Brain Invaders calibration-less P300-based BCI with modulation of flash duration Dataset (bi2015a)

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Abstract - We describe the experimental procedures for an experiment dataset that we have made publicly available at https://doi.org/10.5281/zenodo.3266930 in *mat* and *csv* formats. This dataset contains electroencephalographic (EEG) recordings of 50 subjects playing to a visual P300 Brain-Computer Interface (BCI) videogame named *Brain Invaders*. The interface uses the oddball paradigm on a grid of 36 symbols (1 Target, 35 Non-Target) that are flashed pseudo-randomly to elicit the P300 response. EEG data were recorded using 32 active wet electrodes with three conditions: flash duration 50ms, 80ms or 110ms. The experiment took place at GIPSA-lab, Grenoble, France, in 2015. Python code for manipulating the data is available at https://github.com/plcrodrigues/py.BI.EEG.2015a-GIPSA. The full ID of this dataset *bi2015a.*

Résumé – Dans ce document, nous décrivons une expérimentation pour des données qui ont été publiées sur https://doi.org/10.5281/zenodo.3266930 aux formats *mat* et *csv*. Ce jeu de donnée contient les enregistrements électroencéphalographiques (EEG) de 50 sujets jouant à une interface-cerveau ordinateur (ICO) basée sur la détection des P300 visuels nommée *Brain Invaders*. L'interface utilise le paradigme oddball (ou stimuli discordant) sur une grille de 36 symboles (1 cible, 35 non-cibles) qui sont flashés de façon pseudo-aléatoires afin de générer un potentiel évoqué P300. L'EEG de chaque sujet a été enregistré grâce à 32 électrodes humides pour des durées de flashs de 50, 80 et 110ms. L'expérience a été menée au GIPSA-lab (Université de Grenoble-Alpes, CNRS, Grenoble-INP) en 2015. Nous fournissons également une implémentation python pour manipuler les données à https://github.com/plcrodrigues/py.BI.EEG.2015a-GIPSA.

Introduction

The experiment was designed to study the influence of the flash duration on a calibration-less P300-based BCI system with wet electrodes and as a screening session for potential candidates for a broader multi-user BCI study (1–3). The visual P300 is an event-related potential (ERP) elicited by an expected but unpredictable target visual stimulation (i.e. oddball paradigm (4)), with peaking amplitude 240-600 ms after stimulus onset. In this experiment, there were two event-related stimuli: Target (P300 expected) and Non-Target (no P300). The experiment uses the *Brain Invaders, a* P300-based BCI video-game available as open-source software (5). During the experiment, the output of a real-time adaptive Riemannian Minimum Distance to Mean (RMDM) classifier was used for assessing the participants' command (6,7). This scheme allows a calibration-free classifier (8). This experiment is part of a collective effort to develop plug'n'play opens-ource BCI software at GIPSA-lab (1). An example of application of this dataset can be seen in (9).

Participants

50 subjects (36M, 14F) with mean (sd) age 23.70 (3.19) were recruited for this experiment and randomly paired (see **Erreur ! Source du renvoi introuvable.**). The recruited participants were mostly students and young researchers. At the end of the experiment one ticket of cinema was offered to each subject, for a value of 7.5 euros per subject. All participants provided written informed consent confirming the notification of the experimental process, the notification of the data management procedures and the right to withdraw from the experiment at any moment. The study was approved by the Ethical Committee of the University of Grenoble Alpes (Comité d'Ethique pour la Recherche Non-Interventionnelle).

Among the 50 pairs of participants, 9 have been rejected from the study for the following reasons:

- Participant 1, 45, 48, 49, 50 couldn't finish the experiment due lack of sufficient powering of the pre-amplifier.
- Participant 47: vision not perfectly corrected with binoculars.
- Participant 27, 46: no visible occipital dominant rhythm during installation.
- Participant 44: corrupted data

The data of subject 1 and 27 are provided as they can be of general interest, however the rejected data should not be used for BCI meta-analysis. Data of subjects 44-50 will also be released in a further version of the database.

#	Age	Gender (1=F, 2=M)	notes	#	Age	Gender (1=F, 2=M)	notes
1	24	1	Powering issue	26	22	1	
2	27	2		27	26	2	No visible alpha
3	22	2		28	22	2	
4	32	2		29	19	2	
5	27	1		30	25	1	
6	22	1		31	22	2	
7	23	1		32	24	2	
8	22	2		33	19	2	
9	27	2		34	23	2	
10	25	2		35	23	2	
11	23	2		36	23	2	
12	23	2		37	24	2	
13	18	1		38	22	2	
14	25	1		39	22	2	
15	20	2		40	21	2	
16	22	2		41	20	2	
17	27	1		42	21	2	
18	19	1		43	24	2	
19	21	2		44	25	2	Nan values
20	25	1		45	19	2	Powering issue
21	23	2		46	27	1	No visible alpha
22	22	2		47	21	1	Vision not corrected
23	24	1		48	21	2	Powering issue
24	25	2		49	20	2	Powering issue
25	24	2		50	26	2	Powering issue

Table 1. Age and Gender of the participants.

Material

EEG signals were acquired by means of a research-grade amplifier (g.USBamp, g.tec, Schiedlberg, Austria) and the g.GAMMAcap (g.tec, Schiedlberg, Austria) equipped with 32 wet Silver/Silver Chloride electrodes, placed according to the 10-10 international system (FP1, FP2, AFz, F7, F3, F4, F8, FC5, FC1, FC2, FC6, T7, C3, Cz, C4, T8, CP5, CP1, CP2, CP6, P7, P3, Pz, P4, P8, PO7, O1, Oz, O2, PO8, PO9 and PO10) (**Figure** ***1***). The reference electrode was placed on the right earlobe and the ground electrode at the Fz scalp location. The g.USBamp amplifier was linked by USB connection to the PC where the data were acquired by means of the software OpenVibe (10,11). The data were stored with no digital filter applied and a sampling frequency of 512 samples per second. In order to reduce the jitter, the experimental tags produced by Brain Invaders were synchronized with EEG signals using an USB digital-to-analog converter connected to the g.USBamp trigger channel. The same tagging procedure is used for all Brain Invaders databases (link bi2012a (12), bi2013a (13), bi2014a, bi2014b, bi2015b[1]). This allows comparing the ERPs thanks to a consistent tagging latency (14).

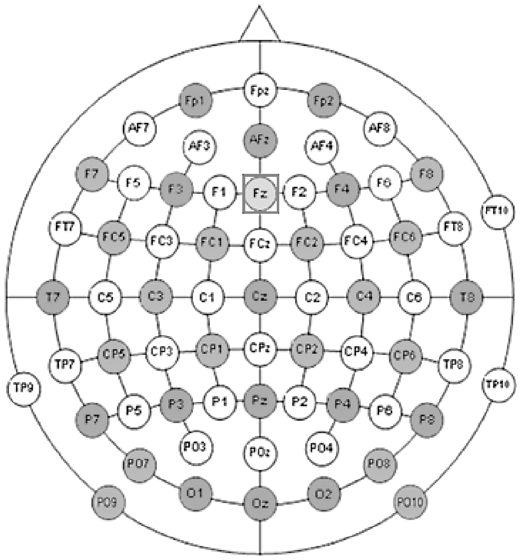

Figure 1. In grey the 32 electrodes placed on the scalp of each subject according to the 10-10 international system. In a square the ground (GRN), placed at FZ. The reference (REF) was placed on the left earlobe (not shown on the figure).

Procedures

For all subjects, the experiment took place in a small room with a surface of four meters square, containing a 24’ screen and all the required hardware materials for acquiring the EEG data. After the EEG headset was placed, the integrity of the recording pipeline was checked by performing preliminary tests, consisting in inspecting recording visible signals such as eye blinks and the occipital dominant rhythm. The experimenter controlled the session from an adjacent room equipped with a one-way glass window.

[1] https://sites.google.com/site/marcocongedo/science/eeg-data

The experiment consisted of three game sessions of Brain Invaders of 9 levels each with different flash duration (see **Table 2**). Before and after the three game sessions, around one minute of resting state and eyes closed conditions were recorded.

	Flash duration (target and non-target)
Session 1	110 ms
Session 2	80 ms
Session 3	50 ms

Table 2. Flash duration for each session

Brain Invaders Interface

The interface of Brain Invaders is composed of 36 aliens. In the Brain Invaders P300 paradigm, a *repetition* is composed of 12 flashes of pseudo-random groups of six symbols chosen in such a way that after each repetition each symbol has flashed exactly two times. Thus in each repetition the target symbol flashes twice, whereas the remaining 10 flashes do not concern the target (non-target), see **Figure 2**. The ratio of Target versus non-Target is therefore one-to-five. A detailed description of this paradigm is available in (5,15,16).

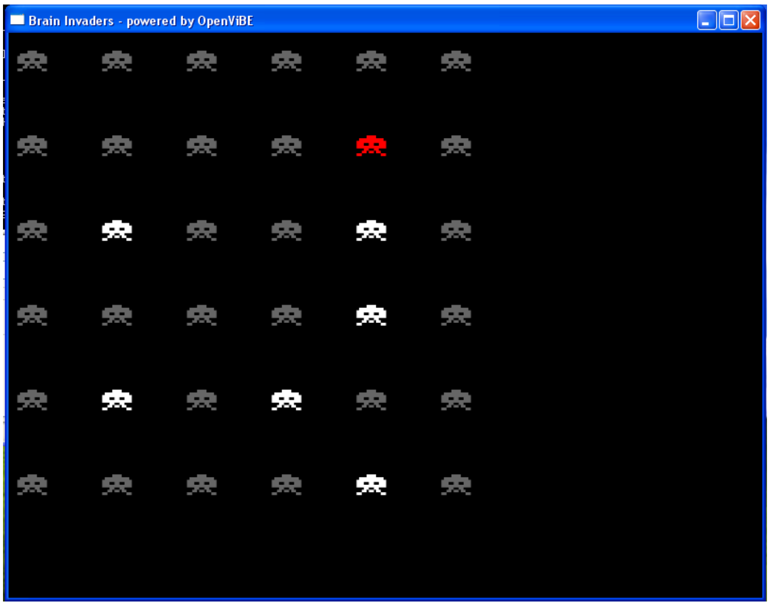

Figure 2. Interface of Brain Invaders during the first level at the moment where a group of six non-Target symbols flash (in white). The red symbol is the Target. The non-Targets which are not flashing are in grey.

A game session was compounded by nine levels, consisting in a unique and predefined configuration of the 36 symbols of the interface. Aliens slowly and regularly moved according to a predefined path keeping constant the inter-distance between adjacent aliens. We found that this level of animation suffice to maintain high the player's attention during the whole experiment.

Once the target symbol destroyed the level ended, a reward screen was shown and the next level was generated (if available). The players had up to eight attempts to destroy the target symbol (a counter was always shown in the bottom part of the interface). If the player missed all eight attempts, the level was started once again from the beginning. As a consequence, the duration for the nine levels was variable, with an average of about five minutes and the experimenter could end the experiment if no control over the BCI system was gained after 10 minutes in order to avoid the raising of a feeling of frustration in the player.

Organization of the Dataset

The EEG recording of the 50 subjects for the three sessions, resting state and eyes closed are provided in *mat* and *csv* formats. Each file is a 2D-matrix where the rows contain the observations at each time sample. The first column of the matrix represents the timestamp of each observation. Columns 2 to 33 contain the recordings on each of the 32 EEG electrodes. In the recording of the sessions, column 34 (Trigger) is filled with zero except at the timestamp corresponding to the onset of a stimulation where it gets the value of one. We also provide columns 35 (Target) which is filled with zeros, except at the timestamp corresponding to the onset of a Target flash where it gets the value of one.

The *Header.mat* (or *Header.csv*) file contains the column names, sorted by ascending column number, including the name of the EEG channels.

We supply an online and open-source example working with Python (9) and using the analysis framework MNE (17,18) and MOABB (19,20), a comprehensive benchmark framework for testing popular BCI classification algorithms. This example shows how to download the data and classify 1s non-Target and Target epochs using the Riemannian MDM algorithm (7).

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