Data Acquisition – Detailed Description

(04/04/2016)

a. Abstract

EEG signals with 256 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 EGI 300 Geodesic EEG System (GES 300), using a 256-channel HydroCel Geodesic Sensor Net (HCGSN) and a sampling rate of 250 Hz has been used to 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. Furthermore, to all subjects the adult medium Geodesic Sensor Net (GSN) was applied. Subjects can also 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.

Table 1 General information about the subjects

Subject ID	Age	Gender	Net Size	Hair Type	Handedness
S001	24	Male	Adult Medium	Regular	Right
S002	37	Male	Adult Medium	Regular	Right
S003	39	Male	Adult Medium	Thick	Right
S004	31	Male	Adult Medium	Short	Right
S005	27	Female	Adult Medium	Thick	Left
S006	28	Female	Adult Medium	Thick	Right
S007	26	Male	Adult Medium	Regular	Right
S008	31	Female	Adult Medium	Thick	Right
S009	29	Male	Adult Medium	Short	Right
S010	37	Male	Adult Medium	Regular	Right
S011	25	Male	Adult Medium	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 GT 740) fast enough to render more frames than the screen can display was used and vertical synchronization. Also, the option "vertical synchronization" of the graphic card was enabled in order to ensure that only whole frames are seen on screen.

High Dimensional – EEG data were recorded with the EGI 300 Geodesic EEG System (GES 300), using a 256-channel HydroCel Geodesic Sensor Net (HCGSN) and a sampling rate of 250 Hz. The topographic representation of the electrodes is illustrated on Figure 1, including the reference electrode (VREF) that corresponds to electrode 257 in the obtained dataset and has zero values. Furthermore, Table 2 determines the approximate correspondence between the 10-20 international system and the 256-channel HCGSN. The adult medium (56 – 58 cm) HCGSN was used. The contact impedance at each sensor was ensured to be at most 40 KΩ before the initialization of every new session.

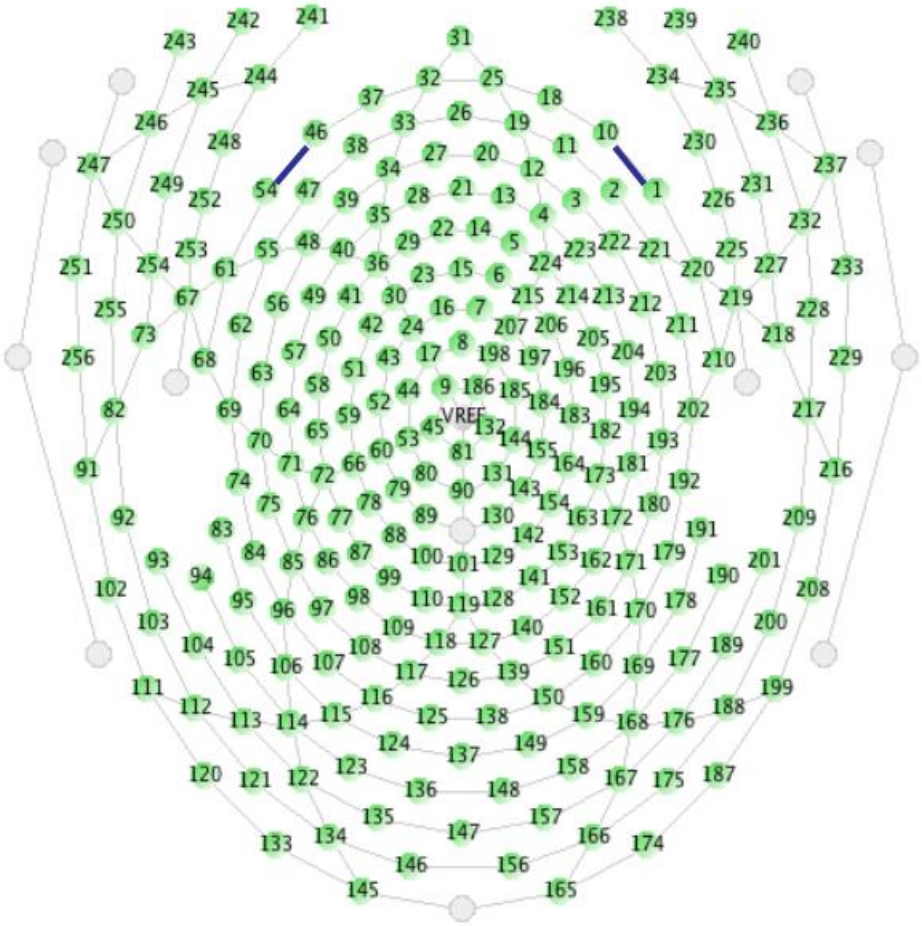

Figure 1: Mapping of the 256-channel Sensor Net

Table 2 Layout illustrating the approximate 10 – 20 equivalent on the 256-channel HydroCel

256 HCGSN	10-20 System	256 HCGSN	10-20 System
47	F7	21	Fz
37	Fp1	183	C4
36	F3	170	P8
2	F8	150	O2
101	Pz	224	F4
126	Oz	190	RM
69	T7	31	NAS
96	P7	18	FP2
94	LM	116	O1
202	T8		

The synchronization of the stimulus with the recorded EEG signal was performed with the aid of the Stim Tracker model ST - 100 (developed by Cedrus), and a light sensor attached to the monitor that added markers (denoted hereafter as Dins) to the captured EEG signal. More specifically, the light sensor was able to detect with high precision the onset of the visual stimuli and place Dins on the EEG signal for as long as the visual stimuli flickered, providing evidence of the lasting period. Subsequently, in the offline data processing, these Dins were used to separate the raw signal into the part generated during the visual stimuli and the part generated during the resting period. The acquisition setup that has been used in our experiments is depicted in Figure 2.

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 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 3).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.

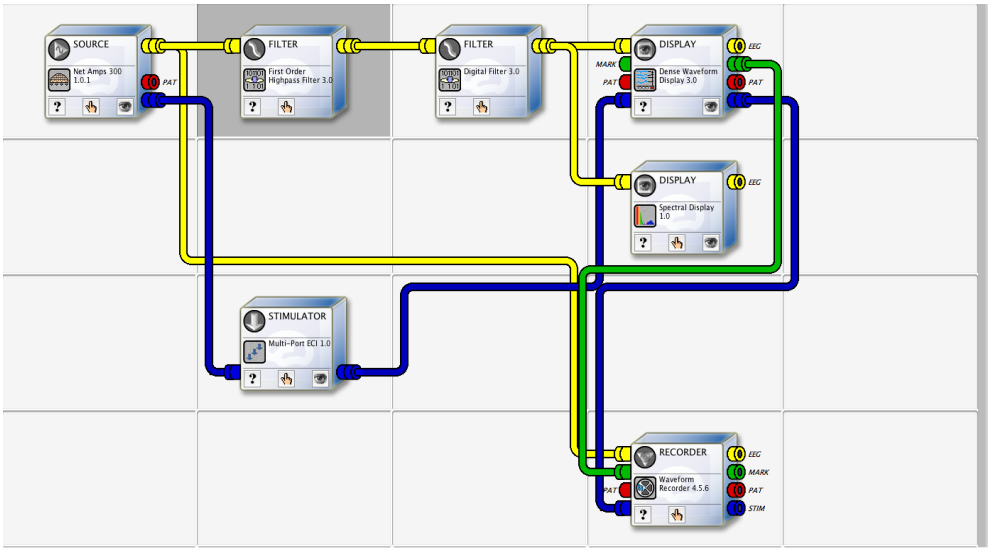

Figure 2: The Acquisition Setup as displayed in the NetStation

The experiment process undertaken by each subject was initiated with 100 seconds of adaptation period (see Figure 4). 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 with the target being selected in a random way in order to avoid habituation. The following 5 minutes interval was left for the subject to rest and be prepared for the next session.

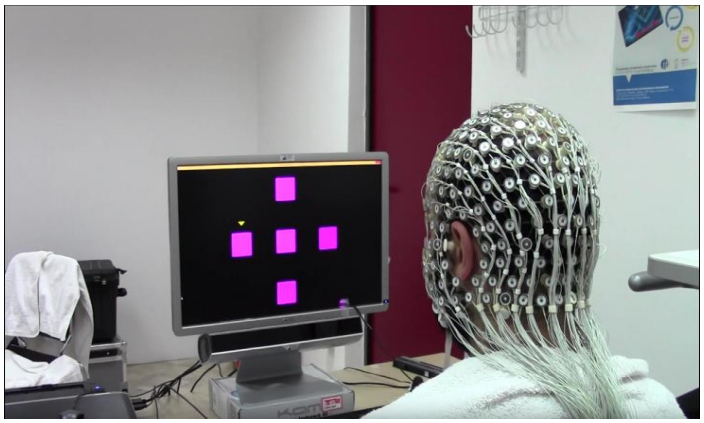

Figure 3: An example of a flickering box as used in the experiment

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 and about the time they had before the resting period would end and 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 ensuring the correct electrode placement, the movement limitation in the experimental environment and that all mobile phones are switched off. 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.

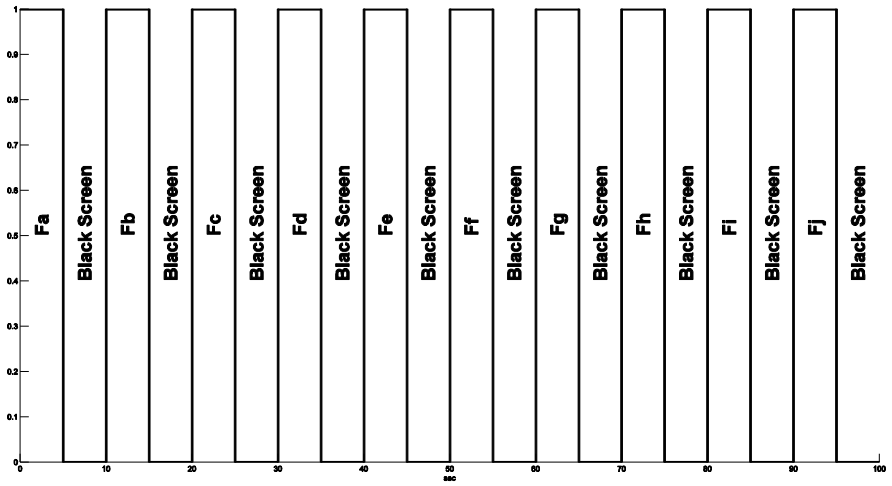

Figure 4. Adaptation Experimental Setup: For a period of 100 sec the five stimuli are presented simultaneously and the subject has to focus randomly on one of them. Between each stimulus a resting period of 5 sec is applied.

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. However, the investigation of the tradeoff between the classification accuracy and the amount of time where the flickering frequency is detected is included in our immediate plans for future work.

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.