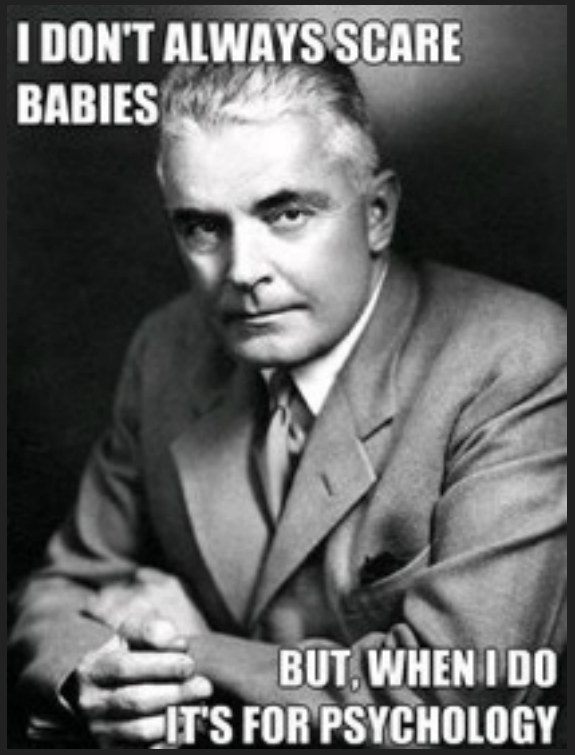
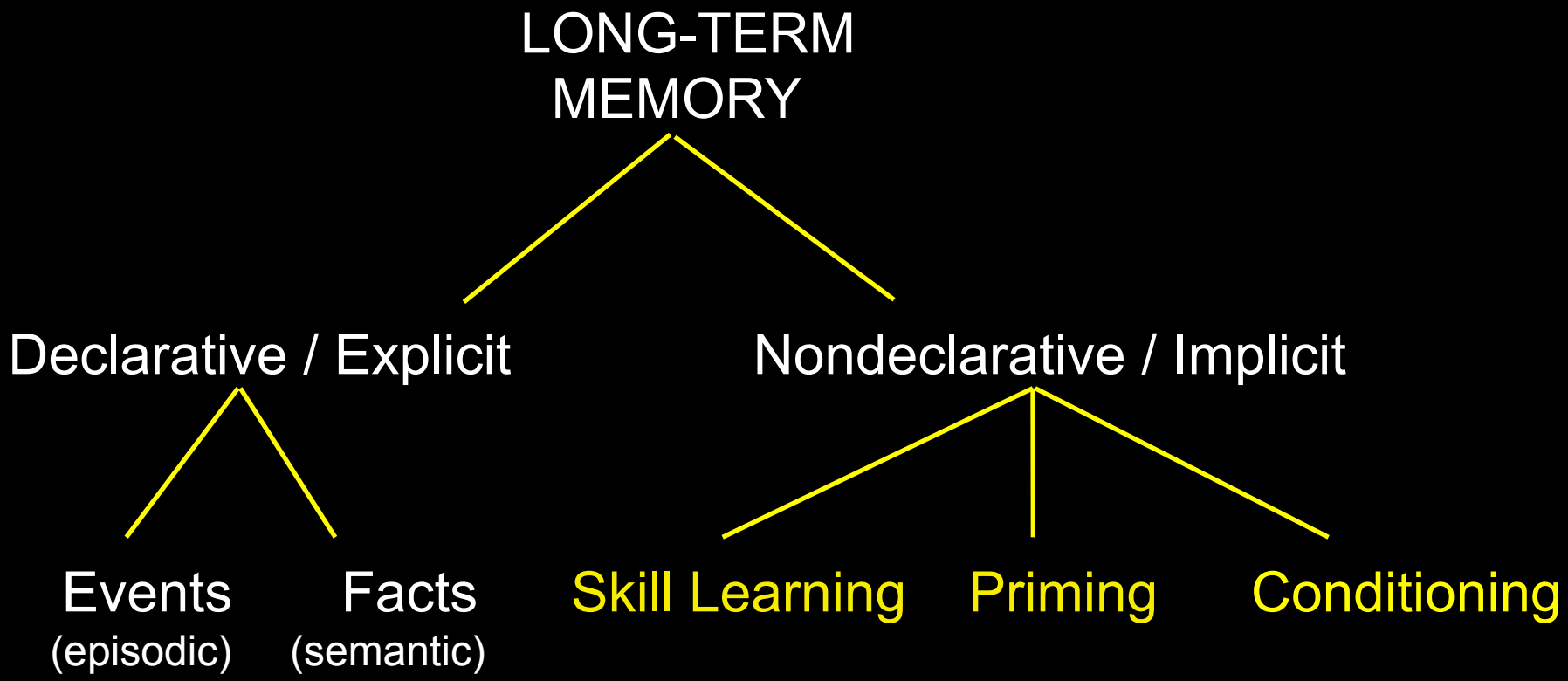
Open SUPA Meeting This Monday

- **Monday, 5/16, 9:30-10:30PM, Old Union 200**
- SUPA is the Stanford Undergraduate Psychology Association, a community of undergraduates interested in psychology
- We put on movie screenings, faculty dinners, career panels, research fairs, social gatherings, and other events for the psychology community
- **Core Members have priority for all events and special opportunities like dinner with Albert Bandura or chatting with Philip Zimbardo**
- Give us the chance to make you fall in love with us :-)



Long-Term Memory Systems



Outline

- Procedural Memory / Skill Learning
  - Define procedural memory
  - Learning through practice
  - Expertise and transfer
  - Neural substrates of procedural memory
- Priming
  - Define priming
  - Principles of priming
  - Neural substrates of priming

Procedural Memory / Skill Learning

- Improved performance (accuracy / speed) on perceptual-motor or cognitive tasks with practice
  - **Perceptual-motor skills**: motor patterns guided by sensory inputs
  - **Cognitive skills**: ability to problem solve and apply strategies
  - Many skills involve a combination of perceptual-motor and cognitive abilities

52 x 17

Types of Perceptual-Motor Skills

- **Closed Loop skills**
  - Performing pre-defined sequences of actions
  - Gymnastics, ice-skating, or diving routines; playing a violin concerto
- **Open Loop skills**
  - Require adjustments based on changes in the environment
  - Playing basketball; playing improvisational jazz
- Most skills fall somewhere on a spectrum of closed to open

How is Procedural Memory Unique?

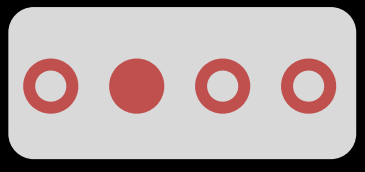
- Differences from declarative memory:
  - Can be acquired without conscious awareness – **implicit learning**
  - Typically hard to verbalize
  - Requires repeated learning trials (extensive practice)

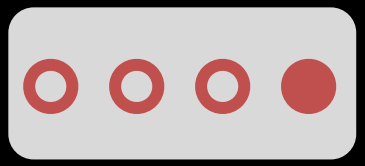
Implicit Learning

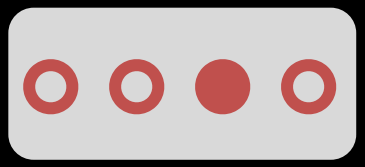
- Serial reaction time (SRT) task
  - Press button that corresponds to visual cue
  - Cues mostly appear in random order, but some sequences repeat:

2431341424 12….43414241221434

  - With training, reaction time (RT) to repeated sequence is faster than to random sequences

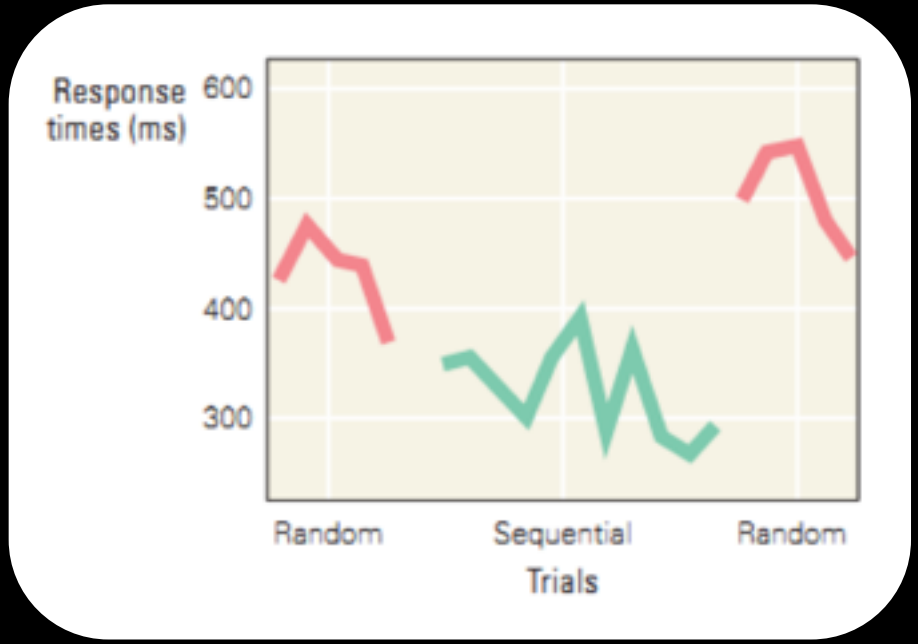







Implicit Learning

- Serial reaction time (SRT) task
  - Press button that corresponds to visual cue
  - Cues mostly appear in random order, but some sequences repeat
  - With training, reaction time (RT) to repeated sequence is faster than to random sequences
  - Typically, participants are unaware of the repeating sequences!



How is Procedural Memory Unique?

- Differences from declarative memory:
  - Can be acquired without conscious awareness – **implicit learning**
  - Typically hard to verbalize
  - Requires repeated learning trials (extensive practice)

- Differences from priming (a form of non-declarative memory):
  - Priming is facilitated performance regarding a *particular stimulus*
  - Skill learning is facilitated performance on a *particular task* involving a range of stimuli

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Power Law of Learning: Mirror Reading Task

In a hole in the ground there lived a hobbit. Not a nasty, dirty, wet hole, filled with the ends of worms and an oozy smell, nor yet a dry, bare, sandy hole with nothing in it to sit down on or to eat: it was a hobbit-hole, and that means comfort.

Power Law of Learning: Mirror Reading Task

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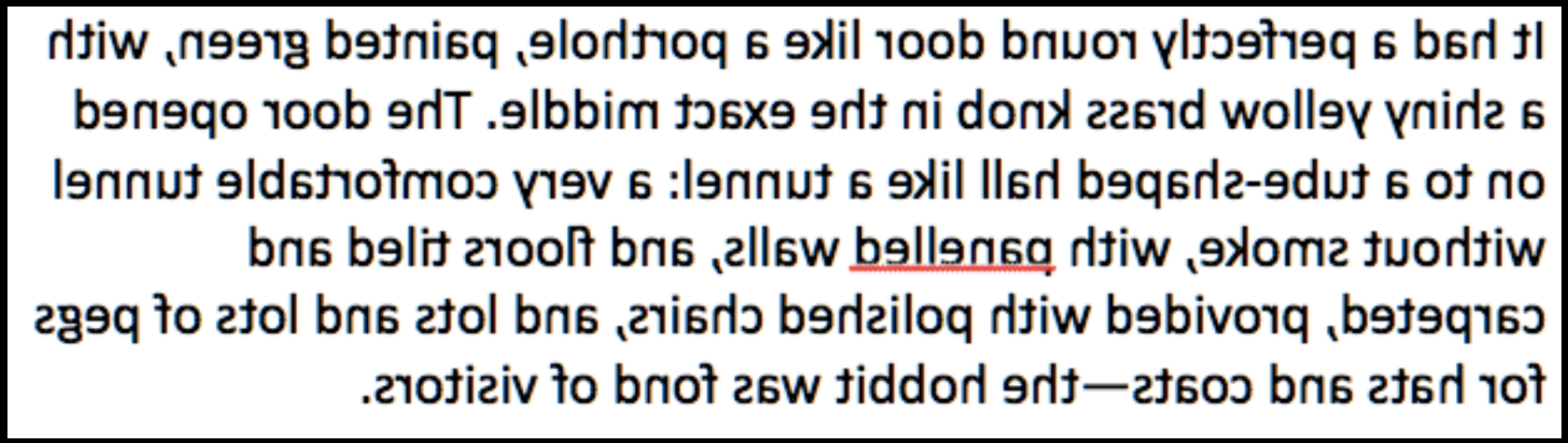
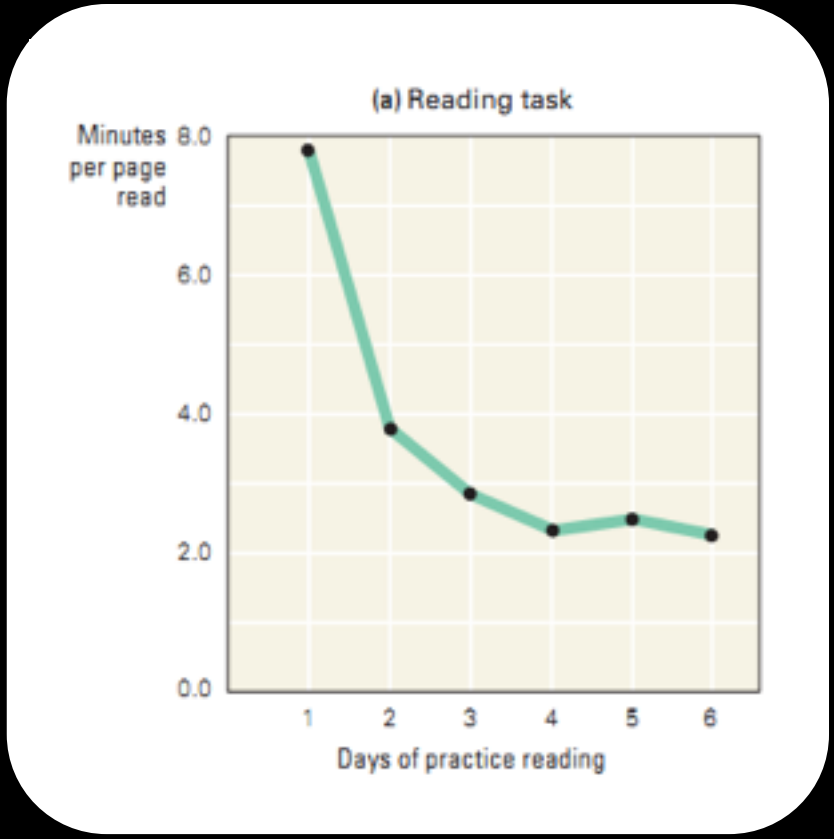
Mirror reversed



Power Law of Learning

- Gains in learning are very rapid at first, but rate of learning declines with practice
  - i.e., the time required to complete a task decreases at a diminishing rate
- Pattern holds true across a wide range of tasks (perceptual-motor, cognitive)
- aka *Law of Diminishing Returns*



Stages of Skill Learning

Fitts' three-stage model (1964)

- Cognitive stage
  - Initial period, typically verbal / explicit, in which attention is required to perform skill
- Associative stage
  - Less reliance on verbal rules
  - More stereotyped behavior
- Autonomous stage
  - Skill is automatic and requires little attention (habitual)

Stages of Skill Learning

Learning to drive a car with manual transmission

- Cognitive stage
  - Clumsy and slow; rules coded verbally
  - Need conscious effort and control
- Associative stage
  - Many actions (i.e., shifting) have become stereotyped
  - Often need conscious control to determine appropriate sequence of actions
- Autonomous stage
  - Driving requires little attention; can listen to the radio and chat with friends
  - May even realize that you don't remember your drive home

Learning through Practice

Many factors influence how effective practice is

- Feedback
  - Knowledge of performance during practice
- Spacing
  - Massed: concentrated practice
  - Spaced: practice spread out over multiple sessions
- Variability
  - Constant: practice focused on a single skill
  - Variable: practice that alternates between a set of skills

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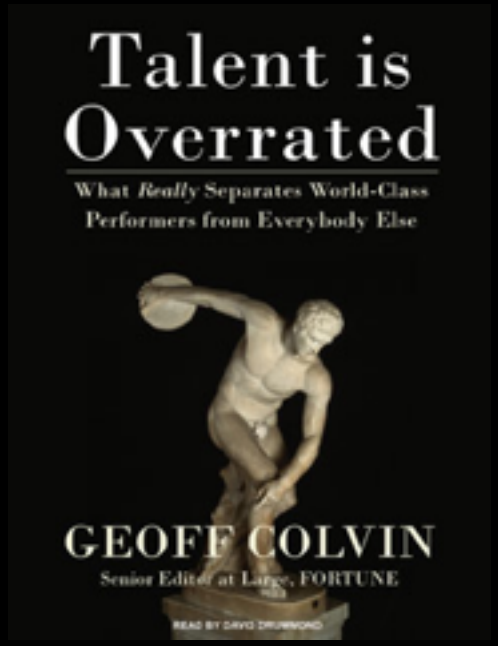
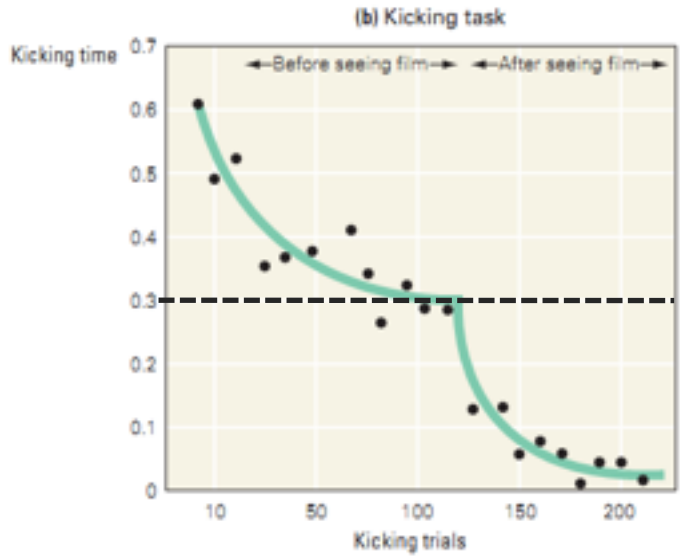
10,000 Hours and Expertise

- Research by Ericsson and others suggests that ~10,000 hours of deliberate practice are required to become an expert
  - Musicians
  - Athletes
  - Medical doctors
  - Chess masters
- Spacing is important – best to practice 2-3 hours per day for many years



Deliberate Practice

- Requires focused attention
- Requires feedback
- Requires regularly changing context and conditions / variability



"Pretty good" plateau

Importance of Failure

- Practice should be challenging
  - To get past a plateau, there must be a risk of failure
  - Can think of failure as another desirable difficulty
- Lacking awareness or not addressing failure is often the reasons that we don't improve with practice
  - Practice doesn't necessarily make perfect!
- "I am always doing that which I cannot do, in order that I may learn how to do it." –Picasso

Transferring Skills

- **Transfer**: generalization of skill learning from one context to another
  - Gymnast joining the diving team
- Generally, however, most skills do not transfer well
- **Transfer specificity**
  - Skateboarder isn't necessarily a good ice skater
  - Relative to a novice, however, skateboarder is more likely to rapidly learn to snowboard

Transferring Specificity

When are skills likely to transfer?

- Thorndike's *identical elements theory* (1901)
  - Transfer depends on the similarity of the training context to the new context
  - The more shared (identical) elements, the better the transfer of skill learning

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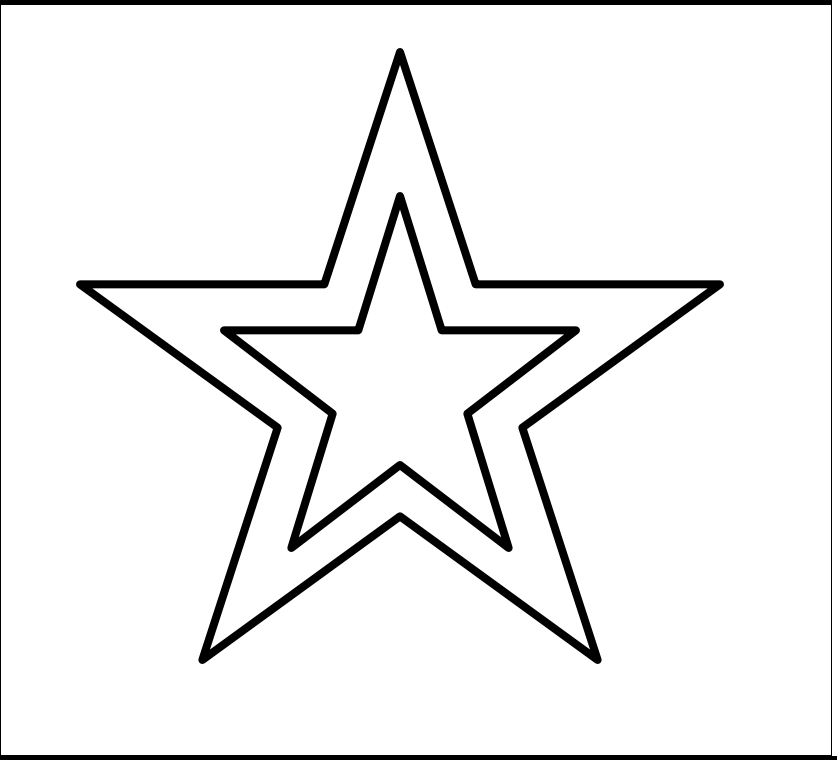
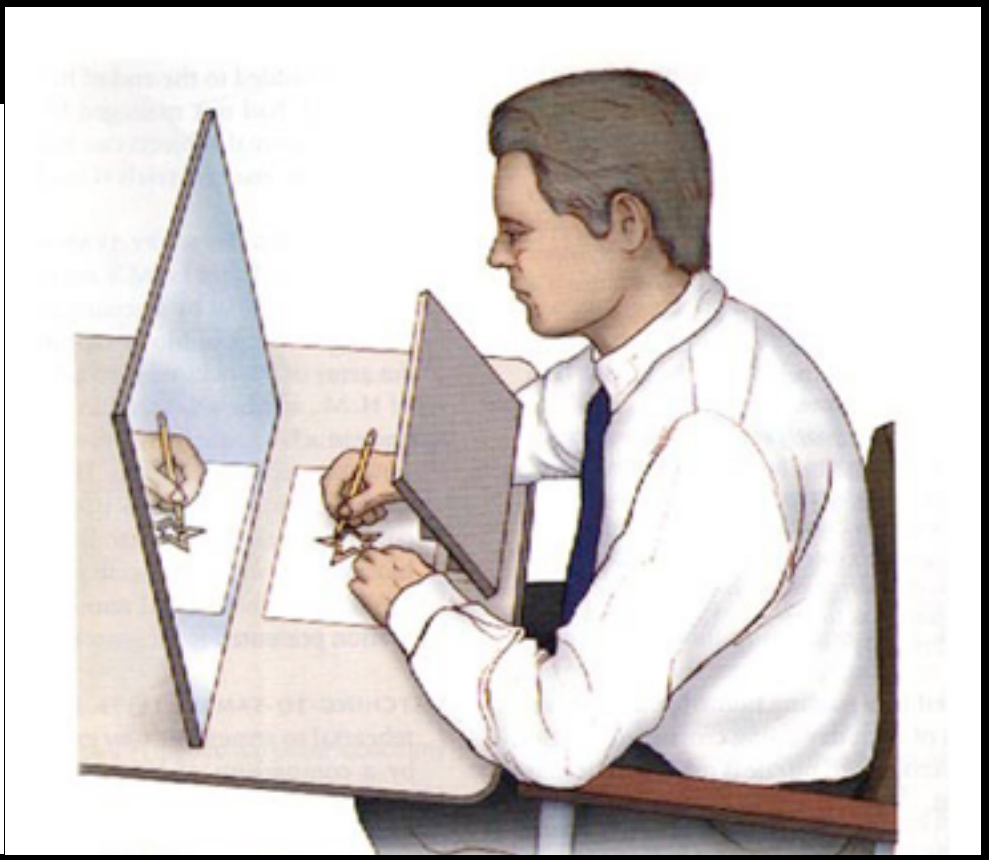
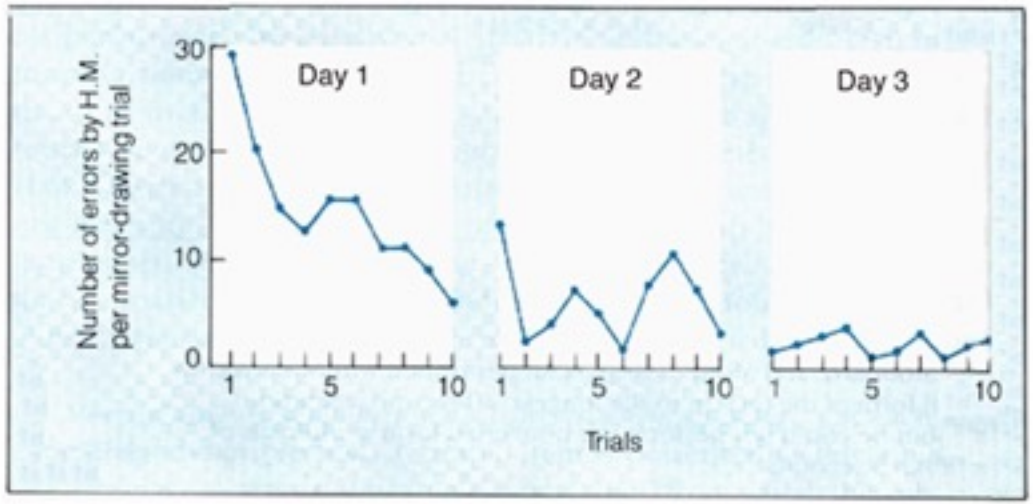
Amnesic Patients Can Acquire New Skills

Mirror Tracing Task







Retention of the mirror-drawing task by H.M. (Adapted from Milner, 1965.)

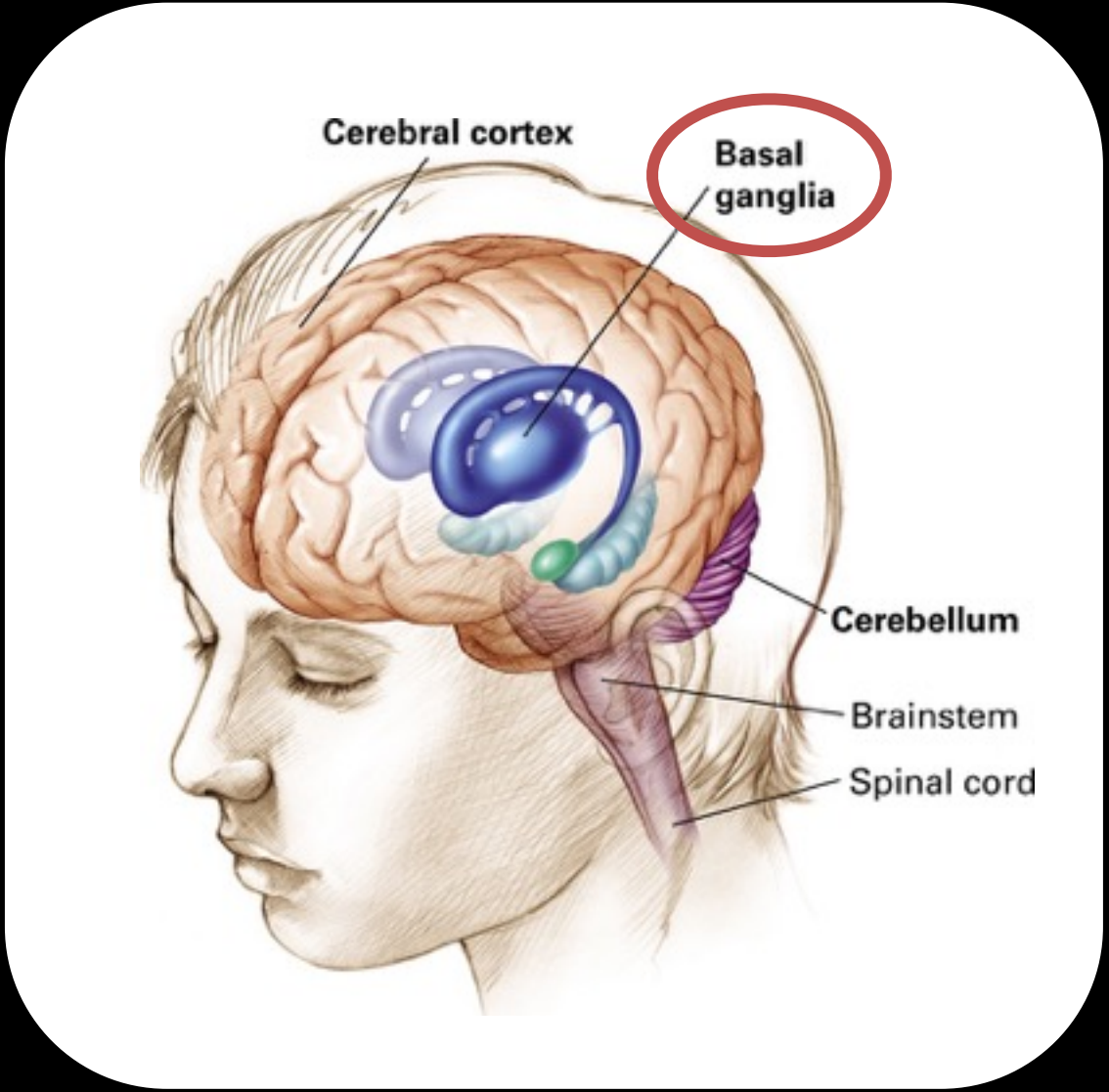
Requires new perceptual-motor mappings

– relating perceptual inputs to motor outputs

– cortical representations of visual percepts need to be associated with cortical representations of motor programs (basal ganglia)

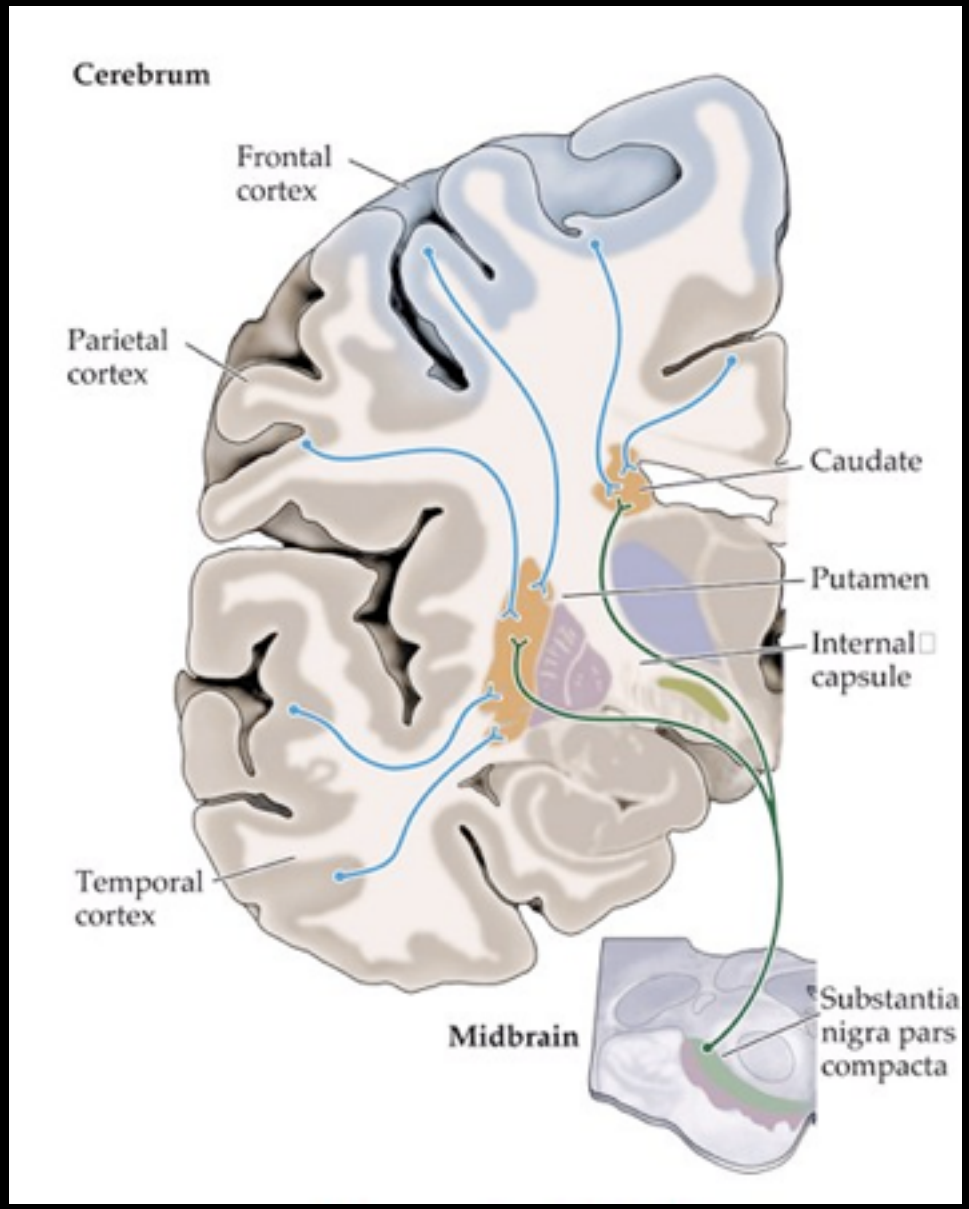
Brain Substrates of Procedural Memory

- Basal ganglia
- Cortex
- Cerebellum



Basal Ganglia

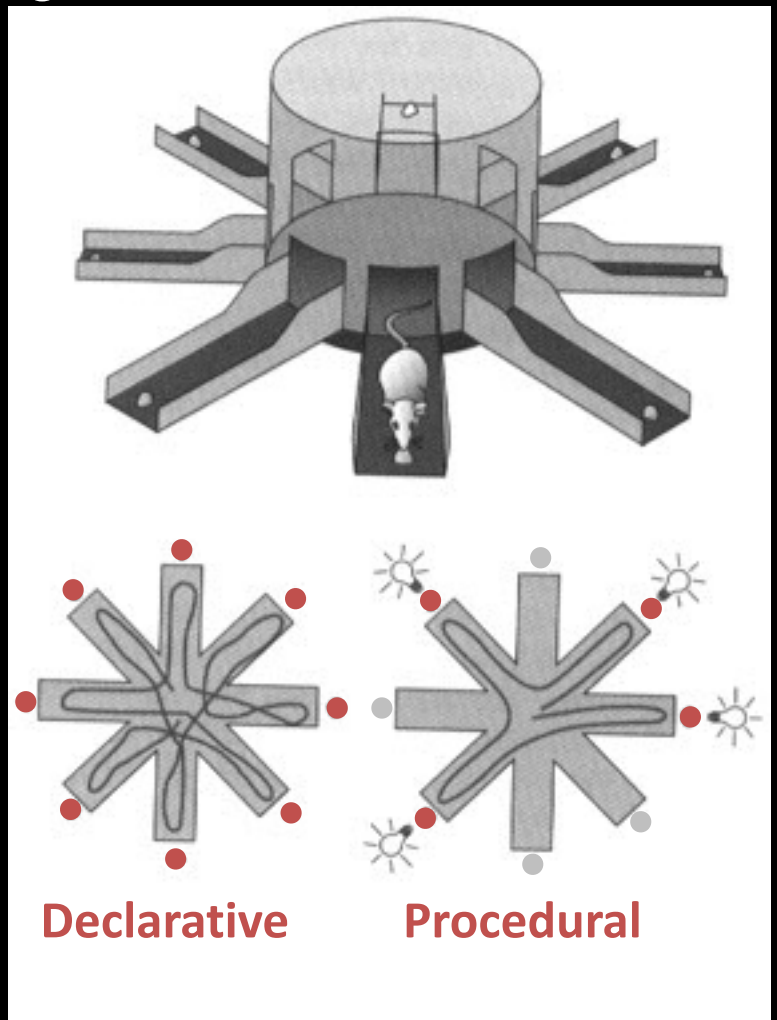
- Receives input from a wide range of cortical areas
- Sends output to the thalamus, which in turn influences motor cortex
- Plays a key role in regulating the direction, speed, and strength of movements



MTL vs. Basal Ganglia Dependent Memory

Two versions of radial arm maze task designed to assess either declarative or procedural learning

- **Declarative**
  - Each arm is baited with food
  - Performance requires remembering which arms have been visited
- **Procedural**
  - Half of the arms are baited and signaled with a light
  - Performance requires entering illuminated arms only (Stimulus-Response)



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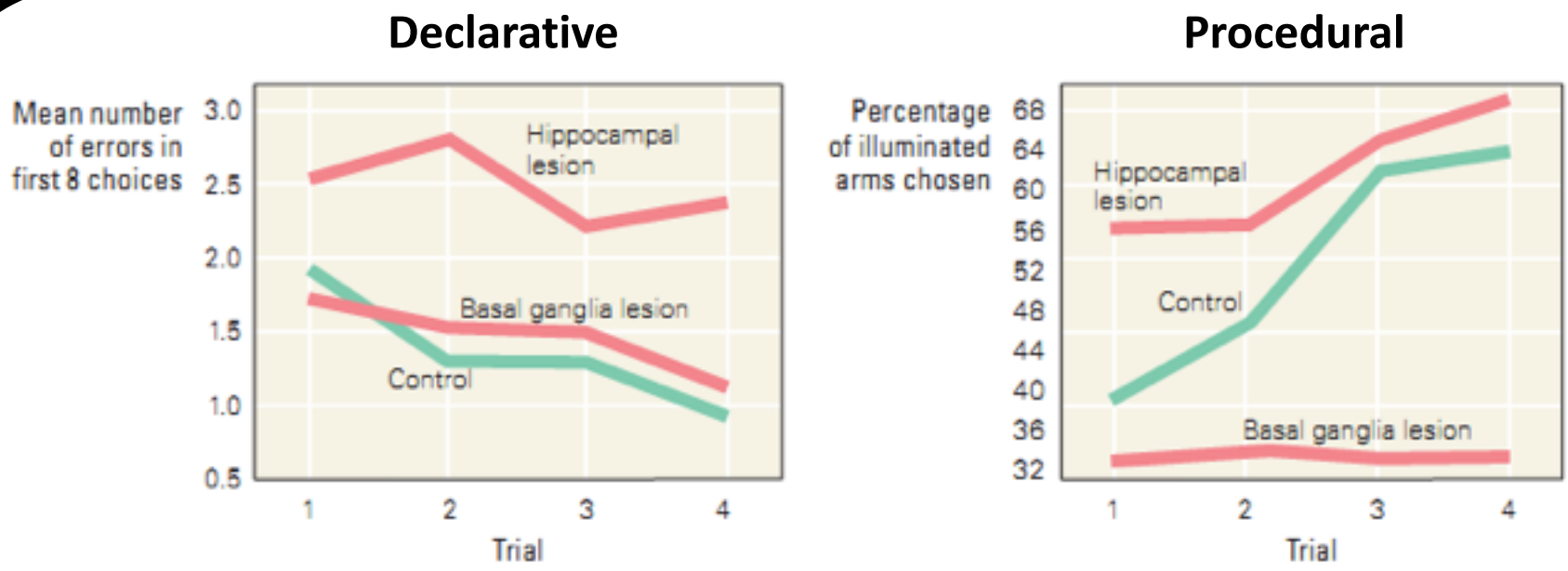


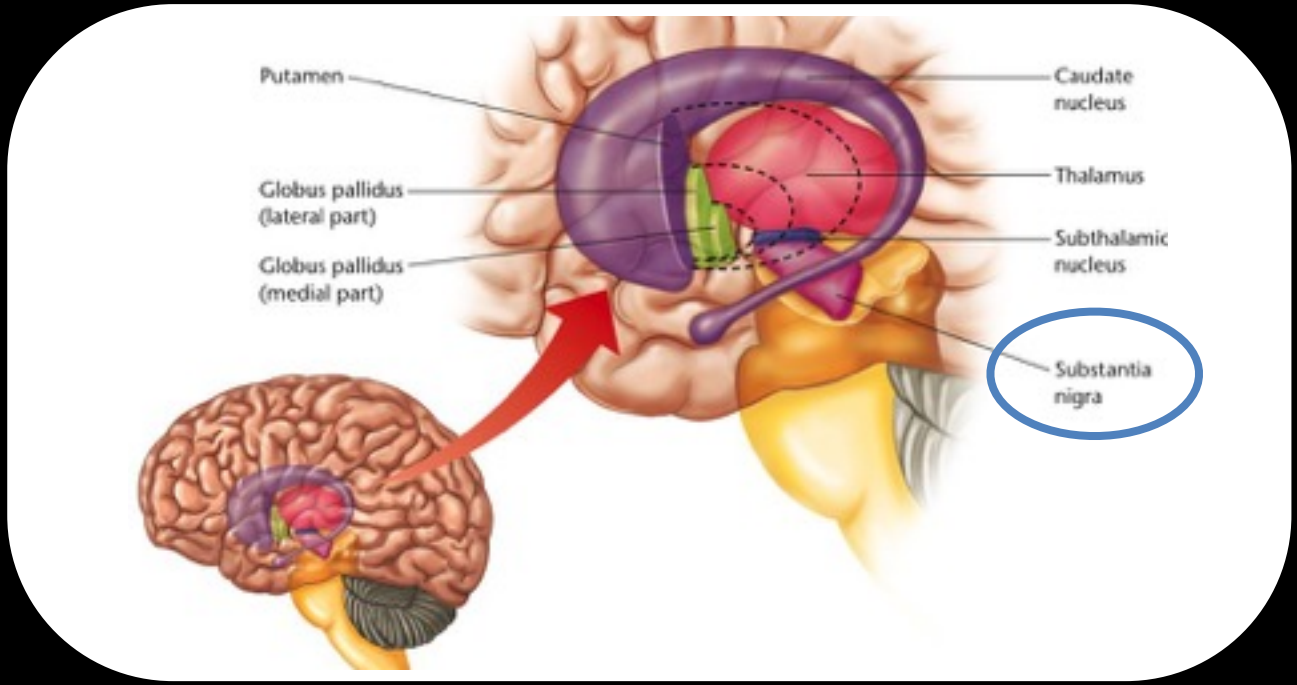
- MTL damage impairs performance on ‘declarative’ version of the task, but not procedural
- Basal ganglia damage impairs performance on procedural version of the task, but not declarative

Parkinson's Disease (PD)

- Neurodegenerative disease affecting about 1 million people in the US, typically later in life
- Primarily a movement disorder
  - Muscle tremors
  - Rigidity
  - Slowness of movement
  - Difficulty initiating spontaneous movements in the absence of stimuli
- Also affects cognition
  - Impairments in procedural learning (both perceptual-motor and cognitive)

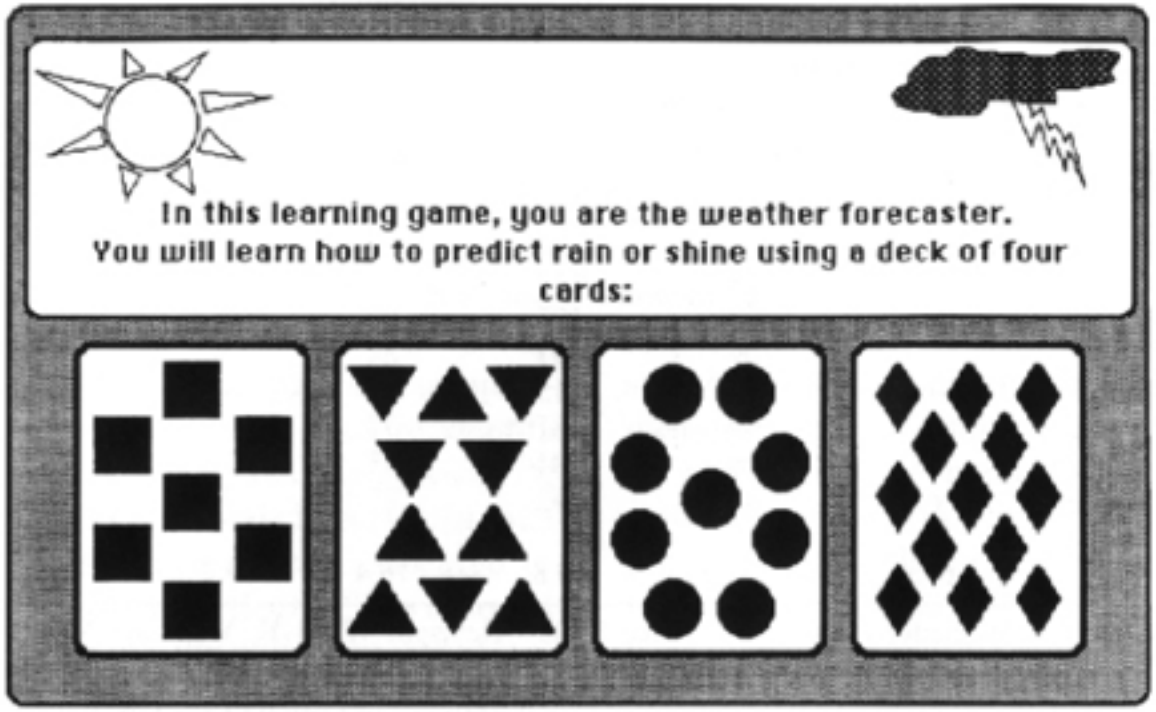
Parkinson's Disease (PD)

- Results from gradual death of neurons in the substantia nigra, which provides dopaminergic input to the BG
  - Decreased input causes dysfunction of the BG, and thus dysfunctional interactions with the thalamus and brainstem



Weather Prediction Task

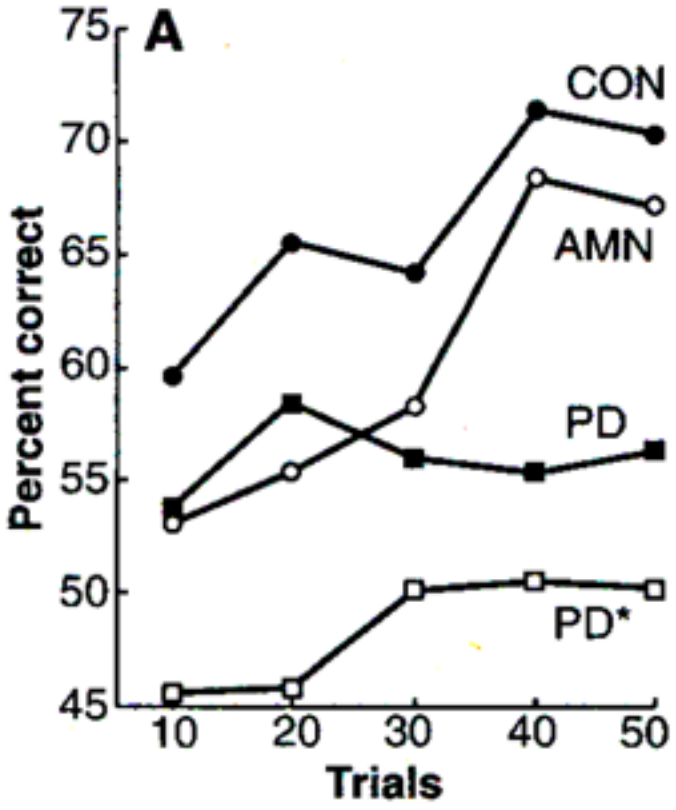
Test of cognitive skill learning that involves probabilistic classification



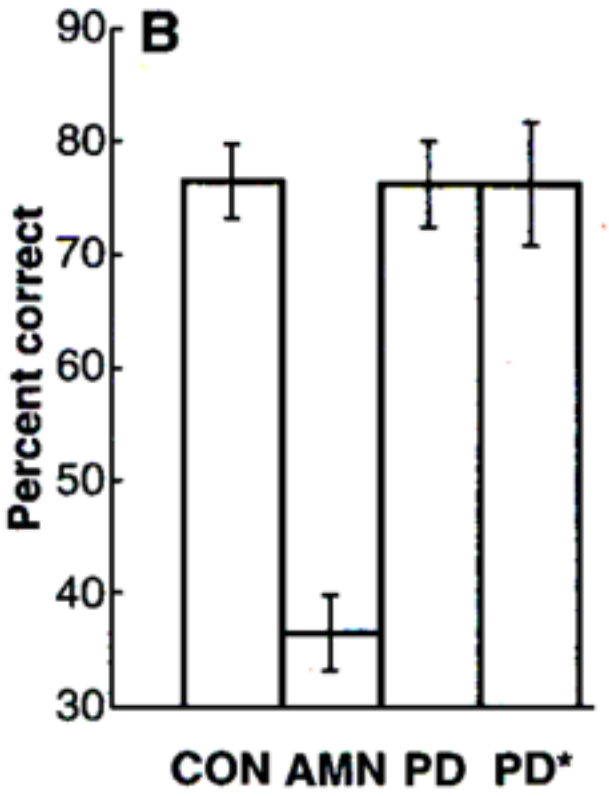
Knowlton et al (1996)

Weather Prediction Task

Skill learning



Declarative memory



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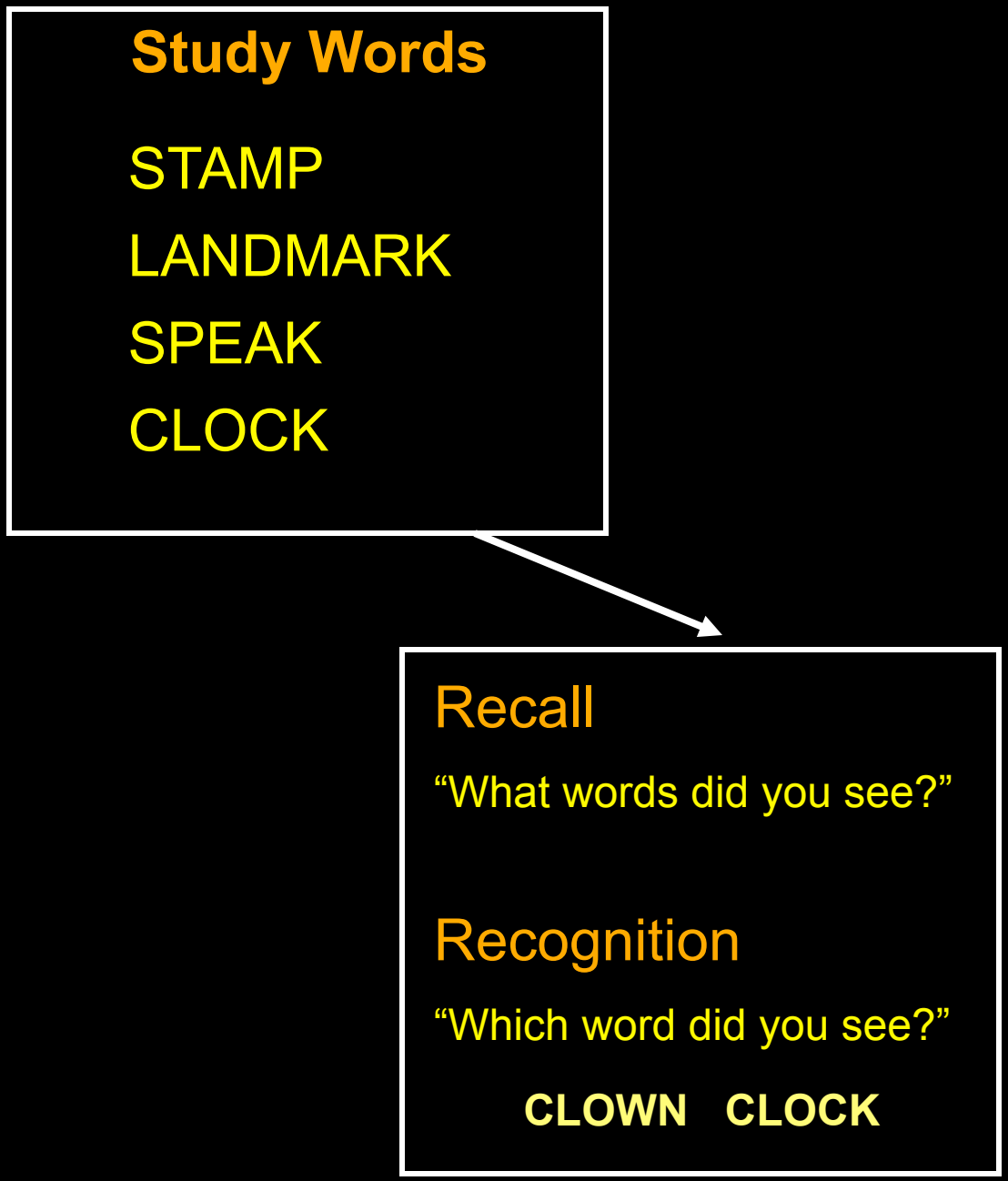
Study Words

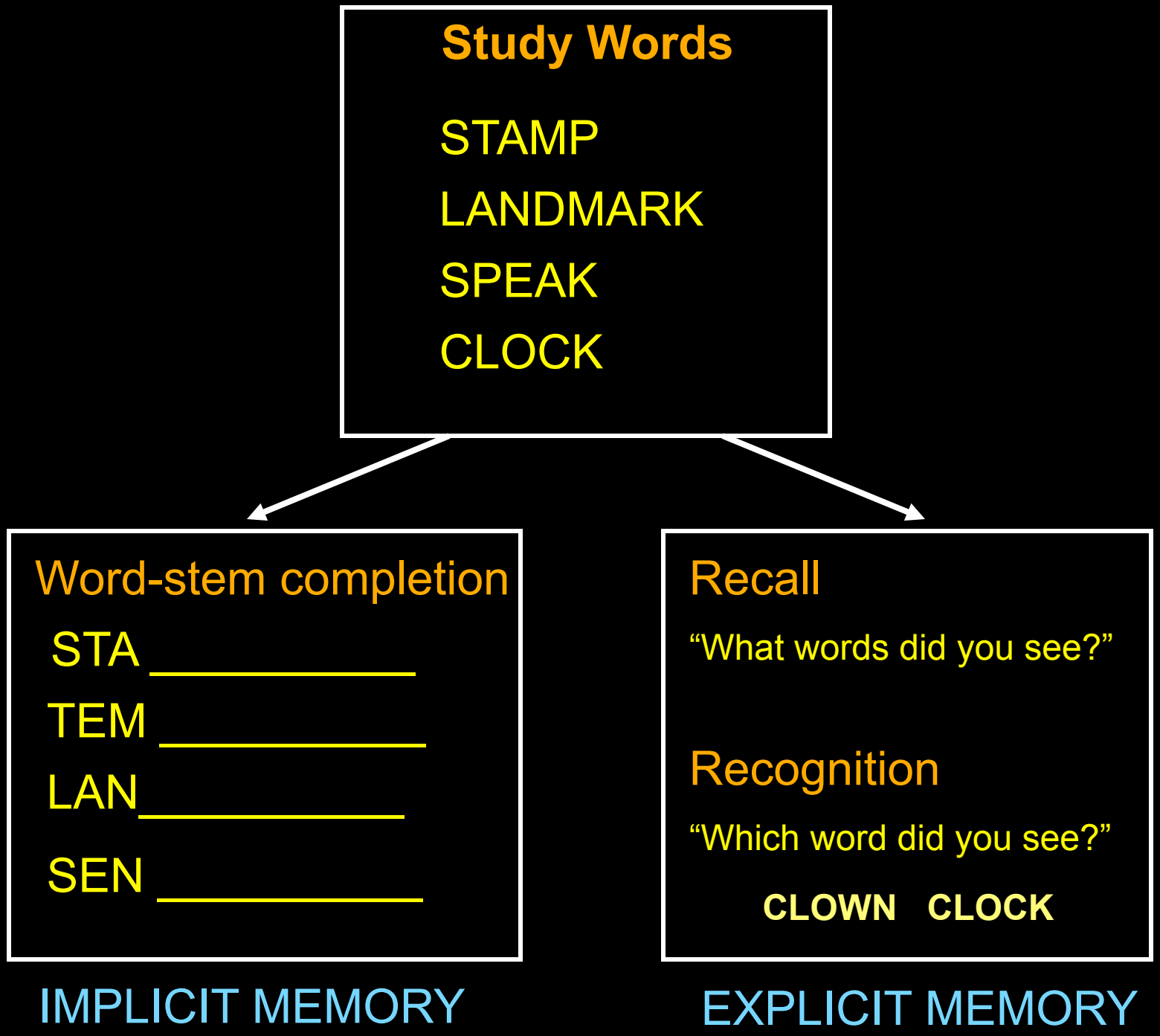
STAMP

LANDMARK

SPEAK

CLOCK


Study Words
STAMP
LANDMARK
SPEAK
CLOCK
Recall
“What words did you see?”
Recognition
“Which word did you see?”
CLOWN CLOCK
EXPLICIT MEMORY


Study Words
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LANDMARK
SPEAK
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Word-stem completion
STA _____
TEM _____
LAN_____
SEN _____
Recall
"What words did you see?"
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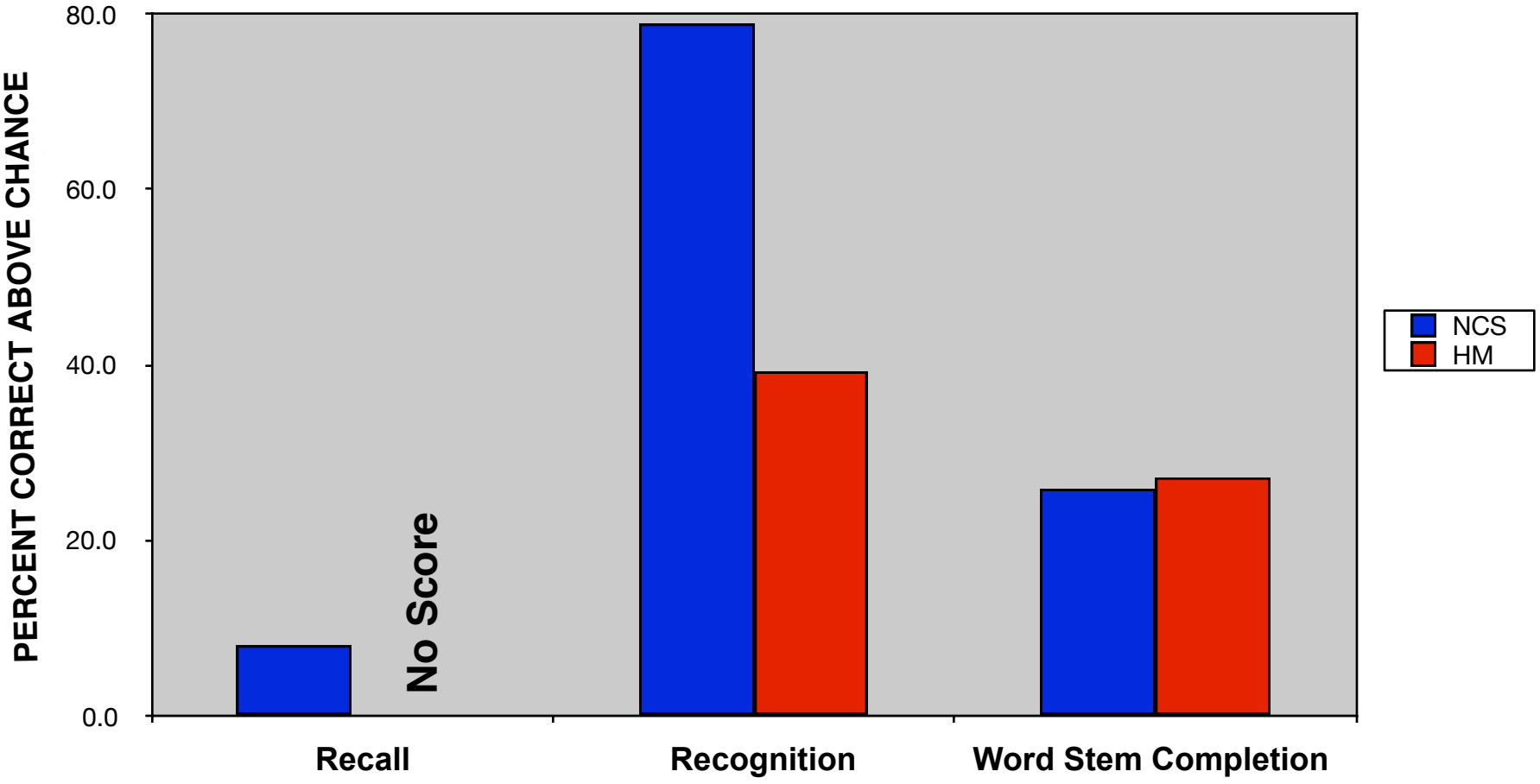
CLOWN CLOCK
IMPLICIT MEMORY
EXPLICIT MEMORY

Explicit vs. Implicit Dissociation in HM



Priming

Change in performance (accuracy, speed) with a **stimulus** (e.g., word or picture) due to prior processing of that stimulus or a related stimulus

Dissociable Memory Processes?

Can priming and declarative memory be dissociated in healthy subjects?

Perceptual Overlap and Generation: Explicit and Implicit Dissociations

STUDY:

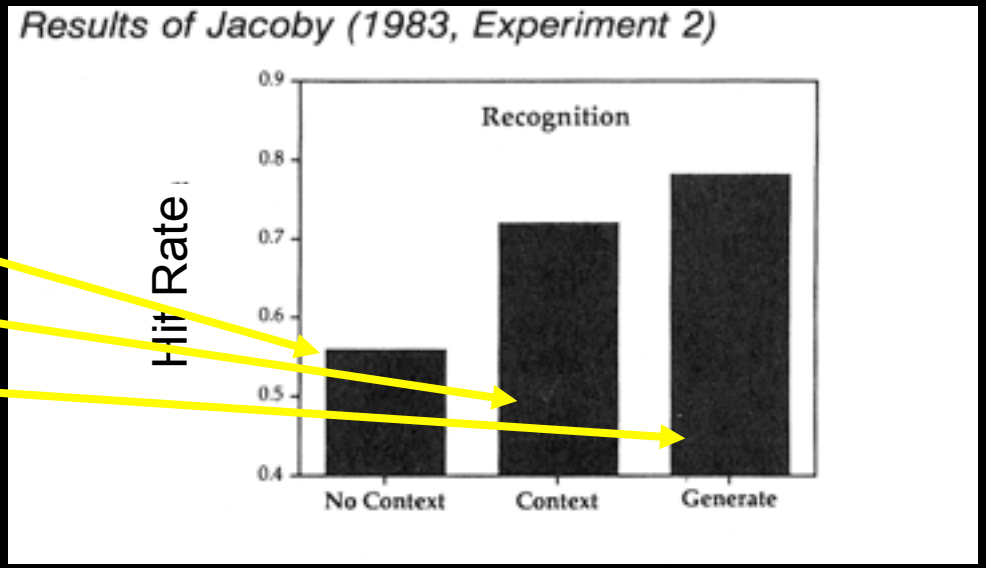
XXXX - COLD

HOT - COLD

HOT - _____

RECOGNITION:

COLD ("old"/"new"?)



Perceptual Overlap and Generation: Explicit and Implicit Dissociations

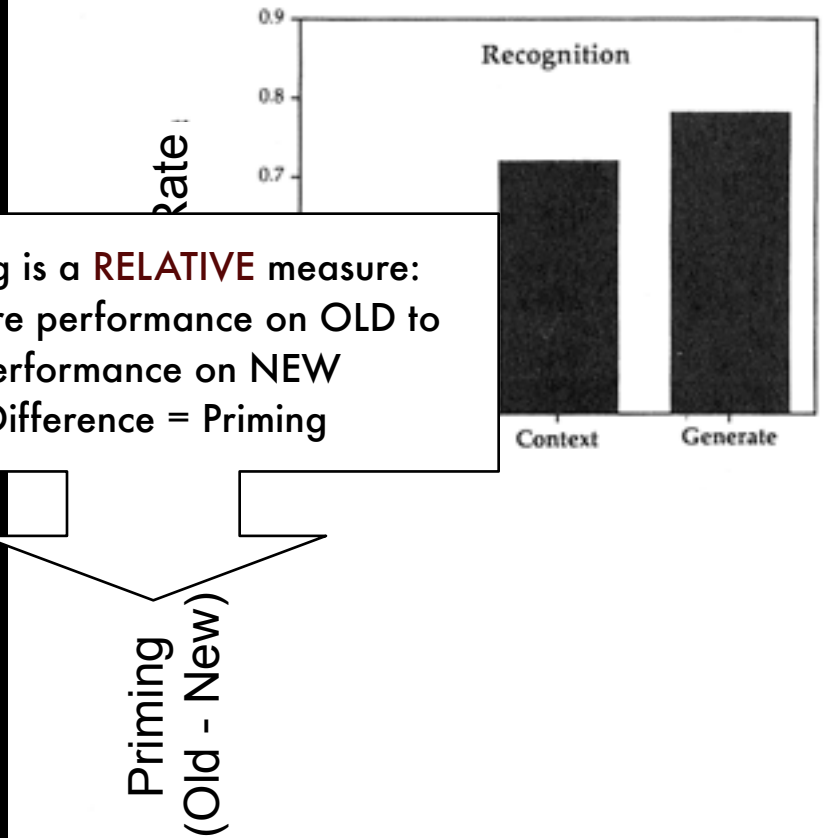
STUDY:
XXXX - COLD
HOT - COLD
HOT - _____

RECOGNITION.
COLD ("old"/"new"?)

PERCEPTUAL IDENTIFICATION:
Flash COLD for 34 msec
Subject attempts to identify flashed word

Priming is a RELATIVE measure:
Compare performance on OLD to performance on NEW
Difference = Priming

Results of Jacoby (1983, Experiment 2)



Note. The study manipulation produced opposite results on recognition memory (an explicit test) and on primed perceptual identification (an implicit test). From "Remembering the Data: Analyzing Interactive Processes in Reading" by L. L. Jacoby, 1983, *Journal of Verbal Learning and Verbal Behavior*, 22, p. 493. Copyright 1983 by Academic Press. Adapted by permission.

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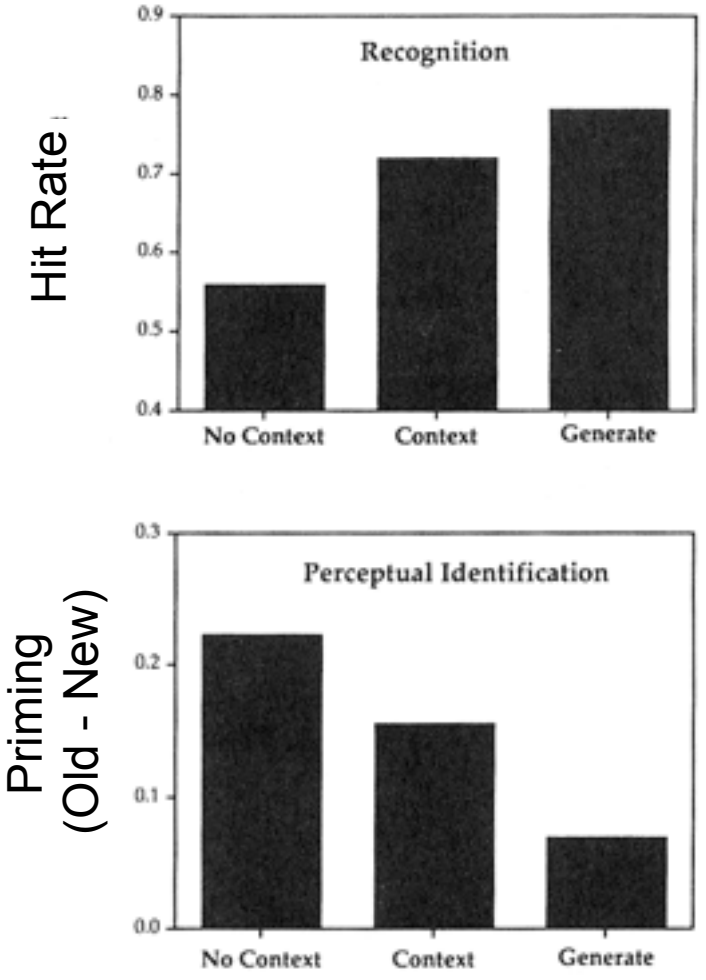

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Participation Prompt #3

- There are many ways in which learning from past experience impacts behavior in the present. Sometimes priming impacts behavior without our awareness—that is, we are unaware that memory is shaping our current thoughts and actions.

- Describe one instance in which priming might have impacted your thoughts or actions.