

The First Stage of Perception : Growth of the assembly

-Donald O Hebb

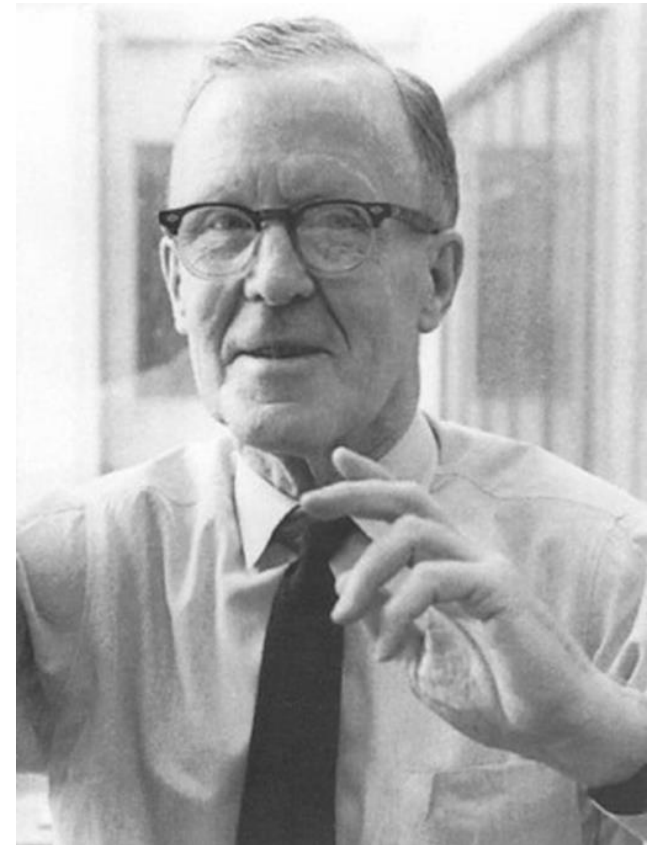
PRESENTED BY:

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Donald Hebb

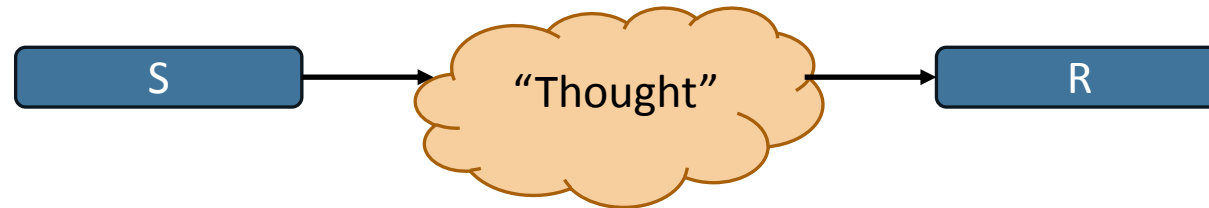


- Born in 1904
- Initially studied to become a novelist, then became a teacher, later became a farmer and then travelled as a laborer
- Finally became a psychologist inspired by Sigmund Freud
- One of the first psychologists to work on neural basis for describing behavior
- 1942 – 1949: Wrote this book, “The Organization of Behavior: A Neuropsychological Theory” while studying primate behavior.



Problem of thought

- $S \rightarrow R$ simple model does not explain animal thought process not fully controlled by the environment
- More like,



- How can we explain autonomous activities in the brain?
- Theories prior to this book:
 - Switchboard theory – similar to a telephone exchange
 - Field theory – Derived from Physics. Brain \rightarrow homogeneous medium of neurons
- But both these do not account for lag or delay between the sensory input and the motor response

Problem of thought (cont.)

- Hebb worked on how to model the mind and the complex process of thought
- Two components:
 - Learning
 - Memory
- Proposed “cell assemblies” to model ‘thought’ in the brain

Dual Trace mechanism [Memory]

- Previously, events → instantaneous reverberatory activity in the brain
 - Transient memory of the stimulus [proposed by Hilgard and Marquis, 1940]
- But some memories → instantaneous established as well as permanently stored
- How to account for these?
 - Hebb proposes:
 - Some transient but unstable reverberatory trace maintains the memory
 - Till some permanent structural change reinforces it

Hebb's Synapse

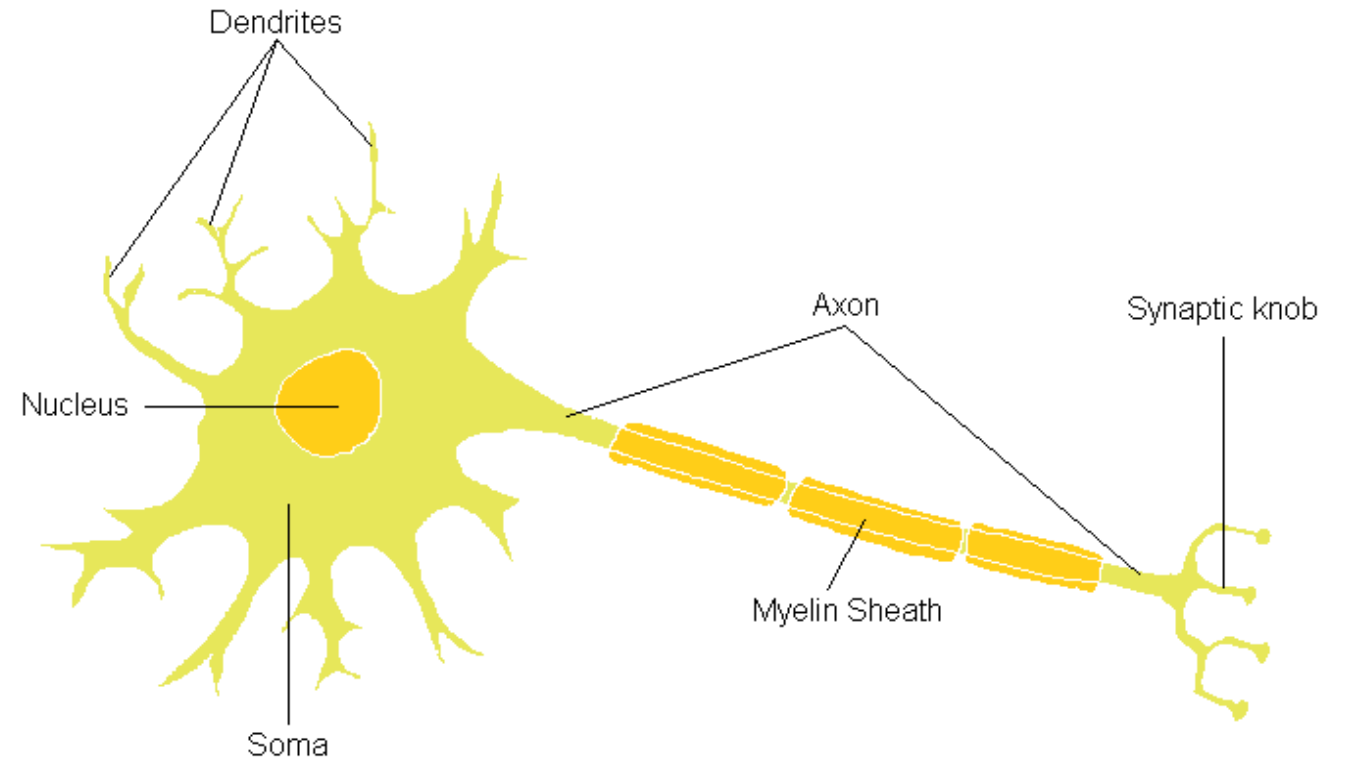
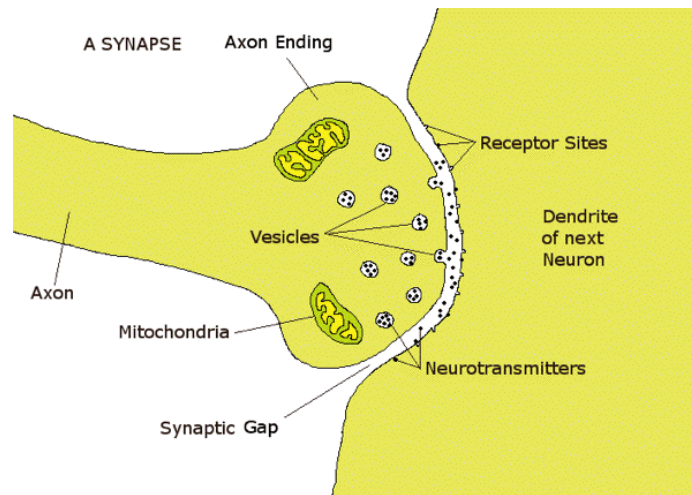
“When an axon of cell A is near enough to excite cell B and repeatedly or persistently takes part in firing it, some growth process or metabolic change takes place in one or both cells such that A's efficiency as one of the cells firing B is increased.”



Cells that fire together, wire together!

Synaptic knobs

- When one cell repeatedly fires another, Axon on first cell develops synaptic knob or enlarges existing ones and increase contact area with soma of second cell



Images from www.ainenn.org

Synaptic Knobs (cont.)

- Fiber 6 connects strongly to nodes C and B but bypasses D
- D and neuron connected with fiber 6 are not strongly associated

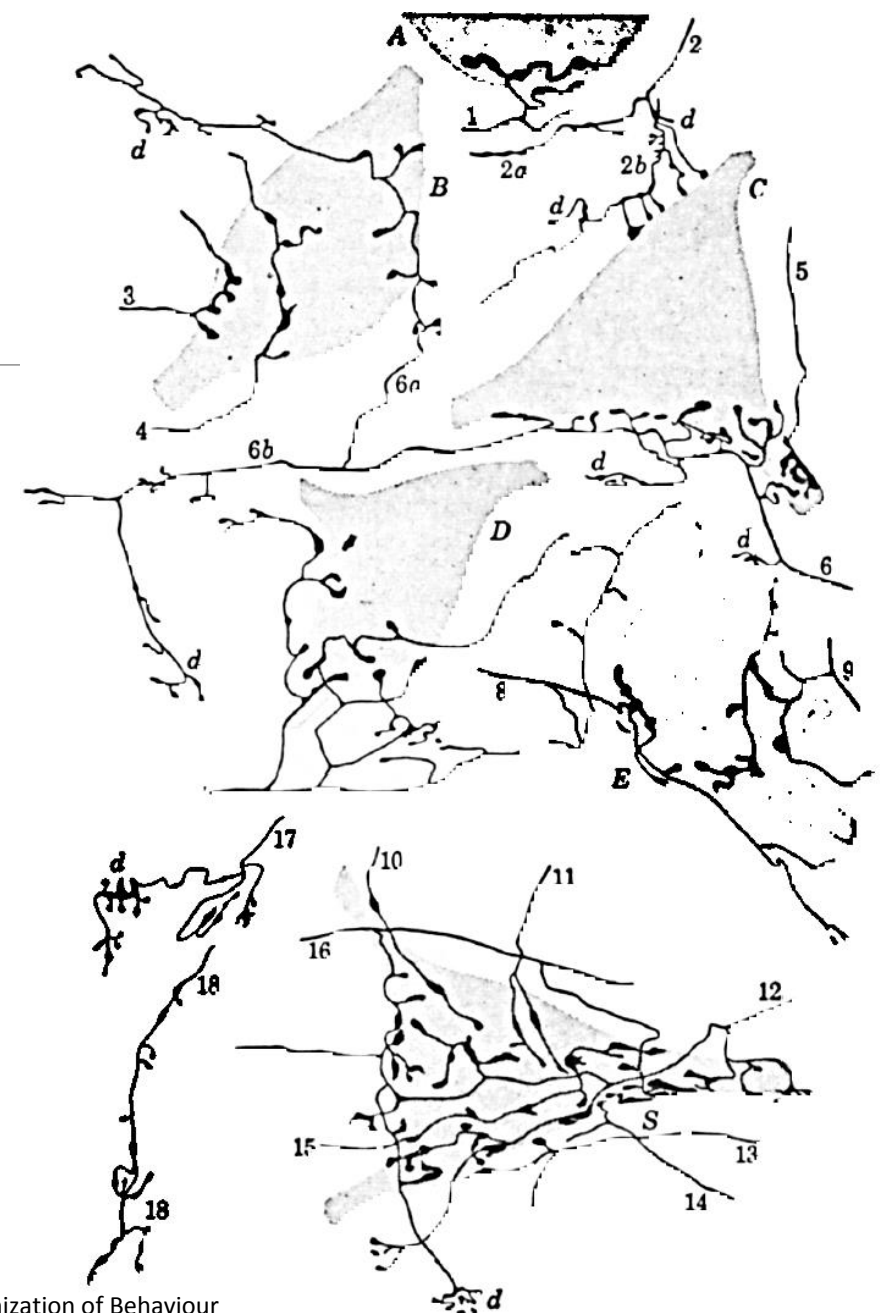


Figure 7, Chapter 4, The organization of Behaviour

Hebbian Learning rule



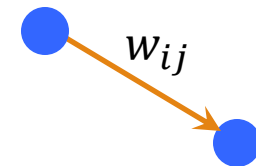
- Mathematically,

$$\Delta w_{ij} = \eta * x_i * x_j$$

where,

- w_{ij} → the weight of the connection from neuron i to neuron j
- x_i, x_j → the binary excitation levels of neuron i and j
- η → learning rate

Pre-synaptic neuron i



Post-synaptic neuron j

The cell assembly

- Two or more cells that are active together repeatedly become 'associated'
- Sensory-Sensory associations formed along with S-R associations
- Example:
 - A, B -> visual-area afferent neurons
 - C leads back to area 17
 - Now,
 - A fires strongly → Cells in Area 18 are excited
 - ⇒ C fires back into Area 17 → B is excited enough to fire
 - ⇒ A's firing causes B's firing
 - Synapses grow at AC and CB
 - With such repeated excitation in 17, A-B [S-S] association is established

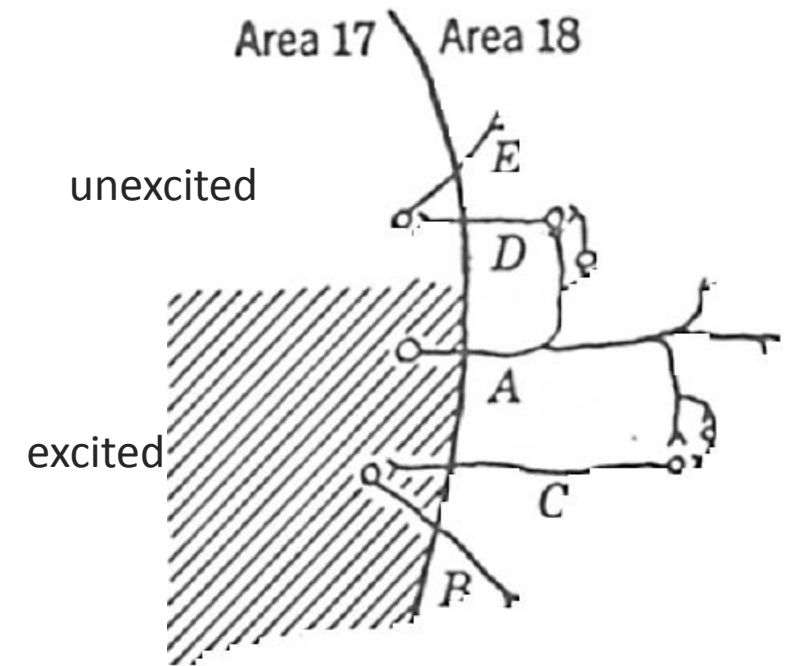


Figure 8, Chapter 4, The organization of Behaviour

The cell assembly (cont.)

- Another example.
- A, B, C → fire together
- A contributes to firing E
- Excitation of B fires D and C
- ⇒ synaptic knobs at AE, BC, BD grow and coordinated activity increases
- Gradually B gets higher control over D and at some point D gets excited enough by B to activate X
- An with repeated firing of X the junction BX is reinforced and a closed loop BDXB is formed → reverberatory excitation

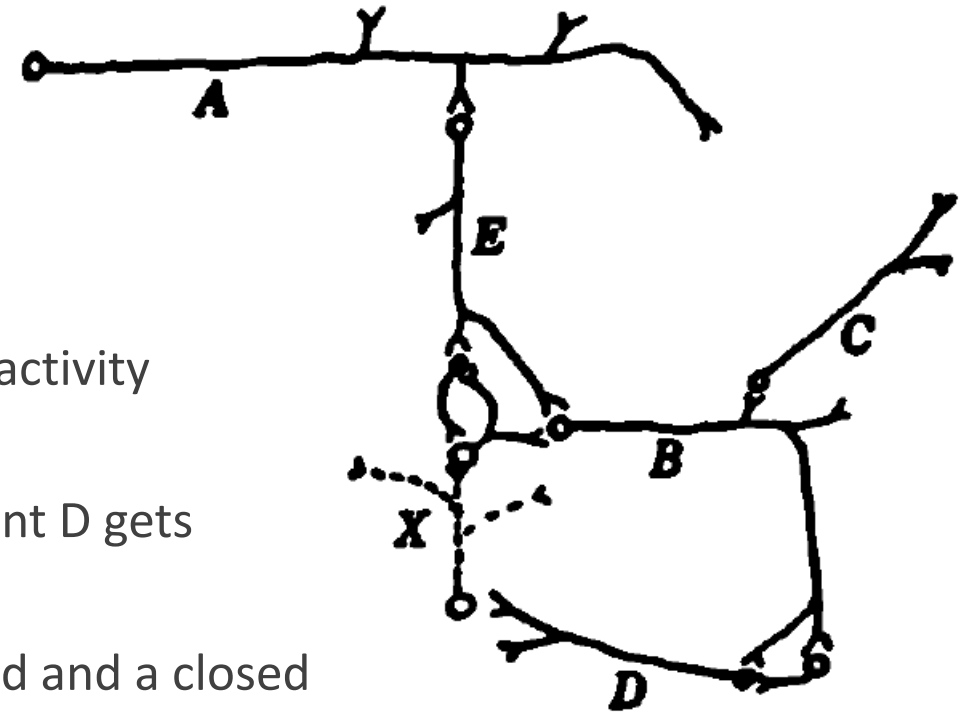


Figure 9, Chapter 4, The organization of Behaviour

The cell assembly (cont.)

Example of cell assembly with long reverberations:

- Arrows here are pathways rather than just single neurons
- Numbers refer to time of excitation
- Simple closed loop: 1-2-3-4
- If the conditions of excitations of others areas remain same, elongated periods of reverberations possible- upto half a second

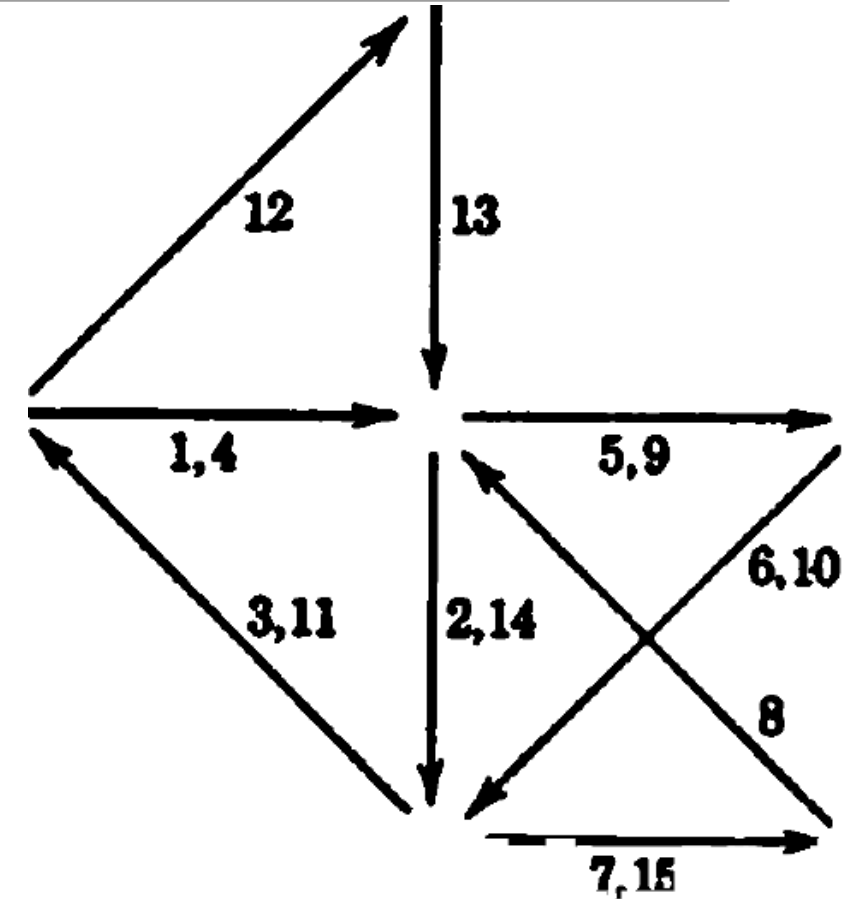


Figure 10, Chapter 4, The organization of Behaviour

Growth of the Assembly

- Increase in synaptic knobs and increased control → change in the transmission and the frequency of excitation of the constituent elements of the assembly
- Fractionation and recruitment can occur:
 - Cells/units unable to take part in the firing in the changed assembly may gradually drop out
 - Other cells, previously incompatible, may now enter the assembly
- Therefore, with perception → Growth in the assembly [though gradual]

Psychological Implications

- Gradual change in the assembly, so prolonged time to integrate each individual perception
- Associations between two perceptions can occur only after both have been formed separately
- Even integrated perceptions may have difficulty in association [even if they are similar conceptually]
- The growth of the assembly not just accounts for but implies changes in behavior over time

Merits:

- Could explain Long Term Potentiation [increase in synaptic strength] very well.
Eg: Pavlov's experiments on classical conditioning and learning
- Could also explain more complex, delayed behavior such as expectation or attention or interest
- Offered a new model to explain how memory and learning happened to create the mind
- One of the first to recognize and propose '*connectionism*' in the architecture of a brain model

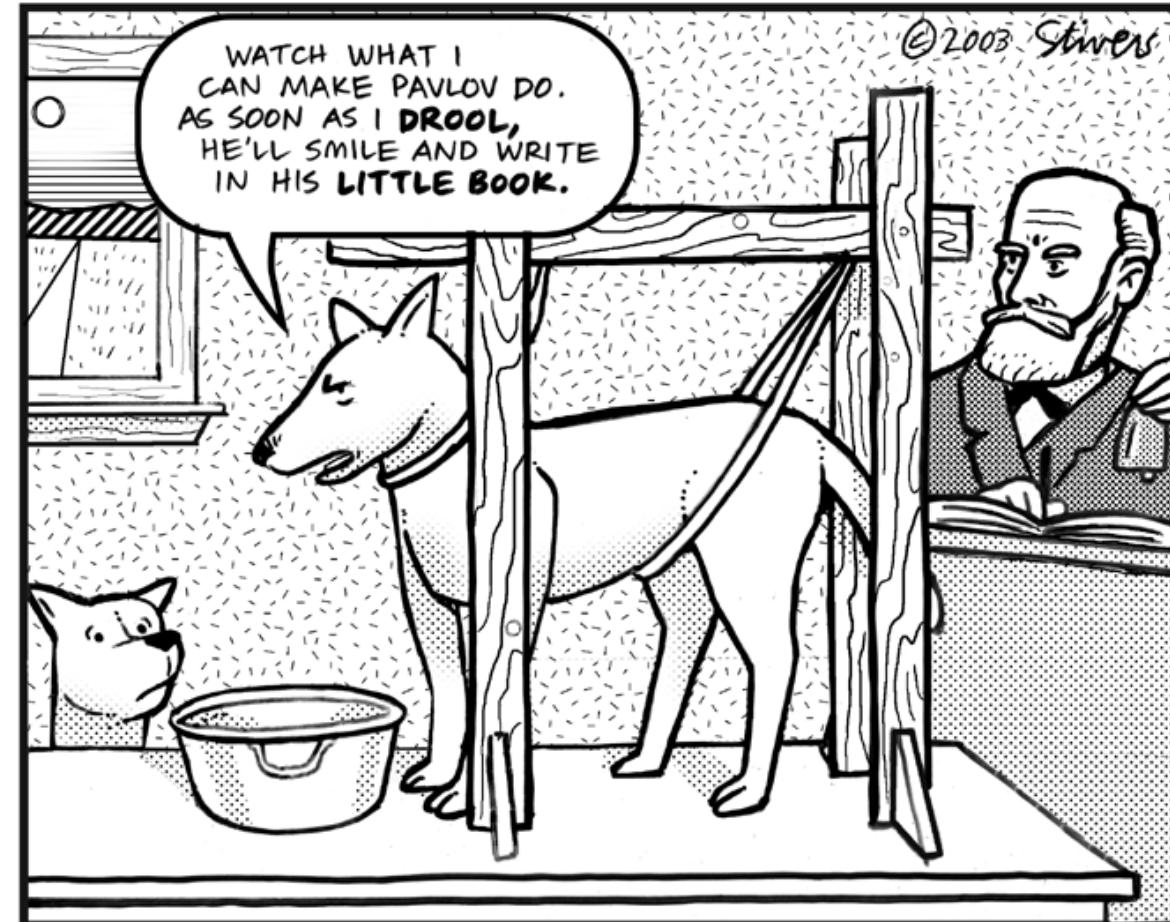


Image from daily-comix.com

Limitations:

- Deals only with increase in strength of connections [Long term potentiation], did not consider cases of decrease in synaptic strength [Long term depression]
- Hebbian learning considers only local excitations and correlations. Does not consider the network as a whole while learning
- Learning rule is unstable – Any dominant signal can cause the weights to increase rapidly and is unbounded.

References

- Hebb, Donald Olding. *The organization of behavior: A neuropsychological theory*. Psychology Press, 2002.
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