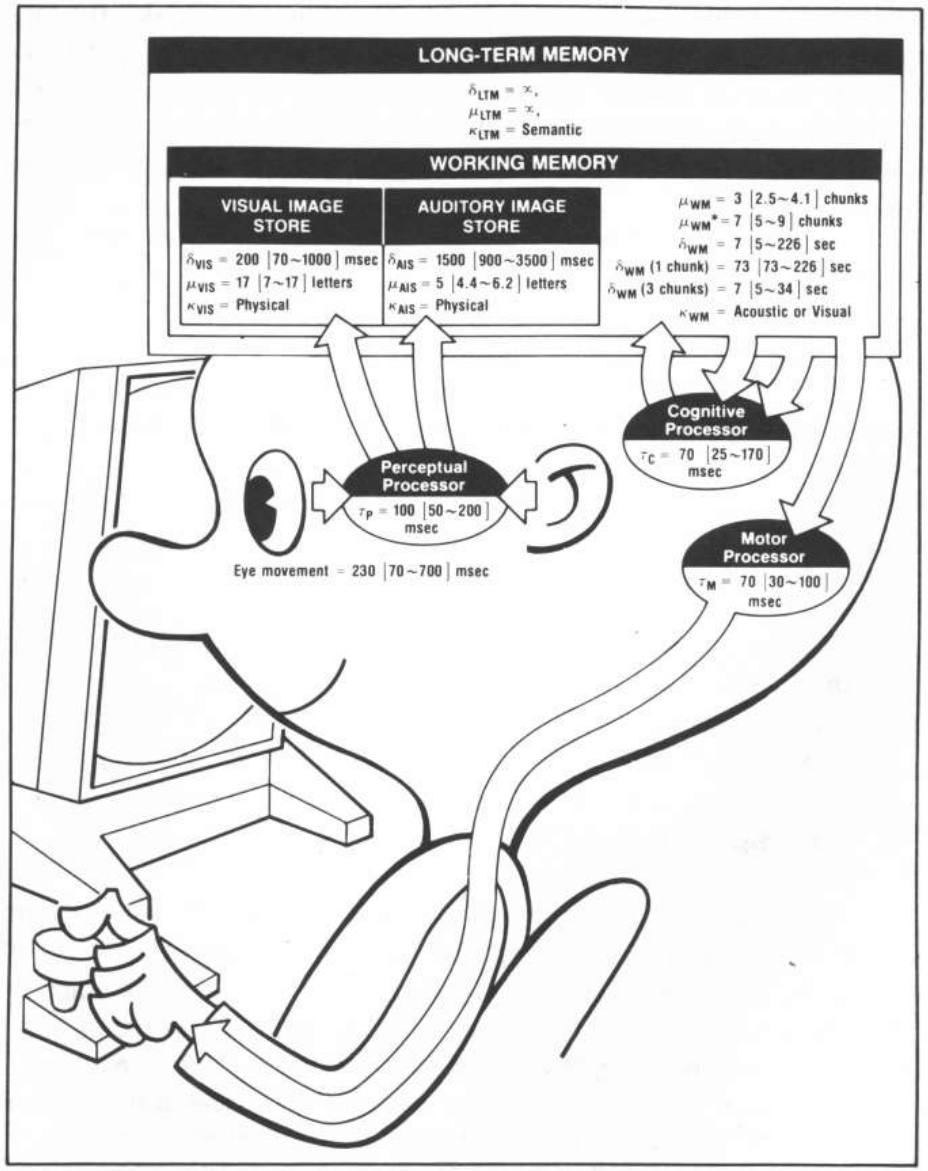
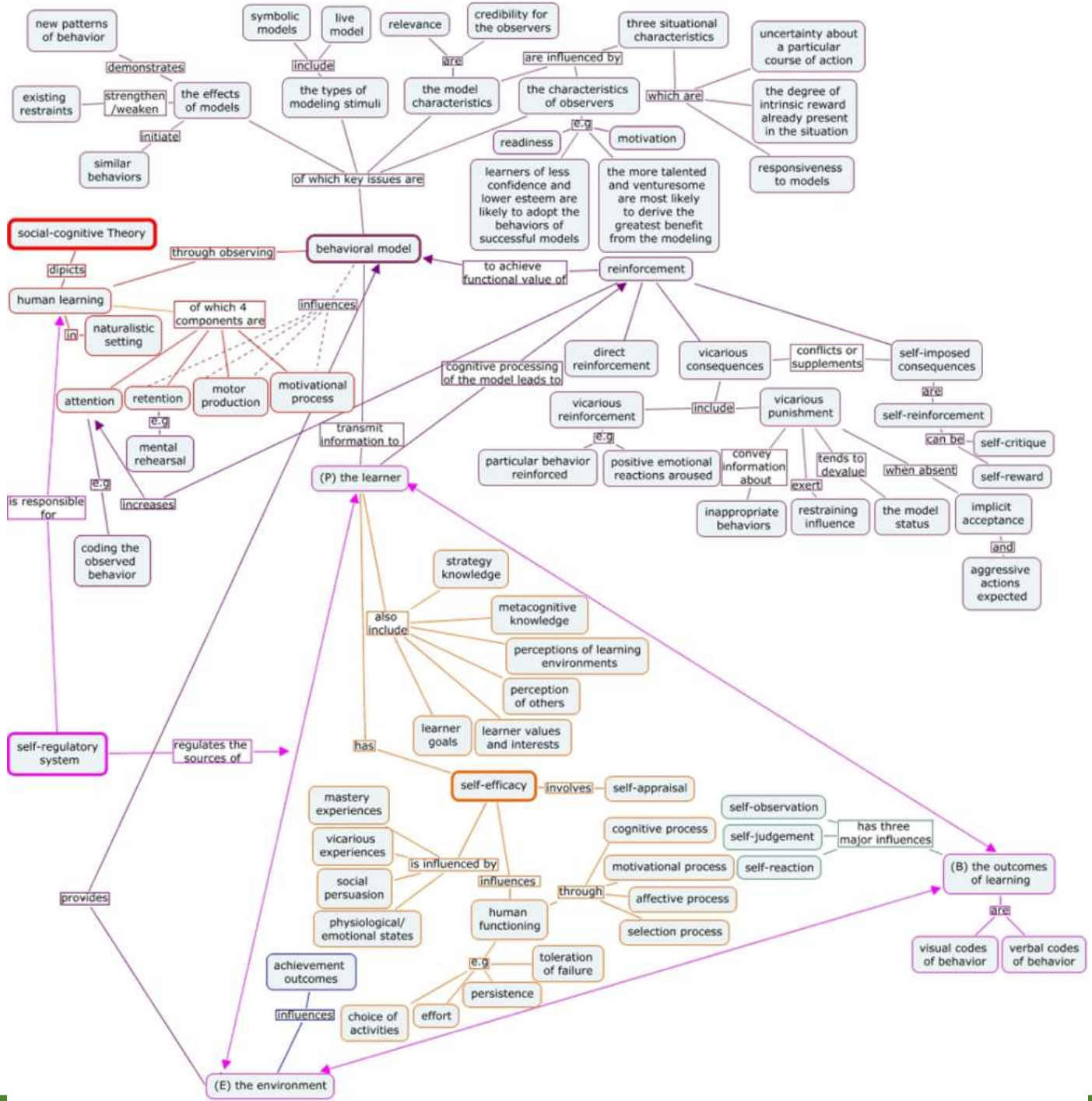
Chapter 4

The Human- 2
COGNITIVE ASPECTS



Overview

- What is cognition?
- Why it is important to understand in HCI
- Describe how cognition has been applied to interaction design
- Explain what are mental models and how to elicit them
- Cover relevant theories of cognition


social-cognitive Theory
dipicts
human learning
in
naturalistic setting
through observing
behavioral model
of which 4 components are
influences
attention
retention
motor production
motivational process
e.g
mental rehearsal
e.g
coding the observed behavior
is responsible for
increases
transmit information to
(P) the learner
of which key issues are
new patterns of behavior
demonstrates
existing restraints
strengthen /weaken
the effects of models
initiate
similar behaviors
symbolic models
live model
include
the types of modeling stimuli
relevance
credibility for the observers
are
the model characteristics
are influenced by
three situational characteristics
uncertainty about a particular course of action
which are
the degree of intrinsic reward already present in the situation
responsiveness to models
the characteristics of observers
e.g
readiness
motivation
learners of less confidence and lower esteem are likely to adopt the behaviors of successful models
the more talented and venturesome are most likely to derive the greatest benefit from the modeling
to achieve functional value of
reinforcement
cognitive processing of the model leads to
direct reinforcement
vicarious consequences
conflicts or supplements
self-imposed consequences
are
self-reinforcement
can be
self-critique
self-reward
vicarious reinforcement
include
vicarious punishment
e.g
particular behavior reinforced
positive emotional reactions aroused
convey information about
inappropriate behaviors
tends to devalue
exert
restraining influence
when absent
the model status
implicit acceptance
and
aggressive actions expected
strategy knowledge
also include
metacognitive knowledge
perceptions of learning environments
perception of others
learner goals
learner values and interests
has
self-efficacy
involves
self-appraisal
mastery experiences
vicarious experiences
social persuasion
physiological/ emotional states
is influenced by
influences
human functioning
through
cognitive process
motivational process
affective process
selection process
self-observation
self-judgement
self-reaction
has three major influences
(B) the outcomes of learning
are
visual codes of behavior
verbal codes of behavior
self-regulatory system
regulates the sources of
provides
achievement outcomes
influences
choice of activities
effort
e.g
persistence
toleration of failure
(E) the environment

What is cognition?

- Thinking, remembering, learning, daydreaming, decision-making, seeing, reading, talking, writing…
- Ways of classifying cognition at a higher level:
  - Experiential vs. reflective cognition (Norman, 1993)
  - Fast vs slow thinking (Kahneman, 2011)

Experiential Vs Reflective

Experiential cognition

It is the state of mind in which we perceive, act, and react to events around us effectively and effortlessly. It requires reaching a certain level of expertise and engagement. Examples include driving a car, reading a book, having a conversation,

and playing a video game

Reflective cognition

Reflective cognition involves thinking, comparing, and decision-making. This kind of cognition is what leads to new ideas and creativity. Examples include designing, learning, and writing a book.

Norman points out that both modes are essential for everyday life but that each requires different kinds of technological support

Which involves fast vs slow thinking?

- 2 + 2 =
- 21 × 29 =
- What color eyes do you have?
- How many colors are there in the rainbow?
- How many months in the year have 31 days?
- What is the name of the first school you attended?

How can understanding cognition help?

- Provides knowledge about what users can and cannot be expected to do
- Identifies and explains the nature and causes of problems that users encounter
- Provides theories, modeling tools, guidance, and methods that can lead to the design of better interactive products

Cognitive processes

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

Multitasking and attention

- Is it possible to perform multiple tasks without one or more of them being detrimentally affected?
- Multitasking can cause people to lose their train of thought, make errors, and need to start over
- Diversity of task may influence overall multitasking performance and time to completion

Multitasking at work

It is increasingly common for workers to multitask

- For example, hospital workers have to attend to multiple screens in an operating room that provide new kinds of real-time information
- This requires clinician's constant attention to check if any data is unusual or anomalous
- Need to develop new attention and scanning strategies

Is it OK to use a phone when driving?

No!

- Driving is very demanding
- Drivers are prone to being distracted
- There is a significant chance of causing accidents
- Drivers' reaction times are longer to external events when talking on the phone in a car (Caird et al., 2018)
- Drivers using their phones rely more on their expectations about what is likely to happen next as conducting a conversation takes up their attention
- Response time is slower to unexpected events (Briggs et al., 2018)
- Drivers often try to imagine what the other person's face is like− the person to whom they are speaking
  - Doing so competes with the processing resources needed to enable them to notice and react to what is in front of them

Are hands-free phones safer to use when driving?

- No, as same type of cognitive processing is happening when talking
- The same thing happens when talking with front seat passenger
  - But both can stop in mid-sentence if a hazard is spotted allowing the driver to switch immediately to the road
  - So, it's less dangerous talking to a front seat passenger than a remote person
  - A remote person on the end of a phone is not privy to what the driver is seeing and will carry on the conversation when there is a hazard
  - This makes it difficult for the driver to switch all their attention to the road

Memory

- Involves recalling various kinds of knowledge that allow people to act appropriately
  - For example, recognizing someone's face or remembering someone's name
- First encode and then retrieve knowledge
- We don't remember everything−it involves filtering and processing what is attended to
- Context is important as to how we remember (that is, where, when, how, and so on)
- We recognize things much better than being able to recall things
- We remember less about objects that we have photographed than when we observe them with the naked eye (Henkel, 2014)

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…
- 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
  - For example, 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

Recognition versus recall

- Command-based interfaces require users to recall from memory a name from a possible set of 100s of names
- Graphical interfaces provide visually-based options (menus, icons) that users need only browse through until they recognize one
- Web browsers provide tabs and history lists of visited URLs that support recognition memory

Personal Information management

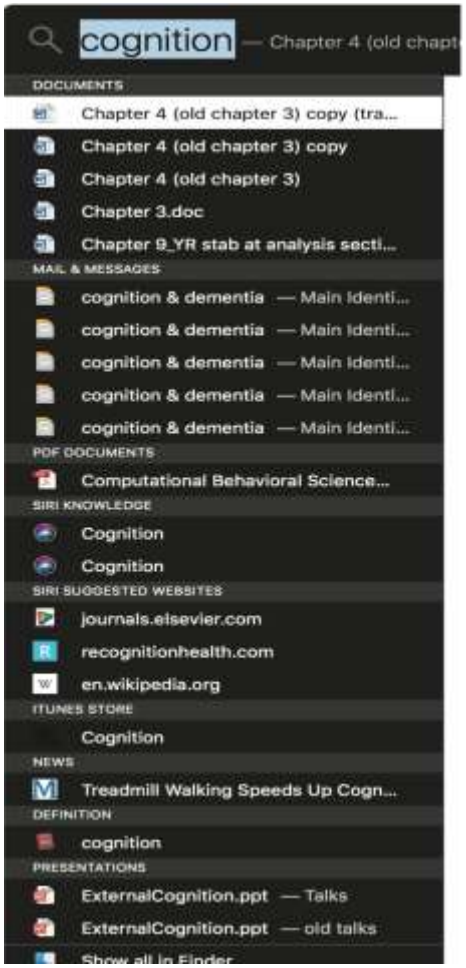
Is a growing problem for many users:

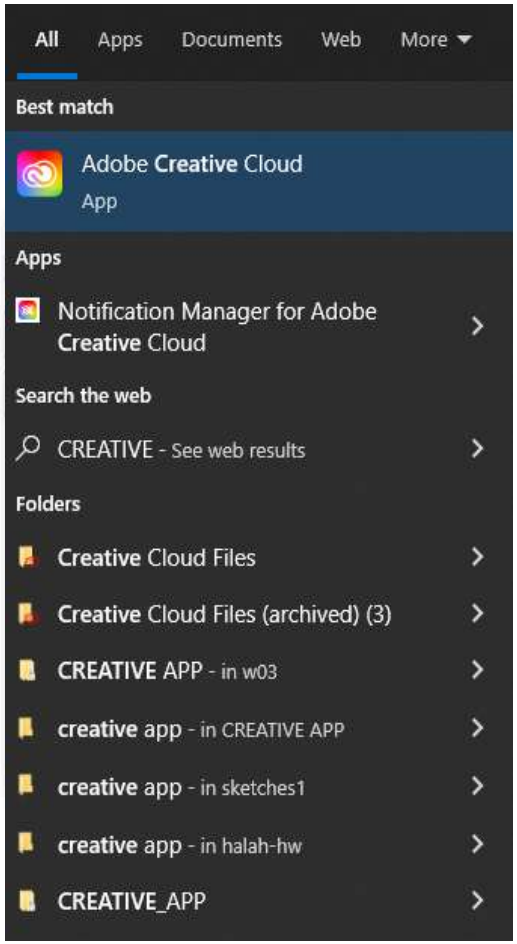
- They accumulate a vast number of documents, images, music files, video clips, emails, attachments, bookmarks, and so forth
- Where and how to save them all; then remembering what they were called and where to find them again
- Naming most common means of encoding them
- But can be difficult to remember, especially when you have 10,000s
- How might such a process be facilitated taking into account people's memory abilities?

Personal Information management

- Bergman and Whittaker, three interdependent processes model (2016) to help people manage their stuff:
  I. How to decide what stuff to keep
  II. How to organize it when storing
  III. Which strategies to use to retrieve it later
- Most common approach is to use folders and naming
- Strong preference for scanning across and within folders when looking for something
- Search engines only helpful if you know the name of the file
- Smart search engines help with listing relevant files for partial name or when type in first letter

Apple's/Windows Spotlight search tool





Memory load

- Online/mobile and phone banking now require users to provide multiple pieces of information to access their account
  - For instance, ZIP code, birthplace, a memorable date, first school attended
  - Known as multifactor authentication (MFA)
- Why?
  - Increased security concerns
- Password managers, such as LastPass, have been developed that require only one master password
  - Reduces stress and memory load on users
- Passwords could become extinct with the widespread use of biometrics and computer vision algorithms

Memory aids

- SenseCam, developed by Microsoft Research Labs (now Autographer)
  - 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, especially those suffering from dementia
- Other aids+ include police vest-cam

Maybe more than memory aid

Design implications

- Reduce cognitive load by avoiding long and complicated procedures for carrying out tasks
- Design interfaces that promote recognition rather than recall
- Provide users with various ways of labelling digital information to help them easily identify it again
  - For example, folders, categories, color, flagging, and time stamping

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

More 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
  - Imagery and analogies are activated
- Deep versus shallow models
  - For example, how to drive a car and how it works

Erroneous mental models

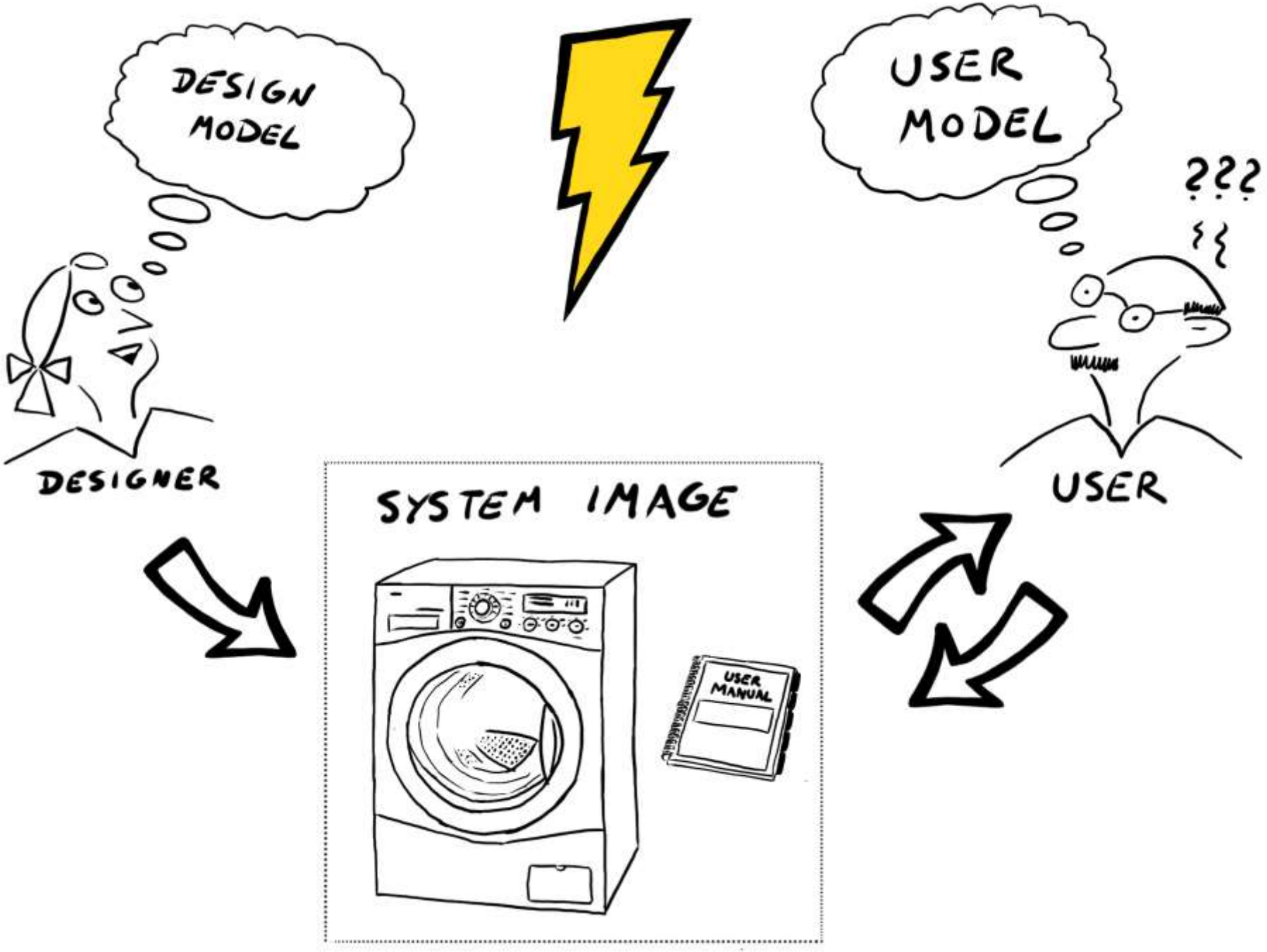
- Lots of people hit the button for elevators and pedestrian crossings at least twice
  - Why? Think it will make the lights change faster or ensure that the elevator arrives!
- What kinds of mental models do users have for understanding how interactive devices work?
  - Poor, often incomplete, easily confusable, based on inappropriate analogies and superstition (Norman, 1983)

How can UX be designed to help people build better mental models?

- Clear and easy to use instructions
- Appropriate tutorials and contextual sensitive guidance
- Provide online videos and chatbot windows when needing help
- Transparency: to make interfaces intuitive to use
- Affordances of what actions an interface allows
  - For example, swiping, clicking, or selecting

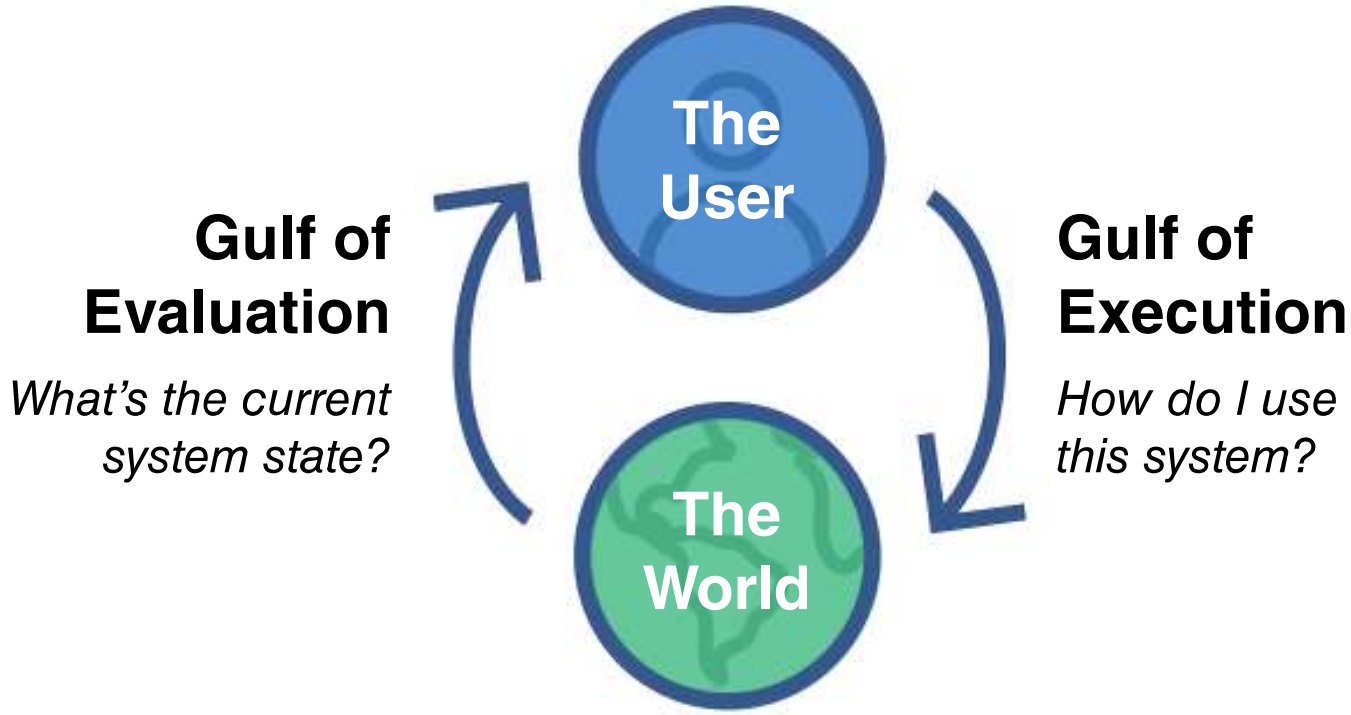
Gulfs of execution and evaluation

- The ‘gulfs’ explicate the gaps that exist between the user and the interface
- The gulf of execution
  - The distance from the user to the physical system
- The gulf of evaluation
  - The distance from the physical system to the user
- Bridging the gulfs can reduce cognitive effort required to perform tasks
- Can reveal whether interface increases or decreases cognitive load and whether it is obvious what to do next (Norman, 1986; Hutchins et al, 1986)



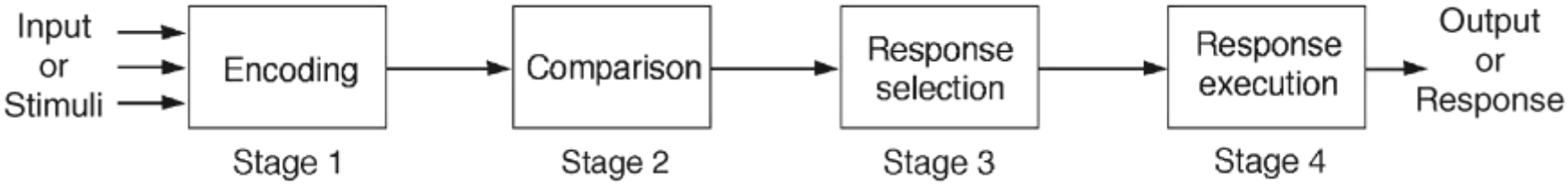
https://oleb.net/blog/2017/07/mental-models-in-api-design/

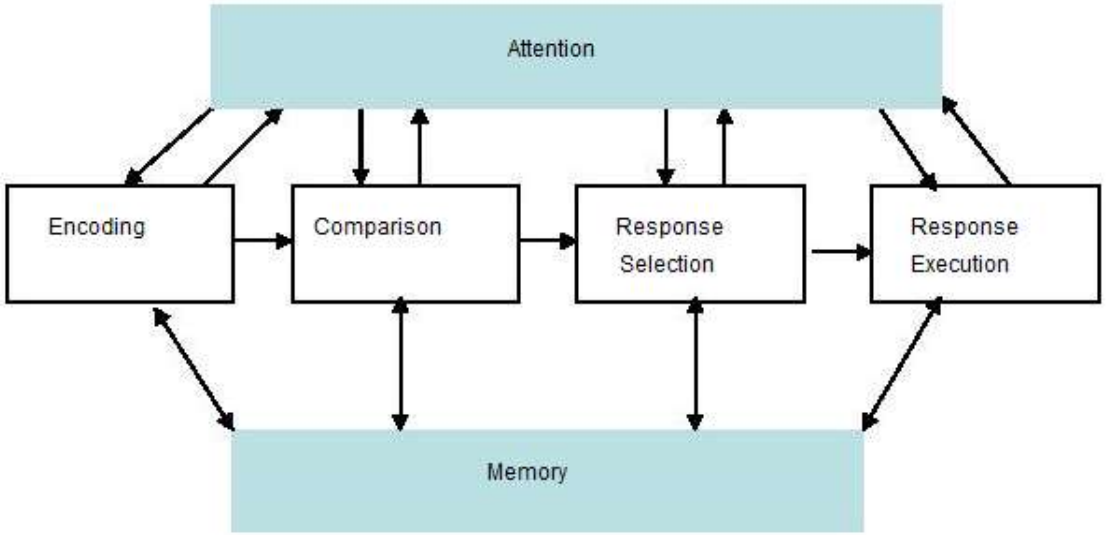
Mental Models- Bridging the gulfs



Information processing

- Conceptualizes human performance in metaphorical terms of information processing stages





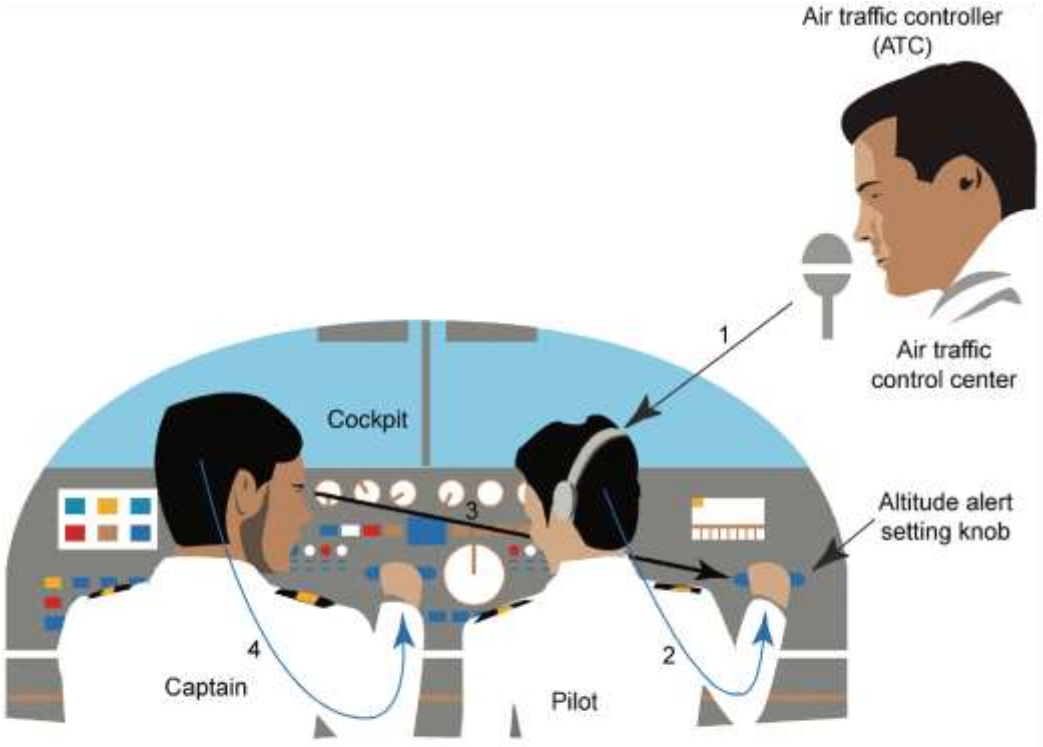
Limitations

- Based on modeling mental activities that happen exclusively inside the head
- Do not adequately account for how people interact with computers and other devices in real world

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)

A cognitive system for ATC



Propagation of representational states:

1 ATC gives clearance to pilot to fly to higher altitude (verbal)

2 Pilot changes altitude meter (mental and physical)

3 Captain observes pilot (visual)

4 Captain flies to higher altitude (mental and physical)

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 (for example, rules and procedures)
- The communication that takes place as the collaborative activity progresses
- How knowledge is shared and accessed

External cognition

- Concerned with explaining how we interact with external representations (such as maps, notes, and diagrams)
- What are the cognitive benefits and what processes involved
- How they extend cognition
- What technologies can we develop to help people carry out complex tasks (for example, learning, problem solving, and decision-making)?

Externalizing to reduce memory load

- Examples include the use of diaries, reminders, calendars, notes, shopping lists, to-do lists
  - Written to remind us of what to do
- Post-its, piles, marked emails are used to:
  - Where placed indicates priority of what to do
- External representations:
  - Remind us that we need to do something (for example, to buy something for mother's day)
  - Remind us of what to do (for instance, buy a card)
  - Remind us when to do something (for example, 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 (for instance, pen and paper)
- Try doing the two sums below (a) in your head, (b) on a piece of paper, and (c) with a calculator.

$$234 \times 456 = ??$$

$$\text{CCXXXIIII} \times \text{CCCCXXXXXVI} = ???$$

- Which is easiest and why? Both are identical sums

Annotation and cognitive tracing

- Annotation involves modifying existing representations through making marks
  - For example, crossing off, ticking, and underlining
- Cognitive tracing involves externally manipulating items into different orders or structures
  - For instance, playing Scrabble or cards

Design implication

- Provide external representations at the interface that can reduce memory load and facilitate computational offloading
  - For example, information visualizations have been designed to allow people to make sense and rapid decisions about masses of data

Embodied Interaction

- The practical engagement with the social and physical environment (Dourish, 2001)
- Creating, manipulating and making meaning through our interaction with things
- How our bodies and active experiences shape how we perceive, feel, and think (Hornecker et al., 2017)
- They enable us to develop a sense of the world at both a concrete and abstract level
- Can provide new ideas about interaction and better design principles
  - For example, we think with our bodies not through them (Kirsh, 2013)

In-depth activity

Write down how you think a contactless card or smartphone app like Apple Pay works

- What information is sent between the card/smartphone and the card reader when it is placed in front of it?
- What is the maximum amount you can pay for something using a contactless card, Apple Pay or Google Pay?
- Why is there an upper limit?
- How many times can you use a contactless card or Apple/Google Pay in a day?
- What happens if you have two contactless cards in the same wallet/purse?
- What happens when your contactless card is stolen, and you report it to the bank? What does the bank do?