Data Acquisition – Detailed Description

(06/06/2016)

a. Abstract

EEG signals with 14 channels captured from 11 subjects executing a SSVEP-based experimental protocol. Five different frequencies (6.66, 7.50, 8.57, 10.00 and 12.00 Hz) have been used for the visual stimulation, and the Emotiv EPOC, using 14 wireless channels has been used for capturing the signals.

b. Demographics of subjects

Eleven volunteers participated in this study. They all were present employees of Centre for Research and Technology Hellas (CERTH). Specifically, 8 of them were male and 3 female. Their ages ranged between 25 to 39 years old. All of them were able-bodied subjects without any known neuro-muscular or mental disorders. Subjects can be categorized based on the hair length and thickness into 3 categories, short hair, regular hair and thick hair, with 3 belonging to the first category, 6 to the second and the remaining 4 to the third. Table 1 summarizes the demographics information about the participating subjects, including all the previously discussed information. Subjects engaged in this experiment were the same as the ones in our two previous experiments (MAMEM Dataset I[1] and MAMEM Dataset II[2])

Table 1: General information about the subjects

Subject ID	Age	Gender	Hair Type	Handedness
U001	24	Male	Regular	Right
U002	37	Male	Regular	Right
U003	39	Male	Thick	Right
U004	31	Male	Short	Right
U005	27	Female	Thick	Left
U006	28	Female	Thick	Right
U007	26	Male	Regular	Right
U008	31	Female	Thick	Right

[1] https://figshare.com/articles/MAMEM_EEG_SSVEP_Dataset_I_256_channels_11_subjects_5_frequencies_/2068677

[2] https://figshare.com/articles/MAMEM_EEG_SSVEP_Dataset_II_256_channels_11_subjects_5_frequencies_presented_simultaneously_/3153409

U009	29	Male	Short	Right
U010	37	Male	Regular	Right
U011	25	Male	Regular	Right

c. Acquisition setup

The visual stimuli were projected on a 22'' LCD monitor, with a refresh rate of 60 Hz and 1680x1080 pixel resolution. The visual stimulation of the experiment was designed using OpenViBE. A graphic card (Nvidia GeForce GTX 970M) fast enough to render more frames than the screen can display. Also, the option "vertical synchronization" of the graphic card was enabled in order to ensure that only whole frames are seen on screen.

High quality EEG data were recorded with the Emotiv Epoc, using 14 wireless channels (via usb connection) and a sampling rate of 128 Hz. Furthermore, there are two reference sensors placed on the bone just behind each ear lobe. The topographic representation of the electrodes, corresponding to the 10-20 International System is illustrated on Figure 1.

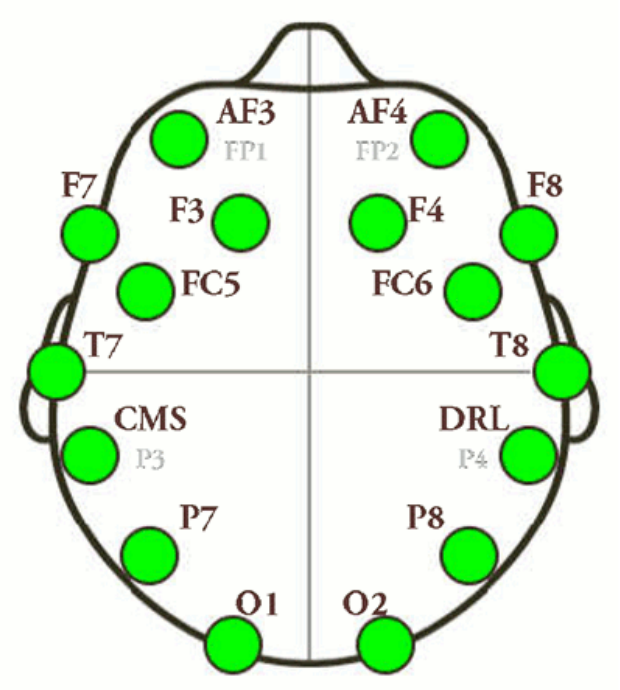

Figure 1: Mapping of the 14-channel Emotiv Epoc

The raw data were acquired from the Emotiv EPOC headset with the help of the Emotiv SDK, and were transmitted to OpenVibe via a Labstreaminglayer inlet[3]. The synchronization between the stimuli and the EEG signal was performed by the OpenVibe application and the output was written in GDF format file.

The stimuli of the experiment were five violet boxes simultaneously flickering in 5 different frequencies (6.66, 7.50, 8.57, 10.00 and 12.00 Hz). Each box was flickering

[3] https://github.com/sccn/labstreaminglayer

in a specific frequency and they were all presented for 5 seconds at the same time, denoted hereafter as trial, followed by 5 seconds without visual stimulation before the flickering boxes appear again. Prior to the stimulation period, one of the boxes was marked by a yellow arrow identifying the box subjects had to focus on (see Figure 2).The marking arrow is shown during the trial, making it easier for the subjects to focus correctly for the trial's whole length. The background color was black for the whole experiment.

The experiment process undertaken by each subject was initiated with 100 seconds of adaptation period (see Figure 3). The adaptation period consisted in the presentation of the 5 selected stimuli with the subject focusing on the indicating one in a random way and was considered a crucial part of the process as the subject had the opportunity to familiarize with the visual stimulation. The first of a total of five identical sessions of the experiment followed the adaptation period with a 30 second interval. Each session includes 25 trials and is divided into two parts by a 30-second resting period. The first part includes 12 trials, whereas the second 13. The target in each trial is being selected in a random way in order to avoid habituation. The following 5 minutes interval is left for the subject to rest and be prepared for the next session.

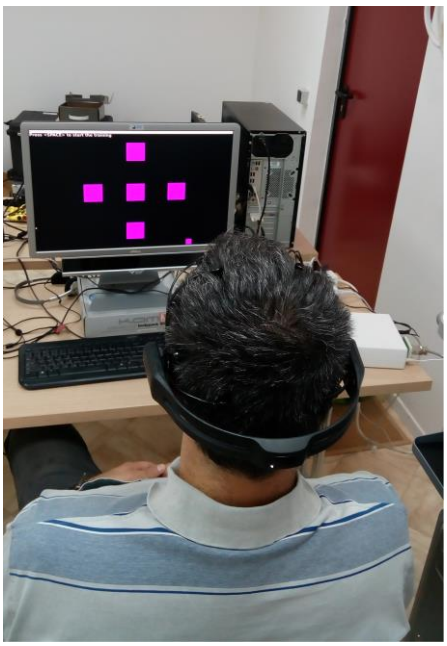

Figure 2: An example of the flickering boxes as used in the experiment

During the experiment one member of the research stuff was present giving oral instructions to the subjects informing them about the resting time they had at their disposal, about the time they had before the resting period would end, as well as about when the next stimuli would appear. In addition, in an effort to minimize the artifacts that could arise by the subject (physiological), the subjects were instructed to limit their movements and try not to swallow or blink during the visual stimulation. Furthermore, the research stuff was responsible for the movement limitation in the experimental environment, that all mobile phones are switched off and ensuring the correct electrode placement. The electrode impedance was monitored throughout the experiment using the TestBench SDK provided by Emotiv. Finally, the participants were cautiously observed and notes were made about unexpected behavior that

could lead to existence of artifacts in the acquired signal, in order to use this information later on during the analysis of the classification accuracy.

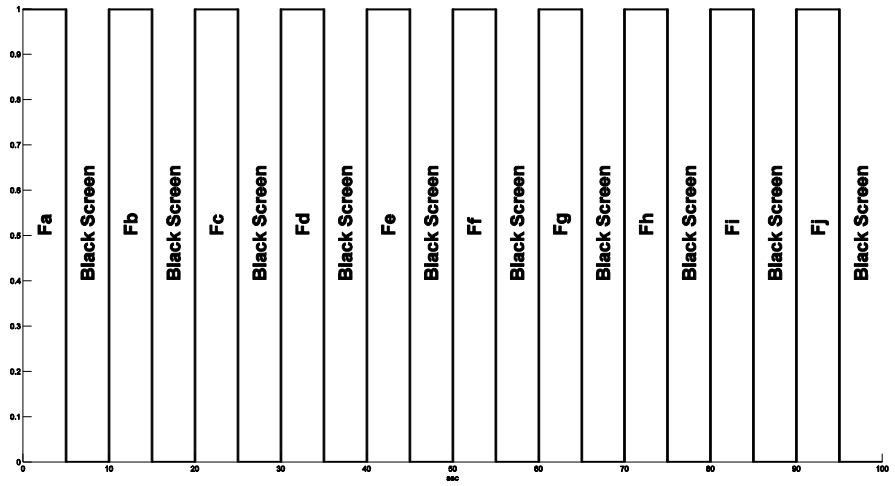

Figure 3: Adaptation Experimental Setup: For a period of 100 sec the five stimuli are presented simultaneously and the subject has to focus randomly on one of them. Between each stimulus a resting period of 5 sec is applied.

d. Important Notes

Flickering frequencies: Usually the refresh rate for an LCD Screen is 60 Hz, creating a restriction to the number of frequencies that can be selected. Specifically, only the frequencies that when divided with the refresh rate of the screen result in an integer quotient could be selected. As a result, the frequencies that could be obtained were the following: 30.00, 20.00, 15.00, 12.00, 10.00, 8.57, 7.50 and 6.66 Hz. In addition, it is also important to avoid using frequencies that are multiples of another frequency, for example making the choice to use 10.00Hz prohibits the use of 20.00 and 30.00 Hz. With the previously described limitations in mind, the selected frequencies for the experiment were: 12.00, 10.00, 8.57, 7.50 and 6.66 Hz.

Trial duration: The duration of each trial was set to 5 seconds, as this time was considered adequate to allow the occipital part of the brain to mimic the stimulation frequency and still be small enough for making a selection in the context of a brain-computer interface. In addition, this setting allows the investigation of the tradeoff between the classification accuracy and the amount of time where the flickering frequency is detected.

Trial manipulation: The trial initiation is defined by an event code (32779) and the end by another (32780). There are five different labels that indicate the box subjects were instructed to focus on (1, 2, 3, 4 and 5) and correspond to frequencies 12.00, 10.00, 8.57, 7.50 and 6.66 Hz respectively. 5 3 2 1 4 5 2 1 4 3 is the trial sequence for the adaptation and 4 2 3 5 1 2 5 4 2 3 1 5 4 3 2 4 1 2 5 3 4 1 3 1 3 is the sequence for each session.

Observed artifacts: During the stimulus presentation to subject S007 the research stuff noted that the subject had a tendency to eye blink. As a result the interference, in matters of artifacts, on the recorded signal is expected to be high.

Informed consent: Before the experiment the participants were carefully instructed about the recording procedure and its requirements and were provided with a form of

consent to sign after reading it thoroughly. After reading the form and listening to our oral instructions, the subjects were motivated to make any questions regarding the procedure in an effort to eliminate misunderstandings about the process. By signing the provided document, the participants stated their voluntary participation in the experiment and their consent to make their data public for research purposes. The entire experimental process has received the approval of the ethics committee of the Centre for Research and Technology Hellas with date 3/7/2015 and for the research grant with number H2020-ICT-2014-644780.

Data Processing: The ssvep-eeg-processing toolbox[4] was created for data analysis purposes. It includes several features and allows the user to experiment with different configurations with minimal code adjustments.

[4] https://github.com/MAMEM/ssvep-eeg-processing-toolbox