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Abstract:

It is generally believed that associative memory in the brain depends on multistable synaptic dynamics, which enable the synapses to maintain their value for extended periods of time. However, multistable dynamics are not restricted to synapses. In particular, the dynamics of some genetic regulatory networks are multistable, raising the possibility that even single cells, in the absence of a nervous system, are capable of learning associations. Here we study a standard genetic regulatory network model with bistable elements and stochastic dynamics. We demonstrate that such a genetic regulatory network model is capable of learning multiple, general, overlapping associations. The capacity of the network, defined as the number of associations that can be simultaneously stored and retrieved, is proportional to the square root of the number of bistable elements in the genetic regulatory network. Moreover, we compute the capacity of a clonal population of cells, such as in a colony of bacteria or a tissue, to store associations. We show that even if the cells do not interact, the capacity of the population to store associations substantially exceeds that of a single cell and is proportional to the number of bistable elements. Thus, we show that even single cells are endowed with the computational power to learn associations, a power that is substantially enhanced when these cells form a population.

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