4.9A Creating a Poisson-Patterned Spike Train

How neurotransmitter release probabilities might create Poisson patterns in a spike train for use in a foraging decision maker

Version of 4/26/03

Perhaps the simplest way to set up a neural circuit that generates Poisson-patterned spikes entirely by way of release probabilities is as follows. Attach a number of neurons, the *input* neurons, to a single *output* neuron. (These are not the same input and output neurons as in the probability matching setup described in section 4.94.) Have the input neurons fire very fast, but assume that they fire absolutely regularly, that is, without fluctuation. Suppose that the output neuron operates as a coincidence detector: it fires only if it receives a certain number of spikes in a very short time window. Arrange things so that this threshold value is reasonably close to the maximum number of spikes that the input neuron can send in the time window. Then, given a fairly low release probability (actual release probabilities are surprisingly low, often between 0.1 and 0.5), there is a very small chance that the threshold value is met or exceeded, and that the output neuron consequently fires, in each short time window. These probabilities are IID, thanks to the IID nature of the release probability; this is enough to generate a spike train from the output neuron with, approximately, a Poisson distribution.

This is, of course, something of an intellectual exercise: there is no reason to think that neurons are set up deliberately, as it were, to generate Poisson patterns (though it would be very interesting if they were). What is important is that there is a very close relationship between Bernoulli patterns and Poisson patterns, and so that the Bernoulli patterns of neurotransmitter release may well underlie, to some extent at least, the Poisson patterns in spike trains.