Mathematical Modelling for Functional Differentiation

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Abstract One of the most striking characteristics of the developing brain is functional differentiation, while emerging interactions develop between networking differentiated areas. To clarify the neural mechanism of functional differentiation, we constructed a mathematical model of self-organization with constraints. By casting different constraints, we investigated the mathematical structures of functional differentiation and obtained the following specific behaviors. (1) We observed the genesis of a neuron-like unit in the developmental process of networking dynamical systems. (2) We observed the genesis of neuron-like units that respond specifically to visual and auditory stimuli, respectively. (3) We observed the genesis of functional modules from randomly uniform networks of oscillations, where the modular organization can be interpreted as the differentiation of a higher cognitive area and a lower motor area interacting with the body. In all cases, the appearance of chaos and chaotic itinerancy in the whole network system brings about the generation of functional elements via an acceleration of symmetry breaking.

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