EEGpal: Main windows

Version 1.4, 16.01.2025

The EEGpal toolbox is developed by Michael DePretto (Michael.DePretto@gmail.com) and Michaël Mouthon (University of Fribourg, michael.mouthon@unifr.ch).

EEGpal is an open-source Matlab-based software for automated/semi-automated EEG data pre-processing and analyses. It proposes Graphical User Interfaces (GUIs) that allow EEG pre-processing to be batched across participants with a high degree of flexibility in processing parameters.

The purpose is to offer a complement to the free software Cartool developed by Denis Brunet (University of Geneva, reference: Brunet D., Murray M., Michel C. (2011) Spatiotemporal analysis of multichannel EEG: CARTOOL. *Computational intelligence and neuroscience*, vol. 2011, 813870. DOI : 10.1155/2011/813870). It is also an alternative to the original EEGLAB GUI (reference: Delorme, A., & Makeig, S. (2004). EEGLAB: an open-source toolbox for analysis of single-trial EEG dynamics. *Journal of Neuroscience Methods, 134*(1), 9-21. DOI: 10.1016/j.jneumeth.2003.10.009).

In summary, the authors propose the EEGpal graphical interface (GUI) as a more practical solution than the EEGLAB and Cartool GUIs for automating preprocessing. The authors recommend the use of Cartool software for the visualisation of EEG traces.

Minimum requirement

Matlab 2018b or later

License

GNU General Public License v4.0 or later

Permissions of this strong copyleft license are conditioned on making available complete source code of licensed works and modifications, which include larger works using a licensed work, under the same license. Copyright and license notices must be preserved. Contributors provide an express grant of patent rights.

Before to start

This section reminds the import terminology and concept to know before to use this toolbox.

What is a Time Frame (TF)?

The abbreviation TF (or tf) used in the toolbox stands for Time Frame. It corresponds to one sampling point the EEG files. This is the smallest unit of time. Its duration depends on the sampling frequency. For example, if the sampling frequency is 2048 Hz, then 1 TF=1/2048= 0.000488s = 0.488 ms.

File types

One of the advantages of the EEGpal toolbox is that it works with a serval EEG file format. For example:

- .bdf : Raw Biosemi files
- .eph : Text file format (with tab column as separator) used in Cartool. The first line is an header which contains info about the number of channel, number of time point and sampling rate
- .ep: Text file format (with tab as column separator) used in Cartool and RAGU software (Koenig, T., Kottlow, M., Stein, M., & Melie-García, L. (2011). Ragu: A Free Tool for the Analysis of EEG and MEG Event-Related Scalp Field Data Using Global Randomization Statistics. Computational Intelligence and Neuroscience, 2011, 1-14. DOI: 10.1155/2011/938925.). Contains only data without any temporal information in it
- .sef: Binary EEG file used in Cartool that contains the data and temporal information. It is the default option proposed in EEGpal because this solution uses the least disk space.
- .set/.fdt: File format used by EEGLAB
- .ris: Inverse solution file used in Cartool
- .freq: Frequency analysis file used in Cartool
- .mrk: marker file. It is a text file which include the events during recording (see FAQ at the bottom of this document for more details)

The EEGpal toolbox offers the possibility to easily switch from one file format to the other, thanks to the export tool or the choice of output file format within each module.

What is the difference between Triggers and Markers?

Usually, we add a tag to the EEG recording to mark the position of an event. This is the function of triggers/markers. The difference is that the triggers are included in the EEG file (this is the case for .bdf and .set file formats), while the markers are recorded in a separate text file named eeg_file.mrk (this is the case for .eph, .ep, .sef file formats). EEGpal automatically detects these two cases and can handle them.

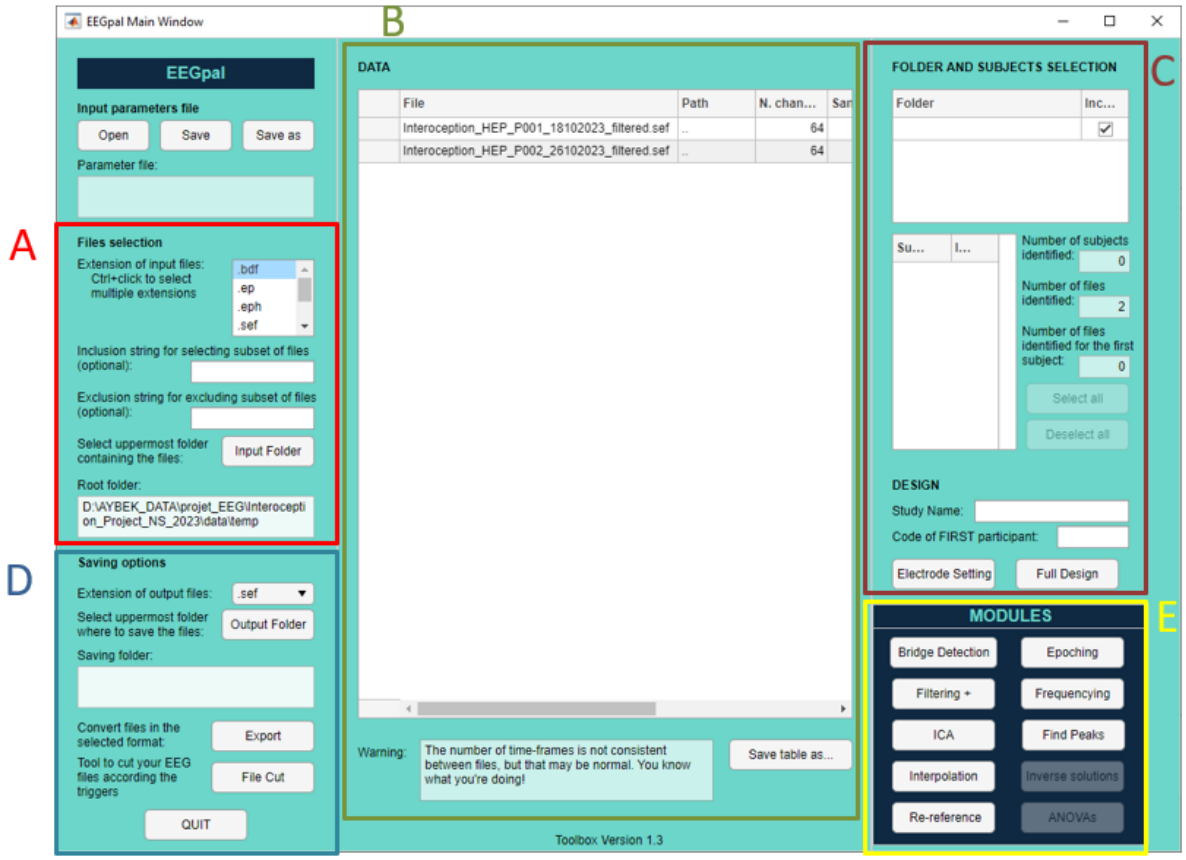
Processing Information File (PIF)

Each time you perform a processing step with an EEGpal tool or module, a Processing Information File (PIF) is created. This is a text file containing a summary of all input and output files and processing parameters. It allows you to keep track of the steps you have performed.

What is a typical EEG processing pipeline in EEGpal?

Everyone has its own recipe but the pipeline used by the Toolbox creator are detailed at the bottom of this document.

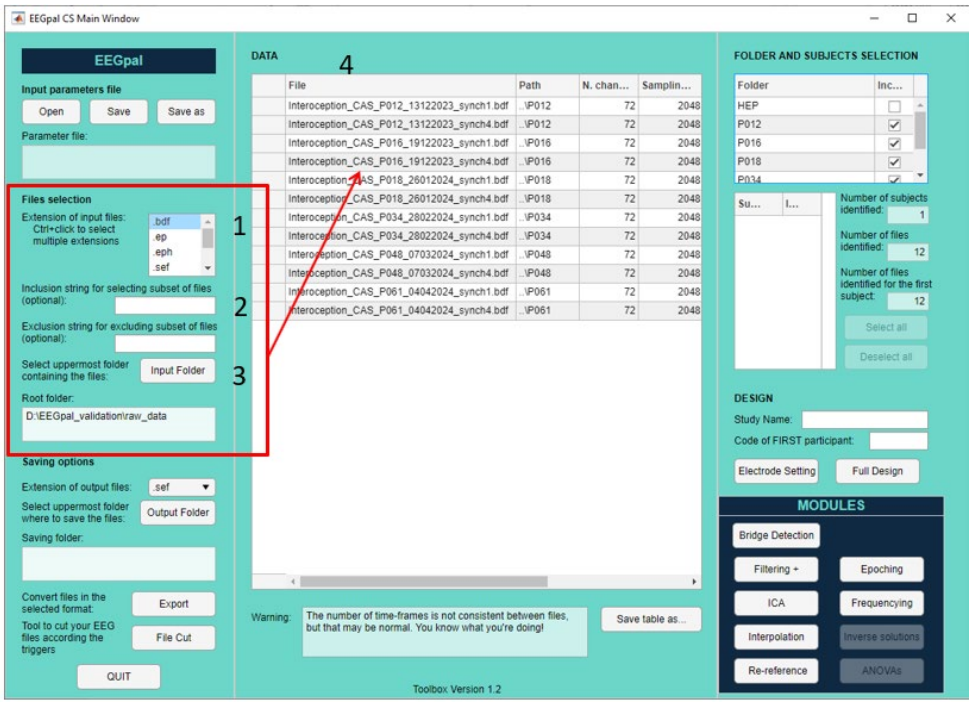
Main window



There is five important section in the EEGpal main window:

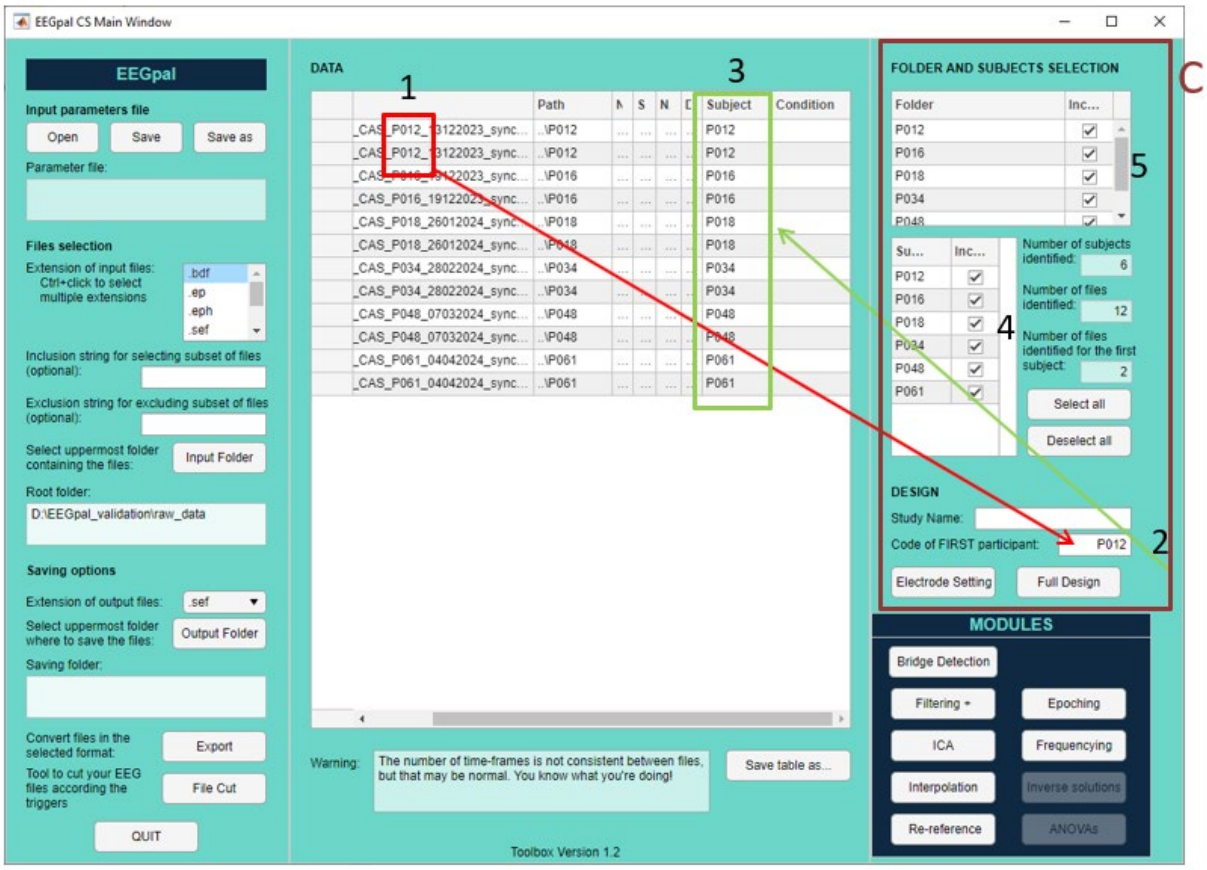
A. **Importation section**: Tool to import/Select the EEG file in the Data table B (see below for details)
B. **Data table**: Contains the list of files which will be used for the next processing step. It contains characteristic info about files like the number of channels, sampling rate, number of time frame, subject and condition
C. **Selection and update info about files listed in Data table**: Specify subject and condition information, sub-selection and electrode localization settings (see below for details)
D. **Saving options and Tools**: Permit to define the default format of file saving as well as export the file of the Data Table in another format. You can also found here the File Cut tool to cut your EEG files
E. **Modules section**: List of preprocessing modules (first columns) and analysis modules (second columns). A help file is provided for each of them.

Import Data



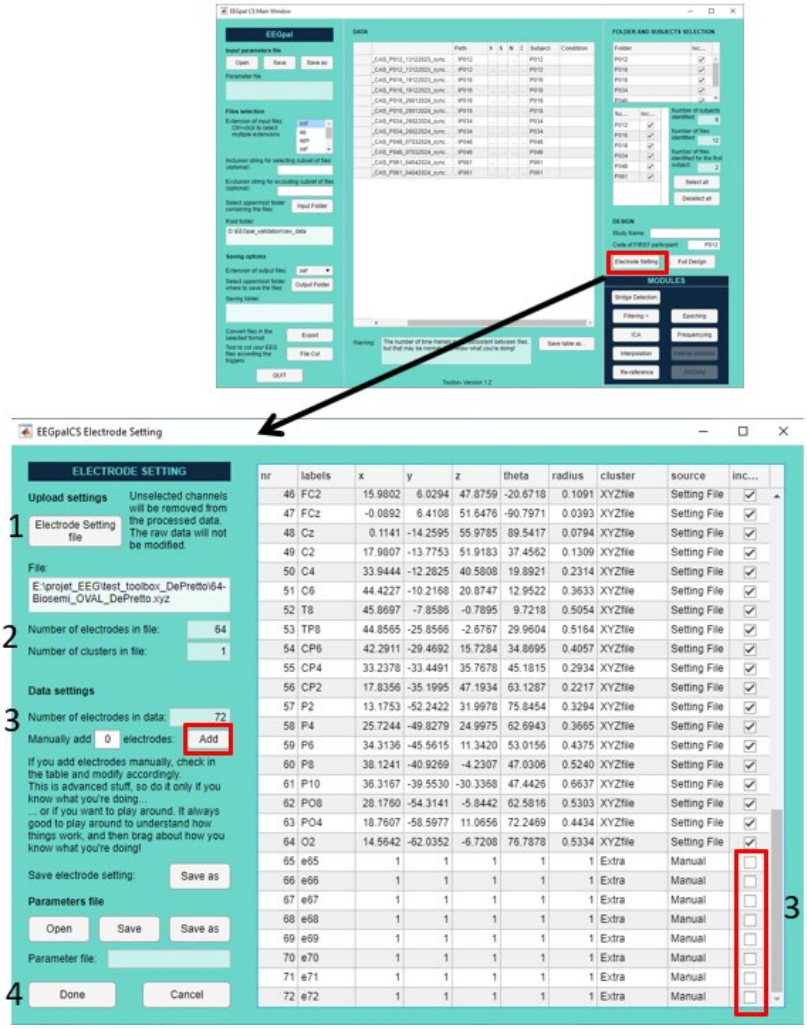
1. Select the raw data format.
2. optional: If you want to filter a part of the files, you can write in a character string that is common to the files you want to select (for example, if you write 'normal', then the toolbox will select only the files with the word normal in their name).
   At the opposite, you can exclude file which contains a specific pattern.
3. Press the Input Folder button and select the directory containing all the EEG files you wish to import. These files can be placed in sub-directories. The toolbox will select all files corresponding to the search criteria defined in 1 and 2, whether they are in the main folder or in sub-folders. It takes some time to fill the list in the central panel. Give Matlab time to complete this list before doing anything.
4. The main panel lists all the files that the toolbox has found. It informs us in order: file name, location on disk, sampling frequency, total number of electrodes recorded in the file, and the number of TFs contained in the file.

Define participant and adjust the selection



1. In order to specify the different subject to the EEGpal toolbox, identify the participant code in the EEG name for the first entry in data table.
2. Enter the code for the first participant (determined in point **1**).
3. The Toolbox will then automatically identify which participant the files belong to. The participant codes are added to the Subject column. Check that the values are correct.
4. You can then deselect specific participants to remove them from the data list.
5. You can also deselect files according the sub-folder from the input folder

Loading the electrode coordinate file



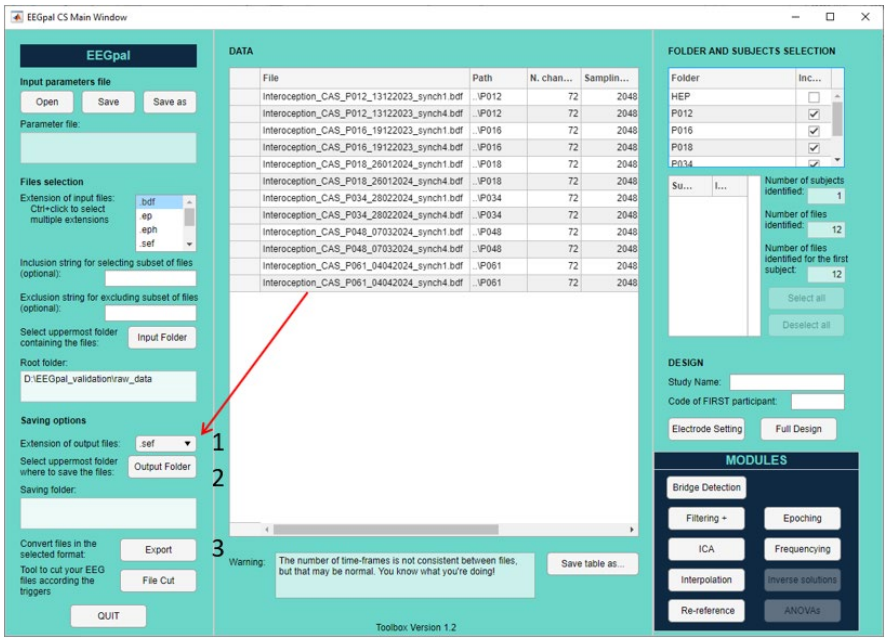
nr	labels	x	y	z	theta	radius	cluster	source	inc...
46	FC2	15.9802	6.0294	47.8759	-20.6718	0.1091	XYZfile	Setting File	☑
47	FCz	-0.0892	6.4108	51.6476	-90.7971	0.0393	XYZfile	Setting File	☑
48	Cz	0.1141	-14.2595	55.9785	89.5417	0.0794	XYZfile	Setting File	☑
49	C2	17.9807	-13.7753	51.9183	37.4562	0.1309	XYZfile	Setting File	☑
50	C4	33.9444	-12.2825	40.5808	19.8921	0.2314	XYZfile	Setting File	☑
51	C6	44.4227	-10.2168	20.8747	12.9522	0.3633	XYZfile	Setting File	☑
52	T8	45.8697	-7.8586	-0.7895	9.7218	0.5054	XYZfile	Setting File	☑
53	TP8	44.8565	-25.8566	-2.6767	29.9604	0.5164	XYZfile	Setting File	☑
54	CP6	42.2911	-29.4692	15.7284	34.8695	0.4057	XYZfile	Setting File	☑
55	CP4	33.2378	-33.4491	35.7678	45.1815	0.2934	XYZfile	Setting File	☑
56	CP2	17.8356	-35.1995	47.1934	63.1287	0.2217	XYZfile	Setting File	☑
57	P2	13.1753	-52.2422	31.9978	75.8454	0.3294	XYZfile	Setting File	☑
58	P4	25.7244	-49.8279	24.9975	62.6943	0.3665	XYZfile	Setting File	☑
59	P6	34.3136	-45.5615	11.3420	53.0156	0.4375	XYZfile	Setting File	☑
60	P8	38.1241	-40.9269	-4.2307	47.0306	0.5240	XYZfile	Setting File	☑
61	P10	36.3167	-39.5530	-30.3368	47.4426	0.6637	XYZfile	Setting File	☑
62	PO8	28.1760	-54.3141	-5.8442	62.5816	0.5303	XYZfile	Setting File	☑
63	PO4	18.7607	-58.5977	11.0656	72.2469	0.4434	XYZfile	Setting File	☑
64	O2	14.5642	-62.0352	-6.7208	76.7878	0.5334	XYZfile	Setting File	☑
65	e65	1	1	1	1	1	Extra	Manual	☐
66	e66	1	1	1	1	1	Extra	Manual	☐
67	e67	1	1	1	1	1	Extra	Manual	☐
68	e68	1	1	1	1	1	Extra	Manual	☐
69	e69	1	1	1	1	1	Extra	Manual	☐
70	e70	1	1	1	1	1	Extra	Manual	☐
71	e71	1	1	1	1	1	Extra	Manual	☐
72	e72	1	1	1	1	1	Extra	Manual	☐

1. Load the .xyz, .els or .locs file containing the spatial coordinates for locating the electrode position on the EEG cap.
   In the current situation there are already two coordinate files for a 64 channel Biosemi configuration in the *Resource* sub-folder of the EEGpal. The *biosemi64_officialAB_update.locs* file contains the coordinates found on the official Biosemi website with a spherical distribution of electrodes. The file *64-Biosemi_OVAL_AB.xyz* is an oval distribution of the electrodes after coregistration with the MNI template in Cartool (more physiologically accurate).
   You can add your own coordinate file directly in the Resource sub-folder of EEGpal to gain time.
2. The toolbox informs you of the number of electrodes present in this coordinate file, as well as the number of clusters. A cluster is a group of electrodes that can be specified within an .els file (e.g. to separate EEG electrodes from external channels).
3. Optional: To remove supplementary channel of non-interest: The toolbox compares with the number of electrodes in the EEG files.

In our case, the EEG files contain 8 more electrodes than the coordinate file (ECG channels). Click on the Add button to manually add these 8 channels to the table on the right. Make sure that these new electrodes are deselected (the default setting) so that they are ignored/deleted (and not interpolated) in the analysis.

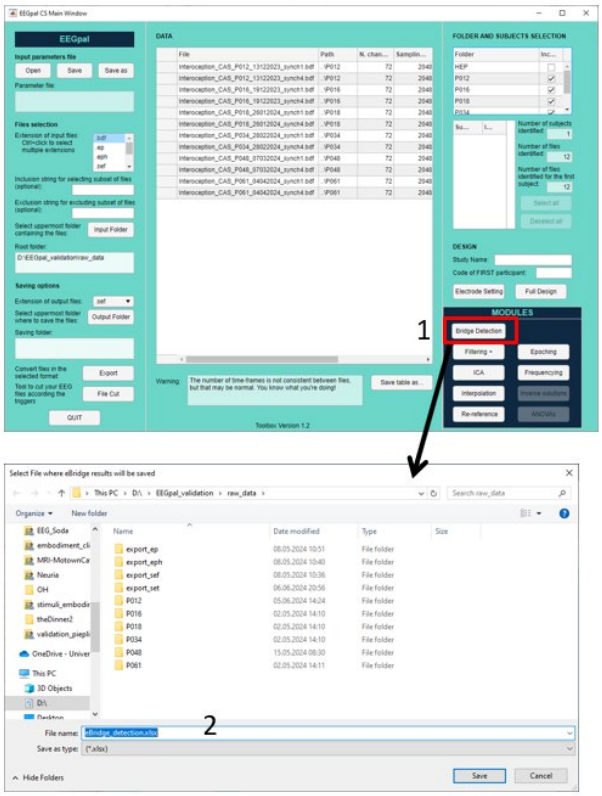
4. Click on Done

Export to another EEG file format



1. Select the output format (.sef, .eph, .ep for Cartool or .set for eeglab)
2. Choice the folder where the files will be stored
3. Click on the Export button

Bridge Detection



1. Press on the “Bridge Detection” button.
2. Select the location of the .xlsx output file

This module calls the eeglab script eBridge which automatically detect if two or more channels are bridged (same signal). Open the .xlsx output file to check if there is any. We will need this info for the ICA and interpolation step.

3. Check the excel file on the C column (percentage of channels that are bridged; if 0 = good to go, no bridge detected, if there is a number we have to delete one of the bridged channels)

Other tools and modules have their own manuals.

Typical EEG processing pipeline (validate by Michaël Mouthon)

In this document, we distinguish the preprocessing, which permits to clean the data for the data analysis (the processing). The preprocessing is similar between the type of analysis but with some variation. Here I will first describe the case of Event Related Analysis (ERP).

Preprocessing

1. Import raw data into the main EEGpal windows and identify the subject as explained in the chapter *Define participant and adjust the selection* of this manual.
2. Specify the spatial position of the channels by loading an electrode coordinate file as explain in the chapter *Loading the electrode coordinate file* of this manual.
3. Perform a *Bridge Detection* in order to check if there is any unwanted connection between channels
4. Use the module *Filtering* for the first clean of the data. Filter to keep the signal between 0.5 and 40 Hz. Add a Line noise removal either by a Notch filter at 50 Hz or by using cleanline
5. Inspect visually the result file in Cartool to check if there are wrong channels (behave totally differently as the neighbors for some time)
6. Use the *ICA* module to perform an ICA decomposition by ignoring bad channels determine in point 3 and 5.
   Inspect manually the 24 first compounds of each file to removed compounds link to Eye artefacts
   Recomposed the signal without the previously selected compounds
7. Use the *Epoching* module to perform a temporary Epoching and inspects visually in Cartool the ERP files. Selected the bad electrodes which negatively impact the ERP to be interpolated
8. Use the *Interpolation* module to interpolated bad electrodes determined in 3,5 and 7.
9. Use the *Refef* module, to change the reference electrode to the average reference
10. Use the Epoching module to compute the final ERPs