Human – Computer Interaction

interaction design

Lecture No. 3

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Theoretical Models
& approaches
part A

Essential Foundations

The concept of Interaction, brings in practice to the foreground

- Interaction styles and communication channels:
  - Command based Interfaces
  - Graphical User Interfaces (GUIs)
  - Hypertext & Web based Interfaces
  - Virtual Reality (VR) Interfaces
- Metaphors & and Container Objects conceptually use:
  - Modal Dialogs Modeling
  - Grammatical Rules
  - Problem Statement Models
  - Event (driven) Models

Axes of analysis - synthesis

- Ergonomic approach
  - The Human-Computer communication is generally a subpart of Human-Machine communication
- Cognitive Sciences are involved
  - E.g., what is the role of linguistics when interaction with a machine?
  - Describe computational behavior, by deploying observable human behavior models through interaction steps
  - Current trends, future directions
- Human-centric design (User Centered System Design)
- For each event will highlight
  - key questions posed
  - indicative results

Human Factors

in Ergonomic Design

Ergonomic Approach

- It involves the study of the actual characteristics of interaction in their real dimensions.
- Often referred to in the literature as a scientific area that deals with human factors (*Human Factors Design*).
- In HCI ergonomic approach was utilized to set standards and rules for the design of interactive systems (*Usability and Ergonomics*).
- Its aim is to analyze and adjust a user's actions as far as *Application Areas and Tasks* are concerned, according to *User Requirements*.
- The *Workflow Systems* and *Workflow Technologies* that had emerged, have started loosing their appeal when **mobile interactive systems** and the "**cloud**" are involved. They should be somehow reconfigured.

Methodological Approaches

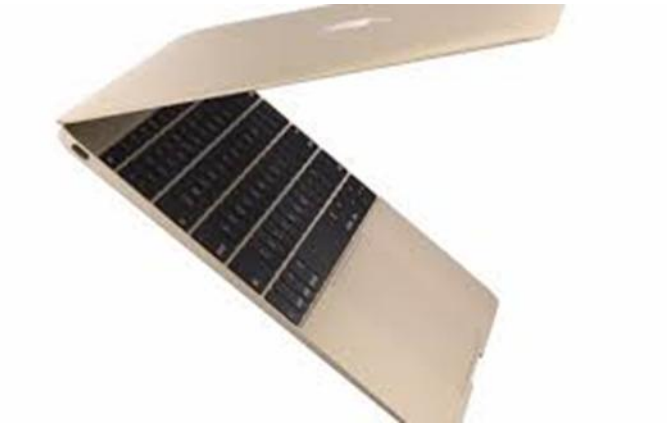
- Reflective Approach (used by the system, for instance in Dynamic and Reflective User Interfaces)
- Laboratory Methods (includes laboratory experiments, taking place away from the location where the actual service is offered)
- Objective evaluation criteria based approaches
  - They use Formal Methods and Analysis Tools (Data Analysis, Comparative Analysis, Expression Analysis, Psychometric Analysis, Neurophysiological Analysis, Morphological Analysis, Component Analysis, Action Analysis, etc)
- Requirements:
  - Adequate amount of time
  - Service users
  - Specialized knowledge
  - Satisfactory budget
- The emphasis is given in:
  - The evaluation of a system's interface, no matter how complex it may be in its deployment (e.g. "Cloud" Computing, Social Networks, International Mobile Networks, etc.)
  - Further improvement of the system may be proposed, based on empirical data and experimental methods.

Epitome: patterns for ergonomic study

- Time to complete a specified process
- Work rate performed per unit time
- Time spent on correcting errors
- (Cumulative) percentage of errors
- Frequency of use for “Help”
- Proportion of positive and negative comments of users
- Number of cycles per process (used for evaluation)
- Etc. ...

Example: MacBook

- It is a value -added device
- It has an improved technical approach as far as its functional characteristics are concerned
- He tries to introduce a new culture that involves communication with the user using novel forms of interaction



Examples MacBook

- There two notable innovations in attempting to offer a paradigm of advanced user-computer communication:
  - Trying to solve the issue of the pointing device, Apple has advanced the trackpad
    - Sensors and actuators inside detect the level of pressure exerted
    - Tangible feedback: a vibration from the surface of the trackpad which gives the sense of touch, in what appears on the screen, and thus provides new ways to interact with the Mac.
  - It has a single port USB-C.
    - This port offers multiple possibilities: it is used to charge charge the device, it is a very fast USB data transfer channel, it serves as a three-fold video communications port, etc. Constantly, new functionality is added, promoting it as a multimodal, object oriented, polymorphic service interface.

Safety of devices with one port

The success of this one-port-fits-all approach, however, has some safety-critical issues like:

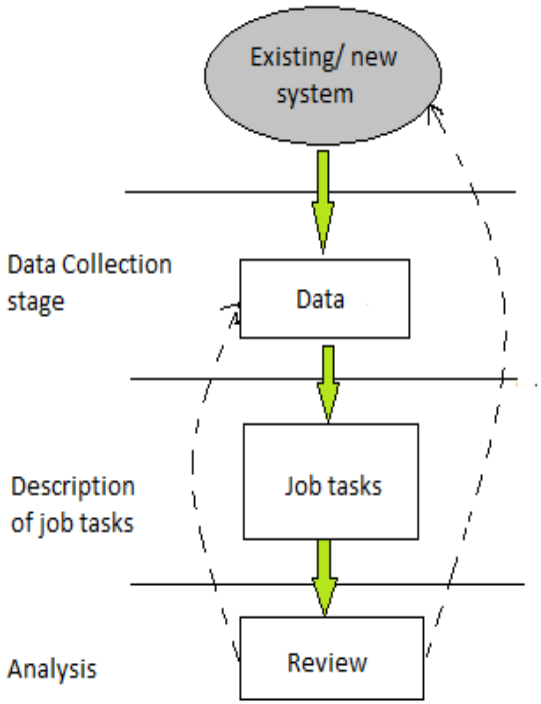
- The one-port architecture has the risk of hardware tapping
- Furthermore, this HCI based improvement, has been taking up fascinating new issues for security workers, like interception, information integrity, trust of systems, etc.

For the time being, it is a reconfigurable novel technical characteristic, fervently adopted by the mobile device manufacturing associations.

Analysis functions

When designing a new system or a new service interface, the following 3 design stages are involved:

- Preamble: Systems, Machines, and Applications
  - Provide the Design Model, the System Image and User's Model for a new system or for a new application for existing systems
- Data Collection stage:
  - Data collection, data entry (e.g.., from cameras, social networks, SMSs and MMSs, etc.), adequate display capacity
- Job or Task-oriented interface:
  - Job descriptions and tasks assigned accordingly. Tasks change with technology.
- Analysis of design errors:
  - Review / **Evaluation**



Hierarchical Analysis Tasks

- The system tries to determine a hierarchical organization of components, states, movements and reactions:
  - It describes how users use the system, how they operate with this for accomplishing their tasks, how they communicate with it, what collective results they get and how they react in obtaining these end-results.
  - Overall, it gives a scalable interaction framework.

Fitts' Law *(1/3)*

- Fitts' law is a diachronic model of human movement when interacting with on-screen applications. It provides an estimation of selection time in ms, i.e. the time required for fast movement of the indicator of the pointing device from a starting position to a final target area, as a function of distance from the target and the size of the target.
- Fitts' law is used to model the act of pointing, in the real world (e.g. with our hand or finger) and on computers (e.g. with a mouse.)
- One of the first embodiments in HCI of Fitts' Law was made by Card , English , and Burr (1978) , who used the **Index** of **Performance** (IP), defined as $\mathbf{1/C_2}$, to compare the performance of different input devices, with the conventional mouse movements considered first of all.
- Recently, the performance on pointing to touch screen soft buttons has been encountered.

$$T = C_1 + C_2 \, log_2(\frac{D}{W} + 1)$$

- ***T*** is the average time required for completion of the movement
- ***C1*** and ***C2*** are empirical constants , and can be determined by adjusting a straight line to measured data
- ***D*** is the distance from the start point to the center of the target
- ***W*** is the width of the target measured along the axis of motion

Fitts' Law *(2/3)*

- Since the advent of Graphical User Interfaces (GUIs), Fitts' law has been tested in experimental conditions where the user must exercise haptic control placing the mouse cursor over a target on the screen, such as a button, or another similar widget.
- Fitts' law can model both **point-and-click** and **drag-and-drop**
- Despite the attractiveness of this generic model for the dynamics of control, users should not forget that the original and stricter form of the law:
  - Validates *motion in one dimension* and not movement in two dimensions (though it has been successfully extended to two dimensions with the Accot-Zhai steering law)
  - Describes *simple mechanical response* exerted as motor commands of the human hand hand, failing to explain about the software acceleration applied to a mouse cursor
  - Describes *movements that have not been exercised*, i.e. movements that are executed after months or years of practice (although some argue that the Fitts' law models' behavior is so low level that extensive training does not make much difference)

Fitts' Law *(3/3)*

Some consequences for user interface design include:

- Buttons and other widgets to be selected in GUIs need to have a reasonable size
- The edges (e.g. the menubar in Mac OS) and the corners (e.g. the button "Start" in Windows XP) of our computer screens are very easily accessed because the pointer remains on the edge of the screen regardless of whether the mouse has moved or not. This may be considered as having an infinite width W.
- Popup menus can usually be opened faster than pull-down menus since the the user avoids excessive cursor moving or cursor positioning.
- The objects in a pie menu typically are selected faster and have a lower error rate than linear menu items, for two reasons:
  - because the items in the pie menu are clustered within a short distance from the center of the menu
  - because the wedge areas of the target, usually extending to the edge of the icon, are very large

Examples

Speed, accuracy and selection times are key factors for

- Games and gamification
  - Better reaction and performance on mobile devices turns users to play games on mobile devices
- Image Formats
- Digital TV
- HD TV, Web TV
- Etc.

Cognitive Psychology

theories in use for HCI

Cognitive Psychology *(1/3)*

- Cognitive Psychology:
  - Is dealing with
    - Procedures concerning the knowledge and intellect
  - It has a highly experimental approach
    - E.g., Cognitive Ergonomics
  - Appeared in the 60's
  - It is more often called Cognitive Psychology and not Cognitive Science because:
    - Its subject is not knowledge per se but the processes by which humans are engaged with knowledge

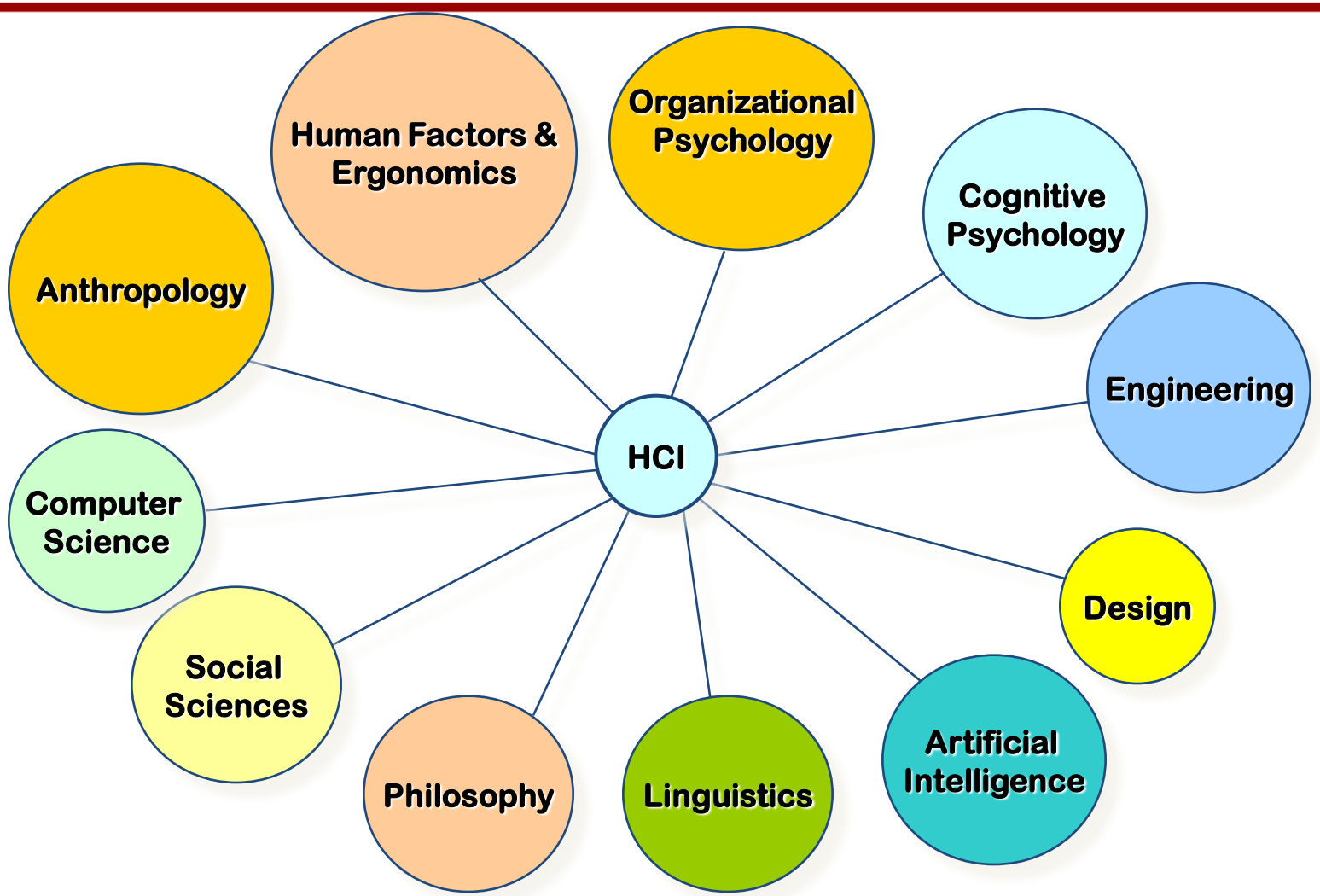
Cognitive Psychology *(2/3)*

- The key question in Cognitive Psychology is how an individual acquires knowledge. Up to this point, the basic position is that the inputted workload and the processing of information, leading to learning and knowledge, follow a process similar to the processing of foods during the operation of digestion.
- By processing acquired stimuli, knowledge is transformed and stored, to be activated when needed.
- This means that the transformation of information into knowledge, involves not only the senses, which filter out external stimuli, but also some processing operations that conceptualize “data” into knowledge.
- These procedures are defined by cognitive functions like perception, short and long term memory handling, language acquisition, thinking and problem solving skills.
- Cognitive Psychology promotes the position that in order to study the learning and adaptation capabilities of users, first one should analytically investigate the transformation of information into knowledge, i.e. phases of cognitive information processing.

Cognitive Psychology *(3/3)*

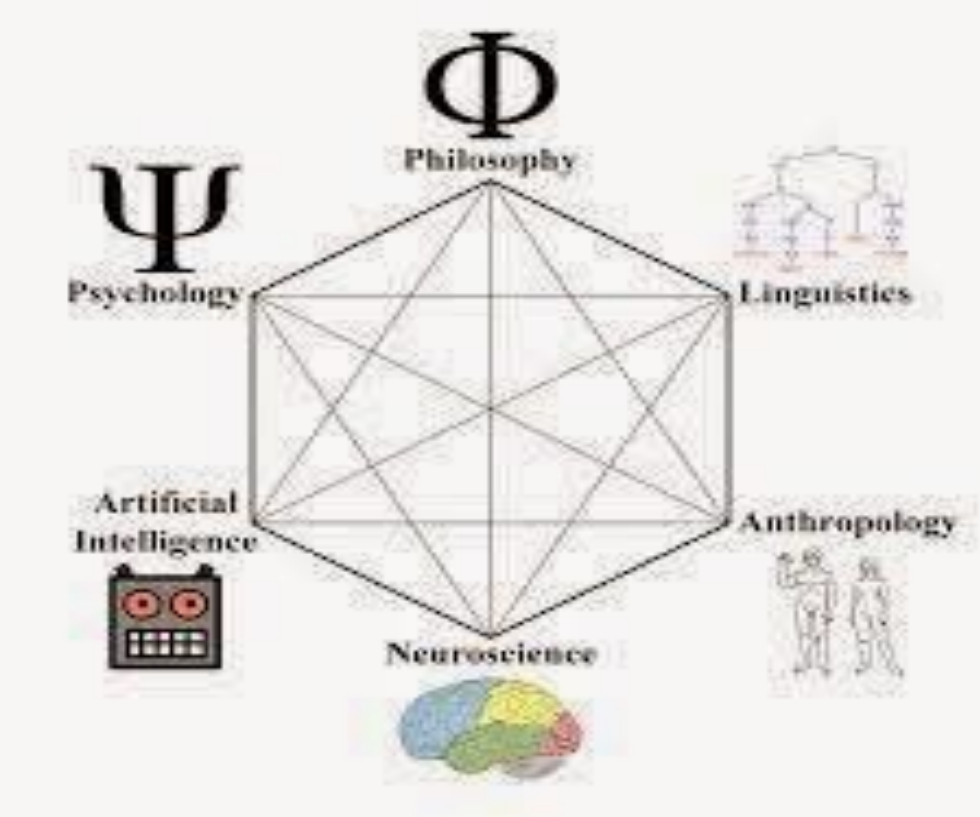
- Cognitive Science: is an interdisciplinary subject area involving, amongst others,
  - Cognitive Psychology
  - Artificial Intelligence
  - Computer Science
  - Linguistics
  - Philosophy
  - Music Perception
  - Etc.
- It aims to provide a correct conceptual model, for explaining how the user interacts with very efficient and intelligent machines, like computing devices.

HCI – Networked Areas of Activity



Cognitive Psychology – Prostheses and Aids

Conventions, devices and perpetual intermediates

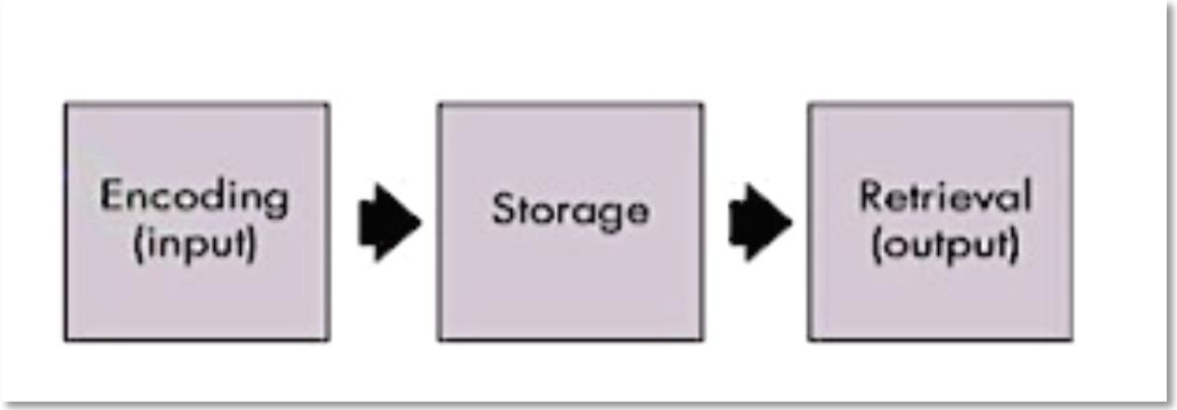


Cognitive Psychology – Processing Patterns *(1/3)*

- The basic idea reflected through out cognitive models is that mind processes can be simulated effectively by computational processes.
- As a side effect, models for the user- computer communication scheme evolve.
  - The interface becomes a buffer of user efficiency
    - The faster it runs a task the more manageable the Interface is characterized as
  - These models help in predicting the performance of a User Interface

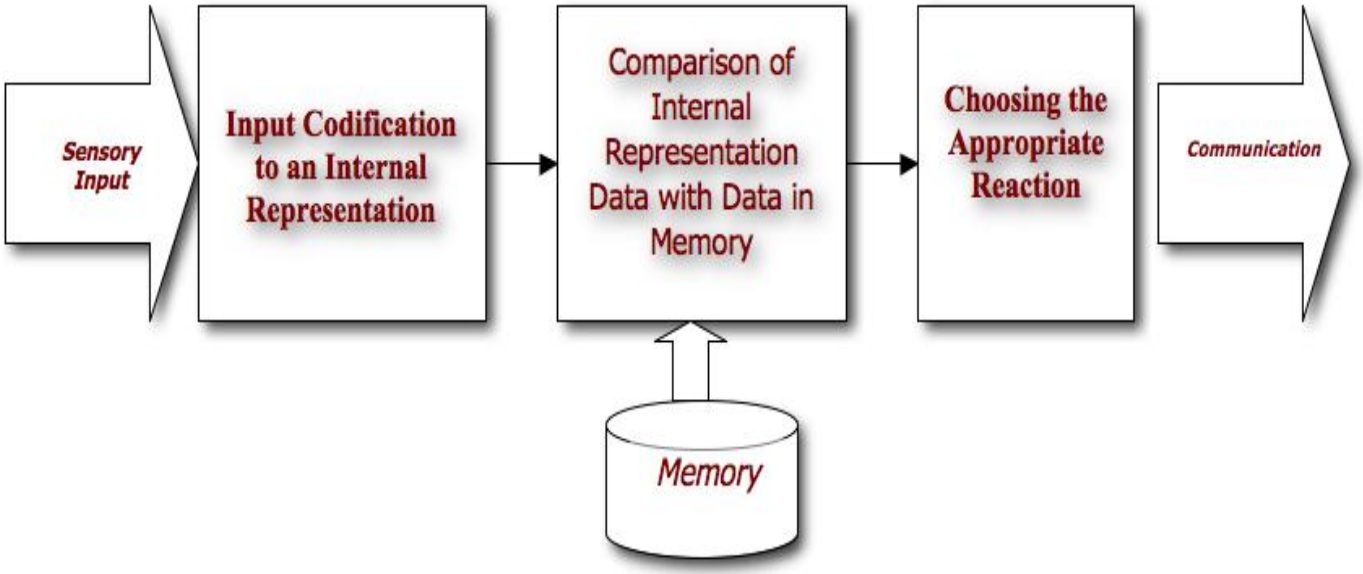
Cognitive Psychology – Processing Patterns *(2/3)*

- According to the Information – processing model, the human brain takes in essentially meaningless information and transforms it into meaningful patterns. This is done in three stages: Encoding – Storage – Retrieval



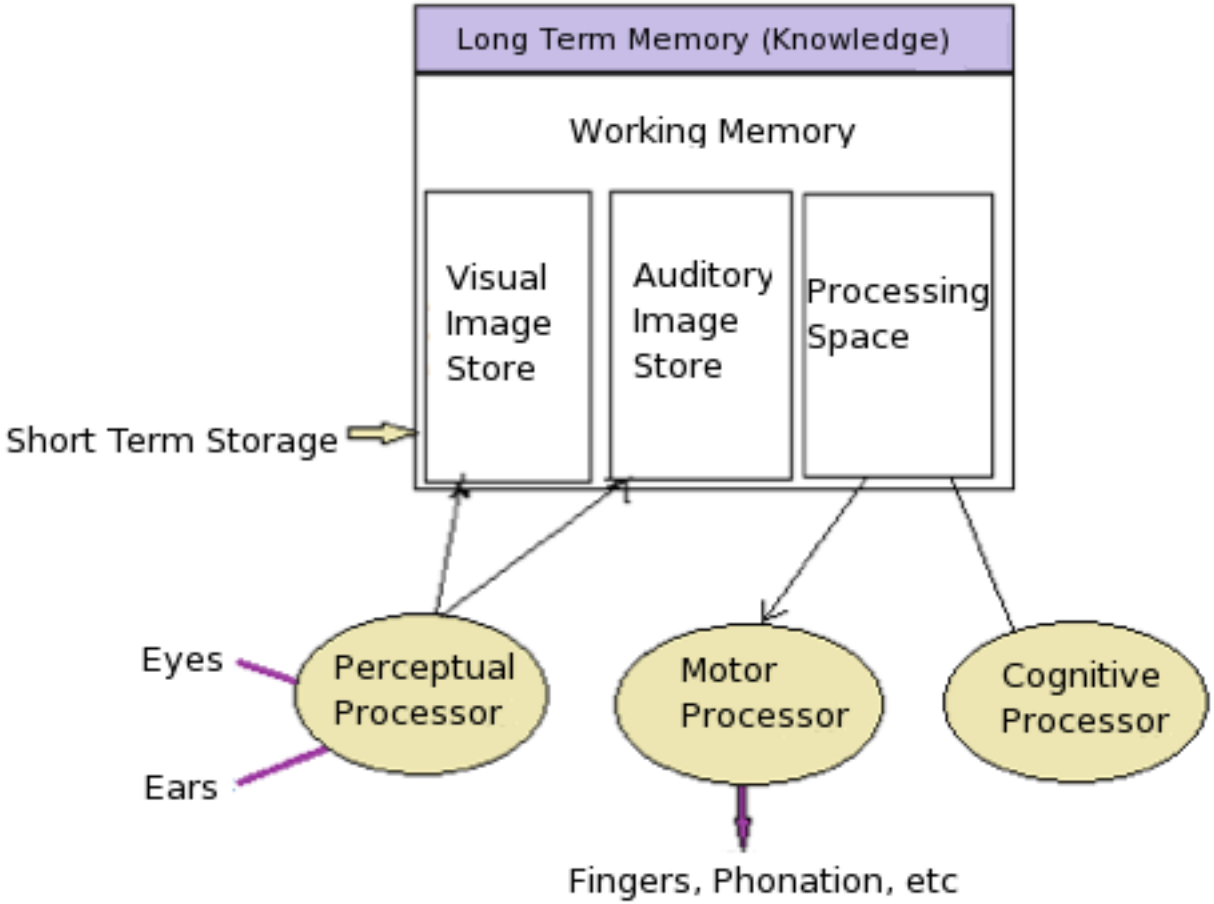
Cognitive Psychology – Processing Patterns *(3/3)*

- In HCI terminology, it becomes apparent that the Human Processor Model, that was first established in mid 1980's, provides a perceptional equivalent in computer terms for the mental, sensory and emotional activity that takes place for a plethora of communication patterns



Model Human Processor *(1/3)*

- When sensory abilities are encountered, the Model Human Processor is formed as follows:

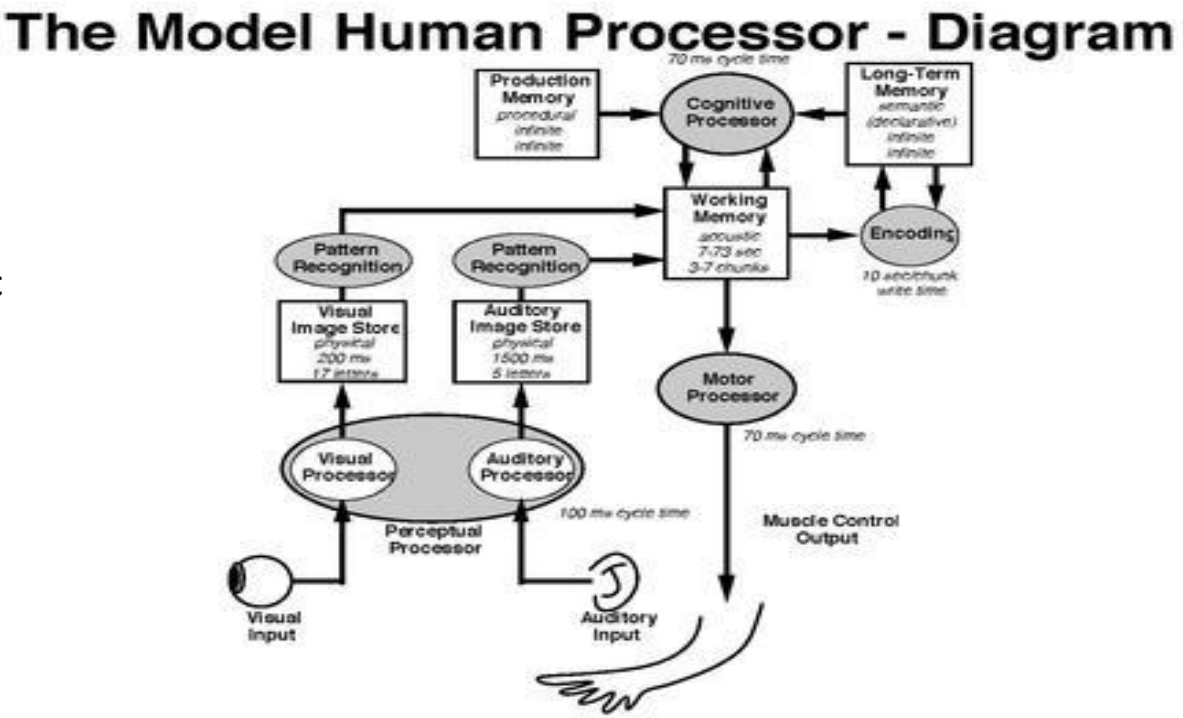


Model Human Processor *(2/3)*

Indeed, the Model Human Processor describes in computer architecture terms the mental activity exercised for competent aural and oral communication, providing a workable simulation for analyzing how human cognition responds in a HCI manner with the plethora of incoming signals that trigger the human body to respond to external or internal stimuli by performing an action.

Model Human Processor *(3/3)*

In terms of HCI literature, it is obvious that cochlear implantation, along with highly immersive and invasive audiovisual and kinetic devices deploy a Brain Computer Interface that more or less revamps the Human Processor Model, that was first established in mid 1980's by adding a blend of virtual reality sensing along with multiple CPU parallelization to the single processor basic model.



Modified from Card, Moran, & Newell (1983)

Human Processes & Cloud

- The processes occurring in the “cloud” – are more or less processes of the human brain.
- The sources are interconnected, forming networks of intelligent agents, but the Interface thus far appears to be chaotic in most cases.
- Social Networks are the observable environments that help us in understanding the operation of the “cloud” and the “web” as the major information providers, enormous in size but some how unorganized in providing reasoning, learning and societal representations.
- Although it is a large structure with many disparate data sources, it is of great significance.

Cloud, so what is it?

- Cloud computing, or simply the “cloud” in our everyday computer jargon, is an extended, worldwide spread structure, which gives us the ability to access and use handy web applications that extend our computer’s functionality without burdening local resources.
- Within this nebulous formation, a network of remote servers is utilized for storing, managing or processing data that otherwise would be dispatched by a local server or a personal computer.
- The “cloud” is a factor that gives added value to mobile devices.

Web 3.0 *(1/2)*

- Within Web 3.x :
- - machines become “smarter”. The search and the information correlation acquires new dynamics allowing natural language queries (semantic web)
- - Social Networking searches lead to the personalization of information
- - Information delivery evolves as fully autonomous from the content format and allows the presentation of different forms, through different channels and with different integration (xml, rich media and multimedia, semantic web ...)
- - Infrastructures promote the fully autonomous use of equipment, enabling simultaneously a variety of everyday-used machinery to be part of gigantic “clouds” or the “Internet of Things”
- - Spatial information becomes a parameter affecting the information generated by varying the form and content (geo-localization)

Web 3.0 *(2/2)*

- The Web 3.x is the so-called next generation Internet with intelligence, where the search and collection of information about semantic and conceptual processing is promoted, instead of keywords used hitherto.
- Computers can understand exactly what you are looking for - instead of simply recognizing keyword characters and combine data effectively, avoiding to provide unnecessary Internet information.

Essential Foundations

- Cognitive science is based on Cognitive Psychology and adds a Computational Dimension to both Usability evaluation and Interaction Design
- Object of study and research:
  - "Knowledge", as a product of the way that human mind responds to stimuli
  - Cognitive models that consider the implications of a wider spectrum of processes in the production of knowledge:
    - Not only local effects (memory, perception, ...)
- The growth of Cognitive Modeling in HCI has developed in accordance with the information processing theory which takes into account the degree of complexity that exists, by interacting with "intelligent" machines, considering
  - Anthropological data and anthropomorphic appearances
  - and, Sociological factors

Anticipating Interface Usability

- Following these steps is easy to anticipate the usability of an interface :
  - Calculate the efficiency of a user with this interface
  - Compare alternative solutions based on user efficiency
  - Rate suitability of different interfaces and discover the factors that restrict or enhance the capabilities of a user
  - Adopt good design and best practice guides

Metaphor – a historical review

- The **desktop metaphor** was first introduced by Alan Kay at Xerox PARC in 1970 and elaborated in a series of innovative software applications developed by the PARC scientists throughout the decade that followed.
- The first computer was using an early version of the desktop was the Xerox Alto.
- The first computer that made the desktop well known was the Apple Macintosh in 1984:
  - The desktop exists in all modern PCs
  - Found in most desktop environments of modern operating systems

In practice, in action

- The revolution that took place on new computing devices (as far as their Metaphors, Paradigm, Idioms are concerned ...) improves the interaction with the device and the cloud.
- We have a new Interaction Design without creating a new Metaphor.

End of the 3rd Lecture

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Reference note

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