Steps toward a Domain Independent Episodic Memory

Andrew Nuxoll

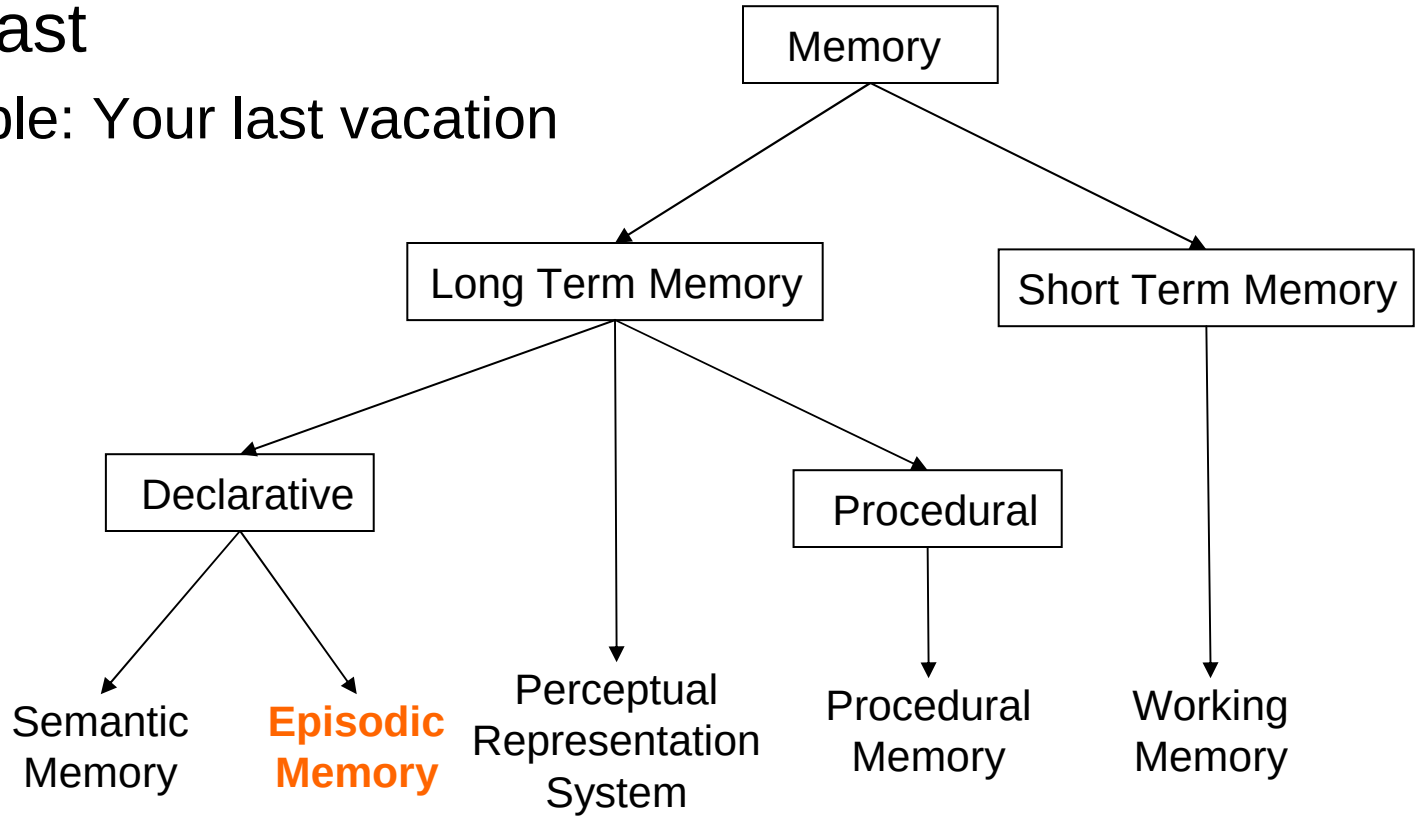
24 May 2006

Outline

- Review
  - Definitions
  - Improving agent behavior
- Improving Domain Independence
  - Improving Match
  - Chunking (with confidence)

What is Episodic Memory?

- Memories of specific events in our past
  - Example: Your last vacation



Research Goals

- Explore the cognitive capabilities granted to an agent with an episodic memory
- Explore what's necessary to build an effective episodic memory for a general cognitive architecture
  - Domain independence 
  - Performance
- Take inspiration from cognitive psychology

Previous Work

- Psychology
  - Observations of Humans - Endel Tulving
- Cognitive Modeling
  - Soar Model (non-architectural) - Erik Altmann
- Artificial Intelligence
  - Continuous CBR - Ram and Santamaría
  - Comprehensive Agents - Vere and Bickmore

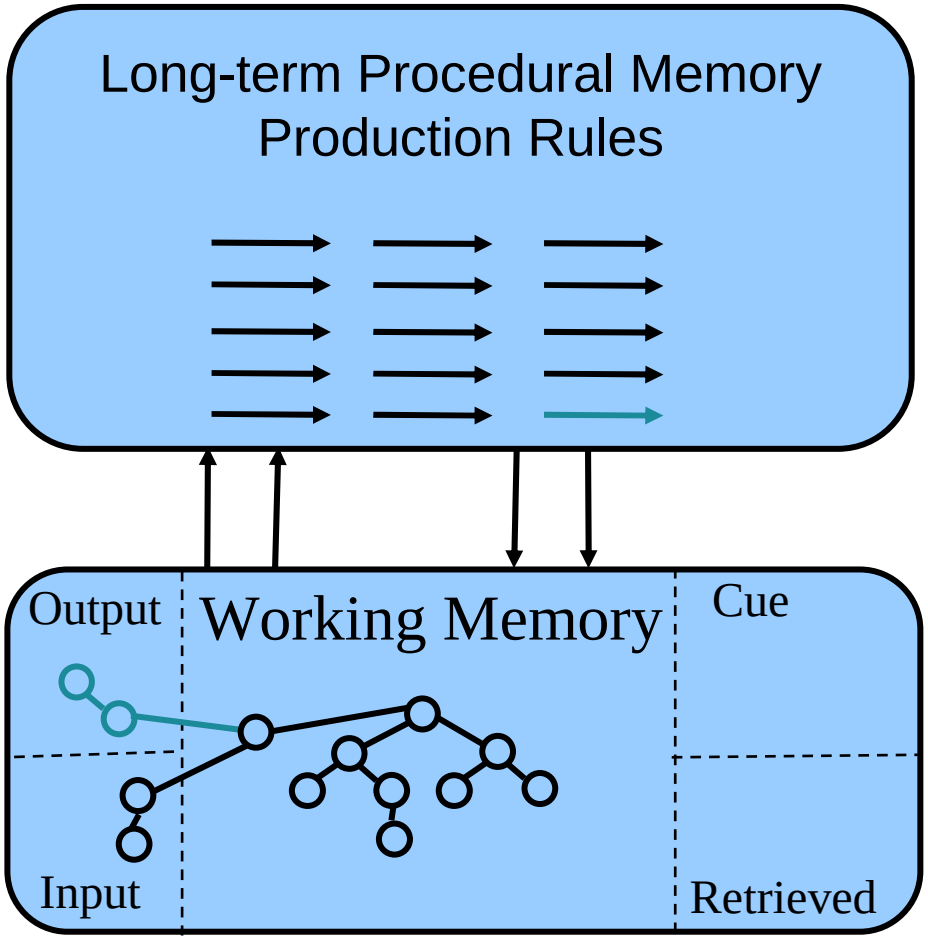
Current Implementation

Encoding

Initiation?

Storage

Retrieval



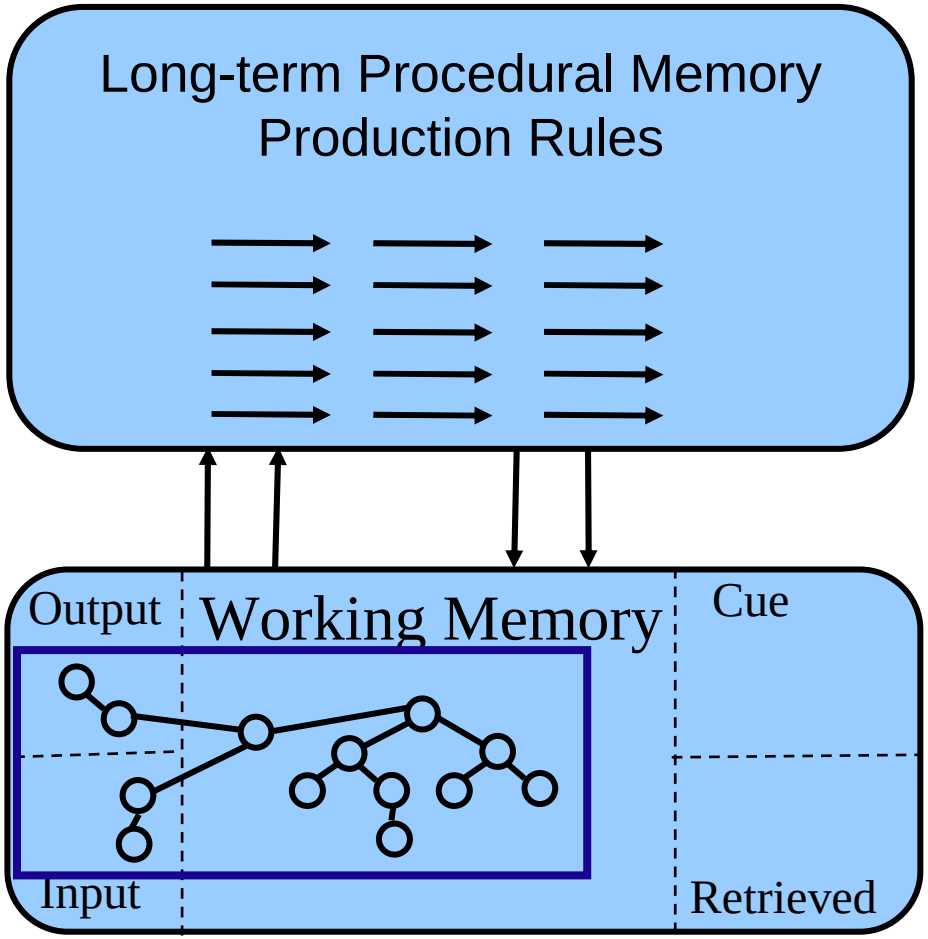
When the agent takes an action.

Current Implementation

Encoding
- Initiation
- Content?

Storage

Retrieval



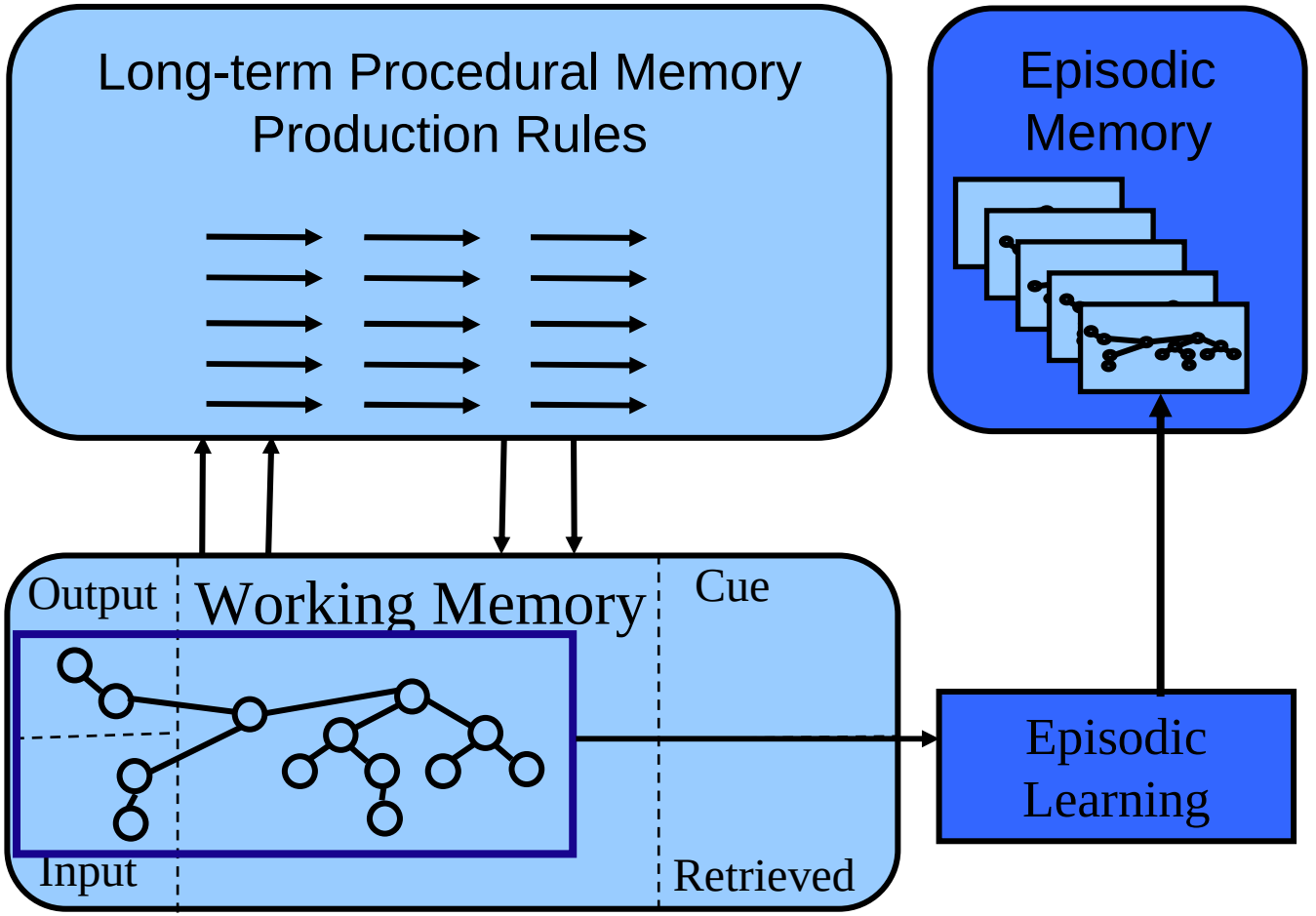
A portion of working memory is stored in the episode

Current Implementation

Encoding
- Initiation
- Content

Storage
- Episode Structure?

Retrieval



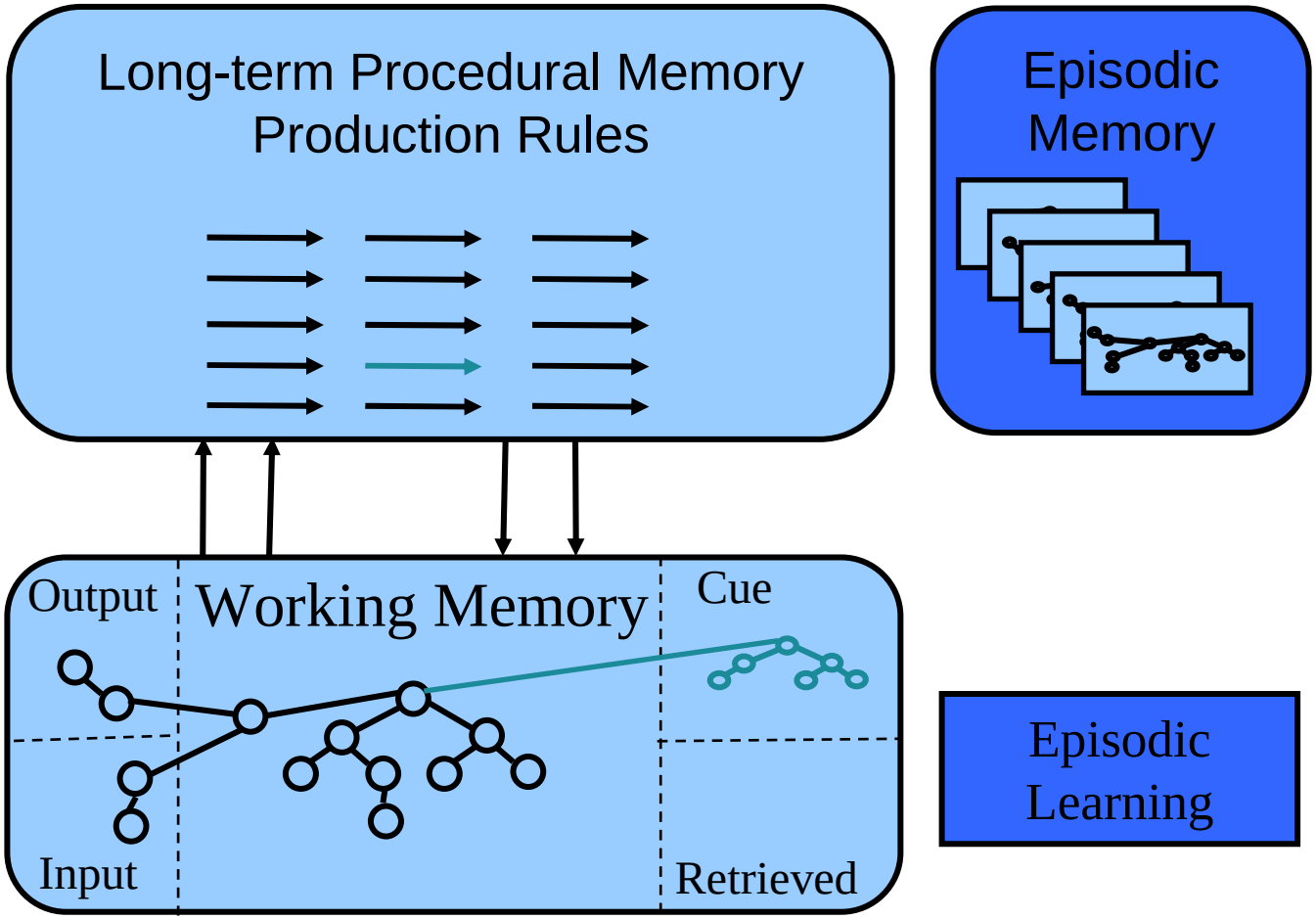
Episodes are stored in a separate memory

Current Implementation

Encoding
- Initiation
- Content

Storage
- Episode Structure

Retrieval
- Initiation/Cue?



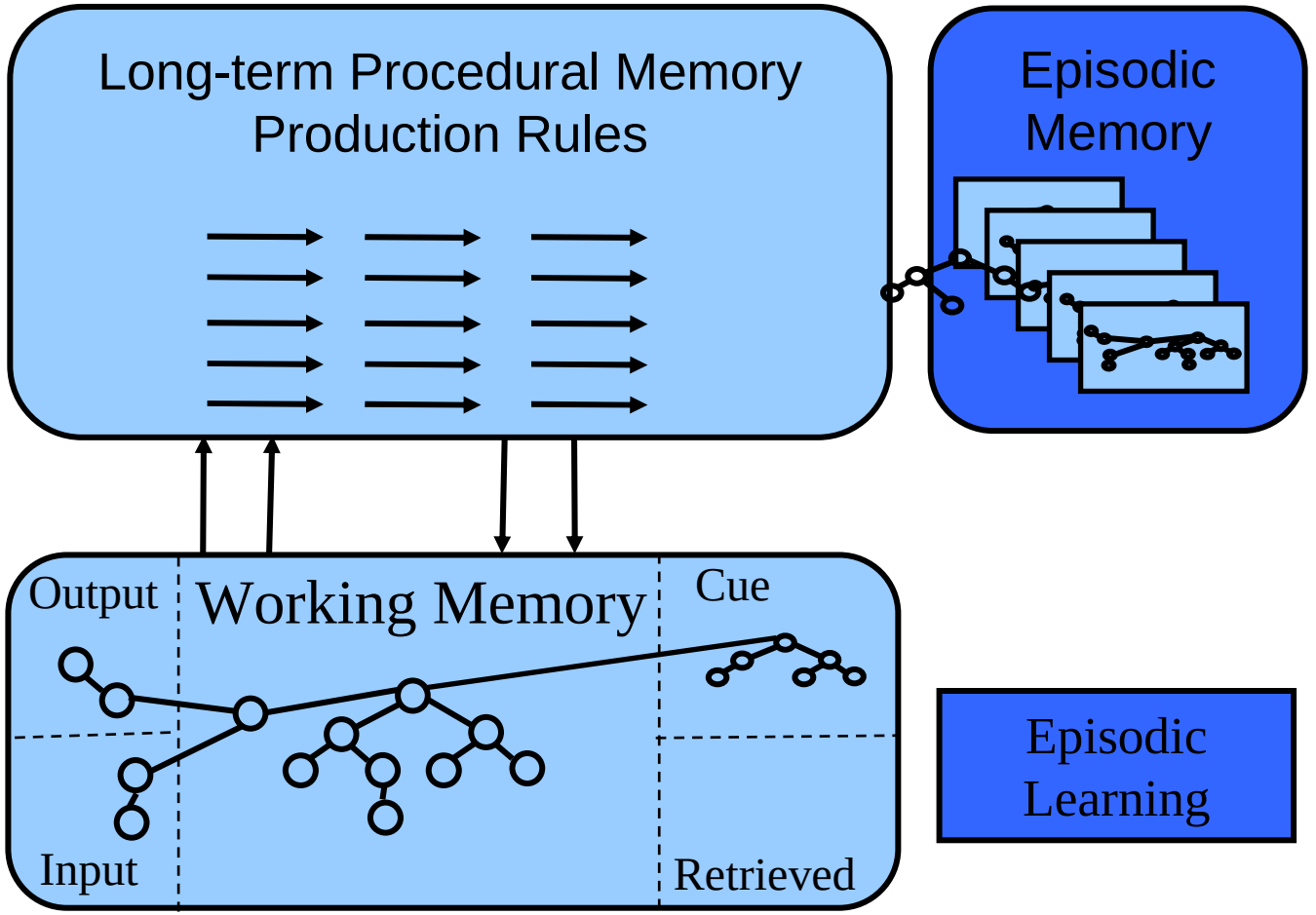
Cue is placed in an architecture specific buffer.

Current Implementation

Encoding
- Initiation
- Content

Storage
- Episode Structure

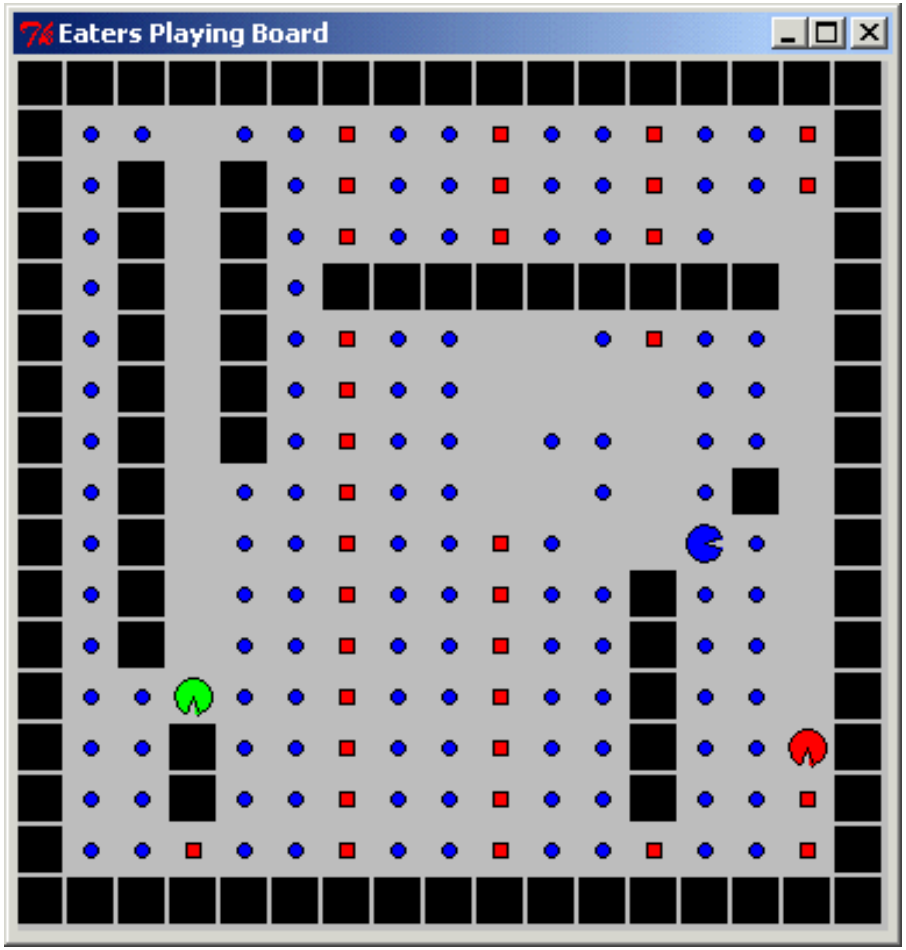
Retrieval
- Initiation/Cue
- Retrieval



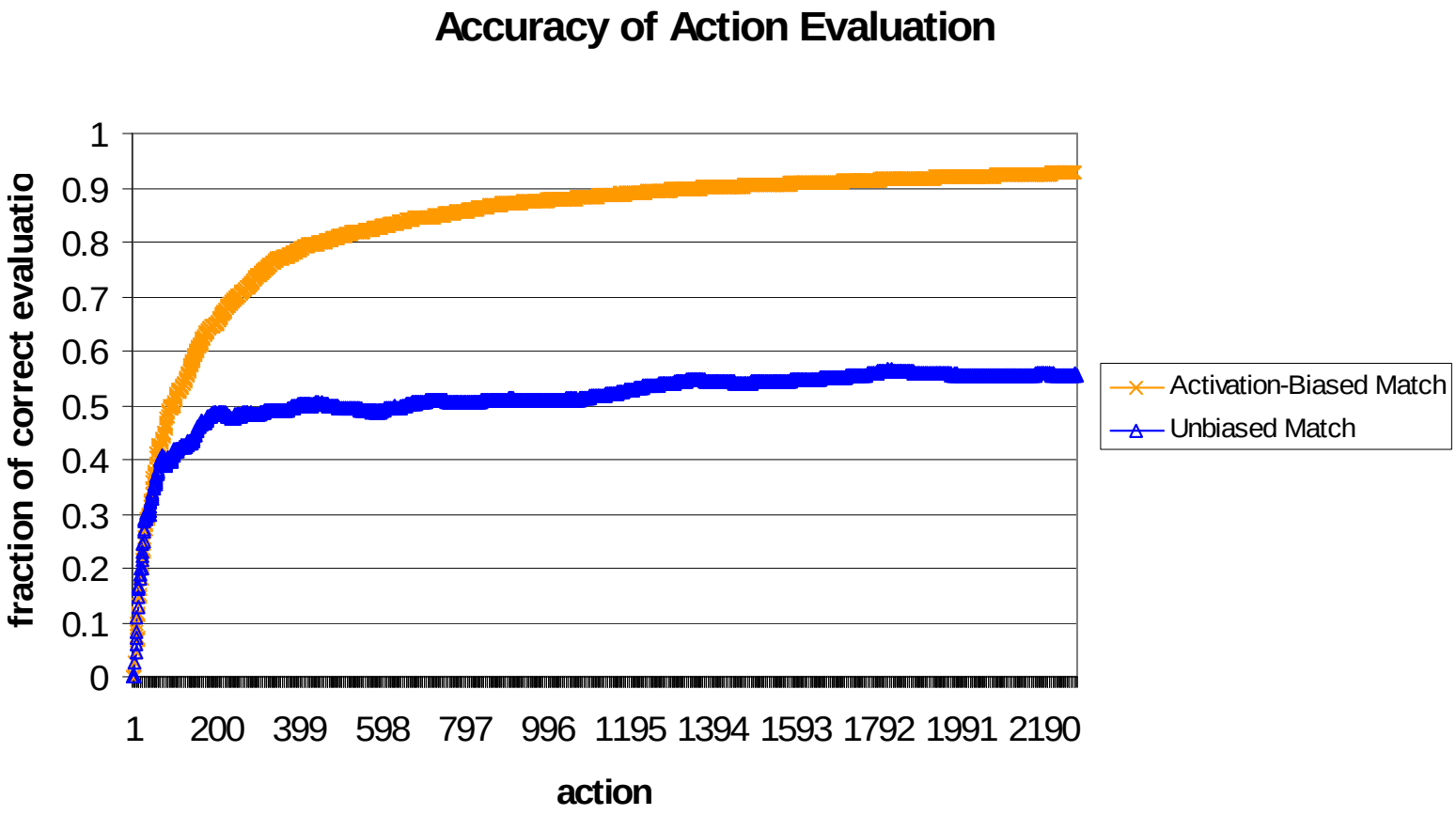
The closest partial match is retrieved.

First Domain: Eaters

- Pacman-like environment
- Decisions based upon results of actions taken in previous, similar situations



Effects of Memory Activation Bias

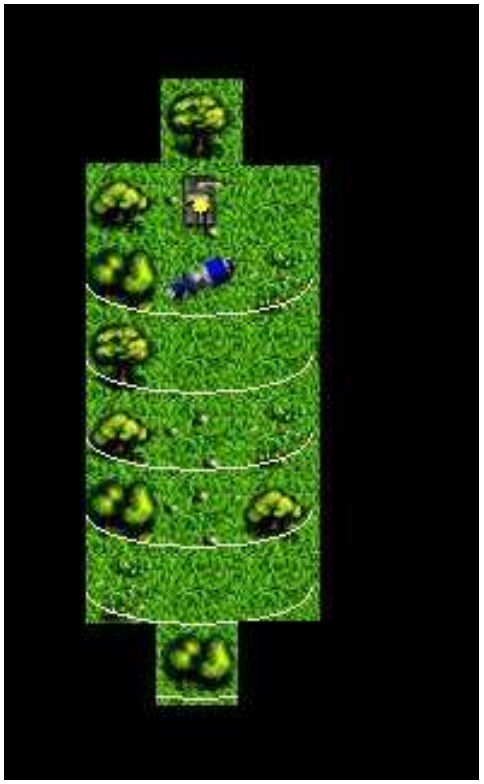


Eaters Results

- Episodic memory improves agent behavior
  - Cognitive Capability: Using past experiences to improve future decisions
- Working memory activation is an effective bias for partial match

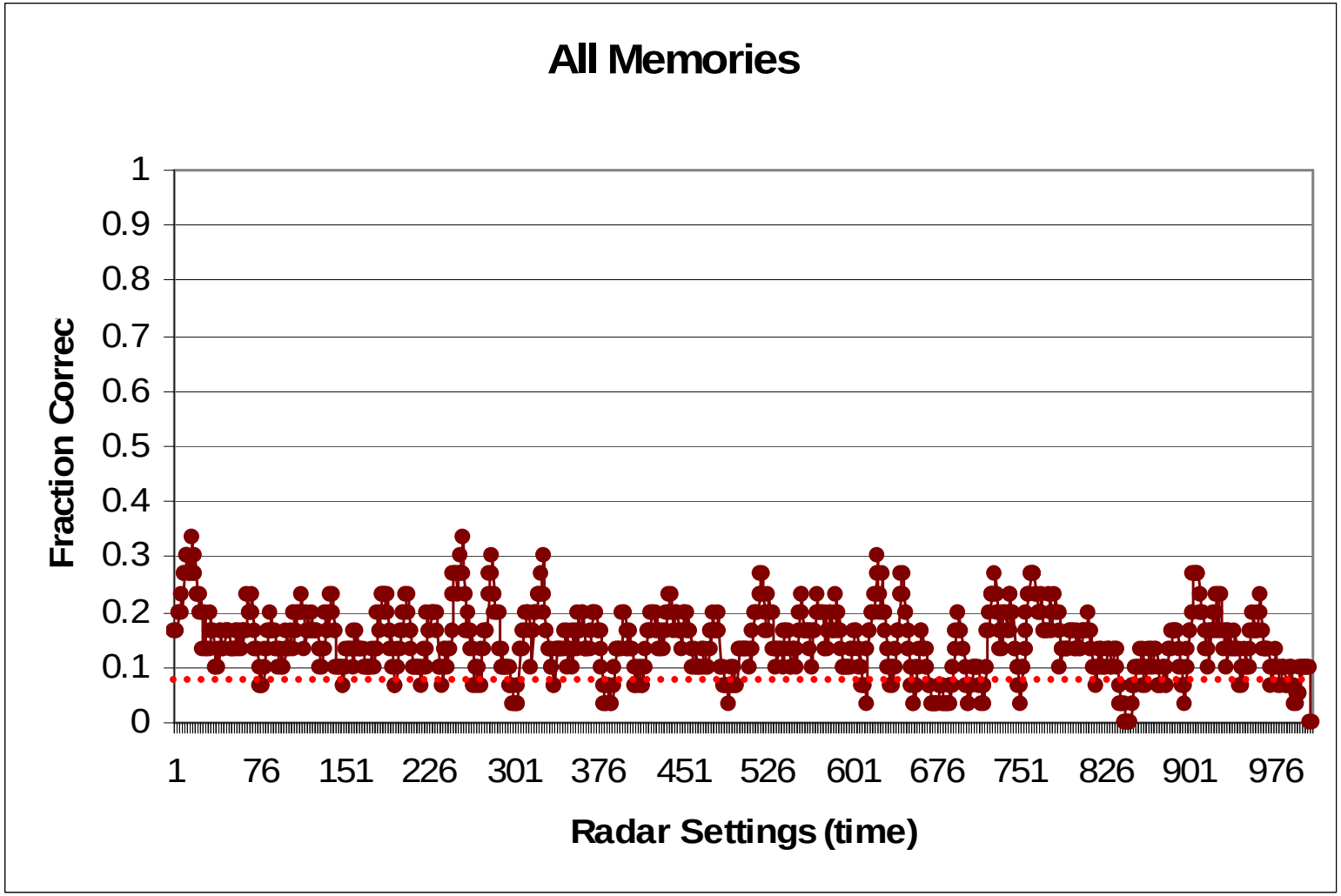
Improving Domain Independence

Second Domain: Tank Soar



- Environment: TankSoar
  - "Two-dimensional Quake"
- Task: conserve energy
  - Selecting proper radar setting to minimize energy consumption
- Key Differences (vs. Eaters)
  - Selective Sensing
  - Limited feedback
  - Small cue

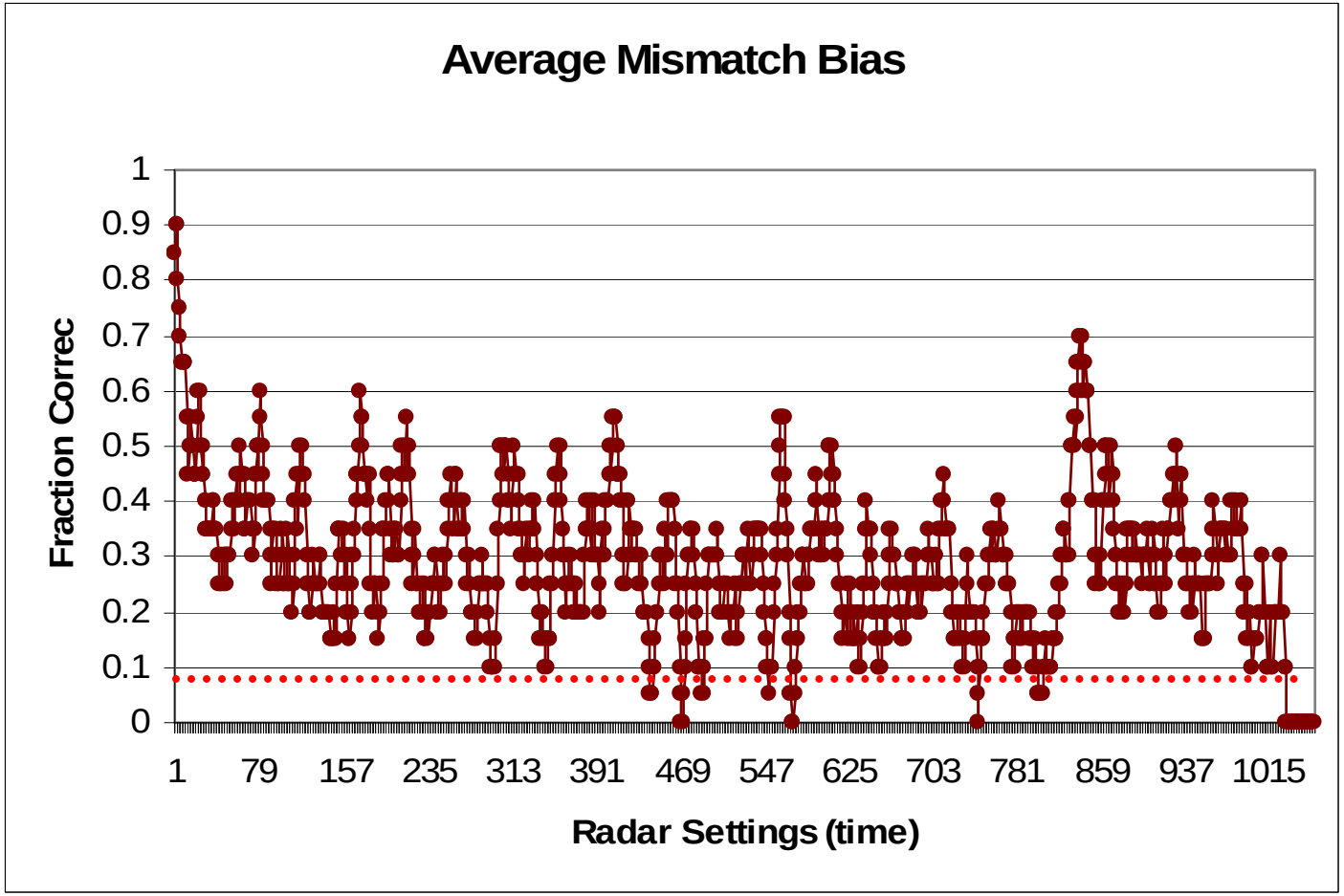
Initial Performance



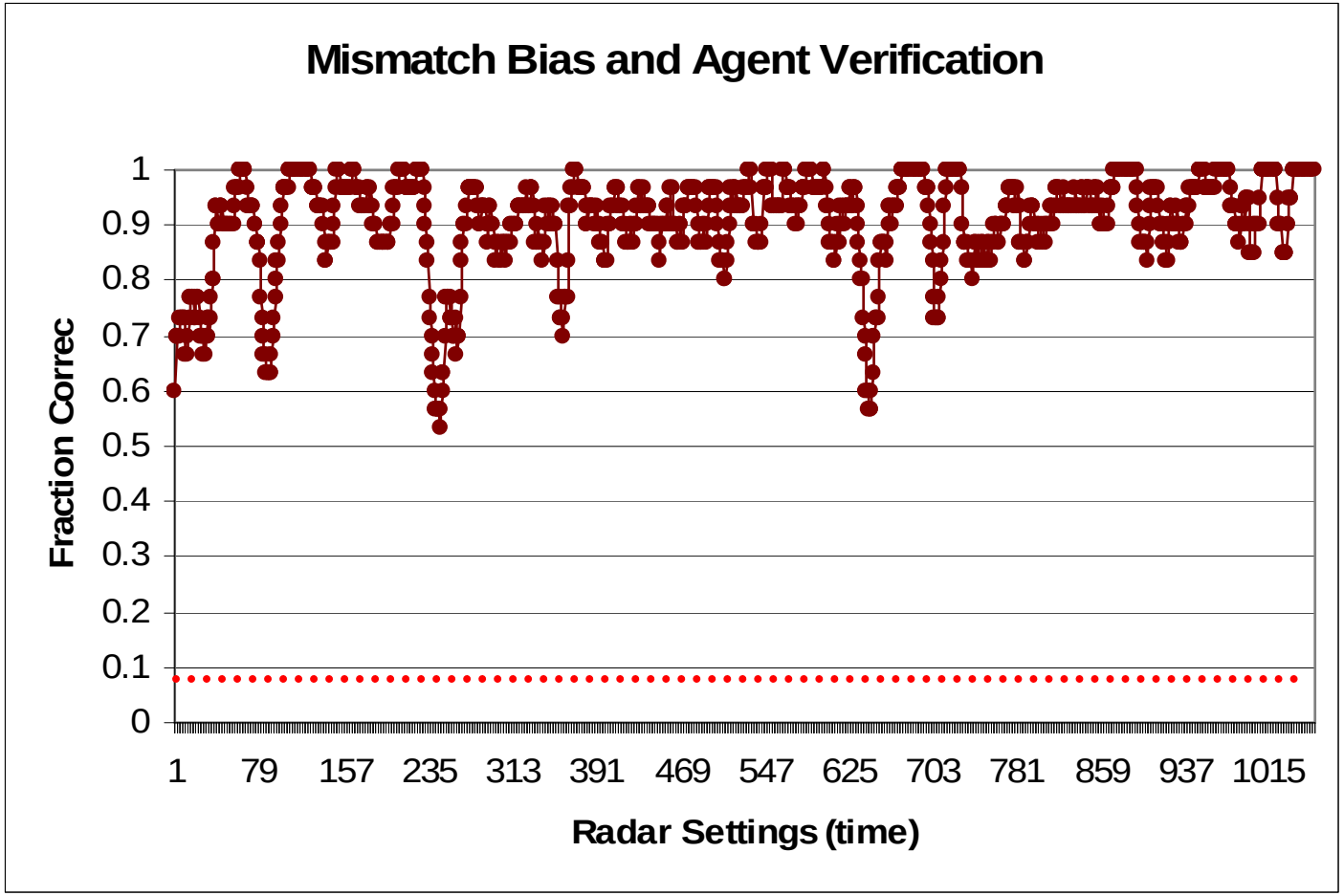
Analysis of Initial Performance

- Incorrect Retrieval
  - Small cue means memory activation bias overrides exact match
- Poor decisions beget poor memories
  - Without feedback, agent uses memories of poor decisions to make future decisions

Bias Against Mismatch



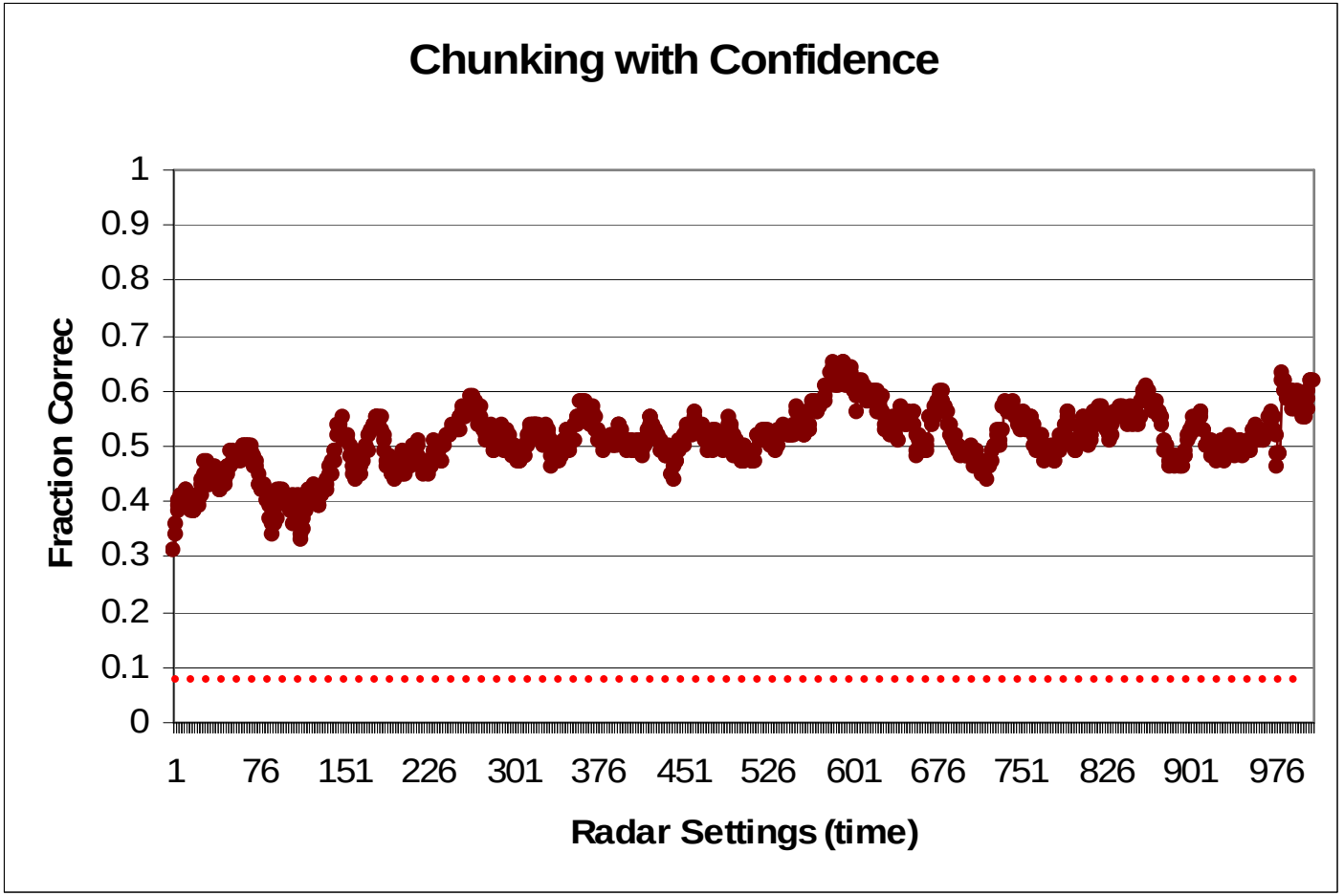
With Agent Verification



Adding Chunking (with confidence)

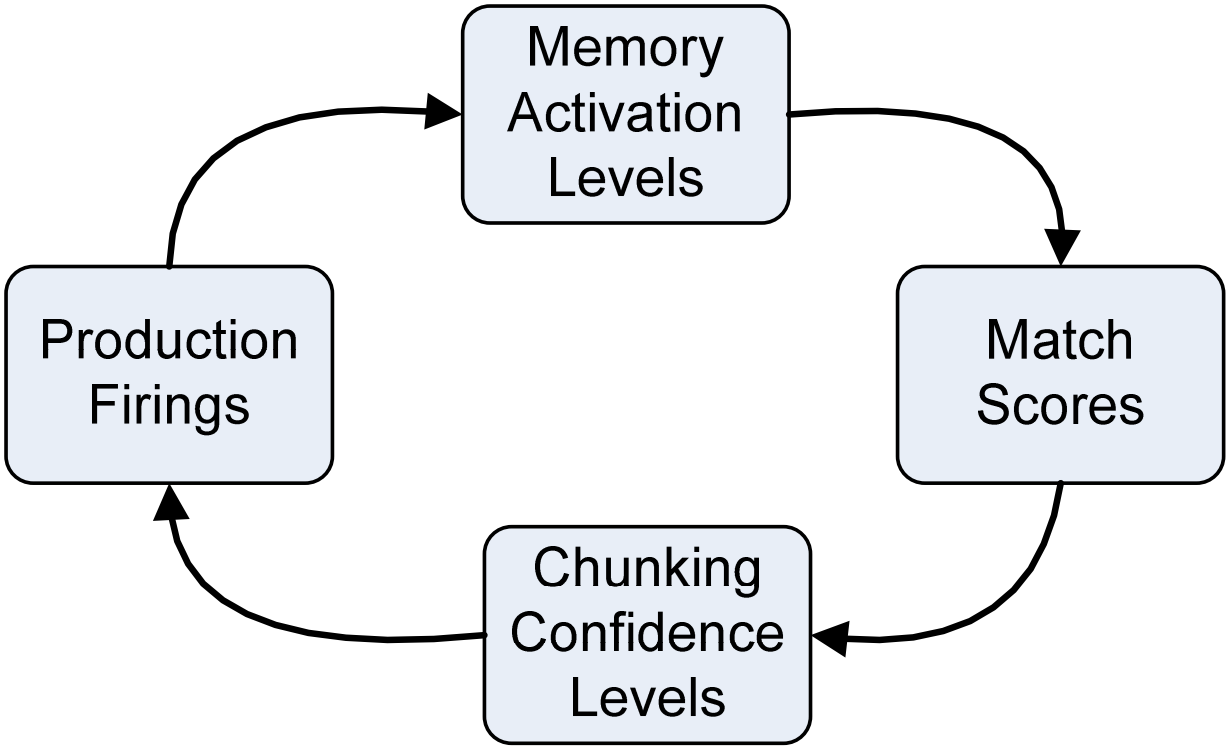
- Chunking allows the agent to “save” behavior resulting from a good retrieval
  - Allow the chunker to backtrace through the retrieval
- Initial data shows match score is a reliable predictor of episode “correctness” in the radar tank domain
  - Therefore, we can use a match score as a measure of agent confidence
  - First experiment with a domain specific (hard-coded) confidence threshold

Chunking Results



Analysis of Chunking Results

- Interdependency between Activation and Confidence



Lessons

- Activation level is a helpful but not reliable predictor of “correctness”
  - Poor memories beget more poor memories
  - Forgetting mechanism?
- Agent $\leftrightarrow$ Episodic Memory System communication is essential
  - Agent cue selection
  - Episode includes meta data
  - Agent episode evaluation

Nuggets

- Demonstrated effectiveness in two domains
- Improved match
- Activation bias is not enough

Coal

- Activation bias is not enough
- Episodic memory meta-data is needed to improve agent behavior