Brain structure under a critical condition mediated by local currents

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The brain may be viewed as a complex network which, at the functional level, is highly heterogeneous and dissasortative, with scale-free distributed degrees [1]. This structure is known to improve both the robustness and efficiency of the network [2] and it is likely to be determined, at least in part, by a process of synaptic pruning. The latter is a physiological process which is known to take place in the brain of many mammals during infancy and which consists in an extensive activity-dependent elimination of synapses [1–3]. In this work, we study the correlation between the topological properties and the cognitive abilities of a neural network which evolves under a process of synaptic pruning. In accordance with previous studies, we seek for a deep correlation between neural network structure and brain activity patterns [4].

Previous studies [5] have analysed the topological process of synaptic pruning by assuming topological microscopic mechanisms for attachment and detachment of links. Here we propose a new model of evolving neural systems in which synaptic pruning is mediated by microscopic rules that depend on physiological information associated to the dynamic of both neurons and synapses. A preliminary study shows that only when the system reaches a memory phase there is a direct correlation between each neuron's degree and the synaptic current it is receiving. This, in fact, implies a strong correlation between the structural and functional topologies during memory and retrieval of information. Furthermore, the final state of the evolving network shows, in this memory regime, critical features such as a scale-free node degree distribution.

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