



**HAL**  
open science

## ”Brain Invaders 2” : an open source Plug & Play multi-user BCI videogame

Louis Korczowski, Alexandre Barachant, Anton Andreev, Christian Jutten,  
Marco Congedo

### ► To cite this version:

Louis Korczowski, Alexandre Barachant, Anton Andreev, Christian Jutten, Marco Congedo. ”Brain Invaders 2” : an open source Plug & Play multi-user BCI videogame. BCI 2016 - 6th International Brain-Computer Interface Meeting, BCI Society, May 2016, Pacific Grove, CA, United States. pp.10.3217/978-3-85125-467-9, 10.3217/978-3-85125-467-9-224 . hal-01318726

**HAL Id: hal-01318726**

**<https://hal.science/hal-01318726>**

Submitted on 19 May 2016

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

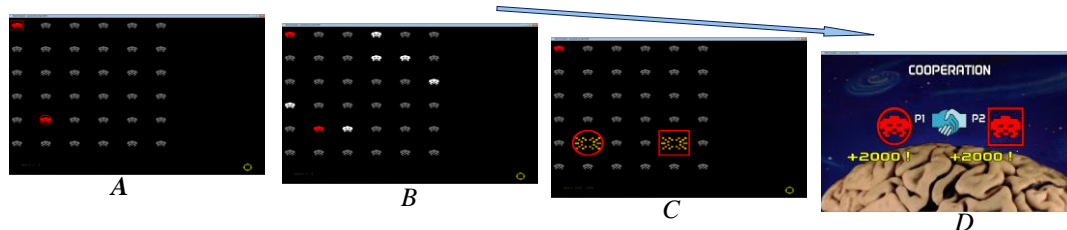
# “Brain Invaders 2”: an open source Plug & Play multi-user BCI videogame

L. Korczowski<sup>\*1</sup>, A. Barachant<sup>2</sup>, A. Andreev<sup>1</sup>, C. Jutten<sup>1</sup>, M. Congedo<sup>1</sup>

<sup>1</sup>GIPSA-Lab, Univ. Grenoble Alpes, CNRS, Grenoble, France. <sup>2</sup>Burke Medical Research Institute, White plains, NY, USA.

\*P.O. Box: 11 rue des Mathématiques, 38400 Saint-Martin-d’Hères. E-mail: louis.korczowski@gipsa-lab.fr

*Introduction:* In 2011 we proposed « Brain Invaders » [1], a BCI videogame inspired from the vintage game Space Invaders. The software was released open source and was compatible with OpenVIBE [2]. The system is based on ERP classification using the oddball paradigm with a grid of 36 possible targets. This second version extends the game to the multi-user scenario. It includes four game modes namely *Solo*, *Collaboration*, *Cooperation*, *Competition* which are suitable for hyperscanning studies. Thanks to a classification algorithm based on Riemannian geometry, the system shows very good accuracy and is fully “Plug & Play”, no calibration phase is needed.



**Figure 1.** Brain Invaders v2: (A) Level initialization. (B) After a short delay, the game flashes randomly all the aliens. (C) The game destroys the most likely alien(s) according to the classification. (D) If the player(s) succeed(s) at destroying the target(s), s/he (they) is awarded by a fixed amount of points or by a factor proportional to the number of repetitions required.

*Material, Methods and Results:* “Brain Invaders 2” includes several characteristics that make it suitable for recreational, educational and research purposes: ■ Random alien target and alien distractor localization on a 6x6 grid (see Fig. 1A). Unpredictable flashing pattern (see Fig. 1B) with pseudo-random generated inter-stimulus interval (ISI) according to an exponential distribution. ■ Supervised adaptive classification method using the minimum distance to mean (MDM) of covariance matrices according to the Fisher information metric [3] and extended in the multi-user case according to [4]. This classification method has shown state-of-the-art performances, yet is simple, and can run on modest computers. ■ The system has been tested extensively on more than 250 subjects in controlled conditions (see Table 1) and also on hundreds of subjects during numerous public demonstrations and competitions (not presented here). It has been described by the participants as engaging and entertaining.

**Table 1** List of the experiments using the Brain Invaders software with the minimum, average and maximum online classification performance of the participants. Chance level is 1/36.

Database	Mode(s)	# subjects	# sessions	Electrodes	Min (%)	Av (%)	Max (%)	Ref.
bi2012a	solo	26	1	17-wet	28.19	47.79	68.94	
bi2013a	solo	24	Up to 8	16-wet	42.86	62.88	92.31	[5]
bi2014a	solo	71	3	16-dry	16.67	35.55	72.97	
bi2014b	solo-collaboration	38	4	2x32-wet	36.73	68.30	94.74	[4]
bi2015a	solo	50	3	32 wet	33.33	68.04	100	
bi2015b	cooperation-competition	44	4	2x32 wet	27.5	74.0	98.75	

*Discussion:* The authors propose a complete state-of-the-art ERP-BCI chain for single-/multi-user. The use of open source code and OpenVIBE allows quick experimental protocol design and classification methods prototyping. This is part of an ongoing research and development effort concerning the Brain Invaders.

*Acknowledgements:* The software is freely available on the GPL license into the package “openvibe-gipsa-extensions”. This research is partially funded by the European Research Council project CHES 2012-ERC-AdG-320684. The authors would like to thank Ekaterina Ostaschenko and Martine Cederhout for the experimental support.

## References

- [1] M. Congedo, M. Goyat, N. Tarrin, G. Ionescu, L. Varnet, B. Rivet, R. Phlypo, N. Jrad, M. Acquadro, and C. Jutten, “Brain Invaders”: a prototype of an open-source P300- based video game working with the OpenViBE platform,” in *5th International Brain-Computer Interface Conference 2011 (BCI 2011)*, Graz, Austria, 2011, pp. 280–283.
- [2] Y. Renard, F. Lotte, G. Gibert, M. Congedo, E. Maby, V. Delannoy, O. Bertrand, and A. Lécuyer, “OpenViBE: An Open-Source Software Platform to Design, Test, and Use Brain–Computer Interfaces in Real and Virtual Environments,” *Presence Teleoperators Virtual Environ.*, vol. 19, no. 1, pp. 35–53, Feb. 2010.
- [3] A. Barachant and M. Congedo, “A Plug&Play P300 BCI Using Information Geometry,” *ArXiv14090107 Cs Stat*, Aug. 2014.
- [4] L. Korczowski, M. Congedo, and C. Jutten, “Single-trial classification of multi-user P300-based Brain-Computer Interface using Riemannian geometry,” in *2015 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, 2015, pp. 1769–1772.
- [5] M. Congedo, “EEG Source Analysis,” HDR Thesis, Université de Grenoble, 2013.