THE BERGEN EEG-fMRI TOOLBOX

– Gradient fMRI Artifatcs Remover Plugin for EEGLAB –

1- INTRODUCTION

This EEG toolbox is developed by researchers from the Bergen fMRI Group (Department of Biological and Medical Psychology, University of Bergen). This toolbox intends to provide advanced solutions for the use of EEG and fMRI simultaneous recording datasets. All the methods are presented on a user-friendly environment (GUI interface) and all the executed code commands are reported, allowing users to perform their own solutions to their datasets.

Gradient fMRI Artifatcs Remover Plugin:

When an EEG and fMRI is recorded simultaneously, the fast change of the magnetic field gradient of the MR scanner produces huge interferences to the EEG record. This results on a EEG record contaminated with induced artifacts from the fMRI scans.
This plug-in is aimed to deliver an output EEG dataset without these interferences and for that, for each EEG channel, each artifact is analyzed separately and head movements are taken in consideration for the removing process. A sequence of 5 steps is suggested for the removing process but users have easy access to each single step command/code generation.

Note: To obtain only the pure neural activation on your dataset, other interferences must be discarded, (e.g. ocular activation, QRS events, chewing, etc.) and therefore we encourage to apply other techniques after this plug-in. For more information, please contact us.

2 – INSTALATION AND REQUISITES

➜Instalation: Simply expand the RAR file and place the content on the \..EEGLAB\PLUGINS\ directory. Please make sure that the EEG_fMRI_recording" folder is now one subfolder of PLUGINS directory.

➜Running: Run EEGLAB; Load or import dataset; Go to the menu "TOOLS" ➜ "BERGEN EEG-fMRI Toolbox" ➜ "Remove fMRI gradients artifacts"

➜Requisites: Matlab 7.4 (r2007a), EEGLAB (http://sccn.ucsd.edu/eeglab/).
Please read how to handle with Large Datasets in
http://www.mathworks.com/support/tech-notes/1100/1107.html

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3 - TUTORIAL GUIDE

STEP 1 – fMRI Volumes onset detection

<u>Options:</u>

➔<u>Use Marker from fMRI recording:</u>

If the dataset was recorded with synchronization of the MR machine, it might contain the references for the beginning of each MR scan. This method uses the EEG.event record to select the references of selected Marker.

- Marker:

    Selecting a marker, an automatic plot of the first 7 fMRI Volumes will appear. A red cross is positioned on each volume onset. If less than 2 references are found on whole dataset, an error message is generated and the Marker is not accepted.

➔<u>Manual fMRI Volumes detection:</u>

This method will scan the dataset for possible peaks related with the beginning or onset of each fMRI volume. It requires only an approximate value for the repetition rate (TR) used by the MR machine. For continuous recording it might require more accurate values. In these situations, users can change the artifact gradient amplitude to tune the trigger value for detection. After all settings are set, press "Read fMRI volumes onset" button and an automatic plot of the first 7 Markers will appear. A red cross is positioned on each reference of Markers. If detection fails, an error message is generated and the user cannot proceed.

- Estimated fMRI repetition rate TR:

    It refers to the Time Repetition (TR) used on the fMRI scans. This is the time between two consecutive fMRI volumes. It can be an estimated value but it must be specified in milliseconds.

- EEG reference channel:

    Users can specify a channel in particular on which the detection method will be based to detect possible onsets. "Auto" option will automatically select the channel with lower gradient. (Attention: make sure that the channel selected is not an accidentally unplugged electrode. Users can check the channel on Preview button.

- Preview:

    This Button will only be available if any EEG reference channel is selected. It plots the gradient of selected channel (it only plots 2.5% of the first half of channel).

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- Artifact threshold:

  Users can change the artifact gradient amplitude to tune the trigger value for detection method. It can be specified in percentage relative to the peaks of the volumes or it can be specified an absolute value (in micro volts). Users can choose to Preview the channel and see a safe or optimal value for threshold.

STEP 2 – Artifact Duration Parameters

Options:

➔Continuous recording:

If selected, the Start of the Artifact will have the same value as the Marker, and the End of the Artifact will be the point immediately before the next marker. (i.e. Start = 0, End = TR).

➔Adjust Start and End of the Artifact Manually:

If selected, user will be able to adjust the Start and End of the artifact relative to the first marker. Start and End values must be in milliseconds and will be positive or negative depending if they are after or before the first marker (respectively). Alternatively, user may select graphically Start and End points. Zoom tool is available and Buttons plus/minus can be used to better accurate the Start and End of the Artifact Volume. Note: Silent Gap cannot be negative. (Note: It is possible to define continuous recording if resulting silent gap is zero).

STEP 3 – Baseline Correction

Options:

➔Use whole artifact average:

This option is only available if there is no silent gap (continuous recording). If selected, each artifact interval defined on step 2 is averaged and shifted to zero.

➔Use average of precedent silent gap:

This option is only available if there silent gap exists. If selected, each artifact interval defined on step 2 is averaged and shifted to the average of precedent silent gap.

➔Use Time Interval average:

If selected, each artifact interval defined on step 2 is averaged and shifted to the average of defined time interval. The time interval is defined on "From" and "To" boxes. The values

must be in milliseconds and will be positive or negative depending if they are after or before the marker (respectively).

- **Advanced Option -** Shift non corrected data to baseline:

  If selected, it will only take effect after shifting the corrected data. In this case, the whole initial part of dataset (until the Beginning of fMRI recording) is averaged and then shifted to the average of the first corrected artifact. In the same way, the last part of the dataset (from the End of fMRI recording until the end of the dataset) is averaged and then shifted to the average of last artifact corrected.

STEP 4 – Correction Method

Options:

➔ Realignment Parameter Informed [(1)]:

- Number of Artifacts that constitute the template:
  Each artifact is estimated to be similar to the artifacts in the neighborhood but when a head movement occurs, the artifacts can change dramatically. Because of that each artifact is expected to be similar to a specific neighborhood, constituting a template. This number refers to the number of artifacts for this template neighborhood;

- Threshold of movement:
  This value must be in milliseconds and between 0 and 1. It implies that it will only be consider movements that occurred with more amplitude than the specified.

- Head movement registry file:
  This file can be a text file (*.txt) and must have dimension [n x 6], where n is the total number of artifact volumes considered for correction and 6 columns are related as the 6 rotation references values (x, y , z, @x, @y, @z).

➔ Moving Average [(2)]:

- Number of Artifacts that constitute the template:
  Each artifact is estimated to be similar to the artifacts in the neighborhood, considering a moving average of several artifacts (template). This number refers to the number of artifacts to be considered on this template;

➔ All artifacts volumes:

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This method will consider all the artifact volumes in consideration for correction, with the same weight.

➔ <u>Load Correction Matrix file:</u>

This option allows users to load their own correction matrix by Matlab (*.MAT) file. This file must contain a variable called weighting_matrix and this variable must be quadratic, meaning that it's dimension must be [N x N], where N is the number of artifacts considered for correction. If N is lower than the Markers (M) detected on Step 1, then the fist (M-N) artifacts will be discard from correction.

STEP 5 – Filtering Options

<u>**Options:**</u>

➔ <u>Resample:</u>

This option uses the `pop_resample()` function from EEGLAB. It down samples the dataset to the specified sample rate.

➔ <u>Pass-band filter:</u>

This option uses the `pop_iirfilt()` function from EEGLAB. To prevent errors, it first applies a Low-pass filter and then the High-pass filter, resulting in the specified Pass-band filter parameters.

4   - REFERENCES

[1] Realignment parameter-informed artefact correction for simultaneous EEG–fMRI recordings, Moosmann et al, 2009.

[2] Weighted moving averages of artifact epochs , Allen et al, 2000.

4 - CREDITS

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5 - INFORMATION

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(if possible send us the report log file to better illustrate your difficulties)