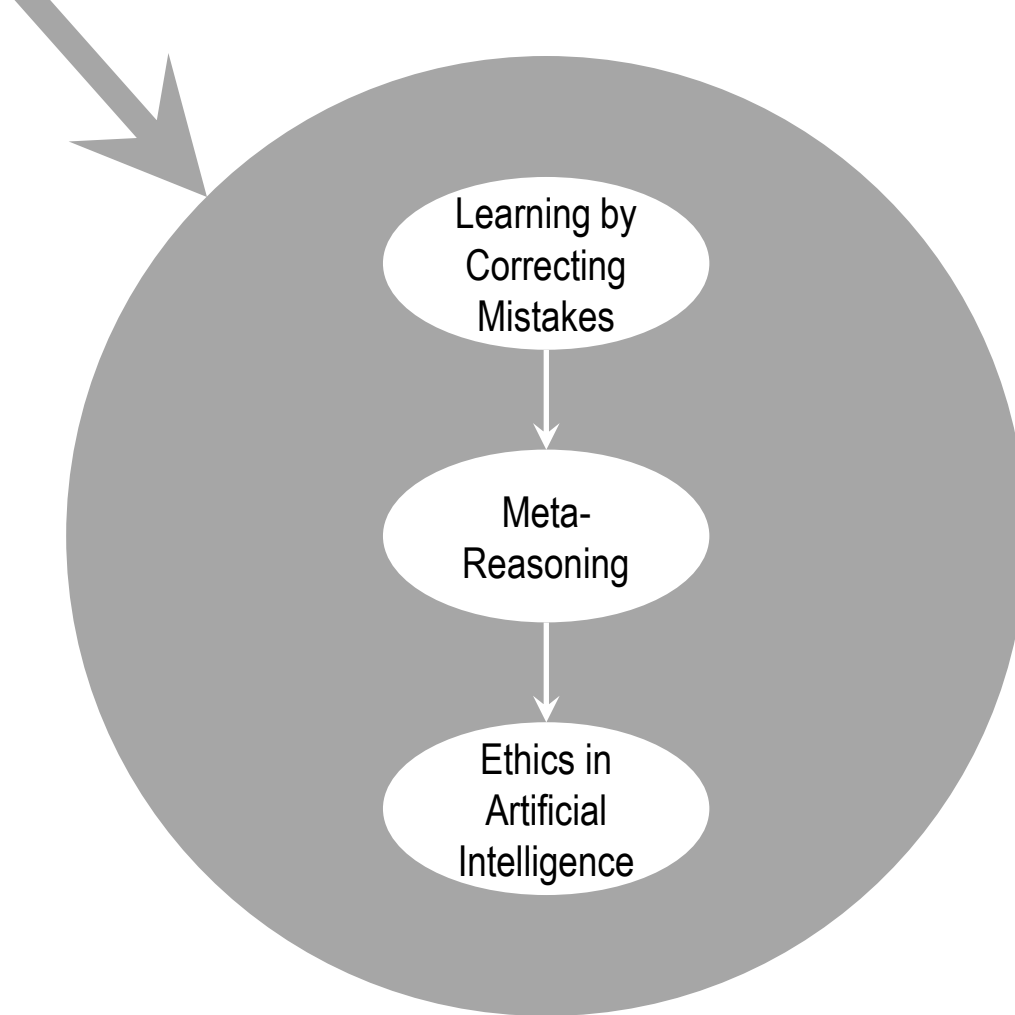




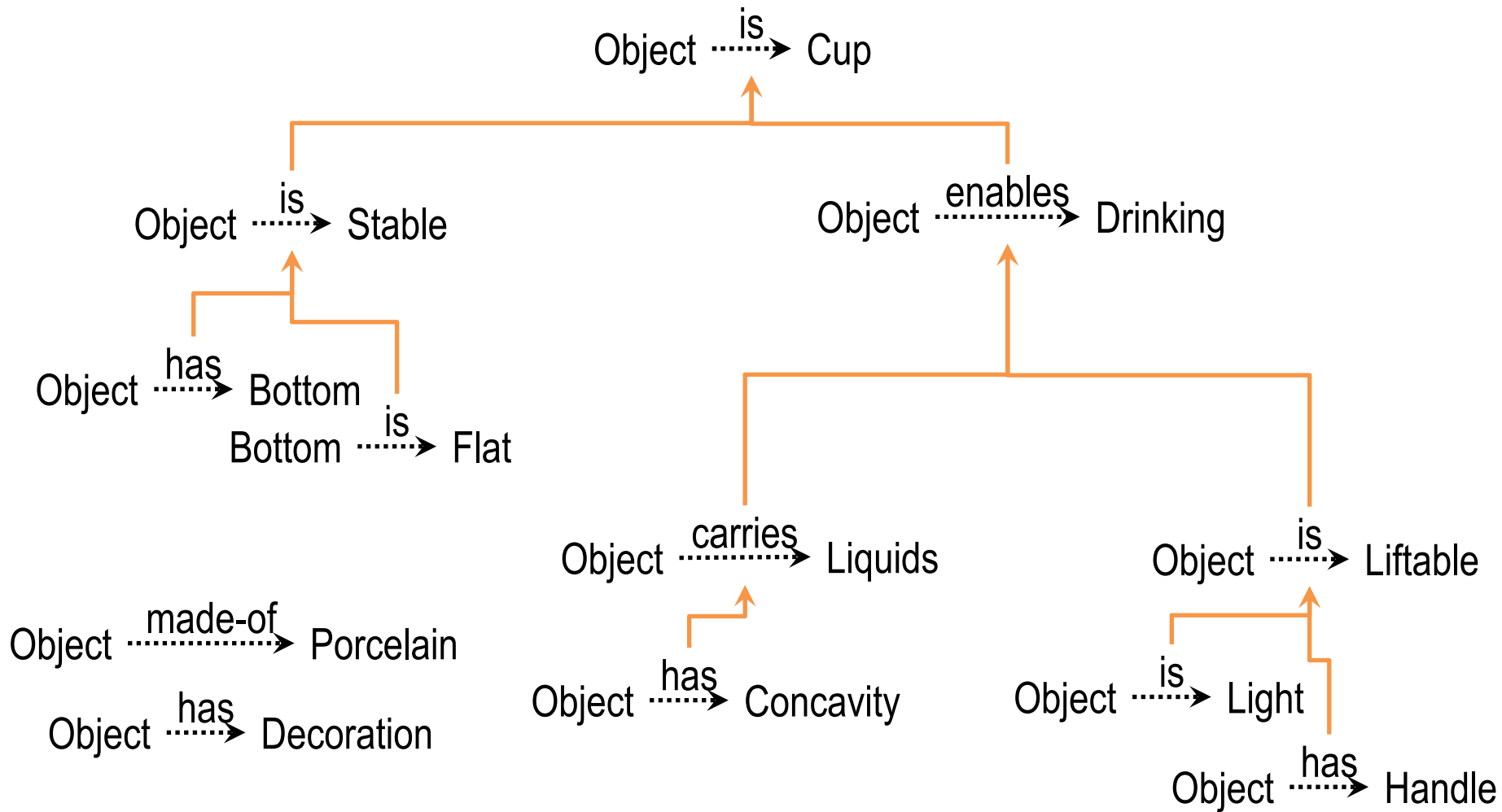
Meta-  
Reasoning

# Metacognition



## Lesson Preview

- Mistakes in knowledge, reasoning, and learning
- Gaps in knowledge and reasoning
- Strategy selection and integration
- Meta-meta-reasoning?
- Goal-based autonomy



# Cognitive System

Metacognition

Deliberation

Reasoning

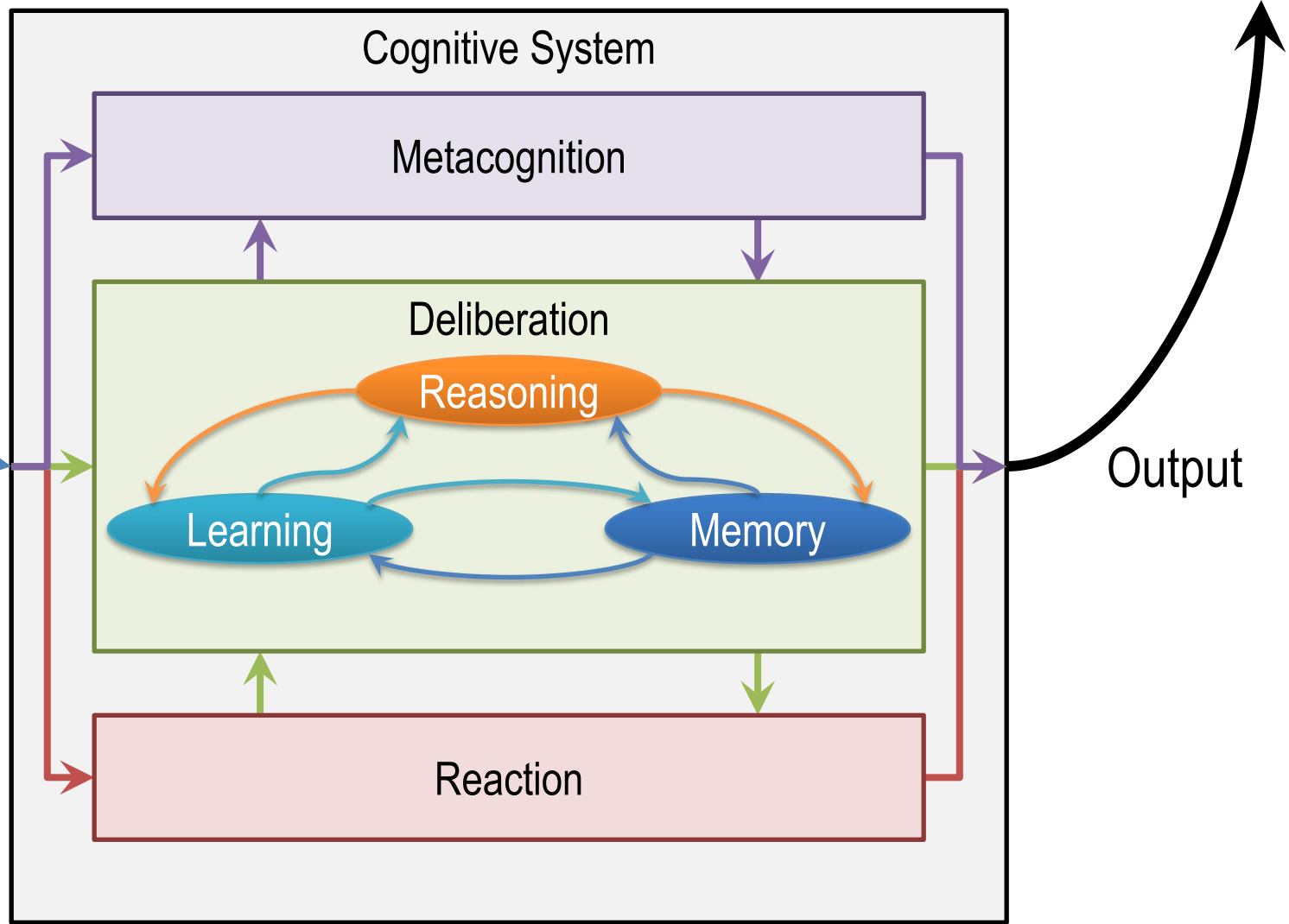
Learning

Memory

Reaction

Input

Output



*Current State*



A on B

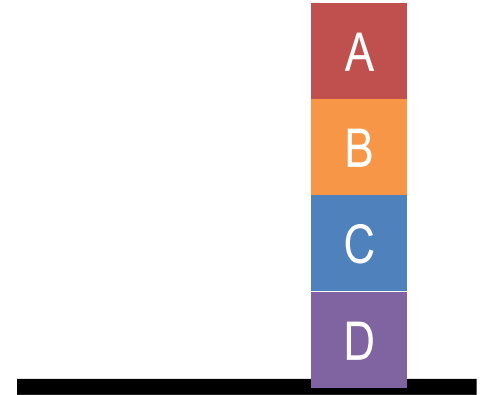
B on C

C on Table

D on Table

$$\Delta = 1$$

*Goal State*



A on B

B on C

C on D

D on Table

# Cognitive System

Metacognition

Deliberation

Reasoning

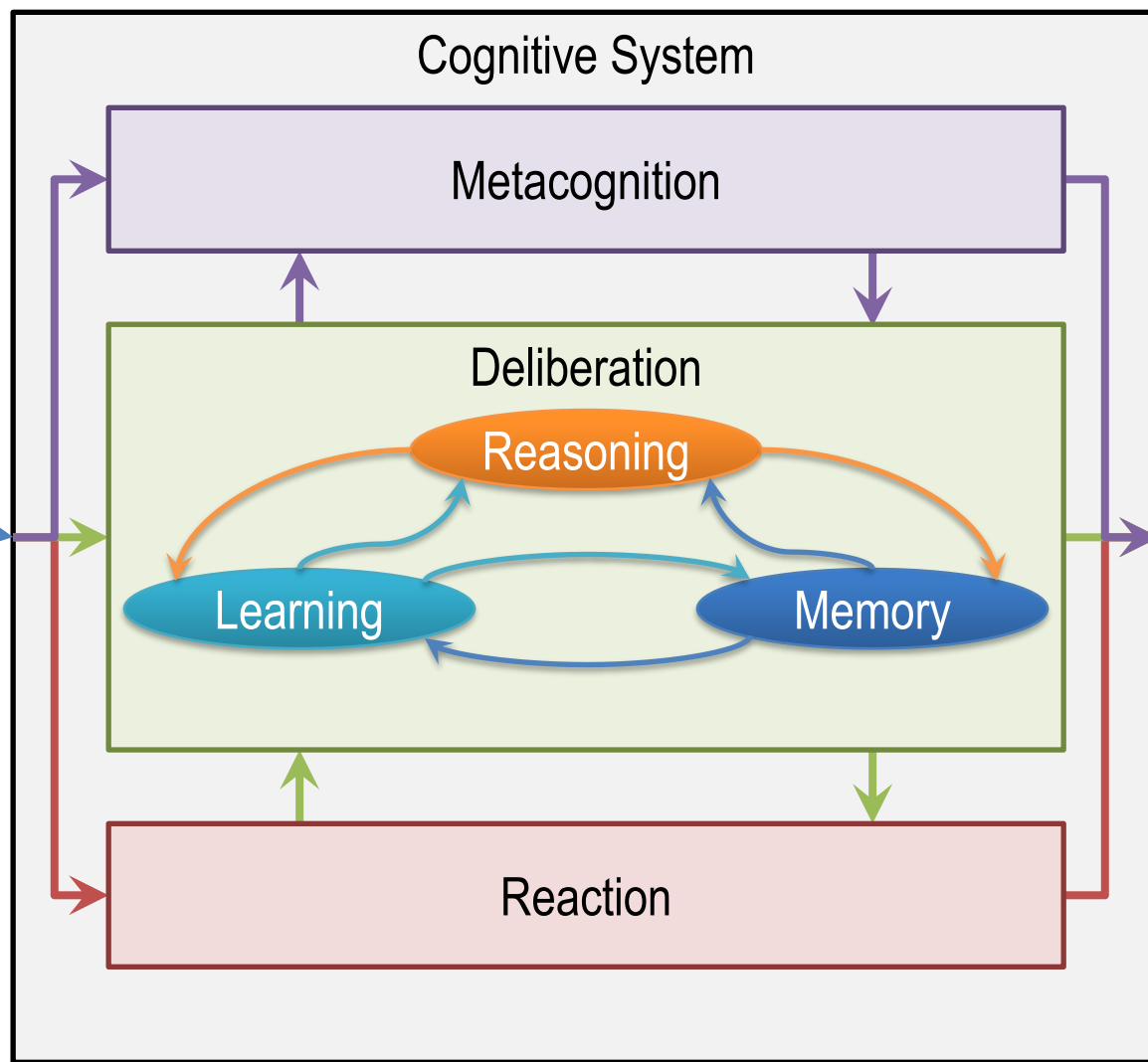
Learning

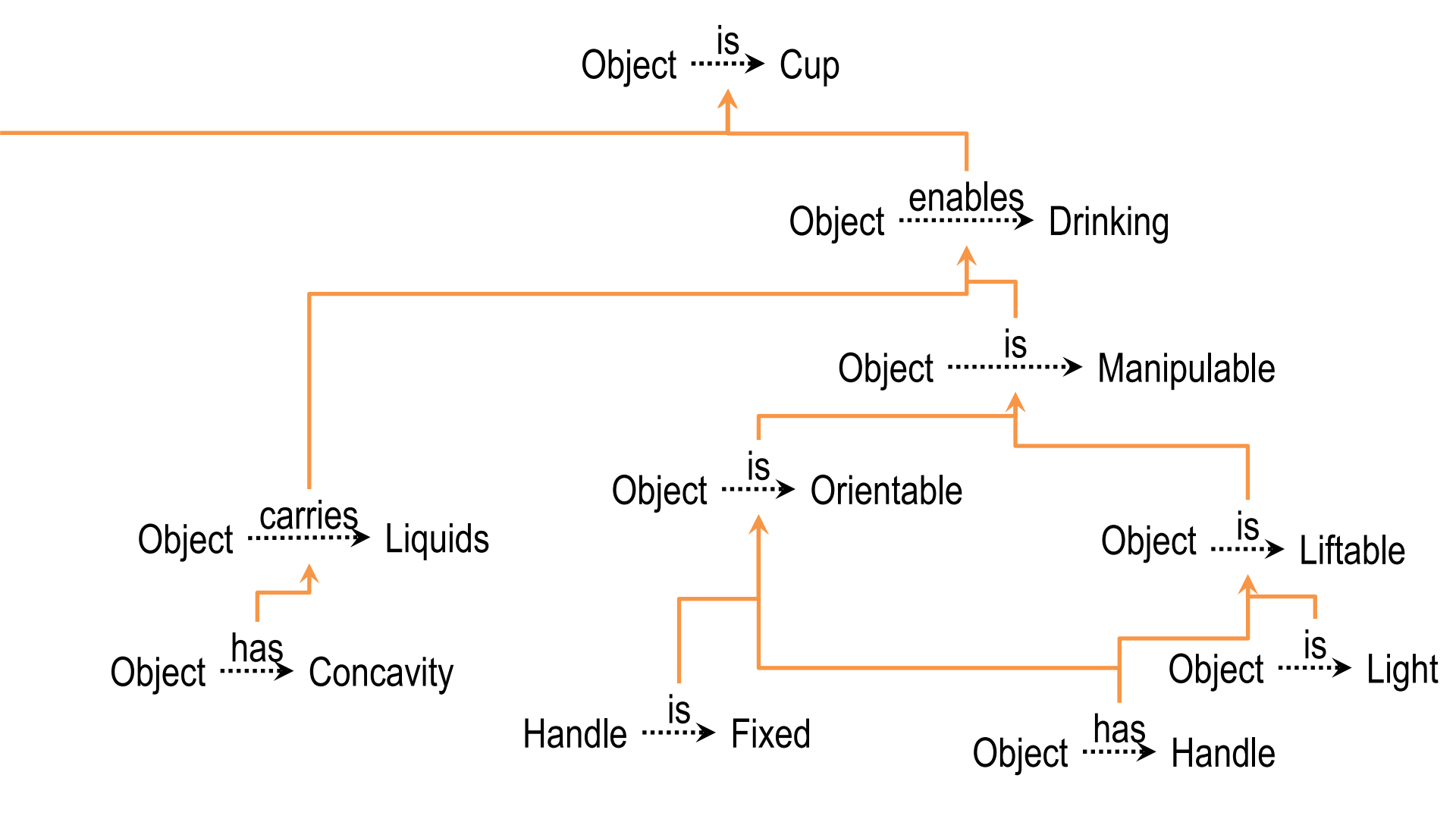
Memory

Reaction

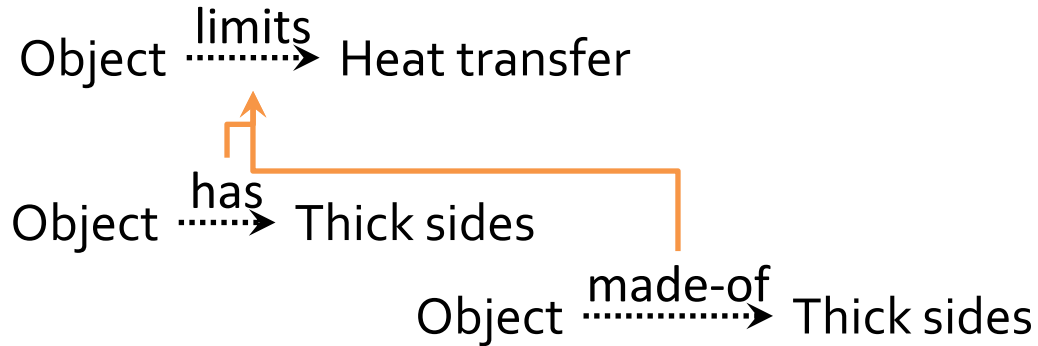
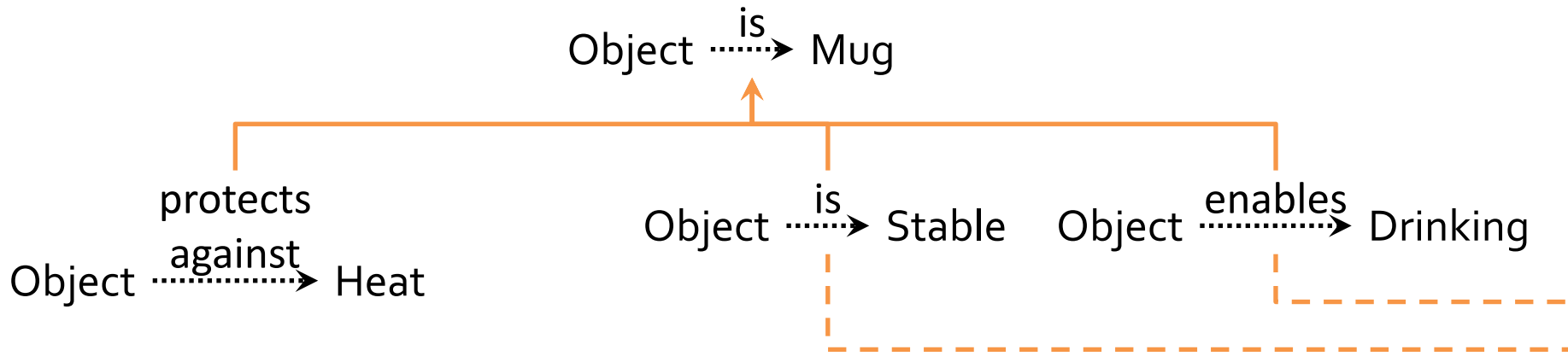
Input

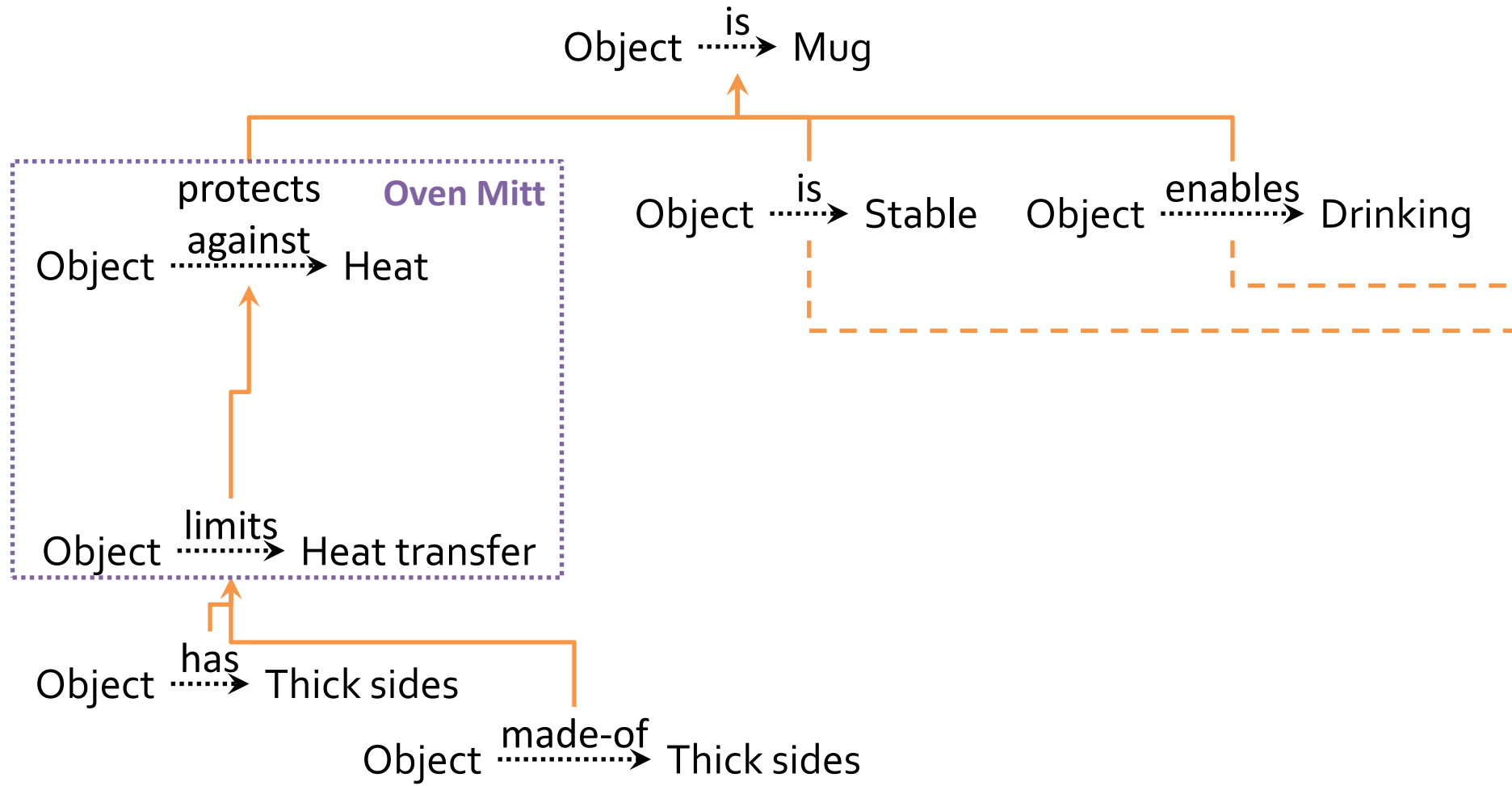
Output



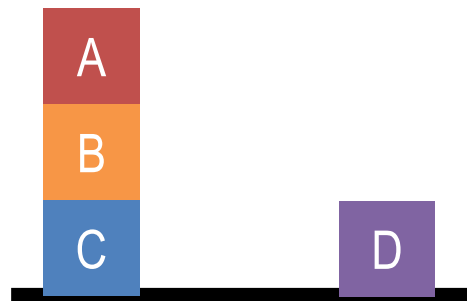








*Current State*



A on B

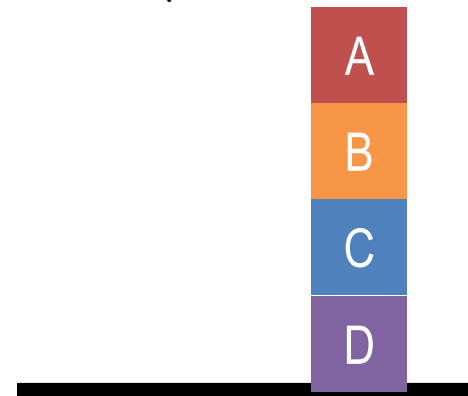
B on C

C on Table

D on Table

$$\Delta = 1$$

*Goal State*



A on B

B on C

C on D

D on Table

# Cognitive System

Metacognition

Deliberation

Reasoning

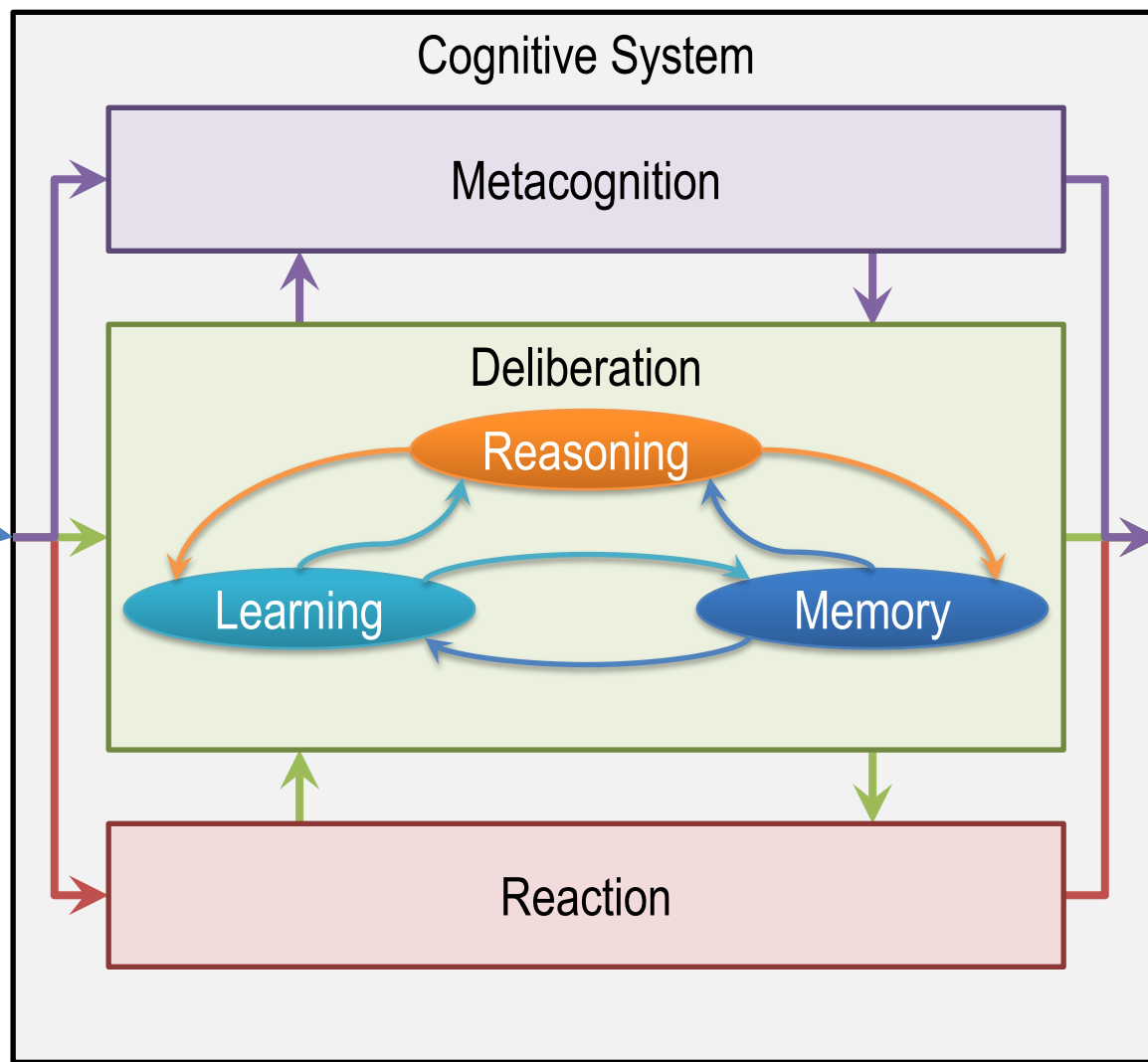
Learning

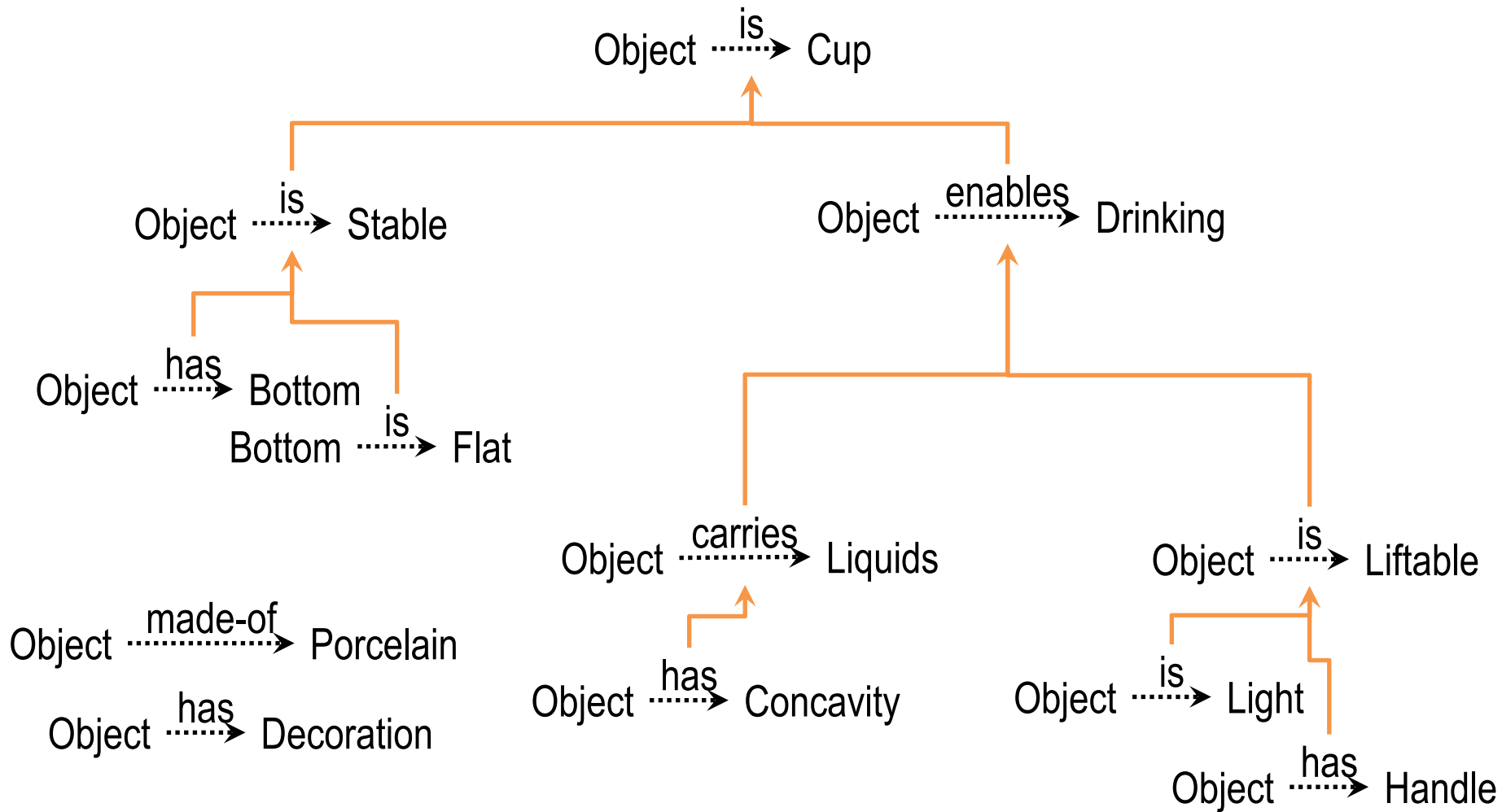
Memory

Reaction

Input

Output





# Cognitive System

Metacognition

Deliberation

Reasoning

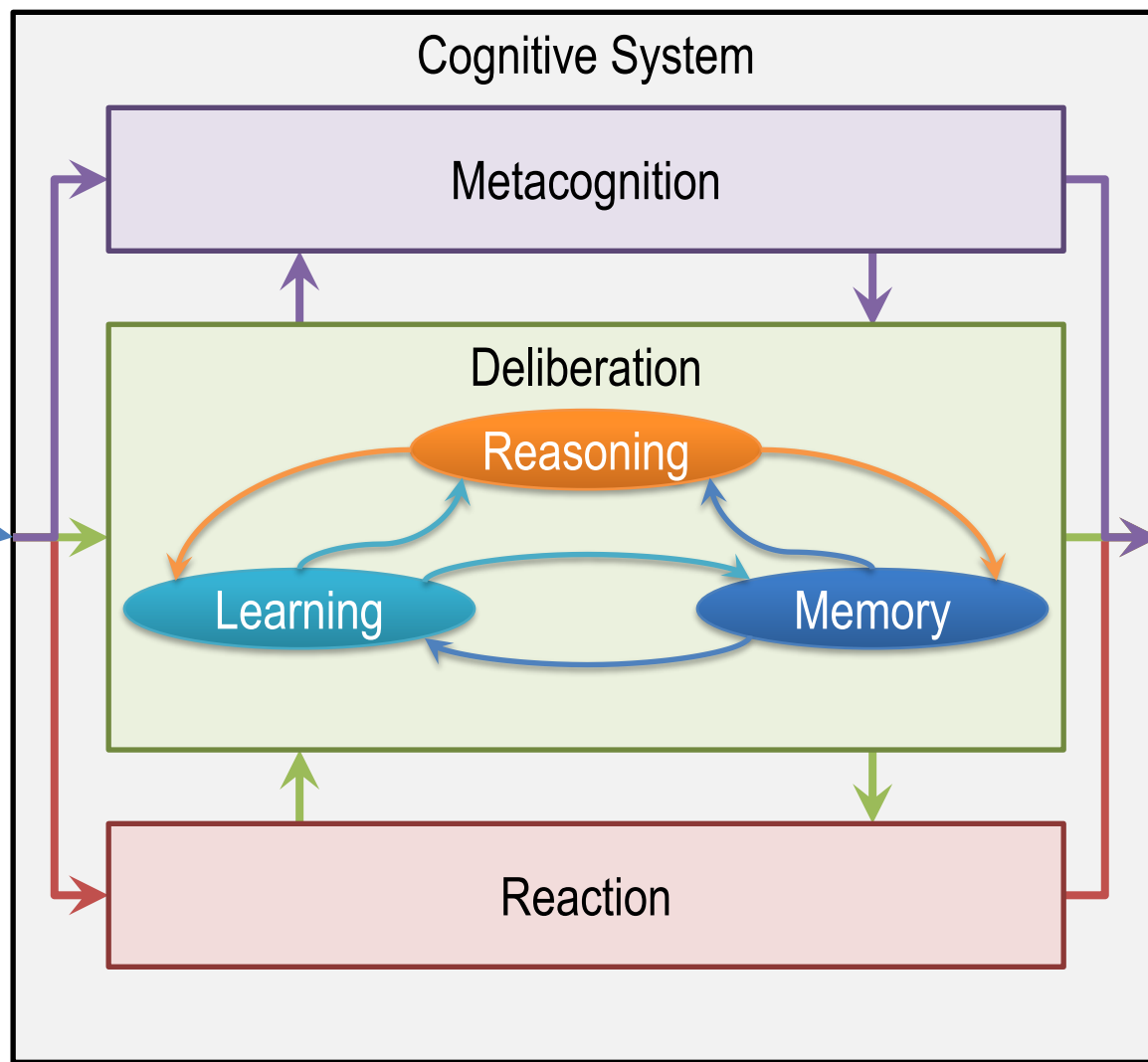
Learning

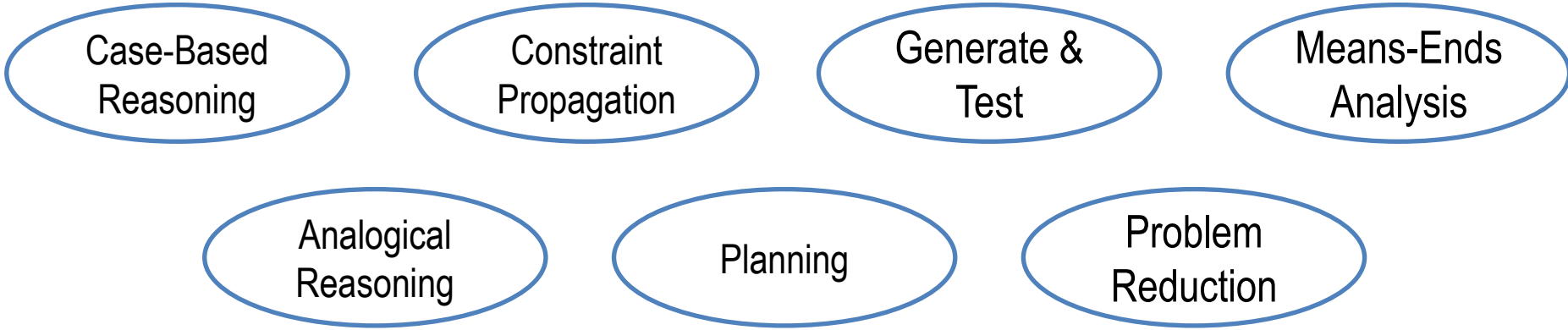
Memory

Reaction

Input

Output





Case-Based  
Reasoning

Constraint  
Propagation

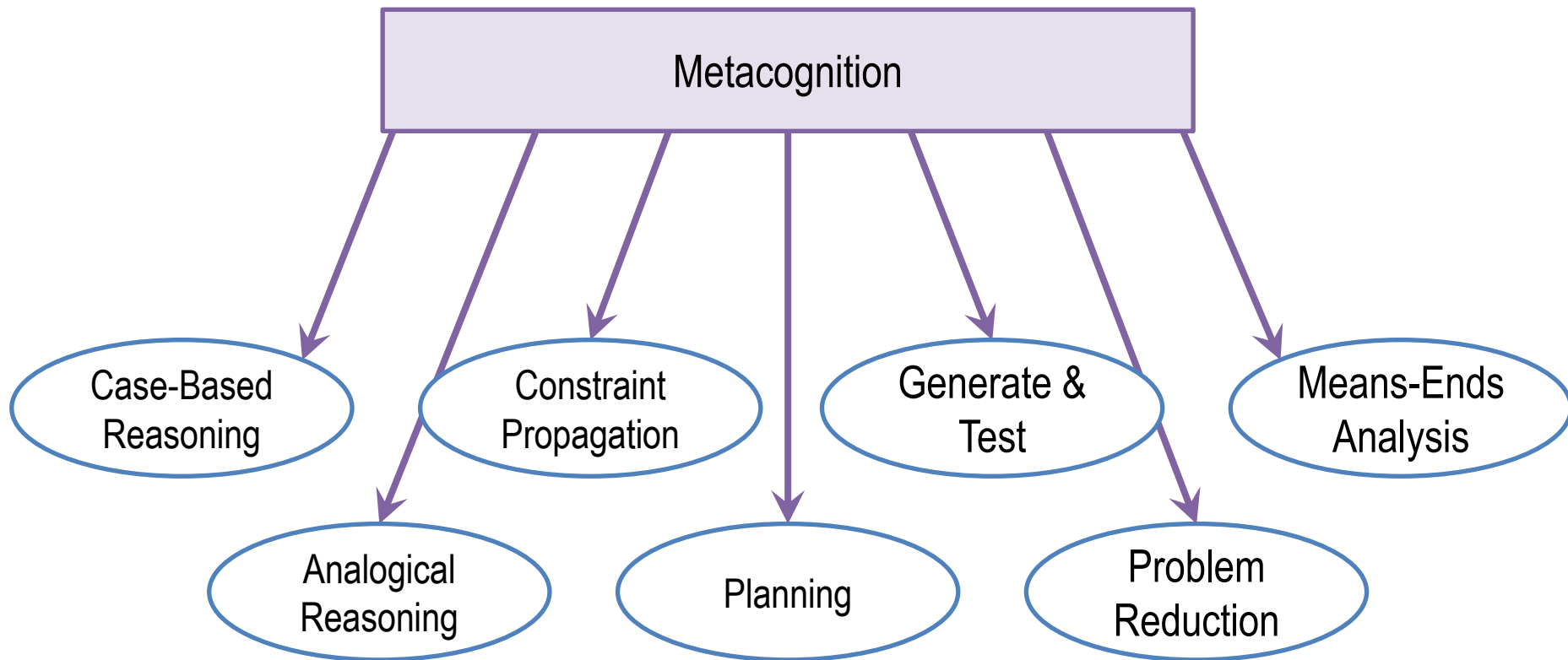
Generate &  
Test

Means-Ends  
Analysis

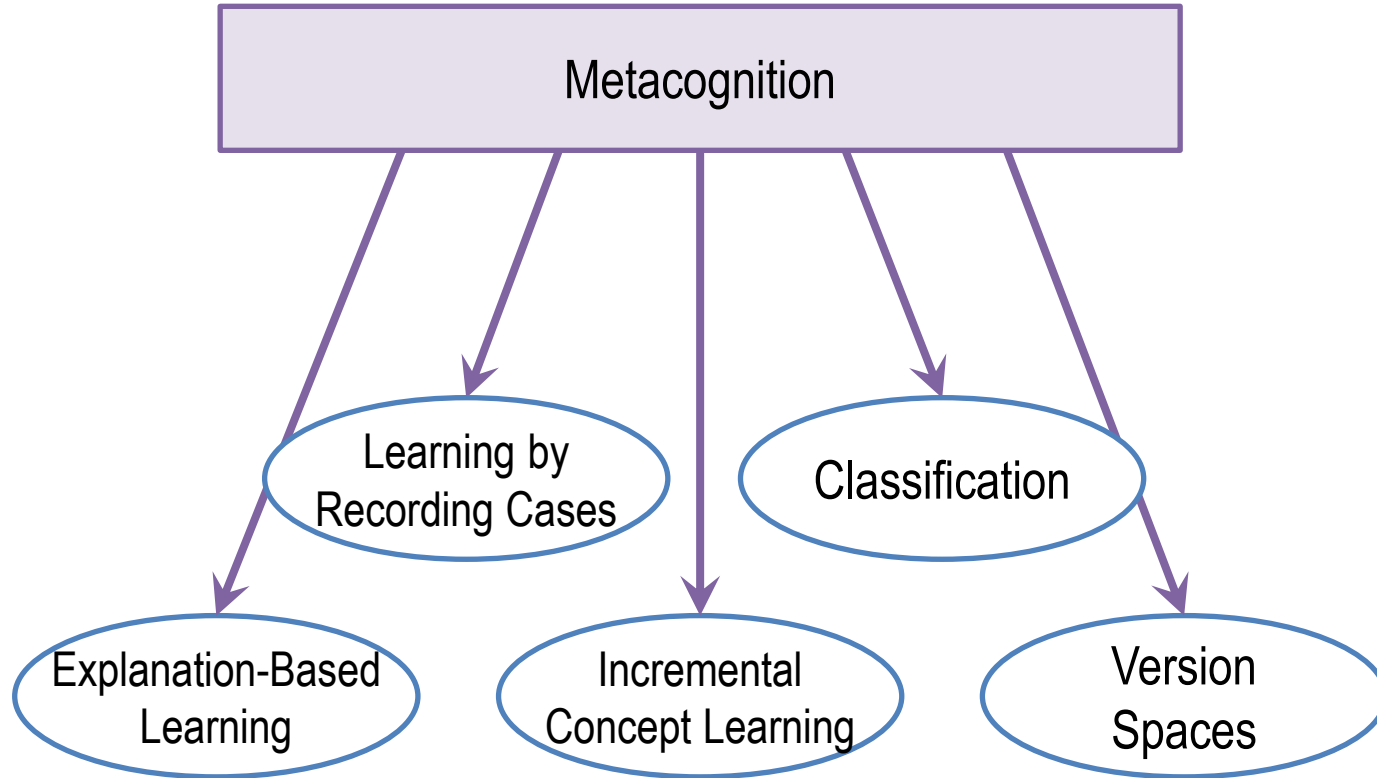
Analogical  
Reasoning

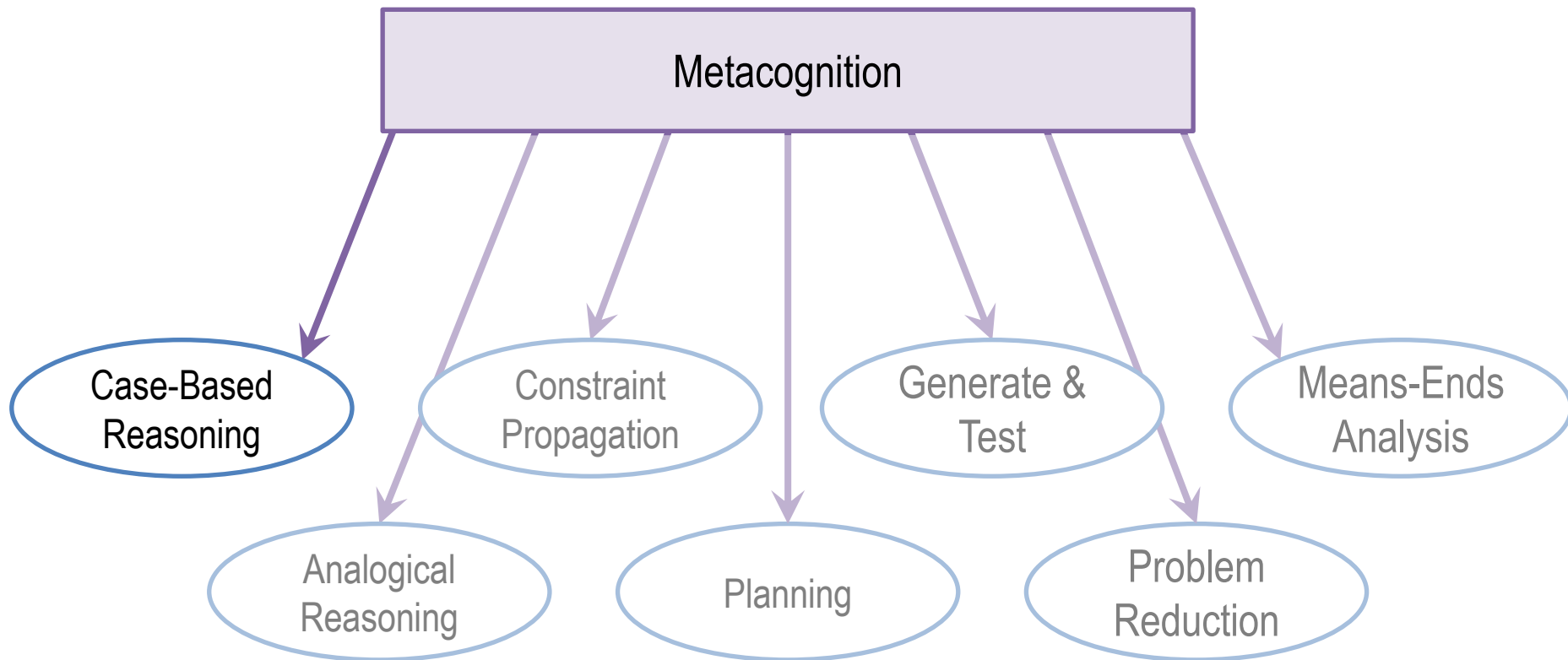
Planning

Problem  
Reduction









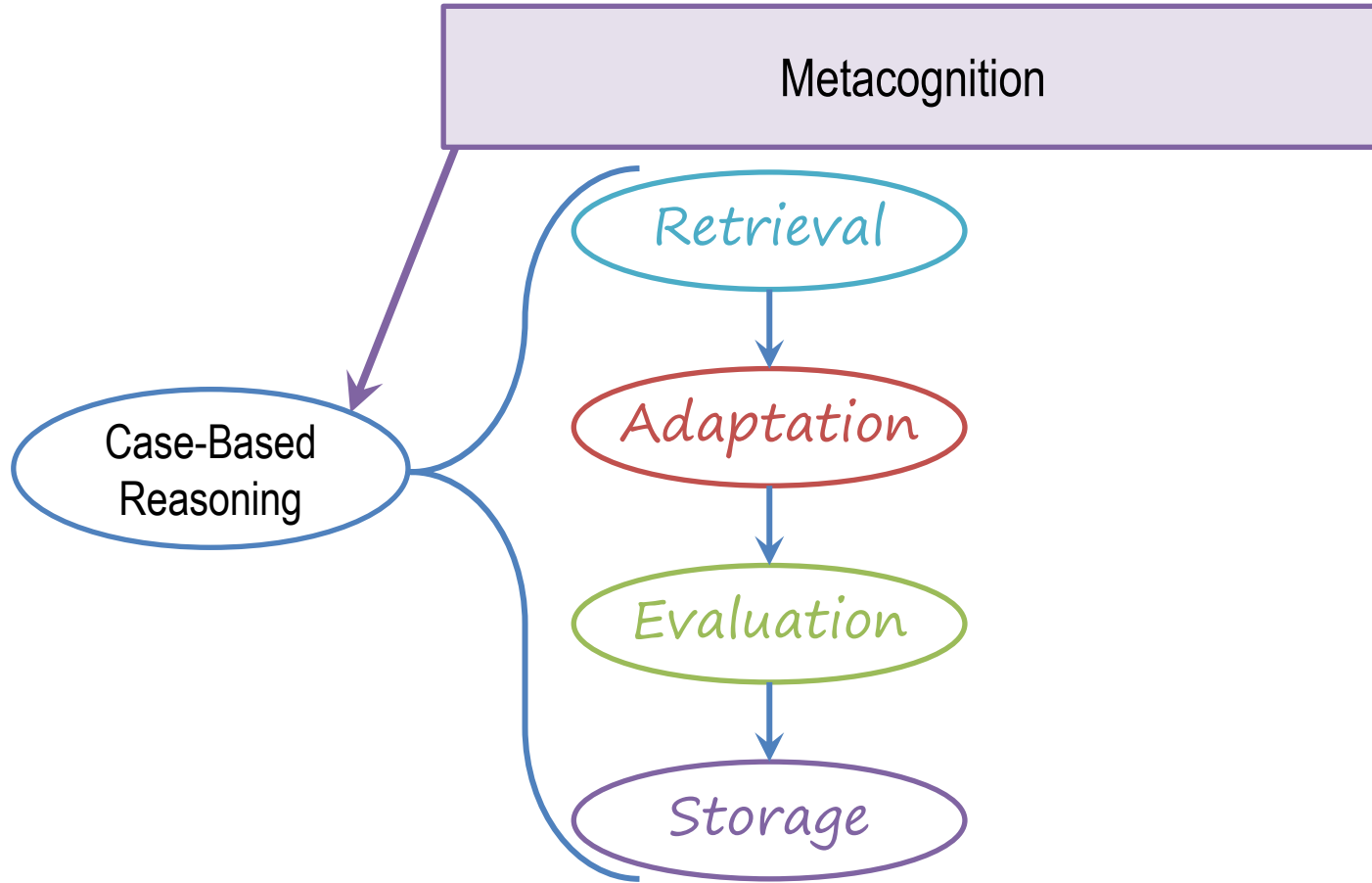
Metacognition

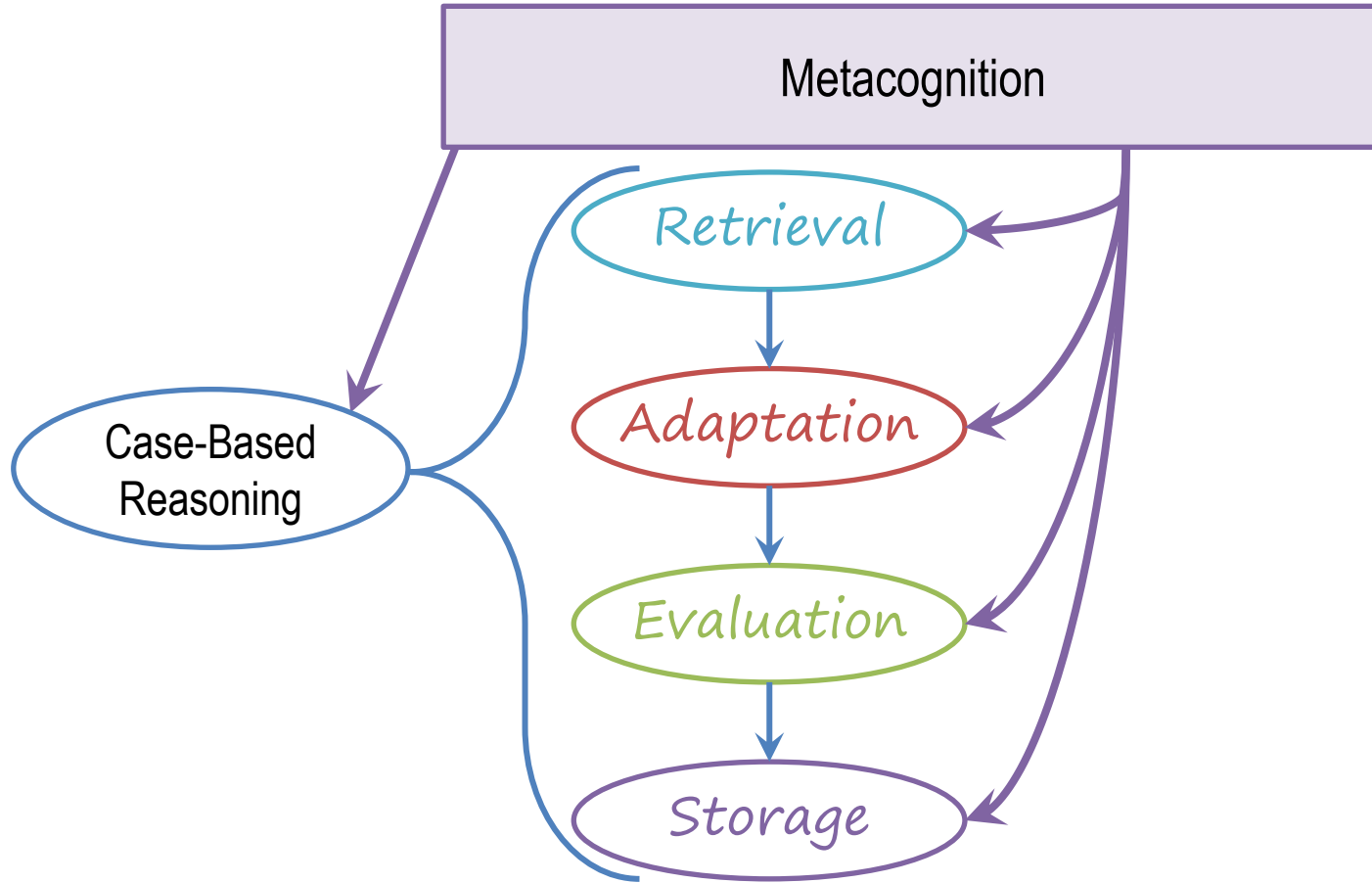


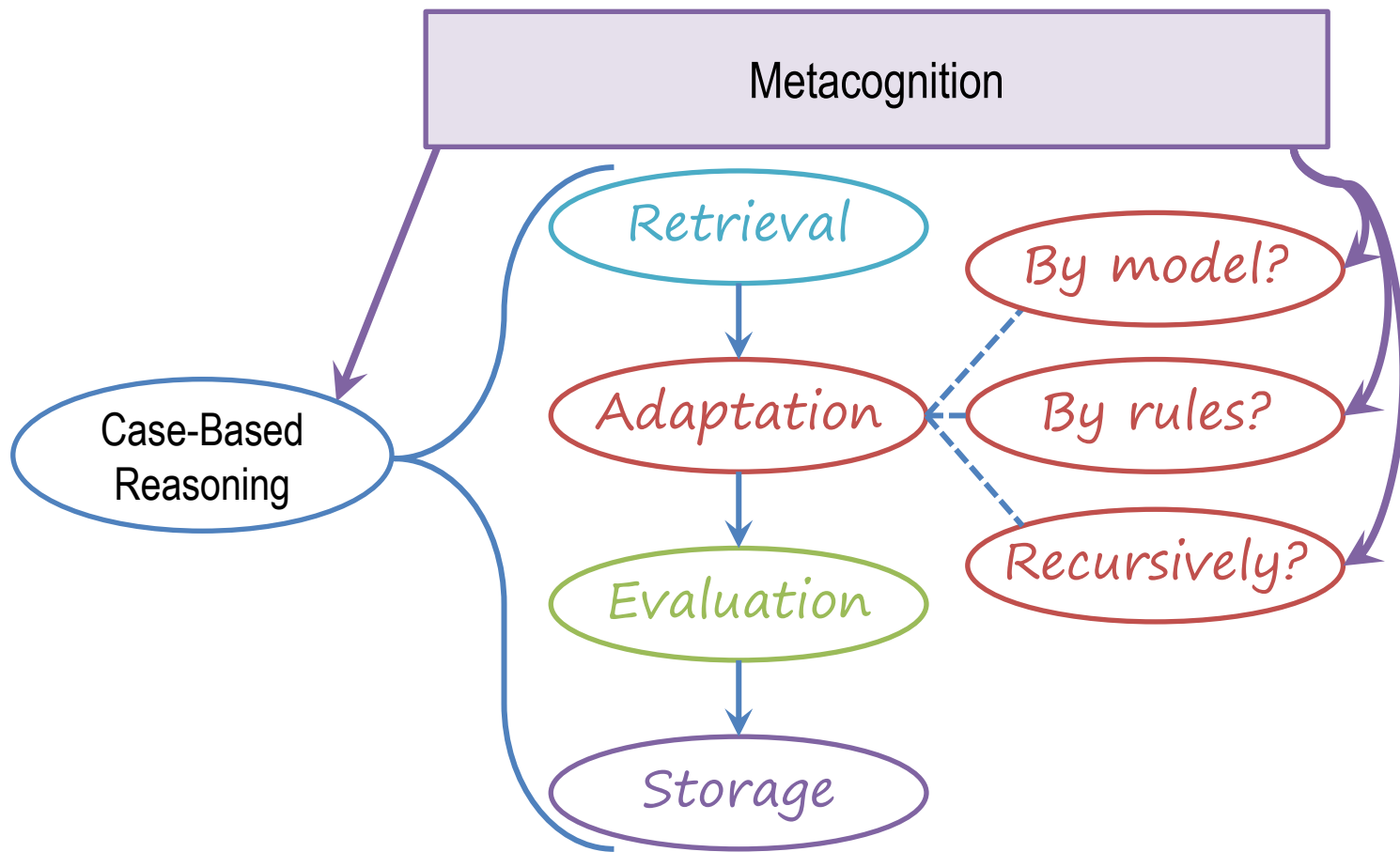
```
graph TD; A[Metacognition] --> B((Case-Based Reasoning))
```

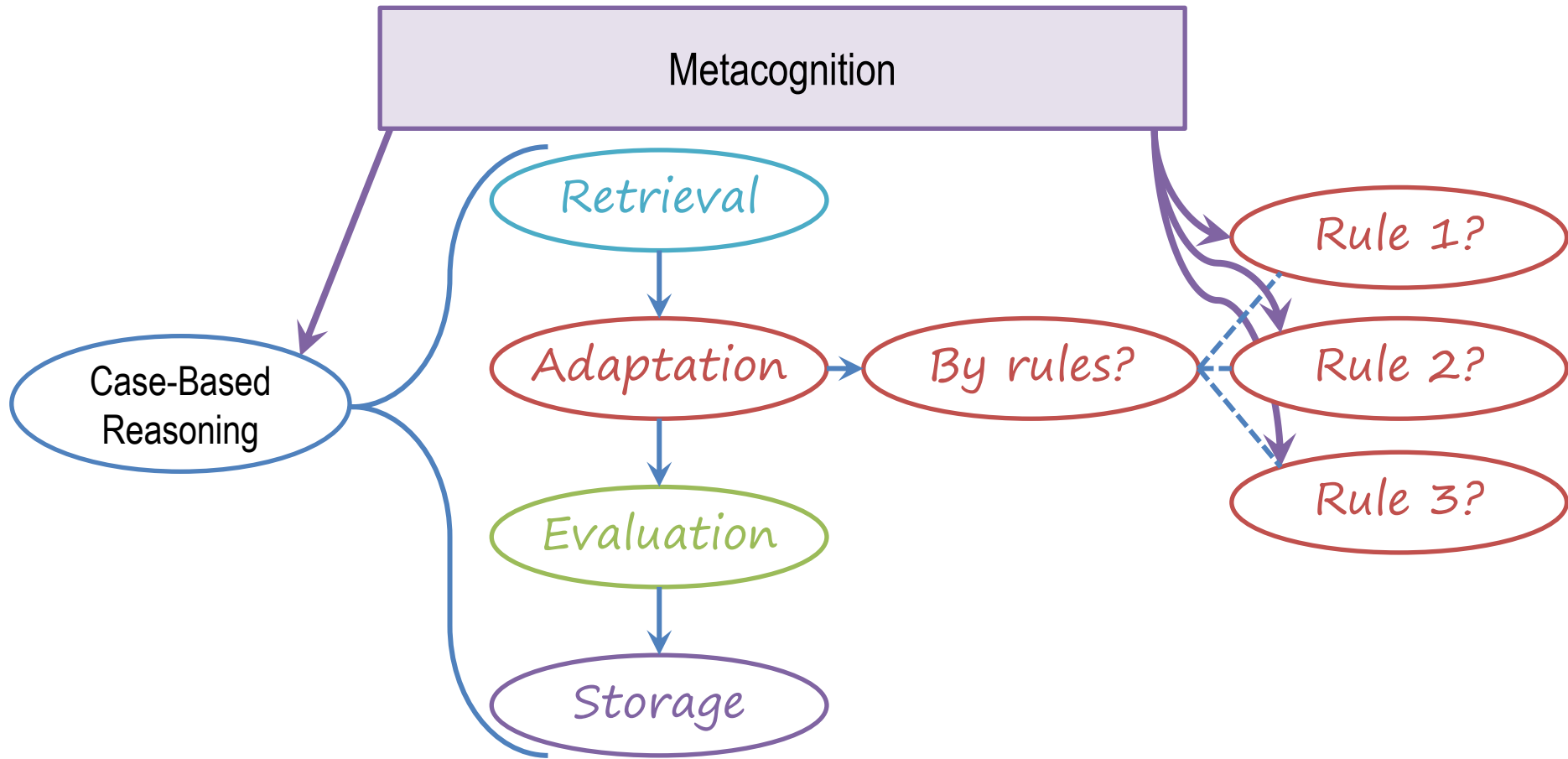
A diagram illustrating a relationship between two concepts. At the top, a light purple rectangular box with a dark purple border contains the text "Metacognition". A dark purple arrow points from the bottom-left corner of this box to a blue oval at the bottom-left. The oval contains the text "Case-Based Reasoning".

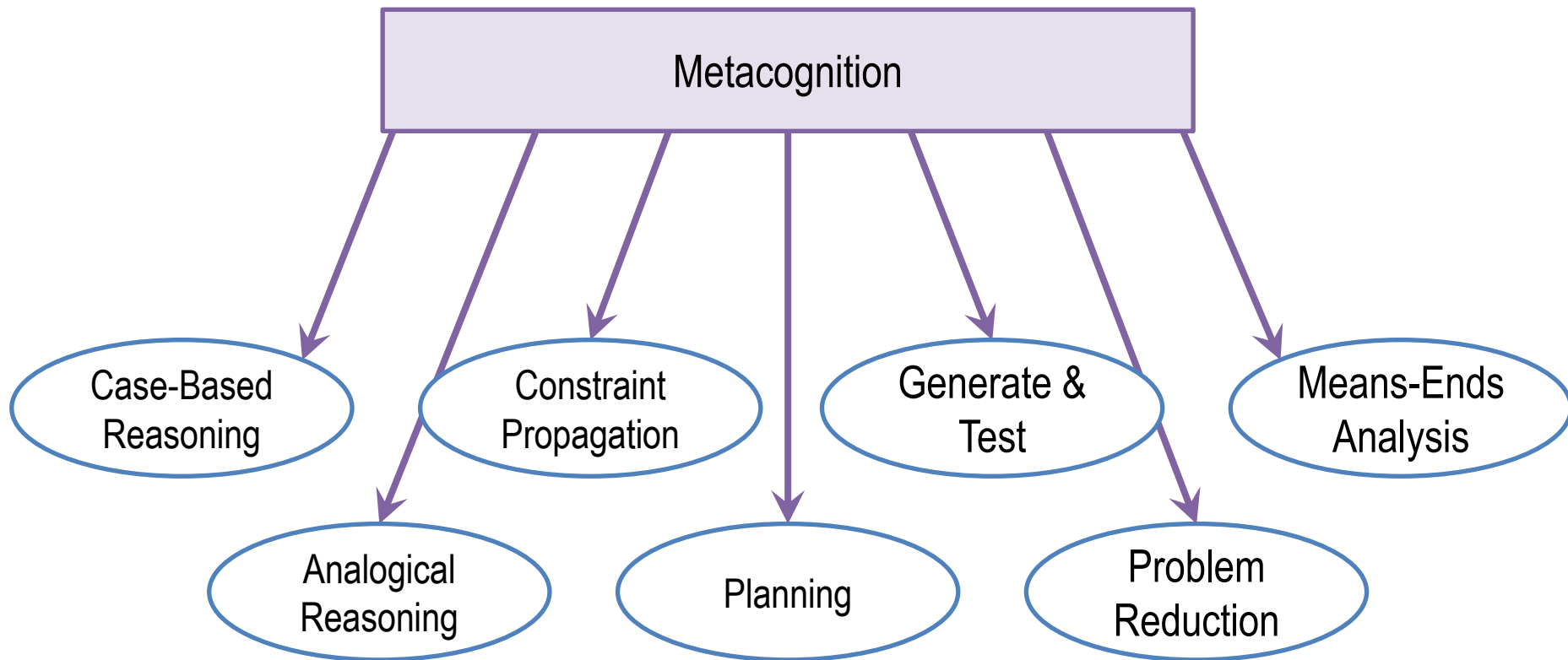
Case-Based  
Reasoning



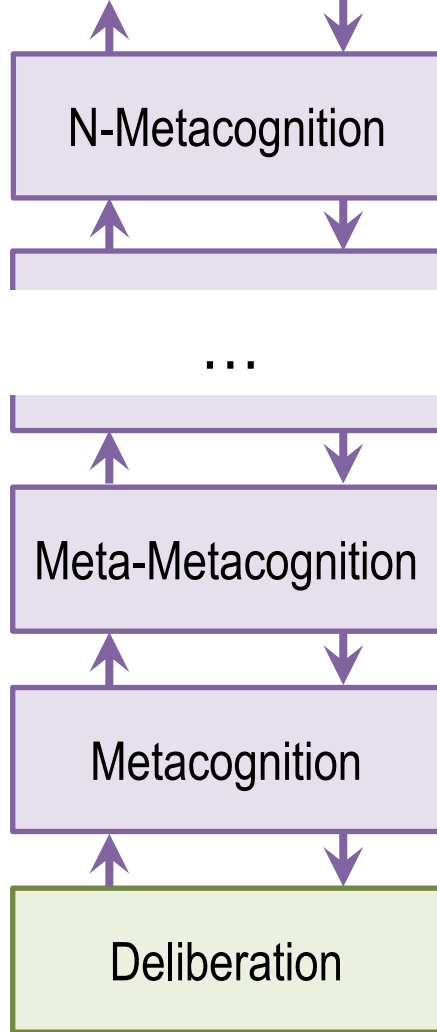








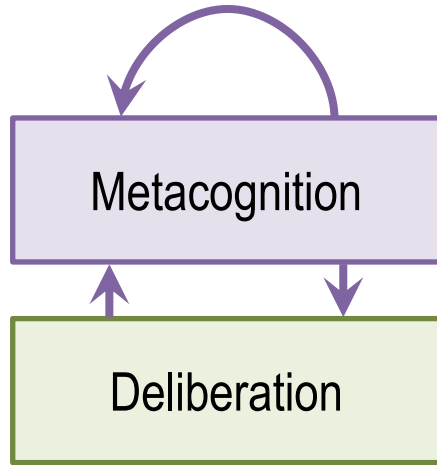




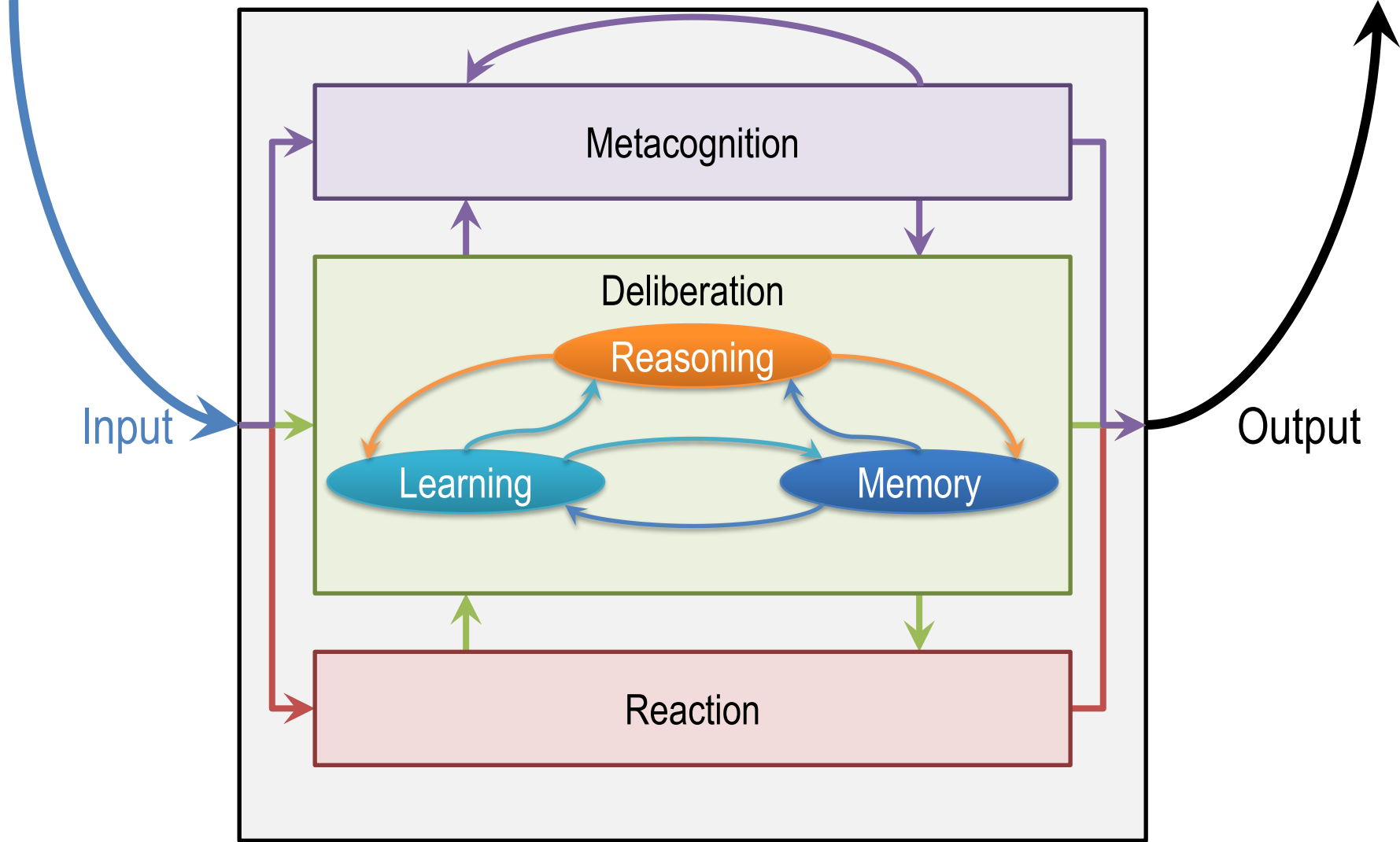
Is this a good way to think about levels of metacognition?

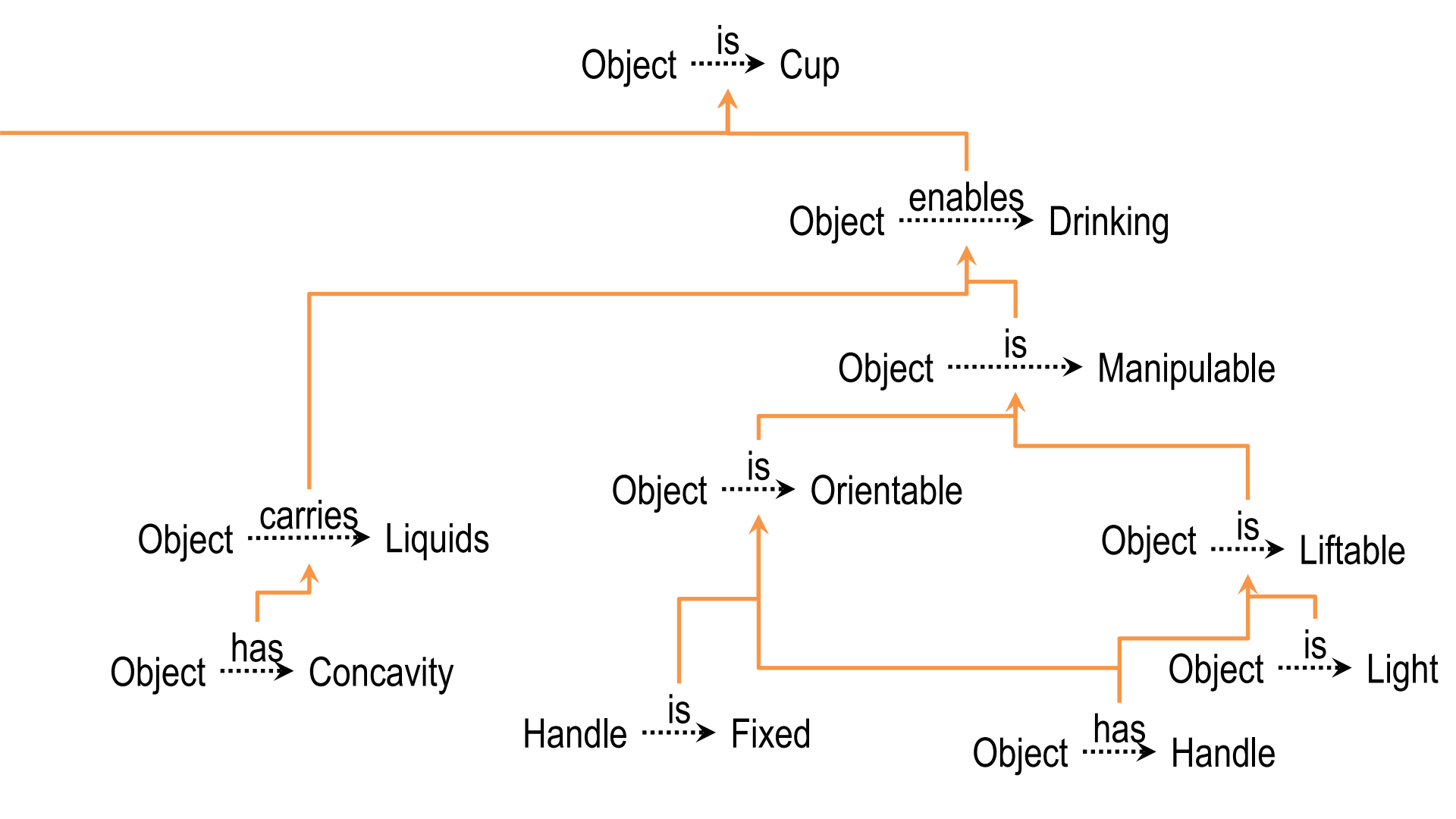
- o Yes, because it is possible to think about every successive level.
- o No, because there is a maximum level of metacognition possible.
  - No, because each level of metacognition is conceptually identical, so they are better represented as self-referential.
- o No, because there is no need to distinguish between metacognition and deliberation.

Is this a good way to think about levels of metacognition?



- o Yes, because it is possible to think about every successive level.
- o No, because there is a maximum level of metacognition possible.
  - No, because each level of metacognition is conceptually identical, so they are better represented as self-referential.
- o No, because there is no need to distinguish between metacognition and deliberation.





## Goal: Painted(Ladder)

On(Robot, Floor)  $\wedge$   
Dry(Ladder)  $\wedge$  Dry(Ceiling)

 **paint-ladder**

On(Robot, Floor)  $\wedge$   
 $\neg$ Dry(Ladder)  $\wedge$  Dry(Ceiling)  
 $\wedge$  Painted(Ladder)

### **climb-ladder:**

Precondition:

On(Robot, Floor)  $\wedge$   
Dry(Ladder)

Postcondition:

On(Robot, Ladder)

## Goal: Painted(Ceiling)

On(Robot, Floor)  $\wedge$   
Dry(Ladder)  $\wedge$  Dry(Ceiling)

 **climb-ladder**

On(Robot, Ladder)  $\wedge$   
Dry(Ladder)  $\wedge$  Dry(Ceiling)

 **paint-ceiling**

On(Robot, Ladder)  $\wedge$   
Dry(Ladder)  $\wedge$   $\neg$ Dry(Ceiling)  
 $\wedge$  Painted(Ceiling)

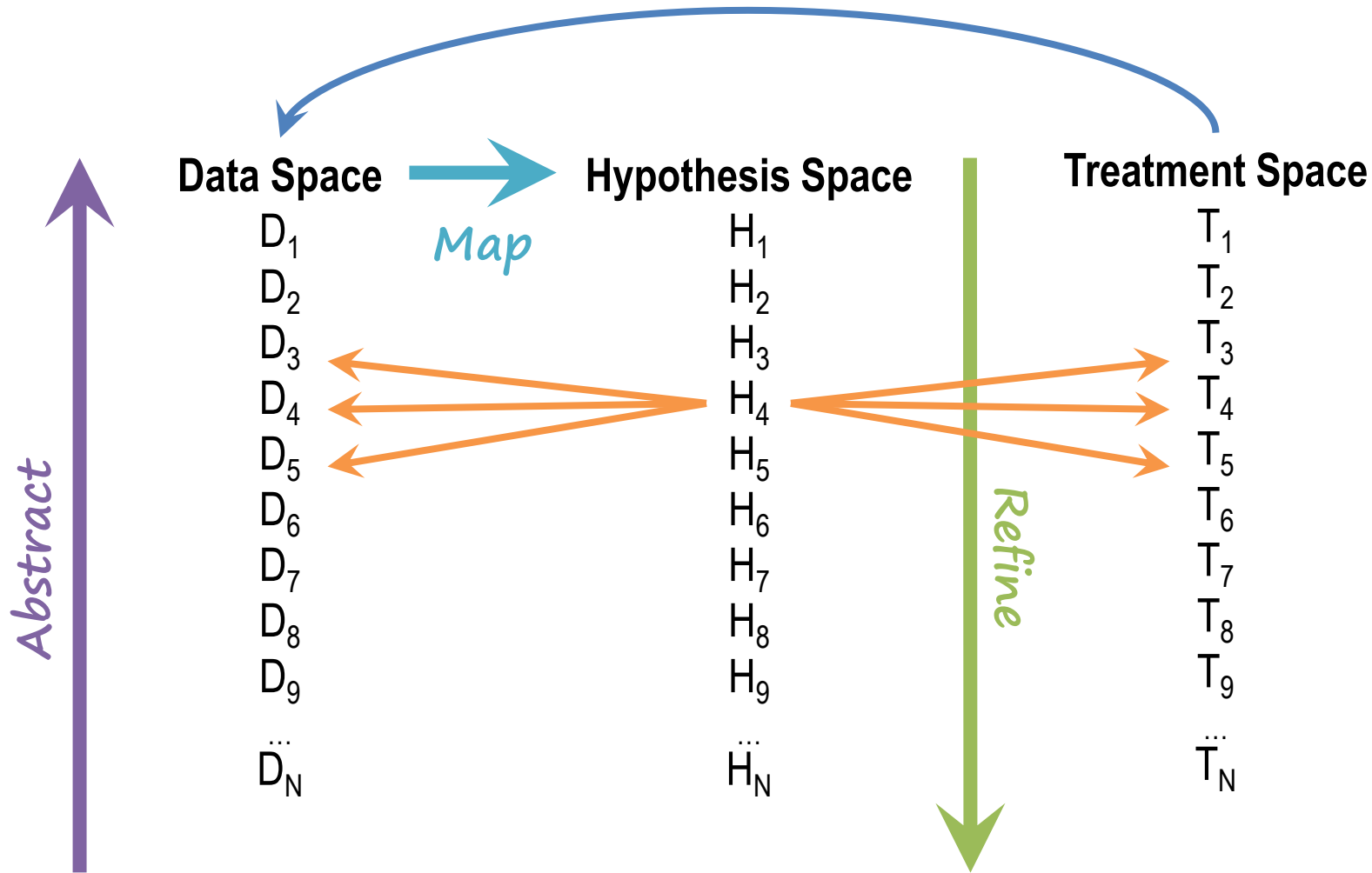
**inning** : 5th  
**portion** : bottom  
**game** : 131  
**weather** : windy  
**runners** : 1st, 3rd  
**outs** : 1  
**batter** : Pierzynski  
**average** : .283  
**bats** : left-handed  
**score** : 1-4  
**goal** : pitch  
**pitch** : throw-fast-ball  
**result** : homerun

(r8) If two operators selected and one has an episode with **result**  
*homerun*  
then prefer other operator

“chunking”

# Version Spaces

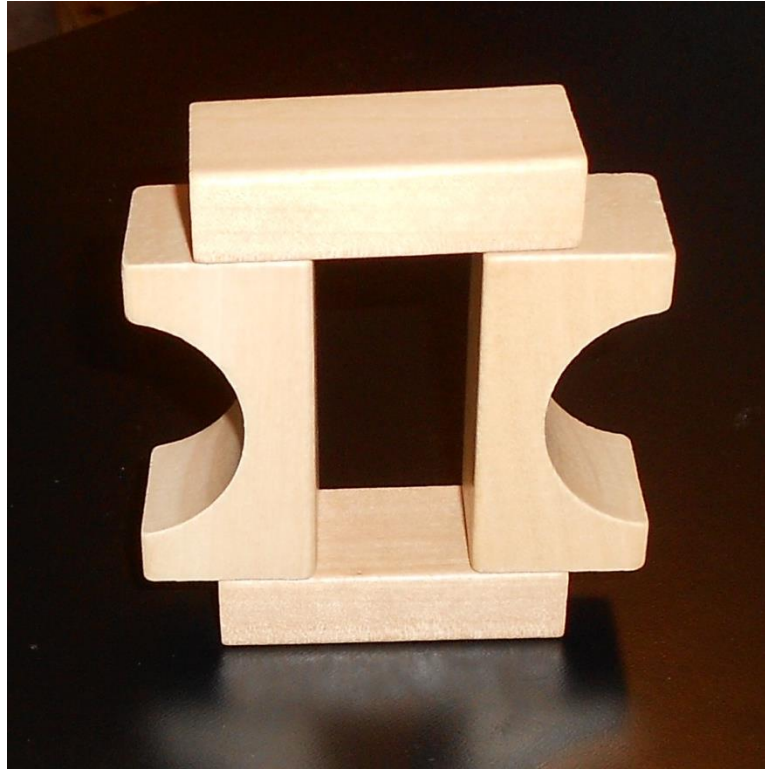






Is this a foo?

☐ Yes



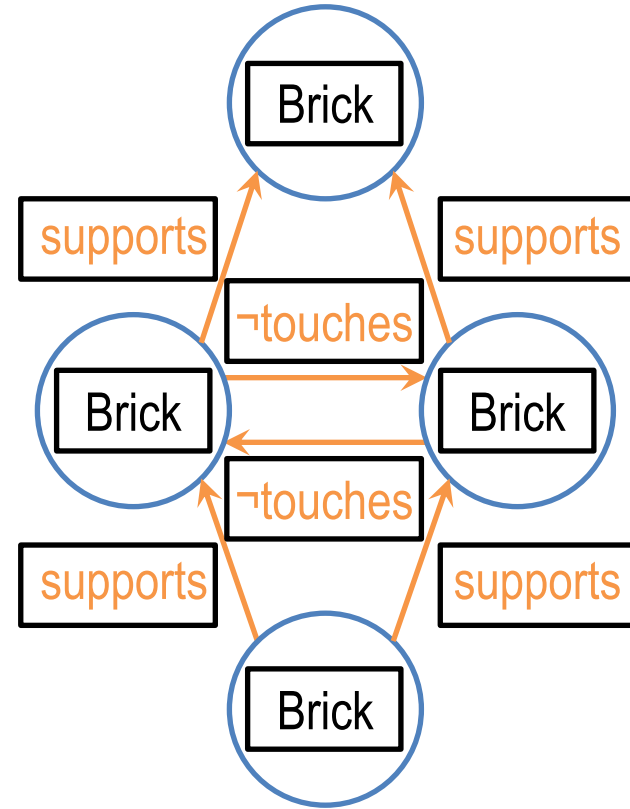
☐ No

This *is not* a foo.



Modify the concept on the right to specialize based on this example.

Current Concept



## Assignment

How would you use meta-reasoning to design an agent that could answer Raven's progressive matrices?

## To recap...

- Resolving mistakes and gaps
- Strategy selection and integration
- Meta-meta-reasoning?
- Goal-based autonomy