Brain dynamics and fractal behavior: about (fast) EEG microstates and (slow) fMRI resting-state networks

Abstract:
Spontaneous brain activity during "resting state" has become an intriguing research topic over the past few years. It allows to probe into the intrinsic organisation of the brain in large-scale functional networks. In the first part of this talk, I will illustrate a surprising link between EEG microstates and fMRI resting-state networks. Specifically, the rapid occurrence signals (100ms 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 10s timescale) and fed into a general linear model to analyze the simultaneous fMRI recordings, revealing four large-scale resting-state networks; i.e., the visual, auditory, self-referential, and dorsal attention networks.

In the second part, 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 monofractality over 6 dyadic scales covering the 256ms-10s 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.

[1] D. Van De Ville, J. Britz, C.M. Michel. EEG Microstate Sequences in Healthy Humans at Rest Reveal Scale-Free Dynamics. (2010). Proceedings of the National Academy of Sciences of the USA. vol 107. pp 18179-18184.
[2] J. Britz, D. Van De Ville, C.M. Michel. BOLD Correlates of EEG Topography Reveal Rapid Resting-State Network Dynamics. (2010). NeuroImage. vol 52. pp 1162-1170.