The Nature of Learning and Memory

Arlo Clark-Foos, Ph.D.

Memory is Everywhere!

- Life Without Memory (Clive Wearing)
  - Video

Clive's Diary

"10:08 a.m.: Now I am superlatively awake. First time aware for years."

"10:13 a.m.: Now I am overwhelmingly awake."

"10:28 a.m.: Actually I am now the first time awake for years."

Nature's Influence on Memory

- Genes determine the possible range.
- Reflex actions, simple behaviors
  - Knee-jerk, swallow, suck, grip

John B. Watson and Rosalie Rayner

Nurture's Influence on Memory

- Experience (and memory of it) determines our individual differences and allows us to improve upon initial behaviors and reflexes.

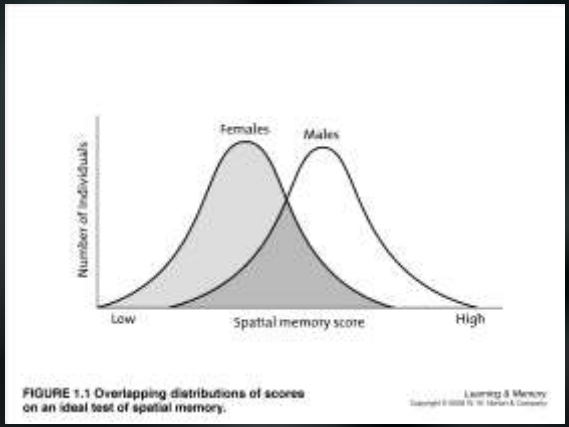


FIGURE 1.1 Overlapping distributions of scores on an ideal test of spatial memory.

Top-Down vs. Bottom-Up Processing

- How well can you read these sentences?

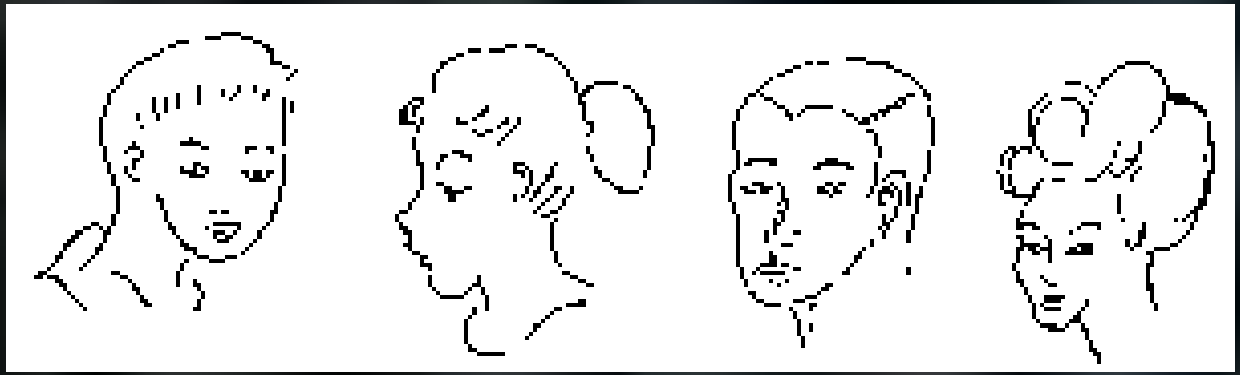
The quick brown fox jumps over the lazy dog.

Pack my box with five dozen liquor jugs.

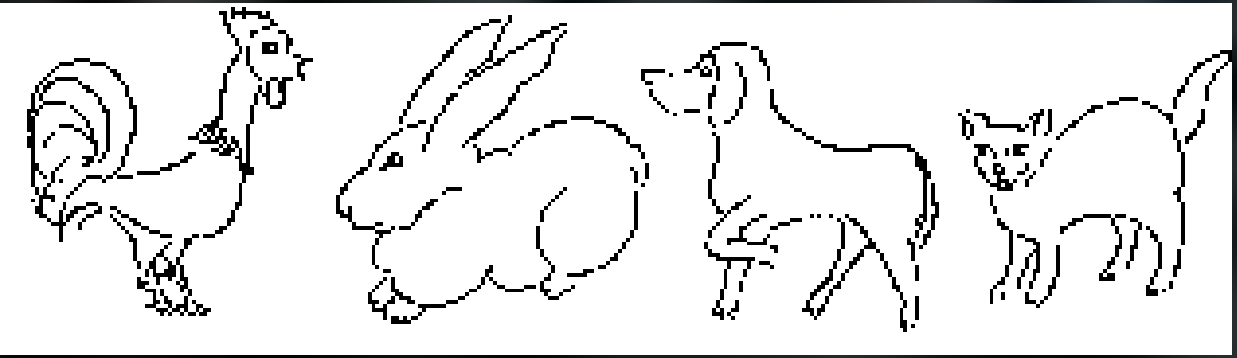
Memory Shapes Future Behavior

- Context and Expectations

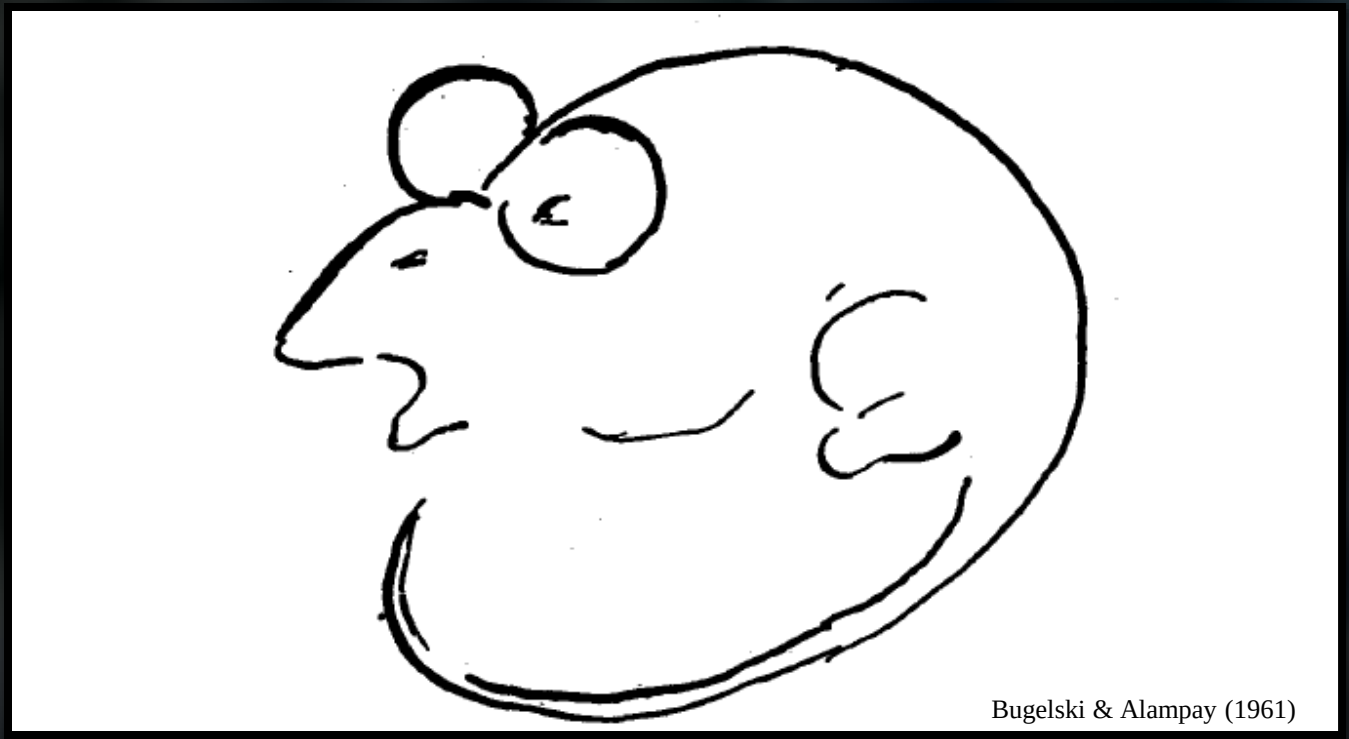
Group 1



Group 2



What do you see?



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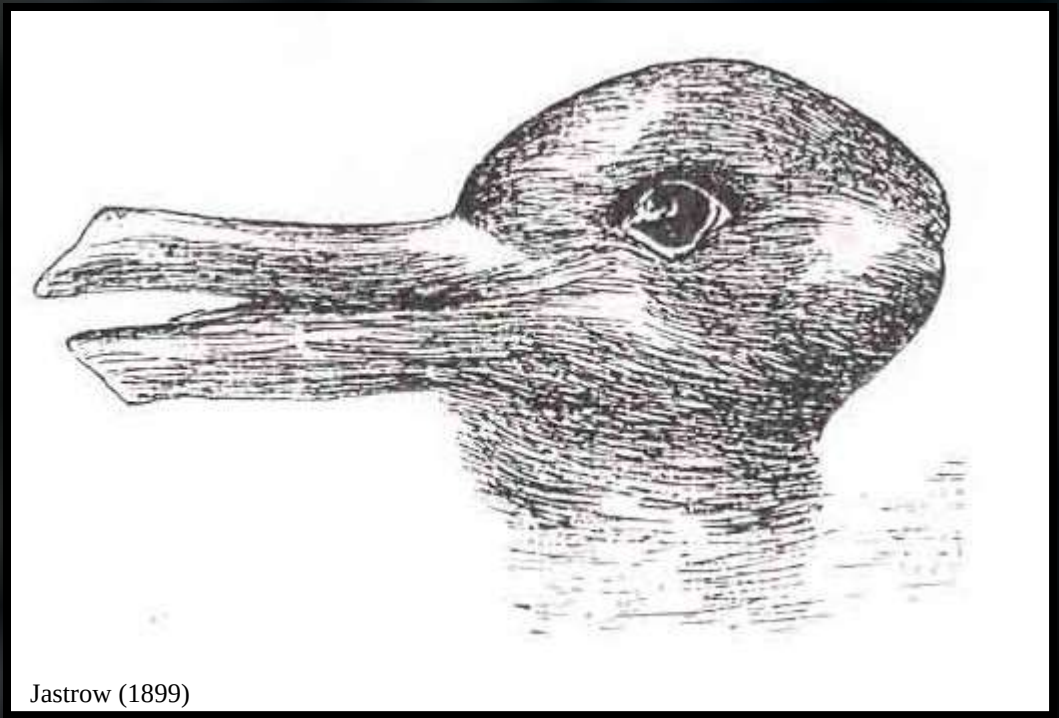
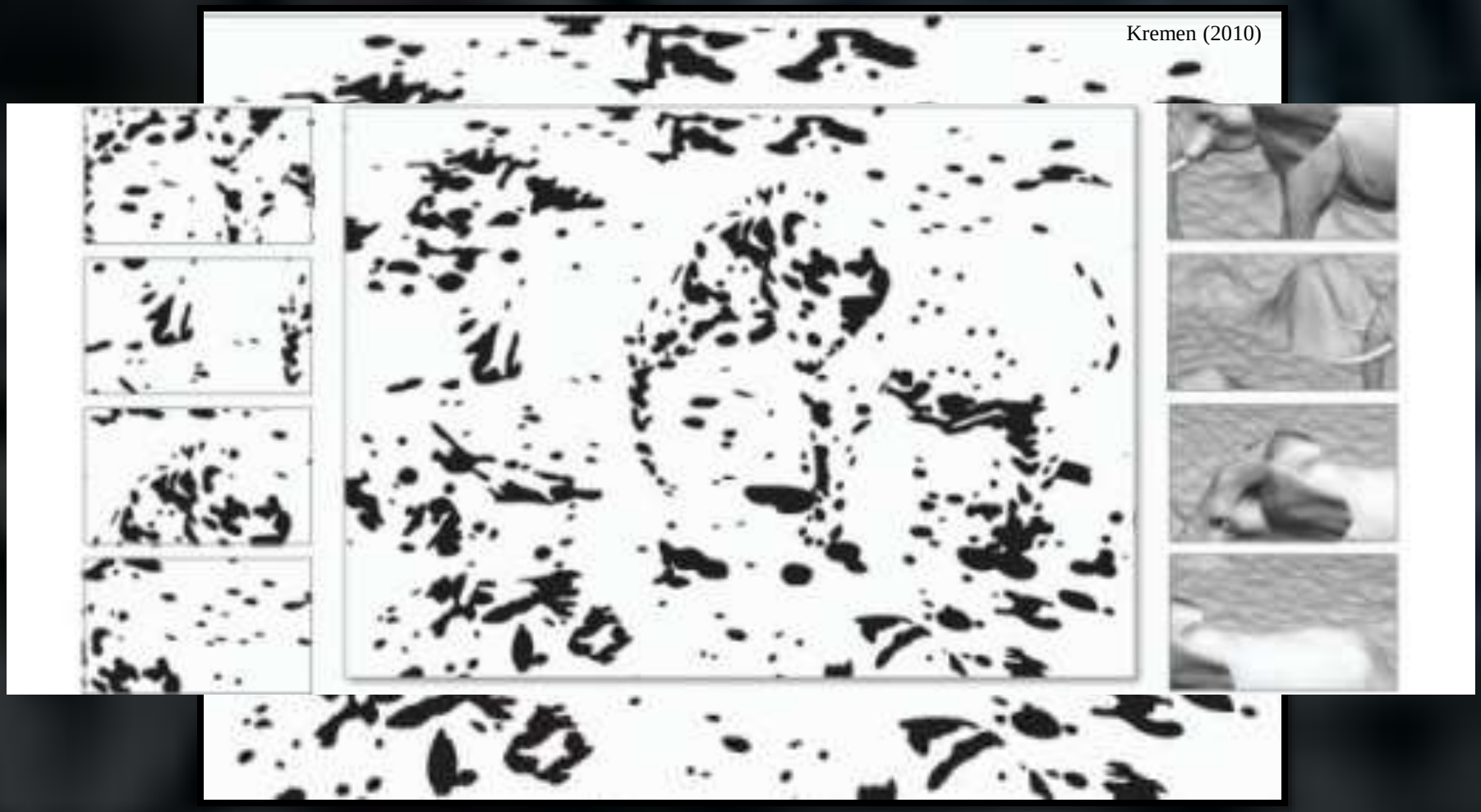
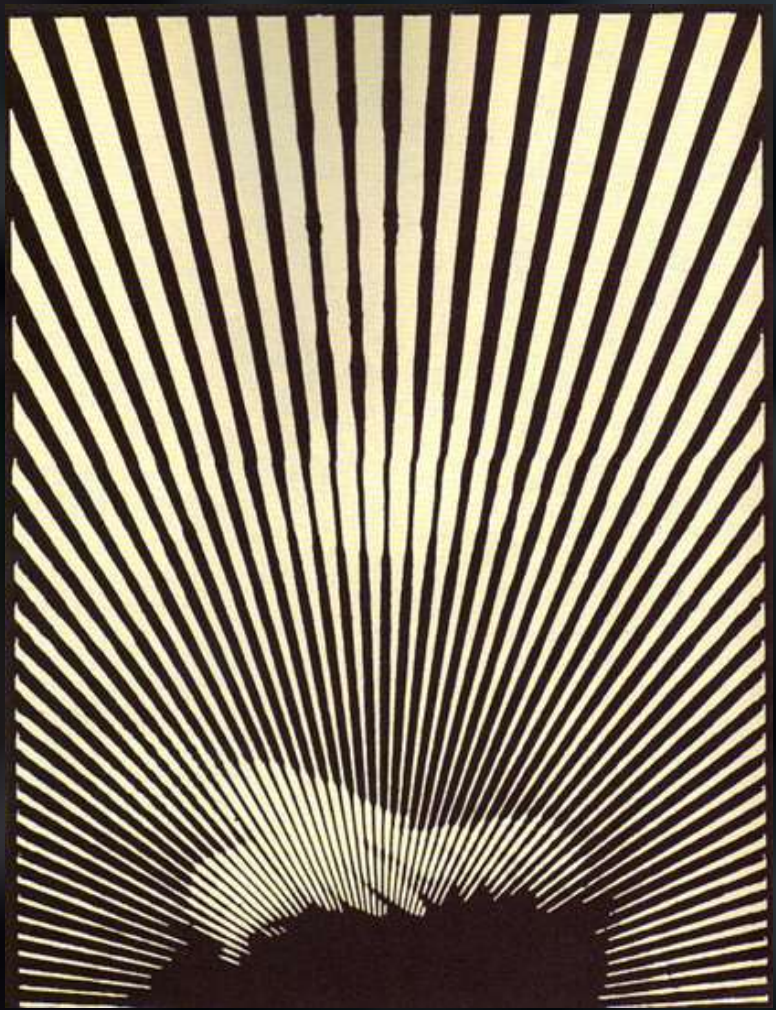


Jastrow (1899)

What do you see?



What do you see?



HISTORICAL APPROACHES TO SCIENCE AND HUMAN MEMORY

Ancient Greeks

- Introspection, Logic, & Philosophy
- Plato's Aviary metaphor

Socrates and Plato

- All knowledge is innate,

  The Republic

- Intuition and Logic

Aristotle

"other animals (as well as man) have memory, but … none … except man, shares in the faculty of recollection"

- Observation and Data ➔ Theories
- Contiguity, Frequency, Similarity
- Memory
  - Replication of sensory perception
  - Passive re-perception
    - *Familiarity?*
- Reminiscence
  - Replaying an entire experience
  - Temporal contiguity
    - *Recollection?*

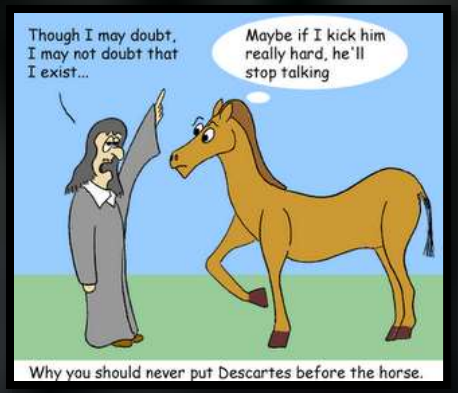
Descartes and Dualism

Mind

Cogito ergo sum

(Descartes, 1637)

Knowledge is mostly innate

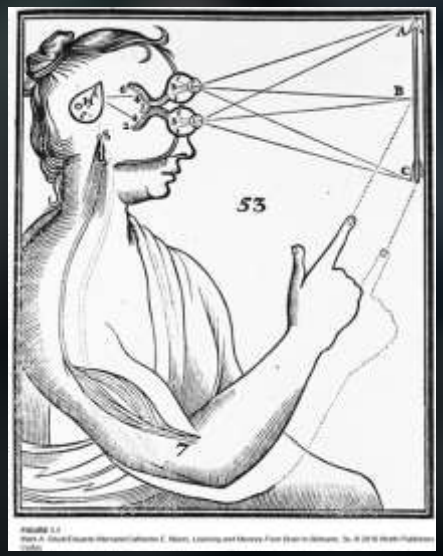


Body

Stimulus, Response (reflex arc)

Like a machine/clock

Animal "Spirits" flow



John Locke's Empiricism

- Absolute Power of the Monarchy
  - Isaac Newton's Light and Robert Boyle's chemicals
    - Associationism (Green, Bitter/Sour vs. Limes)

  - Tabula rasa & Empiricism
    - Knowledge (and memory) come from experience
  - Thomas Jefferson's Declaration of Independence

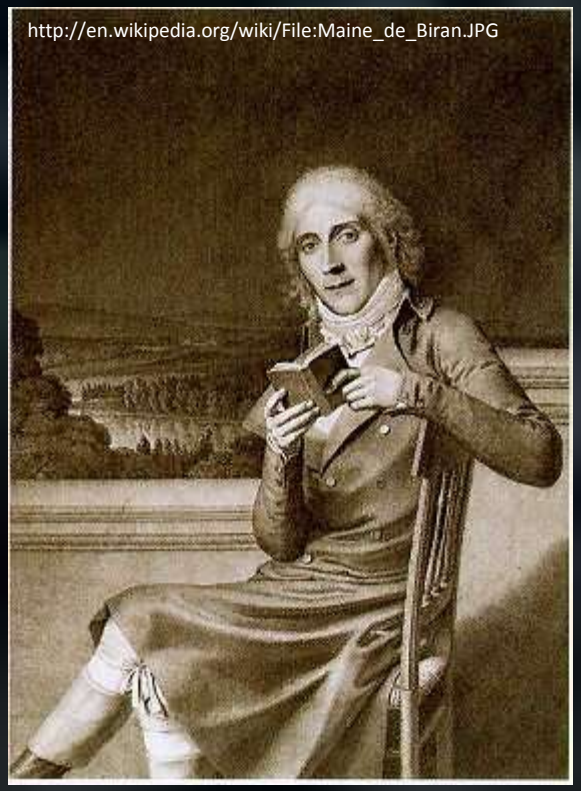
    "Life, liberty, and the pursuit of happiness"

Maine de Biran

(1766-1824)

- Habit
  - Automatic associations, underlie all three basic forms of memory

1. Representative Memory
   - Most complex, flexible
   - * *Conscious recollection*
2. Mechanical Memory
   - Motor / Procedural actions
3. Sensitive Memory
   - Emotional associations

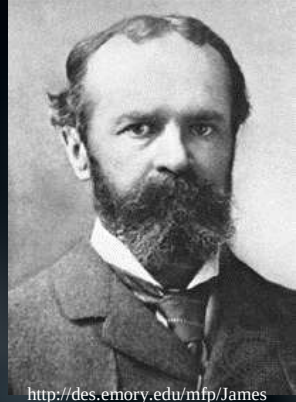

http://en.wikipedia.org/wiki/File:Maine_de_Biran.JPG

Wilhelm Wundt

William James

Father of American Psychology

(1842-1910)


http://des.emory.edu/mfp/JamesWatterson.html

- 1st Intro Psychology course in America (Harvard, 1869)
  - Goal of Psychology: Understand principles that govern formation and maintenance of new skills and memories!

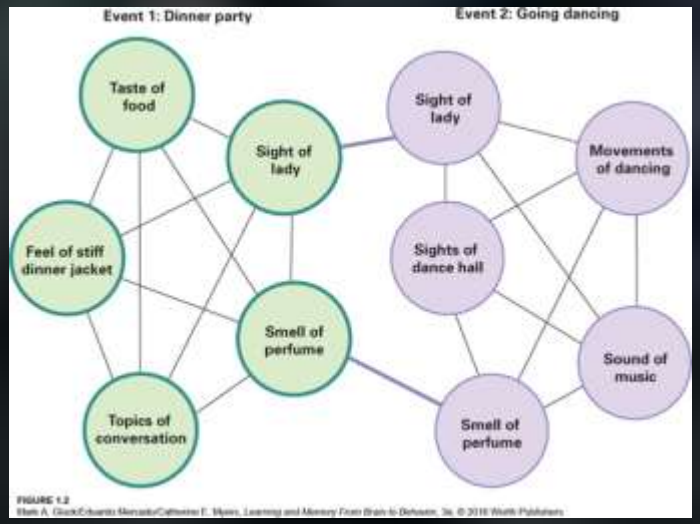
- Empiricism and Associationism (Aristotle and Locke)

Memory depends on:

1. Strengthening of reflex pathways
2. Associational Links

Two Types of Memories

- Primary memory vs. Secondary memory



Theories of Evolution

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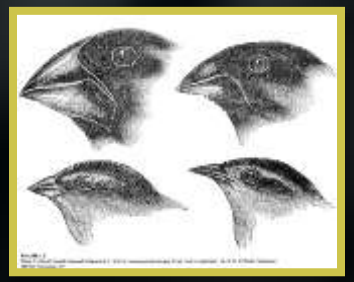
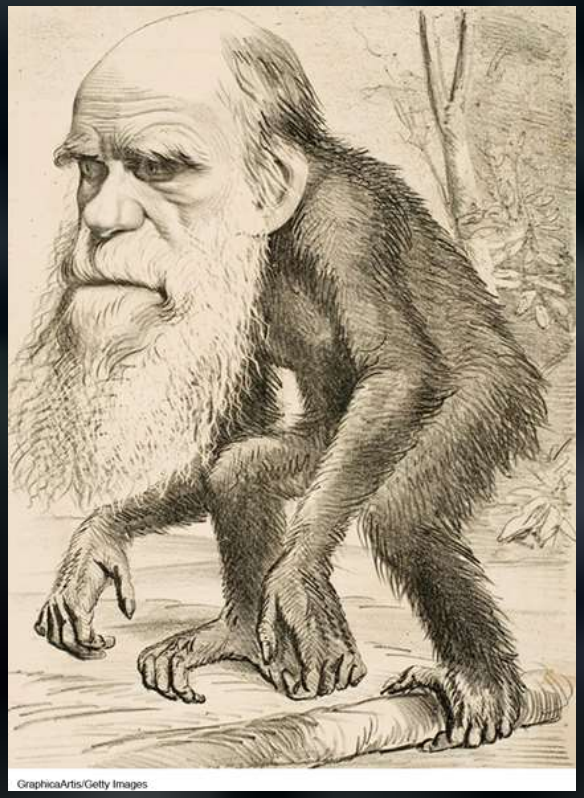
Two Darwins: Erasmus (Evolution) and grandson Charles

(Natural Selection)

Evolutionary Psychology

Greater capacity for learning and memory

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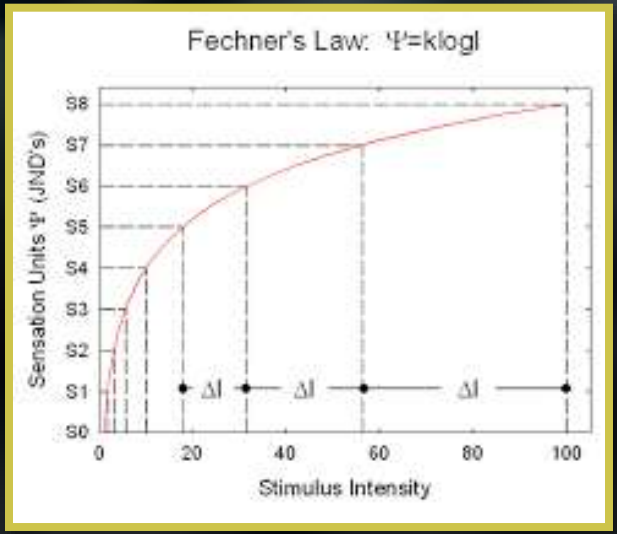
Herman Ebbinghaus

Father of Modern Memory Research

(1850-1909)

- Fechner's Law and JNDs for Perception (Psychophysics)
  - Mathematical and Statistical Analysis
    - Later, Clark Hull
- Sole Participant & Familiarity (CVCs)
- Memory & Forgetting
  - Retention Curves, Savings



Hermann Ebbinghaus

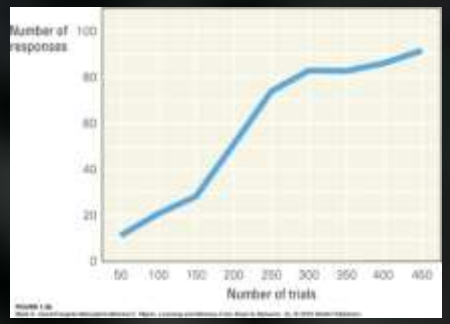
Father of Memory
(1850-1909)

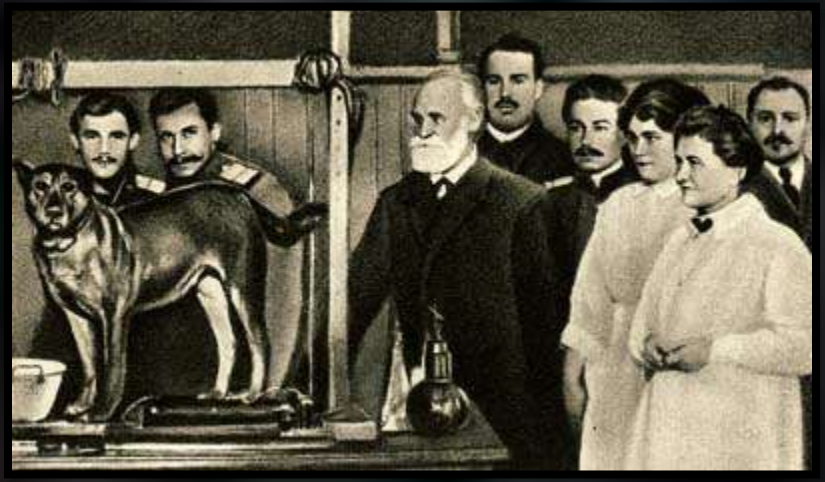
- Experimental Rigor
  - Independent and Dependent Variables
    - Delay Length, List Length, Memory Retention
  - Subject & Experimenter Bias
  - Blind Designs
  - Placebo

Ivan Pavlov

(1849-1936)

- Interaction of nervous system and bodily function (digestion)
  - Like cutting edge technology: Telephones!
  - Nobel Prize in Physiology or Medicine (1904)

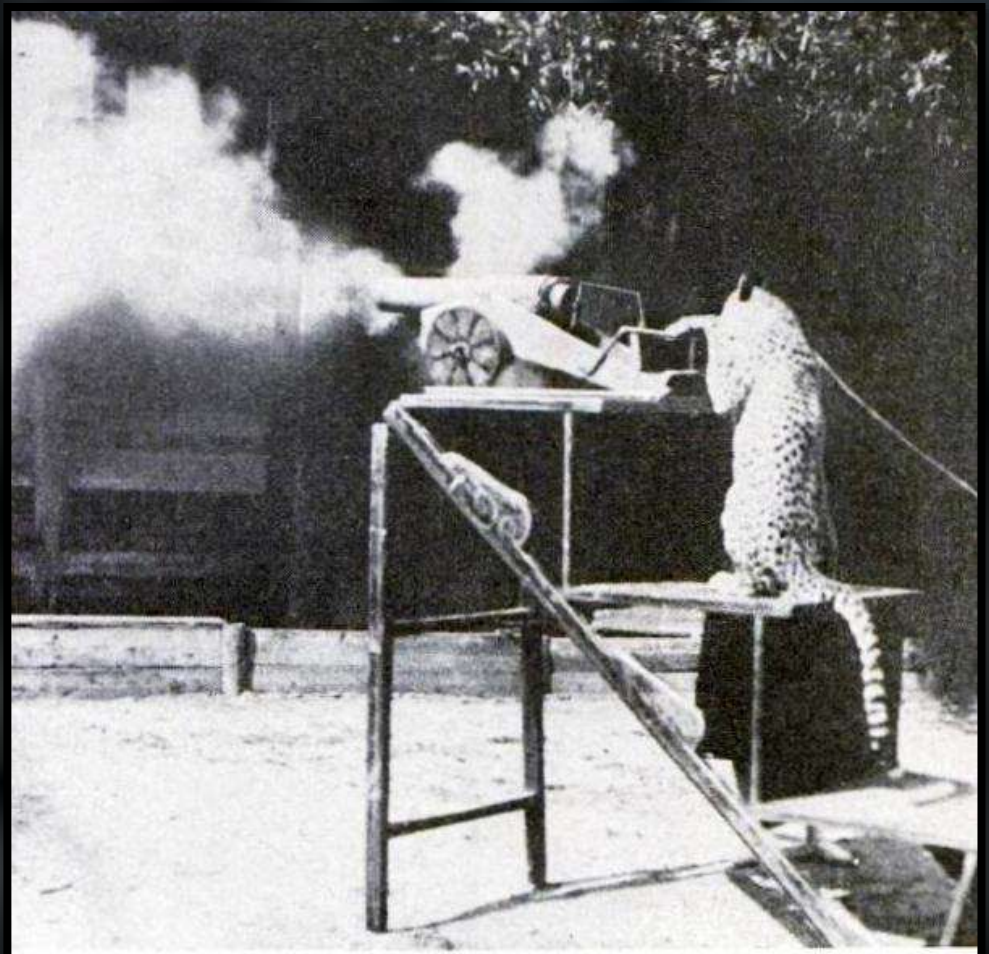




How powerful is Classical (Pavlovian) Conditioning?

- *Psychic Secretion* and Classical Conditioning
  - US, UR, CS, CR
  - Extinction, Generalization

Can a puma fire a canon?



Training by laboratory workers has overcome the puma's fear of firearms

Edward L. Thorndike

(1874-1949)

http://www-distance.syr.edu/pvitaelt.html

- Student of William James
- Instrumental (Operant) Conditioning
  - Law of Effect
    - *The effects of actions affect future actions.*
    - *Adaptive behaviors should evolve.*
  - Reward & Punishment

THE RISE OF BEHAVIORISM

John B. Watson

Father of Behaviorism
(1878-1958)

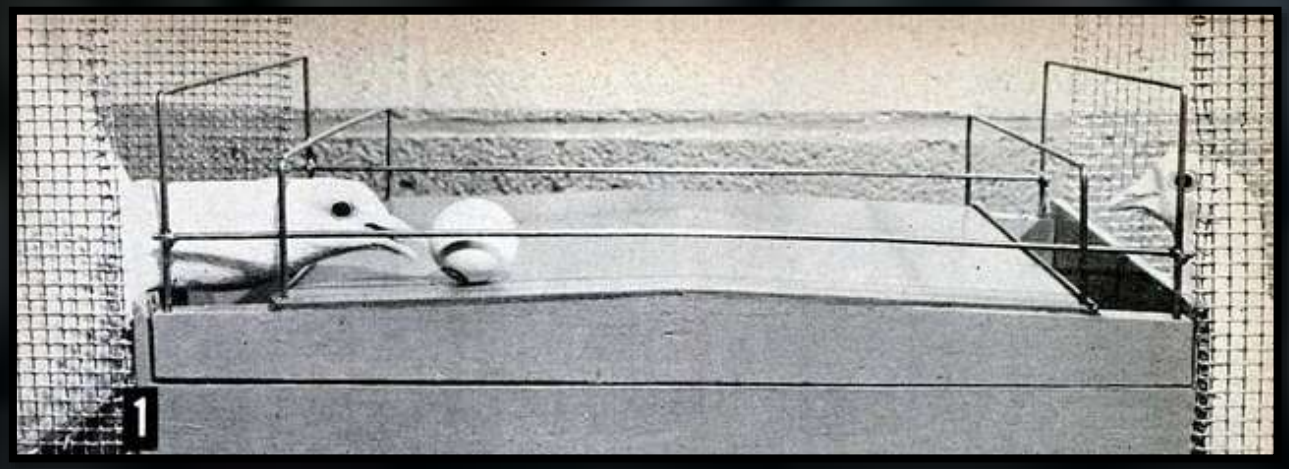
- *"Purely objective experimental branch of natural science"* (1913)
- Rats can run a maze without their senses
  - Everything is S-R
- Little Albert
  - *Little Douglas* *(born 1919 - died 1925)*
    (Beck, Levinson, & Irons, 2009)
- Behaviorism and mental events
  "Give me a dozen health infants…" (1924)

The Burning Question
How is Albert today?

B. F. Skinner

(1904-1990)

- Operant Conditioning
- *Walden Two* (1948)
- Serendipity and Variable Reinforcement
- Radical Behaviorist
  - Chomsky & Language



Behaviorism vs. Cognition

- Edward Tolman (1948/51): Neo-Behaviorist

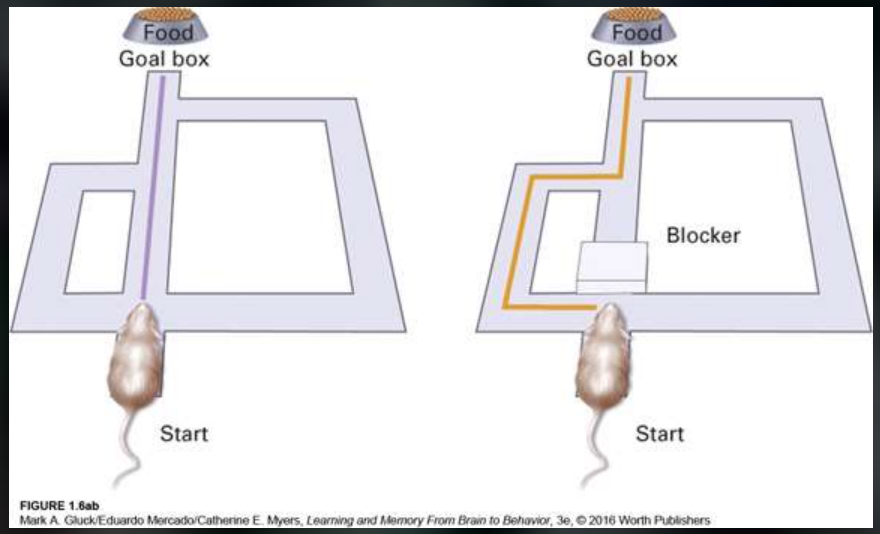


FIGURE 1.6ab
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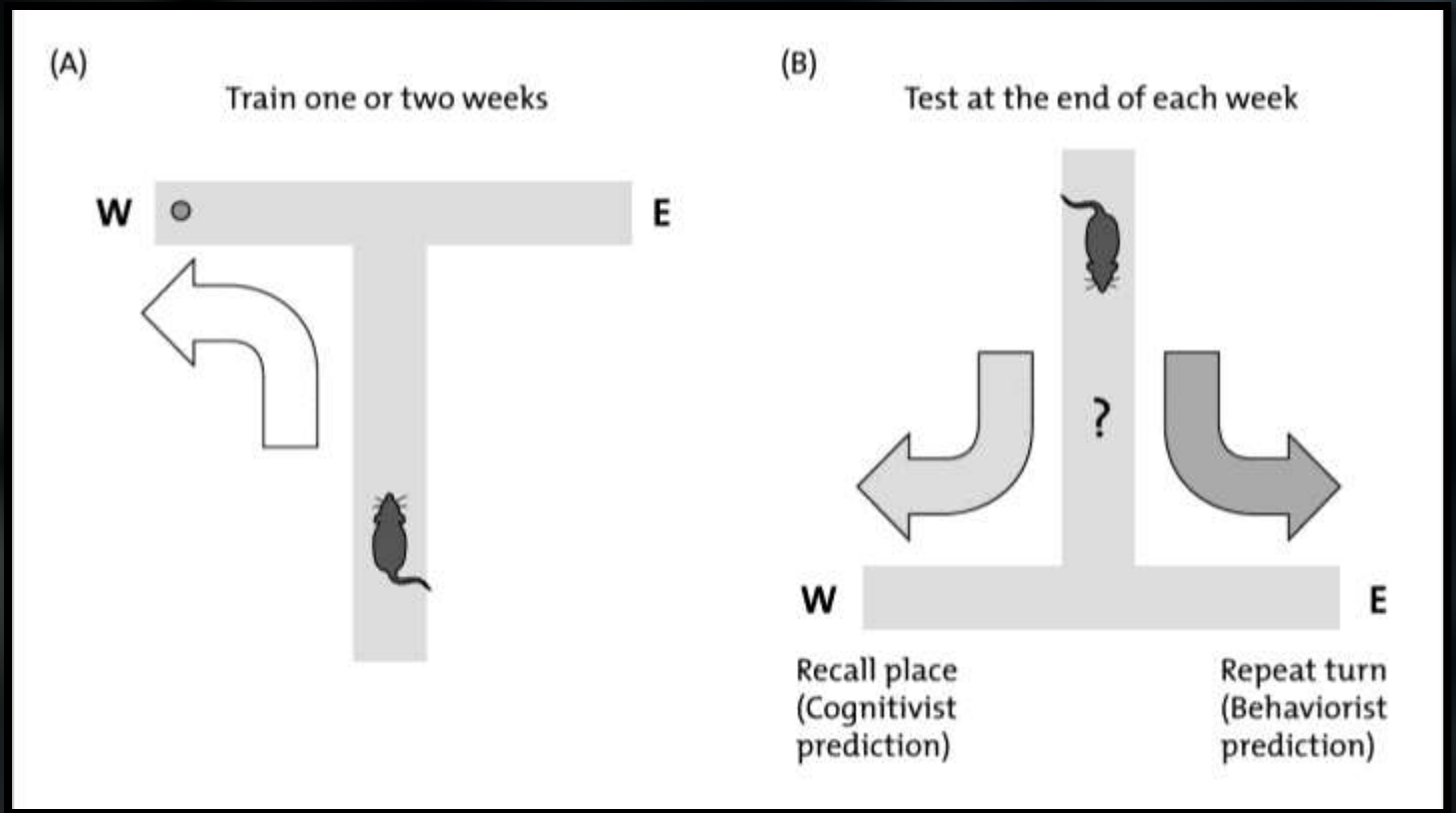
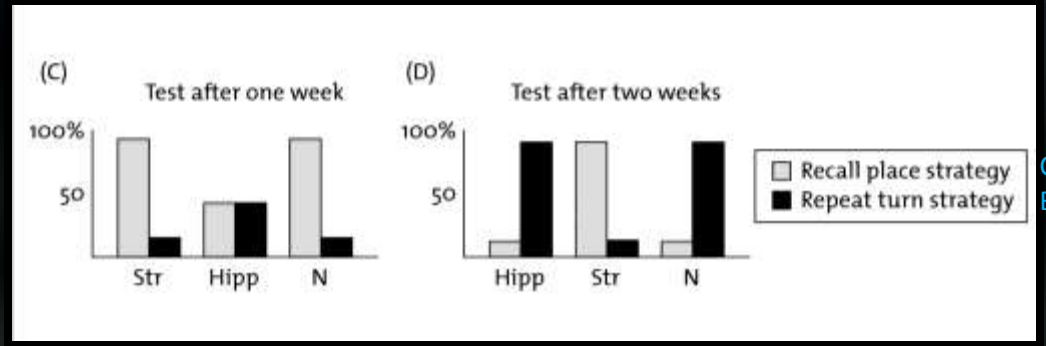
- Cognitive Maps: "*Behavior reeks of purpose*" (1932)
  - Latent Learning

Behaviorism vs. Cognition: T-maze



Behaviorism vs. Cognition: T-maze



Cognitive Prediction
Behaviorist prediction

- Striatum vs. Hippocampus (Packard & McGaugh, 1996)
- Habit vs. Explicit Memory

- Implications: Lowering the dosage for infant Tylenol

Mathematical Psychology

- Clark Hull
  - One equation to control them all!

- W. K. Estes
  - Stimulus Sampling Theory
  - Perturbation Model

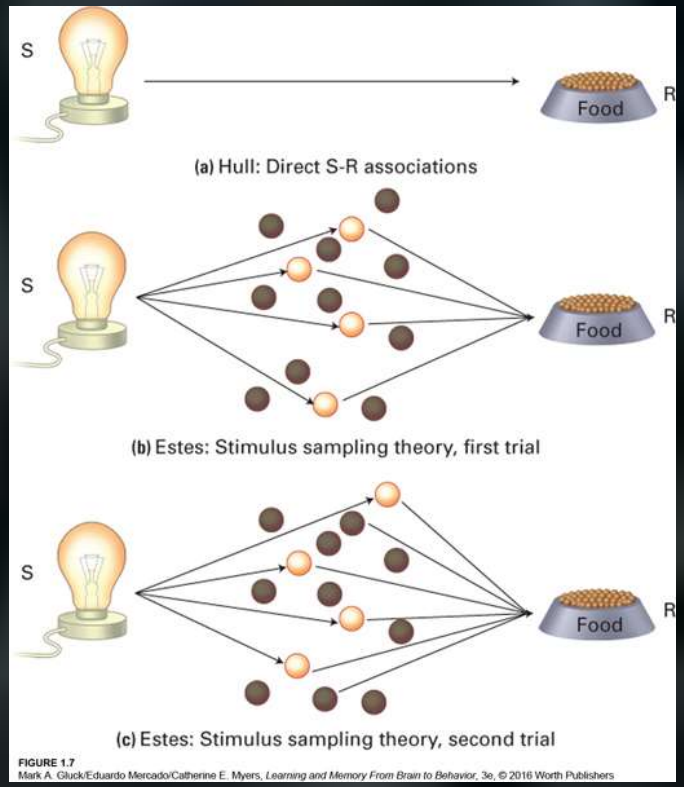


FIGURE 1.7
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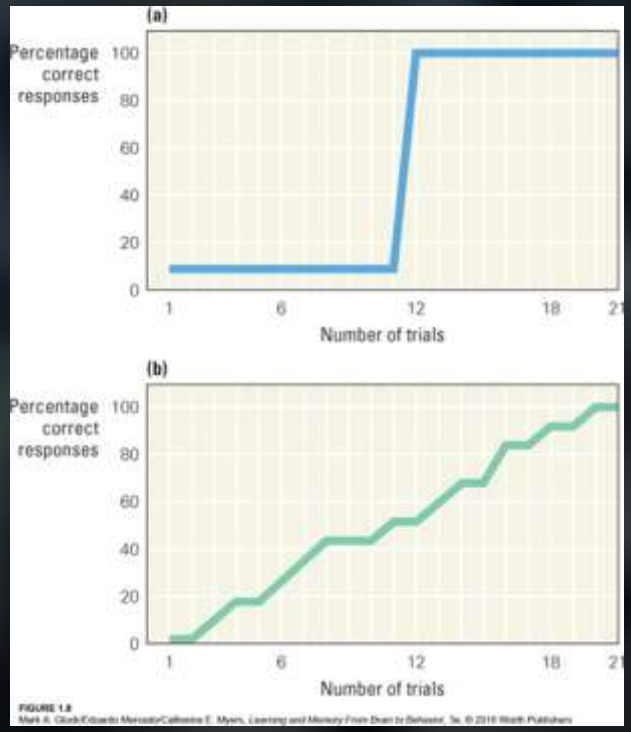
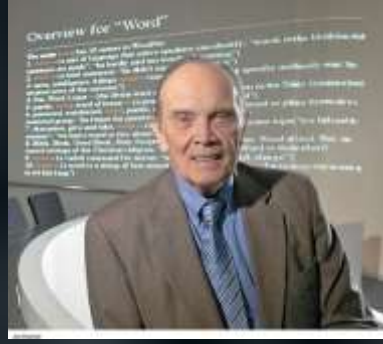
Gordon Bower

- Learning by Insight
  - Aha (single trial learning)
    - Aggregate Data
    - Combination Lock Game
- Mood and Memory
- Multicomponent Theory of the Memory Trace



Information

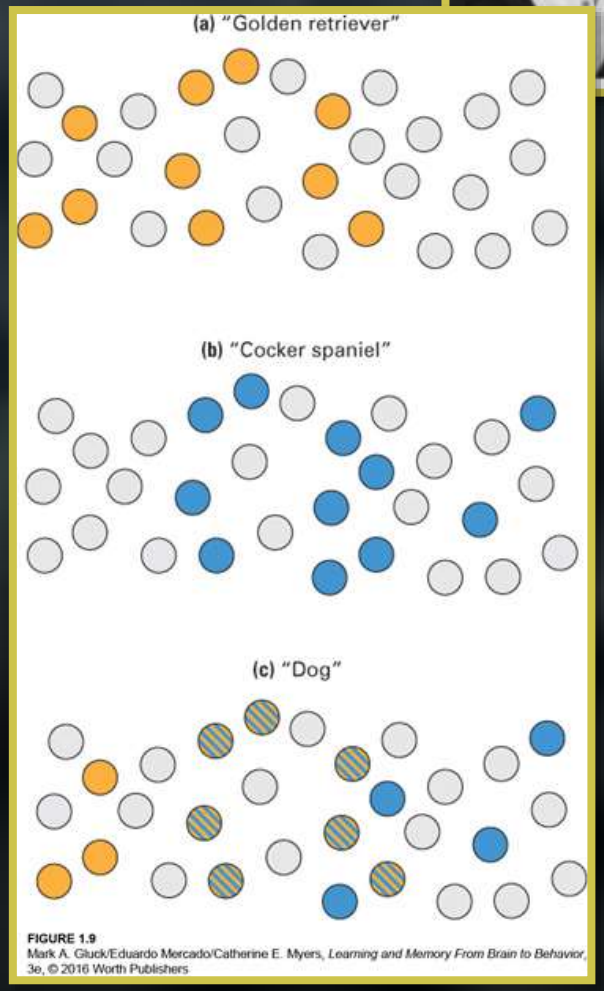


- Claude Shannon @ Bell Labs
  - Information Theory
    - “Chris, a student in your class, is male”
    - Prior knowledge and bits of information.

- George Miller
  - Context and jamming German radios
    - “Help, I’m Drowning” vs Man on Street
  - Total Capacity and Short-term Memory
    - Digit Span and Magic Number 7 ± 2

David Rumelhart

- Connectionist Models
  (Rumelhart & McClelland, 1986)
  - Nodes and Connections
  - Distributed Representations
  - Pick's Disease



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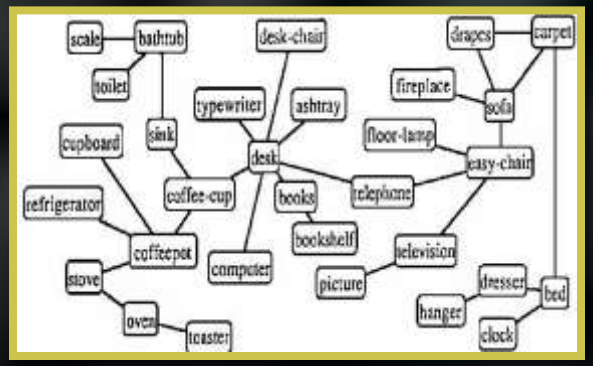

Summary

1. How do sensations or ideas become linked in the mind?
   - Contiguity, Frequency, Similarity (Aristotle), Pavlov, Thorndike, Hull, Skinner, etc.
2. How are memories built from the components of experience?
   - Associationism (Locke), James, Estes, Rumelhart, etc.
3. To what extent are behaviors and abilities determined by biological inheritance (nature) and to what extent by life experiences (nurture)?
   - Empiricism (Aristotle & Locke & Behaviorism) vs. Nativism (Descartes & Kant)
4. In what ways are human learning and memory similar to learning and memory in other animals, and in what ways do they differ?
   - Evolution (Darwins), Computer Models, Continuum of Cognition (Rumelhart & McClelland), etc.
5. Can the psychological study of the mind be rigorously scientific, uncovering universal principles of learning and memory that can be described by mathematical equations and considered fundamental laws?
   - Ebbinghaus, Watson, Hull, Skinner, Estes, and nearly everyone who followed.