BU University

bccn heidelberg-mannheim

upf. Pompeu Fabra Barcelona

Sant Joan de Déu Research Foundation

Metastable Dynamics of Neural Ensembles Special Topic

http://www.frontiersin.org/Systems_Neuroscience/researchtopics

A classical view on neural computation is that it can be characterized in terms of (deterministic) convergence to fixed-point-type attractor states (representing, e.g., memory patterns in Hopfield 1982) or limit-cycle-like sequential transitions among states (representing e.g. motor or syntactical sequences in Elman 1985). Is this still a valid model of how brain dynamics implements cognition? The idea that neuro-computational dynamics is more or less deterministically driven by convergence to simple attractor states has recently been challenged both empirically and by computational work.

For instance, in a series of recent models, intrinsic activity fluctuations play an essential role in enabling multi-attractor networks to display a wider range of phenomena. In this framework, noise fluctuations drive spontaneous transitions between metastable states, i.e. temporally stable states, even in the absence of external stimuli or a task context. Hence, noise would be a major player in brain function, enriching the dynamical repertoire of deterministic attractor networks for more flexible modes of processing. Fluctuations observed during spontaneous activity, or trial-to-trial variations in neuronal responses to the same stimulus, may be physiological manifestations of this neuro-computational substrate.

Other concepts of transient brain dynamics remain within the deterministic setting rather than assigning a fundamental role to noise and variability. According to these ideas brain dynamics are driven by semi-attracting objects on the edge of stability, like 'attractor ruins' or saddle-nodes. E.g., in a series of studies by Rabinovich, Abarbarnel, and colleagues, transient dynamics as observed during invertebrate sensory processing (for instance in Mazor and Lauren, 2005) are produced by sequences of saddle nodes. These dynamical objects attract nearby trajectories, yet are still only transient, even in the absence of considerable noise.

From a different angle, but in a similar spirit, Pouget and colleagues (2012) recently proposed that intrinsic spike irregularity or internal noise may actually not really contribute that much to behavioural trial-to trial variability. Rather, they suggest that its main origin may be suboptimal inference, i.e. the imprecision inevitably associated with deterministic approximations (internal models) to complex environmental situations. Hence, according to these views, observed variability could be accounted for by deterministic processes.

This is a highly interesting debate, touching the very basics of our understanding of neural computation, and hence perhaps one of the most exciting topics currently in systems and computational neuroscience. In this special topic of Frontiers in Systems Neuroscience we welcome experimental studies and modelling contributions addressing the question of stable vs. transient neural population dynamics, and the potential role of noise and trial-to trial variability in neural computation. Major topics are, but are not restricted to:

-Attracting and meta-stable dynamics of neural ensembles, both from empirical and computational modelling perspectives.
-Coding by non-stationary and transient states in neural recordings
-Spontaneous cortical activity dynamics
-Metastable dynamics during cognitive processing
-Oscillatory emergent patterns and propagation of waves in an excitable network
-Trial-to-trial variability

Deadline for abstract submission: 01 Feb 2014; for full article submission: 01 Jul 2014