SOME OBSERVATIONS….

Frequency Analysis

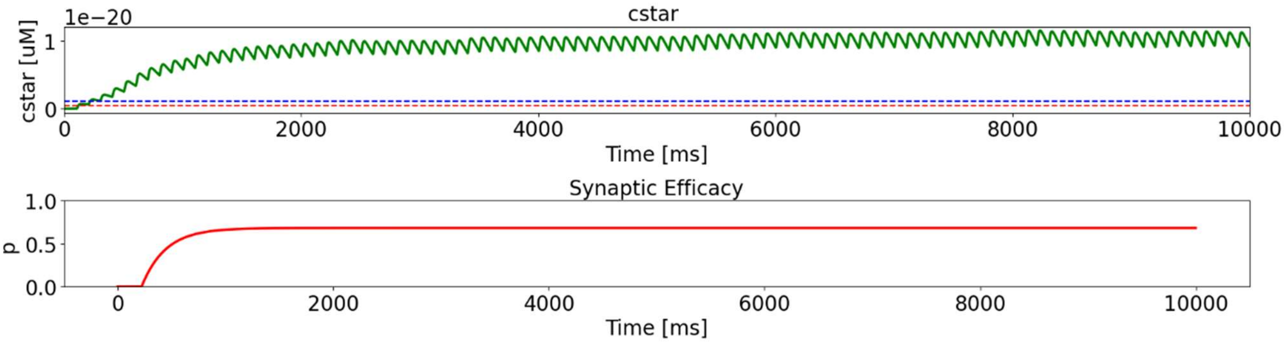
Working with the model proposed by Chindemi et al., we noticed a peculiarity. As stated in the presentation video, the effect of stimulation on synaptic weight depends on the plateau level reached by the leaky calcium integrator c*. However, this is influenced by the frequency at which neurons are stimulated.

For instance, let us consider the case where Δt=+10 ms. In this case, since the pre-neuron spikes before the post-neuron, it should induce LTP. In Chindemi's study, it is assumed that isolated neuron stimulation (or stimulation at low frequencies) does not induce changes in synaptic weight because the variable c* does not reach the thresholds. Such variations are observed only at higher stimulation frequencies. Specifically, in the paper, tests were conducted at a frequency of 10 Hz, which consistently allows for LTP when Δt>0 and LTD when Δt<0.

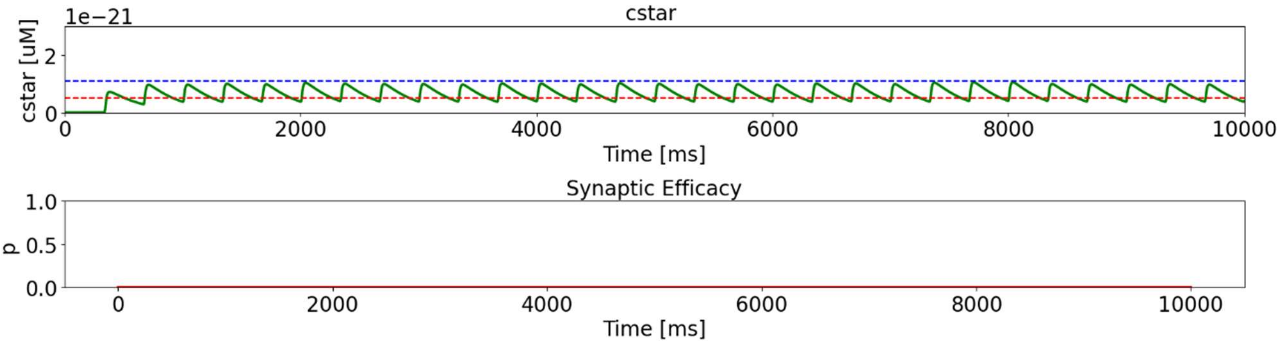
However, under this framework, there could be frequencies where, despite Δt being positive, the plateau value of c* reaches a level above ϑd but below ϑp. This is due to the fact that the plateau value of c* depends on the temporal summation of $[Ca^{2+}]$ levels in the postsynaptic neuron.

We therefore analyzed the frequencies at which the parameters used in the paper by Chindemi et al. remain appropriate. Specifically, we performed this analysis considering Δt=+10ms.

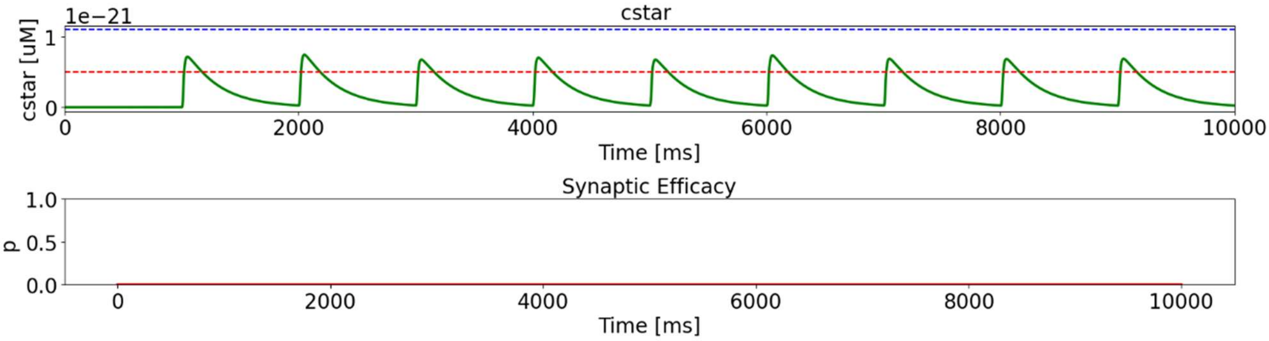
f=10 Hz: In this case, the desired result is obtained (LTP).



f=3Hz: In this case, we observe LTD despite Δt>0. Therefore, our model does not perform well at these frequencies. In this scenario, no changes in synaptic efficacy are observed because we initialized ρ=0 .



f=1Hz (and lower): In our model, despite the stimulation occurring at low frequency, the c* peaks reach the depression threshold, and therefore LTD occurs intermittently.



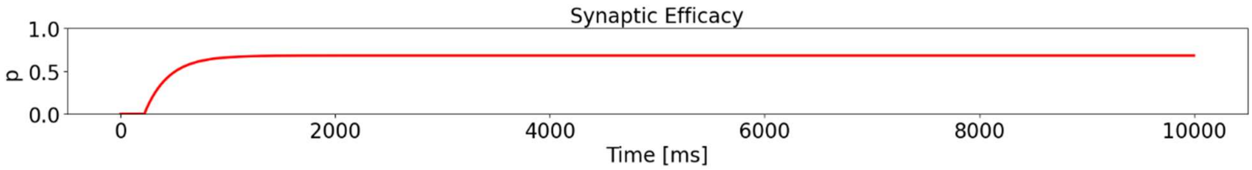
From the graphs shown, we observe that at low frequencies, up to approximately 3 Hz, LTD occurs despite Δt>0. Therefore, our model is suitable for studying stimulations with frequencies higher than this threshold.

This highlights the fact that the parameters used in the calculations must be adjusted according to the simulation protocol and are not universal.

Synaptic efficacy, ρ

The other observation we made is that, with this model, even when neurons are stimulated for a long time with Δt>0 (and at an appropriate frequency), the synaptic efficacy will never reach the value of 1 (the maximum synaptic weight) but will tend toward a value of approximately 0.6806.

$$\frac{d}{dt}\rho = \left(-\rho(1-\rho)(0.5-\rho) + \gamma_p(1-\rho)\Theta[c^* - \theta_p] - \gamma_d\rho\Theta[c^* - \theta_d]\right)/\tau$$



This is due to the fact that, in the differential equation for synaptic efficacy, when the value of c* exceeds ϑ_p (and therefore also ϑ_d) , both contributions of the term γ_ρ (1-ρ) $\Theta[c^*- \vartheta_p]$ and γ_d ρ $\Theta[c^*- \vartheta_p]$ will be taken into account.

To avoid this, it would be necessary to ensure that the Heaviside function returns zero when the value of c* is greater than both ϑ_d and ϑ_p.