Appendix 1

3rd August 2015

Comparison with triplet model

Our model has some similarities with the triplet-STDP model introduced in [1], however note that the triplet model does not distinguish between pre- and postsynaptic components of expression. The triplet model is defined by the following components: presynaptic traces, x_1 and x_2, and postsynaptic traces y_1 and y_2. The weight changes are modelled as a combination of pair and triplet components (*full Triplet* model) as follows

$$\Delta w^- = -X(t)y_1\left[A_2^- + A_3^- x_2(t-\epsilon)\right] \quad (1)$$

$$\Delta w^+ = Y(t)x_1\left[A_2^+ + A_3^+ y_2(t-\epsilon)\right] \quad (2)$$

However, to fit the intra-pairing frequency observed in the young rat visual cortex (VC) [2], a reduced model ($A_3^- = 0$ and $A_2^+ = 0$) was found to be sufficient (*minimal VC Triplet*) [1]

$$\Delta w^- = -X(t)A_2^- y_1 \quad (3)$$

$$\Delta w^+ = Y(t)A_3^+ x_1 y_2(t-\epsilon) \quad (4)$$

Moreover, another slightly more complex model ($A_3^- = 0$) was found to be able to capture triplet and quadruplet experiments performed in the hippocampus [3] (*minimal HC Triplet*)

$$\Delta w^- = -X(t)A_2^- y_1 \quad (5)$$

$$\Delta w^+ = Y(t)x_1\left[A_2^+ + A_3^+ y_2(t-\epsilon)\right] \quad (6)$$

Interestingly, our model also has two LTP and one LTD components, that can be mapped onto the *minimal*

HC Triplet (see Table 1). However, to capture the pharmacological blockade experiments reported in [4], we needed three triplets, rather than one triplet and two doublets as in the *minimal HC Triplet* model.

	LTD	LTP_1	LTP_2
pre-post STDP	$Xd_-y_-y_+$	$Xd_+y_+x_+$	$Yc_+x_+y_-$
minimal HC Triplet	$XA_2^-y_1$	$YA_2^+x_1$	$YA_3^+x_1y_2$
minimal VC Triplet	$XA_2^-y_1$	-	$YA_3^+x_1y_2$

Table 1: Comparison between unified pre- and postsynaptic STDP model and different versions of the *triplet* model (for simplicity we removed the function arguments) [1].

References

[1] Pfister, J.-P. & Gerstner, W. Triplets of spikes in a model of spike timing-dependent plasticity. *Journal of Neuroscience* **26**, 9673–9682 (2006).

[2] Sjöström, P. J., Turrigiano, G. G. & Nelson, S. B. Rate, Timing, and Cooperativity Jointly Determine Cortical Synaptic Plasticity. *Neuron* **32**, 1149–1164 (2001).

[3] Wang, H.-X., Gerkin, R. C., Nauen, D. W. & Bi, G.-Q. Coactivation and timing-dependent integration of synaptic potentiation and depression. *Nature Publishing Group* **8**, 187–193 (2005).

[4] Sjöström, P. J., Turrigiano, G. G. & Nelson, S. Multiple forms of long-term plasticity at unitary neocortical layer 5 synapses. *Neuropharmacology* **52**, 176–184 (2007).