Abstract for an Invited Paper
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Beyond Optimality to Understanding Neuronal Circuits[1]

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I will summarize recent theoretical and experimental work that shows that similar circuit outputs can be produced with highly variable circuit parameters. This work argues that the nervous system of each healthy individual has found a set of different solutions that give “good enough” circuit performance. I will use examples from theoretical and experimental studies using the crustacean stomatogastric nervous system to argue that synaptic and intrinsic currents can vary far more than the output of the circuit in which they are found. These data have significant implications for the mechanisms that maintain stable function over the animal’s lifetime, and for the kinds of changes that allow the nervous system to recover function after injury. In this kind of complex system, merely collecting mean data from many individuals can lead to significant errors, and it becomes important to measure as many individual network parameters in each individual as possible. This work raises the question of the extent to which neuromodulation can be constant with underlying circuit parameter variation. To address this question, we construct two cell reciprocally inhibitory circuits using the dynamic clamp from biological GM neurons of the crab stomatogastric ganglion. We then describe the output of the circuits while sweeping through a range of synaptic and intrinsic conductances, first in control saline and then in the presence of serotonin. We find that serotonin extends the ranges of parameters that produce alternating bursting. Moreover, although serotonin’s effects are highly robust and significant on the entire population, individual networks respond anomalously. These data demonstrate that while neuromodulation may have robust actions on a population, not all individuals may respond as do the majority. These findings have important implications for evolution.

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