Understanding Users

From Preece, Rogers & Sharp's *Interaction Design*

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Overview

- Explain **what cognition is**, and why it is important for interaction design
- Describe **how cognition has been applied to interaction design**
- Provide a number of examples in which cognitive research has led to the design of more effective interactive products
- Explain **what mental model is**
- Give examples of **conceptual frameworks** that are useful for interaction design
- Enable you to try to **elicit a mental model** and be able to understand what it means

Why Understand Users?

- Interacting with technology is cognitive
- Need to take into account cognitive processes involved and cognitive limitations of users
- Provides knowledge about what users can and cannot be expected to do
- Identifies and explains the nature and causes of problems users encounter
- Supply theories, modeling tools, guidance and methods that can lead to the design of better interactive products

Cognitive Process

- Attention
- Perception and recognition
- Memory
- Learning
- Reading, speaking and listening
- Problem-solving, planning, reasoning and decision-making

- **Most relevant to interaction design are attention, perception and recognition and memory**

Attention

- Selecting things to concentrate on at a point in time from the mass of stimuli around us
- Involves audio and/or visual senses
  - Auditory attention: waiting for our names to be called
  - Visual attention: scanning the football score in a newspaper
- **Focused** and **divided attention** enables us to be selective in terms of the mass of competing stimuli but limits our ability to keep track of all events
- Allows us to focus on information that is relevant to what we are doing
- Information at the interface should be structured to capture user's attention
  - E.g. use perceptual boundaries (windows), colors, reverse video, sound and flashing lights

Activity: Price of a Double Room

- Find the price of a double room at the Holiday Inn in Bradley

Pennsylvania
Bedford Motel/Hotel: Crinaline Courts
(814) 623-9511 S: $18 D: $20
Bedford Motel/Hotel: Holiday Inn
(814) 623-9006 S: $29 D: $36
Bedford Motel/Hotel: Midway
(814) 623-8107 S: $21 D: $26
Bedford Motel/Hotel: Penn Manor
(814) 623-8177 S: $19 D: $25
Bedford Motel/Hotel: Quality Inn
(814) 623-5189 S: $23 D: $28
Bedford Motel/Hotel: Terrace
(814) 623-5111 S: $22 D: $24
Bradley Motel/Hotel: De Soto
(814) 362-3567 S: $20 D: $24
Bradley Motel/Hotel: Holiday House
(814) 362-4511 S: $22 D: $25
Bradley Motel/Hotel: Holiday Inn
(814) 362-4501 S: $32 D: $40
Breezewood Motel/Hotel: Best Western Plaza
(814) 735-4352 S: $20 D: $27
Breezewood Motel/Hotel: Motel 70
(814) 735-4385 S: $16 D: $18

Activity: Price of a Double Room

- Find the price of a double room at the Quality Inn in Columbia

South Carolina

City	Motel/Hotel	Area code	Phone	Rates Single	Rates Double
Charleston	Best Western	803	747-0961	$26	$30
Charleston	Days Inn	803	881-1000	$18	$24
Charleston	Holiday Inn N	803	744-1621	$36	$46
Charleston	Holiday Inn SW	803	556-7100	$33	$47
Charleston	Howard Johnsons	803	524-4148	$31	$36
Charleston	Ramada Inn	803	774-8281	$33	$40
Charleston	Sheraton Inn	803	744-2401	$34	$42
Columbia	Best Western	803	796-9400	$29	$34
Columbia	Carolina Inn	803	799-8200	$42	$48
Columbia	Days Inn	803	736-0000	$23	$27
Columbia	Holiday Inn NW	803	794-9440	$32	$39
Columbia	Howard Johnsons	803	772-7200	$25	$27
Columbia	Quality Inn	803	772-0270	$34	$41
Columbia	Ramada Inn	803	796-2700	$36	$44
Columbia	Vagabond Inn	803	796-6240	$27	$30

Activity

- Tullis (1987) found that the two screens produced quite different results
  - 1st screen took an average of 5.5 seconds to search
  - 2nd screen took 3.2 seconds to search
- Why the difference, when both displays have the same density of information (31%)?
- Use of spacing to group => **information structure is visible** => One to use a better search strategy
  - In the 1st screen the information is bunched up together, making it hard to search
  - In the 2nd the characters are grouped into vertical categories of information making it easier
- Show the structure of information clearly so that one can focus on one level while ignoring other levels of information

Multitasking and Attention

- Is it possible to perform multiple tasks without one or more of them being detrimentally affected?
- Ophir et al (2009) compared heavy vs light multi-taskers
  - Heavy were more prone to being distracted than those who infrequently multitask
  - Heavy multi-taskers are easily distracted and find it difficult to filter irrelevant information

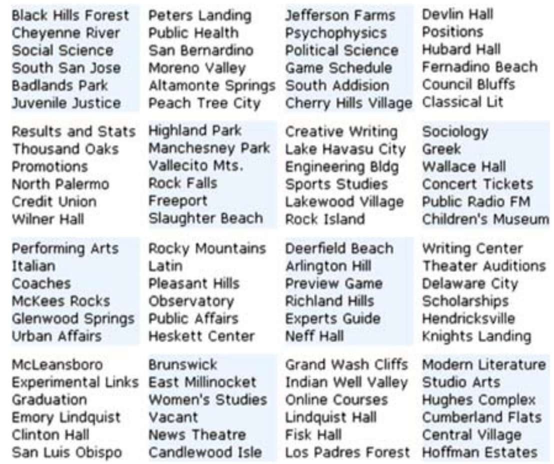
Design Implications: Attention

- **Make information salient** when it needs attending to
- Use techniques that make things stand out like **color, ordering, spacing, underlining, sequencing and animation**
- **Avoid cluttering** the interface with too much information
- Avoid using too much because the software allows it

Perception and Recognition

- **How information is acquired from the world and transformed into experiences** of objects, events, sounds, and tastes
- Vision is most dominant sense, followed by hearing and touch
- Many design guidelines for better perception
  - Grouping items together and leaving spaces between them can aid attention
  - Too much white space on web pages can be detrimental to search (Spool et al, 1997)
  - Grouping using a border is better than using color contrast (Weller, 2004)

Is Color Contrast Good? Find Italian



Are Borders and White Space Better?
Find French

Webmaster Russian Athletics Go Shockers Degree Options Newsletter	Curriculum Emergency (EMS) Statistics Award Documents Language Center Future Shockers	Student Life Accountancy McKnight Center Council of Women Commute Small Business	Dance Gerontology Marketing College Bylaws Why Wichita? Tickets
Geology Manufacturing Management UCATS Alumni News Saso	Intercollegiate Bowling Wichita Gateway Transfer Day Job Openings Live Radio	Thinker & Movers Alumni Foundations Corbin Center Jardine Hall Hugo Wall School	Career Services Doers & Shockers Core Values Grace Wilkie Hall Strategic Plan Medical Tech
Educational Map Physical Plant Graphic Design Non Credit Class Media Relations Advertising	Beta Alpha Psi Liberal Arts Counseling Biological Science Duerksen Fine Art EMT Program	Staff Aerospace Choral Dept. Alberg Hall French Spanish	Softball, Men's McKinley Hall Email Dental Hygiene Tenure Personnel Policies
English Graduate Complex Music Education Advising Center Medical School Levitt Arena	Religion Art Composition Physics Entrepreneurship Koch Arena Roster	Parents Wrestling Philosophy Wichita Lyceum Fairmount Center Women's Museum	Instrumental Nursing Opera Sports History Athletic Dept. Health Plan

Which is easiest to read and why?

What is the time?

What is the time?

What is the time?

What is the time?

What is the time?

Design Implications: Perception

- Representations of information need to be designed to be perceptible and recognizable
- **Icons** and other graphical representations should enable users to readily *distinguish* their meaning
- **Bordering** and **spacing** are effective visual ways of grouping information
- **Sound** should be audible and distinguishable
- **Speech** output should enable users to distinguish between the set of spoken words
- **Text** should be legible and distinguishable from the background
- **Tactile feedback** should allow users to recognize and distinguish different meanings

Multi-Modal Integration

- Different sensory modalities (e.g. sight, sound, touch) become integrated into the coherent, unified, conscious representation that we experience
- A natural perceptual ability to improve sensory uncertainty
- Mc Gurk Effect (Mc Gurk & Mac Donald, 1976)
  - A person's phoneme production was dubbed with a video of that person speaking a different phoneme. The end result was the perception of a third, different phoneme
- Visual capture
  - Due to visual dominance of spatial tasks, one will depend on vision over audition or tactician to solve spatial problems

Memory

- Involves first **encoding** and then **retrieving** knowledge
- We don't remember everything - involves **filtering** and **processing** what is attended to
- **Context** is important in affecting our memory (i.e. where, when)
- Well known fact that we **recognize** things much better than being able to recall thing
- We are better at remembering **images** than words

Processing in Memory

- Encoding is first stage of memory
  - determines which information is attended to in the environment and how it is interpreted
- The **more attention** paid to something, and the **more it is processed** in terms of thinking about it and **comparing** it with other knowledge, …
- The more likely it is to be **remembered**
  - e.g. when learning about HCI, it is much better to reflect upon it, carry out exercises, have discussions with others about it, and write notes than just passively read a book, listen to a lecture or watch a video about it

Context is Important

- Context affects the extent to which information can be subsequently retrieved
- Sometimes it can be difficult for people to recall information that was encoded in a different context:
  - "You are on a train and someone comes up to you and says hello. You don't recognize him for a few moments but then realize it is one of your neighbours. You are only used to seeing your neighbour in the hallway of your apartment block and seeing him out of context makes him difficult to recognize initially"

Activity

- Try to remember the dates of your grandparents' birthday
- Try to remember the cover of the last two DVDs you bought or rented
- Which was easiest? Why?
- People are very good at remembering visual cues about things
  - e.g. the color of items, the location of objects and marks on an object
- They find it more difficult to learn and remember arbitrary material
  - e.g. birthdays and phone numbers

Recognition vs. Recall

- **Command-based interfaces** require users to **recall** from memory a name from a possible set of 100s
- **GUIs** provide visually-based options that users need only browse through until they **recognize** one
- Web browsers, MP3 players, etc., provide lists of visited URLs, song titles etc., that **support recognition** memory

The Problem with the Classic '7±2'

- **George Miller's (1956) theory of how much information people can remember**
- People's immediate memory capacity is very limited
- Many designers think this is useful finding for interaction design

What Some Designers Get Up to..

- Present only 7 options on a menu
- Display only 7 icons on a tool bar
- Have no more than 7 bullets in a list
- Place only 7 items on a pull down menu
- Place only 7 tabs on the top of a website page

- But this is wrong? Why?

Why Wrong?

- Inappropriate application of the theory
- **People can scan lists of bullets, tabs, menu items for the one they want**
- They don't have to recall them from memory having only briefly heard or seen them
- Sometimes a small number of items is good
- But depends on task and available screen estate

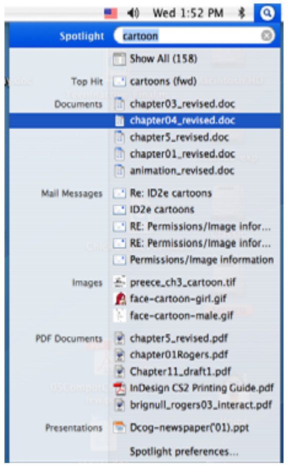
Personal Information Management

- Personal information management is a growing problem for many users
  - vast numbers of documents, images, music files, video clips, emails, attachments, bookmarks, etc.,
  - 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
  - but can be difficult to remember, especially when have 1000s and 1000s
  - How might such a process be facilitated taking into account people's memory abilities?

Memory Involves 2 Processes

- **Recall-directed and recognition-based scanning**
- File management systems should be designed to support 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 color, flagging, image, flexible text, time stamping, etc

Is Apple's Spotlight Search Tool Any Good?



Memory Aids

- **SenseCam** developed by Microsoft Research Labs
- a wearable device that intermittently takes photos without any user intervention while worn
- digital images taken are stored and revisited using special software
- Has been found to improve people's memory, suffering from Alzheimers

Design Implications: Memory

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

Learning

- How to learn to use a computer-based application
- Using a computer-based application to understand a given topic
- People find it hard to learn by following instructions in a manual
  - prefer to learn by doing

Design Implications: Learning

- Design interfaces that encourage exploration
- Design interfaces that constrain and guide learners
- Dynamically linking concepts and representations can facilitate the learning of complex material

Reading, Speaking, and Listening

- The ease with which people can read, listen, or speak differs
- Many prefer listening to reading
- **Reading can be quicker** than speaking or listening
- **Listening requires less cognitive effort** than reading or speaking
- Dyslexics have difficulties understanding and recognizing written words

Applications

- Speech-recognition systems allow users to interact with them by using spoken commands
  - e.g. Google Voice Search app
- Speech-output systems use artificially generated speech
- e.g. written-text-to-speech systems for the blind
- Natural-language systems enable users to type in questions and give text-based responses
  - e.g. Ask search engine

Design Implications: Reading, Speaking & Listen

- Keep the length of speech-based menus and instructions to be short
- Accentuate the intonation of artificially generated speech voices
  - As they are harder to understand than human voices
- Provide opportunities for making text large on a screen,
  - Without affecting the formatting, for people who find it hard to read small text

Problem-solving, Planning, Reasoning and Decision-making

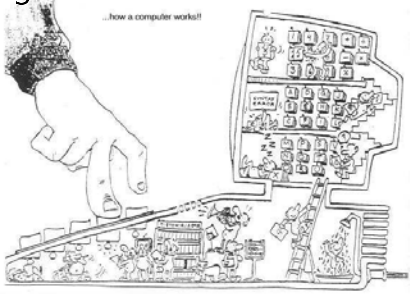
- All involves reflective cognition
  - e.g. thinking about what to do, what the options are, and the consequences
- Often involves conscious processes, discussion with others (or oneself), and the use of artifacts
  - e.g. maps, books, pen and paper
- May involve working through different scenarios and deciding which is best option

Design Implications: Problem-solving, etc

- Provide additional information/functions for users who wish to understand more about how to carry out an activity more effectively
- Use simple computational aids to support rapid decision-making and planning for users on the move

Mental Models

- **Users develop an understanding of a system** through learning about and using it
- Knowledge is sometimes 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

- 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
  - Deep mental model : e.g. How TVs work?
  - Shallow mental model: e.g. How to operate a TV?

Everyday Reasoning and Mental Models

(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?

(b) You arrive home starving hungry. You look in the fridge and find all that is left is an uncooked pizza. You have an electric oven. Do you warm it up to 375 degrees first and then put it in (as specified by the instructions) or turn the oven up higher to try to warm it up quicker?

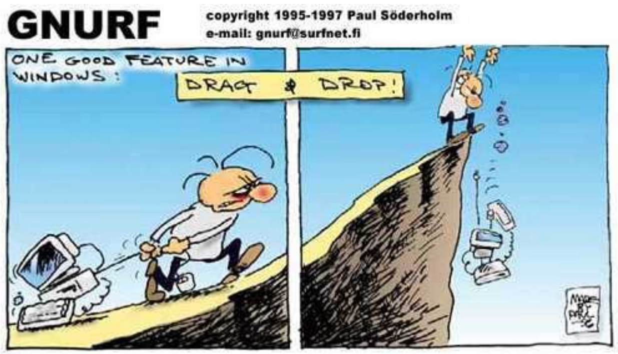
Heating Up a Room or Oven that is Thermostat-Controlled

- 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**

"More is More" Model

- 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
  - **Many people hit the button at least twice**
  - **Why? They think it will make the lights change faster or ensure the elevator arrives (although they know this is not true)**

"Drag and Drop" Mental Model



Computer Mental Model

How Did You Fare?

- Your mental model
  - How accurate?
  - How similar?
  - How shallow?
- Payne (1991) did a similar study and found that people frequently resort to analogies to explain how they work
- People's accounts greatly varied and were often ad hoc

Norman's Theory of Action (1986)

- 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**

E.g.: Reading Latest News on the Web

- Establish a goal
  - Find out about latest news via a news website
- Form an intention
  - Check out the BBC website
- Specify an action sequence
  - Move cursor to a link on browser, .. (in mind)
- Execute action sequence
  - Move cursor to a link on browser
- Perceive the system state
  - See a new page pop up on the screen
- Interpret the state
  - Read that it is the BBC website
- Evaluate the system state with respect to the goals
  - Read breaking news

E.g.: Get More Light

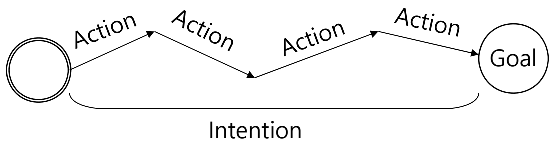
- Establish a goal
  - Get more light
- Form an intention
  - Turn on the desk lamp
- Specify actions at interface
  - Press the switch (actions allowed by interface)
- Execute action
  - ..
- Perceive the system state
  - Brighter
- Interpret the state
  - The lamp is on
- Evaluate the system state with respect to the goals
  - Enough light?

E.g.: Opening a Door

- Goal
  - An open door
- Intention
  - Open the door
- Actions
  - Hold the handle and push/pull the door
- Execution
- Perception
  - Door is moving/not moving
- Interpretation
  - Opened/Locked
- Evaluation

7 Stages: Goal, Intention, Actions, …

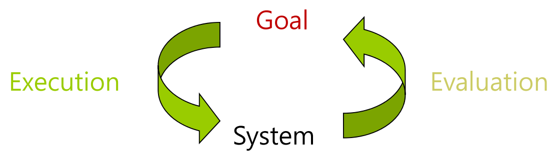
- Confused between a goal, an intention and actions?
  - **A goal is a "state" while an intention is an "action"**



- Confused between perceiving system state and interpret system state?
  - You "perceive" a change by your senses
    - you perceive a change in the interface. You cannot see the internal of the system
  - Interpretation here means mapping from a change in the interface to a change in the system state
    - The mapping is from experience or from the knowledge about the system

Execution/Evaluation Loop

- Execution/Evaluation Loop



  - User establishes the goal
  - Formulates intention
  - Specifies actions at interface
  - Executes action
  - Perceives system state
  - Interprets system state
  - Evaluates system state with respect to goal

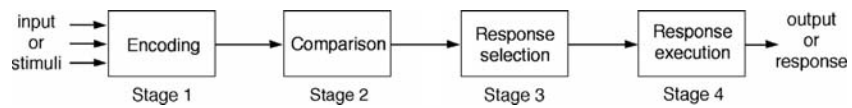
Gulfs of Execution and Evaluation

- 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
  - user's formulation of actions
    ≠ actions allowed by the system
- **"Gulf of Evaluation"**
  - The distance from the physical system to the user
  - user's expectation of changed system state
    ≠ actual presentation of this state
- Bridging the gulfs can reduce cognitive effort required to perform tasks

(Norman, 1986; Hutchins et al, 1986)

Information Processing

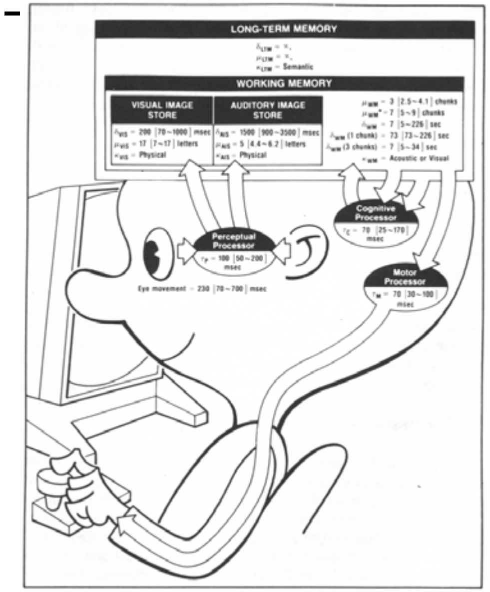
- Conceptualizes human performance in metaphorical terms of information processing stages



Human Processor Model

- **Models the information processes of a user interacting with a computer (Card et al, 1983)**
- 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

Human Processor Model



External Cognition

- External representations of cognition
  - Maps, notes, diagrams, books, multimedia, newspapers, web pages
- Physical tools to aid cognition
  - Pens, calculators, and computer-based technologies
- The combination of external representations and physical tools has greatly extended and supported people's ability to carry out cognitive activities (Norman, 1993)
- Concerned with explaining the cognitive processes involved when we interact with external representations
- Explicates the cognitive benefits of using different representations for different cognitive activities and the processes involved

Externalizing to Reduce Memory Load

- Main cognitive benefits
  - Externalizing to reduce memory load
  - Computational offloading
  - Annotating and cognitive tracing
- Reminders, calendars, notes, shopping lists, to-do lists
  - Written to remind us of what to do
- Post-its, piles, marked emails
  - Where they are placed indicates priority of what to do
- 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

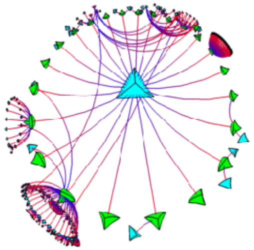
- When a tool is used in conjunction with an external representation to carry out a computation
  - E.g. pen and paper
- Try doing the two sums below (a) in your head, (b) on a piece of paper and c) with a calculator.
  - 234 x 456 =??
  - CCXXXIIII x CCCCXXXXXVI = ???
- Which is easiest and why? Both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

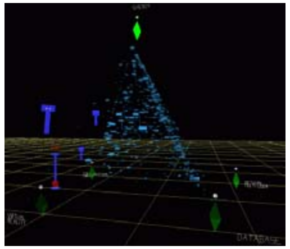
Annotation and Cognitive Tracing

- **Annotation** involves modifying existing representations through making marks
  - Crossing off an item
  - Ticking
  - Underlining a word
  - …
- **Cognitive tracing** involves externally manipulating items into different orders or structures
  - Playing scrabble
  - Playing cards
  - Sketching a design
  - …

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

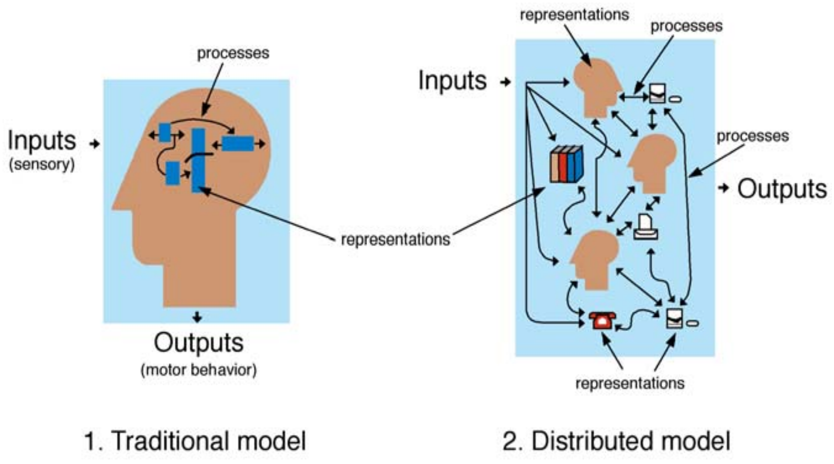




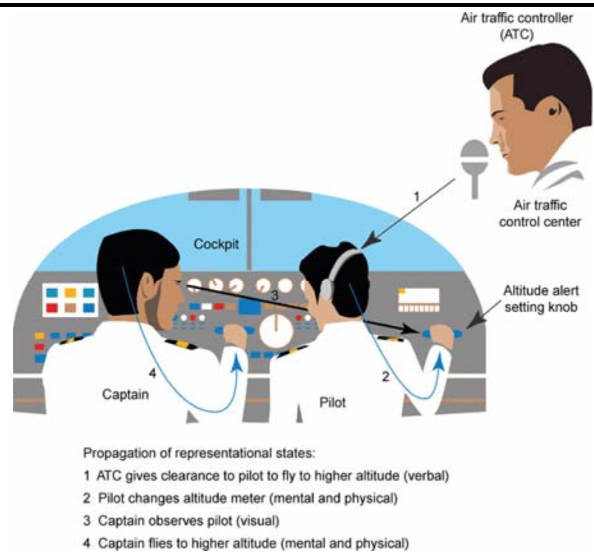
Distributed Cognition

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

How It Differs from Information Processing



In a Cockpit



What's Involved with Distributed Cognition

- The distributed problem-solving that takes place
  - Including the way people work together to solve a problem
- The role of verbal and non-verbal behavior
  - Including what is said, what is implied by glances, winks, etc and what is not said
- 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

Summary

- **Cognition** involves several processes including thinking, attention, learning, memory, perception, decision-making, planning, reading, speaking and listening
- The way an interface is designed can greatly affect **how well users can perceive, attend, learn and remember** how to do their tasks
- Theoretical frameworks, such as mental models and external cognition, provide ways of understanding how and why people interact with products
  - Explain user interaction and predict user performance
  - This can lead to thinking about how to design better products