University of Zurich[UZH]

Department of Economics – Neuroeconomics Seminar

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Nelson Trujillo-Barreta
University of Manchester

The "Discrete Logic" of the Brain - Modelling Brain States' Durations

The study of "brain state(s)" (BS) fluctuations during resting (and task) conditions is a topic of great current interest. It is hypothesised that those characteristic states and the way they are explored by the brain over time (i.e. their transition dynamics and durations) can reflect fundamental computational properties of the brain, being present in human behaviour and neuroscience data. How do we define a BS? What causes a BS to change? How does it relate to a "cognitive state/process"? What dynamical laws do BS transitions obey? Do they leave a characteristic "fingerprint" on data? If so, how can we decode BSs from data? Can we ultimately control them? These and other questions are the subject of intensive current (and I would say future) research and debate. Several definitions of BS have been proposed based on different criteria of how we think BS transitions are reflected on data, and on the type of neuroimaging modality we are dealing with. But whatever the definition/fingerprint of a BS we use, we will unavoidably be facing the challenge of uncovering the dynamics of their transitions based on noisy, high-dimensional and non-stationary data. In practice this usually means segmenting a multivariate time series into a set of time intervals that have a useful interpretation in our domain of study. In this talk, I will focus on a particular instance of this problem, namely, the dynamic allocation of BSs based on magneto/electroencephalography (M/EEG) data, although most of the discussion is valid for other imaging modalities. I will review some of the most common methods currently applied in the literature to deal with this problem, discussing their advantages, disadvantages and flaws. I will introduce a new approach that aims to resolve some of these problems and compare its performance to one of the state-of-the-art methods. This new approach is based on an interpretation of the brain as a hybrid (continuous-discrete) system that has the ability to transition between multiple dynamical regimes or modes of operation. The proposed approach uses models and methods developed for the identification of hybrid systems in order to solve the BS allocation problem. Should time permit, I'll discuss outstanding challenges, possible solutions and future directions, with the aim to foster collaborations in this area.