INF1-CG 2016
Lecture 25

Memory: More computational issues

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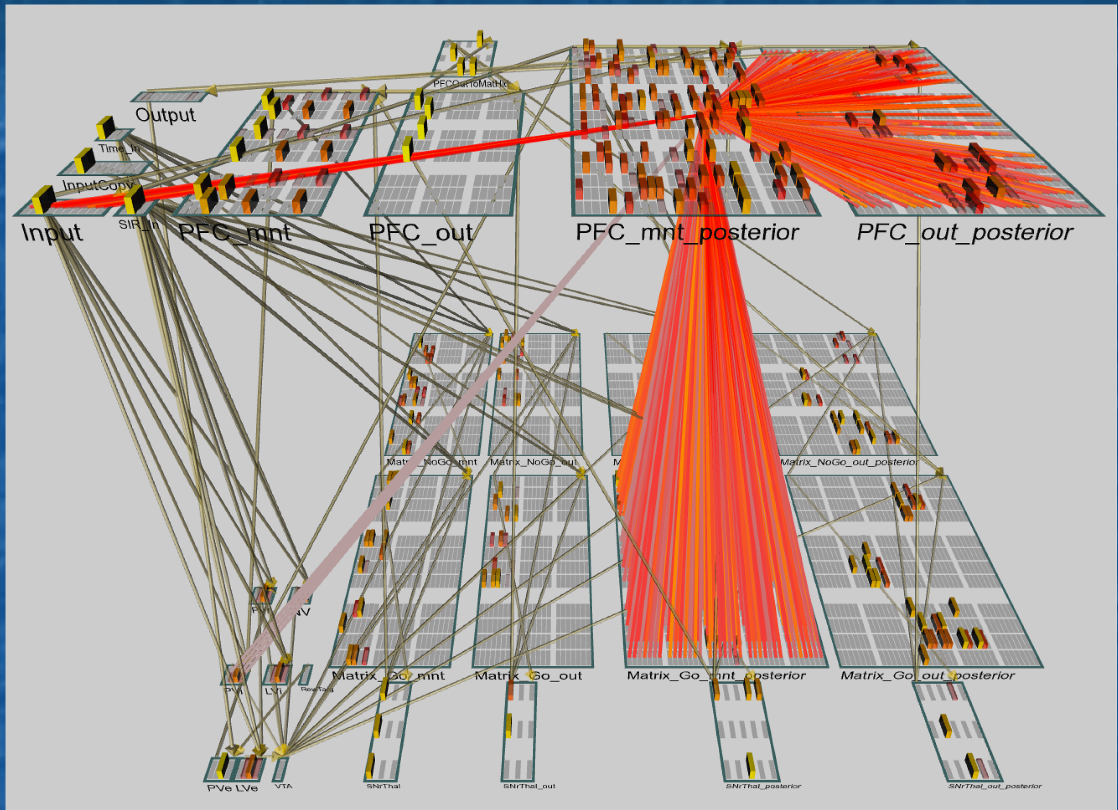
Today's goals



We will look at some more of the computational aspects of memories, and also some of the anatomical implications

Readings for the memory lectures

Luria, A. R., & Solotaroff, L. T. (1987). *The mind of a mnemonist: A little book about a vast memory*. Harvard University Press.

Anderson, J. R., & Schooler, L. J. (1991). Reflections of the environment in memory. Psychological Science, 2(6), 396-408.

Lindsay, S., & Gaskell, M. G. (2013). Lexical integration of novel words without sleep. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 39*(2), 608-622.

The story so far

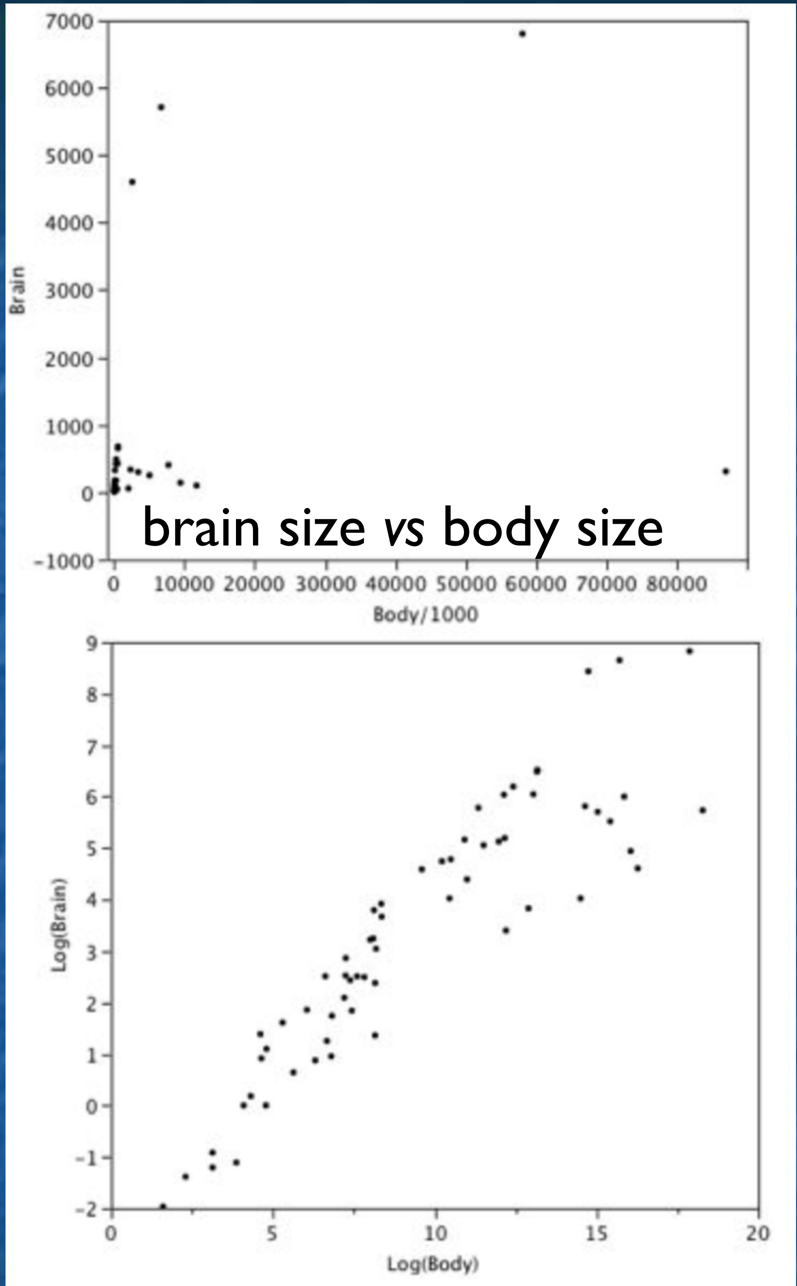
Distinctions (or not) between different types of memory.

Oscillators are a way of date-stamping an experience.

Time elapsed since the experience may be a key factor in the operation of memory.

It may be that cognition tunes into the way the world is (scale invariance; the resemblance between distance in space and time).

Log transform



X	$Log_{10}(X)$
1	0
10	1
100	2

Turning quantities into their logs makes distributions appear more linear.

The brain often seems to do this.

(There may be a deeper understanding of this, grounded in probability.)

The SIMPLE model

Brown, Neath & Chater (2000)

"Scale-invariant Memory, Perception and Learning"

It assumes a psychological space corresponding to a log-transformation of time elapsed since memory formation.

Two retrieval cues become exponentially similar the closer together they are along that dimension.

Retrieval of one entry is interfered with by its neighbours.

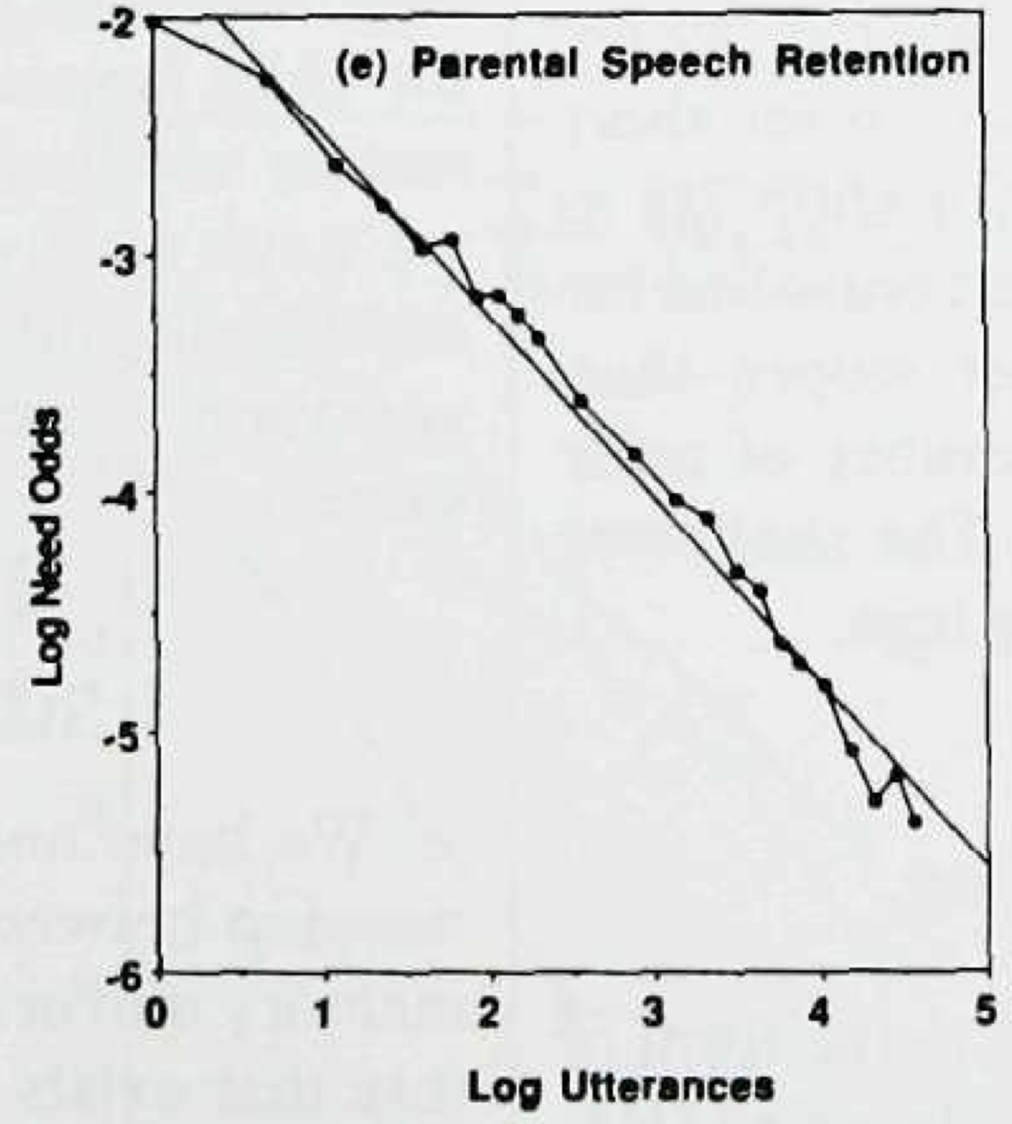
The SIMPLE model

Brown, Neath & Chater (2000)

This retrieval mechanism closely resembles claims for mechanisms governing categorization, perception and learning.
It is an argument against forgetting because of fading.

The "rational" modelling approach

Anderson (1990), Anderson & Schooler (1991)



Cognition adaptively reflects the statistical structure of the environment.

How likely are we to need a particular piece of information at any one time? – its "need probability".

Foraging

What does an animal need to be able to do to forage for food successfully?

It needs to be sensitive to time of day, time of year, distance, rewards from food, costs of travel, recency, familiarity, …

Such requirements may underlie human memory (without reducing human capacities to animal ones).

Structures and mechanisms get reused and reinterpreted during evolution; *beware reductionism*).

How monolithic is memory?

If the same principles can be employed across apparently different types of memory, do we need to say there is a qualitative difference between those memory types?

We still need to accommodate the impairment data.

We can say that more *reconstruction* happens during retrieval of memories from longer ago.

We can have the culture impose hierarchies on our retrieval by selecting for oscillators, perhaps; think of the working day determining what we do.

We're seeing the role of *activity* here.

How monolithic is memory?

In reconstruction, *schemas* (Bartlett, 1932) can be employed: stable networks of assumptions, probabilities, etc., specific to recurring events in the culture, e.g. going to a restaurant, robbing a bank, …

Tuckey and Brewer (2003) report a study in which "eyewitnesses" to a simulated bank robbery interpreted ambiguous gender information according to their schema about bank robbers.

Bank robbers should be male and wear dark clothing and/or a disguise.

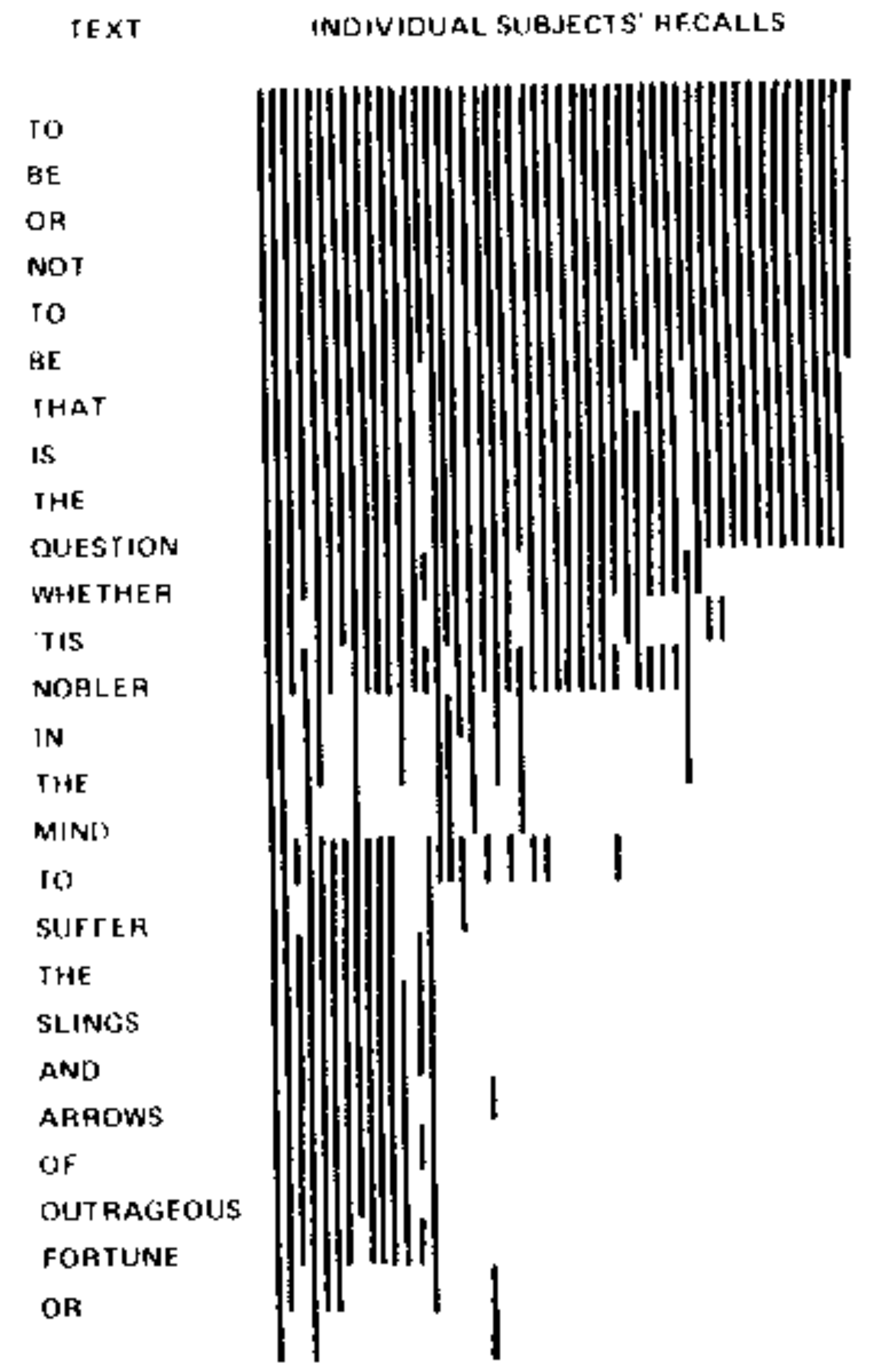
How monolithic is memory?

Language and abstract symbol systems provide a qualitatively new dimension to memory.

We can still see time-elapsed-since-experience as an essential, underlying feature that unifies all of memory, although it may be overshadowed by other factors.

We may see *spatial processing* playing a role, even metaphorically. Remember it is intimately connected to time.

In both vision and memory, the anatomy helped us understand processing. But with both, people's *activity* may be crucial to an understanding.



Language and long-term storage

Rubin, 1977

Long-term storage can be investigated by looking at recall of poems, speeches, *etc*.

Prosody, clause structure, *etc*. seem to play a role.

How monolithic is cognition?

If the same principles concerning competition and scale invariance can be employed across perception, categorisation and learning, how artificial are these areas?

How are these general principles instantiated? Again we need to go back to the anatomy.

Even though there is profound interconnectedness in the brain, and surprising plasticity, different parts of the brain *do* do different things.

False memories and hemispheres

McDermott & Roediger, (1998)

We can induce a "false memory" by showing people a list of words: *royalty, king, palace, princess, throne, prince, coronation, crown, castle, …*

There is then a short distractor task.

Then the "lure": "Did you see *queen*?"

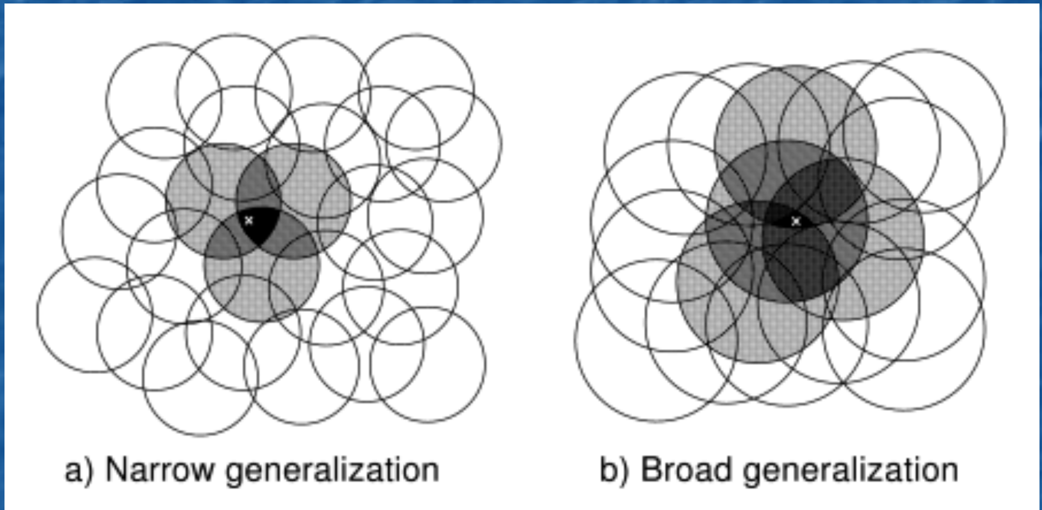
Saying yes indicates a false memory.

(This is *operationalizing* a concept, again.)

False memories and hemispheres

Bellamy & Shillcock, 2007

We can show the lure initially exclusively to the RH or the LH by presenting the word briefly to the left or right of fixation.



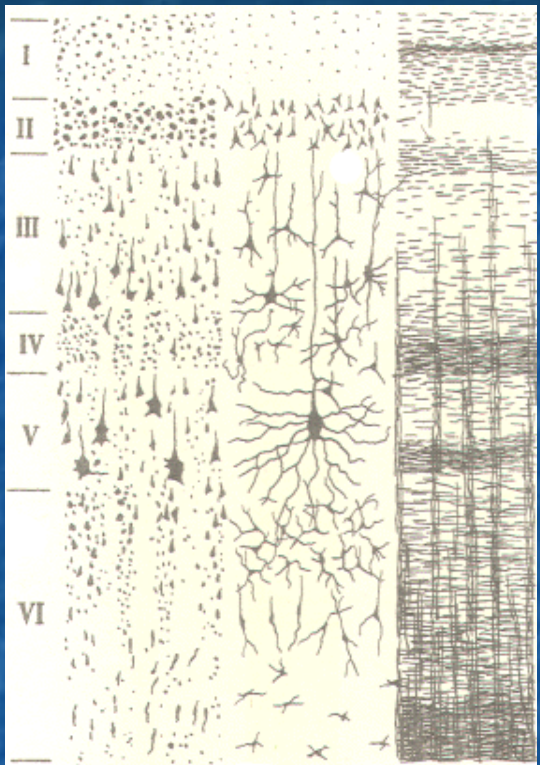
We tested the hypothesis that RH coarse-coding would cause more generalization and more false memories in the left visual field. It did.

Abstractionist *vs.* episodic storage

Does stored linguistic information retain traces of its origins, or is it amodal?

We do seem to retain detailed traces of spoken words, which affect speaking (Goldinger & Azuma, 2004).

Catastrophic interference



Memories are stored across the massive connectivity of the brain.

In computational terms, we see this storage as *weighted connections*.

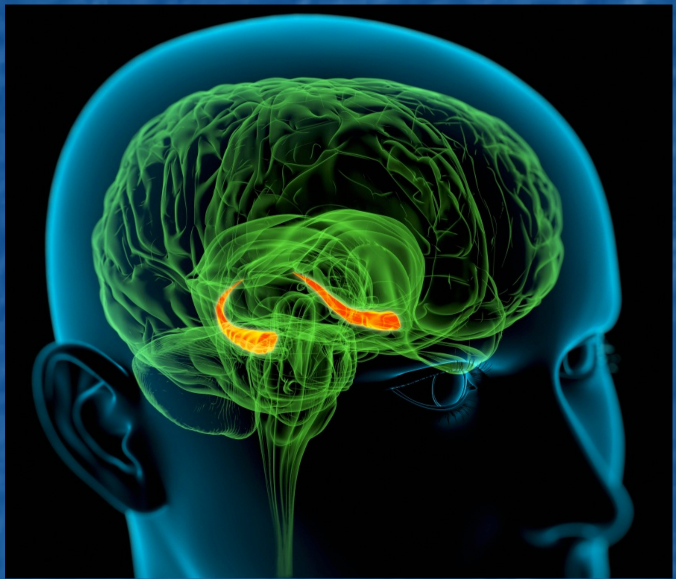
We typically think of it as more or less *distributed*.

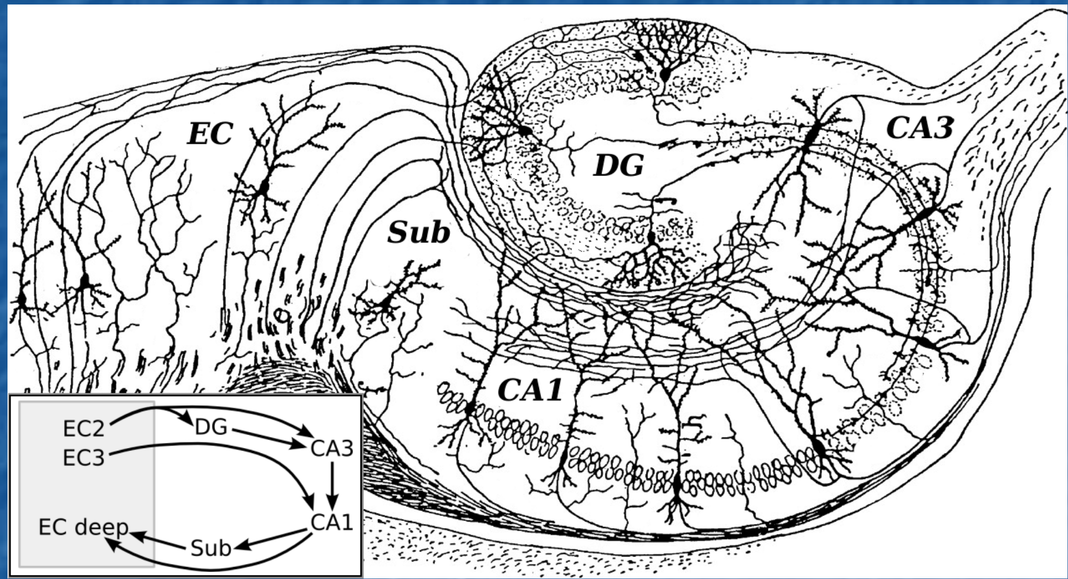
New information is laid down on top of existing connectivity – *superpositional storage*. The last thing we want is for new information to over-write old information.

Catastrophic interference

McClelland, McNaughton & O'Reilly (1995)

We saw in HM that the hippocampus is involved in moving memory from short- to long-term storage.



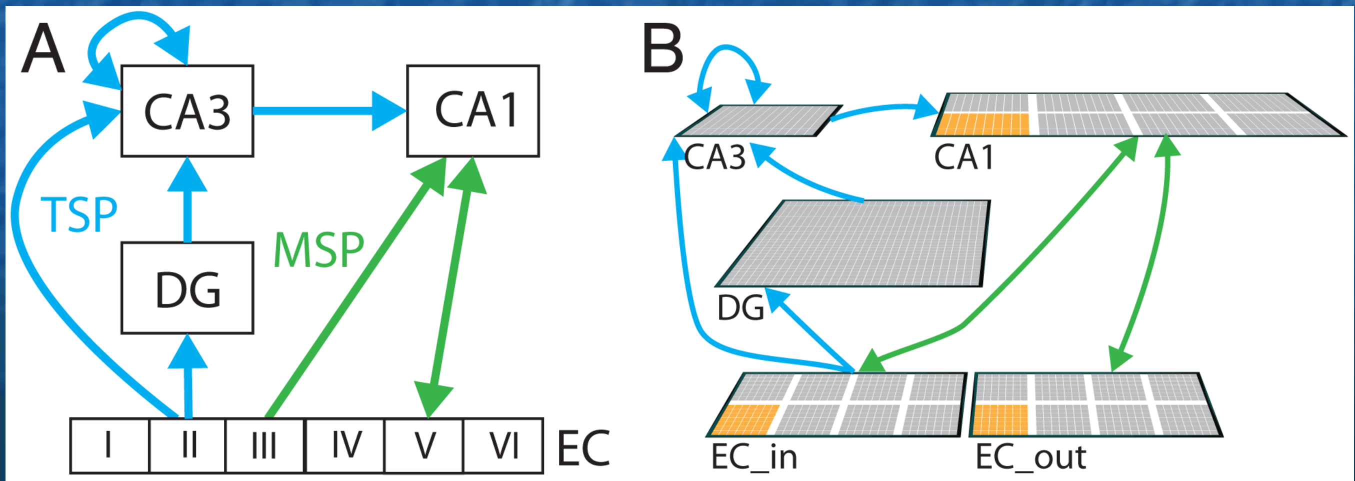


95% of hippocampal structure is in one plane – ideal for keeping things separate.

Hippocampal learning
Ketz, Morkonda & O'Reilly (2013)

Ketz *et al.* explore the pattern of connectivity within the hippocampus using computational simulations.

Different assumptions about connectivity, about flow of activation, about changing *weighted connections*, can reveal the computational potential of brain structures.



Hippocampal learning

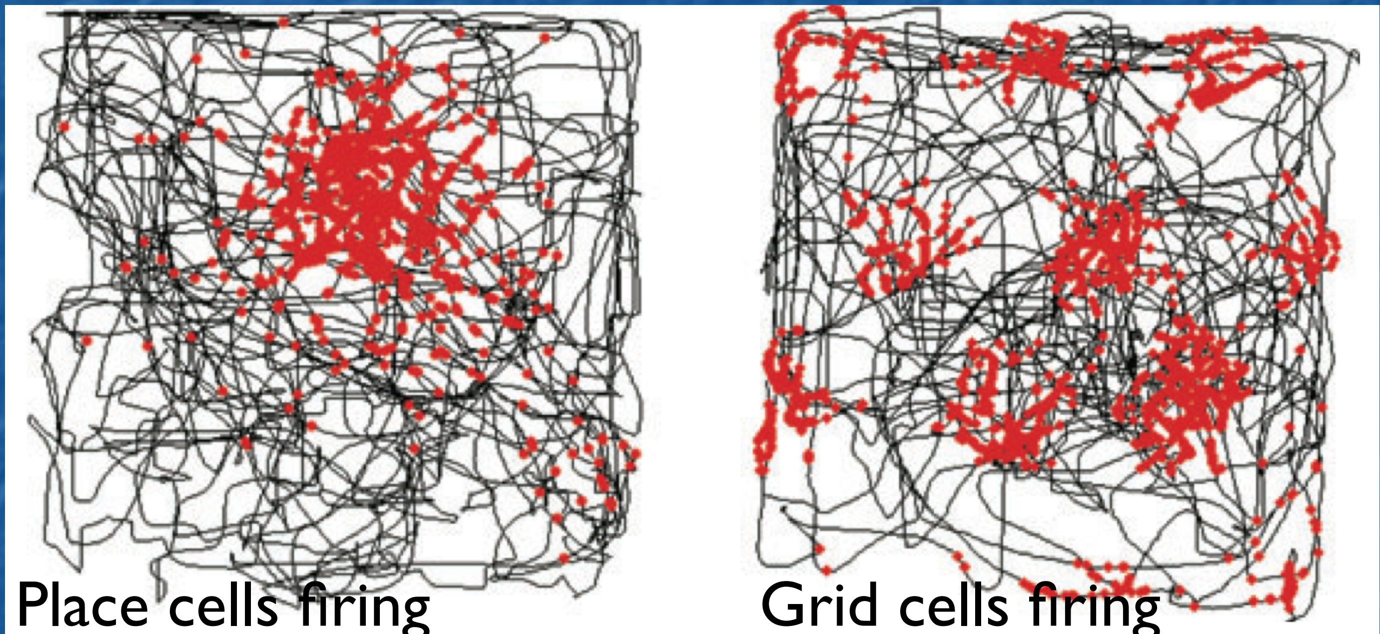
Ramirez *et al.* (2013) were able to create a "false memory" in the mouse hippocampus by optogenetically manipulating dentate gyrus granule cells involved in storing an environmental context.

These neurons were later reactivated (by light) during the conditioning of a fear response connected to a small electric shock.

It was possible to transfer the fear response to the old, benign context simply by this manipulation within the hippocampus.

“Place cells” and “grid cells”

The hipocampus contains cells whose activity reflects the spatial location of the animal (see, e.g., Moser, Kropff & Moser, 2008).



Foster and Wilson (2006) show that a rat may stop and “think” after finding food, and can be replaying activations of such cells in reverse order.

Hippocampal learning

Sherry, Vaccarino, Buckenham & Herz (1989)

The hipocampus is bigger in birds that cache food so that they can return to it.



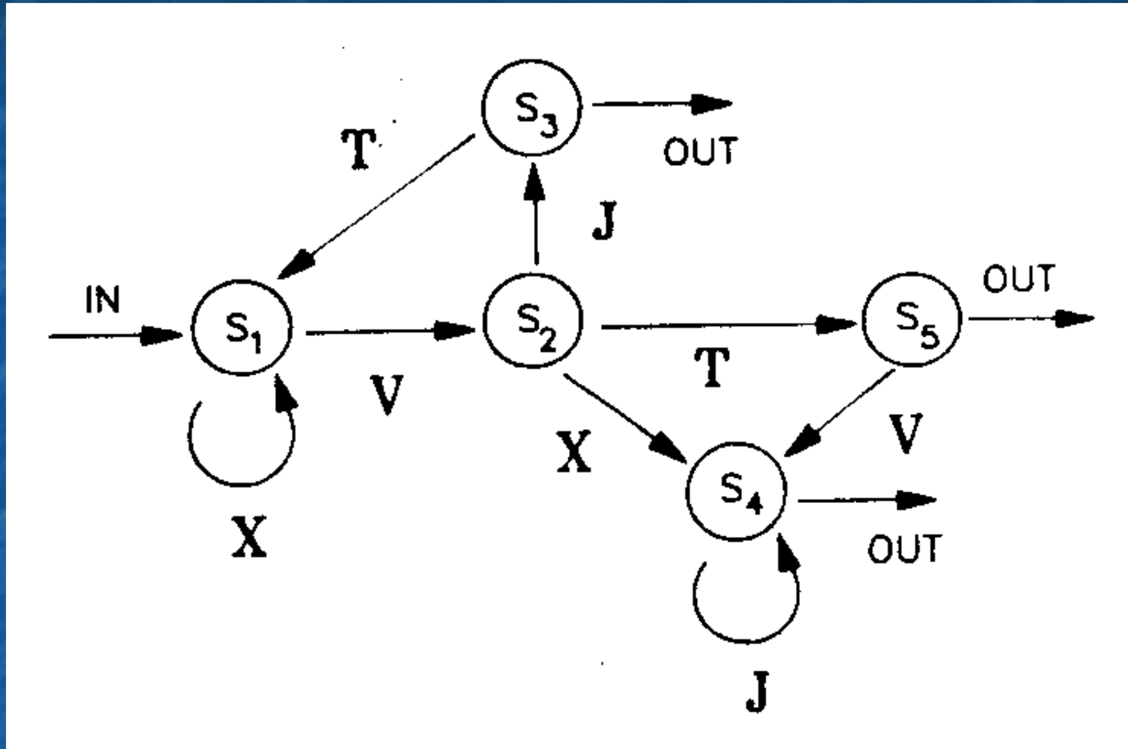
Sleep and word-learning

Lindsay & Gaskell (2013)

Sleep has been implicated in novel word (*cathedruke*) learning, as revealed by subsequent competition effects between similar words (*cathedral*).

There have been numerous suggestions about sleep and memory, including ones of interleaved learning transferring information into longterm storage.

AGL learning of FSGs



Learning of simple strings has been studied since Reber (1967) to look at "grammar learning". Alternative accounts suggest fragment learning and abstraction at test may also account for the transfer data (*cf.* Redington & Chater, 1996).

Principles

Elapsed-time-since-experience is important for memory, particularly in the short term.

Other dimensions can be important, particularly over longer times and more complex environments; e.g. hierarchical organization, as in confusions between last place in different lists.

The anatomy itself can give us clues, through modelling, of functions that may be relevant to memory.

Challenges

Think about how the processes we have talked about might apply in the case of Luria's Shereshevsky, but also in normal everyday tasks.

How might we have memory specific to sensory modality, to certain forms of content, *etc*. but also with more general mechanisms involved?

Think about the status of the role of elapsed time in a model. It is a *real material thing*; it mediates everything else in the model.

Think about the role of people's activity.

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