

Processing of Complex Activity Patterns at the Calyx of Held Synapse: A Computational Analysis

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Cells in the auditory brainstem show high levels of spontaneous activity with rates of up to 100 Hz. *In-vitro* studies examining synaptic properties done in acute brain slices typically neglect this fact. The source of the spontaneous activity, namely the auditory hair cells, is removed in brain slices, resulting in an artificially low level of synaptic activity. As a model, we investigated synaptic transmission by the Calyx of Held synapse in the Medial Nucleus of the Trapezoid Body (MNTB) to determine the effect of sustained *in-vivo* like firing on the dynamics of transmission. In previous work (publication in progress) we showed that synaptic properties such as vesicle release probability changed, when the synapse was conditioned by stimulation with activity patterns similar to the normally present spontaneous firing.

In this study we present a vesicle release model, which can predict the short-term dynamics in conditioned synapses. Experimental data were obtained by recording evoked excitatory postsynaptic potentials (EPSC) in MNTB cells. We stimulated the afferent fibers with patterns mimicking the complex and highly varying natural input. These trains of activity had a Poisson like distribution with alternating mean frequencies ranging from a 5 Hz up to 300 Hz. The main features of the model that we used to predict our experimental traces were a constant release probability and a single exponential recovery.

In contrast to other studies [1] we find that a very basic prediction model with only three free parameters already gives a very good estimation of the recorded EPSC amplitudes. The correlation coefficient of the prediction and its underlying recording is almost 0.9 and therefore very close to the ceiling of predictability. The discrepancy between our study and other studies suggests that effects, which can be observed in artificially silenced brain slices may not necessarily affect the dynamics of synaptic transmission at *in-vivo* like activity levels.

Furthermore, the model predicts an apparent vesicle pool size, which is decreased to almost half of its value in rested synapses. Recovery experiments showed that this could only partly be attributed to the slow recovery time constant known from other studies [2, 3].

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References

1. Graham, B.P., A.Y.C. Wong, and I.D. Forsythe, *A multi-component model of depression at the calyx of Held*. Neurocomputing, 2004. **58-60**: p. 449-454.
2. Wang, L.Y. and L.K. Kaczmarek, *High-frequency firing helps replenish the readily releasable pool of synaptic vesicles*. Nature, 1998. **394**(6691): p. 384-8.
3. Sakaba, T. and E. Neher, *Calmodulin mediates rapid recruitment of fast-releasing synaptic vesicles at a calyx-type synapse*. Neuron, 2001. **32**(6): p. 1119-31.