Its about time

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Animals and humans are able to intuitively compute interval times on scales from less than a millisecond to hours. The mechanisms for parts of this range are known, but not much is known about the mechanisms for computing temporal intervals at the range between hundreds of milliseconds to the several seconds. Recent surprising experimental results indicate that such computations might be present already in primary sensory cortex. But the circuit level mechanisms for representing and learning these temporal intervals have not been characterized.

On the basis of recent experimental results we have developed theory of how temporal intervals are calculated and learned in cortical circuits. We propose that interval time calculations are implemented in a recurrent network, and that such a network can learn temporal intervals that an order of magnitude larger than the intrinsic network time constants. I will describe both a stochastic spiking implementation of the network, and a one-dimensional dynamical mean-field theory that that agrees well with the simulations. The mean-field theory provides intuition of how the network functions and what are its limitations.

Further, we propose that the network can learn these time constants using reinforcement based learning algorithm. I will describe two alternative models of the learning-rule and present very recent experimental evidence that supports one of these models.

Finally, I will describe a unified plasticity model that encompasses both reinforcement dependent and reinforcement independent forms of synaptic plasticity and show how this joint model can account for various experimental results.