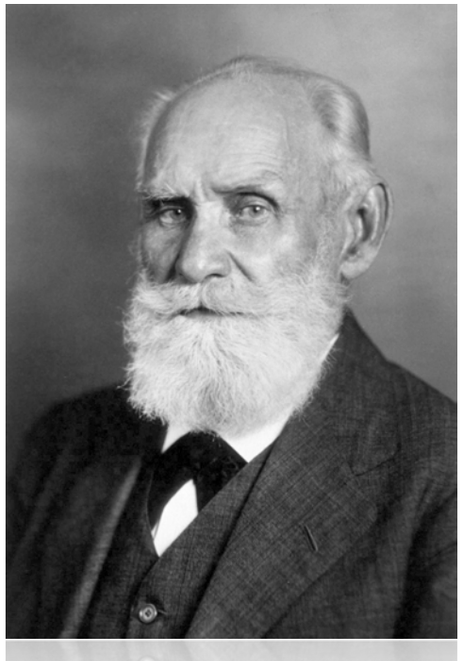
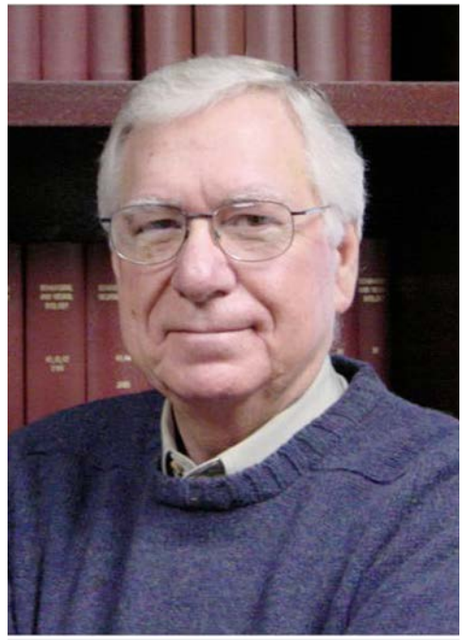
MULTIPLE MEMORY SYSTEMS

Norbert Fortin, PhD



NB209: Behavioral Neuroscience

MULTIPLE MEMORY SYSTEMS

DIFFERENT BRAIN SYSTEMS FOR DIFFERENT TYPES OF MEMORIES

Larry Squire

MEMORY

DECLARATIVE

SEMANTIC
FACTS

EPISODIC
EVENTS

MEDIAL TEMPORAL LOBES
Hippocampus and Parahippocampal region

NONDECLARATIVE

SKILLS & HABITS
MOTOR COGNITIVE
STRIATUM

PRIMING & PERCEPTUAL LEARNING
SHIFTS IN JUDGMENTS AND PREFERENCE
CORTEX

SIMPLE CLASSICAL CONDITIONING
EMOTIONAL RESPONSES
AMYGDALA
SKELETAL RESPONSES
CEREBELLUM

NONASSOCIATIVE LEARNING
HABITUATION SENSITIZATION
REFLEX PATHWAYS

Adapted from Squire (1992)

DECLARATIVE MEMORY SYSTEM
EPISODIC VS SEMANTIC MEMORY

- Declarative memory:
  - Memories that can be “declared” or made “explicit”
  - Flexible expression
- Two types
  - Episodic (autobiographical) memory
    - Memory for events, personal experiences
    - Memory of the event is tied to the spatial and temporal context in which it occurs
  - Semantic memory
    - Memory for facts, general knowledge of the world
    - Context-independent

DECLARATIVE MEMORY SYSTEM
EPISODIC VS SEMANTIC MEMORY

Patient K.C. (interviewed by Endel Tulving)

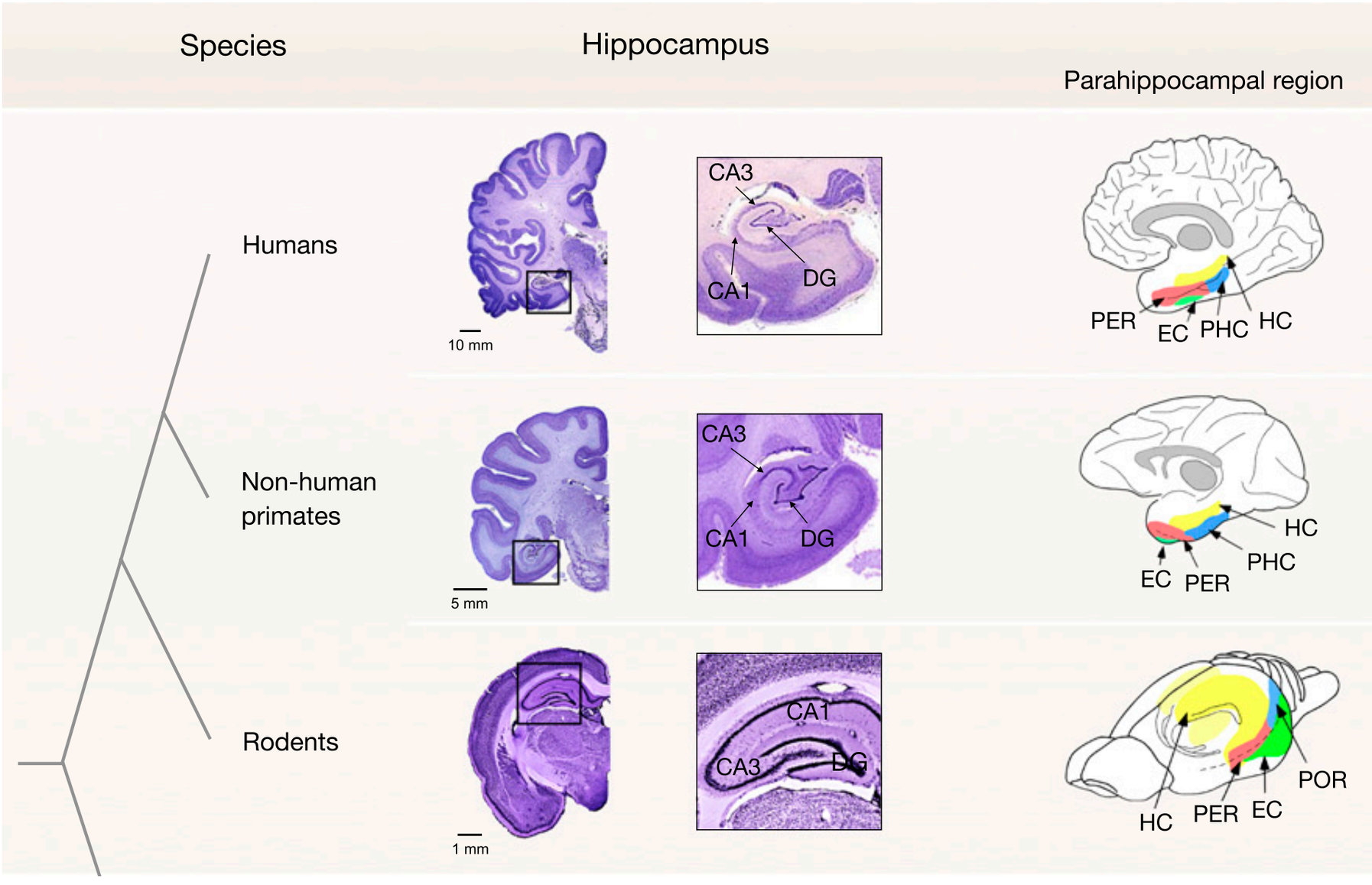
Episodic memory

Semantic memory

DECLARATIVE MEMORY SYSTEM
EPISODIC VS SEMANTIC MEMORY

Depend on the medial temporal lobes

(hippocampus + parahippocampal region)



Allen & Fortin (2013)

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NON-DECLARATIVE MEMORY SYSTEM
HETEROGENEOUS GROUP OF MEMORY ABILITIES

- Different types of memory that **cannot** be “declared”, that **cannot** be made “verbally explicit”

- Memory is expressed by changes in performance or a change in bias

- Not flexible
  - Tied to the same stimuli and/or responses

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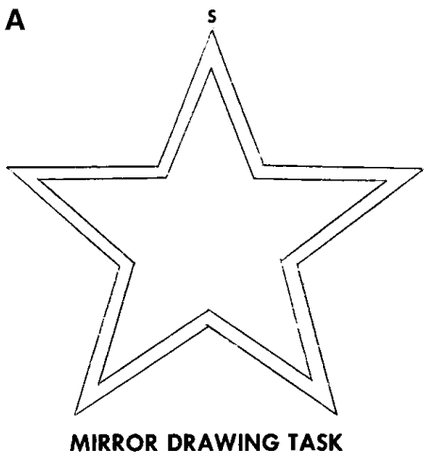
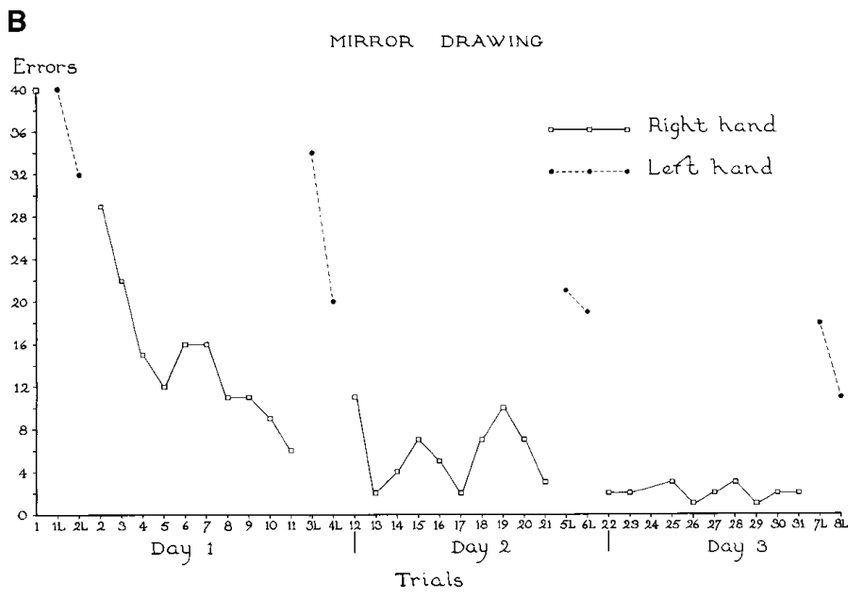
NON-DECLARATIVE MEMORY SYSTEM
SKILLS AND HABITS

Motor skills

Mirror drawing





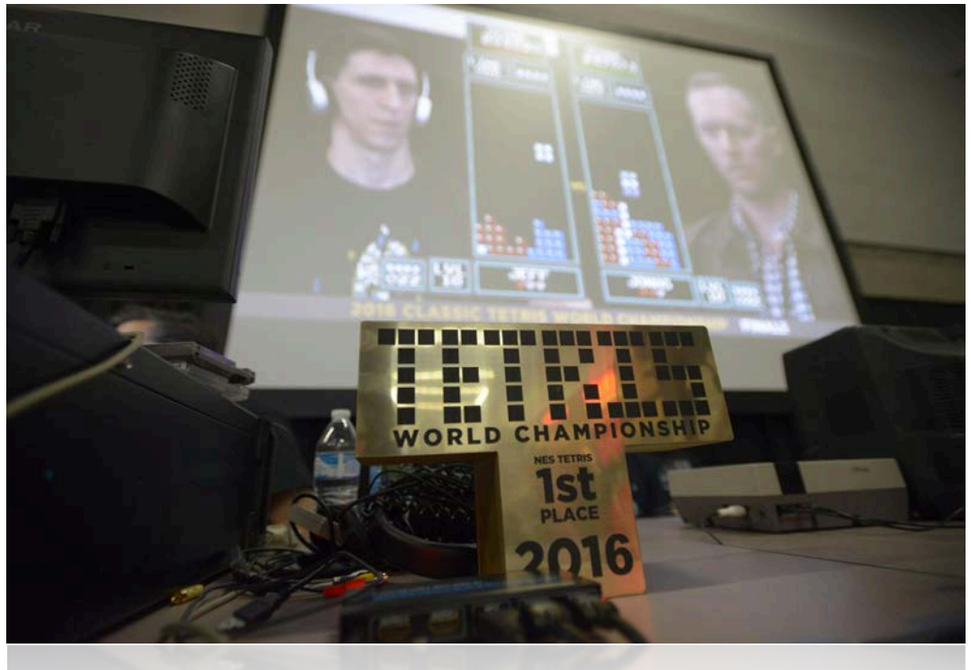
Riding a bike

e.g., concept of countersteering
at higher speeds
(turning left to go right)

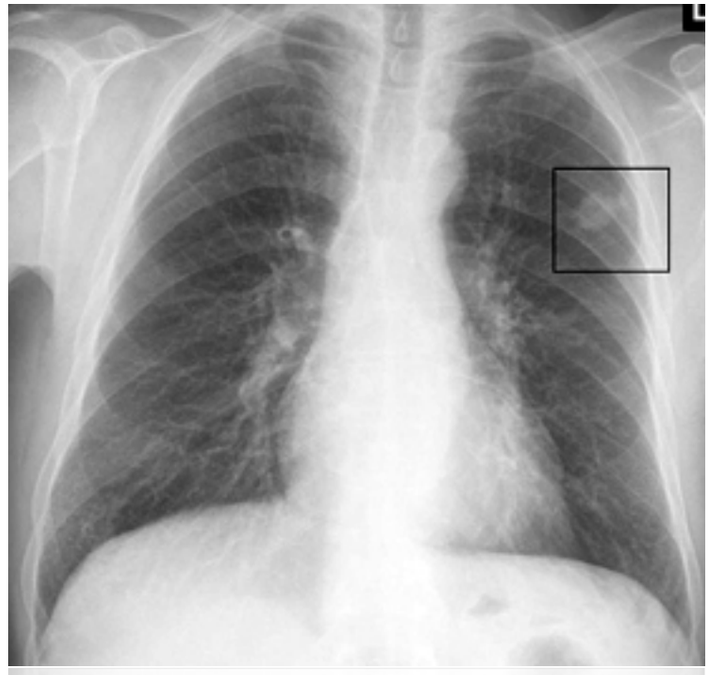
NON-DECLARATIVE MEMORY SYSTEM
SKILLS AND HABITS

Examples of <u>cognitive</u> skills

e.g., mental rotations in gamers



e.g., finding tumors in X-rays



Note: the line is sometimes blurry between "cognitive skills" and "perceptual learning" (see later)

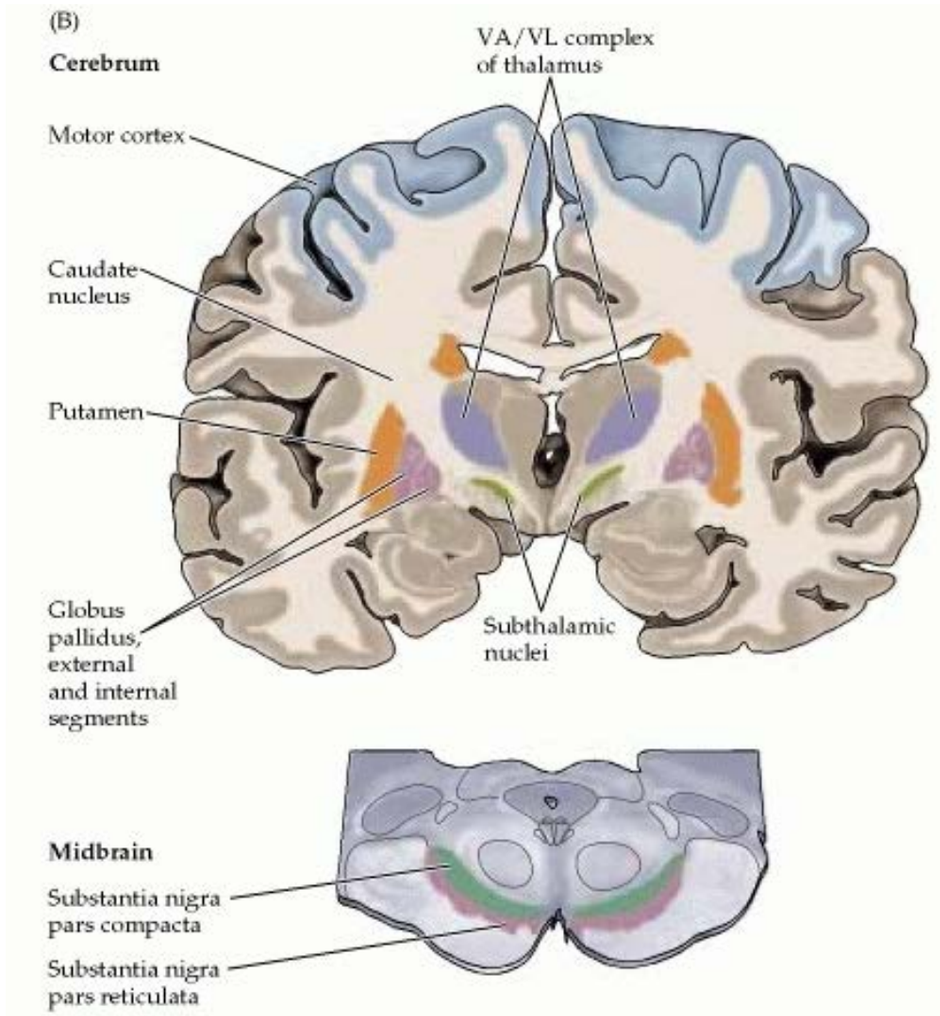
Cognitive skills are thought to involve repeated trial-and-error learning — or stimulus-outcome associations — whereas perceptual learning is thought to develop more gradually and unconsciously

NON-DECLARATIVE MEMORY SYSTEM
SKILLS AND HABITS

Depend on the striatum (caudate nucleus + putamen)

The Basal Ganglia

Striatum



Exam: *In what brain disorders are those structures affected (basal ganglia)?*

How would you expect such patients to perform on tests of skill learning?

NON-DECLARATIVE MEMORY SYSTEM
SKILLS AND HABITS

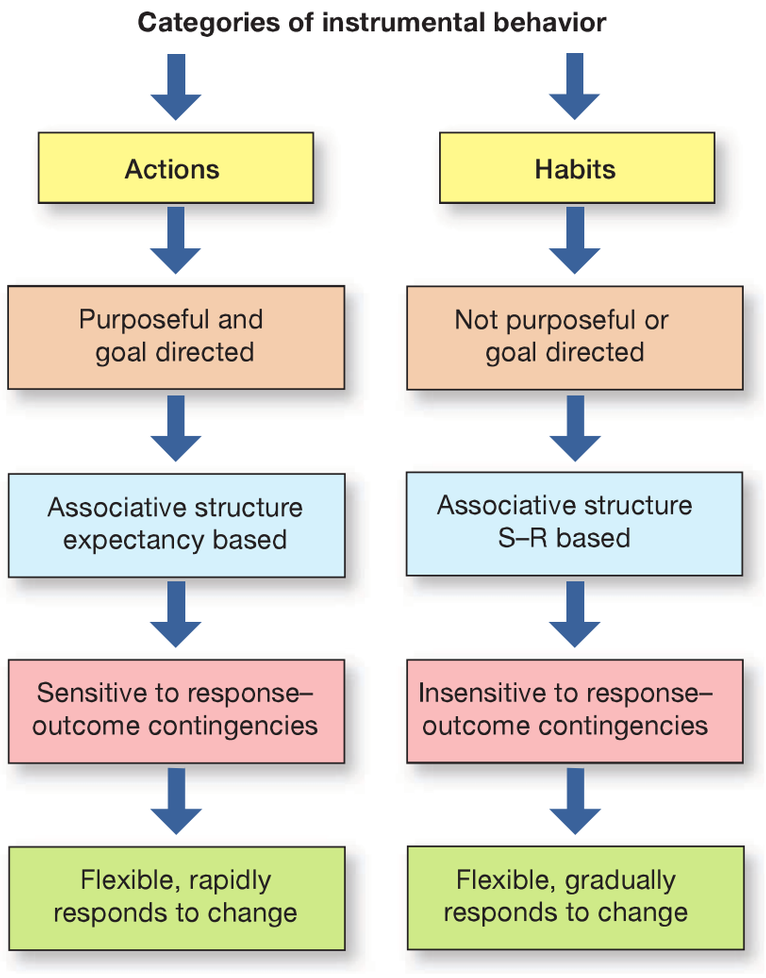
There is a distinction between actions and habits

ACTIONS

Initial learning of complex behavior

(e.g., learning to drive)

"Given this stimulus/situation, if I do this response I should be getting this outcome"



HABITS

Learning to perform complex behavior on "autopilot"

(e.g., driving after many year of practice)

" (no thought) "

Series of stimuli lead to series of responses

Probably involves a mixture of memory and brain systems

Primarily depends on dorsomedial striatum during initial learning, and on dorsolateral striatum as they become more automated

NON-DECLARATIVE MEMORY SYSTEM
SKILLS AND HABITS

How to tell action and habits apart?

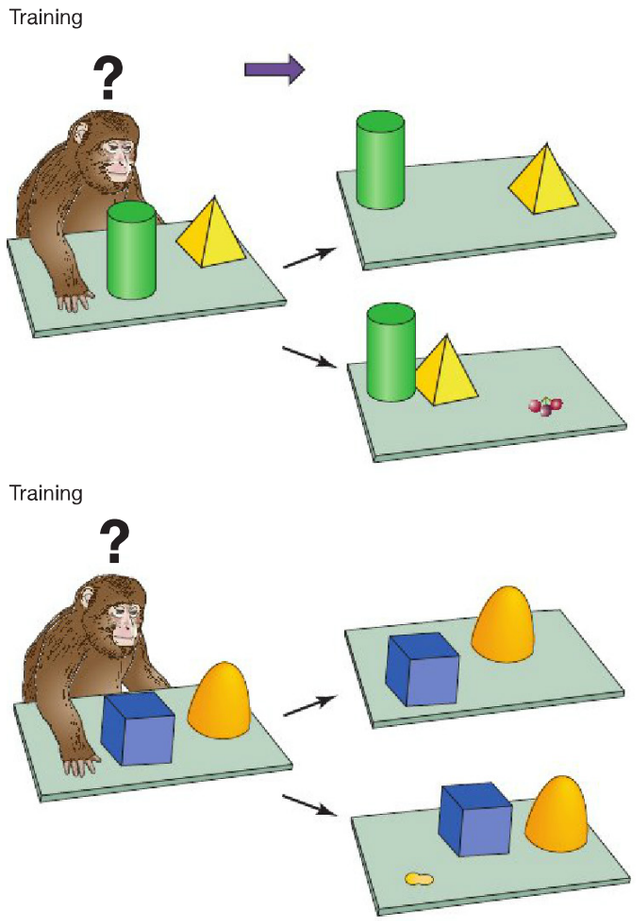


Figure 18.4
The figure illustrates the satiation method for devaluing a reward. A monkey is trained to solve two discrimination problems. In the first problem the pyramid is the correct choice and the reward is a grape. In the second problem the correct choice is the cube and the reward is a peanut. After solving the two problems, the monkey is given a choice between the two correct objects (cube and pyramid). Before the test, however, the monkey is allowed to have either all the grapes or all the peanuts it wants, thus reducing the value of one of the outcomes. Typically, monkeys choose the object that contains the reward that it was not fed prior to the test. (After Baxter and Murray, 2002.)

If devaluing the outcome has an effect, then the behavior is an <u>action</u>

If it does <u>not</u> have an effect, then the behavior is a <u>habit</u>

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NON-DECLARATIVE MEMORY SYSTEM
PRIMING AND PERCEPTUAL LEARNING

Priming: Exposure to one stimulus influences the response to another stimulus

Example 1: "NURSE" is recognized more quickly following "DOCTOR" than following "BREAD"

Example 2: recognizing picture fragments

Perceptual learning:

The more experience you have with some aspect of sensory processing, the better you'll be at it (see also "cognitive skills" earlier)

NON-DECLARATIVE MEMORY SYSTEM
PRIMING AND PERCEPTUAL LEARNING

Depend on many cortical areas

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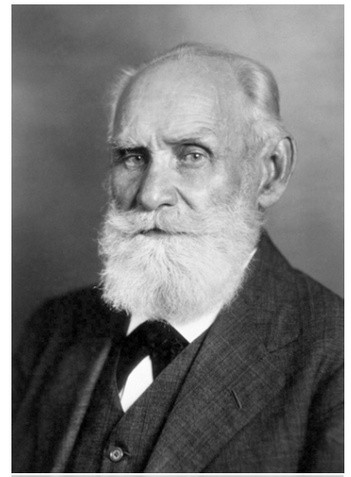
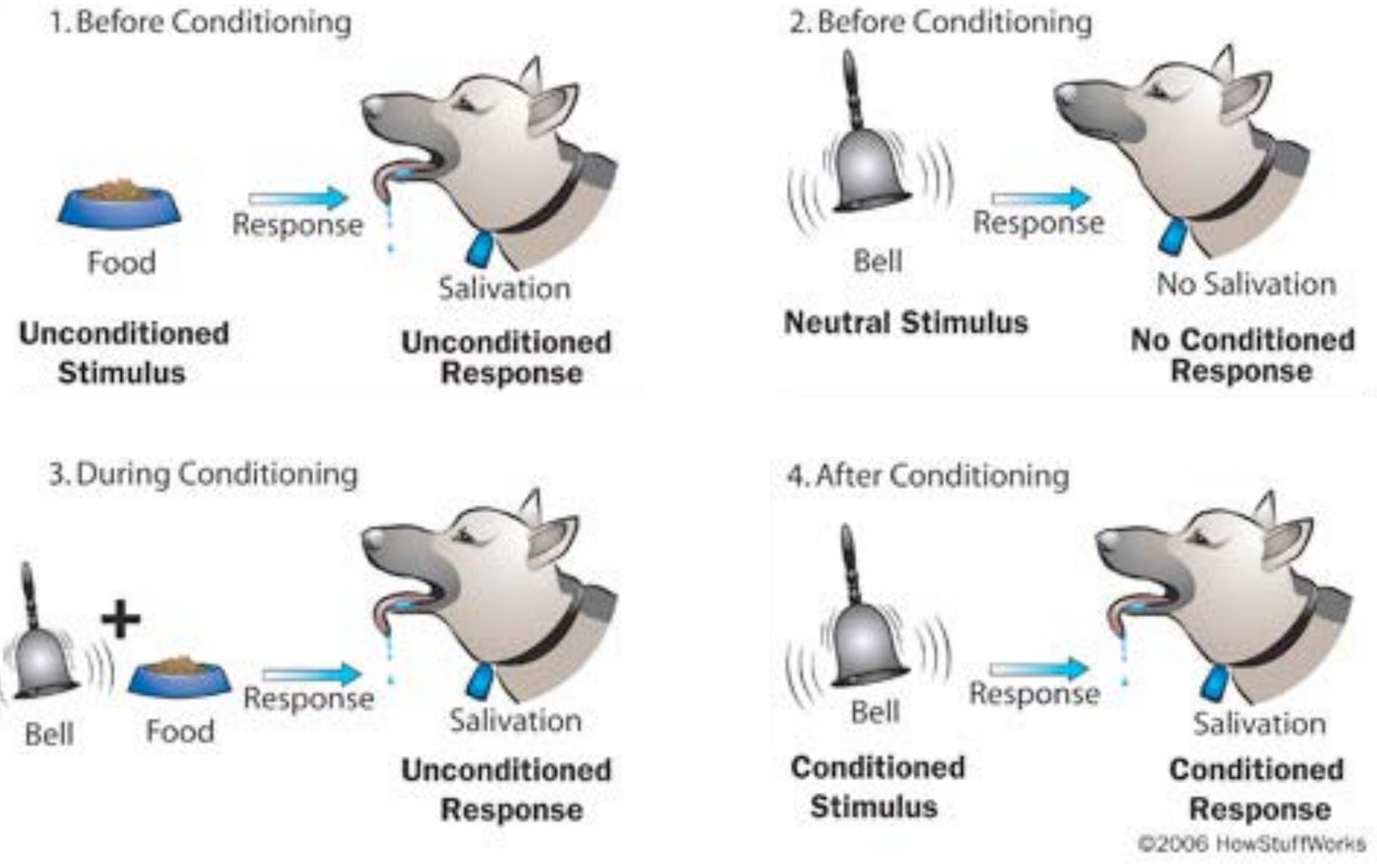
NON-DECLARATIVE MEMORY SYSTEM
CLASSICAL CONDITIONING (PAVLOV, 1927)

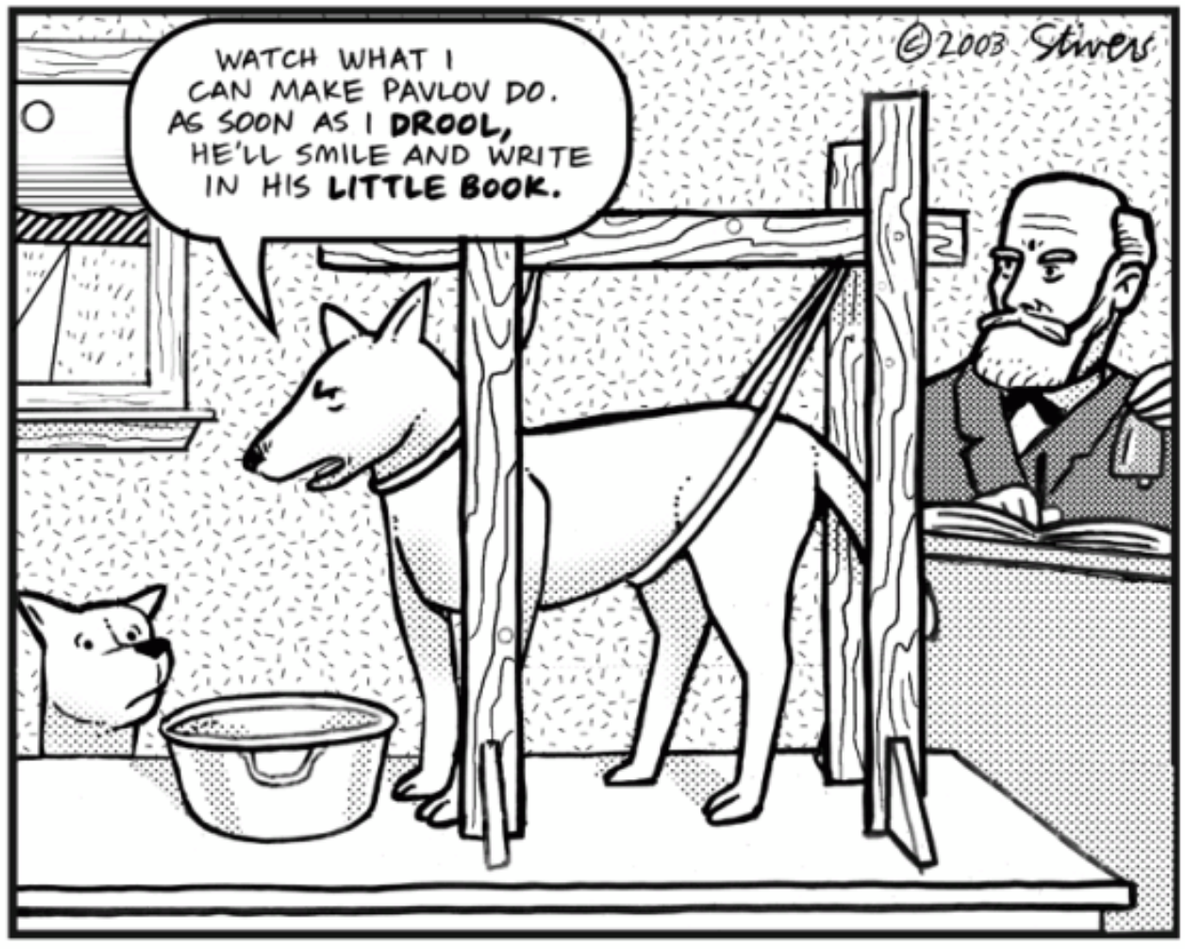


Ivan Pavlov



- Involves the pairing of a stimulus of **innate significance** (Unconditioned Stimulus; US) with a **neutral** stimulus (Conditioned Stimulus; CS)
- The CS will then elicit a Conditioned Response (CR) that is similar to the Unconditioned Response (UR)

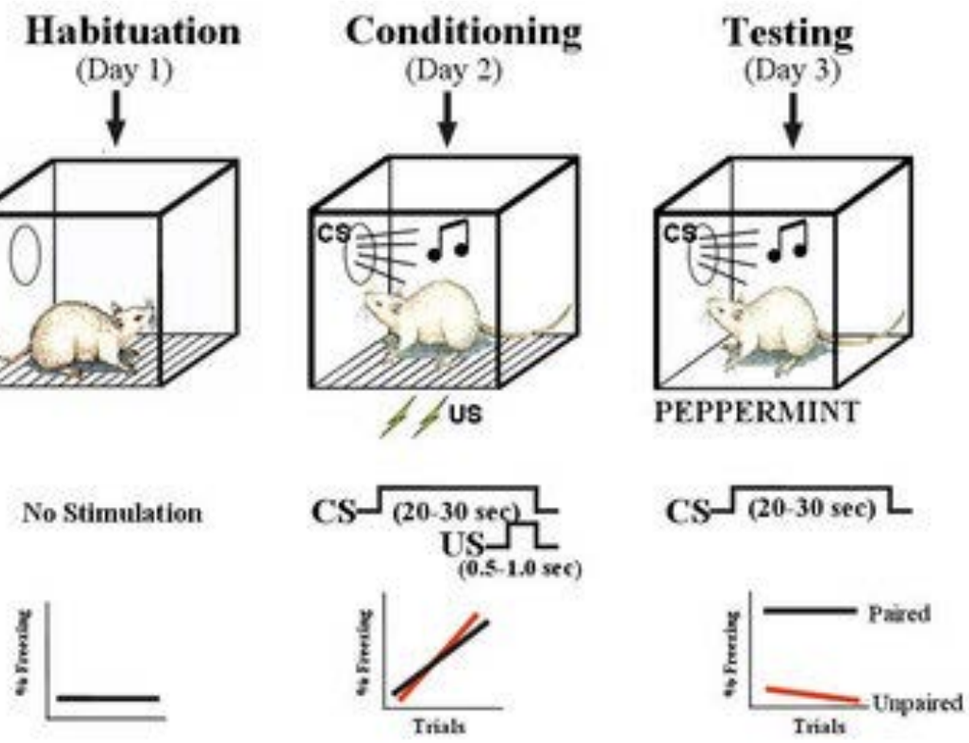
NON-DECLARATIVE MEMORY SYSTEM
CLASSICAL CONDITIONING IN POPULAR CULTURE



NON-DECLARATIVE MEMORY SYSTEM
CLASSICAL CONDITIONING (PAVLOV, 1927)

Some famous examples (there are many others)

Fear conditioning



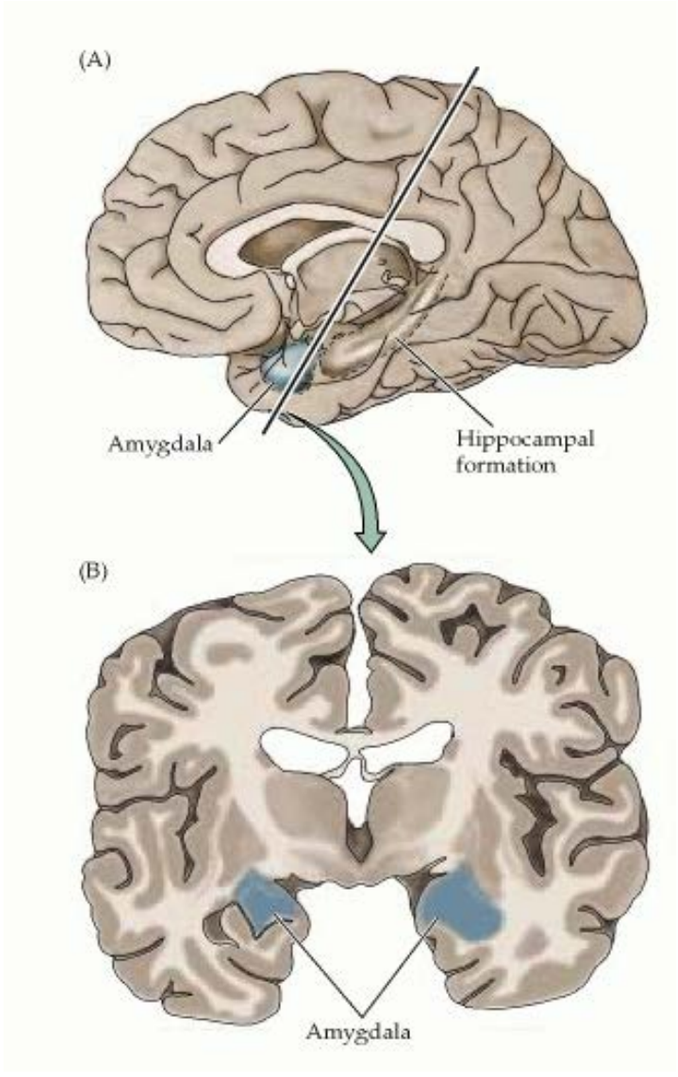
Depends on the amygdala

Eyeblink conditioning

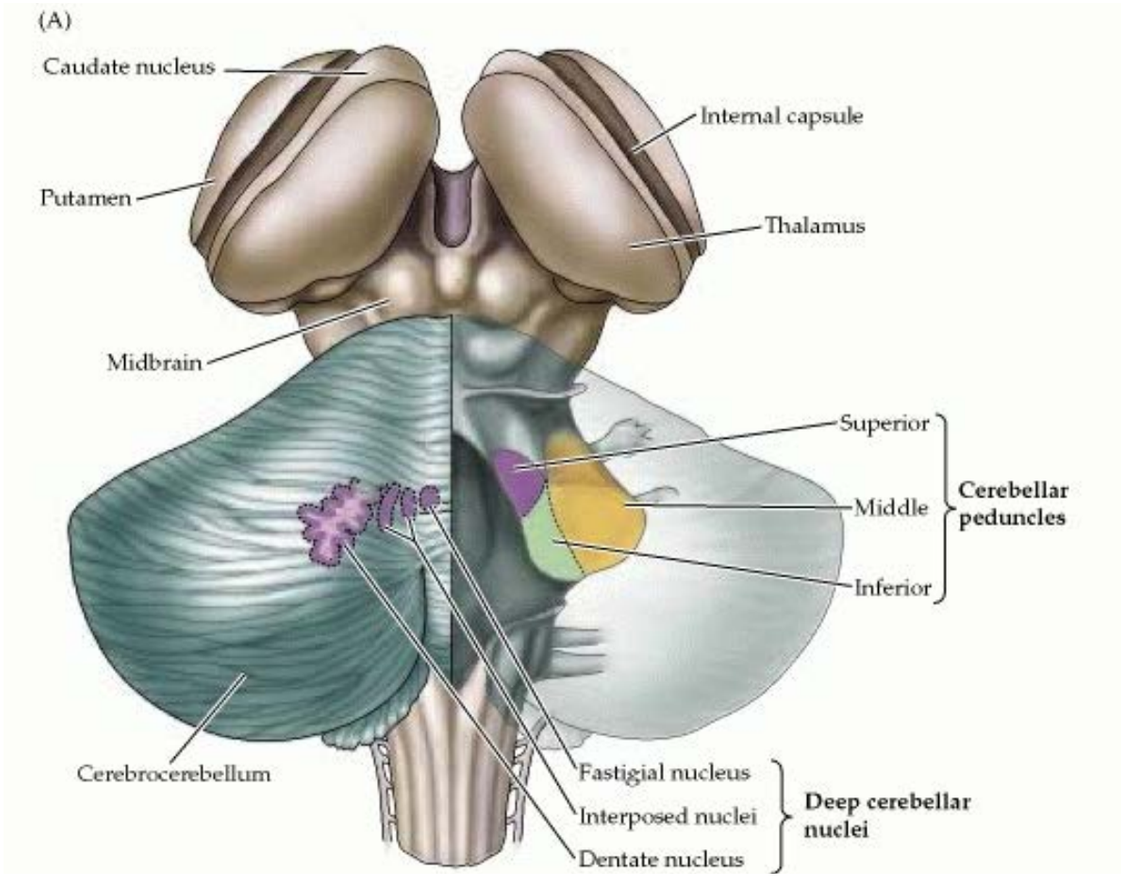
Depends on the cerebellum

NON-DECLARATIVE MEMORY SYSTEM
CLASSICAL CONDITIONING (PAVLOV, 1927)

Fear conditioning



Eyeblink conditioning



Depends on the amygdala

Depends on the cerebellum

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NON-DECLARATIVE MEMORY SYSTEM
NONASSOCIATIVE LEARNING

Eric Kandel

- Habituation
  - Process by which you have a decrease in psychological and behavioral response to a stimulus after repeated exposure to that stimulus over a duration of time
    - e.g., you learn to ignore a new noise if nothing bad happens

- Sensitization
  - Process by which you have an amplification of a response after repeated administrations of a stimulus.
    - e.g., rubbing in the same spot

NON-DECLARATIVE MEMORY SYSTEM
NONASSOCIATIVE LEARNING

Habituation and sensitization are studied extensively in *Aplysia*

Dr. Kandel received the 2000 Nobel Prize in Physiology or Medicine (with Arvid Carlsson and Paul Greengard) for his research on the physiological basis of memory storage in neurons

MULTIPLE MEMORY SYSTEMS
WHY DO WE HAVE MANY?

- Sherry & Schacter (1987) article is a landmark paper in that area

- They proposed the notion of *functional incompatibility*
  - Distinct memory systems evolve only when there is functional incompatibility between the properties of an existing system and the demands posed by a novel environmental problem.

MULTIPLE MEMORY SYSTEMS
WHICH ONES DO WE USE AND WHEN?

- We are using all of them simultaneous to encode information in parallel
- When we recall info, the systems compete. One of the systems will “win” in each particular situation.
- Examples of multiple memory systems at work

NEUROBIOLOGY OF LEARNING AND MEMORY 65, 65–72 (1996)
Article No. 0007

Inactivation of Hippocampus or Caudate Nucleus with Lidocaine Differentially Affects Expression of Place and Response Learning

MARK G. PACKARD* AND JAMES L. MCGAUGH†,[1]

*Department of Psychology, University of New Orleans 70148; and †Center for the Neurobiology of Learning and Memory and Department of Psychobiology, University of California, Irvine 92717

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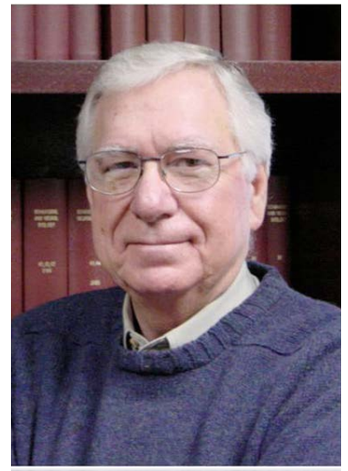
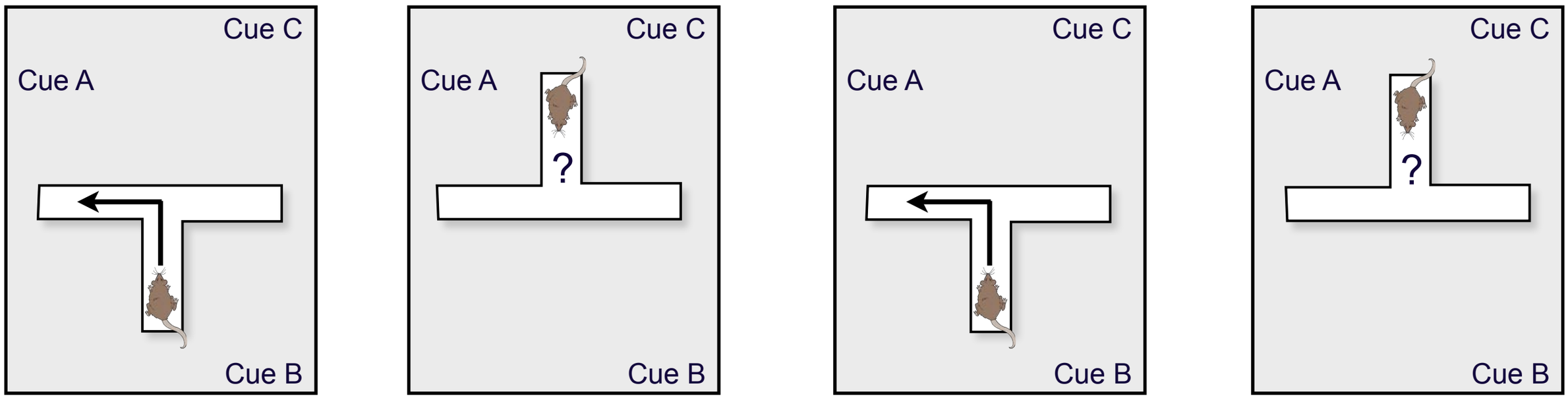


Jim McGaugh (UCI)

- Packard & McGaugh 1996



Day 1 ...

Day 8
(1 probe test)

Rats go to <u>same side of room</u>
(unless hippocampus is inactivated)

Day 9 ...

Day 16
(1 probe test)

Rats make a <u>left turn</u>
(unless striatum is inactivated)