



HAL
open science

Exploiting brain critical dynamics to inform Brain-Computer Interfaces

Pierpaolo Sorrentino, Marie-Constance Corsi, Denis P Schwartz, Nathalie George, Laurent Hugueville, Ari E Kahn, Sophie Dupont, Danielle S Bassett, Fabrizio de Vico Fallani, Viktor K Jirsa

► **To cite this version:**

Pierpaolo Sorrentino, Marie-Constance Corsi, Denis P Schwartz, Nathalie George, Laurent Hugueville, et al.. Exploiting brain critical dynamics to inform Brain-Computer Interfaces. BIOMAG 2022 - 22nd International Conference on Biomagnetism, Aug 2022, Birmingham, United Kingdom. hal-03695441

HAL Id: hal-03695441

<https://inria.hal.science/hal-03695441>

Submitted on 9 Sep 2022

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.

Exploiting brain critical dynamics to inform Brain-Computer Interfaces

Pierpaolo Sorrentino* 1, Marie-Constance Corsi* 2,3, Denis Schwartz2, Nathalie George2, Laurent Hugueville2, Ari E. Kahn 4, Sophie Dupont 2, Danielle S. Bassett 4, Fabrizio De Vico Fallani* 2,3, Viktor Jirsa* 1

*These authors contributed equally

1 Institut de Neurosciences des Systèmes, Marseille, France

2 Paris Brain Institute, Paris, France

3 Inria Paris, Aramis project-team, Paris, France

4 University of Pennsylvania, Philadelphia, USA

Background

Brain-Computer Interfaces (BCIs) is suboptimal in 30% of users. The dynamical processes underlying BCI training are only partly understood, especially the aperiodic, scale-free perturbations. “Neuronal avalanches”, which spread across the whole brain and reconfigure over time [1]. We hypothesize that the sequence of regions recruited by avalanches conveys the processes underlying BCI performance.

Methods

We used MEG data recorded during a motor imagery (MI)-based BCI training session (20 subjects, aged 27.5 ± 4.0 years, 12 men [2]). For each condition, we estimated the avalanche transition matrix (ATM), containing the probability that regions j would be active at time $t+1$, given region i was active at time t [3]. We obtained the edge-wise difference between the ATMs of the two experimental conditions in each subject, validated them via permutation analysis and checked which regions discriminated the most between the two tasks. Then, we correlated the difference of the probabilities associated with the edges to BCI performance.

Results

All the significantly different edges cluster upon the premotor areas, involved during the MI task, and the cuneus, involved during visual processing. In particular, the differences in the probabilities associated with edges incident upon areas such as the right paracentral lobule and the caudal middle frontal bilaterally directly correlate with the BCI scores ($r=0.80$ $p=3 \times 10^{-5}$; $r=0.66$ $p=1.9 \times 10^{-3}$; $r=0.48$ $p=0.035$, respectively).

Discussion

Our results suggest that avalanches capture functionally-relevant processes of interest for alternative BCI designing.

References

- [1] P. Sorrentino *et al.*, "Flexible brain dynamics underpins complex behaviours as observed in Parkinson's disease," *Sci Rep*, vol. 11, no. 1, p. 4051, Feb. 2021, doi: 10.1038/s41598-021-83425-4.
- [2] M.-C. Corsi *et al.*, "Functional disconnection of associative cortical areas predicts performance during BCI training," *NeuroImage*, vol. 209, p. 116500, Apr. 2020, doi: 10.1016/j.neuroimage.2019.116500.
- [3] P. Sorrentino *et al.*, "The structural connectome constrains fast brain dynamics," *eLife*, vol. 10, p. e67400, Jul. 2021, doi: 10.7554/eLife.67400.