

# From Signals to Knowledge and from Knowledge to Action: Peircean Semiotics and the Grounding of Cognition

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# Introduction

## ■ Philosophy of Mind

- How the mind works ?
- What happens inside the mind ?
- How mind elements relate to the real world ?

## ■ Artificial Intelligence

- Computational algorithms inspired by different theories on how mind works

## ■ Cognitive Science

- Scientific theories trying to explain the mechanisms of cognition
- Integrate findings from different origins:
  - Philosophy of Mind, Artificial Intelligence, Neuroscience, Psychology, Linguistics, Social Sciences

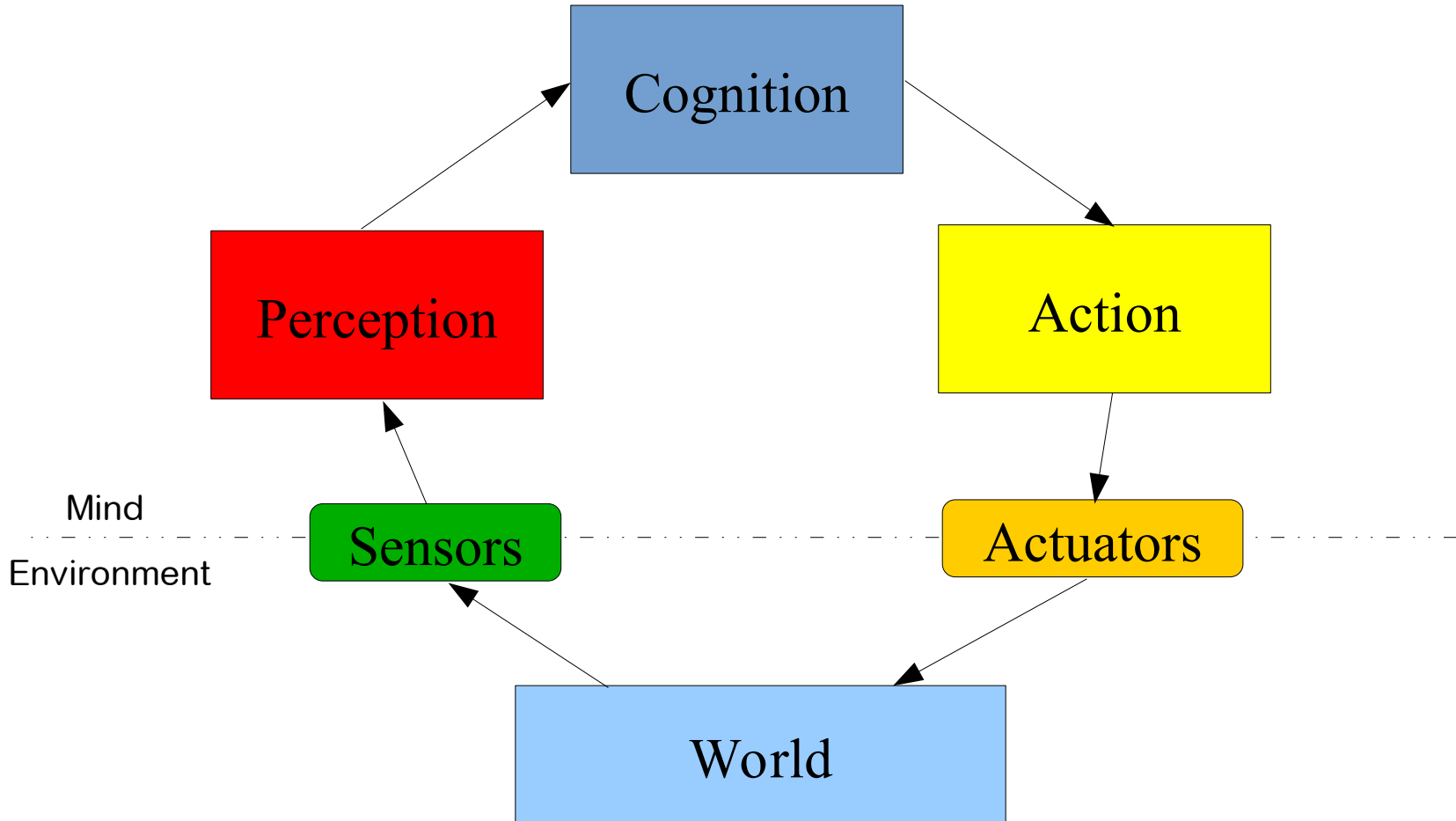
## ■ Cognition

- Process happening inside the mind, which collects data from the world, using sensors, transforms this data into knowledge, and based on this knowledge and internal agent's goals, generates a sequence of actions, affecting the world by means of actuators

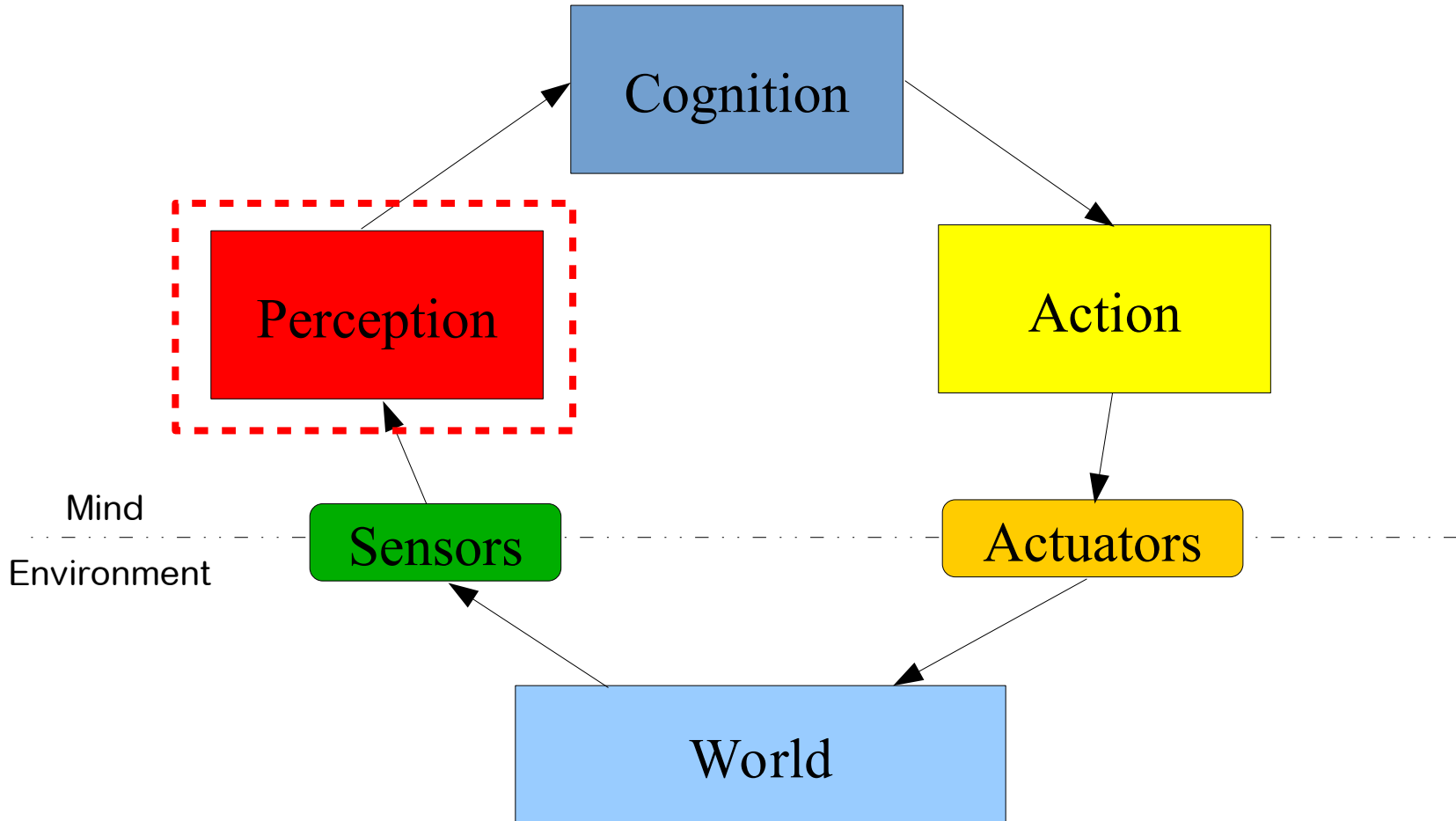
## ■ Models of Cognition

- Theories of possible ways in which cognition might be happening in actual minds
- Can be used in order to generate artificial agents, to be used in the context of artificial intelligence
- Inspiration on the many branches of cognitive science:
  - Philosophy of Mind, Artificial Intelligence, Neuroscience, Psychology, Linguistics, Social Sciences

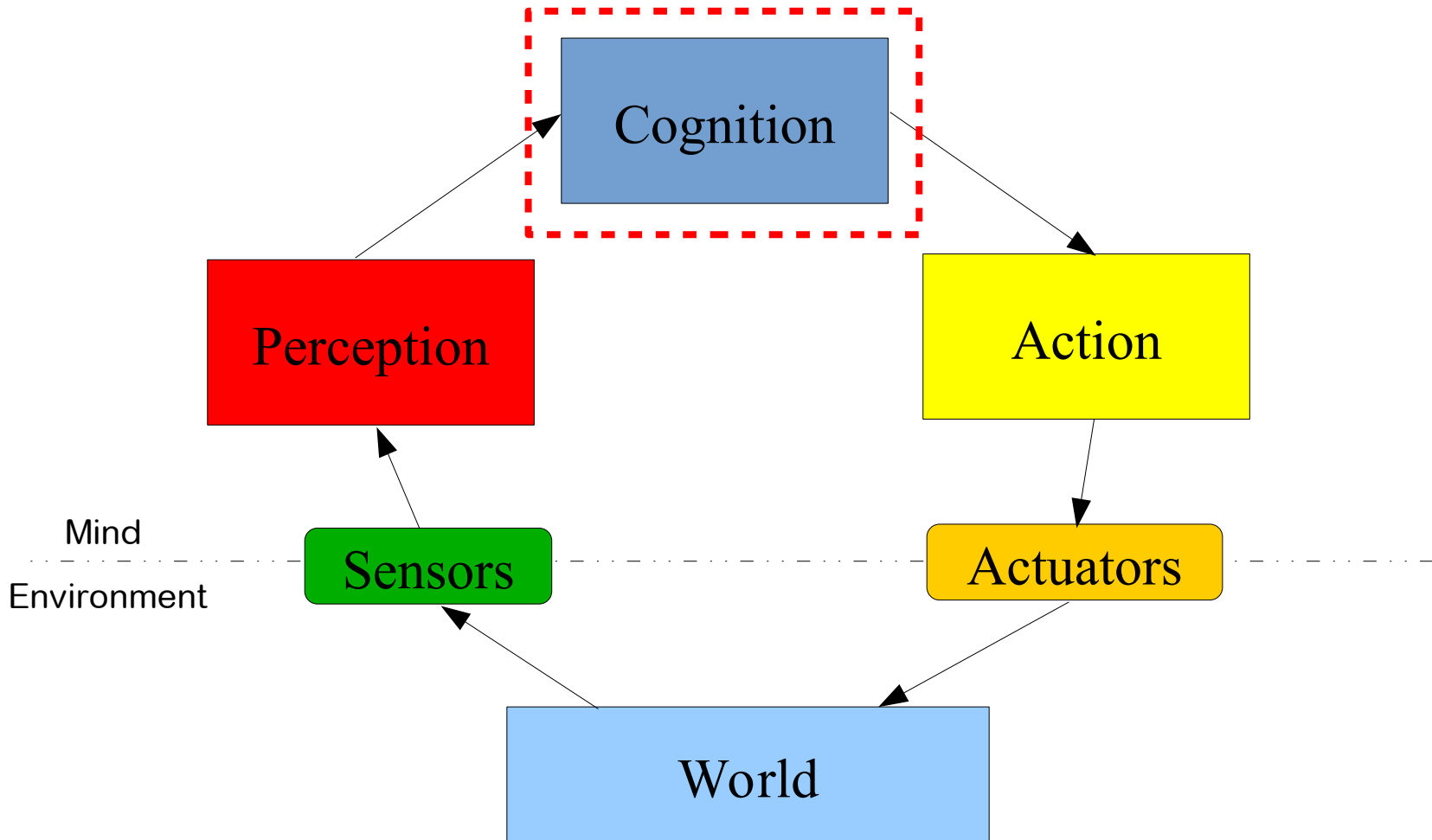
# The Scope of Cognition



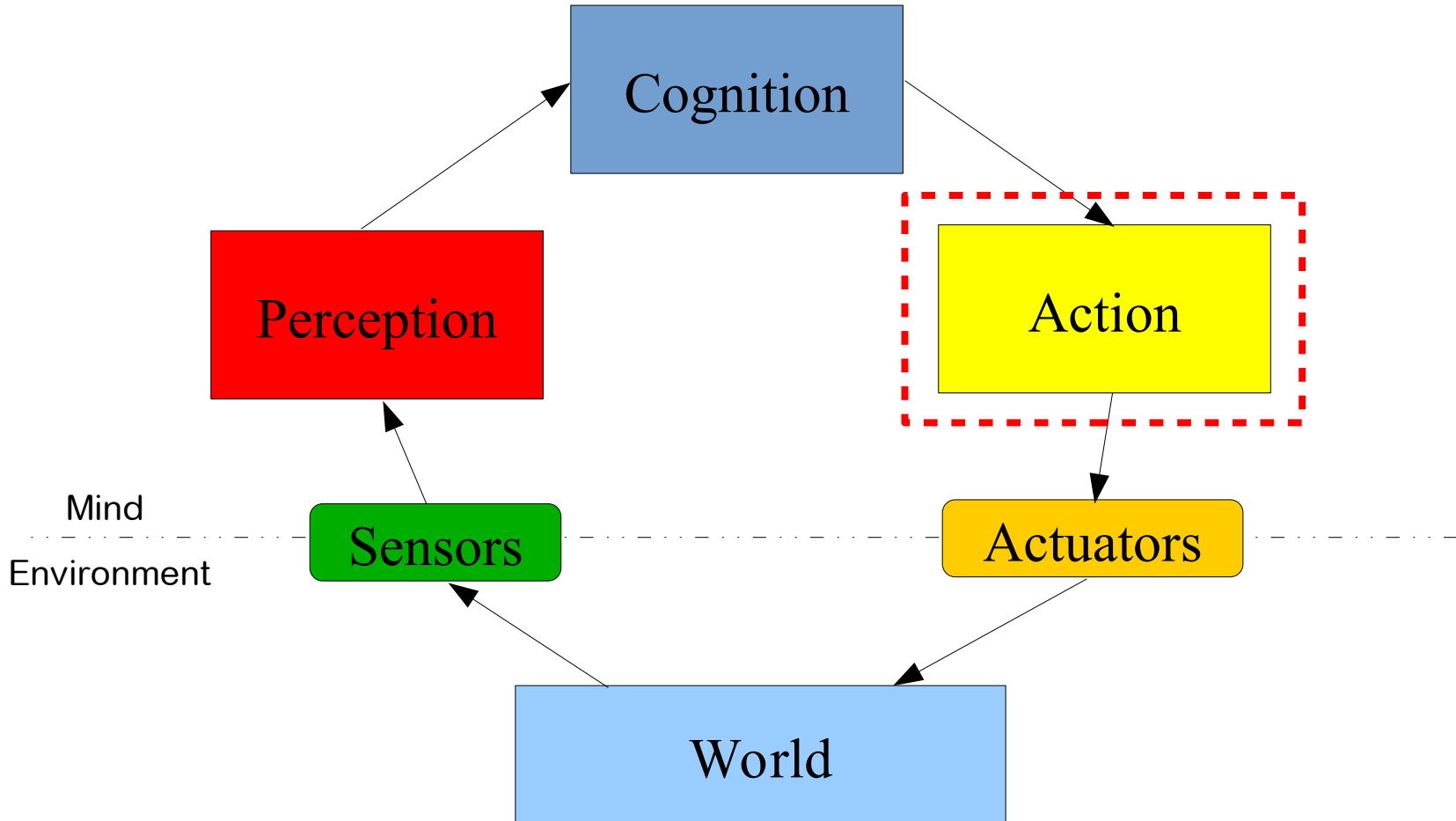
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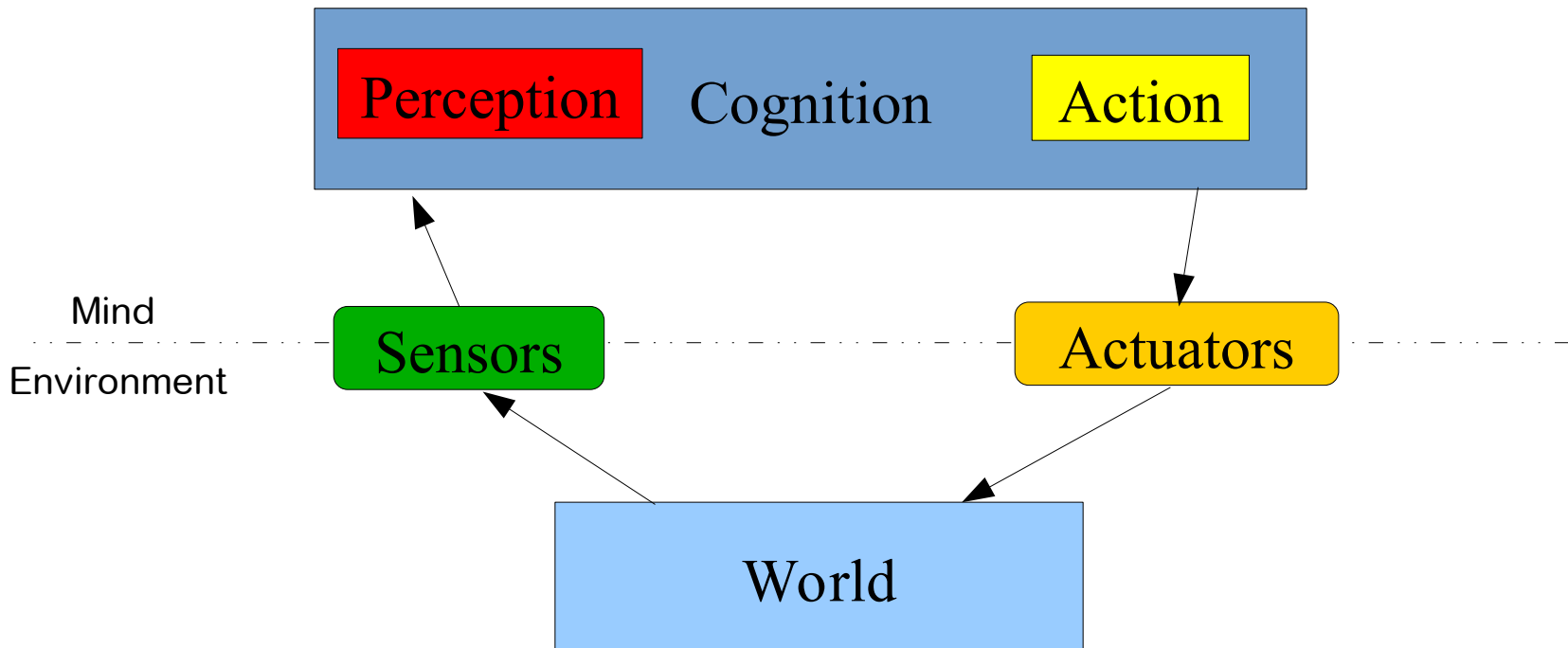
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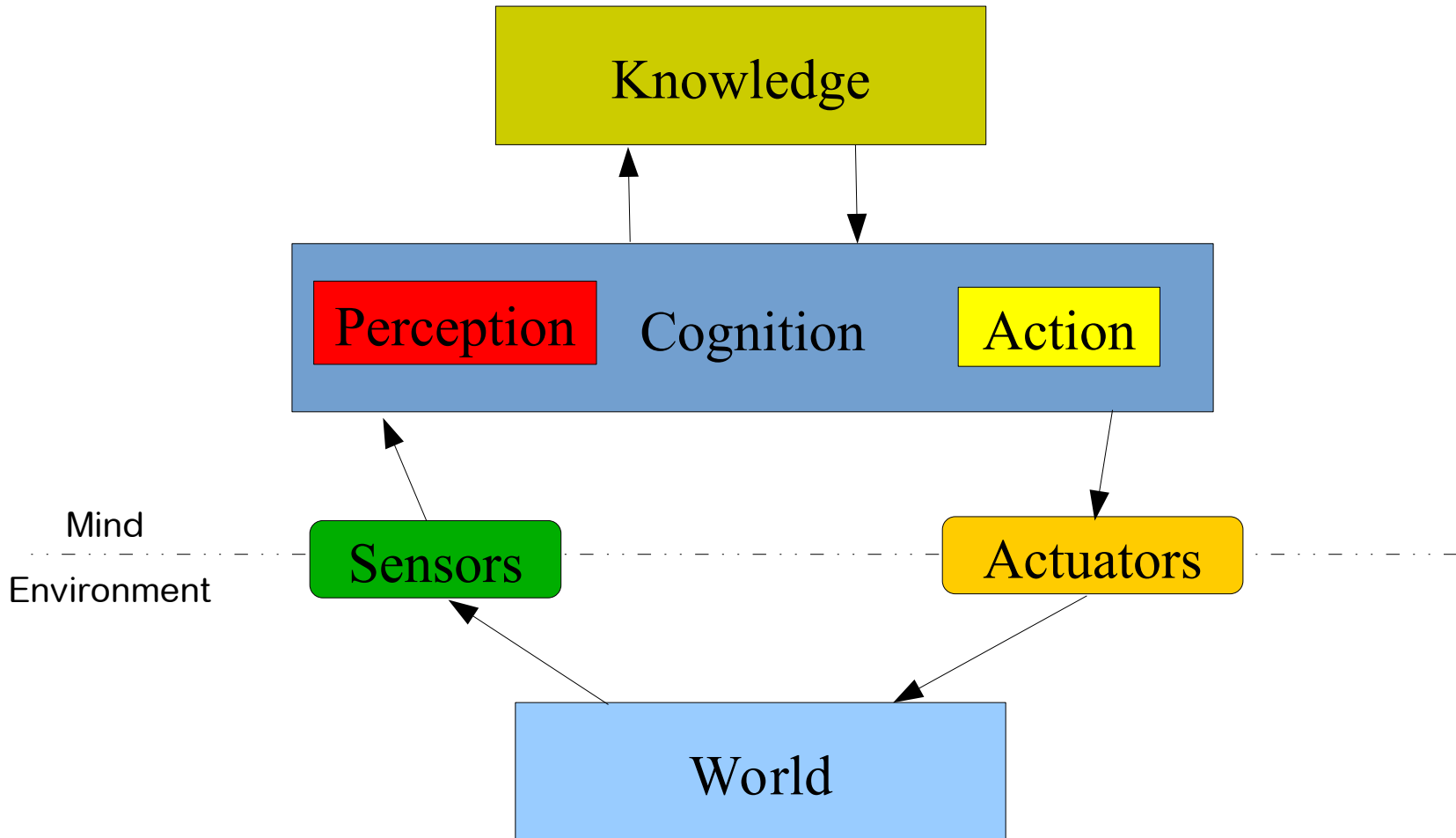


# The Scope of Cognition





# The Scope of Cognition



## ■ Charles Sanders Peirce (1839-1914)

- American philosopher, father of (Peircean) Semiotics and American Pragmatism
  - “One of the most original minds of the later nineteenth century and certainly the greatest American thinker ever” (Bertrand Russell)
  - “One of the greatest philosophers of all times” (Karl Popper)



## ■ Semiotics

- Study of signs and sign processes

## ■ Peircean Semiotics

- Sophisticated and complex, with deep philosophical commitments
- Strong technical terminology requiring a great effort of abstraction in order to be properly understood

# Elements within the Mind and their Categories

- Aristotle (10 basic Categories)
  - Categories are related to the classes of words
  - Substance; Quantity; Quality; Relatives; Somewhere; Sometime; Being in a position; Having; Acting; and Being acted upon
- Kant (12 basic Categories, 3 for each of 4 modalities)
  - Categories are related to kinds of judgment
  - Quantity (Unity, Plurality, Totality), Quality (Reality, Negation, Limitation), Relation (Inherence and Subsistence, Causality and Dependence, Community), Modality (Possibility, Existence, Necessity)
- Peirce (3 basic Categories)
  - Categories are related to the connectivity between ideas
  - Firstness, Secondness, Thirdness

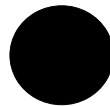
# Peircean Categories

## ■ Firstness

- “The mode of being of that which is such as it is, positively and without reference to anything else”

## ■ Idea of Firstness

- Related to the ideas of potentiality, originality, possibility and independence, randomness, chance, random actions, a feeling not yet converted to reflection, just a glimpse of the reality in the state of pure indetermination;



# Peircean Categories

## ■ Secondness

- “The mode of being of that which is such as it is, with respect to a second but regardless of any third”

## ■ Idea of Secondness

- Related to our experience on current space-time, actuality, to reactive actions, to cause-effect relationships, to the experiential reality, to actual facts, to the perceptive consistency without purpose or judgement yet, a binary relation, a cartesian pair



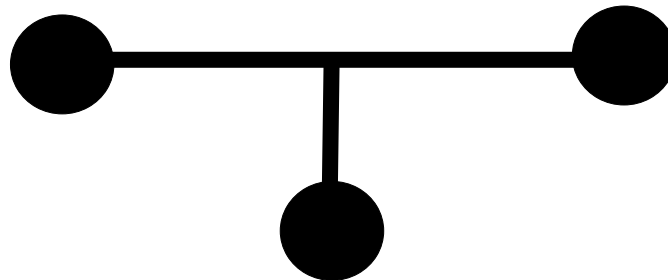
# Peircean Categories

## ■ Thirdness

- “The mode of being of that which is such as it is, in bringing a second and third into relation to each other”

## ■ Idea of Thirdness

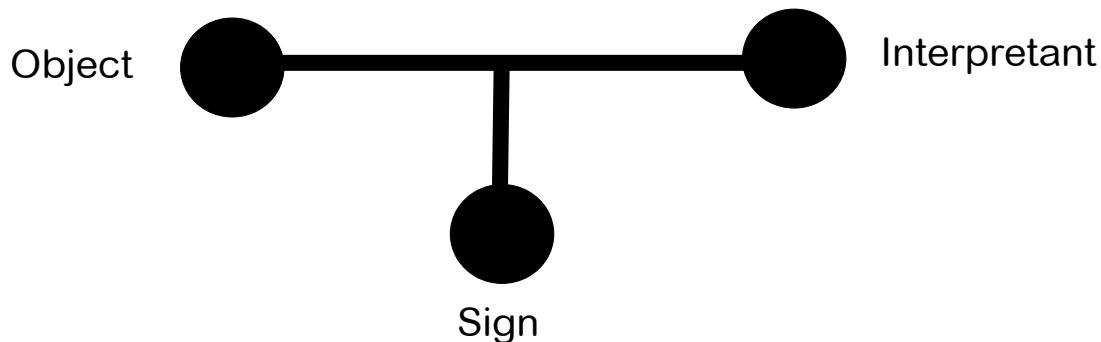
- Related to mediation, to law or habit, to thought and continuity, to purpose and judgement, to the idea of representation, to the sign itself



# Sign or Representation

## ■ Sign (or Representamen)

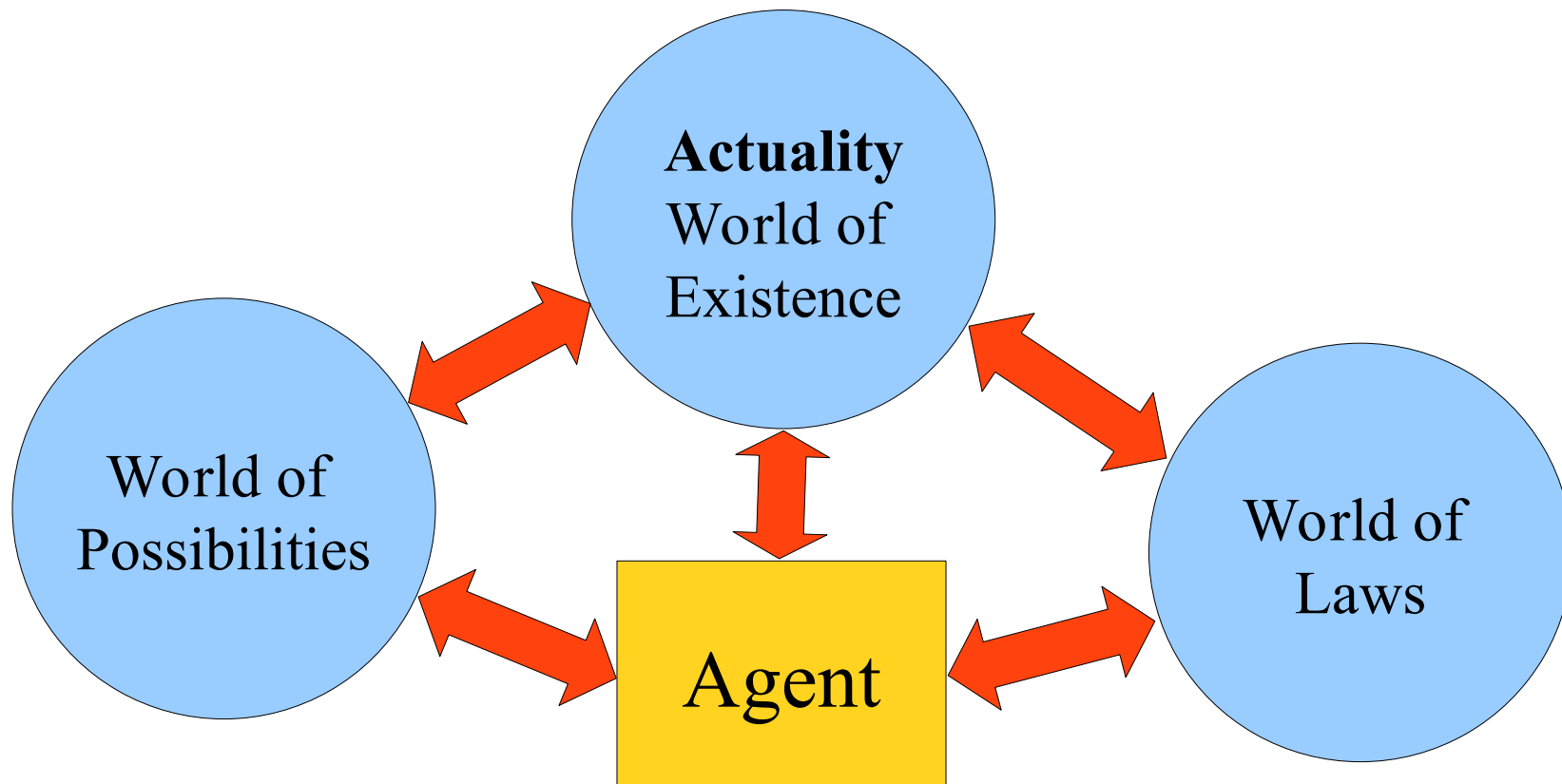
- “A Sign, or Representamen, is a **First**, which stands in such a genuine triadic relation to a **Second**, called its Object, as to be capable of determining a **Third**, called its Interpretant, to assume the same triadic relation to its Object in which it stands itself to the same Object. The triadic relation is genuine, that is, its three members are bound together by it in a way that does not consist in any complexus of dyadic relations”



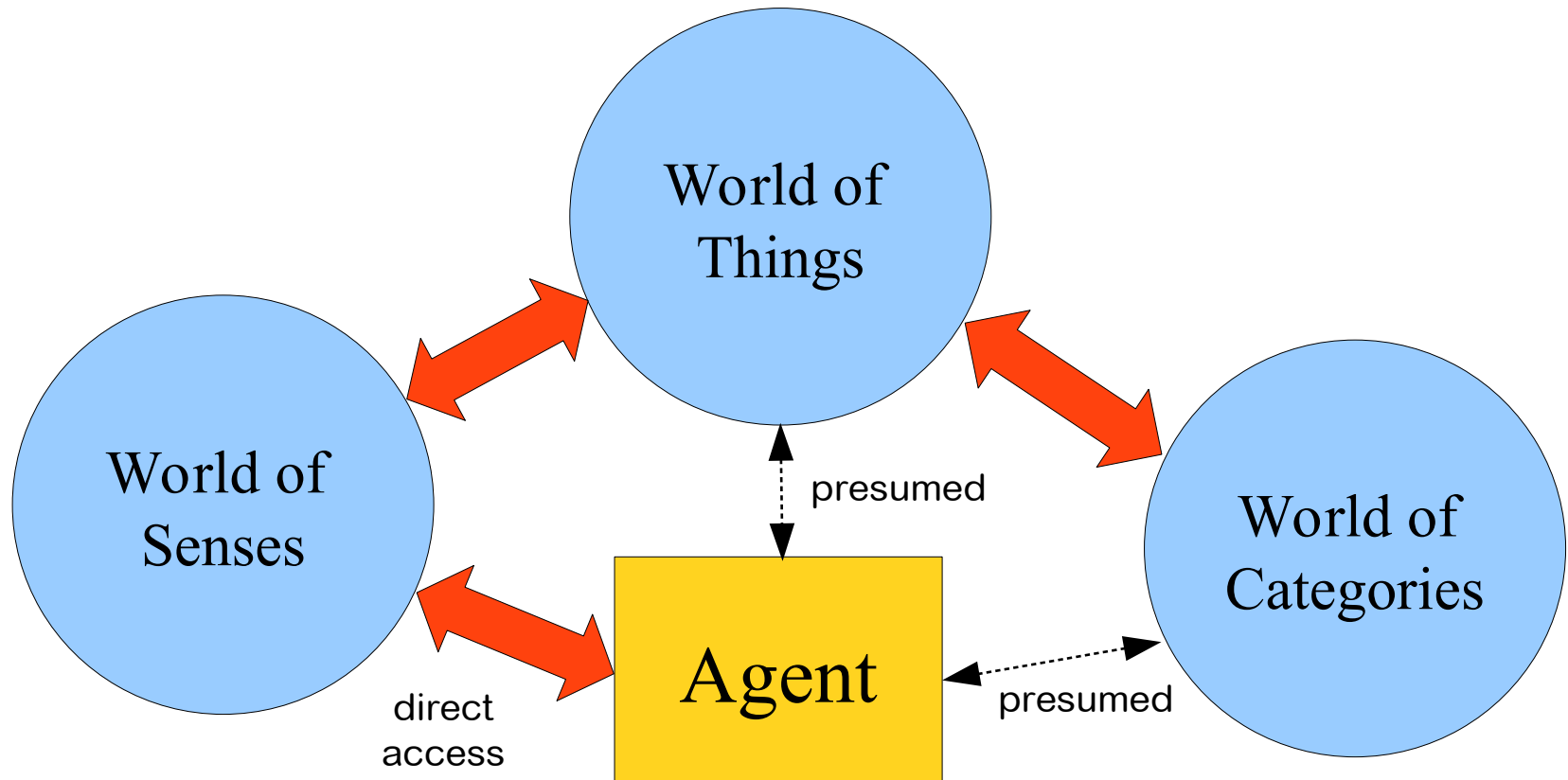
- Ideas (elements of the mind)
  - Encoded within the mind as signs
  - Can be connected to other ideas, forming more complex ideas
    - Can be simple or composed
  - Can be of different types
  - Can express different aspects of reality
    - Possibilities (Imaginations, Speculations, Hypothesis, Plans for the future, Exploration of scenarios): **firstness**
    - Actuality or Existence (Things that are really happening or really happened): **secondness**
    - Laws (Categories, Types, Habits of Behavior, Patterns, Learning Algorithms): **thirdness**
  - Can describe reality by different means
    - Qualities or Properties (**firstness**)
    - Things (**secondness**)
    - Categories of Things/Qualities (**thirdness**)



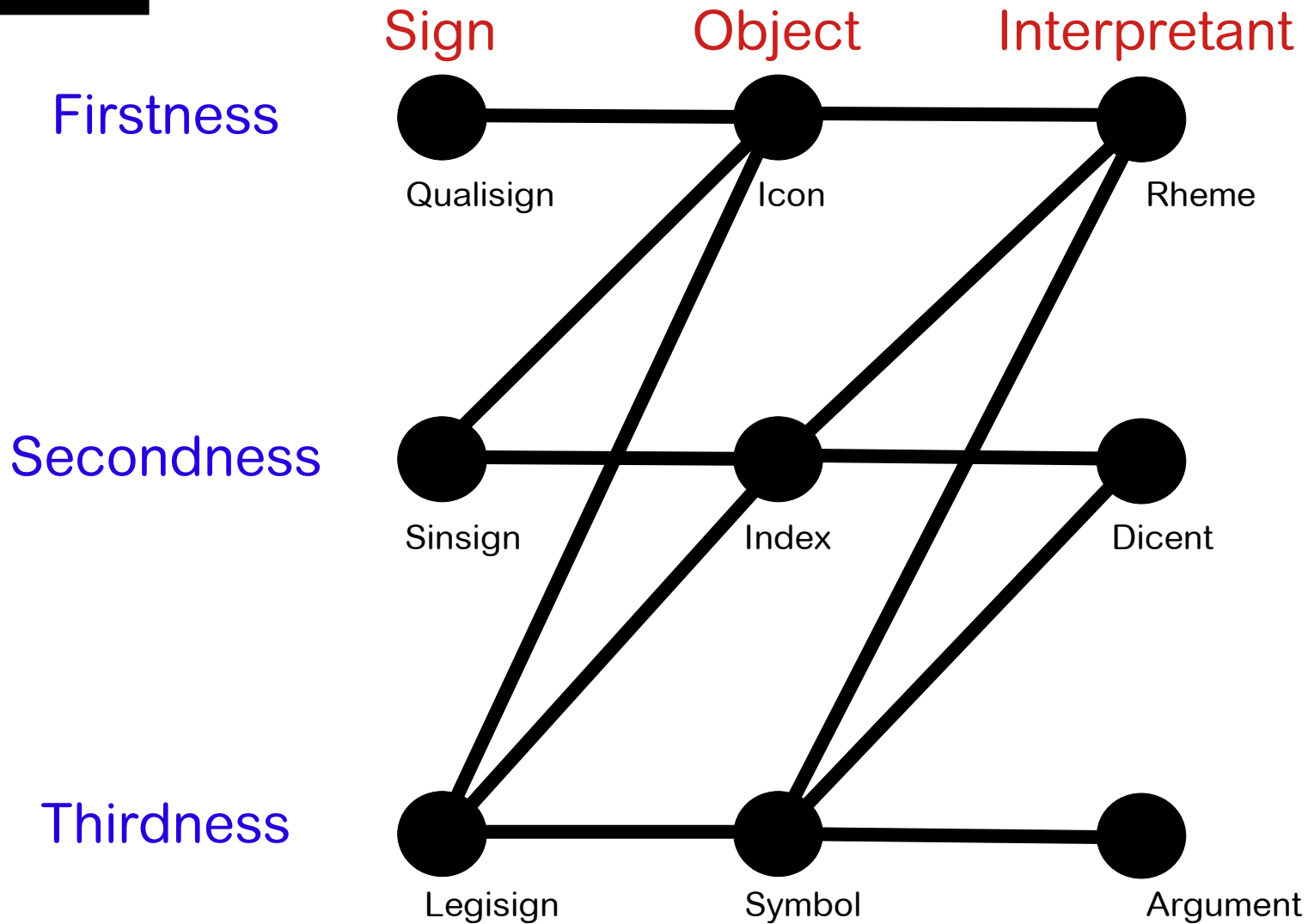
# The Three Worlds of Ideas



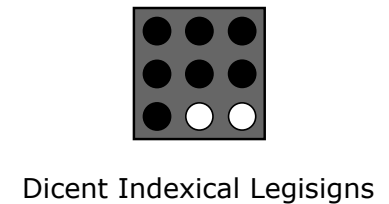
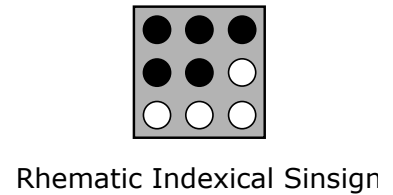
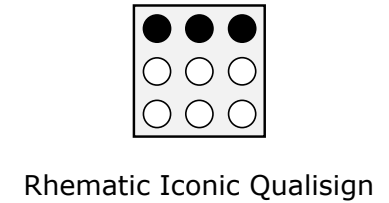
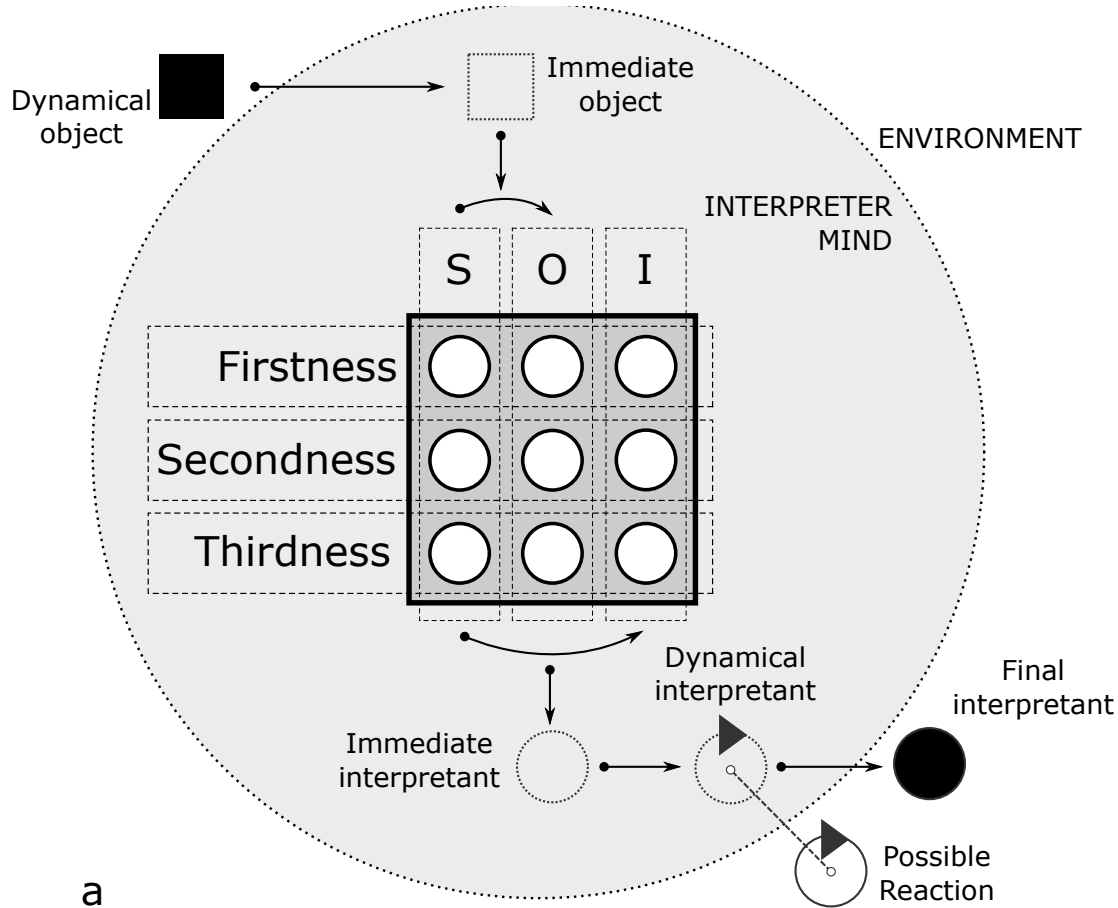
# One Instance of the Three Worlds



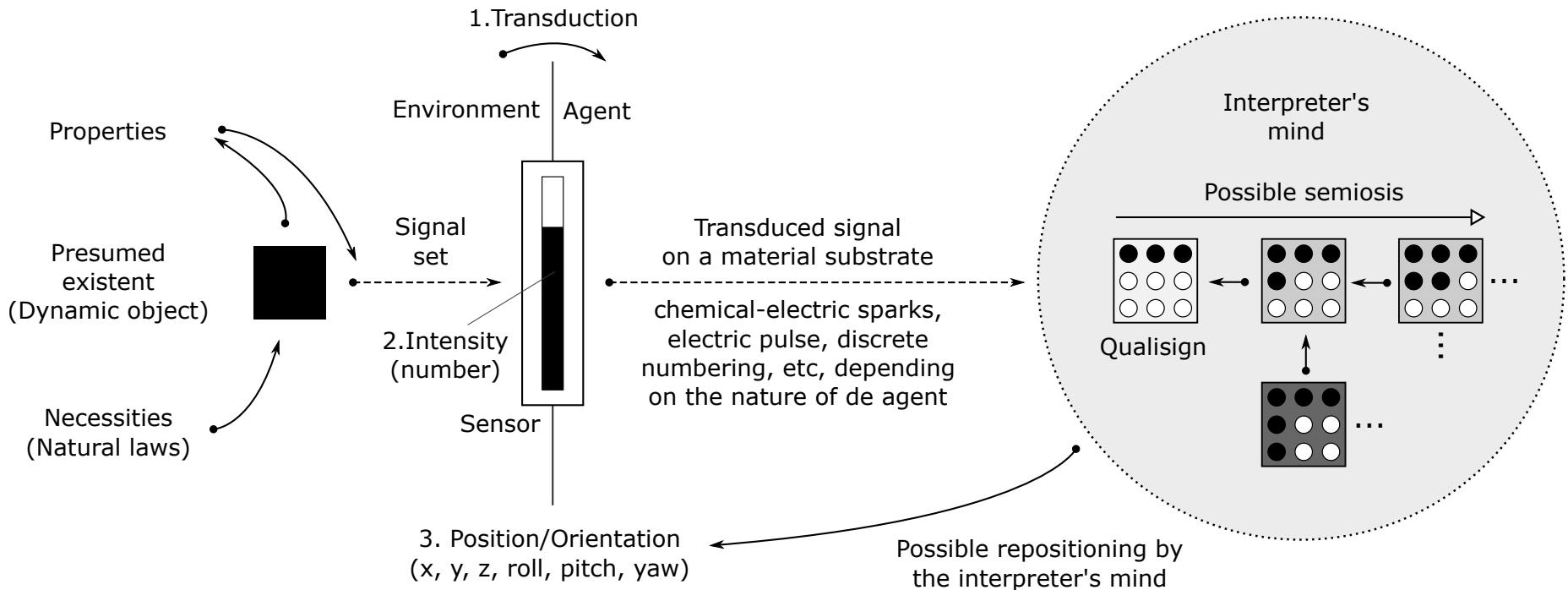
# Classification of the Signs



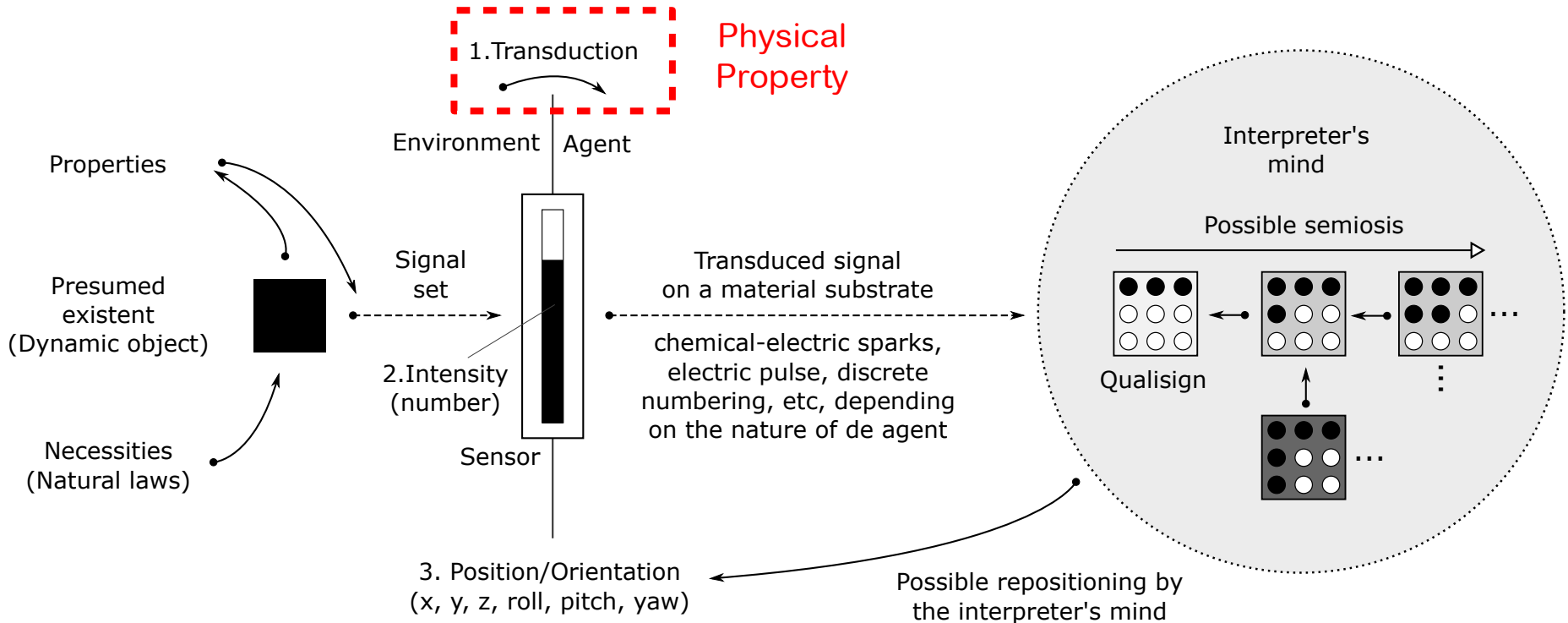
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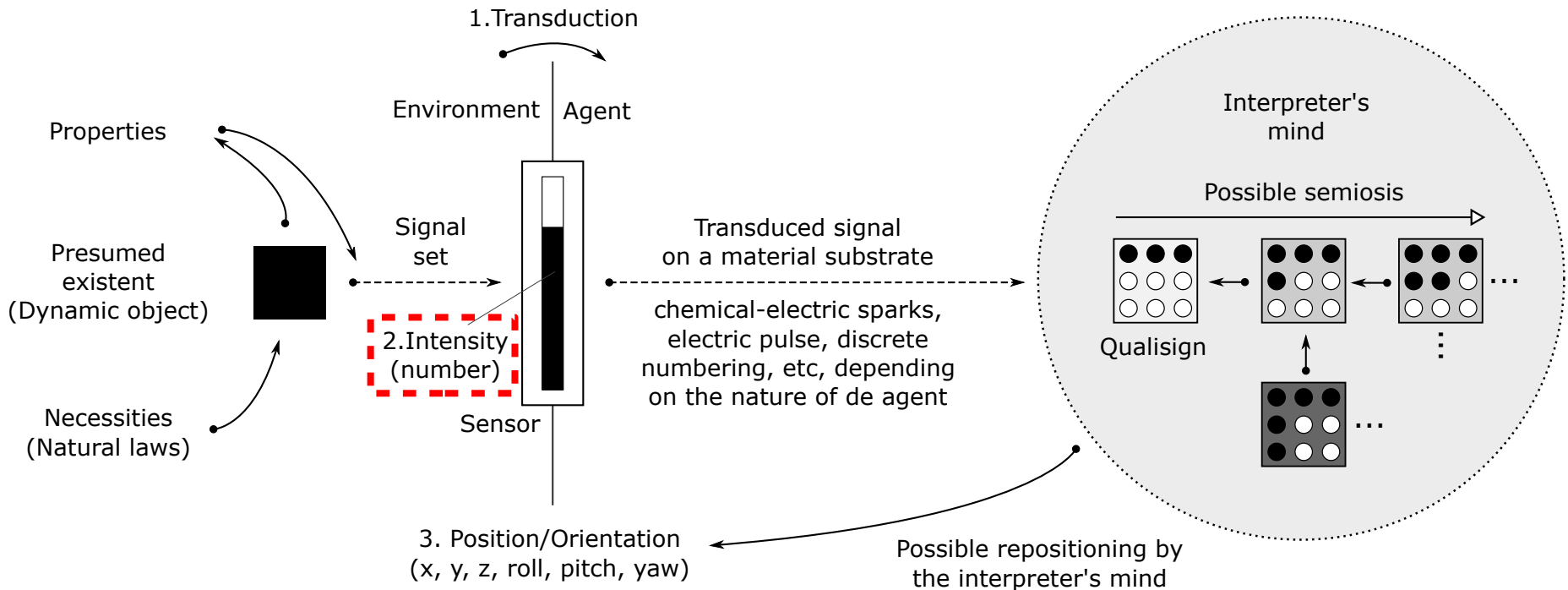
# Accessing the World of Senses



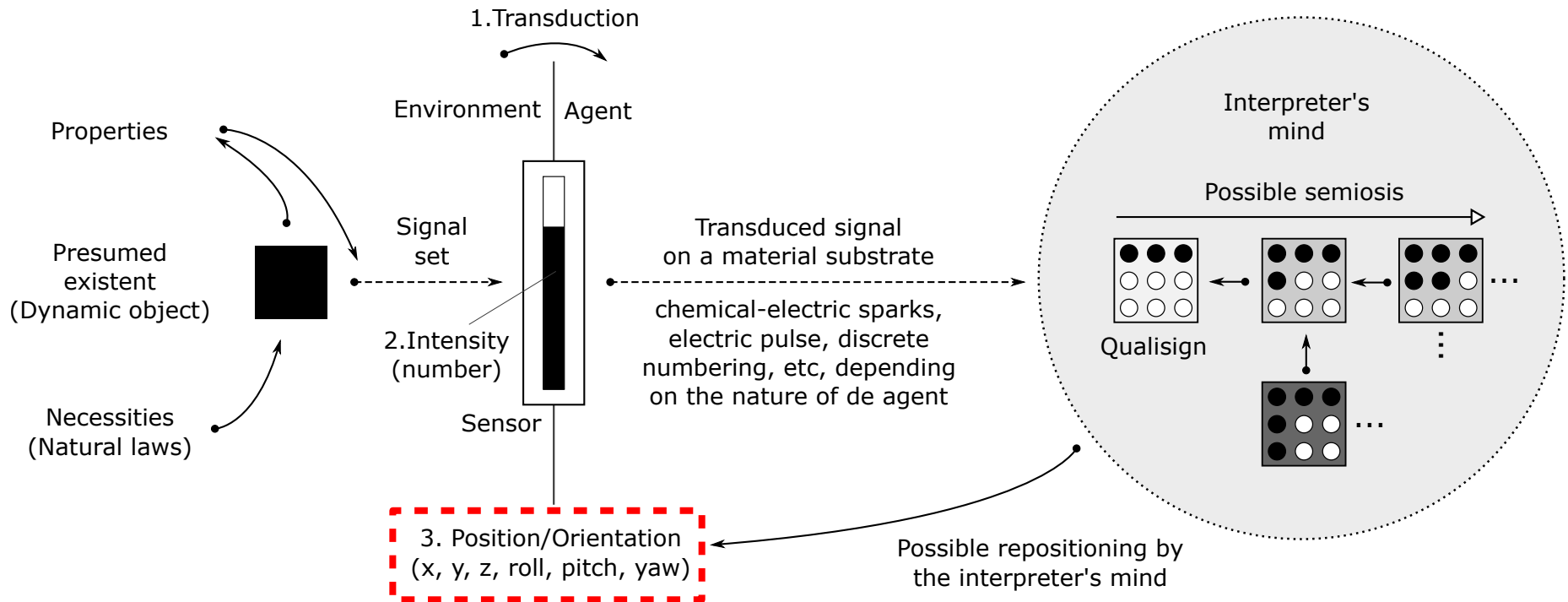
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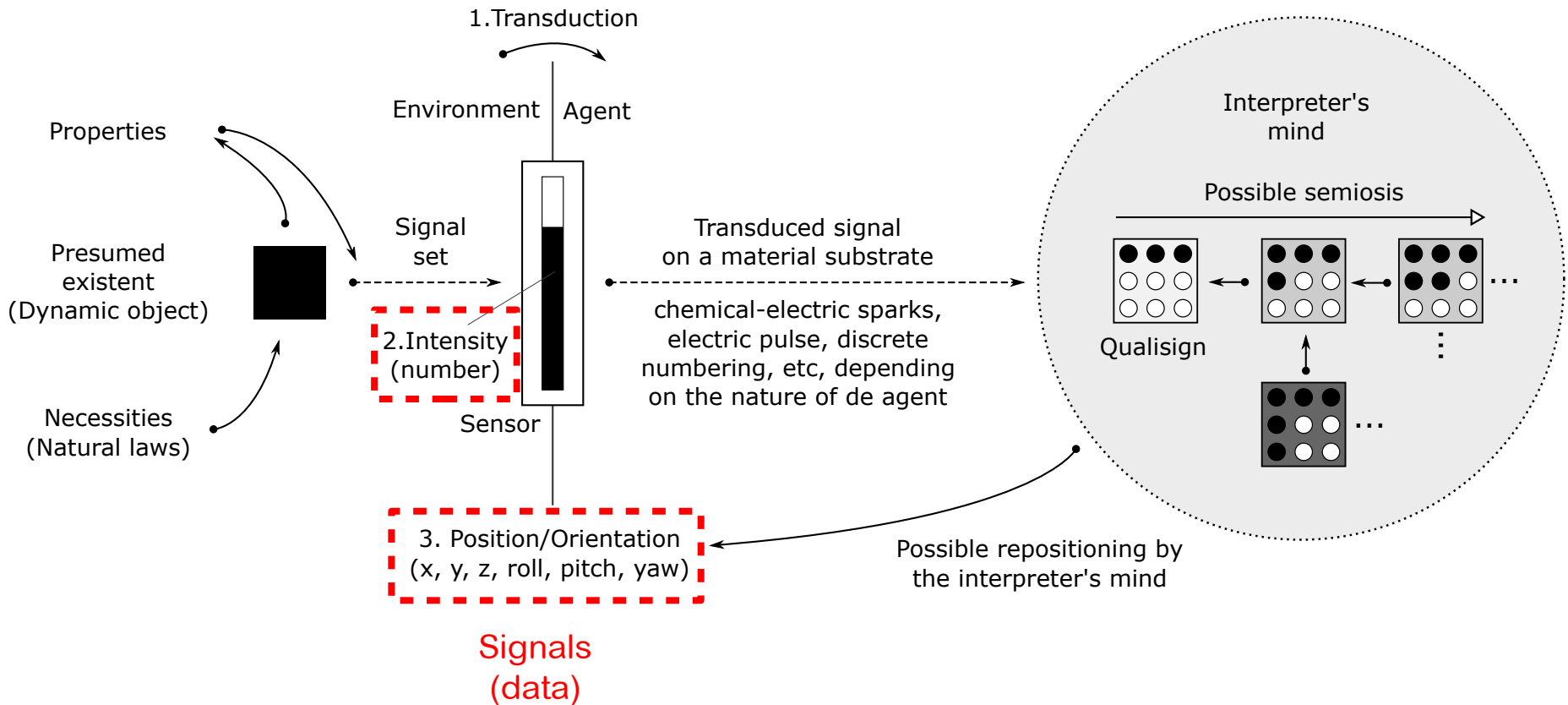


# Accessing the World of Senses

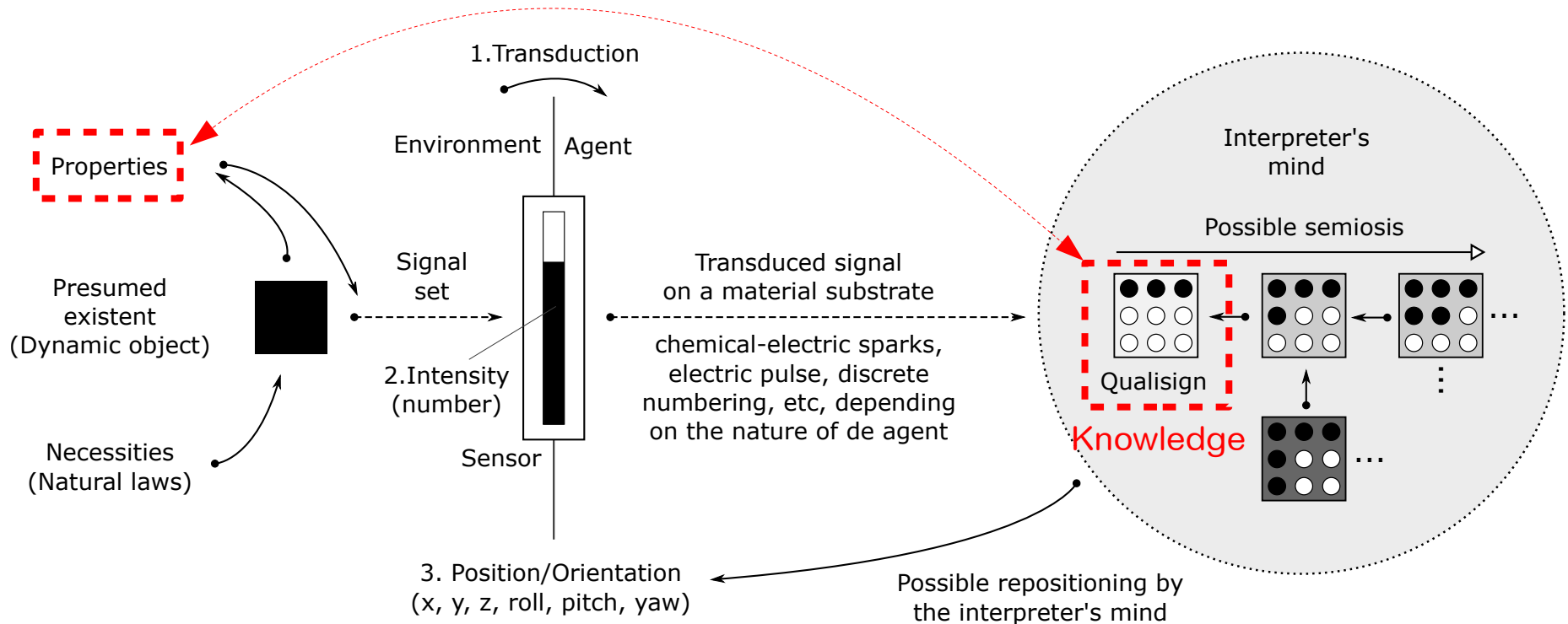




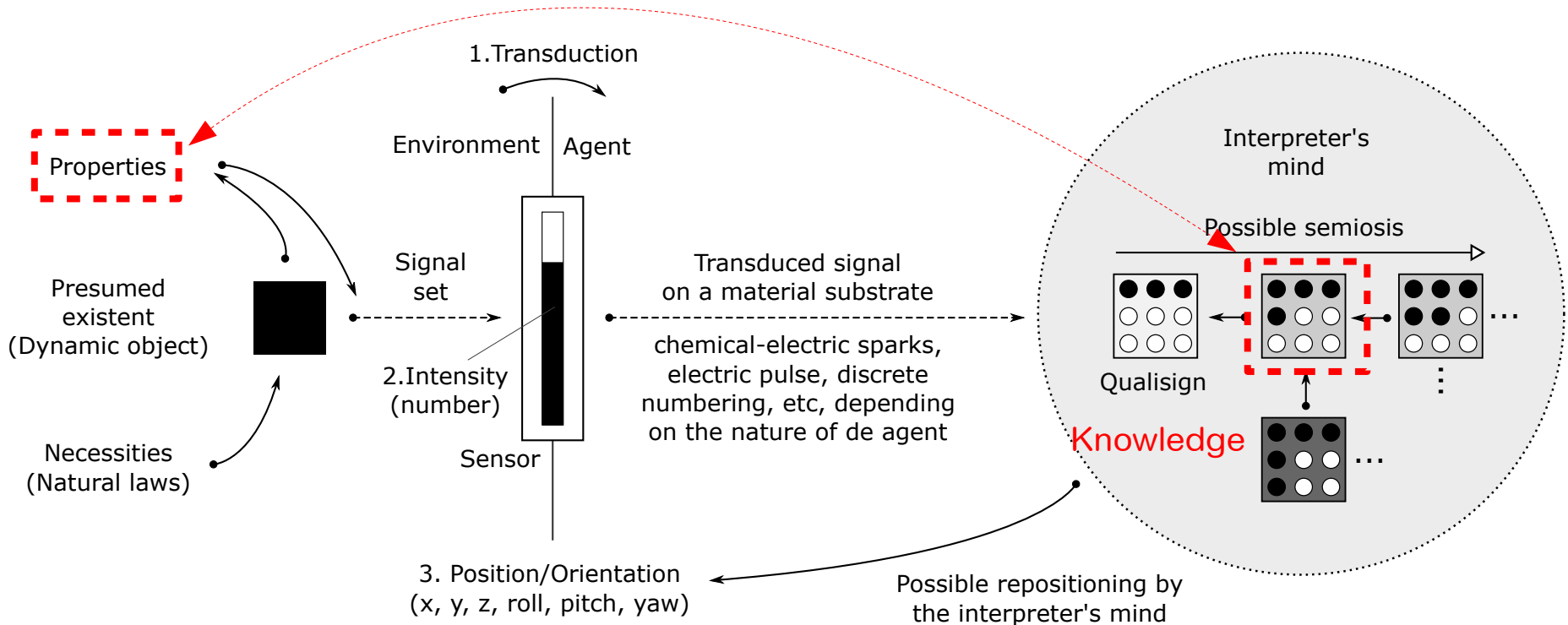
# Accessing the World of Senses



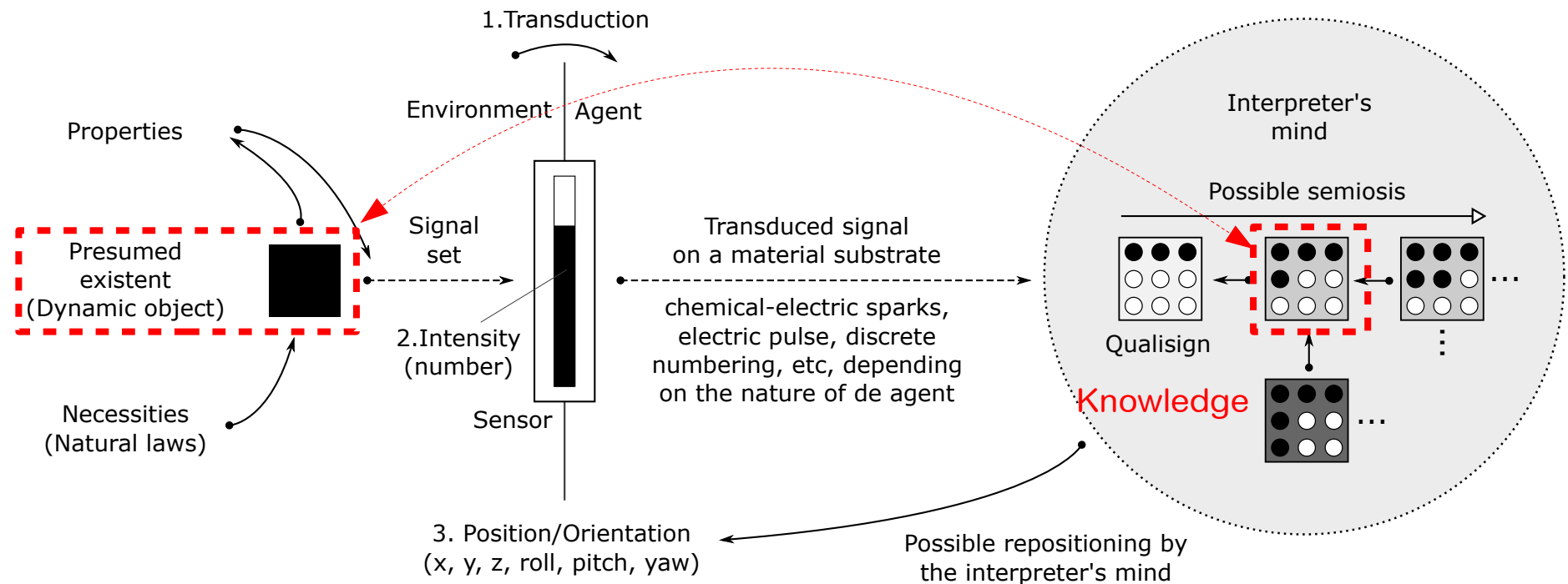
# Accessing the World of Senses



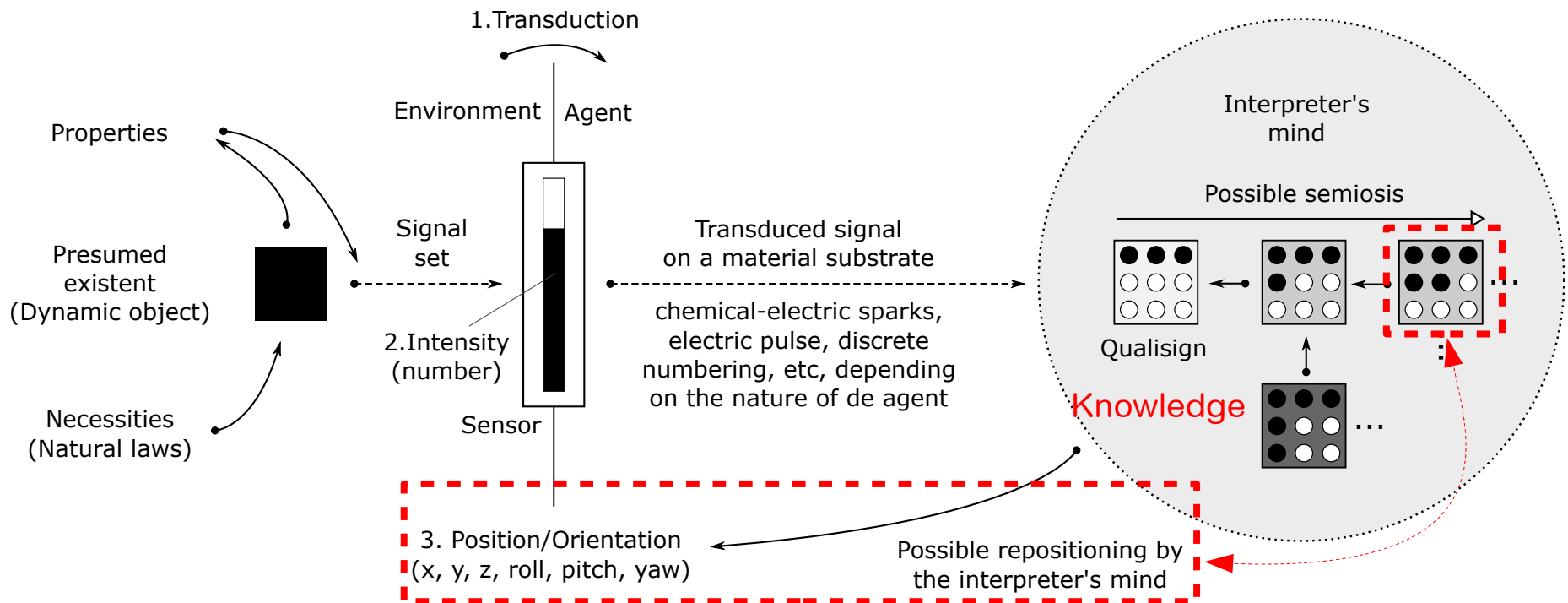
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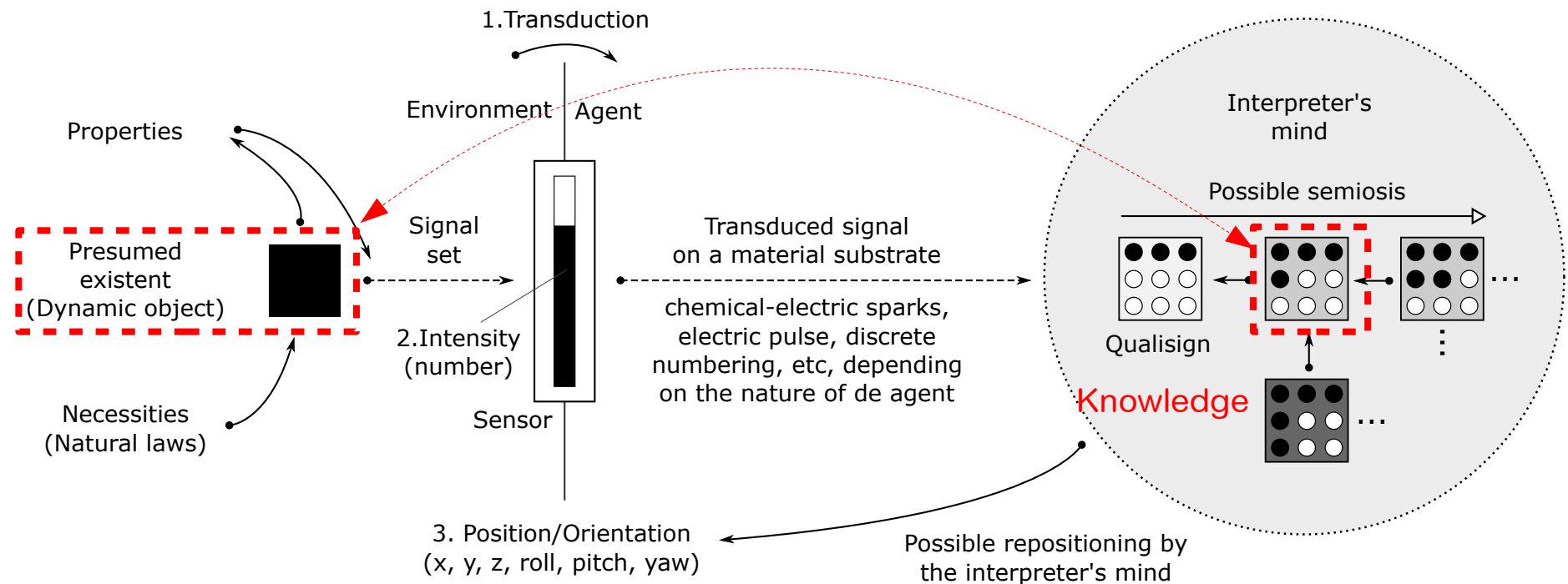
# Guessing the World of Things



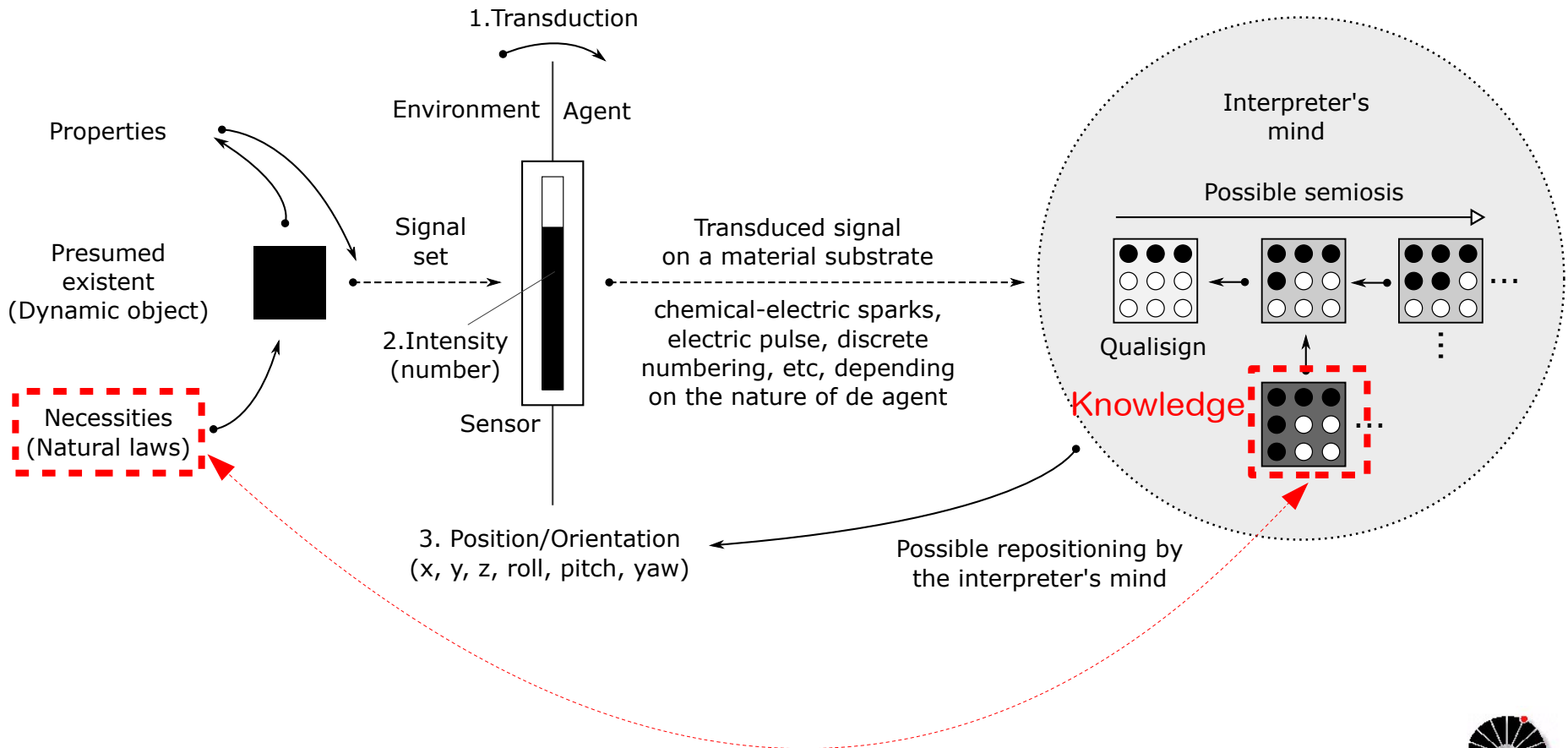
# Sensor Repositioning (Focus of Attention)



# Guessing the World of Things



# Guessing the World of Categories



# Sensors as Sources of Iconic Information

## ■ Icons

- Signs that are connected to their objects by having some sort of similarity or analogy to them
- Can be of three different types:
  - **Images** (firstness): icons which present in themselves the same properties as their objects.
  - **Diagrams** (secondness): icons which in their parts present the same state of affairs as the parts of their objects.
  - **Metaphors** (thirdness): icons which hold in themselves another kind of parallelism, e.g. some sort of analogy to their objects.

## ■ Sensors

- Can be understood as metaphors to the property they measure, by sharing with them the same numerical intensity as these properties, i.e., they are in a relation of analogy to them



# From Signals to Knowledge

## ■ Sensors

- Provide the means for directly generating iconic signs of the physical properties they measure
- The numeric measurements provided by the sensor are in a relation of direct analogy to the physical properties.
- By associating this number to the origin in a particular sensor, we know that this number refers to a particular physical property, which is the property the sensor is able to measure
- Besides that, the information regarding the sensor position and orientation, provides the required data for being the substrate that turns these signals into a sign, becoming knowledge for the agent.
- In becoming full icons, they are put into a direct connection to the properties they represent. This connection is ensured by the way the sensors are constructed, as a transductor

# From Signals to Knowledge

## ■ Index

- Signs that are connected to their object by forcing the attention to a particular object, different from themselves, without describing it, like e.g. a demonstrative or relative pronoun, or in the case of a direct physical connection between the sign and the object, which can be used to draw attention to it
- Attention mechanisms are used to drive the interpreter attention to another sign (e.g., an icon, a symbol or another index), which in the sequence will be used for discovering the original sign's object
- Attention is changed by moving the sensors position/orientation

## ■ Icons and Indexes are both called natural signs

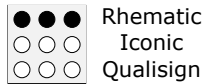
- Because they cannot be dissociated to their object
- The connection to their objects is embedded by nature

## ■ The real objects are always inaccessible to an interpreter

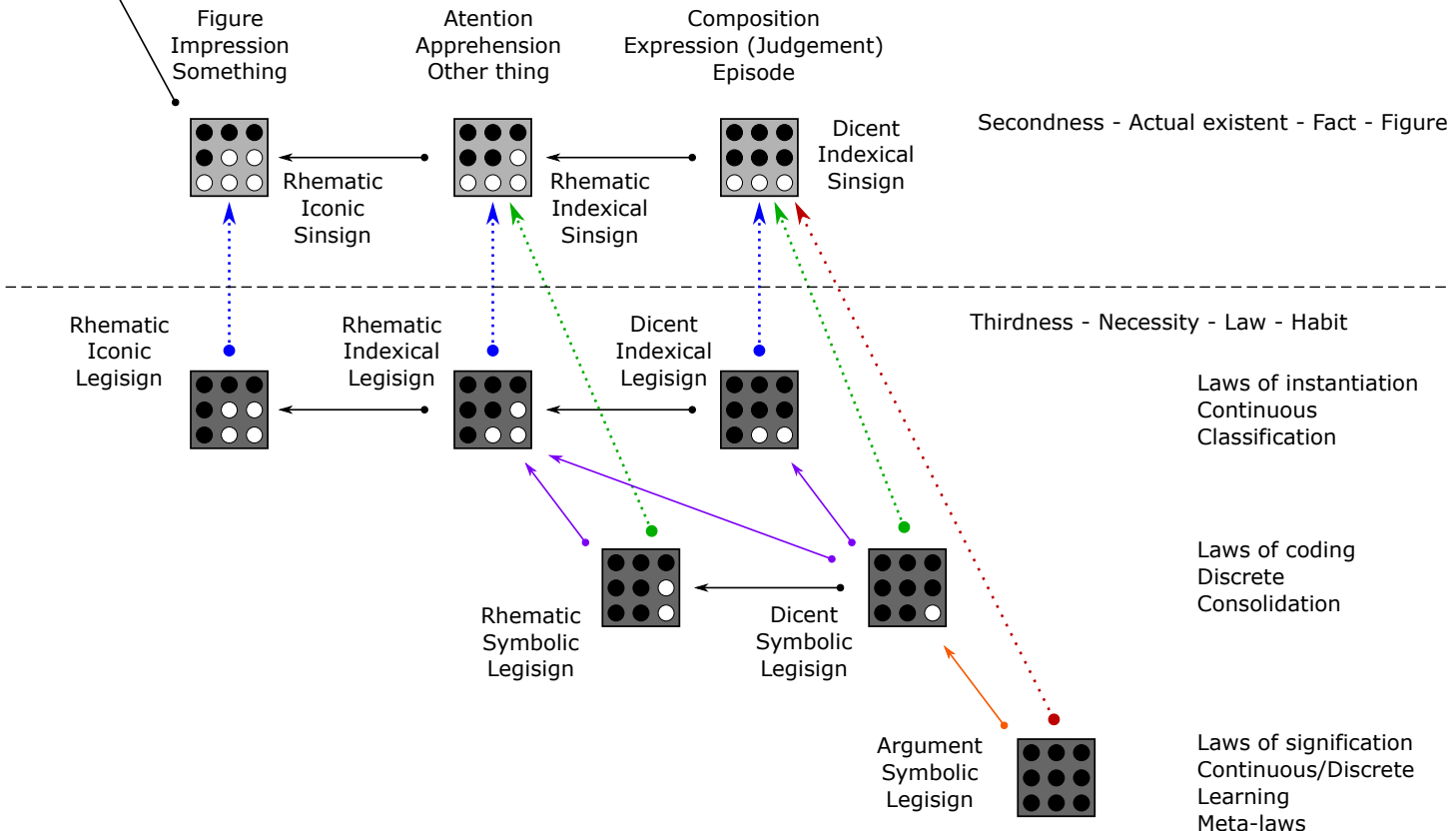
- The closest the interpreter can be of an object is always an icon of it

# Using Different Kinds of Signs to Make Sense of the World

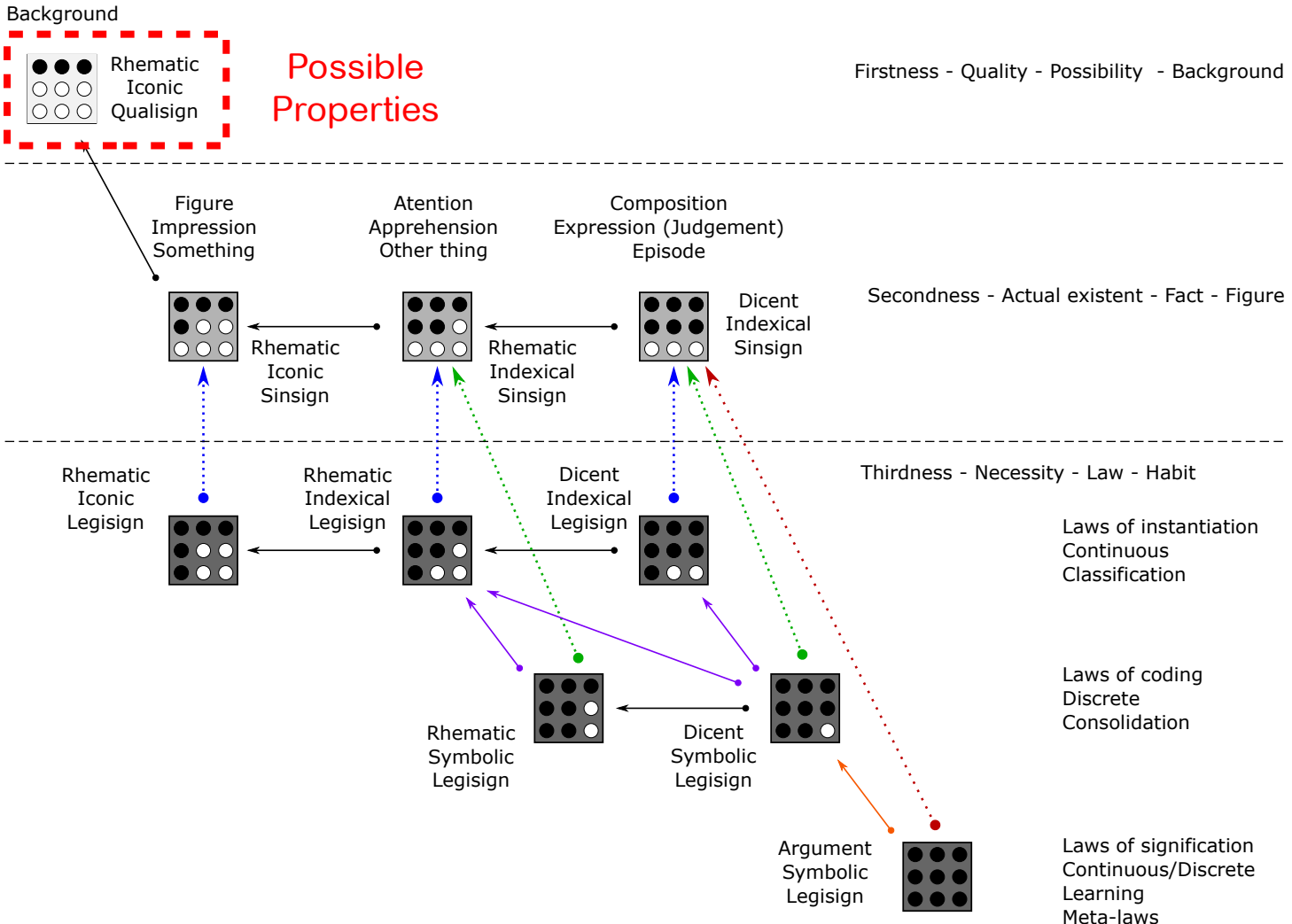
Background



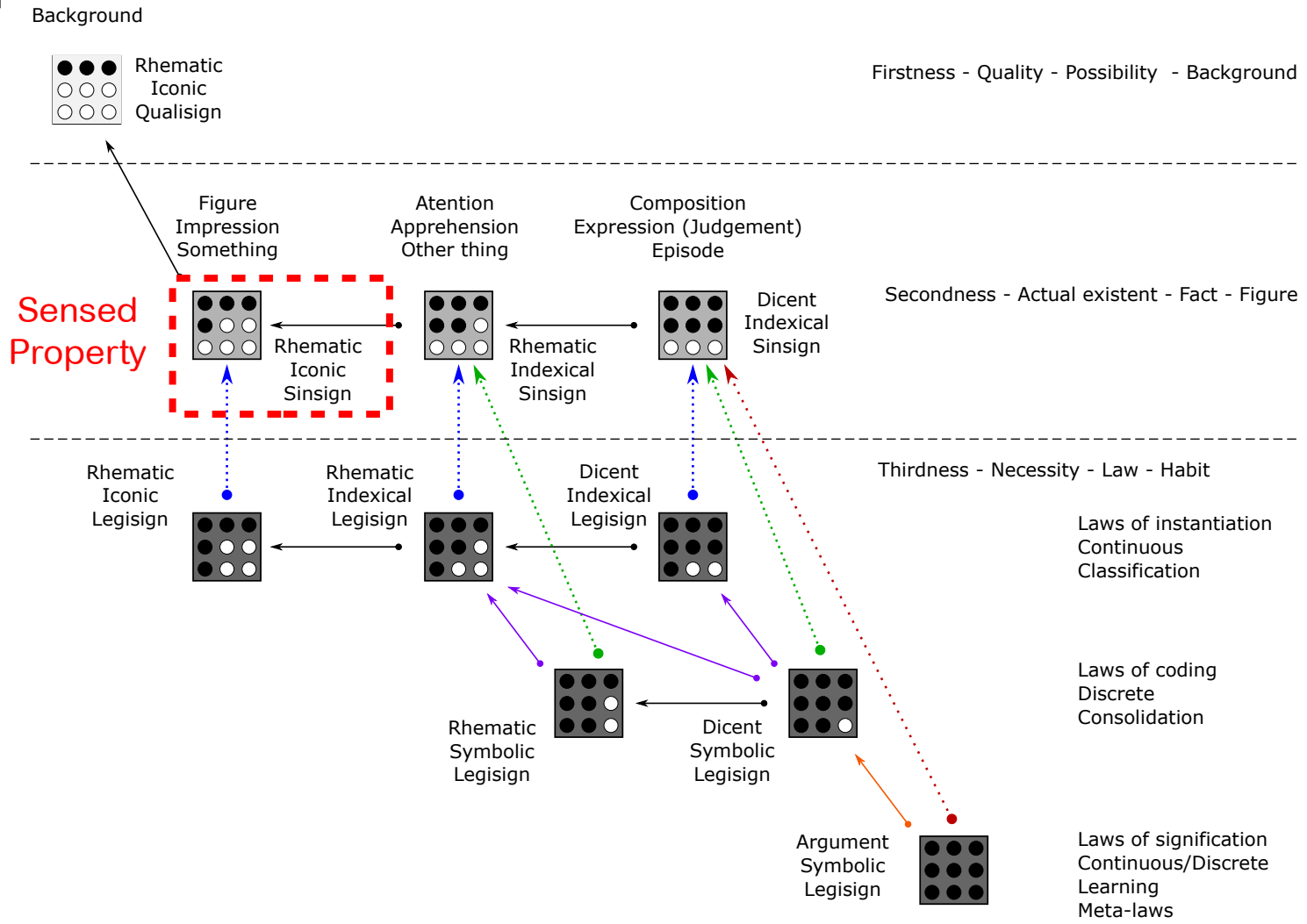
Firstness - Quality - Possibility - Background



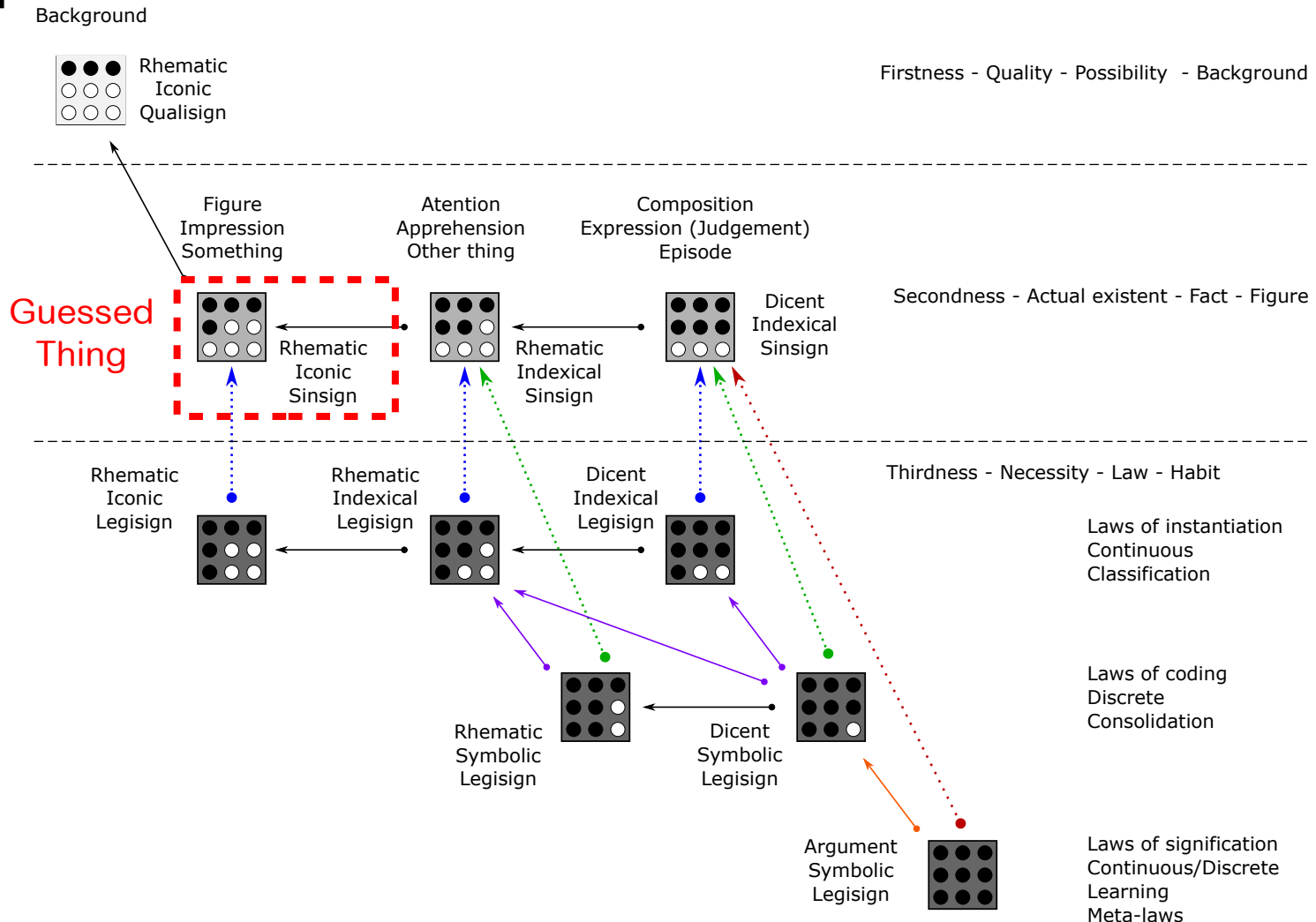
# Using Different Kinds of Signs to Make Sense of the World



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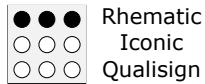


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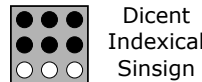
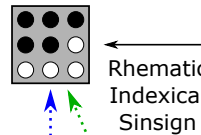
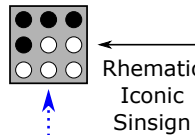


Firstness - Quality - Possibility - Background

Figure  
Impression  
Something

Attention  
Apprehension  
Other thing

Composition  
Expression (Judgement)  
Episode



Secondness - Actual existent - Fact - Figure

Rhematic  
Iconic  
Legisign

Rhematic  
Indexical  
Legisign

Dicent  
Indexical  
Legisign

Thirdness - Necessity - Law - Habit

Laws of instantiation  
Continuous  
Classification

Laws of coding  
Discrete  
Consolidation



Rhematic  
Symbolic  
Legisign

Dicent  
Symbolic  
Legisign



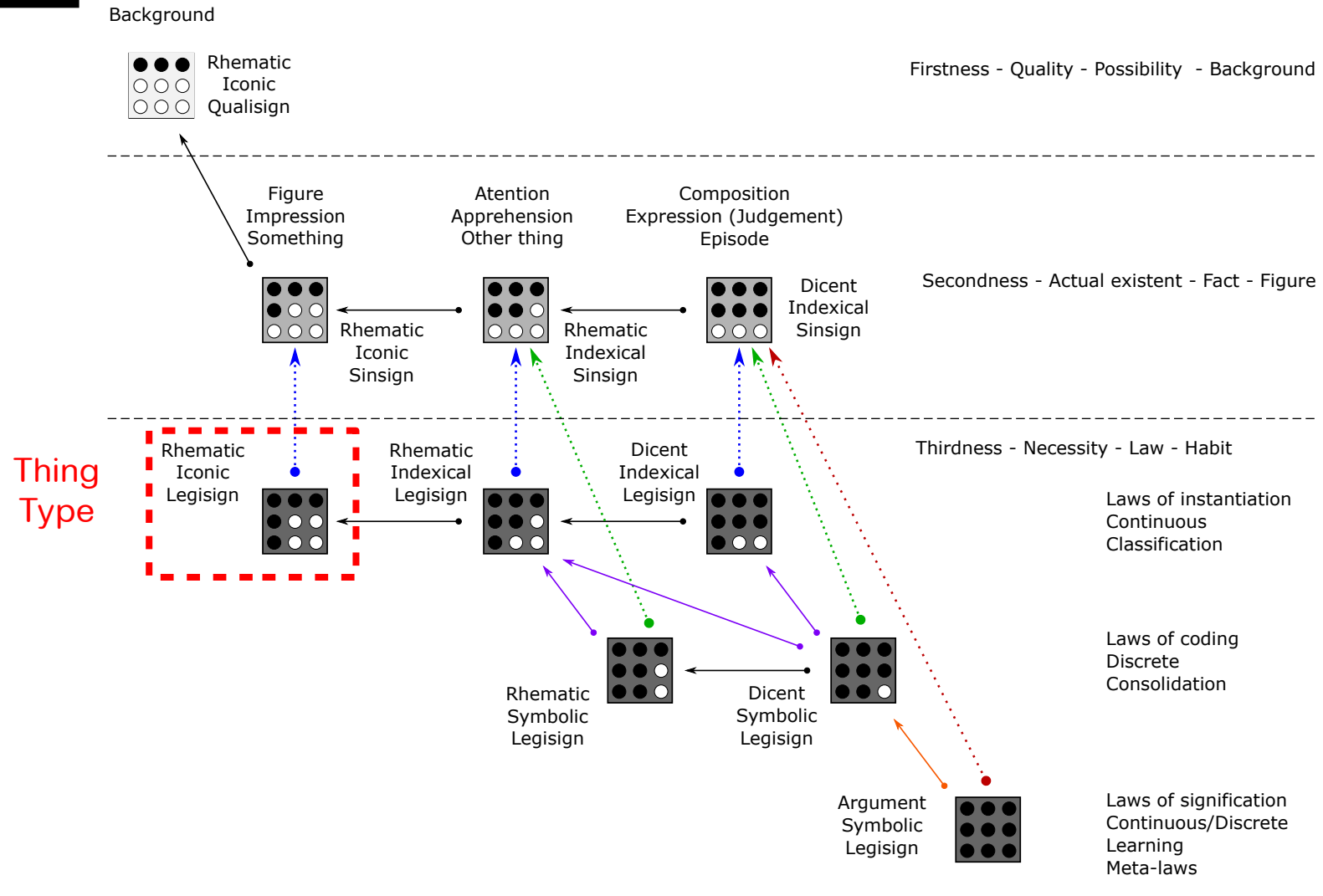
Argument  
Symbolic  
Legisign



Laws of signification  
Continuous/Discrete  
Learning  
Meta-laws

Gussed  
Law

# Using Different Kinds of Signs to Make Sense of the World





# Using Different Kinds of Signs to Make Sense of the World

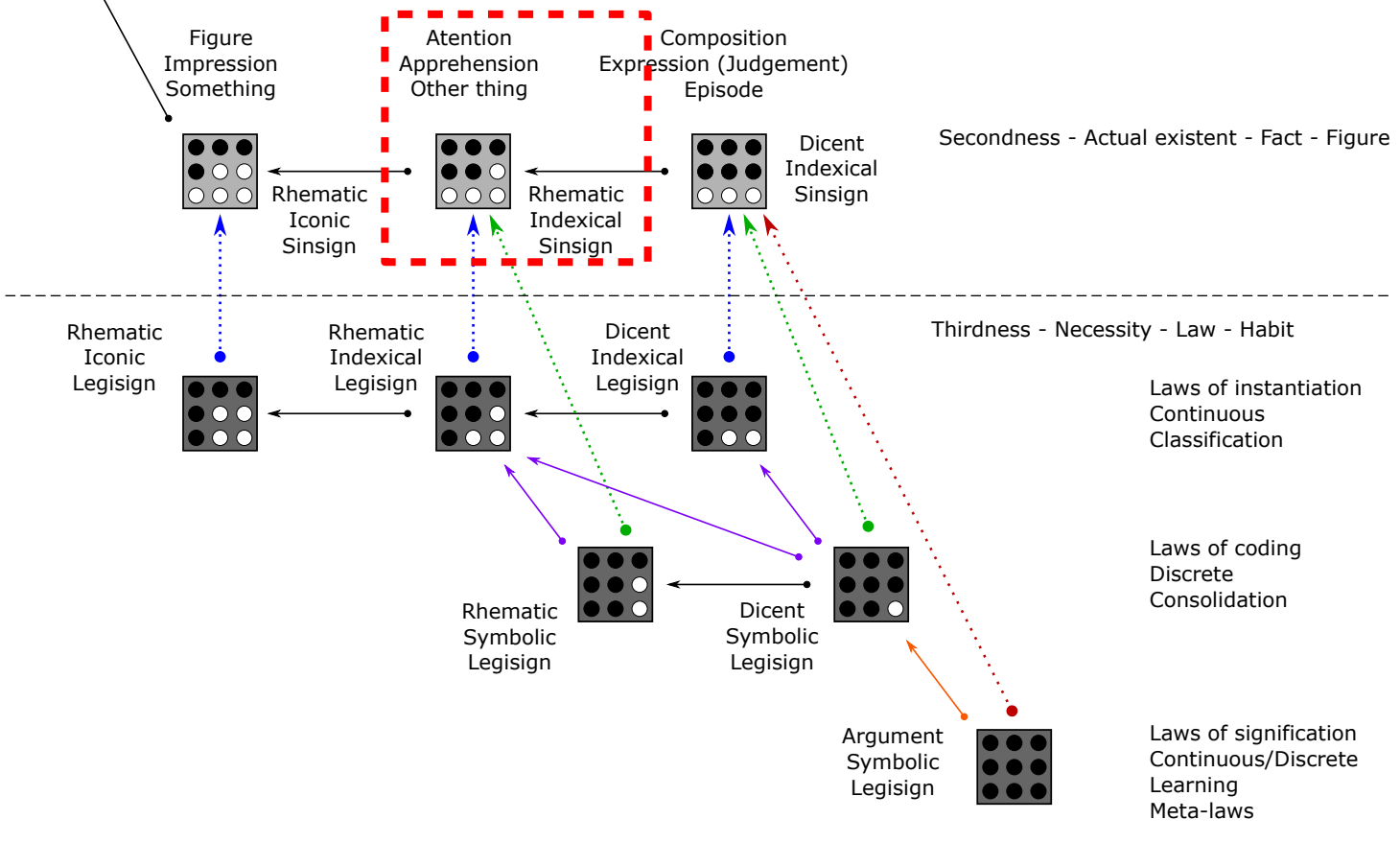
Background



Rhematic  
Iconic  
Qualisign

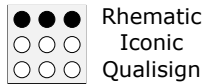
Firstness - Quality - Possibility - Background

Other Thing  
Around

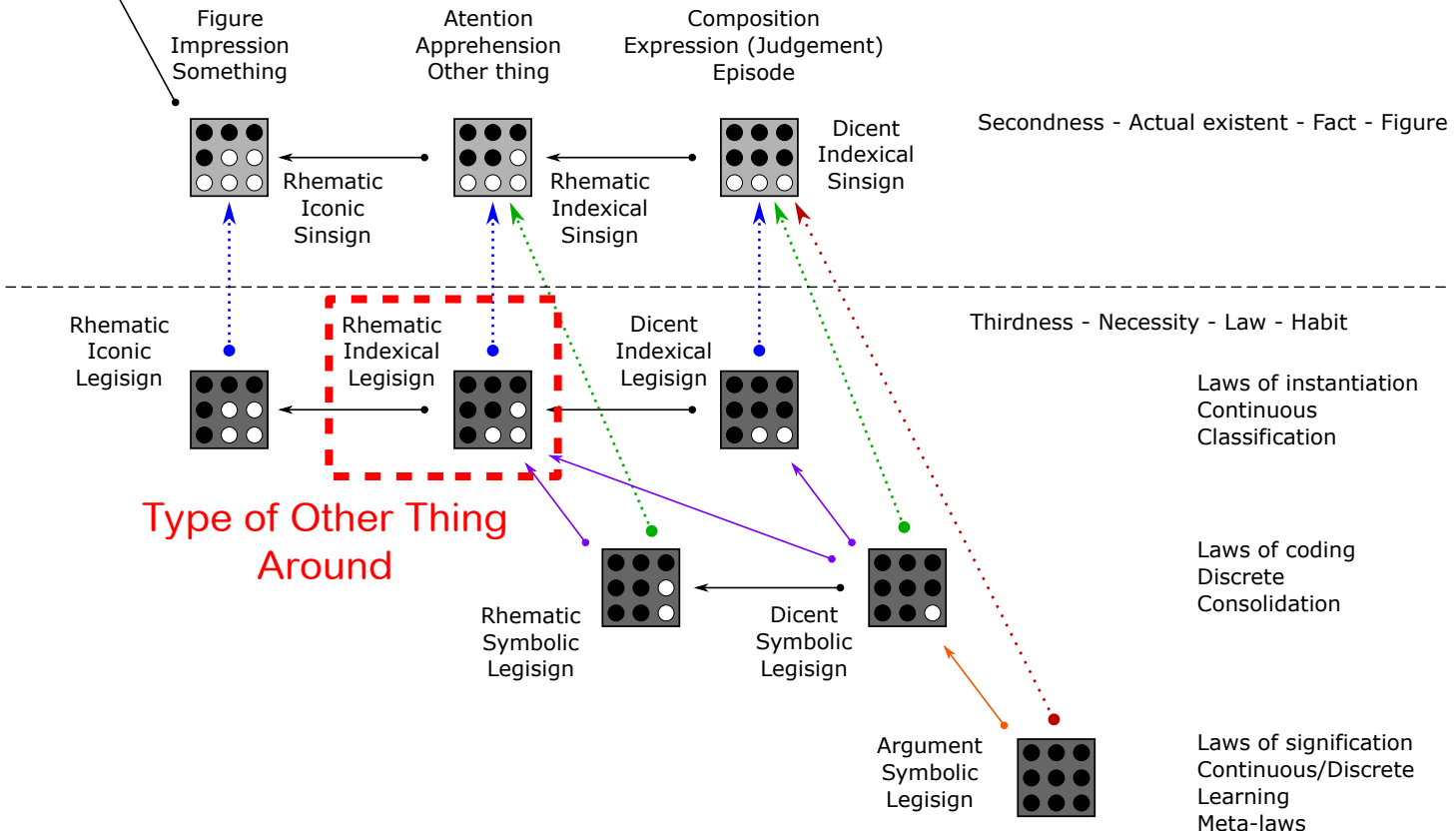


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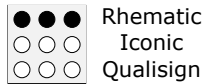


Firstness - Quality - Possibility - Background

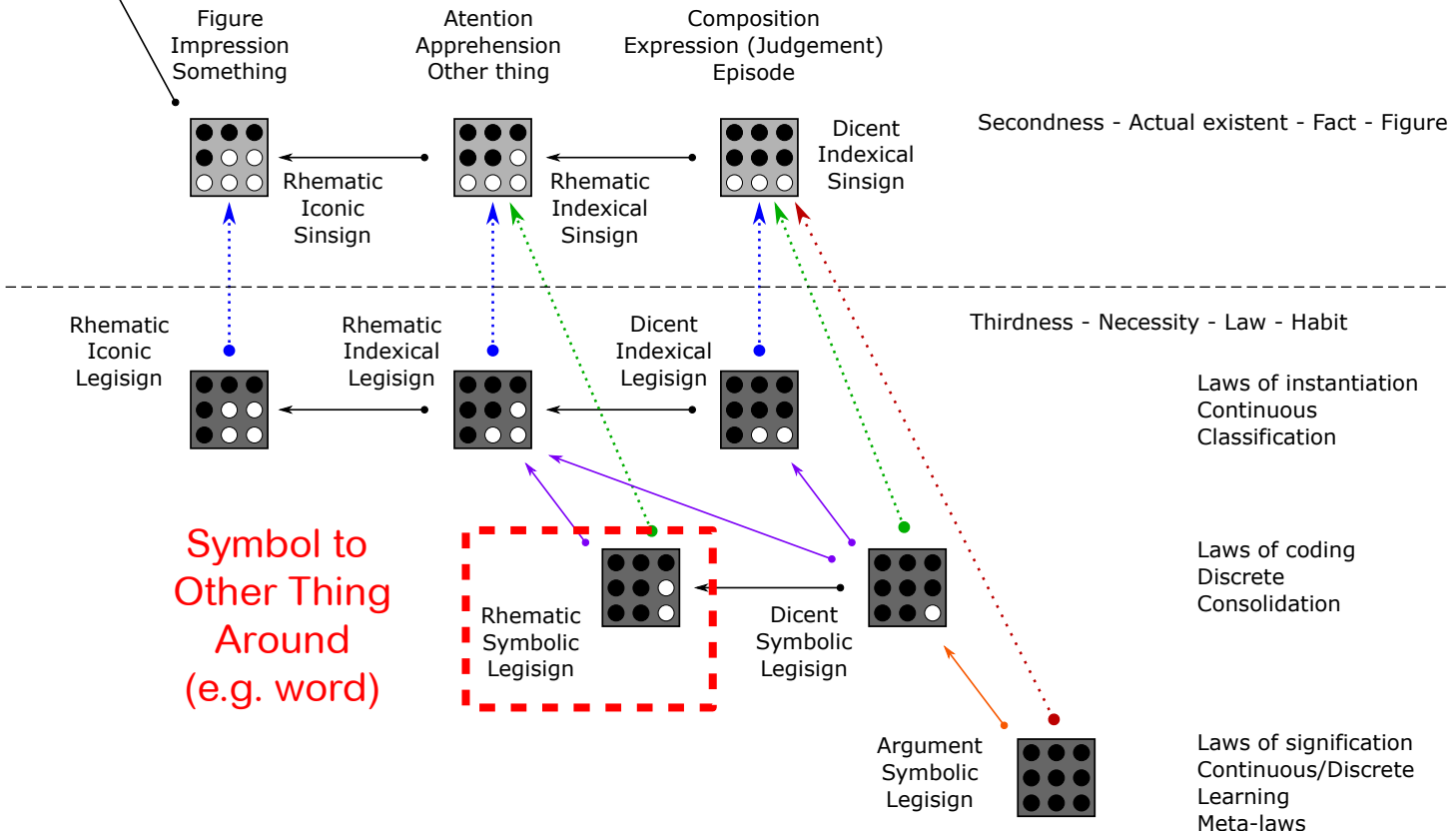


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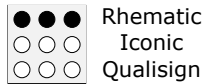


Firstness - Quality - Possibility - Background

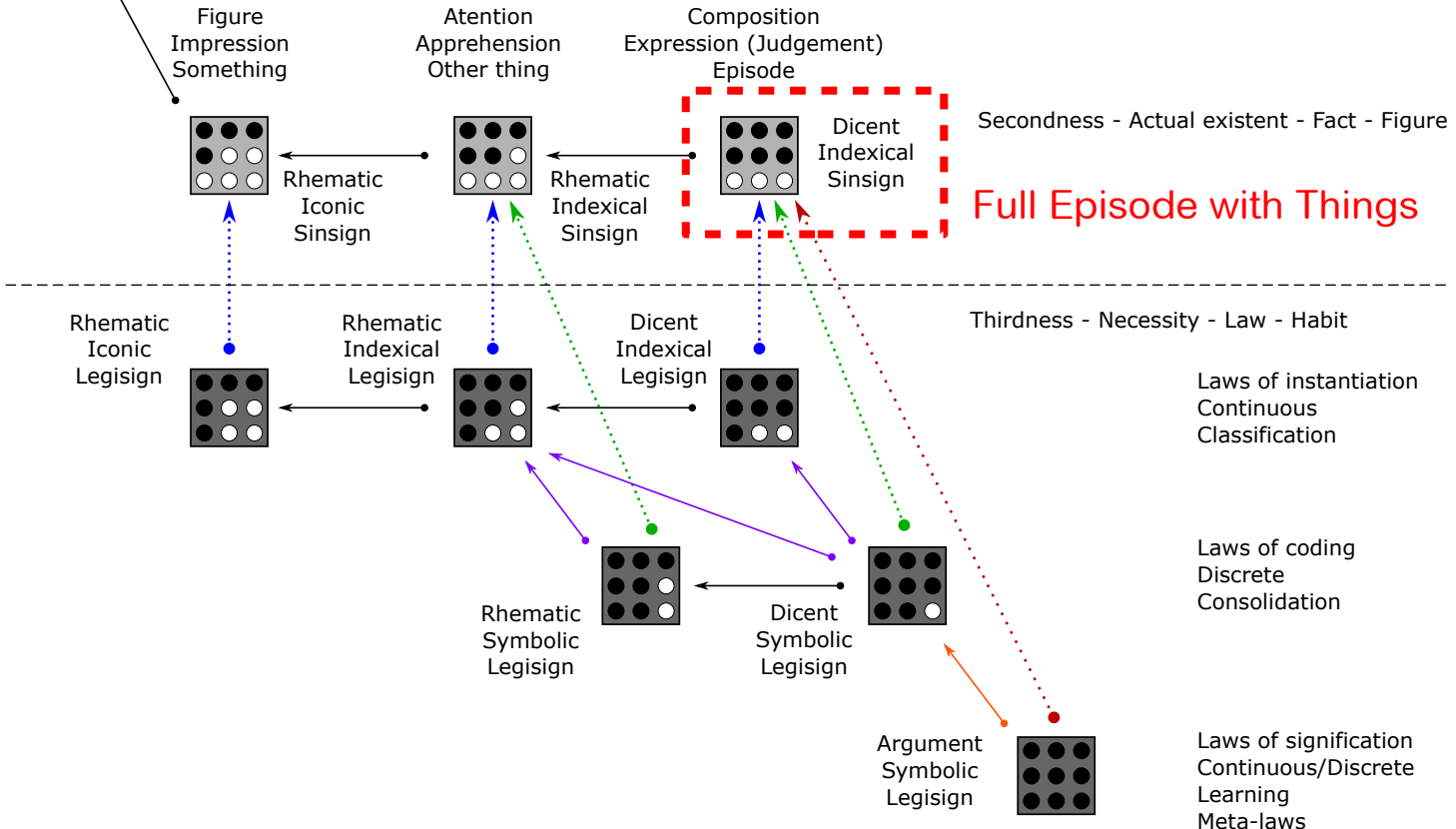


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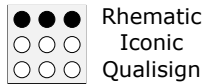


Firstness - Quality - Possibility - Background

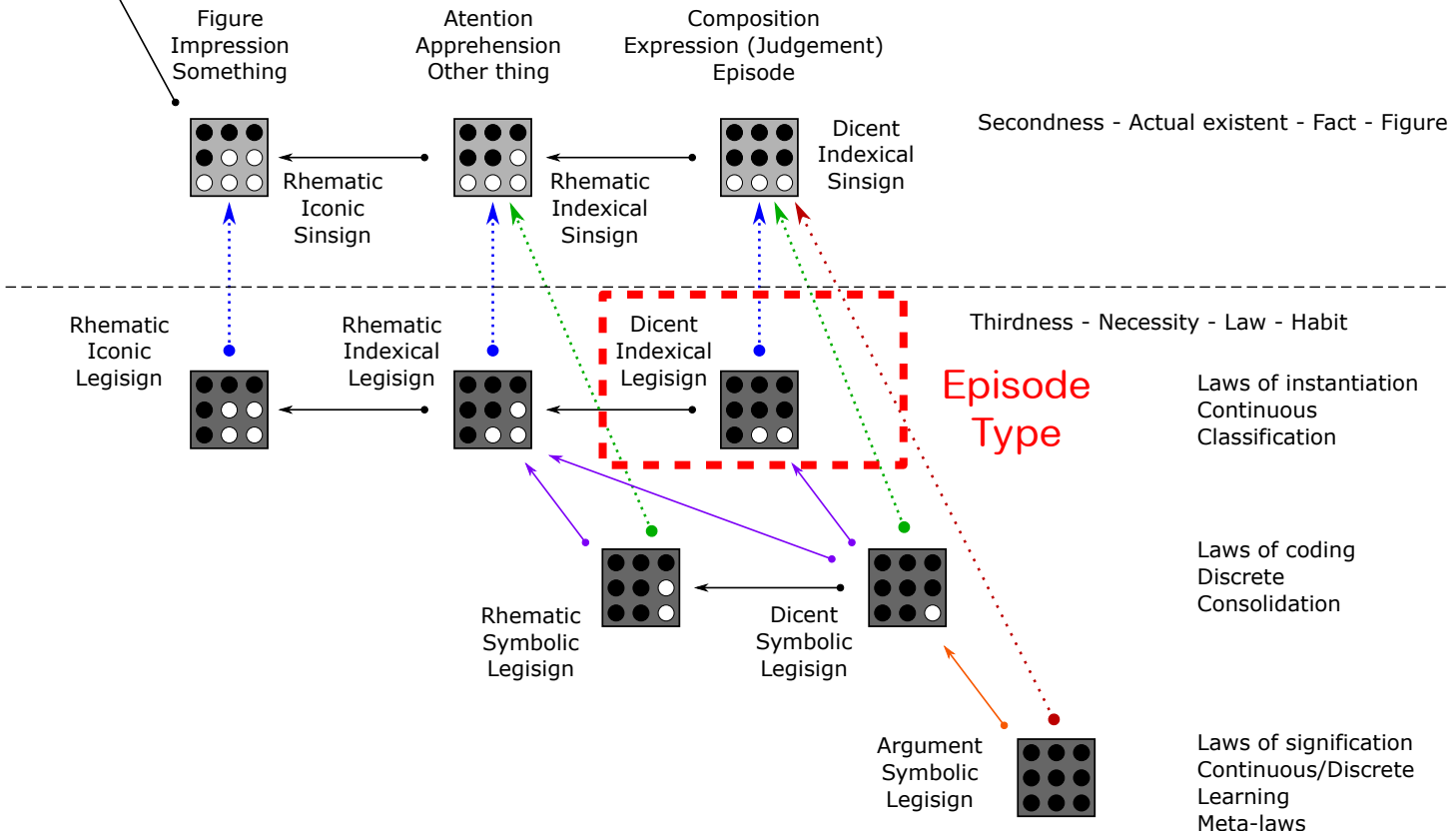


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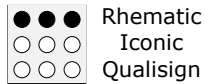


Firstness - Quality - Possibility - Background

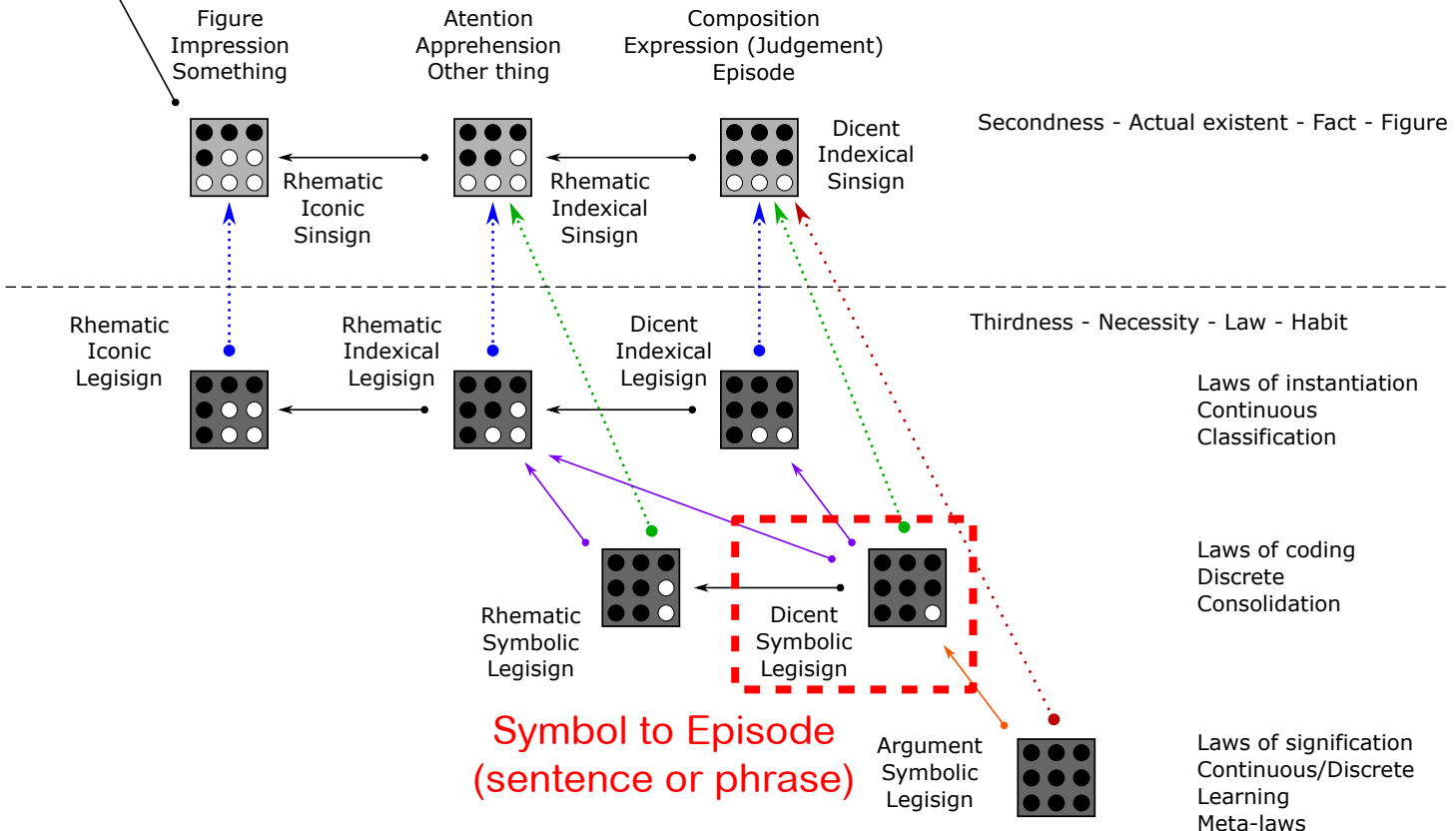


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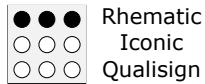


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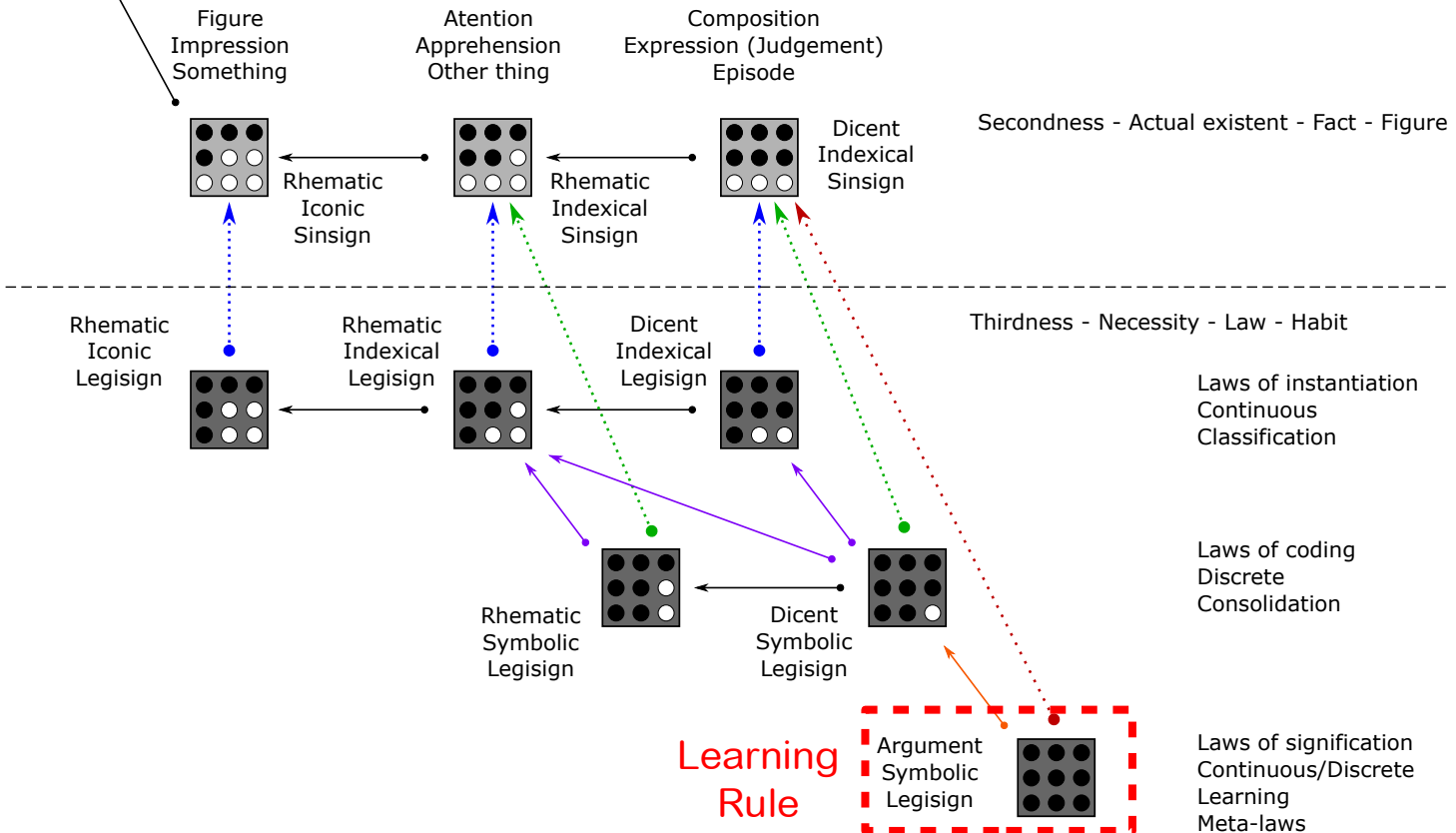


# Using Different Kinds of Signs to Make Sense of the World

Background



Firstness - Quality - Possibility - Background



# From Knowledge to Action

## ■ Semiosis or Sign Process

- Process by means a sign is interpreted, generating a new sign, called its interpretant

## ■ Degenerate kinds of Interpretation might lead to Three kinds of Interpretant

- **Emotional Interpretant:** Interpretant is a feeling
- **Energetic Interpretant:** Interpretant is an action
- **Logic Interpretant:** Interpretant is a new sign

## ■ The Path from Knowledge to Action

- Takes place when the interpretant of the sign is an energetic interpretant



# From Knowledge to Action

## ■ Three Kinds of Energetic Interpretants

- Random Actions (**firstness**)
  - Used during exploratory behaviors
- Reactive Actions (**secondness**)
  - Actions directly generated by a particular set of stimuli
- Goal-based Actions (**thirdness**)
  - Goal: future state the agent is supposed to reach
  - Plan: representation of a set of actions, which should lead the agent to its current state to the desired goal state

## ■ Agent Behavior

- Composed of sequences of actions of these three types

## ■ Peircean Semiotics

- Provides an extensive set of concepts for grounding cognition into a solid philosophical theory
- Provides many insights, which might be useful for the construction of artificial intelligent agents
- Has a rich typology of sign types, which extends far beyond standard approaches to purely symbolic Artificial Intelligence and also more recent approaches trying to fill the symbolic/numeric gap, as e.g. neural networks
  - **Symbols** can be grounded into **indexes** (using attention mechanisms) and **icons** (creating mental simulations), which creates the opportunity for artificial agents to have **full understanding** of natural language sentences and other types of communication
- There is much more than the 10 sign types: this is just the beginning ...