# Knowledge and Mental Models

Lecture #9

From HCI Perspective…

….. by discovering what users know about systems and how they reason about how the systems function, it may be possible to predict learning time, likely errors and the relative easy with which users can perform their tasks ……

-- Donald A. Norman (1992)

Agenda

- Knowledge representation

- Utility of knowledge representation in HCI

- Mental models

- Utility of mental models in HCI
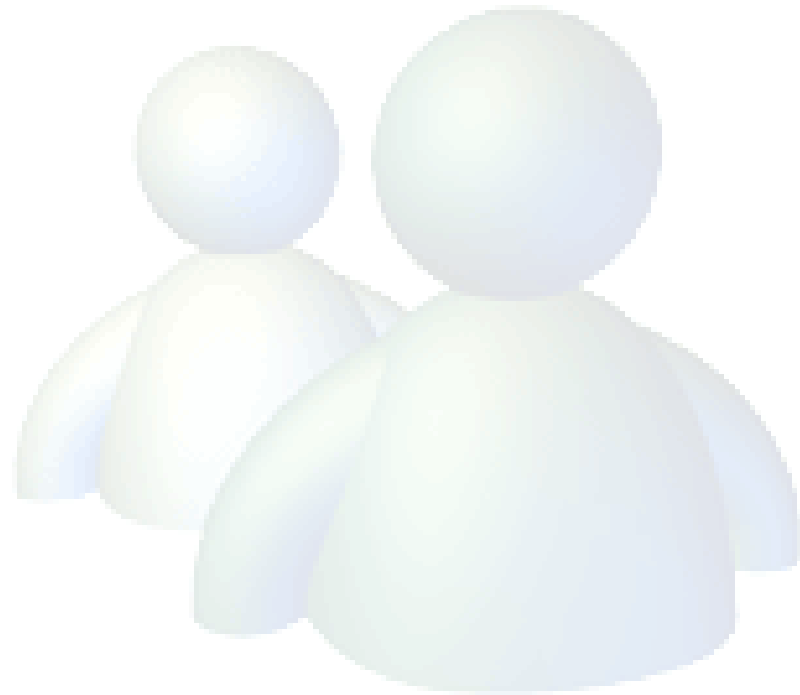
Knowledge: Recognition vs. Recall

- A well established finding in memory research

  - Human can recognize material far more easily than we can recall it from memory

  - Examples:
    - Narrate a description about the location of Indian Museum
      - You have to recall several landmarks etc. on the other hand if you accompany you can better recognize it

    - Teaching SPICE tool to the VLSI design class
      - Teacher can teach well in front of the tool itself otherwise using board or notes

Recognition vs. Recall

- Recognition is more preferable than recall in interface design

- Interface should be designed in such a way that
  - It favors to recognize the information easily than recall information

  Example:
    - Command based system (recall)
    - GUI based system (recognition)

Norman's Notion of Knowledge

Norman (1988) introduced the notions

- Knowledge in the world → Recognition
  - Information stored in the world
  - Less load on memory

- Knowledge in the head → Recall
  - Information stored in the memory
  - Too load on memory

Trade-off Between Head & World

Property	Knowledge in the world	Knowledge in the head
Retrievability	Retrievable whenever visible or audible	Not readily retrievable. Requires memory search or reminding
Learning	Learning not required. Interpretation substitutes for learning	Learning required. Learning required considerable effort
Efficiency of use	Tends to be slowed up by the need to find and interpret the external information	Can be very efficient
Easy of use at first encounter	High	Low
Aesthetic	Can be unaesthetic and inelegant, especially if there is a need to maintain lot information.	Nothing need be visible, which gives more freedom to the designer, which in turn can lead to better aesthetic

A Design Challenge

- As online activities become more widespread, people are having to remember more and more access information, such as password and security check

- The average activity internet users may have separate passwords and usernames for several email accounts, mailing lists, e-shopping sites, e-banking, online auctions etc. Remembering passwords is not easy

- From security perspective it is important that
    - Passwords are random
    - Passwords are frequently changed
    - Constructed from random list of letters and numbers

- But these are the hardest things for people to commit to memory

- Security here is in conflict with memorability!

Solution from Designer?

- Cookie
- Questionnaires
- Gesture
- Locality of reference
- Biometrics

and so on…..

Knowledge in the Head and ID

- Knowledge in the world is a choice of designer
  - Less memory load, direct feel, easy learning etc.

- However, designers may not afford "knowledge in the world" in every design

- Moreover, knowledge in the head is not good always

- Designer must utilize a judicious combination of the both

- Study of Knowledge representation and knowledge organization is helpful

- Mental models is also an important aspects

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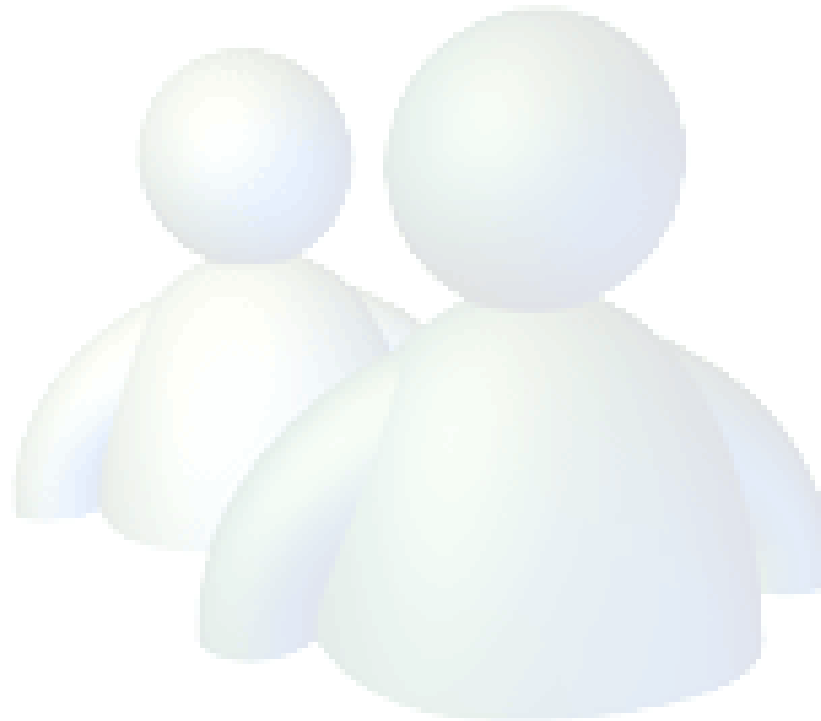
Knowledge Representation

- Knowledge in the head means knowledge stored in the long-term memory

- Here, knowledge are stored in the form of
  - Facts
  - Rules
  - Images
  - Experiences

- There are two types of memory
  - Episodic memory
  - Semantic memory
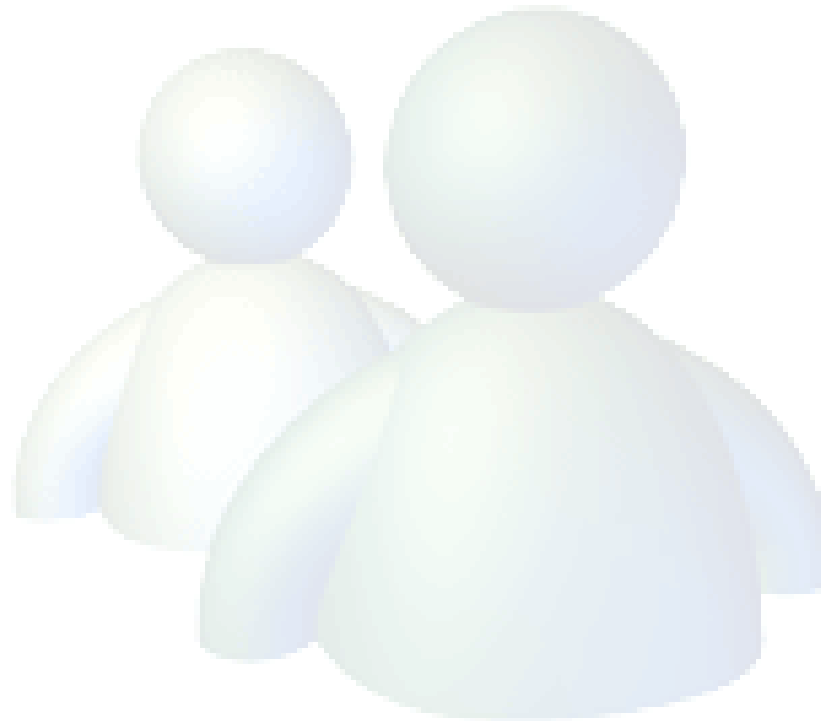
Knowledge Representation

- Episodic memory

  - Store our memory of events and experiences in a serial form

  - When certain information is needed it is retrieved by searching through the memory

- Semantic memory

  - We build up throughout our lives a large body of general knowledge, which is stored in this memory

  - Stored as a structured record of facts, concepts and skills that we have acquired

  - This memory plays important role in carrying out cognitive tasks like thinking and problem solving

Knowledge Representation

- A number of memory structure has been proposed to explain how we represent and store different types of knowledge
    - Distributed representation
    - Analogical representation
    - Propositional representation

- Each of these represents a different aspects of knowledge and as such, the models can be viewed as complementary rather than mutually exclusive

Questions for HCI

- To what extent does the form of representation used at the interface?

- Is it possible to develop interfaces that facilitate thinking and problem solving?

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Knowledge Organization

Whatever be the representation of knowledge, it should be organized in the long-term memory

What are the processes?
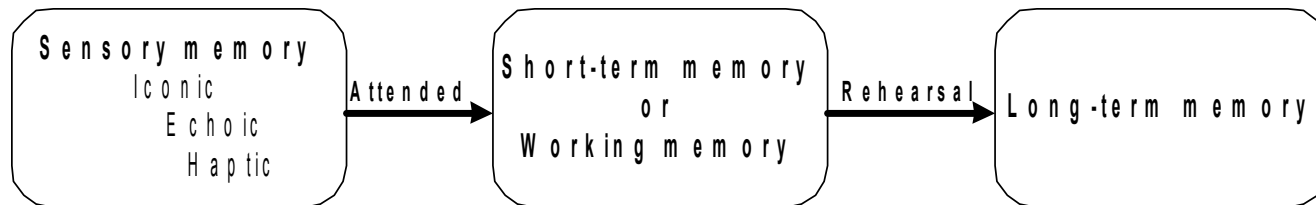
Long-term Memory Processes

- There are three main activities related to long-term memory

  1. Storage or remembering of information

  2. Forgetting

  3. Information retrieval

1. Storage/Remembering Information

- **Two things**

  1. How does information get into the long-term memory?

  2. How can we improve the process of getting information into long-term memory?

1. Storage/Remembering Information

- How does information get into the memory?
  - Information from short-term memory is stored into long-term memory by rehearsal

Sensory memory		Short-term memory		Long-term memory
Iconic Echoic Haptic	Attended →	or Working memory	Rehearsal →	

  - The repeated exposure to a stimulus or the rehearsal of a piece of information transfers it into long-term memory

1. Storage/Remembering Information

- How can we improve the process of getting information into the long-term memory?
  - Total time hypothesis
    - Amount learned is directly proportional to the amount of time spent learning
  - Distribution of practice effort
    - Learning time is more effective if it is distributed over time
      - One hour per week for a month versus four hours in a week
  - Familiar information
    - Remembering Chinese names versus Indian names

2. Forgetting Information

- There are two main theories of forgetting

  - Decay

  - Interference

- Decay

  - Information hold in long-term memory may eventually be forgotten

  - Information in long-term memory decayed logarithmically, that is, it lost rapidly at beginning and then more slowly

2. Forgetting Information

- Interference

  – Information is lost from memory through interference

  – If we acquire new information, it causes the lost of old information

    e.g. if one changes telephone number, more difficult to remembering old number

- Forgetting is also affected by emotional factors

3. Information Retrieval

- It is debatable whether we ever actually forget anything or whether it just becomes increasingly difficult to accesses certain items from memory

- "Tip o tongue" experience; some information is present but cannot be satisfactorily accessed

- Information may not be recalled but recognized or may be recalled only with prompting
    - Retrieval cues
    - Imagery cues

A Question for HCI

- How the concept of knowledge organization can be applied to designing interfaces?

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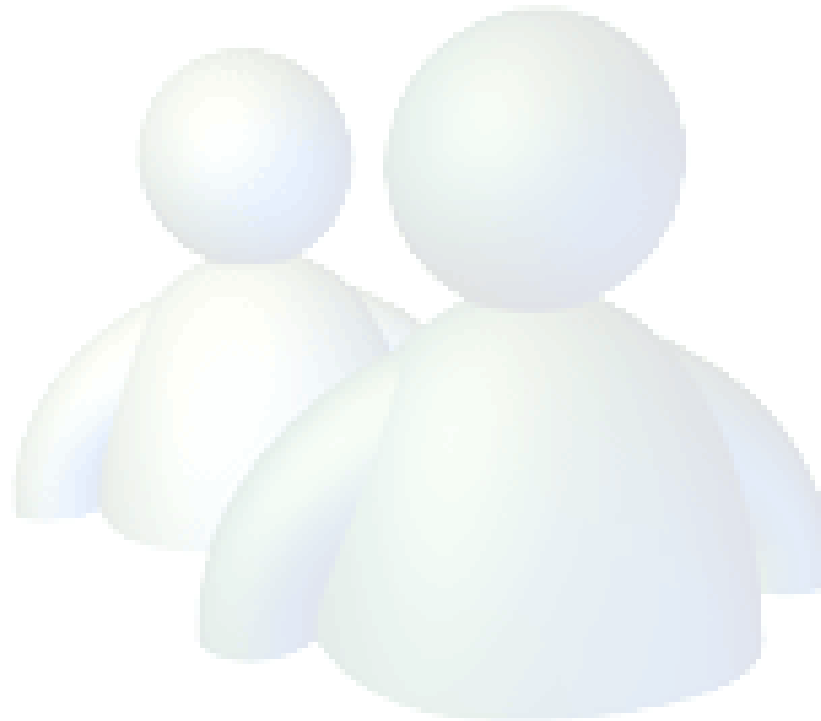
Mental Models

- Mental models research attempts to describe the structure of the mental representation that people use for everyday reasoning and problem solving

- Here is again Donald Norman:

  "The model people have of themselves, others, the environment and the things with which they interact. People form mental models through experience, training and instruction".

Mental Models

- Examples:
  - Many people imagine electricity as being like a fluid flowing through the circuit

  - Calculator users generally had some cover story which explained to their satisfaction what happened inside the device

  - Chilling a room through a thermostat control

Importance of Mental Models

- Personal mental models are

  - Unofficial but useful

  - If sufficiently accurate then it is possible to solve unexpected problems

  - Also, inappropriate models can lead to difficulties

    e.g.

    In electrical line and water supply analogy, people can believe that the electricity would leak out through the light sockets if they were left without a bulb

Structural versus Functional Models

- Main two types of mental models that users employ when interacting with devices

  - Structural model
    - Refers to "How-it-works", that is,
    - the user has internalized the structure of how the device or system works

  - Functional model
    - Refers to "How-to-use it", that is,
    - the user has internalized procedural knowledge about how to use the device or system

Utility of Mental Models in HCI

- Used to describe the internal mechanics of a device in terms of component parts

- The advantages of this model in HCI that it allow a user to predict the effects of any possible sequence of actions and hence to work out (eventually) how to achieve most task possible with the device

- Most useful when a device breaks down and it is necessary to work out how to mend it

- Interfaces need to be designed to help users "grow" productive mental models of relevant aspects of the systems

Recommended Materials

- My Home page
  http://www.iitkgp.ac.in/course/it60110/
  (For the presentation slides of the current lecture

- Book

  Human-Computer Interaction by Jenny Preece and et al. Addison-Wesley, New York

  Chapter 6

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