
Episodic Memory and Cognitive Capabilities

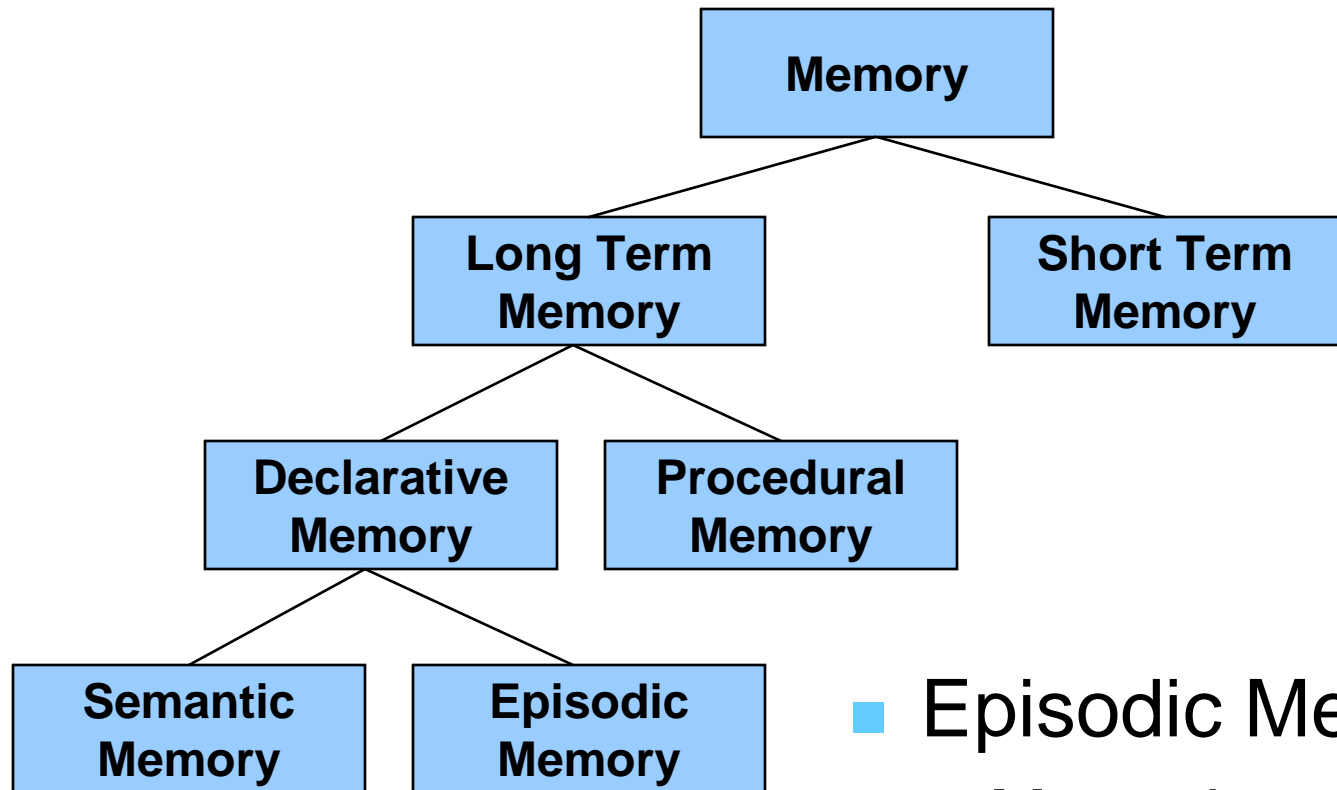
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24 May 2007

Outline

- Review and Introduction
 - Definitions
 - Research Goals
 - TankSoar Domain
- Demonstrating Cognitive Capabilities
 - Action Modeling
 - Virtual Sensors
 - Learning from Past Success and Failure

Long Term Memory



- Episodic Memory
 - Memories of specific events in your past

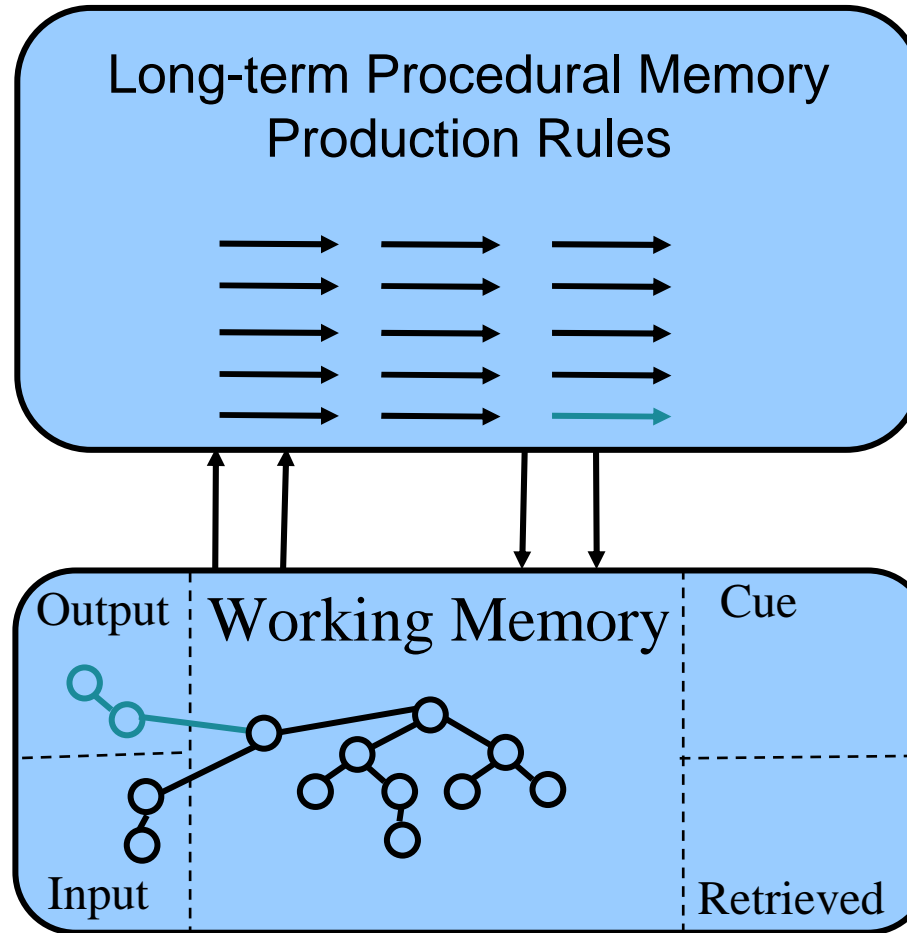
Current Implementation

Encoding

Initiation?

Storage

Retrieval



When the agent takes an action.

Current Implementation

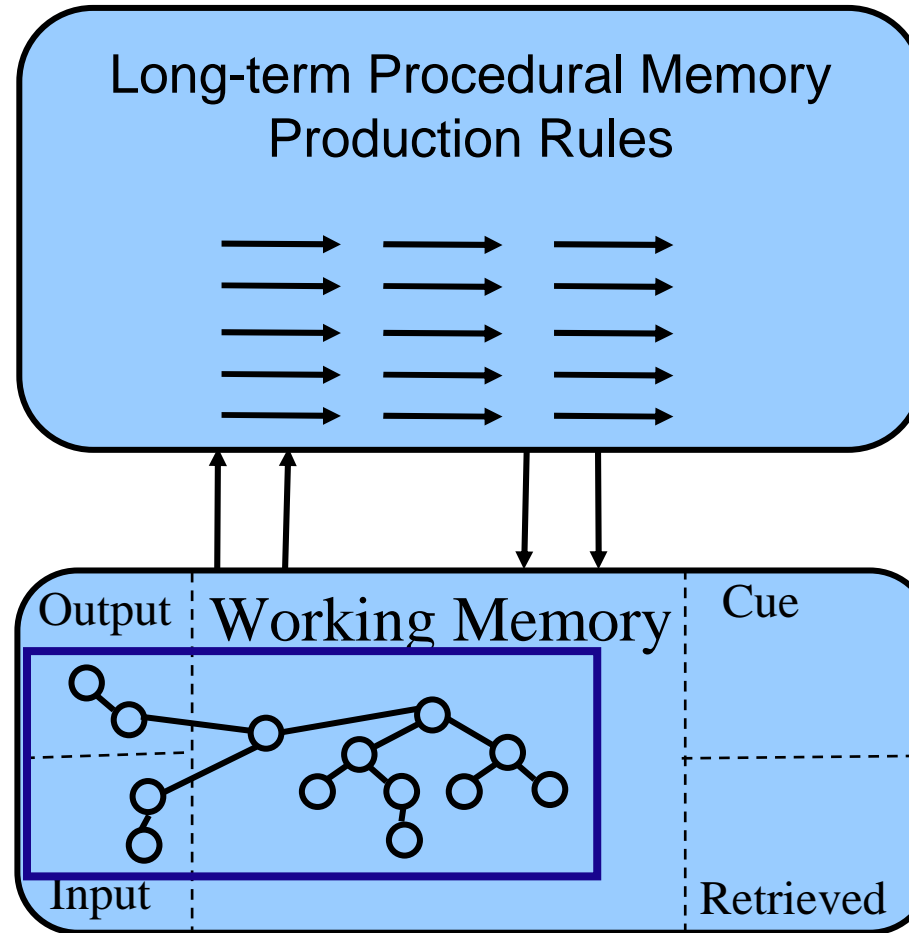
Encoding

Initiation

Content?

Storage

Retrieval



A portion of working memory is stored in the episode

Current Implementation

Encoding

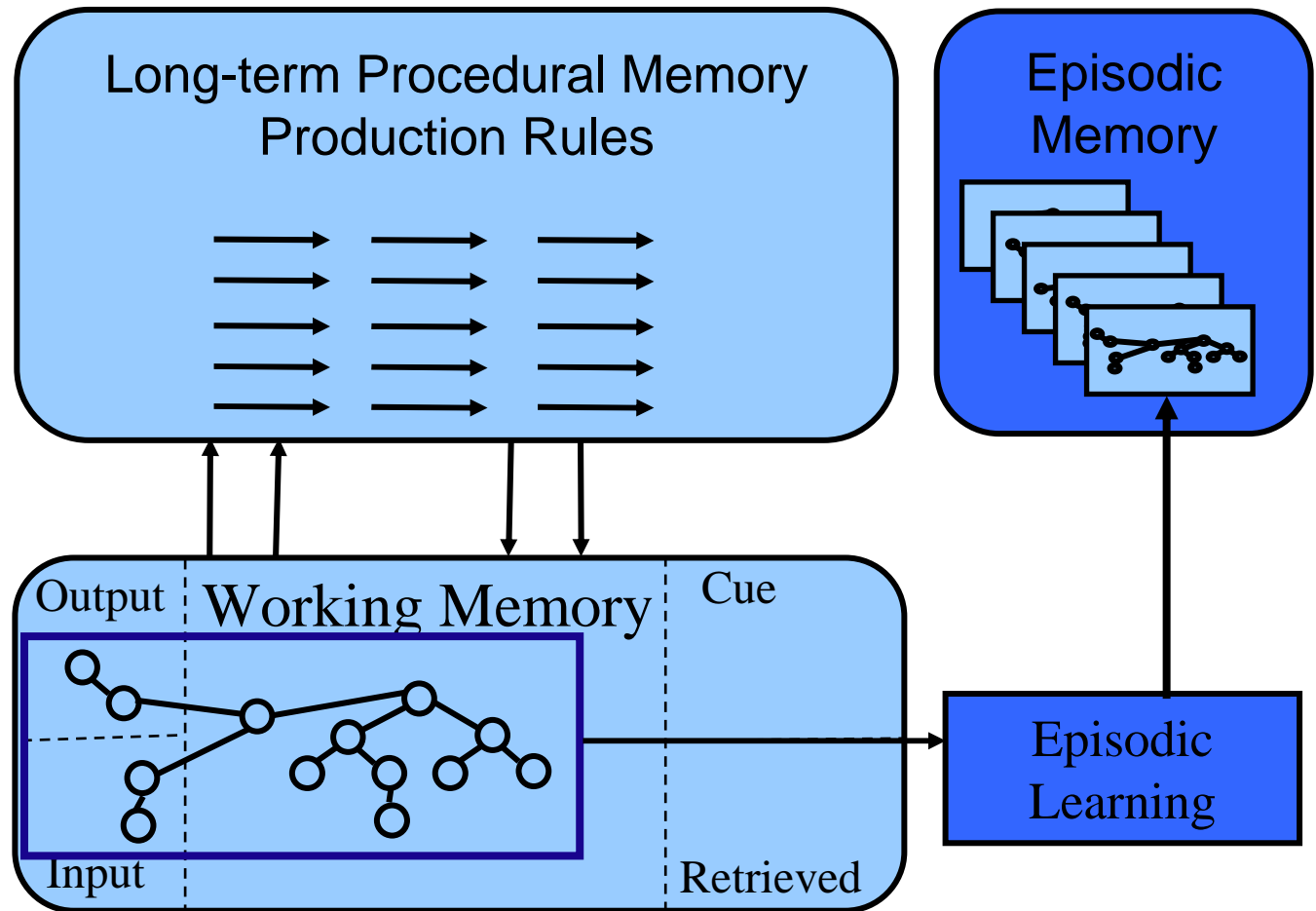
Initiation

Content

Storage

Episode Structure?

Retrieval



Episodes are stored in a separate memory

Current Implementation

Encoding

Initiation

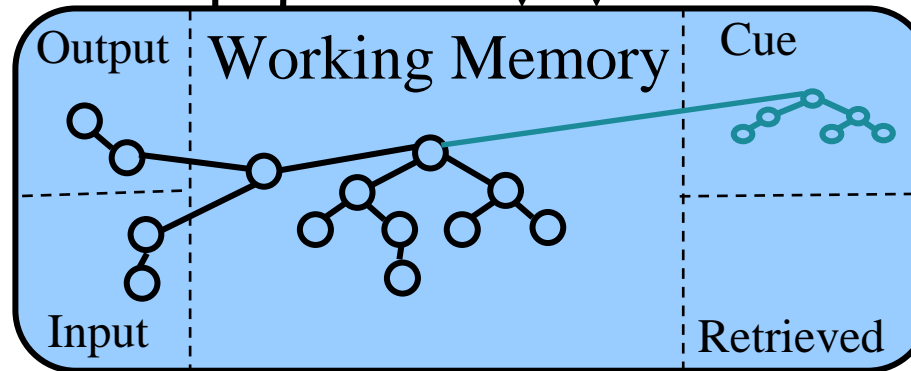
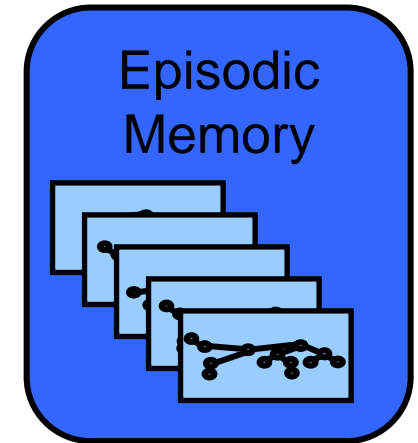
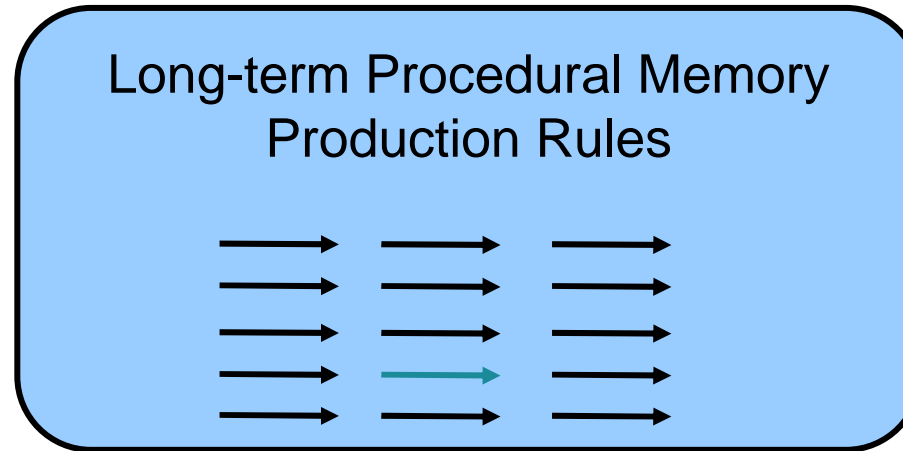
Content

Storage

Episode Structure

Retrieval

Initiation/Cue?



Cue is placed in an architecture specific buffer.

Current Implementation

Encoding

Initiation

Content

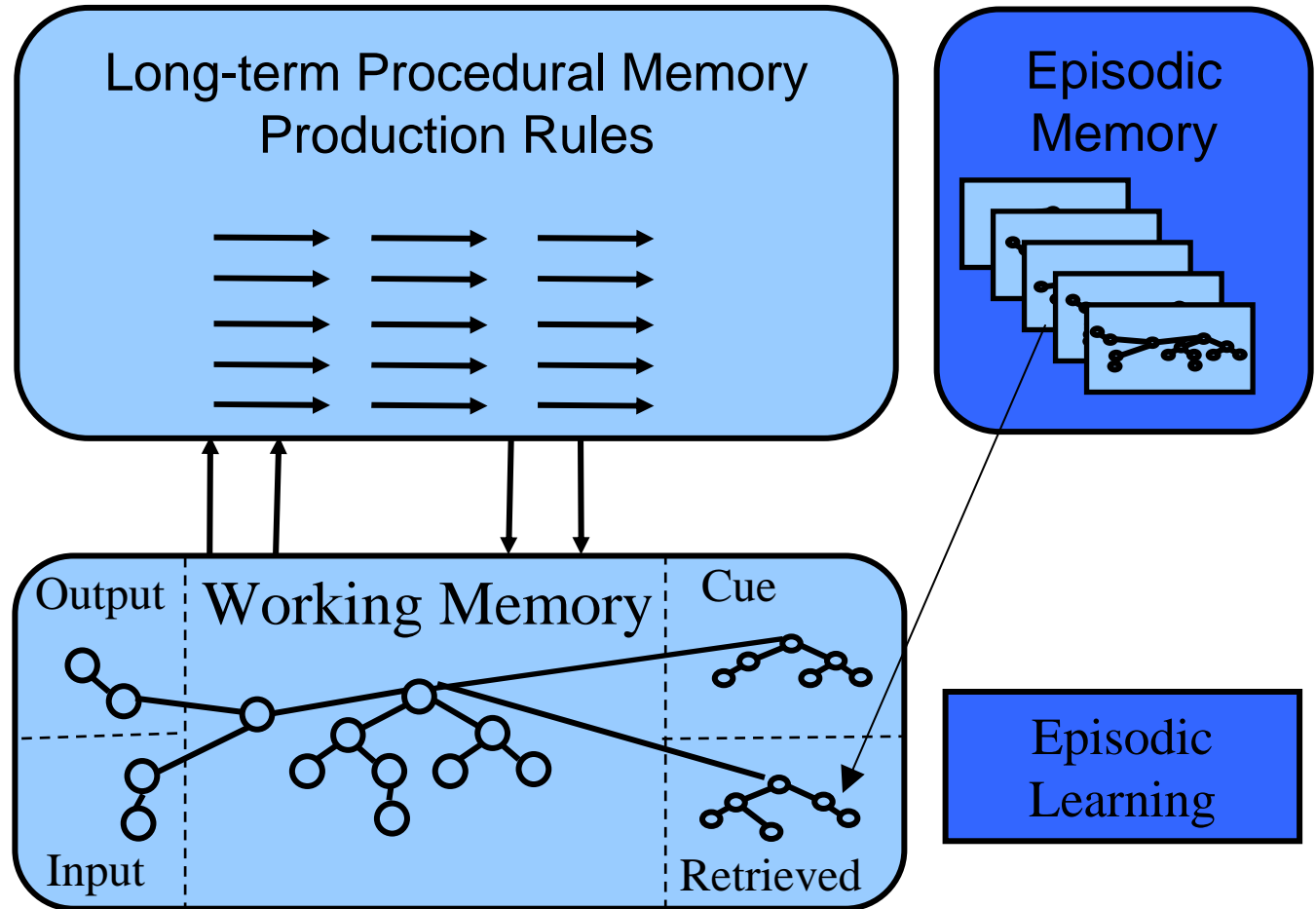
Storage

Episode Structure

Retrieval


Initiation/Cue

Retrieval



The closest partial match is retrieved.


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



Cognitive Capabilities:

How do we use Episodic Memory?

■ Sensing

- Detecting Repetition
- Virtual Sensing 
- Noticing Unusual Input
- Sense of Identity

■ Reasoning

- Action Modeling 
- Recording Previous Successes/Failures 
- Modeling the Environment
- Managing Long Term Goals

■ Learning

- Retroactive Learning
- Reanalyzing with new Knowledge
- Explaining Behavior
- “Boosting” other Learning Mechanisms

TankSoar Domain

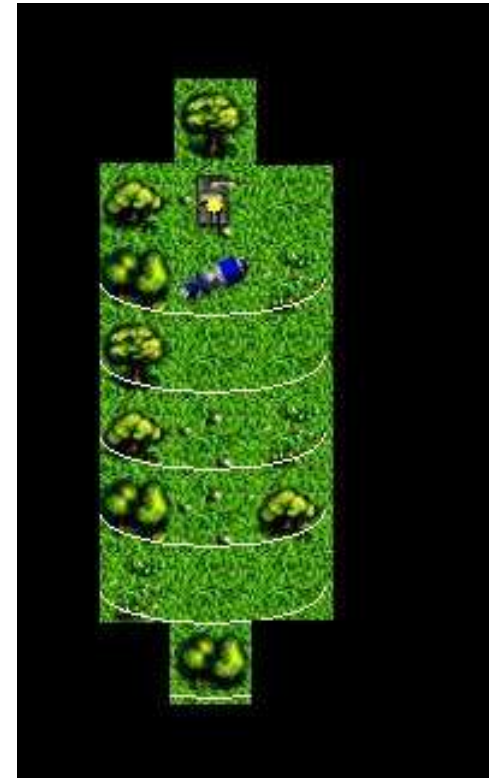
- Tanks in a maze
- Sub-goals
 - Shoot other tanks
 - Don't get shot
 - Don't run out of
 - Energy
 - Missiles
- Multiple sensors and actions



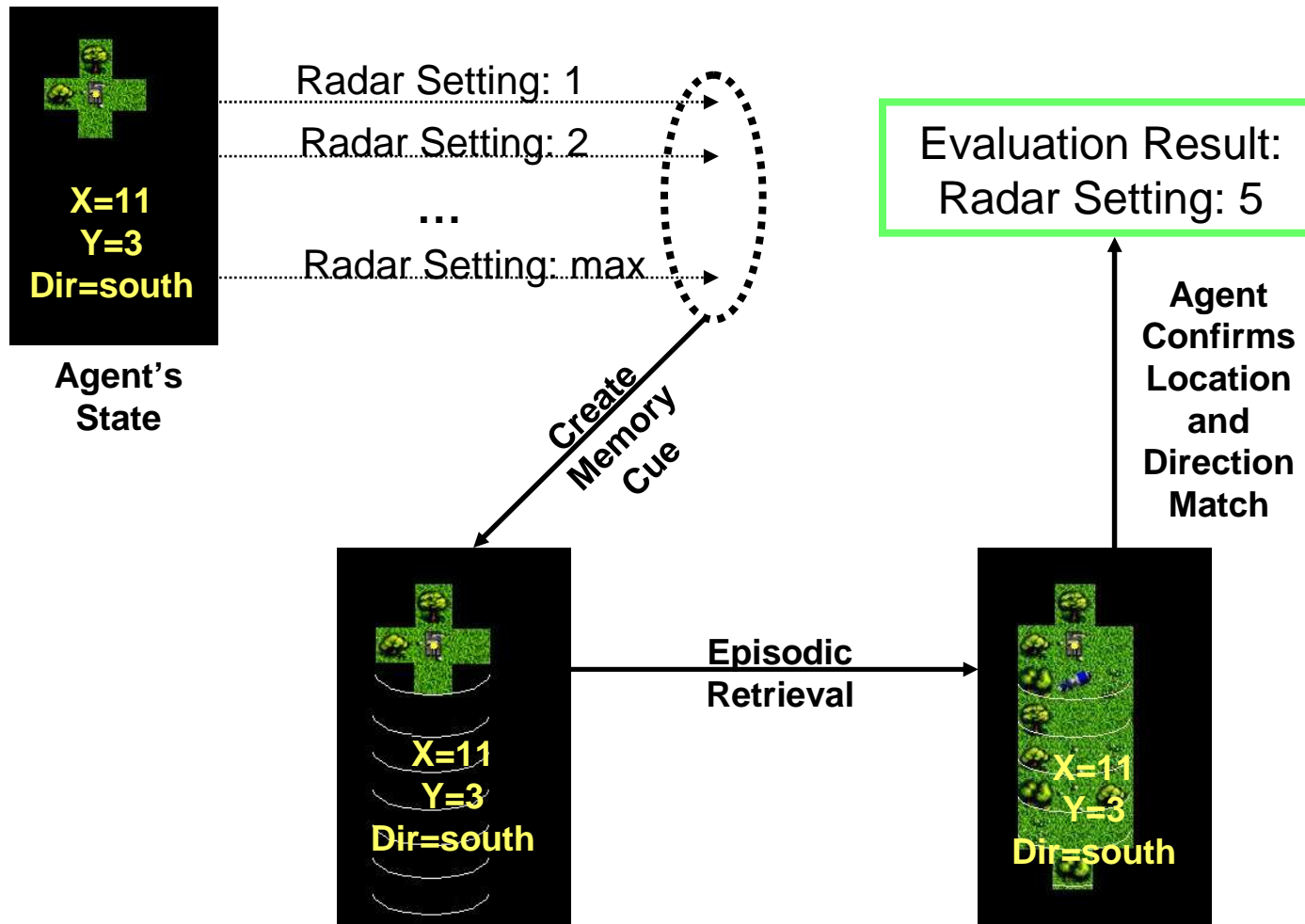
Action Modeling

Cognitive Capability: Action Modeling

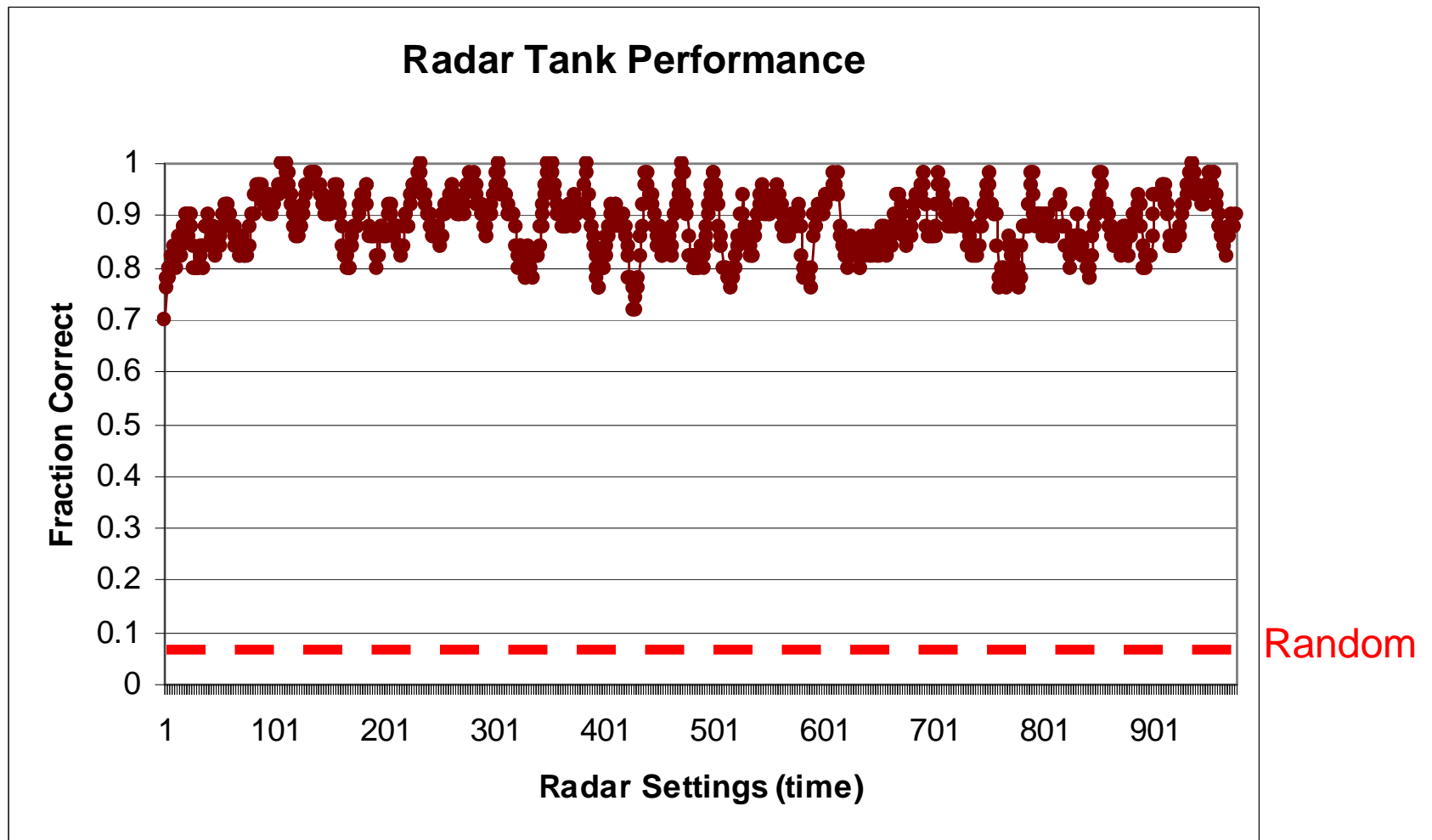
- Action Modeling
 - Definition: Learning the immediate effect of an action
 - Analog: Case-Based Reasoning
- Task: Conserve Energy
 - Selecting proper radar setting to minimize energy consumption



Agent Implementation



Initial Performance



Nuggets

- Episodic memory is an effective medium for action modeling

Coal

- Requires agent have knowledge of whether a retrieved episode is useful

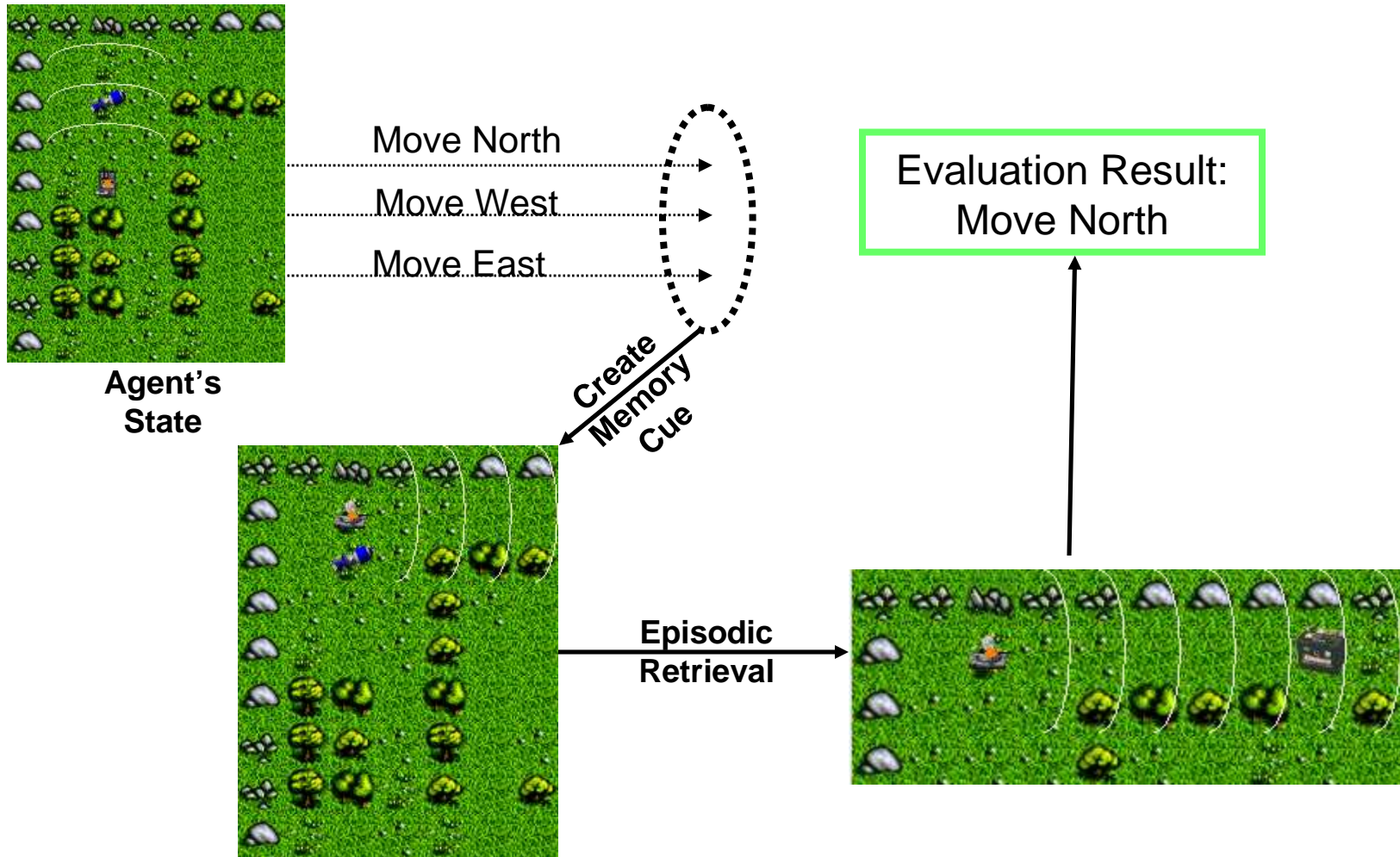
Virtual Sensors

Cognitive Capability: Virtual Sensors

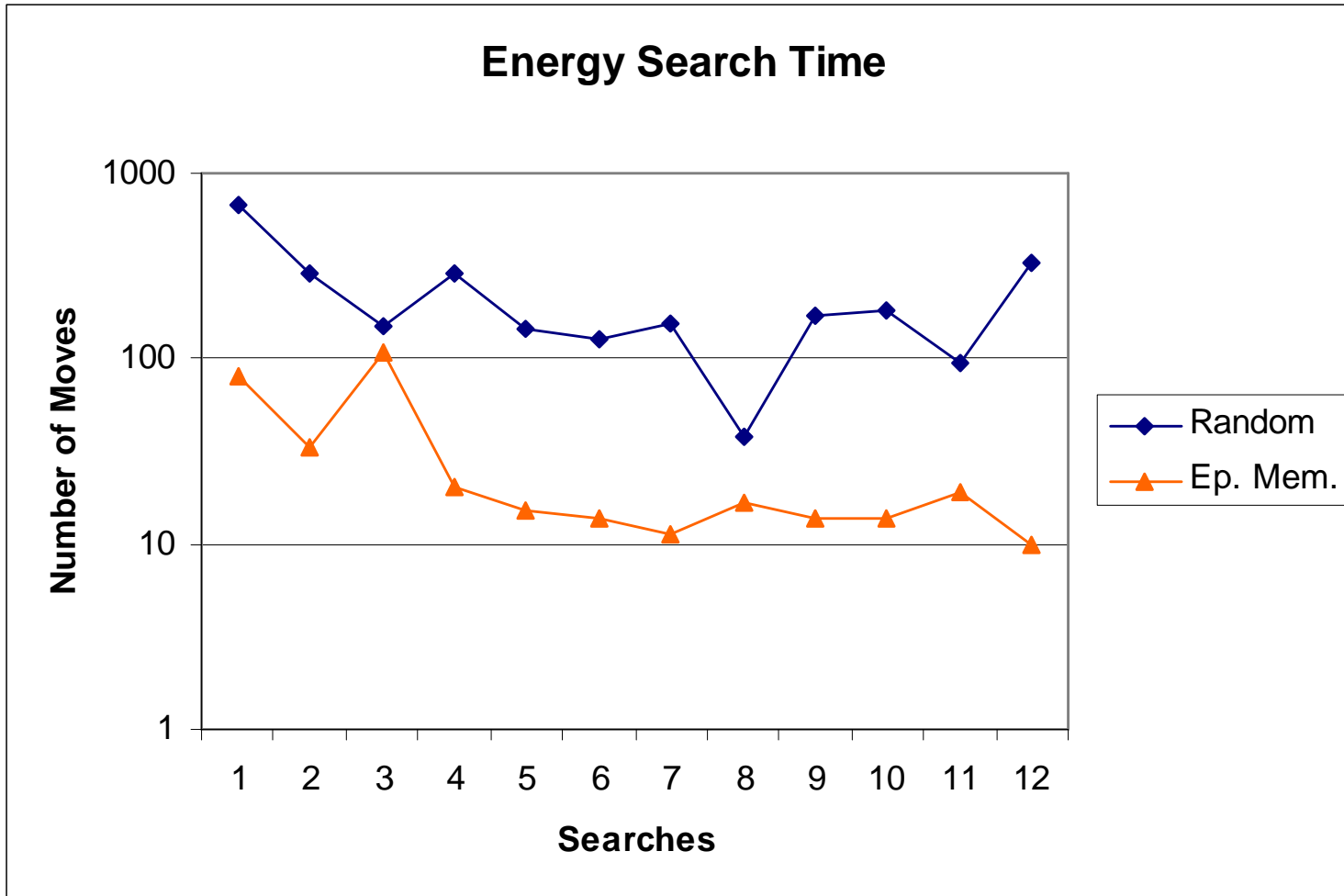
- Virtual Sensors
 - Definition: Retrieving past sensing that is relevant to the current task
- Task: Locate the Battery
 - Using episodic memories to construct a path



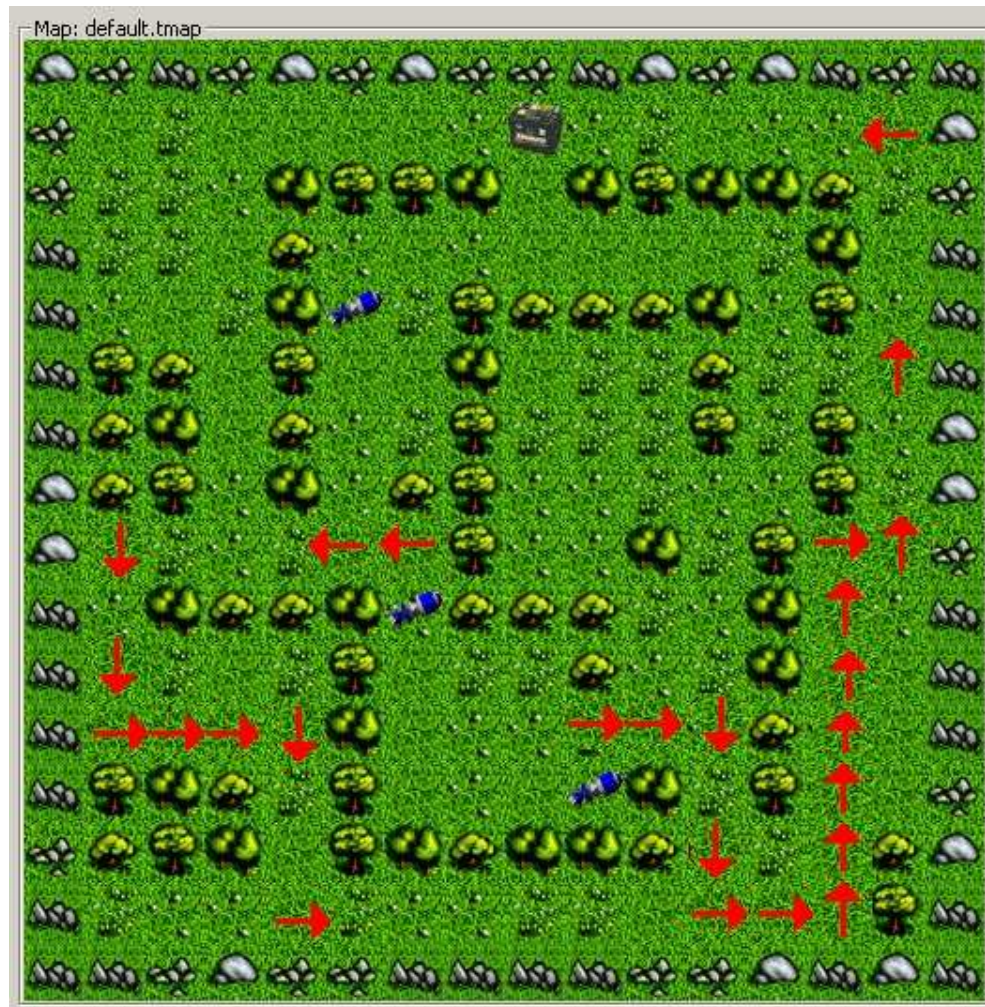
Agent Implementation



Performance



Paths to Battery



Nuggets

- Episodic memory can be used as a virtual sensor

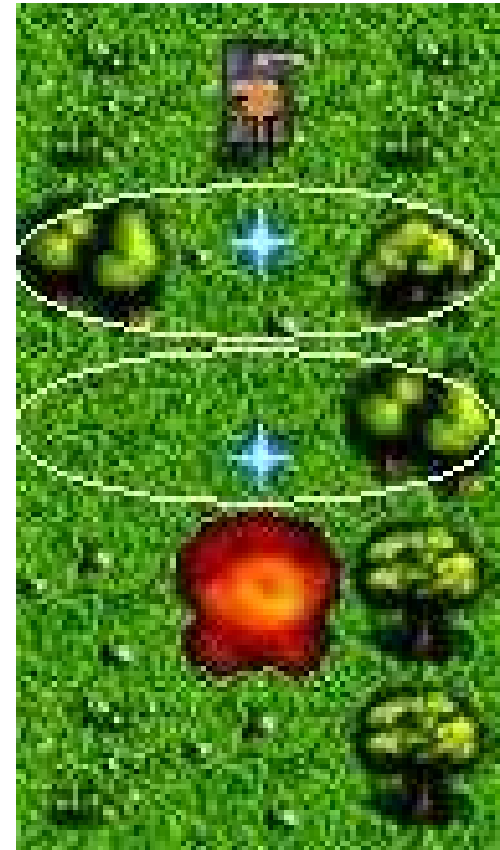
Coal

- Limited investigation of integration of episodic and semantic memory

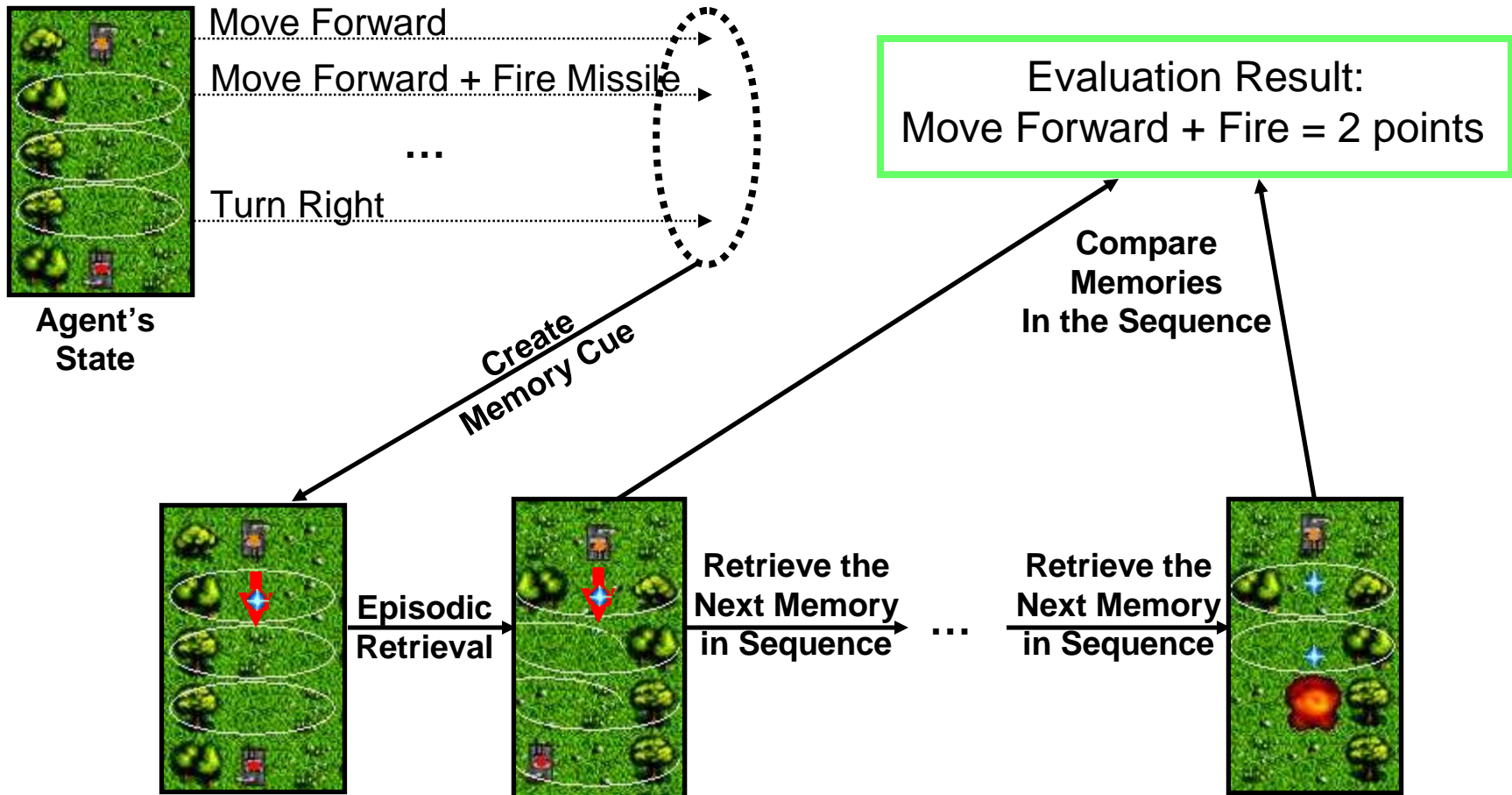
Learning from Past Success and Failure

Cognitive Capability: Learning from Past Success and Failure

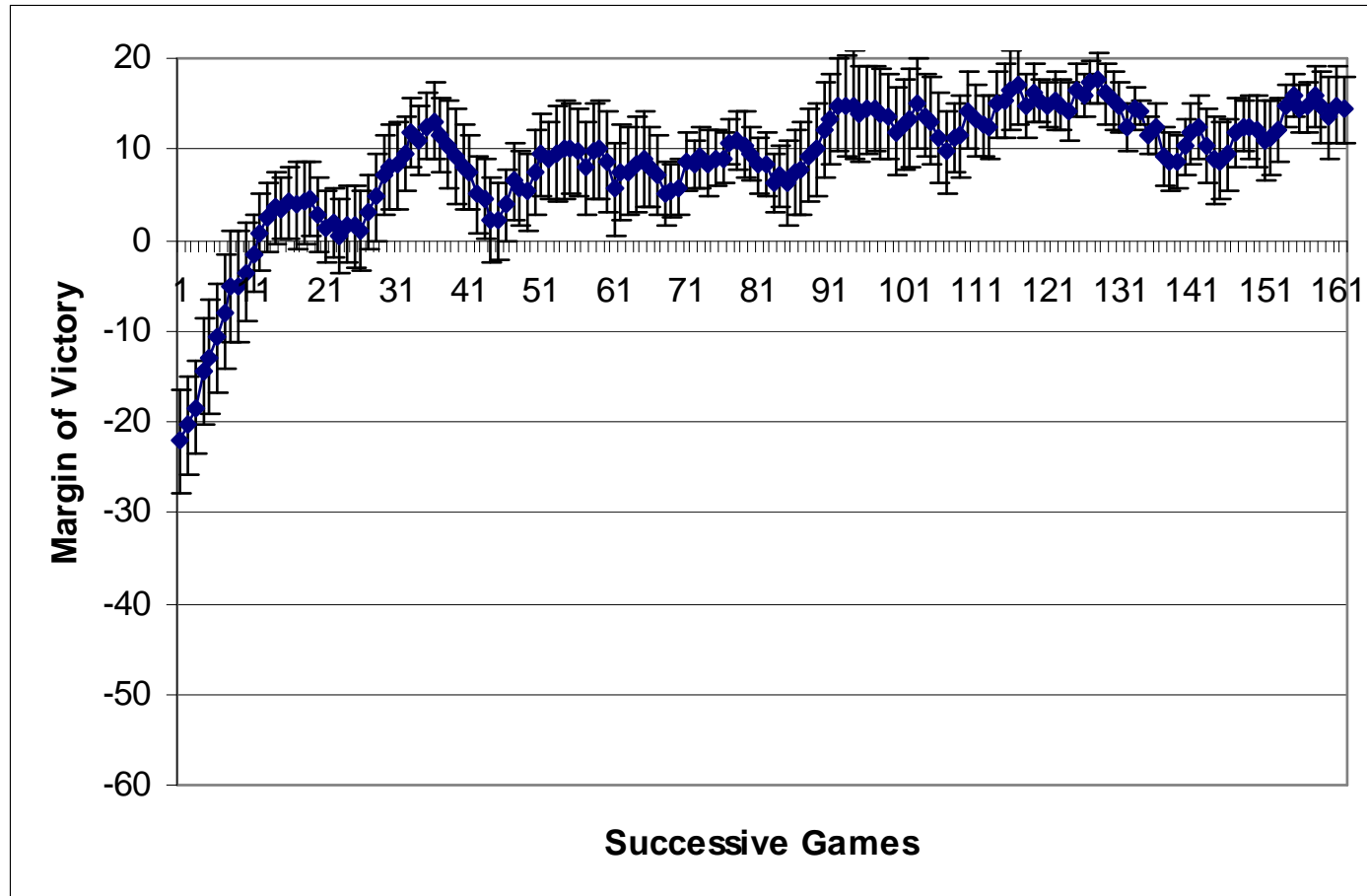
- Learning from Past Success and Failure
 - Definition: Using past performance to guide future behavior
 - More emphasis on long term
- Task: Combat
 - Using episodic memory to determine best tactics in the “attack” subgoal



Agent Implementation



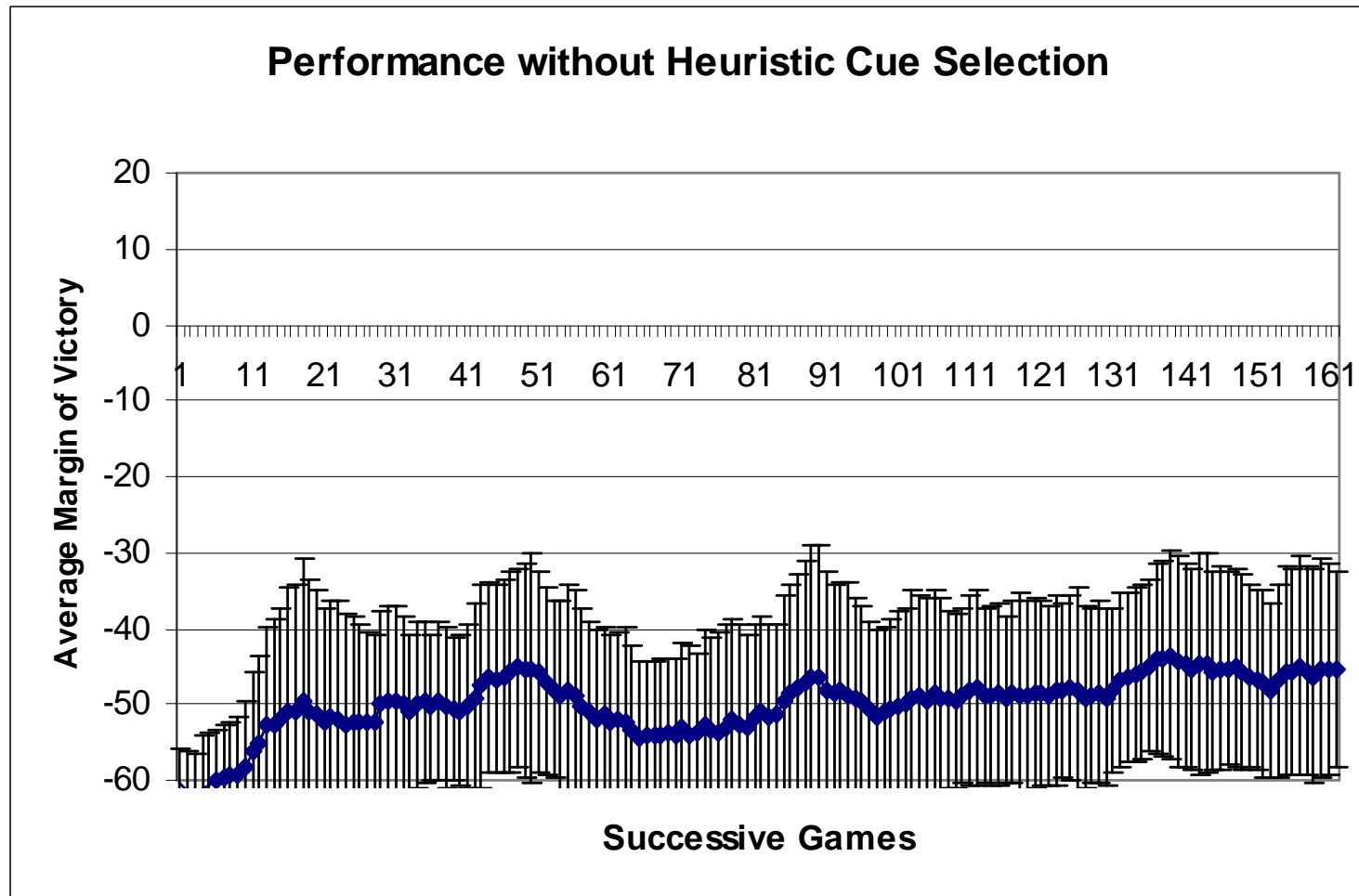
Performance



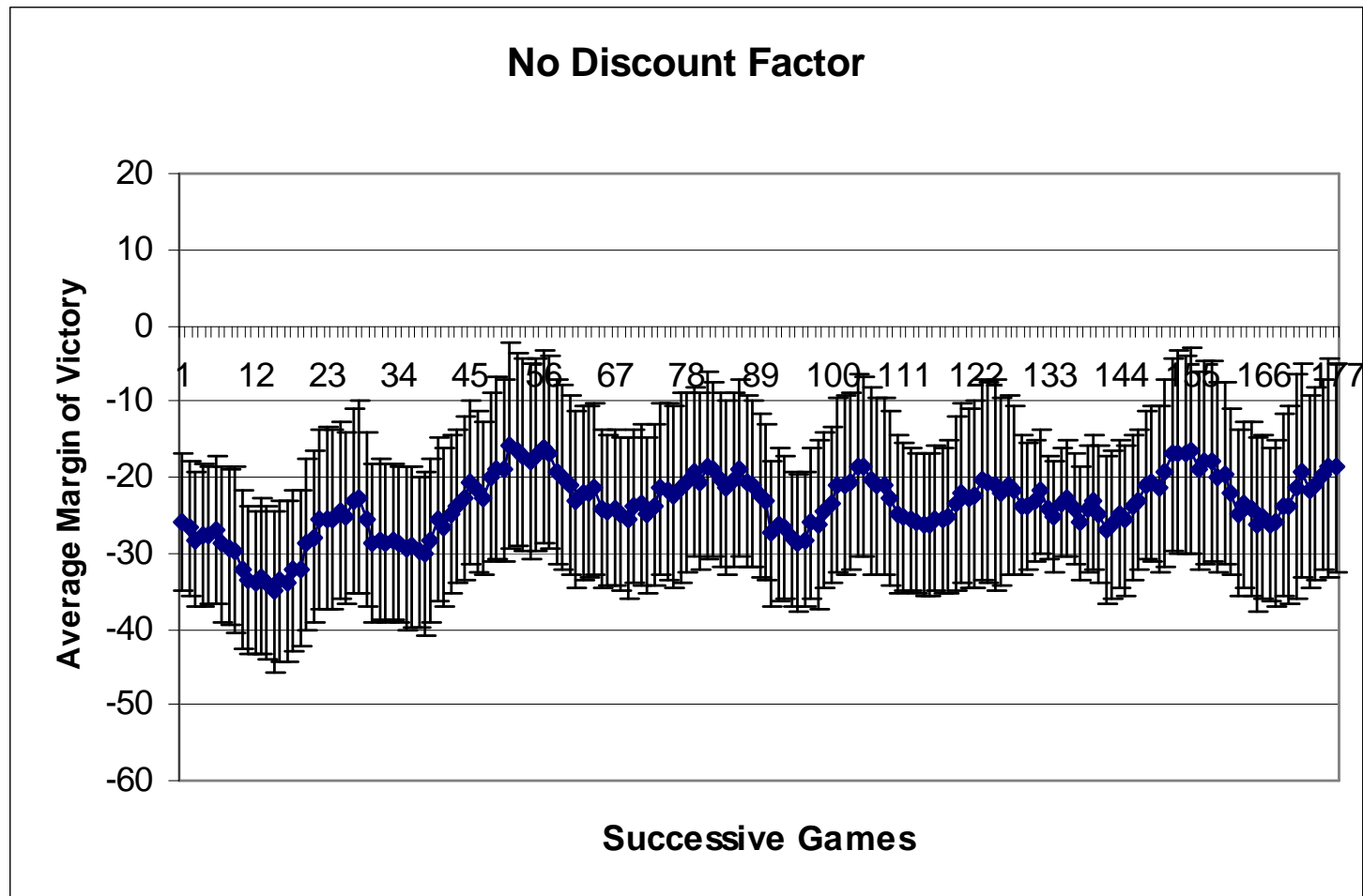
Tactics Learned

- Fight or flight
- Back away and shoot
- Dodging

Without Heuristic Cue



Without Discount Factor



Nuggets

- Episodic memory can be effective at learning long term tactics

Coal

- Requires the use of a discount factor
- Requires heuristic cue selection

Summary

- Episodic memory enables multiple cognitive capabilities including:
 - Action modeling
 - Virtual sensing
 - Learning from past success and failure