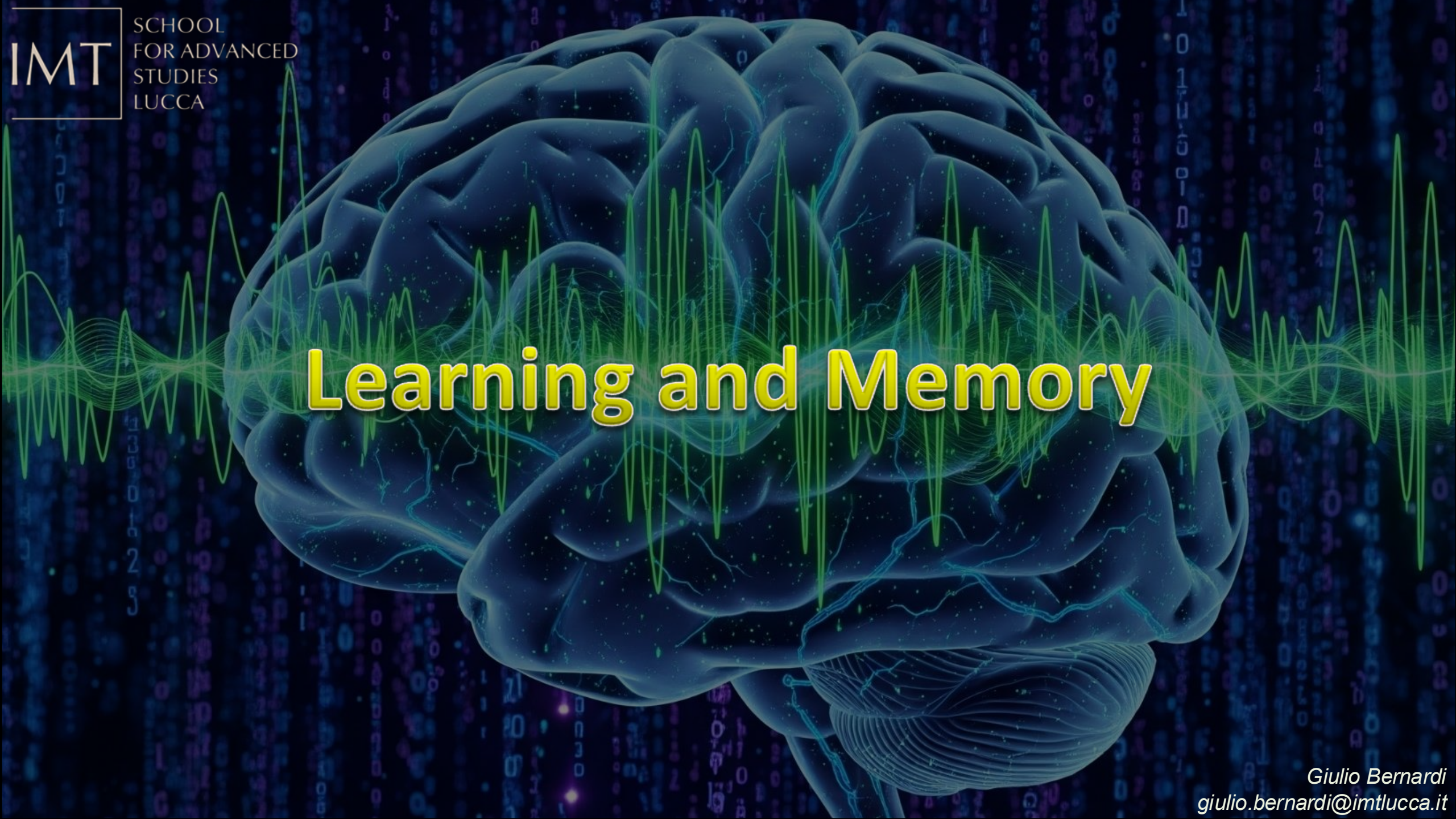


Giulio Bernardi
giulio.bernardi@imtlucca.it

Riprendendo l'ultima lezione:
~Ha spiegato come in generale ci siamo un sacco di artefatti nell' EEG (other muscle, sweating ....)

Learning - Definition

"Learning is a more or less permanent change in the behavior of an organism as a result of experience."

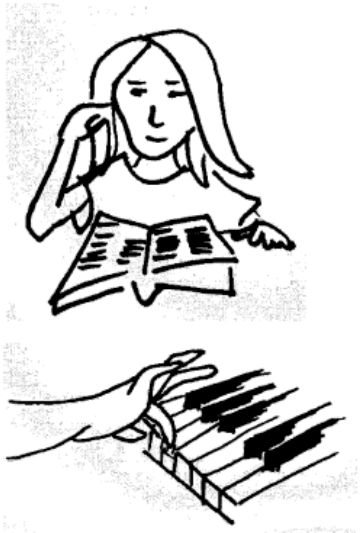
Learning

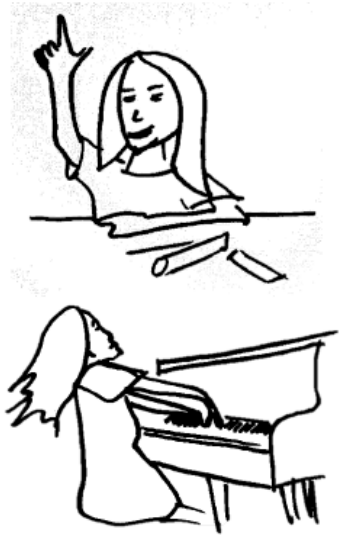
Processes that lead to the acquisition of new knowledge or skills

Memory

Product of learning: acquired knowledge or skills

Phases of memory formation





Sleep important

Encoding

Information perception and processing

Learning

Consolidation

Retention and consolidation of information

Memory

Retrieval

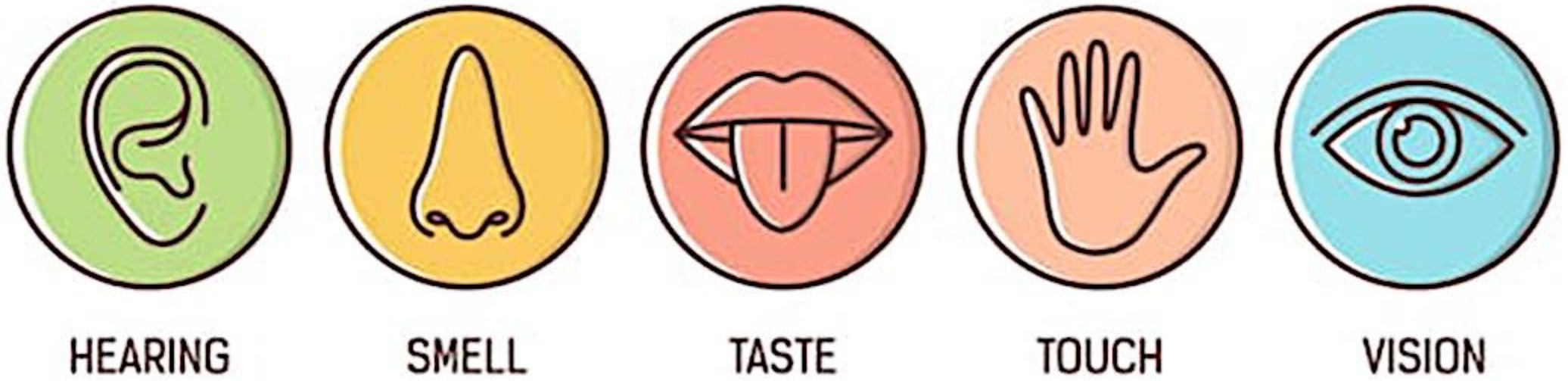
Remembering and using stored information

Remembering

time

Acquiring information about the world

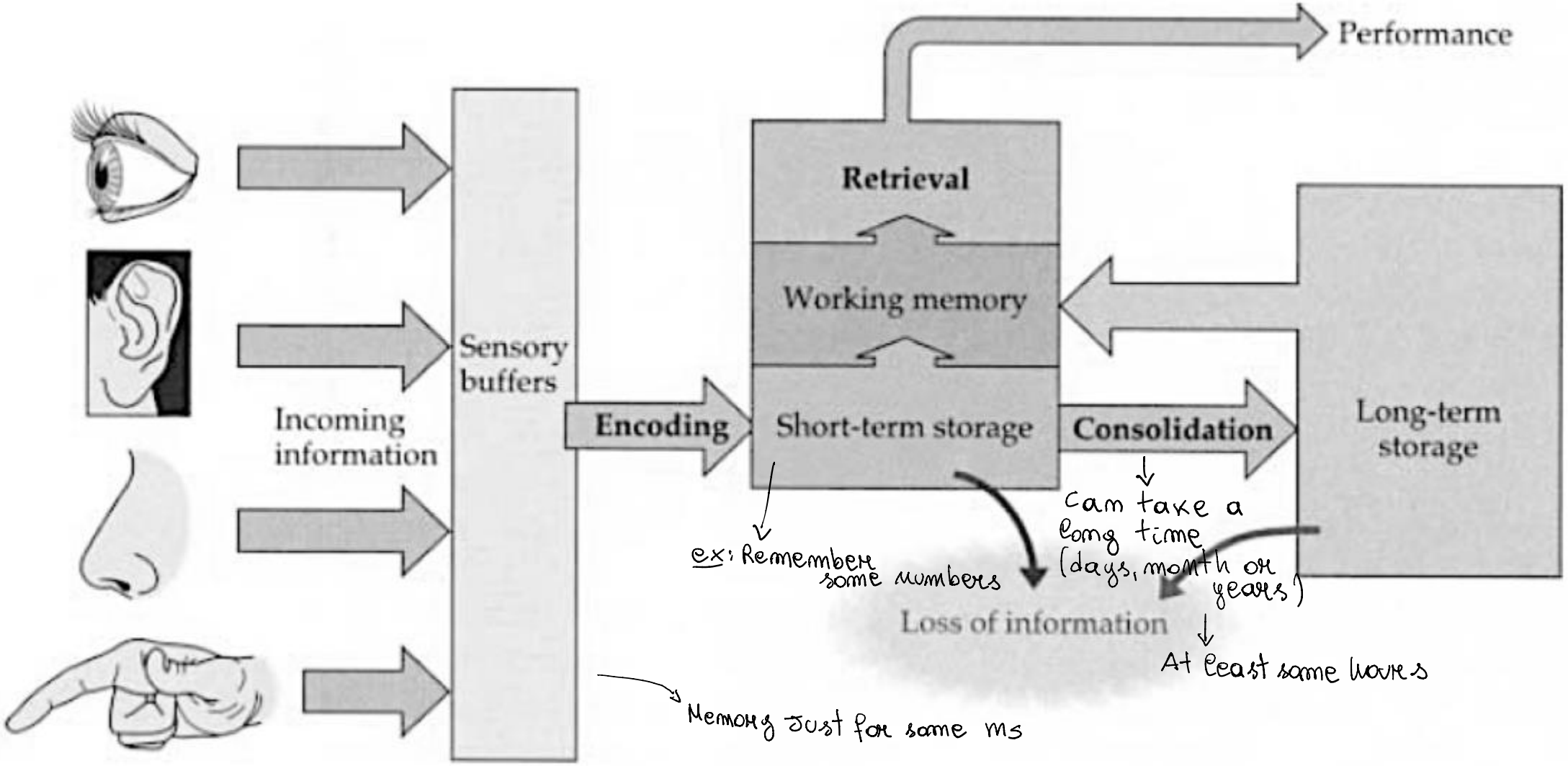
Not only 5 sense. Introspective qualcosa (informazioni da come ti senti)



Min ~ 5

Model of memory processing: Attkinson and Shiffrin

Memory doesn't work very well.
Prob: weaken, lose or alter



Short-term memory / Working memory

info. maybe used by our brain

strongly related

Short-term memory is the brain's temporary storage for a small amount of information that can be actively recalled for a brief period and is essential for tasks like holding a phone number or maintaining a conversation.

The concept of **working memory** replaces the older concept of short-term memory, marking a stronger emphasis on the notion of manipulating information rather than mere maintenance.

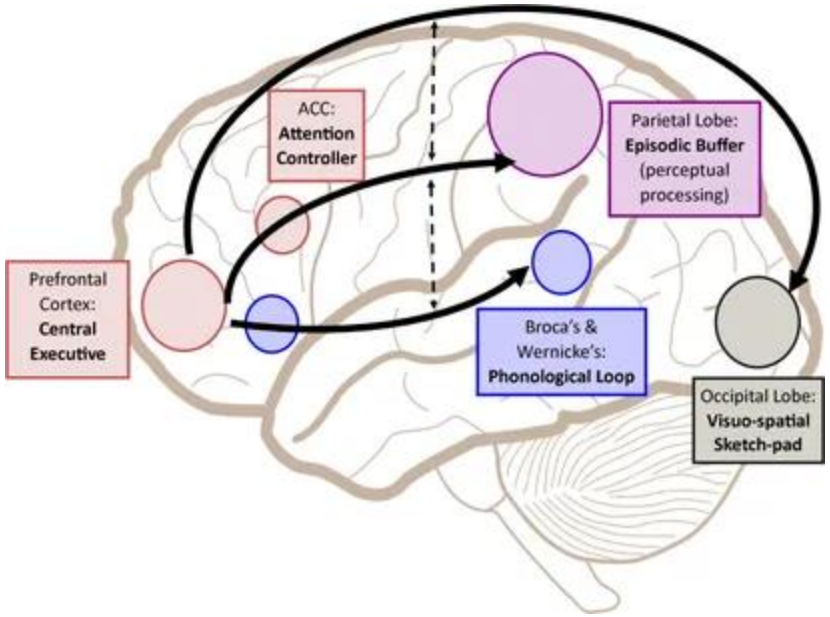
Simu. RAM

During a conversation

> Ti ricordi fino a solo 6-7 numeri/parole

Characteristics:

- **Limited Capacity**: It can hold only a small amount of information at a time.
- **Brief Duration**: Information is retained for a short period, usually a few tens of seconds, though this can extend to a few minutes with rehearsal or active attention.
- **Active and Accessible**: The information is held in an active, readily available state for immediate use.
- **Temporary Storage**: It serves as a temporary space for information before it is forgotten or transferred to long-term memory.



The memory of dreams

1h.15

Report

Altered during ↑ sleep

Encoding

working memory

Retrieval

Generation

in order to keep it, we need to use it and this help stabilize it.

16.20

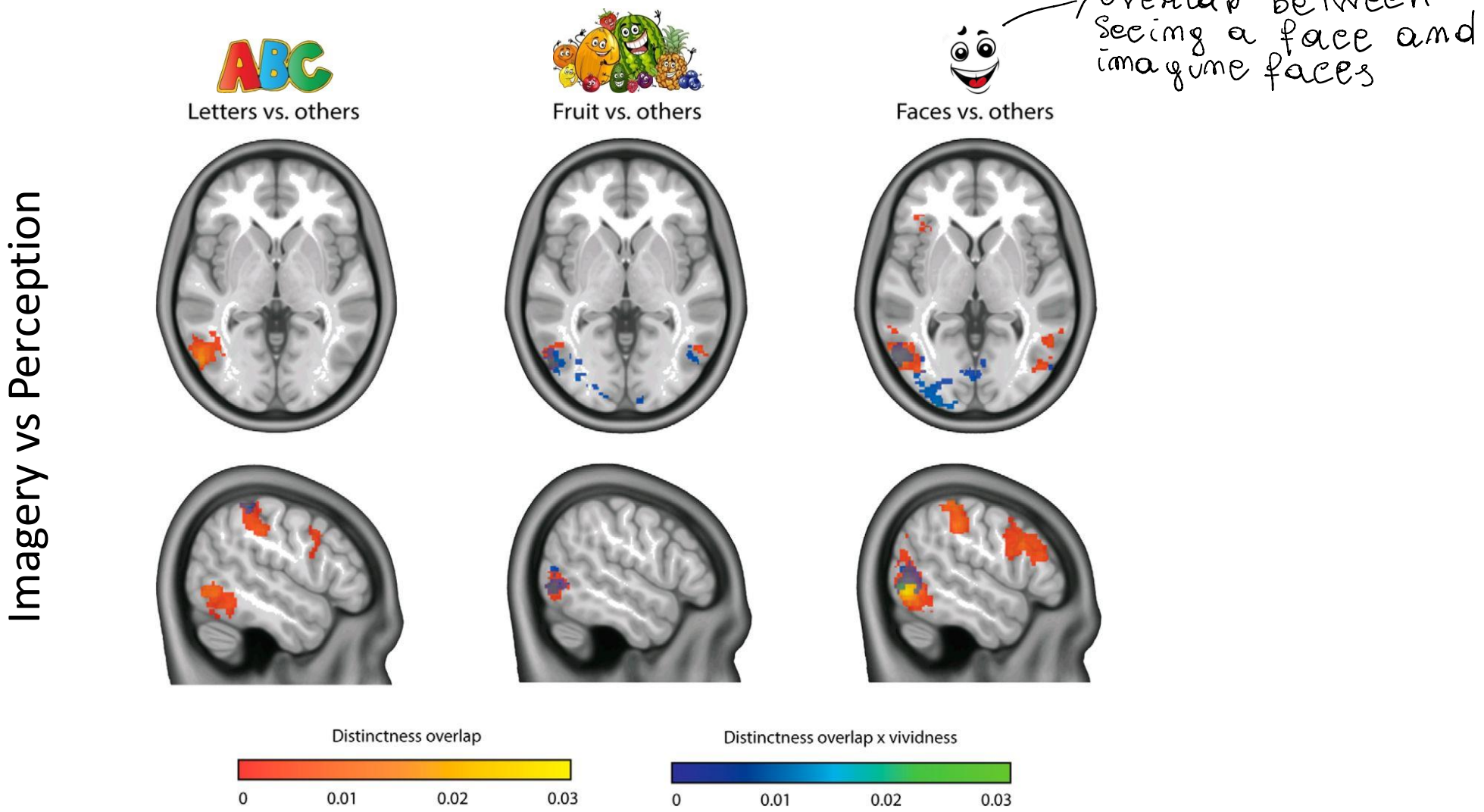
Acquiring information about the world

Memory before 6, generally are fake. Created by us, partendo da roba detta dai genitori/foto

Retinally blind people can both imagine and dream visually if they become blind after 6-7 years of age.

Perception vs Imagery

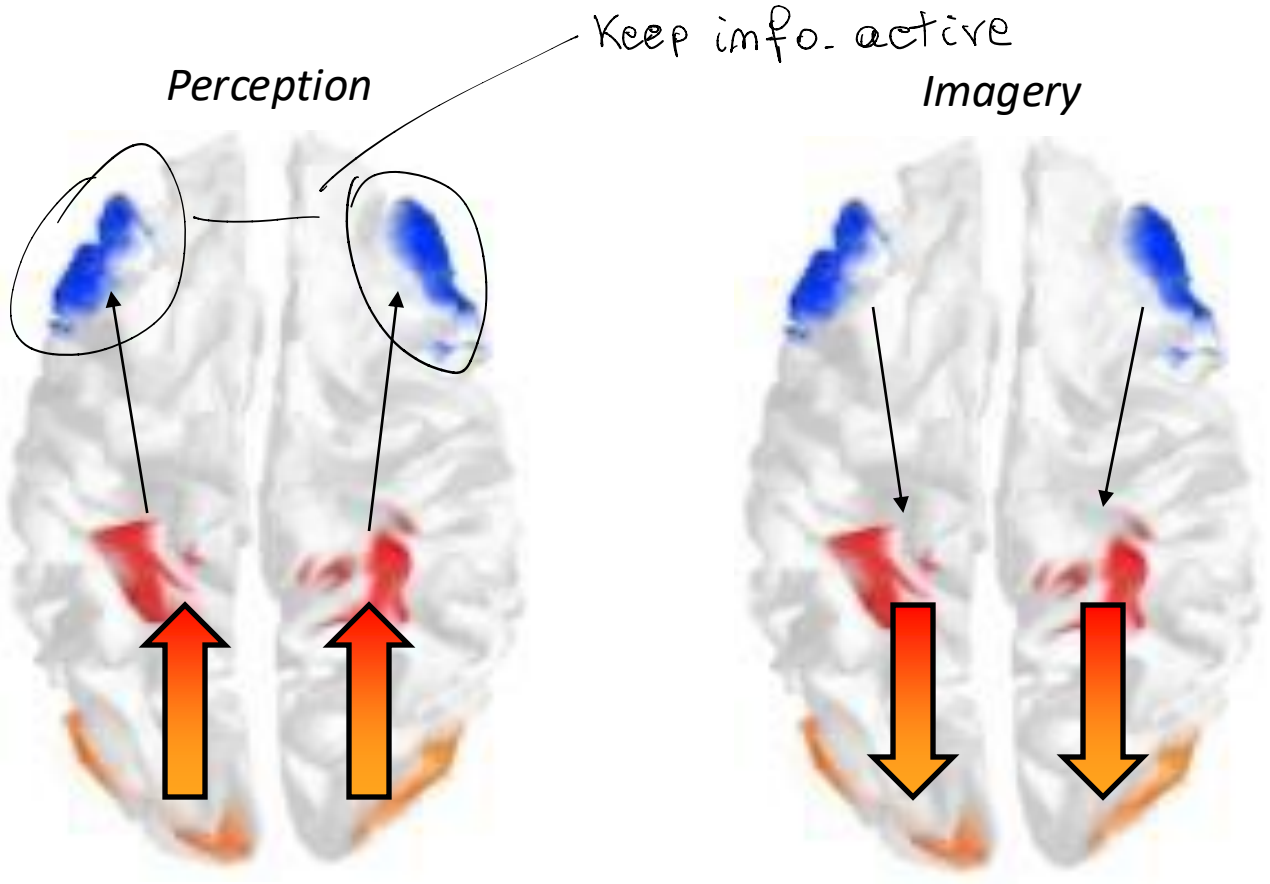
17.43



Dijkstra et al., J Neurosci, 2017

19:30

Perception vs Imagery

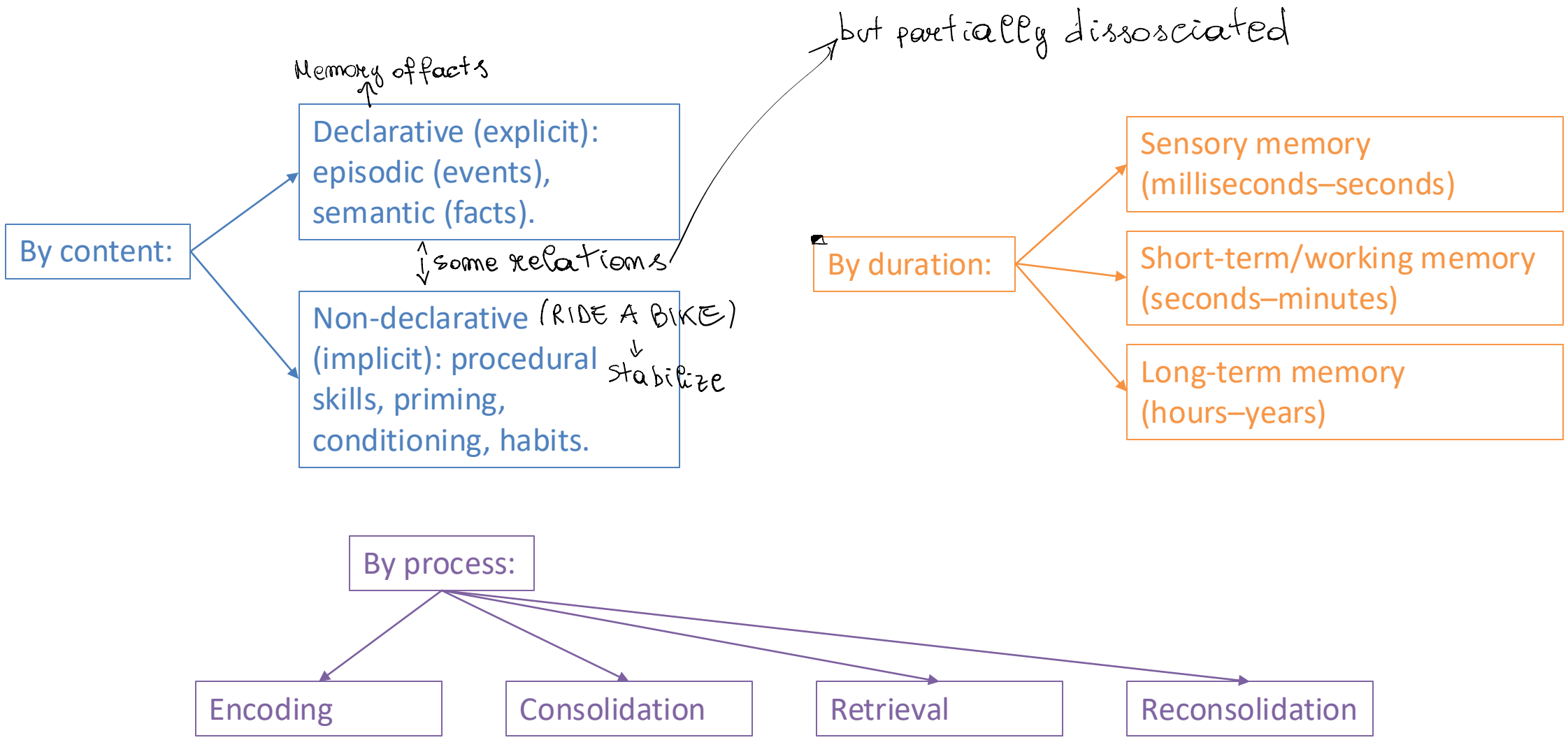


And in Dreams?

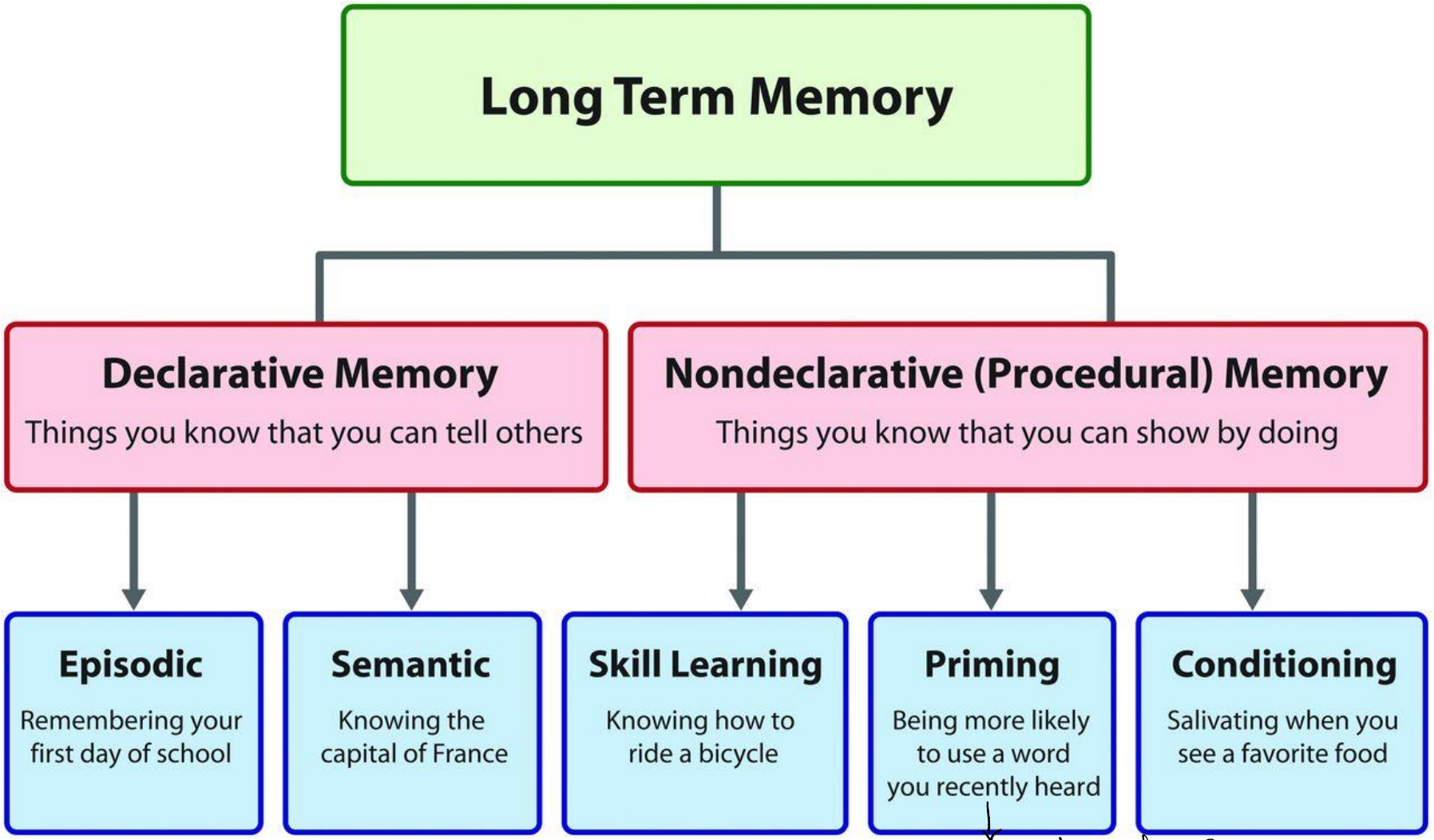
Connectivity analyses showed increased top-down signal flow in parieto-occipital cortices during mental imagery as compared to visual perception.

Dentico et al., NeuroImage, 2017

Memory: Definitions



Memory: Definitions



26:30

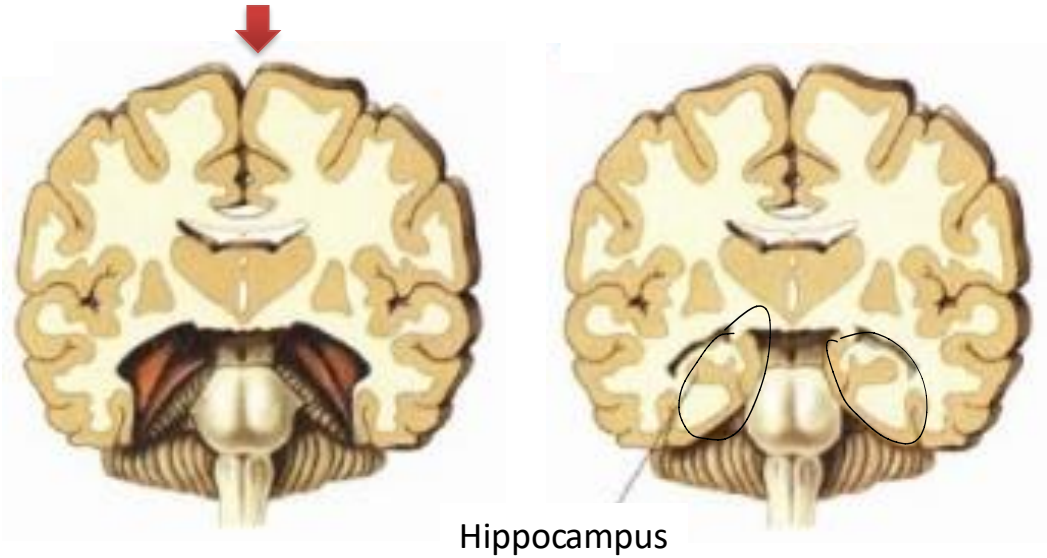
Henry Gustav Molaison (H.M.)

It was impossible to acquire new memory, only short-term

Patient: **H**enry Gustav **M**olaison (1926 –2008)

Start in the hippocampus

Henry Molaison had brain surgery in August 1953 (for epileptic seizures) when he was 27 years old. For 55 years Henry participated in numerous experiments, primarily at Massachusetts Institute of Technology (MIT).



Hippocampus

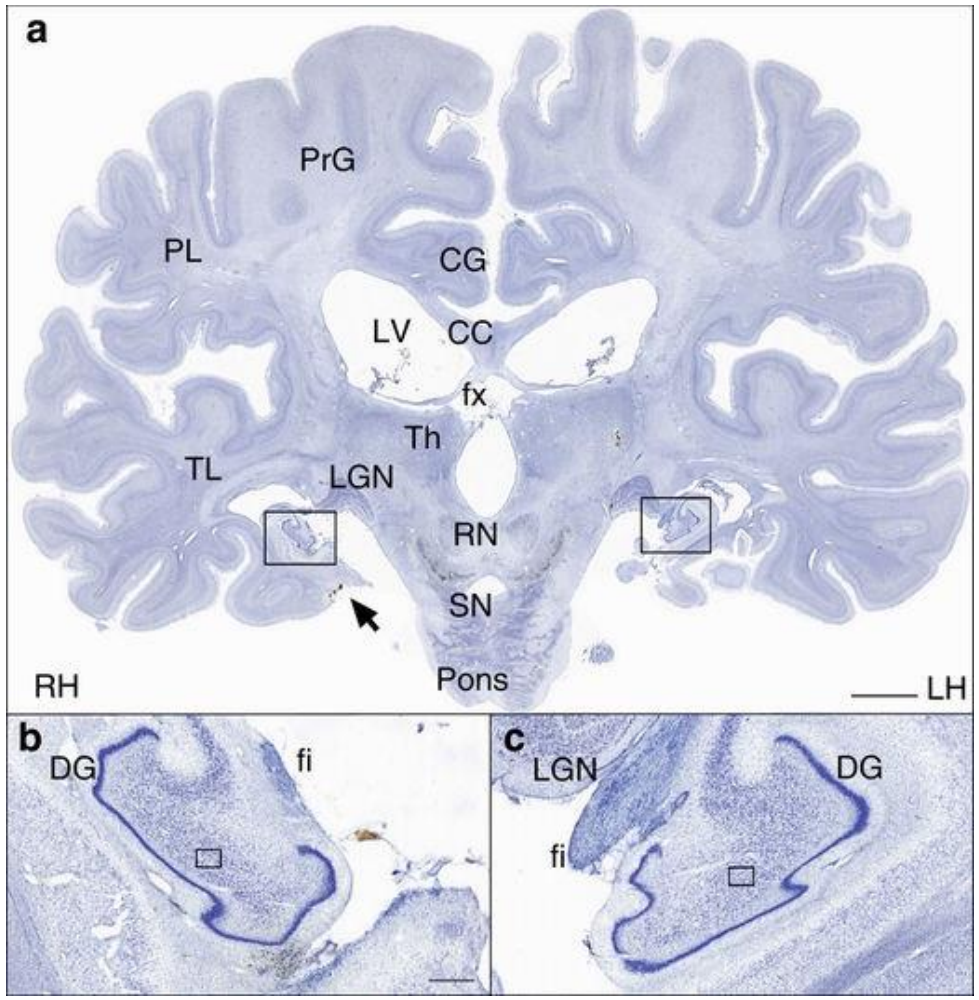
Permanent anterograde amnesia due to bitemporal resection performed in an attempt to cure epilepsy

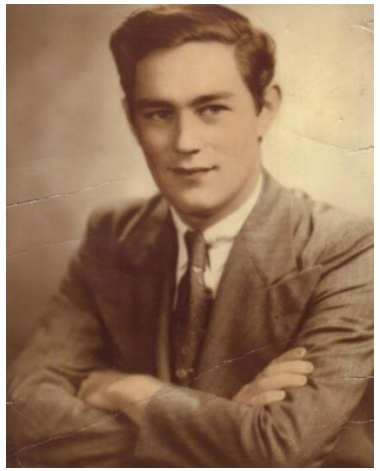
29:30

The hippocampus

Ippocampus ~ not All destroyed, cut connection

Patient: **H**enry Gustav **M**olaison (1926 –2008)





http://brainandsociety.org/patient-hm/

The posterior portion of the hippocampus escaped the ablation. Only a very minimal amount of Entorhinal Cortex survived in H.M.'s brain. The EC (via its superficial layers) is the gateway to the hippocampus for the inflow of information from the cerebral cortex and subcortical nuclei.

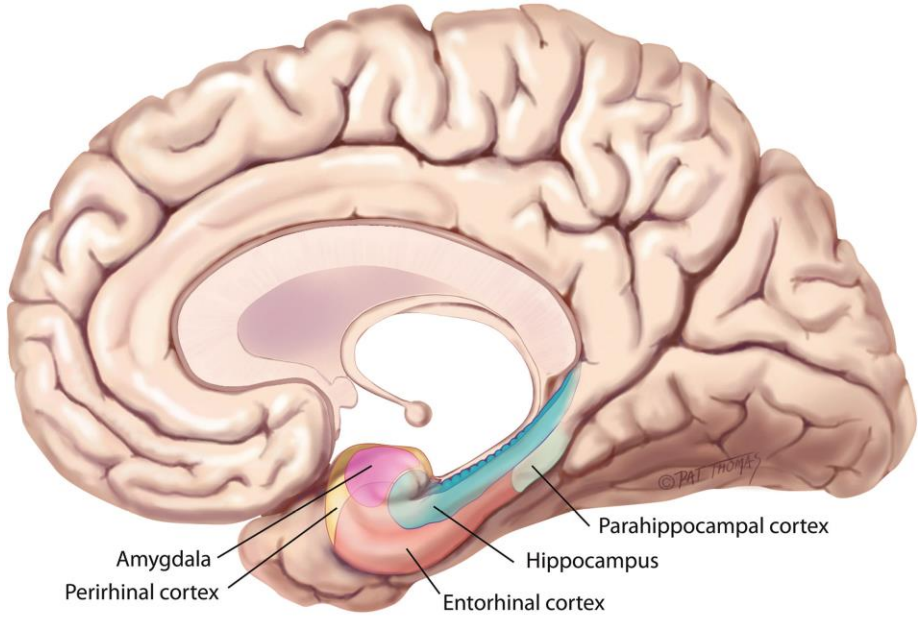
Annese al., Nat Comm, 2014

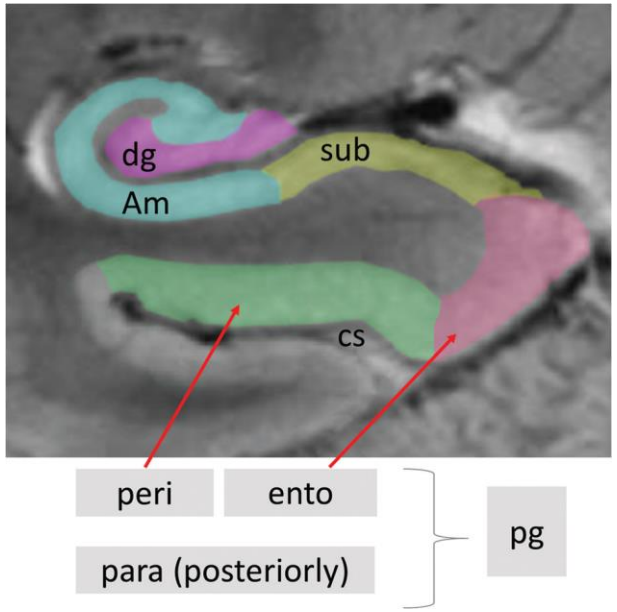
30:20

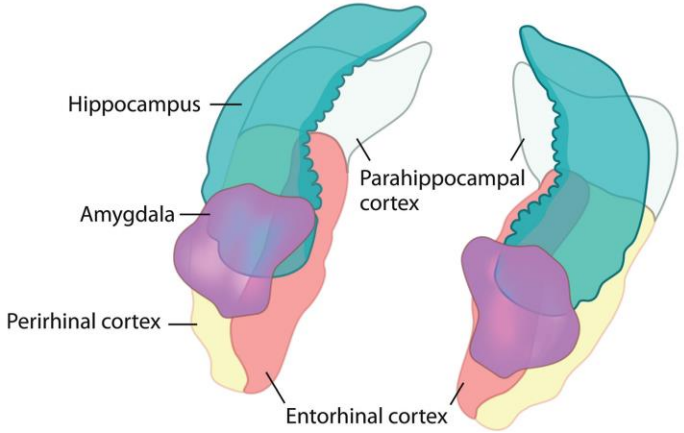
odor → retrive a memore
because ippo near amigdala → Facile accesso agli odori

The medial temporal lobe

it's structure fondamental to acquiree info



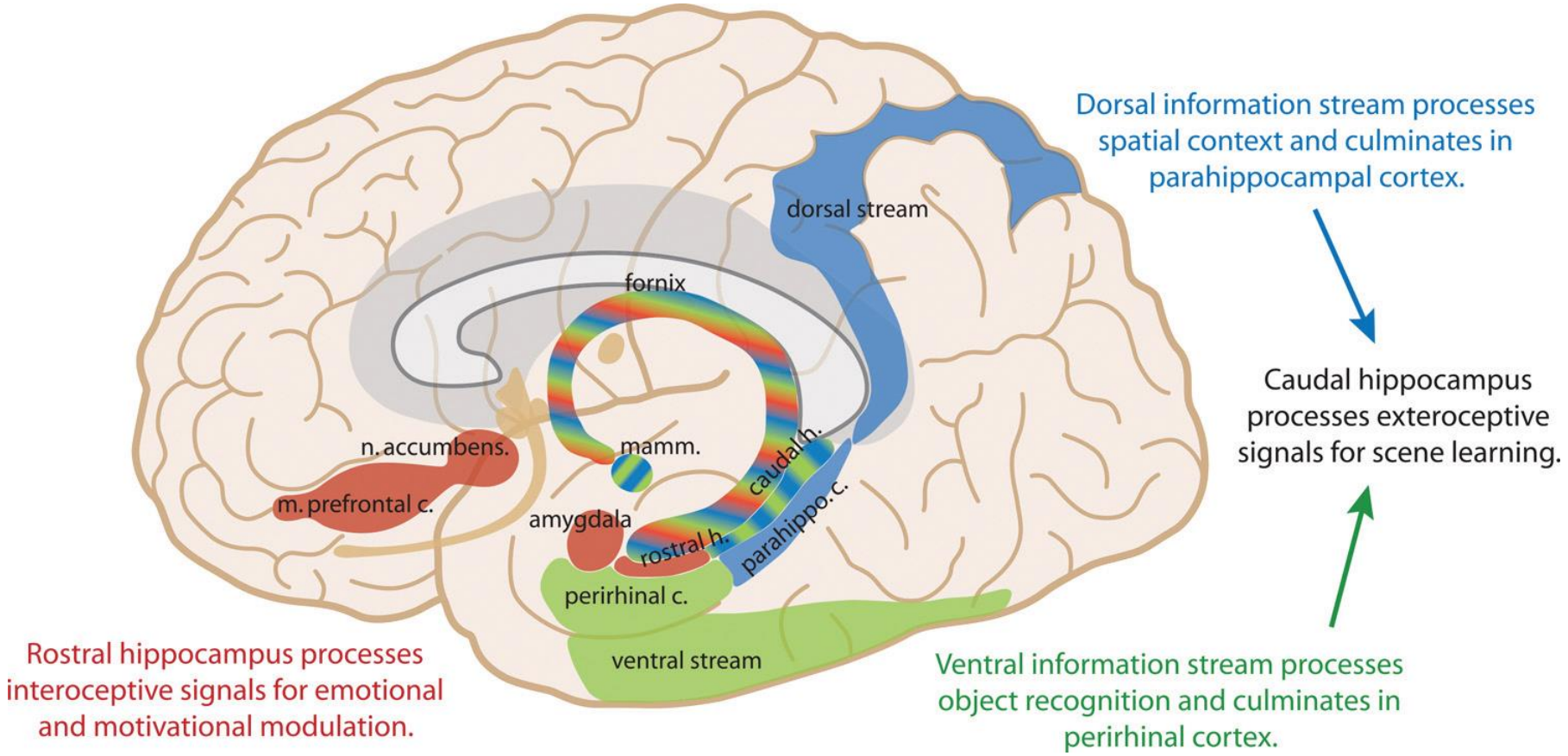




The **medial temporal lobe** consists of the **hippocampal formation** (blue-green) superiorly and the **parahippocampal gyrus** inferiorly. The **entorhinal** (brown) and **perirhinal** (yellow) cortices form the medial and lateral components, respectively, of the anterior portion of the parahippocampal gyrus, while the **parahippocampal cortex** (off-white) forms the posterior portion

32:30

The medial temporal lobe

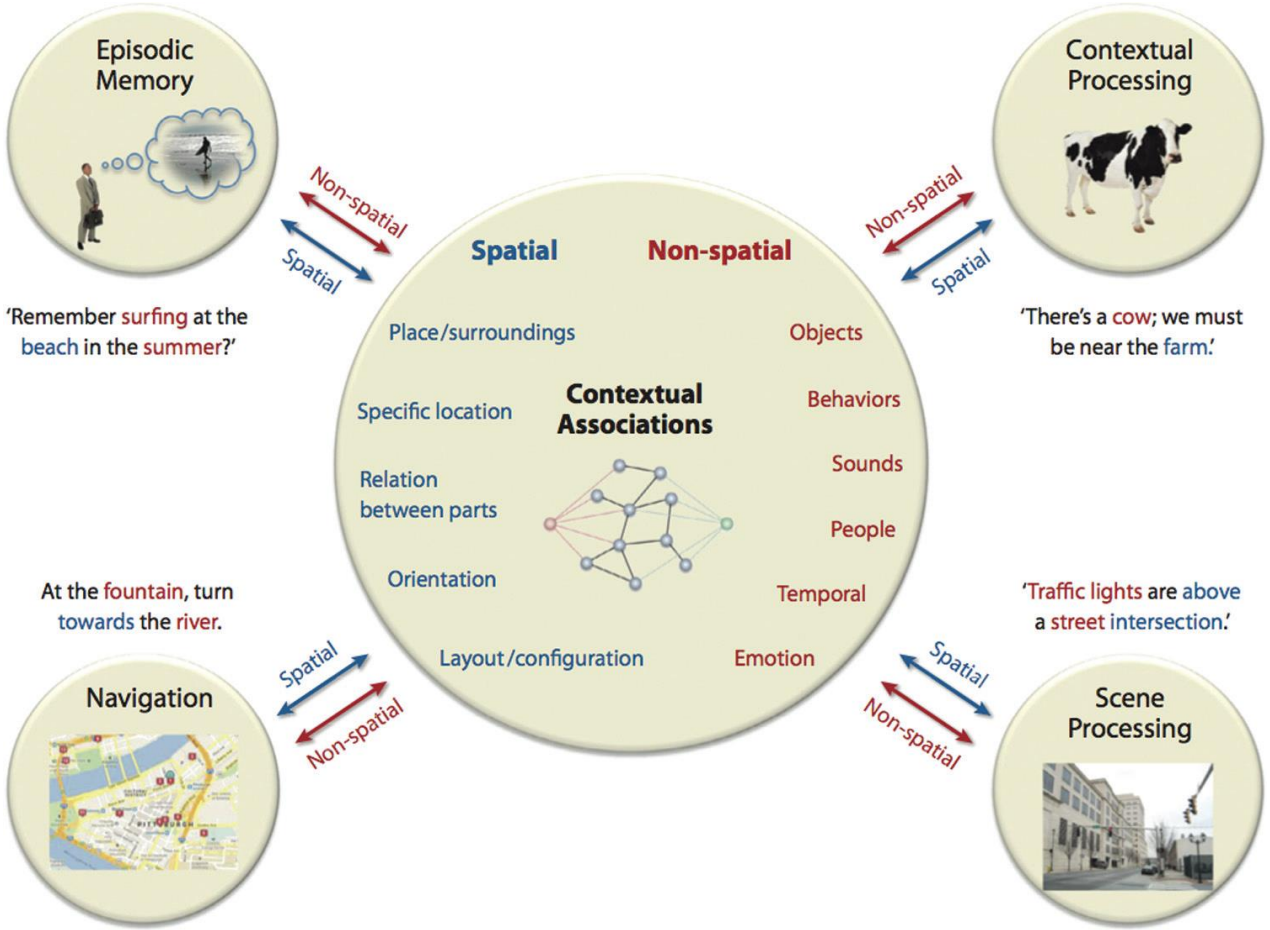


Exteroceptive (external to the organism) information is processed by the parahippocampal gyrus via the ventral and dorsal streams, respectively subserving object recognition and spatial context information. **Interoceptive** (internal to the organism) signals carrying information such as emotions and motivation from the medial prefrontal cortex, nucleus accumbens, and amygdala project to the rostral hippocampal formation and rhinal cortex regions.

33:40

The medial temporal lobe

Hippocampus save also the context and content



The **parahippocampal cortex** functions involve more than just spatial processing. The connections with the different areas of the frontal, parietal, and temporal lobes, including the default network, position the parahippocampal cortex as a critical component in processing **contextual associations**, which are fundamental aspects of higher cognitive functions.

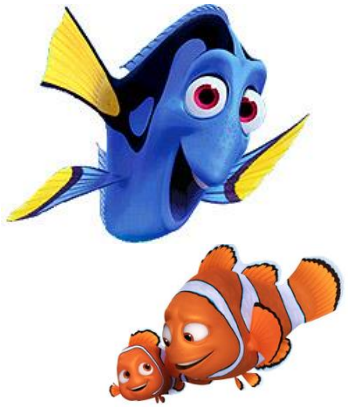
34:50

Hippocampus-independent memories

On each occasion that he was tested on the Famous Faces test (1974, 1977, 1980, 1988, 1989, 1990, 1994, 1997, and 2000) his performance never varied from between 0%-to-20% correct for photos taken after the onset of his amnesia (i.e., portraying people from the 1950s to 1980s). In control subjects the percentage is ~75% for the same period.

It is interesting to note that, for items from the 1940s and 1930s, H.M.'s performance exceeds the control group's mean performance of approximately 40% correct. This is perhaps because the remote memories of the neurologically healthy group have endured more interference over the years than have those of H.M.

Short-term vs. Long-term Memory



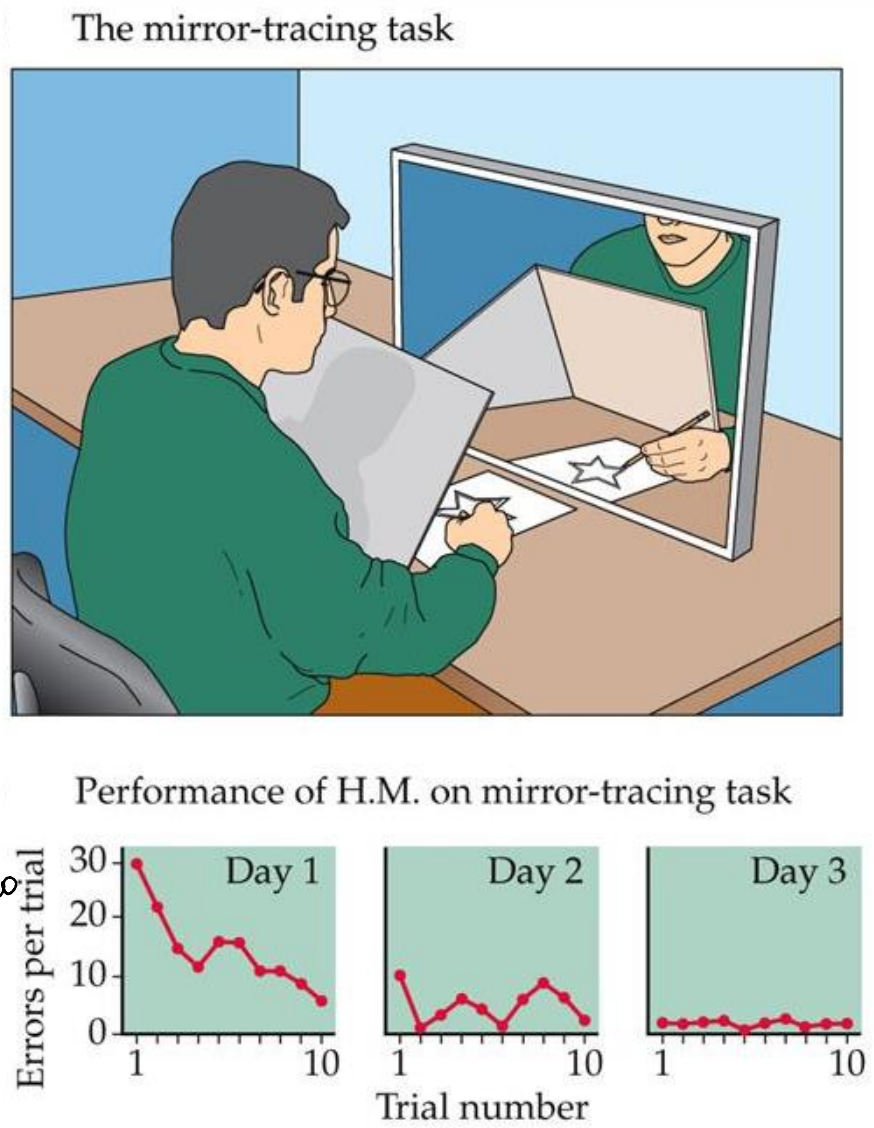
The patient is limited to the immediate present and to the content of his working memory.

"For Henry, it was as if time stopped when he was 16 years old, 11 years before his surgery. He never seemed to get tired of doing what most people would think of as tedious memory tests, because they were always new to him! When he was at MIT, between test sessions he would often sit doing crossword puzzles, and he could do the same ones again and again if the words were erased, as to him it was new each time."

He lost memory of some years before procedure (memorie ancora da consolidare)

Procedural vs. Declarative Memory

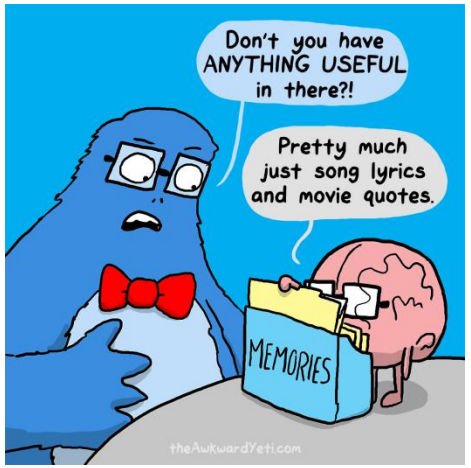
H.M. was able to form procedural memory



Bravo a fare la task ma manco si ricordava di averlo fatto.

Preserved working memory and intellectual abilities.

Maintained ability to acquire new visuo-motor skills (procedural/implicit memory).



Memory process

Encoding

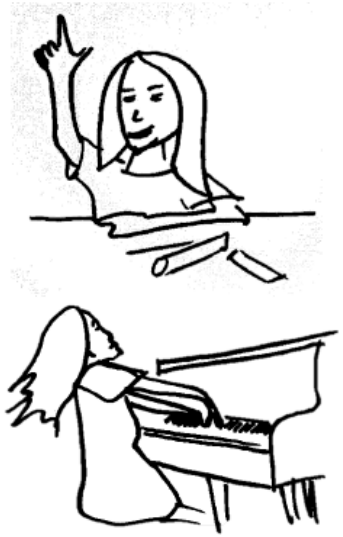
Information perception and processing

Learning

Consolidation

Retention and consolidation of information

Memory



Retrieval

Remembering and using stored information

Remembering

time

4d: 30

Engrams

1> consolidation
> they are not sure of what it is. Per questo lo hanno chiamato engram

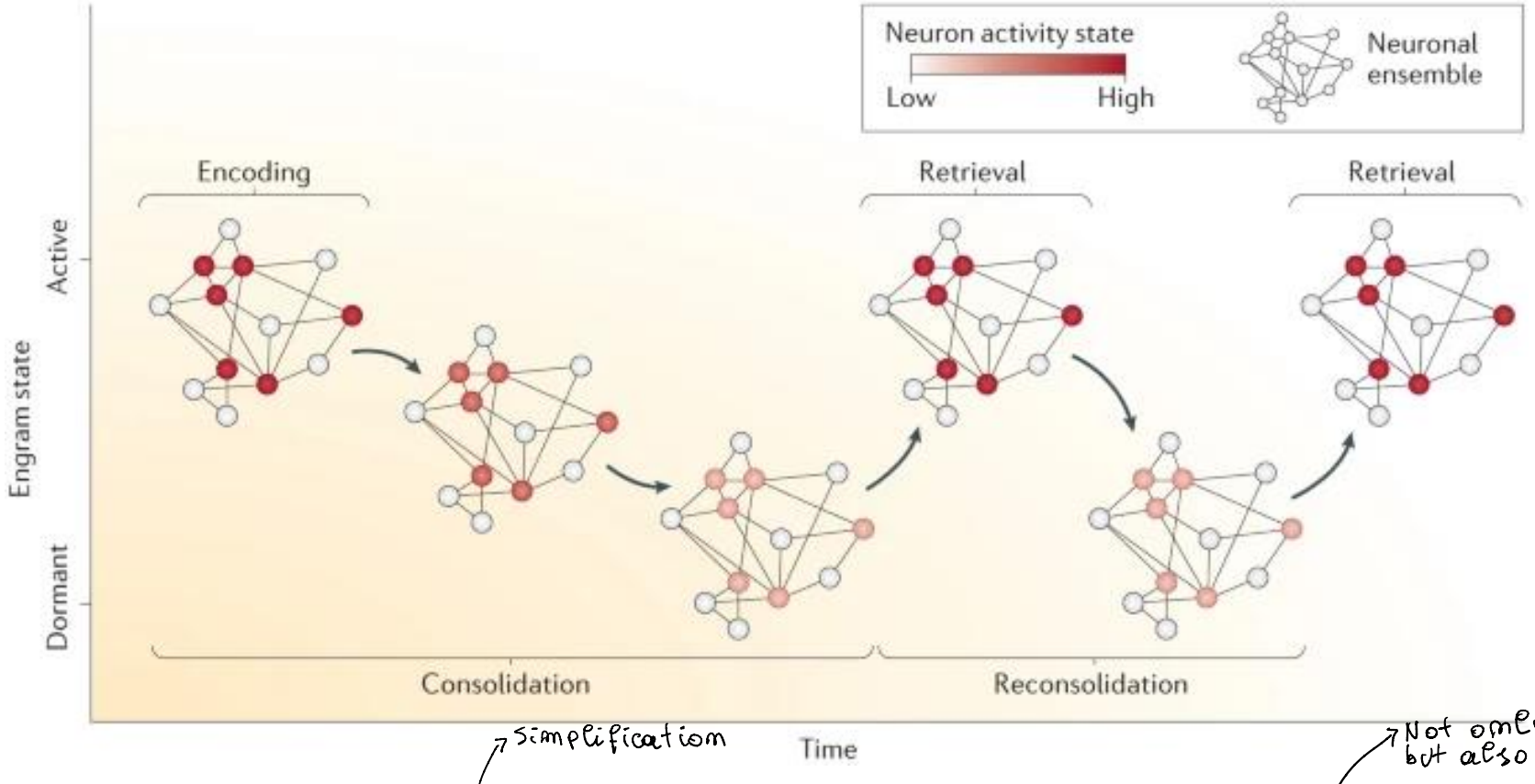
An **engram** is the **physical trace of a memory in the brain**. Semon (1921) suggested that an engram has four defining characteristics:

1) An engram is a **persistent change in the brain** that results from a specific experience or event.
2) An engram has the potential for ecphory; that is, an engram **may be expressed behaviourally** through **interactions with retrieval cues**, which could be sensory input, ongoing behaviour or voluntary goals.
3) The **content** of an engram reflects what transpired at **encoding** and predicts what can be recovered during subsequent **retrieval**.
4) An engram may exist in a **dormant state** between the two active processes of encoding and retrieval. That is, an engram exists beyond the operations and processes required to form and recover it.

An engram provides the necessary **physical conditions for a memory to emerge**.

Engrams ~ change of strength in connection

45:30



simplification

Not only neurons (for se) but also astrocyte

The **formation of an engram** (**encoding**) involves strengthening of connections between collections of neurons (neuronal ensemble) that are active (red) during an event. **Consolidation** further strengthens the connections between these neurons, which increases the likelihood that the same activity pattern can be recreated at a later time, allowing for successful memory retrieval. During consolidation, the engram enters a mainly dormant state. Memory **retrieval** returns the engram back to an active state and transiently destabilizes this pattern of connections. The engram may be restabilized through a process of **reconsolidation** and re-enter a more dormant state.

48:50 ci ritorna all'inizio secondo Audio

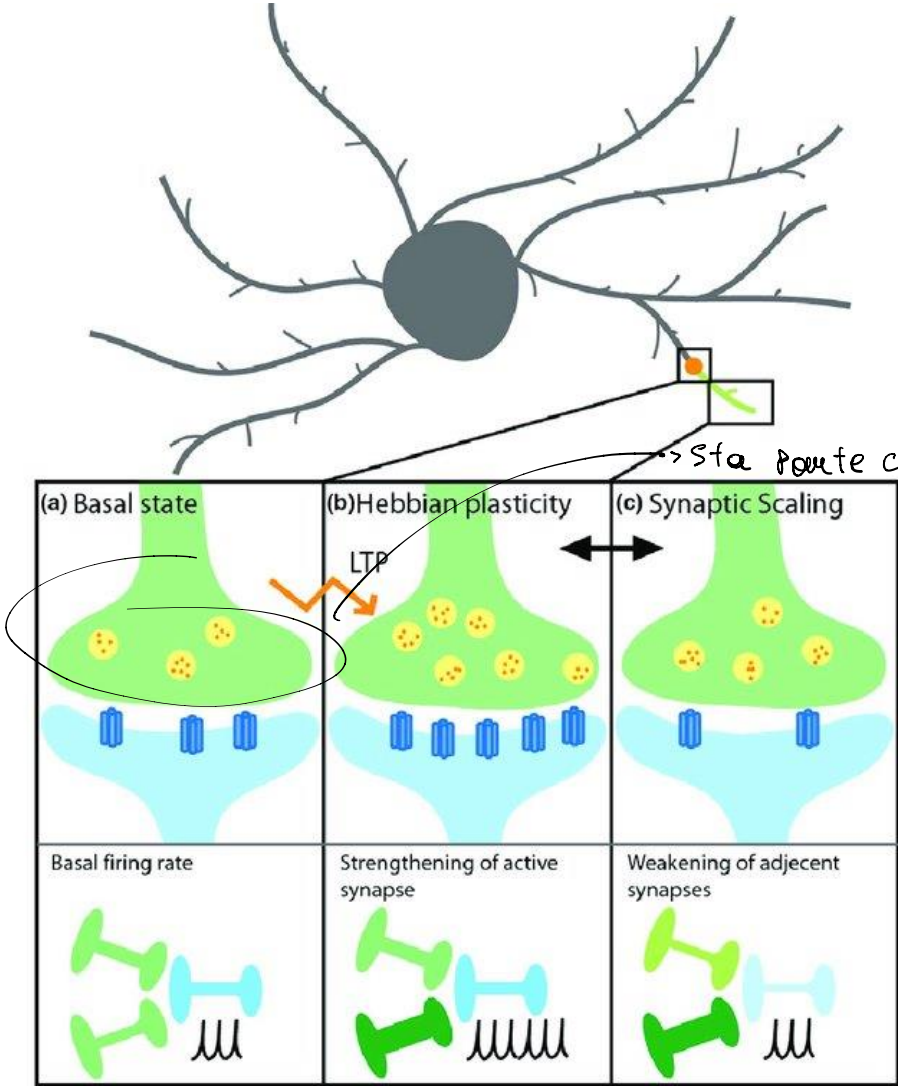
Hebbian plasticity

Allora, credo che: i neuroni che generano un immagine si connettono in un determinato modo. io ricordo quel collegamento.

Donald Hebb (1949): "*neurons that fire together wire together*"

Encoding occurs as connections between neurons are established through repeated use

Long-term potentiation (**LTP**): persistent strengthening of synapses based on recent patterns of activity that produce a long-lasting increase in signal transmission between two neurons. The opposite of LTP is **long-term depression** (**LTD**), which produces a long-lasting decrease in synaptic strength.



→ Sta parte cambia modificando il collegamento

Anche gli astrocyte possono modificarsi (ci vuole tempo)

Synaptic Plasticity

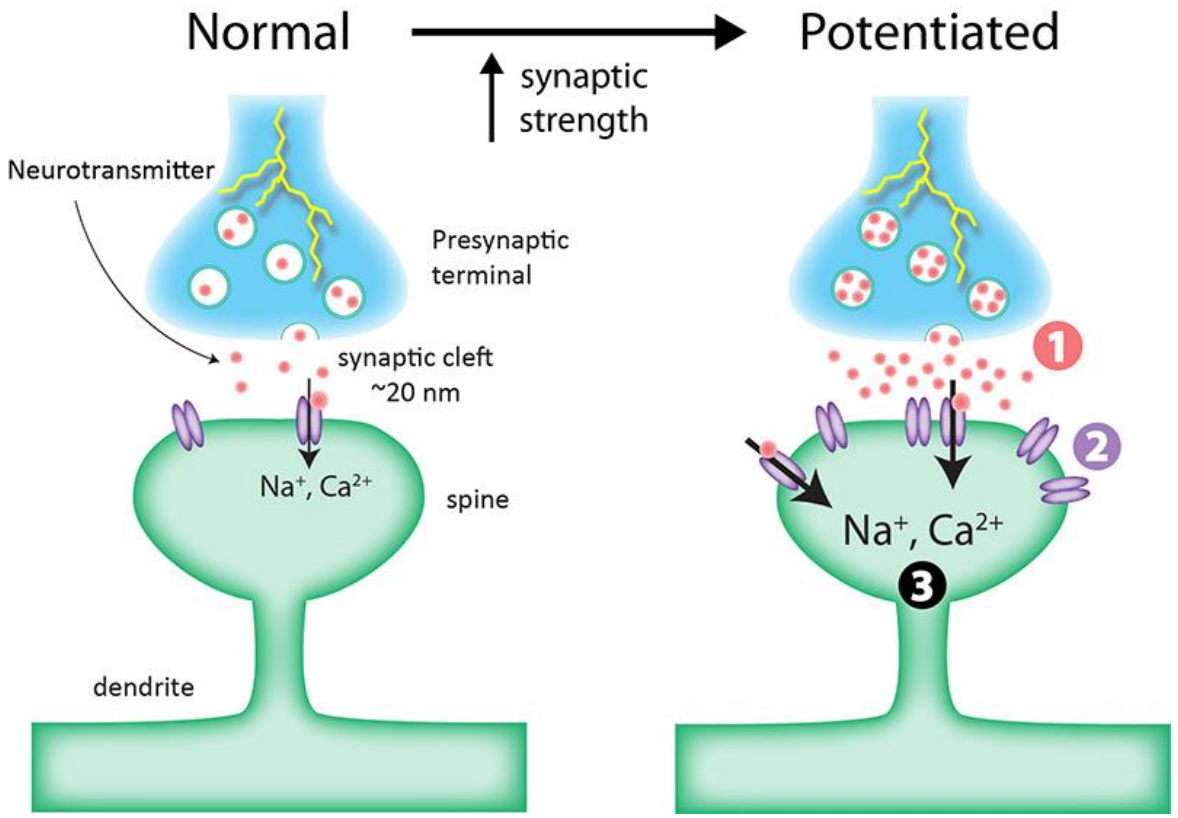
i thing that may lead to change is to see something many time

Synaptic plasticity: ability of the brain to strengthen, weaken, destroy and create neural synapses as the basis for learning.

The effect of a learning experience depends on the content of such an experience. Reactions that are **favored** will be **reinforced** and those that are deemed **unfavorable** will be **weakened**.

Short term: strengthening or weakening of a connection by modifying the preexisting proteins leading to a modification in synapse connection strength.

Long term: new connections may form or the number of synapses at a connection may be increased, or reduced.

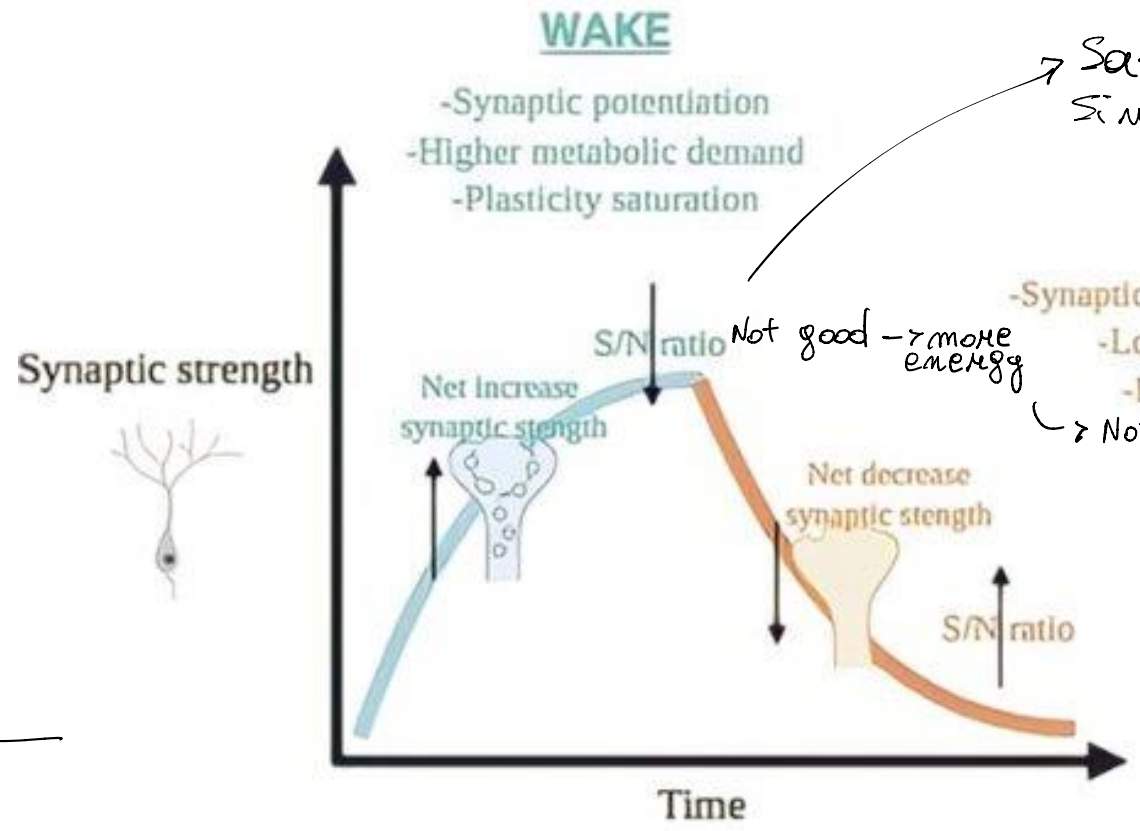


Homeostatic plasticity

T56.40

sta roba è una teoria
↓
Supposizione da studi animali

Negli uomini io potresti fare con il TMS (strong connection → TMS si propaga bene)
↓
Mentre dormi non succede



→ Saturation of Sinapsis

Not good → more energy

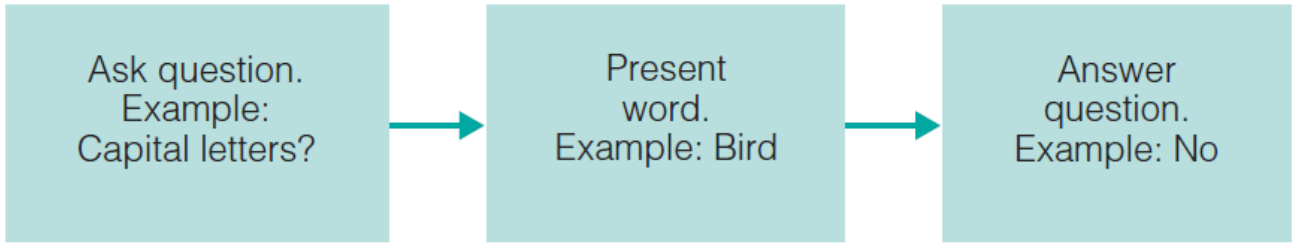
↳ Not sustainable for a long time

→ Sleep (?)

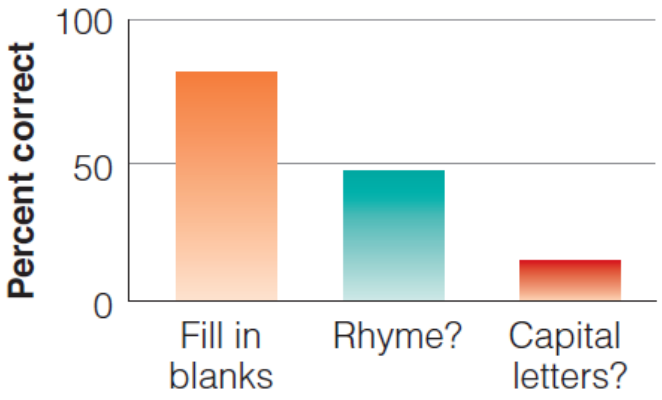
l'idea è che durante il giorno hai tanto segnale utile → SNR (good)
di notte hai poco segnale utile SNR (Bad)

Synaptic potentiation during **waking** is connected to a **homeostatic increase in slow-wave activity** (SWA) during sleep, during which the systematic normalization of synaptic strength (**synaptic downscaling**) takes place. Larger and most potentiated synapses may remain unscaled. **Weak connections may be eliminated**, whereas the relative strength of the remaining connections is preserved.

Levels of processing



(a)



(b)

1. **Shallow** processing: A question about **physical features**
Question: Is the word printed in capital letters?
Word: bird
2. **Deeper** processing: A question about **rhyming**
Question: Does the word rhyme with train?
Word: pain
3. **Deepest** processing: A **fill-in-the-blanks** question
Question: Does the word fit into the sentence "He saw a on the street"?
Word: car

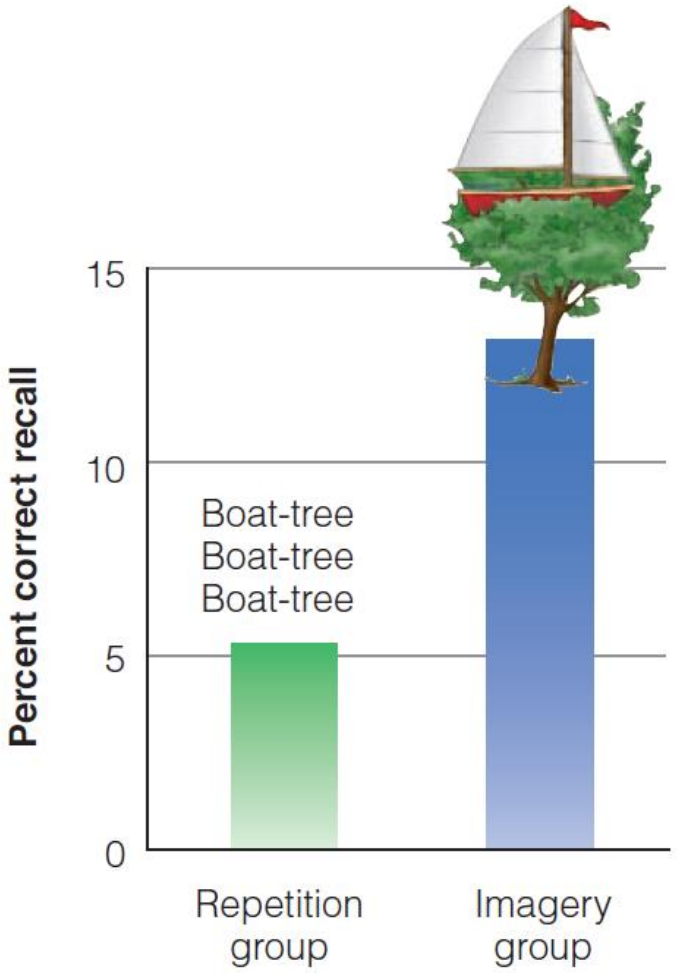
The deeper the processing, the better the memory (Tulving & Craig, 1975).

1:09:30

Imagery

It's easier to remember something —> using visualization

Tecnica usata in tecniche di memoria

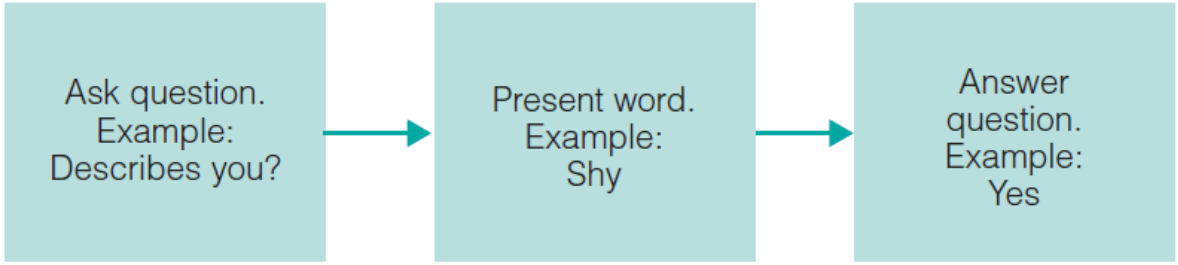


Visual imagery of the learning content helps with encoding.

Bower & Winzenz 1970

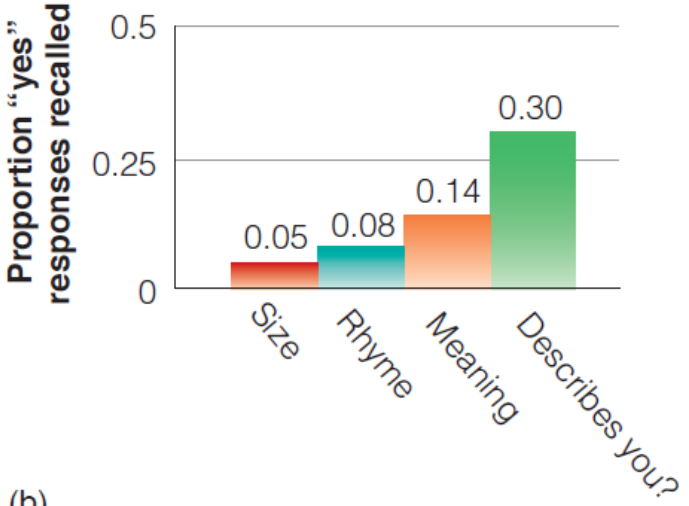
Self-reference

1:12



Effect of self-reference: Creating reference to the self facilitates learning!

(a)



(b)

1. Physical characteristics of word
   "Printed in small case?
   Word: *happy*
2. Rhyming
   "Rhymes with *happy*?"
   Word: *snappy*
3. Meaning
   "Means the same as *happy*?"
   Word: *upbeat*
4. Self-reference
   "Describes you?"
   Word: *happy*

Quanto ci pensi

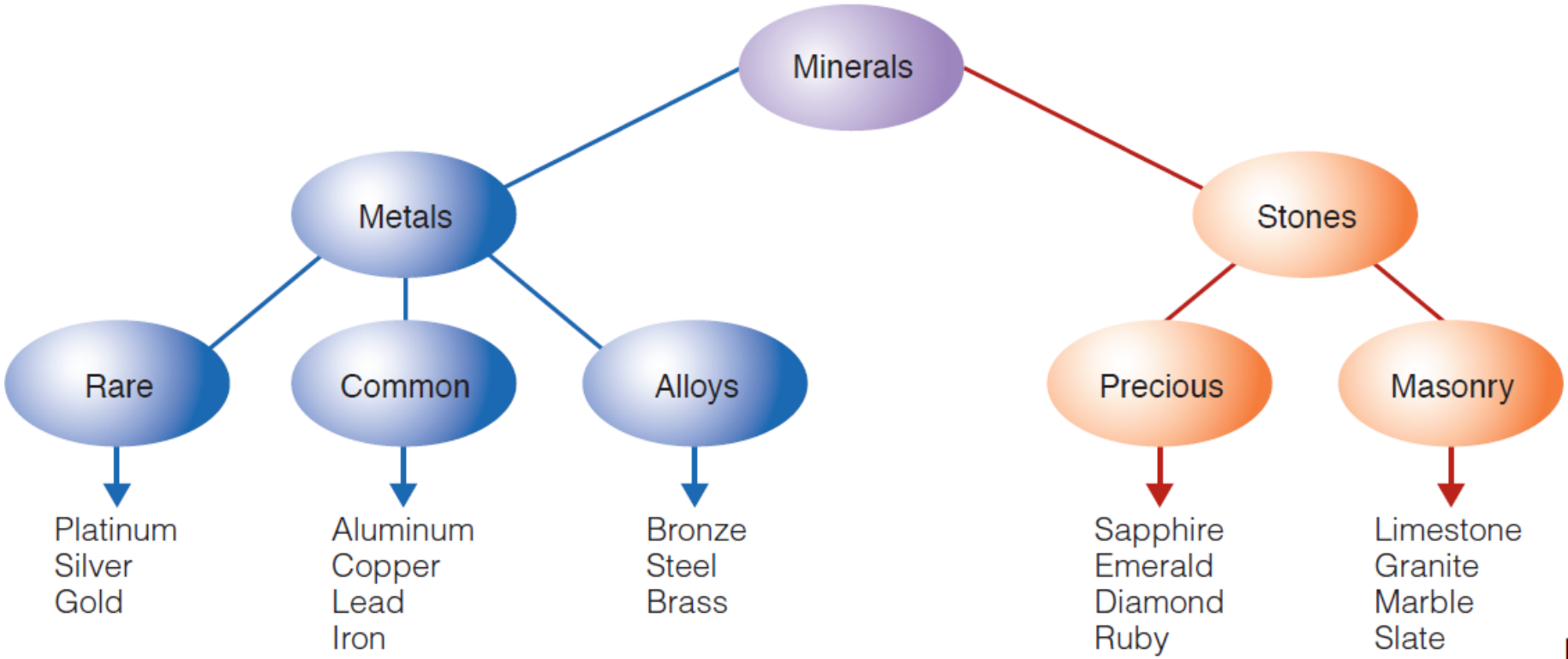
Rogers et al. 1977

Organization and structure

1:13:30

It's easier to learn & > clustering them

Stucturing learning materials: Create good recall cues.

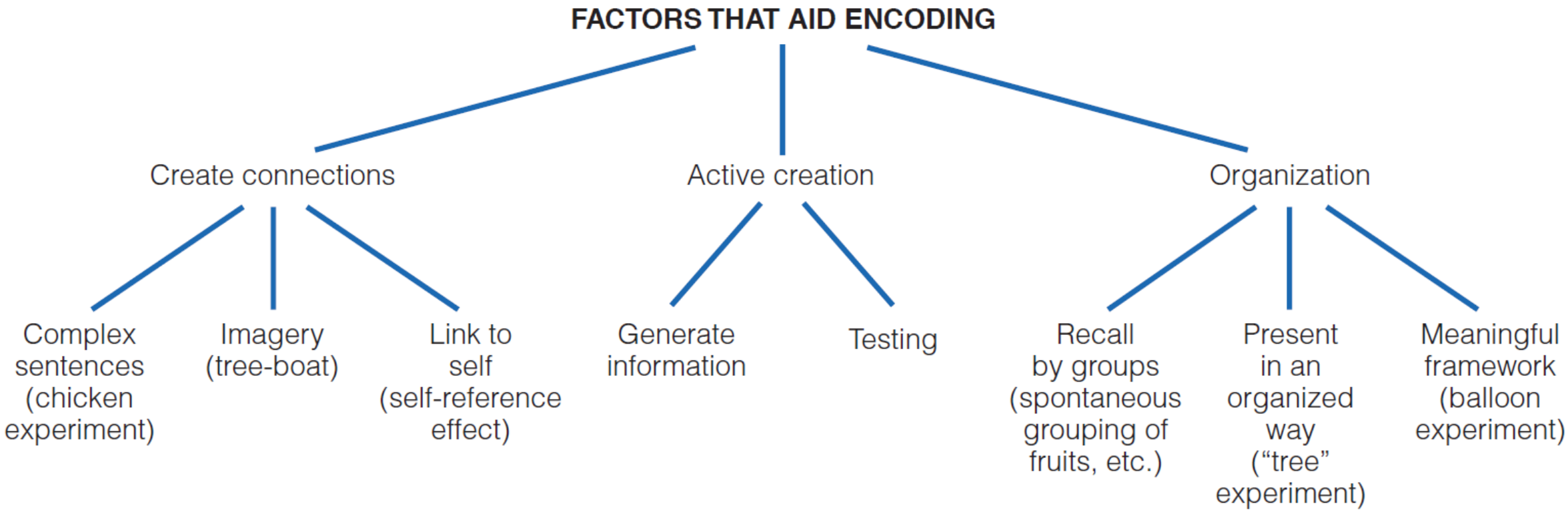


Bowers et al. 1969

73 words remembered with sensible sorting, only 21 with arbitrarily grouped into categories!

Factors that aid encoding

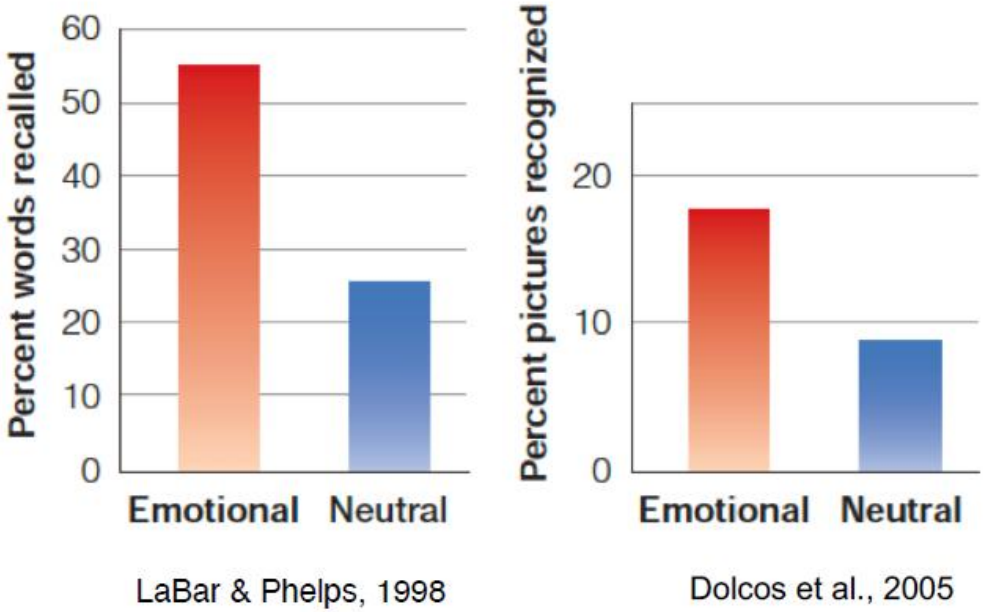
1:14:30



1:15:40 (FINE 1° AUDIO)

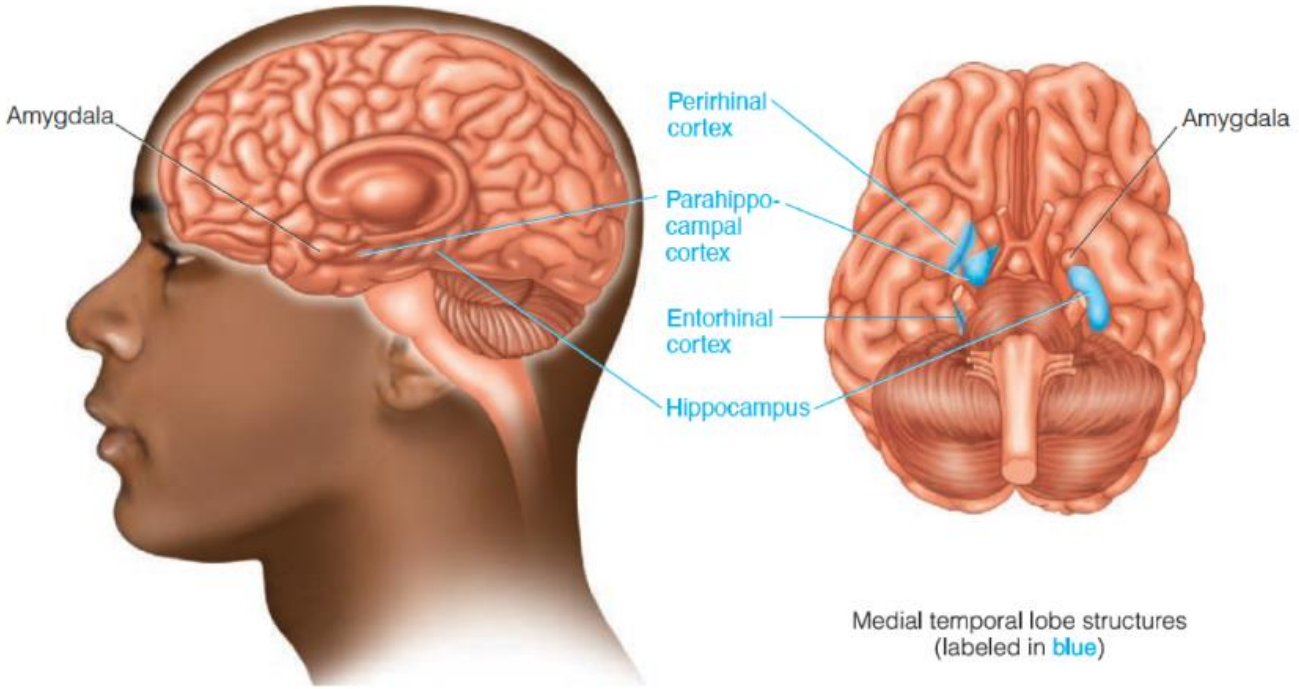
Emotional memory

IF something has an emotional charge -> it's easier to remember
PTSD -> esempio estremo di sta cosa

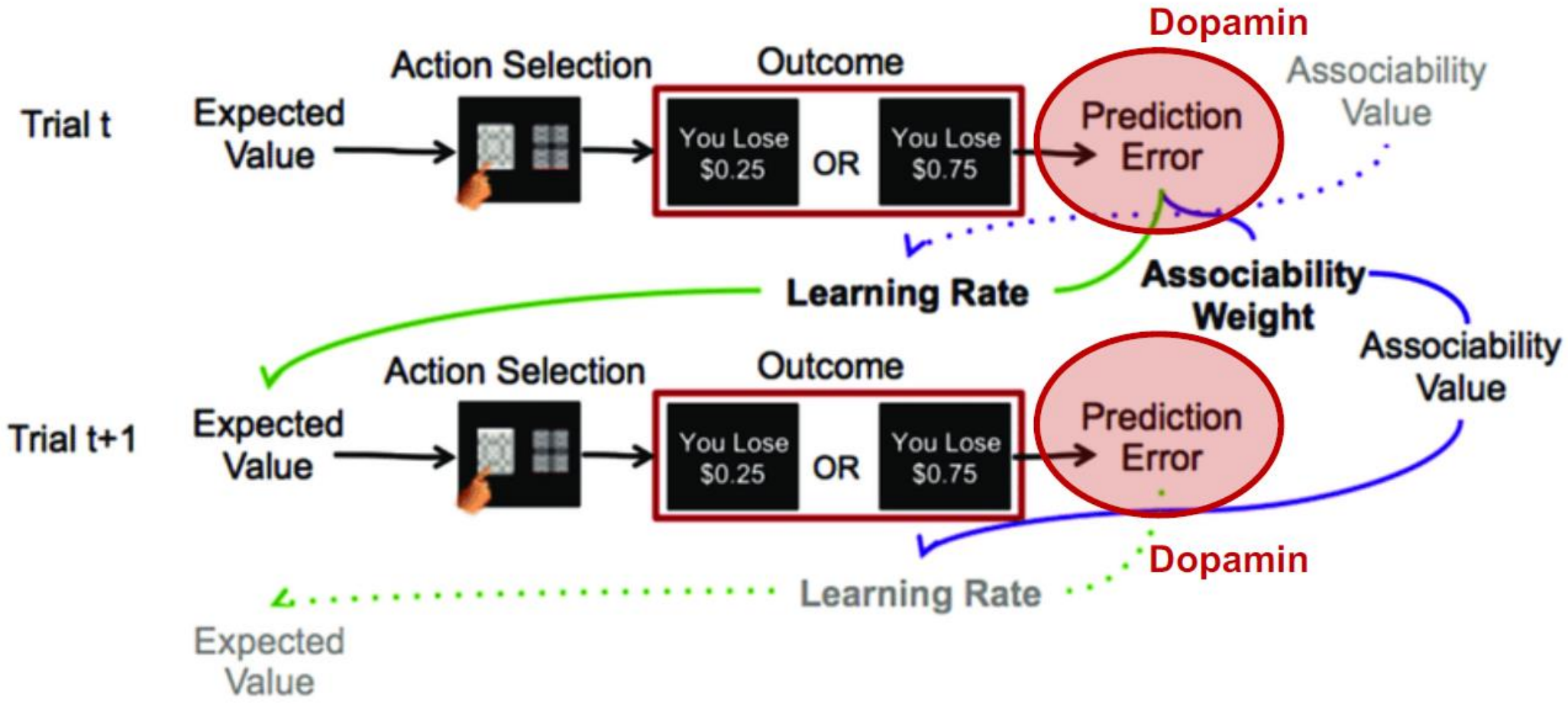


Kevin LaBar and Elizabeth Phelps (1998) tested participants' ability to recall arousing words (for example, profanity and sexually explicit words) and neutral words (such as street and store) immediately after they were presented

Florin Dolcos and coworkers (2005) tested participants' ability to recognize emotional and neutral pictures 1 year after they were initially presented and
observed better memory for the emotional pictures



Reinforcement Learning and Prediction Errors



2 min

Flashbulb Memories

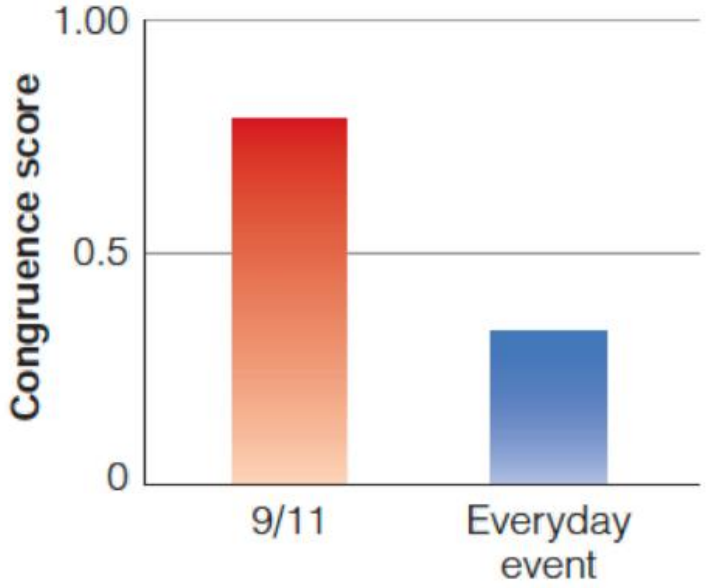
ESEMPIO: Tutti si ricordano cosa stavano facendo quando è accaduto il 9/11

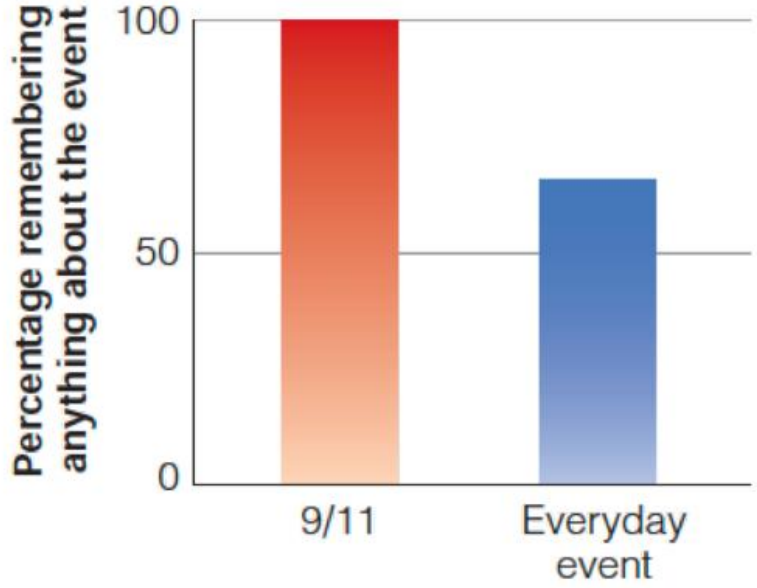
Flashbulb memory: a vivid, detailed, and enduring memory of the circumstances in which someone first learned about a surprising, emotionally arousing, or consequential event.

Key Features:

- **Vividness**: People often recall memories with a strong sense of detail (where they were, who they were with, what they were doing).
- **Emotional intensity**: Typically tied to highly emotional or shocking events (e.g., personal tragedies).
- **Confidence**: Individuals are usually very confident about the accuracy of these memories.
- **Content**: Often includes contextual details (location, time of day, ongoing activity, emotional reactions).

Flashbulb Memories





"How did you hear the news?"
"Where were you when you heard about the attack?"
"Who was present?"
They also had the participants answer the same questions for an everyday event.

05:30

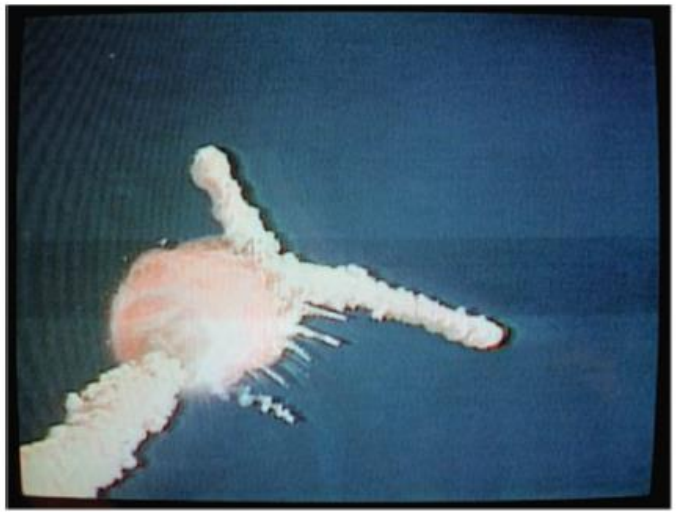
Flashbulb Memories

I was in my religion class and some people walked in and started talking about [it]. I didn't know any details except that it had exploded and the schoolteacher's students had all been watching, which I thought was so sad. Then after class I went to my room and watched the TV program talking about it, and I got all the details from that.

Two and a half years later, her memory had changed to the following:
When I first heard about the explosion I was sitting in my freshman dorm room with my roommate, and we were watching TV. It came on a news flash, and we were both totally shocked. I was really upset, and I went upstairs to talk to a friend of mine, and then I called my parents.

↓

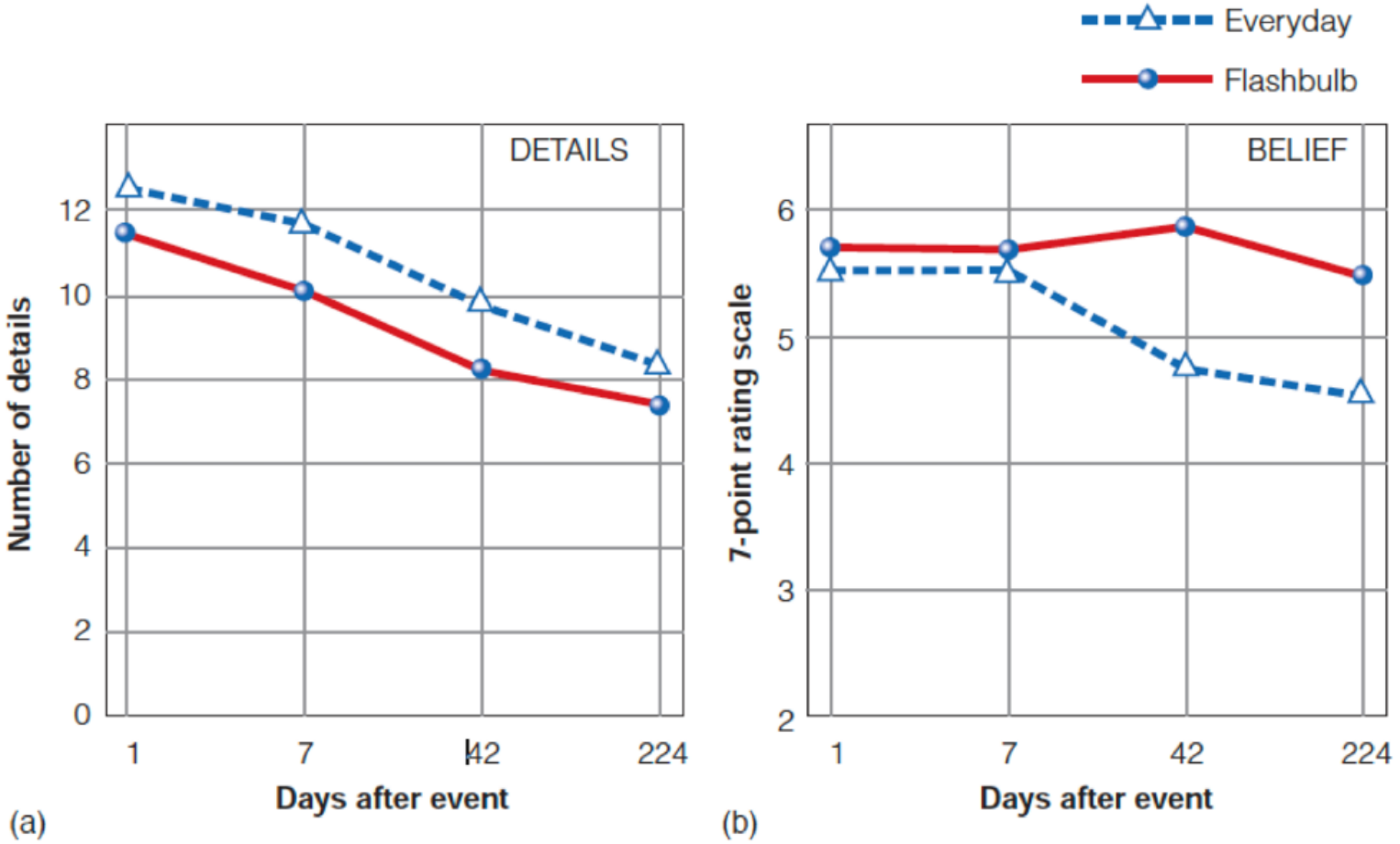
Probably she removed the first part of the memory



Challenger spaceshuttle
Explosiom

Flashbulb Memories

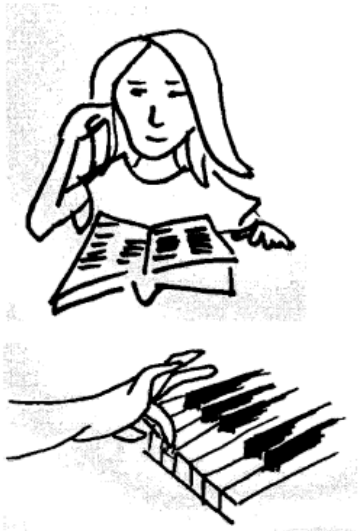
Emotion are a crucial components



Flashbulb memories are not necessarily more accurate than ordinary memories. They can be subject to distortion, just like other autobiographical memories, but the feeling of certainty is stronger.

Memory process

10:40



Encoding

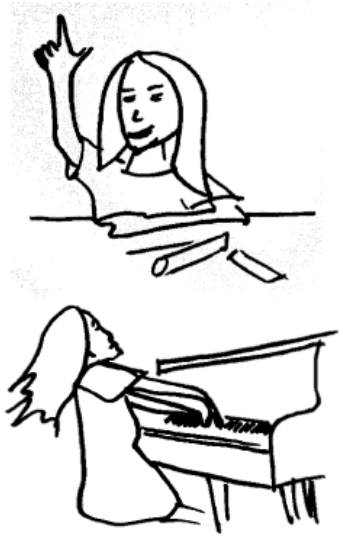
Information perception and processing

Learning

Consolidation

Retention and consolidation of information

Memory



Retrieval

Remembering and using stored information

Remembering

time

Consolidation

11:40

Ippocampo —> useless for old memory

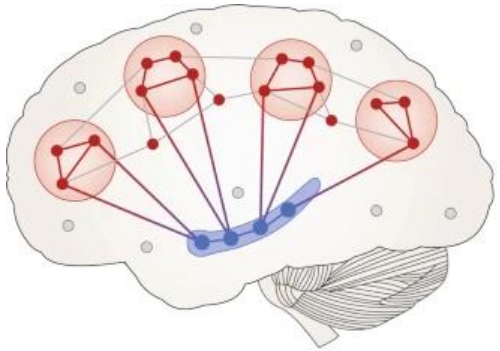
Consolidation: Processes that stabilize a memory trace after its initial acquisition.

writing in the brain

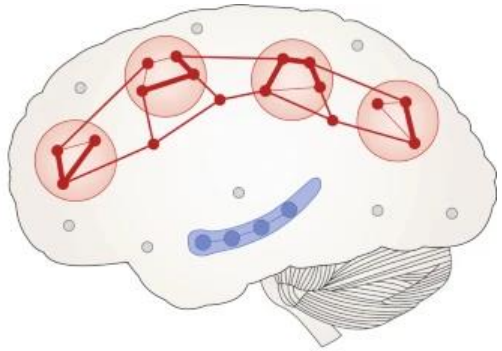
Synaptic consolidation (initial consolidation): Is achieved faster than systems consolidation (minutes-hours). Depends on Long-term potentiation (LTP).

Systems consolidation: It is a reorganization process in which memories from the hippocampal region, where memories are first encoded, are moved to the neo-cortex in a more permanent form of storage. Takes days to months.

Consolidation



Consolidation: Processes that stabilize a memory trace after its initial acquisition.



Over time, connections are formed between the cortical areas relevant for the memory, while the hippocampal connections become less important.

Eventually, the hippocampal connections become unnecessary and the cortical connections stand alone as an integrated representation of the memory.

Consolidation

15 (è formato indietro)

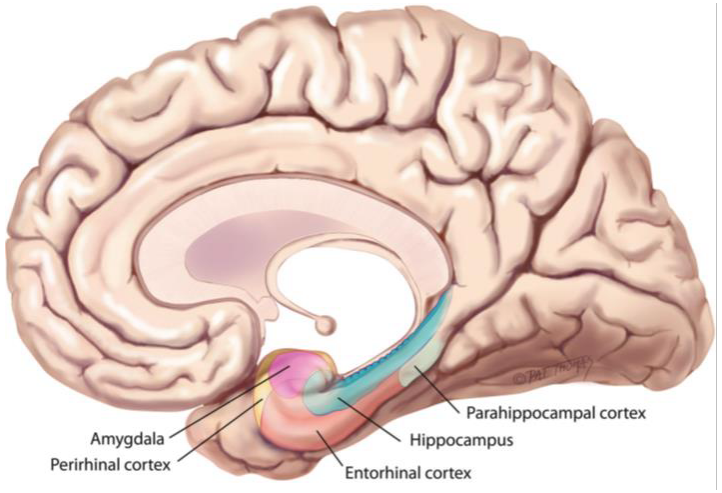
Memory

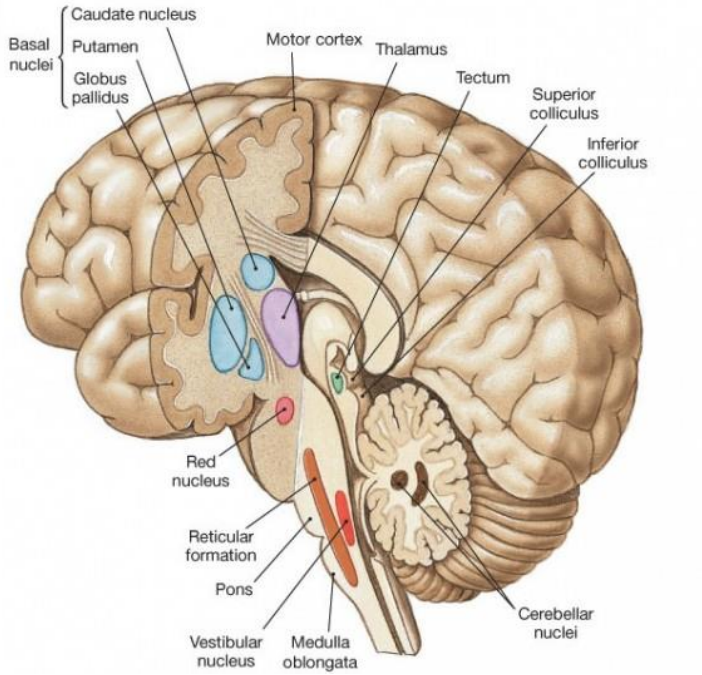
Declarative

Conscious recall of facts, episodes, and lists

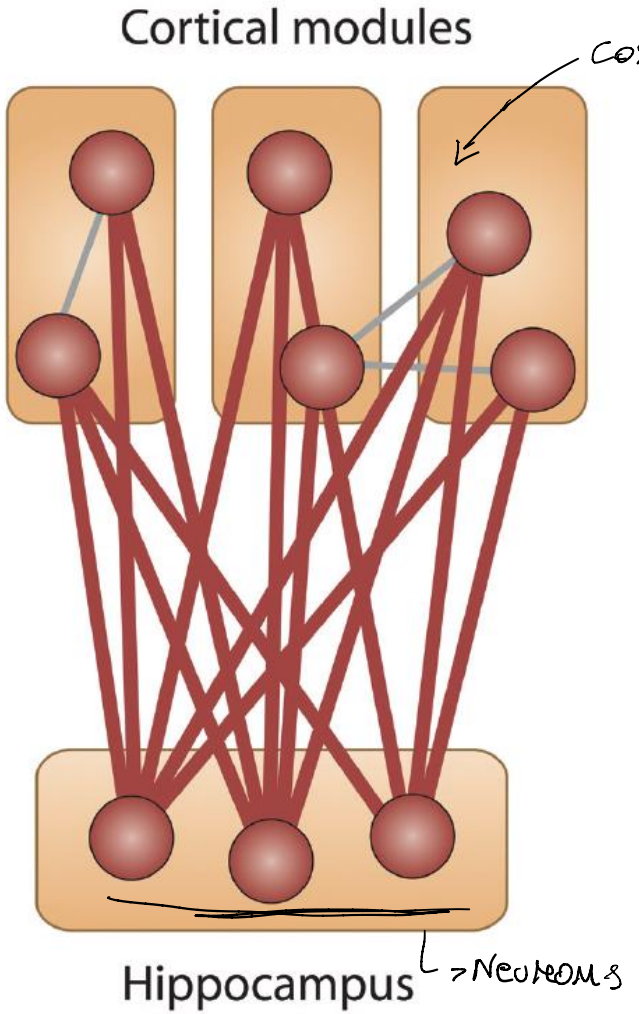
Procedural

Knowledge exercised in the performance of some task



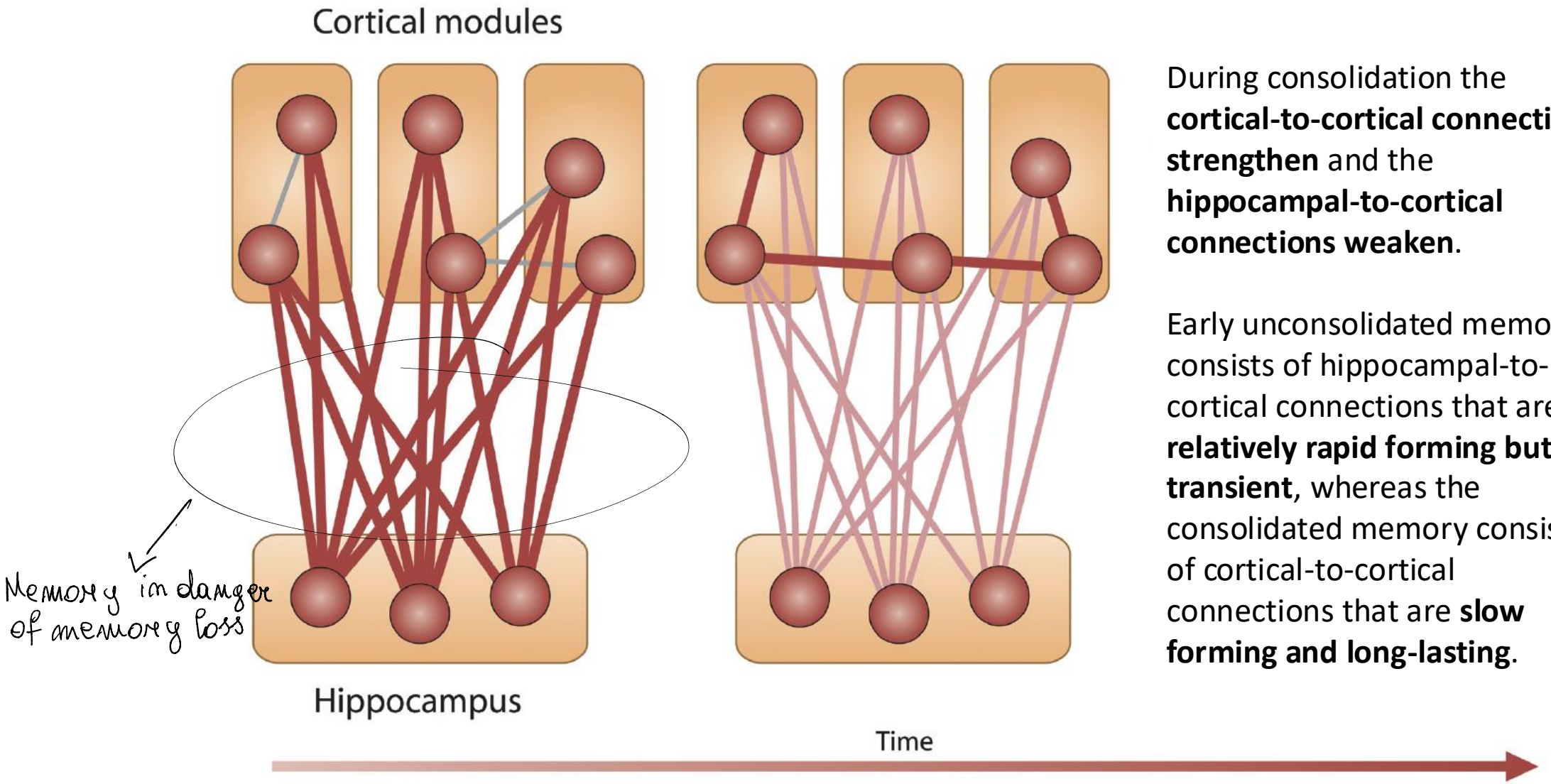


Consolidation



A particular event with auditory, visual, and spatial information is acquired (encoded). The **hippocampus** holds a **unified representation** of the event and the auditory information is distributed to the superior aspect of the temporal lobe, the spatial information is distributed to the parietal lobe, and the visual information is distributed to the occipital cortex. The memory traces are formed as connections

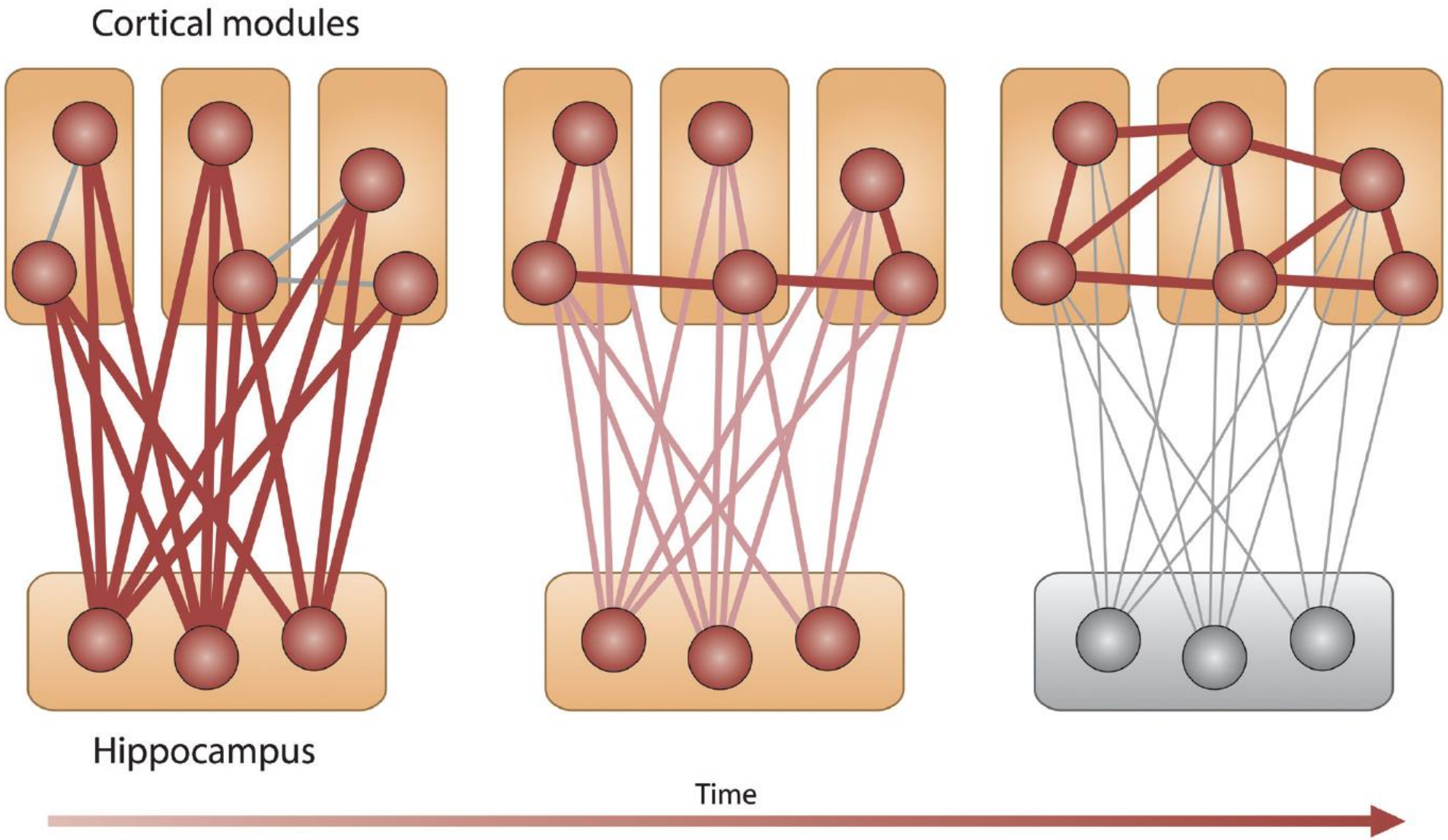
Consolidation



During consolidation the **cortical-to-cortical connections strengthen** and the **hippocampal-to-cortical connections weaken**.

Early unconsolidated memory consists of hippocampal-to-cortical connections that are **relatively rapid forming but transient**, whereas the consolidated memory consists of cortical-to-cortical connections that are **slow forming and long-lasting**.

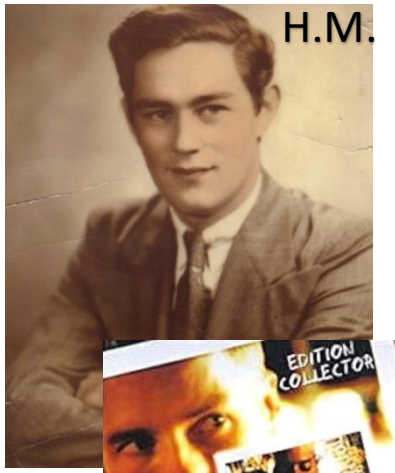
Consolidation



Ribot's law

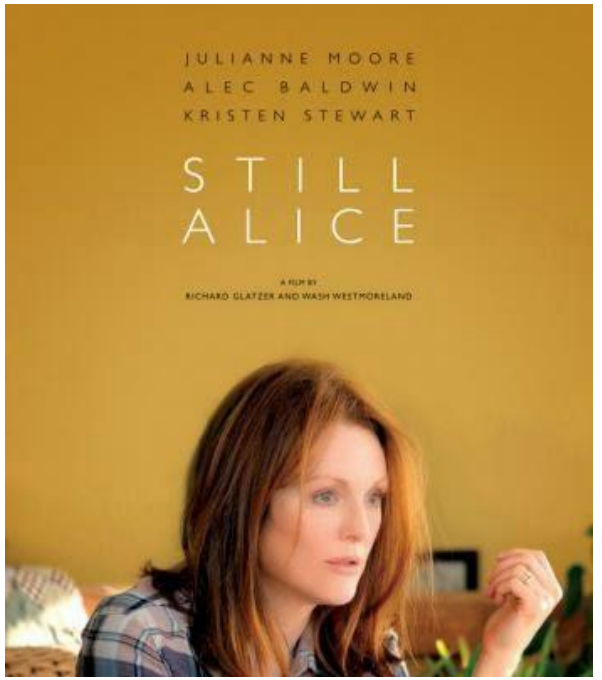
Ribot's Law is a principle of **retrograde amnesia**, proposed by French psychologist Théodule Ribot in 1881, which states that **recent memories are more vulnerable to loss than older, more remote memories**. This temporal gradient in memory loss suggests that memories undergo a consolidation process over time, becoming more stable and resistant to disease or damage as they age.

Retrograde Amnesia: The loss of memory for events that happened before an insult/injury.



Anterograde Amnesia: The inability to form new memories after brain injury.

Alzheimer's Disease



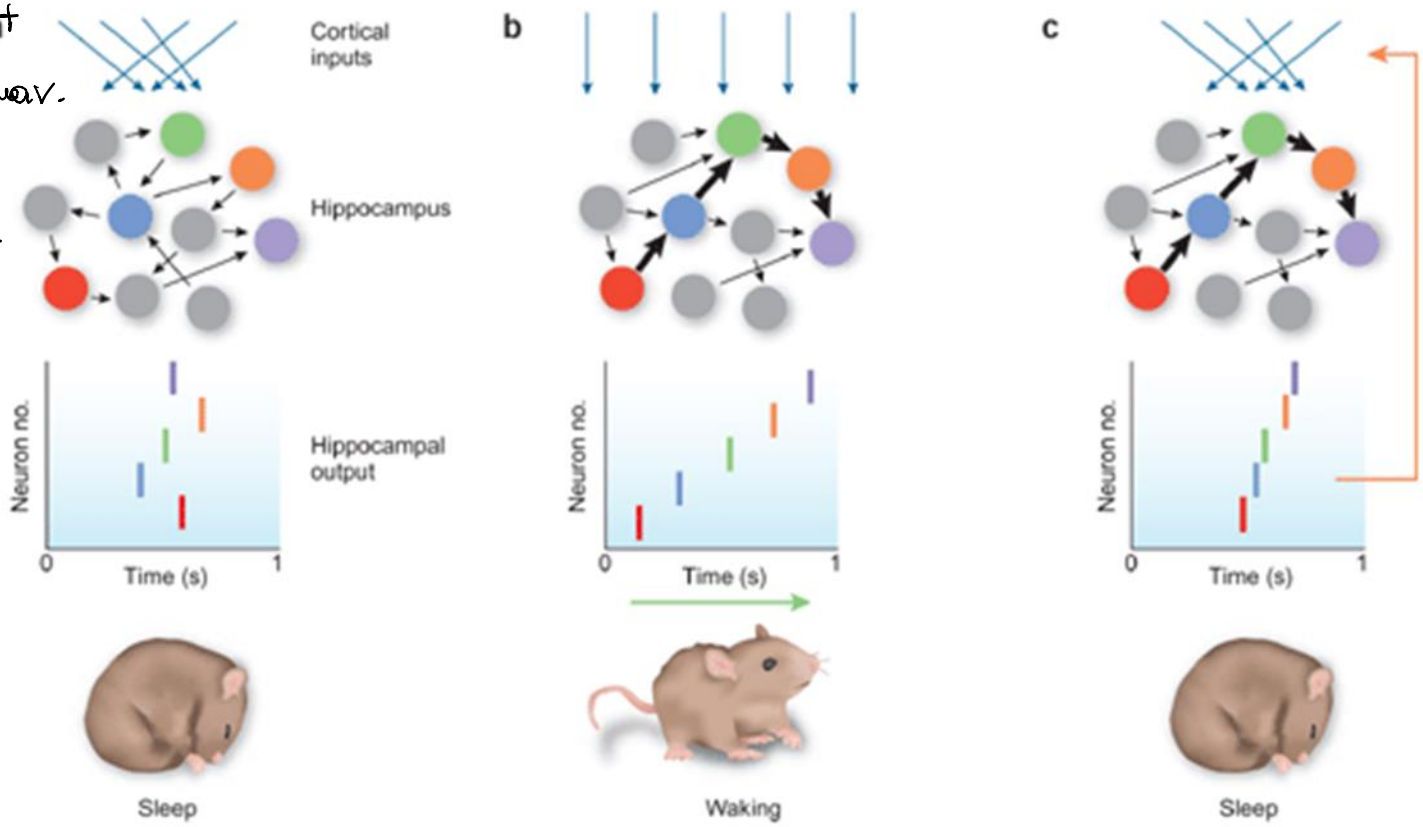
Hippocampal and Cortical Replay during Sleep

17:30

you create a labyrinth, during each movement different neurom will fire → you give a color and with that you know the way.

REPLAY (not perfect)

Nom e'ho capito beme

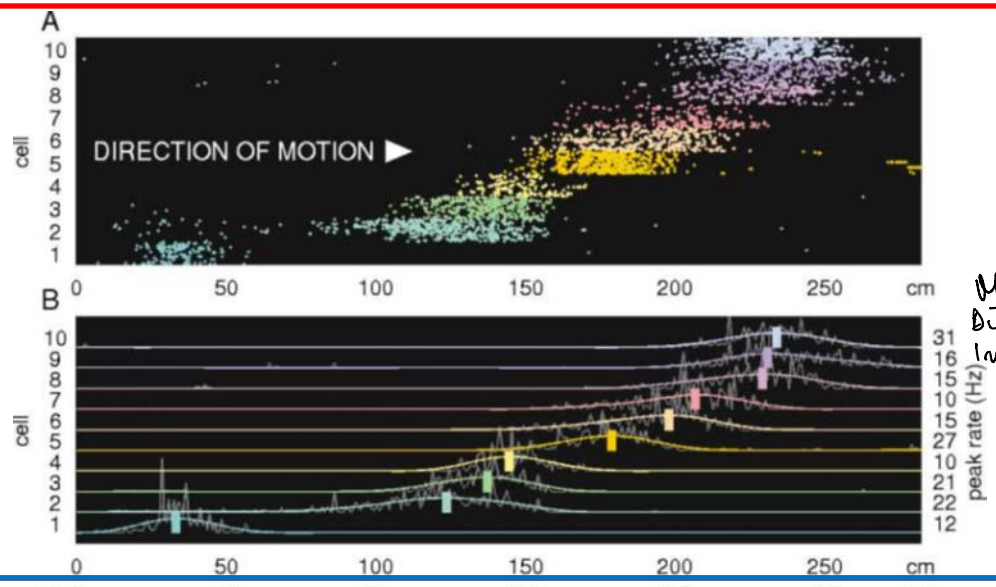


In rodents, neurons in hippocampus and cortex that were active during a previous experience have been observed to spontaneously reactivate during non-REM sleep. Similarly in humans, a reactivation of brain activity related to a previous experience has also been observed in the hippocampus during sleep.

Hippocampal and Cortical Replay during Sleep

20:30

wakefulness

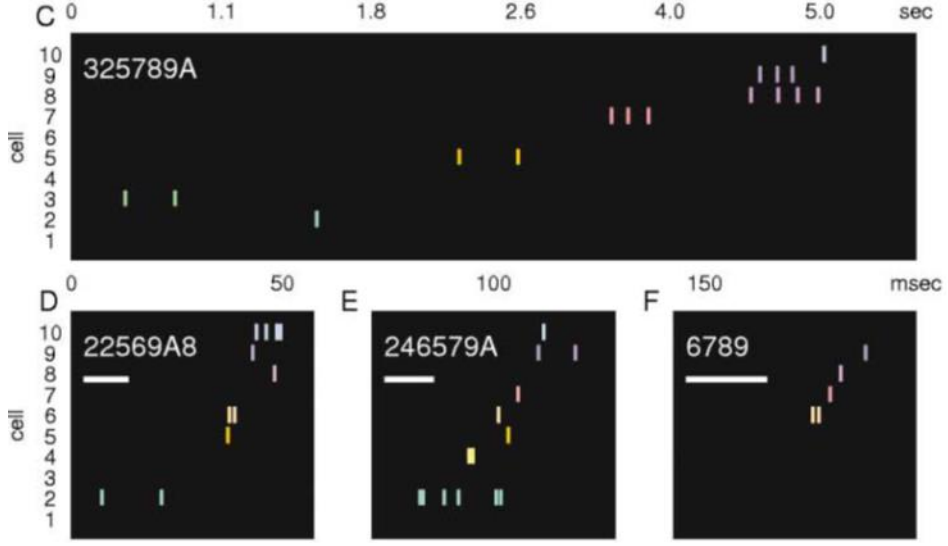


→ Place field sequence

Mentre dorme rivede il pattern di colori del labirinto a volte backw. Inoltre il tempo con cui questo accade è molto diverso

→ Smoothed version

slow wave sleep



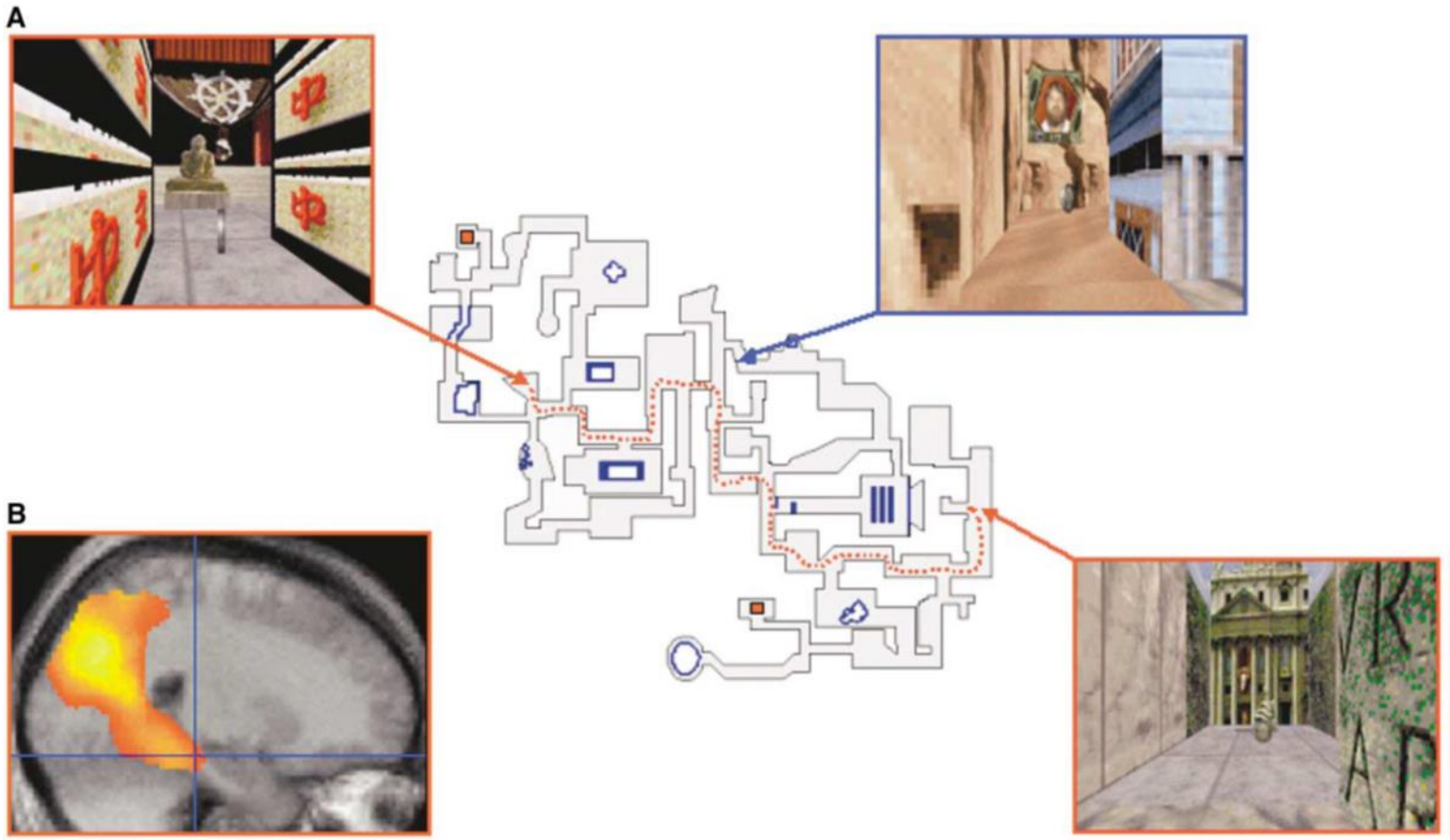
Examples of hippocampal firing bursts during sleep

Hippocampal neurons repeatedly fire in a precise order in long sequences involving four or more cells during SWS immediately following, but not preceding, the experience. The SWS sequences occurred intermittently in brief (~100 ms) bursts, each compressing the behavioral sequence in time by approximately 20-fold.

Lee & Wilson, Neuron, 2002

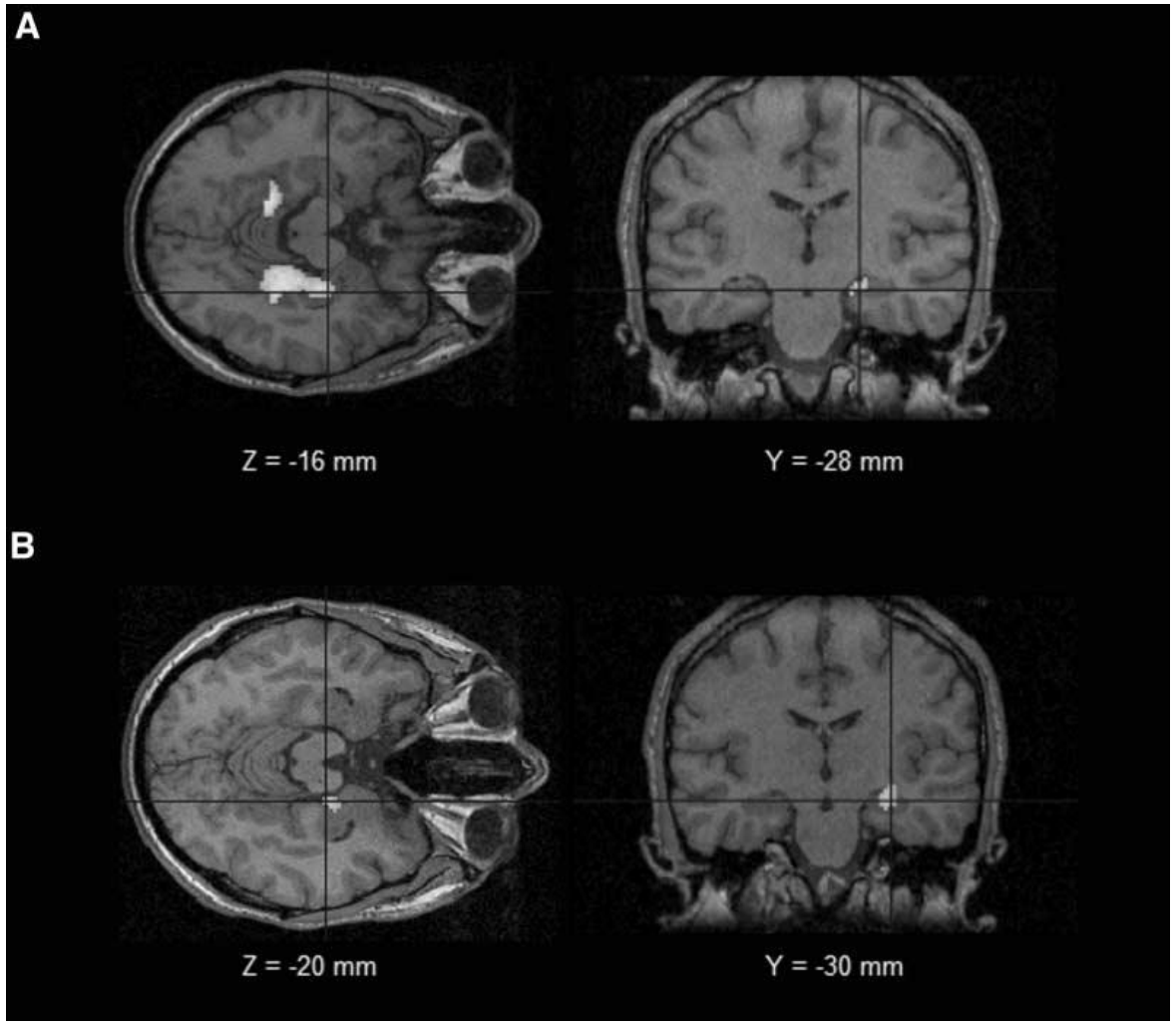
Hippocampal and Cortical Replay during Sleep

Similarly in humans, a reactivation of brain activity related to a previous experience has also been observed in the hippocampus during sleep.



Peigneux et al, Neuron, 2004

Hippocampal and Cortical Replay during Sleep



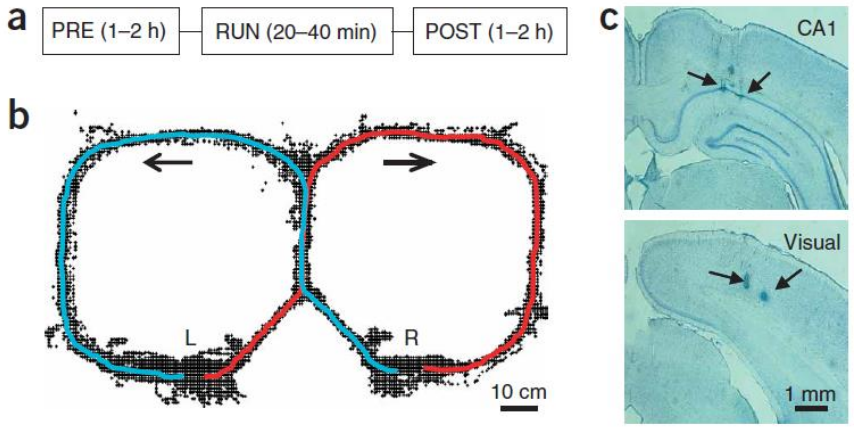
Hippocampal and parahippocampal regions that both activated in subjects scanned awake during route retrieval in the town (test vs control condition) and activated more in trained than in (A) nontrained or (B) SRTtrained subjects scanned during SWS.

Peigneux et al, Neuron, 2004

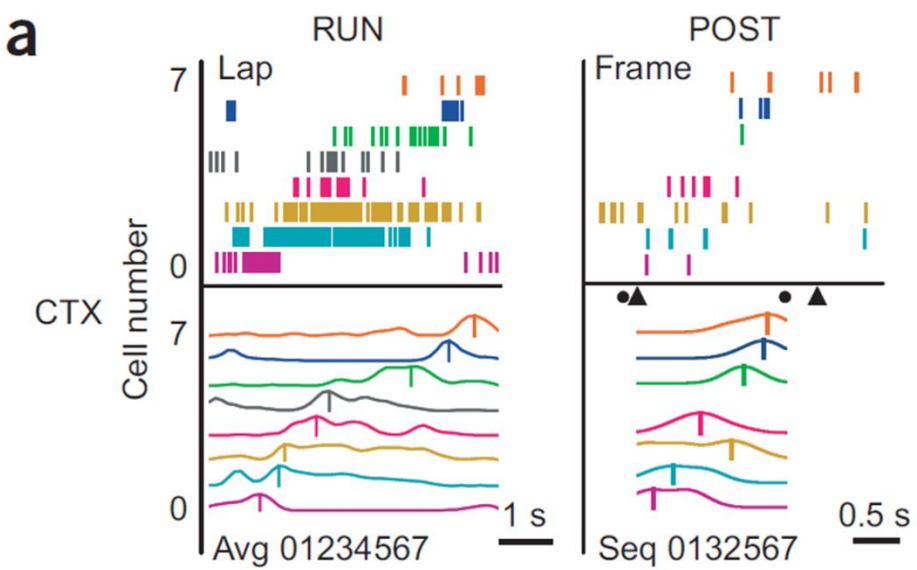
Hippocampal and Cortical Replay during Sleep

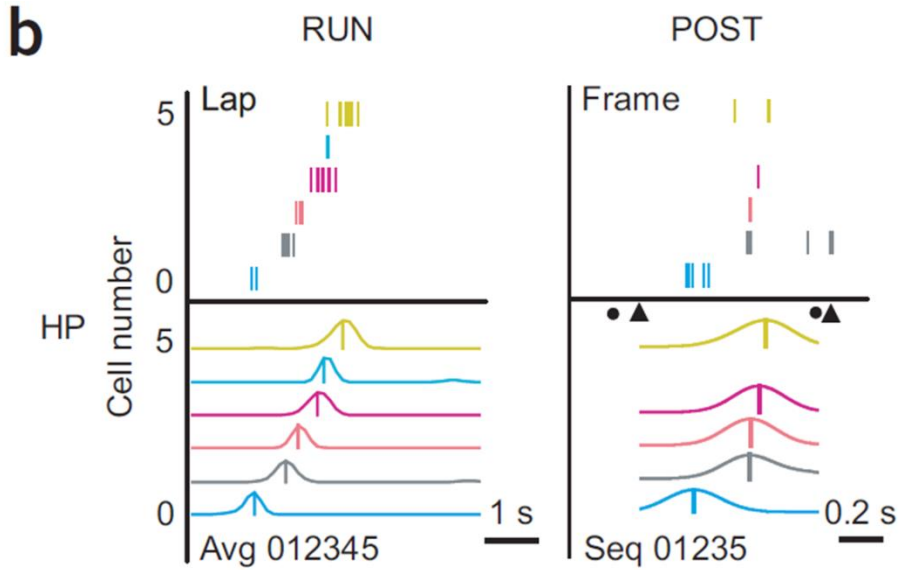
22:35

Memory Replay(?) memory for some days



Replay events in the **V1** and **HP** were coordinated to reflect the same experience. These results imply simultaneous reactivation of coherent memory traces in the cortex and hippocampus during sleep that **may contribute to** or **reflect the result of** the memory consolidation process.

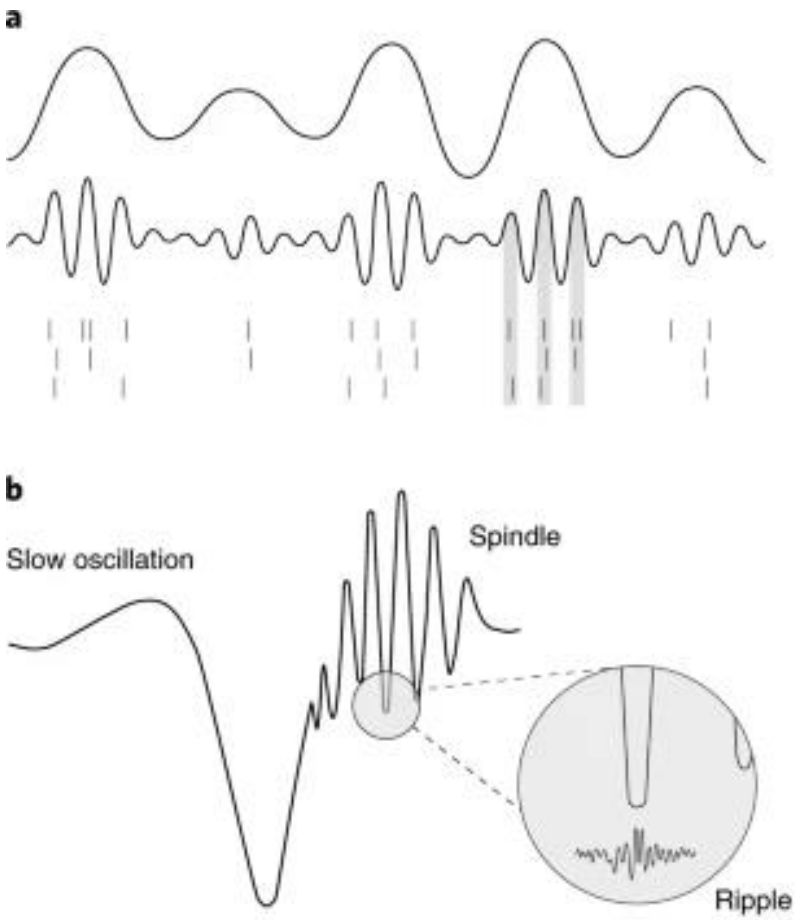


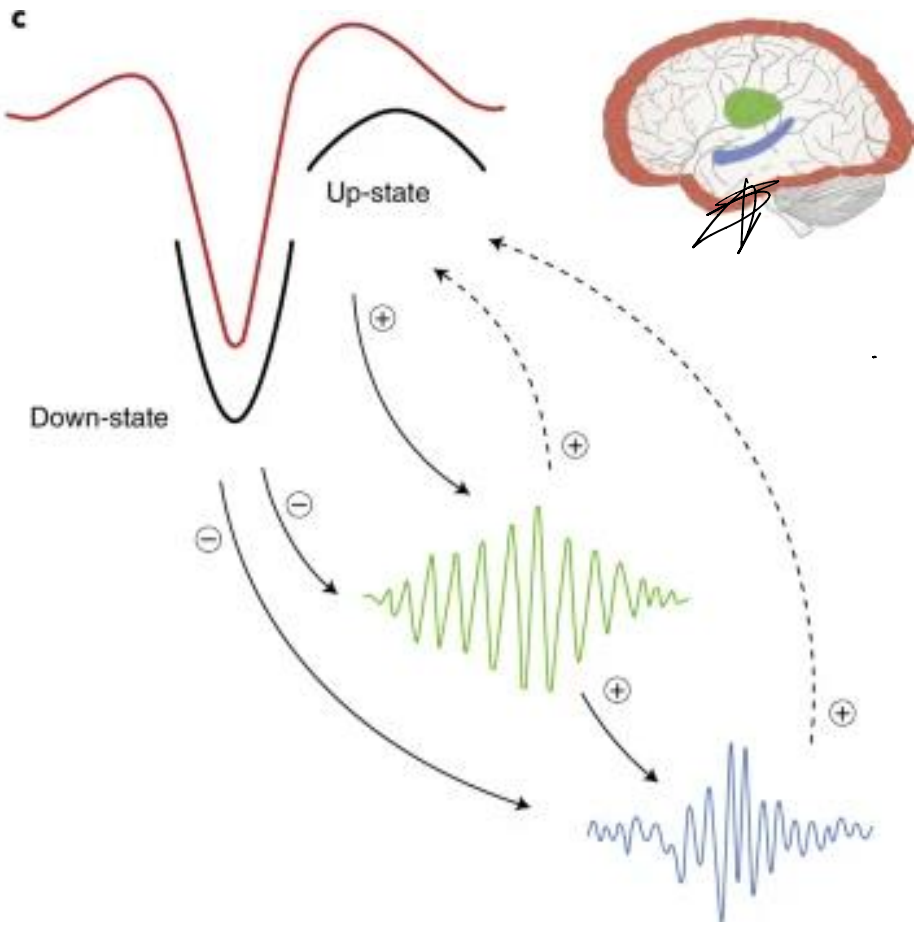


Ji & Wilson et al, Neuron, 2007

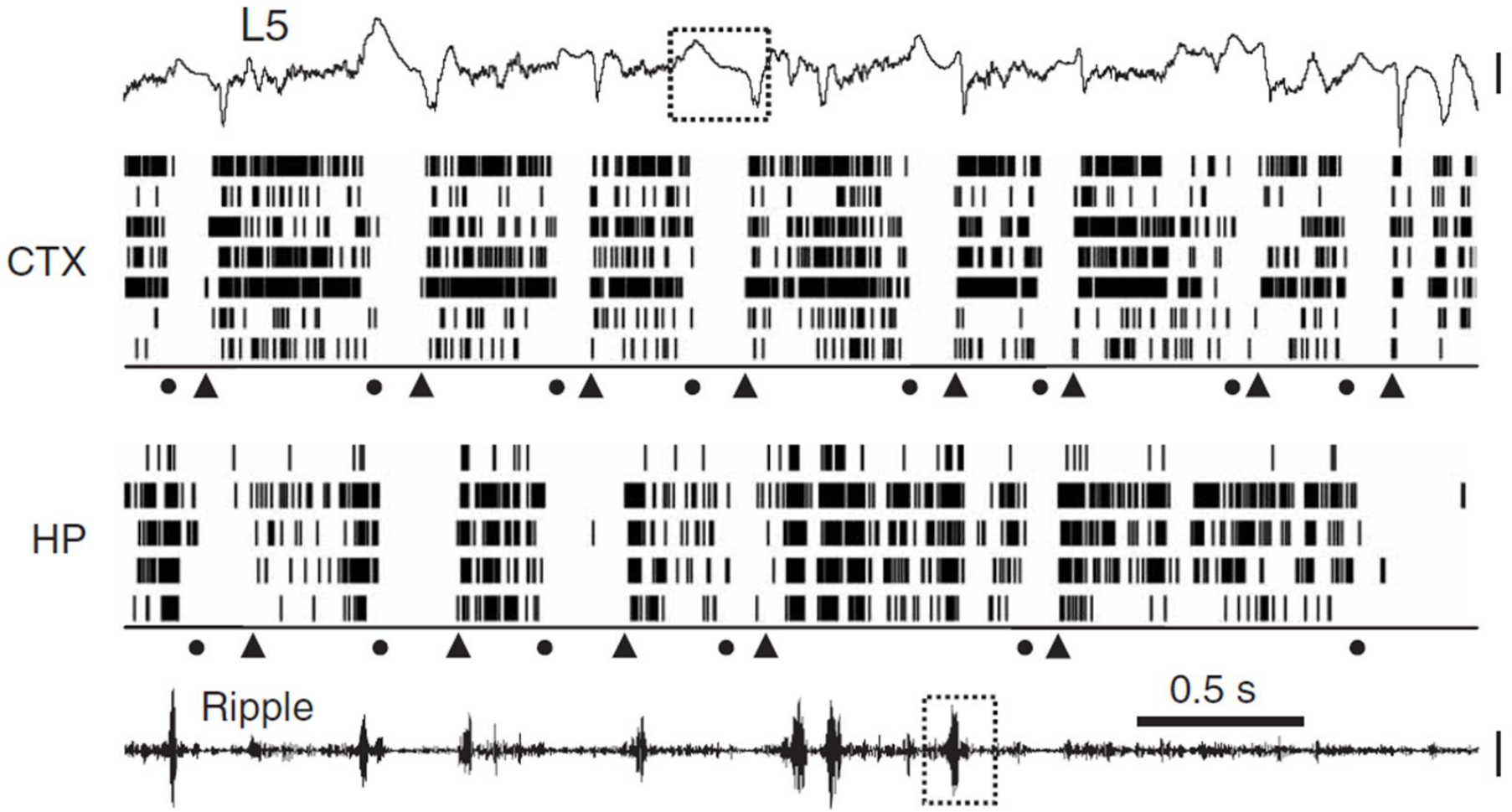
Hippocampal and Cortical Replay during Sleep

24:48





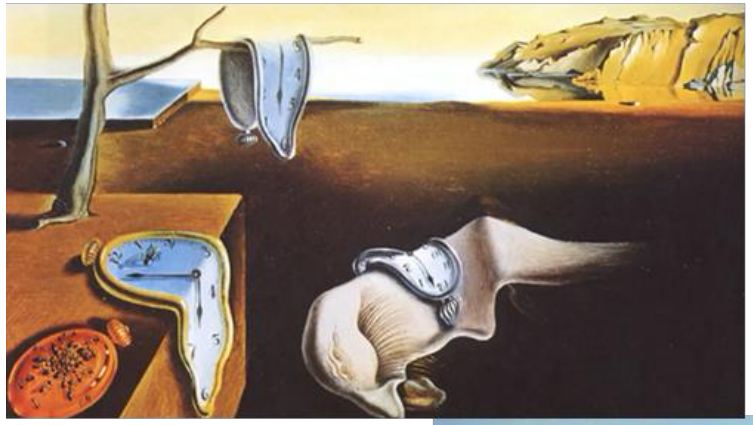
Hippocampal and Cortical Replay during Sleep

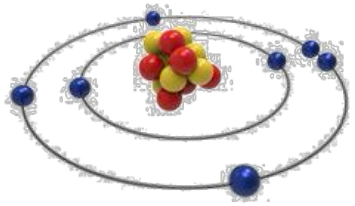


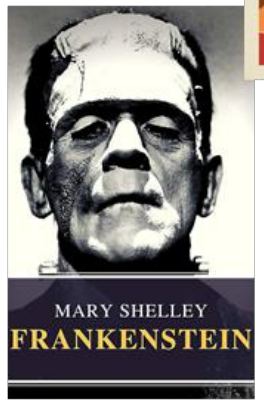
Spiking patterns are organized into frames, defined as periods of stepwise increase in neuronal population activity

Ji & Wilson et al, Neuron, 2007

Sleep, memory processing, insight and creativity

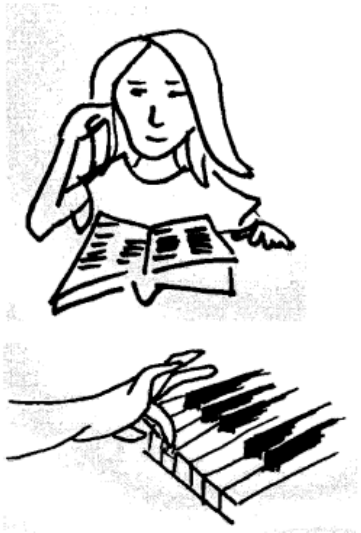






Memory process

32



Encoding

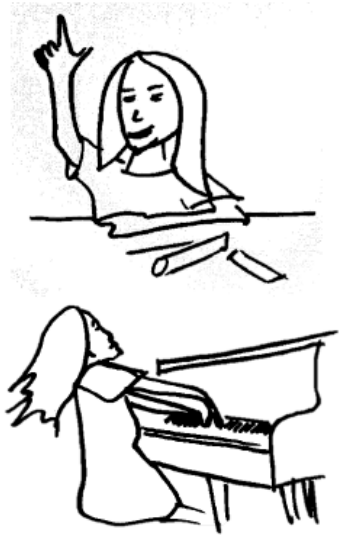
Information perception and processing

Learning

Consolidation

Retention and consolidation of information

Memory



Retrieval

Remembering and using stored information

Remembering

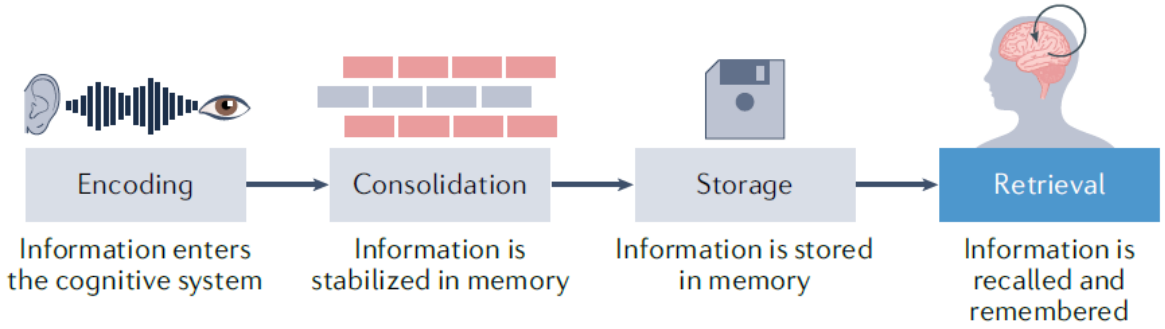
time

Retrieval

Retrieval: the act of accessing information from memory.

Retrieval can take the form of **recall**, in which one searches memory for a specific piece of information and is able to produce it.

Retrieval is also involved in **recognition**, as when a person judges that they have seen or encountered something before.

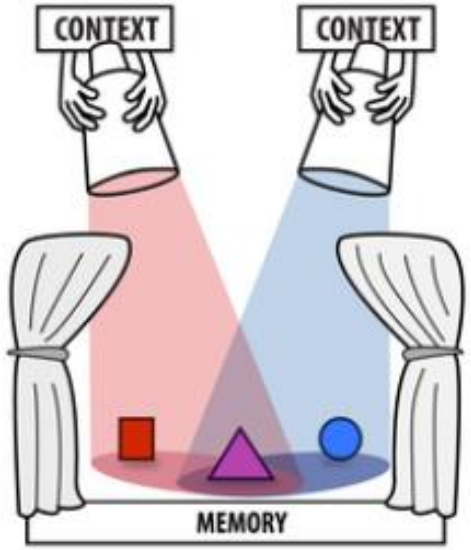


Retrieving information from memory is assumed to (partly) reactivate **contextual features** of the original experience, owing to the connections forged between the information and the surrounding context at the time of encoding.

Similarly, being in an environment that shares features (**cues**) with the original encoding context can also facilitate retrieval of the information.

Retrieval

Spontaneous retrieval is involuntary, triggered by cues with little effort, whereas **voluntary** retrieval is a deliberate, goal-directed process to recall past events. Spontaneous memories often arise unexpectedly, like from **Proust's Madeleine story**, and may feel more meaningful. Voluntary retrieval involves an intention to find a specific memory, often requiring conscious effort.



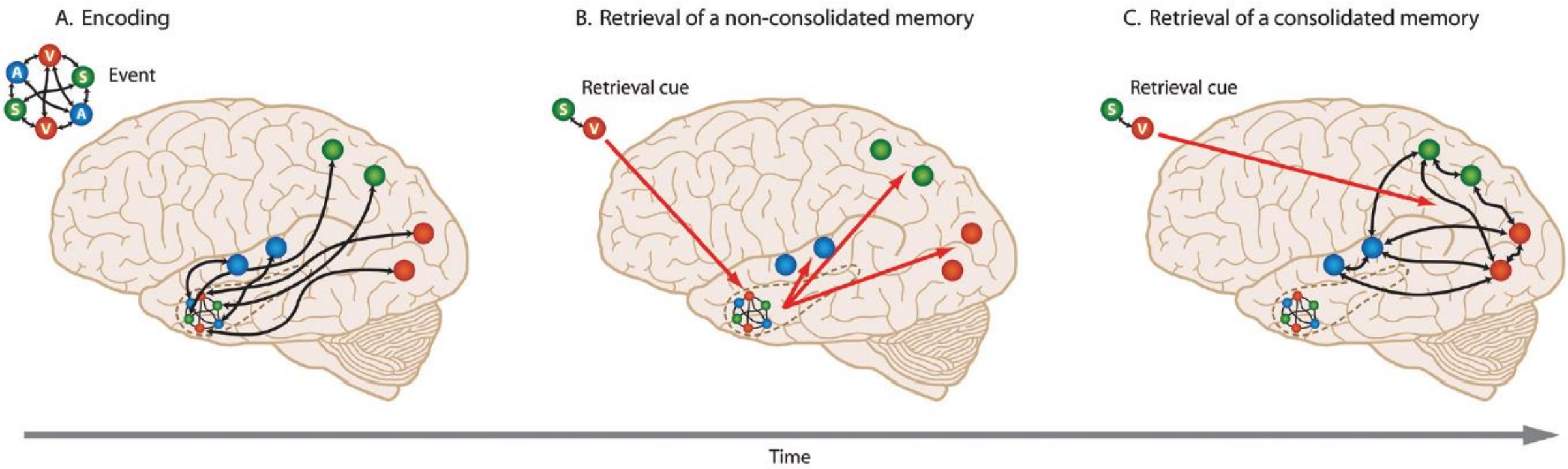
Context-based cues

Perception-based cues

State-based cues

Retrieval

35:10

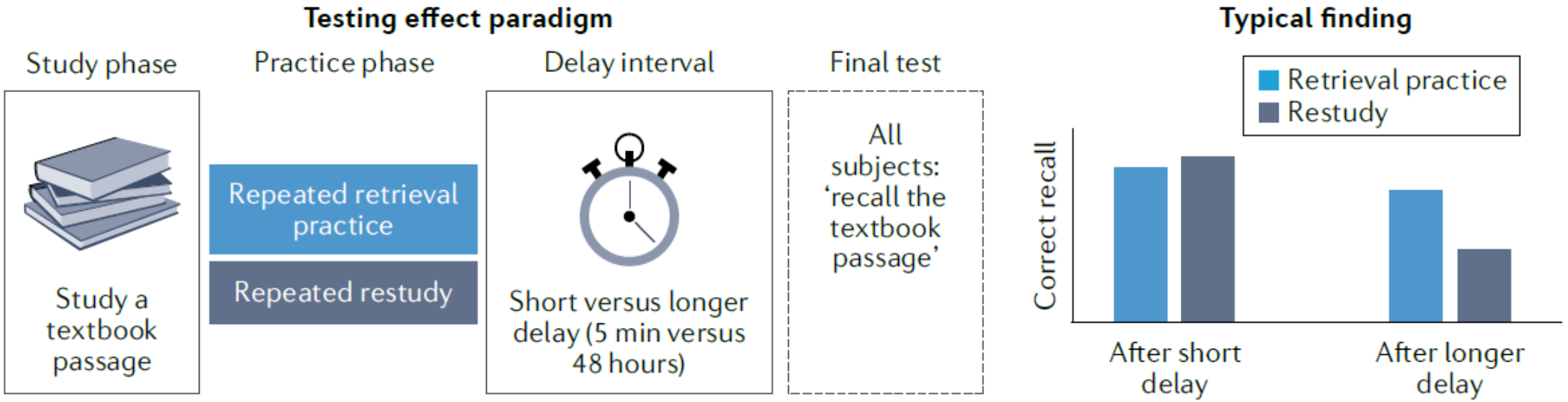


Effects on retrieved information

36 — Ritorna a h5.30
READ

Enhancing memory via retrieval. The act of accurately retrieving information at one point in time increases the likelihood that the information will be accurately retrieved at a later point in time. This phenomenon is referred to as the **testing effect** — because tests of memory require retrieval — or the **retrieval practice effect**. The retrieval practice effect is even more pronounced if participants in the retrieval condition are given feedback on their failed retrieval attempts.

Enhancement has also been ascribed to the greater mental effort necessary during retrieval practice relative to other practice formats, or to more elaborative semantic processing of the materials during retrieval practice relative to other formats.



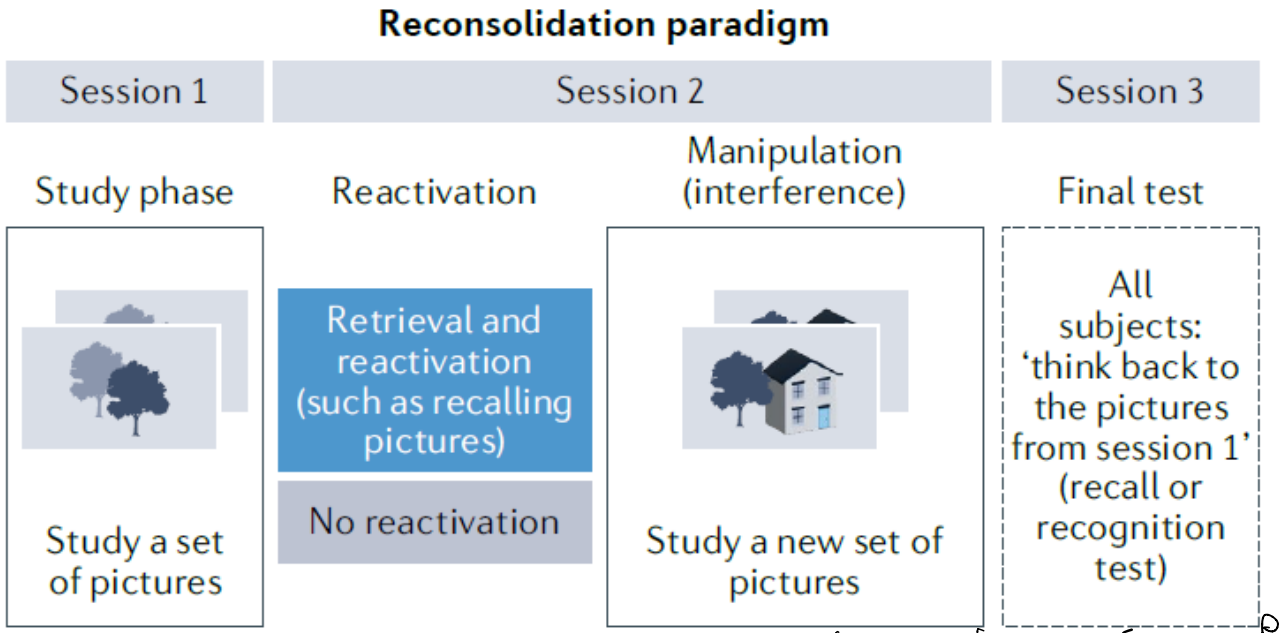
Effects on retrieved information

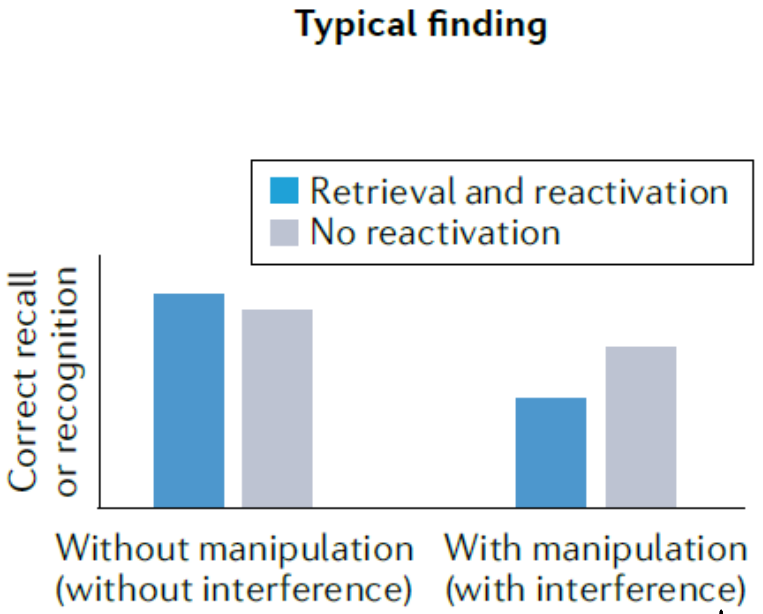
36.3 5

Modifying memory via retrieval. If an error creeps into your description of a memory, **a retrieval practice effect can also occur for the erroneous information**. Thus, that error might be remembered as part of the memory in the future. The more the error is repeated in overt or covert retrieval (for example, when thinking about an event), the more it will become a part of your memory.

Retroactive interference: interfering effect of learning later information on recall of information already learned.

Reconsolidation: When a memory is retrieved, the memory trace becomes labile again and is subject to modification.





→ le richiami ma le mischi (ha detto un caso dove non capita)

Effects on related information

Big salto va diretto alle conclusioni

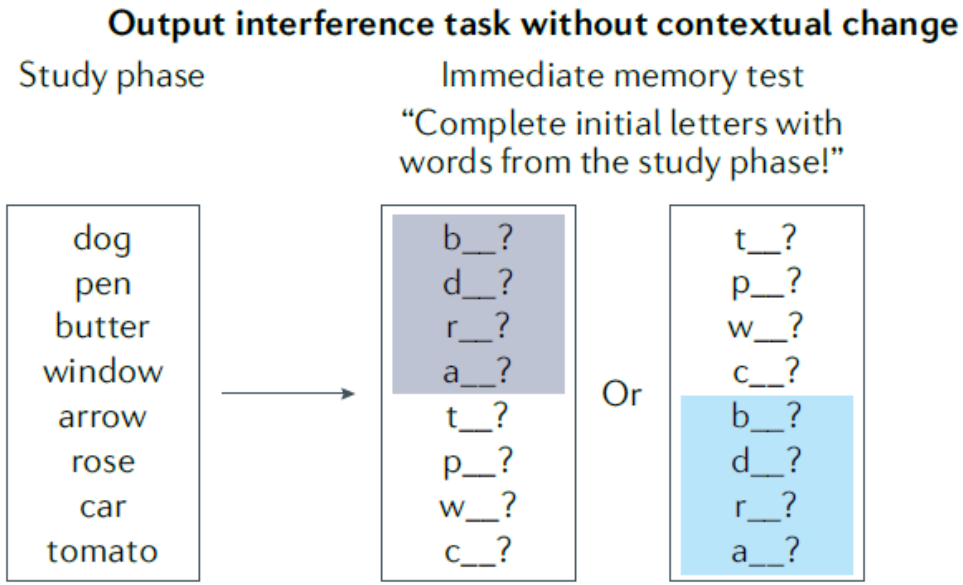
Retrieval from memory often does not include everything that could be retrieved; people tend to focus on what is most important or most relevant given their current goal or situation.

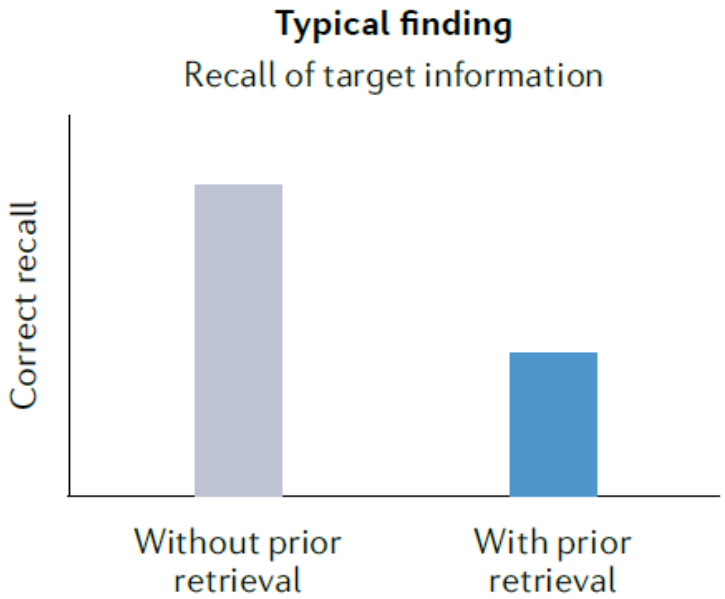
Self- limiting retrieval. A rather intuitive assumption is that memory retrieval, once successfully initiated, should progress naturally, with each remembered event increasing the chances of remembering associated events. However, early findings indicated that successful recall of one piece of information restricts subsequent recall of related information. In short, retrieval is a self- limiting process.

Effects on related information

When recalling multiple items, items that are cued to be retrieved later in a test are less likely to be retrieved successfully than items cued to be retrieved earlier in a test.

Strength- based blocking: Successful retrieval of some items early in the test strengthens these items in memory. Later in the test, when trying to recall related information, the already retrieved and strengthened information continues to be retrieved, effectively blocking access to the (unstrengthened) remaining information.





Effects on related information

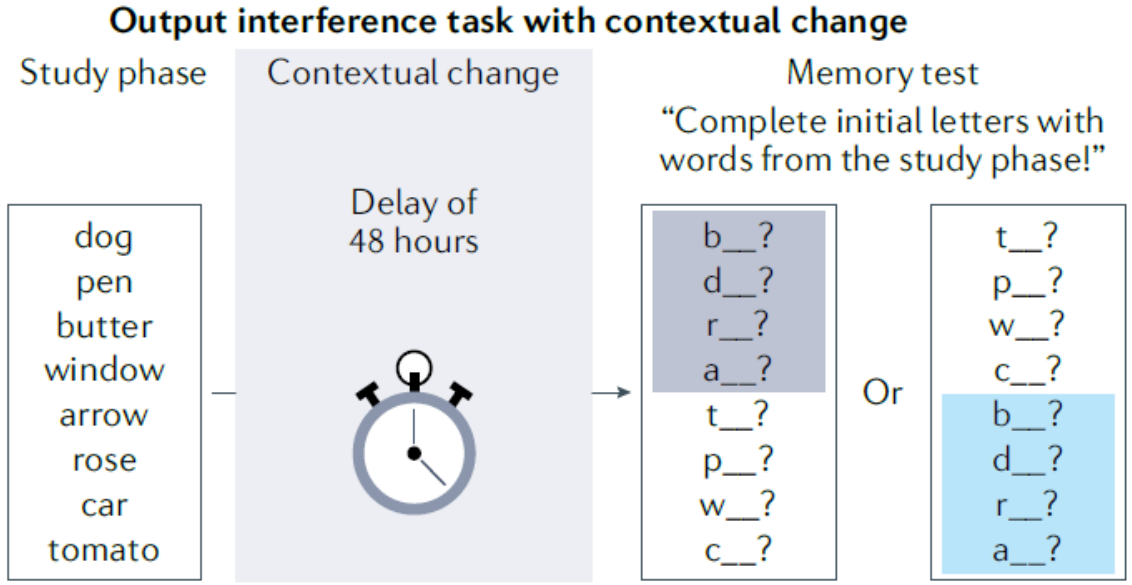
Retrieval- induced forgetting: repeated retrieval enhances memory for the directly practised items relative to a control condition without any practice — but also impairs memory for items related to the practised materials.

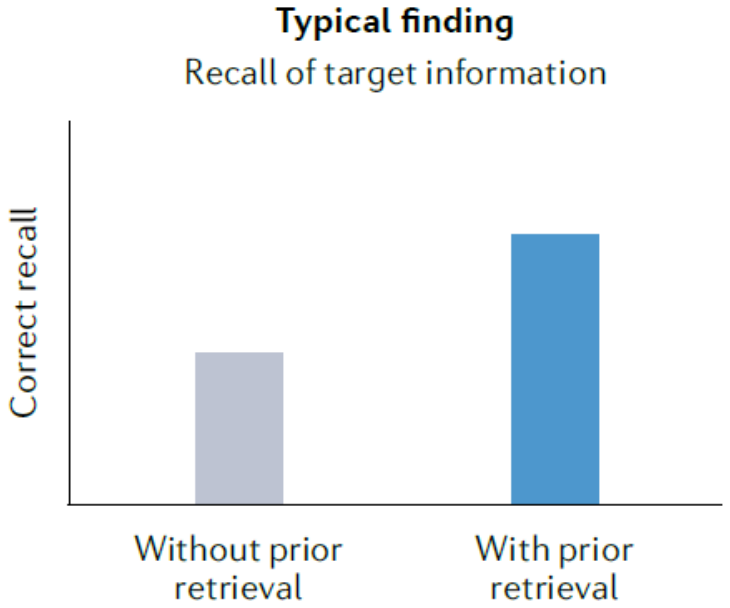
One proposed explanation of the impairment in retrieving related items is that forgetting might be caused by inhibitory control processes that operate during practice to resolve interference arising from related information in memory.

For instance, in order to search for one target word, other competing words in memory must be inhibited.

Effects on related information

Self- propagating retrieval. The notion that memory retrieval can propagate itself (known as retrieval-induced facilitation) is a natural progression of the work on retrieval-induced forgetting. These facilitation effects emerged after relatively long retention intervals of 24 hours between selective retrieval practice and a final memory test. The largest benefits of retrieval practice still occurred for directly practised information but related information also benefited with this long delay.





Effects on related information

Why selective retrieval practice sometimes creates forgetting and sometimes facilitation for related materials?

Retrieval-induced facilitation for non-tested materials only emerged if study materials were presented in a **coherent** (rather than random) **order** and when the final memory test was conducted after a **long retention interval** of 24 hours or even 7 days (rather than after a shorter interval of 20 minutes) → **Change of context and reduction of overlap/interference!**

Effects on subsequent encoding

Retrieving information seems to permit better encoding of new information. If the new information is correct, recall of the event is enhanced. If misinformation is presented after retrieval of the original information, then erroneous recollection of the original events will result.

Effects of Retrieval

Information affected	Positive effects	Negative effects
Retrieved information	With accurate retrieval (recall or recognition), later retention is improved	The act of retrieval opens a window for possible changes in memory from both external and internal influences
Related information	In some circumstances, the act of retrieval can lead to retrieval of related information	The act of retrieval can inhibit recall of related information under other conditions
To-be-encoded information	The act of retrieval can facilitate encoding of additional information	The act of retrieval can facilitate encoding of misinformation

46:30

Conclusions

Cosa stra interessante:

Durante una fase di Rehab. (Post stroke patient) ha perso certi movimenti.
Un modo per allenarlo potrebbe essere quello di fargli immaginare il movimento.