What is Cognition?

- *It* encompasses the mental functions by which knowledge is acquired, retained, and used: perception, learning, memory, and thinking.
- cognicioun, “ability to comprehend, mental act or process of knowing”, from Latin cognoscere “to get to know, recognize,” from assimilated form of com “together” + gnoscere “to know” ..(from https://www.etymonline.com/word/cognition).

- Most important is ‘reasoning’

Understanding the definition/word cognition

- The word seems straightforward, yet it is often a cause of debate in the psychological and neuroscience fields, particularly about whether a behaviour of an animal that happens not to be human is truly “cognitive”, in a similar sense to human cognition.
- Does this mean the birds “know” about the displacement of water by sinking objects?

(/www.cell.com/current-biology/fulltext/S0960-9822(09)01455-9).

- Researchers have long investigated whether birds possess the mental equivalent of a compass, driven by observation of sun or stars, or a map, driven by geomagnetism.
- That is, mental maps and compass bearings are representations of information that imply specific c properties, the bread-and-butter of cognitive theorizing.

Cognition in non-human animals

- J. David Smith, Ph.D., a comparative psychologist at the University at Buffalo who has conducted extensive studies in animal cognition, says there is growing evidence that animals share functional parallels with human conscious metacognition -- that is, they may share humans' ability to reflect upon, monitor or regulate their states of mind.
- Among these species are dolphins and macaque monkeys (an Old World monkey species).

The case of Anna H

Oliver Sacks

- Dear Dr. Sacks,

My (very unusual) problem, in one sentence, and in non-medical terms, is:

I can't read. I can't read music, or anything else.

In the ophthalmologist's office, I can read the individual letters on the eye

chart down to the last line. But I cannot read words, and music gives

me the same problem. I have struggled with this for years, have been

to the best doctors, and no one has been able to help.

I would be ever so happy and grateful if you could find the time to see me.

Sincerely yours,

Anna H.

The case of Anna H

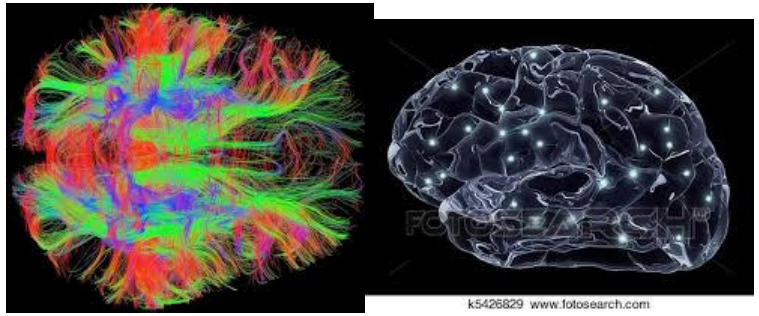
- Given a battery of neuropsychological tests—tests of visual perception, of memory, of verbal fluency, etc.—Mrs. H. did particularly badly in the recognition of drawings: she called a violin a banjo, a glove a statue, a razor a pen, and pliers a banana.
- Shown a photograph of a face, she could perceive that the person was wearing glasses, nothing else
- In contrast to her severe visual problems, her speech comprehension, repetition, and verbal fluency were all normal.
- A PET scan showed lower activity in the posterior Visual cortex (dominantly on the left side)

The case fo Howard Engel

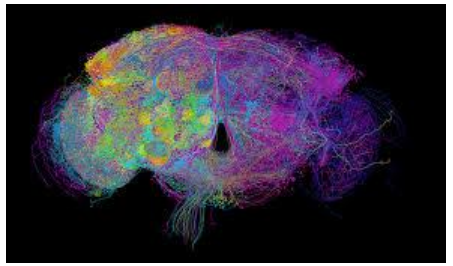
- Howard Engel, a Canadian novelist, who told me that he had a somewhat similar problem following a stroke. “The area affected,” he relates, “was my ability to read. I can write, but I can’t read what I’ve just written. . . . So, I can write, but I can’t rewrite. . . . My vision for the most part is unaffected until I look at a text. Then, whatever I’m looking at turns into unfamiliar blocks of type that could at first glance be taken for Serbo-Croatian. Familiar words, including my own name, are unfamiliar blocks of type and have to be sounded out slowly. Each time a name recurs in an article or review, it hits me as unfamiliar on its last appearance as it does on the first. . . . I have just started [writing] a crime novel in which the hero has similar problems.” Though Engel was a fair sight reader, he told me later, he had no musical alexia

Caenorhabditis elegans

302 neurons and 7,000 connections



86 billion neurons in our brains



Drosophila melanogaster

roughly 135,000 *neurons* in the brain

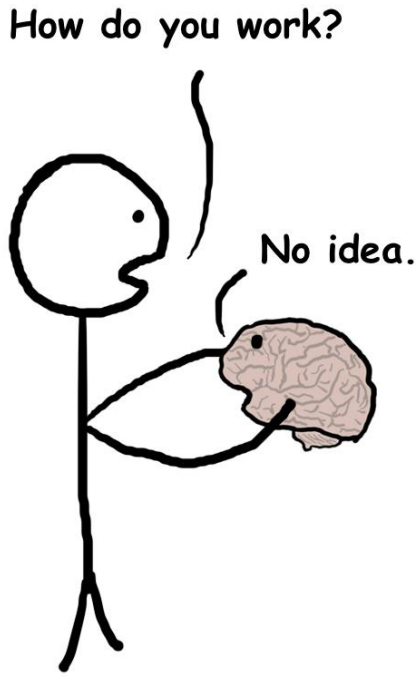
What is not known still?

- **What is the brain made of?**
- **How does the brain change in disease?**
- **How do neurons talk to each other?**
- **How does the brain compute?**
- **What will it mean to understand our brains?**

https://alleninstitute.org/what-we-do/brain-science/news-press/articles/5-unsolved-mysteries-about-brain

Top unsolved or most researched topics in neuroscience

- Perception
- Consciousness
- Learning and memory:
- Neuroplasticity
- Development and evolution:
- Cognition and decisions
- Language
- Diseases



Consciousness:

Neuronal basis of:

- subjective experience
- Cognition
- Wakefulness
- Alertness
- Arousal
- Attention

How do brains simulate the future?

Essentially, it asks: what is consciousness? Or how do we think?

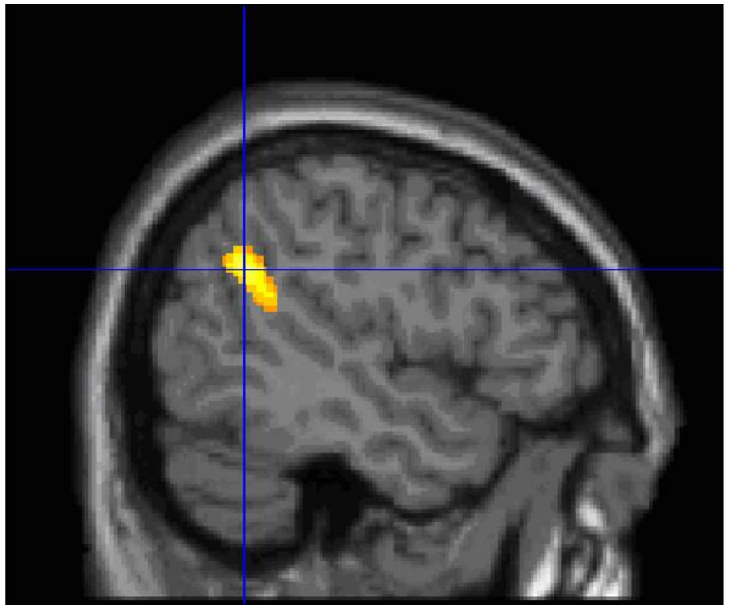
Is simulation possible without learning & the experience that comes with learning?

Are we conscious of things we have no knowledge off ?

Dreams

Recalling dreams: The high-recallers and the low-recallers.

- temporo-parietal junction (information-processing hub and attention orienting toward external stimuli) and medial prefrontal cortex



Credit: © Perrine Ruby / Inserm

Visual/mental imagery & vivid projections of images internally!

- The Question is: how is the image formed, stitched and presented.
- Or is visual imagery really visual?

Sleep walking

- Brutal act: Case of Scott Falater – 43 year old who stabbed his wife & ducked her in the pool in 1997. When interrogated, he claimed does not recall the complete act - When he was tried, the prosecution claimed that after the murder had been committed, Falater changed his clothes, put the murder weapon in a Tupperware container, put the container in a trash bag with his boots and socks, stashed the bag in the spare tire well in the trunk of his car, and took and hid all the items that showed that he was the person who killed her.
- On June 18, 1999 a prosecution expert testified that Falater's actions were "too complex" to have been carried out while sleepwalking. Four weeks later, Scott Falater was found guilty of first degree murder and sentenced to life in prison without chance of parole

phantom limbs

- the vivid impression that the limb is not only still present, but in some cases, painful.
- Patient recognizes that the sensations are an illusion(unreal vision) not a delusion (false beliefs).
- Case of elaborate sensory memories

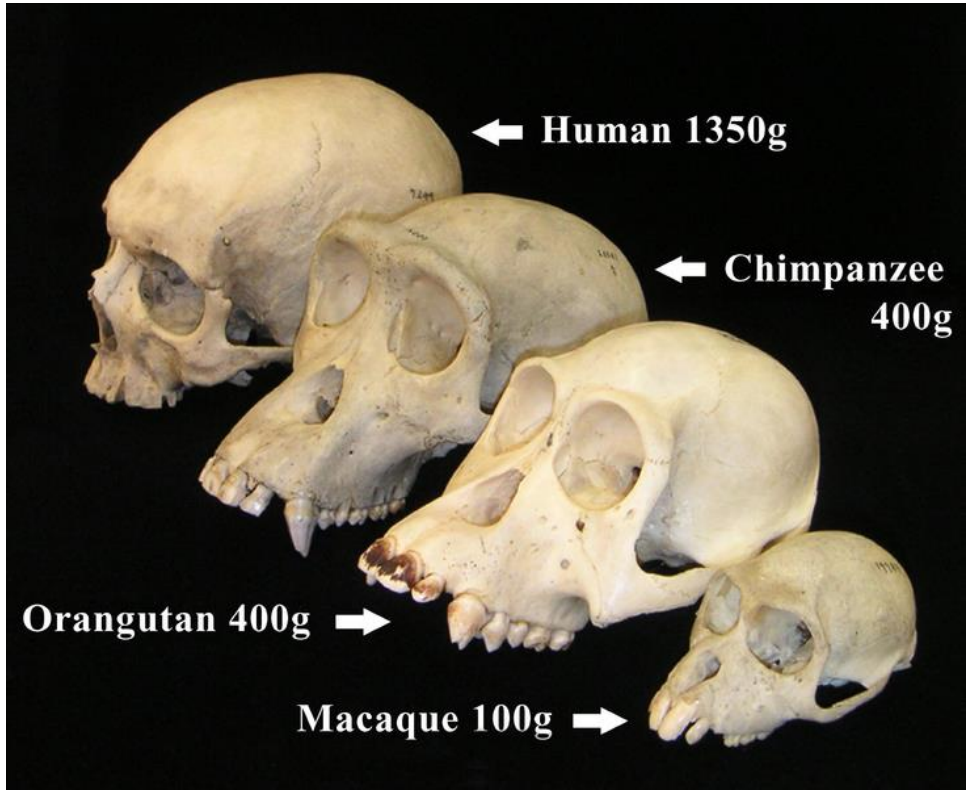
Ongoing debates today

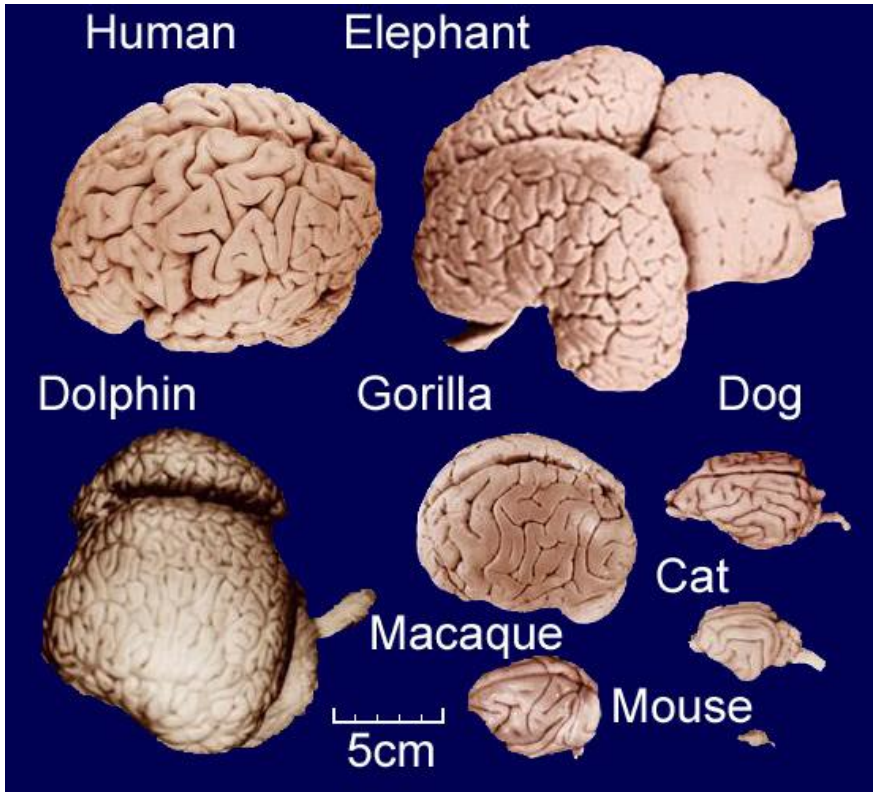
- Local versus widespread functions in the brain
- The neuron doctrine (*Advocates of the neuron doctrine claimed that the nervous system was composed of discrete cellular units. Proponents of the alternative reticular theory, on the other hand, argued that the entire nervous system was a continuous network of cells, without gaps or synapses between the cells*)
- The question of consciousness
- Unconscious inferences in vision
- Capacity limits in the brain
- Short-term and long-term memory: are they separate?
- The biological bases of emotions – to an extent established (the role of hormones & limbic lobe)
- Nature *versus* nurture, genes *versus* environment

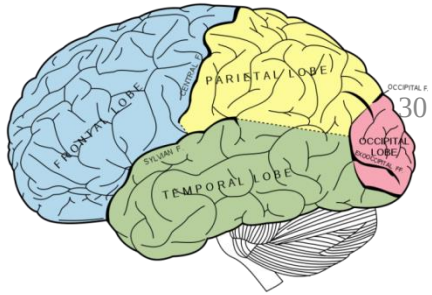
Interesting titbits & myths

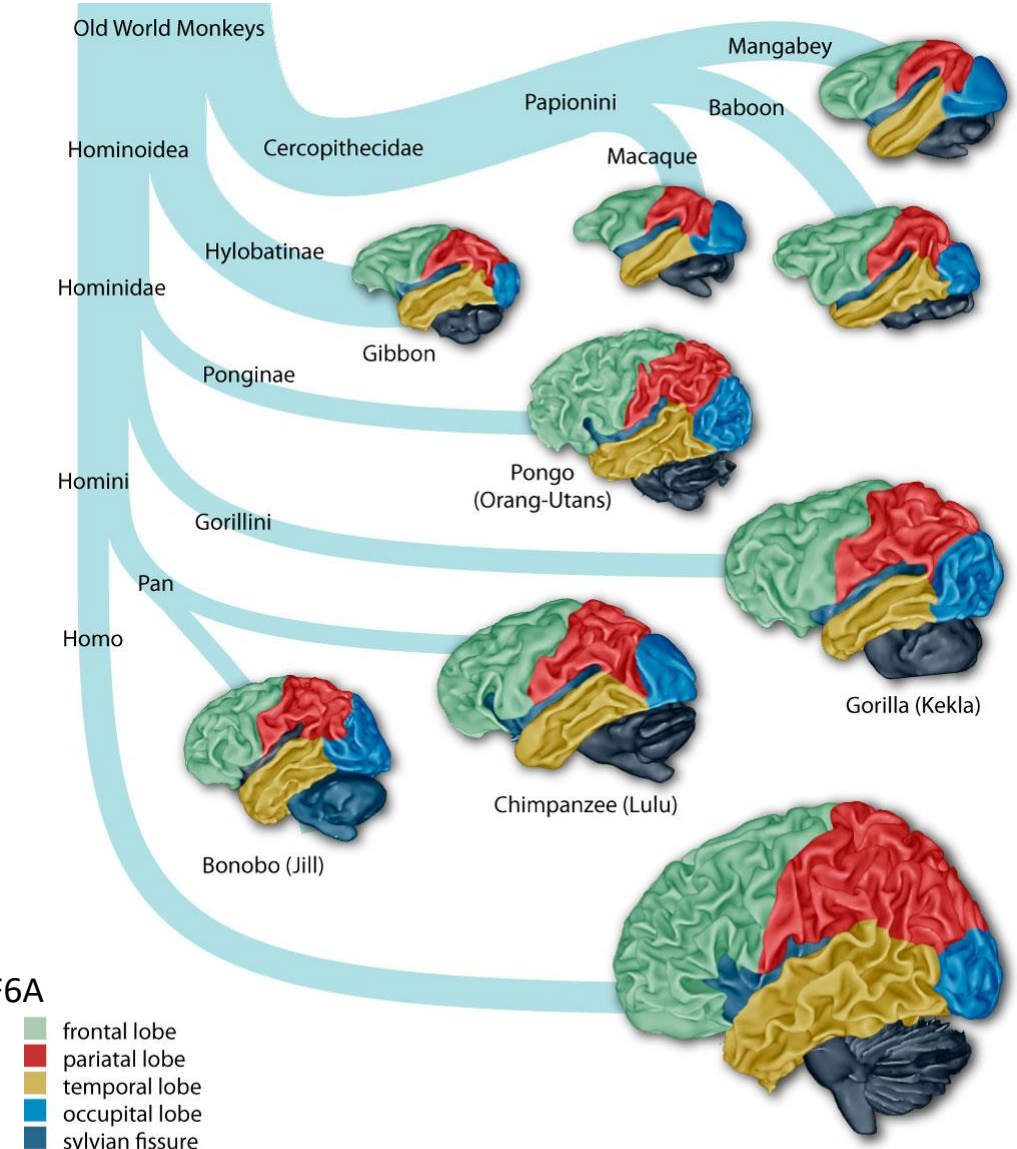
- The fastest (simple) reaction time to a stimulus is about 100 milliseconds, and the time it takes for a sensory stimulus to become conscious is typically a few hundred milliseconds.
- Until Andreas Vesalius, a Belgian physician (1514 – 1564), it was widely believed that women had one less rib than men, based on the Biblical story of Adam and Eve.
- Descartes is often considered to be the originator of modern mind/body philosophy.

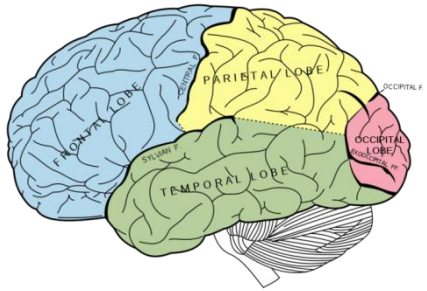
Different brains for different folks!





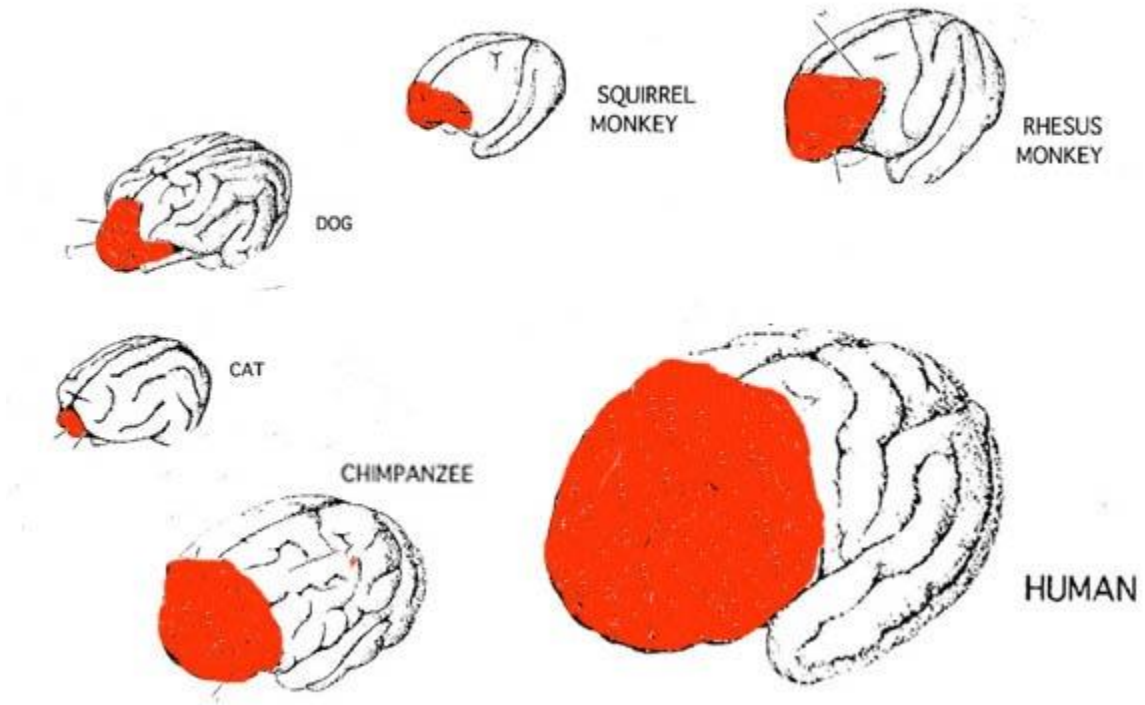


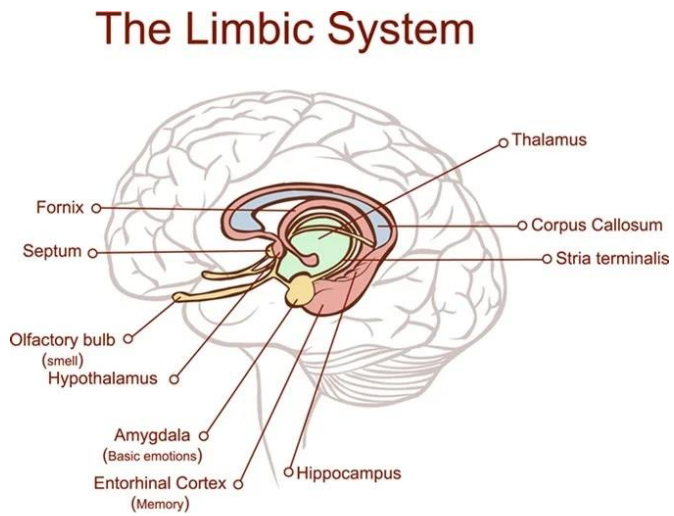


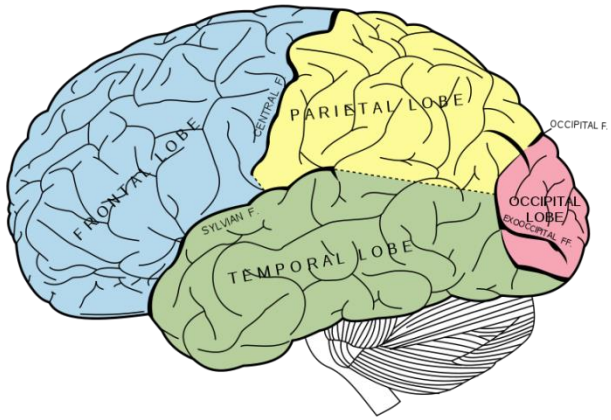


https://www.youtube.com/watch?v=zsXP8qeFF6A

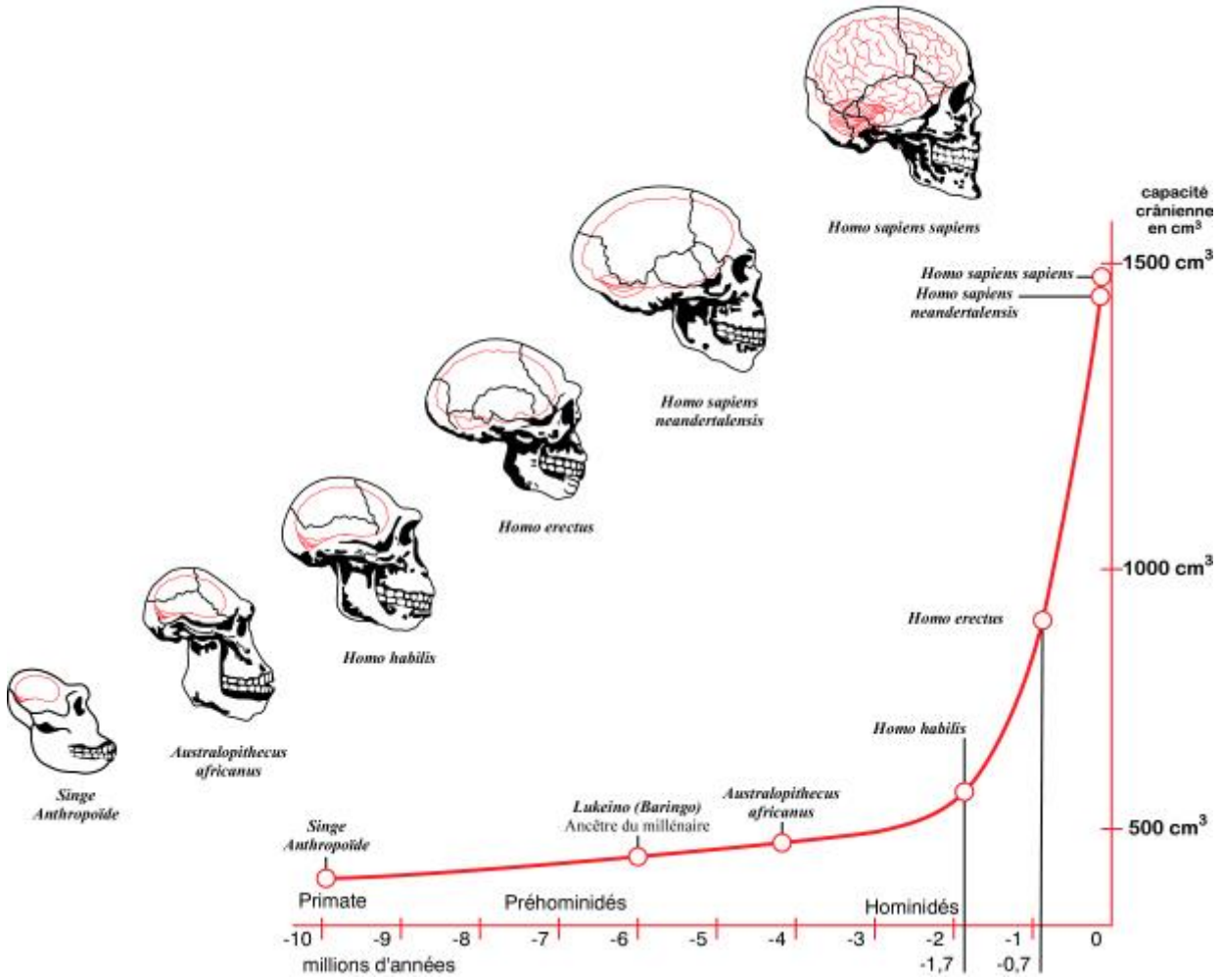
Fig. HE: Visualization of evolution of brains in primates based on the inner surface. The lobes, the sylvian fissure and the hindbrain (brainstem and cerebellum) are colorized for better orientation.



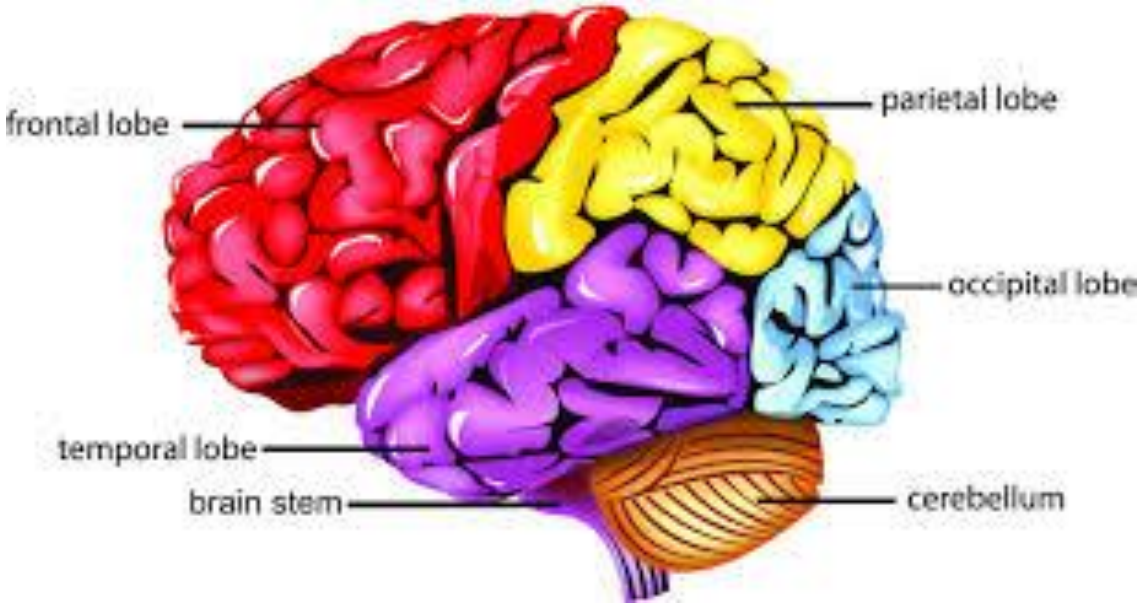


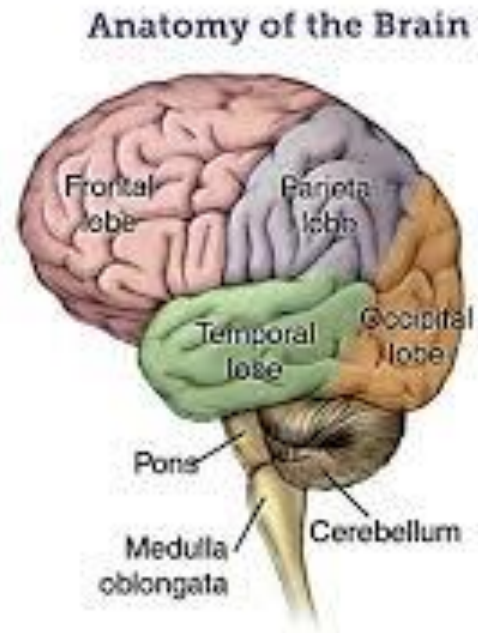


Source:**Evolution of Paleolithic Cosmology and Spiritual Consciousness, and the Temporal and Frontal Lobes, Rhawn Joseph,** Journal of Cosmology, 2011, Vol. 14.



Source:**Evolution of Paleolithic Cosmology and Spiritual Consciousness, and the Temporal and Frontal Lobes, Rhawn Joseph,** Journal of Cosmology, 2011, Vol. 14.

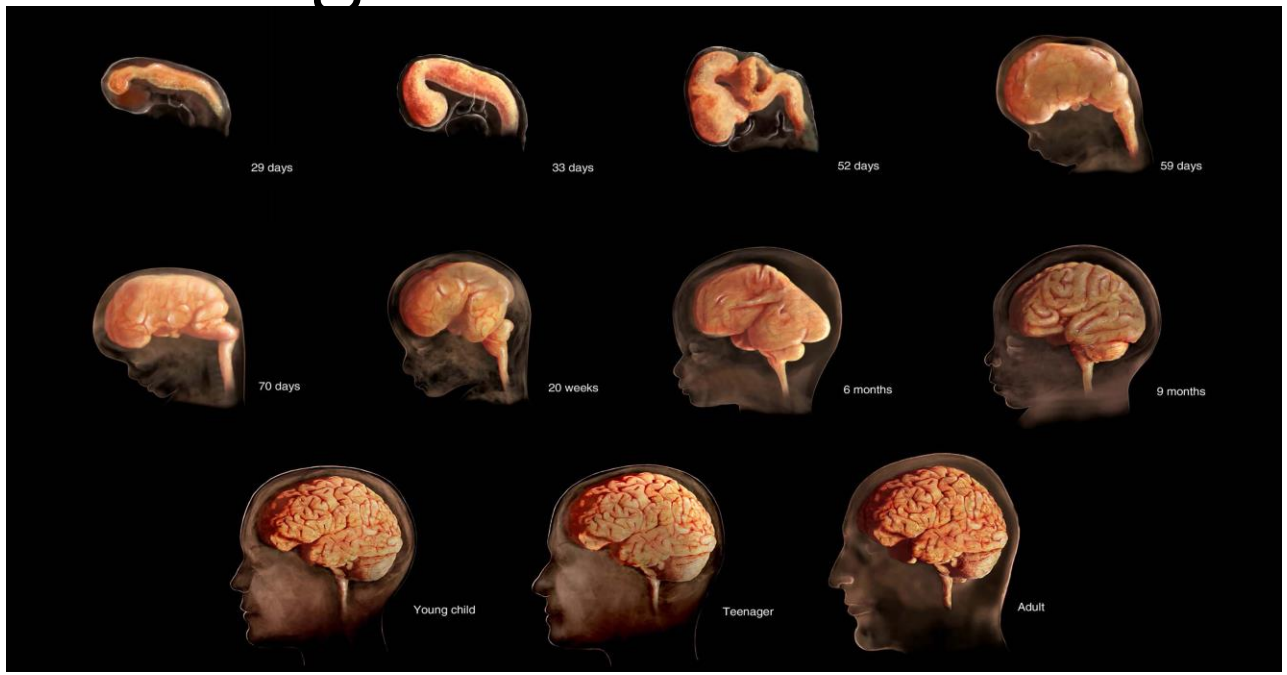

frontal lobe
parietal lobe
occipital lobe
temporal lobe
brain stem
cerebellum


Anatomy of the Brain
Frontal lobe
Parietal lobe
Temporal lobe
Occipital lobe
Pons
Medulla oblongata
Cerebellum

So, what's the difference - cognitively

- Expanded working memory
- Ability to maintain representation of the goal, despite distractions.
- Retrieve representations of events from distant past – episodic memory.
- Prediction of future events
- Conscious awareness of one' s feelings & thoughts.
- Understand 'good' & 'bad' and feeling of shame over violations.
- Seeking new experiences
- Invent relations

Brain growth

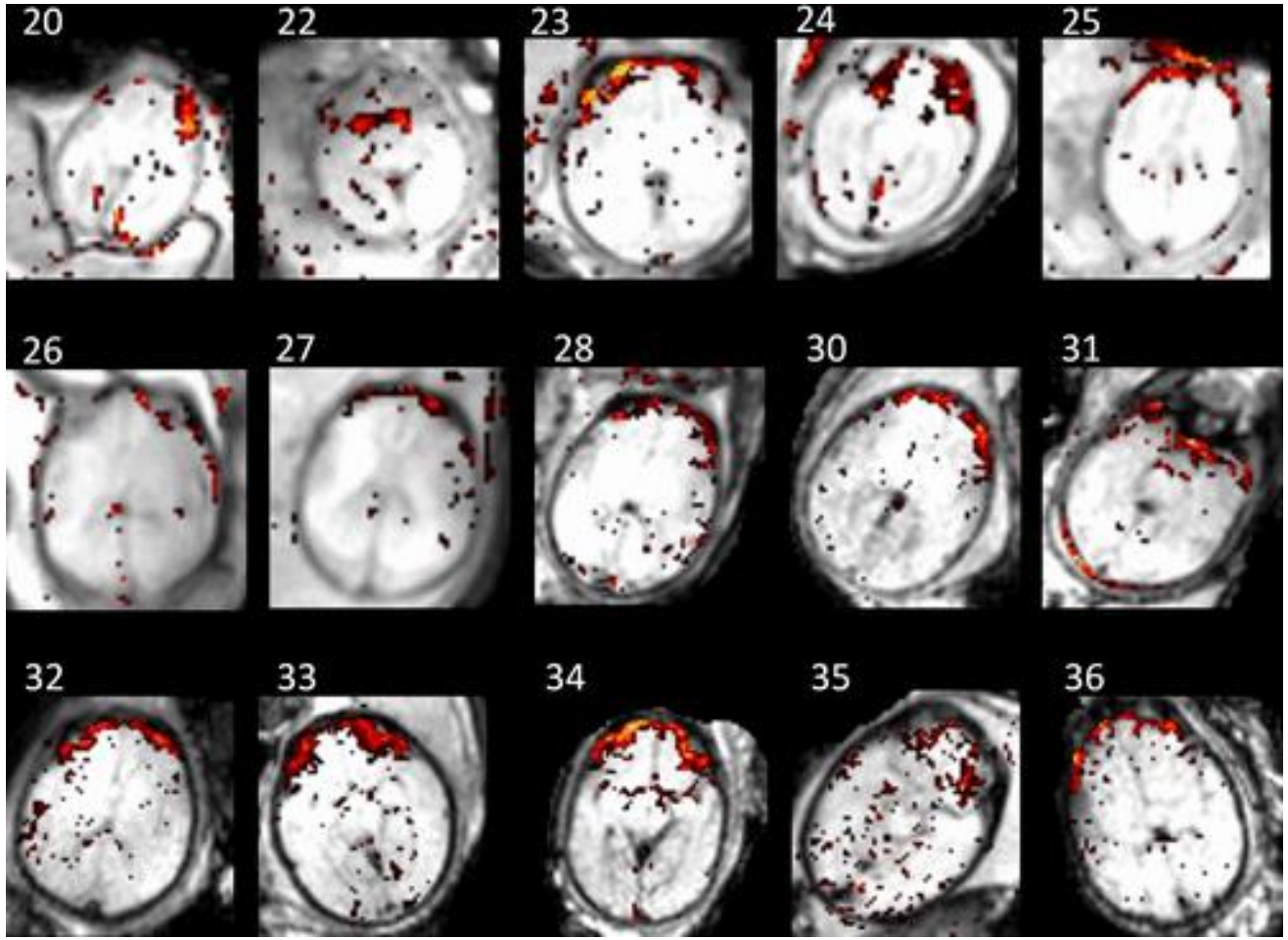


6th–7th week of gestation and matures in a caudal to rostral arc,
thereby forming the medulla,
pons,
and midbrain

7th–9th gestational week the fetus displays spontaneous movements, 1 week later takes its first ‘‘breath,’’ and by the 25th week demonstrates stimulus-induced heart rate accelerations

20th to 27th weeks the fetus responds with arousal and body movements to vibroacoustic and loud sounds delivered to the maternal abdomen.

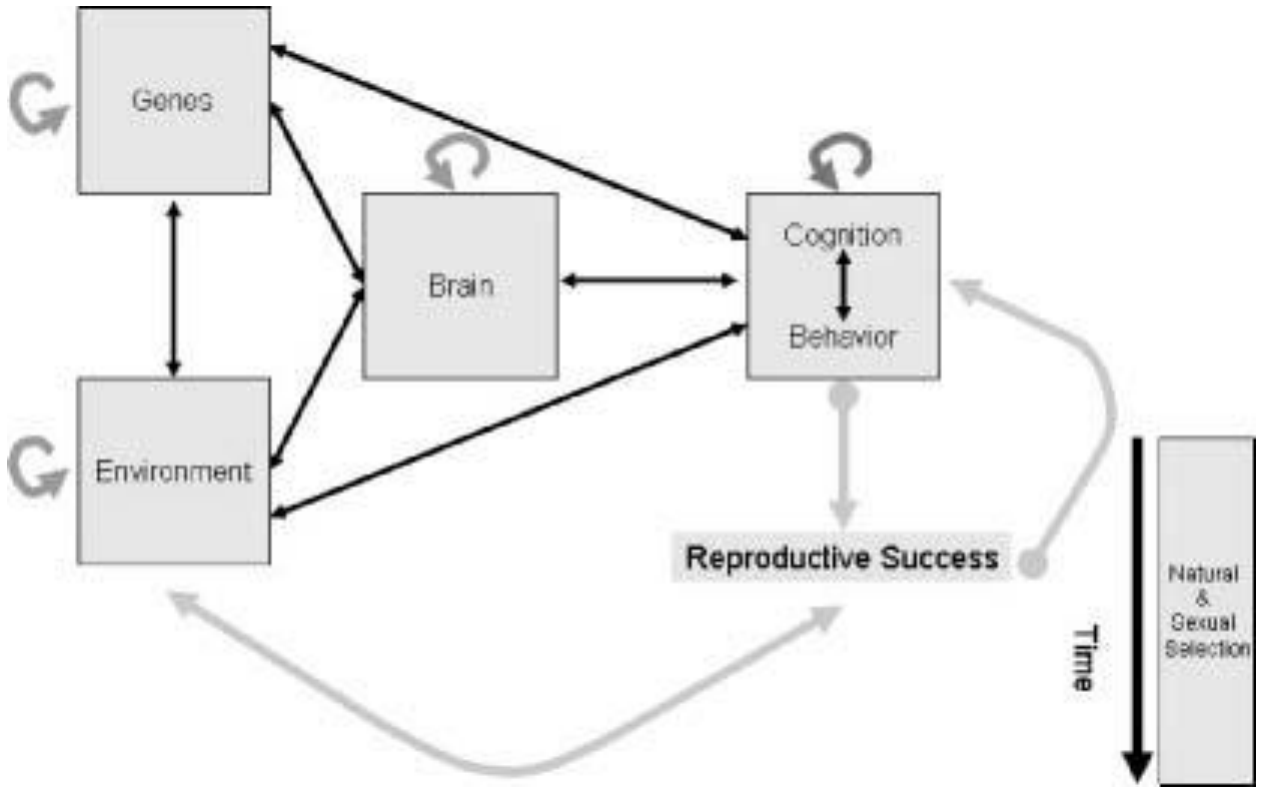
Image: © TheVisualMD/Science Source.



Resting state fMRI of fetusus. In 2012, Veronika Schöpf et al. captured functional images of fetal brains at gestational weeks 20–36 (the numbers in the figure above indicate gestational week). The team was the first to show that resting-state networks can be detected *in utero*

+ve news!!

- Although various limbic nuclei become functionally mature over the course of the first several postnatal months and years, the neocortex and lobes of the brain take well over 7, 10, and even 30 years to fully develop and myelinate



Evolutionary cognitive neuroscience involves complex systems that not only interact with each other but in which each entity also interacts with itself.

Source: evolutionary cognitive neuroscience – edited by Platek et al.,

Nutrition effect

- In a recent review, 19 out of 21 studies reported impaired mental, motor, socio-emotional, or neurophysiologic functioning in infants with iron deficiency anemia compared to infants without iron deficiency anemia.[1].

- In a recent study in China, children born to mothers with iron deficiency anemia in late pregnancy had a significantly lower mental development index score than children of non-iron-deficient mothers at 12, 18, and 24 months of age.[2]

- Similarly, in Nepal, daily iron/folic acid supplementation beginning in early pregnancy resulted in significantly better scores in working memory, inhibitory control, and fine motor functioning in children at 7 to 9 years of age [3]

- [1]Walker et al. 2007. Child development: risk factors for adverse outcomes in developing countries. *The lancet*, *369*(9556), pp.145-157.
- [2] *Chang S, et al.2013. Effect of iron deficiency anemia in pregnancy on child mental development in rural china. Pediatrics.*
- *[3] Christian, P et al., Prenatal micronutrient supplementation and intellectual and motor function in early school-aged children in Nepal. JAMA, 2010. 304(24): p. 2716-23.*

Learning About the World around us
Visual System

Part 2 of the book

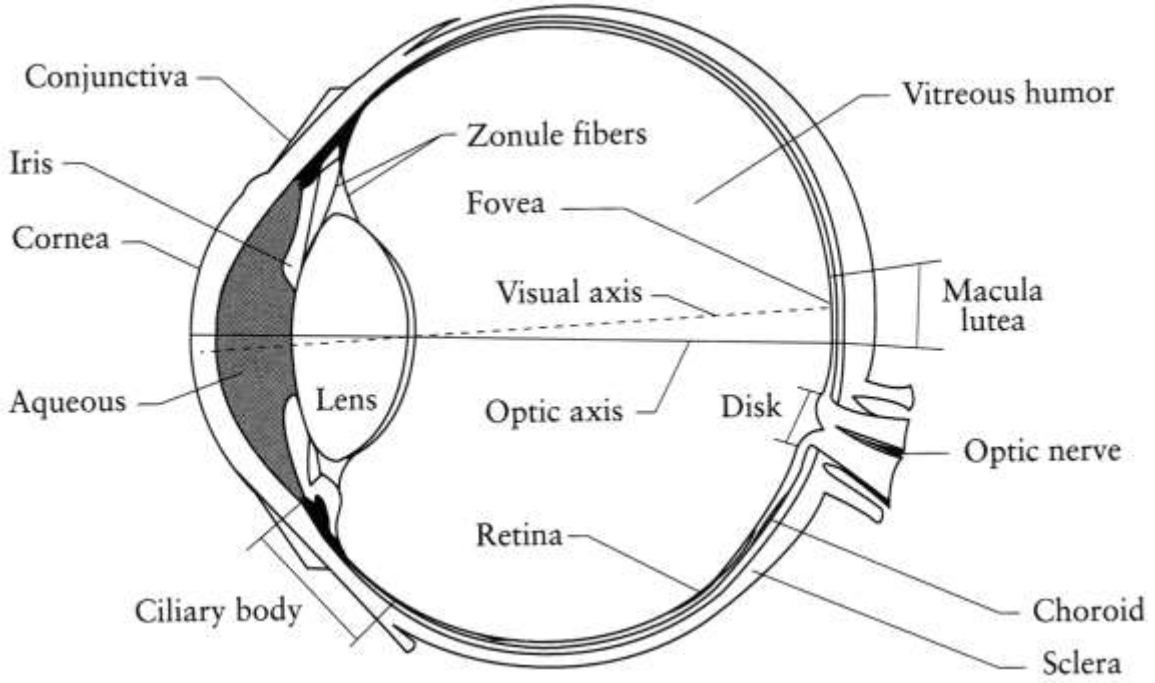
Kavita Vemuri

The Eye and Light

The visual system

- Color
- Shapes
- Depth
- Motion
- Texture
- ??

The Eye is a camera?

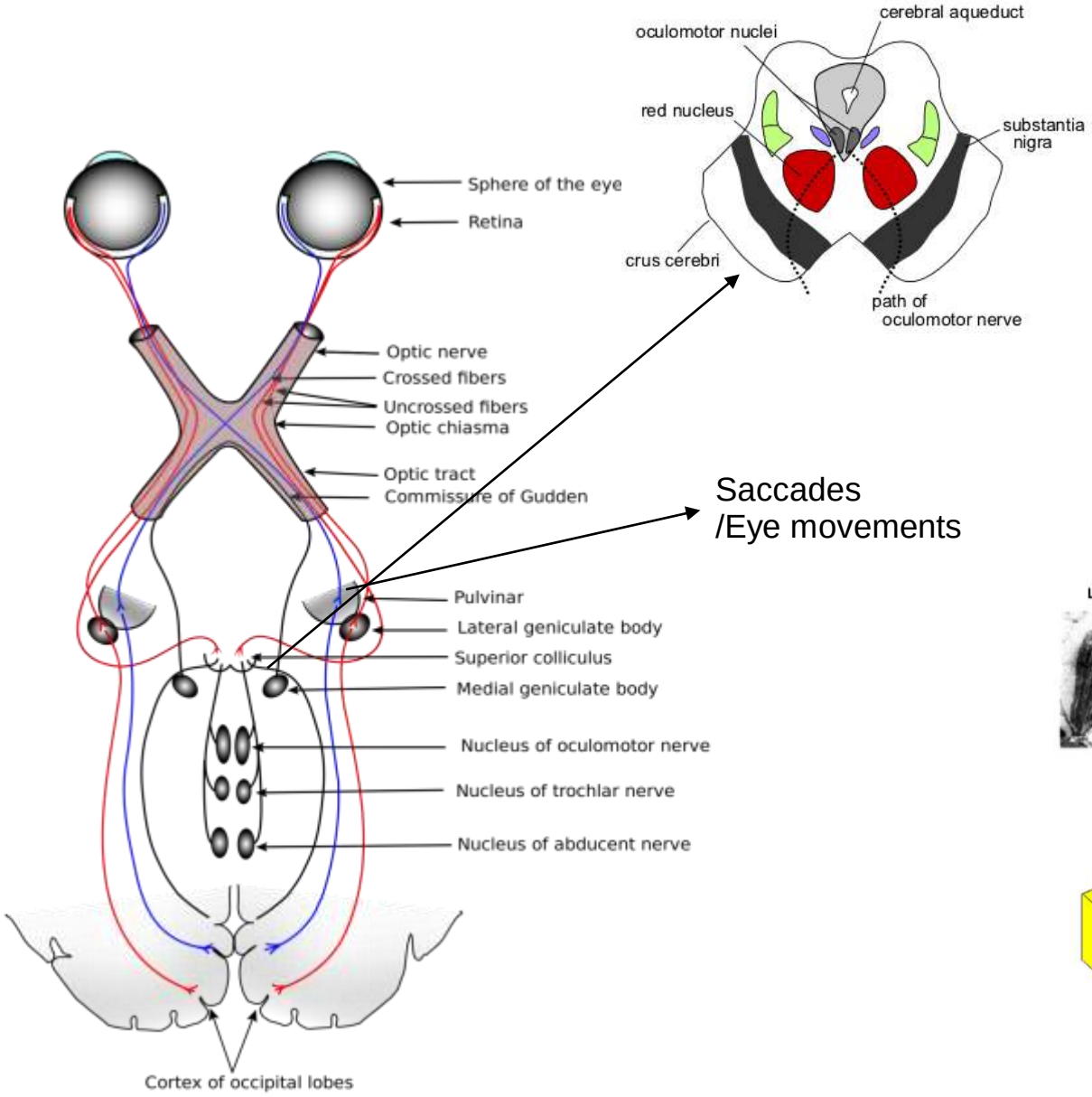


The camera is designed as the eye!

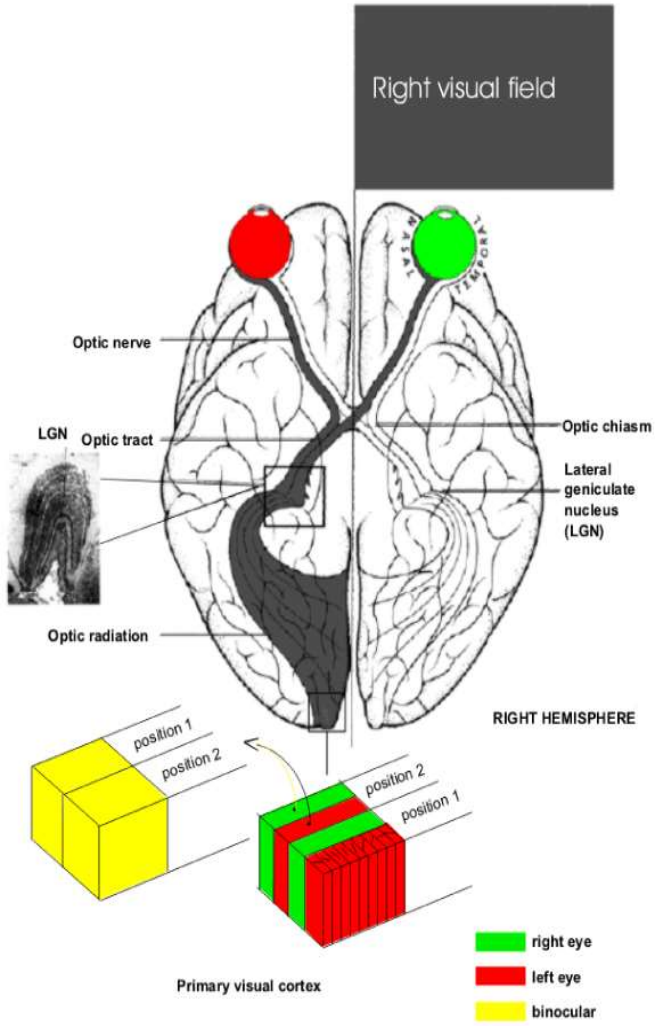
- **Iris** - colored annulus with radial muscles
- **Pupil** - the hole (aperture) whose size is controlled by the iris
- What's the "film"?

  –photoreceptor cells (rods and cones) in the **retina**

Pathway to Visual Cortex

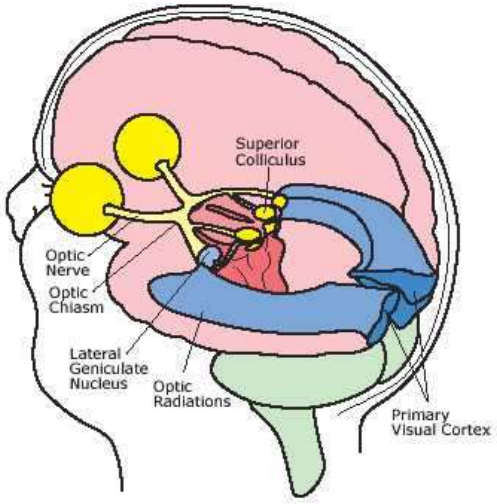


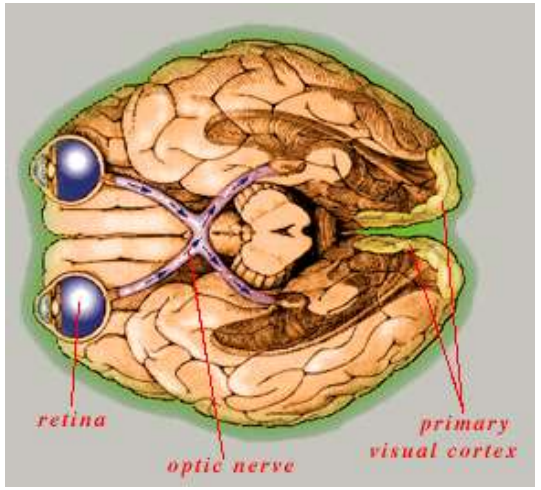
Saccades
/Eye movements



The Visual System

Both eye and brain are required for functional vision

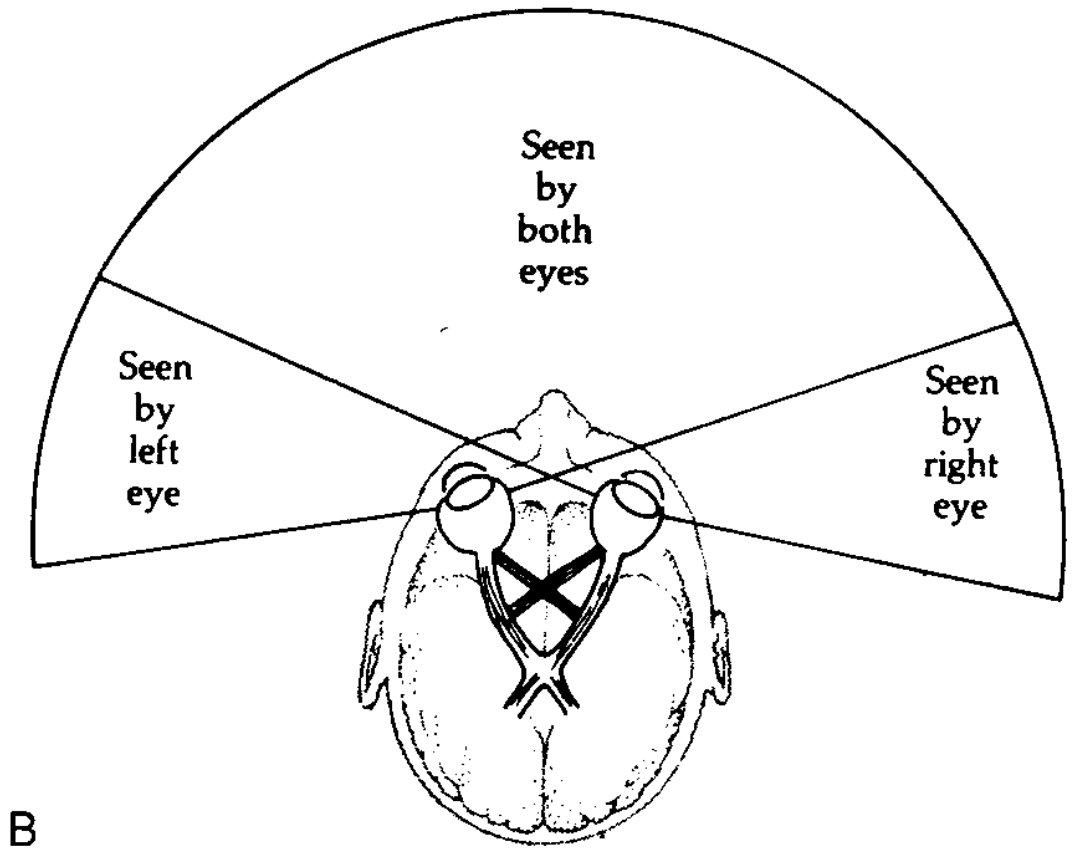




Two kinds of blindness:

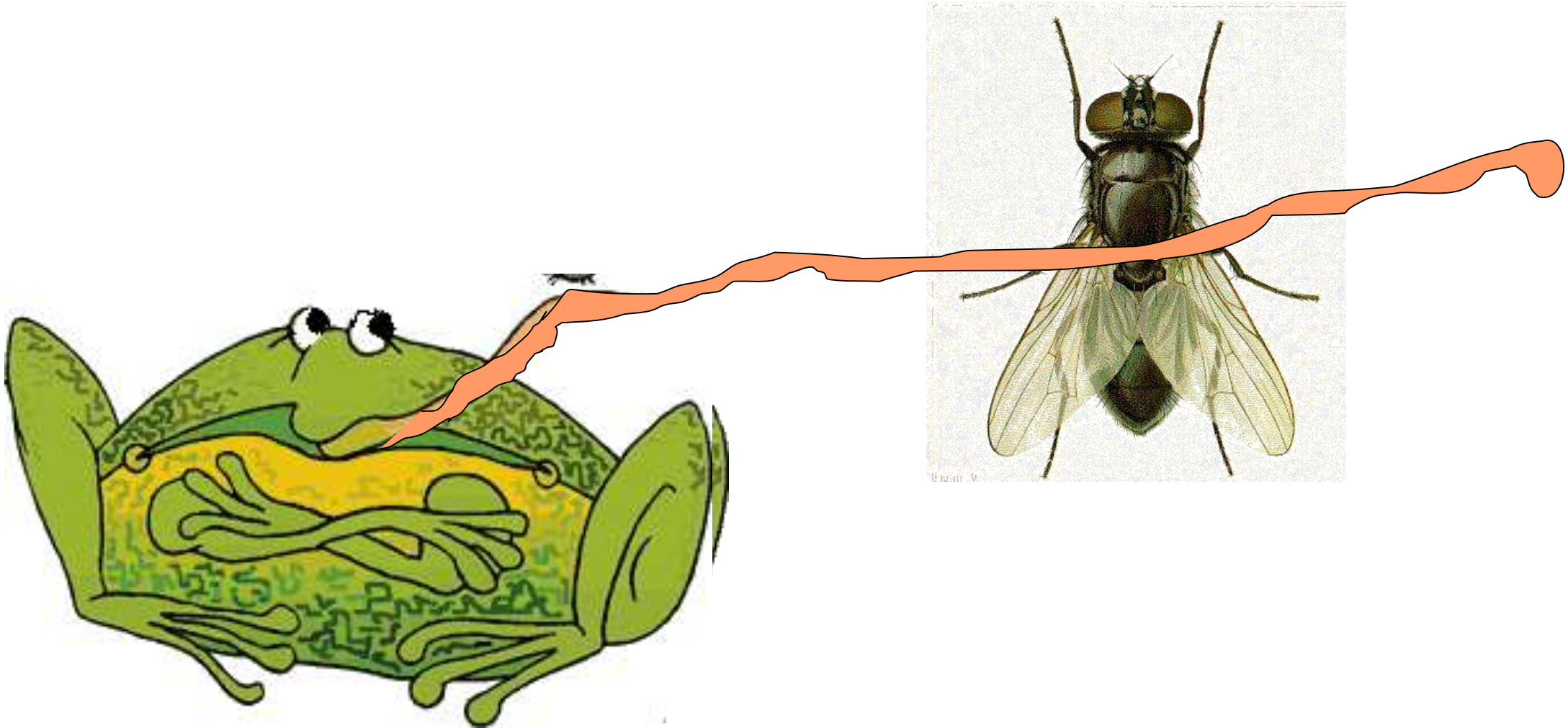
- Normal blindness (eye dysfunction)
- Cortical blindness (brain dysfunction)

Monocular Visual Field: 160 deg (w) X 135 deg (h)
Binocular Visual Field: 200 deg (w) X 135 deg (h)

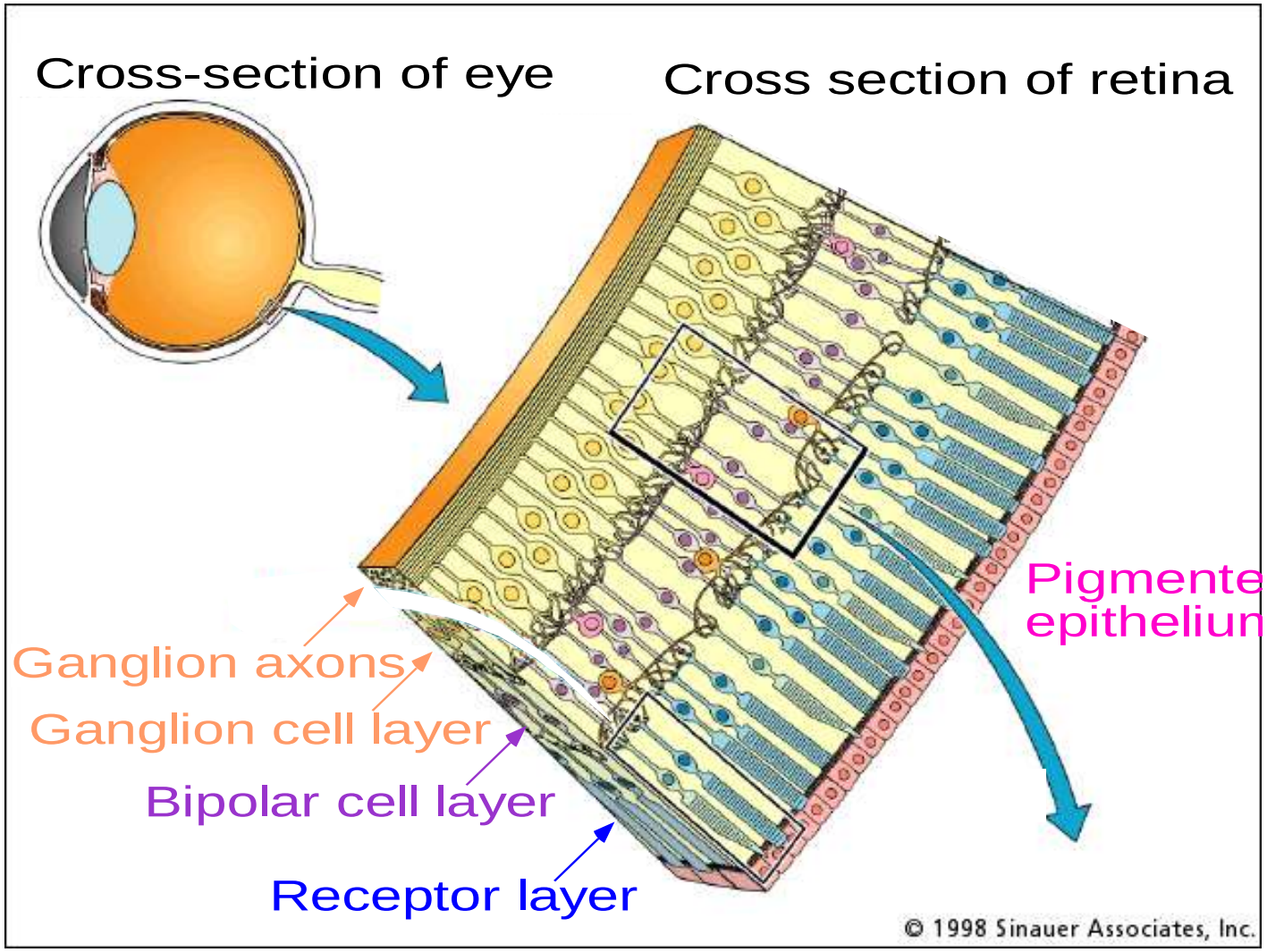


B

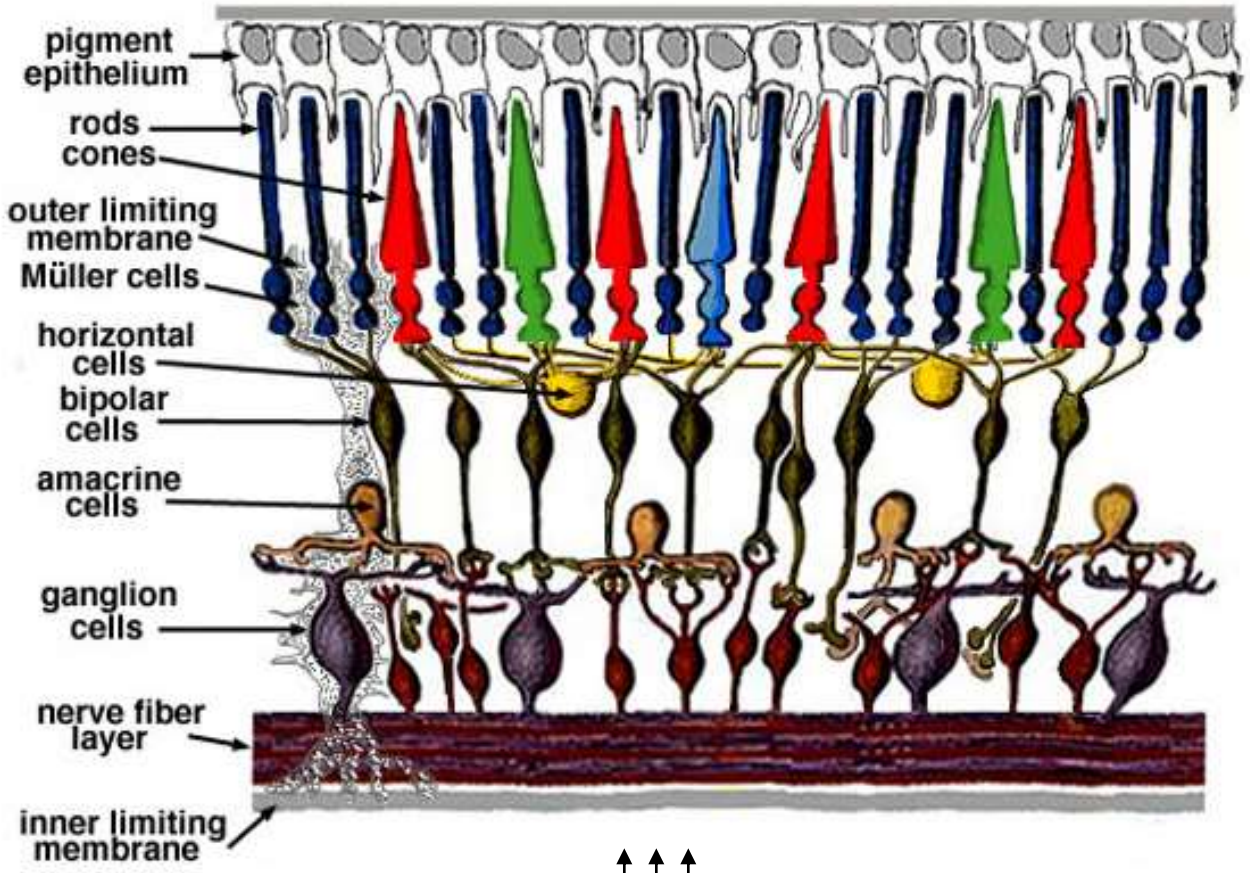
The Visual Grasp Reflex moves the eyes towards a suddenly appearing peripheral signal



The Retina


Cross-section of eye
Cross section of retina
Pigmente
epitheliun
Ganglion axons
Ganglion cell layer
Bipolar cell layer
Receptor layer
© 1998 Sinauer Associates, Inc.

Retina up-close



↑↑↑

Light

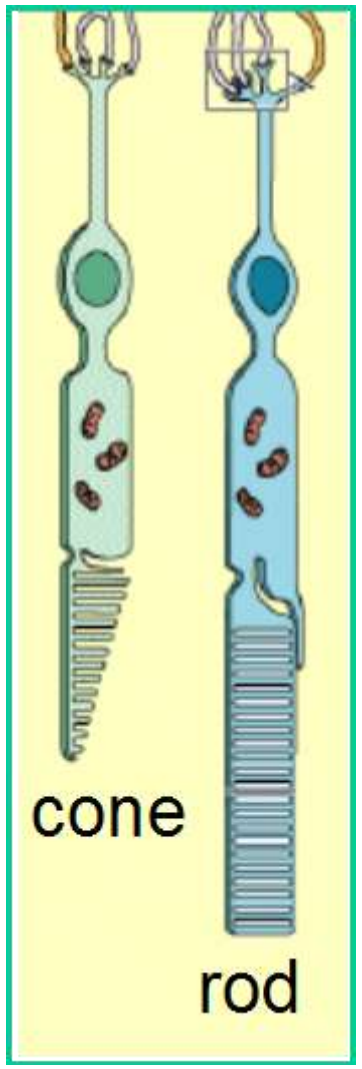
Two types of light-sensitive receptors

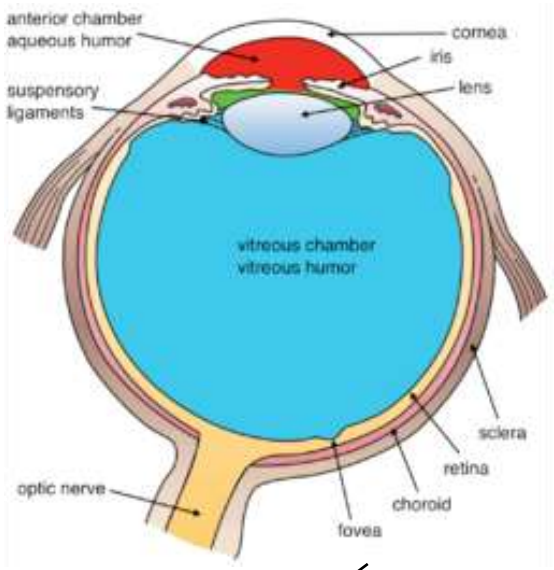
Cones

- cone-shaped
- less sensitive
- operate in high light
- color vision

Rods

- rod-shaped
- highly sensitive
- operate at night
- gray-scale vision



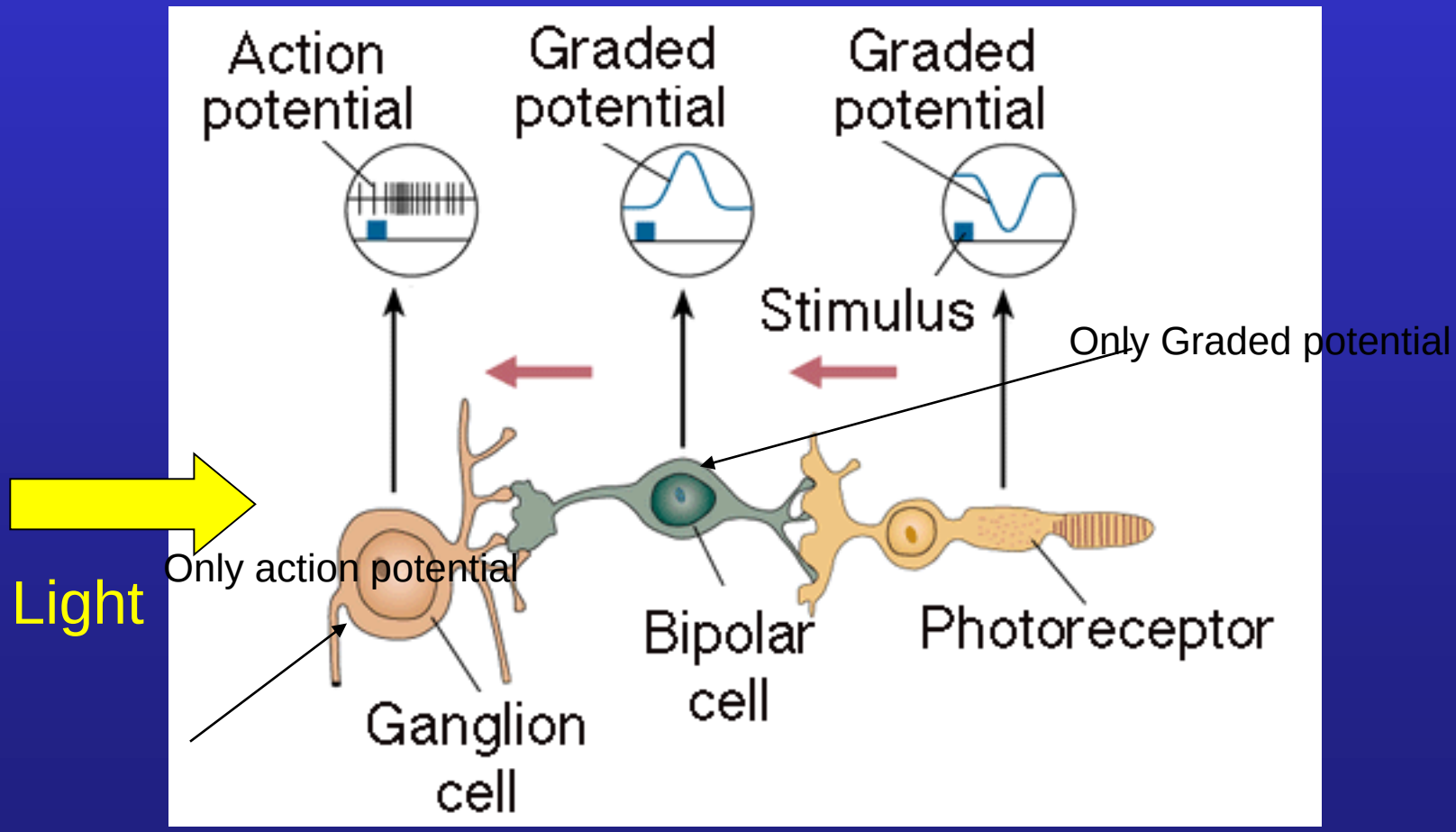


0.3 mm diameter rod-free area

Retina is organized into macula, optic disc, fovea and peripheral retina

Retinal Receptive Fields

Receptive field structure in bipolar cells



Transmission from the eye.

- Light or darkness cause changes in neurotransmitter release

in photoreceptors.

- Bipolar cells become either hyperpolarized or depolarized by light.

- Changes in glutamate release by the bipolar cells cause changes in the membrane potential of ganglion cells.

- If the ganglion cell is depolarized to threshold, it produces action potentials that are then conducted to the brain via axons that run in the optic nerve

Retinal ganglion cells respond to edges

Input image
(cornea)

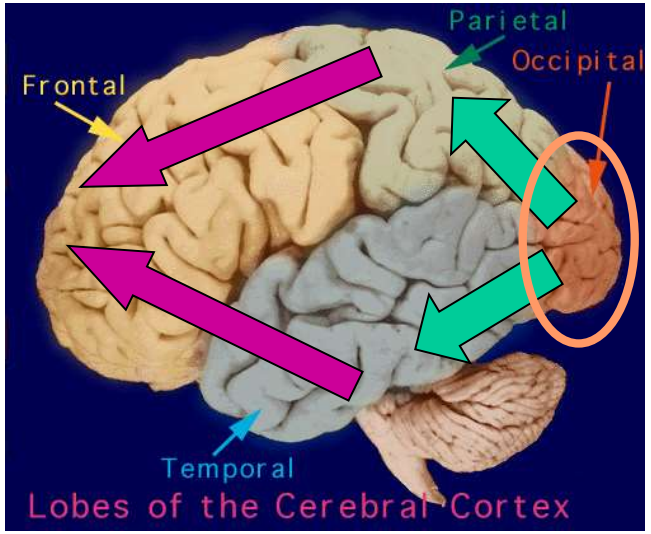
"Neural image"
(retinal ganglion cells)

Center-surround receptive fields: emphasize edges.

http://www.cns.nyu.edu/~david/courses/perception/lecturenotes/ganglion/ganglion.html

The pathways in the brain

Eyes register optical information

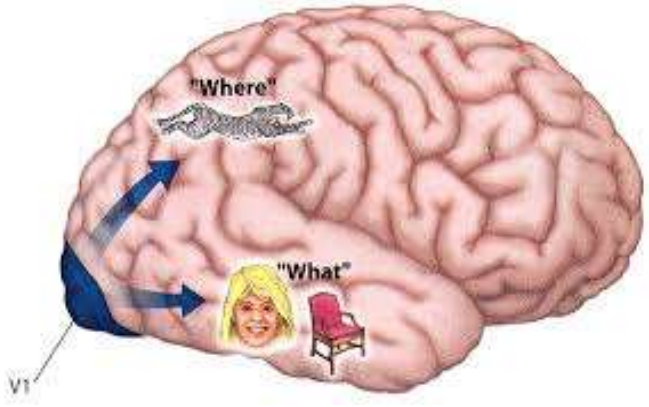


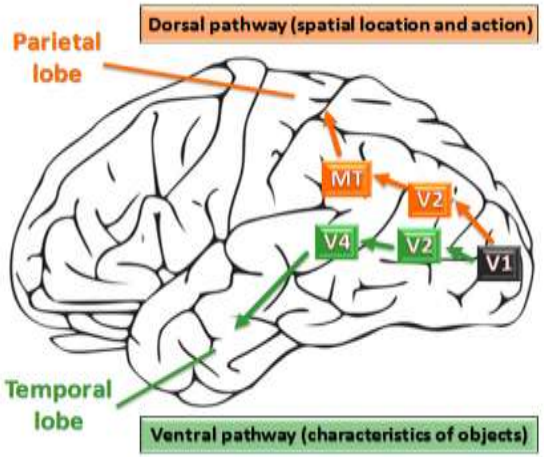
Two pathways from V1

"What" pathway to temporal cortex

"Where" pathway to parietal cortex

Convergence on frontal cortex





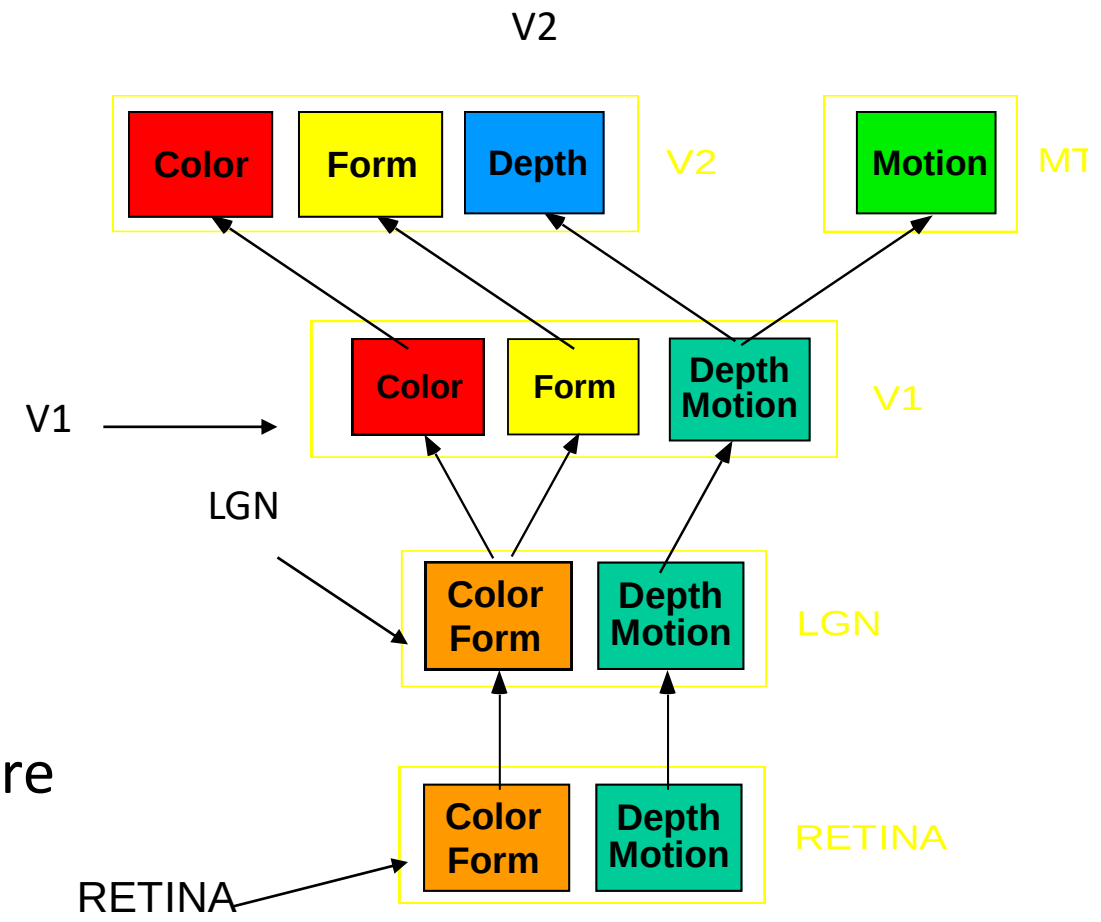
Feature-based Pathways Hypothesis

Visual Features

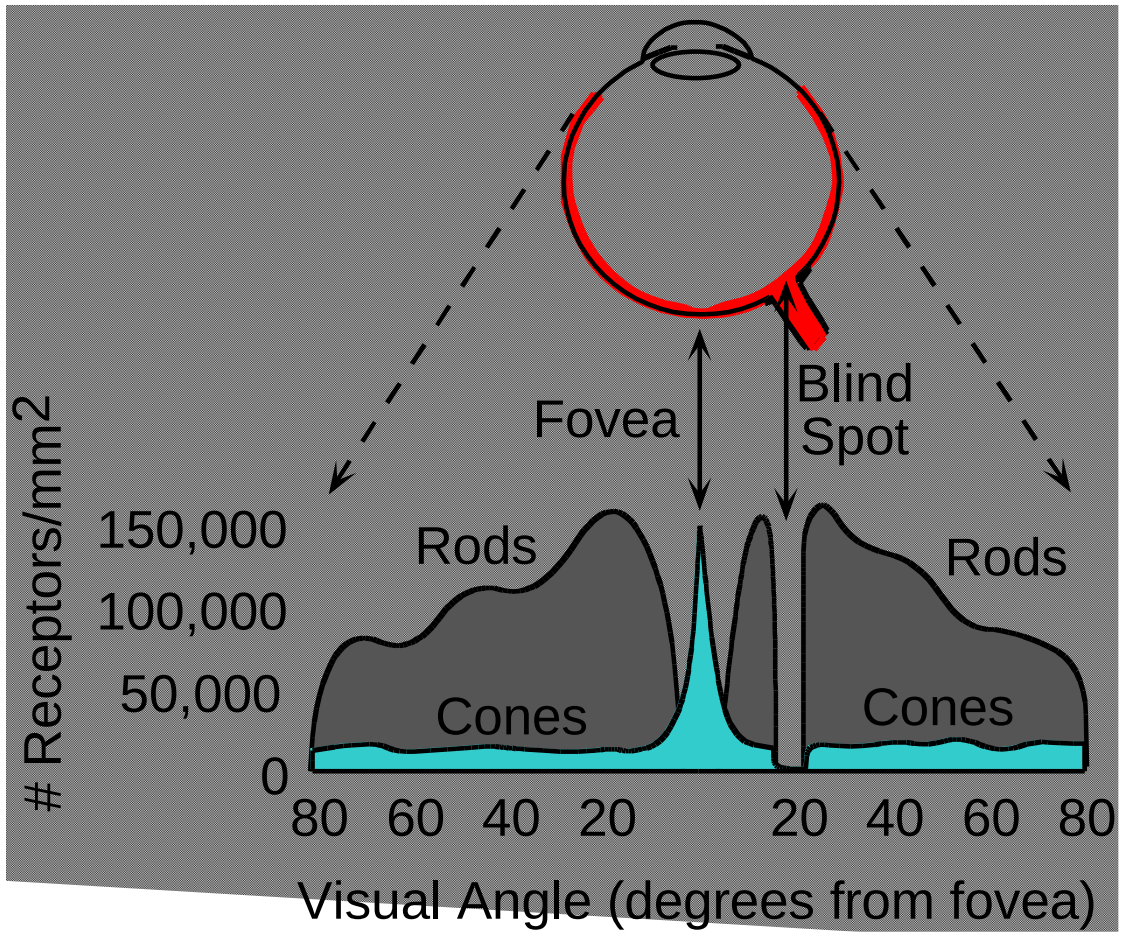
Color
Shape
Depth
Motion

Featural Pathways

Separate neural pathways in which different features are processed.



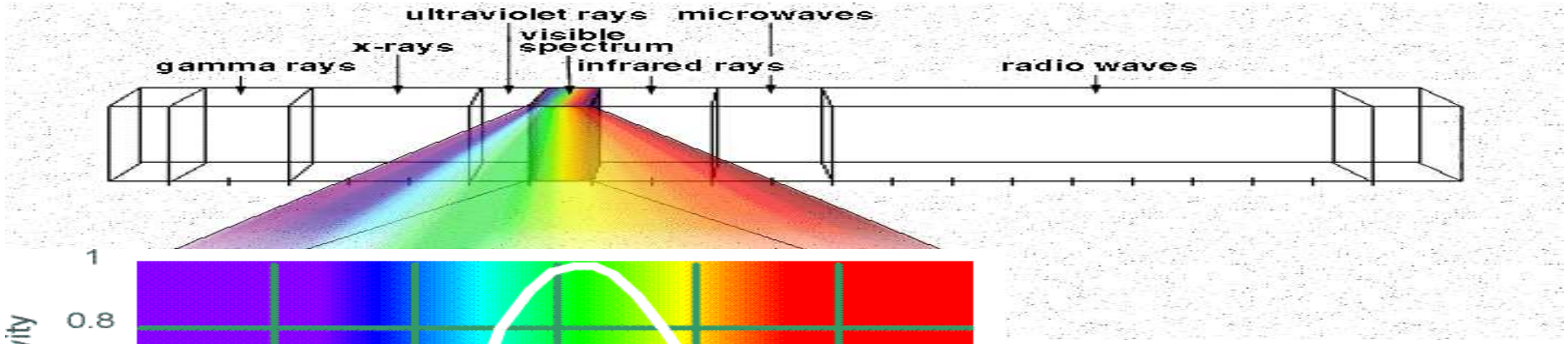
Distribution of Rods and Cones

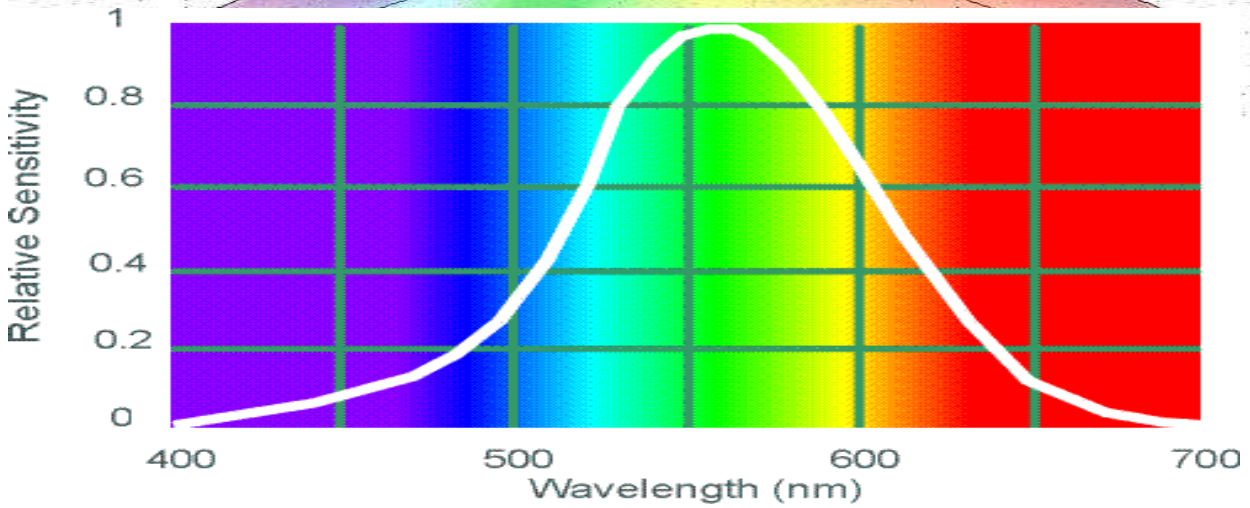


Night Sky: why are there more stars off-center?

Color Perception

Electromagnetic Spectrum

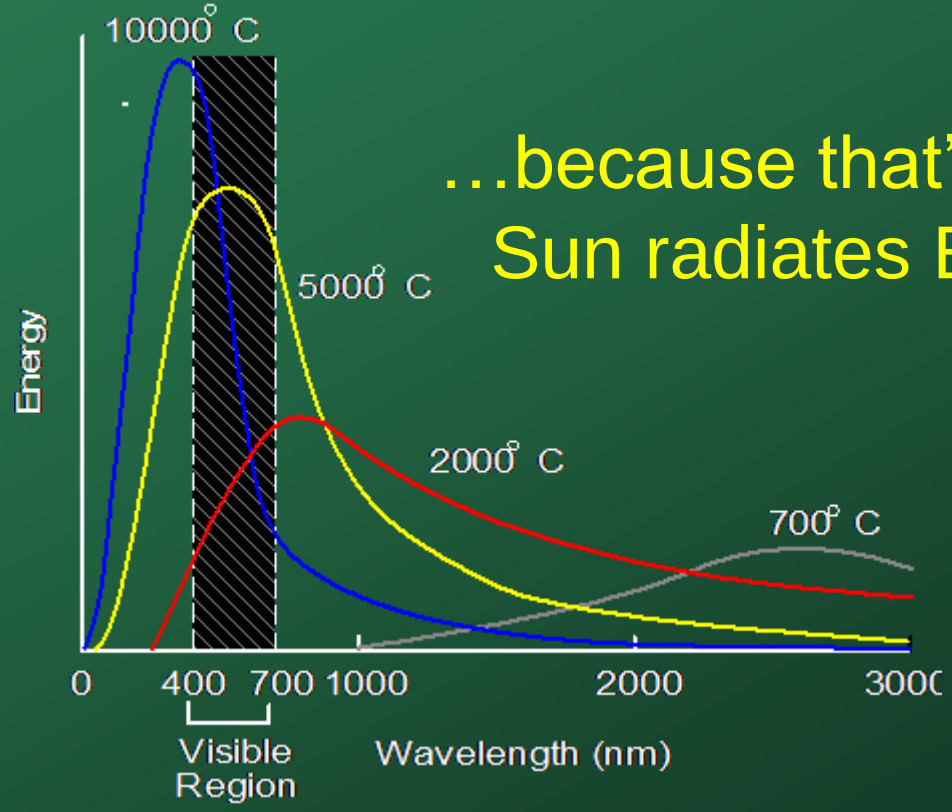




Human Luminance Sensitivity Function

Visible Light

Why do we see light of these wavelengths?

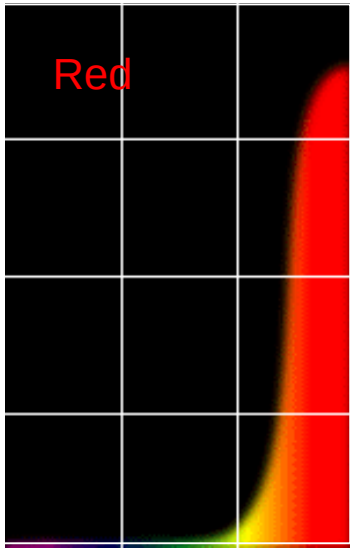


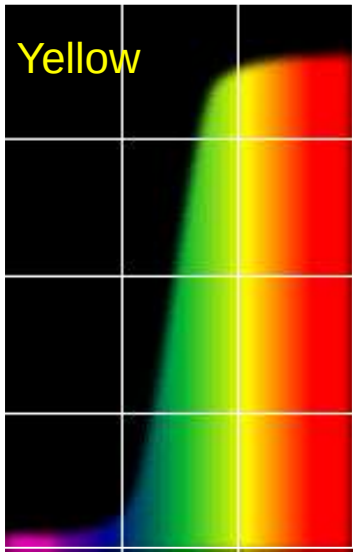
…because that's where the Sun radiates EM energy

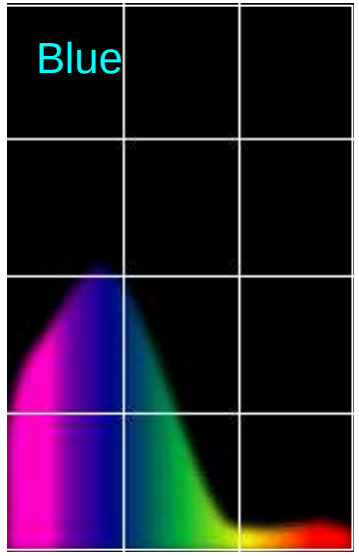
The Physics of Light

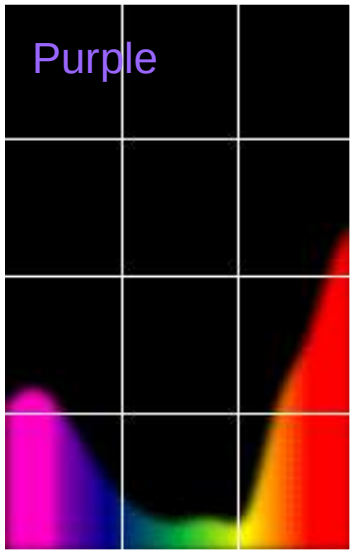
Some examples of the reflectance spectra of surfaces



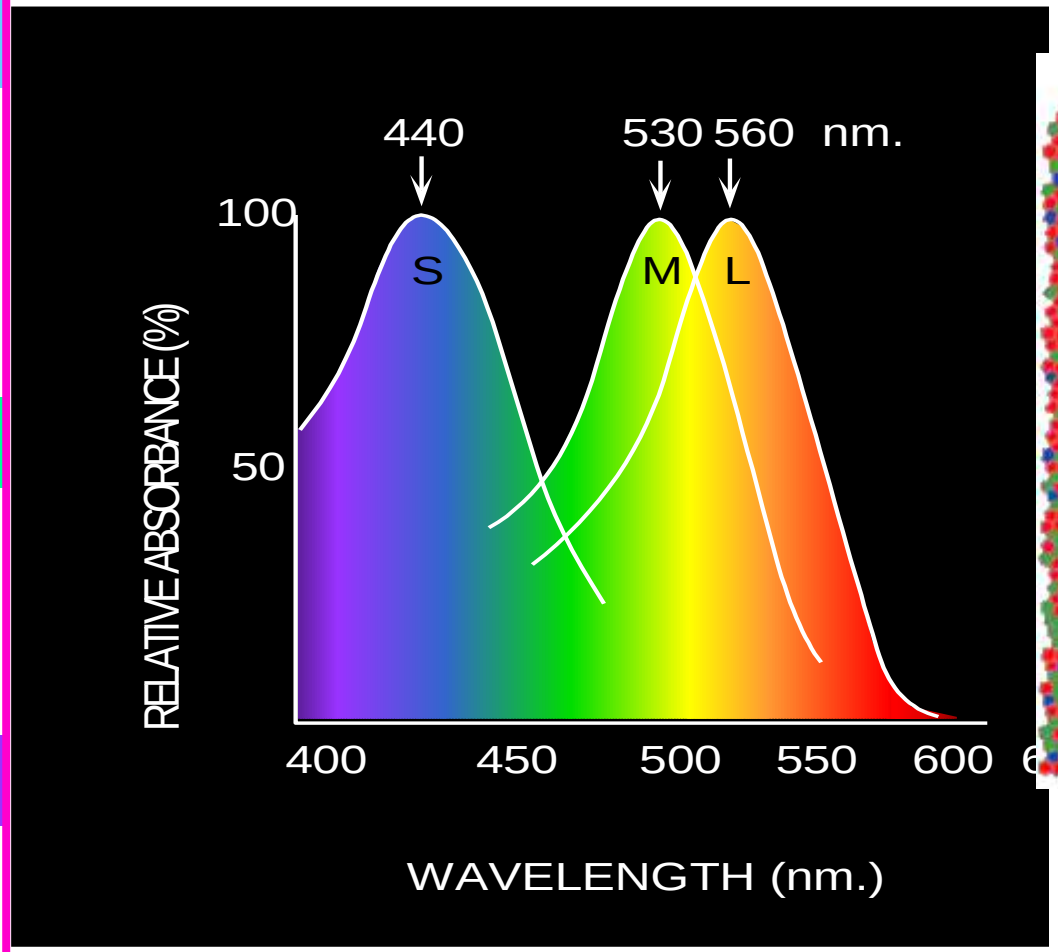


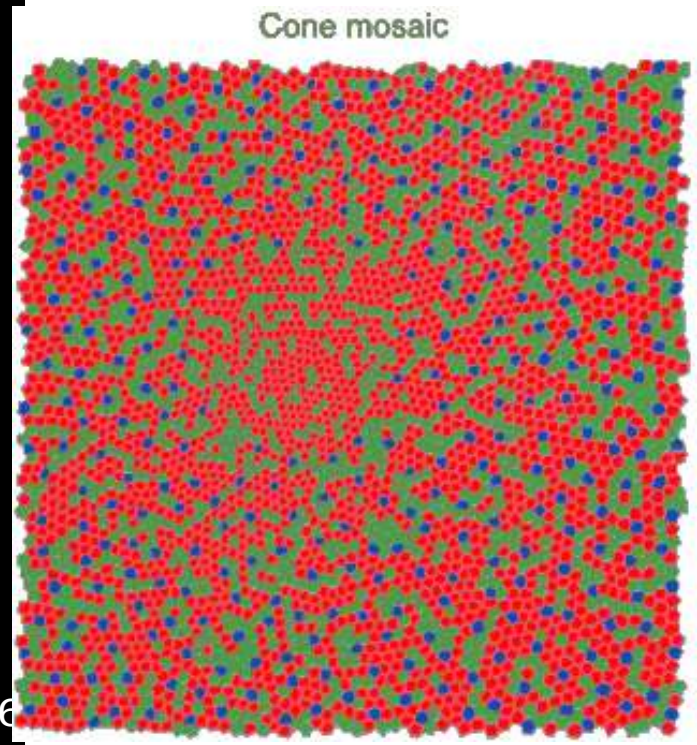




Physiology of Color Vision

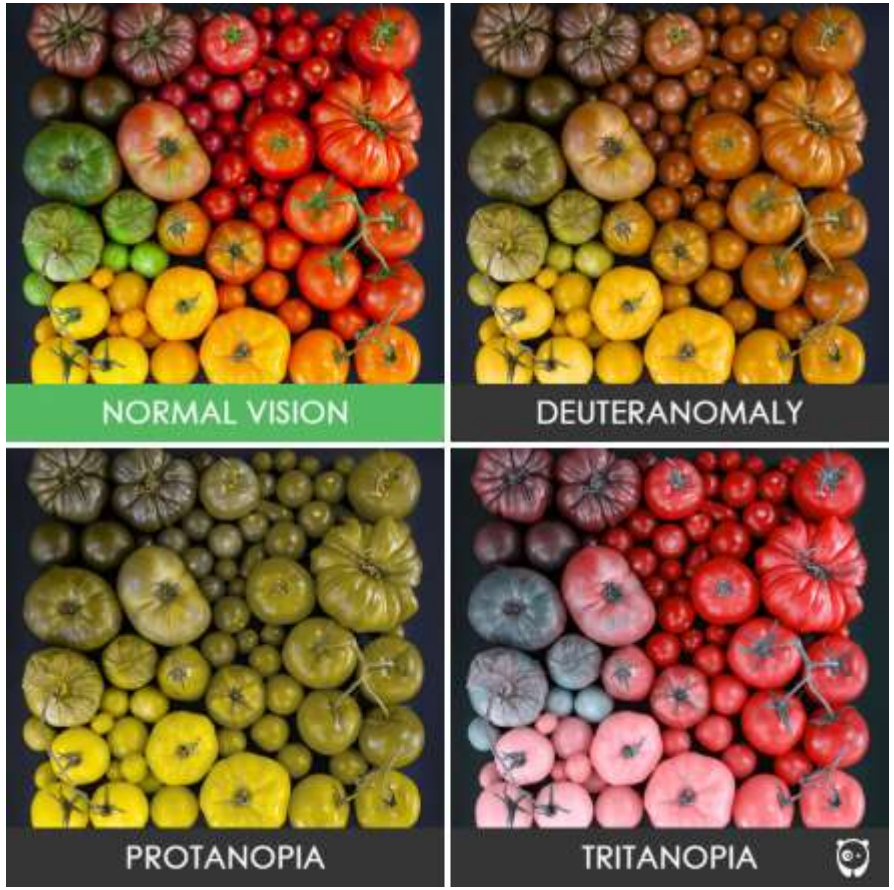
Three kinds of cones:

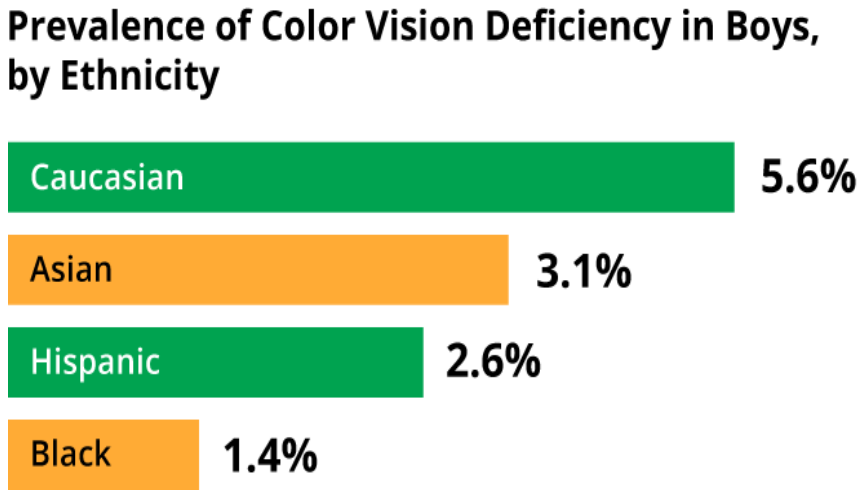




?

Color deficiency





4,005 California children ages 3 to 6 in Los Angeles and Riverside Counties

Xie et al.,
April 2014 in the journal *Ophthalmology*.

Deuteranomaly: reduced sensitivity to green light and is the most common form of colour blindness
Protanopia: reduced sensitivity to red light
Tritanopia: reduced sensitivity to blue light – extremely rae.

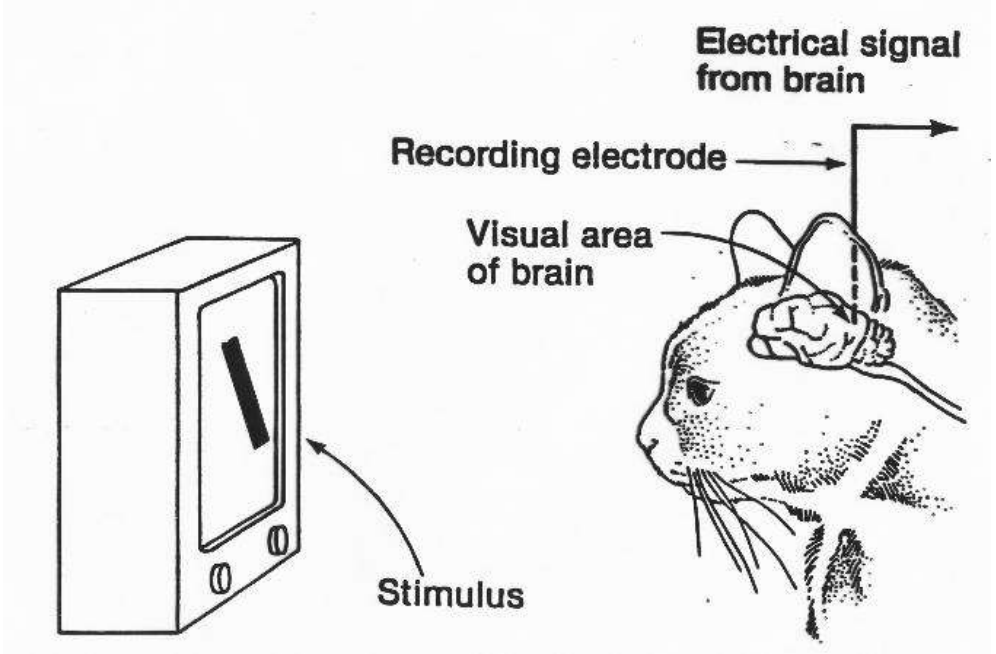
From rods and Cones to LGN and V1

Cortical Receptive Fields

Single-cell recording from visual cortex

David Hubel & Thorston Wiesel

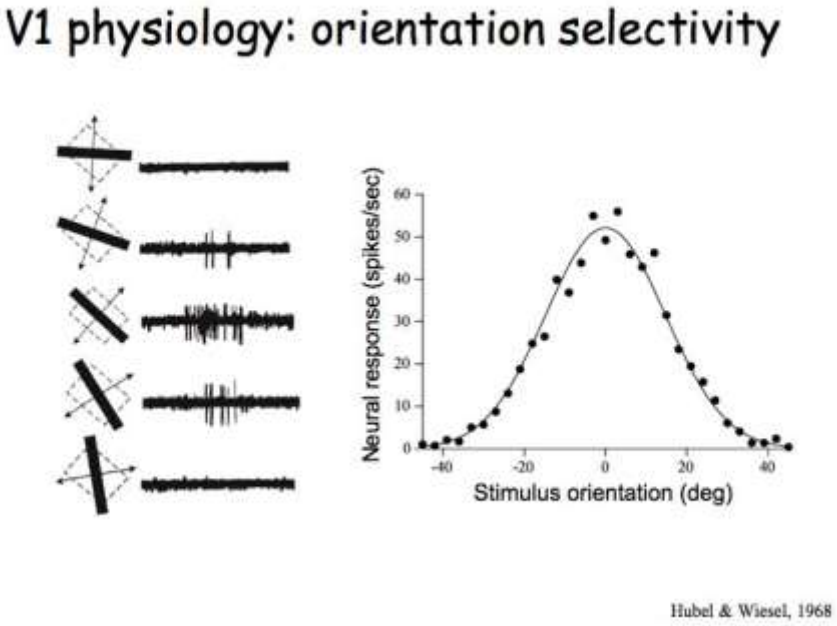
Hubel and Wiesel



http://www.cns.nyu.edu/~david/courses/perception/lecturenotes/V1/LGN-V1-slides/hw-2-cortical-rfs-640x480.mov

Function of the V1

- David Hubel and Torsten Wiesel discovered the functional organization and basic physiology of neurons in V1.
- They discovered three different types of neurons that can be distinguished based on how they respond to visual stimuli that they called: *simple cells*, *complex cells*, and *hypercomplex cells*.
- V1 neurons transform information (unlike LGN cells whose receptive fields look just like those of ganglion cells) so that they are *orientation selective* and *direction selective*.



summary

The visual system is composed of many interactive functional parts:

Eye (optics of image formation)

Retina (light transduction)

LGN (waystation?)

Area V1 (hypercolumns)

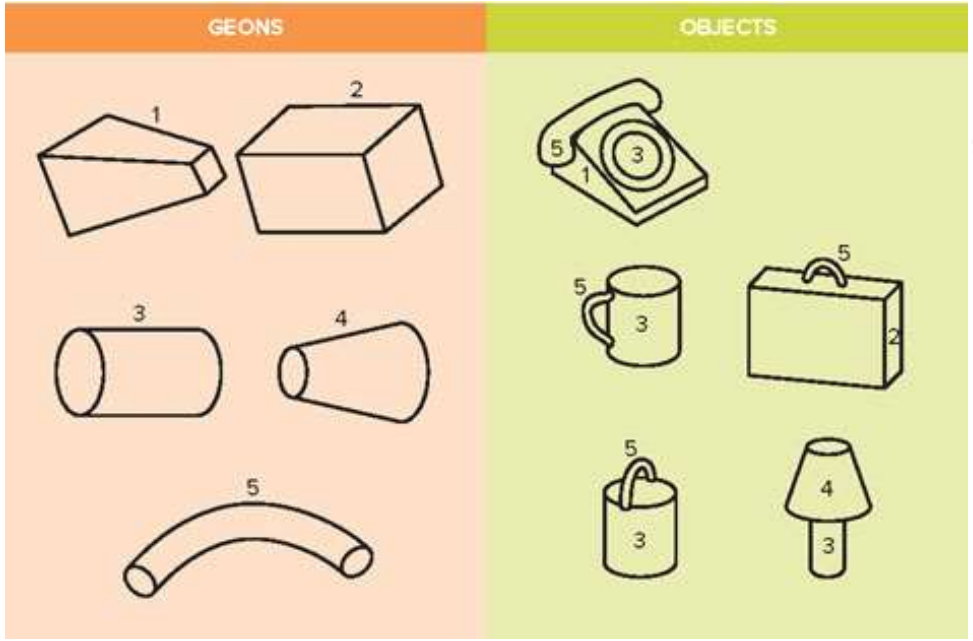
Higher cortical areas (features)

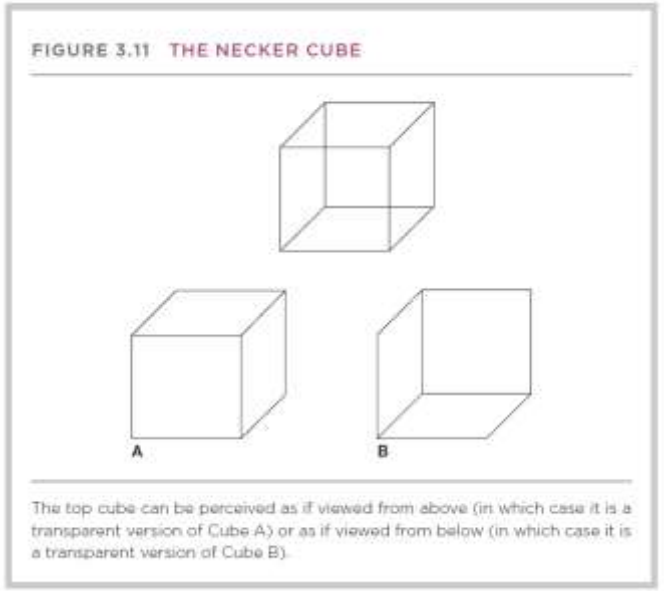
Cortical pathways (what/where)

Object recognition

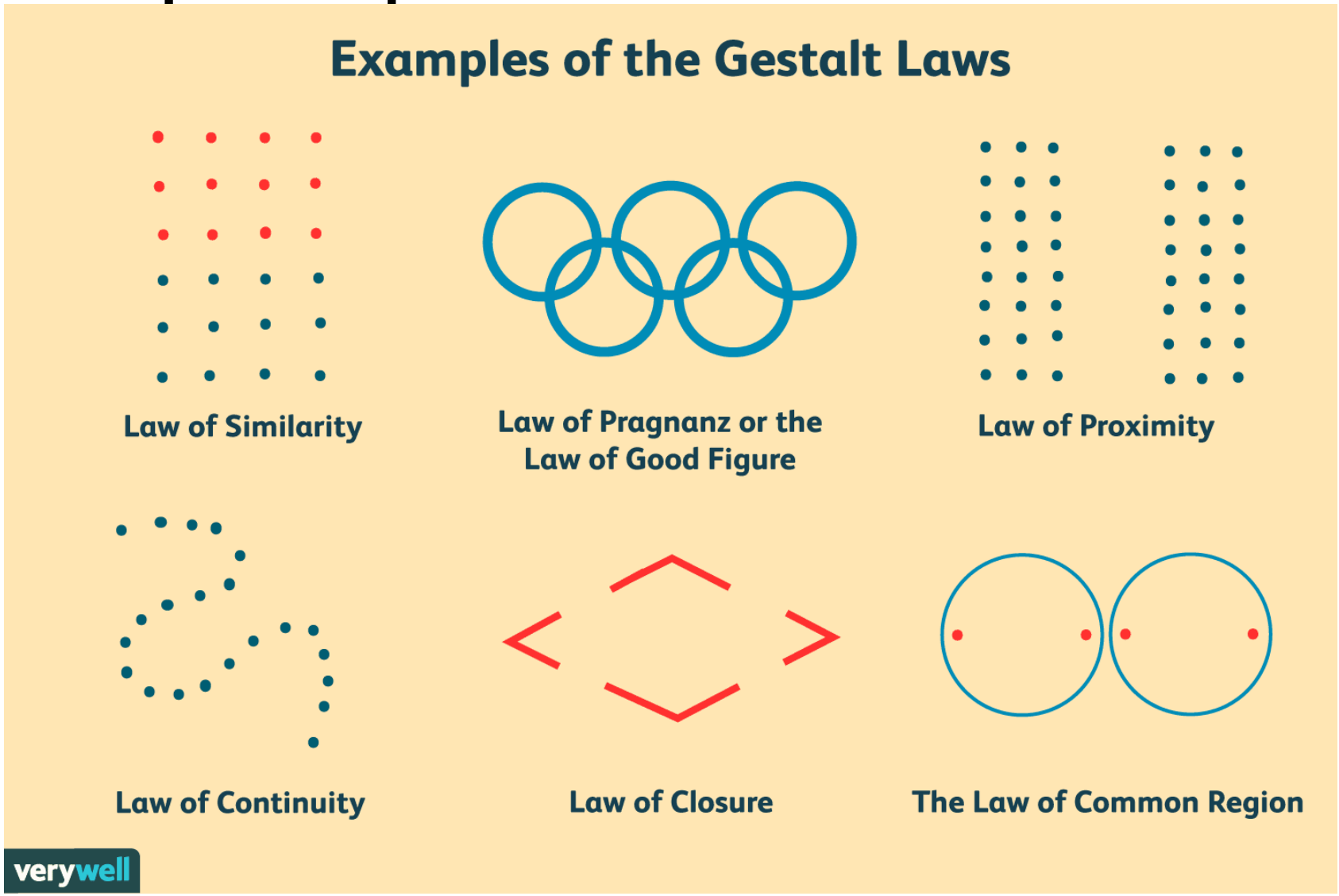
Gestalt principles of perceptual organization

- The Gestaltists argued that the organization is contributed by the perceiver; this is why, they claimed, the perceptual whole is often different from the sum of its parts.



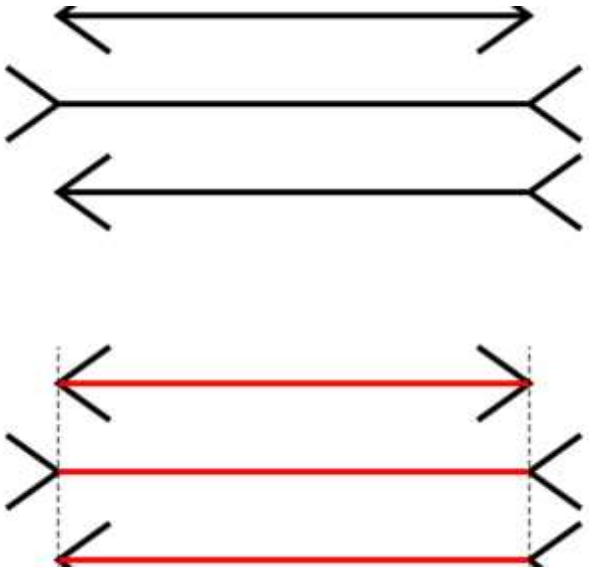


Gestalt principles



Helmholtz's theory of unconscious inference(1867)

- It states that some of our perceptions are a result of unconscious assumptions we make about the environment.
- Includes the **Likelihood principle** – we perceive an object that is most likely to have caused the pattern.



Object Recognition

How Humans Recognize Objects: Segmentation, Categorization and Individual Identification

Object agnosia (see only the faces)

How Do We Recognize Objects From Different Viewpoints?

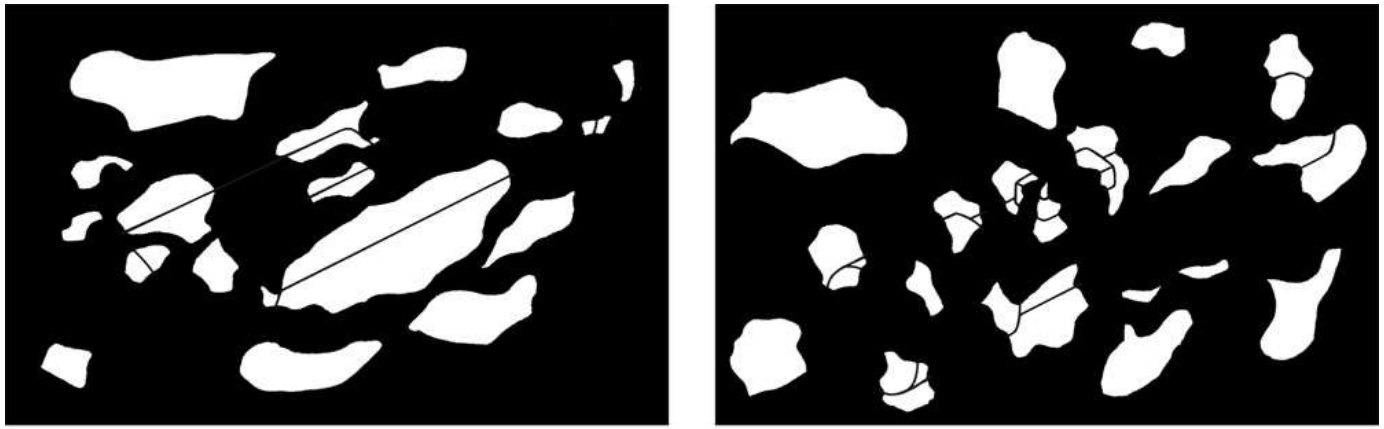
- Two competing theories:

- Structural description models

- Image description models

Structural-Description Models:

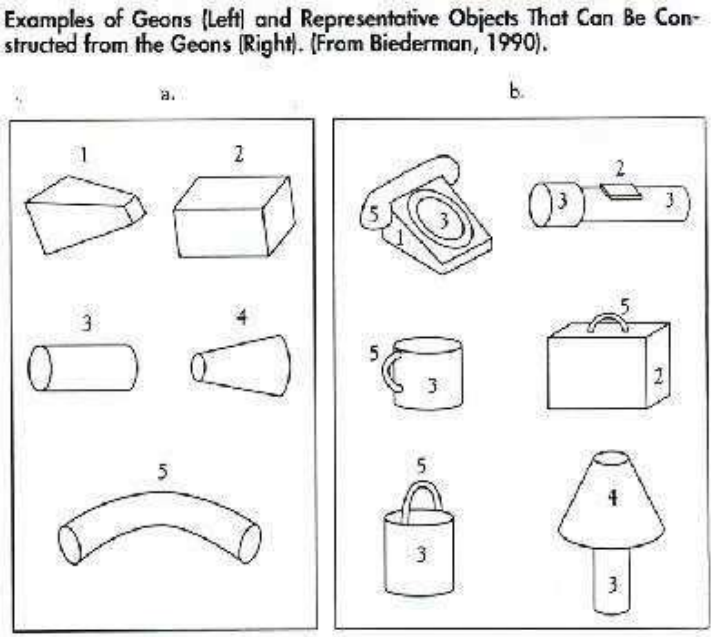
- Recognition by Components (RBC) {Biederman (1985)}
- Geons (“Geometric Ions”)
- Each geon is uniquely identifiable from most viewpoints *(viewpoint invariant).*
- Only 36 geons needed to make thousands of objects.
- Objects can be identified if the geons can be identified:
- which geons are present?
- what is the spatial relation among geons?



(a)

(b)

Figure 5.35 (a) It is difficult to identify the object behind the mask because its geons have been obscured.
(b) Now that it is possible to identify geons, the object can be identified as a flashlight.



Recognition by Components

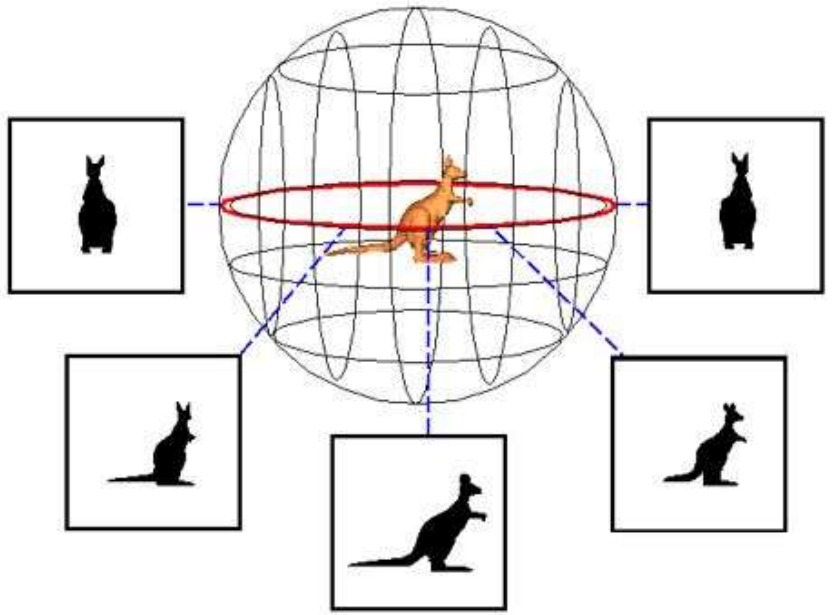
Strengths

- – Viewpoint invariant
- – Parts-based
- – May be able to deal with partial occlusion via feedback
- – Represent 3-D structure

Weaknesses

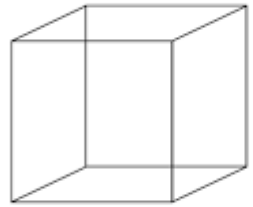
- – Complexity of representation
- – Doesn’t easily represent subtle metric differences (e.g.,distance between eyes)
- – Recognition is at the level of categories (chair vs. table) rather than individuals (my office chair vs. my kitchen chair)

Viewpoint-dependent theory of recognition



- This is an alternative theory. You store in your head a bunch of characteristic views (mental images) of objects. You recognize a new image by finding the closest match. That is, you don't use 3D shape to recognize objects. Only the 2D views of the objects

Image-Description Models



- Ability to identify 3-D objects comes from stored 2-D viewpoints from different perspectives
- – For a familiar object, view invariance occurs
- – For a novel object, view invariance does not occur

This shows that an observer needs to have the different viewpoints encoded before recognition can occur from all viewpoints

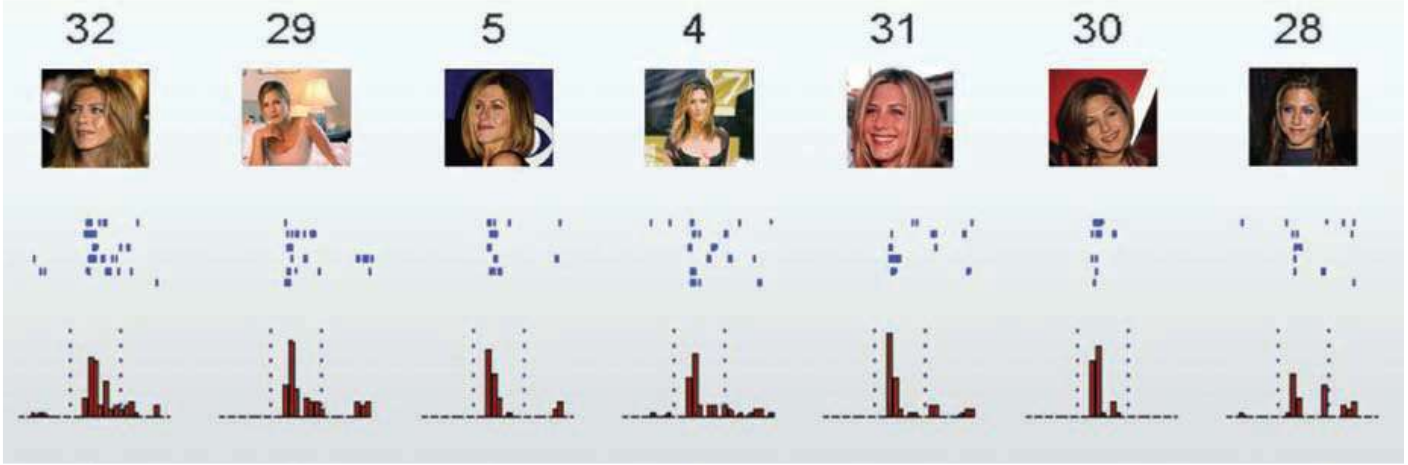
Object recognition

- Schneider's (1969) suggestion that two distinct pathways support visual orientation toward object features.
- Research stemming from this idea has inextricably linked object recognition to the experiences of space, time, and persistence over time, i.e., individual identity (Scholl, 2007; Fields, 2012).
- Without a spacetime "container" and individual, time-persistent objects, motion and causation cannot be defined; hence object recognition underlies these experiences as well.
- **Will object recognition be possible without memory?**

https://www.frontiersin.org/articles/10.3389/fpsyg.2016.00400/full

Object Recognition

- Researchers in one study were able to do single-cell recording within the brains of people who were undergoing surgical treatment for epilepsy. The researchers located cells that fired strongly whenever a picture of Jennifer
- Aniston was in view — whether the picture showed her close up (picture 32) or far away (picture 29), with long hair (picture 32) or shorter (picture 5). These cells are largely viewpoint-independent; other cells, though, are viewpoint-dependent.



Pattern Recognition

Face,Speech/music,text, art

Theories of pattern recognition:

1. Template-matching theory.
2. Feature detection theories
3. Prototype theories

Prototype theory is preferred, because (a) it appears to be amore flexible approach (since prototypes can be updated continuously with new experiences), and (b) fewer representations need to be stored.

Extreme cases:

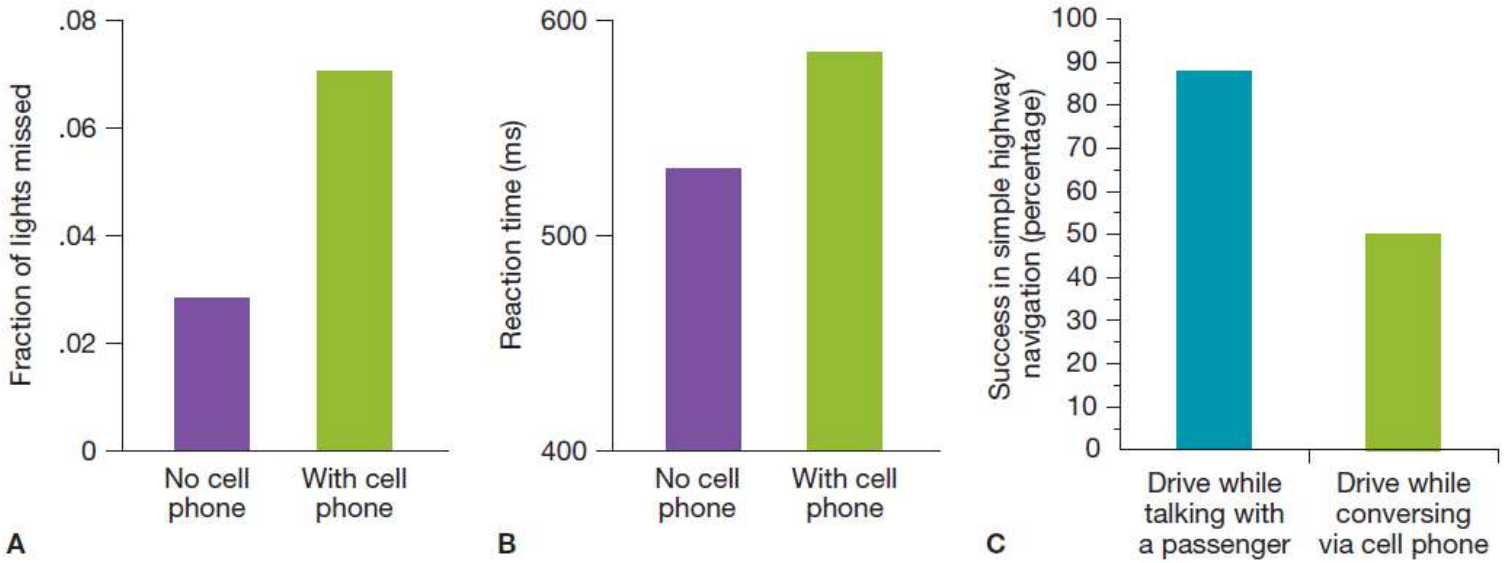
Apophenia (early stages of schizophrenia).

Pareidolia: ringing phone while taking a shower.

Gambler's fallacy: school oneself to see patterns

Multitasking & Attention

FIGURE 5.19 CELL PHONE USE AND DRIVING



Many studies show that driving performance is impaired when the driver is on the phone (whether hand-held or hands-free). While on the phone, drivers are more likely to miss a red light (Panel A) and are slower in responding to a red light (Panel B). Disruption is not observed, however, if the driver is conversing with a passenger rather than on the phone (Panel C). That's because the passenger is likely to adjust her conversation to accommodate changes in driving—such as not speaking while the driver is navigating an obstruction.

(AFTER STRAYER & JOHNSTON, 2001)

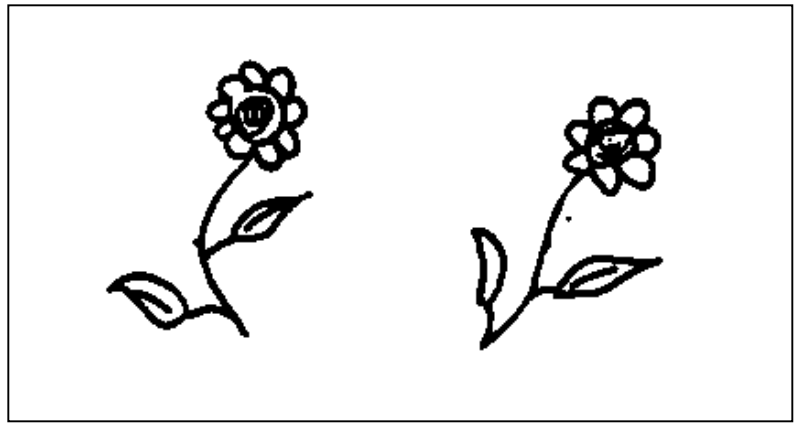
FIGURE 5.21 STROOP INTERFERENCE

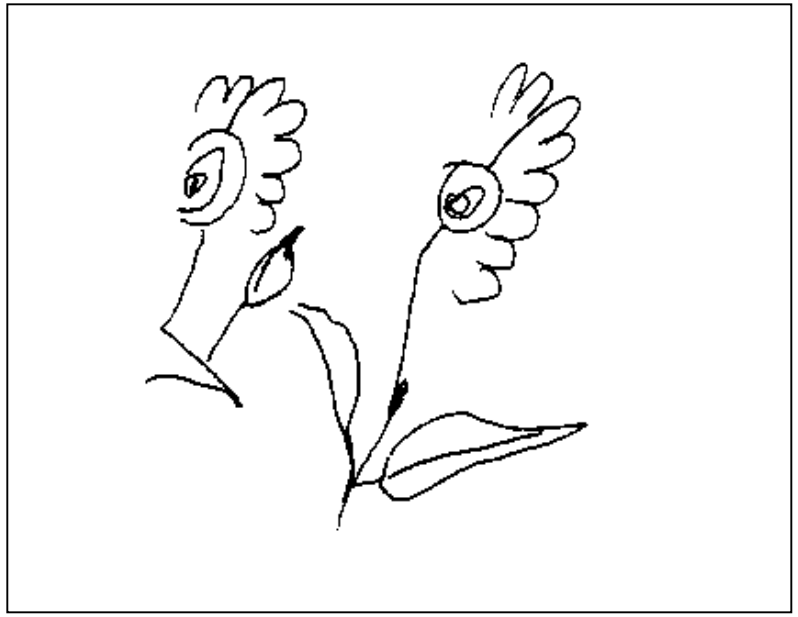
As rapidly as you can, name out loud the colors of the *ink* in Column A. (You'll say, "black, green" and so on.) Next, do the same for Column B—again, naming out loud the colors of the ink. You'll probably find it much easier to do this for Column A, because in Column B you experience interference from the automatic habit of reading the words.

Alan Burgess

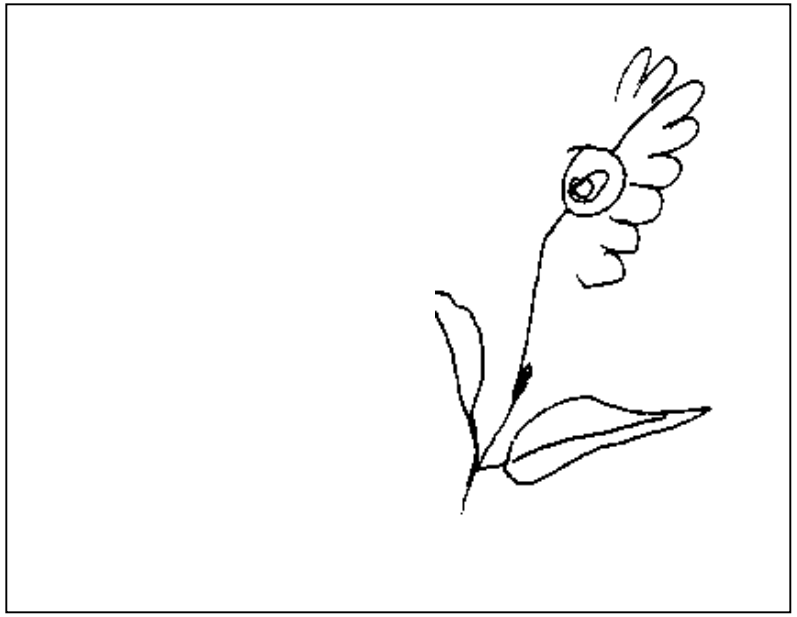
- hemispatial neglect – an inability to pay attention to sensory stimuli on his left side .
- Stroke damaged the parietal lobe on the right side of his brain, the part that deals with the higher processing of attention. The damage causes him to ignore people, sounds, and objects on his left.
- research suggests that people with normal vision perform better at visual attention tasks when they are rewarded for good performance and Dr Malhotra and his team have found the same thing in neglect patients.

Dr Paresh Malhotra, senior lecturer in neurology at Imperial College London





Object-centred Neglect



Object and Location-based Neglect

What/Where Pathways
Evidence from Neuropsychology

Visual agnosia: apperceptive agnosia (features) and associative agnosia (meaning).

Inability to identify objects and/or people

Caused by damage to inferior (lower) temporal lobe

Disruption of the "what" pathway

https://www.youtube.com/watch?v=ze8VVtBgK7A

Face recognition – prosopagnosia.

2006 study revealed that about one in 50 Americans is affected by Prosopagnosia.

https://www.youtube.com/watch?v=-vQGPcYfIAo

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

Memory - I

IBC, Spring 2022

Agenda

- Introductory lecture, broad overview
- Modal model
- Serial position curves and what we can infer about short term memory, long-term memory, etc

What is memory?

- *THE ABILITY TO STORE AND RETRIEVE INFORMATION OVER TIME*

Memory Test


Bed
Sheets
Xylophone
Pillow
Dream
Rest
Tired
Snore
Yawn
Darkness
Blanket
Couch
RESTY

Memory Test

Sheets?

Sleep?

Dream?

Mattress?

Snore?

<u>Memory Illusion</u>:

False but subjectively compelling memory

We view memory like this:

It’s more like this

Reconstructive View of Memory

- Memories are not **reproduced** like a tape playing
- Memories are actively constructed and **reconstructed**

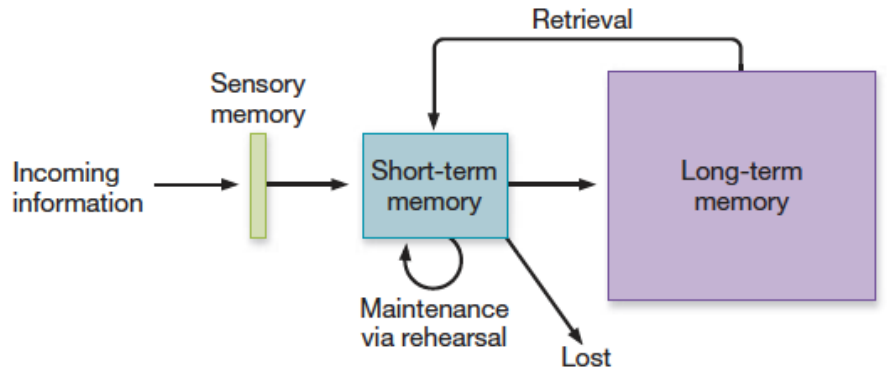
Memory

- **Memory**: the ability to store and retrieve information over time
- There are three key components of memory:
  - **Acquisition/Encoding**: the process by which we transform what we perceive, think, or feel into a memory.
  - **Storage**: the process of maintaining information in memory over time
  - **Retrieval**: the process of bringing to mind information that has been previously encoded and stored

How is information acquired?

- Atkinson and Shiffrin (1968): The modal model

FIGURE 6.1 AN INFORMATION-PROCESSING VIEW OF MEMORY



Diagrams like this one depict the flow of information hypothesized by the modal model. The model captures many important truths but must be updated in important ways. Current theorizing, for example, emphasizes that short-term memory (now called "working memory") is not a place serving as a "loading dock" outside of long-term memory. Instead, working memory is best understood as an activity, in ways described in the chapter.

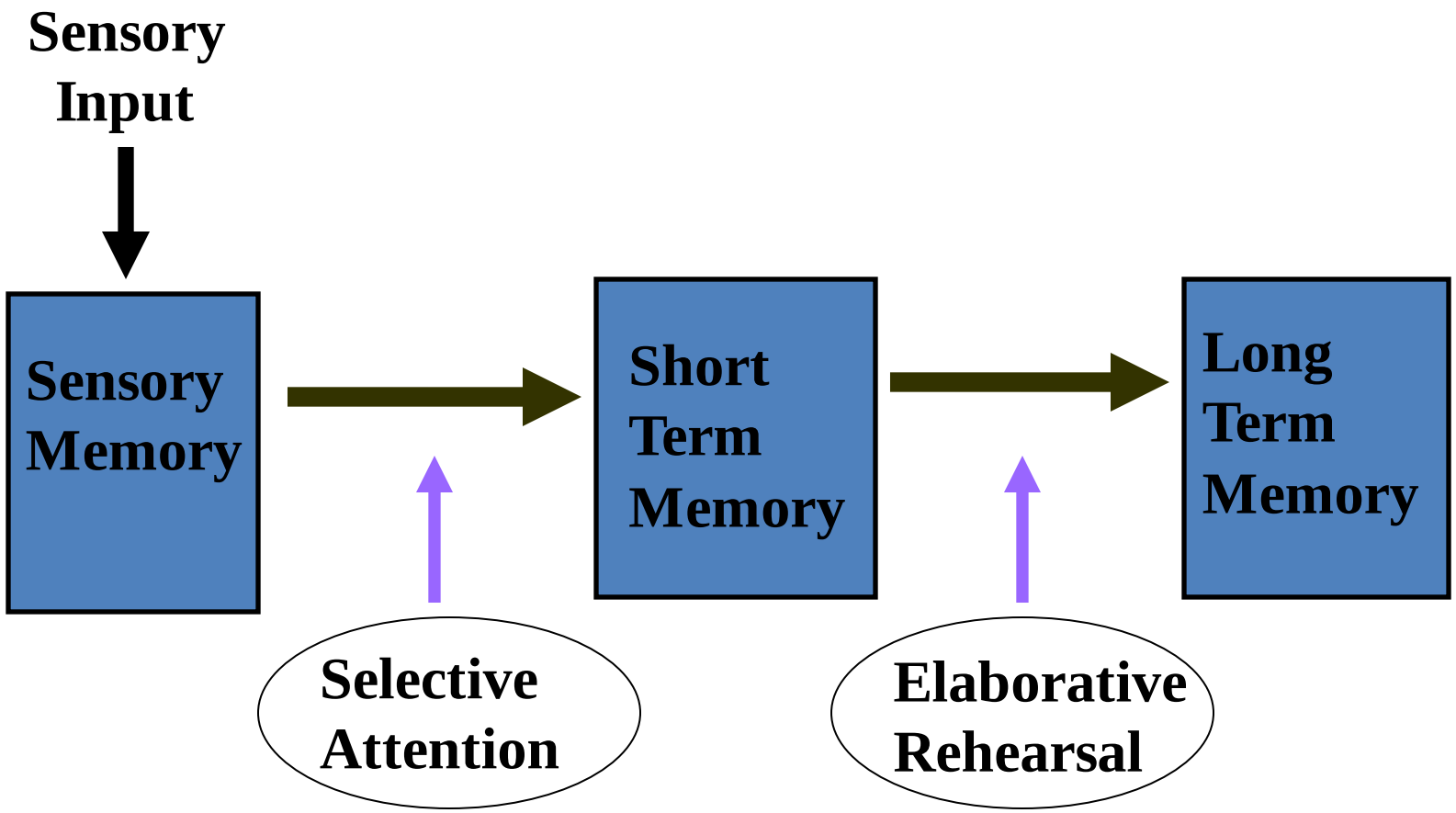
Storage

- There are three major kinds of memory storage:
  - **Sensory memory**: storage that holds sensory information for a few seconds or less
    - **Iconic memory**: a fast-decaying store of visual information
    - **Echoic memory**: a fast-decaying store of auditory information
  - Short-term memory (STM)
  - Long-term memory (LTM)

Three System Memory

	Sensory Memory	Short-term Memory	Long-term Memory
Function			
Span			
Duration			

Three Systems of Memory



Three Systems of Memory

- Each stage is different in terms of
  - **Span**: How much information
  - **Duration**: How long
  - **Function**: What is done with the stored info

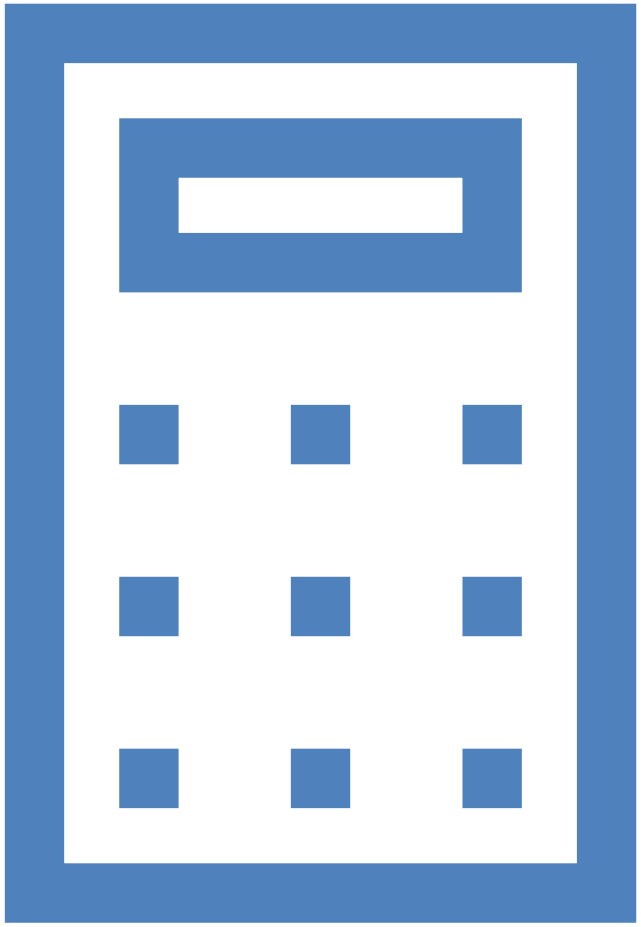
Sensory Memory

- Sensory registers: temporary storage of sensory information
- Registers a great deal of information from the environment
- Separate sensory memory exists for each sense
- Quickly fades: less than 1 sec (visual) or a few sec (auditory)

Sensory Memory

- Selective attention
  - With limited mental resources, only part of the stimulus field is being focused
  - Control what information is processed further
  - Information that passes through an attentional gate is transferred to short-term memory

- Sperling task (1960)



Sperling Task

- Sperling (1960)
  - Presented matrix of letters for 1/20th second
  - Report as many letters as possible

Sperling Task

- Sperling (1960)
  - Presented matrix of letters for 1/20th second
  - Report as many letters as possible

Sperling Task

- Sperling (1960)
  - Presented matrix of letters for 1/20th second
  - Followed by low, medium, or high tone
  - Tone signaled which row to report

HIGH

MEDIUM

LOW

Sperling Task

- Sperling (1960)
  - Presented matrix of letters for 1/20th second
  - Followed by low, medium, or high tone
  - Tone signaled which row to report
  - Recall was almost perfect

How’d they do that?

- **Visual sensory memory** (iconic memory)
  - Holds an image for about a second

- **Auditory sensory memory** (echoic memory)
  - Holds sound info from a few to several seconds

Three System Memory

	Sensory Memory	Short-term Memory	Long-term Memory
Function	Temporary storage		
Span	High		
Duration	Less than 1 sec or a few sec		

Storage: Maintaining Memories Over Time

- There are three major kinds of memory storage:
  - Sensory memory
  - **Short-term memory (STM)** or working memory: storage that holds non-sensory information for more than a few seconds but less than a minute; can hold about 7 items
    - **Rehearsal**: the process of keeping information in STM by mentally repeating it
    - **Chunking**: combining small pieces of information into larger clusters that are more easily held in STM
    - **Working memory**: active maintenance of information in STM.
  - Long-term memory (LTM)

Short-term Memory

- Working memory
  - Helps to work with info held in short-term memory
  - Maintenance
    - Hold info in short-term memory
  - Manipulation
    - Work on that information

Short-term Memory

- Span
  - Immediate memory span: Max # of items you can recall perfectly after seeing once
  - Magic number: 7±2 (?) **meaningful** items
  - With new information coming, displacement or bumping out will happen
    - Interference – loss of info due to incoming, competing information
    - Decay – fading of info from memory over time
  - Enlarge Span?
    - Chunking and organization

Short-term Memory

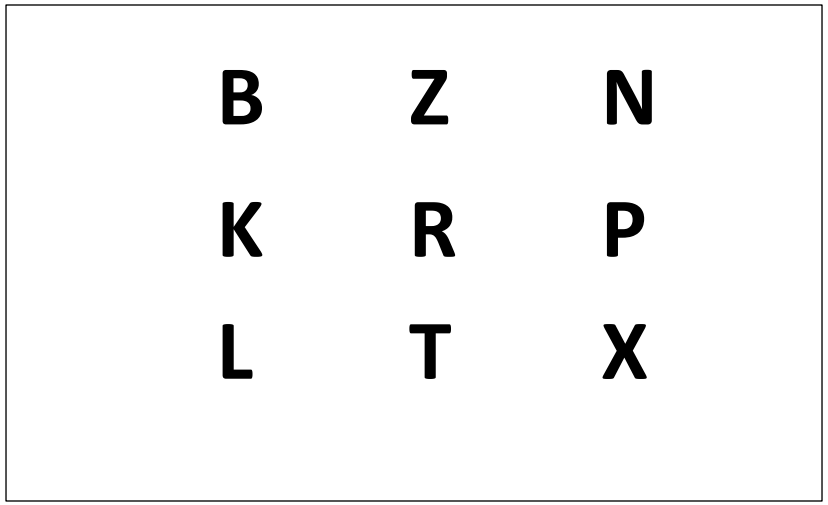
- Chunking and organization
  - GROUPINGBYMEANINGFULUNIT
    (Grouping by meaningful unit)
  - Increase the amount of information held in short-term memory

JFKCIAUSANBC

JFKCIAUSANBC

Short-term Memory

- Duration
  - Less than 20 sec without rehearsal
  - *Brown-Peterson task*
    - *A group of 3 letters presentation*
    - *Count backward by 3 from some number*



Short-term Memory

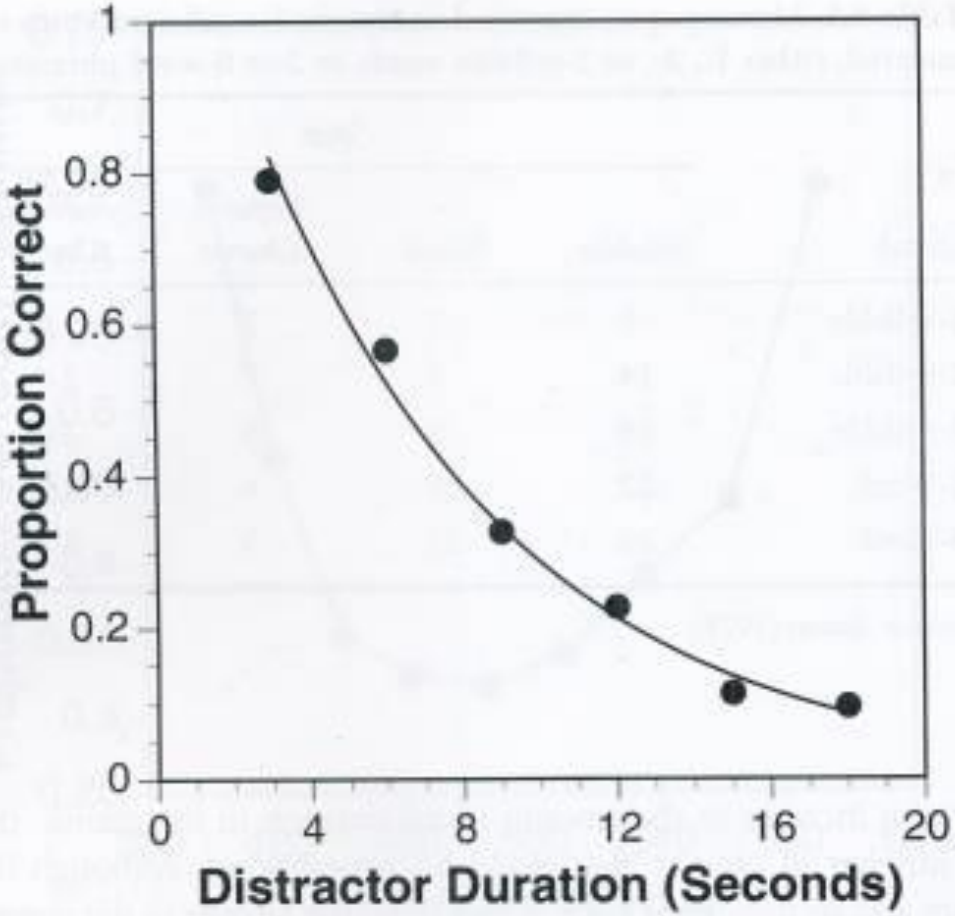


Figure 4.3 Proportion of consonant trigrams correctly recalled as a function of the distractor task duration. Source: Peterson & Peterson (1959).

Short-term Memory

- Brief storage of information currently being used
- Stores limited amount of info for limited time
- Duration: less than 20 sec

Three System Memory

	Sensory Memory	Short-term Memory	Long-term Memory
Function	Temporary storage of sensory info	Storage of info currently being used	
Span	High	Limited (*Chunking)	
Duration	Less than 1 sec or a few sec	Less than 20 sec	

Storage: Maintaining Memories Over Time

- There are three major kinds of memory storage:
  - Sensory memory
  - Short-term memory (STM)
  - **Long-term memory (LTM)**: storage that holds information for hours, days, weeks, or years; no known capacity

Long-term Memory

- The transfer of information between short-term and long-term memory
- Store information indefinitely
  - Maybe for a life time
- Permastore
  - May endure for decades

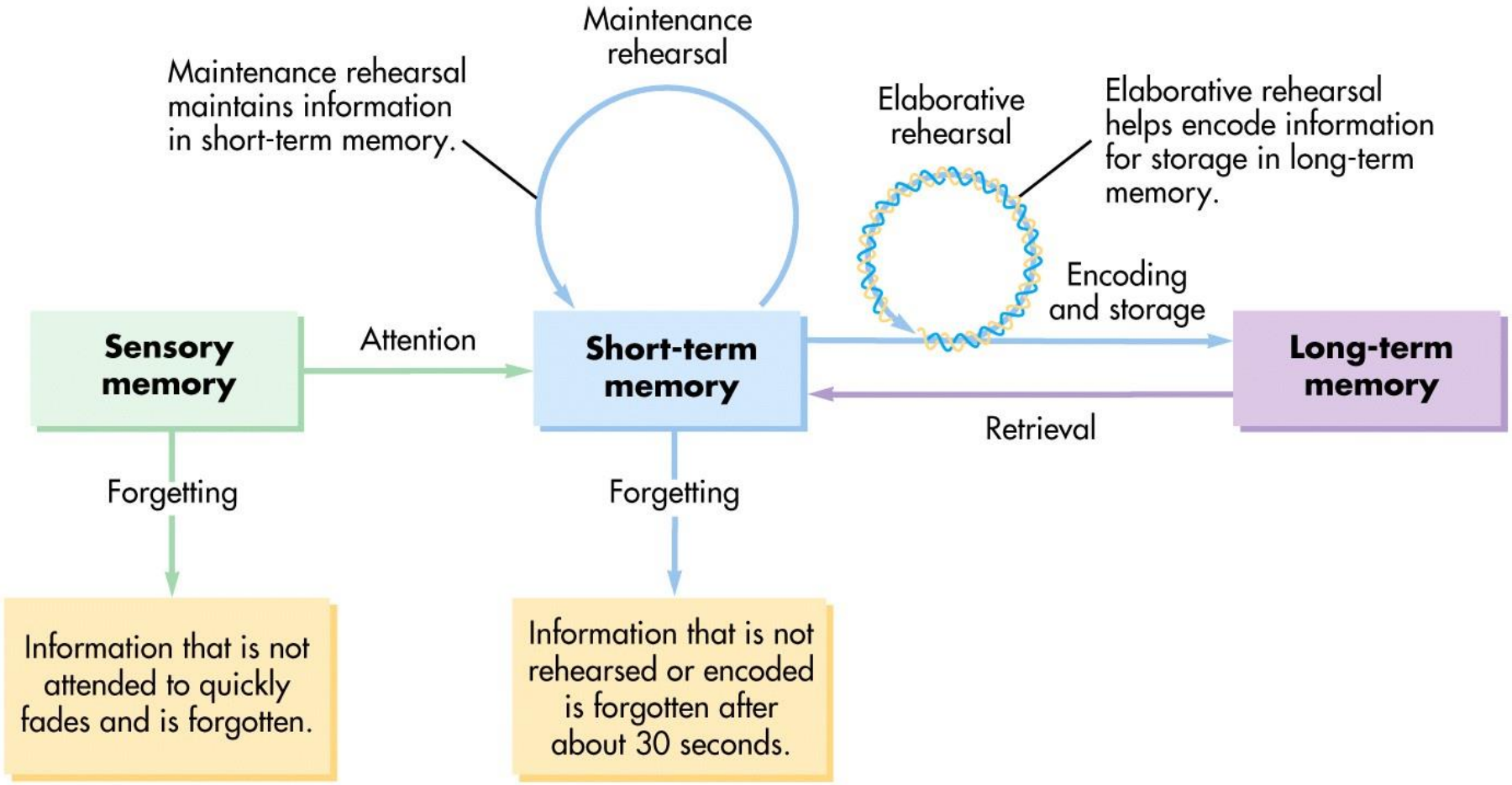
Long-term Memory

- Expectations affect what is recalled
  - Heard: The karate champion *hit* the cinder block
  - Remembered: The karate champion *broke* the cinder block
- Psychology: Science of Exceptions
  - Jill Price (40s) – recalls every daily event in great detail since 1980s
- Prone to distortion
  - Eyewitness testimony

Three System Memory

	Sensory Memory	Short-term Memory	Long-term Memory
Function	Temporary storage of sensory info	Storage of info currently being used	Storage of info indefinitely
Span	High	Limited (*Chunking)	Unlimited
Duration	Less than 1 sec or a few sec	Less than 20 sec	For a lifetime

Three System Memory



Insights from free recall memory performance

Are STM and LTM different systems? Do they contribute differentially to different memory tasks?

Primacy and Recency Effects

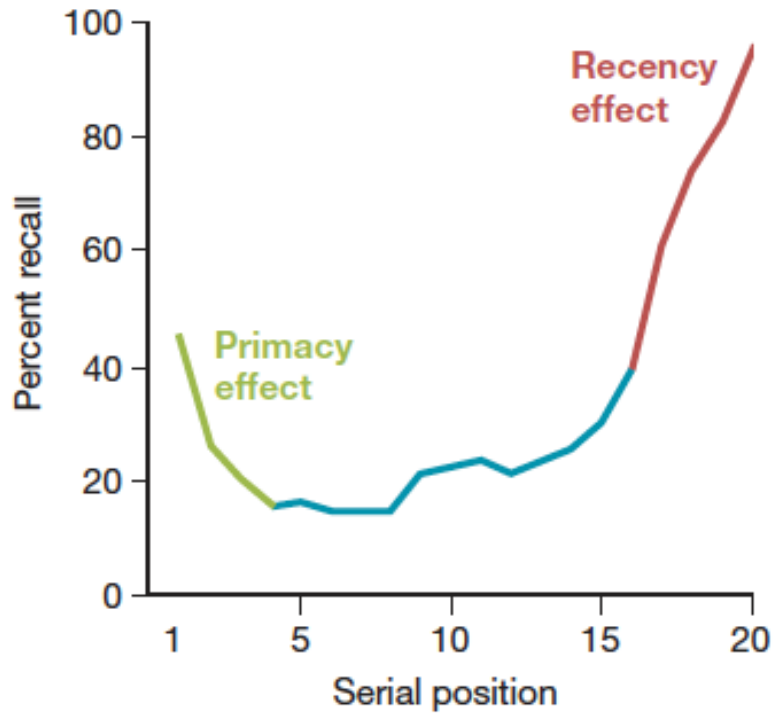


FIGURE 6.2 PRIMACY AND RECENCY EFFECTS IN FREE RECALL

Research participants in this study heard a list of 20 common words presented at a rate of one word per second. Immediately after hearing the list, participants were asked to write down as many of the words on the list as they could recall. The results show that position in the series strongly affected recall—participants had better recall for words at the beginning of the list (the primacy effect) and for words at the end of the list (the recency effect), compared to words in the middle of the list.

How do we explain primacy and recency effects?

- Recency – output from working memory
- Primacy – more attention, rehearsal time

If primacy and recency are driven by two different memory "systems", it should be possible to manipulate them independently

Add a distractor task at the end of the study list = "delayed free recall" with a "filled delay".

Serial position curve of a distractor-filled delayed free recall task compared to immediate free recall or unfilled delay period

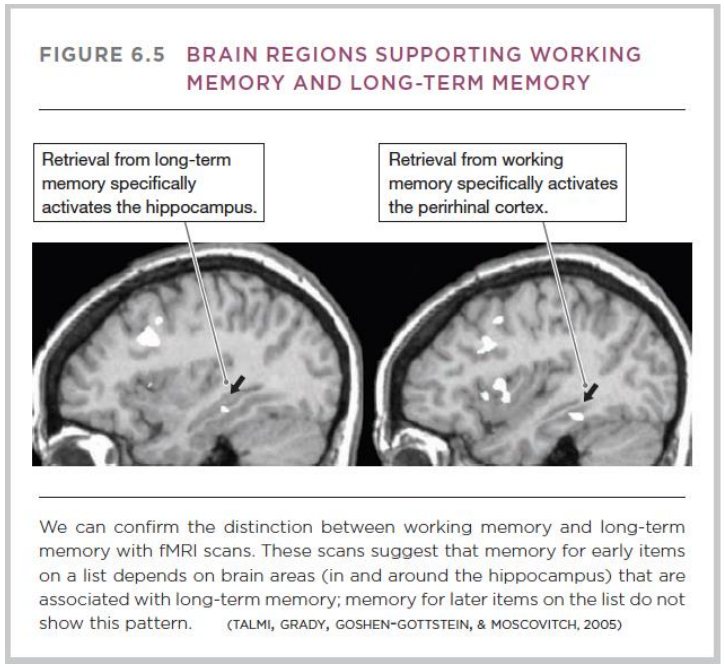


FIGURE 6.5 BRAIN REGIONS SUPPORTING WORKING MEMORY AND LONG-TERM MEMORY

We can confirm the distinction between working memory and long-term memory with fMRI scans. These scans suggest that memory for early items on a list depends on brain areas (in and around the hippocampus) that are associated with long-term memory; memory for later items on the list do not show this pattern. (TALMI, GRADY, GOSHEN-GOTTSTEIN, & MOSCOVITCH, 2005)

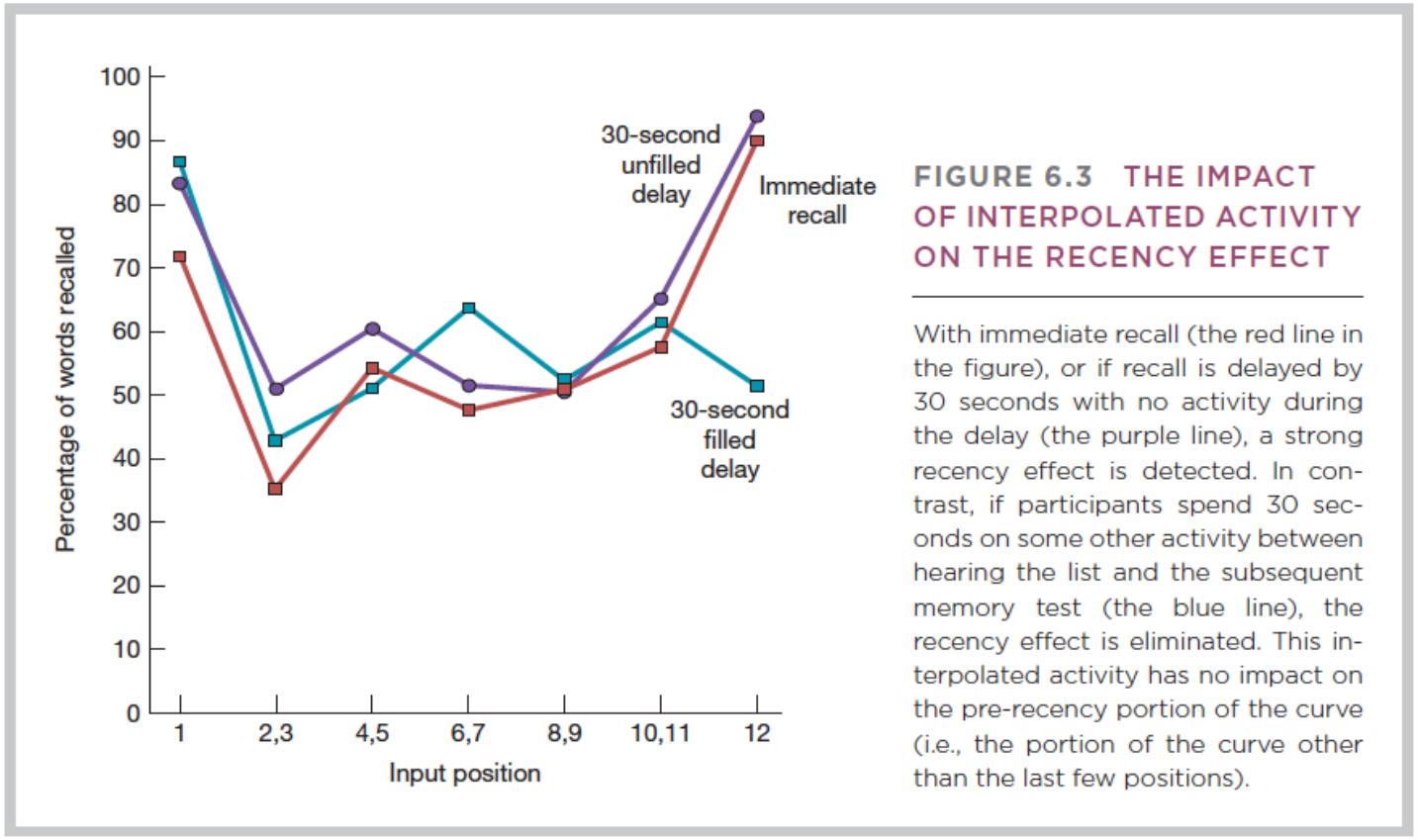


FIGURE 6.3 THE IMPACT OF INTERPOLATED ACTIVITY ON THE RECENCY EFFECT

With immediate recall (the red line in the figure), or if recall is delayed by 30 seconds with no activity during the delay (the purple line), a strong recency effect is detected. In contrast, if participants spend 30 seconds on some other activity between hearing the list and the subsequent memory test (the blue line), the recency effect is eliminated. This interpolated activity has no impact on the pre-recency portion of the curve (i.e., the portion of the curve other than the last few positions).

Interim conclusions from recency effects

- Recency --> driven by items held in working memory which are easier to access, so they get recalled first.
- Disappears when you introduce a filled delay period.
- Open and shut case?

Think again: long-term recency effects!

- Why do we get recency effects in a continuous-distractor free-recall task?! Not covered in the text book.

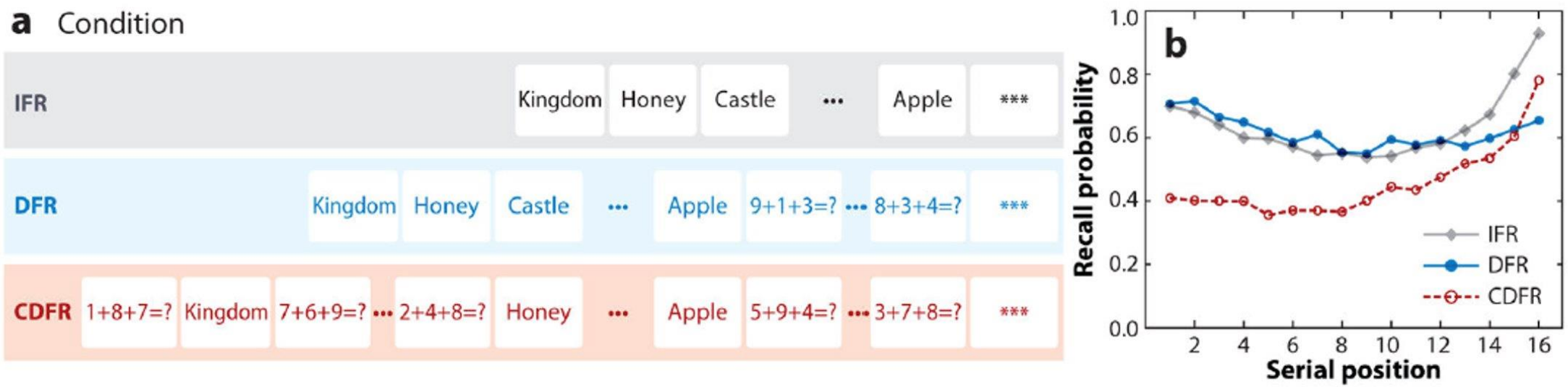
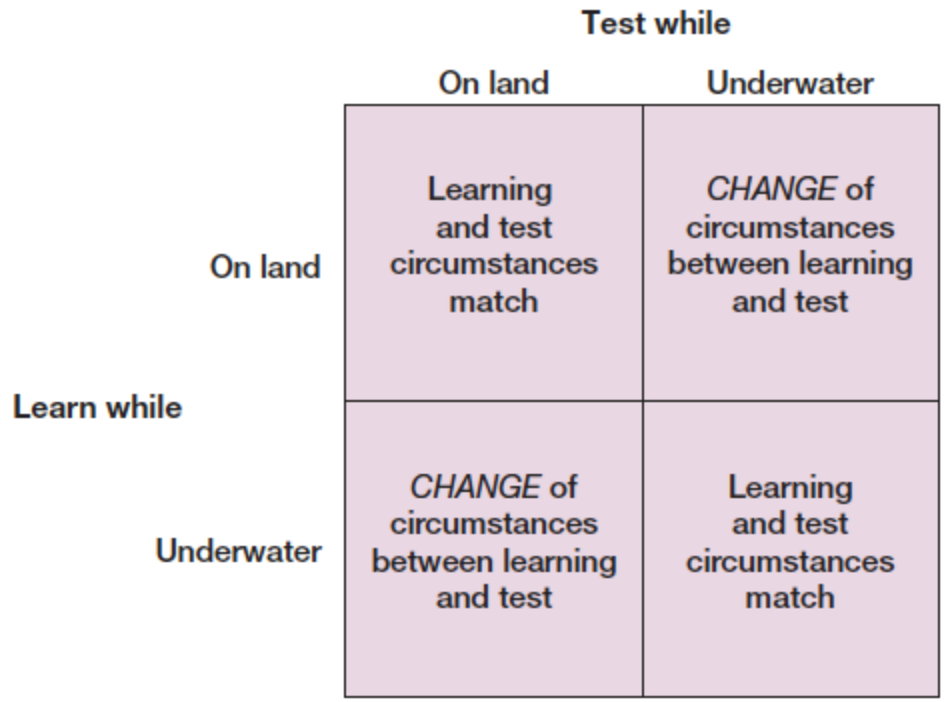


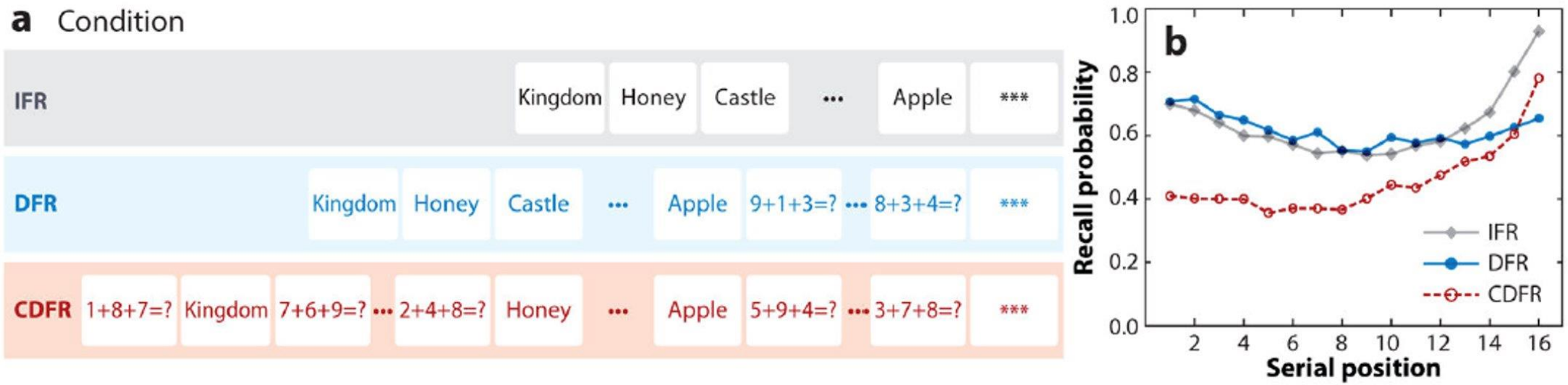
FIGURE 7.2 THE DESIGN OF A CONTEXT-DEPENDENT LEARNING EXPERIMENT

Half of the participants (deep-sea divers) learned the test material while underwater; half learned while on land. Then, within each group, half were tested while underwater; half were tested on land. We expect a retrieval advantage if the learning and test circumstances match. Therefore, we expect better performance in the top left and bottom right cells.



Similarity of testing context to study context matters

- Now, think again about long-term recency effects



The testing context is most similar to the study context at the end of the list, if you assume that context is something that changes very gradually

Temporal Context Model (TCM)

Gradually changing temporal context during experience

A

B

C

D

***

ABC

Recovery of temporal context during re-experience

E

F

C

ABC

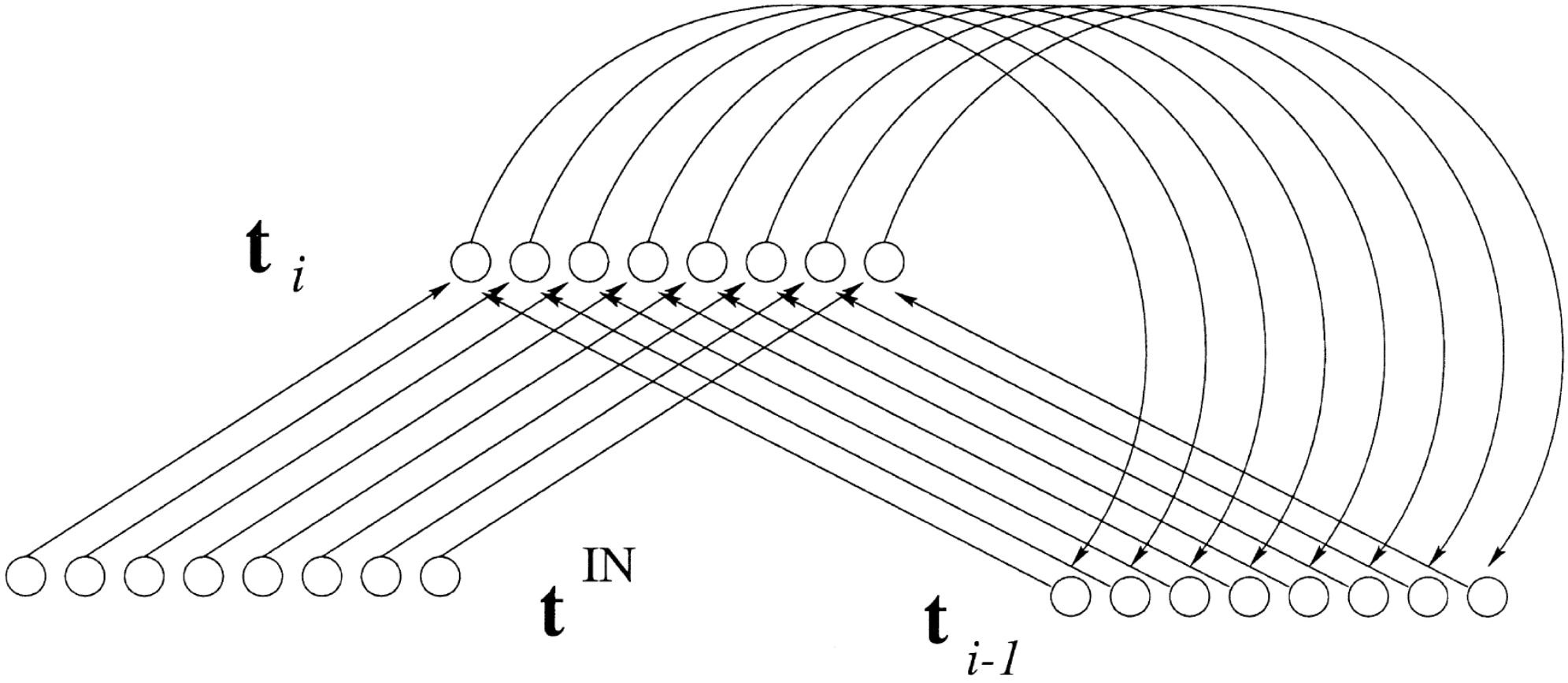
Retrieved temporal context

Current temporal context

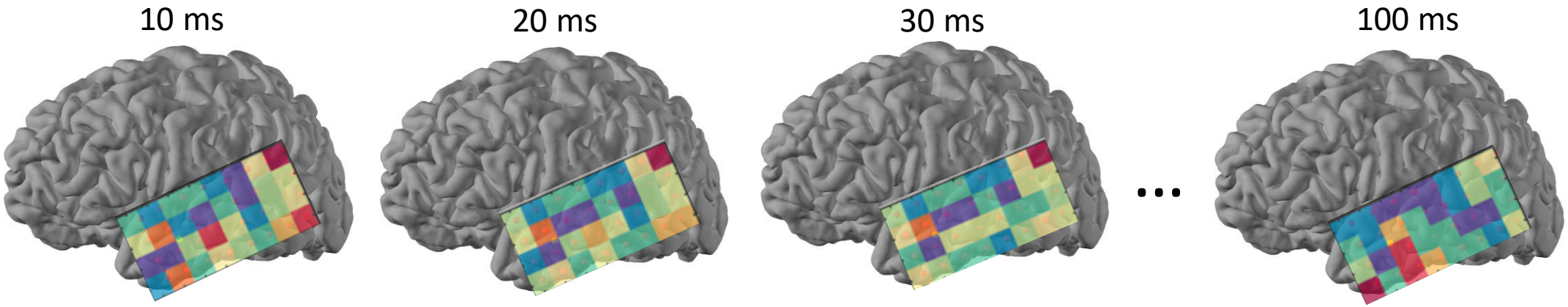
EFC

Oh no! Man get fruit NOW or man die!

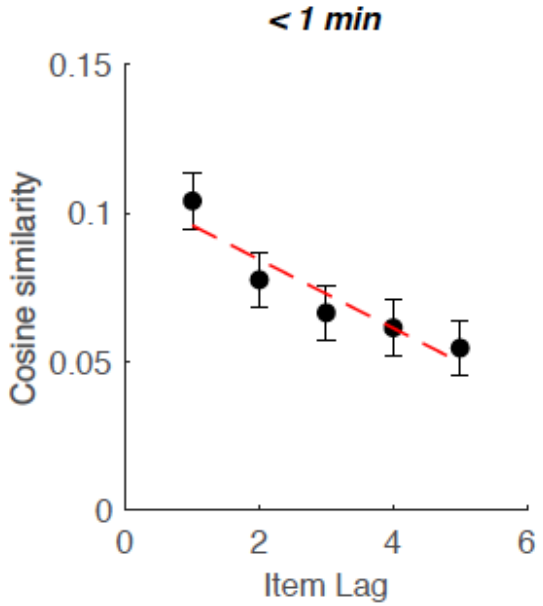
Slowly varying temporal context as a RNN

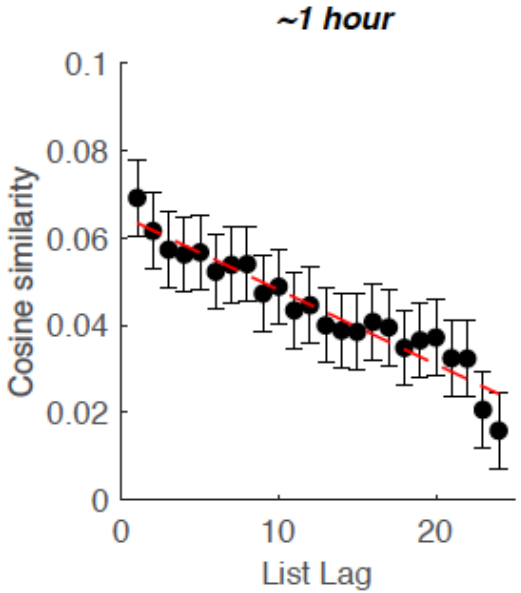


Context representations changing over time



N = 31





Sreekumar, Swift, Kaplan, El-Kalliny, Inati, & Zaghloul, *In Prep*

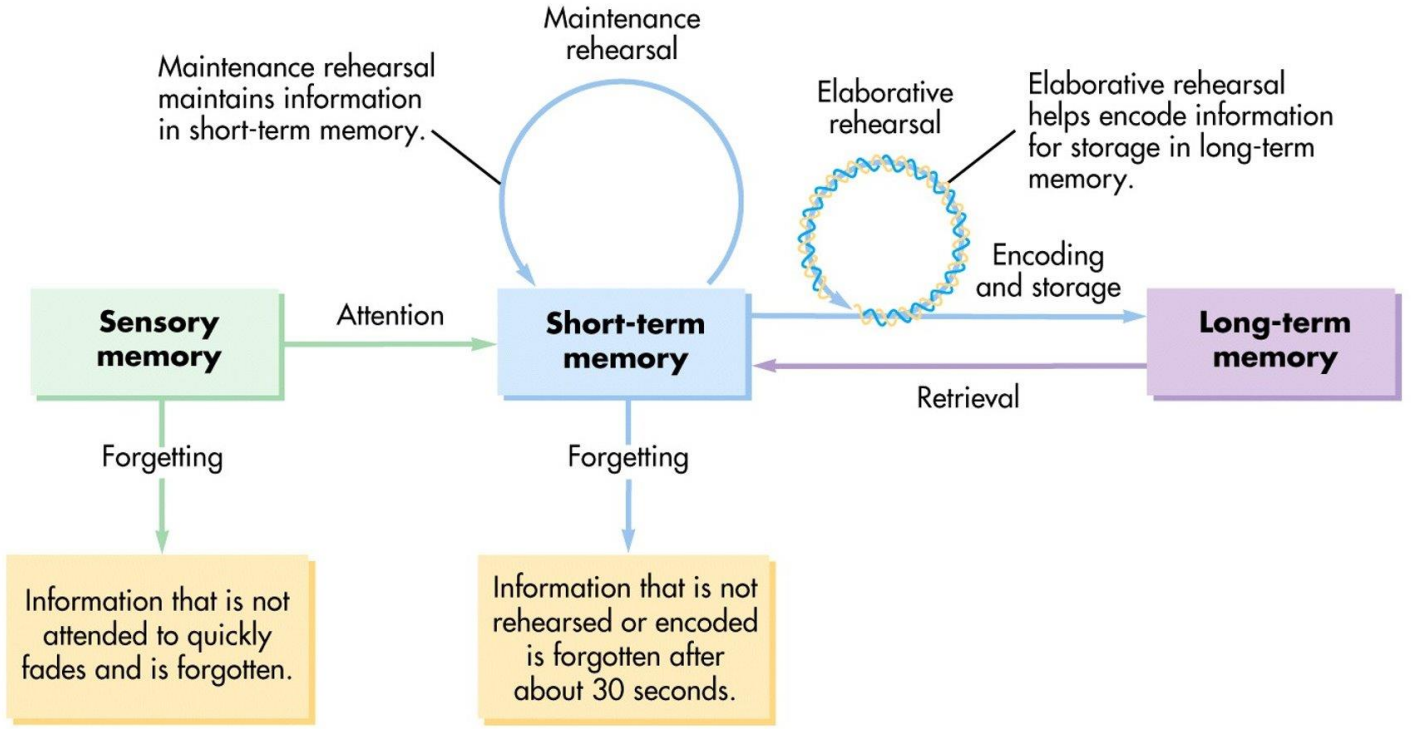
If context similarity is the explanation, why is recency attenuated in delayed free recall but not continuous distractor free recall?

- Both tasks have the same delay after the last item
- A potential answer: free recall retrieval is a competitive retrieval: competition amongst items. So the more distinctive the items are, the better they can be recalled. Continuous distractors make the last items (most recent) distinctive. So, there is an added benefit of distinctiveness, explaining recency effects in CDFR but not in DFR.
- Compare test context match with last item and test context match with other items: a greater difference for CDFR, explaining long-term recency effects.
- So a short term memory buffer by itself cannot explain all recency effects in free recall because it cannot explain this difference in recency between DFR and CDFR.

So is our dual store model of memory correct?

- Is there really such a big difference between STM and LTM or should we instead focus on common principles (such as distinctiveness, context-based retrieval) that can explain phenomena across different tasks and conditions?
- This is an open debate..

A few quick notes about how information might move from working memory to more long-term storage

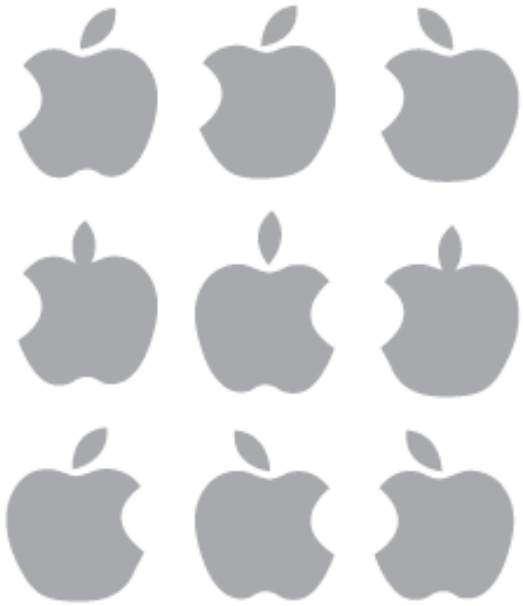


Multiple passive exposures are insufficient

FIGURE 6.10 MEMORY FOR AN OFTEN-VIEWED LOGO

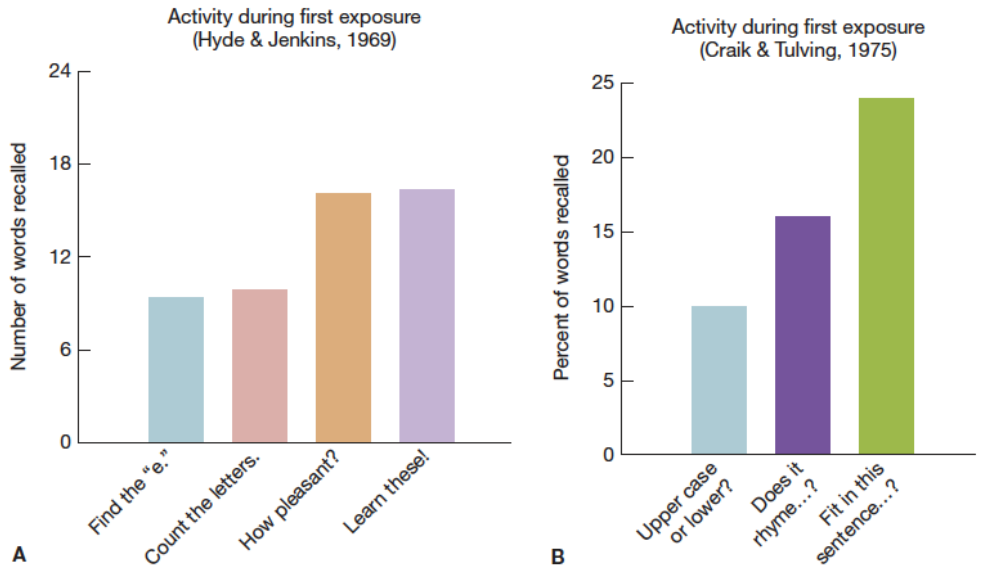
Most people have seen the Apple logo countless times, but they've had no reason to pay attention to its features. As a result, they have poor memories for the features. Test yourself. Can you find the correct version among the options displayed here?

(THE ANSWER IS AT THE END OF THE CHAPTER.)



The need for active and deep encoding

FIGURE 6.12 THE IMPACT OF DEEPER PROCESSING



The two sets of results shown here derive from studies described in the text, but they are part of an avalanche of data confirming the broad pattern: Shallow processing leads to poor memory. Deeper processing (paying attention to meaning) leads to much better memory. And what matters seems to be the level of engagement; the specific intention to learn (because participants know their memory will be tested later on) contributes little.

Other techniques to improve LTM

SPACED REPETITION

TESTING EFFECT

HOW WOULD YOU APPLY THIS TO PREPARE FOR EXAMS?

Brain activity when you correctly remember

Univariate analysis

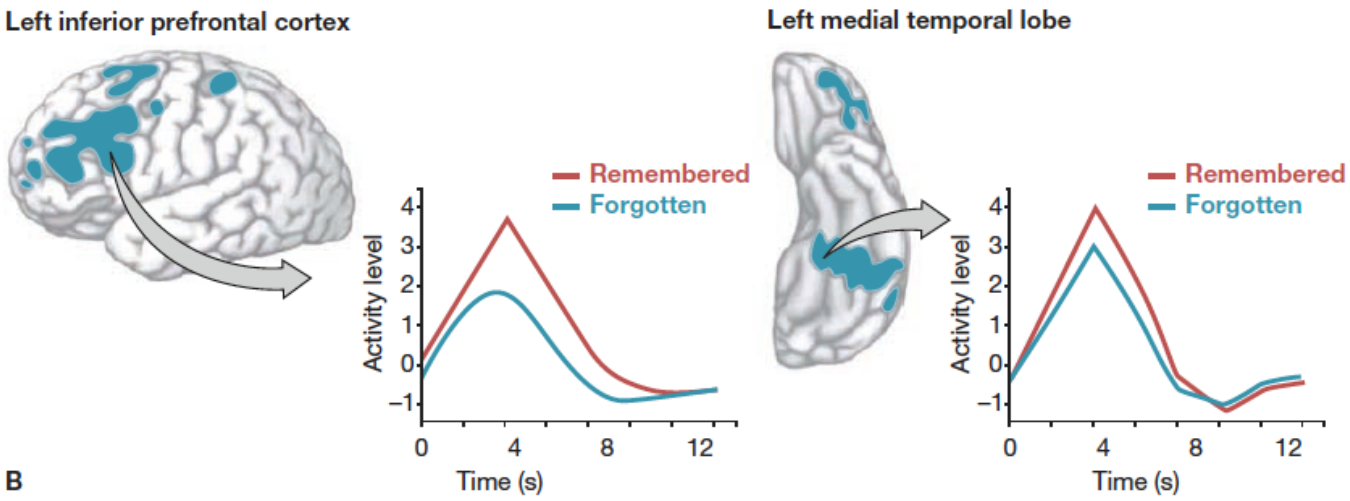
FIGURE 6.11 BRAIN ACTIVITY DURING LEARNING

Learn a series of words, and, during learning, record the neural response to each word.

Test memory for the words.

Based on what happened at Time 2, go back and examine the data from Time 1, looking separately at what happened during learning for words that were later remembered, and what happened during learning for words that were later forgotten.

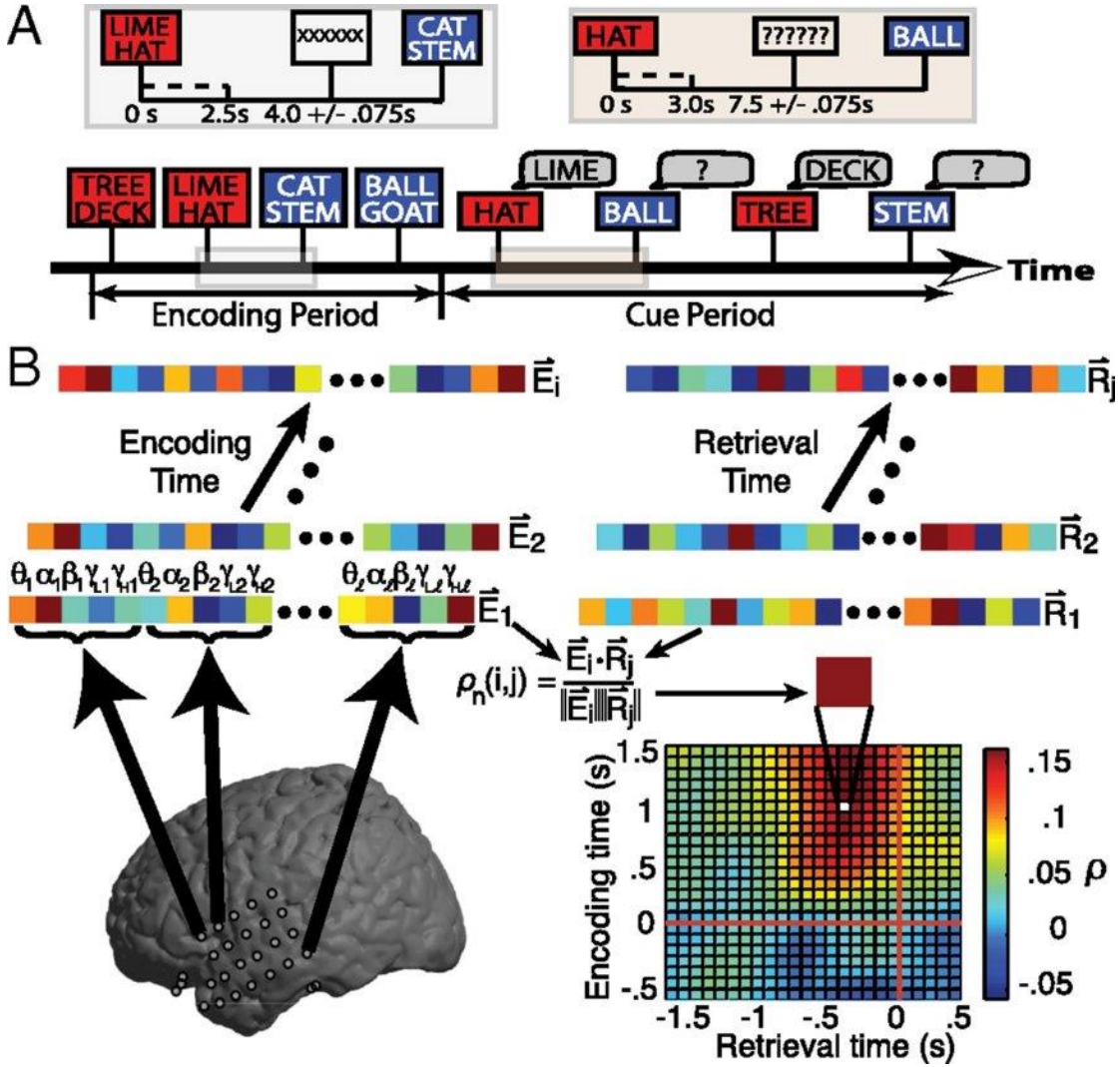
A



B

Brain activity when you correctly remember

Multivariate analysis

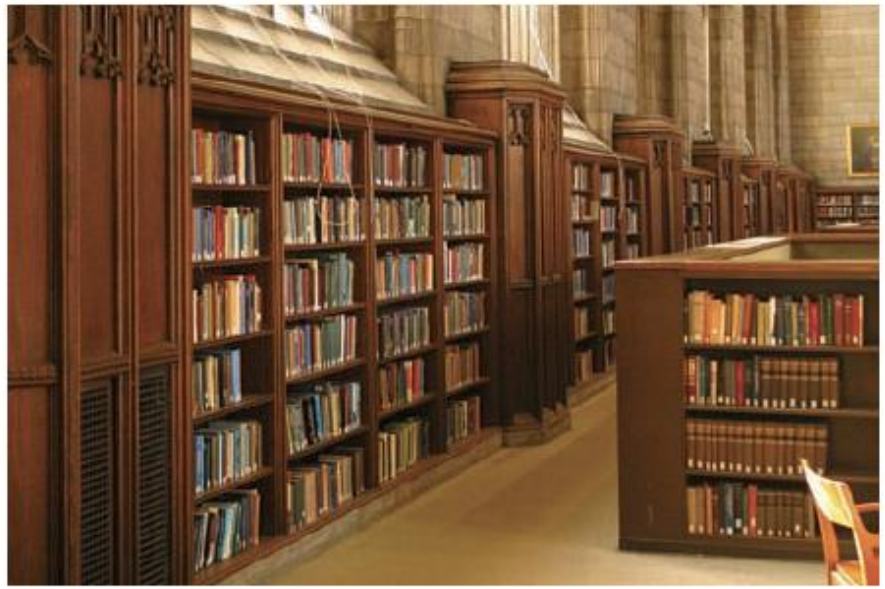


Robert B. Yaffe et al. PNAS 2014;111:52:18727-18732

The role of "connections" - memory cues

Why does spaced repetition enhance LTM?

Context cues and making different ones?



WHY DO MEMORY CONNECTIONS HELP?

When books arrive in a library, the librarians must catalogue them. This doesn't facilitate the "entry" of books into the library, because the books are in the building whether they're catalogued or not. But cataloguing makes the books much easier to find later on. Memory connections may serve the same function: The connections don't "bring" material into memory, but they do make the material "findable" in long-term storage later.

Using "connections" as a memory strategy

FIGURE 6.14 MNEMONIC STRATEGIES

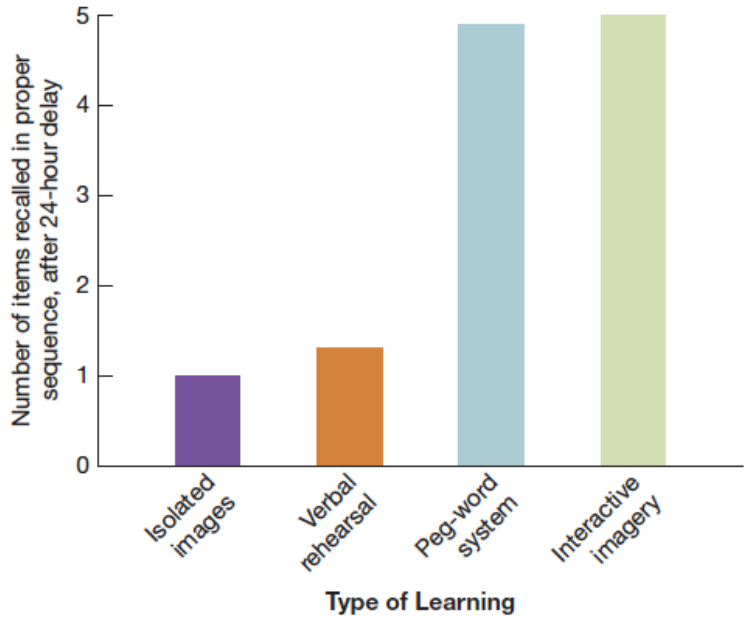
With a bit of creativity, you can make up mnemonics for memorizing all sorts of things. For example, can you name all ten of the Canadian provinces? Perhaps there is a great mnemonic available, but in the meantime, this will do. It's a complicated mnemonic but unified by the theme of the early-morning meal: "**B**reakfast **C**ooks **A**lways **S**ell **M**ore **O**melets. **Q**uiche **N**ever **B**ought; **N**ever **S**old. **P**erhaps **E**ggs **I**n **N**ew **F**orms?" (You're on your own for remembering the three northern territories.)

"Peg words"

One is a bun.
Two is a shoe.
Three is a tree.
Four is a door.
Five is a hive.
Six are sticks.
Seven is heaven.
Eight is a gate.
Nine is a line.
Ten is a hen.

Mnemonics are powerful memory aids

FIGURE 6.15 THE POWER OF MNEMONICS



Mnemonics can be enormously effective. In this study, students who had relied on peg words or interactive imagery vastly outperformed students who'd used other memorizing strategies. (AFTER ROEDIGER, 1980)

Memorization vs Understanding

- All the prior discussion was only about what improves memory.
- Rote memory however does not imply you will be able to use the information you learned in novel situations.
- Understanding is not the same as memorization.
- Understanding comes also from using connections! You have to be actively engaged, constantly trying to make connections to your existing knowledge but also to other new information that you get.

So is spaced repetition testing the best way for you to study?

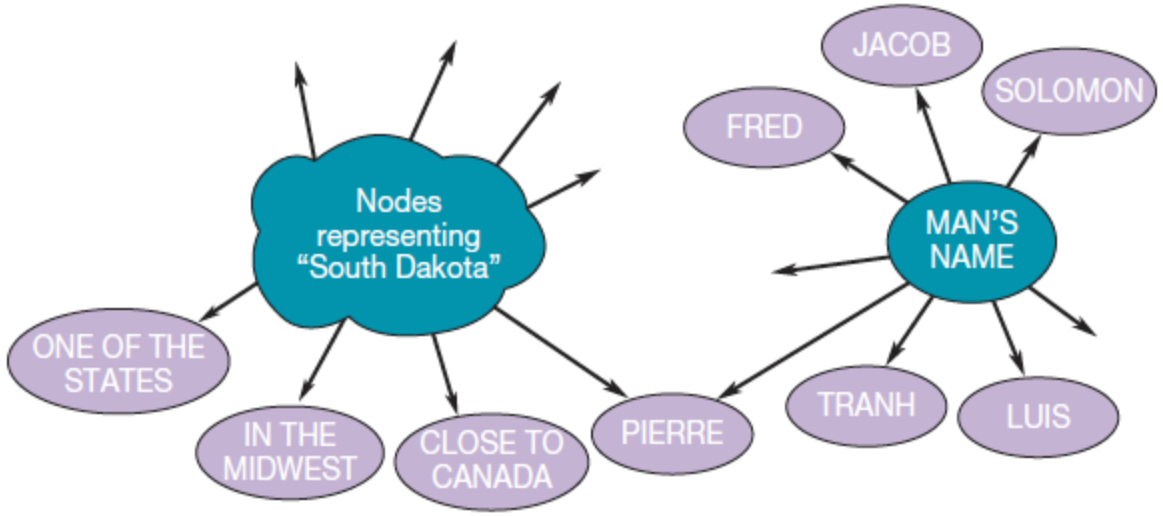
- Well, it will depend on what kind of test it is!
- Going to test your memory?
- Going to test how you can apply the material to novel situations?

Next:

- More on cues, retrieval, etc.
- Remembering complex events: Episodic memory; Autobiographical memory.

Spreading Activation

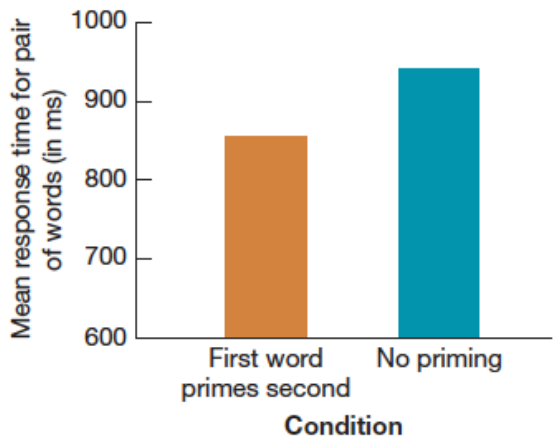
FIGURE 7.5 ACTIVATION OF A NODE FROM TWO SOURCES



Semantic Priming

- Lexical decision-making
- Pair of words
- CAKE SHOE
- BREAD BUTTER

FIGURE 7.6 SEMANTIC PRIMING



Participants were given a lexical-decision task involving pairs of words. In some pairs, the words were semantically related (and so the first word in the pair primed the second); in other pairs, the words were unrelated (and so there was no priming). Responses to the second word were reliably faster if the word had been primed—providing clear evidence of the importance of subthreshold activation.

(AFTER MEYER & SCHVANEVELDT, 1971)

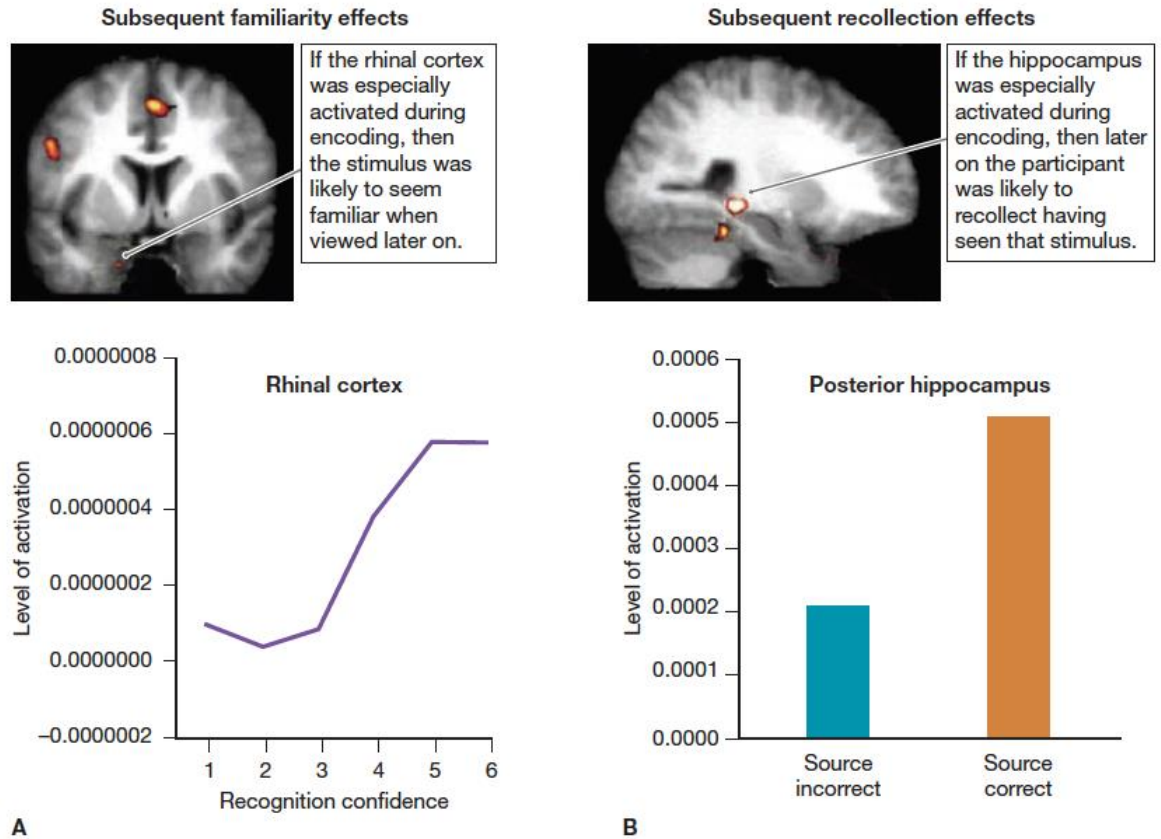
Recognition Memory

- Thought to rely on a memory strength signal
- Signal Detection Theory applies
- Can have familiarity without source memory (Remember/Know judgments)

Can you have source memory without a familiarity signal?!

- Capgras syndrome
- Detailed recollection of when you met your family last, what they look like, etc.
- When they are around however and in view, they feel strangely unfamiliar..

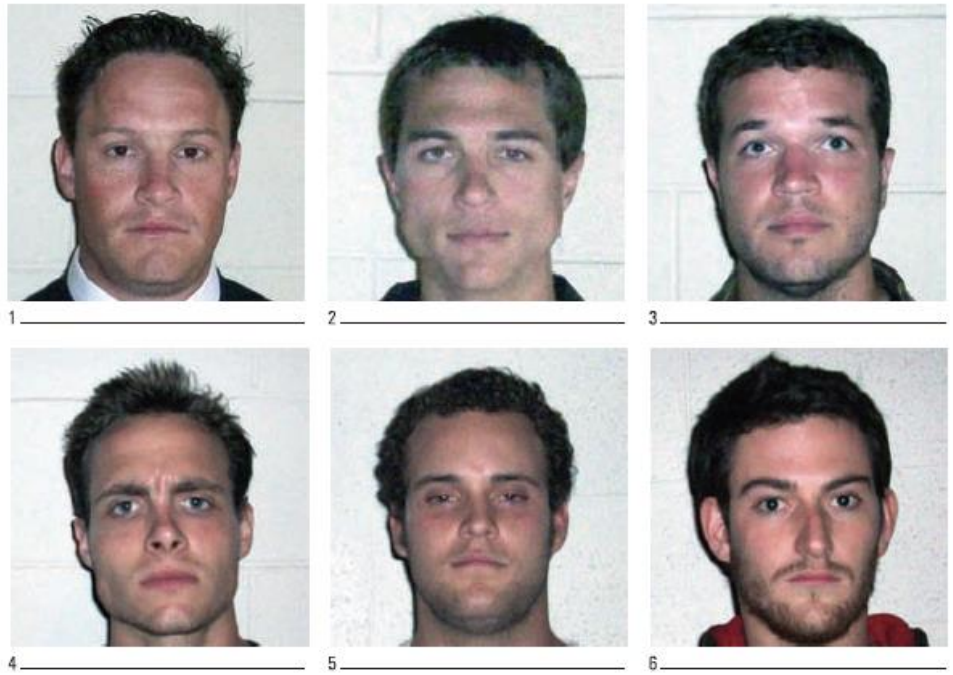
FIGURE 7.7 FAMILIARITY VERSUS SOURCE MEMORY



Familiarity vs source memory

FIGURE 7.8 A PHOTO LINEUP

Middletown Police Department Lineup ID: 24601 20 Mar 2009



1 2 3

4 5 6

FOR OFFICIAL USE ONLY

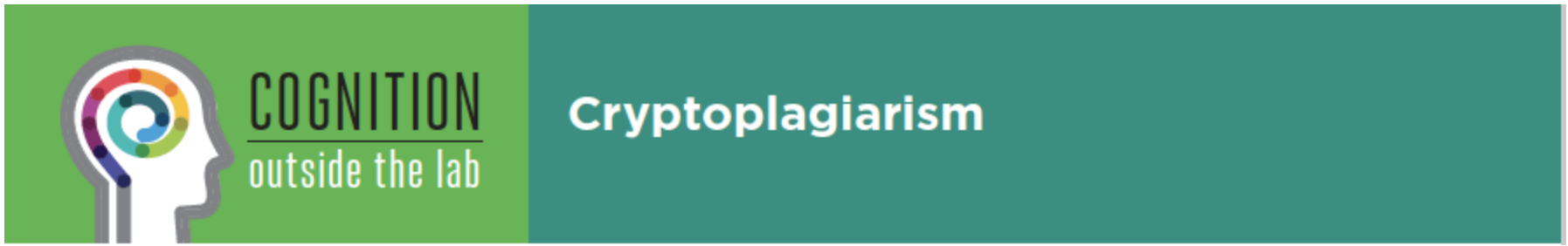
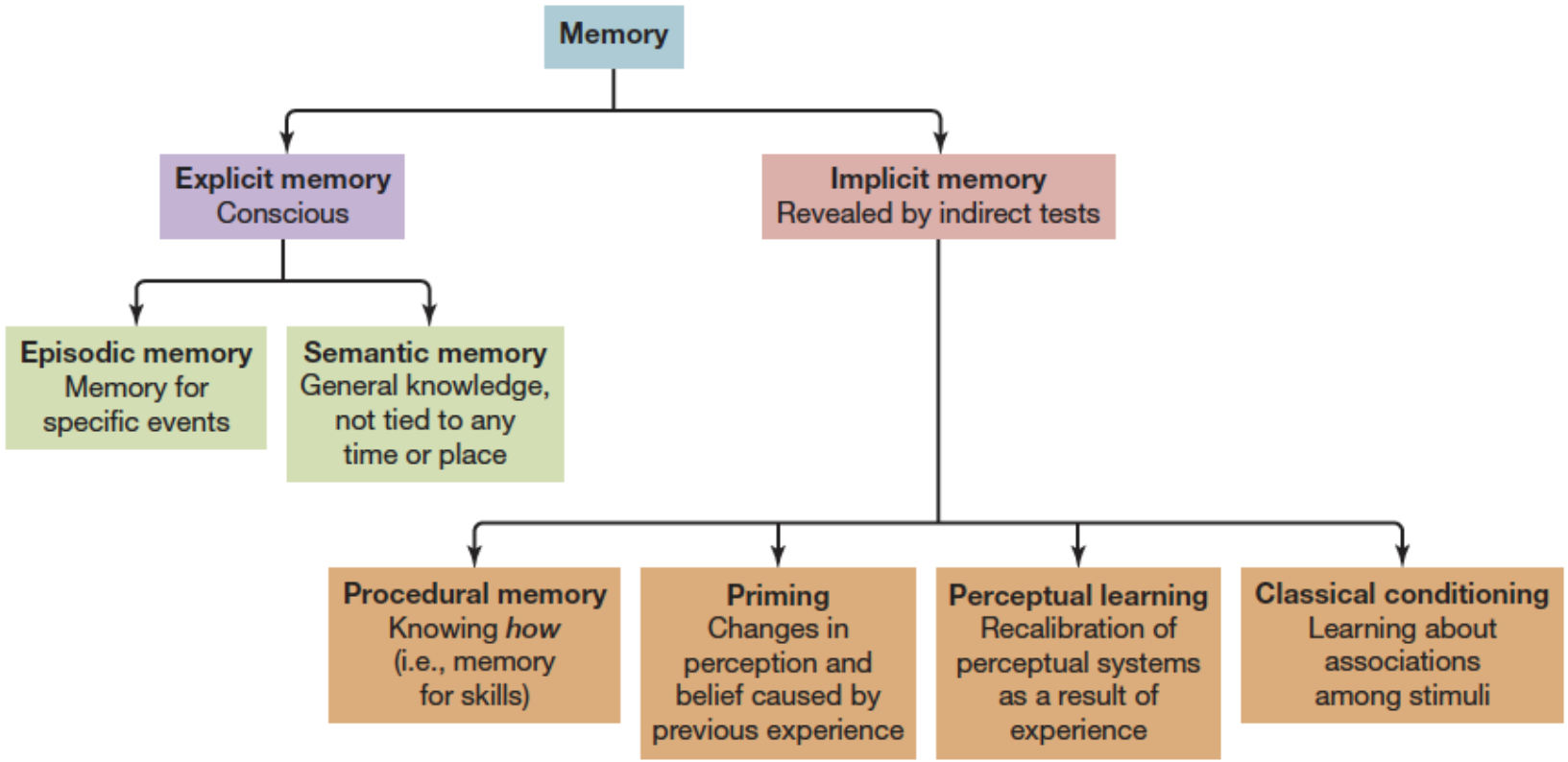

COGNITION
outside the lab
Cryptoplagiarism

FIGURE 7.11 HIERARCHY OF MEMORY TYPES



In our discussion, we've distinguished two types of memory—explicit and implicit. However, there are reasons to believe that each of these categories must be subdivided further, as shown here. Evidence for these subdivisions includes functional evidence (the various types of memory follow different rules) and biological evidence (the types depend on different aspects of brain functioning).

FIGURE 7.13 SEMANTIC MEMORY WITHOUT EPISODIC MEMORY

Kent Cochrane—known for years as "Patient K.C."—died in 2014. In 1981, at age 30, he skidded off the road on his motorcycle and suffered substantial brain damage. The damage caused severe disruption of Cochrane's episodic memory, but it left his semantic memory intact. As a result, he could still report on the events of his life, but these reports were entirely devoid of autobiographical quality. In other words, he could remember the bare facts of, say, what happened at his brother's wedding, but the memory was totally impersonal, with no recall of context or emotion. He also knew that during his childhood his family had fled their home because a train had derailed nearby, spilling toxic chemicals. But, again, he simply knew this as factual material—the sort of information you might pick up from a reference book—and he had no recall of his own experiences during the event.

Hypnosis? Repressed memories?

A Drawings done by hypnotized adult told that he was 6 years old

B Drawings done at age 6

Why do we make memory errors?

FIGURE 8.1 THE OFFICE USED IN THE BREWER AND TREYENS STUDY

No books were in view in this office, but many participants, biased by their expectations of what should be in an academic office, remembered seeing books.

(AFTER BREWER & TREYENS, 1981)

Memory and more

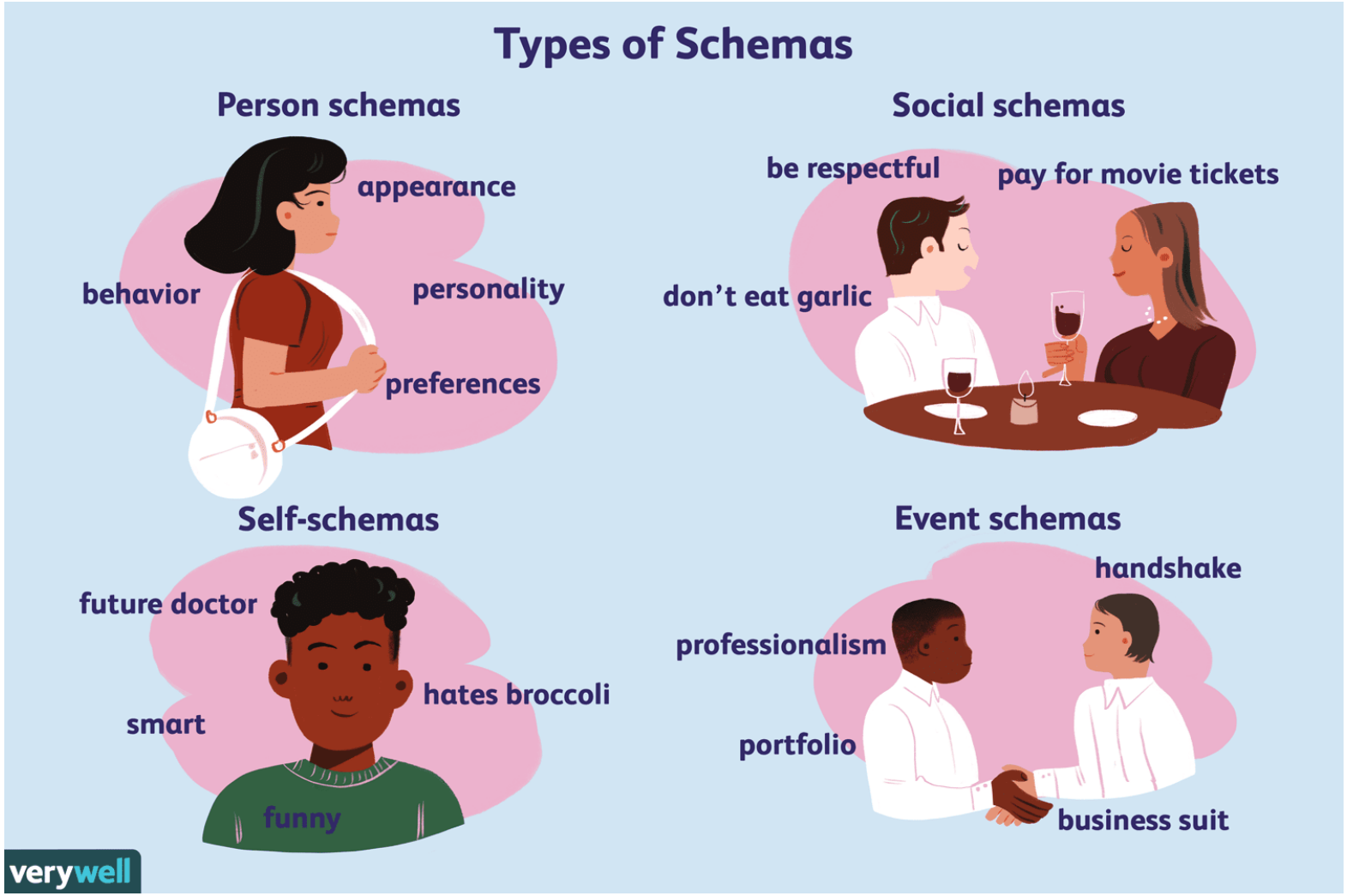
31st March 2022

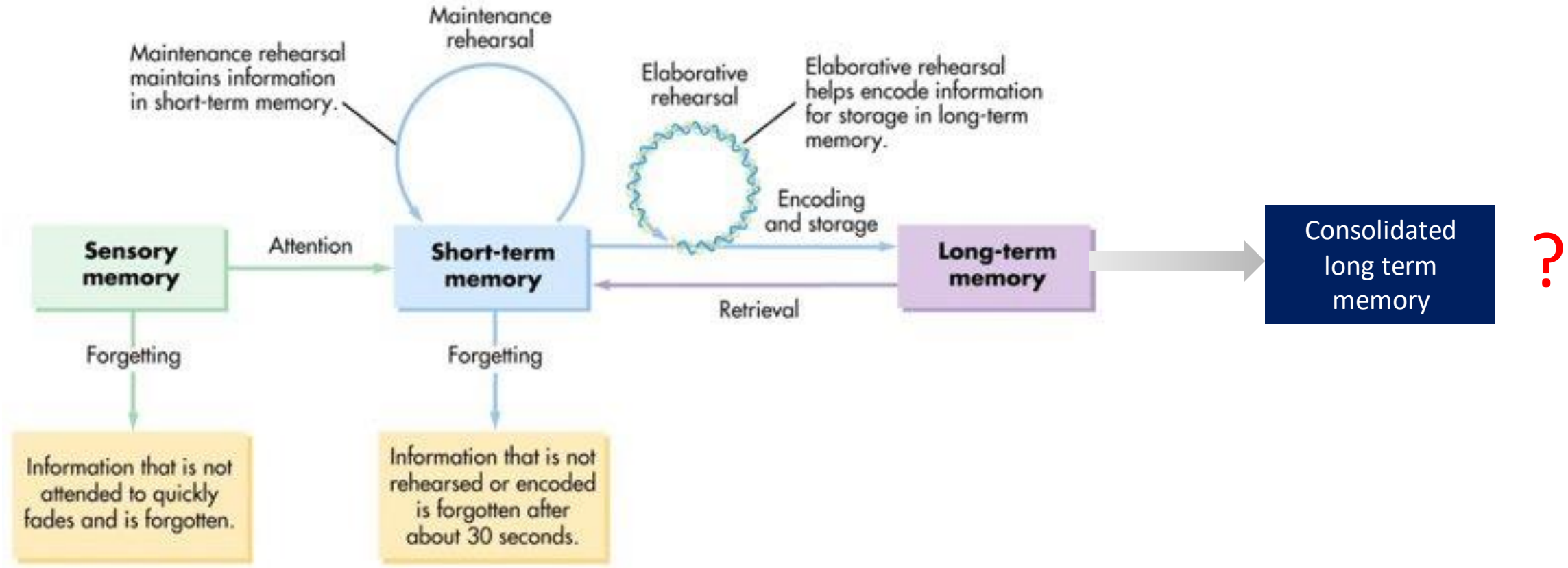
Bhaktee Dongaonkar

What do you typically do when you go to a restaurant?

Schemas

A schema is a cognitive structure that serves as a framework for one's knowledge about people, places, objects, and events.



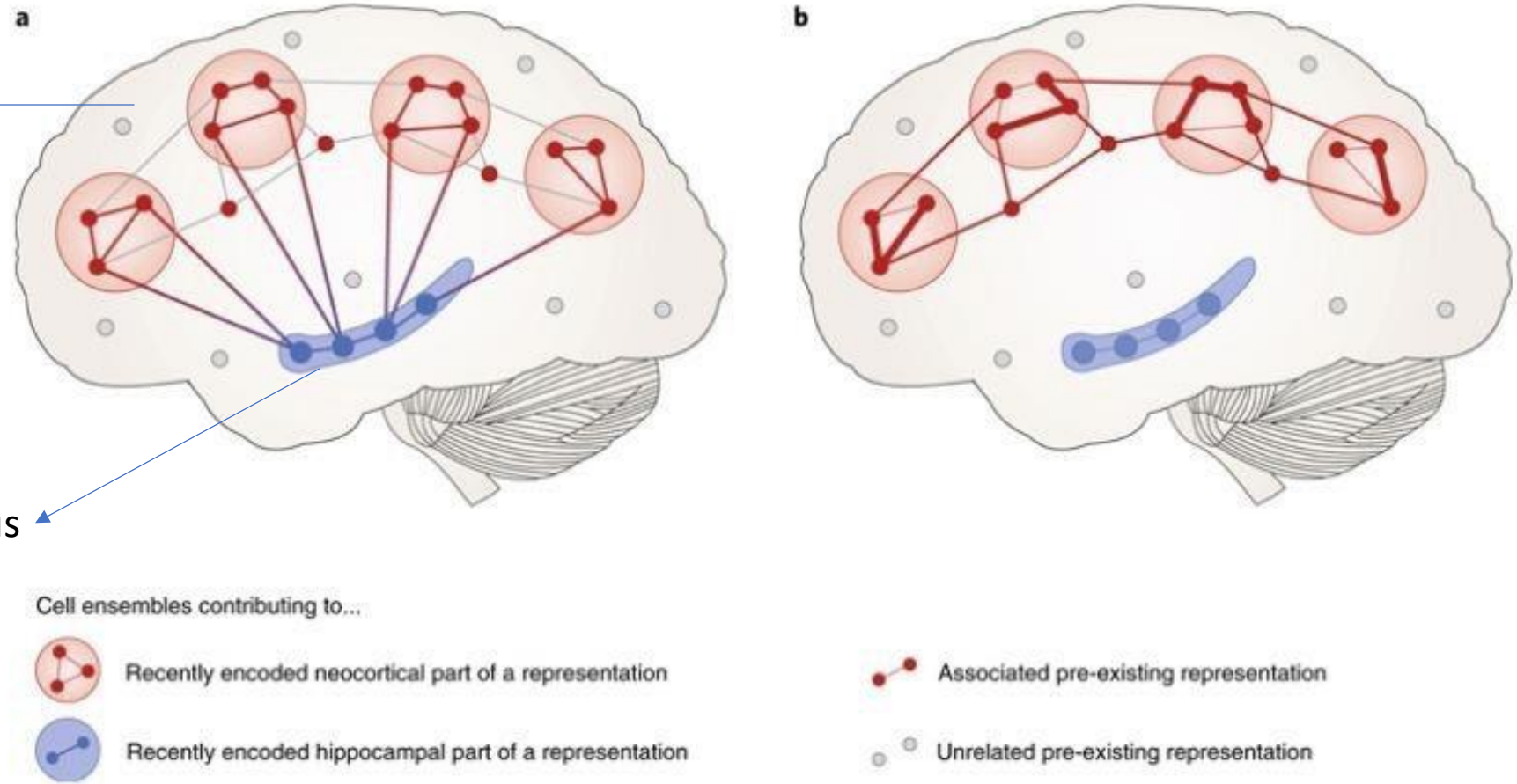


verb
1.make (something) physically stronger or more solid.
"the first phase of the project is to consolidate the outside walls"

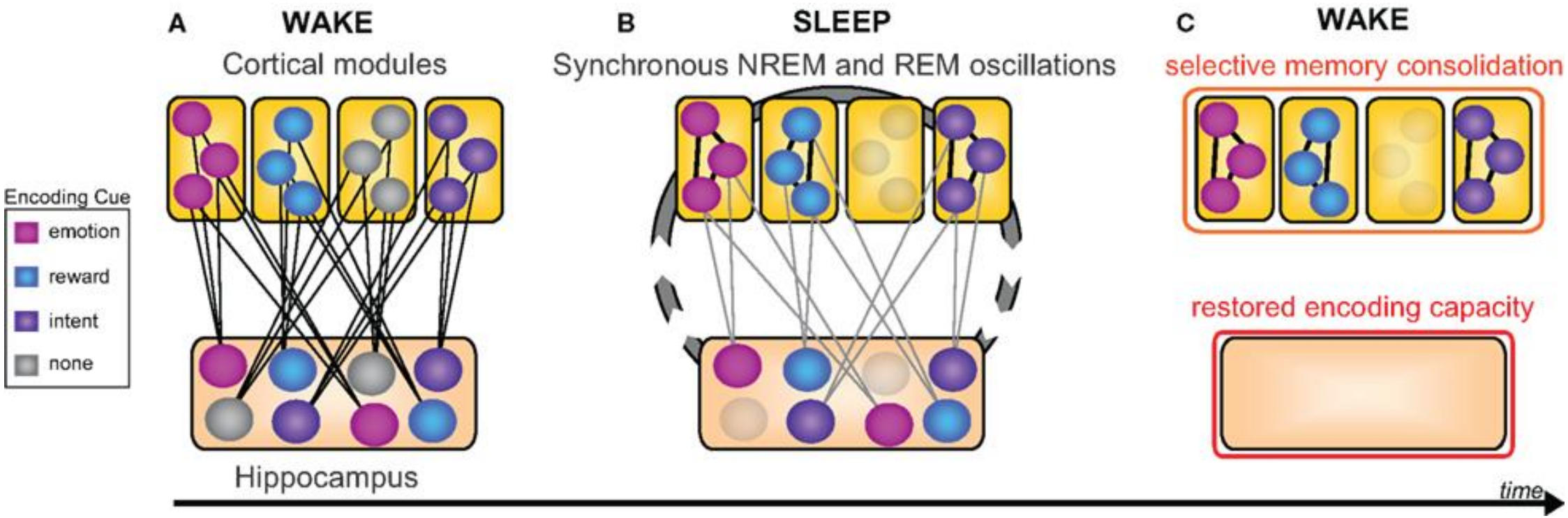
2. combine (a number of things) into a single more effective or coherent whole.
"all manufacturing activities have been consolidated in new premises"

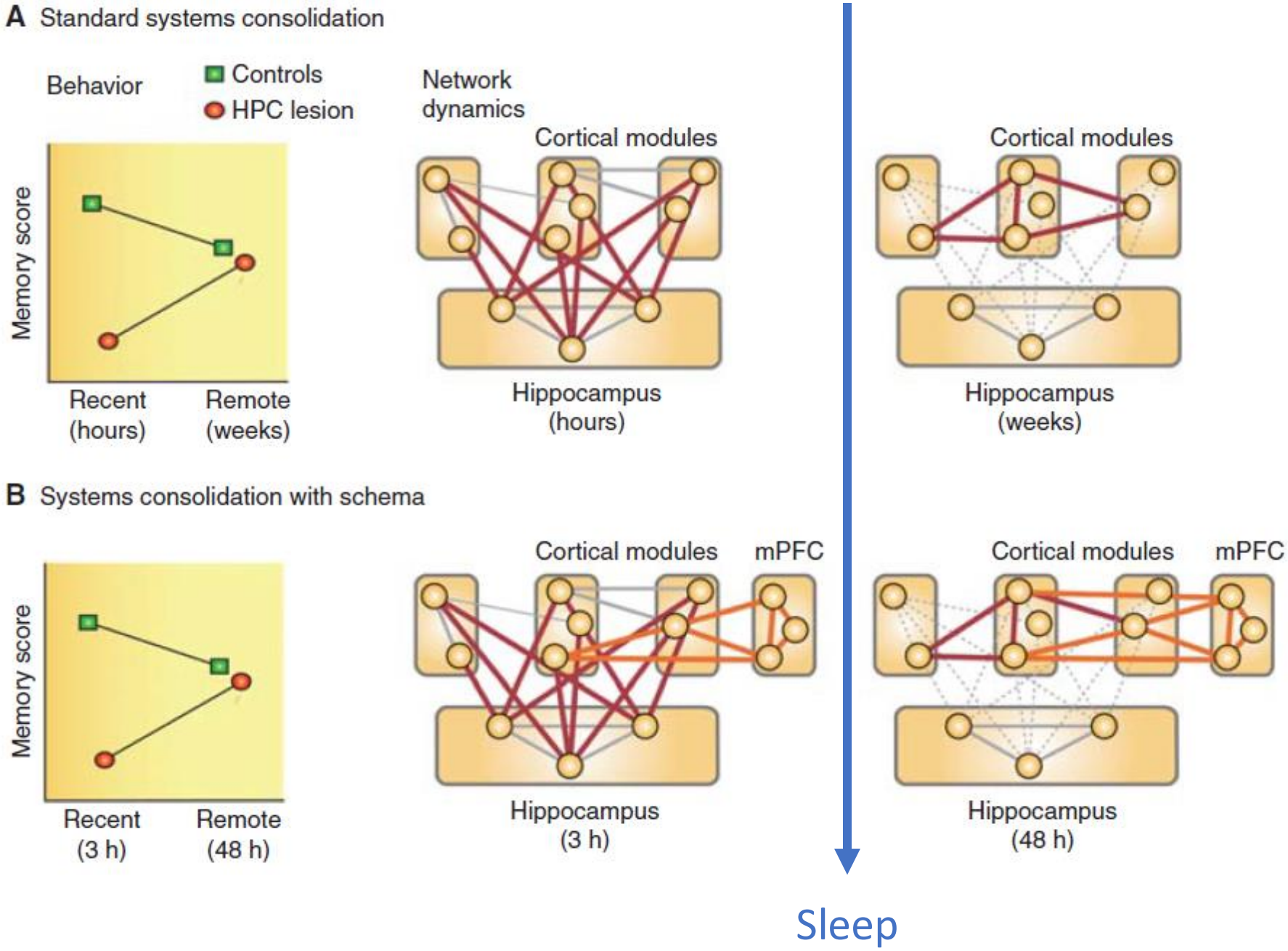
neocortex

hippocampus

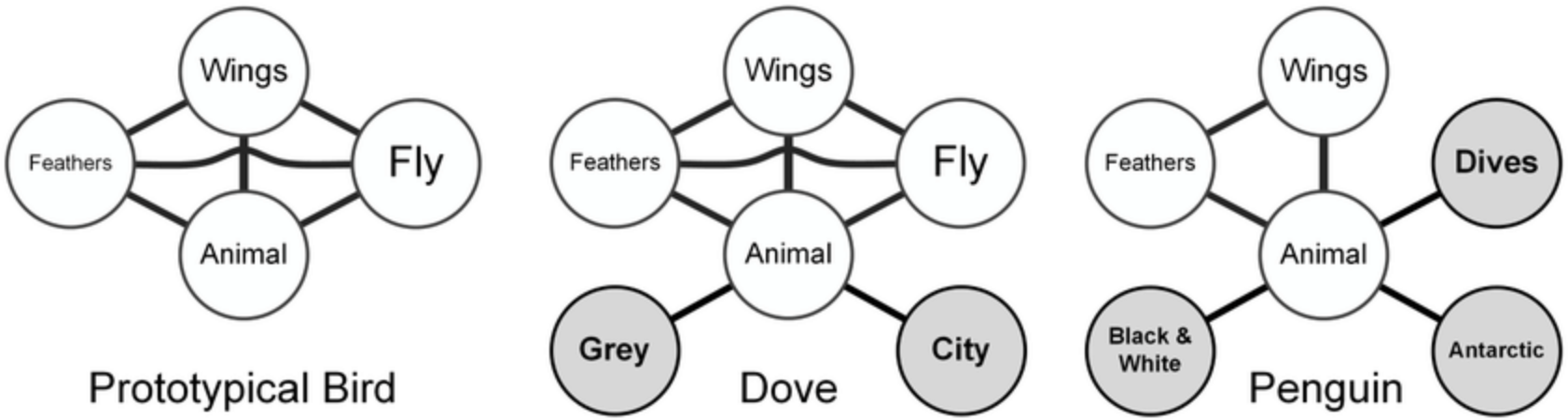


nature neuroscience

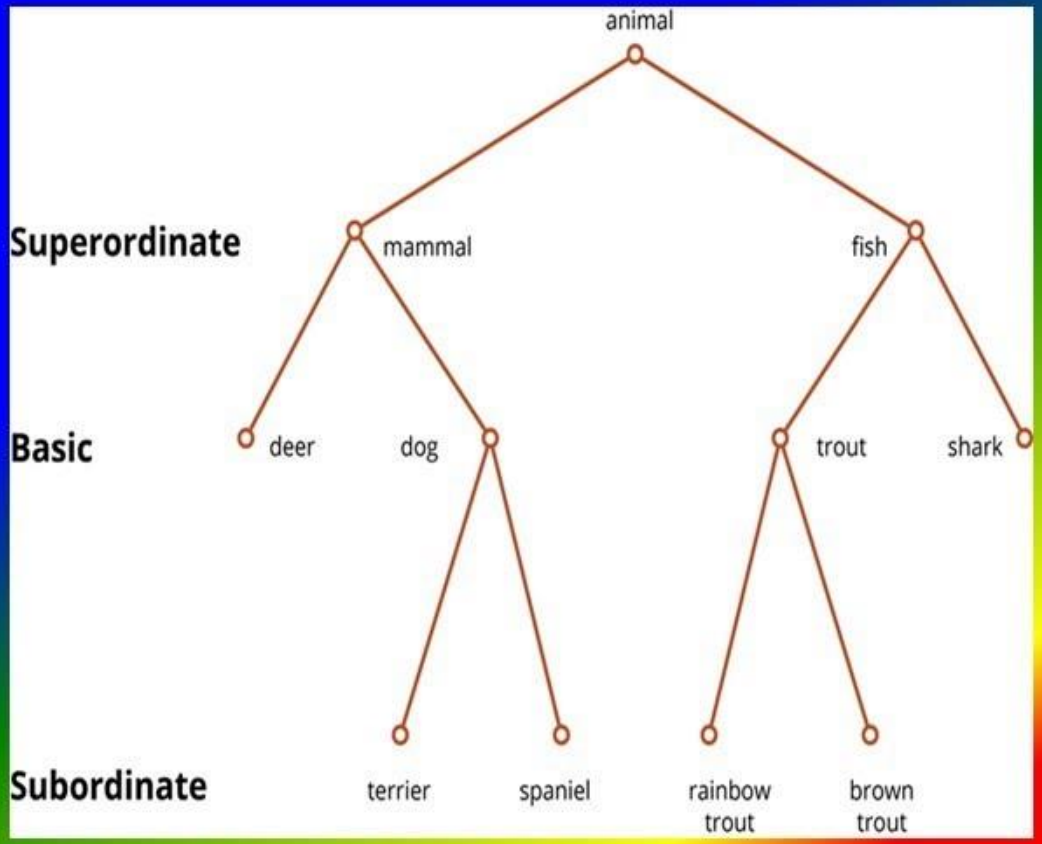

A
WAKE
Cortical modules
B
SLEEP
Synchronous NREM and REM oscillations
C
WAKE
selective memory consolidation
restored encoding capacity
Encoding Cue
emotion
reward
intent
none
Hippocampus
time

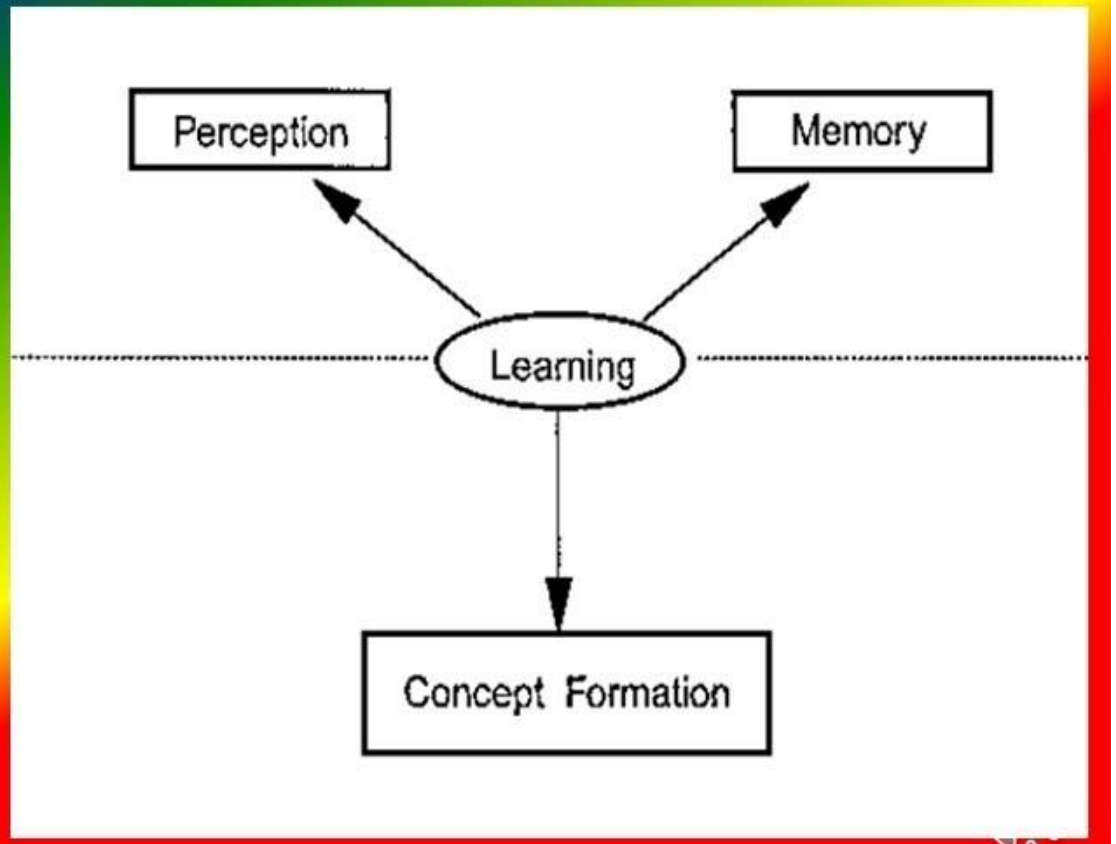

A Standard systems consolidation
Behavior
Controls
HPC lesion
Memory score
Recent
(hours)
Remote
(weeks)
Network
dynamics
Cortical modules
Hippocampus
(hours)
Cortical modules
Hippocampus
(weeks)
B Systems consolidation with schema
Memory score
Recent
(3 h)
Remote
(48 h)
Cortical modules
mPFC
Hippocampus
(3 h)
Cortical modules
mPFC
Hippocampus
(48 h)
Sleep

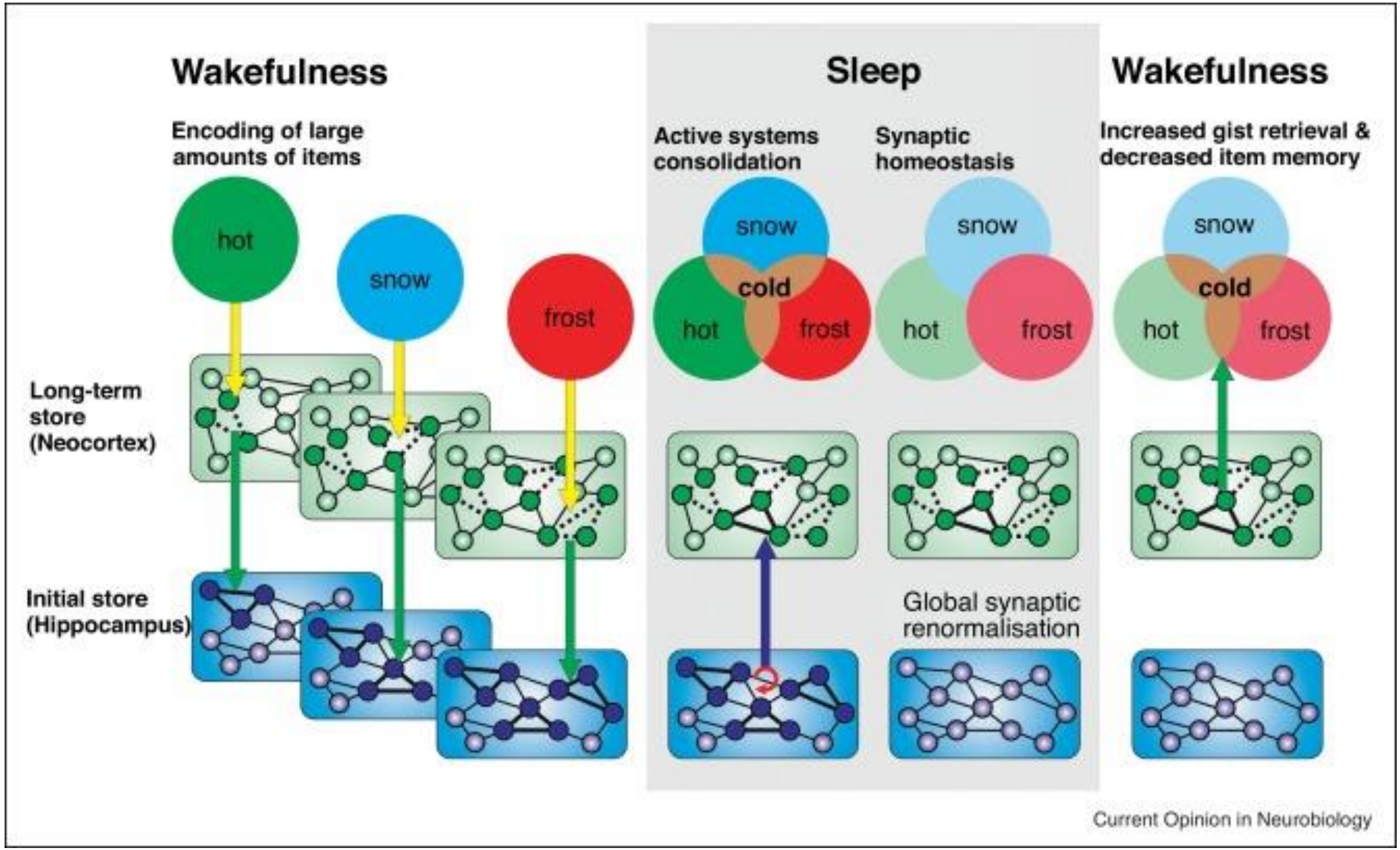
Concept of a Bird

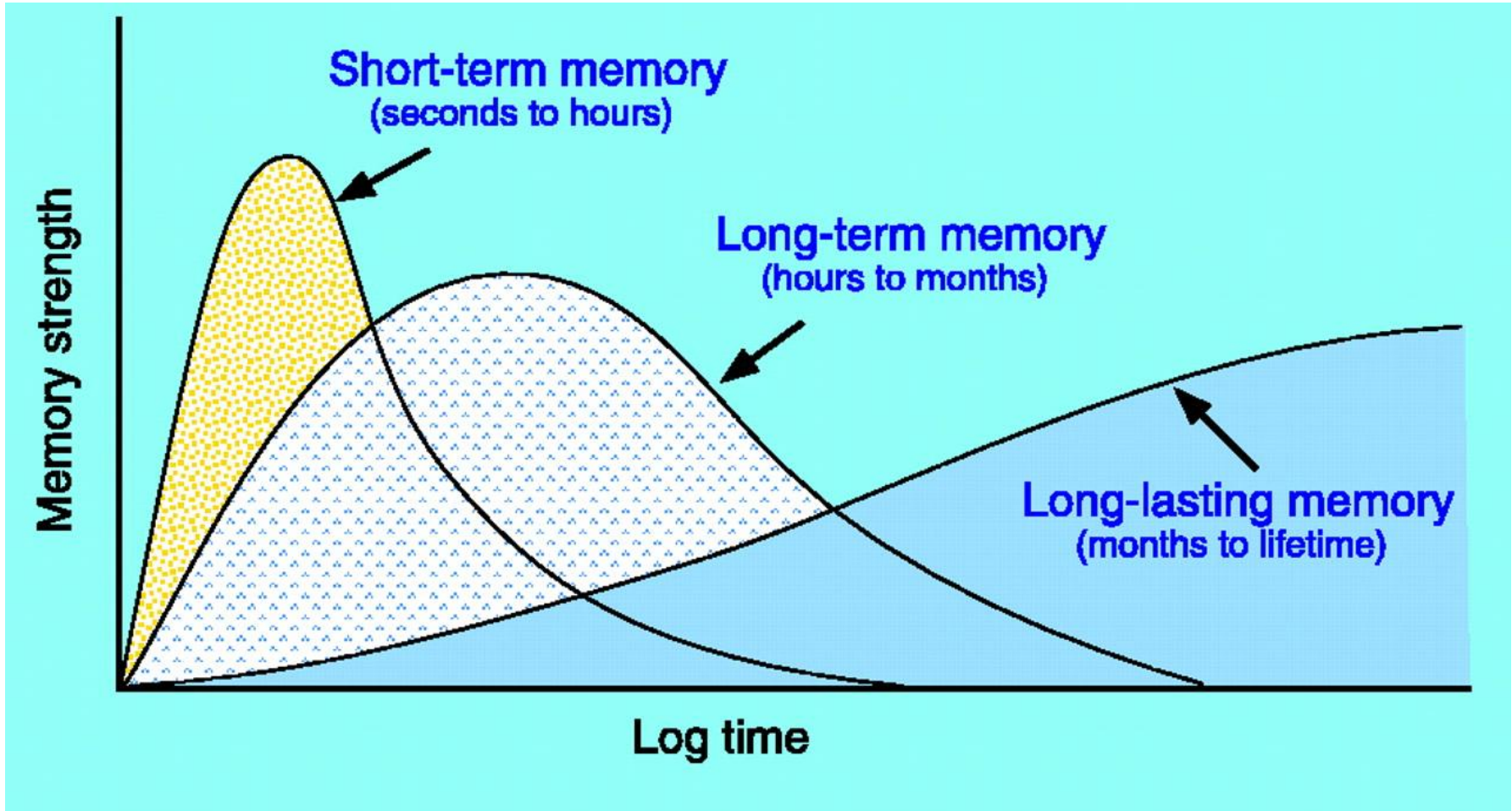


CONCEPT FORMATION

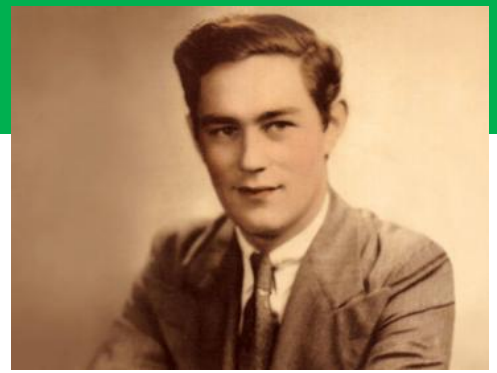


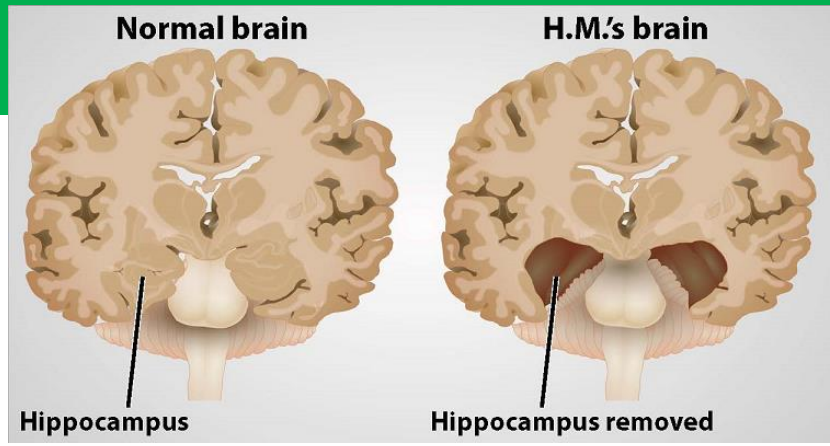



Wakefulness
Sleep
Wakefulness
Encoding of large amounts of items
Active systems consolidation
Synaptic homeostasis
Increased gist retrieval & decreased item memory
hot
snow
frost
cold
Long-term store (Neocortex)
Initial store (Hippocampus)
Global synaptic renormalisation
Current Opinion in Neurobiology


Short-term memory
(seconds to hours)
Long-term memory
(hours to months)
Long-lasting memory
(months to lifetime)
Memory strength
Log time

Patient HM





- Henry Molaison (1926-2008)
- At age 7, HM was knocked down by a bicycle
- Accident resulted in seizures, could not lead a normal life
- At 27, HM's bilateral medial temporal lobes removed to control his seizures.
- After surgery, HM could remember his name, family, and childhood.
- But he could not remember his day- to- day activities, not even his doctor, Dr. Scoville, who visited HM daily.

Patient HM

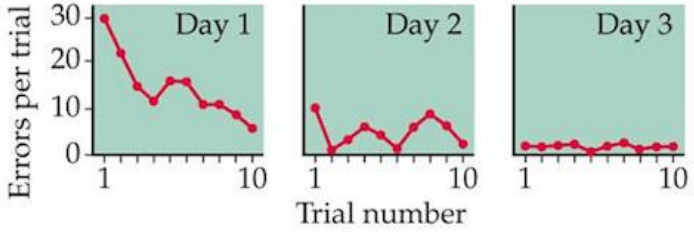
Dr. Brenda Milner
Clinical Neuropsychologist
McGill University
Montreal, Canada

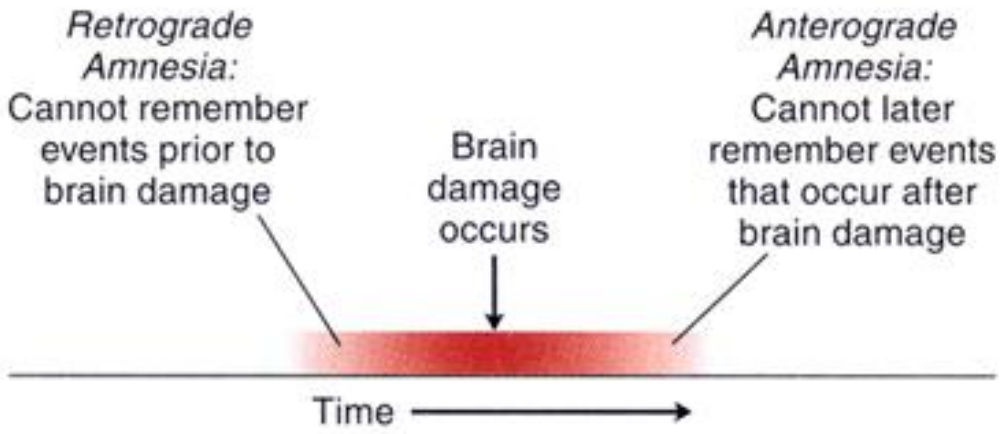
- IQ was intact.
- Could remember facts, schemas, and general knowledge.
- Could learn motor skills (like tracing a star by looking at its mirror reflection) over many practice trials, but was never conscious of these learning sessions.
- Short term memory was intact

- NO LONG TERM MEMORY

(a) The mirror-tracing task

(b) Performance of H.M. on mirror-tracing task

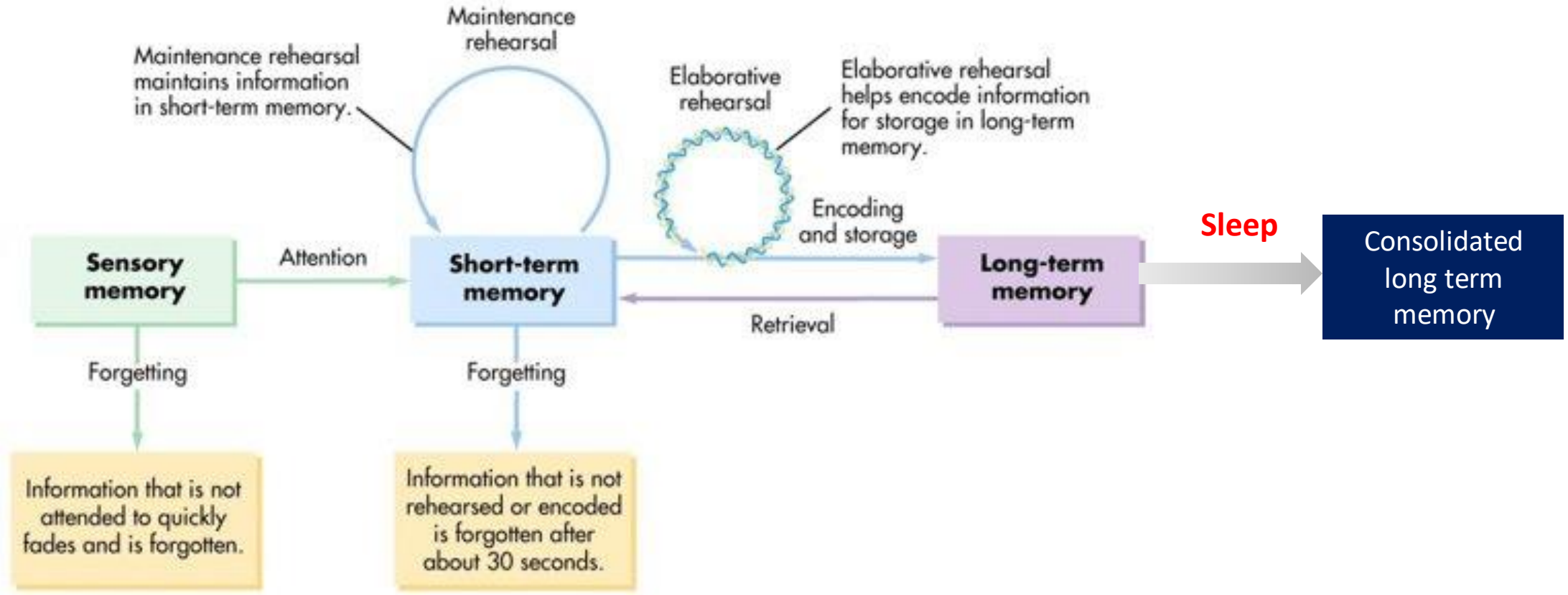




Retrograde amnesia - difficult to remember events from the past few years leading up to his surgery

Antero-grade amnesia – HM could not form new memories

He lived only in the present.


Maintenance rehearsal
Maintenance rehearsal maintains information in short-term memory.
Elaborative rehearsal
Elaborative rehearsal helps encode information for storage in long-term memory.
Encoding and storage
Sensory memory
Attention
Short-term memory
Long-term memory
Retrieval
Forgetting
Forgetting
Information that is not attended to quickly fades and is forgotten.
Information that is not rehearsed or encoded is forgotten after about 30 seconds.
Sleep
Consolidated long term memory

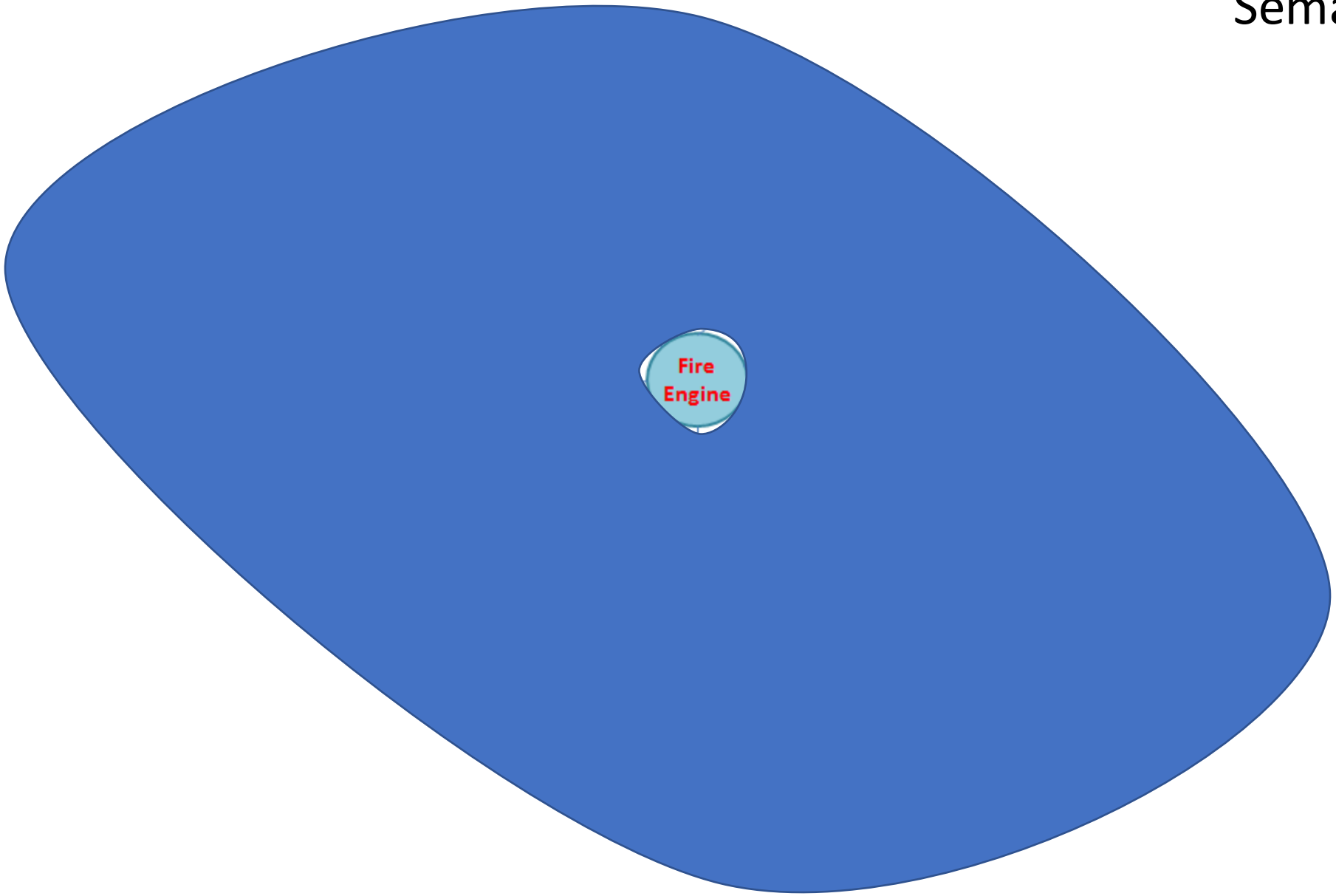
What are memories used for?

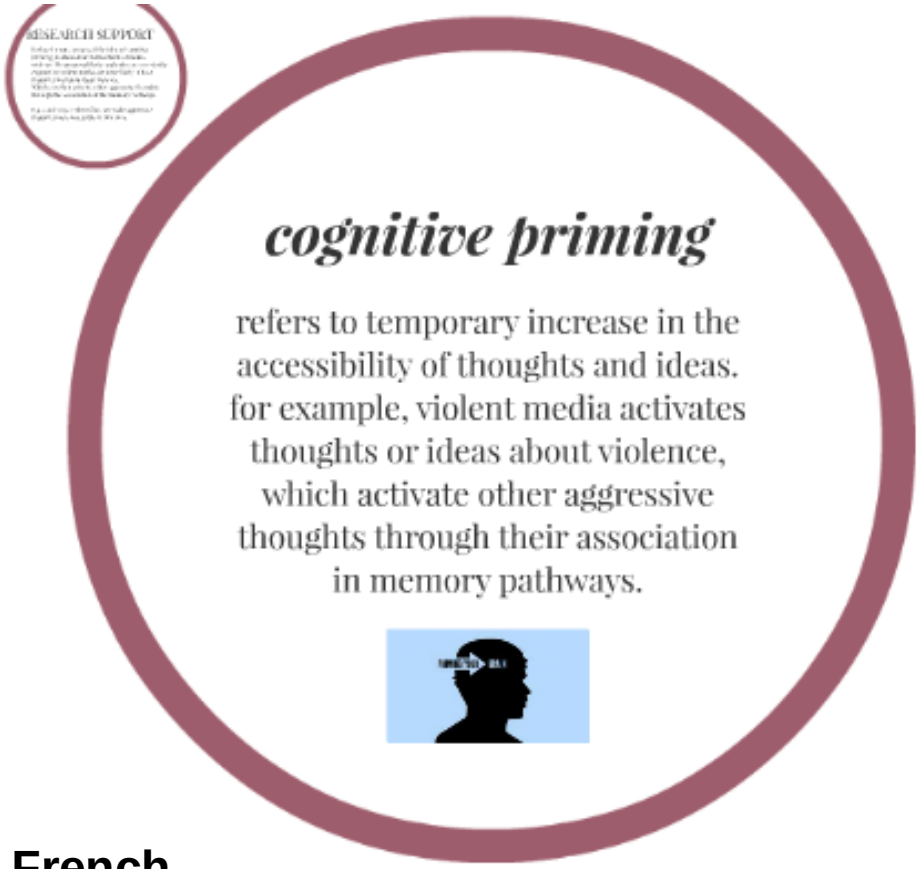
Visual Priming

2

Red
Blue
Orange
Yellow
Gr___

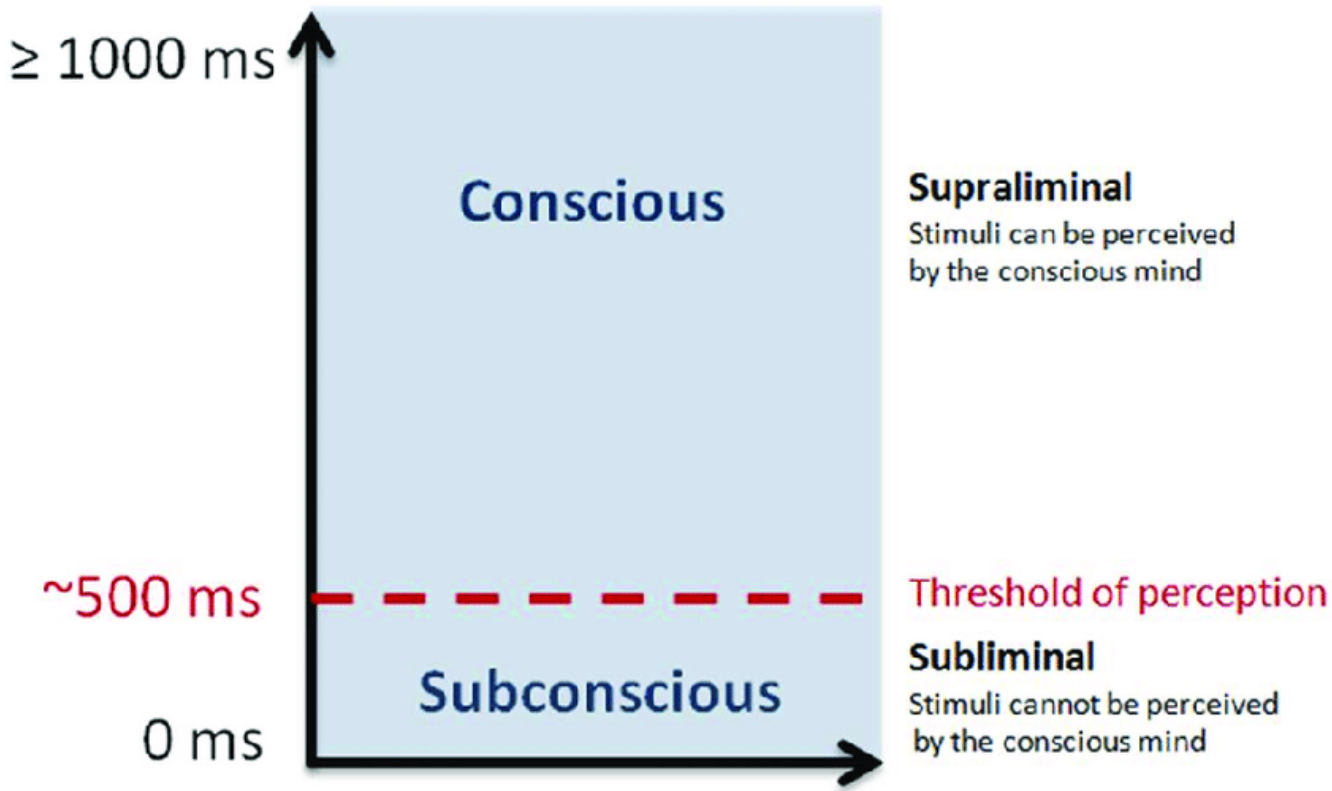
Semantic Priming





You own a restaurant and a ordered too much French wine. A good way to psychologically prime your clients into buying this type of wine is to play French music in the background.

Priming works by using associations made in our subconscious, and are almost always unnoticeable to the subject.


≥ 1000 ms
Conscious
Supraliminal
Stimuli can be perceived
by the conscious mind
~500 ms
Threshold of perception
Subliminal
Subconscious
Stimuli cannot be perceived
by the conscious mind
0 ms

http://karakreative.blogspot.com/2013/02/graphic-designer-of-month-paul-rand.html
http://vimeo.com/putorti

http://tech.fortune.cnn.com/2011/06/27/quoras-designing-woman/
http://topics.nytimes.com/top/reference/timestopics/people/f/shepard_fairey/index.html

Is India a safer place to live in now compared to a decade ago?

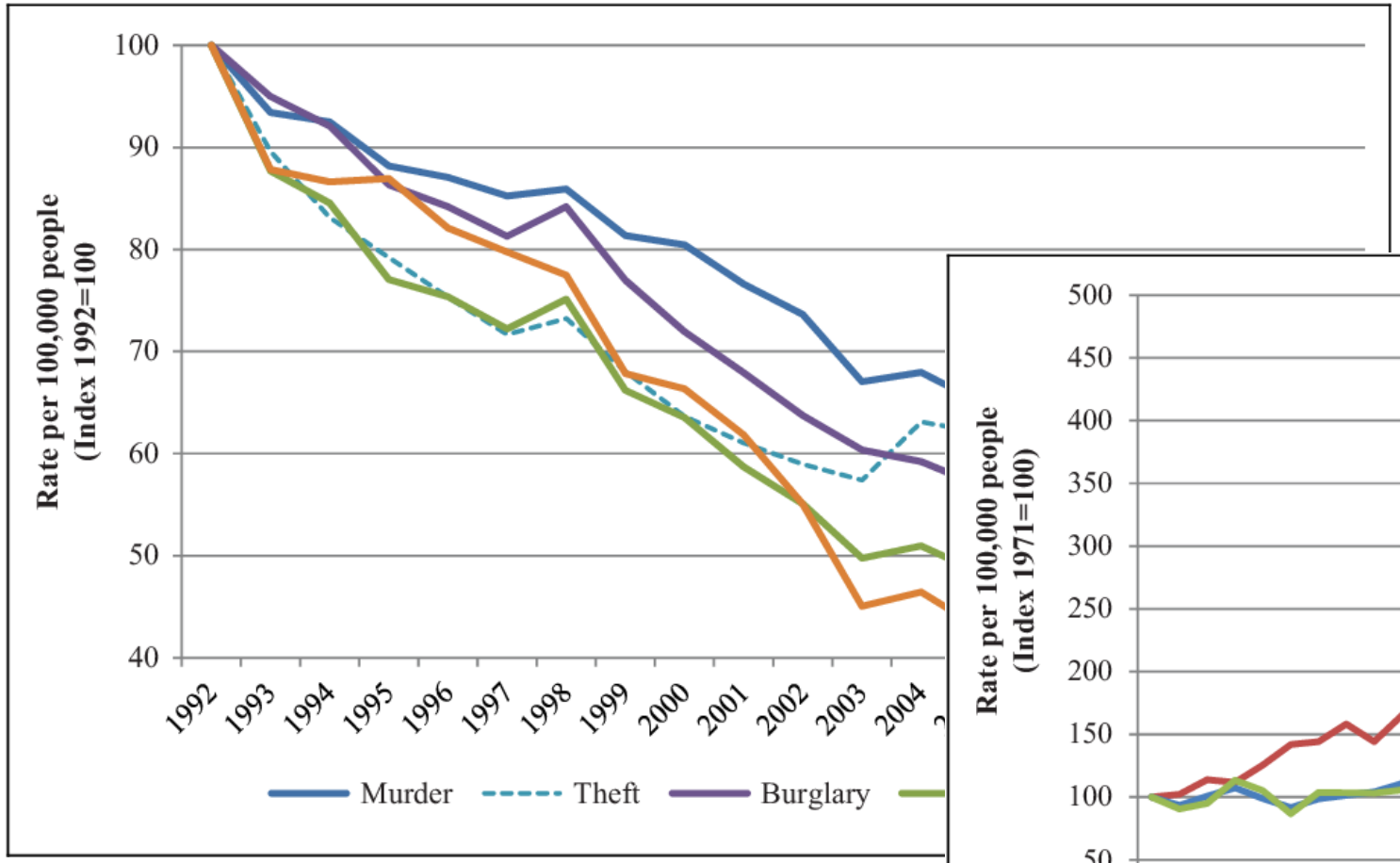
Does the letter *k* occur more often at the beginning of a word or as the third letter?

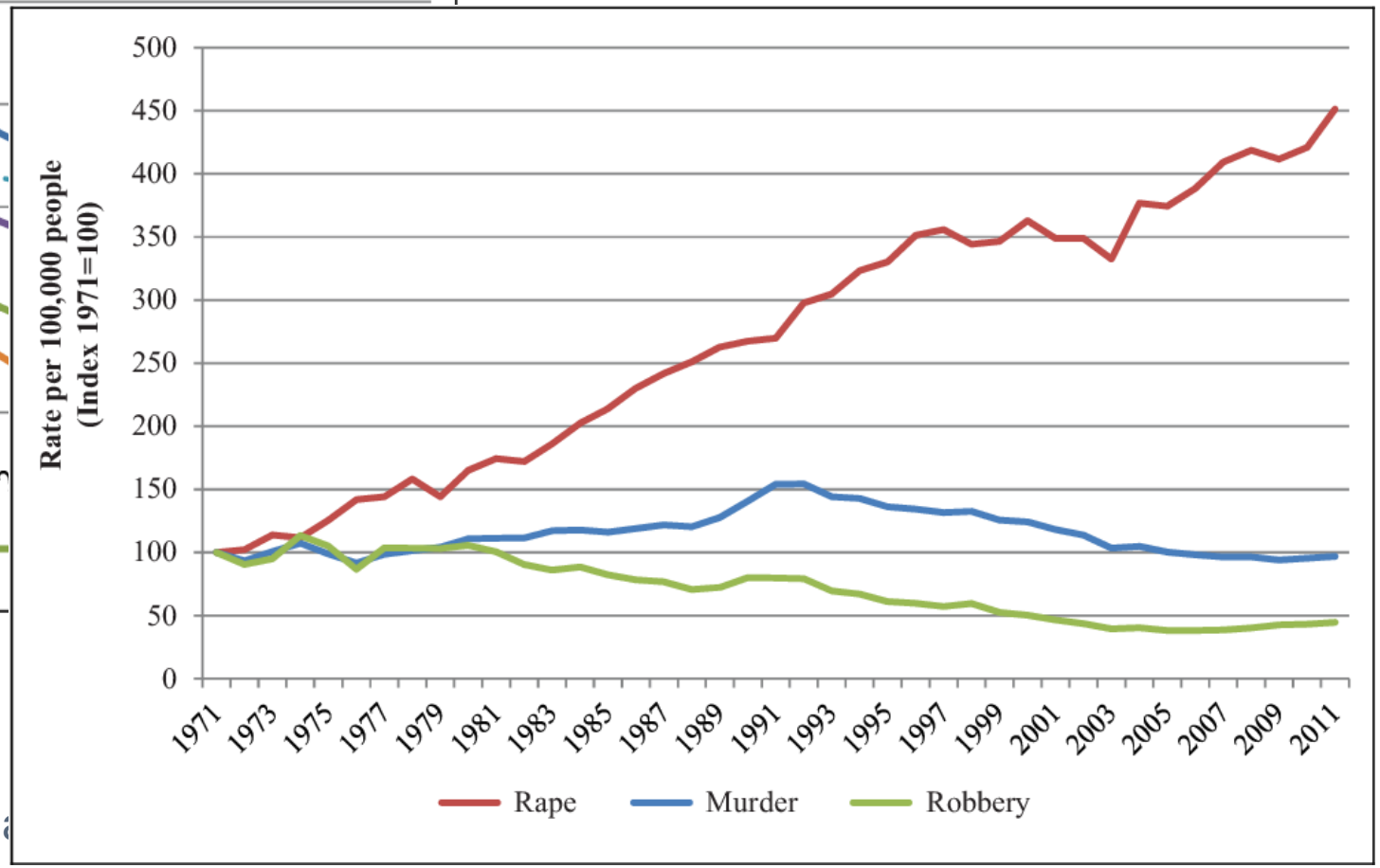
Covid has killed a devastating number of people !

Does the letter *k* occur more often at the beginning of a word or as the third letter?

K in first position	105 (69.1%)
K in third position	47 (30.9%)

Is India a safer place to live in now compared to a decade ago?





Published in 2015

Crime Rates in India S. Ansari, A. Verma, K. Da

1.Frequent is easier to recall than infrequent

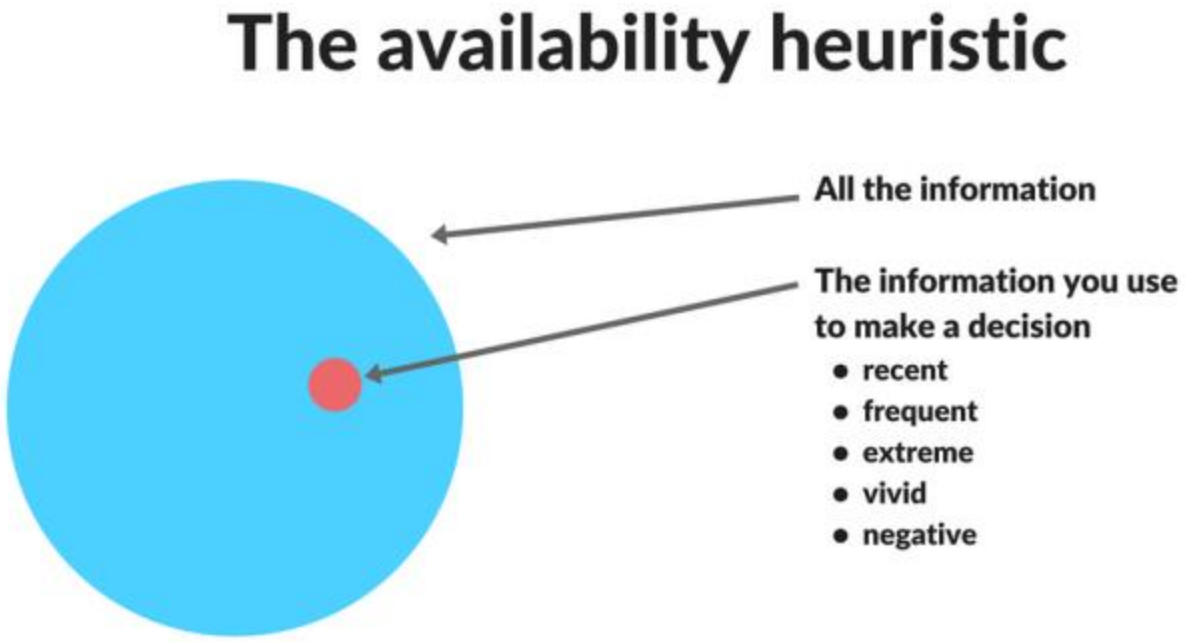
2.Extreme is easier to recall than ordinary

3.Negative is easier to recall than positive

4.Recent is easier to recall than the distant past

5.Vivid is easier to recall than non-vivid

what comes to mind the easiest—what's most available—is true.



Donald J. Trump ✓
@realDonaldTrump

Follow

In the East, it could be the COLDEST New Year's Eve on record. Perhaps we could use a little bit of that good old Global Warming that our Country, but not other countries, was going to pay TRILLIONS OF DOLLARS to protect against. Bundle up!

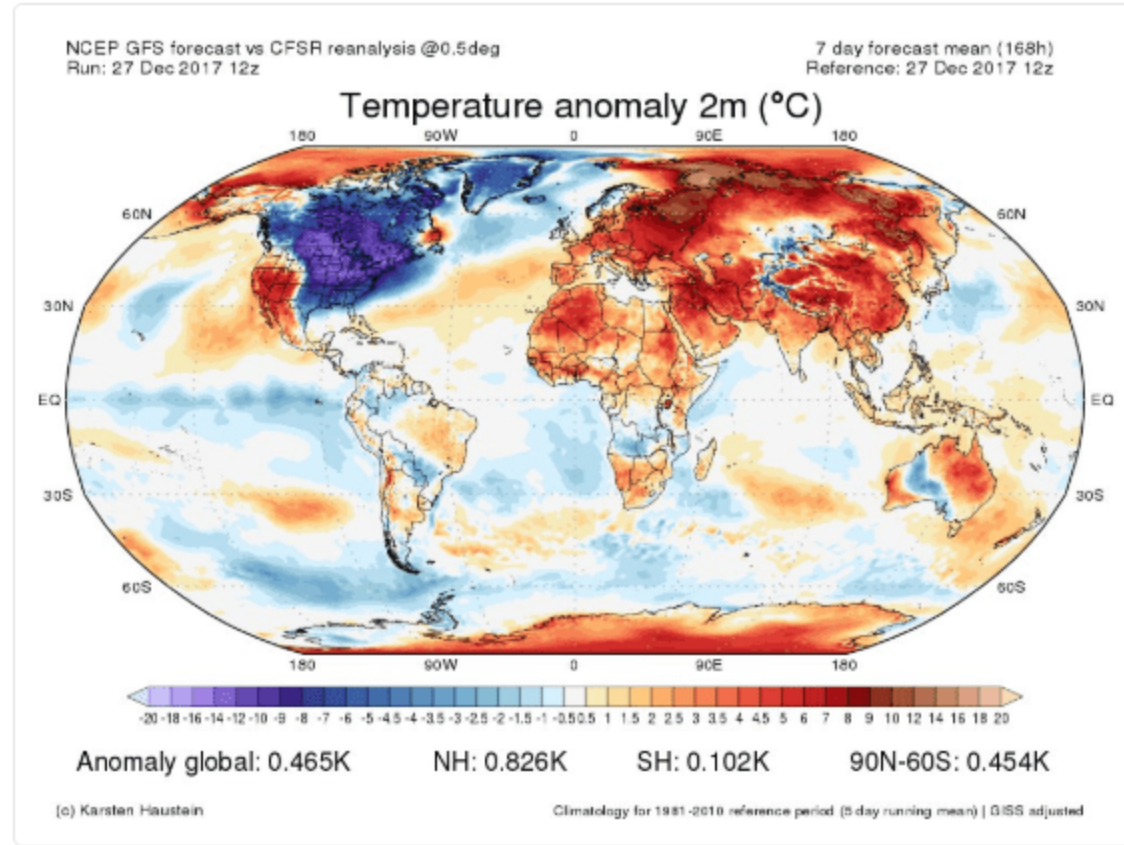
4:01 PM - 28 Dec 2017

Zack Labe ✓
@ZLabe

Follow

The coldest weather (relative to average) will be positioned right over North America through at least the next 7-days...

[Maps: karstenhaustein.com/climate]

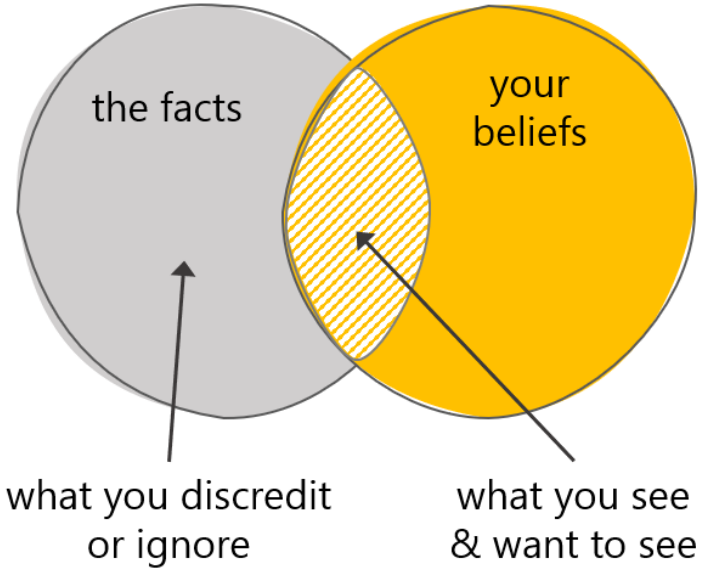


9:15 AM - 27 Dec 2017

A particular university ranks high because it takes high ranking students

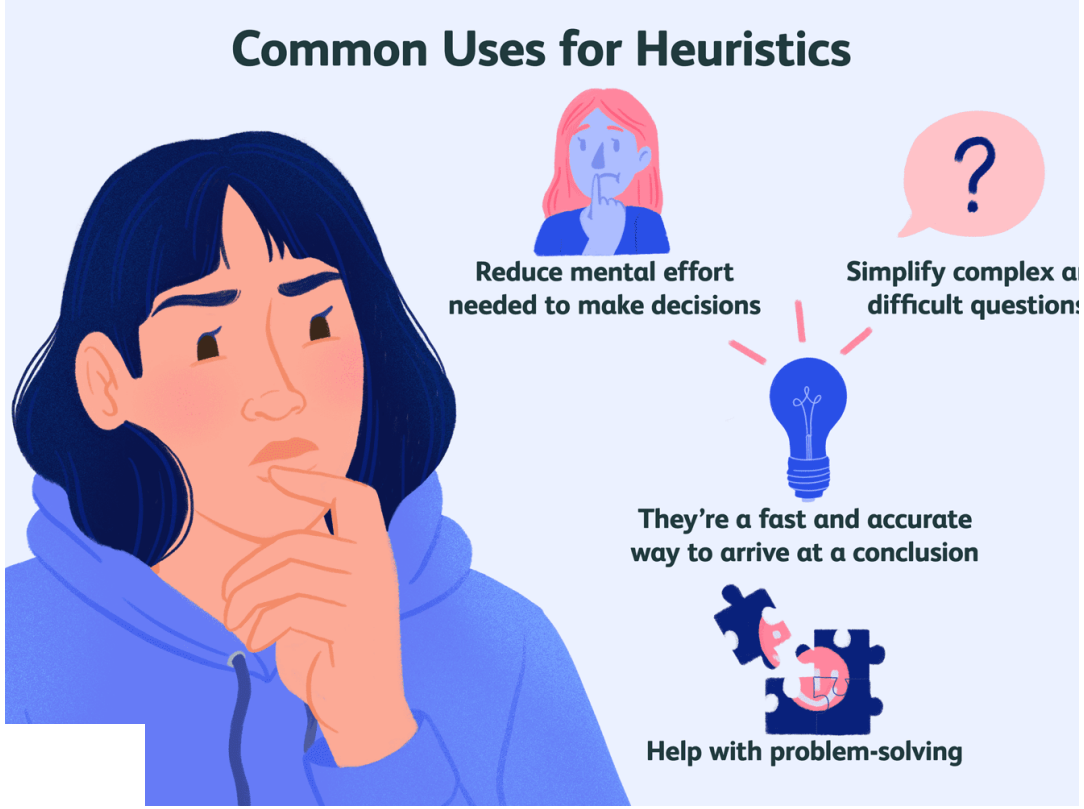
Voters seek info that supports their opinion/beliefs

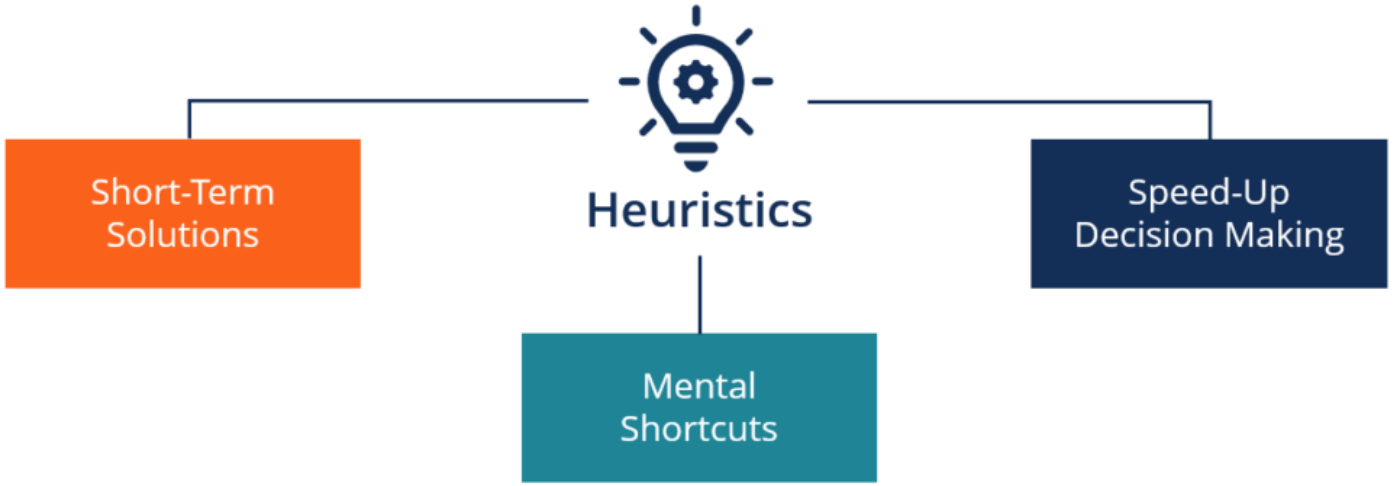
will ignore information from news broadcasters
that contradicts their existing views.

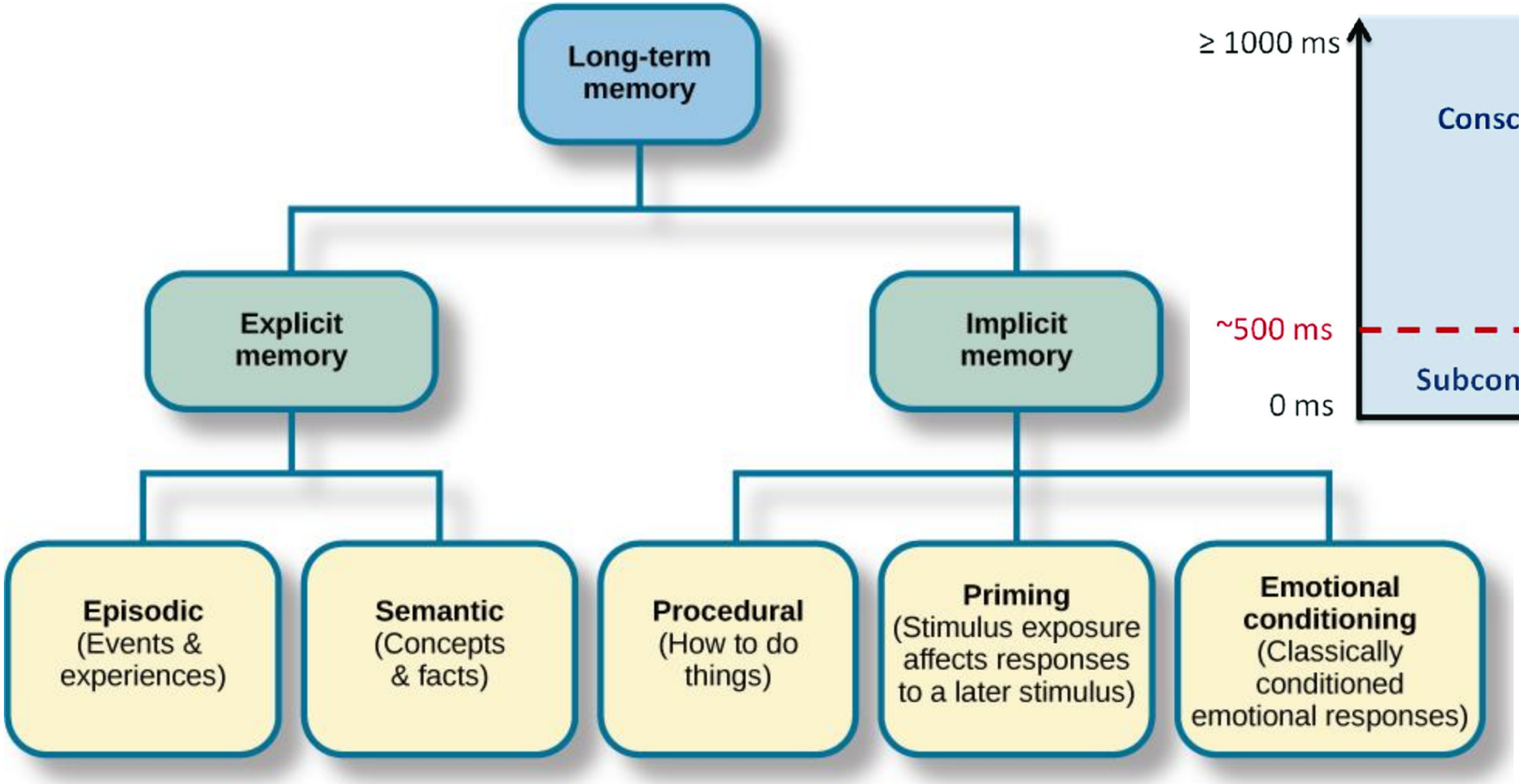


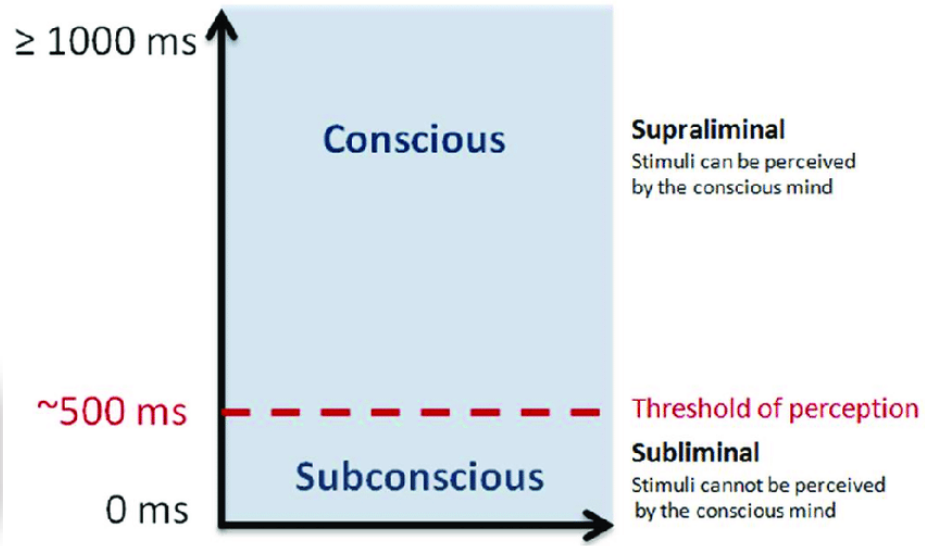
Confirmation bias

Heuristics?


Common Uses for Heuristics
Reduce mental effort needed to make decisions
Simplify complex a difficult question
They're a fast and accurate way to arrive at a conclusion
Help with problem-solving


Short-Term Solutions
Heuristics
Speed-Up Decision Making
Mental Shortcuts

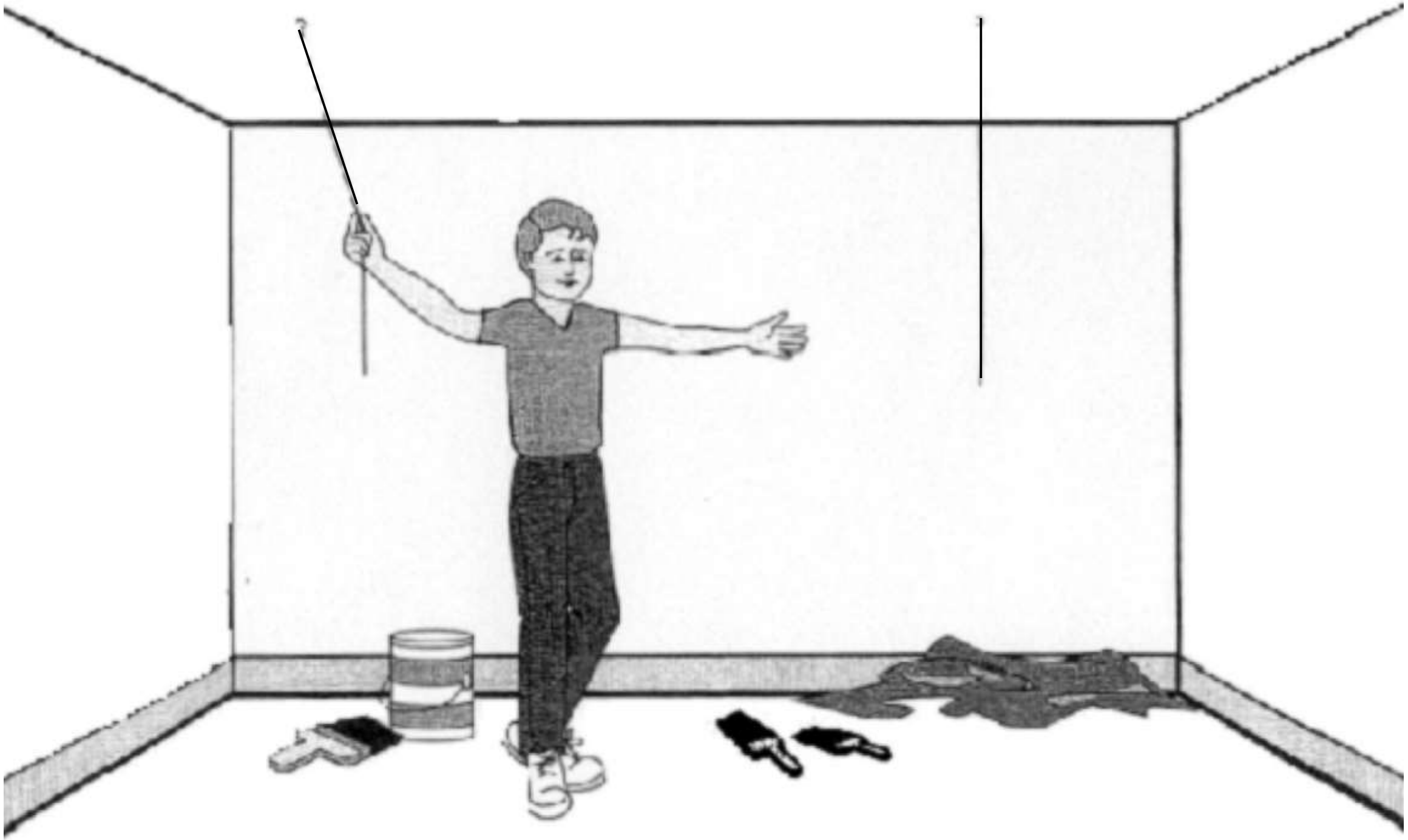

Long-term memory
Explicit memory
Implicit memory
Episodic (Events & experiences)
Semantic (Concepts & facts)
Procedural (How to do things)
Priming (Stimulus exposure affects responses to a later stimulus)
Emotional conditioning (Classically conditioned emotional responses)

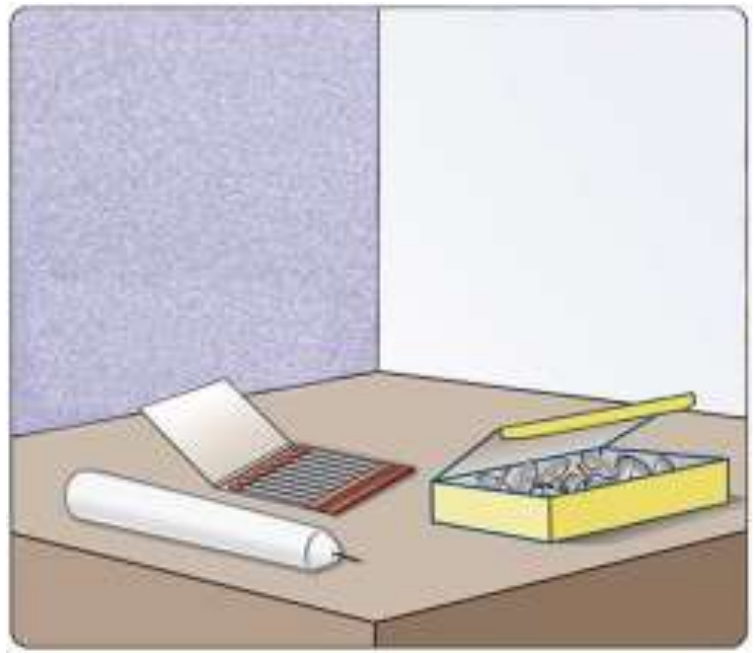

≥ 1000 ms
Conscious
Supraliminal
Stimuli can be perceived by the conscious mind
~500 ms
Threshold of perception
Subliminal
Stimuli cannot be perceived by the conscious mind
Subconscious
0 ms

Memory and more

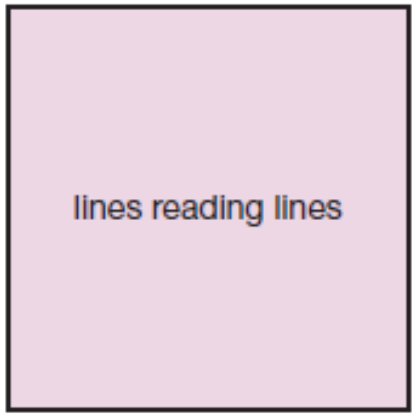
6th April 2022

Bhaktee Dongaonkar





Functional fixedness



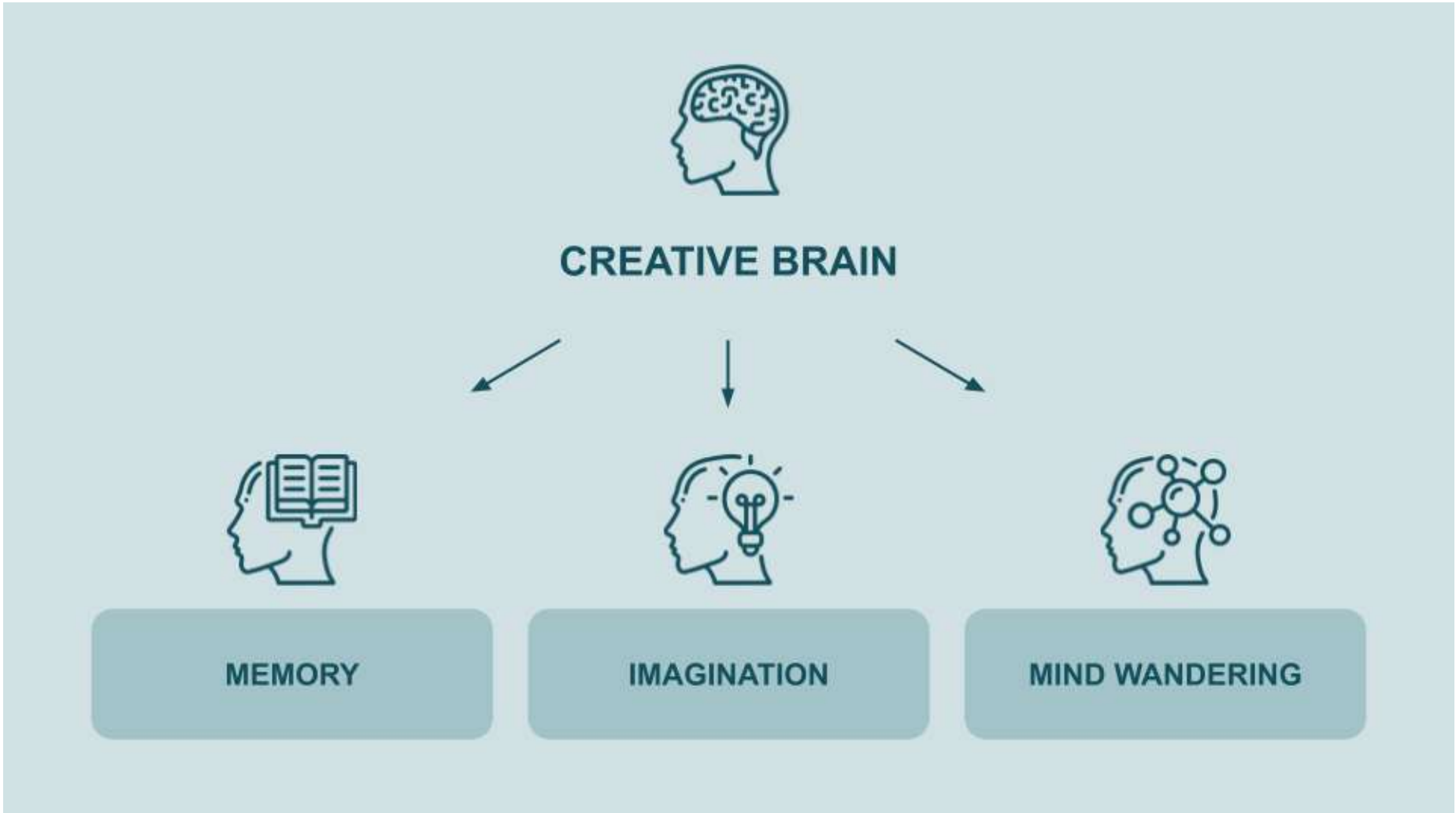
Semantic memory

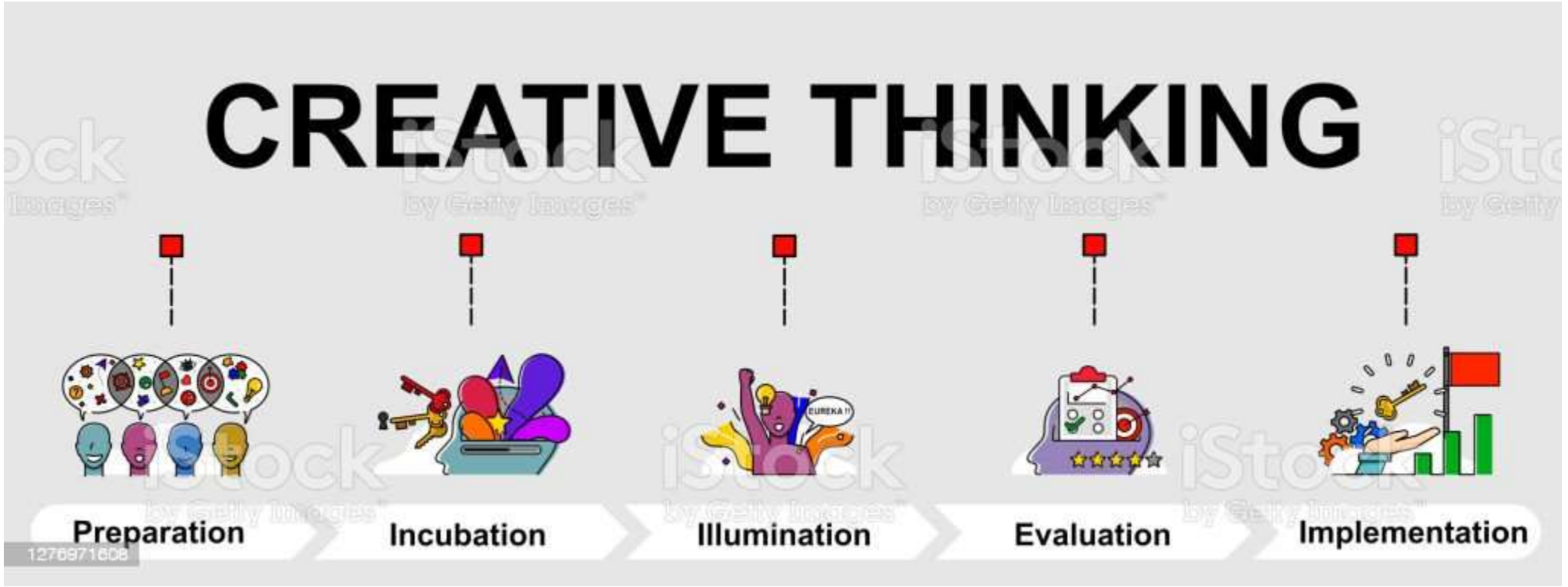
Suppose you are a doctor faced with a patient who has a malignant tumor in his stomach. To operate on the patient is impossible, but unless the tumor is destroyed the patient will die. A kind of ray, at a sufficiently high intensity, can destroy the tumor. Unfortunately, at this intensity the healthy tissue that the rays pass through on the way to the tumor will also be destroyed. At lower intensities the rays are harmless to healthy tissue but will not affect the tumor. How can the rays be used to destroy the tumor without injuring the healthy tissue?

Analogy

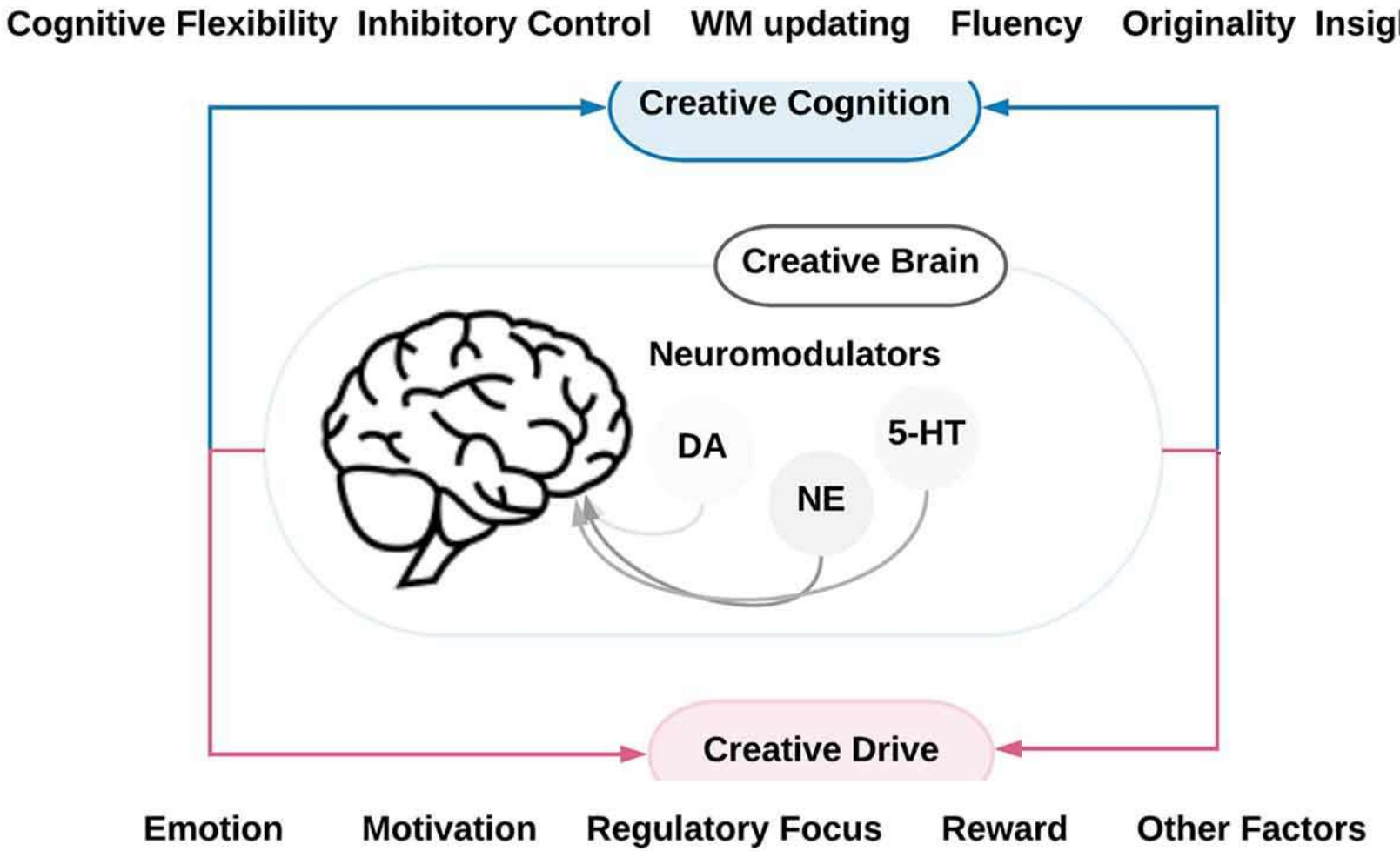
A dictator ruled a country from a strong fortress, and a rebel general, hoping to liberate the country, vowed to capture the fortress. The general knew that an attack by his entire army would capture the fortress, but he also knew that the dictator had planted mines on each of the many roads leading to the fortress. The mines were set so that small groups of soldiers could pass over them safely, since the dictator needed to move his own troops to and from the fortress. However, any large force would detonate the mines, blowing them up and also destroying the neighboring villages.

The general knew, therefore, that he couldn't just march his army up one of the roads to the fortress. Instead, he devised a simple plan. He divided his army into small groups and dispatched each group to the head of a different road. When all were ready, he gave the signal and each group marched up a different road to the fortress, with all the groups arriving at the fortress at the same time. In this way, the general captured the fortress and overthrew the dictator.


CREATIVE BRAIN
MEMORY
IMAGINATION
MIND WANDERING

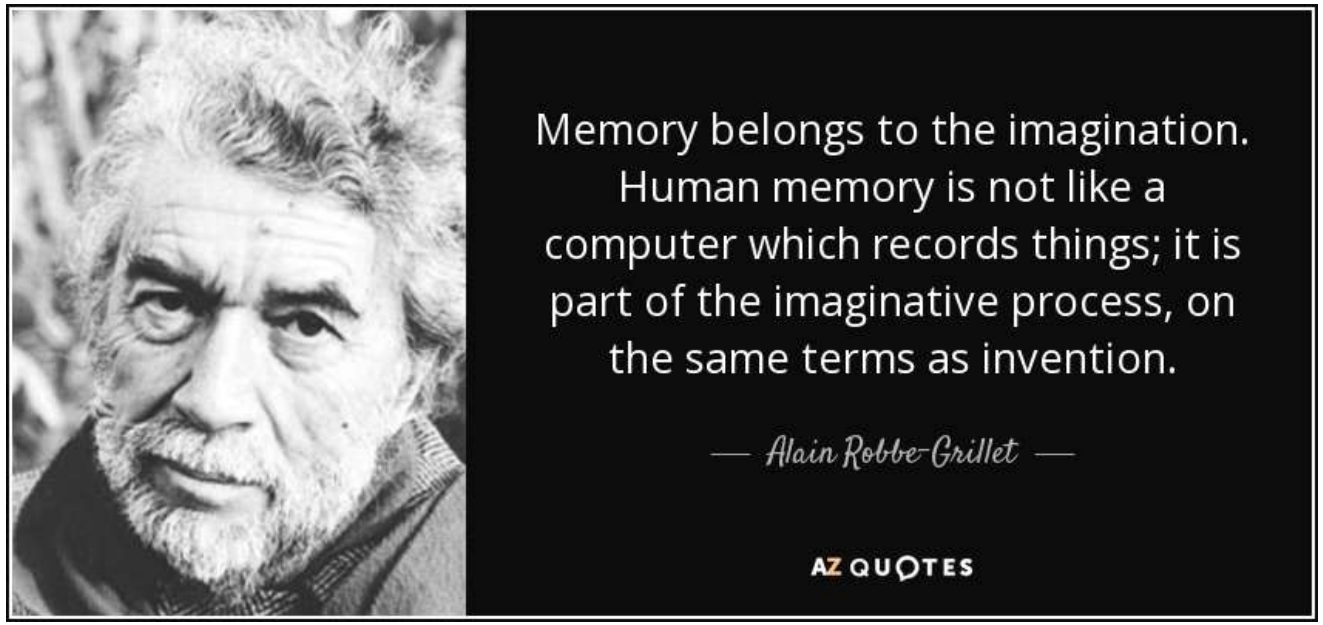


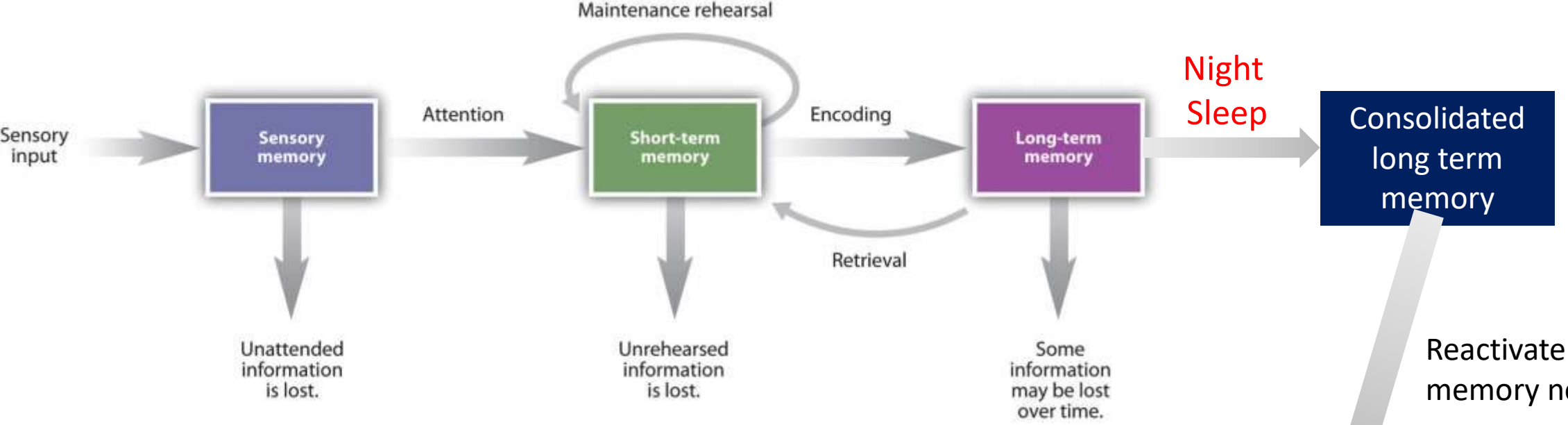
- Solving air and water pollution problems
- Increasing profits (creative marketing)
- Innovation – designing new gadgets/products
- Teaching!



- the ability to adapt our behaviour and thinking style in response to the environment.
- Become less rigid in your thinking
- Mental flexibility to try out new ideas or

Imagination





Night Sleep

Consolidated long term memory

Reactivate memory networks

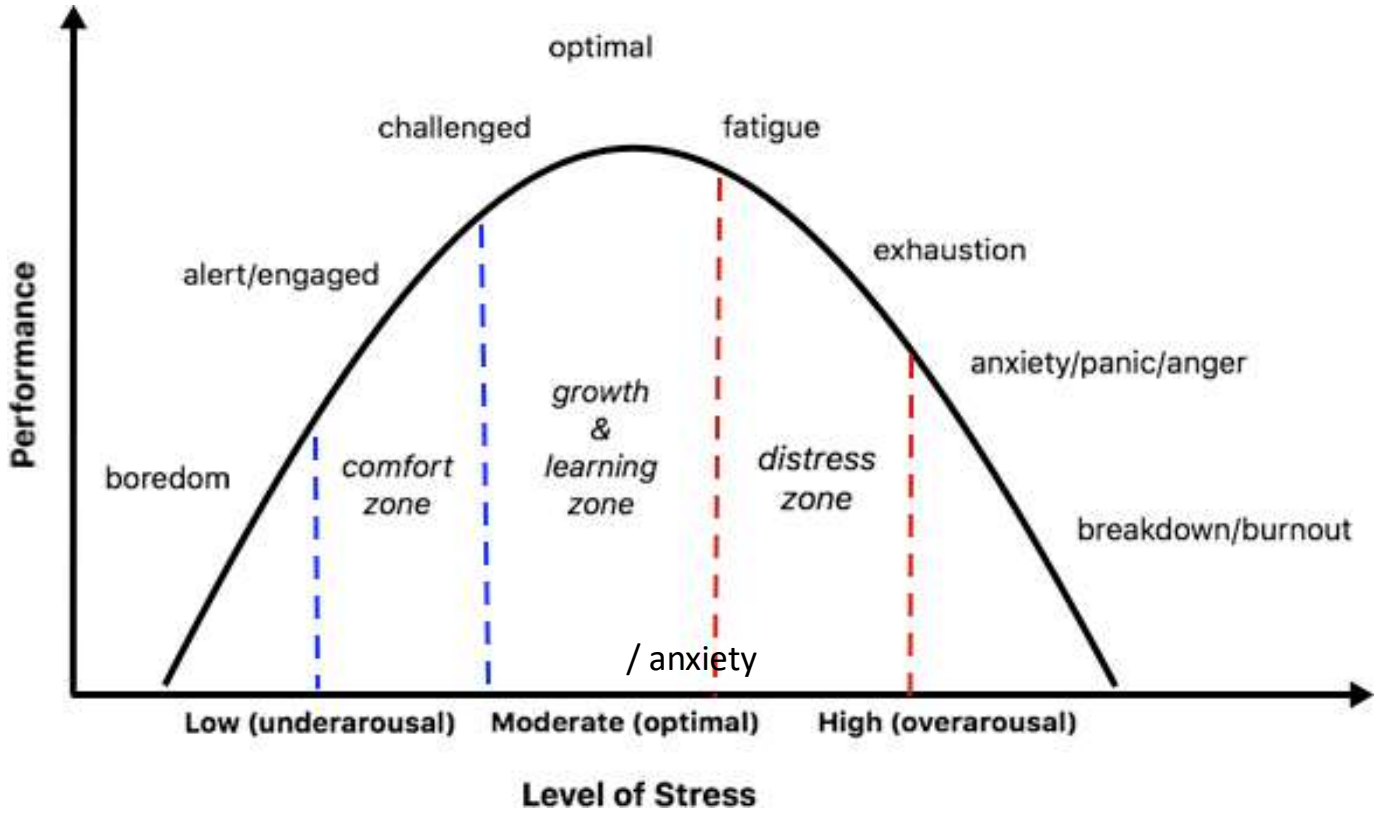
Labile memory trace

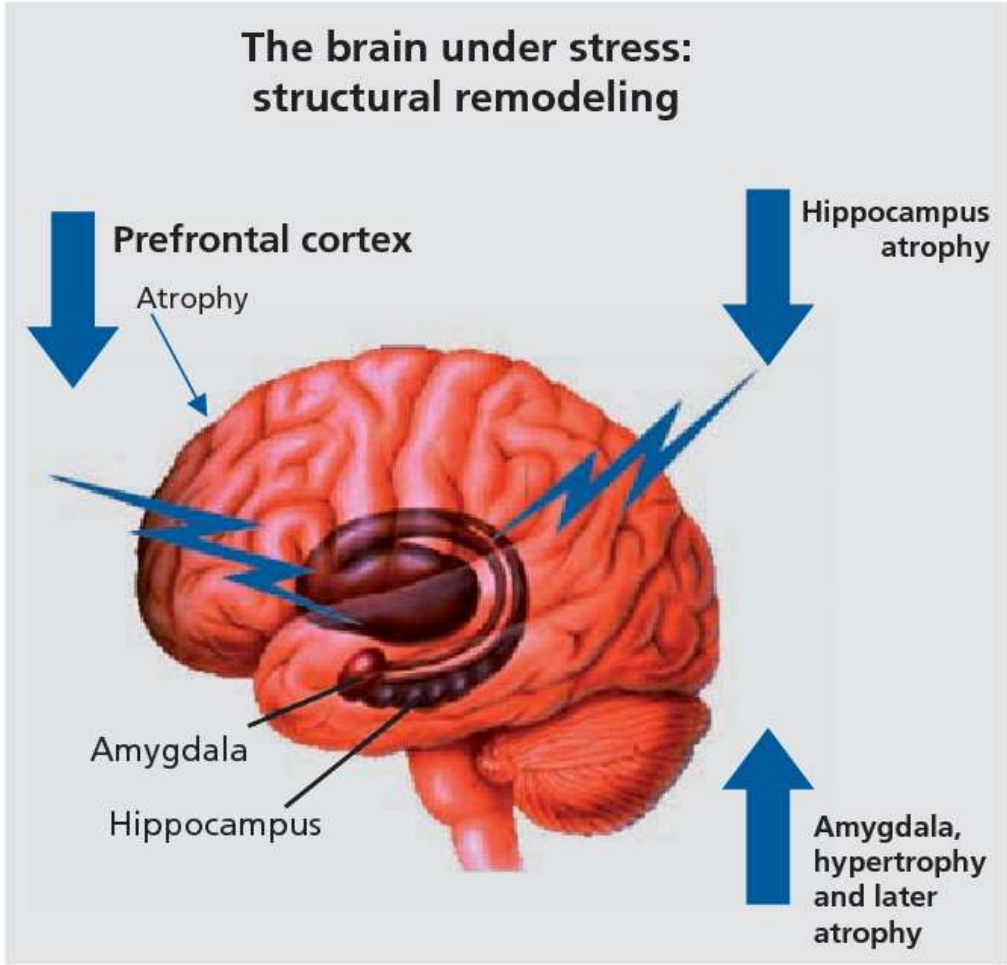
New but related experience

Stress & Depression

Updated memory

Emotional (state) memories
Traumatic memories (sudden stress/episodic stress)





Case Study

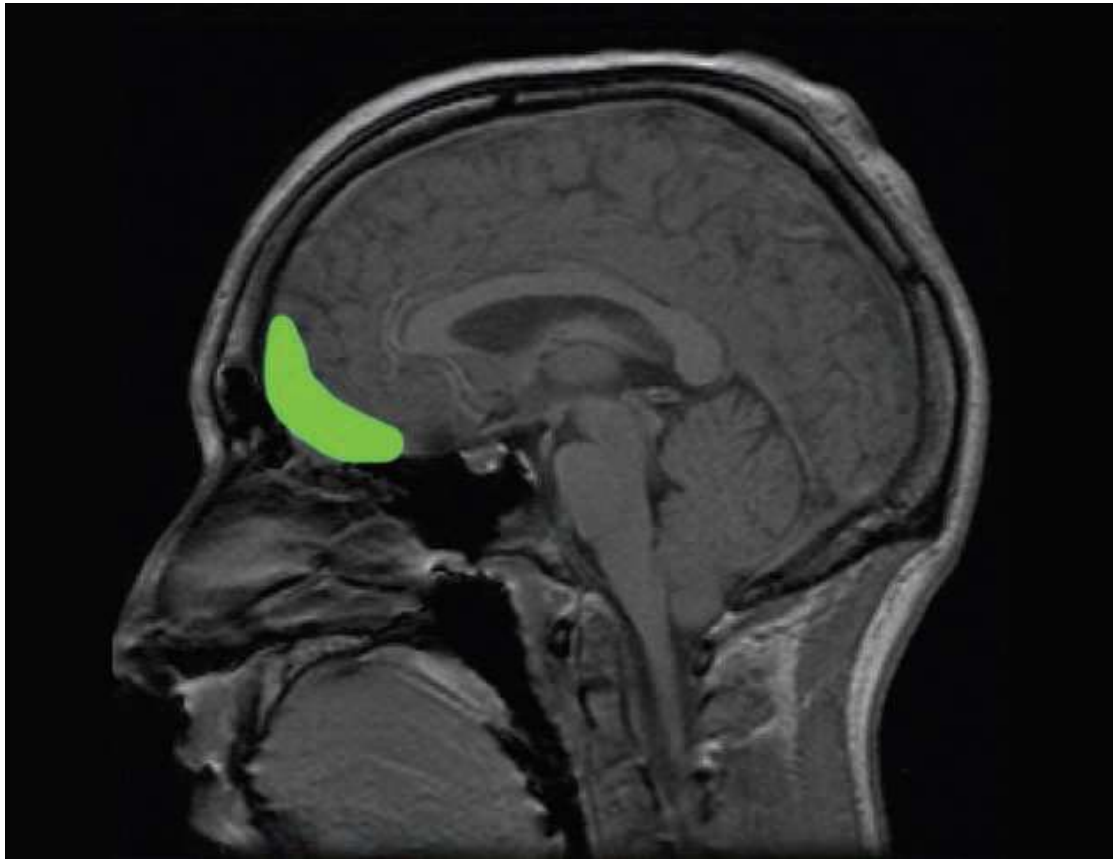
Patient Elliot:

- Had a brain surgery to remove a tumour.

- Perfect IQ.

- But He'd spend an entire afternoon deciding whether to classify a set of records by "place" or by "date." He needed so much time to choose where he'd eat lunch that he was likely to miss lunchtime.

What is the underlying functionality that seems to be affected?

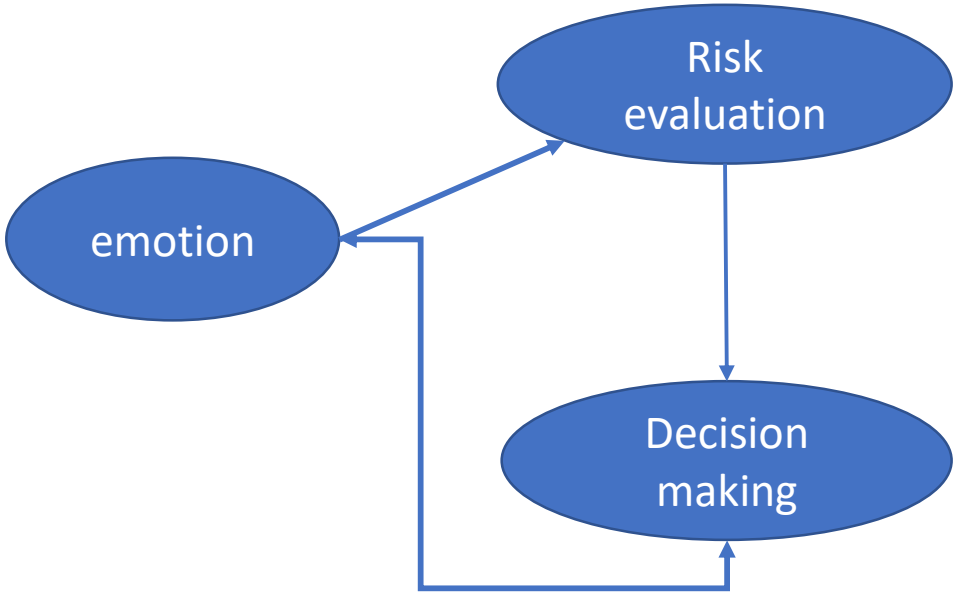


- Behavior 2: Elliot showed no bodily response at all if shown pictures depicting tragedy or aggression; he didn't react to sexual images, or gruesome pictures of wounds, or any other image that for most people cause a powerful emotional response

In scheduling an appointment, he needed 30 minutes, staring at his calendar, to decide which of two days would be better for him

What is missing or deficit?

- Why did Elliot’s lack of emotion lead to paralysis in his decision making?



Judgement and Reasoning

Judgements

- “It might seem odd to suggest that people could make different perceptual decisions even if perception is unchanged. This is possible, however, if people are implicitly or explicitly encouraged to make different decisions about ambiguous information”

Confidence as a diagnostic tool for perceptual aftereffects
•Regan M. Gallagher,
•Thomas Suddendorf &
•Derek H. Arnold
Scientific Reports **volume 9**, Article number: 7124 (2019)

How do we make judgements?

- **Frequency estimate** — an assessment of how often various events have occurred in the past.
- If frequency info is missing, rely on attribute substitution – that is, deduce it to be a rare event.
- Additionally, mostly rare events with emotional and hence it has higher precedence for memory recall.
- This process of relying on *availability* as a substitute for *frequency* — is a form of attribute substitution known as the **availability heuristic** (Tversky & Kahneman, 1973).
- In most cases, we rely on *resemblance or similarity* instead of *probability – which is known as* **representativeness heuristic**.

Example: Availability heuristic

representativeness heuristic.

ATTRIBUTE SUBSTITUTION – reduces cognitive load

TABLE 12.1 DIFFERENT TYPES OF ATTRIBUTE SUBSTITUTION

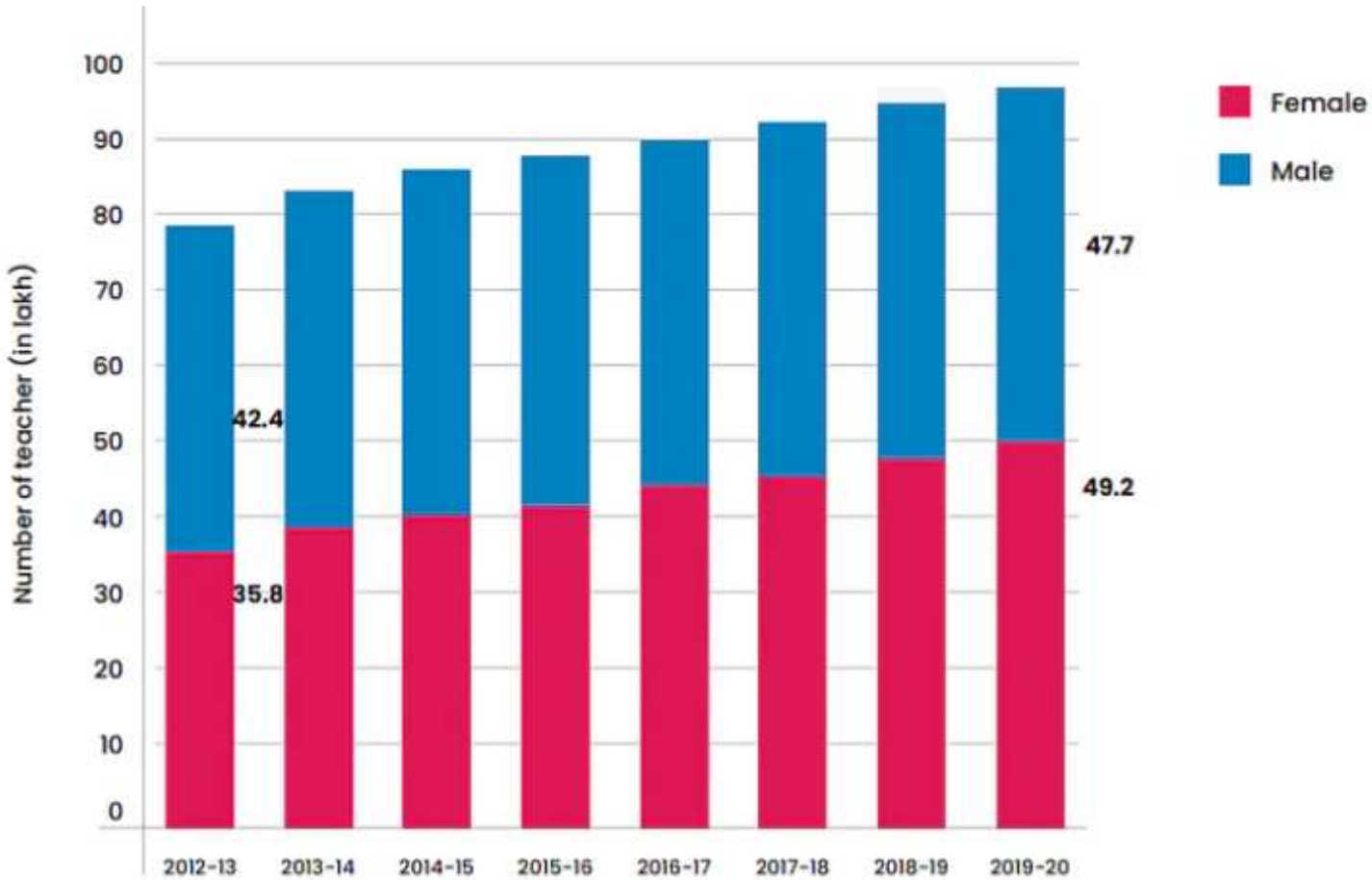
You want to judge . . .	Instead you rely on . . .	This usually works because . . .	But this strategy can lead to error because . . .
Frequency of occurrence in the world	Availability in memory: How easily can you think of cases?	Events that are frequent in the world are likely to be more available in memory.	Many factors *other than* frequency in the world can influence availability from memory!
Probability of an event being in a category or having certain properties	Resemblance between that event and other events in the category	Many categories are homogeneous enough so that the category members do resemble one another.	Many categories are not homogeneous!

Heuristic is an efficient strategy that **<u>usually</u>** leads to the right answer.
Heuristics allow errors; that's the price you pay in order to gain the efficiency.

Frequency leading to availability

- “Are there more words in the dictionary beginning with the letter *R* (‘rose,’ ‘rock,’ ‘rabbit’) or more words with an *R* in the third position (‘tarp,’ ‘bare,’ ‘throw’)?”
- Most people insist that there are more words beginning with *R* (Tversky & Kahneman, 1973, 1974), but the reverse is true — by a margin of at least 2-to-1.

- Q: are there more male or female school teachers in India – if so, what is the approximate ratio?

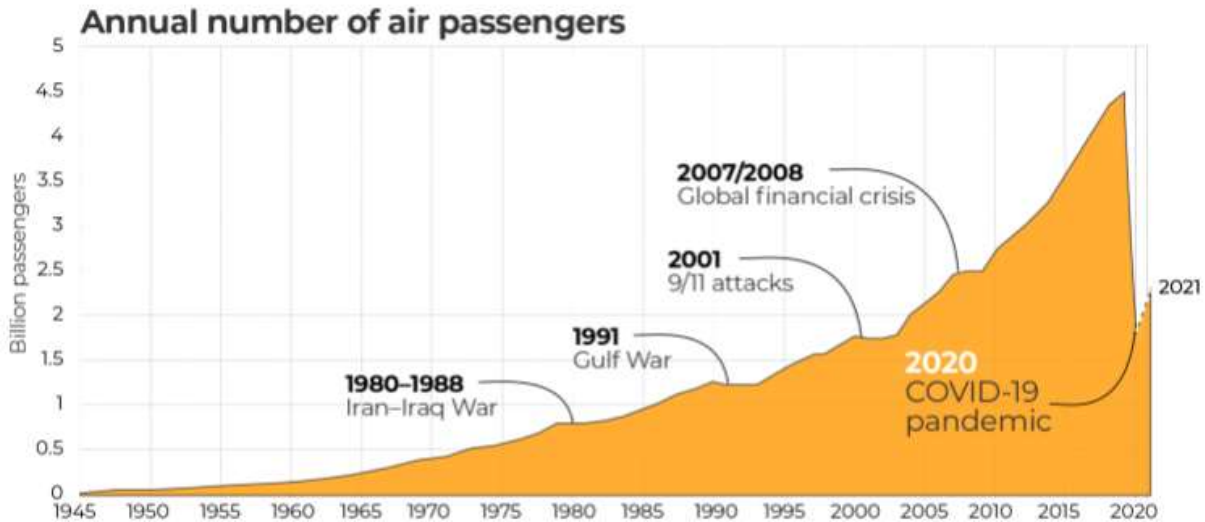


Number of teachers (in lakh) by gender, all India 2012-13 to 2019-20 (Source: Unified District

TRAVEL

COVID-19 effect on air travel

Before the pandemic, some **4.5 billion passengers took 42 million flights** worldwide. Passenger travel in **2020 dropped by 60 percent** compared with 2019.



2019

Passengers:
4.5 billion
Flights:
42 million

2020

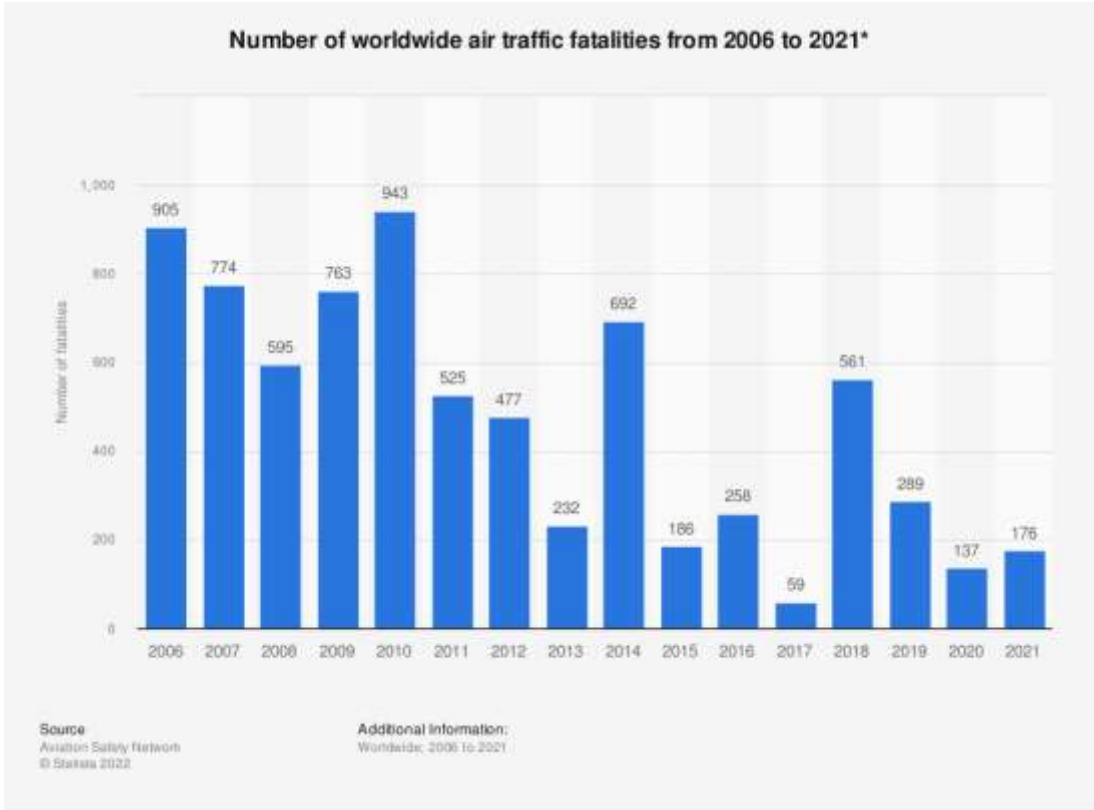
Passengers:
1.8 billion ▼ 60% compared to 2019
Flights:
24 million

2021

Passengers:
2.3 billion* ▼ 49% compared to 2019
Flights:
28 million*

* As of December 8, 2021
Source: International Civil Aviation Organization (ICAO), FlightRadar24 | December 8, 2021

@AJLabs ALJAZEERA



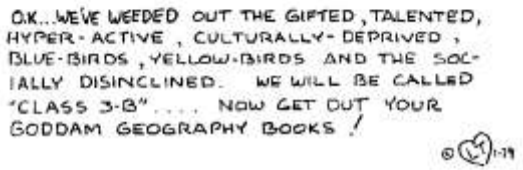
ODDS OF WINNING INDIAN LOTTERIES

DAY OF DRAW	LOTTERY	JACKPOT ODDS	ANY PRIZE ODDS	COST PER TICKET	COST PER BOOK OF TICKETS	FIRST PRIZE
Sunday	Pournami	1 in 9,000,000	1 in 119	₹40	₹750	₹7,000,000
Monday	WIN WIN	1 in 9,000,000	1 in 119	₹40	₹750	₹6,500,000
Tuesday	Sthree Sakthi	1 in 9,000,000	1 in 119	₹40	₹750	₹7,000,000
Wednesday	Akshaya	1 in 9,000,000	1 in 119	₹40	₹750	₹6,000,000
Thursday	Karunya Plus	1 in 9,000,000	1 in 119	₹40	₹750	₹7,000,000
Friday	Nirmal	1 in 9,000,000	1 in 119	₹40	₹750	₹6,000,000
Saturday	Karunya	1 in 9,000,000	1 in 119	₹50	₹1250	₹10,000,000 (1 crore)

Kerala man who bought lottery ticket on way to bank for loan wins Rs 12 crore prize

Why do we have errors in judgement?

- Homogeneity
- Relying on Heuristics (coin toss: H H H H H H ?)
- Cultural differences (Masuda and Nisbett (2001))
- Detecting Covariation – errors in cause & effect estimations. And importantly Illusions of covariation.



American and Japanese students

What leads to these illusions & assessment of covariation ?

- **confirmation bias** — a tendency to be more alert to evidence that *confirms* your beliefs rather than to evidence that might *challenge* them (Nisbett & Ross, 1980; Tweney, Doherty, & Mynatt, 1981).
- **base-rate information -** information about how frequently something occurs in general.
- For example, people are more alert to a base rate phrased as “12 out of every 1,000 cases” than they are to the same information cast as a percentage (1.2%) or a probability (.012). (See Gigerenzer & Hoffrage, 1995; also Brase, 2008; Cosmides & Tooby, 1996.)
- **Role of Chance -** one instance shaping the outcome of an entire event.
- **Education:**
- **Belief perseverance**

Could it be, then, that human judgment is fundamentally flawed?

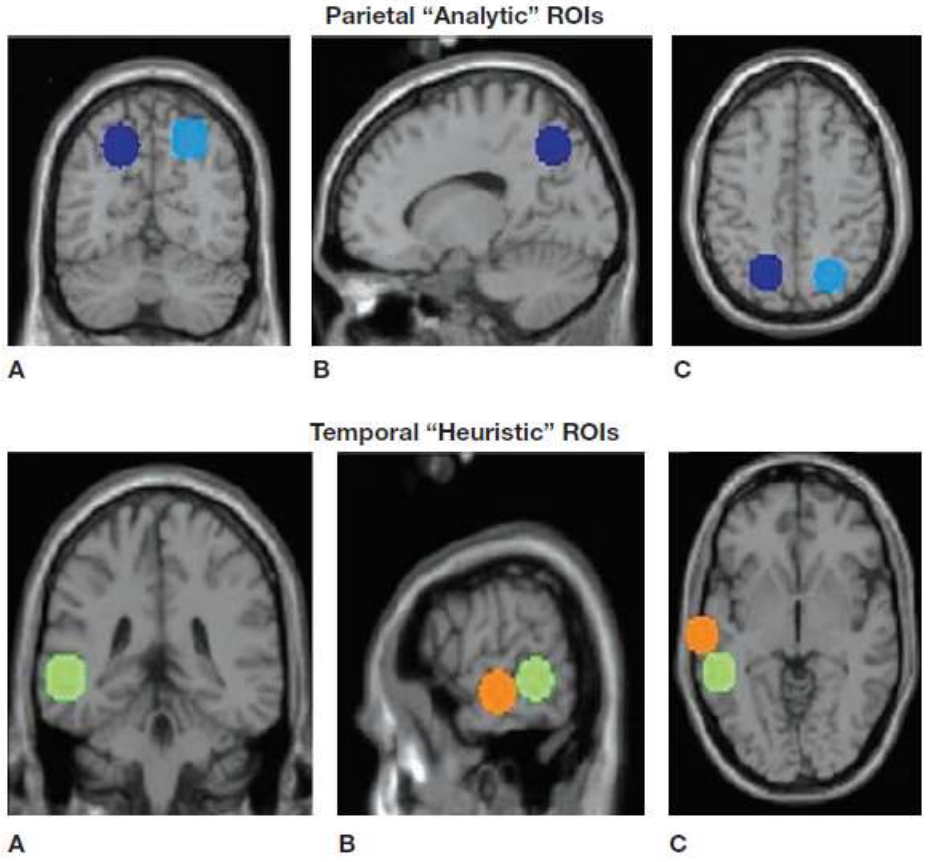
Confirmation bias takes many forms:

- First, when people are assessing a belief or a hypothesis, they’re more likely to seek evidence that might confirm the belief than evidence that might disconfirm it.
- Second, when disconfirming evidence is made available to them, people often fail to use it in adjusting their beliefs.
- Third, when people encounter confirming evidence, they take it at face value; when they encounter disconfirming evidence, they reinterpret the evidence to diminish its impact.
- Fourth, people often show better memory for confirming evidence than for disconfirming evidence, and, if they do recall the latter, they remember it in a distorted form that robs the evidence of its force.
- Finally, people often fail to consider alternative hypotheses that might explain the available data just as well as their current hypothesis does.

Answer? – types of thinking.

- **dual-process model: Type 1** as the label for the fast, easy sort of thinking and
- **Type 2** as the label for the slower, more effortful thinking

FIGURE 12.2 DUAL-PROCESS MODELS AND THE BRAIN



Many theorists propose that there are (at least) two distinct modes of thinking. Here, the colored patches highlight "regions of interest" (ROIs) when participants were relying on Type 2 ("Analytic") thinking and when they were relying on Type 1 ("Heuristic") thinking.

THE COGNITIVE REFLECTION TEST (CRT) – used to measure Type 1 & II thinking

(1) A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball.

How much does the ball cost? _____ cents

(2) If it takes 5 machines 5 minutes to make 5 widgets, how long would it

take 100 machines to make 100 widgets? _____ minutes

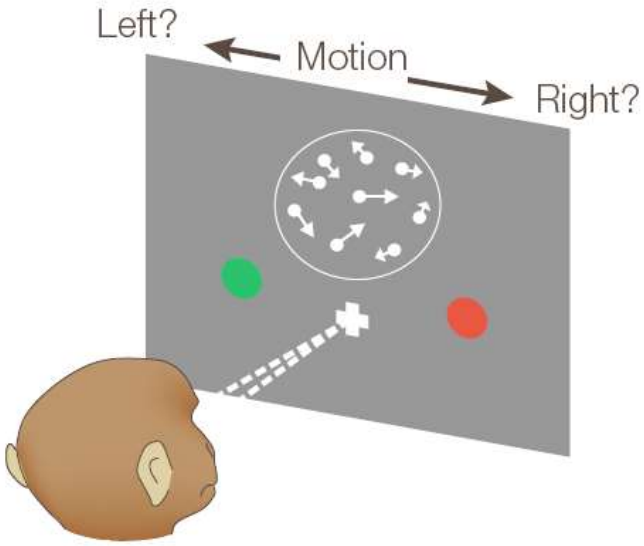
(3) In a lake, there is a patch of lily pads. Every day, the patch doubles in size.

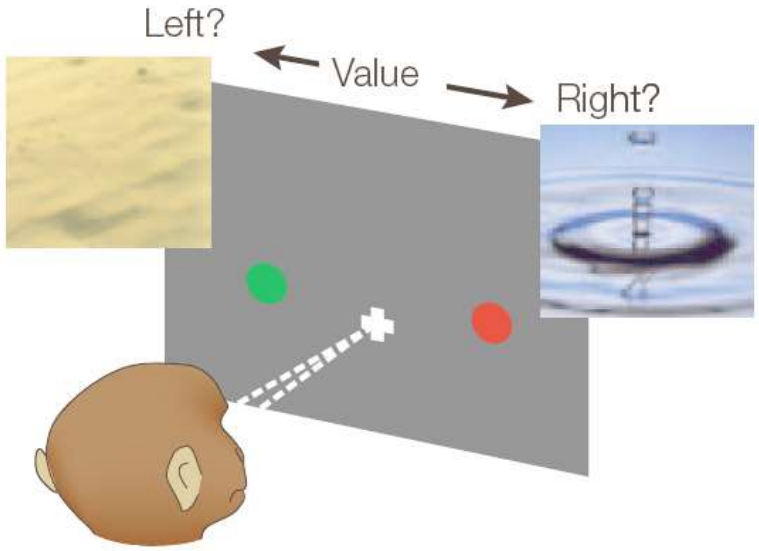
If it takes 48 days for the patch to cover the entire lake, how long would it

take for the patch to cover half of the lake? _____ days

Introduction

- Decision making?
- –The process or ability to choose among the alternatives presented.
- •Research suggests that the brain considers various sources of information before making a decision.
- •But how does it do this? And why does the process sometimes go awry?





From Sugrue, Corrado and Newsome
Nature Neuroscience, 2005, Vol 6, May 2005

Neuroscientists have long questioned how the human brain makes decisions, from where to gaze to complex moral judgments

Brain and DM

- Our brains appear wired to enable us to make unconsciously the best decisions possible with the information we're given.
- The process is organized like a court trial.
- –Sights, sounds, and other sensory evidence are entered and registered in sensory circuits in the brain.
- –Other brain cells act as the brain's "jury," compiling and weighing each piece of evidence.
- –When the accumulated evidence reaches a critical threshold, a judgment — a decision — is made.

Brain Facts, SFN

Theoretical Framework

- **Decision Making can be thought of as a form of Statistical Inference ????**
- Decision = select among competing hypotheses h1, h2, …
- priors P(h1):

–Probability that h1 is correct before collecting any evidence = a bias (or prejudice)

- evidence (e):

–information we can collect in favour of h1.

–Only useful when we know how likely it is to be true if the hypothesis is true i.e., if we have conditional probabilities such as P(e|h1) = the likelihood

- value(v):

–subjective costs and benefits for each outcome

Estimations – Emotions and DM

- Imagine that the United States is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimates of the consequences of the programs are as follows:
- If Program A is adopted, 200 people will be saved.
- If Program B is adopted, there is a one third probability that 600 people will be saved, and a two thirds probability that no people will be saved.

- (from Tversky & d. kahneman. “the framing of decisions and the psychology of choice,” *science* 211© 1981).

Estimations – emotions, probability and DM

- Imagine that the United States is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimates of the consequences of the programs are as follows:
- If Program A is adopted, 400 people will die.
- If Program B is adopted, there is a one third probability that nobody will die, and a two thirds probability that 600 people will die.

Framing effect

- Imagine that you serve on the jury of an only-child sole-custody case following a relatively messy divorce. The facts of the case are complicated by ambiguous economic, social, and emotional considerations, and you decide to base your decision entirely on the following few observations. To which parent would you award sole custody of the child?

Parent A:

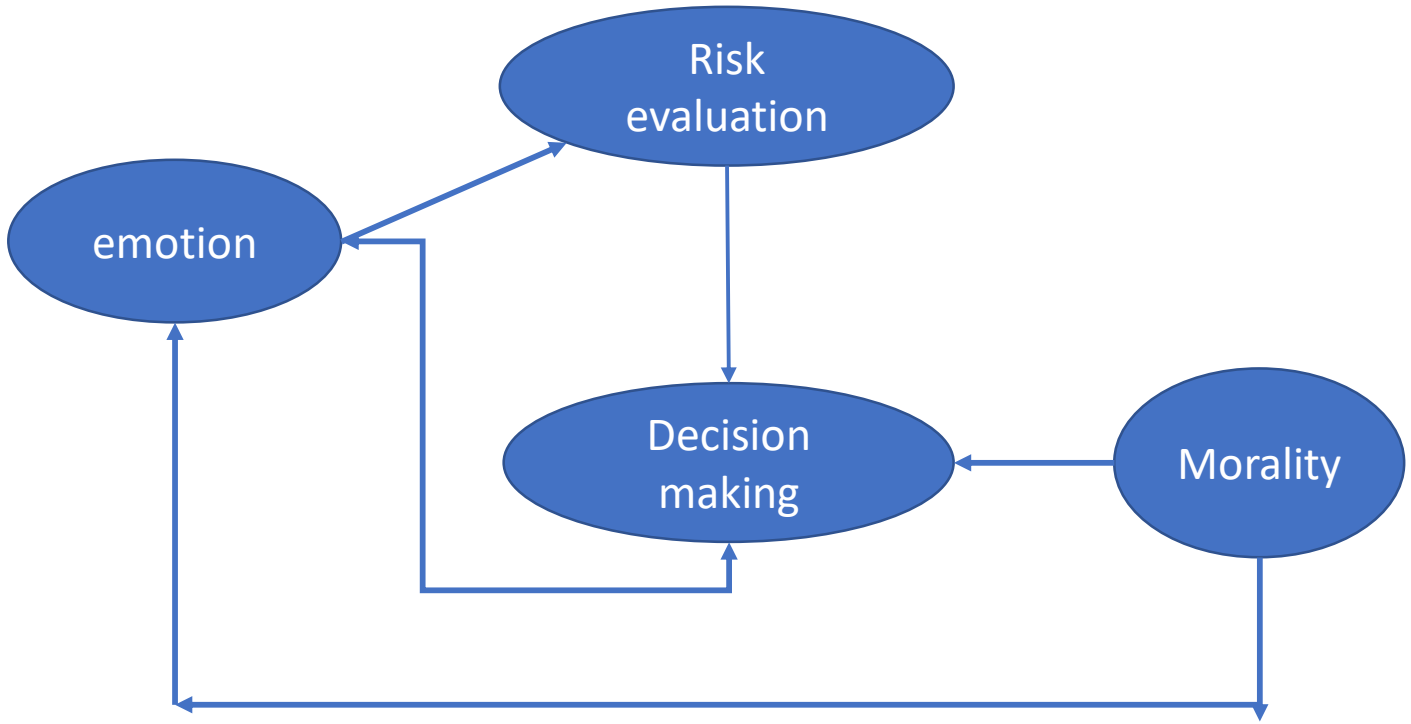
- average income
- average health
- average working hours
- reasonable rapport with the child
- relatively stable social life

Parent B

- above-average income
- very close relationship with the child
- extremely active social life
- lots of work-related travel
- minor health problems

Framing effect

- When asked the question shown here, 64% of the research participants decided to award sole custody to Parent B.
- Other participants, however, were asked a different question: “To which parent would you deny sole custody?” Asked this question, 55% of the participants chose to deny sole custody to Parent B (and so, by default, to award custody to Parent A).
- Thus, with the “award” question, a majority votes for granting custody to Parent B; with the “deny” question, a majority votes for granting custody to Parent A.


Risk evaluation
emotion
Decision making
Morality

Language

IBC

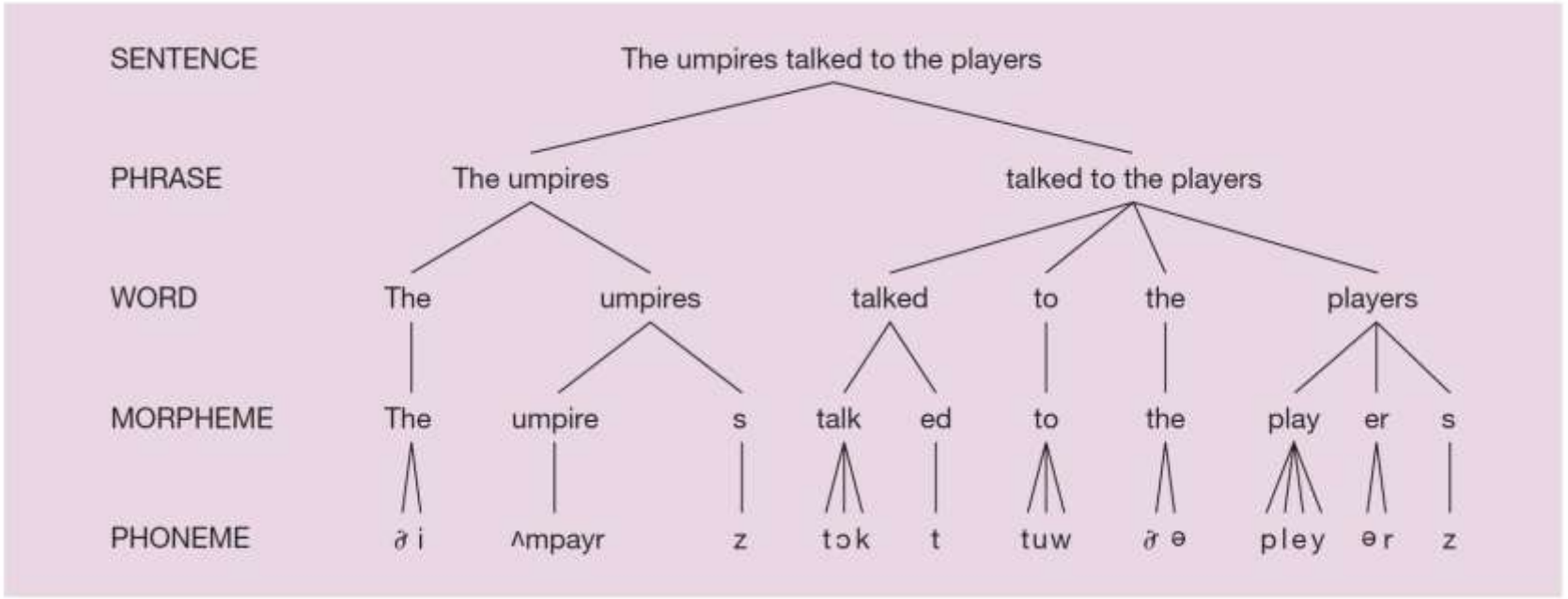
The marvels of language

Gabby Gifford

Gabby Giffords made a miraculous recovery after she was shot in the head in January. (ABC News)

- •**Language**: a system for communicating with others using signals that are combined according to rules of grammar and to convey meaning
- –Human language is more complex, involves words representing intangible things, and is used to think and conceptualize (different than other animal species)
- •**Grammar**: a set of rules that specify how the units of language can be combined to produce meaningful messages

The hierarchy of linguistic units



Linguistic Units

Phoneme: the smallest unit of sound that is recognizable as speech rather than random noise

Phonological rules: a set of rules that indicate how phonemes can be combined to produce speech sounds

Morphemes: the smallest meaningful units of language

Morphological rules: a set of rules that indicate how morphemes can be combined to form words

Syntactical rules: a set of rules that indicate how words can be combined to form phrases and sentences

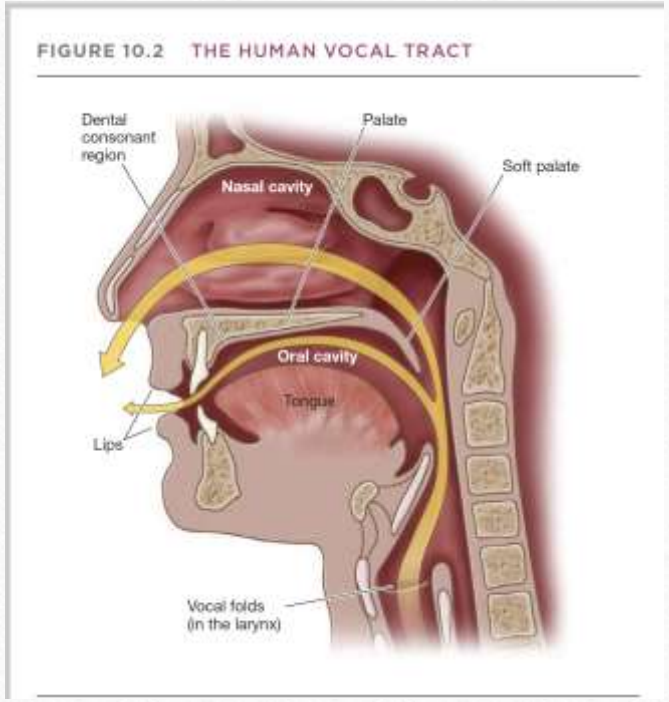
Deep structure versus surface structure:

Deep structure: the meaning of a sentence

Surface structure: how a sentence is worded

Phonology

The study of speech sounds and the rules that govern them.



Speech production

- **Manner of production**
- [p], [b] air flow briefly stopped
- [f], [z], [r] air passage restricted but air flow is not blocked

Speech production

- **Voiced vs unvoiced sounds**
- Voiced sounds: [v], [z], [n]
- Unvoiced sounds: [f], [s], [t], [k]

Speech production

- Where is the airflow restricted? **Place of articulation.**
- “bilabial” sounds like [p] and [b]?
- close your lips
- “labiodental” sounds like [f] and [v]?
- Top teeth close to bottom lip
- “alveolar” sounds like [t] and [d]?
- tongue just behind your upper teeth

Now, we can describe any sound; [p]

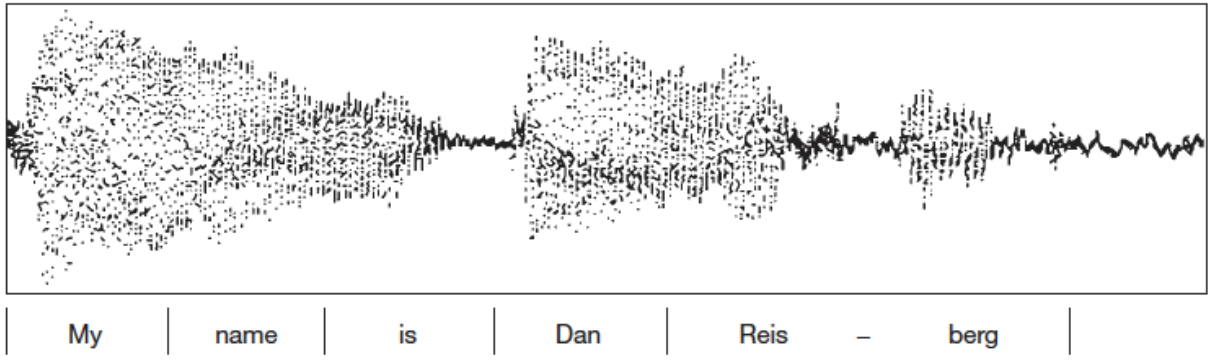
- manner of production: air moving through the mouth (not the nose) and with a full interruption to the flow of air.
- voicing: unvoiced.
- place of articulation: bilabial.

Combine features to produce the phonemes of a language

- 40 in English
- 12 in some
- 140+ in some
- Simple combinations of features described previously

Speech Perception

- Just perceive these sound features?
- More complex
- Speech segmentation



Speech illusions, ambiguity in segmentation

"Boy, he must think we're pretty stupid to fall for that again."

Coarticulation

- [s]: what is the acoustic pattern?
- [s] in soup
- [s] in sin
- [s] in Sam
- Depends on context!

Aids to speech segmentation

- We don't use all of our vocabulary, so a limited number of words that are used regularly
- Top-down and bottom-up effects combine: the role of expectations and knowledge in aiding bottom-up speech segmentation (I.e., directly from the stimulus).
- Categorical perception

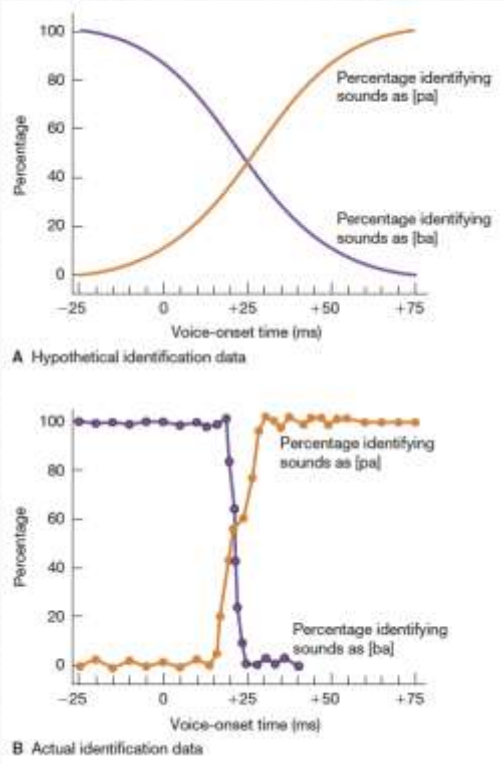
Phoneme restoration effect

- Legislatures
- Legi*latures – insert noise
- The state governors met with their respective legi*latures.

Pollack and Pickett (1964)

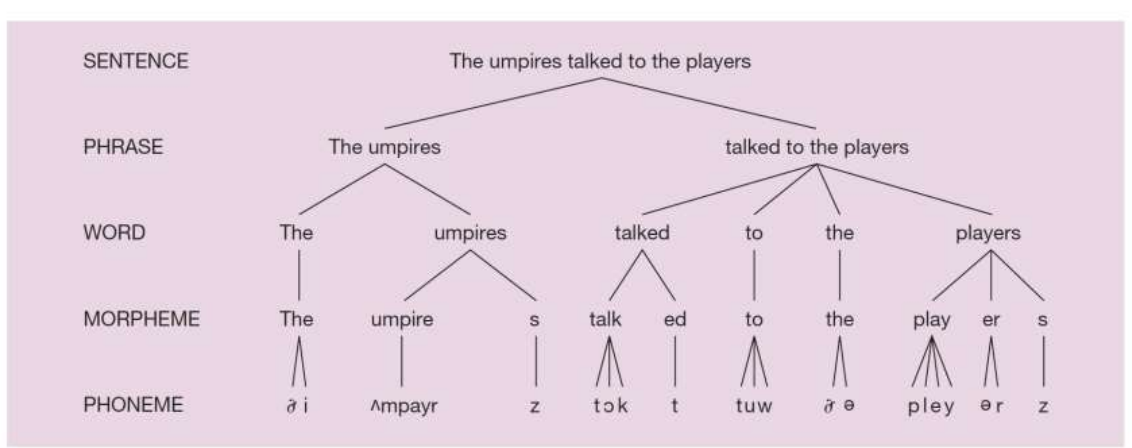
- Natural conversations
- Spliced individual words
- <50% identified when no context is present

Categorical Perception



Combine phonemes

- To create morphemes
- Morphemes --> words
- But there are rules to how morphemes can be combined
- e.g. The last sound in "going" can appear at the end of a word but not at the beginning.



Phonemes and words

- Making new words
- Hacking
- Malware
- Generativity of language
- 20 word max limit: 100,000,000,000,000,000,000 possible sentences using a vocabulary of 60-80k.

What does it mean to know a word?

(1) * She can place the books on the table.
(2) * She can place on the table.
(3) * She can sleep the books on the table
(4) * She can sleep on the table.

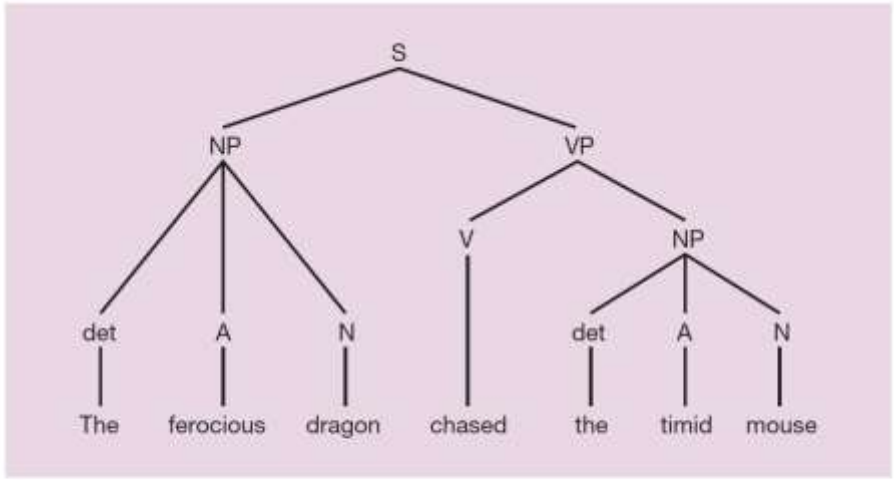
Syntax

- The rules governing how words can be combined to make phrases and sentences.
- I hit the ball.
- I hit ball the. *

Is syntax related to meaningfulness?

- Can something be judged to be ungrammatical if the sentence/phrase is meaningless?
- Colorless green ideas sleep furiously. (Noam Chomsky)

Syntax

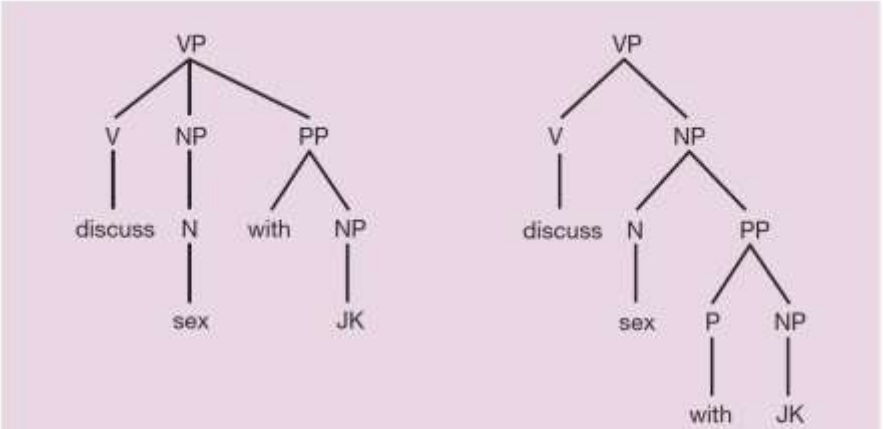


The diagram shows that the overall sentence (S) consists of a noun phrase (NP) plus a verb phrase (VP). The noun phrase is composed of a determiner (det) followed by an adjective (A) and a noun (N). The verb phrase is composed of a verb (V) followed by a noun phrase (NP).

Phrase structure and sentence parsing

A	B
The large tomato made a satisfying splat when it hit the floor.	The large tomato made a satisfying splat when it hit the floor.

Phrase structure ambiguity



He wants to discuss sex with Jimmy Kimmel.
I saw the gorilla in my pajamas.
The shooting of the hunters was terrible.
They are roasting chickens.
Visiting relatives can be awful.
Two computers were reported stolen by the TV announcer.

Garden Paths

- Time flies like an arrow.
- (But fruit flies, in contrast, like a banana.)

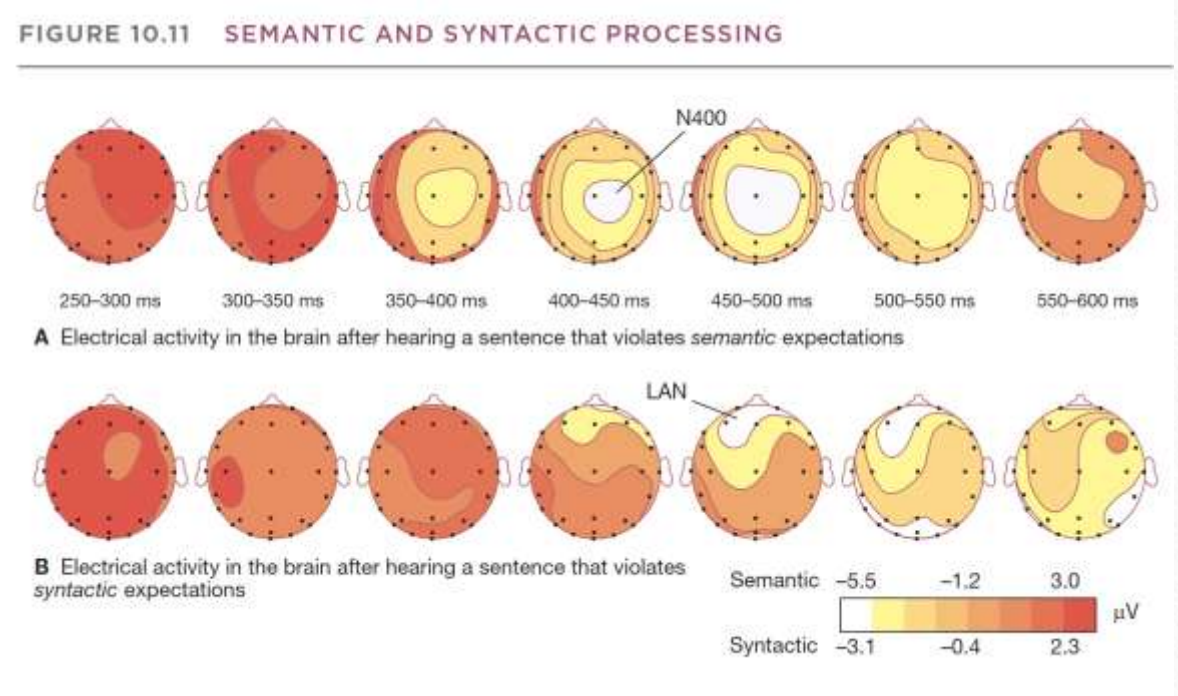
Ambiguity within a sentence

- The old man the ships.

Brain signatures

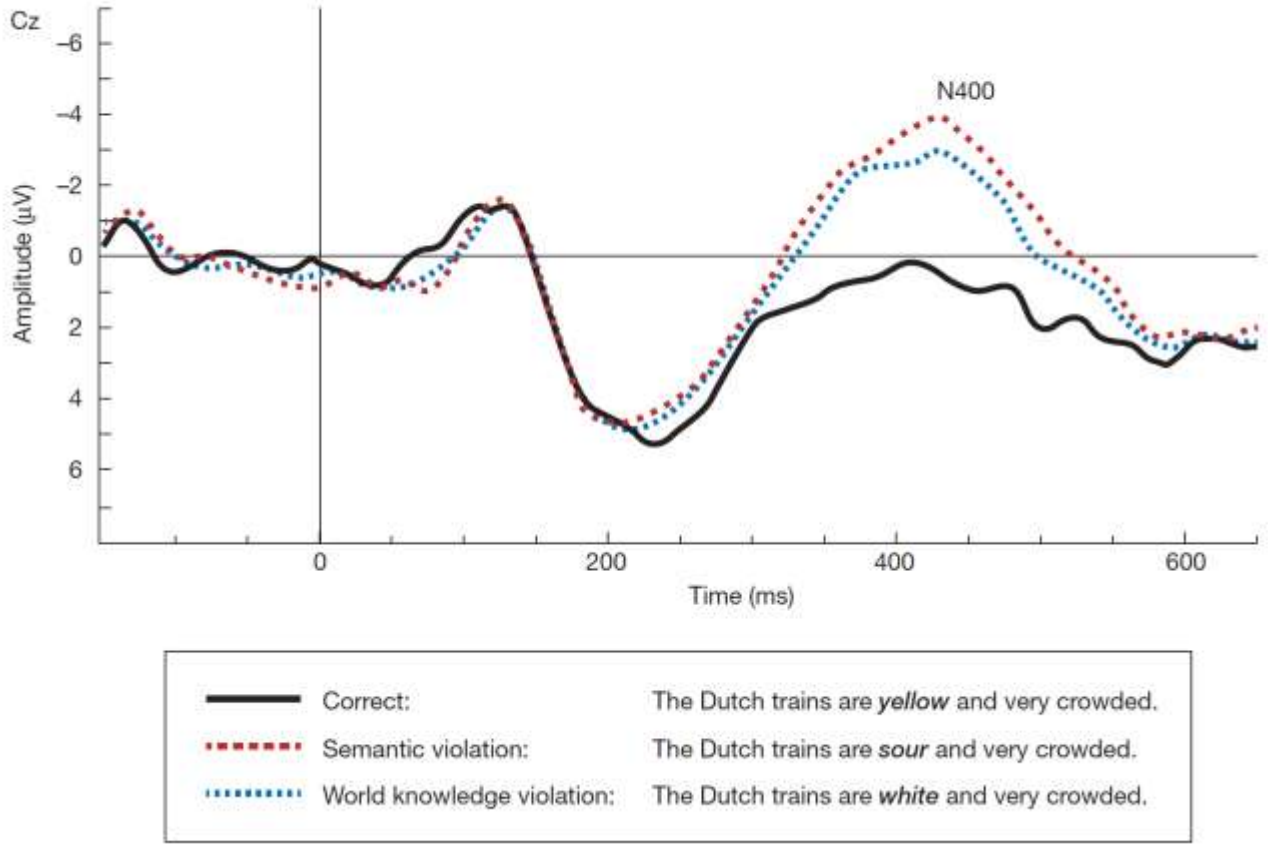
He drinks his coffee with cream and dog

He prefers to solve problems herself



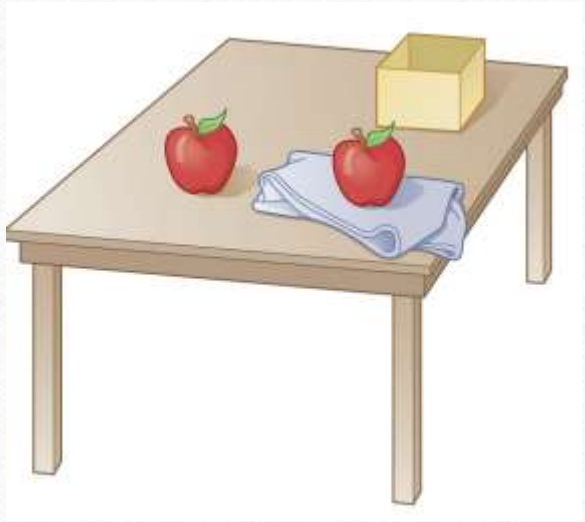
Extralinguistic context

FIGURE 10.12 N400 BRAIN WAVE



Extralinguistic context

- Put the apple on the towel into the box.



Speech intonation: prosody

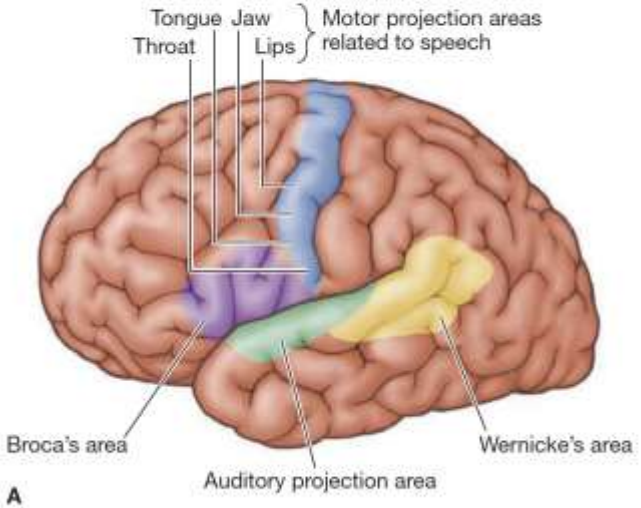
- Rahul caught the ball.
- That catch by Sourav was pretty good, wasn't it?
- Did Rahul catch the flying cap?
- Prosody can help parse garden-path sentences
- The horse raced past the barn fell.

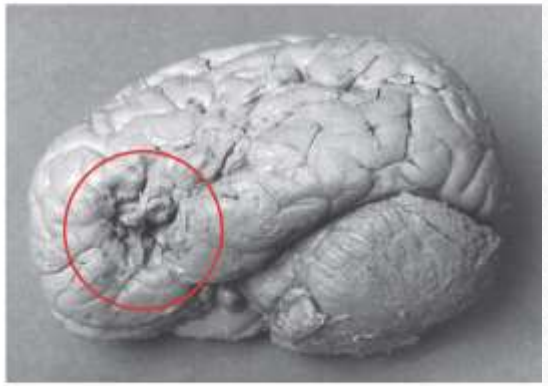
Pragmatics: your knowledge of how the language is typically used?

- Do you know the time?
- Susan: I'm leaving you.
- John: Who is he?

Biological bases of language: Lessons from aphasias

FIGURE 10.14 BRAIN AREAS CRUCIAL FOR THE PERCEPTION AND PRODUCTION OF LANGUAGE





Broca's aphasia

- https://www.youtube.com/watch?v=JWC-cVQmEmY&ab_channel=tactustherapy

Wernicke's aphasia

- https://www.youtube.com/watch?v=3oef68YabD0&ab_channel=tactustherapy

Language learning: statistical regularities

- bidakupadotigolabubidaku
- bidakupadotigolabubidaku
- 8 month olds
- dakupadakupadakupa

Language learning: principles

- 3 yrs: no need to memorize each word, rules can be applied
- e.g. add "ed" to create a past-tense
- Over-regularization errors: "thinked"

Language learning: nature vs nurture

A MODERN WILD BOY

Does language shape thought/cognition?

- The Whorfian hypothesis
- **Linguistic relativity hypothesis**: the proposal that language shapes the nature of thought; originated by Benjamin Whorf (1897-1941)
- Debated over decades
- Lera Boriditsky

Left/right?

https://www.youtube.com/watch?v=RKK7wGAYP6k&ab_channel=TED

Haviland (1993); Majid et al (2004) ; Boroditsky & Gaby (2010)

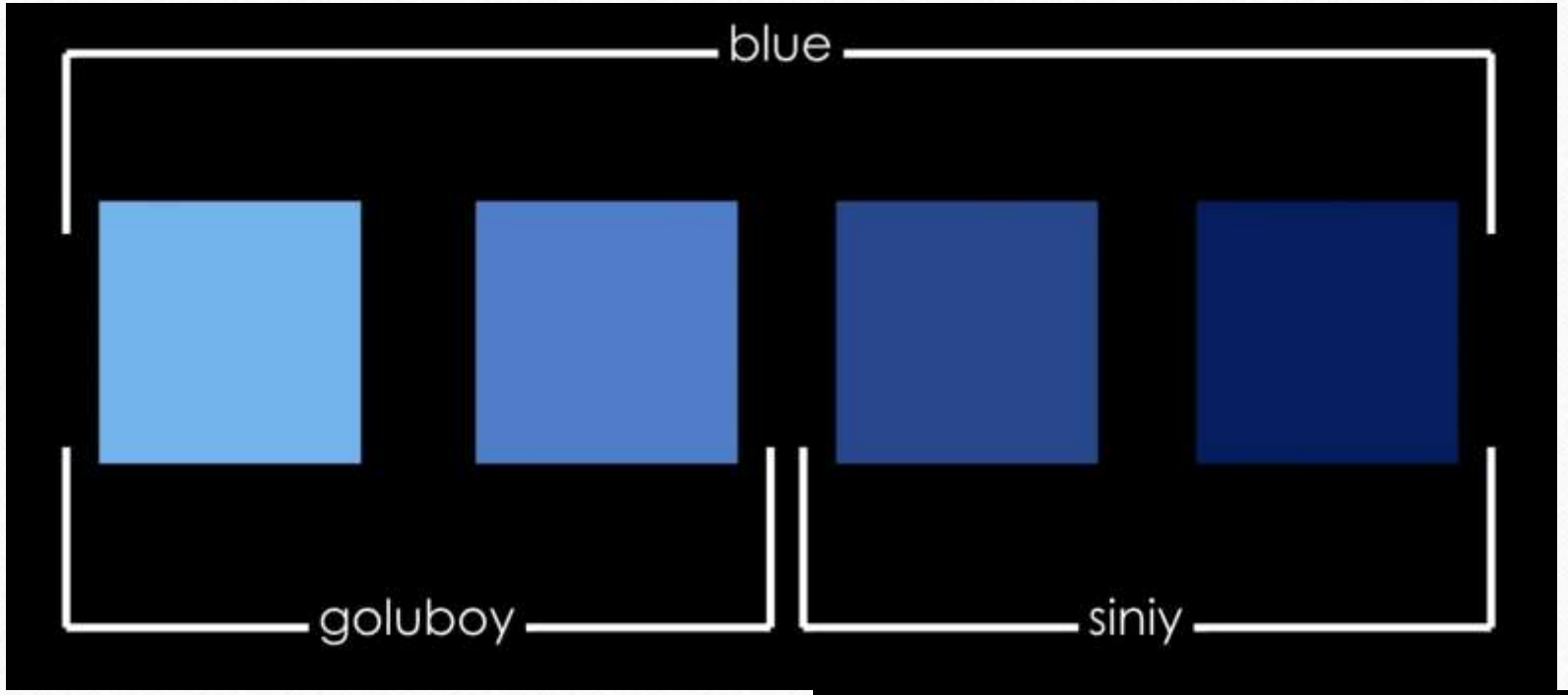
Close your eyes

- Point north-west

Thinking about time

Boroditsky & Gaby (2010); Boroditsky (2011); Fuhrman & Boroditsky (2010)

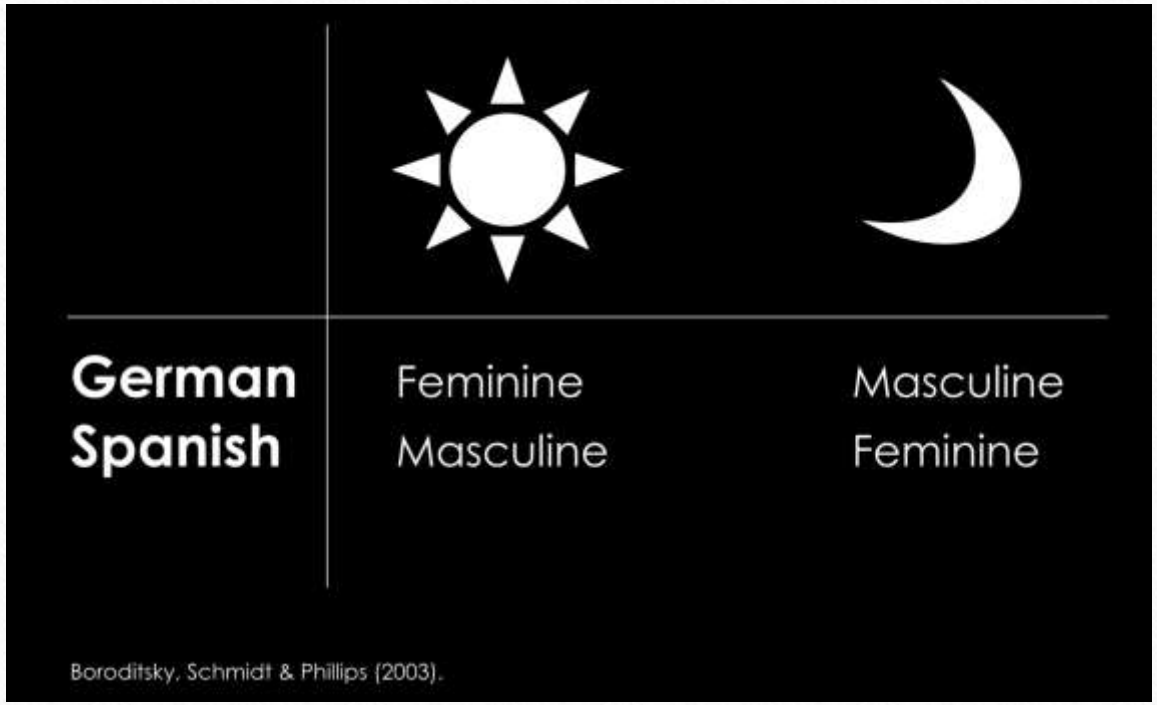
Basic color perception?



Winawer, Witthoft, Wu, Frank, Wade, Boroditsky (2007), *PNAS;* Thierry et al (2009) *PNAS.*

How do we think about things?

Describe a bridge



How do you perceive and remember events?

I broke my arm: ok in English, to describe an accident. Not ok in others.

English speakers more likely to remember who did it, Spanish speakers may be less likely to remember who did it but may remember better that it was an accident.

Language influences thought and cognition

Counting --> math ---> tech advances.

American undergrad study participants

- Need to expand to other languages and cultures..
- Differences in cognition between cultures/languages
- Bilinguals: differences in cognition based on language of presentation?
- So much left to be studied... need to expand cogsci beyond the American undergrad population.

Final thoughts

- How many languages in the world?
- 7000
- Can create more, but we're losing linguistic diversity (at around 1 per week)
- I for instance am not very comfortable writing/reading my native language Malayalam. How many of you are similar? Think about what that eventually does to linguistic diversity.