Computation with Action Potential Delay Dynamics

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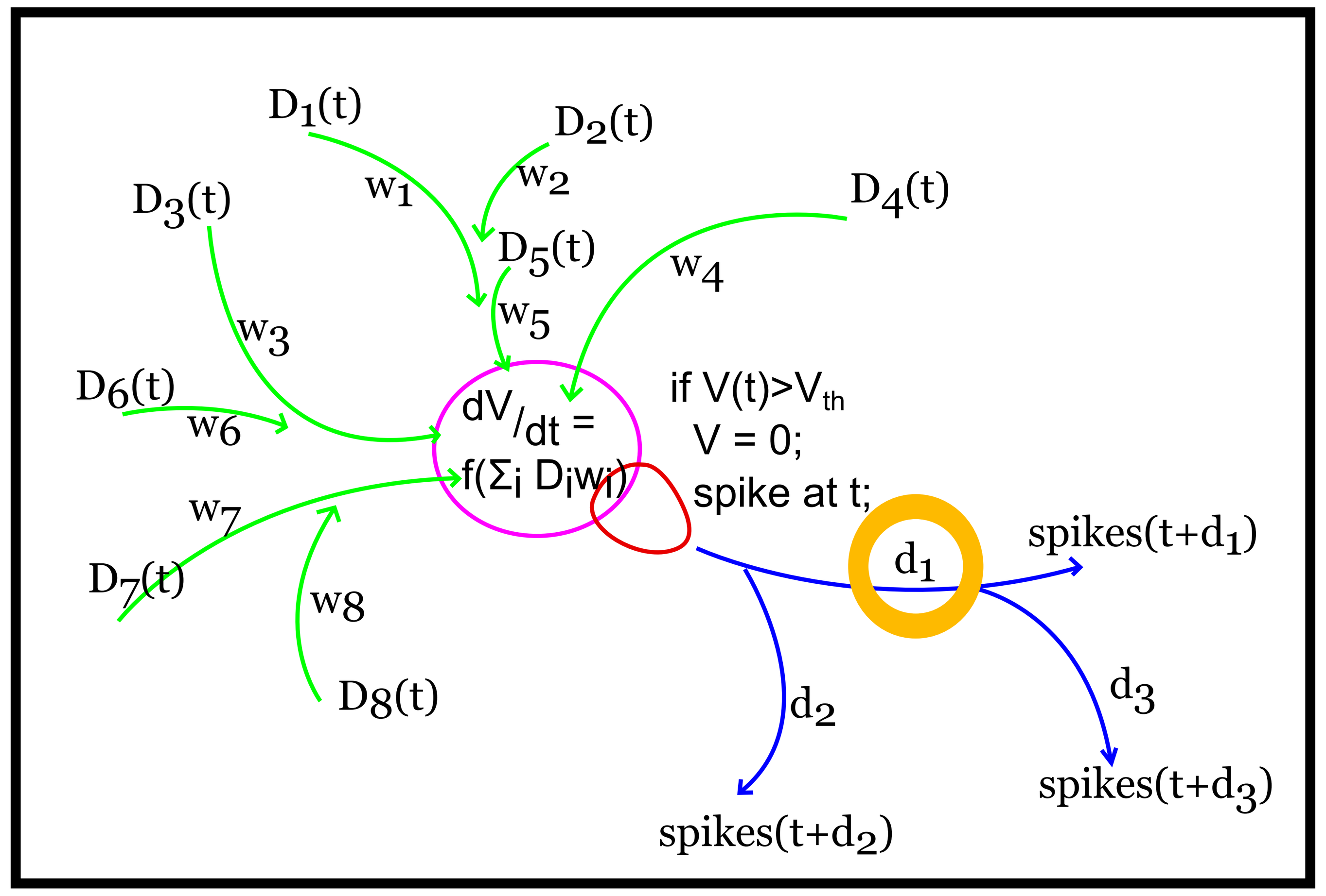
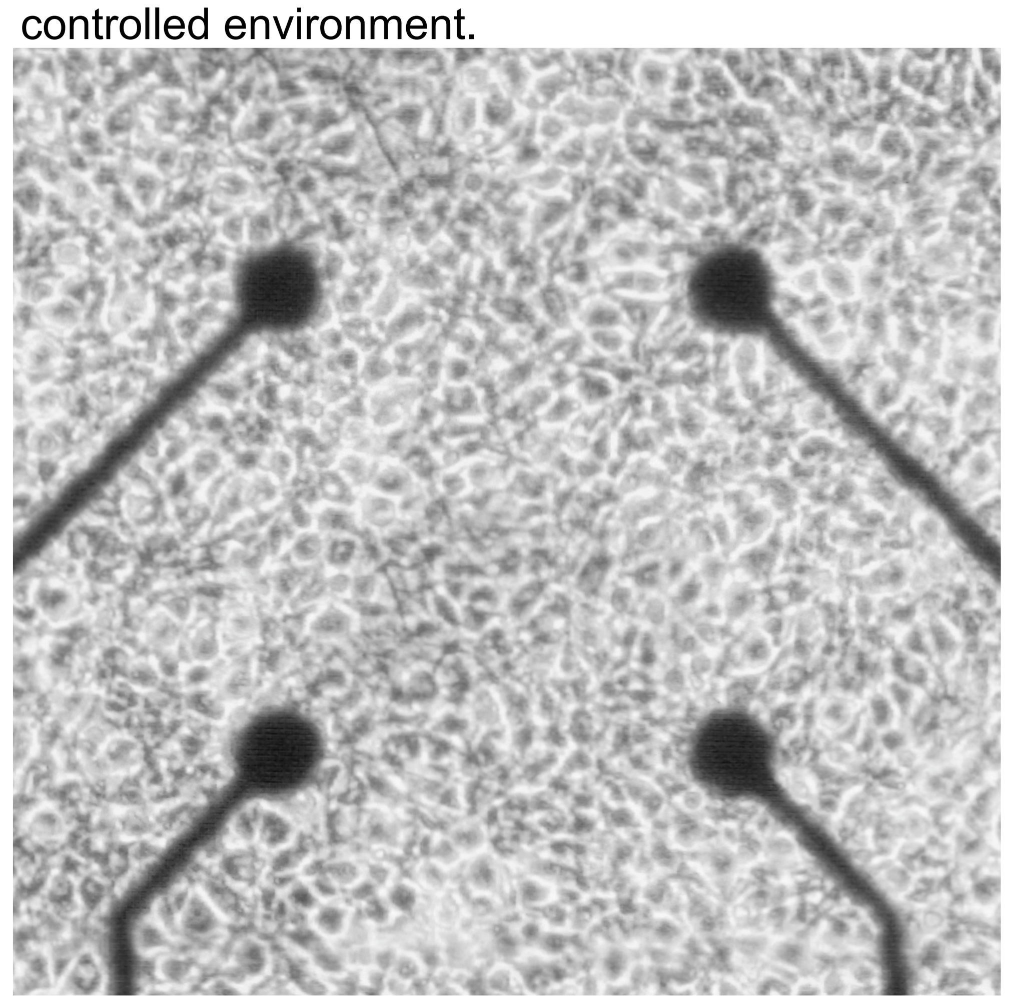
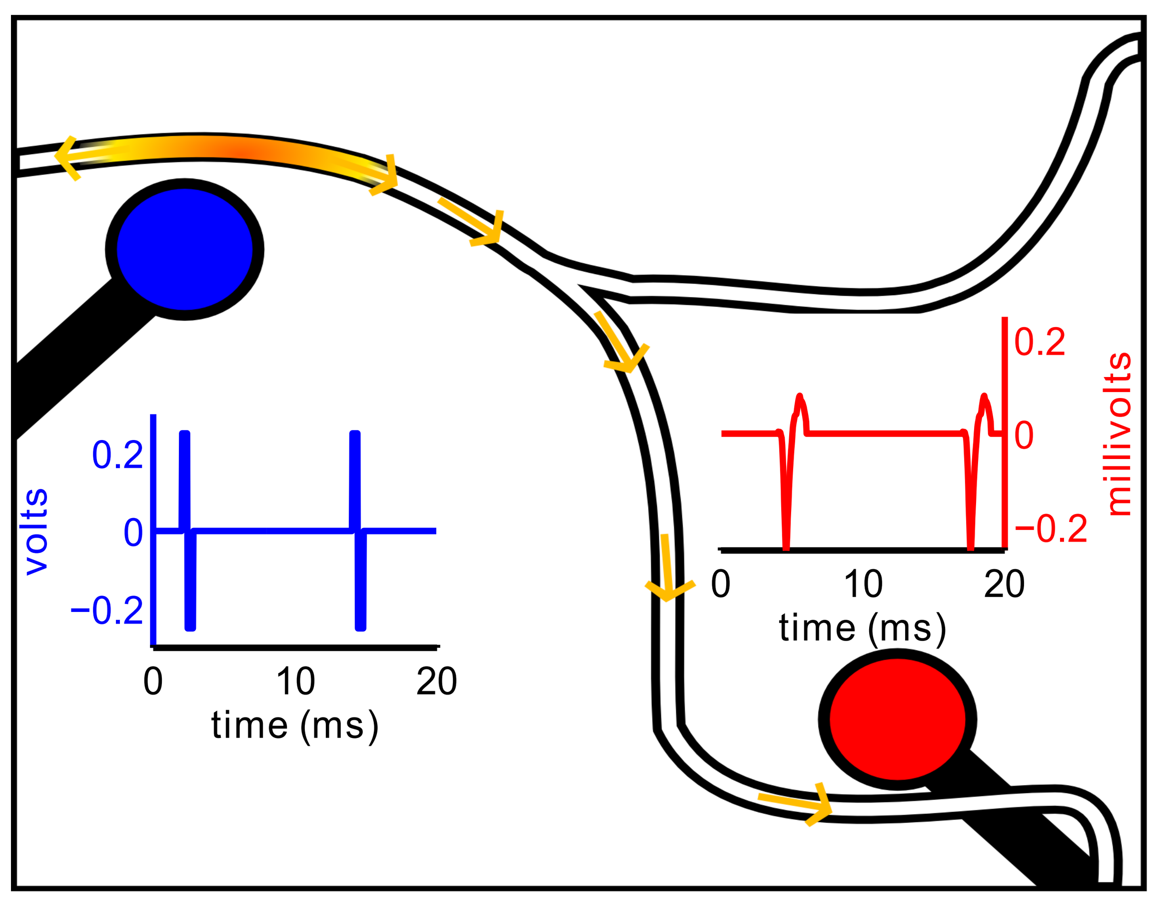
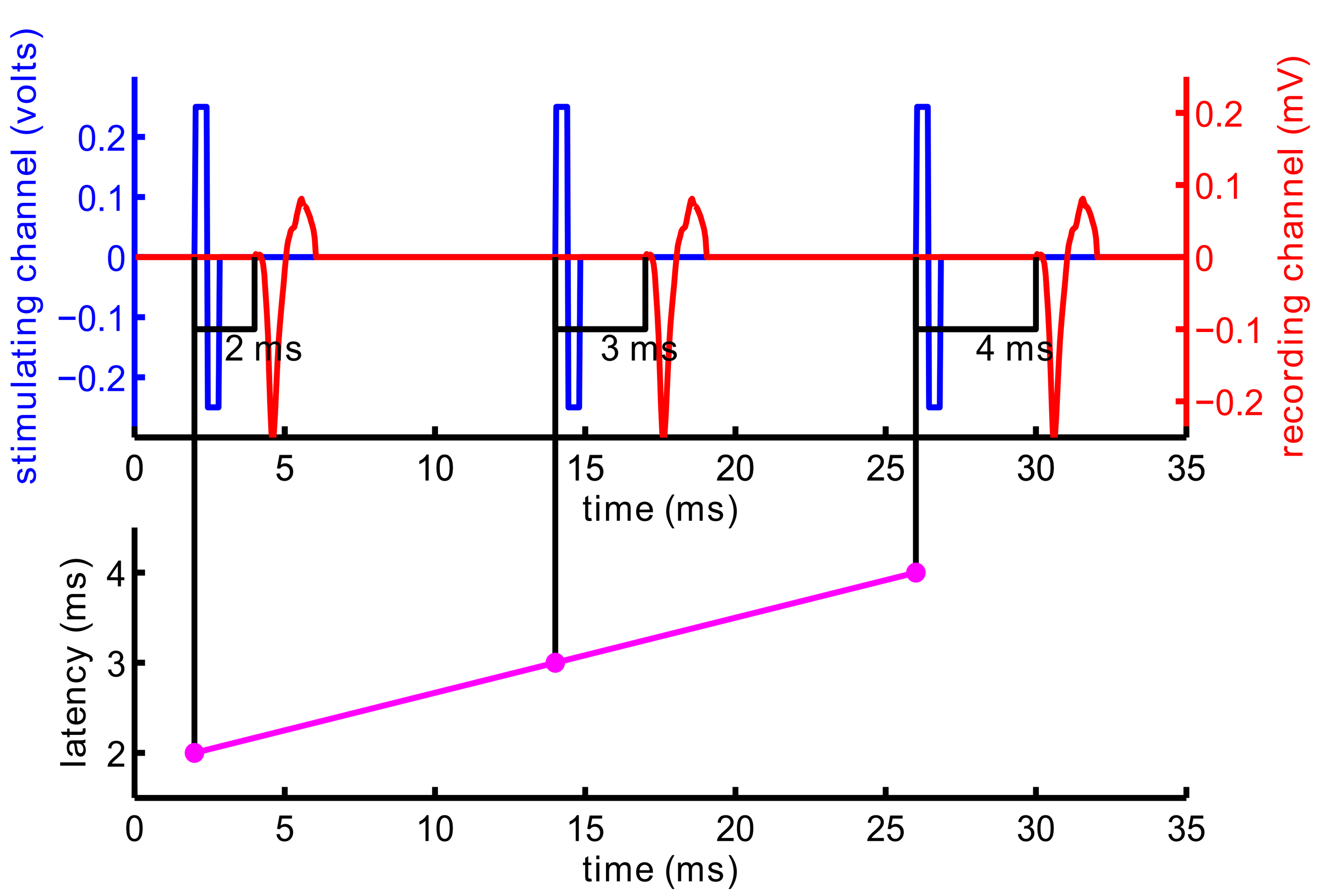


Models of neural computation (left) can be informed through study of dissociated cortical networks grown on multielectrode arrays (below). This system gives high bandwidth, long term access to developing neural systems, in a highly controlled environment.

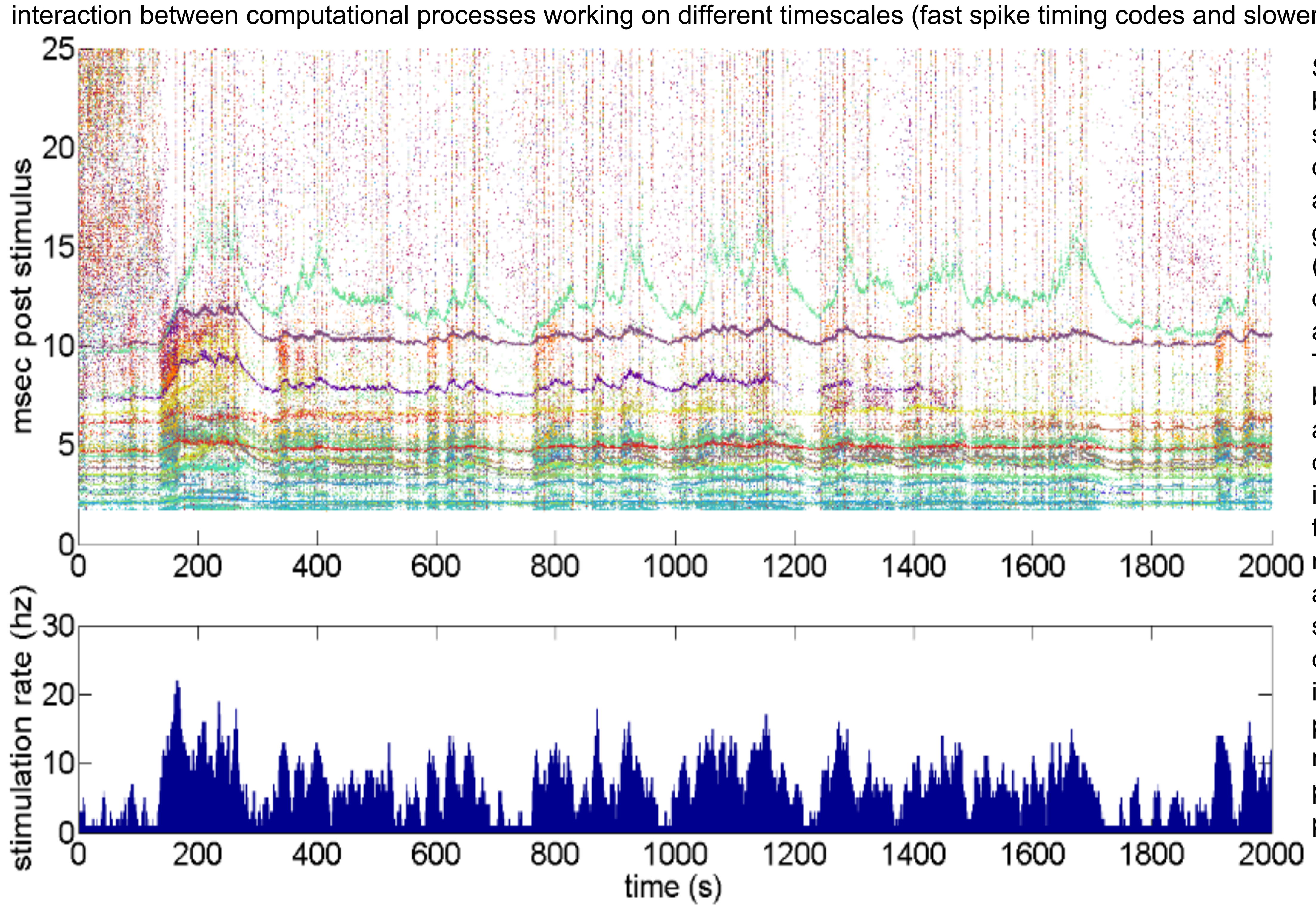


Biologically Inspired Artificial Neural Networks, such as Spiking Neural Networks (SNNs), promise to provide significant advances over classic Artificial Neural Networks (ANNs) by performing computations in ways similar to the living brain. SNNs use discrete action potentials, which require a finite amount of time to travel between neurons. Most SNNs assume this axonal conduction delay to be constant, in spite of growing biological evidence that this conduction delay shows both long term and short term plasticity. We are working to explore the computational implications of these dynamics.





Pulsatile electrical stimulation of a single electrode can be used to measure action potential propagation delay (left), an important compon of neural computation (highlighted above left). When the frequency of this pulsatile stimulation is modulated, propagation delays of many different neurons change (below). This shows that propagation delay is itself a function of the firing rate of the neuron, which allows for interaction between computational processes working on different timescales (fast spike timing codes and slower spike rate codes) .



Stimulation frequency can be modulated to encode signals from real world dynamical systems, such as the electric power generator turbine speed (upper right). Propagation delays contain information about this signal (right). The information contained by the propagation delays at a given point in time complements the information contained in the firing rate of the neuron. Furthermore, this additional information is shown to be computationally useful, as it can improve the performance of an artificial neuron tasked with performing time series prediction.