2. Human Cognition

Contents

Cognitive Psychology

The science of psychology has been very influential in Human Computer Interaction. In this course we will look at some of the main developments and theories in cognitive psychology (the study of human **perception**, **attention**, **memory** and **knowledge**), and the ways in which these have been applied in the design of computer interfaces.

Cognition and Cognitive Frameworks

Cognition is the process by which we gain knowledge. The processes which contribute to cognition include:

- understanding
- remembering
- reasoning
- attending
- being aware
- acquiring skills
- creating new ideas

A key aim of HCI is to understand how humans interact with computers, and to represent how knowledge is passed between the two.

The basis for this aspect of HCI is the science of cognitive psychology. The results of work of cognitive psychologists provide many lessons which can be applied in the design of computer interfaces. These results are expressed in the form of **cognitive frameworks.** This section describes some of the important frameworks which have been developed by psychologists.

Human Information Processing

HCI is fundamentally an information-processing task. The human information processing approach is based on the idea that human performance, from displayed information to a response, is a function of several processing stages. The nature of these stages, how they are arranged, and the factors that influence how quickly and accurately a particular stage operates, can be discovered through appropriate research methods.

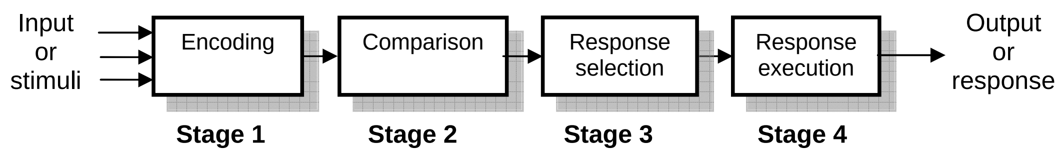
Human information processing analyses are used in HCI in several ways.

- basic facts and theories about information-processing capabilities are taken into consideration when designing interfaces and tasks

- information-processing methods are used in HCI to conduct empirical studies evaluating the cognitive requirements of various tasks in which a human uses a computer

- computational models developed in HCI are intended to characterize the information processing of a user interacting with a computer, and to predict, or **model**, human performance with alternative interfaces.

The idea of human information processing is that information enters and exits the human mind through a series of ordered stages (Lindsay & Norman, 1977), as shown in the figure:

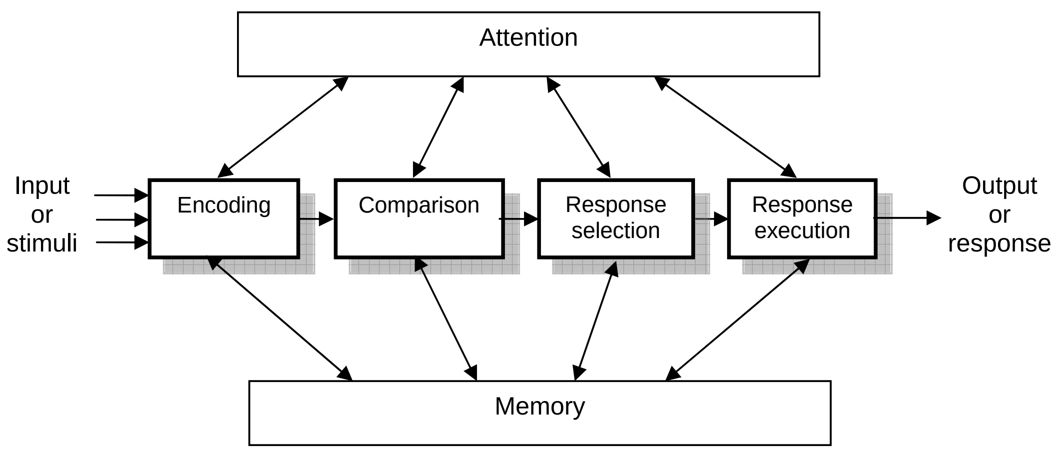


The Extended Human Information Processing model

The basic information processing model shown above does not account for the importance of:

- **attention** the processing only takes place when the human is focussed on the task
- **memory** the information may be stored in memory and information already in memory may be used in processing the input

The figure below illustrates the extended human information processing model (Barber 1988). It shows that attention and memory interact with all the stages of processing

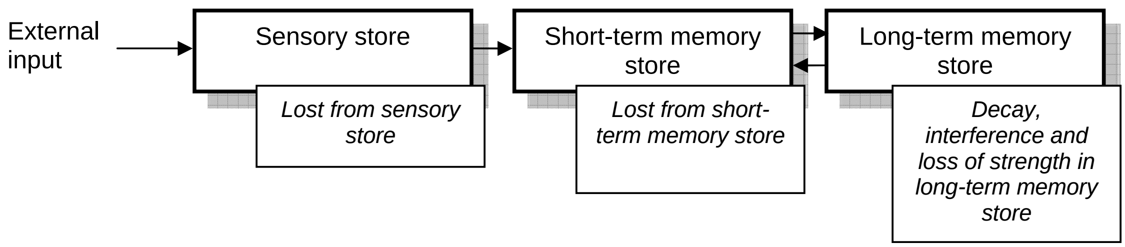


An important question when researching into memory is how it is structured. Memory can be broadly categorised into three parts, which have links between them, moving the information which comes in through the senses.

The Multi-Store model of memory

In 1968, Atkinson and Shiffrin developed a model of memory formed of three 'buffers', which will store memories and control processes which move information between the buffers. The three stores identified are:

- **sensory information store**
- **short-term memory** (more recently known as **working memory**)
- **long-term memory**



The Model Human Processor

An important concept from cognitive psychology is the **model human processor (MHP)** (Card, Moran, and Newell, 1983). This describes the cognitive process that people go through between perception and action. It is important to the study of HCI because cognitive processing can have a significant effect on performance, including task completion time, number of errors, and ease of use. This model was based on the human information processing model.

The model human processor consists of three interacting systems. Each has its own memory and processor.

- **perceptual processor**
  - outputs into audio storage
  - outputs into visual storage
- **cognitive processor**
  - outputs into working memory.
  - has access to:
    - working memory
    - long term memory
- **motor processor**
  - carries out actions

The MHP model was used as the basis for the **GOMS** family of techniques proposed by Card, Moran, and Newell (1983), for quantitatively modeling and describing human task performance. GOMS stands for Goals, Operators, Methods, and Selection Rules.

Problems with the Model Human Processor approach

- **It models performance as a series of processing steps**
  - is that appropriate?
- **It is too focused on one person, one task**
- **It is an overly simplistic view of human behavior**
  - ignores environment & other people

Beyond the Model Human Processor

More recent research in cognitive frameworks has focussed on:

- **How knowledge is represented**
- **How mental models are used in HCI**
- **How users learn and become experienced on systems**
- **How interface metaphors help to match user's expectations (and how they don't!)**
- **How a person's mentally-held conceptual model affects behaviour**

This represents a change in emphasis from human factors to human actors - a change in focus on humans from being :passive and depersonalized to active and controlling.

The person is considered as an autonomous agent able to coordinate and regulate behavior, not a passive element in a human machine system

Computational versus Connectivist Approaches

Cognitive theories are classed as either **computational** or **connectionist**.

The **computational approach** uses the computer as a metaphor for how the brain works, similar to the information processing models described above.

The **connectionist approach** rejects the computer metaphor in favour of the **brain metaphor**, in which cognition is represent by neural networks. Cognitive processes are characterized as activation of nodes and connections between them.

Distributed Cognition

Distributed cognition is a framework proposed by Hutchins (1991). Its basis is that to explain human behavior you have to look beyond the individual human and the individual task. The functional system is a collection of actors, technology, setting and the interrelations to one another. Examples of functional systems which have been studied include:

- ship navigation
- air traffic control
- computer programming teams

The technique is used to analyze coordination of components in the functional system. It looks at

- information and how it propagates through the system
- how it transforms between the different representational states found in the functional system

One property of distributed cognition that is often discovered through analysis is **situation awareness** (Norman, 1993) which is the silent and inter-subjective communication that is shared among a group. When a team is working closely together the members will monitor each other to keep abreast of what each member is doing. This monitoring is not explicit - rather the team members monitor each other through glancing and inadvertent overhearing

The **two main concerns** of distributed cognition are:

- To map out how the different representational states are coordinated across time, location and objects
- To analyze and explain breakdowns

Example:

An electricity power plant was redesigned so that the old system consisting of a single large display screen which could be seen by all of a team of three operators was replaced by individual workstation screens for operators. This worked well until there was a problem which resulted in dangerous gases being released. The team of operators had great difficulty in finding the source of the problem and deciding what to do.

Because they no longer have access to all the information, they have to spend time explicitly co-ordinating their understanding of the situation by talking to each other. Under the old system, the knowledge would be shared – one operator would know what was happening with another's area of the plant without explicit communication. Although the team's individual responsibilities would still have been clearly divided, the knowledge of the system would be shared.

How could the new system of individual workstations be modified to make better use of distributed cognition?