EEG/NIRS Dataset During Mental Arithmetic and Word Chain

Contact: Han-Jeong Hwang (h2j@kumoh.ac.kr)

Citation: Jaeyoung Shin, Do-Won Kim, Klaus-Robert Müller*, Han-Jeong Hwang*, “Improvement of information transfer rate by hybrid EEG-NIRS brain-computer interface with short task duration: offline and pseudo-online analyses”, Sensors, 18(6), 1827, 2018.

Experimental Paradigm

The participants sat on a comfortable armchair in front of a 50-inch white screen. The distance between the participants and the screen was approximately 1.6 m. The experiment was composed of three sessions involving three types of tasks: MA, WC, and baseline (BL). During the MA task, the participants were instructed to perform continuous single digit (between 6 and 9) subtraction from a random three-digit number (e.g., 567-8: 567-8 = 559, 559-8 = 551, 551-8 = 543, etc.). During the WC task, the participants were instructed to continuously come up with a word starting with the last letter of a former word (e.g., in English: B: Boy–year–rabbit–tree, etc.) as fast as possible. The participants were instructed to avoid repeating the same words. The WC task was performed in the participants’ native language (Korean). Because the first letter changed depending on the word the participants came up with, it was difficult to control the level of task difficulty with the initial letter of the WC task. Thus, different initial letters were presented for the participants to avoid getting used to the task. The participants reported that they had produced approximately four to five words for each trial. During the MA and WC tasks, the participants did not articulate the answers because lip motions may have contaminated the EEG and NIRS signals. However, an experimental supervisor educated the participants on how to perform the task prior to the experiment, and the supervisor repeatedly asked the participants to be get involved in the experiment sincerely at the end of every single session. For the BL, the participants were asked to relax without any thoughts. Figure 1 shows a schematic diagram of the experimental paradigm. Before and after a session, pre- and post-rest were conducted for 1 min with a fixation cross displayed on the screen. A single session comprised 30 trials (10 repetitions per task). Each trial started with 2 s corresponding to the visual introduction of the task. In the instruction period, an initial calculation problem (a random three-digit number minus a single-digit number between 6 and 9) or a single letter was given for the MA and WC tasks, respectively. A fixation cross was displayed for the BL. After the instruction period, a task period of 5 s, which was shorter than that of previous studies (10 s). A fixation cross was shown to avoid unnecessary ocular movement. The task period ended with a “STOP” sign on the screen and was followed by a resting period that was randomly assigned between 13 and 15 s. At the beginning and end of the task period, a short beep (250 ms) was played. All instructions were displayed on the screen by a video projector.

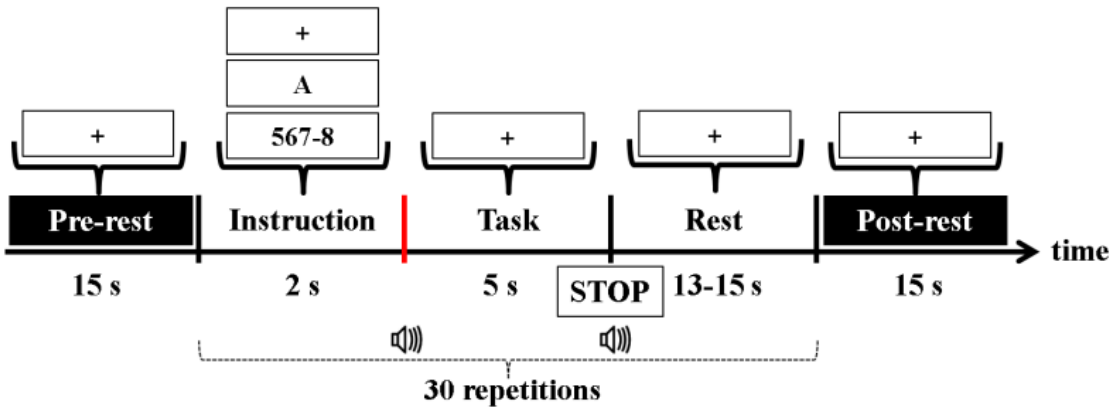

Figure 1. Schematic sequence diagram of the experimental paradigm for one session. Each session consists of a 15-s resting period, 30 repetitions of a given task, and a 15-s resting period. Each task starts with a 2-s visual introduction, followed by a 5-s task period and a 13–15-s rest period starting with a "STOP" sign on the screen for 2 s. At the beginning and end of the task period, a short beep was played for 250 ms. At the instruction, +, A, and 567-8 indicate the baseline (BL), word chain (WC), and mental arithmetic (MA) tasks, respectively. The red vertical line indicates the task onset. The task onset was the time when the participants started to perform the numerical calculation (MA), state words (WC), and be relaxed (BL).

Data recording

The EEG data were recorded by the BrainAmp EEG amplifier (Brain Products GmbH, Gilching, Germany) with a linked mastoids reference at a sampling rate of 1000 Hz after analog band-pass filtering from 0.016 to 1000 Hz. Twenty-two active electrodes were fixed on a custom-made elastic cap (EASYCAP GmbH, Herrsching, Germany) and placed at AFp1, AFp2, AFF1h, AFF2h, AFF5h, AFF6h, F3, F4, F7, F8, Cz, C3, C4, T7, T8, Pz, P3, P4, P7, P8, POO1, and POO2. The ground electrode was placed on Fz [28]. The NIRS data were recorded by NIRScout (NIRx GmbH, Berlin, Germany) at a sampling rate of 12.5 Hz. Five light sources and three detectors resulting in nine channels were fixed on the same cap as the EEG electrodes around Fpz. The inter-optode distance was 30 mm. Figure 1 shows the placement of the EEG electrodes and NIRS channels. The EEG electrodes were uniformly distributed over the scalp. However, because it is widely known that brain activity related to MA and WC tasks is observed in the (pre)frontal area [31,43,44], EEG electrodes located in the (pre)frontal area were only employed for the data analysis (see Figure 1). The NIRS channels were originally located only on the prefrontal cortex (PFC). The EEG amplifier was also used to measure the EOG that was recorded at the same sampling rate as that of the EEG using two vertical (above and below the left eye) and two horizontal (the outer canthus of each eye) electrodes. The EEG, NIRS and EOG signals were simultaneously recorded. To synchronize the signals, external triggers were sent to each amplifier through parallel ports using MATLAB (MathWorks, Natick, MA, USA).

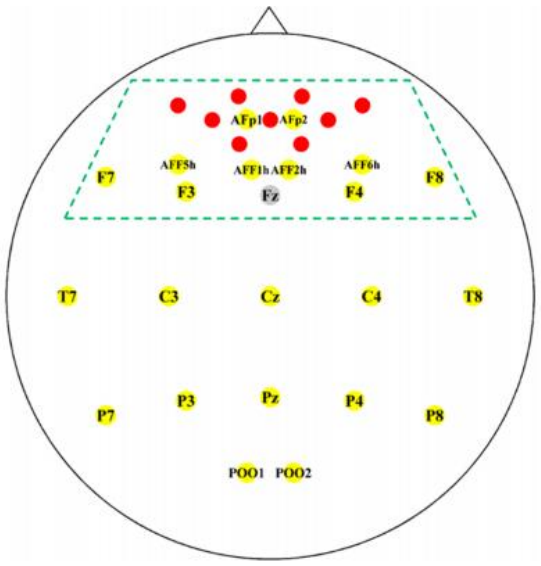

Figure 2. Placement of the EEG electrodes (yellow with labels) and the location of the NIRS channels (red). A ground electrode (gray) was located at Fz. An NIRS channel was created by a pair of neighboring source and detector optodes. Only EEG and NIRS channels within the (pre)frontal area denoted by the green dashed line were used for the data analysis

Data file description

The MATLAB-compatible resource (in vendor-agnostic format) consists of EEG/EOG data and NIRS data separately. The name of each zip file consists of participant code and modality, e.g., “VP001-EEG” for EEG data and “VP001-NIRS” for NIRS data. Each zip file has continuous data (cnt), marker (mrk), and montage (mnt) for datasets A-C each. Each file comprises of MATLAB structure array with several fields. For NIRS data, the cnt files contain deoxy/oxy-hemoglobin data as separate fields. For data structure information, please refer to the BBCI toolbox.