Data in Brief 53 (2024) 110260

Contents lists available at ScienceDirect

Data in Brief

journal homepage: www.elsevier.com/locate/dib

Data Article

A simultaneous EEG-fNIRS dataset of the visual cognitive motivation study in healthy adults

Tustanah Phukhachee[a], Thanate Angsuwatanakul[b], Keiji Iramina[c], Boonserm Kaewkamnerdpong[d,*]

[a] Computer Engineering Department, Faculty of Engineering, King Mongkut's University of Technology Thonburi, Bangkok 10140, Thailand
[b] College of Biomedical Engineering, Rangsit University, Pathum Thani 12000, Thailand
[c] Graduate School of Systems Life Sciences, Kyushu University, Fukuoka 819-0395, Japan
[d] Biological Engineering Program, Faculty of Engineering, King Mongkut's University of Technology Thonburi, Bangkok 10140, Thailand

A R T I C L E I N F O

Article history:
Received 23 January 2024
Revised 20 February 2024
Accepted 21 February 2024
Available online 27 February 2024

Dataset link: A simultaneous EEG-fNIRS dataset of the visual cognitive motivation study in healthy adults (Original data)

Keywords:
Educational neuroscience
Electroencephalography
Functional near-infrared spectroscopy
Intrinsic motivation
Memory
Visual cognitive motivation task

A B S T R A C T

This article described a publicly available dataset of the visual cognitive motivation study in healthy adults. To gain an in-depth understanding and insights into motivation, Electroencephalography (EEG) and functional near-infrared spectroscopy (fNIRS) were measured simultaneously at shared locations while participants performed a visual cognitive motivation task. The participants' choices in the cognitive motivation task were recorded. The effects of their motivation were identified in the recognition test afterward. This dataset comprised EEG and fNIRS data from sixteen healthy adults (age: 21- 37 years; 14 males and 2 females) during the cognitive motivation task with visual scenic stimuli. In addition, the motivation and the corresponding motivation effect were also provided. This dataset provides understanding and analyzing opportunities for the process of attention and decision while the brain undergoes an induced motivated state and its effect on the recognition performance.

* Corresponding author.
E-mail address: boonserm.kae@kmutt.ac.th (B. Kaewkamnerdpong).

https://doi.org/10.1016/j.dib.2024.110260
2352-3409/© 2024 The Author(s). Published by Elsevier Inc. This is an open access article under the CC BY-NC license (http://creativecommons.org/licenses/by-nc/4.0/)

© 2024 The Author(s). Published by Elsevier Inc.
This is an open access article under the CC BY-NC license
(http://creativecommons.org/licenses/by-nc/4.0/)

Specifications Table

Subject	Neuroscience: Cognitive
Specific subject area	Cognitive neuroscience, Motivation, Memory, Neuroimaging
Data format	EEG: Raw, Filtered (preprocessed epoch) fNIRS: Raw
Type of data	EEG signal – .edf fNIRS signal – .csv EEG trigger (annotations) – .txt Preprocessed EEG data – .mat Participant information and stimulus category – .xlsx EEG recording location – .ced Recording graphical location – .pdf
Data collection	Sixteen healthy adult participants with no prior visual perception or memory disorders were recruited. EEG-fNIRS data were simultaneously measured at 32 shared locations based on the international 10/20 system while the participants performed visual cognitive motivation tasks. After a 10-minute break, the participants took a recognition test. The fNIRS data were measured by Hitachi ETG-7100 with a 10 Hz sampling frequency. Nihon Kohden Neurofax EEG-1100 was used for EEG recording within a sampling frequency of 500 Hz. The raw EEG signals were preprocessed using MATLAB (R2014b) with open source toolbox EEGLAB v13.4.4b.
Data source location	Institution: Kyushu University City/Town/Region: Fukuoka Country: Japan
Data accessibility	Repository name: Mendeley Data Data identification number: 10.17632/z92nw4n73t Direct URL to data: https://data.mendeley.com/datasets/z92nw4n73t
Related research article	T. Phukhachee, S. Maneewongvatana, T. Angsuwatanakul, K. Iramina and B. Kaewkamnerdpong, Investigating the Effect of Intrinsic Motivation on Alpha Desynchronization Using Sample Entropy, Entropy 21(3) (2019), 237. https://doi.org/10.3390/e21030237

1. Value of the Data

- This dataset was procured from a visual cognitive motivation experiment. The brain activity data (EEG and fNIRS) are suitable for studying brain functions related to attention and recognition under the effect of motivation [1,2].
- A multimodal approach of simultaneous EEG-fNIRS, in which two data that complement each other are measured at the same time and locations, offers the potential for better information on brain activity as opposed to each individual method [3,4].
- The data can be used for analyzing brain signals to understand the relationship among attention, motivation, and recognition processes within human brains.
- The data can also be used to build and validate classification models and brain networks that help identify the patterns and characteristics of brain data related to attention, motivation, and recognition for related brain-computer interface (BCI) applications.
- This data can be useful for researchers in various fields. For example, more information on brain activity relating to motivation from the multimodal approach can help neuroscientists study the process related to motivation more thoroughly. The combination of motivation and their corresponding effect could provide information on effective-motivated brain processes for learning and BCI applications of innovative learning in education and biomedical engineering fields.

2. Background

Motivation has various positive influences on human activity and has been a topic of interest in the educational psychology field. To gain an in-depth understanding and insights into motivation, we must learn from the related brain activity during motivation events. Brain activity signals can be acquired with various methods. Each modality has its own strengths and weaknesses. EEG and fNIRS were chosen because they are non-invasive methods, relatively inexpensive, and flexible for use in real-world environments. Additionally, the strengths of each method can help overcome the weaknesses of the other. EEG has high temporal resolution but low spatial resolution, while fNIRS has relatively low temporal resolution with relatively high spatial resolution and is also robust to noise. The simultaneous EEG-fNIRS measurement allows us to obtain both electrophysiological and hemodynamical brain activity data with high temporal and spatial resolution at the same time and locations. This data should provide better opportunities to capture and thoroughly understand brain activity related to motivation, which later leads to cognition in humans. Our previous study [1] used the dataset and found a significant difference in the continuous alpha desynchronization pattern between motivation effects while the participant was motivated.

3. Data Description

The dataset includes simultaneously measured EEG and fNIRS signals at shared locations during the cognitive motivation experiment of 16 healthy participants. The experiment was divided into two parts: the cognitive motivation task and the recognition test. The brain activity signals were collected only when the participants performed cognitive motivation tasks. The participants can freely choose whether they want to remember the scenic stimulus or not. The results from the recognition test were used to determine whether the participants could recognize the scene later on. From the experiment, the trials from each participant can be divided into four categories based on the motivation and resulting recognition: Want-to-Remember and Remembered (RR), Want-to-Remember but Forgot (RF), Do-Not-Want-to-Remember but Remembered (FR), and Do-Not-Want-to-Remember and Forgot (FF).

The main folder of this dataset contains the files that provide the overall information of the experiment, including

- "Participant_information.xlsx", which contains the information on each participant, including age and gender;
- "Graphical_recording_head_model.pdf", which is the graphical head model illustrating all recording locations of EEG electrodes and fNIRS optodes;
- "Raw_EEG_channel_reference.xls", which contains the mapping information between the EEG channel label from the machine and the standard EEG channel name;
- "fNIRS_to_EEG_channel_reference.xlsx", which contains the mapping information between the fNIRS channel number and the correlated EEG channel name (Probe1 is the locations on the left hemisphere of the head while Probe2 is the right hemisphere of the head);
- "Location.ced", which provides the EEG electrode locations in a channel data file format (.ced) for EEGLAB;
- "Total_epoch.xlsx", which provides the total number of epochs for each motivation-recognition category (RR, RF, FR, and FF) of all participants;
- "EEG_temporal_period_scale.mat", which is a binary MATLAB file format (.mat) that contains the variable named "times" (with size 1×6500) representing temporal scale in milliseconds for each preprocessed EEG data epoch given in the dataset.

The data for each participant was provided in separate folders titled by their ID, S01-S16. Each participant folder contains the EEG and fNIRS data in separate subfolders. Fig. 1 shows the

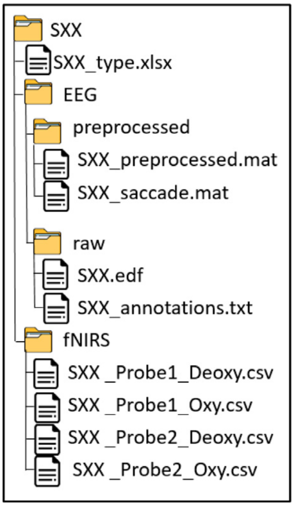

Fig. 1. The folder structure of EEG and fNIRS data for each participant in this study.

example of the data folder structure for each participant, where *XX* represents the participant ID.

For each participant, the motivation-recognition types for each data epoch are provided in the file "*SXX_type.xlsx*". In the EEG subfolder, the raw and preprocessed data were provided in separate folders. The raw EEG data are in the form of continuous EEG data in European data format (.edf) named "*SXX.edf*". During each trial in the experiment, there are three trigger events. This includes the stimulus appearing, the stimulus disappearing, and the response given; the onset time for all events is provided in the form of an identical trigger ("Annotation") DC9 in text file format (.txt) named "*SXX_annotations.txt*." For some participants, the experimental data may be separated into two parts because a short break was requested during the experiment. In such cases, the part number is added in the filename, for example, "*SXX_part1.edf*", "*SXX_part2.edf*", "*SXX_part1_annotations.txt*", and "*SXX_part2_annotations.txt*".

The preprocessed EEG data are in binary MATLAB file format (.mat) named "*SXX_preprocessed.mat*". Each MATLAB file contains four cognitive motivation variables (RF, RR, FF, and FR); the epoch data are separated into four cognitive motivation categories. Each variable contains 3-dimension matrix data: channel, temporal period, and epoch. The epochs that are determined to have saccade characteristics were removed from the preprocessed data and recorded in MATLAB file format named "*SXX_saccade.mat*".

The fNIRS subfolder provides the raw data in comma-separated values file format (.csv) from the measurement machine (Hitachi NIRS ETG-7100). Because there are two probe sets, the fNIRS data are separated into two files. The fNIRS machine measures the hemodynamic response in terms of oxygenated (Oxy) and deoxygenated (Deoxy) hemoglobin with a sampling frequency of 10 Hz. The data files are separated into two files for oxygenated and deoxygenated hemoglobin. Hence, for each participant, the raw fNIRS data are contained in four files: "*SXX_Probe1_Deoxy.csv*", "*SXX_Probe1_Oxy.csv*", "*SXX_Probe2_Deoxy.csv*", and "*SXX_Probe2_Oxy.csv*". For the participants who needed a short break during the experiment, the file names are indicated with the part number, e.g., "*SXX_Part1_Probe1_Deoxy.csv*" and "*SXX_Part2_Probe1_Deoxy.csv*". In each file, the rows of the fNIRS data indicate the data for different times. The three events occurring during each trial are shown in column "*Mark*," where 1 represents when the stimulus appeared, 2 represents when the stimulus disappeared, and 3 represents when the response was given.

4. Experimental Design, Materials and Methods

4.1. Participants

The inclusion criteria of this experiment are healthy individuals in their adulthood with no prior visual perception or memory disorders. We estimated the sample size for this study according to the Lemeshow method [5]. We used the parameters derived from Yoo et al. [2], which studied a similar cognitive motivation task; however, the data was obtained using functional magnetic resonance imaging (fMRI) measurement instead of fNIRS. Since the participants can freely determine whether or not they want to remember the stimulus, the population proposition (P) was set as 0.5. For each choice of their determination, the result can be either want-to-remember or do-not-want-to-remember. Therefore, the 0.25 absolute precision for minimum sample size estimation was used in this minimum sample size estimation. By applying the functions of the confidence level estimation methodology [5], a minimum of 15 participants was required to ensure a sound, statistically robust representation for analytical purposes (95% confidence level).

There were 16 participants recruited with informed consent. The participants were 14 male and 2 female adults, aged between 21 and 37. All experimental procedures were approved by the Experimental Ethics Committee of the Faculty of Information Science and Electrical Engineering, Kyushu University.

4.2. Experimental procedure

The visual cognitive motivation experiment was divided into two parts: a cognitive experiment and a recognition test. In the cognitive experiment, participants were presented with random, unique visual stimuli, which were indoor or outdoor scenes from the Scene UNderstanding (SUN) database [6]. Each stimulus was displayed on the screen for 3 s. This period is referred to as an attention period. After that, the screen was changed to illustrate the fixation cross. The fixation screen was shown for 9 s. During this period, the participant was allowed to decide freely whether they would like to remember the scene. This period is referred to as a decision period. The response was made by clicking mouse buttons: the left button for the case where they wanted to remember the stimulus scene and the right button for the case where they did not want to remember the stimulus scene. There was no constraint in the participant's decision; hence, the number of responses for the motivation types from one participant could be different from another. The 9 s during the decision period seems longer than required for the EEG experiment; however, it was set for the hemodynamic response measurement with fNIRS. The long decision period may reveal some interesting characteristics in a hemodynamic change of the fNIRS modality. After the decision period, the screen was changed to illustrate another stimulus scene. To amend the effect of repetition suppression (RS), a random brief delay was added between the decision period and the appearance of the following stimulus. This procedure is presented in Fig. 2.

After 250 scenes, the cognitive experiment ended. With this setup, each cognitive experiment was completed in around 50 minutes for each participant. This excludes the setup time and

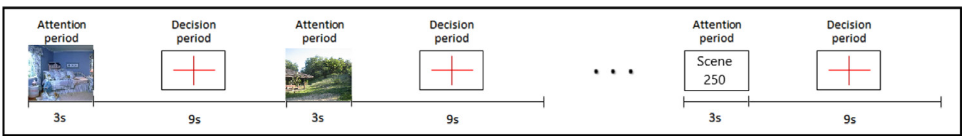

Fig. 2. The motivation-based cognitive experimental procedure used to gather the simultaneous EEG-fNIRS data in this study.

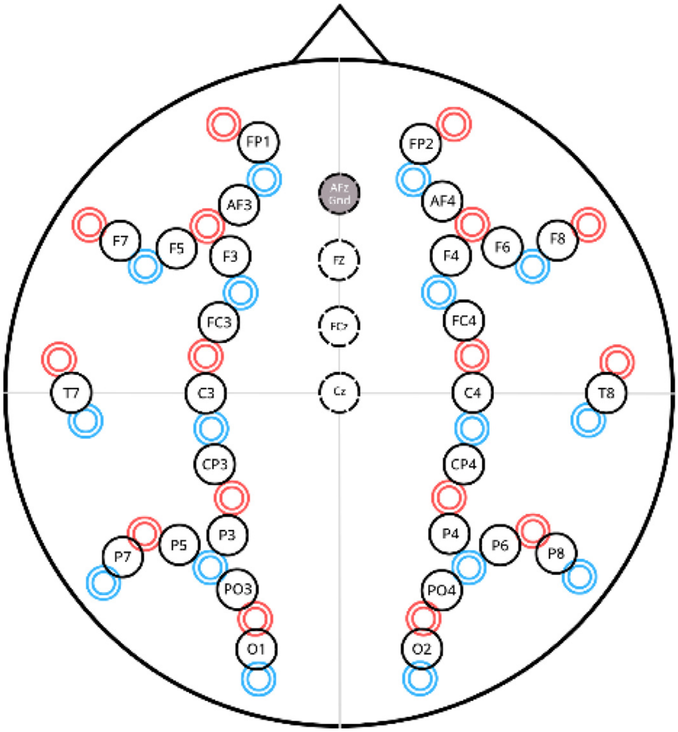

Fig. 3. The graphical recording head model for EEG and fNIRS recording locations for the cognitive motivation experiment task.

the short break requested by participants. The participants rested for 10 minutes. The scene recognition test was then started. In the recognition test, 500 random scenes comprising 250 scenes from the cognitive experiment and 250 new scenes were presented one by one. The participants answered whether they could recognize the scenes in the cognitive experiment or not. This recognition test was used to confirm the effect of motivation during the experiment. There are no time constraints. The brain signals were not measured during this recognition test.

4.3. Equipment

During the cognitive experiment, the Nihon Kohden Neurofax EEG-1100 equipment with 32 electrodes was used to measure EEG data with a sampling frequency of 500 Hz. The fNIRS signals were obtained using fNIRS Hitachi ETG-7100. The recording locations for both modalities are illustrated in Fig. 3. With this setup, both electrophysiological and hemodynamical data can be measured simultaneously at the same location. The mapping information for the correlated fNIRS channels to the EEG electrodes is provided in the file "*fNIRS_to_EEG_channel_reference.xlsx*".

4.4. EEG dataset and EEG data preprocessing

The data were preprocessed using MATLAB (R2014b) with the open-source toolbox EEGLAB v13.4.4b [7]. First, the data was mapped to their corresponding electrode locations. Then, average referencing was applied. The average referencing was conducted by using the *reref* function from the EEGLAB toolbox. The method subtracts the average potential of all electrodes from each electrode signal for each time point. The bandpass filter of 0.5–50 Hz and a notch filter of 60 Hz was applied to remove physiological and power line noise, respectively.

The signals were marked into epochs corresponding to their responsive event regarding stimulus onset. Each epoch in this dataset contains data from 1 second before the stimulus being presented to 12 s after the stimulus appeared. The temporal scale in milliseconds for these preprocessed EEG data of each epoch was given in the "*EEG_temporal_period_scale.mat*" file. The epochs with a voltage higher than 500 μV or lower than −500 μV were considered abnormal value epochs and discarded. The epochs were then analyzed with Independent Component Analysis (ICA). The independent components related to eye-blinking artifacts were removed. Lastly, the epoch that has a saccade characteristic was discarded. In addition, all epochs with no response received during their decision period were excluded.

The data epochs of each participant were categorized based on their motivation and resulting recognition into four categories: Want-to-Remember and Remembered (RR), Want-to-Remember but Forgot (RF), Do-Not-Want-to-Remember but Remembered (FR), and Do-Not-Want-to-Remember and Forgot (FF). The preprocessed data in this dataset includes 1426 epochs for the Want-to-Remember case (R); 1094 epochs resulted in the Remembered case (RR), whereas 332 epochs resulted in the Forgot case (RF). There are 1618 epochs for the Do-Not-Want-to-Remember case (F); 1092 epochs resulted in the Remembered case (FR), whereas 526 epochs resulted in the Forgot case (FF). The information on the number of epochs for each participant was included in the file "*Total_epoch.xlsx*".

4.5. fNIRS dataset

In this dataset, the fNIRS data were provided in raw format from the measurement machine (fNIRS Hitachi ETG-7100 equipment). However, the participants' identification information has been removed and set as participant ID format (S01-S16) for ethical purposes. No further processing was done on the fNIRS dataset.

Limitations

The data in this dataset were acquired from the Asian population, whose ages ranged from 21 to 37 years old. Therefore, this data may not be able to represent the general population, especially for older and younger generations. Due to the long period of the experiment, the raw data of some participants in this dataset may contain a high number of EEG epochs with saccade characteristics. However, these epochs were removed in the EEG preprocessed data.

Ethics Statement

The experiment was carried out in accordance with the Declaration of Helsinki. All participants in the experiment of this dataset volunteered, read, and signed written informed consent. The experiment was approved by the Experimental Ethics Committee of the Faculty of Information Science and Electrical Engineering, Kyushu University (ISEE H26-3, 23 June 2014).

Data Availability

A simultaneous EEG-fNIRS dataset of the visual cognitive motivation study in healthy adults (Original data) (Mendeley Data).

CRediT Author Statement

Tustanah Phukhachee: Methodology, Software, Writing – original draft; **Thanate Angsuwatanakul:** Resources, Data curation; **Keiji Iramina:** Conceptualization, Supervision; **Boonserm Kaewkamnerdpong:** Conceptualization, Project administration, Writing – review & editing, Investigation, Funding acquisition.

Acknowledgements

This work was supported by the Hitachi Scholarship Foundation. The first author is grateful for the support of Petchra Pra Jom Klao Ph.D. Research Scholarship from King Mongkut's University of Technology Thonburi, Thailand.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] T. Phukhachee, S. Maneewongvatana, T. Angsuwatanakul, K. Iramina, B. Kaewkamnerdpong, Investigating the effect of intrinsic motivation on alpha desynchronization using sample entropy, Entropy 21 (3) (2019) 237.
[2] J.J. Yoo, O. Hinds, N. Ofen, T.W. Thompson, S. Whitfield-Gabrieli, C. Triantafyllou, J.D Gabrieli, When the brain is prepared to learn: enhancing human learning using real-time fMRI, Neuroimage 59 (1) (2012) 846–852.
[3] T. Angsuwatanakul, J. O'Reilly, B. Kaewkamnerdpong, K. Ounjai, K. Iramina, Multiscale entropy as a new feature for EEG and fNIRS analysis, Entropy 22 (2) (2020) 189.
[4] R. Li, D. Yang, F. Fang, K.-S. Hong, A.L. Reiss, Y. Zhang, Concurrent fNIRS and EEG for brain function investigation: a systematic methodology-focused review, Sensors 22 (15) (2022) 5865.
[5] K.S. Lwanga, S. Lemeshow, Sample Size Determination in Health Studies: A Practical Manual, World Health Organization, 1991.
[6] J. Xiao, J. Hays, K.A. Ehinger, A. Oliva, A. Torralba, SUN Database, Large-scale scene recognition from Abbey to Zoo, in: IEEE Computer Society Conference on Computer Vision and Pattern Recognition, San Francisco, CA, USA, 2010, pp. 3485–3492.
[7] A. Delorme, S. Makeig, EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis, J. Neurosci. Methods 134 (1) (2004) 9–21.