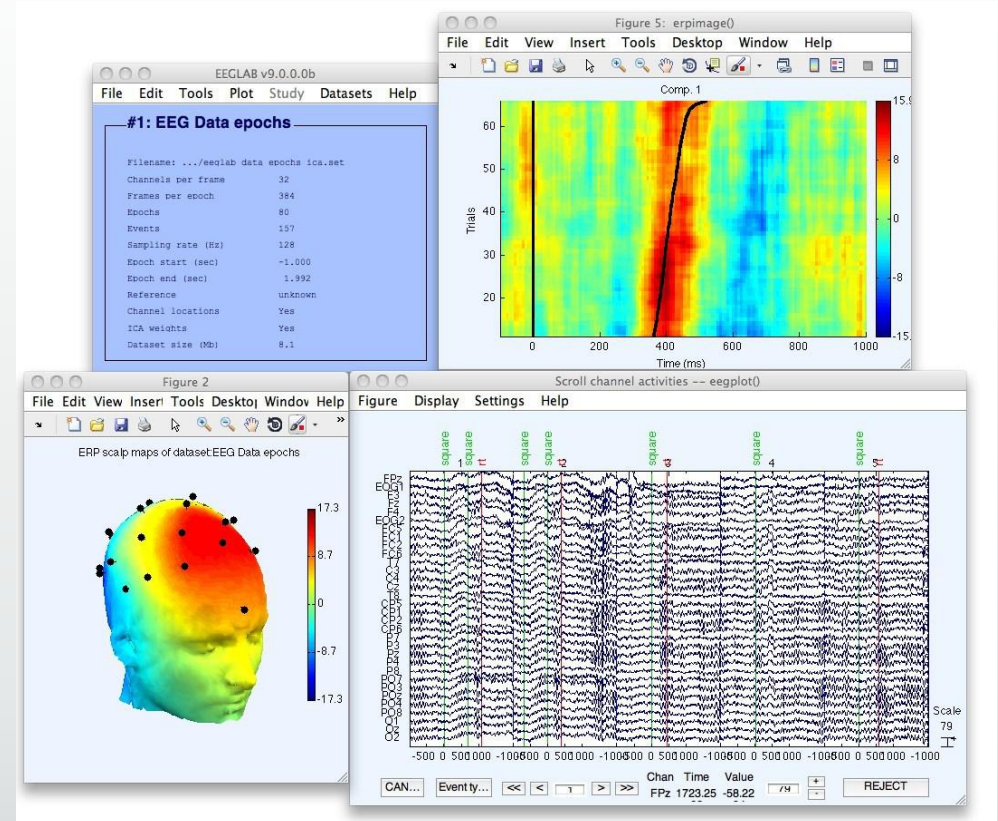


Topic 4 – EEG Analysis

By. Dr. Chris S. Crawford

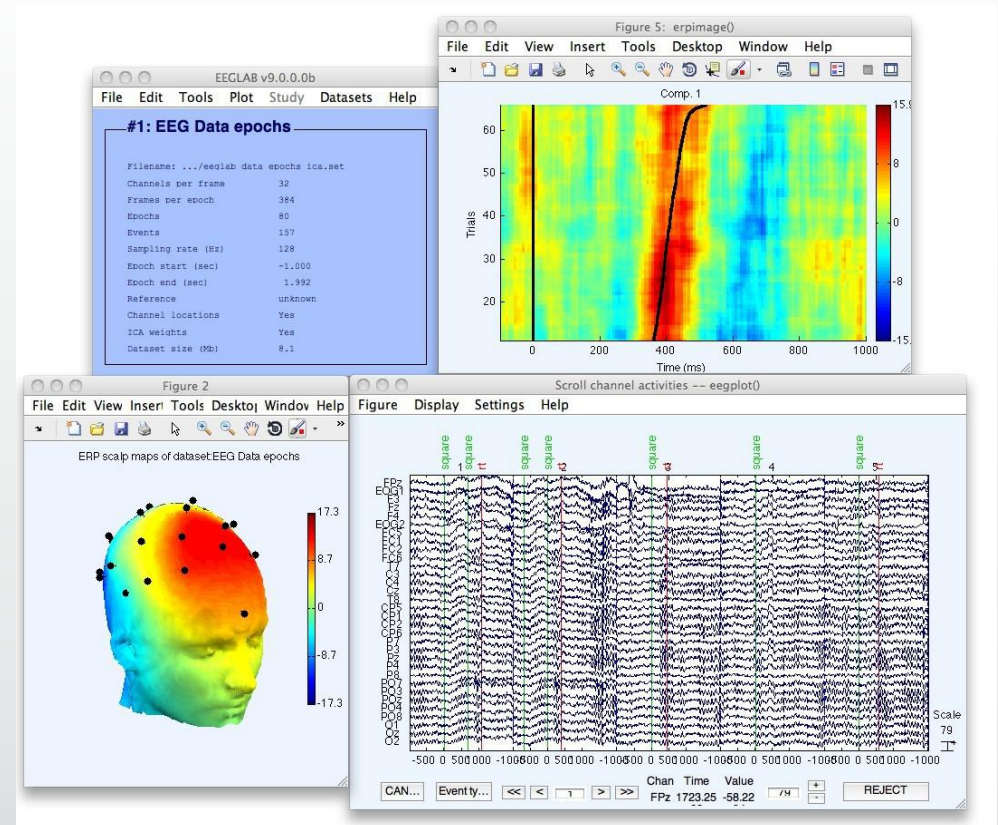
EEGLAB

- MATLAB toolbox & graphic user interface for EEG data analysis
- Over 600 functions
- Over 100k downloads
- Over 10k subscribers



EEGLAB Goals for Today

- Install MATLAB
- Install EEGLAB Plugin
- Load EEG data using MATLAB / EEGLAB
 - Import raw data
 - Load Channel locations
 - Re-reference data
 - Remove Unwanted channels
 - Filter data
 - Remove Line noise
- Scroll through raw EEG data
- Create Plots
- Compare TD vs. ASD



Install MATLAB

- <https://oit.ua.edu/software/matlab/>

How to Obtain MATLAB

Students and faculty can visit the MATLAB portal through the button below. Through the portal, users can run the installer, view video tutorials and obtain software support. Users will first be prompted for their myBama username and password, then users will be directed to a MATLAB login page. Users with an existing MATLAB account can login, or users can create an account. After logging in with or establishing a MATLAB account, the download will be available.

MATLAB Portal



Install MATLAB

- Sign in / Create MathWorks Account

MathWorks is pleased to provide a special license to you as a member of University of Alabama, The. This license is intended to be used only for academic/course work and not for commercial purposes.

Sign in to your existing MathWorks Account

Sign In

Install MATLAB

- Create MathWorks Account

Create MathWorks Account

Email Address

To access your organization's MATLAB license, use your work or university email.

Location

United States

How will you use MathWorks software?

Select one...

Are you at least 13 years or older?

☐ Yes

☐ No

Cancel

Create

Install MATLAB

- Sign in using your MathWorks Account

Sign in to your MathWorks Account

Email Address or User ID:

Password:

[Forgot Password?](#)

☒ Keep me signed in

Sign In

Install MATLAB

- Sign in using your MathWorks Account

Download R2018b (includes R2018b Update 2)

Download and run the Installer

- When prompted, sign in as cscrawford@ua.edu
- Select your license
- Choose the products, toolboxes, and blocksets that you want to install

Windows (64-bit)

macOS (64-bit)

Linux (64-bit)

Related Links

[R2018b System Requirements](#)

[View instructions for running the installer](#)

[R2018b Updates Release Notes](#)

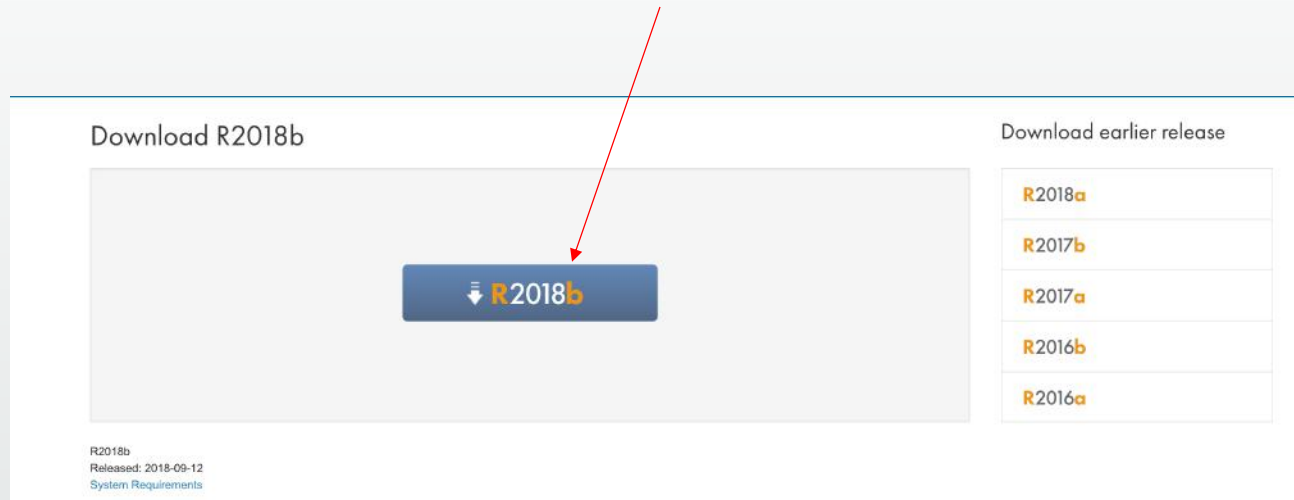
Need Help?

- **How do I install the toolboxes and blocksets that I just added to my license?**

Run the installer and follow the steps to download your license and new products.

Install MATLAB

- Download version **R2018b**



The image shows a screenshot of the MATLAB download page. It is divided into two main sections: "Download R2018b" on the left and "Download earlier release" on the right. In the "Download R2018b" section, there is a large blue button with a white download icon and the text "R2018b". A red arrow points to this button. Below this button, there is a small text block containing "R2018b", "Released: 2018-09-12", and a link for "System Requirements". The "Download earlier release" section contains a list of previous versions: R2018a, R2017b, R2017a, R2016b, and R2016a.

Download R2018b

Download earlier release

R2018b
Released: 2018-09-12
[System Requirements](#)

R2018a
R2017b
R2017a
R2016b
R2016a

Install EEGLAB Plugin

- <https://sccn.ucsd.edu/eeglab/downloadtoolbox.php>

Download EEGLAB

▼ [Click here](#) to download the latest EEGLAB version.

EEGLAB latest version is version 14. EEGLAB older versions are available [here](#) and [here](#). Revision details are available on the [EEGLAB wiki](#). If you have a version of Matlab older than 7.6 (2008b), download EEGLAB version 4.5b [here](#).

To install EEGLAB

1. Unzip the EEGLAB zip file in the folder of your choice
2. Start Matlab
3. Change the Matlab path to the EEGLAB folder you have just uncompressed
4. Type "eeglab" and press enter on the Matlab prompt

Download EEGLAB development head (requires Matlab)

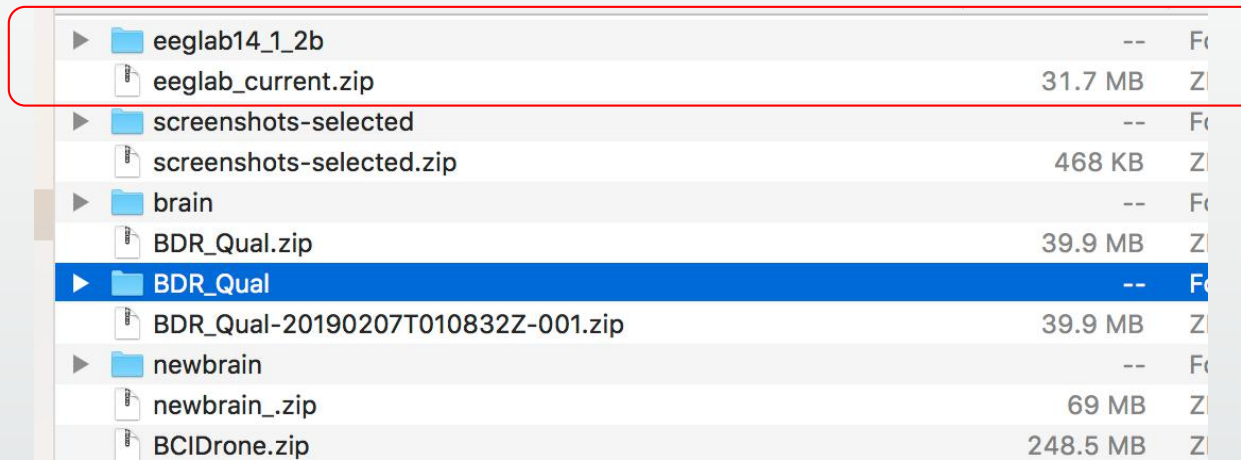
Using the development head requires a special software called Git available for free on the Internet. Using the development head is useful to benefit from the latest bug fixes and update your version of EEGLAB daily. Detailed steps to download the EEGLAB development head are available on the [EEGLAB wiki](#).

Download a compiled version of EEGLAB

EEGLAB compiled version for windows OS 32-bit does not require Matlab. If you have access to Matlab though, we recommend the versions above since the EEGLAB compiled version is quite old (2009) and does not have all the features of the Matlab version. Download the [zip file here](#) and follow instructions on how to install the EEGLAB compiled version on the [EEGLAB wiki](#).

Install EEGLAB Plugin

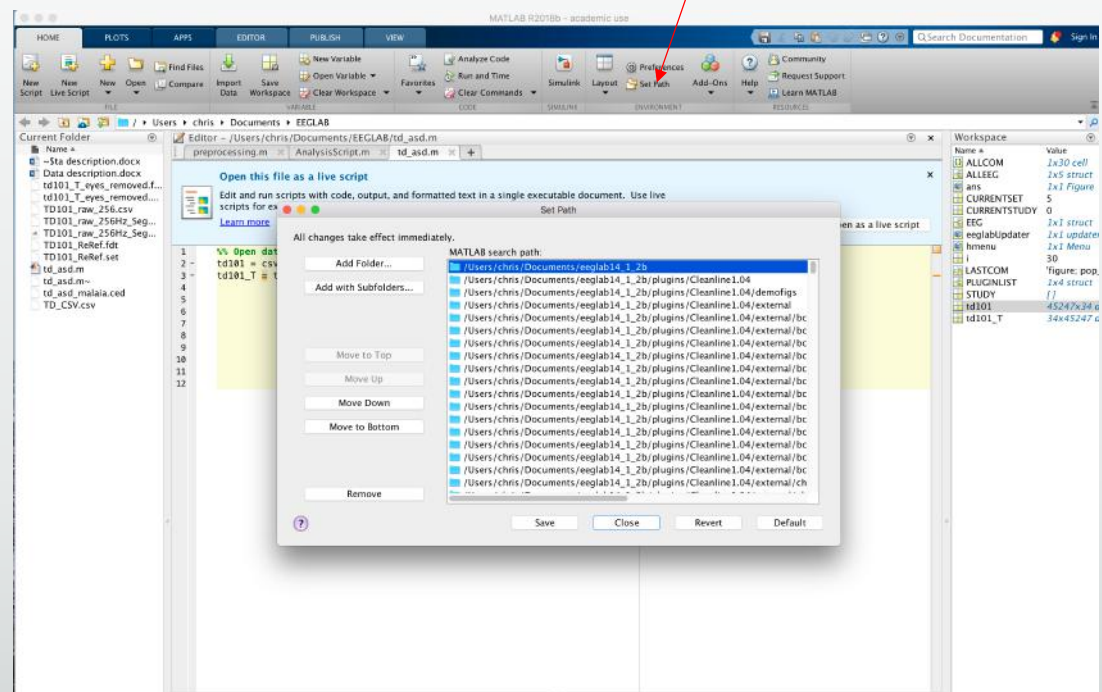
- Unzip eeglab_current zip file



▶	folder	eeglab14_1_2b	--	Folder
	zip	eeglab_current.zip	31.7 MB	Zip file
▶	folder	screenshots-selected	--	Folder
	zip	screenshots-selected.zip	468 KB	Zip file
▶	folder	brain	--	Folder
	zip	BDR_Qual.zip	39.9 MB	Zip file
▶	folder	BDR_Qual	--	Folder
	zip	BDR_Qual-20190207T010832Z-001.zip	39.9 MB	Zip file
▶	folder	newbrain	--	Folder
	zip	newbrain_.zip	69 MB	Zip file
	zip	BCIDrone.zip	248.5 MB	Zip file

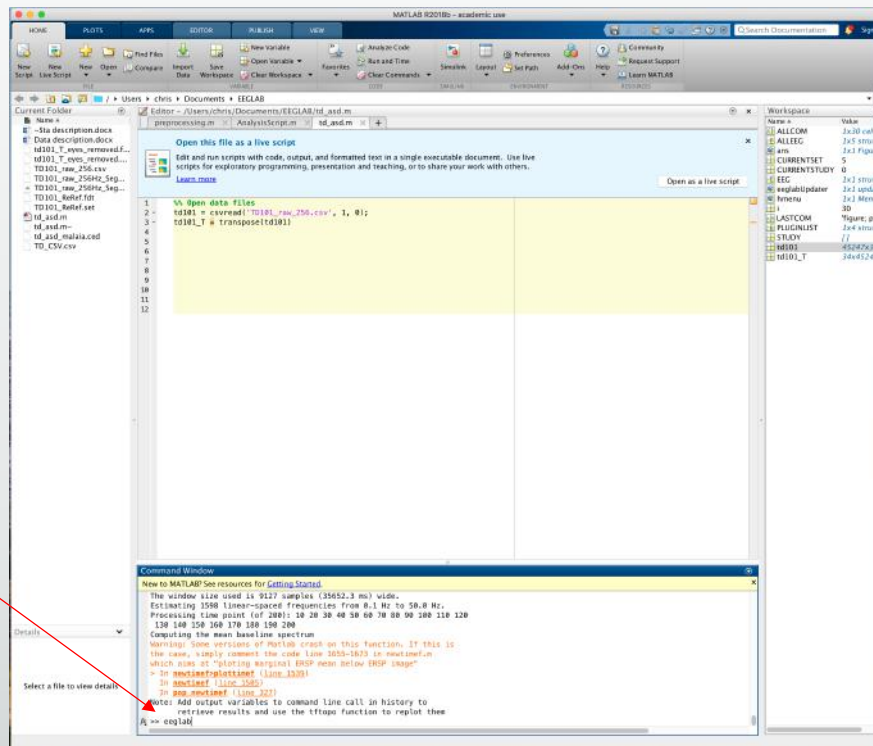
Install EEGLAB Plugin

- Add eeglab folder to MATLAB (Set Path)

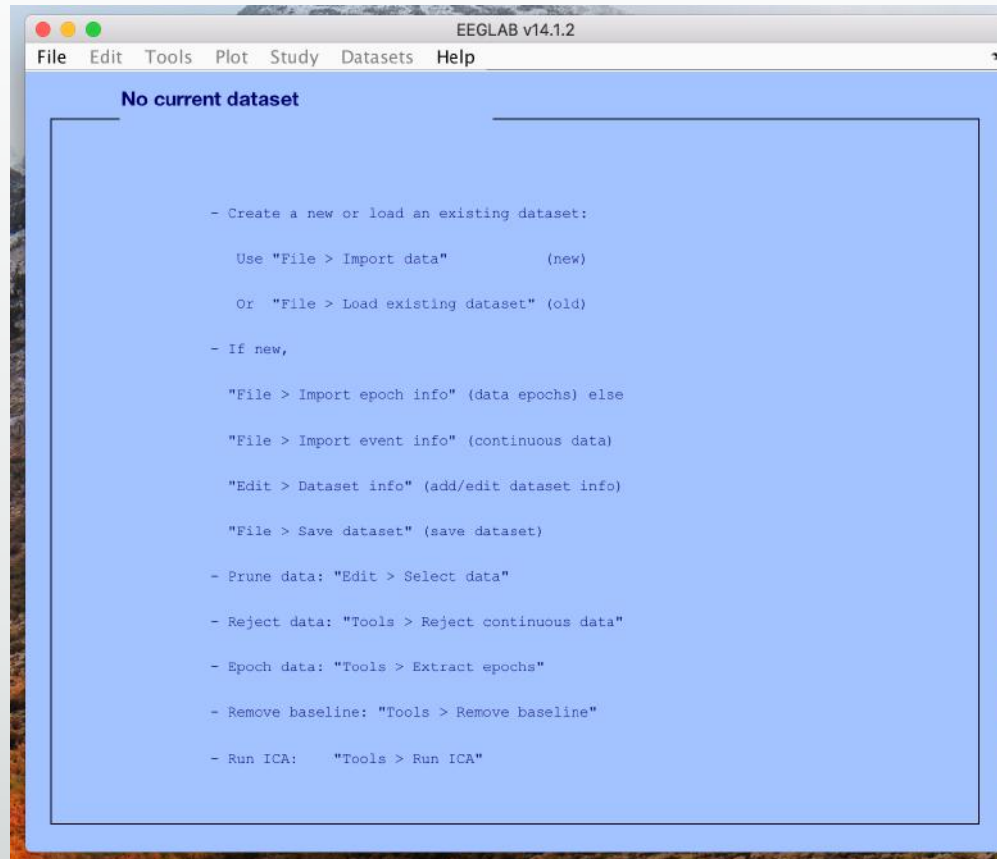


Install EEGLAB Plugin

- Enter 'eeglab' in command window



Install EEGLAB Plugin



Import Raw EEG Data

Navigate to folder containing EEG data

Load .csv file

Row offset

Column offset

The image shows the MATLAB R2018b - academic use interface. The 'Current Folder' pane on the left displays the contents of the '/Users/chris/Documents/EEGLAB' directory, including files like 'td101_raw_256.csv' and 'td_asd.m'. The 'Editor' pane in the center shows the script 'td_asd.m' with the following code:

```
1  %% Open data files
2  td101 = csvread('TD101_raw_256.csv', 1, 0);
3  td101_T = transpose(td101);
```

Red arrows point from the text labels to specific parts of the interface: 'Navigate to folder containing EEG data' points to the 'Current Folder' pane; 'Load .csv file' points to the 'csvread' function; 'Row offset' points to the value '1' in the 'csvread' function; and 'Column offset' points to the value '0' in the 'csvread' function. The 'Workspace' pane on the right shows the current state of the workspace, including variables like 'td101' and 'td101_T'.

Name	Value
ALLCOM	1x1 cell
ALLEEG	[]
ans	1x1 Figure
CURRENTSET	0
CURRENTSTUDY	0
EEG	1x1 struct
eeglabUpdater	1x1 updater
hmenu	1x1 Menu
i	30
LASTCOM	'[ALLEEG EEG ...]
PLUGINLIST	1x4 struct
STUDY	[]
td101	45247x34 d
td101_T	34x45247 d

Import Raw EEG Data

Navigate to folder containing EEG data

Load .csv file

Row offset

Column offset

The image shows the MATLAB R2018b - academic use interface. The 'Current Folder' pane on the left displays the contents of the '/Users/chris/Documents/EEGLAB' directory, including files like 'td101_raw_256.csv' and 'td_asd.m'. The 'Editor' pane in the center shows the script 'td_asd.m' with the following code:

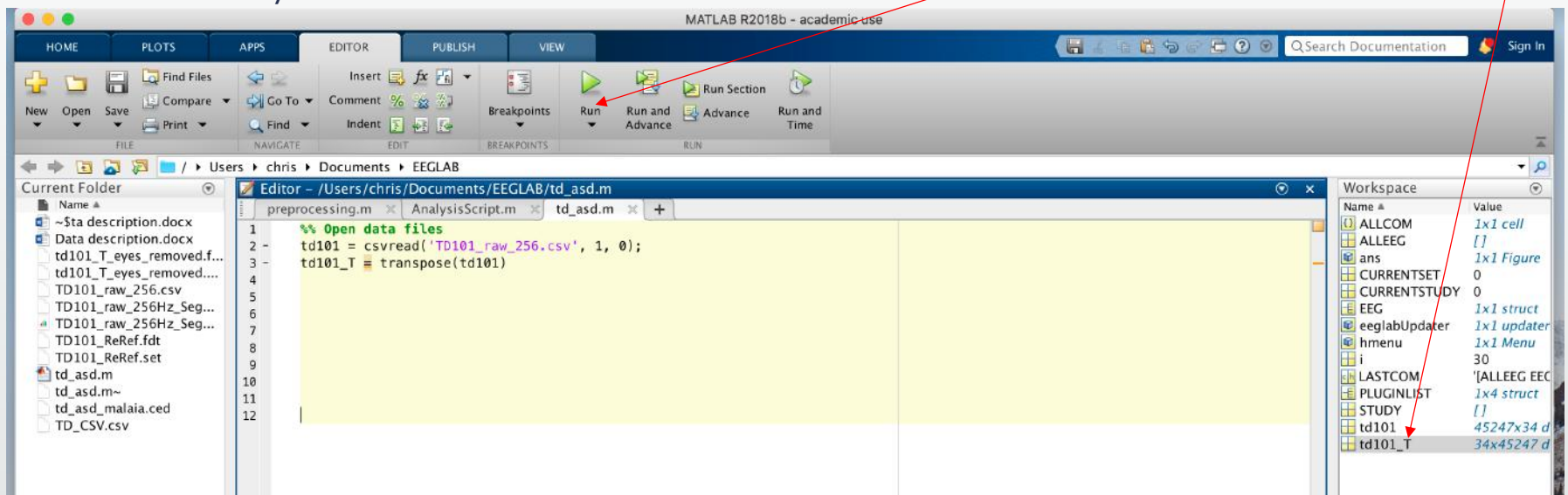
```
1  %% Open data files
2  td101 = csvread('TD101_raw_256.csv', 1, 0);
3  td101_T = transpose(td101);
```

Red arrows point from the text labels to specific parts of the interface: 'Navigate to folder containing EEG data' points to the 'Current Folder' pane; 'Load .csv file' points to the 'csvread' function; 'Row offset' points to the '1' in the 'csvread' function; and 'Column offset' points to the '0' in the 'csvread' function. The 'Workspace' pane on the right shows the current state of the workspace, including variables like 'td101' and 'td101_T'.

Name	Value
ALLCOM	1x1 cell
ALLEEG	[]
ans	1x1 Figure
CURRENTSET	0
CURRENTSTUDY	0
EEG	1x1 struct
eeglabUpdater	1x1 updater
hmenu	1x1 Menu
i	30
LASTCOM	'[ALLEEG EEG CURRENTSET CURRENTSTUDY STUDY]'
PLUGINLIST	1x4 struct
STUDY	[]
td101	45247x34 d
td101_T	34x45247 d

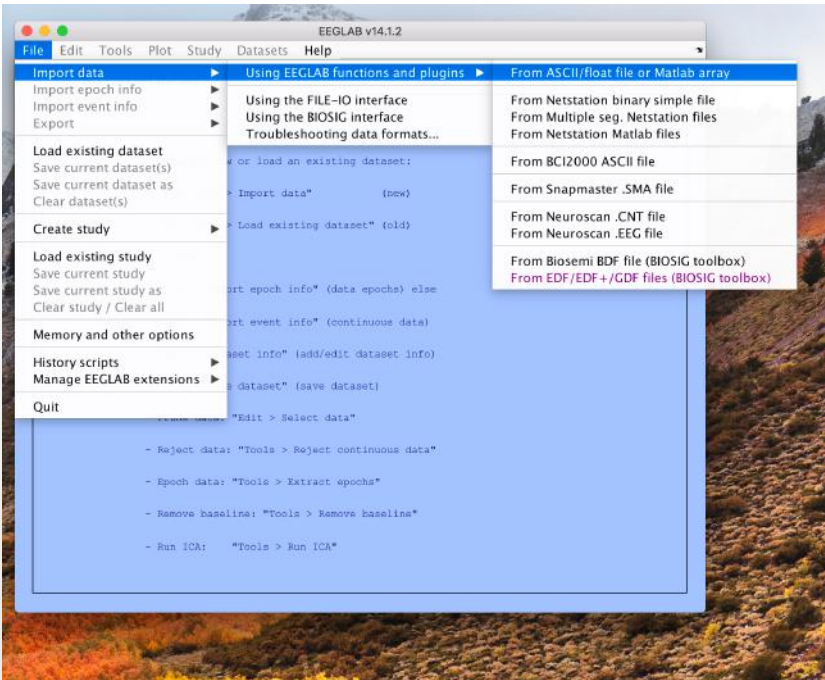
Import Raw EEG Data

- Create EEG data array from .csv file



Import Raw EEG Data

- Import EEG Matlab array



TD101_raw_256Hz_Segments_1_2																								
Fp1 - LkE	Fp2 - LkE	Fp2 - LkE	F7 - LkE	F3 - LkE	Fz - LkE	F4 - LkE	F8 - LkE	FC5 - LkE	FC1 - LkE	FC2 - LkE	FC6 - LkE	M1 - LkE	T7 - LkE	C3 - LkE	Cz - LkE	C4 - LkE	T8 - LkE	M2 - LkE	CP5 - LkE	CP1 - LkE	CP2 - LkE			
27254.956	19317.281	17631.542	148863.435	905.818	7305.244	3916.886	13269.967	9306.168	4771.267	6249.602	17139.554	-251.649	14244.619	9045.092	11544.966	17449.297	19116.443	251.649	15330.548	14030.78	6528.91			
27251.737	19313.915	17628.802	148860.231	904.089	7302.871	3916.978	13264.339	9305.525	4770.44	6250.375	17140.215	-248.044	14241.952	9046.354	11543.826	17449.15	19118.391	248.044	15332.075	14030.21	6528.634			
27251.076	19315.293	17629.886	148871.854	903.74	7303.809	3920.932	13266.932	9307.823	4774.633	6252.545	17145.716	-248.614	14244.564	9048.083	11546.088	17453.251	19124.148	248.614	15337.224	14035.708	6534.372			
27249.77	19313.142	17629.301	148881.108	903.611	7303.57	3919.957	13268.385	9305.892	4774.155	6252.582	17146.34	-252.623	14247.469	9051.356	11546.677	17457.517	19127.44	252.623	15341.178	14039.901	6536.781			
27245.577	19311.689	17625.639	148845.017	900.172	7299.709	3918.302	13268	9302.251	4771.856	6251.239	17149.577	-252.918	14248.021	9050.749	11544.856	17458.014	19128.911	252.918	15338.953	14039.239	6537.737			
27247.911	19313.069	17628.692	148834.854	896.696	7298.2	3918.56	13271.714	9301.772	4772.279	6251.846	17151.747	-253.396	14250.191	9050.859	11544.452	17459.927	19132.625	253.396	15347.835	14039.735	6540.937			
27247.36	19311.635	17627.405	148849.398	894.913	7298.973	3921.833	13275.649	9302.306	4772.683	6252.416	17154.45	-249.865	14252.895	9052.661	11545.096	17463.034	19132.037	249.865	15350.446	14043.8	6542.316			
27246.092	19309.409	17625.859	148846.239	894.03	7297.833	3920.509	13277.397	9304.88	4773.088	6252.306	17157.301	-250.49	14256.02	9054.353	11545.481	17465.241	19134.723	250.49	15361.628	14044.186	6543.18			
27246.11	19309.28	17626.539	148836.687	893.993	7297.042	3919.148	13282.197	9304.31	4773.805	6252.986	17159.929	-251.906	14258.32	9054.538	11545.831	17463.991	19135.568	251.906	15353.793	14045.933	6544.542			
27242.377	19305.749	17624.903	148839.012	890.389	7292.665	3916.555	13278.886	9301.129	4770.44	6250.154	17159.691	-253.488	14255.818	9052.091	11542.815	17461.453	19133.508	253.488	15343.035	14042.255	6540.496			
27242.469	19306.043	17624.24	148856.312	887.685	7289.649	3913.576	13277.01	9300.136	4765.64	6246.605	17159.453	-254.407	14256.15	9051.779	11540.258	17458.841	19131.945	254.407	15341.748	14039.497	6539.227			
27245.06	19307.865	17626.686	148870.364	886.361	7287.405	3914.036	13282.491	9302.14	4766.946	6246.955	17162.707	-251.575	14261.832	9051.356	11539.891	17458.75	19136.708	251.575	15344.23	14039	6538.583			
27240.152	19301.17	17620.655	148849.83	880.366	7282.937	19301.689	13279.144	9299.547	4764.757	6242.577	17160.408	-250.803	14263.027	9047.789	11535.974	17455.494	19136.028	250.803	15336.286	14034.274	6533.599			

Import Raw EEG Data

- Import EEG Matlab array

The image displays the MATLAB R2018b environment with the EEGLAB toolbox. The main window shows the 'td_asd.m' script in the Editor, which contains the following code:

```
1 % Open data files
2 - td101 = csvread('TD101_raw_256.csv', 1, 0);
3 - td101_T = transpose(td101)
```

The Workspace window on the right shows the following variables:

Name	Value
ALLCOM	1x1 cell
ALLEEG	[]
ans	1x1 Figure
CURRENTSET	0
CURRENTSTUDY	0
EEG	1x1 struct
eeglabUpdater	1x1 updater
hmenu	1x1 Menu
i	30
LASTCOM	TALLEEG EEG
PLUGINLIST	1x4 struct
STUDY	[]
td101	45247x34 d
td101_T	34x45247 d

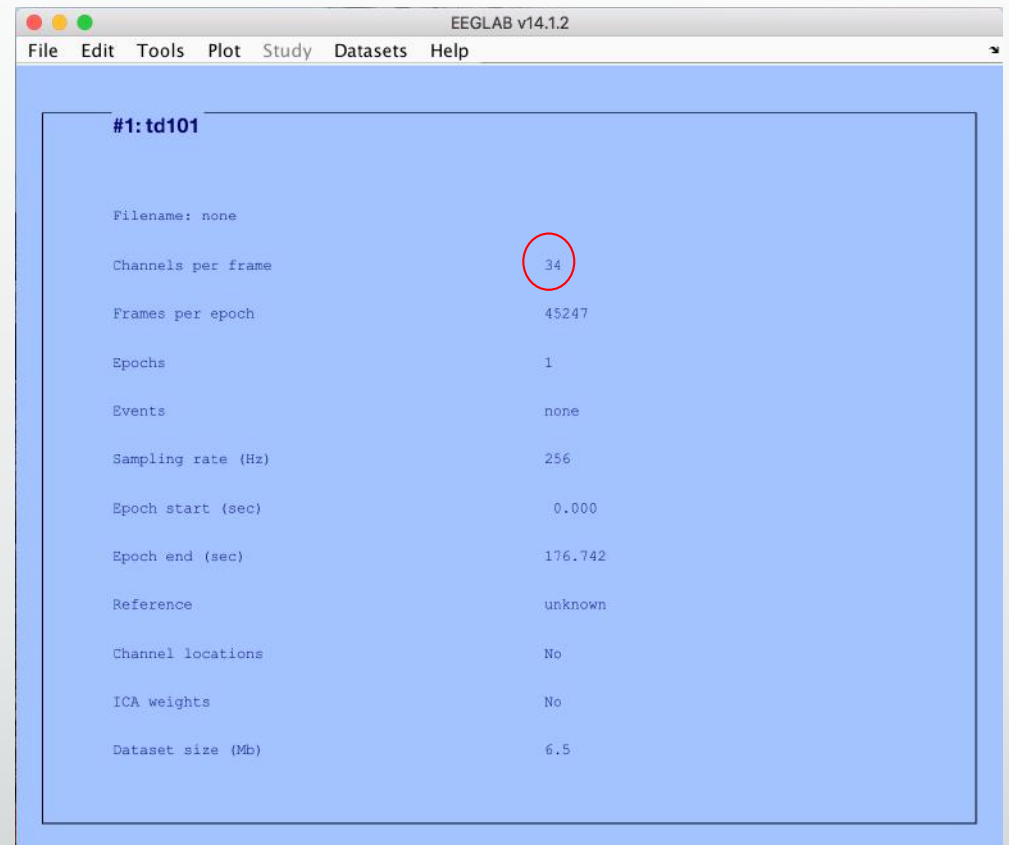
An 'Import dataset info' dialog box is open, showing the following fields:

- Data file/array (click on the selected option): **Matlab va...** (selected), **td101_T** (entered), **Browse**
- Dataset name: **td101**
- Data sampling rate (Hz): **256** (circled in red)
- Time points per epoch (p->continuous): **0**
- Start time (sec) (only for data epochs): **0**
- Number of channels (D->set from data): **-34** (circled in red)
- Ref. channel indices or mode (see help):
- Channel location file or info: **From other dataset** (selected), **Browse**
- ICA weights array or text/binary file (if any): **From other dataset** (selected), **Browse**
- ICA sphere array or text/binary file (if any): **From other dataset** (selected), **Browse**

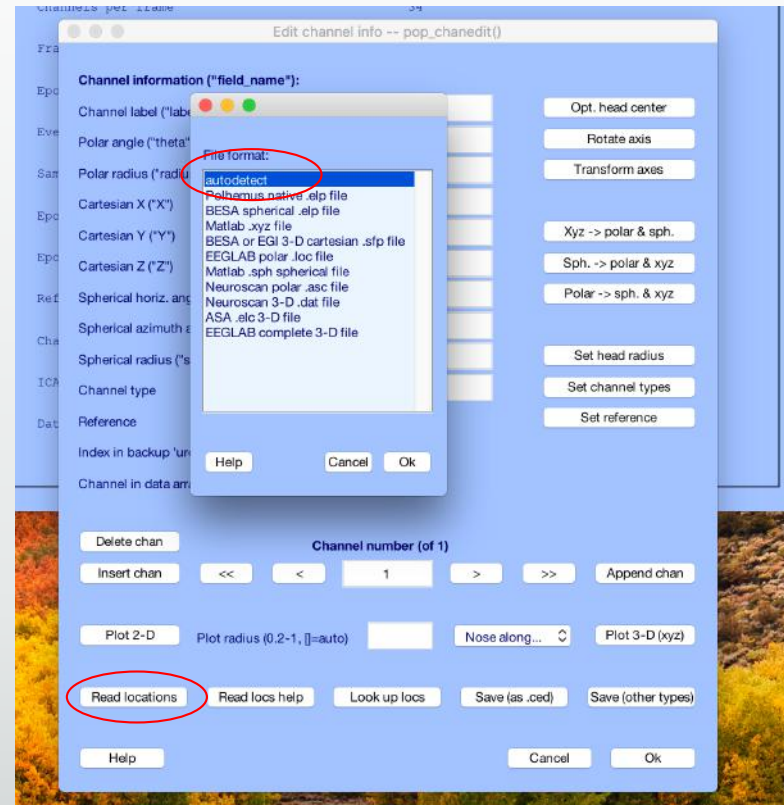
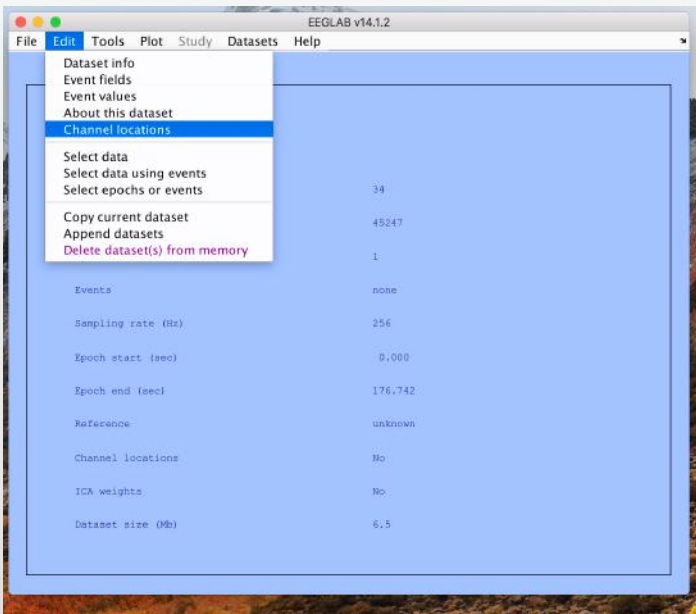
Buttons: **Help**, **Cancel**, **Ok**

Import Raw EEG Data

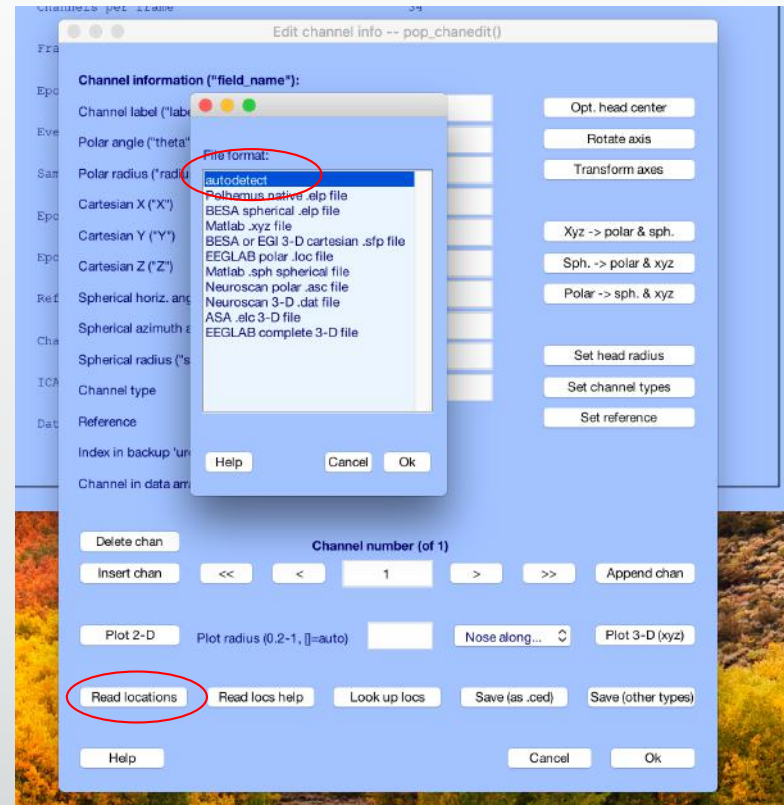
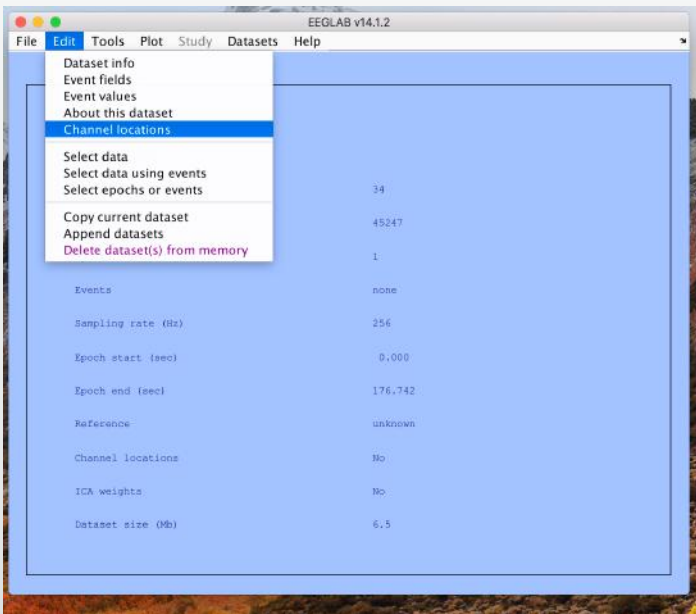
- Import EEG Matlab array



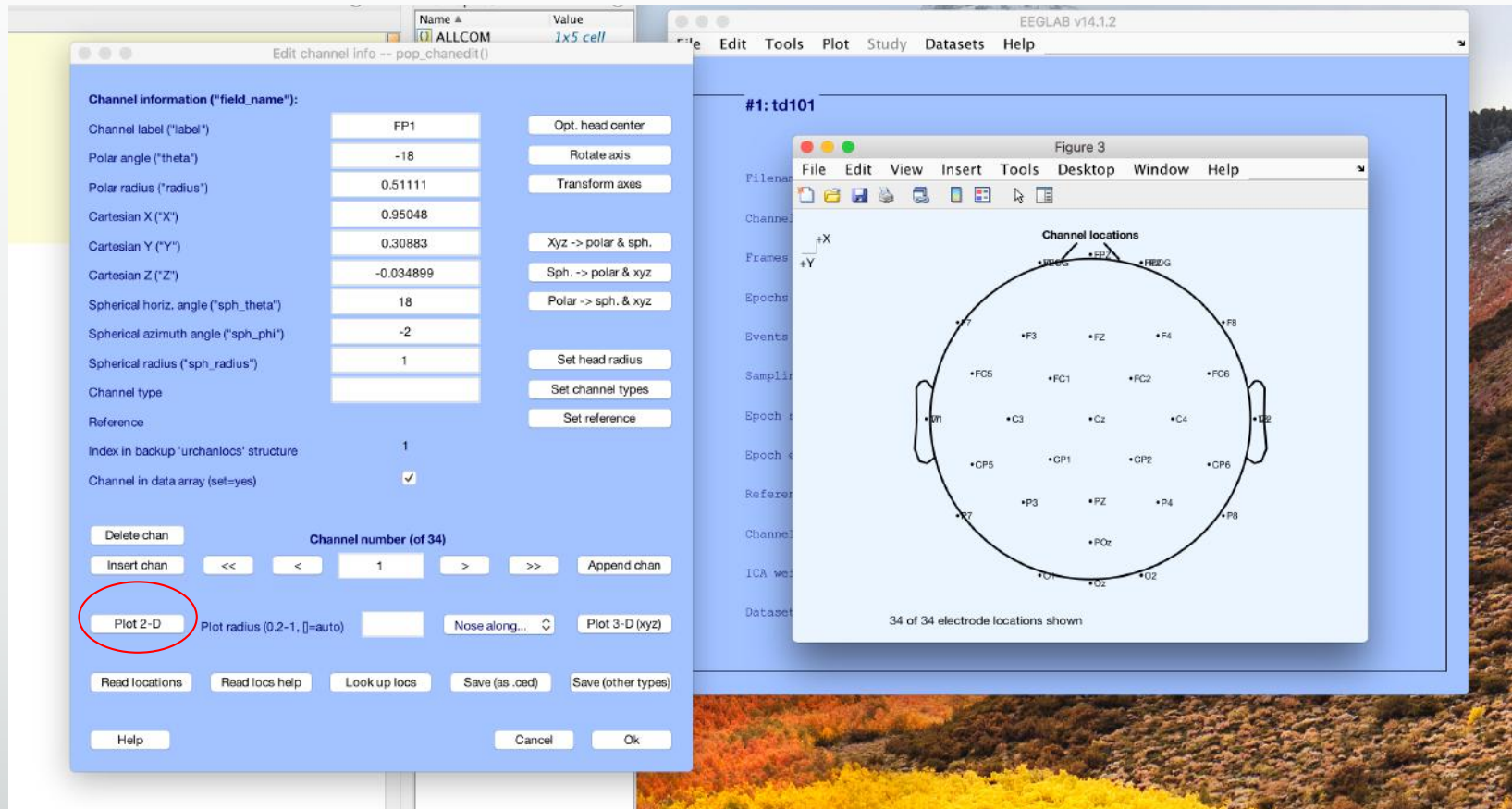
Load channel locations



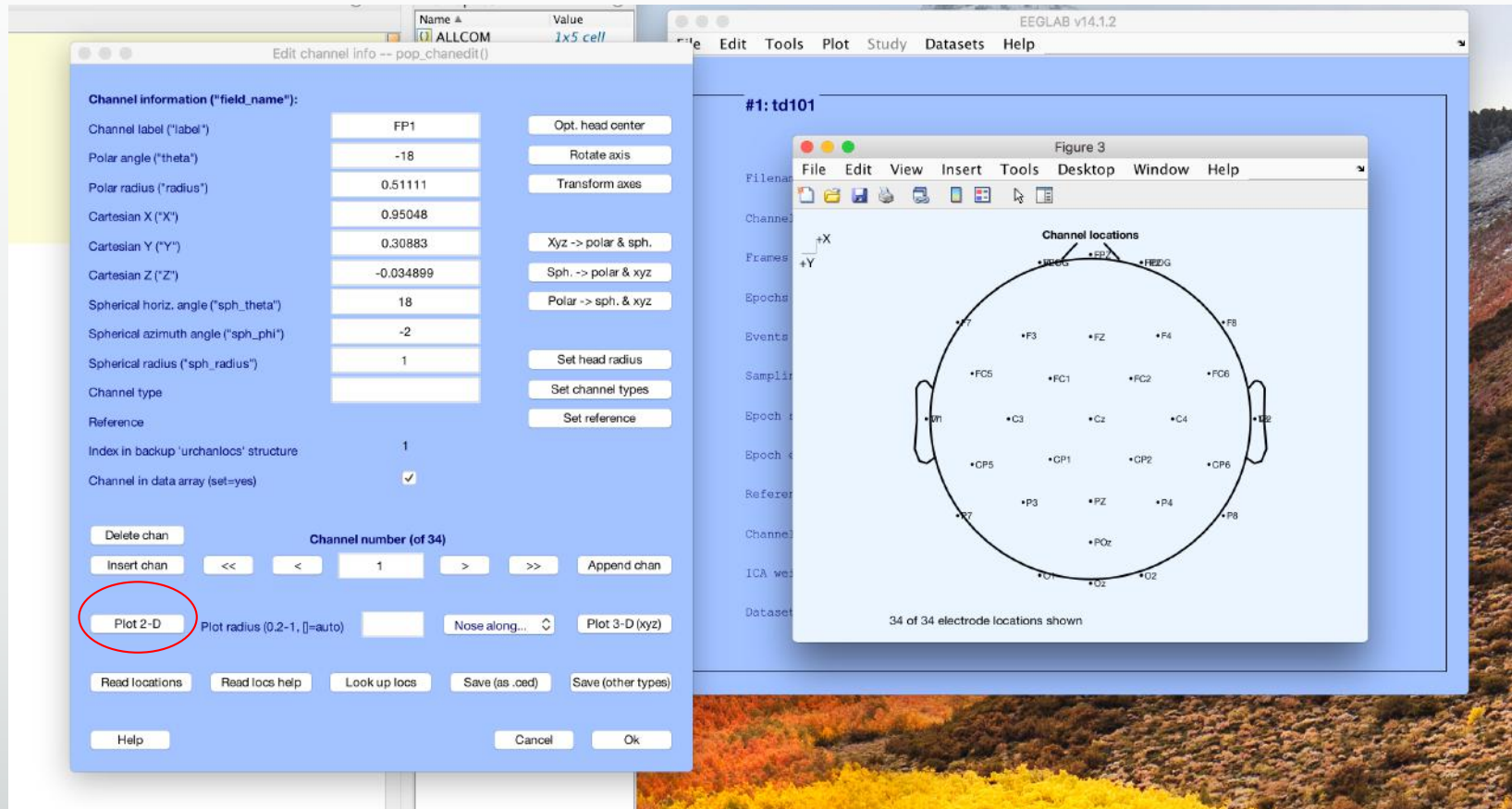
Load channel locations



Load channel locations

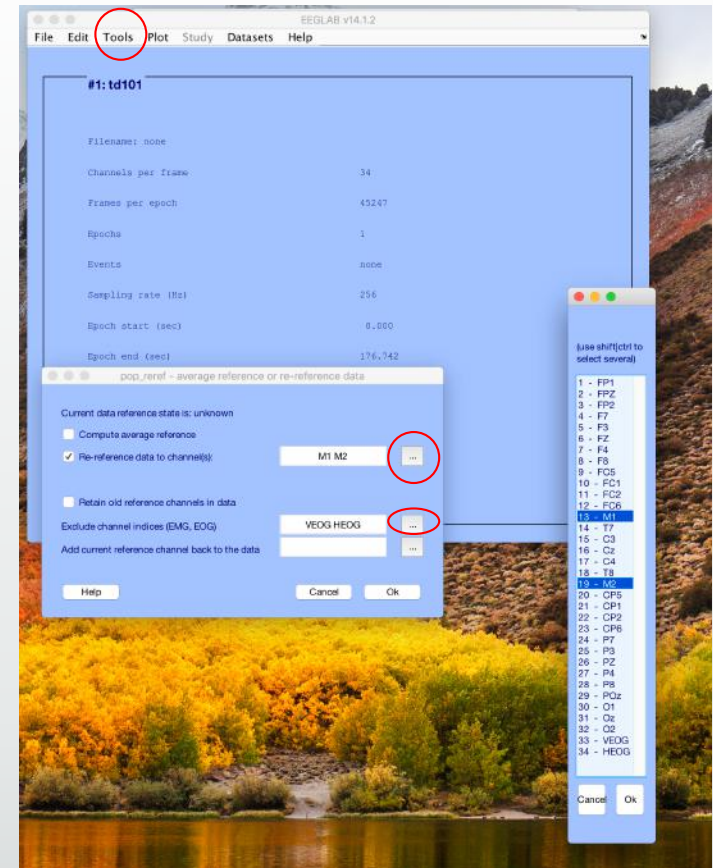
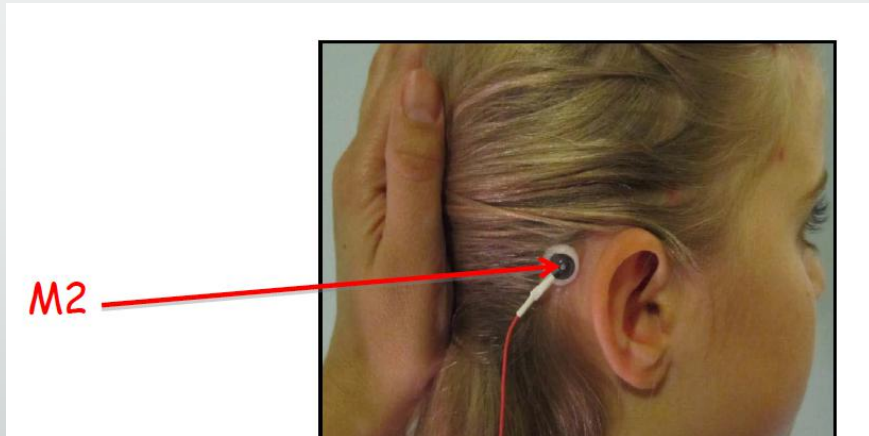
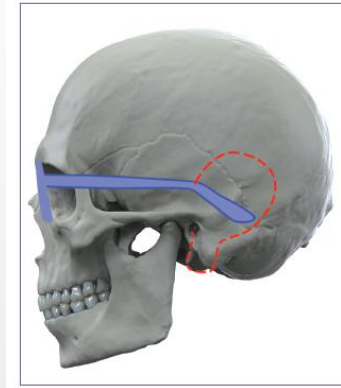


Load channel locations



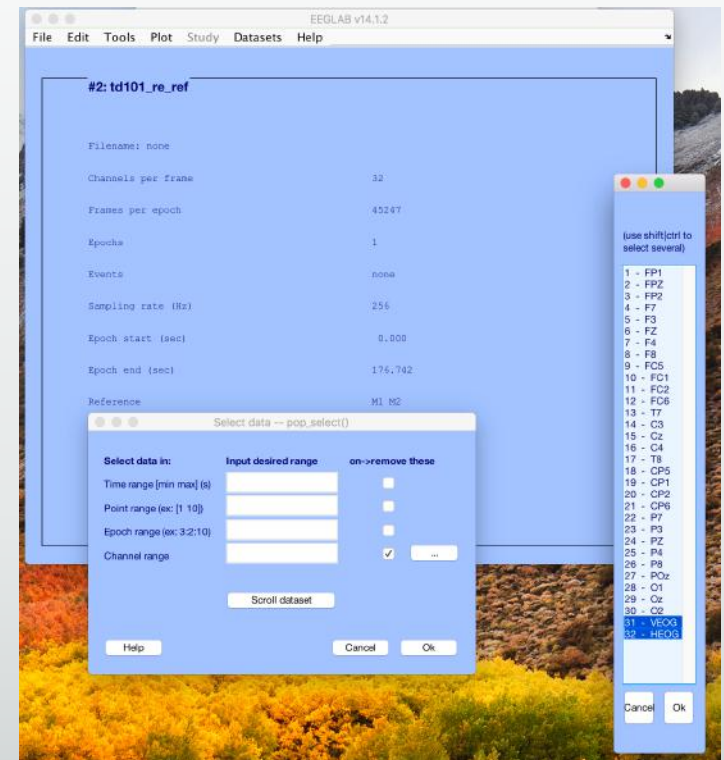
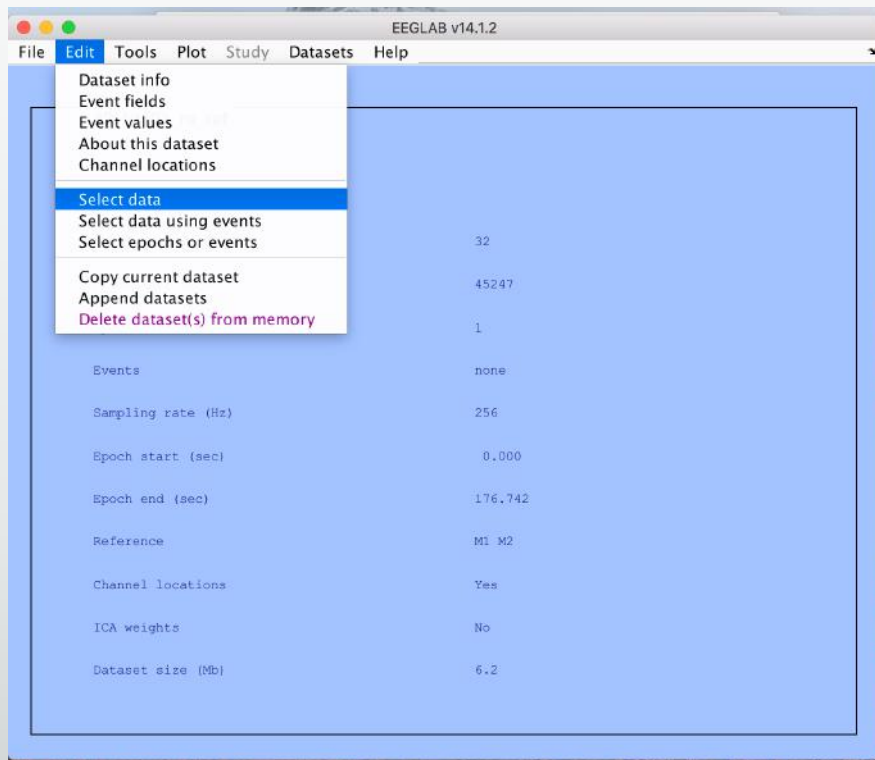
Re-reference data

- M1 & M2 are reference electrodes
- Bony area behind ears
- Record less signal from the brain
- Records noise similar to other electrodes



Remove unwanted channels

- Remove EOG artifacts caused by eye movements



Filter data

- Low-pass filter (**below**): all frequencies **below** a defined frequency are **passed** and all frequencies **above** this limit are **rejected**.
- High-pass filter(**above**): all frequencies **above** a defined frequency are **passed** and all frequencies **below** this limit are **rejected**.
- Band-pass filter(**between**): all frequencies **between** defined **lower** and **upper** frequency limits are passed.
- Band-stop / notch filter: **inverse of band-pass filter**; all filters **between** lower and upper frequency are **rejected**

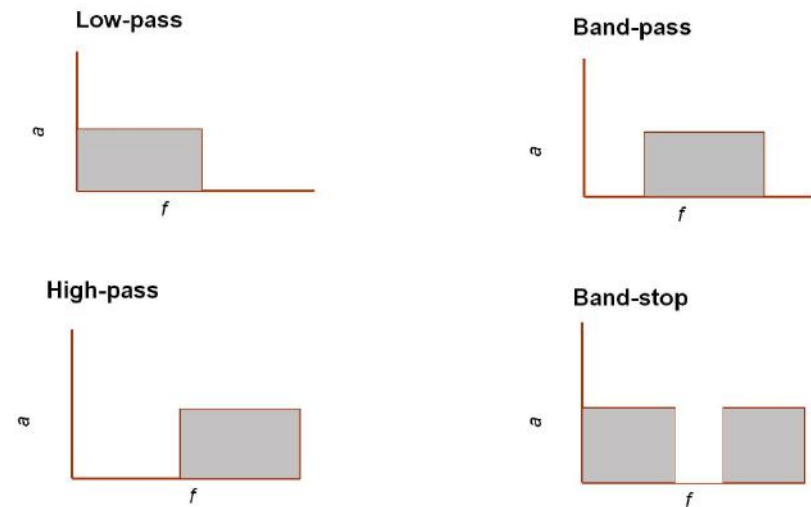
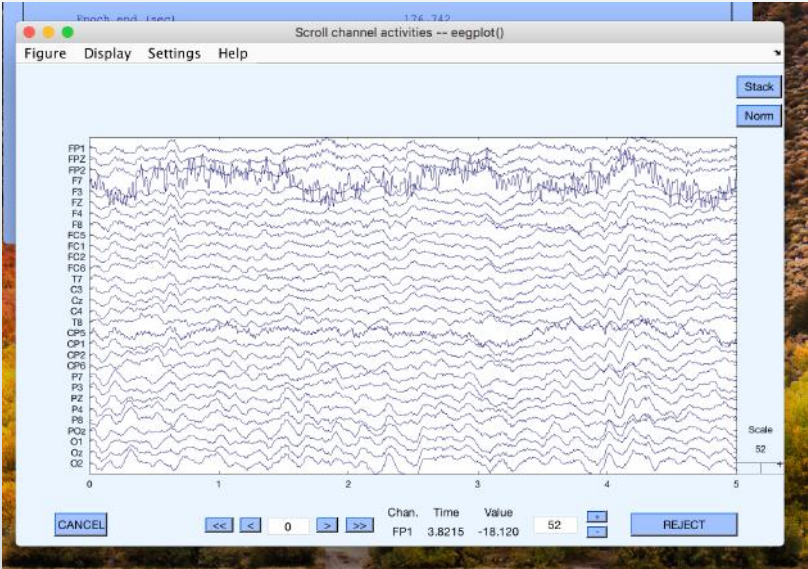
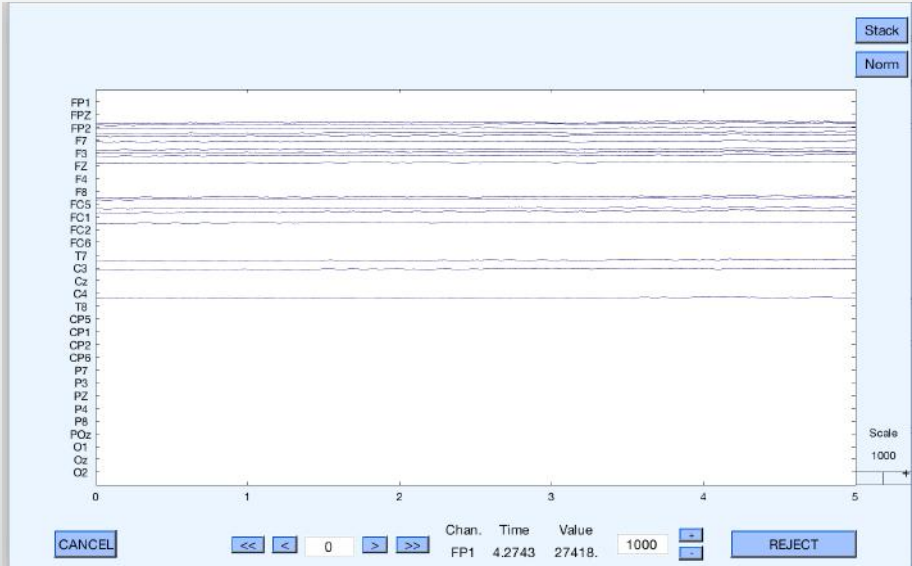
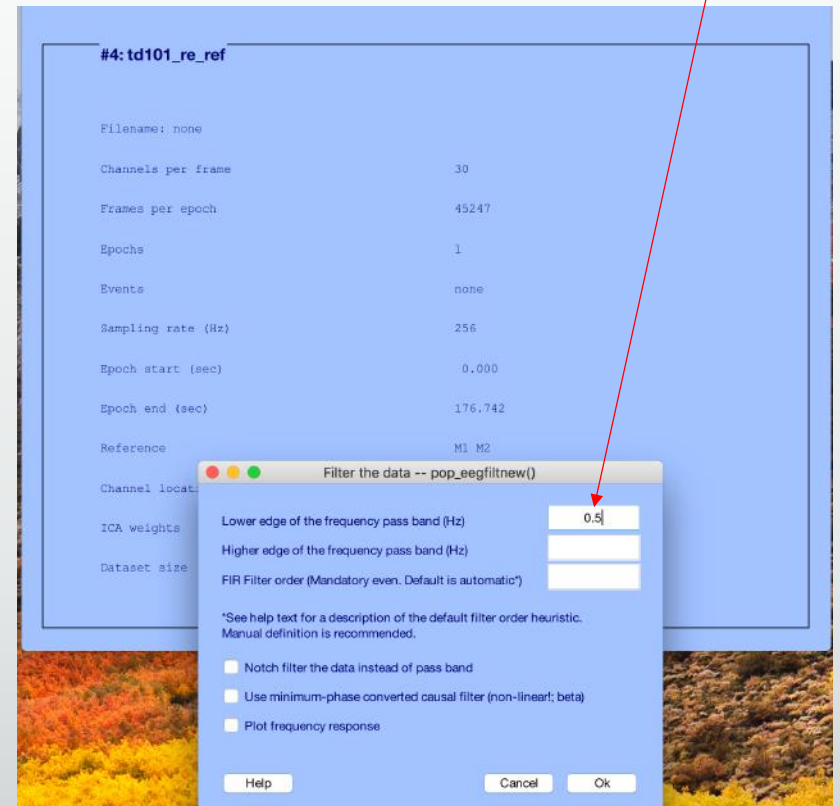
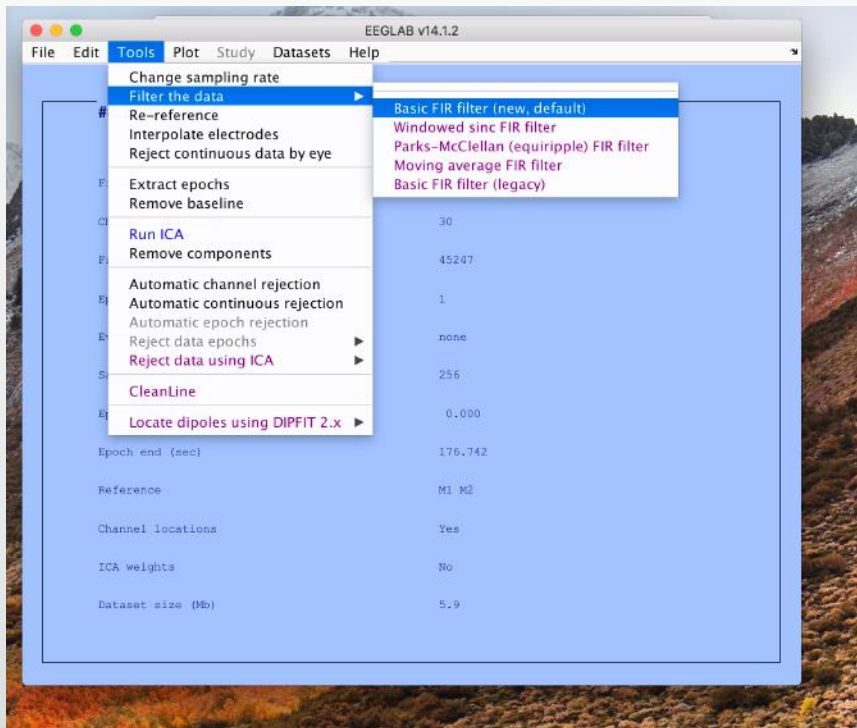


Figure 1: Four basic filter types (f =frequency, a = amplitude).

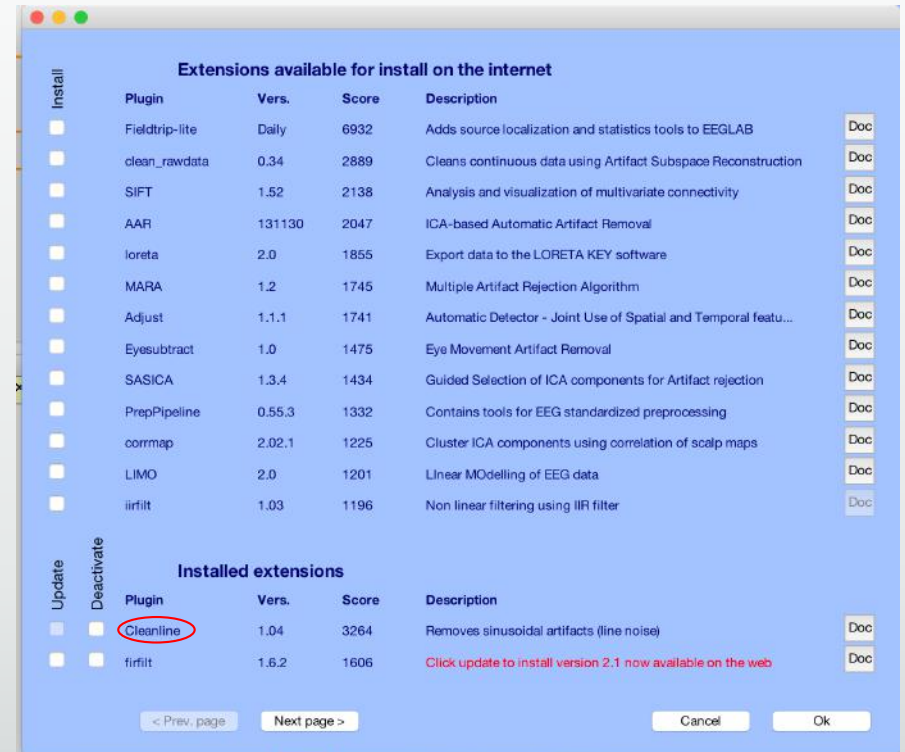
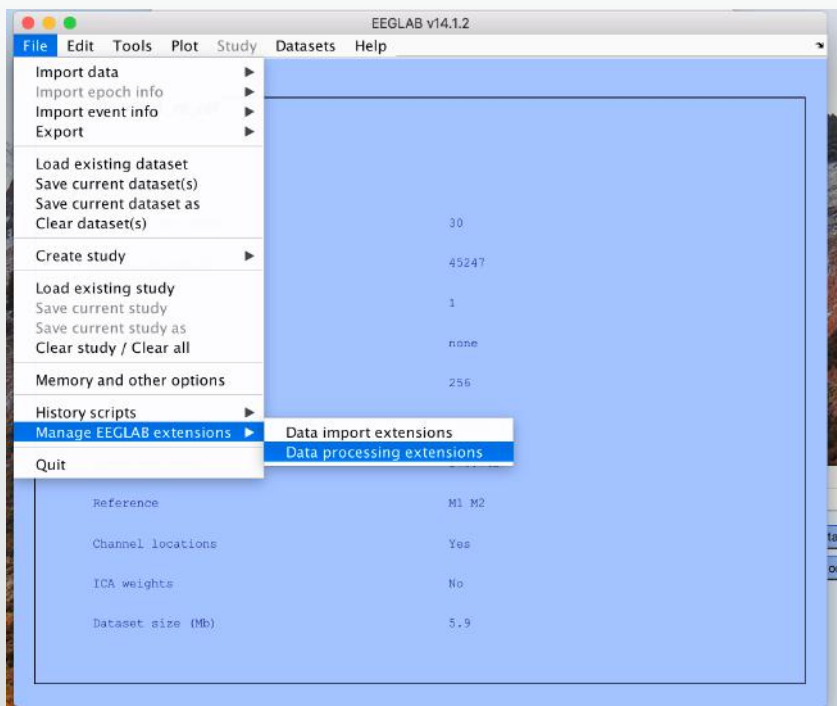
Filter data



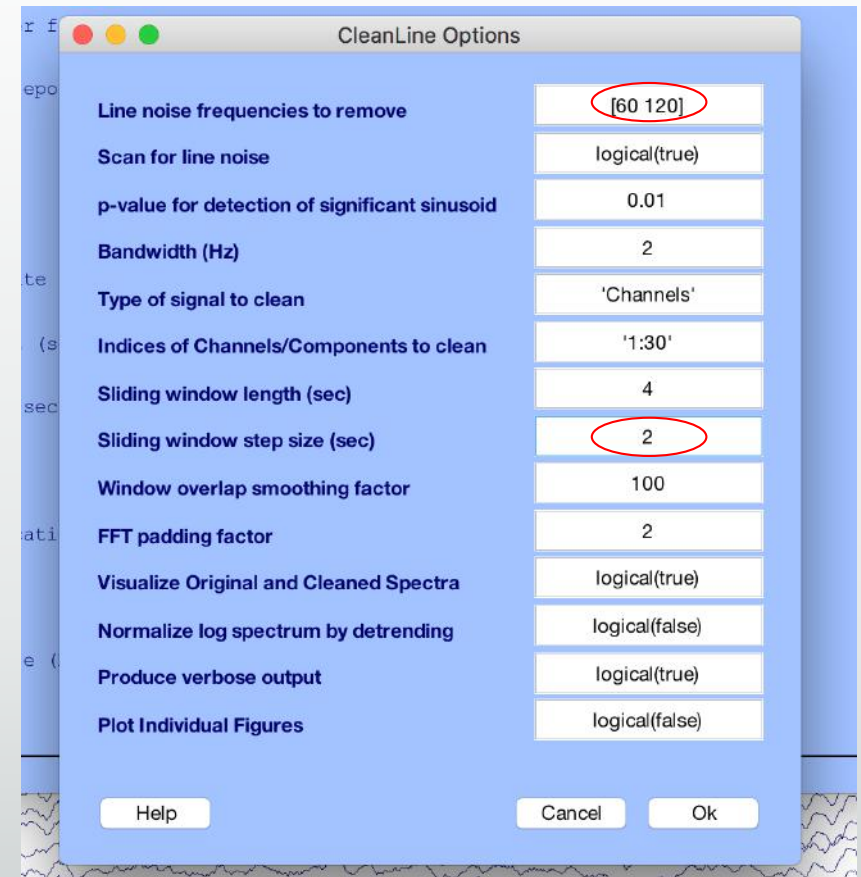
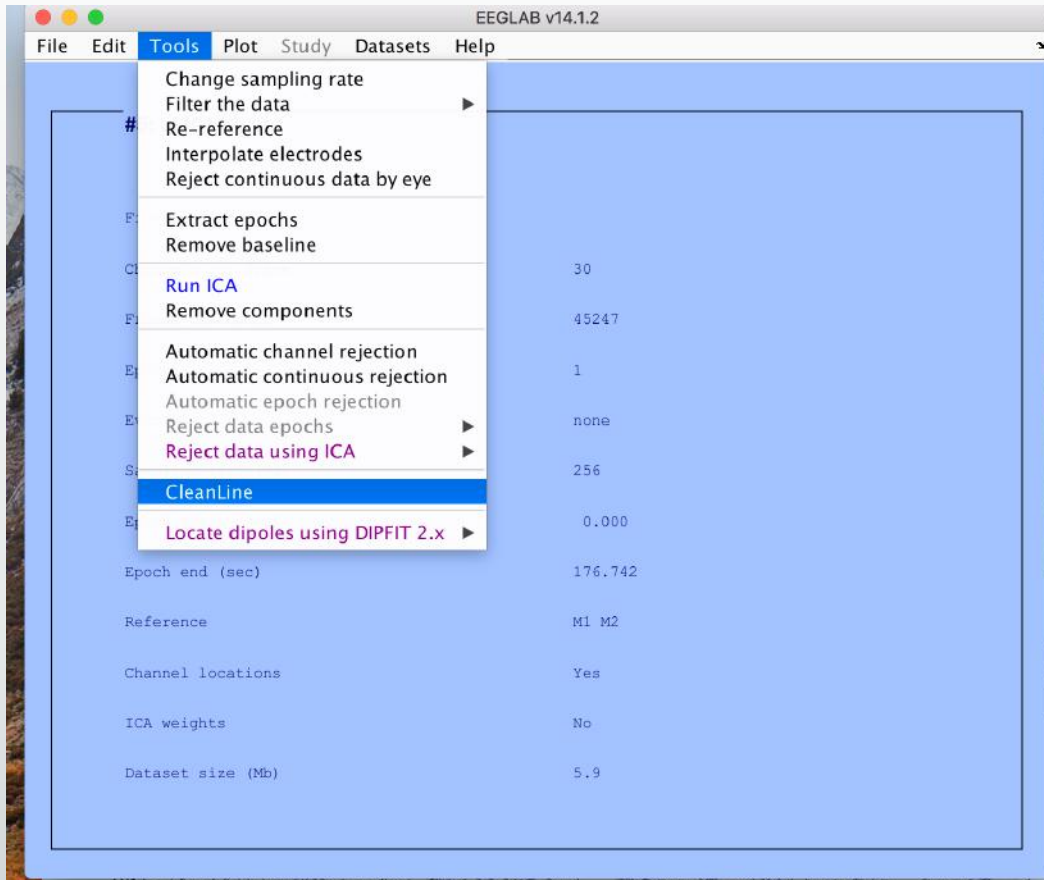
Filter data



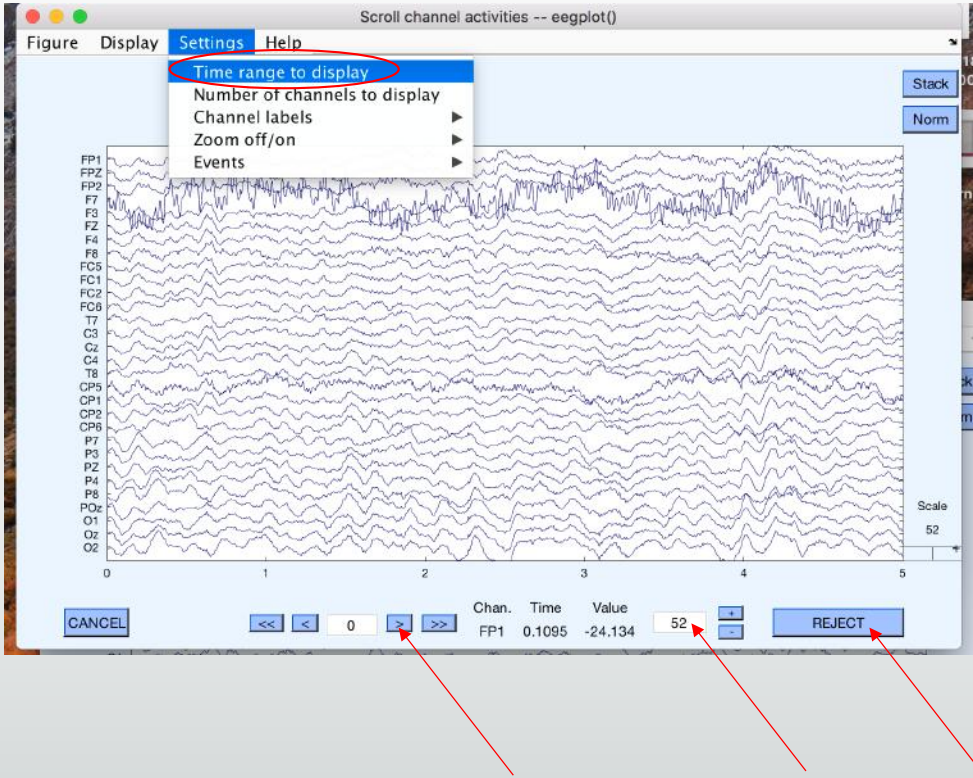
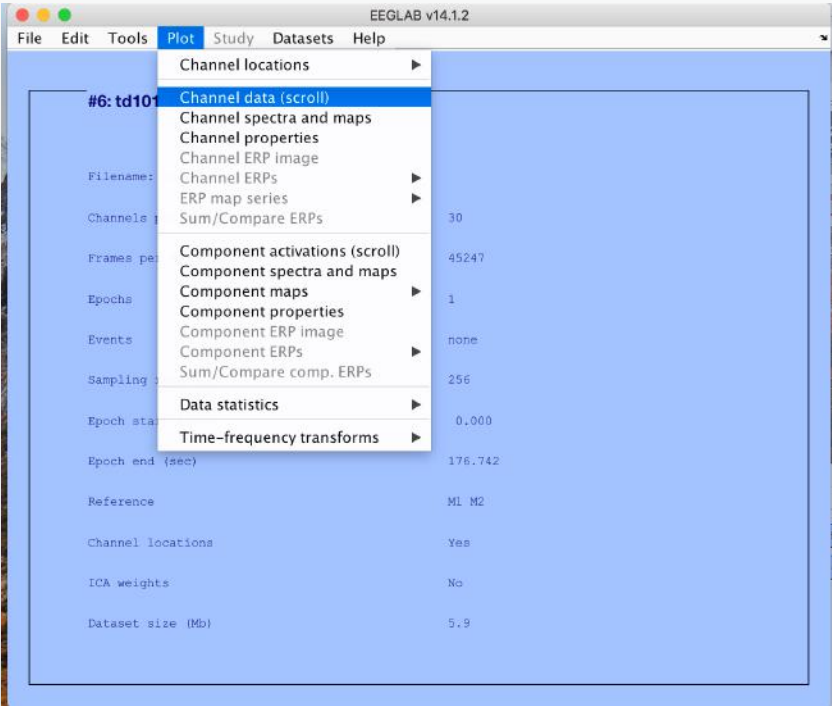
Remove Line Noise



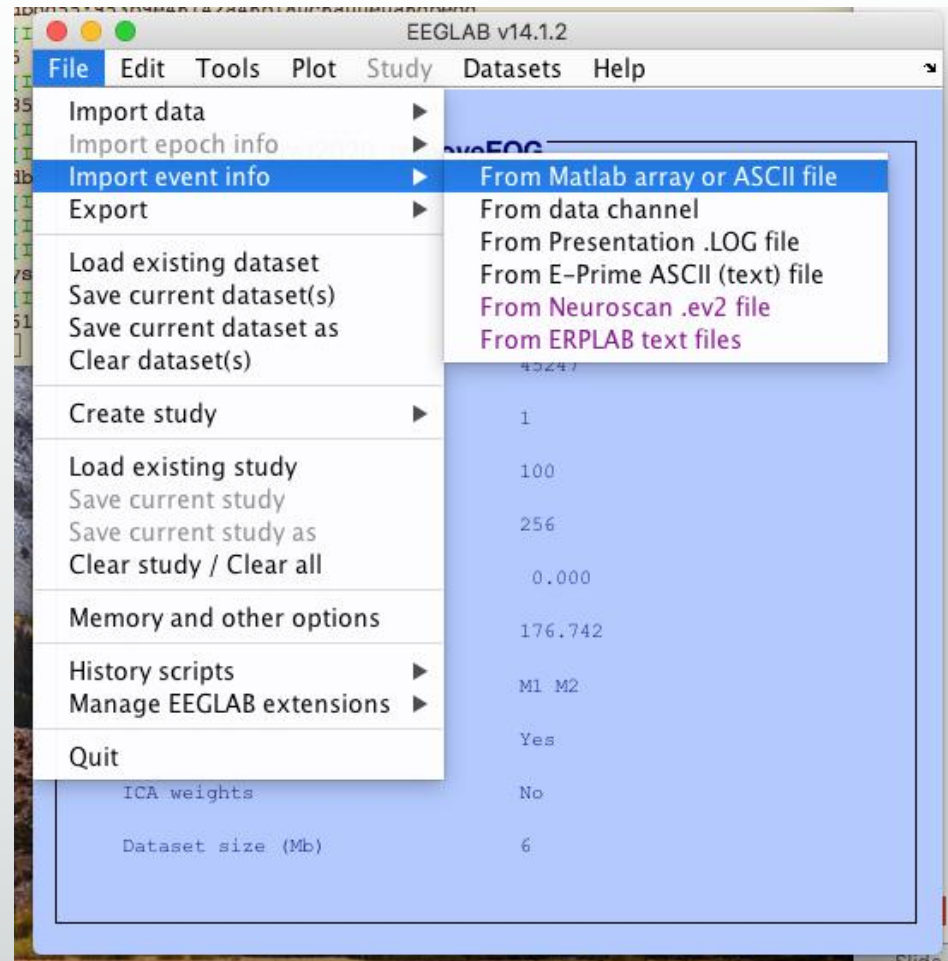
Remove Line Noise



Scroll Through EEG Data



Import Events



Import Events

Import event info – pop_importevent()

Event indices	Append events?	Event file or array	<input type="button" value="Browse"/>
<input type="text"/>	<input type="checkbox"/> Yes/No	<input type="text" value="tutorial_eventtable.ext"/>	
	NB: No = overwrite		
Input field (column) names	<input type="text" value="latency type position"/>	Ex: type latency duration	
Number of file header lines	<input type="text" value="1"/>	(latency field required above)	
Time unit (sec)	<input type="text" value="1"/>	Ex: If ms, 1 E-3	
Align event latencies to data events	<input type="text" value="NaN"/>	See Help	
Auto adjust new events sampling rate	<input type="checkbox"/>		
<input type="button" value="Cancel"/>		<input type="button" value="Help"/>	<input type="button" value="Ok"/>