Exploiting brain critical dynamics to inform Brain-Computer Interfaces

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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 cunei, 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 ($r=0.80$ $p=3x^{10-5}$; $r=0.66$ $p=1.9x10^{-3}$; $r=0.48$ $p=0.035$, respectively).

Discussion

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

References

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