Ear-EEG Dataset During Mental Arithmetic

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

Citation: Soo-In Choi, Chang-Hee Han, Ga-Young Choi, Jaeyoung Shin, Kwang Soup Song, Chang-Hwan Im, Han-Jeong Hwang*, " Feasibility of Using Ear-EEG to Develop an Endogenous Brain-Computer Interface", Sensors, August 29, 2018.

Experimental Paradigm

Eighteen healthy individuals were recruited for this study (21–31 years of age; mean 24.5 ± 2.67 years, 10 males and eight females). Figure 1 shows the schematic diagram of the main experiment conducted to confirm whether an endogenous BCI paradigm can be realized using only ear-EEG. Two cognitive tasks, MA and LC, were employed in the main experiment. During MA, the subjects were instructed to sequentially subtract a single-digit number (between 5 and 9) from a three-digit number (e.g., 594 − 8). Fifty pairs of 3-digit and 1-digit numbers were randomly selected and presented to each subject, but the order of the 50 MA tasks was same between the subjects. We asked subjects to perform the consecutive subtraction as quickly as possible during the task period. During LC, they were instructed to mentally imagine vocalization of English letters from A to Z at 1 Hz without vocalization. The LC task was designed to maintain a steady and constant level of light cognitive load, which was introduced because subjects tend to randomly think something that might disturb the low loading state in a conventional resting state. All subjects completed five sessions. Each experimental session started with an initial resting state in which a blank was first displayed for 5 s, which was followed by resting state where the string 'ABC' with an asterisk were presented. The subjects imagined vocalization of the English alphabet for 10 s while focusing on the asterisk at the center of a monitor screen that was used as a fixation mark to prevent severe ocular movement. A single trial was comprised of a task instruction of 5 s, followed by a task period of 10 s with a black fixation cross, and a variable resting period ranging from 10–15 s. During the task instruction period, either the MA problem or the 'ABC' string (LC) was randomly displayed on the screen for 5 s. The task started by presenting a black fixation cross that lasted for 10 s, during which the subjects performed either MA or LC according to an instruction presented on the monitor. The task period was followed by rest. A short beep was presented for 300 ms at every screen transition to provide subjects with explicit information of screen transition. Each session consisted of 10 MA and 10 LC trials, and a short break was given for several minutes between sessions. All subjects performed 50 MA and 50 LC trials (10 trials × 5 sessions).

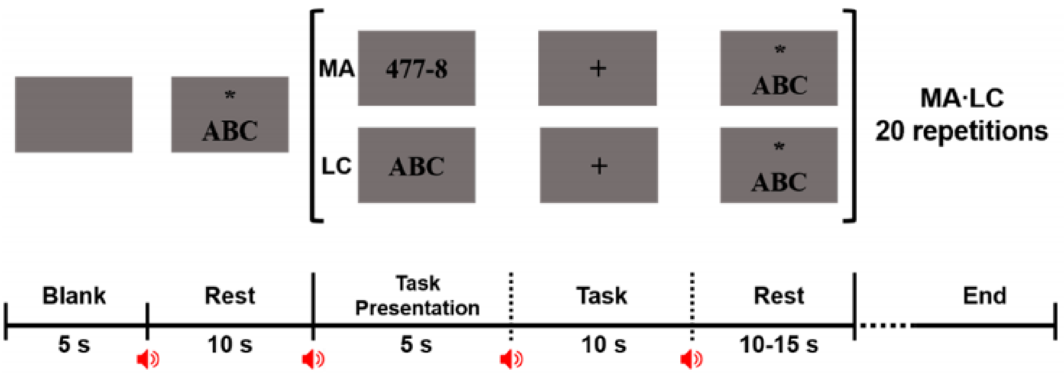

Figure 1. Experimental paradigm

Data recording

EEG data were recorded in a sound-proof room, and subjects were seated in a comfortable armchair in front of a 21-inch monitor about 1 m away. During the experiment, the subjects were asked to refrain from any body movement to minimize physiological artifacts. A binaural audio system (Britz, BR-1000A, Cuve Black2, Paju-si, South Korea) was placed on both sides of the monitor, and it provided the subjects with auditory cues during the experiment. EEG data were recorded using thirty-one electrodes of a multi-channel EEG apparatus (Brain Products, GmbH, Gilching, Germany). Scalp-EEGs were measured using twenty-five electrodes attached to the scalp according to the international 10–20 system (Fp1–2, Fz, F3–4, 7-8, FC5–6, Cz, C3–4, T7–8, CP1–2, Pz, P3–4, 7–8, PO7–8, O1, and O2), while ear-EEG data were measured using six electrodes attached behind the ears (three electrodes for each ear). In order to measure ear-EEG, we first cleaned the skin behind the ears using an alcohol, a double-sided sticker was attached on the skin, a rubber ring holder was mounted on the sticker, and an electrode was inserted into the holder. Same types of electrodes were used to measure both scalp- and ear-EEG. The detailed information of electrode positions for scalp-EEG and ear-EEG is illustrated in Figure 1. Reference and ground electrodes were attached at FCz and Fpz, respectively. The sampling rate was 1000 Hz, and impedance was maintained below 10 kΩ during the entire experiment. The scalp- and ear-EEG were independently re-referenced before the analysis.

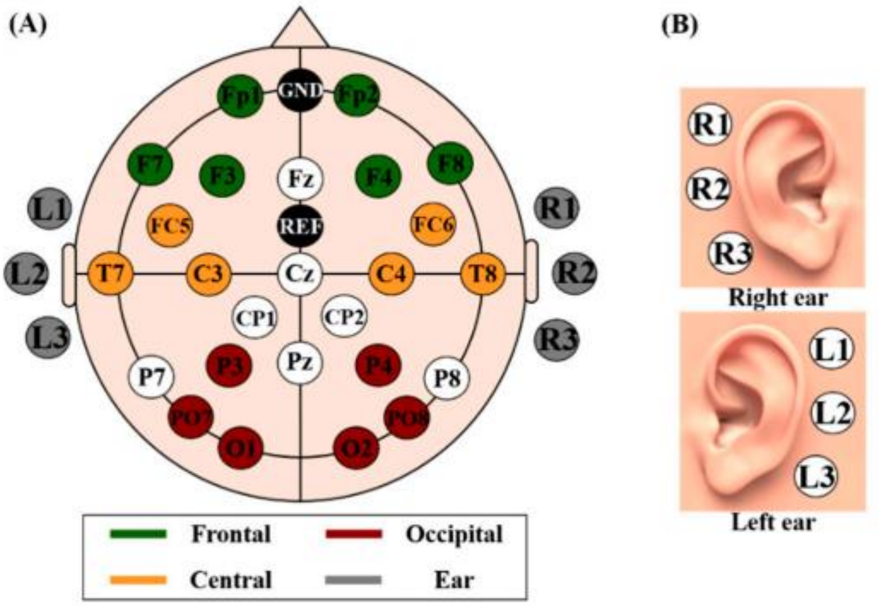

Figure 2. Electrode positions used to record EEG data. (A) The brain area is divided into four regions of interests (ROIs) for data analysis (frontal, central, occipital, and ear area). (B) The electrode placement for ear-EEG

Data file description

The MATLAB-compatible resource (in vendor-agnostic format) consists of EEG data. The name of each zip file consists of date of data measurement and subject name, e.g., “20170707_YHY” for EEG data. Each zip file has continuous data (cnt), marker (mrk), and montage (mnt) for 5 sessions. Each file comprises of MATLAB structure array with several fields. For data structure information, please refer to the BBCI toolbox. The description text file of the uploaded dataset explains the data structure in more detail.