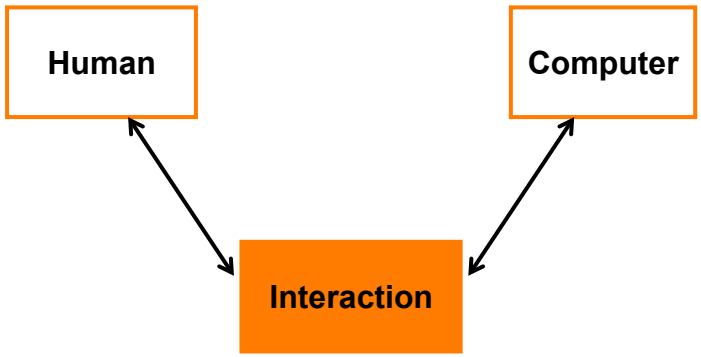
Interactive System components



Human

Human

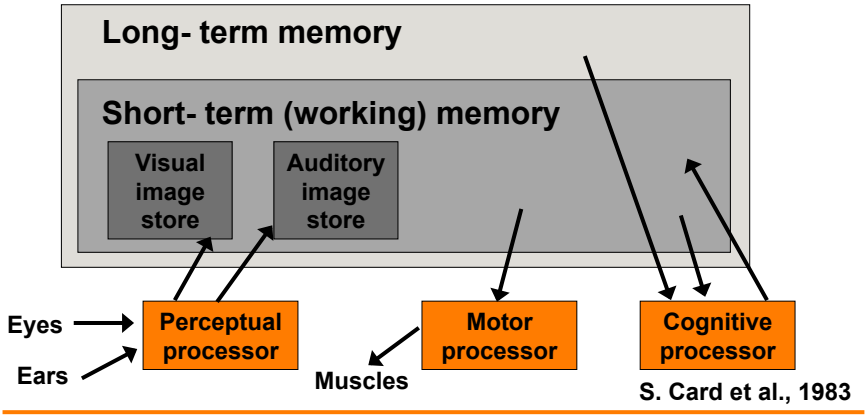
- **Human have limited capacities to process information**
- **The information is received and sent through several input/output channels:**
  - Visual
  - Auditory
  - Haptic
  - Movement
- **The information is stored in memory:**
  - Sensory memory
  - STM
  - LTM
- **The information is processed and applied:**
  - Reasoning
  - Problem solving
  - Knowledge acquisition
  - Error
- **Users share many capabilities, but, at the same time, they have many different characteristics that influence the way they interact with the surrounding environment.**

Human

- "Model Human Processor" (S. Card et al., 1983) – a simplified view of the human processing involved in interacting with computer systems:
  - Perceptual system – handle the sensory stimulus from the outside world.
  - Motor system – controls actions.
  - Cognitive system – provides the necessary processing to connect the two above.
- Processing and memory is required at all levels.
- The model includes a set principles of operation which dictate the behaviour of the systems under certain conditions.

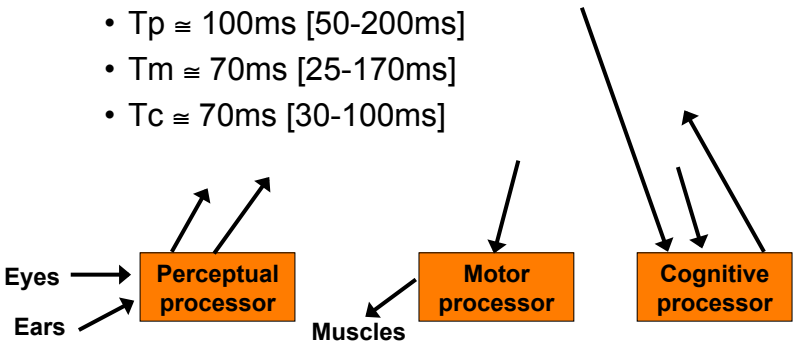
Human

- Model Human Processor (MHP)



Human

- Model Human Processor (MHP)
  - Processors' cycle time
    - Tp ≅ 100ms [50-200ms]
    - Tm ≅ 70ms [25-170ms]
    - Tc ≅ 70ms [30-100ms]



Human

- Model Human Processor (MHP)
  - Perceptual fusion
    - 2 events (stimuli) in the same cycle time (Perceptual processor – Tp ≅ 100ms) appear fused (in the same frame).
    - Motion picture - 1/Tp frames/second are enough
    - Feedback in < Tp feels instantaneous
    - Sense of causality

Human

- A more simple model:
  - Receive information and respond through input/output channels.
  - The information is stored in memory.
  - The information is processed and applied in several ways.
- Human capabilities are relevant…
- …as well as the individual differences.

Human - I/O channels

- Input → senses
- Output → motor control

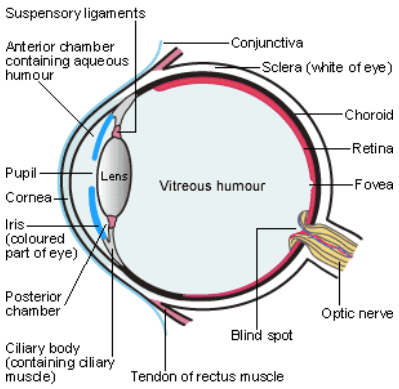
- Senses:
  - Sight, hearing, touch, smell and taste.

- Fingers, eyes, head, vocal system.

Human - I/O channels

- VISION
  - Primary source of information for the average person
  - Two stages:
    - Reception of physical stimuli
    - Stimuli interpretation and processing
  - Vision apparatus: eye
    - Mechanism that receives light and transform it in electrical energy.
    - Light is reflected from objects; their image is focused upside down in the back of the eye.
    - The retina contains 2 types of photoreceptors: rods, highly sensitive to light, allowing us to see under a low level of illumination (dominate peripheral vision); and cones, allowing colour vision (sensitive to different wavelength of light).
    - Ganglion cells: X-cells detect patterns and Y-cells detect movement.

Human - I/O channels



Human - Vision

- Perceiving size and depth
  - Visual acuity is the ability of a person to perceive fine details.
  - If we expect an object to be a certain size then we can judge its distance accordingly.
  - If objects overlap, the object which are partially covered is perceived to be in the background.

Human - Vision

- Brightness
  - Subjective reaction to levels of light
  - Affected by the luminance of the objects
  - Luminance (amount of light emitted by an object), depends on the amount of light falling on the object's surface and its reflective properties.
  - Contrast depends on the luminance of the object and the luminance of the background.
  - Visual acuity increases with increased luminance, but flicker also increases (noticeable in peripheral vision).

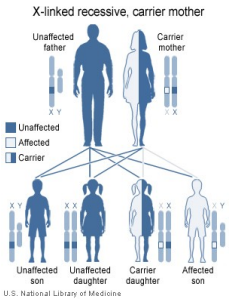
Human - Vision

- Colour
  - Three components: hue, intensity and saturation
  - Cones are sensitive to light of different wavelengths. There are 3 different types of cones, each sensitive to a different colour light.
  - Only 3-4% of the fovea is occupied by cone which are sensitive to blue light (blue acuity is lower – don't use blue for small details).
  - 8% of males and 1% of females suffer from colour blindness.

Human - Vision

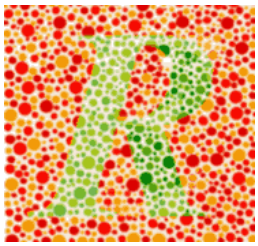
- Colour blindness
  - "Recessive" gene located in chromosome X
  - Males can only transmit colour blindness to their daughters.
  - Better night vision

Genotype	Phenotype
$X_D \mid X_D$	Female with normal vision
$X_D \mid X_d$	Female with normal vision
$X_d \mid X_d$	Female with colour blindness
$X_D \mid Y$	Male with normal vision
$X_d \mid Y$	Male with colour blindness



Human - Vision

- Colour Blindness
  - Ishihara test



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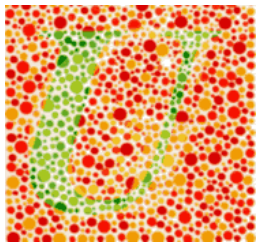

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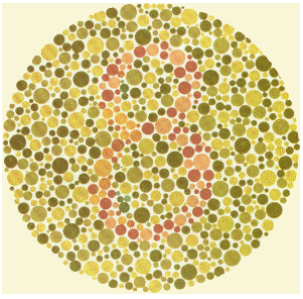
Human - Vision

- Colour blindness
  - Ishihara test

Image	Normal vision	Deficient perception of red and green	Lack of colour perception
1	R	E	--
2	U	G	--

Human - Vision

- Colour blindness
  - Ishihara test

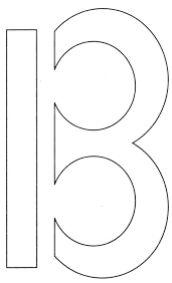


Human - Vision

- Visual processing
  - Visual processing involves the transformation and interpretation of a complete image, from the light that is thrown onto the retina.
  - Our expectations affect the way an image is perceived:
    - If we know that an object is a particular size, we will perceive it as that size no matter how far it is from us.
  - Visual processing compensates for the movement of the images on the retina and changes in luminance.

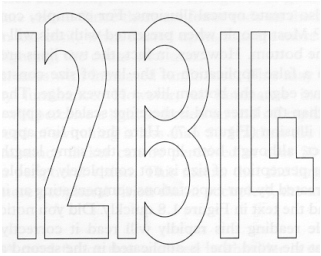
Human - Vision

- Visual processing
  - Context is used to solve ambiguities



Human - Vision

- Visual processing

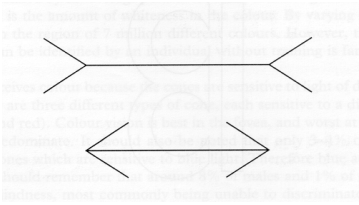


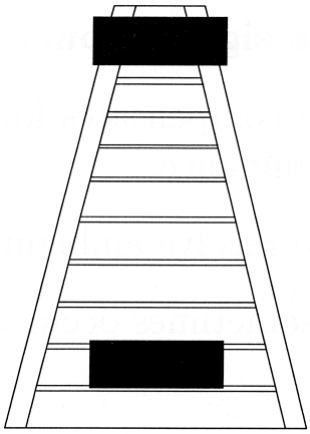
Human - Vision

- Visual processing

  Optical illusions sometimes occur due to overcompensation

  – The Muller-Lyer illusion





  – The Ponzo illusion

Human - Vision

- Reading
  - Several stages
    - Visual pattern perception (characters and words)
    - Decode with reference to an internal representation of language
    - Interpretation by syntactic and semantic analysis
  - Font size, spacing, line length have influence in the reading speed.
  - Adults read approximately 250 words a minute.
  - Reading from a computer screen is slower than from a book. Possible reasons: longer line length, fewer words on a page, orientation.

Human - Vision

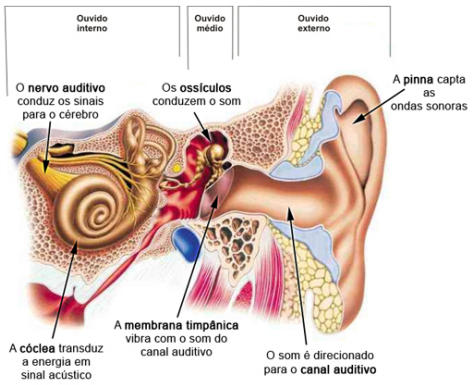
- Reading
  - Font sizes of 9 to 12 points are equally legible, given proportional spacing between lines.
  - Line lengths of between 58 e 132 mm are equally legible.
  - Negative contrast (dark characters on a light screen) provides higher luminance and, therefore, increased acuity than positive contrast.

Human - Audio

- Hearing
  - Provides us with information about our environment:
    - Objects, distances, directions, ...
  - Try to close your eyes and listen:
    - What sounds can you identify?
    - Where do they come from?
  - Human ear
    - Outer ear: protects the middle ear, collects sound waves and channels them down the ear canal to the middle ear and amplifies some sounds.
    - Middle ear: transmits the sound waves, as vibrations, to the inner ear.
    - Inner ear: Chemical transmitters are released and causes impulses in the auditory nerve.

Human - Audio

O ouvido humano



Human - Audio

- Sound (vibrations in the air):
  - Pitch – sound frequency
  - Loudness - amplitude
  - Timbre - type or quality
- Humans are able to identify sound's location
- Audible frequencies: 20Hz a 20kHz
  - Less accuracy at high frequencies.
- The auditory system filters the sound – we are able to distinguish sounds despite of the background noise
  - Cocktail party effect

Human - Audio

- How can we use the properties of sound, effectively, in interface design?

Human - I/O channels

- Touch
  - Provides important feedback information about the surrounding environment.
    - Catch a glass of water without feelling it.
    - Manipulation of objects in virtual reality systems.
  - It is an essential sense for visual impaired people.
  - Stimuli are received by sensory receptors in the skin.
  - Some areas of the body are more sensitive than others.
    - Two-point threshold test
  - We are aware of the position of our body and limbs (affect performance).

Human - I/O channels

- Movement
  - Movement time:
    - Stimuli reception → processing → response generation
    - Depends on physical characteristics: age, fitness, ...
  - Reaction time
    - Depends on the type of stimuli
      - visual: 200ms
      - auditory: 150ms
      - pain: 700ms
    - Combined stimuli reduces reaction time.
    - Reduce with skills and practice and increases with fatigue.

Human - I/O channels

- Movement
  - Accuracy:
    - Speed of reaction results in reduced accuracy?
      - Depends on the task and the user
      - Video games / Keyboard operators
  - Speed and accuracy to move to particular target on the screen (button, icon, menu item).
    - Depends on the size of the target and the distance that have to be moved.

Human - Movement

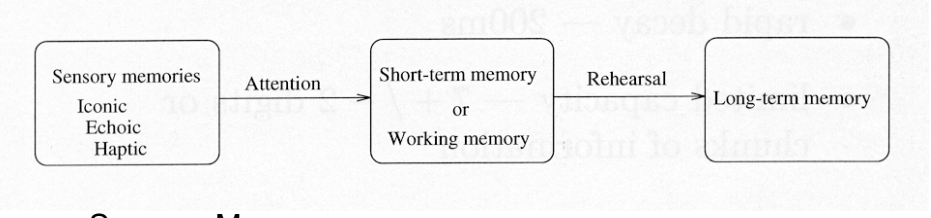
- Fitts' Law
  - Describes the time a user takes to select a target on the screen.
  - Time Mt to move your hand to a target of size S at distance D is:
    - $Mt = a + b \log_2 (D / S + 1)$
      - Mt – movement time
      - a e b – empirically determined constants
      - D - distance
      - S - size
  - In general:
    - Targets should be as larger as possible
    - Distances should be as small as possible

Human - Movement

- Fitts' Law
  - Targets at screen edge are easy to hit
    - Mac/Windows menubar
  - Hierarchical menus
    - Windows – 500ms timeout (sense of causality is lost).
    - Mac - triangular zone, spreading from the mouse to the submenu, in which the mouse pointer can move without losing the submenu.
  - Linear pop-up menus vs pie menus

Human - Memory

- Three types of memory:



- Sensory Memory
  - Buffers for stimuli received through the senses:
    - iconic – visual stimuli
    - echoic – aural stimuli
    - haptic – touch
  - Constantly overwritten as new information arrives.

Human - STM

- Short-Term Memory (STM)
  - "Scratch-pad" for temporary recall of information
    - Example: Mental calculations, reading.
    - Quick access: 70ms
    - Quick decay: 200ms
    - Interference causes faster decay
    - Limited capacity: 7 ± 2 information blocks (Miller's rule).
    - Desire to complete and close tasks held in the STM

Human - STM

- Example:

7561093

Human - STM

- Example:

?

Human - STM

- Example:

36B789C563

Human - STM

- Example:

?

Human - STM

- Example:

643 71B 83M6

Human - STM

- Example:

?

Human - STM

- Example:

WAU HTP NYD KSD YHB

IBM BMW FBI URL ATM

ABC DEF GHI JKL MNO

Human - LTM

- Long-Term Memory
  - Knowledge repository
    - Slow access time: 1/10 second
    - Little decay (if any)
    - Huge capacity (or unlimited)
  - Two types:
    - Episodic: memory of serial events.
      - Ex: remember de events that took place in a certain moment of our lives.
    - Semantic: structured record of facts, concepts and skills. Represents relationships between information.
      - Ex: if Snoopy is a dog => Snoopy has 4 legs.
    - Semantic LTM derived from episodic LTM

Human - LTM

- Processing in the LTM
  - Information storage
    - STM → LTM by rehearsal
    - Studies show:
      - Total time hypothesis - The amount of information learned is proportional to the amount of time spent learning.
      - Distribution of practice effect - Learning time is most effective if it is distributed over time.
      - Structure, meaning and familiarity make information easier to remember.

Human - LTM

- Example:

Hot Fair Big Age Value Idea New

Human - LTM

- Example:

?

Human - LTM

- Example:

Egg Orange Rose Car Glasses House Shoe

Human - LTM

- Example:

?

Human - LTM

- Processing in the LTM
  - Forgetting
    - Information is gradually and slowly lost.
    - LTM is selective and influenced by emotions
      - We tend to remember highly emotive events than mundane ones.
      - "Good old days"
    - Apparently, new information replaces the old one (retroactive inhibition), but sometimes old memory interferes with new information (proactive inhibition).
    - Do we forgot information or we just are not able to retrieve it?
      - Tip of the tongue experience
      - Recognition

Human - LTM

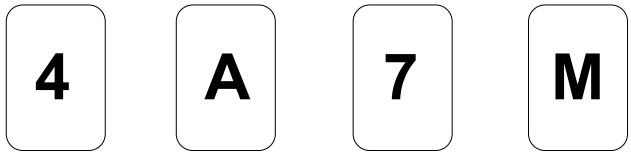
- Processing in the LTM
  - Information retrieval
    - Recall (relembrar)
      - Information is reproduced from memory. Cues can be helpful (categories, images, …)
    - Recognition (reconhecer)
      - The presentation of the information provides the knowledge that the information has been seen before. Easier than the recall process – the information is the cue.
    - Example: Colleagues from the 4th grade, quiz shows.

Human - Thinking

- Reasoning
  - Deductive: derives the logically necessary conclusion from the given premises.
    - Ex: Ex: If x=4 AND if y=1 Then 2x+y=9
  - Inductive: generalize from cases we have seen to infer information about cases we have not seen.
    - Ex: all the elephants I have seen have trunks, so all the elephants have a trunk.
    - Not reliable: we can only prove that it is false.
    - We are better using positive than negative evidences.
  - Abductive: reasoning from a fact to the action or state that causes it. Method we use to derive explanations.
    - Ex: Manuel drives at high speed if he is drunk => if Manuel drives at a high speed than he is drunk.
    - Not reliable: the cause could be different than the usual, leading to false explanations → confusion in interactive systems.

Human - Thinking

- Reasoning
  - Watson's cards
    - Each card has a number on one side a and a letter on the other.
    - Which cards would you need to pick up to test the truth of the statement: “If a card has a vowel on one side it has an even number on the other ”?



Human - Thinking

- Problem solving
  - Finding a solution to a unfamiliar task, using the knowledge we have.
  - Several theories: Gestalt, Problem Space theory, Analogy.
    - Gestalt
      - Problem solving is both productive and reproductive.
      - Productive problem solving involves the understanding and restructuring of the problem.
      - Reproductive problem solving is based on the reutilization of knowledge.

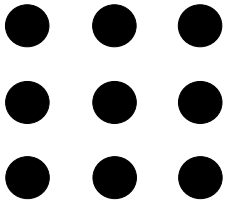
Human - Thinking

- Problem solving
  - Gestalt (productive restructuring):
    - Maier's pendulum problem
      - 2 pieces of string hanging from the ceiling
      - They were to far apart to catch hold of both at once
      - Available objects: pliers, extensions, …
      - How to tie the pieces of string together?

Human - Thinking

- Problem solving

  📖 Conceptual Blockbusting, James L. Adams, Basic Books, New York, 2001



Human - Thinking

- Problem solving
  - Problem space theory (Newell & Simon)
    - The problem space comprises problem states.
    - There is an initial state and a final state (solution).
    - Problem solving involves generating the intermediate states using legal state transition operators.
    - Heuristics can be used to select the operators (when the problem space is huge).
      - Ex: means-ends analysis

        Move a desk
        - » Initial state: desk is on the north wall.
        - » Final state: desk is on the south wall.
        - » Several possibilities: carry, push, pull…
        - » …but we know that it is easier to carry a light object than an heavy object → subgoal: empty the desk first.

Human - Thinking

- Problem solving
  - Analogy
    - Old knowledge is used to solve a new problem => mapping by analogy.
    - Mapping by analogy may be more difficult if the problem domains are different.
  - Skill acquisition
    - Problem solving we have considered so far concentrates on handling unfamiliar problems.
    - Most of the time, the problems that we face are not completely new.
    - We gradually acquire skills in a particular domain area.

Human - Thinking

- Types of errors and mental models
  - Several different types of errors
    - Slips (Desvios): right intention, but failed to do it right. Causes: physical skills, inattention,… If a pattern of behaviour has become automatic and we change some aspect of it, the more familiar pattern may break through and cause an error.
      - Ex: I use to go to Lisbon, by A2, through 25 de Abril bridge. Once I need to go through ponte Vasco da Gama bridge, it is probable that I just pass by the right exit. That happens, because 90% of the time I drive on the A2, I do not exit in that exit.
    - Mistakes (erros): Wrong intention. Cause: incorrect understanding, incorrect mental models (different from actual system). We build our own theories to understand the causal behaviour of systems - mental models: partial, unstable, inconsistent.
      - Ex: stairs light switch x bell

Human – Individual differences

- Individual differences
  - In interface design we should consider individual differences
  - Three main types of differences
    - Long term: sex, physical and intellectual capabilities
    - Short term: stress, fatigue, …
    - Changes: age, idiosyncrasies…
  - Be aware if a design decision may exclude part of the target users population.
  - In the same group of target users significant differences can be noticed.
  - The users should not be forced to work on their perceptual and cognitive limits. They should feel comfortable in using the systems.

Human - Emotions

- Emotions
  - The biological response to physical stimulus is called affect.
  - Affect influences how we respond to situations
    - Positive emotions - creative thinking, complex problem solving
    - Negative emotions – restrict reasoning.

"Negative affect can make it harder to do even easy tasks; positive affect can make it easier to do difficult tasks."

Donald Norman, Emotional Design

  - Build interfaces that promote positive responses (aesthetic).

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