Chapter V

Cognitive Aspects & Scientific Theories for Ergonomic

Outline

I. Introduction

II. Human Processor:

    1. Perceptuol processor
    2. Motor processor
    3. Cognitif processor

III. Human memory

IV. Consequences on HCIs Conception : scientific ergonomics theories

V. Conclusion

The objective of this course is to give you some elements from psychology/cognitive science in relation to scientific theories relevant to the design and evaluation of interactive systems.

I. Human Processor (Card, Moran & Newell)

Theory that describes human information processing as a system with three main processors: perceptual, cognitive, and motor, along with associated memory systems.

1. Perceptual Processor: manages external stimuli detected by sensory receptors (sight, sound, touch, etc.) and transforms them into an internal representation that the cognitive system can use. Handles sensory input, processing external stimuli. It has a cycle time of about 100 milliseconds.

2. Cognitive Processor: Performs thinking, decision-making, and problem-solving using information from both working and long-term memory. It has a cycle time of about 70 milliseconds.

3. Motor Processor: Translates the cognitive decision into physical actions, such as pressing a button or moving a mouse. It also has a cycle time of about 70 milliseconds.

Each processor has a memory (capacity, persistence) and a speed.

1. Perceptual Processor : Sight

- Field of view :180°
- Attention Focus

  visual acuity : A black line 0.04 mm thick on a white background can be easily distinguished by an individual at a distance of 50 cm.

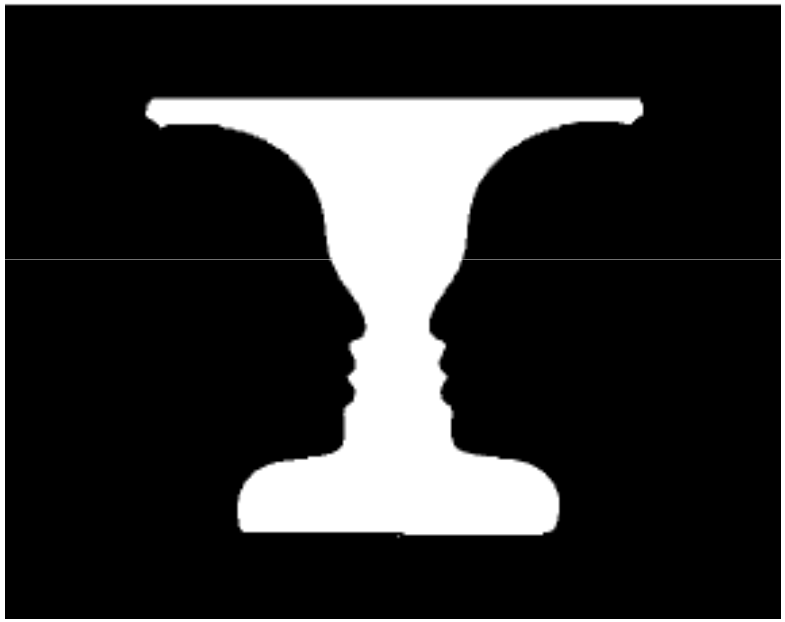
- Peripheral perception

  less sensitive to colors, more sensitive to movements: it is often very difficult to spot a bird in a tree, but we perceive it immediately the moment it flies away.

- Perception of color, movement, depth (3D perception).

What do you see?

Rubin's Vase, or
The Two Faces ?



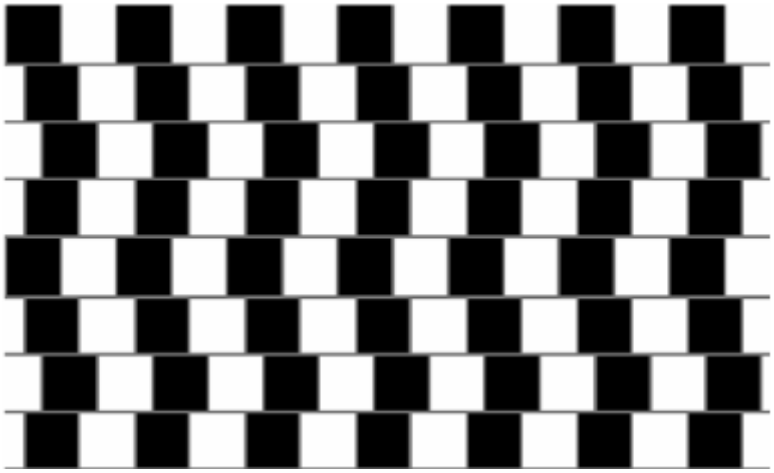
We can "trick" our visual system, as these two optical illusions demonstrate.

Look at this image

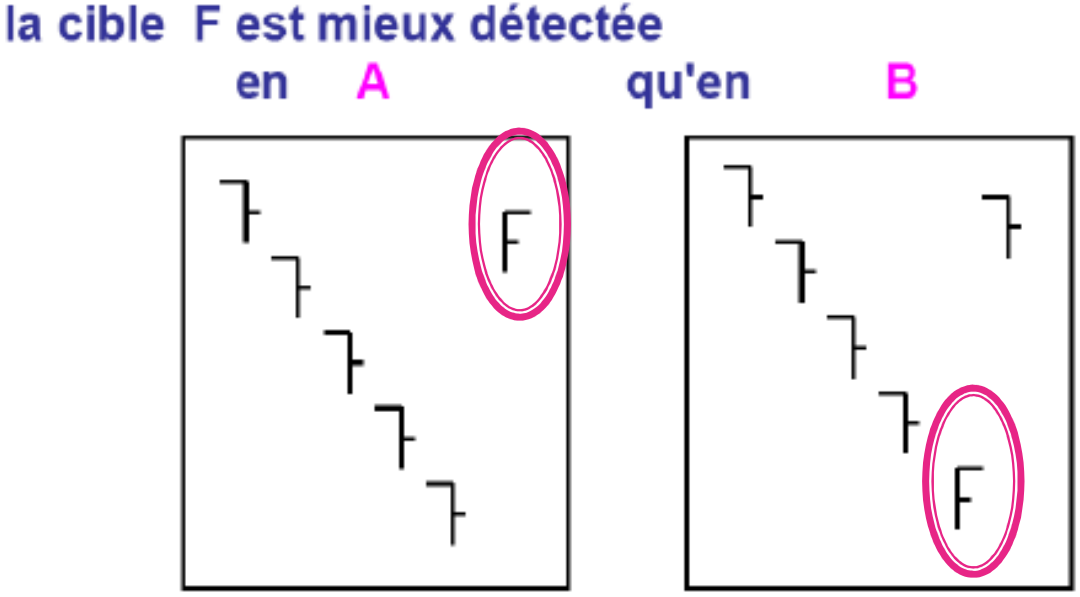
You will gradually see faces appear.

Once certain faces are spotted, it's impossible to stop seeing them…

Other illusions



Are the "horizontal" lines parallel or slanted?



1. **Perceptual Processor** : **Sight**

- Memory capacity = 17 characters
- Memory persistence = 200 ms
- Processor base cycle time = 100 ms

Two stimuli separated by less than 100 ms tend to merge.

1. **Perceptual Processor** : Hearing

- Memory capacity = 5 characters (or equivalent)
- Memory persistence = 1500ms
- Processor base cycle time = 100ms

Despite its capabilities, hearing is rarely used by current interactive systems, aside from various beeps and recorded signals.

The current trend is toward interactive systems that use speech (multimodality).

1. **Perceptual Processor** : Touch

In human-computer interaction, "perceptual processing: touch“ relate to the development of interfaces and systems that mimic human sensory capabilities.

Example: braille keyboard for blind and visually impaired.

1. **Perceptual Processor** : Touch

- Tactile sense

  Hot, cold, pressure , Pain

- Proprioceptive sense

  Body positioning in space, therefore perception of the shape of a grasped object.

- Kinesthetic sense

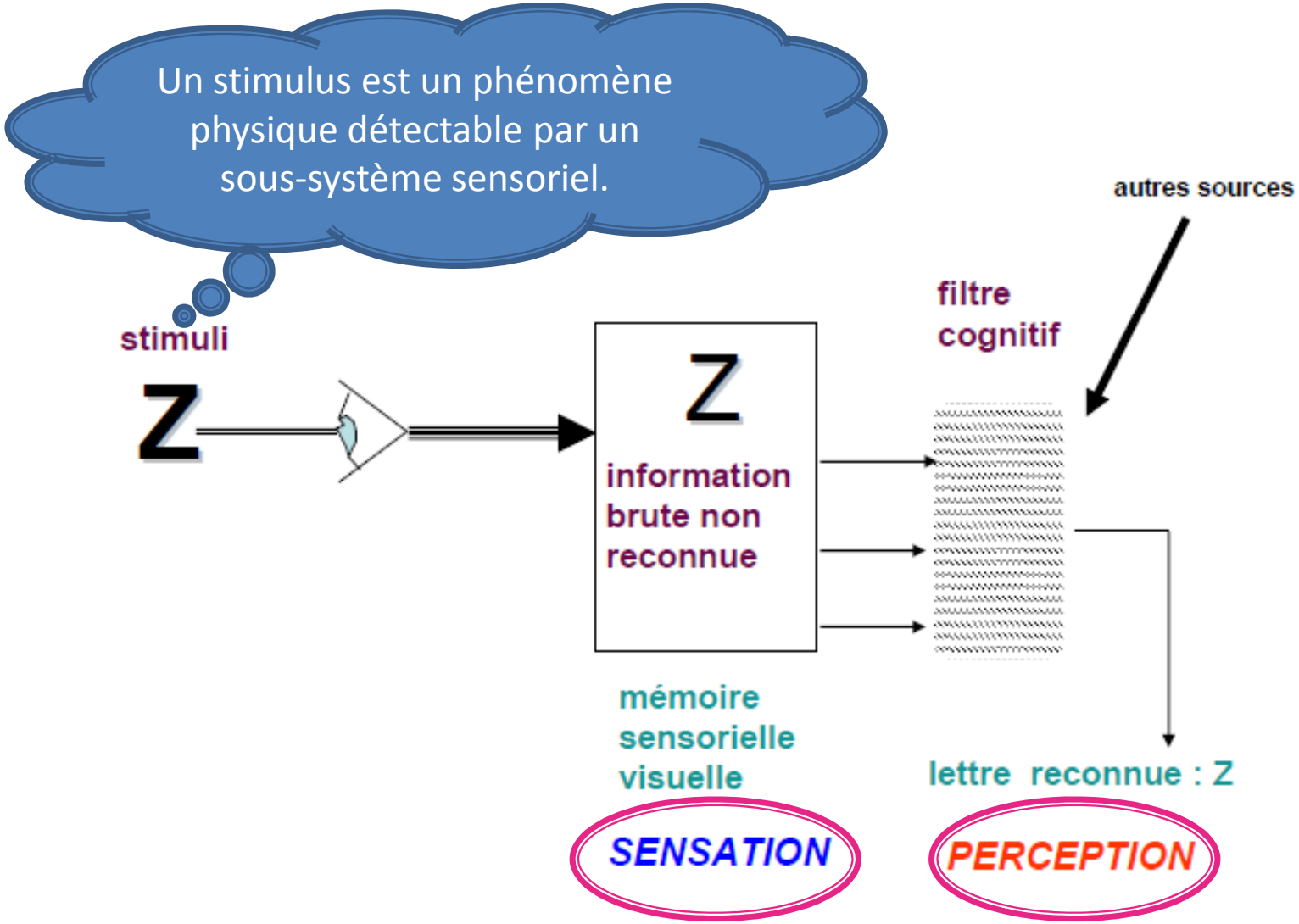
  Perception of muscle effort, therefore the resistance/weight of an object.

Examples:

- ✓ using multiple finger gestures (one finger for manipulation, two for zooming, etc.)
- ✓ using tappers (tactors) in gloves to simulate the sensation of touching virtual objects in a VR environment.
- ✓ robots with advanced touch sensitivity to perform complex tasks like grasping objects or navigating unknown environments.

2. Cognitif processor: decision-maker

Uses the information from the perceptual system (stored in working memory) and long-term memory to make decisions, solve problems, and schedule actions.



Quickly state the color of each word

Stroop effect: Interference between a primary task (identifying the color) and a cognitive process (reading a word).

Read this character

Past experience and context have an effect on how we interpret the elements of the group.

3. **Motor Processor**: Responsible for actions

- Translates the decisions and instructions from the cognitive system into physical actions, such as moving a mouse, typing on a keyboard, using a gesture, or giving a voice command.

- It has a specific processing time (around 70 milliseconds).

II. Human Memory

How is information stored ?

Human Processor

- 3 processors
  - Perceptual ou sensory
  - Cognitif
  - Motor

- Memory hierarchy
  - working memory (RAM)
    - Sensory memory
    - Short-term memory
  - Long-term memory

Sensory Memory

- Sensory register (buffer), is a brief collection of information (stimuli) from our senses. This includes hearing, touch, smell, taste and vision.
- These memories are constantly overwritten as information reaches us.
- Information is transferred to short-term memory if it is deemed worthy of being received.

Short-term Memory

Holds information being manipulated, like the registers of a computer.

Example : calculate 35 x 6

An other test : look at this series 

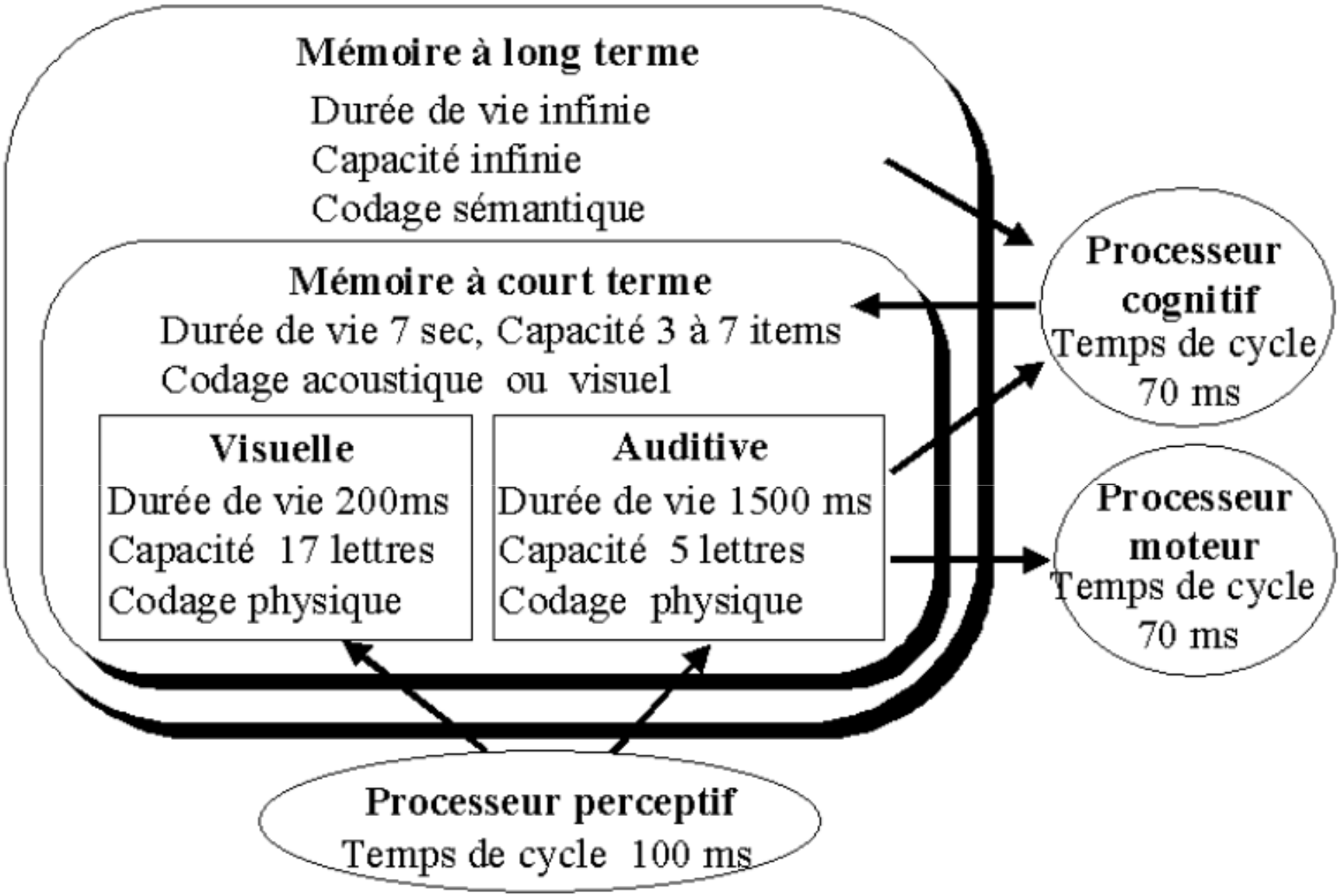
Now, write down as many numbers as possible .
How much?

Characteristics

- ❑ Working memory
- ❑ Capacity for a few items (7 +/- 2)
- ❑ Storage time: 10 to 30 seconds

Long-term Memory

- Our principal memory.
- Informations, experiences, and knowledges are stored there.
- Characteristics
  - Very large (unlimited) capacity,
  - Relatively long access time (1/10s),
  - Forgetting occurs more slowly,



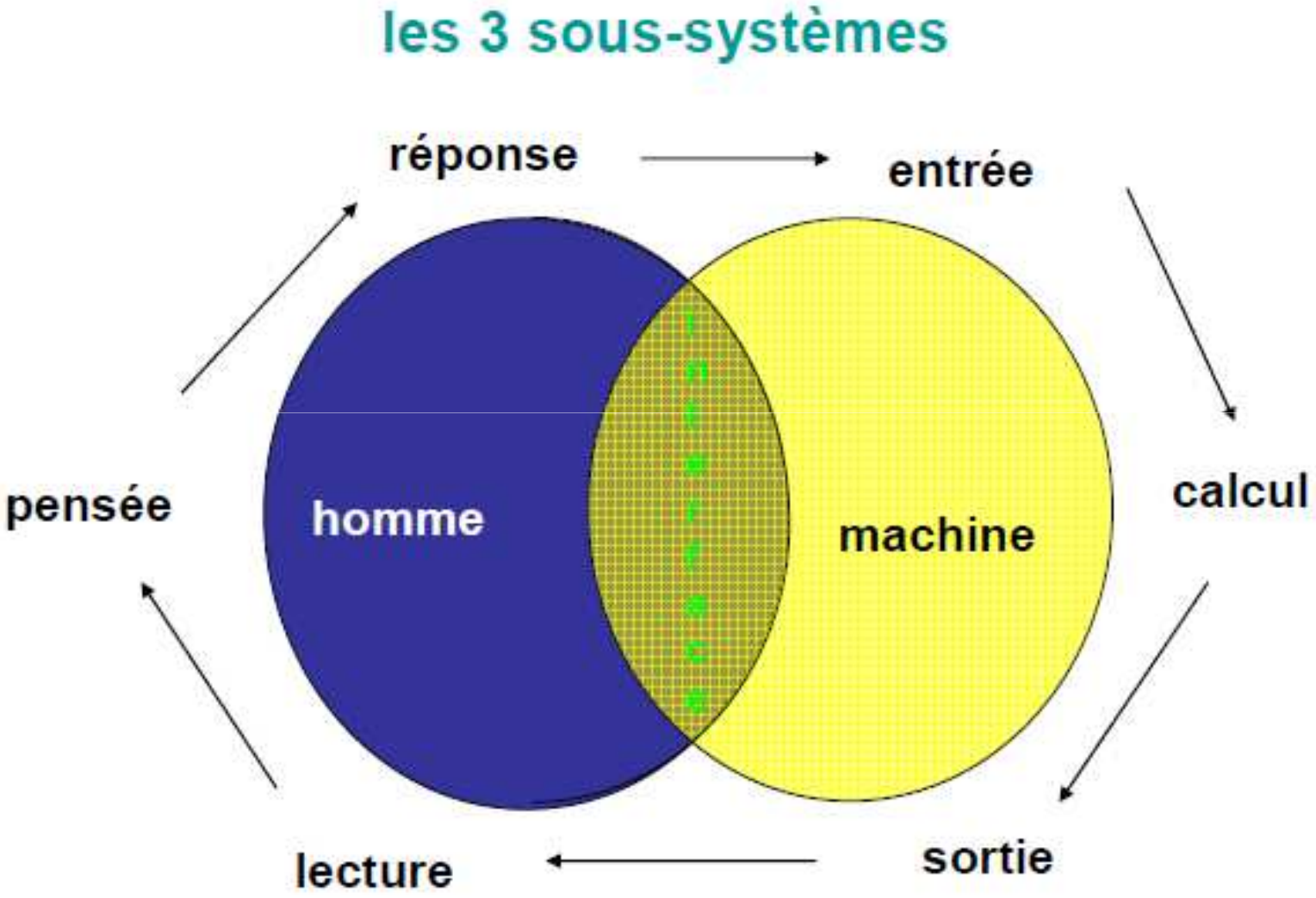
Boy G. *Assistance à l'opérateur : une approche de l'intelligence artificielle. Tecknea, 1988*

The Model Human Processor

This model outlines a flow where sensory input is processed perceptually, interpreted cognitively, and translated into physical actions.

The action changes the state of the computer system, which then provides feedback that the user perceives, restarting the cycle.

Representing the individual vs. computers



III. Scientifics Theories for ergonomic

Theory 1: Memory

Theory 2: Magical Miller's Number

Theory 3: Hick law

Theory 4: The 2-Second Principle

Theory 5: 3-Click Principle

Theory 6: Baby Duck syndrome (ou du rétroviseur)

Theory 7: Potentiality (Affordance)

Theory 8: Perception

Theory 9: Colors

Theory 10: On-screen reading

Theory 11: Fitts's Law

Theory 12: Text Display

Theory 1: Memory
Long-term vs. Short-term

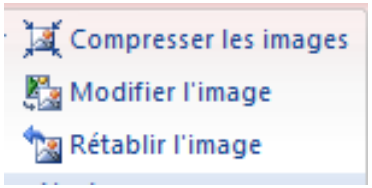
Short-term memory :

Users struggle to remember information.

- Grouping related items
  - Visuals
    - letters, numbers, words
    - forms, size
    - color, localization
  - Acoustic
    - beginning sound, …
    - number of syllables, …

Long-term memory :

- Use repetition and association,
- Use dual coding,
- Use constant elements, …



Theory 2: Miller's Magical Number, 1956

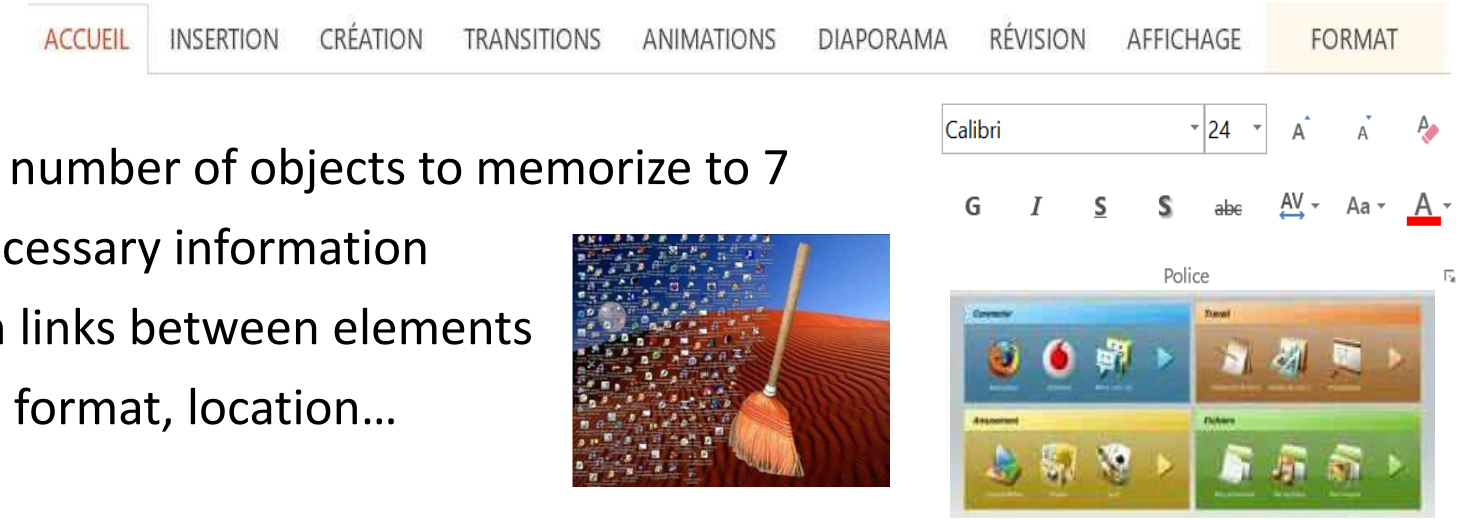
- This law states that the average person can only hold about **7 items +/-2 (so a range of 5 to 9)** in their short-term or working memory at one time.
- Anything beyond this limit can lead to cognitive overload and make information difficult to remember or process effectively.

lundi
mardi
mercredi
jeudi
vendredi
samedi
dimanche

Risks

The user forgets, wastes time searching particularly for infrequently used software.

Solutions

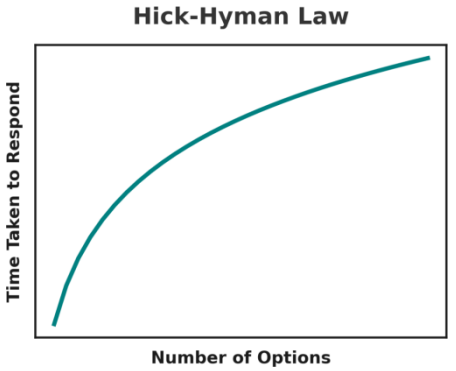


- Limit the number of objects to memorize to 7
- No unnecessary information
- Establish links between elements via color, format, location…

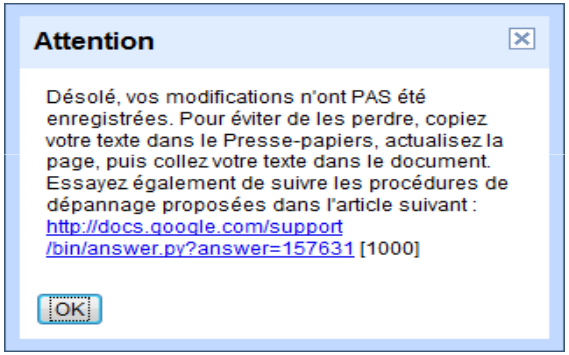
Theory 3: Hick Law

States that decision time increases logarithmically as the number of choices increases.

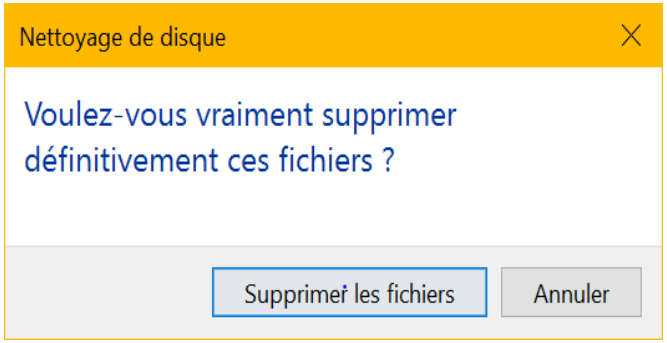
Suggests that fewer options lead to faster decisions, a concept used to guide interface design.



- **Risks**
  - The user can make a mistake, waste time.



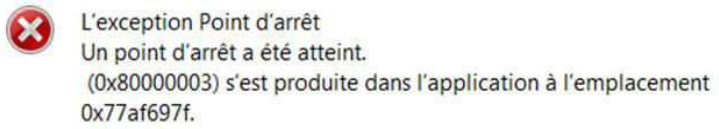
- **Solutions**
  - Limit the number of items,
  - Avoid unnecessary information,
  - Use concise messages..

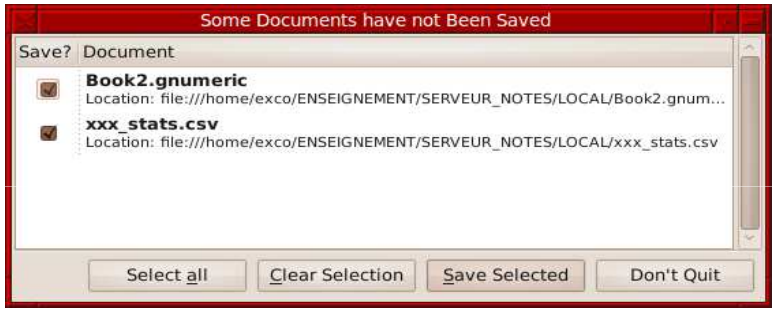


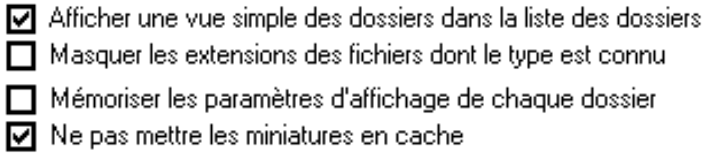
Theory 3: Hick Law

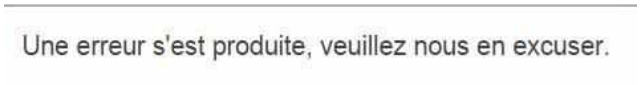
Language used

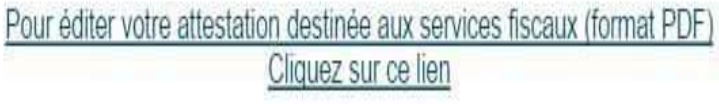
- Avoid dead ends
- Use the user's language
- Avoid abbreviations
- Respect the order of actions
- Messages should be:
  - ✓ concise
  - ✓ consistent
  - ✓ active voice
  - ✓ affirmative
  - ✓ clear and explicit
  - ✓ polite

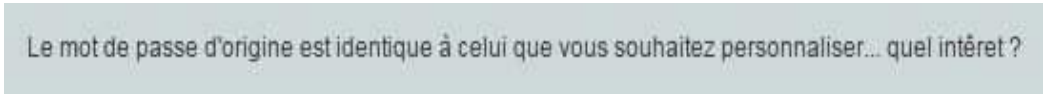






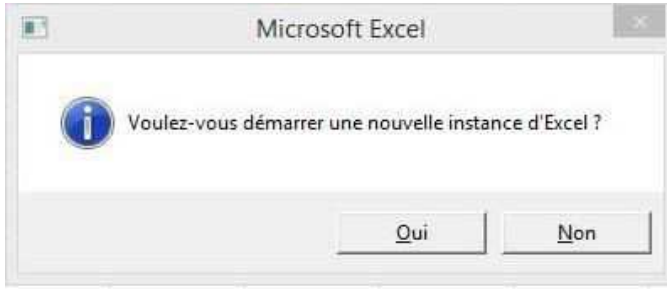






Theory 4: The 2-Second Principle

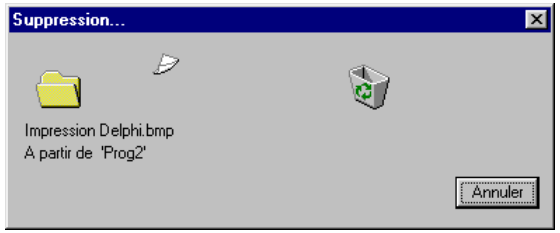
- **Principe**
  - Do not wait more than 2 seconds for the system to respond.

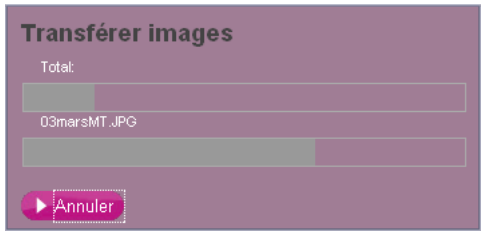


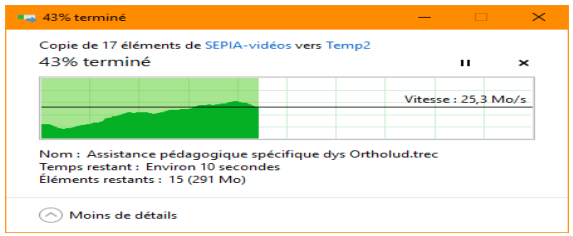
- **Risques**
  - L'utilisateur peut relancer l'action,
  - Bugs or error messages.

- **Solutions**
  - Quick actions: indicators of actions taken.

  - Long-term actions: dynamic indicators of ongoing action.







Theory 5: 3-Click Principle

- **Principe**
  - The desired information must be accessible:
    - ✓in 3 clicks (web)
    - ✓quickly

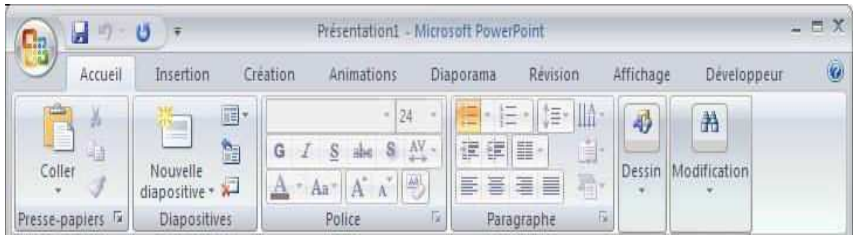
- **Risques**
  - The user can abandon the task /application

- **Solutions**
  - Make important actions accessible directly or at least quickly
  - Adapt to the situation

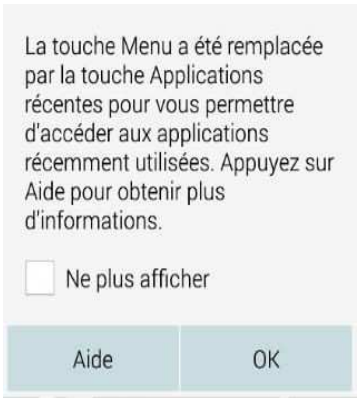
Theory 6: Baby Duck syndrome (du rétroviseur)

- **Principe**
  - refers to a user's tendency to prefer the first software interface they learned and to judge new versions negatively.

    « c'était mieux avant »
- **Risques**
  - ✓Rejection of new applications/versions,
  - ✓Problem for innovations, software evolution.



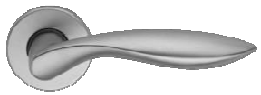
- **Solutions**
  - Evolution within consistency,
  - Supporting change



Theory 7: Potentiality (Affordance)

Principle

refers to the relationship between an object's properties and a user's capabilities that suggests how the object can be used.

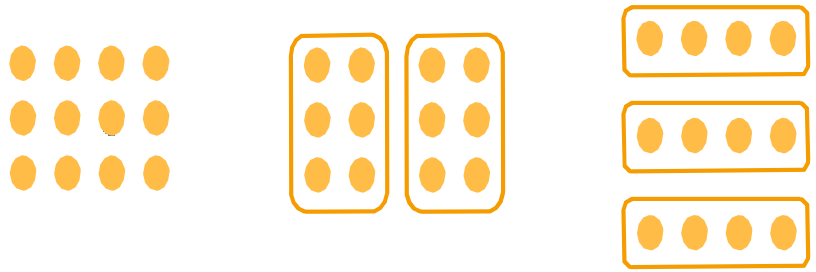
- Signs implicit  or explicit 

- **Risques**
  - Hesitation, waste of time
  - non-use

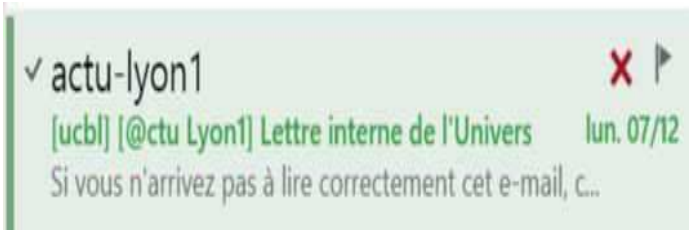
- **Solutions**
  - Help distinguish between clickable and non-clickable elements
  - Encourage user interaction
    - ✓Shape, label, color, location, behavior


Theory 8: Gestalt Theory
Proximity

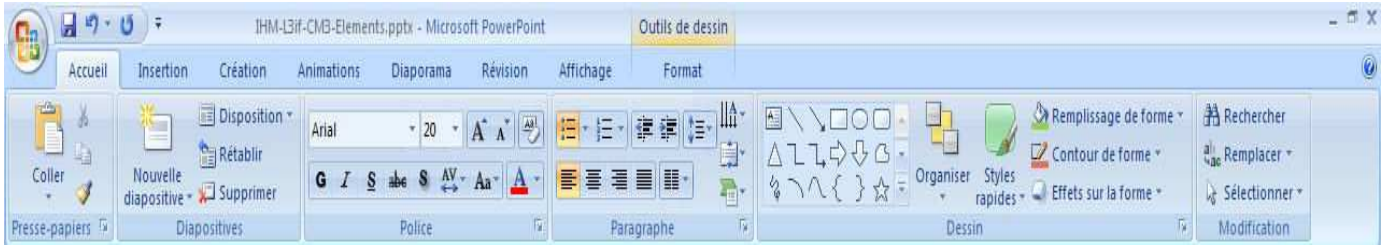
- **Proximity Law**
  - The brain tends to associate things that are physically close.



- **Risques**
  - To associate opposing concepts / actions



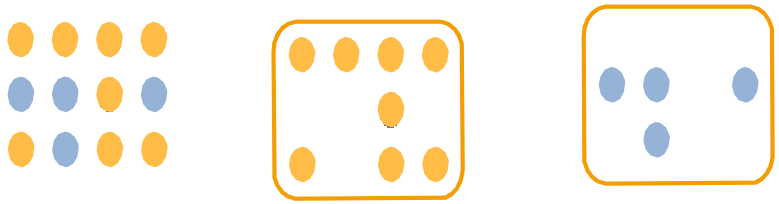
- **Solutions**
  - Bring together similar elements / separate different elements



Theory 8: Gestalt Theory
Similarity

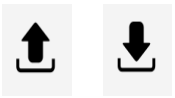
- **Similarity Law**
  - The brain tends to associate things that are similar

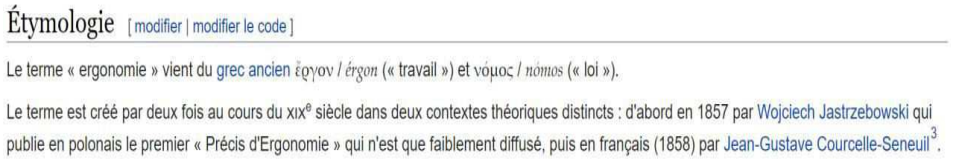
    (based on shape, color, size, behavior…)



- **Risques**
  - Confusing similar objects

- **Solutions**
  - Associate commonalities with similar elements
  - Mark the different elements with specific characteristics





Theory 9: a) Color readability

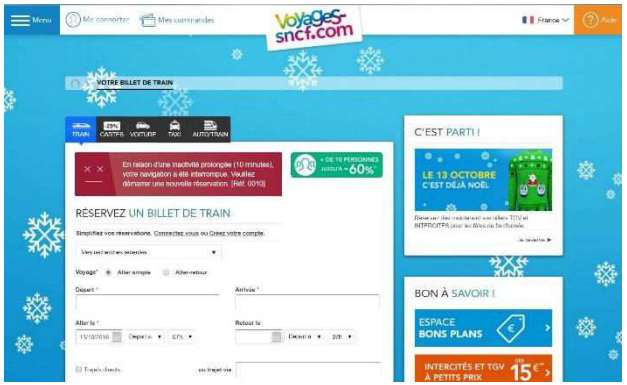
Lisibilité des couleur

- **Principle**
  - **high** contrast between text and background
  - **Dark** characters on a **light** background
    - ✓Preferably black characters on a white background
    - ✓Except in low-light environments (night, specific tasks)
    - ✓ Limited number of colors

Interface graphique	Interface graphique

- **Risques**
  - Insufficient contrast which limits readability

- **Solutions**
  - Avoid certain color combinations
  - Limit the number of colors

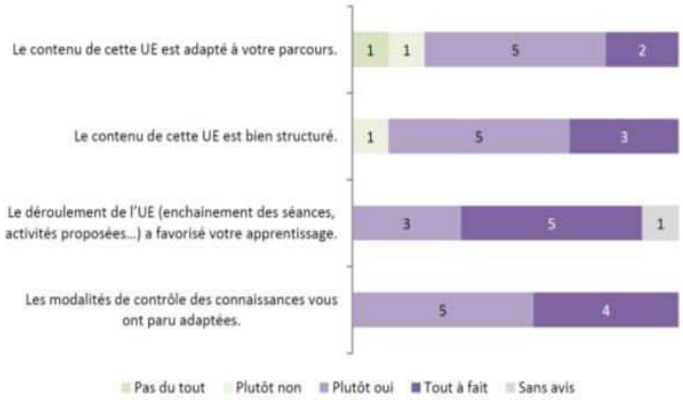


Théorie 9: b) Meaning of colors

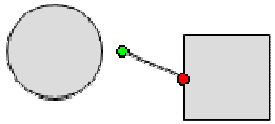
Signification des couleurs

- **Principle**
  - The colors have a common meaning.

    - example : red= stop / green= go
    - en chine, red= joie

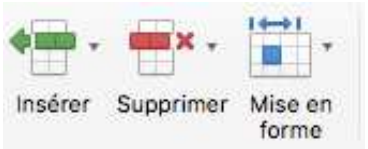


- **Risques**
  - Misunderstanding of the interface
  - Misinterpretation of the color code



- **Solutions**
  - Follow standard color codes
    - ✓Green: validation, success

    - ✓Red: alert, stop, failure



  - use neutral colors if there is no specific need
  - Pay attention to local and cultural specificities.

Théorie 9: c) Relevance of colors

Pertinence des couleurs

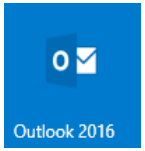
▶ Principle

Using colors to signify something in a relevant way

▶ Risques

– Objects of the same color incorrectly associated

– Colors not/misperceived



▶ Solutions

Same type of information, ⇒ same color

Different types of information, ⇒ contrasting colors

Similar types of information, ⇒ low-contrast colors

Combine/clarify the information

Théorie 9: d) Color portability

Portabilité des couleurs

- **Principle**
  - The information conveyed by color must be available everywhere, always, for everyone.

- **Risques**

  Poor color rendering (distinction, contrast, number of colors)

  ✓ in certain contexts (outdoors, at night)

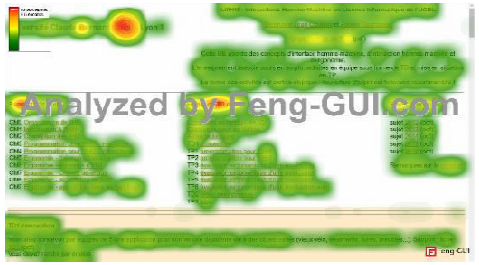
  ✓depending on the screen, the device (video projectors, smartphones)

  ✓for some users (color blindness): 8-10% of men, 0.5% of women

- **Solutions : interface testing tools**
  - Consistently contrasting colors
    - **Contrast Checker**
  - Color set suitable for color blindness
    - outils de test : **ColorOracle** (desktop), ColorBlindness SimulateCorrect (mobile), Colorblind Web Page Filter (web)

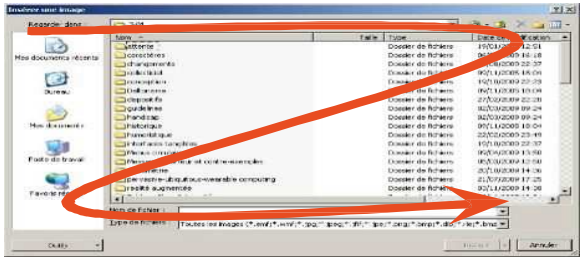
Theory 10: On-screen reading
« Parcours »

- **Technique**
  - ✓eye-tracking
  - ✓Online eye-tracking simulator



Screen navigation

- ✓First screen view
  Z-shaped scan
- ✓Then Selective scan



- ✓Search engine
  - ➢F-shaped / comb

Theory 10: On-screen reading «Above the fold»

- **Principle**

The main information must be visible "above the fold”

- Title of a newspaper, even when folded,
- Main content of a web page before scrolling.


Le Monde

La France et l'U.R.S.S. ont conclu un traité d'alliance et d'assistance mutuelle prévu pour une durée de vingt ans

A NOS LECTEURS

L'ALLIANCE franco - soviétique

LE RETOUR A PARIS DU GÉNÉRAL DE GAULLE

AU CONSEIL DES MINISTRES

LA CRISE GRECQUE

TEXTE DU PACTE

LA WEHRMACHT CONTRE-ATTAQUE aux confins belgo-luxembourgeois

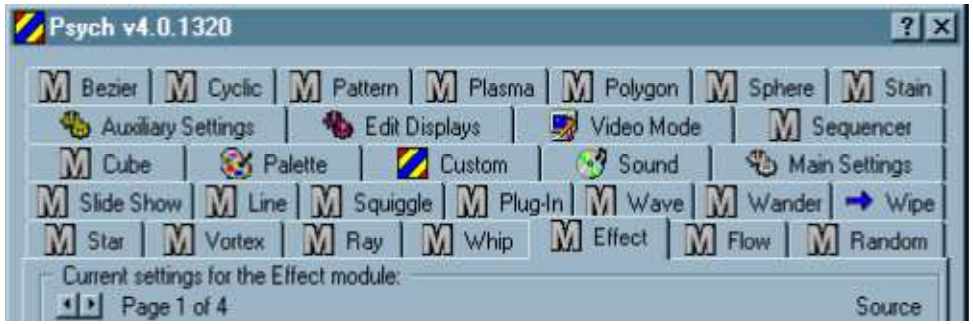
Dans la plaine d'Alsace l'ennemi s'efforce d'élargir ses positions

Theory 11: Fitts's Law

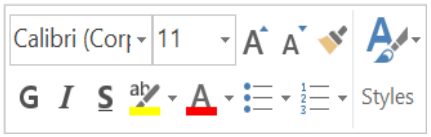
- Principle

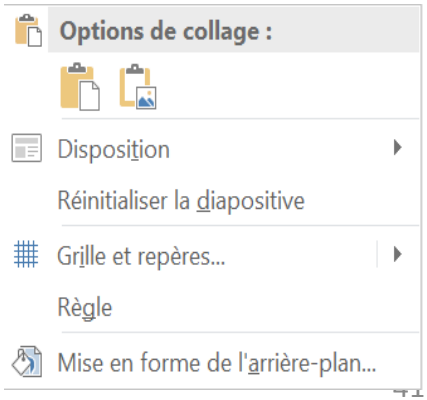
  a predictive model stating that the time it takes a **pointer** (such as a mouse cursor, a human finger, or a hand) to move to and select a target(ex.button) depends on the distance to the target and its size.

- Risques
  - Wasted time,
  - Clics outside the target.



- Solutions
  - Respect the screen layout
  - Adapt sizes and locations
  - Context menus





$t = 0.1 \log 2D/L$

D (cm)	L (cm)	t (s)
10	1	0.4
10	0.1	0.8
30	0.5	0.7

t : mouvement time

D: distance to the target

L: width of the target

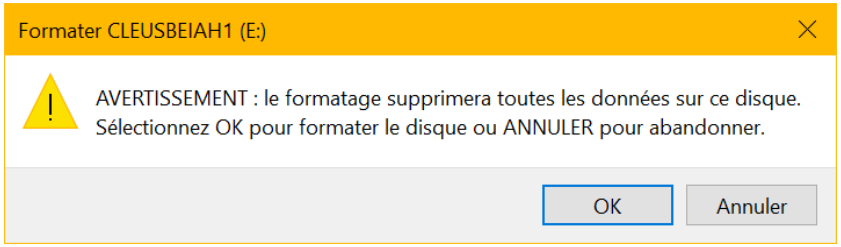
Theory 12: Text Display

- **Principles of typography**
  - Sans-serif fonts are more readable on screen
    - (Arial, Calibri, Helvetica, Geneva…)
  - Styles slow down reading, making it less readable:
    - **gras**
    - *italics*
    - Underlined (+ confusion with links)
    - CAPITAL LETTERS
  - ban the ***JUMPSUITS***

- **Risques**
  - Loss of readability
  - Slower reading

- **Solution**

Use styles to highlight certain elements only



V. Conclusion

Interfaces often assume that their user:

1. has two hands
2. can see and hear and has good motor control
3. is intelligent and resourceful
4. can read and understand English
5. is familiar with the conventions of typical GUIs
6. is motivated to learn how to use the interface
7. has the time to solve problems when they arise

But…

What percentage of the population has all of these characteristics?

V. Conclusion (suite)

1. Don't assume you know what's best for the user.

2. Don't assume you know all of the user's goals, tasks, and habits.

3. From a certain perspective, the user's time is more valuable than the programmer's or designer's time

Questions …