Human Computer Interaction

THE BASICS FOR USER-CENTERED DESIGN

POLITECNICO DI TORINO

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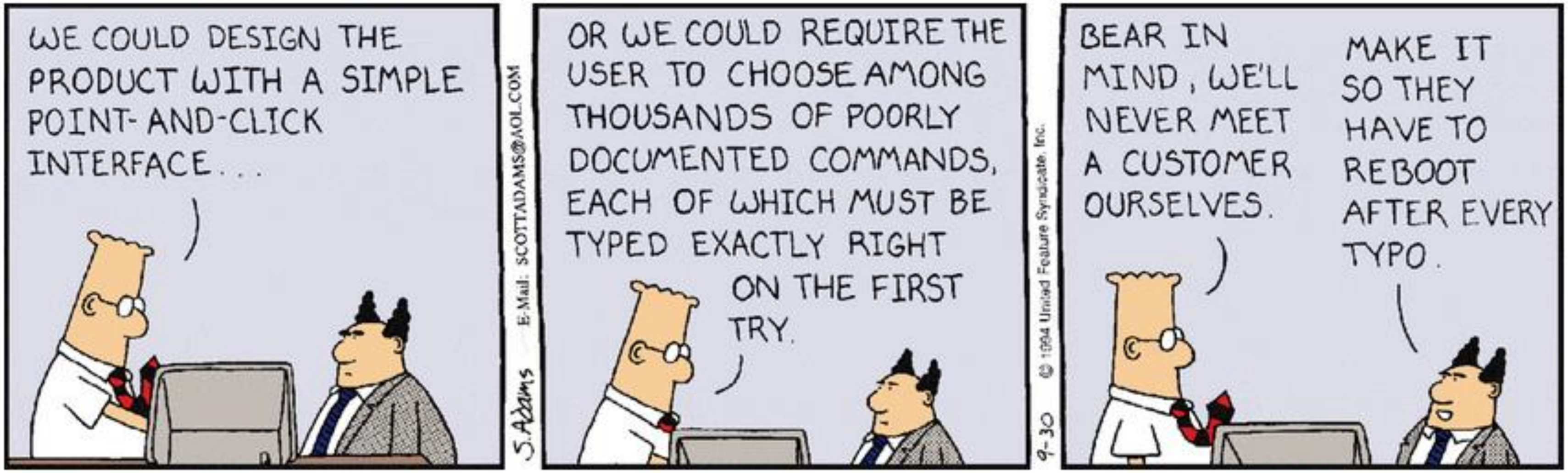
e-Lite

User-centered design

- Definition
- Human Computer Interaction
- User experience
- User-centered design process for web sites

User-centered design

Friday September 30, 1994



http://dilbert.com/

What is design?

- A simple definition is

Achieving goals within constraints

- Goals
  - What is the purpose of the design we are intending to produce?
  - Who is it for?
  - Why do they want it?
- Constraints
  - What materials must we use?
  - What standards must we adopt?
  - How much can it cost?
  - How much time do we have to develop it?
  - Are there health and safety issues?
- Trade-of
  - Choosing which goals or constraints can be relaxed so that others can be met

The golden rule of design

- Understand your material

- What is our material???

- Understand computers
  - Limitations, capacities, tools, platforms
- Understand people
  - Psychological, social aspects, human error

User-centered design

- UCD is a design philosophy and a process in which the needs, wants, and limitations of the end user of an interface or document are given extensive attention at each stage of the design process
- Multi-stage problem solving process that not only requires designers to analyze and foresee how users are likely to use an interface, but to test the validity of their assumptions with regards to user behavior in real world tests with actual users
  - Such testing is necessary as it is often very difficult for the designers of an interface to understand intuitively what a first-time user of their design experiences, and what each user's learning curve may look like

User-centered vs participatory

- User-centered design (Norman & Draper, 1986)
  - Approach to designing and developing software or products where a professional team focuses on user needs in an iterative fashion throughout the product life cycle
  - The team usually consists of creative and business professionals who together strategize, plan, create, and implement a project
  - Designers generate solutions placing users mainly in a reactive role
- User participatory design (Schuler & Namioka, 1993)
  - When users either contribute to the design and content development process or manage the entire development process on their own
  - Users take a more active involvement in the process and become a key group of stakeholders
  - Involves users more deeply in the process as co-designers by empowering them to propose and generate design alternatives themselves

User focus

- Know thy user(s)
  - It is important to be aware that there is rarely one user of a system
- Who are they? Probably NOT like you!!!
- You are NOT the USER if you are DESIGNER

User focus

- Talk to them

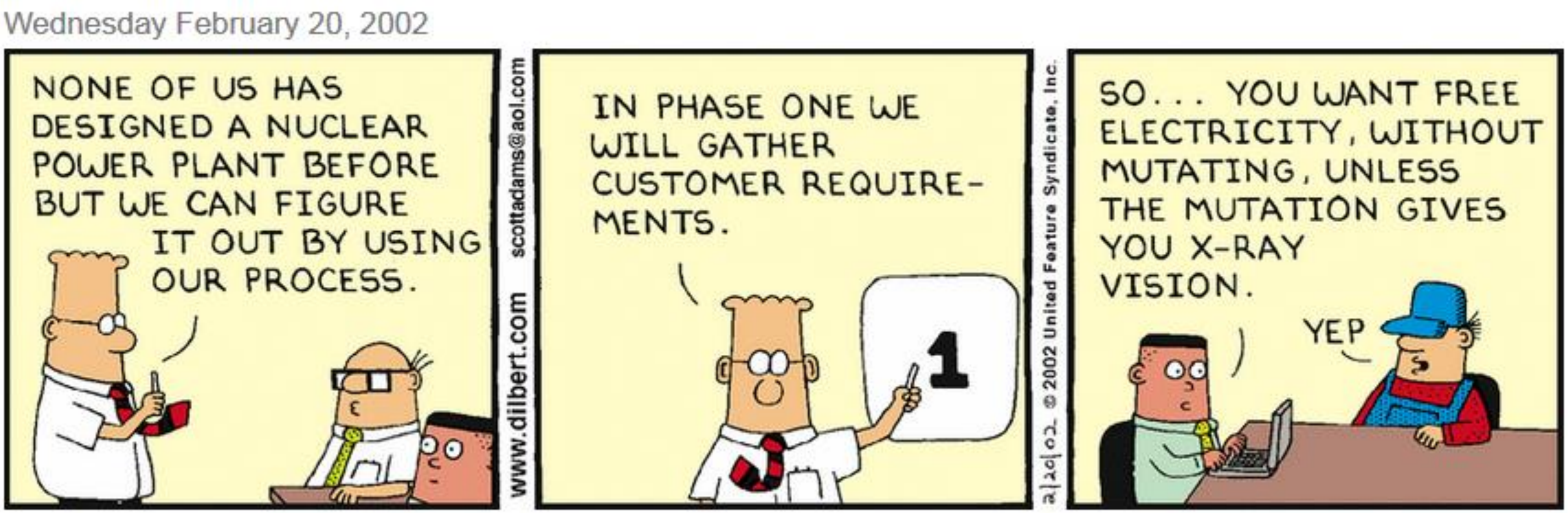
Eadweard Muybridge's time-lapse photography

- Watch them

- Use your imagination
  - Personas: rich pictures of an imaginary person who represents your core user group

UCD principles

- User involvement in development stages



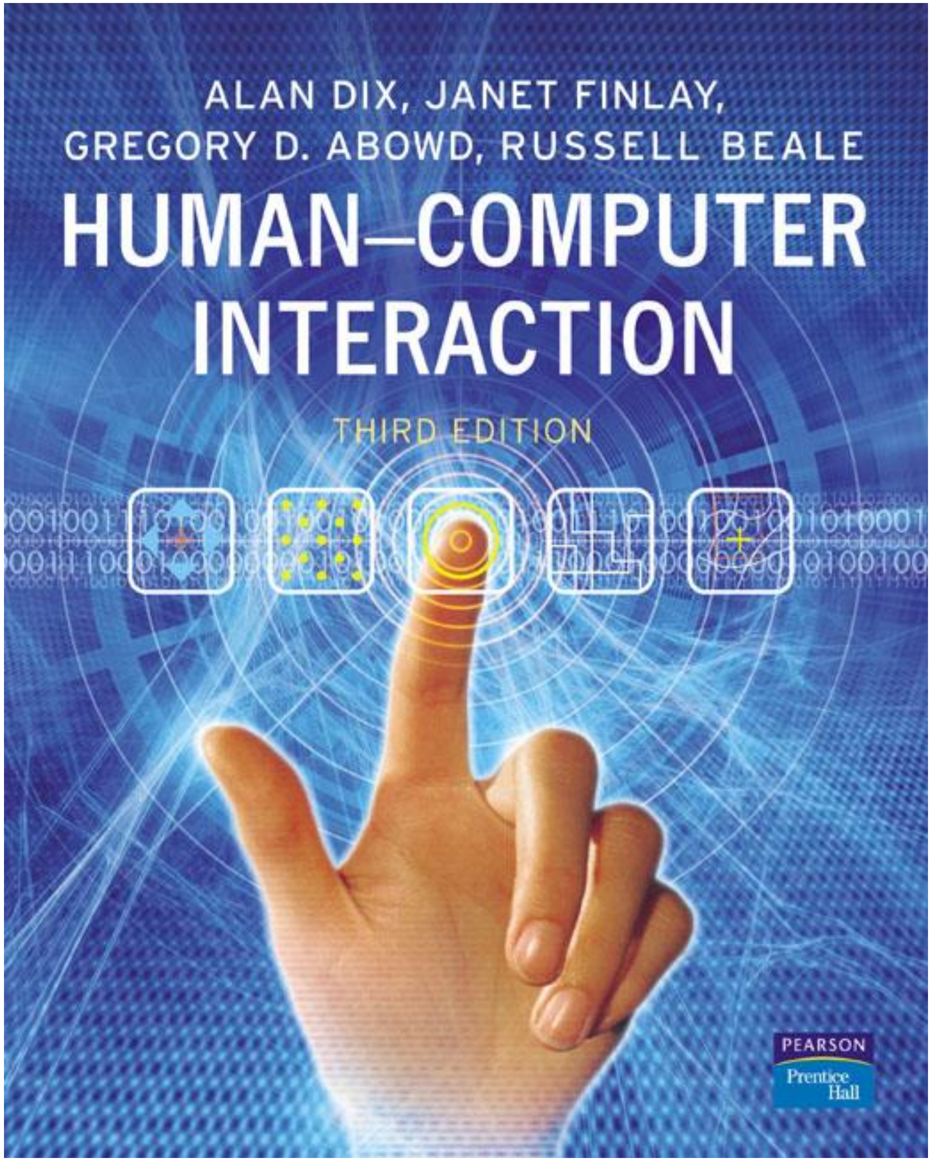
- Design iteration
- Multi-disciplinary design teams
  - Psychology, ergonomics, engineering & graphic design

UCD activities

- Understand & specify context of use
- Specify user & organization requirements
- Produce prototypes: design solutions

- Evaluate designs with users against requirements

HUMAN COMPUTER INTERACTION



Human Computer Interaction

- In the beginning, there were humans
- In the 1940s came computers
- Then in the 1980s came interaction

- What happened between 1940 and 1980? Were humans not interacting with computers then?
- Yes, but not just any human

UNIVAC I (UNIVersal Automatic Computer I), 1951

Human

- Humans are limited in their capacity to process information
  - Important implications for design
- Information is received and responses given via a number of input and output channels
  - Visual channel
  - Auditory channel
  - Haptic channel
  - Movement
- Information is stored in memory
  - Sensory memory
  - Short-term (working) memory
  - Long-term memory

Human

- Information is processed and applied
  - Reasoning
  - Problem solving
  - Skill acquisition
  - Error
- Emotion influences human capabilities
- Users share common capabilities but are individuals with differences

Computer

- A computer system consists of various elements, and each of them affects the user of the system
- Input devices for interactive use
  - Text entry: traditional keyboard, phone text entry, speech and handwriting
  - Pointing: mouse, touchpad, stylus, …
  - 3D interaction devices
- Output display devices for interactive use
  - Different types of screen (bitmap display)
  - Large displays and situated displays for shared and public use
  - Digital paper in the near (?) future
- Virtual reality systems and 3D visualization
- Various devices in the physical world
  - Physical controls and dedicated displays
  - Sound, smell and haptic feedback
  - Sensors for nearly everything (movement, temperature, bio-signs)

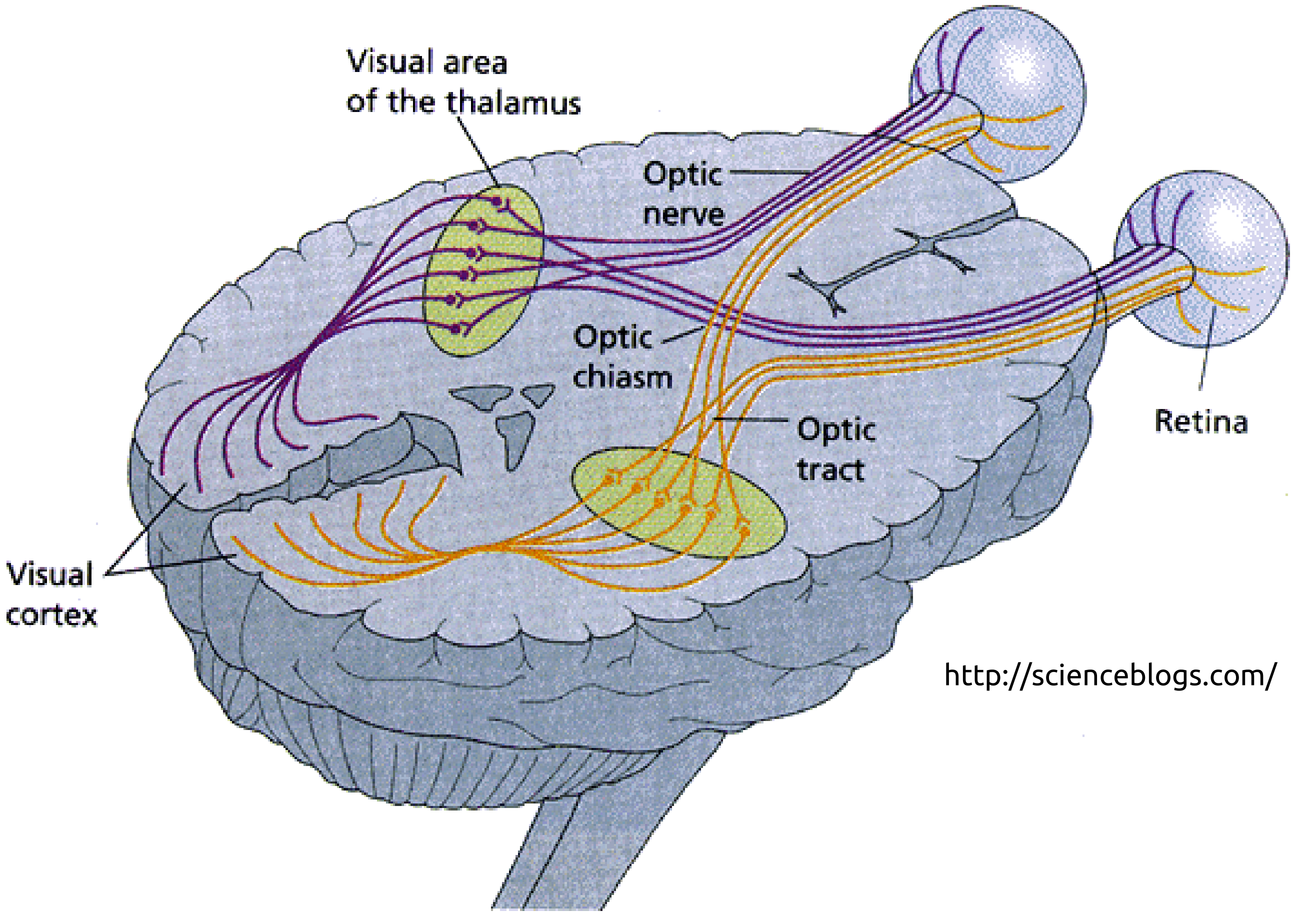
Computer

- Paper output and input
  - Different types of printers and their characteristics, character styles and fonts
  - Scanners and optical character recognition
- Memory
  - Short-term memory: RAM
  - Long-term memory: magnetic and optical disks
  - Capacity limitations related to document and video storage
  - Access methods as they limit or help the user
- Processing
  - The effects when systems run too slow or too fast
  - Limitations on processing speed
  - Networks and their impact on system performance

Interaction

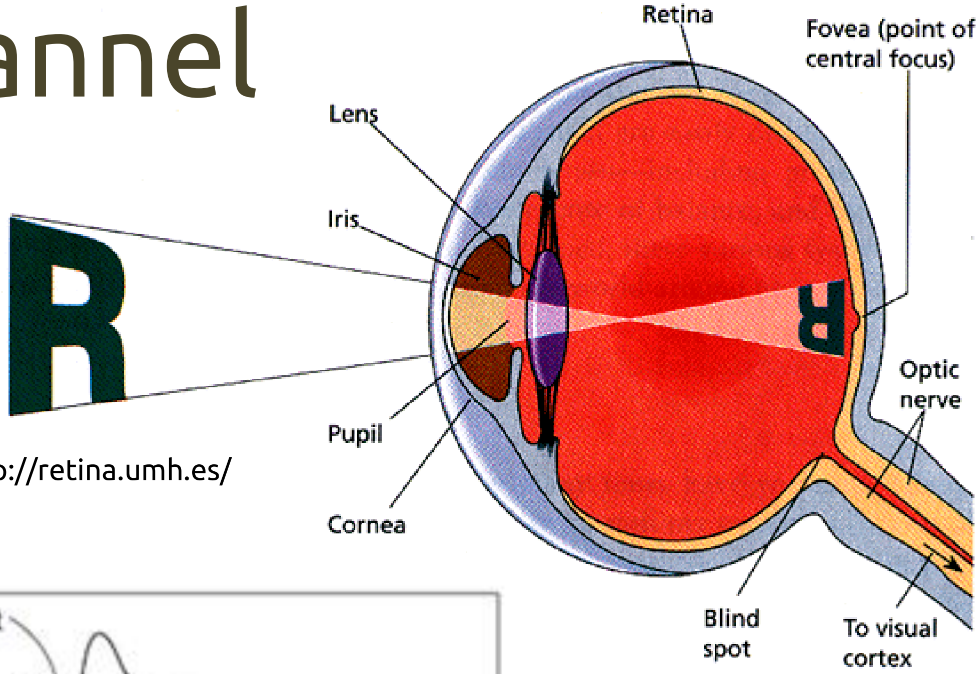
- Interaction models help to understand what is going on in the interaction between user and system
  - Translations between what the user wants and what the system does
- Ergonomics looks at the physical characteristics of the interaction and how these influence its effectiveness
- The dialog between user and system is influenced by the style of the interface
- The interaction takes place within a social and organizational context that affects both user and system

The vision channel

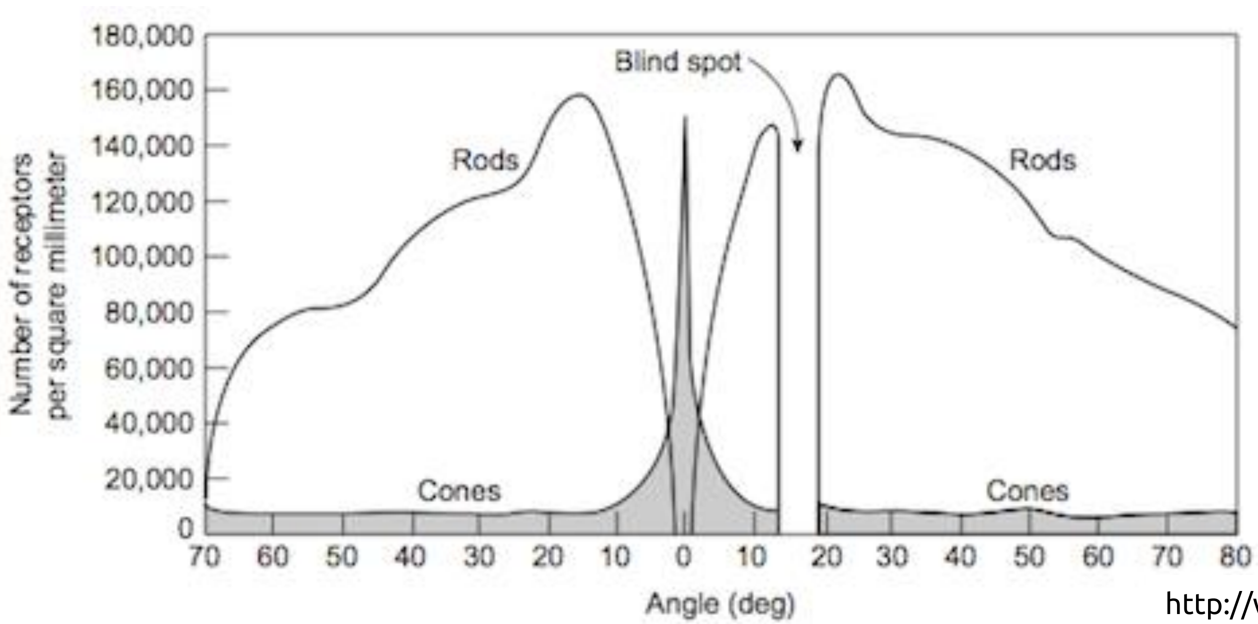


http://scienceblogs.com/

The vision channel



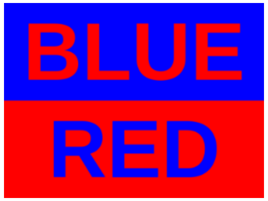
http://retina.umh.es/



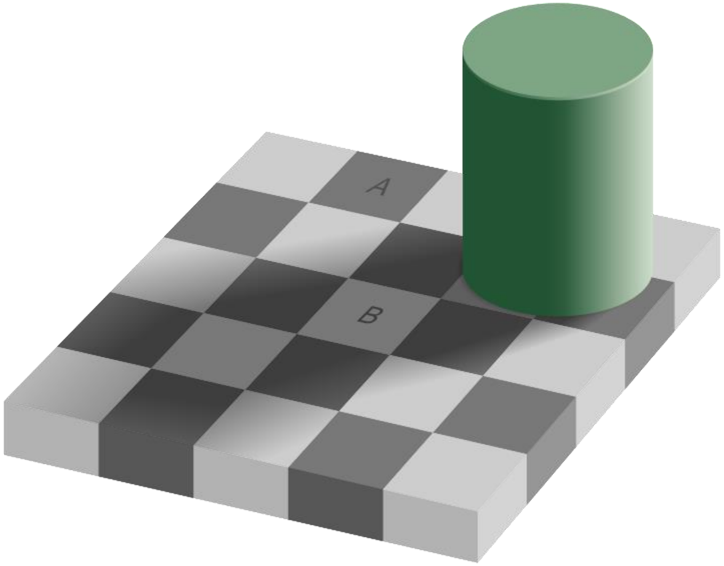
http://www.uxmatters.com/

Visual perception

- Color and depth (chromostereopsis)



- Color contrast



https://en.wikipedia.org/

Example: the «tonal perspective»

Jan Brueghel the Elder. The Great Fish Market (1603)

Visual perception

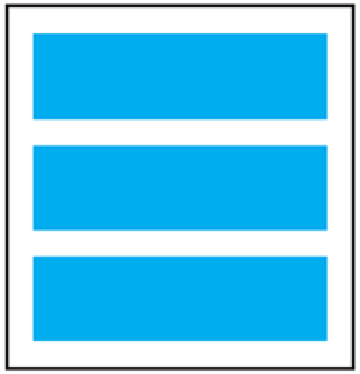
- Ambiguous shapes

http://www.simplypsychology.org/

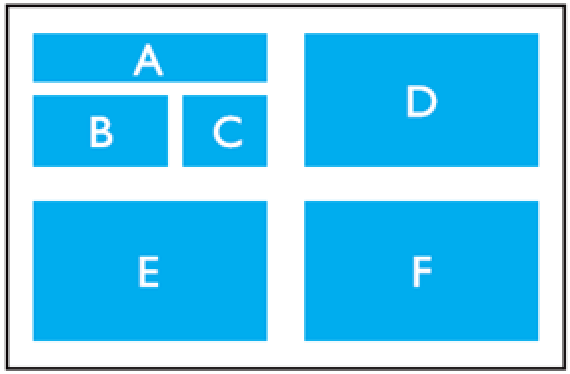
- Optical illusions affect page symmetry
  - We tend to see the center of a page as being a little above the actual center
  - If a page is arranged symmetrically around the actual center, we will see it as too low down
  - In graphic design this is known as the “optical center” and bottom page margins tend to be increased by 50% to compensate

White space in layout

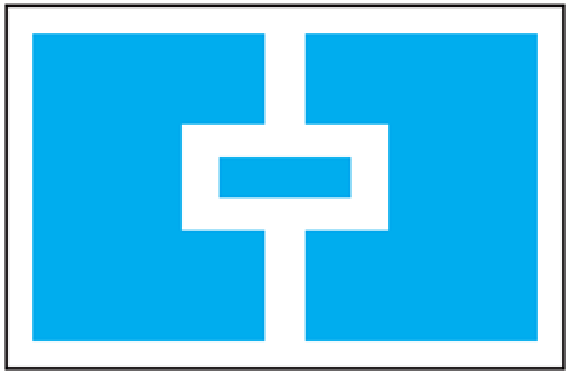
- Space to separate



- Space to structure



- Space to highlight



Reading

The quick brown
fox jumps over the
the lazy dog.

- Adults read approximately 250 words a minute
  - It is unlikely that words are scanned serially, character by character
  - Experiments have shown that words can be recognized as quickly as single characters
- Familiar words are recognized using word shape
  - Removing the word shape clues (e.g. by capitalizing words) is detrimental to reading speed and accuracy

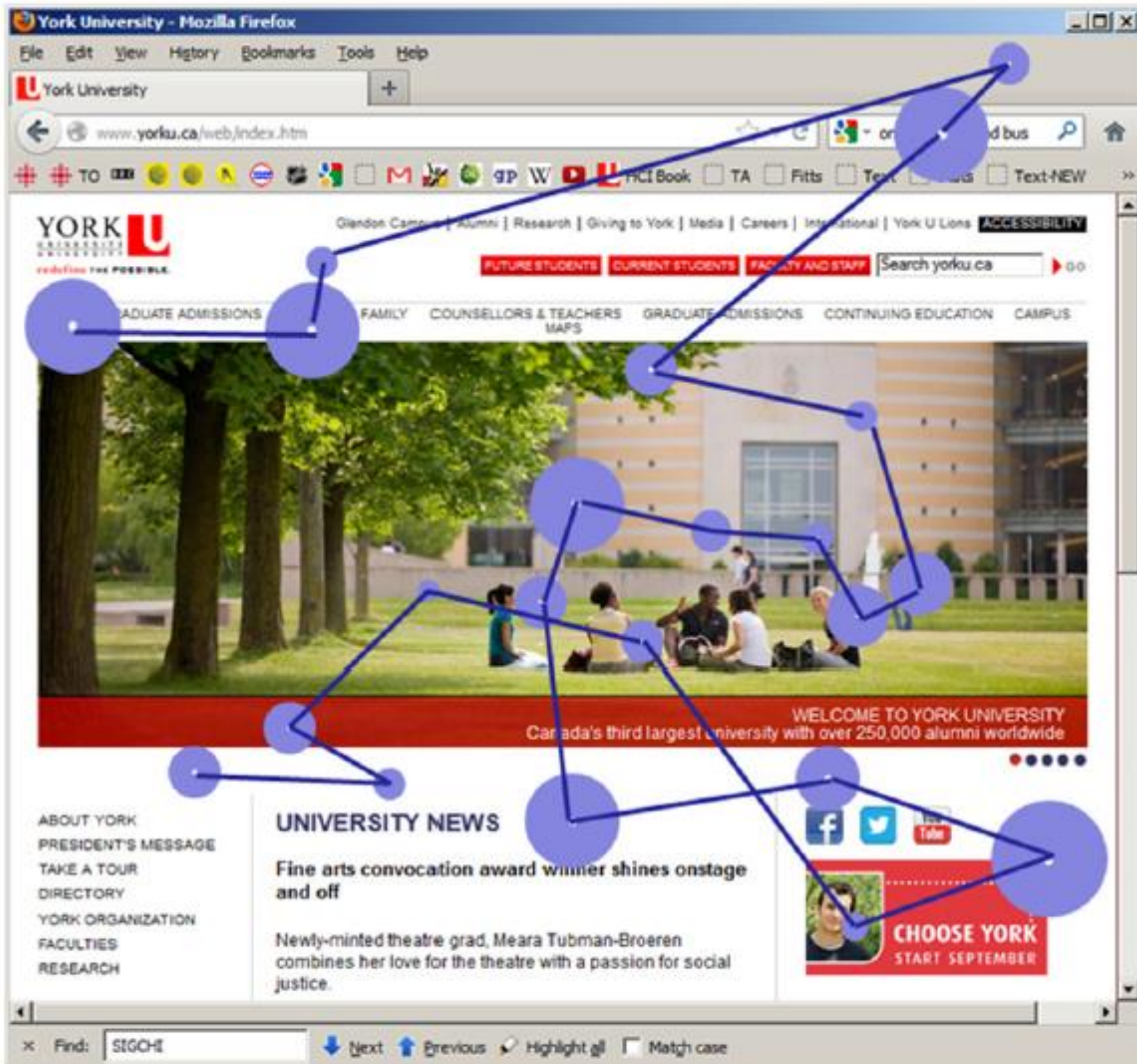
FINISHED FILES ARE THE RESULTS OF YEARS OF SCIENTIFIC STUDY COMBINED WITH THE EXPERIENCE OF MANY YEARS.

Left-right brain conflict

- Say the color and not the word

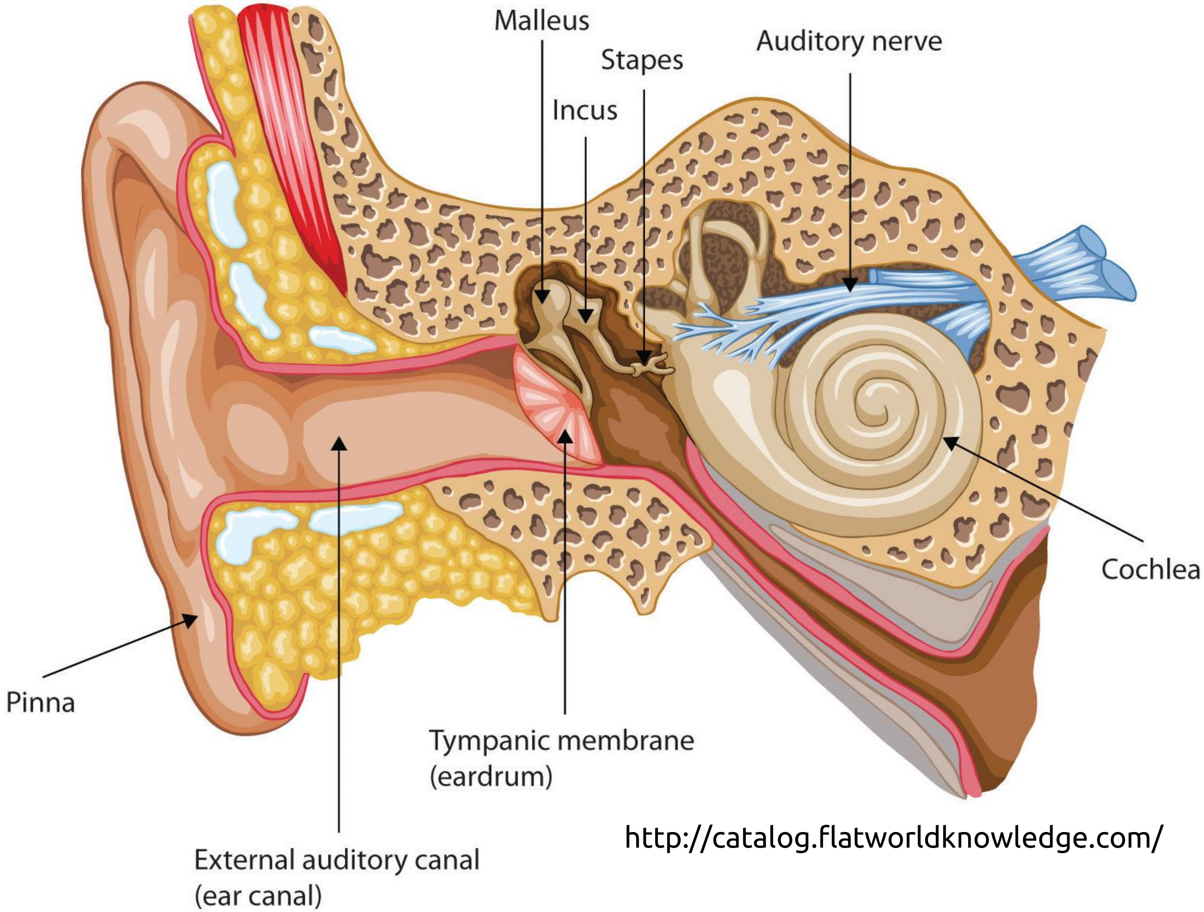
Scanpath

- Eye-tracking device



The auditory channel

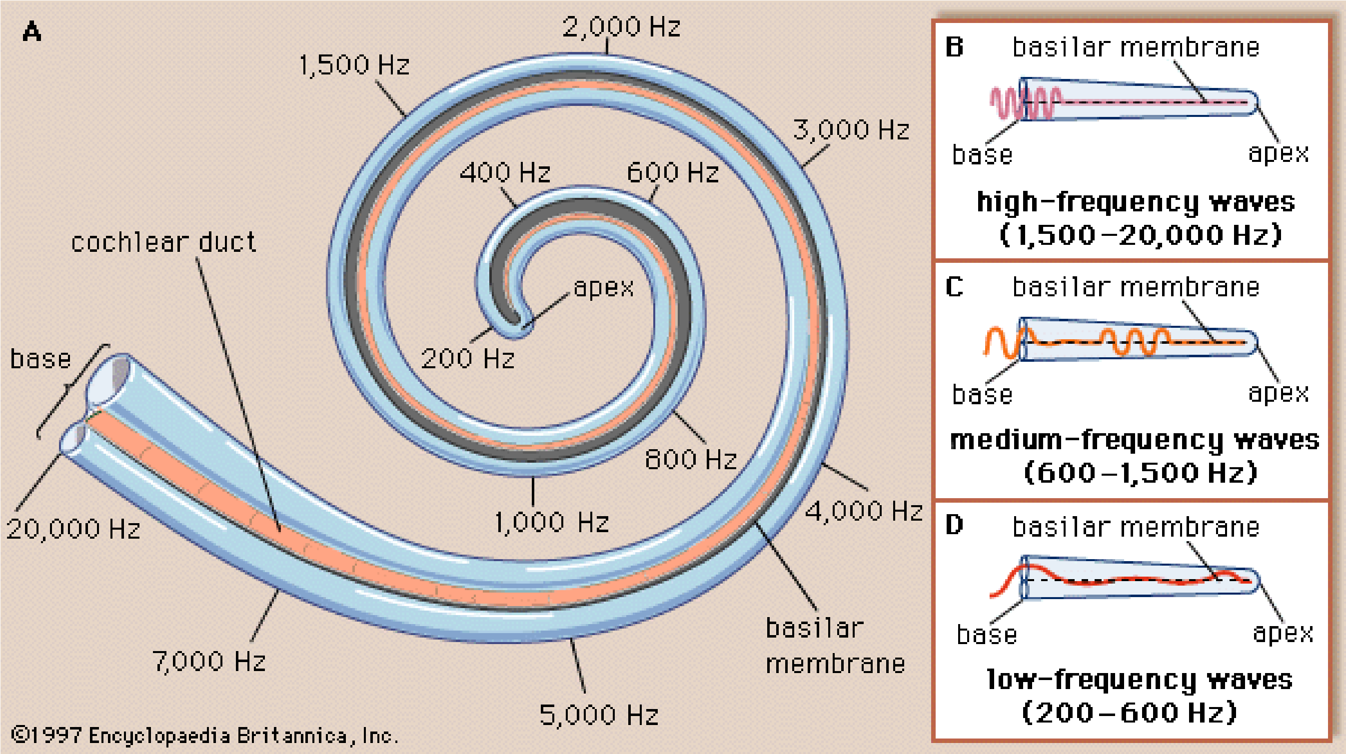
- The sense of hearing is often considered secondary to sight, but we tend to underestimate the amount of information that we receive through our ears



http://catalog.flatworldknowledge.com/

The auditory channel

- Cochlea: frequency analysis



Auditory illusions

- Mysterious melody

Diana Deutsch, 1973
http://deutsch.ucsd.edu/psychology/pages.php?i=207

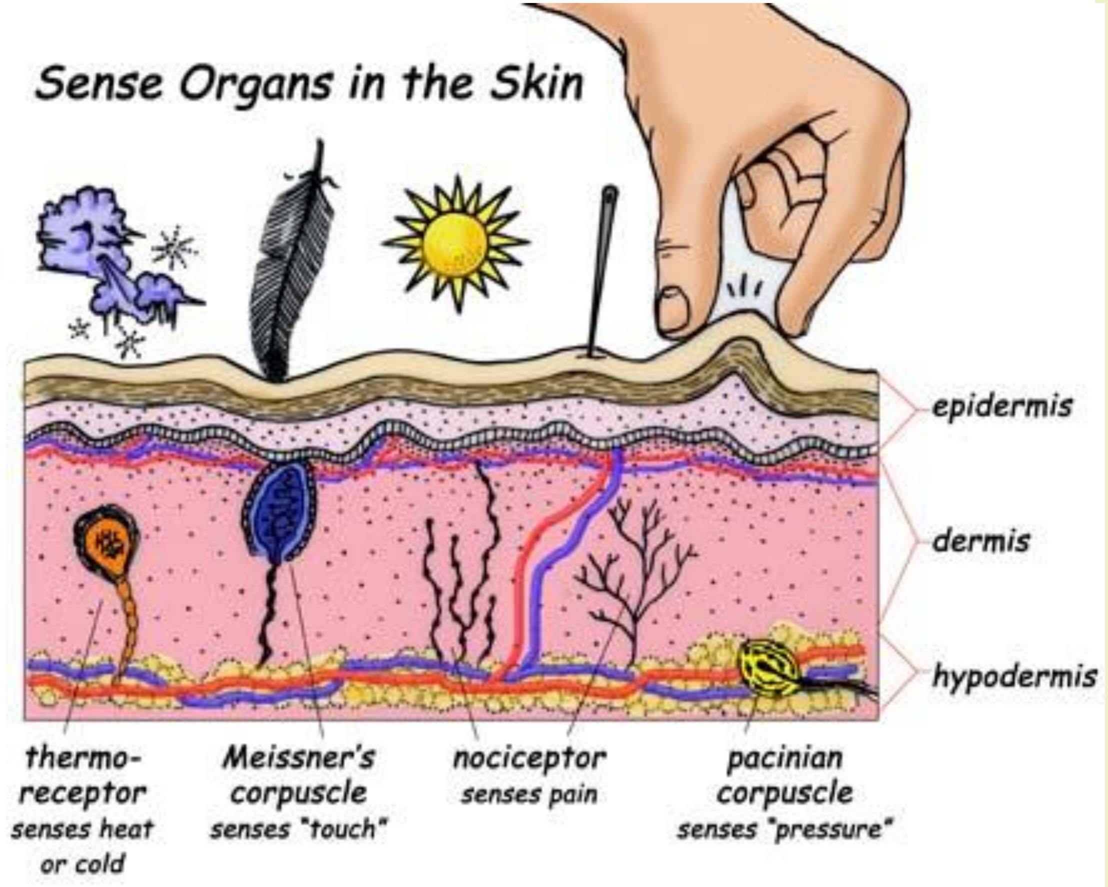
- Very similar to …

Non-speech sound in interfaces

- Attention
  - E.g., to attract the user's attention to a critical situation or to the end of a process
- Status information: continuous background sounds can be used to convey status information
  - E.g., monitoring the progress of a process without the need for visual attention
- Confirmation: a sound associated with an action to confirm that the action has been carried out
  - E.g., associating a sound with deleting a file
- Navigation: using changing sound to indicate where the user is in a system
  - E.g., what about sound to support navigation in hypertext?

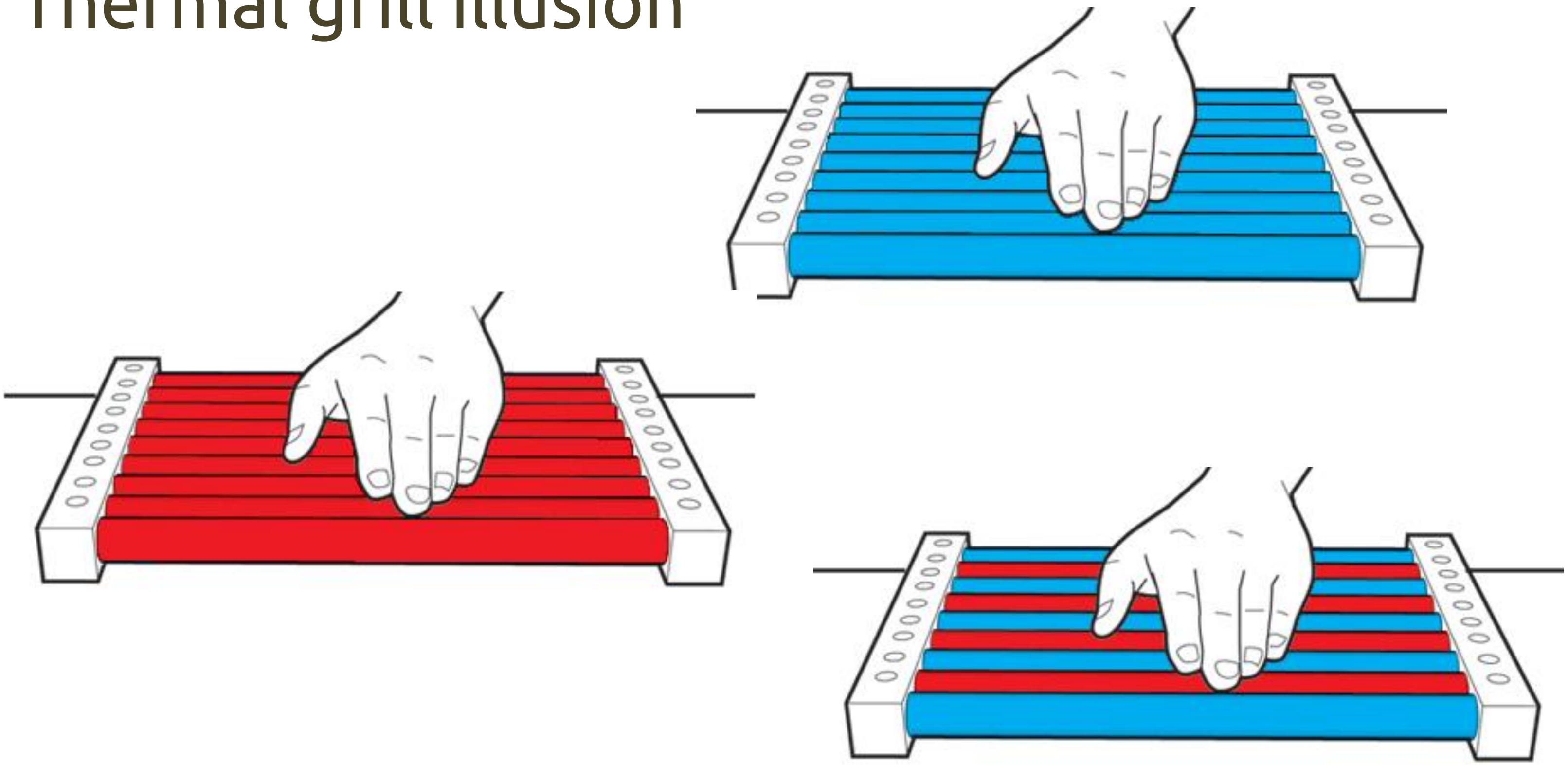
Touch: haptic perception

- Do not underestimate the importance of touch
  - E.g., feeling buttons depress is an important part of the task of pressing the button
  - In some virtual reality games user can see the computer-generated objects which they need to manipulate but they have no physical sensation of touching them



Tactile illusion

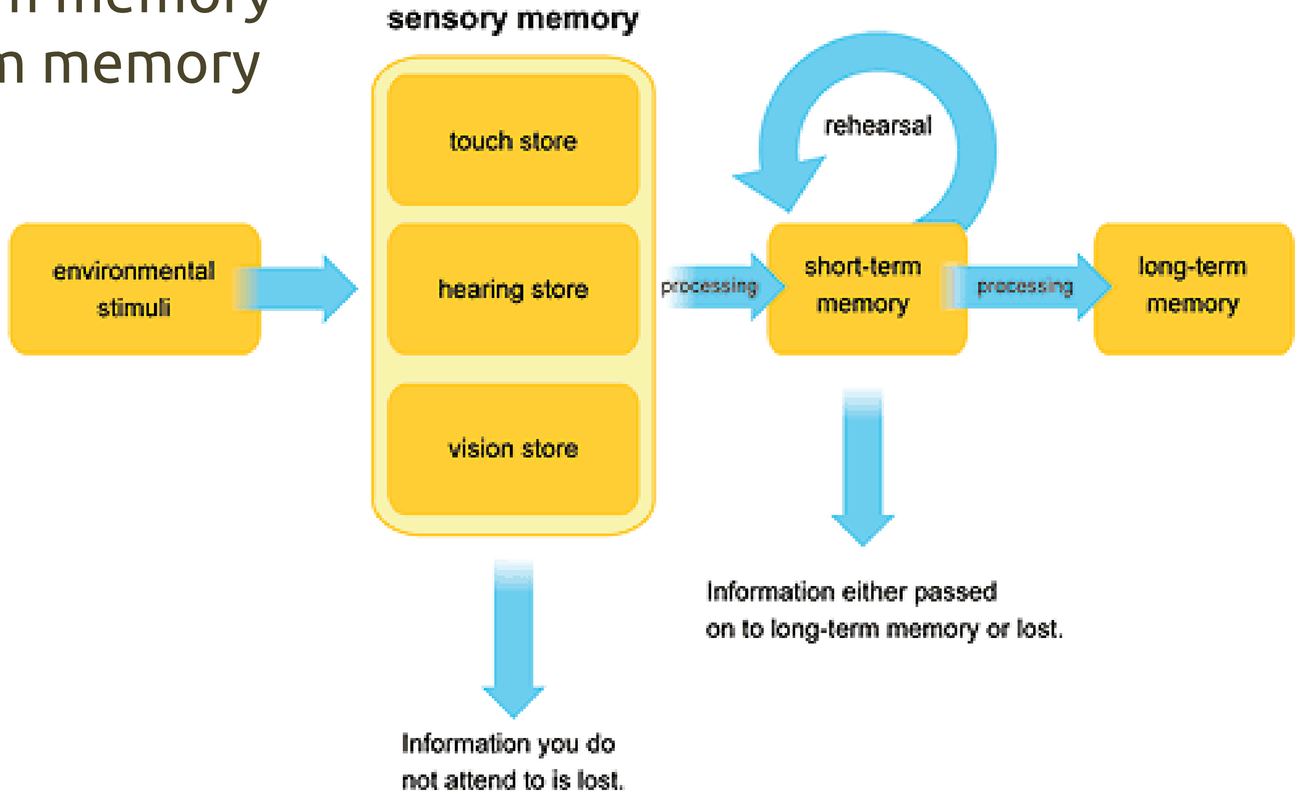
- Thermal grill illusion



http://www.scientificamerican.com/

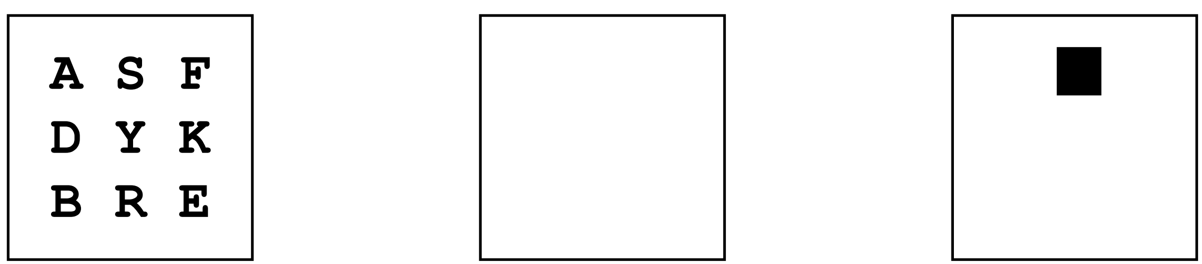
Human memory

- Multi-store memory model (Atkinson & Shiffrin)
  - Sensory register
  - Short-term memory
  - Long-term memory



Sensory register

- Temporary memory which maintains the signals coming from the sensory systems for a few tenth of second (0.1 sec <= t <= 0.5 sec)
  - Enough for recognizing the input configuration
- Sensory systems can perceive and send to the sensory register much more information than what can be processed
- Experiment

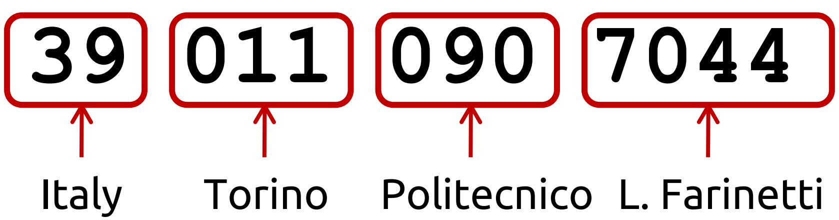


50 msec

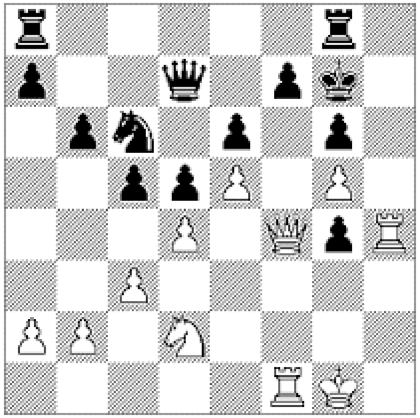
50 msec

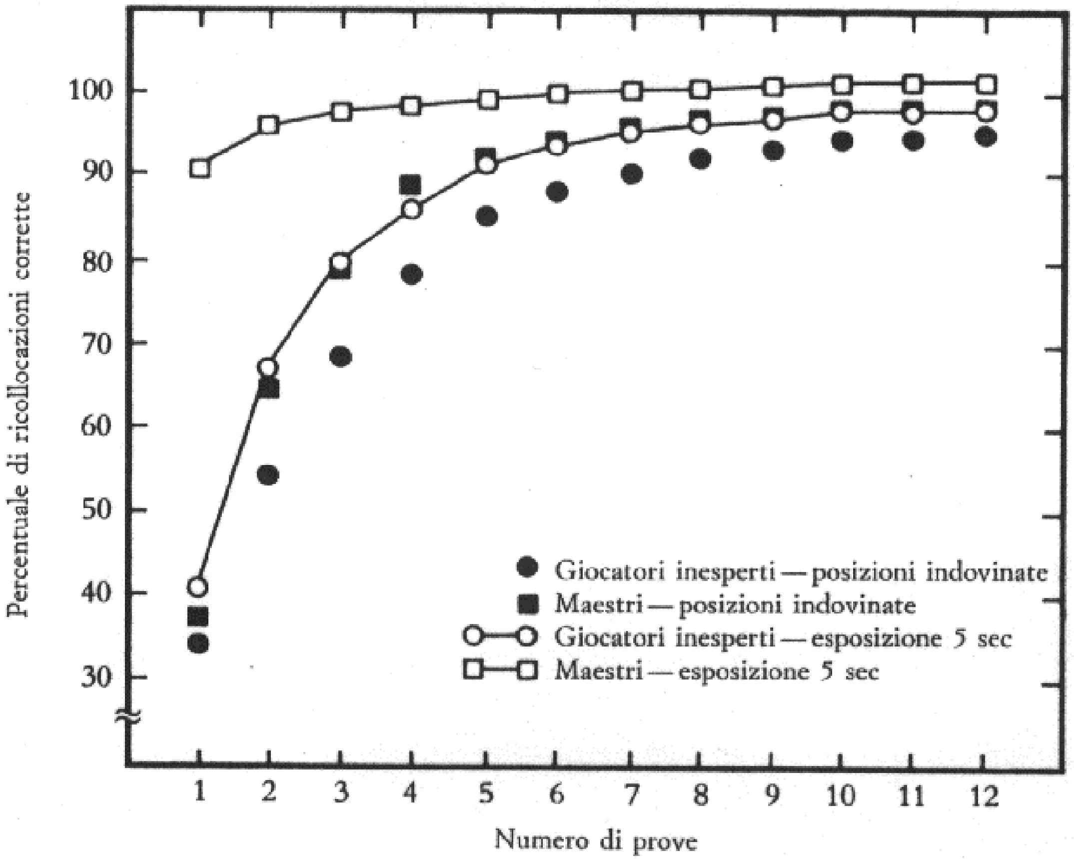
Short-term memory

- Characterized by:
  - limited capacity
  - short retention time
- Number of “items” that the short time memory can contain: 7 ± 2
- This “magic number” (memory span) does non change when items become more complex



De Groot experiment





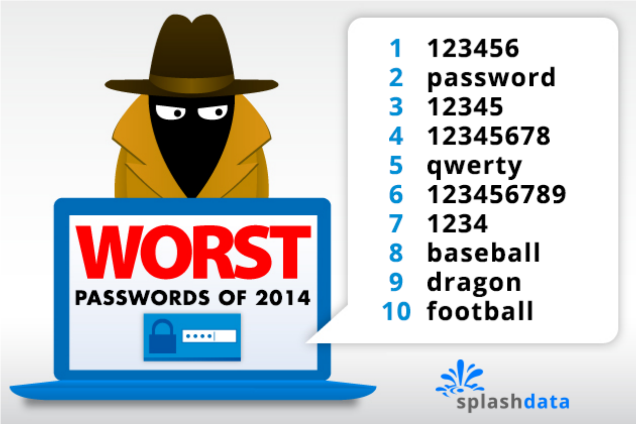
Short-term memory and design

- Early automatic teller machines (ATMs) gave the customer money before returning their bank card
  - On receiving the money the customer would reach closure and hence often forget to take the card
- Modern ATMs return the card first

Long-term memory

- Characterized by:
  - unlimited capacity
  - unlimited retention time
- Divided in categories
  - Semantic memory
  - Episodic memory
- Strategies for facilitating memory retention

Memorable or secure?



- As online activities become more widespread, people have to remember more and more access information, such as passwords and security codes
- From a security perspective it is important that passwords are random
  - Words and names are very easy to crack: passwords should be frequently changed and constructed from random strings of letters and numbers
  - These are the hardest things for people to remember: many people use the same password for all their online activities (rarely if ever changing it) and choose a word or a name that is easy for them to remember
- Solution: to construct a nonsense password out of letters or numbers that will have meaning (e.g. initials of names, numbers from significant dates or postcodes, …)
  - What is remembered is the meaningful rule for constructing the password, and not a meaningless string of alphanumeric characters

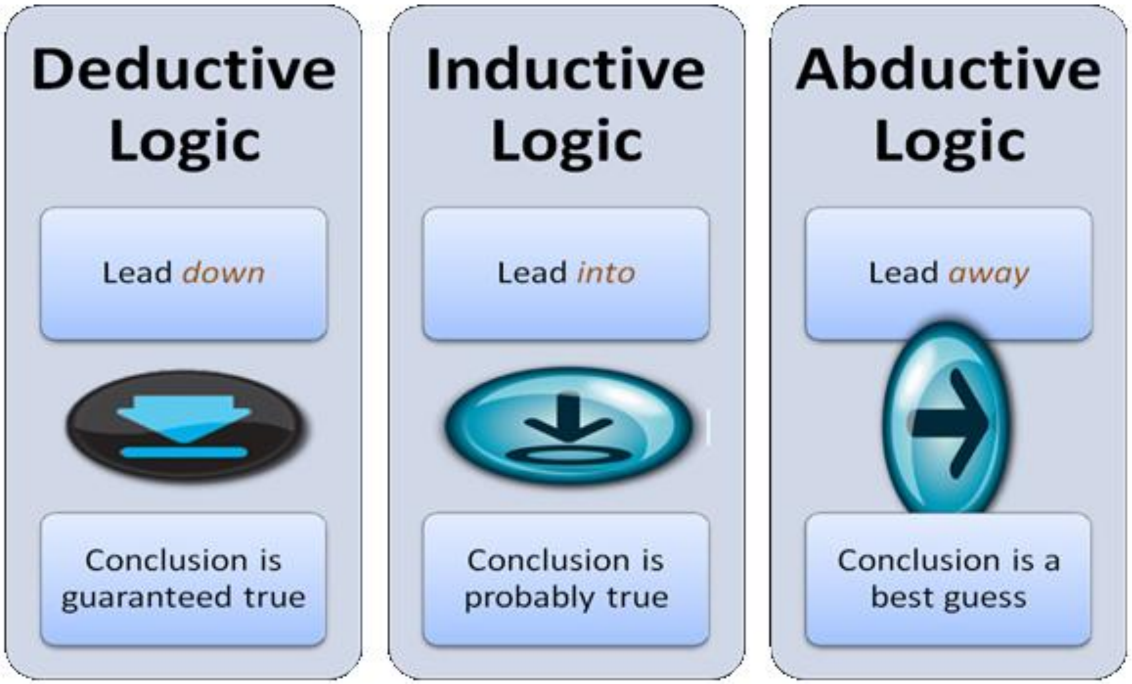
Reasoning

- The process by which we use the knowledge we have to draw conclusions or infer something new about the domain of interest
- Different types of reasoning
  - Deductive: derives the logically necessary conclusion from the given premises

Monkeys like bananas
Lucy is a monkey
→
Lucy likes bananas

  - Inductive: generalizing from cases we have seen to infer information about cases we have not seen (the “story” of the black sheep)
  - Abductive: reasoning from a fact to the action or state that caused it (e.g. “we know that Sam always drives too fast when she has been drinking”…)

Reasoning


Deductive Logic
Lead *down*
Conclusion is guaranteed true
Inductive Logic
Lead *into*
Conclusion is probably true
Abductive Logic
Lead *away*
Conclusion is a best guess


Sherlock Holmes.

Inductive reasoning example

- Wason's cards
  - 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"?

Problem solving

- May 11th , 1997
  - Deep Blue, a chess-playing computer, beat Gary Kasparov, the world’s top Grand Master, in a full tournament

Problem solving

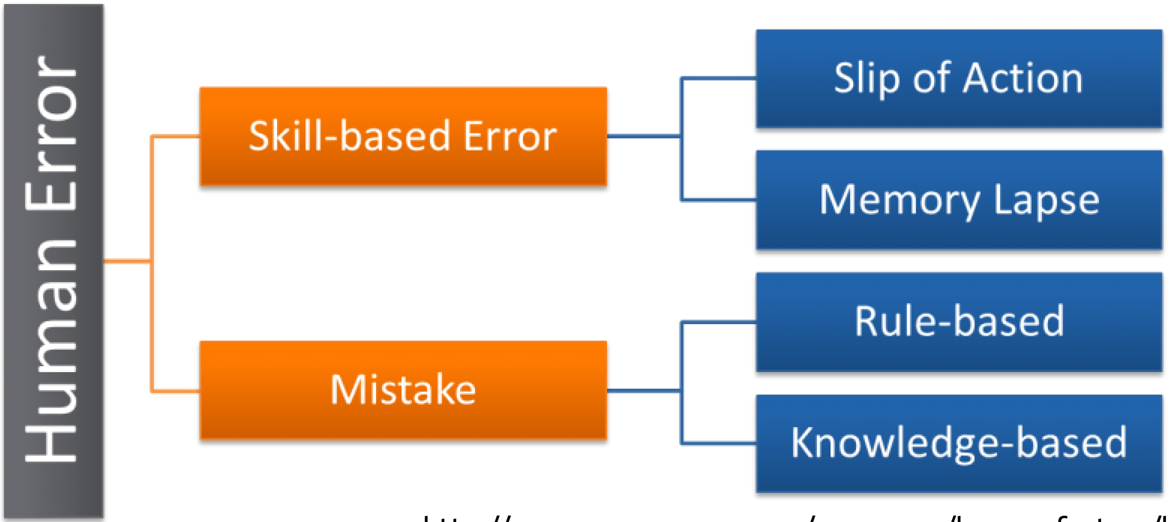
- This was the long-awaited breakthrough for the artificial intelligence community, who have traditionally seen chess as the ultimate test of their art
- However this does not mean they play in the same way
  - For each move played, Deep Blue investigated many millions of alternative moves and counter-moves (brute force approach)
  - In contrast, a human chess player only considers a few dozen; if the human player is good, these are the right few dozen (ability to spot patterns)
- Vision, as an example, is much more complex for a computer than playing chess

Humans

- Users …
  - have lousy memory
  - don't always see everything
  - get confused of too many things
  - get tired and bored
  - don't pay attention always
  - get easily distracted
- And therefore make mistakes

Errors

- We do make errors. Why?
- There are different types of errors
  - Skill-based errors: failures of action or unintentional actions
  - Mistakes: failures in planning



http://www.nopsema.gov.au/resources/human-factors/human-error/

Errors

- Skill-based errors
  - Tend to occur during highly routine activities, when attention is diverted from a task
  - The individual has the right knowledge, skills, and experience to do the task properly, and the task has probably been performed correctly many times before
  - Highly experienced people may be more likely to encounter this type of error than those with less experience
  - Memory lapse: occurs after the formation of the plan and before execution
  - Slip of action: an unintentional action, that occurs at the point of task execution

Errors

- Mistakes
  - Rule-based mistakes: incorrect application of a good rule, correct application of a bad rule, failure to apply a good rule (or violation)
  - Knowledge-based mistakes: incorrect understanding (or model) of a situation or system due to insufficient knowledge
- People build their mental models, i.e. their own theories to understand the causal behavior of systems

Mental models

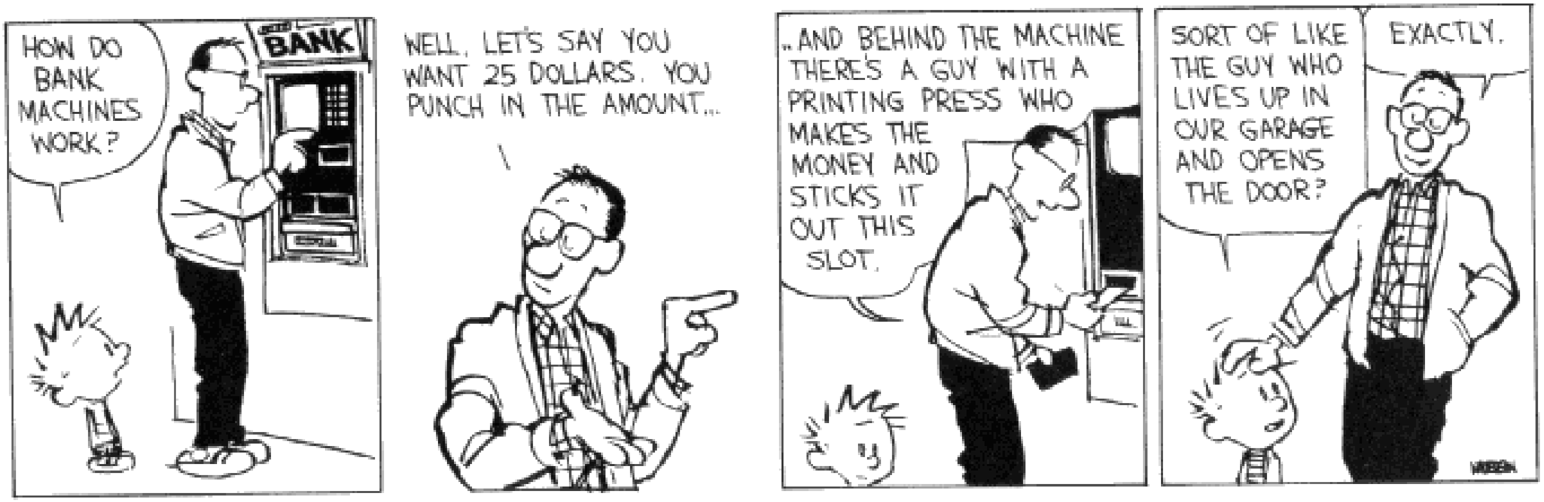
- Norman (1988)
  - The models people have of themselves, others, the environment, and the things with which they interact
- Jameson (2000)
  - User's mental model of a system is a set of beliefs about system's (perhaps unobservable) structure and how system works
  - Mental models are used to explain observable events in terms of unobservable structures and events
- What are mental models good for?
  - Predicting what will happen when the user performs some action for the first time
  - Understanding what has happened when the system shows some unexpected behavior

Mental models

- Often mental models are:
  - Partial: people do not have a full understanding of how a whole system works
  - Instable and subject to change
  - Internally inconsistent: people may not have worked through the logical consequences of their beliefs
  - Unscientific and possibly based on superstition rather than evidence
  - Based on an incorrect interpretation of the evidence
  - Parsimonious: people would rather do extra physical operation than mental planning

Mental model types

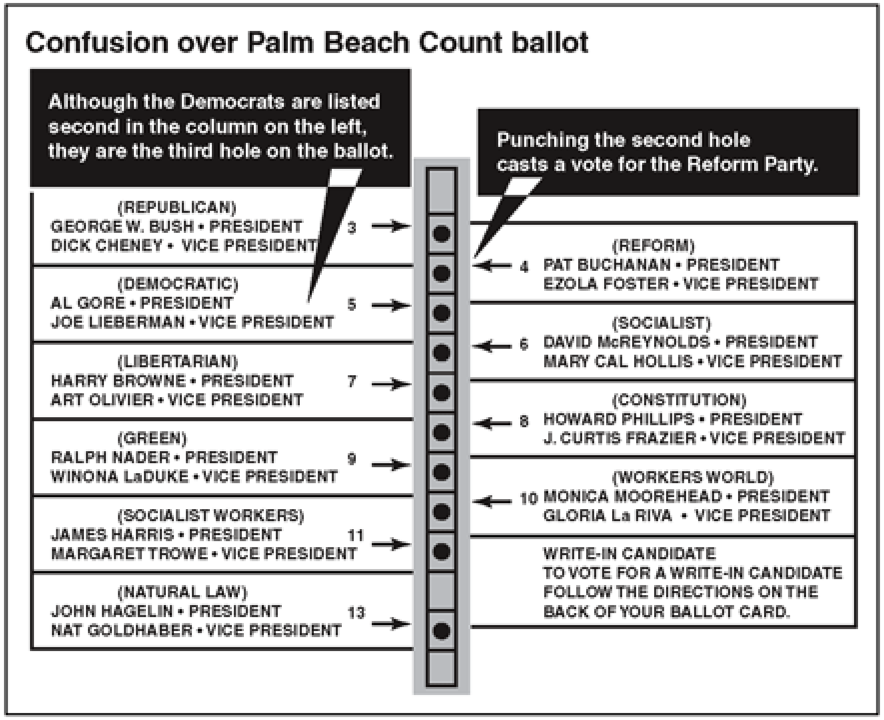
- Structural models
  - How is the composition of the “system”?
  - Example: stylized underground map
- Functional models
  - How does a system work?
  - What causes what?
- Structural models are far more common in humans

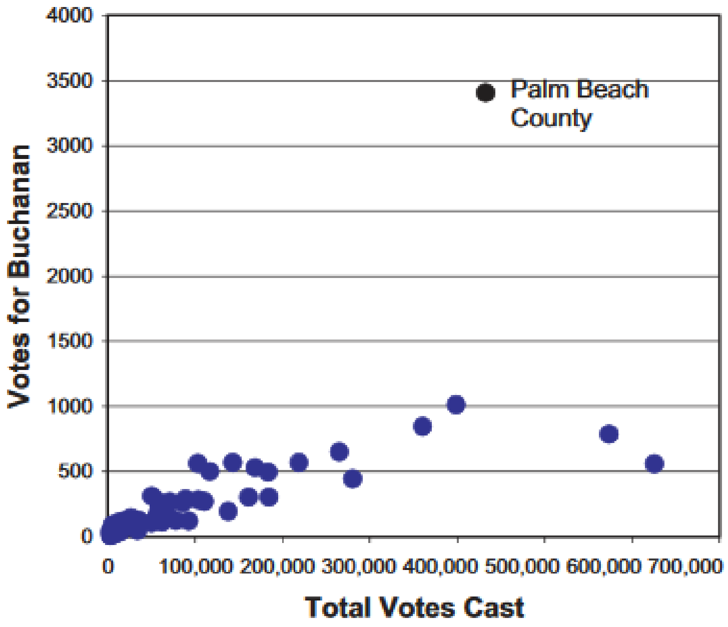


http://www.gocomics.com/calvinandhobbes

Wrong mental model example

- Palm Beach County election ballot in 2000: “butterfly ballot”





- Who is the “responsible” for errors?
  - The user or the designer?
- Good user interface design is important!!!

Emotion

- Emotion involves both physical and cognitive events
- Our emotional response to situations affects how we perform
  - Positive emotions enable us to think more creatively and to solve complex problems
  - Negative emotion pushes us into narrow, focused thinking
  - A problem that may be easy to solve when we are relaxed becomes difficult if we are frustrated or afraid
- Implications for design
  - In situations of stress people will be less able to manage difficult interfaces
  - If people are relaxed they will be more forgiving of limitations in the design
- Suggestion: interfaces that promote positive responses (aesthetics or reward) are more successful

Individual differences

- Design for all (or universal design or inclusive design)
  – Designing all products to be aesthetic and usable to the greatest extent possible by everyone, regardless of their age, ability, or status in life
  – Special needs, equal opportunities, social inclusion

Design examples

- Products designed for people with special needs …

Sliding doors with sensors

Washing machine

Accessible ATM with visual, auditory and tactile feedback

Design examples

- … that simplifies everybody's life

Typewriter
(«cembalo scrivano», 1855)

Subtitles

Speech recognition software

Design examples

- … that simplifies everybody's life

Velcro

Mixer faucet

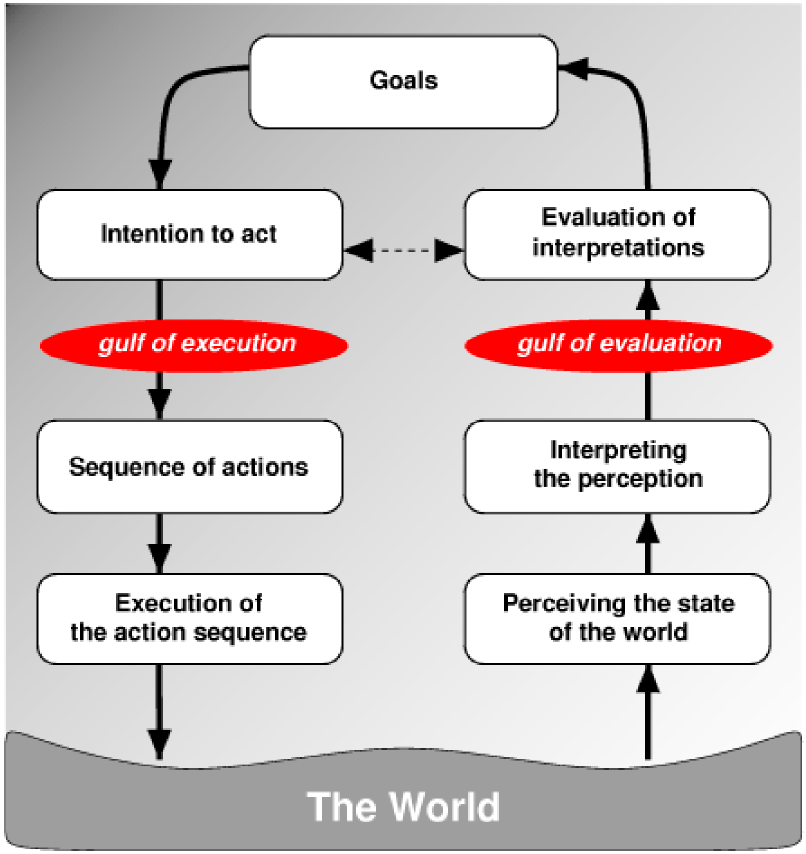
"Target ClearRx Prescription System" by Deborah Adler e Klaus Rosburg MoMA, New York

Psychology and the design of interactive systems

- Sometimes straightforward conclusions can be drawn
  - E.g., we can deduce that recognition is easier than recall and allow users to select commands from a set (such as a menu) rather than input them directly
- However, in the majority of cases, application is not so obvious or simple
- Need for tools
  - Design guidelines
  - Models for design
  - Techniques for evaluation

Interaction

- Norman's model of interaction
    1. Establishing the goal
    2. Forming the intention
    3. Specifying the action sequence
    4. Executing the action
    5. Perceiving the system state
    6. Interpreting the system state
    7. Evaluating the system state with respect to the goals and intentions
- Example: switch a light on, save a file



Norman’s model of interaction

- Gulf of execution
  - The difference between the user’s formulation of the actions to reach the goal and the actions allowed by the system
- Gulf of evaluation
  - The distance between the physical presentation of the system state and the expectation of the user
- The interface should reduce these gulfs

Norman’s model of interaction

- Human errors: slips or mistakes?
- Slips
  - You have formulated the right action, but fail to execute that action correctly
  - You understand the system well and you know exactly what to do to satisfy your goals, but perhaps you mistype or you accidentally press the mouse button at the wrong time
  - May be corrected by, for instance, better screen design
- Mistakes
  - If you don’t know the system well you may not even formulate the right goal
  - For example, you may think that the magnifying glass icon is the ‘find’ function, but in fact it is to magnify the text
  - Require far more radical redesign or improved training, perhaps a totally different metaphor for use

Interaction styles

- The dialog between the computer and the user
- Most common interface
  - Command line interface
  - Menus
  - Natural language
  - Question/answer and query dialog
  - Form-fills and spreadsheets
  - WIMP (windows, icons, menus and pointers)
  - Point and click (web)
  - Three-dimensional interfaces

References

- A. Dix, J. Finlay, G. D. Abouw, R. Beale, “Human-Computer Interaction, 3rd Edition”, Pearson
- I. Scott MacKenzie, “Human-Computer Interaction. An Empirical Research Perspective”, Elsevier

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