EEGLAB introduction

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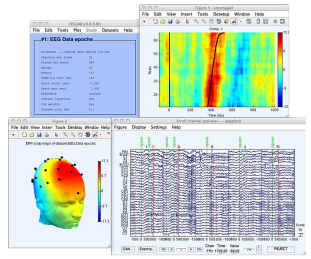
EEGLAB History Timeline



1997 — EEG/ICA Toolbox (Salk Institute)

2001 — 1st EEGLAB for artifact rejection (Salk Institute)

2003 — EEGLAB issued to wide audience (Salk Institute) and NIH support

2006 — EEGLAB plug-ins, STUDY structure

2011 — EEGLAB, the most widely used EEG research environment

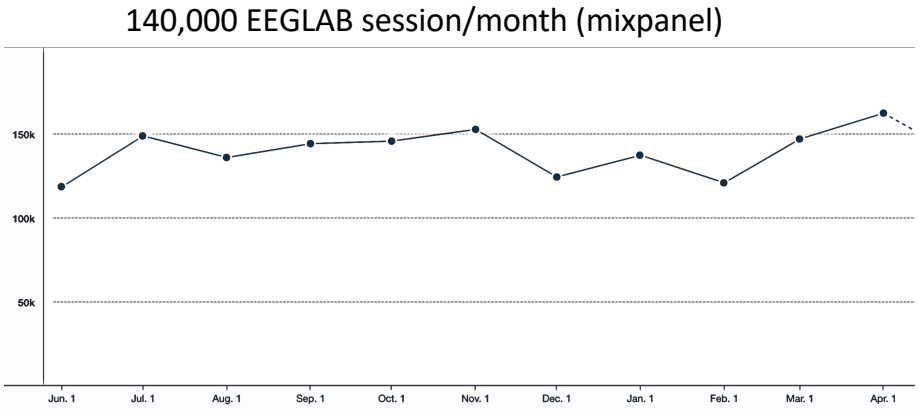
2018 — EEGLAB STUDY use single trial and LIMO integration

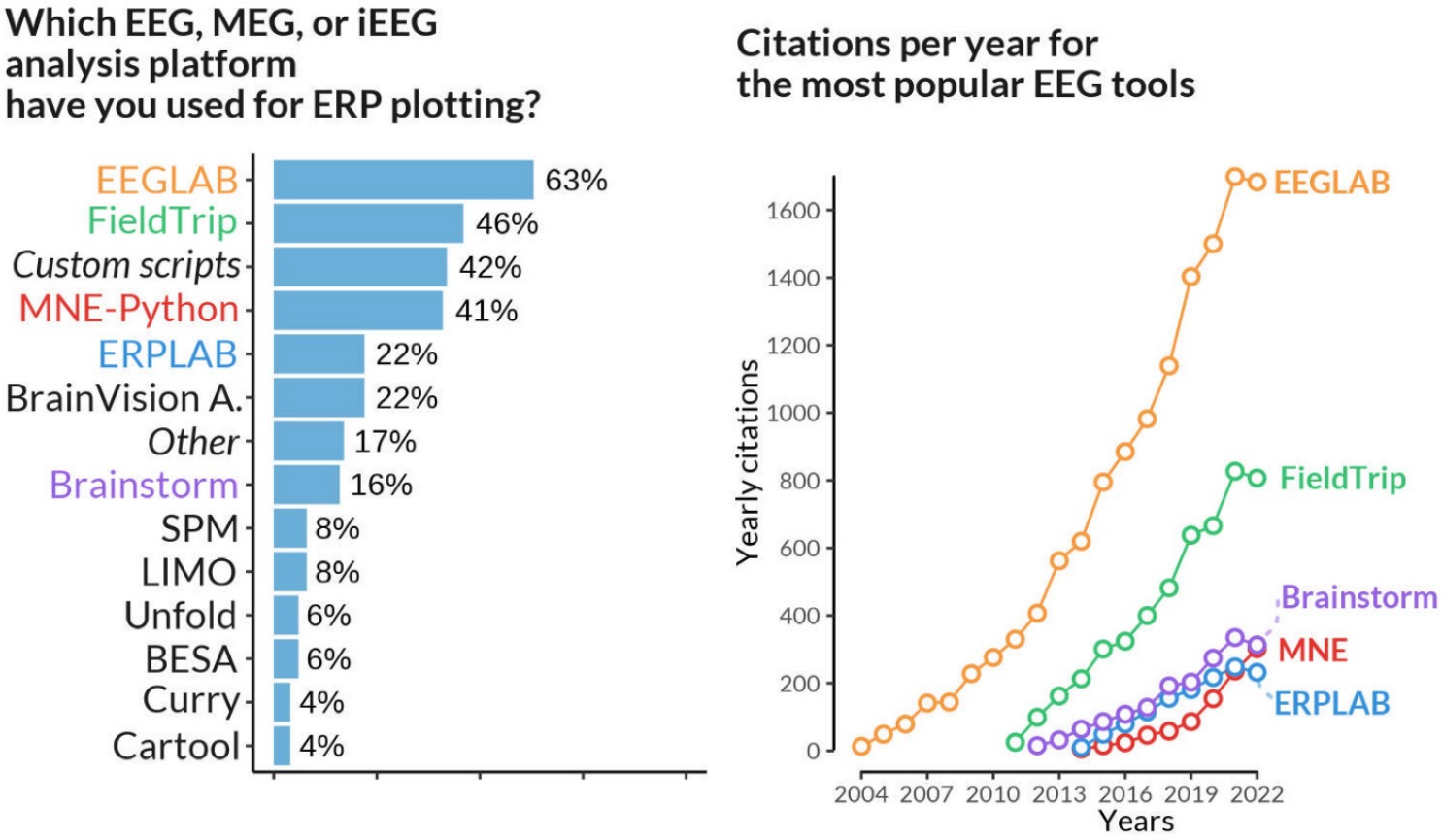
2021 — BIDS integration, big data pipelines, New website

2024 — Automation on Cloud platforms

EEGLAB in a few numbers

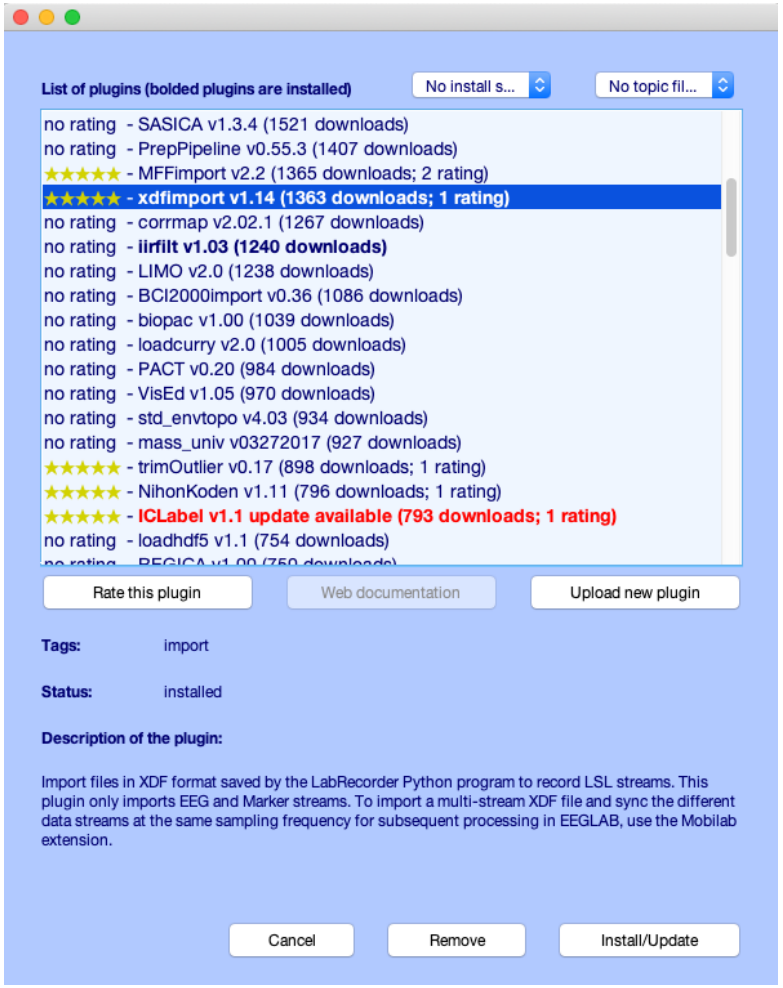
- About 600 functions (150 000 lines of code)
- About 400,000 download over the past 10 years
- 15,500 users on the diffusion list
- Supporting 423 million of dollars of research as of 2022
- NIH funding since 2003
- 151 plugins



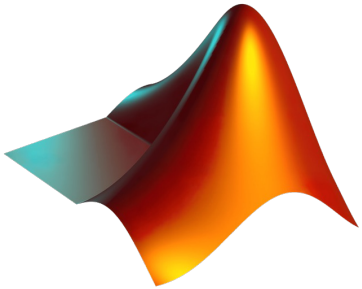


Mikheev V, Skukies R, Ehinger BV. The Art of Brainwaves: A Survey on Event-Related Potential Visualization Practices. Aperture Neuro. 2024;4. doi:10.52294/001c.116386

EEGLAB plugin manager (151 plugins)



Which MATLAB version?



Download R2020b

R2020b

Download earlier release

- R2010a
- R2009bSP1
- R2009b
- R2009a
- R2008b

Additional MATLAB toolboxes

- Signal processing toolbox
- Statistics toolbox
- Optimization toolbox
- Image processing toolbox

Matlab based open source

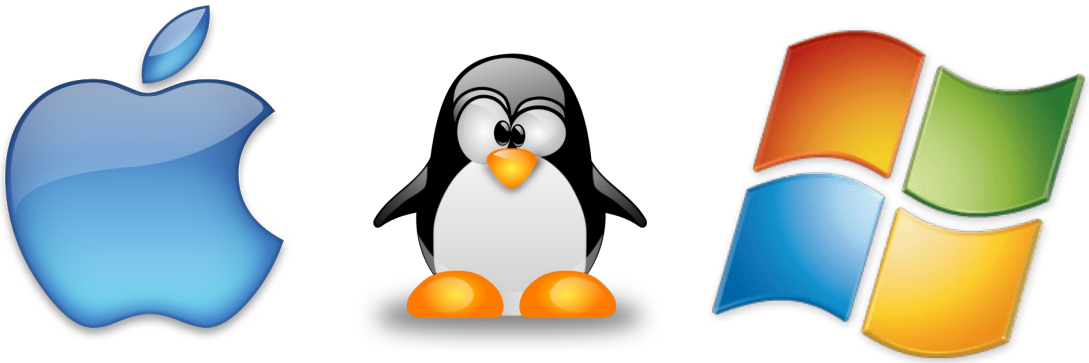
Pros

- Easy to program, highly modular and extendable
- Not dependent on any platform (64-bit) and highly optimized
- Large community of users (latest development in signal processing research)
- Powerful scripting capabilities

Cons

- Matlab commercial license required
- Matlab commercial toolboxes recommended (signal processing, statistics)

Which Operating System?



EEGLAB on MATLAB
vs EEGLAB compiled

scientific reports

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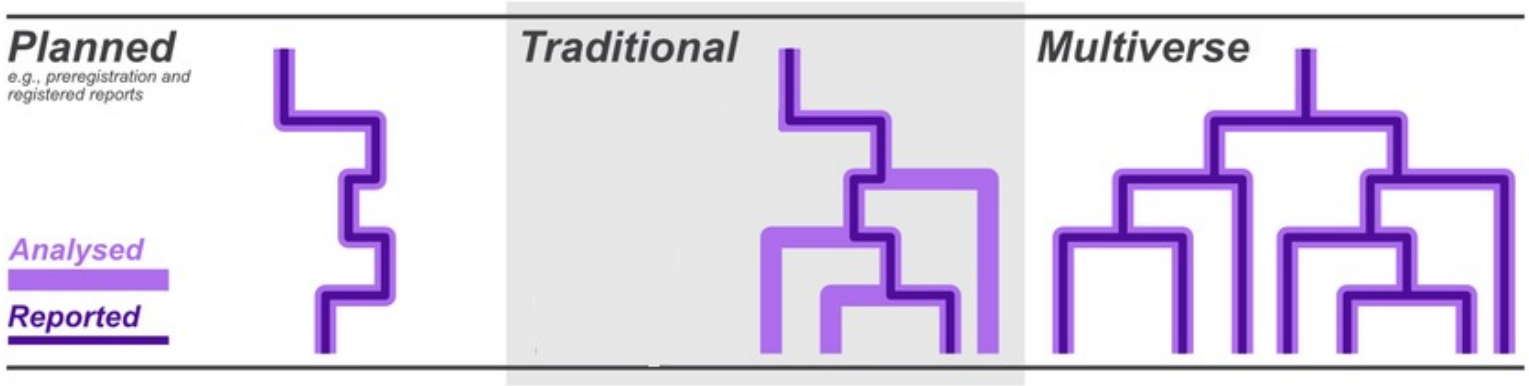
Article | Open access | Published: 09 February 2023

EEG is better left alone

Arnaud Delorme ✉

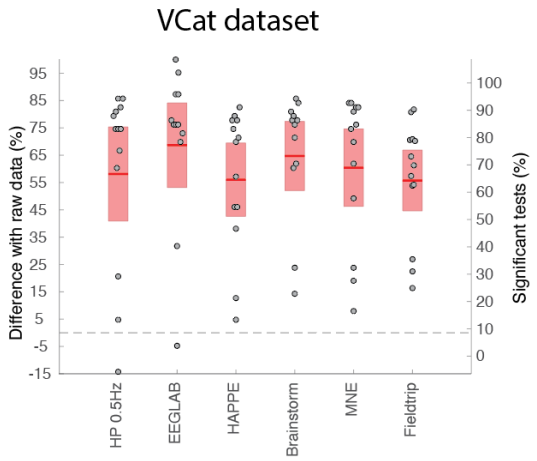
Scientific Reports **13**, Article number: 2372 (2023) | Cite this article

94k Accesses | **176** Citations | **166** Altmetric | Metrics



Is there an optimal preprocessing pipeline?

- Each automated artifact rejection optimized (EEGLAB, MNE, Brainstorm, Fieldtrip)



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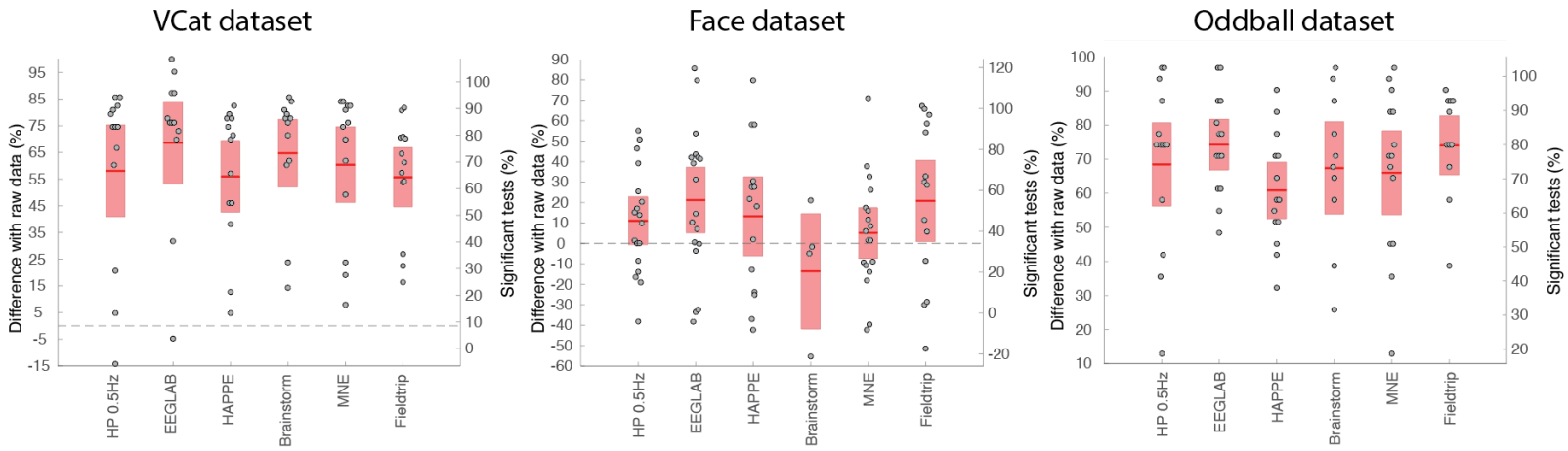
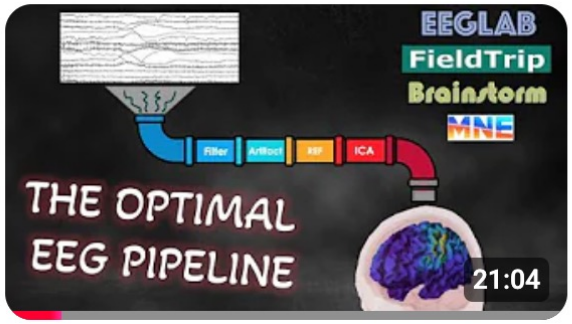


- Compared to high-pass at 0.5Hz, not much improvement of any pipeline (although EEGLAB pipeline the only one significantly superior to 0.5 Hz high pass for all 3 datasets – no other pipeline superior to 0.5 Hz high pass for any dataset)
- EEGLAB minor advantage due to line-noise contaminated channel interpolation and ICA automated rejection

YouTube videos



What is the optimal automated EEG pipeline?

8.6K views • 2 years ago

What is the best ERP baseline?

3.8K views • 2 years ago

What is the best EEG reference?

6.9K views • 2 years ago

A FieldTrip EEG automated processing pipeline

3.6K views • 2 years ago

A Brainstorm EEG automated processing pipeline

4.1K views • 2 years ago

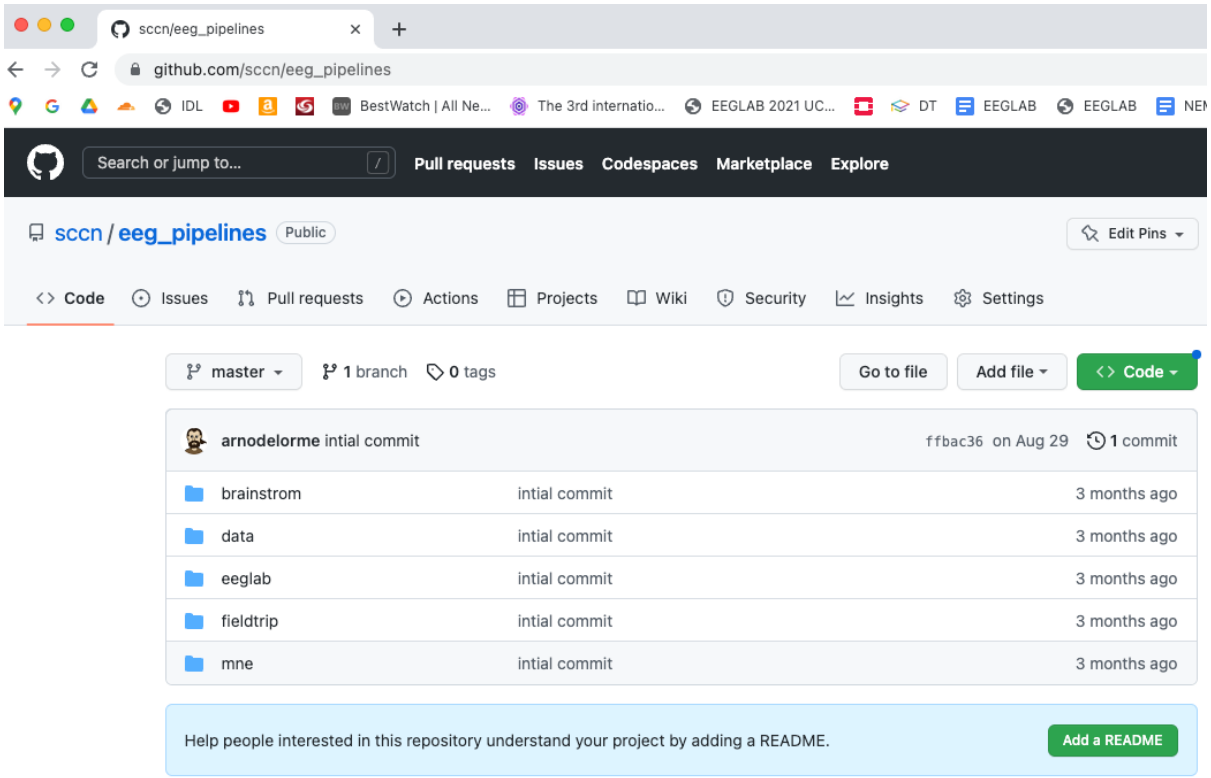
An MNE EEG automated processing pipeline

9.6K views • 2 years ago

Process EEG data in EEGLAB then build an automated pipeline

9.3K views • 2 years ago

Automated pre-processing pipelines available



- Has test data
- Please comment and help improve the automated pipeline for each software

EEGLAB reference articles

Delorme, A., Makeig, S. (2004) EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. *Journal of Neuroscience Methods*, 134(1), 9-21.

Makeig, S., Debener, S., Onton, J., Delorme, A. (2004) Mining event related dynamics. *Trends in cognitive Neuroscience*, 8(5), 204-210.

Delorme, A., Mullen, T., Kothe, C., Bigdely-Shamlo, N., Akalin, Z., Vankov, A., Makeig, S. (2011) EEGLAB, MPT, NetSIFT, NFT, BCILAB, and ERICA: New tools for advanced EEG/MEG processing. Computational Intelligence, article ID 130714.

Delorme, A., Kothe, C., Bigdely, N., Vankov, A., Oostenveld, R., Makeig, S. (2010) Matlab Tools for BCI Research? In "human-computer interaction and brain-computer interfaces". Editors : Tan, D. and Nijholt, A. Springer Publishing.

Delorme, A., Makeig, S. (2009) Open Source Programming for Interpreted Language: Graphic Interface and Macro Bridging Interface. 2009 Fifth International Conference on Signal-Image Technology & Internet-Based Systems (SITIS, indexed in IEEE), Nov. 29 2009-Dec. 4 2009, 430-434.

Delorme, A., Palmer, J., Onton, J., Oostenveld, R., Makeig, S. (2012) Independent EEG sources are dipolar.PLoS One, 7(2).

Delorme, A., Miyakoshi., M., Jung, T.P., Makeig, S. (2014) Grand average ERP-image plotting and statistics: A method for comparing variability in event-related single-trial EEG activities across subjects and conditions. J Neurosci Methods. 2014 Oct 22. pii: S0165-0270(14)00363-X. doi: 10.1016/j.jneumeth.2014.10.003

Get ready

1. Install instructions: https://forum.cuttingeeg.org/tag/eeglab

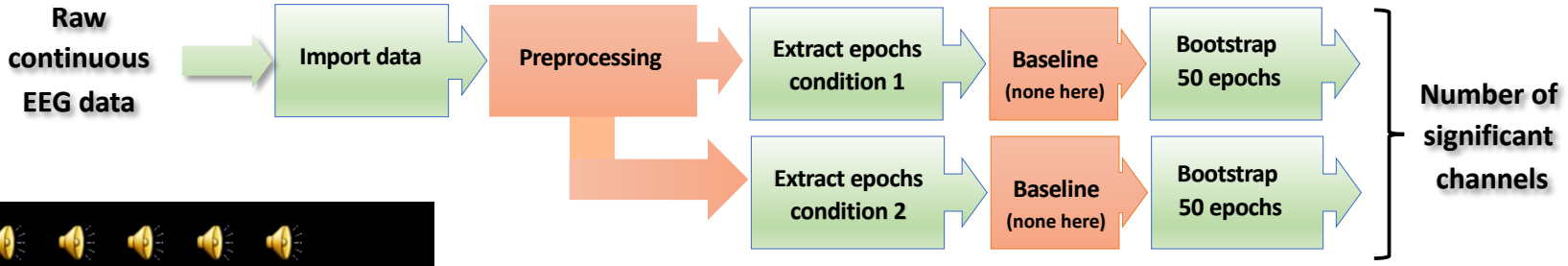
2. Data (ask for the flashdrive)
- Download the pruned dataset (ds000117_pruned)
- Download group dataset (ds002718)

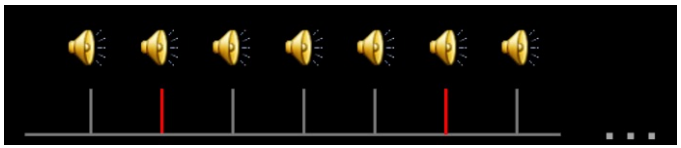
3. Install git (Windows Git-bash; Linux or Osx 😇)

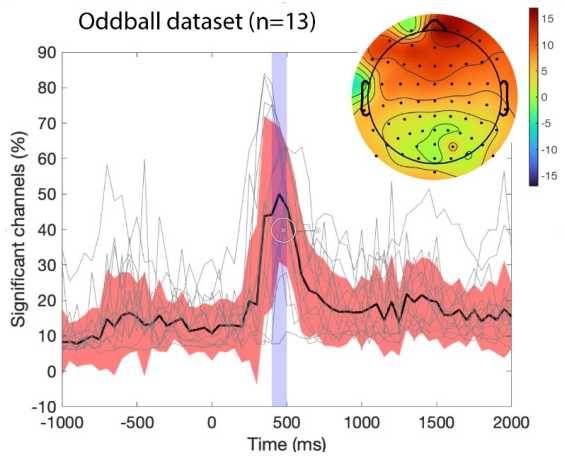
4. Clone EEGLAB: https://github.com/sccn/eeglab (see README) or use flashdrive
- Start MATLAB then EEGLAB
- (use plugin manager menu item File > Manage EEGLAB extensions)
- Install File-IO plugin
- Install Fieldtrip-lite plugin
- Install picard plugin

5. Clone slides and script repository from https://github.com/sccn/practical_MEEG2025

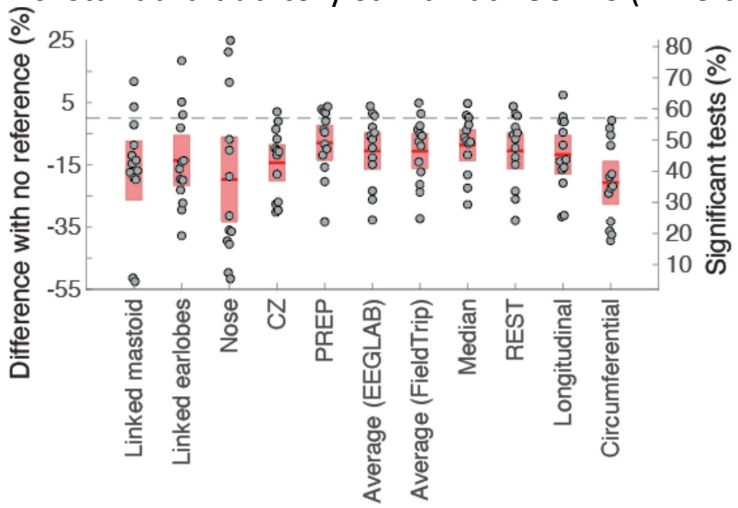
Influence of the reference on ERPs





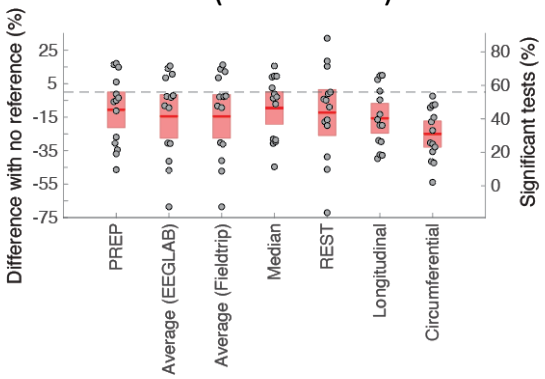


Oddball vs. standard auditory stimuli at 450 ms (BIDS ds003061)

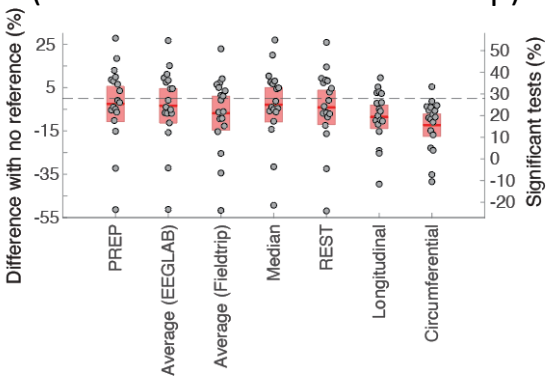


Influence of the reference on ERPs

Animal vs non-animal task
(BIDS 2680)

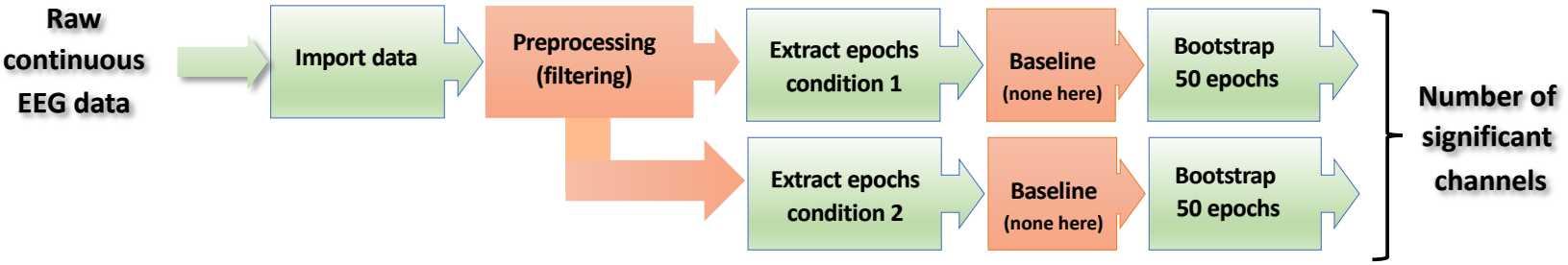


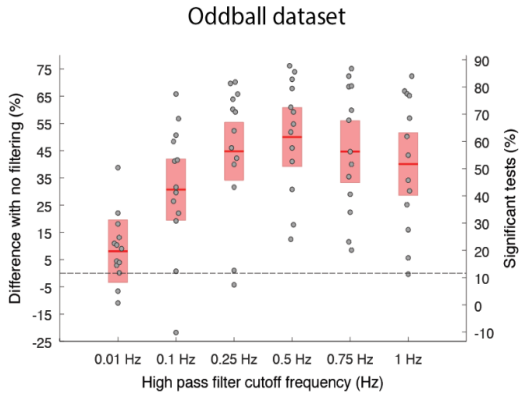
Face scrambled vs. famous
(dataset used at this workshop)

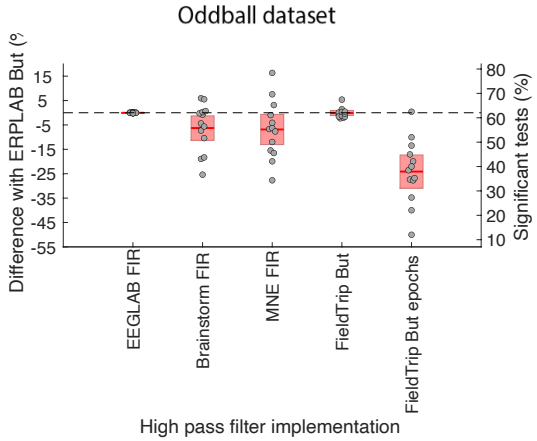


- It is unknown why using a reference decreases the number of significant channels when comparing 2 conditions for these 3 datasets
- No reference wins (REST not superior)

Influence of HP filtering on ERPs







- The frequency cutoff is important
- Usually 0.5Hz is a good value

- The type of filter FIR or IIR is not critical
- Raw data should be filtered not epochs (e.g., FieldTrip preprocessing)