Example of Learning over 18 years
No prior talent needed

Passionate Pumpkin carving 12 year old girls grow up to have good brains, high IQs, and graduate from UCSF School of Medicine on May 19, 2015!

How We Learn: Memory & the Brain

or Where did I put those keys?

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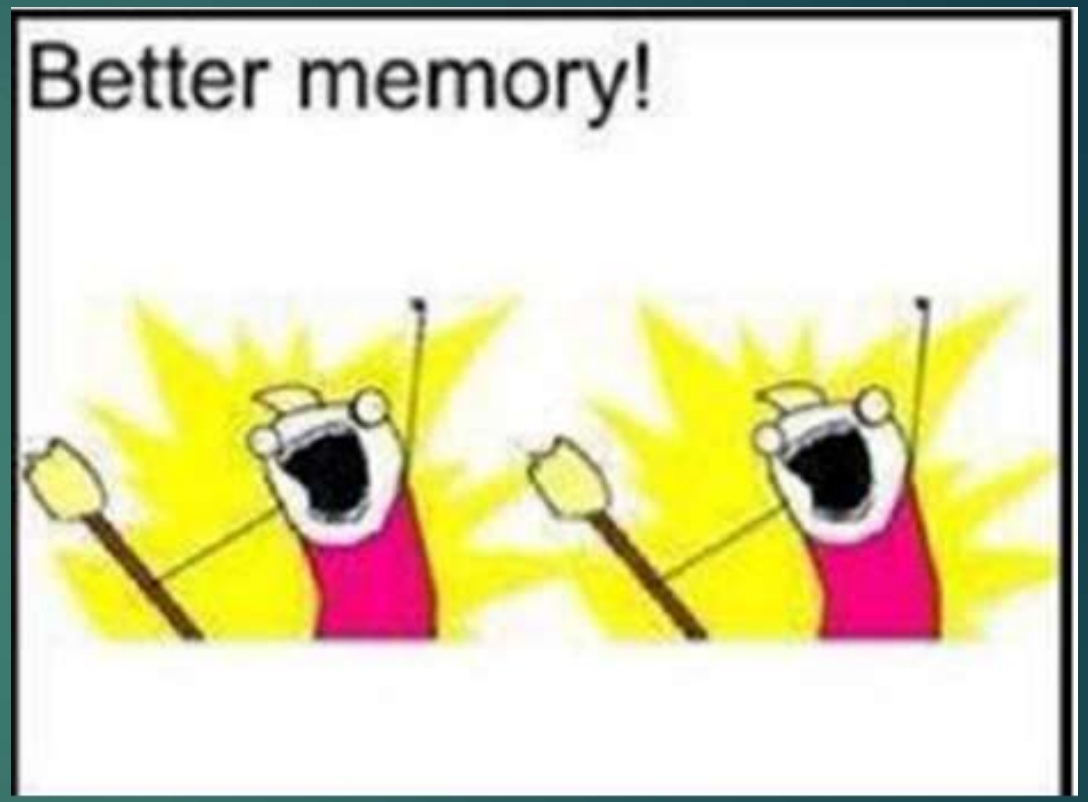
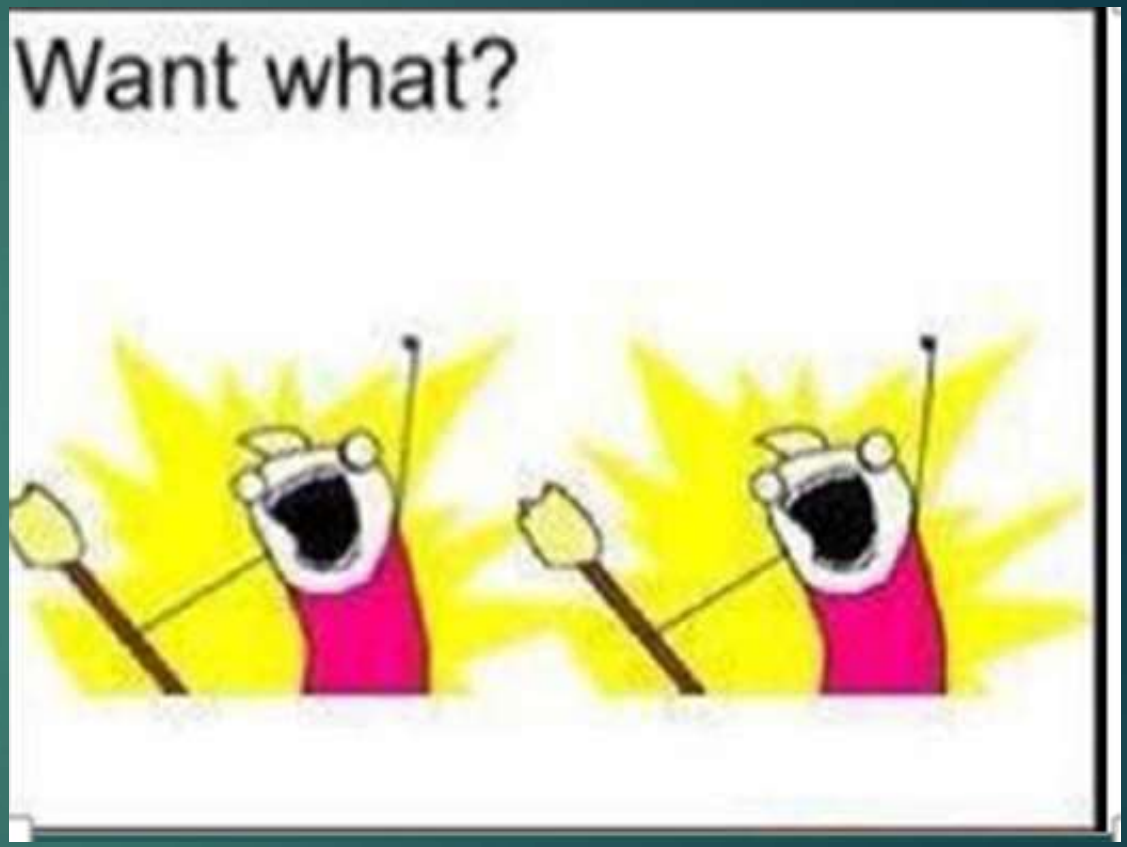
What do we want?


Better memory!


When do we want it?


Want what?

My intention:

- Review what we know about human memory and its brain underpinnings
- Based on current brain research, review what we know works best in attempting to learn new material.
- Give you 20 tips on how to remember new information

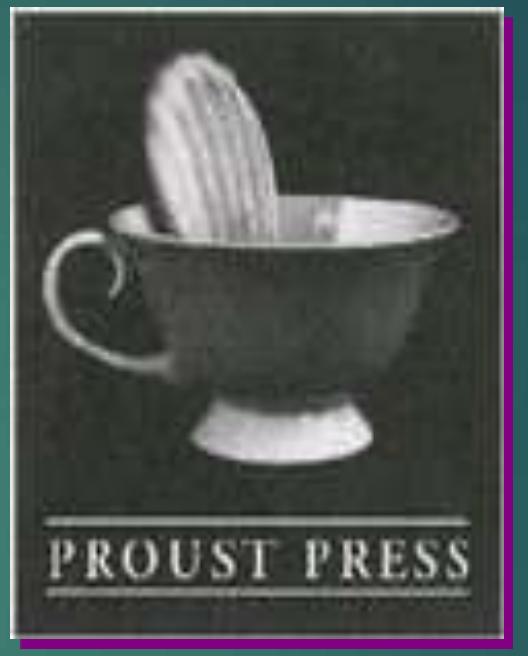
Proust & his Madeleine: Olfaction and Memory

"I raised to my lips a spoonful of the tea in which I had soaked a morsel of the cake. No sooner had the warm liquid mixed with the crumbs touch my palate than a shudder ran trough me and I sopped, intent upon the extraordinary thing that was happening to me. An exquisite pleasure invaded my senses..... And suddenly the memory revealed itself. “

Marcel Proust

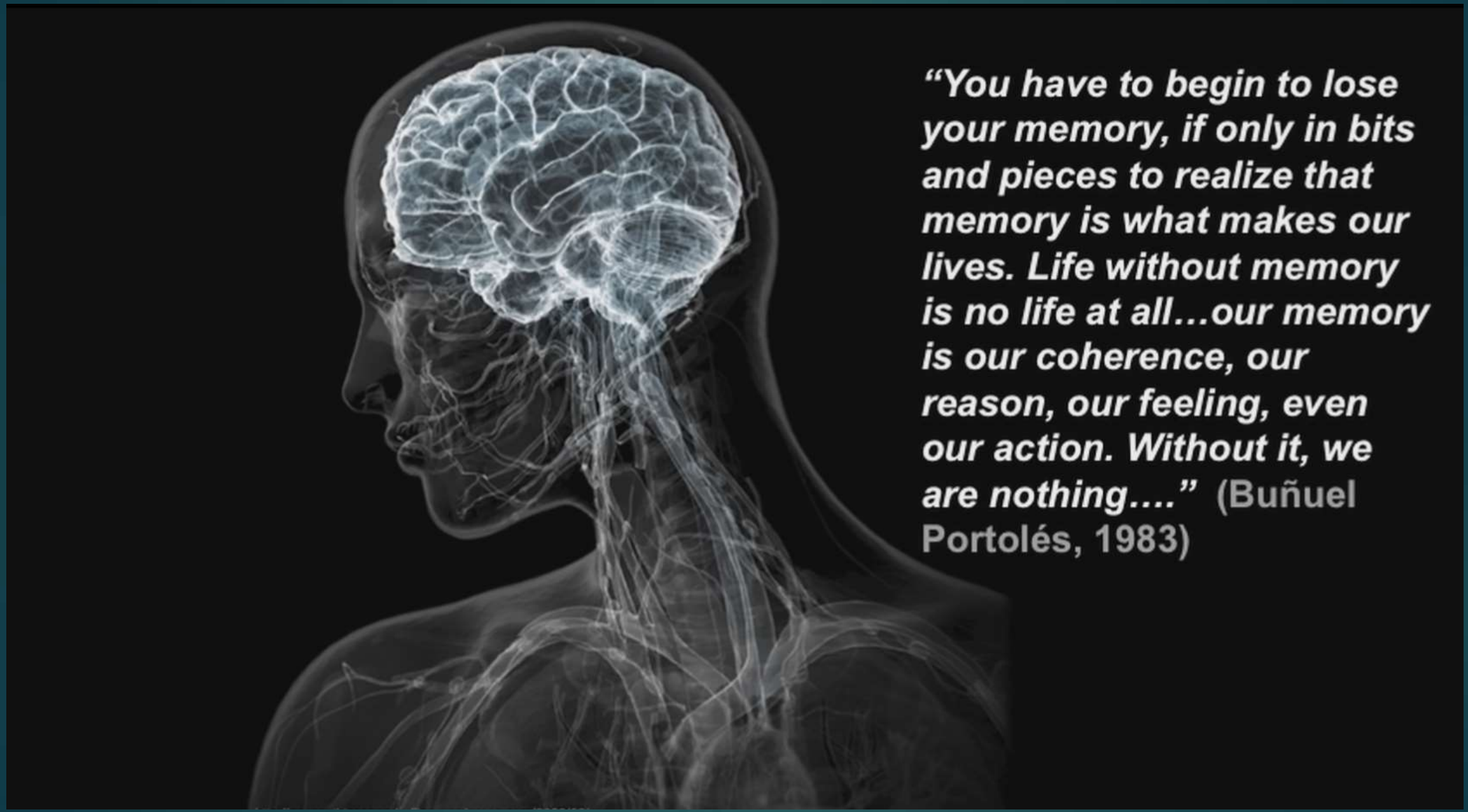
À la recherche du temps perdu (known in English as: *In Search of Lost Time* or *Remembrance of Things Past*):

7 Volumes, 4000 pp.



Proustian Effect: fragrances elicit more emotional and evocative memories than other memory cues

Study: Proustian Products are Preferred: The Relationship Between Odor-Evoked Memory and Product Evaluation: Lotions preferred if they evoke personal emotional memories


"You have to begin to lose your memory, if only in bits and pieces to realize that memory is what makes our lives. Life without memory is no life at all…our memory is our coherence, our reason, our feeling, even our action. Without it, we are nothing…." (Buñuel Portolés, 1983)

Forget me not

Life is beautiful and worth remembering: your first kiss, your first car, your first steak, your first drink, your first love — you get the idea.

Episodic memory is at core of our being; it is who we are

Conclusions in this talk are based on current scientific studies

- APA assessment of current findings:
- Strength of conclusions:
  - Strong: well-designed, randomized, controlled trials or well-designed quasi-experiments (lack random assignment) -- ****
  - Moderate: Correlational research with strong statistical controls for selection bias -- ***
  - Low: based on expert opinion derived from strong findings or theories in related areas and/or expert opinion buttressed by direct evidence that does not rise to the moderate or strong levels -- **

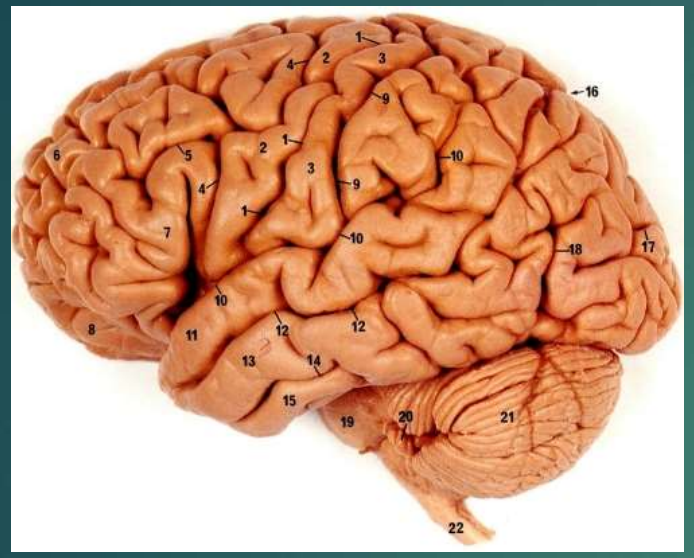
Memory: Some Definitions

- Memory is the location where information is kept, i.e. memory store
- Memory can refer to the thing that holds the contents of an experience, i.e. memory trace, engram
- Memory is process used to acquire (learning), store, or retrieve (remember) information
- Learning is the potential to alter behavior as consequence of experience
- For something to be remembered, it must first be learned

Memory Test

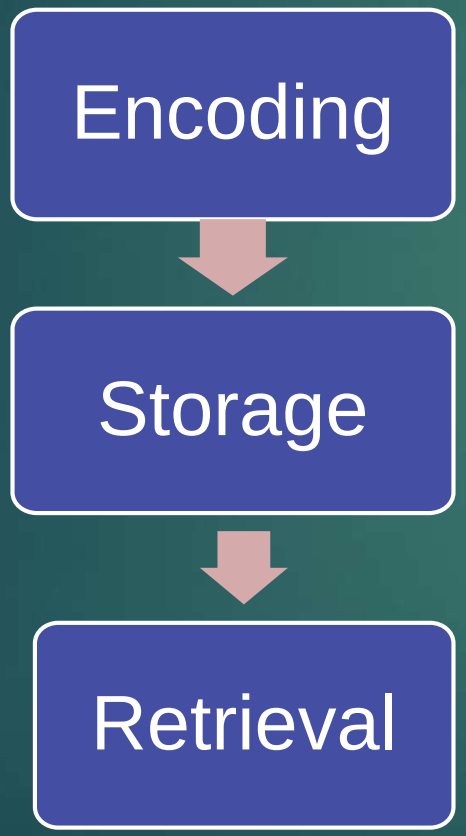
- Charlie lives in Glen Park
- Alfred Nobel (of prize fame) invented dynamite
- In 1868, Alfred Nobel allowed first dynamite factory in USA to be built in Glen Park canyon (near Charlie's house!)
- It blew up in 1869. Moved to 19th and Kirkham. It too blew up in 1870.

Where we store new experience and information



How Does Memory Work?
An Information-Processing Model

Here is a simplified description of how memory works:

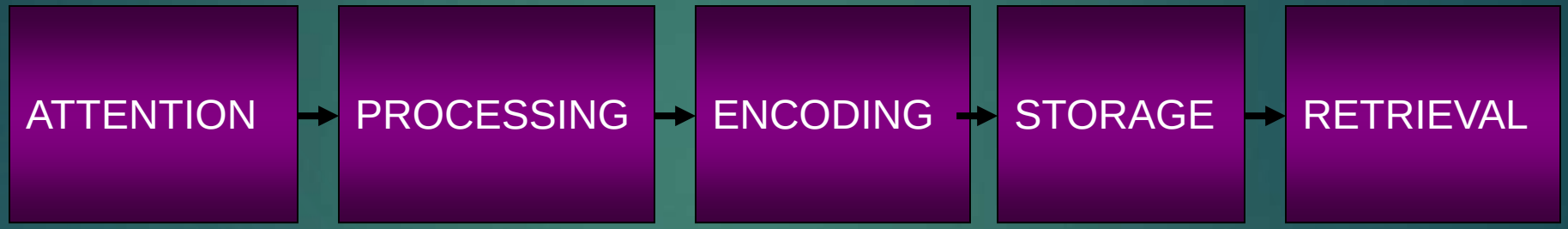


- **Encoding:** the information gets into our brains in a way that allows it to be stored; into short term working memory
- **Storage:** the information is held in long term memory in a way that allows it to later be retrieved
- **Retrieval:** reactivating and recalling the information, producing it in a form similar to what was encoded

Learning: Ability to learn new things

Learning is a restless, piecemeal, subconscious, sneaky process that occurs all the time, when we are awake and when we are asleep.

Older Explanation of Memory



William James: *"My experience is what I agree to attend to.“*

Tip #1: There is no memory without first paying attention.

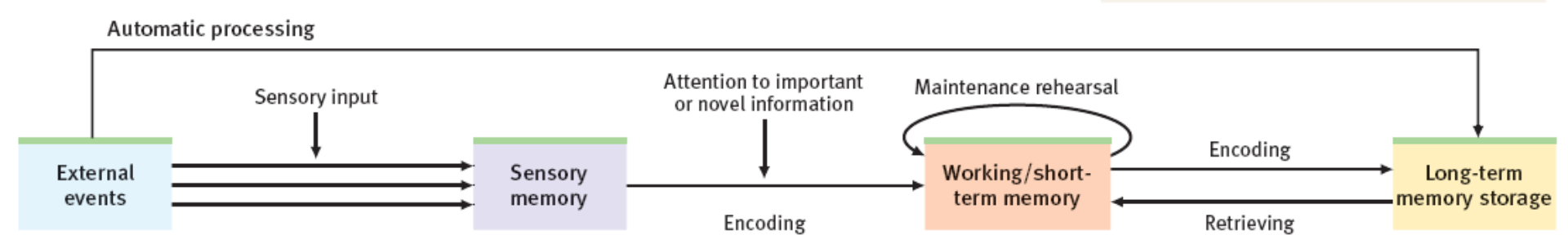
Models of Memory Formation

The Atkinson-Shiffrin Model (1968)

1. Stimuli are recorded by our senses and held briefly in **sensory memory**.
2. Some of this information is processed into **short-term memory** for immediate use and encoded through *rehearsal* .
3. Information then moves into **long-term memory** where it can be retrieved later.

Modifying the Model:

- More goes on in short-term memory besides rehearsal; this is now called **working memory**.
- Some information seems to go straight from sensory experience into long-term memory; this is **automatic processing**.



Dual-Track Processing: Explicit and Implicit Memories

So far, we have been talking about **explicit/ "declarative" memories.** *These are facts and experiences that we can consciously know and recall.*

Our minds acquire this information through **effortful processing**. Explicit memories are formed through studying, rehearsing, thinking, processing, and then storing information in long-term memory.

Some memories are formed without going through all the Atkinson-Shiffrin stages. These are **implicit memories**, the ones we are not fully aware of and thus don't "declare"/talk about.

These memories are typically formed through **automatic processing**. Implicit memories are formed *without our awareness that we are building a memory*, and without rehearsal or other processing in working memory.

5 Erroneous Beliefs about Memory

- 1. Memory works like a video camera, recording the world around us onto a mental tape that we can later replay.
  - Memory is actually always a reconstruction; not a perfect recording.

- 2. An unexpected occurrence is likely to be noticed—even when people's attention is elsewhere.
  - 77% miss a gorilla suit in a basketball game;

5 Memory errors

- *3. Hypnosis can improve memory—especially when assisting a witness in recalling details associated with a crime.*
  - People under hypnosis—and even those who are not—can often be led by questioners to "recall" things that never occurred.
  - Eye witness memory is so bad that NJ juries must be told so.

5 errors

- *4. Amnesia sufferers usually cannot remember their identity or name.*
  - This is a case of psychogenic amnesia; First case: Ansel Bourne, a Rhode Island preacher in 1887. Its most famous sufferer is the fictional Jason Bourne, the secret agent made flesh on film by Matt Damon.

- 5. *Once a memory is formed, it is set in stone.*
  - Memory is moldable (i.e. conversation) & distortable.

Memory Beliefs & Myths

- "After head injury, people can forget who they are and not recognize others, but be perfect in every other way“
- No neurological condition produces this except late state dementia.
- No one ever forgets their name and identity except for psychiatric issues

Memory Beliefs & Myths

- The Gilligan Island Memory cure: “Sometimes a second blow to the head can help a person remember things that were forgotten"
- In reality, this causes more traumatic brain injury.

Multiple Historical Metaphors for Memory based on then current technology

- In Plato's Theaetetus, metaphor of a stamp on wax
- 1904 the German scholar Richard Semon: the engram.
- Photograph
- Tape recorder
- Mirror
- Hard drive
- Neural network

False Assumption: perfect image or recording, lasts forever

Purpose of Memory

- We think of memory as a record of our past experience.
- But the idea is not just to store information, but to store relevant information.
- Memory is the use of our experience to guide future behavior.
- We process memory in order to solve problems and to do social interactions.
- Things we should learn from, things that are particularly important or that have strong emotions tied to them, may be things that are going to be important in the future.

Evolution of Memory

- Memory evolved, via natural selection, to enhance survival and reproductive fitness.
- Events that potentially effected our survival lead to superior long-term retention, i.e. visual and traumatic memory.
- Memory is constructive, especially sensitive to visual imagery and processing of meaning.
- Memory is inherently associative; we link new info to what we know.

J. Nairne & J. Pandeirada, Cur. Dir. In Psy. Sc., 2008

Cambrian: 500 MYA – The nose lead to memory

- Olfaction (smell), locomotion & spatial position initially drove the development of memory
- Hippocampus (brain's memory central) is highly connected to smell
- Hippocampus has place (spatial) cells
- It specializes in connecting new to old information

Evolution of Memory 2: We have a primate brain

- On African savannah, 2 M years ago*, Homo erectus*: Hunted, gathered, avoided predators; Memory = Survival
  - Used all Sensory systems: Touch, Vision, Smell, Hearing, Taste
  - Visualspatial location memory for food location and predator detection
  - Visual & emotional memory for any past trauma (predator avoidance)
  - Visual & olfactory memory of foods, esp. those that make you sick
  - Recall ability for only few dozen members of our group: facial recognition; memory for socially appropriate, moral, behavior; sexual interaction
  - Context was everything: more visual context, more cues, better memory

- Memory still works this way

Memory now: Tasks not evolved for, but now need to remember

- Dates
- Names
- Social Security number
- Telephone numbers
- Addresses
- Facts for an exam
- Pin codes
- Shopping lists
- Facebook friends
- Parking lot floor number

Tip # 2: Best way to remember things is to encode them into the format that your primate brain was good at processing (use visual & contextual images).

Remember these numbers:

Pretty Difficult.

Now image there is a lion behind each of those numbers

Visual images and locations are easier to remember


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

Which numbers were you supposed to remember?

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25

Visual memory is more powerful than verbal or numeric memory

Remember the following words

- chair
- tiger
- elephant
- couch
- bookcase
- lion
- table
- zebra

Tip #3: Using categories increases memory

- Remind yourself of the category:
- Furniture:
  - chair, couch, bookcase, table
- Animals:
  - tiger, elephant, lion, zebra

Memory: A Current Review

Memory: The most common neurological complaint

Memory: The foundation of cognition and self identity

Memory: Not a unitary process

Multiple memory systems with different brain sites

Diverse Nomenclature

Memory: A reconstruction, not a replay, reproduction or perfect image

Memory is not one thing or in one place in your brain; it is a Non-Unitary Process

There are patients who exhibit memory dissociations:

1 – No new factual learning, but normal behavioral learning

2 – Impaired short term Working Memory, but normal long term memory (LTM)

3 – Impaired LTM, but normal Working Memory

4 – No recognition memory of vegetables, but intact knowledge of how to cook them

5 – No knowledge of inanimate objects, but normal knowledge of animate objects

6 – New skill learning (i.e. riding a bicycle), but failure to remember where, when, and under what conditions skill was learned.

Memory in the Movies

Best Amnesia film;
Error: Planning

Error: Engram
Location

Rashomon:
One of the Great films of all time:
Whose memory is correct?

Amnesia in the Movies

- Rashomon ***
- Spellbound (Peck & Bergman)
- Anastasia
- Paycheck
- Memento **
- 50 First Dates
- Bourne Identity
- Long Kiss Goodnight
- Manchurian Candidate
- Eternal Sunshine of the Spotless Mind
- Finding Nemo
- The Majestic
- Mulholland Drive **
- Paris, Texas
- The Lookout (accurate) **
- Unknown White Male (Fugue)

Memory on TV & in the Movies

- Most amnestic (inability to remember) conditions in films bear little relation to reality.

- Although clinically rare, profound amnesia is a common cinematic device

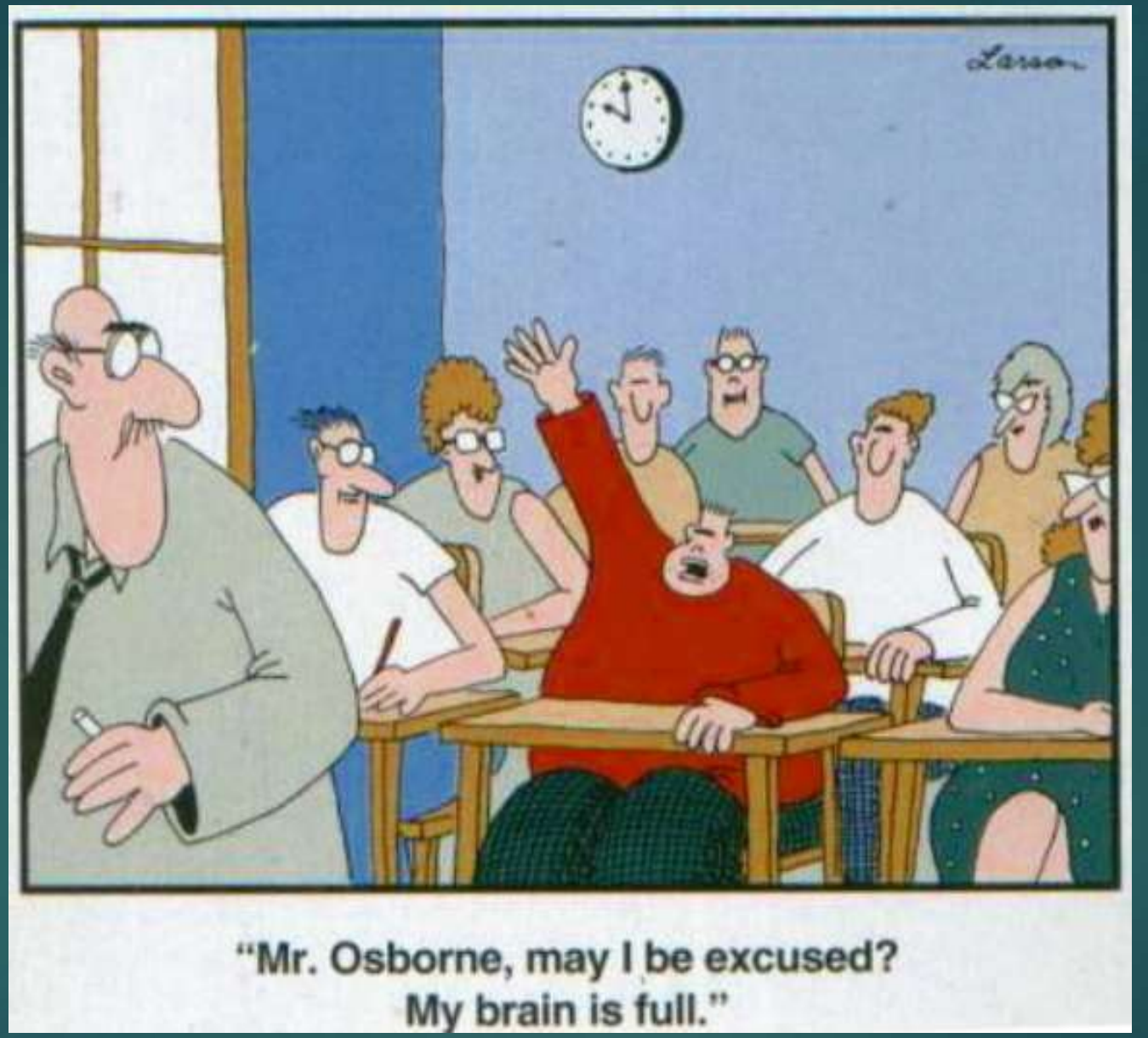
S. Baxendale, *BMJ*. 2004:
“Memories aren't made of this: amnesia at the movies”

Memory on TV & in the Movies 2

- In the movies, **TBIs result in:**
  - **a profound loss of memory for the past**
  - **with intact new learning**,
  - the **exact opposite of neurologically based amnesia** (= no new learning and a small loss of past memories).

- In the cinema, **two head injuries are better than one**. One of the commonest "cures" for an amnesic syndrome sustained as a result of a severe head injury is another head injury.

- In most films **memories are not lost, just made temporarily inaccessible**. Recovery of memory is possible, via various unlikely means.



How much memory space does the brain have?

Long Term Memory: Human Brain's Memory Capacity

Number of Neurons: 86 billion

Number of Glial Cells: 86 billion

Number of neuronal synapses: 10^{13} (10 trillion)

Number of neuronal impulses transmitted in a lifetime: 10^{23} (100 sextillion)

For comparison: Library of Congress has only 32 trillion bytes of info in 530 miles of selves

Our brain could hold 3 million TV shows

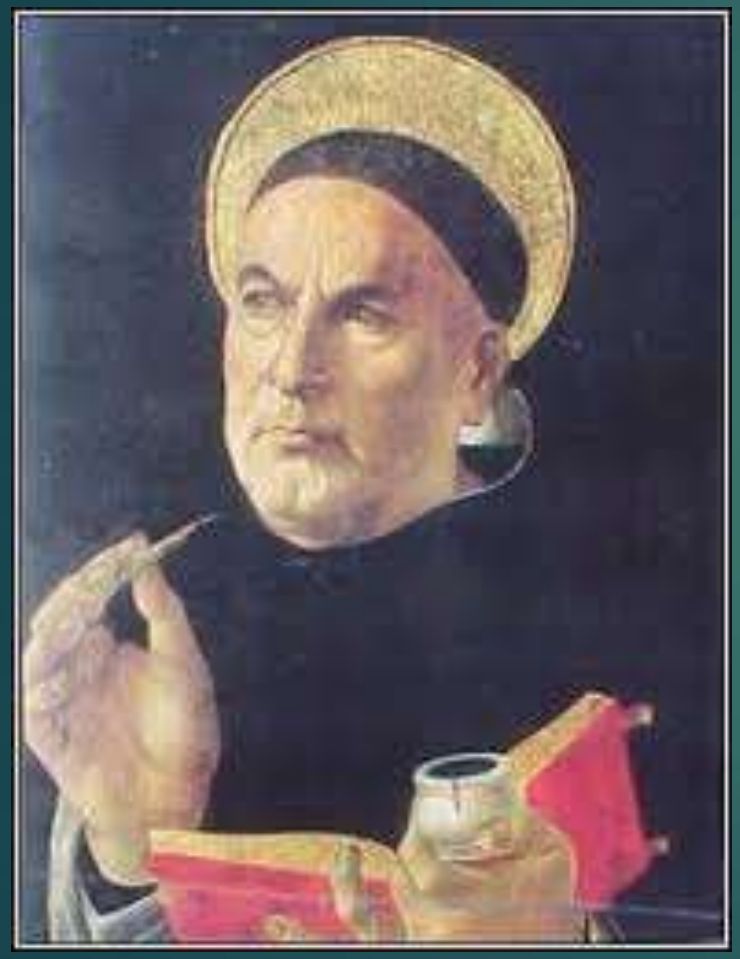
LTM: storage of vast amounts of information, coded by perception and meaning; no upper limit; we never run out of memory space

Simonides of Ceos: Inventor of the Memory Palace

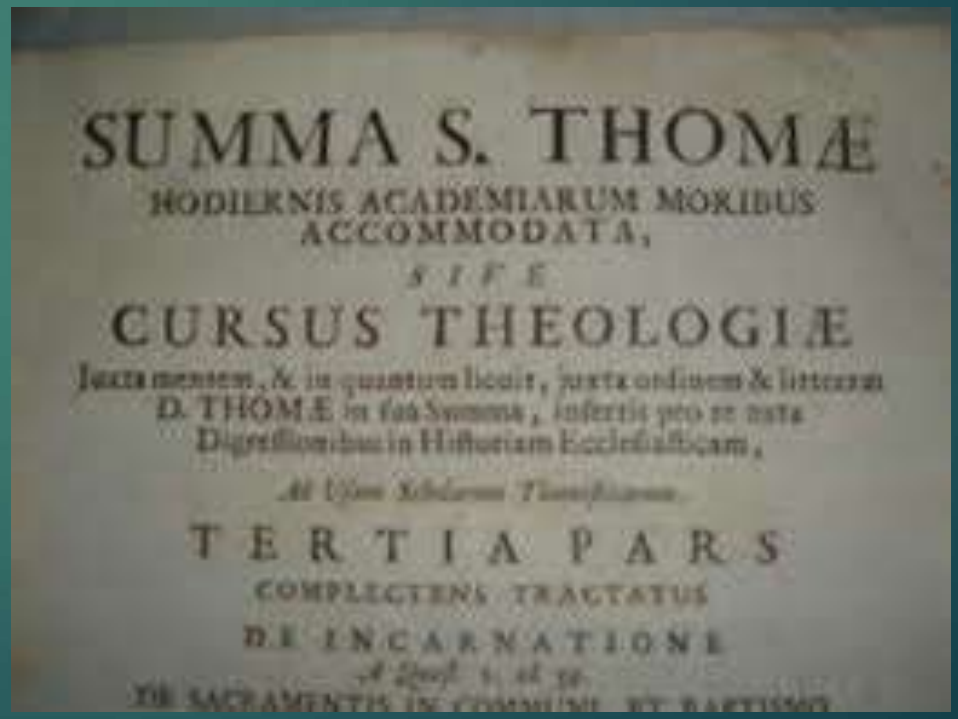
- Greek lyric poet (556-468 BC); Classic tale of his attending a banquet where he recited a poem and then was called out by 2 visitors; banquet hall roof collapsed killing everyone inside; all bodies crushed beyond recognition.
- Bereaved relatives could not identify any of the bodies until Simonides returned and correlated their identities to their positions (*loci* in Latin) at the main table before his departure.
- He later drew on this experience to develop the 'memory theater' or 'memory palace', a system for mnemonics.
- According to Cicero, Themistocles wasn't much impressed with the poet's invention: "I would rather a technique of forgetting, for I remember what I would rather not remember and cannot forget what I would rather forget."

Phenomenal Memory

Thomas Aquinas: (1265–1274)
Lived during age of mnemonics



Dictated the *Summa Theologica* (3100 pp) from memory


SUMMA S. THOMÆ

HODIERNIS ACADEMIARUM MORIBUS ACCOMMODATA,

SIVE

CURSUS THEOLOGIÆ

Juxta mentem, & in quantum licuit, juxta ordinem & litteram D. THOMÆ in ejus Summa, insertis pro re nata Digressionibus in Historiam Ecclesiasticam,

Ad Usum Scholarum Thomisticarum.

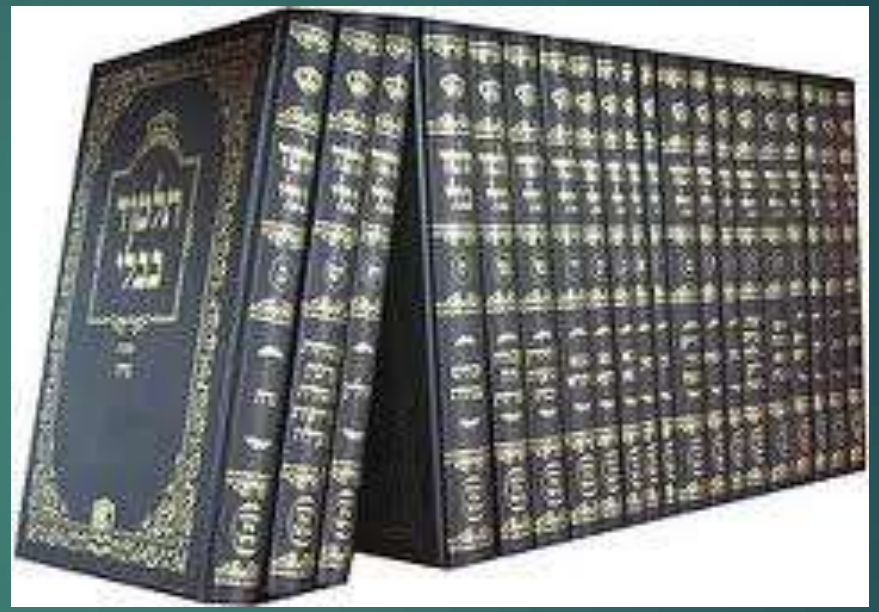
TERTIA PARS

COMPLECTENS TRACTATUS

DE INCARNATIONE

DE SACRAMENTIS IN COMMUNI, ET BAPTISMO

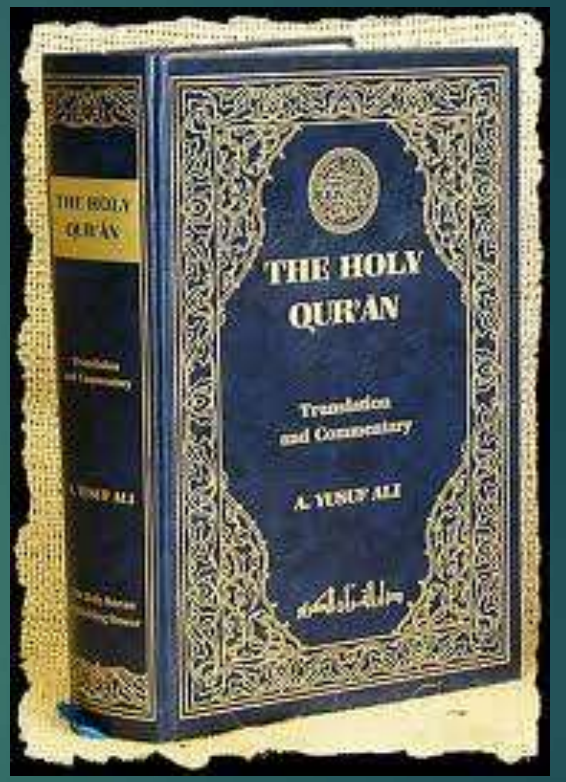
Jewish Talmudic Scholars:
Single minded perseverance in their studies



Stories of ultra-Orthodox Jews who memorized all 5,422 pages of the Babylonian Talmud so thoroughly that when a pin was stuck through any of the Talmud's 63 books, they could tell you which words it passed through on every page.

1917 *Psych Review*: group of Polish Talmudic scholars (Shass Pollak) who did this

Islamic Koran Scholars

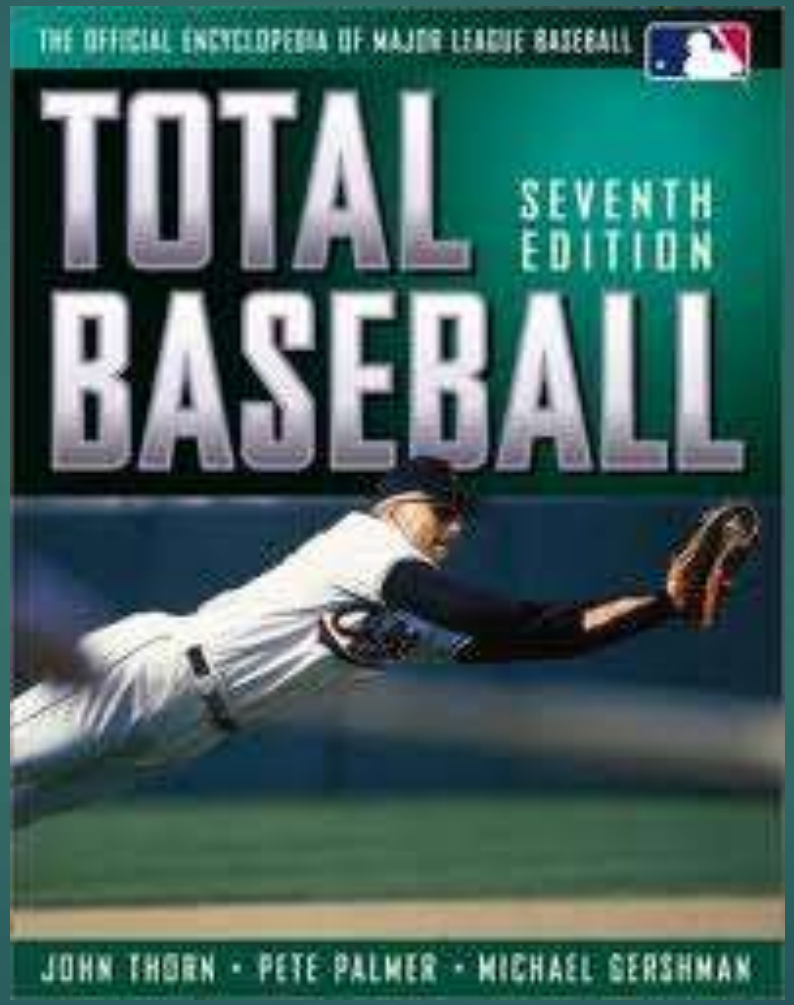


West African griots: Oral genealogists - social memory

Oral genealogists

Walking history books, preserving their ancient stories and traditions through song

Baseball fanatics



Great human memorization ability

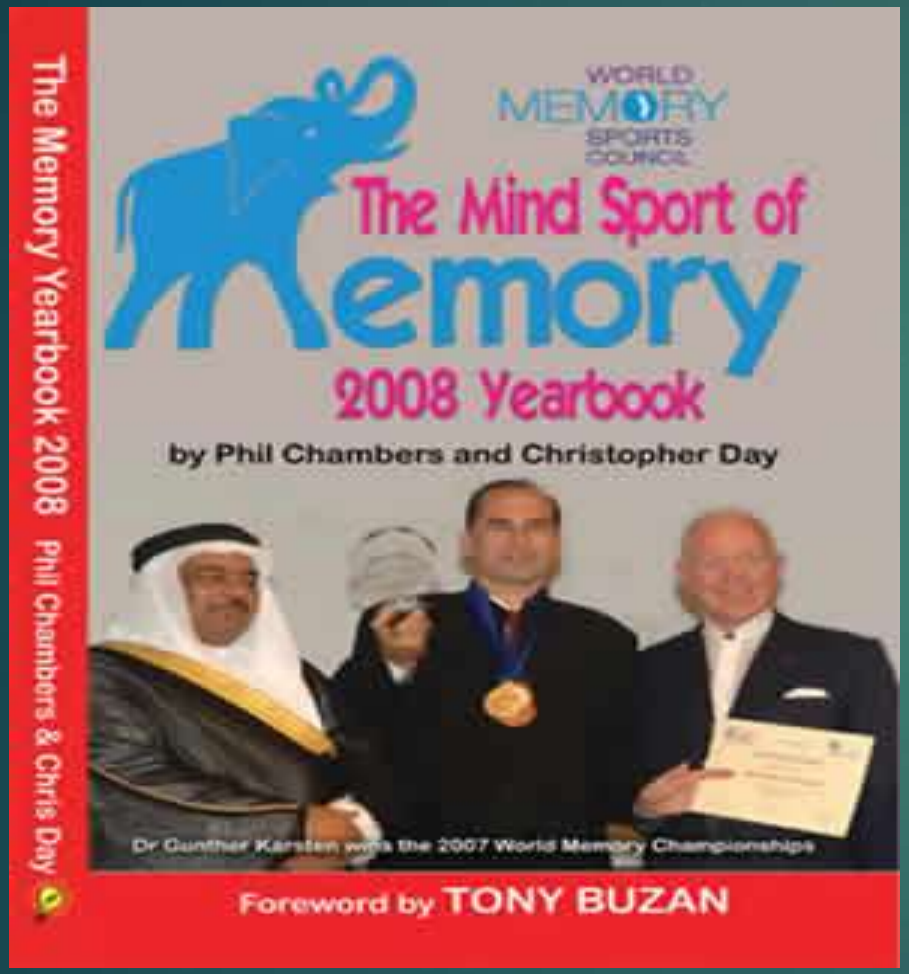
- Despite these prior examples of great memory ability, there is continuing question of whether there is such a thing as photographic or eidetic memory, without the use of mnemonics.

- Current opinion: photographic memory has never been scientifically demonstrated to exist.

That is what it takes to become a world memory champ.

Could you memorize the exact order of a deck of cards during the 53 seconds it takes elevator to get to the top of Empire State Building?

World Memory Championships



The 19th USA Memory Championship will be held on Saturday, May 7, 2016 in Hershey, PA.

http://www.memorise.org/index.htm

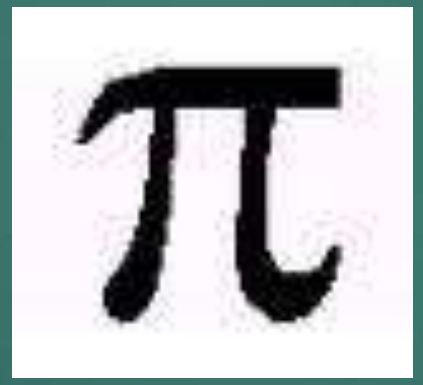
USA National Memory Championship

- March 13, 2007, New York: Joshua Foer memorized the order of a deck of cards in 1 minute 40 seconds
- World Champions: 1 deck in 30 seconds
- To attain the rank of grand master of memory, you must be able to perform three feats. You have to memorize:
  - 1,000 digits in under an hour,
  - Precise order of 10 shuffled decks of playing cards in the same amount of time,
  - 1 shuffled deck in less than two minutes.
  - 36 grand masters of memory in the world; but they have normal memory functioning otherwise;
  - FMRI = larger R hippocampus activation

Moonwalking with Einstein - Joshua Foer

Greatest Feats of Memory

- Oct 4, 2006:
  - Akira Haraguchi, age 60,
  - Recited *Pi* to 100,000 decimal places from memory in 16 hours



  - Later forgot most of it
  - He assigned kana sound symbols to numbers, allowing for the memorization of Pi as a collection of stories.

Alexander Luria, *Mind of a Mnemonist*: Study of Russian Journalist, Solomon Veniaminovich Shereshevskii

Do you see any pattern?

6	6	8	0
5	4	3	2
1	6	8	4
7	9	3	5
4	2	3	7
3	8	9	1
1	0	0	2
3	4	5	1
2	7	6	8
1	9	2	6
2	9	6	7
5	5	2	0
x	0	1	x

Note: With only 2 to 3 min study of such a table, S. was able to reproduce it in reverse order, horizontally, or vertically, or to reproduce the diagonals.

Hyperthymesia

- A journalist who never took notes. Editor was disturbed and sent him for testing.
- S. used two “strategies” or abilities typical of mnemonists:
  - Rich synesthesia-like quality to his perception of stimuli - leads to stronger associative links:
    - sounds had shapes, colors;
    - letters had taste, fragrance
  - Vivid and elaborate visual imagery of things he should remember
- Lacked normal forgetting filter. Had poor EF (problem solving).

Highly Superior Autobiographical Memory: Hyperthymestic syndrome: excessive (hyper) and remembering (thymesis)

- Jill Price, Brad Williams,Rick Baron, Bob Petrella, Marilu Henner, a star of the hit TV show 'Taxi'; 56 known

- All together in James McGaugh & Dr. Larry Cahill's lab: When he asked the group when a 7.1 earthquake hit the San Francisco-Oakland area, all replied, "October 17th, 1989."

- Perfect recollection of events of everyday of their lives
- Temporal lobes and caudate nucleus are 7-8 s.d. larger
- All have OCD-like behaviors; collect things

Interest in topic is important

- Only 2 of 55 in the United States have successful marriages

(Parker, McGaugh, 2006; Cahill,)

Highly Superior Autobiographical Memory

I am thirty-four years old. I can take a date, between 1974 and today, and tell you what day it falls on, what I was doing that day and if anything of great importance occurred on that day; I can describe that to you as well. I do not look at calendars beforehand and I do not read twenty-four years of my journals either. Whenever I see a date flash on the television (or anywhere else for that matter) I automatically go back to that day and remember where I was, what I was doing, what day it fell on and on and on and on and on. It is non-stop, uncontrollable and totally exhausting…Most have called it a gift but I call it a burden. I run my entire life through my head every day and it drives me crazy!!!… .

Parker et al., 2006

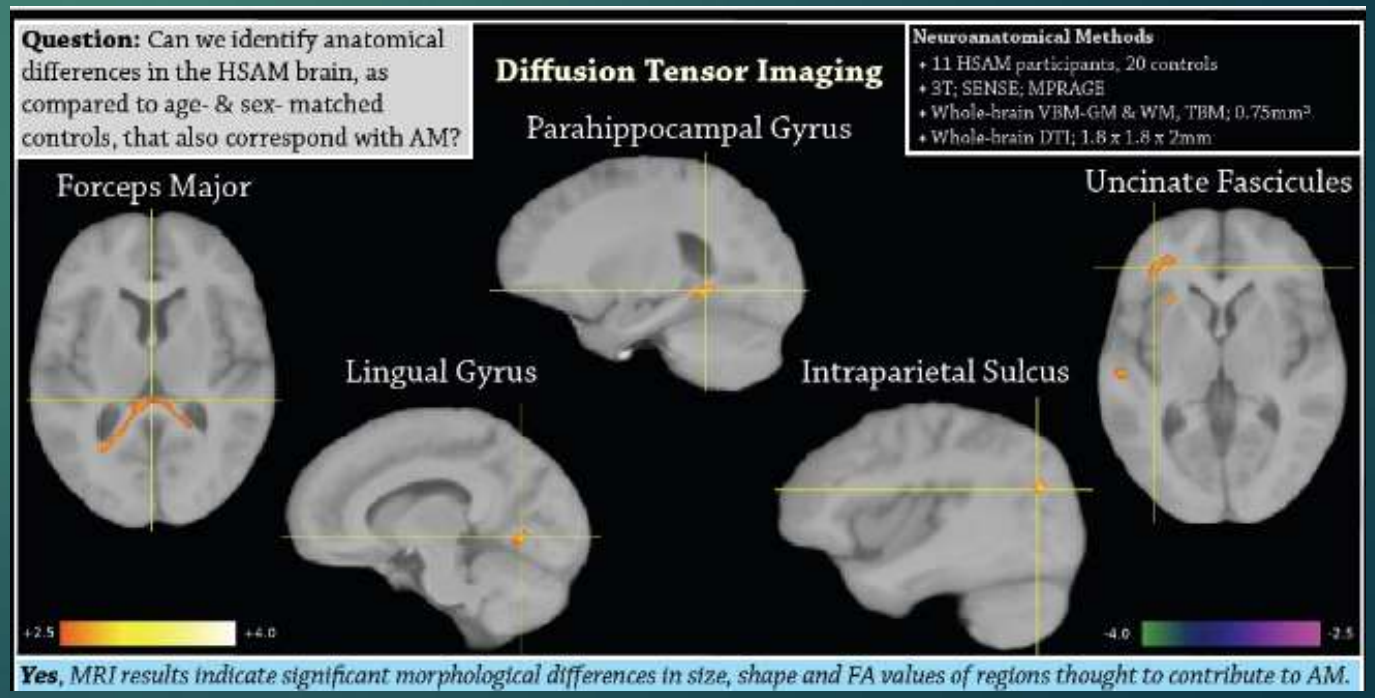
Superior Autobiographical Memory

- Instant access to virtually every day of their lives; no forgetting
- Louise Owen is 37 yo professional violinist in NYC.
- When asked what happened on Oct. 19, 1987, Owen said,
  - "It was a Monday. That was the day of the big stock market crash, and the cellist Jacqueline du Pre died that day."
  - When asked on what day the Berlin Wall fell, Owen said, "November 9th, 1989, which was a Thursday."
- Bob Petrella: 50 years of fantasy Holland College Basketball team history

HSAM: highly superior autobiographical memory

- Significantly larger left temporal-parietal junction & left posterior insula, as well as the lentiform nucleus (obsessive-compulsive disorder link).
- Some have a tendency to hoard things or avoid germs, though none have been diagnosed with OCD.

- They do not exhibit better cognition in other realms, incl. other forms of memory.
- Genetic



Severely Deficient Autobiographical Memory (SDAM)

- 3 healthy, high functioning adults with the reverse pattern: lifelong severely deficient autobiographical memory (SDAM) with otherwise preserved cognitive function.

- Self-reported selective inability to vividly recollect personally experienced events from a first-person perspective; no fMRI activation of normal areas for episodic memory

- Deficit specific to episodic (especially visual), rather than semantic processes. Past is experienced in the absence of recollection; fail to subjectively re-live past events.
- With the exception of complex figure recall, standard neuropsychological measures of recognition, cued recall, and free recall were normal and even superior in some of the SDAM cases.

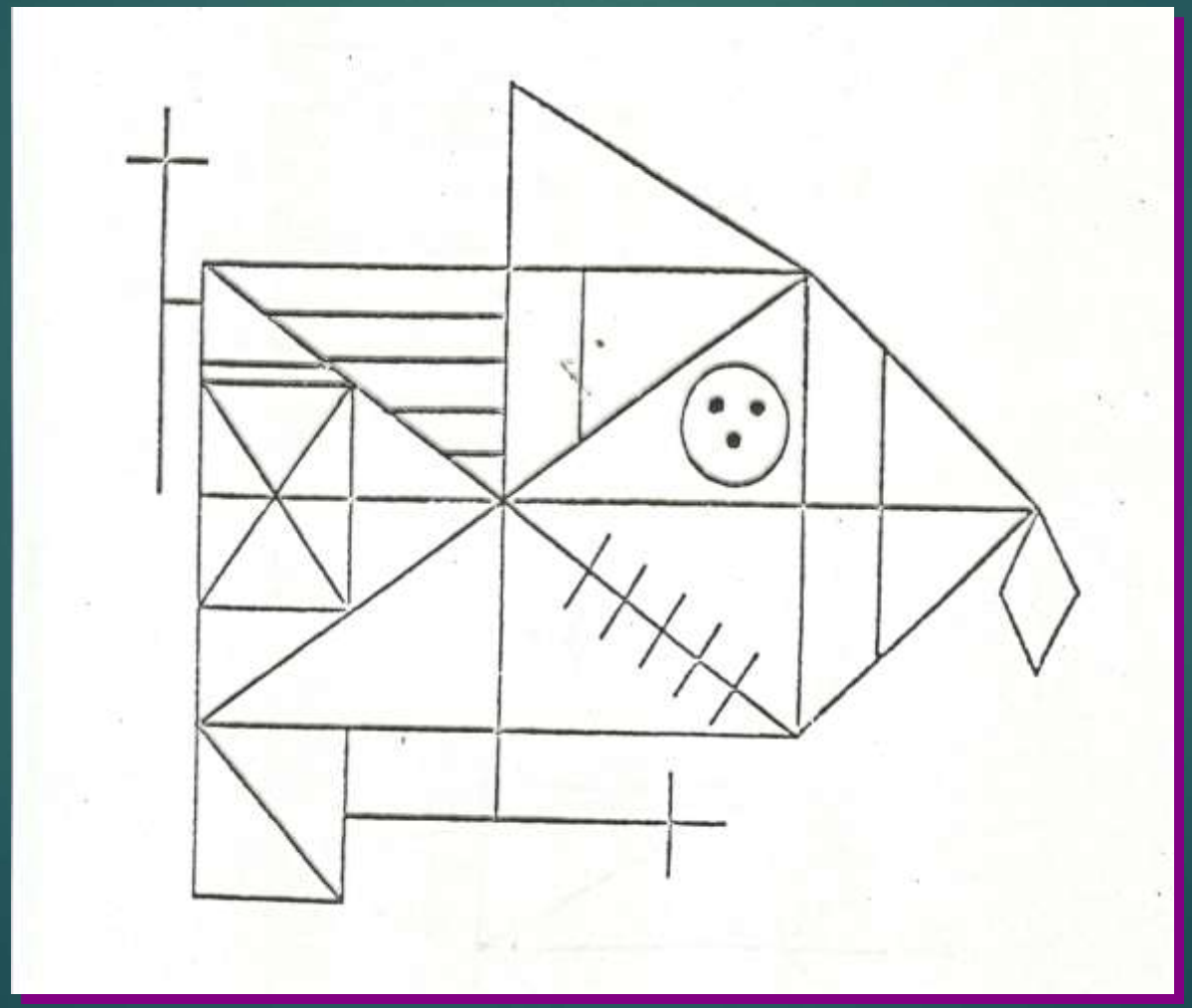
Daniela J. Palombo, et al., , 2015

SDAM

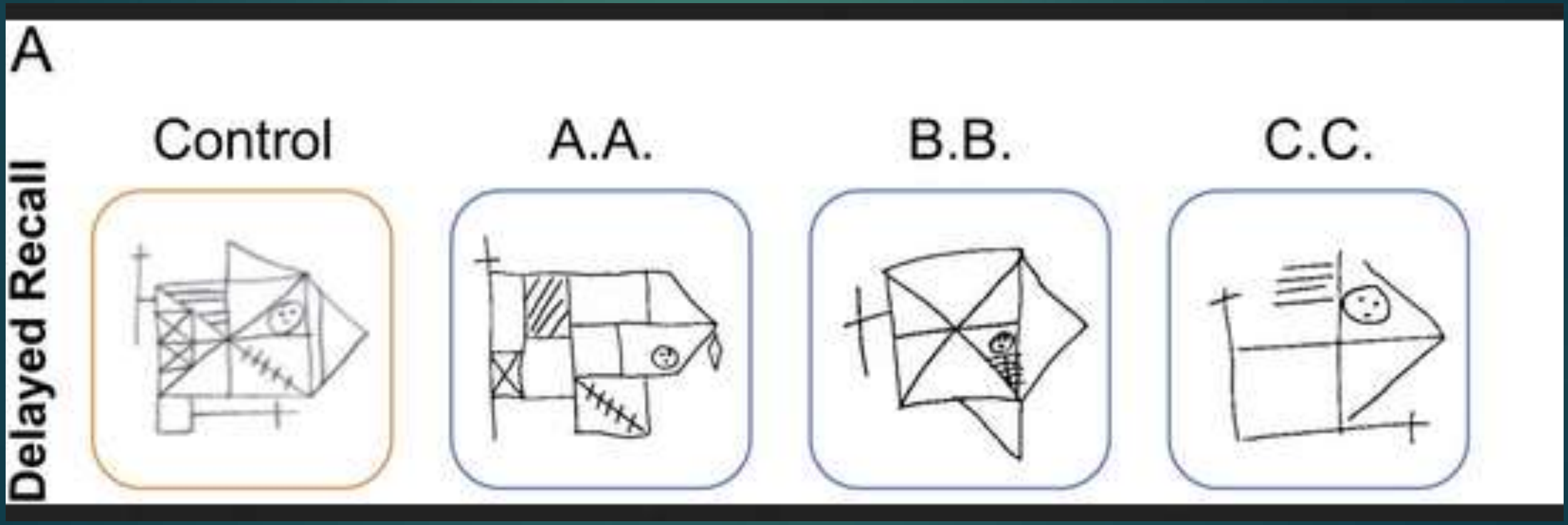
- Impaired activation of midline frontal and precuneus are engaged in association with mental time travel and recollection of contextually specific details/ autobiographical memory retrieval.

- Normal performance on everyday mnemonic tasks mediated by non-episodic processes.

Rey Complex Figure: Visual memory requires hippocampus and frontal strategy



SDAM pts on Rey Complex Figure



Normal

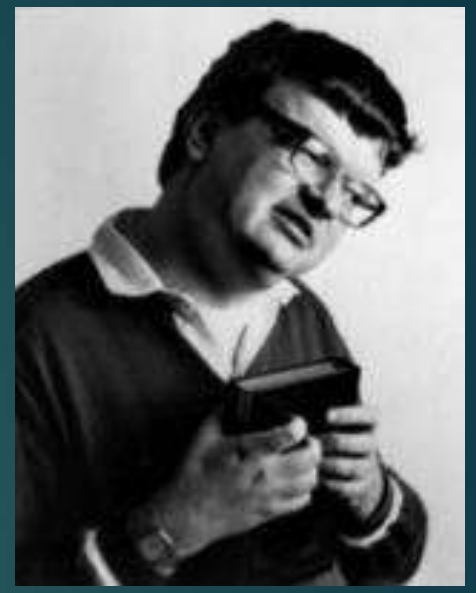
What is your memory style?

- Tendency to remember episodic details versus facts is reflected in intrinsic brain patterns.

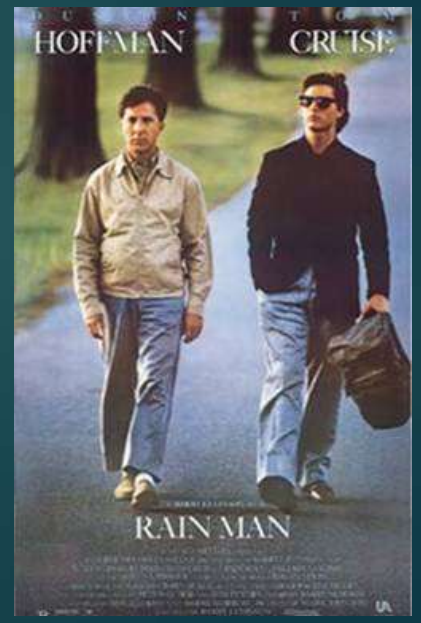
- Those who endorsed richly-detailed autobiographical memories had higher medial temporal lobe connectivity to regions at the back of the brain involved in visual processes

- Those tending to recall the past in a factual manner (minus the rich details) showed higher medial temporal lobe connectivity to areas at the frontal lobe involved in organization and reasoning

Rain Man: Autistic Savant Kim Peek



- Claim that he memorized every page of the 9,000-plus books he has read at 8 to 12 seconds per page (each eye reads its own page independently); never scientifically researched
- No corpus callosum
- Fewer than 25 prodigious savants living: Leslie Lemke (music), Alonzo Clemens (sculpting), Richard Wawro (painting), Stephen Wiltshire (drawing), Tony DeBlois (music)
- Non-normal brains: always profound memory ability in savants, with severe deficits in other cognitive domains

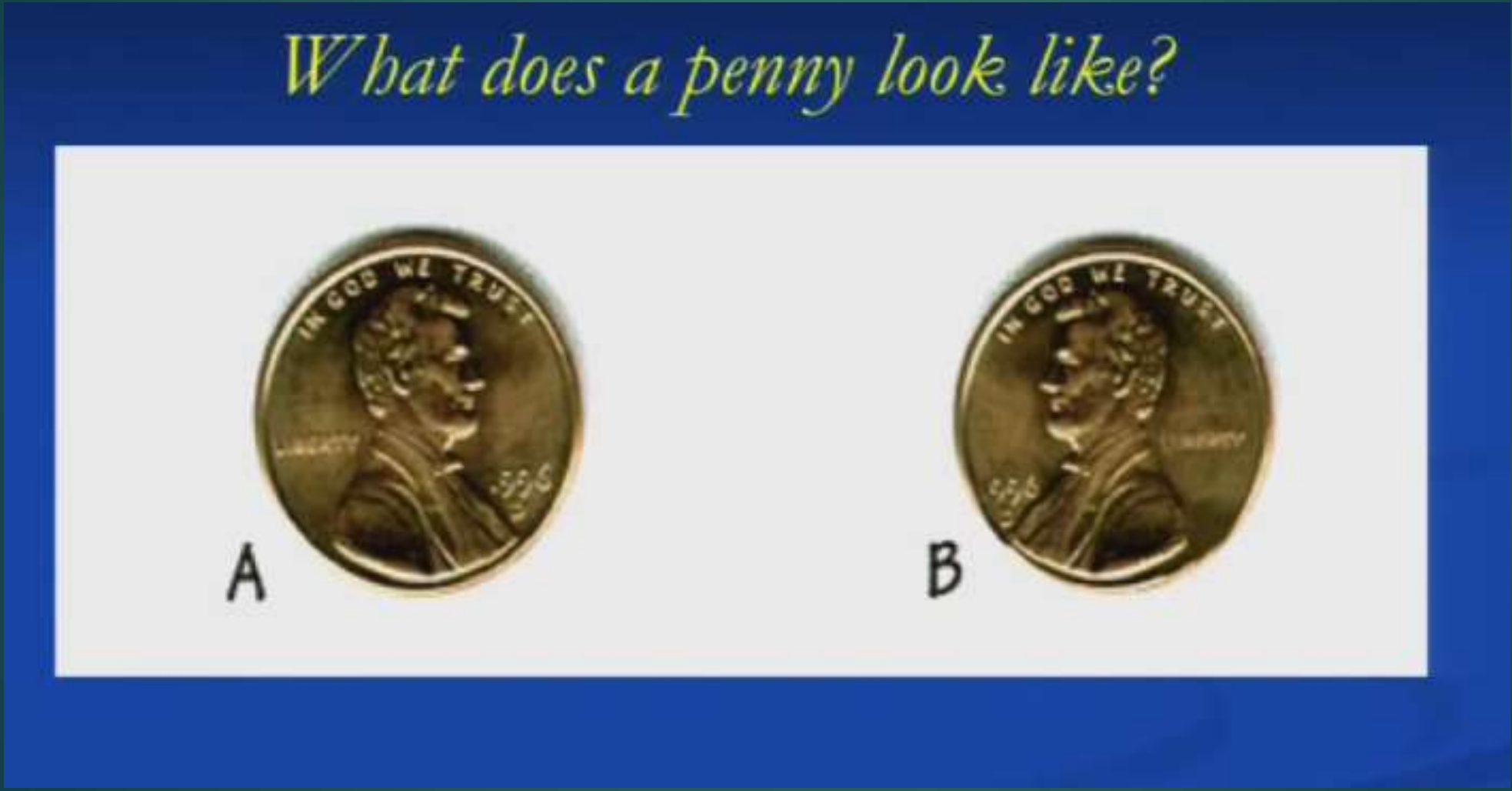


Artist Stephen Wiltshire Recreates View Of London After Just One flight over the city

Great Memory in Birds

- The Nutcracker and Western Scrub Jay (birds) can remember:
  - thousands of food cache locations over a year:
    - when and where they hide food,
    - whether they are being watched at the time.

Penny: Repeat encounters do not a memory make



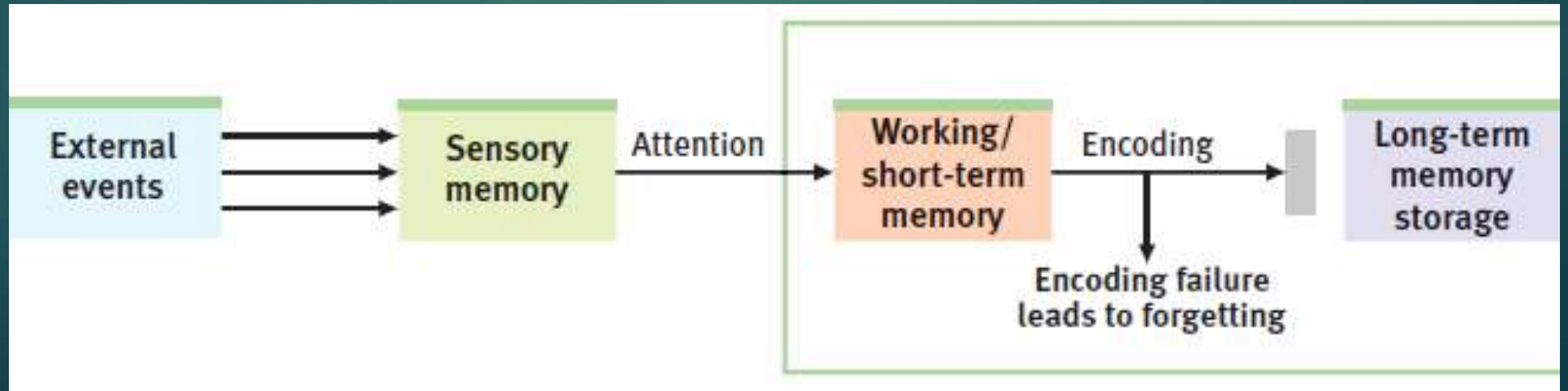
And the correct answer…

All other US coins point to the left.

Answer: A

Encoding Failure

- If we got the penny image wrong, did we fail to **retrieve** the information?
- It could be that we never paid attention to the penny details and didn't select them from sensory memory to hold in working memory.
- Even if we once looked at the penny and paid attention to it, we still didn't bother rehearsing it and **encoding** it into long term memory.



Memory Task

Choose only 1 list and
try to remember the words.
Go!

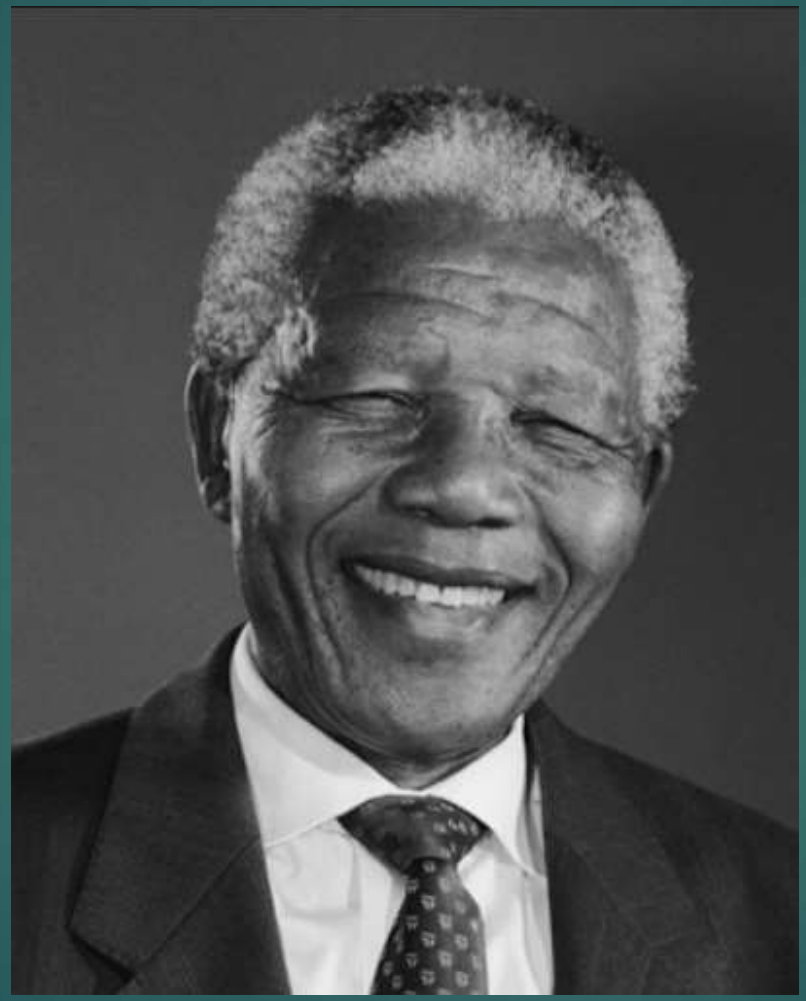
List 1	List 2
Bed	Thread
Rest	Pen
Awake	Eye
Tired	Sewing
Dream	Sharp
Wake	Point
Snooze	Prick
Blanket	Thimble
Doze	Haystack
Slumber	Thorn
Snore	Hurt
Nap	Injection
Peace	Syringe
Yawn	Cloth
Drowsy	Knitting

Your memory is amazing

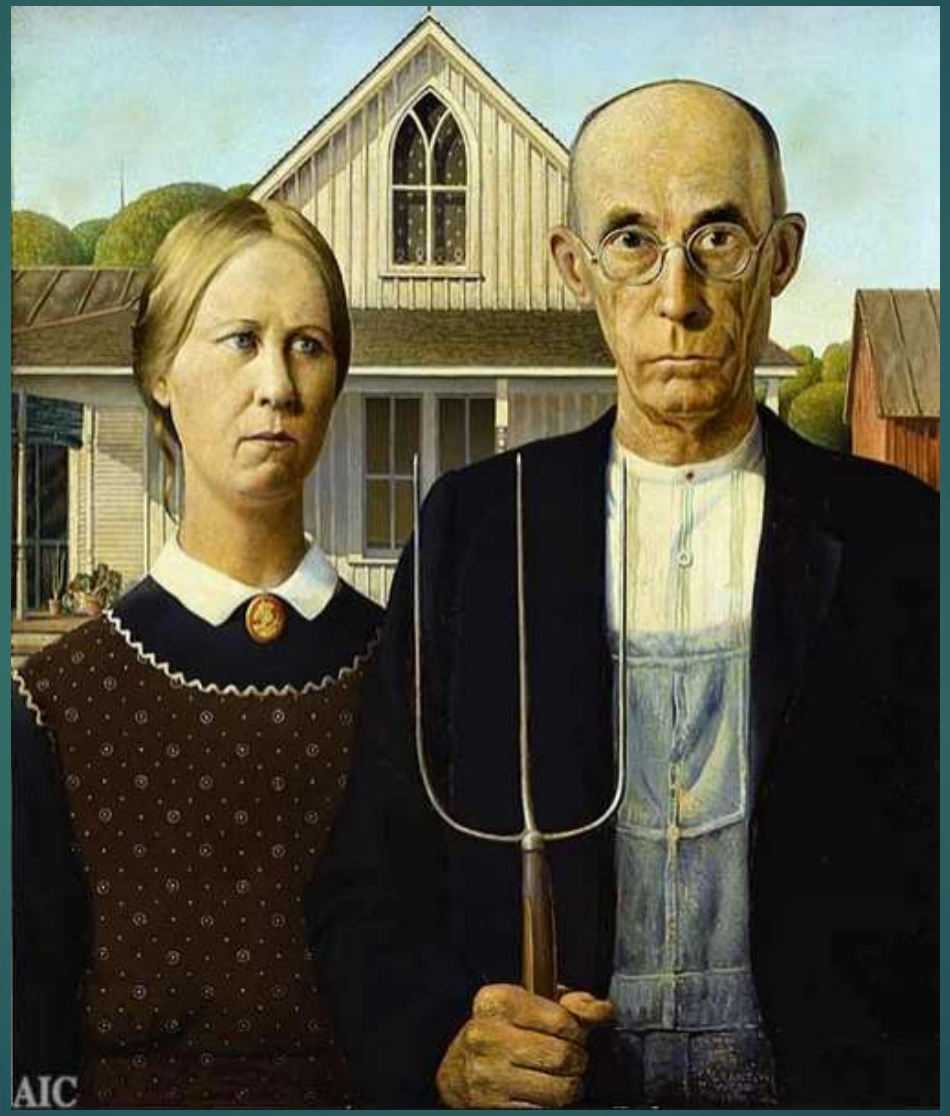
I want you to look at 15 pictures.

They will appear quickly.

Just keep looking at the screen.




Everett Collection / Rex Features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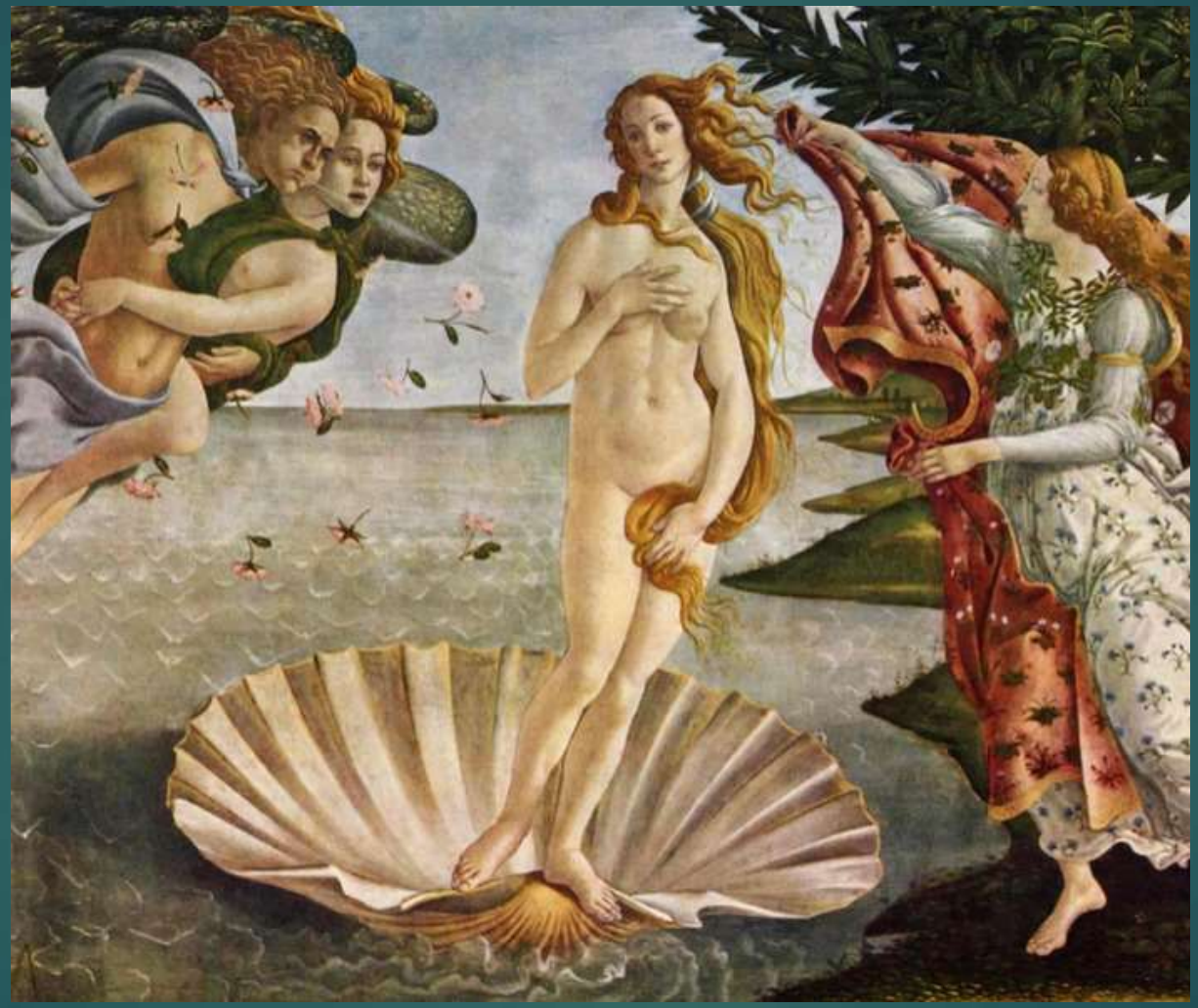


Modern Era of Memory in the Lab: Herman Ebbinghaus

Creator of 2,300 new nonsense syllables

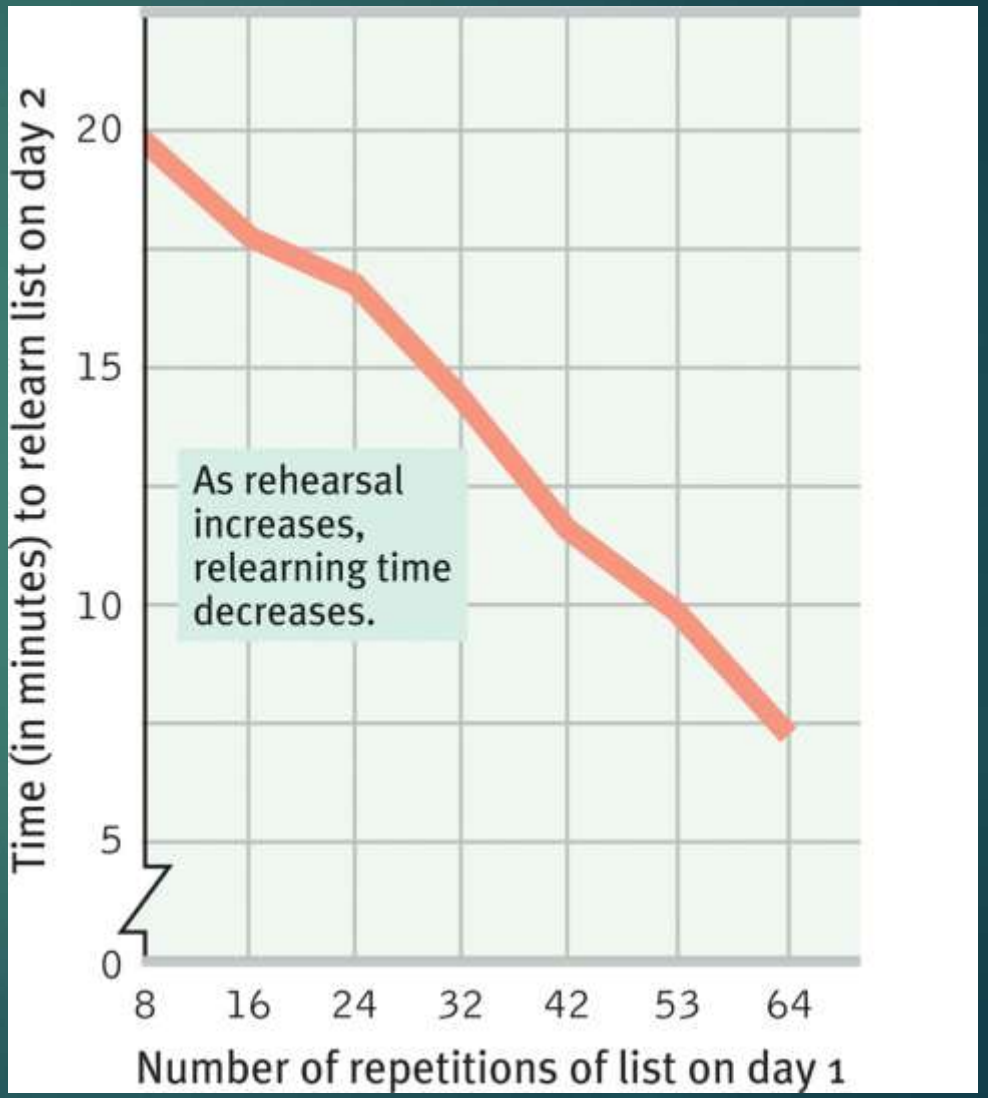
Examples: Rur, Hal, Mek, Bes, Sok, Dus

More practice sessions produced more retention of memory, and slower rate of forgetting

1885: *Über das Gedächtnis (Memory: A Contribution to Experimental Psychology)*

Relearning Time as a Measure of Retention

- In the late 1800s, Hermann Ebbinghaus studied another measure of memory functioning: how much time does it take to relearn material you have studied before?
- He studied the memorization of nonsense syllables (THB YOX KVU EHM) so that depth of processing or prelearning would not be a factor.
- The more times he **rehearsed** out loud on day 1, the less time he needed to **relearn**/memorize the same letters on day 2.



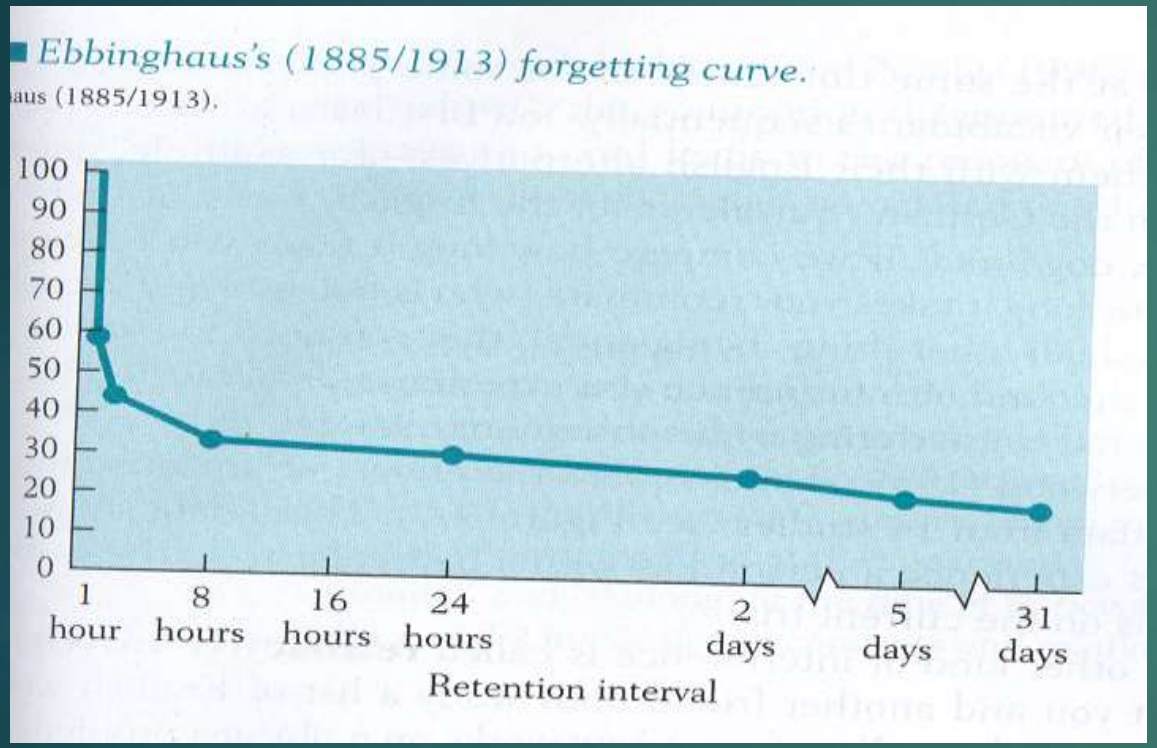
Ebbinghaus's Discoveries and Contributions

- Learning curve: The more repetitions of a memory, the better the recall
- Distributed practice/Spaced repetition effect: We learn better if we spread it out over time, not cramming the night before.
- Forgetting Curve: Forget more as time passes; more rapid initially, but the rate of forgetting slows as time increases
- Invented tests of memory: recall, recognition, percent savings (less time to relearn)
- Sleep effect : forgetting is reduced when sleep occurred in the retention interval

“Our brains, remarkable as they are, could not begin to contain and give equal weight to our every moment of life.” (Glore, 1987)

We are born to forget.

Forgetting Curve: Time reduces Recall



The Forgetting curve:
People forget:

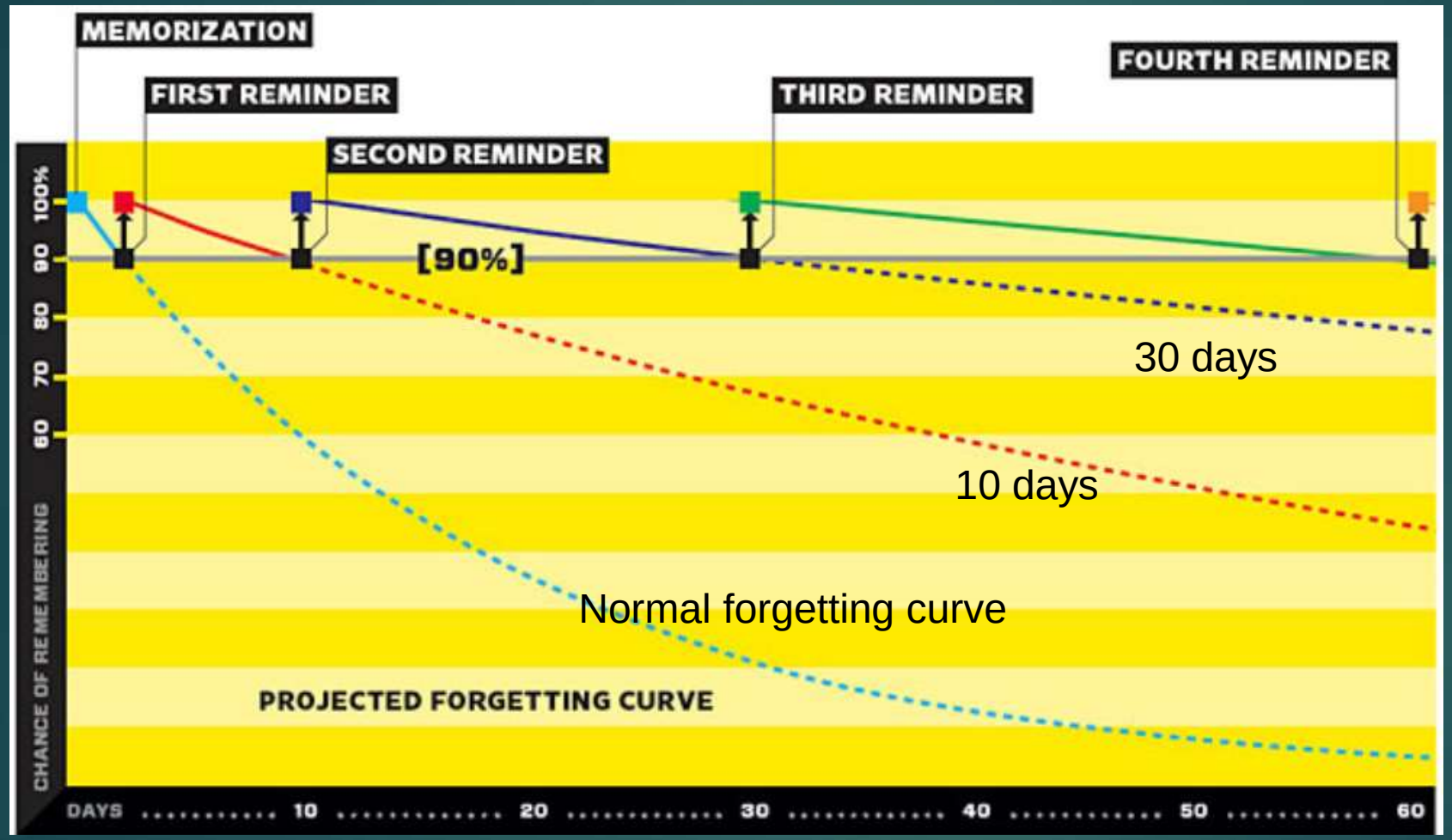
42% after 20 min
56% after one hour,

67% after one day,
72% after 2 days,

79% after 31 days .

Information is lost over time when there is no attempt to retain it

Tip # 4: Rehearsal (repetition) increases memory



4 spaced repetitions increases memory by 90%)

Spacing out repetitions significantly improves retention.

Forgetting

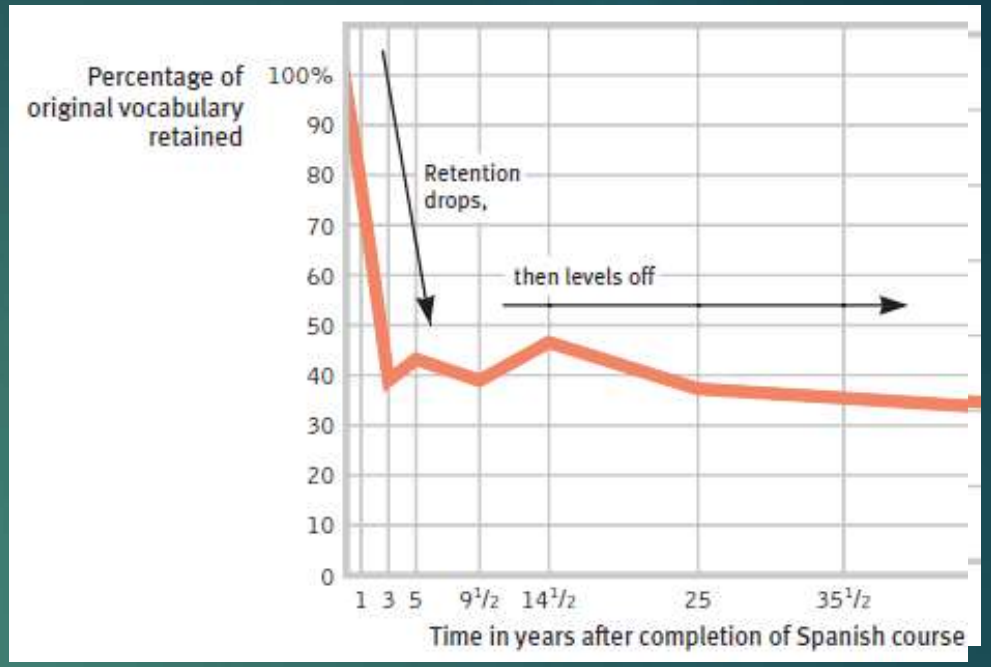
We forget more than we remember.

Why we forget:

- Due to weak original encoding
- Lack of a retrieval cue
- Proactive Interference (new interferes with consolidation of older items memory)
- Time and the replacement in the neural network by later experiences; competition for conscious access
- Repetitive experiences of same type (you'll remember the one special meal you had at a special restaurant, but you won't remember what you had for lunch a year ago Tuesday)

Storage Decay

- Material encoded into long term memory will decay if the memory is never used, recalled, and re-stored.
- Unused connections and networks wither while well-used memory traces are maintained.



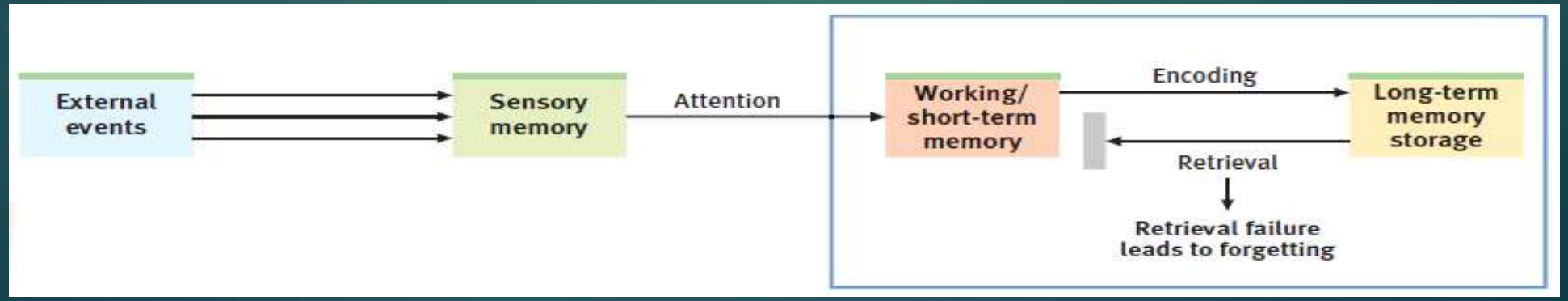
- Decay tends to level off. Memory for both nonsense syllables and Spanish lessons decays rapidly.
- However, what hasn't decayed quickly tends to stay intact long-term.

Tip of the Tongue: Retrieval Failure

- Sometimes, the memory itself does not decay. Instead, what decays are the associations and links that help us find our way to the stored memory.

- As a result, some stored memories seem just below the surface: “I know the name...it starts with a B maybe…”

- To prevent retrieval failure when storing and rehearsing memories, you can build multiple associations, linking images, rhymes, categories, lists, and cues.



The Power of Forgetting

- Benefits of forgetting:
  - It is a spam filter (can focus on what you want to remember, not all the other stuff; suppresses (forgets) competing, unwanted information. Blocks out distractions
  - Bjork & Bjork: Any technique that causes forgetting is a “desirable difficulty” in that:
    - it forces the brain to work harder to dig up a memory or skill
    - and that added work intensifies subsequent retrieval and storage strength

Things We Normally Forget

“Forgetting Symptom”	Percentage
Telephone numbers	58%
People’s names	48%
Where car is parked	32%
Where car keys are	31%
Groceries	28%
Reason for entering room	27%
Directions	24%
Appointments	20%
Store location in mall	20%
Lose items around the house	17%
Wallet	17%
Content of daily conversations	17%

Memory Retrieval

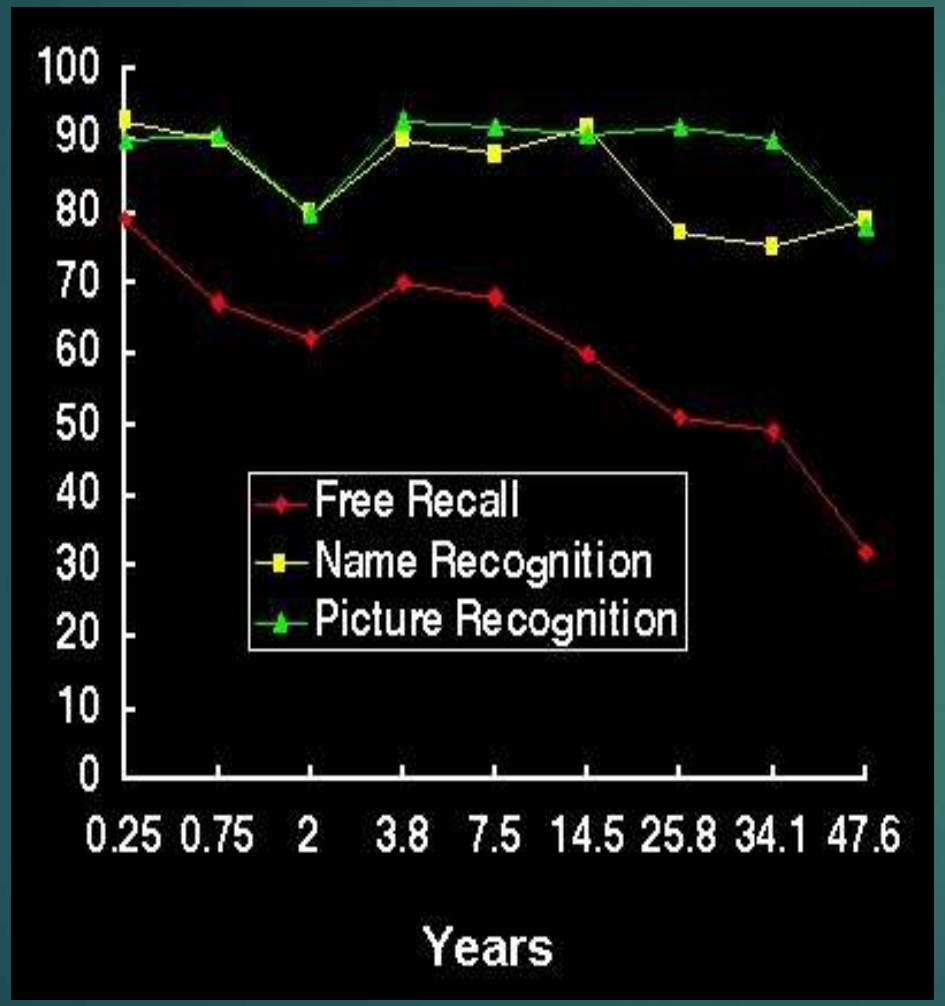
- **Recall**: some people, through practice, visual strategies, or biological differences, have the ability to store and recall thousands of words or digits, reproducing them years later ("fill-in-the-blank")
- **Recognition:** the average person can view 2500 new faces and places, and later can notice with 90 percent accuracy which ones they've seen before ("multiple choice")
- **Procedural learning:** We tend not to remember how we learned motor memories, i.e. learning to ride bike

Lessons from each of these demonstrations:

1. our **storage** and **recall** capacity is virtually unlimited

2.our capacity for **recognition** is greater than our capacity for recall

Recall and Recognition of High School Classmates



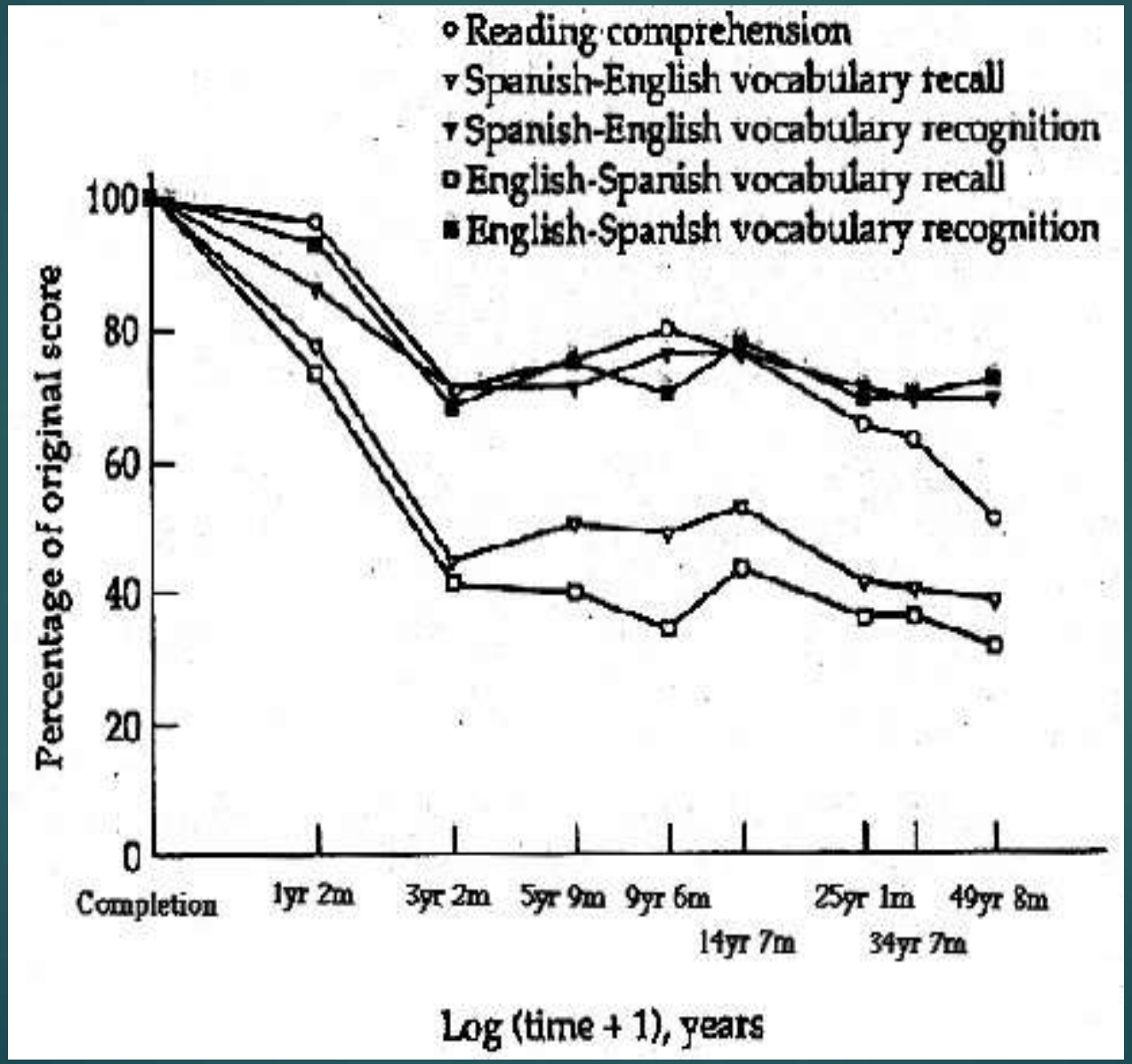
Free recall (red) is poor

Picture recognition is best;

Name recognition is good;

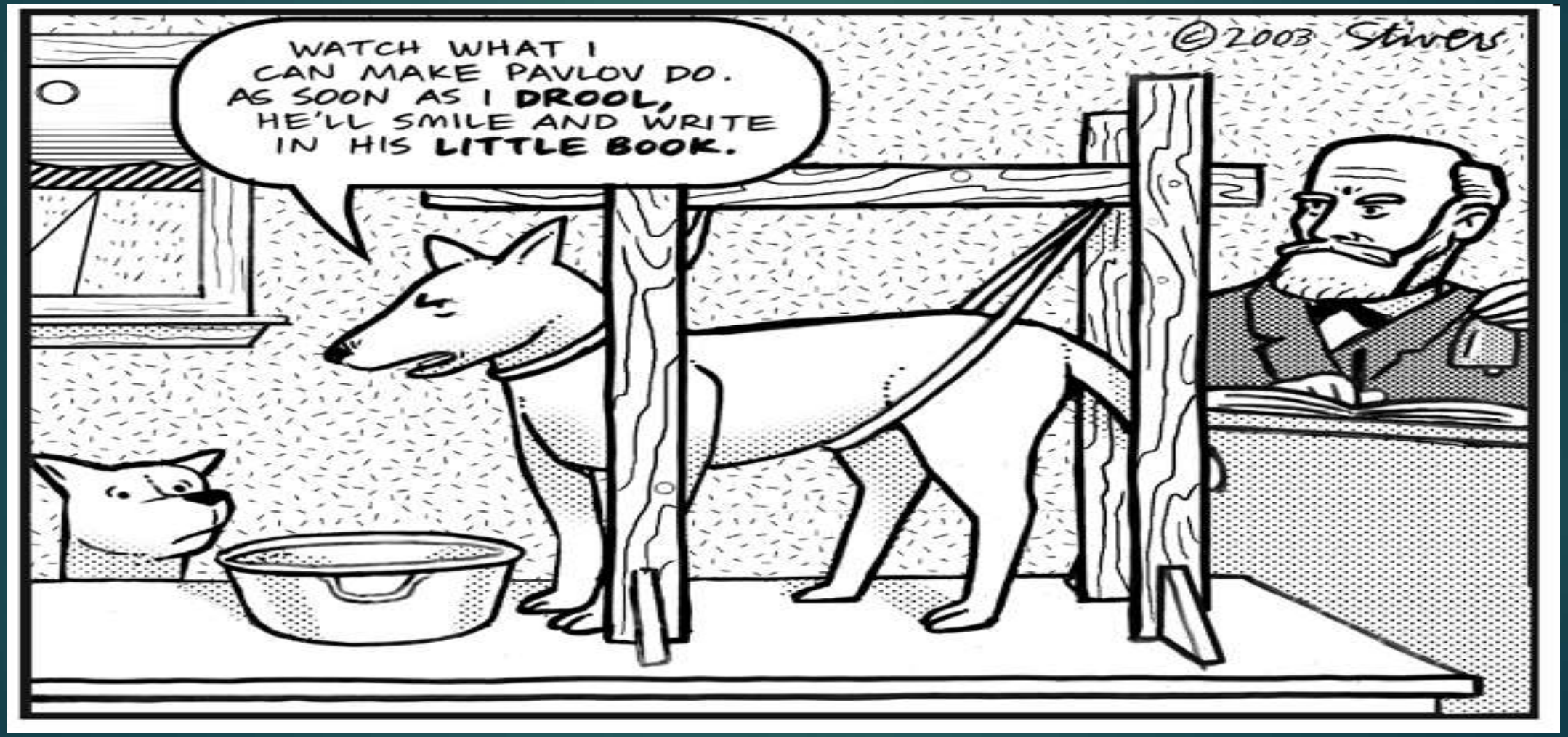
Bahrick et al., 1975

Memory for High School Spanish



Bahrick, 1984

Pavlov: Conditioned response



Pavlov's New Neighbors: Acme Doorbell Co.

Theory of Disuse

- Any memory has 2 strengths: a storage strength & a retrieval strength

- Storage strength: how well we learned something (builds up with study, & more with use), i.e. multiplication table;
  - What we have deliberately committed to memory; it can increase but not decrease; it has large capacity; it is a measure of familiarity

- Retrieval strength: measure of how quickly memory comes to mind, how accessible it is; without reinforcement, fades quickly; relatively small capacity

Robert & Elizabeth Bjork, UCLA

Tip #5 – Harder it takes you to retrieve, better the memory

- Imagine being at a party with everyone you have known:
  - Parents: high storage & retrieval;
  - Newly met neighbors: retrieval high, not familiar (storage low);
  - High school janitor: low storage & retrieval

- Remembering and naming a person increases both types of memory strengths;
  - forgetting for awhile can add to memory strength;
  - harder you work to retrieve, greater the increase in both strengths

Hidden value of Ignorance: Testing as memory

- Fluency illusion: belief that facts are easy to remember right now, they'll remain that way tomorrow. We forget that we forget. Main reason for poor test performance.

- Fluency illusion examples (all passive): verbatim copying, highlighting, study guides, chapter outlines

- Fluency:
  - easier it is to call a fact to mind, smaller the increase in learning.
  - Repeating facts right after you learn them (reviewing) gives you no added memory benefit.

- Desirable difficulty: harder your brain has to work to dig out a memory, the greater the increase in learning

Neuroplasticity: new synaptic connections

- Memory: Connections between neurons rewire based on experiences
- Brain is less ‘hard-wired’ than we used to believe
- Neuroplasticity is fundamental property of brain:
  - Capacity of nervous system to modify its organization
  - Changes in neuronal structure and function is the result of experience
  - Changes largely within the synapse

Aplysia Californica → 2000 Nobel Prize

Chemistry of Long Term Potentiation in synapses

Eric Kandel

Nobel Prize: What happened in Glen Park?

Synaptic changes store memories

- Current dominant theory: Long-term potentiation (LTP) –
  - Long lasting increase in synaptic strength between neurons following high-frequency stimulation

- "*The molecular and cellular changes mediating the induction of LTP in the hippocampus are widely considered to provide a basis for memory*" (McGaugh, 2000)

Memory in Brain

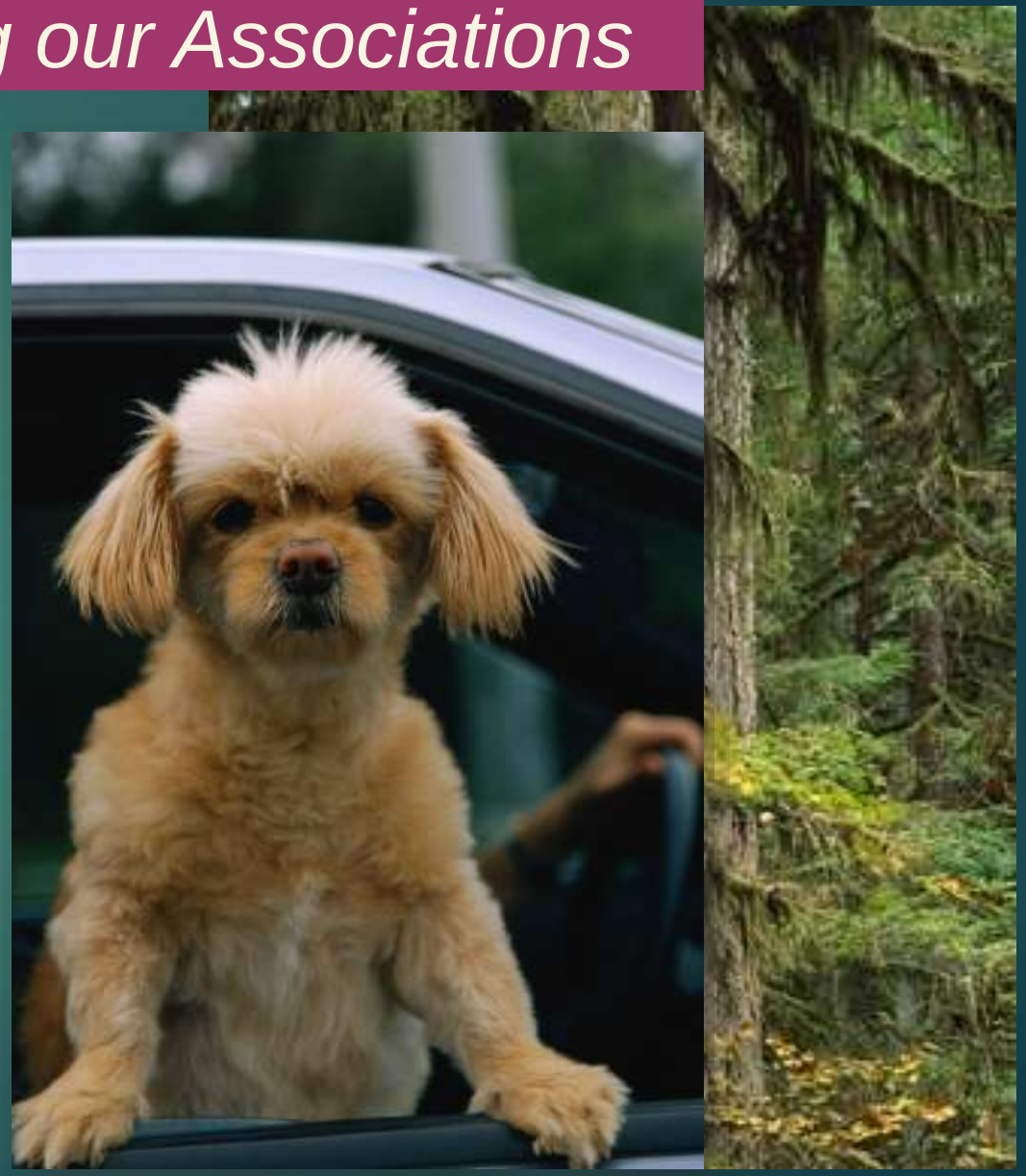
- **Hebb Rule:** If neurons fire together, they wire together. Memory is formed by neuronal interactions.
  - If synapse between 2 neurons repeatedly activates, the postsynaptic neuron fires and structure or chemistry of synapse will change

- Long term potentiation:
  - Electrical stimulation results in neuron sensitization and enhanced response

Priming:

Retrieval is Affected by Activating our Associations

- **Priming** triggers a thread of associations that bring us to a concept, just as a spider feels movement in a web and follows it to find the bug.
- Our minds work by having one idea trigger another; this maintains a flow of thought.

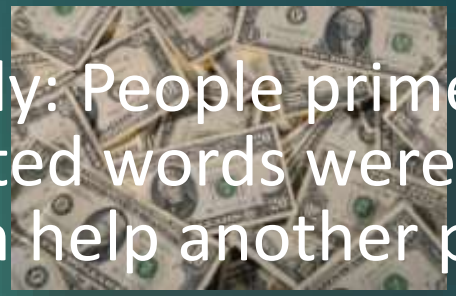


Priming Example: Define the word “bark.”

Now what is the definition of “bark”?

The Power of Priming

- Priming has been called “invisible memory” because it affects us unconsciously.
- In the case of tree “bark” vs. dog “bark,” the path we follow in our thoughts can be channeled by priming.
- We may have biases and associations stored in memory that also influence our choices.



Study: People primed with money-related words were less likely to then help another person.

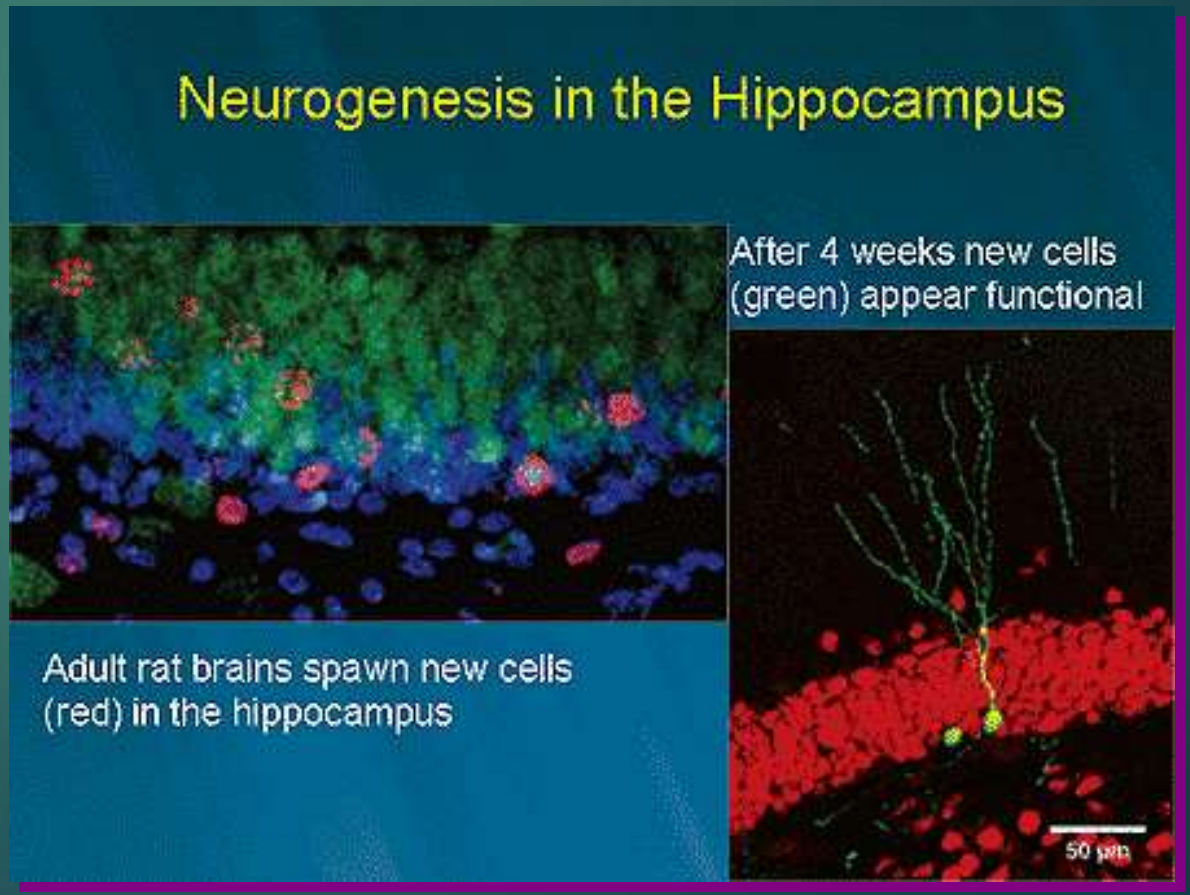
Study: Priming with an image of Santa Claus led kids to share more candy.

Study: peo rimed with a missing ter then misinterp biguous adult-child inter s kidnapping.

Neurogenesis

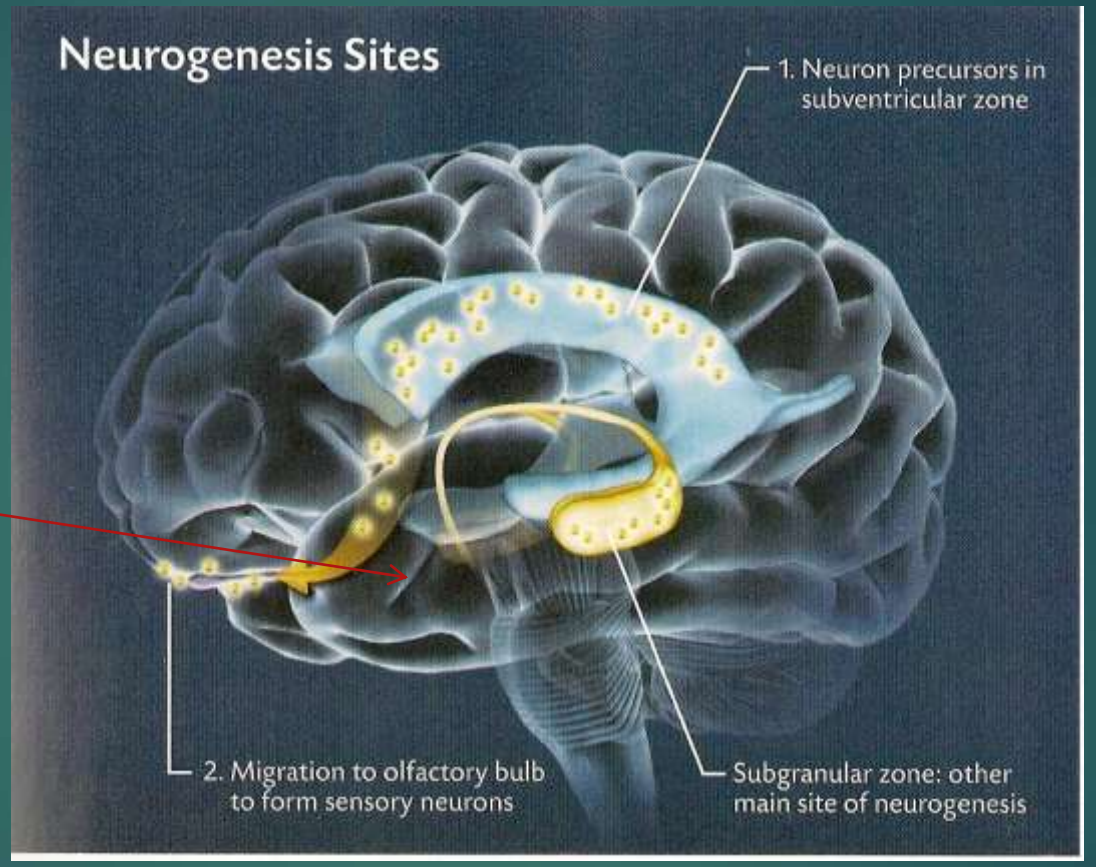
- Neurogenesis: growth of new neurons in the adult brain; Stem cells can become new adult neurons

1,400 cells a day,
esp. in dentate gyrus of hippocampus



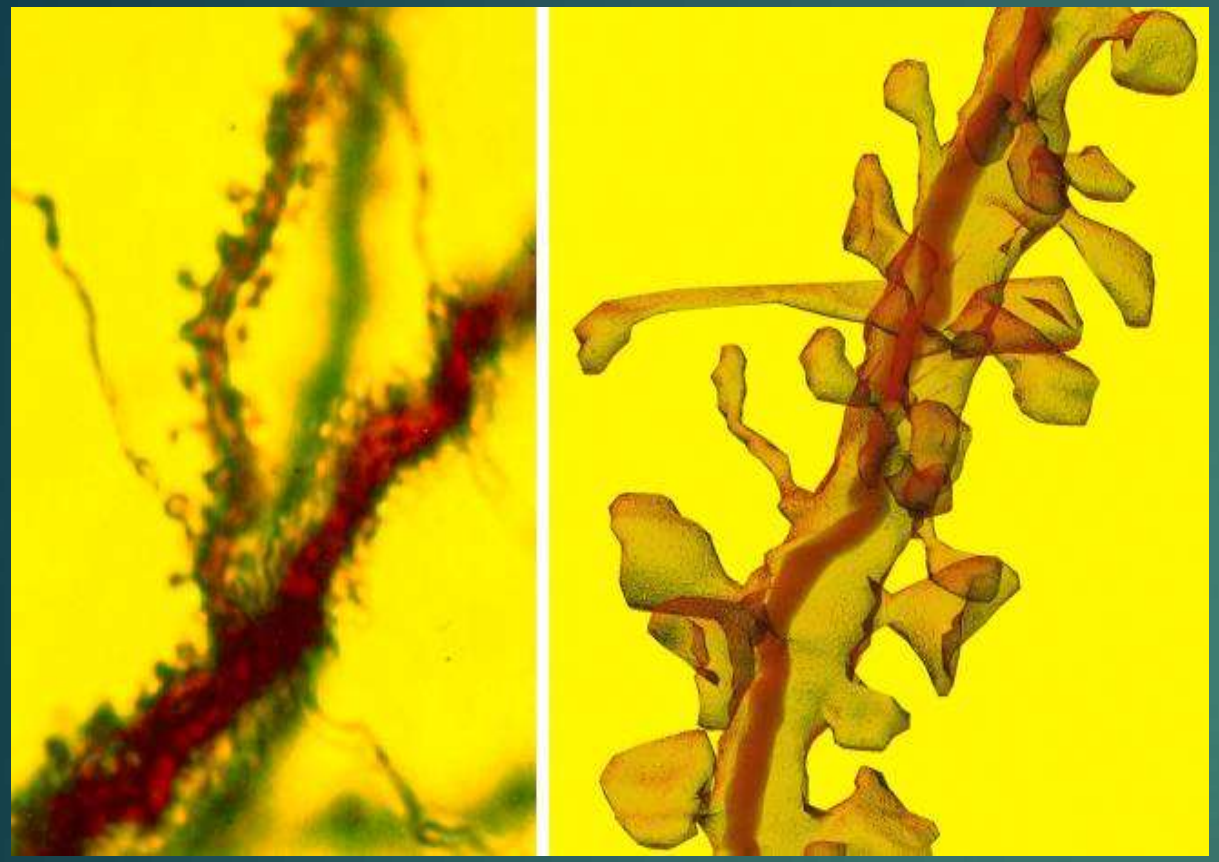
Neurogenesis: 3 major sites

Interneurons in Striatum



1400 new neurons per day, enough to replace all the neurons in the dentate gyrus of the hippocampus over a lifetime; needed for new memories

Dendrites under Electron Microscope



Dendrites connect via synapse to other neuron & receives info.
Highly dynamic: can appear in hours to days and also disappear

Dendrites and Synapses

Hippocampal dendritic spines, unlike their cortical cousins, do not last.

Brain's cerebral cortex encodes long-term memories by forming and stabilizing synapse-bearing dendritic spines.

Learning involves changes in dendrites and LTP in synapses.

Neocortex appears to contain a mix of transient and long-lasting dendritic spines.

Compared to cortex, many more spines crowd hippocampus.

Dendrites and Synapses 2

- In mice, there is a complete replacement of hippocampal spines every three to six weeks.
- Moreover, in adult neocortices more than half of spines seem to be permanent, and those that are transitory have an average lifespan of about five days.

- About 60 percent of cortical spines remained stable over long periods of time

There are multiple memory systems in the brain

- 1 Working Memory: short term: telephone number
- 2 Factual (Declarative) Memory:
  - Episodic (Personal) Memory: first kiss
  - Semantic (Knowledge) Memory: Cleopatra
- 3 Behavioral Memory: How to…
- 4 Prospective Memory: remembering future intention

Working Memory

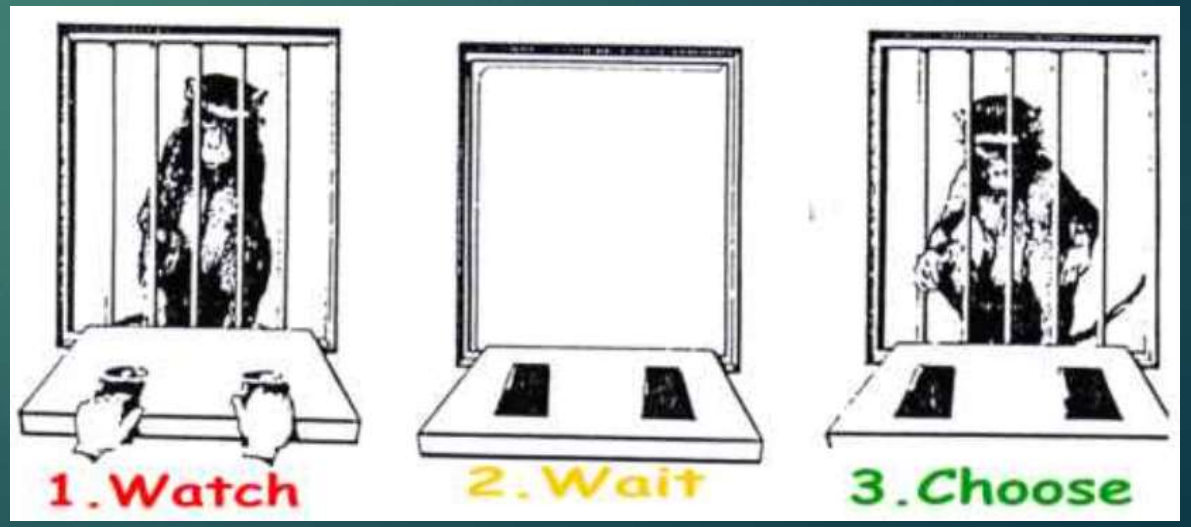
Short-Term Memory and the Magic Number 7

1956: "The Magic Number 7, Plus or Minus Two"

George Miller's paper demonstrated the average capacity of short-term memory is 7

Short Term Memory/Working Memory = 7 +/- 2

- **STM or WM**= limited short term capacity storage, maintained via rehearsal
- Capacity: Miller's Constant -- 7 +/- 2
- Decays if unrehearsed in 20 seconds
- Time to use a phone number
- Delayed response in monkey experiments



Working Memory

- More recent research suggests that the average person, free from distraction, can hold about:
  - **7 digits, 6 letters, or 5 words.**

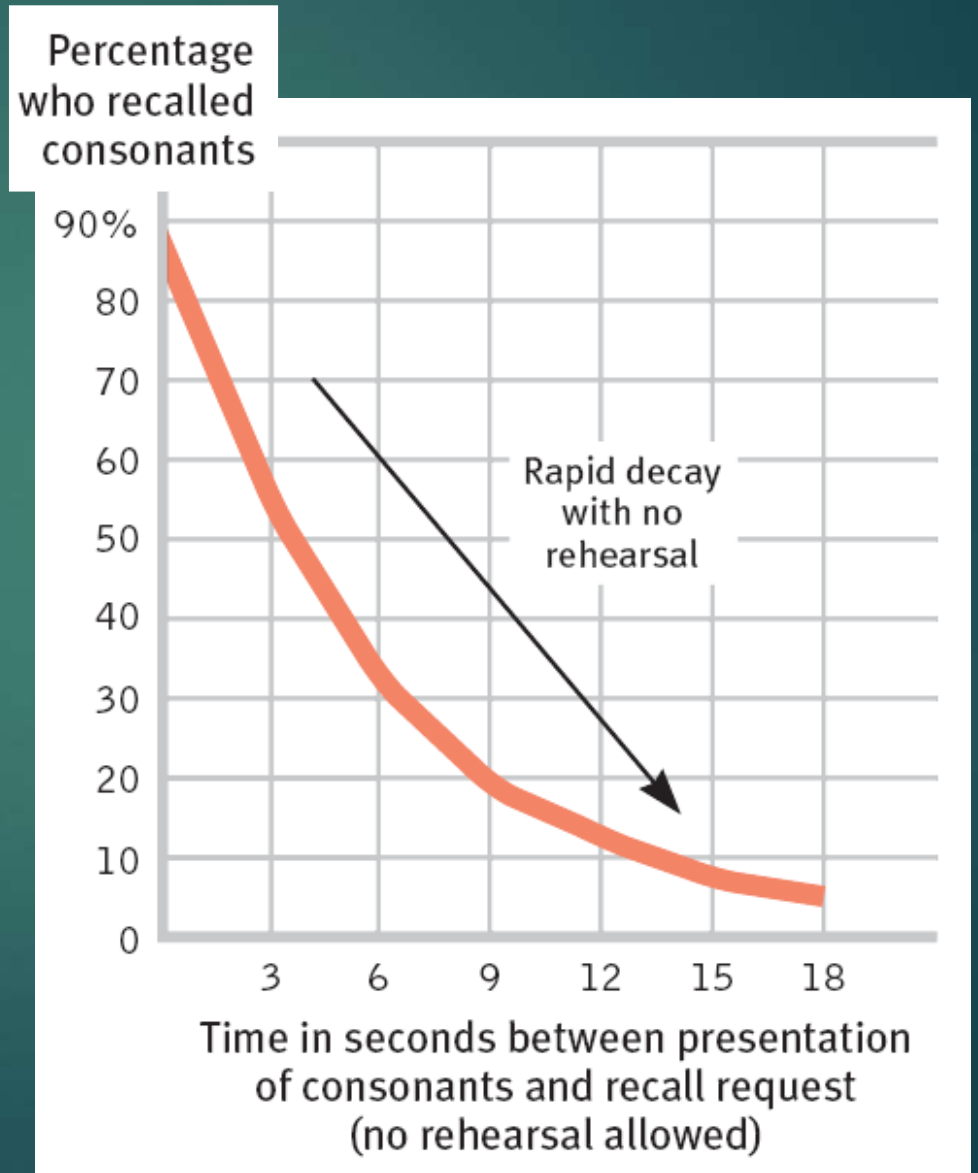
- Low working memory (WM) is strongly linked with poor academic outcomes. Developmental increases in WM are strongly associated with time spent in the classroom, above and beyond chronological age.

Test: see how many of these letters and numbers you can recall after they disappear. Forget the hyphen before the V.

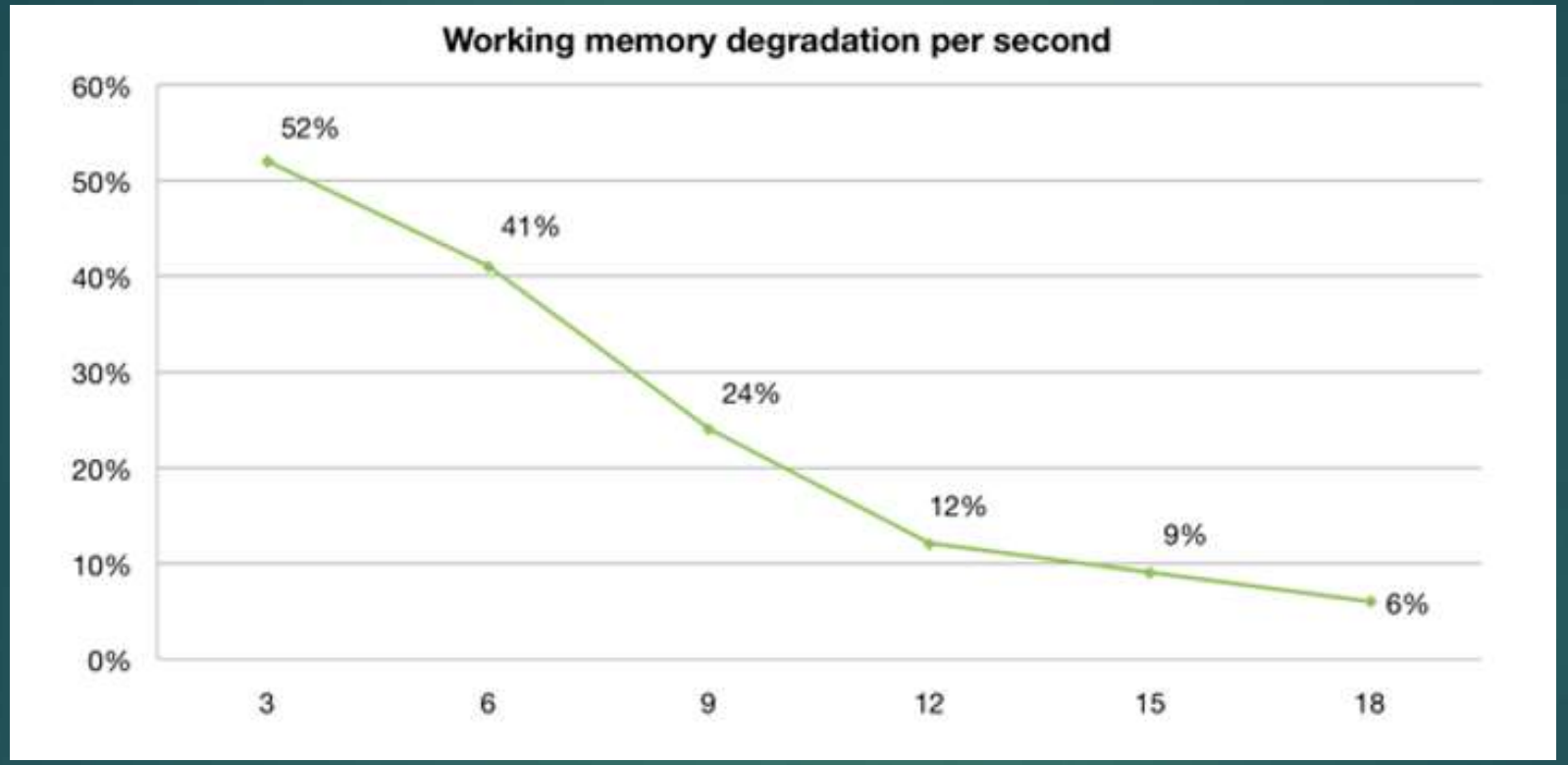
Test:

Duration of Short-Term Memory (STM)

- After 12 seconds, most working memory without rehearsal decays and can not be retrieved



Working Memory degrades, especially with distraction

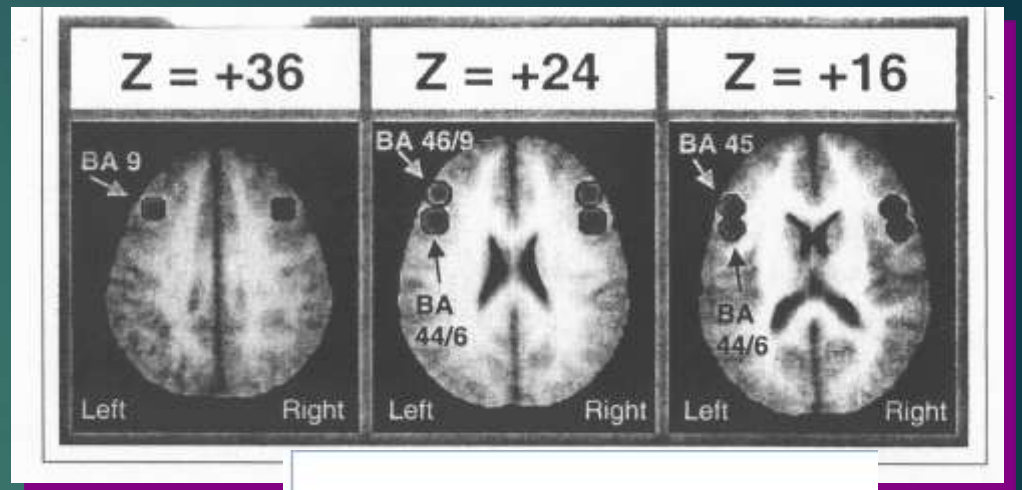


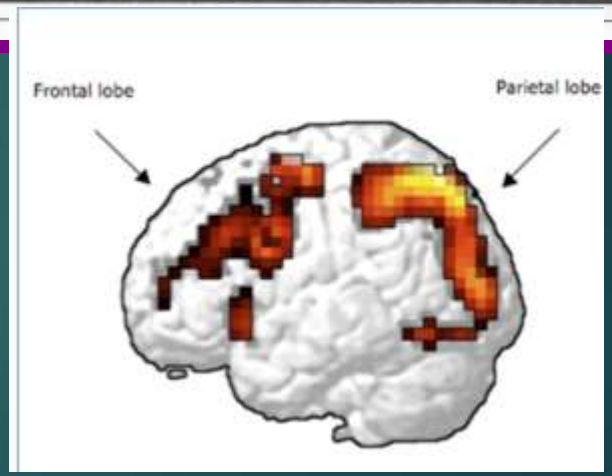
After 15 seconds, less than 10% of original memory is preserved.
Memory degradation occurs after seconds, not minutes.
Distractions cause dramatic losses in WM.

Neuroanatomy of Working Memory

Dorsolateral Prefrontal Working Memory (WM):

- Limited capacity system for temporary storage and manipulation of information
- Neurons turn on during delay period (12 sec)
- Good WM requires optimal dopamine function
- Area 46 & 9: Spatial location WM – “where” system; Area 45: Visual feature WM – “what” system; Area 44: Linguistic WM
- Most WM tasks use a network of PFC and parietal areas. During WM task connectivity b/w areas ↑↑





P. Goldman-Rakic (1995)

Choking up: WM can hold only so much info

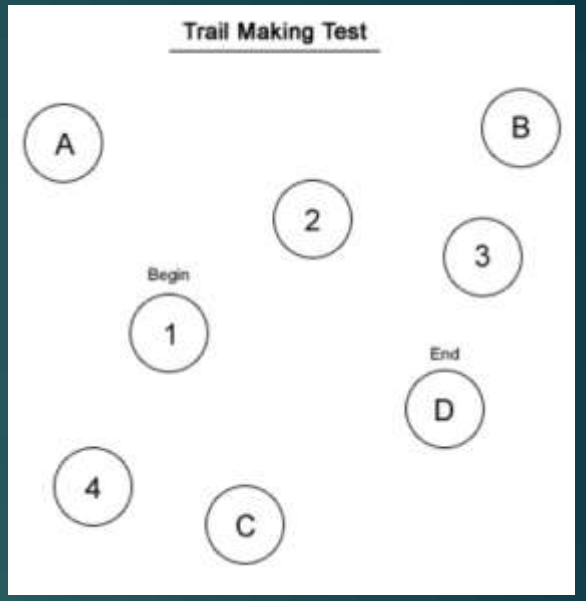
- More WM capacity a person has, the better their performance on academic tasks (problem solving and reasoning); correlates with higher IQ.
- Some subjects with higher working memory levels performed very poorly during the high pressure testing situation, choke under pressure
- Worrying about a situation (such as solving an arithmetic problem in front of a group of people) takes up the WM that is available for figuring out the math problem

Tip # 6: Defeat Stereotype threat

- Negative stereotypes hinder stigmatized individuals' performance on difficult tasks.
- Examples: being reminded you are African American before a test; reminded that you are elderly before a memory test; that you are a woman before a math test
- This threat leads to lower performance by reducing WM capacity

- Tip: Writing about your thoughts and feelings about an upcoming math exam for 10 minutes, improves test performance.

Testing Working Memory vs. Sustained Attention



Working Memory:
Digits Forward and Backward
Arithmetic (Multiple 15 x 13 in your head)
Letter Number

Divided Attention:
PASAT (Add 2 numbers, add next number to last, etc.

Sustained Attention:
IVA CPT (Computerized: hit button when you see a 1; if 2, do nothing

Childhood Poverty: Worse Working Memory

- Chronic stress from growing up poor appears to have a direct impact on working memory.

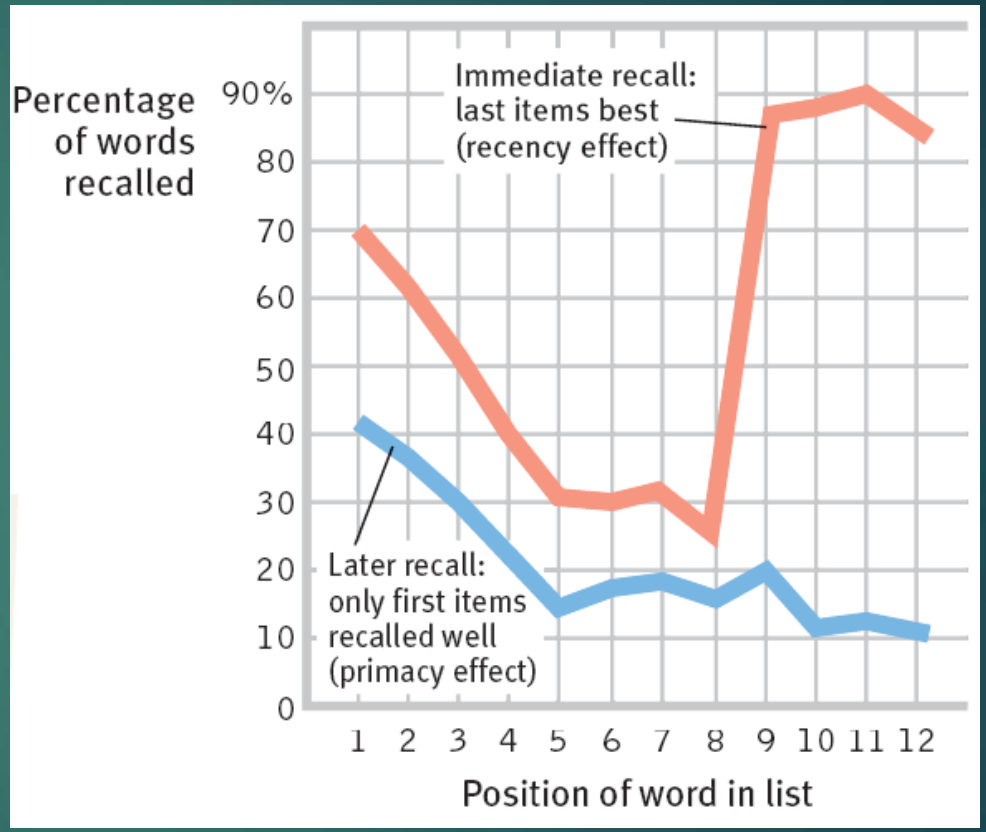
- The longer the children lived in poverty, the higher their stress load and the lower they tended to score on working-memory tests. Those who spent their entire childhood in poverty scored about 20 percent lower on working memory than those who were never poor; 20% thinner cortex

- 14 year study of 95 children from households above and below the poverty line
- Rated the level of stress (scale of "allostatic load"); measured their levels of the stress hormones cortisol, epinephrine and norepinephrine, as well as their blood pressure and body mass index, and tests at age 17 to measure their working memory.

G. Evans, 2009

The Serial Position Effect

The serial position effect refers to the tendency, when learning information in a long list, to *more likely recall the first items* (**primacy effect**) *and the last items* (**recency effect**).



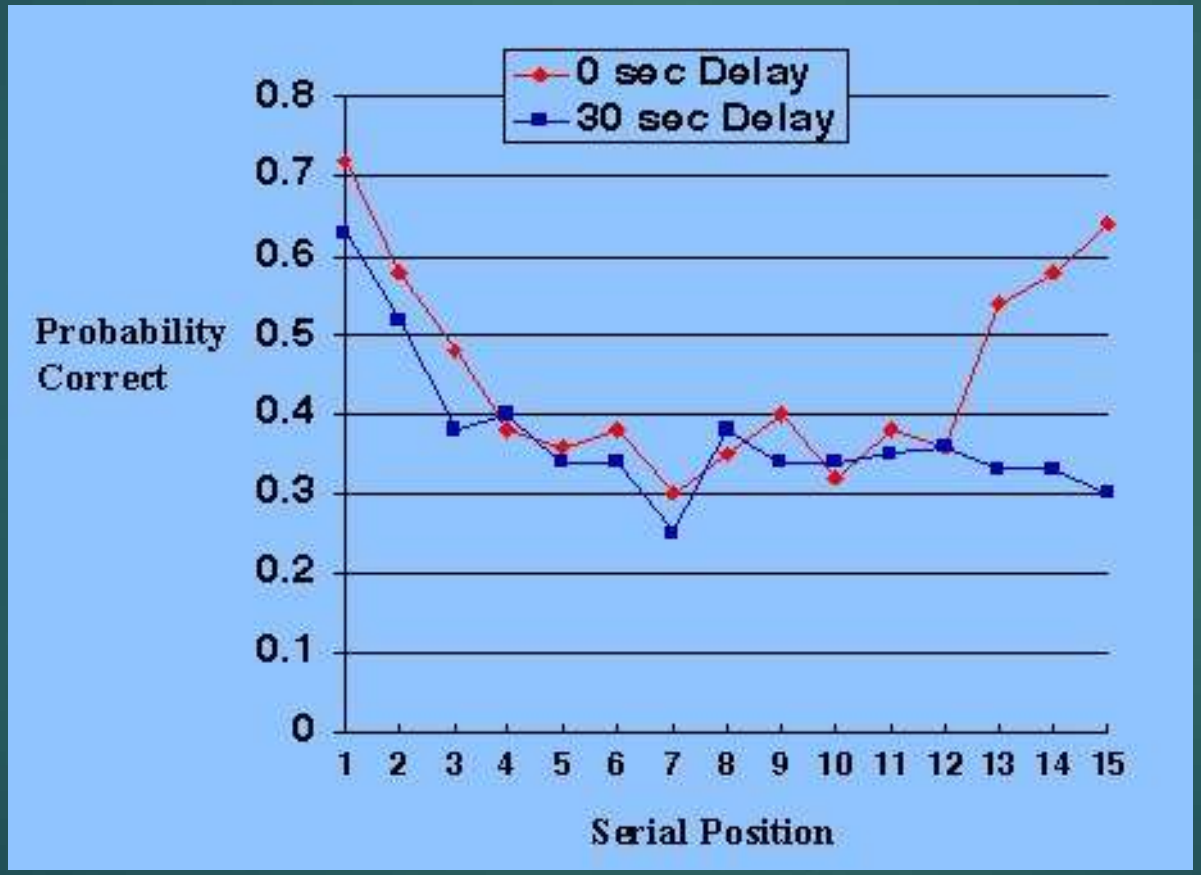
Immediate Recall

Later Recall

Which words of your national anthem are easiest to recall?

Tip #7: Serial Position Effect

We remember 1st and last parts better than the middle



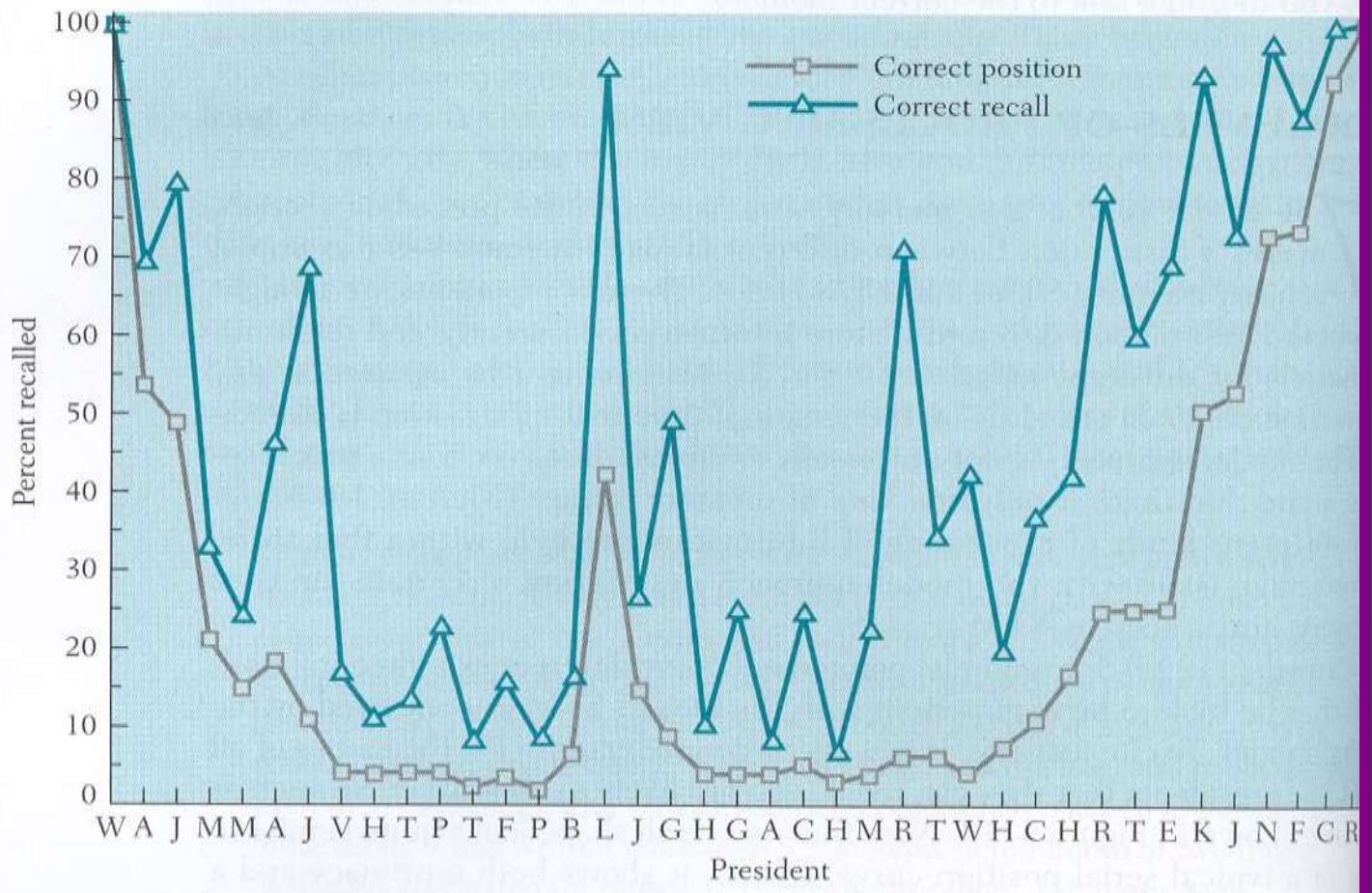
0 sec. delay

30 sec delay

Memory impaired remember only last part.

Unusual Recall of United States Presidents

FIGURE 5–10 ■ *Recall of the names of U.S. presidents as a function of their ordinal position.*
SOURCE: Crowder (1993, p. 143).

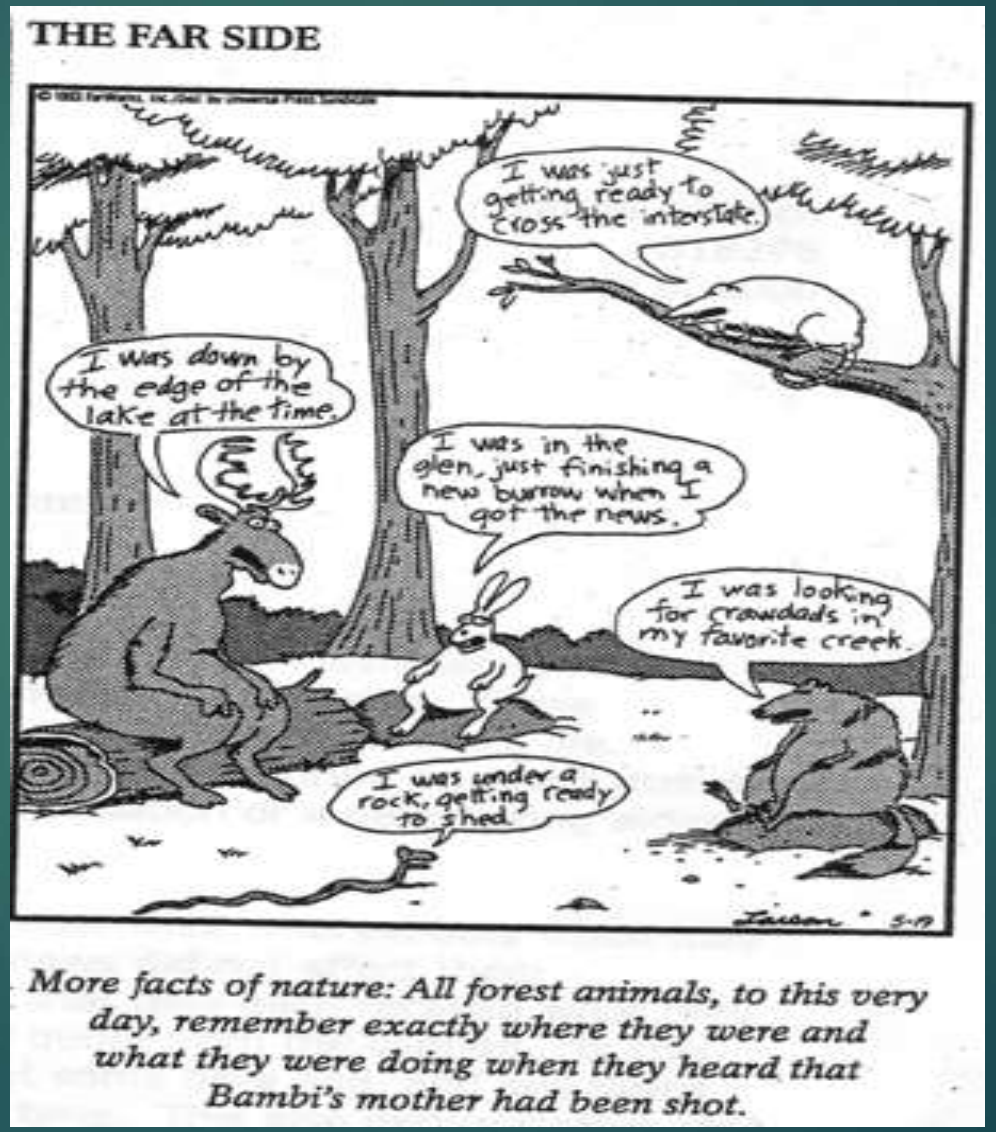


“An impression may be so exciting emotionally as almost to leave a scar upon the cerebral tissues.”

William James (1890)

Flashbulb Memory: My Daughter Lea at age 4 & Bambi's mother

All animals know where they were when Bambi's mother died.

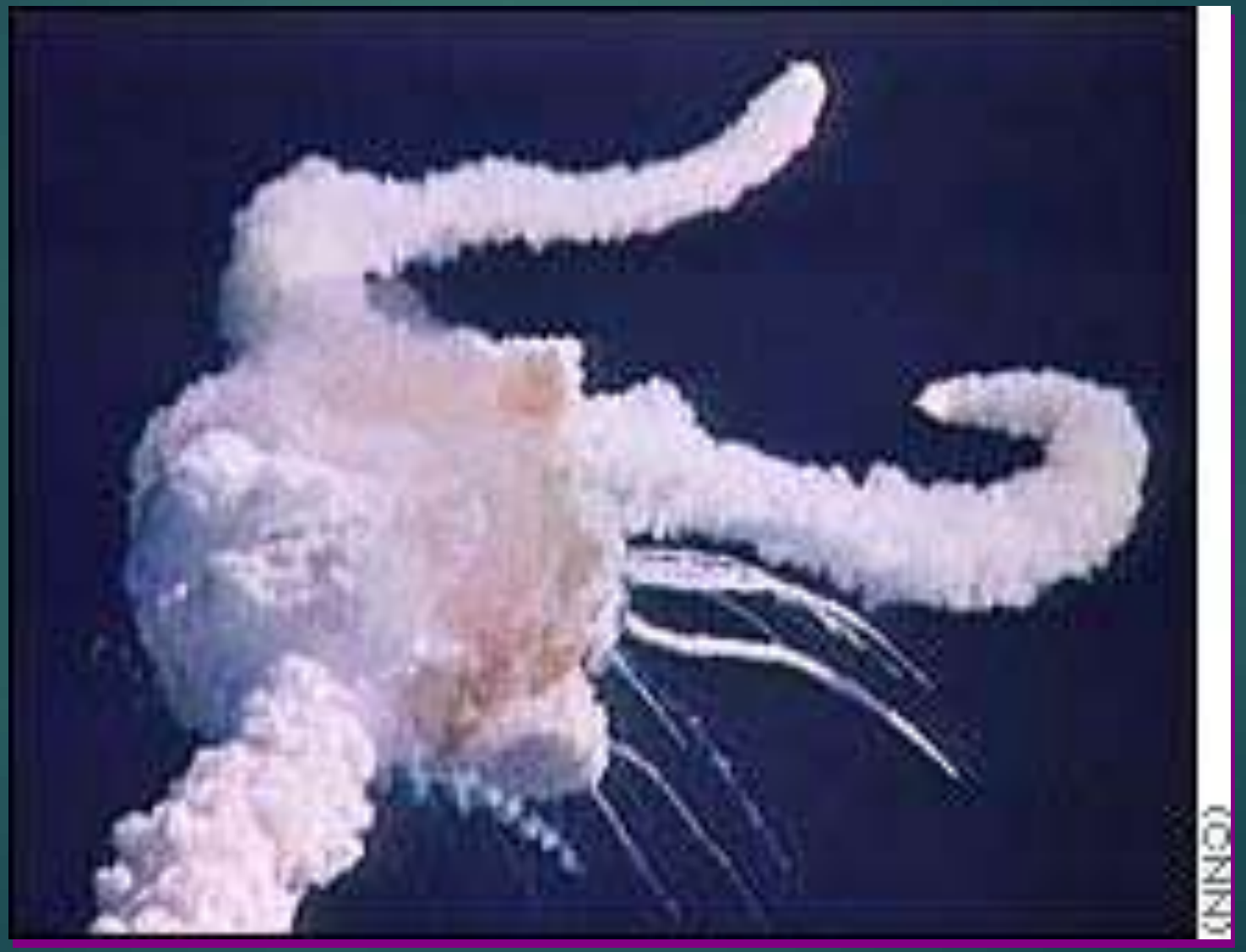


Flashbulb Memory 1: Nov. 22, 1963

CJV: 2 pm in classroom two at Mission San Luis Rey College

Flashbulb Memory 2: 1968

Flashbulb Memory 3: 1986



Flashbulb Memory 4: 1989

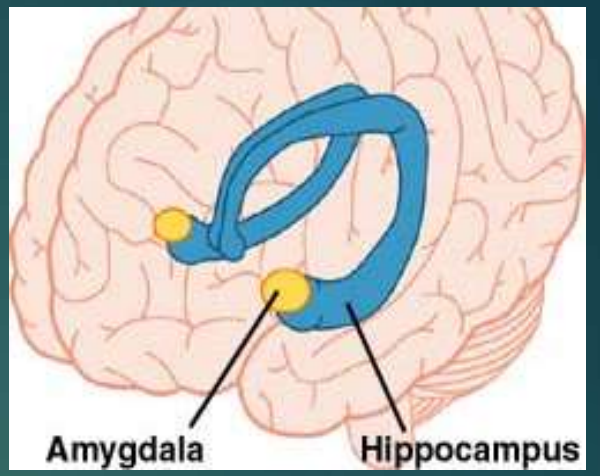
Flashbulb Memory 5: 9/11/2001

9/11/ 2001: 97% of Americans "can remember exactly where they were or what they were doing the moment they heard about the attacks"

Emotions and Memory

- Strong emotions, especially stress, can strengthen memory formation.
- **Flashbulb memories** refer to emotionally intense events that become “burned in” as a vivid-seeming memory.
- Note that flashbulb memories are not as accurate as they feel.
- Vividly storing information about dangers may have helped our ancestors survive.

Emotions, Stress Hormones, the Amygdala, and Memory

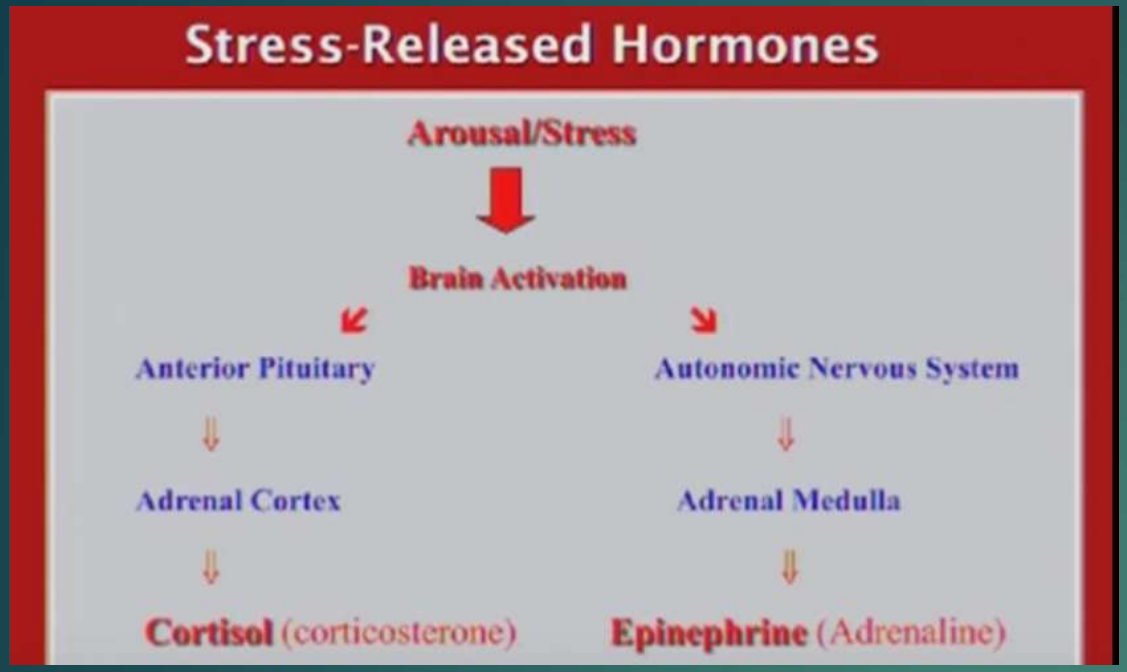


How does intense emotion cause the brain to form intense memories?

1. Emotions can trigger a rise in stress hormones.
2. These hormones trigger activity in the amygdala, located next to the memory-forming hippocampus.
3. The amygdala increases memory-forming activity and engages the frontal lobes and basal ganglia to "tag" the memories as important.

As a result, the memories are stored with more sensory and emotional details.

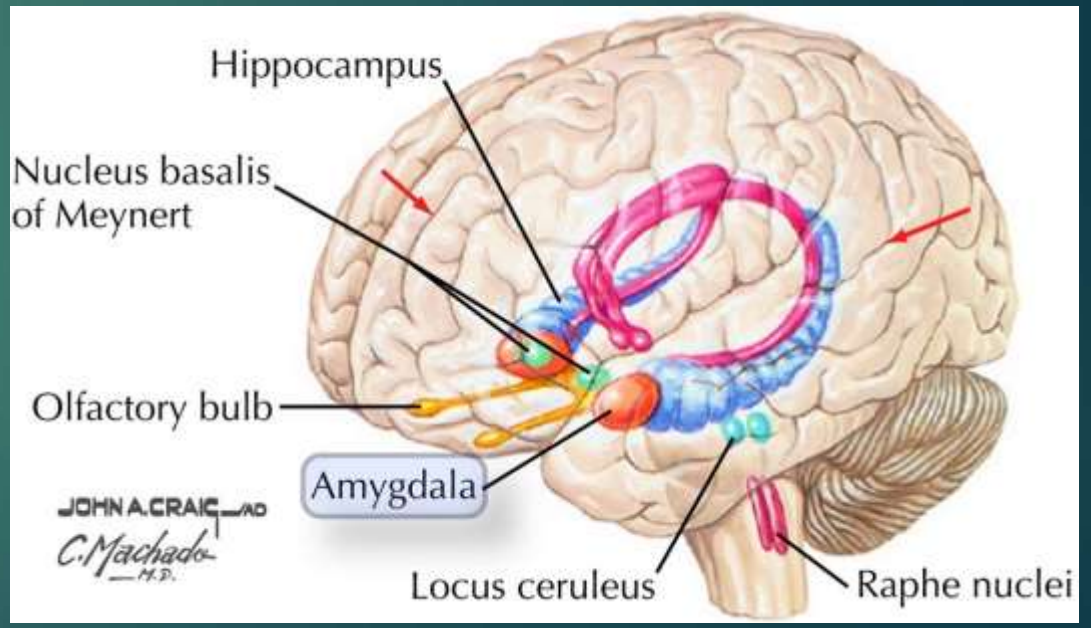
- These details can trigger a rapid, unintended recall of the memory.
- Traumatized people can have intrusive recall that is so vivid that it feels like re-experiencing the event.



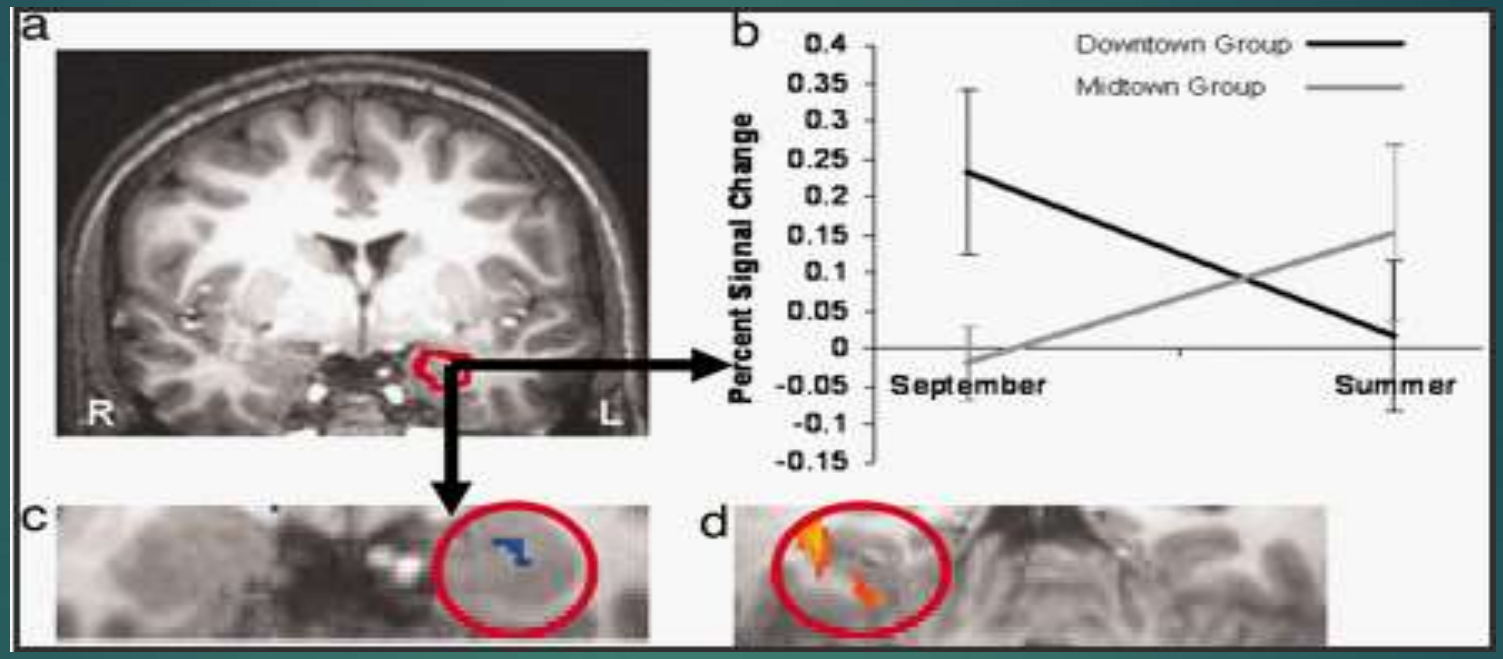
Amygdala has more brain connections to other brain regions than any other region

Traumatic/emotional/excitement Memory: Stress hormones in the amygdala create stronger memories; controls the consolidation of memory;

There are a number of ways to block this memory formation



Proximity to World Trade Center:
Recall and Amygdala



Participants **who were <u>closer to the WTC showed decreased activation in the posterior parahippocampal cortex</u>** and **<u>increased activation in the amygdala bilaterally</u>** during retrieval of 9/11 memories relative to summer memories

Sharot, et al., PNAS, 2008

Tip #8: More emotional the event, the better the recall

- Flashbulb Memories - Where were you when: JFK or MLK killed, Challenger (1/26/86), O.J. Trial Decision, 1989 SF earthquake, 9/11/2001, cancer dx, trauma happened
- Flashbulb Memory: what, where, who with, doing what
- Traumatic memories are basically really intense flashbulb memories.
- Marked by vividness, immediacy, visual primacy and emotionally intensity
- More emotional the reaction (Amygdala), stronger the memory
- But can become distorted

Lay theories of personal identity: memory or morality?

- John Locke thought autobiographical memories were the key to personal identity.

- Study of other people's perception of someone's identity: memory does not sustain someone's "true self."

- Instead, the winner was *morality:* Moral traits are considered more important to personal identity than any other part of the mind.

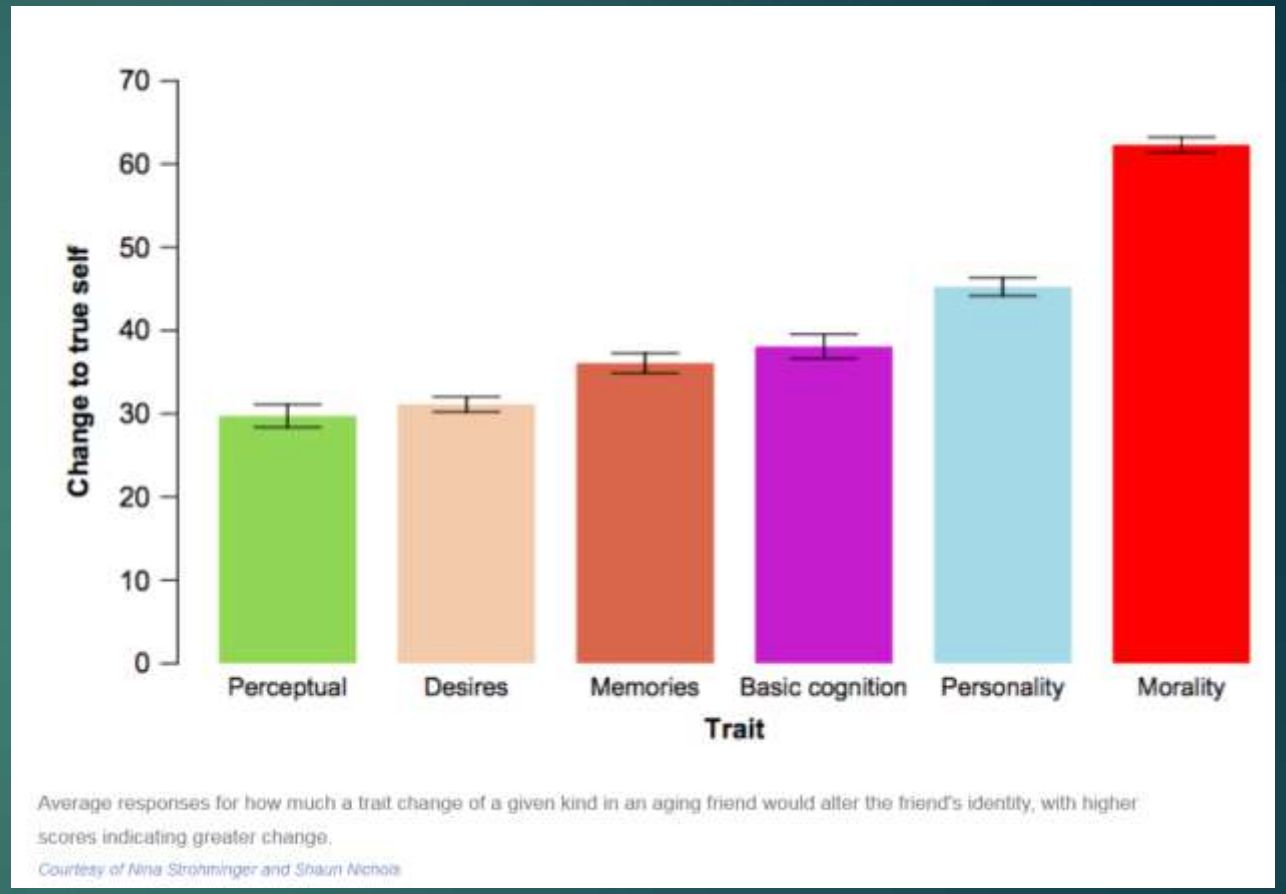
N. Strohminger & S. Nichols

Autobiography or Moral behavior?

What would make your wife a different person?

“If she stopped being kind. I’m saying if she turned into a permanent bitch with no explanation. Her soul would be different.’

Even heaven and hell are for morally good or bad, not whether you were good or bad bowler.



Average responses for how much a trait change of a given kind in an aging friend would alter the friend's identity, with higher scores indicating greater change.

Courtesy of Nina Strohminger and Shaun Nichols

Identity-conferring part of a person is his moral capacities.

Trauma and Memory

- Severe personal trauma: rape, assault, etc.
- Traumatic Memory: fragmentary sensory components of traumatic event with no linguistic narrative of event (Implicit memory; mediated by Amygdala, not Hippocampus);
- Traumatic memories are generally encoded without significant left hemisphere and associated language systems input. Rather they are strongly sensory, somatic, and emotional. As a result, these memories are generalized and decontextualized.
- PET: Evocation of traumatic memory shows Right Hemisphere increased activation of limbic, amygdala, and visual centers, and decreased Left Broca's area

(Krystal, et al. 1998).

Development of Memory

Patricia J. Bauer, 2007:

- Object shape recollection: Infants will look longer at something new than something they are familiar with;
  - shorter the look, better the recall

- From age six months to two years, memory increases from about 24 hours to remembering a year in the past

- Adults' earliest memory of childhood tends to be of emotional events, either positive or negative

Development of Memory 2

- Infants
  - recognize mother within hours;
  - deferred imitation by 1 year;
  - references to past events by age 2;
  - recall at 2-3 locked to vocabulary level
- Capacity: WM increases with age and school exposure

  (age 4 = 3 items; age 12= 7 items)
- Rehearsal ability develops from age 5 to 10
- Use of memory categorization to remember develops

Development of Memory 3

- Parental reminiscing style influences child's autobiographical memory: talking a lot, questions, details, emotions

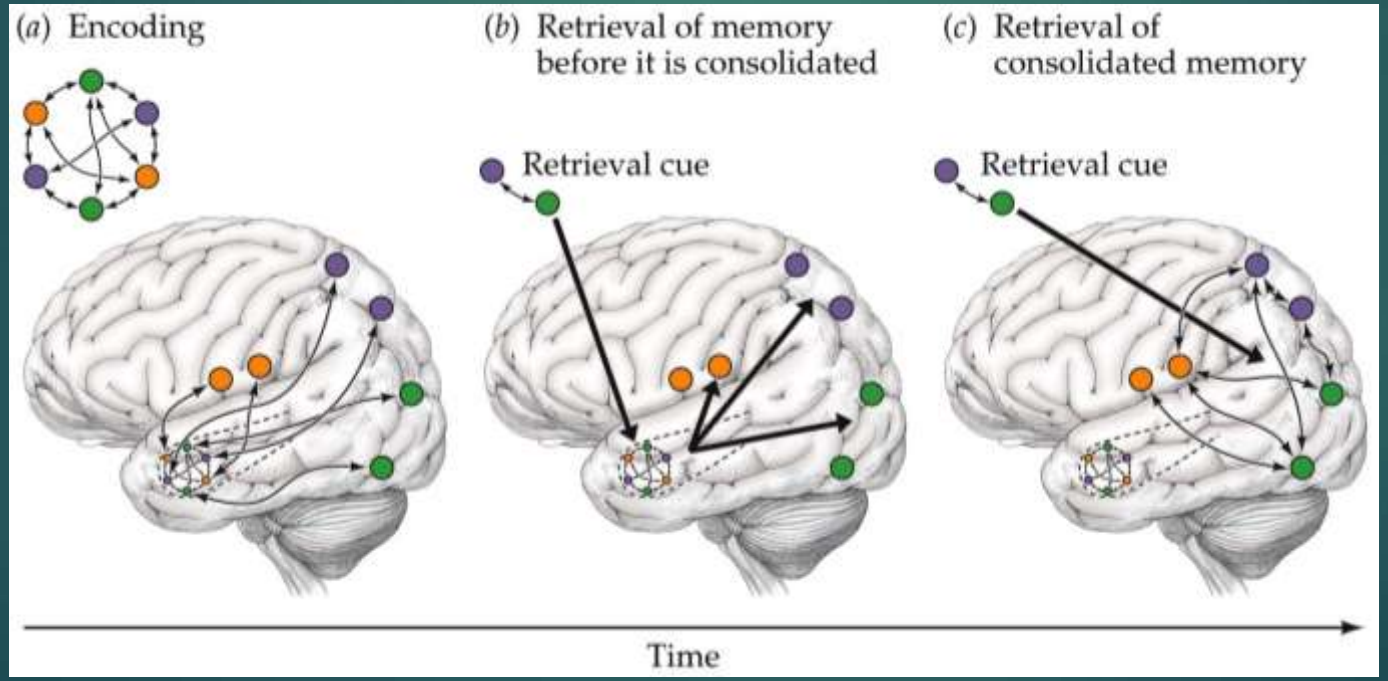
- Adult women have longer, more detailed, more vivid, more emotionally laden autobiographical memories than men

- Individuals from Western cultures have earlier age of first memory and have longer and more detailed memories of childhood than those from Asian cultures (related to social emphasis on importance of the individual vs. social)

Fivush & Nelson, 2004

So where is memory stored? It's complicated

- Multiple brain regions are involved in encoding long-term memory (as shown by fMRI)



Need hippocampus Don't need it

The Location of the Engram

- What is Long Term Memory:
  - Perceptual experience is stored as the outcome of the specific sensory perceptual processing operation and in the same areas involved in the original perception and analysis of the event.

- The increased probability of a network firing a similar pattern is how network of neurons “remembers.”

- Locus of storage determined by sensory modality relevant to original learning and nature of the information, i.e. shape, color, function

The Location of the Engram: Entire brain

- Distributed Network of associations: Memory is located in multiple locations corresponding to specific sensory aspects located in different sensory areas via sensory network activation

- Synaptic pathway reinforcement as creator of our long term memories via long term potentiation.

- Location of LTM: All over the brain: Posterior Occipital, Parietal, Temporal lobes, Frontal (for motor programs); & BG and Cerebellum

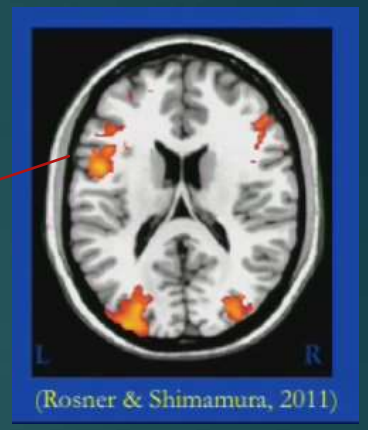
Brain and Memory

- Multiple brain regions are involved in encoding a new memory
- Consolidation of memory involves the hippocampus but the hippocampal system does not store long-term memory.
- LTM storage occurs in the cortex, where the memory was first processed and held in short-term memory.

Tip #9: Self Generation effect

- If you personally generate a memory, you will remember it 30% better recall post self generation

- Example:
  - Read: Garbage – Waste
  - Generate (fill in the blank): Quarrel - F_ght



- Talk about it to others or in front of mirror or use flashcards

Neuroanatomy of Memory Functioning

Hippocampus: Dentate, CA1, CA3

Entorhinal Cortex

Subiculum: 1st 15 seconds

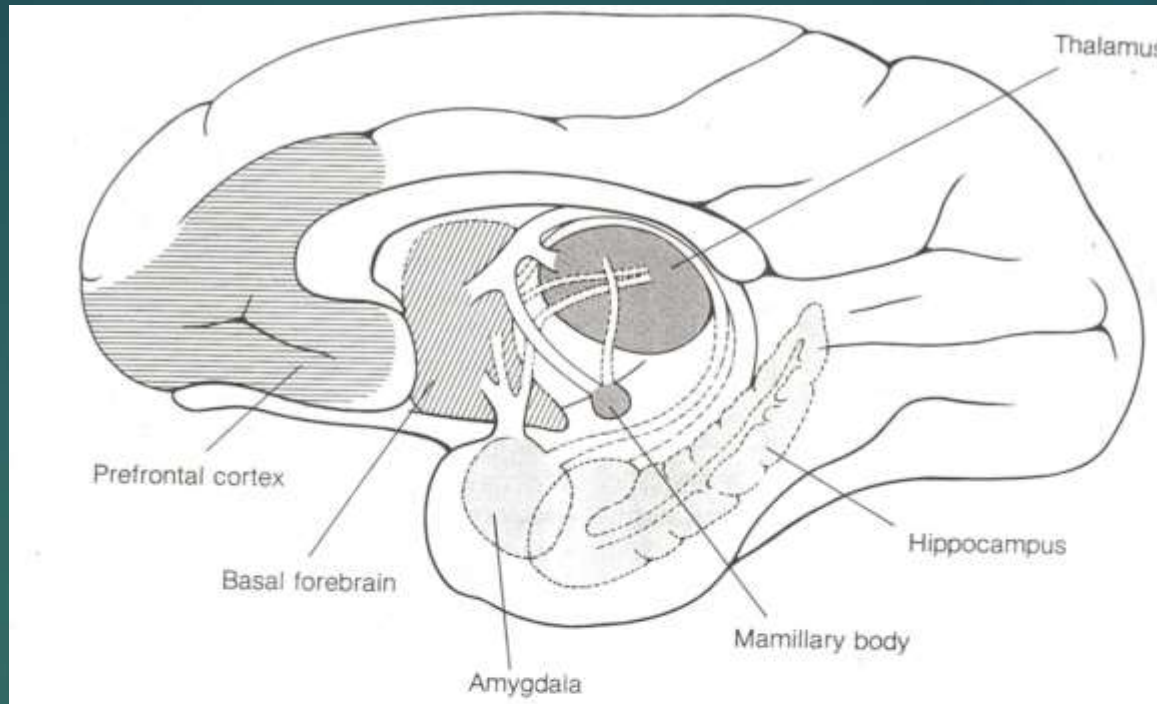
Parahippocampal Cortex

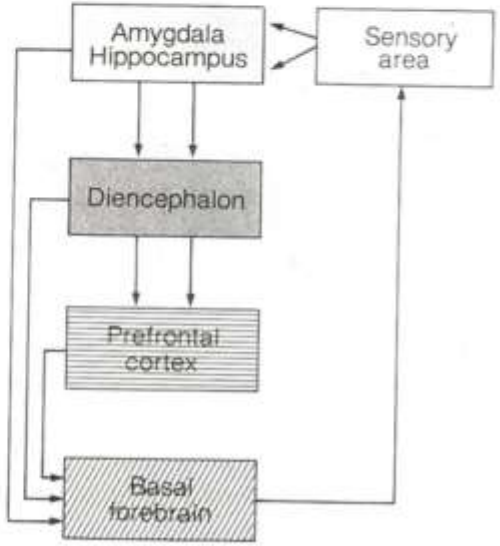
Perirhinal Cortex

Amygdala

Diencephalon: Thalamus & Hypothalamus: Mammillary Bodies

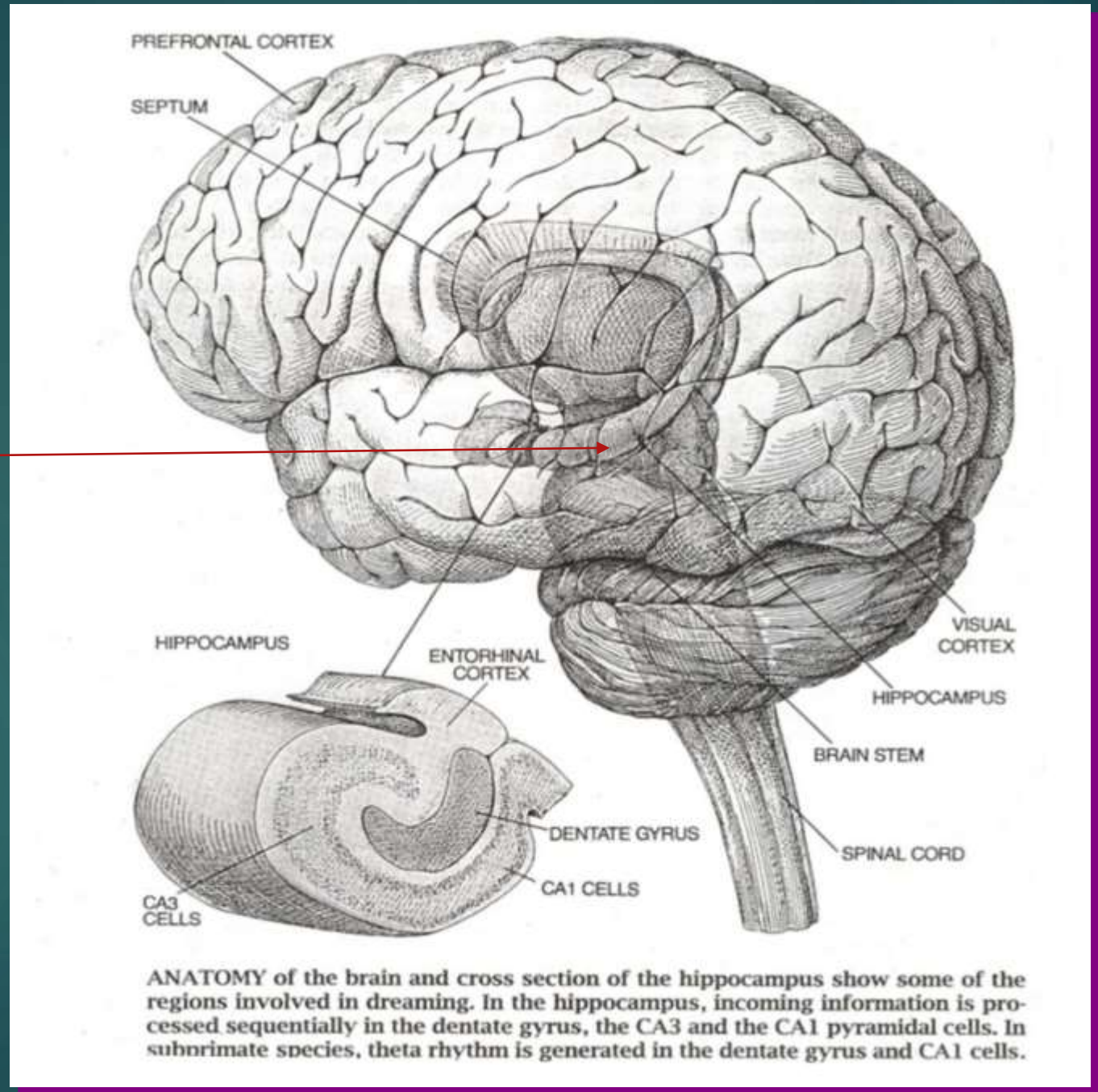
Ventromedial Prefrontal & Basal Forebrain


Thalamus
Prefrontal cortex
Basal forebrain
Amygdala
Mamillary body
Hippocampus

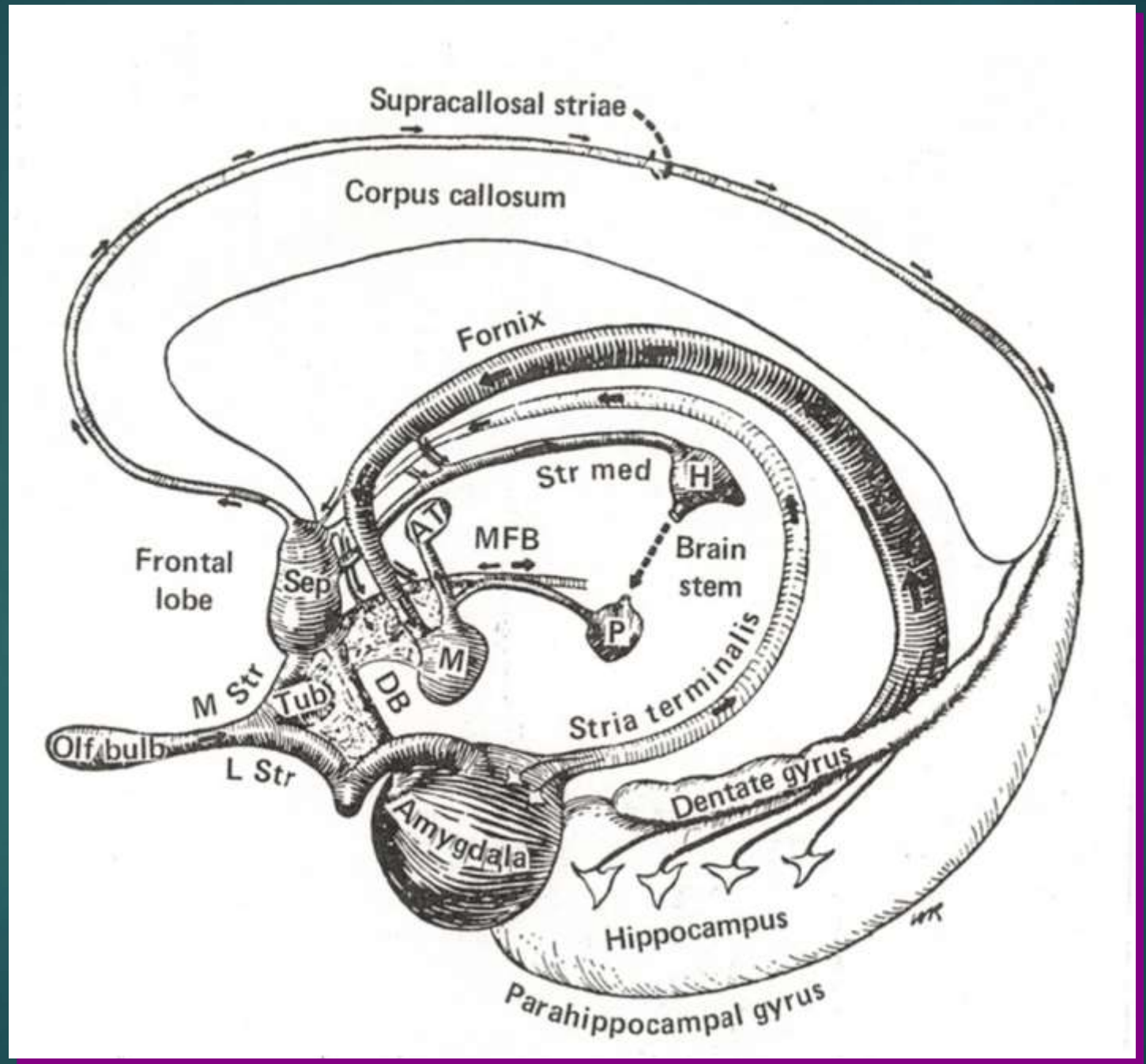

Amygdala
Hippocampus
Sensory area
Diencephalon
Prefrontal cortex
Basal forebrain

Location of Hippocampus

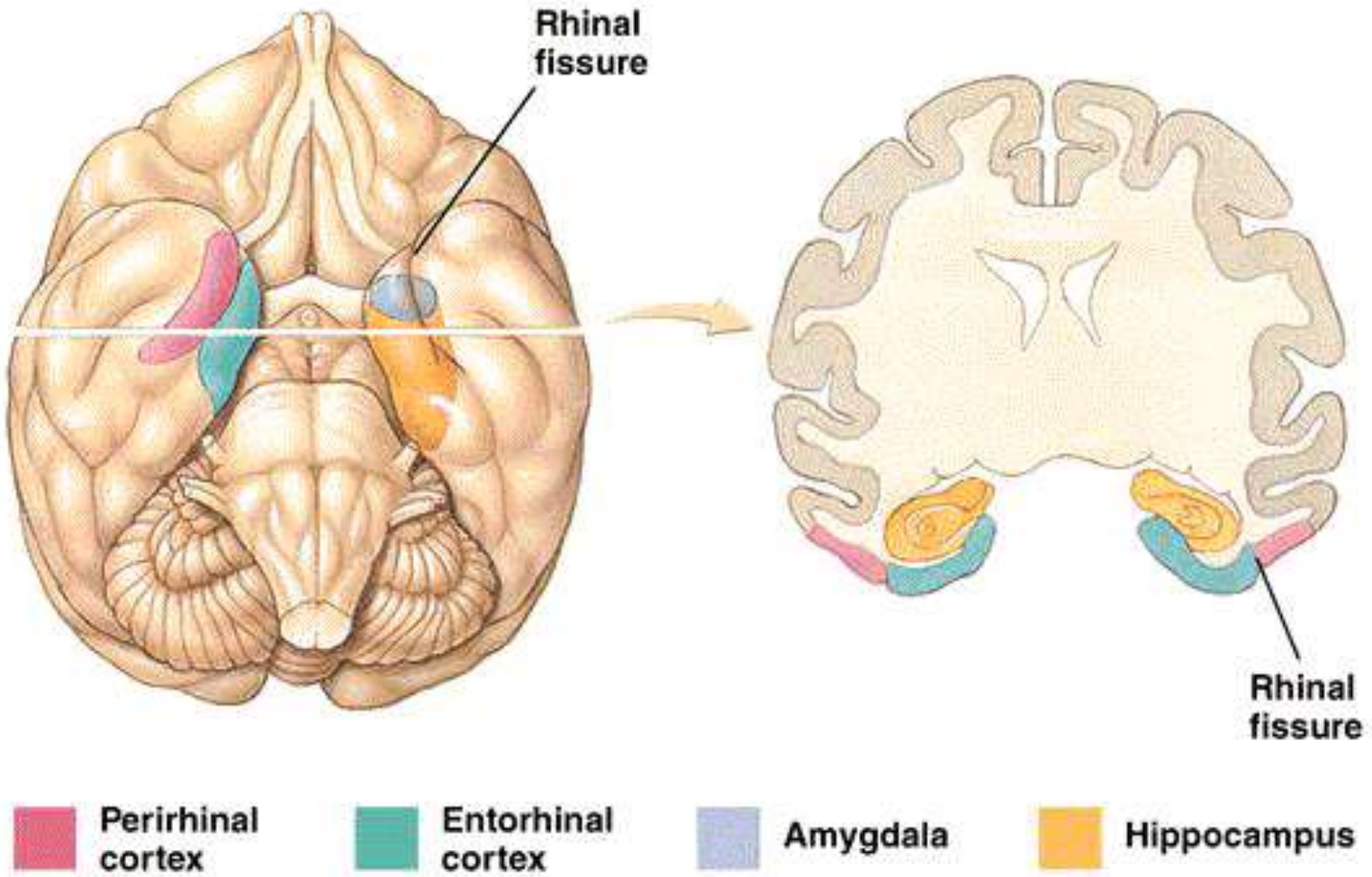
Hippocampus



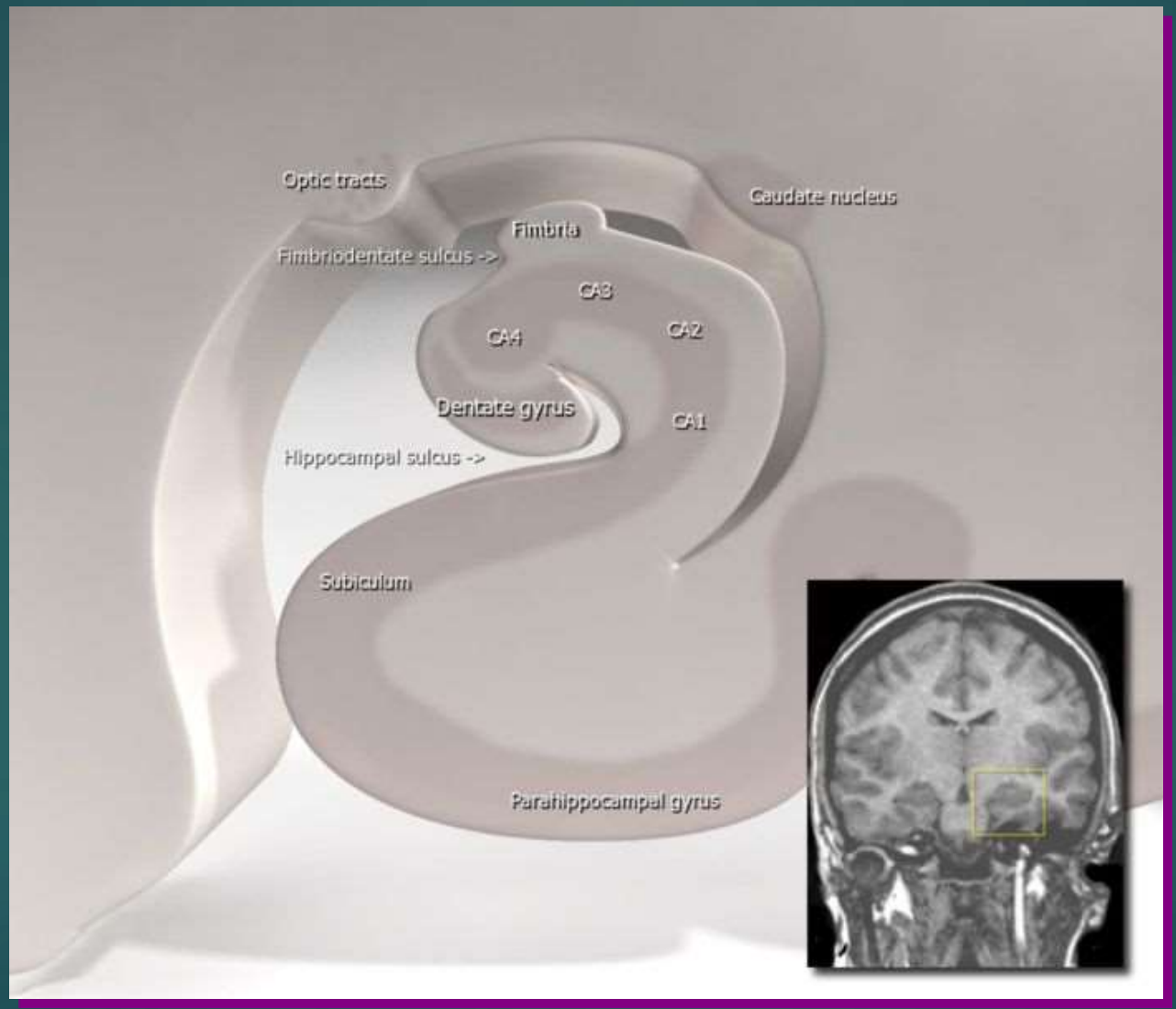
ANATOMY of the brain and cross section of the hippocampus show some of the regions involved in dreaming. In the hippocampus, incoming information is processed sequentially in the dentate gyrus, the CA3 and the CA1 pyramidal cells. In subprimate species, theta rhythm is generated in the dentate gyrus and CA1 cells.


Supracallosal striae
Corpus callosum
Fornix
Str med
H
AT
MFB
Brain
stem
Frontal
lobe
Sep
P
M
M Str
Tub
DB
Stria terminalis
Olf bulb
L Str
Dentate gyrus
Amygdala
Hippocampus
Parahippocampal gyrus

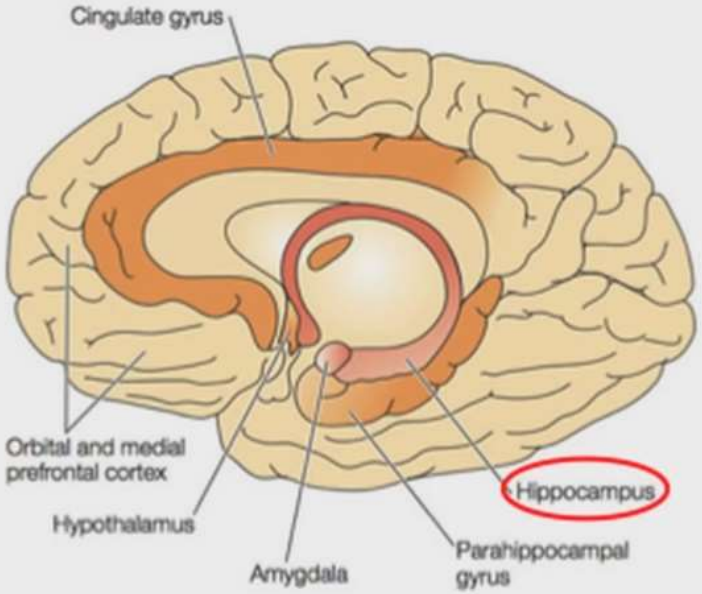
► The Three Major Structures of the Medial Temporal Lobe



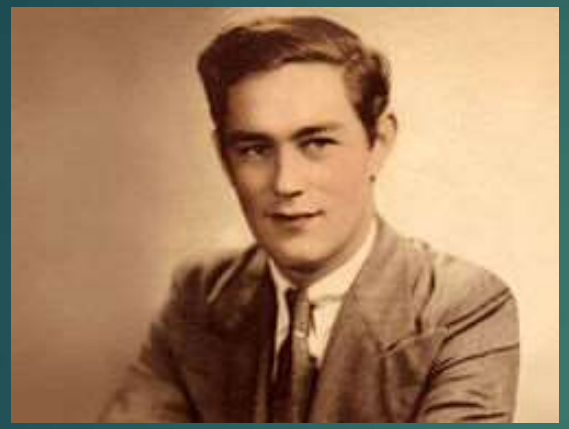
Hippocampus, Subiculum, Parahippocampal Gyrus

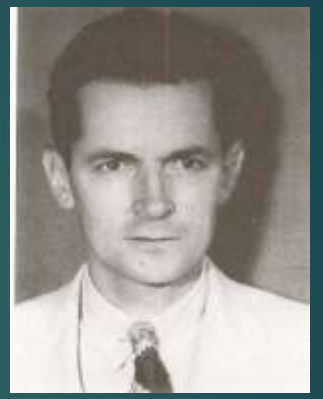


Hippocampus



Henry Gustav Molaison, 1926-2008





William Scoville MD

Brenda Milner PhD

Patient H. M.

The most important patient in the history of neuroscience.
100 researchers studied him

Permanent Present Tense - Suzanne Corkin

Patient H.M.:

Henry Gustav Molaison, 82, of Windsor Locks, CT died on Dec. 12, 2008.

He knew that his father's family came from Thibodaux, La., and his mother was from Ireland, and he knew about the 1929 stock market crash and World War II and life in the 1940s.

And in 1953, he underwent an experimental brain operation in Hartford to correct a seizure disorder, and became the perfect practitioner of being “in the moment”.

He is known in the medical and scientific literatures as the amnesic patient, H.M., the most important patient in the history of neuroscience.

HM

Henry Molaison
Scoville & Milner, 1957

"What do you do during a typical day?"

"See, that's tough – what I don't…I don't remember things."

"Do you know what you did yesterday?"

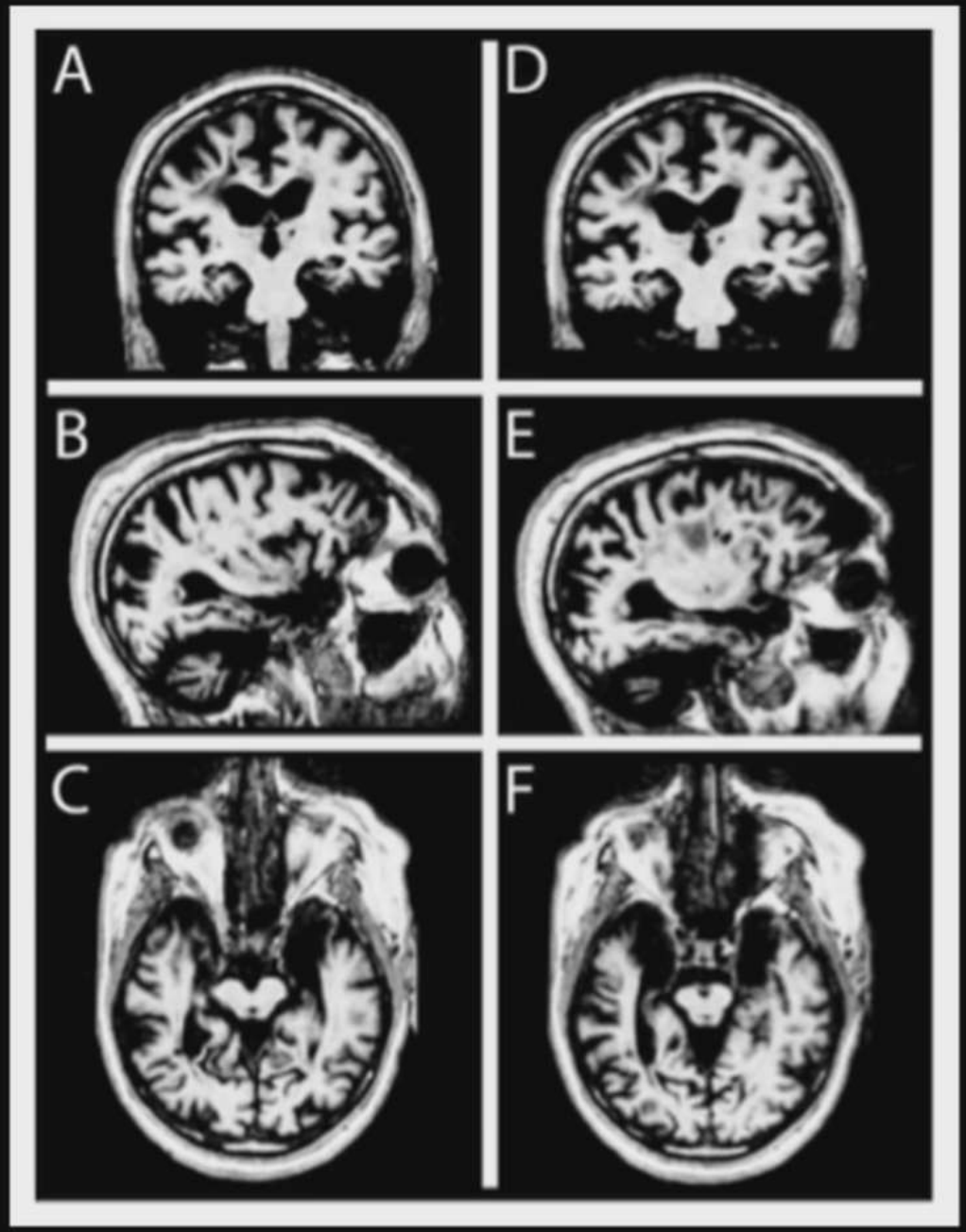
"No, I don't."

"How about this morning?"

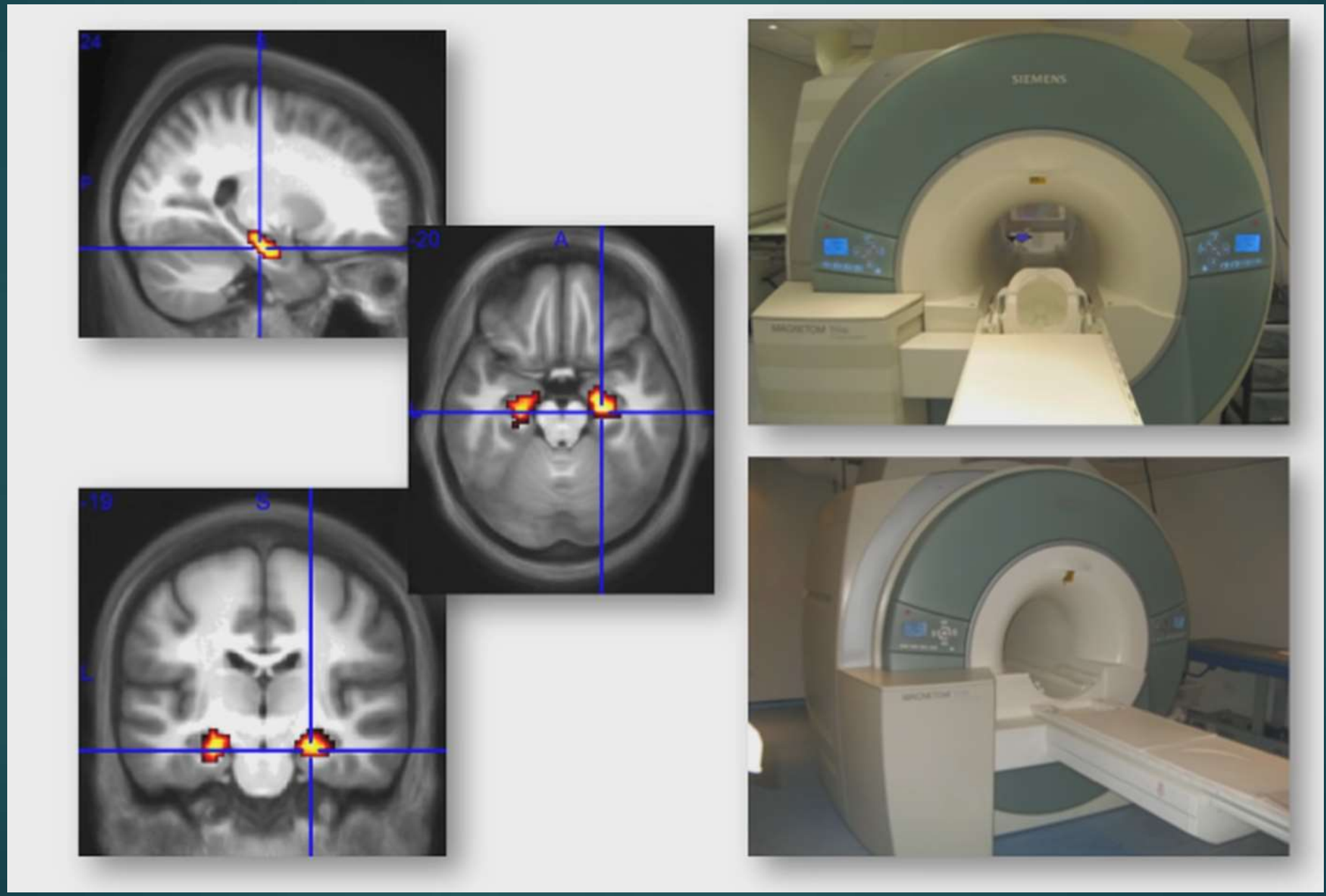
"I don't even remember that."

"Could you tell me what you had for lunch today?"

"I don't know, tell you the truth. I'm not-"



Recalling past experiences activates hippocampus on fMRI



H.M.

- Because of his severe epilepsy (due to bike accident at age 10) that had foci in the medial temporal lobe, he had a bilateral medial temporal lobectomy in 1953.
- The good news was that it greatly reduced his epileptic problems.
- The bad news was that he showed a severe anterograde amnesia – no more new learning.
- In last 54 years, 100 investigators have studied him.

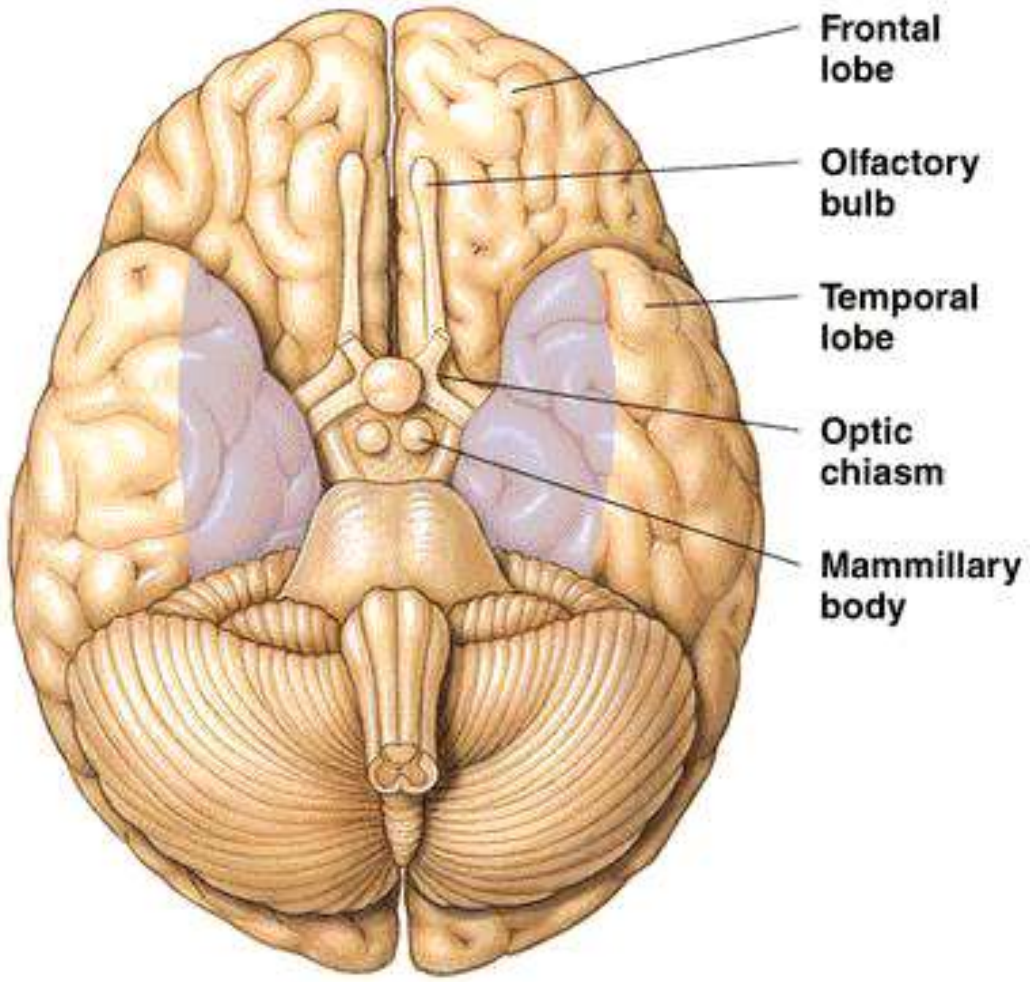
Milner et al., 1968; Corkin, *Perfect Present*

H.M. 2

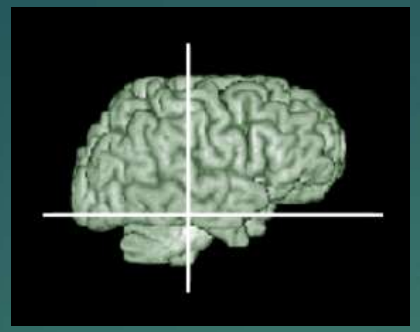
- Absence szs at 10; GM szs at 16; bilateral medial temporal surgery at 27
- H.M.'s fame began in 1957 with publication of Scoville & Milner's paper, "Loss of recent memory after bilateral hippocampal lesions." (cited 1744 x since 1957)
- Their conclusion: Severity of amnesia (loss of new learning ability) correlates with size of hippocampal removal

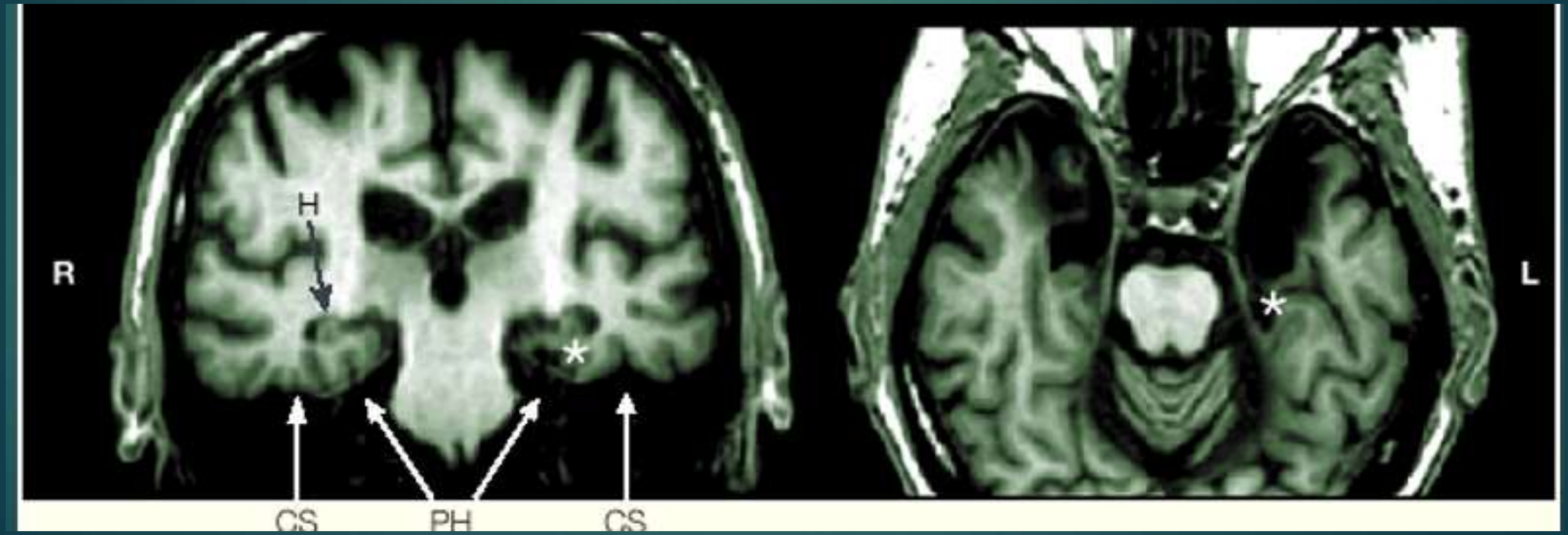
Scoville & Milner, *JNNP,* 1957

► Medial Temporal Lobectomy



H.M.





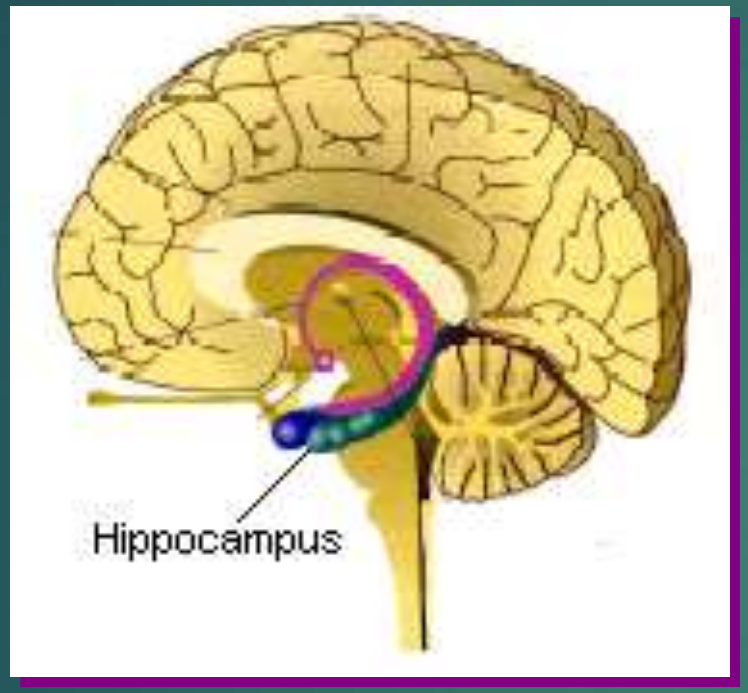
Assessment of H.M.

Brenda Milner

Suzanne Corkin

Permanent Present Tense

Storing Memories: The Case of H. M.



- **Surgical removal of hippocampus (bilateral)**
- **Severe new learning deficit (anterograde amnesia)**
- **Some memory loss for recent memories (retrograde amnesia of 11 years)**
- **Intact working memory, normal IQ, normal knowledge base**

"Right now, I'm wondering. Have I done or said something amiss? You see, at this moment everything looks clear to me, but what happened just before? That's what worries me. It's like waking from a dream."

Source: A.P. Shimamura, 2003

Hippocampus

- Important for formation of new episodic (personal) memories

- Important for encoding perceptual aspects of memories
  - Novel events, places, and stimuli

- Important for declarative memory
  - Involved in recollection and familiarity

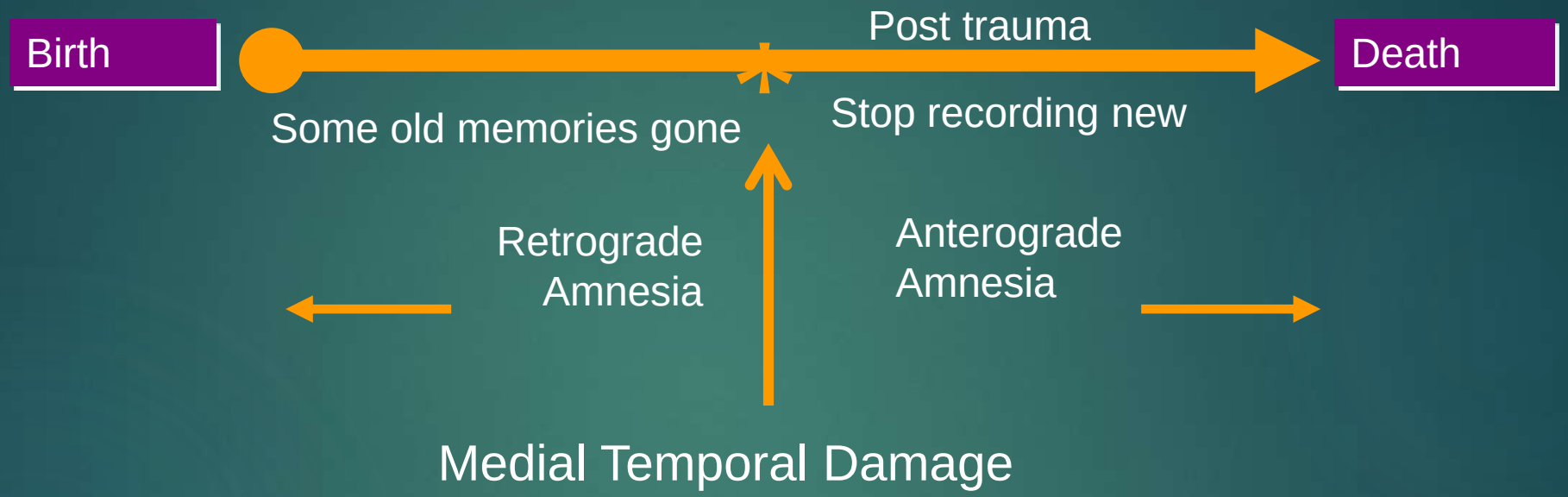
- Plays a critical role in forming what-when associations (memory for the order in which specific events occurred). Rats with hippocampal damage were shown to have normal memory for the individual items presented (what) but fail to remember the temporal relationships among events

H.M.’s Hippocampal Amnesia

- Global declarative (factual) amnesia, irrespective of:
  - Kind of memory test (FR, CR, Rcg, MC)
  - Kind of verbal, visual, spatial stimuli (words, digits, faces, tones, mazes, events)
  - Kind of sensory modality (5 senses)

- Deficit episodic (personal) and semantic (knowledge) memory
- Normal working memory
- Normal language (lexical and grammatical) processing
- Normal premorbid semantic knowledge (WAIS Info, Comp, Sim, Voc over 48 years)

Classic Model of Neurological Amnesia

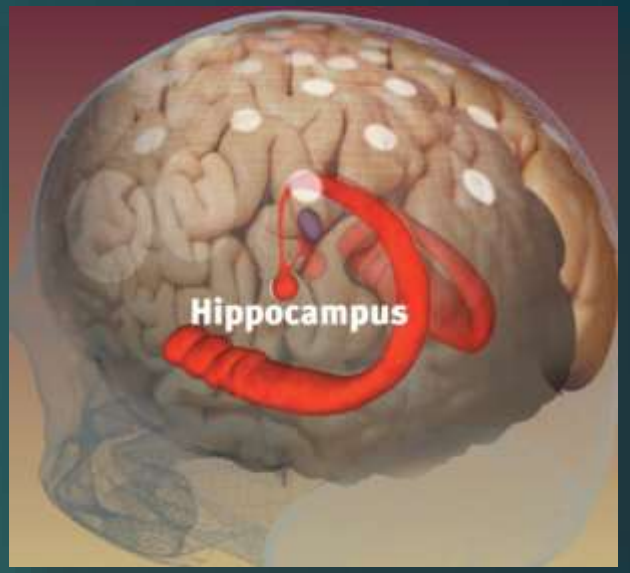


- Anterograde amnesia (loss of new learning ability) is the hallmark feature of neurological amnesia
- Retrograde amnesia is often temporally graded

Source: A.P. Shimamura, 2003

Explicit Memory Processing

Explicit/declarative memories include *facts, stories, and meanings of words* such as the first time riding a bike, or facts about types of bicycles.



- **Retrieval** and use of explicit memories, which is in part a working memory or executive function, is directed by the frontal lobes.

- **Encoding and storage** of explicit memories is facilitated by the hippocampus. Events and facts are held there for a couple of days before **consolidating**, *moving to other parts of the brain for long-term storage*. Much of this consolidation occurs during sleep.

The Two Types of Amnesia

Retrograde amnesia *refers to an inability to* ***retrieve*** *memory of the past.*

- Retrograde amnesia can be caused by head injury or emotional trauma and is often temporary.
- It can also be caused by more severe brain damage; in that case, it may include anterograde amnesia.

Anterograde amnesia refers to an *inability to* ***form*** *new long-term declarative/ explicit memories.*

- H.M. lived with no memories of life after surgery.
- See the movie *Memento.*
- Most other movie amnesia is retrograde amnesia.

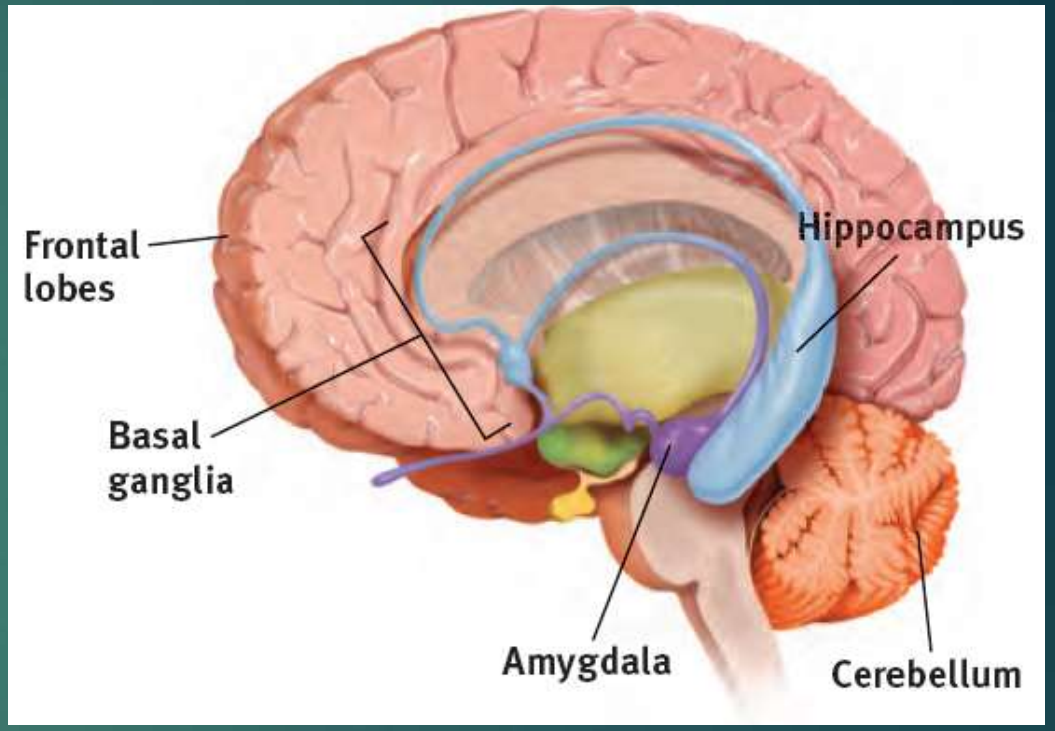
Procedural Memory: Automatic Nonconscious Processing
Some experiences go directly to long-term implicit memory

Some experiences are processed automatically into procedural/behavioral memory, without any effortful/working memory processing:

- **procedural memory**, such as knowing how to ride a bike, and well-practiced knowledge such as word meanings
- **conditioned associations**, such as a smell that triggers thoughts of a favorite place
- Visual spatial experience (information about **space)**, such as being able to picture where things are after walking through a room
- information about **time**, such as retracing a sequence of events if you lost something
- information about **frequency**, such as thinking, “I just noticed that this is the third texting driver I’ve passed today.”

The Brain Stores Reactions and Skills: Procedural Memory Processing

Procedural memories include skills, procedures, and conditioned associations.



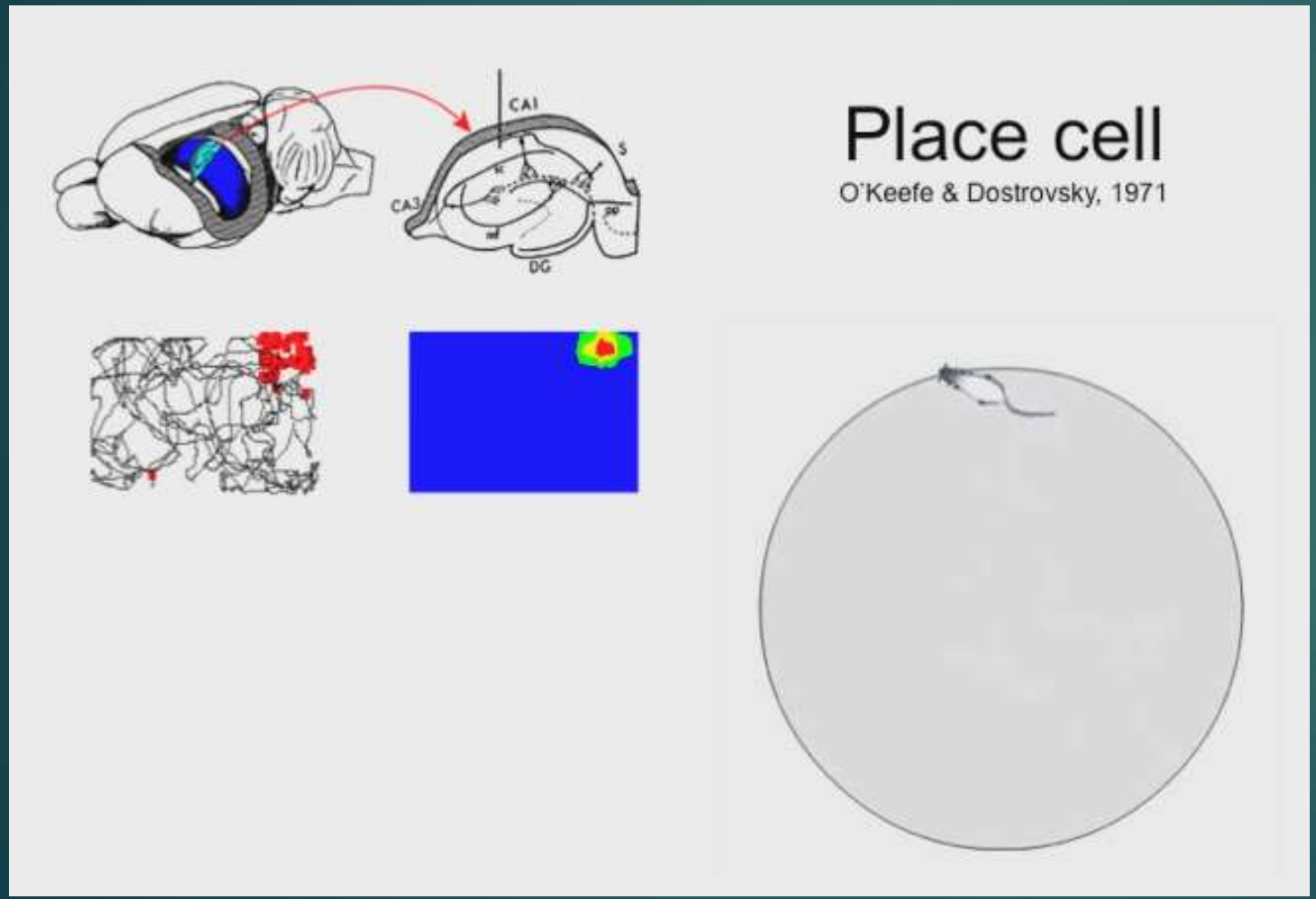
- **The cerebellum** ("little brain") forms and stores our conditioned responses. *We can store a phobic response even if we can't recall how we acquired the fear*.

- The **basal ganglia**, next to the thalamus, controls movement, and forms and stores procedural memory and motor skills.
- *We can learn to ride a bicycle even if we can't recall having the lesson.*

Knowledge Gained from H.M.

- Importance of hippocampus
- STM (WM) and LTM are different forms of memory
- Need medial temporal lobes for memory encoding and consolidation
- Two memory systems discovered:
  - Declarative (Explicit) vs. Behavioral (Procedural) memory:
  - Declarative: Higher level (cortico-limbic) cognitive or associative memory
  - Habit or procedural memory, which relies on more primitive circuitry (cortico-striatal)

Spatial Memory: Spatial location in hippocampus of mice



Place cells in Hippocampus specialize in remembering specific locations.

Crucial for route planning; rats can pre-play 15 future spatial experiences

Role of Hippocampus 2

- Spatial information: right hippocampus is larger in taxi drivers
- Anterior hippocampus indexes generic novelty: adds new to old info
- Posterior hippocampal responses index familiarity to stimuli that have behavioral relevance
- The replay of the hippocampal memory sequence during sleep plays a crucial role in the formation of rapid acquisition of a long-term memory.

Neuroplasticity: Experience changes our brains: London Taxi Drivers

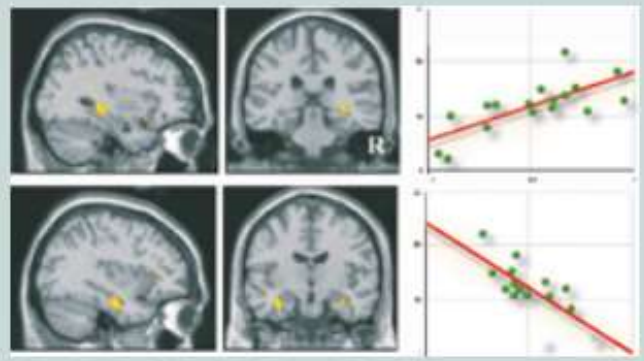
If you lived in London, and wanted to grow your hippocampus, which driving job would you choose?

Knowledge exam: 3 of 10 pass

25,000 streets
1400 landmarks

Study of London Taxi cab drivers (vs. bus drivers): To earn their licenses, cab drivers in training spend three to four years driving around the city on mopeds, memorizing a labyrinth of 25,000 streets within a 10-kilometer radius of Charing Cross train station, as well as thousands of tourist attractions and hot spots. "The Knowledge" exams that only about 50 percent of hopefuls pass.

Larger Right Posterior Hippocampus in London Taxi Drivers: 7% larger , but otherwise normal memory



Christoph Schneider, based on an original from: Maguire EA, Woollett K, Spiers HJ. 2006. London taxi drivers and bus drivers: A structural MRI and neuropsychological analysis. Hippocampus 16:1091-1101.

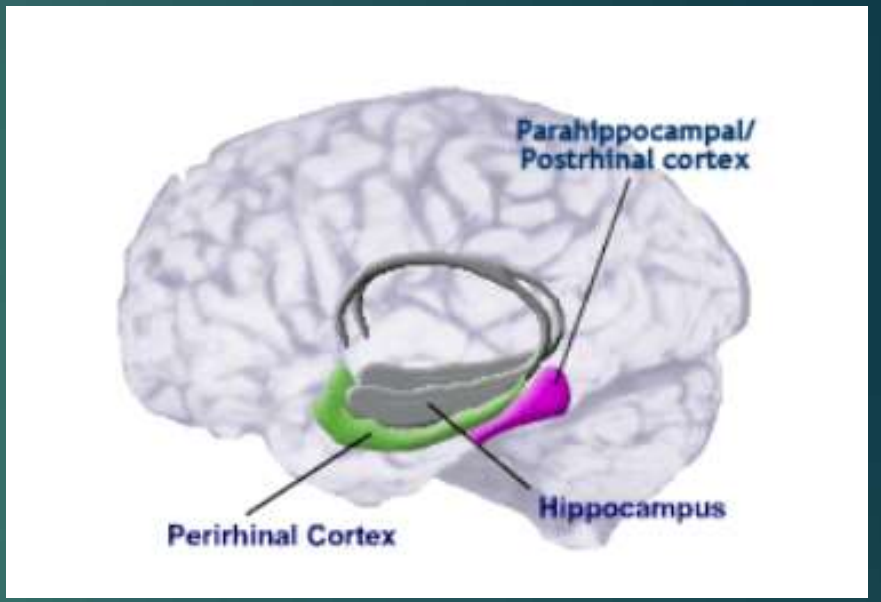
Enlarged the posterior hippocampus at the expense of the anterior

London taxi drivers who earned their licenses performed far better than those who failed—even though they had performed equally four years earlier. And MRIs showed that the successful trainees' hippocampi had grown over time.

The successful trainees did not perform better on all tests of memory, however. Licensed taxi drivers did worse than non-taxi drivers on the Rey-Osterrieth Complex Figure Test.

3 Medial Temporal Processors

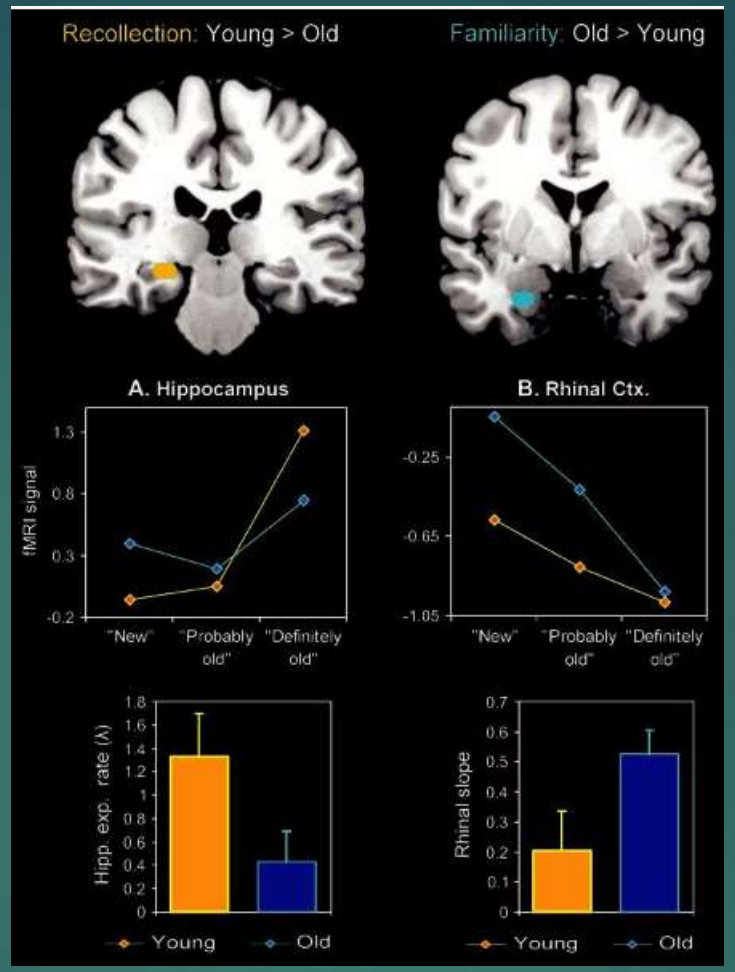
- Recollection: Hippocampus: processes bound representations of items in context (e.g., what)



- Familiarity: Perirhinal cortex - specific items (e.g., who and what)
- Context: Parahippocampal cortex - context (e.g., where and when) in which these items were encountered
- Hippocampal lesions produce impaired recollection but generally leave intact familiarity-based recognition

Charan Ranganath, 2010

Aging decreases recollection in hippocampus



Aging increases familiarity in perirhinal cortex

The effects of aging:
Recollection in the hippocampus was decreased by aging,

Familiarity in the rhinal cortex was increased by aging.

Amnesia: Present = Past ≠ Future; no time travel or future

- Amnesia: inability to record and store new information.
- If we have amnesia, you lose ability to make a plan.
- Plans are our memories of what we intend to do.
- People with amnesia live in the present and in the long past.
- Cannot imagine a scene of what might happen to them in the future; can imagine an object, but not a scene

D. Addis, et al., Psy. Sc, 2008

Role of Hippocampus

- Hippocampus is needed temporarily to bind together distributed sites in neocortex that together represent a whole memory.
- Index, search engine to database of memory
- Novelty detector: compares incoming sensory info to stored knowledge; if difference, triggers dopamine increase.
- Specialty is binding new to old information
- Ceases to play a crucial role in the retention of a specific memory after about 2 years.

Hippocampus & Prefrontal Cortex

- The hippocampus is our memory search engine,
- The prefrontal cortex is the filter determining which memory is the most relevant to retrieve
- Storing information alone is not enough for a good memory.
- PFC gives you ability to access the relevant information without being distracted by similar competing pieces of information.

Role of Hippocampus: Future prediction – “It’s a poor sort of memory that only works backwards”

- Actual reason for memory and function of hippocampus: memory is not about the past; it’s about the future

- Memory is about helping predict and infer from previous experience and prior knowledge, what to do next, where to go, what to expect, how to survive

“Recalling the past…occurs only with the intention of making it possible to foresee the future” (Kant, 1798)

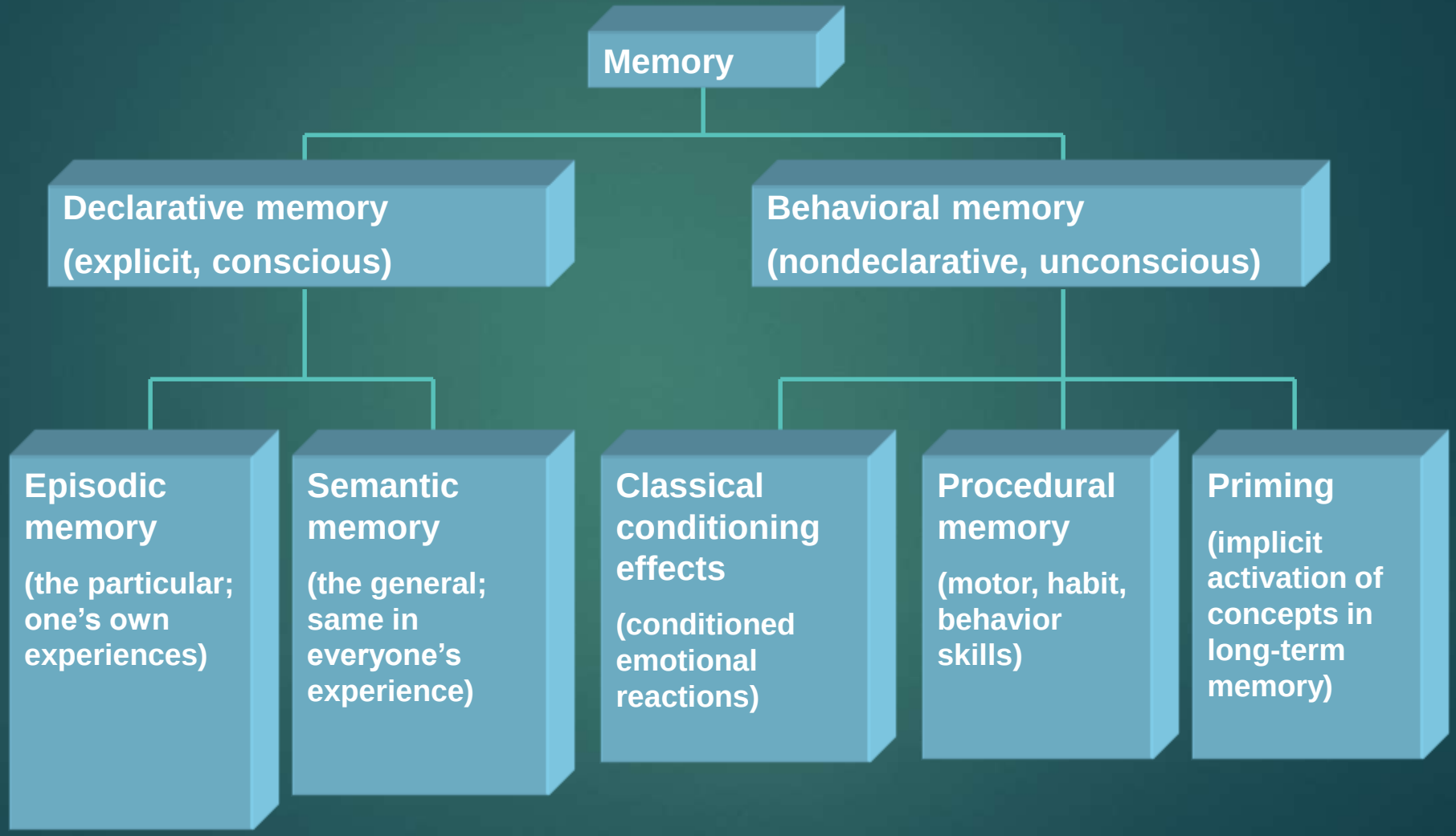
“It’s a poor sort of memory that only works backwards” (White Queen, *Through the Looking Glass*, Lewis Carroll, 1871)

Memory retrieval is a reconstruction

Memory is not an exact storehouse or copy, i.e. apple not located in 1 neuron, not byte on hard drive

Memory is an active, reconstructive process, that can be constructed, elaborated, distorted, and lost.

Taxonomy of Representational Memory



Factual Memory: Remembering What…

- Fact Memory
- Explicit information
- Remembering faces
- Remembering telephone numbers
- Remembering names
- Recalling dates
- Visualizing maps and locations

Declarative Memory:
Medial Temporal/hippocampus and Frontal Diencephalon

- Initial input into LTM: both episodic & semantic
- Fast process
- Conscious & Effortful
- Specialty: 1 trial rapid acquisition
- Sensory multimodal
- Poor reliability (forget; retrieval errors)

Episodic Personal Memory: Mental Time Travel

- Episodic or Specific Event Memory
- Details of personal experience
- Where, when, how of acquisition of the memory
- Personal, subjective experience
- Temporally and spatially dated
- Contextual
- Requires Frontal processing

- Localized to bilateral anterior and right posterior hippocampus

Tulving, 1972,1983, 2002

Semantic Memory: Knowledge

- Knowledge: What we “know”

- General Knowledge

  i.e. Cleopatra, 1492, Buddha

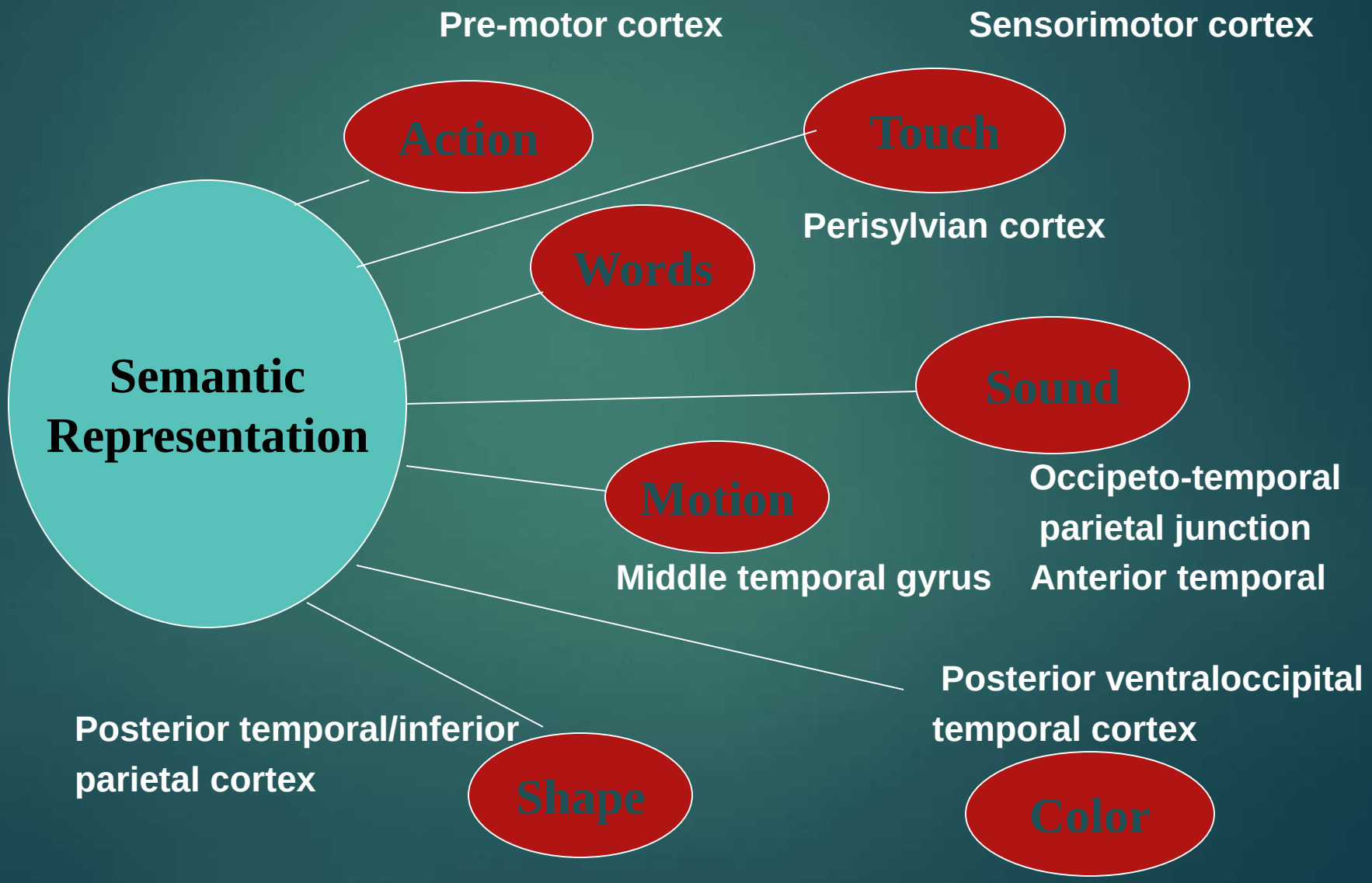
- Organization based on meaning, semantic networks

  - lexical (Animal Naming)

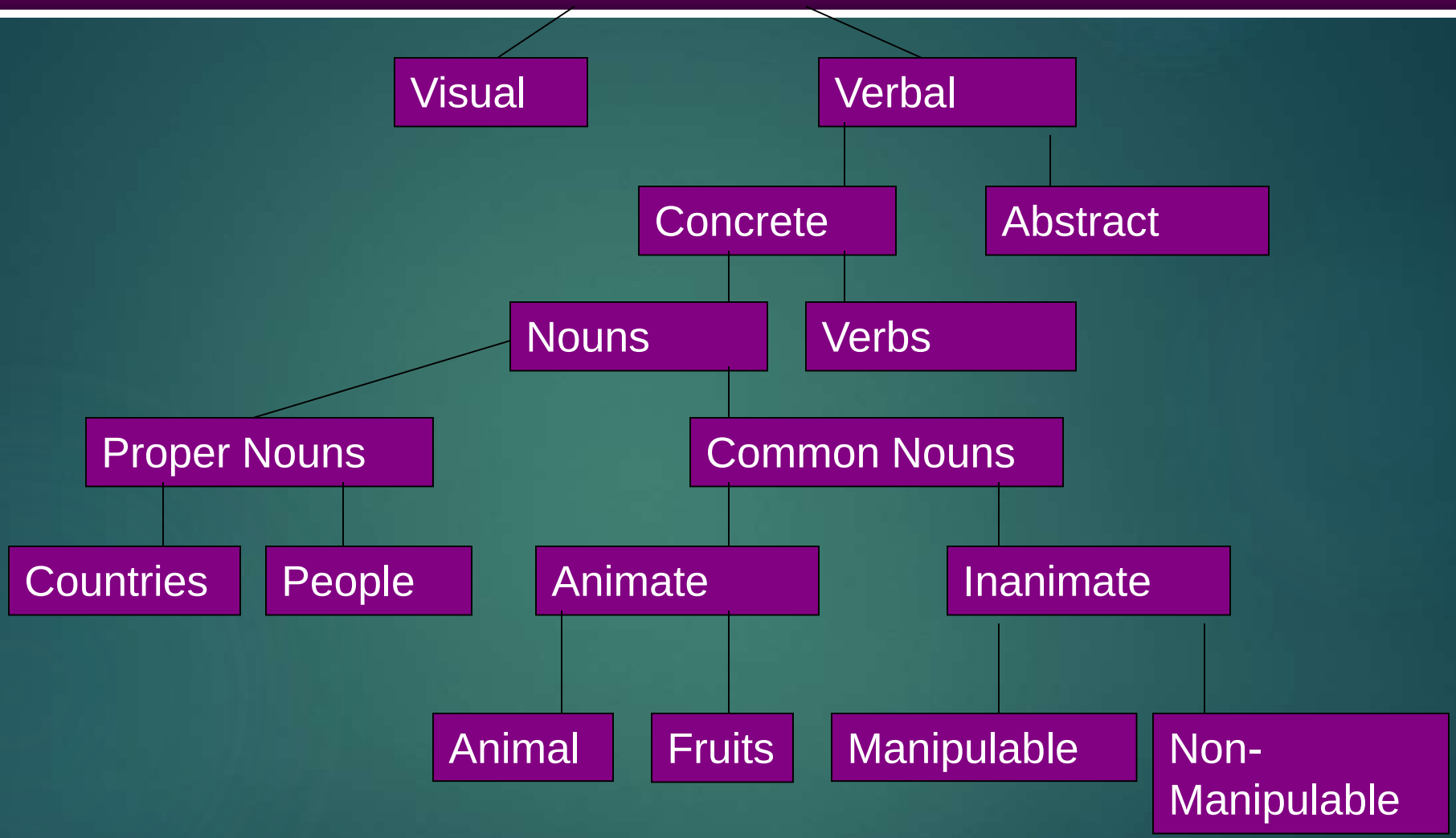
  - 1st letters of words (FAS)

- Visual more ancient and powerful than verbal

Locations of Semantic Memory



Topography of Semantic Knowledge revealed by strokes



Other Known Categories: indoor / outdoor, vegetables

Naming Errors: Ubiquitous; unrelated to memory ability

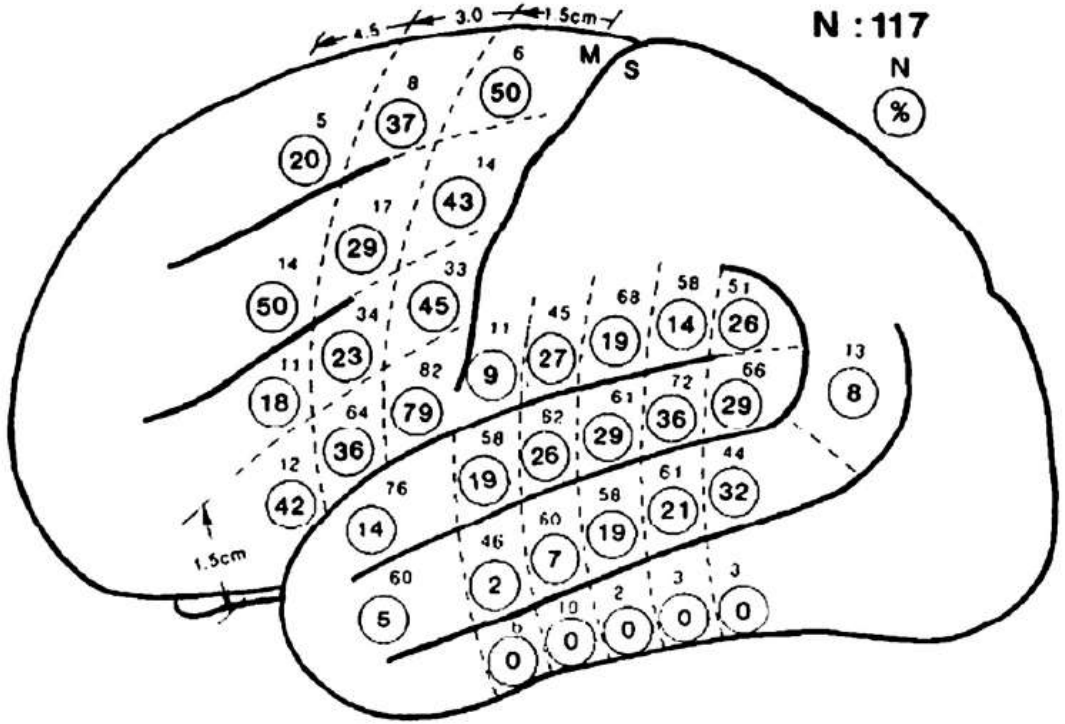


Fig. 4. Intraoperative stimulation data demonstrating individual variability of cortical sites essential for naming in the left, dominant hemisphere in 117 patients (from Steinmetz and Seitz 1991; data from Ojemann et al. 1989). Numbers in the circles are percentages of patients with an evoked naming error following stimulation of that area; numbers above the circles are numbers of patients stimulated in that area (reproduced with permission from *Neuropsychologia*).

Naming vs. Recognition

- What is name of this person?
- Princess Diana

- State several facts about this person
- Married Prince Charles
- Mother of William & Andrew
- Died in car crash

Tip # 10: More meaningful a memory, the better we remember it

Schachter: Depth of Processing Theory

Level of Processing	Type of Encoding	Example
Shallow	Structural/visual	Written in upper or lower case letters?
Intermediate	Phonemic/acoustic	Does word rhyme with bog, bar, etc.?
Deep	Semantic (meaning of a word)	“Does the word go in this sentence: You buy candy in a _____ .”

Memory is better if it is meaningful

- All better memory is based on association, elaboration, & deep encoding

- Baker/baker paradox:
  - Show same picture of man;
  - 1 told he is a baker; 1 told his surname is Baker
  - Being told profession always produces better memory (baker has larger context of associations)

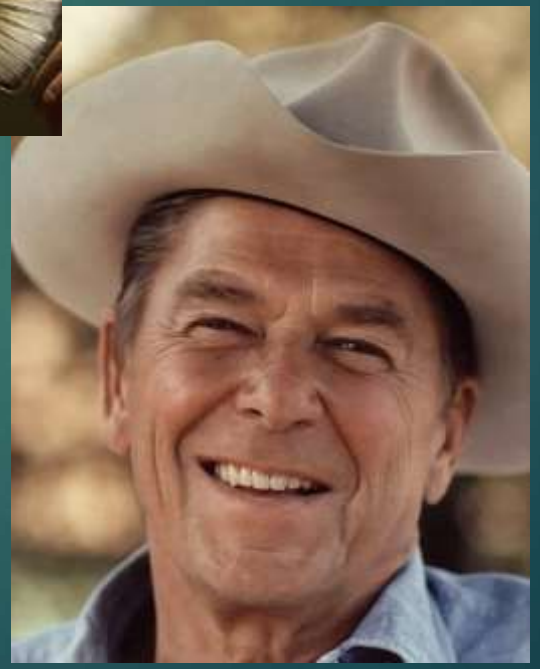
- To make something memorable, you first have to make it meaningful.

Joshua Foer:
Moonwalking With Einstein: The Art and Science of Remembering

How to remember names

- Meet man named Ronald wearing loud shirt who is a car salesman who loves fishing and wants to sell fishing gear
- You need to create a web of associations.
- First, you should repeat any name said to you. “Ronald, why do you love fishing.”
- Link the name you have just learnt to something you already know. Ronald Reagan was president.
- Link their name to something else about them. Ronald McDonald always wore bright colors.
- Imagine Ronald McDonald hitting Ronald Reagan with a fish.

Ronald McDonald hitting Ronald Reagan with a fish.



Old vs new advice about learning

- Classic recommendation for studying and memorizing a topic: Find a quiet, isolated study space and study same topic for several hours and later review your underlined or highlighted material, especially on the night before the test; and review your material by rereading it.

- New research says: Learning is more powerful with distractions, quitting before you're done, having distraction periods, taking a test before you know anything, mixing up the learning, changing locations, spacing study times, finding meaning, napping, and falling asleep.

How we learn by Benedict Carey

What does not work in learning

- Reviewing highlighted text
- Rereading text: you crucially fail to know when you have not learned specific material

Francis Bacon, 1620: Importance of testing yourself

- “If you read a piece of text through 20 times, you will not learn it by heart so easily as if you read it 10 times while attempting to recite it from time to time and consulting the text when your memory fails.”
- Reciting from memory is self testing
- Despite current testing policy wars, a test is not only a measuring tool; it alters what we remember and changes how we subsequently organize knowledge in our minds. It greatly improves memory.

Tip #11: Repeatedly self test yourself

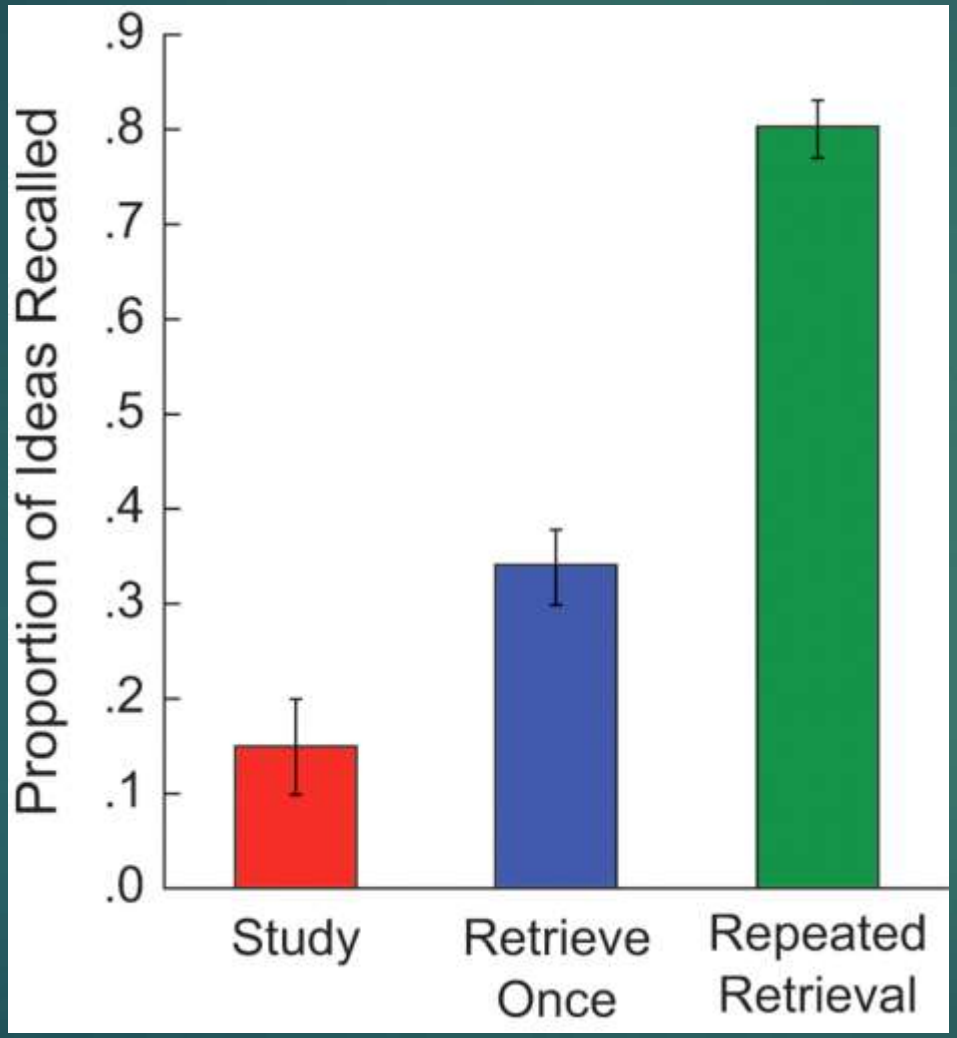
- "Retrieval practice"—correctly producing a studied item—increases the likelihood that you'll get it right the next time.
- Repeated retrieval is good for memory.
- Testing is a memory strengthener.
- Successful testing—getting the answer right—that makes the difference in memory performance later on.

Karpicke, Science, 2008

Testing makes perfect 2

- Read a text and then spend 20 minutes recalling as much as possible by writing down what you have read:
  - perform about 50 % better on tests the next week
- Students who were repeatedly tested on material significantly outperformed those who just repeatedly studied it, 80% vs. 35% recall
- Flash cards and other quiz-yourself techniques are among the best approaches to learning and retaining new information.
- Other flashcard programs: iPhone AnkiMobile Flashcards, Mnemosyne: http://mnemosyne-proj.org

Long-term retention after studying once, practicing retrieval once (followed by rereading), or practicing repeated retrieval.



- 400% increase compared to studying once:
  - reading a text in 1 study
  - period & then repeatedly recalling it in 3 retrieval periods

Current Directions in Psychological SCIENCE

Karpicke J D Current Directions in Psychological Science 2012;21:157-163

Self Testing increases learning

- Best practice: Study vs reciting from memory – read for 1st 40 % of study period, then recite from memory
- Spend 1st third of your time memorizing, and the remaining 2/3rds reciting from memory
- Other testing methods: flashcards, friend quizzing you, recite in a mirror, explain to someone else
- Self Testing or retrieval practice = extra effort deepens storage and retrieval strength; forces you to choose an answer and gives you immediate feedback
- You do not know a topic until you can teach it.

What works: Self testing is a form of self generation

- Self testing: flash cards, answering questions at the back of a book chapter or fielding questions lobbed by a study buddy.

- Self-testing offers an accurate assessment of what has not been learned and whether one needs to keep studying.

- Another useful technique is to periodically pause when reading to ask why a statement in the text is true.

- Can you remember this number?

2009177618125678

Tip #12: Chunking – mentally grouping details

- **Chunking** (adding meaning) leads to better recall

- N L B I A T F C S R M V

  Versus

- N F L- C B S- I R A- M T V

- Examples: Your phone number or Social Security number

Chunking

Now can you remember this number?

2009 1776 1812 5678

(this is called chunking!)

Coming Up Next:
Example of Procedural Memory

- Old typewriting skills are procedural memory

Over learned Skill

Procedural/Behavioral Memory: Remembering how…

- Skills, habits
- Playing a musical instrument
- Playing sports
- Riding a bicycle, driving a car
- Reading mirror-reversed word
- Playing Chess, bridge
- Grammatical structures
- Interpersonal Skills
- Depression
- Transference in psychotherapy
- Cognitive Behavioral Therapy

Procedural/Implicit/Nondeclarative Memory

- Heterogeneous systems: perceptual systems, striatum, cerebellum
- Gradual experience culminates in unconscious behavioral change
- No access to learning episode or context
- Reliable, highly resistant to change
- Sensory modal hyper specific (typing ≠ piano)

Example of Neuroplasticity:

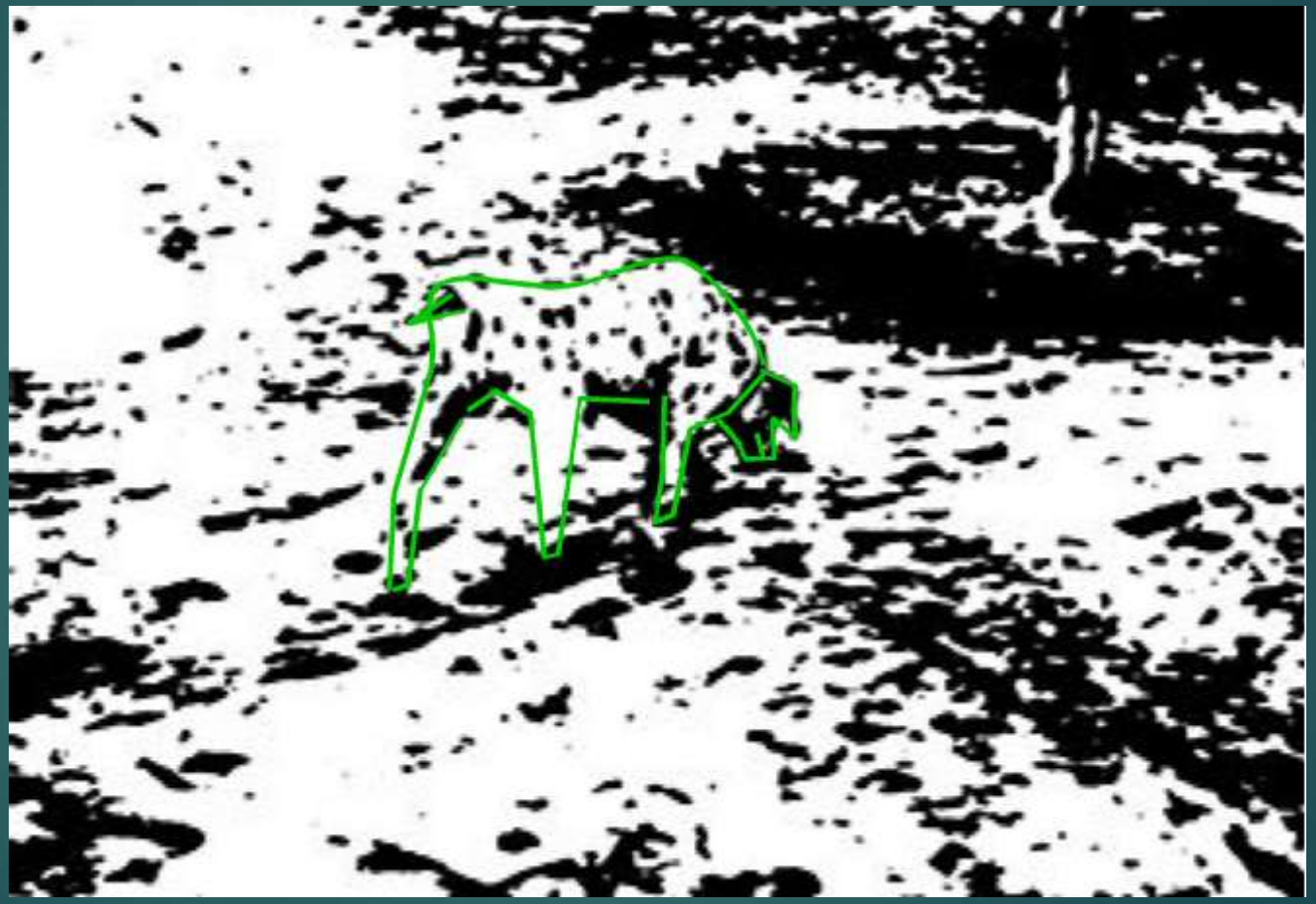
We all have the power to change one another's brain.

On the next slide I will forever change your brain.

R.C. James's Camouflaged Dalmatian

Your brain (perception and memory processes) is permanently changed by each experience

Dalmatian Revealed



Tip #13: For behavioral memory: Do it – don't think about it.

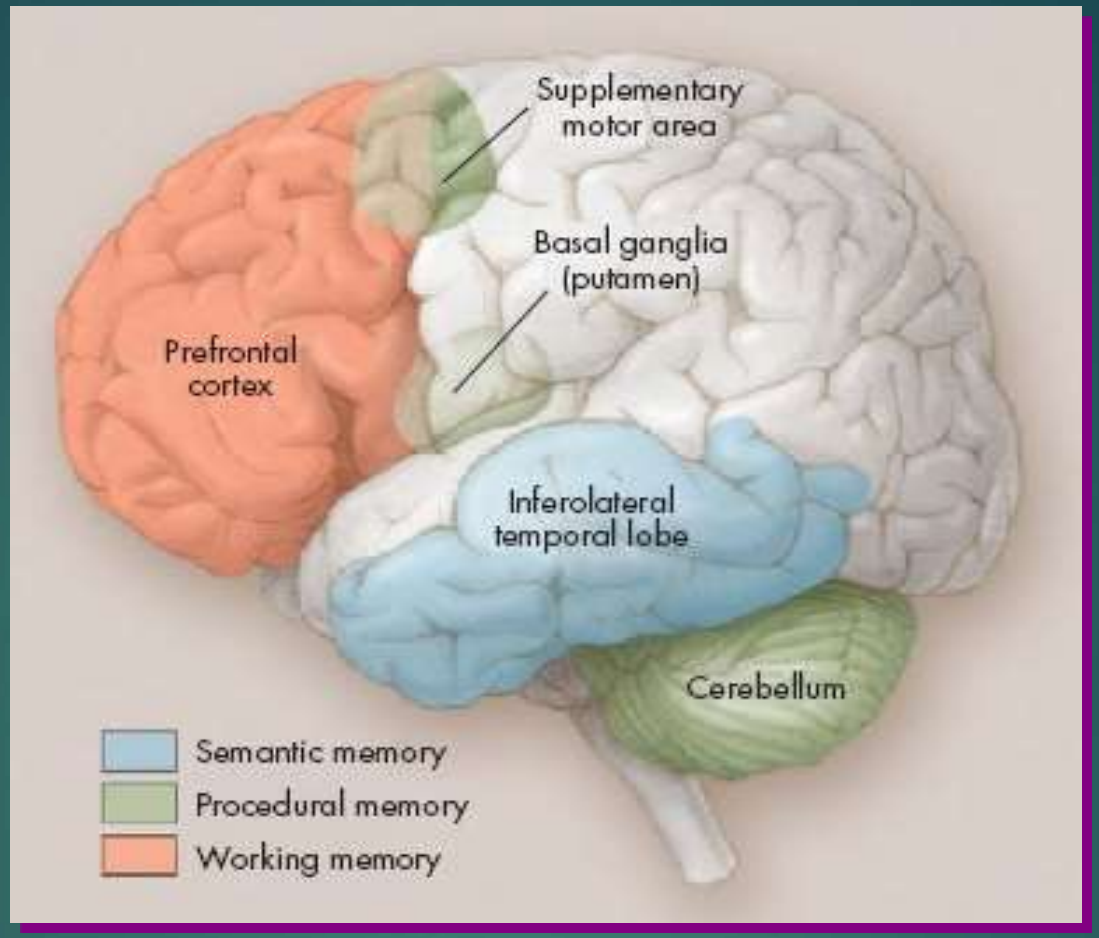
- Yogi Berra (NY Yankee catcher & manager) and Behavioral Memory:
  "You can't think and hit a baseball at the same time."

- If you make an implicit process explicit, you can wreck it.

- Lesson: Do it. Don't think about it.

Perceptual Discrimination: learning without thinking

- Hitting a baseball expertise: 90 mph fast ball; 400ms to the plate; brain needs 250ms to decide to swing; player not aware he's swinging until ball is 10 feet away
- Chess grand master:
  - chess computer considers 200 M moves;
  - human player considers 4 moves ahead per turn;
  - chess masters vs novices – both 4 moves ahead; but chess master can memorize a chess position in under 5 seconds (mental photo of board), but still have normal memory ability; they encode in larger perceptual chunks, a familiar configuration of pieces; extract most meaningful set of cues; cannot do it for arrangements of chess pieces that could never occur in a game



Working Memory: Prefrontal cortex
Semantic memory: Inferolateral temporal
Procedural: Basal ganglia, cerebellum, and supplementary motor

Budson AE, Price *BH.N Engl J Med* 2005;352:692–9.

Dry Cleaning Effect

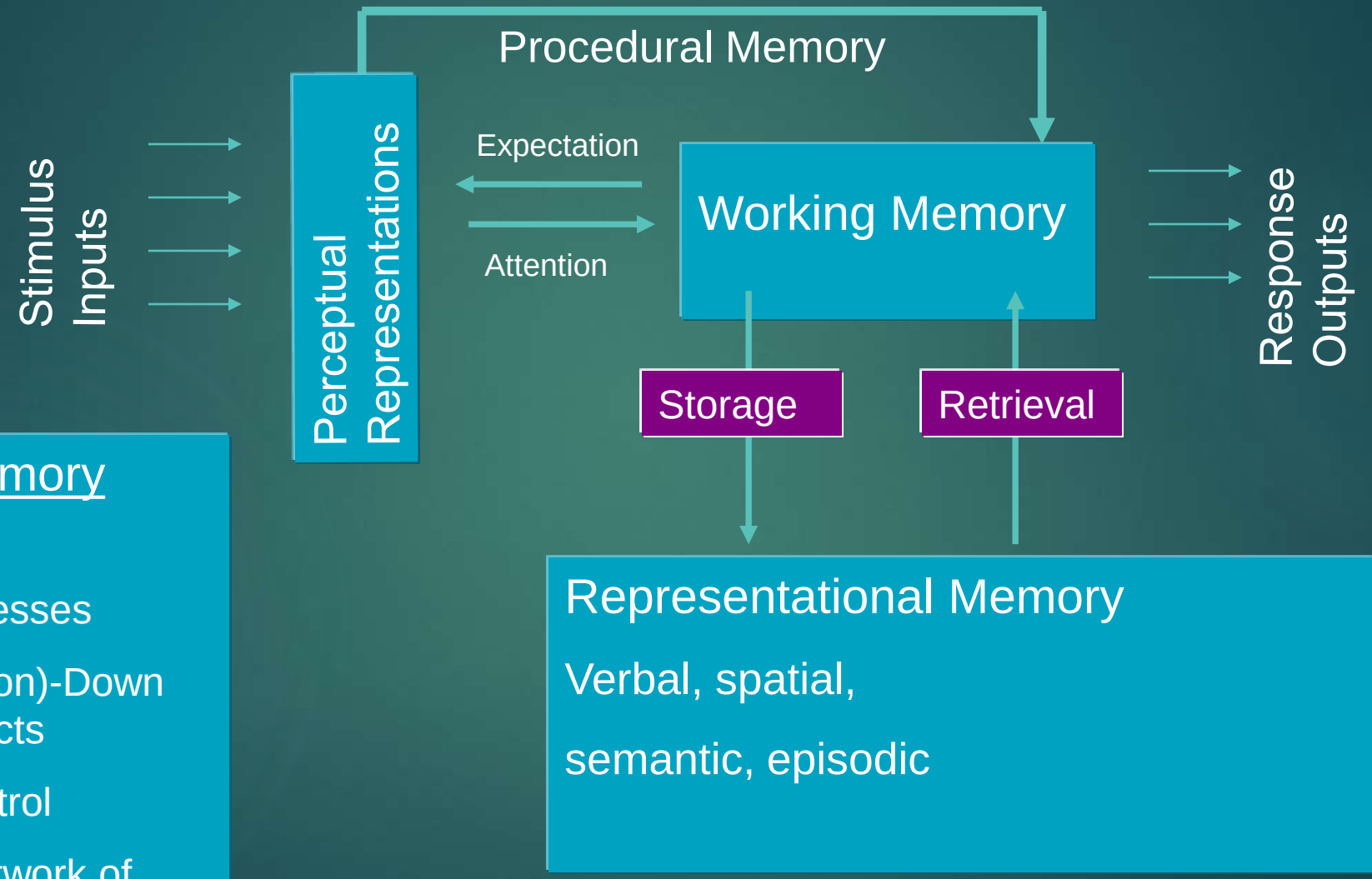
- Ever forget to drop off dry cleaning (or child) on the way to work?

- This minor error of memory is evidence of two competing parts of the brain, one that creates habits, and another involved in novel learning.
  - Driving to work is a habit, done on autopilot;
  - going to the dry cleaner is a comparatively novel task.
  - Both systems function simultaneously.

- The striatum, part of procedural memory, stores habits and acts like an autopilot. The hippocampus handles new challenges.

C. Pittenger, Proc. Nat. Acad. Sc, 2008

An Information Processing Model of Memory



Revised Memory Model

Dynamic Processes

Top (Expectation)-Down (Sensory) Effects

Executive Control

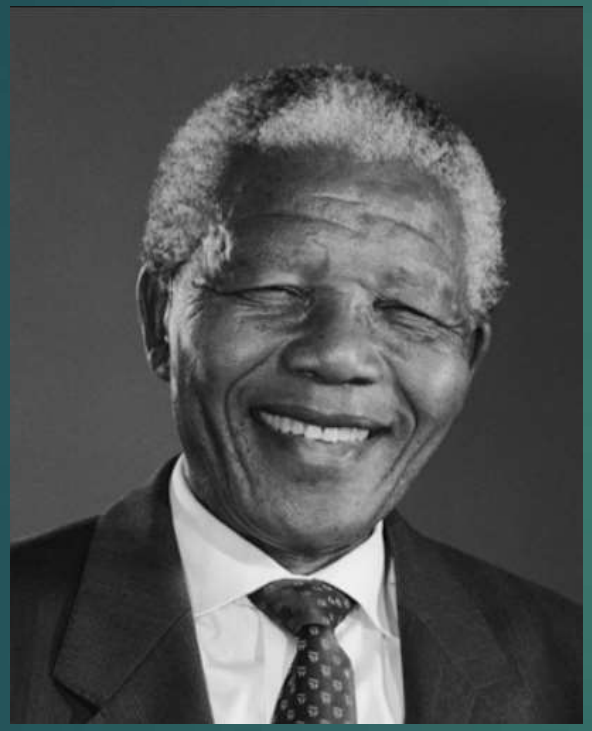
Distributed Network of Associations

Source: A.P. Shimamura, 2003

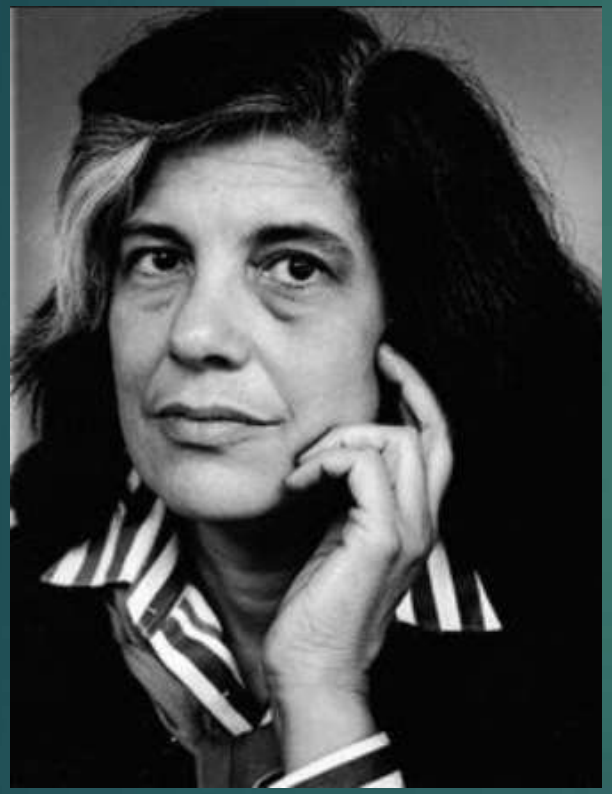
Remember those 15 pictures you saw before?

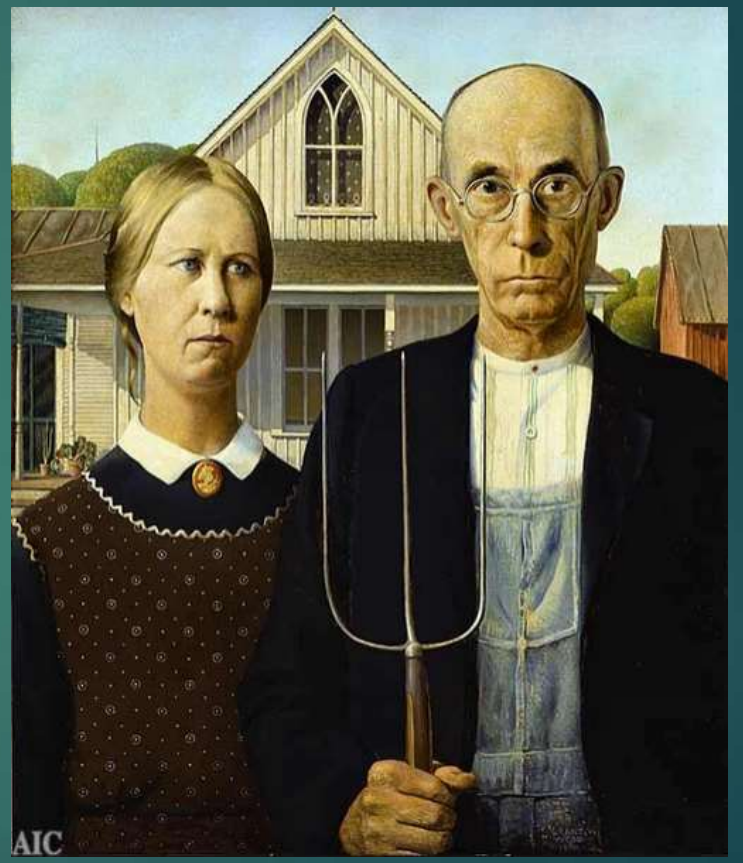
Which of next 2 pictures was the one presented 30 minutes ago?

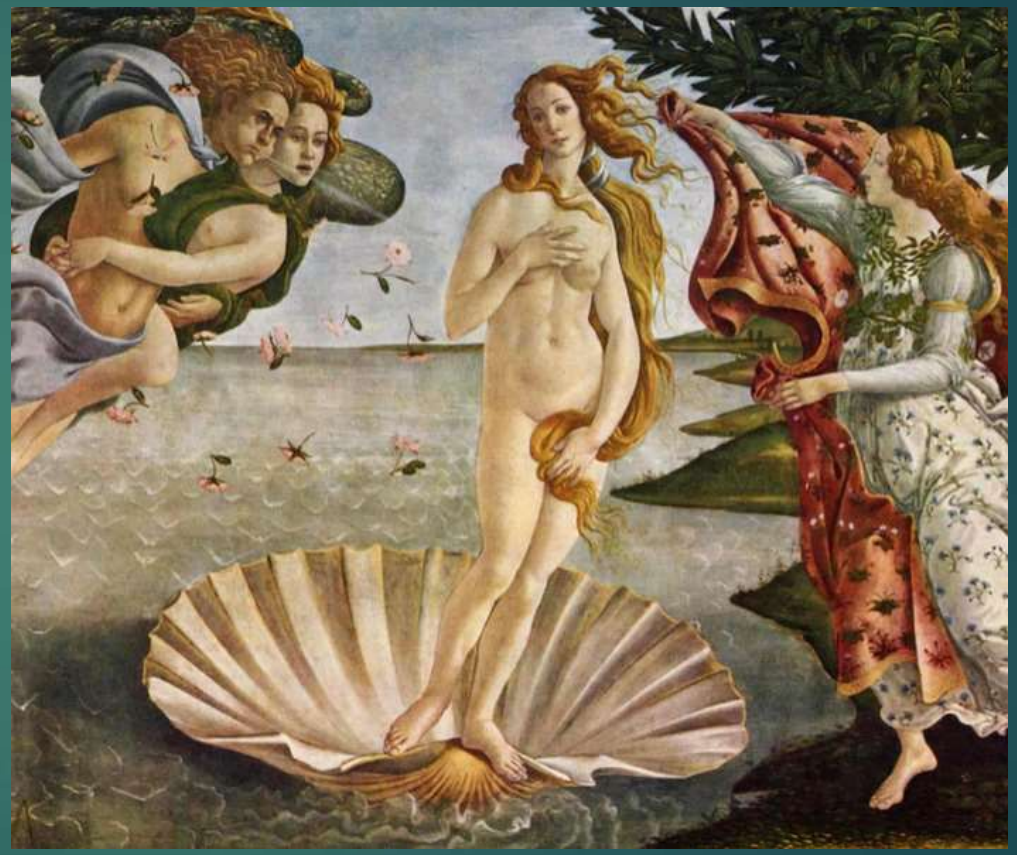
This symbol () will identify which picture you saw before after you look at the two pictures.




Everett Collection / Rex Features




AIC



I assume you remembered all of the 15 pictures. Correct?
Your visual memory is amazing!

Tip #14: Use Visual Imagery to remember

Picture superiority effect in Memory

- Almost perfect memory for visual images.
- Pictures are remembered better than words
- Studies for 30 years: picture superiority effect has demonstrated that subjects are more likely to remember items if they are presented as pictures versus words
- Older individuals use this phenomena more than younger
- Standing (1973): 10,000 images over 5 days; 2 days later, 2 image choice, 83% recognition of original images
- MIT study: 2000 images for 3 seconds in 2.5 hours; 92% accuracy

Shepard, 1976; Mintzer & Snodgrass, 1999

Example of using visual imagery to remember a name: New psychologist at work: Christy Hogan

+

Tip # 15: To Sleep is to Remember:
One of the primary function of sleep is to consolidate memory

- In 1994 neurobiologists Avi Karni, Dov Sagi and their colleagues at the Weizmann Institute of Science in Israel showed that when volunteers got a night of sleep, they improved at a task that involved rapidly discriminating between objects they saw, but only when they had had normal amounts of REM sleep; deprived of REM sleep, the improvement disappeared.

- Sleep optimizes memory consolidation,
- Waking brain optimizes encoding of memories

Giuditta et al., 1995; Mednick, et al., 2003

Sleeping is crucial for Memory

- Sleep: repeated reactivation of the new memories during off-line time (sleep)
- Current Conclusion: Sleep improves retention & comprehension of what one has studied the day before. Memory improvements with sleep = 10 to 30% better.
- **Sleep is causal in the consolidation of memory.**
- A single night of sleep deprivation produces a significant deficit in hippocampal activity during episodic memory encoding, resulting in worse subsequent retention

Memory and Sleep:
Practice followed by a night of sleep makes perfect

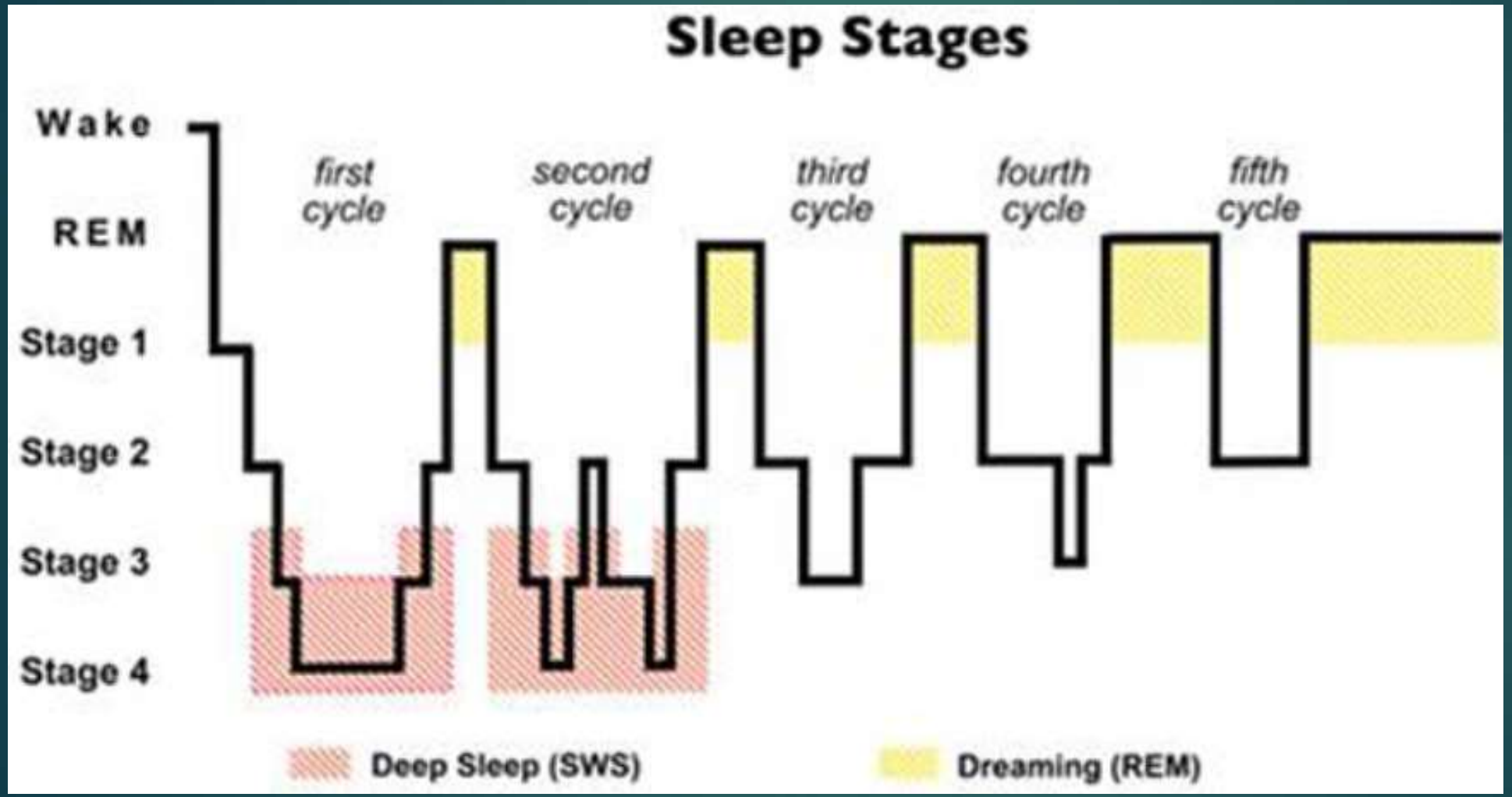
- Declarative memory: If you have no sleep the night before, do 40% worse on list learning task.

- Procedural memory improvement with sleep: learn to type “41324” with left hand
  - One group learned sequence in AM and redid 12 hours later
  - If learn in PM, sleep for night, 20-30% better than prior AM condition

- Stronger effects for sleep occurring shortly after learning than for sleep at a later time (remember better if sleep within 3 rather than 10 hours later).

Walker, 2008

Sleep Stages: different brain wave patterns; each state consolidates specific type of memory?



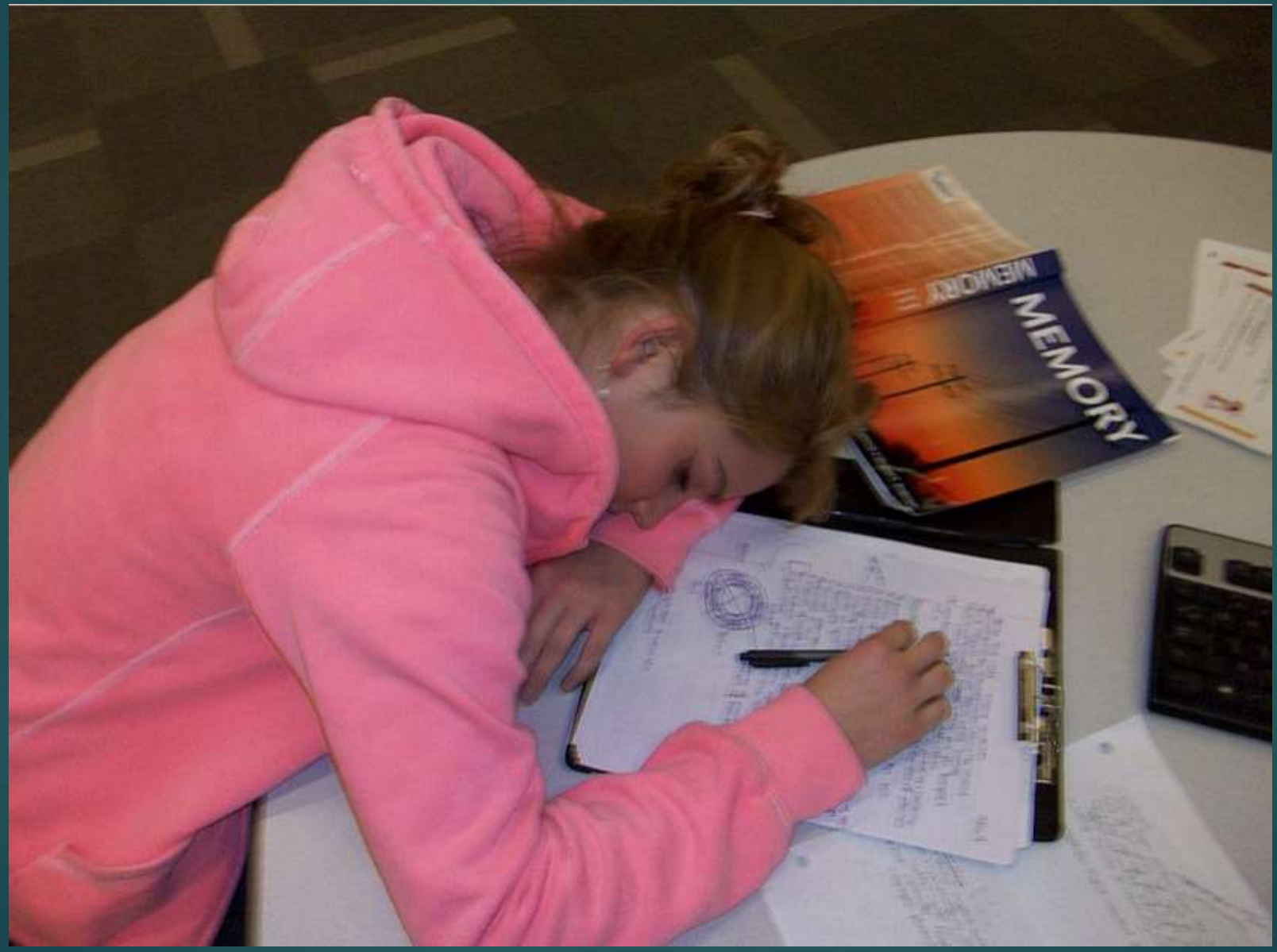
REM:
Dreaming

nonREM

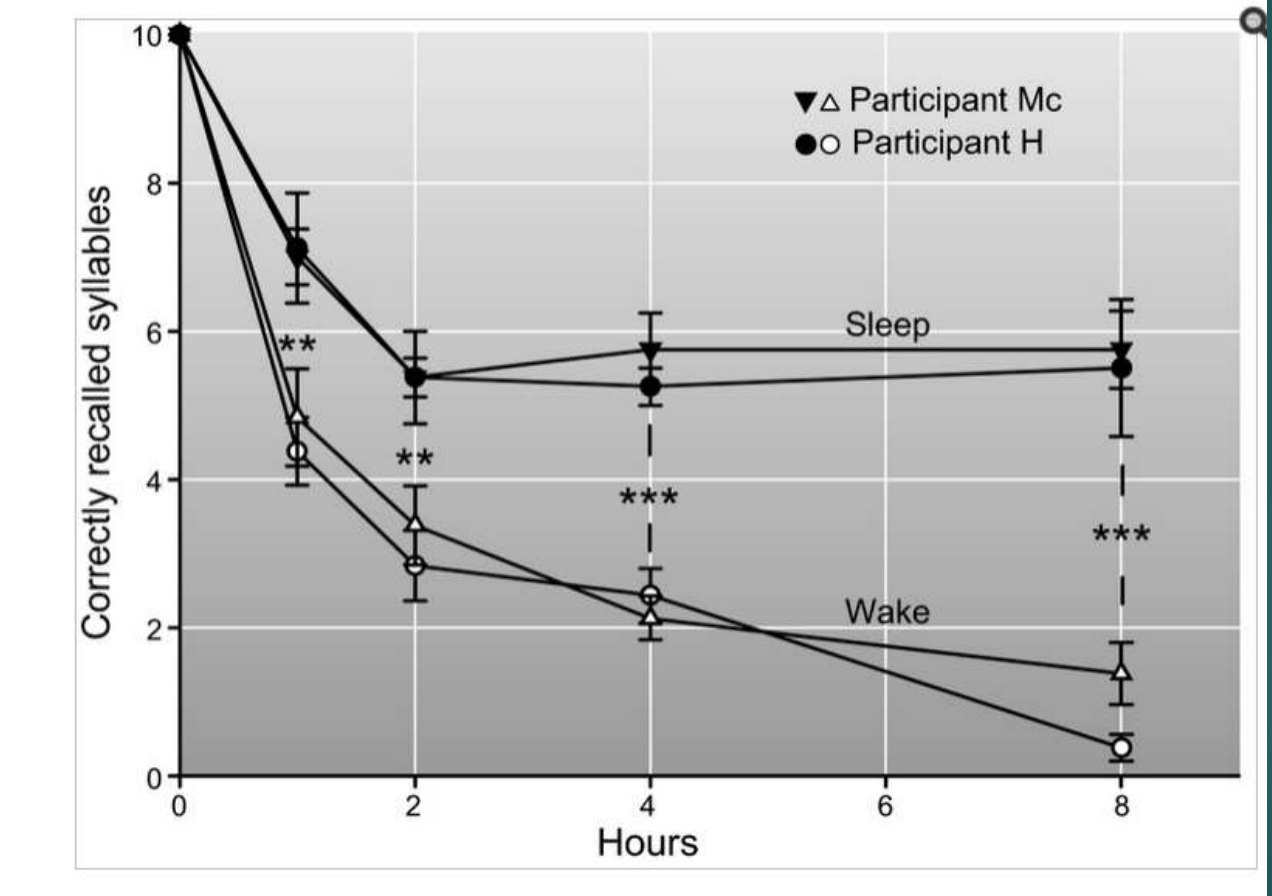
Dual Process Hypothesis of Sleep Stages

- Dual processes hypothesis assumes that different sleep stages serve the consolidation of different types of memories.
- Declarative memory profits from slow wave sleep (early),
- Procedural memory is supported by REM sleep (later).

Napping and memory



Effects of sleep and wake intervals of different length after learning on memory for senseless syllables.



Sleep after learning leads to superior recall of syllables after the 1-, 2-, 4-, and 8-h retention interval, compared with wake intervals of the same length.

Jenkins and Dallenbach

A Nap is as good as a Night

- Naps of 60 or 90 minutes contain slow wave deep sleep and REM.
- People who study in the morning (any type of factual content) do ~30 percent better on an evening test if they had a 60 minute nap than if they haven't.
- 90 minute nap significantly enhances prior procedural learning, i.e. dance sequences, piano sequences, etc.;
- A 60 to 90 minute nap may give same benefits in memory consolidation that you would from sleeping for 8 hours at night.

Sara Mednick, et al., 2003

Sleep review of your day: Cortex and Hippocampus in Sync

The transfer of daily events to long-term memory occurs especially during deep, dreamless sleep

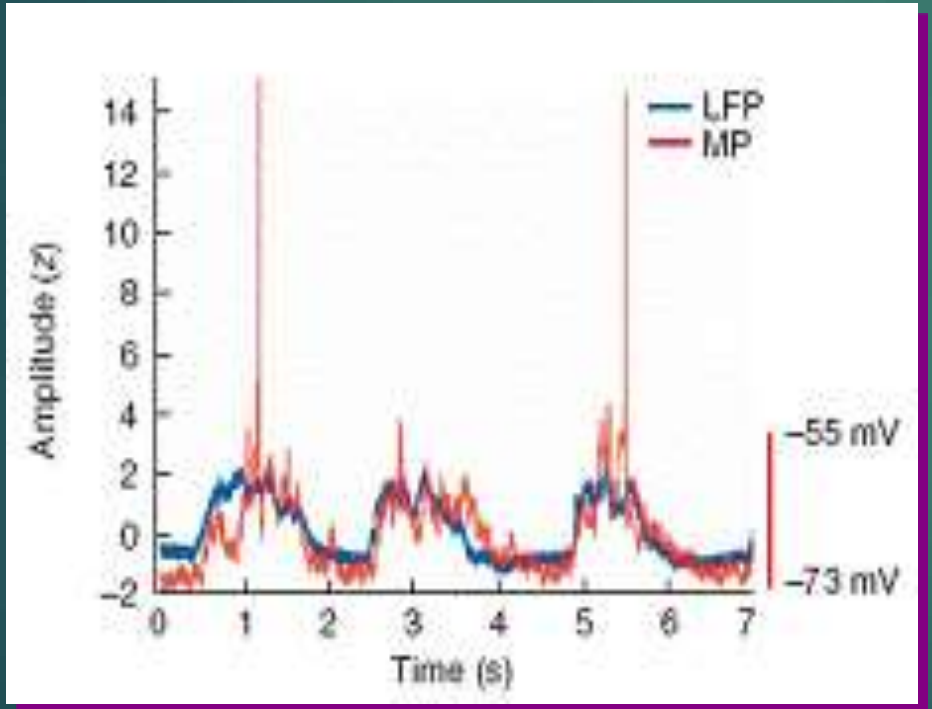


Image: Mayank Mehta/Brown University

While you were asleep ...The brain's neocortex (blue) and the hippocampus (red), show synchronized, slow oscillations. The interneuron oscillations in the hippocampus appear just after the cortical oscillations, initiated by neocortex.

Sleep disruption and Memory

- Alcohol and benzodiazepines all block memory consolidation in the hippocampus

- Getting poor or insufficient sleep:
  - raises your risk of obesity, heart disease and diabetes;
  - increases your blood pressure;
  - makes you accident-prone,
  - besides reducing your Tetris ability

- Continuous sleep required for memory consolidation. Sleep interruptions erode Memory.


"ON THE CONTRARY, I CAN'T RECALL A THING FROM FIFTY YEARS AGO, BUT I REMEMBER EXACTLY WHAT I HAD FOR LUNCH YESTERDAY."

Phillip's Milk of Amnesia

for people who can't remember shit.

Memory Testing in 1920: Sir Frederic Charles Bartlett “War of the Ghosts” Memory Story:

- One night two young men from Egulac went down to the river to hunt seals and while they were there it became foggy and calm. Then they heard war-cries, and they thought: “Maybe this is a war-party.” They escaped to the shore, and hid behind a log. Now canoes came up, and they heard the noise of paddles, and saw one canoe coming up to them. There were five men in the canoe, and they said:
- “What do you think? We wish to take you along. We are going up the river to make war on the people.”
- One of the young men said, “I have no arrows." " Arrows are in the canoe, “they said.
- “I will not go along. I might be killed. My relatives do not know where I have gone. But you," he said, turning to the other, “may go with them.”
- So one of the young men went, but the other returned home.
- And the warriors went on up the river to a town on the other side of Kalama. The people came down to the water and they began to fight, many were killed. But presently the young man heard one of the warriors say, “Quick, let us go home: that Indian has been hit.” Now he thought: “Oh, they are ghosts.” He did not feel sick, but they said he had been shot.
- So the canoes went back to Egulac and the young man went ashore to his house and made a fire. And he told everybody and said: “Behold I accompanied the ghosts, and we went to fight. Many of our fellows were killed, and many of those who attacked us were killed. They said I was hit, and I did not feel sick.”
- He told it all, and then he became quiet. When the sun rose he fell down. Something black came out of his mouth. His face became contorted. The people jumped up and cried.
- He was dead.

Memory Testing Today:
California Verbal Learning Test-2

- List Learning: List A (16 new words with 4 categories) repeated over 5 trials
- Learning curve over 5 trials:

  5th trial should be better than 1st; expect a J learning curve
- Trial 1: measures attention
- Trial 5: expect 9+
- List B: 16 new words - an interference list: Proactive Inhibition (old inhibits new)
- Cueing: should help

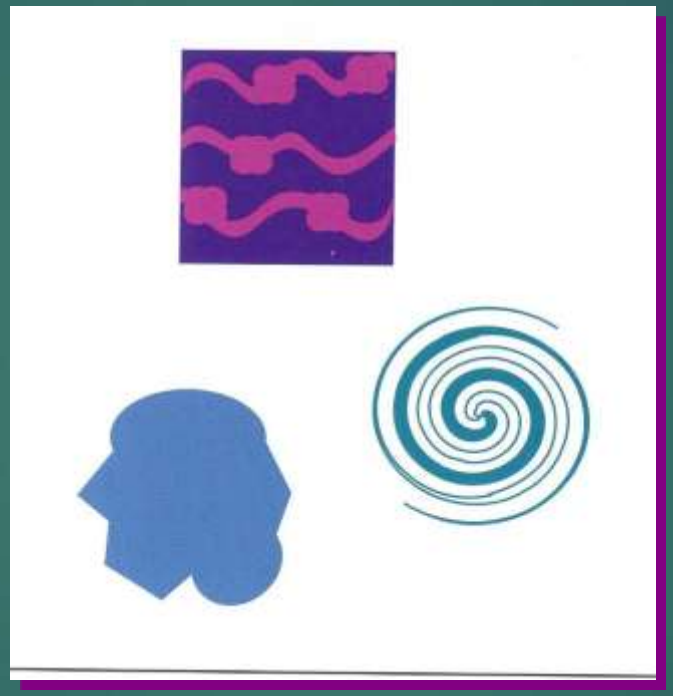
Memory Testing 2: CVLT-2

- Long Delay (20-30 minutes, filled with nonverbal tests): the real test, should be close to last Trial 5 result
- Semantic Clustering (use embedded categories): asked to list words in each of 4 categories), i.e. all words that were animals
- Recognition Hits: Given word – say yes or no if word was on List A

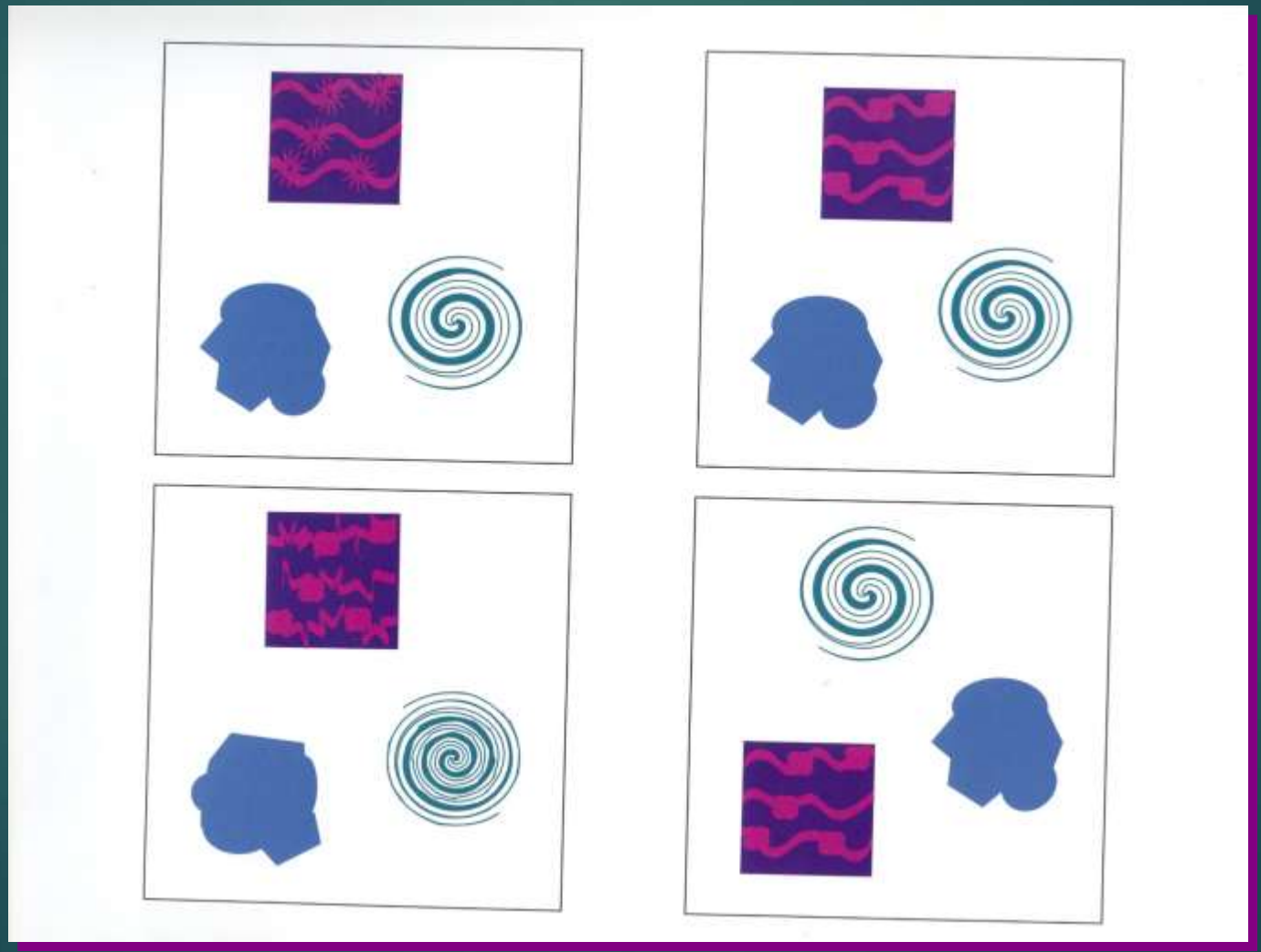
Memory Testing 3: CVLT-2

- Intrusion rate (not presented words given) – EF effects
- False Positives (Yes to wrong word on recognition trial) - EF effects
- Response Bias: Number of Yes vs. Nos; AD say yes to all

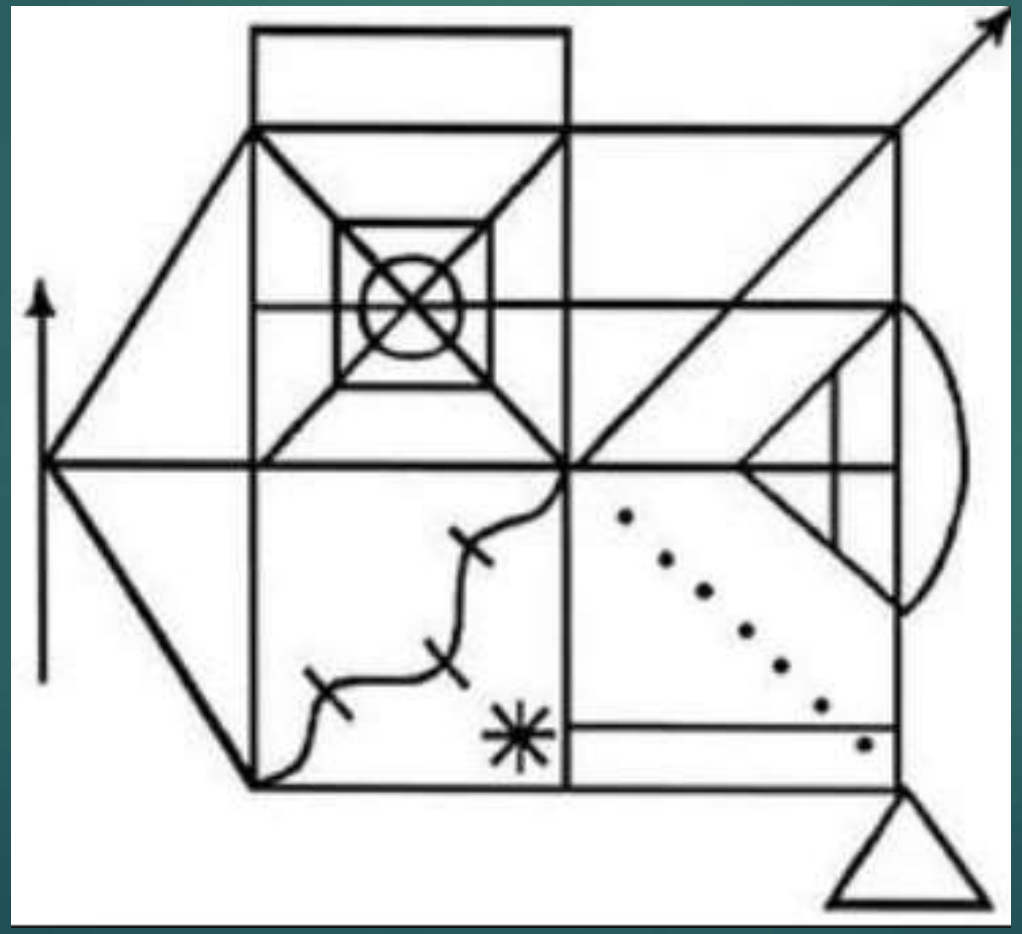
Visual Memory Tests: Issue of verbal encodeability



NAB Shape Learning 2

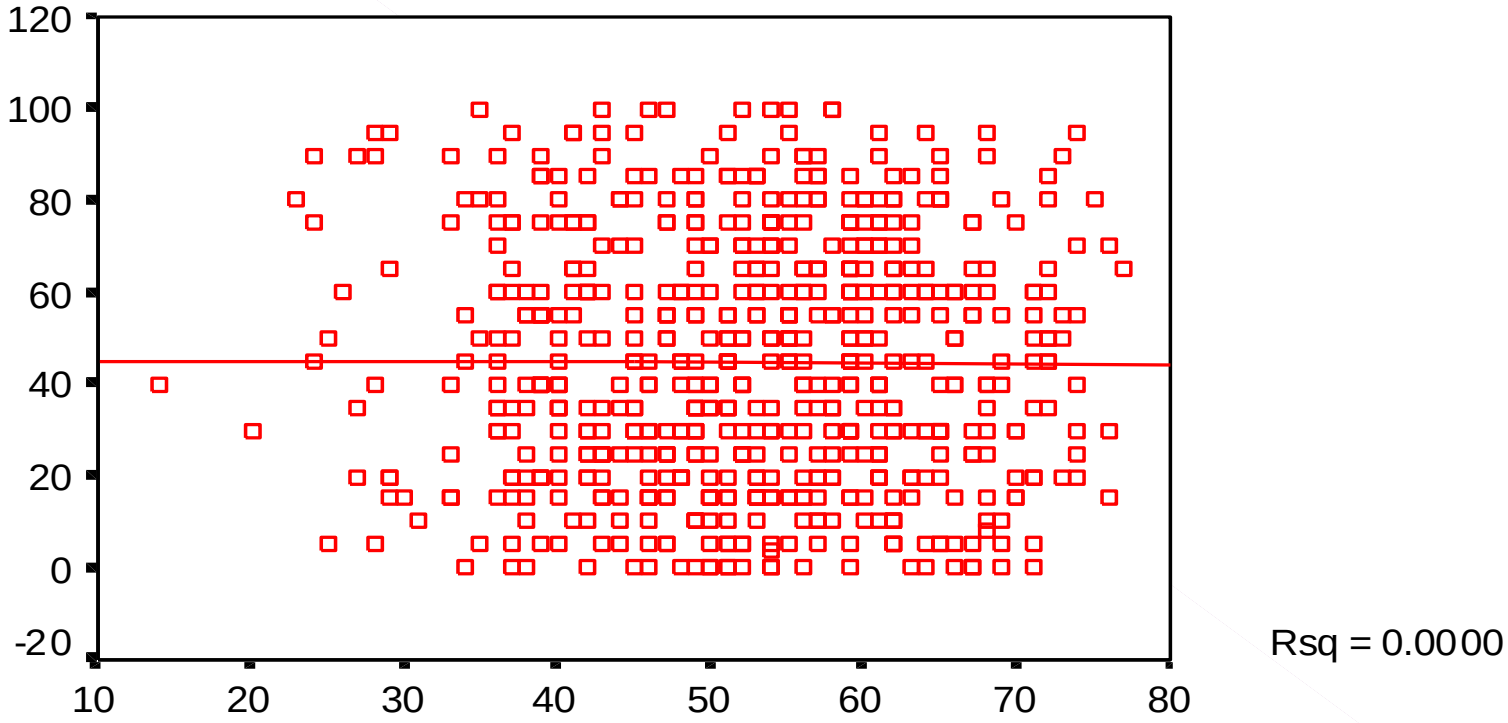


Complex figures: Copy and remember



Verbal memory complaints versus verbal memory test scores

Zero correlation in 995 cases



Green, 2003

Importance of Testing for Effort

- As effort (trying your best) decreases, scores on most neuropsychological tests decrease significantly and systematically

- Memory is particularly sensitive to effort

- Failure to remove poor effort cases is a fatal flaw in studies claiming that condition X is linked with cognitive deficits.

- Condition X may be PTSD, chronic pain, panic attacks, mild TBI, depression, memory disorder.

Green, 2006

Age related memory decline

Number recalled after 1 trial

Normal Aging and Memory

- Intact Working Memory, Semantic Memory
- Decrease in how much factual info you can learn, but normal forgetting rates: Learn less items, but don’t forget them

  Recall: 12 new words, age 20,

  7 new words, age 80
- Frontal memory effects increase
- Name-Face recognition decreases

Older have nicer pasts: less amygdala reaction

- Older people tend to see the past through rose-colored glasses
  - remember fewer negative images than younger participants
  - reduced interactions between the amygdala and the hippocampus, when shown negative images.

- Seniors are able to regulate emotion better than younger people, so they are less affected by upsetting events.

Memory Testing Tips

- Worried well (Attention vs. Memory):
  - If you forget where you put your car keys, don't worry.
  - If you forget you own a car, worry.
- Many “memory” problems are attention glitches: where are the keys
- Rarely see an Alzheimer’s patient come alone and voluntarily to my office
- Note the use of partners as external memory prostheses.

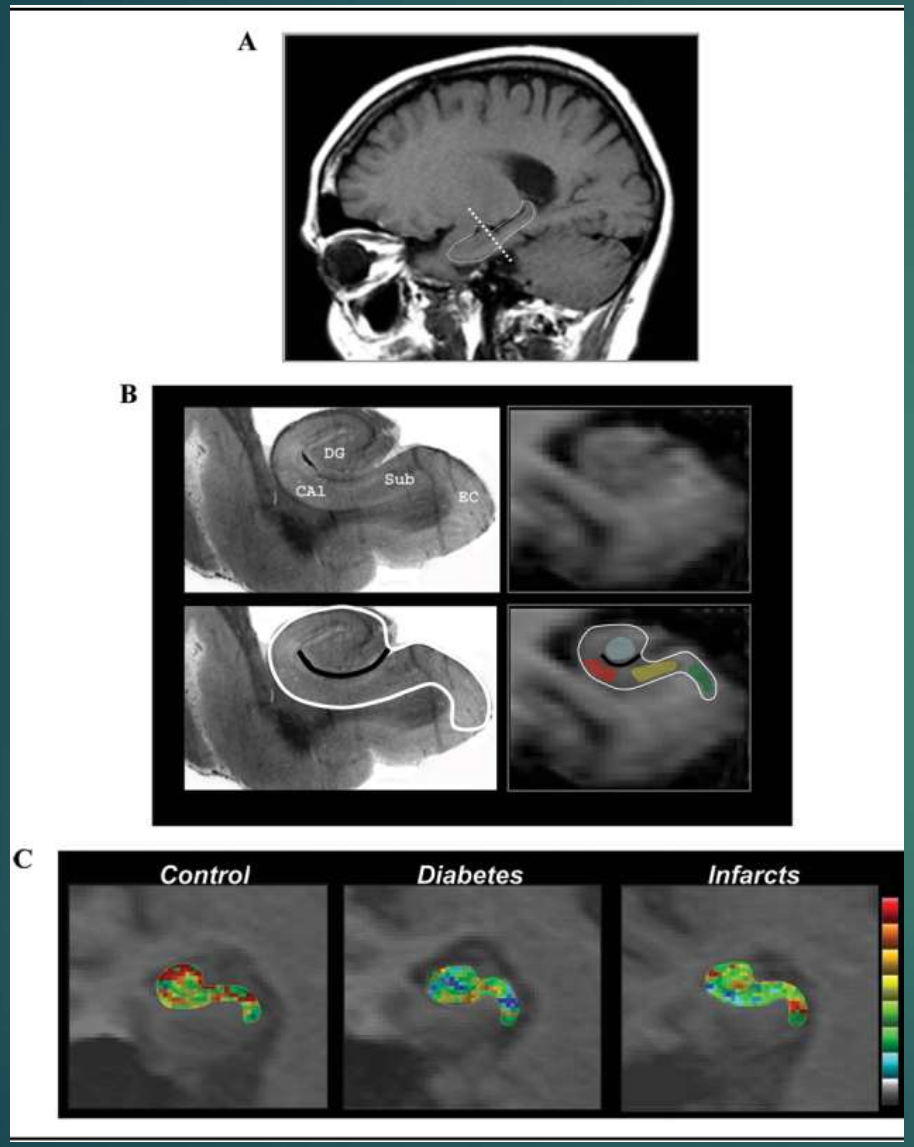
Patient to his Psychiatrist:

- Patient: Doctor, I can't remember anything! I forgot what happened yesterday. I forgot what my car looks like. I can't even remember my own name.
- Psychiatrist: How long have you had this problem?
- Patient: What problem?

Neuropathology of Memory Functioning

- **Dementias:**
  - Alzheimer's
  - Parkinsonism
  - Huntington's
  - Pick's
  - Creutzfeldt-Jacob's
- **Infections:**
  - Encephalitis, esp.
    - Herpes
  - Meningitis
- **Vascular:**
  - Stroke
- **Head Trauma**
- **Toxic/Metabolic:**
  - Korsakoff's
  - Chronic Alcoholism
- **Neurosurgery:**
  - Temporal Lobectomy
- ECT
- Epilepsy
- Anoxia/Hypoxia
- Brain Tumors
- Hodgkin's lymphoma (paraneoplastic syndrome: antibodies attack brain cells

AD & DM affect Hippocampus differently



- Diabetes & infarcts related to hippocampal dysfunction

- Dentate gyrus linked to diabetes & blood glucose levels
-
- CA1 & subiculum linked to infarcts & transient hypoperfusion;
-
- AD targets entorhinal cortex

- Normal blood glucose levels increase dentate function, i.e. via exercise

Red = greater Cerebral Blood Flow

Wu, et. al., Ann Neurol, 2008

Medial Temporal Amnesia:

Alzheimer's, H.M., severe TBI

- Severe Anterograde Amnesia: No new learning
- Some period of Retrograde Amnesia: loss some old memories; keep oldest memories, but not just made new memories

Anterograde Amnesia = No new learning

- Perceive but do not record
- Do not know they have a memory problem
- New person is always a stranger
- No memory for meals
- Eternal present, no worry, no plans
- Able to learn new behaviors, but they don’t know that they know how
- Don’t read stories: can’t keep sequences in mind, or scenes

Anterograde Amnesia

- Affects LTM, new learning
- Impairs factual and episodic new learning
- Impairs new learning in all sensory modalities

But…

- Spares Working Memory
- Spares prior General Knowledge
- Spares behavioral memory
- Music memory spared

Summary of Anatomy of Memory

- Memory is a distributed function of brain
- Two functionally & anatomically integrated circuits: medial (Hippocampus) & lateral (Amygdala) circuits
- Amnesia is associate with medial temporal, thalamic & basal forebrain damage which affects integrity of 2 systems
- Functional impairment of both circuits (hippocampally based *medial limbic circuit* and the amygdala-based *lateral limbic circuit*) is necessary for severe amnesia;
- Less severe forms of memory deficit can result from more restricted lesions that affect only 1 circuit.

TGA: Transient Global Amnesia

- Sudden Loss of memory
- Know their identities, but cannot retain recent memory, where they were and how they got there. They show no other symptoms.
- TGA usually occurs after the person engages in strenuous activity -- such as having sex, vigorously exercising, suddenly immersing into icy or hot water, straining to dig a stuck car or even bumping the head.
- The unifying thing about each of them is they produce a sudden and significant change in blood flow
- Levitra, which is a pill for erectile dysfunction, lists TGA as a possible adverse reaction.

Prospective Memory: Remembering a delayed intention

- PM = remember to execute an intention at an appropriate later time
- First you must form the intention, then remember it, then activate it at the right time
- Research: Airline industry – major cause of pilot error
- Relies upon executive (frontal) as well as mnemonic (hippocampal)resources.
- Prospective memory is one of the best predictors of the ability to live independently
- Serious prospective memory failures can hinder the performance of instrumental activities of daily living (IADLs; e.g., medication adherence).

Herpes Encephalitis: AA & RA

- N = 10: Dense amnesia in 60%, and a less severe anterograde memory impairment in the others.
- Severity of amnesia related with severity of damage to medical limbic system structures such as the hippocampus, with bilateral damage

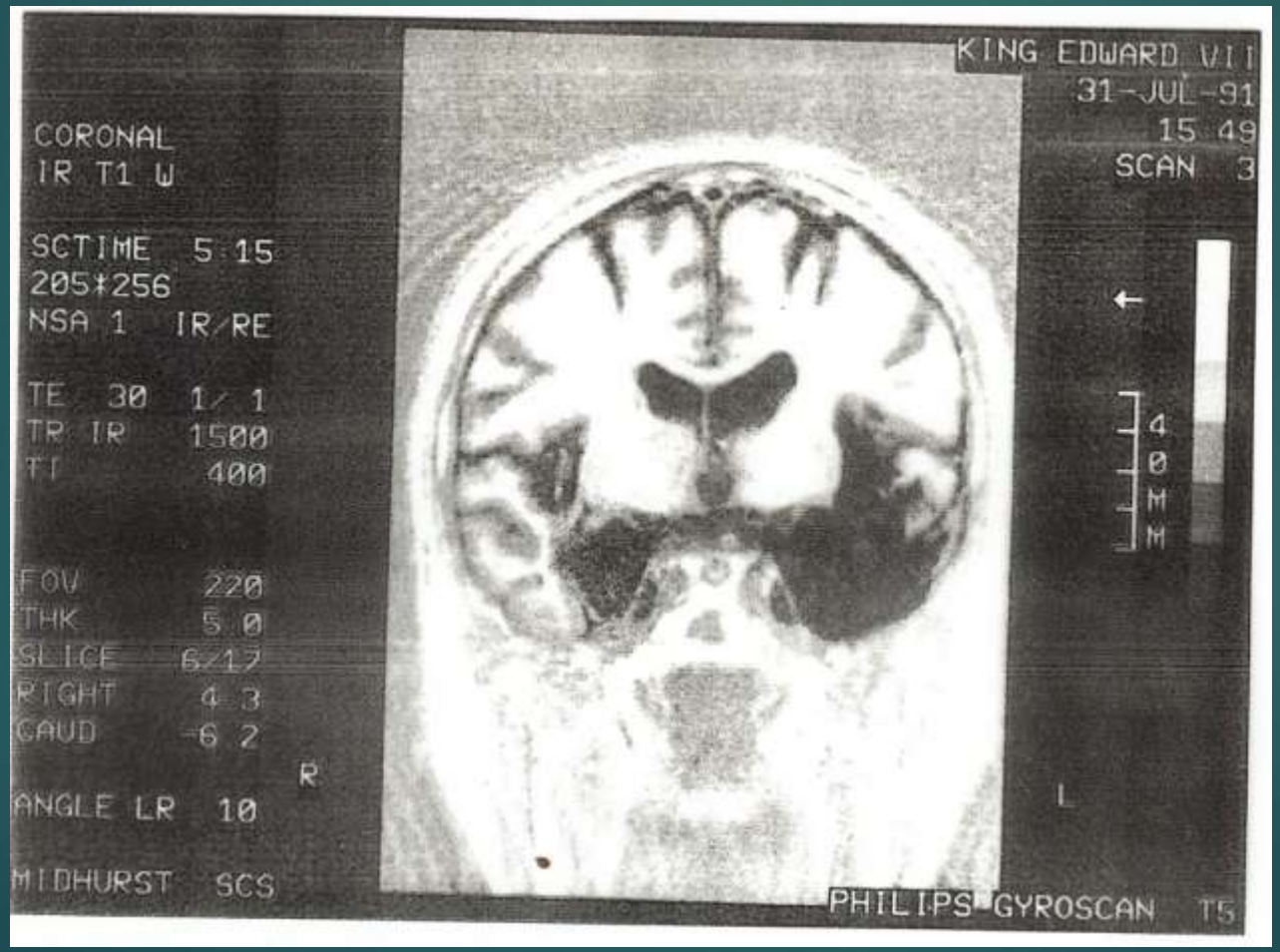
Kapur, 1994

Famous Amnesia Cases: Clive Wearing

- One of the worst cases of amnesia; due to Herpes simplex encephalitis, 1985:
- Conductor, encyclopedic musicologist and BBC music producer
- Severe AA and RA (90 second sensory store); normal implicit memory
- Plays Piano and Harpsichord and conducts and reads music
- Diary:

8:31 AM: Now I am really, completely awake.
9:06 AM: Now I am perfectly, overwhelmingly awake.
9:34 AM: Now I am superlatively, actually awake.

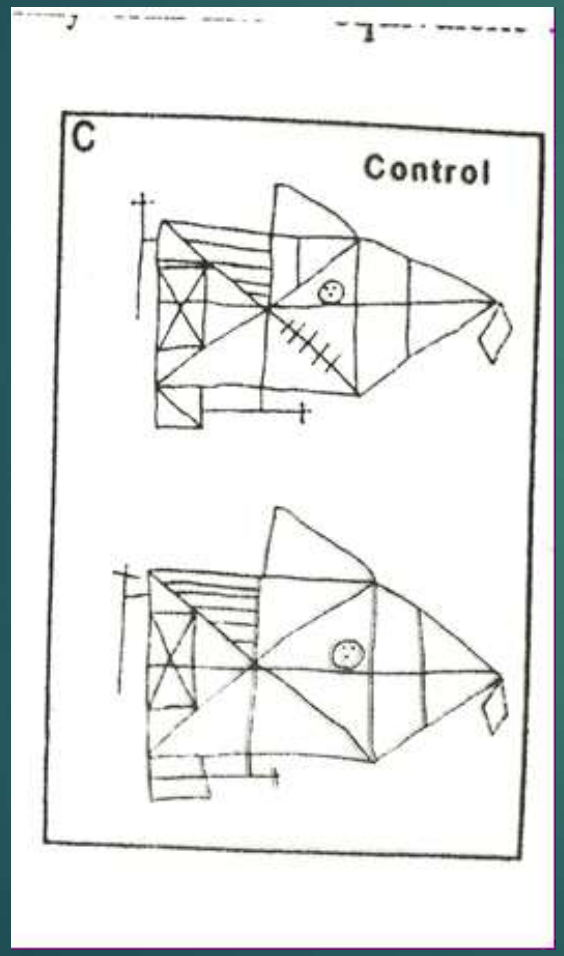
Clive Wearing CT:
No Left Temporal or Hippocampus



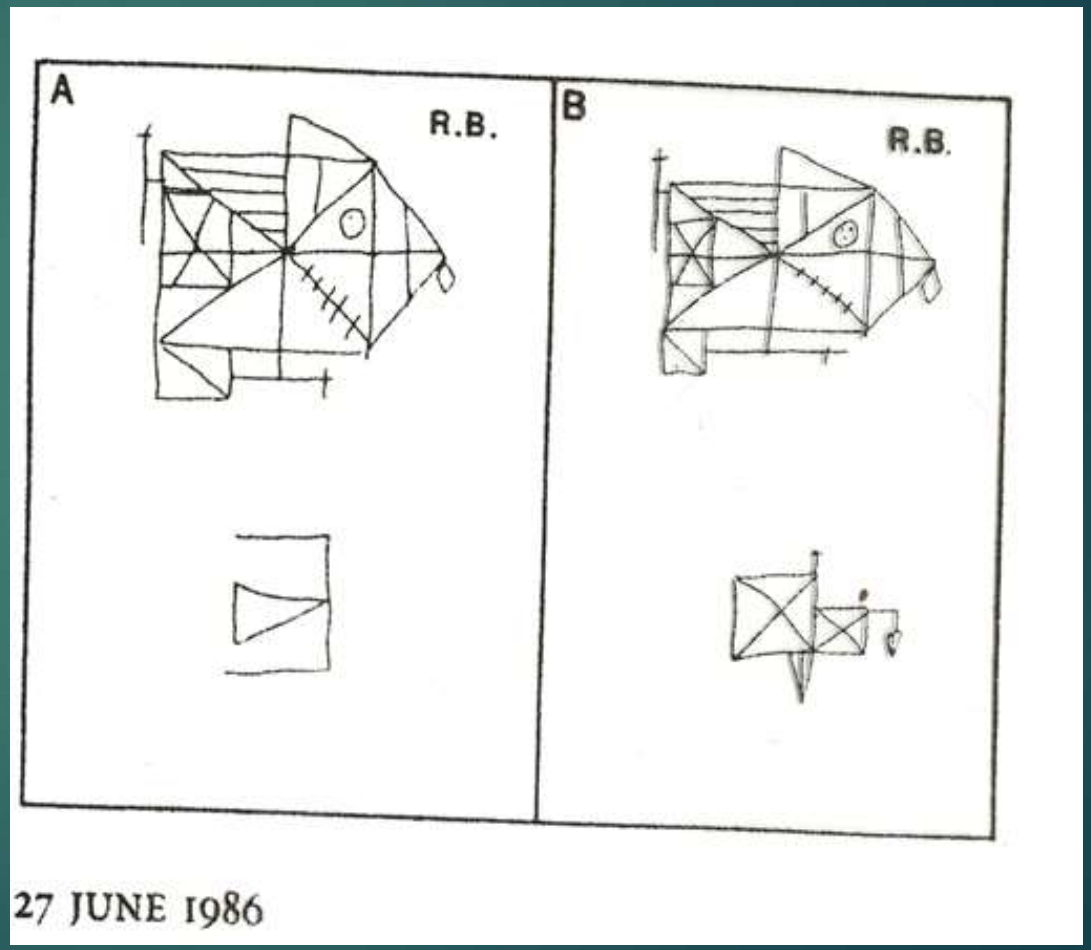
Rey Complex Figure:
Example of impaired visual memory

Copy

Memory
Of figure



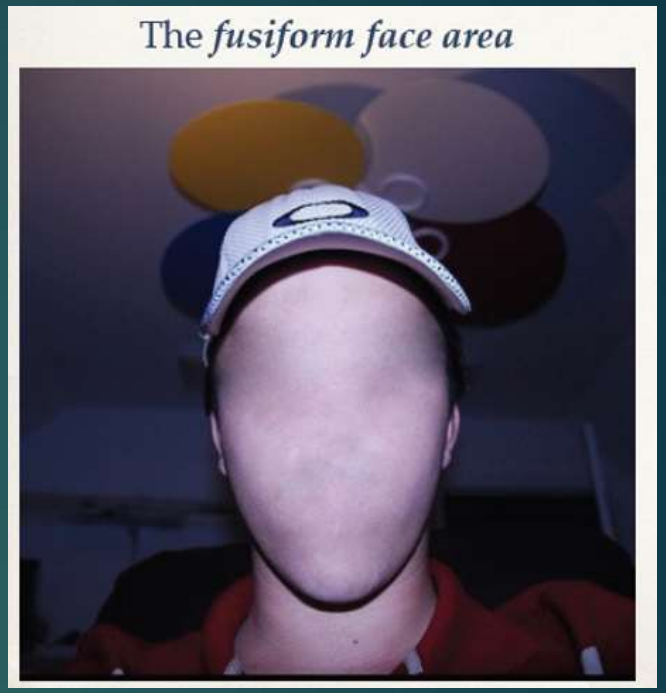
Normal



Impaired

Prosopagnosia (face blindness)

- Impaired recognition of known faces with normal visual acuity; a visual agnosia
- Upper left visual field cut
- Fusiform Face area in RH ↓
- Primarily a visual memory, not perceptual, dysfunction



- Oliver Sachs, Jane Goodall

Gender and Memory

- Women superior in memory:
  - episodic memory.
  - Verbal episodic memory tasks, such as remembering words, objects, faces, pictures or everyday events
  - location of car keys
  - remembering faces, especially of females
  - remembering tasks requiring little to no verbal processing, such as recognition of familiar odors
  - remember better if info given by male baritone voice
- Female episodic memory advantage increases when women utilize verbal abilities and decreases when visuospatial abilities are required
- Men outperformed women in remembering symbolic, visuospatial information.

A. Herlitz & J Rehnman, Psych. Science, 2008

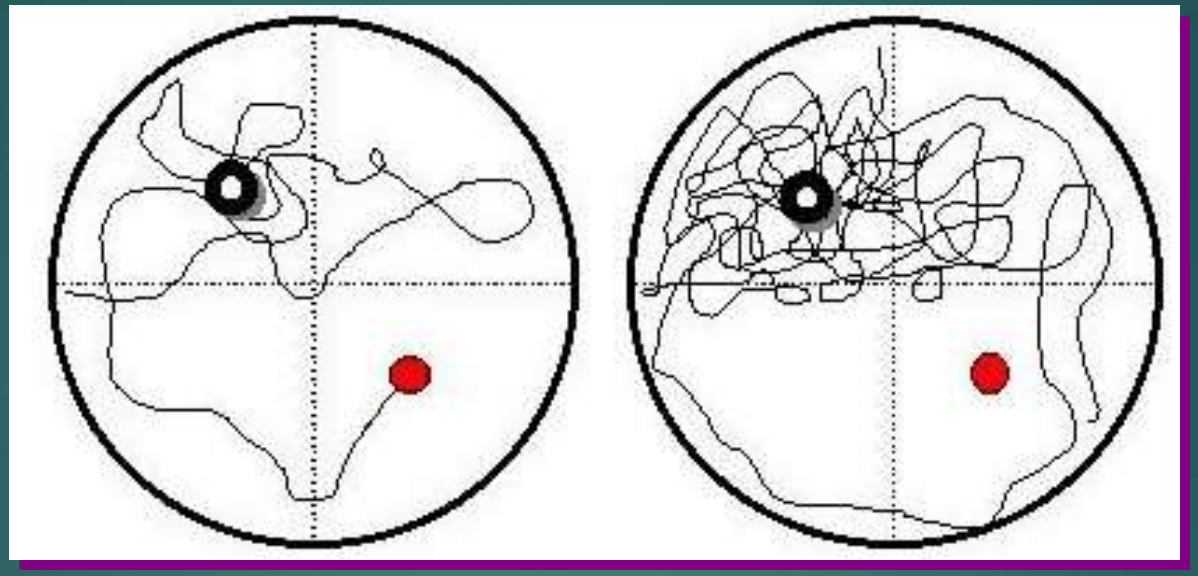
Frontal Memory Disorders

- Reduced Working Memory
- Sensitivity to interference effects
- Reduced search/retrieval of information
- Impaired source memory (context)
- Impaired serial/temporal order
- Deficient metamemory (knowledge of own memory)
- Primacy effect: increase
- Confabulation
- Intrusions/Omissions
- Failure to release from proactive interference
- Impaired prospective memory

Examples:
Names-Faces
Retrieving recent events
Planning to do things

Memory and Alcohol: Finding the new spot

Normal Control



Binger

The black, open circle is the old location and the solid red circle is the new location. Control rats (left) rapidly altered their behavior to find the new location.

Weeks after treatment when alcohol was no longer present, binge treated rats (right) perseverated on the old location. They never found the new location.

Korsakoff's Syndrome: chronic alcoholism

- Damage to the mediodorsal nuclei of the thalamus and mammilary bodies via
  - thiamine deficiency
  - fencing foils (Case N.A.) via nostril
  - snooker cues (Case B.J.) via nostril
- Anterograde and retrograde amnesia.
- If frontal deficits: lack of awareness of deficits (anosognosia)

Traumatic Brain Injury

- TBI: Most common cause of amnesia (permanent loss of new learning)
- PTA: Post Traumatic Amnesia (post confusion, retrograde amnesia for events prior to injury and anterograde amnesia for the accident itself and for all future learning)
- Often significant and permanent Anterograde amnesia and minor Retrograde amnesia

ADHD and Memory

- Impaired Working Memory and Sustained Attention
  i.e. Digit Span Backwards, IVA test
- Frontal executive dysfunctions
  i.e. WCST
- Trial one on list learning impaired:
  i.e. CVLT2
- One time only memory exposure poor, i.e. conversations

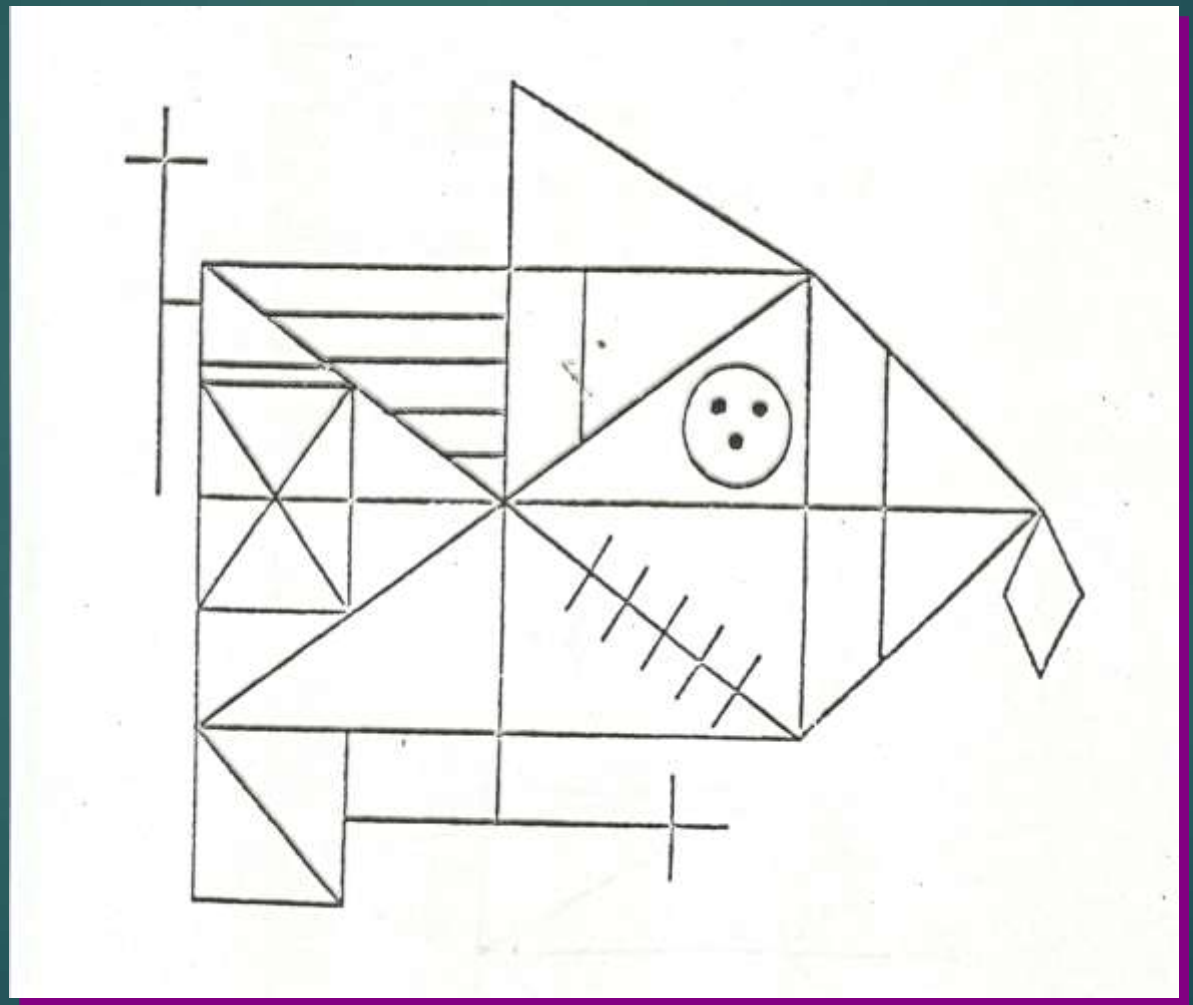
Alzheimer's Disease

- Age 85 = 37% of population
- Anterograde and retrograde amnesia.
- Rapid forgetting is core feature
- Intrusions and False Positives increase
- Semantic Knowledge deterioration
- Working Memory and implicit memory deficits occur later.

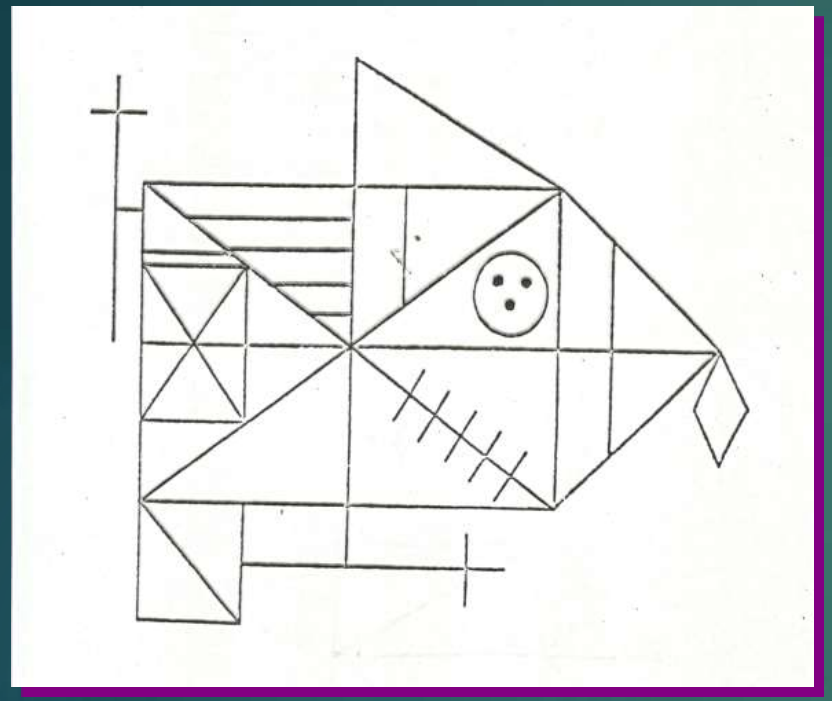
Alzheimer's CVLT

	Raw Score	SS	
Trial 1	**1**	**-3**	
Trial 5	**5**	**-3**	
Short Delay	**2**	**-4**	
Long Delay	**0**	**-4**	**zero recall at 2 minutes**
Long Delay/Cue	**0**	**-4**	
Sem. Clustering	**1**	**-1**	
Recency Region	**62%**	**+5**	
Cued Recall Intrus	**15**	**+5**	
Recognition Hits	**6**	**-4**	
False Positives	**5**	**+2**	
Discriminability		**-4**	

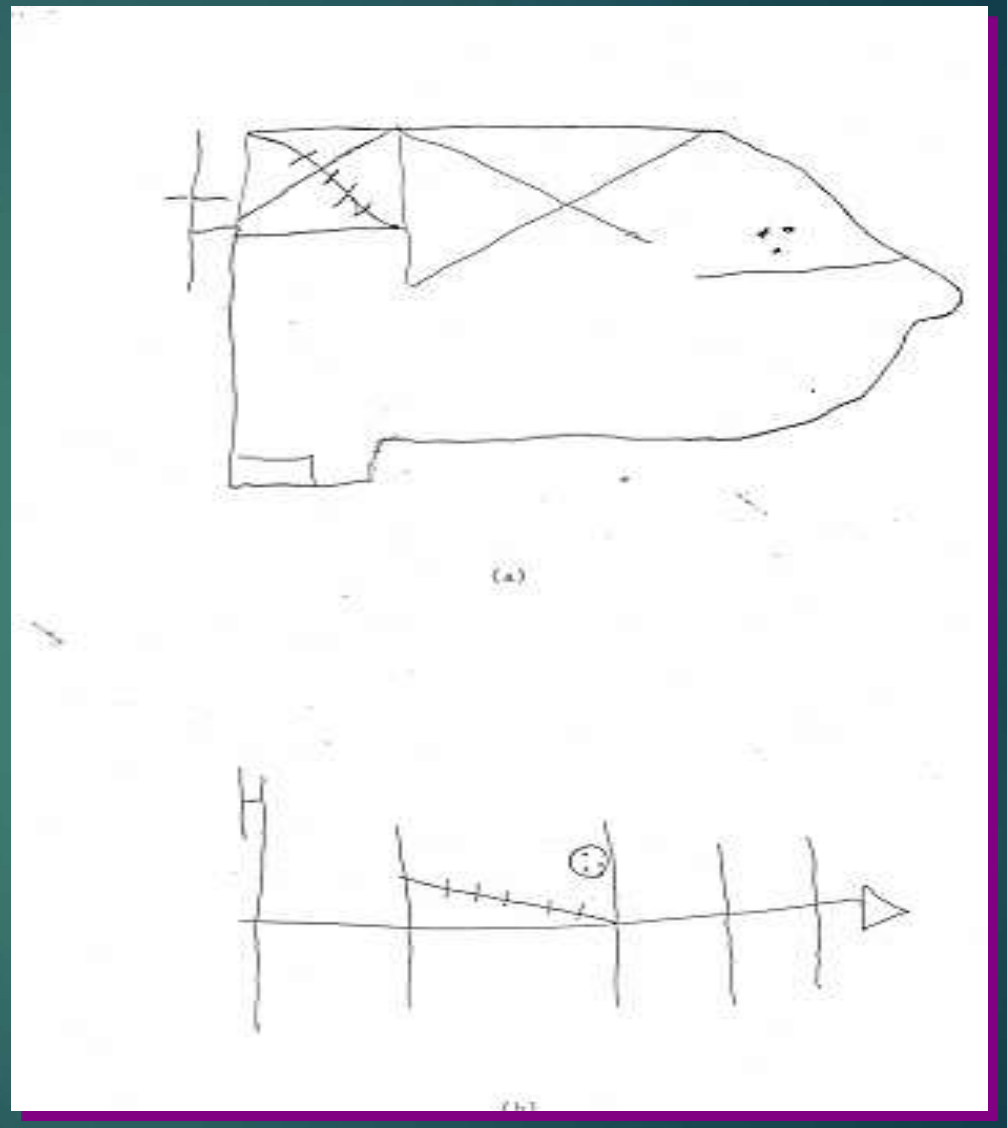
Rey Complex Figure



Alzheimer's RCF



Normal



AD

Normal Memory Decline vs. Alzheimer's

- Normal aging:
  - Dentate gyrus of hippocampus more impaired
  - entorhinal cortex is relatively spared
- In Alzheimer's disease, it's almost exactly reversed.
- Physical exercise and lower blood sugar improve dentate gyrus functioning

Small, 2008

Tip #16 : Physical exercise protects memory

- The Dentate gyrus linked to diabetes implicated blood glucose as a pathogenic mechanism
- The Entorhinal cortex (CA1 & subiculum) linked to infarcts suggested transient hypoperfusion as a pathogenic mechanism
- These results show how diseases of late life differentially target the hippocampus, identify elevations in blood glucose as a contributing cause of age-related memory decline
- Physical exercise is a protection for good memory in older people

Risk Factors for Memory Decline

- Age: greatest risk factor
- Genetics/family hx – 3-4 fold increased risk; earlier, faster
- TBI: 2 x if moder-severe; WWII soldiers – 10x
- Down's syndrome
- MCI
- High blood levels of homocysteine (heavy diet of meat) : 2x
- Apolipoprotein (Epo4)
- Gender: women (live longer) > men
- Pot belly in middle age (2.7 greater risk)
- Not finishing high school (80 % greater risk vs. completion)
- Prolonged stress = more fibrillary tangles
- Chronic worry = 40% more MCI
- Obesity (42% greater dementia; 80% Alz); being underweight (36%)

Memory Killers

- Cardiovascular conditions
- Smoking
- Malnutrition (Thiamine/B1↓↓)
- Binge drinking
- No exercise

Subcortical Neurocognitive Disorders (Dementias)

- Huntington's, Parkinson's, HIV, MS:

- Normal encoding
- Poor spontaneous recall
- Normal recognition (cues help)

- Some Behavioral Memory deficits

Cancer

- N = 1,305 participants reported they had cancer or a history of cancer. 14% of participants who had cancer reported memory impairment
- Brain releases anti-inflammatory proteins to fight cancer that can affect brain
- People with a history of cancer have a 40 percent greater likelihood of experiencing memory problems that interfere with daily functioning.
- “Cancer related cognitive dysfunction," suggesting that it goes beyond the "chemobrain" label

Pascal Jean-Pierre, 2010

Electroconvulsive Shock

- Temporary Anterograde Amnesia
- Retrograde amnesia
- Subsequent work showed that the amnesia gradients may stretch back as long as 3 years.

Depression and Memory

- Decrease in Working Memory
- Effort decreases
- Normal Acquisition/encoding
- Decreased spontaneous recall
- Normal recognition memory
- Complaints!

Hippocampal Atrophy in Mood Disorders

- The relationship between severe depression and the hippocampus is essentially toxic.
- The more intense the history of depression, the smaller the hippocampus.
- Hippocampal size is inversely correlated with illness duration, number of hospitalizations, recurrences.
- Decreased neurogenesis may underlie hippocampal atrophy

Gorwood, et al., AJP, 2008

Antidepressants: Increase Hippocampal Volume

Schizophrenia and Memory

- Working Memory deficit (dopamine effect)
- Executive dysfunction
- Episodic Memory impairment
- Cognitive Types:
  - 35% ~Normal
  - 50% Subcortical Type: poor free recall, normal recognition
  - 15% Cortical Dementia Type: poor free recall and recognition
- Normal Procedural memory
- Cognitive deficits predict life outcome better than psychiatric symptoms

Schizophrenia and Hippocampal Atrophy

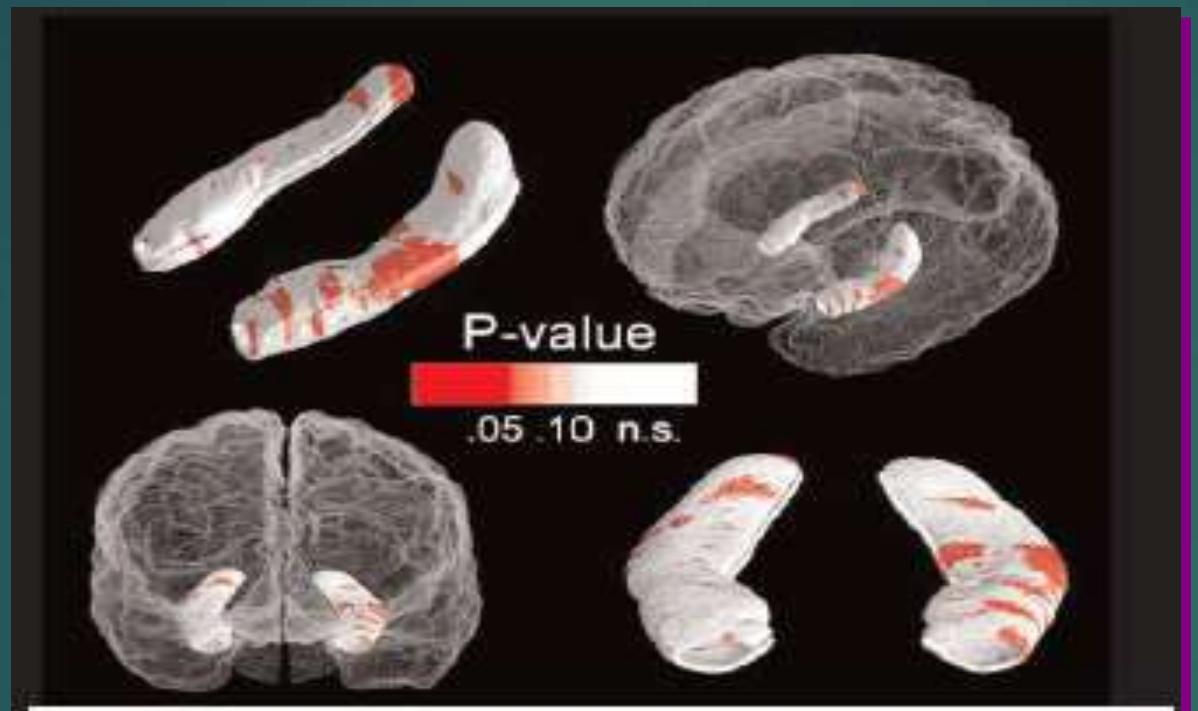


Figure 2. Statistical mapping of deformations in the hippocampal formation that distinguish individuals with schizophrenia (n = 62) from healthy volunteers (n = 60). Note that the deformations (corresponding to volume reductions) in patients are most prominent in the mid-to-anterior hippocampus and appear greater in the left hemisphere.

Memory and Anticholinergic Medications

- Anticholinergic: Inhibiting or blocking the physiological action of acetylcholine
- Drugs: urinary incontinence (Detrol, Ditropan), HTN, asthma, anti-Parkinsonian, older tricyclic anti-depressants

- 80 % of elderly use an anticholinergic medication
- 50% faster rate of cognitive decline, but not higher rate of Alzheimer's
- Incontinence drugs most causative

J. Tsao, 2008

Age and Memory Decline

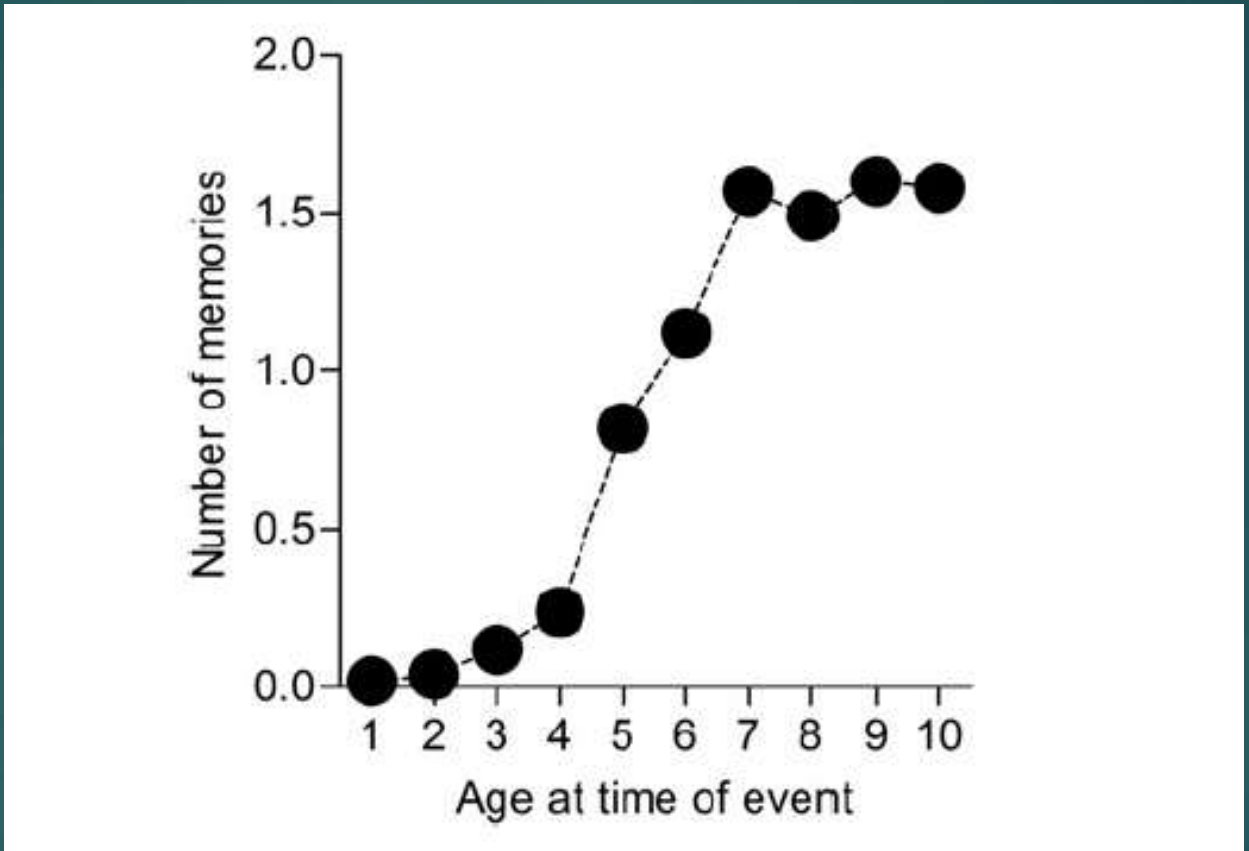
- Preserved:
  - semantic memory (factual and conceptual knowledge),
  - procedural memory
  - language abilities

- Begin to decline in your 20s:
  - episodic memory (recall of experiences and events)
  - spontaneous recall (of names)
  - working memory
  - processing speed
  - selective attention
  - ability to multitask

Infantile Amnesia

- Adults rarely recall memories before age of 3-4
- Continuous autobiographical memory from age 3 1/2
- Old theory: Availability of verbal encoding in childhood correlated to later verbal expression of memory in adulthood
- But animals also exhibit infantile amnesia; no language involved
- New theory: high neurogenesis levels negatively regulate the ability to form enduring memories, most likely by replacing synaptic connections in preexisting hippocampal memory circuits

Infantile Amnesia 2



Distribution of autobiographical memories from the first decade of life showing two phases of infantile amnesia. Participants (20, 35, and 70 yr of age) reported very few memories before the age of three. The number of memories reported to have occurred from the ages of 3–7 yr increased linearly and leveled off from 7–10 yr of age.

Memory and Emotions: Amygdala

- Emotional significance of stimuli: 50 ms (100 x faster than conscious thought)
- Amygdala: Facial expression, Fear recognition, Learned fear response
- Arousal leads to improved recall
- Over-arousal leads to fragmented recall
- Amygdala normally enhances acquisition of declarative knowledge regarding emotionally arousing stimuli
- Amygdala damage impairs emotional memory gist but not details of complex stimuli

Neurochemistry and Memory

- Norepinephrine and Amygdala: inverted U function: high or low levels interfere with memory consolidation
- Oxytocin: Inhibits some memory consolidation; enhances encoding of positive social memory (happy faces)
- Estrogen: Improves memory
- Glucocortisoids: high levels inhibit memory; sustained activity leads to hippocampal cell death (Cushing's = hippocampal atrophy)
- Dopamine: required for normal Working Memory
- Alcohol, cocaine, marijuana: negative memory effects

More Neurogenesis with Exercise

New dentate gyrus hippocampus neurons, in mice that have unlimited access to wheels and running, is twice that in mice living in standard cages. Exercise related to blood flow: more fit, more blood flow oxygenation.

Factors that Decrease Neurogenesis

- Aging
- Recurrent Major Depression
- Disrupted sleep
- Chronic Stress
- Chronically high Cortisol
- Radiation
- TBI

Factors that Increase Neurogenesis

- Physical Exercise
- Antidepressants (in depressed & normals) (> in young than old)
- Fewer calories consumed
- Fasting
- Type of food content (omega-3 fatty acids from algae)
- Anti-depressants & ECT

Neurogenesis and SSRIs (Prozac)

- 4-6 week lag time of SSRIs for full antidepressant effect

- Lag time due to time it takes Serotonin to stimulate neurogenesis in hippocampus
- More new neurons in dentate gyrus of hippocampus
- More dendrites as well

R. Hen, J Neuroscience, 2008

Type of Fat affects Memory

- 2012 Harvard study: women >65
- Worse memory: red meat, butter (food high in saturated fats); transfats
- Better memory: olive oil, sunflower oil, seeds, nuts and avocados (monounsaturated fats)
- Link between high cholesterol and a higher risk of developing Alzheimer's

Psychogenic Amnesia: Dissociative Fugue

- Loss of autobiographic information or personal identity in absence of dementia or delirium; Victims lose only the memories tied to their identity; a loss of episodic memory.
- Never neurologically based (except most severe dementia)
- Characterized in part by sudden and unexpected travel combined with an inability to recall one's past
- First case: Ansel Bourne, a Rhode Island preacher in 1887. Its most famous sufferer is the fictional Jason Bourne, the secret agent made flesh on film by Matt Damon.

Memories are reconstructions, not replays

- Memories are:
  - Not recordings, but rather re-codings, reconstructions
  - They are not audio or visual recordings, but a recoded blend of events from the external world, as interpreted by each person's unique cognitive schemata/inferences.
  - False and misleading information can be integrated into memory.

Memory is Malleable

- Every time we recall a past event, its encoding in our neuronal synapses becomes malleable, and thus potentially subject to change.

- Every time you test newly learned material you add new contexts.

Conversations can alter existing memories

- Retrieval-induced forgetting: Every time you tell a story from memory, there is possibility that you will remember that version, not the original version.

- Conversations intervening between initial encoding and subsequent remembering can provide a context for speakers to implant new memories, alter existing ones, and induce forgetting—in themselves and in their listeners

- Social taboos about what to say and not to say in a conversation may play a noteworthy role in shaping memories, particularly collective memories, through socially shared retrieval-induced forgetting

Hirst & Echterhoff, 2008

Memory Task

What was the main theme of the words in your list?

Example of induced false memory

40% of people include
“sleep” for List 1
“needle” for list 2

List 1	List 2
Bed	Thread
Rest	Pen
Awake	Eye
Tired	Sewing
Dream	Sharp
Wake	Point
Snooze	Prick
Blanket	Thimble
Doze	Haystack
Slumber	Thorn
Snore	Hurt
Nap	Injection
Peace	Syringe
Yawn	Cloth
Drowsy	Knitting

False Memory

- Hearing a list of related words including *bed*, *rest*, and *tired* leads people to claim that *sleep* was presented, when in fact it was not These examples represent just a few of the many ways in which memory can go astray.

- Not only are these errors easily created, but they often become vivid false memories that are held with high confidence.

- Highly persistent

(Roediger & McDermott, 1995).

Source Memory

In the 1980 presidential campaign, Ronald Reagan repeatedly told a heartbreaking story of a World War II bomber pilot who ordered his crew to bail out after his plane had been seriously damaged by an enemy hit. His young belly gunner was wounded so seriously that he was unable to evacuate the bomber. Reagan could barely hold back his tears as he uttered the pilot's heroic response: "Never mind. We'll ride it down together."

...this story was an almost exact duplicate of a scene in the 1944 film "A Wing and a Prayer." Reagan had apparently retained the facts but forgotten their source.

Schacter 1996

Eyewitness Testimony

- Jury Trial: witness points to defendant and says “It’s him.”
- Eyewitness testimony, especially if confident, has disproportionate effect on belief by juror
- But memory can be altered by presenting misdirecting questions
- Answering the question “How fast was the white sports car going when it passed the barn while traveling along the country road?” increases witnesses’ later reports of having seen a nonexistent barn in an earlier video (Loftus, 1975, p. 566).
- Studies: Convincing evidence that eyewitness testimony is poor.

Suggested False Memories

False memory affects future behavior

- People can easily create false memories of their past and such memories can have long-term effects on our behavior.

- False suggestion that subjects had become ill after eating egg salad as a child.

- Four months later, they not only gave the food lower evaluations and also avoided egg salad sandwiches more than any of the other participants.

E. Geraerts, et al., Psy. Sc., 2008

Repressed Memory vs False Memories: Memory Wars

- Controversy surrounding repressed memory came to a head in the 1990s.

- Some believe that traumatic memories could be repressed for years only to be recovered later in therapy, others questioned the concept, noting that lack of scientific evidence in support of repressed memory.

- Gap between clinicians and researchers:
  - 60-80% of clinicians, psychoanalysts, and therapists: traumatic memories are often repressed and can be retrieved in therapy,
  - less than 30% of research-oriented psychologists.

- Belief in repressed memory is still prevalent among the general public.

Implanted False Memory

Implanted False Memories 1:
Lost in Mall at age 6

People remembered or knew they had met Bugs Bunny when they visited Disneyland

Except for the fact that Bugs is Warner Brothers character

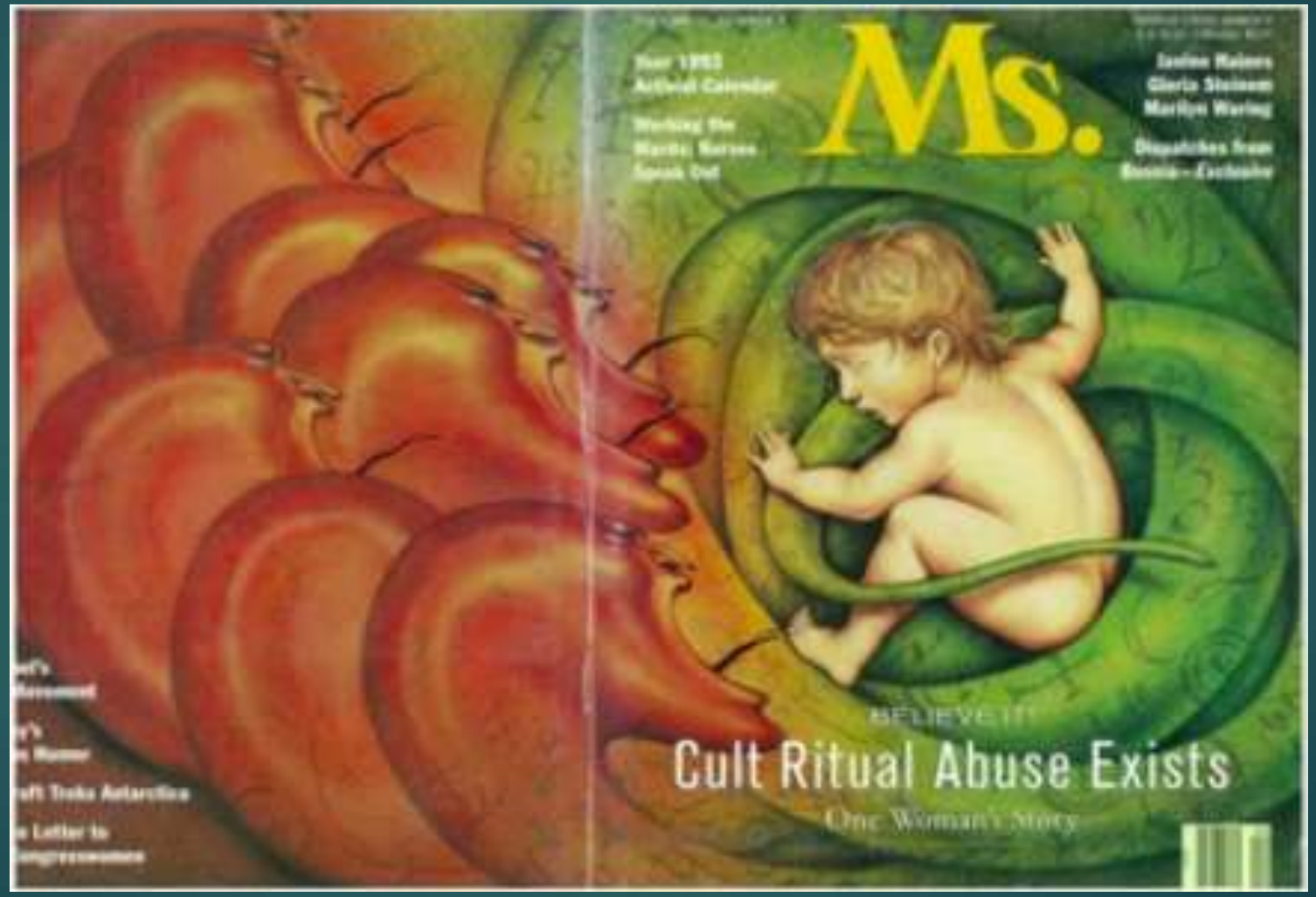
Implanted False Memories in studies

Near drowning

Attack by vicious dog

Demonic possession

Ritual Satanic Abuse: Therapeutic Invention



Loftus: Evidence-based Justice Acknowledges Our Corrupt Memories

- Film clips of car accidents, estimate the speed of the cars.
- Misinformation effect: The wording of the questions, she found, had a profound effect on the estimates.
- People who were asked, “How fast were the cars going when they smashed into each other?” gave higher estimates on average than those with whom the verb 'hit' (vs. “contacted) was used (and later remembered non existent broken glass).
- Well-meaning psychotherapists could inadvertently implant false memories into patients' minds
- In a line-up, police officers can influence identification,
- NJ Judge: Jurors must be told of fallibility of memory
- But see 100 corroborated cases: http://blogs.brown.edu/recoveredmemory/about/background/

Trauma and Memory

- Amnesia for traumatic event occurs in some victims for every type of trauma.
- Childhood sexual abuse had highest degree of total amnesia (19-38%)
- Age and dose related: The younger at time of trauma and more prolonged the trauma, greater level of significant amnesia

Loftus, 94; Williams, 94; van der Kolk, 96

1996 Crime Victims Compensation Program in WA: Recovered Memory Therapy – Be Careful

- 183 claims of repressed memories of childhood abuse:
- 100% report torture/mutilation (no evidence), 97% satanic ritual abuse; 76% infant cannibalism; 69% torture with spiders
- 100% in therapy 3-5 years after 1st memory
- 10% SI before therapy; 67% following therapy
- 7% hospitalizations → 37%; self mutilation 3% →27%;
- 83% employed → 10% employed 3 y into therapy
- 77% married → 48% divorced/separated
- 23% lost parental custody
- 100% estranged from families

Trauma and Memory

Conclusions:

Traumatic events are most often not repressed or forgotten

It is harder to forget trauma than to repress it.

False memory can be formed by suggestion (therapists can induce false memory)

Autobiographical memory is not a video camera, faithfully recording events; it is malleable by latter events and questions.

You can't trust memory in a tortured brain

- Coercive interrogation techniques to extract information from terrorist suspects
- Extreme stress has a deleterious effect on the frontal lobe and is associated with the production of false memories.
- The hippocampus and prefrontal cortex, are rich in receptors for hormones that are activated by stress and sleep deprivation and which have been shown to have deleterious effects on memory.
- Studies of extreme stress with Special Forces Soldiers have found that recall of previously-learned information was impaired after stress occurred.

O'Mara et al., 2009

PTSD and Memory

- Decreased hippocampal volume (7-25%): Vietnam Vets with most combat, women with repeated sexual abuse,
- Unclear if it is cause or consequence of PTSD (probably a risk factor).
- Extreme Amygdala arousal disrupts hippocampal function, leaving memory to be stored as affective states or sensorimotor memories
- Amygdala mediated memories are indelible (PTSD, borderline PD)

Intrusive memory removal via Tetris after a trauma

- If you have intrusive memories:
- Play Tetris
- Playing Tetris for 2-3 hours after a trauma, reduces PTSD sxs
- It also has been shown to control other intrusive thoughts
- Both Tetris and a memory cannot be in the same WM space

PTSD & Tetris: Disrupting Traumatic Memory

- The neurobiology of memory suggests a 6-hr window to disrupt memory consolidation.
- Visuospatial cognitive tasks selectively compete for resources required to generate mental images.
- A visuospatial computer game (e.g. “Tetris”) will interfere with flashbacks.
- The “Tetris” condition produced a significant reduction in flashback frequency over 1-week.

EA Holmes, PLOS, 2009

PTSD Reduction

- **Paxil** increases verbal declarative memory and hippocampal volume in PTSD

- Pitman (2002): **Propanolol** (40 mg qid) within 6 hours of trauma (10 day course) ; a beta-adrenergic (epinephrine) blocker
- 50% reduction in PTSD sxs; fewer nightmares & flashbacks
- Intravenous administration of **hydrocortisone** over a period of 6 days plus taper decreases the incidence of PTSD
- Quickly giving **morphine** to wounded troops: 53 percent lower risk of PTSD

- These drugs don't erase memory — rather, they prevent the overproduction of stress hormones that encode attached fear response.

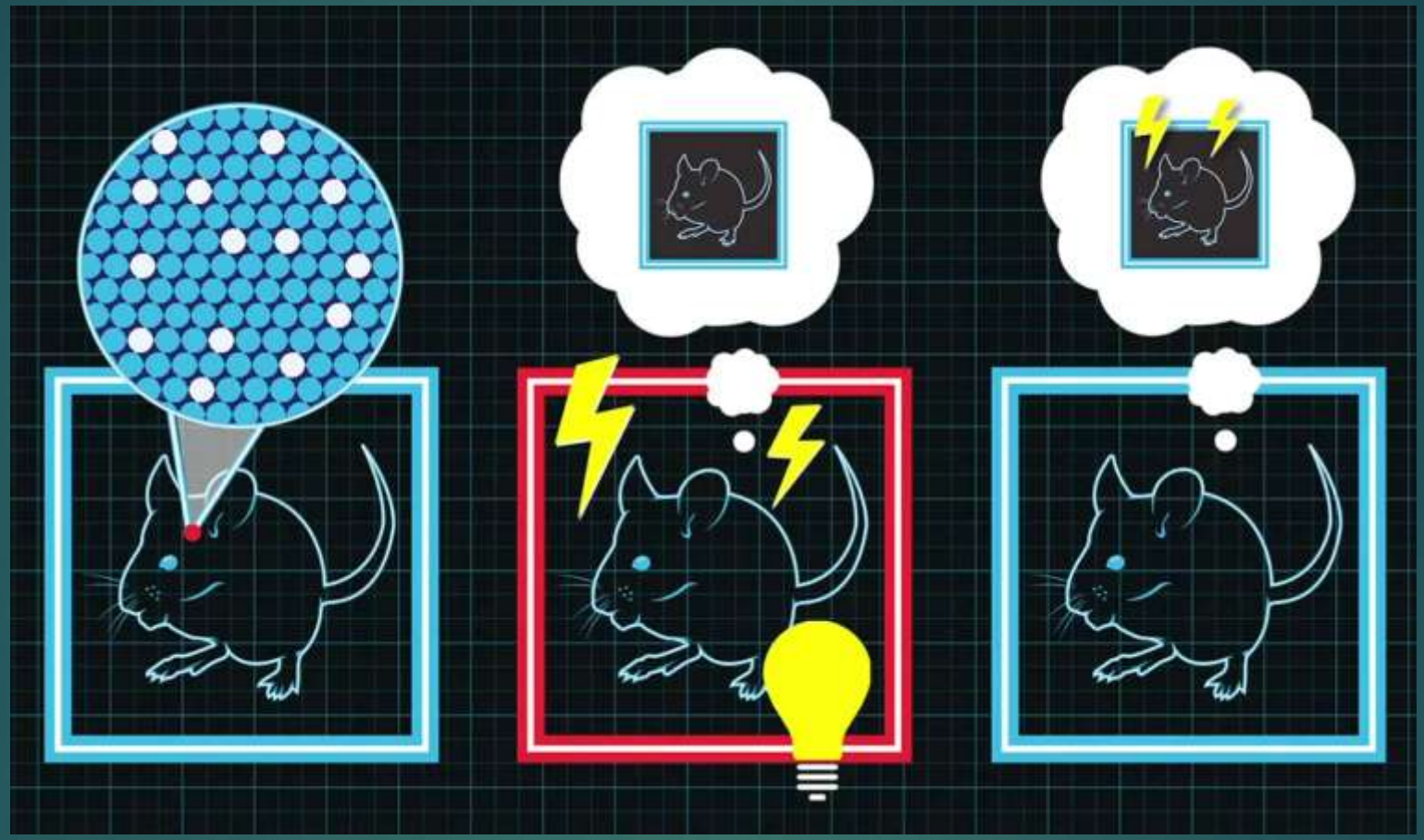
A. Brunet, 2009; Herbst, 2004:

Erasing memories: Reconsolidation of Memory

- Rats were shocked when tone played. They froze in fear.
- Days after consolidation of memory, tone replayed to reactive this memory.
- Drug given to prevent Amygdala from creating storage proteins.
- Rats stopped reacting to tone.
- Some long term memory can be erased.

Nader, 2000

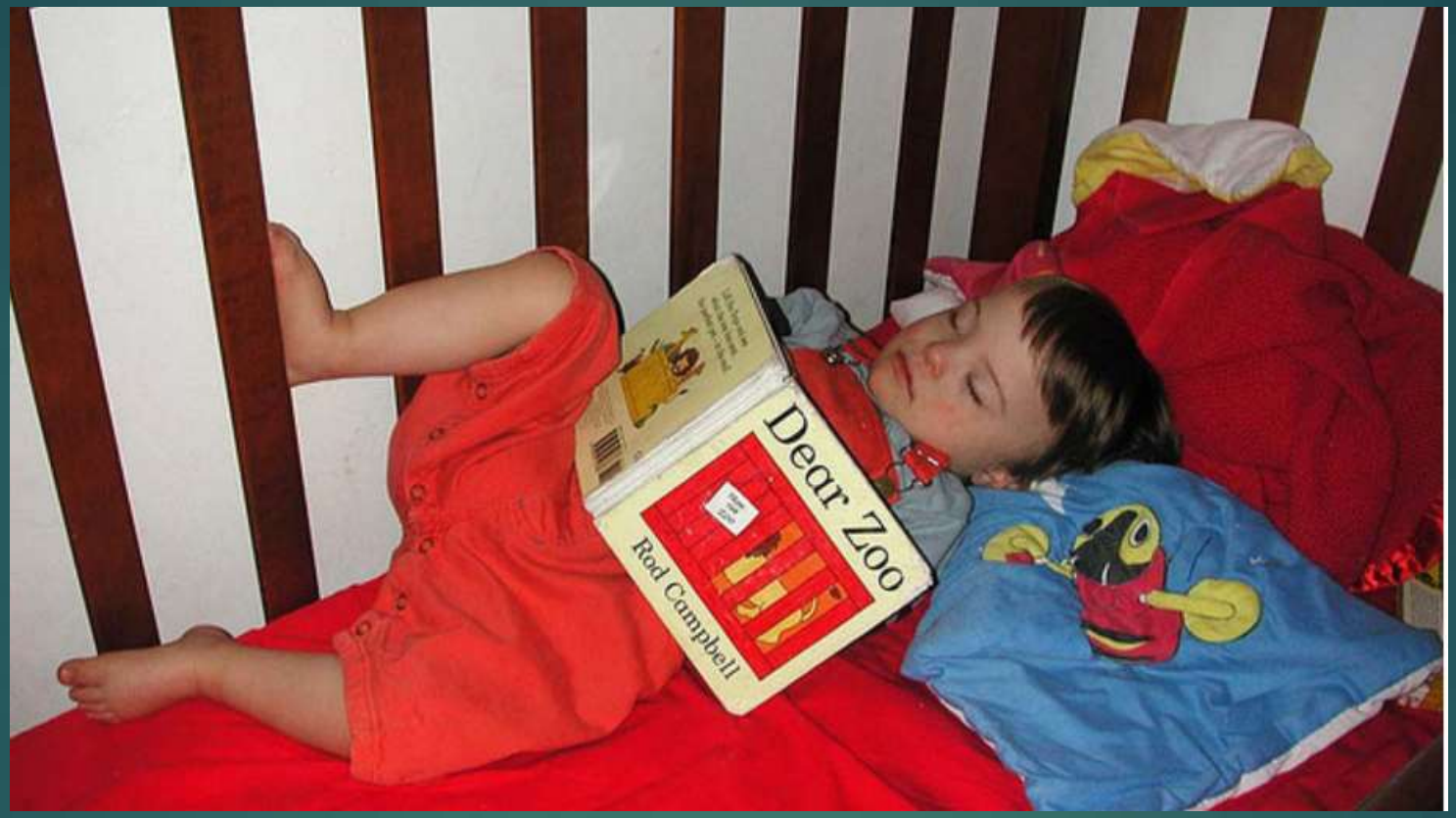
Can now create a false memory in a mouse



- Three steps to plant a fake memory in a mouse. First, let the mouse build a real memory of a safe room (left). Second, put the mouse in a room with an electrified floor. Shock the mouse — but add the memory of the shock to the memory of the first room. Third, put the mouse back in the safe room — which the mouse now incorrectly “remembers” as dangerous.

Credit: courtesy of Evan Wondolowski/Collective Next

Learning Strategies



Unfortunately, learning through book osmosis doesn't make the learning strategies list.

Memory Tips for Remembering

- Pay Attention!
  - Faces & Names: Always ask them again & repeat out loud (attach an image)
  - Prevent “car parking amnesia”: look back at location from where you end up
  - Never put things in “special” places (SS check in p. 585 of *War & Peace*), only in regular places (“memory box” on your dresser, or near front door)
- Rely on technology
  - Post its or paper grocery list
  - Smart Phones: phone numbers, people & addresses, calendar event reminders, picture of your license plate, argument resolution for facts
- Be responsive: self generation effect
  - Use your knowledge
  - Tell people what you have learned
  - Best way to learn is to teach

Effortful Processing Strategies
Chunking

- Why are credit card numbers broken into groups of four digits? Four "chunks" are easier to encode (memorize) and recall than 16 individual digits.

→ Memorize: XIDKKFCFBIANA ACPCVSSUVROFLNBAQ

- **Chunking:** *organizing data into manageable units*

XID KKF CFB IAN AAC PCV S SU VRO FNB AQ

- **Chunking** works even better if we can assemble information into meaningful groups:

X IDK KFC FBI BA NAACP CVS SUV ROFL NBA Q

X IDK KFC FBI BA NAACP CVS SUV ROFL NBA Q

Memory Tips

- Make it a habit. When you put your keys down, stop and say out loud, "I'm putting my keys on my dresser."
- Memory box or place: same place all time
- Create a visual cue, i.e. milk carton by door
- Repetition: When you meet people at a party and they give you their names, focus on the name and nothing else, and practice using that name in conversation, by saying the name back. Add a visual cue.

Memory Tips

- Most important: Repeated self testing

- Spaced, repeated practice, not cramming night before
  - Speed-packing a cheap suitcase -- it holds its new load for a while, then most everything falls out.

  - When the neural suitcase is packed carefully and gradually, it holds its contents for far, far longer.

Benefit of chewing gum

- Two separate studies:
- Recall improved by 35% on delayed recall in those who chewed gum
- Chewing gum raises heart beat by 3 BPM, increasing blood to brain

Benefits of Doodling

- If you are in a boring meeting, the best thing you can do is try to make it more interesting, but if that's not going to happen, your best bet is to doodle.
- It's not so much that doodling is good for your concentration, but that daydreaming is bad.
- Doodlers recalled 7.5 names and places – 29% more than the average of 5.8 remembered by the control group.

Andrade, App. Cog. Psych, 2009

Memory is better if…

- Intentional learning better than incidental learning
- Elaborative rehearsal better than rote memory
- Memory is better if visual image formed
- Information that you generated is learned better than if you just read or hear it, i.e. self testing vs. relooking at notes
- Memory is better if you perform a task rather than watch someone else do it or read about it
- If you look away when asked a question

Memory is better if…

- Memory is better the second time you learn something
- Pictures are remembered better than words
- Concrete information remembered better than abstract info
- Positive information is remembered better than negative (Pollyanna effect), except if sudden, negative trauma
- Memory is better for frequent info for recall testing, but better for rare info for recognition
- If you are left handed (more corpus callosum connections)

Memory is worse if…

- Memory is worse on recall tests in groups than when alone
- Memory is worse on recognition tests when alone than in groups

Learning from our Mistakes

- We learn more from our mistakes than from our successes
- Faster recognition of situations (brain signal appears only 1/10th of a second later) in which we previously made an error
- Errors result in better learning
- Except for frontally damaged pts: anterior cingulate does not alert to negative feedback in these pts

Aristotle on Practice

“We are what we repeatedly do.

Excellence, then, is not an act, but a habit.”

10,000 Hour Rule: Practice Makes Perfect

- Dr. K. Anders Ericsson: became curious about 7 +/- 2; With 20 hours practice, 20 digits; 200 hrs = 80 digits
- He investigated chess grandmasters and the stars of the PGA tour, Scrabble champions and brain surgeons, concert pianists and circus acrobats: average IQ of people at the top of their field
- Talent comes from learning by doing. For example, when Ericsson studied classical pianists, he found that the winners of competitions had practiced over 10,000 hours by the age of 20, while less accomplished performers only practiced between 2,000 and 5,000 hours.

- The best performers are almost always the ones who practice the most.

- **See *Outliers: The Story of Success* by Malcolm Gladwell**

Learning Strategies

- Taking notes during class?
- A consistent learning environment?
- Single topic-focused study?
- All are exactly opposite of the best strategies for learning.
- Highlighting, underlining and rereading, methods that many students use, are ineffective.

Tip #17 : Move around/change the context of learning

- State-dependent or context-dependent learning:
  - Recall is best when retrieval environment is the same as learning environment, i.e. scuba diving, being drunk, etc.

Changing your learning environment (Context)

- We perform better on tests when in the same internal state of mind as when we studied.
- We recall better when we are in the same mood as when we learned something.

- Bipolar disorder: have state dependent memory – remember best what happened in manic phases when manic and vice versa for depressed phases

- Drugs: do better in same intoxicated state; but strong external hint (i.e. a category) is stronger reminder

- Music: remember more with same music

Tip #18: The more cues, the better the learning

- The more places in which you study the same material, the better the later recall.

- Most people remember more if they vary their study or practice location. More environments in which you rehearse, the more lasting memory.

- Study: Students studied a list of 44 words for same amount of time in either in 1 or 2 rooms. When tested 3 hours later for 10 minutes in new room: 1 room = 16 word recall; 2 room = 24 word recall; 40% increase in recall from change of venue

Context changes

- Doesn’t matter which aspects of environment you vary, so long as you vary what you can; vary the circumstances in which you prepare; each alteration of the routine enriches the skill being rehearsed

- The more contexts we have, the more cues we have available to retrieve the information at the time of the test.

- Examples of different learning environments: change location, alter study time, how you engage material (read/discuss), type vs write, listening to music

Tip #19: Spacing Out: Break up study time

- Cramming isn't useless. The all nighter is time tested student behavior. Cramming is like overstuffing a cheap suitcase. Contents hold for awhile, then all falls out. You will not remember the material next semester. Massed practice (cramming) results in only one context.

- Distributed learning or the spacing effect: 50% better memory

- Spacing: Better retrieval if spaced learning, results in multiple contexts.

- Breaking up study or practice time (dividing it into 2 or 3 sessions instead of 1) is far more effective for learning than cramming.

- Spacing study time is the most powerful and reliable technique known to science to deepen and extend memory.

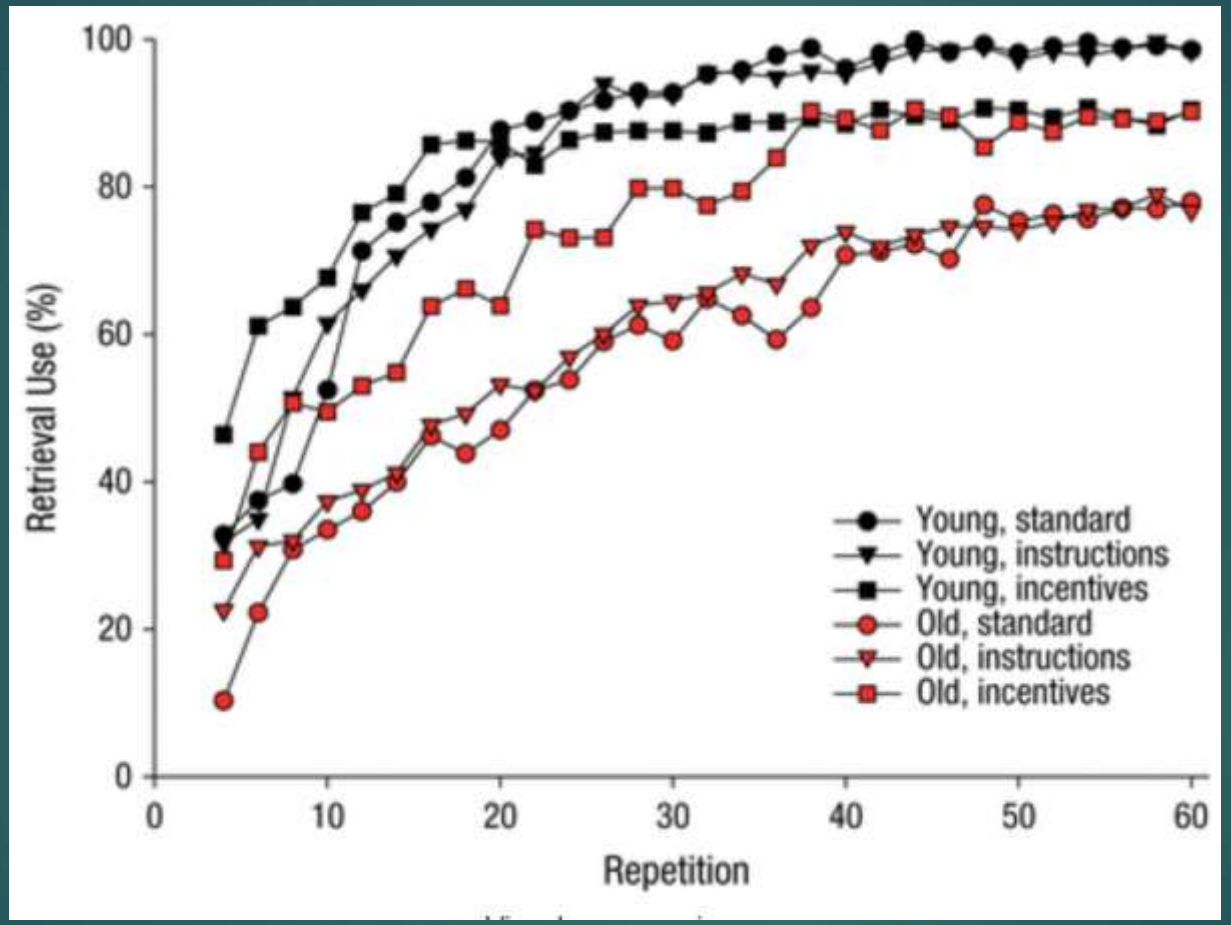
Spacing it for a given test date

Time to Test	First Study Interval
1 week	1-2 days: today, tomorrow, day before test
1 month	1 week: today, 1 week, day before
3 months	2 weeks
6 months	3 weeks
1 year	1 month

The further away the exam, larger the optimal interval between sessions 1 and 2.
Optimal first Interval declines as a proportion of time-to-test.
If in a week, best interval is a day or 2.
If in six months, 3 to 5 weeks. For most situations, working with intervals of 1 day, 2 days, or 1 week. You will retain the material for much longer.

Wiseheart & Pashler, 2008

Tip #20: You remember better if you get paid to remember better



Squares: Both Young & Old had better memory if paid for performance

Tip #20: Mix it up; do not repeatedly study same thing

- Bean bag experiment: 2 groups, both blindfolded (could look after they made throw); 1 group aimed at bull's eye 3 feet away; 1 group aimed at 2 targets (two feet & four feet away)
- Finally test was on a 3 foot target; Group 2 won with closer tosses

- Variation improves movement awareness; varied practice forces you to internalize rules of motor adjustment that apply to any hittable target

- Mixed or interrupted practice sessions more powerful than focused block practice (focusing on 1 skill at a time)

Mixing it up: real world requires judgment & memory

- Practice vs Performance: In repetitive practice you have control, but in performance, external reality is in control
- Repetition of same behavior improves skill, then plateaus; varied practice has slower apparent rate of improvement in each practice, but greater learning overall.
- Systematically altering practice encourages different information processing; can degrade performance during practice, but generates greater performance capabilities overall.
- Under this practice: involves spacing effect, context change

Interleaving/Mixing it up: preparing for life's curve balls

- Interleaving: The strategy suggest that instead of spending an hour working on your tennis serve, you mix in a range of skills like backhands, volleys, overhead smashes, and footwork.
- Interleaving: mixing related but distinct material during study; vs. sheer repetition of same material
- Examples: piano scales & theory; endurance and strength training in football; new math equations & prior material; new Spanish words and old words
- If test is a potpourri, then homework should be the same.
- Interleaving prepares the brain for the unexpected. A dose of review and a dose of surprise. It's not an adventure until something goes wrong.

YouTube and Memory

- Stephen Wiltshire draws Rome from memory
- Clive Wearing: Living Without Memory

Internet Memory Sites

- Braingle: http://www.braingle.com/mind/memory.php
- Memory Gym:

  http://www.memorise.org/
- Helpguide: http://www.helpguide.org/life/improving_memory.htm

Have a good Week

Memory biography

- *How We Learn* by Benedict Carey
- *Perfect Present* by Suzanne Corkin
- *Moonwalking with Einstein* by Joshua Foe
- *Make it stick* by Peter Brown, Henry Roediger, Mark McDaniel
- *The Memory Book* by Harry Lorayne and Jerry Lucas
- *The Art of Memory* by Frances Yates

- Art of Memory Website: http://artofmemory.com/

- www.charlesjvellaphd.com
- Go to Public Lectures