Atelier
« Dynamiques invariantes d'échelle et réseaux en neurosciences »
21-24 octobre 2013

Workshop on
Scale-Free Dynamics and Networks in Neurosciences
October 21–24, 2013

Criticality and global brain state: Scale-free dynamics of EEG microstate sequences

Dimitri Van De Ville[*†]

Dimitri.VanDeVille@unige.ch; Dimitri.VanDeVille@epfl.ch

WEB: http://miplab.epfl.ch/vandeville/

Spontaneous brain activity during "resting state" has become an intriguing topic of brain research over the past years. It allows probing into intrinsic organisation of the brain in large-scale functional networks. I will first illustrate a surprising link between EEG microstates and fMRI resting-state networks (RSNs). Specifically, the rapid occurrence signals (100 ms dynamics) of the EEG microstates—only four microstates are predominant to describe spontaneous EEG—are convolved with the hemodynamic response function (reducing the dynamics to the 10 s timescale) and fed into a general linear model to analyze the simultaneous fMRI recordings, revealing four large-scale RSNs; i.e., the visual, auditory, self-referential, and dorsal attention networks. Then I will uncover the mechanism that explains how timescales so different can be linked. Specifically, we underpin the hypothesis that scale-free behavior of EEG microstate dynamics is responsible for this surprising connection. Using wavelet-based fractal analysis, we found a clear signature of mono-fractality over 6 dyadic scales covering the 256 ms–10 s range. Moreover, the degree of long-range dependency was maintained when shuffling the local microstate labels, but became indistinguishable from white noise when equalizing microstate durations, which indicates that temporal dynamics are their key characteristic. In sum, the four rapidly varying EEG microstates seem to represent the neurophysiological correlates of four known RSNs and their scale-free dynamics allow them to be measured at the slow fMRI timescale. These findings further motivate the emerging interest in fluctuations in functional connectivity; i.e., non-stationary dynamics of RSNs are meaningful and better understanding of the underlying mechanisms can ultimately improve imaging markers for neurological disease and disorder.

[*]Département de radiologie et informatique médicale, Université de Genève, Rue Gabrielle-Perret-Gentil 4., 1211 Genève 14, SWITZERLAND
[†]Institute of Bioengineering, EPFL, 1015 Lausanne, SWITZERLAND

References

Britz, J., D. Van De Ville, and C. M. Michel. 2010. *BOLD correlates of EEG topography reveal rapid resting-state network dynamics*, NeuroImage **52**, no. 4, 1162–1170.

Van De Ville, D., J. Britz, and C. M. Michel. 2010. *EEG microstate sequences in healthy humans at rest reveal scale-free dynamics*, Proceedings of the National Academy of Sciences of the USA **107**, no. 42, 18179–18184.