Representations

(HP2T)

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- **The semantic Gap**
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The Semantic Gap[1,2]

Observation (Diversity of representations). Humans model reality via a composite process. This process is not neutral. **Different** people **mentally represent** the world differently.

Intuition (Semantic Gap). The **Semantic Gap** is the phenomenon which happens because of the impossibility for humans and machines to perceive the world in the same way (as it really is?).

Observation (misalignment of representations). The Semantic Gap is the source of the **pervasive misalignment** of the mental models of the world that **humans**, and also **machines**, build.

- [1] Smeulders, A. W., Worring, M., Santini, S., Gupta, A., & Jain, R. (2000). Content-based image retrieval at the end of the early years. IEEE Transactions on pattern analysis and machine intelligence, 22(12).
- [2] Giunchiglia, F., Erculiani, L., & Passerini, A. (2021). Towards visual semantics. *SN Computer Science*, *2*(6).

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World and mental representations

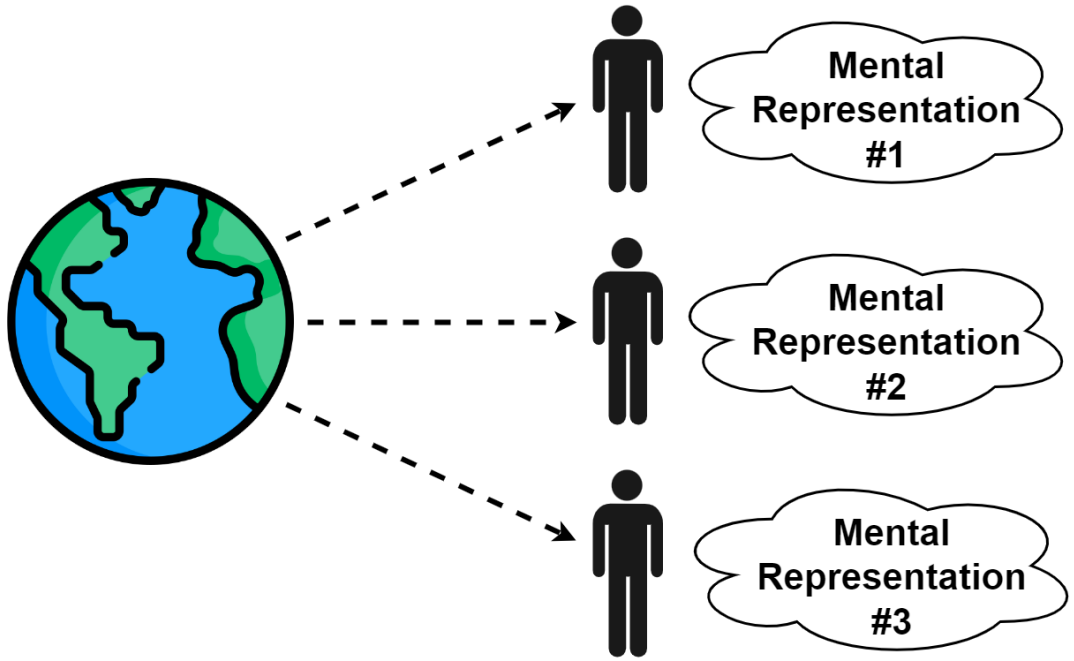
Intuition (World) The **world** is what we perceive through the five senses and assume it exists. It is the spatio-temporal dimension in which humans live and interact with other humans and everything else around them.

Intuition (Memory) When we perceive the world we create in our mind a **memory (historical representation)** of what we have perceived, the memory being itself a part of the world.

Intuition (Mental Representations) Mental representations are a part of a person's memory. Mental representations are such that there is a correspondence between their contents and what is the case in the world they describe.

Intuition (Semantic gap) The **semantic gap** is the difference between the world and a human's mental representation of the world itself, what (s)he has perceived, as witnesses by the multiple different personal mental representations.

World and mental representation (continued)



Two types of Mental representations

- **Analogical mental representation**
- **Linguistic mental representation**

The first is generated from perception.
The second is generated from linguistic input.
Both generate the other.

The **knowledge** of a person (her **memory**) is the set of all her analogic mental representations (**subconscious memory**) plus the set of all her linguistic mental representations (**semantic memory**, **episodic memory**)

Analogical mental representations

Intuition (Analogical mental representations) Analogical mental representations are mental representations that **depict** the world as we perceive it through ***perception***. They are complex articulations of **percepts** into **facts.**

Examples (Analogical mental representations). What we represent (from hearing and sight) using photos, videos, paintings, recordings (what about taste, tact, smell?)

Observation (Analogical mental representations). They enable us to acquire information about the world, directly from the world. They allow humans

- to act in the world,
- to learn from what has been previously perceived and
- to build an understanding of the world itself.

Linguistic mental representations

Intuition (Linguistic mental representations) Linguistic mental representations are mental representations that **describe** mental analogical representations using language. They use **assertions** formed using the alphabet and formation rules of a selected assertional **language**.

Intuition (Assertions, sentences). Assertions are simplified **sentences** that are used to describe facts and are constructed by composing words mentioning percepts.

Examples (Linguistic mental representations). What we mentally represent using any natural language, the language of signs, ER / EER Graphs, tables.

Examples (non-linguistic mental representations). What we represent using a painting, a picture, a photo, any analogical representation (why?).

Linguistic mental representations (continued)

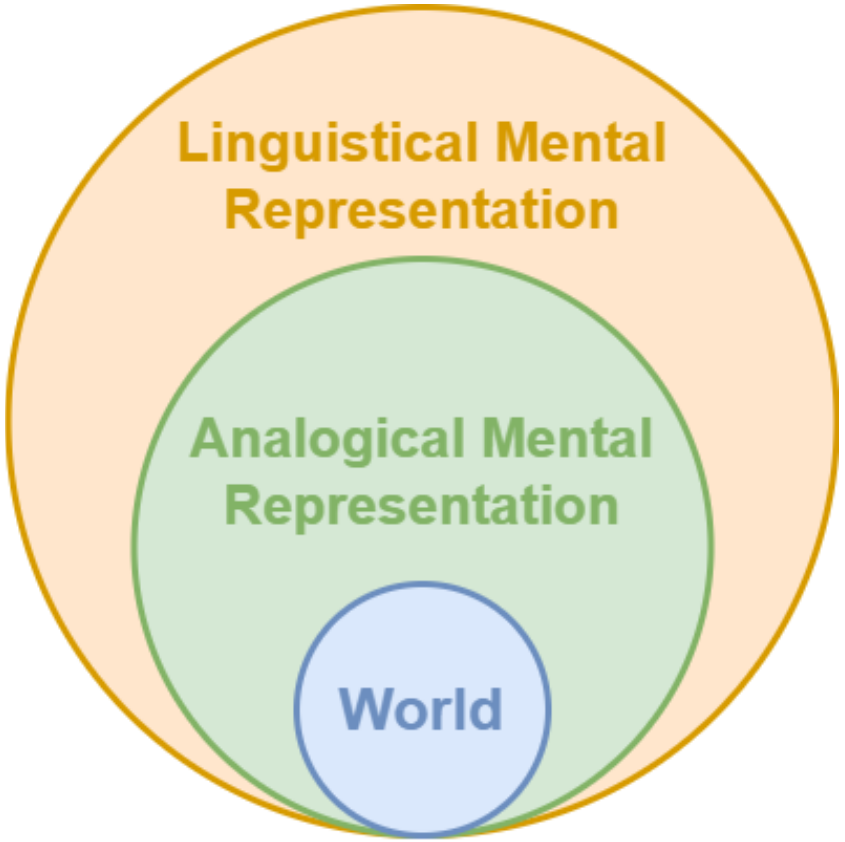
Intuition 2.7 (Linguistic mental representations) Linguistic mental representations are mental representations that **describe** mental analogical representations using language.

From ***percepts*** (from analogical mental representations) to ***concepts*** (*via* alphabet) to ***assertions*** (*via* formation rules) which describe what is the case (***Knowledge).***

Observation 2.4 (Linguistic mental representations) Linguistic mental representations are used to describe what is happening in analogical mental representations. They allow humans

- to communicate to other humans about our mental representations (and,thus, indirectly about the world),
- to learn from what has been previously described or perceived, and
- to reason in order to derive unknown facts from what we already know.

Mental representations



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Partiality of mental representations

Observation 2.6 (Partiality of mental representations)

Because of the semantic gap, mental representations never describe the world completely.

Number of mental representations

Observation 2.7 (Number of mental representations). Because of partiality

There are ***indefinitely many analogical mental representations*** that describe **the same real world situation**.

There are ***indefinitely many linguistic mental representations*** for **the same analogical representation**.

Diversity of mental representations

Observation 2.8 (Diversity of mental representations) Because of partiality, any two mental representations are necessarily ***different***, depending on the ***spacetime*** coordinates under which they are generated, and the ***purpose*** of the person who generates them.

Example (Time-motivated diversity of mental representations) Fausto now and Fausto 20 years ago.

Example (Space-motivated diversity of mental representations) Fausto yesterday at the beach and Fausto now in class

Example (Purpose-motivated diversity of mental representations) A car (or any other artifact) from the point of view of the car constructor (possibky without driver licence) or from the point of view of the user?

Observation. How do I know that the person I saw 20 years ago at the beach, while being his swim instructor, is the same person I see now in class?

(In)Consistency of mental representations

Intuition 2.9 (Consistency and inconsistency of mental representations) A mental representation is ***inconsistent*** when it is represents a state of the world which is impossible for how we know it. ***Consistency*** means absence of inconsistency.

Two mental representations are ***(mutually) inconsistent*** when it is impossible for those two mental presentations to represent the (same part of the) world, as he know it.

Two consistent mental representations can be diverse but still ***compatible*** in the sense that there is a (analogical representation of the) world which is described by both.

(In)Consistency of mental representations (continued)

Intuition 2.9 (Consistency and inconsistency of mental representations) A mental representation is ***inconsistent*** when it is represents a state of the world which is impossible *for how we know it*. ***Consistency*** means absence of inconsistency.

Examples (Consistent or inconsistent theories?)

- A person in two different places in different moments
- A person in two different places in the same moment
- A flying person
- A flying person on the moon
- A deep fake

Intuition 2.9 (Consistency and inconsistency of mental representations). Clash of knowledge in the model and / or theory. But, where does knowledge come from?

Subjectivity of mental representations

Observation 2.9 (Subjectivity of mental representations) Given the world they perceive, humans build one or more among the many possible mental analogical and linguistic representations of what they have perceived.

Observation 2.11 (Subjectivity, inconsistency and objectivity) Two subjective mental representations may be (mutually) inconsistent. The presence of inconsistency provides evidence of the subjectivity of the mental representations involved.

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Representations

Intuition 2.10 (Representations) A **representation** is a part of the world, developed by a human, that represents that human's mental representation of the world

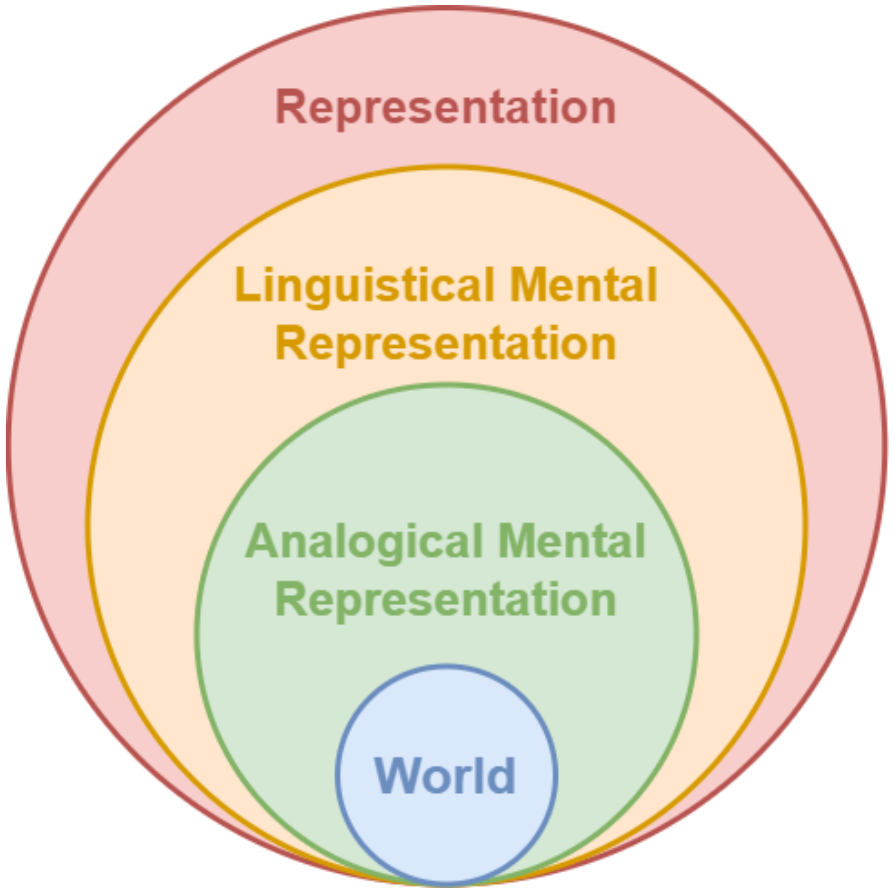
Representations are **accessible**, via one of the five senses, to other humans.

A representation can be perceived, in the same way as the reality it represents. The perception of a representation and of its represented reality can be compared for similarity checking.

Intuition 2.11 (Representations) Representations are the objectivation of mental representations. They allow humans

- to make public their mental representations,
- to communicate their mental representations,
- to build long standing public memories of their mental representations.

Representations (continued)



Two types of representation

- **Analogical representations**
- **Linguistic representations**

Representations

Intuition 2.11 (Analogical Representations) Analogical representations **depict** analogical mental representations.

Examples (Analogical representations). Photos, videos, paintings, recordings (representation of what we see and hear, what about taste, tact, smell?)

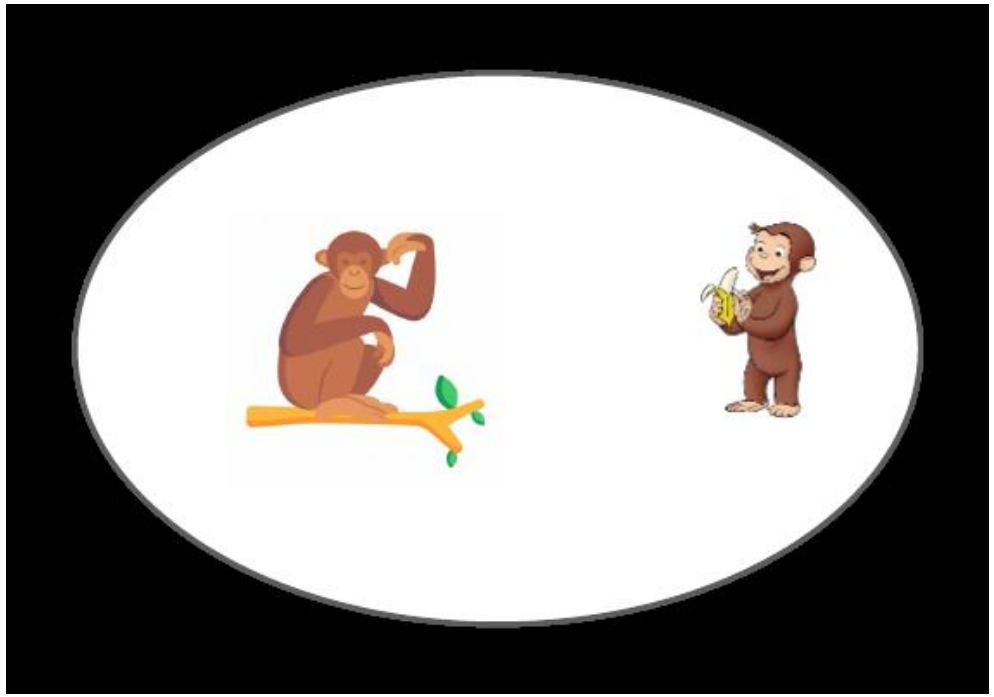
Intuition 2.12 (Linguistic Representations) Linguistic representations **describe** analogic mental representations.

Examples (Linguistic representations). What we represent using any natural language, the language of signs, Java, Python, ER / EER Graphs, tables

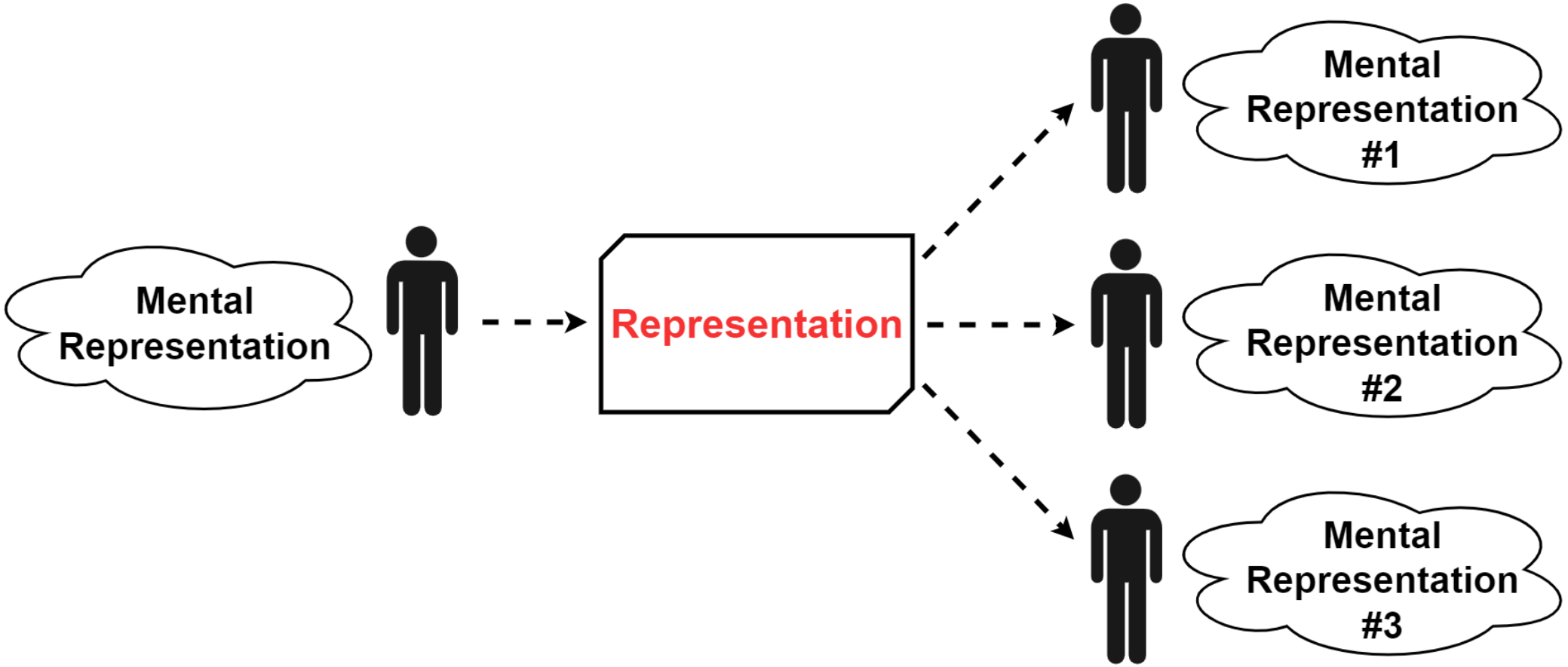
Intuition 2.11 (Analogical vs Linguistic Representations) How we build analogical representations is innate. We learn how to build linguistic representations. This is why all the CS teaching – till now – has focused on how to build linguistic representations.

Linguistic vs. analogical representations

- There is a tree
- There is a banana
- The monkey is eating a banana
- The monkey is sitting on a tree
- The monkey is scratching its head



Mental representations of representations



Mental representations of representations (continued)

Observation (Difficulty). The previous slide may suggest that there is no solution to the problem of subjectivity of mental representations. However this is not the case!

Observation (Requirement on representations). Representations are built with the goal of minimizing the probability of different interpretations and, therefore, of mental representations.

Observation (Using representations). Different interpretations may still arise. Risk minimized (not eliminated) via software and knowledge engineering methodologies.

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Key Notions

- Semantic Gap, mental representation, memory
- Analogical mental representations
- Linguistic mental representations
- Partiality and number of mental representations
- Diversity of mental representations
- (Mutual) (in)consistency of mental representations
- Subjectiviy of mental representations
- Representations, analogical representations, linguistic representations

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