CS 6795 Introduction to Cognitive Science Review

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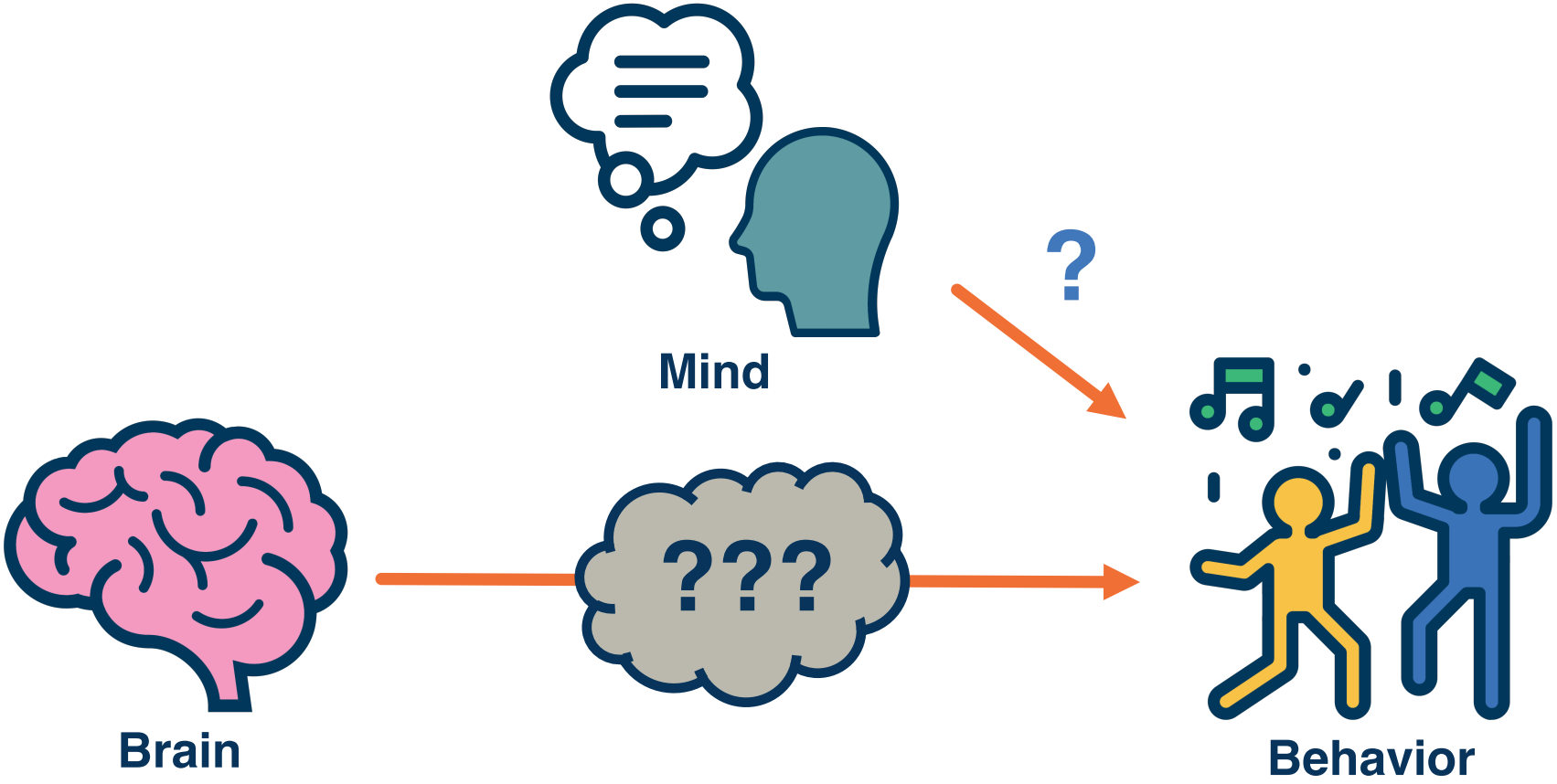
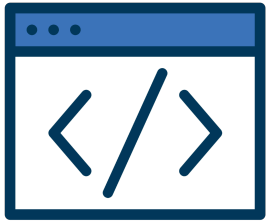


What is Mind?

Software

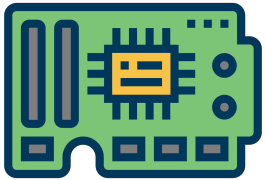


- The computer contains **"data structures"**
- **Algorithms** affect changes to data structures

Mind

- The mind contains/holds/manifests **"mental representations"**
- The mind performs **procedures** on those representations – affecting changes to those representations

Hardware



- **Physical structures** that implements data structures
- **Processors** that execute algorithms

Brain

- The **physical instantiation** of "data structures"
- **Parallel processors** that execute procedures

Mind-Computer-Brain Analogy

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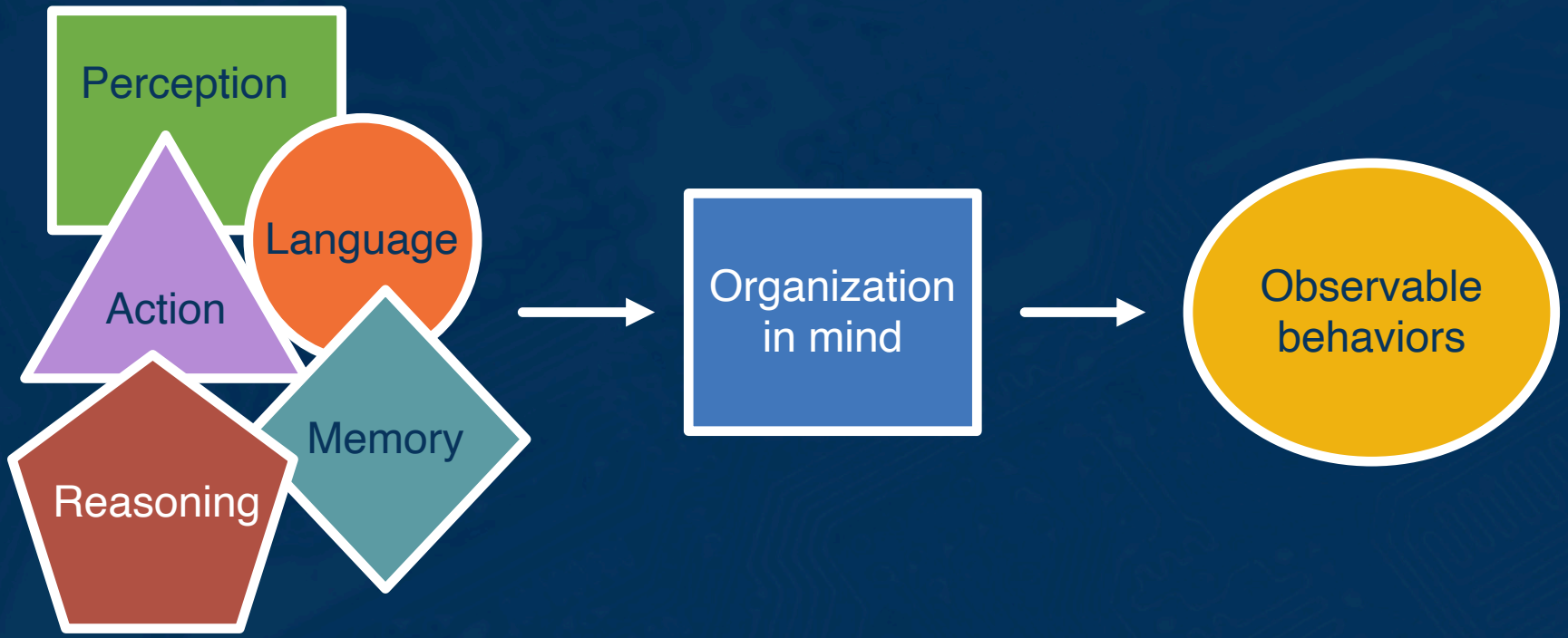
A System's View of the Mind



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Debate: What is the Boundary of the System?

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Behaviors that occur in **seconds**

Behaviors that occur in **milliseconds**

Behaviors that occur in **millions of seconds**

Behaviors at Different Timescales

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CRUM:
Computational-Representational Understanding of Mind

Mind:

- The mind contains/holds/manifests **“mental representations”**
- The mind performs **procedures** on those representations – affecting changes to those representations

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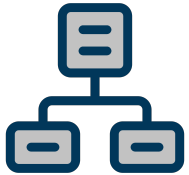
David Marr:
Neuroscientist & AI researcher

www.neuroscience.cam.ac.uk

First: Computational Level

Understanding the problem: Task analysis, problem specification



Second: Algorithmic Level

Identify data structures, input, algorithm/sequence of steps, output

Third: Implementation Level

Physical realization of the system

The Tri-Level Hypothesis (Marr, 1982)

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1. How Does the Mind Work?

2. What is the Inner Language of Thought?

3. CRUM & Tri-Level Hypothesis

First: Computational Level

Second: Algorithmic Level

Third: Implementation Level

Summary: Representations and Processes

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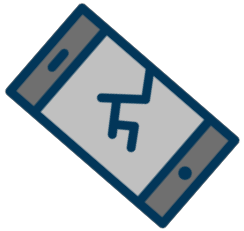
Deduction

Premise

Conclusion

Abduction



Effect

Likely cause

Induction

Sample

Population

Three Kinds of Logic

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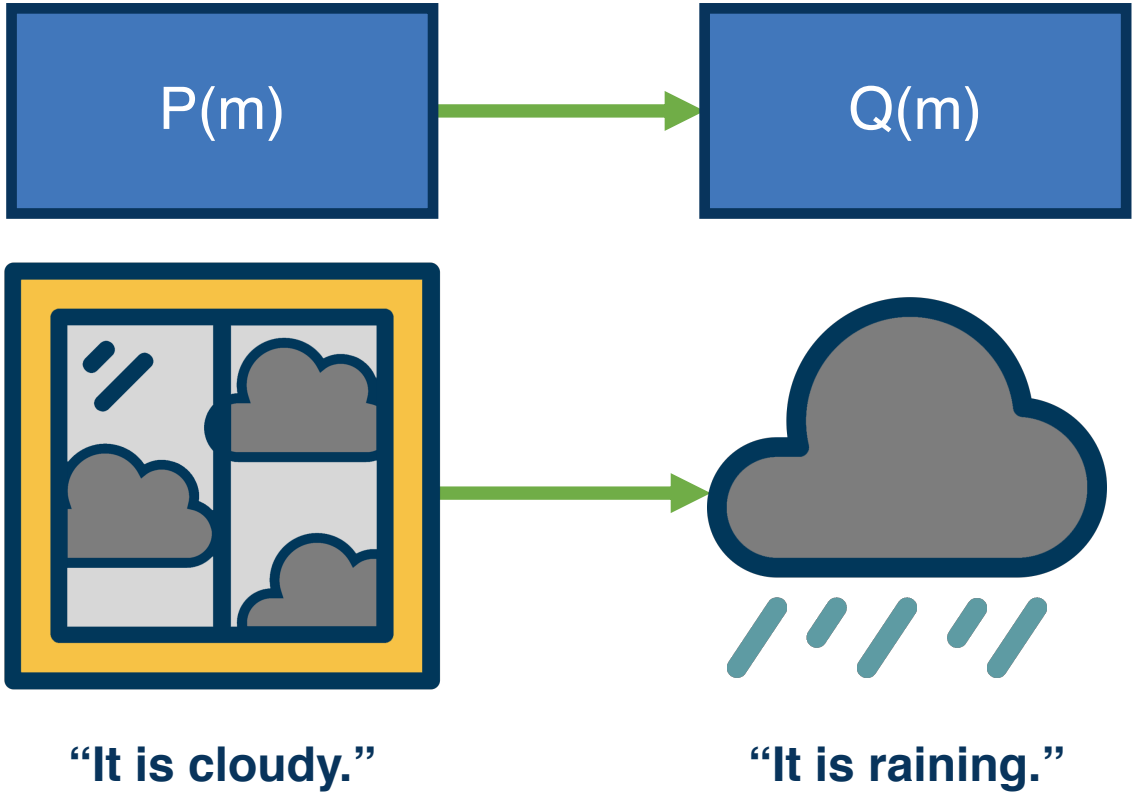


Deductive Logic

Representation

Well formed sentences composed of literals

A

B

Negation: ~A

Disjunction: A or B

Conjunction: A and B

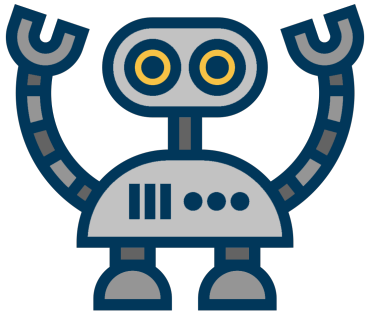
Conditional Probabilities: P(A | B)

Computation

Bayes' Theorem:

$$P(B \mid A) * P(A) = P(A / B) * P(B)$$

$$P(B \mid A) = P(A / B) * P(B) / P(A)$$



Probabilities theory is more prevalent in **AI and Robotics**

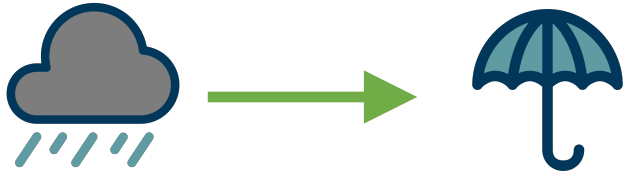
Form of Rules

IF… → THEN…

"**If** it rains…" → "…**then** I will take an umbrella"

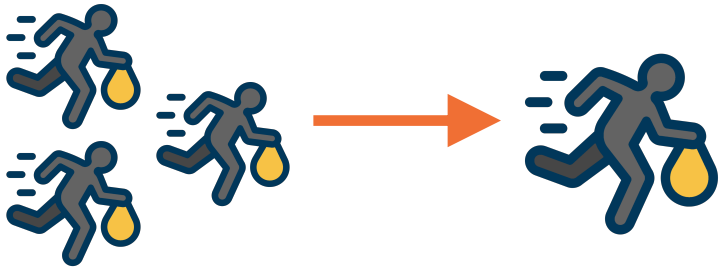
Heuristic

- Heuristics can be **very useful**



"If it's raining, take an umbrella"

- Heuristics can also **lead to errors**
  - **Availability Heuristic**



A **Heuristic** is one type of control knowledge

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Less Formal

More Formal

Qualia Concepts

Exemplar Concepts

Prototypical Concepts

Axiomatic concepts

Types of Concepts

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Concepts are an **equivalent class** of the **perceptions** in the world.

We have concepts because the **world is very complex**.

Concepts allow us to **index our actions**.

Types of Concepts

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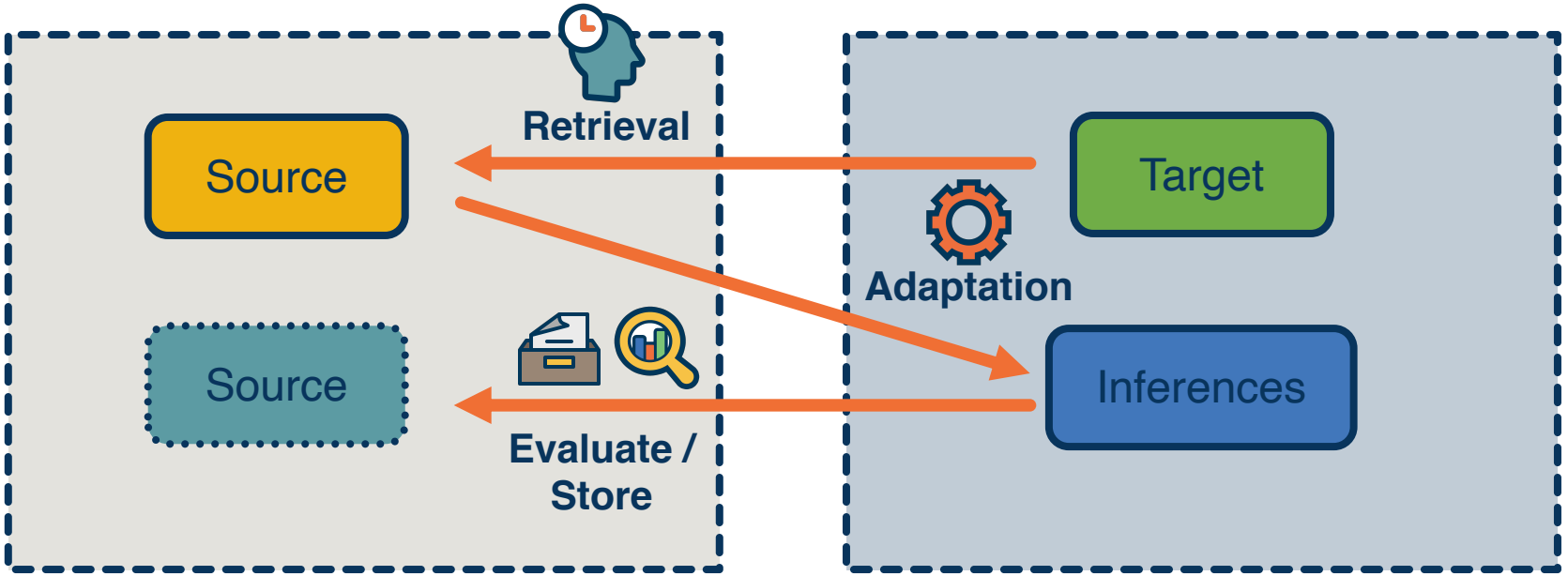
Incomplete Information

Limited Computational Power

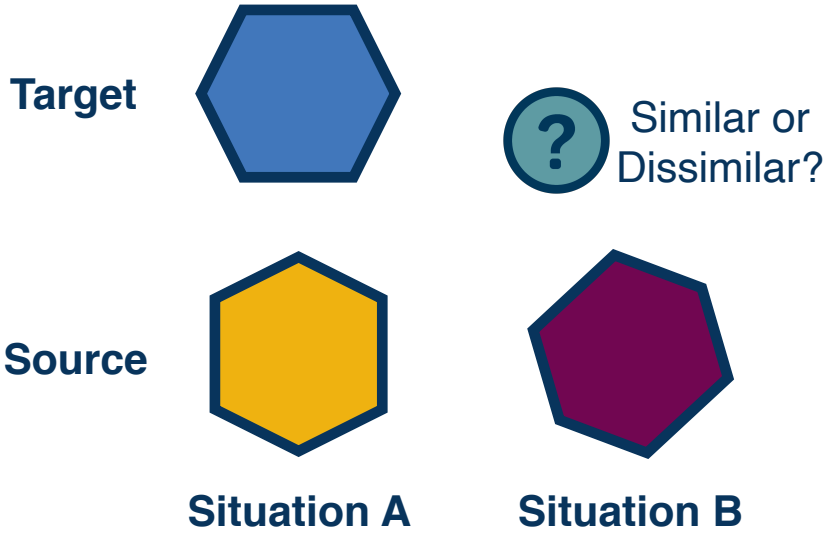
Long-term:
Large, can store a large amount of knowledge, slowly evolving

Working memory, Short-term:
Small, 7+/- 2 units, rapidly evolving, focus of Attention



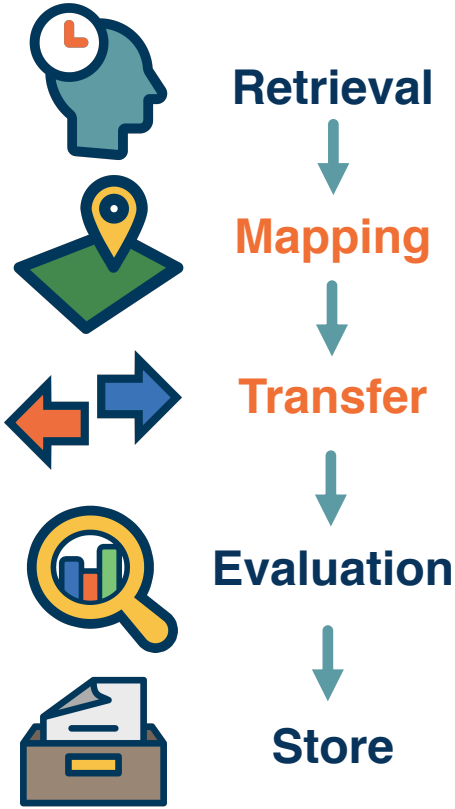
Two Kinds of Memory

Representations



The key to noticing differences is the **casual relations that produce outcomes relevant** to your goals.

Computation



Original Rotation Reflection Scaling

Mental Rotation Thought Experiment

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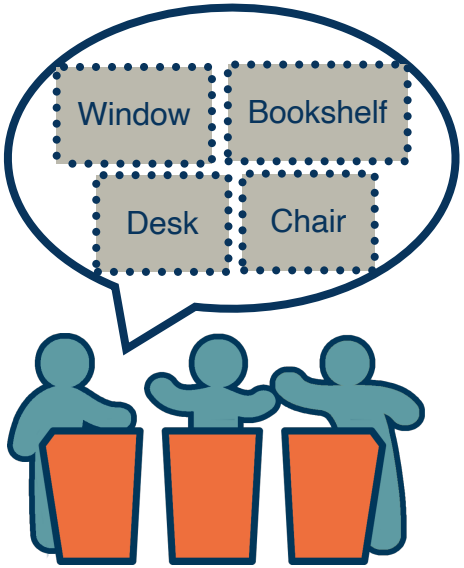
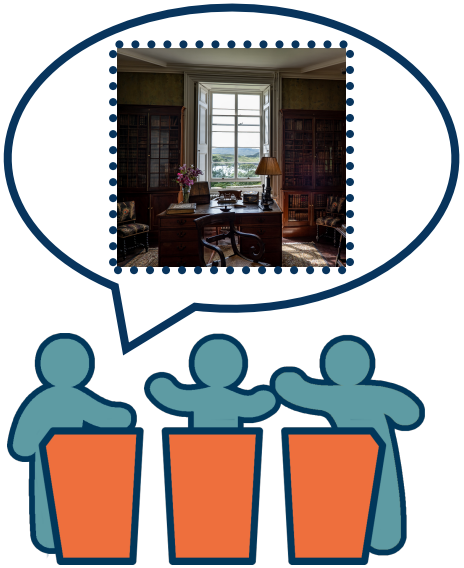
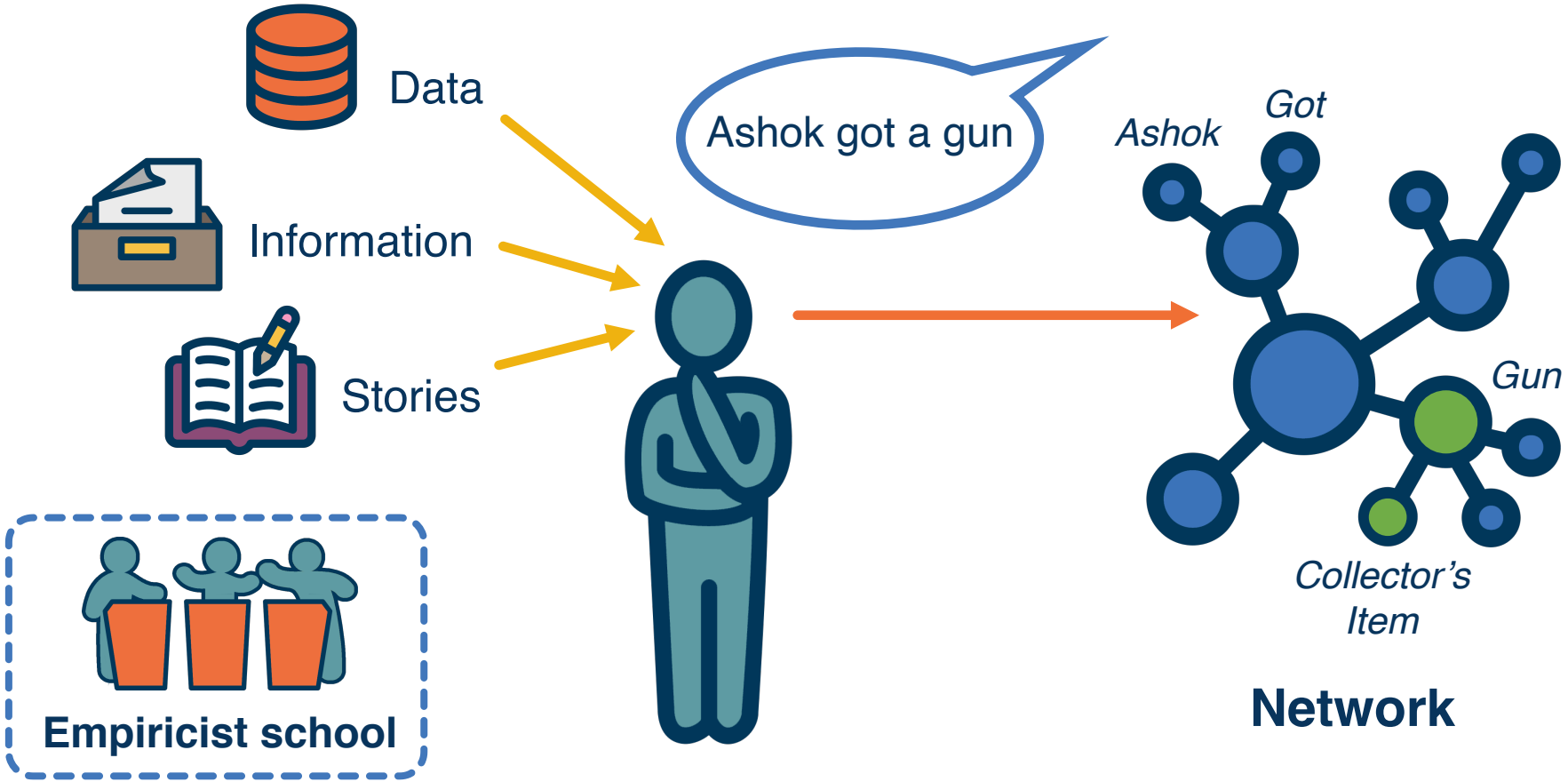


Rationalist school

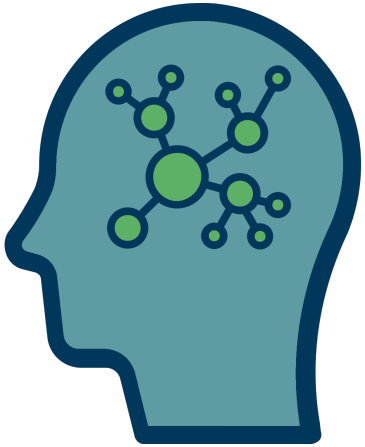


Empiricist school

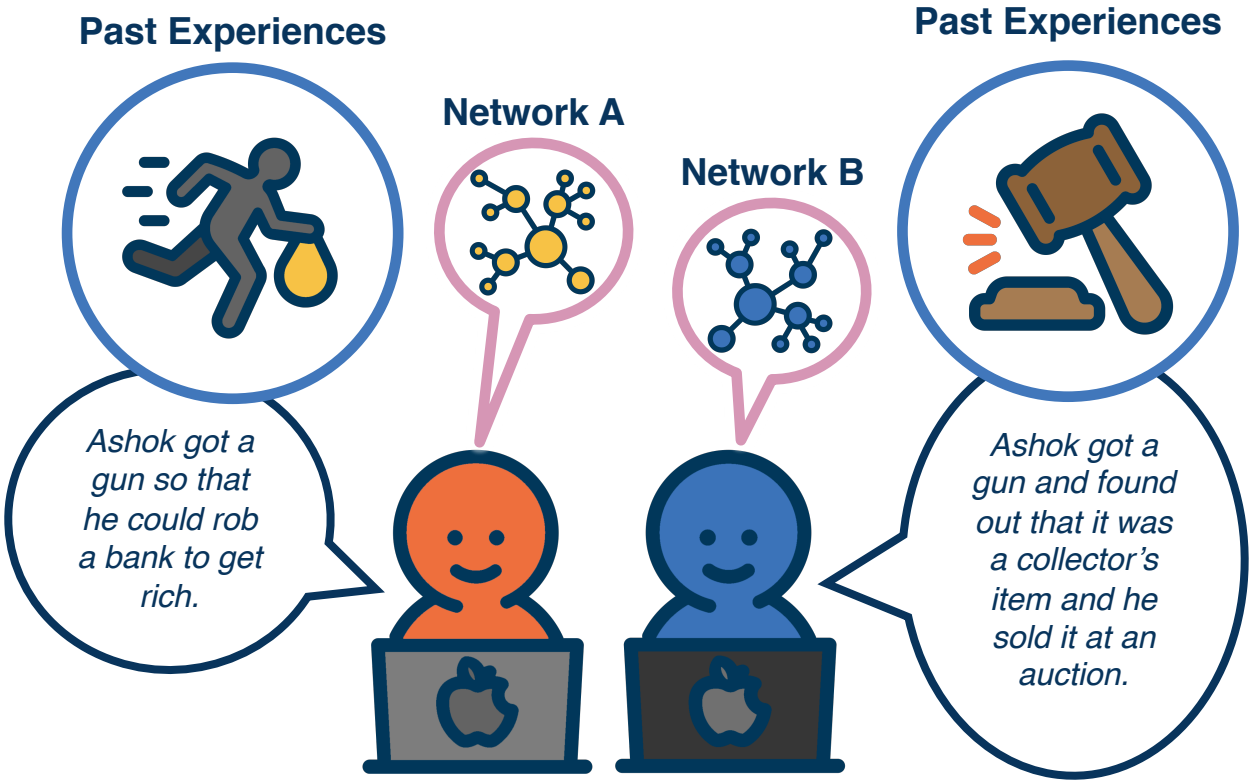
Logic/ Probability — Rules — **Concepts** — Analogies — Images — Connections


Data
Information
Stories
Empiricist school
Ashok got a gun
Ashok
Got
Gun
Collector's Item
Network

Connectionism



Theory based on the **notion of association**



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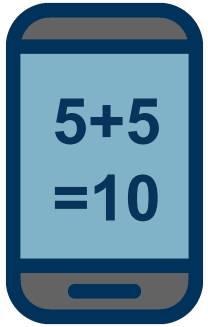
High-level Content

Task, Knowledge Level

Algorithm, Symbol Level

Hardware, Implementation Level

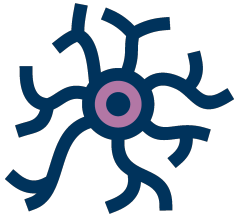
Low-level Architecture



Computation

Chips and Circuits

Driving a car



Neurons

How Mind Works

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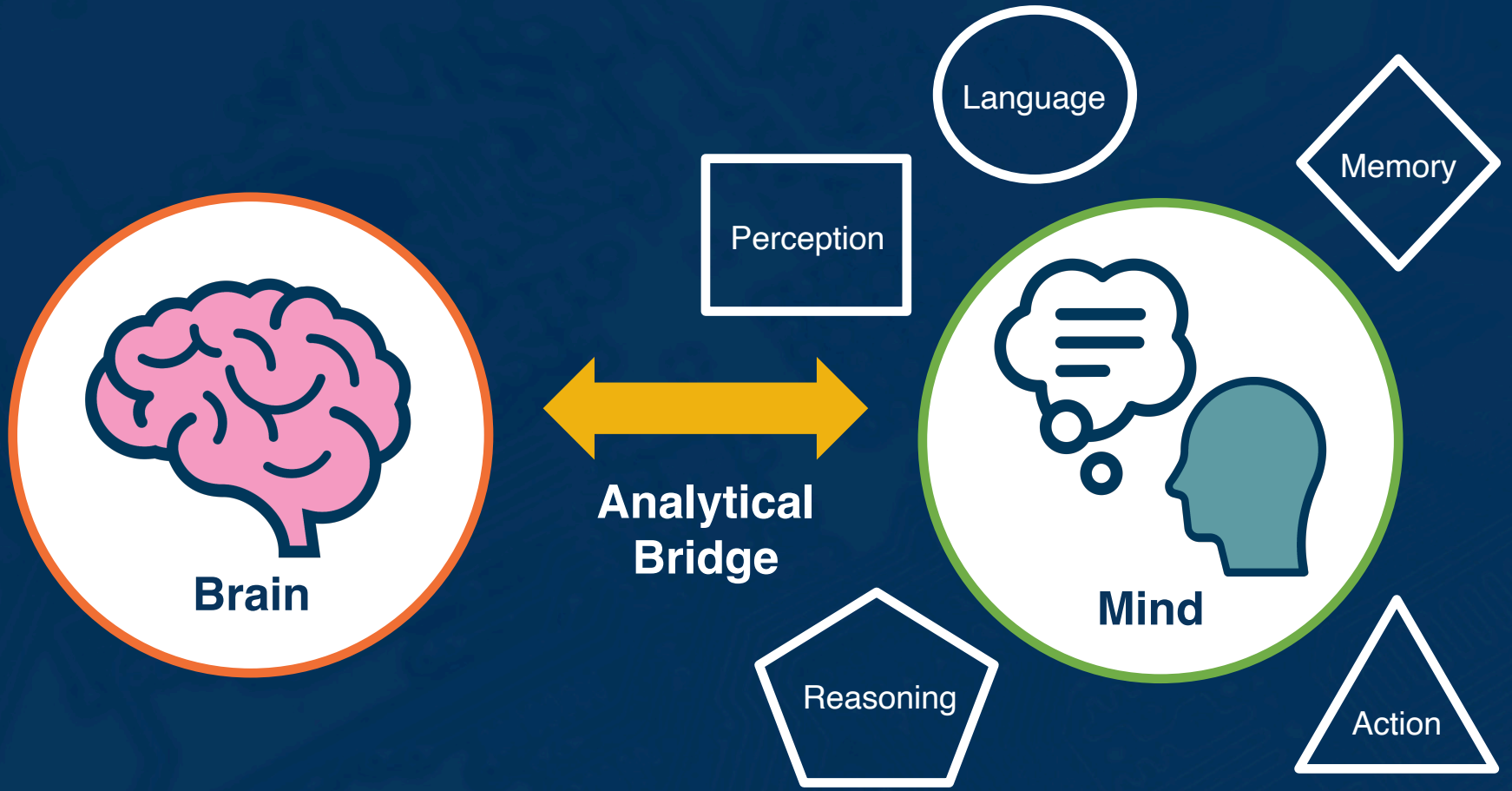

CRUM and Brain Theories

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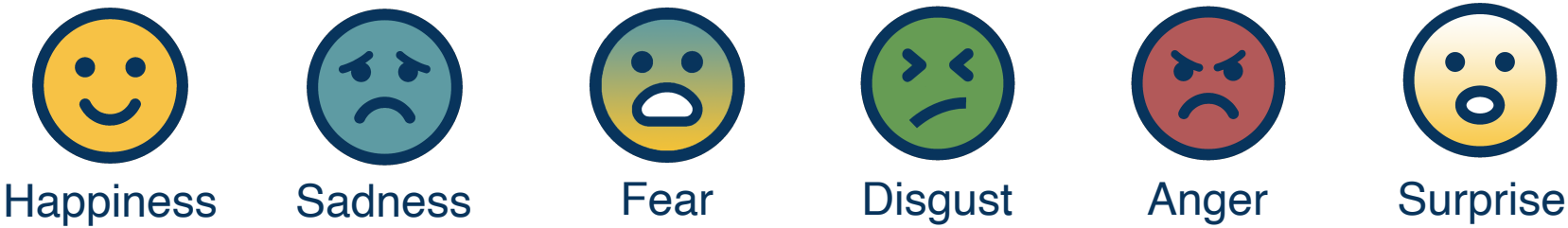

Six Basic Emotions

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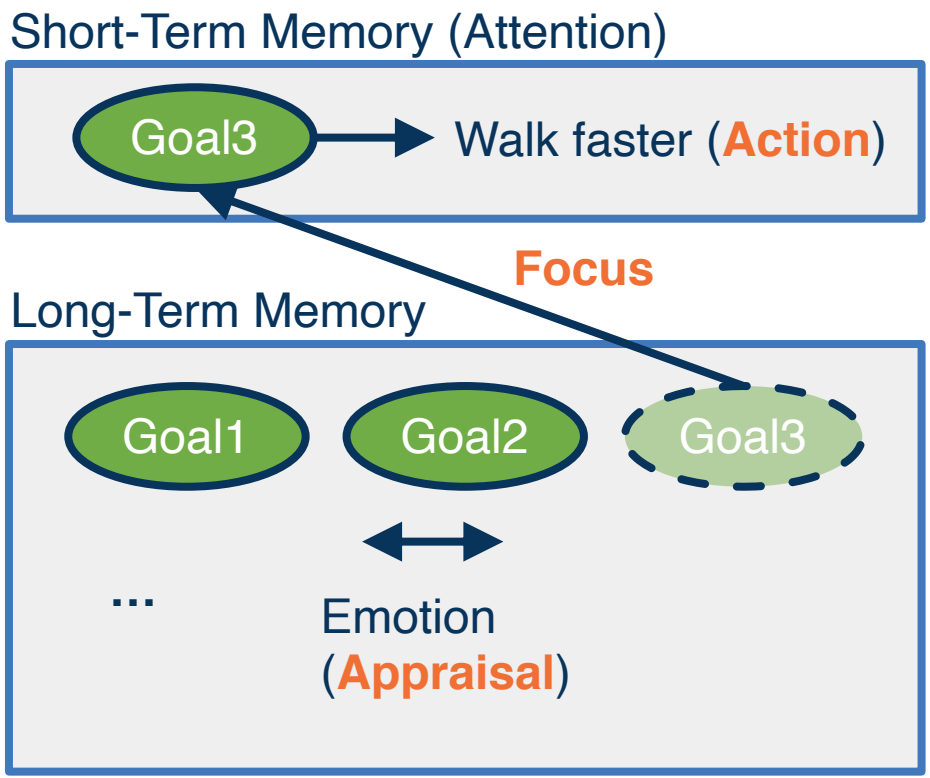
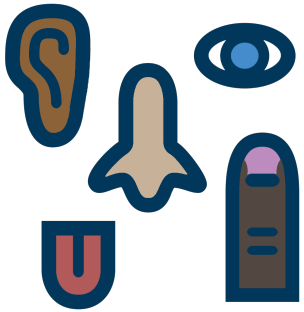
Appraisal, Focus, Action



CRUM Expansion will involve:

- New **representations** for emotions
- Computational **procedures** to act upon the representation

Objective Experiences:



Perceptions

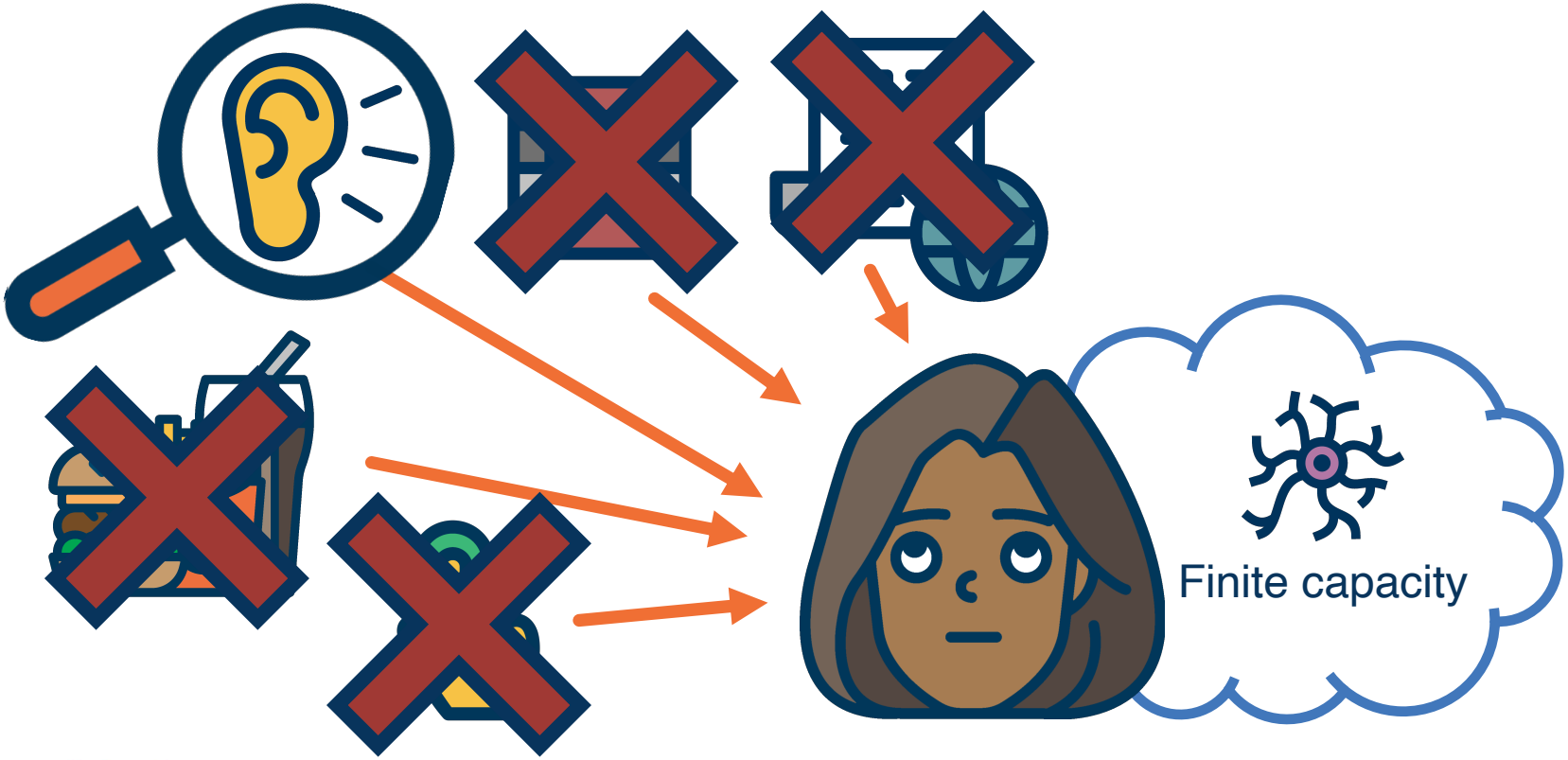
Objective Experience

Subjective Experiences:

Thoughts

Feelings

Consciousness helps us **focus our attention**.



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Embodied Cognition: Body Shapes Our Behavior

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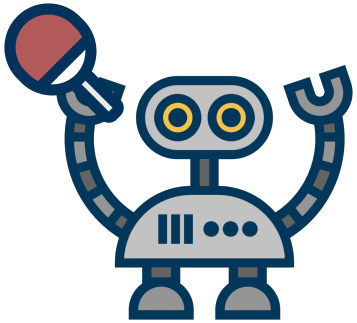
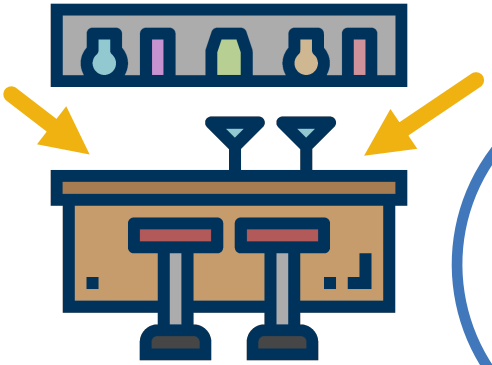


Ping Pong Robot

Human Behavior



How does a bartender keep track of all the drinks?

Reaction

Environment shapes behavior

Embodied Cognition:
Body shapes our intelligent behavior.

Situated Cognition:
We react to our environment.

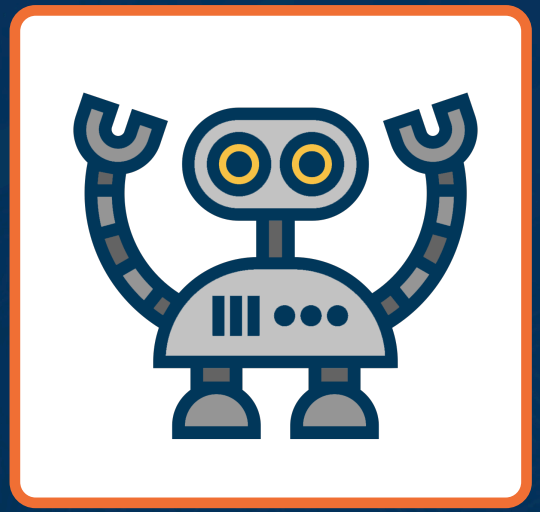
Distributed Cognition:
We distribute cognitive load to the environment.

*"**Through others** we become ourselves"*

Vygotsky

Humans

Primates



Robots

Learning by Imitation

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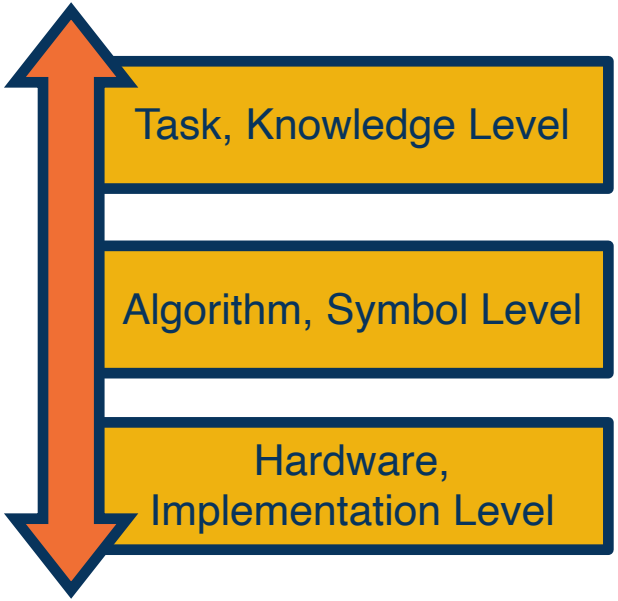

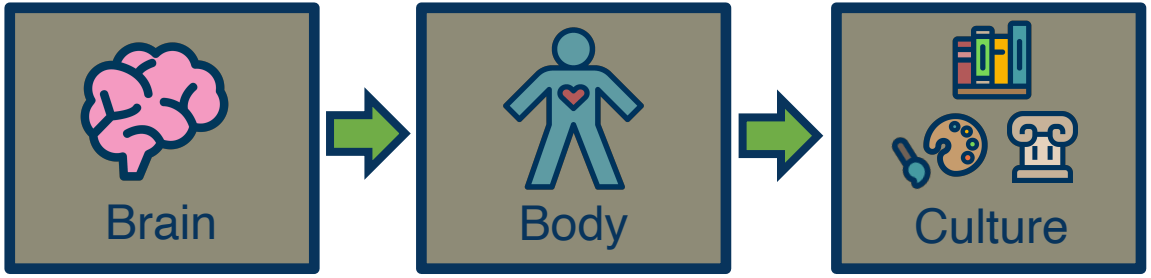

How to calculate 5+5	How to drive a car	How to collaborate
Neurons, Neuro-transmitters	Neurons, Neuro-transmitters, **arms, legs, eyes, etc.**	**???**

CRUM in Different Boundaries

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Cognitive Science Society

https://cognitivesciencesociety.org/

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