GongLab wiki

EEGLAB/ERPLAB: data analysis

For conventional EEG data analysis, we preferred using ERPLAB as a plugin in EEGLAB. For data recording: save each run/block of data and concatenate across runs/blocks after completing the experiment for each subject. This could be helpful when data recording is interrupted by accident.

Read first

A full documentation for ERPLAB is posted here: ERPLAB wiki [https://github.com/lucklab/erplab/wiki/Manual]

Read this paper before you start to play with ERPLAB: Lopez-Calderon, J. & Luck S.J. (2014). ERPLAB: an open-source toolbox for the analysis of event-related potentials. Front Hum Neurosci. 8(213):1-12

For advanced user, the ERP Methodology Blog could be particularly useful: ERPLAB blogs [https://erpinfo.org/blog?offset=1588392367635]

For time-frequency analysis of EEG data, FIELDTRIP toolbox could be better, a full documentation is posted here: Fieldtrip docs [https://www.fieldtriptoolbox.org/documentation]

To install plugins in EEGLAB, see the link below. In general, we installed BIOSIG, ERPLAB, CORRMAP, CleanRawData, Filedtrip-lite. Extensions [https://eeglab.org/others/EEGLAB_Extensions.html]

Assignment of EXG electrodes

Below listed the EXG electrodes that are assigned to particular location (keep the naming consistent to avoid confusions)

Bilateral mastoids	**Eye electrodes**	**Backup electrodes**
EXG1: Left mastoid (M1)	EXG3: left-upper eye (SO1)	EXG7: backup electrodes for bad channels
EXG2: Right mastoid (M2)	EXG4: left-lower eye (IO1)	EXG8: backup electrodes for bad channels
	EXG5: left-lateral eye (LO1)	
	EXG6: right-lateral eye (LO2)	

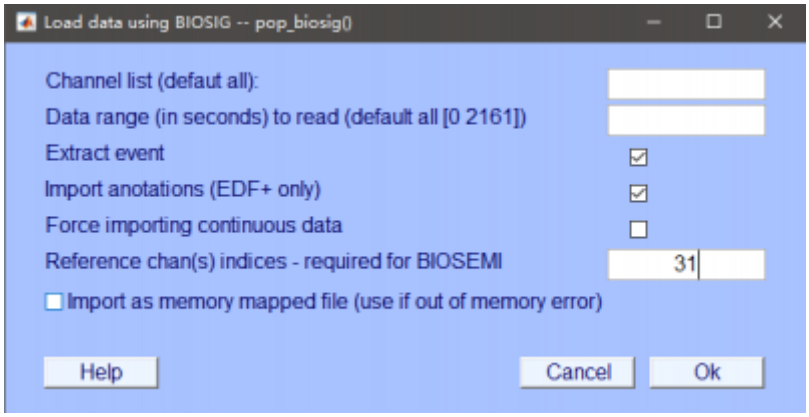
ERPLAB: preprocessing pipeline

Here are the brief summary of the preprocessing steps along with relevant Matlab functions .

1. Loading data

File → Import data → Using EEGLAB functions and plugins → From Biosemi BDF file

1) Make sure you have BIOSIG Toolbox installed before loading data.
2) A single channel should be used as reference when importing raw data to BioSemi system. In the pop-out window, select reference electrodes (Pz is preferred, code: 31) and click “ok”
NOTE: Pz is chosen because it is anatomically close to CMS-DRL location. All signals should be re-referenced to an average mastoid.
3) Save the file as SubID_raw (e.g. S001_raw), this create FDT and SET files.



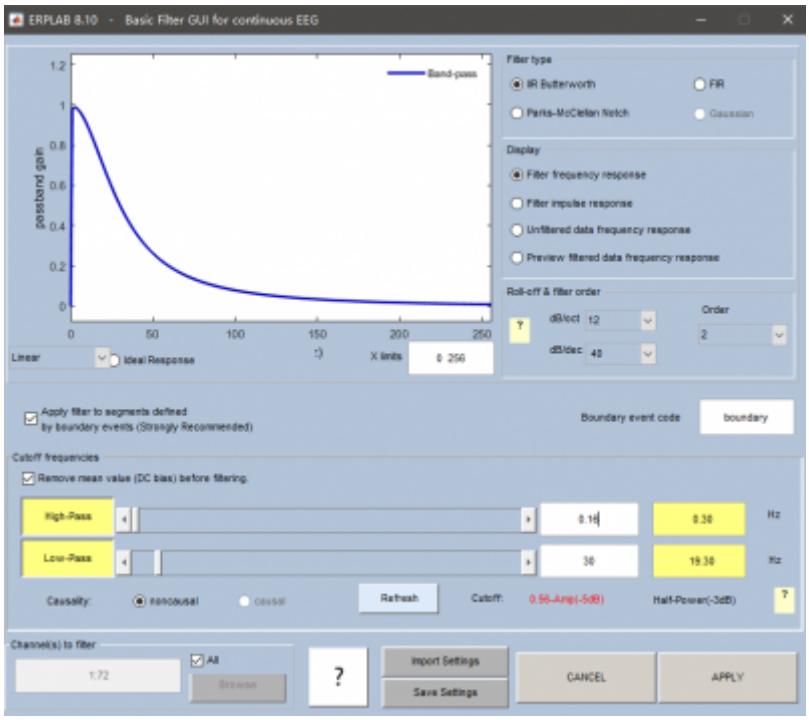
2. Append dataset

Edit → Append datasets
Because we collected EEG data by run/block. We need to concatenate the datasets across runs for each subject before preprocessing.

3. Filter the data

ERPLAB → Filter and frequency tools → Filters for EEG data

1) Make sure you have MATLAB Signal Processing Toolbox installed.
2) Filter type: IIR Butterworth
3) Click “Apply filter to segments defined by boundary events”
4) Cutoff frequencies: select Remove mean value (DC bias) before filtering
5) Note that BDF files have a large DC offset, you should either use BioSemi supplied “Converter” to BDF→EDF (I use the default setting of 0.16 hz highpass filter) or filter the data once in EEGLAB.
6) Cutoff frequencies:“0.1 (high-pass) – 30 (low-pass)”
7) Roll-off & Filter order: Order (2nd or 4th order filer, 12 or 24 dB/octave roll-off)



4. Add channel locations

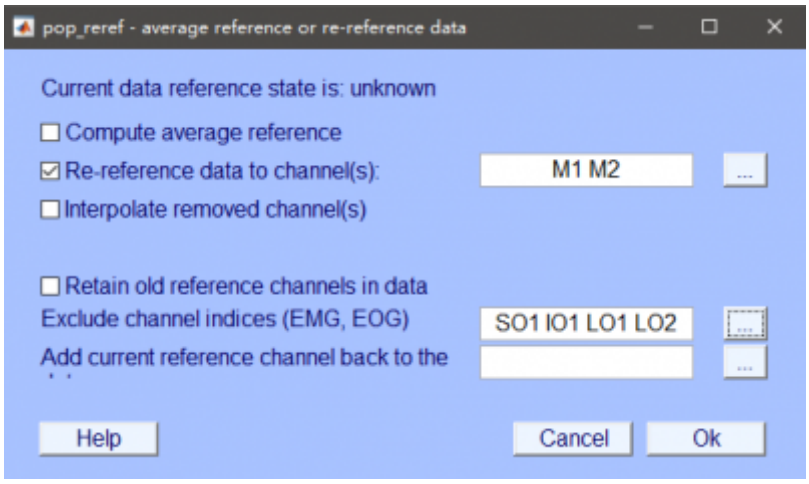
Edit → Channel locations
Accept the default and define the EXG electrodes in the pop-out window.

5. Downsample the data (optional)

Tools → Change sampling rate

6. Re-reference

Tools → Re-reference the data
1) Select M1 and M2 as the reference channels
2) Exclude EOG channels



7. Create the event list

ERPLAB → EventList → Create EEG Eventlist → Advanced
EVENTLIST provides information for each event, including a numeric code, a text label, a time of occurrence, enable/disable flag (to mark events that should be excluded because of errors during data collection). Here is an example of how the eventlist looks like:

1) Enter Event Info and Bin Info, then click “update line”
2) Equation List → Save list as a text file
3) Write resulting EVENTLIST to a text file (not sure why this step is necessary) → Apply
4) A pop-out window asked for Info to be used as Event Type, select “Numeric Codes”

eventcode	condName	notes
114	attRL	attend red on the left
214	attRR	attend red on the right
124	attGL	attend green on the left
224	attGR	attend green on the right

8. Assign bins

ERPLAB → Assign bins (BINLISTER)
How to assign bins? See the “Cheat Sheet” below for detailed description help BINLISTER [https://github.com/lucklab/erplab/wiki/Assigning-Events-to-Bins-with-BINLISTER:-Tutorial] BDF-library [https://github.com/lucklab/erplab/wiki/BDF-Library]

9. Epoch data

ERPLAB → Extract bin-based epochs
The choice of time window depends on your experiments. In general, we used a pre-stimulus period (-200 ms to 0 ms) as the baseline activity.

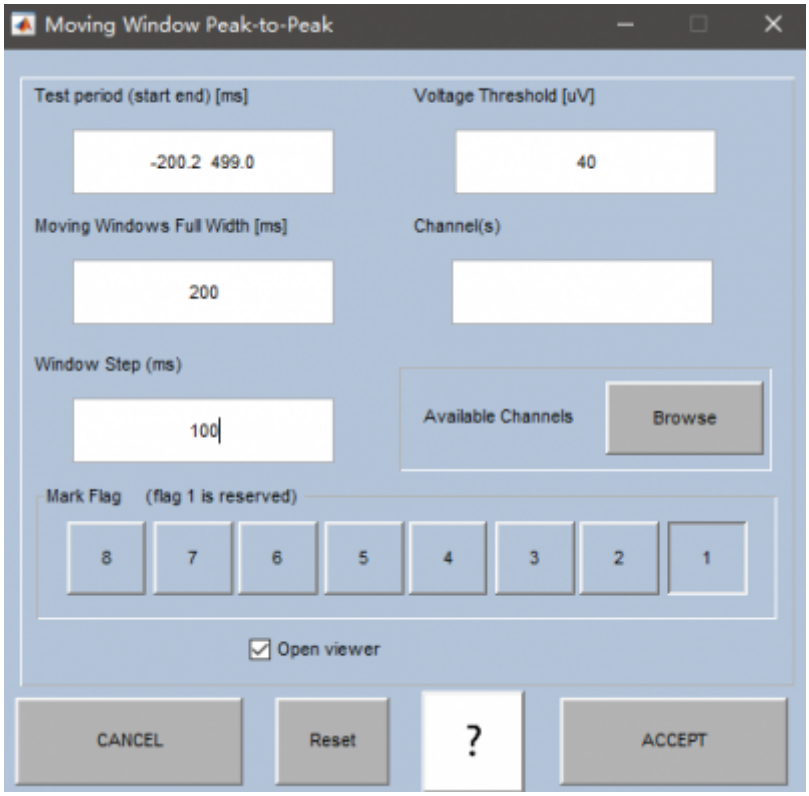
10. Artifact detection and rejection of bad epochs

There are many sources of artifacts that can lead to drift of EEG signals. Clean up the data in a semi-automatic manner is the guarantee of further analysis.

How to deal with eye movement?

ERPLAB → Artifact detection in epoched data → Moving window peak-to-peak threshold

1) Suggested voltage threshold: 40 µV.
2) Run this on eye channels only: enter the code number of EOG channels.
3) By default, the window width is 200 ms and the stepsize is 100 ms.



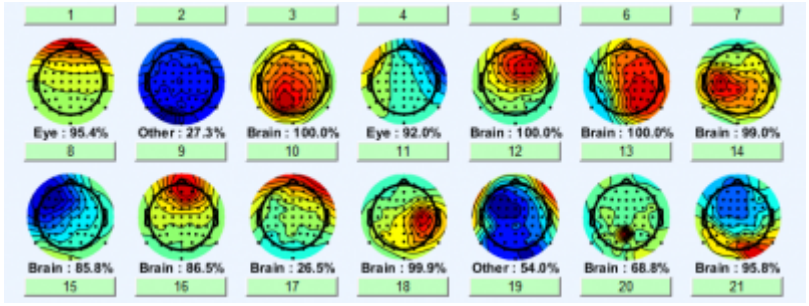
How to correct eye movement: ICA correction

Note that ICA Correction *correct*, not exclude trials with eye movement. If blinks are unavoidable in the epoch that interest you, try correction method.

1) **Tools → Decompose data by ICA**

Accept the default (ICA algorithm: “runica”) and select “EEG” as the channel type (this step took a long time).

2) **Tools → Classify components using ICLabel → Label component**



3)**Tools → Remove component from data**

Compare the data before versus after IC removal to ensure that obvious eye movements are corrected.

Useful tips:

Having difficulty deciding which ICs should be removed? Here is a great overall that describes how to use the combination of scalp distribution, time course and frequency to distinguish among artifacts: learn about ICA labels [https://labeling.ucsd.edu/tutorial/labels]

To understand the potential issues with ICA-based correction, refer to this link:

hints for using ICA for correction [https://erpinfo.org/blog/2018/6/18/hints-for-using-ica-for-artifact-correction.]

How to deal with other general artifacts?
ERPLAB → Artifact detection in epoched data → Simple voltage threshold

1) Suggested voltage threshold: ±75 μV
2) Run this on all scalp channels to exclude large artifacts
3) CORRMAP was recommended to perform a semi-automatic identification of common EEG artifacts
Corrmap plugin [http://www.debener.de/corrmap/corrmapplugin1.html]

Final check: visual inspection of artifacts (manual artifact removal)
If you reach this step, all basic preprocessing is done, you could export the data and perform more experiment-specific analyses according to your need in MATLAB.

Advanced use

1. Average the ERPs

ERPLAB → Compute averaged ERPs
1) Keep default setting: exclude epochs marked during artifacts detection
2) Keep track of the summary per bin (the output in command window tells you the proportion of rejected trials for each bin)

2. Compute difference waves

ERPLAB → ERP operations → ERP Bin Operations
In ERP studies, we often need to compare waveforms between different conditions, or between different electrode sides (e.g., contralateral vs. ipsilateral). Here is a useful reference that guides you to do compute the difference in GUI: ERP bin operations [https://github.com/lucklab/erplab/wiki/ERP-Bin-Operations]

1) Select channels on the left side (odd code, 1,3,5 …) and right side (even code, 2,4,6 …)
2) Select the conditions (bin number)
3) Define the condition names that correspond to the bins
4) Check if the code in Bin Operation GUI looks right

3. Compute regional activity

ERPLAB → ERP operations → ERP Channel Operations
Channels can be created and modified as the Bin operation.
