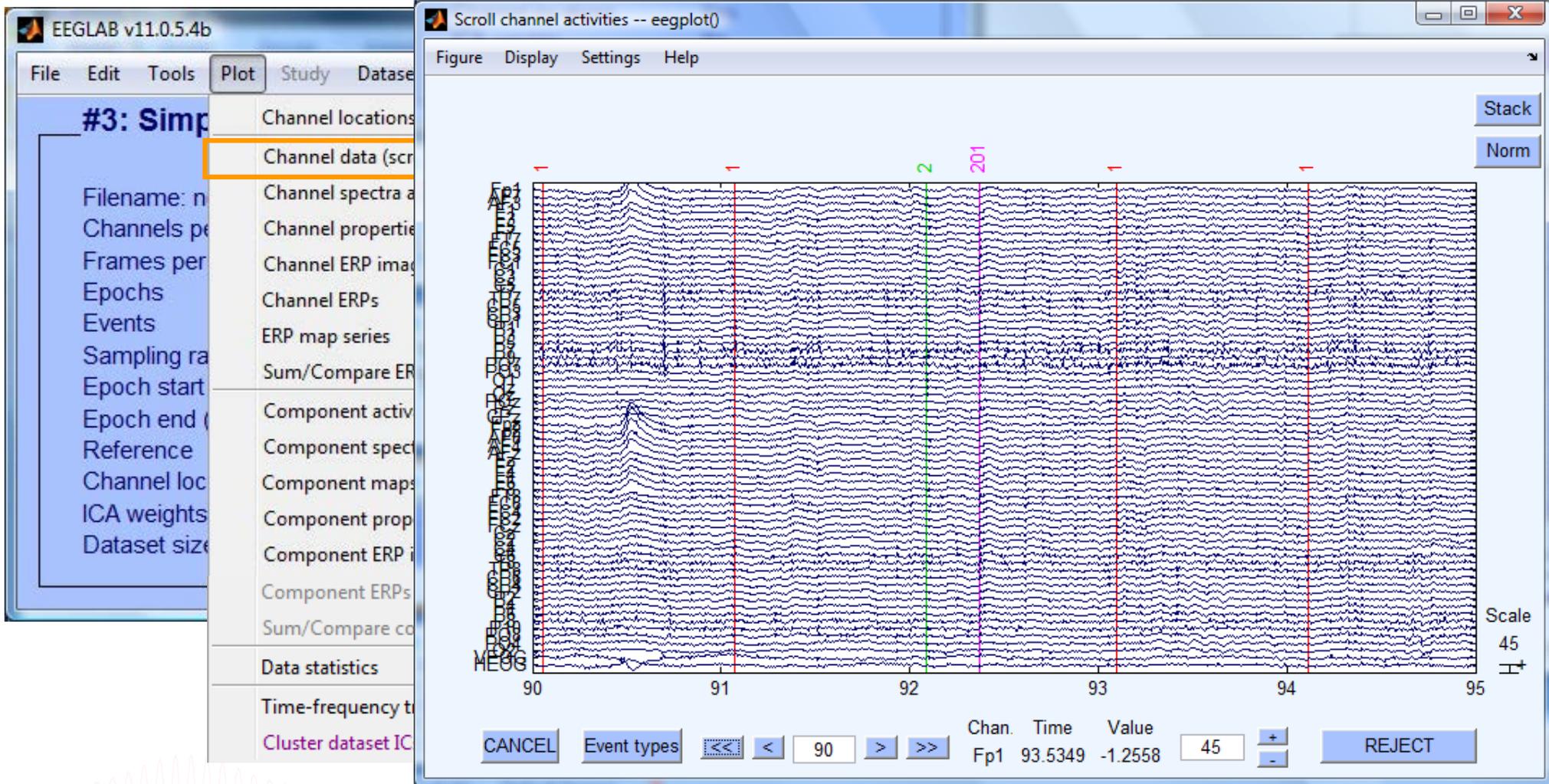
0.5 Hz high-pass filter

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

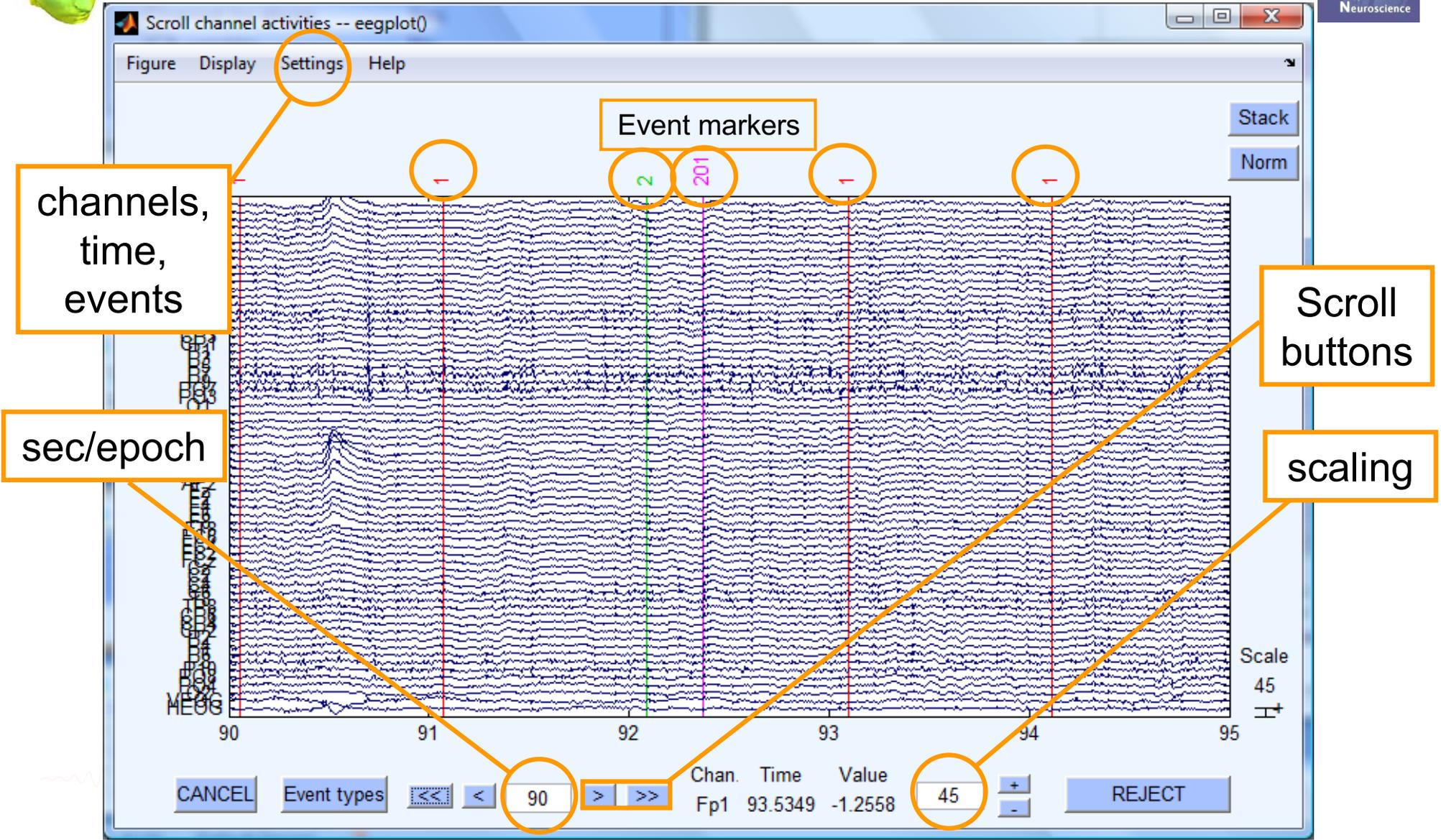
0.5 Hz high-pass filter
Cleanline



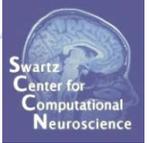
Scroll channel data



Scroll channel data



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

STOP!
Save your dataset here; if you epoch before ICA you can import ICA weights to this dataset later time points

Run ICA



Data Cleaning for ICA

Variant 1: Continuous Data



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)

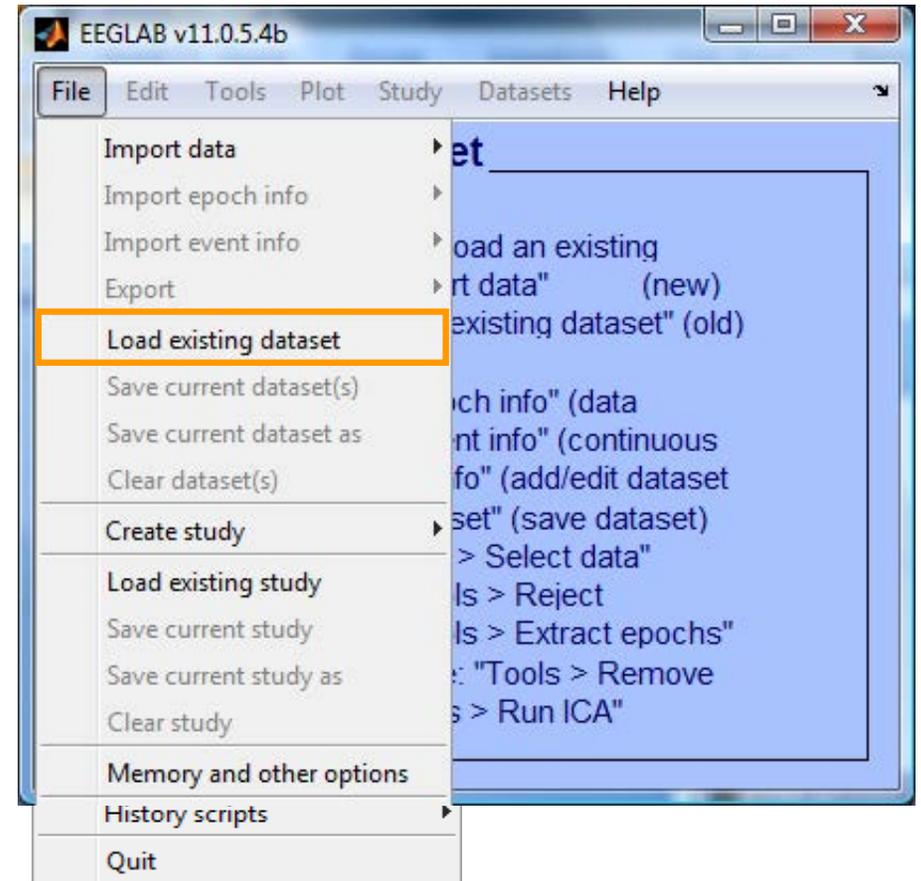
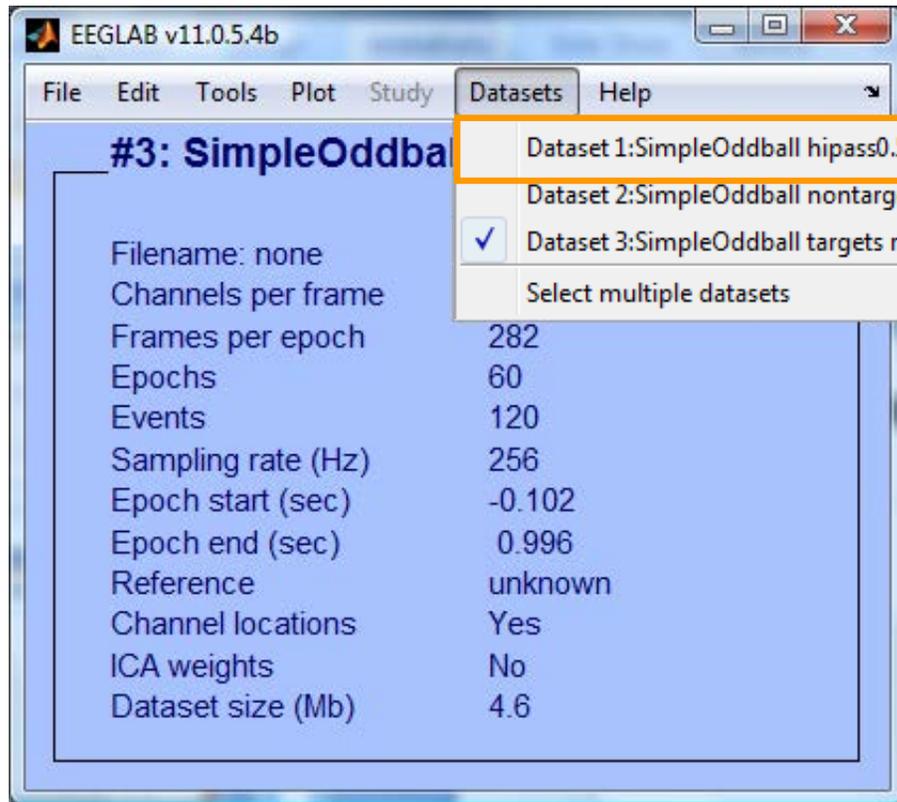
Remove line noise
(if necessary)

Identify/reject
bad channels

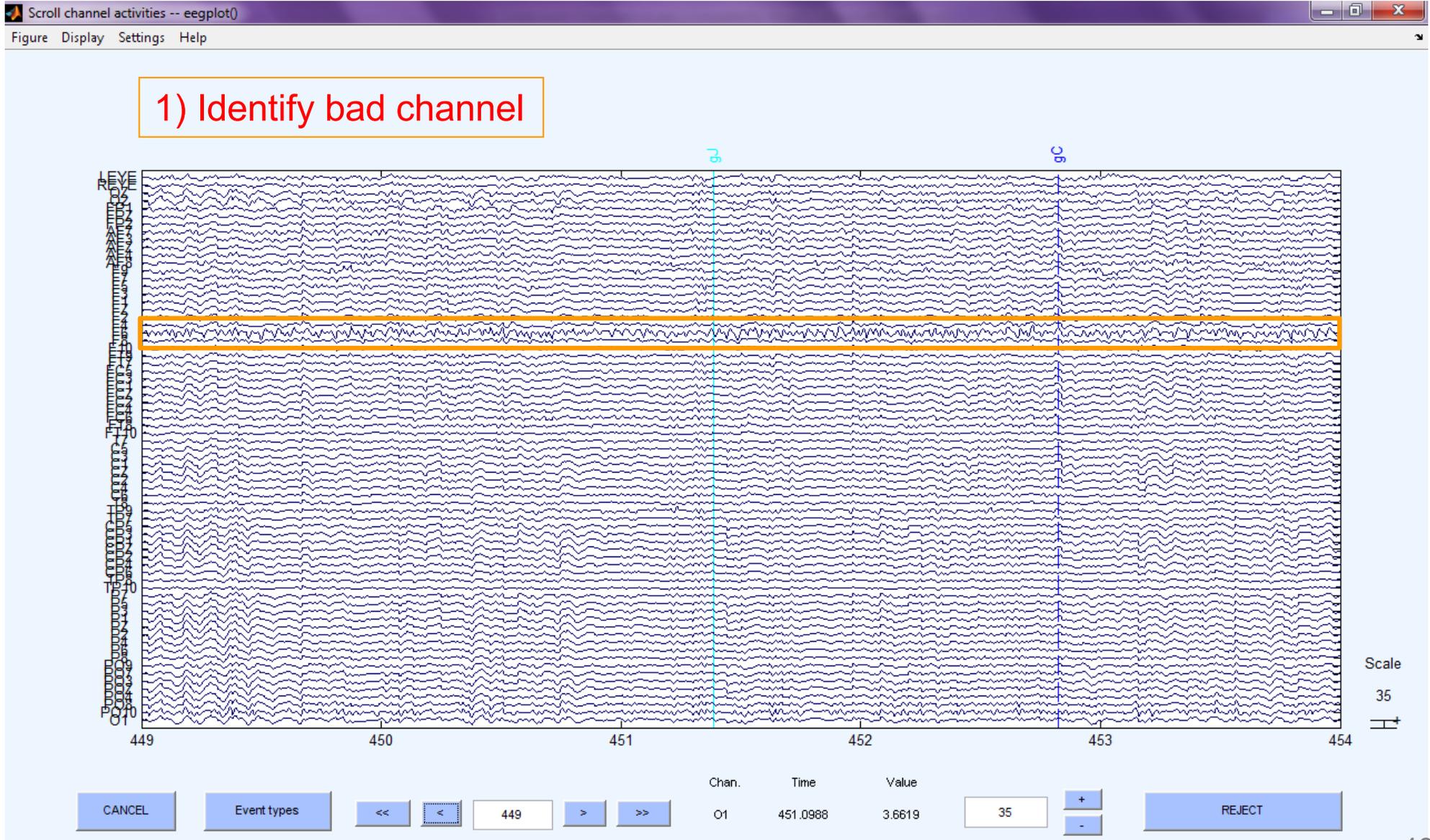
Reject large artifact
time points

Run ICA

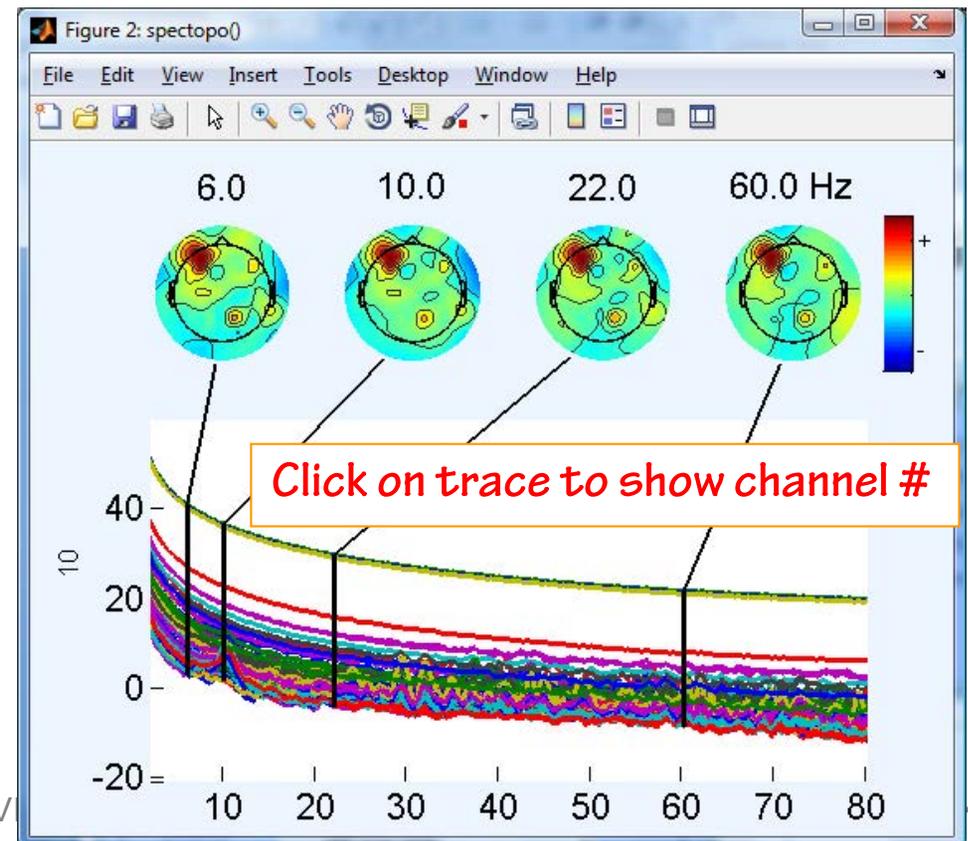
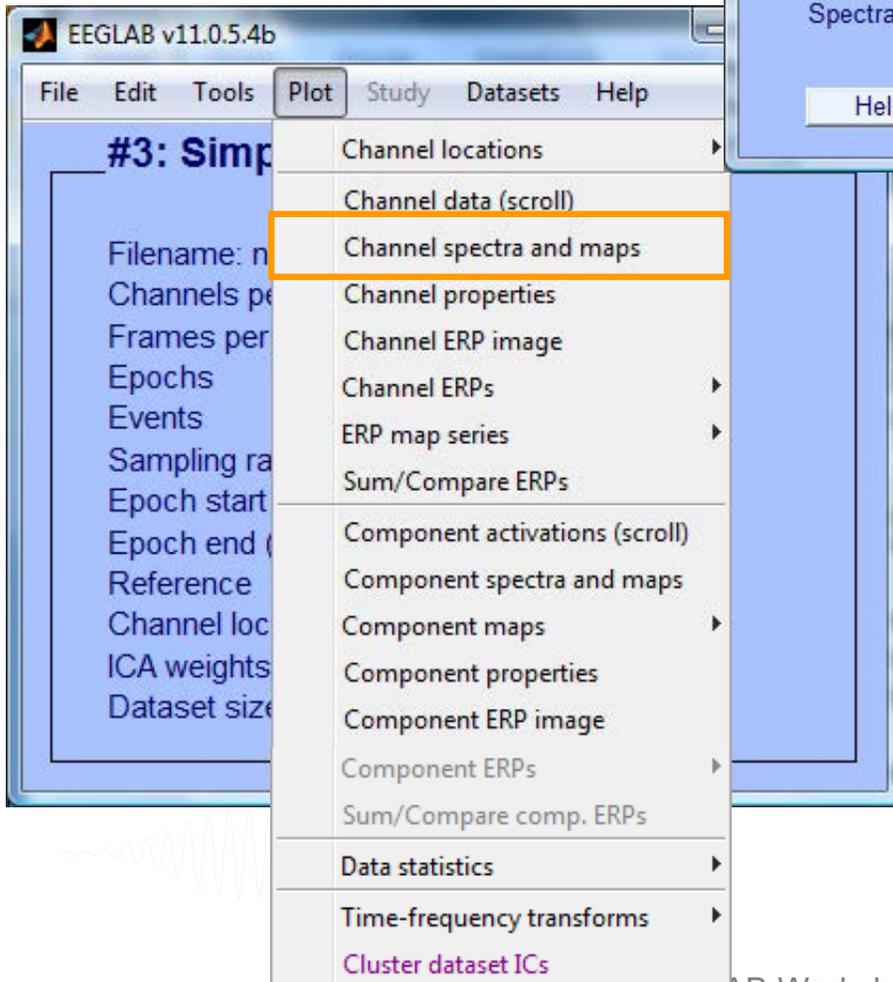
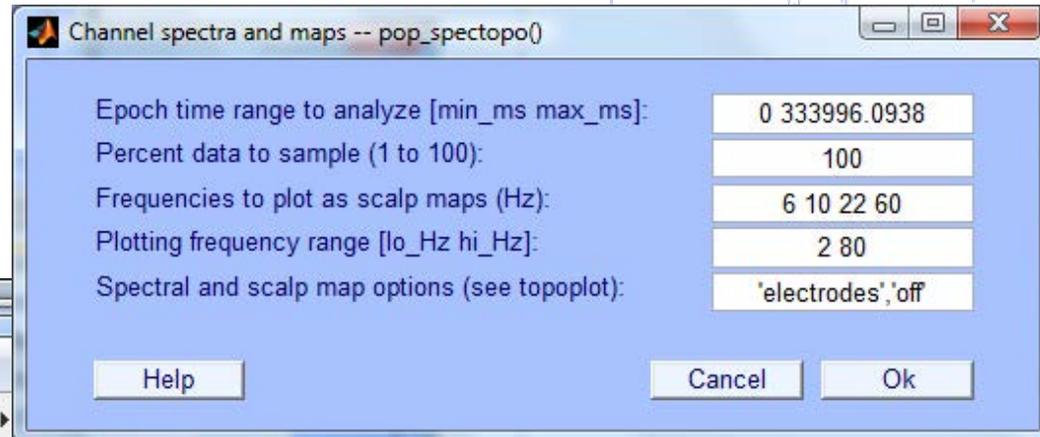
Retrieve or reload continuous EEG dataset



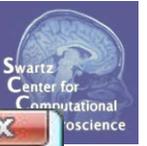
Manually identifying bad channels



Manually identifying bad channels



Manually identifying bad channels



EEGLAB v11.0.5.4b

File Edit Tools Plot Study Datasets Help

#3: Simple

Channel locations

Channel data (scroll)

Channel spectra and maps

Channel properties

Filename: n

Channels p

Frames per

Epochs

Events

Sampling ra

Epoch start

Epoch end

Reference

Channel loc

ICA weights

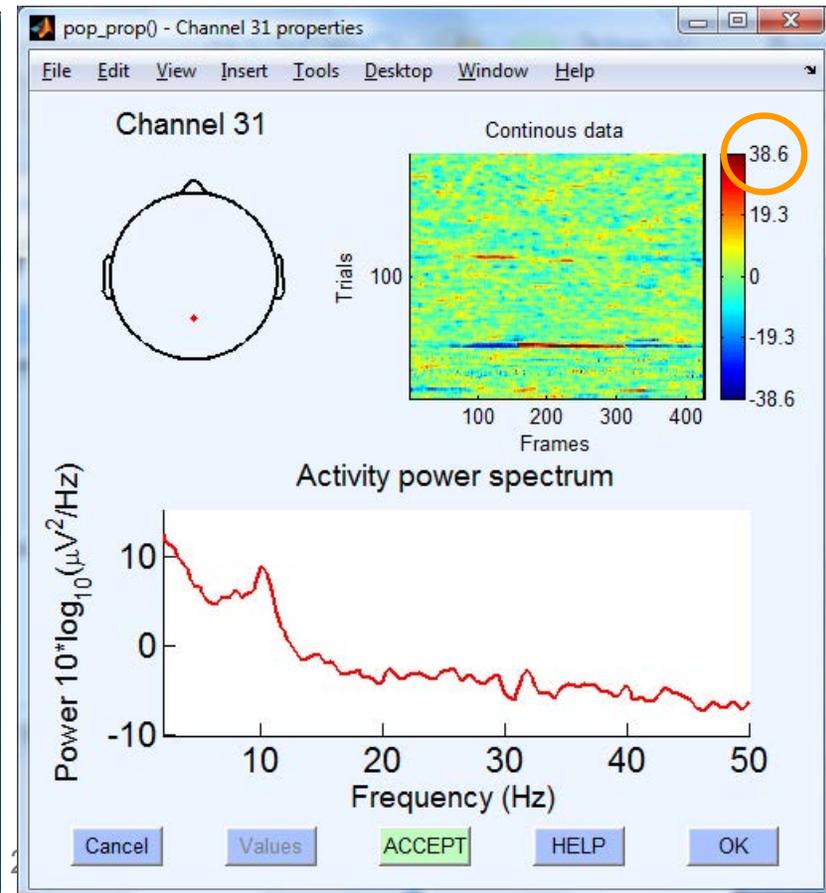
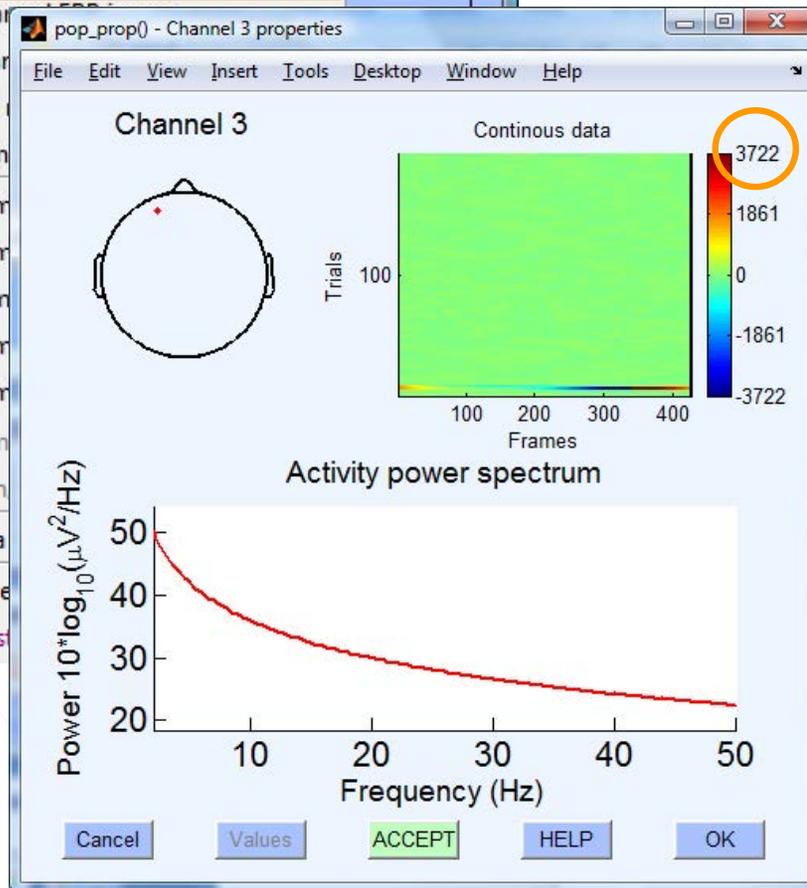
Dataset size

Component properties - pop_prop()

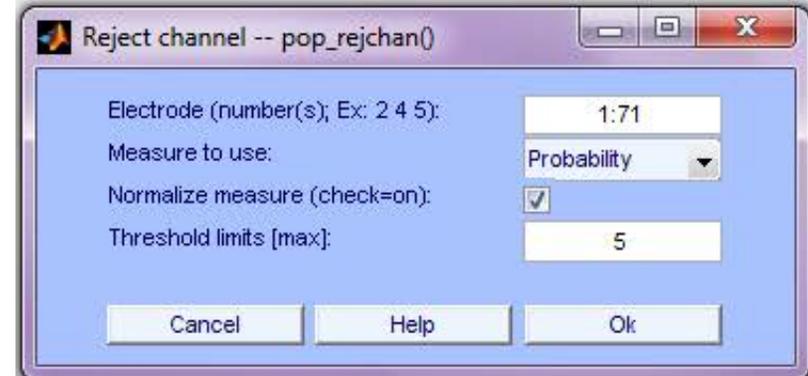
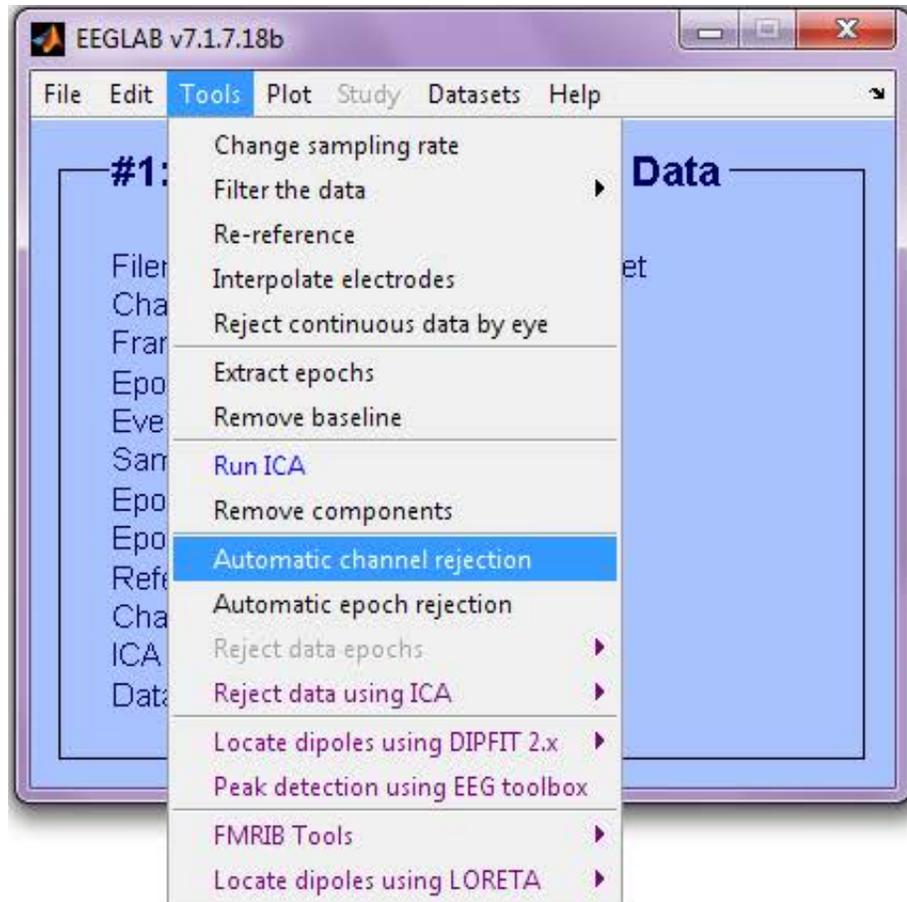
Channel index(ices) to plot: 3,31

Spectral options (see spectopo() help): 'freqrange', [2 50]

Help Cancel Ok



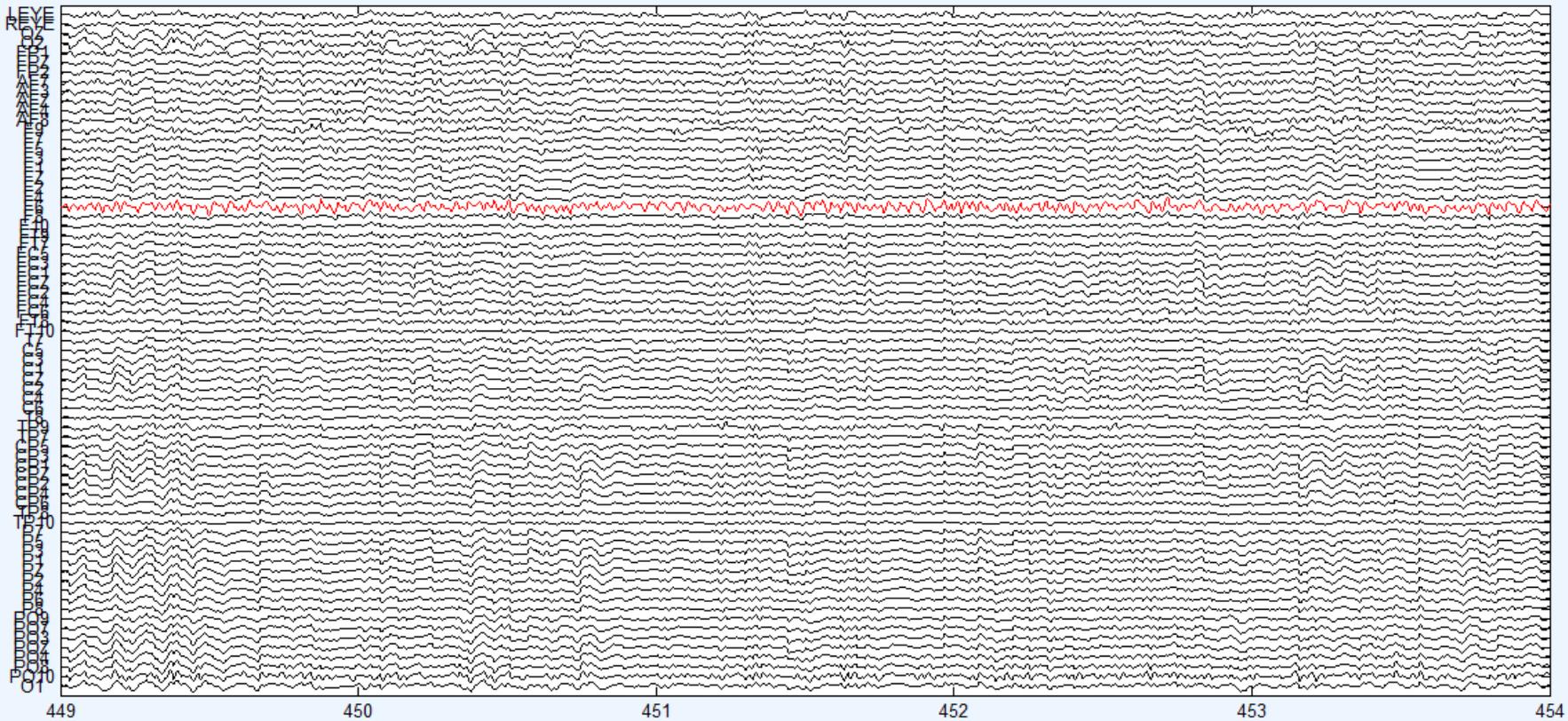
Auto-detection of noisy channels



Auto-detected noisy channel



Scroll component activities -- eegplot() - □ X
Figure Display Settings Help

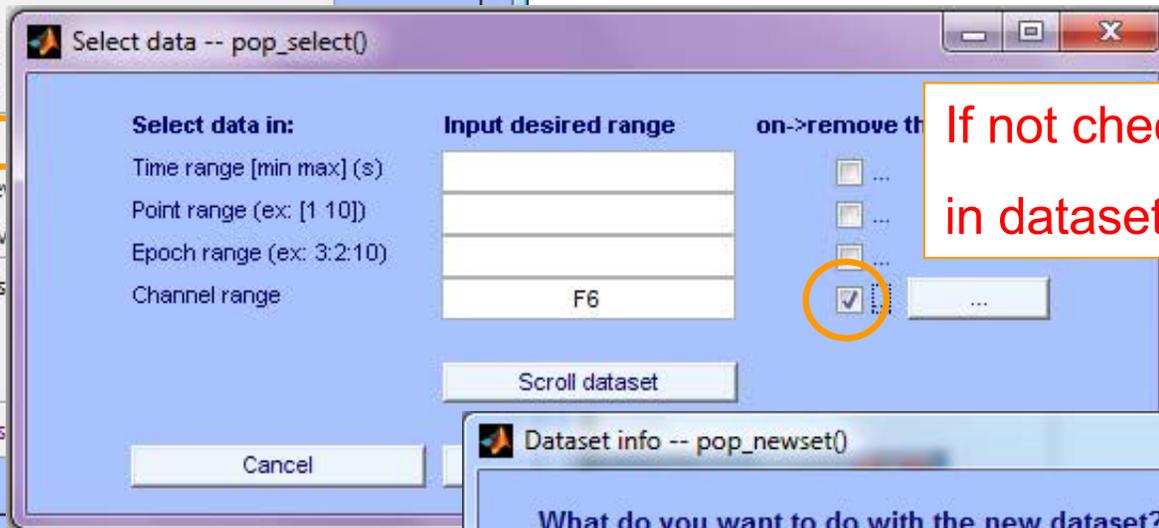
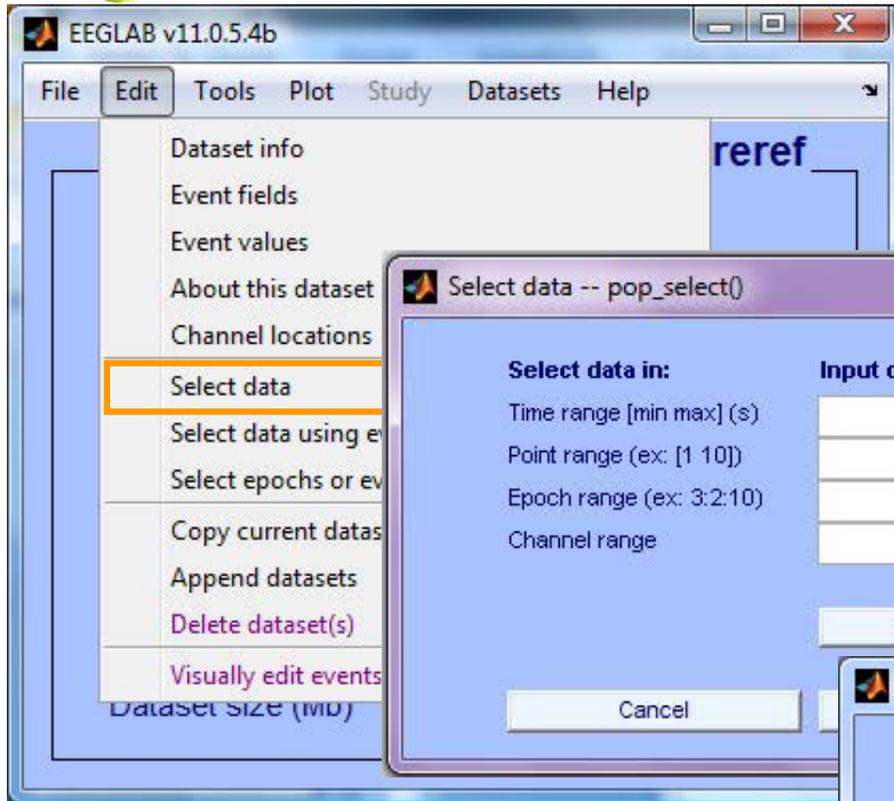
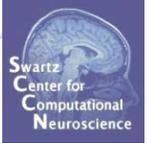


CANCEL << < 449 > >>

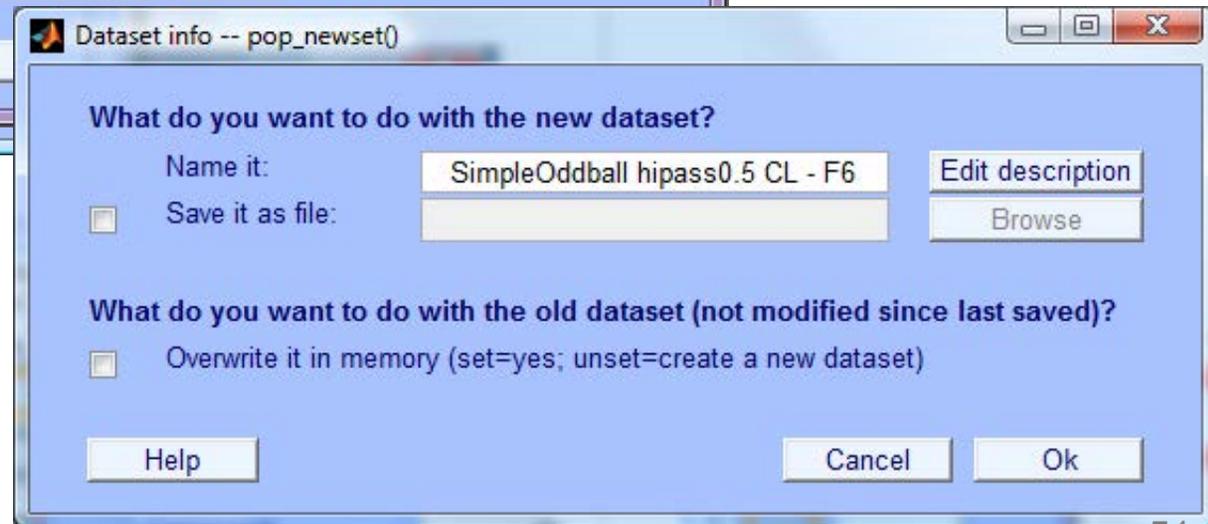
Chan.	Time	Value
TP8	452.1146	-2.6647

35 +
- REJECT

Removing channel(s)



If not checked, will result in dataset with one channel



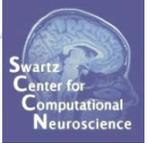
Removing channel(s)



- You may want to interpolate bad channels rather than remove them altogether. Don't do this!
- The loss in dimensionality will affect the ICA decomposition
- Preferred solution:
 - **Delete** the bad channels before running ICA
 - STUDY tools will interpolate missing channels automatically



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

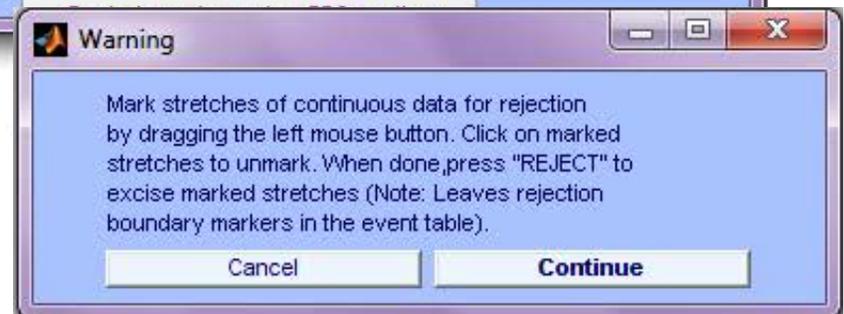
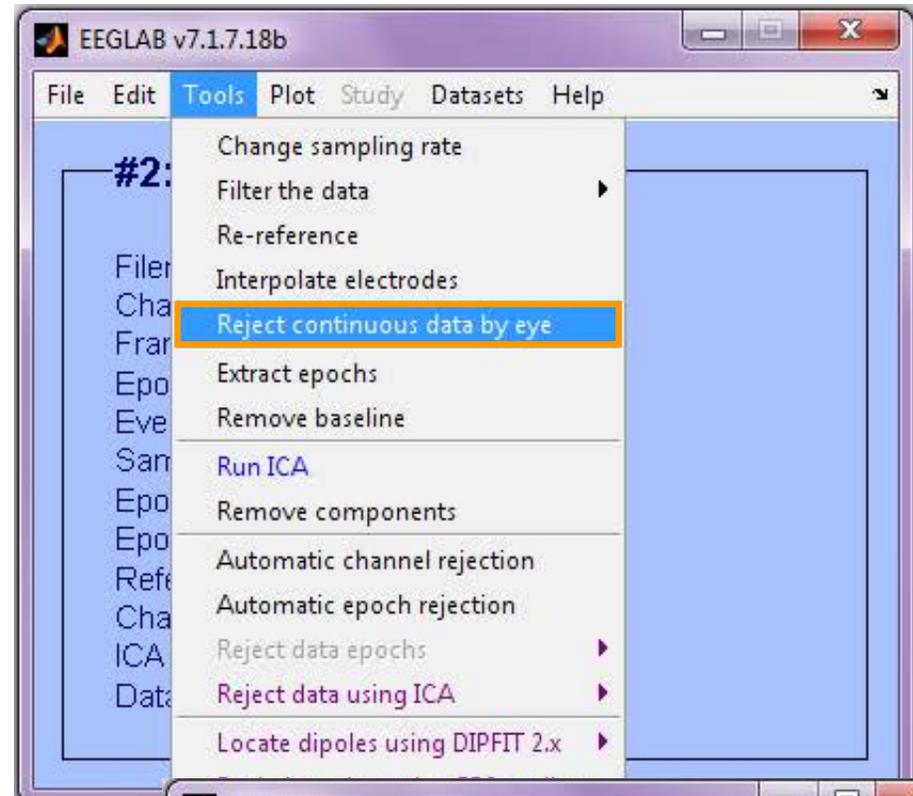
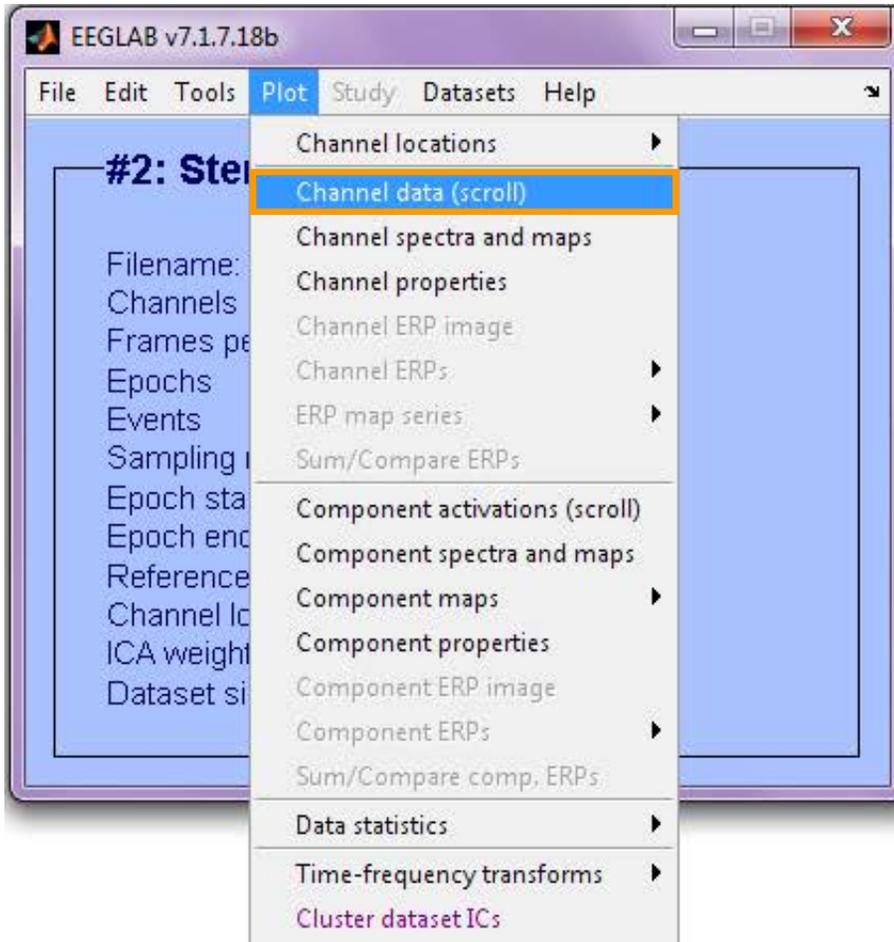
Reject large artifact
time points

Run ICA

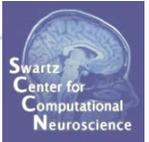
Reject continuous data



Equivalent

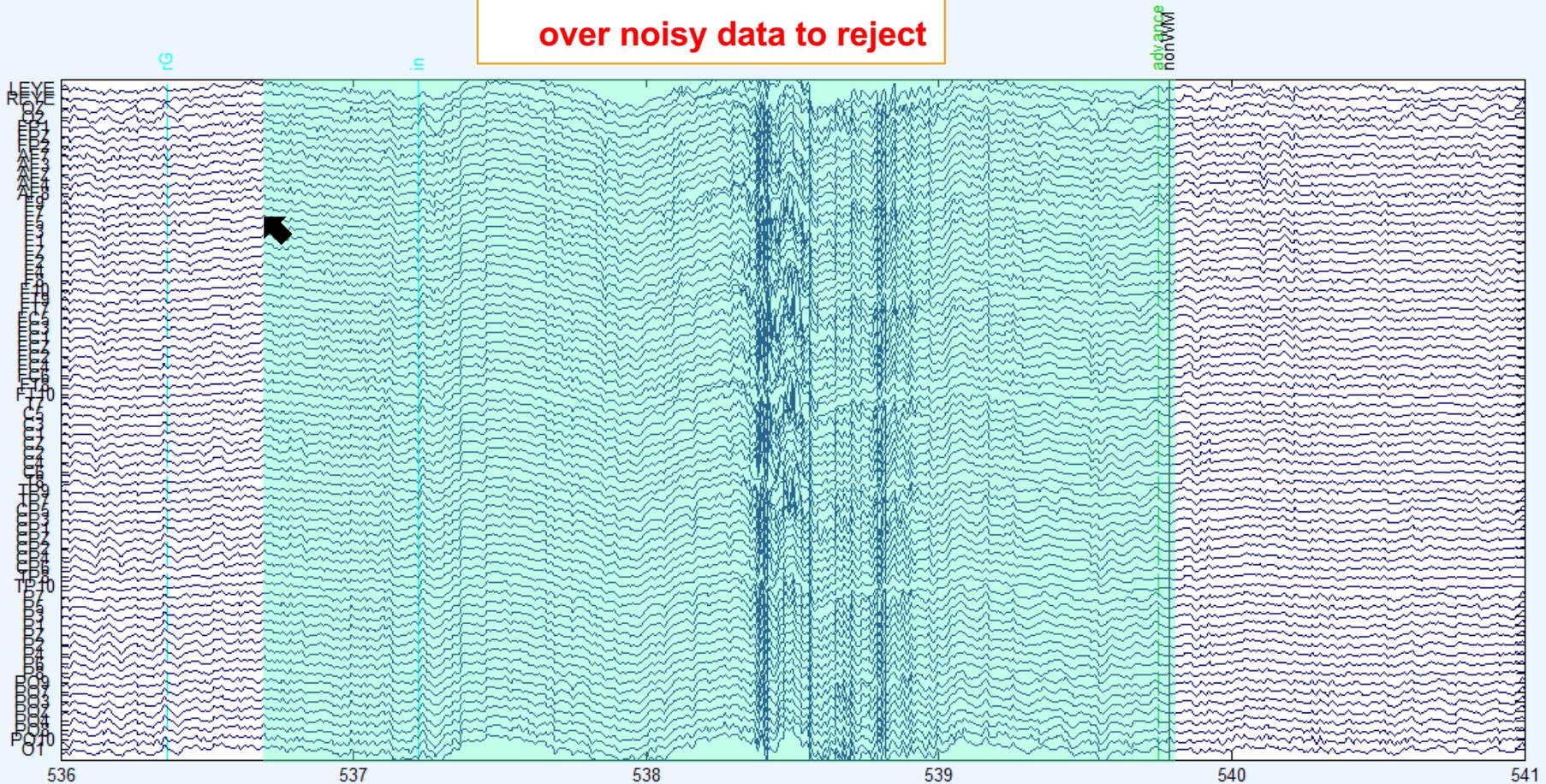


Reject continuous data



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

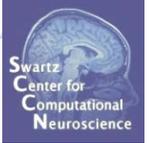
Click and drag with mouse over noisy data to reject



Scale 35

CANCEL Event types << < 536 > >> Chan. Time Value 536 539.9355 4.8773 35 + REJECT -

Rejecting data for ICA



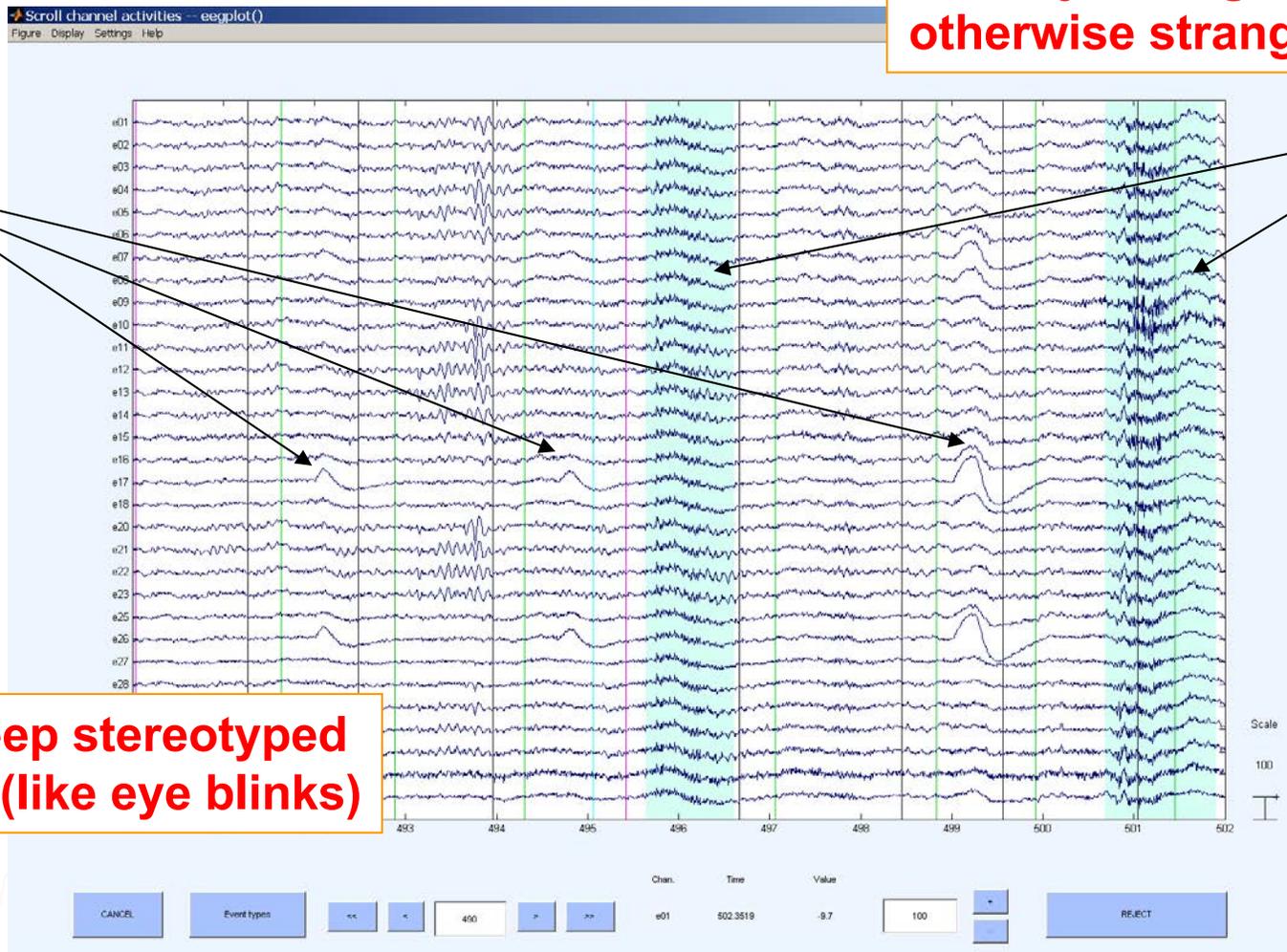
To prepare data for ICA:

Reject large muscle or otherwise strange events...

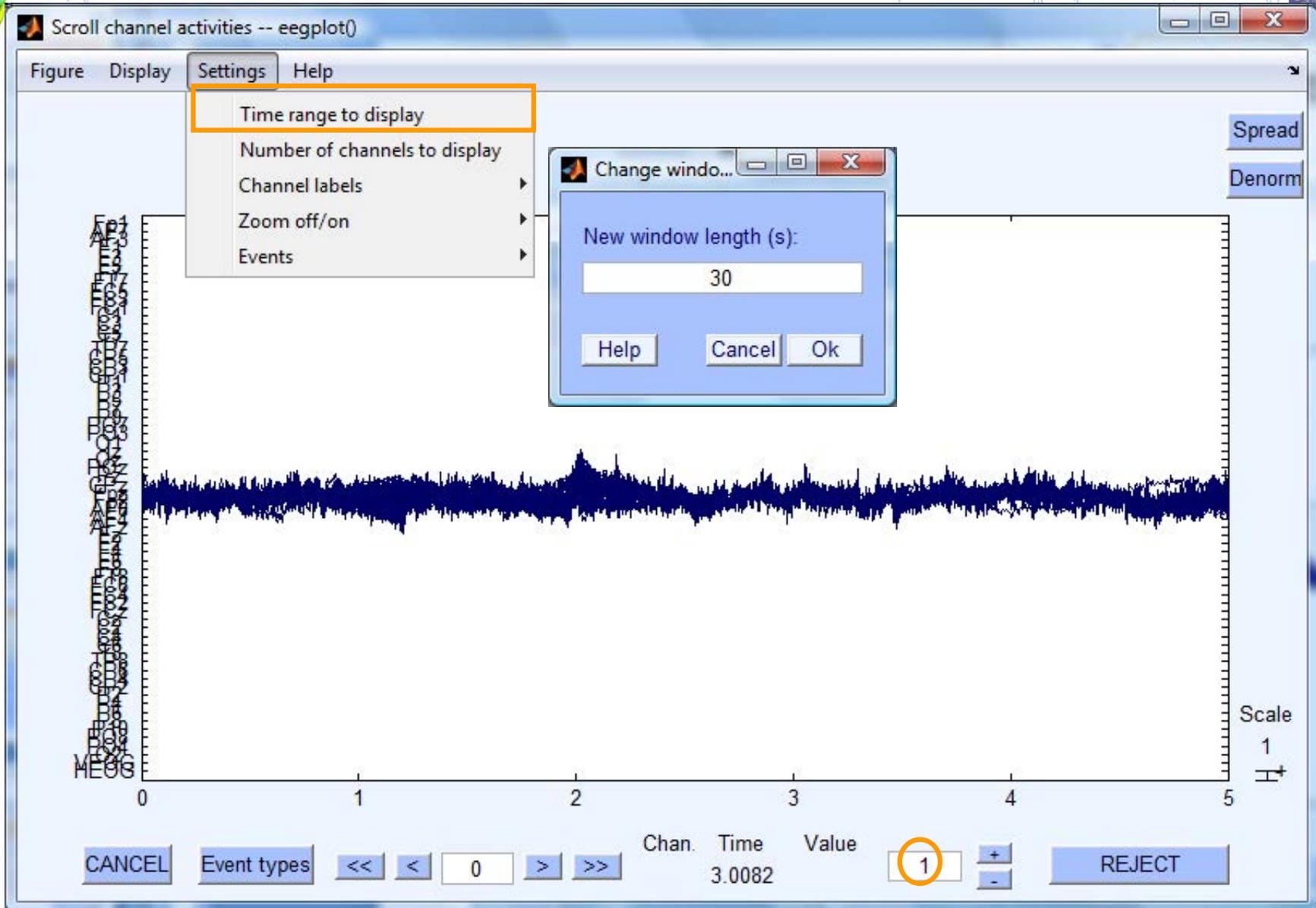
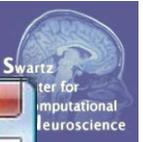
Reject

Keep

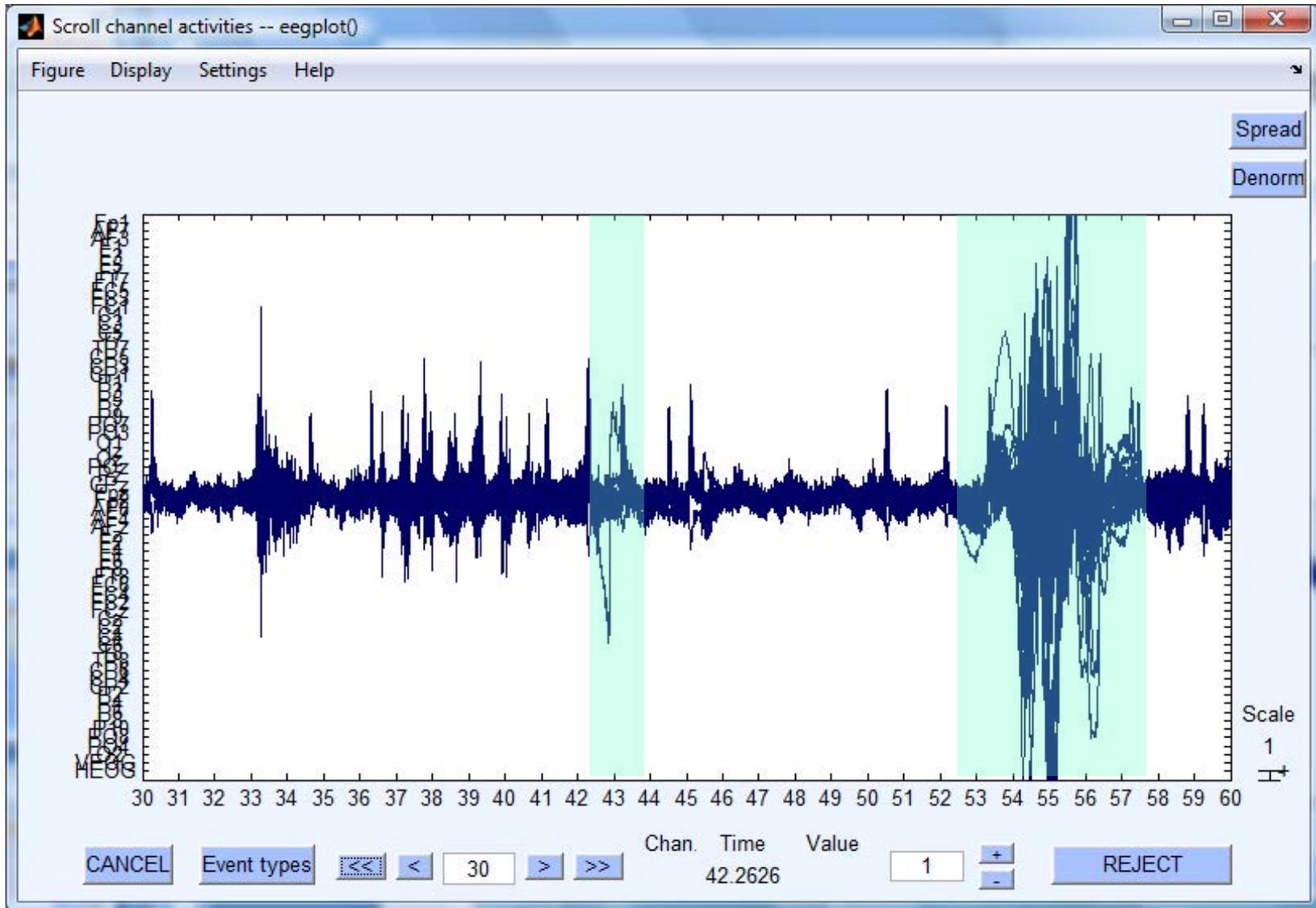
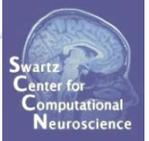
... but keep stereotyped artifacts (like eye blinks)



Fast (but sloppy) artifact rejection



Fast (but sloppy) artifact rejection



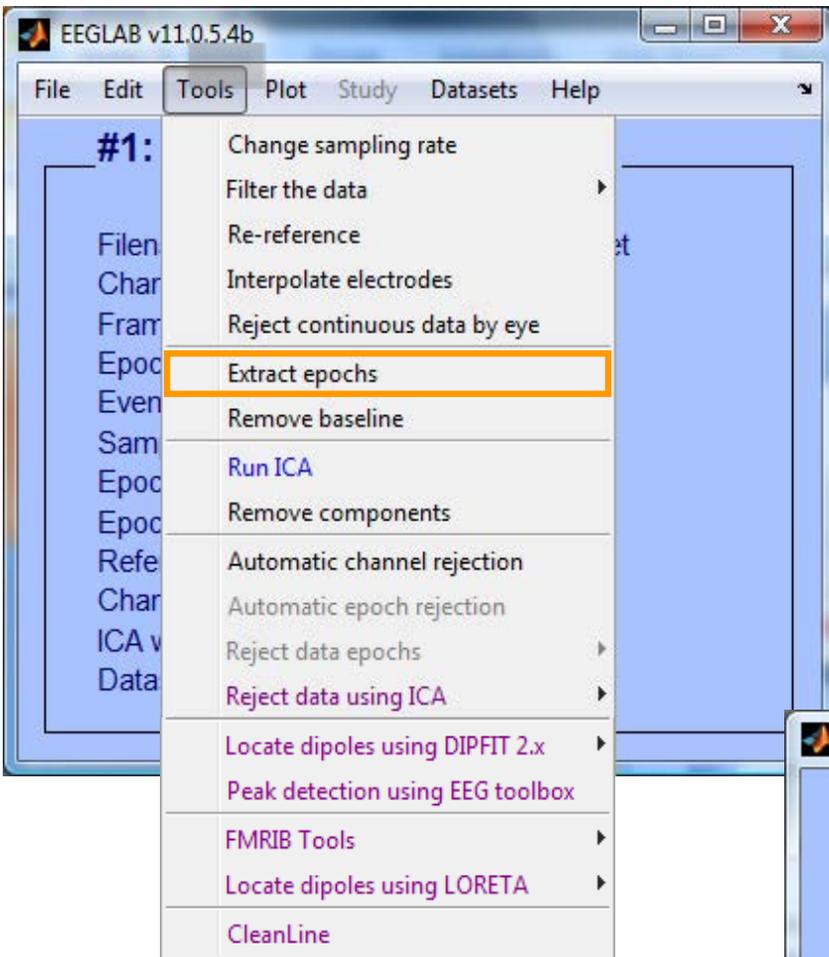
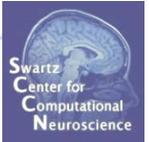


Data Cleaning for ICA

Variant 2: Epoched Data

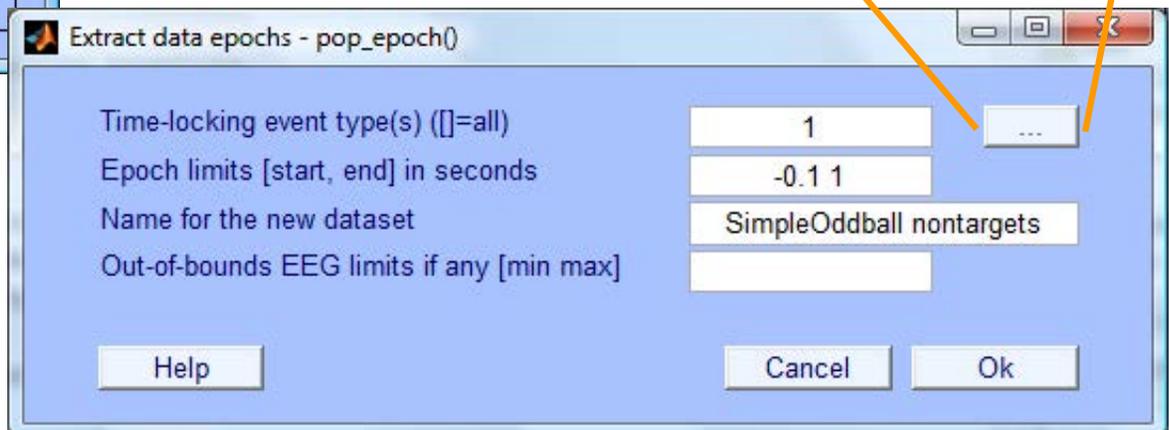
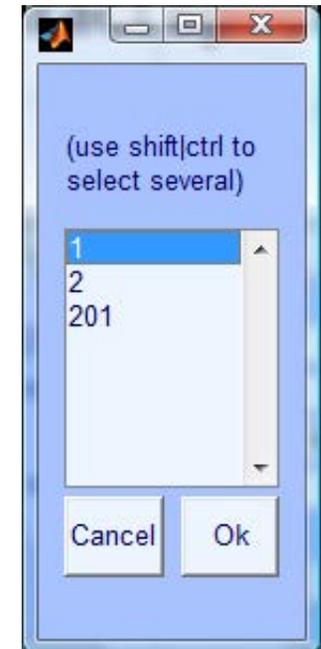


Extract epochs

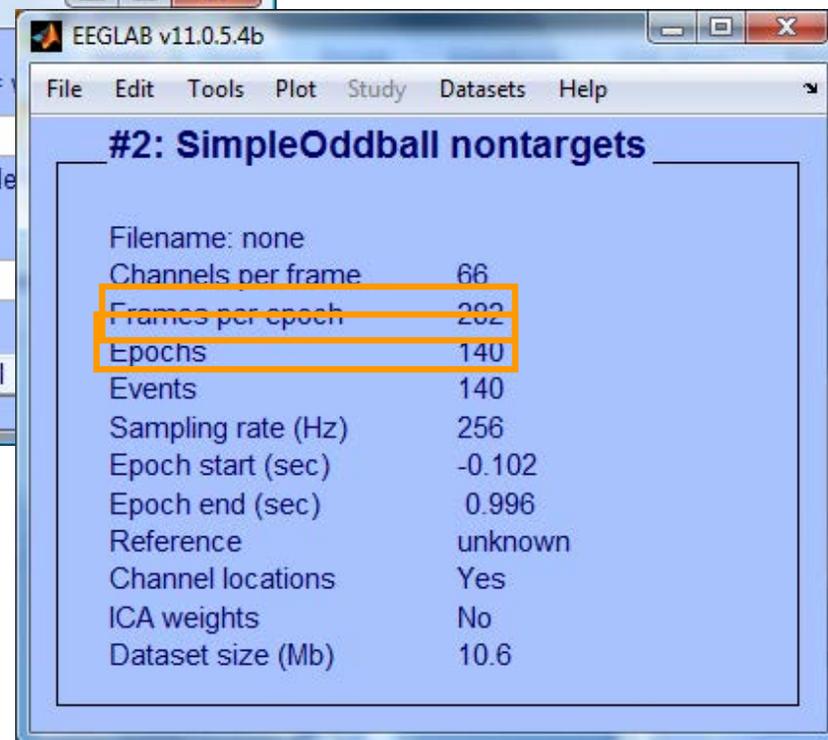
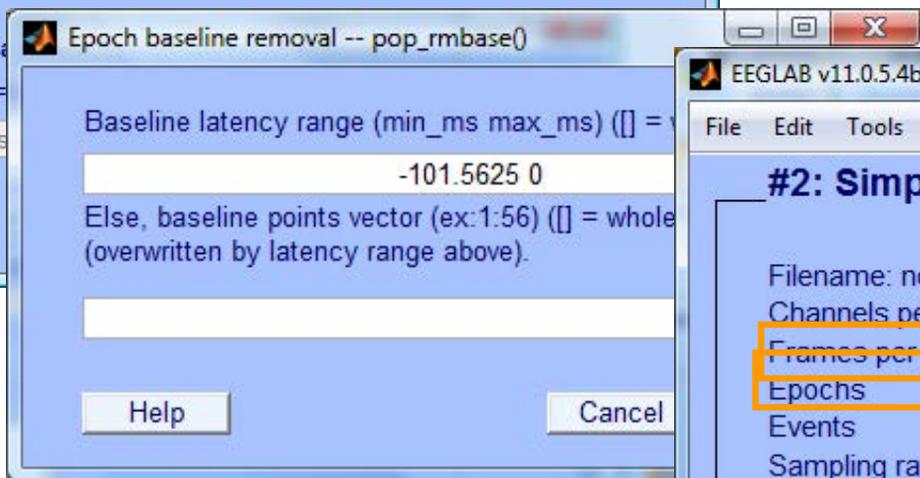
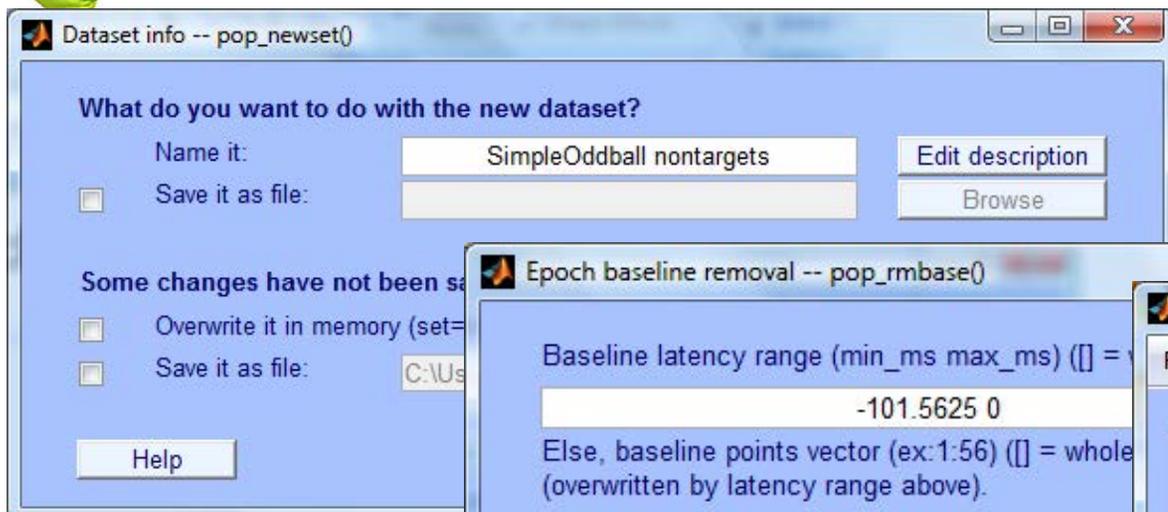
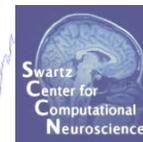


>> `eeg_eventtypes` (EEG)

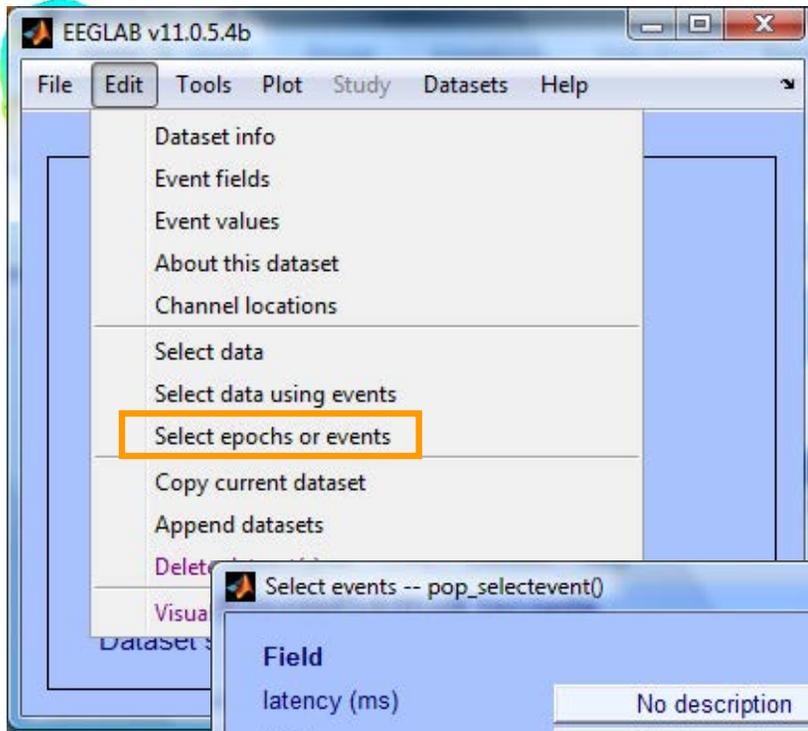
1	140
2	60
201	60



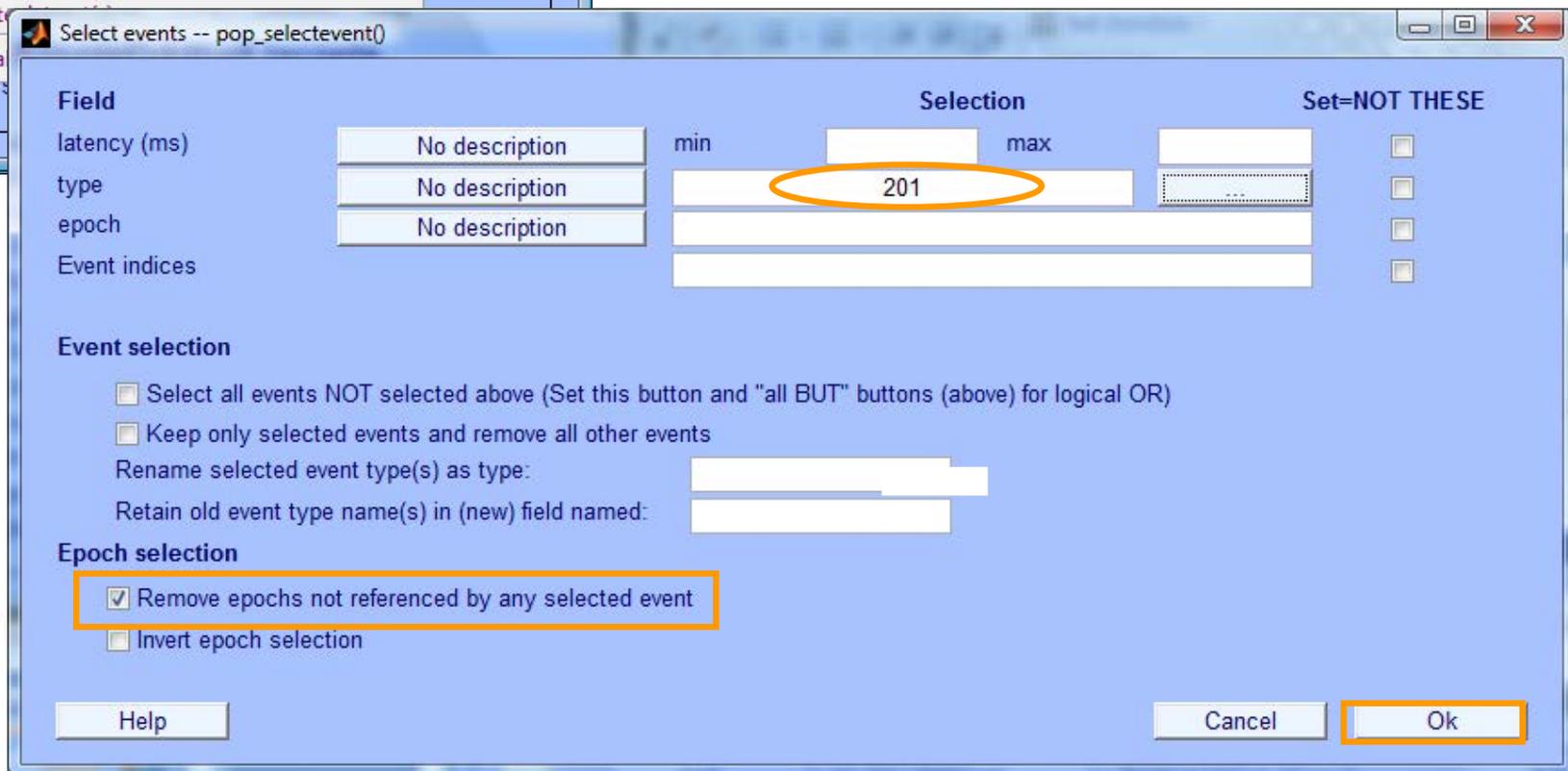
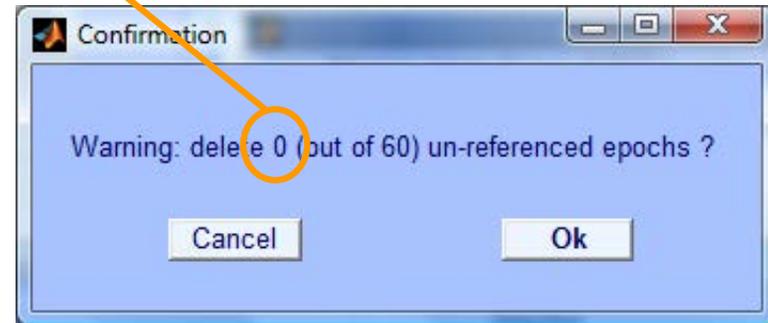
Extract epochs

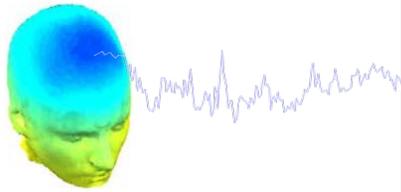


Select a subset of epochs

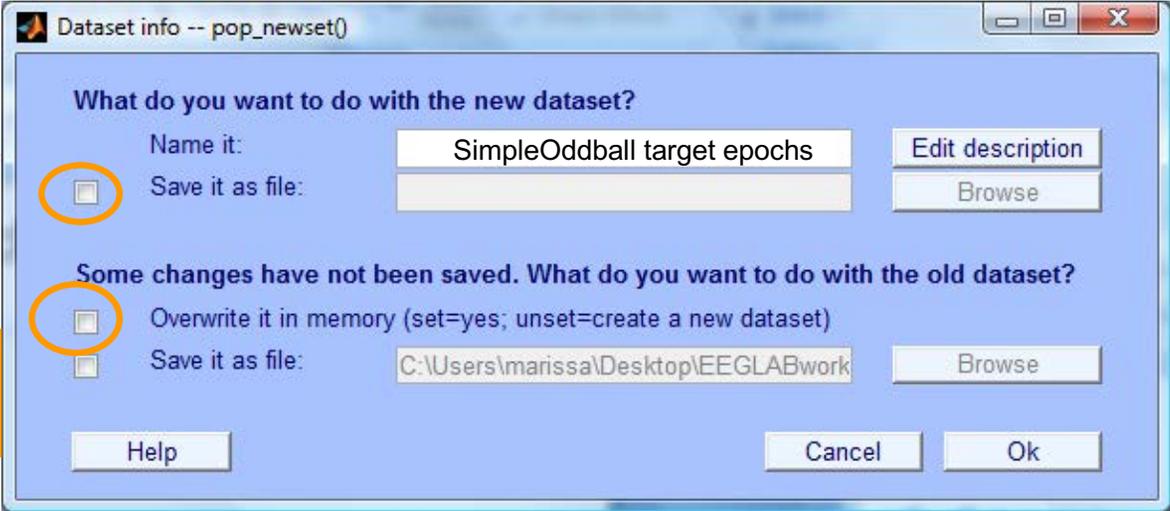


'0' because the subject did not miss any targets

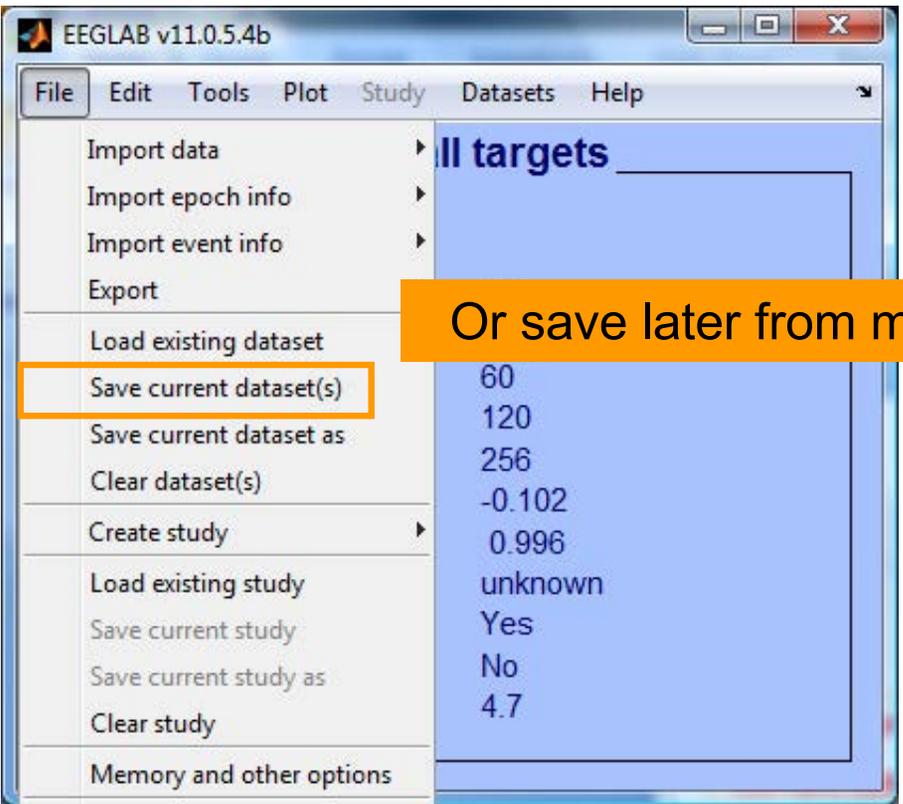




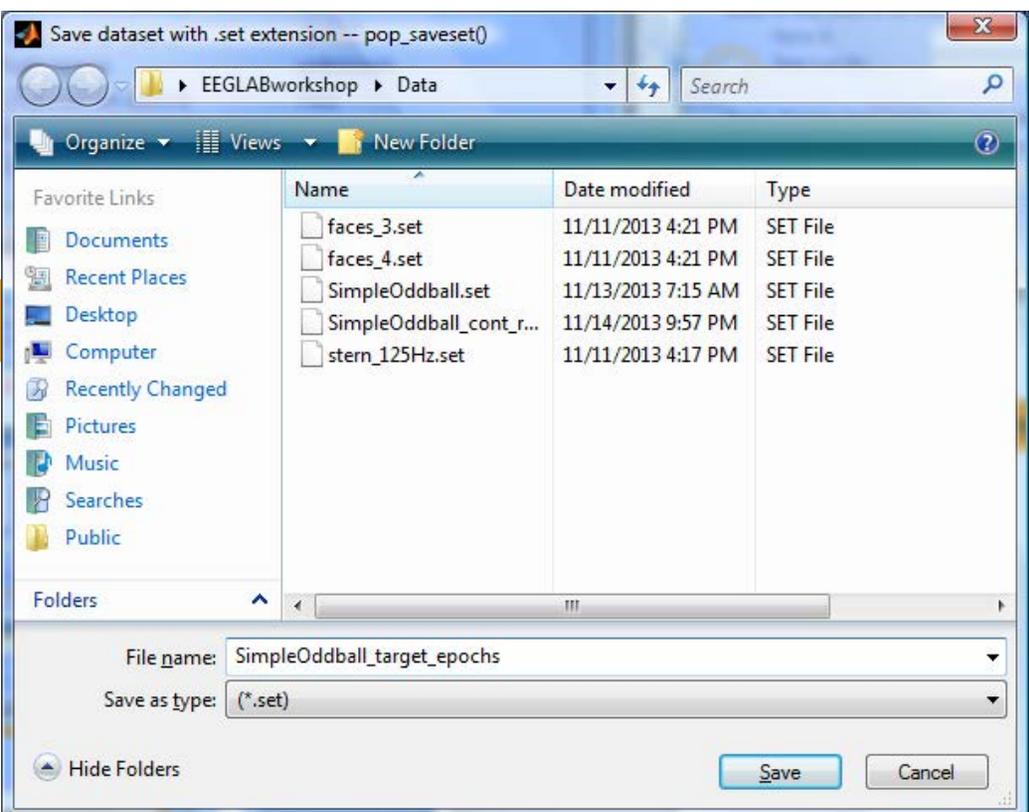
'Do not overwrite current dataset'



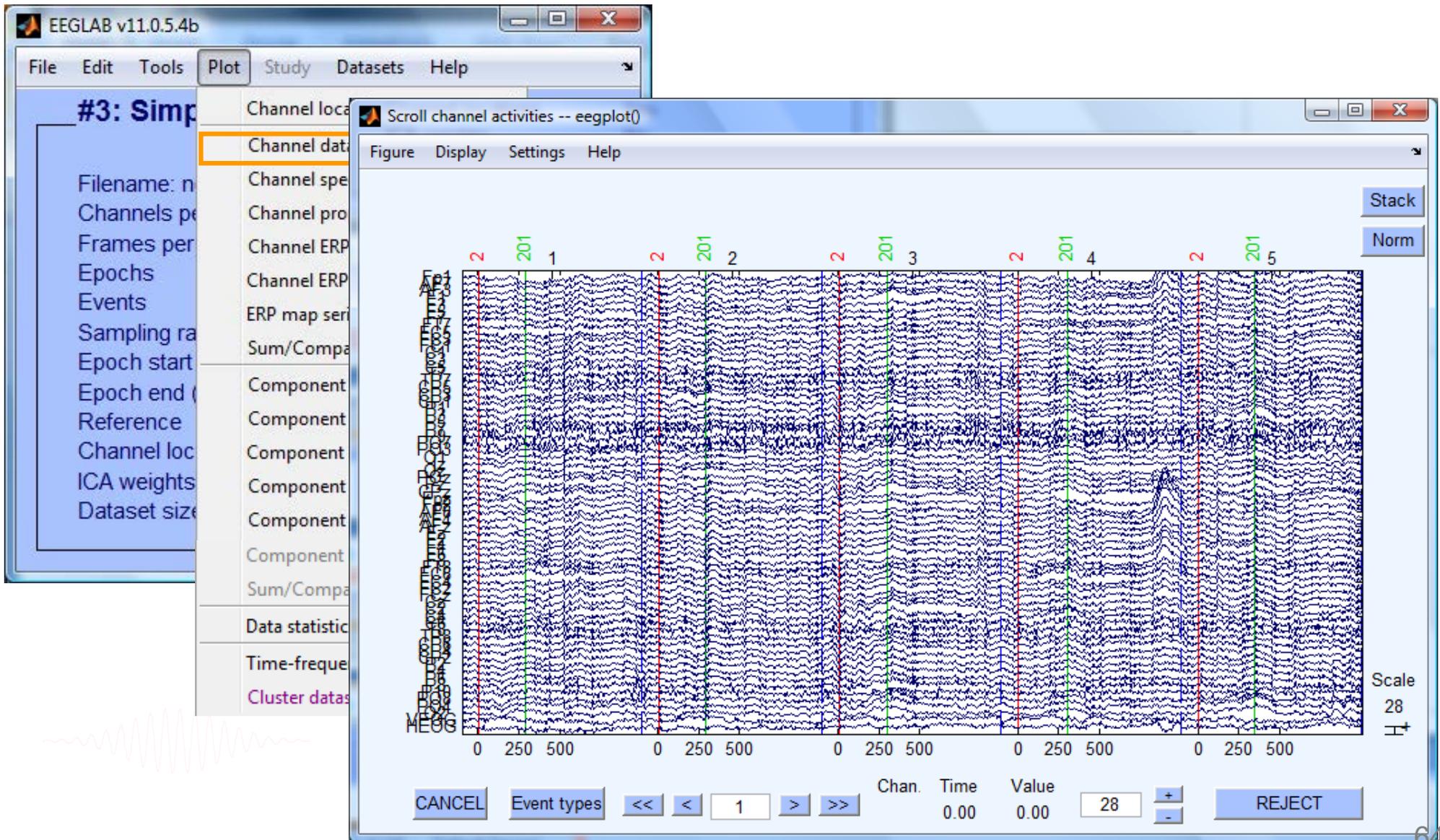
Save dataset (optional)



Or save later from menu



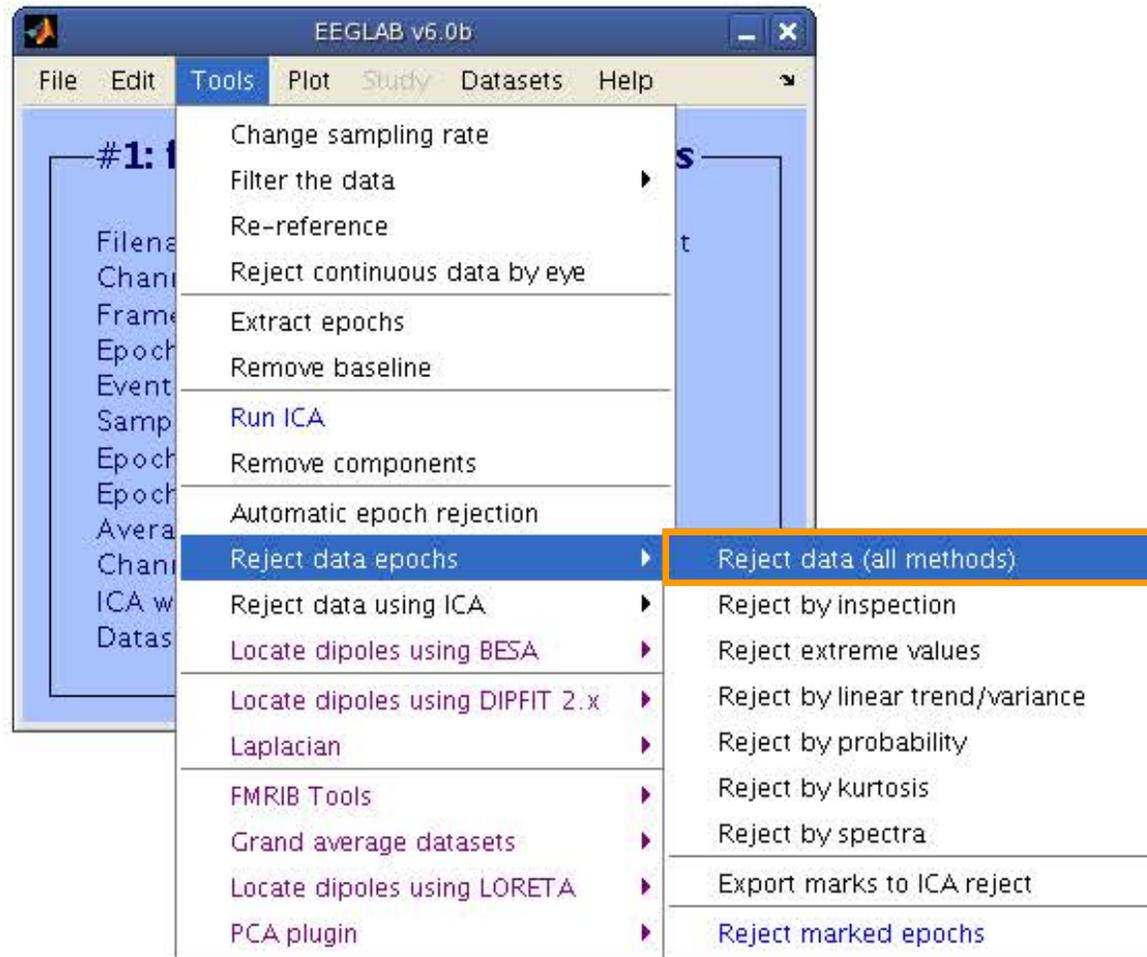
Scroll (epoched) channel data



Reject epochs with artifact



Reject data epochs



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

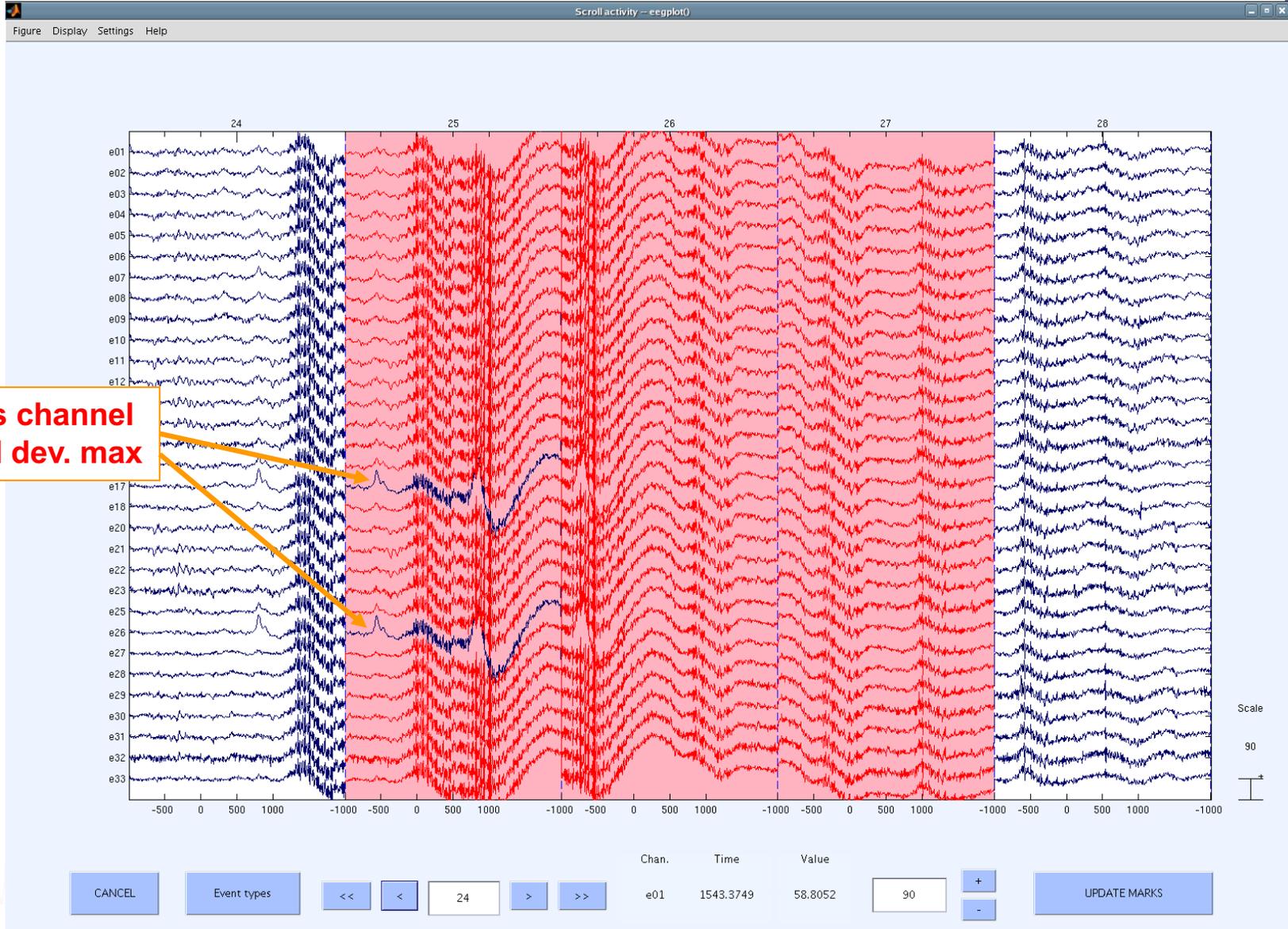
Show all trials marked for rejection by the measure selected above or checked below | /

<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

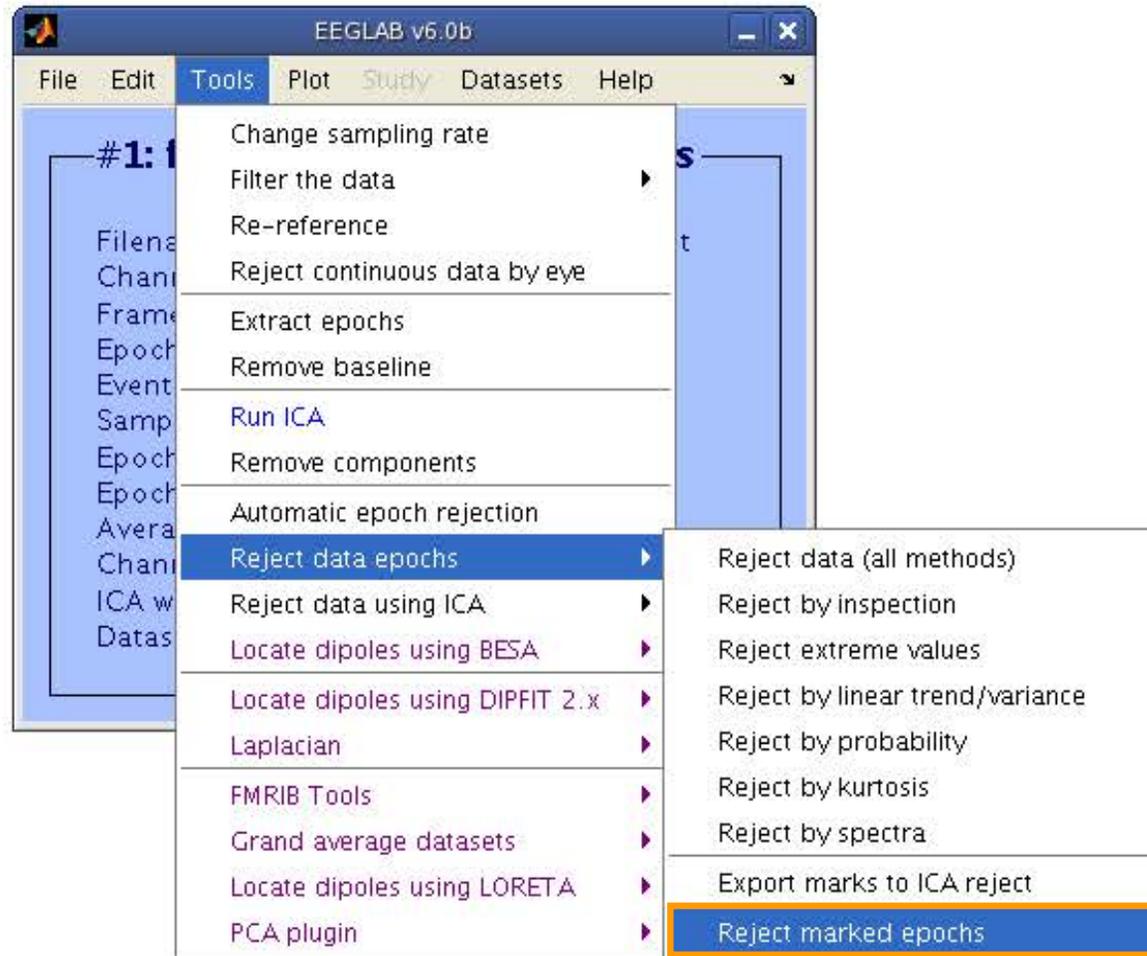
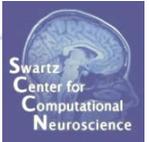
visual inspection

probability

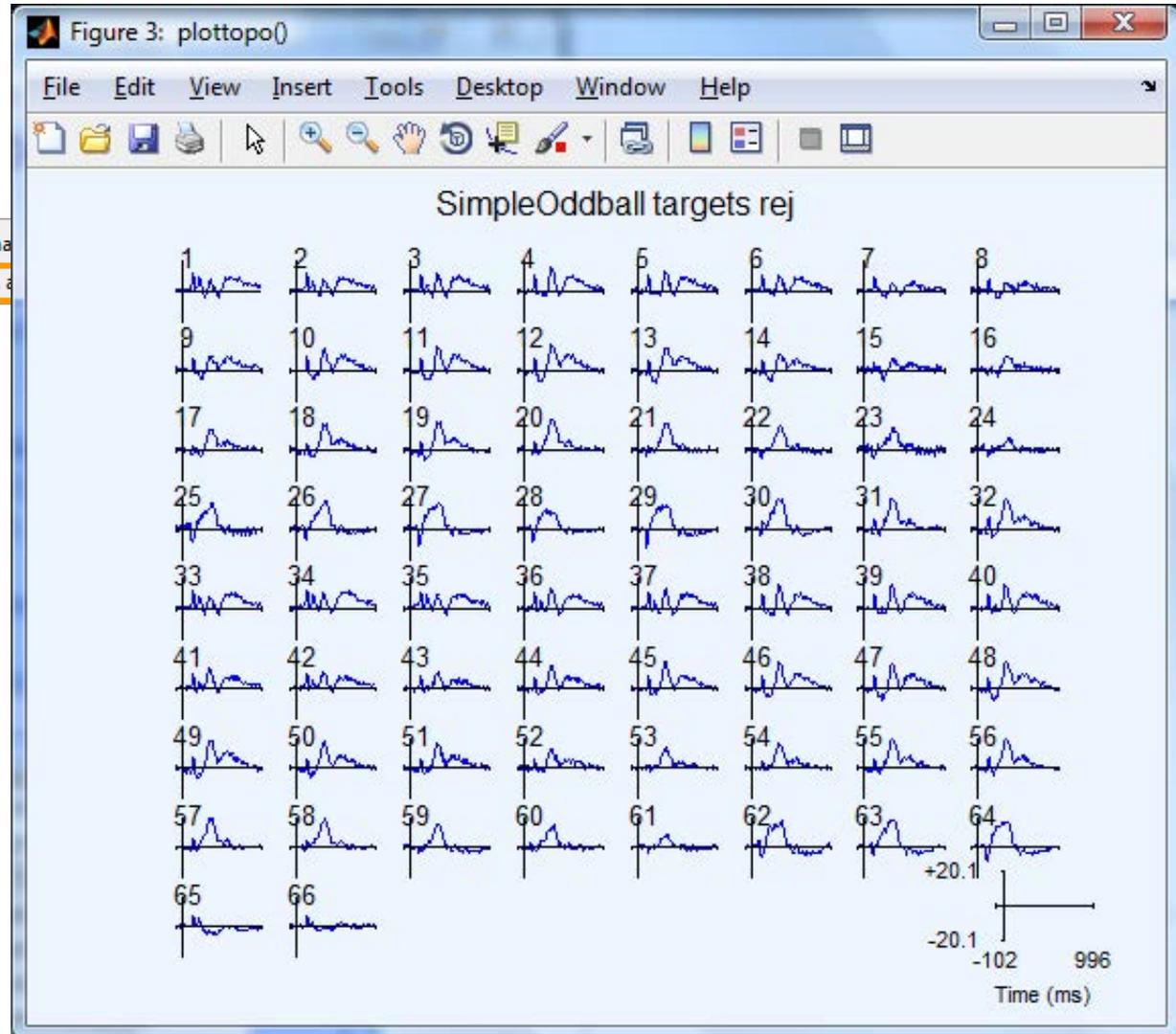
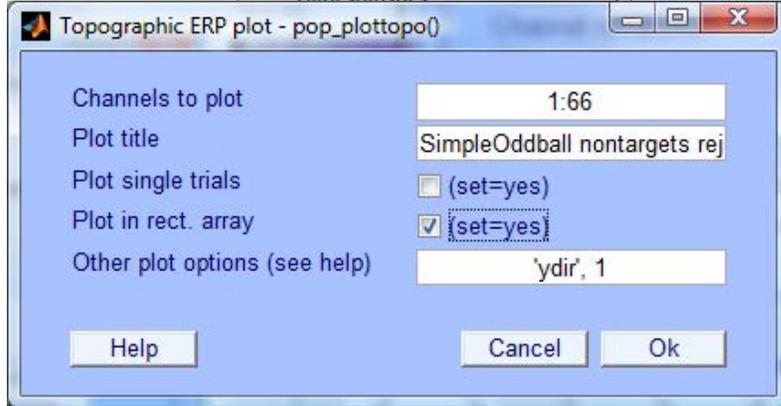
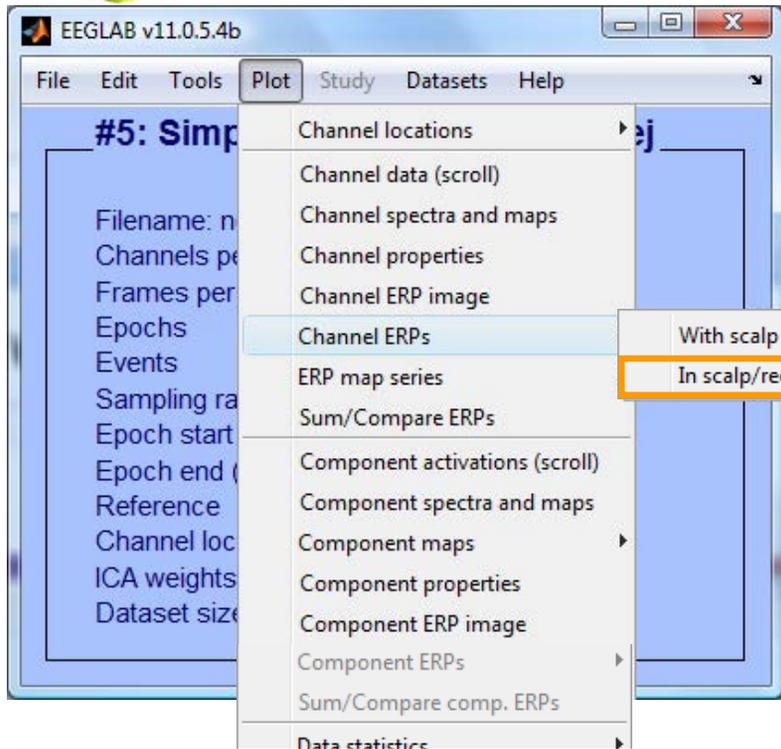
Reject data epochs



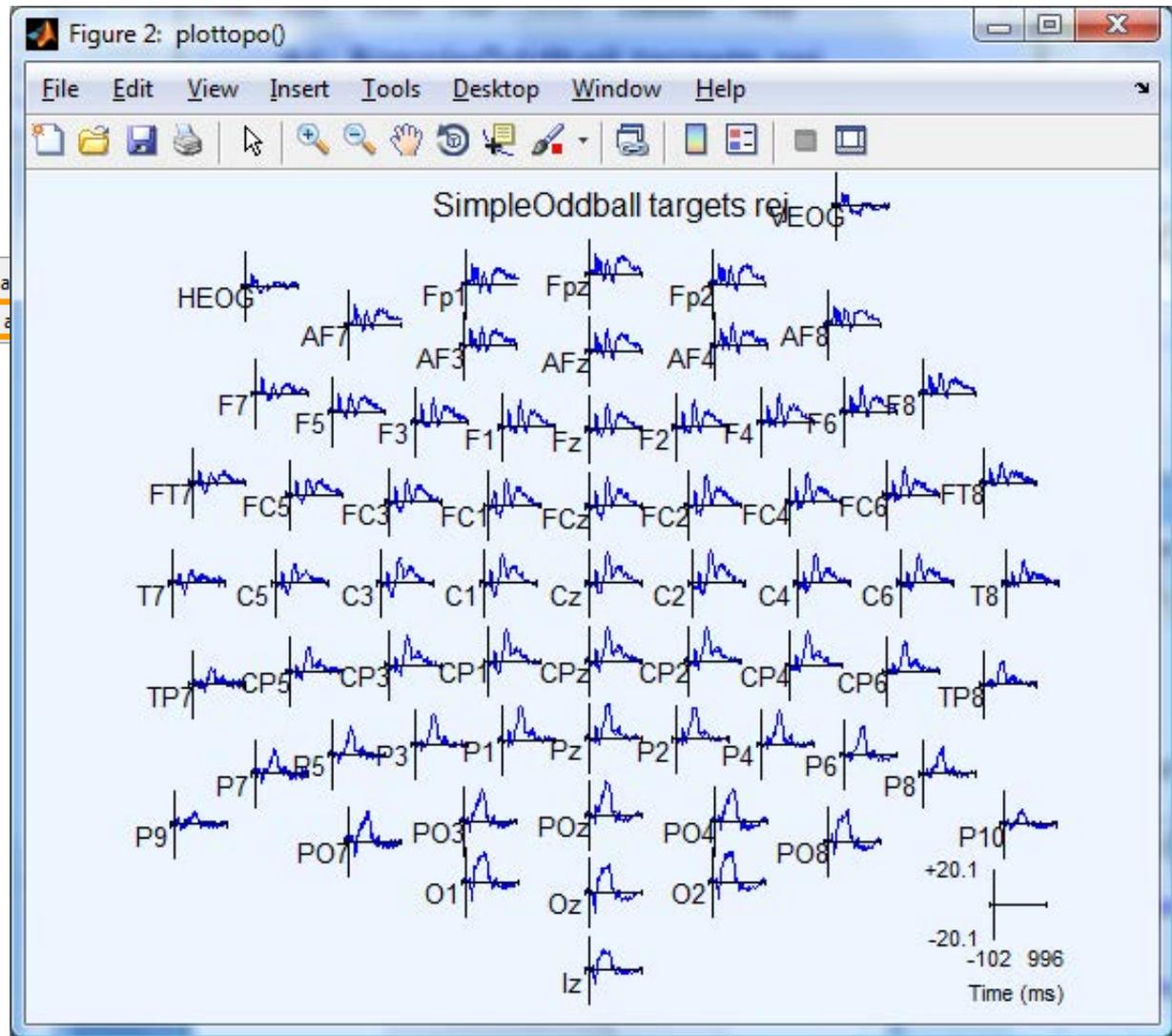
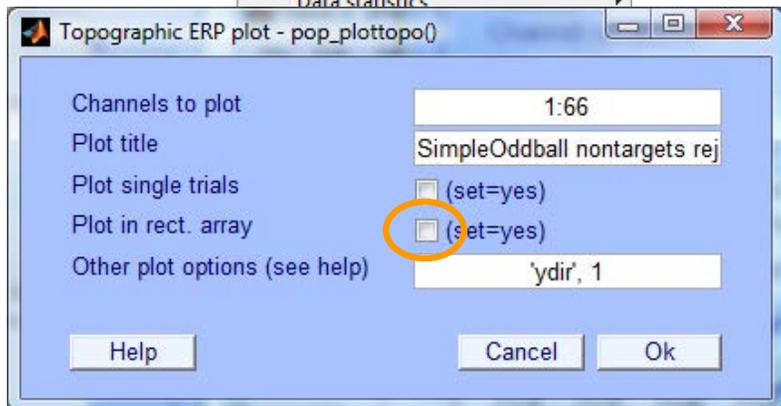
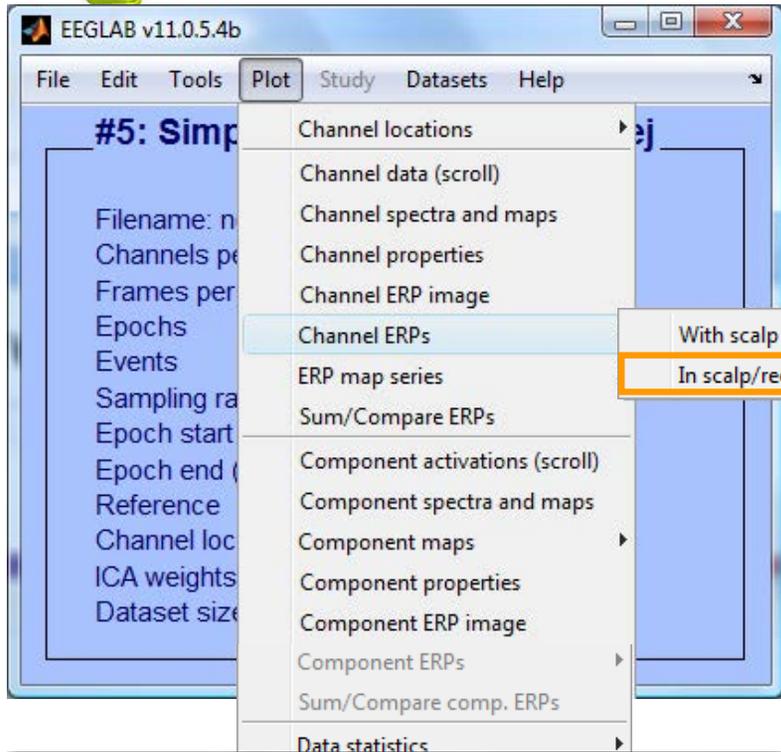
Reject data epochs



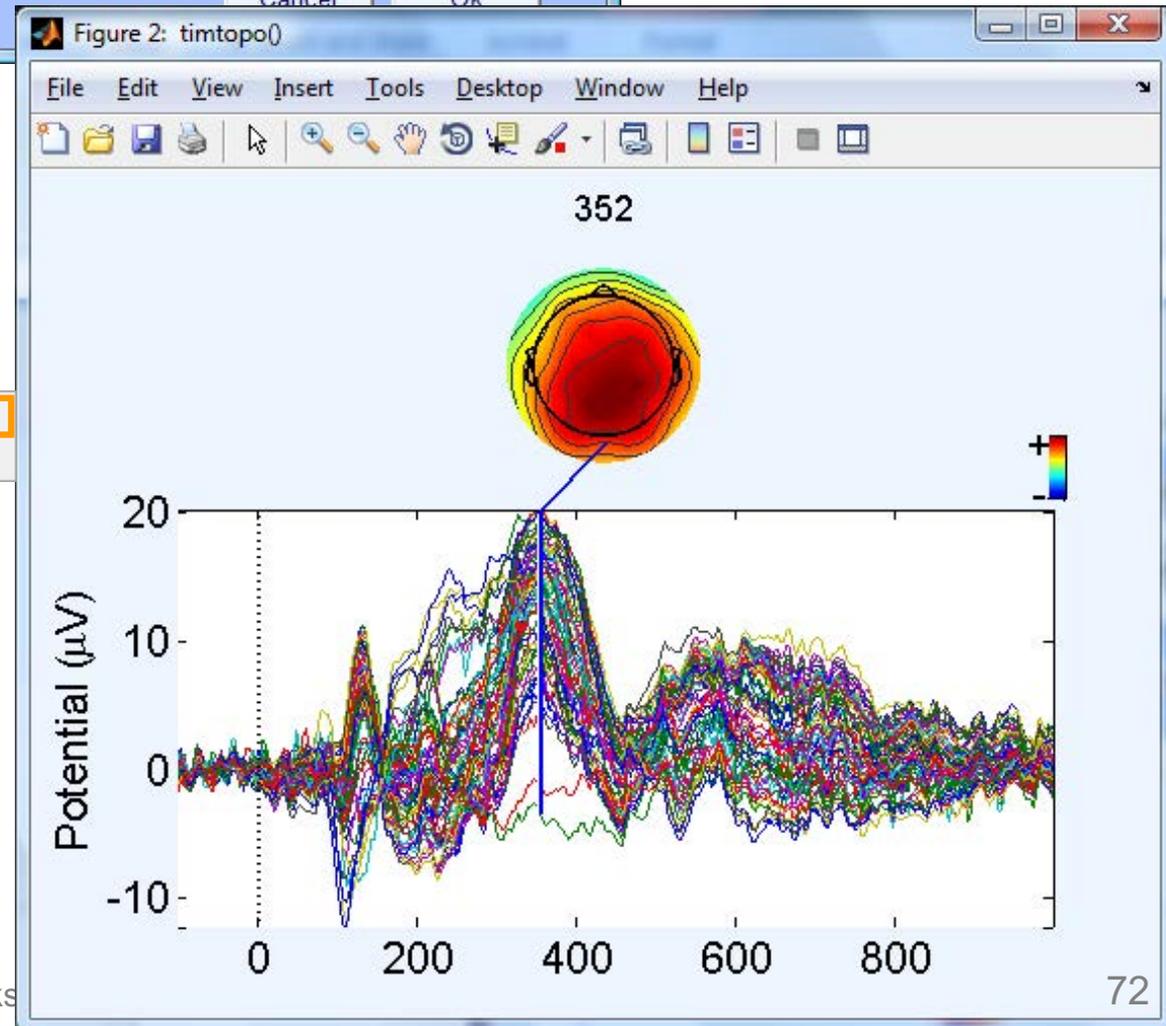
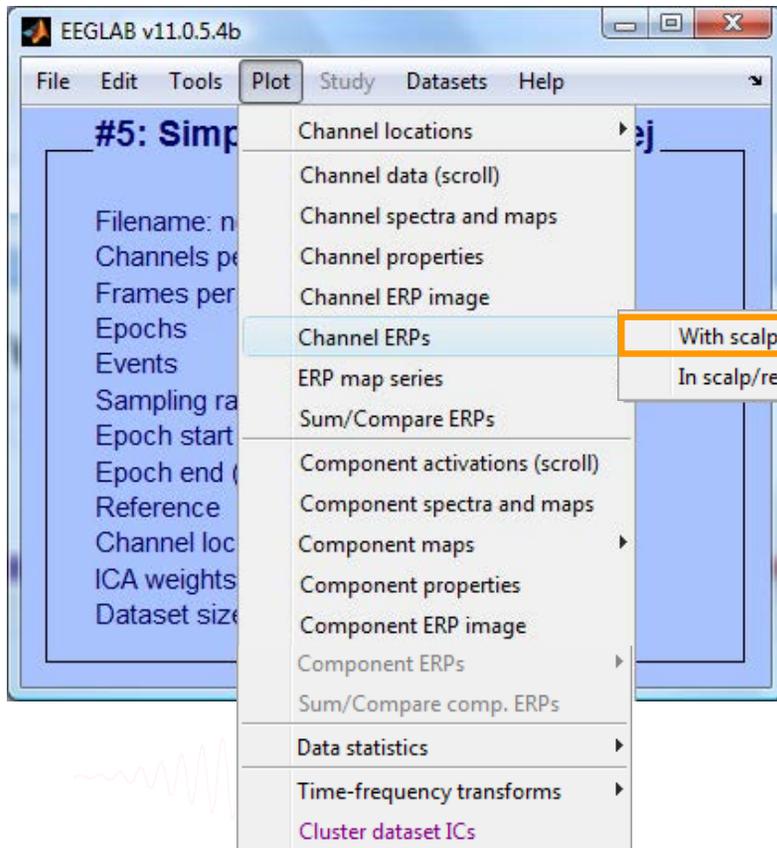
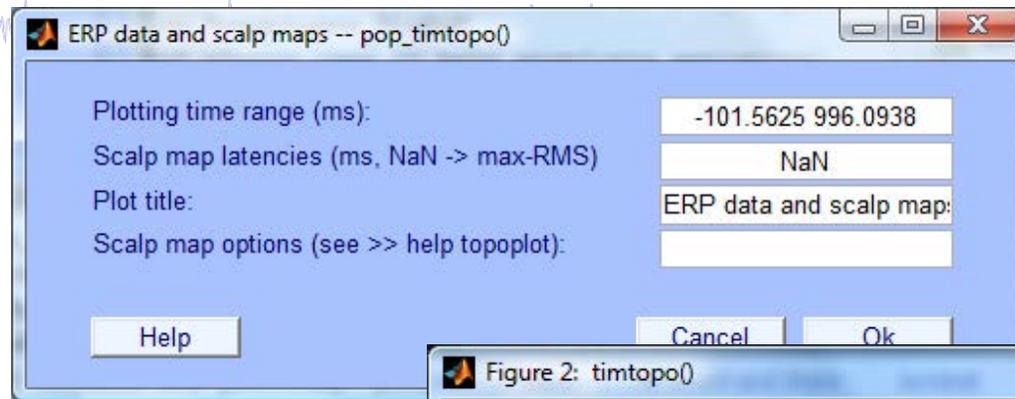
Visualize ERP in rectangular array



Visualize ERP in topographic array



Visualize ERP scalp distribution



Visualize channel ERPs in 2D



EEGLAB v11.0.5.4b

File Edit Tools **Plot** Study Data

#4: SimpleOddball

- Channel locations
- Channel data (samples)
- Channel spectra
- Channel properties
- Channel ERP images
- 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

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

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

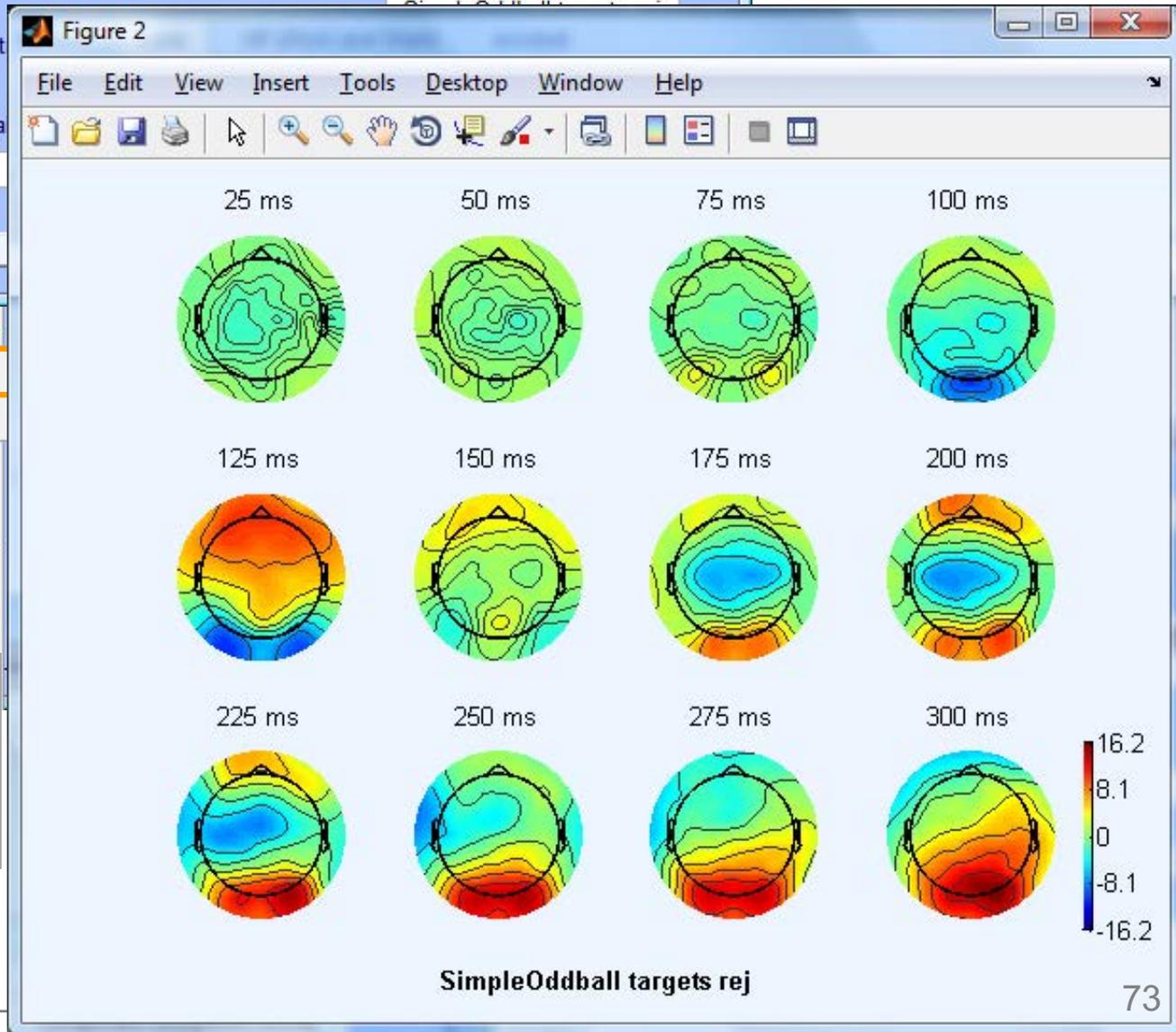
Plotting ERP scalp maps at these latencies
(range: -102 to 996 ms, NaN -> empty):

25:25:300

Plot title
Plot geomet...

-> Additional...

Help



Visualize channel ERPs in 3D



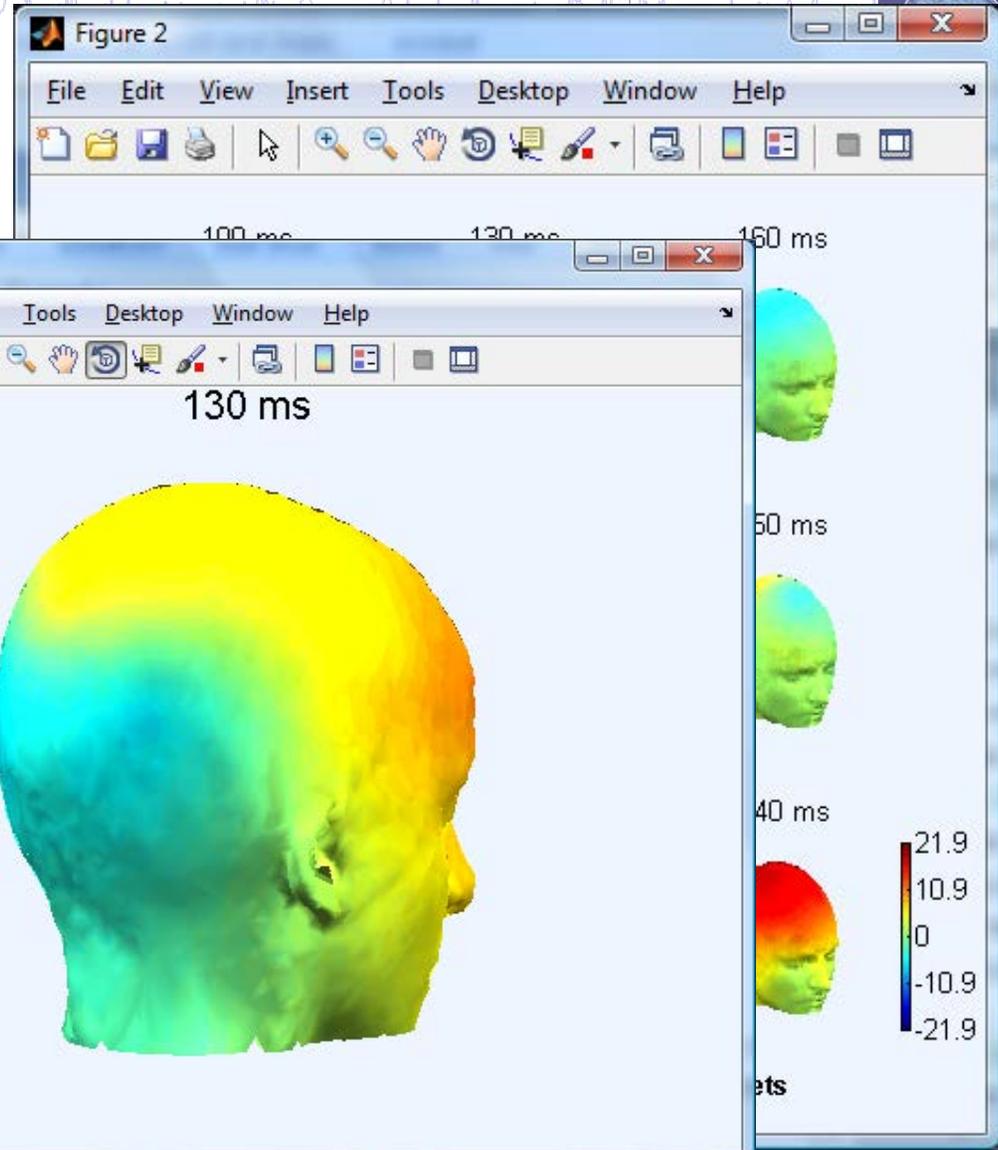
EEGLAB v11.0.5.4b

File Edit Tools **Plot** Study Datasets Help

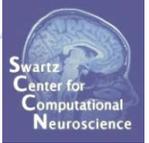
#4: Simp

Filename: n
Channels pe
Frames per
Epochs
Events
Sampling ra
Epoch start
Epoch end (c
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



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

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

