MI-OpenBCI: Grasping Movement vs. Relax EEG Dataset acquired with consumer-grade devices

Victoria Peterson[*1,2], Catalina Galván[2], Hugo Hernández[2] and Ruben Spies[1,3]

[1]*Instituto de Matemática Aplicada del Litoral, IMAL, CONICET-UNL, Santa Fe, Argentina.*
[2]*Facultad de Ingeniería, Universidad Nacional de Entre Ríos, FIUNER, Oro Verde, Entre Ríos, Argentina.*
[3]*Departamento de Matemática, Facultad de Ingeniería Química, Universidad Nacional del Litoral, Santa Fe, Argentina*

1 General information

This data set consists of electroencephalography (EEG) signals from 10 healthy subjects (four females, right-handed, mean age $\pm$ SD = 26.1 $\pm$ 4.0 years, as described in Table 1) of a study published in [1]. The participants had no previous brain-computer interface (BCI) experience and all gave their informed consent. The BCI protocol consisted of two conditions, namely the kinesthetic imagination of grasping movement of the dominant hand and rest/idle condition. Each subject participated in one single session, of about 1.5 hours. The session comprised four (4) runs of forty (40) trials (20 trials per class, randomly presented), yielding a total of 160 trials at the end of the session. A modified version of the Graz protocol [2] was used for the EEG data acquisition. The sampling frequency was set to 125 Hz. In order to ensure that the subject was not making any real hand movement during the motor imagery (MI) trial, surface electromyography (EMG) was also acquired during the experiment. Both brain and muscle activity were measured by using low-cost devices and free multi-platform software.

ID	Sex	Age	Dominant Hand
S02	Male	28	Right
S03	Female	29	Right
S04	Male	30	Right
S05	Male	29	Right
S06	Male	30	Right
S07	Female	20	Right
S08	Male	25	Right
S09	Female	28	Right
S10	Male	26	Right
S12	Female	22	Right

Table 1: Demographic information of the participants in our study.

[*]vpeterson@santafe-conicet.gov.ar

2 EXPERIMENTAL PARADIGM

The study was conducted in a non-shielded office, with a room divider between the experimenters and the participant. Figure 1 summarizes the stages of the experiment in a block diagram design. At the beginning of the session each subject was clearly instructed about the mental tasks to be performed. To assess motor imagery ability, five kinesthetic mental exercises of the KVIQ-10 questionnaire [3] were performed. Before the experiment started, the EMG rest signal was acquired for a period of 20 seconds. During the experiment, the subject was comfortably seated in front of a computer screen with both arms resting on a desk. In order to ensure kinesthetic (and no visual) MI, the dominant hand was placed inside a cardboard box. Five experimental runs were made. The first one (called RUN0), which is not included in this data set, was performed with the unique objective of better explaining the protocol to the subject.

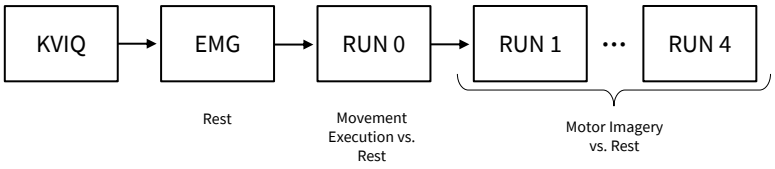

Figure 1: Schematic representation of the experiment as a block diagram. The experiment started with the KVIQ questionnaire. After the electrode setting, the EMG rest signal was acquired. Five runs were asked to be performed by the user. The first run, called RUN0, involved real grasping movement in order to better explain the protocol and to help the subject focus on the sensation of performing the movement. The rest of the runs (RUN1-RUN4) were equal, consisting of MI vs. Rest conditions.

After the stimulation protocol started, 20 seconds of baseline EEG were registered. Each trial of the stimulation protocol began with a fixation cross ($t = -3$ s), followed by an audible beep cue two seconds later ($t = -1$ s). At $t = 0$ s, the subjects were asked to imagine either grasping movements of the dominant hand or just to relax for a period of 4 s. The visual cue, a red arrow pointing to the right, was presented only for the MI trials. The subjects were ask to carry out the MI task until the red arrow disappeared from the screen. No feedback was provided at any stage. Between trials, a break of random duration (between 2.5 and 4.5 s) followed. At the end of each run, the subject was asked to distend and relax for a longer period of time ($>$ 2 min). The stimulation protocol used is schematically depicted in Figure 2.

3 DATA RECORDING

In this data set, brain EEG has been measured by using low-cost devices and free multi-platform software. The EEG signal was acquired by using the Electro-Cap System II (Electrocap, USA) connected to the OpenBCI Cyton + Daisy board (OpenBCI, USA). Fifteen (15) electrodes covering the sensorimotor cortex (Fz, F3, F4, F7, F8, Cz, C3, C4, T3, T4, Pz, P3, P4, T5, T6) were selected. The reference and ground electrodes were placed at the left and right ear lobes, respectively (see Figure 3). The sampling frequency of the OpenBCI amplifier was 125 Hz. The OpenBCI board was wirelessly connected to a dedicated PC (OS Linux, Intel®

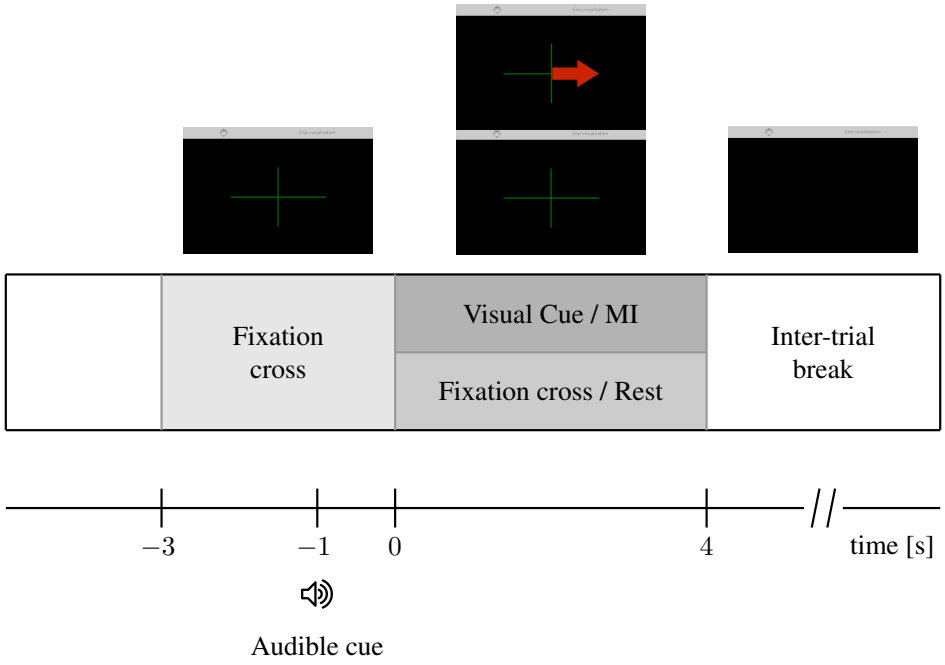

Figure 2: Stimulation protocol used, with timing references, in seconds.

Core^{TM} i7-6700K CPU @ 4.00GHz $\times$ 8) by the USB Dongle. The OpenViBE platform, acquisition server and designer, was used for the protocol presentation, visualization and storage of both the EEG signals and the time mark stamps. During acquisition, the EEG signals were filtered between 0.5 and 45 Hz with a 3rd order Butterworth bandpass-filter. In addition, in a post-processing step a backward-forward bandpass 5th order Butterworth filter between 1 and 40 Hz was applied to the acquired signal.

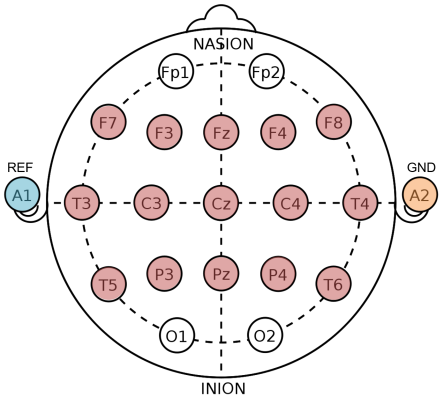

Figure 3: Electrode configuration of the Electro-cap. Red colored circles illustrate the location of the 15 electrodes used for acquisition. The A1 (left ear lobe) and the A2 (right ear lobe) electrodes were used as reference and ground, respectively.

4 DESCRIPTION OF DATA FILES

The EEG data are stored in Matlab's .mat-file format, one file per subject. Each file comprises a "DataEEG" struct arrray which contains the four fields detailed below:

- DataEEG.x: 4 s filtered EEG data matrix (number of samples [501] $\times$ number of channels [15] $\times$ number of trials [160]). Note that due to technical problems for subject S01 one run was shorter yielding a total of 150 trials.
- DataEEG.y: class labels vector (number of trials $\times$ 1), being 1 for MI class and 2 for RELAX.
- DataEEG.s: sampling frequency [125].
- DataEEG.c: channel names description (1 $\times$ number of channels).

REFERENCES

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