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From Corticogenesis to Functional Networks

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The development and function of the cerebral cortex of the mammalian brain is a complex orchestration of cellular dynamics leading to a highly specialised structure. The present study explores the development of a gene regulatory network that abstracts the underlying DNA and genetic expression responsible for this anatomical process. An agent-based model is created in the high performance software, BioDynaMo, to model the 3D spatial formation of the neocortex. A laminated structure of neuronal cell bodies is produced through stochastic cell fate determination and cell numbers are verified. Multicompartmental neurons are grown using local guidance cues to generate realistic circuit morphologies. Entire cortical columns are simulated with the potential for multicolumn connectivity analysis.

When stimulated in NEST, these spatially informed circuits are found to produce homeostatic network dynamics through realistic afferent connectivity and input regimes. Synaptic weights are updated through a BCM based approach to produce networks with realistic cortical activity. This modelling approach allows investigations into the effects of each stage of development and the emergence of functional circuitry in the cortex. Initial analysis is carried out on network motifs and encoding of synthetic stimuli showcasing emergent computational units. The networks grown mimic canonical microcircuit connectivity. A full study is underway to analyse the emergent functional circuits that can be grown in this realistic corticogenesis simulation. The model is set up to validate a set of hypotheses regarding emergent circuitry, electrophysiology and also the effect of activity during development in the cortex.

Acknowledgements

References

Preferred form of presentation

Talk (& optional poster)

Keywords

Corticogenesis, function, dynamics, homeostasis, agent based model

Topic area

Models and applications

Speaker time zone

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Primary author: ABUBACAR, Umar (University of Surrey)

Co-author: Dr BAUER, Roman (University of Surrey)

Presenter: ABUBACAR, Umar (University of Surrey)

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