1

So far...

- **Units**: ions, conductance, membrane potential, firing.
- **Networks**: transformations, amplifications, attractors, basic building blocks of cognition.

How do networks ever come to do interesting things?

- **Learning**

2

Learning

- Describe an "ideal" learning system. (If you could design one, what features would it have?)
- Describe the human learning system. (How do our models need to learn to capture how we learn?)

3

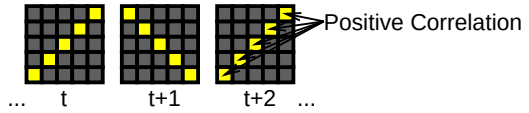
Learning

- Tuning detectors locally to achieve global results.
- Two main types:
  - Learning internal **model** of environment (Ch 4)
  - Learning to solve a **task** (produce output from input) (Ch 5)
  - Doing both at the same time (Ch 6)

4

Model learning

Pick up on correlations in the world.



(whether for pixels in visual images, emotions and people, behaviors, etc.)

Simulation.

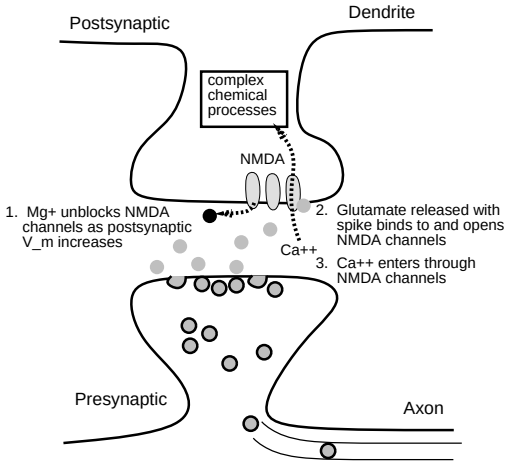
5 Biology: Associative/Hebbian LTP/D

Biology suggests associative or Hebbian learning: LTP and LTD. ("Units that fire together wire together!")

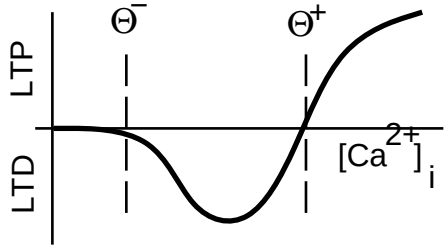
Synaptic efficacy (weights) change when neurons are excited:

- Going up: Long Term Potentiation (LTP)
- Going down: Long Term Depression (LTD).

6 NMDA = Associativity: Both Pre & Post Active



7 Biology: NMDA-mediated LTP/D

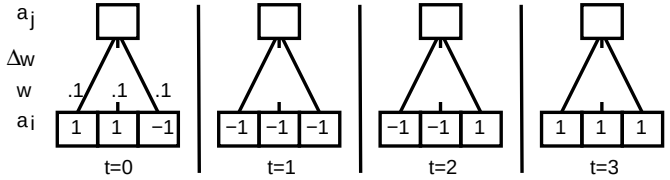


Strong activity (Ca^{++}) = LTP, weak = LTD

8 Hebbian Learning Picks up on Correlations

Simple Hebb rule: $\Delta w_{ij} = \epsilon a_i a_j$

Linear Activation: $a_j = \sum_i a_i w_{ij}$



Weights get stronger for the two units that are correlated, don't get stronger for uncorrelated unit!

9 Problems

Simple Hebb rule: $\Delta w_{ij} = \epsilon a_i a_j$

Weights will grow infinitely large.

Normalize by subtracting off weight.

$$\Delta w_{ij} = \epsilon a_j (a_i - w_{ij}) \quad (1)$$

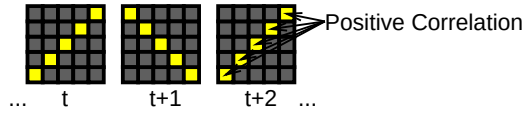
10 Biological Correspondence

$$\Delta w_{ij} = \epsilon a_j (a_i - w_{ij})$$

When both a_j and a_i large: Lots of $Ca^{++} \rightarrow$ LTP
When a_j large but a_i small: Some $Ca^{++} \rightarrow$ LTD
When a_j small: Mg+ blocking NMDA channels $\rightarrow$ nothing.
Simulations.

11 Model learning

Pick up on correlations in the world.



(whether for pixels in visual images, emotions and people, behaviors, etc.)

Based on Hebbian (LTP/LTD) mechanisms.