A Cognitive Theory of Everything:

The LIDA Technology as an Artificial General Intelligence

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and the
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What is general intelligence?

- Machines with human-level, and even superhuman, intelligence
- Generalize their knowledge across different domains
- Reflect on themselves
- Create fundamental innovations and insights

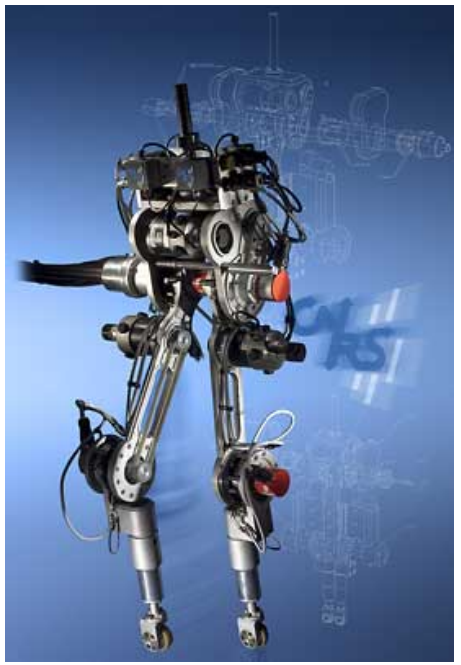
(From the AGIRI web site)

Artificial General Intelligence?

A brain
in a vat
won't do

Where to find intelligence?

In an autonomous agent.

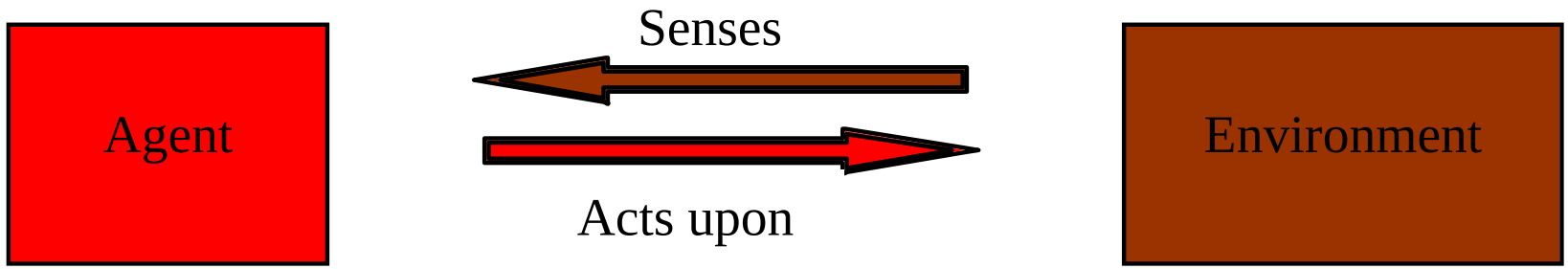


What is an *autonomous agent*?

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

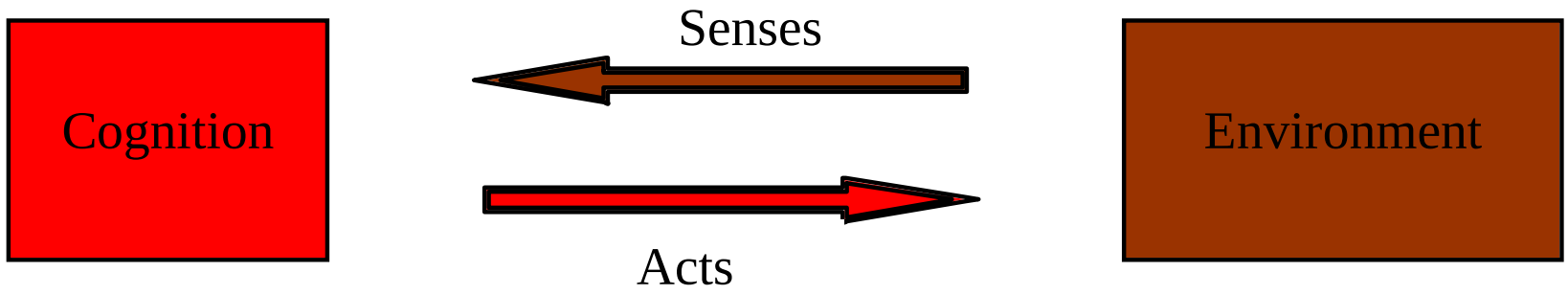
- Senses its environment
- Acts on it
- Over time
- In pursuit of its own agenda
- So that its actions affect its future sensing

An Agent in its Environment



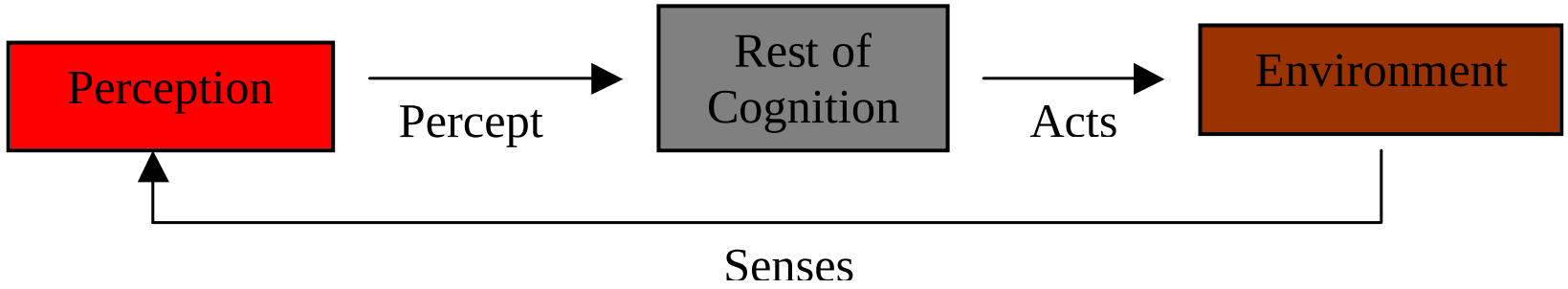
- The agent senses its environment and acts on it, over time, in pursuit of its own agenda.
- It must have built in sensors, effectors, and drives, or primitive motivators.

Cognition



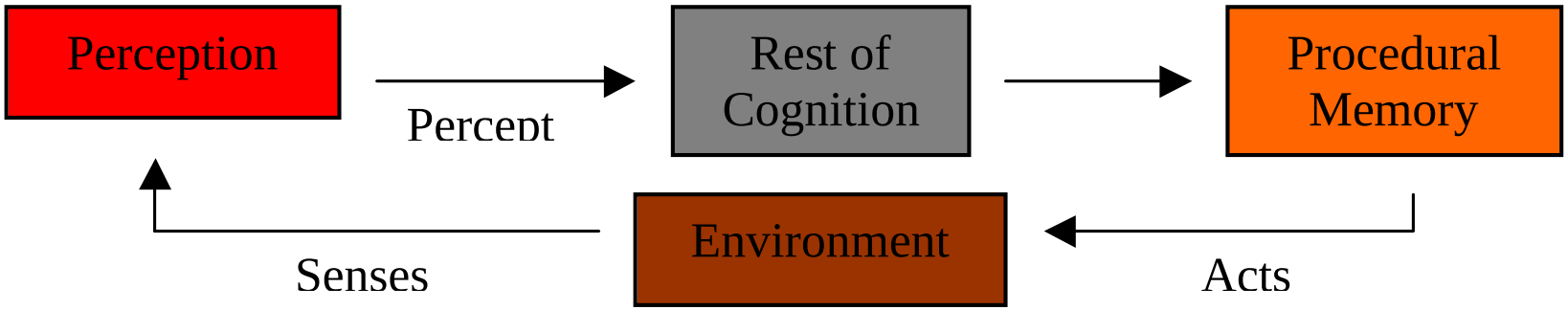
- Cognition will be the term I use for the endless cycle of deciding what to do next.
- This use is broader than that typically used in psychology, which omits perception & action

Perception



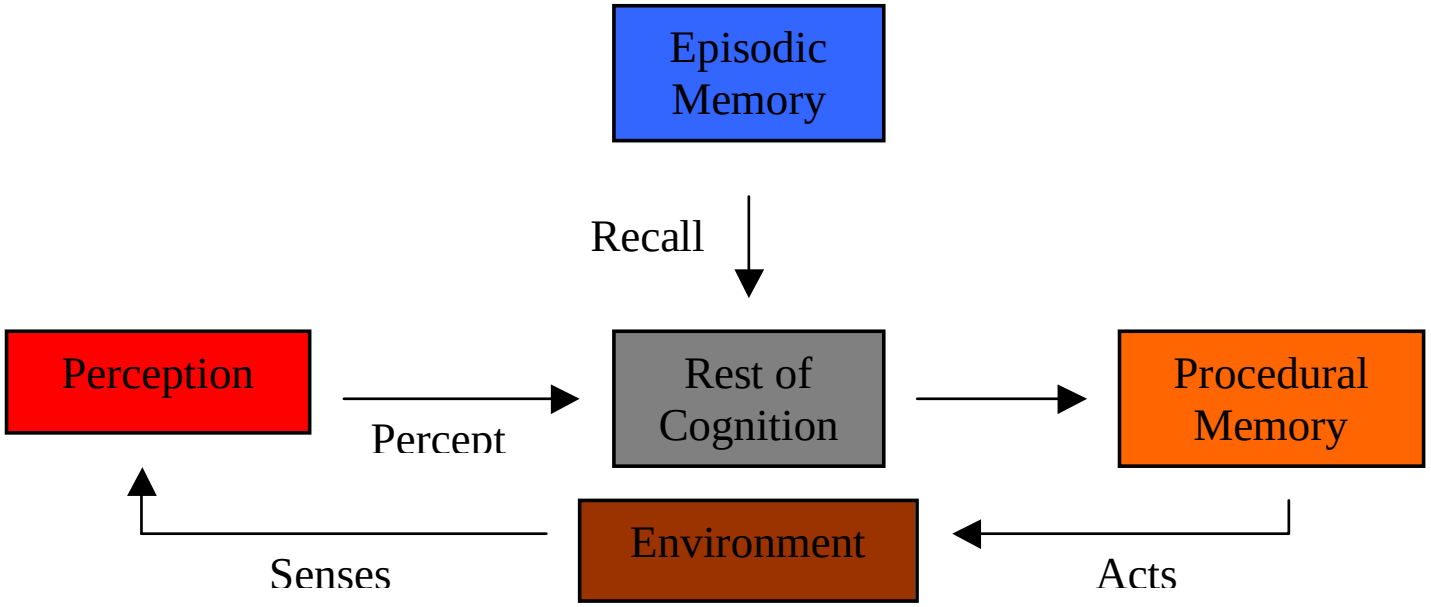
- Perception–assigning meaning to sensory data
- Meaning measured as knowing what to do
- Assignment can be bottom-up and/or top-down

Procedural Memory



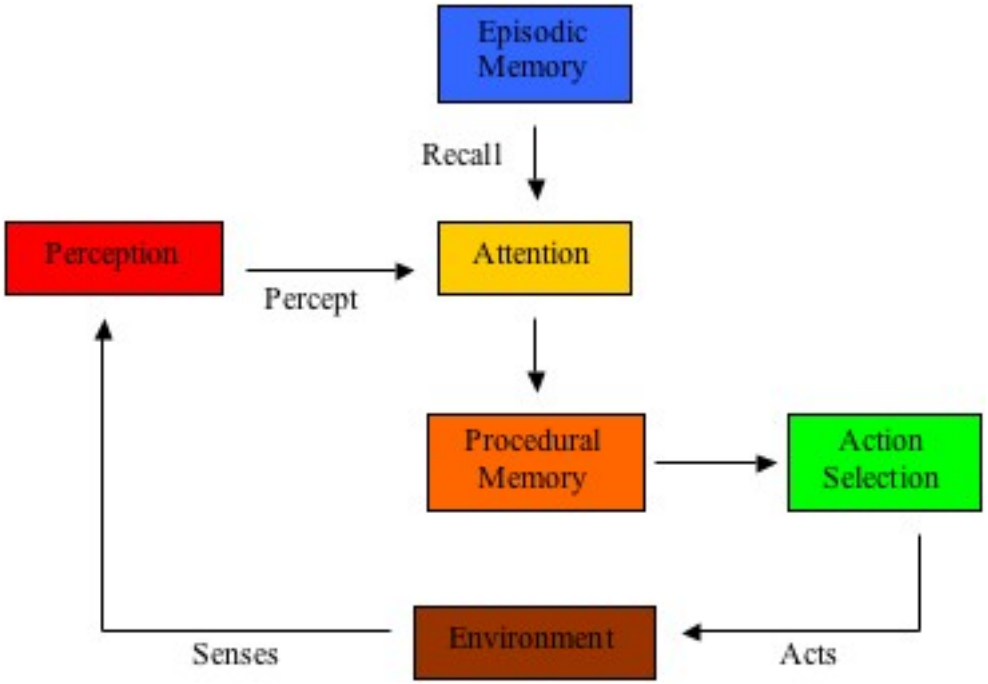
- Procedural memory—stores a repertoire of tasks, and streams thereof
- Not to be confused with sensory-motor memory, which knows how to perform tasks

Episodic Memory



- Episodic memory—content-addressable, associative, memory for events–what, when, where
- Recalled via mental images—visual, auditory, etc

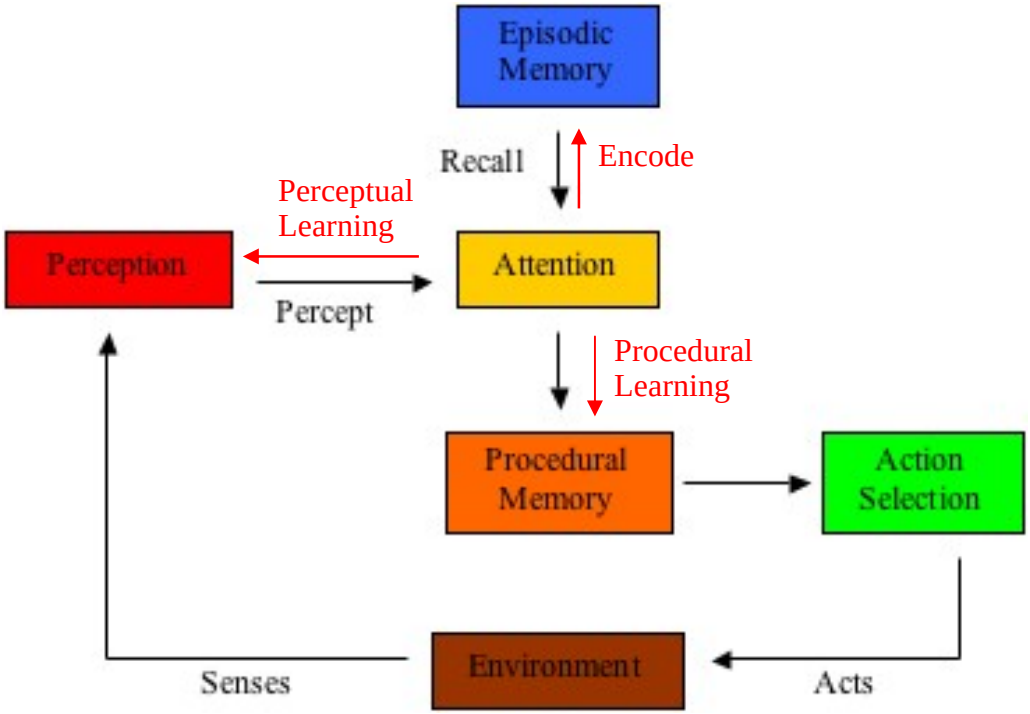
Attention & Action Selection



- Attention—
  a filtering 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 to improve skills or acquire new ones

Artificial General Intelligence

Where to find it?

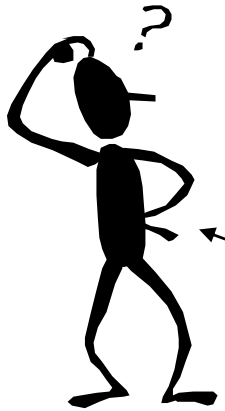
If you want smart software,
copy it after a human.

LIDA

- IDA — a conceptual and computational model of human cognition without learning
- LIDA — Learning IDA

IDA: an Intelligent Distribution Agent

Dialogue with sailors
Read personnel data
Check job requisition lists
Enforce Navy policies
Choose jobs to offer members
Negotiate with them about jobs



Detailer

Telephone

Internet

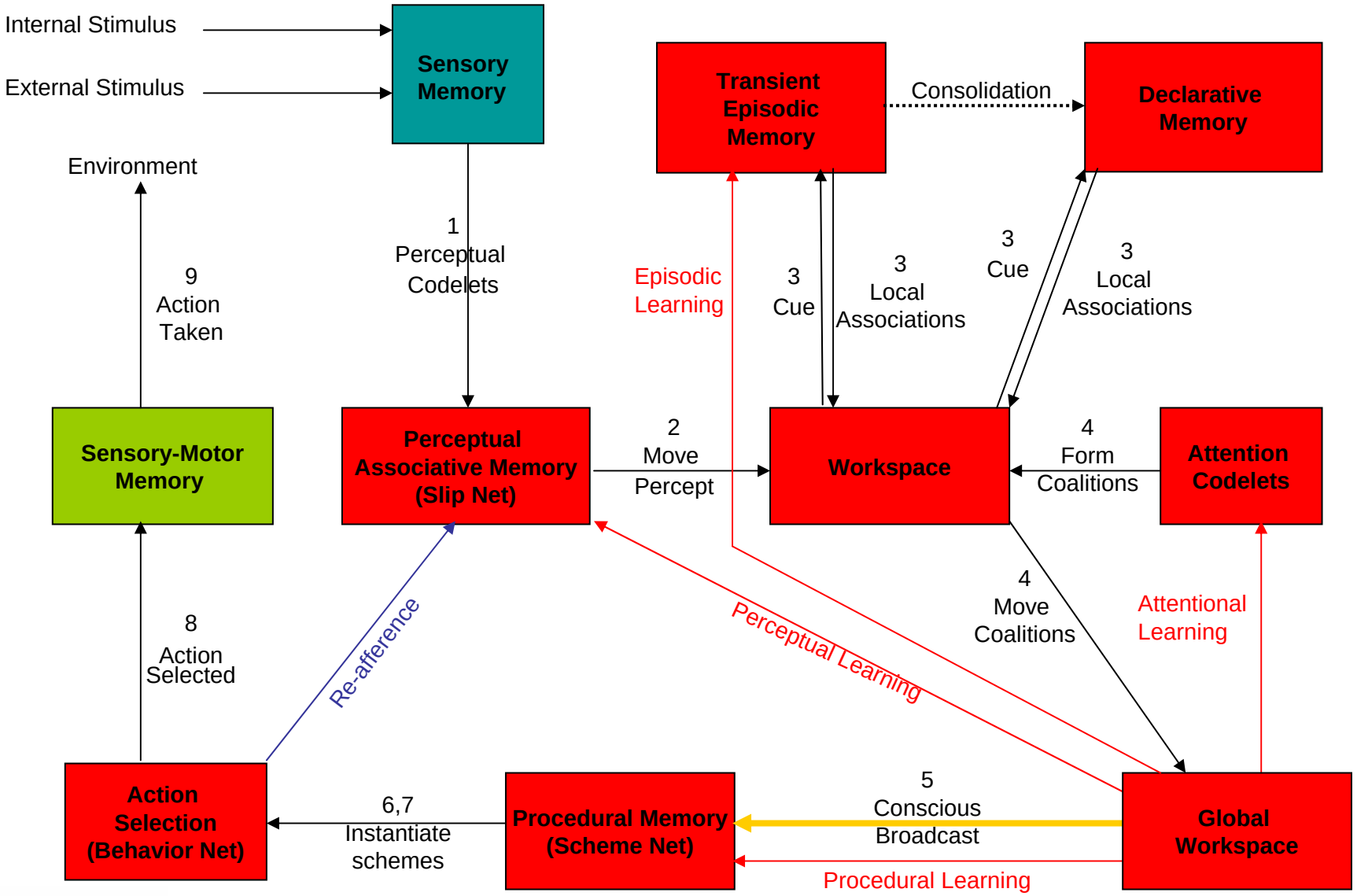
IDA

LIDA Implements Theories of Cognition

- Situated (embodied) cognition — Varela, Thompson & Roach
- Perceptual symbol systems —Barsalou
- Working memory—Baddeley
- Memory via affordances—Glenberg
- Long-term working memory—Ericsson & Kinstch
- Global workspace theory—Baars
- Cognitive architecture—Sloman

LIDA Cognitive Cycle

- Employs basic modules of cognition
- Employs primary cognitive processes
- A sort of “cognitive atom”
- Higher level cognitive processes utilitize multiple cognitive cycles
- Deliberation, volition, problem solving, metacognition, etc


Internal Stimulus
External Stimulus
Sensory Memory
Transient Episodic Memory
Consolidation
Declarative Memory
Environment
9 Action Taken
1 Perceptual Codelets
Episodic Learning
3 Cue
3 Local Associations
3 Cue
3 Local Associations
Sensory-Motor Memory
Perceptual Associative Memory (Slip Net)
2 Move Percept
Workspace
4 Form Coalitions
Attention Codelets
4 Move Coalitions
Attentional Learning
8 Action Selected
Re-afference
Perceptual Learning
Action Selection (Behavior Net)
6,7 Instantiate schemes
Procedural Memory (Scheme Net)
5 Conscious Broadcast
Global Workspace
Procedural Learning

Human Cognitive Cycle Processing

- Hypothesis—Human cognitive processing is via a continuing iteration of Cognitive Cycles
- Duration— Each cognitive cycle takes roughly 200 ms
- Cascading—Several cycles may have parts running simultaneously in parallel
- Seriality— Consciousness maintains serial order and the illusion of continuity
- Start— Cycle may start with action selection instead of perception

Neuroscience Evidence

- Halgren et al — Rapid distributed fronto-parieto-occipital processing stages during working memory in humans (Halgren, E., C. Boujon, J. Clarke, C. Wang, and P. Chauvel. 2002. Rapid distributed fronto-parieto-occipital processing stages during working memory in humans. *Cerebral Cortex* 12:710-728.)
- Freeman — High resolution EEG brings us another step closer to the NCC? (Freeman, W. J., B. C. Burke, and M. D. Holmes. 2003. Aperiodic Phase Re-Setting in Scalp EEG of Beta-Gamma Oscillations by State Transitions at Alpha-Theta Rates. *Human Brain Mapping* 19:248-272.)
- Lehmann et al — Brain electric microstates and momentary conscious mind states as building blocks of spontaneous thinking: I. Visual imagery and abstract thoughts. (Lehmann, D., H. Ozaki, and I. Pal. 1987. EEG alpha map series: brain micro-states by space-oriented adaptive segmentation. *Electroencephalogr. Clin. Neurophysiol.* 67:271-288, and Lehmann, D., W. K. Strik, B. Henggeler, T. Koenig, and M. Koukkou. 1998. Brain electric microstates and momentary conscious mind states as building blocks of spontaneous thinking: I. Visual imagery and abstract thoughts. *Int. J. Psychophysiol.* 29:1-11.)

Multi-cyclic Cognitive Processes

- Deliberation and volition
- Automazation
- Non-routine problem solving
- Metacognition
- Self-awareness

A Domain for an AGI Agent?

- An AGI agent must come with sensors, motivators and effectors, i.e., a domain

- For it to generalize the domain must be broad enough to have several sub-domains

AGI and Learning

- An AGI agent is too much to build
- Hence, an AGI agent must learn
- How?
- To start, best it learns like a human

Some Principles of Human Learning

- There's no learning from scratch
- We learn what we attend to
- Learning is incremental and continual
- Learning is a generate and test process
- Much of memory is associative and content addressable

Selectionist & Instructionalist Learning

- Selectionist Learning
  - Representations selected for reinforcement from a redundant repertoire
- Instructionalist Learning
  - new representations constructed
- LIDA learns in both modes

An AGI Agent Must

- Initially be copied after humans
- Have a rich and broad domain
- Employ many multi-cyclic processes
- Be capable of both selectionist and instructionalist learning in several modes

Must an AGI Agent …?

- Be functionally conscious?
- Phenomenally conscious?
- Capable of imagining (internal virtual reality)?
- Be implemented with feelings as drives and modulators of learning?

Trends toward AGI

- Developmental Robotics
  - IEEE Technical Committee
- Autonomic Computing Systems
  - IBM
- Self-Aware Computer Systems
  - DARPA Workshop 2004
- Integrated Intelligent Capabilities
  - AAAI'06 Special Track

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