



# Human-Computer Interaction 2024/2025

## Lecture Class 2

### The User: Human Information Processing System and User Profile



universidade  
de aveiro

deti

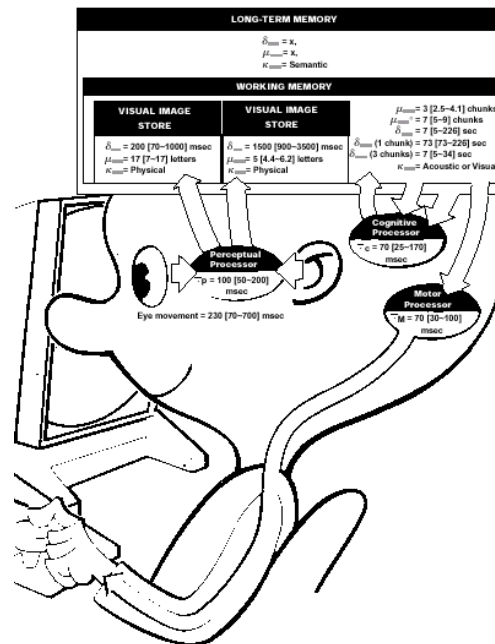
departamento de  
electrónica, telecomunicações  
e informática



Interactive systems are meant to be used by people: the users and must be designed considering their characteristics

# The User

## Human Information Processing Systems and User Profile

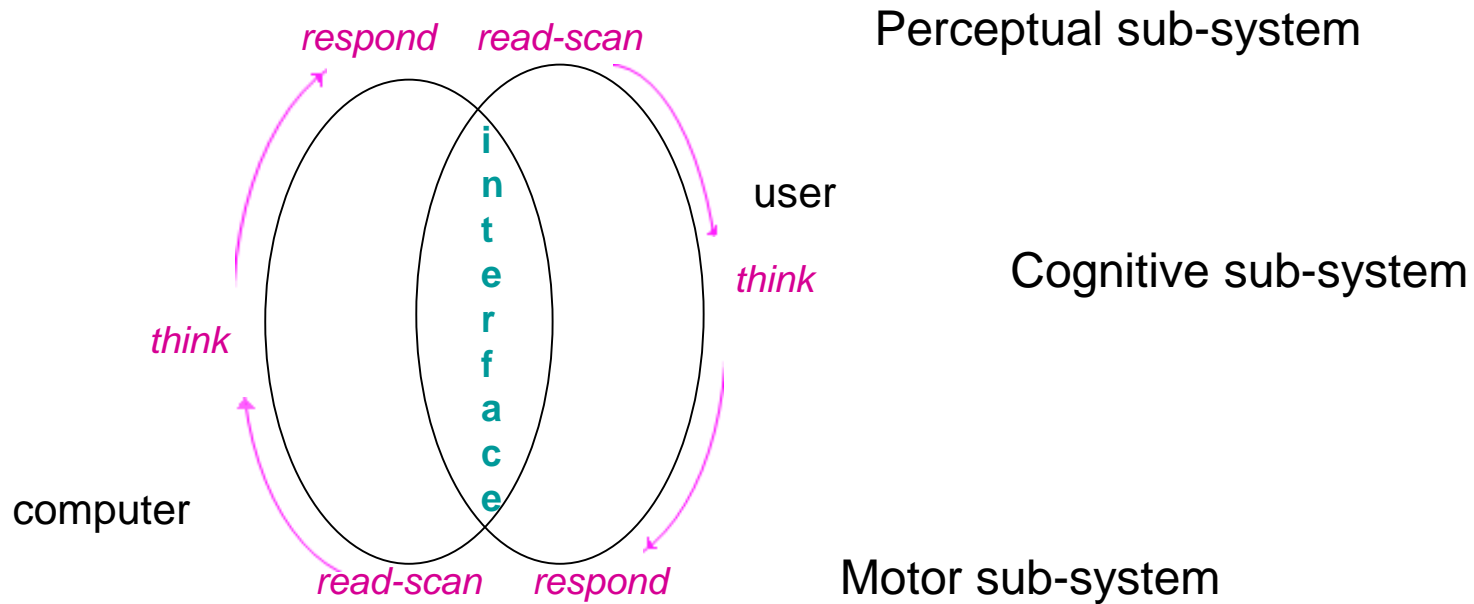


<https://www.id-book.com/>

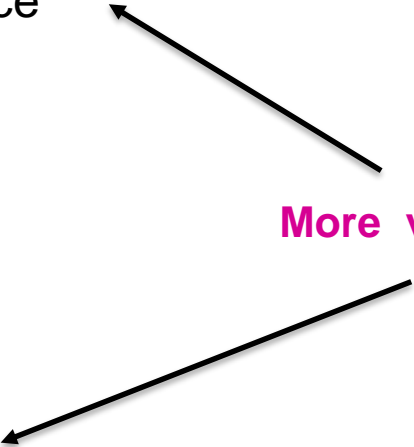
# Outline

- Users Profile – relevant characteristics for interactive systems design
- Human Information Processing System (HIPS)
  - Perceptual sub system
    - Sight, Hearing, Touch, Smell, Taste
      - + Proprioception, Kinesthesia ...
  - Cognitive sub-system
  - Memory
- Other relevant characteristics
- Implications on the design of interactive systems

## Dialog in an interactive system



# User profile

- Human Information Processing System (HIPS)
  - Knowledge and experience
  - Work and task
  - Physical characteristics
  - Environment/context
- 
- The diagram consists of two black arrows. The first arrow originates from the text 'More variable among users' and points diagonally upwards and to the left, ending at the bullet point '- Knowledge and experience'. The second arrow originates from the same text and points diagonally downwards and to the left, ending at the bullet point '- Environment/context'.

**More variable among users**

**There are many user models to be used in the design of Interactive systems (e.g. personas, GOMS, KLM, ...)**

Human senses and cognition have characteristics that determine or limit what we can perceive and process





# What we see does not depend only of the stimuli!

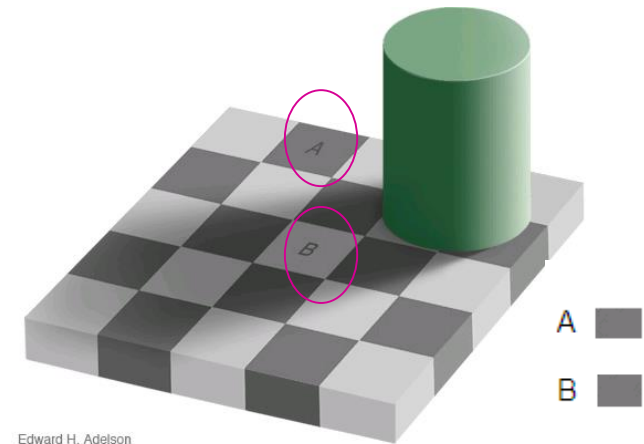
Two very powerful visual illusions:

The Ames' room



<https://www.youtube.com/watch?v=aS-vzPuZzuk>

The Adelson's illusion



Edward H. Adelson

<https://michaelbach.de/ot/lum-adelsonCheckShadow/index.html>



# What we see does not depend only of the stimuli!

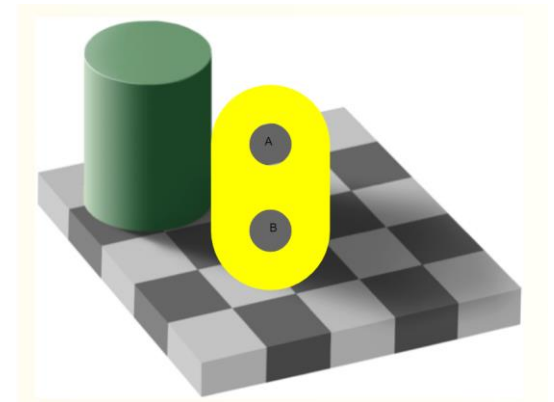
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# Human Information Processing System (HIPS)

- Humans have different capabilities that might be considered when designing interactive systems
- Information is received through various input channels (senses)
- Information is stored in memory
- Emotions may influence capabilities
- Users share common characteristics but differences cannot be ignored

# Human Information Processing System (HIPS):

main aspects relevant to interactive systems design

Perceptual sub-system

memory – perceptual buffer (iconic, echoic, ...)  
process – pattern recognition

Cognitive sub-system

memory -  
    short term/working memory (STM)  
    long term memory (LTM)  
processes -  
    selective attention  
    problem resolution  
    learning  
    ...

**HIPS**  
**bottleneck**

Motor sub-system

## Perceptual sub-system – I/O

- **Input:** 5+ senses

Sense is a physiological capacity of organisms that provides data for perception

- Some more relevant than other

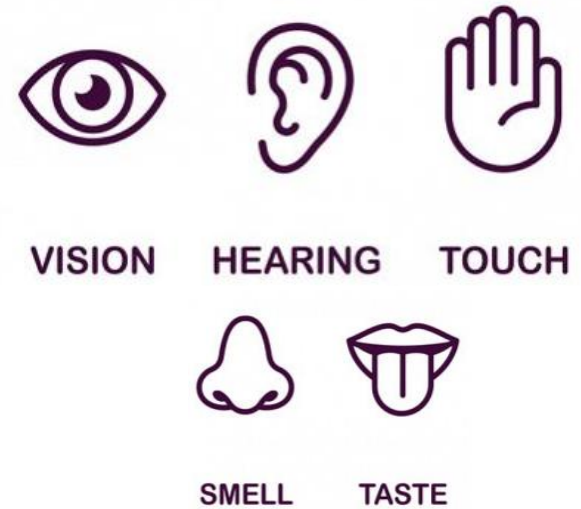
- For HCI, vision is preferred,

but hearing and touch are more and more important ...

- Proprioception (more important in some types of systems: Virtual reality)

- **Output:** communication system

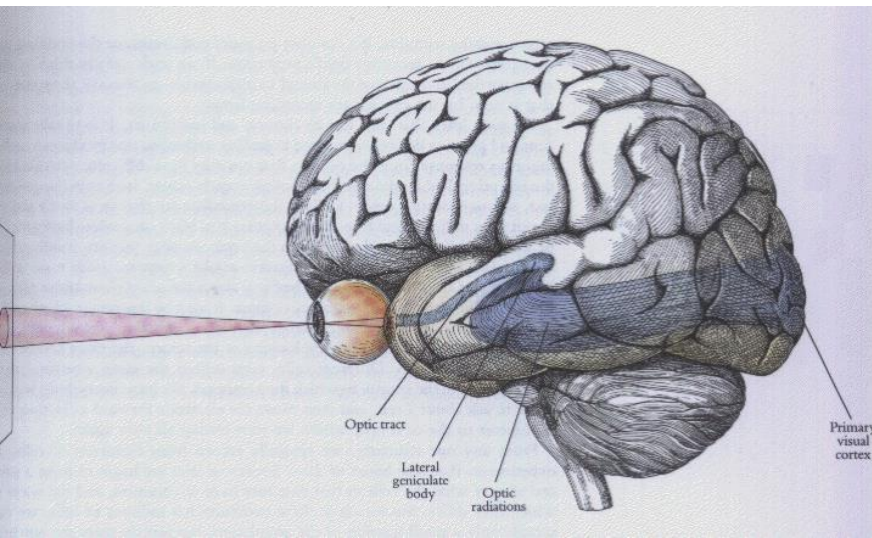
- vocal, gestures, eye gaze, ,...



The five Aristotelian senses  
(but there are other...)

# Vision

- Relevant for HCI:
  - Color perception and peripheral vision
  - Compensation of movements and illumination changes
  - Context used to solve ambiguities
  - May be tricked: Visual illusions come from excessive compensation.



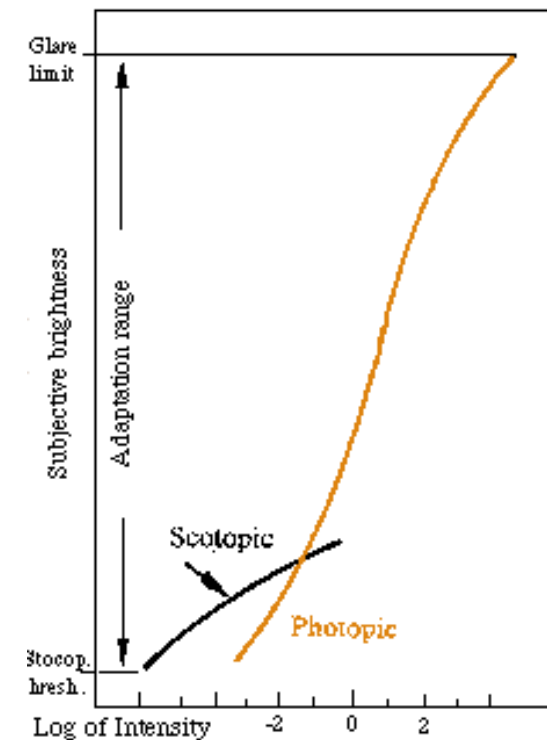
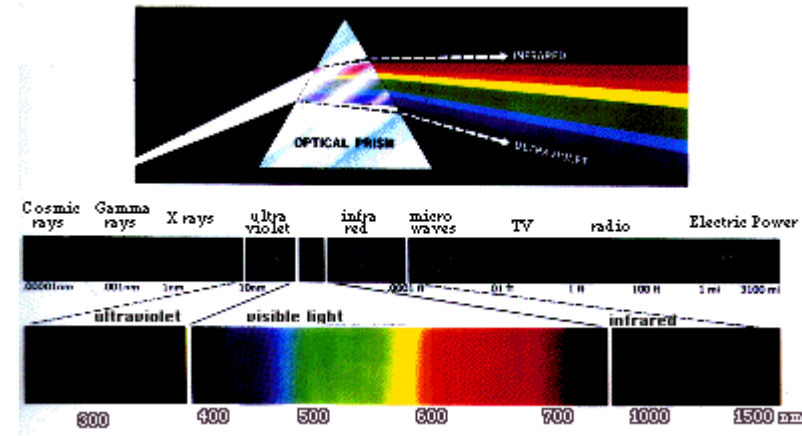
Eye – sensor

Brain - processor

(Hubel, 1988)

- Two types of vision:
- Scotopic – works at low illumination levels; not sensitive to wave length
- Photopic – works at higher illumination levels; sensitive to wave length
  - > color perception

(in low intensity light there is no color)



- The light passes through the iris, is focused by the lens and projected on the retina

- Two types of sensor cells:

- Rods – scotopic vision

- Cones – photopic vision

- Some people have abnormal cones and do not see color as most people

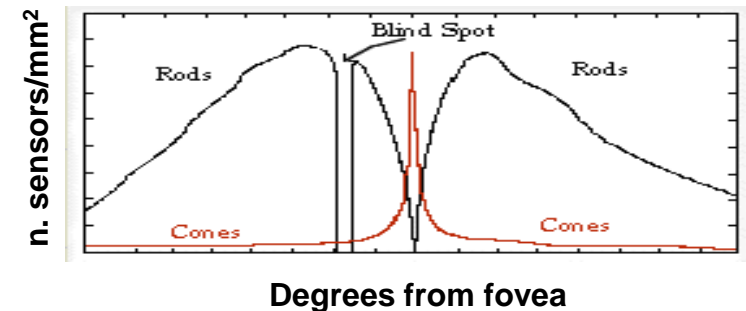
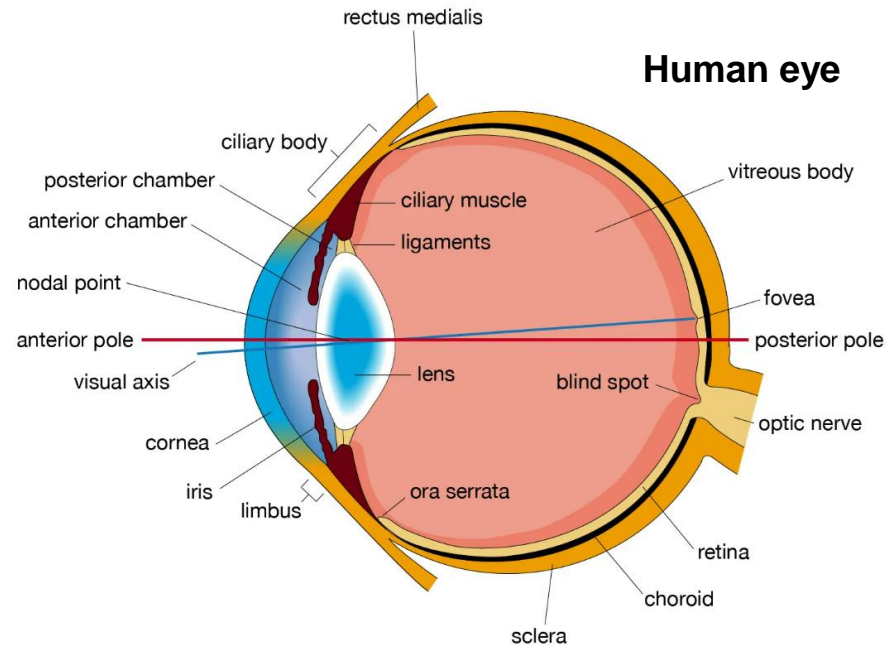
- Color vision is mostly in the center

- Three types of cones:

- Green - 64%

- Red - 33%

- Blue - 2% (less sensitive)



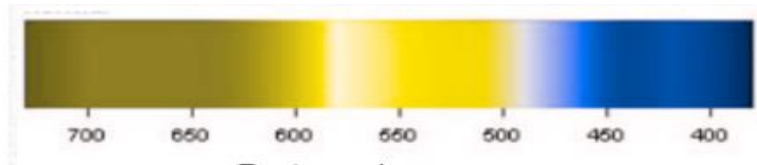
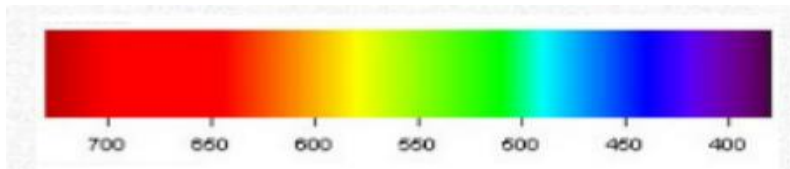


Colour blindness affects a significant percentage of users

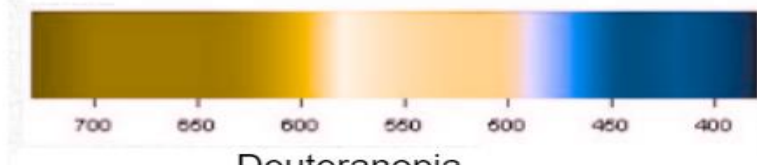


# Color blindness

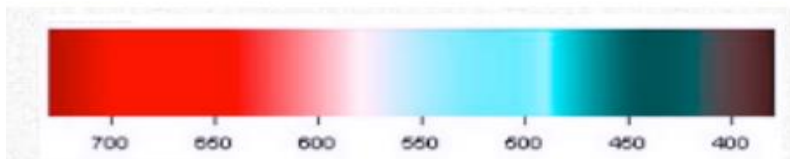
Ishihara test for red-green blindness  
(daltonism or deuteranopia)



Protanopia



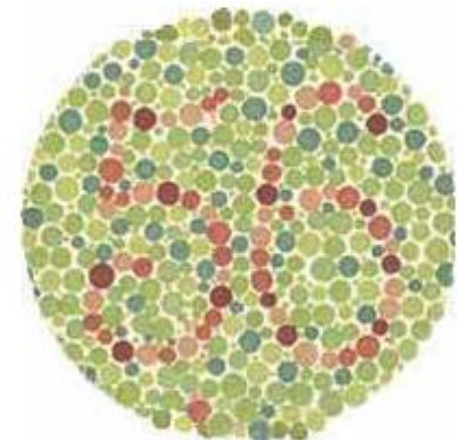
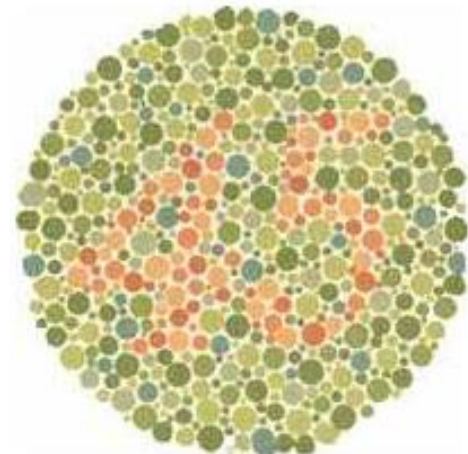
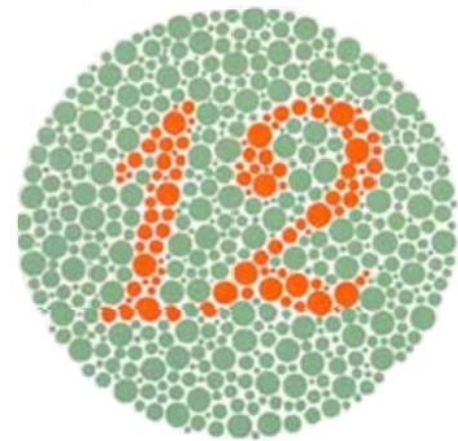
Deuteranopia



Tritanopia

(Shinobu Ishihara, 1917)

- The test includes 38 figures

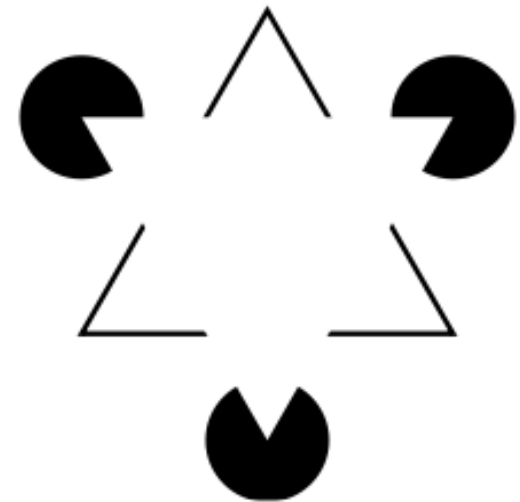


# Pattern Recognition

Process that matches information from a stimulus with information retrieved from memory

- It is a very powerful process
- It is subconscious
- It does not use only current data
- It solves ambiguities
- Occurs also in other senses

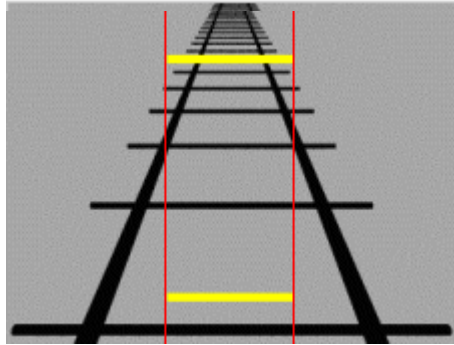
The quick brown  
fox jumps over the  
the lazy dog.



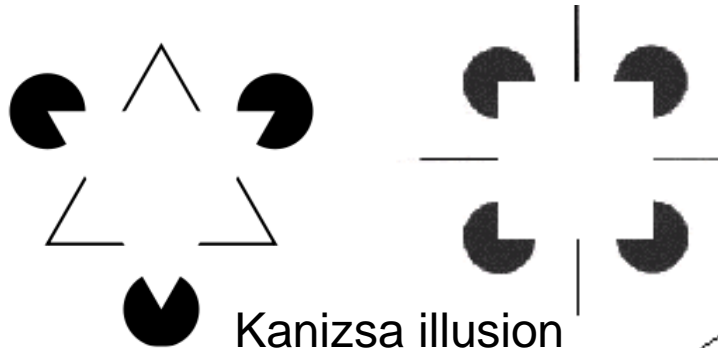
(Kaniza illusion, Wikipedia)

# Visual Illusions illustrate that **what we see does not depend only of the stimulus**

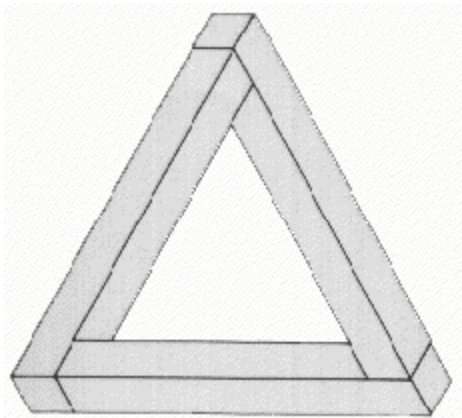
- bring out particular good adaptations of our visual system to standard viewing situations
- under some artificial manipulations can cause inappropriate interpretations of the visual scene



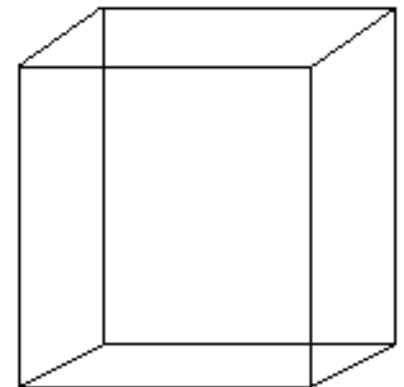
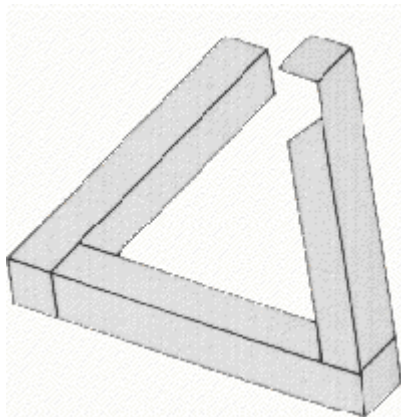
Ponzo illusion



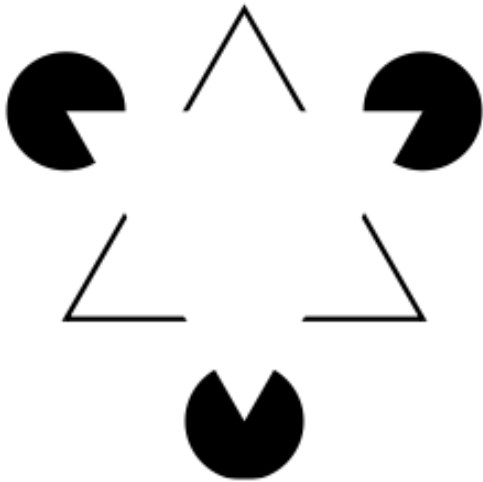
Kanizsa illusion



Penrose triangle:  
Impossible object?



Necker cube



Kanizsa illusion:

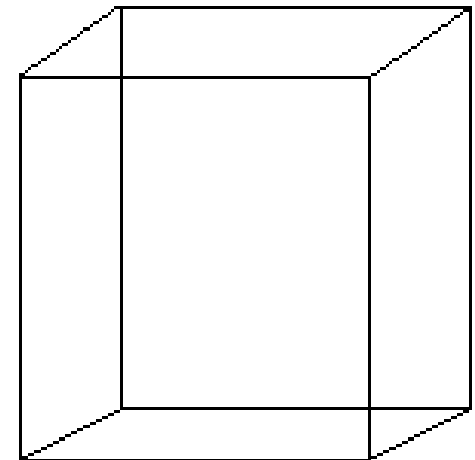
Although there are no actual triangles a sort of pattern recognition phenomenon is triggered and the image is interpreted as two overlapping triangles (simple explanation)

[https://en.wikipedia.org/wiki/Illusory\\_contours](https://en.wikipedia.org/wiki/Illusory_contours)

Necker cube:

Cube with no visual cues as to its orientation; it can be interpreted to have either the lower-left or the upper-right square as its front side

[https://en.wikipedia.org/wiki/Necker\\_cube](https://en.wikipedia.org/wiki/Necker_cube)

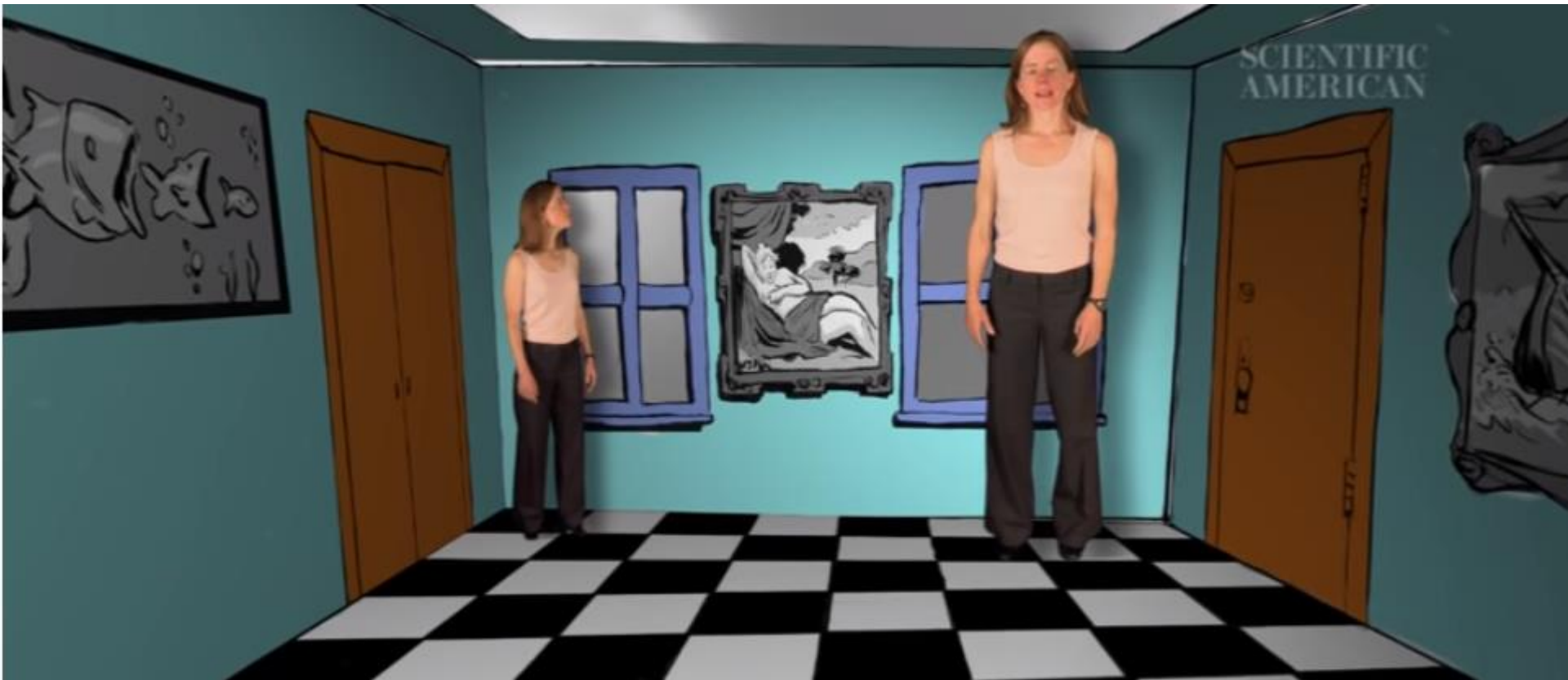
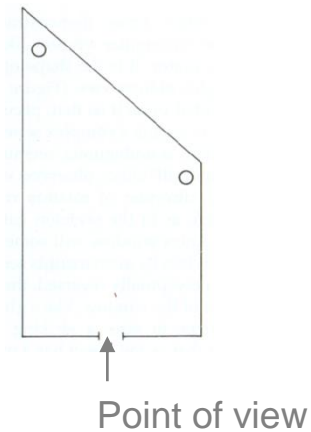




## Ames Room

(what we see does not depend only of the stimulus)

A room that pushes the boundaries of human perception...



<https://www.youtube.com/watch?v=gJhyu6nIGt8>

<https://www.youtube.com/watch?v=aS-vzPuZzuk>

## Other senses



<https://en.wikipedia.org/wiki/Sense>

- Hearing
  - Information on direction, objects and distance
  - Only sense that is really 3D
  - Cannot be “turned off”
  - Human hearing - 20Hz to 15KHz
  - Filtering is possible (Background noise – “cocktail party” example)



# Other senses

- Touch
  - Important feedback
  - Key for people with sight problem
  - Several receptors in skin:
    - Thermoreceptors: cold and hot
    - Nociceptor: pain
    - Mecanoreceptor: pressure
  - Some areas more sensitive (fingers)



<https://en.wikipedia.org/wiki/Sense>

Simulators are complex interactive systems that stimulate several senses...

<https://www.the737experience.co.uk/>

<https://surgicalscience.com/systems/lapsim/>

[https://en.wikipedia.org/wiki/Flight\\_simulator](https://en.wikipedia.org/wiki/Flight_simulator)



## Other senses

- Smell and Taste
  - Complex chemical senses
  - High latency
  - Difficult to use in HCI
  - Some experimental work exists (and some commercial products)
- And others (as proprioception - awareness of your body position)



<https://en.wikipedia.org/wiki/Sense>

<https://www.khanacademy.org/test-prep/mcat/processing-the-environment/somatosensation/v/proprioception-kinesthesia>

<https://neuro-marseille.org/en/blog/our-true-sixth-sense-on-arte/>



A virtual wine cellar game, with wine glasses to be grasped and sniffed

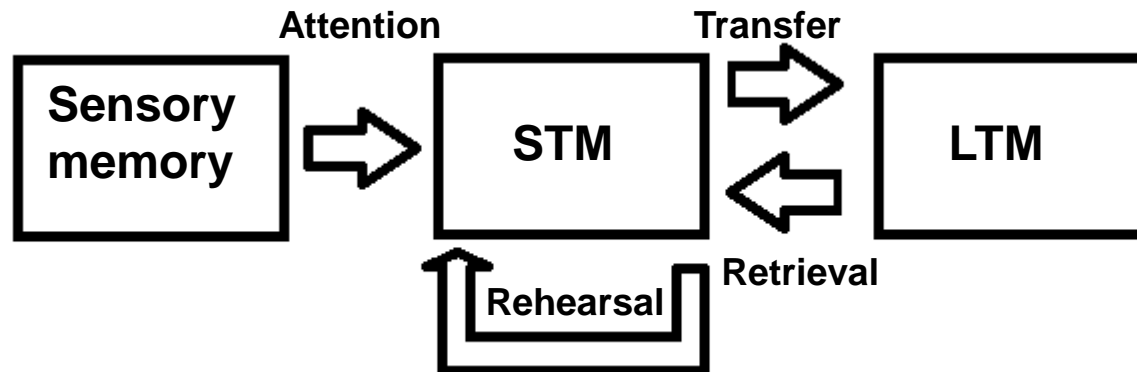
Simon Niedenthal, S et al., “A graspable olfactory display for virtual reality”,  
*International Journal of Human-Computer Studies*, vol. 169, 2023

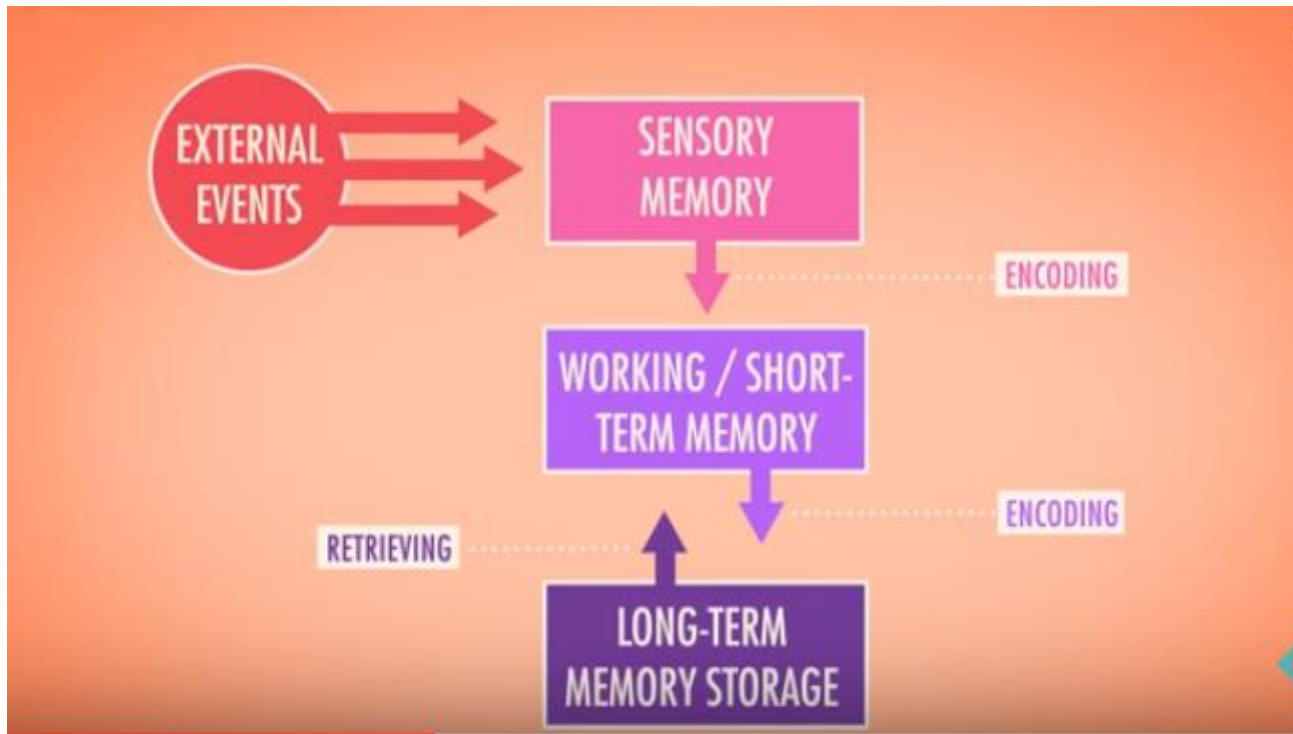
<https://doi.org/10.1016/j.ijhcs.2022.102928>

# Memory

The **Atkinson–Shiffrin model** (1968) (a.k.a. multi-store model or modal model) asserts that human memory has three components:

- Sensory memory
- Short-term memory -> working memory (more recent concept)
- Long-term memory





How we make memories - Crash Course Psychology #13

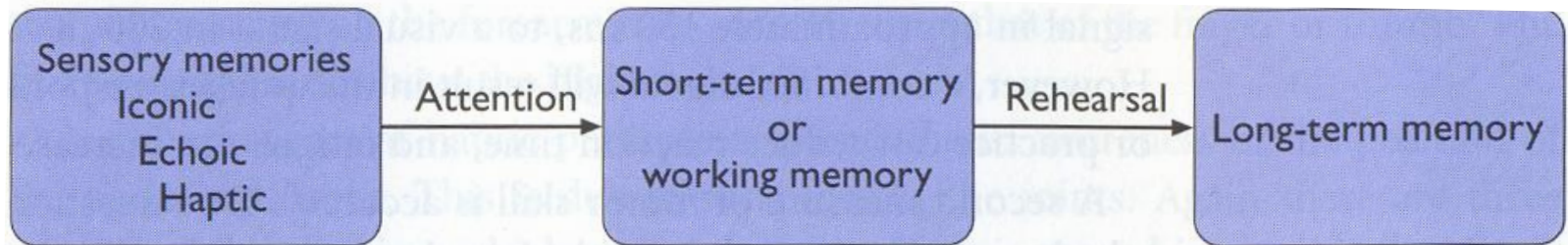
<https://www.youtube.com/watch?v=bSycdIx-C48>

How we remember and forget - Crash Course Psychology #14

<https://www.youtube.com/watch?v=HVWbrNls-Kw>

# Memory

- The Atkinson–Shiffrin model (1968) memory three components:
  - Sensory memory / iconic memory, very short
    - A few seconds
  - Short-term memory / working memory
    - +/- 18 seconds, 7+/-2 items
  - Long-term memory
    - ~Infinite capacity





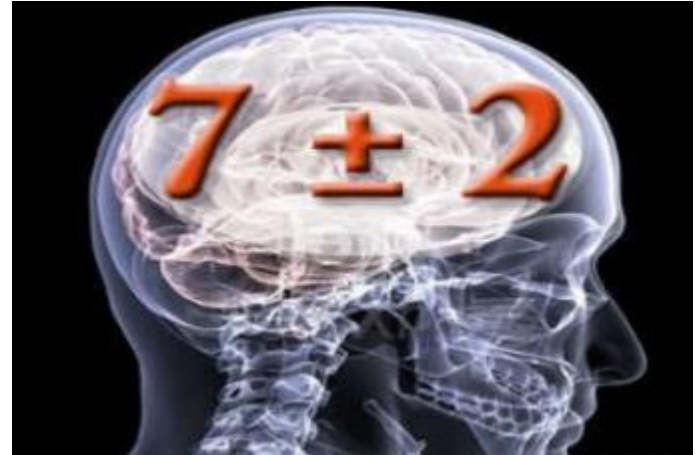
# Short Term Memory (STM) / Working memory

- Working memory:
  - Mental calculus ( $6 \times 35$ )
  - Reading (understand a sentence)
  - ...
- Characteristics:
  - Quick access  $\pm 70\text{ms}$
  - Quick forget
  - Limited capacity  $7 \pm 2$
  - Can be increased with **chunking**, to enter long-term memory

# Short Term Memory (STM) / Working memory

a few characteristics:

- Short duration: a few seconds (<30s)
- Limited capacity:  $7 \pm 2$  elements



what is an element?

example: try to memorize the following numbers

649325401741
111122223333

which is easier?

and this one: 351234370517 ?

# Short Term/ working Memory (STM)

649325401741 → 12 digits

111122223333 → 3 digits and a rule

234370200

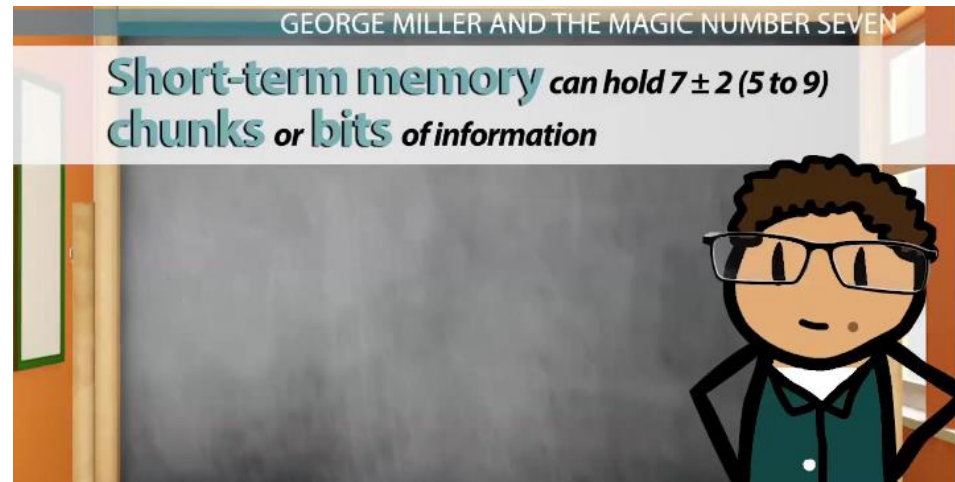
	<u>351</u>	<u>234</u>	<u>370</u>	<u>517</u>	
	↙	↙	↘	↘	
	Portugal	Aveiro	University area	IEETA building	

These numbers correspond to different “chunks”

**Chunk:** the largest meaningful unit that a person recognizes; depends on the person knowledge

- **Chunking** refers to an approach for making more efficient use of short-term memory by grouping information
- Resulting chunks are easier to commit to memory than a longer uninterrupted string of information.
- Can be used for making more efficient use of short-term memory by grouping information

<http://study.com/academy/lesson/george-miller-psychologist-theories-on-short-term-memory-lesson-quiz.html>

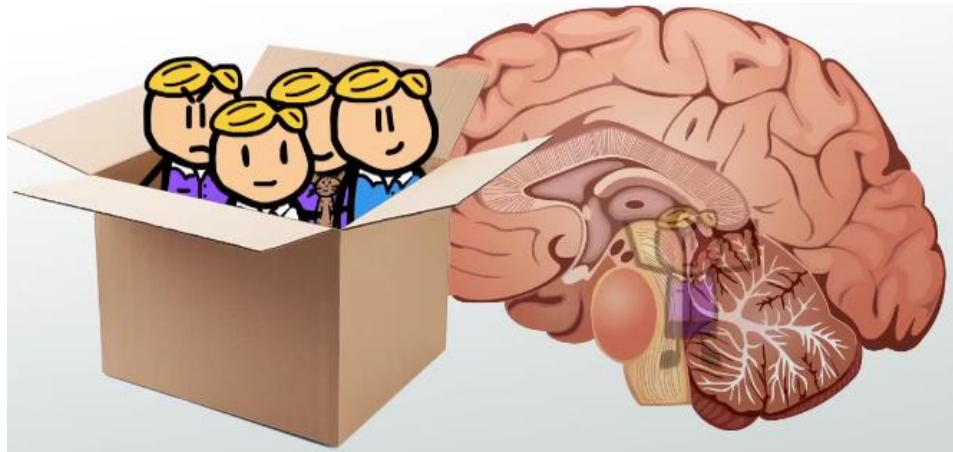


# Long Term Memory

Stage of the dual memory model (Atkinson-Shiffrin memory model)  
Informative knowledge can be stored for long periods of time

Main characteristics:

- “Infinite” capacity and duration
- non reliable access



<http://study.com/academy/lesson/long-term-memory-definition-types-examples.html>

# Long-term Memory - Recognition vs. Recall

- Information retrieval - Recognition vs. Recall
  - Recognition: remembering with the help of a visible cue
    - aka “Knowledge in the world”
  - Recall: remembering with no help
    - aka “Knowledge in the head”
- **Recognition is much easier**
  - so e.g. menus are more learnable than command languages

# Design Implications

## Memory

- Reduce cognitive load by **avoiding long and complicated procedures** for carrying out tasks.
- Design interfaces that promote **recognition rather than recall** by using familiar interaction patterns, menus, icons, and consistently placed objects.
- Provide users with a variety of ways of labeling digital information (e.g. files, emails, and images) to help them easily identify it again through the use of folders, categories, color, tagging, time stamping, and icons.



# Selective attention

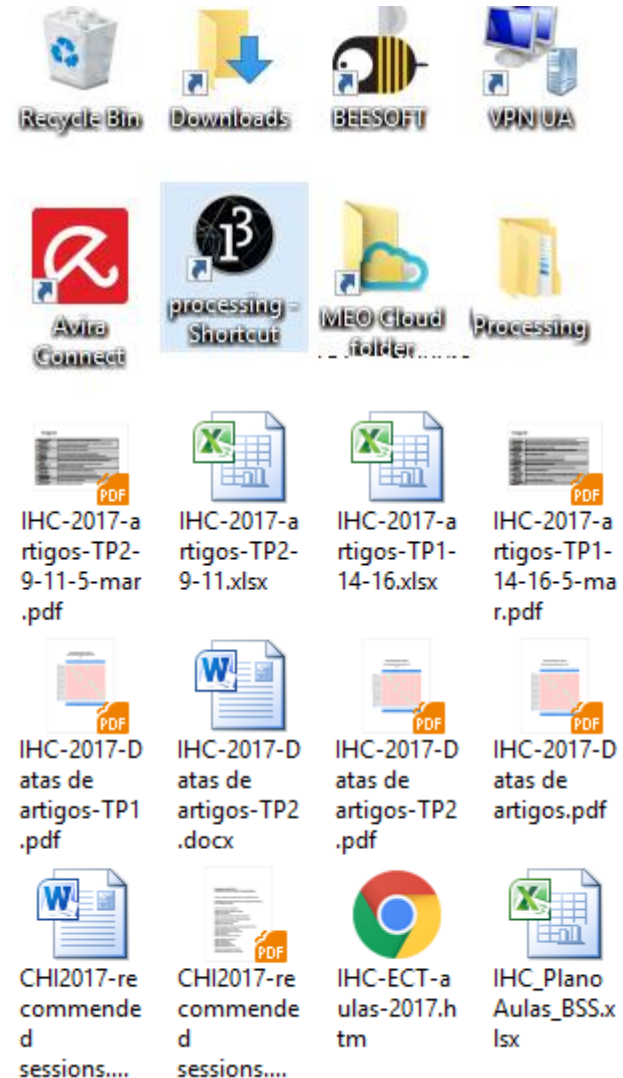
Occurs when we block out certain features of our environment and **focus on one particular feature**

It may be:

- Voluntary
- Involuntary

Both can be (and are) exploited in UIs

Calling your attention to an application



<https://dictionary.apa.org/selective-attention>

<https://www.khanacademy.org/test-prep/mcat/processing-the-environment/attention-language/v/selective-attention>

## Inattention blindness

**Failure to notice** an unexpected stimulus when other **attention demanding tasks** are being performed

What **impact** may it have on interactive systems design?

The relationship between what is in the visual field and perception depends much on attention



[https://www.youtube.com/watch?v=IGQmdoK\\_ZfY](https://www.youtube.com/watch?v=IGQmdoK_ZfY)

# Design Implications

## Attention

- Consider context. **Make information salient** when it requires attention at a given stage of a task.
- **Avoid cluttering** visual interfaces with too much information.
- Consider designing different ways of supporting effective switching and returning to a particular interface.

# Design Implications

## Learning

Design user interfaces that encourage exploration

Design user interfaces that constrain and guide users to select appropriate actions when initially learning.

# Design Implications

## Problem solving

- Provide information and help that are easy to access for people who want to understand more about how to carry out an activity more effectively (e.g., web searching).
- Use simple and memorable functions to support rapid decision-making and planning.
- Enable users to set or save their own criteria or preferences

# Emotion

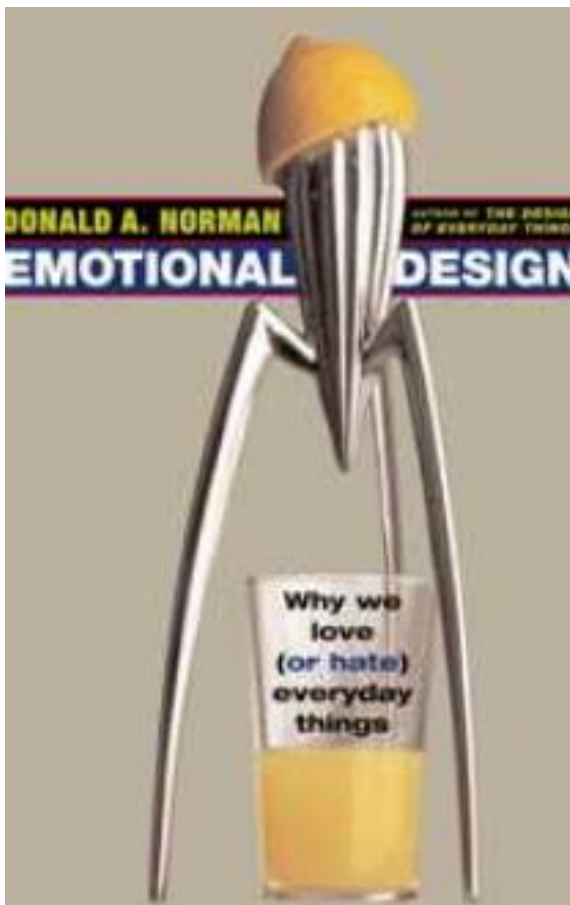
- Various theories on how it works
- Involves cognitive and physical response to stimuli
- Biological response to a physical stimuli is called affect
- Affect Influences how we react to situations

**“Negative affect can make it harder to do even easy tasks;  
positive affect can make it easier to do difficult tasks”**

(Donald Norman)

Not only the cognitive system is important

But also the **emotional system**



- **Emotional design is a critical part of design**
- Donald Norman videos:

<http://www.youtube.com/watch?v=Wl2LkzIkacM>

[http://www.youtube.com/watch?v=\\_PM3uqPNrWY](http://www.youtube.com/watch?v=_PM3uqPNrWY)

<https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/affective-computing>

- As ... moved from designing and evaluating work-oriented applications towards dealing with **leisure-oriented applications**, ... we have had to consider e.g. what constitutes an *experience*, how to deal with users' **emotions**, and understanding *aesthetic* practices and experiences”



<https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/affective-computing>

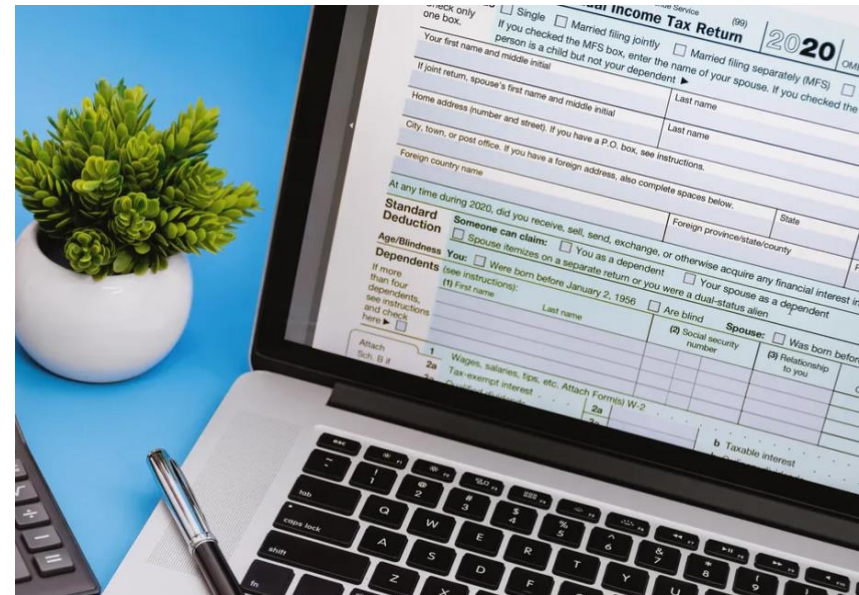
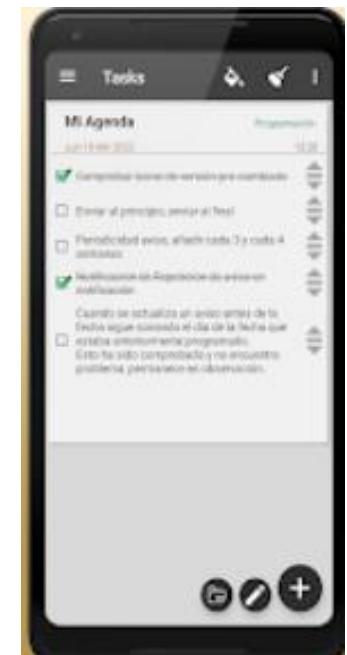




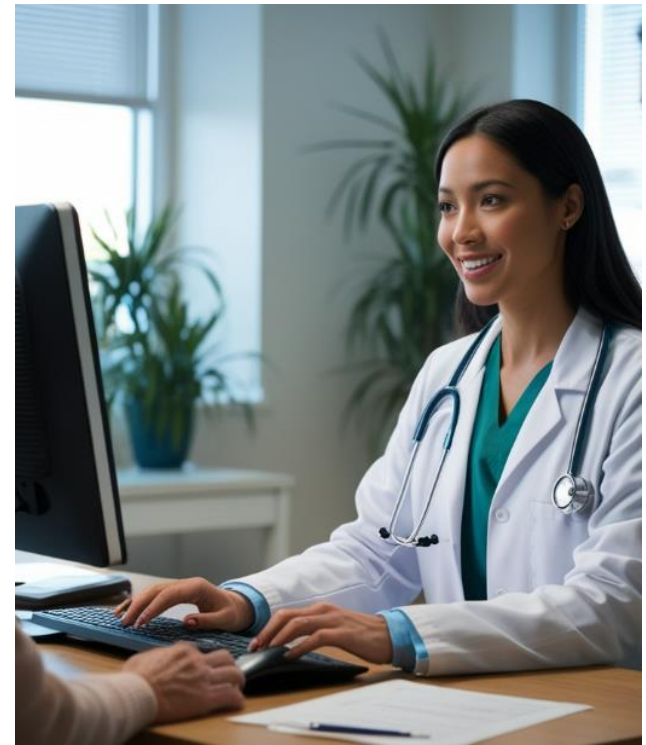
Users have different abilities,  
contexts and motivations

We need to know who are the **users**, their characteristics, context, and what motivates them

Is it the same to design a system to be used every day or once a year?



Is it the same to design a system for a doctor to use at their office or at an Emergency Room?





Is it the same to design a system for teenagers, adults or elderly users?



<https://news.sky.com/story/alarming-study-reveals-everyday-tech-problems-facing-older-people-as-millions-dont-use-internet-at-all-12964823>



# User Profile- other characteristics (besides HIPS)

- Experience and knowledge - education and reading level  
experience with the system and task  
mother language  
computer literacy ...
- Work and task - usage frequency  
training  
usage type (mandatory, optional)  
usage of other systems ...
- Physical Characteristics – color vision deficiencies  
physical deficiencies  
handedness  
age ...

Don't forget cultural aspects!!...

## How do these characteristics influence UI design?

- Much system experience, but low task experience -> more semantic help
- Much task experience but low system experience -> more syntactic help
- High usage frequency -> easy to use
- Low usage frequency -> easy to learn and remember
- Mandatory -> easy to use
- Optional -> easy to learn and remember
- Color (particularly red and green) should not be used as only cue to convey information
  - Etc., ...

## The take away:

- Users are much different from designers/developers
- Users vary a lot among themselves
- Users change along time (evolve, forget...)

## Final recommendations:

**We should consider the users as an unknown species and study them scientifically**

**Remember: You are not the user!**





# Main bibliography

- Jenny Preece and Helen Sharp, *Interaction Design – Beyond Human-Computer Interaction*, 5th edition, John Wiley, 2019  
([http://www.id-book.com/chapter3\\_teaching.php](http://www.id-book.com/chapter3_teaching.php))
- John Carroll, Human Computer Interaction - brief intro, *The Encyclopedia of Human-Computer Interaction*, 2nd edition <https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/affective-computing>
- Alan Dix, Janet Finlay, Gregory Abowd, Russell Beale, *Human-Computer Interaction*, 3rd edition, Prentice Hall, 2004

Thanks to leonardo.ai