T4

# Cognitive Systems

*2020 edition*

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# PSI 3560 – COGNITIVE SYSTEMS

*class T4*

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# MODELLING COGNITION

The computational approach to cognitive modelling, representation and processes, the nature of the cognitive problem, autonomy, knowledge and conceptual systems

Session T4

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# Summary

Second session ( 9:20 – 11:00 )

- Setting the scenario
- The computational approach to modelling
  - Extending Marr's computational theory
- The nature of the *cognitive problem*
  - Knowledge and conceptual systems
  - Representation and processes
  - The issue of autonomy

# Setting the scenario

- Building an application
  - Conceptual design
  - Specifications
  - Project formalization
  - Design
  - Tests
  - Application deployment

- Building a **cognitive** application
  - Requires the notion of cognition in several of the above steps

APPLICATION CONCEPT

DESIGN

APPLICATION
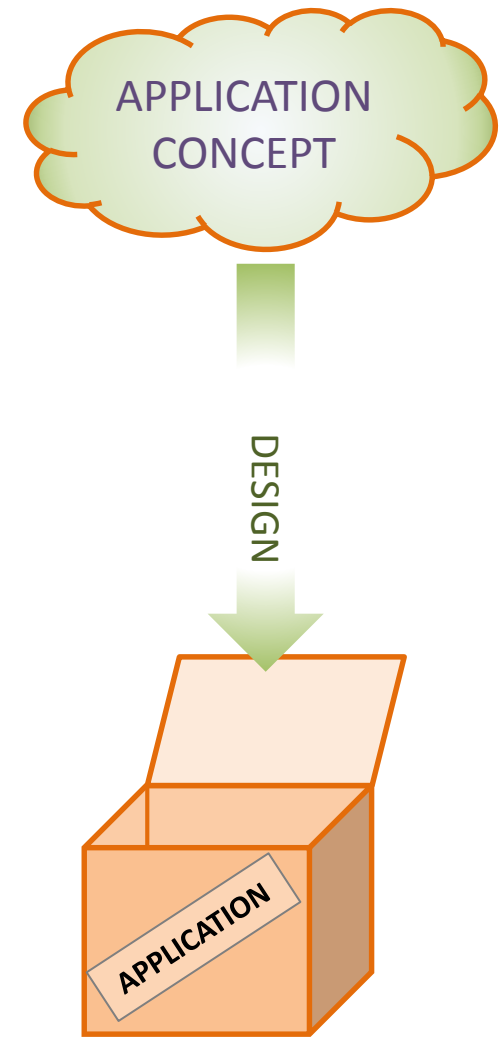
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# Building cognitive applications

- ## Technical steps
  - ### Conceptual design
    - Uses → what for ?
    - Use → how ?
  - ### Pre-project
    - Functional specification → what it does ?
    - Foundational specification → how to accomplish ?
  - ### Project
    - Formal specification → (cognitive) architecture
    - Design specification → choice of methods
    - Project formalities → contract, deadline, costs
  - ### Design
  - ### Implementation
  - ### Tests
  - ### Application deployment

WHAT
COGNITION
IS

What kind of
Cognitive system
the application is:
- A cognitive agent
- A cognitive tool

# Setting the scenario

- Building a cognitive application
  - A *working definition* of cognition is enough for design purposes

Cognition

Cognitive process

Knowledge

Cognitive tool

Cognitive Agent

+ Autonomy

or

APPLICATION CONCEPT

DESIGN

APPLICATION
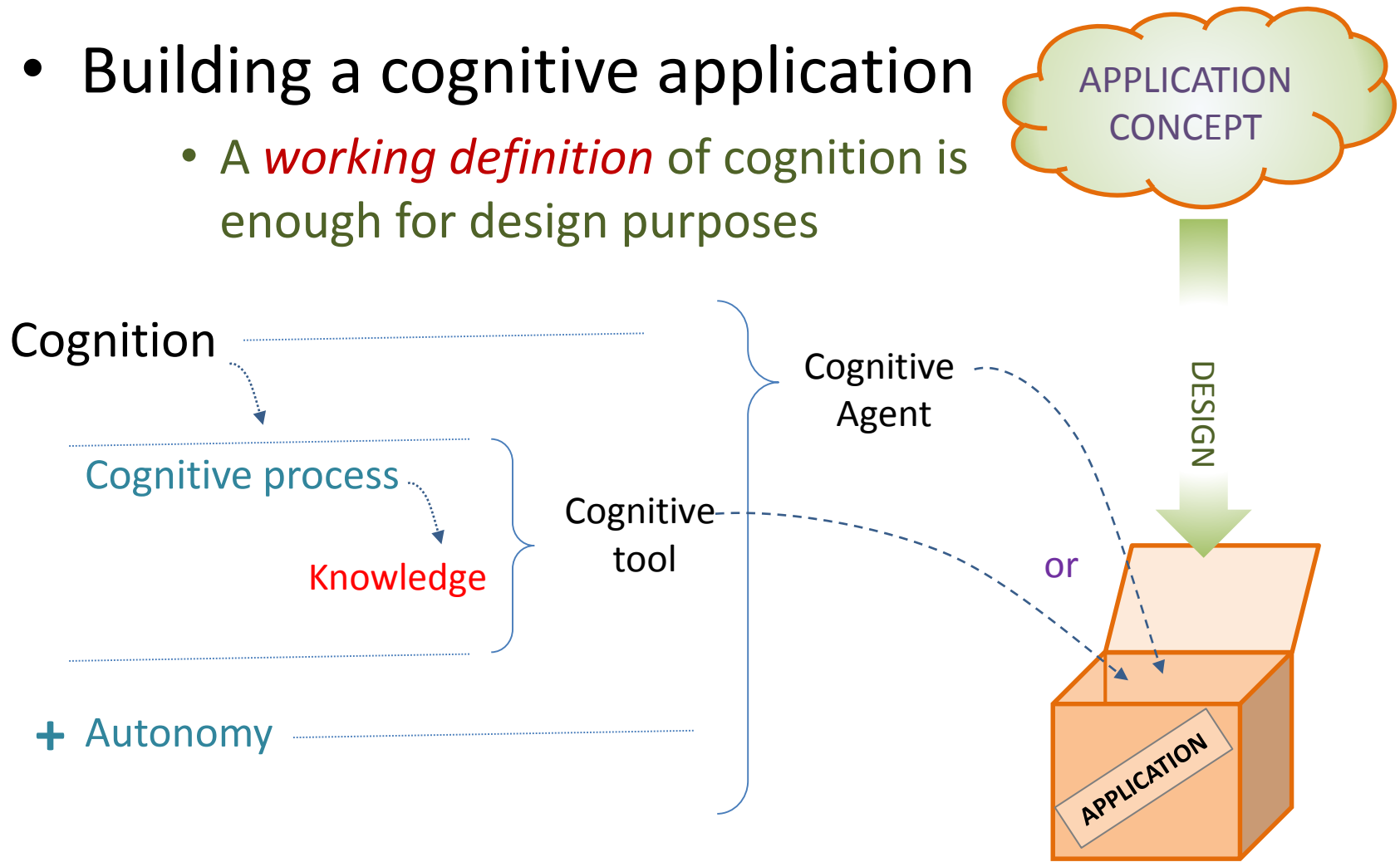
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# Setting the scenario

- A <u>working definition</u> for *cognition*
  - Cognition is based on cognitive processes
    - A cognitive process is a process that builds **knowledge** from information

  - Knowledge is information
    - Knowledge is information with  meaning
    - Meaning associated to the *non-contextual* referent of the information
      - Intrinsic or **semantic** meaning



*Information*    is about...    SOMETHING

*referent*

# Setting the scenario
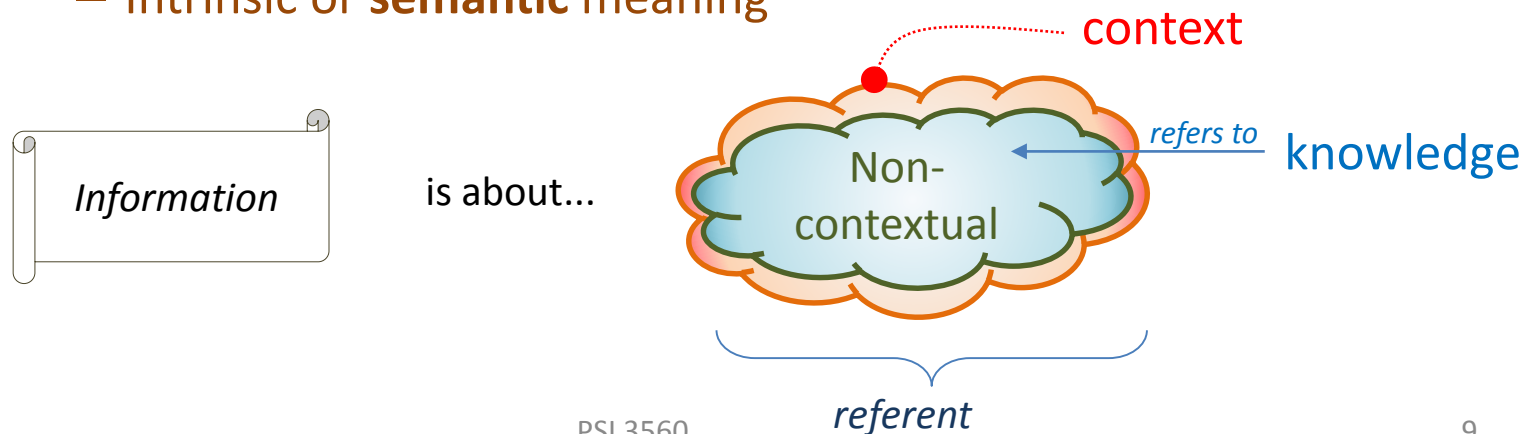
- Cognitive processes
  - A cognitive process is a process that builds **knowledge** from information

  – Knowledge is information
    - Knowledge is information with meaning
    - Meaning associated to the *non-contextual* referent of the information
      – Intrinsic or **semantic** meaning

*Information* is about... 

context

Non-contextual

*refers to* knowledge

*referent*

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# Setting the scenario...



"hmmm ...yummy yummy *cookie*"

"look baby ... *cookie*"

" *cookie* good... so good"

contextual part

*cuky !*

... *means* ...

knowledge

bits of tasty things

# Setting the scenario

– So, rephrasing our working definition of cognitive process:

> • A cognitive process is a process that builds **knowledge** from the pieces of information that are not context-dependent.
> – i.e. , those that have *Intrinsic or **semantic** meaning*

– Some advanced remarks :
  » Obs.1: this definition is arguable, and someone prefer to say that cognitive processes build knowledge from non-derived content (Adams & Aizawa 2005,2010; Fodor 1987,1990 ; Dretske 1981, 1988; Searle 1980,1984).

  » Obs.2: Since we are looking for just a working definition enough for cognitive systems design, we'll adopt our proposed definition (Kogler 2015, 2017, 2019 *in preparation*) which is correct, although arguable.

• A question for further concerning: how does one specify and implement a cognitive process ?

• We'll come back to this question later.

# Setting the scenario

- ## Building a cognitive application

  - A *working definition* of cognition is enough for design purposes
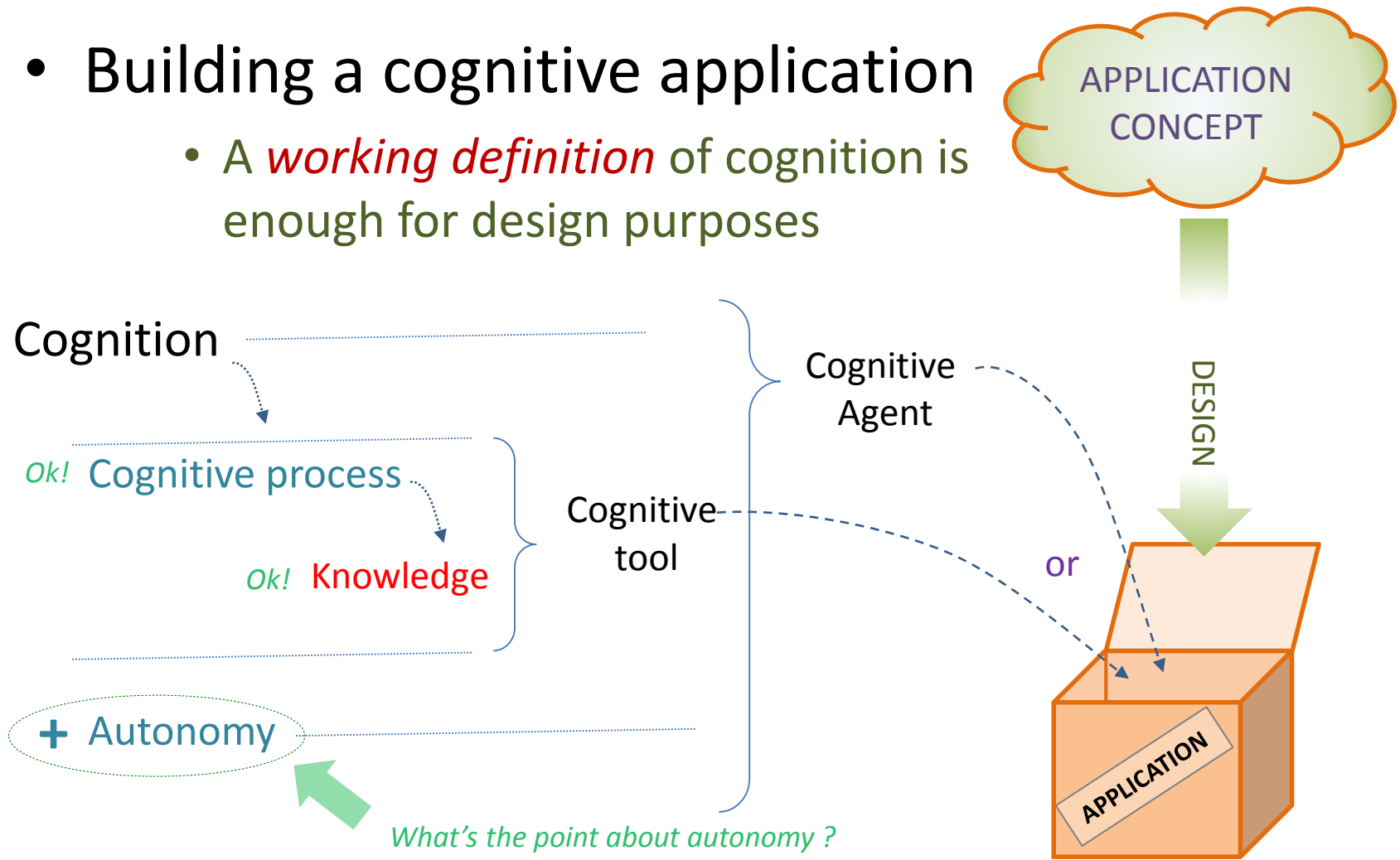
# Setting the scenario

- Autonomy is related with how the action is triggered
  - Reaction → action following a (fixed) rule
  - Adapted action → action following a flexible, modifiable scheme
    - Scheme → composed (re)action
    - Requires perception to accomplish a proper composition
      - Perception → kind of predictive process
        » Uses context-dependent mechanisms to make predictions
  - Complex action → capable of innovation, respected to changes of environment.
    - Uses knowledge → information that doesn't refer to a specific environment
      - A generalization over the environments
    - Constrained by the agent's own goals
      - The intrinsic specific ways of the agent to make actions
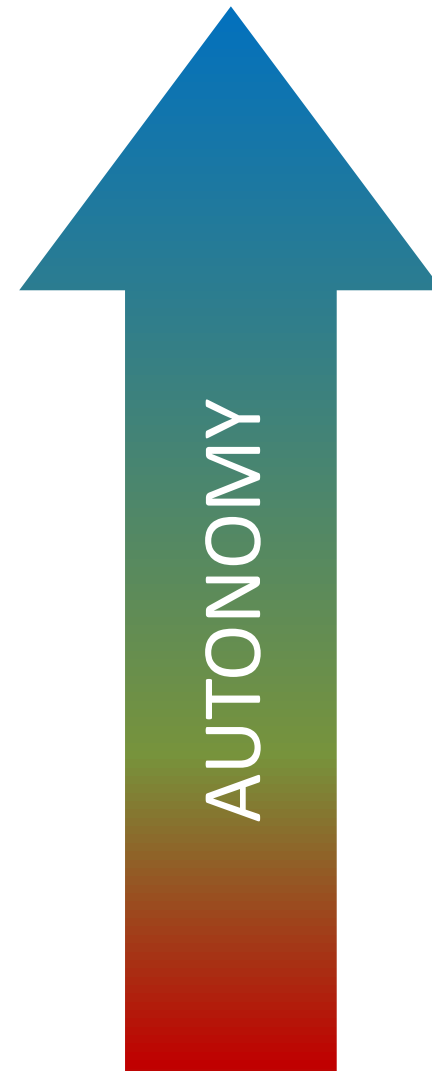
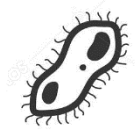# Setting the scenario

Kinds of behavior

**cognitive agents**

**perceptive agents**

**reactive agents**

AUTONOMY

intelligent

knowledge based

adaptive / predictive

adaptive

reactive

purely reactive

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# Setting the scenario

- Cognitive process
  - A cognitive process is a process that builds **knowledge** from the pieces of information that are not context-dependent.
- Agent
  - Entity capable of deciding and generating its own actions
- Autonomous action
  - Action based on **autonomous decisions** → the agent set its own goals
  - Goal setting
    - by the constitutive capacity of performing actions
    - by the possibilities of adaptations resulting from predictions
    - by simulating and planning scenarios of action using knowledge
      - » Obs.: Not required that the goal setting be conscious

# Setting the scenario

- – Cognitive process
  - A cognitive process is a process that builds **knowledge** from the pieces of information that are not context-dependent.
- – Cognition and cognitive agent
  - Cognition is a <u>system of cognitive processes</u> organized to improve the agent's autonomy.
    - – Cognition is an agent's feature → it presupposes an agent.
    - – Such agent is called a cognitive agent.
- – Cognitive tool
  - Any application whose operation involves some cognitive process is a cognitive tool.
- – Cognitive systems are of two types:
  - Cognitive agents
  - Cognitive tools

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# Setting the scenario

- ## How to build a cognitive application ?
  1. Conceptual analysis
  2. Design phase

  - Conceptual analysis:
    - What the application does ?
      » It is a cognitive system that does… ?
    - How does it do that ?
      » Agent or tool ?

APPLICATION CONCEPT

DESIGN

Cognitive Agent

or

Cognitive tool
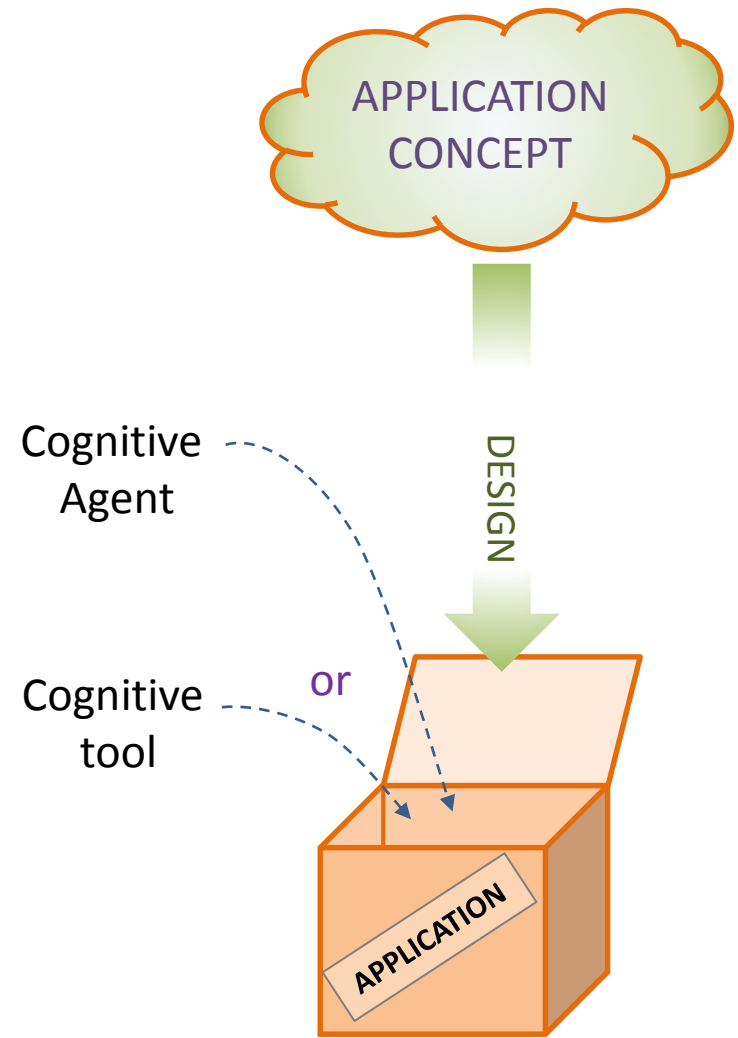
APPLICATION

# Setting the scenario

- Conceptual analysis:
  - What the application does ?
    - » It is a cognitive system that does… ?
  - How does it do that ?
    - » Agent or tool ?

- After the <u>formal statement</u> of *what the application does*,

- Then comes the problem of **modelling the cognitive system**



APPLICATION CONCEPT

DESIGN

Cognitive Agent

Cognitive tool

or

APPLICATION
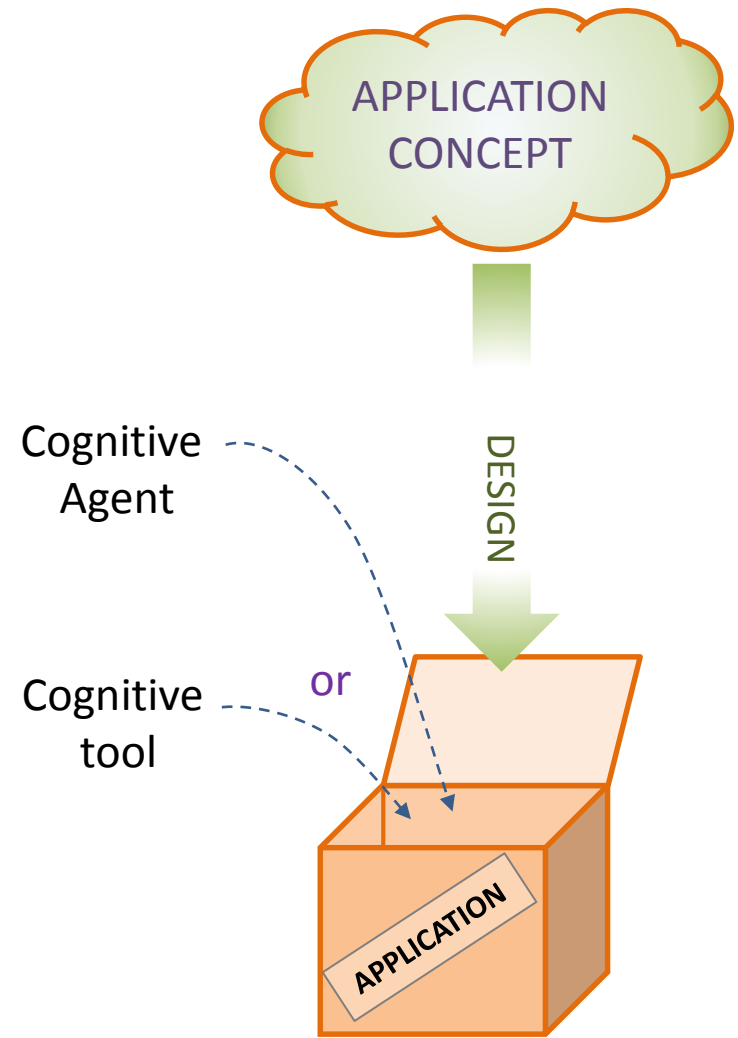
# Cognitive system modelling

- David Marr's approach
  - Extending the Marr's approach of perception (1975-1980) to model cognitive systems

  - Marr's computational theory
    - Three levels of analysis
      1. Computational model
      2. Algorithmic specification
      3. Physical implementation

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# Cognitive system modelling

- **David Marr's approach**
  - Marr's computational theory
    - Three levels of analysis
      - Computational model
        » What kind of computations are required ?
          - Filtering, interpolations, extrapolations, detections, predictions, estimation, decision making, planning ?
        » What is the nature of the computations ?
          - Logical, statistical , both ?
      - Algorithmic model
        » Representation → how to encode the data
        » Algorithm → how to transform the encoded data into the solution
      - Physical implementation

# The nature of the cognitive problem

- From the definition:
  - Cognition is a system of processes that build knowledge from pieces of information that are not context-dependent, organized to improve the agent's autonomy
    - We have two computational problems:
      - How to devise a cognitive process, or
        - » To build knowledge from pieces of information that are not context-dependent
      - How to organize this system of processes in order to improve the agent's autonomy

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# The nature of the cognitive problem

- The first computational problem:
  - How to devise a cognitive process, or
    - » To build knowledge from pieces of information that are not context-dependent

- This problem consists in understanding:
  - How information is presented
  - How knowledge is presented
  - How to identify the pieces of information that are not context-dependent
  - How to assemble these pieces as knowledge

# The nature of the cognitive problem

- The two first points are questions of representation
    - How information is presented
    - How knowledge is presented
- And the two following ones are procedural issues
    - i.e. , refer to the nature of the processes that operate on the representations
        - How to identify the pieces of information that are not context-dependent
        - How to assemble these pieces as knowledge

# The nature of the cognitive problem

- Knowledge and conceptual systems
  - A brief metaphysical prelude (ontology)
    - Ontology = theory about the world
    - World = objects + relations
    - World configuration = relations among objects
    - Event = change in the world configuration
    - Phenomenon = observation of the event
      - When observed by an agent, the agent **registers** data about the phenomenon
      - Data is the result of encoding in the representational basis of the agent, of the registration of the phenomenon

# The nature of the cognitive problem

- Knowledge and conceptual systems
  - A brief metaphysical prelude (ontology)
    - Phenomenon = observation of the event
      - When observed by an agent, the agent **registers** data about the phenomenon
      - Data is the result of encoding in the representational basis of the agent, of the registration of the phenomenon
    - Information = corresponds to the effect produced in the observer by encoding the data
      - This effect *can be measured* and is called **information measure.**
        » Ex.: Shannon's information measure

# The nature of the cognitive problem

- Coming back to the two first points that we considered as questions of representation
  - How information is presented
  - How knowledge is presented
  - To the first question we can say that the information is presented as data.
    - So, knowledge is not data.
    - Knowledge is built from data.
  - Knowledge is encoded in the state of the cognitive system.

# The nature of the cognitive problem

- And there are two remaining questions
  - How to identify the pieces of information that are not context-dependent
  - How to assemble these pieces as knowledge

- These are procedural issues
  - i.e. , they refer to the nature of the processes that operate on the representation
    - The processes can be of logical or statistical nature, or both
    - They are going to be explored on the next two items of the syllabus:
      » Artificial Intelligence (classes T5-T6)
      » Machine Learning (classes T7-T8)

# Course project

- Technical steps
  - Conceptual design
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    - Use → how ?
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Cognitive system
the application is:
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# This is all for today.

## See you next week !

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