

Artificial Cognitive Systems

Module 7: Memory and Prospection

Lecture 1: Types of memory; the role of memory

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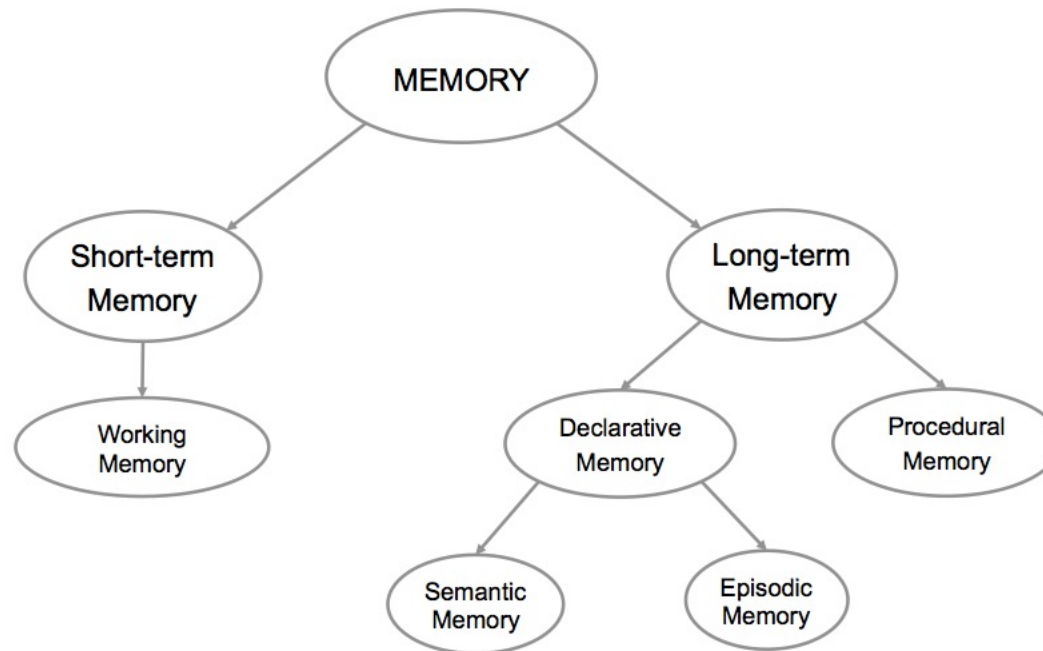
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Memory

- Memory plays a crucial and sometimes unexpected role in cognition
- Strong parallel between **memory** and **knowledge**
- Memory and knowledge are equivalent: **they both encapsulate the experience** that arises from interaction with the world
- Memory is **not** just as a **passive** mechanism for storing knowledge about the past

Types of Memory

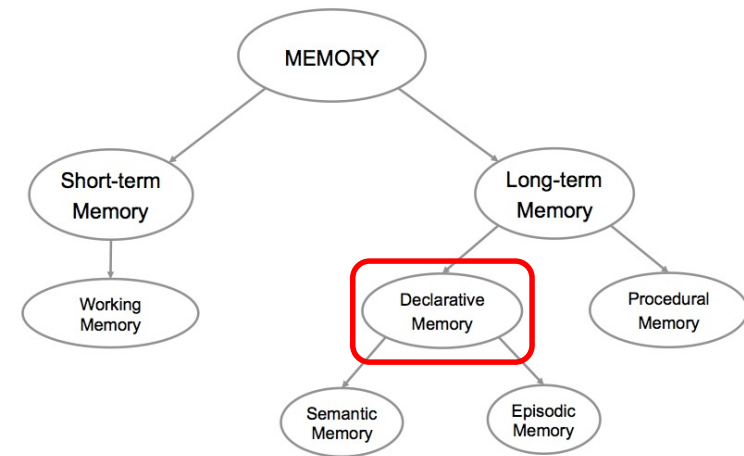
- Declarative
- Procedural
- Semantic
- Episodic
- Long-term
- Short-term
- Working
- Modal
- Amodal
- Symbolic
- Sub-symbolic
- Hetero-associative
- Auto-associative



Types of Memory

Declarative

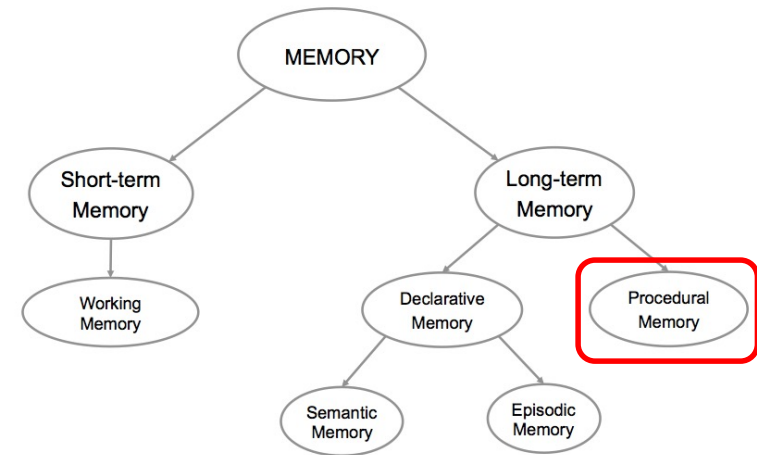
- **Knowledge of things / facts**
- “Knowing that”
- **Propositional memory** (true or false)
- Can be communicated from one agent to another through language
- Can be acquired in a single act of perception or cognition
- Accessible to conscious recall
- **Explicit memory**



Types of Memory

Procedural

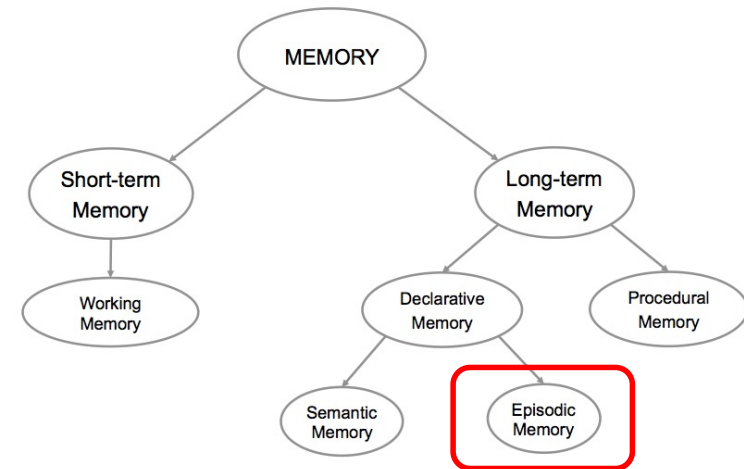
- **Skill-oriented memory of actions**
- “Knowing how”
- Can only be demonstrated
- Acquired progressively and may require an element of practice
- Not accessible to conscious recall
- **Implicit memory**
- **Non-declarative memory**



Types of Memory

Episodic

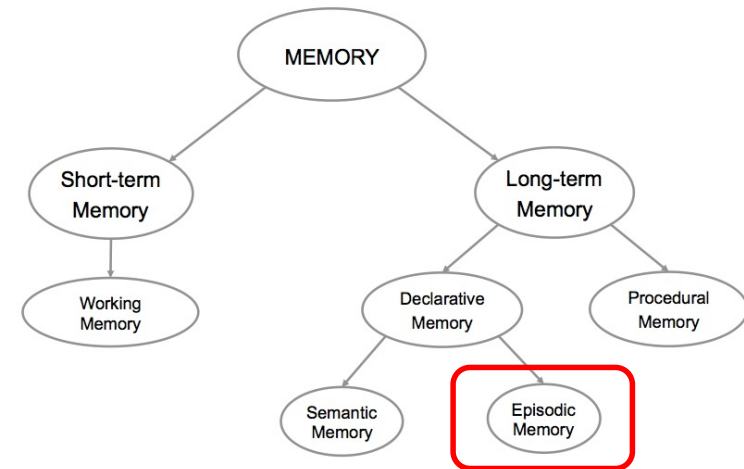
- Specific instances in the agent's experience:
autobiographical
- **Explicit spatial and temporal context**
 - what happened, where it happened, and when it happened
 - This temporal sequencing is the only element of structure in episodic memory
- Sub-symbolic



Types of Memory

Episodic

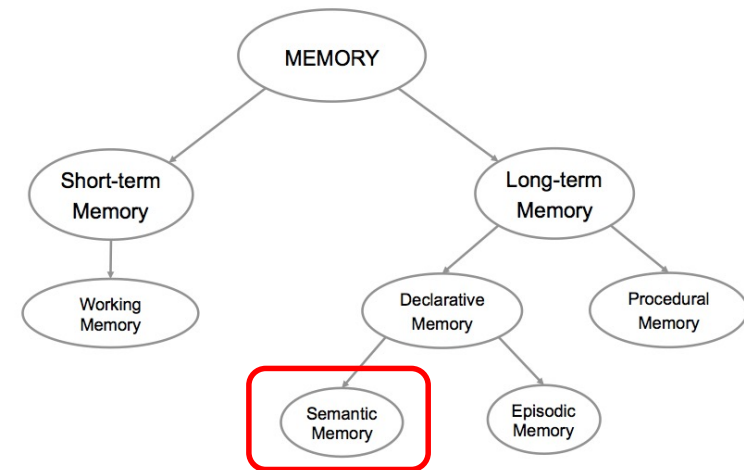
- Episodic memory is a **constructive process**
 - Each time an event is assimilated into episodic memory, past episodes are re-constructed a little differently each time
 - Related to the role that episodic memory plays in the process of internal simulation that forms the basis of prospection



Types of Memory

Semantic

- General knowledge about the agent's world: facts, ideas, and concepts
- May be independent of the agent's specific experiences
- Memory necessary for the use of language
- Derived from episodic memory through a process of generalization and consolidation
- Symbolic



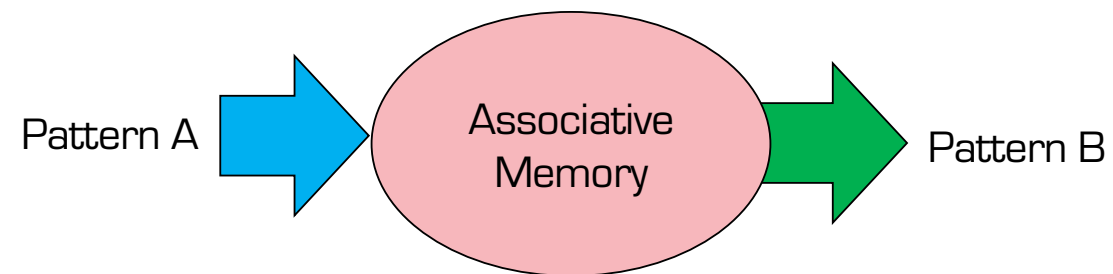
Types of Memory

- **Modal** memory
 - Tied directly to a particular sensory modality such as vision, audition, or touch
 - Episodic memory though is more likely to be modal since it is closely tied to an agent's specific experiences
- **Amodal** memory
 - Amodal memory has no necessary association with the sensorimotor experiences
 - Semantic declarative facts, represented symbolically, are typically amodal

Types of Memory

Associative memory

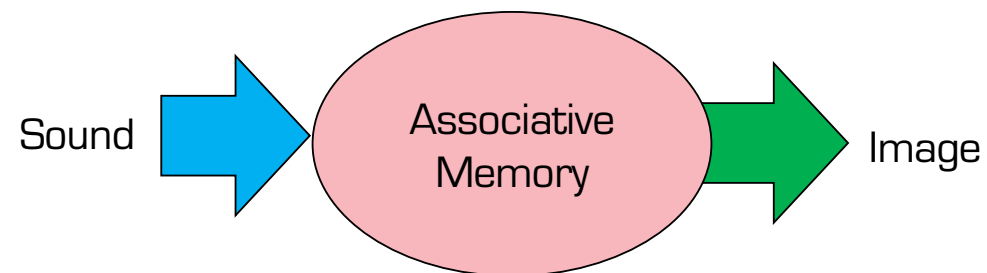
- An element of information or some pattern is linked to another
- The first element or pattern is used to recall the second, by association



Types of Memory

Hetero-associative memory

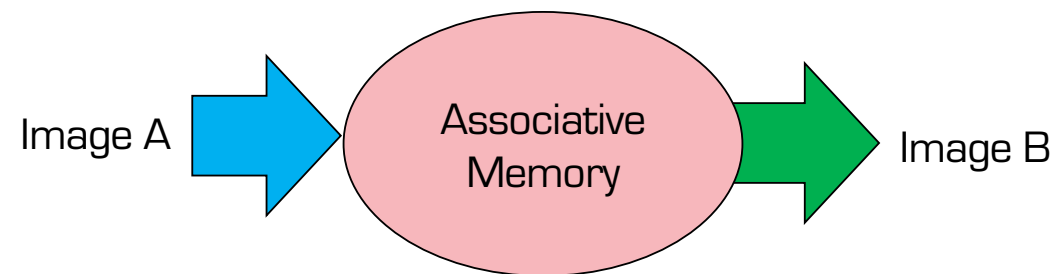
- Recalls a memory that is different in character from the input
- A particular smell or sound, for example, might evoke a visual memory of some past event



Types of Memory

Auto-associative memory

- Recalls a memory of the same modality as the one that evoked it
- A picture of a favourite object might evoke a mental image of that object in vivid detail



Role of Memory

The role of memory – why do we remember things?

- To recognize objects, events, and people we've encountered before
- To act towards them in some appropriate way (attraction/avoidance)
- Memory is what makes it possible for the changes that occur as a result of learning and development to persist
- **Memory also is what makes it possible to project forwards into the future**



Role of Memory

One of the central pillars of cognitive capacity:

- the ability to **simulate internally the outcomes of possible actions** and select the most appropriate one for the current situation
- Memory can be seen as a mechanism that allows a cognitive agent **to prepare to act**, overcoming through anticipation the inherent “here-and-now” limitations of its perceptual capabilities
- **a cognitive system** doesn't operate just on the basis of its current sensory data but **readies itself for what it expects and adjusts to the unexpected**

Role of Memory

Memory is an **active** & **constructive** process, and it is fundamentally **associative**

- Memories are recalled by associated triggers, possibly other memories
- If you have a network of associative memories, you can run through this network **backwards** or **forwards**
- Running through it **forwards** provides the **anticipatory predictive** element of memory suggesting possible sequence of events leading to a desired goal
- Running through it **backwards** provides a way of **explaining** how some event or other might have occurred or **imagining** ways in which it might have turned out differently

Role of Memory

“It’s a poor sort of memory that only works backwards”

Remarks of the White Queen to Alice
in Lewis Carroll’s *Through the Looking Glass*

Memory is Prospective



Role of Memory

“It’s a poor sort of memory that only remembers what has actually happened”

Remarks by Tom Ziemke

Memory is Constructive



Forgetting

- The cause of the process of forgetting — and dual process of memory retention — are not well understood
- It appears that different memory retention mechanisms apply in different forms of memory
 - Short-term memory
 - Forgetting is an intrinsic property
 - Short term memory depends on persistent elevated firing rates in local sub-populations of neurons in the absence of external cues
 - Forgetting happens naturally when the activity of these neurons decreases

Forgetting

Long-term declarative episodic memory ... less clear what factors influence forgetting

- Possible causes include
 - decay,
 - interference between memories, and
 - interference from mental activity and memory formation
- Even less clear what are the mechanisms of forgetting in non-declarative procedural memory

Recommended Reading

Vernon, D. *Artificial Cognitive Systems – A Primer*, MIT Press, 2014; Chapter 7.