



How Minds Work

Tools for Thinking about Minds: An Ontology for Cognition

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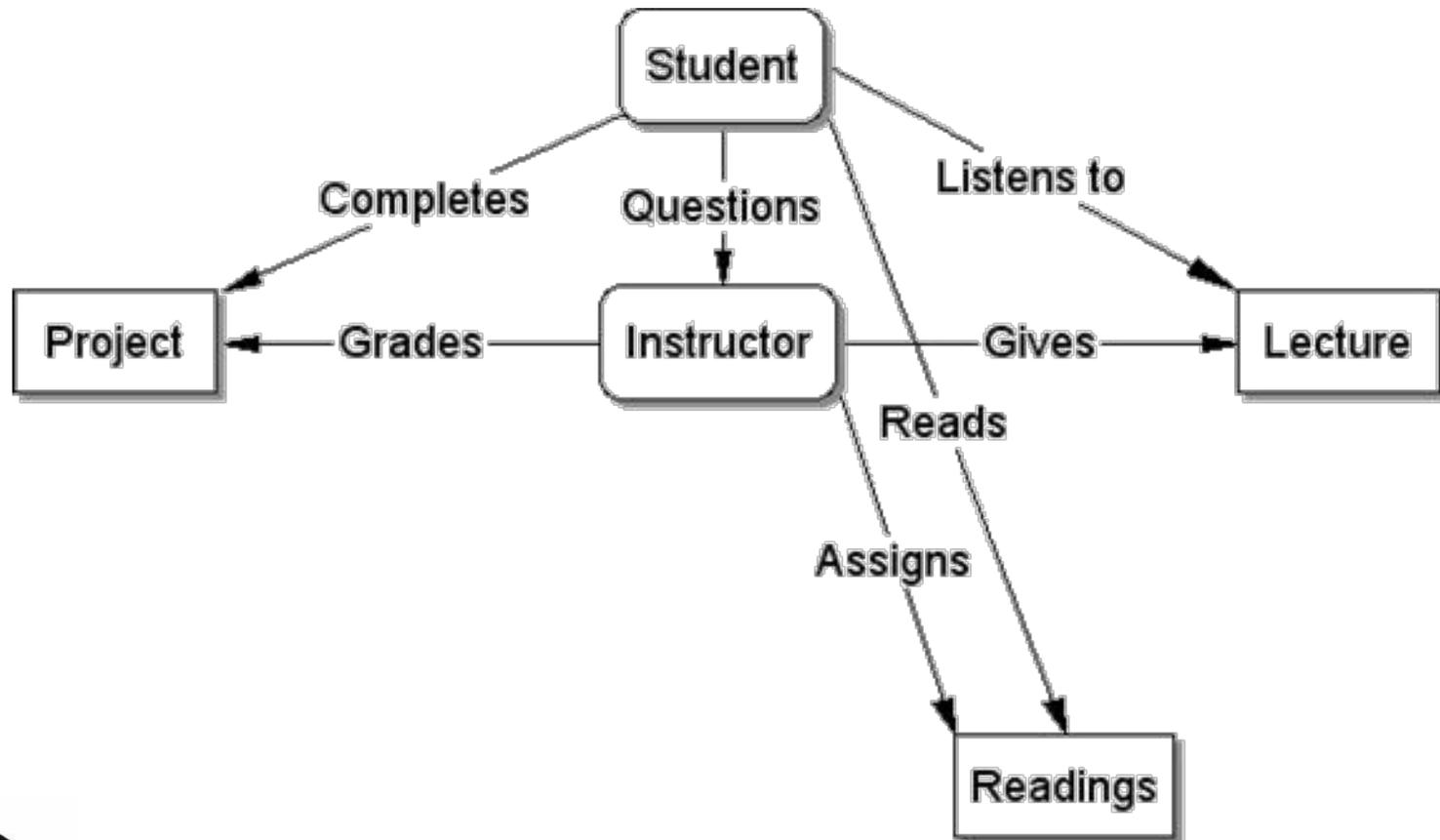


Ontology?

- Philosophy—the study of the nature and relations of being
- Computer Science—a specification of the objects in a system and their relations
- How Minds Work—a particular collection of entities, relations, processes



A Simple Ontology



An Ontology for Cognition

- Entities, relations, processes
- Useful for the study of how minds work
- That is, for the study of cognition



What is a *mind*?

A **mind** is a control structure
for an autonomous agent.



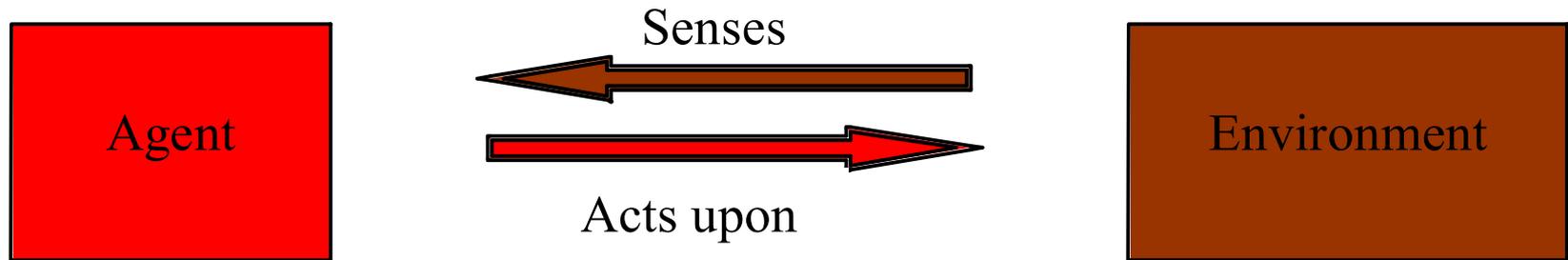
What is an *autonomous agent*?

A system embedded in, and part of,
an **environment**, that

- **Senses** its environment
- **Acts** on it
- Over time
- In pursuit of its own **agenda**
- So that its actions affect its future sensing



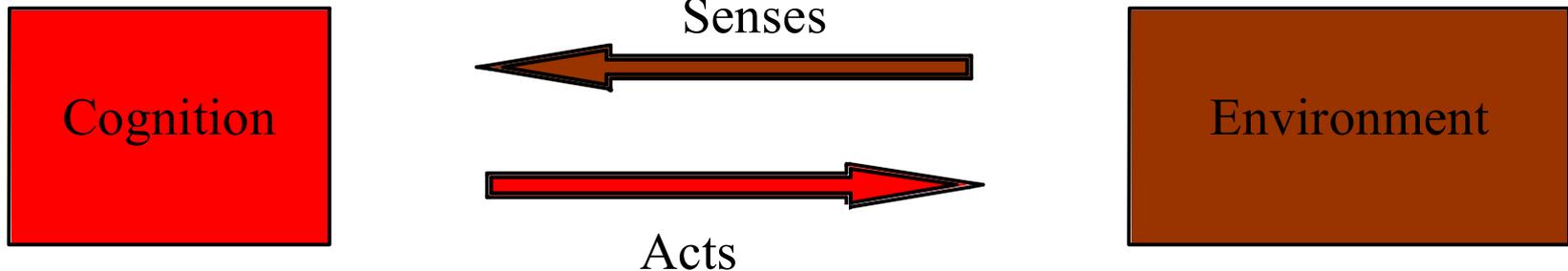
An Agent in its Environment



- The agent senses its environment and acts on it, over time, in pursuit of its own agenda.
- It must have built in **drives**, or motivators, **sensory receptors**, and **effectors**.



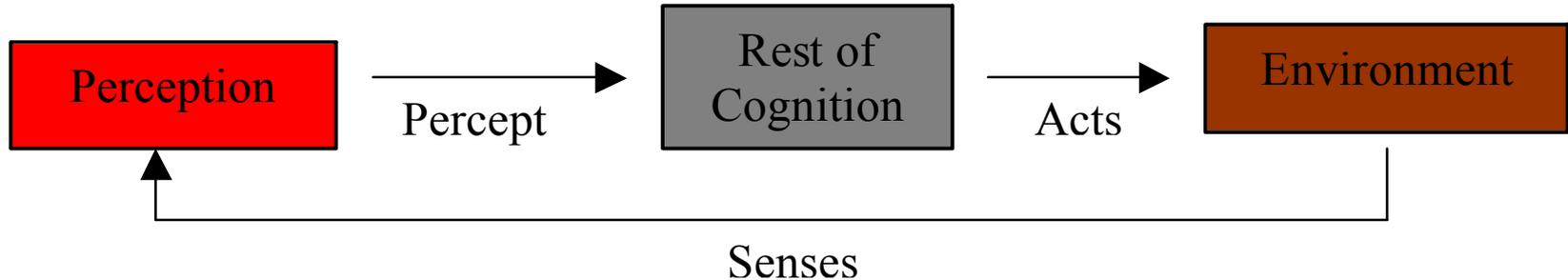
Cognition



- **Cognition** will be the term used for the endless cycle of deciding what to do next.
- This use is broader than that typically used in psychology, which omits perception & action



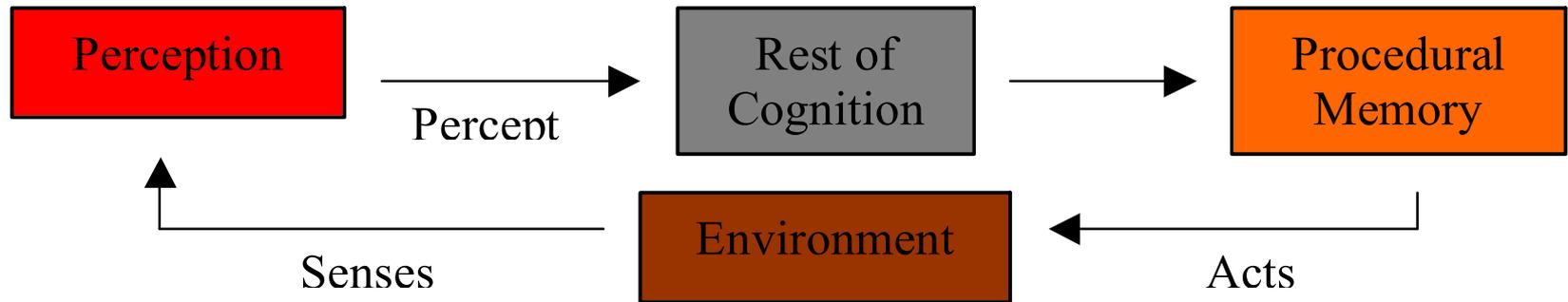
Perception



- **Perception**—assigning **meaning** to sensory data
- Meaning defined as knowing what to do
- Can be **bottom-up** and/or **top-down**



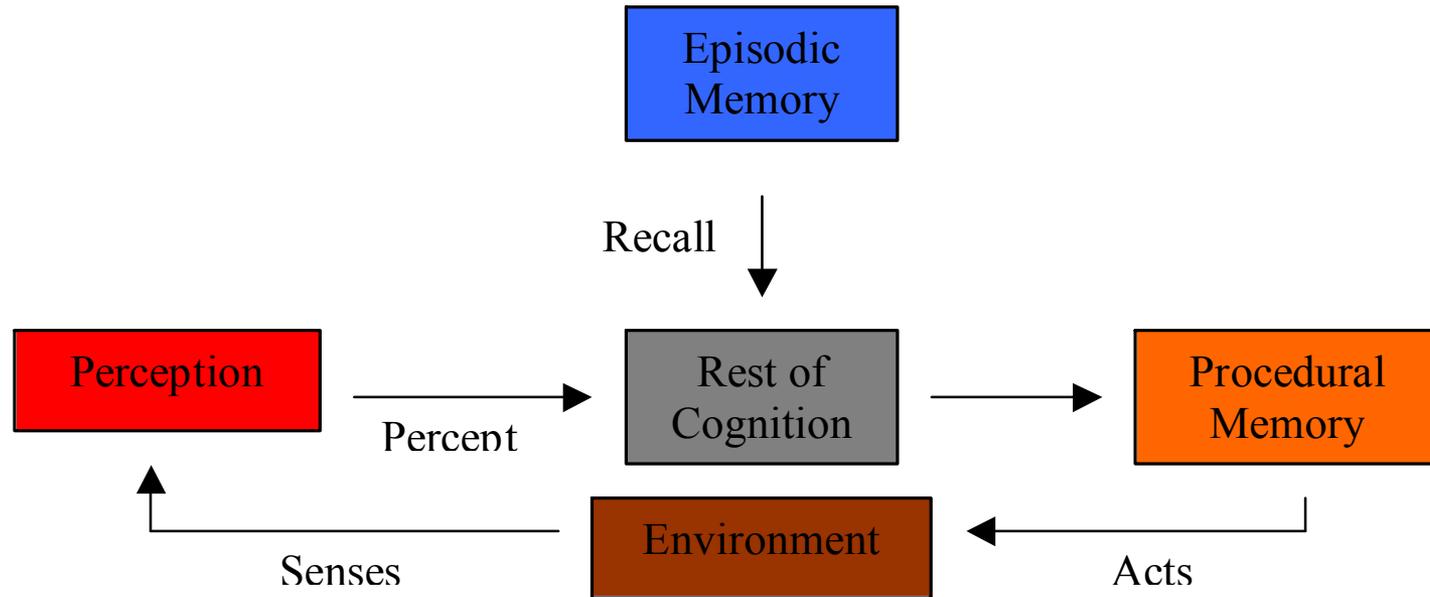
Procedural Memory



- **Procedural memory**—stores procedures for performing tasks, and sequences thereof
- **Procedural learning**—improves performance of old tasks, learns new ones



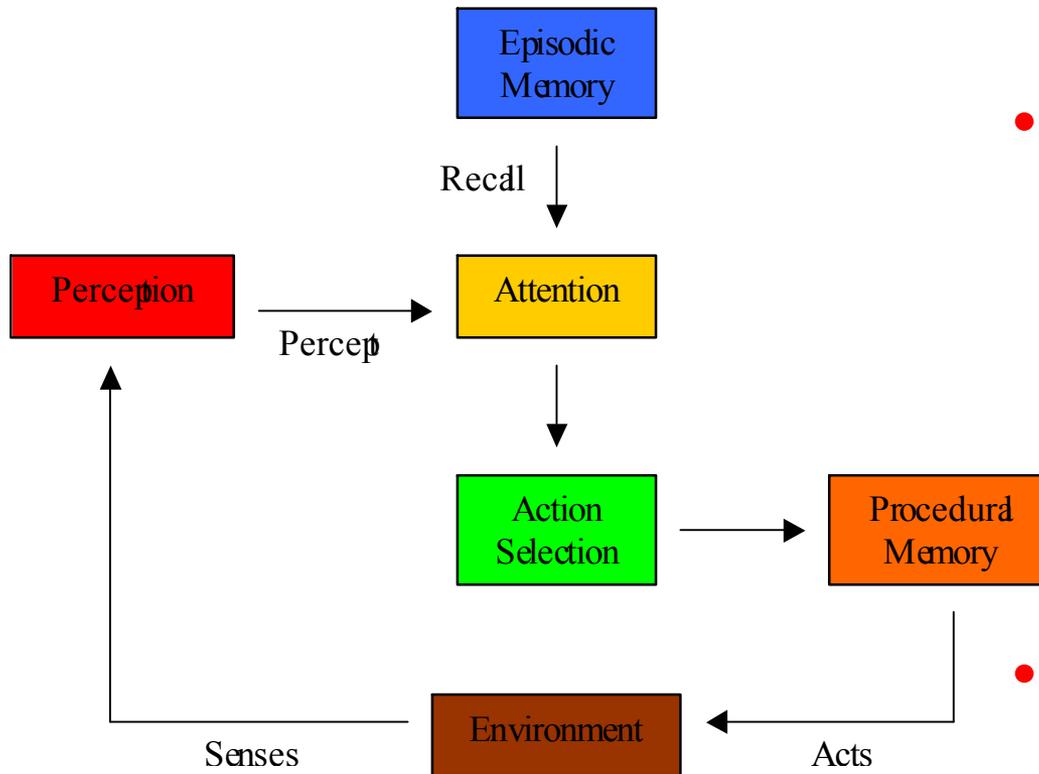
Episodic Memory



- **Episodic memory**—content-addressable, associative, memory for events—what, when, how
- Recalled via **mental images**—visual, olfactory, etc



Attention & Action Selection

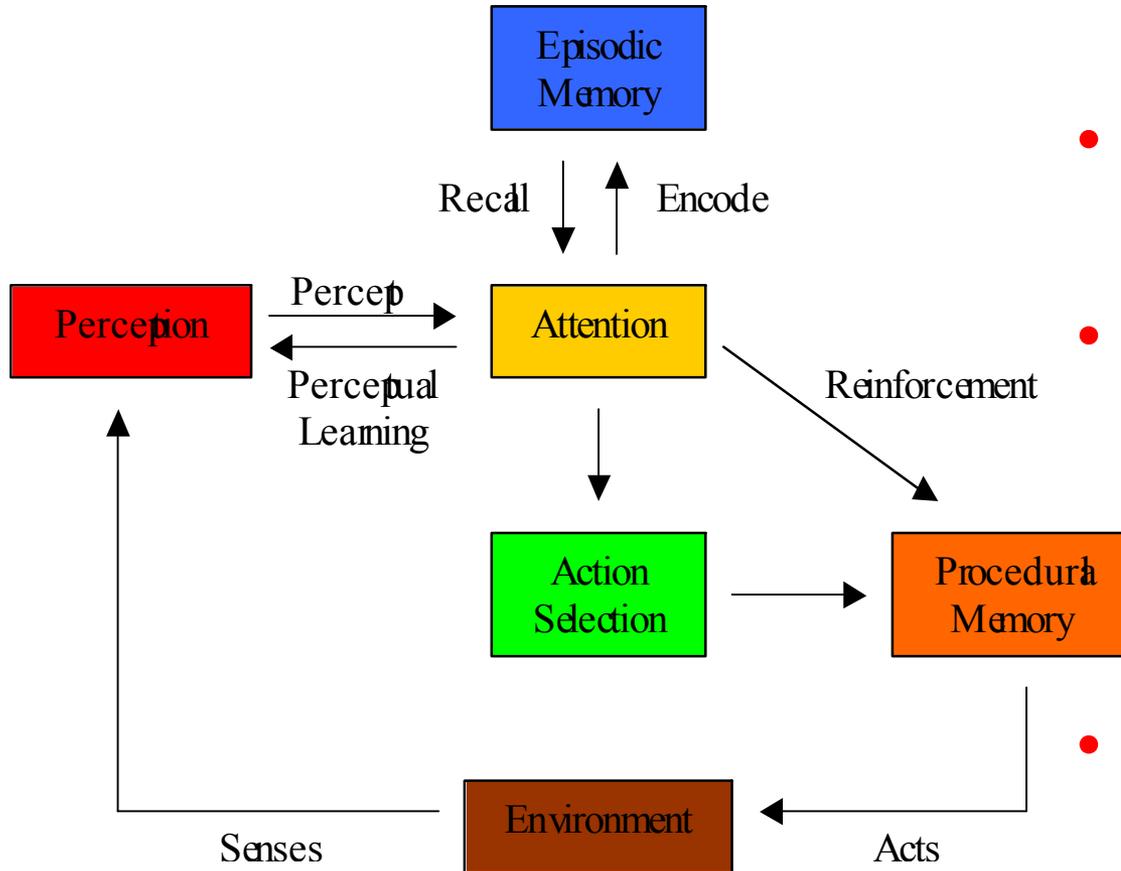


- **Attention**— process of bringing to consciousness

- **Action selection**— process of choosing what to do next



Learning



- Perceptual learning of meanings
- Episodic learning of events
- Procedural learning of skills by reinforcement



Drives, Goals & Intentions

- **Drive** — primary motivator
- **Goal** — restructure the environment or the agent's relation to it
- **Volition** — process of arriving at a goal
- **Intention** — agent's volitional resolve to achieve a goal
- Goals can be in the service of other goals, ultimately of drives



Actions

- Volitional — high level
- **Informationally** (consciously) **mediated**
- **Automatized**
- Can be
 - External (exogenous)
 - Internal (endogenous)



Action Selection Processes

- **Reactive** — direct choice, though perhaps quite complex
- **Deliberative** — options constructed & evaluated, plans created
- **Metacognitive** — thinking about thinking, more strategic

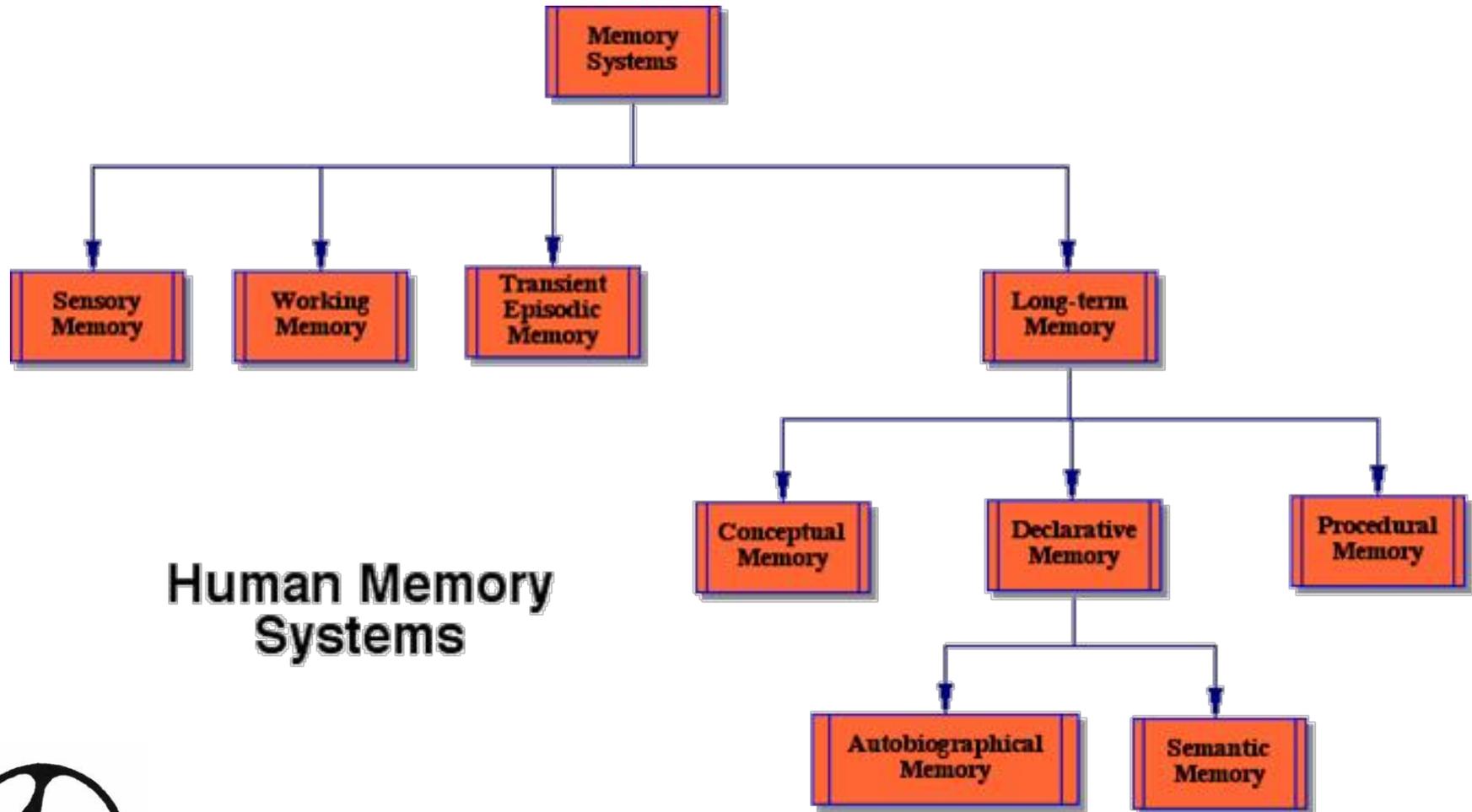


Cognitive Processes

- Are always cyclic—executing through a continuing sequence of **cognitive cycles**
- May complete during a single cycle—bottom up
- May require a number of cycles to complete—multicyclic—top down

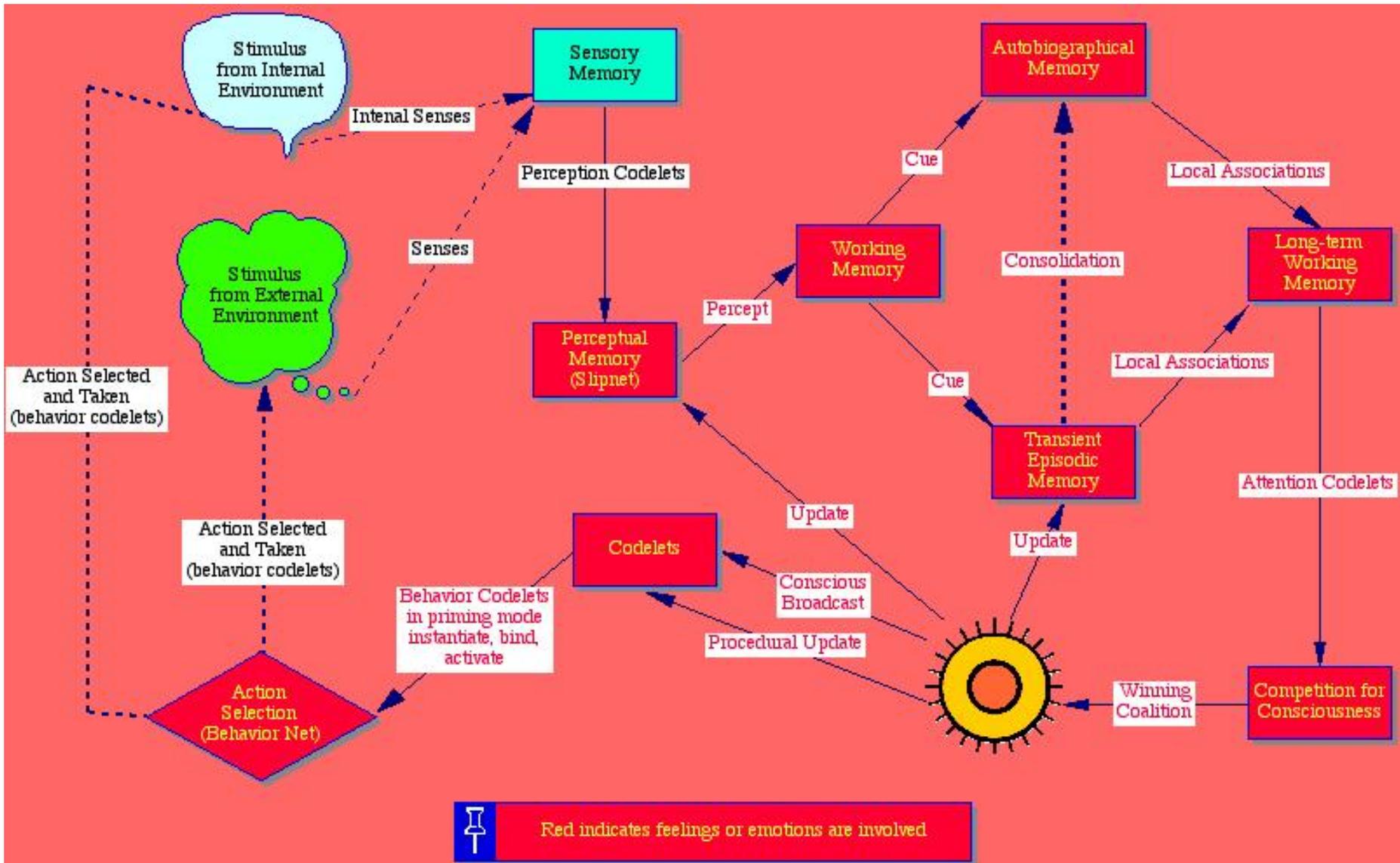


Memory Systems



Human Memory Systems





Readings

- **Sloman, A. 1999. What Sort of Architecture is Required for a Human-like Agent? In *Foundations of Rational Agency*, ed. M. Wooldridge, and A. S. Rao. Dordrecht, Netherlands: Kluwer Academic Publishers.**



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