A modular model of presynaptic function

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Synapses of almost every type exhibit large dynamic changes in connection strength during ordinary use; the phenomenon is termed short-term plasticity. The resulting input/output function computed in the time domain varies greatly between synapses. Multiple presynaptic mechanisms are involved, but the identity of the mechanisms, how they interact, and the implications for biological computation are not understood. Our quantitative analysis of rate-limiting mechanisms in synaptic vesicle trafficking questioned the assumption that mass action of freely diffusing vesicles plays a role, and generated a mathematically simpler modular model where presynaptic terminals could be thought of as assemblies of individually-tuned frequency filters, operating in parallel. The modular model provides a starting point for developing a general theory for the role of synaptic dynamics in biological computation. I will discuss how and why we developed the new model and a series of cell biology experiments that test its validity.