

# Learning with three factors: modulating Hebbian plasticity with errors

Mohit Kulkarni mohitm@iitk.ac.in

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## 1 3 factor hebbain learning: Review paper

Łukasz Kusmierz, Takuya Isomura, Taro Toyoizumi

### 1.1 What does 3 factor mean

Associative Hebbian learning indicates association between two factors, but lot of the times it is also influenced by a third factor

$$\begin{aligned}\dot{w} &= F(pre, post, g, w) \\ \dot{w} &= gH(pre, post)\end{aligned}\tag{1}$$

pre and post are the pre and post synaptic activities, w is the synaptic strength and g is the third factor we talk about and H is the hebbian function

- When pre and post are spike trains, then the learning rule is STDP.
- Neuromodulators modulate hebbian plasticity. In hippocampus,  $D_1$  subunit dopamine receptor reverses LTD(long term depression) to LTP(long term potentiation).
- GABAergic inhibition directly supresses local dendritic  $Ca^{+2}$  signaling.

### 1.2 Functional role of 3-factor learning

- in RL, the reward r is the third factor, could also use  $\delta$  reward prediction error
- Aggregated label learning(Gutig), is a semi-supervised scheme which solved temporal credit assignment.
- Independent component analysis can be performed using a third factor that sums the activity of the output neurons.

### 1.3 Generation of the third signal

- in RL, a feedforward neural network encodes the value function. prediction error drives the learning.
- In unsupervised learning , a self supervisory signal is generated
- Many third factors can be calculated as a sum of nonlinearly transformed activities of a population of neurons.
- In ICA, the third factor is  $g = \sum_k \log p(u_k) + const..$  This third factor can be biologically encoded byb GABA.

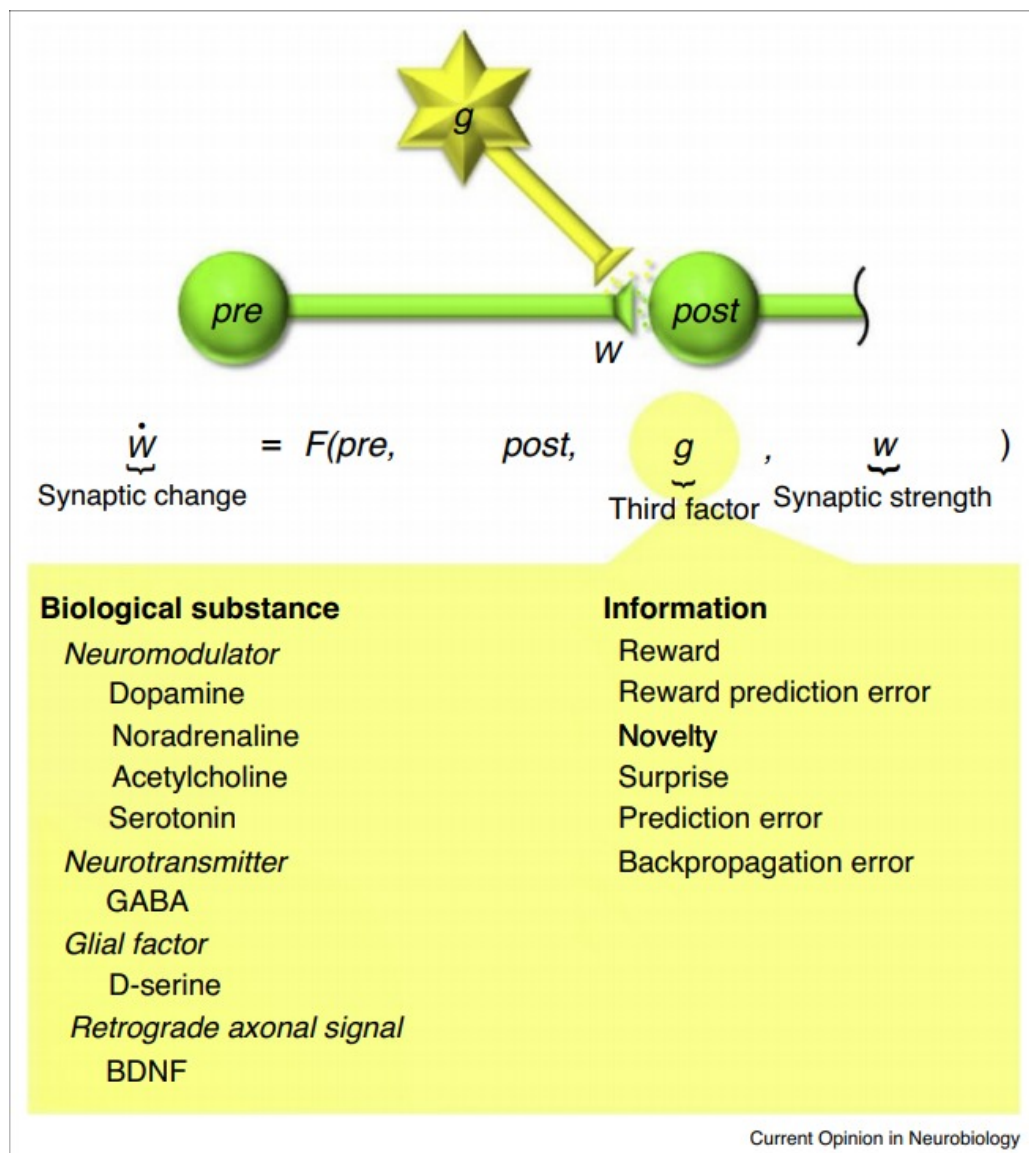


Figure 1:

## 1.4 Propagation of the third signal

Solving the spatial credit assignment problem

- in BP, there is a vector propagation of error signals from post to pre neurons.
- Other learning rule predicts that Apical Dendrites could act in the top-down error propagation.
- A more general approach is Target Propagation, Difference TP, where neuron is trained locally. Can be thought of as learning the BP algorithm

## 1.5 Papers cited that i can read later

- An approximation of the error back-propagation algorithm in a predictive coding network with local Hebbian synaptic plasticity
- Spiking neurons can discover predictive features by aggregate-label learning

- Triplets of Spikes in a Model of Spike Timing-Dependent Plasticity
- Towards an integration of deep learning and neuroscience