Introduction to Human-Computer Interaction

"The best way to predict the future is to invent it."
Alan Kay (XEROX PARC)

http://www.irit.fr/~Philippe.Truillet

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Evaluation

- Group project
  - Report
  - Low-Fidelity Prototype
  - High-Fidelity Prototype

Special thanks to …

- This lecture is inspired from:
  - Sylvie Athènes
  - Patrick Baudisch
  - Michel Beaudoin-Lafon
  - Stéphane Chatty
  - Emmanuel Dubois
  - Jean-Daniel Fekete
  - Scott McCrickard
  - Philippe Palanque
  - Jean-Luc Vinot

  and many other people …

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Another quote

« *I have always wished for my computer to be as easy to use as my telephone; my wish has come true because I can no longer figure out how to use my telephone.* »

Bjarne Stroustrup (designer of C++)

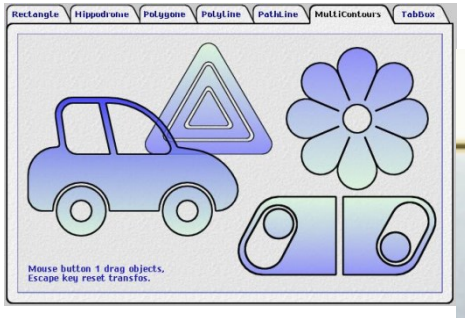
In your opinion ...

When was this machine?

Xerox Star 8010 (april 1981)

What is the **difference** with current computers?

Meanwhile…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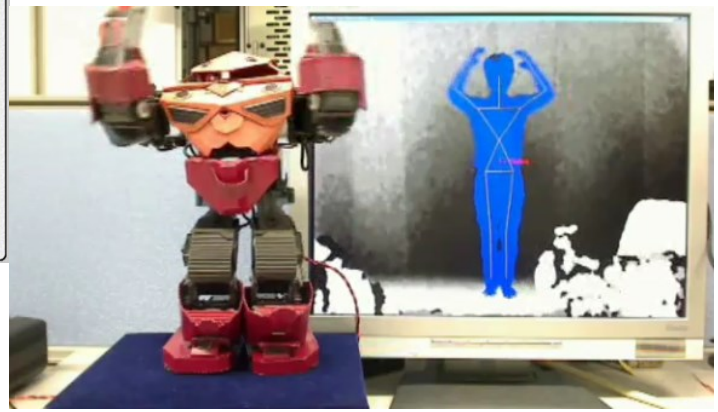

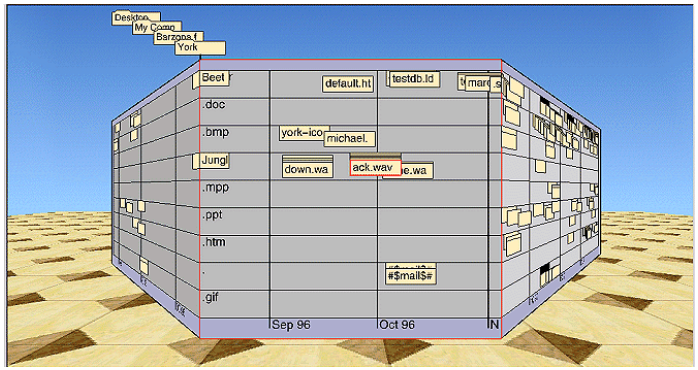
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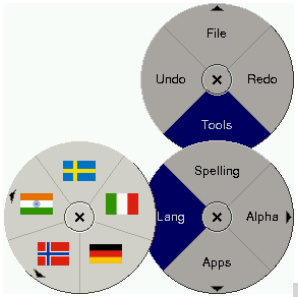
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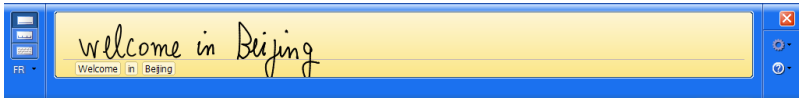
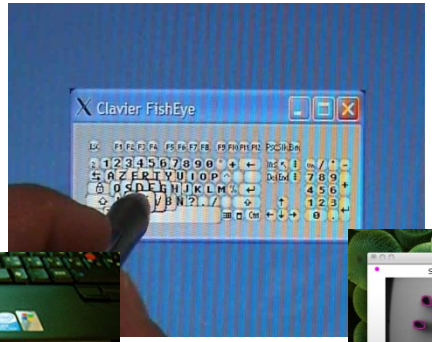
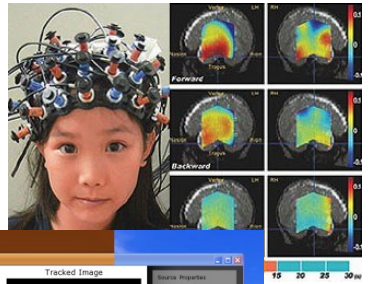
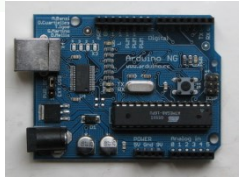
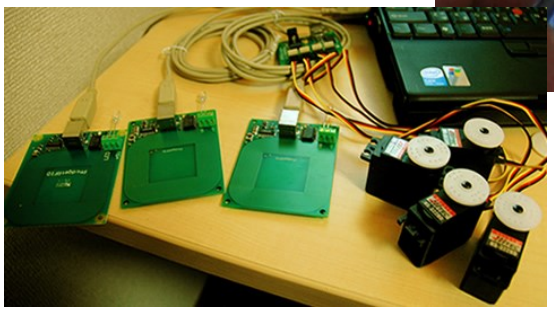
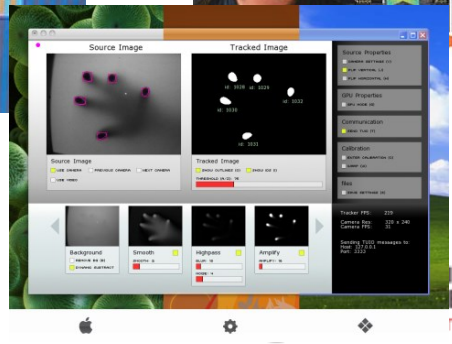

welcome in Beijing
Welcome
in
Beijing


Clavier FishEye








Source Image
Tracked Image

Why HCI is so important?

- The study of an interface with information.
  - It is not just 'how big should I make buttons' or 'how to layout menu choices'
  - It can affect
    - Effectiveness
    - Productivity
    - Morale
    - Safety

Example: a car with poor HCI

- Take 5 minutes to write down one common device with substantial HCI design choices and discuss with the neighbor the pros and cons. How does it affect you or other users?

What is HCI?

- **The Human**
  - Single user, groups, I/O channels, memory, reasoning, problem solving, error, psychology
- **The Computer**
  - Desktop, embedded system, data entry devices, output devices, memory, processing
- **The Interaction**
  - Direct/indirect communication, models, frameworks, styles, ergonomics

What do humans do well?

- Sense low level stimuli
- Pattern recognition
- Inductive reasoning
- Multiple strategies
- Adapting
- “Hard and fuzzy things”

What do computers do well?

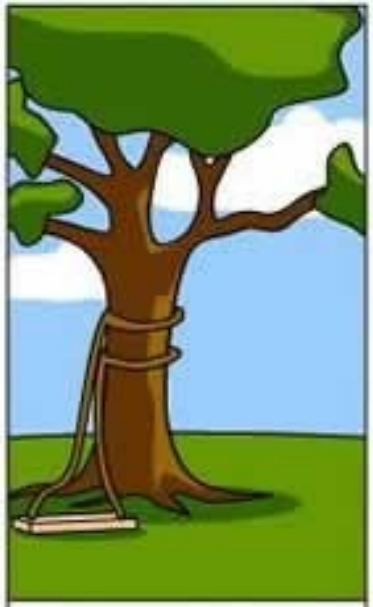
- Counting and measuring
- Accurate storage and recall
- Rapid and consistent responses
- Data processing/calculation
- Repetitive actions
- “Simple and sharply defined things”

	HUMAN	COMPUTER
STRENGTHS	Powerful pattern recognition Powerful selective attention Capacity to learn Infinite-capacity LTM Rich, multikeyed LTM	High-capacity memory "Permanent" memory Very fast processing Error-free processing Reliable memory access
WEAKNESSES	Low-capacity working memory Fast-decaying working memory Slow-processing Error prone processing Unreliable access to LTM	Simple template matching Limited learning capacity Limited-capacity LTM Limited data integration

How the customer explained it

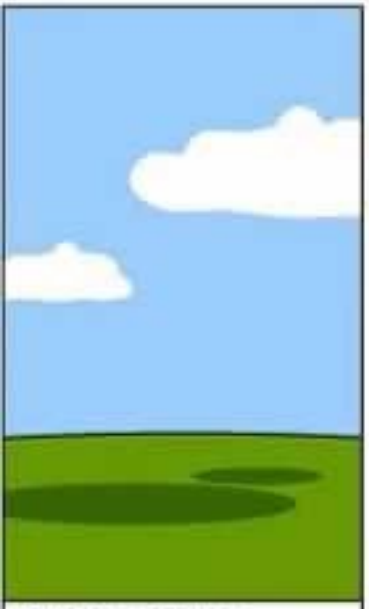
How the Project Leader understood it

How the Analyst designed it

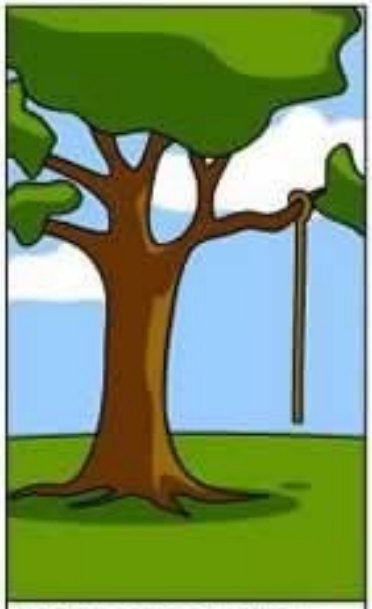


How the Programmer wrote it

How the Business Consultant described it

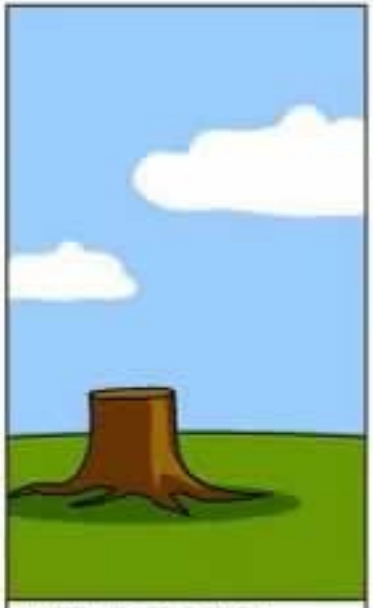


How the project was documented



What operations installed

How the customer was billed

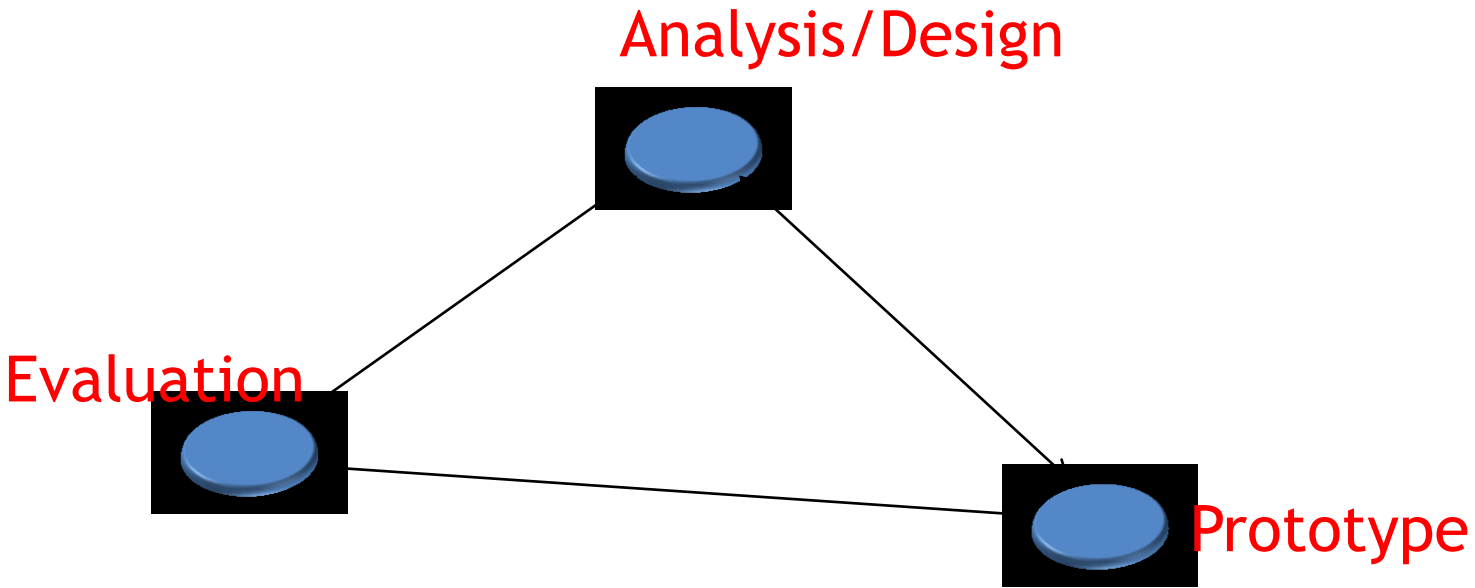


How it was supported

What the customer really needed

« Au programme »

- Introduction to HCI, issues
- The triptych of HCI



interface or interaction?

Interface Homme-machine - Wikipédia - Mozilla Firefox

Fichier Édition Affichage Historique Marque-pages Outils ?

http://fr.wikipedia.org/wiki/IHM

définition IHM

Hotmail SafeSMS Personnaliser les liens Windows Media Windows Déconnexion Le streaming avec JMF l'API Java Sound Présentation de Java...

Créer un compte ou se connecter

article discussion modifier historique

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- Modifications récentes
- Accueil des nouveaux arrivants
- Faire un don

Rechercher

Consulter
Rechercher

Interface Homme-machine

(Redirigé depuis IHM)

L'**interface Homme-machine** ou **interaction humain-machine** (IHM) étudie la façon dont les humains interagissent avec les ordinateurs ou entre eux à l'aide d'ordinateurs, ainsi que la façon de concevoir des systèmes informatiques qui soient ergonomiques, c'est-à-dire efficaces, faciles à utiliser ou plus généralement adaptés à leur contexte d'utilisation.

Sommaire [masquer]

Les technologies [modifier]

http://fr.wikipedia.org/w/index.php?title=IHM&redirect=no

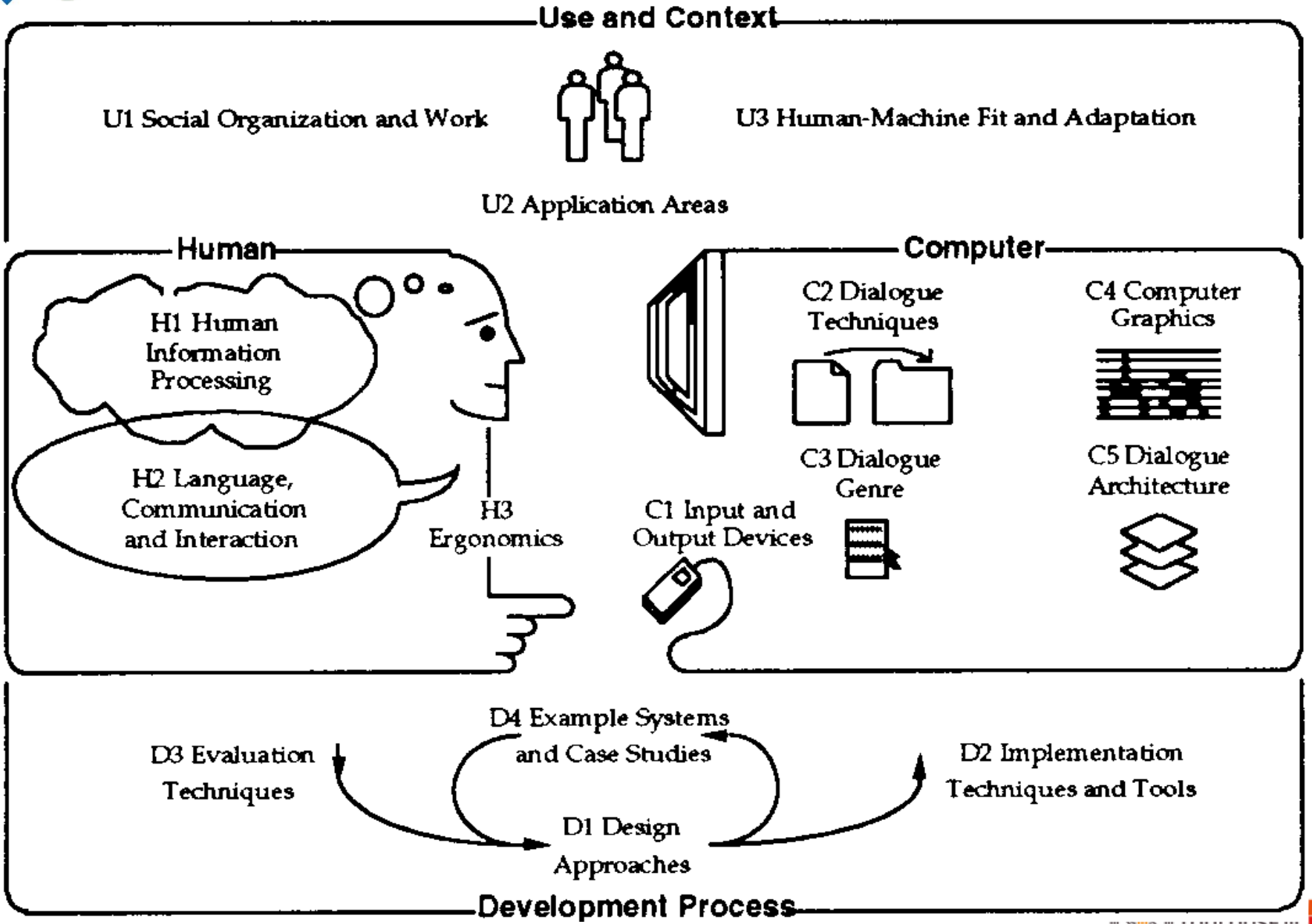
interface or interaction?

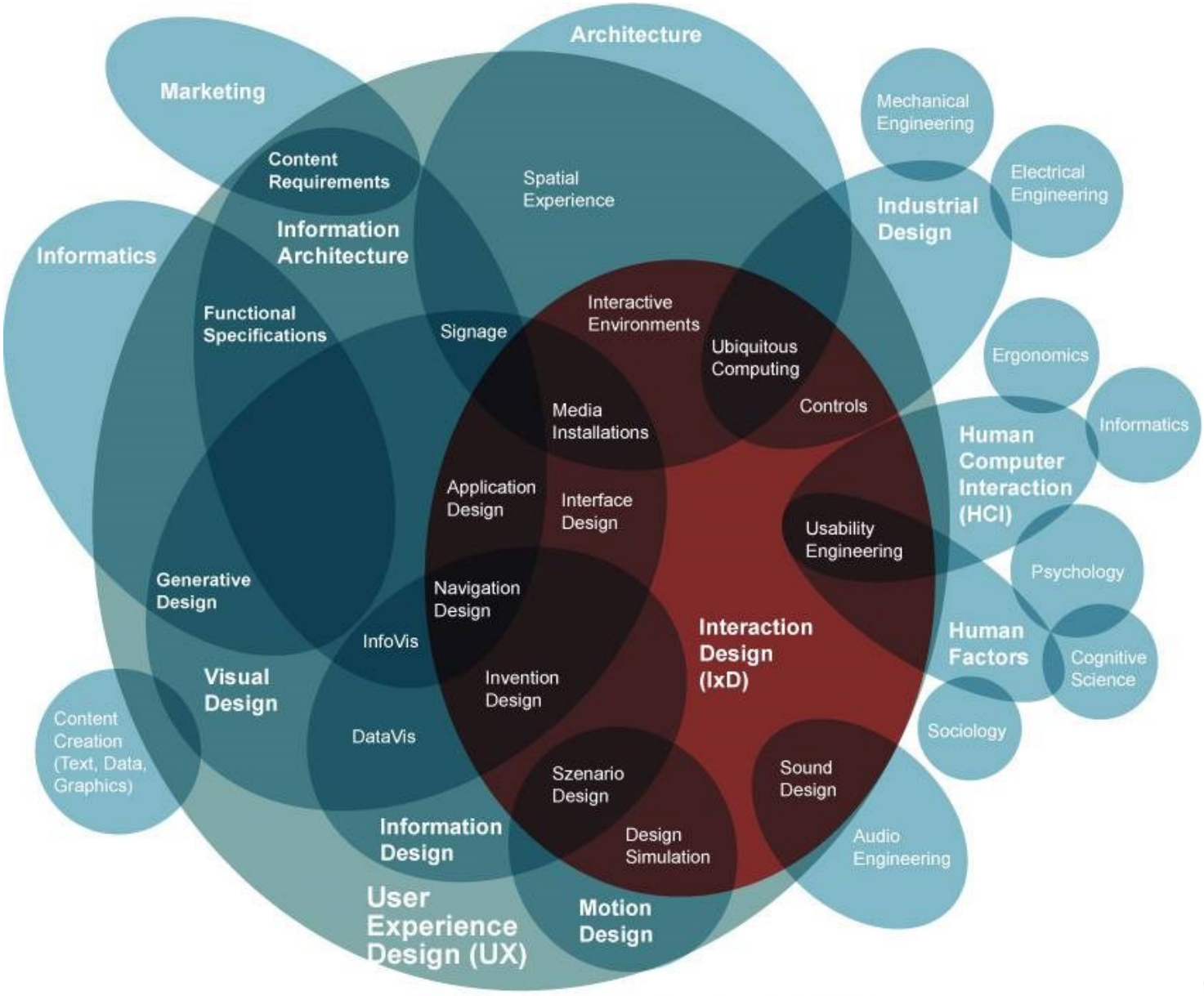
- 50 years in HCI
  https://interstices.info/50-ans-dinteraction-homme-machine-retours-vers-le-futur/

Visicalc (1979)

A Head-Mounted Three Dimensional Display(1968)

Digital Desk (1993)


Use and Context
U1 Social Organization and Work
U3 Human-Machine Fit and Adaptation
U2 Application Areas
Human
H1 Human Information Processing
H2 Language, Communication and Interaction
H3 Ergonomics
Computer
C2 Dialogue Techniques
C4 Computer Graphics
C3 Dialogue Genre
C5 Dialogue Architecture
C1 Input and Output Devices
D4 Example Systems and Case Studies
D3 Evaluation Techniques
D2 Implementation Techniques and Tools
D1 Design Approaches
Development Process



definition

Computer-Human Interaction

- **Human–computer interaction** (**HCI**) is the study of interaction between people (users) and computers. It is often regarded as the intersection of computer science, behavioral sciences, design and several other fields of study.

conferences

- CHI, UIST, NordiCHI,… (ACM)
- Interact (IFIP)
- HCI (BCS)
- IHM (AFIHM)
- HCI International
- …
- TEI, ITS, … (ACM)

websites (recommanded)

- http://dl.acm.org 

- http://interactions.acm.org 

- https://hxd.research.microsoft.com/work/being-human-human-computer-interaction-in-the-year-2020.php (**2008**)

Bibliography

- The Design of Everyday Things, Norman, MIT Press, 4th printing, 2001
- The Psychology of HCI, Card, Moran & Newell, Lawrence Erlbaum, 1983
- Usability Engineering, Rosson, Carroll, Morgan Kaufmann Publishers, 2002
- Designing the user interface, Shneiderman, Plaisant, Pearson Eds, 4th edition, 2005
- …

A Credo

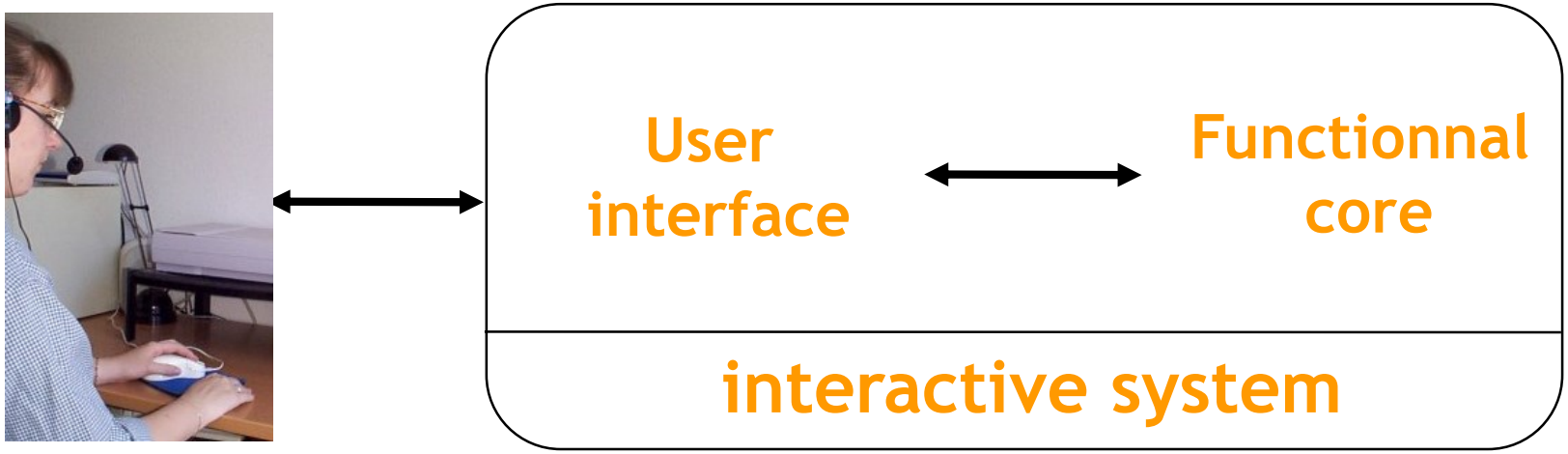
Augmentation, not automation

- "I tell people: look, you can spend all you want on building **smart agents and smart tools…**

- I'd bet that if you then give those to twenty people with no special training, and if you let me take twenty people and really condition and **train them** especially to learn how to **harness the tools…**

- The **people with the training will always outdo** the people for whom the computers were supposed to do the work."

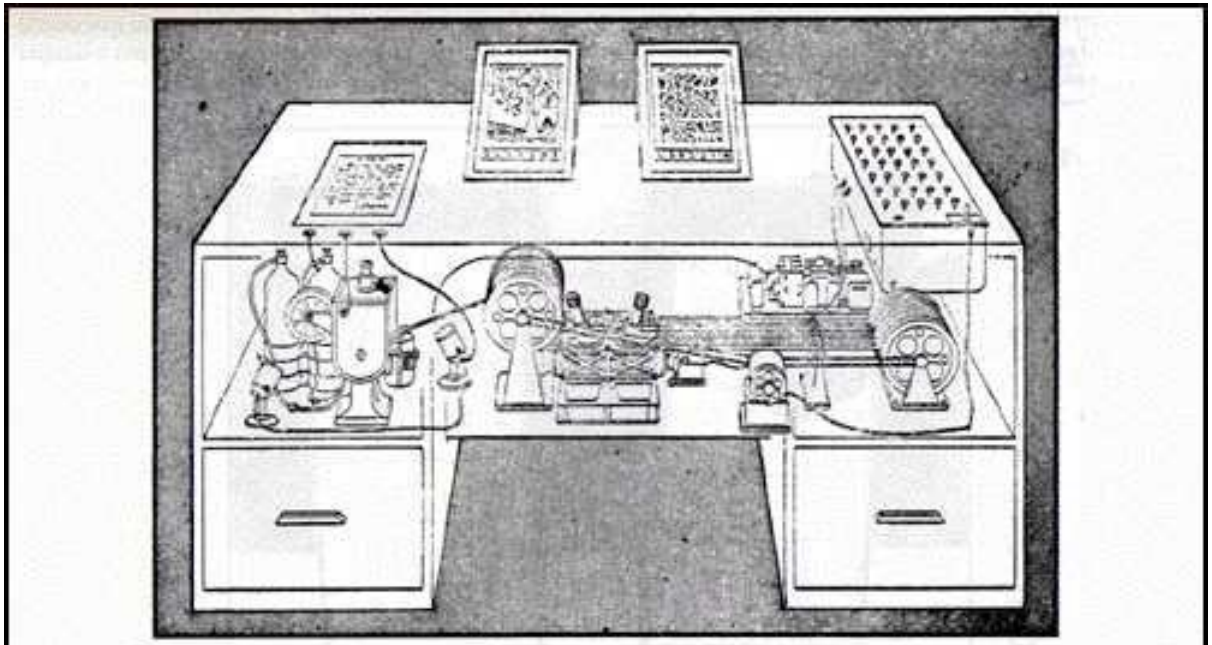
Interactive systems



History of HCI

- Memex (Bush, 1945) : "as we may think"

"*…when one of these items is in view, the other can be instantly recalled merely by tapping a button*"



Memex in the form of a desk would instantly bring files and material on any subject to the operator's fingertips. Slanting translucent viewing screens magnify supermicrofilm filed by code numbers. At left is a mechanism which automatically photographs longhand notes, pictures and letters, then files them in the desk for future reference (*LIFE* 19(11), p. 123).

“as we may think”

- published in the **atlantic monthly in 1945!**
- (reprint communications of the ACM)
- futuristic inventions / trends ?
  - wearable cameras for photographic records
  - encyclopedia britannica for a nickel
  - automatic transcripts of speech
  - memex
  - trails of discovery
  - direct capture of nerve impulses

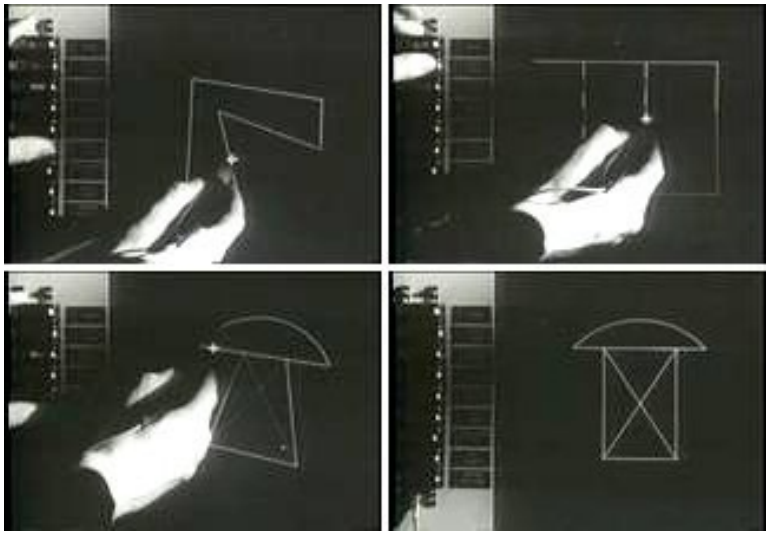
History of HCI

- Xanadu (Nelson, 1960)
  - 1st project on hypertext

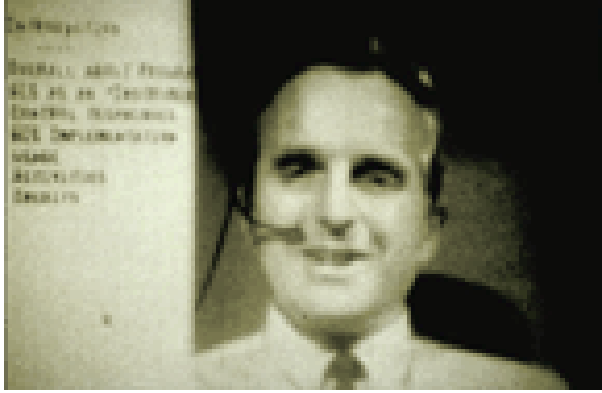
Still an active project → Xanadu Space (2007)
http://xanadu.net

History of HCI

- Sketchpad (Sutherland, 1963)
  - direct manipulation of geometric forms with the optical pen (MIT)

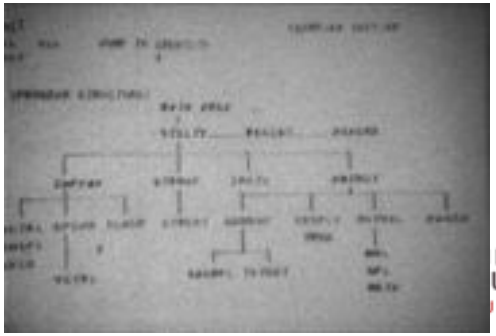


History of HCI

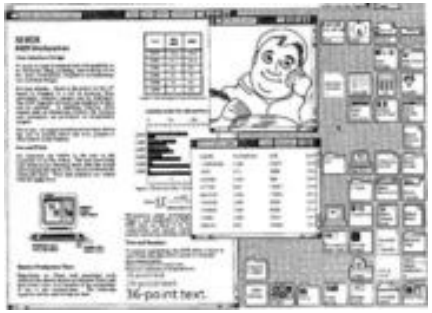


- NLS/Augment (Engelbart, 1968)
  - first **mouse**
  - first **word processing & 2D editing**
  - first implementation of **hypertext**

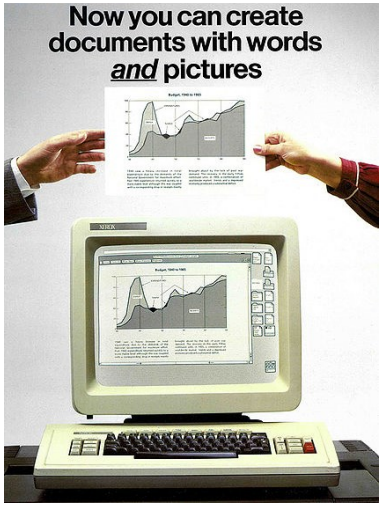
  - first document **version control**
  - first **groupware** (shared screen teleconferencing)
  - first **context-sensitive help**
  - many, many more!

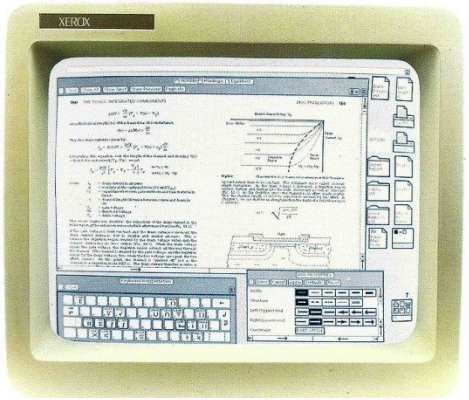


History of HCI 5/8



- Star (Xerox PARC, 1981)
  - Windows
  - Menus
  - Scrollbars
  - Pointing
  - Consistency





- Xerox was the first to have
  - Bitmap display
  - Graphical user interface, desktop metaphor
  - Ethernet, Laser printing

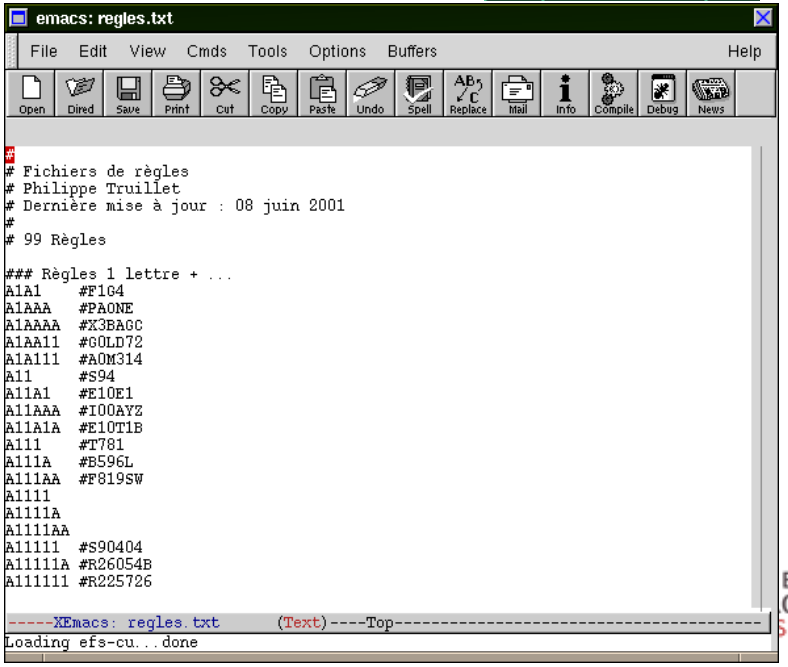
History of HCI

- Macintosh (Apple, 1984)
  - Menu bar
  - Modal dialog box

A huge success

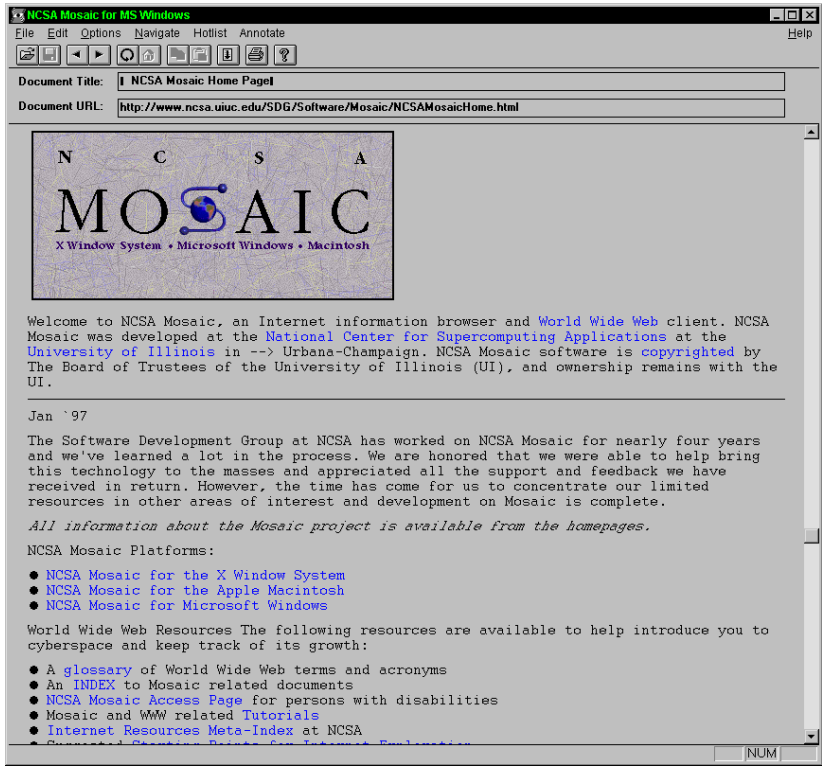
History of HCI

- X-Window (MIT, 1985)
  - client/server model
    - what/how separation
    - Transparency use of network



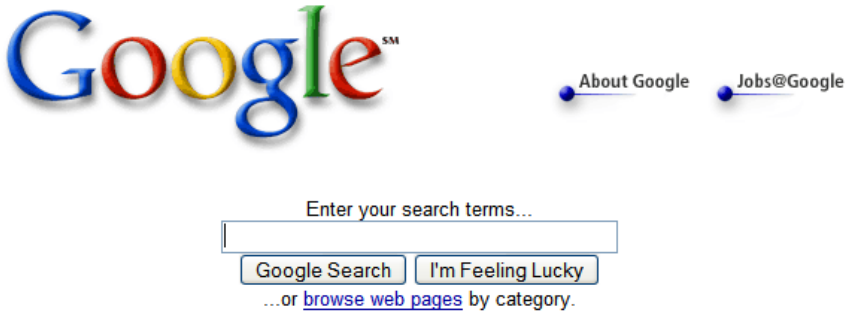
History of HCI

- World-Wide Web (Berners-Lee, CERN, 1990)
  - Hypertext model
  - poor protocol
  - poor interactive possibilities



Function vs Usage

- Less is more!

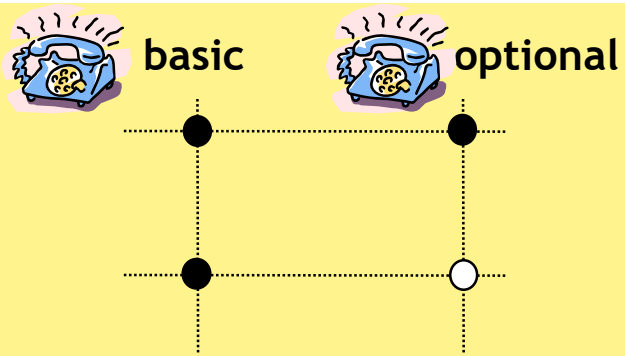


HCI Goals

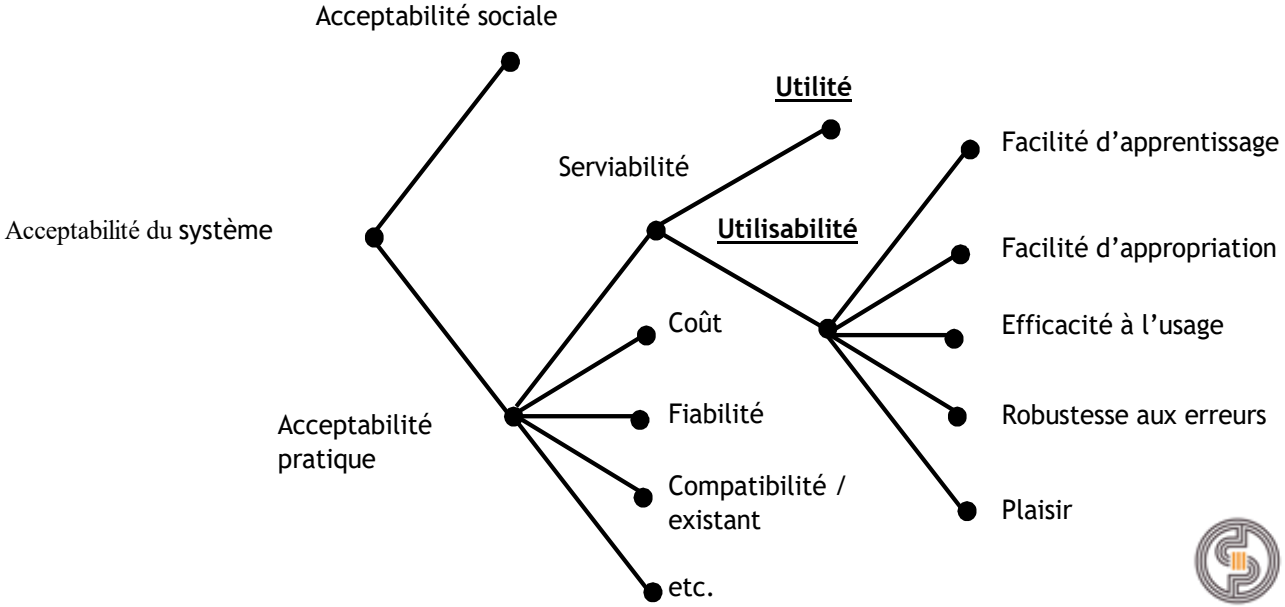
- **Influence academic and industrial researchers**
  - Understand a problem and related theory
  - Hypothesis and testing
  - Study design (we'll do this!)
  - Interpret results
- **Provide tools, techniques and knowledge for commercial developers**
  - competitive advantage (think ipod)
- **Raising the computer consciousness of the general public**
  - Reduce computer anxiety (error messages)
  - Common fears:
    - I'll break it
    - I'll make a mistake
    - The computer is smarter than me
  - HCI contributes to this!

U & U

- **usability**
  = adequacy to user needs

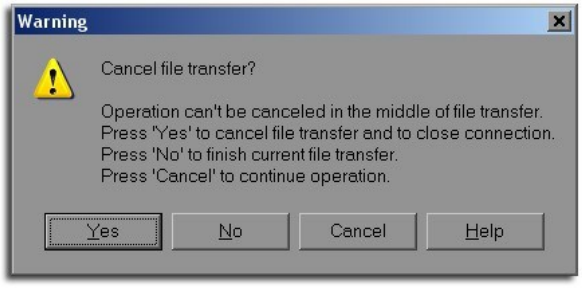


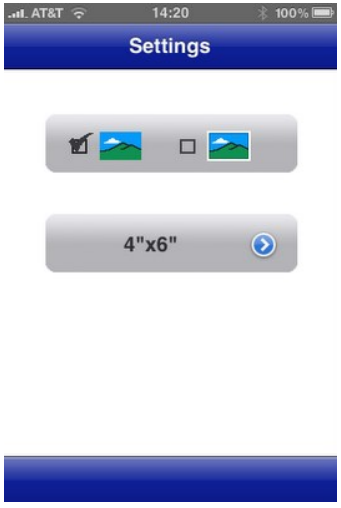
- **utilisability**
  = adequacy to user capabilites

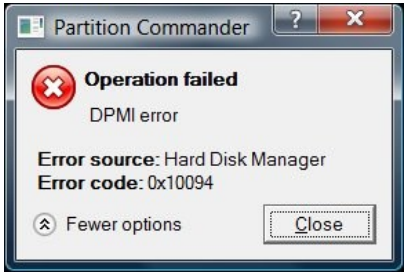


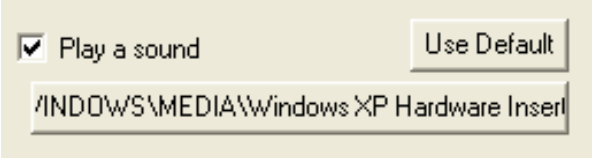
Bad design examples

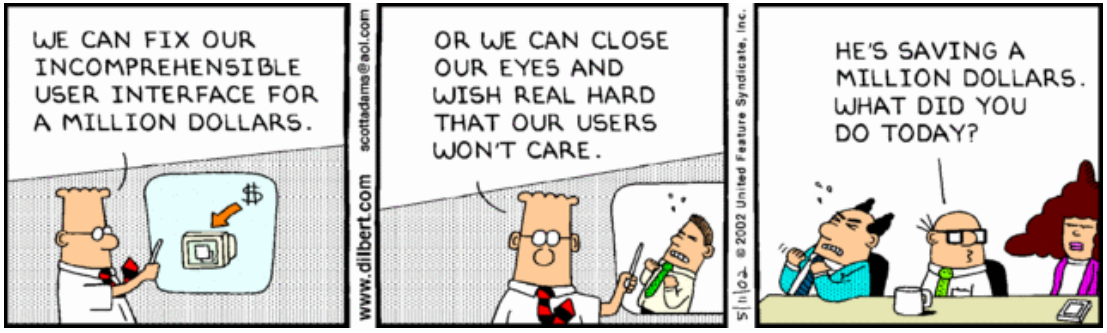
- ambiguous text
- un-useful functionalities
- not well structured screens
- too much screens
- unknown context
-



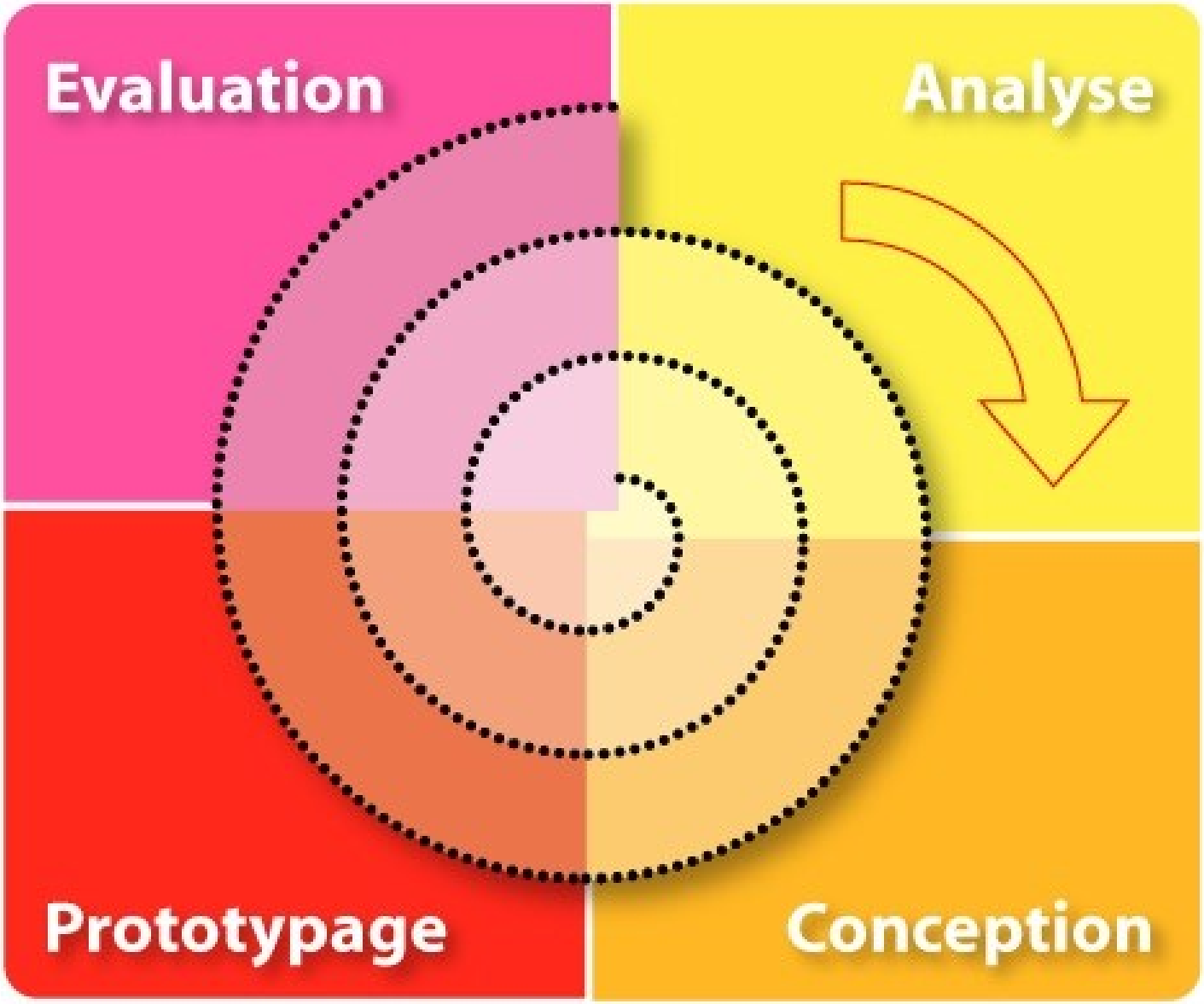








A main cycle …



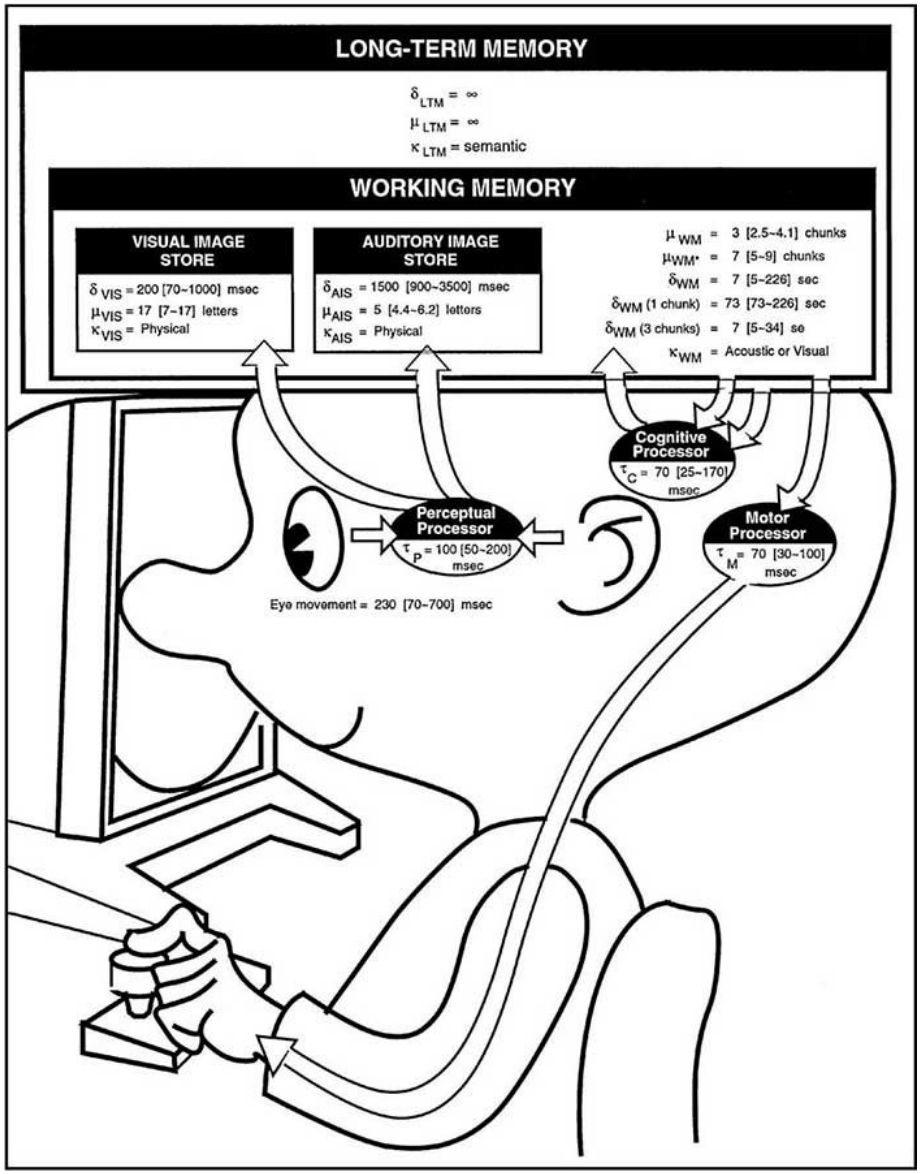
Analysis

- Understand and take into account the user

- Understand « tasks » of the users
  - Task models (low-lewel like GOMS, Keystroke or more high-level as CTTE, …)
  - Observations, questionnaires, …

Human models

- Perception capabilities?
- Processing capabilities?
- Action capabilities?



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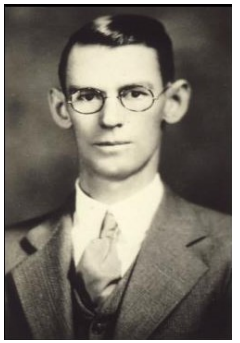
Perception

context



- Stroop's task [1935]

green
red
blue
orange
black
purple

green
red
blue
orange
black
purple

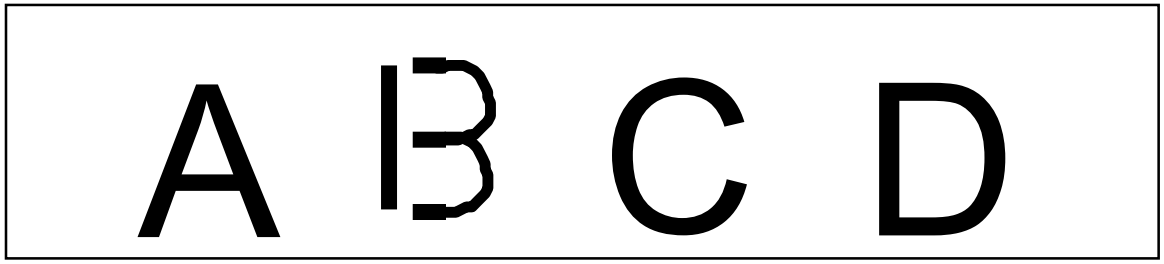
perception

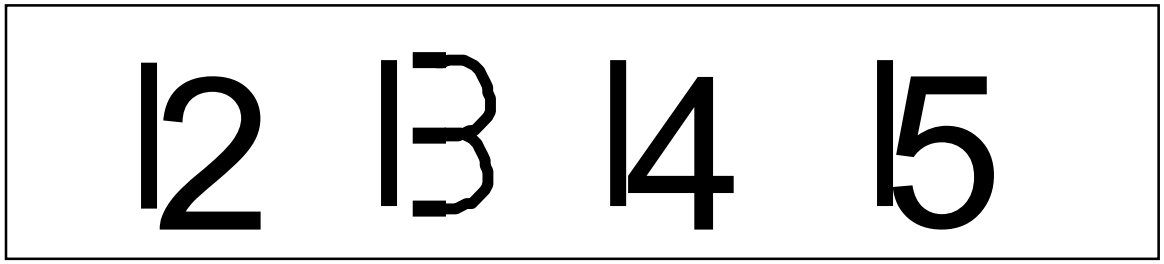
context

- automatic and non intentional process
  - interferency effect
    - required time to name the color is more important when the word is not written in the same color
  - or facilitation effect
    - required time to name the color is less important when the word is written in the congruent color

Perception
context

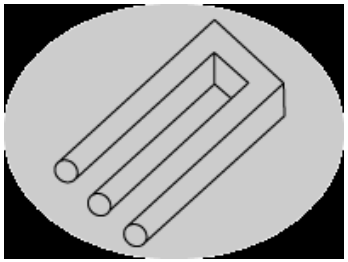
- context is important to perceive information

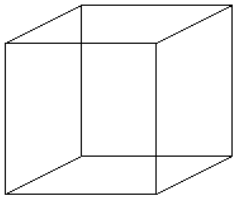


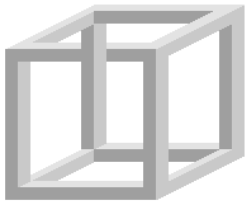


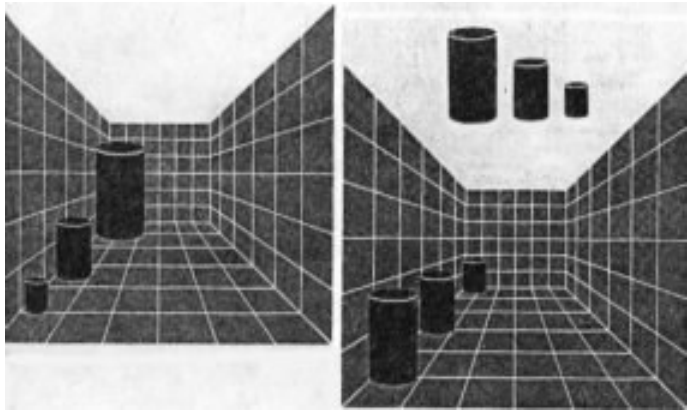
perception

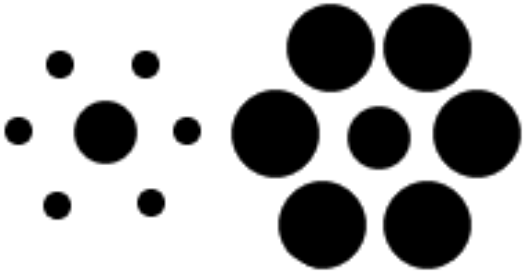
context

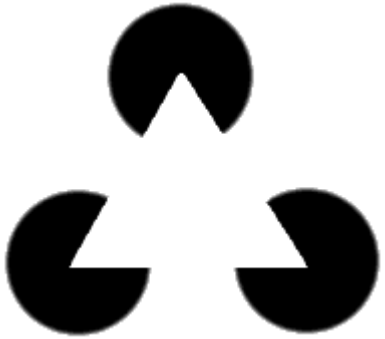


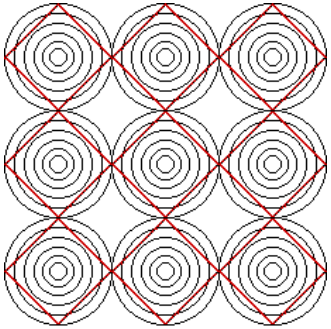


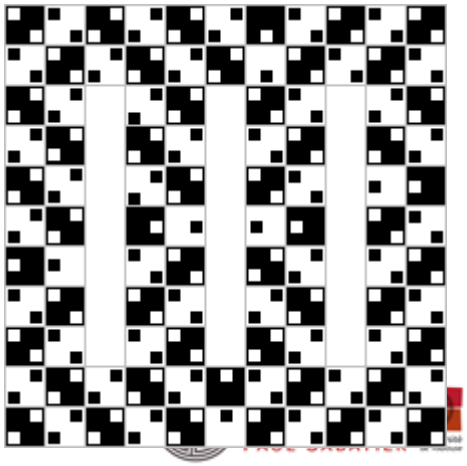










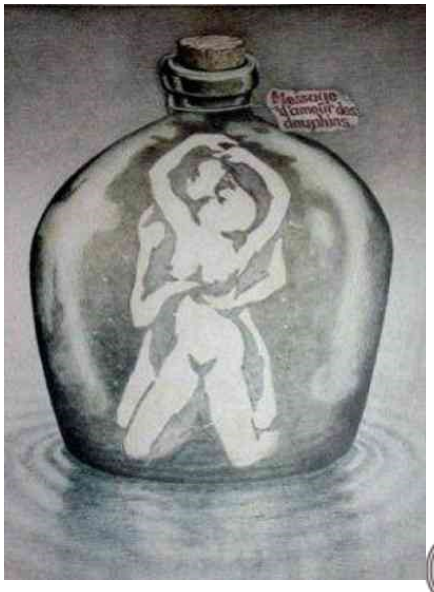


perception

comprehension

- We perceived more easily what make sense for us

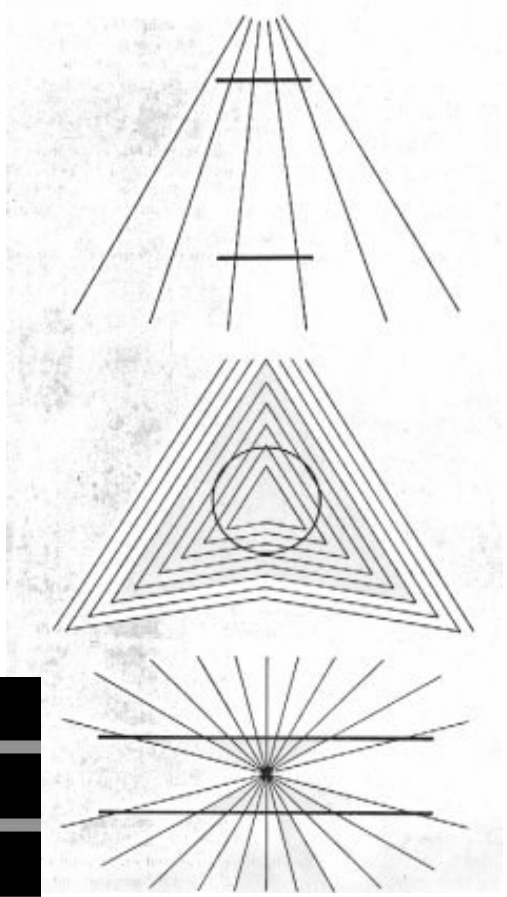
  - HEC ATR ANU PTH ETR EET
  - THE CAT RAN UP THE TREE



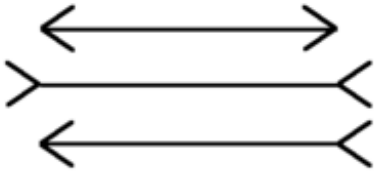
perception

sensations

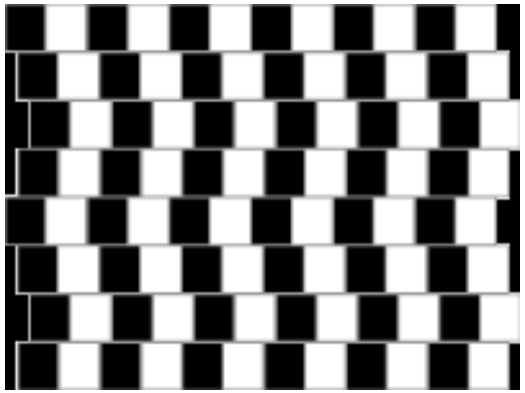
- Luckiesh' pictures (1965)

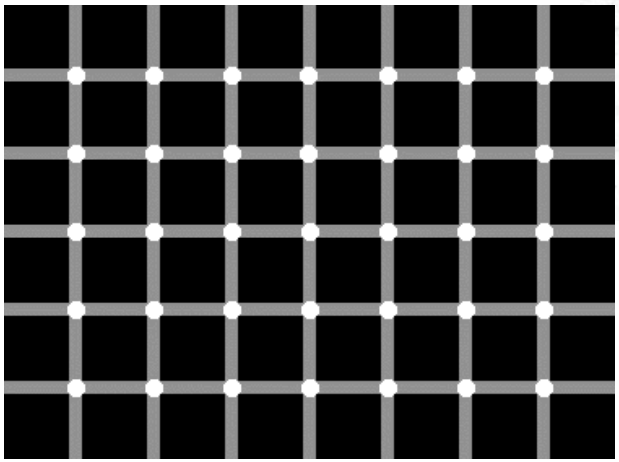


- Müeller-Lyer' illusion (1889)



- …

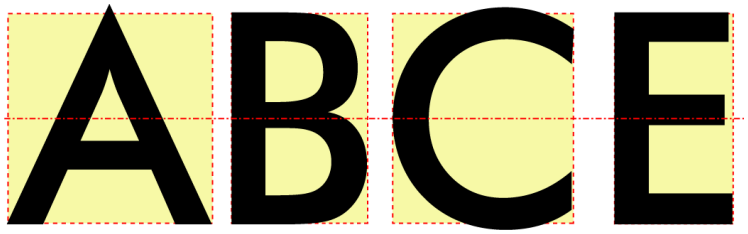




perception

corrective illusion

- optic effects and correction



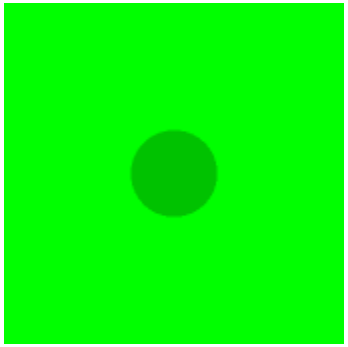
B612 Font - http://b612-font.com/

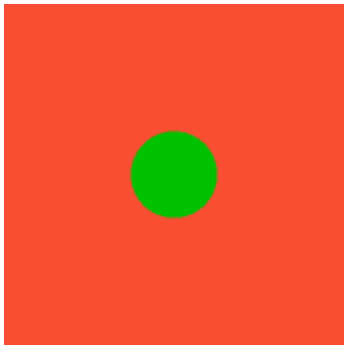
OpenDyslexic Font https://opendyslexic.org/

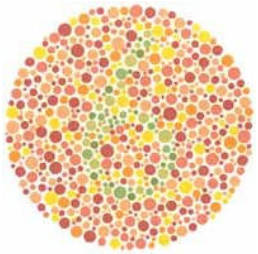
perception

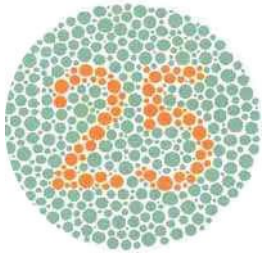
contrast

- simultaneous contrast
  - color interaction
  - optic instability

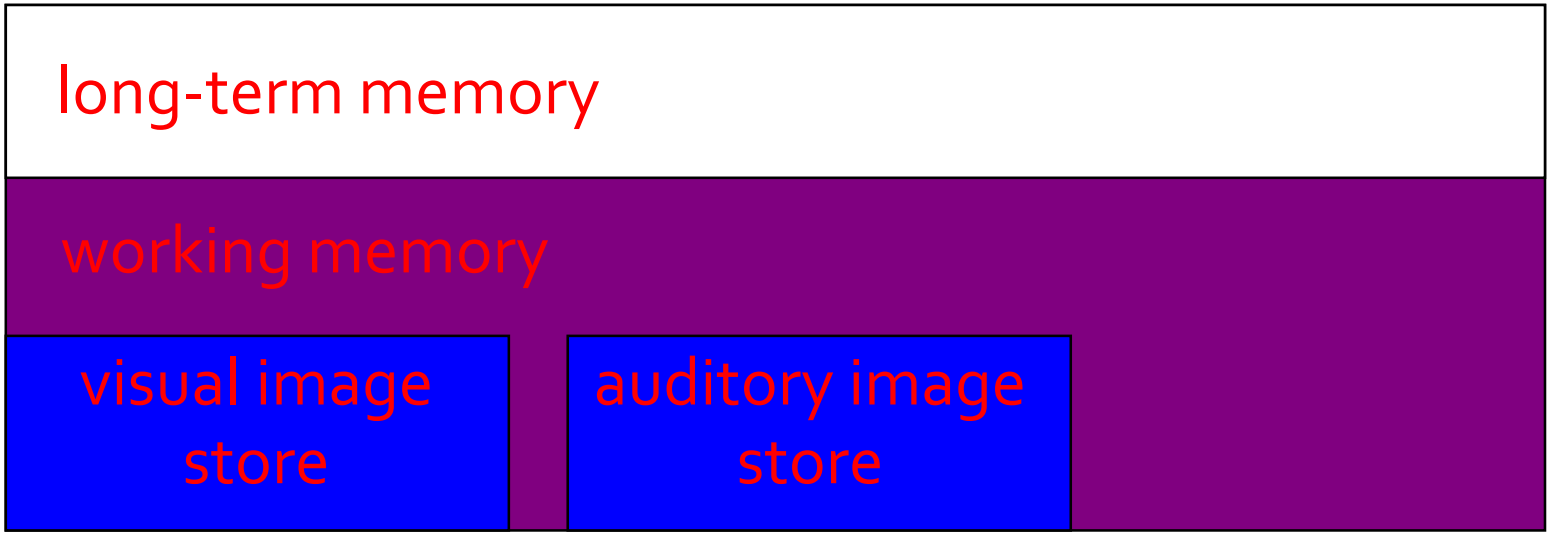








model human processor

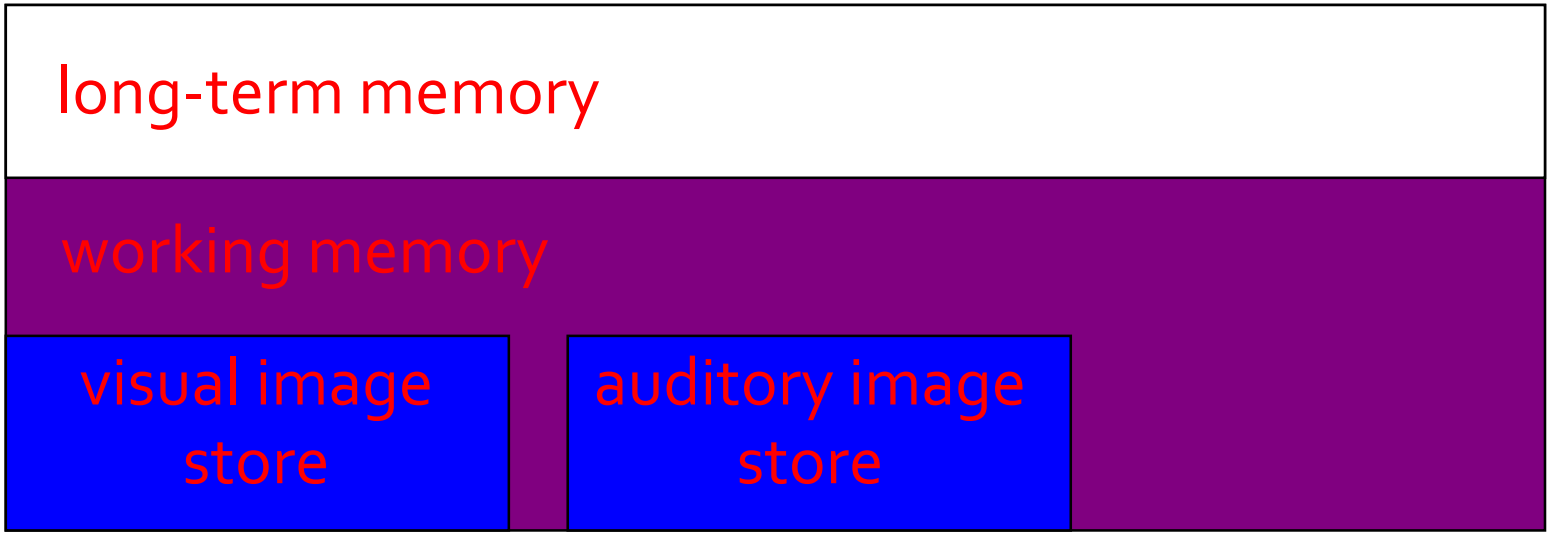


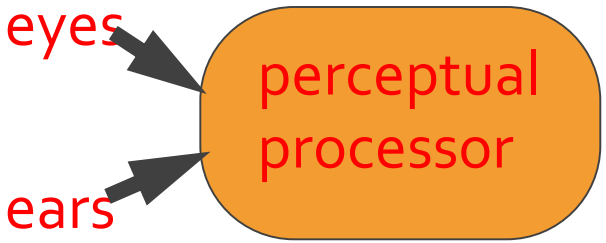
[Card, Moran, & Newell '83] based on empirical data

eyes

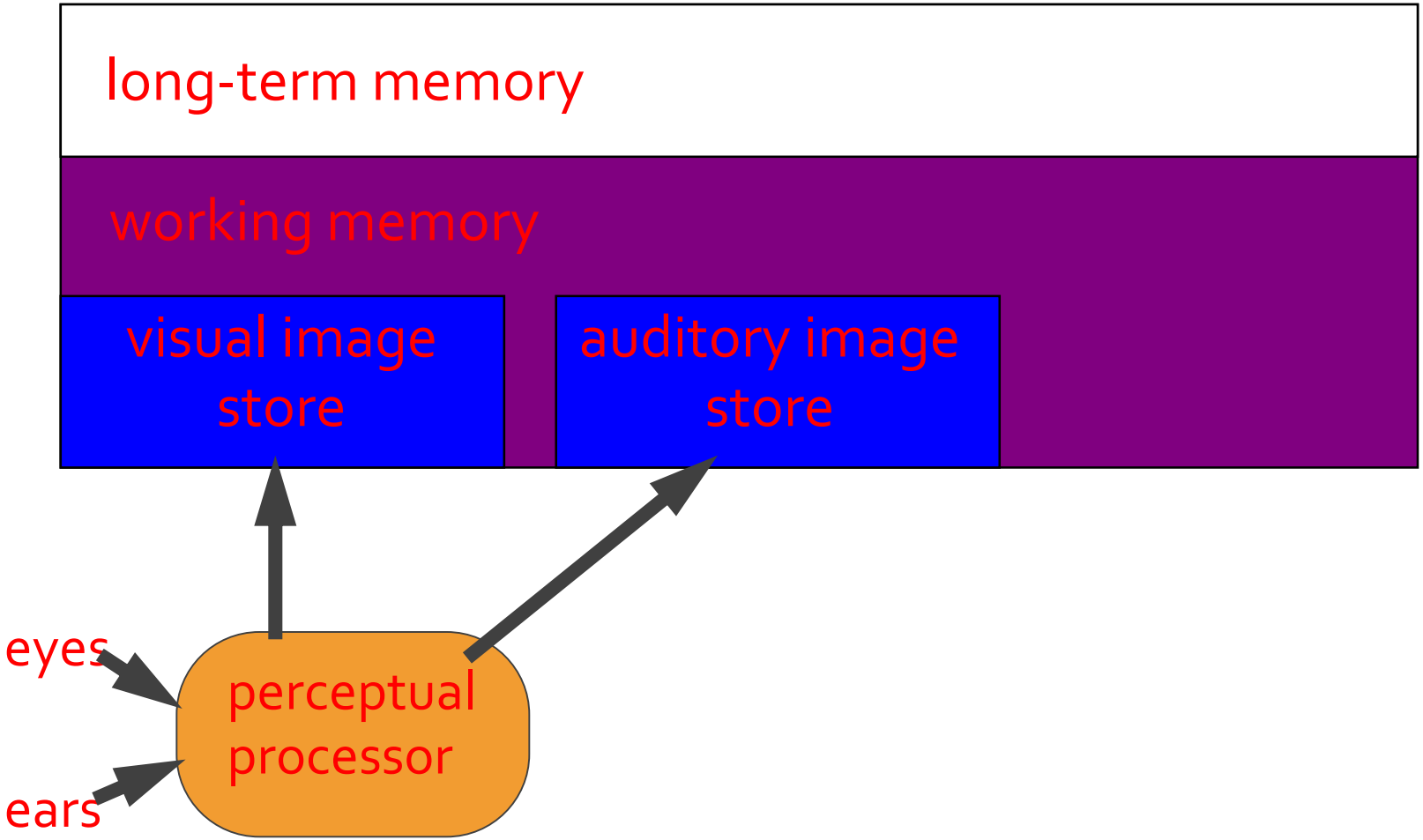
ears

model human processor

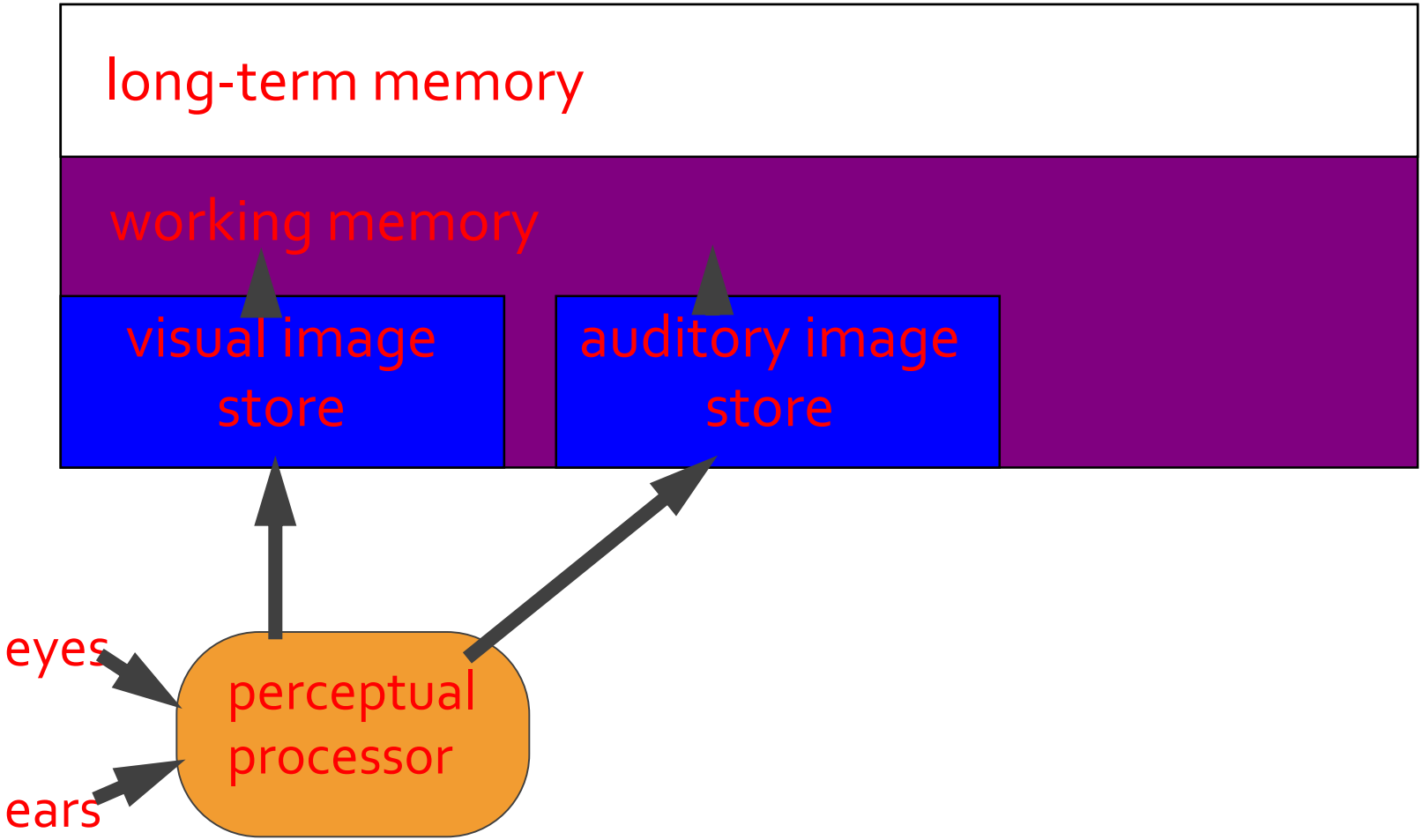




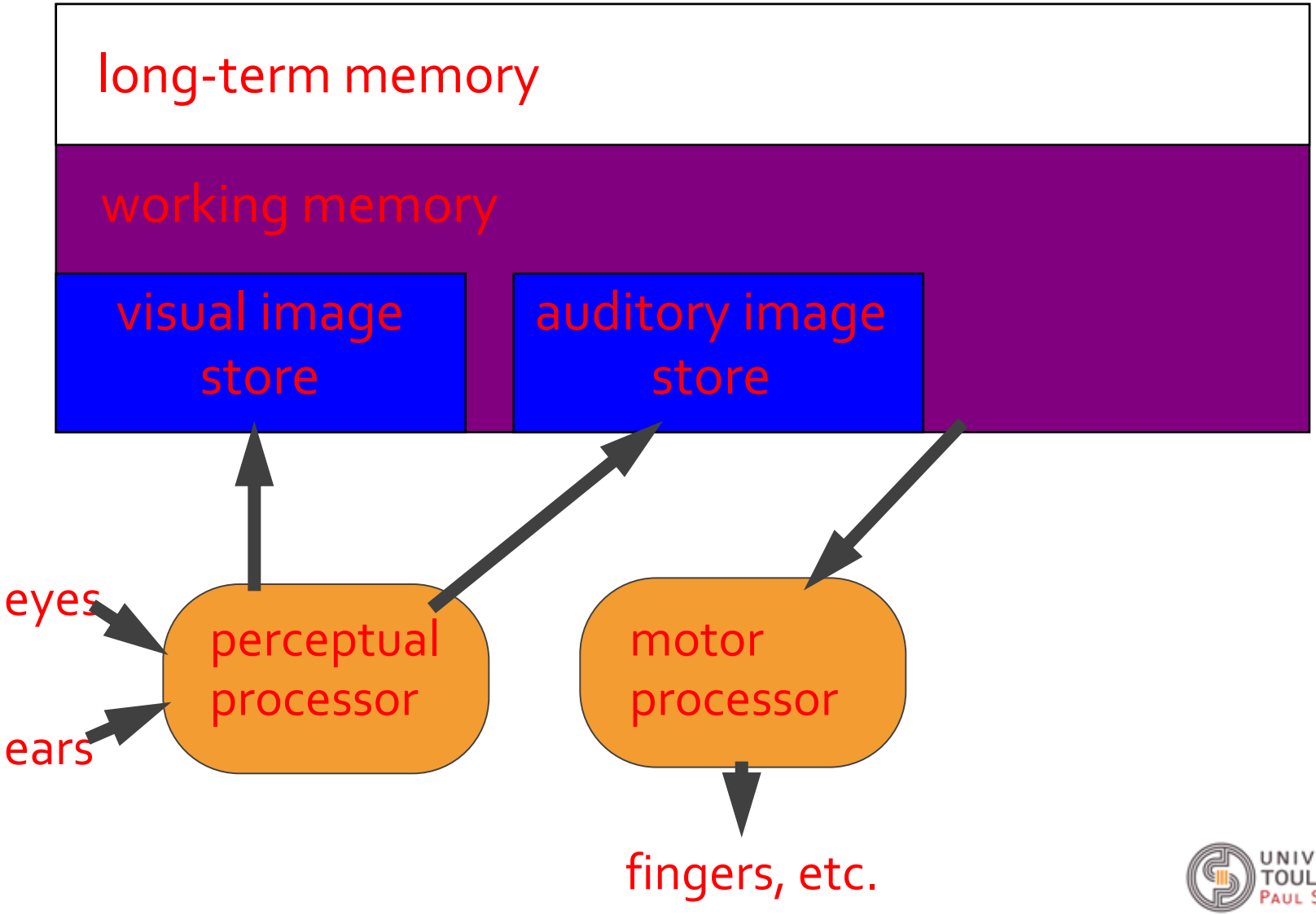
model human processor



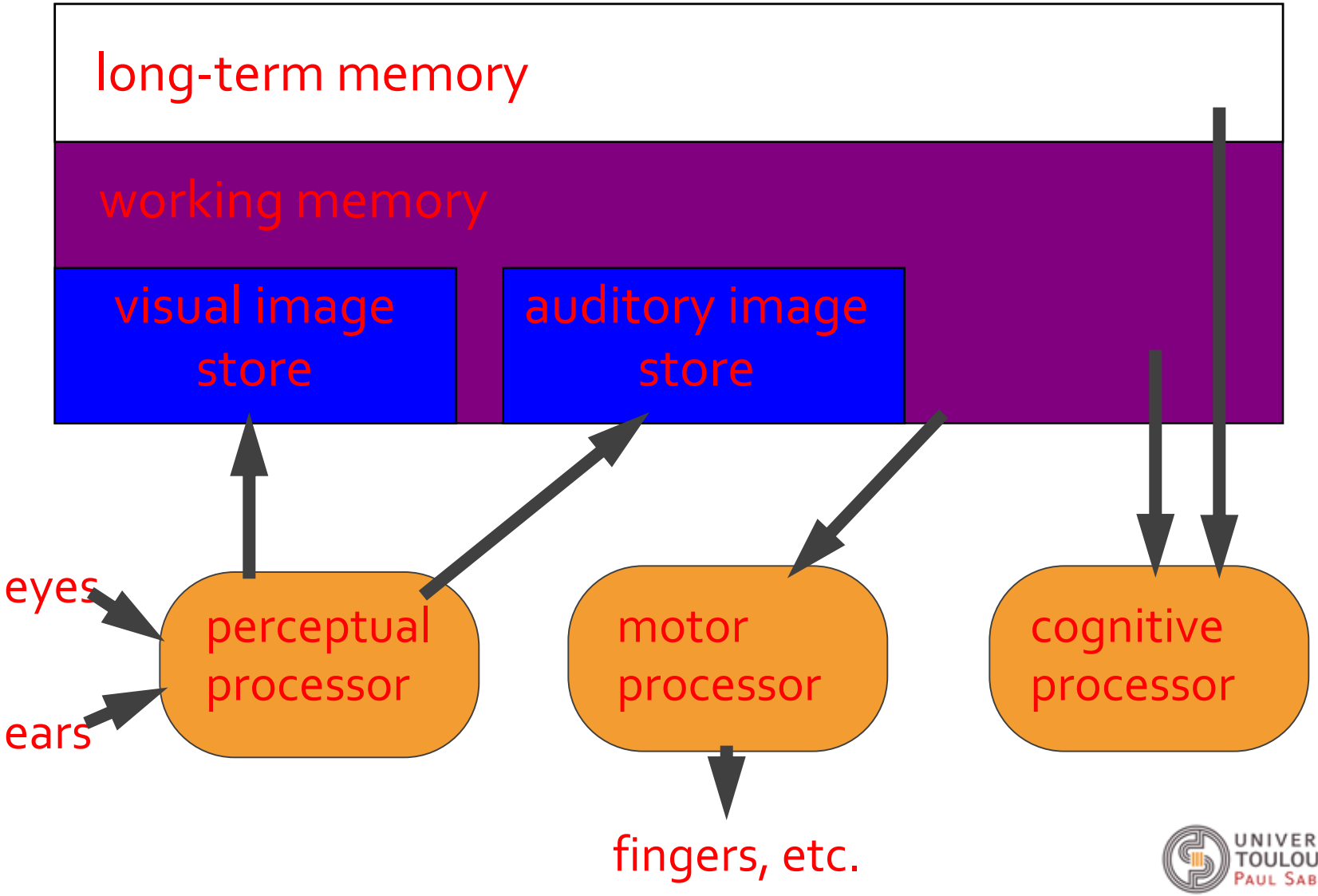
model human processor



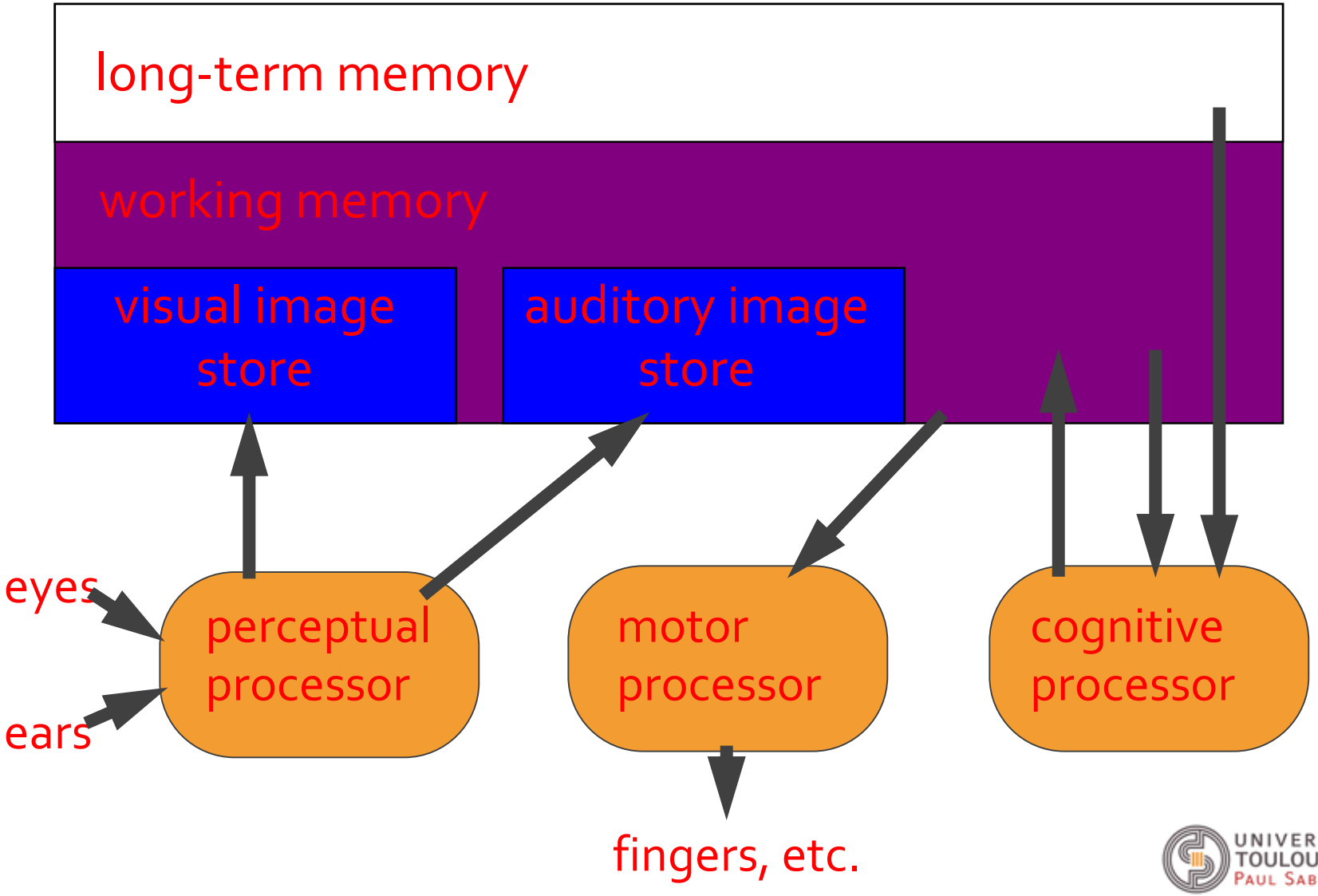
model human processor



model human processor

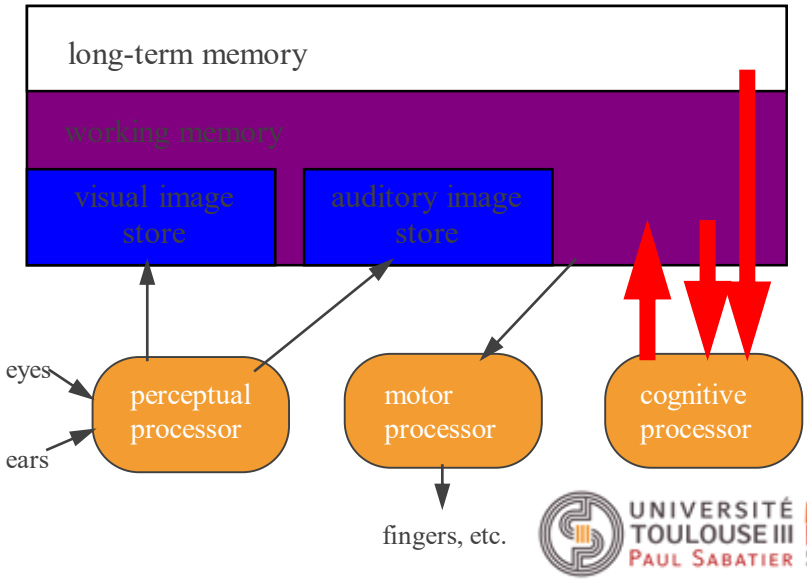


model human processor



recognize-act cycle

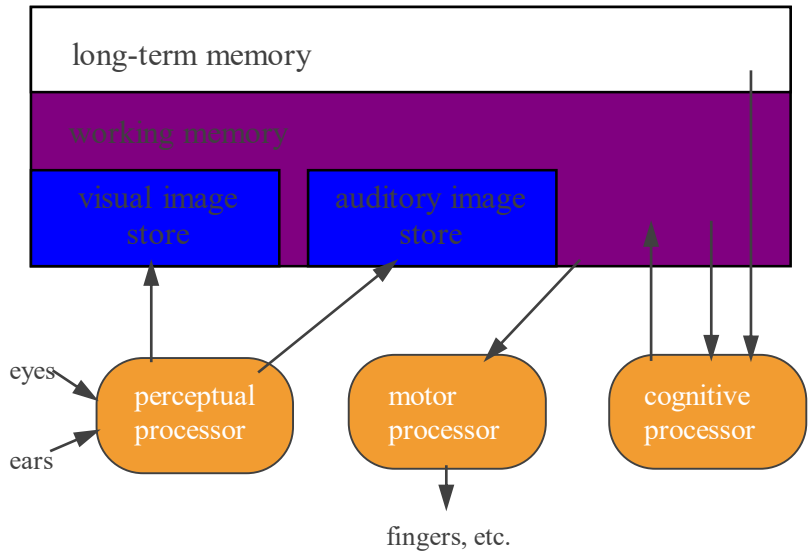
- on each cycle:
  - 1. contents in working memory **initiate actions** associatively linked to them in long term memory
  - 2. actions **modify** the contents of working memory



summary

- **model human processor**
  - model allows us to make predictions, e.g., distinct events
    taking place in same cycle will be perceived as one

- key time to remember: **100 ms**



human constraints

- **serial in action**
  light → respond by pressing key

- **parallel in recognition**
- driving, reading signs, & hearing

- limiting parameters:
- processors have **cycle time ~100-200 ms**
- memories have **capacity, decay time, & type**

Limitations of Short-Term Memory

- Miller's 7 +/- 2 magic number
  - people can recognize 7 +/- 2 chunks of information at a time and hold these chunks in memory for 15-30 seconds
- Chunking
  - ability to cluster information together
  - size of chunk depends on knowledge, experience, and familiarity

types of memory

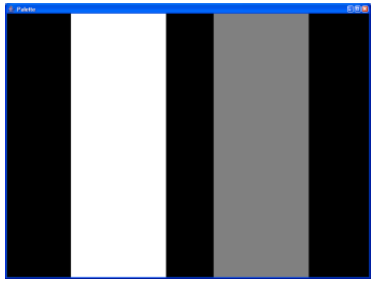
- **working memory (short term)**
- **small capacity,** can store 7 ± 2 "chunks"
  - 6174591765 vs. (617) 459-1765
  - DECIBMGMC vs. DEC IBM GMC
- **rapid access** (~70ms) & decay (~200 ms)
  - pass to long-term memory after a few seconds of continued storage

- **long-term memory**
- **huge capacity** (if not "unlimited")
- **slower access** (~100 ms) with little decay

principles of operation

Fitts' Law

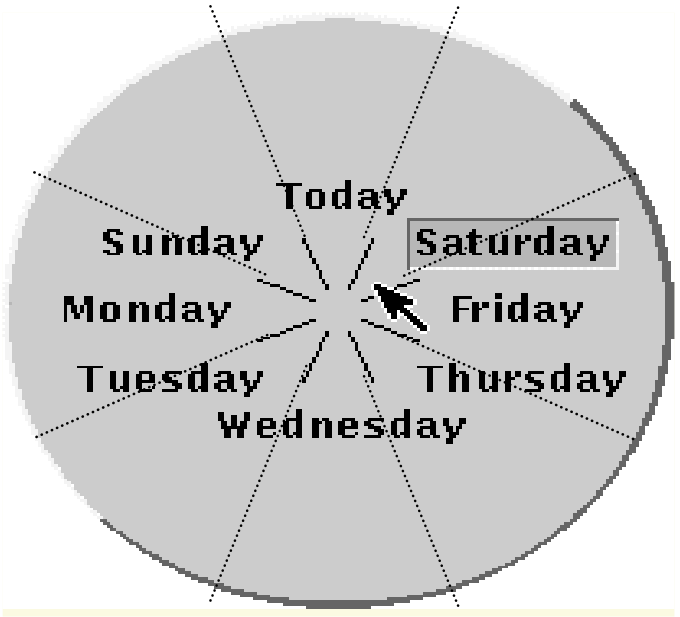
- moving hand is a **series of micro corrections**
  - correction takes $T_p + T_c + T_m = 240$ msec
  - (perception + cognition + motor)



- time T_{pos} to move the hand to target of a given size which is distance D away is given by:
  - $T_{pos} = a + b \log_2 (distance/size + 1)$
- → time to move the hand to target depends on the **relative precision** required

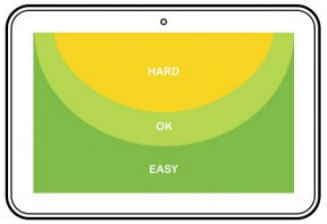
Fitts' law example

pop-up linear menu



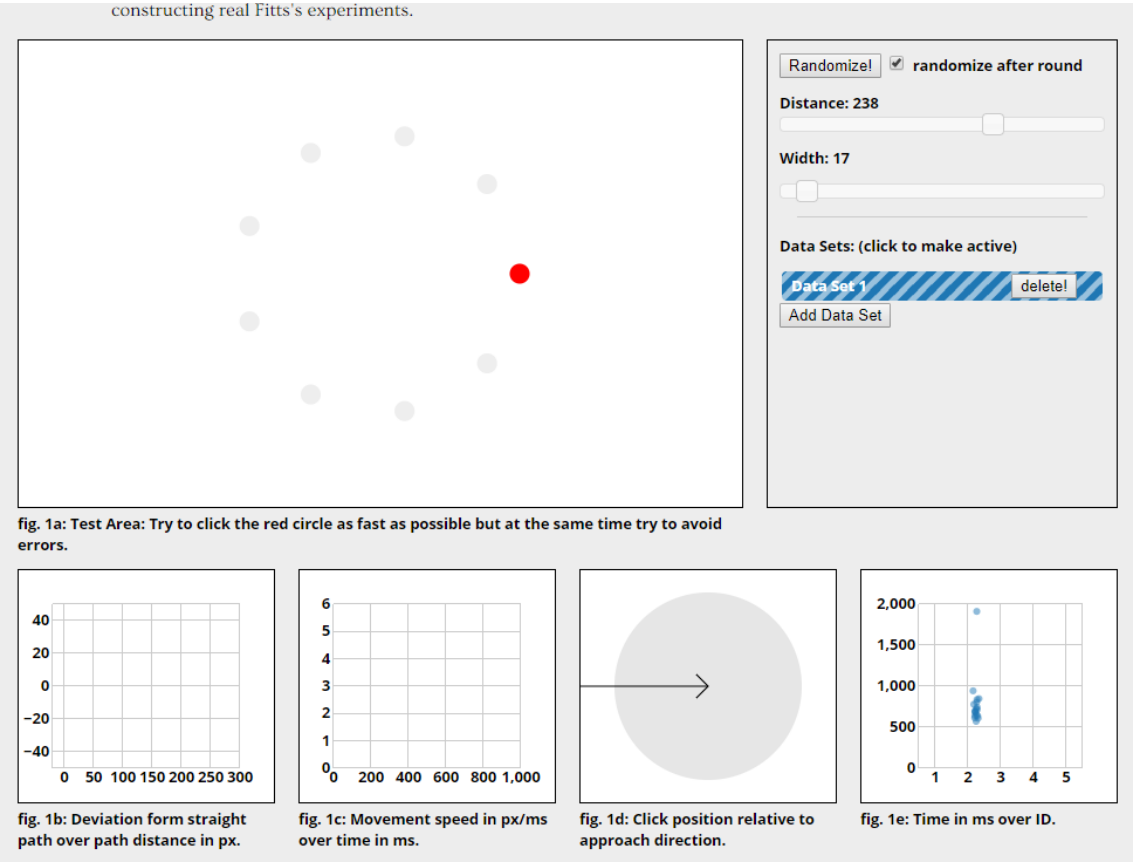
pop-up pie menu

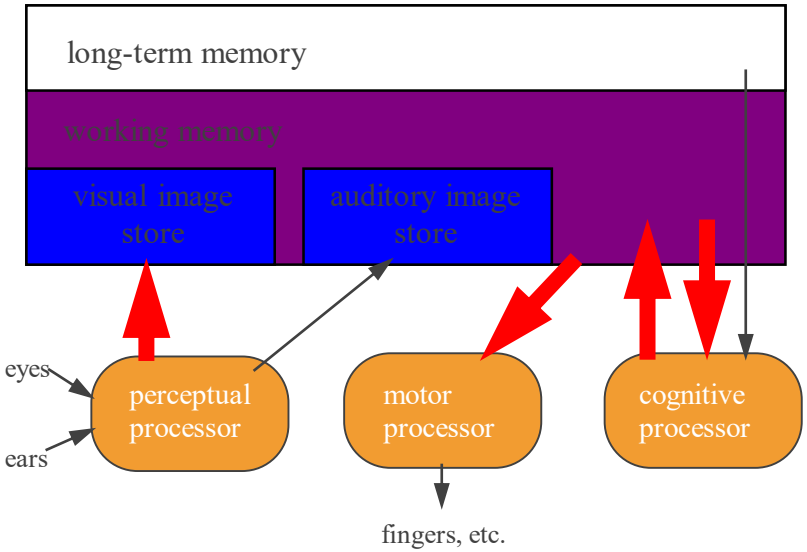
- which will be **faster on average?**



Fitts' law example

- http://simonwallner.at/ext/fitts





linear menu requires

= 240ms per step

- pie menus:
  1. the target is **large**
  2. users are good at **reproducing direction**
  → users can acquire target

without additional perceive-process-act cycles

Perception

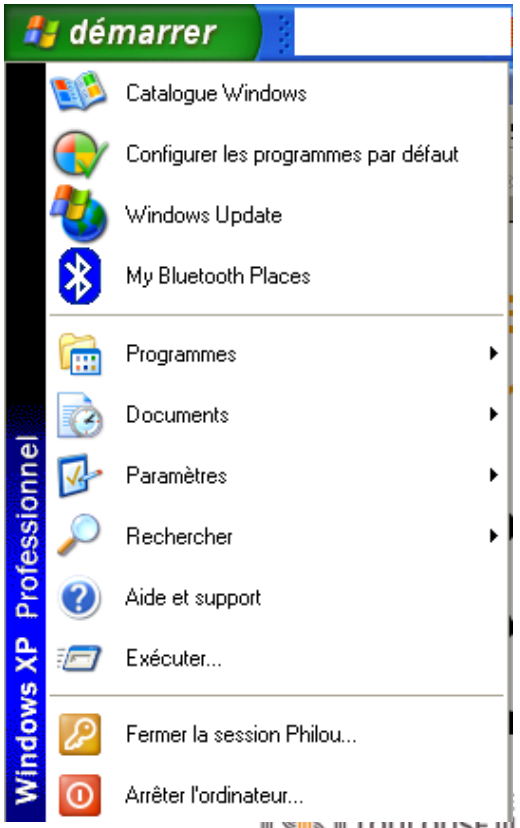
- Hick-Hyman law (1952-1953)
  - time to perceive one information within n

Hick-Hyman Law

$T = b \log_2(n+1)$

In case of non equal probabilities

$T = b \sum p_i \log_2(1/p_i+1)$

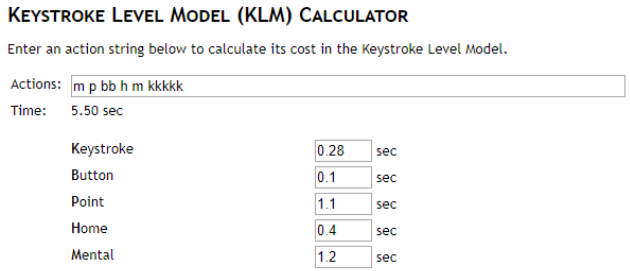


KLM and GOMS

- Keystroke-level model
  - Task acquisition: user builds mental representation
  - Task execution: uses system facilities
  - Decompose execution phase into motor and mental operators

- GOMS model
  - Goals
  - Operators
  - Methods
  - Selection rules
- CCT, NGOMSL, TAG, others elaborated on this model

Models

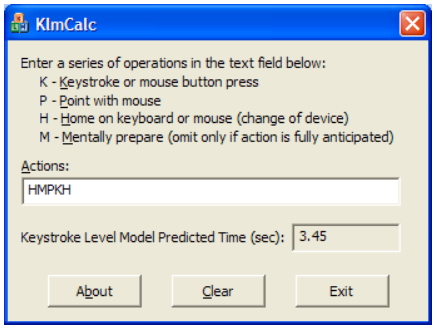


- Keystroke : time for operators
  - K : 0,2 s
  - P : (between 0,8 et 1,5 s) [Fitts'law]
  - H : 0,4 s
  - D : 0,9n + 0,16i (n : segments / i : length)
  - M : 1,35 ms
  - R : max(0,n-t)

http://courses.csail.mit.edu/6.831/2009/handouts/ac18-predictive-evaluation/klm.shtml
http://www.syntagm.co.uk/design/klmcalc.shtml

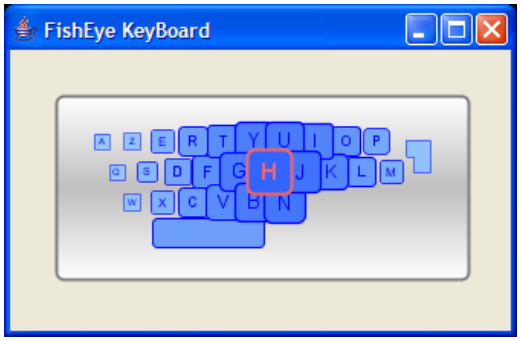
Models

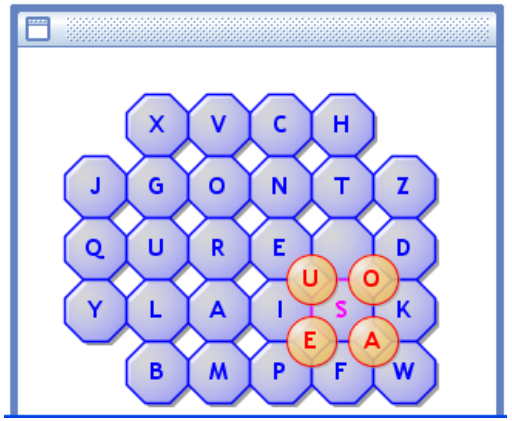
- Keystroke : cursor move in a word processing system
  - method : take the mouse, move it and select target
  - Meth = H(mouse)P(pointer)K(click)H(return)
  - Mental activity
    Meth = HMPMKH
  - Anticipation
    Meth= HMPKH



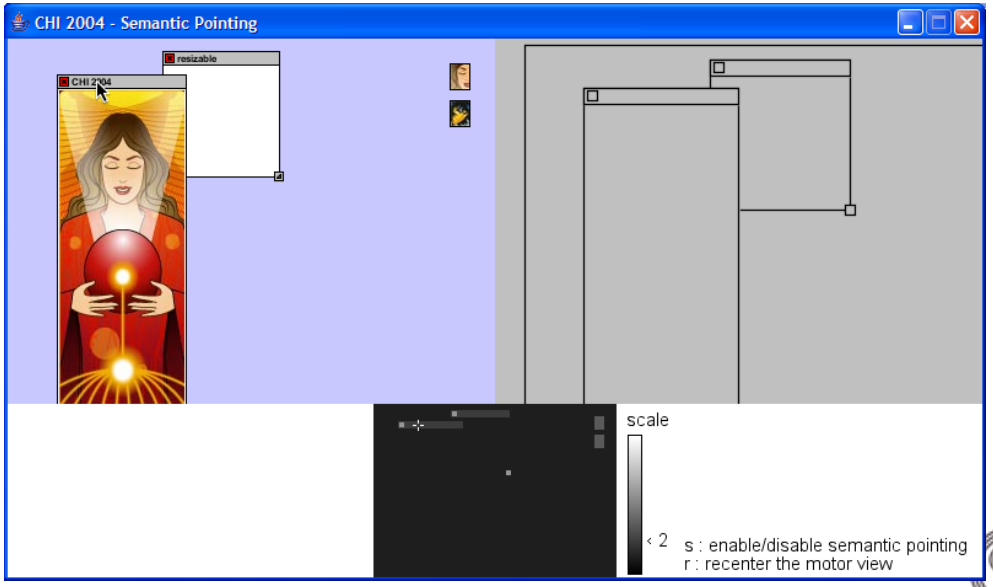
➔ **Time: 3,45 s**

Applications

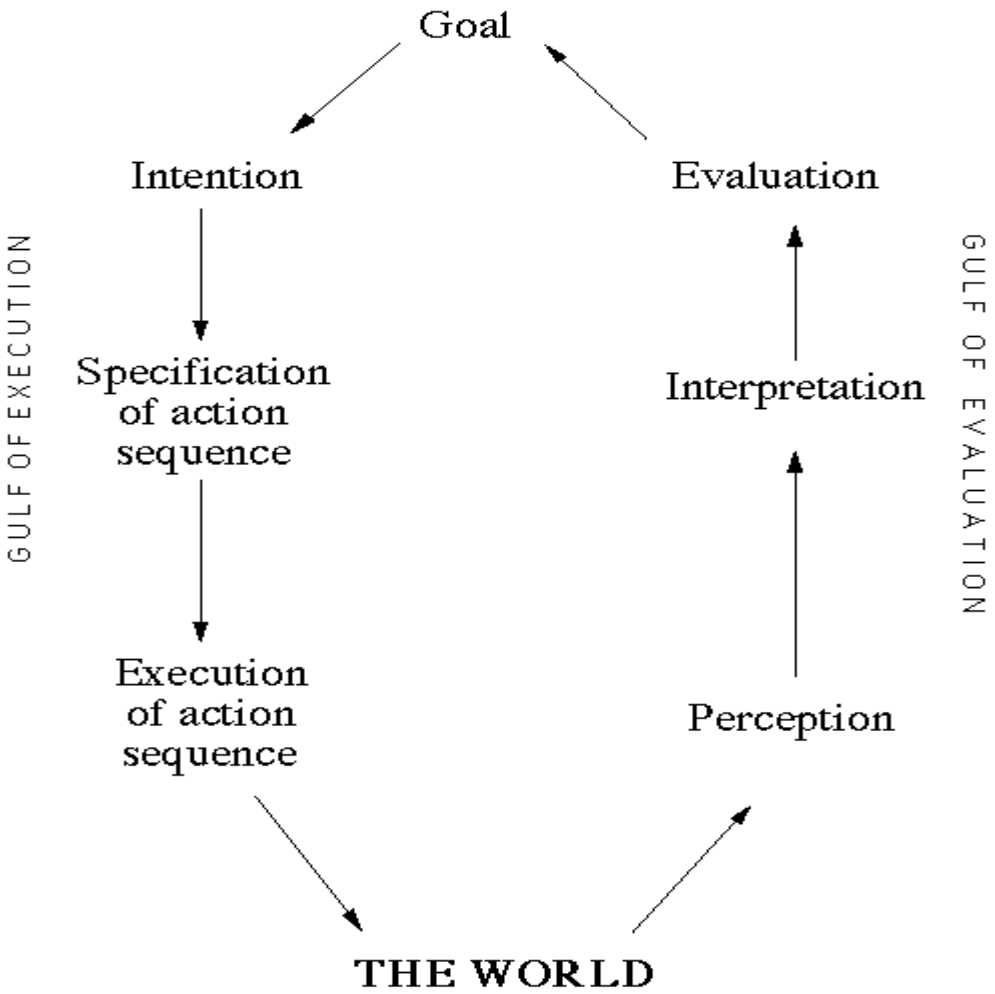




- applications:
  - optimized keybords
  - Semantic pointing
  - …



Action Theory

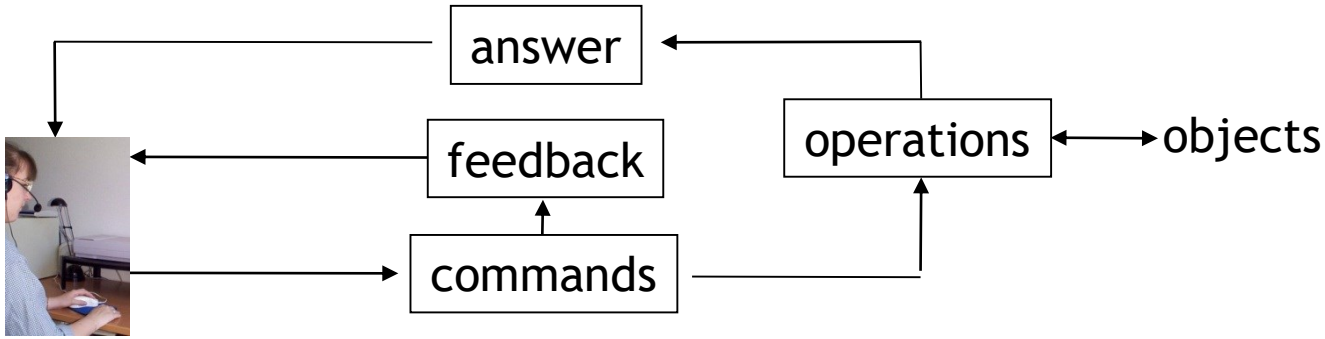


Action Theory

- **Gulf of execution**
  - Difference/mismatch between user's intentions and allowable actions
- **Gulf of evaluation**
  - Amount of effort to interpret the system state and determine how well expectations and intentions have been met

Action Theory

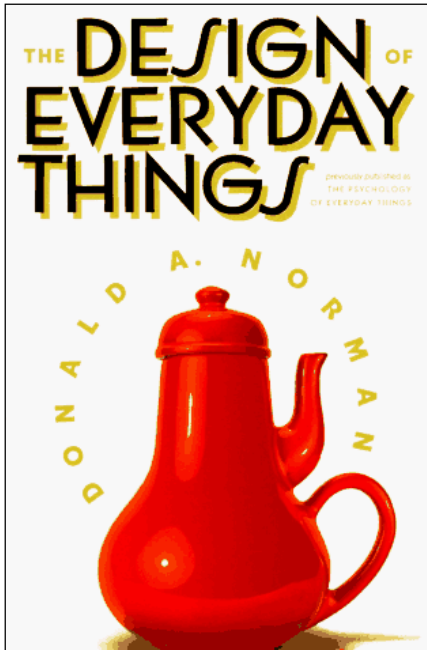
- perceptual and conceptual model
  - ***perceptual*** model: mental model developed by the user
  - ***conceptual*** model: description and working of the system



distance between these two models determines usability

Action Theory

- **affordance** (Gibson)
  - Perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used



model mismatch

- mismatch between

designer's conceptual models

& customer's conceptual models

leads to

- slow performance
- errors
- frustration

design guidelines

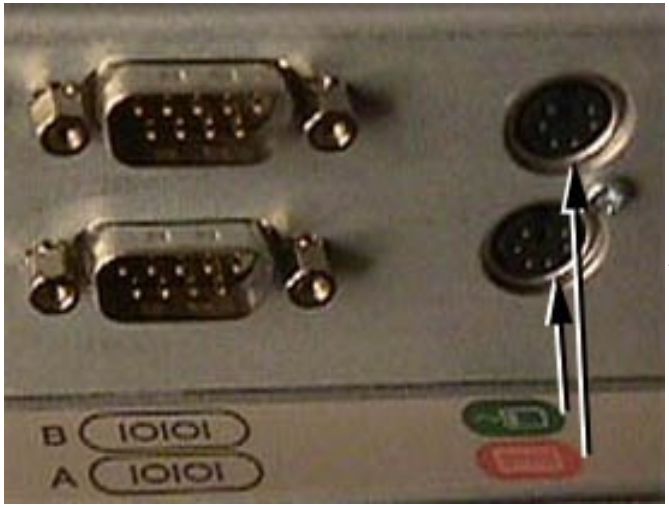
- **1. affordance:** show the underlying conceptual model
  - how UI controls impact object
- **2. discoverability:** make things visible
  - if object has function, interface should show it
- 3. pick affordances that **match the user's conceptual model**
  - example: for consumers: infix calculator, not postfix
- **4. provide feedback**
  - what you see is what you get! (wysiwyg)

Action Theory

James J. Gibson (1977), The Theory of Affordances.
In *Perceiving, Acting, and Knowing,* Eds. Rt Shaw and J Bransford, ISBN 978-0-470-99014-8

Action Theory

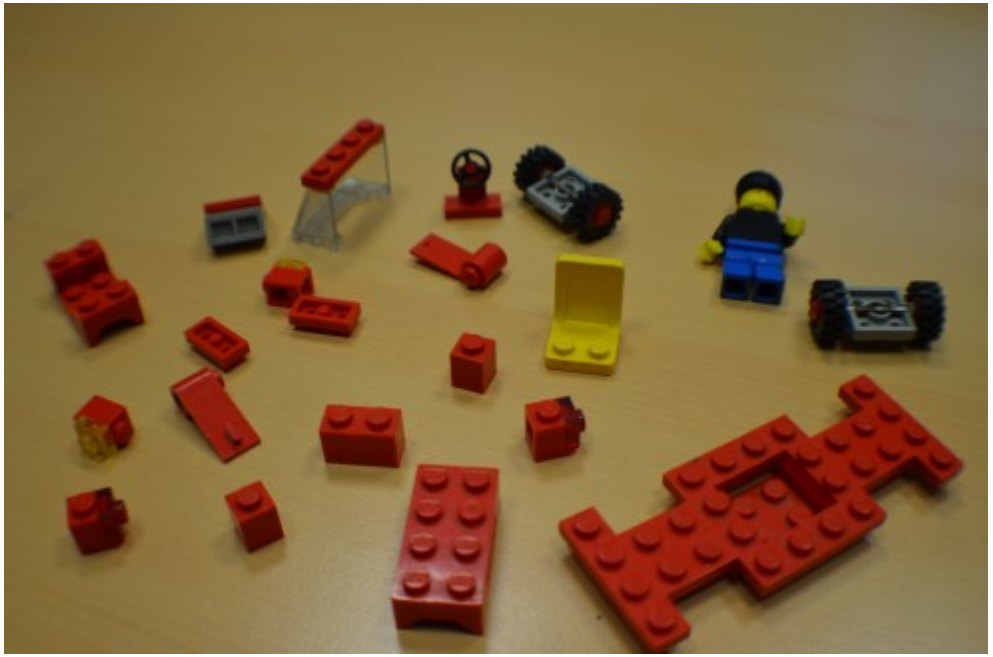
- bad example affording solutions



http://www.baddesigns.com

Action Theory

- exercise:
  - assembling Legos
- question:
  - what is it?
- analyze …



Action Theory

- affordance of elements (cylinders and holes)
- constraints
  - physical
    - world's properties
  - semantical
    - our knowledge of the world and situations
  - cultural
    - Cultural conventions (example: headlights)
  - logical
    - all elements have to be used

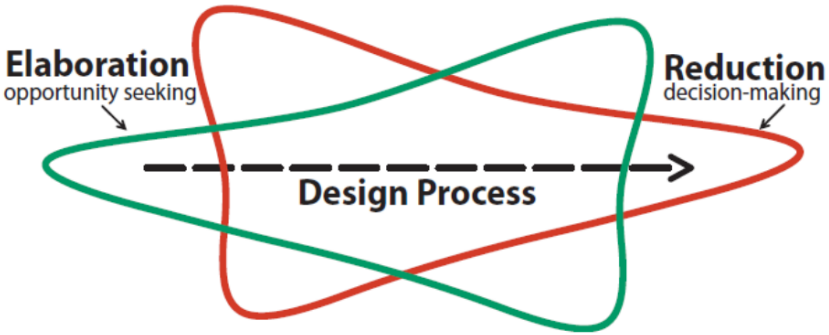
Design

" There is no single recipe for human-centered design "

R. Kling & S. L. Star, 1998

"The best way to have a good idea is to have lots of ideas."

L. Pauling



UCD : User Centered Design

Long live ISO 9241-210 (2010) !

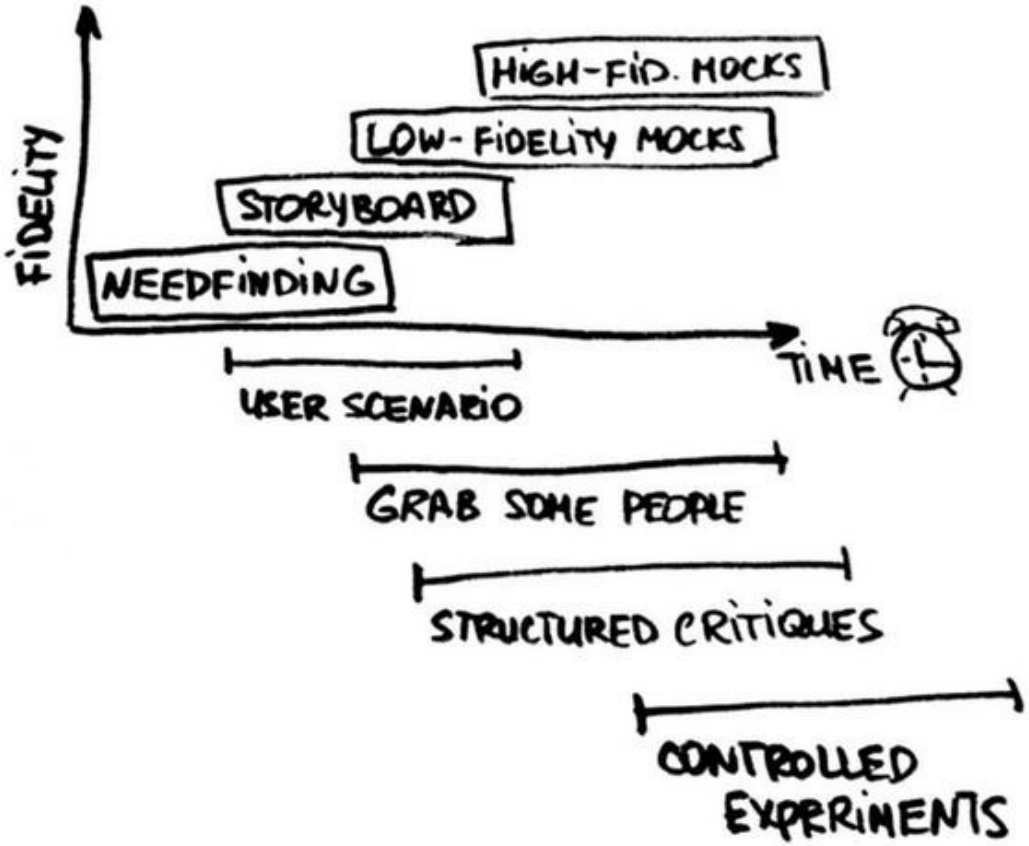
The standard describes 6 key principles that will ensure your design is user centred:

- The design is based upon an explicit **understanding of users**, **tasks** and **environments**.
- Users are involved throughout design and development.
- The design is driven and refined by user-centred evaluation.
- The process is iterative.
- The design addresses the whole user experience.
- The design team includes multidisciplinary skills and perspectives.

https://www.iso.org/standard/52075.html

UCD : User Centered Design

Participative & iterative Process



Introduction to Design and Usability

- Thus far, we have considered
  - Strengths and limitations of the human
  - Characteristics of the computer
  - Guidelines for interaction
- Next questions:
  - How do we design and evaluate interfaces?
  - Why are there so many poorly designed products?
  - How can we evaluate and improve products?

Principles of Design

- Provide a good conceptual model
  - How does it work?
  - What does it say to the user?

- Make things visible
  - What can user see/feel/grab/push?
  - What does it look like it will do?

How to Do Things

- **The wrong way**
  - Make things invisible
  - Be arbitrary
  - Be inconsistent
  - Make operations unintelligible
  - Be impolite
  - Make operations dangerous

- **The right way**
  - Use knowledge in the world and knowledge in the head
  - Simplify structure
  - Make things visible (invite exploration)
  - Provide mappings
  - Exploit constraints
  - Design for error

The Evolution of Design

- Design is evolutionary, not revolutionary
  - Few designs are right the first time
  - Test, modify, retest
- Carroll and Rosson design characterization
  - Design is a process, not a state
  - Design process is nonhierarchical
  - Design process is radically transformational
  - Design involves discovery of new goals

Three Pillars of Design

- **Guidelines documents**
  - Words/icons, screen layout, I/O, action sequences, training
- **User interface software tools**
  - Hypercard, MacroMind Director
  - Visual Basic. Delpi, Java, Tcl/Tk
- **Expert reviews and usability testing**
  - Pilot tests, surveys, analysis, metrics

Development Methodologies

- Business-oriented approaches to software development
- Why use them?
  - Many (most?) software development projects fail to achieve their goals
  - Need to enhance developer/user relationship
- Academicians bridged the way
  - Hix and Hartson 1993; Nielsen 1993

Participatory Design

- Pros
  - More accurate info about tasks
  - Opportunity for users to influence design decisions
  - Increased user acceptance
- Cons
  - Very costly
  - Lengthens implementation time
  - Builds antagonism with users whose ideas are rejected
  - Force designers to compromise designs

PD: Participatory Design

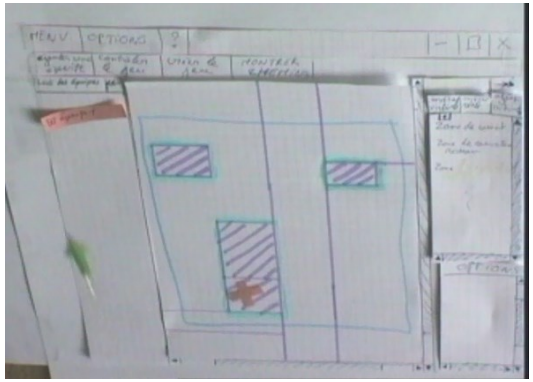
brainstorming, scenarios et prototyping

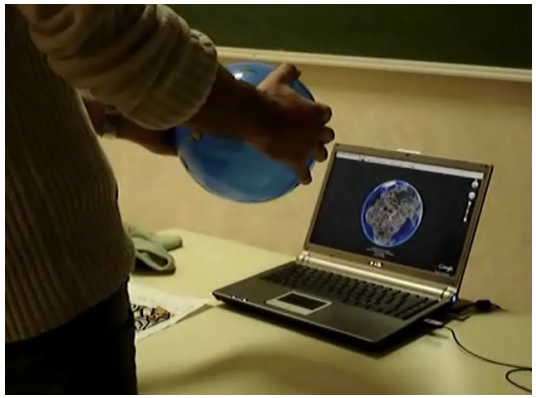
- Before the structured development
- designers develop one or more operational models to demonstrate an idea
- prototypes implement the ideas…

PD: Participatory Design

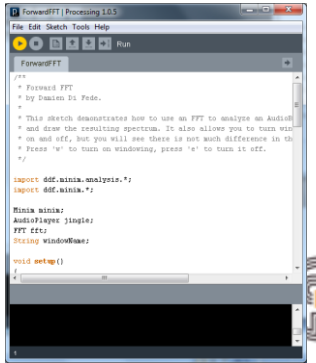
brainstorming, scenarios et prototyping

- … visible, understandable and testable!
  - Low-fidelity prototypes: paper, vidéo





  - High-fidelity prototypes : scripts, distributed code, …



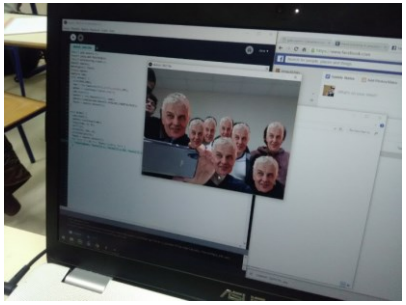
Prototyping

- Some useful and interesting tools:
  - **Frameworks**
    - https://gomockingbird.com/home
    - http://mockupbuilder.com
    - https://balsamiq.com/products/mockups
    - https://proto.io
  - **Languages** : Processing.org, Python, Qt, …
  - **Libraries**
    - OpenCV
    - NyARToolkit
    - Speech API (reconnaissance et synthèse de parole), …
  - **API and devices**
    - Processing.org / arduino
    - Phidgets
    - Kinect, Leap Motion, Myo Armband
    - CCV / TUIO
  - **Middlewares** (event-driven dev) : dbus, ROS, MQTT, ivy, …

Ingenuity I/O

Prototyping

- **Processing** (http://www.processing.org)
  - another **java** layout
  - For designers and artists primarily
  - « father » of arduino ;)



C. Reas, B. Fry, Processing: A Programming Handbook for Visual Designers and Artists, MIT Press, 2007, ISBN-10: 0262182629

GroupLab Phidgets
Physical widgets for prototyping physical user interfaces

Prototyping

- **Phidgets** (http://www.phidgets.com)
  - Set of physical devices easily connectable
  - Interface with numerous languages (even web-services)

S. Greenberg, S. and C. Fitchett, Phidgets: Easy Development of Physical Interfaces through Physical Widgets. In Proceedings of the 14th Annual ACM Symposium on User Interface Software and Technology - ACM UIST'01, ACM Press, pages 209-218, November 11-14

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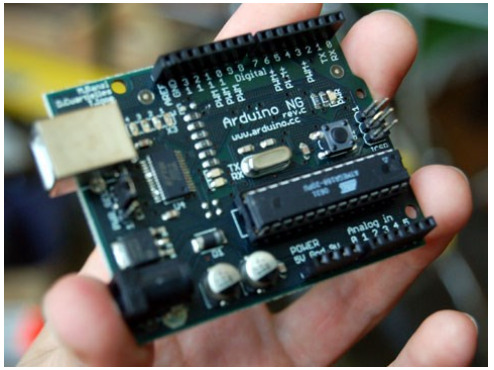
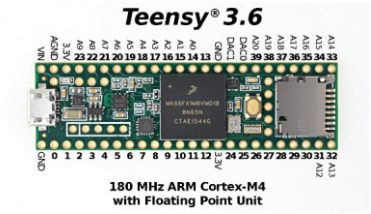
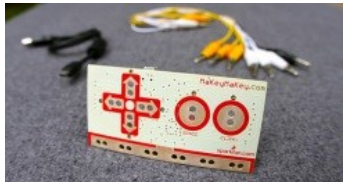
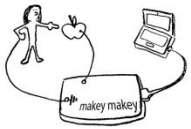
Prototyping

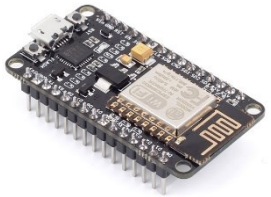


- **Arduino** (http://www.arduino.cc)
  - 'low cost' Microcontroller (about 20 €)
  - Programmable in C
  - interface with physical sensors and effectors
  - Communicates easily with a PC (serial - usb, bluetooth, Zigbee or Ethernet - wired, wireless)
- Other kind of projects:
  - Wiring (http://wiring.org.co)
  - Teensy (http://www.pjrc.com/teensy)
  - Makey makey (http://www.kickstarter.com/projects/joylabs/makey-makey-an-invention-kit-for-everyone









Prototyping

- There are many examples based on many languages (Python, Qt, …), libraries and devices used …

- Remain one of the major problems: what evaluate and how?

Evaluation

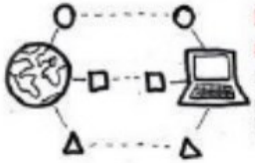
- predictive evaluation
- Based on models (GOMS, KLM, …)

- Evaluation
- heuristics
- ergonomic criteria
- Interviews, questionnaires, …

Ten Usability Heuristics by Jakob Nielsen

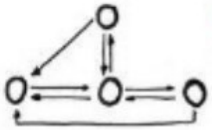
Visibility of system status

Give the users appropriate feedback about what is going on.



Match between system and the real world

Use real-world words, concepts and conventions familiar to the users in a natural and logical order.



User control and freedom

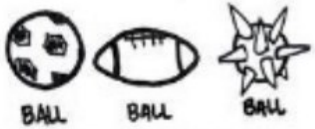
Support undo, redo and exit points to help users leave an unwanted state caused by mistakes.

Error prevention

Prevent problems from occurring: eliminate error-prone conditions or check for them before users commit to the action.

Aesthetic and minimalist design

Don't show irrelevant or rarely needed information since every extra elements diminishes the relavance of the others.

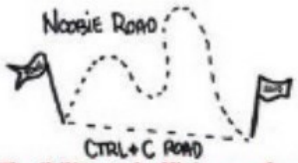


Consistency and standards

Follow platform conventions through consistent words, situations and actions.

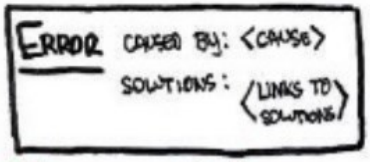
Recognition rather than recall

Make objects, actions, and options visible at the appropriate time to minimize users' memory load and facilitate decisions.



Flexibility and efficiency of use

Make the system efficient for different experience levels through shortcuts, advanced tools and frequent actions.



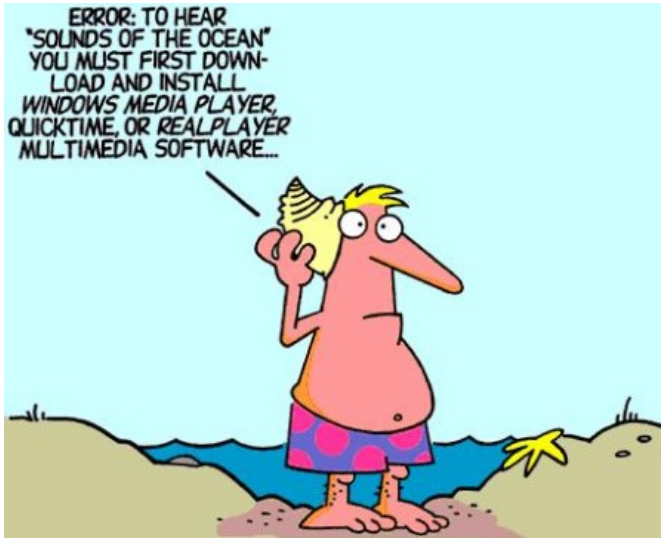
Help users recognize, diagnose, and recover from errors

Express error messages in plain language (no codes) to indicate the problem and suggest solutions.

Help and documentation

Make necessary help and documentation easy to find and search, focused

Conclusions



- important issues
- strong constraints

- many challenges due to changing technologies, multi-tasking …

- And a work … obviously "*handworked*"