Oscillatory correlates of cortical function in an attractor network model

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Abstract

Oscillations as an inextricable aspect of neural dynamics pervade the experimental neuroscience literature. They have been extensively studied at different levels of brain organisation. Despite the accumulation of evidence about the functional relevance of the rhythms ranging from delta to gamma reported in the context of working memory paradigms, perceptual tasks, sleep, attentional modulation and sensory as well as motor information processing, the understanding of the origins and mechanisms underlying these cognitive correlates is limited. We adopt a computational modelling approach to study functional aspects of cortical oscillatory dynamics. To this end, we use a large-scale mesoscopic attractor network model, which exhibits oscillatory behaviour as a robust emergent feature of neuronal activity and, most importantly, as a correlate of the network's functional states. Attractor networks serve in our work then as a biologically-inspired modelling framework suitable for simulations of both short- and long-term memory paradigms as well as perceptual tasks. The dynamics exhibited by these networks are thus hypothesised to reflect cortical processes of memory retrieval, stimulus perception or pre-stimulus idling conditions. With a sufficient level of biophysical detail, biologically-plausible spatial extent and cortex-inspired modular architecture of our connectionist models, we have managed to reproduce a large body of experimental findings reported mainly in the context of working memory and threshold stimulus detection tasks, and to generate numerous predictions available for experimental verification. In this talk, they will be reviewed with emphasis on the correlational phenomena that combine the emergent oscillatory dynamics, described in terms of power, phase, coherence of different neurophysiologically relevant spectral components and cross-frequency coupling, with psychophysical and behavioural outcome measures such as memory load, stimulus detection rate or reaction times among others. The presented work provides computational insights into the neural mechanisms underlying the aforementioned correlational and modulatory effects observed in experimental studies. In a broader perspective, it also demonstrates the potential of large-scale mesoscopic attractor network models as a framework enabling to link different levels of biological findings, and thus facilitating multi-scale understanding of the cortical function and its neural substrate.