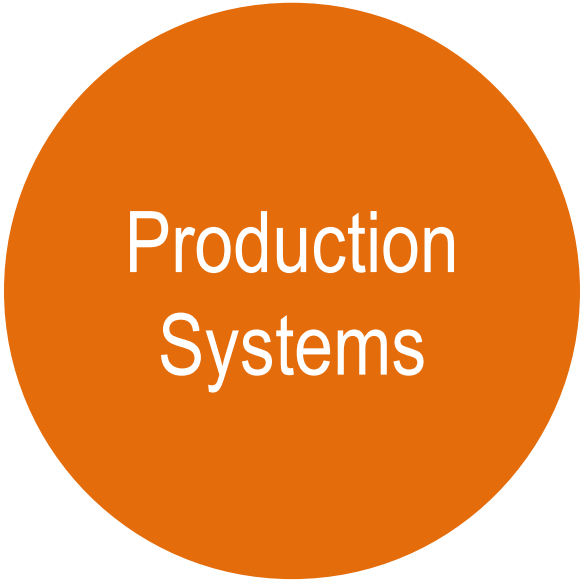
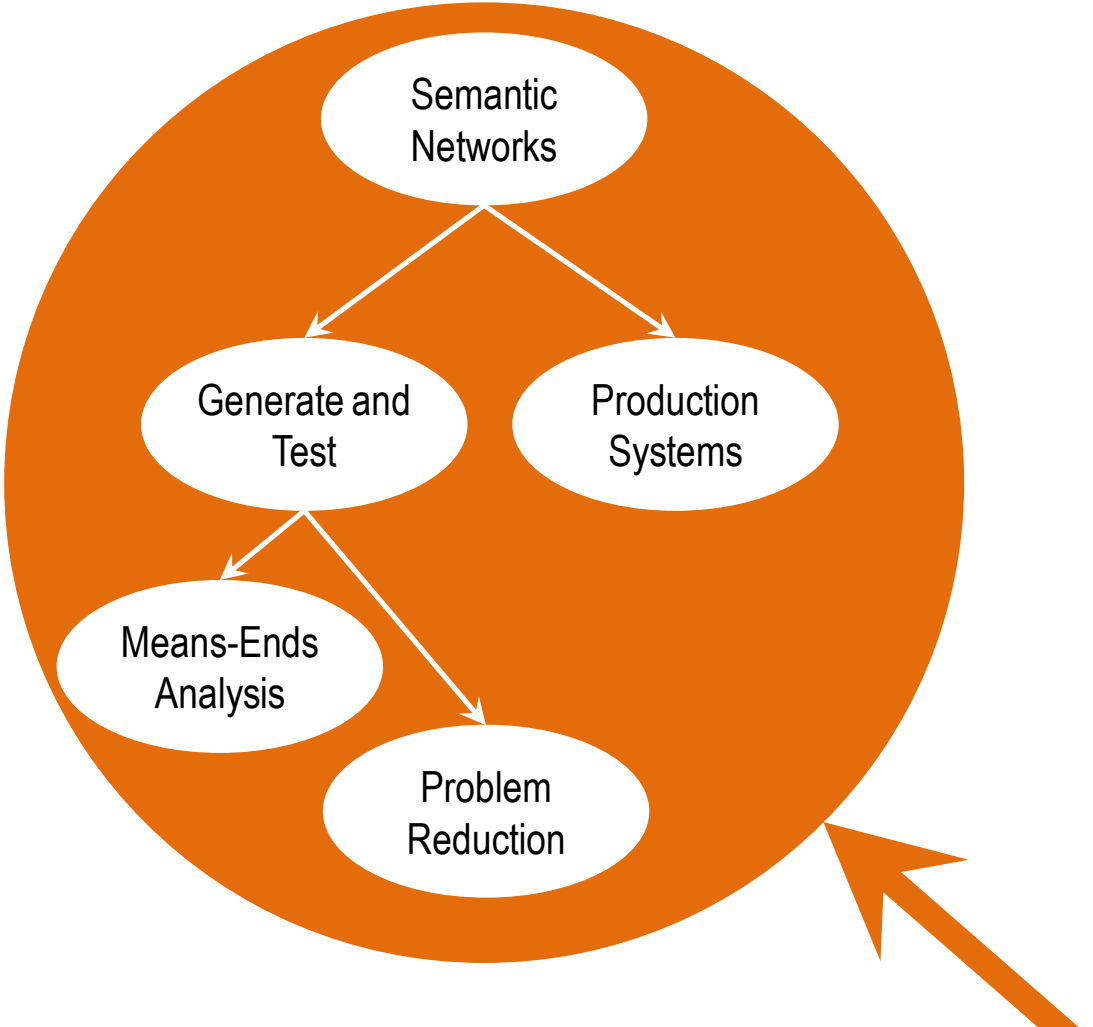

Production
Systems

Fundamentals



Lesson Preview

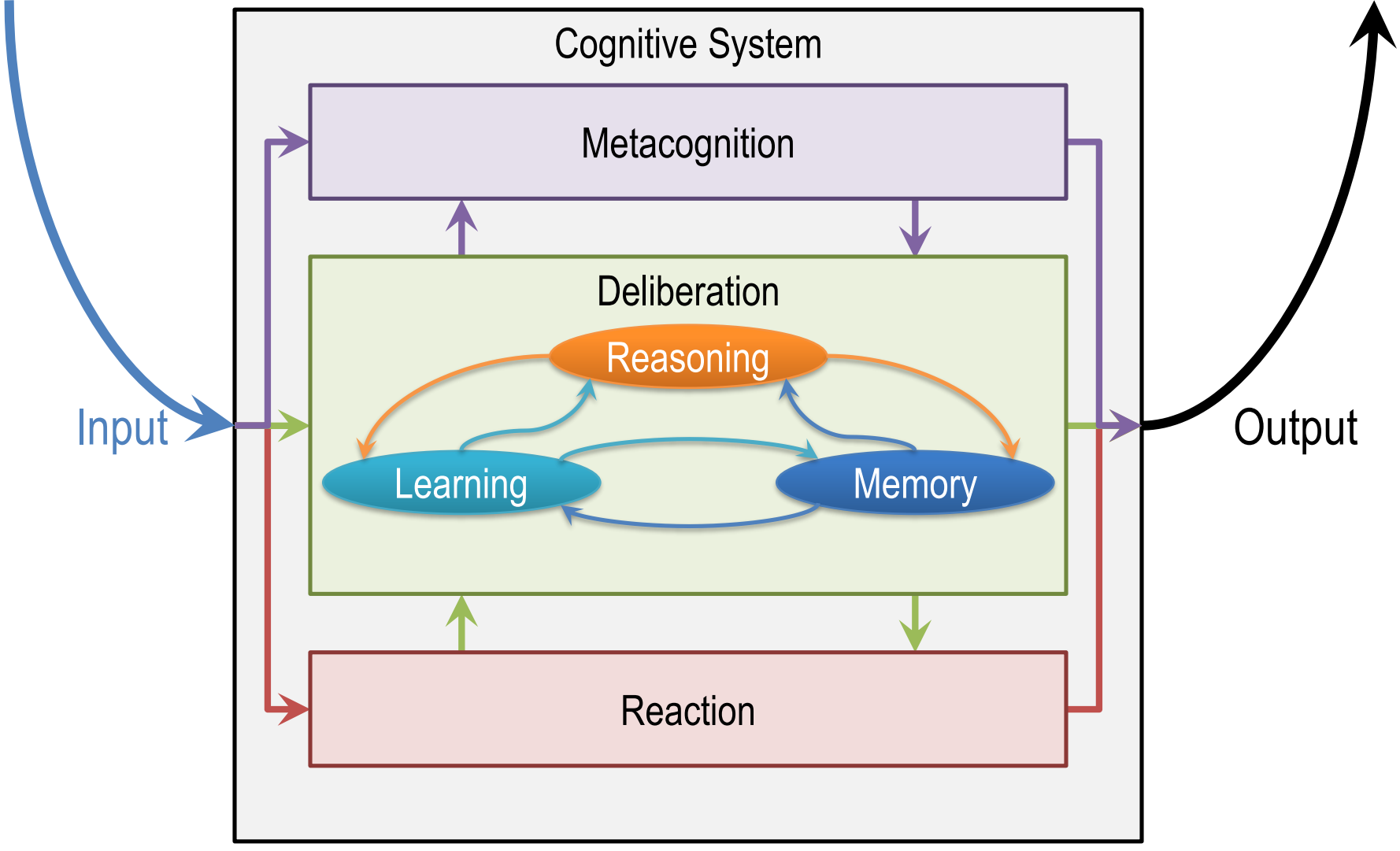
- Cognitive architectures
- Production systems
- Chunking

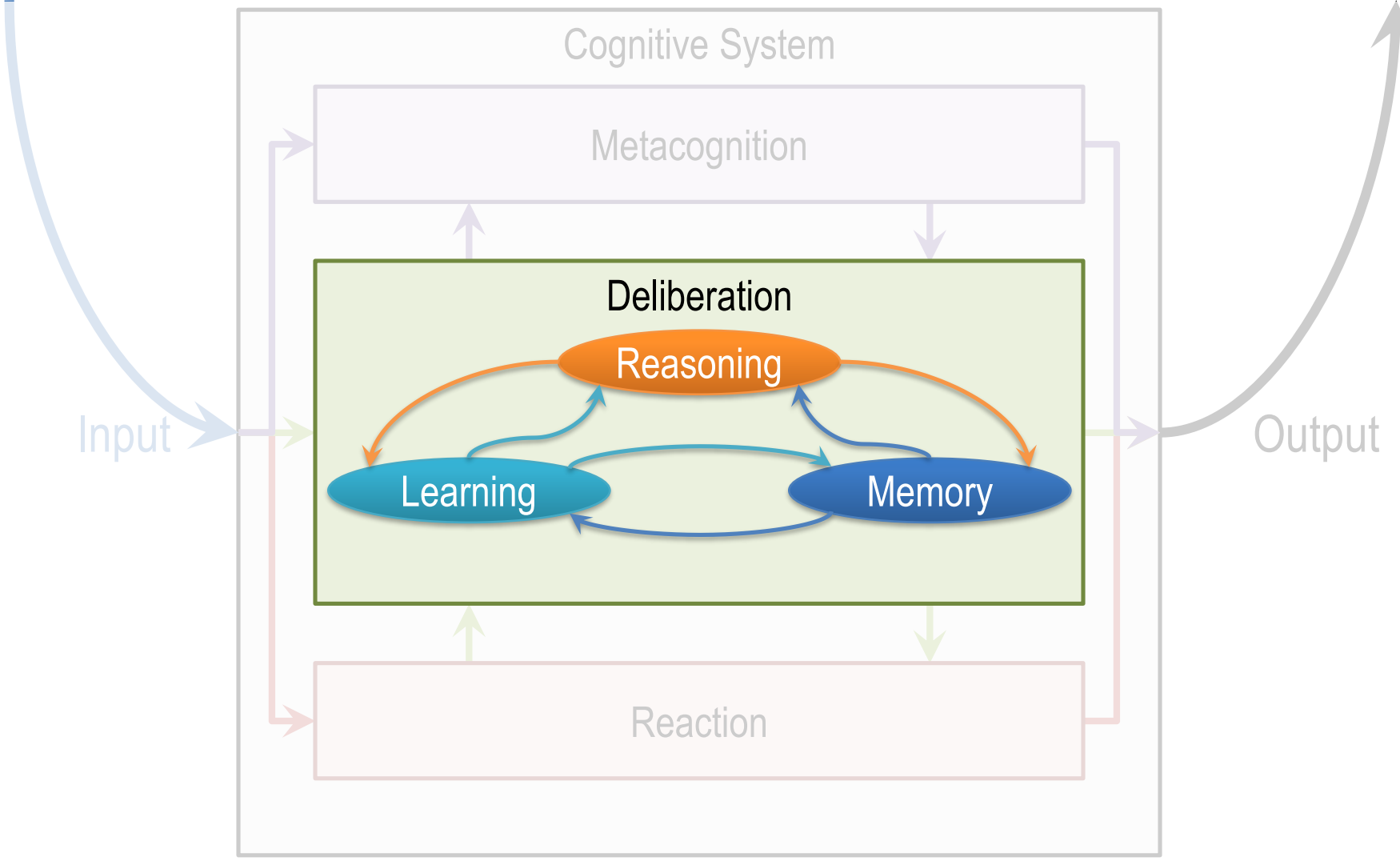
It's the top of the 7th inning. There are runners on 2nd and 3rd base. There are two outs. The batter, Martin Prado, has an average of .256 and bats fourth in the batting order. We are winning 3-2. I struck this batter out last time. My goal is to escape the inning.

What should the pitcher do?

o Pitch to the batter

● Intentionally walk the batter


Cognitive System
Metacognition
Deliberation
Reasoning
Learning
Memory
Reaction
Input
Output


Cognitive System
Metacognition
Deliberation
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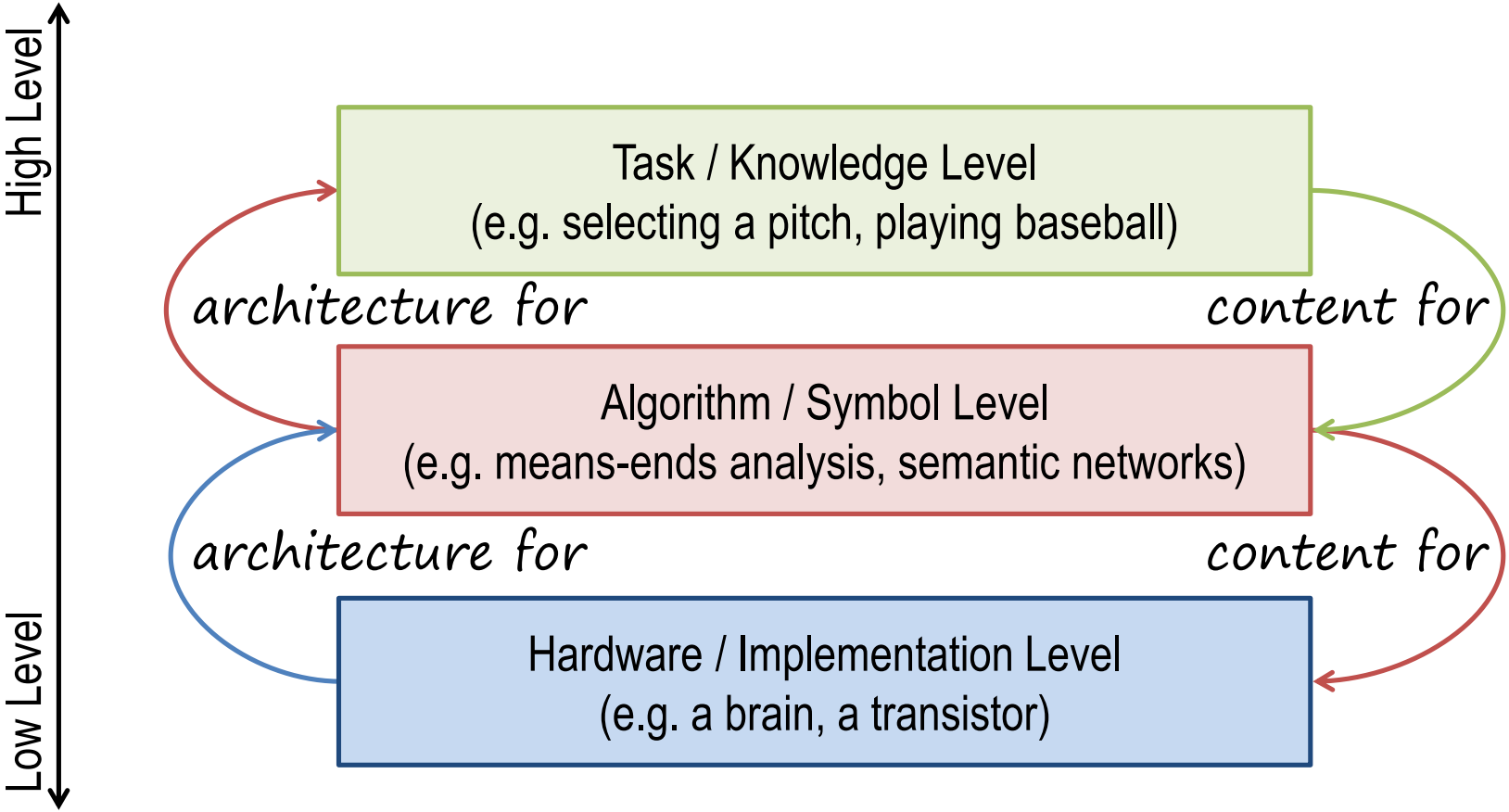
Memory
Reaction
Input
Output


High Level
Low Level
Task / Knowledge Level
(e.g. selecting a pitch, playing baseball)
architecture for
content for
Algorithm / Symbol Level
(e.g. means-ends analysis, semantic networks)
architecture for
content for
Hardware / Implementation Level
(e.g. a brain, a transistor)

What are the layers of Watson?

the physical computer
searching and decision-making
answering the inputted clue

Assumptions of a Cognitive Architecture

- Goal-oriented
- Rich, complex environment
- Significant knowledge
- Symbols and abstractions
- Flexible and function of the environment
- Learning

Architecture

+

Content

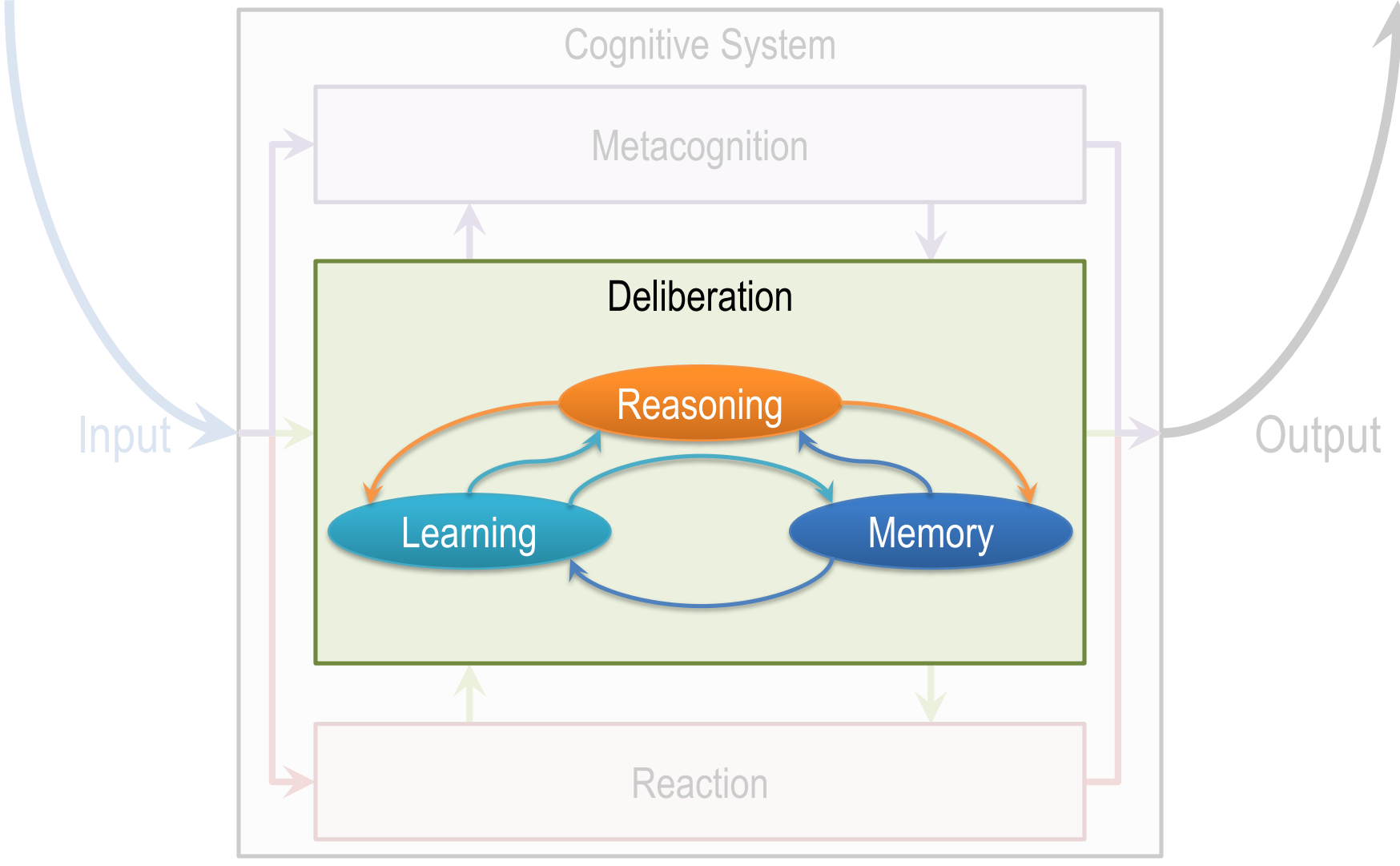
=

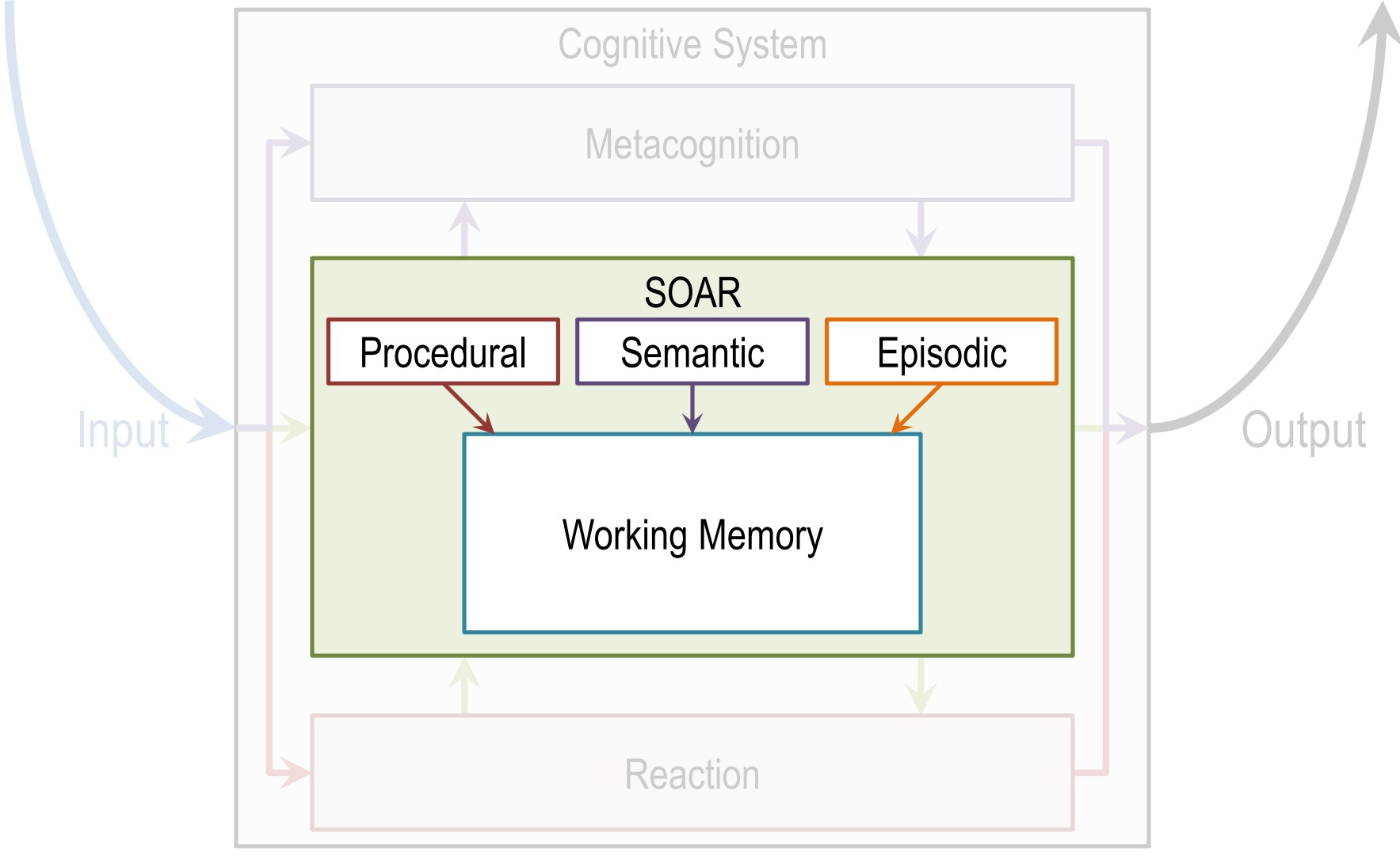
Behavior

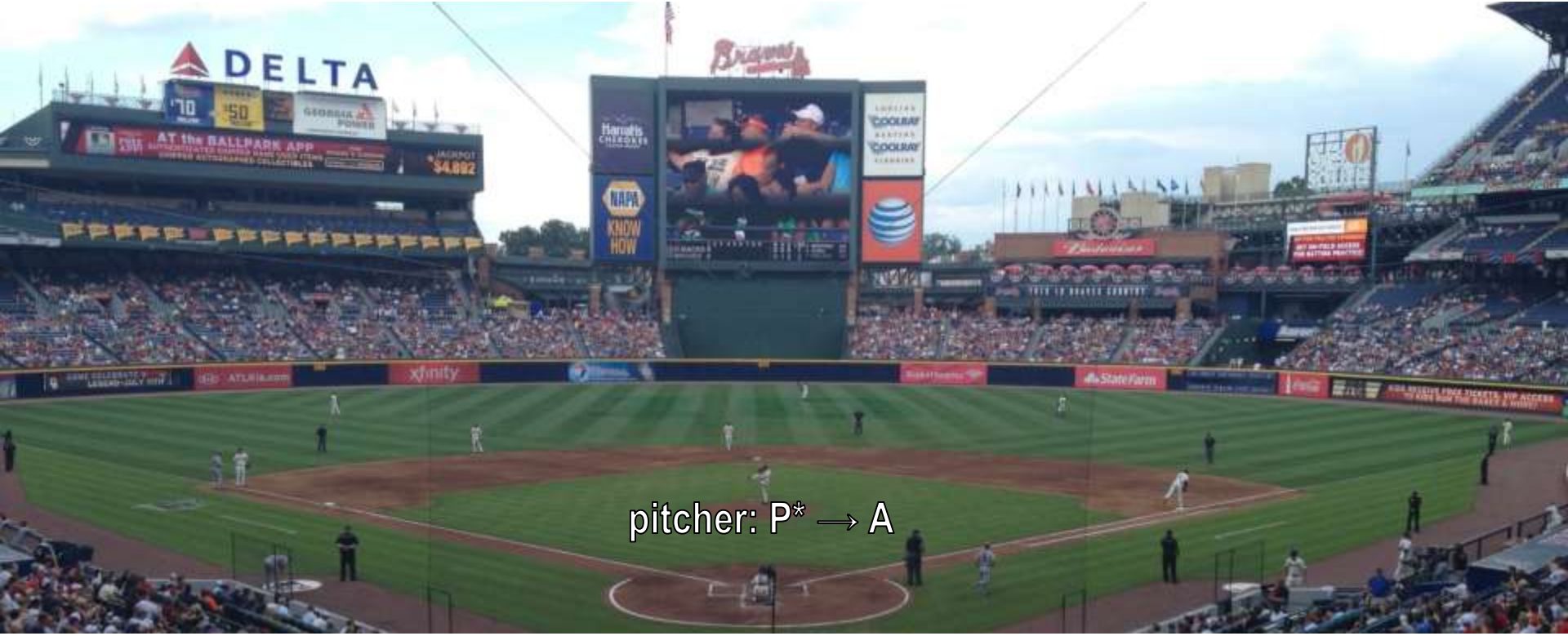
Function for cognitive architectures:

$$f: P^* \rightarrow A$$

Percepts → Action


Cognitive System
Metacognition
Deliberation
Reasoning
Learning
Memory
Reaction
Input
Output


Cognitive System
Metacognition
SOAR
Procedural
Semantic
Episodic
Working Memory
Reaction
Input
Output


DELTA
AT the BALLPARK APP
JACKPOT
$4,882
NAPA
KNOW HOW
xfinity
State Farm
pitcher: P* → A

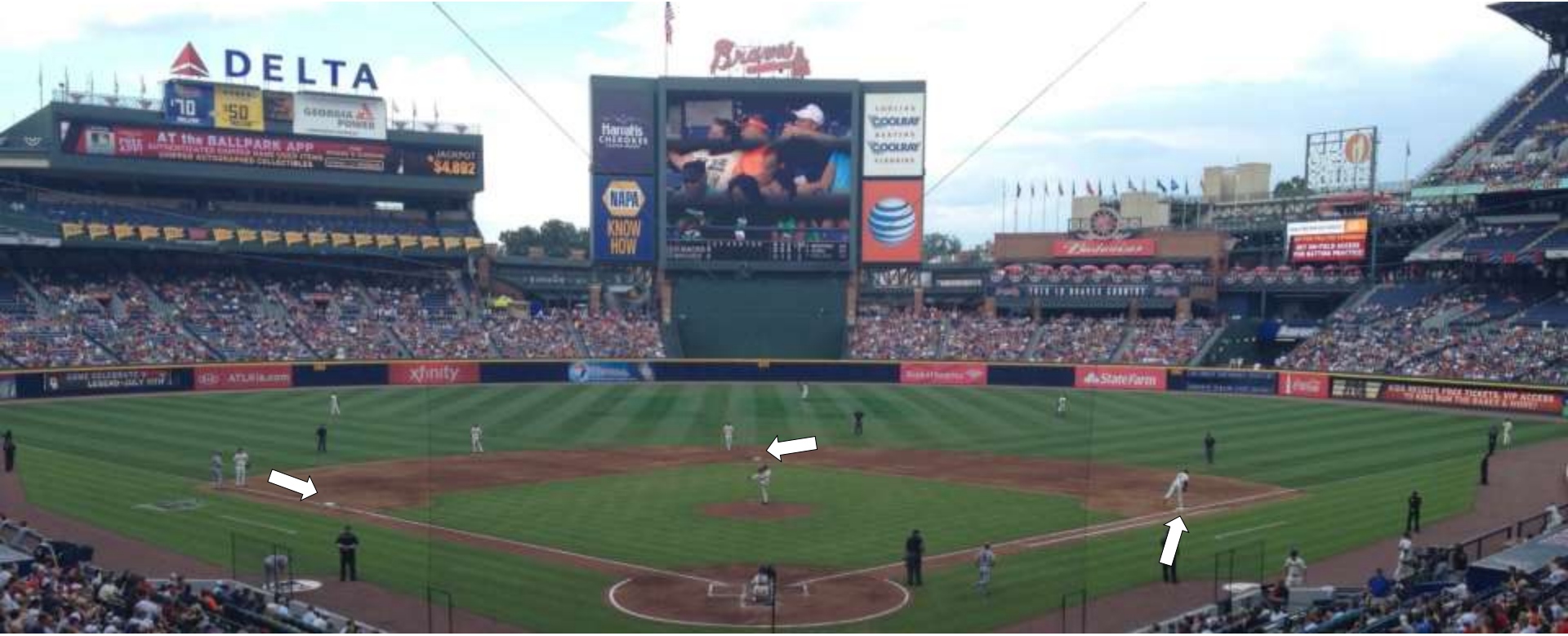
It's the top of the 7th inning. There are runners on 2nd and 3rd base. There are two outs. The batter, Martin Prado, has an average of .256 and bats fourth in the batting order. We are winning 3-2. I struck this batter out last time. My goal is to escape the inning.

What should the pitcher do?

o Pitch to the batter

● Intentionally walk the batter

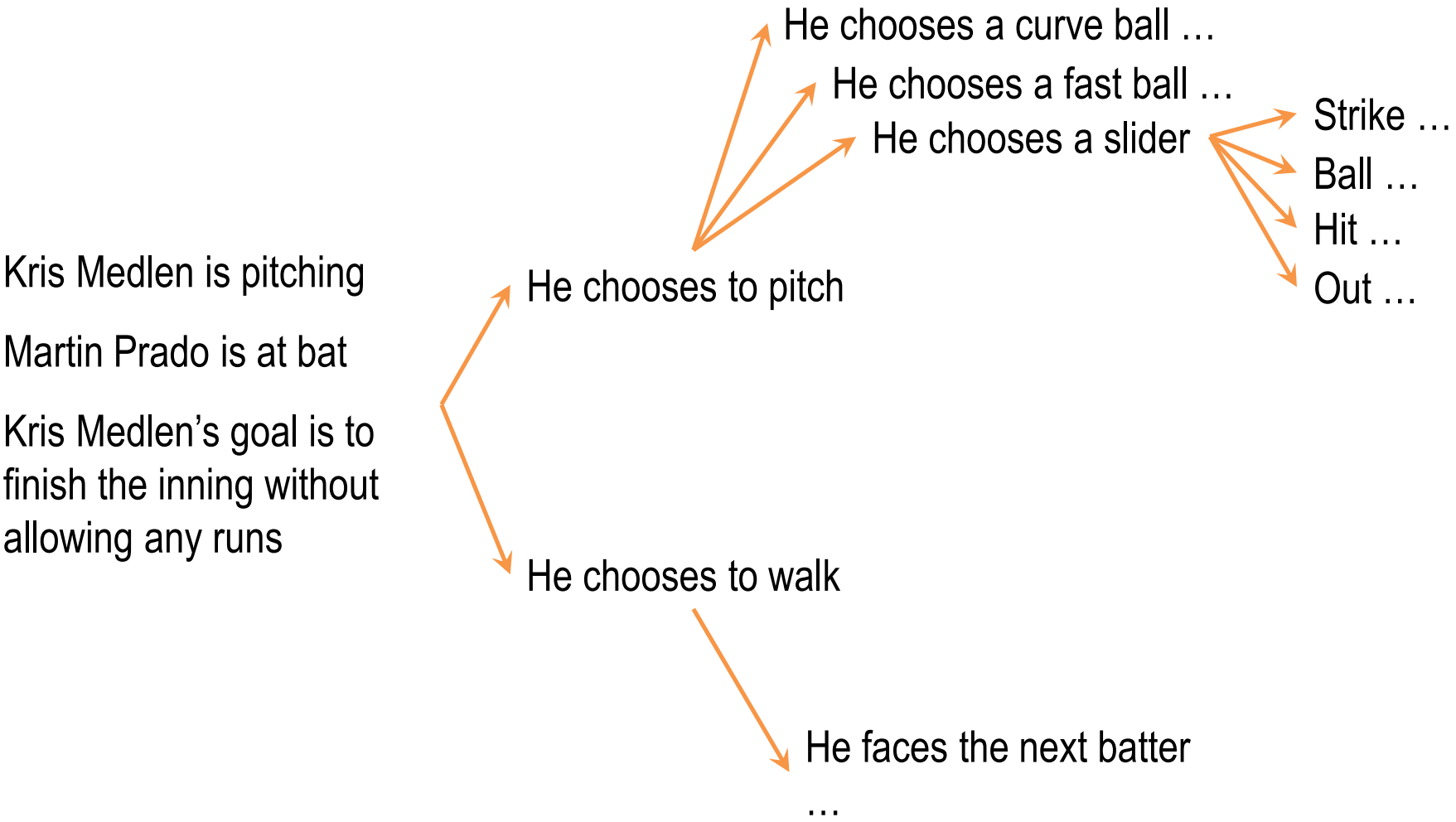

DELTA
AT the BALLPARK APP
JACKPOT
$4,882
NAPA
KNOW HOW
xfinity
ATLBlue.com
State Farm

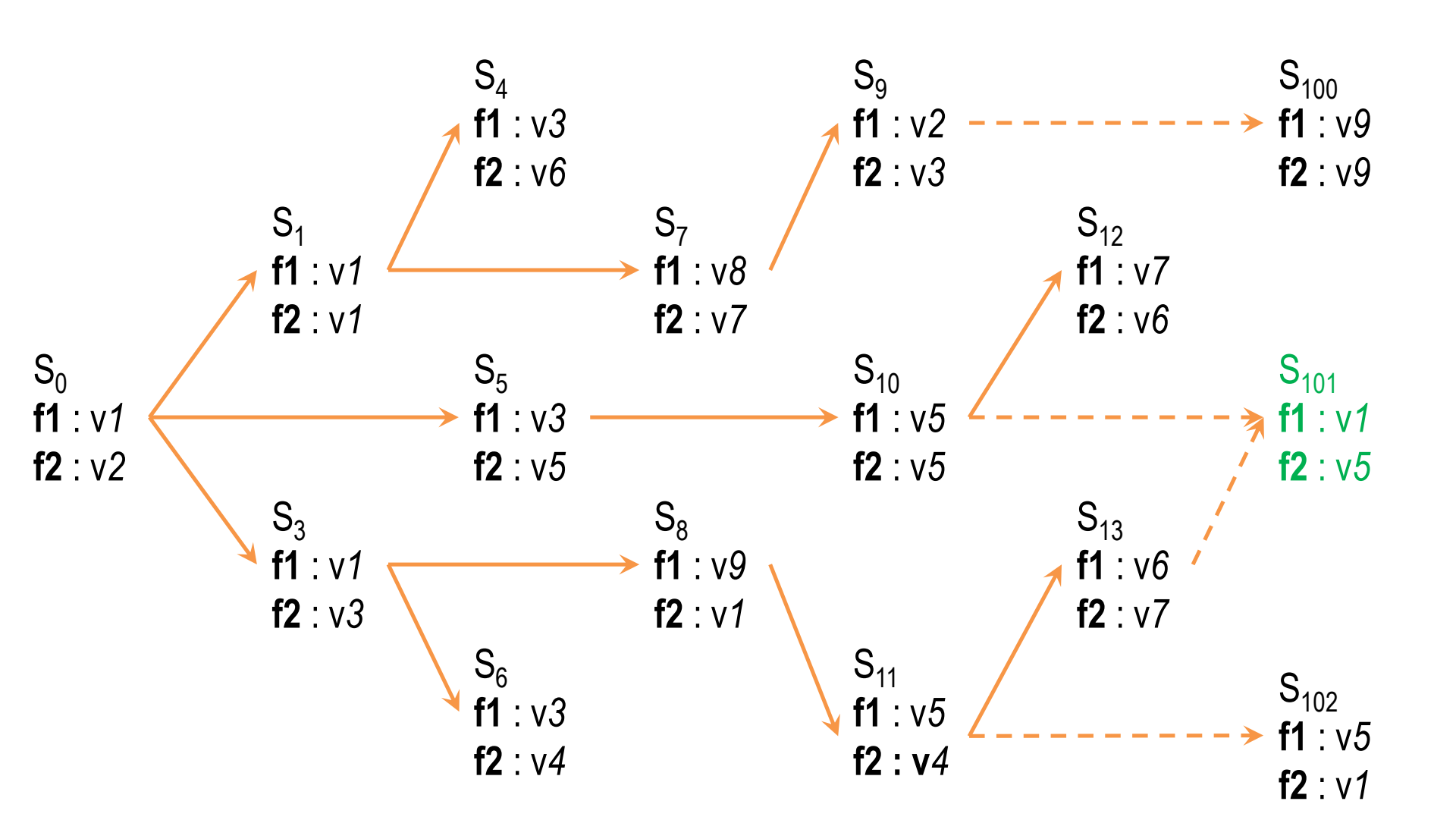

DELTA
AT the BALLPARK APP
JACKPOT
$4,882
NAPA
KNOW HOW
Braves
Budweiser
xfinity
State Farm


DELTA
AT the BALLPARK APP
JACKPOT
$4,882
NAPA
KNOW HOW
xfinity
State Farm


DELTA
AT the BALLPARK APP
JACKPOT
$4,882
NAPA
KNOW HOW
xfinity
State Farm

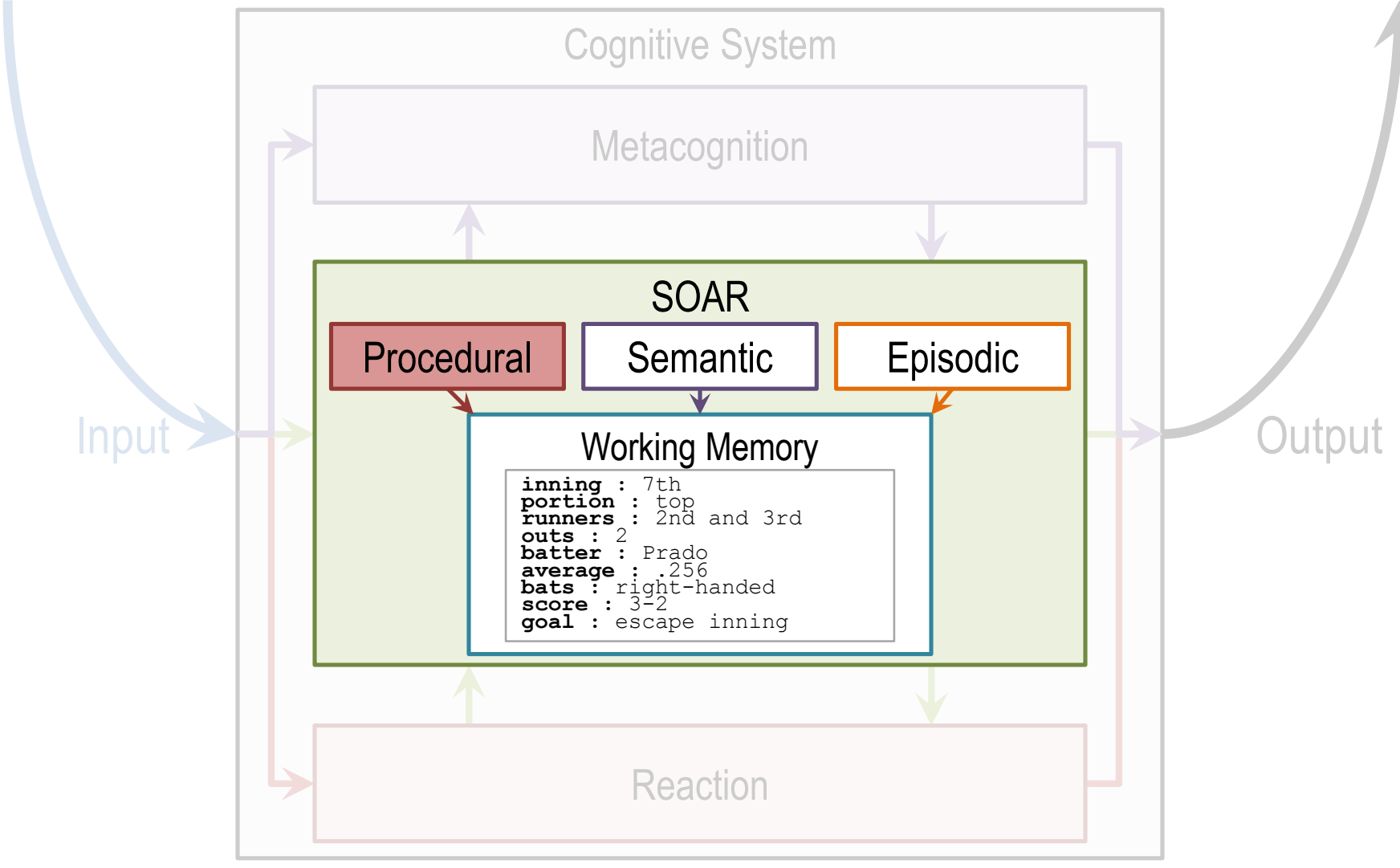

DELTA
AT the BALLPARK APP
JACKPOT
$4,882
NAPA
KNOW HOW
xfinity
State Farm


He chooses a curve ball …
He chooses a fast ball …
He chooses a slider
Strike …
Ball …
Hit …
Out …
Kris Medlen is pitching
Martin Prado is at bat
Kris Medlen's goal is to finish the inning without allowing any runs
He chooses to pitch
He chooses to walk
He faces the next batter
…


S0
f1 : v1
f2 : v2
S1
f1 : v1
f2 : v1
S3
f1 : v1
f2 : v3
S4
f1 : v3
f2 : v6
S5
f1 : v3
f2 : v5
S6
f1 : v3
f2 : v4
S7
f1 : v8
f2 : v7
S8
f1 : v9
f2 : v1
S9
f1 : v2
f2 : v3
S10
f1 : v5
f2 : v5
S11
f1 : v5
f2 : v4
S12
f1 : v7
f2 : v6
S13
f1 : v6
f2 : v7
S100
f1 : v9
f2 : v9
S101
f1 : v1
f2 : v5
S102
f1 : v5
f2 : v1

It's the top of the 7th inning. There are runners on 2nd and 3rd base. There are two outs. The batter, Martin Prado, has an average of .256 and bats fourth in the batting order. We are winning 3-2. I struck this batter out last time. My goal is to escape the inning.

```
inning : 7th
portion : top
runners : 2nd and 3rd
outs : 2
batter : Prado
average : .287
bats : right-handed
score : 3-2
goal : escape inning
```


Cognitive System
Metacognition
SOAR
Procedural
Semantic
Episodic
Working Memory
inning : 7th
portion : top
runners : 2nd and 3rd
outs : 2
batter : Prado
average : .256
bats : right-handed
score : 3-2
goal : escape inning
Reaction
Input
Output

inning : 7th
portion : top
runners : 2nd and 3rd
outs : 2
batter : Prado
average : .256
bats : right-handed
score : 3-2
goal : escape inning

(r1) If goal is to *Escape*, I perceive 2 outs, I perceive a runner on 2nd and I perceive no runner on 1st
then suggest goal intentionally walk batter (*Intentional Walk*)

(r2) If goal is to *Escape*, I perceive fewer than 2 outs, or I perceive a runner on 1st, or I perceive no runner on 2nd, or I perceive no runners
then suggest goal to get the batter out via pitching (*Pitch*)

(r3) If goal is *Intentional Walk*
then suggest intentional-walk operator

(r4) If goal is *Pitch* and I perceive a new batter who is left/right-handed
then add **batter** *not out*, **balls** *0*, **strikes** *0*, **bats** *left/right*

(r5) If the goal is *Pitch* and **batter** *not out*
then suggest throw-curve-ball operator

(r6) If the goal is *Pitch* and **batter** *not out* and **bats** *left-handed*
then suggest throw-fast-ball operator

(r7) If only one operator has been selected
then send operator to the motor system and add **pitch** *thrown* to state

... ...

inning : 7th
portion : top
runners : 2nd and 3rd
outs : 2
batter : Prado
average : .256
bats : right-handed
score : 3-2
goal : escape inning

What operator is selected?

- intentional-walk
- throw-curve-ball
- throw-fast-ball
- None, the system cannot decide.

(r1) If goal is to *Escape*, I perceive 2 outs, I perceive a runner on 2nd and I perceive no runner on 1st
then suggest goal intentionally walk batter (*Intentional Walk*)

(r2) If goal is to *Escape*, I perceive fewer than 2 outs, or I perceive a runner on 1st, or I perceive no runner on 2nd, or I perceive no runners
then suggest goal to get the batter out via pitching (*Pitch*)

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then suggest intentional-walk operator

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then suggest throw-curve-ball operator

(r6) If the goal is *Pitch* and **batter** *not out* and **bats** *left-handed*
then suggest throw-fast-ball operator

(r7) If only one operator has been selected
then send operator to the motor system and add **pitch** *thrown* to state

... ...

inning : 7th
portion : top
runners : 1st, 2nd, 3rd
outs : 2
batter : Hill
average : .269
bats : right-handed
score : 3-2
goal : escape inning

What operator is selected?

- o intentional-walk
- ● throw-curve-ball
- o throw-fast-ball
- o None, the system cannot decide.

(r1) If goal is to *Escape*, I perceive 2 outs, I perceive a runner on 2nd and I perceive no runner on 1st
then suggest goal intentionally walk batter (*Intentional Walk*)

(r2) If goal is to *Escape*, I perceive fewer than 2 outs, or I perceive a runner on 1st, or I perceive no runner on 2nd, or I perceive no runners
then suggest goal to get the batter out via pitching (*Pitch*)

(r3) If goal is *Intentional Walk*
then suggest intentional-walk operator

(r4) If goal is *Pitch* and I perceive a new batter who is left/right-handed
then add **batter** *not out*, **balls** *0*, **strikes** *0*, **bats** *left/right*

(r5) If the goal is *Pitch* and **batter** *not out*
then suggest throw-curve-ball operator

(r6) If the goal is *Pitch* and **batter** *not out* and **bats** *left-handed*
then suggest throw-fast-ball operator

(r7) If only one operator has been selected
then send operator to the motor system and add **pitch** *thrown* to state

... ...

inning : 7th
portion : top
runners : 1st, 2nd, 3rd
outs : 2
batter : Parra
average : .273
bats : left-handed
score : 3-2
goal : escape inning

What operator is selected?

- intentional-walk
- throw-curve-ball
- throw-fast-ball
- None, the system cannot decide.

(r1) If goal is to *Escape*, I perceive 2 outs, I perceive a runner on 2nd and I perceive no runner on 1st
then suggest goal intentionally walk batter (*Intentional Walk*)

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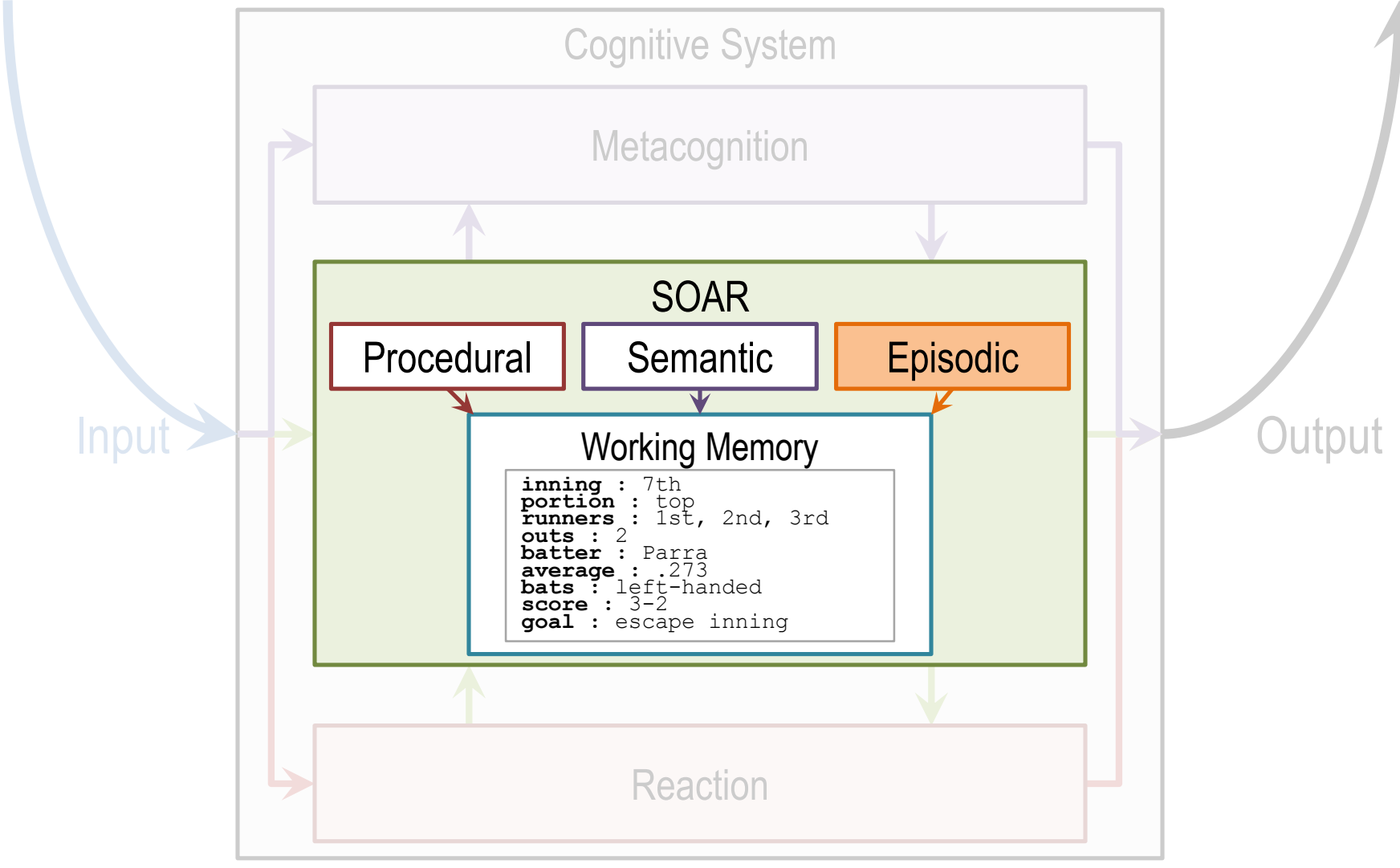
... ...


Cognitive System
Metacognition
SOAR
Procedural
Semantic
Episodic
Working Memory
inning : 7th
portion : top
runners : 1st, 2nd, 3rd
outs : 2
batter : Parra
average : .273
bats : left-handed
score : 3-2
goal : escape inning
Reaction
Input
Output

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

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"

inning : 7th
portion : top
runners : 1st, 2nd, 3rd
outs : 2
batter : Parra
average : .273
bats : left-handed
score : 3-2
goal : escape inning

What operator is selected?

- o intentional-walk
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- o throw-fast-ball
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then suggest goal to get the batter out via pitching (*Pitch*)

(r3) If goal is *Intentional Walk*
then suggest intentional-walk operator

(r4) If goal is *Pitch* and I perceive a new batter who is left/right-handed
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(r5) If the goal is *Pitch* and **batter** *not out*
then suggest throw-curve-ball operator

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(r7) If only one operator has been selected
then send operator to the motor system and add **pitch** *thrown* to state

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

Assignment

How would you use a production system to design an agent that could answer Raven's Progressive Matrices?

To recap…

- Cognitive architectures
- Production systems
- Action selection
- Chunking