# User Manual for resting-state EEG Cleaning

## 1 Prerequisite

* The following steps are included in the EEGcleaning\_example\_EEGlab.m in the project folder 2100\_00 TEMPLATE Projec\EEGcleaningFunctions. The functions can also be used separately if only a few of them are needed.
* There is an example script also for EMG cleaning. By default, the analysis flow first involved EEG cleaning, them EMG, and finally, matching the trials (if needed)
* Note that here the order of the steps is set such that the functions work better if the previous steps were first completed.
* Before running the steps below, you should have loaded the data from the raw data file, epoched them, and if desired, downsampled to, e.g., 1000 Hz.
* The functions use EEGlab visualization (topoplot), so EEGlab must be running on the background.
  + Alternatively, just set the topoplot function path to your working path list
* This analysis protocol is not suitable for cleaning evoked responses

## 2 Detrending

* Function: bnp\_detrendLaplace
* trend fitting is performed by I\*inv(I+Laplacian\*Laplacian’\*lambda^2)\*Data, where Laplacian is the Laplacian operator in the matrix format
* If lambda is increased the trendline becomes smoother (containing lowest frequencies). Small lambda makes the trendline follow the data more precisely.
* This fitting is fairly robust with respect to short deflections and spikes. However, it will generally affect longer-lasting deflections such as blinks, which have considerable amount of low-frequency power.
  + Blinks can still be identified and removed by ICA, since all channels are filtered in the same way, and the topographies have not been changed.

## 3 Channel-wise noise estimation

* Function: bnp\_estimateNoise\_EEGlab
* Data-driven SOUND is run to estimate the uncorrelated noise over the channels
* Lead-field matrix can be used to estimate how large bias is in the noise estimation due to neural noise
  + The noise level is commonly slightly over-estimated in the periphery of the EEG cap. This bias is very small in high-density EEG, but can get significant when the channels are sparse.
* LFM can be estimated roughly in a spherical head model based on the (default) EEG channel locations (in the EEGlab data struct)
  + Function: ComputeSphericalLFM
  + More sophisticated LFM computation can be alternatively used

## 4 Rejecting bad channels and trials

* Function: bnp\_detectNoisyChannelsEpochs\_EEGlab
* Channels and trials are rejected based on the estimated noise
  + noise can be scaled by the bias coefficients if available
* The noise standard deviation is estimated for each channel and trial.
  + If the noise level exceeds the threshold in over 10 % of the trials, the channel is rejected
  + The threshold is given relative to the median value of all standard deviations. The median is computed using 98% lowest standard deviations
  + After channel rejection, the range of the remaining noise signals is computed for each channel and trial. If the range exceed the given threshold the trial is rejected
  + The threshold is given relative to the median of the range values.
* Set the channel rejection threshold by left-clicking on the top left subplot (?)
  + The bottom left subplot shows the channels to be rejected
  + The middle plot shows examples of rejected channels in red and accepted in blue
  + The right-most plot shows the noise estimates from the same channels
* Set the rejection threshold of the trials by left-clicking on the left subplot (?)
  + In the middle, the rejected signals are in red, the accepted ones are in blue. On the right, there are the respective noise estimates.

## 5 Re-referencing

* Average reference can now be set

## 6 Independent component analysis

* Function: bnp\_detectBadICs\_EEGlab
* FastICA is run and the components are shown one at the time
  + ‘tanh’ contrast function and symmetric mode are used.
  + For each component, the topography and the waveforms are shown
* Components are rejected by pressing the space, otherwise left-click to proceed (?)

After cleaning EEG epochs, proceed to EMG cleaning, and finally, match the EMG and EEG trials if needed

## 7 Aligning the EEG and EMG trials

Function: bnp\_alignEEGandEMGtrials; example of usage in the script EEGcleaning\_example\_EEGlab.m

* After setting the bad EEG trials, the EEG and EMG trials must be matched if your analysis involves single-trial statistics/correlations/causalities between EEG and EMG data
* If you defined bad trials separately for several EMG channels, the alignment needs to be separately performed for each EMG channel.

## 8 Saving

* Take care of saving all the variables you may need in further analysis