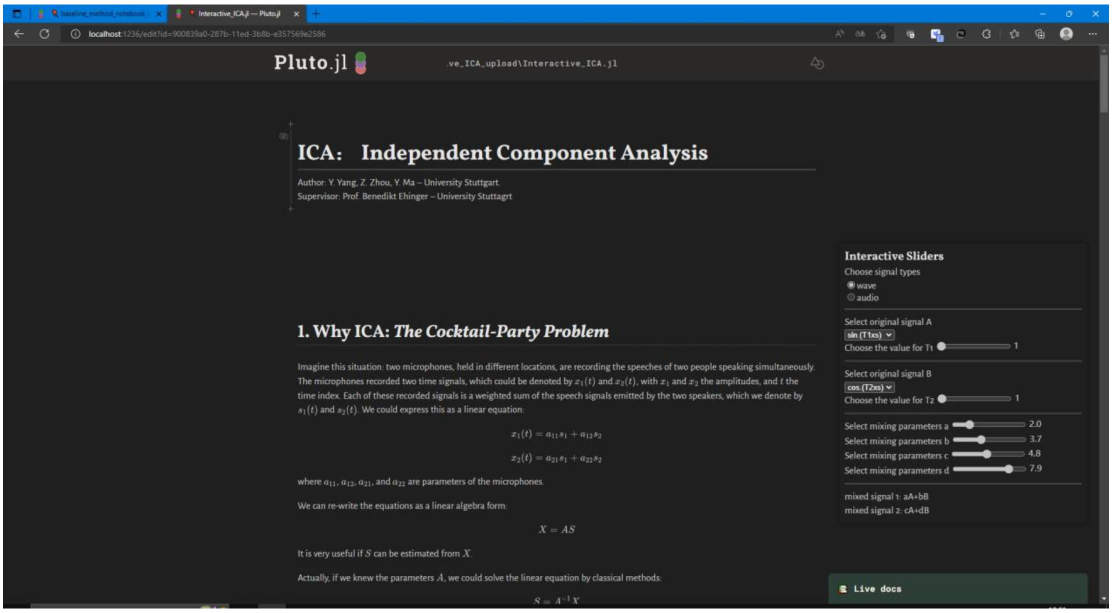
Experiment for EEG lab

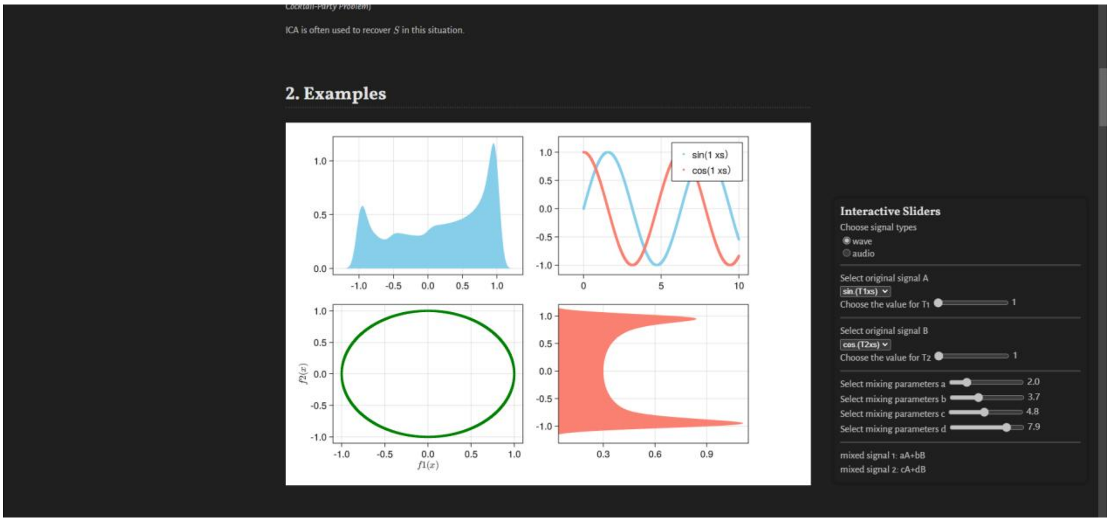
Author: Y. Yang, Z. Zhou, Y. Ma – University Stuttgart.

Supervisor: Prof. Benedikt Ehinger – University Stuttagrt

LAB1： ICA Algorithm

For wave signal





2.3. Arbitrary Case

A more abstract case is to have two unique signals s_1 and s_2 and generate their mixture x by weight-adding:

$$x_1 = s_1 - 2s_2$$

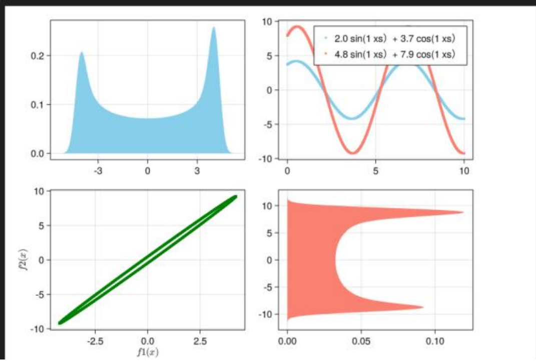
$$x_2 = 1.73s_1 + 3.41s_2$$

To describe the above in a linear algebra matrix: $X = AS$, where:

$$X = [x_1, x_2]^\top$$

$$S = [s_1, s_2]^\top$$

$$A = \begin{bmatrix} 1 & -2 \\ 1.73 & 3.41 \end{bmatrix}$$



Interactive Sliders

Choose signal types

- wave
- audio

Select original signal A: sin (T1xs)

Choose the value for T1: 1

Select original signal B: cos (T2xs)

Choose the value for T2: 1

Select mixing parameters a: 2.0

Select mixing parameters b: 3.7

Select mixing parameters c: 4.8

Select mixing parameters d: 7.9

mixed signal 1: aA+bB

mixed signal 2: cA+dB

Live docs

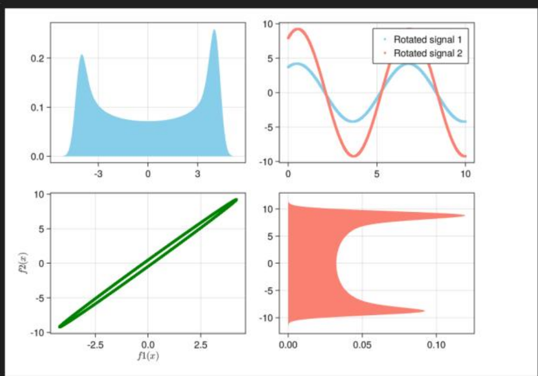
2.4. Signal rotation

In linear algebra, a rotation matrix is a transformation matrix that is used to perform a rotation in Euclidean space. For example, using the convention below, the matrix

$$A = \begin{bmatrix} cos\theta & -sin\theta \\ sin\theta & cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

the rotation angle will be \theta, from 0° to 180°

Select rotation angle 0



Interactive Sliders

Choose signal types

- wave
- audio

Select original signal A: sin (T1xs)

Choose the value for T1: 1

Select original signal B: cos (T2xs)

Choose the value for T2: 1

Select mixing parameters a: 2.0

Select mixing parameters b: 3.7

Select mixing parameters c: 4.8

Select mixing parameters d: 7.9

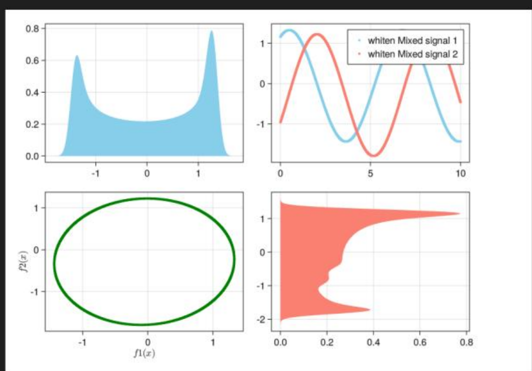
mixed signal 1: aA+bB

mixed signal 2: cA+dB

Live docs

$$\begin{aligned} &= (C^{-\frac{1}{2}}x_m)(C^{-\frac{1}{2}}x_m)^\top \\ &= C^{-\frac{1}{2}}x_m x_m^\top C^{-\frac{1}{2}} \\ &= C^{-\frac{1}{2}}CC^{-\frac{1}{2}} \\ &= I \end{aligned}$$

Thus $x_w = Vx_m = C^{-\frac{1}{2}}x_m$ is the whitened signal.



Interactive Sliders

Choose signal types

- wave
- audio

Select original signal A: sin (T1xs)

Choose the value for T1: 1

Select original signal B: cos (T2xs)

Choose the value for T2: 1

Select mixing parameters a: 2.0

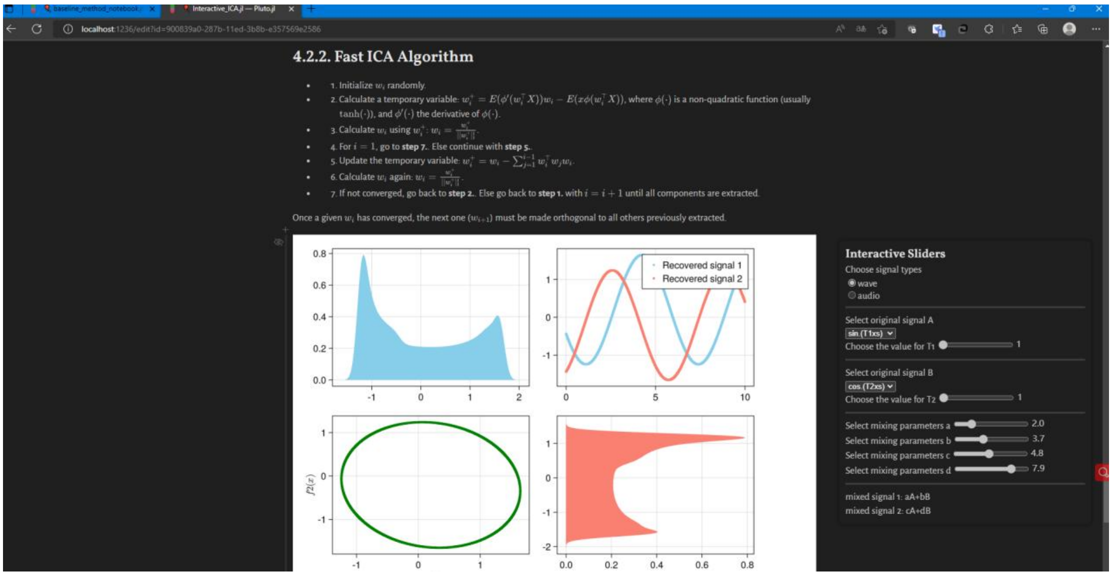
Select mixing parameters b: 3.7

Select mixing parameters c: 4.8

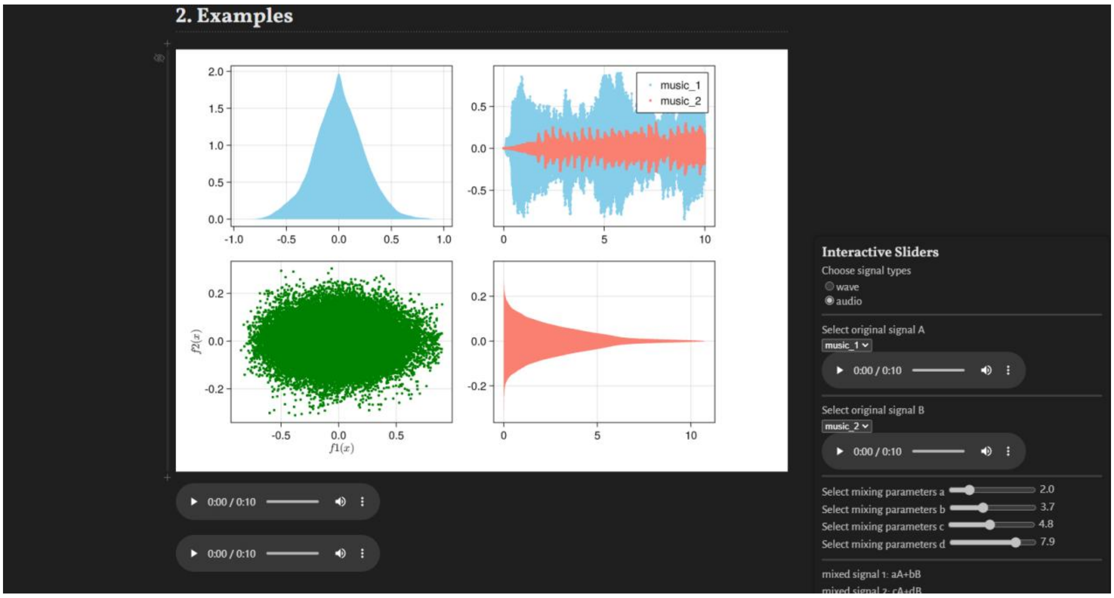
Select mixing parameters d: 7.9

mixed signal 1: aA+bB

mixed signal 2: cA+dB



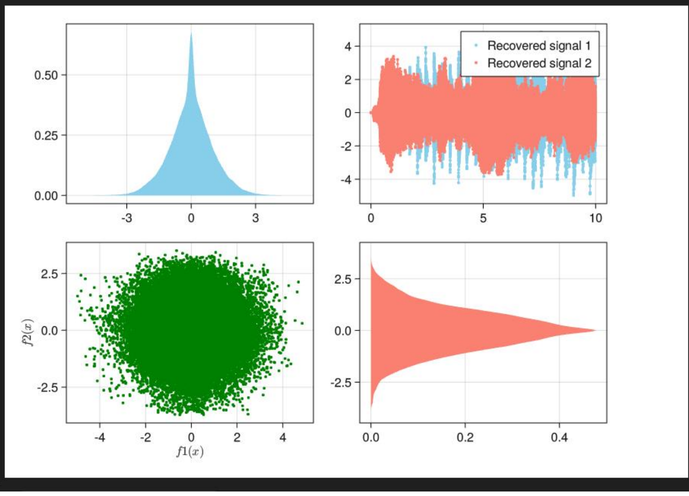
For audio signal



4.2.2. Fast ICA Algorithm

- 1. Initialize w_i randomly.
- 2. Calculate a temporary variable: $w_i^+ = E(\phi'(w_i^\top X))w_i - E(x\phi(w_i^\top X))$, where $\phi(\cdot)$ is a non-quadratic function (usually $\tanh(\cdot)$), and $\phi'(\cdot)$ the derivative of $\phi(\cdot)$.
- 3. Calculate w_i using w_i^+: $w_i = \frac{w_i^+}{||w_i^+||}$.
- 4. For $i = 1$, go to **step 7.**. Else continue with **step 5.**.
- 5. Update the temporary variable: $w_i^+ = w_i - \sum_{j=1}^{i-1} w_i^\top w_j w_i$.
- 6. Calculate w_i again: $w_i = \frac{w_i^+}{||w_i^+||}$.
- 7. If not converged, go back to **step 2.**. Else go back to **step 1.** with $i = i + 1$ until all components are extracted.

Once a given w_i has converged, the next one (w_{i+1}) must be made orthogonal to all others previously extracted.



Interactive Sliders

Choose signal types

○ wave
◉ audio

Select original signal A [music_1]

0:00 / 0:10

Select original signal B [music_2]

0:00 / 0:10

Select mixing parameters a 2.0
Select mixing parameters b 3.7
Select mixing parameters c 4.8
Select mixing parameters d 7.9

mixed signal 1: aA+bB
mixed signal 2: cA+dB

Live docs

LAB2： reference and re-reference

Pluto.jl

Reference and Re-reference

Author: Y. Yang – University Stuttgart.
Supervisor: Prof. Benedikt Ehinger – University Stuttagrt

Table of Contents

Change it up

Select a reference way : [Mastoid]

Select a channel : [POz]

Voltage as a Potential Between Two Sites

The EEG is always recorded as a potential for current to pass between two electrodes. The voltage between a scalp electrode and this ground electrode could then be recorded. However, voltages recorded in this way would still reflect electrical activity at both the scalp electrode and the ground electrode, so it would not provide some sort of absolute measure of electrical activity at the scalp electrode. Moreover, any environmental electrical noise that is picked up by the amplifier's ground circuit would influence the measured voltage, leading to a great deal of **noise** in the recording.

Active, Reference and Ground electrode

To solve the problem of noise being picked up by the ground circuit, EEG amplification systems use **differential amplifiers** With a differential amplifier, three electrodes are used to record activity: an **active** electrode (A) placed at the desired site, a **reference** electrode (R) placed elsewhere on the scalp, and a **ground** electrode (G) placed at some convenient location on the subject's head or body. The differential amplifier then amplifies the difference between the AG voltage and the RG voltage (AG - RG).

$$[active - ground] - [reference - ground] = active - reference$$

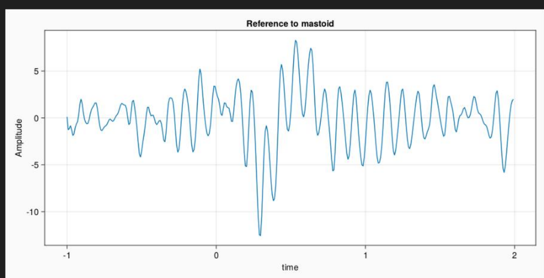
Ambient electrical activity picked up by the amplifier's ground circuit will be the same for the AG and RG voltages and will therefore be eliminated by the subtraction. Reference during recording is also called **online reference**.

How the choice of the reference may affect your data.

We'll use the example dataset contained in the EEGLab distribution. In this experiment, the subject covertly attended to a selected location on the computer screen (the green square) and responded with a quick thumb button press only when the disk was presented at this location. They were to ignore circles presented at the unattended locations (the blue squares).

Table of Contents

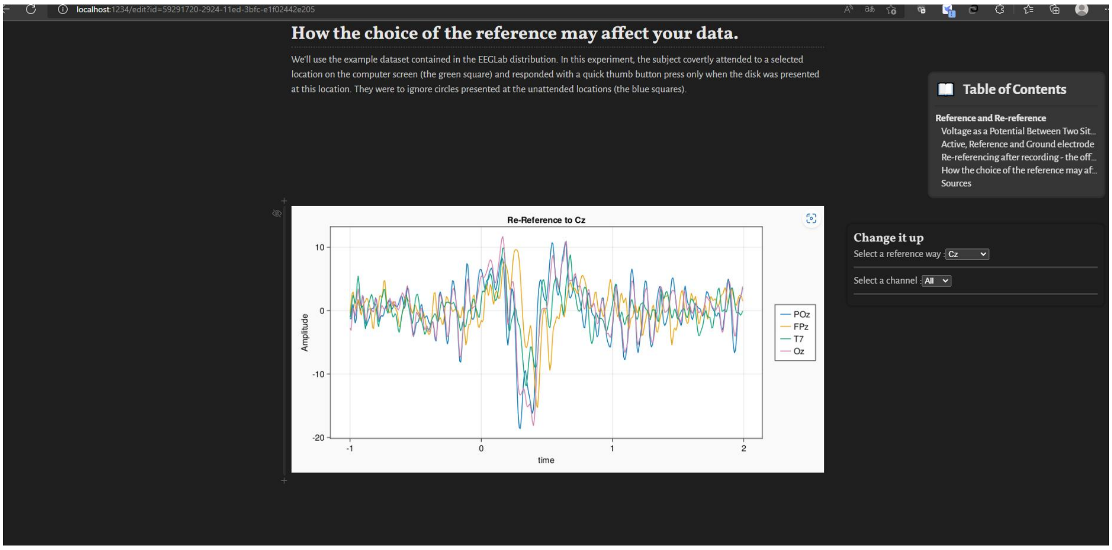
Reference and Re-reference
Voltage as a Potential Between Two Sit...
Active, Reference and Ground electrode
Re-referencing after recording - the off...
How the choice of the reference may af...
Sources



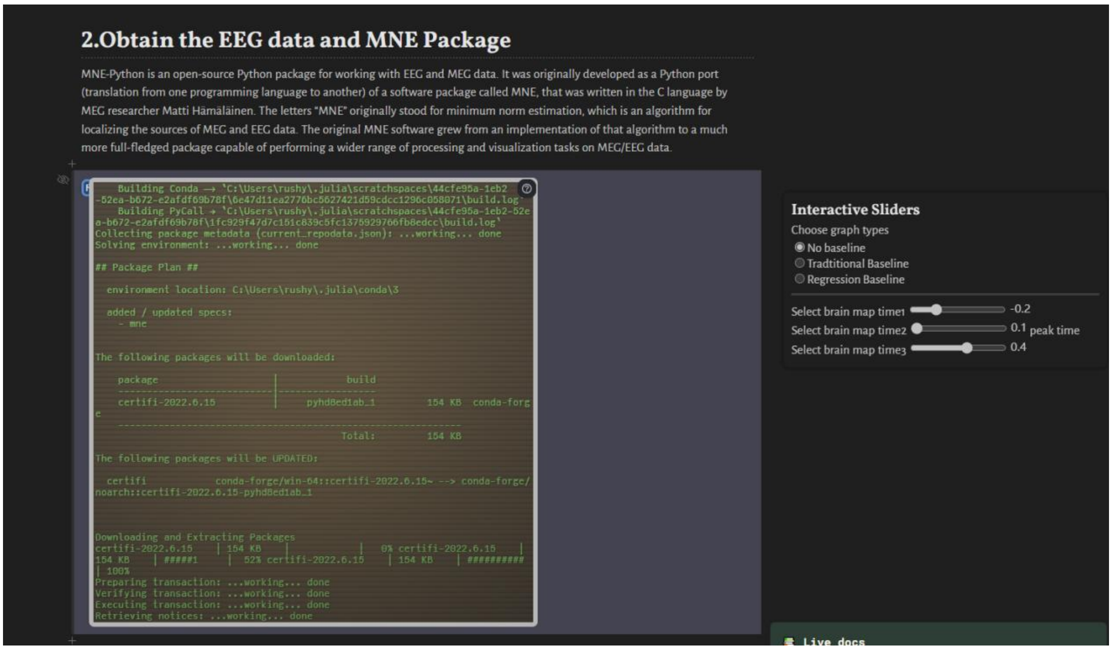
Change it up

Select a reference way : [Mastoid]

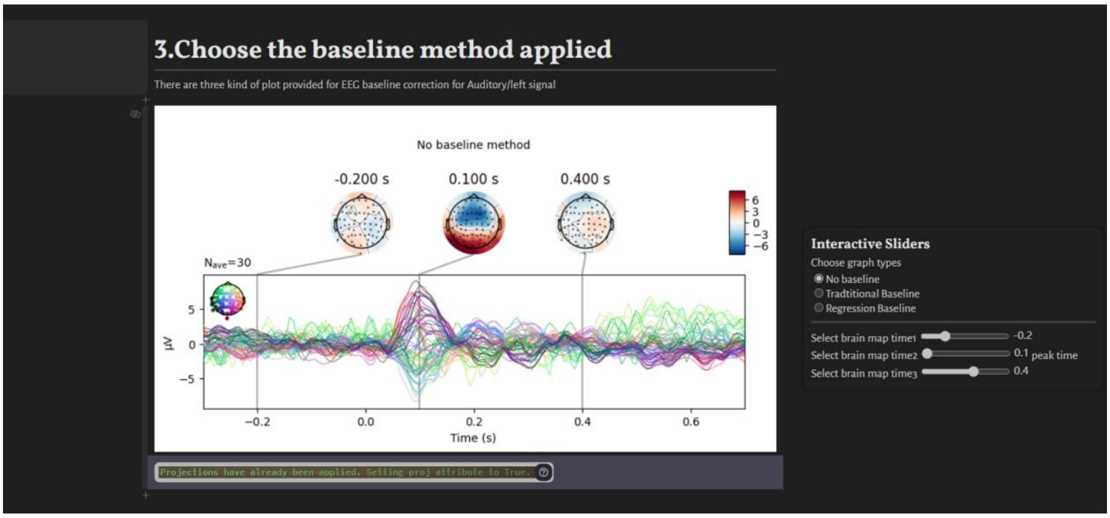
Select a channel : [POz]



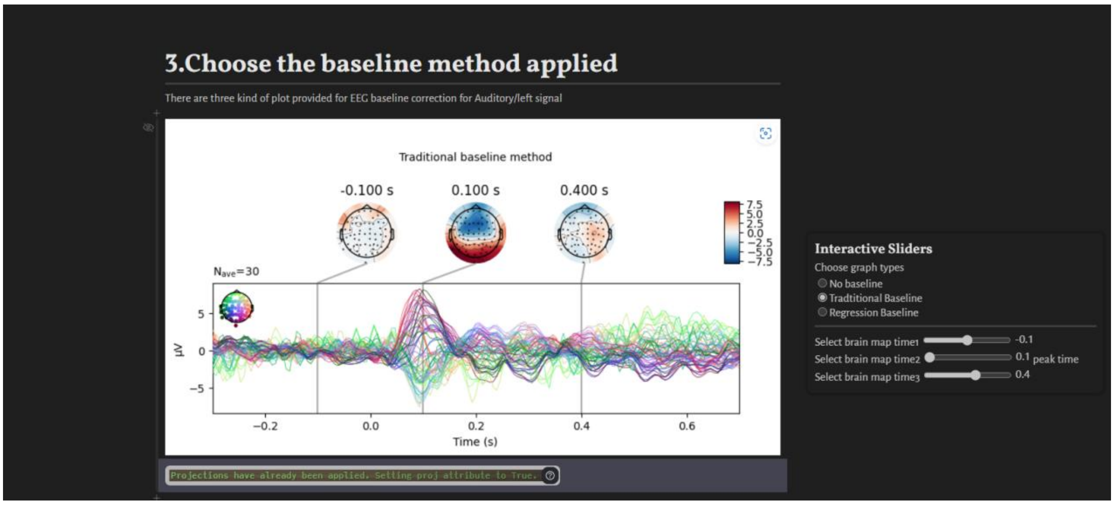
LAB3: Traditional baseline method and regression baseline method



2.Obtain the EEG data and MNE Package
MNE-Python is an open-source Python package for working with EEG and MEG data. It was originally developed as a Python port (translation from one programming language to another) of a software package called MNE, that was written in the C language by MEG researcher Matti Hämäläinen. The letters "MNE" originally stood for minimum norm estimation, which is an algorithm for localizing the sources of MEG and EEG data. The original MNE software grew from an implementation of that algorithm to a much more full-fledged package capable of performing a wider range of processing and visualization tasks on MEG/EEG data.
Building Conda → `C:\Users\rushy\.julia\scratchspaces\44cfe95a-1eb2-52ea-b672-e2afdf69b78f\6e47d11ea2776bc5627421d59cdcc1296c058071\build.log`
Building PyCall → `C:\Users\rushy\.julia\scratchspaces\44cfe95a-1eb2-52ea-b672-e2afdf69b78f\1fc929f47d7c151c839c5fc1375929766fb8edcc\build.log`
Collecting package metadata (current_repodata.json): ...working... done
Solving environment: ...working... done
Package Plan
environment location: C:\Users\rushy\.julia\conda\3
added / updated specs:
- mne
The following packages will be downloaded:
package
build
certifi-2022.6.15
pyhd8ed1ab_1
154 KB
conda-forge
Total:
154 KB
The following packages will be UPDATED:
certifi conda-forge/win-64::certifi-2022.6.15~ --> conda-forge/noarch::certifi-2022.6.15-pyhd8ed1ab_1
Downloading and Extracting Packages
Preparing transaction: ...working... done
Verifying transaction: ...working... done
Executing transaction: ...working... done
Retrieving notices: ...working... done
Interactive Sliders
Choose graph types
No baseline
Tradtitional Baseline
Regression Baseline
Select brain map time1
-0.2
Select brain map time2
0.1 peak time
Select brain map time3
0.4
Live docs



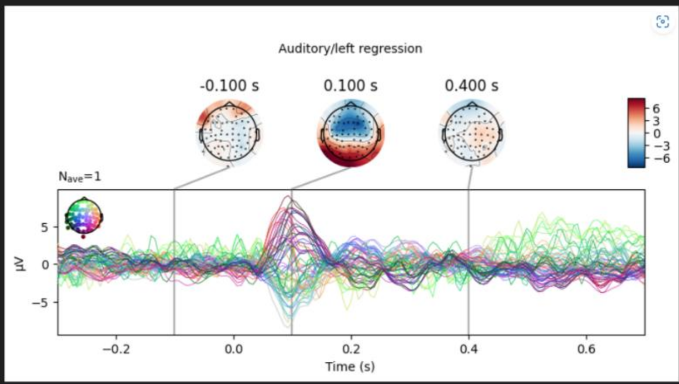
3.Choose the baseline method applied
There are three kind of plot provided for EEG baseline correction for Auditory/left signal
No baseline method
-0.200 s
0.100 s
0.400 s
Time (s)
μV
Projections have already been applied. Setting proj attribute to True.
Interactive Sliders
Choose graph types
No baseline
Tradtitional Baseline
Regression Baseline
Select brain map time1
-0.2
Select brain map time2
0.1 peak time
Select brain map time3
0.4



3.Choose the baseline method applied
There are three kind of plot provided for EEG baseline correction for Auditory/left signal
Traditional baseline method
-0.100 s
0.100 s
0.400 s
Time (s)
μV
Projections have already been applied. Setting proj attribute to True.
Interactive Sliders
Choose graph types
No baseline
Tradtitional Baseline
Regression Baseline
Select brain map time1
-0.1
Select brain map time2
0.1 peak time
Select brain map time3
0.4

3.Choose the baseline method applied

There are three kind of plot provided for EEG baseline correction for Auditory/left signal



Projections have already been applied. Setting proj attribute to True.

Interactive Sliders

Choose graph types

- No baseline
- Tradtitional Baseline
- Regression Baseline

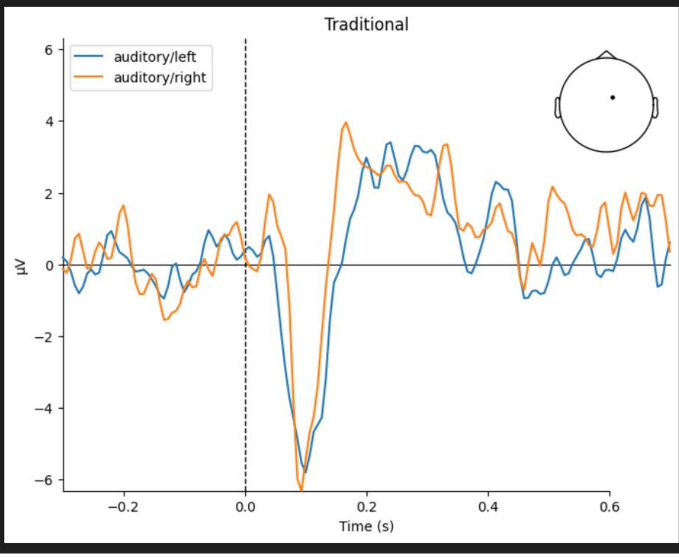
Select brain map time1 -0.1

Select brain map time2 0.1 peak time

Select brain map time3 0.4

4.Plot the ERPs

Now let's look at the betaβ values for the two conditions (auditory/left and auditory/right) channel 21: these are the coefficients that represent the "pure" influence of the experimental stimuli on the signal, after taking into account the (time-varying!) effect of the baseline. We'll plot them together, side-by-side with the traditional baseline approach:



Interactive Sliders

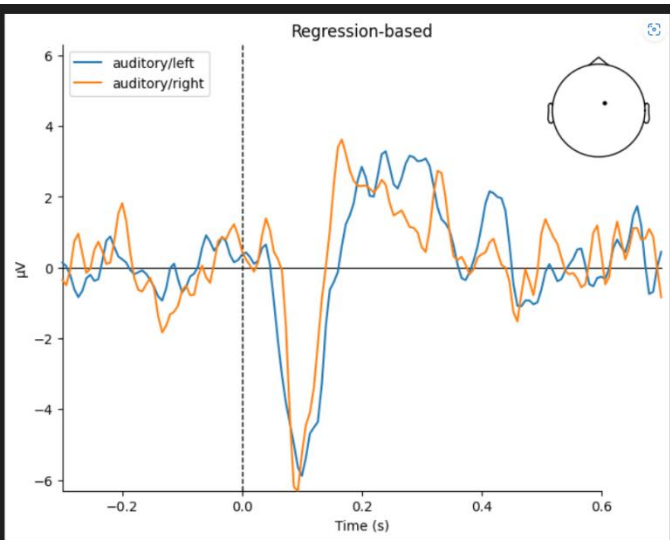
Choose graph types

- No baseline
- Tradtitional Baseline
- Regression Baseline

Select brain map time1 -0.1

Select brain map time2 0.1 peak time

Select brain map time3 0.4



Interactive Sliders

Choose graph types

- No baseline
- Tradtitional Baseline
- Regression Baseline

Select brain map time1 -0.1

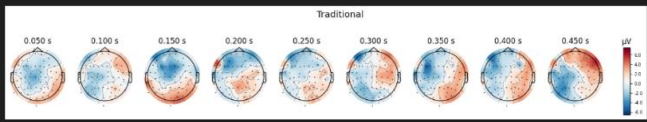
Select brain map time2 0.1 peak time

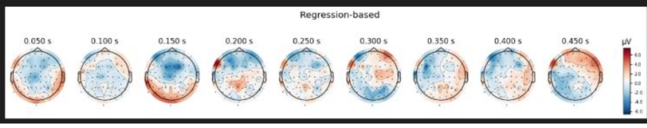
Select brain map time3 0.4

They look pretty similar, but there are some subtle differences in how far apart the two conditions are (e.g., around 400-500 ms).

5.Plot the scalp topographies and difference waves

Now let's compare the scalp topographies for the traditional and regression-based approach for the auditory/left and auditory/right signals





Interactive Sliders

Choose graph types

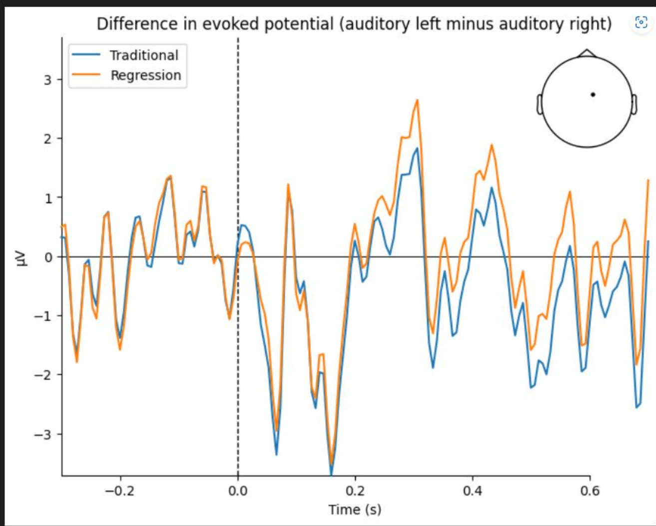
- No baseline
- Tradtitional Baseline
- Regression Baseline

Select brain map time1 -0.1

Select brain map time2 0.1 peak time

Select brain map time3 0.4

We can see that the regression-based approach shows stronger difference between conditions early on (around 100), weaker differences later (around 50 ms, and again around 450 ms).This is also reflected in the difference waves themselves: notice how the regression-based difference wave is further from zero around 150 ms but closer to zero around 250-350 ms.



Interactive Sliders

Choose graph types

- No baseline
- Tradtitional Baseline
- Regression Baseline

Select brain map time1 -0.1

Select brain map time2 0.1 peak time

Select brain map time3 0.4

We can see that from 0ms to 300md the difference for traditional and regression method between auditory left and auditory right are very likely. However, from 300ms to 600ms, the difference becomes greater.

We can see that from 0ms to 300md the difference for traditional and regression method between auditory left and auditory right are very likely. However, from 300ms to 600ms, the difference becomes greater.

6. Sources

[HTML: MNE-Python]

[HTML: Regression-based baseline correction]

[HTML: JuliaPy/PyCall.jl]

[PDF: (How much baseline correction do we need in ERP research? Extended GLM model can replace baseline correction while lifting its limits]

Interactive Sliders

Choose graph types

- No baseline
- Tradtitional Baseline
- Regression Baseline

Select brain map time1 -0.1

Select brain map time2 0.1 peak time

Select brain map time3 0.4