

# Learning New Verbs with Retrospective Projection

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# Outline

- ① Introduction
- ② What to learn?
- ③ How to learn?
- ④ Conclusions

# Introduction

- Focus on
  - Action verbs: *move*
  - Perceptible goal: `in(object12, pantry)`
  - Composition of known primitives: `pick-up(object12), put-down(object12, pantry)`

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- Learning Mechanism
  - Interactive instruction
  - Retrospective projection
    - episodic memory of performing the task in an instructed trial
    - generalize from that specific, *situated* experience

# Required Knowledge

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- Procedural Knowledge
  - selection knowledge for breaking ties between known primitives
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  - procedural memory



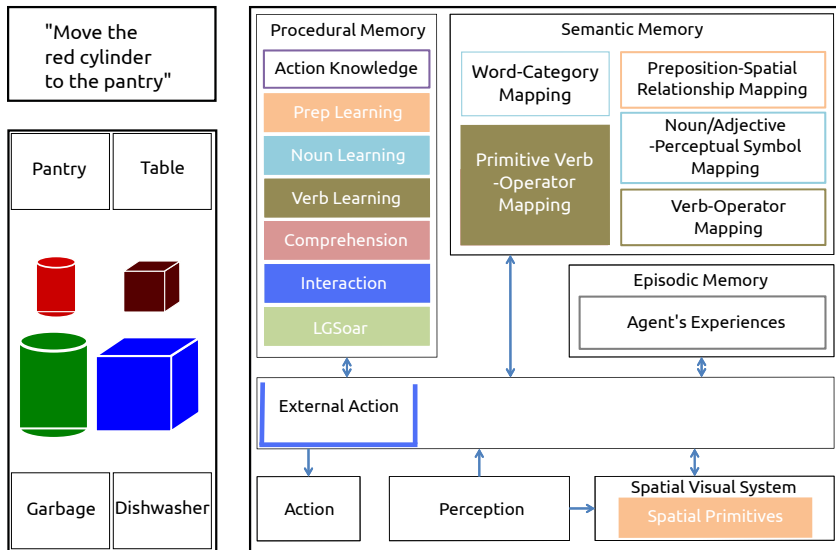
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- Semantic Knowledge
  - goal predicates: `in{pantry, the red block}`
  - explicit, declarative description from the instructor: "*The goal is the red block is in the pantry*".
  - semantic memory

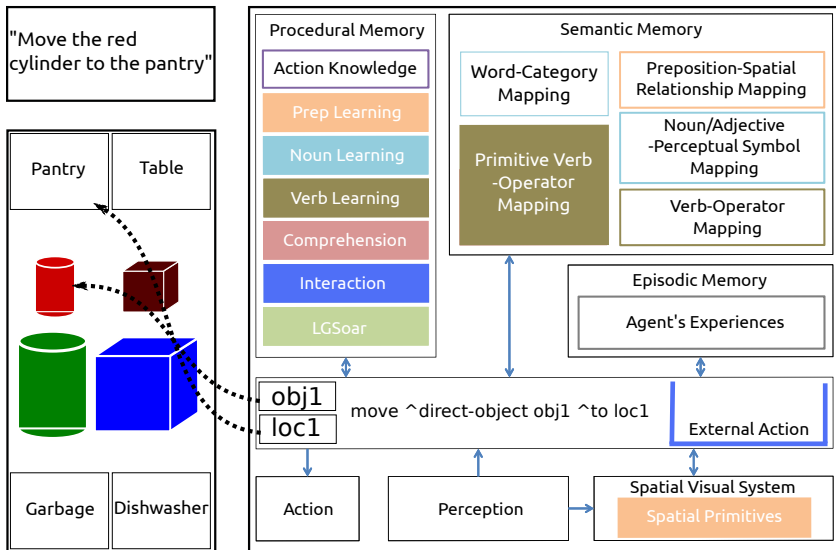
# Acquire Linguistic Mapping

[Failure: Grounded Comprehension Phase]



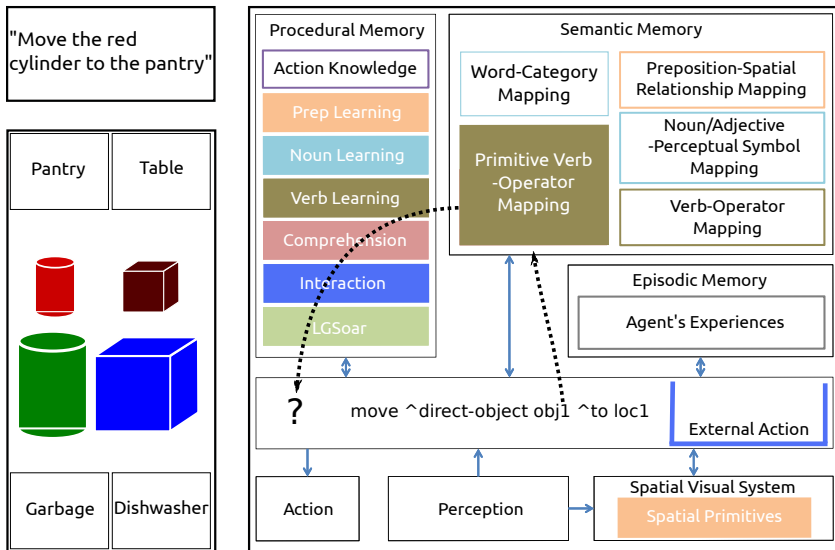
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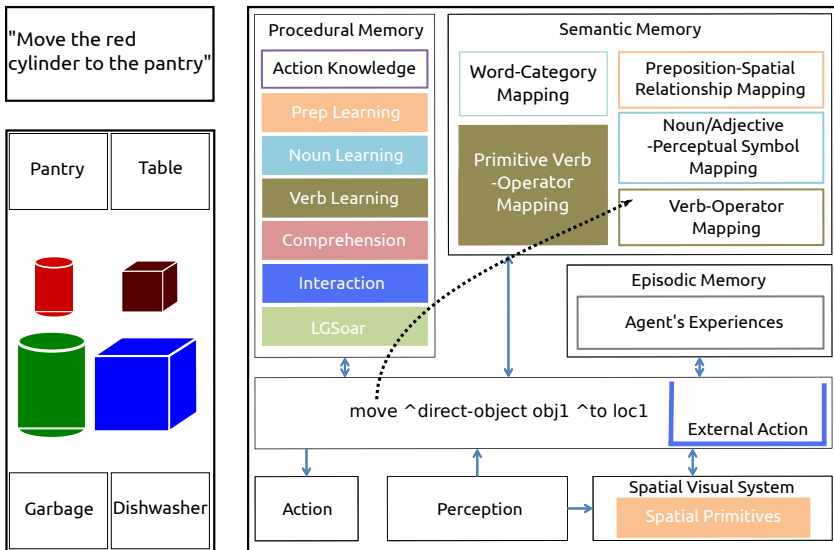
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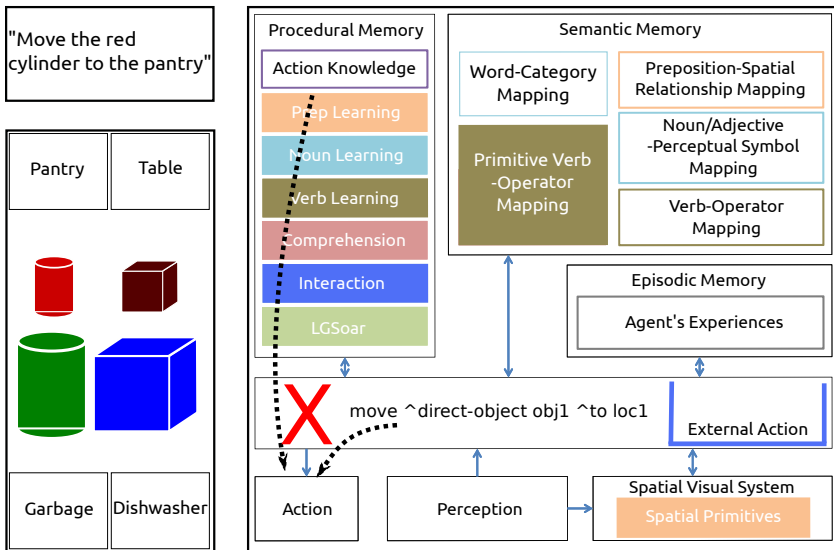
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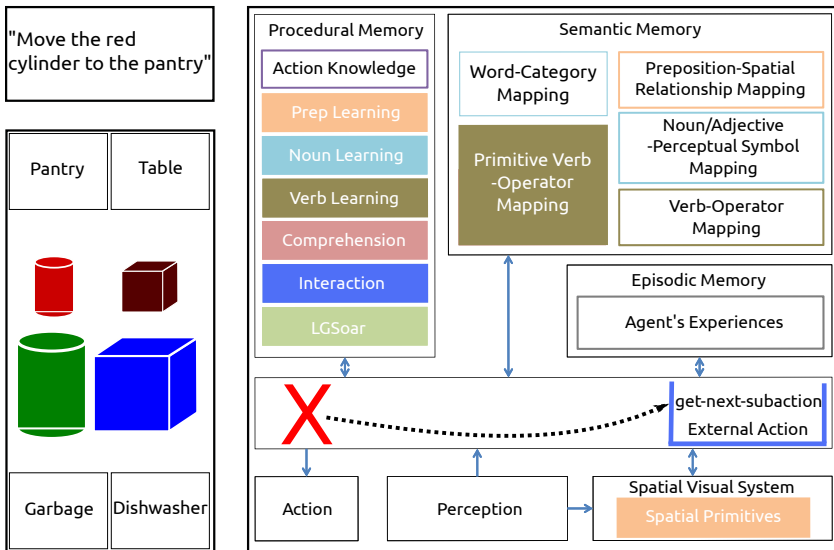
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[Failure: Behavior Execution Phase]



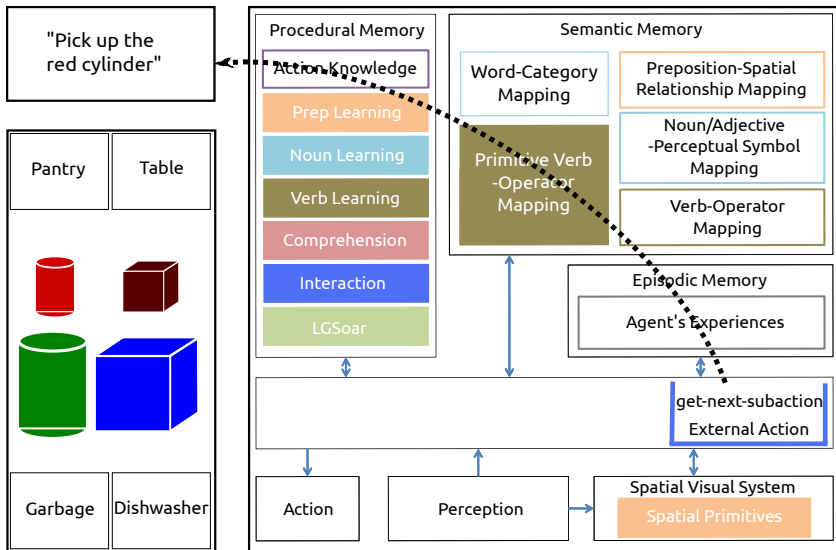
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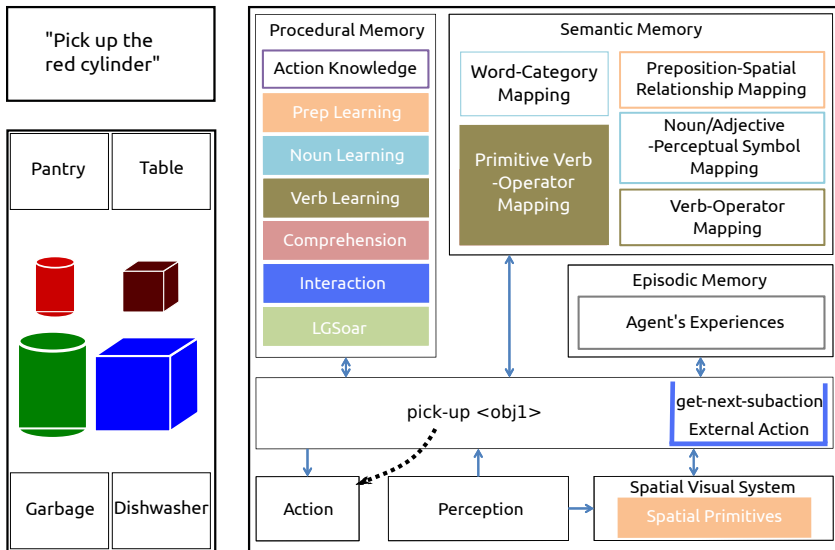
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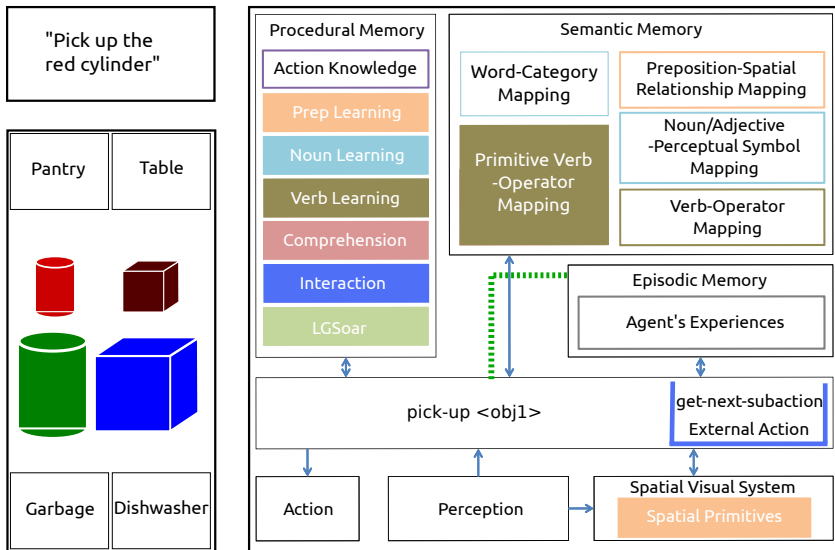
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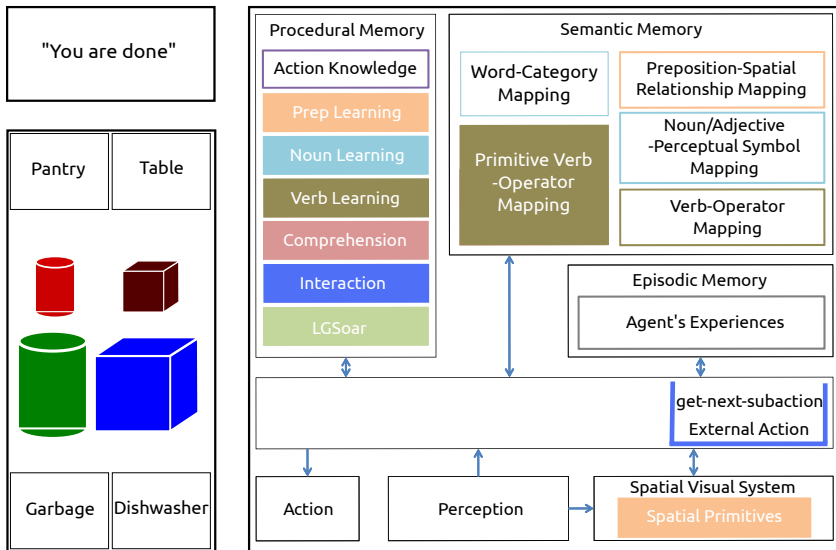
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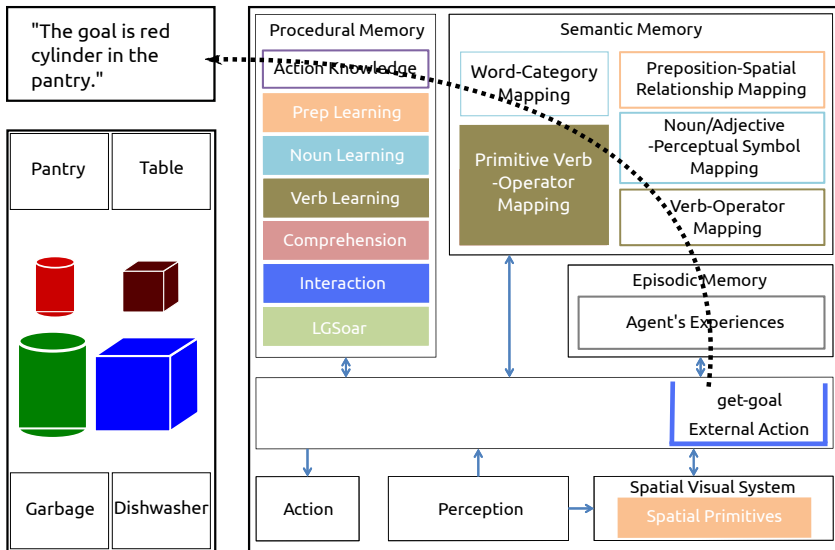
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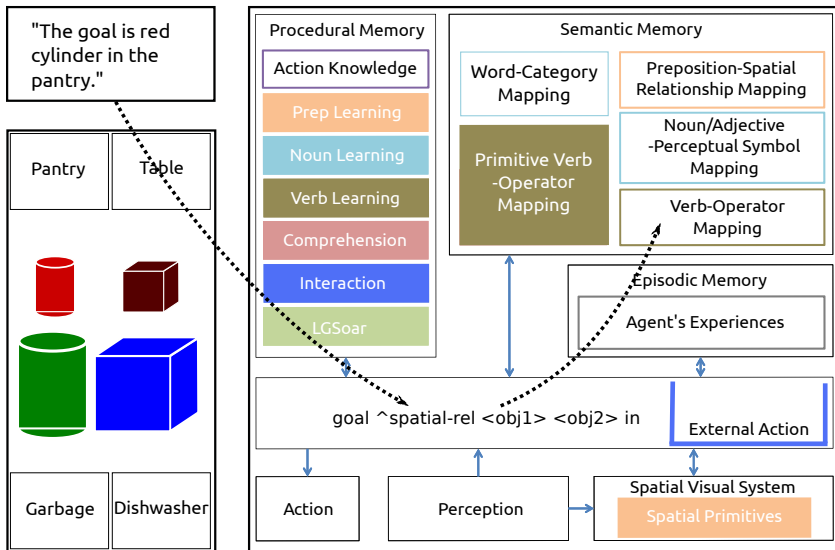
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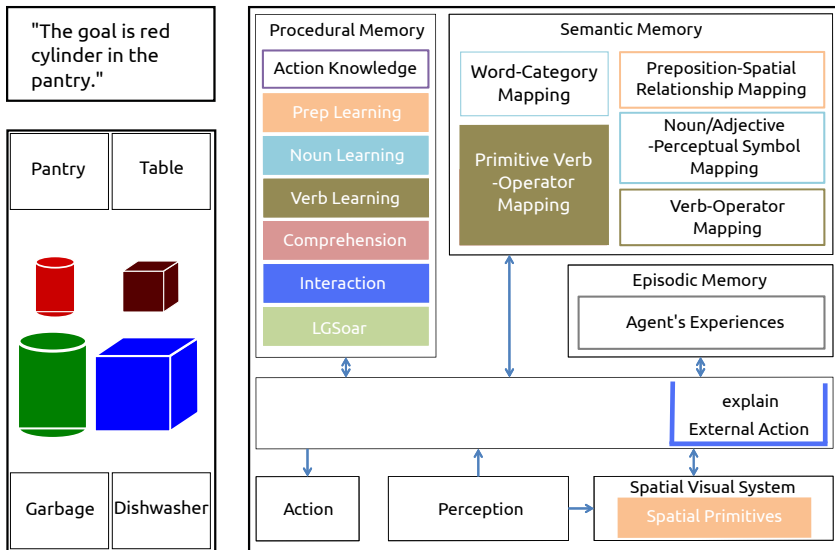
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# Acquire Procedural Knowledge

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## **Stage I: Retrospective Recall**

# Acquire Procedural Knowledge

[Failure: Behavior Execution Phase]

## **Stage I: Retrospective Recall**

- De-couple from the current state

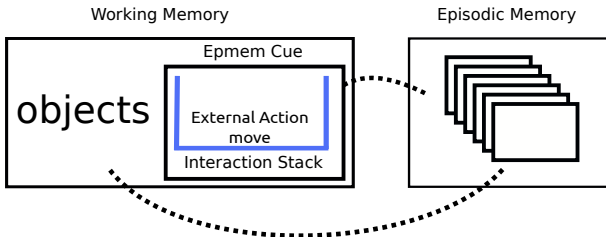


# Acquire Procedural Knowledge

[Failure: Behavior Execution Phase]

## Stage I: Retrospective Recall

- De-couple from the current state
- Recreate the 'beginning' state: **explanation**

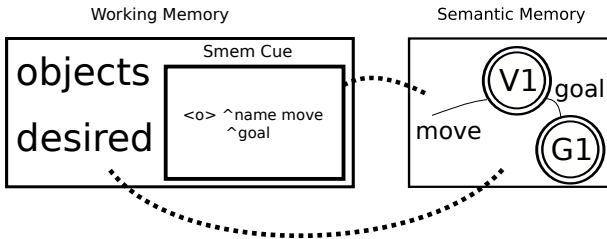


# Acquire Procedural Knowledge

[Failure: Behavior Execution Phase]

## Stage I: Retrospective Recall

- De-couple from the current state
- Recreate the 'beginning' state: **explanation**
- Assign the desired state

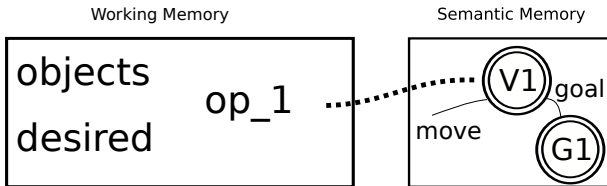


# Acquire Procedural Knowledge

[Failure: Behavior Execution Phase]

## Stage I: Retrospective Recall

- De-couple from the current state
- Recreate the 'beginning' state: **explanation**
- Assign the desired state
- Propose the operator to be learned in **explanation**



# Acquire Procedural Knowledge

[Failure: Behavior Execution Phase]

## **Stage II: Forward Projection**

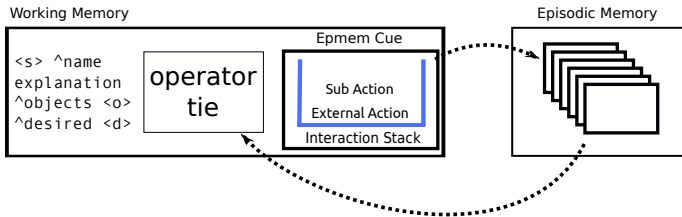
- Selection Space using Situated Experience

# Acquire Procedural Knowledge

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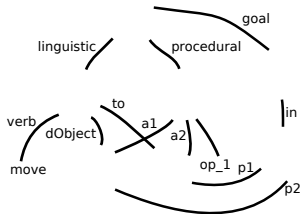
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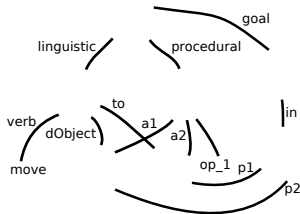
# Acquired Knowledge

- New Verb-Operator Mapping



# Acquired Knowledge

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- Selection Chunks

## chunk-1

```
<s1> ^name op_1 ^argument1 <o1> ^argument2 <l1> ^object <o1>  
^object <o2> <o2> ^category location
```

```
<s1> ^operator <op2> <op2> ^name pick-up ^argument1 <o1>
```

```
-->
```

```
<s1> ^operator <op2> >
```

## chunk-2

```
<s1> ^name op_1 ^argument1 <o1> ^argument2 <l1> ^object <o1>  
^grabbed <o1> ^object <o2> <o2> ^category location
```

```
<s1> ^operator <op2> <op2> ^name put-down ^argument1 <o1>  
^argument2 <l1>
```

```
-->
```

```
<s1> ^operator <op2> >
```

# Future Work

- Construct a taxonomy of verbs/actions based on
  - argument structure; intransitive, transitive, di-transitive
  - goal semantics
  - interactions required
- Currently, declarative goal specification is required
  - can this be acquired through multiple executions of the task?
- Learn proposal knowledge
  - associate with object affordances



# Nuggets and Coal

- Nuggets
  - Learning is embedded within an interaction, language understanding framework
  - Impasse driven
    - agent acquires ‘useful’ knowledge about the task
  - Multiple kinds of knowledge is acquired
    - knowledge of a ‘verb’ is distributed across modalities
- Coal
  - Incomplete
    - proposal knowledge
    - selection knowledge between composite verbs
  - Evaluation
    - Quantitative measure of generality of learning