Soar Tutorial

Day 1

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Tutorial Outline

1. Cognitive Architecture
2. Core Soar — Monday
3. Reinforcement Learning
4. Substates and Impasses
5. Chunking — Tuesday
6. Semantic Memory
7. Episodic Memory
8. SML

Cozmo-Soar Hackathon!

Wednesday

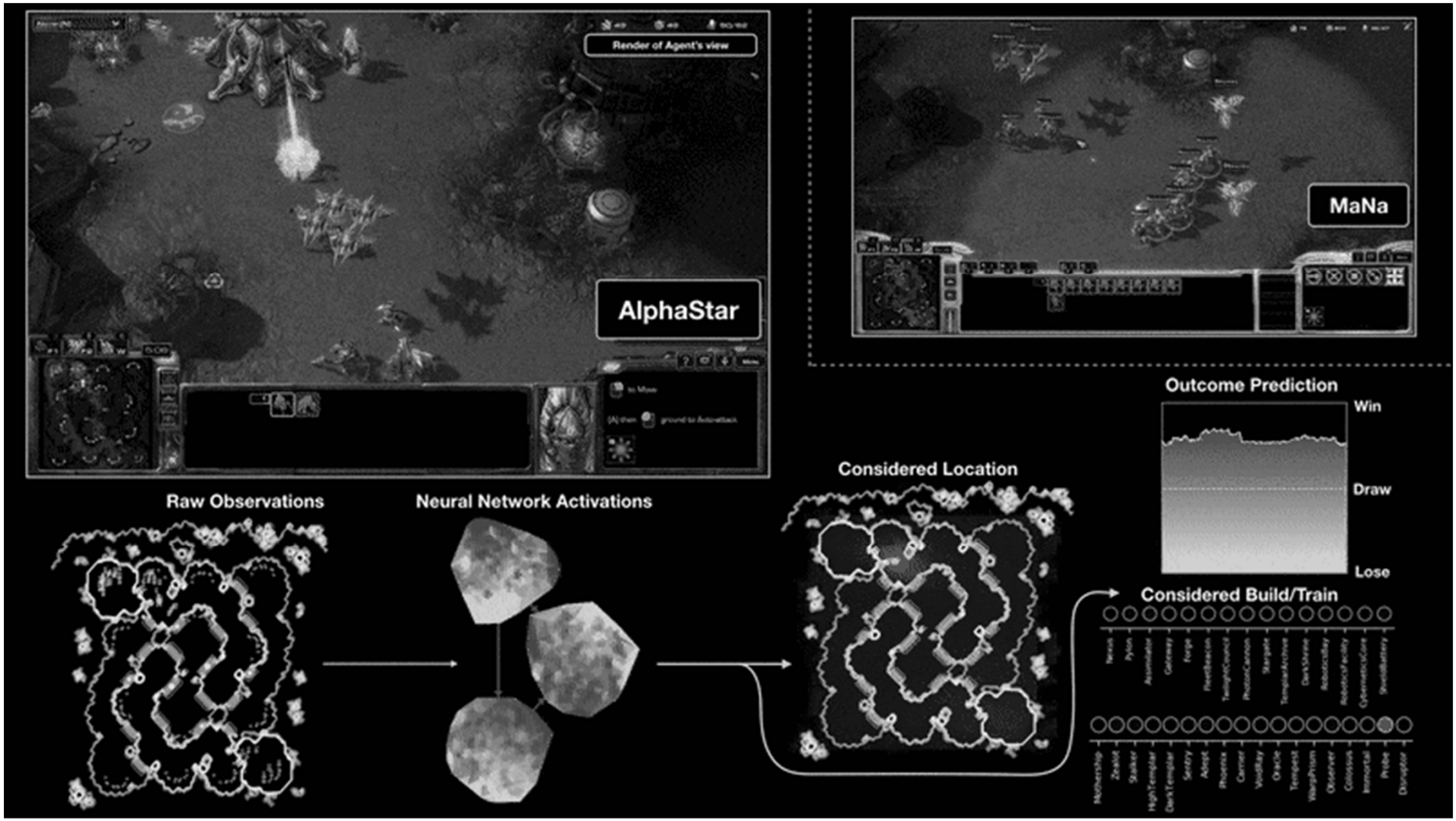
1997: Deep Blue [Chess]

2011: Watson [Jeopardy]

Autonomous Driving

2016: Alpha-Go

AlphaStar


Render of Agent's view
AlphaStar
MaNa
Outcome Prediction
Win
Draw
Lose
Considered Location
Raw Observations
Neural Network Activations
Considered Build/Train

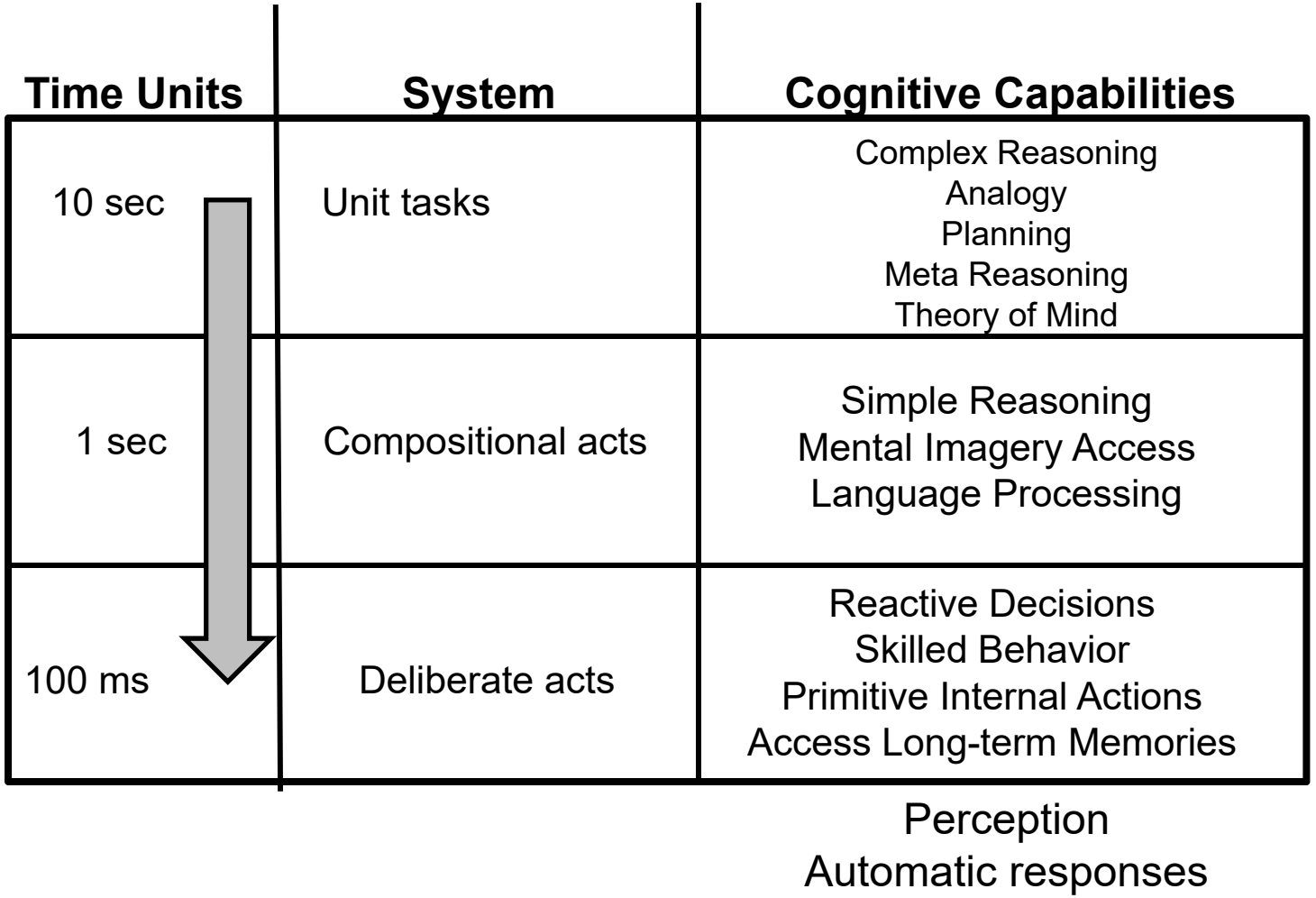
Observations

- Task specific –
  - One-off systems
  - Use specialized algorithms that are appropriate for those particular problems.
- Very successful…
- **Hypotheses:**
  - **Σ AI Technologies ≠ General Intelligence.**
  - **You need to work on how all of the pieces fit together to develop General Intelligence.**

Newell's Time Scale of Human Action

Scale (sec)	Time Units	System	Band	
10^7	months			
10^6	weeks		Social	
10^5	days			
10^4	hours	Task		
10^3	10 min	Task	Rational	
10^2	minutes	Task		System 2
10^1	10 sec	Unit task		
10^0	1 sec	Compositional	Cognitive	System 1
10^{-1}	100 ms	Deliberate act		
10^{-2}	10 ms	Neural Circuit		
10^{-3}	1 ms	Neuron	Biological	System 0 Implementation
10^{-4}	100 µs	Organelle		

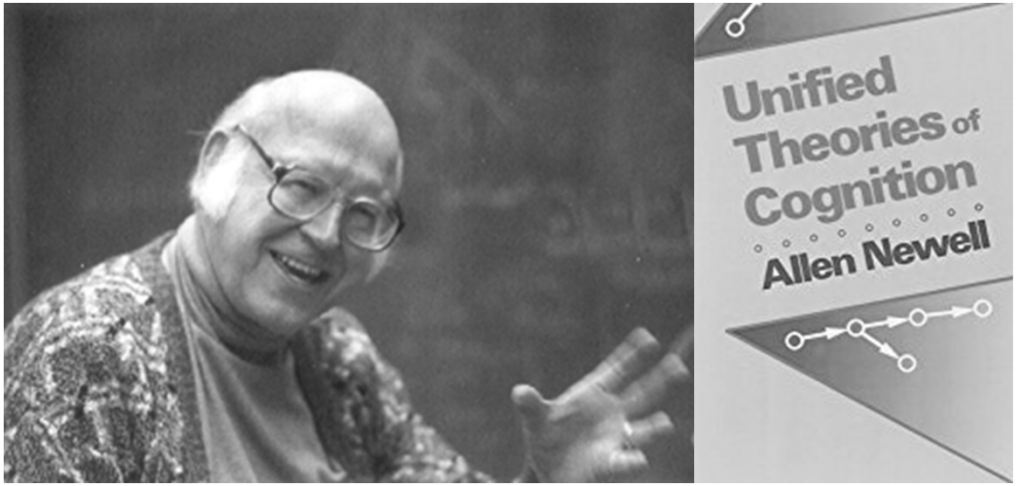
Cognitive Band



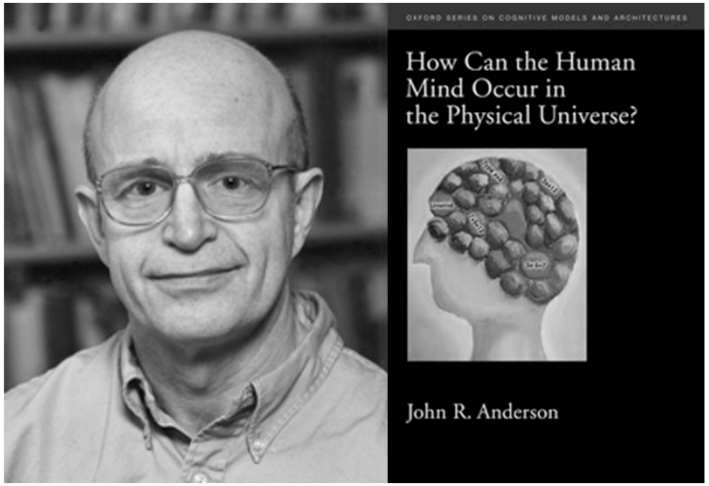
- Promiscuous intermixing of cognitive capabilities.
- Ubiquitous learning: automatic and continuous.
  - "Compiles" System 2 to System 1.

Cognitive Architecture Hypothesis

- How are sensing, action, reasoning, and learning integrated in a general, autonomous intelligent agent?
- Complex cognition arises from a combination of:
  - a fixed set of computational building blocks (memories, processes, representations, learning mechanisms); and
  - knowledge (learned through experience).



Allen Newell



John Anderson

Different Goals of Cognitive Architecture Research

Biological modeling:

- Model what we know about the brain: neurons, neural circuits, …
- Predict neural activity and cognitive behavior
- Examples: LEABRA, SPAUN

Psychological modeling:

- Model human performance in a wide range of cognitive tasks
- Predict human reaction time and error rates for psychological tasks
- Examples: ACT-R, EPIC, CLARION, LIDA, CHREST, 4CAPS

AI Functionality:

- Toward human-level intelligence *inspired* by psychology and biology
- Emphasizes more complex cognitive processing, longer time scales
- Examples: Soar, Companions, Sigma, ICARUS, CogPrime

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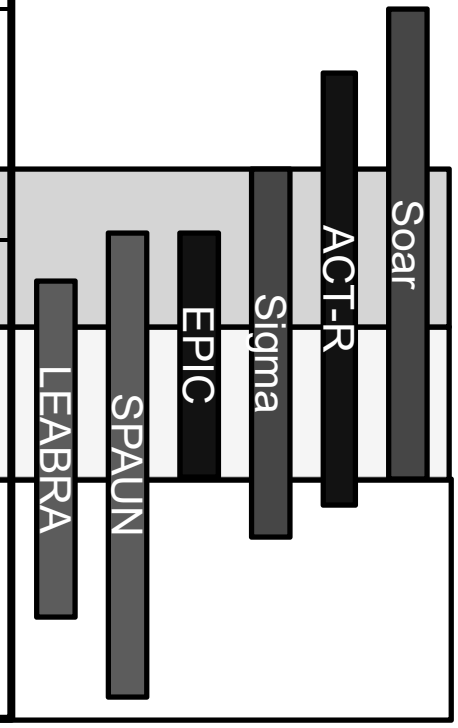
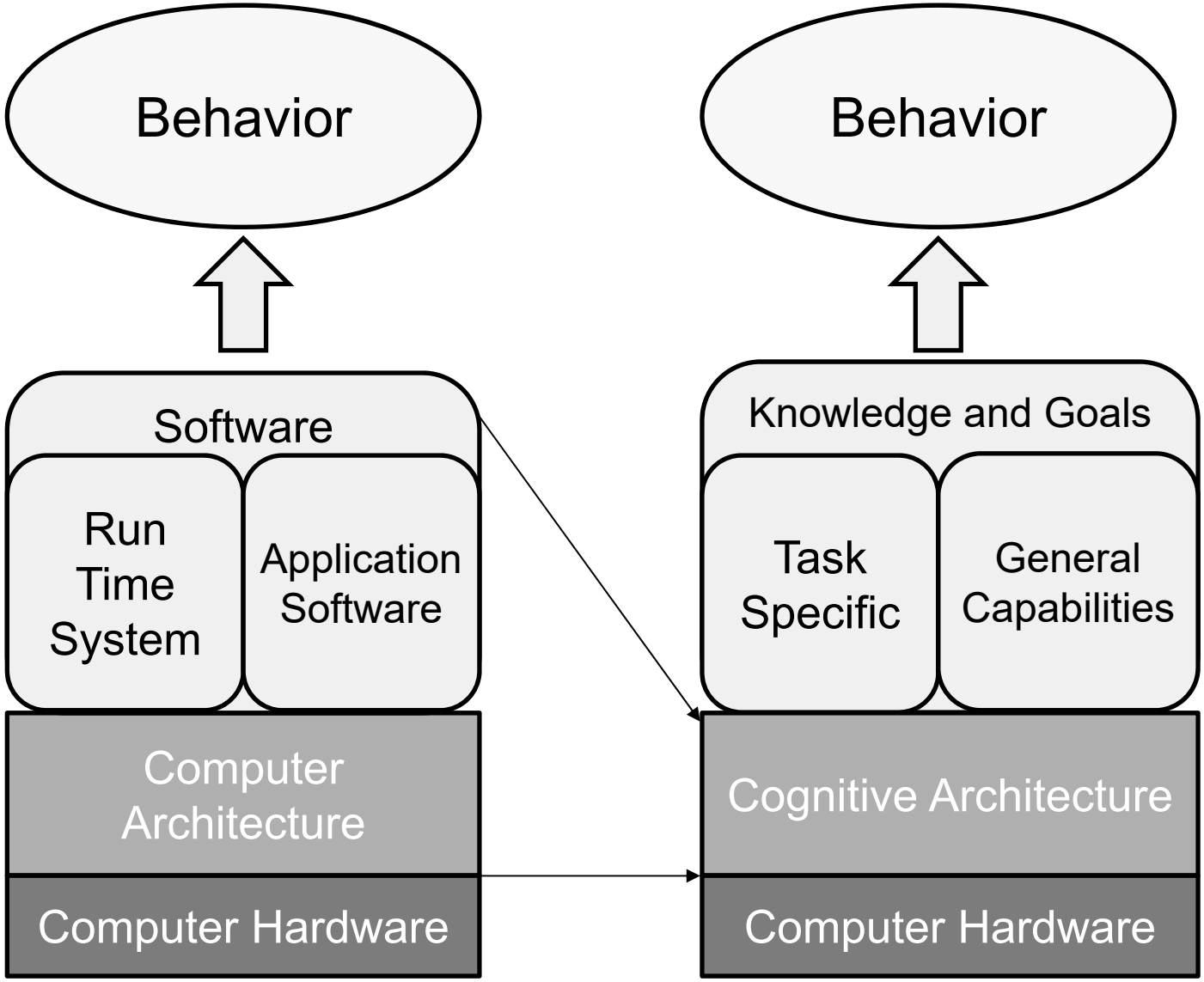


Computer and Cognitive Architectures

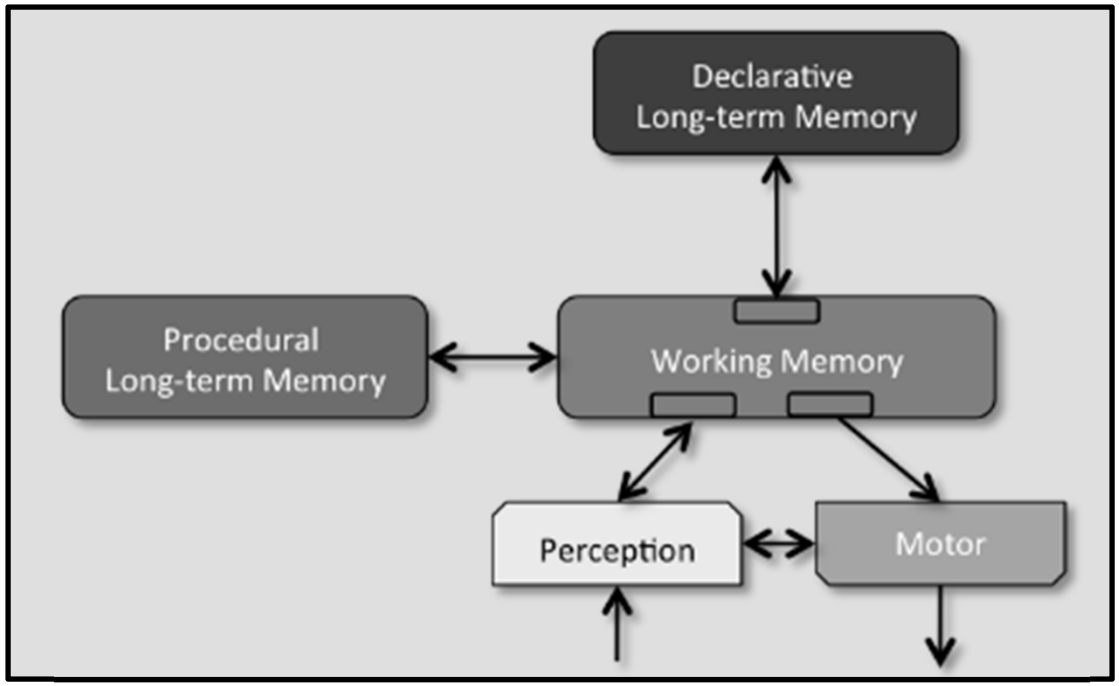


Common Model of Cognition

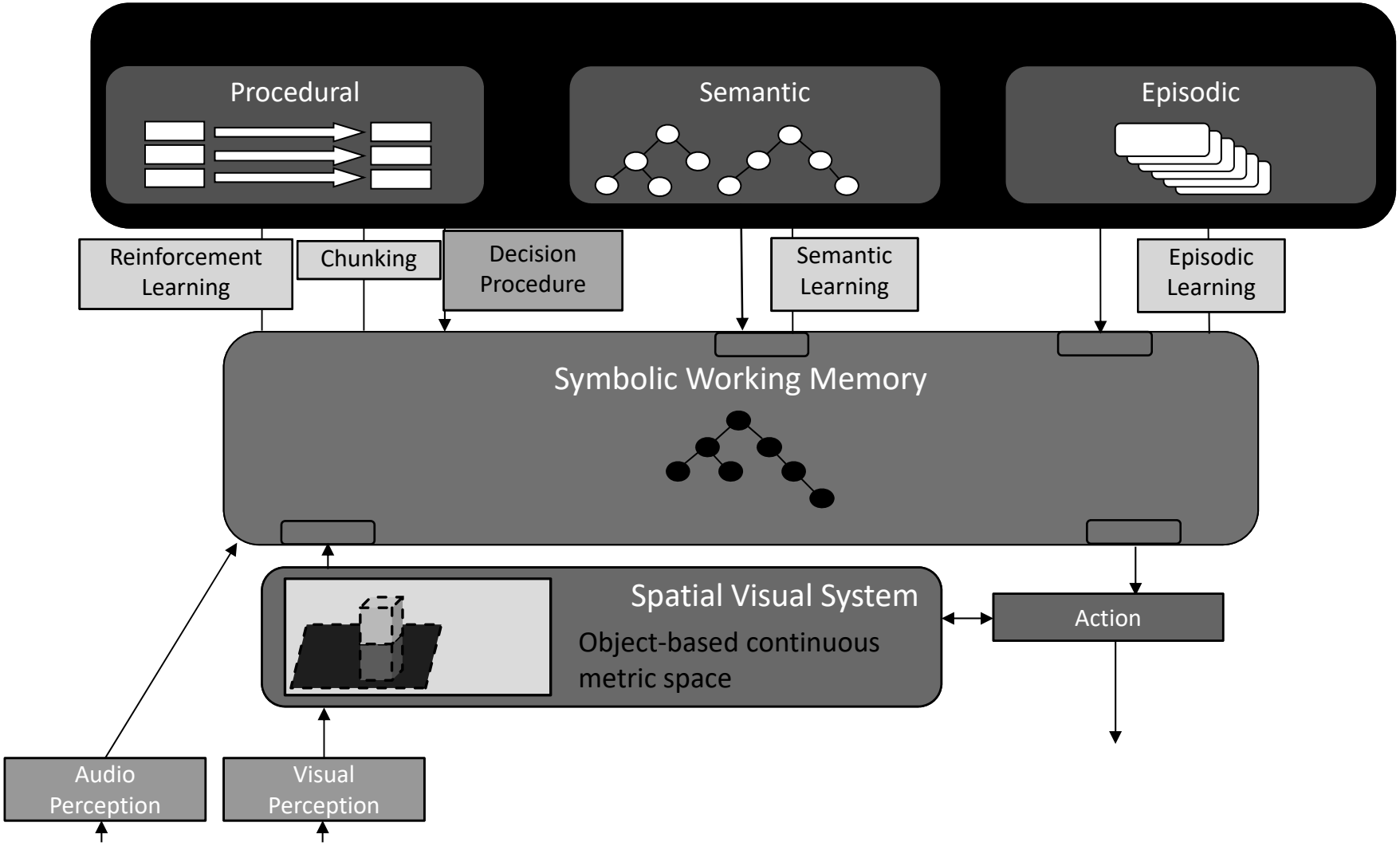
- What needs to be in a human-like cognitive architecture
  - An abstract community consensus
  - Not itself a cognitive architecture
- Consensus of existing cognitive architectures
  - Soar, Act-R, Sigma
- Potential benefits
  - Coherent baseline to facilitate shared cumulative progress
    - Focus efforts to extend and break the consensus
    - Framework around which evaluation data can be organized
    - Interlingua for describing and comparing architectural approaches
  - Guidance in
    - Extending research on individual components
    - Interpreting experiments and suggesting new ones
    - Constructing intelligent applications
  - Testable theory for different structures and functions of the mind

Common Model of Cognition

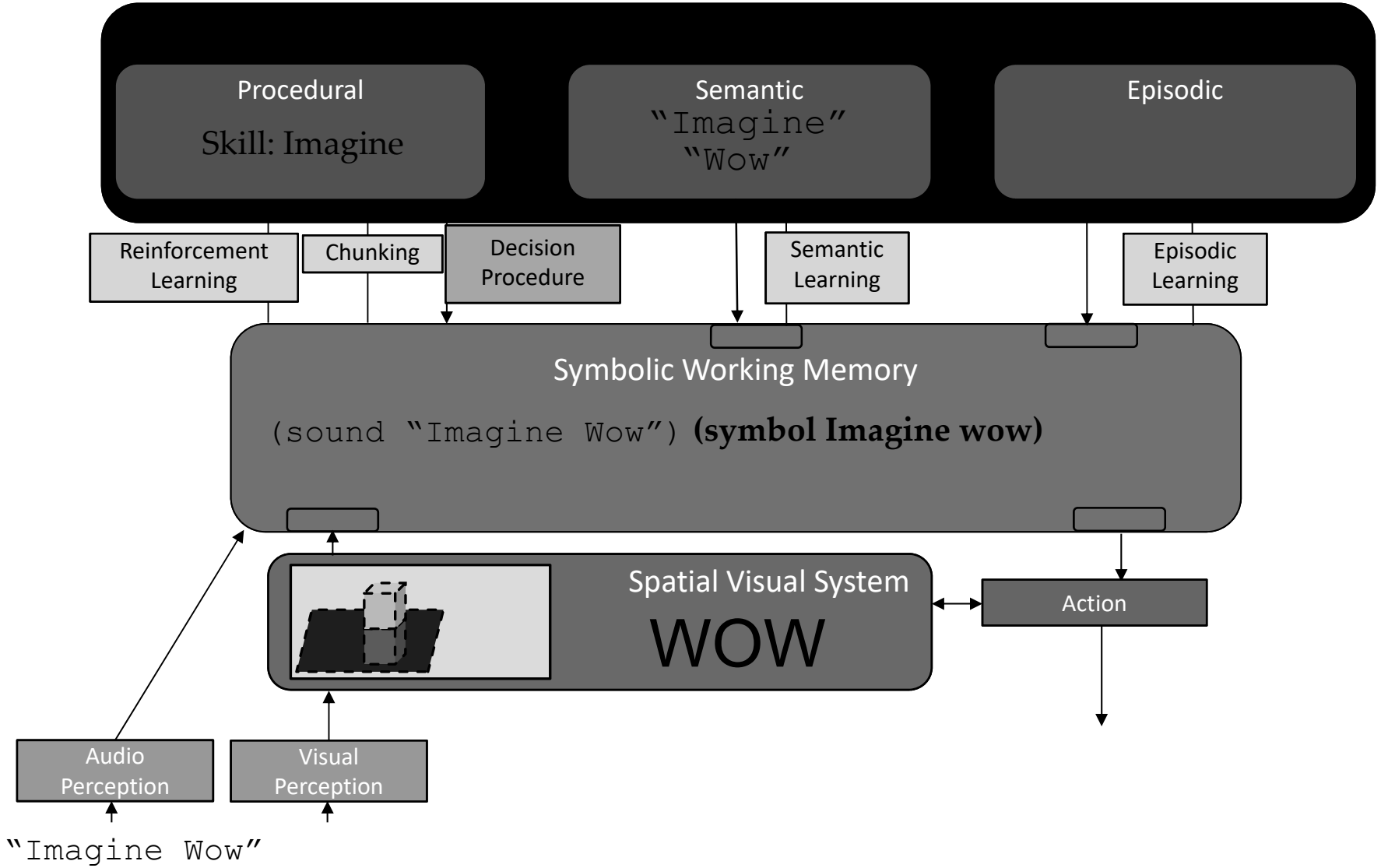
A. Structure and Processing
B. Memory and Content
C. Learning
D. Perception and Motor



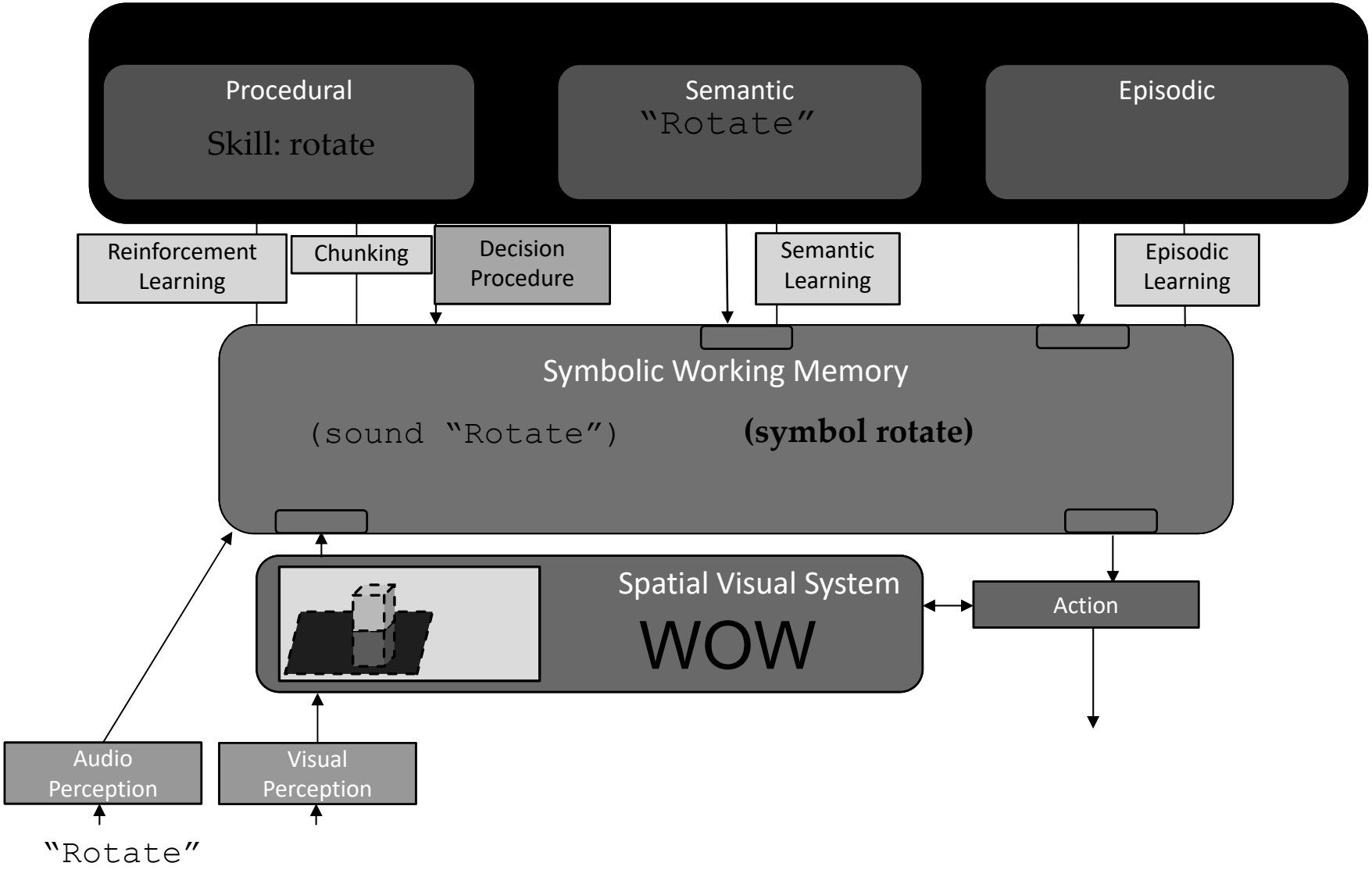
Soar 9


Procedural
Semantic
Episodic
Reinforcement Learning
Chunking
Decision Procedure
Semantic Learning
Episodic Learning
Symbolic Working Memory
Spatial Visual System
Object-based continuous metric space
Action
Audio Perception
Visual Perception

Soar 9


Procedural
Skill: Imagine
Semantic
"Imagine"
"Wow"
Episodic
Reinforcement Learning
Chunking
Decision Procedure
Semantic Learning
Episodic Learning
Symbolic Working Memory
(sound "Imagine Wow") (symbol Imagine wow)
Spatial Visual System
WOW
Action
Audio Perception
Visual Perception
"Imagine Wow"

Soar 9


Procedural
Skill: rotate
Semantic
"Rotate"
Episodic
Reinforcement Learning
Chunking
Decision Procedure
Semantic Learning
Episodic Learning
Symbolic Working Memory
(sound "Rotate")
(symbol rotate)
Spatial Visual System
WOW
Action
Audio Perception
Visual Perception
"Rotate"

Cognitive Architecture

Like a programming language but …

- A fixed, continual processing cycle
  - Serial and parallel processing with no program counter
  - Conditional action is the norm instead of the exception
- Fixed small set of data representations
  - Symbolic and non-symbolic
- Has multiple long-term memories and learning mechanisms
- Can have significant innate knowledge