ToMCAT-Offline-Viz

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Background & Setup

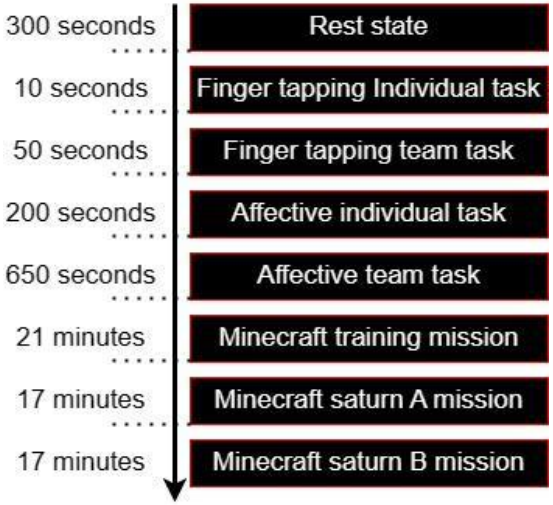
05-01-2023

ToMCAT

ToMCAT, which stands for Theory of Mind-based Cognitive Architecture for Team, is a joint initiative between Computer Science and Social Science. Its main objective is to design an artificially intelligent (AI) teammates that will address some of the capabilities that they must have, including inferring the internal states of other agents solving problems collaboratively with them, and communicating with them in a socially-aware manner.

At the moment, there is a process of collecting data that requires an individual to participate in a variety of activities, some of which involve individual tasks while others are team-based.

ToMCAT is funded by DARPA (Defense Advanced Research Projects Agency).



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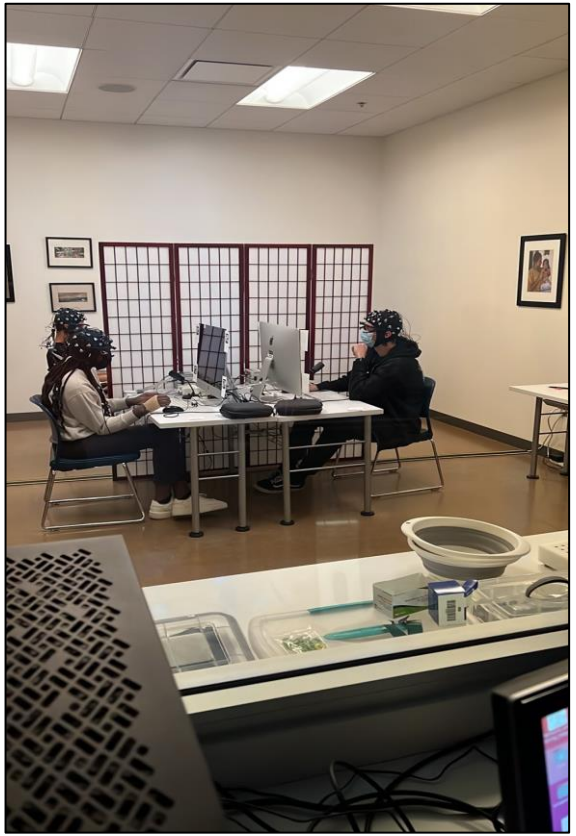
Experiment Room

View from Control Room



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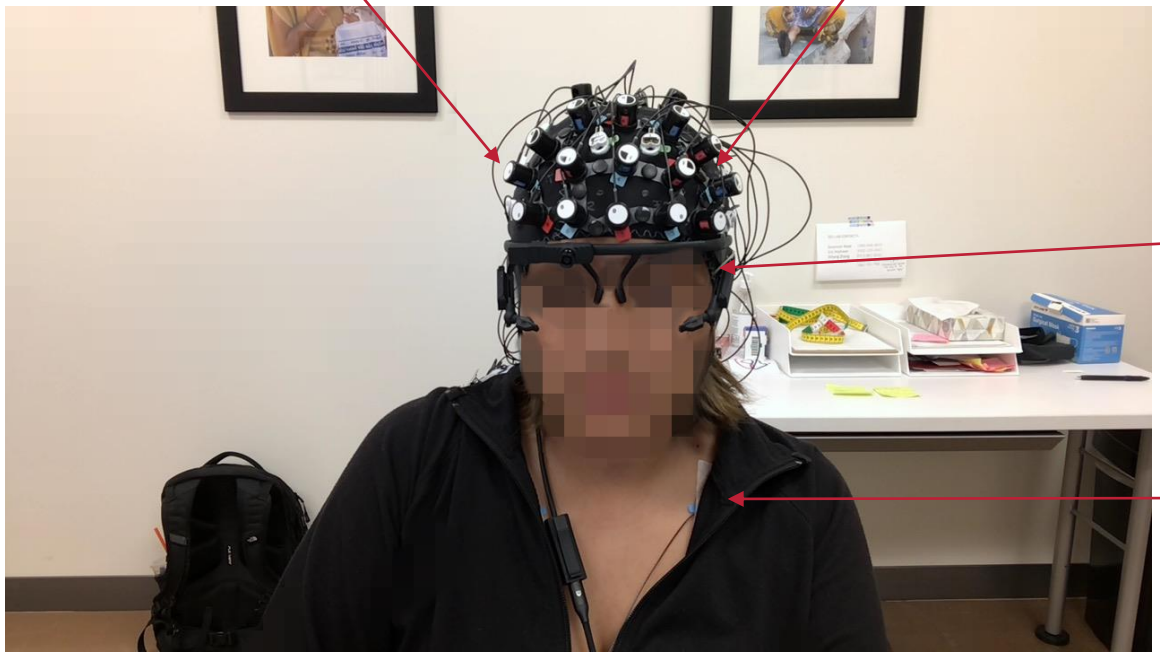
fNIRS (Functional Near-Infrared Spectroscopy) Optodes

EEG (Electroencephalogram) Electrodes



Eye tracker

EKG:Electrocardiogram

GSR (Galvanic Skin Response): On right hand

- fNIRS records BOLD (Blood Oxygen Level Dependent) signals

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Introduction & Research Question

05-01-2023

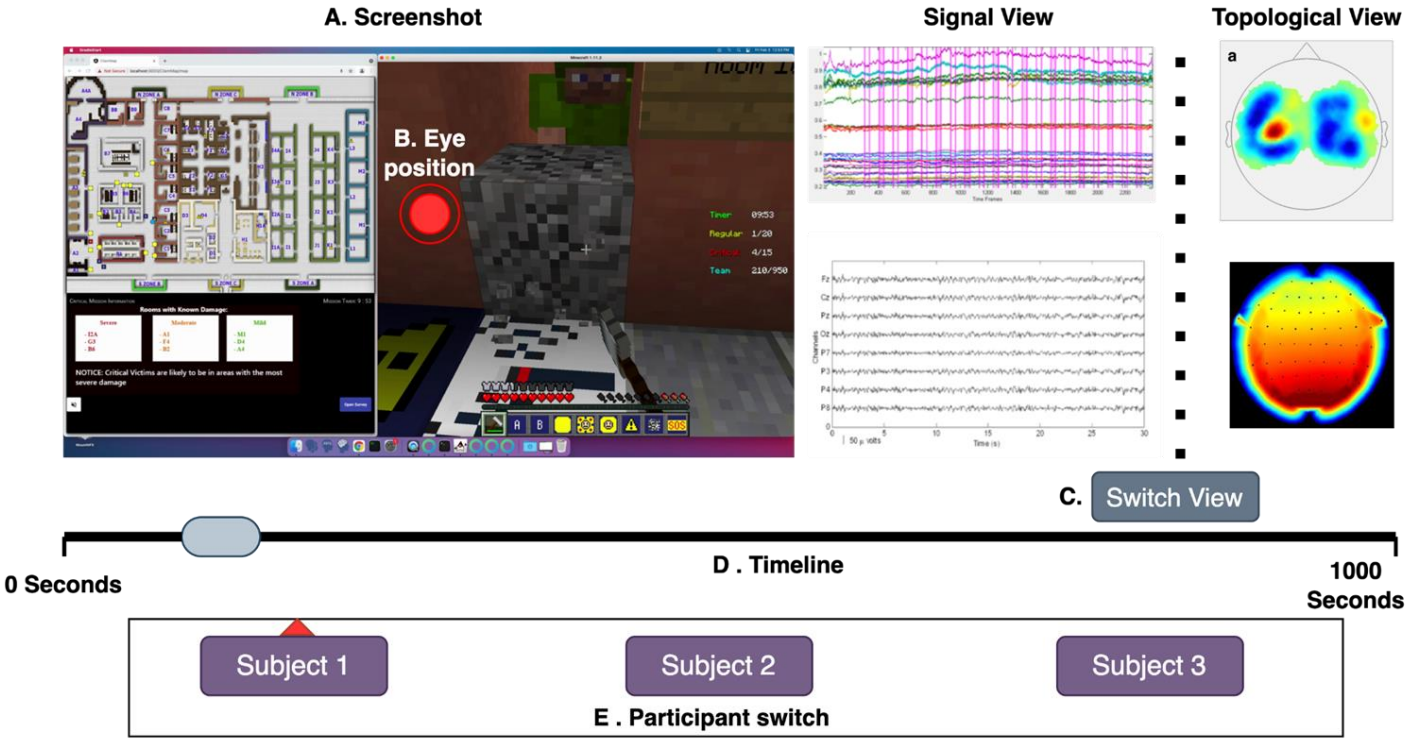
How will our tool help?

- The ToMCAT offline visualization tool is a joint venture aimed at creating a comprehensive multimodal tool that integrates functional near-infrared spectroscopy (fNIRS), eye tracking, and electroencephalography (EEG) data.

- This tool can offer a complete analysis of cognitive and perceptual functions such as attention, working memory, and emotion.

- This tool is expected to simplify the work for social scientists.

Design we proposed



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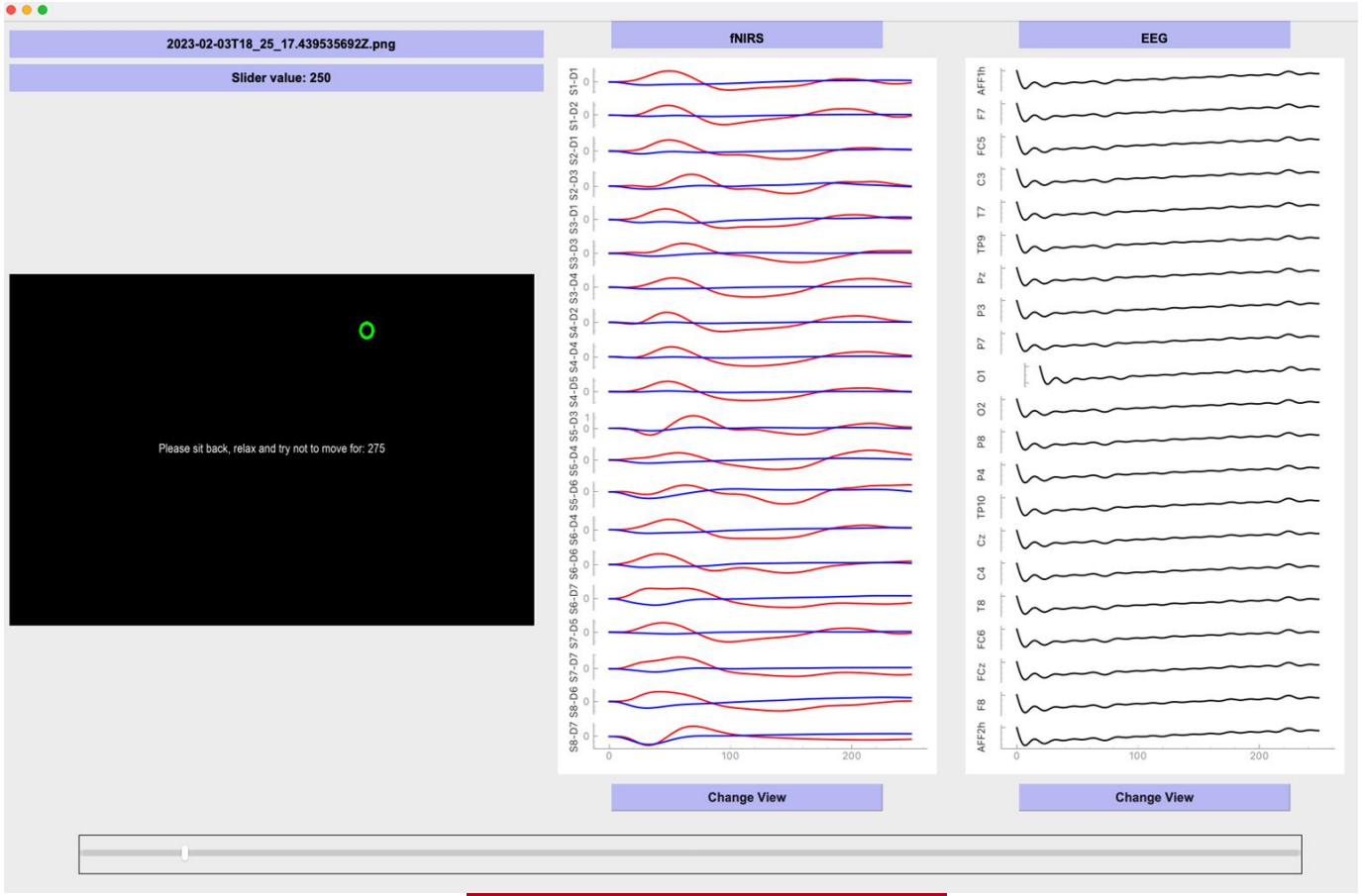
This is what we achieved.



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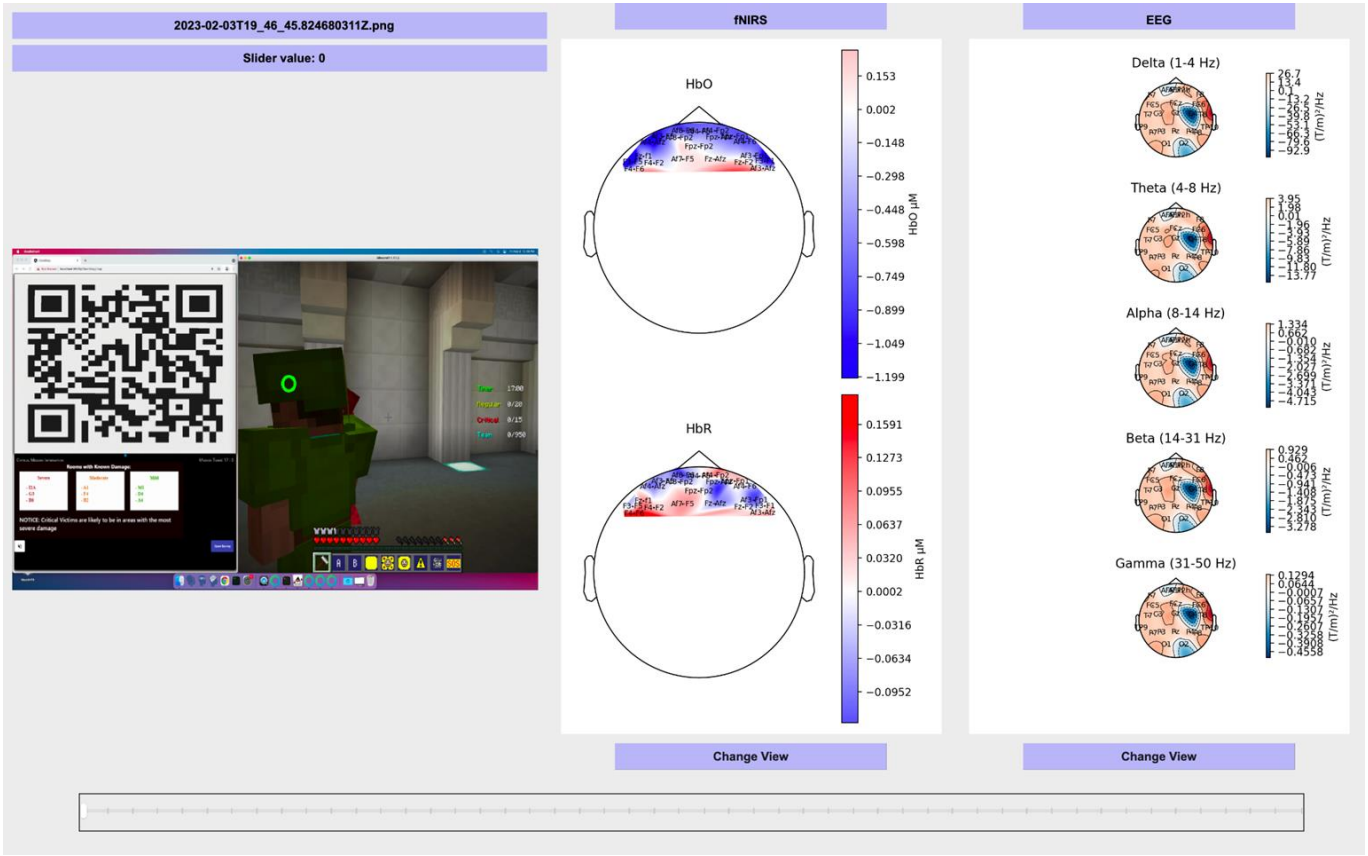
This is what we achieved.



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Related works

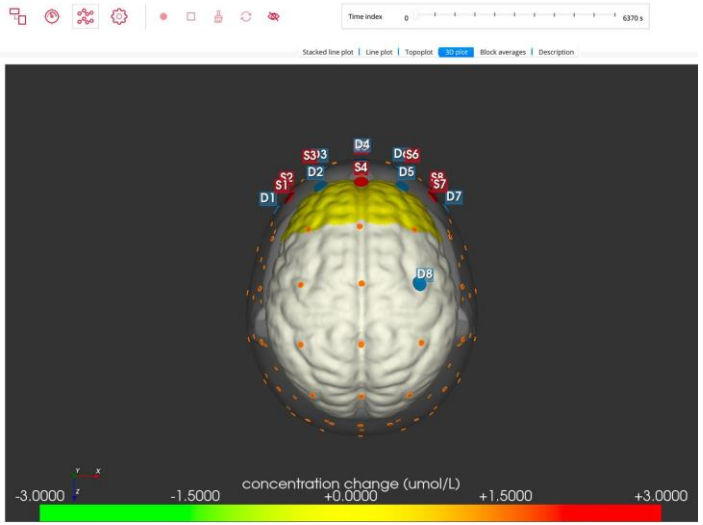
Aurora

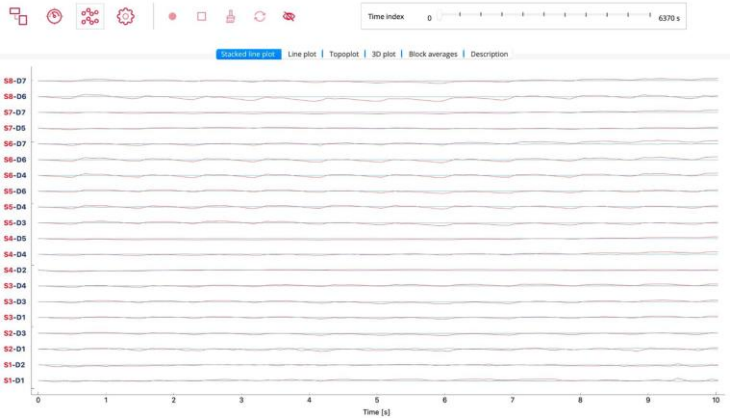
Great tool to visualize collected fNIRS data.

Disadvantage: The timestamps are in frames rather than the precise time of experimentation that social scientists require for precise comparisons.

Due to the fact that the dataset is composed of both screenshots and fNIRS data acquired through timestamps, using this software to visualize the results becomes challenging.

https://nirx.net/software





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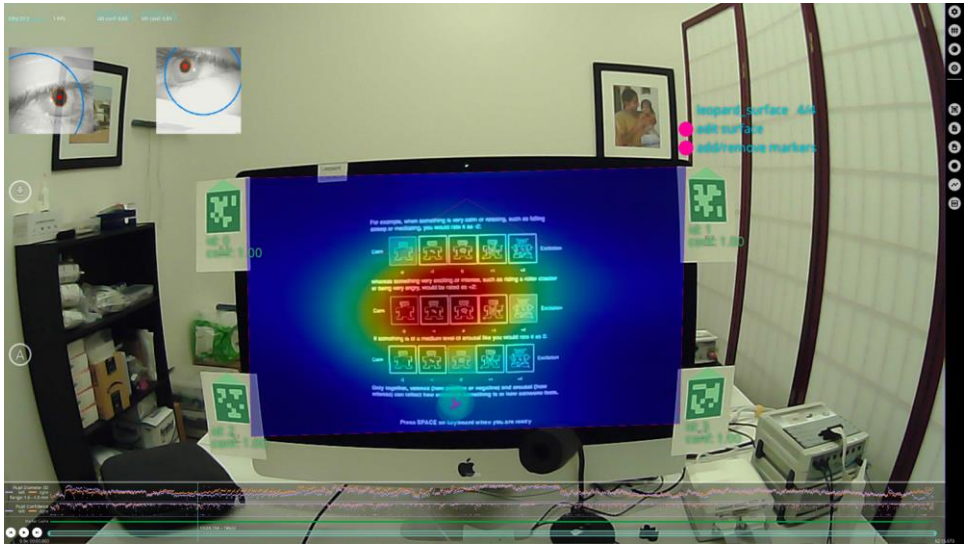
Pupil player

Great tool to visualize collected pupil dilation and fixation with the world view.

Disadvantage: The visualization contains irrelevant information that we are not concerned with, particularly regarding the world view.

Additionally, the tool cannot be utilized to map brain data visualization.



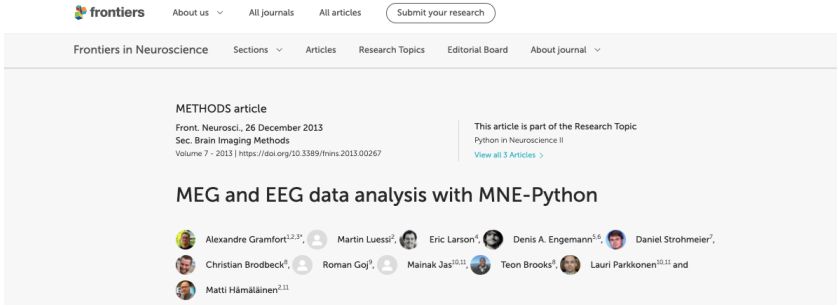
https://docs.pupil-labs.com/core/software/pupil-player/

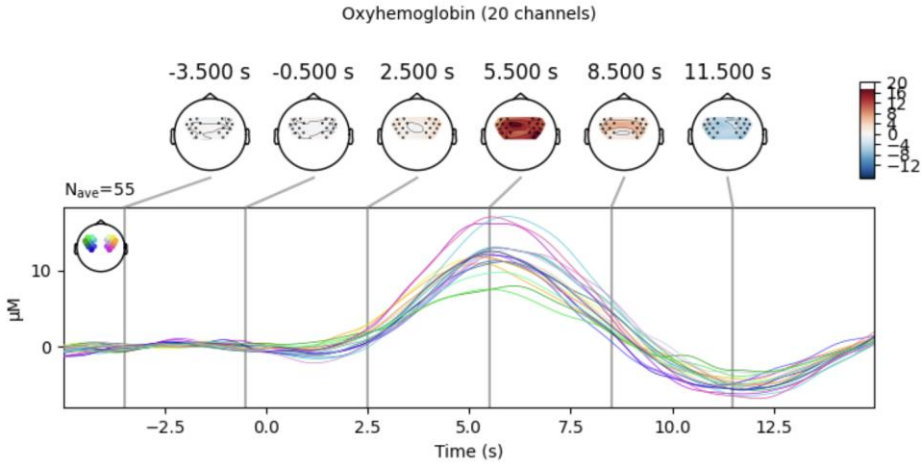
MNE Python

Great tool to visualize EEG data and minor support for fNIRS as well.

Disadvantage: The social scientists wants customization on visualizing all the data in the tool.

Nonetheless, we utilize this tool to plot fNIRS and EEG data onto a topographic brain map.





https://mne.tools/stable/auto_tutorials/preprocessing/70_fnirs_processing.html

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Research Plan

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Data Description - from Lang lab

Type	Format	Metadata
Screenshots	PNG image	(Resolution: 1280X720, File size ~ 600 kB) Sampled at 10 fps
fNIRS	CSV	(File size approx 53 MB) Sampled at 10.2 Hz
Eye Tracker	CSV	(File size approx 140 MB) Sampled at 200 Hz
EEG	CSV	(File size approx 1.2 GB) Sampled at 500 Hz

Approximately 116 GB for one experiment with three subjects

Techniques

Superimpose eye-tracking data onto screenshots to gain insights into the visual attention of team members. The process involves overlaying or combining the eye-tracking data onto the screenshots. By doing so, you can visualize and analyze where team members' visual attention is focused within the interface or content.

Navigation: The slider is a user interface component that allows you to **compare** and navigate through different time points or variations in each modality working in sync to facilitate the analysis of variations.

The user can use this interface to **derive, explore and extract** meaningful information or conclusions from the eye-tracking and fNIRS data or eye-tracking and EEG data. They can also identifying patterns, relationships, or trends with the eye when a player is playing.

Techniques

Juxtaposition of eye-tracking screenshots and Near-Infrared Spectroscopy (fNIRS) or Electroencephalography (EEG) data on the right-hand side of the screen, providing information on neural activity, for comparison or analysis.

The signal view for fNIRS displays the processed data as **line plots**, showing the HbO and HbR data over time. The signal view for EEG displays the processed data as line plots, showing the electrical activity as microvolts(mV) over time. Line plots provide a clear visualization of signal **trends**, fluctuations, and **patterns**, allowing researchers to analyze temporal dynamics of brain activity.

We have used **QtGraph** to visualize signal view.

Techniques

We are generating **topological view** which interpolates the values at each sensor location to create a smooth 2D map, allowing you to visualize the spatial distribution of the data across the sensor array. Color is used as a visual encoding technique to represent different brain activity levels or intensities in the topological view.

We have used **MNE** library to achieve topological view

There will be a switch between signal and topological views of the fNIRS and EEG data with a button based on their preference. When analyzing fNIRS data, researchers can focus on two aspects: **trend and similarity**

Why topological view, signal view and eye tracking by positioning pupil data on screenshots?

- **Topological View**: Represents brain activity spatially, showing the distribution and patterns of neural activity across different regions of the brain using color-coding or heatmaps.
- **Signal View**: Displays fNIRS and EEG data as line plots, allowing researchers to analyze variations, trends, and patterns in the signals over time.
- **Eye Tracking by superimposing Pupil Data on Screenshots**: Records eye movements and gaze behavior, and overlays pupil data onto screenshots of visual stimuli to understand visual attention and fixation patterns of participants.
- **Correlates visual attention with neural activity**: By combining eye tracking data with fNIRS and EEG data, researchers can analyze how visual stimuli attract visual attention and influence brain responses.

CITI and COI Training

Since Rupal and Harshita were not a part of the ToMCAT Project, they were required to do the below IRB (CITI) and COI training courses:

1. Native American
2. Social and behavioral BASIC

Results & Demo

05-01-2023

Rest State Literature Review

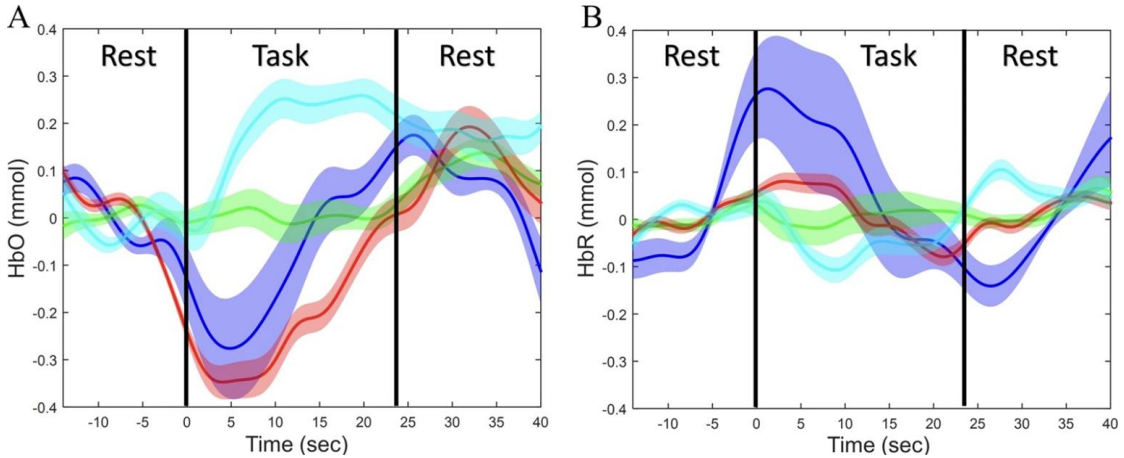
Article | Open Access | Published: 20 January 2020

Reliability of Frontal Eye Fields Activation and Very Low-Frequency Oscillations Observed during Vergence Eye Movements: an fNIRS Study

Chang Yaramothu, Xiaobo Li, Cristian Morales & Tara L. Alvarez

Scientific Reports **10**, Article number: 712 (2020) | Cite this article

1904 Accesses | **3** Citations | **1** Altmetric | Metrics



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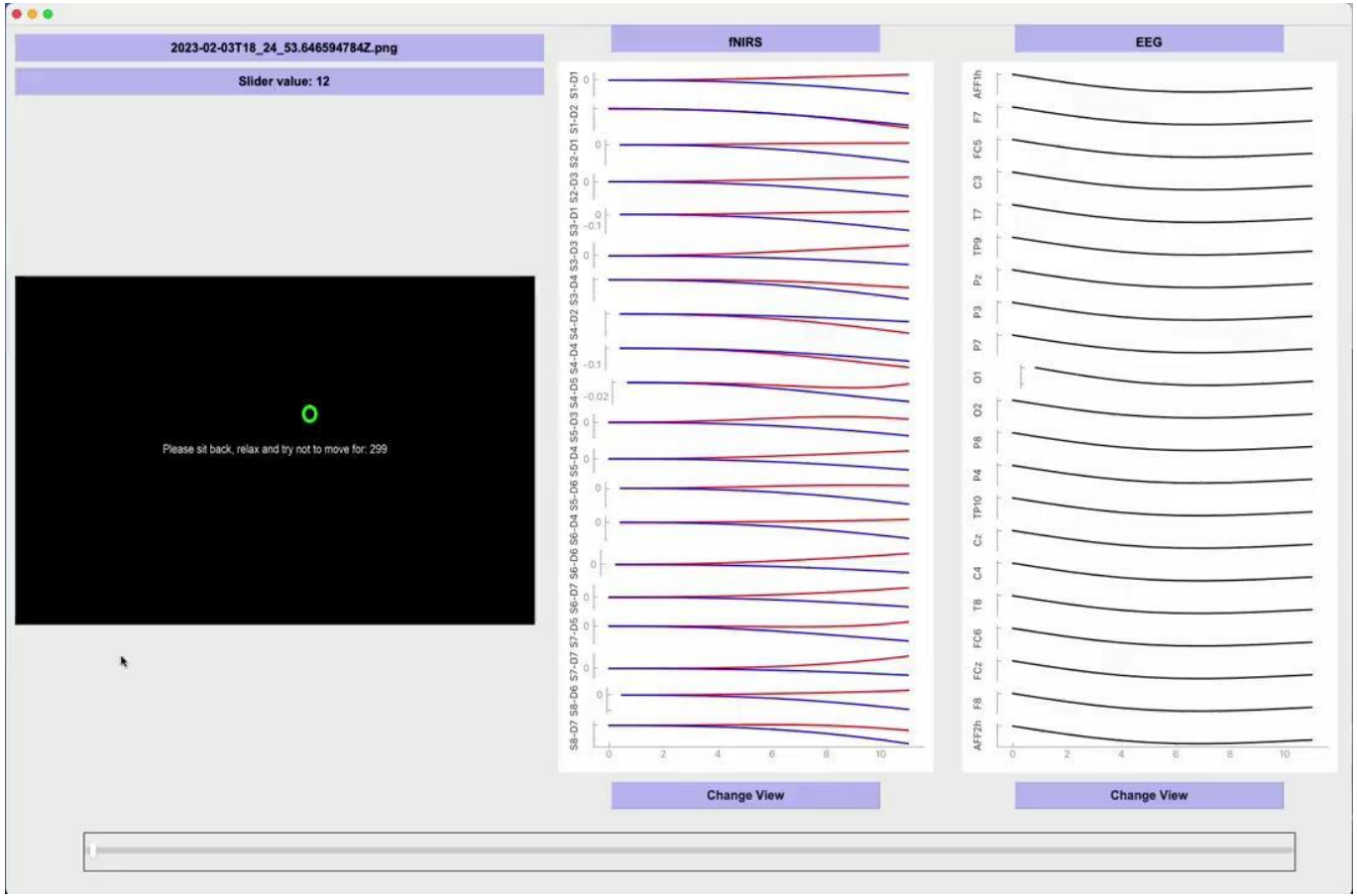
Rest State



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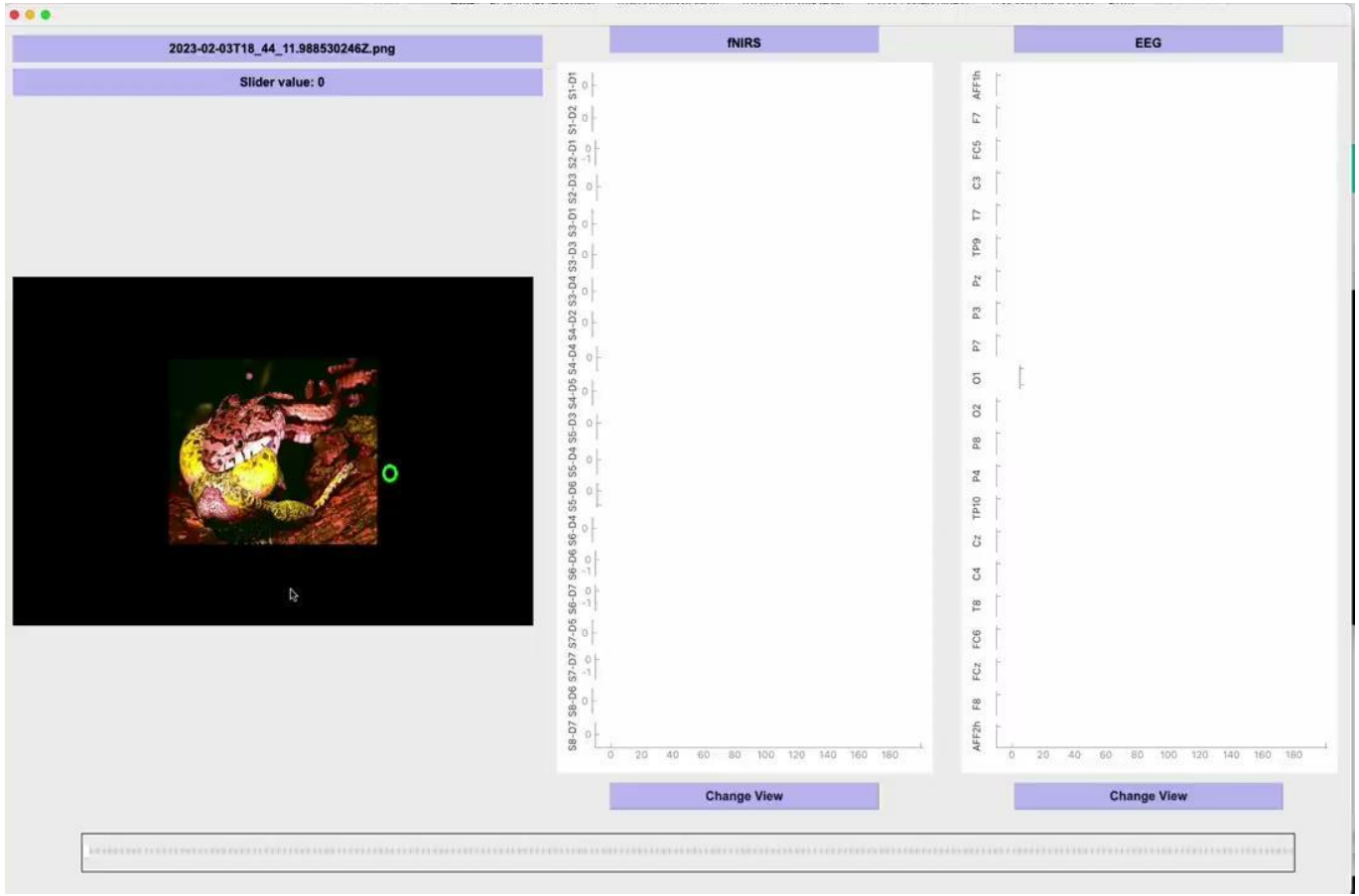
Affective State



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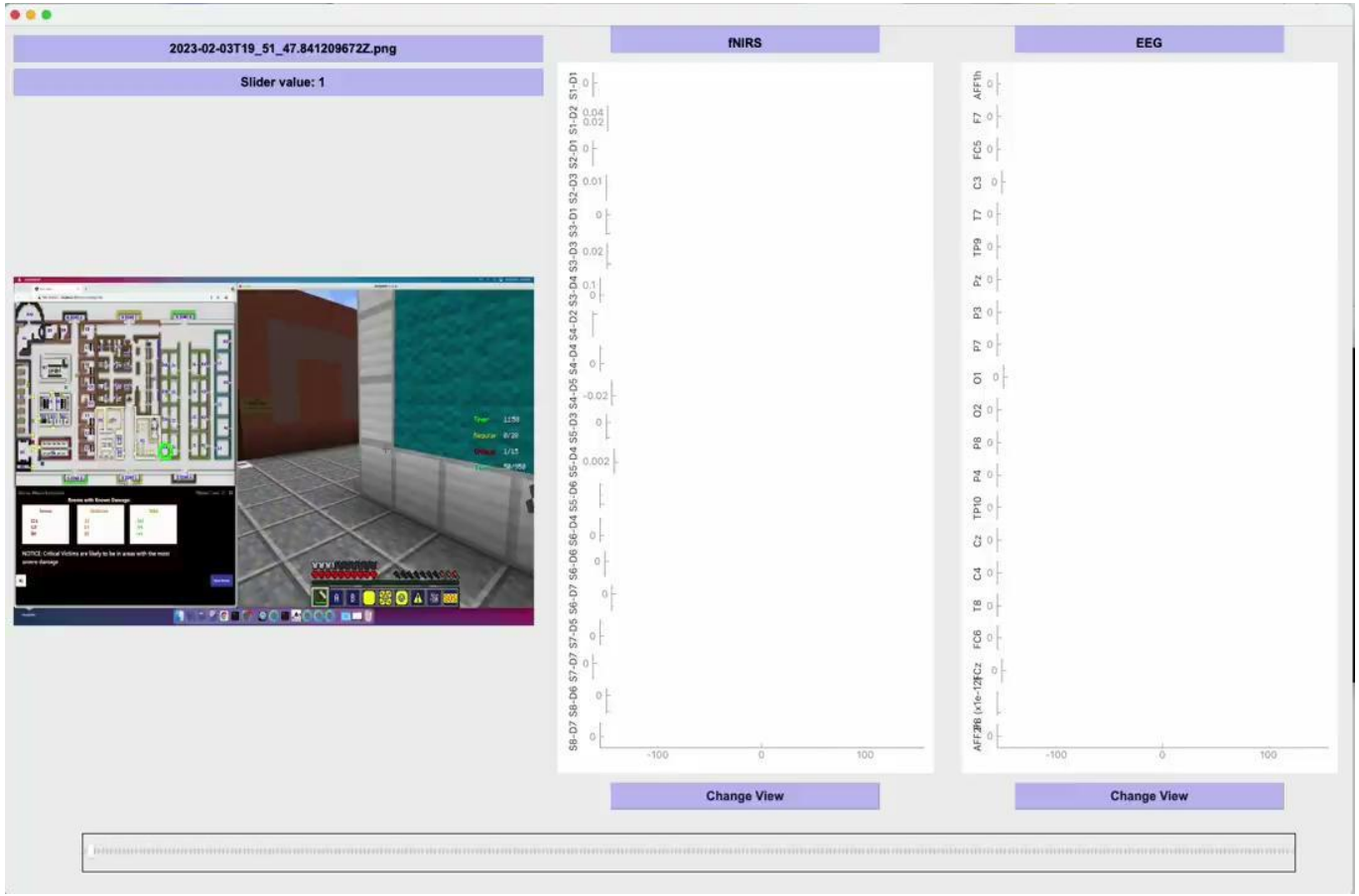
Minecraft


2023-02-03T19_51_47.84120967ZZ.png
Slider value: 1
fNIRS
EEG
Change View
Change View

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1. Pupil Labs. Pupil Player. Retrieved September 15, 2021, from https://docs.pupil-labs.com/core/software/pupil-player/.

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1. Kulkarni, A. M., Karyakarte, R. P., & Upadhyay, A. D. (2020). Determination of heavy metals in commercially available herbal formulations using Atomic Absorption Spectroscopy (AAS) and Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS). Scientific Reports, 10(1), 1-12. doi: 10.1038/s41598-020-57597-4.

Thank you

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Questions?