Biomedical and hospital informatics
Master 1

Human Machine Interface
Interface Homme Machine
GB 722

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Chapter 2 Contributions of cognitive psychology in Human-Machine design (HMI)

1. Introduction

- The key to the success of any human-machine interface comes down to the degree of ease that the user will find when interacting with the machine which amounts:
  - to minimizing the learning cost,
  - reducing the risk of error,
  - exploiting all the advanced features of the system by the latter.

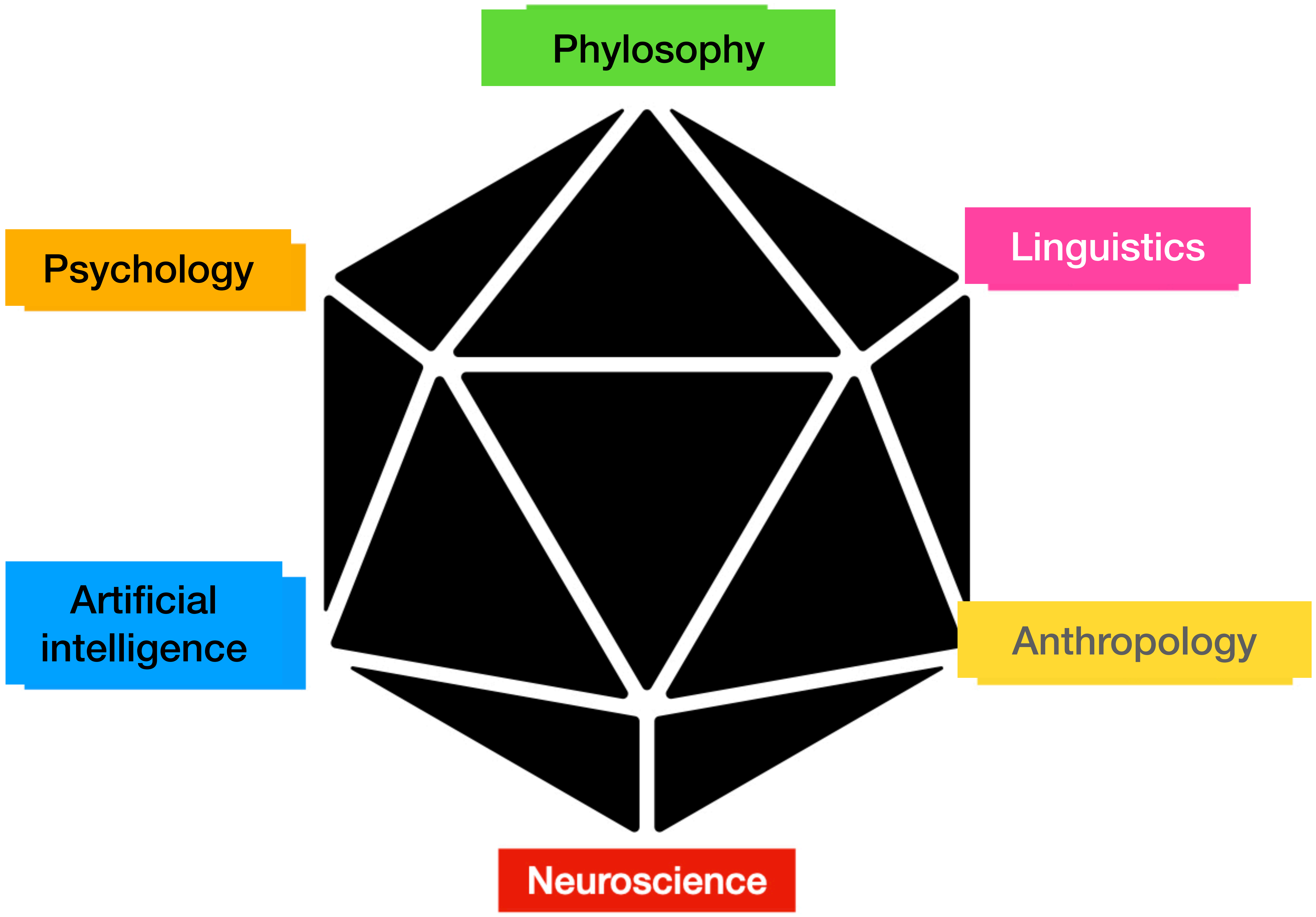
1. Introduction

- In this order, the idea is to study and understand the characteristics of the user, their way of thinking, of perceiving the elements of their environment, their reactions to a certain event.

2. Definition

- Cognitive sciences are sciences which aim to describe, explain, or even stimulate knowledge processes.
- Cognitive sciences form a discipline which mainly combines psychology, linguistics, artificial intelligence, anthropology, philosophy and neuroscience. Sociology and social psychology tend to be integrated into it, as do neuropsychology, psycholinguistics and psychophysics.
- The objects studied in this field are: perception, language, reasoning, action, which can be approached from different aspects (mathematical, psychological, biological).

2. Definition



3. The human processor model

- The human processor model aims to represent the human as an information processing system governed by rules.

- This model makes it possible to evaluate the usability of a product.

- It conceptualizes in a simplified manner the human process during an interactive phase with a computer system.

3. The human processor model

- In this model the human is seen as an information processing system which comprises 3 interdependent subsystems :
  - the sensory system responsible for perception,
  - the motor system responsible for movements
  - and the cognitive system responsible for reasoning and decision making.

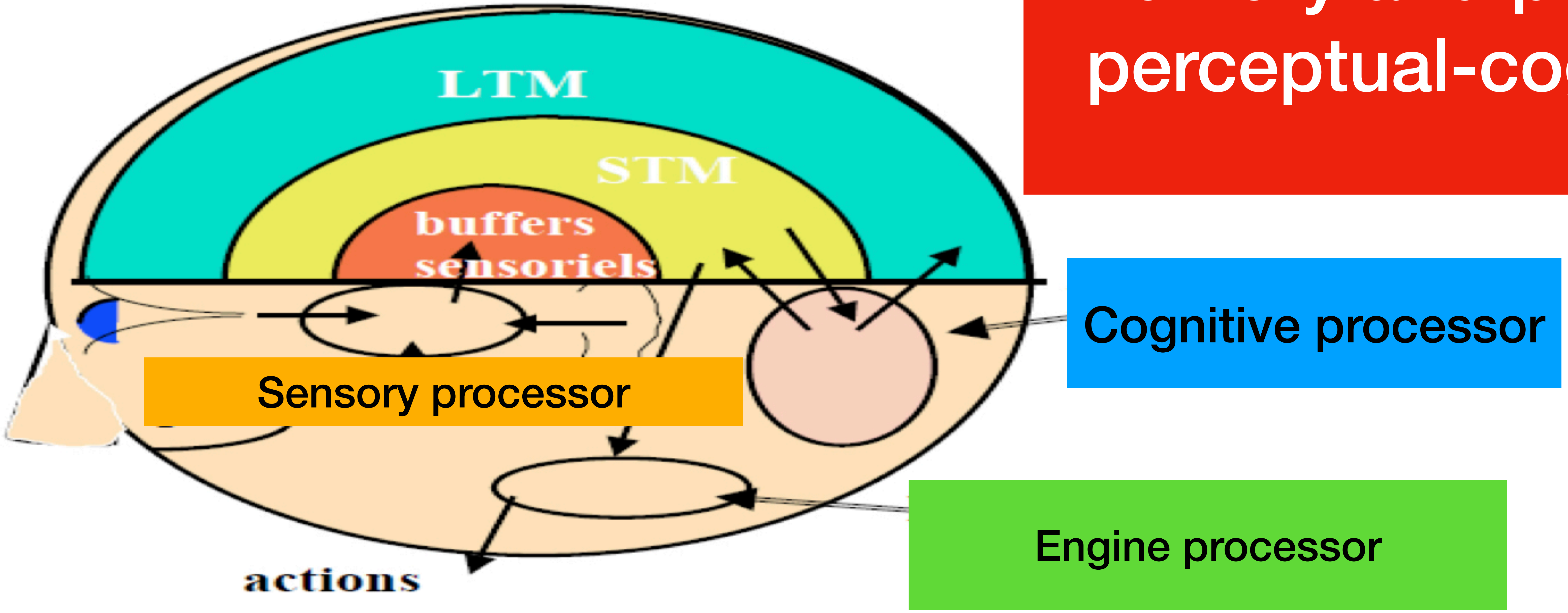
3. The human processor model

- Each of these subsystems has a **processor** and a **memory**.
- The processors are characterized by their **cycle time (Sensory_cycle_time, Motor_cycle_time, Cognitive_cycle_time)** which includes the memory access time.
- Each memory is characterized by **the type of information stored, its capacity, and its persistence**

3. The human processor model

General diagram CARD 1983

memory and processes of the perceptual-cognitive system



3.1 The human processor model : the sensory system

- The sensory system Is the set of subsystems each specialized in the processing of a class of stimuli, where each subsystem has a specific memory called **sensory memory** and an **integrated processing mechanism (processor)**.

- Stimuli are physical phenomena detectable by a sensory subsystem (We have 5 senses: **touch, hearing, smell, taste, sight)**. They are encoded in sensory memory to express the physical properties of the phenomenon.

3.1 The human processor model : the sensory system

- The sensory system includes:
  - **A Sencoriel_cycle_time processor** = 100 ms
  - **Two specific memories,** one visual (V), the other auditory (A). linked to the short-term memory of the cognitive processor.

3.2 The human processor model : the cognitive system

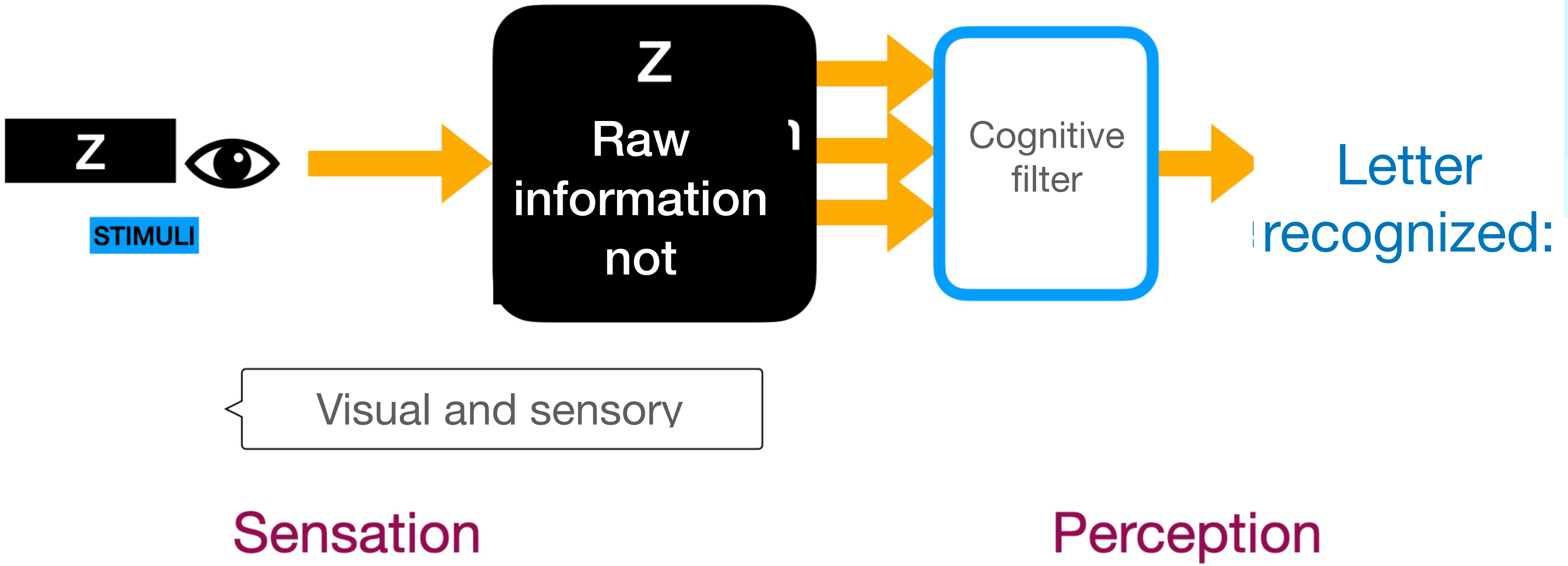
- The cognitive system controls the behavior of the individual by depending on the contents of its memory. This memory includes:
  - Short Term Memory / Short Time Memory: also called working memory, it is this which holds the information being manipulated..
  - Long Term Memory: is the place where permanent knowledge is stored. It is the support of all the accumulated knowledge which guides us in the smallest actions that we carry out..

3.2 The human processor model : the cognitive system

- The cognitive processor follows the "Recognition-Action" processing cycle (analogous to the "Search-Execution" cycle of usual computers).

- The cognitive system receives symbolic information from short-term memory. It then uses the information stored in long-term memory to make action decisions and formulate a response. Actions taken by the cognitive processor modify the content of short-term memory

3.2 The human processor model : the cognitive system



3. 3 The human processor model : the motor system

- The motor system is responsible for movements.
- In the context of human-computer interaction, the movements concerned are the manipulations of keyboards, screens and designation devices.
- A movement is not continuous but is made up of a series of discrete micro-movements.
- Each micro-movement is accomplished on average in 70 ms. This time constitutes the basic cycle of the engine system processor.

3.3 The human processor model : the motor system

- There are two types of movements:
    - **fine movements (mouse movements),**
    - **and large movements: (keyboard strokes).**
- When the frequency of transitions from one type to another is high, this implies significant concentration and a heavy load. It is advisable in any HMI design to minimize eye movements through intelligent organization of the screen in relation to the task.

3.4 The human processor model in the HMI

- The human processor model is a unifying framework for various psychological knowledge that uses computational terminology.
- However, this model is interested in performances (motor and perceptual) than in cognition, and moreover it does not indicate any design method.

4. Norman’s theory of action

- Norman’s theory of action is a cognitive approach to HMI design.
- It allows you to detail each step of an action that the human will carry out on an HMI.
- This involves trying to understand how the user of a system executes an action by analyzing the different steps that allow him to achieve his goal in order to draw some conclusions and improve the design of the interface.

4. Norman's theory of action

- This model structures the accomplishment of a task into 7 activities:

  1. **The establishment of a goal** : it's the mental representation of the state to be achieved;

  2. **The formation of an intention:** it represents the decision to act to achieve the goal;

  3. **The specification of a sequence of actions** : where the intention must materialize in a sequence of actions on the physical control devices;

4. Norman's theory of action

4. **Execution of actions** where these are motor acts which lead to a change in the physical state of the system;

5. **Perception of the state of the system**;

6. **Interpretation of the state of the system** as a psychological variable;

7. **Evaluation of the state** of the system in relation to the goal.

4. Norman’s theory of action

4.1 Norman's theory of action: Example

- **Example:**
  - analyze the action "**delete a file**" using Norman's theory of action:

4.1 Norman's theory of action: Example

1. Set the goal:
    - **Delete a file.**
2. The goal must be transformed into intention:
    - **Delete the file using the delete buttons.**

4.1 Norman's theory of action: Example

3. The intention is transformed into a sequence of actions (specification of actions):

- **Raise your hand, move it then place it on the mouse;**
- **Move the mouse so that the cursor is positioned on the file to be deleted sea ;**
- **Use your fingers to click the left mouse button;**
- **Move the mouse again so that the cursor is positioned on the delete button;**
- **Use your fingers to click the left mouse button;**
- **Confirm my choice;**
- **use your rights and click on the yes button.**

4.1 Norman's theory of action: Example

4. Executing the actions (which are specified in step 3).

5. Perception of the environment: **see if the file has been deleted.**

6. Interpretation: the perception must then be interpreted according to our expectations, **see if the file exists or not**.

7. Evaluation: **compare the current state of the system with the defined goal**

5. GOMS and Keystroke models : GOMS

- The GOMS model **(Goal, Operator, Method, Selection)** is inspired by the human processor model which aims to model the behavior of the individual at different levels of abstraction from the task to the physical action.

- The essential contribution of the GOMS model is a formal structure which makes it possible to organize the design process.

- The design method induced by GOMS is carried out along two axes:
    - the analysis of the task (since it is this which determines the behavior)
    - and the predictive evaluation of the user's behavior in accomplishing this task.

5. GOMS and Keystroke models : GOMS

- The elements of the model are defined as follows:

1. **The goal:** is defined hierarchically. A complex goal is achieved if several subgoals are achieved recursively. **Example:** deleting a word means deleting character by character.

2. **Operators:** elementary actions which, once executed, cause a change in state, **Example:** delete a character

3. **A method:** describes the process for achieving a goal. **Example:** deleting a character by pressing the Delete button.

4. **Selection rule:** a selection rule expresses the choice of a method when there is a conflict. **Example**: if "condition true" then use method M;

5. GOMS and Keystroke models : Keystroke

- The Keystroke method is an objective measurement tool that allows you to compare the possible choices of a command language (syntactic and lexical).
- The elements considered are the physical actions that users perform to implement a command.
- This is a quantitative method of performance evaluation which evaluates the execution time of a task where the latter represents the sum of the acquisition time and the execution time.

5. GOMS and Keystroke models : Keystroke

- Keystroke introduces six operators to describe the execution of an elementary task, namely:
  - **K: “Keystroking”,** keystrokes on the keyboard or mouse**,**
  - **P: “Pointing”,** designation,
  - **H: “Homing”,** repatriation of the hand,
  - **D: “Drawing”,** action of drawing,
  - **M: “Mental activity”,** mental activity,
  - **R: “Response time”,** system response time.