SKILL MEMORY

PSYC 461 - LEARNING & MEMORY

ARLO CLARK-FOOS, PH.D.

I GOT SKILLZ

- Skill…*Ability that can improve over time through practice*
  - *Perceptual-Motor*
    - *Nunchuck skills, bow hunting skills, athletes, musicians, driving, drinking, etc.*
  - *Cognitive*
    - *Computer hacking skills, managing time, reasoning, reading*
  - *Many skills combine both types.*

Let's see an example from John Ridley Stroop (1935)

CONGRUENT COLOR
AND NAME

RED

BLUE

GREEN

RED

YELLOW

BLUE

BLUE

GREEN

YELLOW

RED

Stroop (1935)

INCONGRUENT COLOR
AND NAME

RED

BLUE

GREEN

RED

YELLOW

BLUE

BLUE

GREEN

YELLOW

RED

Stroop (1935)

KNOWING HOW VS. KNOWING WHAT

Table 8.1 Comparison of memories for skills, events, and facts

Skill memories	Memories for events and facts
1. Are difficult to convey except by direct demonstration	1. Can be communicated flexibly, in different formats
2. May be acquired without awareness	2. Have content that is consciously accessible
3. Require several repetitions	3. Can be acquired in a single exposure

TABLE 8.1
Mark A. Gluck/Eduardo Mercado/Catherine E. Myers, *Learning and Memory From Brain to Behavior*, 3e, © 2016 Worth Publishers

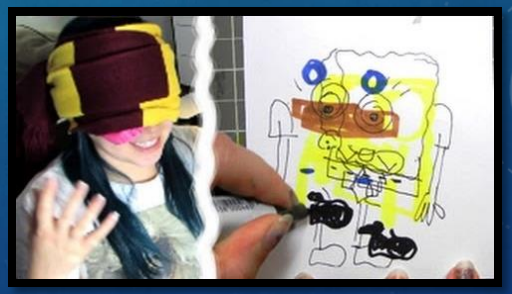
- Practice, Instruction, Observation
- *Key is that the behavior/ability can improve with practice*
- *Open vs. Closed Skills*
  - *Likely on a continuum*

PERCEPTUAL-MOTOR VS. COGNITIVE

- Which comes first?
  - Babies develop perceptual-motor first
  - Difficult to perform cognitive skills (reading and writing) without some perceptual motor skills (e.g. producing speech, drawing lines).
  - Many species can perform perceptual-motor (evolution)
- Your mom was wrong, you aren't special
  - Animals can have cognitive skills too (remembering, tool/strategy use)
  - https://www.youtube.com/watch?v=-zdzROgOELM

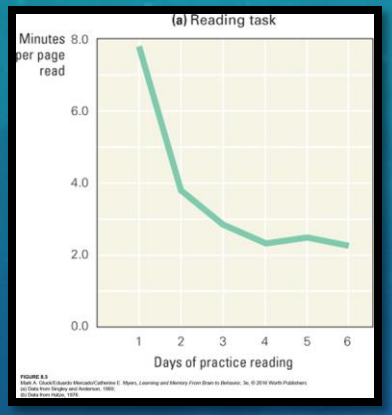
PAINTING FENCES

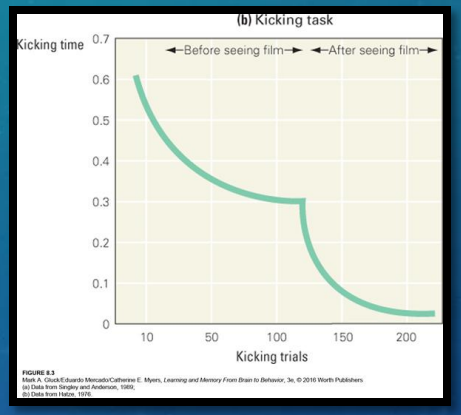
- What makes an expert?
  - 10,000 hours?
- Thorndyke (1927)'s blindfolded line drawing
  - Repetition isn't always enough…Need feedback
  - *Knowledge of Results*



PRACTICE MAKES PERFECT

- Power Law of Practice
  - Learning is negatively accelerated

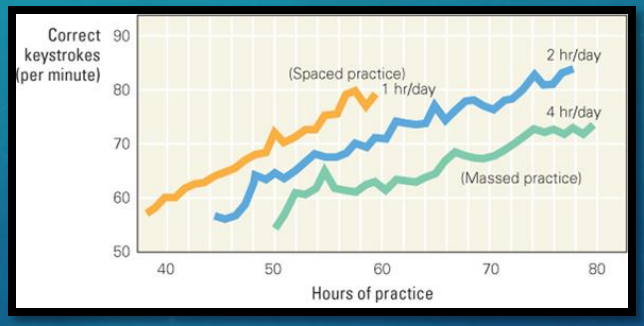




  - Feedback type and frequency affect learning
    - Perceptual-Motor
      - Frequent helps in short-term, infrequent helps in long-term

NOT ALL PRACTICE IS EQUAL

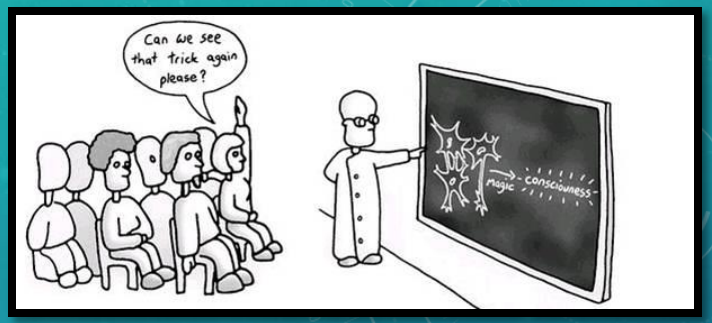
- Spaced vs. Massed Practice
  - Short-term vs. Long-term gains
  - Post-office employees and a keyboard

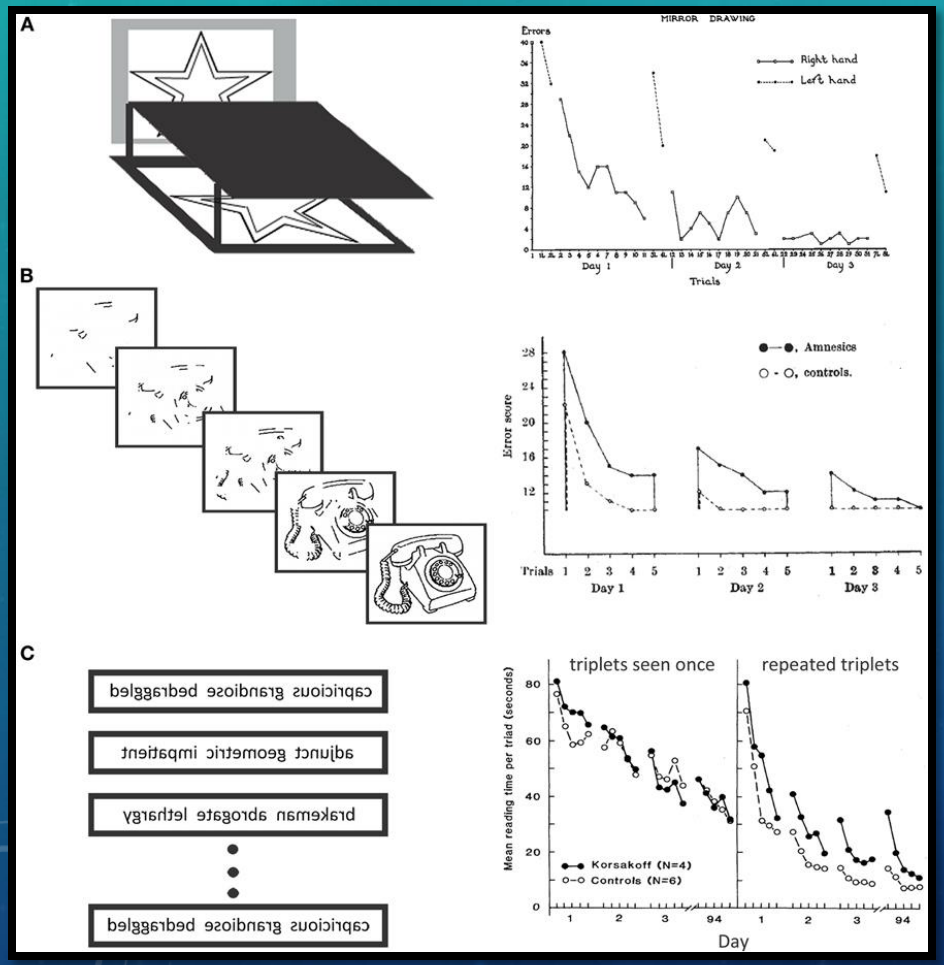


- Constant vs. Variable Practice
  - Gradual increases help even though simple skills may take little effort

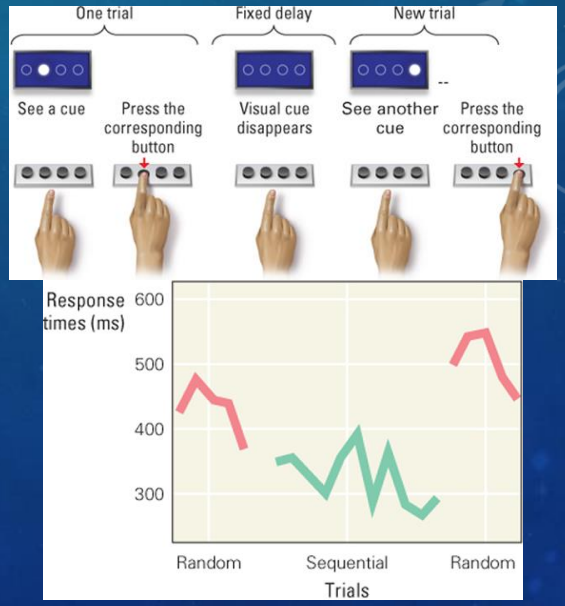
Major Scales									
C Major	C	D	E	F	G	A	B	C	
C# / Db Major	C#	D#	E#	F#	G#	A#	B#	C#	or
	Db	Eb	F	Gb	Ab	Bb	C	Db	
D Major	D	E	F#	G	A	B	C#	D	
Eb Major	Eb	F	G	Ab	Bb	C	D	Eb	
E Major	E	F#	G#	A	B	C#	D#	E	
F Major	F	G	A	Bb	C	D	E	F	
F# / Gb Major	F#	G#	A#	B	C#	D#	E#	F#	or
	Gb	Ab	Bb	Cb	Db	Eb	F	Gb	
G Major	G	A	B	C	D	E	F#	G	
Ab Major	Ab	Bb	C	Db	Eb	F	G	Ab	
A Major	A	B	C#	D	E	F#	G#	A	
Bb Major	Bb	C	D	Eb	F	G	A	Bb	
B / Cb Major	B	C#	D#	E	F#	G#	A#	B	or
	Cb	Db	Eb	Fb	Gb	Ab	Bb	Cb	

IS IT CONSCIOUS?

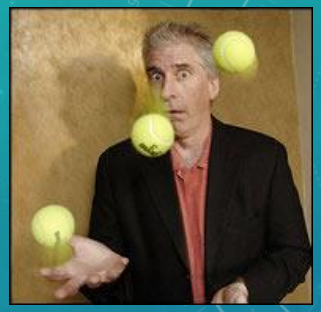




- Explicit vs. Implicit Learning
  - Amnesiacs
    - Mirror Tracing, Gollins Partial Picture, Backwards reading
  - Serial Reaction Time Task



EXPERTISE



http://chrisbliss.com/amazing-juggling-finale-page/

- Reflexes vs. Motor Programs (Habits)
  - Interruptions in routine
  - Perceptual-motor AND Cognitive
    - Quick, what is the product of 5 times 7?

Table 8.2 Fitts's three-stage model of skill learning

Stage	Characteristics	Example
1. Cognitive stage	Performance is based on rules that can be verbalized.	Using written instructions to set up a tent
2. Associative stage	Actions become stereotyped.	Setting up a tent in a fixed sequence, without instructions
3. Autonomous stage	Movements seem automatic.	Setting up a tent while carrying on a discussion about politics

- Paul Fitts (1964) and Skill Acquisition
  1. Cognitive Stage
     - Effort to encode, Repeating steps verbally, Relying on memory
  2. Associative Stage
     - Rely less on memories and verbalization of steps.
  3. Autonomous Stage
     - Skill occurs effortlessly and quickly, *"Don't choke!"*

- Talent/Gift vs. Practice
  - Mozart (prodigy) vs. Jon Smith (ordinary)
  - Genes or Experience
  - Rotor-pursuit in identical and fraternal twins (Fox et al., 1996): Twinsburg

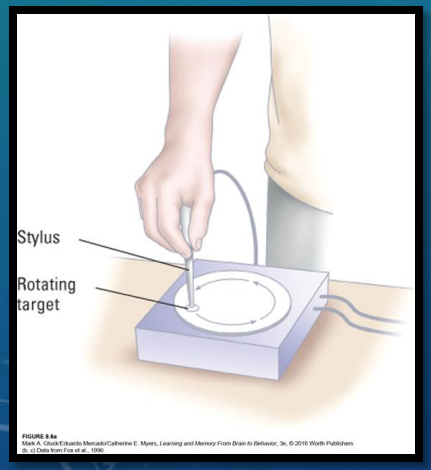


FIGURE 8.6a
Mark A. Gluck/Eduardo Mercado/Catherine E. Myers, *Learning and Memory From Brain to Behavior*, 3e, © 2016 Worth Publishers
(b, c) Data from Fox et al., 1996.

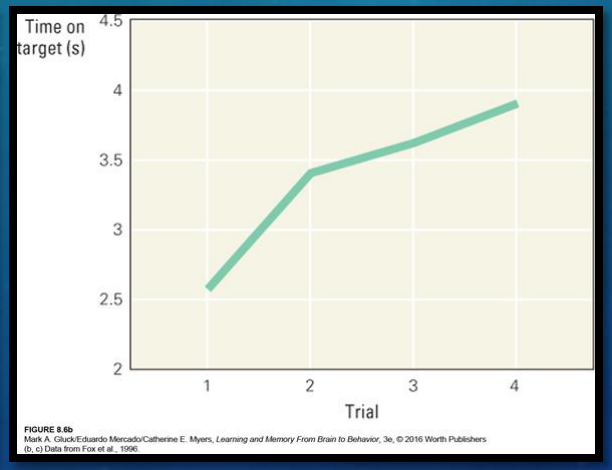


FIGURE 8.6b
Mark A. Gluck/Eduardo Mercado/Catherine E. Myers, *Learning and Memory From Brain to Behavior*, 3e, © 2016 Worth Publishers
(b, c) Data from Fox et al., 1996.

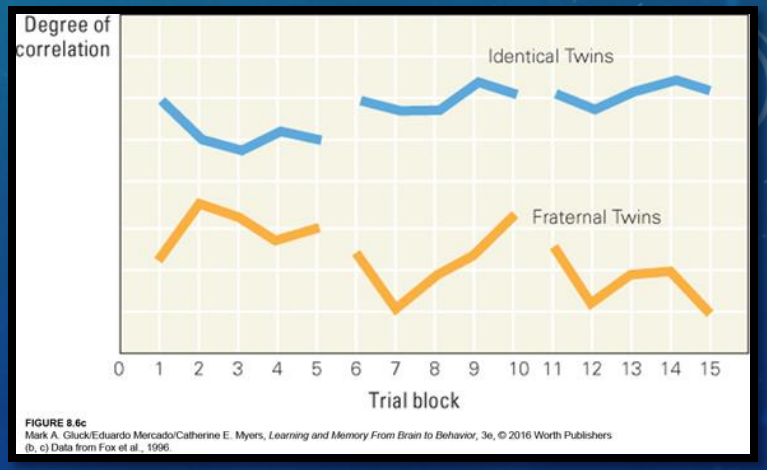


FIGURE 8.6c
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(b, c) Data from Fox et al., 1996.

SKILL TRANSFER

- Mexican vs. Sushi

- Transfer Specificity
  - Writing with your feet
  - Athletic Practice

  - Identical Elements Theory (Thorndike & Woodworth, 1901)
    - Remember Transfer Appropriate Processing?

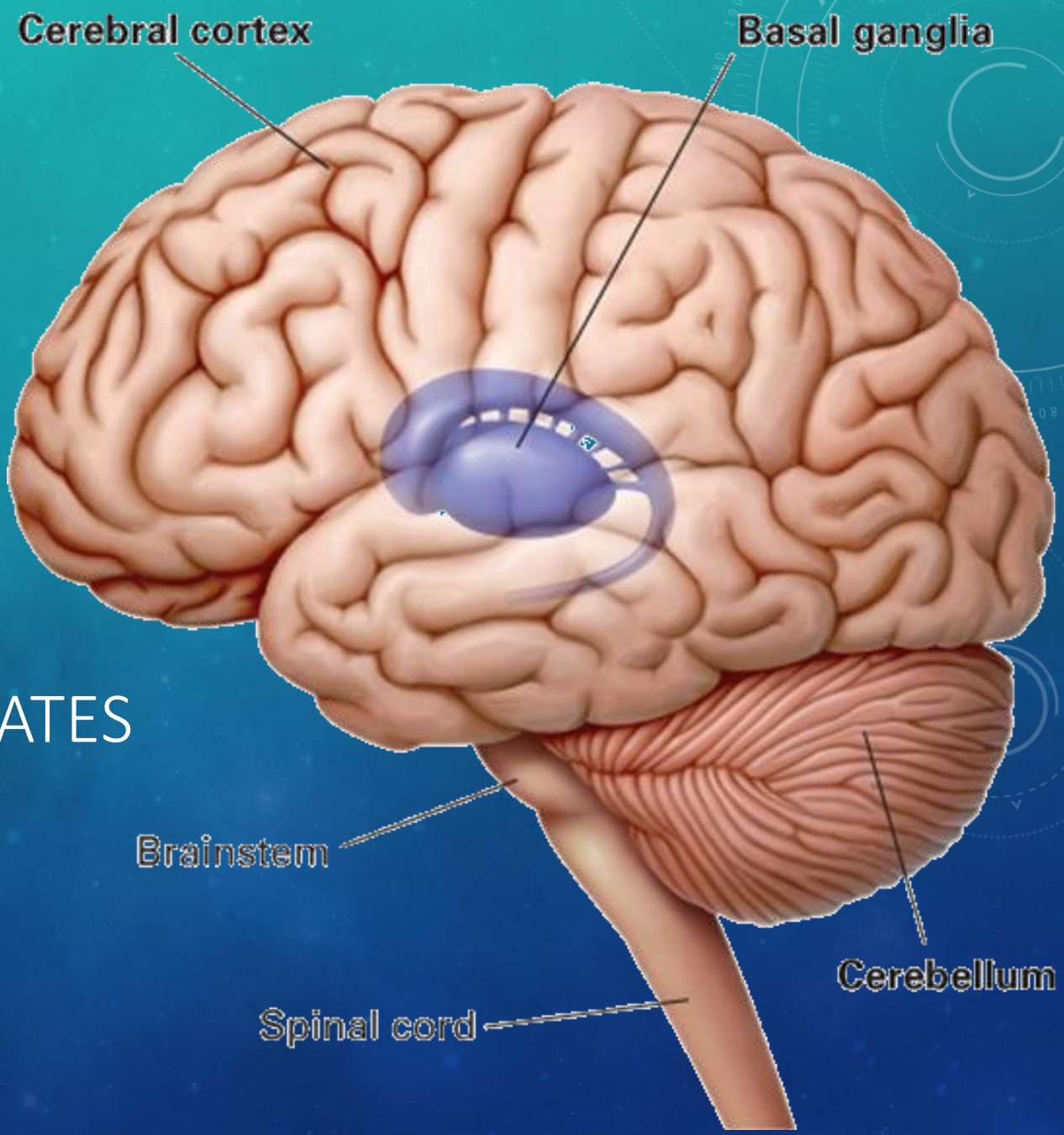
    - Does Guitar Hero contribute to **learning set formation**?

Janet Kimber/Getty Images

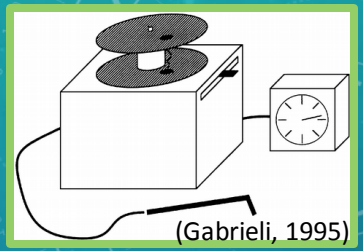
SKILL DECAY

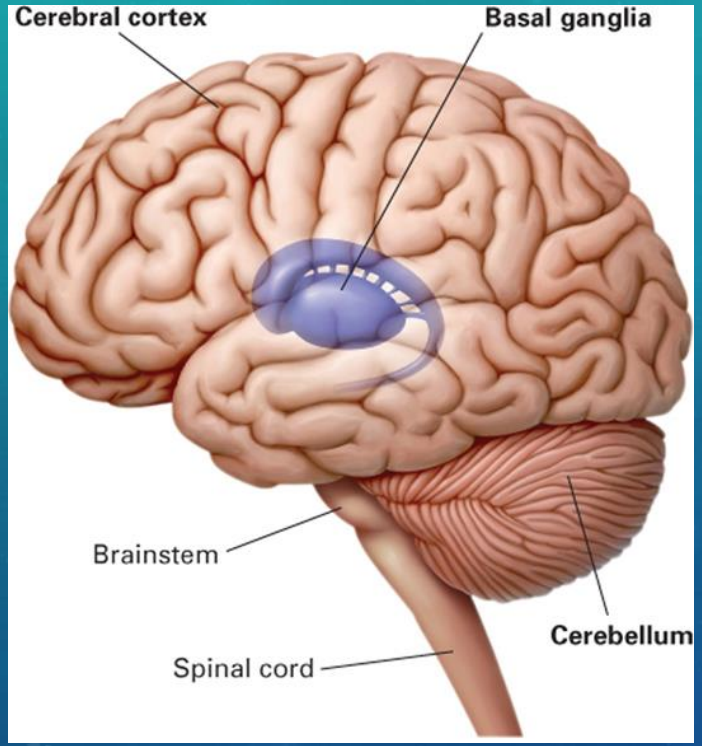
- *"like riding a bike"*
- Non-use (e.g., injury)
- Unlearning follows same pattern as learning
  - Negative acceleration
  - Retroactive Interference
  - Sleep increases consolidation of skill memory for pressing keys in sequence
    - Walker et al. (2003)

BRAIN SUBSTRATES



BASAL GANGLIA (DORSAL STRIATUM) AND SKILL LEARNING



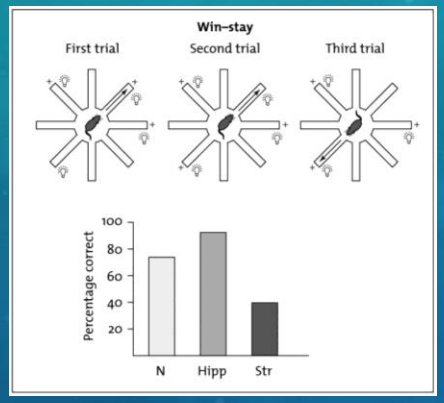


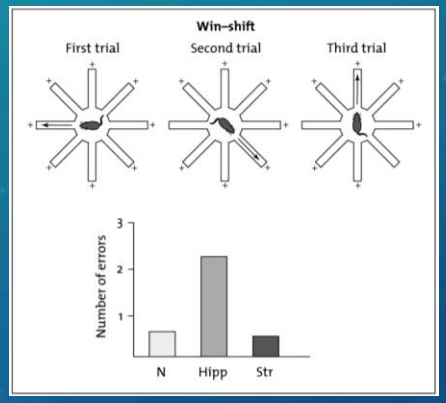
- Inputs from **cerebral cortex** (**sensory cortices**)
- Outputs to **thalamus**, **brain stem**, and **spinal cord**
  - *Coordinating sensory and motor*
    - *(e.g., rotor pursuit task)*

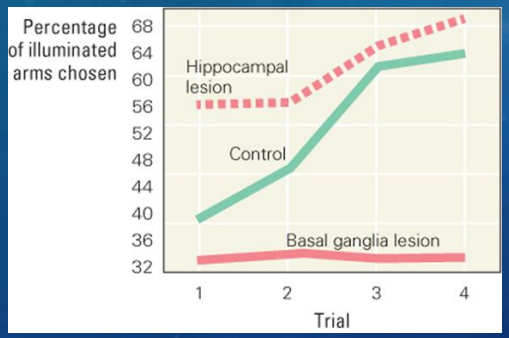
- **Parkinson's Disease**
  - Muhammad Ali
    - Facts/Events vs. Skills

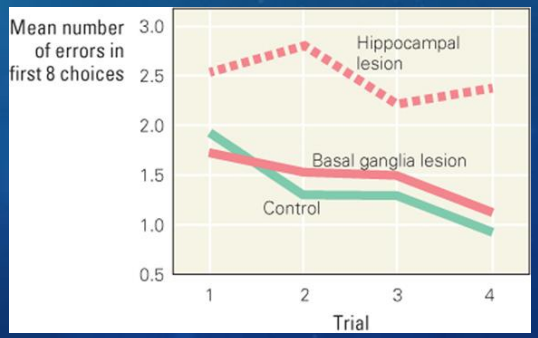
WHAT BASAL GANGLIA?: LESION STUDIES

- Packard, Hirsh, & White (1989)







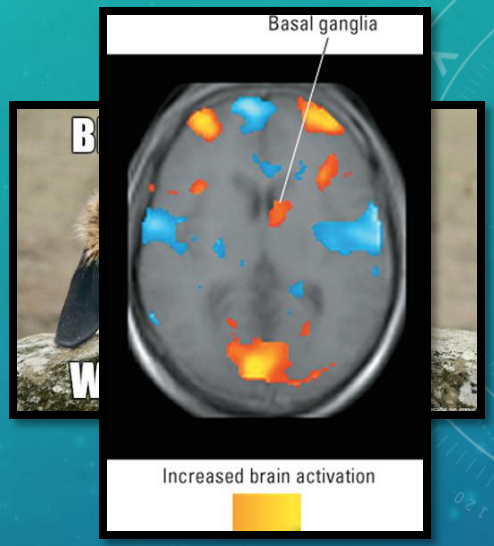


LEAVE IT IN AND WATCH IT WORK

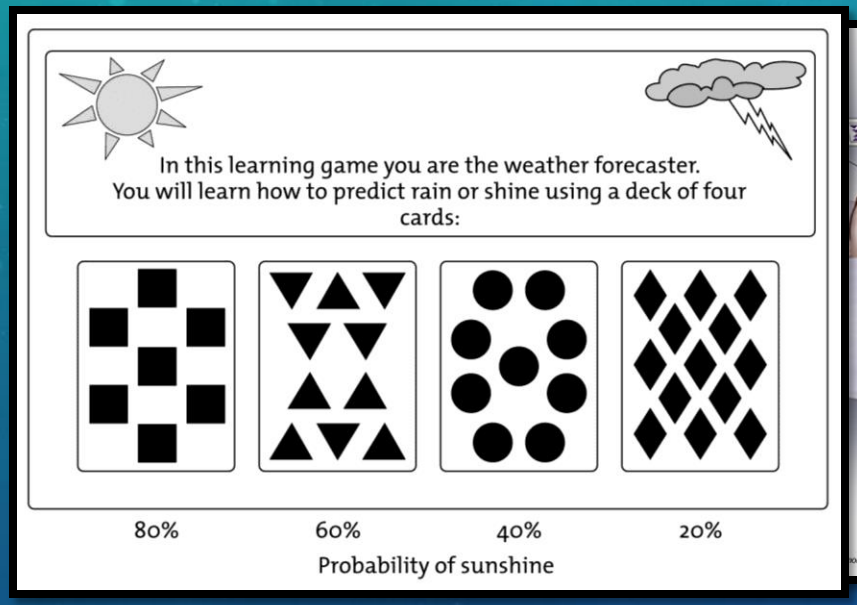
- T-Maze with Tones (Jog et al., 1999)
- Four Patterns of Activation in During Learning
  1. Firing at the start of the trial
  2. Firing at the end of the trial
  3. Firing when the tone plays
  4. Firing when they turn
     - With practice, more neurons in the basal ganglia responded <u>only during 1 and 2</u>.

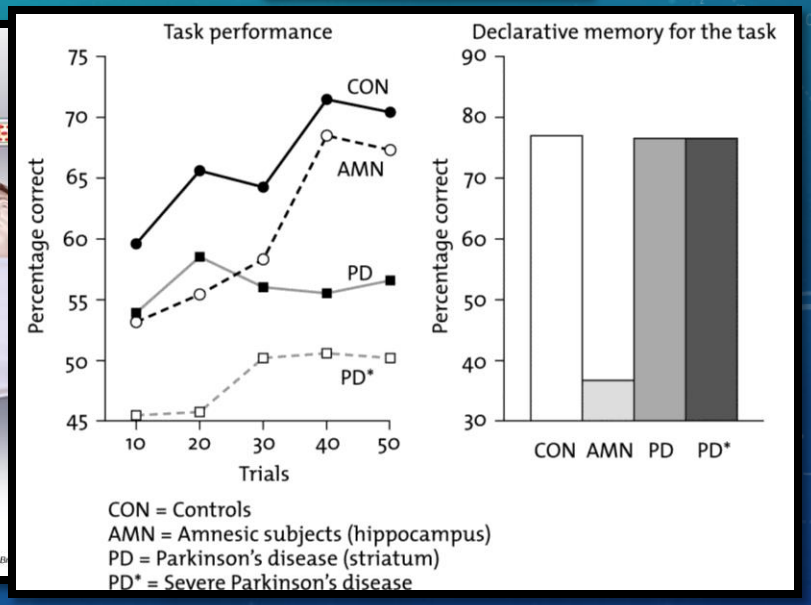
- Automatic completion of motor programs
  - Fitt's model of skill acquisition.

PREDICTING THE WEATHER: COGNITIVE SKILL LEARNING



- e.g., Knowlton, Squire, & Gluck (1994)



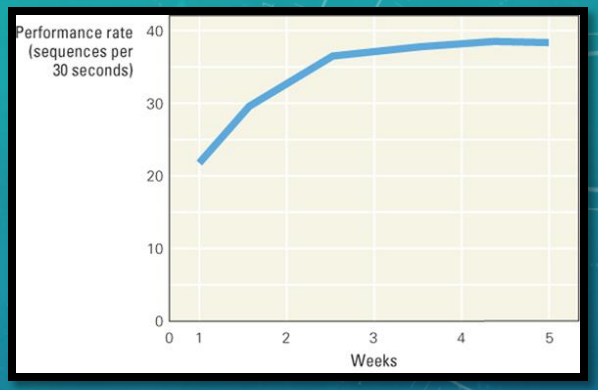


- Exact role of basal ganglia in learning/storing skill memory still unclear so far

CORTICAL REPRESENTATION OF SKILLS

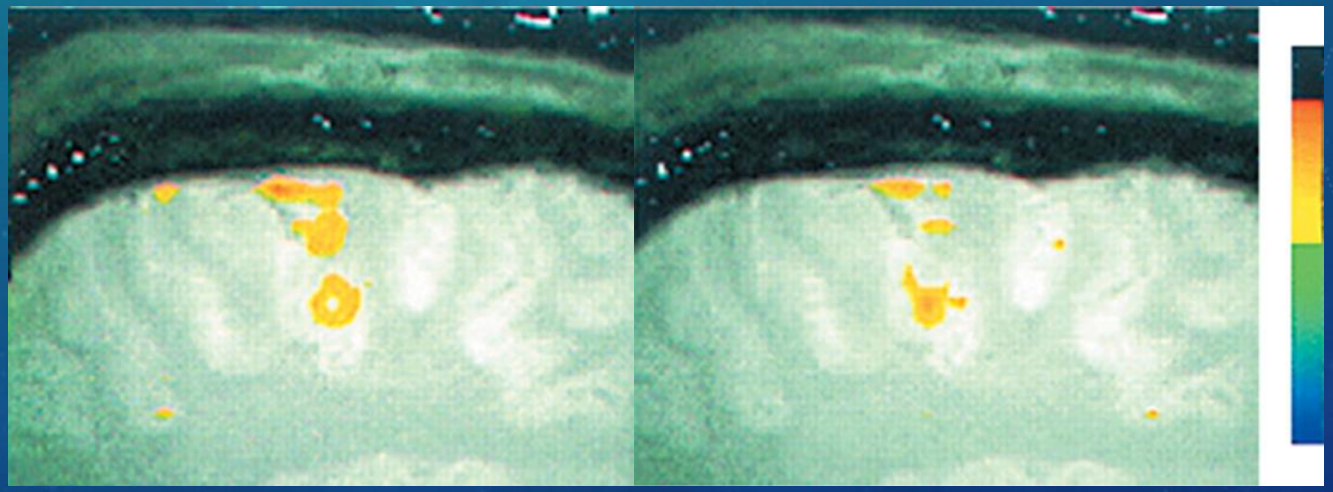
- BOLD signals in fMRI
- Structural changes in fingering hand (not bow hand)
  - Increase in gray matter
  - *Musician's dystonia*
    - Too much practice?
- Tactile Discrimination Task
  - Monkeys, Handgrips, and Delayed Match to Sample with Tactile Stimulation
    - Sensory and Motor Changes

ARE SKILLS STORED IN CORTEX?



- Correlation is NOT Causation

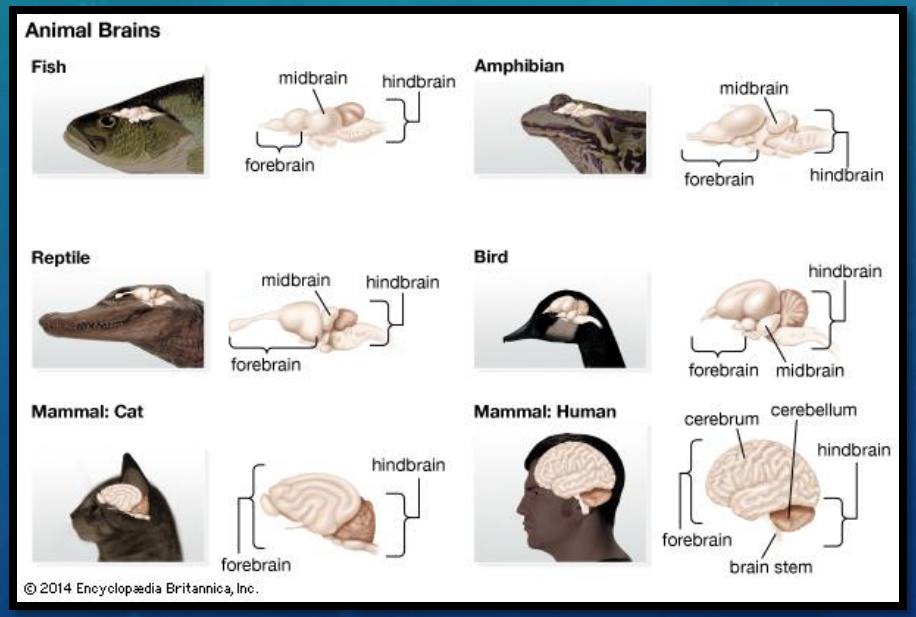
- Measure activity during training on a finger movement task (Karni et al., 1998)
  - Structural changes occur later during learning

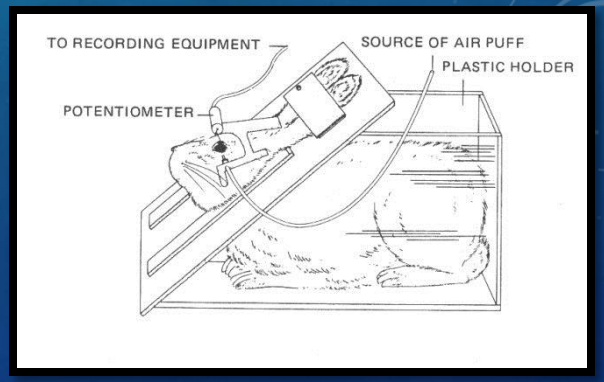


Trained Untrained

REMEMBER THE CEREBELLUM (AND THE ALAMO)

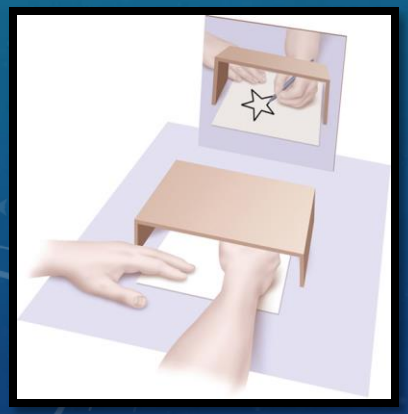
- Some animals have very little cerebral cortex: Birds, Fish
  - Cerebellum
  - Lesions impair motor performance (music, writing, eyeblink)

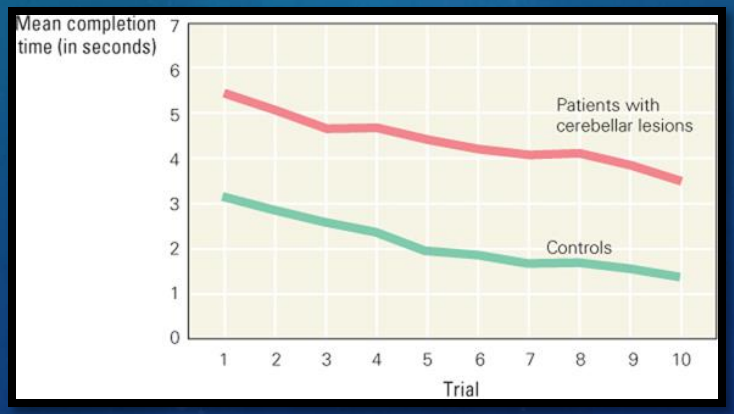


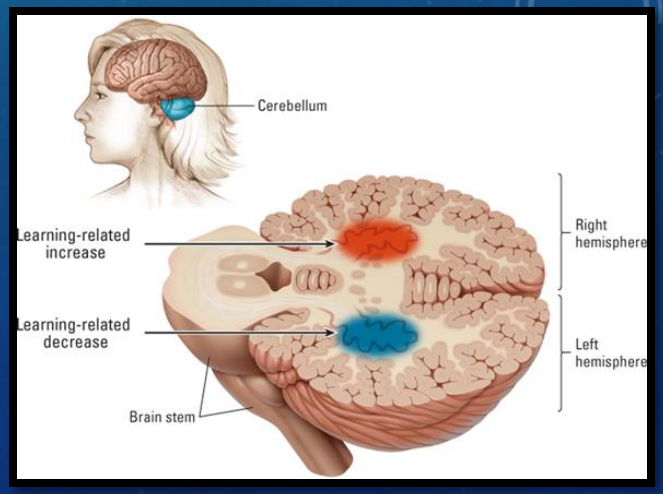


TIMING

- Performing and forming memories of skills
  - Increased activity in humans learning finger movements (Friston et al., 1992)
  - Increased number of synapses in Rat Acrobats (Kleim et al., 1997)
    - Unrelated to pure activity (no change from running a wheel)
  - Same effects for observational learning (Leggio et al., 2000; Torriero et al., 2011)
  - Mirror Tracing/Reading and Cerebellar Damage
    - Activity from cognitive or motor skill learning?

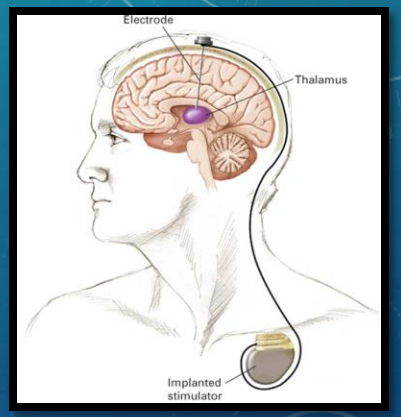


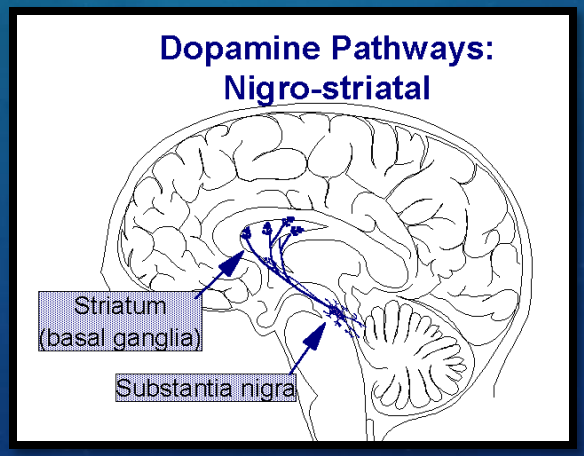


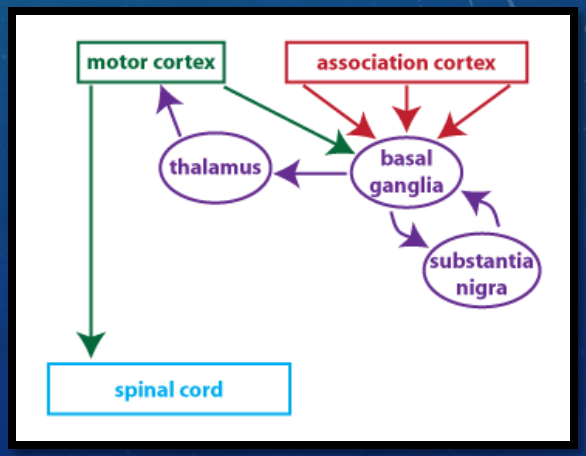


PARKINSON'S DISEASE: A DISTURBANCE IN BASAL GANGLIA & THE SUBSTANTIA NIGRA

- Loss of DA neurons in SNc, therefore less DA for basal ganglia
  - Muscle rigidity/tremors
  - Deep Brain Stimulation (DBS) can temporarily reduce symptoms
    - Possibly stuck in repeating patterns
    - L-Dopa and *Awakenings* (1990), with Robin Williams (Oliver Sacks) and
    - Dustin Hoffman (Leonard Lowe)

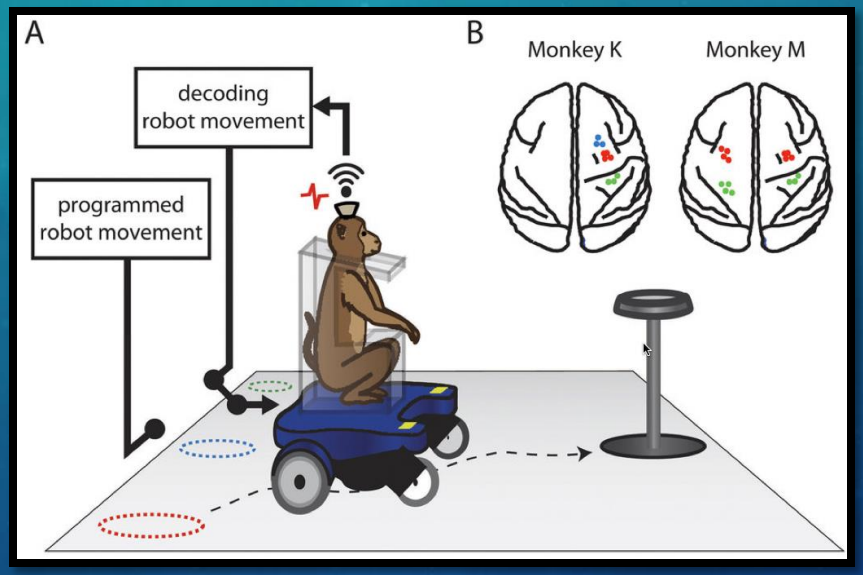






HUMAN-MACHINE INTERFACE (AGAIN)

- Motor prostheses



https://www.youtube.com/watch?v=vktmg2ANtl8