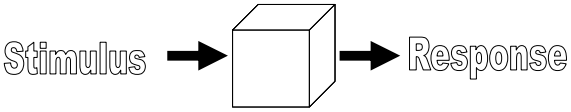
Theories of Learning

If you forget today's lecture, the irony won't be lost on me.
The .ppt file can be downloaded at:
http://amdrae.ssc.uwo.ca/Chris/downloads/learning.ppt

Learning as the Behaviorist sees it



Theme for the day: "What's in the box?"

Clark Hull

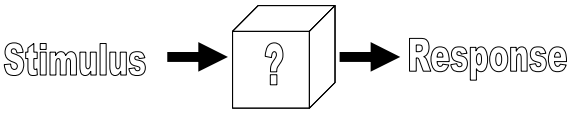
- Polio at age 24 left him disabled, wore an iron brace, used a cane
- Read Pavlov, interested in conditioned reflexes and learning
- Also influenced by Isaac Newton's writings
  - physics & psychology are related
  - Apparent in later formulations

Hull: Hypothetico-Deductive Model

- Hull was of the behaviorist tradition
  - **Conditioning** provides the *how*

But…

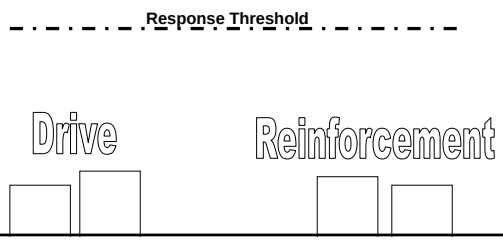
- Black boxes aren't explanatory
- Wanted a model to predict behavior
- Noted that conditioning theory failed to deal convincingly with motivation.



Hull: Hypothetico-Deductive Model

- Problem: what promotes learning S-R connections?
- Answer: **Drives** (borrowed from Freud's **instincts**) provide the *why*
- Drives
  - Internal (hunger)
  - External (peer pressure)
- Reinforcement – reduces drive
  - Primary (food)
  - Secondary (money)

Hull: Drives



Hull: Hypothetico-Deductive Model

How likely are you to light up the BBQ?
(reaction potential ${}_SE_R$)

Hull: Hypothetico-Deductive Model

- What factors will influence ${}_SE_R$?
  - Experience with BBQ food at reducing hunger? (${}_SH_R$)
  - How hungry are you? (D)
  - How salient is the hunger? (V)
  - How much food are we talking here? (K)
  - Are we just tired? (I_R)
  - Does our roommate usually give in and cook dinner? (${}_SI_R$)

Hull: Hypothetico-Deductive Model

- Let's plug in some numbers to see a prediction:
  - Age 20: 17 summers of BBQ food (6 BBQs per summer), assume 50% satisfaction rate
    - ${}_SH_R = 1 - 11^{-.03(17 \times 6 \times .50)} = 0.97$
  - You've been to the gym:
    - About 80% as hungry as you've ever been (D=.8)
    - Your hunger is pretty salient (V = 1.0)
    - You're really tired (I_R = .27)
  - Your moocher roommate does 1/3 of the cooking
    - Only 2 hotdogs left in the house (K=.8)
    - (${}_SI_R$ = .33)

      .97 x 0.8 x 1.0 x .8 – 0.27 - .33 = .02
- Note that this formulation is *probabalistic*

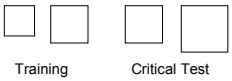
Spence: Inhibition & Excitation

- Recall from Hull's theory:
  - ${}_SE_R$ (energy available to respond to stimulus) depends on both positive (excitation) and negative (inhibitory) values
- Gestalt phenomena had been difficult to explain using S→R paradigm
- Spence showed how learned associations (habit strength, ${}_SH_R$) can explain these phenomena

Spence: Inhibition & Excitation

- Train an animal to respond to a square of a certain size (16 x 16 cm) versus a smaller square (12.6 x 12.6 cm)
- Over 100 trials:
  - Strong habit strength for larger square
    - ${}_SH_R = 1 - 11^{-.03(100)} = .999$
  - Strong inhibition for the smaller square
- What about the Gestalt problem?

Spence: Inhibition & Excitation



Training Critical Test

	S	M	L
S	1	.64	.08
M		1	.64
L			1

- Inhibition and habit strength generalize to similar objects as a function of similarity
  - Training: S is most similar to S, M most similar to M
  - Critical test: inhibition from S transfers to most similar object (M), habit strength for M applies to M, but also applies to similar object (L)
- Response to Gestalt objections to behaviourism

Hull: Hypothetico-Deductive Model

How is this model lacking?

- Where are these numbers coming from?
- Proper number & relationship between the parameters?
- In other words, this model is not the final word

Hull: Hypothetico-Deductive Model

What makes this model worth mentioning?

- Hull & Spence spent their careers expanding the phenomena that S-R theory could account for
- Makes specific predictions using operationally defined *inhibition* and *excitation*
- Acknowledges the role of an organism's goals

Edward Tolman

- Went to MIT instead of family business
- Switched into philosophy [psych] from electrochemistry after reading William James
- Pacifist during WWI, lost his job at Northwestern
- Moved on to Berkeley where he did all his big work

Tolman: Cognitive Maps

- Best known for his work with rats
- Used behavioral methods (was a behaviorist) to gain an understanding of the mental processes of humans and other animals (not a radical behaviorist)
- Theory: animals use knowledge flexibly rather than simply learning automatic responses

Tolman: Cognitive Maps

- Debate at the time between:
  - Hull: S→R
    - reinforcement driven view
  - Tolman: S→S
    - draws on Gestalt principles to argue that animals learn the connections between stimuli without any explicit biologically significant event to make learning occur

Tolman: Cognitive Maps

- Learning without reinforcement
  - Supporting his ideas were experiments where satiated rats explored a maze
    - Knowledge of food locations not reinforced
  - When hungry, the rats correctly navigated directly to food locations
    - If reinforcement required for learning, how did they learn the location when they aren't hungry?

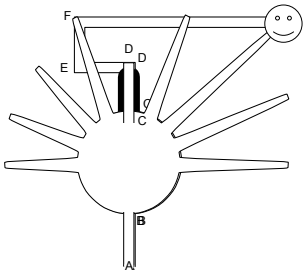
Tolman: Cognitive Maps

- Tolman believed a map of the environment is learned
- Cognitive maps contain expectancies made up of sign gestalts
  - Following landmarks
  - Chain of associations
  - Like following directions you get from mapquest
- Important to think of it as a *map*

Tolman: Cognitive Maps

- Why is it a map?
  - Stores relative locations of objects/stimuli
  - S→R alternative: learn associations between landmarks
  - Navigation with changed landmarks should be impossible

Tolman: Cognitive Maps



Hebb: Hebbian Learning

- Donald Hebb was a Canadian neuroscientist at McGill
- Studied under Lashley
  - Engram
- 1949: *The Organization of Behavior*
  - Explained a physiological mechanism for learning
  - Very influential (940 citations in psychinfo)

Hebb: Hebbian Learning

- Based on correlational learning (James, 1890)
  - When two events co-occur or follow in succession, the connections between the neural representations of these events will be strengthened
  - "Cells that fire together wire together"
    - **Excitatory** (+) connections form when two events reliably occur together
    - **Inhibitory** (-) connections form when two events are mutually exclusive

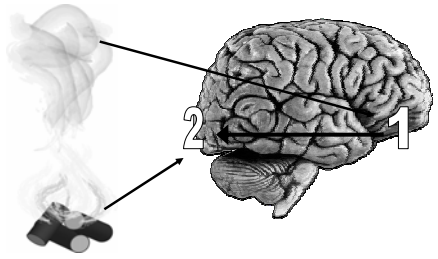
Hebb: Hebbian Learning

- "Where there's smoke, there's fire."

Event 1: Smoke (sight/smell)
Event 2: Fire (sight)

Hebb: Hebbian Learning

- "Where there's smoke, there's fire."



Hebb: Hebbian Learning

- **Cell Assemblies**
  - Interconnected cluster of neurons
  - The physiological mechanism for learning
  - Learning occurs at synapses between neurons
    - Information is **not** in the neurons themselves
    - Grandmother cell
  - *Strengthening* (increasing the excitatory/inhibitory potential) of connections
    - chemical change (e.g., more neurotransmitter)
    - additional connections or growth

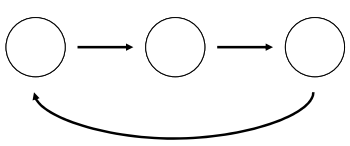
Hebb: Hebbian Learning

- **Phase sequences**
  - Individual neurons participate in multiple cell assemblies
    - red associated with {cherries, fire hydrants, …}
  - Context constrains phase sequences to relevant associations

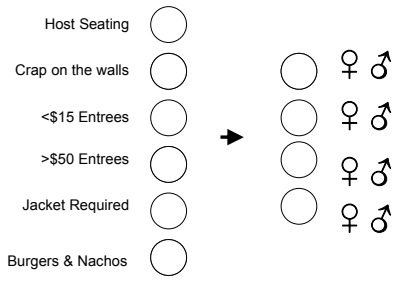
Hebb: Hebbian Learning

- **Reverberation**
  - Remembering single episodes
    - Connection strength a function of #simultaneous activations
  - Mechanism for storage of events in long term memory, maintaining memory stores in working memory
  - Cell assemblies may have *reentrant* connections

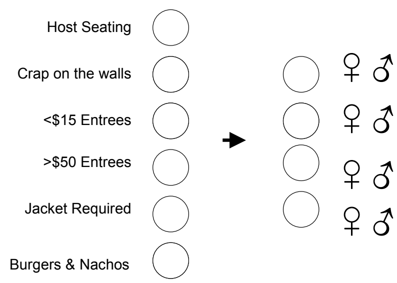
Hebb: Hebbian Learning



Hebb: Hebbian Learning

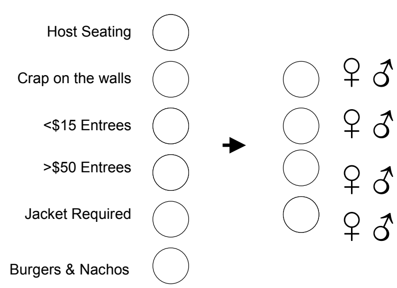


Hebb: Hebbian Learning



Hebb: Hebbian Learning

Hebb: Hebbian Learning



Hebb: Hebbian Learning

- Research
  - Biological plausibility
  - Computer modeling
- Business/Industry
  - Data mining
  - Computers/Robotics (AI)
- Law Enforcement
  - Criminal profiling