



Data import Basic ERP visualization

Arnaud Delorme (thanks to Marissa Westerfield)



Installing EEGLAB and data folder

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

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今今回221~6~5	sers + marissa + Documents + MATLAB			200
Command Window				Command History
In New to MATLAB? Watch this	Video, see Examples, or read Getting Started			× 8-4 11/14/2013 5
				EEG

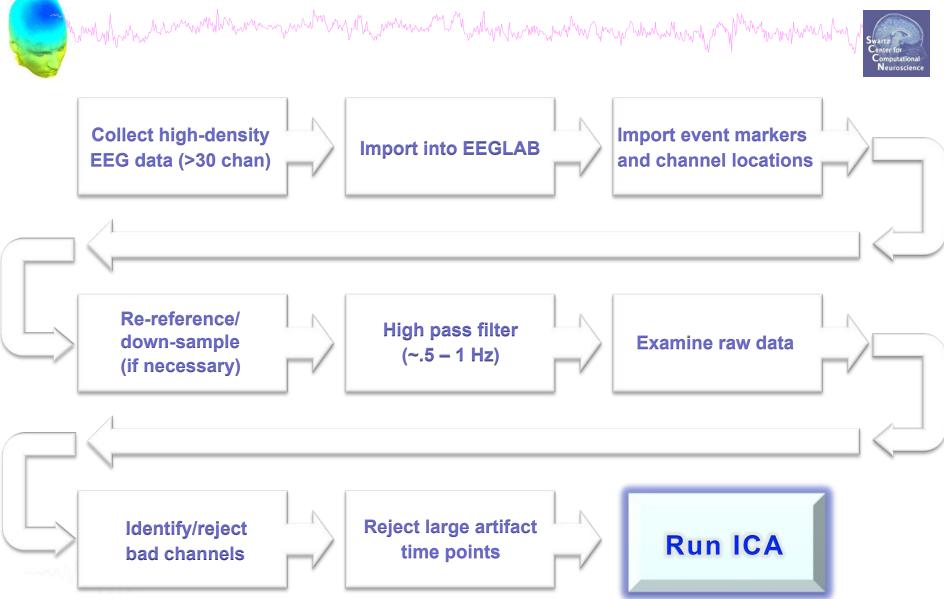
The EEGLAB Matlab software

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main graphic interface

MATLAB R20136	A DECEMBER OF THE REAL	
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Name -	New to MATLAB? Watch this <u>Video</u> , see <u>Exemples</u> , or read <u>Getting Sta</u> // >> englab	File Edit Tools Fiel Study Datasets Help
		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
etaita sady	*	Epoch data: "Tools > Extract epochs" Remove baseline: "Tools > Remove Run ICA: "Tools > Run ICA"

Pre-processing pipeline



Importing a dataset



Edit Tools Plat Stud	ly Datasta Help 💌	
Import data	Using EEGLAB functions and plugins	From ASCE/float file or Matlab array
Import epoch info	Using the FILE-IO interface	From Netstation .mff (FILE-IO toolbox)
Import event info	Using the BIOSIS interface	From Netstation binary simple file
Export.	Troubleshooting data formats	From Multiple seg. Netstation files
Load existing dataset	Extensit menaper (mm)	From Netstation Matlab files
Save current dataset(i)	ich info" (data	From 8CI2000 ASCII file
Save current dataset as	nt info" (continuous	From Snapmaster SMA file
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Save current study	Is > Extract epochs"	From Biosemi BDF and EDF files (BDF plugin
Save current study as	r "Tools > Remove	From EDF/EDF+/GDF files (E805IG toolbox)
Clear study	s > Run ICA*	From ANT EEPirobe .CNT file
Memory and other options		From ANT EEProbe AVR file
History scripts	•	From BCI2000 JDAT file
Quit		From BIOPAC MATLAB files
		From Brain Vis. Recvhdr file
		From Brain Vis. Anal. Matlab file
Tip for Biose	mi users:	From CTF folder (MEG)
	-	

Use the 'BDF plugin' version

of the Biosemi BDF/EDF importer

From INStep .ASC file From 4D .m4d pdf file

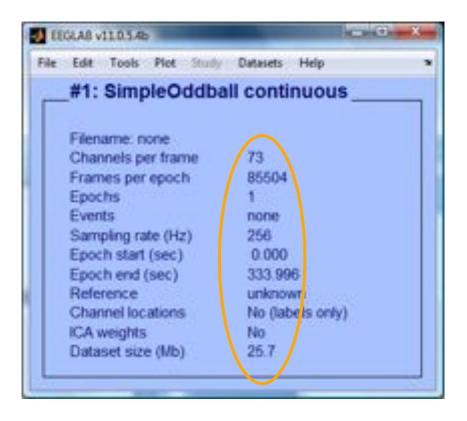
From Procom Infinity Text File

From ERPSS .RAW or .RDF file

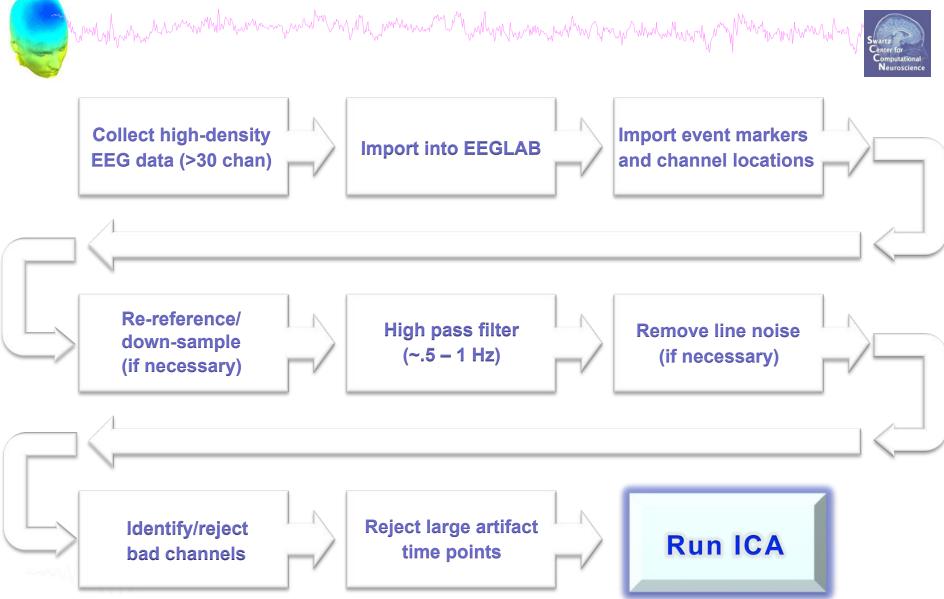
Imported EEG data

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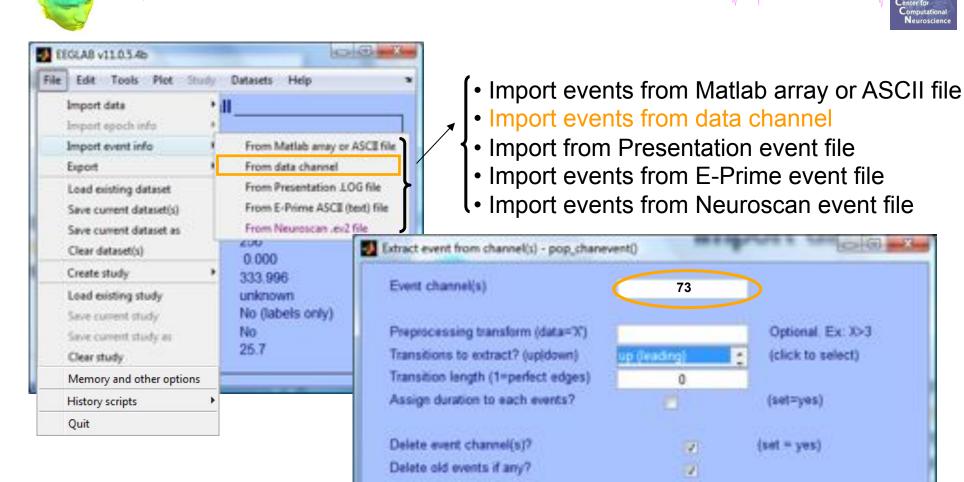


Pre-processing pipeline



Import data events

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All events of same type?

Help

(Often imported automatically during data import)

Cancel

Ok

Appearance of an event channel in raw data

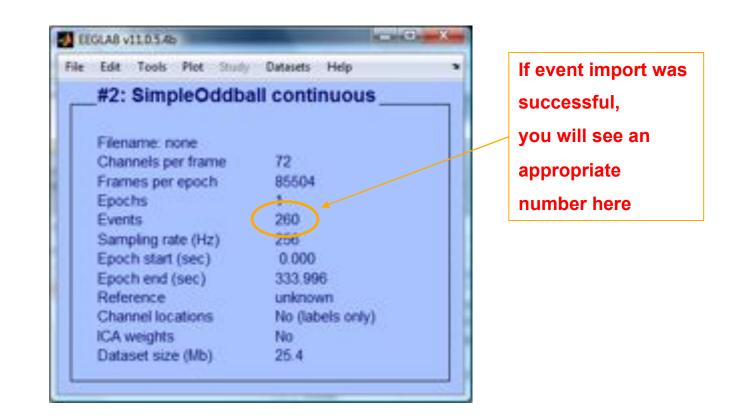


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Imported data events

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Sample data: basic P300 paradigm

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File

SimpleOddball.set

Data

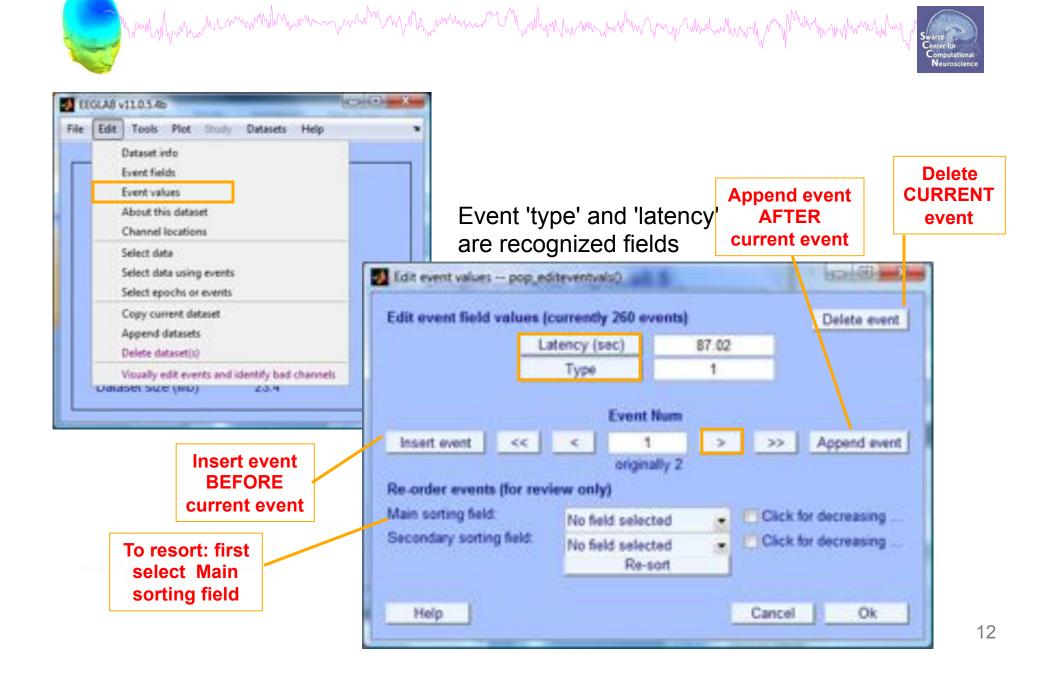
68 channel EEG, 256 Hz sampling rate, Biosemi system, re-referenced during import to averaged left and right mastoid electrodes

Task

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



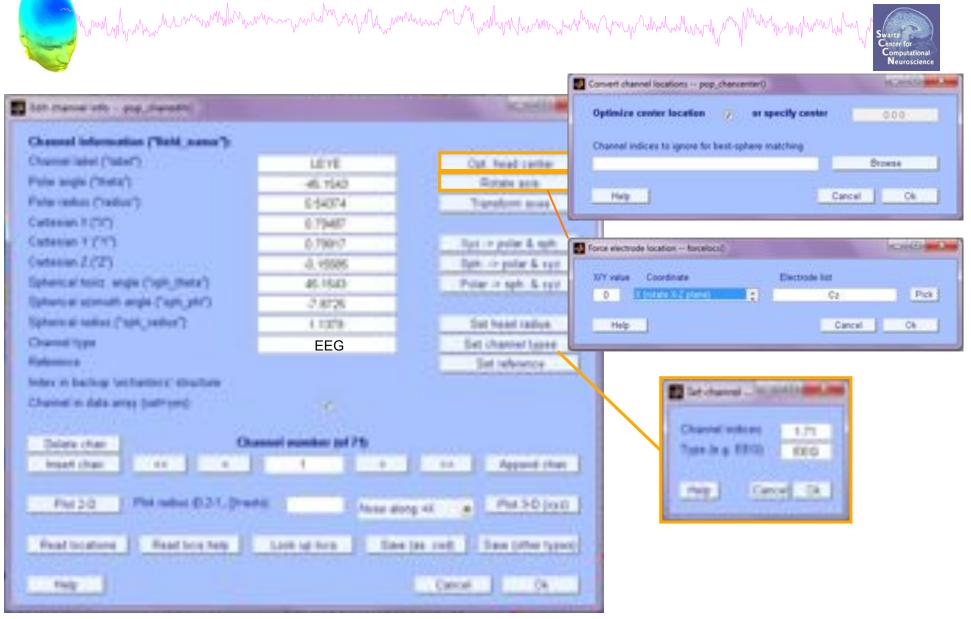
Review event values

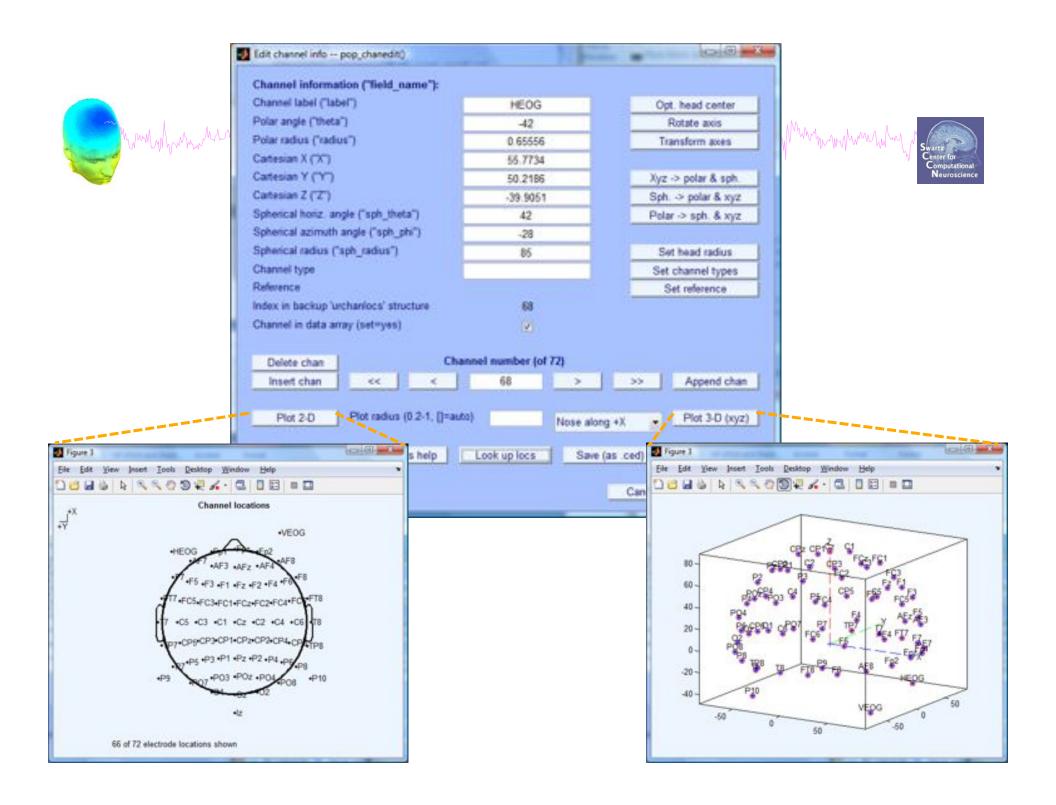


Import channel locations

mpuly was a solution of the so	MVVV II Edit channel info pop_chanedit()	-	00
	Channel information ("field_name"):		
¥	Channel label ("label")	Fp1	Opt. head center
(GLA8 v11.0.5.4b	Polar angle ("theta")	-17.926	Rotate axis
Edit Tools Plot Study Datasets Help	 Polar radius ('radius'') 	0.51499	Transform axes
Dutaset info	Catesian X ('X')	80.784	
Event fields	Cartesian Y ('Y')	26.133	Xyz -> polar & sph.
Event values	Catesian Z ("Z")	-4.0011	Sph> polar & xyz
About this dataset	Spherical horiz. angle ("sph_theta")	17.926	Polar -> sph. & xyz
Channel locations	Spherical azimuth angle ("sph_phi")	-2.698	
Select data	Spherical radius ("sph_radius")	85	Set head radius
Select data using events	Channel type		Set channel types
Select epochs or events	Reference		Set reference
Copy current dataset	Index in backup 'urchanlocs' structure	1	
Append datasets	Channel in data array (set=yes)	(<u>v</u>)	
Delete dataset(s)			
Visually edit events and identify bad channels Uddaset size (mo) 2019	Delete chan Ch	sannel number (of 72)	
Dataset size (ND) 20.4	inset chan << <	1 >	>> Append chan
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Polhemus, BESA,)			
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Import channel locations





Imported channel locations

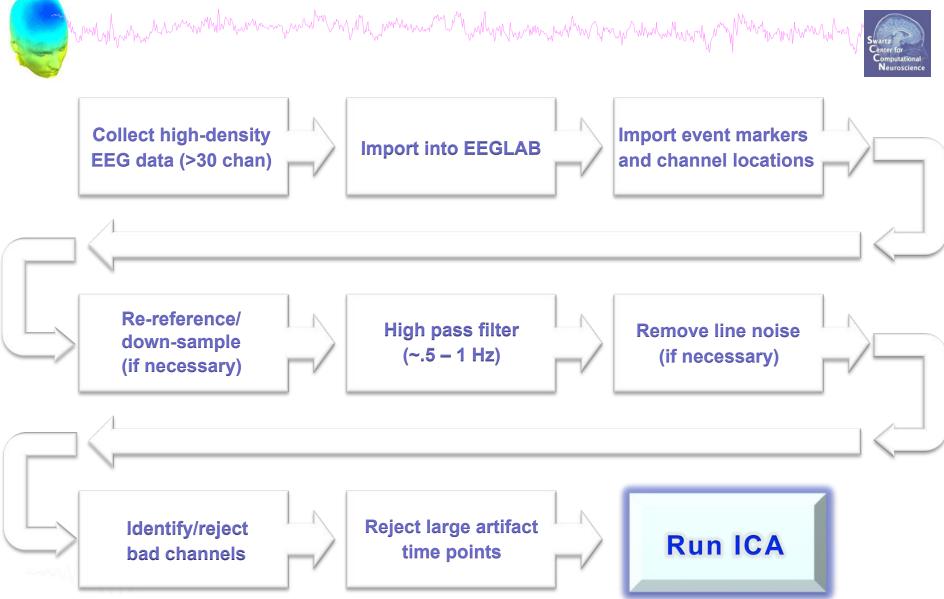
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	Frames per epoch	85504	
	Epochs	1	
	Events	260	
	Sampling rate (Hz)	256	
	Epoch start (sec)	0.000	
	Epoch end (sec)	333.996	
	Reference	unknown	
	Channel locations	Yes	
	ICA weights	140	
	Dataset size (Mb)	26.5	



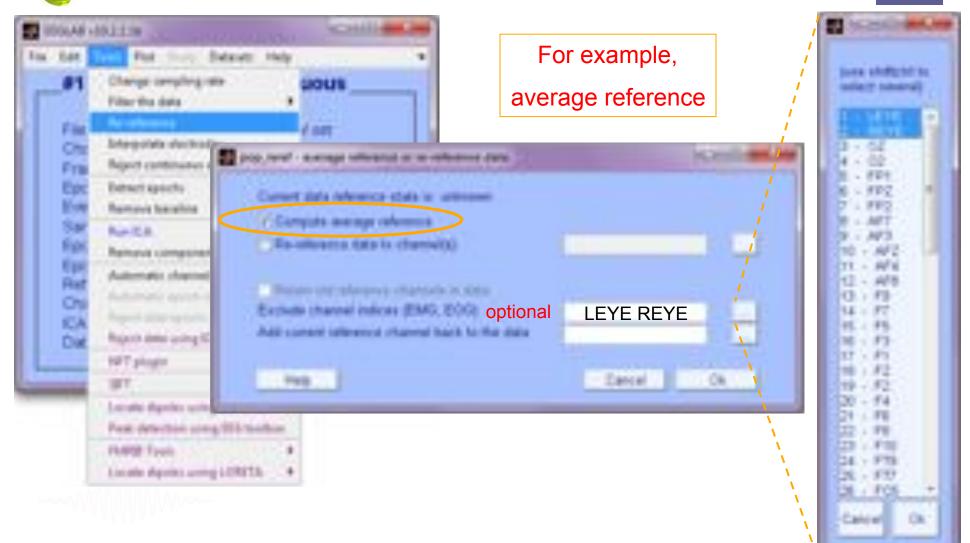
Pre-processing pipeline



Re-reference data (if necessary/desired)

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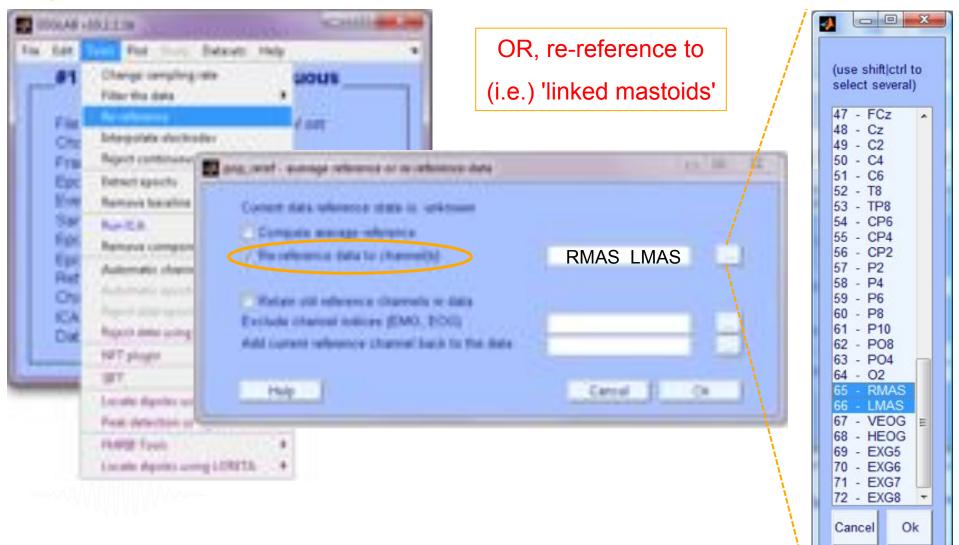


Re-reference data (if necessary/desired)



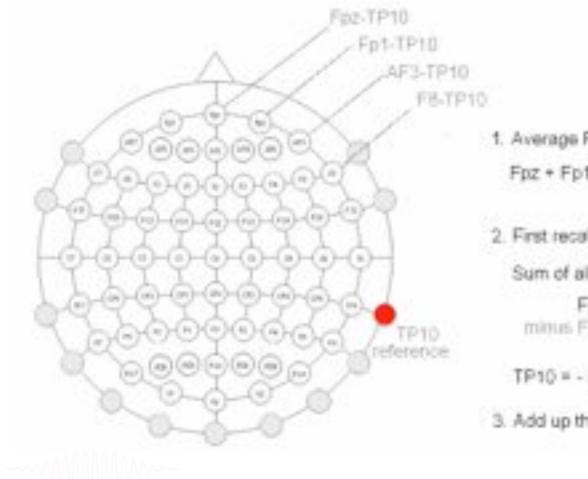
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1. Average Reference assumption Fpz + Fp1 + AF3 + F8 + FT8 + ... + TP10 = 0

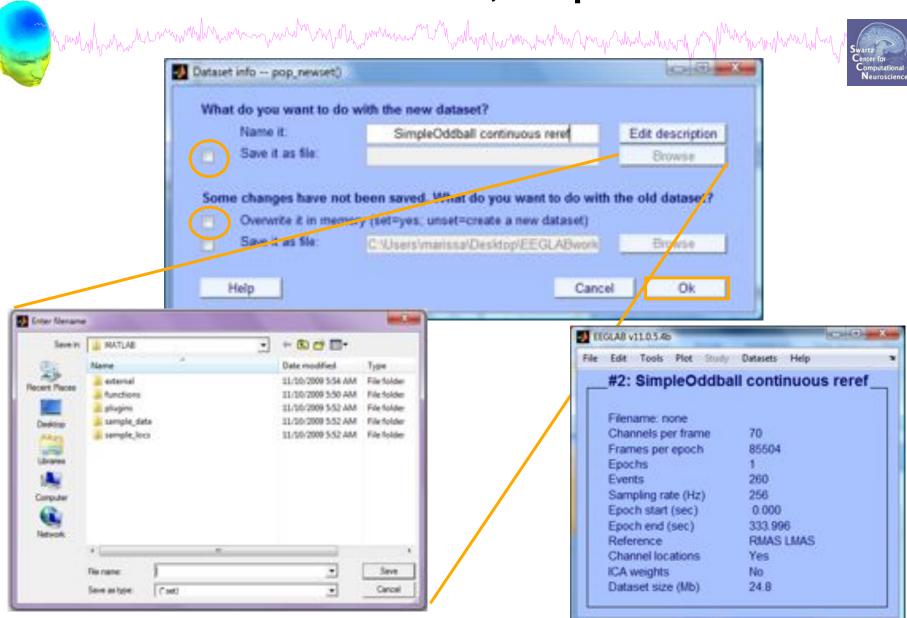
 First recalculate the activity at reference TP10 Sum of all electrode activity =

Fpz + Fp1 + AF3 + F8 + ... - 64TP10 minus Fpz + Fp1 + AF3 + F8 + ... + TP10 = 0

TP10 = - (Sum of all electrode activity)/65

3. Add up the activity of TP10 to all channels

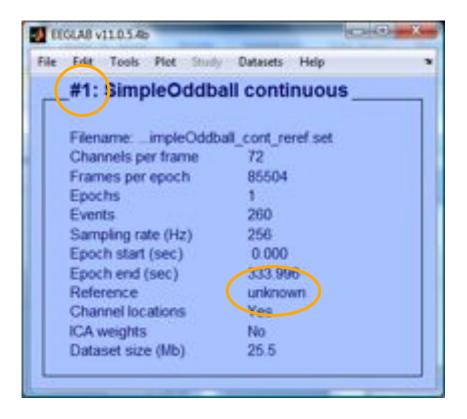
Save new dataset, keep old one

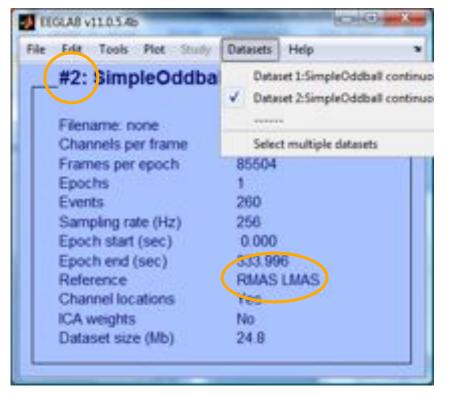


Multiple active datasets (ALLEEG)





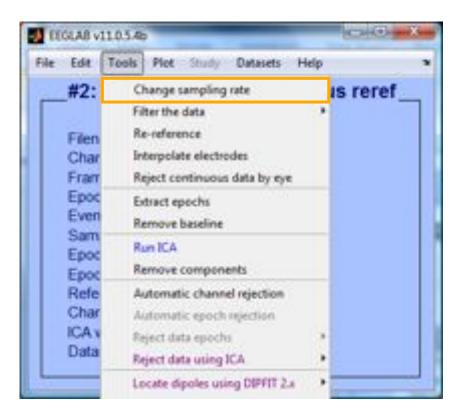




Resample data (if necessary)

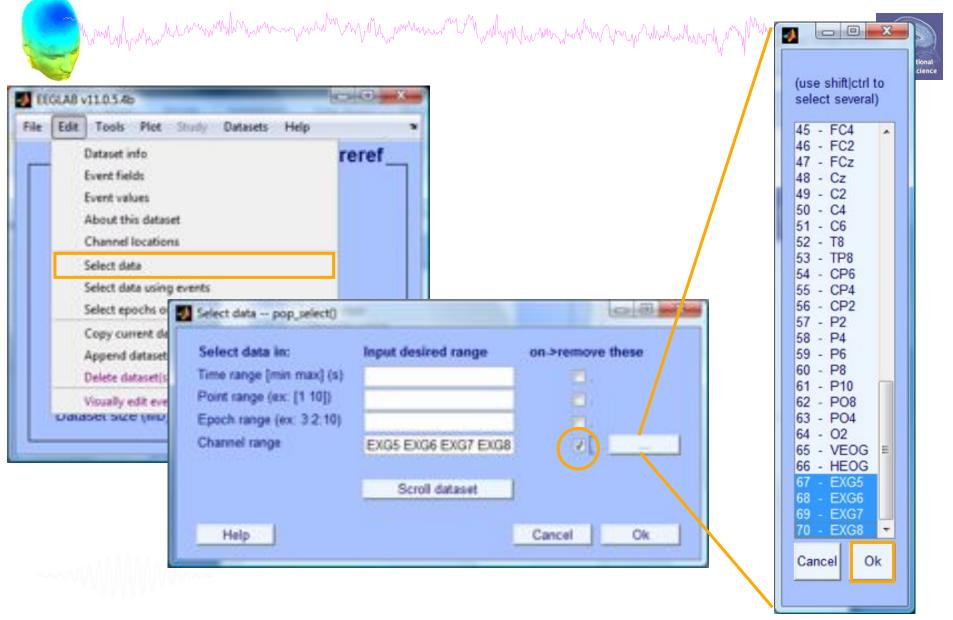
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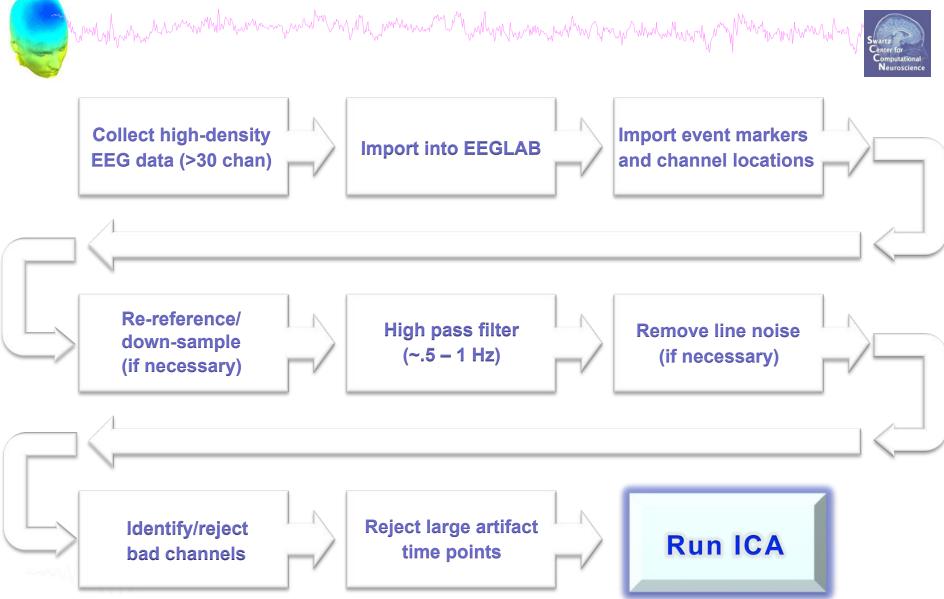




Remove unwanted channels



Pre-processing pipeline



Load an existing dataset



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Quit						

Cancel

Open.

Filter the data (if necessary/desired)



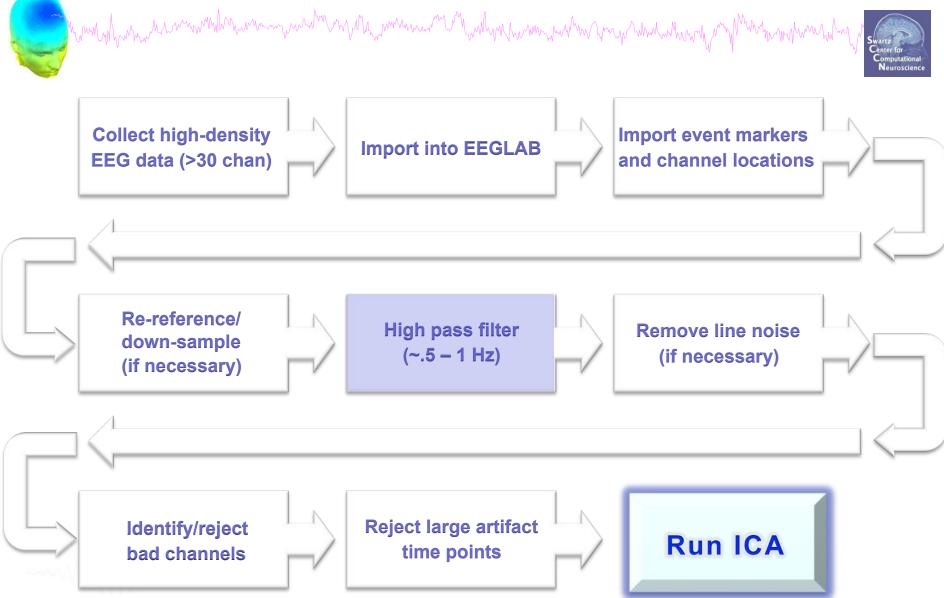
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Lower cut off frequencies require longer stretches of continuous data

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Sam Epoc Epoc	Run ICA Remove components			sliter frequency response (check, recommended) or firls (u	ncheck, leg	for ICA
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Pre-processing pipeline





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Quit		Manage data processing plugins Manage deactivated plugins

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101213		Plugin	Version	Description	
)		ERPLABIliters	1.00	Interface ERPLAB liters (requires seperate ERPLAB instalat	Dol
)		Cleanline	1.21	Automatic artifact rejection	Dec
3		BERGEN	1.1	Removal of MRI-related gradient artifacts from simultaneous	Doc
allender	Deadivate	Plugin	Version	Installed plutings	
6	ŏ	brainmovie	0.1	Brainmovies (command line only)	Dec
5	0	cormap	2.00	New version 1.03 available. Click update to install.	Dist
		eeg_toolbox	1.0	Interface EEG toolbox functions for ERP peak detection	Dec
		MRIb	1.21	Remove fMRI antitacts from EEG	Dot
		MP_clustering	1.00	Measure projection clustering of ICA components	Dot
		MutualInfoClustering	1.00	Mutual information clustering	Dist
		StudyEnvtopo	0.9	Add envirops capabilities to STUDY	Dist
3		VisEd	1.05	New version 1.04 available. Click update to install.	Co
		iirfit	1.02	Non linear filtering	Dox
Ő		loreta	1.1	New version 1.0 available. Click update to install.	Dee

Cancel

Ok

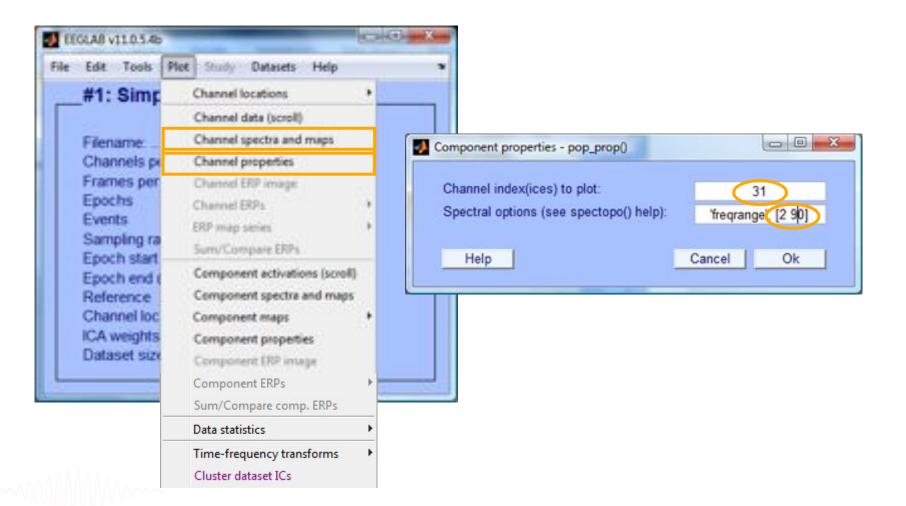
Remove line noise (Cleanline)

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Sam Epoc Epoc	Run ICA Remove components	Sliding window length (sec) 4 Sliding window step size (sec) 2
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	Locate dipoles using DIPFIT 2.x Peak detection using EEG toolbox	Produce verbose output Plot Individual Figures uncheck (set)
	FMRIB Tools	Help Cancel Ok

Plot channel spectra



Filter comparisons

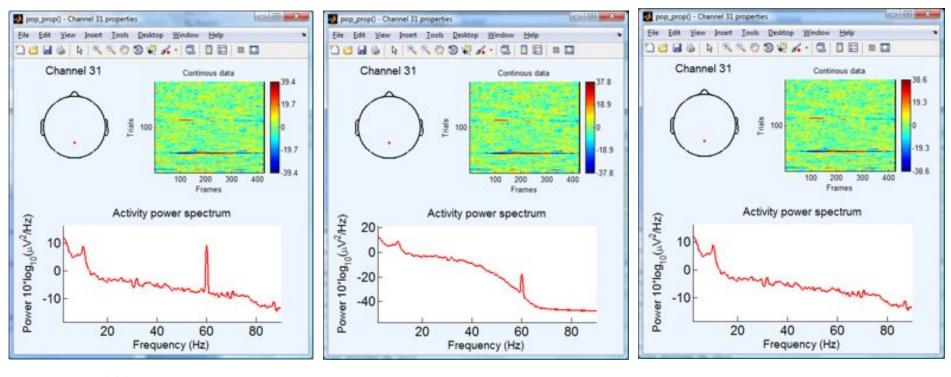


0.5 Hz high-pass filter

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

0.5 Hz high-pass filter Cleanline

Neuroscienc



-----WWW.----

Other useful plugins



- Cleanline (developed by Tim Mullen)
 <u>http://www.nitrc.org/projects/cleanline/</u>
- ERPLAB Toolbox (developed by Steve Luck and Javier Lopez-Calderon at UC Davis)

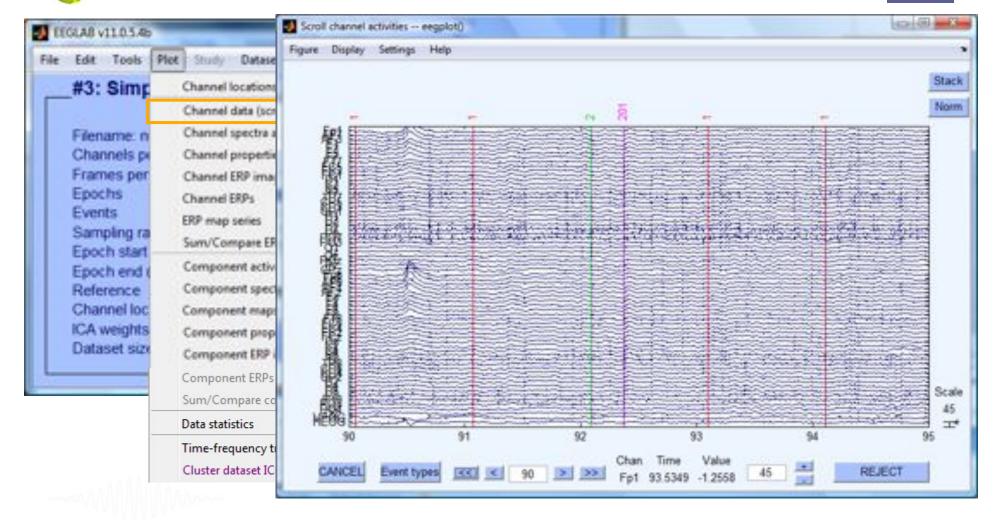
http://www.erpinfo.org/erplab/erplab-home/



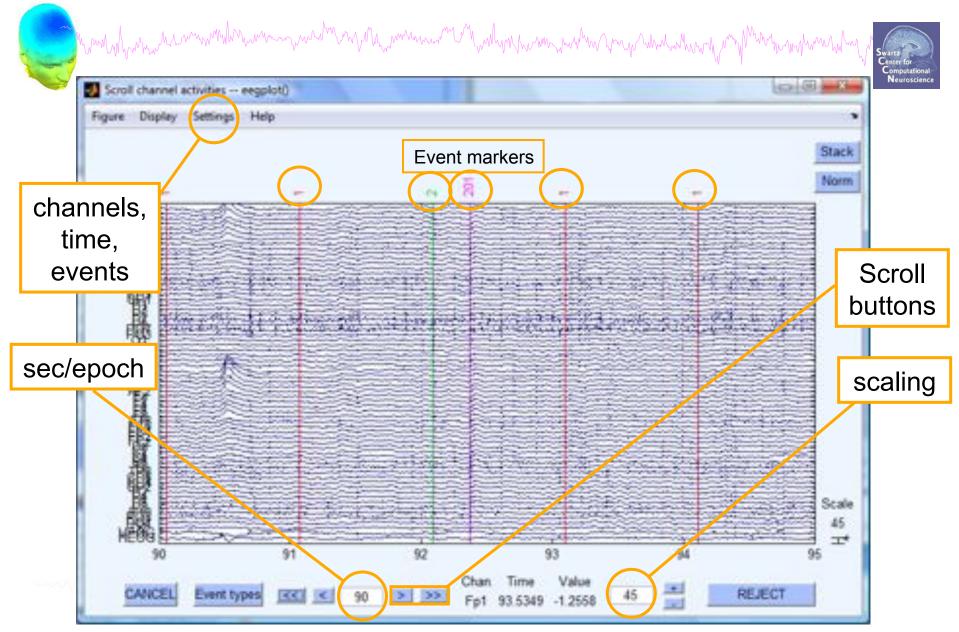
Scroll channel data



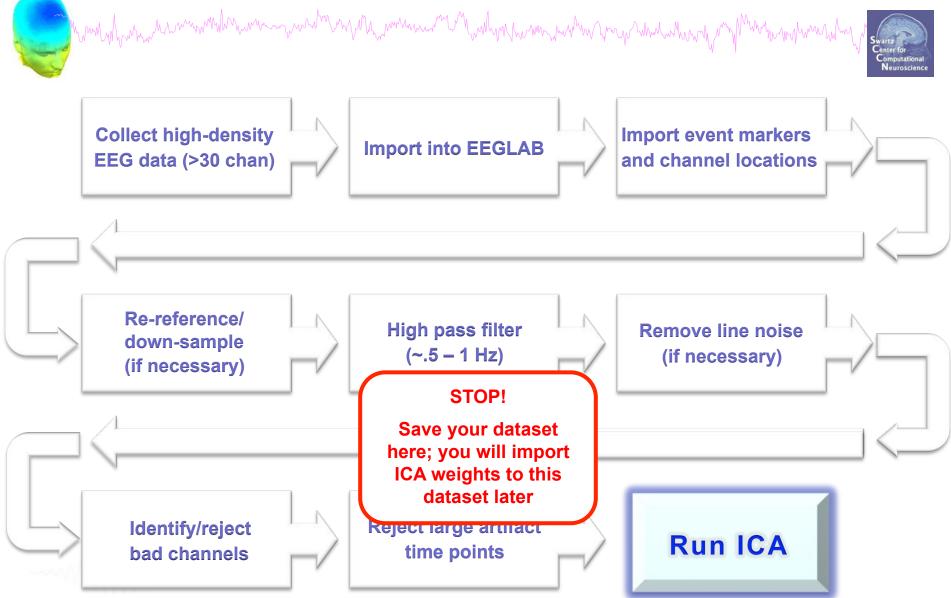




Scroll channel data



Pre-processing pipeline



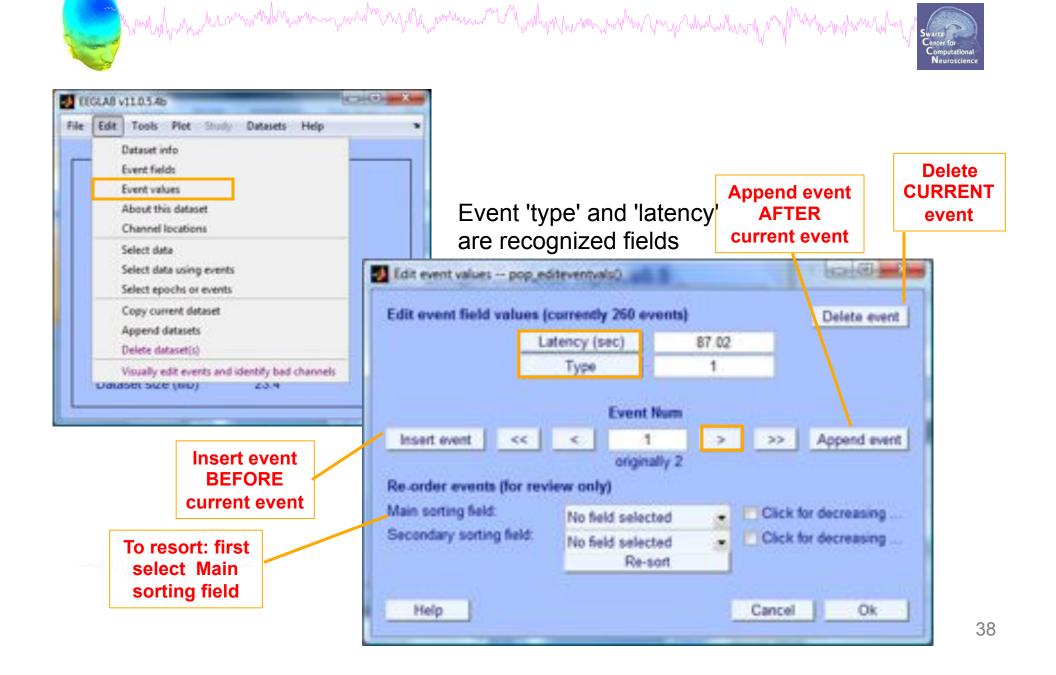
Visualizing ERPs

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Swartz Center for Computational Neuroscience

- Epoch data according to different event types
- Reject epochs containing artifact
- Various plot types (channel and scalp topography)

Review event values



Extract epochs

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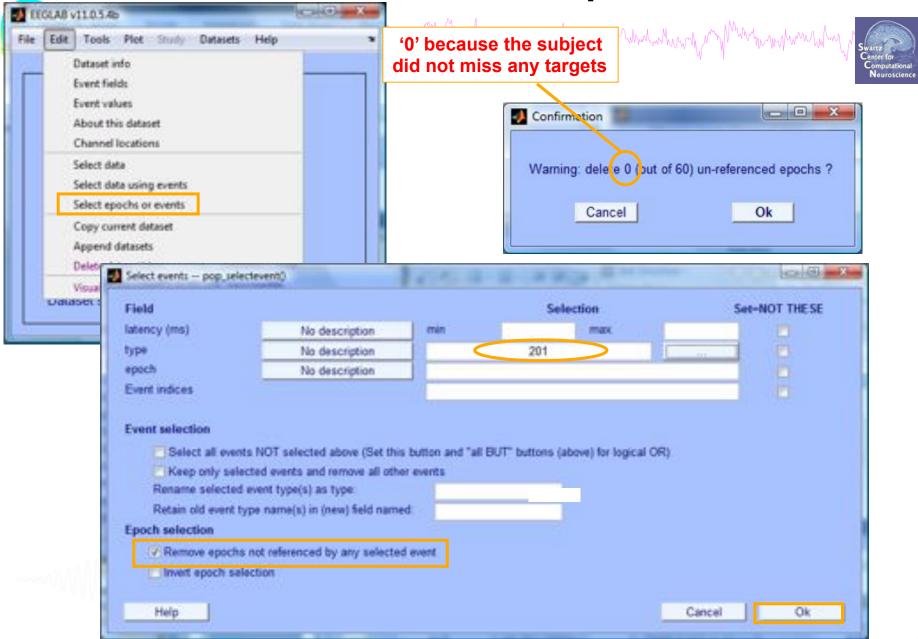


Char ICAN Data Automatic epoch spection Reject data epochs Reject data epochs Reject data using ICA Locate dipoles using DIPFIT 2.x Peak detection using EEG toolbox FMRIB Tools	#1: Filer Cha Fran Epo Ever Sam Epo Epo	Filter the data Re-reference Interpolate electrodes Reject continuous data by eye Extract epochs Remove baseline Run ICA Remove components		<pre>>> eeg_eventtypes(EEG) 1 140 2 60 201 60</pre>	(use shift ctrl to select several) 1 2 201 201 • Cancel Ok
Peak detection using EEG toolbox Time-locking event type(s) ([]=all) FMRIB Tools 1	ICA	Automatic epoch rejection Reject data epochs			
FIVIRID TOOIS			•	Extract data epochs - pop_epoch()	
Ecolar alpha ang concern		FMRIB Tools Locate dipoles using LORETA	b	Epoch limits [start, end] in seconds Name for the new dataset	-0.1 1 SimpleOddball nontargets

Extract epochs

ataset info pop_newset)		0.0		
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Select a subset of epochs

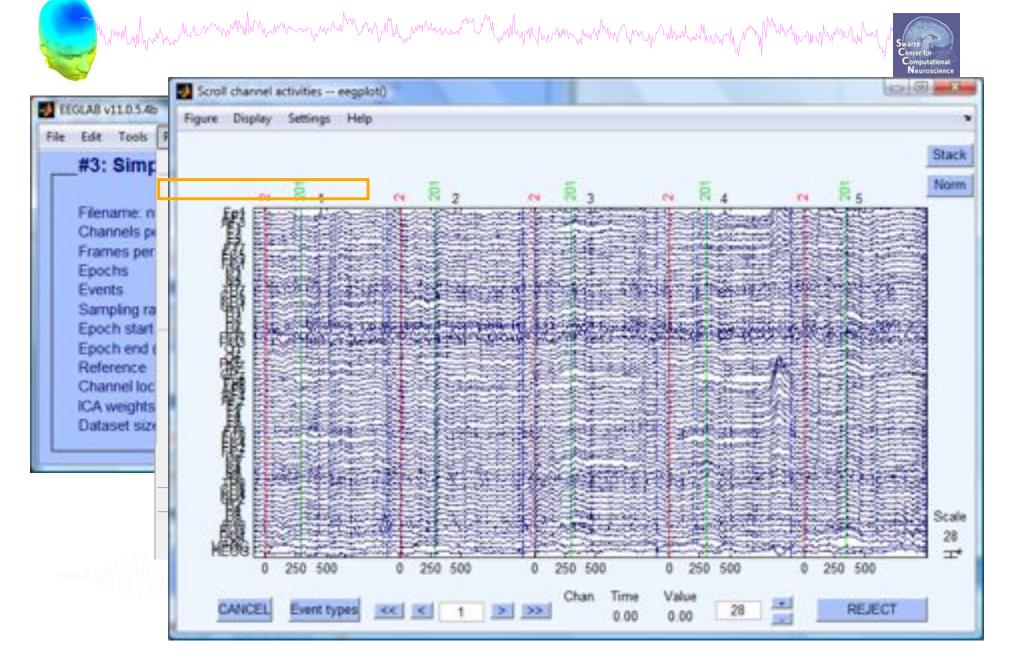




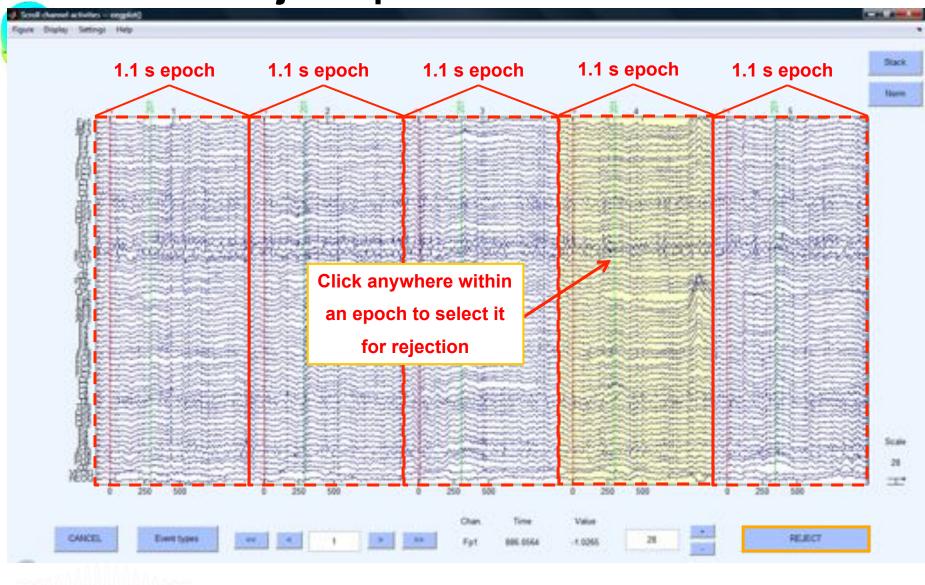
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Memory and other options		Hide Folders			Save	Cancel

Scroll (epoched) channel data



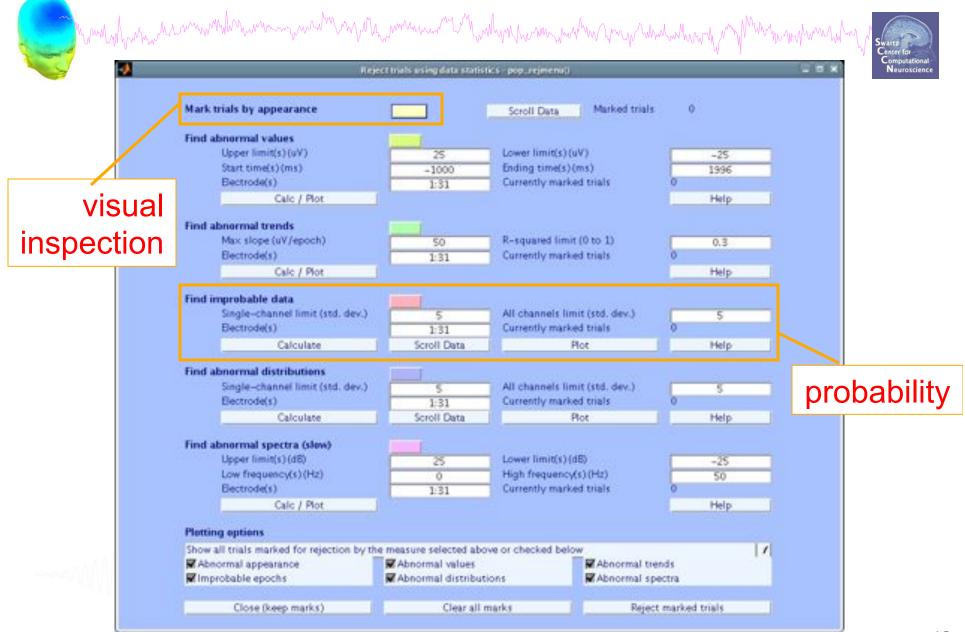
Reject epochs with artifact

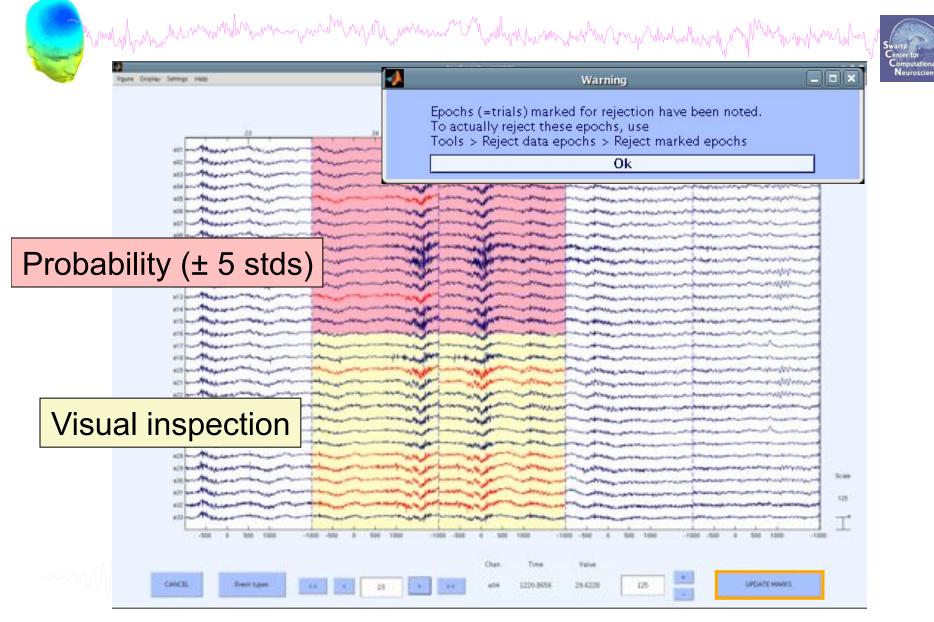




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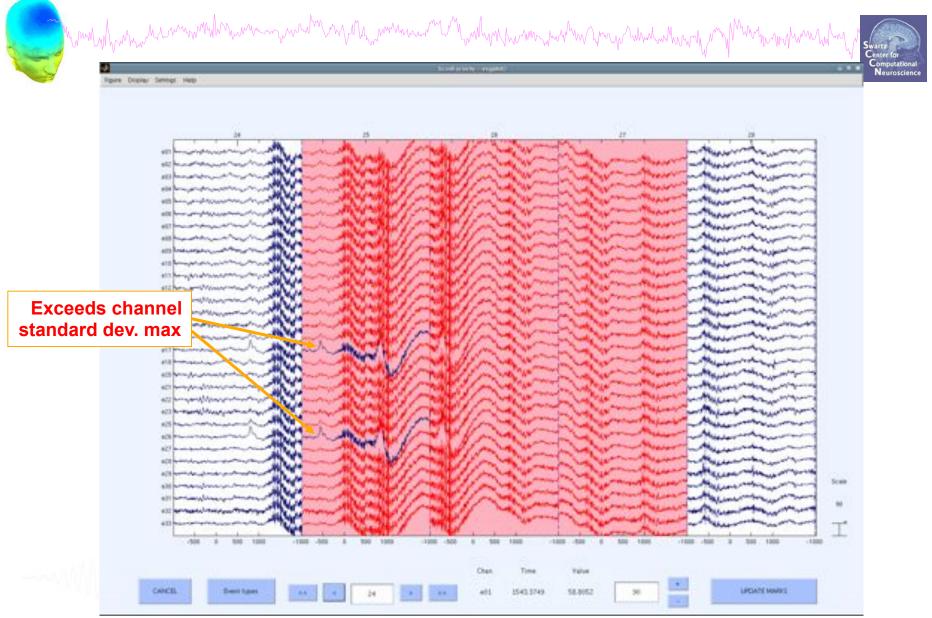
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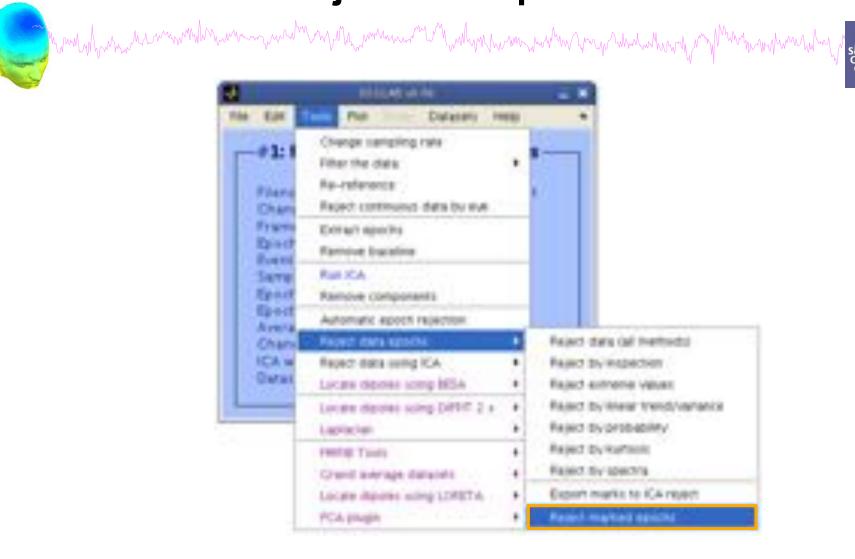




#### Plot channel measures over time





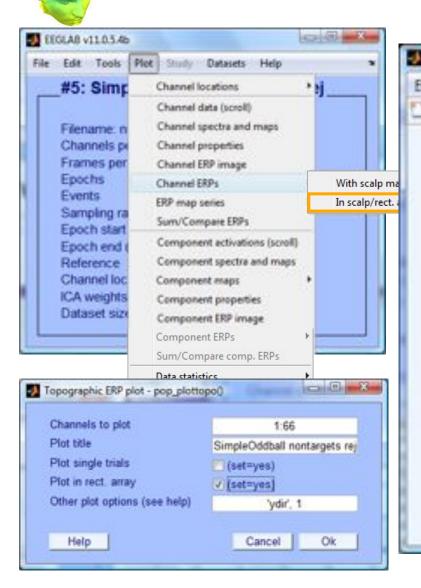


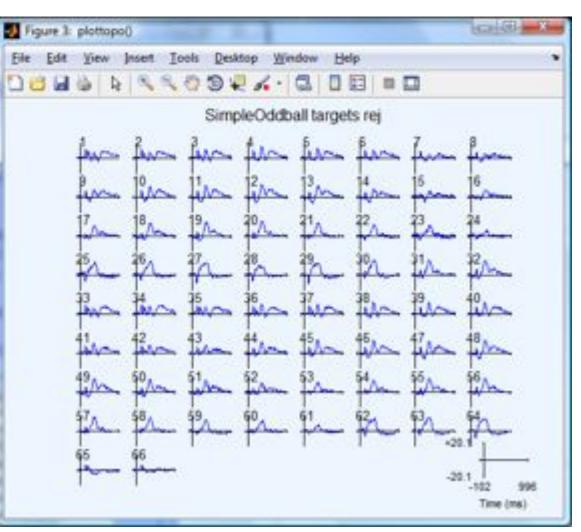
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Neuroscience

# Visualize ERP in rectangular array

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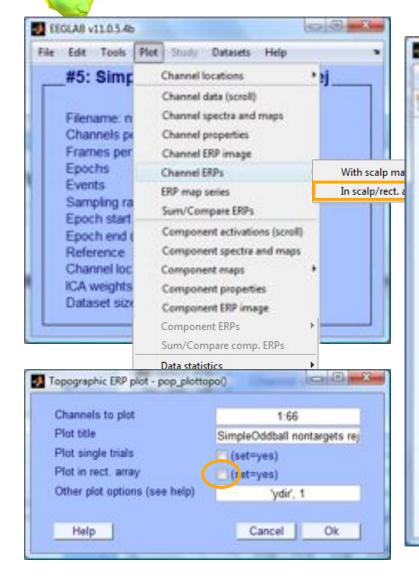


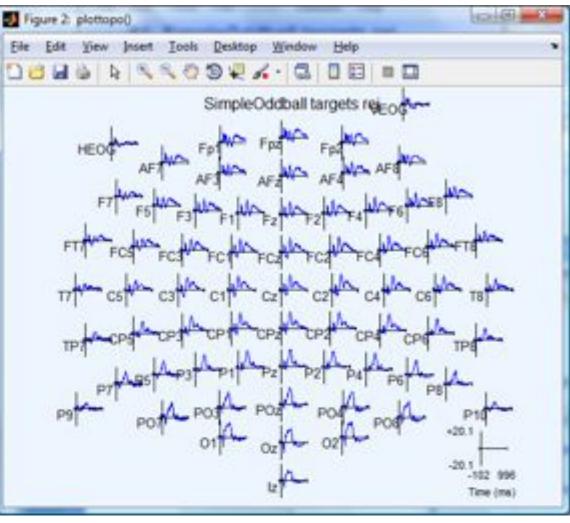
Neuroscience

# Visualize ERP in topographic array

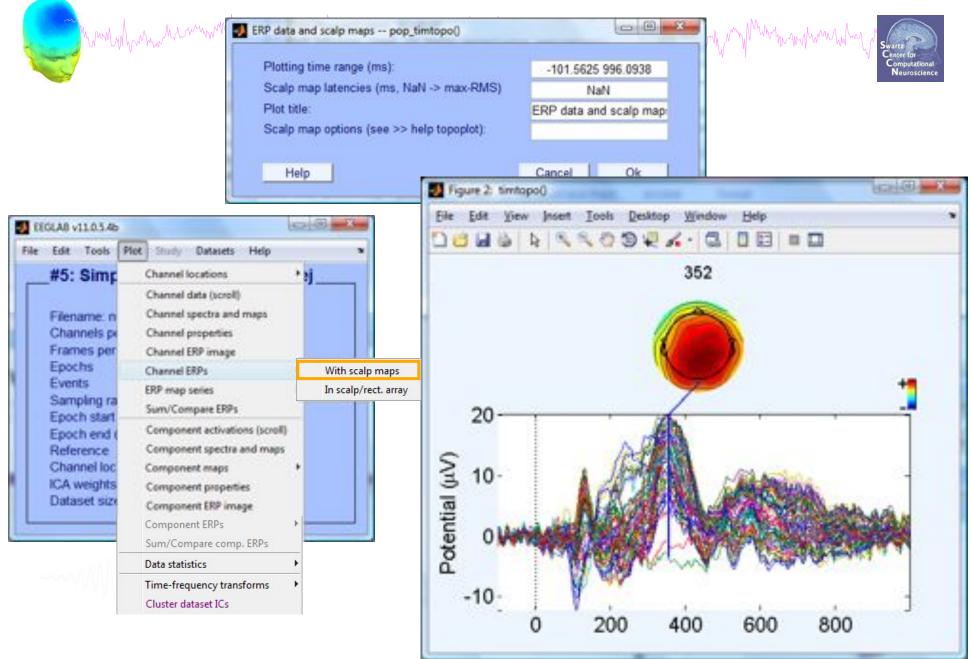
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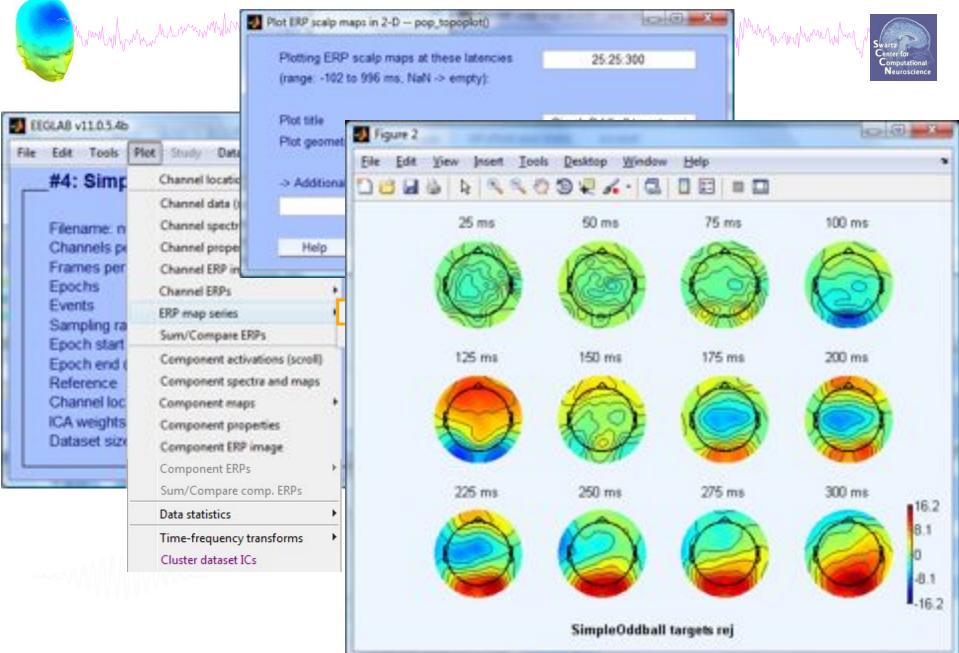




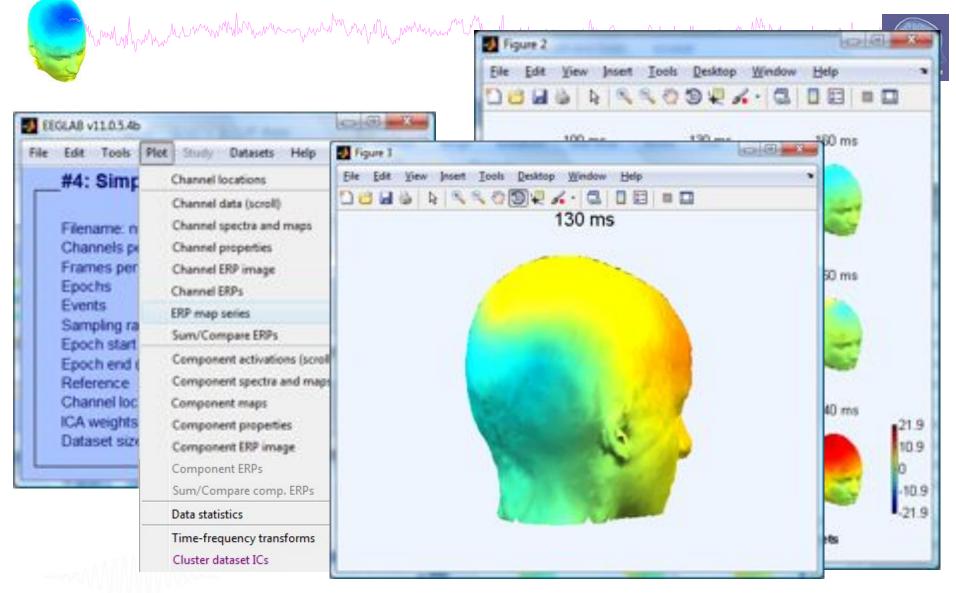
#### **Visualize ERP scalp distribution**



## Visualize channel ERPs in 2D



# Visualize channel ERPs in 3D



# Exercises

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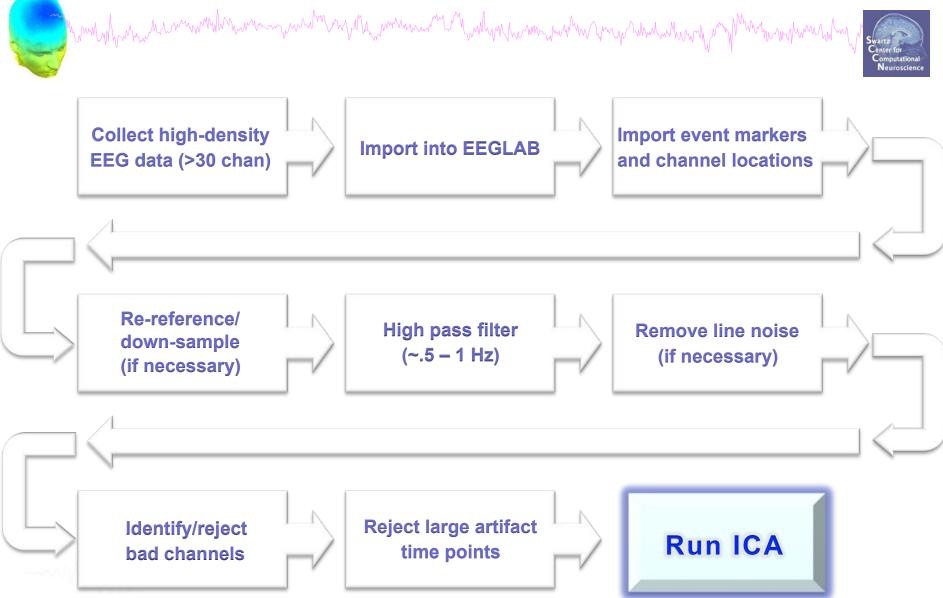
- Load SimpleOddball.set
- Rereference data to average reference
- Hi-pass filter the continuous data, then save
- Epoch the data on circles (event type 1) and stars (event type 2)
- Scroll the epoched data and perform visual rejection of epochs
- Explore the automated artifact rejection tools
- Save 'clean' epoched datasets for circles and stars



# **EEGLAB** Processing

# Data cleaning for ICA

## **Pre-processing pipeline**



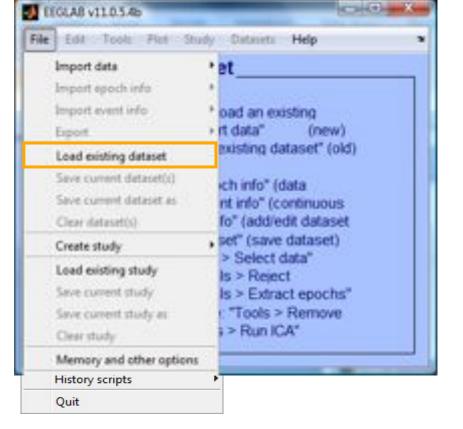
## **Retrieve or reload continuous EEG dataset**



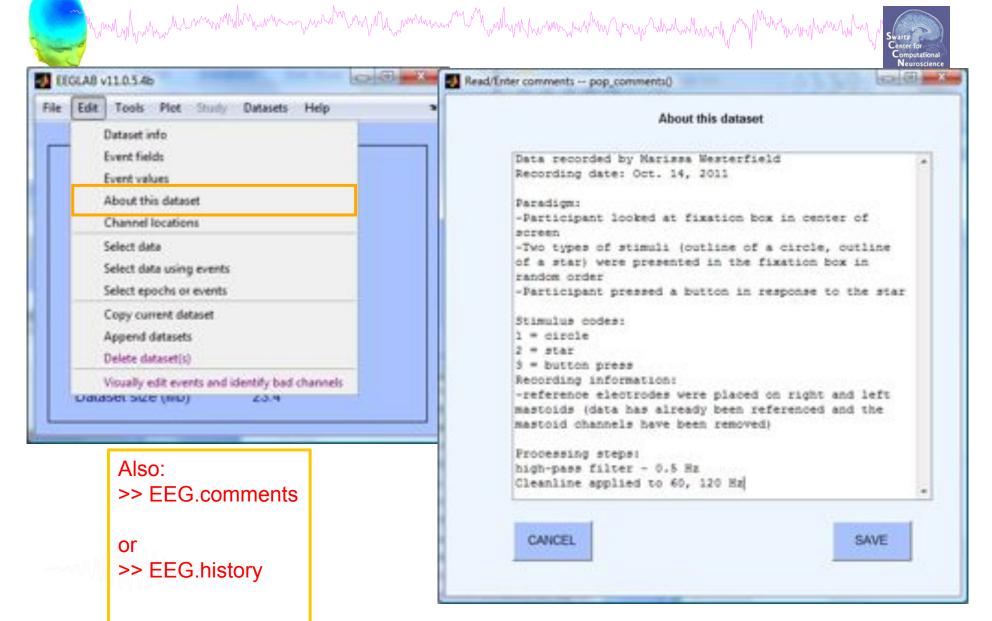
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| le Edit Tools Plot Study | Dat  | asets Help >                          |
|--------------------------|------|---------------------------------------|
| #3: SimpleOddba          |      | Dataset 1:SimpleOddball hipass0.5 CL  |
|                          |      | Dataset 2:SimpleOddball nontargets re |
| Filename: none           | ~    | Dataset 3:SimpleOddball targets rej   |
| Channels per frame       |      | Select multiple datasets              |
| Frames per epoch         | 2    | 82                                    |
| Epochs                   | 6    | 0                                     |
| Events                   | 1    | 20                                    |
| Sampling rate (Hz)       | 2    | 56                                    |
| Epoch start (sec)        | - 30 | .102                                  |
| Epoch end (sec)          | 0    | 996                                   |
| Reference                | u    | nknown                                |
| Channel locations        | Y    | es                                    |
| ICA weights              | N    | 0                                     |
| Dataset size (Mb)        | - 4  | 6                                     |



## **Comments and dataset history**

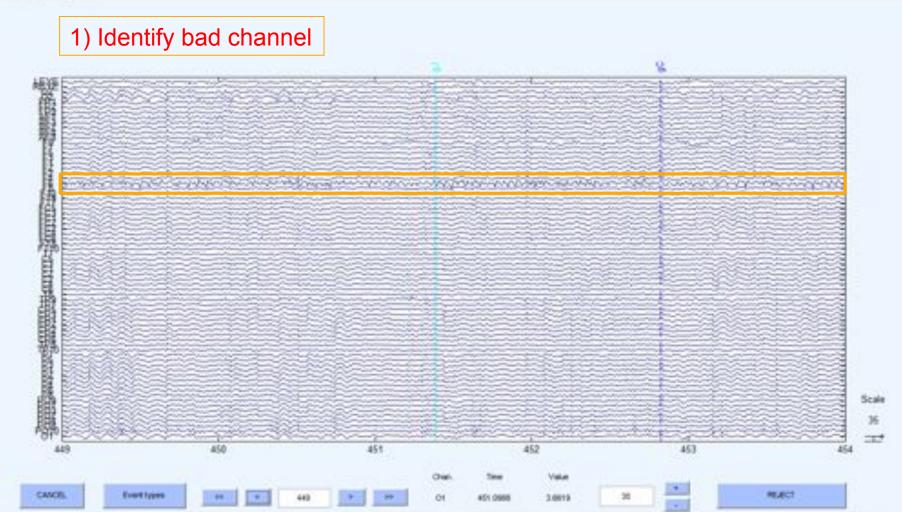


## Manually identifying bad channels

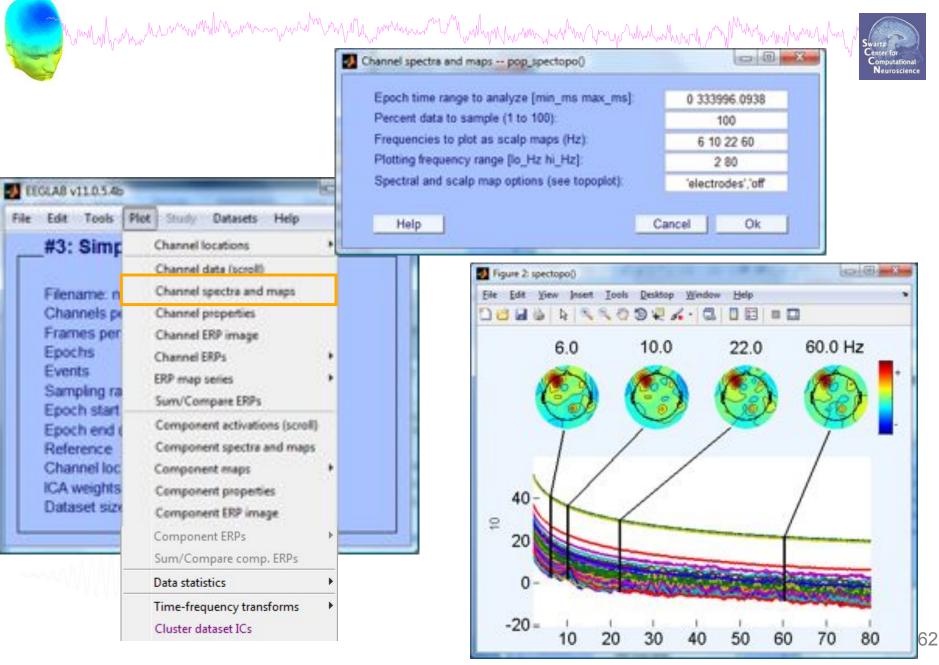


Scoll channel activities in resplicit

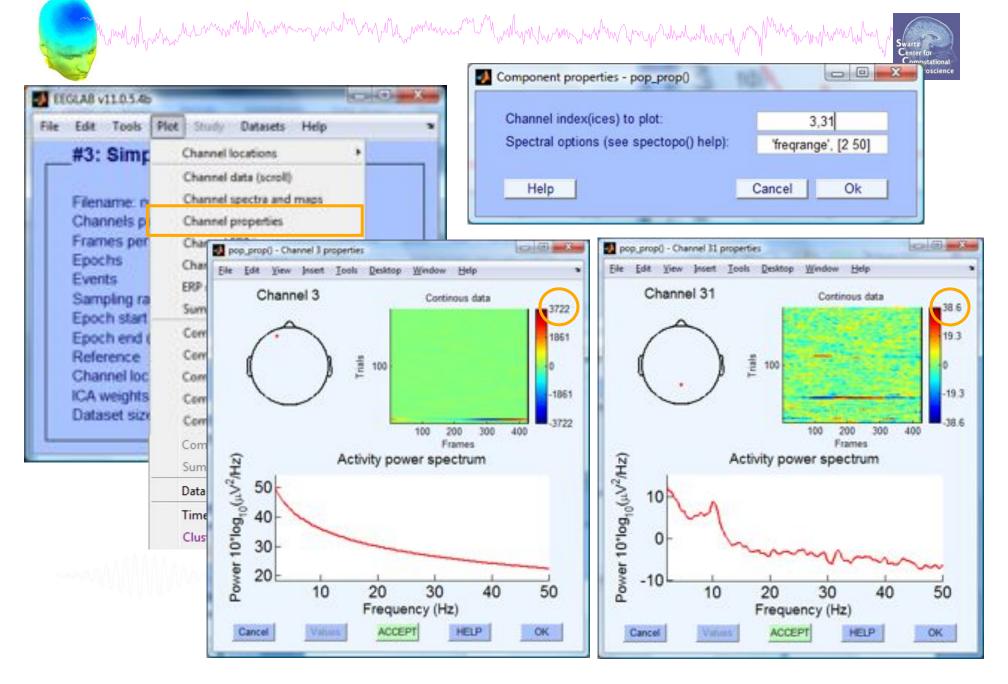
Figure Display Settings Help



## Manually identifying bad channels



## Manually identifying bad channels



# Auto-detection of noisy channels



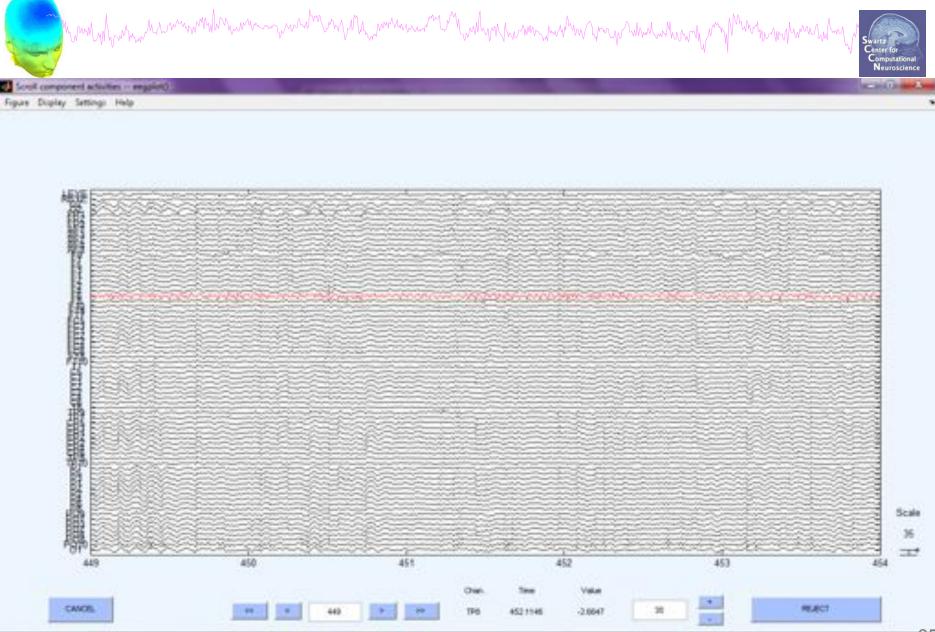




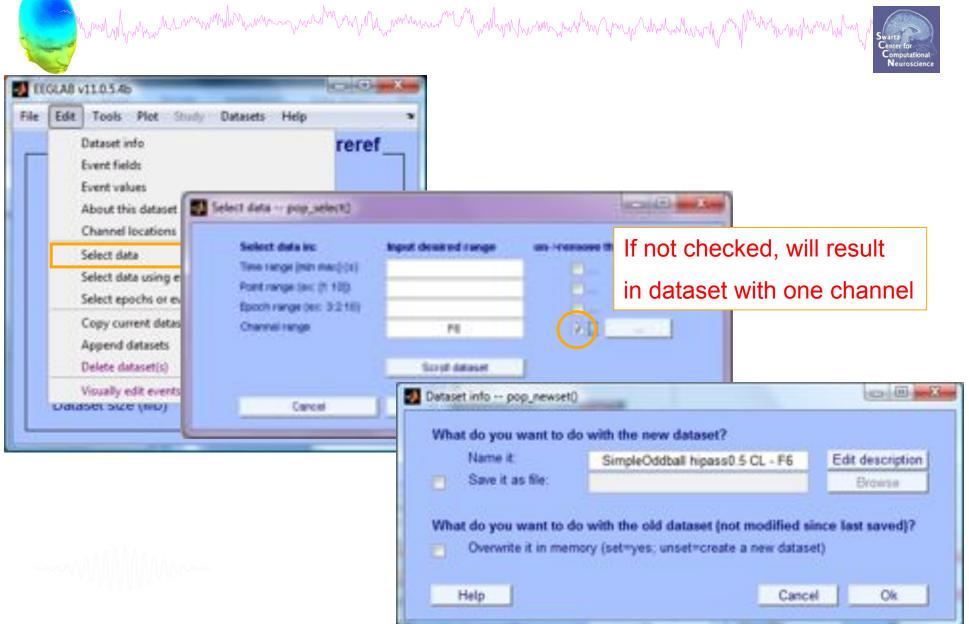
| Incold Incold |
|---------------|
| 1.75          |
| Probability . |
| 12            |
| -4            |
|               |
| DR .          |
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----www.MMM

#### **Auto-detected noisy channel**



# **Removing channel(s)**



# Removing channel(s)

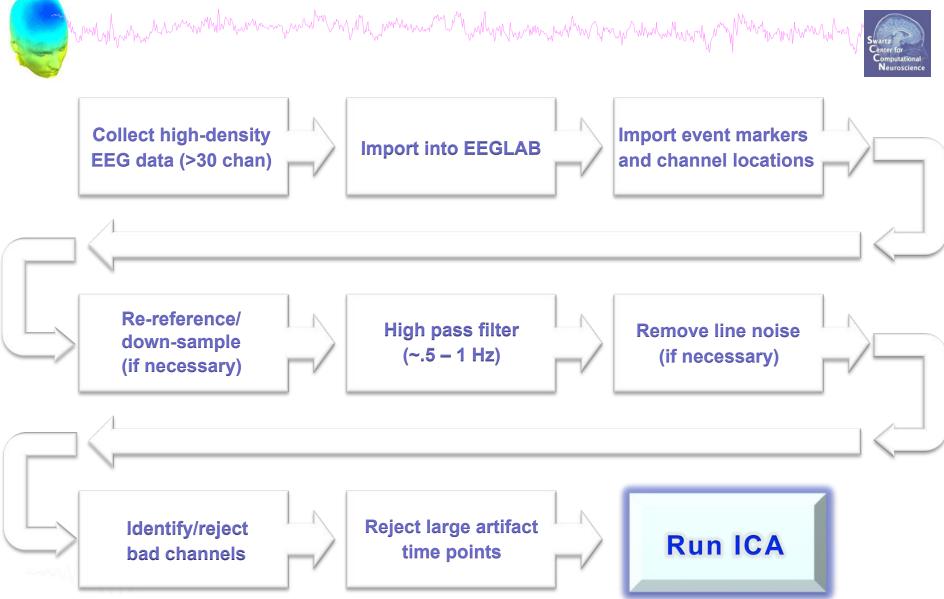


• You may prefer to interpolate bad channels rather than remove them altogether

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- The loss in dimensionality will affect the ICA decomposition
- Usual solution:
  - Delete the bad channels before running ICA
  - STUDY tools will do much of this automatically (interpolate missing channels, etc)

## **Pre-processing pipeline**

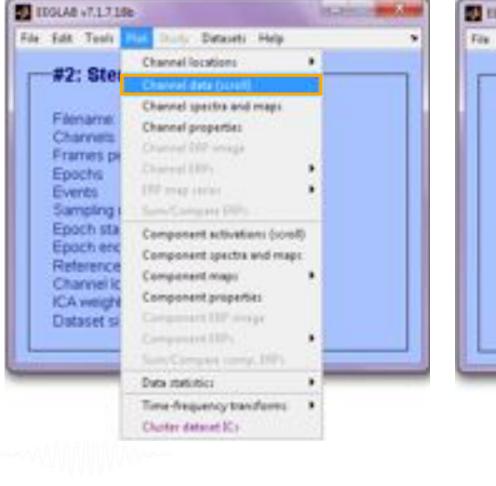


# **Reject continuous data**



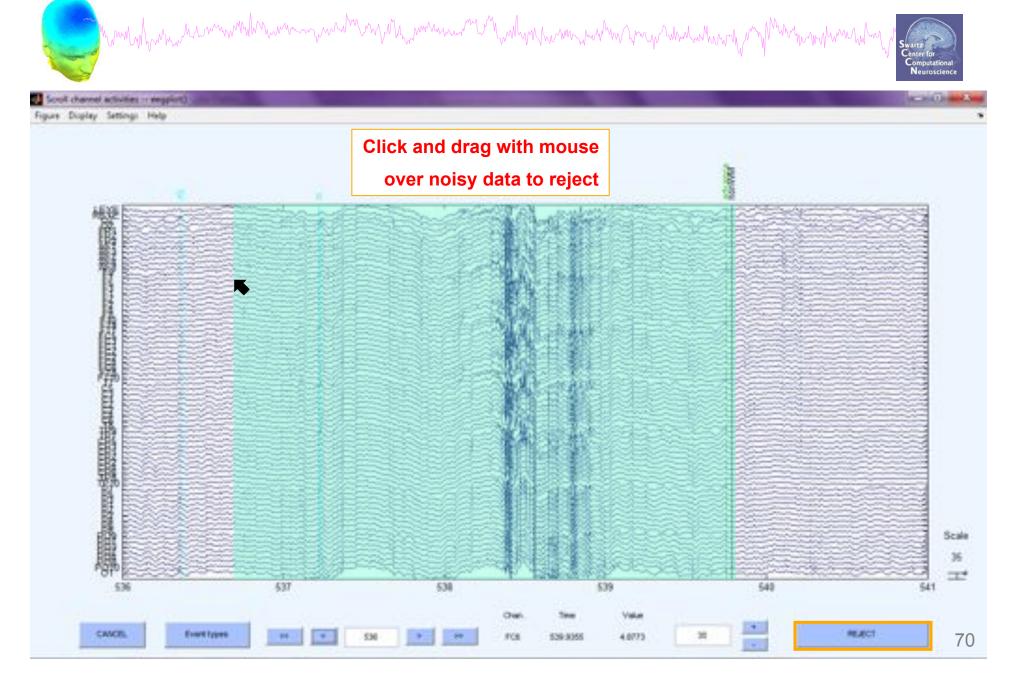


#### Equivalent

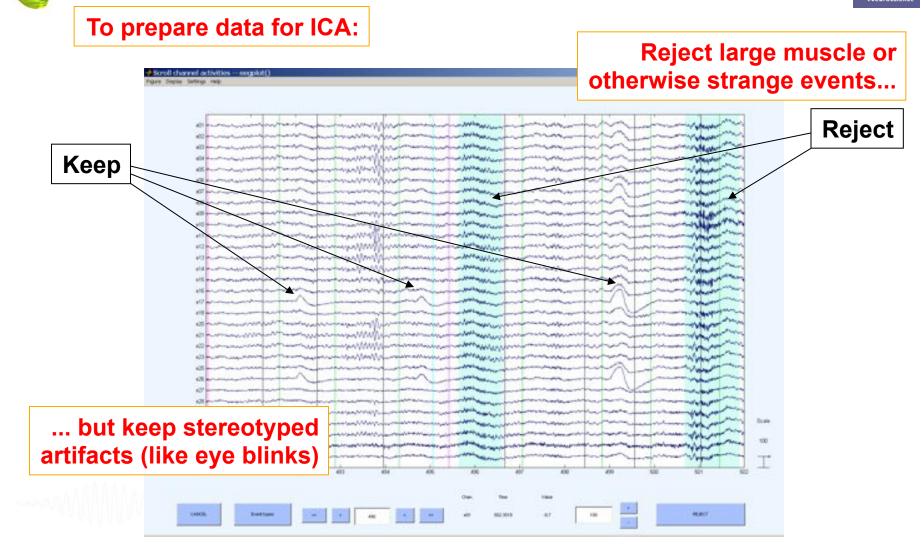


| t Tool Plot multi Detecets Hi                                                                                                                                                | rip.                                              |        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|--------|
| Change sampling rate                                                                                                                                                         |                                                   |        |
| Fiberthe data                                                                                                                                                                |                                                   |        |
| Re-reference                                                                                                                                                                 |                                                   |        |
| Trapolate electrodei                                                                                                                                                         |                                                   |        |
| Reject continuous and by eye                                                                                                                                                 |                                                   |        |
| bitact epichs                                                                                                                                                                |                                                   |        |
| Remove beseline                                                                                                                                                              |                                                   |        |
| Run ICA                                                                                                                                                                      |                                                   |        |
| Remove components                                                                                                                                                            |                                                   |        |
| Automatic channel rejection                                                                                                                                                  |                                                   |        |
| Autometic epoch rejection                                                                                                                                                    |                                                   |        |
| Fearch Este specific                                                                                                                                                         | A                                                 |        |
| di Reject data scierg NA                                                                                                                                                     |                                                   |        |
| Locate dipelecturing DIPVET 2.x                                                                                                                                              | 2                                                 |        |
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| Mark destrictions of continuous at<br>by dragging the last incurse but<br>stretches to unwark. When don'<br>excase marked stretches (hitse<br>boundary markets in the event) | on. Click on mar<br>Agence 745-80<br>Law-ex Hands | 10 AT  |
| Cancel                                                                                                                                                                       | - Con                                             | den.ee |

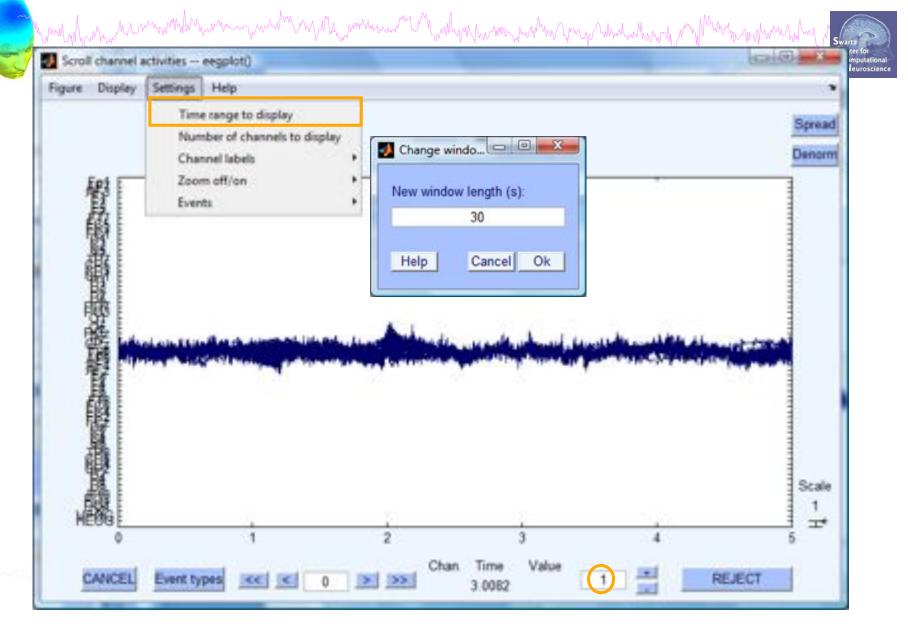
#### **Reject continuous data**



# 



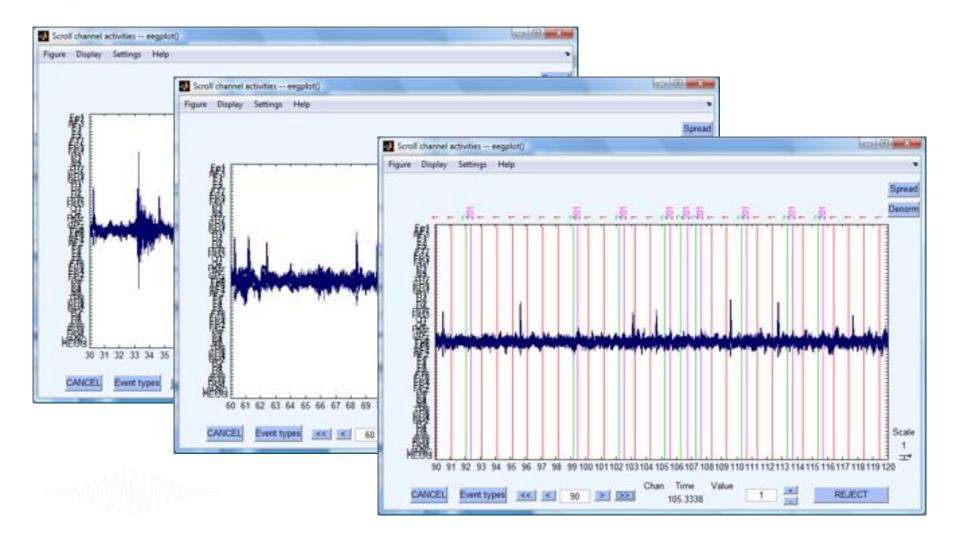
# Fast (but sloppy) artifact rejection



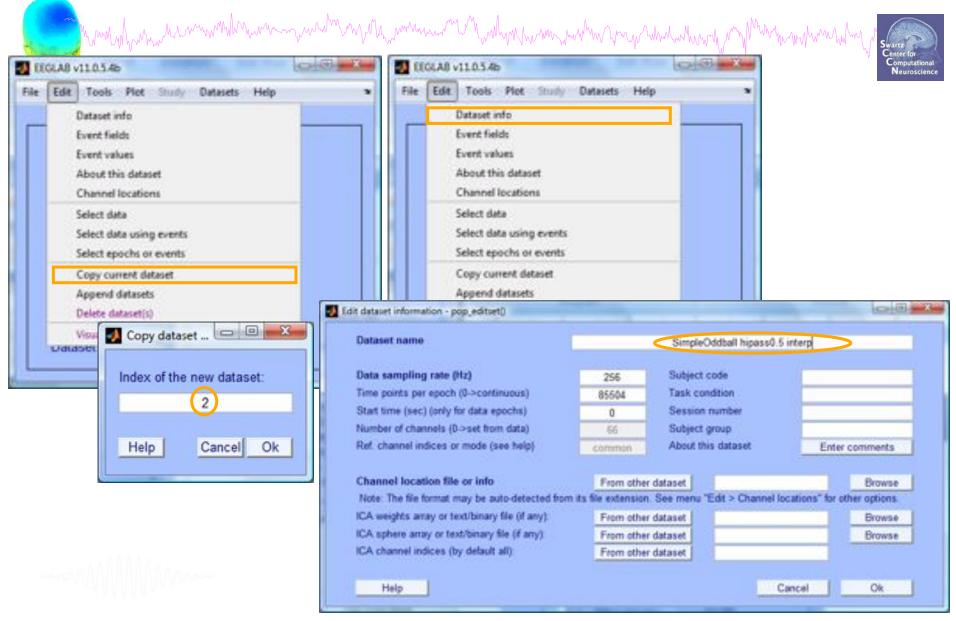
# Fast (but sometimes sloppy) artifact rejection

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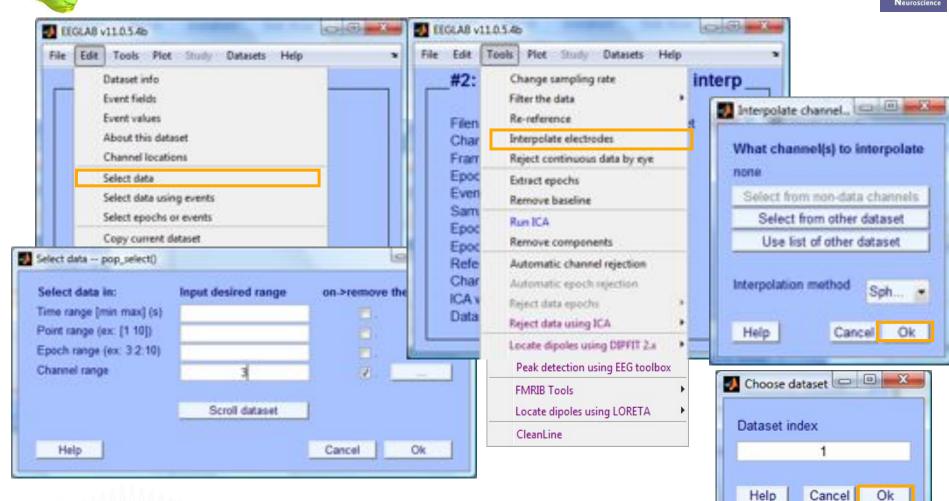


### Interpolate bad channel(s)



## Interpolate bad channel(s)

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# Exercises

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 Load a previously filtered version of SimpleOddball.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

- Scroll the epoched data and perform visual rejection of epochs
- Explore the automated artifact rejection tools



## **Pre-processing pipeline**

