



The University of Chicago  
Department of Statistics

STATISTICS COLLOQUIUM SERIES

---

**NICOLAS BRUNEL**

Laboratory of Neurophysics and Physiology, University of Paris V

**Is Brain Connectivity Optimal?**

**MONDAY, October 24, 2011, at 4:00 PM**

133 Eckhart Hall, 5734 S. University Avenue

*Refreshments following the seminar in Eckhart 110.*

**ABSTRACT**

It is widely believed that synaptic modifications underlie learning and memory. This hypothesis has led to the study of many ‘learning rules’ that implement in a simplified way how synaptic efficacy is controlled by neuronal activity. This talk will focus on a complementary research direction: investigating optimal storage properties in neural circuits.

The first part of the talk will focus on the perceptron, the simplest feed-forward network model, as a simplified model of the granule-Purkinje cell pathway in the cerebellum. The distribution of synaptic weights of a perceptron that optimizes storage capacity can be computed exactly. This distribution has two striking features: (i) it contains a large number (at least 50%) of exactly zero weights (‘silent’ or ‘potential’ synapses); (ii) positive weights are distributed according to a monotonically decreasing function. We find that the theoretical distribution fits closely the distribution of synaptic weights of connections between granule cells and Purkinje cells, suggesting Purkinje cells function close to their optimal capacity in adult rats, which we estimate to be about 5Kb per cell.

In the second part of the talk, I will consider a network with a fully connected recurrent architecture, as a simplified model for local pyramidal cell networks of neocortex. If the network is asked to store a large number of fixed point attractor states, the distribution of synaptic weights turns out to be exactly the same as the one for a perceptron, and hence contains a large fraction of ‘silent’, or ‘potential’ synapses. Finally, I will consider the joint distribution of synaptic weights for pairs of neurons, and compare the theoretical results with recently published data on synaptic connectivity in cortical slices.

For further information and inquiries about building access for persons with disabilities, please contact Dan Moreau at 773.702.8333 or send him an email at [dmoreau@galton.uchicago.edu](mailto:dmoreau@galton.uchicago.edu). If you wish to subscribe to our email list, please visit the following website:  
<https://lists.uchicago.edu/web/arc/statseminars>.