Nodes and Modes: Modelling Large-scale Neural Activity

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Models of large-scale neural activity have a rich history, although their contributions to computational and translational neuroscience have only been recently highlighted. Large-scale models aggregate the activity of populations of neurons into local ensembles, which then interact across scales to yield whole brain patterns of activity (and behaviour). I will first overview neural mass models, in which populations are modelled as discrete nodes interacting through structural connections yielding complex “many-N” patterns of activity. Neural masses have mainly been used as generative models of resting state activity. I will then review neural field models in which aggregate behaviour of neurons changes continuously across the cortex and via sub-cortical loops. Neural fields can be decomposed into spatiotemporal (eigen)modes, which are then truncated to relatively low order to capture cortical behaviour. As a translational example, I will show that the transition from quiet to active sleep in newborn infants can be modelled as a reorganization of large-scale cortical eigenmodes. Active sleep is defined by reduced energy in a uniform mode of neural activity and increased energy in two more complex anteroposterior modes. This reorganization is attenuated in preterm infants and predicts visual performance at two years. More generally, I will argue that the re-organization of eigenmodes – or "brain harmonics" may be a fundamental principle of brain activity across the lifespan.

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