Informatics 1 Cognitive Science

Lecture 21: Learning and Memory Part 1

Matthias Hennig

School of Informatics
University of Edinburgh
mhennig@inf.ed.ac.uk

What is memory?

What is memory?

- Storage and retrieval of information
- Includes not only facts (hard to learn), but abilities, skills, and experiences
- Lifelong learning and forgetting
- Imperfect but robust (unlike computer memory)
- Comes in different qualities (unlike computer memory)

Computer memory versus cognitive memory

In computers:

- Memory and algorithmic processing are separated
- Address-based access for recall

In the brain:

- Memory is a cognitive ability and inseparable from processing (the software is the hardware)
- Recall uses content-addressable access

Memory Systems

Is all memory the same?

- What did you have for dinner yesterday?

Which questions feel easy to answer, and why?

Is all memory the same?

- What did you have for dinner yesterday?
- What did you have for dinner on 9 March last year?

Which questions feel easy to answer, and why?

Is all memory the same?

- What did you have for dinner yesterday?
- What did you have for dinner on 9 March last year?

- What is the capital of Scotland?

Which questions feel easy to answer, and why?

Is all memory the same?

- What did you have for dinner yesterday?
- What did you have for dinner on 9 March last year?

- What is the capital of Scotland?
- What is the capital of New Zealand?

Which questions feel easy to answer, and why?

Is all memory the same?

- What did you have for dinner yesterday?
- What did you have for dinner on 9 March last year?

- What is the capital of Scotland?
- What is the capital of New Zealand?

- Do you know how to tie your shoelaces?

Which questions feel easy to answer, and why?

5

Is all memory the same?

- What did you have for dinner yesterday?
- What did you have for dinner on 9 March last year?

- What is the capital of Scotland?
- What is the capital of New Zealand?

- Do you know how to tie your shoelaces?
- Can you explain to the person next to you how to do this?

Which questions feel easy to answer, and why?

Memory Systems: Examples

- **What did you have for dinner yesterday?**
  Episodic memory — recent personal event, easy to recall

- **What did you have for dinner on 9 March last year?**
  Episodic memory — distant personal event, hard to recall

- **What is the capital of Scotland?**
  Semantic memory — well-known fact (for us), easy to recall

- **What is the capital of New Zealand?**
  Semantic memory — less familiar fact, may be harder to recall (Wellington)
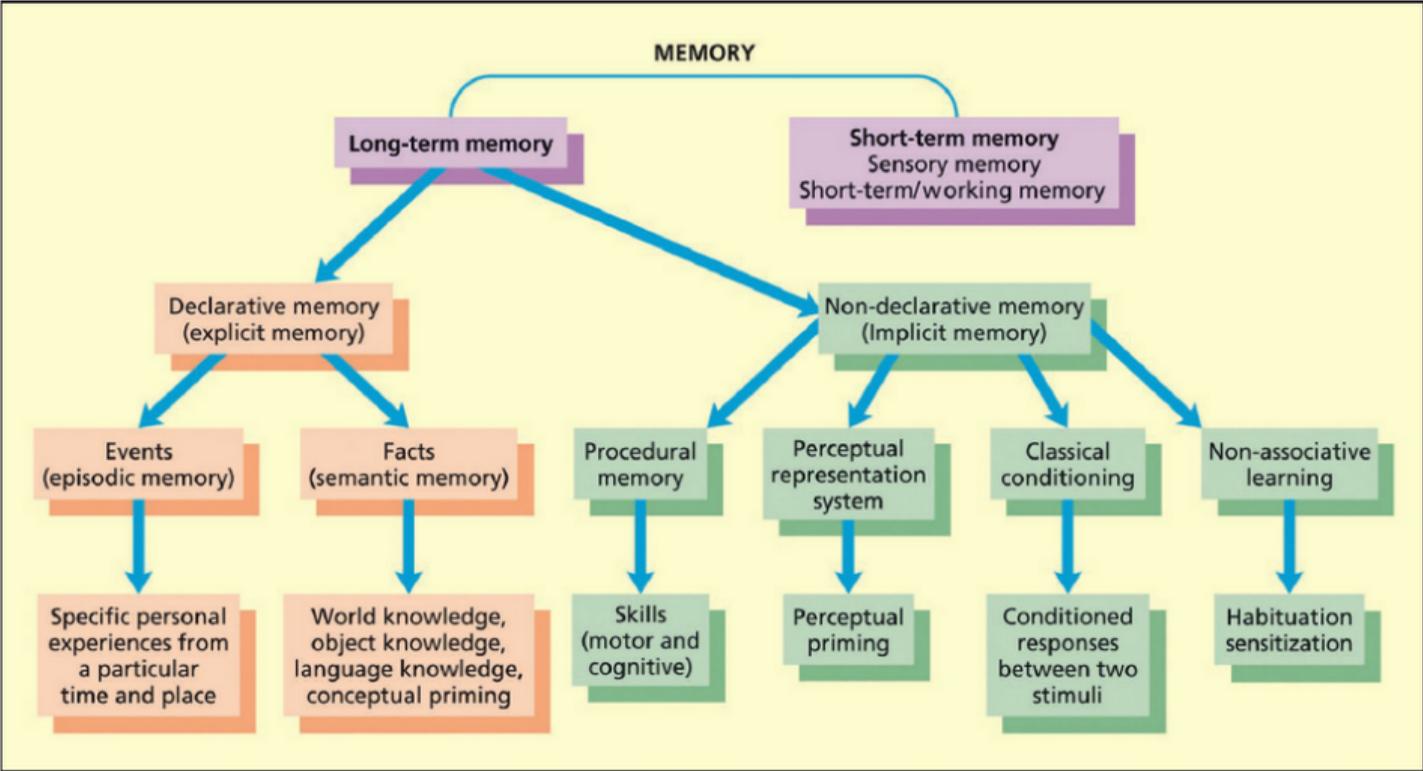
- **Do you know how to tie your shoelaces?**
  Implicit/Procedural memory — skill, easy to perform

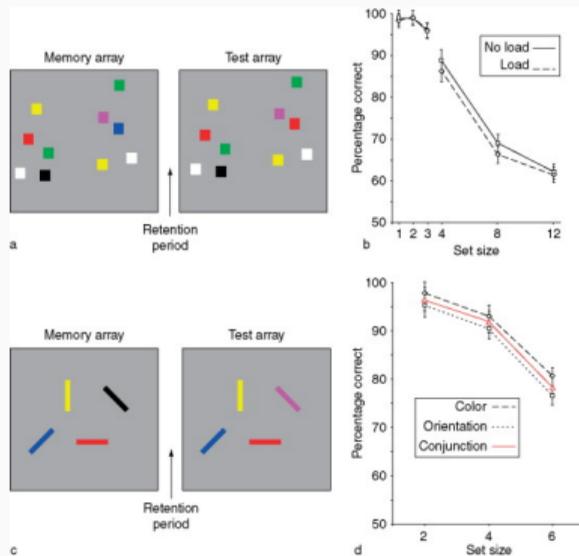- **Can you explain how to tie your shoelaces?**
 *Explicit memory* — hard to verbalise implicit knowledge

Short Term Memory

- Retaining information for short time periods (900 ms in experiments)
- (a) change detection paradigm, spot the same/different colour (load: participant speaks); (c) change detection paradigm using colour and orientation
- Capacity limited (about 4 items, not George Miller's Magical Number 7±2)

8

Working Memory as reverberating neural activity
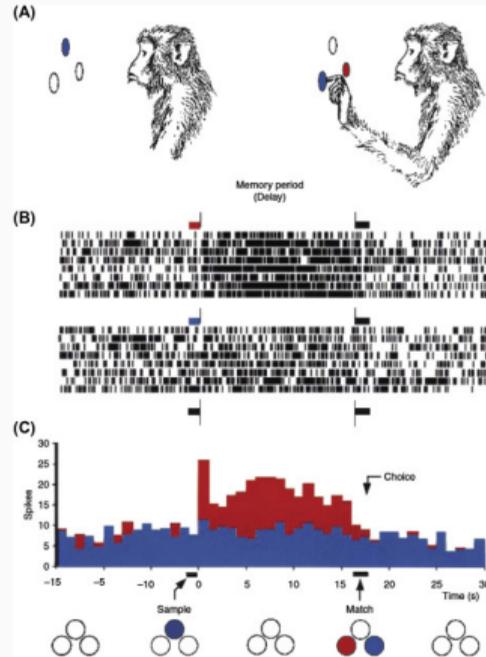
- A delayed match to sample (DMTS) task
- Suggests information maintained through reverberating neural activity (PFC)
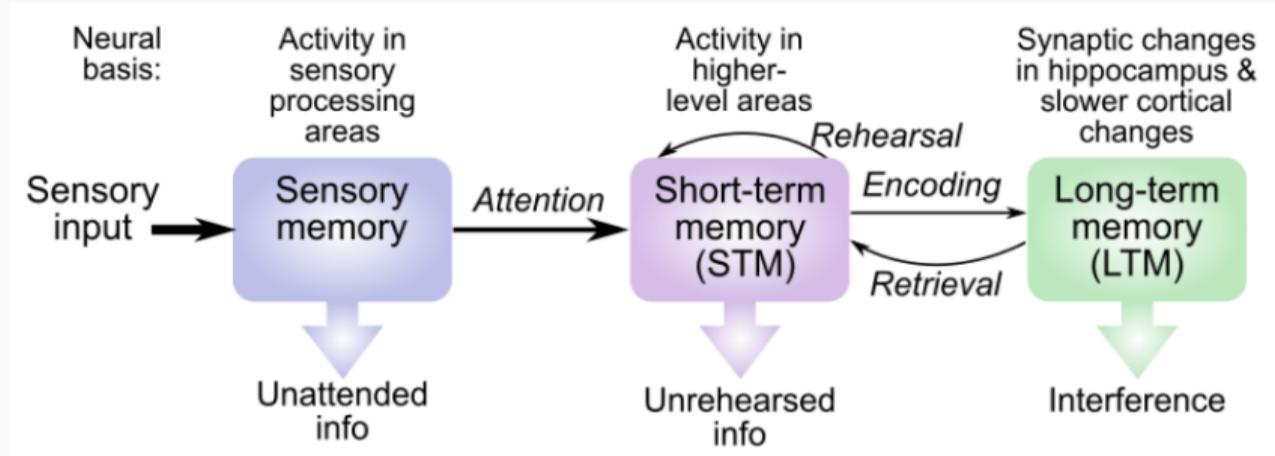
Working Memory is more than a temporary store

TABLE 2
CORRELATIONS BETWEEN SPANS AND READING
COMPREHENSION IN EXPERIMENT 1

	Reading comprehension measures		
	Fact questions	Pronoun reference questions	Verbal SAT
Reading span test	.72*	.90*	.59*
Word span test	.37	.33	.35

* $r(18)$, $p < .01$.

- Participants read sentences (e.g. "When at last his eyes opened, there was no gleam of triumph, no shade of anger. The taxi turned up Michigan Avenue where they had a clear view of the lake.")
    - Reading span test: Recall the last word of each sentence
    - Word span test: Word recall from a list of words read to participants
    - Reading comprehension tests: Recall of the meaning of the sentences
    - SAT: Verbal Scholastic Aptitude Test (measures comprehension)
- Individual performance is correlated: WM capacity is related to comprehension

Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. Journal of verbal learning and verbal behavior,

- Neural activity maintains short term memory
- Attention selects information for STM
- STM content that is encode in STM can enter long term memory

Long Term Memory
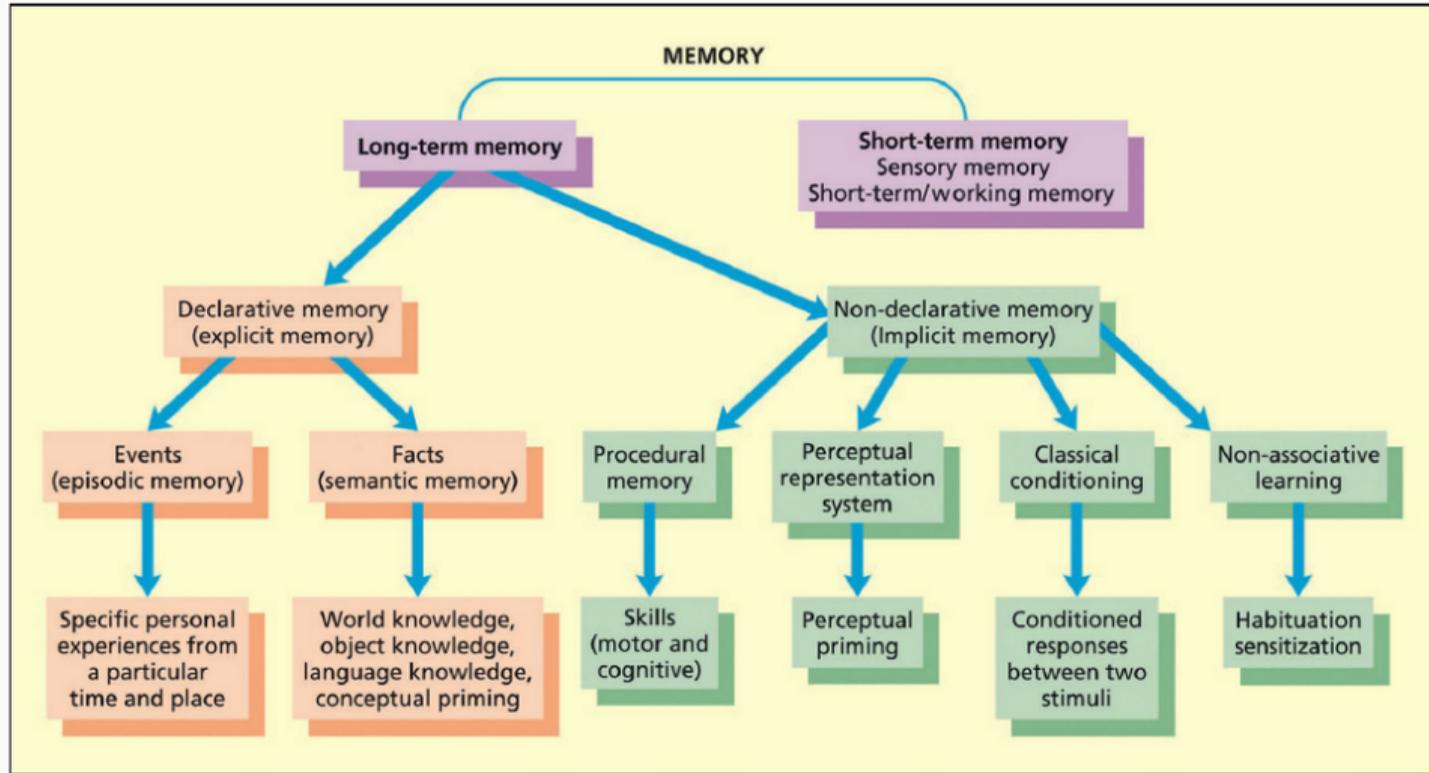
- Neural activity maintains short term memory

Implicit Memory

- Does not require active recollection, typically unconscious
- Skill learning (procedural), conditioning and habituation
- Examples: motor skill learning like tying shoe laces, driving a bike or car, climbing difficult routes on rock

Explicit Memory

Also known as *Declarative Memory*. Divided into:

Semantic memory Factual knowledge about the world, such as: "What is the capital of Scotland?". Involves multiple cortical regions. Information is retained for long times.

Episodic memory Personal events memory. Examples: "Name the route Adam Ondra climbed?", "What did you have for dinner last night?". Involves the medial temporal lobe, which includes the hippocampus. Selective and forgetful.

Often episodic memories are slowly stored away as semantic memories through consolidation.

A famous case study: Patient HM

- Bilateral hippocampal removal to cure epilepsy in 1953.
- Couldn't form memories of events after the lesion (anterograde amnesia)
- but was able to learn new procedures, and some short-term memory.
- This showed:
  - different mechanisms/sites for declarative and non-declarative memory
  - different mechanisms/sites for short and long-term memory
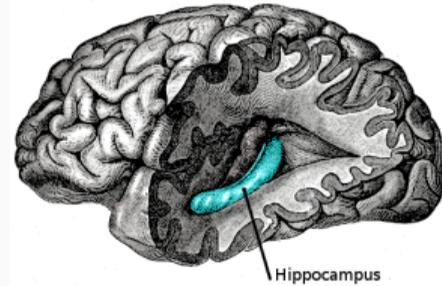
Henry Gustav Molaison (1926–2008)

Summary

- Memory is a cognitive ability inseparable from processing — unlike computer memory
- Multiple memory systems:
  - **Short-term / Working memory**
  - **Implicit memory**
  - **Explicit memory**
- STM and LTM are dissociable systems (Patient HM)
- The hippocampus is critical for forming new explicit (episodic) memories
- Episodic memories are consolidated into semantic memories over time