



Neural Circuits: Wiring and Tuning

Navee Kaur

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Synaptic Tuning

Three specific concepts associated with synaptic tuning:

- ❖ Long-Term Potentiation (LTP)
- ❖ Long-Term Depression (LTD)
- ❖ Spike-Timing Dependent Plasticity (STP)

[Source](#)

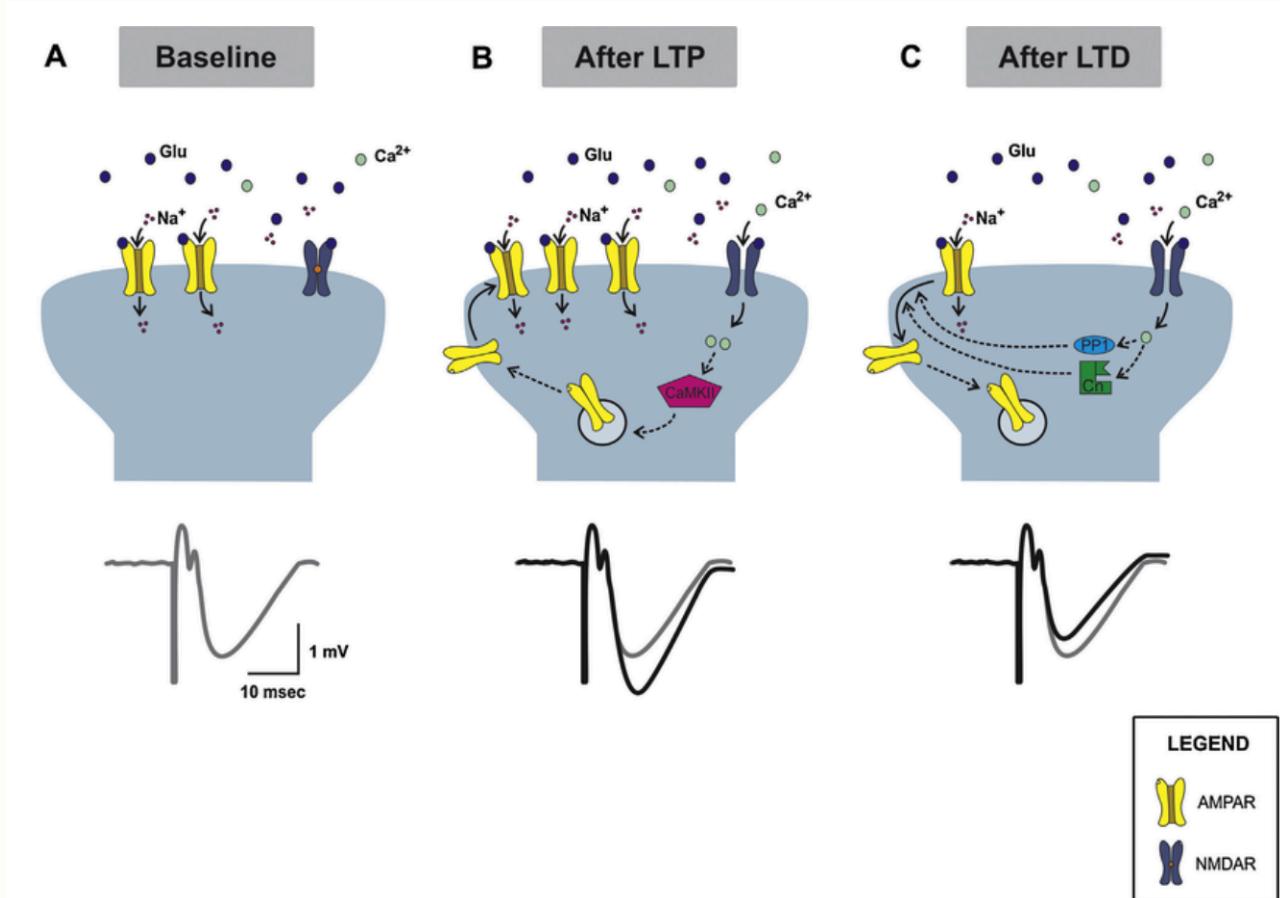


LTP:

- ❖ High-frequency presynaptic stimulation, or
- ❖ Low-frequency stimulation with postsynaptic depolarisation.

LTD:

- ❖ Low frequency stimulation
- ❖ Decrease in synaptic efficacy.



Significance





Definition of STDP

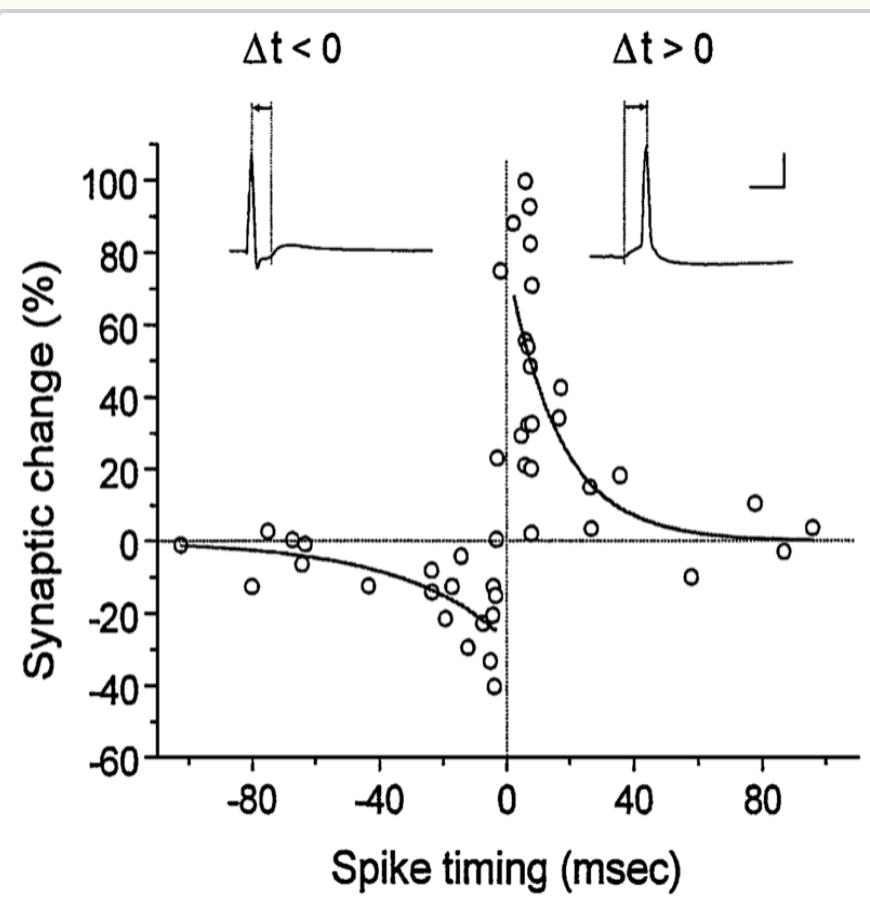


Figure 96: Spike-timing dependent plasticity measured in biological tissue (rat hippocampal neurons; adapted from [Bi2001]).

Hardware Implementation of STDP Example

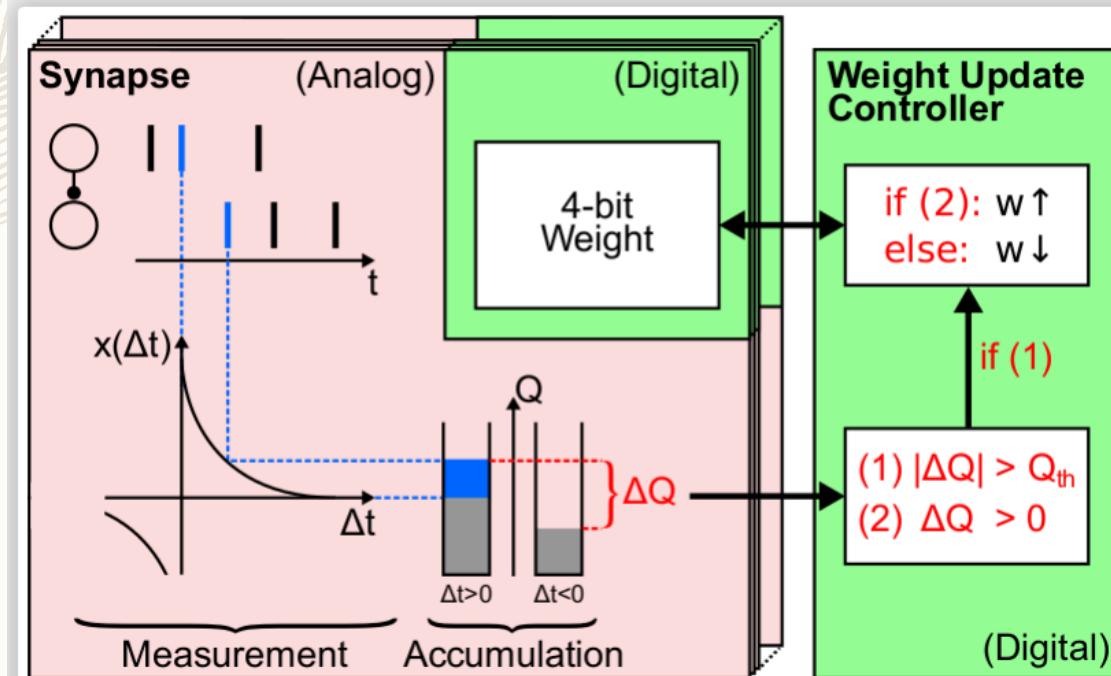
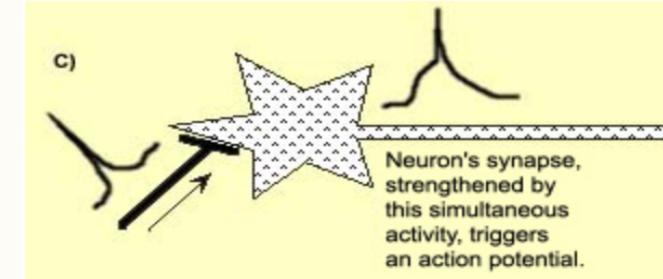
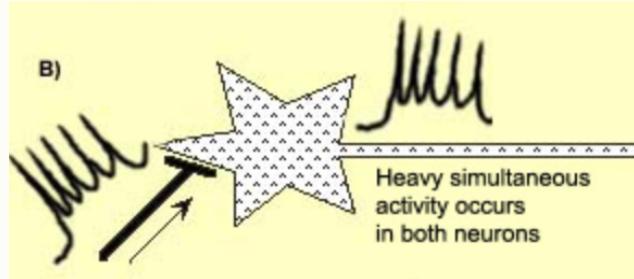
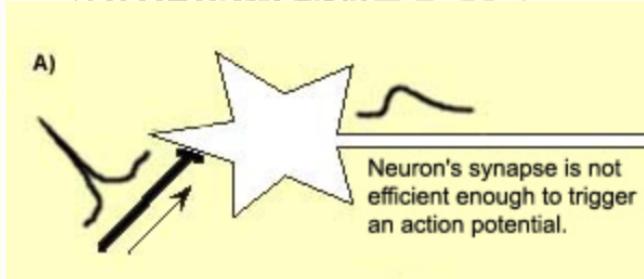


Figure 97: Hardware implementation of STDP (adapted from [Pfeil2015Phd]).

“Neurons that fire together wire together.”

❖ Hebb’s Law

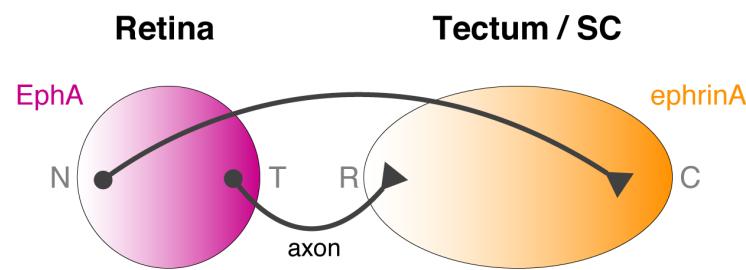


Synaptic Wiring

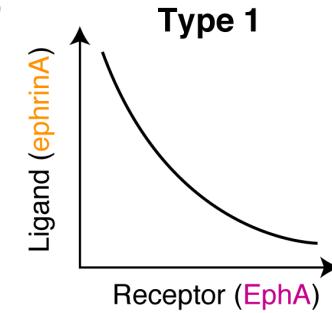


❖ Topographic Maps

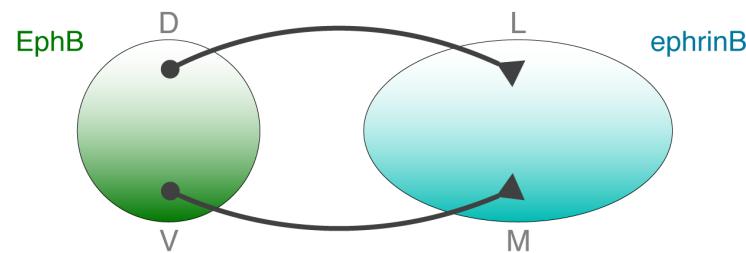
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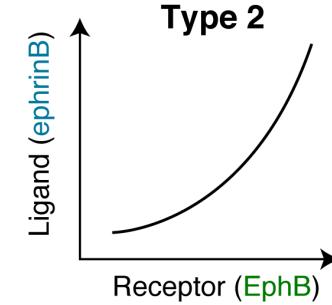
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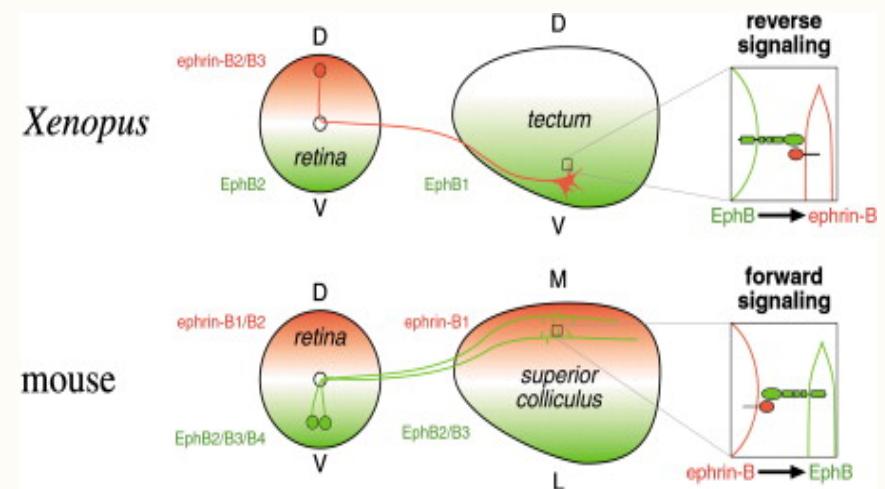
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Map Development Mechanisms

- ❖ Chemospecific matching:
 - *Similarity between input neurons (or output) is encoded by similarities expressed with a molecular gradient.*
- ❖ Based off of Sperry's Chemoaffinity Hypothesis

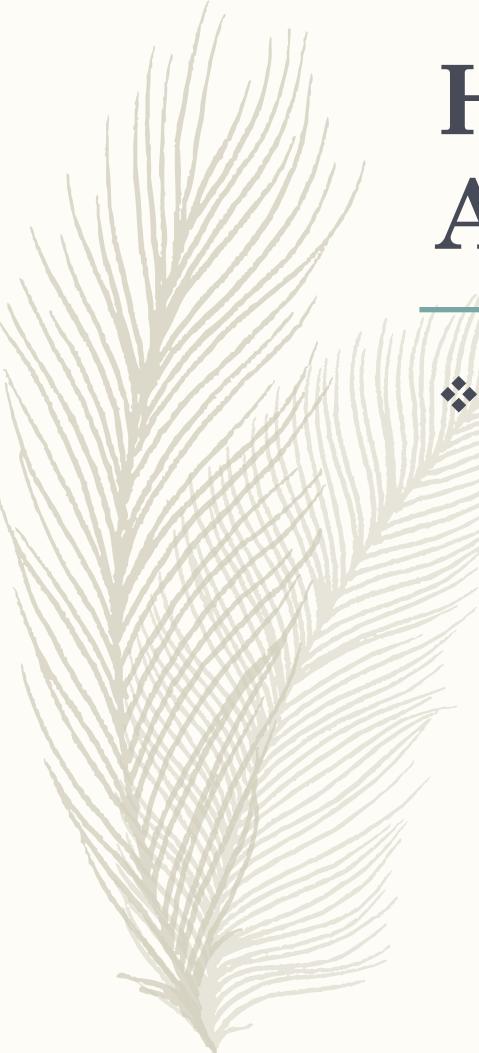




Map Development Mechanisms

❖ Activity-dependent matching:

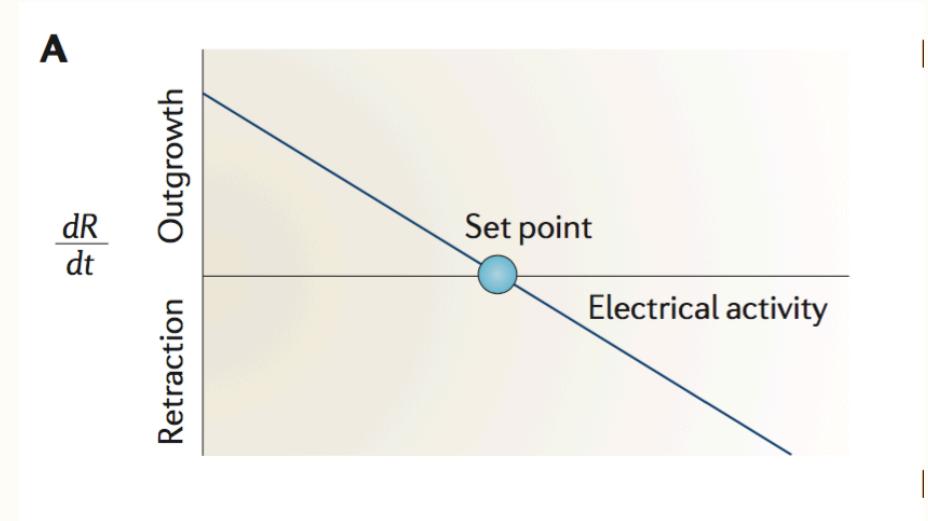
- *Similarity is encoded by correlations in activity*
 - Coactive = more similar



How Does This Information Affect Our Model?

❖ Our model:

- *Activity-dependent*
- *Focuses on one neuron at a time.*





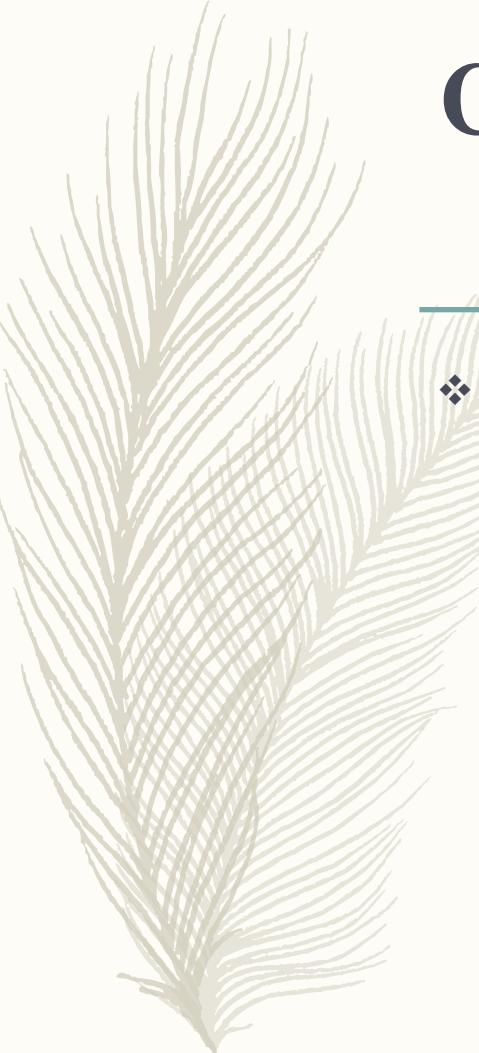
Short vs. Long-Distance Guidance

Long-Distance:

- ❖ Chemotaxis mechanisms
- ❖ Structural type mechanisms

Short-Distance:

- ❖ Similar to our model



Conclusion

- ❖ How do we fine tune the strength of our current model?
 1. Axonal Guidance
 2. Strengthening/weakening of individual synapses based on relative timing of pre/postsynaptic timing.