

# Simultaneous Acquisition of EEG and NIRS during Cognitive Tasks for an Open Access Dataset

We provide an open access multimodal brain-imaging dataset of simultaneous electroencephalography (EEG) and near-infrared spectroscopy (NIRS) recordings. Twenty-six healthy subjects performed three standard cognitive tasks: 1) n-back (0-, 2- and 3-back), 2) Go/No-go, and 3) verbal fluency tasks. The data provided includes: 1) measured data, 2) demographic data, and 3) basic analysis results. For n-back (dataset A) and Go/No-go tasks (dataset B), event-related potential (ERP) analysis was performed, and spatiotemporal characteristics and classification results for “target” vs. “non-target” (dataset A) and “Go” vs. “No-go” (dataset B) are provided. Time-frequency analysis was performed to show the EEG power spectrum to differentiate the task-relevant activations. Spatiotemporal characteristics of hemodynamic responses are also shown. For the verbal fluency task (dataset C), the EEG power spectrum and spatiotemporal characteristics of hemodynamic responses are analyzed, and the potential merit of hybrid EEG-NIRS BCIs was validated with respect to classification accuracy. We expect that the dataset provided will facilitate performance evaluation and comparison of many neuroimaging analysis techniques.

## Data Acquisition

EEG data was recorded using a multichannel BrainAmp EEG amplifier (Brain Products GmbH, Gliching, Germany) at 1000 Hz sampling rate. Thirty EEG active electrodes were placed on a stretchy fabric cap (EASYCAP GmbH, Herrsching am Ammersee, Germany) according to the international 5-5 system (Fp1, Fp2, AFF5h, AFF6h, AFz, F1, F2, FC1, FC2, FC5, FC6, Cz, C3, C4, T7, T8, CP1, CP2, CP5, CP6, Pz, P3, P4, P7, P8, POz, O1, O2, TP9 (reference) and TP10 (ground)). The EEG amplifier was also used to measure the electrooculogram (EOG).

NIRS data was acquired with a NIRScout (NIRx Medizintechnik GmbH, Berlin, Germany) at a sampling rate of 10.4 Hz. Sixteen sources and sixteen detectors were placed at frontal (sixteen channels around AFz, AF3, AF4, AF7 and AF8), motor (four channels each around C3 and C4), parietal (four channels each around P3 and P4), and occipital (four channels around POz) areas. An adjacent source-detector pair configures a physiological channel; 36 physiological channels were configured. The physical NIRS channels, each of which was composed of a pair of a source and a detector, were created around AFpz, AFp3, AFp4, AFp7, AFp8, AF1, AF2, AF5h, AF6h, AF7, AF8, AFFz, AFF3h, AFF4h, AFF5, AFF6, FCC3, FCC4, C3h, C4h, C5h, C6h, CCP3, CCP4, CPP3, CPP4, P3h, P4h, P5h, P6h, PPOz, PPO3, PPO4, PO1, PO2, and POOz. The source-detector distance was set to 30 mm for all the channels. NIRS optodes were fixed on the same cap as the EEG electrodes. NIRS physiological channels are located on (pre)frontal (sixteen channels), motor (four channels around C3 and C4 each), parietal (four channels around P3 and P4 each), and occipital areas (four channels around POz).

EOG was recorded using two vertical (above and below the right eye) and two horizontal (outer canthus of each eye) disposable electrodes at the same sampling rate as the EEG data.

## Data Organization

### *Data Structure*

Please refer to [basic data structures of the BBCI Toolbox](#).

## EEG data

- **cnt**: continuous EEG data including EOG

**cnt\_nback**: cnt for n-back task (3 blocks are concatenated)

**cnt\_gonogo**: cnt for Go/No-go task (3 blocks are concatenated)

**cnt\_vf**: cnt for verbal fluency task (3 sessions are concatenated)

- **mrk**: task onset markers

**mrk\_nback**: mrk for n-back task.

Number	Description	Number	Description
16	0-back target	96	3-back non-target
48	2-back target	112	0-back session
64	2-back non-target	128	2-back session
80	3-back target	144	3-back session

**mrk\_gonogo**: mrk for Go/no-go task.

Number	Description
16	Go
32	No-go
48	session

**mrk\_vf**: mrk for verbal fluency task.

Number	Description
16	verbal fluency
32	baseline

## NIRS data

- **cnt**: continuous NIRS data

**cnt\_nback**: cnt for n-back task (3 blocks are concatenated)

- **.deoxy**: deoxy hemoglobin data

- **.oxy**: oxy hemoglobin data

**cnt\_gonogo**: cnt for Go/No-go task (3 blocks are concatenated)

- **.deoxy**: deoxy hemoglobin data

- **.oxy**: oxy hemoglobin data

**cnt\_vf**: cnt for verbal fluency task (3 sessions are concatenated)

- **.deoxy**: deoxy hemoglobin data

- **.oxy**: oxy hemoglobin data

- **mrk\_nback**: mrk for n-back task

Number	Description
7	0-back session
8	2-back session
9	3-back session

- **mrk\_gonogo**: mrk for Go/No-go task

Number	Description
3	Go/No-go session

- **mrk\_vf**: mrk for verbal fluency task

Number	Description
1	verbal fluency
2	baseline

## Download

Data was downsampled to 200 Hz (EEG) and 10 Hz (NIRS). Any signal processing method was not applied to the raw data except the methods described below:

EEG: data conversion to MATLAB compatible format

NIRS: data conversion to MATLAB compatible format

## Citation

We would be grateful if you cite following articles:

1. Jaeyoung Shin, Alexander von Lühmann, Do-Won Kim, Jan Mehnert, Han-Jeong Hwang and Klaus-Robert Müller, "Simultaneous Acquisition of EEG and NIRS during Cognitive Tasks for an Open Access Dataset, *Scientific Data*, submitted.
2. Jaeyoung Shin, Alexander von Lühmann, Benjamin Blankertz, Do-Won Kim, Han-Jeong Hwang and Klaus-Robert Müller, "Open Access Dataset for EEG+NIRS Single-Trial Classification," *IEEE Trans. Neural Syst. Rehabil. Eng.*, in press
3. Blankertz B, Tangermann M, Vidaurre C, Fazli S, Sannelli C, Haufe S, Maeder C, Ramsey LE, Sturm I, Curio G, Mueller KR, The Berlin Brain-Computer Interface: Non-Medical Uses of BCI Technology, *Open Access Front Neuroscience*, 4:198, 2010.