

Spreading Activation in Soar: An Update

Steven Jones

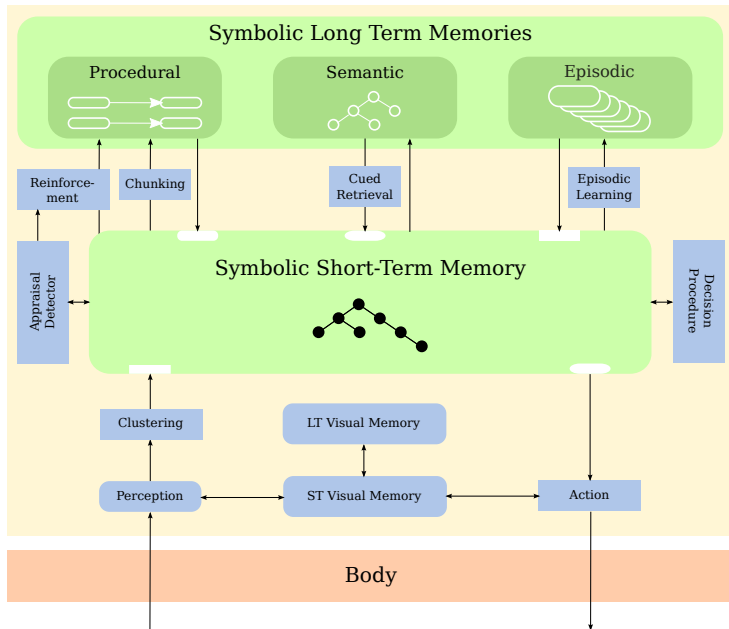
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Overview

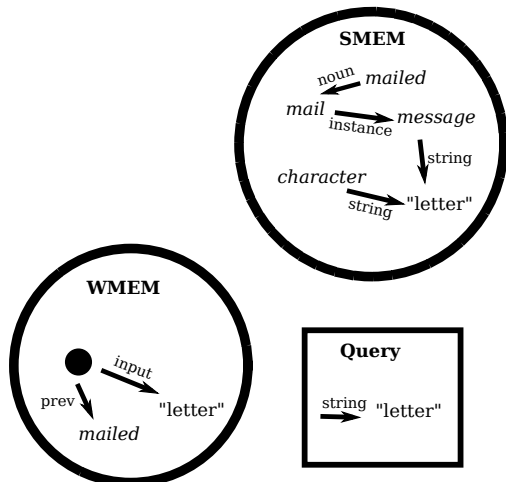
- 1 Problem: Ambiguous Contextualized Retrieval
- 2 Approach: Spreading Activation
 - The Naive Way
 - Improvements
- 3 Evaluation



Ambiguous Cue-based Retrieval

The postman[1] mailed[1] the letter[2] .

To disambiguate:
message, character



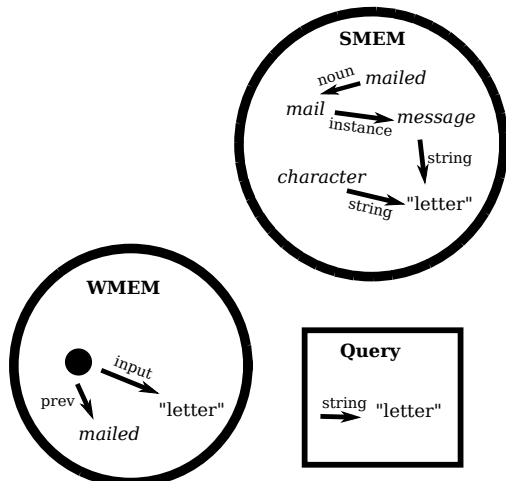
Ambiguous Cue-based Retrieval

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To disambiguate:

message, character

What if we have more information?

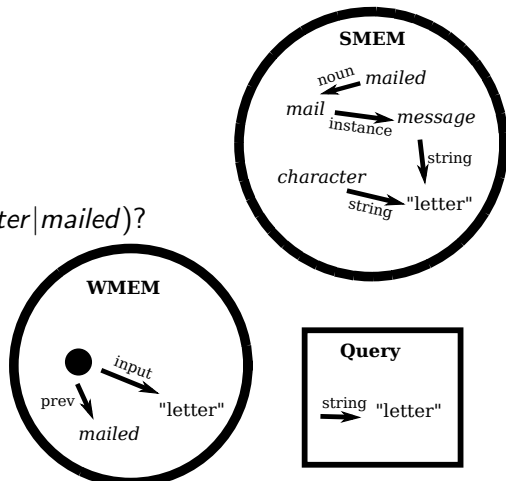


Ambiguous Cue-based Retrieval

The postman[1] mailed[1] the letter[2] .

To disambiguate:
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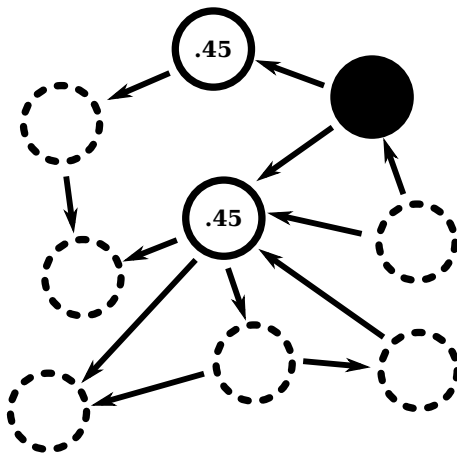
$$P(\text{message}|\text{mailed}) > P(\text{character}|\text{mailed})?$$



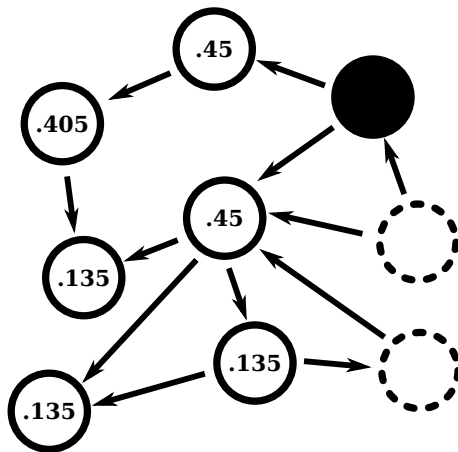
Approach: Spreading Activation

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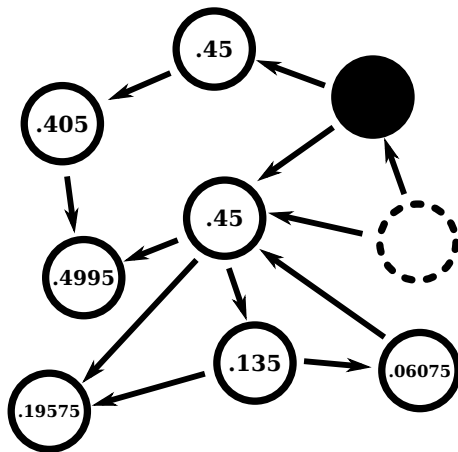
Spreading Activation: The Model



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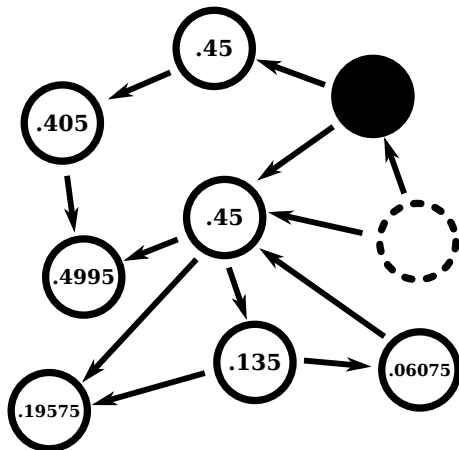
Spreading Activation: The Model



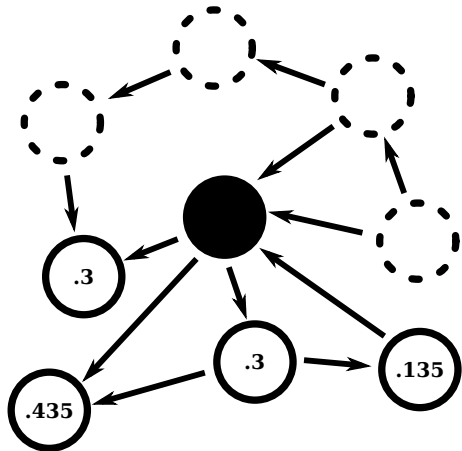
Spreading Activation: The Model

Properties

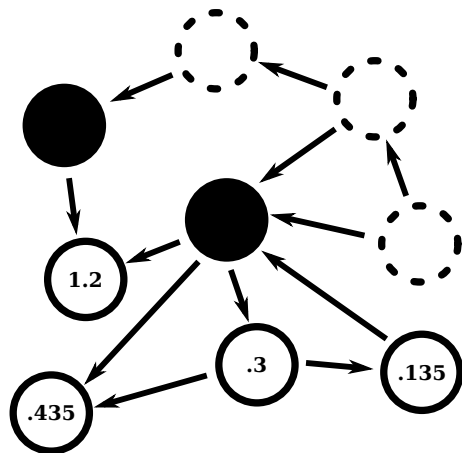
- Decays with distance from context.
- More connections to a node give higher value.



How to calculate? What algorithm?



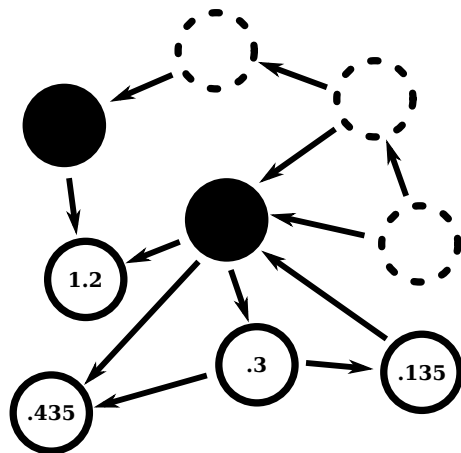
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How to calculate? What algorithm?

Problems

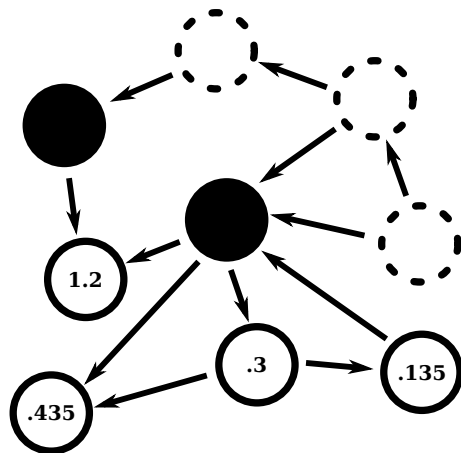
- Always recompute from scratch



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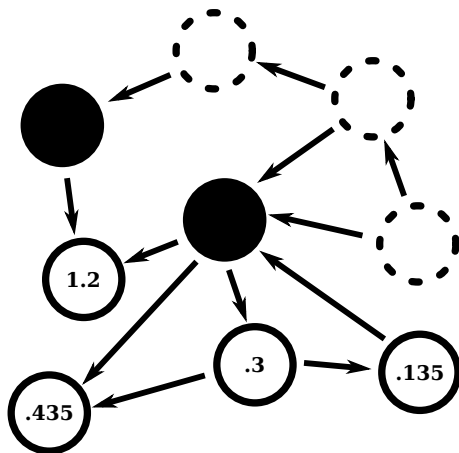
- Always recompute from scratch
- Won't reuse good values



How to calculate? What algorithm?

Problems

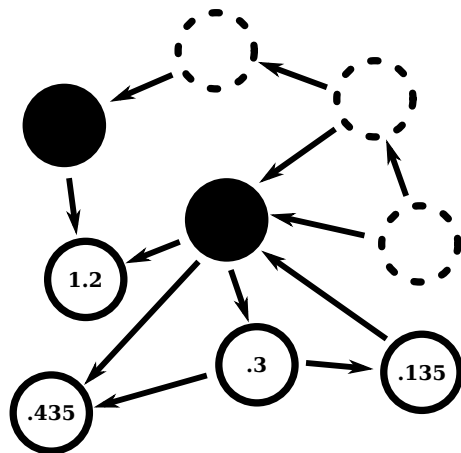
- Always recompute from scratch
- Won't reuse good values
- Might not even need calculated values



How to calculate? What algorithm?

Problems

- Wasted Computation



How to avoid wasteful computation during a task

- Only process changes
- Cache already-calculated spread
- Precalculate
- Defer processing until queries
- Don't process in unambiguous queries
- Only process spread for potential query results

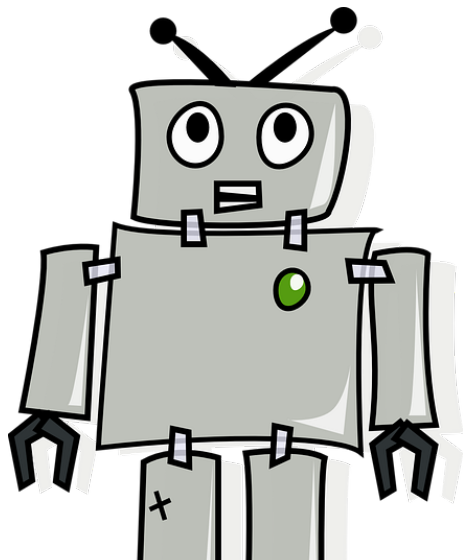
How to avoid wasteful computation during a task

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- **Defer processing until queries**
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Bold improvements already exist in ACT-R.

An Example of Waste

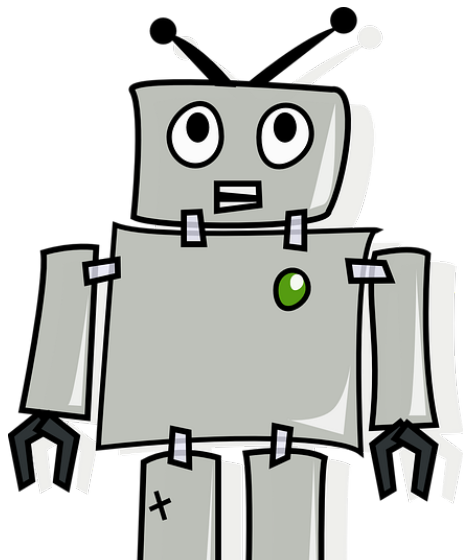
List for Context:



An Example of Waste

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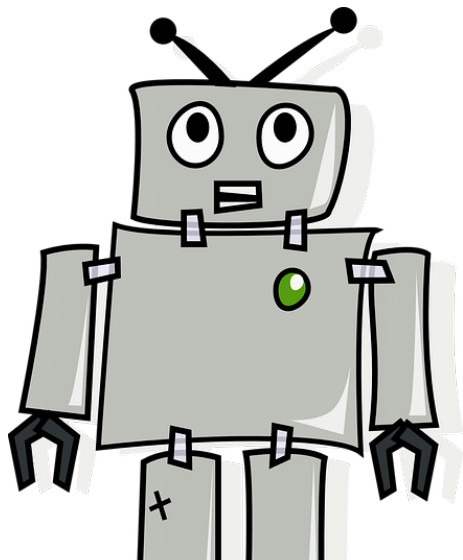
- apple



An Example of Waste

List for Context:

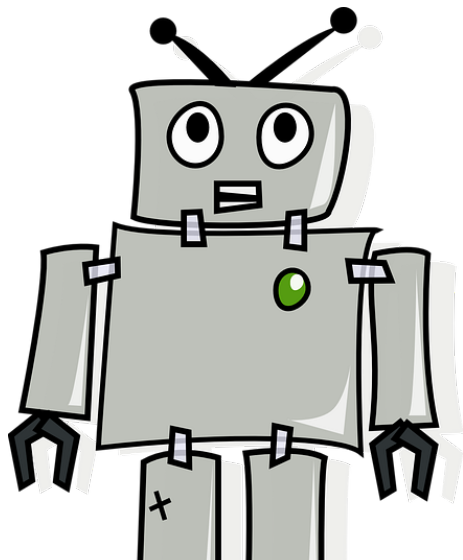
- apple
- banana



An Example of Waste

List for Context:

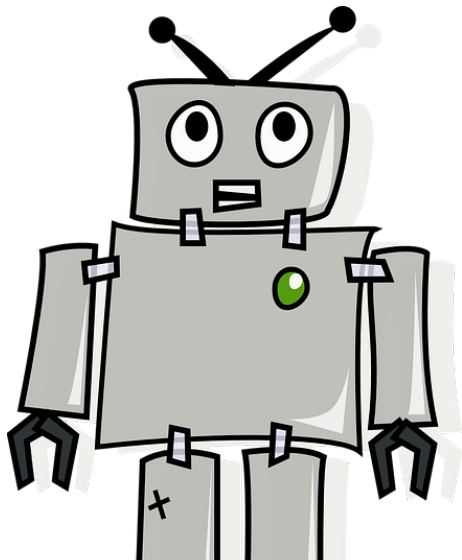
- apple
- banana
- watermelon



An Example of Waste

List for Context:

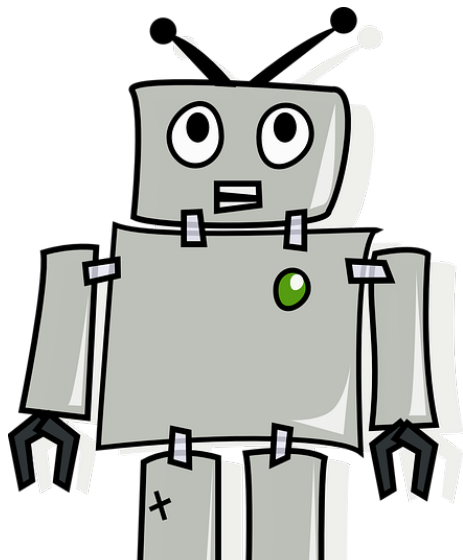
- apple
- banana
- watermelon
- orange



An Example of Waste

List for Context:

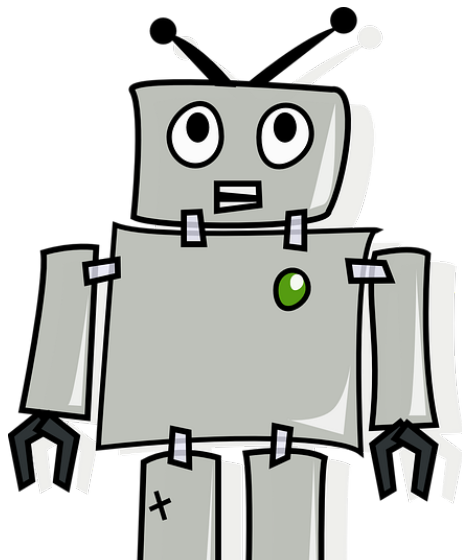
- apple
- banana
- watermelon
- orange
- grape



An Example of Waste

List for Context:

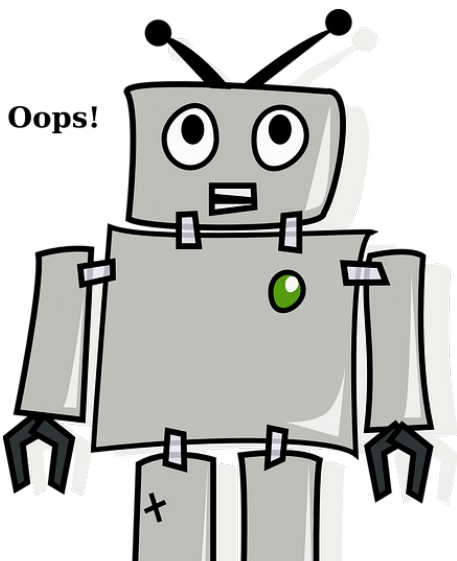
- apple
- banana
- watermelon
- orange
- grape
- potato



An Example of Waste

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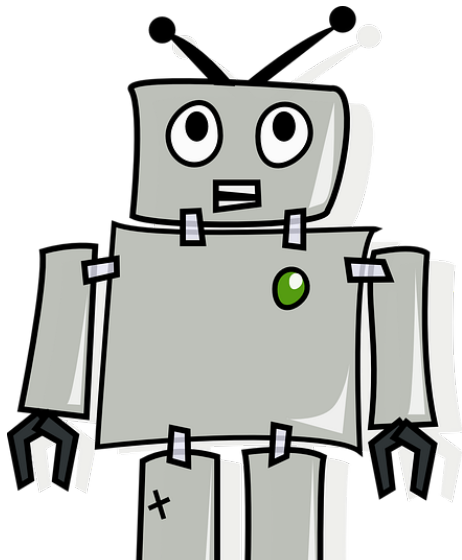
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An Example of Waste

List for Context:

- apple
- banana
- watermelon
- orange
- grape

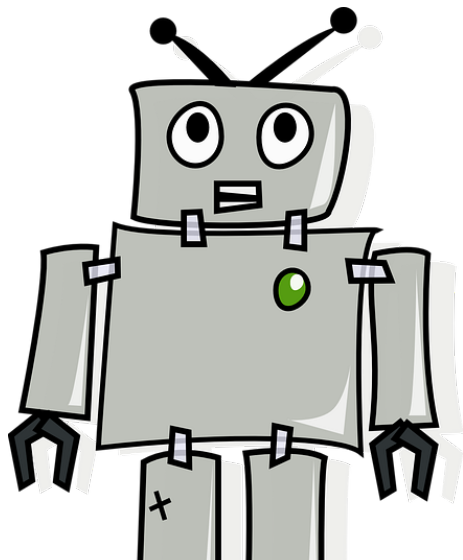


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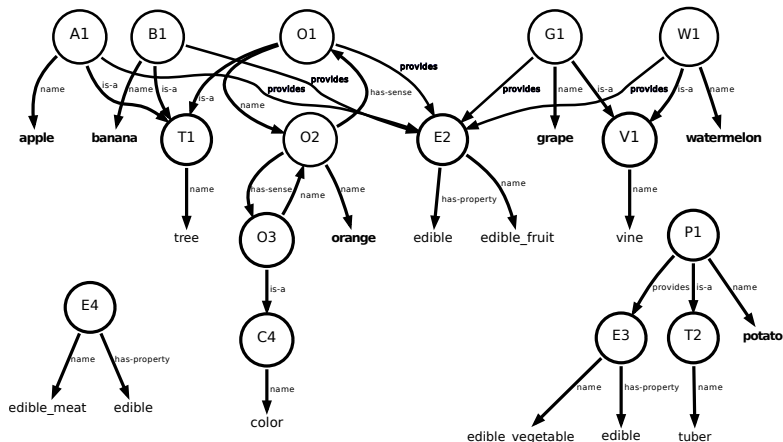
List for Context:

- apple
- banana
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- orange
- grape

Then, ask questions (do queries).



An Example of Waste



An Example of Waste

Decision Cycle	LTI source
12345678	@A1 (apple)
2345678	@B1 (banana)
345678	@W1 (watermelon)
45678	@O2 (orange)
5678	@G1 (grape)
678	@P1 (potato)

Bold indicates spreading activation calculation.

Change-Only Processing

Decision Cycle	LTI source
12345678	@A1 (apple)
2345678	@B1 (banana)
345678	@W1 (watermelon)
45678	@O2 (orange)
5678	@G1 (grape)
678	@P1 (potato)

Change-Only Processing

Decision Cycle	LTI source
1 2345678	@A1 (apple)
2 345678	@B1 (banana)
3 45678	@W1 (watermelon)
4 5678	@O2 (orange)
5 678	@G1 (grape)
6 78	@P1 (potato)

Spread Caching

Suppose that at $t=-3$ and -5 , the agent had already encountered apple and watermelon, respectively.

Decision Cycle	LTI source
1 2345678	@A1 (apple)
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Spread Caching

Suppose that at $t=-3$ and -5 , the agent had already encountered apple and watermelon, respectively.

Decision Cycle	LTI source
<i>1</i> 2345678	@A1 (apple)
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4 5678	@O2 (orange)
5 678	@G1 (grape)
6 78	@P1 (potato)

Blue italics indicates reduced computation by caching.

Precalculation

Decision Cycle	LTI source
1 2345678	@A1 (apple)
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Query-Deferred Processing

Postpone the spreading calculations until the query (when they are needed).

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1 2345678	@A1 (apple)
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Query-Deferred Processing

Postpone the spreading calculations until the query (when they are needed).

Decision Cycle	LTI source
1234567 8	@A1 (apple)
234567 8	@B1 (banana)
34567 8	@W1 (watermelon)
4567 8	@O2 (orange)
567 8	@G1 (grape)
678	@P1 (potato)

Ambiguity-Only Processing

Cue:

Answer:

Decision Cycle	LTI source
1 2 3 4 5 6 7 8	@A1 (apple)
2 3 4 5 6 7 8	@B1 (banana)
3 4 5 6 7 8	@W1 (watermelon)
4 5 6 7 8	@O2 (orange)
5 6 7 8	@G1 (grape)
6 7 8	@P1 (potato)

Ambiguity-Only Processing

Cue: ^capital-of "Michigan"

Answer: Lansing

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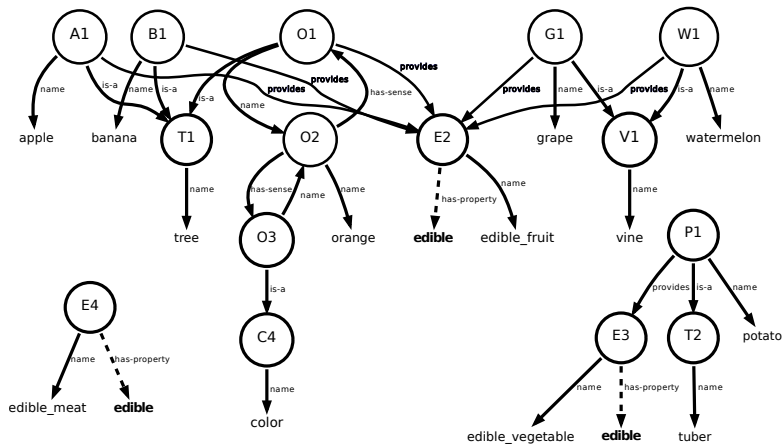
Ambiguity-Only Processing

Cue: ^has-property “edible”

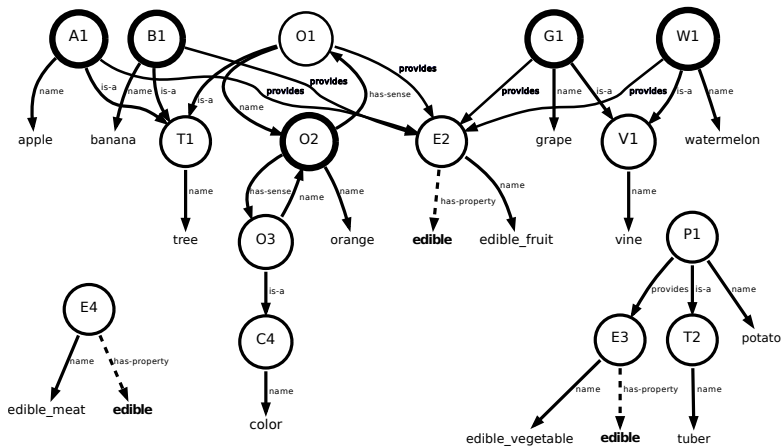
Answer: Edible Fruit, Edible Vegetable, Edible Meat

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Ambiguity-Only Processing



Candidate-Only Processing



Candidate-Only Processing

Cue: ^has-property “edible”

Answer: Edible Fruit, Edible Vegetable, Edible Meat

Recipients of Spread: Edible Fruit, Tree, Color, Vine

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Candidate-Only Processing

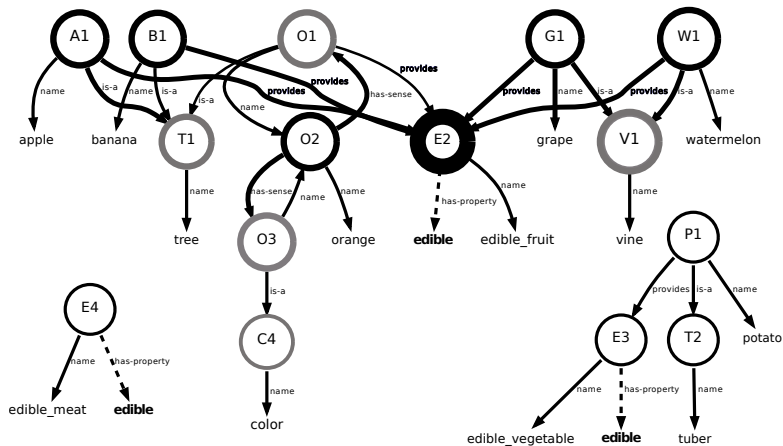
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Candidate-Only Processing



Evaluation

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Word Sense Disambiguation

Original sentence:

The postman put the letter in the mailbox.

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Corpus annotation:

The postman[1] put[1] the letter[2] in the mailbox[1] .

Word Sense Disambiguation

Original sentence:

The postman put the letter in the mailbox.

Corpus annotation:

The postman[1] put[1] the letter[2] in the mailbox[1] .

What the agent receives:

postman[?] put[?] letter[?] mailbox[?]

“letter” corresponding to message, not character

Measure of Improvements

Task Performance

- How many guesses does it take to get the right word sense?

Time

- How long does a processing cycle take?

Measure of Improvements

Task Performance

- ~~How many guesses does it take to get the right word sense?~~

Time

- How long does a processing cycle take?

Word Sense Disambiguation

Data Set - SemCor:

- Annotated version of a subset of the Brown corpus
- 352 texts of 2000 words each from fiction, nonfiction, books, journals, but no poetry
- >200,000 WordNet 3.0 sense references for nouns and verbs

Semantic Memory - WordNet 3.0:

- WordNet synonyms, antonyms, hypernyms, hyponyms, part-of, derivationally-related
- 470,000 nodes, 1,500,000 edges
- ~ .5GB

Working Memory (Context):

- Previous words

Results

Spreading Activation Mechanism	Spread Time (s)
Naive Spreading	>100,000
+ Change-Only Processing	3316
+ Caching	1200
+ Precalculation	810
+ Query-Deferred Processing	803
+ Ambiguity-Only Processing	778
+ Candidate-Only Processing	245

Timed performance on the WSD task across seven variants.

Rows with prefaced with “+” denote an additional cumulative improvement.

Bold indicates an improvement implemented in ACT-R.

Nuggets and Coal

Nuggets

Coal

Nuggets and Coal

Nuggets

- Much faster spreading activation

Coal

Nuggets and Coal

Nuggets

- Much faster spreading activation
- Worst case is only as bad as previous worst case

Coal

Nuggets and Coal

Nuggets

- Much faster spreading activation
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Coal

- No demonstration of spreading activation's utility

Nuggets and Coal

Nuggets

- Much faster spreading activation
- Worst case is only as bad as previous worst case

Coal

- No demonstration of spreading activation's utility
- Precalculation requires “large” database files

Future Work

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Edge Weights

Spreading Activation could be made to change over time similarly to
Base-level Activation.