

A mathematical model for the hippocampus: towards the understanding of episodic memory and imagination

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ABSTRACT

How does the brain encode episode? Episodic memory has become interested in neuroscience community since the finding of malfunctions on the formation of episodic memory caused by the damage of hippocampus. On the other hand, simple memory has been explored in various contexts, in particular, since Marr ' s theory for archecortex (incl. the hippocampus), where Marr considered the hippocampal CA3 to be responsible for associative memory. However, a conventional mathematical model of associative memory guaranteed only a single association in case without any given rule for the order of successive association. Recently, the clinical studies for the patients who have the damage of hippocampus show that such patients cannot make a new story, caused by the lack of capability of imagining new things. Both episodic memory and imagining things include various common characteristics: imagery, the sense of now, retrieval of semantic information, and narrative structures. Taking into account these findings, we made a model of hippocampus CA3 and CA1. Our mathematical model shows striking characters such as representing episode, encoding input time series and decoding it, based on the emergence of affine rules in CA1 and chaotic rules in CA3. We also conducted experiments with rats ' hippocampus slices. We obtained similar behaviors to those predicted by the model.