MEMORY

The story of HM

He knew his name.
He knew that his father's family came from Thibodaux, La., and his mother was from Ireland, and he knew about the 1929 stock market crash and World War II and life in the 1940s
But he could remember almost nothing after that

In 1953, he underwent an experimental brain operation in Hartford to correct a seizure disorder, only to emerge from it fundamentally and irreparably changed. He developed a syndrome neurologists call profound **amnesia**

He had lost the ability to form new memories

For the next 55 years, each time he met a friend, each time he ate a meal, each time he walked in the woods, it was as if for the first time

Fifty First dates?????


ILIAD ODYSSEY

kab	vut	giz	kel	poj
gep	nol	rab	dur	hig
mip	jot	kaz	hin	ber
ceg	mak	las	rud	fir

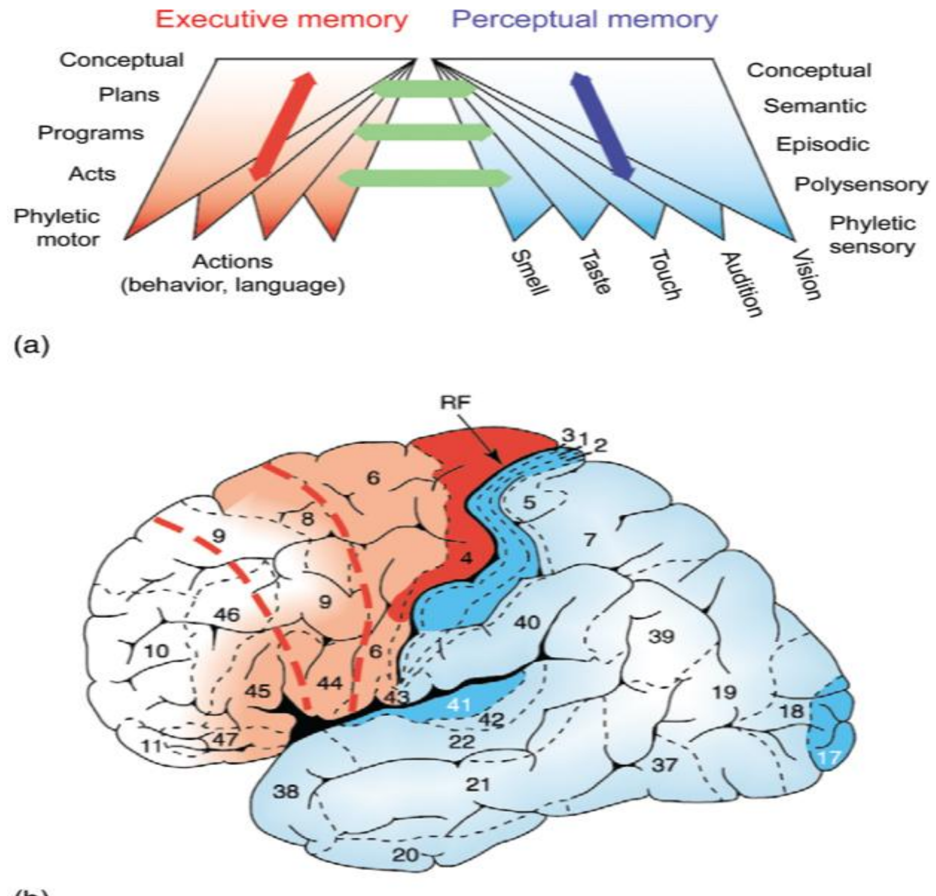
cat	sat	wet	net	fun
sun	dog	log	man	can
bin	pin	hot	cot	ten
cap	nap	leg	peg	hat

Memory

Memory can be defined as a lasting representation that is reflected in thought, experience, or behavior

Learning is the acquisition of such representations -- involving a wide range of brain areas and activities

Memory storage is believed to involve widespread synaptic alterations in cortex



Source: Fuster, 2003.

- **There are different types of memory**
- **Different parts of the brain are involved in memory**
- **Learning and memory occur over time and involve many events**

  eg: encoding, storage (learning); retrieval (memory)
- **All memory involves changes as a result of experience (learning) that allow the individual to alter future behaviour**
- **Memory is not a snapshot of an event, but an electrically encoded representation**

Memory Processes

Registration (or encoding) – the *transformation* of sensory input (such as a sound or visual image) into a form which allows it to be entered into (or registered in) memory. With a computer, for example, information can only be encoded if it's presented in a format the computer recognizes

- HOW IS SENSORY INFORMATION PROCESSED IN A WAY THAT ALLOWS IT TO BE STORED?
- HOW ARE THINGS REMEMBERED?

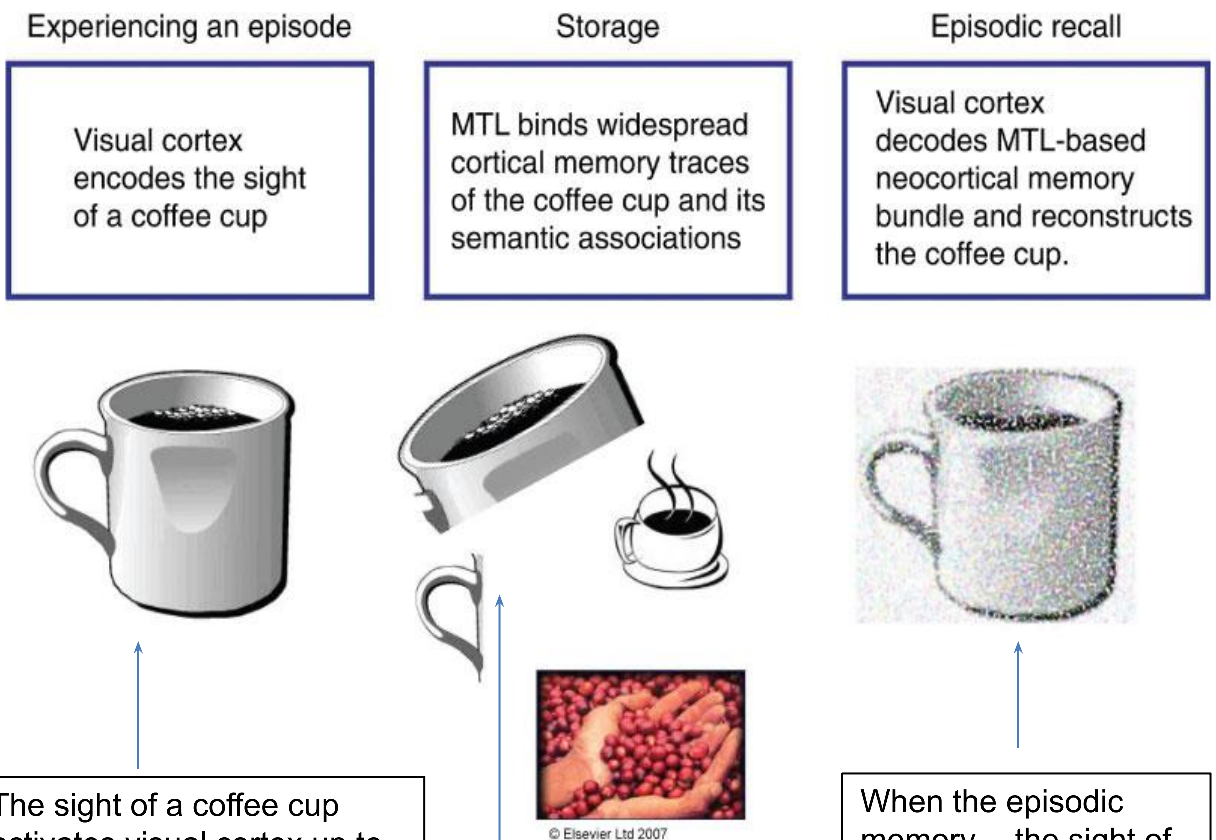
Storage – the operation of *holding* or *retaining* information in memory. Computers store information by means of changes in the system's electrical circuitry; with people, the changes occurring in the brain allow information to be stored, though exactly what these changes involve is unclear

- WHERE ARE OUR MEMORIES 'KEPT'?
- IS THERE MORE THAN ONE KIND OF MEMORY?

Retrieval – the process by which stored information is *extracted* from memory

- ARE THERE DIFFERENT KINDS OF REMEMBERING?
- WHAT DO WE REMEMBER?
- WHY DO WE FORGET?

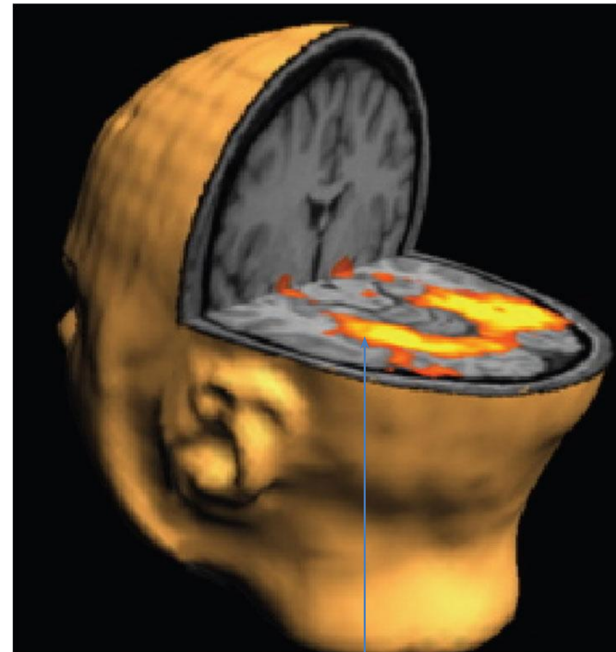
Example of how MTL helps store and retrieve episodic memories



The sight of a coffee cup activates visual cortex up to the level of object perception

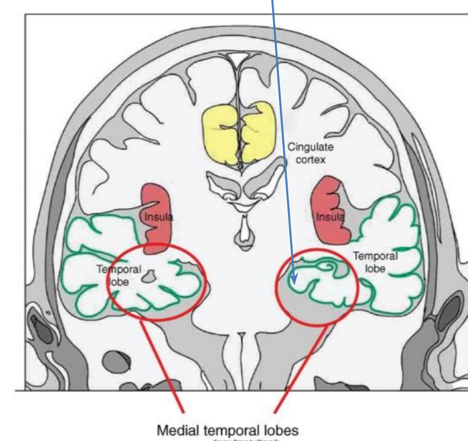
Memory storage: MTL coordinates widespread memory traces throughout cortex

When the episodic memory -- the sight of the coffee cup -- is cued the following day, MTL is once again involved in retrieving and organizing widespread memory traces



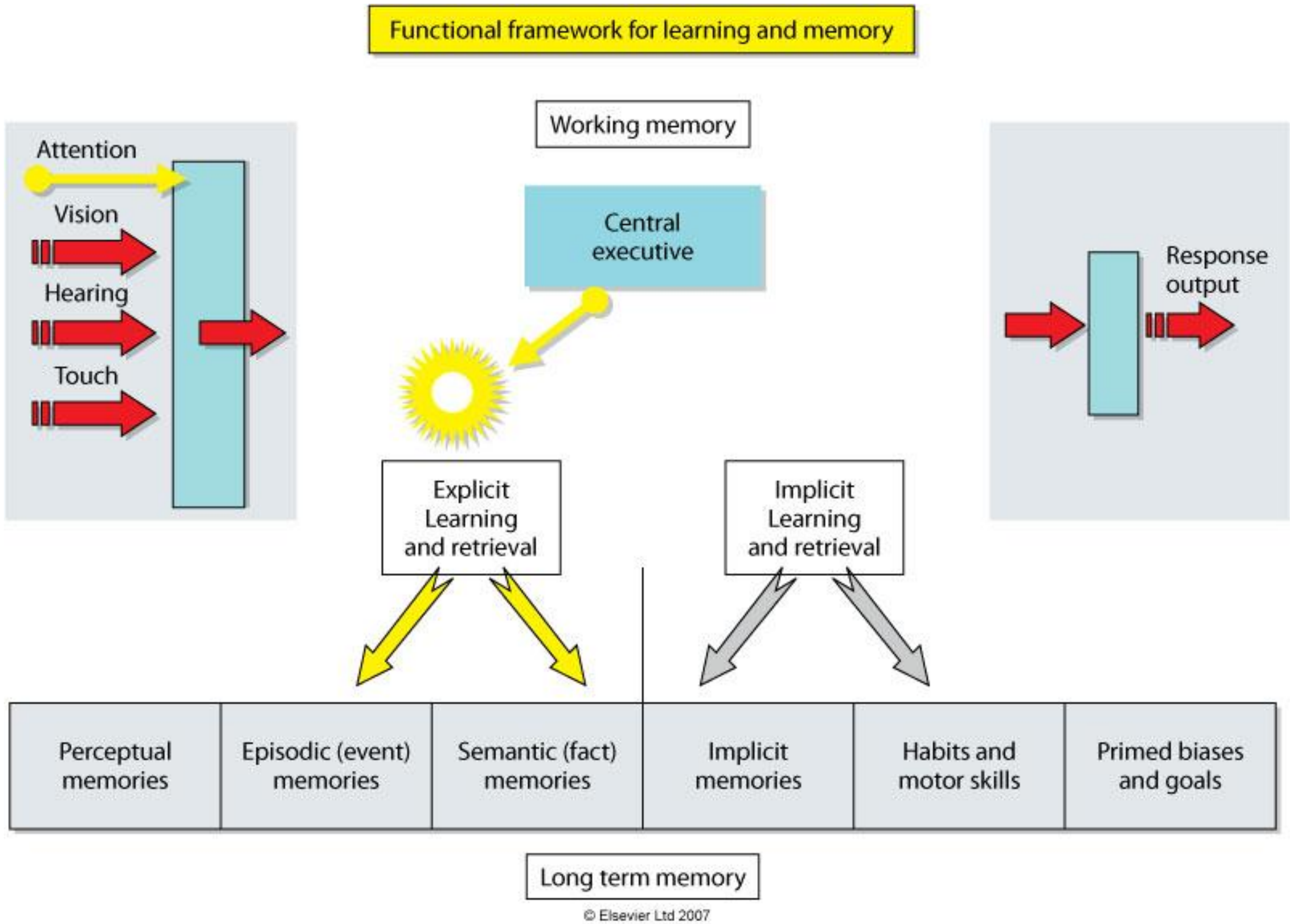
Source: left, Aminoff and Daroff, 2003; right, Corkin et al., 1997.

Medial Temporal Lobe



Learning and memory in the functional framework

Sensory input goes to working storage, part of working memory, which in turn allows information to be actively maintained and manipulated



Introspect….

- Can saying ‘I can’t remember’ mean different things?
- Do you consider yourself to have a good/poor’ memory? What criteria do you apply in making that assessment?

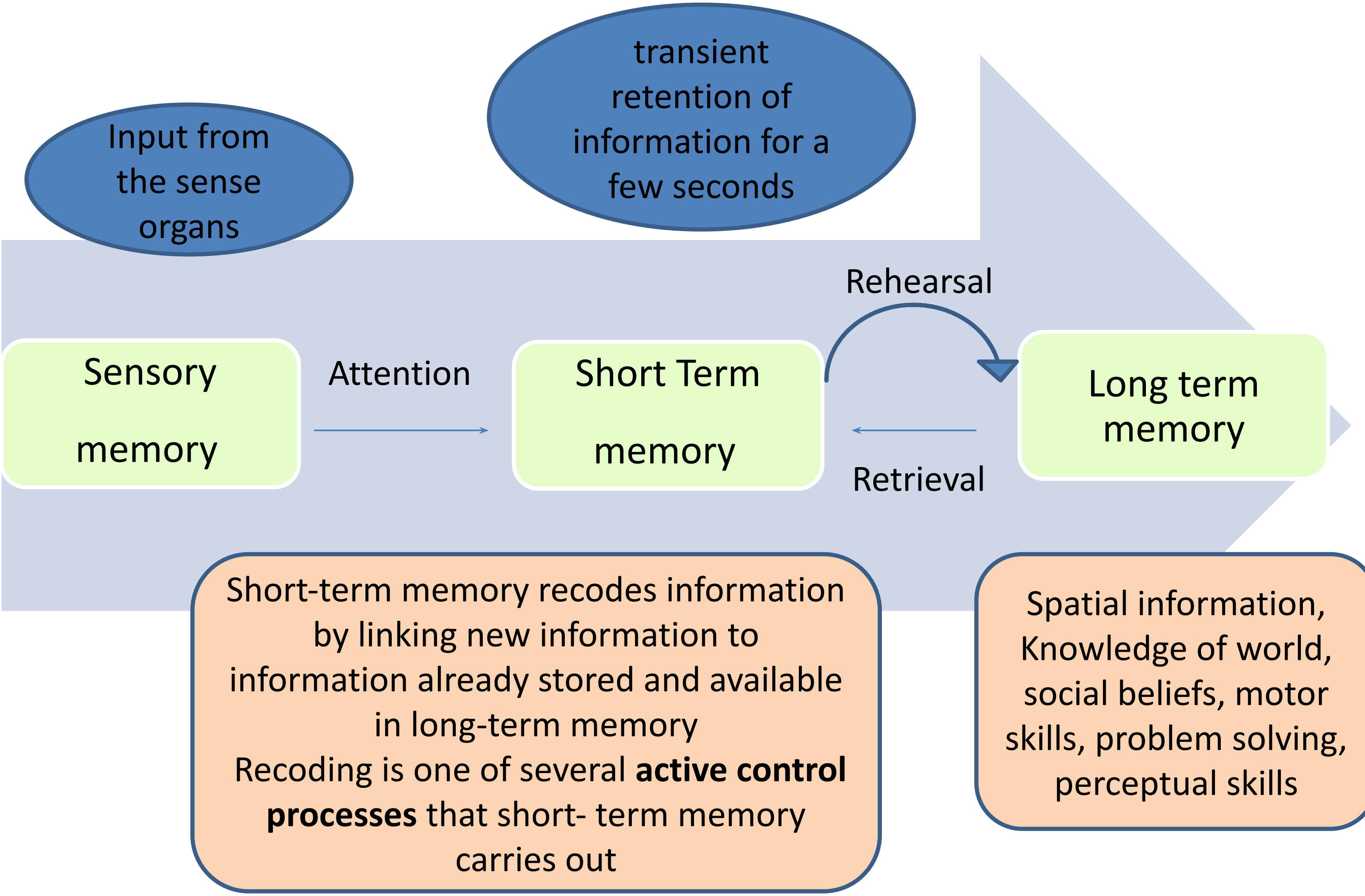
When people complain about having a ‘poor memory’, they might mean storage or retrieval (but they simply say ‘I can’t remember’)

History of memory research…

- Ebbinghaus (1885), the pioneer of memory research

- Hebb (1949)
- Broadbent (1958)
- Atkinson and Shiffrin (1968, 1971)
- Tulving
- Craik and Lockhart

Multi-store model of memory



Visual Sensory memory

X	M	R	J
C	N	K	P
V	F	L	B

Coding in STM…

Shulman (1970) showed participants lists of ten words

Recognition of the words was then tested using a visually presented 'probe word', which was either:

a ***homonym*** of one of the words on the list (such as 'bawl' for 'ball')

a ***synonym*** (such as 'talk' for 'speak')

If an error was made on a synonym probe, some matching for meaning must have taken place (i.e. semantic coding)

Visual images (such as abstract pictures, which would be difficult to store using an acoustic code) can also be maintained in STM, if only briefly

There are three or four main types of encoding

- **Acoustic encoding** is the processing and encoding of sound, words and other auditory input for storage and later retrieval. This is aided by the concept of the **phonological loop**, which allows input within our **echoic memory** to be sub-vocally rehearsed in order to facilitate remembering

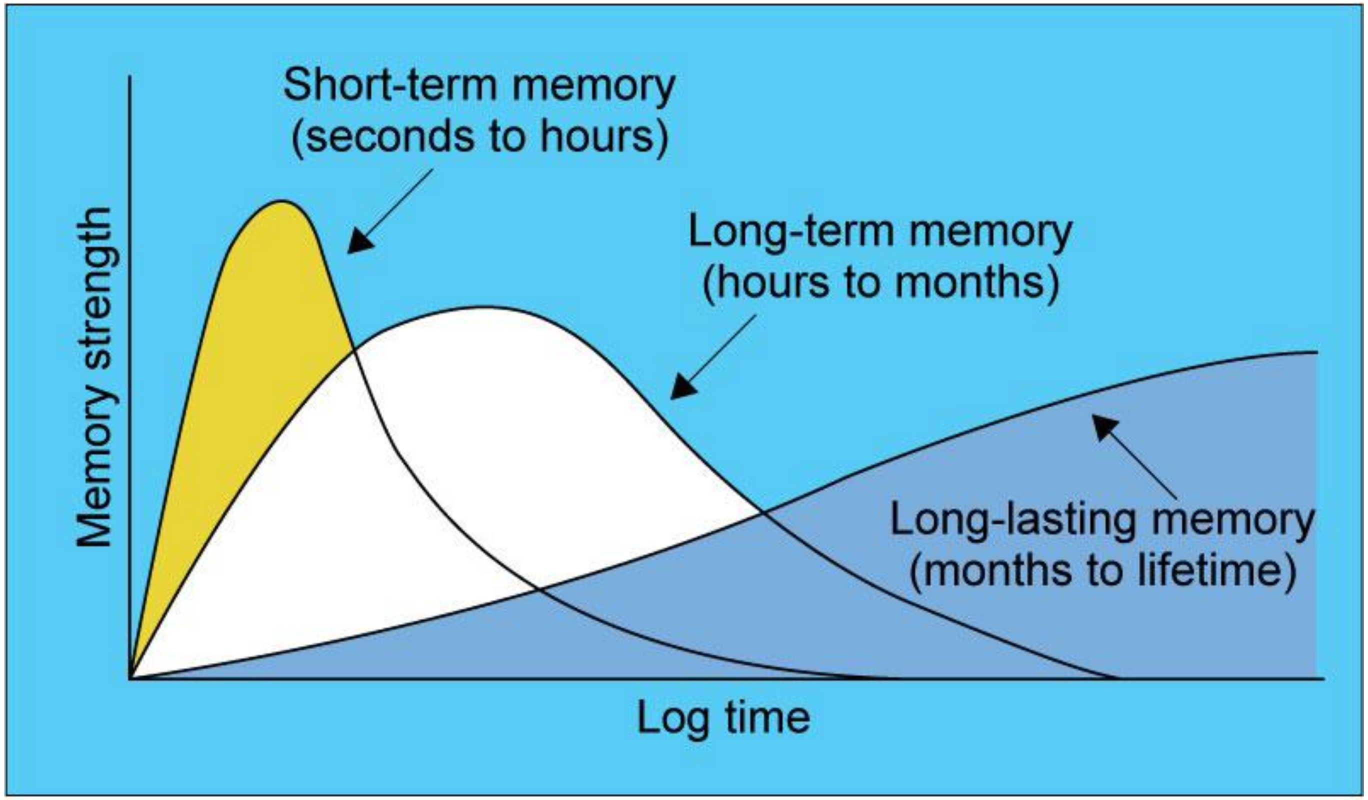
- **Visual encoding** is the process of encoding images and visual sensory information. Visual sensory information is temporarily stored within the **iconic memory** before being encoded into long-term storage. The **amygdala** (which has a primary role in the processing of **emotional** reactions) fulfills an important role in visual encoding, as it accepts visual input in addition to input from other systems and encodes the positive or negative values of **conditioned stimuli**

- **Tactile encoding** is the encoding of how something feels, normally through the sense of touch. Physiologically, neurons in the primary **somatosensory cortex** of the brain react to vibro-tactile stimuli caused by the feel of an object

- **Semantic encoding** is the process of encoding sensory input that has particular **meaning** or can be applied to a particular **context**, rather than deriving from a particular sense

For encoding for short-term memory storage in the brain relies primarily on **acoustic encoding**, while encoding for long-term storage is more reliant

Rapid consolidation: synaptic mechanisms



Source: McGaugh, 2000.

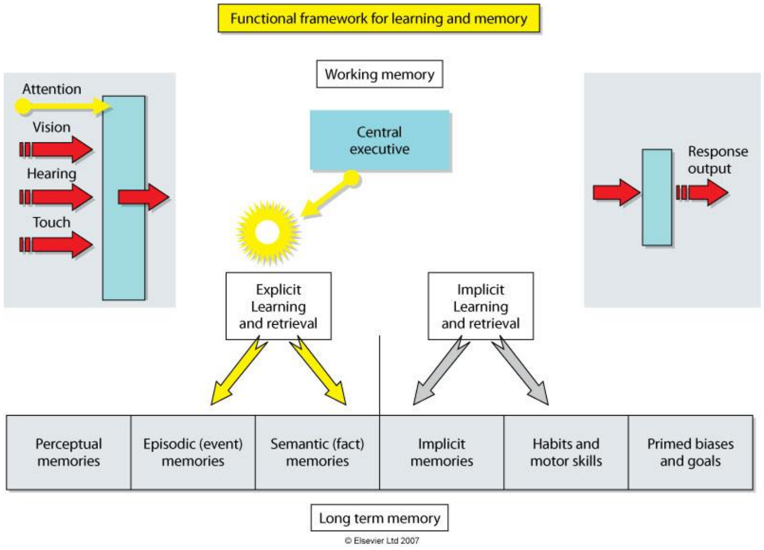
Three overlapping time courses for consolidation proposed by James McGaugh at the University of California, Irvine

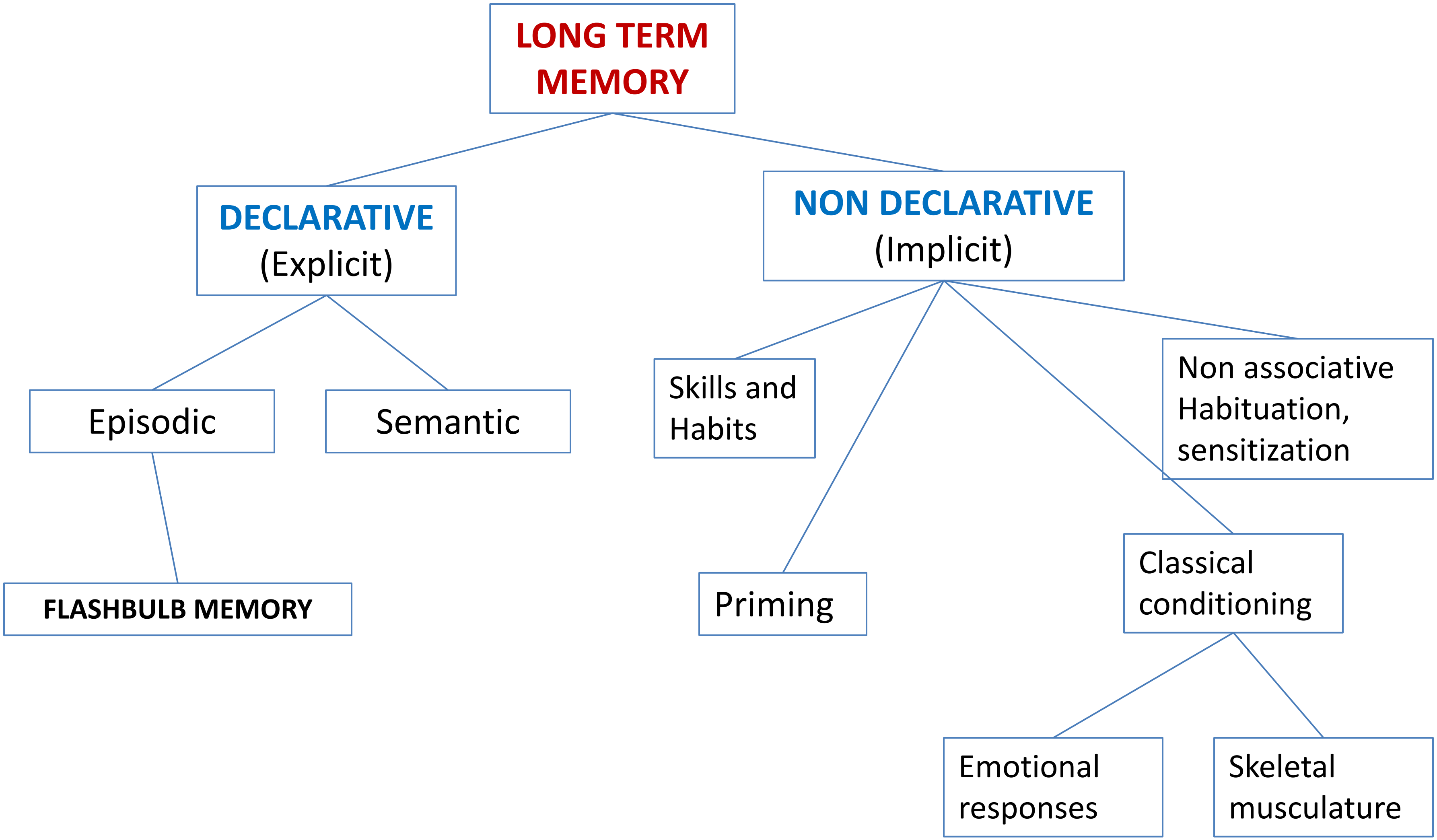
[Professor McGaugh's website]

Levels of Processing

Craik and Lockhart's *levels-of-processing* (LOP)

- The structural components (the memory system) results from the operation of memory processes
- Memory is a *by-product of perceptual analysis*. This is controlled by the central processor, which can analyze a stimulus (such as a word) on various levels:
  - At a ***superficial (or shallow***) level, the surface features of a stimulus (such as whether the word is in upper or lower case) are processed
  - At an ***intermediate (phonemic or phonetic***) level, the word is analyzed for its sound
  - At a ***deep (or semantic) level,*** the word's meaning is analyzed
- The level at which a stimulus is processed depends on both its nature and the processing time available. The more deeply information is processed, the more likely it is to be retained




LONG TERM MEMORY
DECLARATIVE (Explicit)
NON DECLARATIVE (Implicit)
Episodic
Semantic
Skills and Habits
Non associative Habituation, sensitization
FLASHBULB MEMORY
Priming
Classical conditioning
Emotional responses
Skeletal musculature

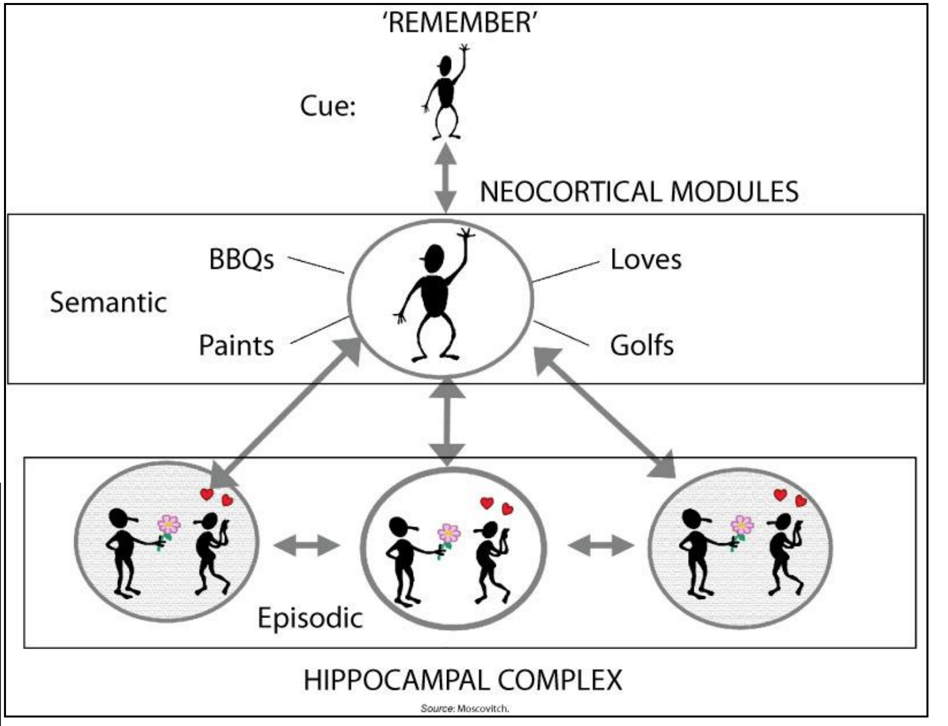
Episodic and Semantic Memory

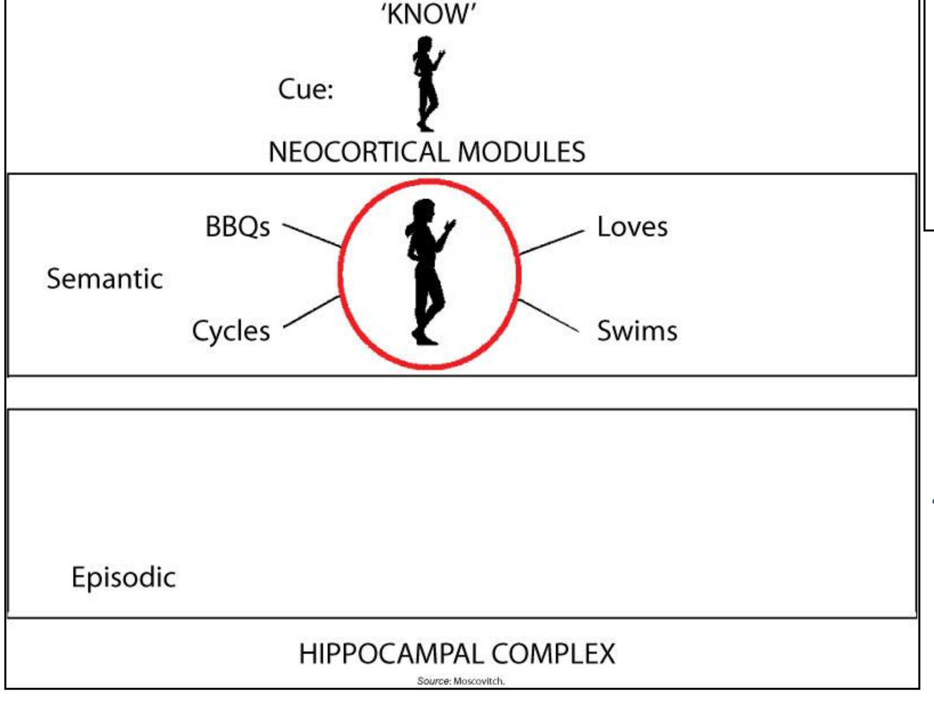
Episodic memory (EM): an 'autobiographical' memory responsible for storing a record of our past experiences – the events, people, objects and so on which we've personally encountered. EMs usually have a *spatio-temporal context*: e.g. 'Where did you go on your holiday last year?' and 'What did you have for breakfast this morning?'). They have a *subjective* (self-focused) reality, but most could, in principle, be verified by others.

Semantic memory (SM): our store of general, factual knowledge about the world, including concepts, rules and language, 'a mental thesaurus, organised knowledge a person possesses about words and other verbal symbols, their meanings and referents' (Tulving, 1972). SM can be used without reference to where and when that knowledge was originally acquired. But SM can also store information about ourselves (such as how many brothers and sisters we have, or how much we like Psychology).

Episodic vs Semantic: Remembering vs Knowing

Remembering autobiographical episodes involves an active reconstruction of the original (conscious) episode

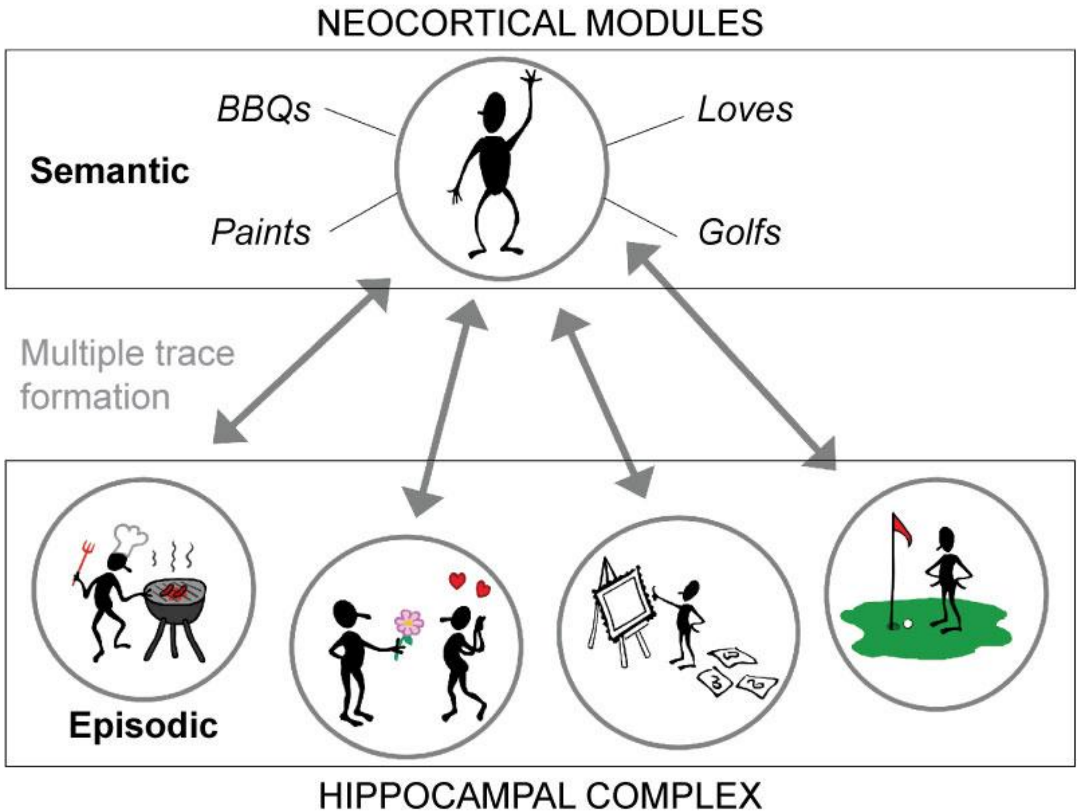




Knowing semantic memories does not require active reconstruction of the original episode, it is assessed by a 'feeling of knowing'

Episodic memories may turn into semantic memories over time

A model for how semantic and episodic memories may be related: semantic memories may be the cortical residue of many episodic memories



Source: Moscovitch, 2004, modified with permission.

Explicit memory

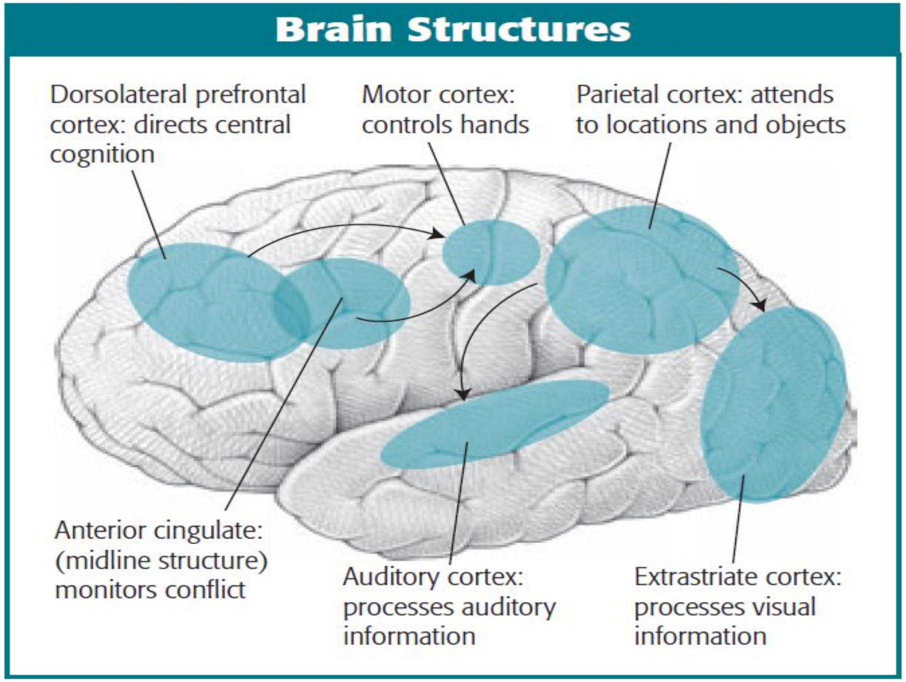
Processing information over time

Memory timelines:

- **Less than a second – "attention to something"**
- **Seconds to minutes – Working Memory**
- **Minutes to years – Long Term Memory**

Immediate Memory

Different areas of the brain contribute to alertness awareness and attention



Prefrontal regions are responsible for the creation of memories

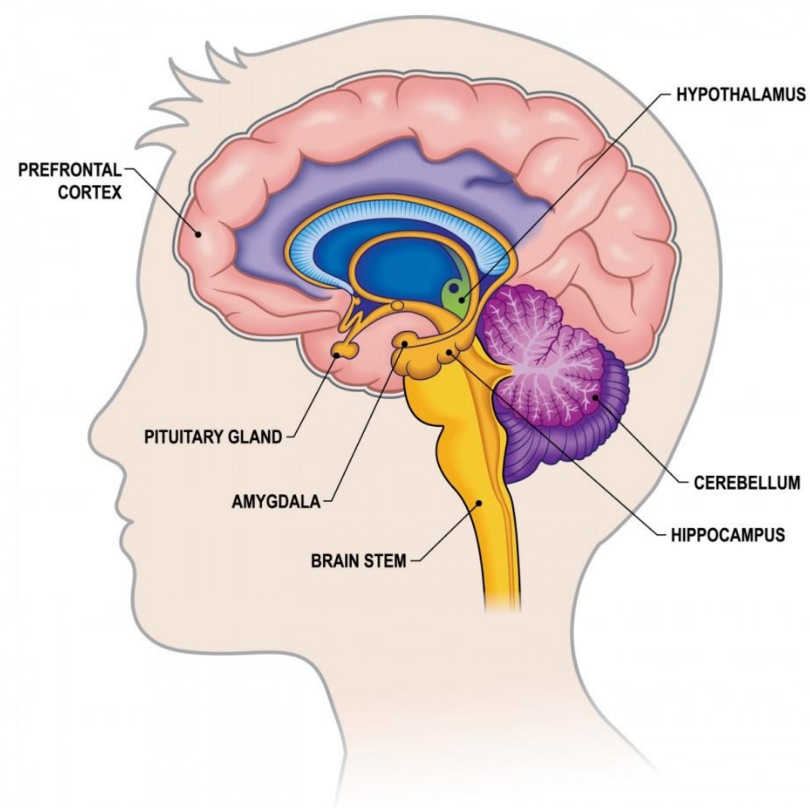
The hippocampus and surrounding structures in the temporal cortex are responsible for the permanent storage of these memories

Explicit or Declarative memory

- Memory of facts and events and spatial memory
- Can be consciously recalled
- Easy to acquire, easy to forget

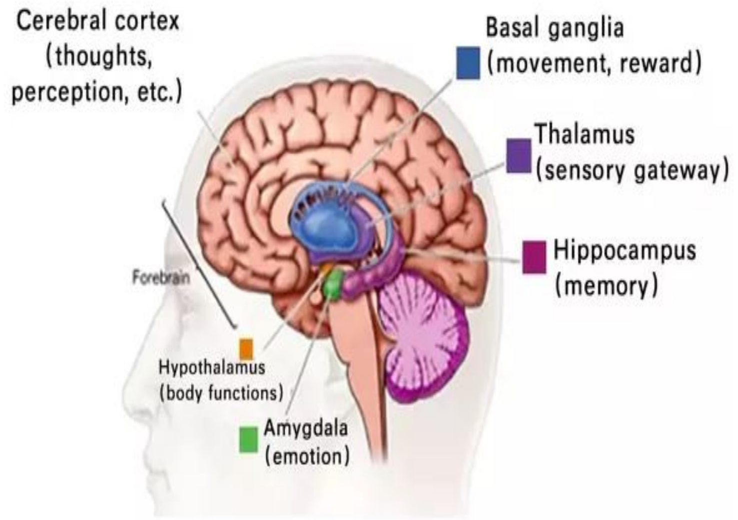
Brain areas involved:
- Hippocampus
- Pre-frontal cortex
- Amygdala (emotional memory)
- Cingulate Gyrus

And many more other structures



Brain areas in LTM

- **Left Hippocampus** – facts, episodes, words – responsible for constructing an autobiography
- **Right Hippocampus** – Spatial memory
- **The hippocampus compares present with past experience**
- Processing through the hippocampus is necessary for learning and for memory consolidation to occur



??? Did You Know ???

Research using **functional magnetic resonance imaging** (fMRI) suggests that **verbs** and **nouns** are stored in different ways in the brain.
Concrete nouns are stored in areas of the brain used to sense or manipulate the referent objects, leading to a theory of meaning based largely on **function**.

Did you know?

When presented with a **visual stimulus**, the part of the brain which is activated the most depends on the nature of the image

A blurred image, for example, activates the **visual cortex** at the back of the brain most

An image of an unknown face activates the **associative** and **frontal** regions most

An image of a face which is already in working memory activates the **frontal regions** most, while the visual areas are scarcely stimulated at all

Reading out loud (or even whispering or mouthing it) forms **auditory links** in our memory pathways, as well as visual ones from looking a page or screen

So, we remember ourselves producing and saying the information as well as reading it visually, which may improve our overall retrieval of memories

But this process works best, when just SOME of the information (e.g. the most important words or concepts) is read out loud, and the rest not, as this takes advantage of the **"oddball effect"** whereby we remember the more unusual or distinctive information best

Studies have shown that information is transferred between the hippocampus and the cerebral cortex during **deep sleep**, and sleep appears to be essential for the proper consolidation of long-term memories
However, even **daytime naps** can help improve memory to some extent, and helps with the memorization of important facts

Is complexity of the material related to memory?

In a positive example of **disfluency** (the subjective feeling of difficulty associated with any mental task), a study at **Princeton University** has shown that students learning new material printed in a **difficult-to-read font** or typeface were able to recall significantly more than those learning the same material in a font considered **easy to read**

It is believed that presenting information in a way that is hard to digest means that a person has to concentrate more, leading to **deeper processing** and therefore better retrieval afterwards

Cognition. 2011 Jan;118(1):111-5. doi: 10.1016/j.cognition.2010.09.012. Epub 2010 Oct 30.

Fortune favors the bold (and the Italicized): effects of disfluency on educational outcomes.

Diemand-Yauman C[1], Oppenheimer DM, Vaughan EB.

Author information

1 Princeton University, Department of Psychology, Princeton, NJ 08540, United States.

Abstract

Previous research has shown that disfluency--the subjective experience of difficulty associated with cognitive operations - leads to deeper processing. Two studies explore the extent to which this deeper processing engendered by disfluency interventions can lead to improved memory performance. Study 1 found that information in hard-to-read fonts was better remembered than easier to read information in a controlled laboratory setting. Study 2 extended this finding to high school classrooms. The results suggest that superficial changes to learning materials could yield significant improvements in educational outcomes.

PMID: 21040910 DOI: 10.1016/j.cognition.2010.09.012

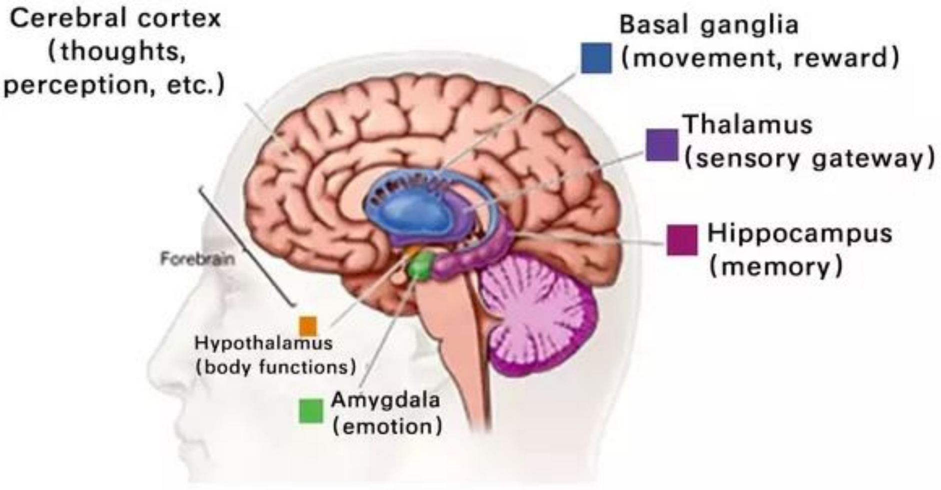
[Indexed for MEDLINE]

Implicit or Non declarative memory

- Memory for skills habits and behaviours
- Operates without conscious awareness once learned
- Requires repetition and practice
- Less likely to be forgotten once learnt
- Allows many types of behaviour to be on "auto Pilot"

Brain areas involved in Implicit memory

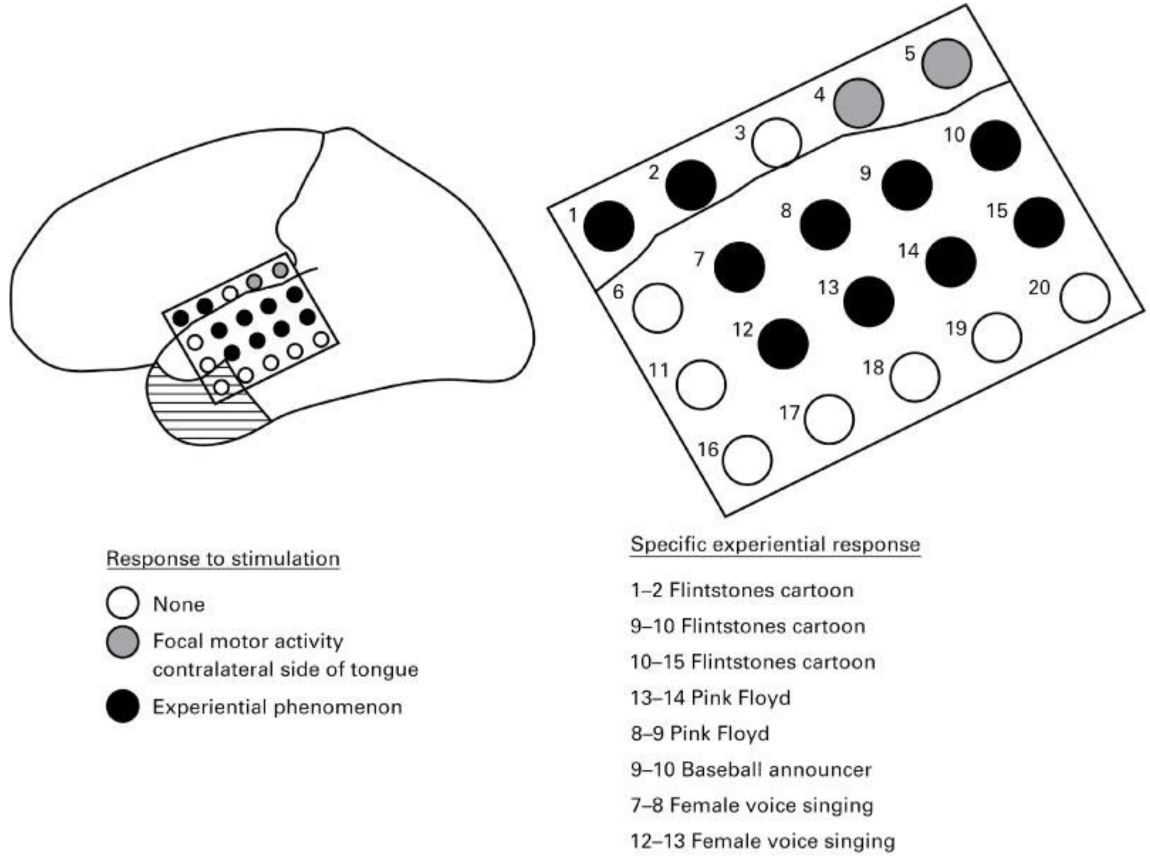
- Basal Ganglia involved in motor programs
- The Cerebellum plays a critical role in the timing and execution of learned, skilled motor movement (typing)



Electrically evoked autobiographical memories

For more than 50 years, neurosurgeons have reported that awake patients report vivid, specific conscious recollections during temporal lobe stimulation.

Electrode grids are typically placed on the surface of the temporal lobe and areas are systematically stimulated and the patient's reported memories are noted.



Source: Moriarty *et al.*, 2001.

Information processing Model of Memory

Defined by quantity

Sensory Memory

Iconic memory
(0.5 secs)

Echoic memory
(3-4 secs)

→

Working Memory
(7 +- 2)

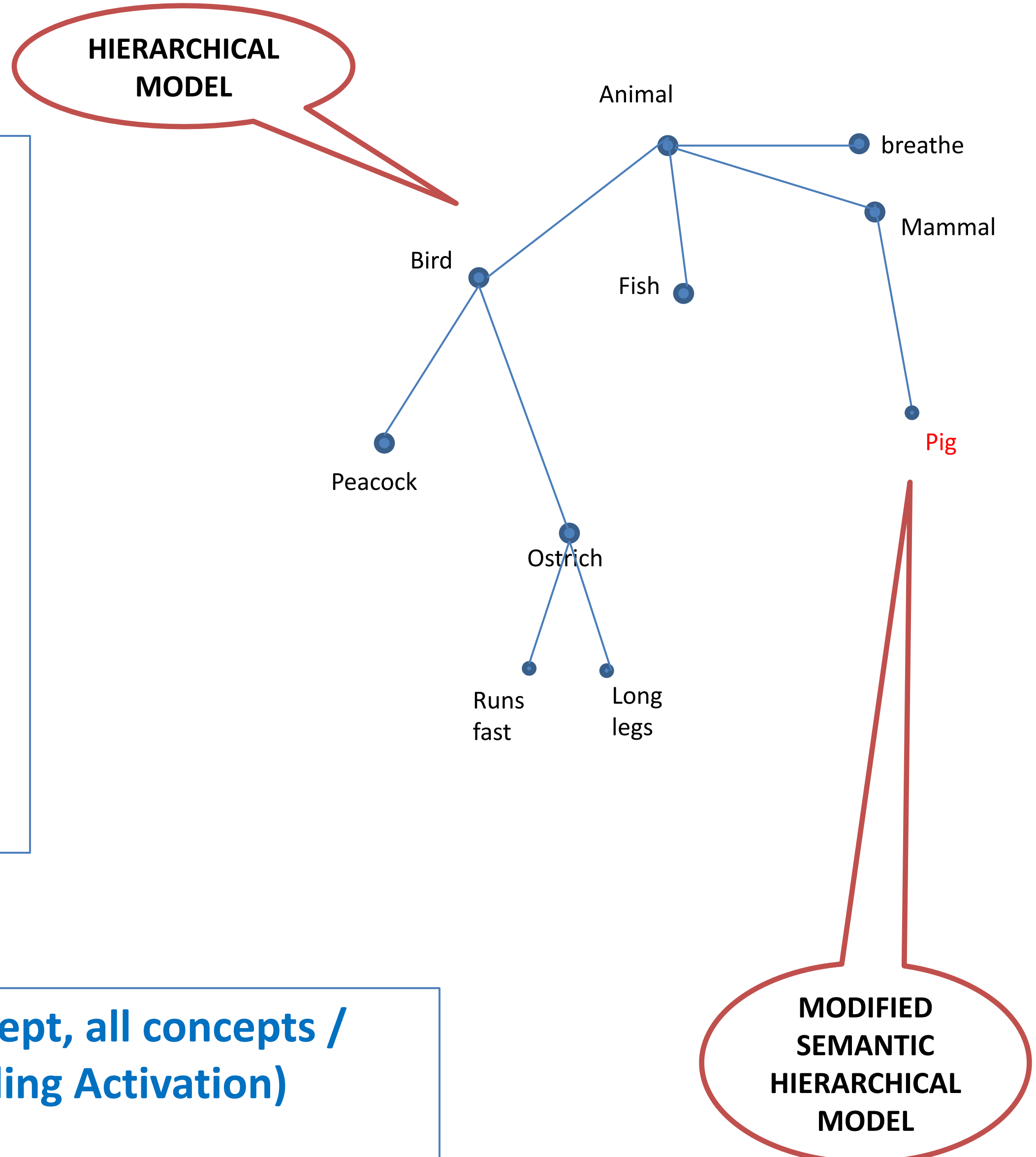
→

Long Term Memory

Spreading Activation Theory

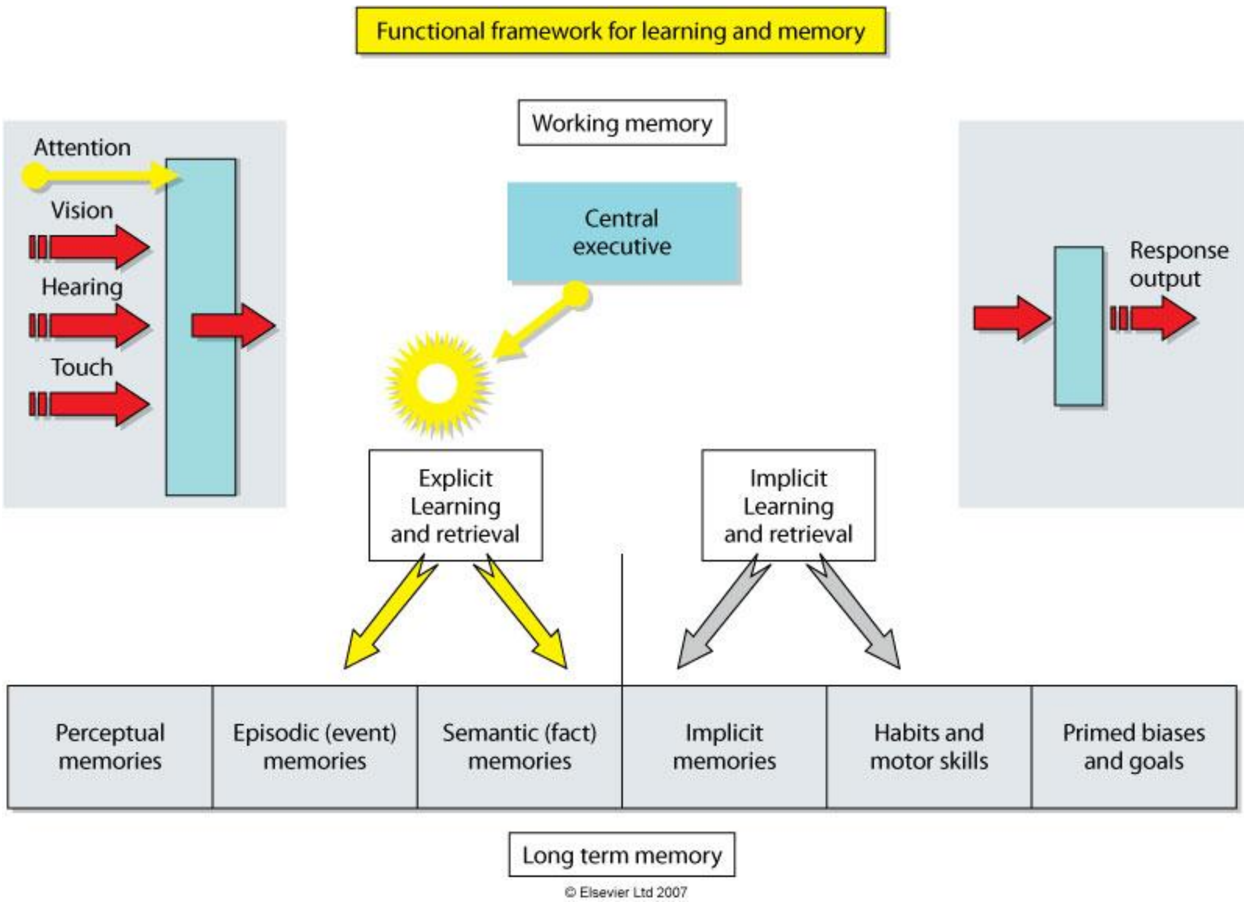
Semantic Network Model

- Concepts are organized in the brain in terms of connected ideas
- As in Computer - different nodes represent concepts and these nodes are connected by links
- Depending on how connected the nodes are the links may be shorter (closely related ideas) or longer (less related ideas)



When you have an activate a concept, all concepts / related ideas fire together (Spreading Activation)
Eg: school ……

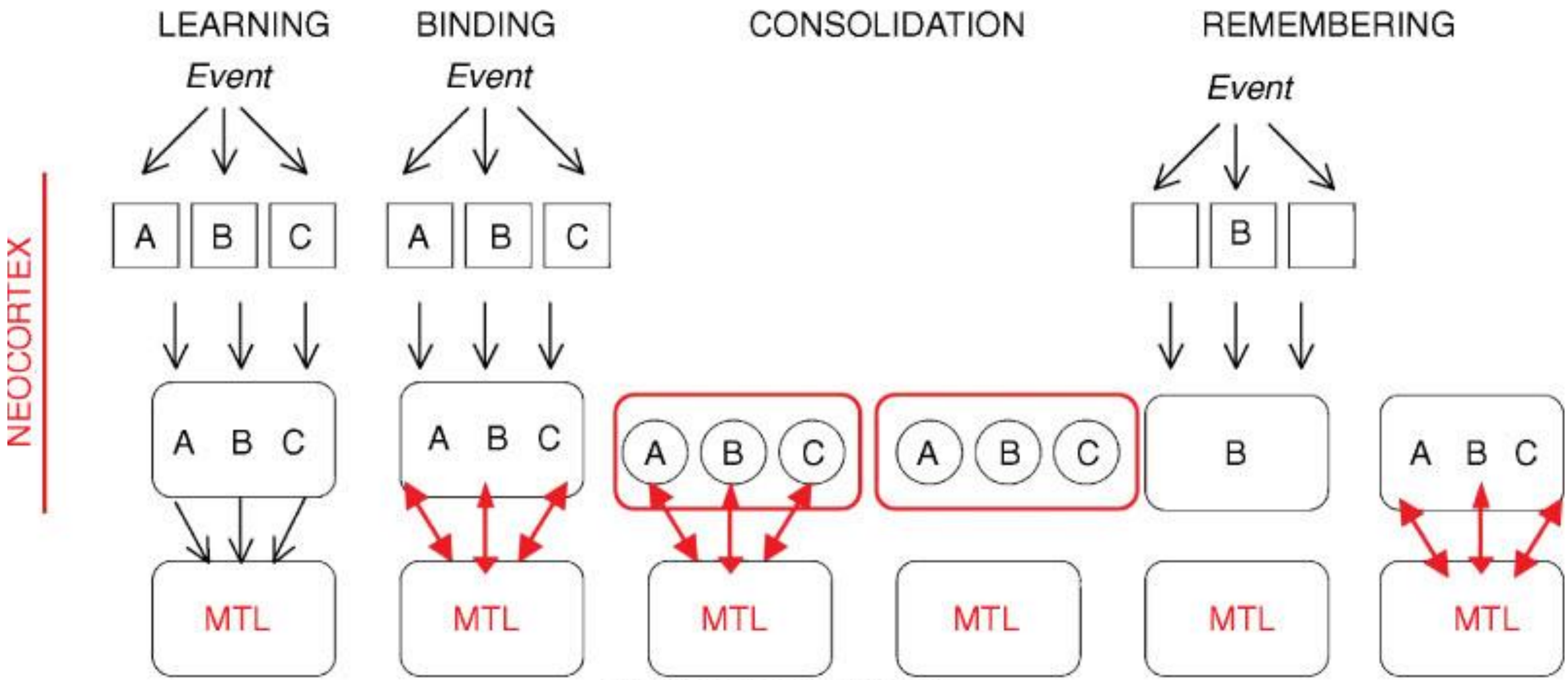
Working Memory



- Very limited in capacity
- Temporary and vulnerable to disruption
- Has the ability to hold some information for some time
- WM must be constantly "dumped"
- Helps in planning behaviour
- Involves majorly Pre-frontal cortex

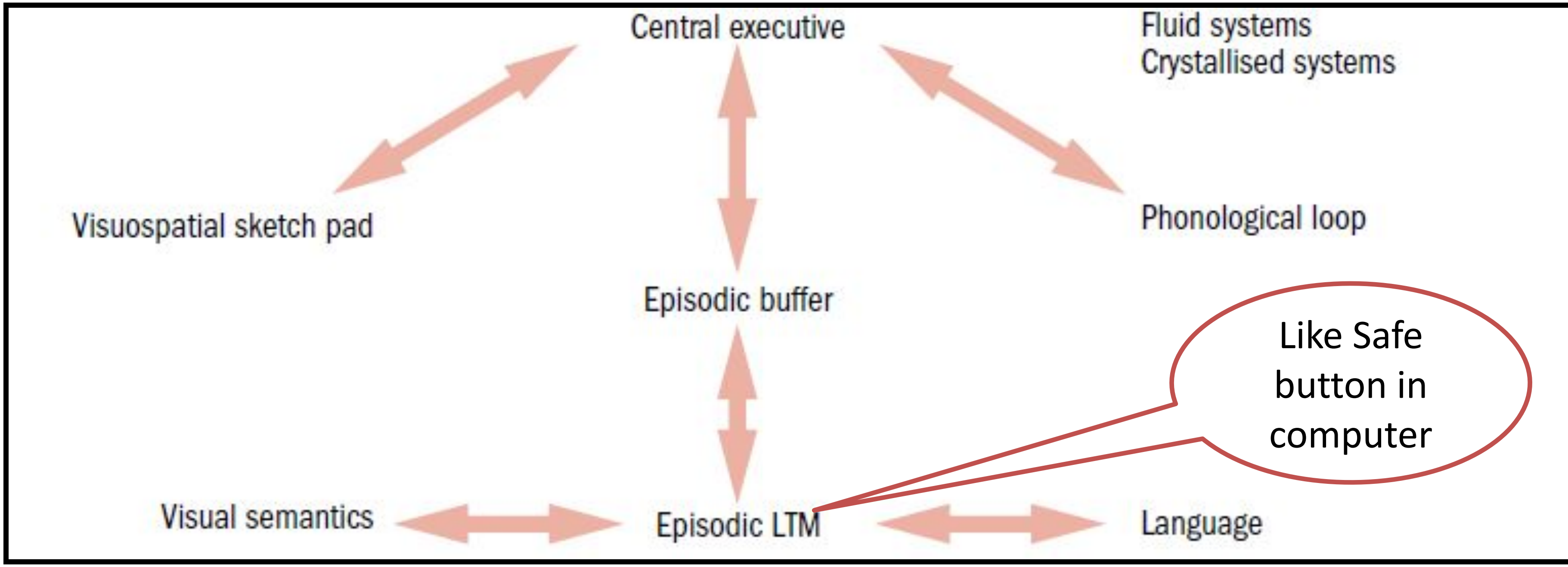
From Consolidation to Storage

Explaining Spread activation through Medial Temporal Lobe activation



Source: Moscovitch, modified with permission.

The working-memory (WM) model: rethinking STM



The working memory model, showing the central executive and its subsystems

Central Executive

- Involved in higher mental processes, such as **decision-making, problem-solving and making plans**
- More specifically, it co-ordinates the performance on two separate tasks, and attend selectively to one input while inhibiting others (Baddeley, 1996)
- Although capacity-limited, it is very flexible and can process information in any sense modality (*modality-free*)
- It resembles a pure attentional system (Baddeley, 1981)

The Articulatory (or Phonological) loop

- It can be thought of as a *verbal rehearsal loop* used when, for example, we try to remember a telephone number for a few seconds by saying it silently to ourselves
- It is also used to hold words we're preparing to speak aloud
- It uses an a*rticulatory/phonological code*, in which information is represented as it would be spoken (**the *inner voice***)

The Visuo-spatial scratch (or sketch) pad

- This can also rehearse information, but deals with visual and/or spatial information as, for example, when we drive along a familiar road, approach a bend, and think about the road's spatial layout beyond the bend (Eysenck, 1986)
- It uses a visual code, representing information in the form of its visual features such as size, shape, and colour (**the *inner eye***)
- The scratch pad appears to contain separate visual and spatial components
- The ***more active spatial component*** is **involved in movement perception and control of physical actions**, while the ***more passive visual component*** **is involved in visual pattern recognition** (Logie, 1995)

How is memory measured?

The RETRIEVAL process

- ***Recognition**:* This involves deciding whether or not a particular piece of information has been encountered before (as in multiple-choice tests, where the correct answer is presented along with incorrect ones). The sensitivity of recognition as a form of retrieval was demonstrated by Standing (1973)

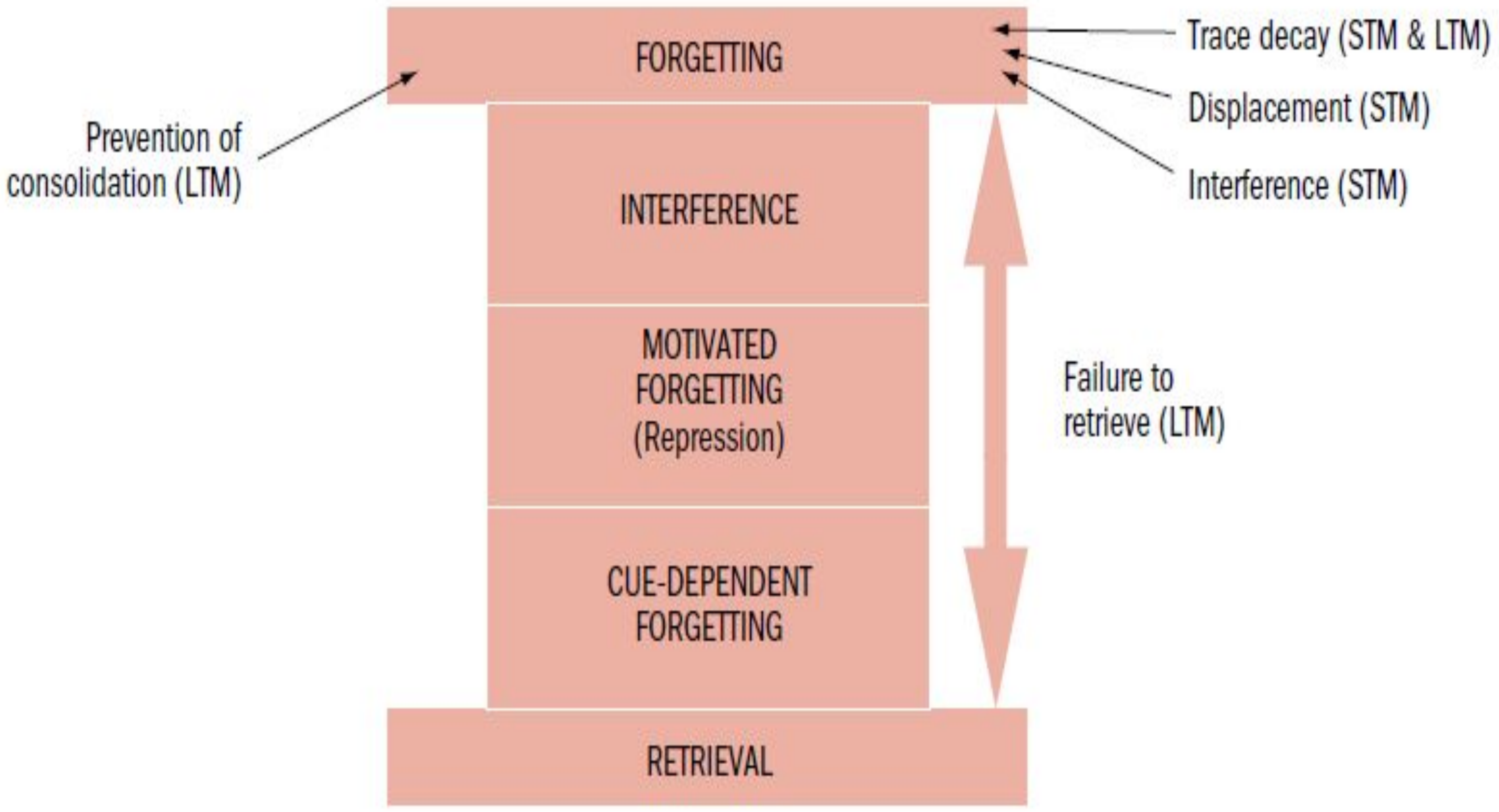
- ***Recall:*** This involves participants actively searching their memory stores in order to retrieve particular information (as in timed essays). Retrieval cues are missing or very sparse. The material can be recalled either in the order in which it was presented (*serial recall*) or in any order at all (*free recall*)

How is memory measured?
The RETRIEVAL process

- ***Memory-span procedure***: This is a version of serial recall, in which a person is given a list of unrelated digits or letters, and then required to repeat them back immediately in the order in which they were heard. The number of items on the list is successively increased until an error ismade. The maximum number of items that can consistently be recalled correctly is a measure of *immediate memory span*

- ***Paired-associate recall:*** Participants are required to learn a list of paired items (such as ‘chair’ and ‘elephant’). When one of the words (e.g. ‘chair’) is re-presented, the participant must recall the paired word (‘elephant’)

THEORIES of FORGETTING



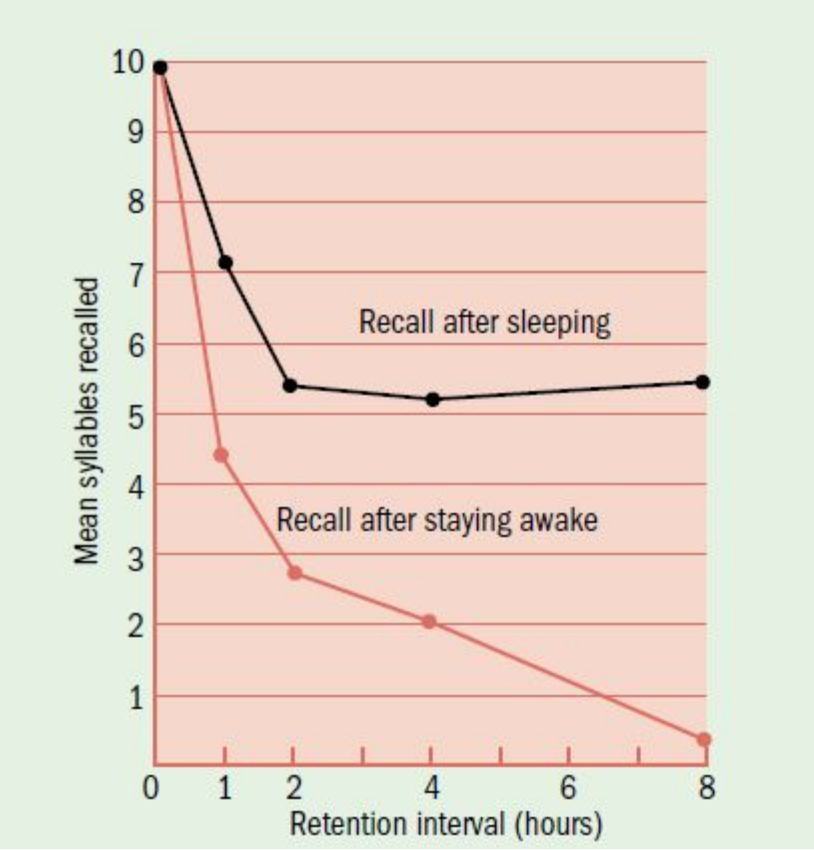
Theories of forgetting, including retrieval failure

If you want to remember, sleep on it

(Jenkins and Dallenbach, 1924)

- Participants learnt a list of ten nonsense syllables. Some then went to sleep immediately (approximating the ideal 'do nothing' state), while the others continued with their normal activities. After intervals of one, two, four or eight hours, all participants were tested for their recall of the syllables.
- While there was a fairly steady increase in forgetting as the retention interval increased for the 'waking' participants, this wasn't true for the sleeping participants (see Figure 17.12).
- If decay is a natural result of the passage of time alone, then we should have expected equal forgetting in *both* groups. The results suggest that it's what happens *in between* learning and recall that determines forgetting, not time as such. This led Jenkins and Dallenbach to conclude that:

Forgetting is not so much a matter of decay of old impressions and associations as it is a matter of interference, inhibition or obliteration of the old by the new.



Mean number of syllables recalled by participants in Jenkins and Dallenbach's experiment

Displacement theory

In a limited-capacity STM system, forgetting might occur through *displacement*

When the system is 'full', the oldest material in it would be displaced ('pushed out') by incoming new material

Waugh and Norman (1965) using the *serial probe task* □ Participants were presented with 16 digits at the rate of either one or four per second
One of the digits (the 'probe') was then repeated, and participants had to say which digit followed the probe

Hypothesis:

- If the probe was one of the digits at the beginning of the list, the probability of recalling the digit that followed would be small, because later digits would have displaced earlier ones from the system
- If the probe was presented towards the end of the list, the probability of recalling the digit that followed would be high, since the last digits to be presented would still be available in STM
- When the number of digits following the probe was small, recall was good, but when it was large, recall was poor. This is consistent with the idea that the earlier digits are replaced by later ones

Since less time had elapsed between presentation of the digits and the probe in the four-per-second condition, there would have been less opportunity for those digits to have decayed away. This makes it unclear whether displacement is a process distinct from decay

Retrieval-failure theory / cue dependent forgetting

using the correct cues to remember

- According to *retrieval-failure theory*, memories cannot be recalled because the correct retrieval cues aren't being used
- The role of retrieval cues is demonstrated by the ***tip-of-the-tongue phenomenon* (TOT)**,
  - in which we know that we know something but cannot retrieve it at that particular moment in time (**Brown and McNeill, 1966**)

Context-dependent forgetting	State-dependent forgetting
Occurs in absence of relevant environmental or contextual variables. These represent *external* cues.	Occurs in absence of relevant psychological or physiological variables. These represent *internal* cues.
Abernathy (1940): One group had to learn and then recall material in the same room, while a second group learned and recalled in different rooms. The first group's recall was superior.	Clark *et al*. (1987): Victims' inabilities to recall details of a violent crime may be due at least partly to the fact that recall occurs in a less emotionally aroused state. (See Chapter 21.)
Godden and Baddeley (1975): Divers learned lists of words either on land or 15 feet under water. Recall was then tested in the same or a different context. Those who learned and recalled in different contexts showed a 30% deficit compared with those who learned and recalled in the same context.	McCormick and Mayer (1991): The important link may be between mood and the sort of material being remembered. So we're more likely to remember happy events when we're feeling happy rather than sad.

Interference theory

According to *interference theory*, forgetting is influenced more by what we do before or after learning than by the mere passage of time

In ***retroactive interference/inhibition*** **(RI),** *later* learning interferes with the recall of *earlier* learning. For example, if you originally learned to drive in a manual car, then learned to drive an automatic, when returning to a manual, you might try to drive it as though it were an automatic

In ***proactive interference/inhibition*** **(PI),** *earlier* learning interferes with the recall of *later* learning

- For example, say you learned to drive on a car in which the indicator lights are turned on by using the stalk on the left of the steering wheel, and the windscreen wipers by the stalk on the right. After passing your driving test, you buy a car in which this arrangement is reversed. When you're about to turn left or right, you activate the windscreen wipers!

Amnesias…

H.M. (Milner *et al.,* 1968)
H.M. (Henry Molaison) is probably the single most studied amnesic patient in the history of Neuropsychology (Rose, 2003).

He'd been suffering epileptic fits of devastating frequency since the age of 16. In 1953 (aged 27), he underwent surgery aimed at alleviating his epilepsy. The anterior two-thirds of his hippocampus, most of his amygdala, plus part of the temporal lobe (on both sides of his brain) were removed While this was fairly successful in curing his epilepsy, at the time the role of these brain structures in memory was unknown, and he was left with severe ***anterograde amnesia*:**

he had near normal memory for anything learned before the surgery, but severe memory deficits for events that occurred afterwards

Clive Wearing

(based on Baddeley, 1990; Blakemore, 1988; Wearing, 2005)

- Clive Wearing was the chorus master of the London Sinfonietta and a world expert on Renaissance music, as well as a BBC radio producer

- In March 1985, he suffered a rare brain infection caused by the cold sore virus (*Herpes simplex*). The virus attacked and destroyed **his hippocampus, along with parts of his cortex**

- Like H.M., he lives in a snapshot of time, constantly believing that he's just awoken from years of unconsciousness. For example, when his wife, Deborah, enters his hospital room for the third time in a single morning, he embraces her as if they'd been parted for years, saying, 'I'm conscious for the first time' and 'it's the first time I've seen anybody at all'

- At first, his confusion was total and very frightening to him. Once he held a chocolate in the palm of one hand, covered it with the other for a few seconds until its image disappeared from his memory When he uncovered it, he thought he'd performed a magic trick, conjuring it up from nowhere. He repeated it again and again, with total astonishment and growing fear each time

Clive Wearing
(based on Baddeley, 1990; Blakemore, 1988; Wearing, 2005)

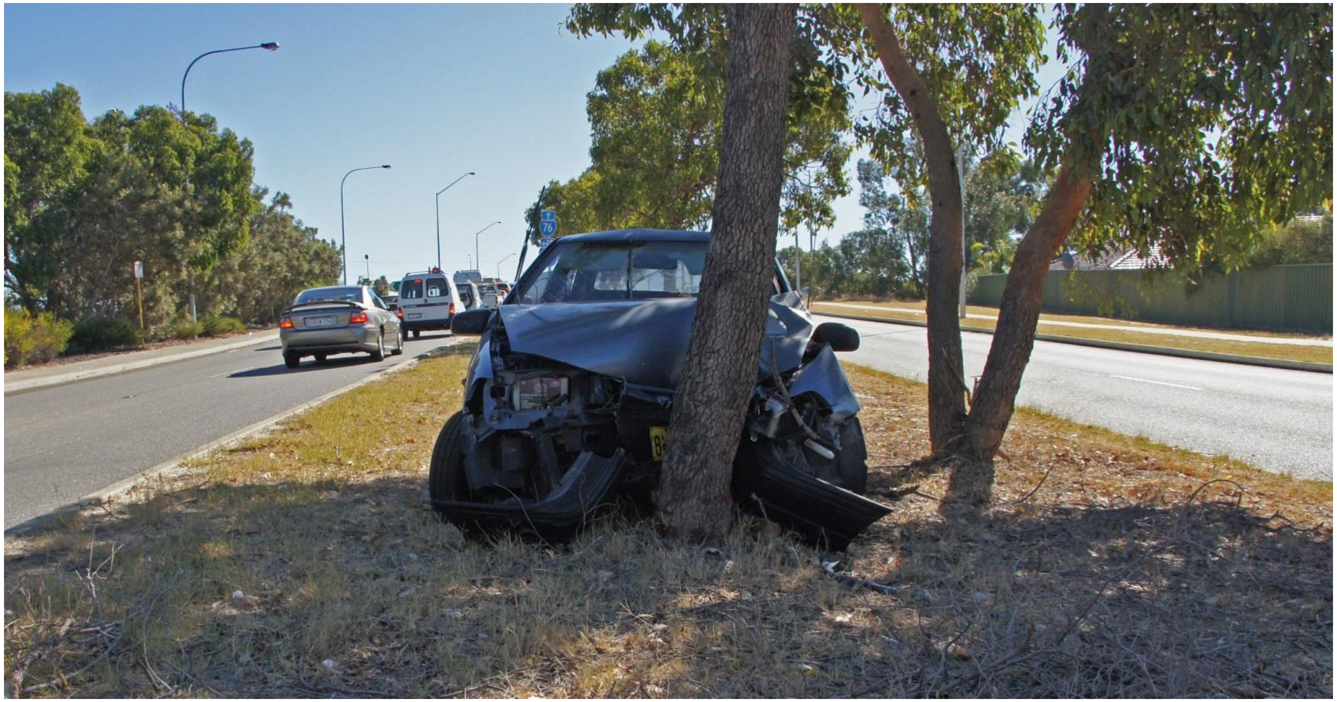
- Like H.M., he can still speak and walk, as well as read music, play the organ and conduct. In fact, his musical ability is remarkably well preserved. Also like H.M, he can learn new skills (e.g. mirror-reading), which he performed just as well three months later. Yet for Clive, it's new every time.

- But unlike H.M., his capacity for remembering his earlier life is extremely patchy. For example, when shown pictures of Cambridge (where he'd spent four years as an undergraduate and had often visited subsequently) he only recognized King's College Chapel – the most distinctive Cambridge building – but not his own college. He couldn't remember who wrote *Romeo and Juliet*, and he thought the Queen and the Duke of Edinburgh were singers he'd known from a Catholic church

Do we actually “see” what we see?

Experiment

Picture 1



Picture 2

EYE WITNESS TESTIMONY

- **Expt 1:** 7 films of traffic accidents, ranging in duration from 5 to 30 seconds, were presented in a random order to each group

- After watching the film participants were asked to describe what had happened as if they were eyewitnesses. They were then asked specific questions, including the question

  "About how fast were the cars going when they (smashed / collided / bumped / hit / contacted) each other?"

- **Expt 2:** Another group asked same Qs and queried a week later – whether they saw any broken glass

What if we remembered everything?

The Case of A.J. (Parker *et al.*, 2006)

- A 42-year-old woman from California, A.J., (real name, Jill Price) remembers every day of her life since her teens in extraordinary detail. Mention any date since 1980, and she's immediately transported back in time, picturing where she was, what she was doing, and what made the news that day. She can also identify the day of the week for any date since 1980 and give the correct date for apparently insignificant events

- She's locked in a cycle of remembering that she describes as 'running a movie that never stops'. She describes her constant recall as 'non-stop, uncontrollable and totally exhausting' and as a 'burden' of which she's both warden and victim

Technology as an aid or barrier to memory

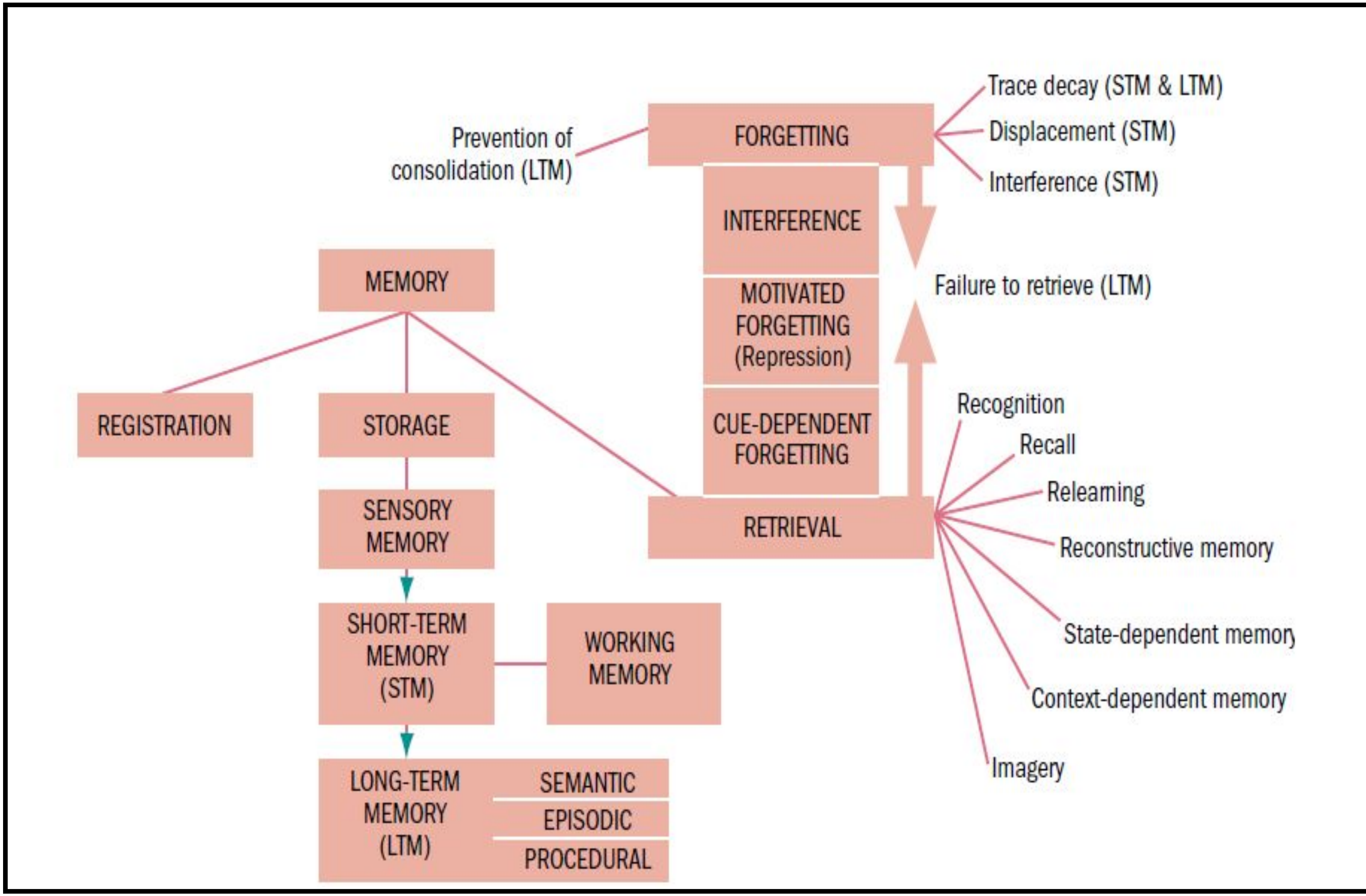
Wegner and Ward (2013)

- According to Wegner and Ward, the internet is not just replacing other people as sources of memory and someone to share information with, but also our own cognitive faculties, undermining the impulse to ensure that some important, just-learned facts get inscribed into our biological memory banks. They call this the *Google effect*

Sparrow *et al.* (2011)

- Participants were asked to copy 40 memorable factoids (e.g. 'An ostrich's eye is bigger than its brain') into a computer
- Half were told their work would be saved on the computer; the other half were told that it would be deleted. In addition, half of each group was asked to remember the information, regardless of whether it was being saved

- Those participants who believed the computer had saved their work were much *worse* at remembering; this tendency persisted when they were explicitly asked to keep the information in mind



A summary of the three components of memory and theories of forgetting