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Random wiring limits the development of functional structure in large recurrent neuronal networks

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Spike-timing dependent plasticity (STDP) has traditionally been of great interest to theoreticians, as it seems to provide an answer to the question of how the brain can develop functional structure in response to repeated stimuli. However, despite this high level of interest, convincing demonstrations of this capacity in large, initially random networks have not been forthcoming. Such demonstrations as there are typically rely on constraining the problem artificially. Techniques include employing additional pruning mechanisms or STDP rules that enhance symmetry breaking, simulating networks with low connectivity that magnify competition between synapses, or combinations of the above (see, e.g. [1-3]).

Here, we describe a theory for the stimulus-driven development of feed-forward structures in random networks. The theory explains why the emergence of such structures does not take place in unconstrained systems [4] and enables us to identify candidate biologically motivated adaptations to the balanced random network model that might facilitate it. Finally, we investigate these candidate adaptations in large-scale simulations.

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