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Stochastic Dynamics in Bump Attractor Models of Spatial Working Memory

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Mammalian spatial navigation systems utilize several different sensory information channels. This information is converted into a neural code that represents the animal's current position in space by engaging place cell, grid cell, and head direction cell networks. We begin by analyzing a classical model of short term memory, wherein stationary pulse solutions (bumps) correspond to a mammal's representation of position in two dimensions. Through asymptotic analysis, we can study the effects of weak external inputs into the network. We find bumps tend to drift towards local attractors endowed by external inputs. Furthermore, when weak spatiotemporal noise is introduced, bumps tend to diffuse. This can disrupt the position code over short time windows, causing a degradation in location recollection. To address position errors induced by noise, we introduce a novel addition to the model that incorporates the effects of sensory landmarks. Through the inclusion of an external control signal, representing the effects of sensory landmarks in a given environment, errors can be reduced significantly. Our analysis concludes with extensions to multilayer (coupled) networks. We can again derive a low-dimensional approximation of the network dynamics that describes how heterogeneity, noise, and velocity input impact bump position. In particular, we find excitatory synaptic coupling between layers promotes correct velocity integration by reducing the effects of noise, a phenomena known as `reliability through redundancy'.

This seminar is sponsored by the RTG Quantitative Biology.

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For further information see http://esam.northwestern.edu

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Refreshments will be served at 3:30pm in M416