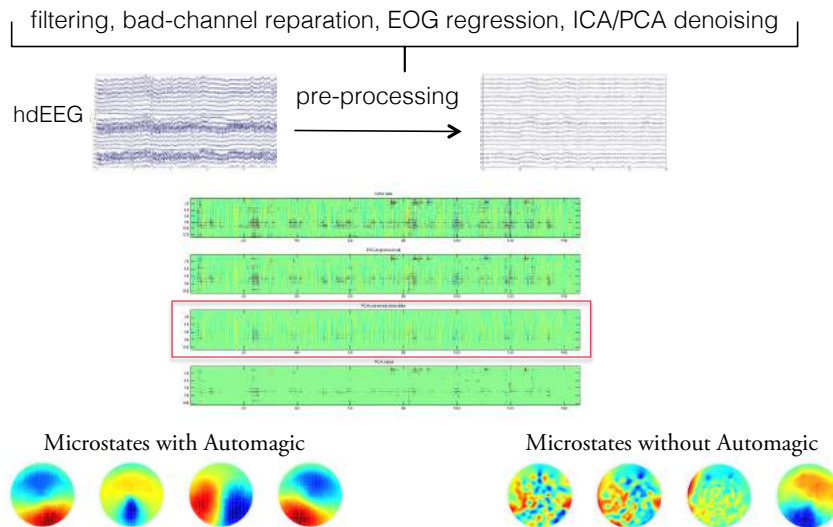


# Tutorial: Automagic EEG toolbox & Microstates toolbox

Nicolas Langer & Andreas Pedroni



## Outline

- Importance of Clean Data
- Common Artifacts in EEG
- What is Automagic
- What does Automagic
- Step-by-step tutorial on example data
- Pre-processing steps:
  - Filtering
  - Bad Channel Detection and Interpolation
  - EOG Regression
  - ICA / PCA

# Importance of Clean EEG Data

- Event-Related Potentials (ERPs) are tiny
  - Many experimental effects are less than a millionth of a volt
- ERPs are embedded in noise that is 20-100  $\mu\text{V}$
- Averaging is a key method to reduce noise
  - S/N ratio is a function of  $\sqrt{\text{\# of trials}}$
  - Doubling  $\text{\# of trials}$  increases S/N ratio by 41% [ $\sqrt{2}=1.41$ ]
  - Quadrupling  $\text{\# of trials}$  doubles S/N ratio [ $\sqrt{4}=2$ ]

# Importance of Clean EEG Data

- Just having a lot of trials is often not enough to get clean data
- It pays to reduce sources of noise before the noise is recorded
- Hansen's Axiom: There is no substitute for clean data
- Cleaning up noise after recording has a cost
  - Averaging requires lots of trials (lots of time)
  - Filters can distort the time course of the ERPs
- “By reducing sources of noise before they are recorded, you could cut an hour off every recording session or cut the number of subjects in each experiment by 25% (or even more)” Steven Luck

# Common Artifacts in EEG data

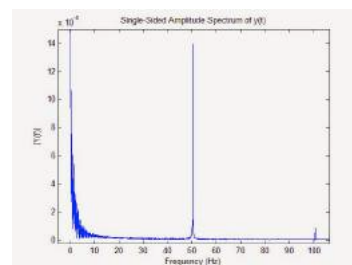
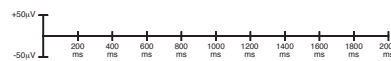
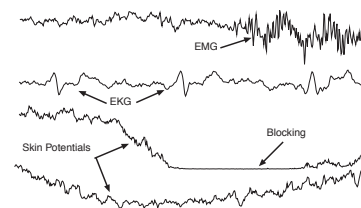
## Common Artifacts in EEG:

### Subjects related Artifacts:

- Any minor body movement (EMG)
- Cardiac activity
- Blinks and eye-movement
- Sweating

### Technical Artifacts:

- 50/60 Hz power line
- Impedance fluctuations
- Movement of cables
- Broken wire contacts
- Too much electrode gel/paste



# What to do with Artifacts?

## Artifact-rejection vs. Artifact-correction

- Throw out trials with problematic artifacts (e.g., rejection threshold  $>100 \mu V$ ); at the same time don't throw out „good“ trials
- Data gets lost!
- Use data reduction methods to eliminate artifacts (increase SNR)
- No data is lost!
- Automagic does Artifact-correction

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## What is Automagic

- Automagic is a MATLAB based toolbox for preprocessing of EEG-datasets.
- GUI vs. Open Source
- MATLAB (Octave) => Python version under construction
- Where to find it:
- <https://github.com/amirrezaw/automagic>

# What does Automagic?

1. Automagic automatically removes artifacts (e.g. eye movements, noisy electrodes, etc.) from your raw EEG-data.
2. Automagic lets you check the entire dataset for remaining artifacts. You will be able to select and remove these manually in a very efficient way.
3. You can rate the quality of individual EEG-files.

## Pre-processing with Automagic

### Filtering

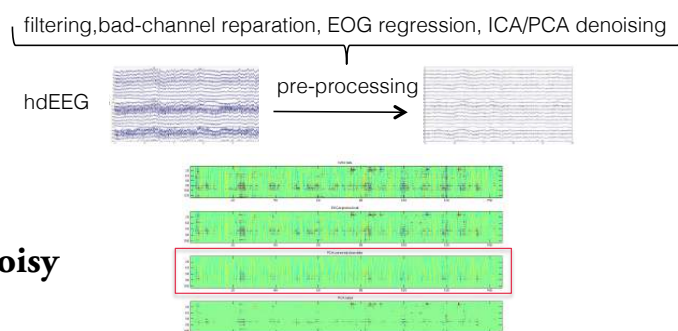
- Highpass-filter (~1Hz)
- Optional lowpass-filter
- Notch-filter (50/60Hz)

### Detect and interpolate noisy electrodes

### Regress out eye-artifacts

### ICA or PCA

### Visual inspection and rating of data quality



# STEP-BY-STEP TUTORIAL

Let's do some practical stuff

## Step-by-step Tutorial

### System Requirements

You need MATLAB installed and activated on your system to use *Automagic*. *Automagic* was developed and tested in MATLAB R2015b and newer releases.

### Installation

Download the *Automagic EEG Toolbox* to a folder of your choice.

<https://github.com/amirrezaw/automagic>

Navigate to *gui/* folder

Double click the file named *Automagic* or *Automagic.mlappinstall*. Wait until MATLAB displays a dialogue box.

Please select Install. You will be notified as soon as the installation is complete.

### How to Run Automagic

Start MATLAB.

Select the APPS tab.

Click on the Automagic icon. You might have to expand the APPS tab to see the *Automagic* icon by clicking the small triangle pointing down on the far right of the APPS tab.



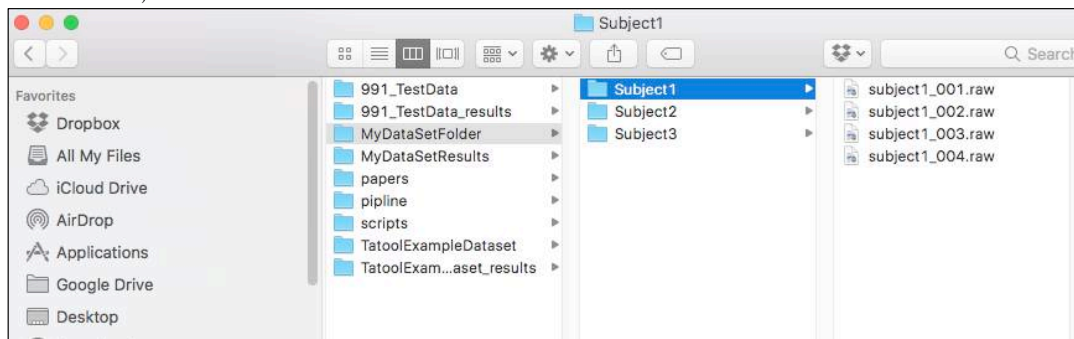
Smilla Pedroni (2016)

# Step-by-step Tutorial

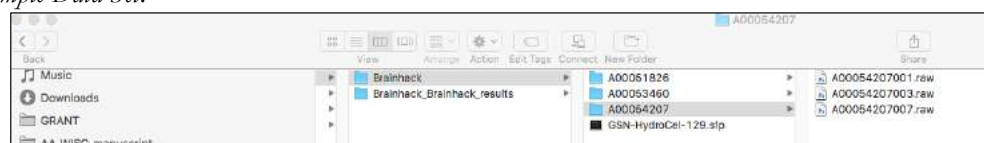
Before you start Automagic... prepare your data

## Folder organization:

Each subject has a folder and the EEG files have the same names as the folder



## Example Data Set:



# Step-by-step Tutorial

## Work Flow in Automagic

1. Create a new project or load an existing project.
2. Preprocess the data.
3. Rate data and manually select bad channels if any.
4. Interpolate all bad channels.
5. Repeat steps 3 and 4 until all data is rated.

## The Automagic GUI

The Automagic GUI is divided into three main sections: Project, Filtering, and Pre-Processing.

**Project Section:**

- Select Project:** A dropdown menu with "Create New Project..." and a small arrow icon.
- Project Name:** A text input field with the placeholder "Type the name of your new project..."
- File Extension (e.g. .raw, .dat):** A text input field.
- EEG System:** Two radio buttons: "EGI (HCGSN)" (selected) and "Other..."
- Channel location file:** A "Choose ..." button and a text input field.
- Channel location file type:** A text input field with the placeholder "e.g. stp".
- EOG channels:** A checked checkbox and a text input field with the placeholder "space separated indices, e.g. 1 32 8 14 17 21 25 125 126 127 128".
- Downsampling Rate:** A dropdown menu with the value "2".
- Data Folder:** A "Choose ..." button and a text input field with the placeholder "Choose where your raw data is..."
- Project Folder:** A "Choose ..." button and a text input field with the placeholder "Choose where you want the results to be saved..."
- Create New:** A button at the bottom right of the Project section.

**Filtering Section:**

- Notch Filter:** Two radio buttons: "US (60Hz)" and "Europe (50Hz)" (selected).
- High Pass Filter:** A checked checkbox labeled "(Recommended)" and a text input field with the value "1".
- Low Pass Filter:** An unchecked checkbox and a text input field with the value "None".
- Configurations...:** A button at the bottom of the Filtering section.

**Pre-Processing Section:**

- Run:** A button at the top of the Pre-Processing section.
- Manual Rating:** A section containing a "Start Rating" button.
- Interpolation:** A section containing an "Interpolate All" button.



## 1. Create a new project or load an existing project

The screenshot shows a software interface with three main panels: Project, Filtering, and Pre-Processing. The 'Project' panel on the left contains the following fields and controls:

- Select Project:** A dropdown menu with 'Create New Project...' selected.
- Project Name:** A text input field with the placeholder 'Type the name of your new project...'.
- File Extension (e.g. .raw, .dat):** An empty text input field.
- EEG System:** Two radio buttons, 'EGI (HCGSN)' (selected) and 'Other...'.
- Channel location file:** A 'Choose ...' button and an empty text input field.
- Channel location file type:** A text input field with the placeholder 'e.g. stp' and a note 'space separated indices, e.g. 1 32 8 14 17 21 25 125 126 127 128'.
- EOG channels:** A checked checkbox and an empty text input field.
- Downsampling Rate:** A dropdown menu with '2' selected.
- Data Folder:** A 'Choose ...' button and a text input field with the placeholder 'Choose where your raw data is...'.
- Project Folder:** A 'Choose ...' button and a text input field with the placeholder 'Choose where you want the results to be saved...'.
- Create New:** A button at the bottom right of the panel.

The 'Filtering' panel in the middle contains:

- Notch Filter:** Two radio buttons, 'US (60Hz)' and 'Europe (50Hz)' (selected).
- High Pass Filter:** A checked checkbox labeled '(Recommended)' and a text input field with '1'.
- Low Pass Filter:** An unchecked checkbox and a text input field with 'None'.
- Configurations...:** A button at the bottom.

The 'Pre-Processing' panel on the right contains three buttons: 'Run', 'Start Rating', and 'Interpolate All'.

## 1b. Specify your data (super easy with EGI data)

This screenshot is identical to the one above, showing the same software interface. The 'Project' panel on the left contains the same fields and controls as described in the previous block. The 'Filtering' panel in the middle contains the same controls, but with 'Europe (50Hz)' selected for the Notch Filter. The 'Pre-Processing' panel on the right contains the same buttons: 'Run', 'Start Rating', and 'Interpolate All'.

Let's quickly look at the configurations if  
you don't have EEG data recorded with  
an EGI system

... other data formats need a bit more work

(yes, the EEG world needs a similar approach as BIDS (Gorgolewski), maybe the ESS-format)

The screenshot shows the 'Project' configuration window in MNE-Python. A red circle highlights the 'File Extension' and 'EEG System' fields. Two callout boxes provide instructions:

- Box 1: "1. Specify the file extension of your EEG data" points to the 'File Extension' field.
- Box 2: "2. Click here if you don't have EEG data recorded with an EGI system" points to the 'Other...' radio button under 'EEG System'.

The window includes various configuration options such as 'Channel location file', 'Channel location file type', 'EOG channels', 'Downsampling Rate', 'Data Folder', and 'Project Folder'. It also features sections for 'Filtering' (Notch Filter, Low Pass Filter) and 'Pre-Processing' (Run, Start Rating, Interpolate All).

## ... Specifying the electrodes location file (only if you don't have EGI data)

The screenshot shows the 'Project' tab of a software interface. The 'Channel location file' field is highlighted with a callout box that says: 'select, where the electrodes coordinate file is located. (Cartesian, Spherical or Polar information needed)'. The 'Channel location file type' field is also highlighted with a callout box that says: 'e.g. sfp'. The 'EOG channels' field is checked. The 'Filtering' section shows 'Notch Filter' set to 'Europe (50Hz)' and 'High Pass Filter' set to '(Recommended)'. The 'Pre-Processing' section has a 'Run' button. The 'Manual Rating' section has a 'Start Rating' button. The 'Interpolation' section has an 'Interpolate All' button. The 'Project' section has a 'Create New Project...' button. The 'Project Name' field is 'Type the name of your new project...'. The 'File Extension' field is empty. The 'EOG System' is set to 'Other...'. The 'Downsampling Rate' is set to '2'. The 'Data Folder' and 'Project Folder' fields are 'Choose ...'. The 'Create New' button is at the bottom.

## ... Specifying the EOG channels (only if you don't have EGI data)

The screenshot shows the 'Project' tab of a software interface. The 'EOG channels' field is checked and highlighted with a callout box that says: 'Automatic needs to know the EOG electrodes, to regress out the eye artifacts (EOG regression is optional)'. The 'Channel location file' field is 'Choose ...'. The 'Channel location file type' field is 'e.g. sfp'. The 'EOG channels' field is checked. The 'Filtering' section shows 'Notch Filter' set to 'Europe (50Hz)' and 'High Pass Filter' set to '(Recommended)'. The 'Pre-Processing' section has a 'Run' button. The 'Manual Rating' section has a 'Start Rating' button. The 'Interpolation' section has an 'Interpolate All' button. The 'Project' section has a 'Create New Project...' button. The 'Project Name' field is 'Type the name of your new project...'. The 'File Extension' field is empty. The 'EOG System' is set to 'Other...'. The 'Downsampling Rate' is set to '2'. The 'Data Folder' and 'Project Folder' fields are 'Choose ...'. The 'Create New' button is at the bottom.

Let's assume we have EEG data  
recorded with an EGI system  
(see example data)

We're using the example data on github...

The screenshot shows a software interface for EEG data processing, organized into several panels. The 'Project' panel on the left contains fields for 'Select Project' (with a 'Create New Project...' button), 'Project Name' (filled with 'Brainhack'), 'File Extension' (set to '.raw'), 'EEG System' (with radio buttons for 'EGI (HCGSN)' and 'Other...'), 'Channel location file' (with a 'Choose ...' button), 'Channel location file type' (with a dropdown showing 'e.g. .sp'), 'EOG channels' (with a checked checkbox), 'Downsampling Rate' (set to '2'), 'Data Folder' (with a 'Choose ...' button), and 'Project Folder' (with a 'Choose ...' button). A 'Create New' button is at the bottom of this panel. The 'Filtering' panel in the center-right has sections for 'Notch Filter' (with radio buttons for 'US (60Hz)' and 'Europe (50Hz)'), 'High Pass Filter', and 'Low Pass Filter' (with a 'None' button). A 'Configurations...' button is below the filtering options. The right side of the interface has three stacked panels: 'Pre-Processing' with a 'Run' button, 'Manual Rating' with a 'Start Rating' button, and 'Interpolation' with an 'Interpolate All' button. A callout box with the text 'EEG data recorded with EGI' has two arrows pointing to the 'EGI (HCGSN)' radio button and the 'File Extension' field.

## ... Specifying downsampling rate (just for visualization)

The screenshot shows the 'Project' tab of the Brainhack interface. The 'Downsampling Rate' is set to 2. A callout box points to this field with the text: 'Downsample your data, it's just for visualization...'. Other visible settings include Project Name 'Brainhack', File Extension '.raw', EEG System 'EGI (HCGSN)', and various filtering options in the 'Filtering' section.

Project

Select Project

Project Name

File Extension (e.g., .raw, .dat)

EEG System ☒ EGI (HCGSN) ☐ Other...

Channel location file

Channel location file type

EOG channels ☒

Downsampling Rate

Data Folder  Choose where your raw data is...

Project Folder  Choose where you want the results to be saved...

Filtering

Notch Filter ☐ US (60Hz) ☒ Europe (50Hz)

High Pass Filter ☒ (Recommended)

Low Pass Filter ☐

Pre-Processing

Manual Rating

Interpolation

## ... Specifying the path to the data

This screenshot is identical to the one above, but the callout box points to the 'Data Folder' field with the text: 'Where are your data located?'. The 'Downsampling Rate' is still set to 2.

Project

Select Project

Project Name

File Extension (e.g., .raw, .dat)

EEG System ☒ EGI (HCGSN) ☐ Other...

Channel location file

Channel location file type

EOG channels ☒

Downsampling Rate

Data Folder  Choose where your raw data is...

Project Folder  Choose where you want the results to be saved...

Filtering

Notch Filter ☐ US (60Hz) ☒ Europe (50Hz)

High Pass Filter ☒ (Recommended)

Low Pass Filter ☐

Pre-Processing

Manual Rating

Interpolation

## ... Specifying the path of the output

The screenshot shows the 'Project' tab of the Brainhack software. The 'Project Name' is 'Brainhack' and the 'File Extension' is '.raw'. The 'EEG System' is 'EGI (HCGSN)'. The 'Channel location file' is empty. The 'Channel location file type' is 'eg. stp'. The 'EOG channels' are checked. The 'Downsampling Rate' is '2'. The 'Data Folder' is '/Volumes/methlab/Brainhack/'. The 'Project Folder' is '/Volumes/methlab/Brainhack\_Brainhack\_results/'. The 'Filtering' section shows 'Notch Filter' set to 'Europe (50Hz)', 'High Pass Filter' set to '(Recommended)' with a value of '1', and 'Low Pass Filter' set to 'None'. The 'Pre-Processing' section has buttons for 'Run', 'Start Rating', and 'Interpolate All'. A callout box points to the 'Data Folder' and 'Project Folder' fields, asking 'Where should the output of the pre-processing be saved? Automagic makes a suggestion'. A red circle highlights the '3 subjects...' and '6 files...' options in the 'Configurations...' dropdown.

Project

Select Project: Create New Project...

Project Name: Brainhack

File Extension (e.g. .raw, .dat): .raw

EEG System: ☒ EGI (HCGSN) ☐ Other...

Channel location file: Choose...

Channel location file type: eg. stp

EOG channels: ☒ space separated indices, e.g.

Downsampling Rate: 2

Data Folder: Choose... /Volumes/methlab/Brainhack/

Project Folder: Choose... /Volumes/methlab/Brainhack\_Brainhack\_results/

Create New

Filtering

Notch Filter: ☐ US (60Hz) ☒ Europe (50Hz)

High Pass Filter: ☒ (Recommended) 1

Low Pass Filter: ☐ None

Configurations...

Pre-Processing

Run

Manual Rating

Start Rating

Interpolation

Interpolate All

Where should the output of the pre-processing be saved? Automagic makes a suggestion

3 subjects... 6 files...

## ... Specifying the notch filter

The screenshot shows the 'Project' tab of the Brainhack software. The 'Project Name' is 'Brainhack' and the 'File Extension' is '.raw'. The 'EEG System' is 'EGI (HCGSN)'. The 'Channel location file' is empty. The 'Channel location file type' is 'eg. stp'. The 'EOG channels' are checked. The 'Downsampling Rate' is '2'. The 'Data Folder' is '/Volumes/methlab/Brainhack/'. The 'Project Folder' is '/Volumes/methlab/Brainhack\_Brainhack\_results/'. The 'Filtering' section shows 'Notch Filter' set to 'Europe (50Hz)', 'High Pass Filter' set to '(Recommended)' with a value of '1', and 'Low Pass Filter' set to 'None'. The 'Pre-Processing' section has buttons for 'Run', 'Start Rating', and 'Interpolate All'. A callout box points to the 'Notch Filter' section, asking 'Have you recorded the data in the US or in Europe?'. A red circle highlights the '3 subjects...' and '6 files...' options in the 'Configurations...' dropdown.

Project

Select Project: Create New Project...

Project Name: Brainhack

File Extension (e.g. .raw, .dat): .raw

EEG System: ☒ EGI (HCGSN) ☐ Other...

Channel location file: Choose...

Channel location file type: eg. stp

EOG channels: ☒ space separated indices, e.g. 1 32 8 14 17 21 25 126 127 128

Downsampling Rate: 2

Data Folder: Choose... /Volumes/methlab/Brainhack/

Project Folder: Choose... /Volumes/methlab/Brainhack\_Brainhack\_results/

Create New

Filtering

Notch Filter: ☐ US (60Hz) ☒ Europe (50Hz)

High Pass Filter: ☒ (Recommended) 1

Low Pass Filter: ☐ None

Configurations...

Pre-Processing

Run

Manual Rating

Start Rating

Interpolation

Interpolate All

Have you recorded the data in the US or in Europe?

3 subjects... 6 files...

## ... Specifying the high pass filter

The screenshot shows the 'Project' and 'Pre-Processing' sections of the software. The 'Project' section includes fields for 'Select Project' (Create New Project...), 'Project Name' (Brainhack), 'File Extension' (.raw), 'EEG System' (EGI (HCGSN)), 'Channel location file', 'Channel location file type', 'EOG channels' (checked), 'Downsampling Rate' (2), 'Data Folder' (/Volumes/methlab/Brainhack/), and 'Project Folder' (/Volumes/methlab/Brainhack\_Brainhack\_results/). The 'Pre-Processing' section includes 'Run', 'Start Rating', and 'Interpolate All' buttons. The 'Filtering' section is highlighted, showing 'Notch Filter' (US (60Hz) and Europe (50Hz)), 'High Pass Filter' (checked (Recommended) with a value of 1), and 'Low Pass Filter' (None). A callout box points to the 'High Pass Filter' section with the text 'Select you're high pass filter (optional low pass filter)'.

## ... More options available

The screenshot shows the same software interface as the previous one, but with a callout box pointing to the 'Configurations...' button in the 'Filtering' section. The callout box contains the text 'More options...'. The 'Filtering' section shows the same settings as before, but the 'Configurations...' button is highlighted.

Settings

☒ Reduce number of channels (only applicable for EGI)

Filtering:

High pass order: Default

Low pass order: [ ]

Channel rejection criterias:

☒ Kurtosis

Threshold: 3

☒ Probability

Threshold: 4

☒ Spectrum

Threshold: 4

☐ ICA

☒ PCA

lambda: Default

tolerance: 1e-07

maxIter: 1000

Interpolation: spherical

Set back to defaults

Cancel

OK

Some of the EGI electrodes are rather measuring muscle activity than brain activity . We exclude those electrodes (see for e.g. Langer et al., 2016)

Define the filter order...

Select the number of standard deviation to define an outlier

Choose between ICA and PCA (default).

parameters of PCA (see inexact\_alm\_rpca.m)

Choose your preferred interpolation method

... Press the „Create New“ button  
(Automagic will tell you, if you have specified everything correctly)

Project

Select Project: Create New Project...

Project Name: Brainhack

File Extension (e.g. .raw, .dat): .raw

EEG System: ☒ EGI (HCGSN) ☐ Other...

Channel location file: Choose ...

Channel location file type: eg. stp

EOG channels: ☒

Downsampling Rate: 2

Data Folder: Choose ... /Volumes/methlab/Brainhack/

Project Folder: Choose ... /Volumes/methlab/Brainhack\_Brainhack\_results/

Filtering

Notch Filter: ☐ US (60Hz) ☒ Europe (50Hz)

High Pass Filter: ☒ (Recommended) 1

Low Pass Filter: ☐ None

Configurations...

Pre-Processing

Run

Manual Rating

Start Rating

Interpolation

Interpolate All

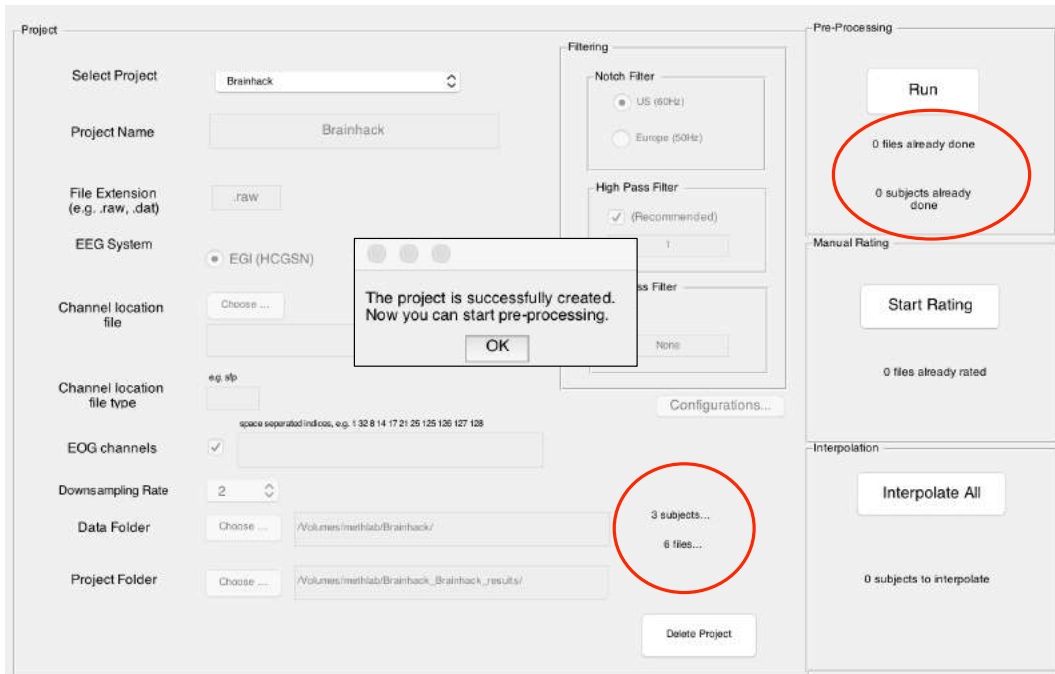
3 subjects... 6 files

Ready??

Create New

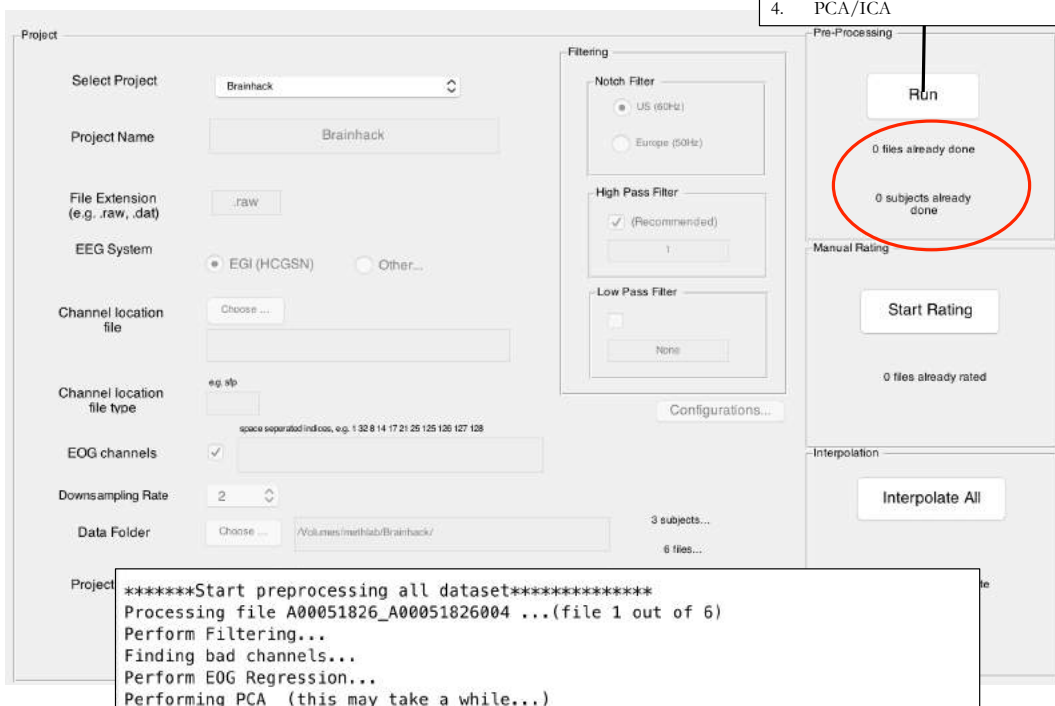


... Automagic will show you, how many subjects and files were found



## 2. Let's start the pre-processing

- Run pre-processing
1. Filter
  2. Automated bad channel detection
  3. EOG regression
  4. PCA/ICA



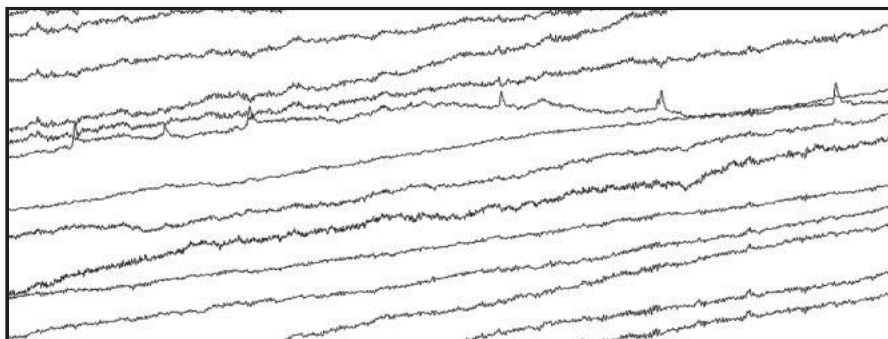
# FILTERING

pop\_eegfiltnew.m (EEGLAB)

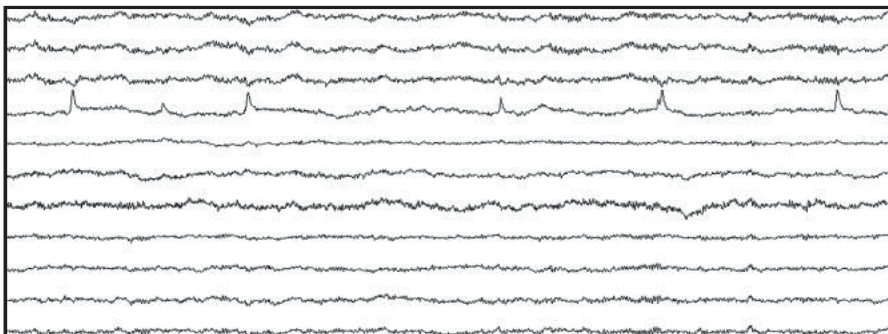
## Filtering

High-pass filter: Remove low frequencies

EEG,  
Unfiltered

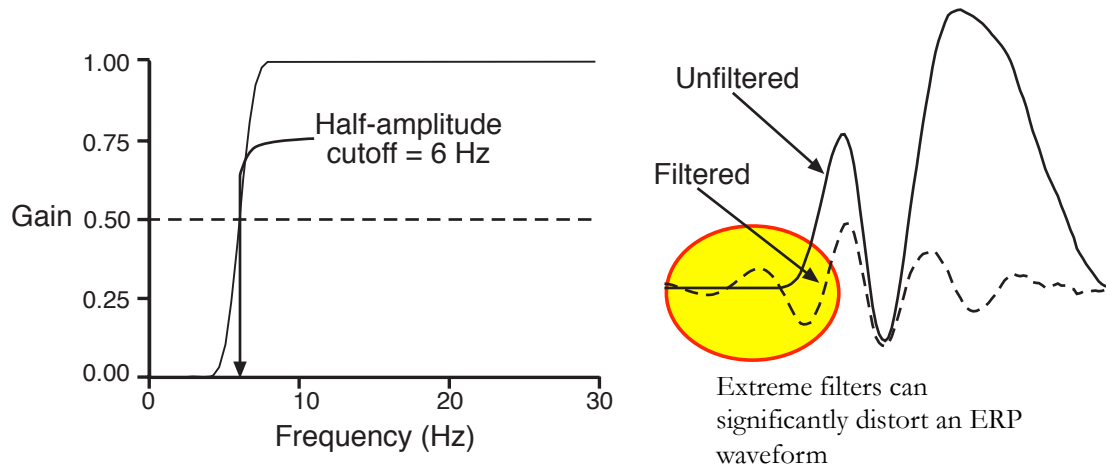


EEG,  
Filtered @ 0.1  
Hz



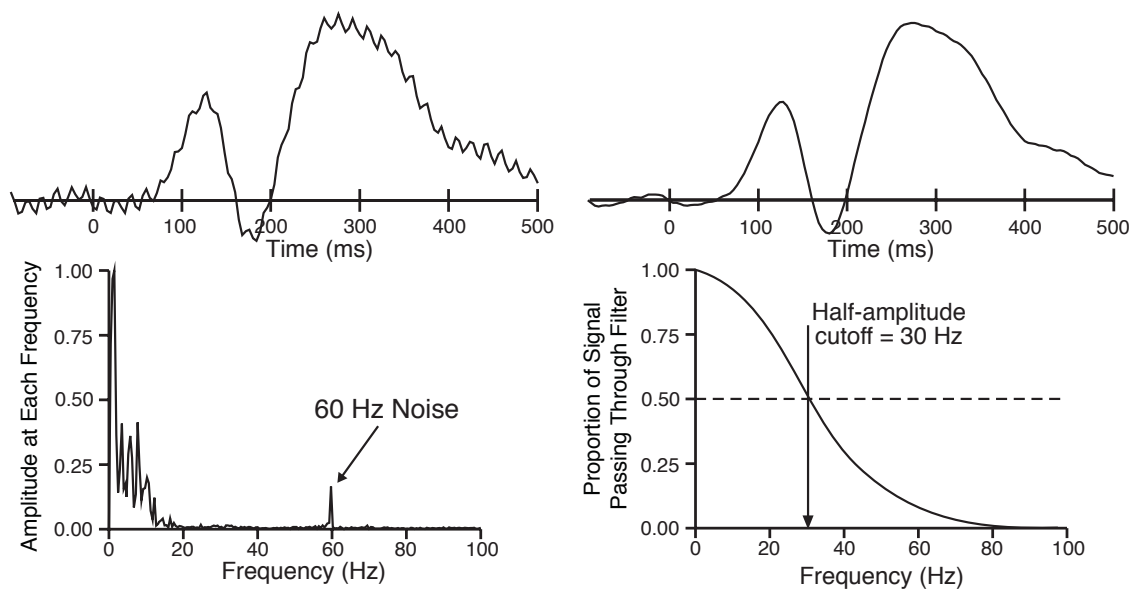
# Filtering

High-pass filter: Remove low frequencies



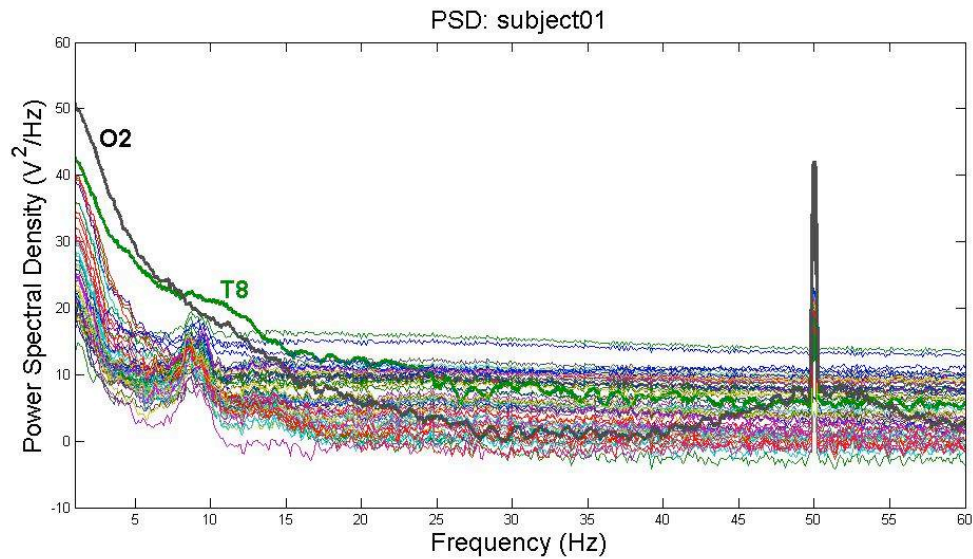
# Filtering

Low-pass filter: Remove high frequencies



# Filtering

Notch filter: removes power line artifacts (50/60 Hz)



## BAD CHANNEL DETECTION

pop\_rejchan.m (EEGLAB)

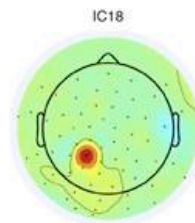
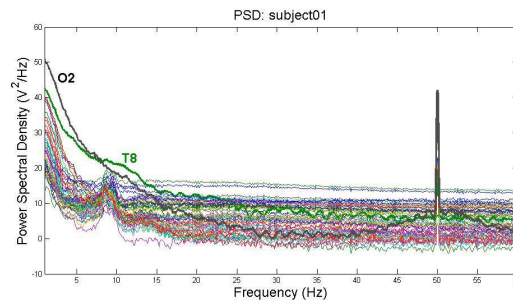
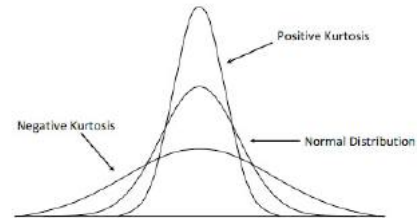
# Noisy Electrodes

Noisy electrodes are defined as statistical outliers (e.g.  $> 3$  STD) based on:

Probability

Kurtosis (Verteilung der Daten)

(Frequency) Spectrum



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# EOG Regression

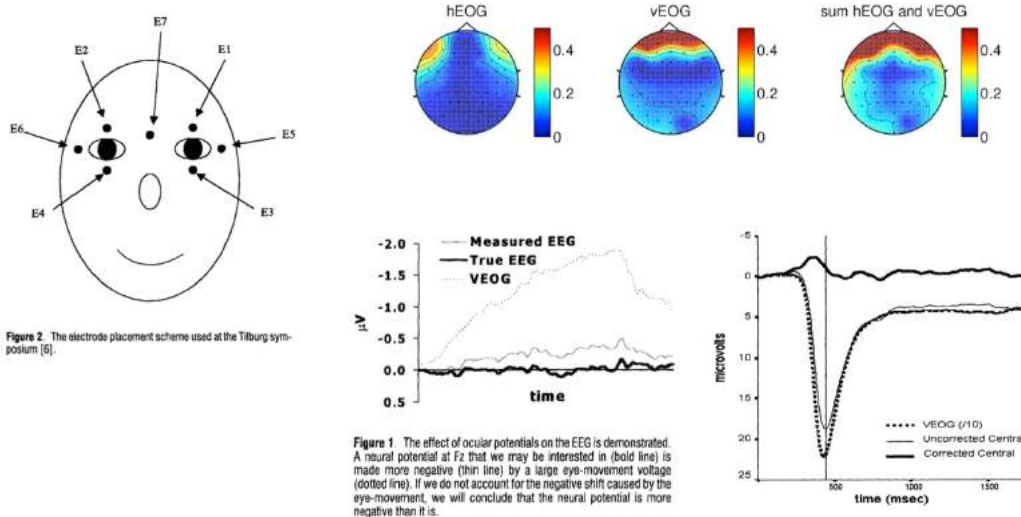
Parra, L.C., Spence, C.D., Gerson, A.D., Sajda, P. (2005). Recipes for the linear analysis of EEG. *Neuroimage*, (28): 326-341.

# EOG Regression

Electrooculography (EOG)

- Goal: Estimate contribution of EOG artifact at each EEG channel and subtract it
- Problem: Signal at EOG electrodes contains non-artifact activity as well as artifact activity
  - The first technique (Gratton et al., 1983) “overcorrects” and distorts the scalp distribution of the ERP components
- The best approaches use more sophisticated ways of estimating the actual ocular activity
  - EOG Regression (Parra et al., 2005)

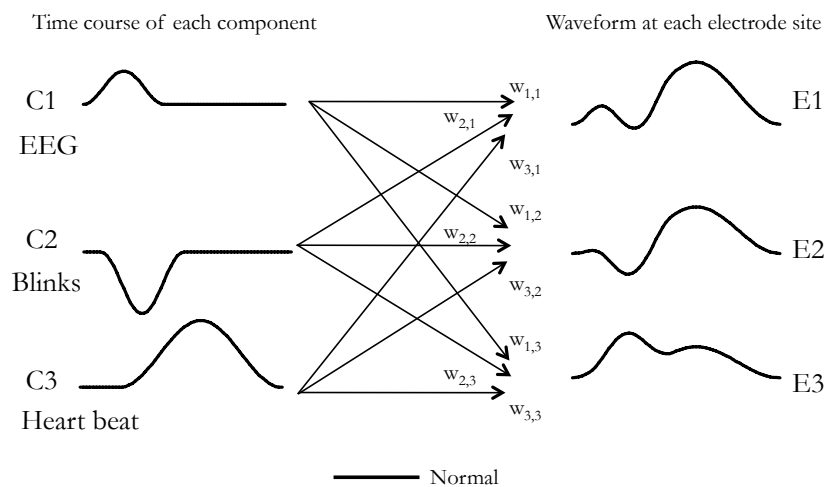
## EOG regression



# Independent Component Analysis (ICA)

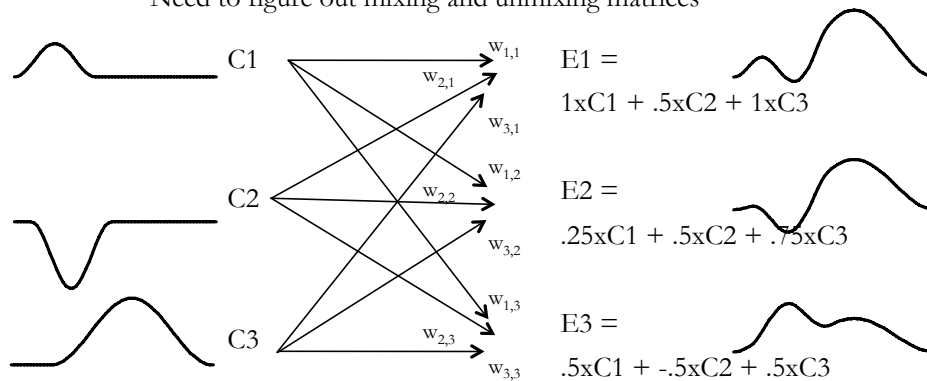
Winkler I., Haufe S., Tangermann, M. (2011). Automatic Classification of Artifactual ICA-Components for Artifact Removal in EEG Signals. *Behavioral and Brain Functions*, 7:30.

## General Logic



# Mixing and Unmixing

Need to figure out mixing and unmixing matrices

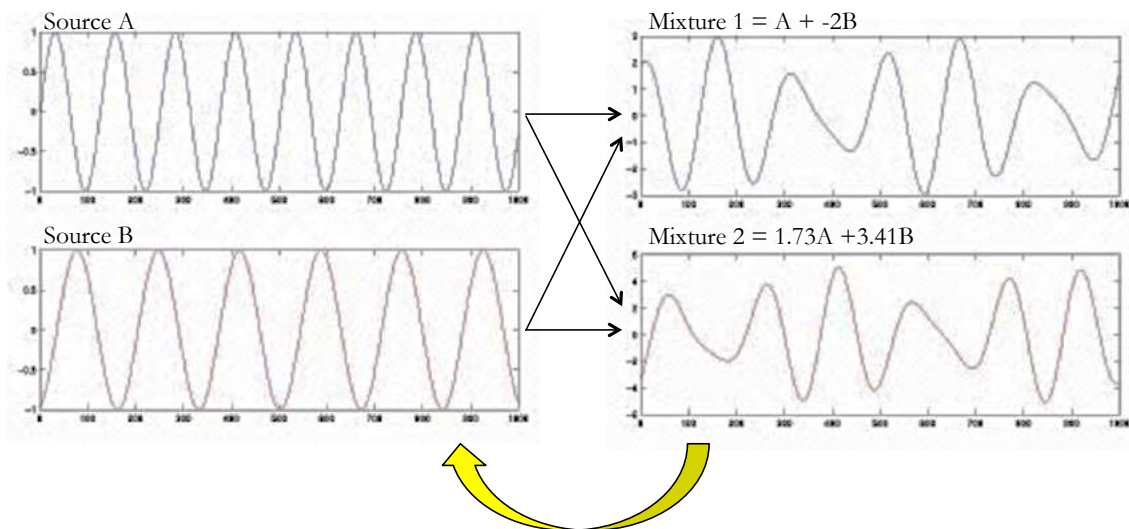


$w_{i,j}$  = weight from component  $i$  to Electrode  $j$   
 $w_i$  = scalp distribution of component  $i$

Mixing  
Matrix

	Component 1	Component 2	Component 3
Electrode 1	1	0.5	1
Electrode 2	0.25	0.5	0.75
Electrode 3	0.5	-0.5	0.5

# Mixing and Unmixing



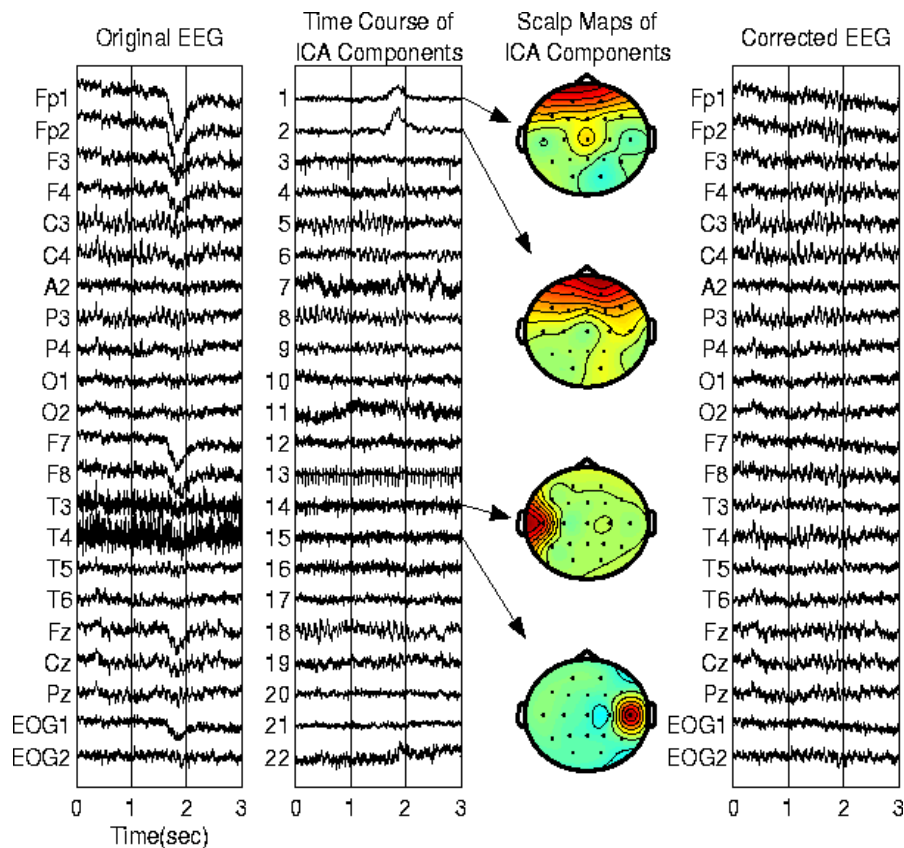
Goal of ICA- Figure out an “unmixing” matrix that will allow us to recover the time courses of the sources from the observed mixtures

Blind Source Separation- No assumptions about the sources except that (a) they are independent, and (b) # of sources = # of mixtures

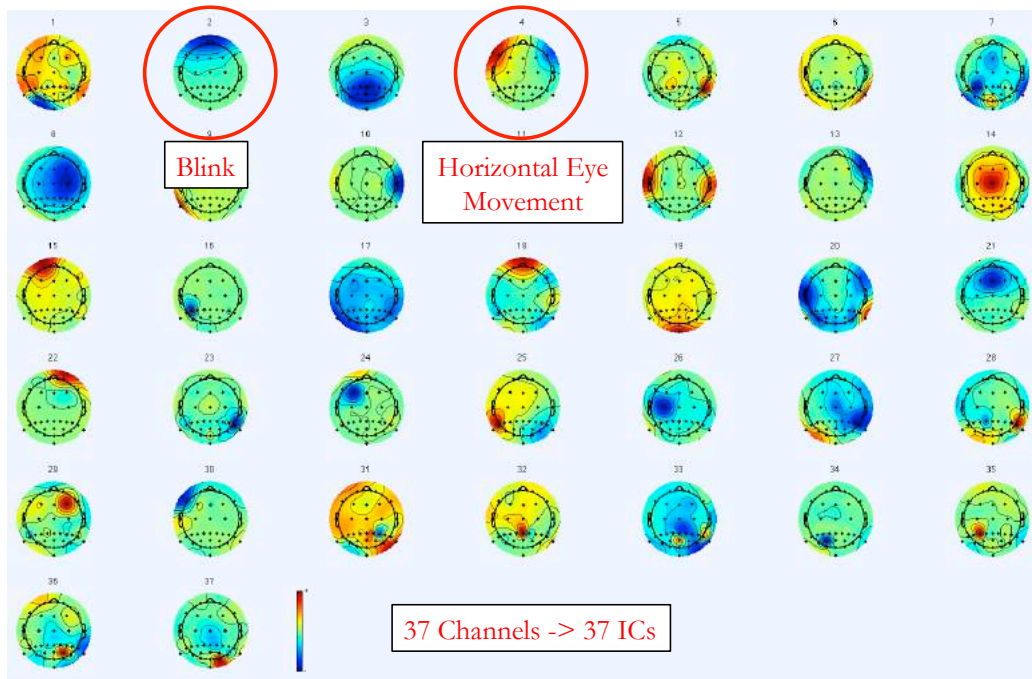


# Artifact Correction with ICA

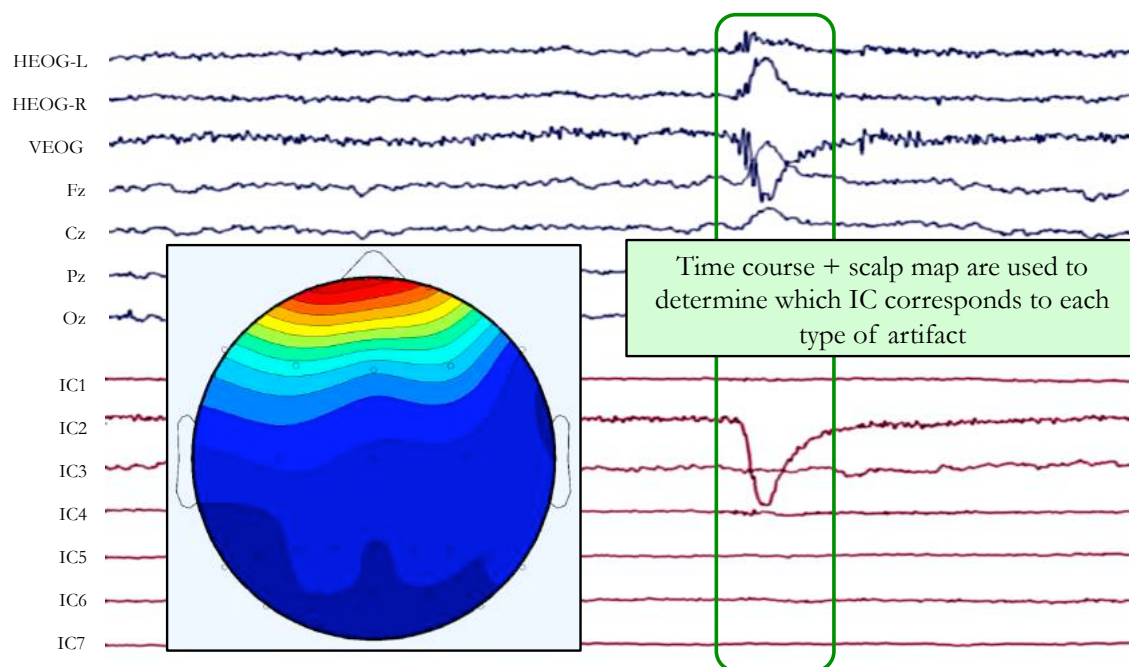
- In most (but not all) cases, artifacts will have a fixed scalp distribution and will be statistically independent of brain activity of interest.
  - Examples: Blinks, line noise
- To remove artifact, data are reconstructed by simply adding together the non-artifact components



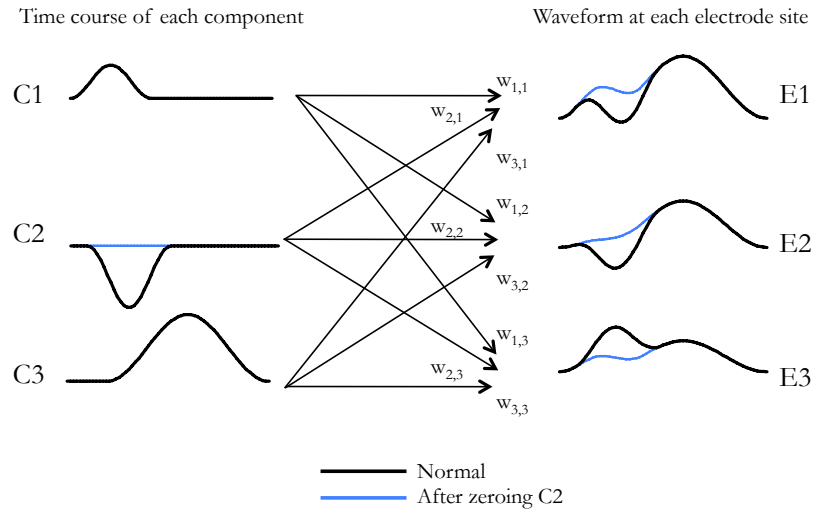
# ICA Component Maps



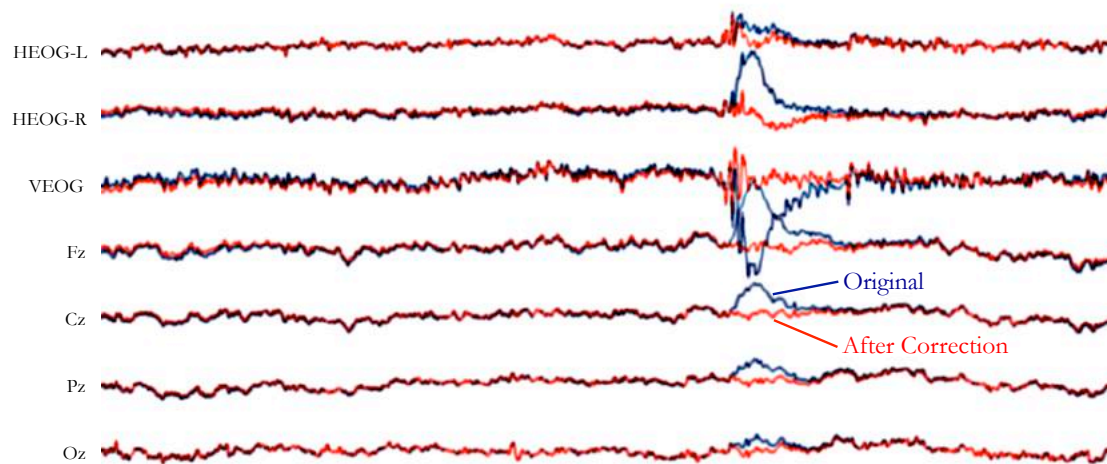
## Single-Trial Time Course



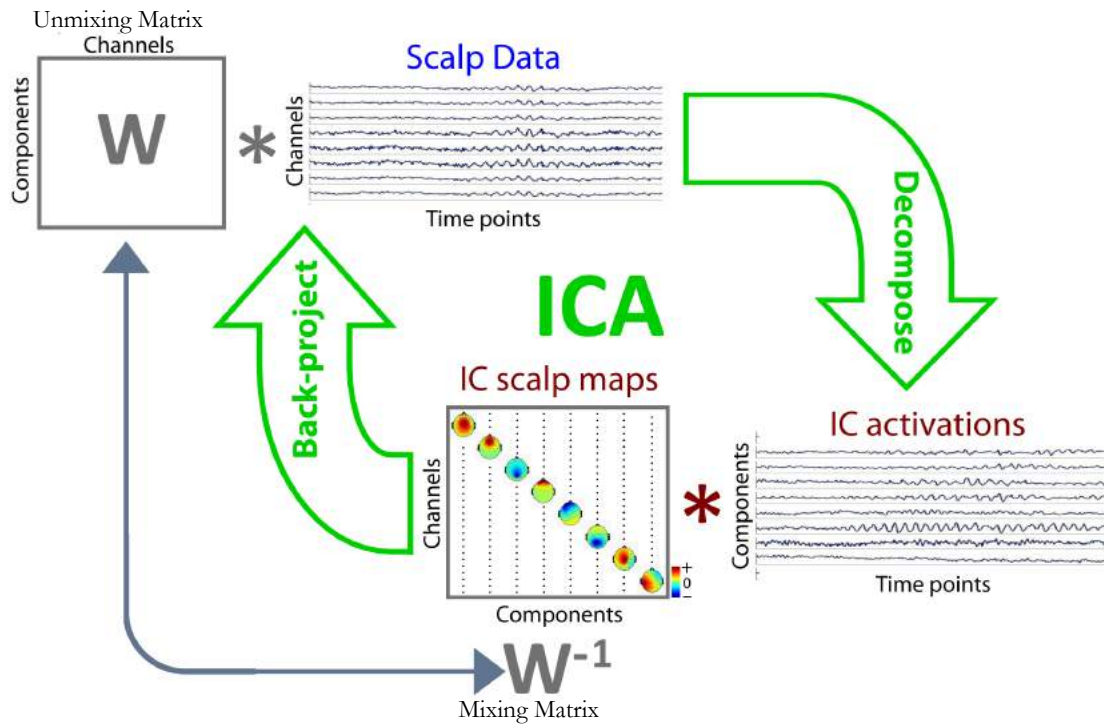
# General Logic



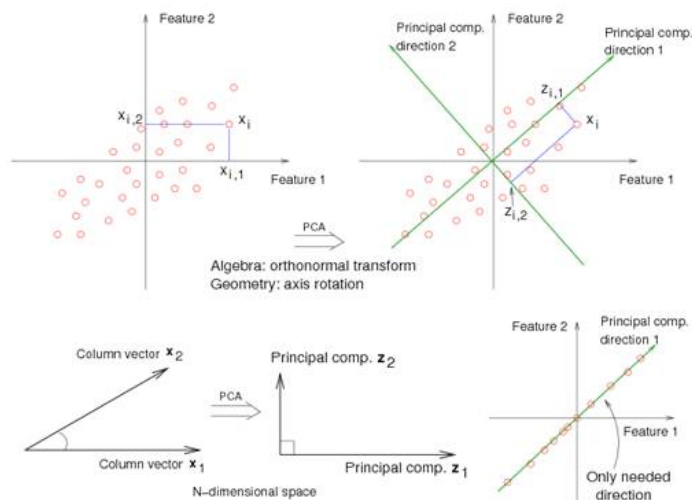
## Single Trial After Correction



# ICA Flow



# Modified PCA



Lin Z., Chen M., Ma Y. (2010). The Augmented Lagrange Multiplier Method for Exact Recovery of Corrupted Low-Rank Matrices. arXiv:10095055.

# BACK TO AUTOMAGIC...

## Pre-processing with Automagic

### Filtering

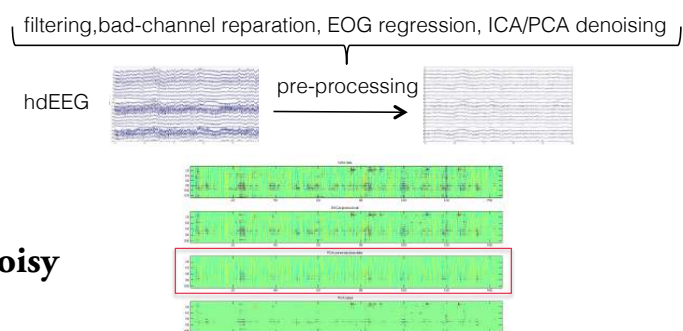
- Highpass-filter (~1Hz)
- Optional lowpass-filter
- Notch-filter (50/60Hz)

### Detect and interpolate noisy electrodes

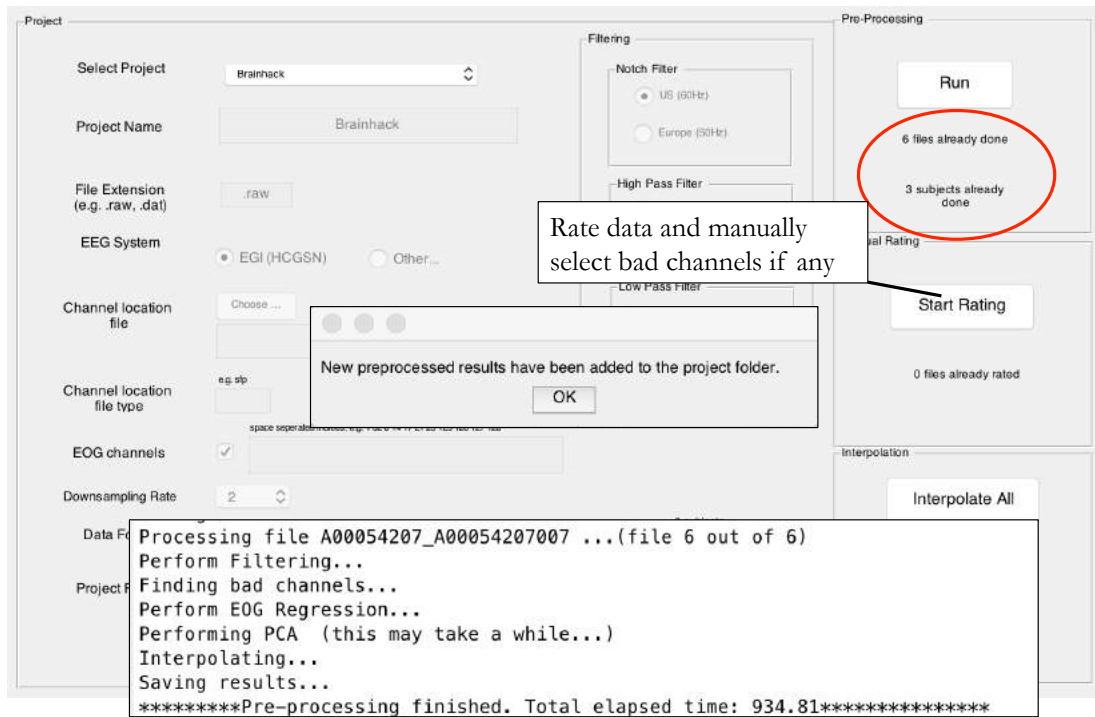
### Regress out eye-artifacts

### ICA or PCA

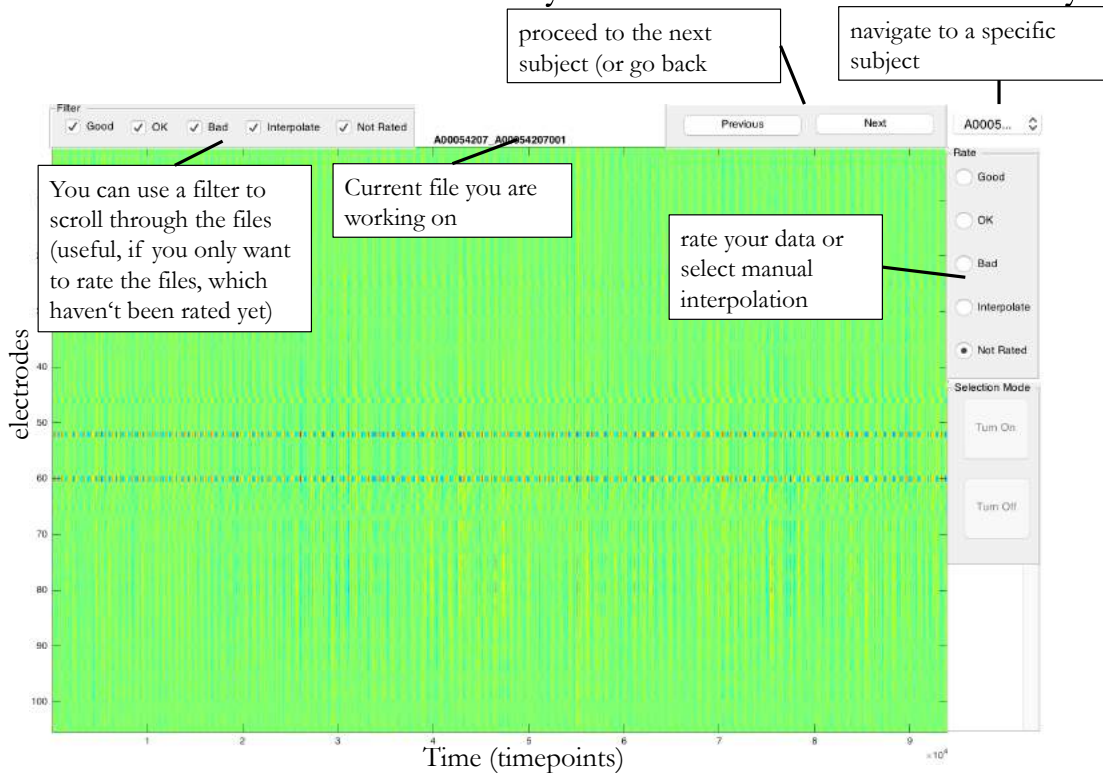
### Visual inspection and rating of data quality



### 3. Rate data and manually select bad channels if any

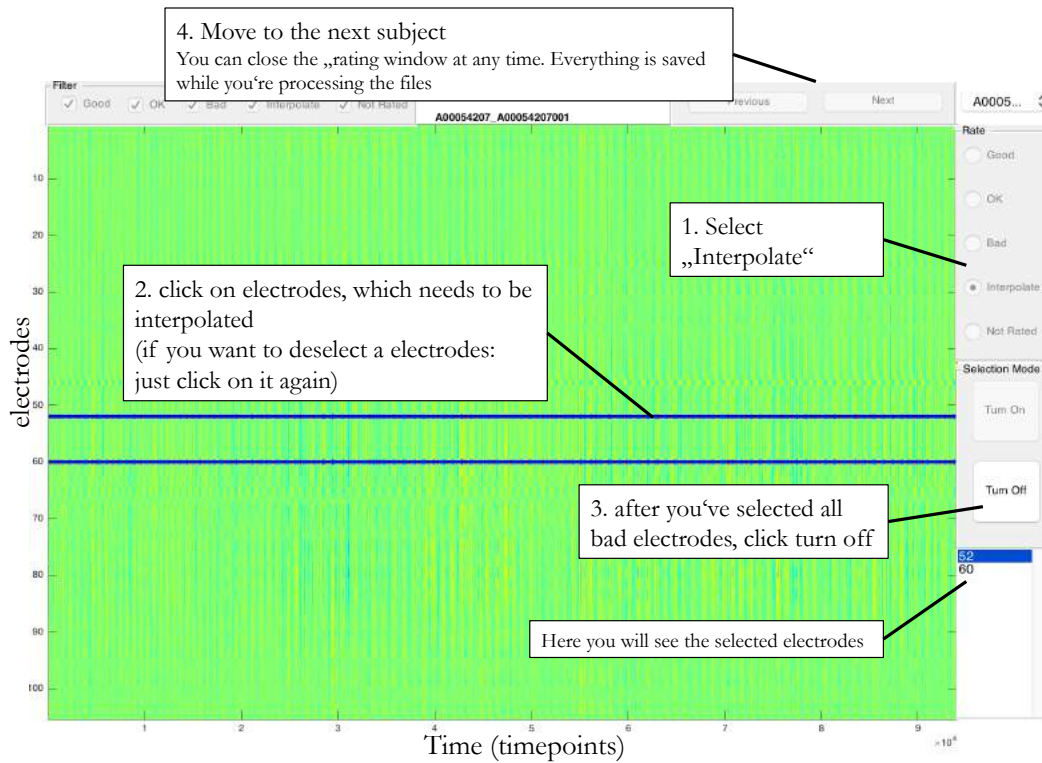


### 3. Rate data and manually select bad channels if any





### 3. Manually select bad electrodes



### 4. Interpolate all bad channels

Project

Select Project: Brainhack\_1hz

Project Name: Brainhack\_1hz

File Extension (e.g. .raw, .dat): .raw

EEG System: ☒ EGI (HCGSN) ☐ Other...

Channel location file: Choose...

Channel location file type: e.g. stp

EOG channels: ☒

Downsampling Rate: 2

Data Folder: Choose...

Project Folder: Choose...

Filtering

Notch Filter: ☒ US (60Hz) ☐ Europe (50Hz)

High Pass Filter: ☒ (Recommended)

Low Pass Filter: ☐ None

Pre-Processing

Run

6 files already done

3 subjects already done

Manual Rating

Start Rating

6 files already rated

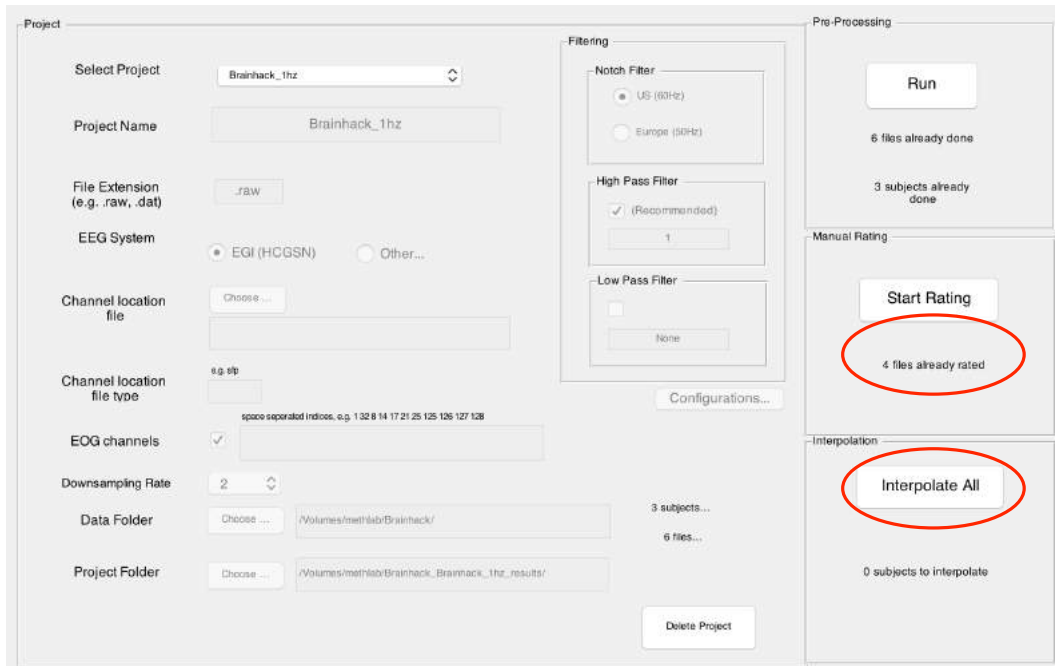
Interpolate All

2 subjects to interpolate

Click here to interpolate the bad electrodes

```
*****Start Interpolation*****
Processing file A00054207_A00054207001 ...(file 1 out of 2)
Removing 2 channel(s)...
Interpolating missing channels...
Processing file A00054207_A00054207003 ...(file 2 out of 2)
Removing 2 channel(s)...
Interpolating missing channels...
Interpolation finished. Total elapsed time: 11.38
>>
```

5. Repeat steps 3 and 4 until all data is rated



## Pre-processing with Automagic

### Filtering

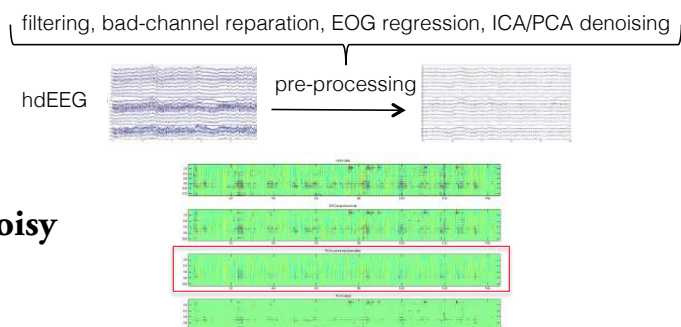
- Highpass-filter (~1Hz)
- Notch-filter (50Hz)

### Detect and interpolate noisy electrodes

### Regress out eye-artifacts

### ICA or PCA

### Visual inspection and rating of data quality





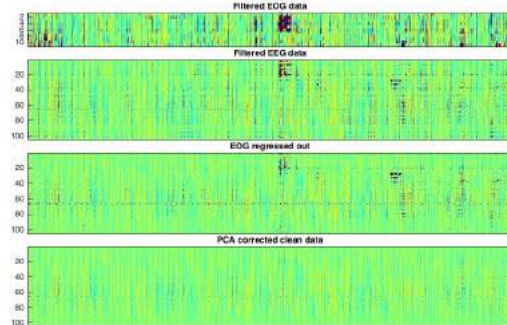
# OUTPUT of Automagic

- What's in the „Results“ folder:



Automagic creates for each EEG file 3 output files:

- Data quality image (.jpg)
- **The final (clean) pre-processed file (.mat)**
- The downsampled raw file (reduced2\_xxx.mat)



There's also a „*project\_state.mat*“ file in the results folder. You can ignore that, but don't delete it.

# OUTPUT of Automagic

The final (clean) pre-processed file: **nomenclature**

**g**ip\_subject1\_file1.mat

First letter indicates quality of the data:

g = good  
o = okay  
b = bad  
n = not rated (yet)

**gip**\_subject1\_file1.mat

An „i“ indicates that some electrodes were interpolated.

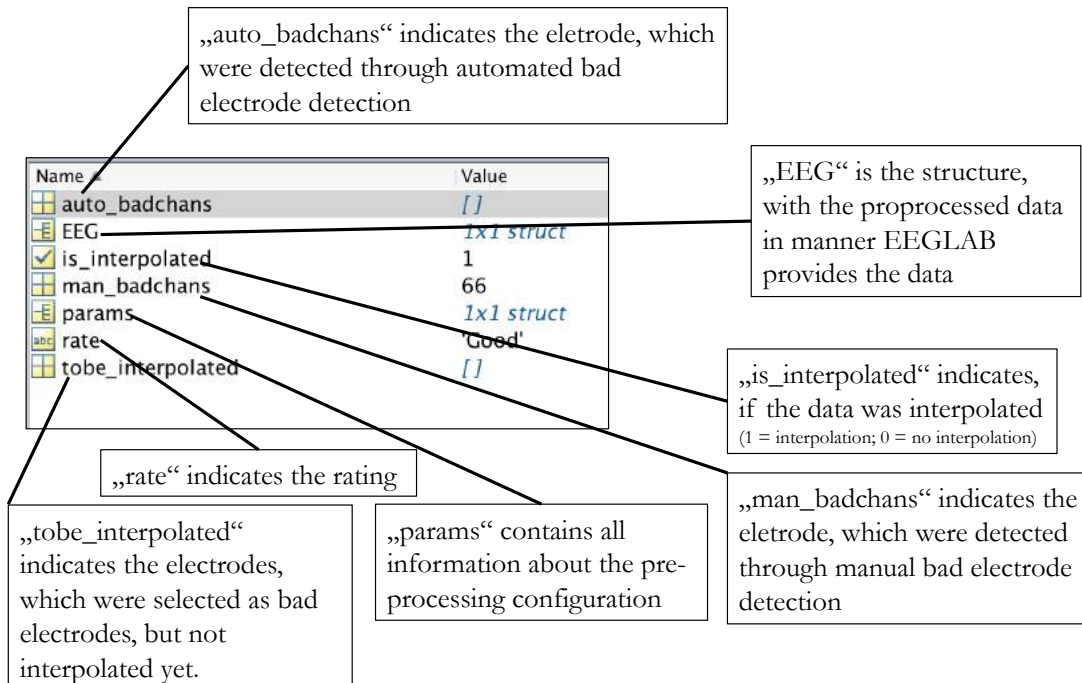
An „p“ indicates that data was pre-processed

**Other possible file names:**

gp\_subject1\_file1.mat  
go\_subject1\_file1.mat  
oi\_subject1\_file1.mat  
op\_subject1\_file1.mat  
bi\_subject1\_file1.mat  
bp\_subject1\_file1.mat  
np\_subject1\_file1.mat

## OUTPUT of Automagic

The final (clean) pre-processed file contains 7 variables in MATLAB  
(try to load it in MATLAB)

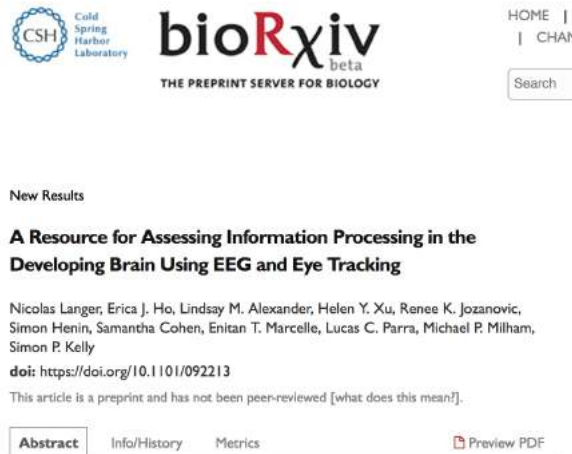


## Do I really need to use the GUI?

- NO! You can use the individual pre-processing files independent from the gui. (see Automagic manual)
- All m-files are in the „preprocessing“ folder

# You need data? Here you go:

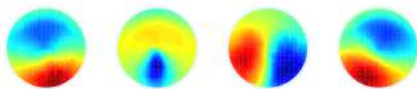
## FREE EEG AND EYE-TRACKING DATA SET



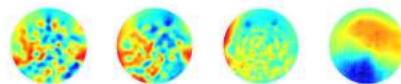
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## Validation

Microstates with Automagic



Microstates without Automagic



# Credentials

„No one can do EEG pre-processing better than I do, except maybe Automagic. It's magic.“ Donald Trump, 2017, Journal of Alternative Facts