Integrating Clustering and Semantic Memory in Soar

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Research Goals

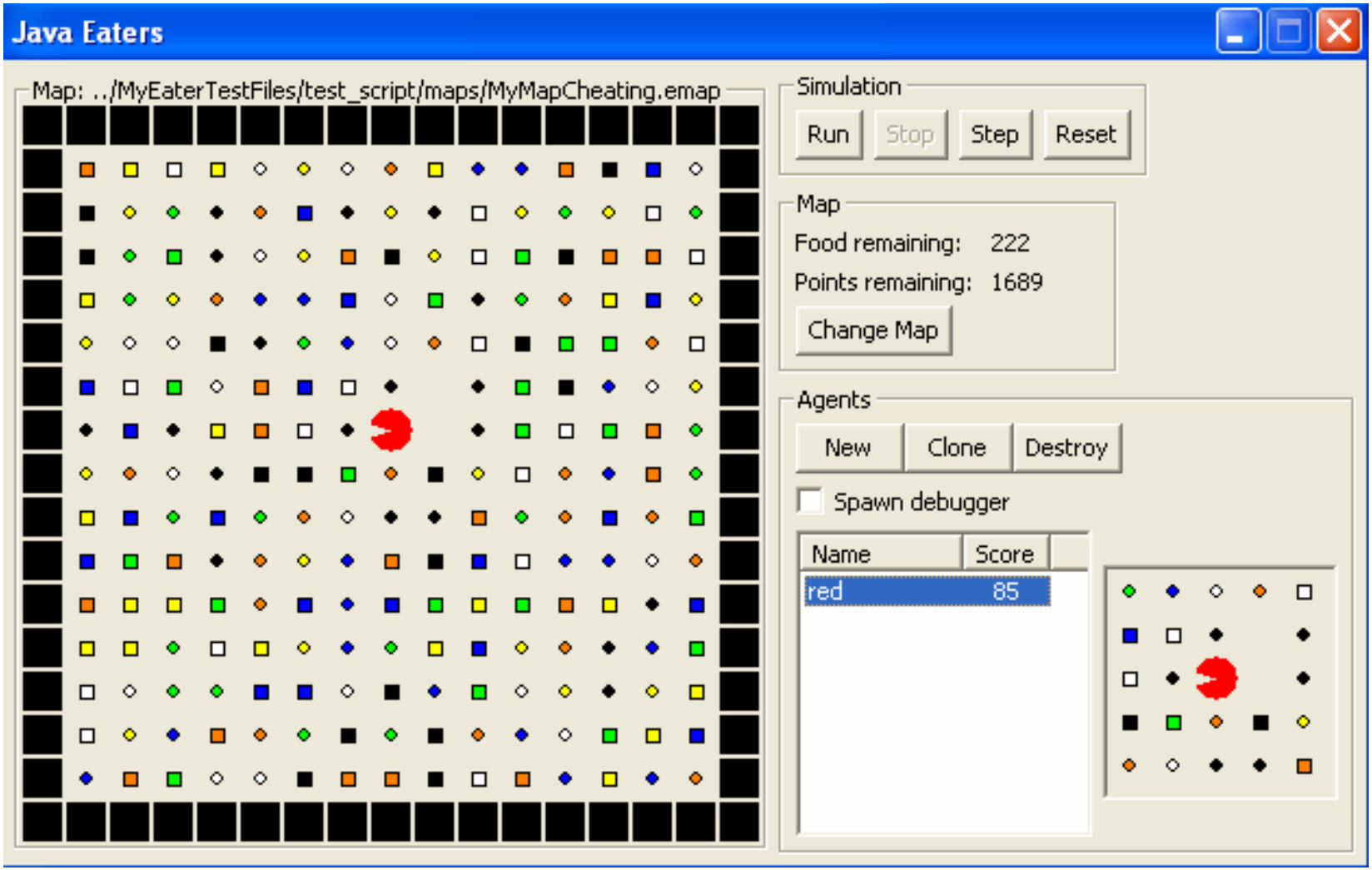
- To improve general functionality of Soar by semantic memory
  - Explore new cognitive capabilities
    - Category learning

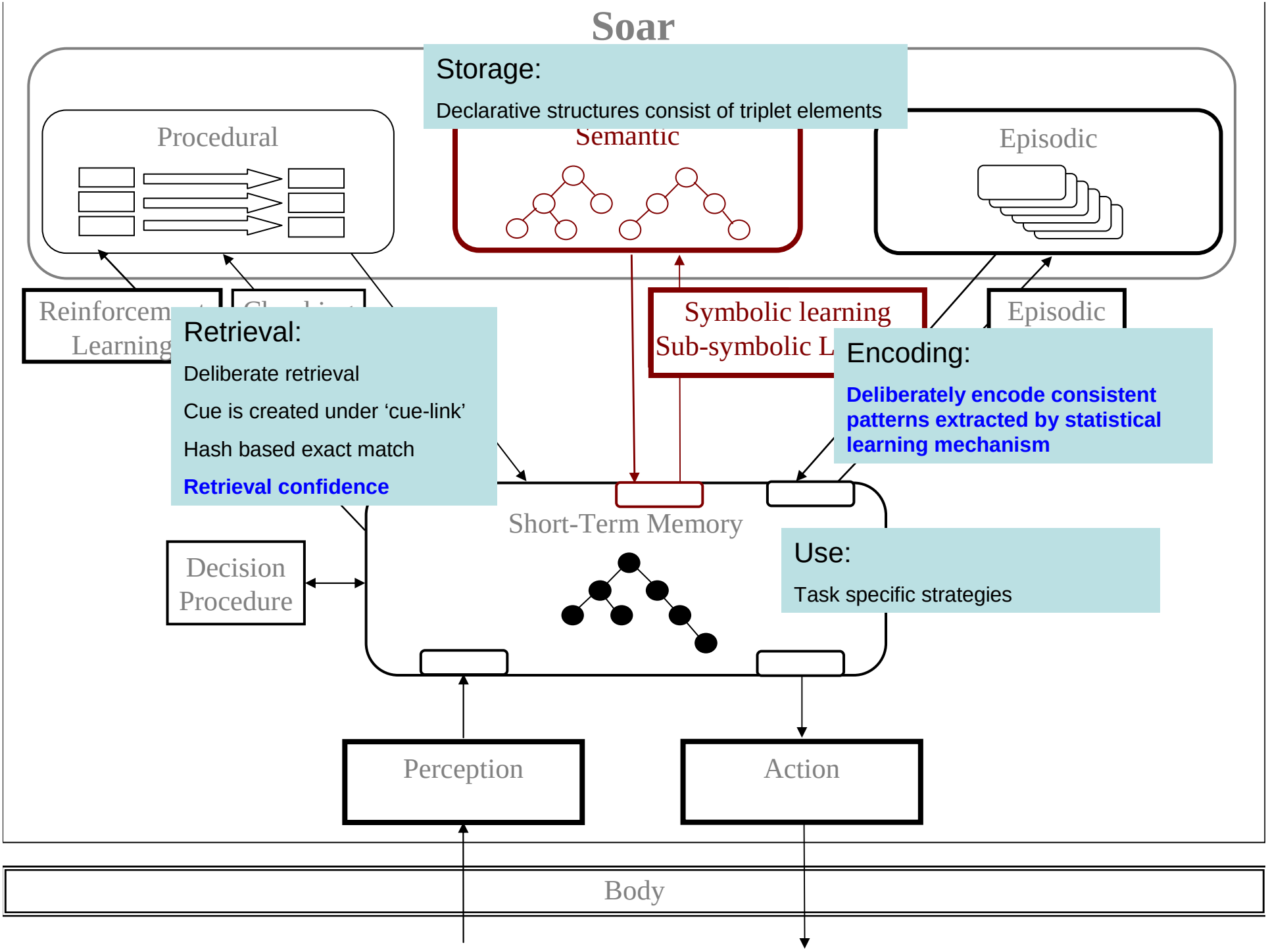
- To understand semantic memory in the context of a general cognitive architecture
  - How to use semantic memory in specific tasks?
    - Hierarchical structure

Overview of Experiment

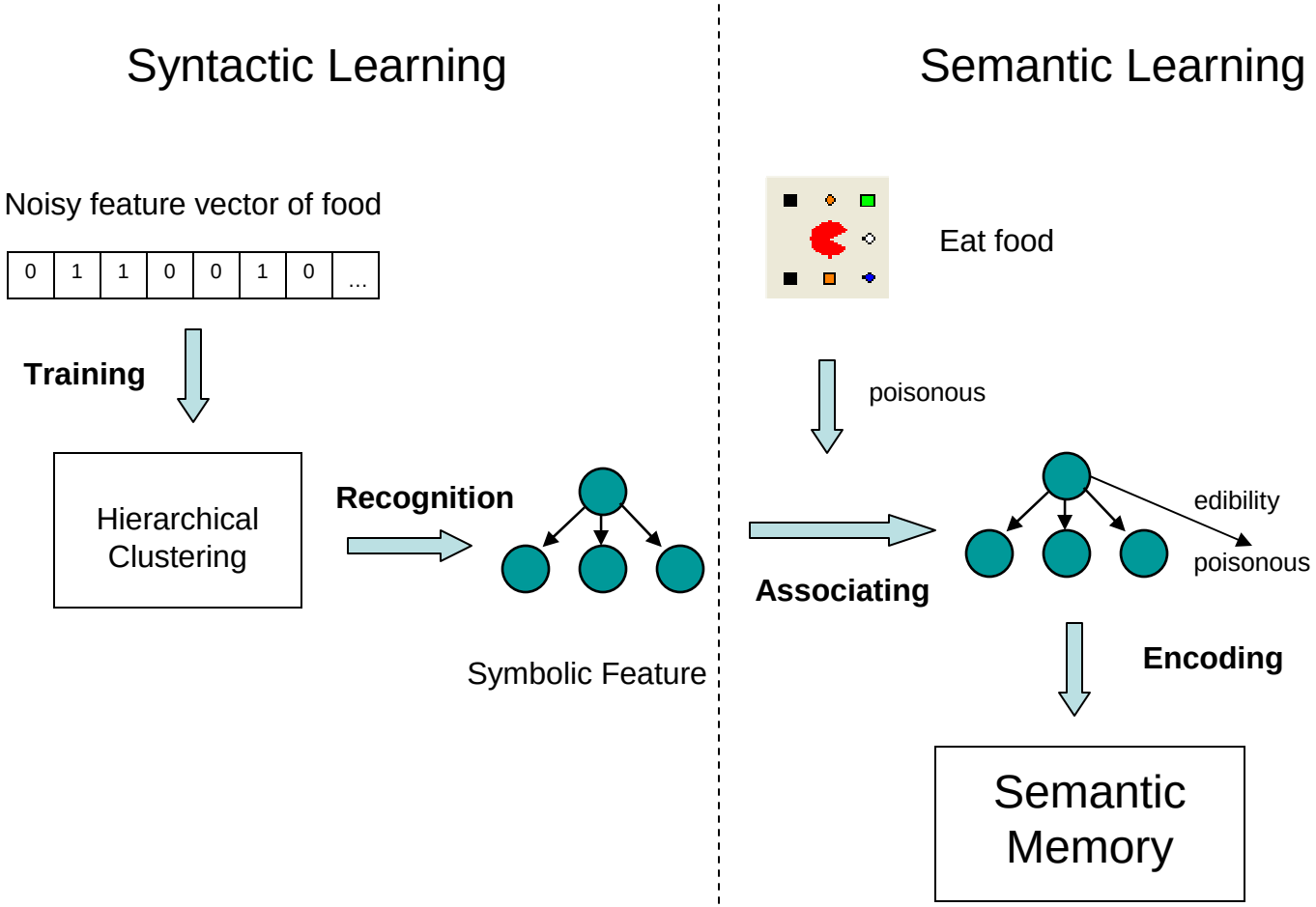
- Purpose:
  - Test in external environment
  - Need more challenging task with stochastic environment
- Implementation:
  - Integrated statistical learning component
  - Semantic memory provides confidence of retrieval
- Task: Eater's domain
  - Interactive simulated environment
  - The environment is readily available
  - Enrich the domain: inject noise, hierarchical structure

The Eater's Domain




Soar
Storage:
Declarative structures consist of triplet elements
Procedural
Semantic
Episodic
Reinforcem
Learning
Symbolic learning
Sub-symbolic L
Episodic
Retrieval:
Deliberate retrieval
Cue is created under 'cue-link'
Hash based exact match
Retrieval confidence
Encoding:
Deliberately encode consistent patterns extracted by statistical learning mechanism
Short-Term Memory
Decision Procedure
Use:
Task specific strategies
Perception
Action
Body

Overview of Task and Implementation



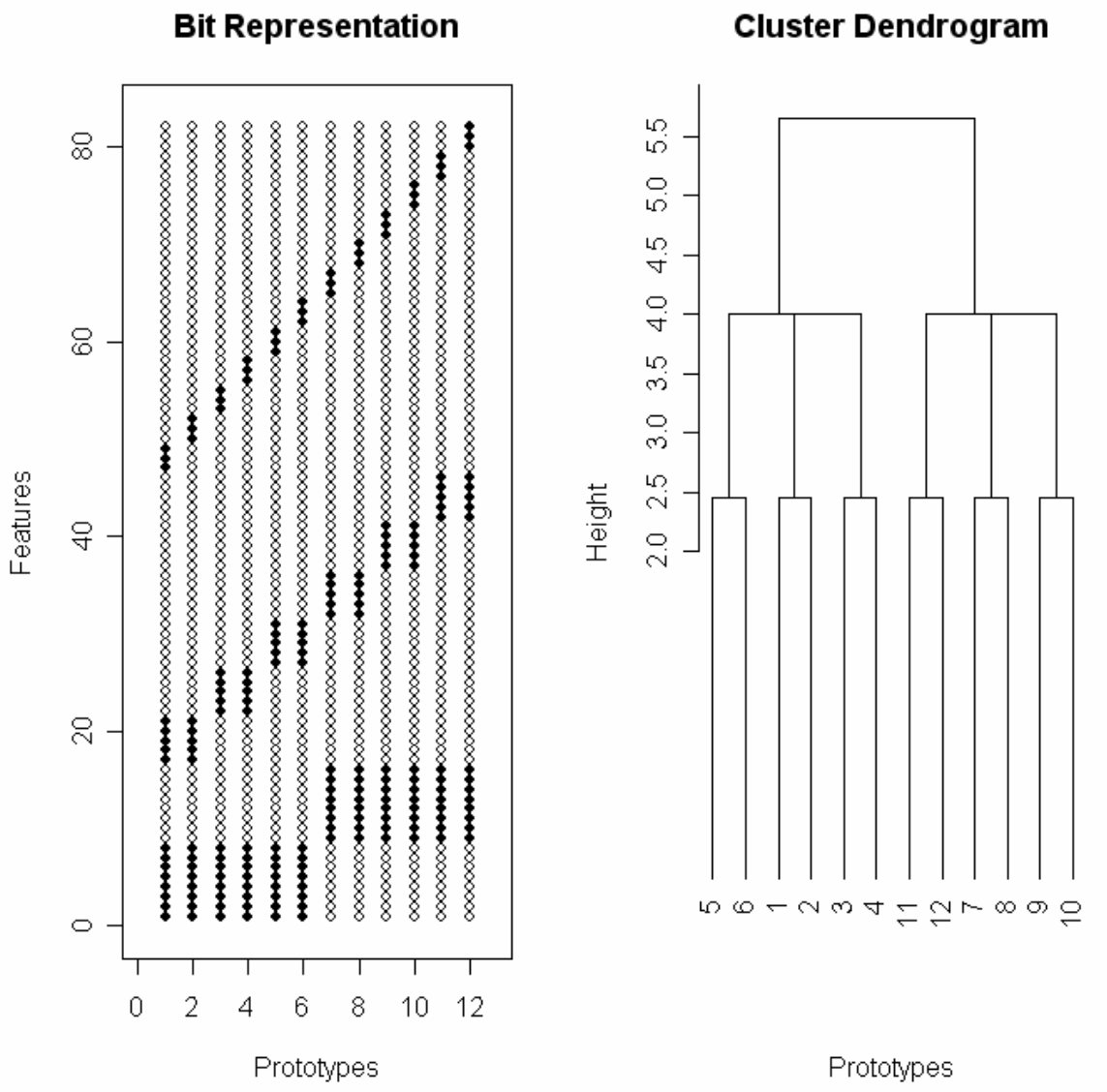
Why use Hierarchical Clustering?

- Semantic learning is based on saving and retrieving instances
  1. Save original instances without clustering
     - Number of unique instances increases linearly
     - Exact match based memory retrieval will not find matches
     - Partial match based memory retrieval is computational expensive
  2. Save instances with reduced features after clustering
     - Instances are collapsed into small set of categories
     - Representation has reduced dimension
     - Underlying structure is still preserved

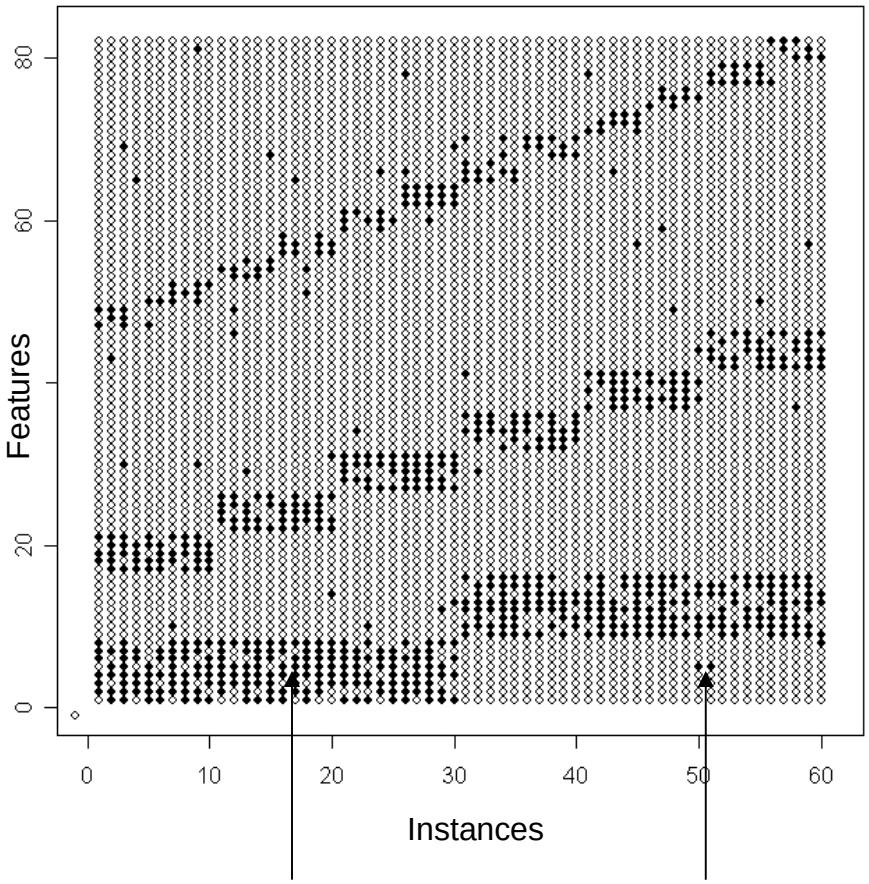
The Hierarchical Clustering Algorithm used in our Implementation

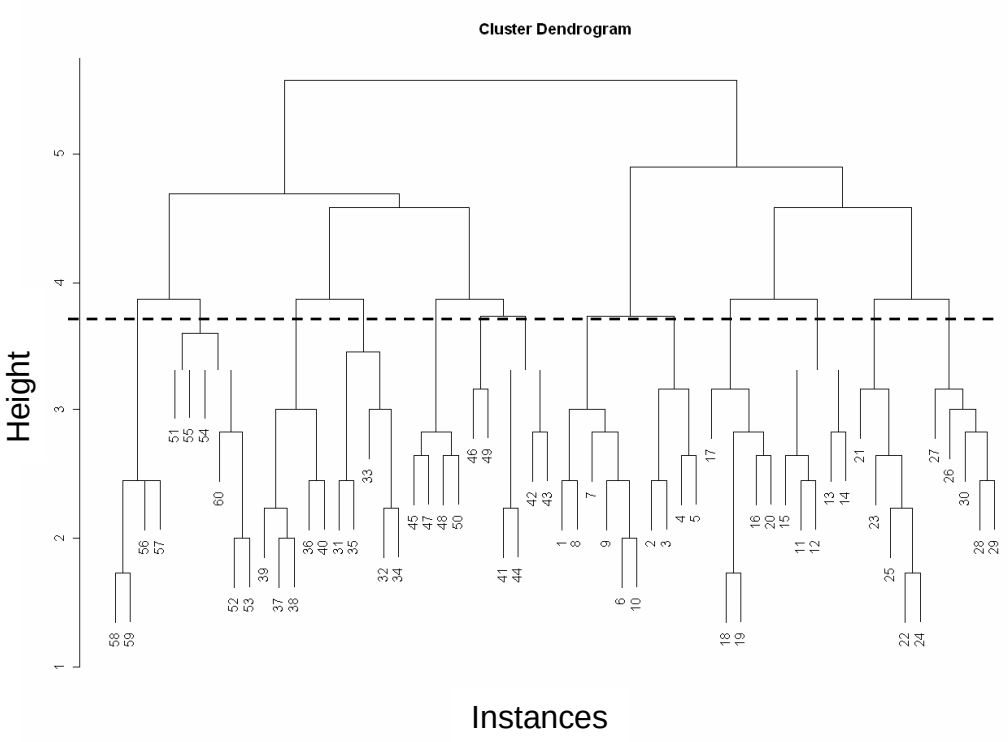
- Online learning algorithm
  - Neural network based
- Unsupervised learning
- Hierarchically refined classification

Food Prototypes



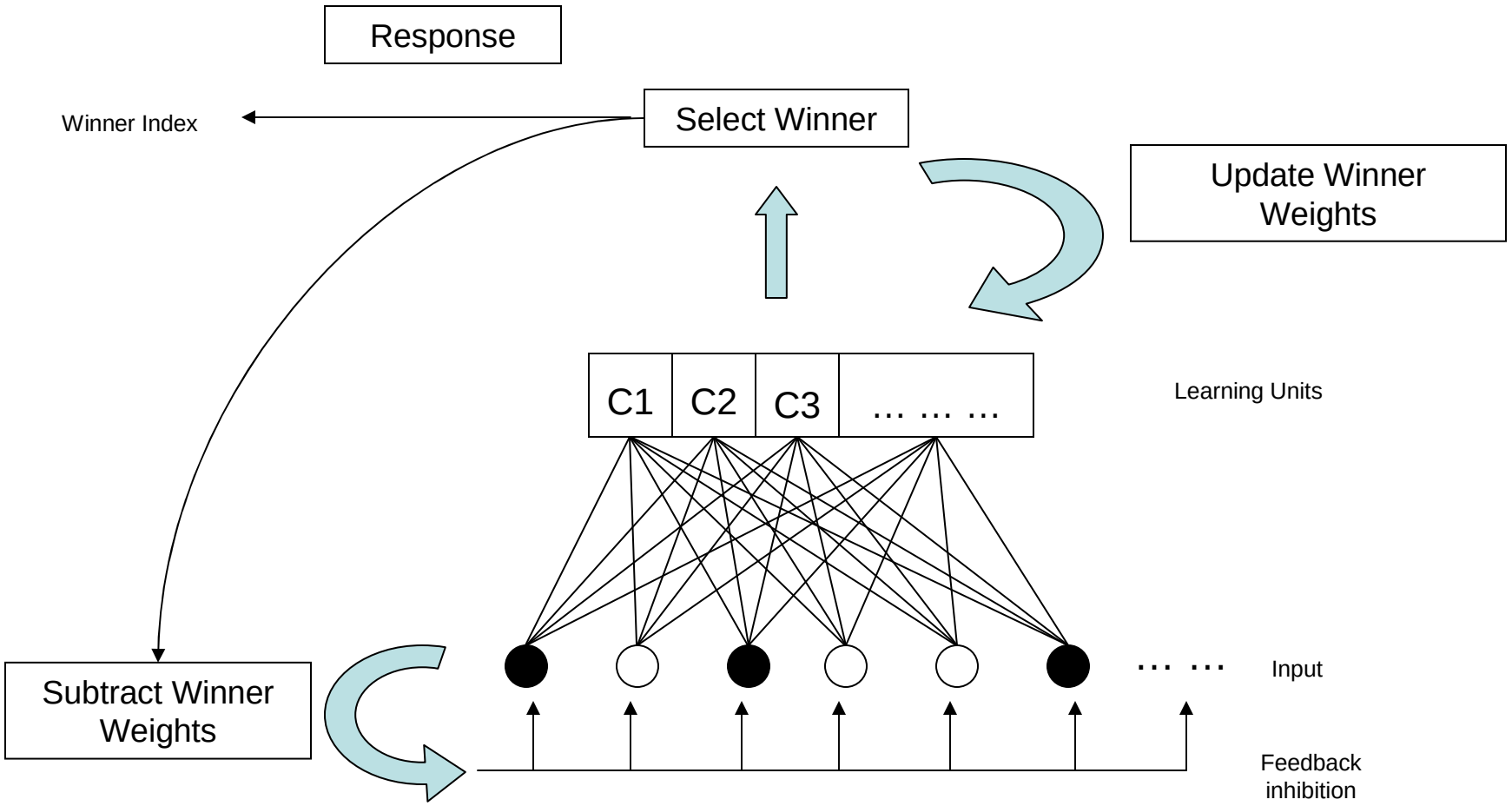
Food Instances with Noise



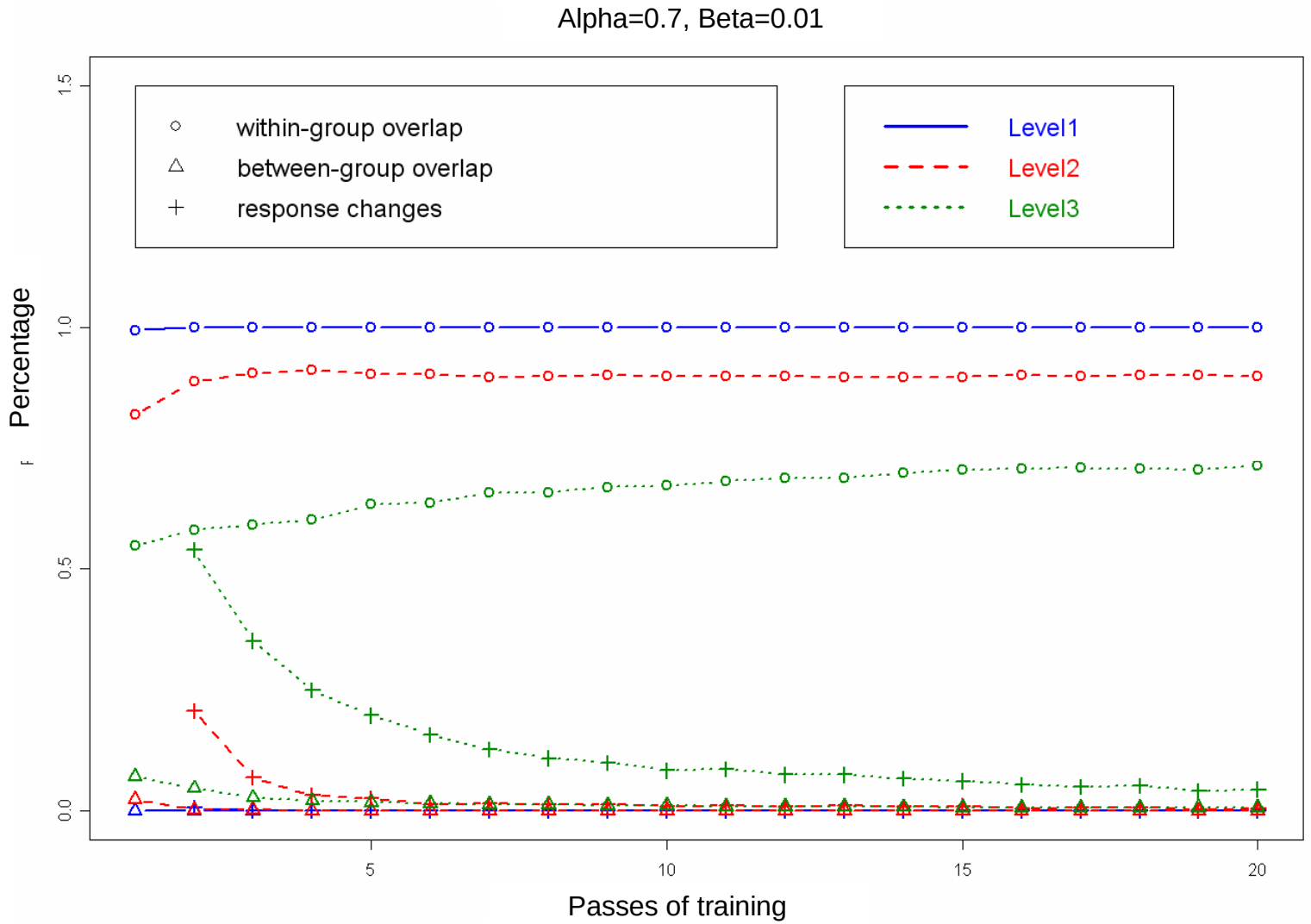


Alpha (true positive) = 0.7 Beta (false positive) = 0.01

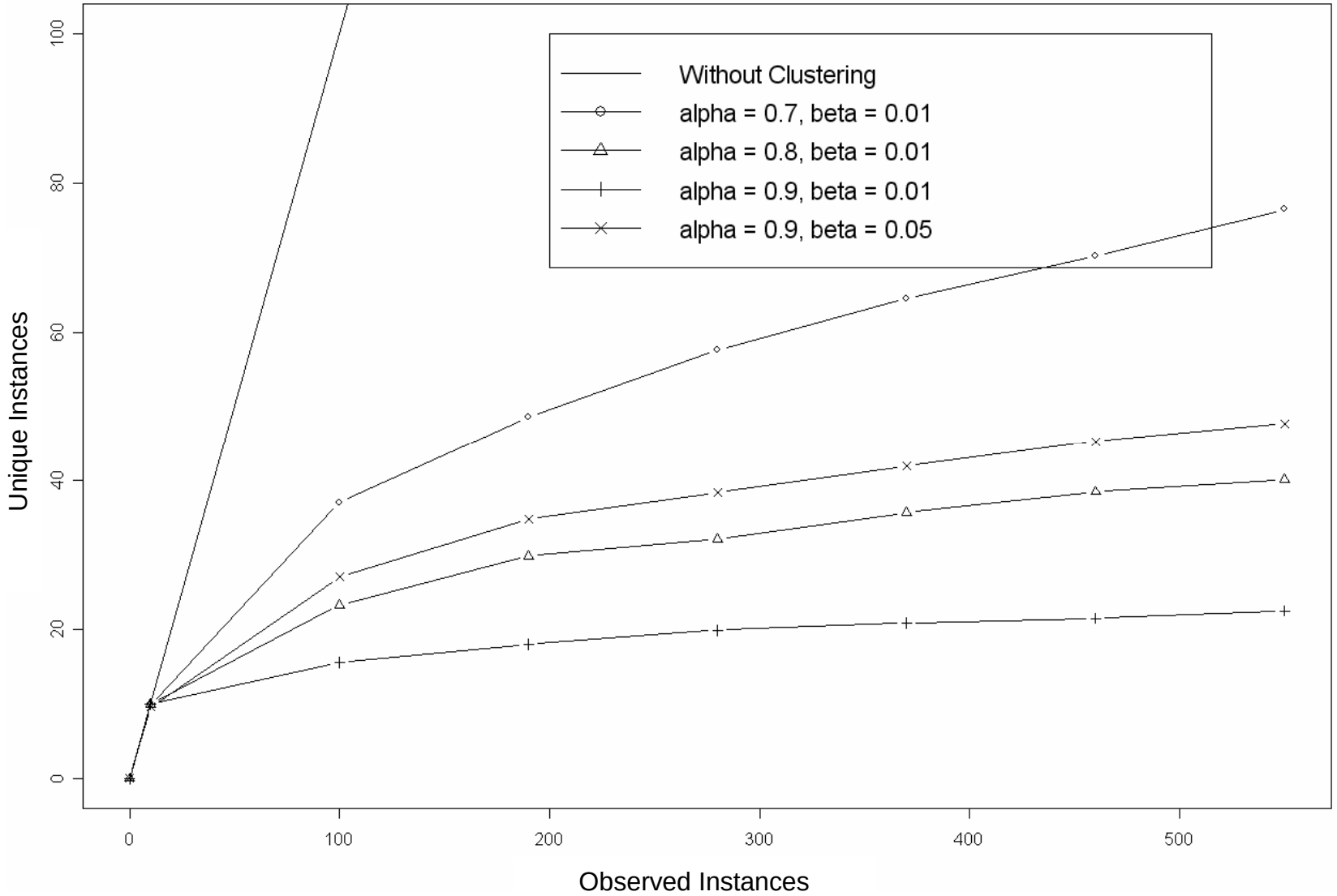
Hierarchical Clustering



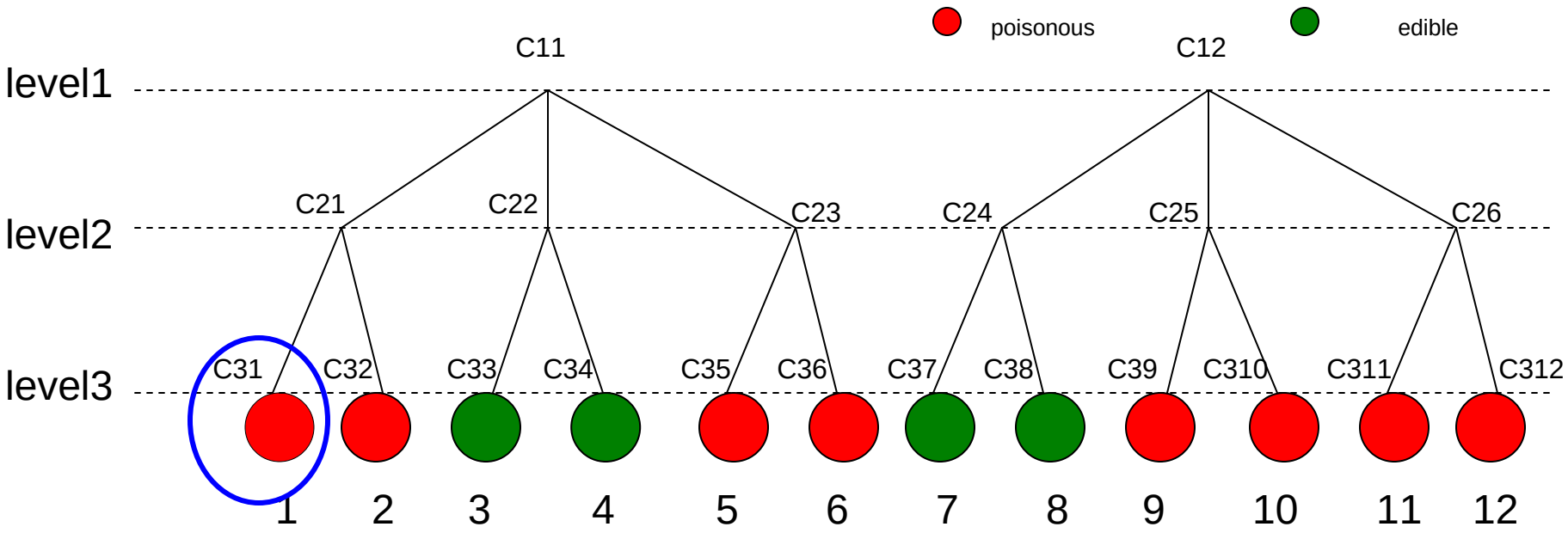
Noise Tolerance of the Hierarchical Clustering Algorithm



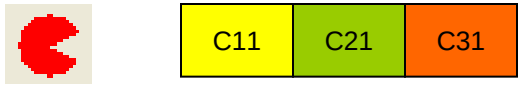
Clustering Reduces the Number of Unique Instances

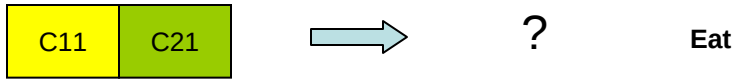


The Complete Task

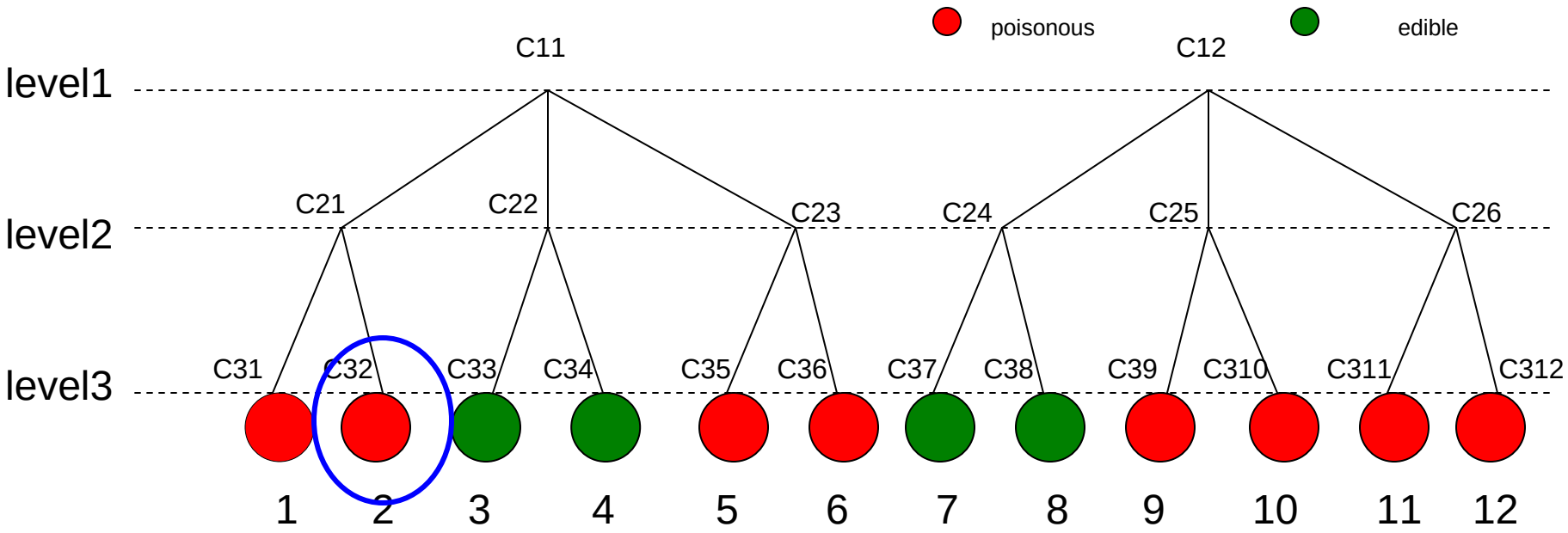


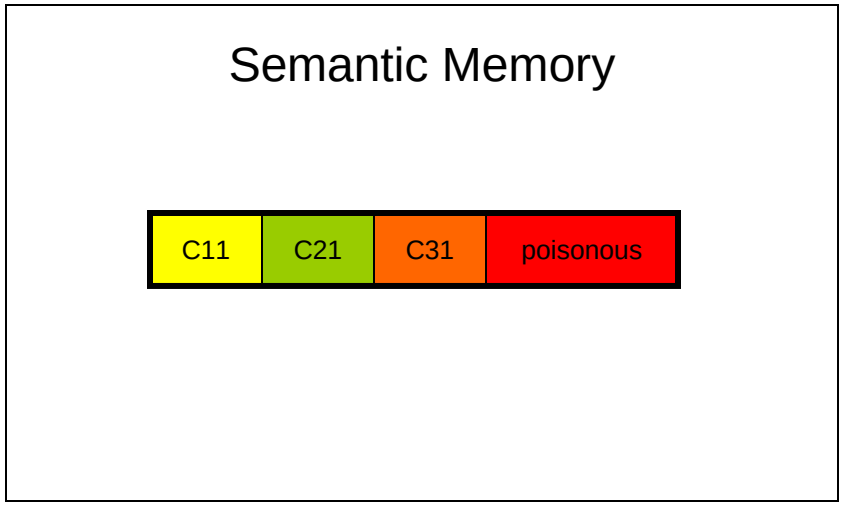
Semantic Memory

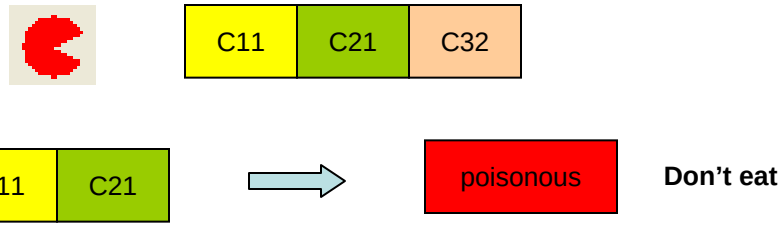




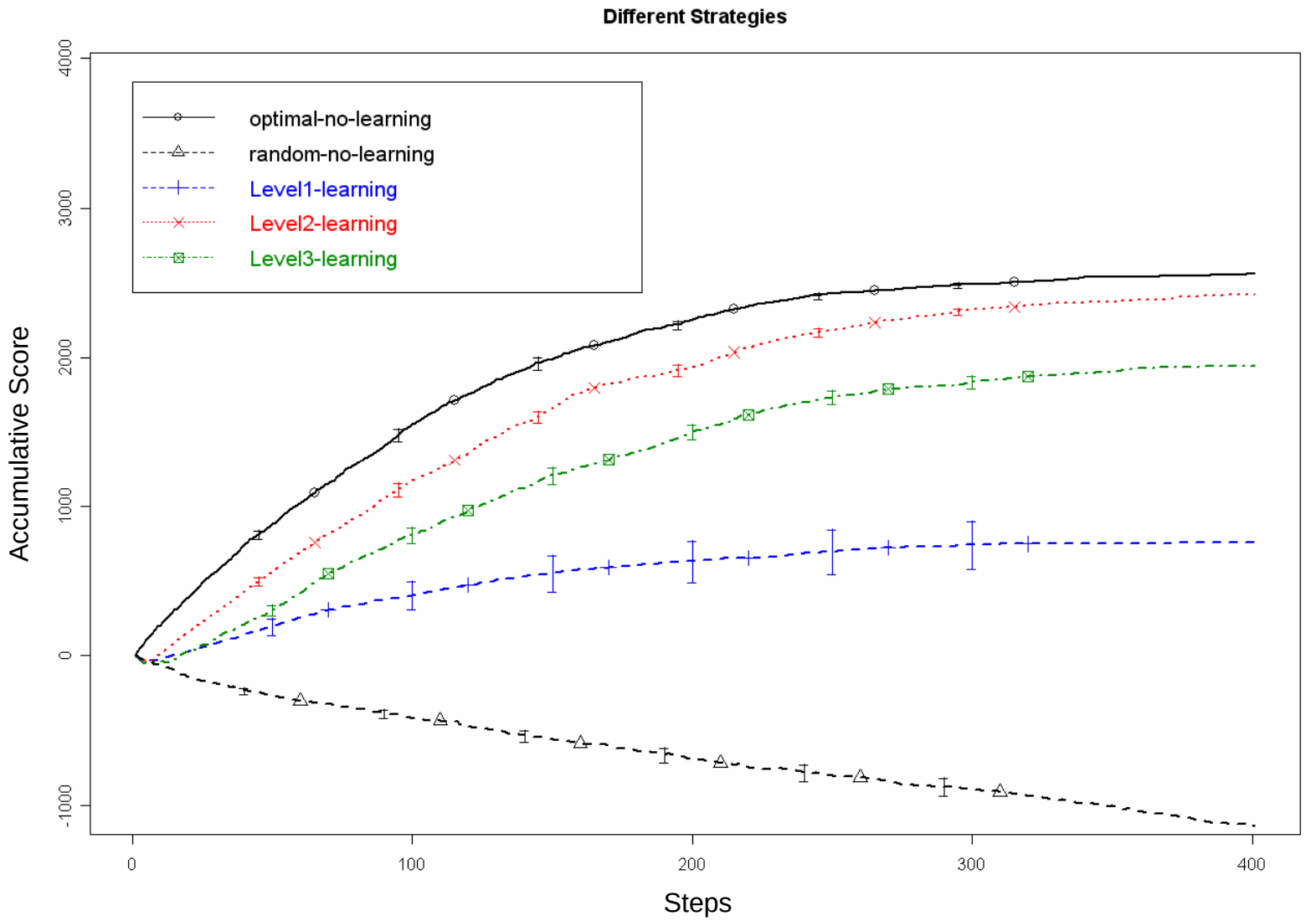
The Complete Task



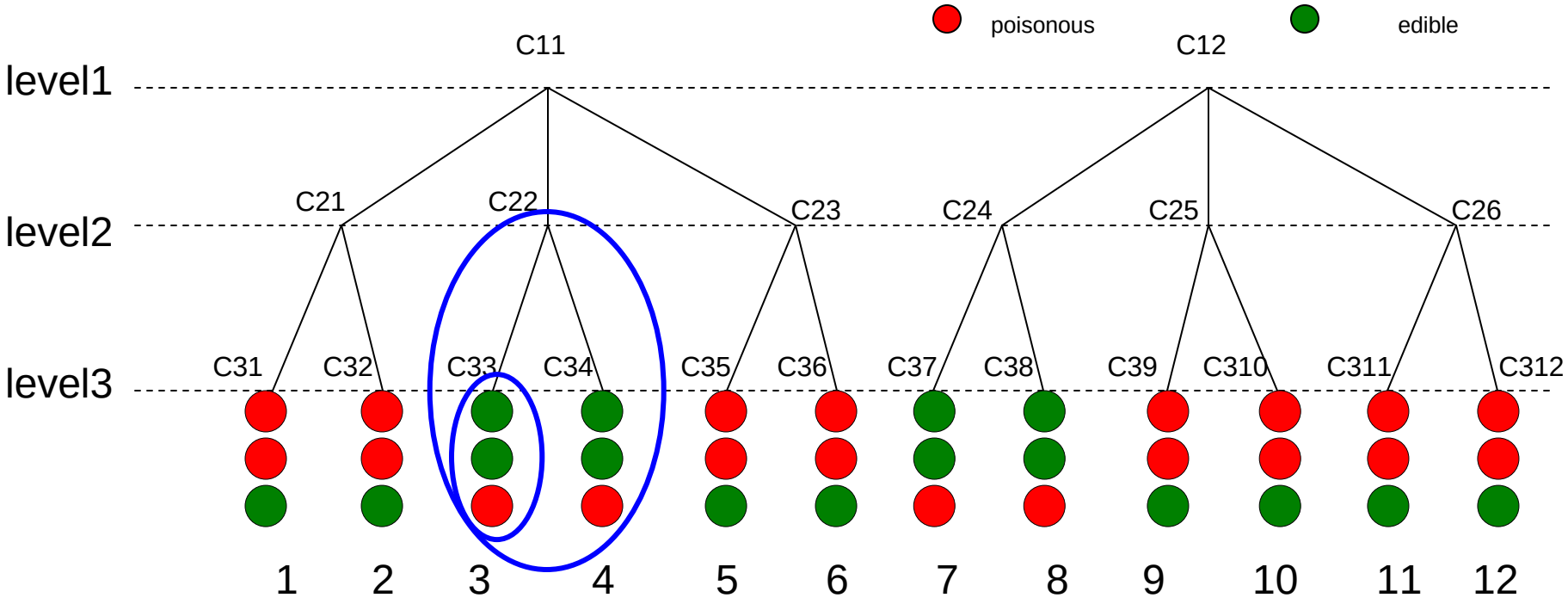




Compare Different Strategies



The Situation with More Noise



Semantic Memory

C11	C22	C33	edible
C11	C22	C33	poisonous
C11	C22	C34	edible
C11	C22	C34	poisonous

Reference history

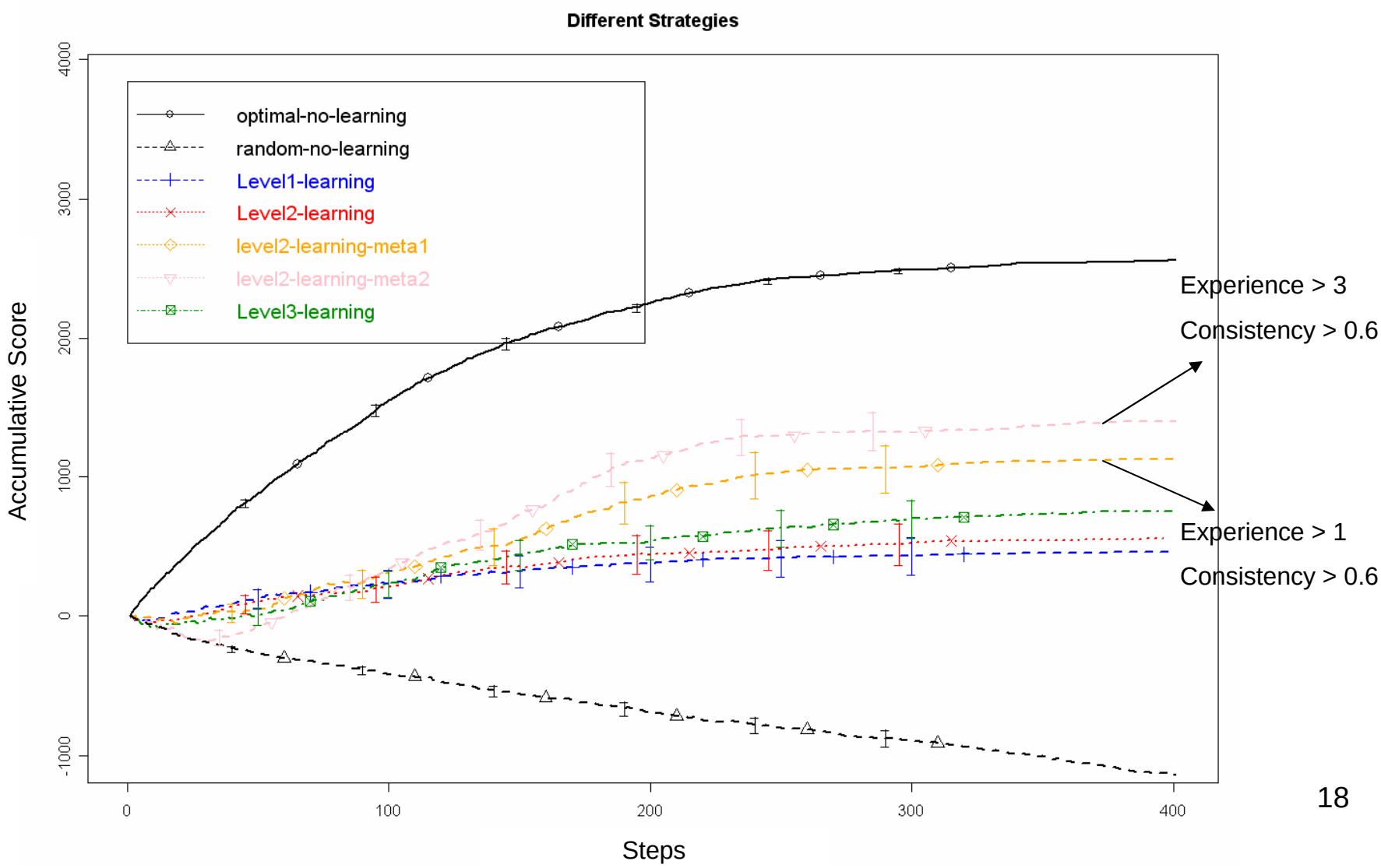
- 5, 11, 13
- 7, 9
- 12, 14, 15, 21
- 25

C11 C22 C33

C11 C22

edible
^experience 10
^consistency 0.7

Retrieval Confidence Helps Decision Making



Summary

- Nuggets
  - Tested semantic memory in stochastic external environment
  - Integrated hierarchical clustering
  - New capability of learning abstract categories from instances (distinctive capability from episodic memory)
  - Semantic memory provides retrieval confidence useful for decision making
- Coals
  - The input in the task is arbitrarily constructed
  - Eater's domain is simple: simple reasoning, simple decision making and limited actions
  - Learning strategies in the experiment are simple
  - Haven't fully explored the benefit of hierarchical structure
  - Integration of hierarchical clustering algorithm is preliminary

Thank You