FUNCTION FOLLOWS DYNAMICS

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Neurons in the brain are wired into a synaptic network that spans multiple scales, from local circuits within cortical columns to fiber tracts interconnecting distant areas. However, brain function require the dynamic control of inter-circuit interactions on time-scales faster than synaptic changes. In particular, strength and direction of causal influences between neural populations (described by the so-called *directed functional connectivity*) must be reconfigurable even when the underlying structural connectivity is fixed. Such directed functional influences can be quantified resorting to causal analysis of time-series based on tools like Granger Causality or Transfer Entropy. The ability to quickly reorganize inter-areal interactions is a chief requirement for performance in a changing natural environment. But how can manifold functional networks stem "on demand" from an essentially fixed structure? We explore the hypothesis that the self-organization of neuronal synchronous activity underlies the control of brain functional connectivity [1]. Based on simulated and real recordings of critical neuronal cultures in vitro [2], as well as on mean-field and spiking network models of interacting brain areas [1,3], we have found that "function follows dynamics", rather than structure. Different dynamic states of a same structural network, characterized by different synchronization properties, are indeed associated to different functional digraphs. Switching between functional networks can occur spontaneously [2] or be induced deterministically through local transient perturbations — particularly effective if properly phased [1]— or local plasticity [3]. Furthermore, we have found that "information follows dynamics". Firing rate oscillations act as a large capacity "carrier channel" for representations encoded in spiking patterns. Since neuronal firing can be irregular even when rate oscillations are regular, the self-organization of interacting "analog" rhythms allows thus the routing of large amounts of "digital-like" information [1,3].

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[2] Stetter O, Battaglia D, Soriano J, Geisel T (2012) PLoS Comput Biol, *in press*; preprint: `arXiv:1201.0732`

[3] Kirst C, Timme M, Battaglia D, *in preparation.*