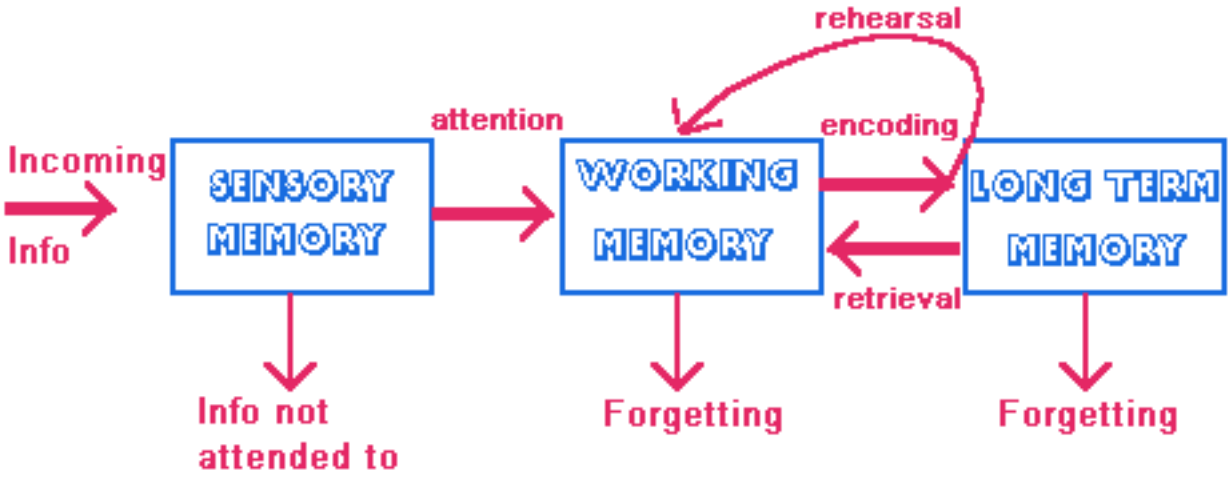
Understanding the user
Memory and theory of actions

Types of memory



Sensory Memory

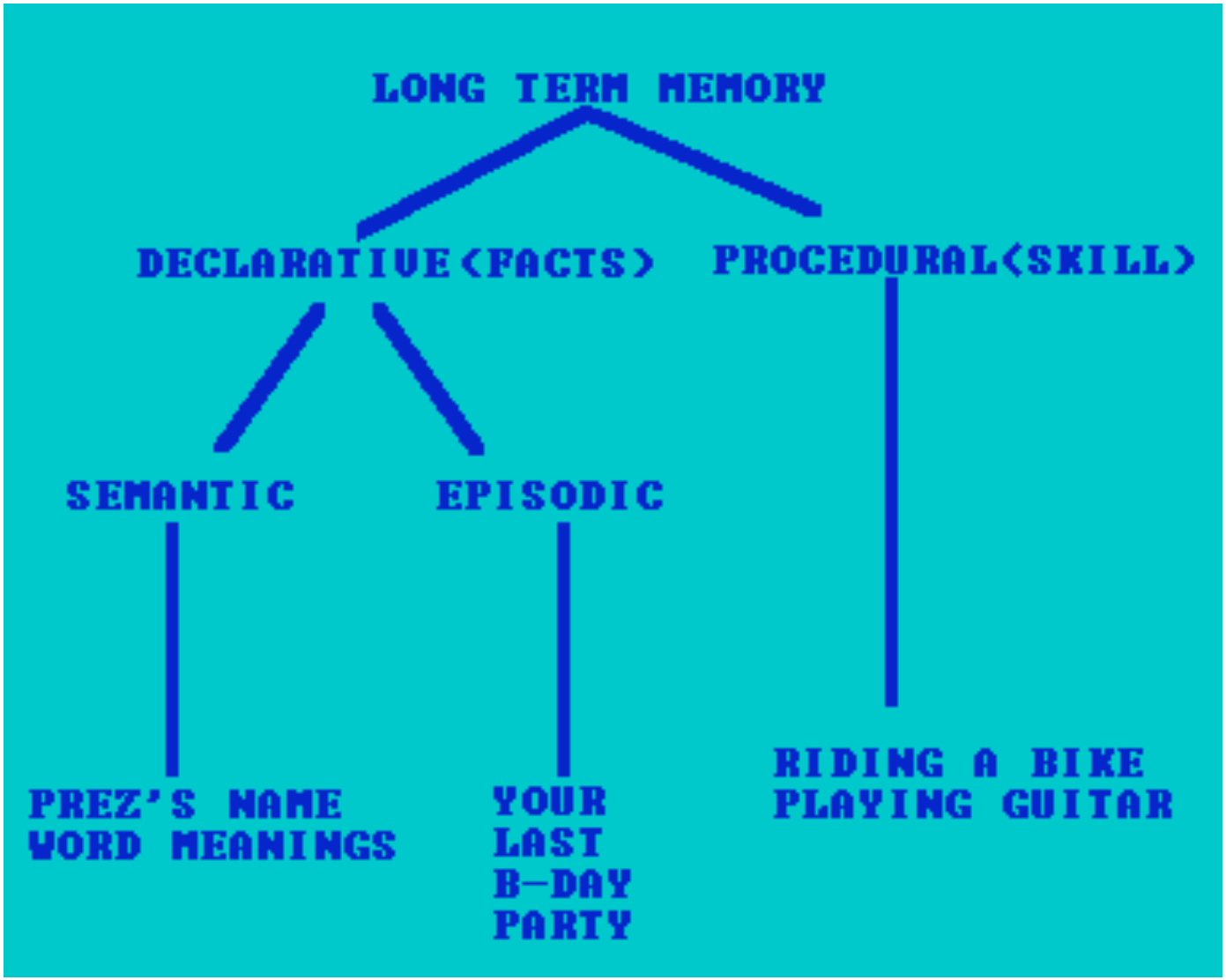
- buffers for stimuli received through the senses.
  - *iconic memory* for visual stimuli,
  - *echoic memory* for aural stimuli
  - *haptic memory* for touch.
- Information is passed from sensory memory into short-term memory by attention
- filtering the stimuli to only those which are of interest at a given time)

Short-term memory

- Note-pad for temporary recall of the information under processing
  - to understand this sentence you need to hold in your mind the beginning of the sentence while you read the rest.
- It decays rapidly (200 ms.)
- Has a limited capacity: (7+-2 items)
- Chunking of information can lead to an increase in short term memory capacity
- A hyphenated phone number is easier to remember than a single long number
- Interference often causes disturbance in short-term memory retention. This accounts for the desire to complete the tasks held in short term memory as soon as possible.

Long-term memory

- LTM is intended for storage of information over a long time
- Information from the working memory is transferred to it after a few seconds
- Unlike in working memory, there is little decay
- Different types of long-term memory:
- Declarative (facts) vs. Procedural (skills)
  - *Episodic* memory: memory of events and experiences in a serial form. It is from this memory that we can reconstruct the actual events that took place at a given point in our lives.
  - Semantic memory: a structured record of facts, concepts and skills that we have acquired. The information in semantic memory is derived from that in our own episodic memory, such that we can learn new facts or concepts from our experiences.


LONG TERM MEMORY
DECLARATIVE(FACTS)
PROCEDURAL(SKILL)
SEMANTIC
EPISODIC
PREZ'S NAME
WORD MEANINGS
YOUR
LAST
B-DAY
PARTY
RIDING A BIKE
PLAYING GUITAR

LTM activities

- Storage, deletion and retrieval
- Information from STM is stored in LTM by rehearsal or repeated exposure to a stimulus
- Deletion is mainly caused by *decay* and *interference*.
  - Emotional factors also affect LTM
- Information retrieval: recall and recognition
  - Recall: the information is reproduced from memory
  - Recognition: presentation of the information provides the knowledge that the information has been seen before.
- Recognition is of lesser complexity, as the information is provided as a cue
- Recall can be assisted by retrieval cues which enable to quickly access the information in memory

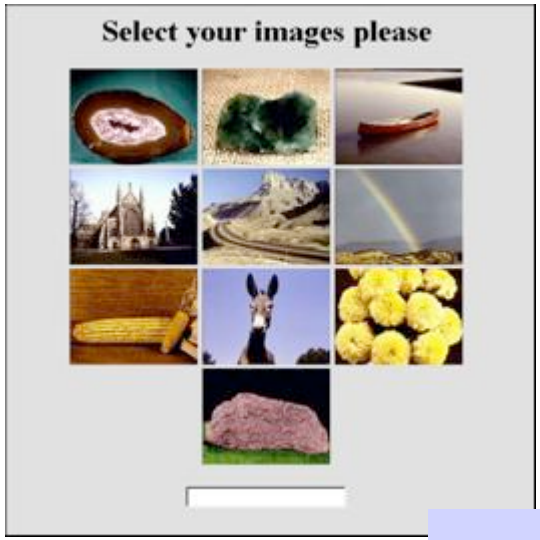
Memory

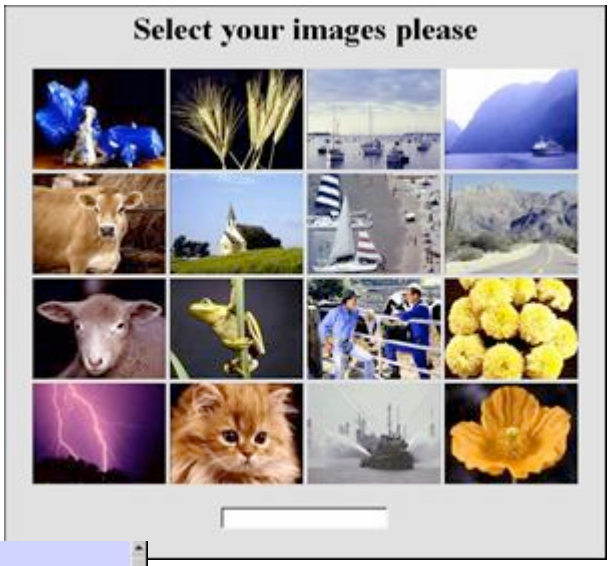
- Involves encoding and recalling knowledge and acting appropriately
- We don't remember everything - filtering and processing
- Context is important
- We recognize things much better than being able to recall things
  - The rise of the GUI over command-based interfaces
- Better at remembering images than words
  - The use of icons rather than labels
- People's working memory capacity is limited (7+-2 items) – DO NOT OVERGENERALIZE

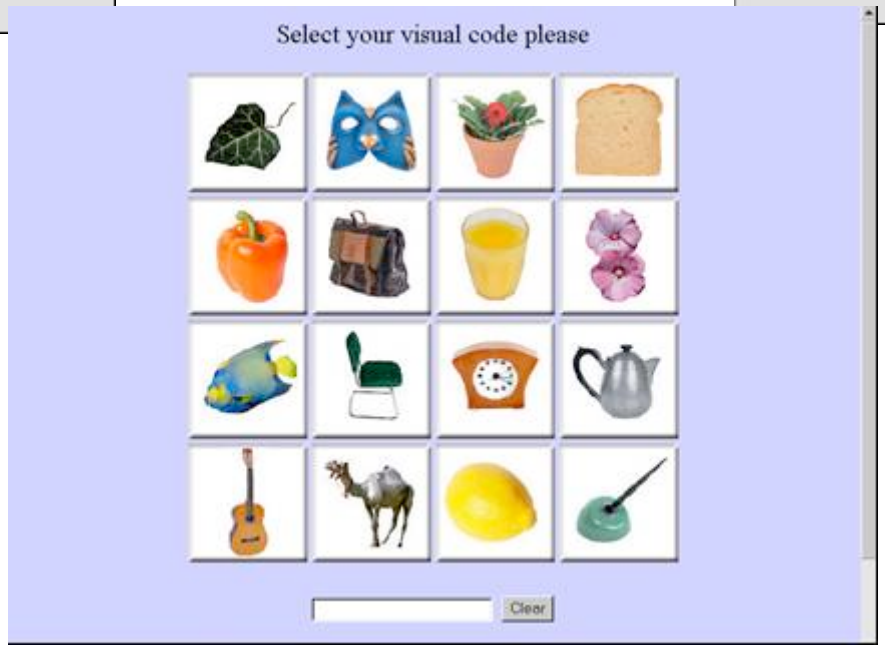
Design problems

- Operate a system (interface design)
- User authentication
  - On-line banking
  - Graphical authentication
  - Biometrics
- Personal information management
  - All my files, folders, pictures, music etc.
  - Where are them??

Graphical authentication







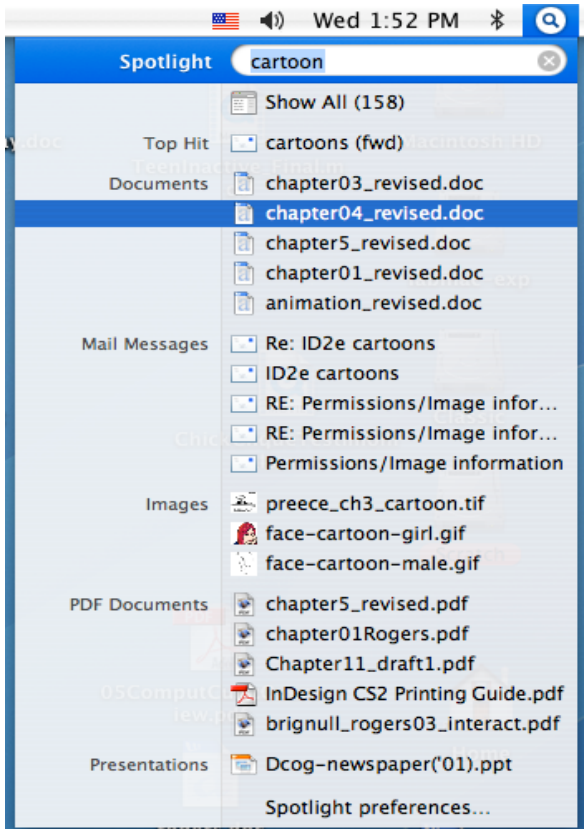
Personal information management

- PIM is a growing problem for most users
  - Who have vast numbers of documents, images, music files, video clips, emails, attachments, bookmarks, etc.,
  - Major problem is deciding where and how to save them all, then remembering what they were called and where to find them again
  - Naming most common means of encoding them
  - Trying to remember a name of a file created some time back can be very difficult, especially when have 1000s and 1000s
  - How might such a process be facilitated taking into account people's memory abilities?

Personal information management

- Memory involves 2 processes
  - recall-directed and recognition-based scanning
- File management systems should be designed to optimize both kinds of memory processes
  - e.g., Search box and history list
- Help users encode files in richer ways
  - Provide them with ways of saving files using colour, flagging, image, flexible text, time stamping, etc

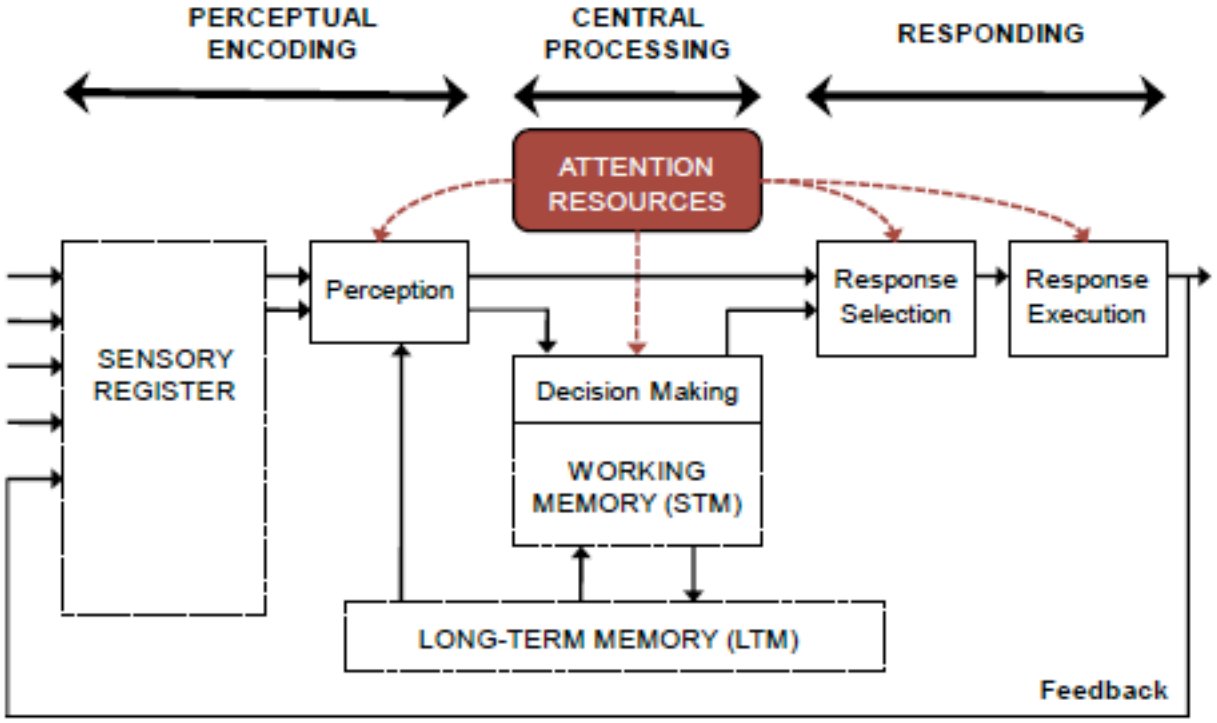
Apple’s Spotlight search



Design implications

- Don’t overload users’ memories with complicated procedures for carrying out tasks
- Design interfaces that promote recognition rather than recall
- Provide users with a variety of ways of encoding digital information to help them remember where they have stored them
  - e.g., categories, color, flagging, time stamping

A more advanced cognitive model



Wickens (1984)

Cognitive frameworks

- Conceptual framework that help to explain and predict user behaviour
  - Mental model
  - Theory of action
  - Information processing
  - Distributed cognition

Mental models

- Users develop an understanding of a system through learning and using it
- Knowledge is often described as a mental model
  - How to use the system (what to do next)
  - What to do with unfamiliar systems or unexpected situations (how the system works)
- People make inferences using mental models of how to carry out tasks

Mental models & system design

- Understanding how people develop mental models can
  - help designing systems which are compatible with the user mental model
  - Make systems transparent so people can understand them better and know what to do
  - Help the communication of more appropriate mental models of system functionality

Mental models

- Craik (1943) described mental models as internal constructions of some aspect of the external world enabling predictions to be made
- Involves unconscious and conscious processes, where images and analogies are activated
- Deep versus shallow models (e.g. how a car work and how to drive it)

Everyday reasoning

(a) You arrive home on a cold winter's night to a cold house. How do you get the house to warm up as quickly as possible?

Set the thermostat to be at its highest or to the desired temperature?

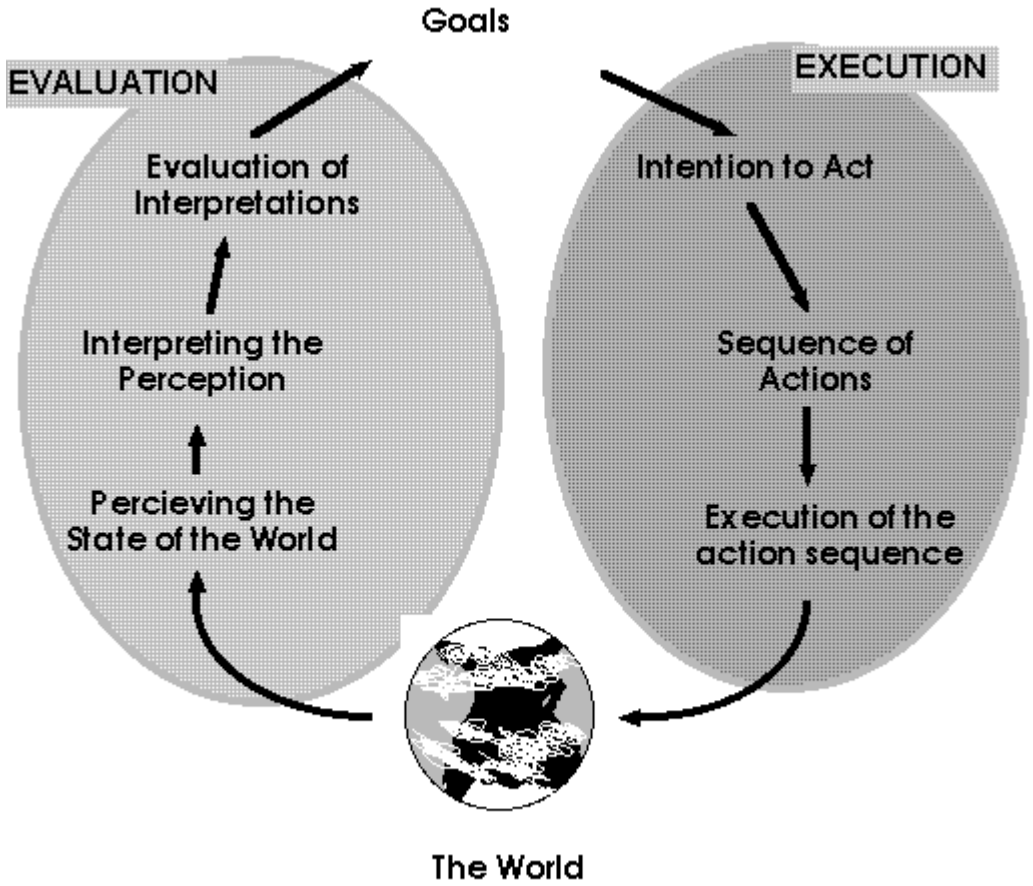
Heating up a room

- Many people have erroneous mental models (Kempton, 1996)
- Why?
  - General valve theory, where ‘more is more’ principle is generalised to different settings (e.g. gas pedal, gas cooker, tap, radio volume)
  - Thermostats based on model of on-off switch model

Heating up a room

- Same is often true for understanding how interactive devices and computers work:
  - Poor, often incomplete, easily confusable, based on inappropriate analogies and superstition (Norman, 1983)
  - e.g. elevators and pedestrian crossings - lot of people hit the button at least twice
  - E.g., pressing enter several time when the system is not responding
  - Why? Think it will make the lights change faster or ensure the elevator arrives!

Theory of action (Norman 1986)



Theory of action

- Proposes 7 stages of an activity
  - Establish a goal
  - Form an intention
  - Specify an action sequence
  - Execute an action
  - Perceive the system state
  - Interpret the state
  - Evaluate the system state with respect to the goals and intentions
  - Norman's (1986)

The gulfs

- The ‘gulfs’ explicate the gaps that exist between the user and the interface
- Gulf of execution
  - the distance from the user to the physical system
  - design the system to ease the process of getting from intention to execution
- Gulf of evaluation
  - the distance from the physical system to the user
  - design the system to ease the interpretation and evaluation of the system response for the user after interaction
- Need to bridge the gulfs in order to reduce the cognitive effort required to perform a task

Overcoming the gulfs

- **Affordance**
  - The possible perceived actions of an object.
- **Mappings**
  - A relationship between an objects controls and the effects of the control.
- **Constraints**
  - Limitations to the possible actions of an object.
- **Conventions**
  - Cultural elements that a shared group have become accustom to.
- **Feedback**
  - Provide continuous acknowledgement of users actions.

Breaking news on the web

(i) Set goal to find out about breaking news

decide on news website

(ii) Form an intention

check out BBC website

(iii) Specify what to do

move cursor to link on browser

(iv) Execute action sequence

click on mouse button

(v) Check what happens at the interface

see a new page pop up on the screen

(vi) Interpret it

read that it is the BBC website

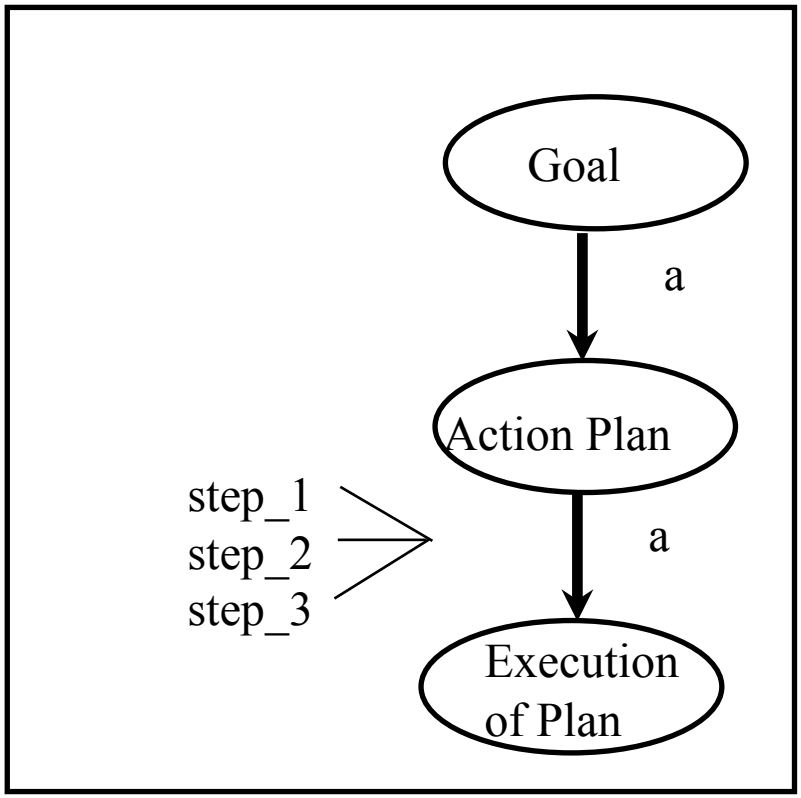
(vii) Evaluate it with respect to the goal

read breaking news

How realistic?

- Human activity does not proceed in such an orderly and sequential manner
- Stages can be missed, repeated or out of order
- Do not always have a clear goal in mind but react to the world
- Theory is only approximation of what happens and is greatly simplified
- Help designers think about how to help users monitor their actions

Automatic behaviour



a) *Initial learning stage*:

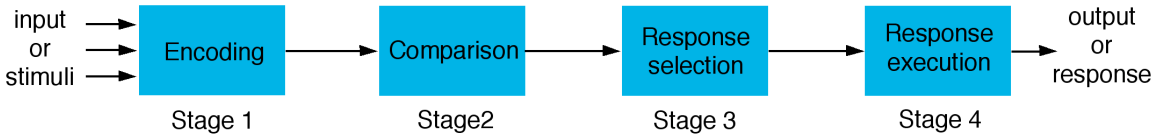
Step-by-step procedures. An Action Plan must be defined.

b) *Time=x*:

the action plan is directly retrieved from memory.

Information processing

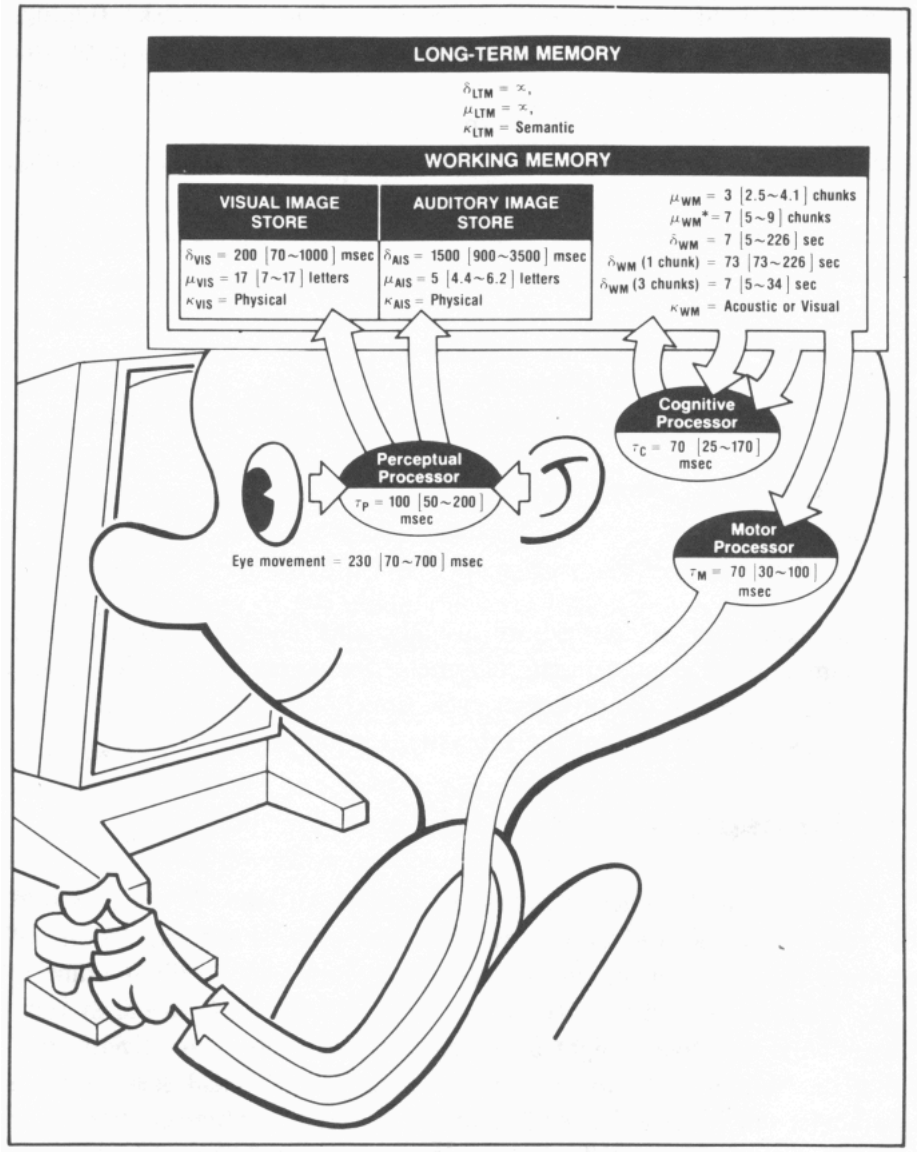
- Conceptualizes human performance in metaphorical terms of information processing stages



Model Human processor

- Model the information processes of a user interacting with a computer
- Predicts which cognitive processes are involved when a user interacts with a computer
- Enables calculations to be made of how long a user will take to carry out a task
- (Card et al, 1983)

The human processor model



Distributed cognition

- Concerned with explaining how we interact with external representations (e.g. maps, notes, diagrams)
- What are the cognitive benefits and what processes involved
- How they extend our cognition
- What computer-based representations can we develop to help even more?

Externalizing to reduce memory load

- Diaries, reminders, calendars, notes, shopping lists, to-do lists Post-its, piles, marked emails
- External representations:
  - Remind us that we need to do something (e.g. to buy something for mother's day)
  - Remind us of what to do (e.g. buy a card)
  - Remind us when to do something (e.g. send a card by a certain date)

Computational offloading

- When a tool is used in conjunction with an external representation to carry out a computation (e.g. pen and paper)
- Try doing the two sums below (a) in your head, (b) on a piece of paper and c) with a calculator.
  - 234 + 456 =??
  - 234 +
  - 456
  - CCXXXIV + CDLVI = ???
- Which is easiest and why?

Annotation and cognitive tracing

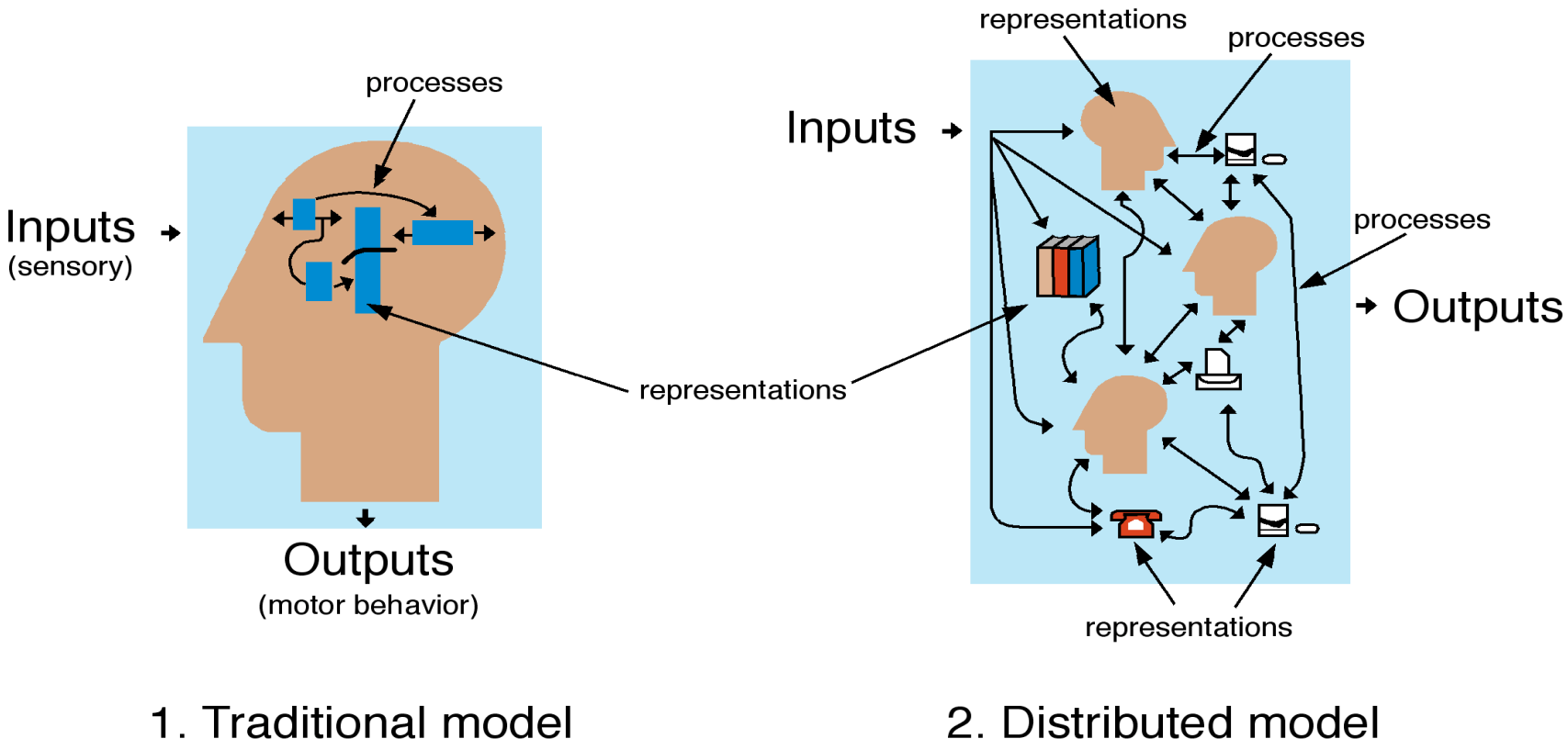
- Annotation involves modifying existing representations through making marks
  - e.g. crossing off, ticking, underlining

- Cognitive tracing involves manipulating items into different orders or structures
  - e.g. playing scrabble, playing cards

Distributed cognition

- Concerned with the nature of cognitive phenomena across individuals, artifacts, and internal and external representations (Hutchins, 1995)
- Describes these in terms of propagation across representational state
- Information is transformed through different media (computers, displays, paper, heads)

How it differs from information processing



1. Traditional model

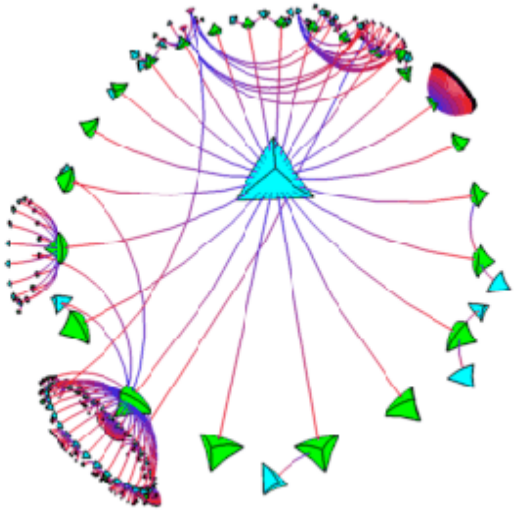
2. Distributed model

What's involved

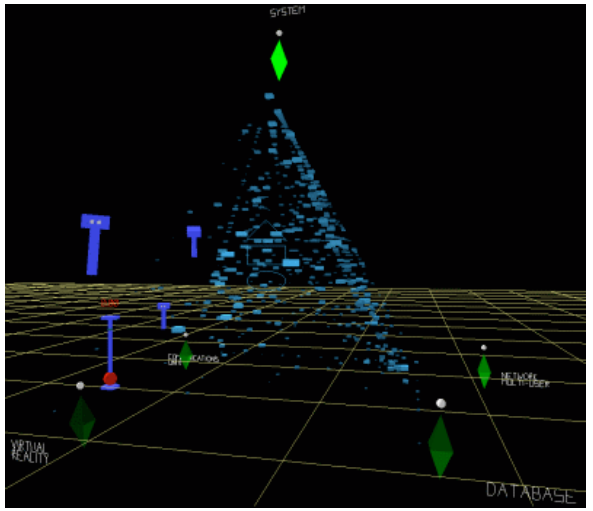
- The distributed problem-solving that takes place
- The role of verbal and non-verbal behavior
- The various coordinating mechanisms that are used (e.g., rules, procedures)
- The communication that takes place as the collaborative activity progresses
- How knowledge is shared and accessed

Design implication

- Provide external representations at the interface that reduce memory load and facilitate computational offloading



e.g. Information visualizations have been designed to allow people to make sense and rapid decisions about masses of data



Learning

- How to use a computer
  - Little reliance on manuals
  - Learning by doing
    - (GUI supports exploration importance of undo)
    - ‘training-wheel approach:
- Using a computer to understand a given topic
  - E-learning; m-learning

Example

Design implications

- Design interfaces that encourage exploration
  - Interactive guided tour; wizards; safe recovery
- Design interfaces that constraint and guide users to select appropriate actions when initially learning
- Dynamically link concrete representations and abstract concepts

Language comprehension

- Reading, speaking and listening
  - Duration (written language is permanent)
  - Time required (reading can be quicker)
  - Workload (listening requires less cognitive effort than reading or speaking)
  - Formality (written language more formal and grammatical)
  - Individual differences (age, skills)
  - Multimodality (gesture and speech)

Design implications

- Keep the length of speech-based instruction to a minimum (e.g., no more than 3 or 4 menu options)
- Provide opportunities for personalising fonts and size
- Use multimodal outputs, combining speech and direct manipulation for improving speech performance

Example

Key points

- Cognition involves many processes including attention, memory, perception and learning
- The way an interface is designed can greatly affect how well users can perceive, attend, learn and remember how to do their tasks
- The conceptual framework of ‘mental models’ and ‘theory of action’ provide ways of understanding how and why people interact with products, which can lead to thinking about how to design better products

Reading

- Preece: chapter 3