BICA: Biologically-Inspired Cognitive Architecture

John Laird

26th Soar Workshop

Major New DARPA Project

- Goal: Capture the Magic of the Human Mind
  - Look beyond traditional AI
  - Computation and Psychology: Cognitive Architecture
  - Biology: Brain Computation
- Programmatics
  - Phase I: 13 months, started in October 2005
    A. Cognitive Architectures (4)
    B. Biologically-based Computation (8)
    C. Evaluation (1)
    D. Basic Research (3-4)
  - Phase II: 4-5 years, starting in ~March 2007
    - 2-3 (Big) Groups

Evaluation (Yearly)

- Cognitive Decathlon (details still up in the air)
  - Psychology Experiments Across the Frontiers of Cognition
    - Functional Integration, Flexibility, Metacognition, Social Embeddedness
  - Embedded within same environment as challenge problems
- Challenge Problems
  - Simulated robot embedded complex environment
  - Find IEDs in a (hot, dry, dusty) urban environment

- Emphasizing
  - Learning, learning, learning,
  - Vision, vision, vision,
  - Language, language

Four Possible Approaches

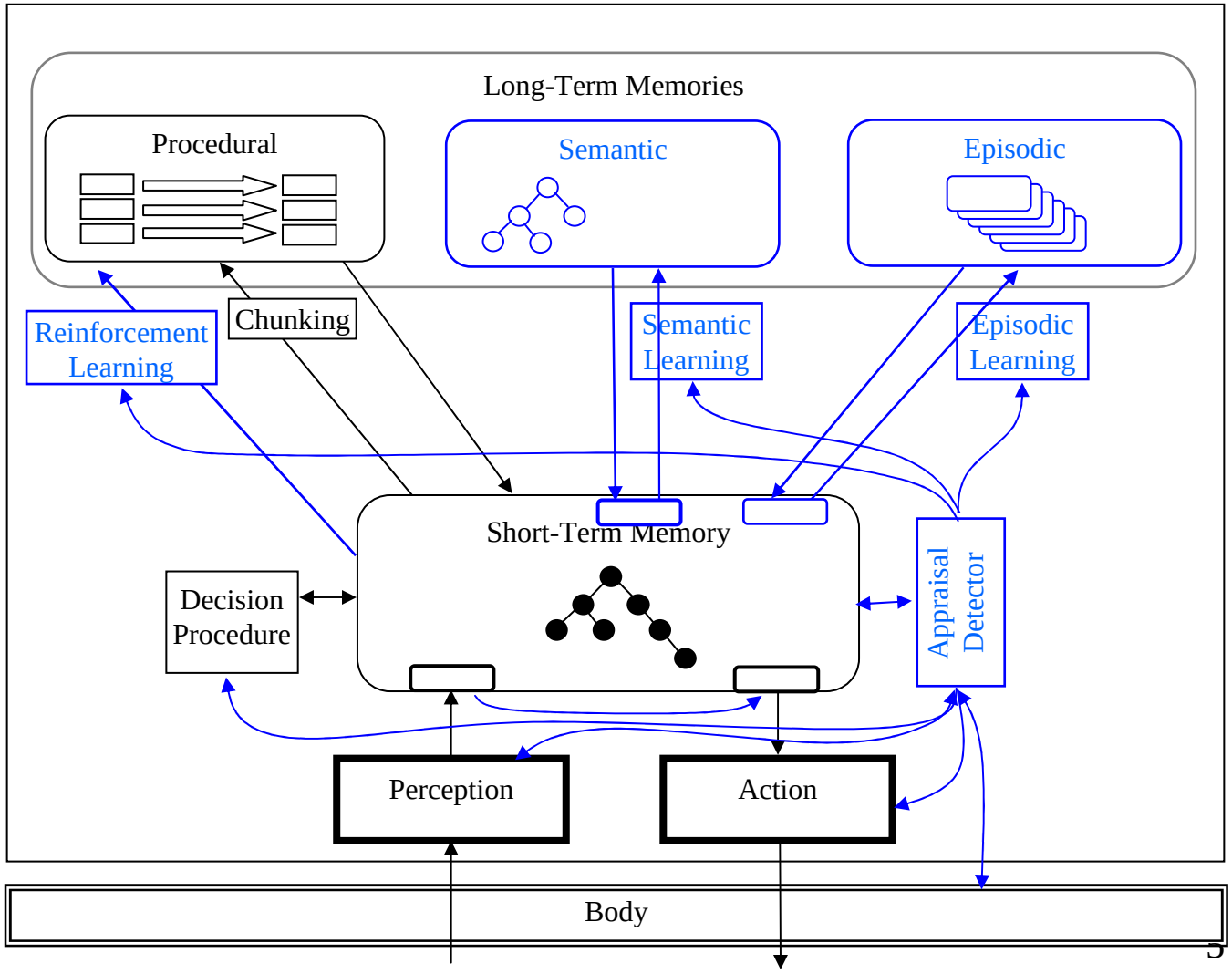
1. Cognitive architectures with
   a. added abstract biologically-inspired functions
   b. added perceptual-motor inputs and outputs
   c. biologically-inspired module implementation

2. Biological architectures, cognitively constrained

1a. CA with added abstract biologically-inspired functions

- Abstract functionality e.g., reinforcement learning, emotion
- But no direct connection to underlying computational process

Cognitive Architecture
+
Episodic, Semantic, Reinforcement Learning
+
Emotion



The Future for Soar-style Cognitive Architectures

- Generate coherent, purposeful behavior across a wide variety of tasks
- Use many sources and types of knowledge
  - Perception, personal history, facts, abstractions, skills, models, …
  - Gained by experience, observation, communication, and programming
  - Are immediately taskable
- Combine knowledge in novel ways to generate novel behavior
  - Not a slave to experience or current situation
  - Can use abstraction, hypothetical situations, internal simulation
- In real time using conventional computational hardware

But unable to achieve *wild learning:*

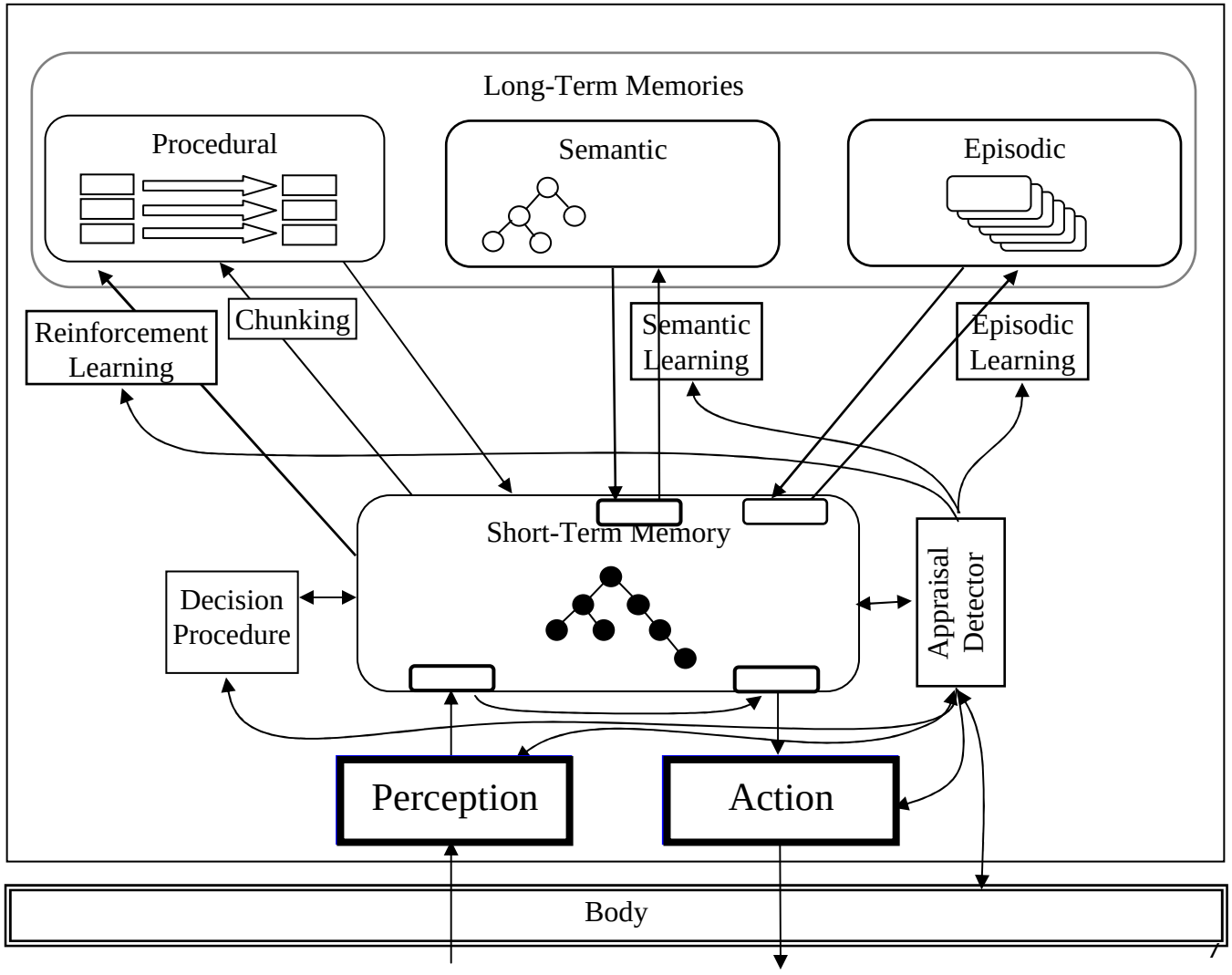
- ubiquitous automatic learning of unexpected types of regularities
- in noisy, feature-rich environments
- that combine with previously learned concepts and relations
- that give rise to hierarchies of new symbols, concepts, and relations
- that lead to prediction, anticipation, comprehension, …

1b. CA with added perceptual-motor I/O

- Brain-based computation for perception & motor control
- Cognitive architecture remains essentially unchanged

Cognitive Architecture
+
Biologically Based
Sensing and Action

Transduction
of continuous features to
symbol



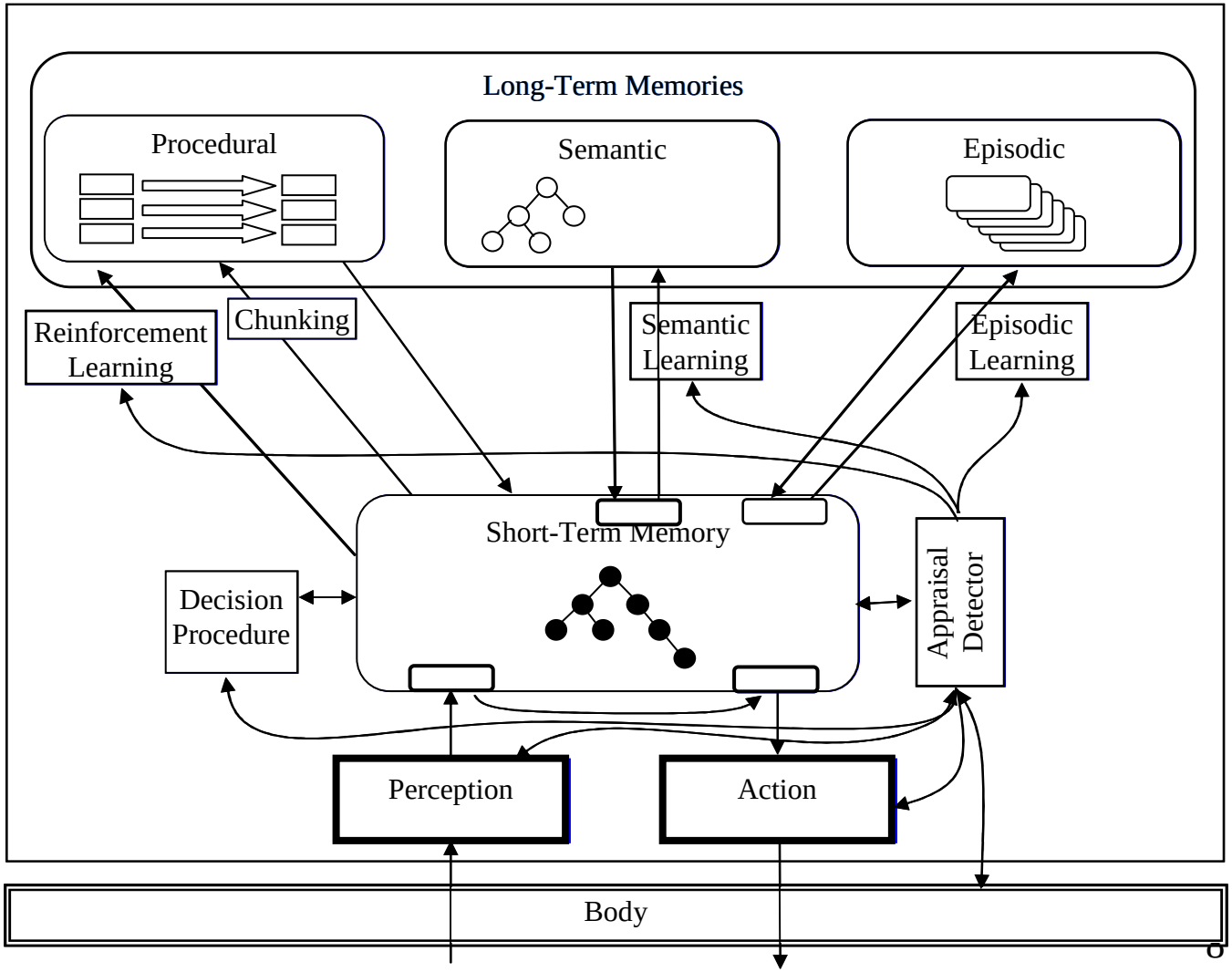
1c. CA with biologically-inspired module implementation

- Brain-based computation for existing CA components
- Retains overall structure of cognitive architecture

Cognitive Architecture

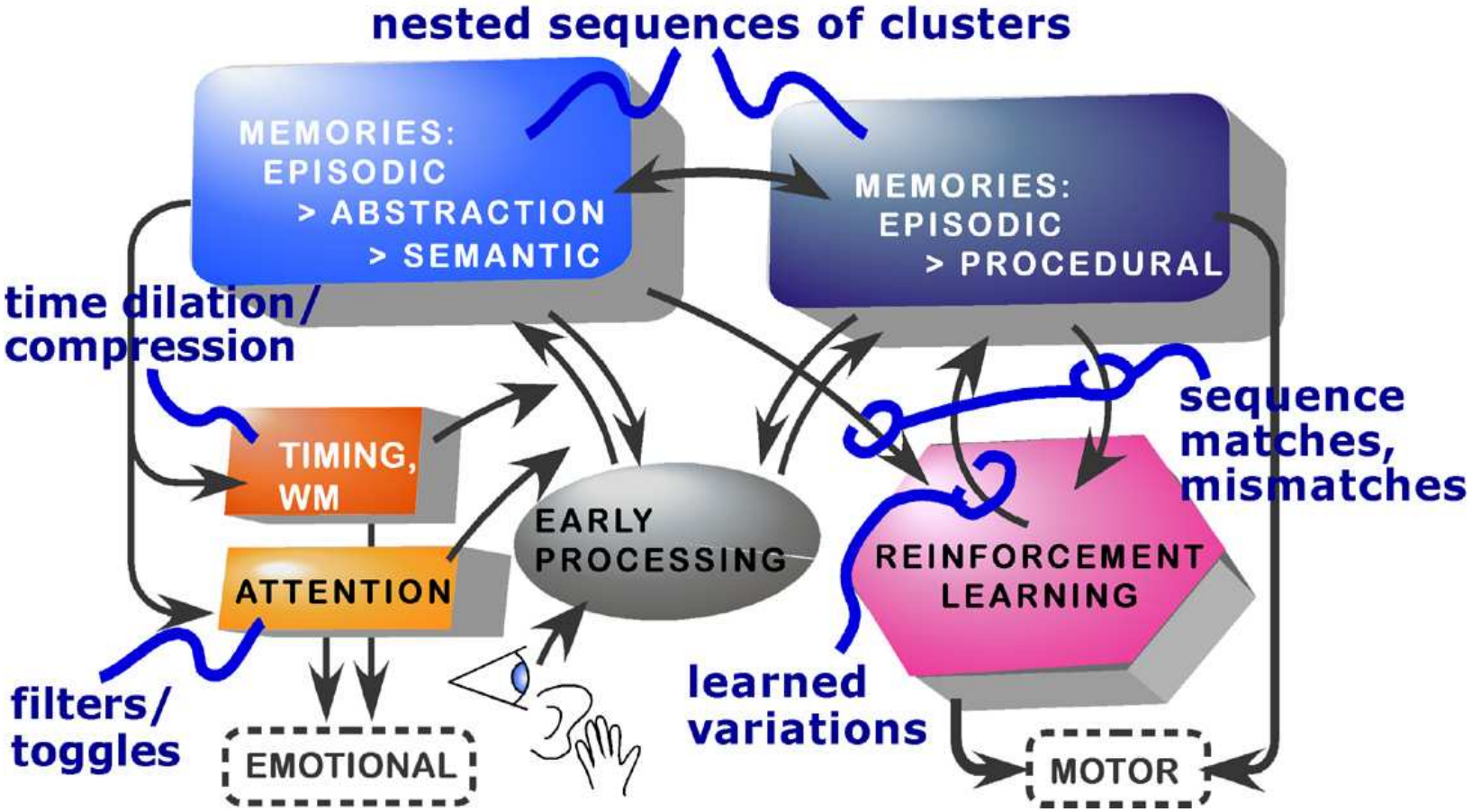
Replace with Biologically Based Components

Component interaction: Symbolic & non-symbolic



2. Biological architecture, cognitively constrained

- New architecture; biologically derived
- Cognitive functions emerge from component interactions



Nuggets and Coal

- Nuggets:
  - *Chance of a lifetime* to explore integration of brain-based computation and cognitive architecture.
- Coal
  - Incredible amount of work
    - Synthesizing different computational approaches
    - Managing large group across many institutions
    - Developing/Engineering tasks and agents