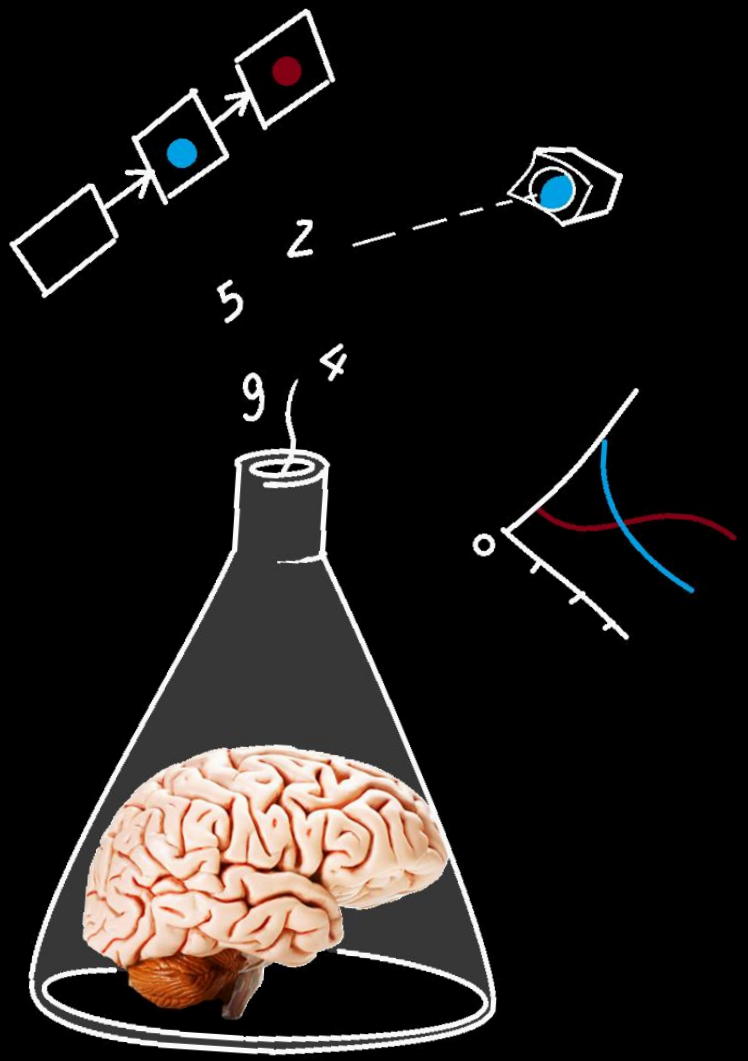
Cognitive Psychology

23-09

Memory & Decision-making

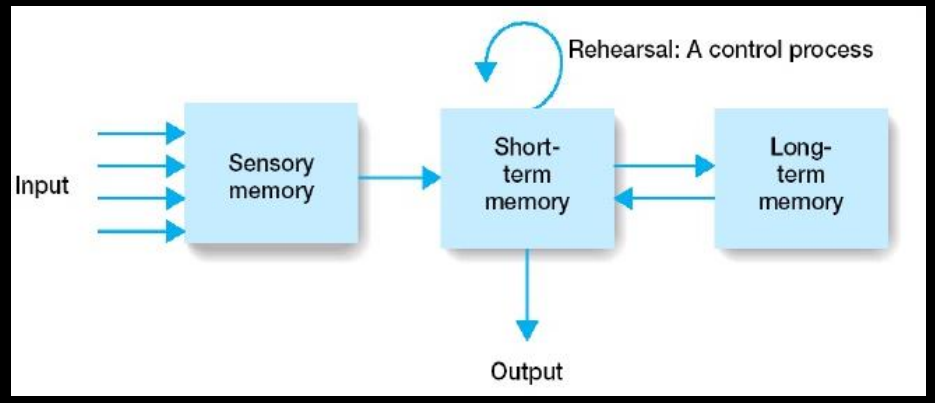


Joshua Snell J.J.Snell@VU.nl

Memory is…

Any way in which a past experience affects future thoughts or behaviors

The Modal Model of Memory – 1968



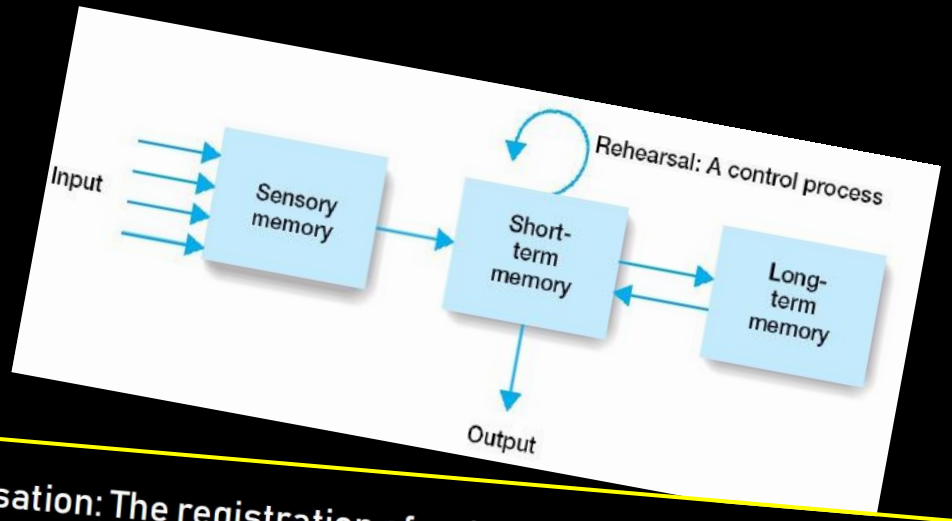
Today, we still conceptualize various stages of memory

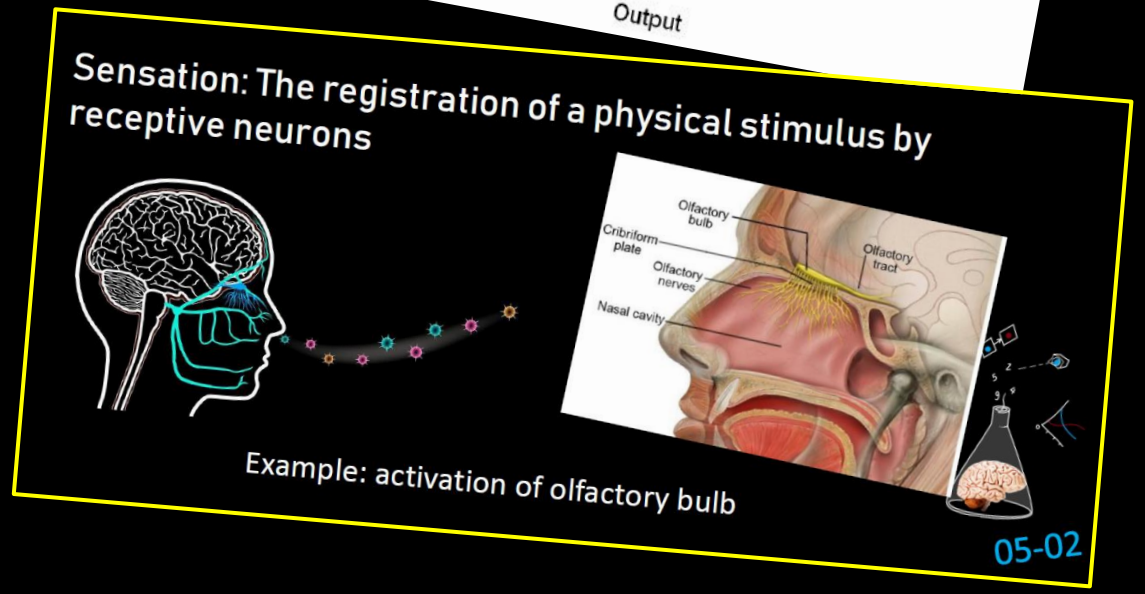
Sensory, STM/WM, LTM

What's the difference between sensory- & short term memory (STM)?

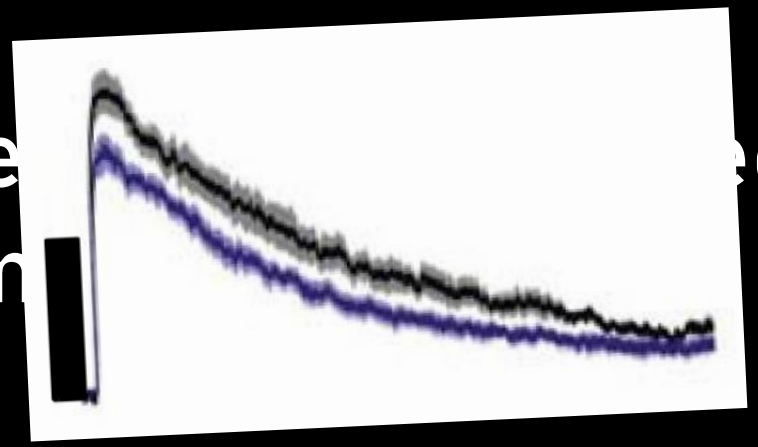
Think back of lecture 3:
sensation vs. perception!

Sensation ≈ sensory memory, because neural activity caused by a sensation isn't turned off like a light switch





What's the [redacted]een sensory- & short term



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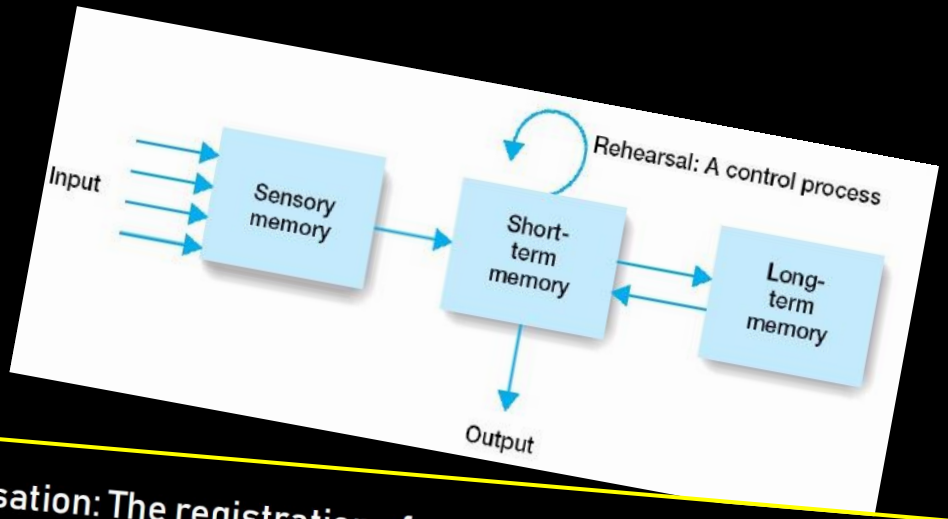

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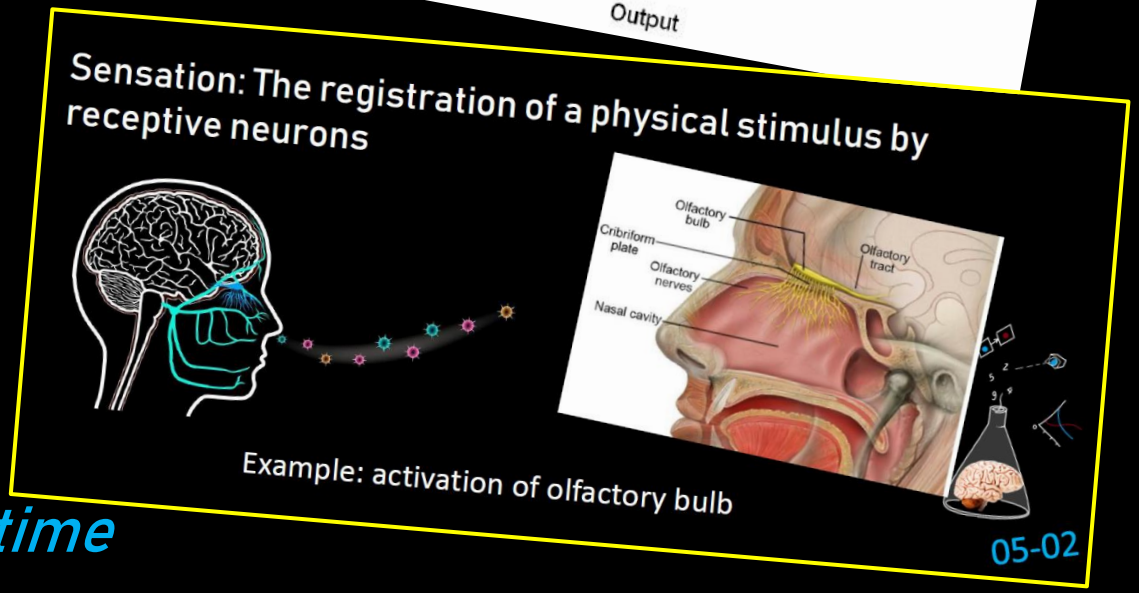


Activity in early regions decays over time

What's the difference between sensory- & short term memory (STM)?

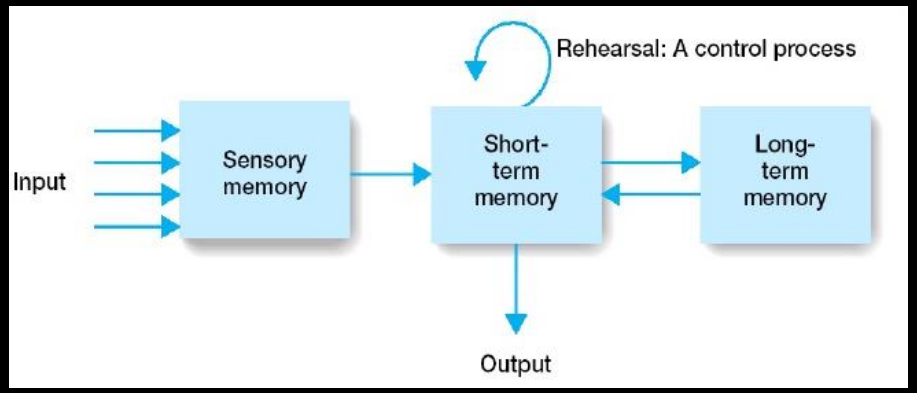
Think back of lecture 3:
sensation vs. perception!

Sensory memory examples

What's the difference between sensory- & short term memory (STM)?

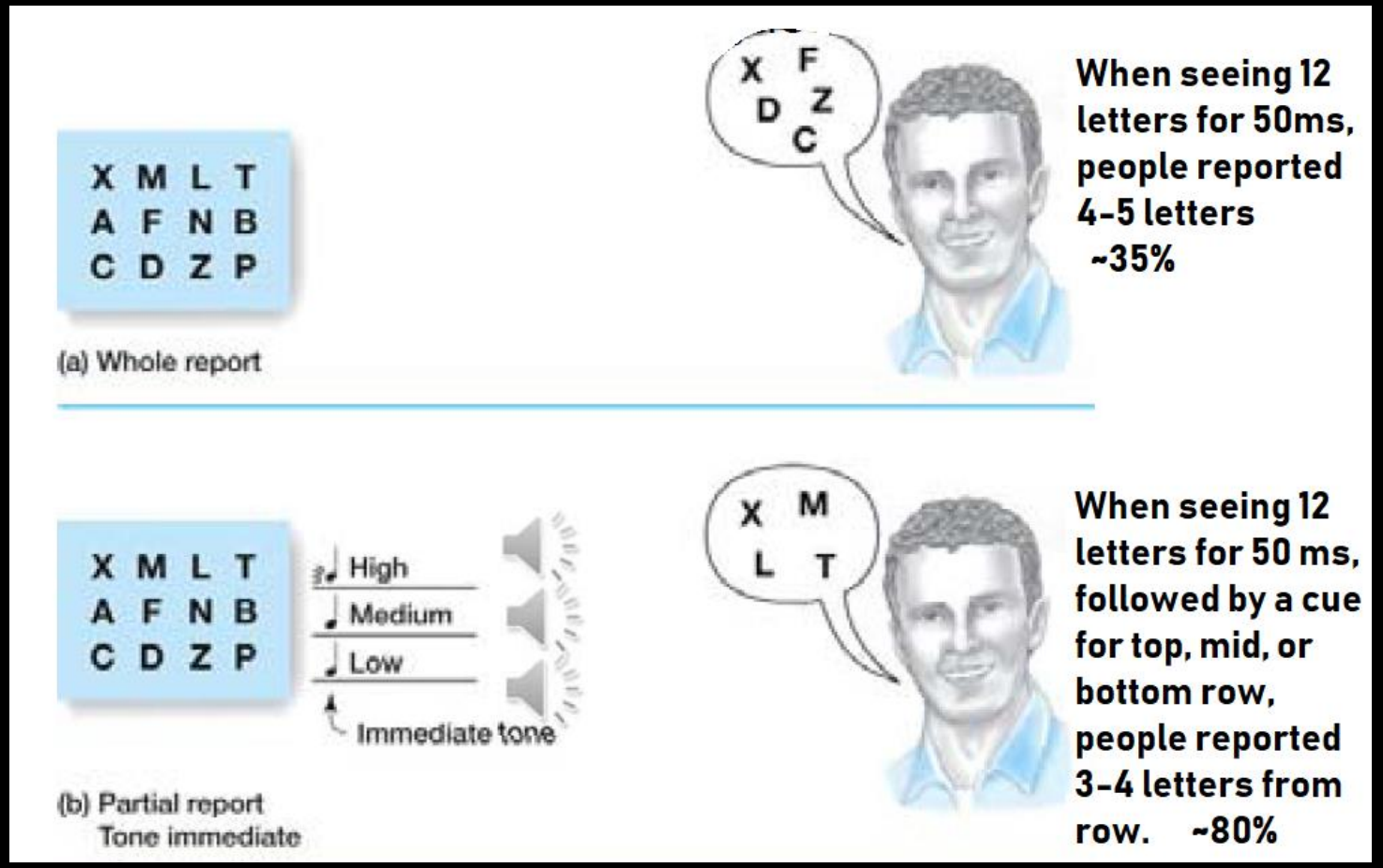
Our senses register a lot of information (e.g. the whole visual field), but only part of it is consciously processed

A.K.A. only part of it enters STM (= attentional orienting!)



What's the difference between sensory- & short term memory (STM)?

Sperling (1960)

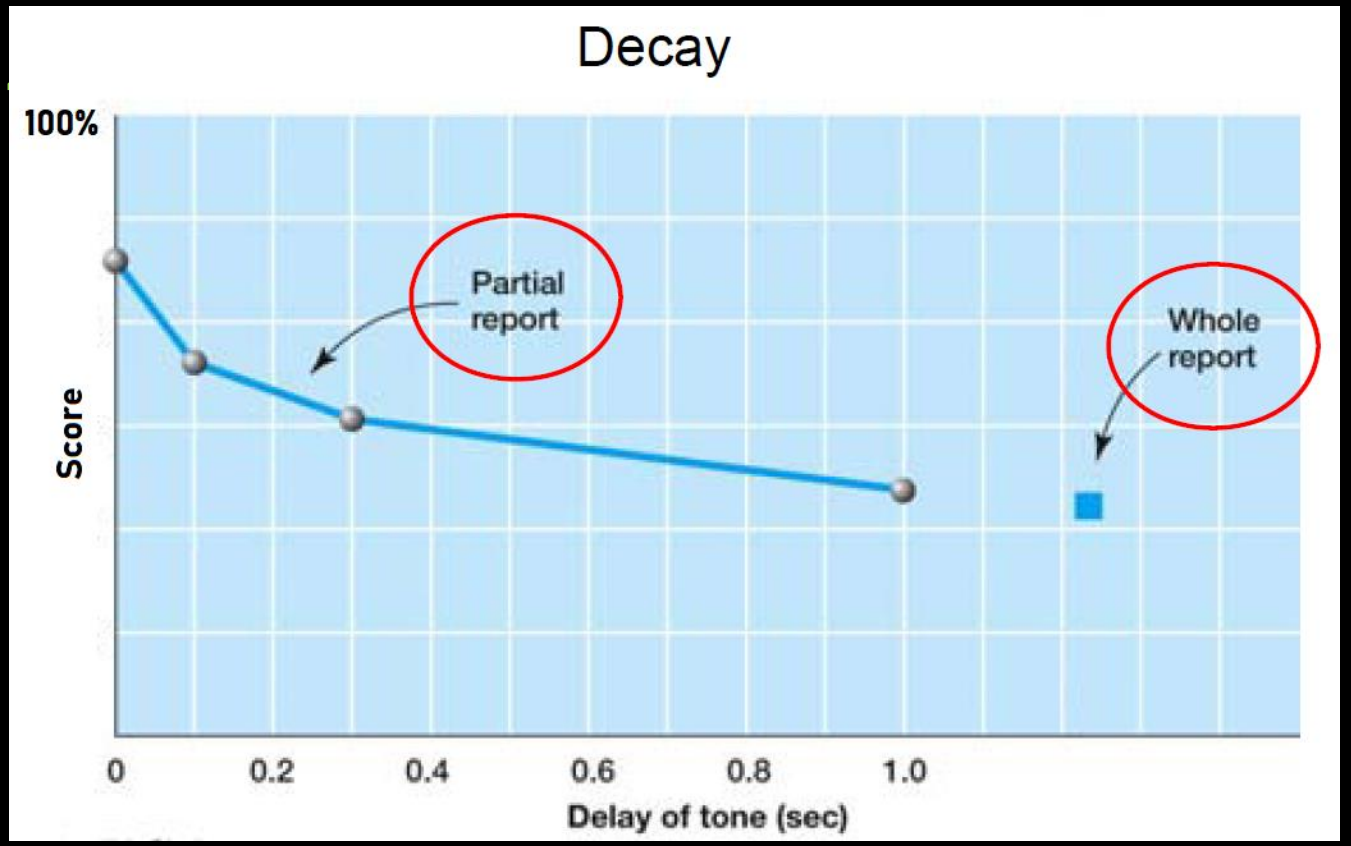


What's the difference between sensory- & short term memory (STM)?

Sperling (1960) "Short-lived sensory memory registers all or most of the information that hits our visual receptors, but this information decays within less than a second"

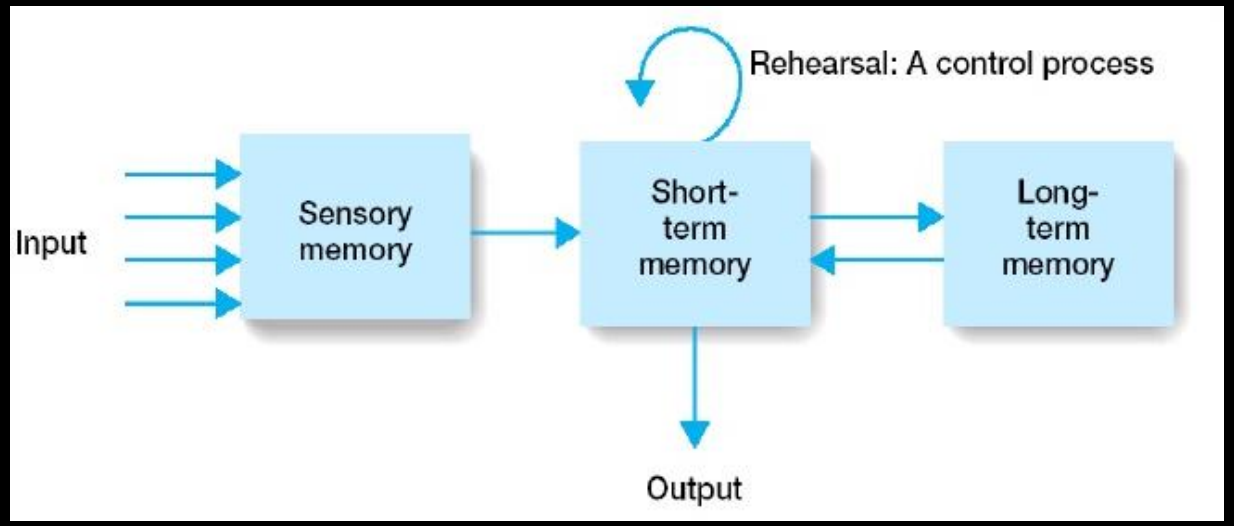
What's the difference between sensory- & short term memory (STM)?

Sperling (1960)



What's the difference between sensory- & short term memory (STM)?

STM is the first stage where we can pro-actively retain things



STM: what's the limit?

Try to memorize the following sequence

529846731

STM: what's the limit?

Try to memorize the following sequence
and the next...

1234567891234567 89

STM: what's the limit?

529846731

vs.

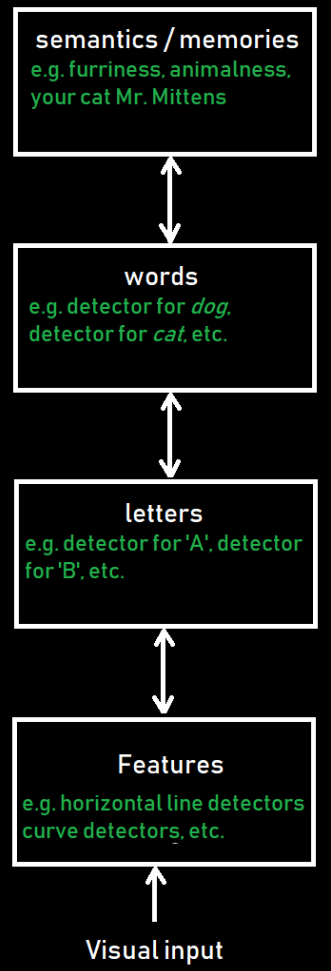
123456789123456789 *chunking*

The learned relationships among objects are a matter of long-term memory

... yet, this knowledge does aid STM

→ interdependence

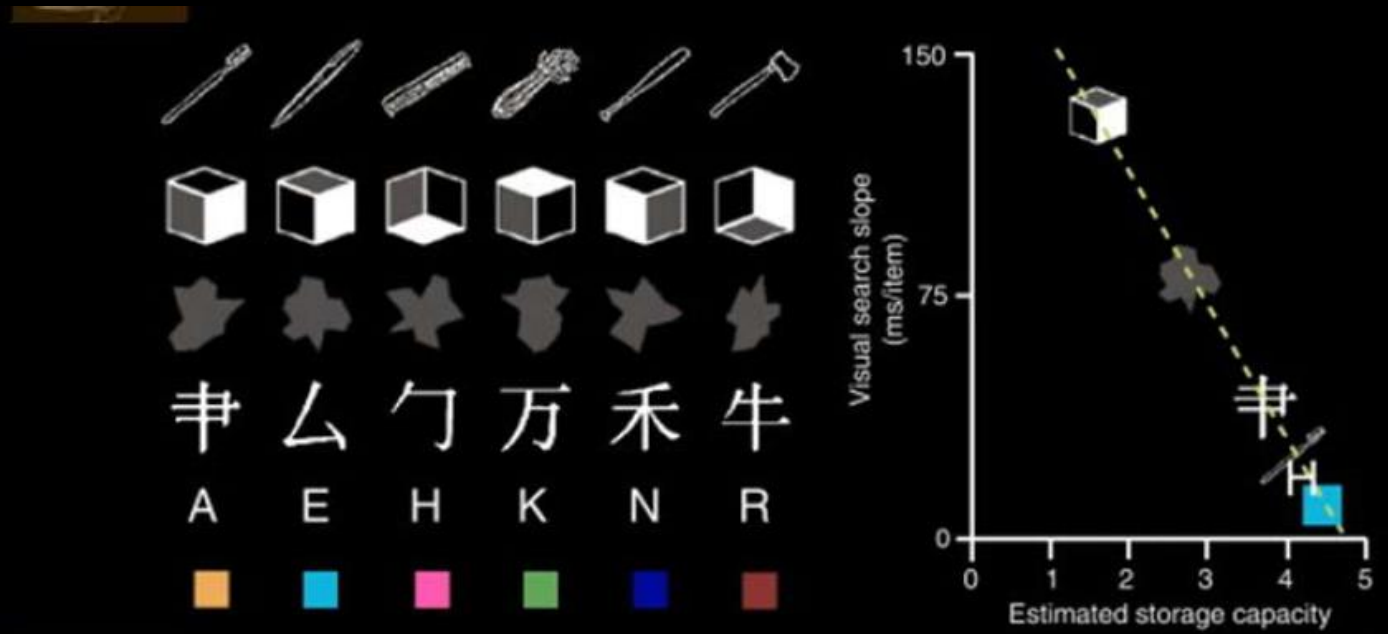
Interaction between top-down & bottom-up (perception lecture) works for memory too!



STM: what's the limit?

Instead of framing the limit in terms of number of objects, frame it in terms of amount of information.

Some item types are more difficult to remember



Alvarez, G. A., & Cavanagh, P. (2004). The capacity of visual short-term memory is set both by visual information load and by number of objects. *Psychological Science*, *15*(2), 106–111.

STM: actively memorizing stuff, and…?

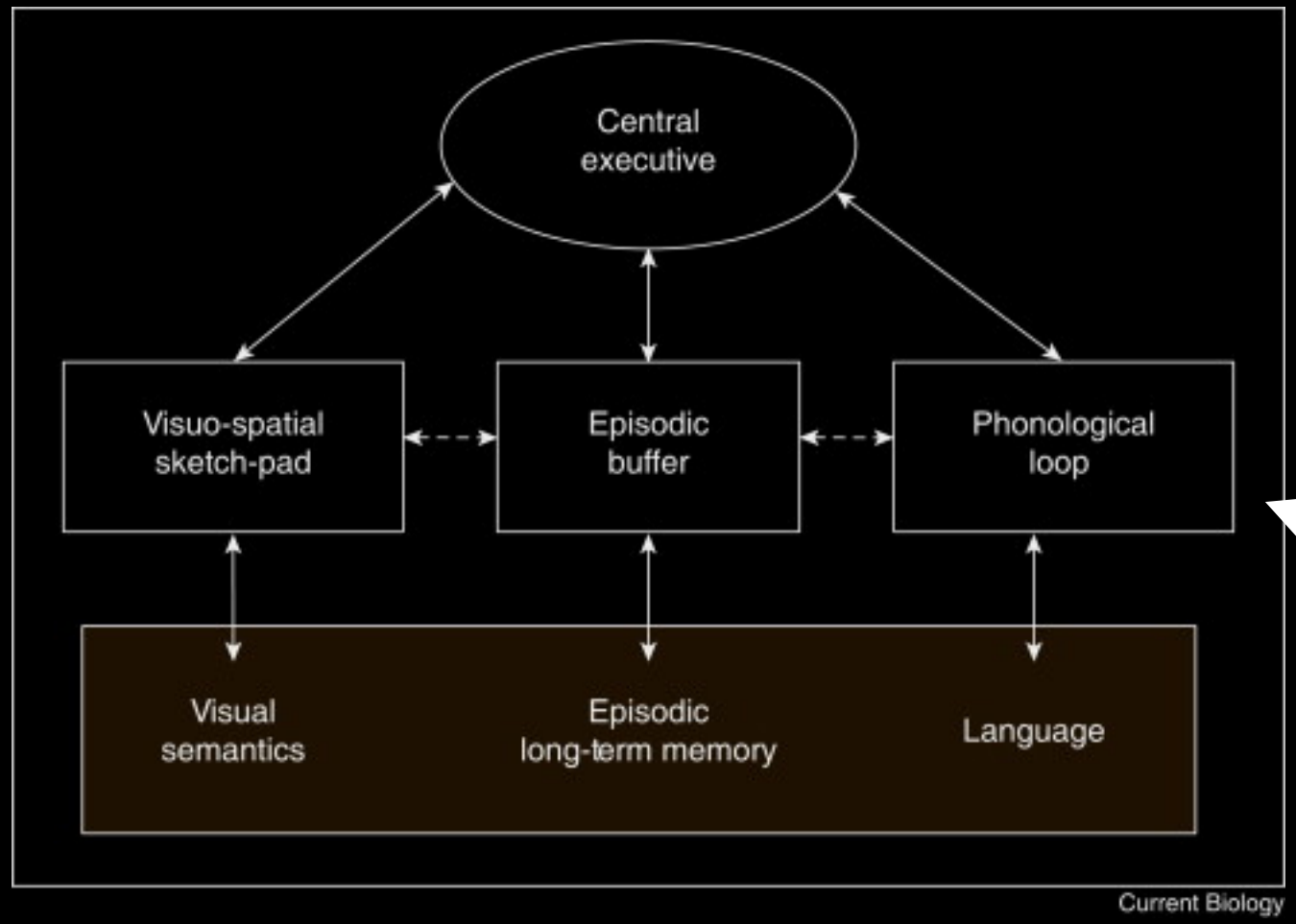
Calculate (3^3)/2

This task relied on STM; yet you did more than just memorize.

Enter Baddeley & Hitch (1974)

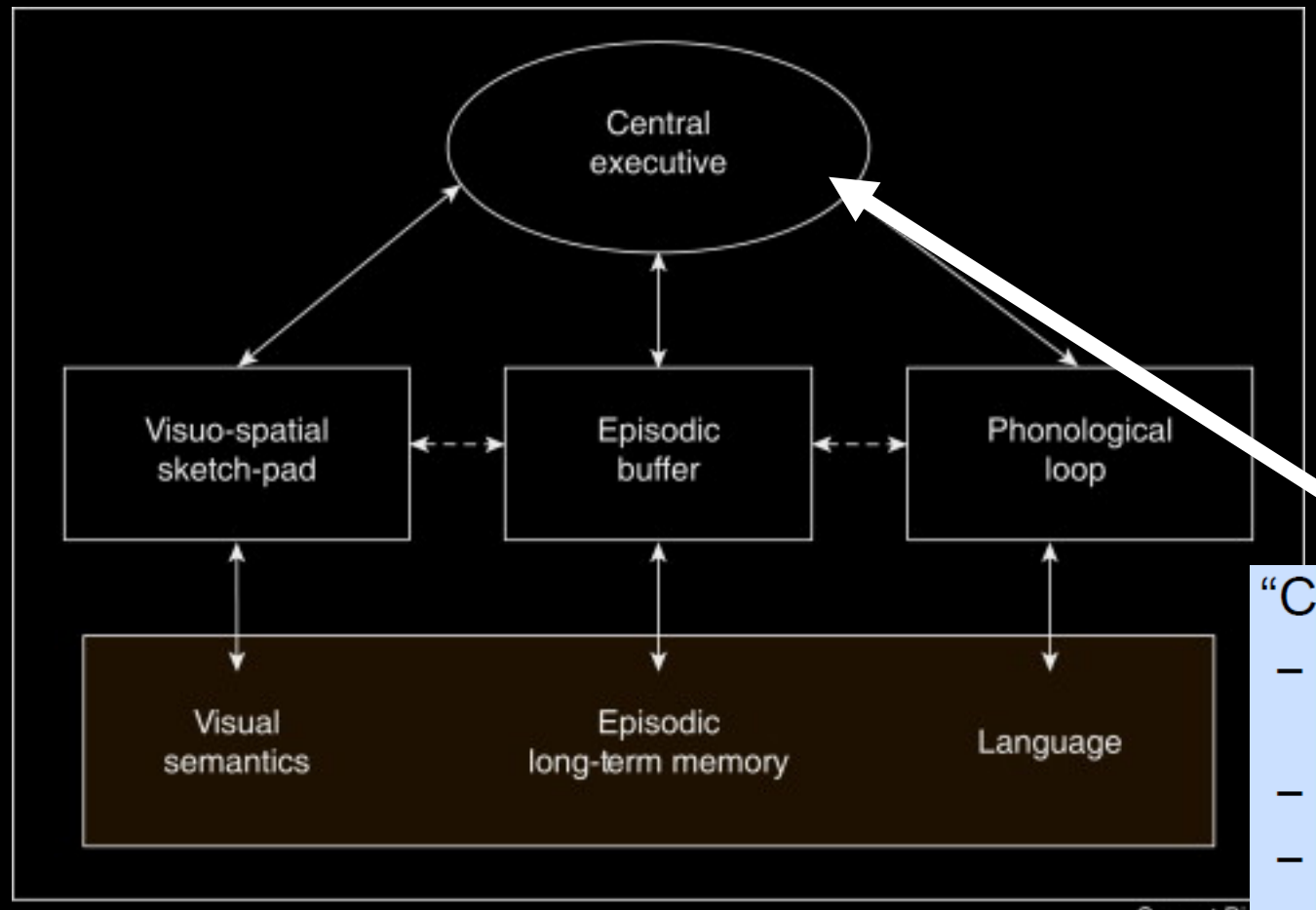
Working memory

Working Memory



“slave systems”

Working Memory



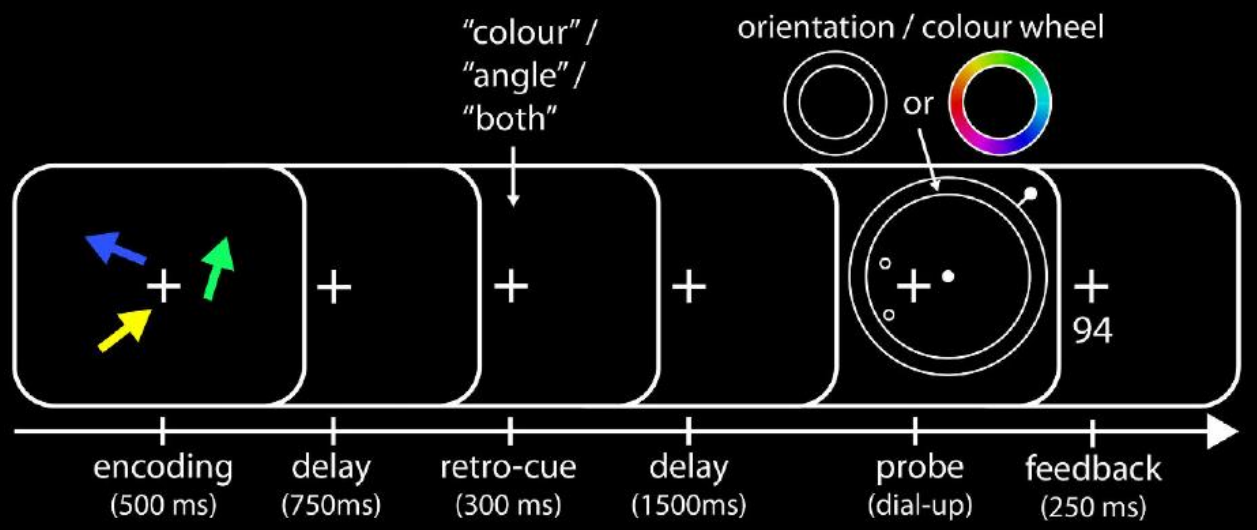
"Central processor"

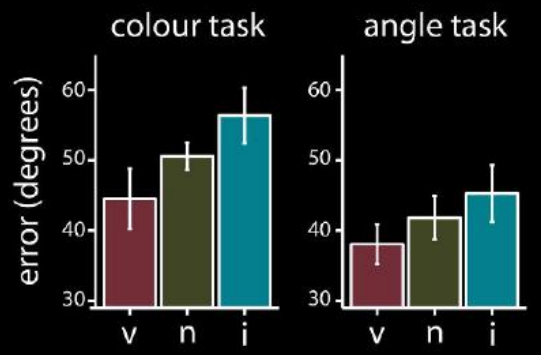
- Recruit slave systems to encode, maintain and retrieve information
- Distribute mental resources when multitasking
- Prevent irrelevant information from entering working memory
- Coordinate higher cognitive operations (e.g. mental arithmetic)

Working Memory

The visuo-spatial sketchpad: a ‘space’ to navigate in – *with attention*

Freek van Ede (from the VU)





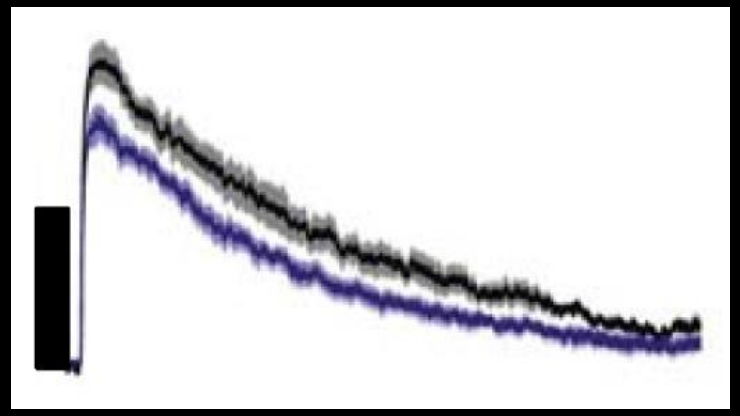
Attention can be moved within WM space

→ a form of ‘manipulating’ information in WM

Working Memory

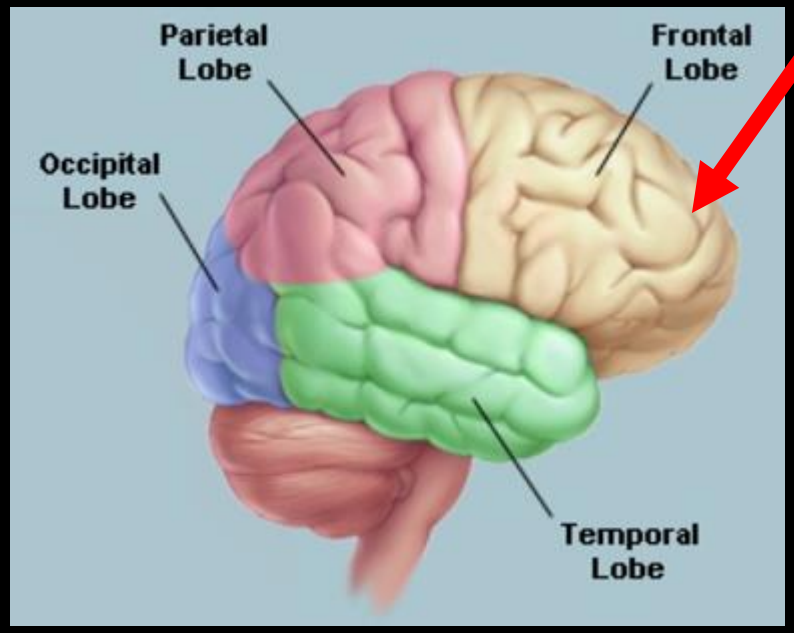
How does it work in the brain?

Sensory memory is easy: residual activity in early perceptual regions of the brain

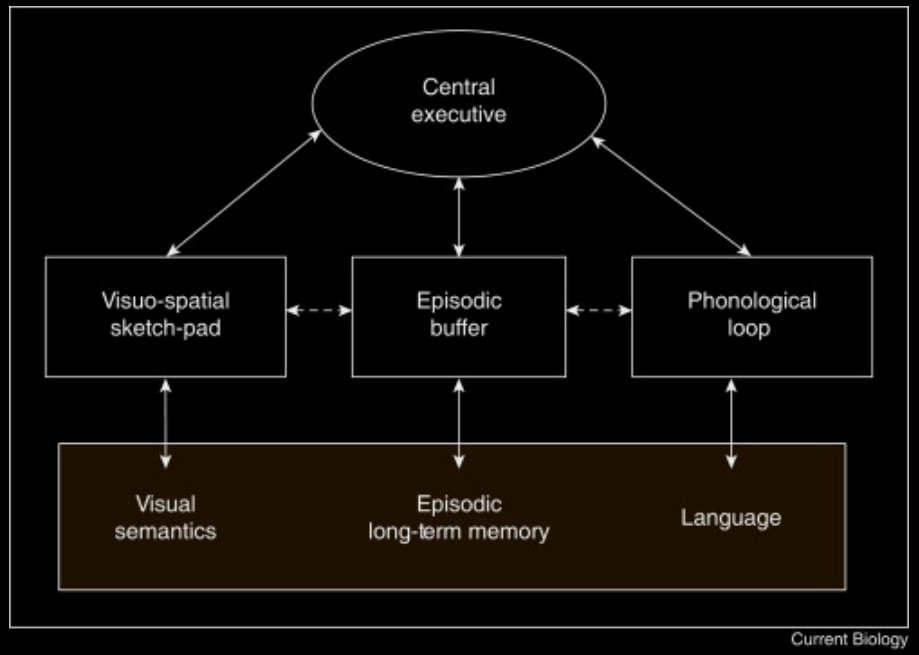


Working Memory

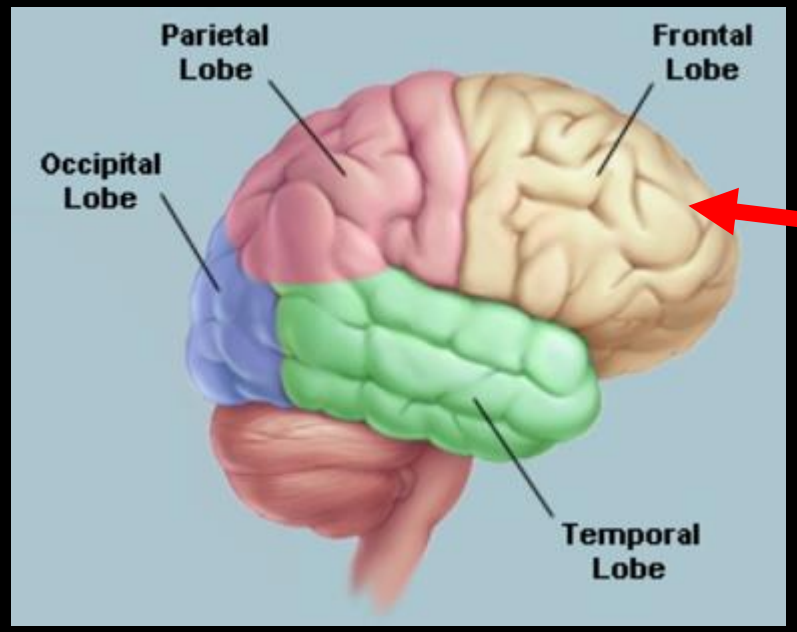
Various regions of the brain have been associated with each of these WM components

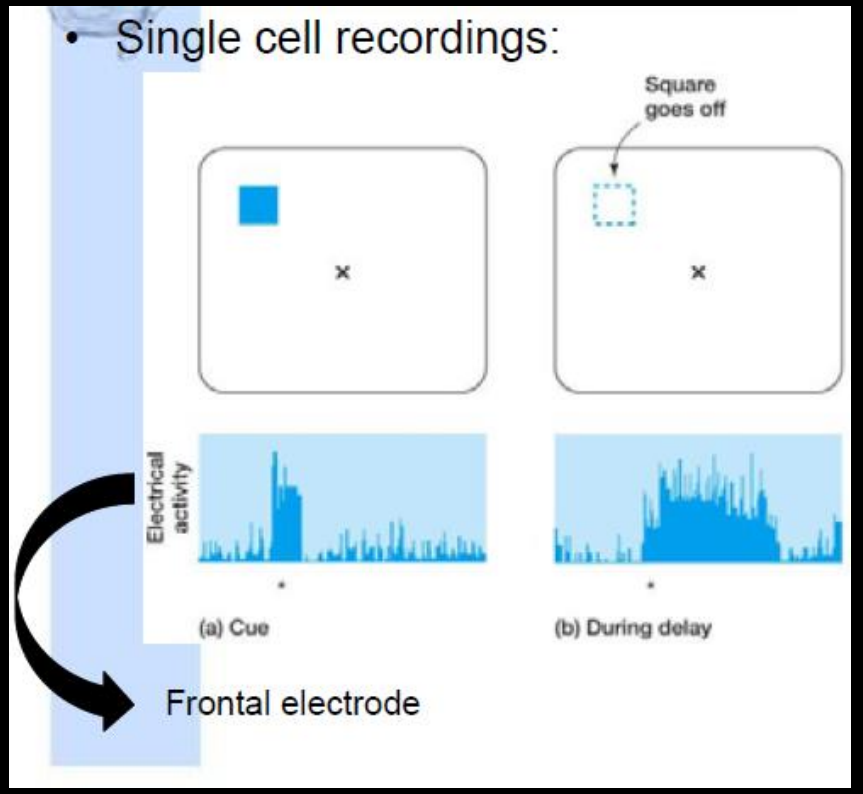


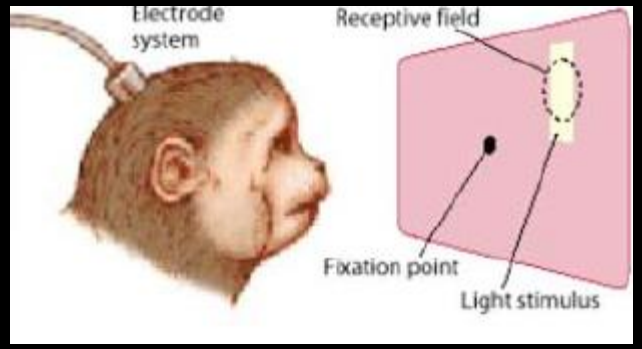
The prefrontal cortex is key



WM in the brain

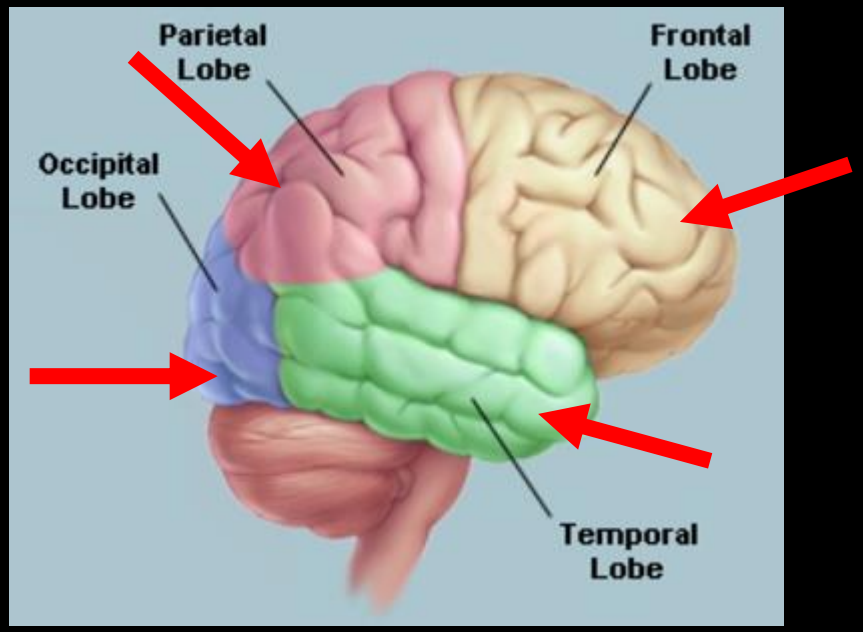






WM in the brain

PFC is key… but so are all our perceptual areas



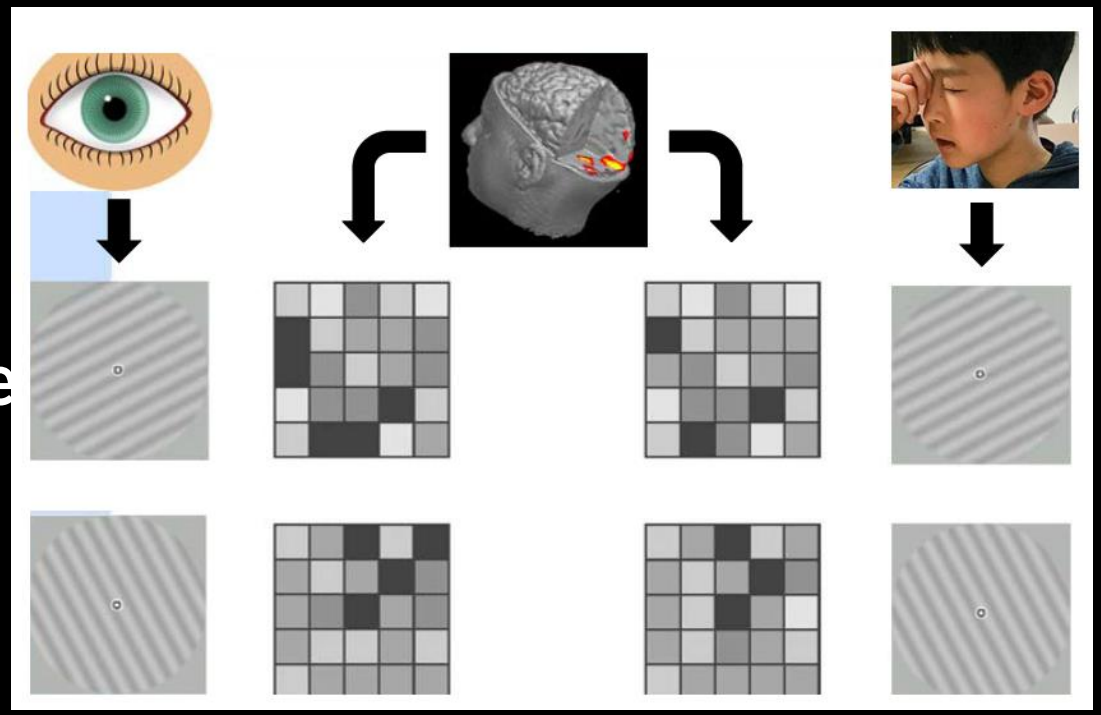
WM in the brain

PFC is key… but so are all our perceptual areas

We can ‘read minds’ by looking at the visual cortex

So memories are ‘stored’
– or at least read out –
in the visual cortex too

→ ‘Higher’ regions like the PFC coordinate activation in perceptual regions during retention



Long term memory → what is it?
how is it different from
STM / WM?

What is LTM?

LTM is the seemingly infinite archive into which we have stored every experience since our existence

What is LTM?

Imagine chewing on your desk

Taste and smell are hard-to-describe- but very robust memories

What is LTM?

8-month old babies depict more attention for familiar words than novel words

...But 20 years later, these humans will probably not remember that they took part in that experiment

Procedural / implicit memory (statistical learning)
vs. episodic memory

What is LTM?

- LTM is the seemingly infinite archive into which we have stored every experience since our existence

- Though the archive is infinite, stored files may ‘wither’

What is LTM?

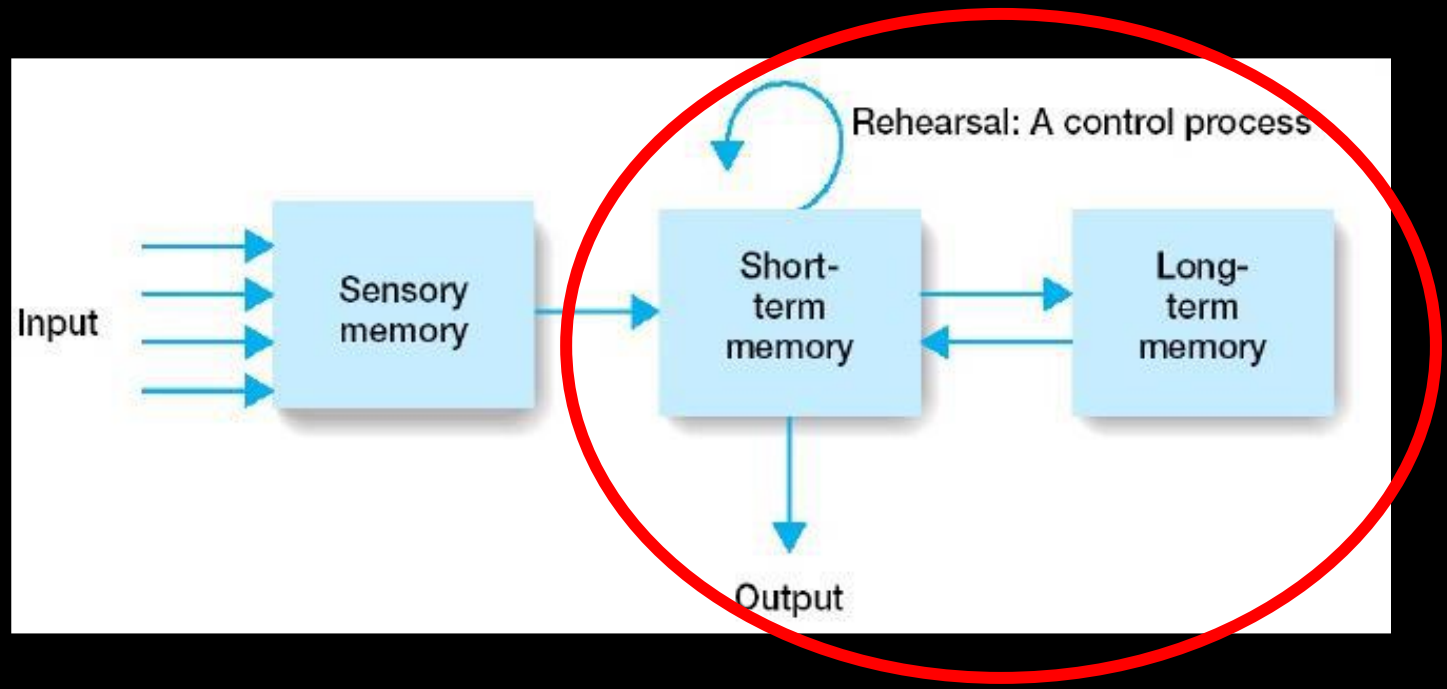
- LTM is the seemingly infinite archive into which we have stored every experience since our existence

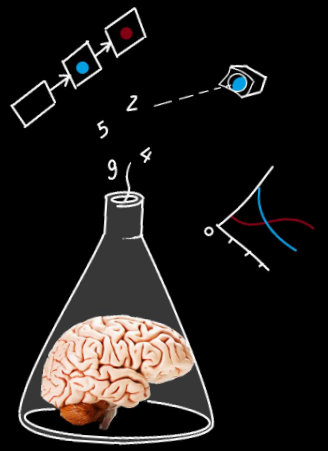
- Though the archive is infinite, stored files may ‘wither’

- Throughout our lives, we are automatically building the archive – for strategic purposes

learning, automatization, bolstering WM

The interaction between WM and LTM

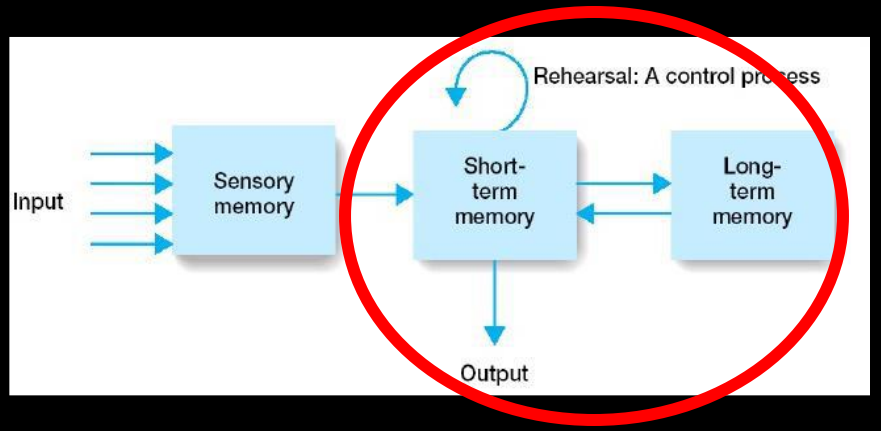


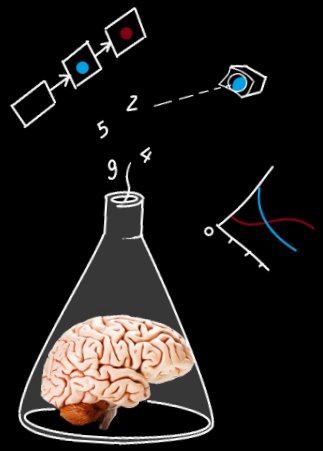


First of all: how do we know that these are really two separate things in the brain?

The interaction between WM and LTM

Clive Wearing: STM ‘alright’, LTM impaired

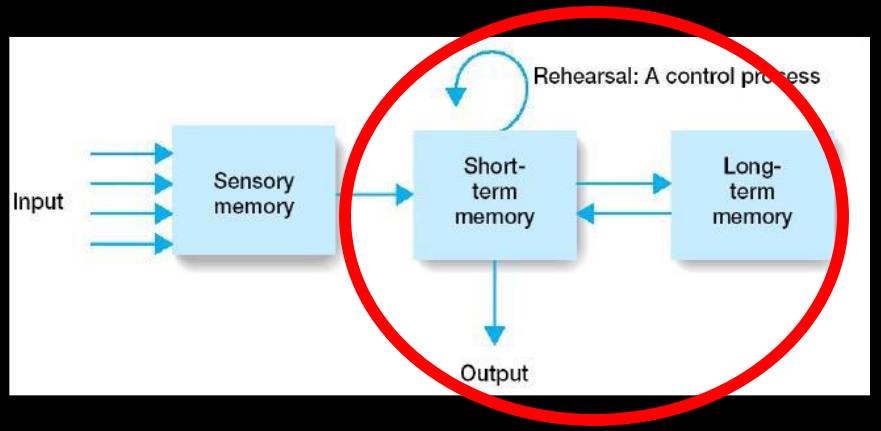


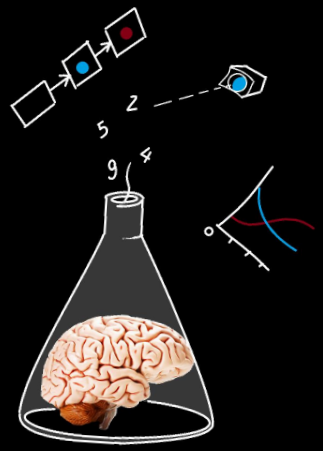


First of all: how do we know that these are really two separate things in the brain?

The interaction between WM and LTM

Patient K.F.: impaired WM, but LTM intact





First of all: how do we know that these are really two separate things in the brain?

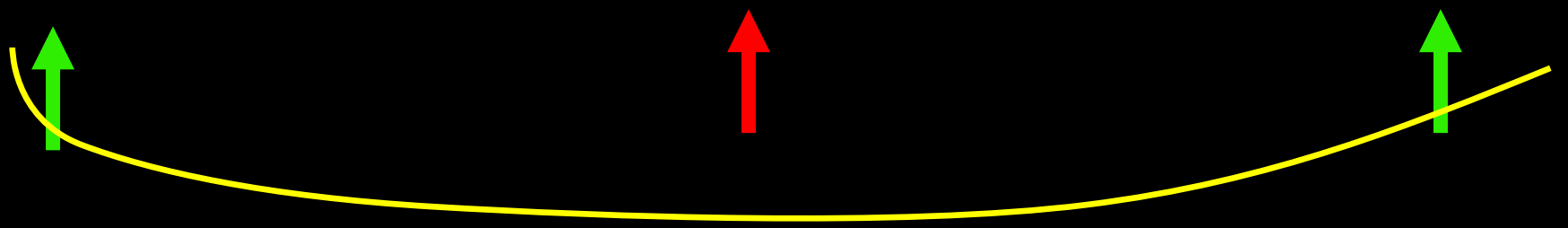
The interaction between WM and LTM

First of all: how do we know that these are really two separate things in the brain?

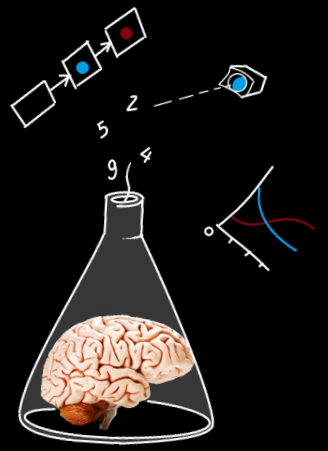
An experiment without patients: *The serial position curve*

briefly presented one-by-one:

tree – laptop – sphinx – earbud – mouse – lamp – pocket



When asked to recall as many words as possible, subjects report the first and last words best



The interaction between WM and LTM

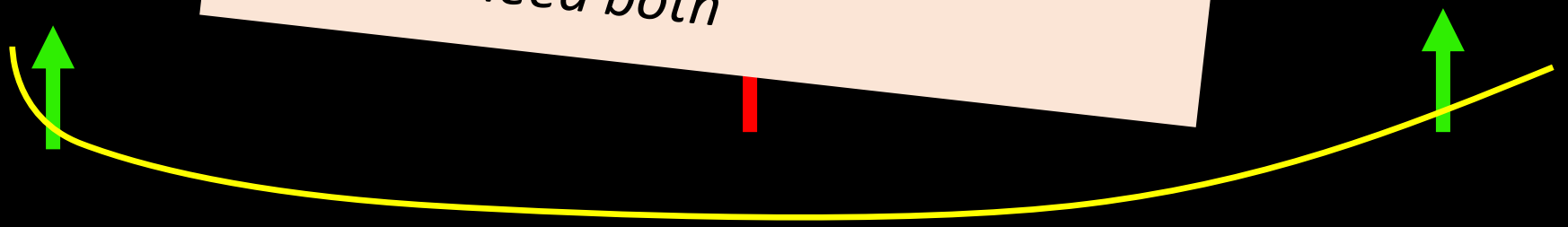
First of all: how do we know that these are really two separate things in the brain?

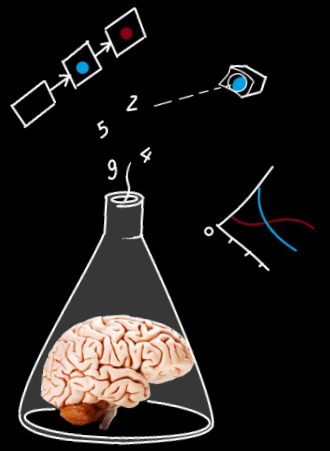
An experiment without patients: *The serial position curve*

briefly presen

tree – lap *mp – pocket*

Neither STM nor LTM can account for both these effects simultaneously; ergo, we need both





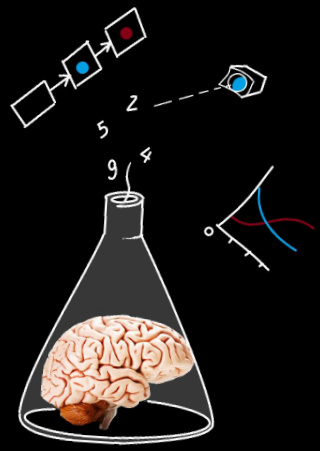
When asked to recall as many words as possible, subjects report the first and last words best

The interaction between WM and LTM

First of all: how do we know that these are really two separate things in the brain?

primacy effect (first word advantage): first words get full attention; STM not occupied by other things, and/or words were rehearsed for a longer amount of time

recency effect (last word advantage): Last words are still in STM

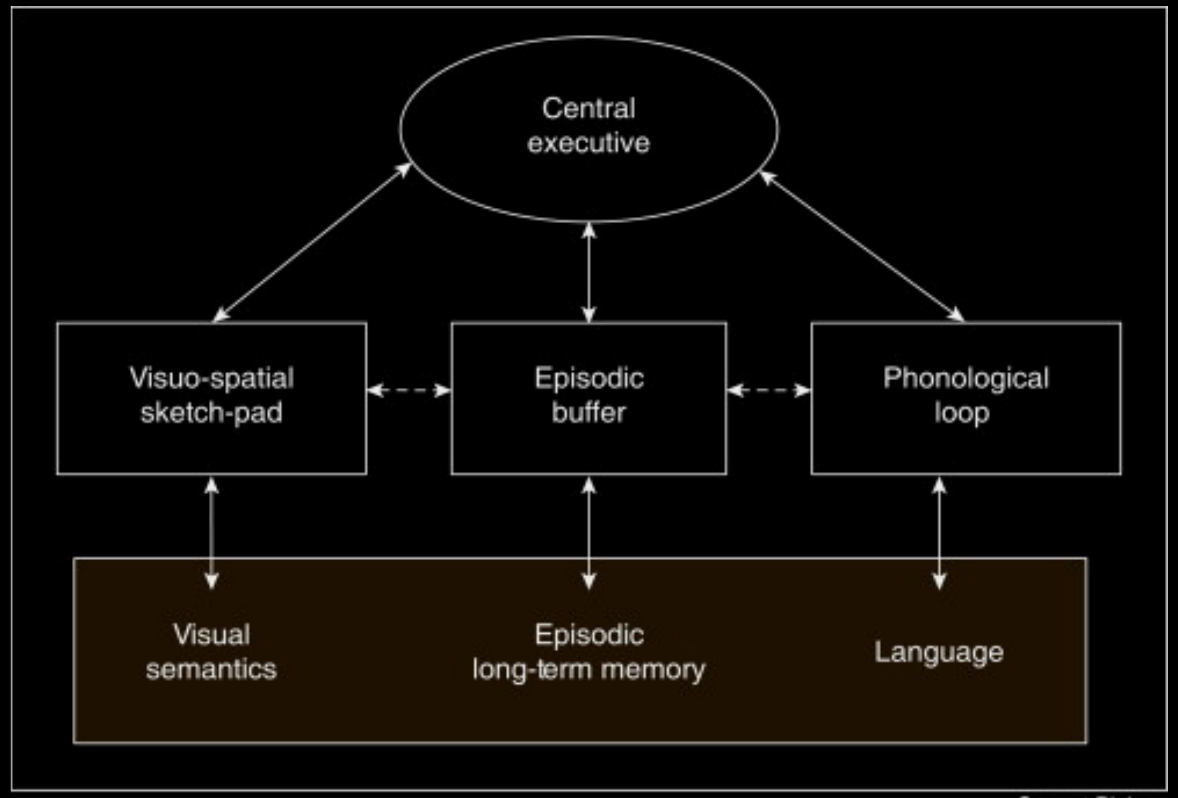


The interaction between WM and LTM

Information in LTM is constantly re-activated by the things that we keep in WM. This information in turn bolsters whatever is kept in WM.

- Meaning of words
- Relevant past events
- Goals

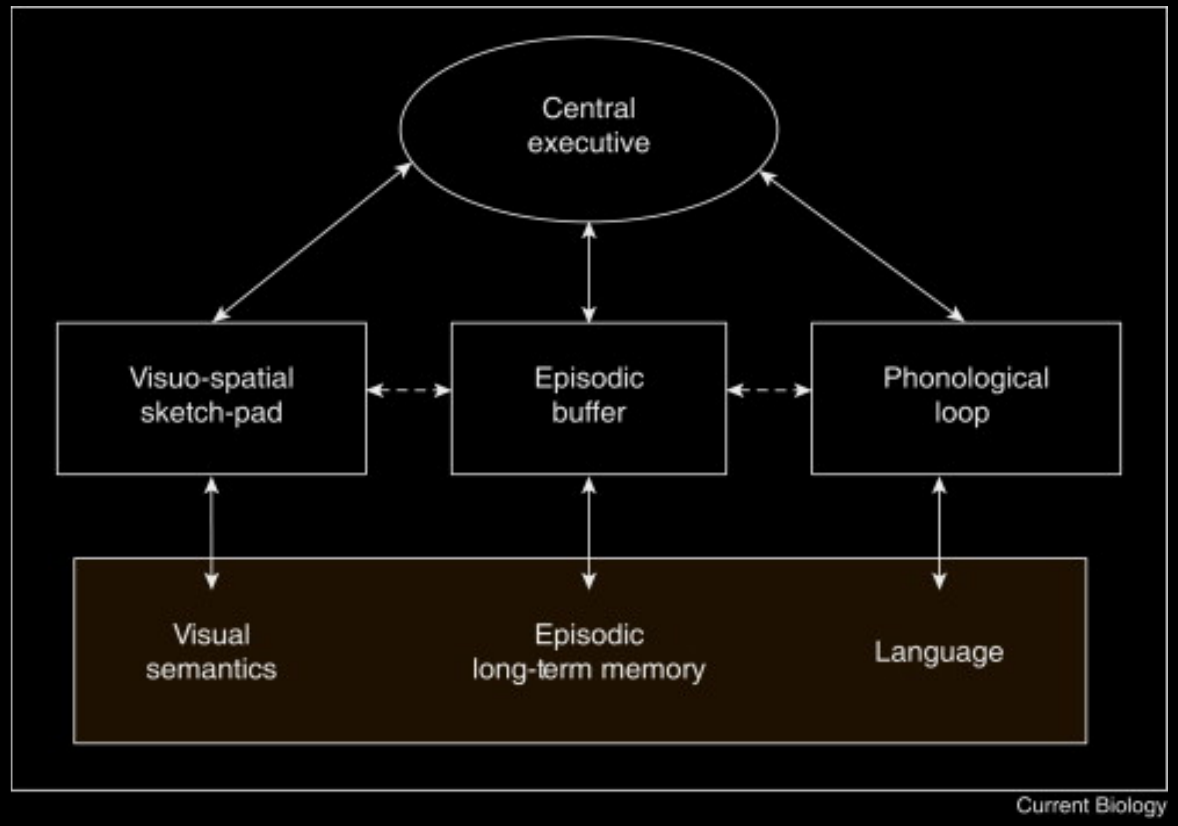
Neural mechanisms later



The interaction between WM and LTM

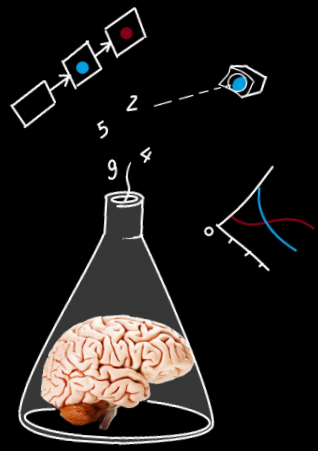
Information in LTM is constantly re-activated by the things that we keep in WM. This information in turn bolsters whatever is kept in WM.

Example:



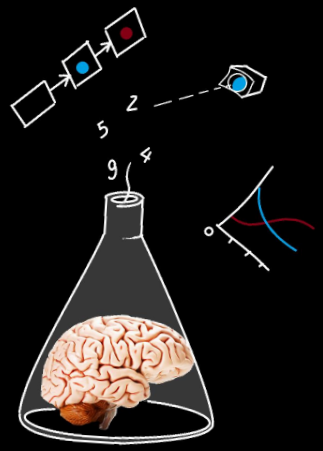
The various types of LTM

Episodic
Procedural
Implicit vs. explicit
Semantic



The various types of LTM

Episodic (explicit)
Procedural (implicit)
Implicit vs. explicit
Semantic (explicit) other word for explicit: *declarative*



What's the difference between
semantic and episodic memory?

Past experiences vs. facts

'mental time travel'

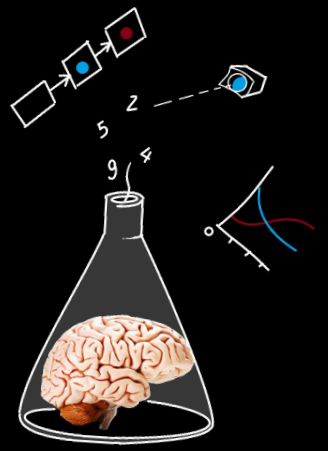
learned relationships

What's the difference between semantic and episodic memory?

A double dissociation: two patients…

Displayed good knowledge about many things but forgot things that happened 3 minutes prior

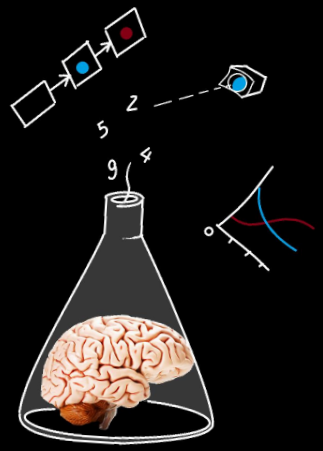
Didn't know the meanings of words anymore, didn't recognize close relatives; but could recount the previous day, week, or year



How does LTM work in the brain?

STM: prefrontal + perceptual regions

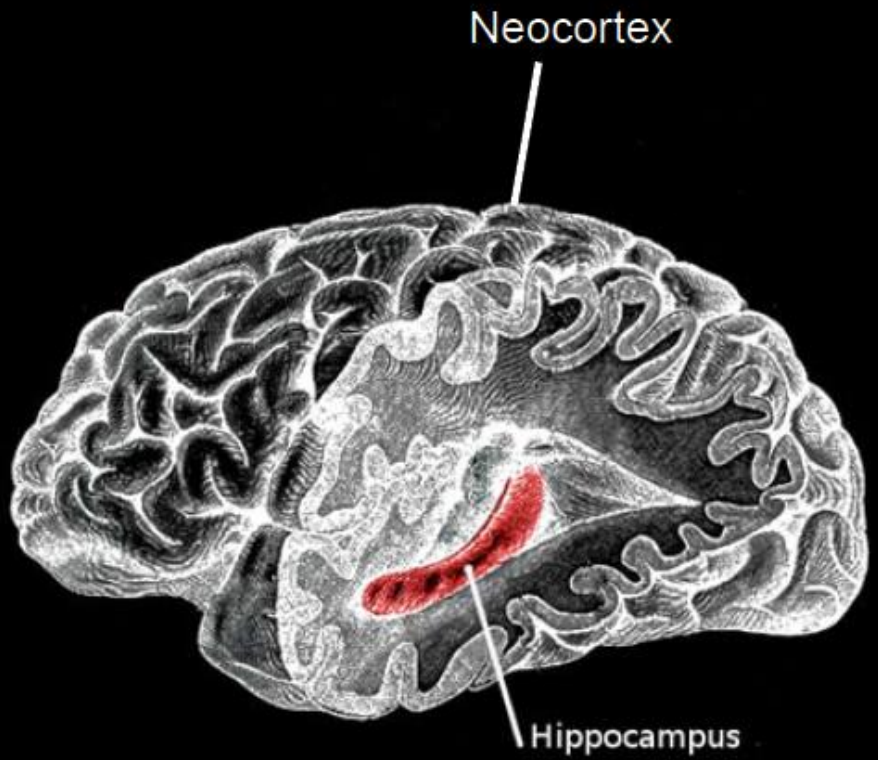
LTM: *Hippocampus* in the medial temporal lobe

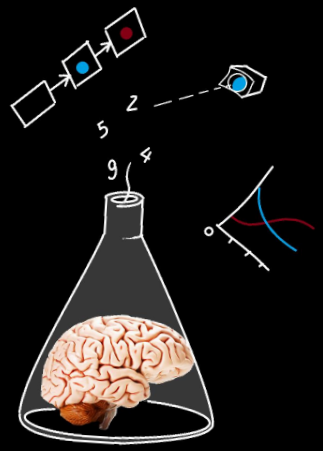


How does LTM work in the brain?

Hippocampus in the medial temporal lobe strongly involved in memory tasks

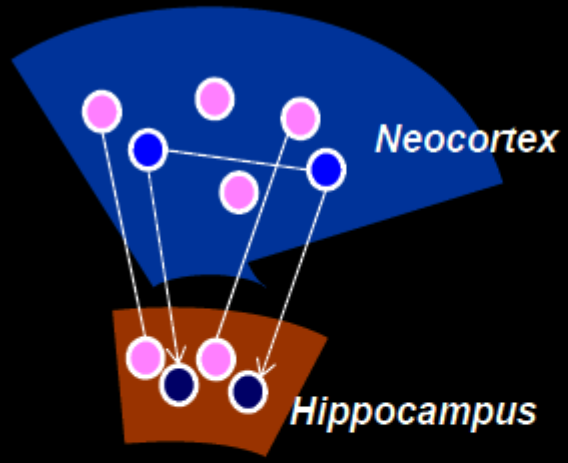
When depriving people of sleep, memories don't stick as well



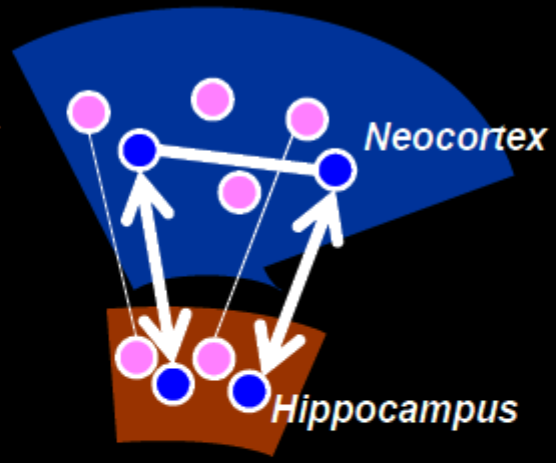


How does LTM work in the brain?

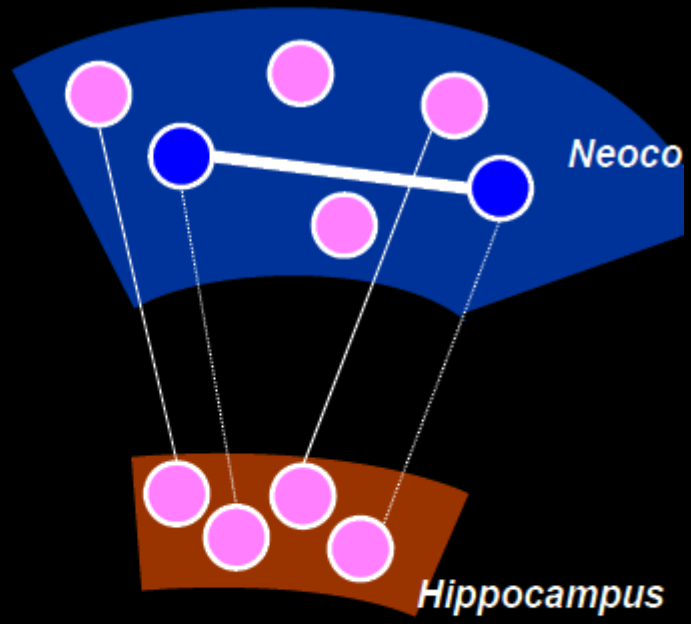
Consolidation



1. Cortical neurons activate associated hippocampal cells



2. Hippocampal cells later on re-activate the cortical cells, allowing the connection in the neocortex to strengthen



3. The cortical assocation is consolidated (LTP), the hippocampal connection is allowed to deteriorate

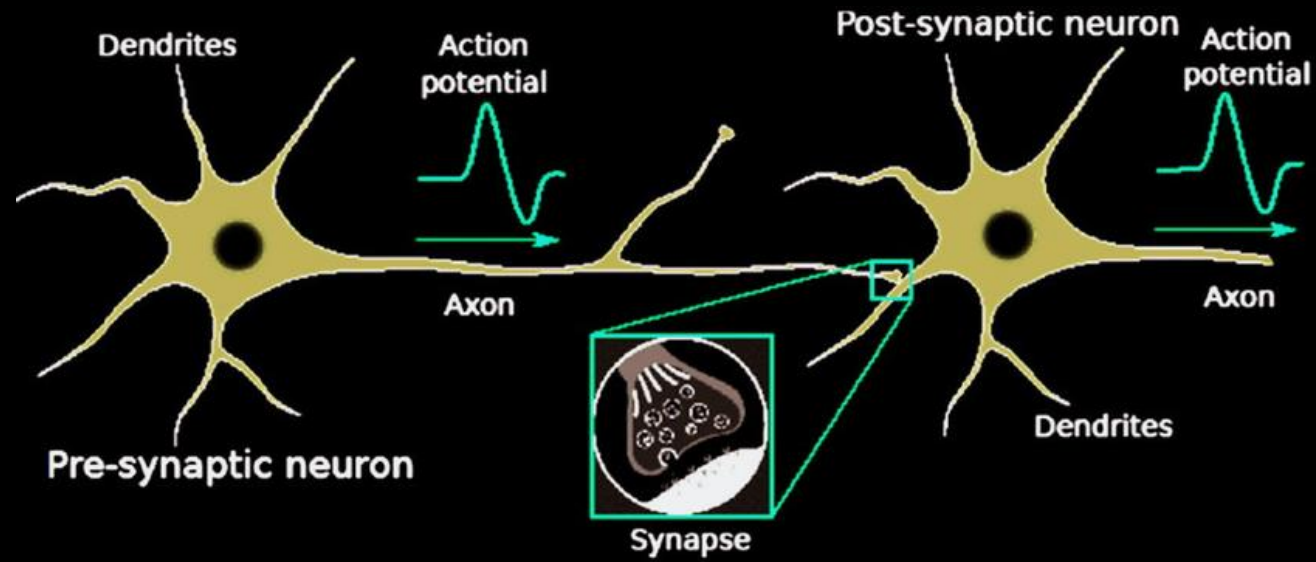
How does LTM work in the brain?

LTM and STM work similarly in the sense that perceptual regions of the brain are involved (memorizing a visual = 'simulating' seeing something)

...but what about implicit learning?

...but what about implicit learning?

Learning at the level of single neurons:
with repeated activation, there is a chemical change at the synapse. The *synaptic transfer* is strengthened
Ergo, faster processing
e.g., stronger connections between letters and words



Recap

Memory: any way in which a past experience impacts present/future thoughts or behaviors.

Several memory stages: sensory memory, STM / WM, LTM

Sensory memory = trace (residual) activity; *high* capacity

STM = active maintenance (due to attentional focus); *low* capacity

WM = STM whereby information is not just memorized, but also *manipulated*

Prefrontal cortex is key, but in cadence with perceptual regions ('slave systems')

Recap

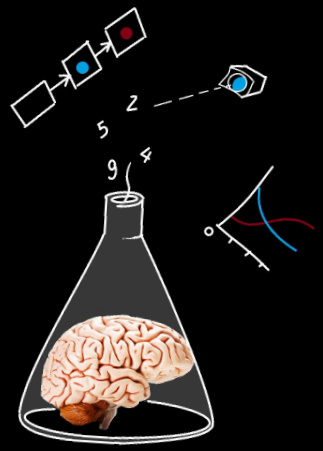
LTM: the seemingly infinite archive into which we stow files that may wither over time
Close interactions between WM & LTM: LTM is activated by the things kept in WM, and this info in turn bolsters WM content

Evidence for separate systems: patients, serial position curve

Understand the various types of LTM: semantic, episodic, implicit vs. declarative, procedural, statistical learning / priming

Episodic / declarative memory: interaction hippocampus and cortex

Implicit learning can also be explained at the level of single neurons



Part 2:

Decision-making

Decision-making

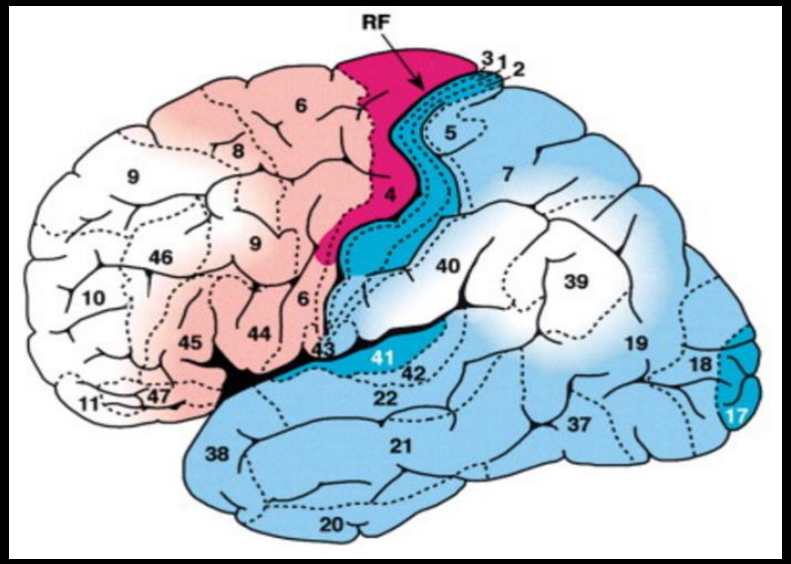
First of all: *do we make decisions?*

Free will is an endless debate

"Decision" implies multiple options
...But decisions can always be explained → if we've completely figured out the brain, can we fully predict human behavior?

Decision-making

Perception & Action



Decision-making is the bridge between perception (+memory, emotions, biases, predispositions, etc. etc. etc.) and action

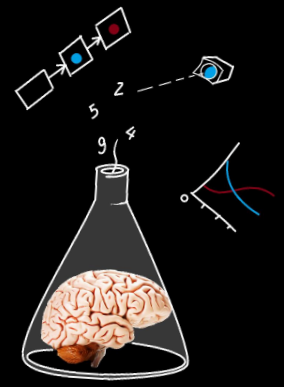
Expected utility theory

"Given knowledge about what the outcomes of various options will be, people choose whatever yields maximum value"

Not true

Confirmation biases and overconfidence biases

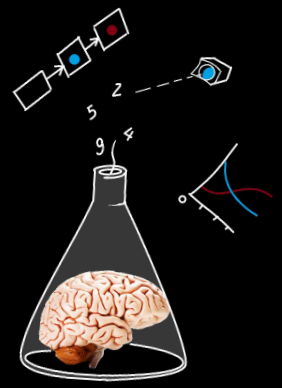
We give more weight to information that confirms our expectations



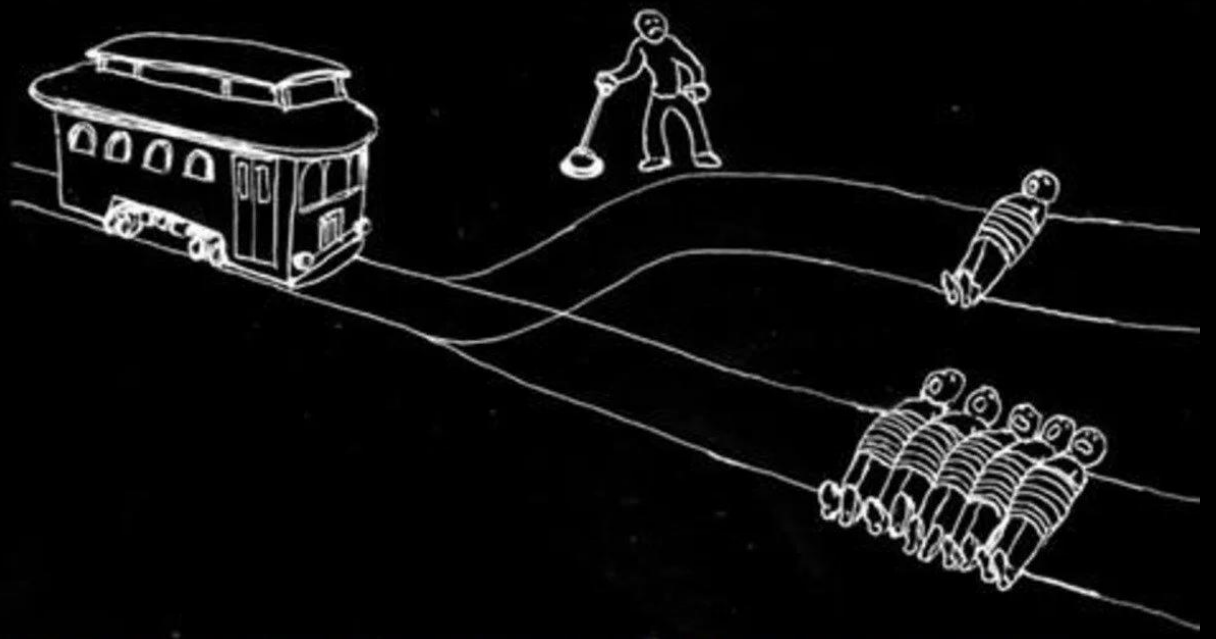
Confirmation biases and overconfidence biases

We trust ourselves more than others

75% of drivers think they
belong to the best 25%

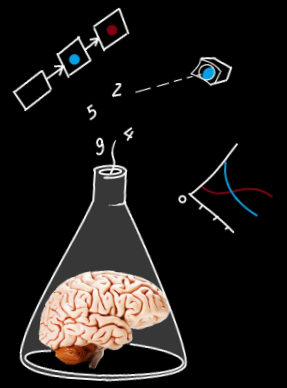


Decision-making



You find yourself at a lever. A runaway trolley approaches five people who are tied to a set of tracks. Pulling the lever will divert the trolley to a different set of tracks, where only one person is tied down.

Do you pull the lever?



Decision-making

Expected utility theory: “having all relevant information, people will make a decision that yields the most utility/value/achievement”

Prospect theory: “people act on *predicted* emotions”

How good would I feel if I win?
How bad would I feel if I lose?

People are often *risk-averse;* but it also depends on how the problem is framed!

Decision-making

Framing: when emphasizing gains, people become more risk-averse, but when emphasizing losses, people become more risk-taking

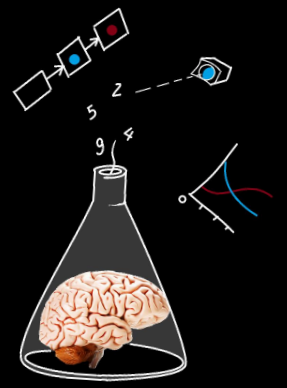
"Imagine that the United States is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimates of the consequences of the programs are as follows:…."

A: 200 are saved

B: 1/3 chance that 600 are saved, 2/3 chance that none are saved

C: 400 will die

D: 1/3 chance that none die, 2/3 chance that 600 die



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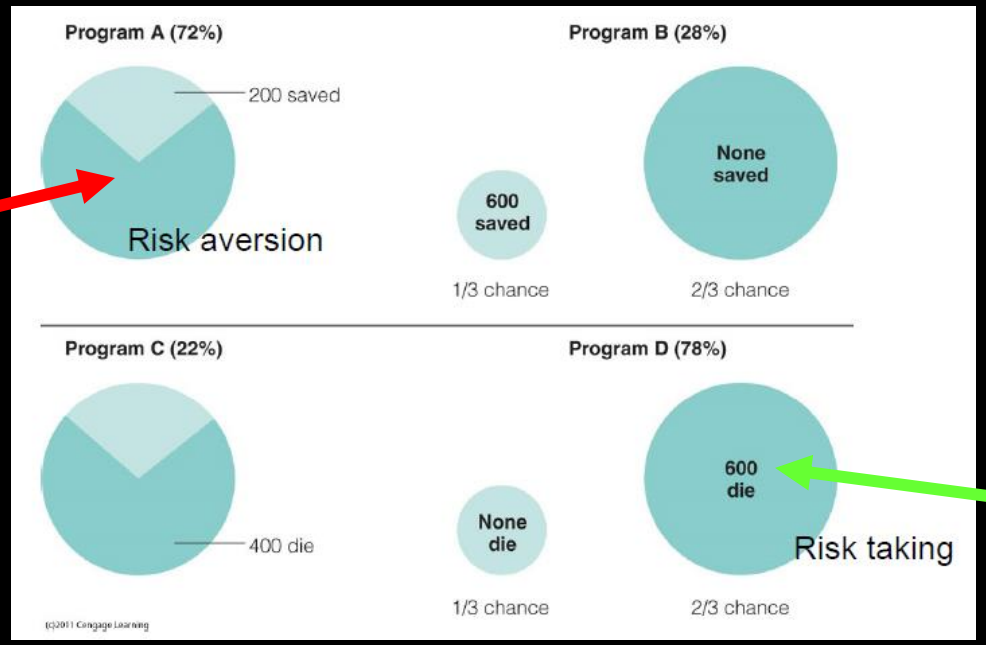

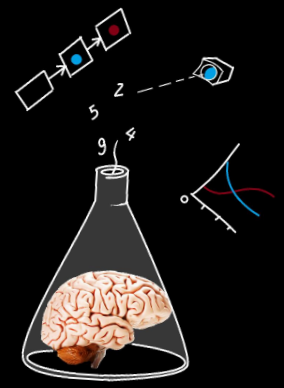

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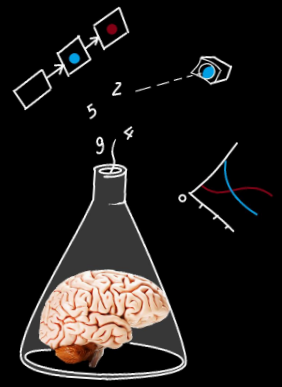
Decision-making

Judges are animals too

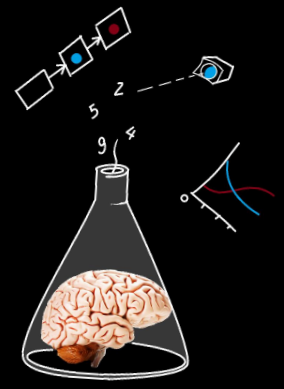


Decisions in the brain

An ‘unfairness’ region in the brain:
the anterior insular cortex

Higher activity → less likely to
accept an unfair offer

“We have 10$, I give you 3$
and keep 7$ myself”

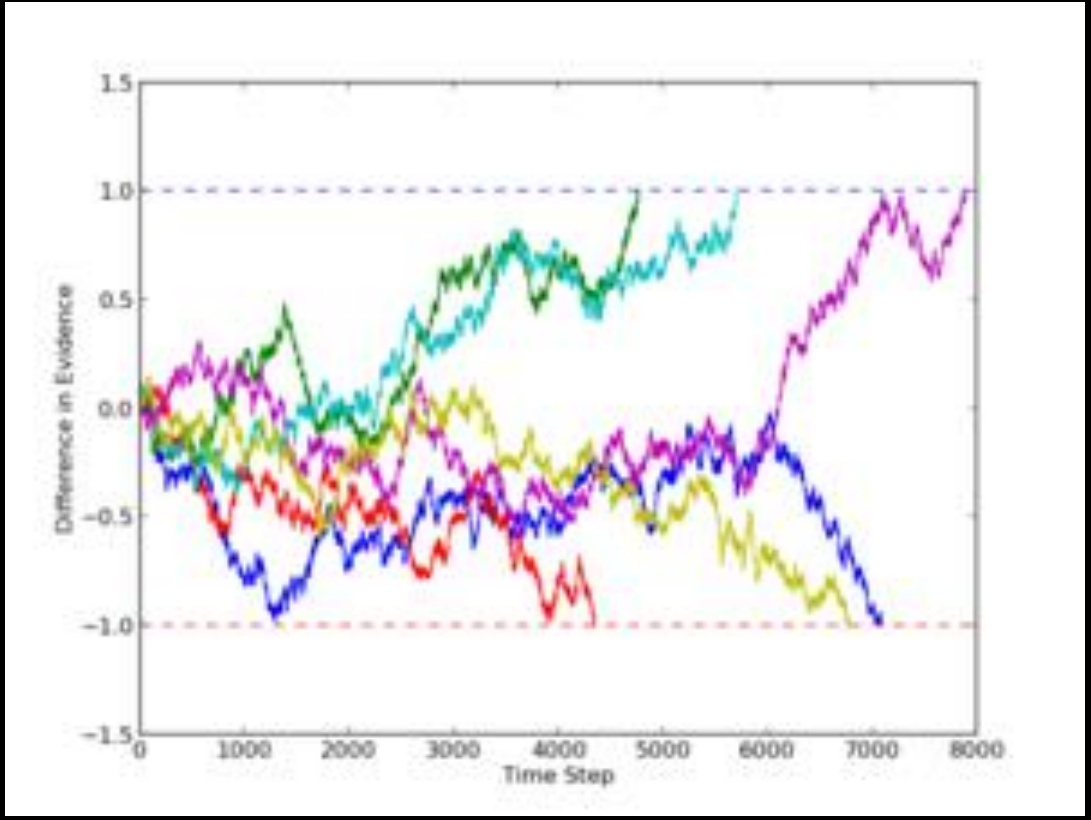


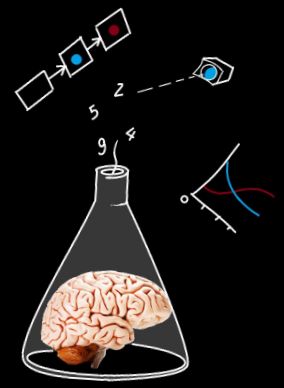
The drift diffusion model

Binary decisions in the brain

Two competing neuronal clusters, evidence accumulates until one cluster (representing one decision) reaches threshold

Until then:
doubt





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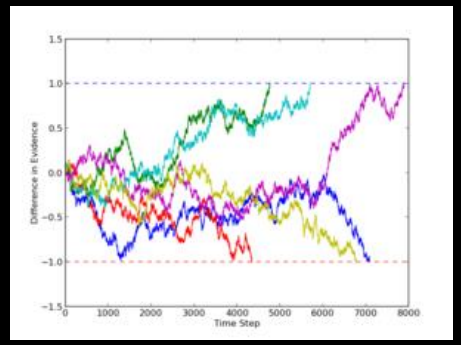
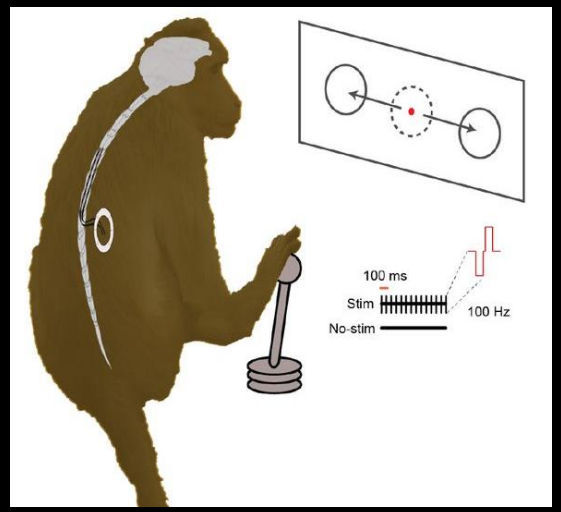
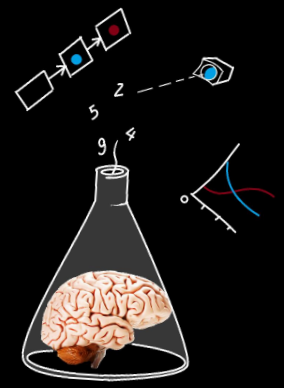


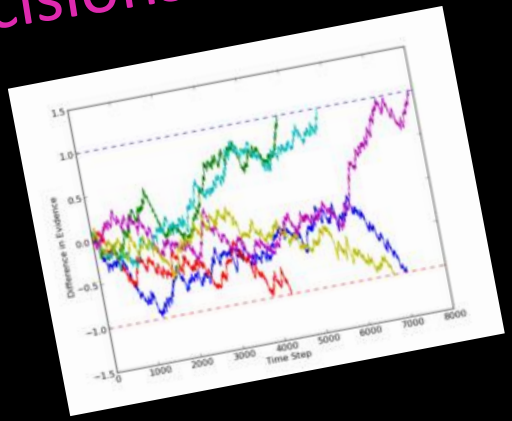


Neural evidence: in Rhesus monkeys, direction-selective neuronal clusters are activated until one cluster's *spike rate* hits threshold

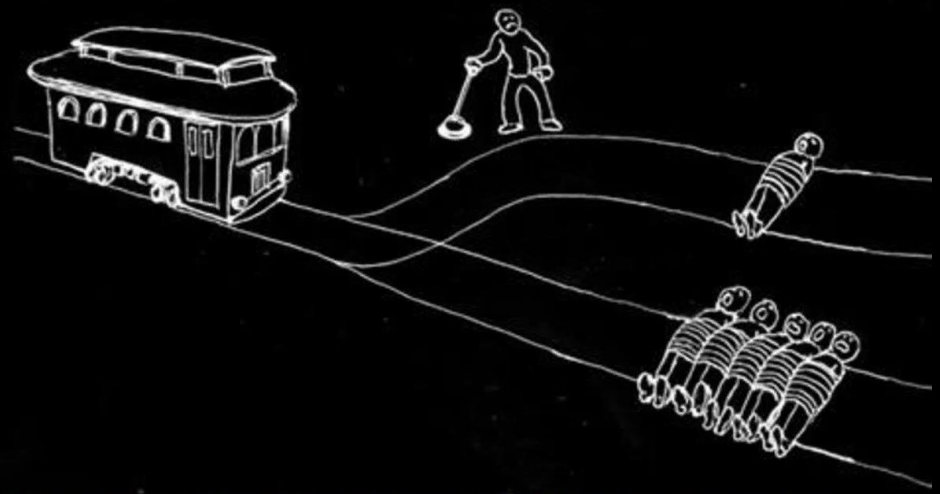


The drift diffusion model

Binary decisions in the brain



Does it hold for more complex decisions?



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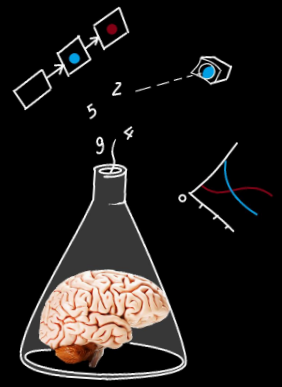
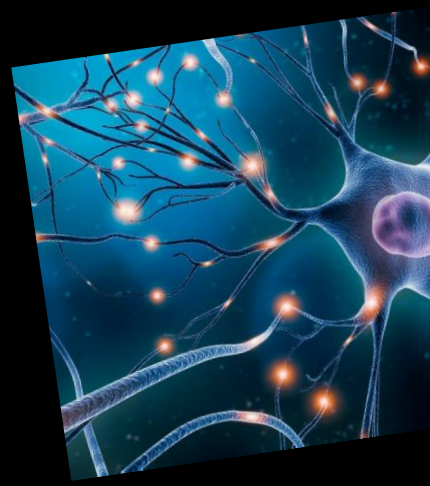


Ultimately, to understand decision-making is to understand the brain entirely...

We have neuronal clusters driving the onset of billions of actions

Those clusters are excited in billions of ways



We can predict ‘decisions’ of single neurons and human populations; nothing in between