Mon 29 Dec

Lecture 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

Based on material from:

- Sharp, H., Preece, J. and Rogers, Y.(2019). *Interaction Design Beyond Human-Computer Interaction*. 5th Ed. Sussex: John Wiley & Sons Ltd.

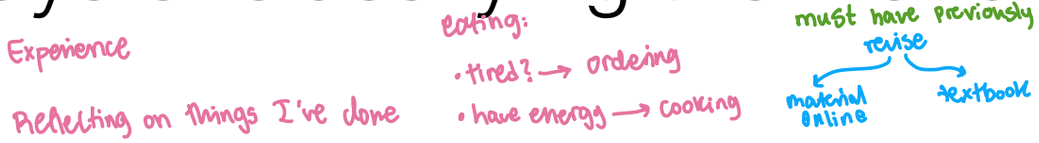
Learning Outcomes

- Explain the important of understanding users
- Discuss the main elements of cognitive process

What is cognition?

- Thinking, remembering, learning, daydreaming, decision-making, seeing, reading, talking, writing…

- Ways of classifying them at a higher level



- Experiential vs reflective cognition (Norman, 1993)

- Fast vs slow thinking (Kahneman, 2011)

Which involves fast vs slow thinking?

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

Not attentive bcuz don't matter

Why do we need to 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
- Provides theories, modelling tools, guidance and methods that can lead to the design of better interactive products

Nature interaction that requires them less time

Cognitive processes

Stimuli that help attention:
Audio: listening
Visual: slides
Heptic: vibration

1. Attention: selecting things to focus on
2. Perception and recognition:
3. Memory
4. Learning
5. Reading, speaking and listening
6. Problem-solving, planning, reasoning and decision-making

① Divided attention: multitask
② Focus

1. Attention

- Selecting things to concentrate on at a point in time from the mass of stimuli around us
- Allows us to to focus on information that is relevant to what we are doing
- Involves audio and/or visual senses
- Focussed 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
- Information at the interface should be structured to capture users' attention, e.g. use perceptual boundaries (windows), colour, reverse video, sound and flashing lights

Activity: 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: Find the price for a double room at the Quality Inn in Columbia

Faster:- spaces categories & grouping

South Carolina

City	Motel/Hotel	Area code	Phone	Rates Single	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, since both displays have the same density of information (31%)?**
- **Spacing**
  - In the 1st screen the information is bunched up together, making it hard to search
  - In the 2nd screen the characters are grouped into vertical categories of information making it easier

Multitasking & attention

parallel tasks

surgeons:

pilot: whole team works together simultaneously

- **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**
- **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

Multitasking experiment

- Lotteridge et al. (2015) conducted another study involving writing an essay under 2 conditions: relevant or irrelevant information

- heavy multitaskers were easily distracted but able to put this to good use if the distracting sources were relevant to the task in hand
- irrelevant information was found to negatively impact task performance

Multitasking at work

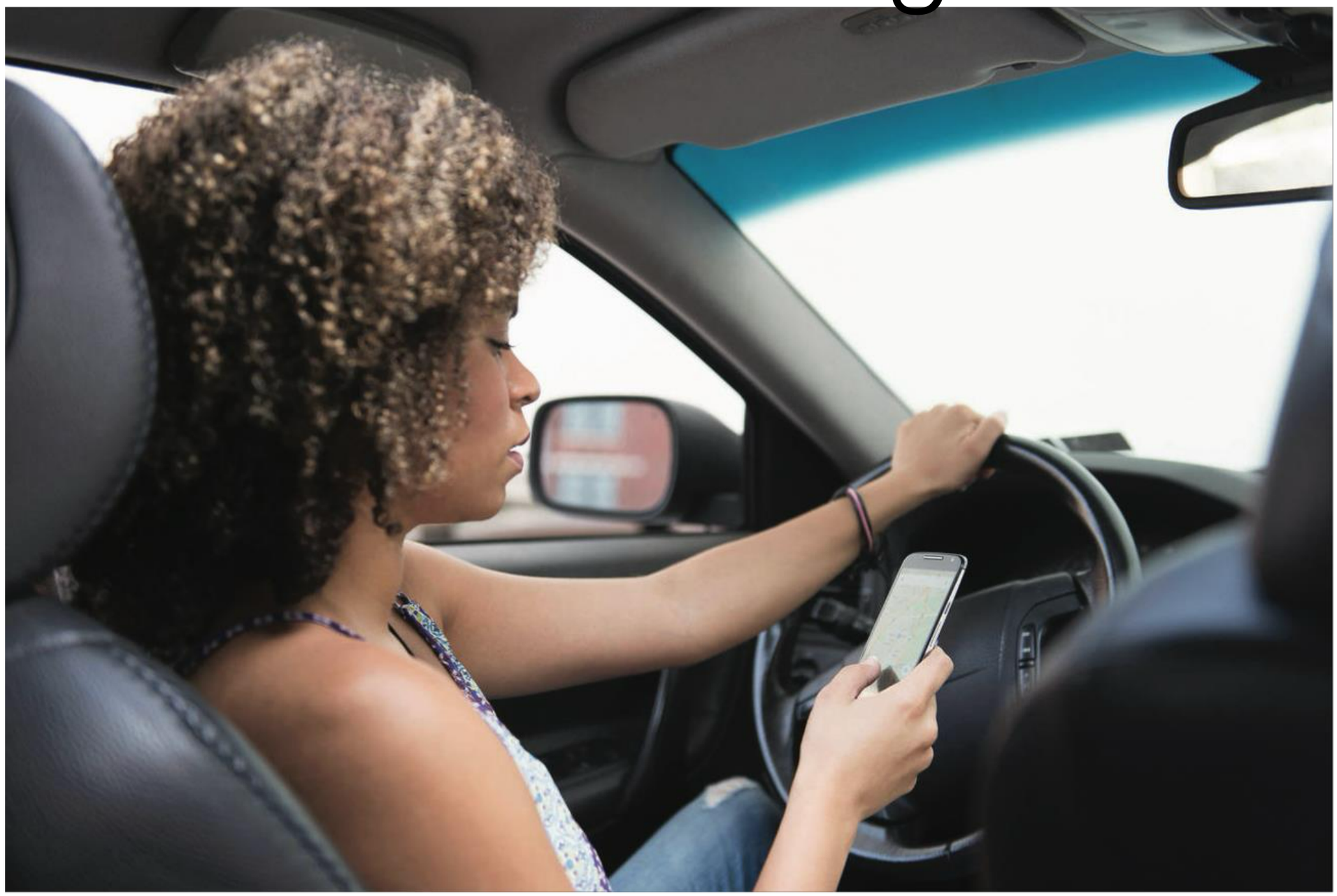
Increasingly common for workers to multitask

- e.g. hospital workers have to attend to multiple screens in an operating room that provide new kinds of real-time information

- 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….

even no hands

- 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)
- Phone drivers rely more on their expectations about what is likely to happen next as conversation taking 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 – whom they are talking to
    - this 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
- Same happens when talking with front seat passenger
- but both can stop in mid-sentence if see a hazard meaning driver can switch immediately to the road
- So 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
- makes it difficult for the driver to switch all their attention to the road

Design implications for 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
- Consider designing different ways of supporting effective switching and returning to an interface

2. Perception

Read

- **How information is acquired from the world and transformed into experiences**

- **Obvious implication is to design representations that are readily perceivable, e.g.**
  - Text should be legible
  - Icons should be easy to distinguish and read

Is color contrast good? Find italian

Black Hills Forest	Peters Landing	Jefferson Farms	Devlin Hall
Cheyenne River	Public Health	Psychophysics	Positions
Social Science	San Bernardino	Political Science	Hubard Hall
South San Jose	Moreno Valley	Game Schedule	Fernadino Beach
Badlands Park	Altamonte Springs	South Addision	Council Bluffs
Juvenile Justice	Peach Tree City	Cherry Hills Village	Classical Lit
Results and Stats	Highland Park	Creative Writing	Sociology
Thousand Oaks	Manchesney Park	Lake Havasu City	Greek
Promotions	Vallecito Mts.	Engineering Bldg	Wallace Hall
North Palermo	Rock Falls	Sports Studies	Concert Tickets
Credit Union	Freeport	Lakewood Village	Public Radio FM
Wilner Hall	Slaughter Beach	Rock Island	Children's Museum
Performing Arts	Rocky Mountains	Deerfield Beach	Writing Center
Italian	Latin	Arlington Hill	Theater Auditions
Coaches	Pleasant Hills	Preview Game	Delaware City
McKees Rocks	Observatory	Richland Hills	Scholarships
Glenwood Springs	Public Affairs	Experts Guide	Hendricksville
Urban Affairs	Heskett Center	Neff Hall	Knights Landing
McLeansboro	Brunswick	Grand Wash Cliffs	Modern Literature
Experimental Links	East Millinocket	Indian Well Valley	Studio Arts
Graduation	Women's Studies	Online Courses	Hughes Complex
Emory Lindquist	Vacant	Lindquist Hall	Cumberland Flats
Clinton Hall	News Theatre	Fisk Hall	Central Village
San Luis Obispo	Candlewood Isle	Los Padres Forest	Hoffman Estates

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

Activity

- **Weller (2004) found people took less time to locate items for information that was grouped**
  - Using a border (2nd screen) compared with using color contrast (1st screen)

- **Some argue that too much white space on web pages is detrimental to search**
  - Makes it hard to find information

- **Do you agree?**

Which is easiest to read and why?

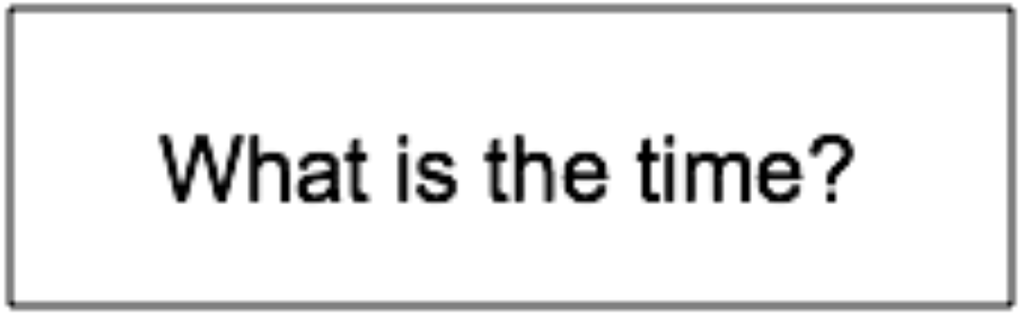
1

2

3

4

5



accessible to colorblind
constrast makes sense

Remember:
who are users?
match to what they need

Design implications

imp to allow users easily

- Icons should enable users to readily *distinguish* their meaning
- Bordering and spacing are effective visual ways of grouping information
- Sounds should be audible and distinguishable

sound indicate line is unavailable

- Speech output should enable users to distinguish between the set of spoken words

clear sound, system able to process

- Text should be legible and distinguishable from the background
- Tactile feedback should allow users to recognize and distinguish different meanings

physical sensation
- vibration
- texture
- touchscreen

Tue 30 Dec

Design implications

- Research proper color contrast techniques when designing an interface
  - Yellow on black or blue is fine
  - Yellow on green or white is a no-no
- Haptic feedback should be used judiciously

short-term
STM
LTM
long-term

3. 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)

- We recognize things much better than being able to recall things

3. Memory

- We remember less about objects 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**
  - 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 neighbor 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

recognition is better than recalling

- Command-based interfaces require users to recall from memory a name from a possible set of 100s
- GUIs provide visually-based options (menus and icons) that users need only browse through until they recognize one
- Web browsers, MP3 players, etc., provide lists of visited URLs, song titles, tabs, history lists and 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
- But…

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?**

wrong because
people have privilage of seeing
recognition better

Why?

- 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 (PIM)

case studys

- **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?

Personal information management (cont)

- **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

Personal information management (cont)

- Is a growing problem for many users
  - they accumulate a 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 10,000s
  - How might such a process be facilitated taking into account people's memory abilities?

Personal information management (cont)

- Bergman and Whittaker 3 interdependent processes model (2016) to help people manage their stuff:

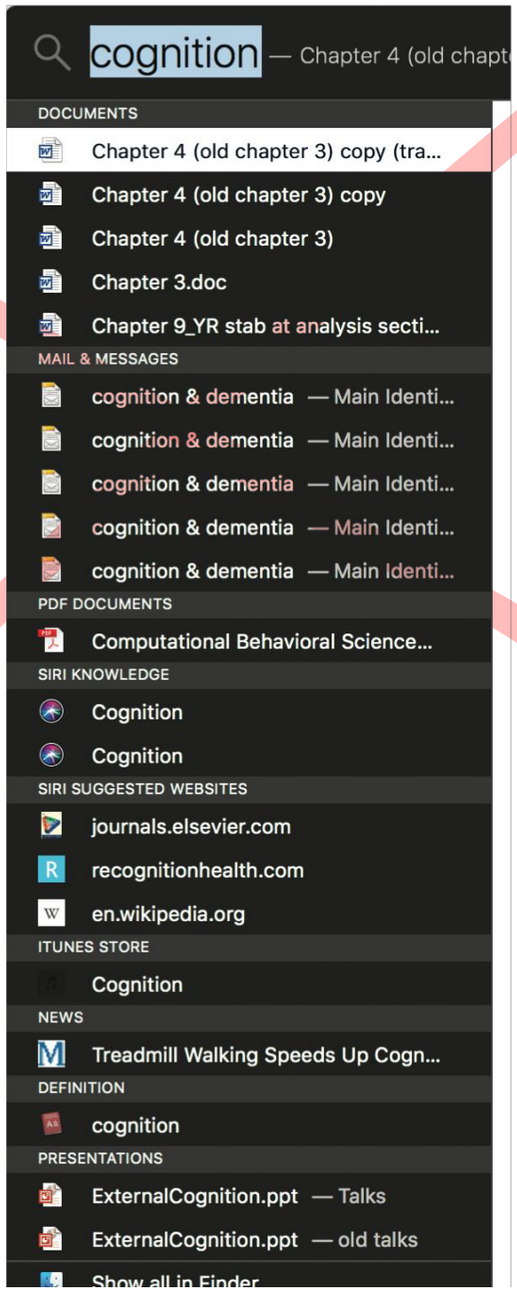
  (i) how to decide what stuff to keep

  (ii) how to organize it when storing

  (iii) which strategies to use to retrieve it later

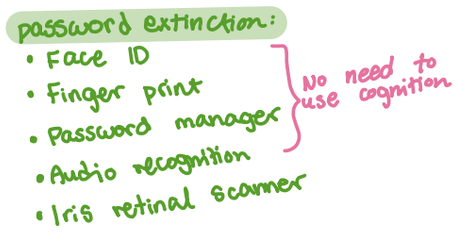
- Most common approach is to use folders and naming
- Strong preference for scanning across and within folders when looking for something
- Search engines only helpful if know the name of the file
- Smart search engines help with listing relevant files for partial name or when type in first letter

Apple’s Spotlight search tool



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



Memory load

- Online/mobile and phone banking now require users to provide multiple pieces of information to access their account
  - e.g. 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 - only need one master password
  - Reduce stress and memory load on users
- Passwords could become extinct with the widespread use of biometrics and computer vision algorithms

Digital Forgetting

vanish from digital world

- When might you wish to forget something that is online?
  - When you break up with a partner
  - Emotionally painful to be reminded of them through shared photos, social media, etc.,
- Sas and Whittaker (2013) suggest ways of harvesting and deleting digital content
  - e.g. making photos of ex into an abstract collage
  - helps with closure

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 various ways of encoding information to help them remember
  - e.g. categories, color, flagging, time stamping

4. Learning

- How to learn to use a computer-based application

we skip manual until..... we need it

- 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

Learning

Involves the accumulation of skills and knowledge involving memory

Two main types:

trying to understand material

1. Incidental learning (e.g. recognizing people's faces, what you did today)
2. Intentional learning (e.g. studying for an exam, learning to cook)

Learning material again for major main objective is to learn

- Intentional learning is much harder!
- Many technologies have been developed to help (e.g. digital media, animations, VR)

Design implications

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

5. Reading, speaking & 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

- Speech-based menus and instructions should be short

- Accentuate the intonation of artificially generated speech voices
  - they are harder to understand than human voices

- Provide opportunities for making text large on a screen

Sun 4 Jan

6. Problem Solving, planning, reasoning and decision making

Cook? order in? tired

Prepare for major:
Study? Don't? consequence good grades = bad grades

- **All involves reflective cognition** → decision
  - 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

Trello → group managment app

- 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

Dilemma

- The app mentality is making it worse for people to make their own decisions because they are becoming risk averse (Gardner and Davis, 2013)

issue: trustworthy
D360: trust it with money
↳ convince by emphasizing security

  - Instead they now rely on a multitude of apps
    - This makes them increasingly anxious
    - Unable to make decisions by themselves
    - Need to resort to looking up info, getting other's opinions on social media and comparing notes
- Do you agree?
- Did it happen to you when deciding which university/school to go to?

Cognitive Frameworks

These are used to explain and predict user behavior at the interface

- based on theories of behavior
- focus is on mental processes that take place
- Also use of artifacts and representations

Most well known are:

1- Mental models: theories & behavior

2- Gulfs of execution and evaluation

3- Distributed cognition

4- External and embodied cognition

1. Mental model

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

  Developed during early stages of life

- **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**

1. Mental model (cont)

- **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**
  - images and analogies are activated

toddler stand on table, fall down, learn not to do

- **Deep versus shallow models**
  - e.g. how to drive a car and how it works

How to ride bike? can't explain, demonstrate (Deep model)
Cook curry? instructions (shallow)

Everyday reasoning and mental models

- 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?

- 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?

As humans, we have erroneous mental model

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

Heating up a room or oven that is thermostat-controlled (cont)

- **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
  - Why? Think it will make the lights change faster or ensure the elevator arrives!

Exercise: ATMs

- **<u>Write down how an ATM works</u>**

  - How much money are you allowed to take out? ~ $5,000
  - If you went to another machine and tried the same what would happen? NO
  - What information is on the strip on your card? How is this used? Information is stored,
  - What happens if you enter the wrong number? 3 trials
  - Why are there pauses between the steps of a transaction? Prevent errors
    What happens if you try to type during them? Nothing happen
  - Why does the card stay inside the machine? Card first then money
  - Do you count the money? Why? NO

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**

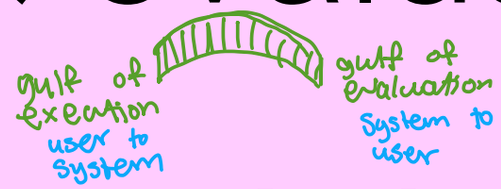
- **People's accounts greatly varied and were often ad hoc**

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 → once see interface, know how to navigate
- Affordances of what actions an interface allows

  See obj, know how to use
  - e.g. swiping, clicking, selecting

2. Gulf of execution & evaluation



- **The 'gulfs' explicate the gaps that exist between the user and the interface**

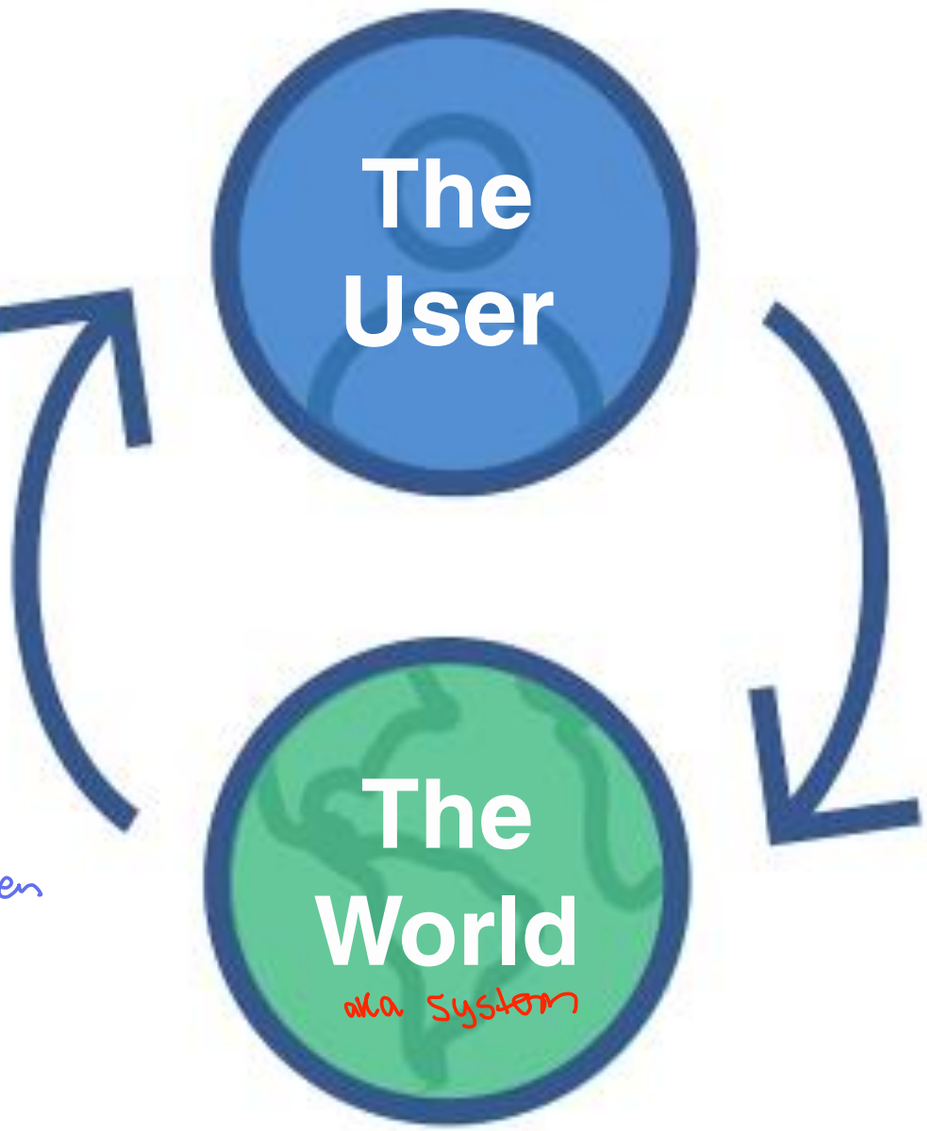
- **The gulf of execution**
  - the distance from the user to the physical system

- **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**

Bridging the gulfs



Gulf of Evaluation

What's the current system state?

System ask for password
unlock with password to open

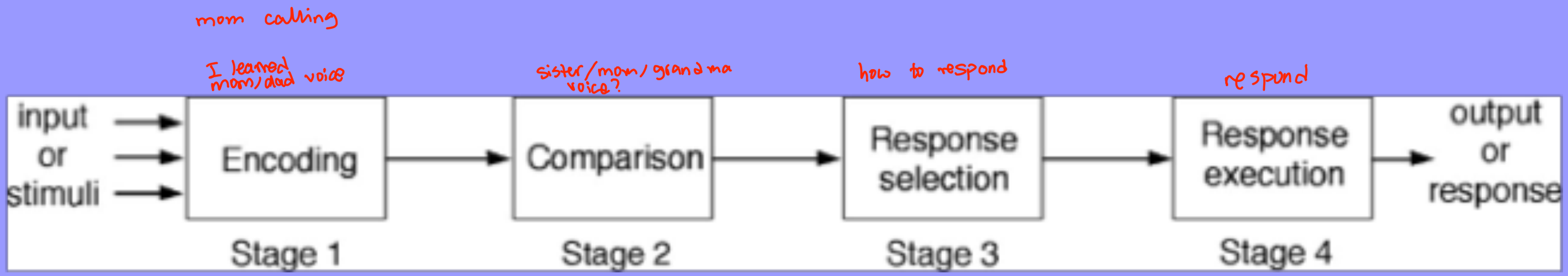
Gulf of Execution

How do I use this system?

card
iPhone

3. 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

4. Distributed Cognition

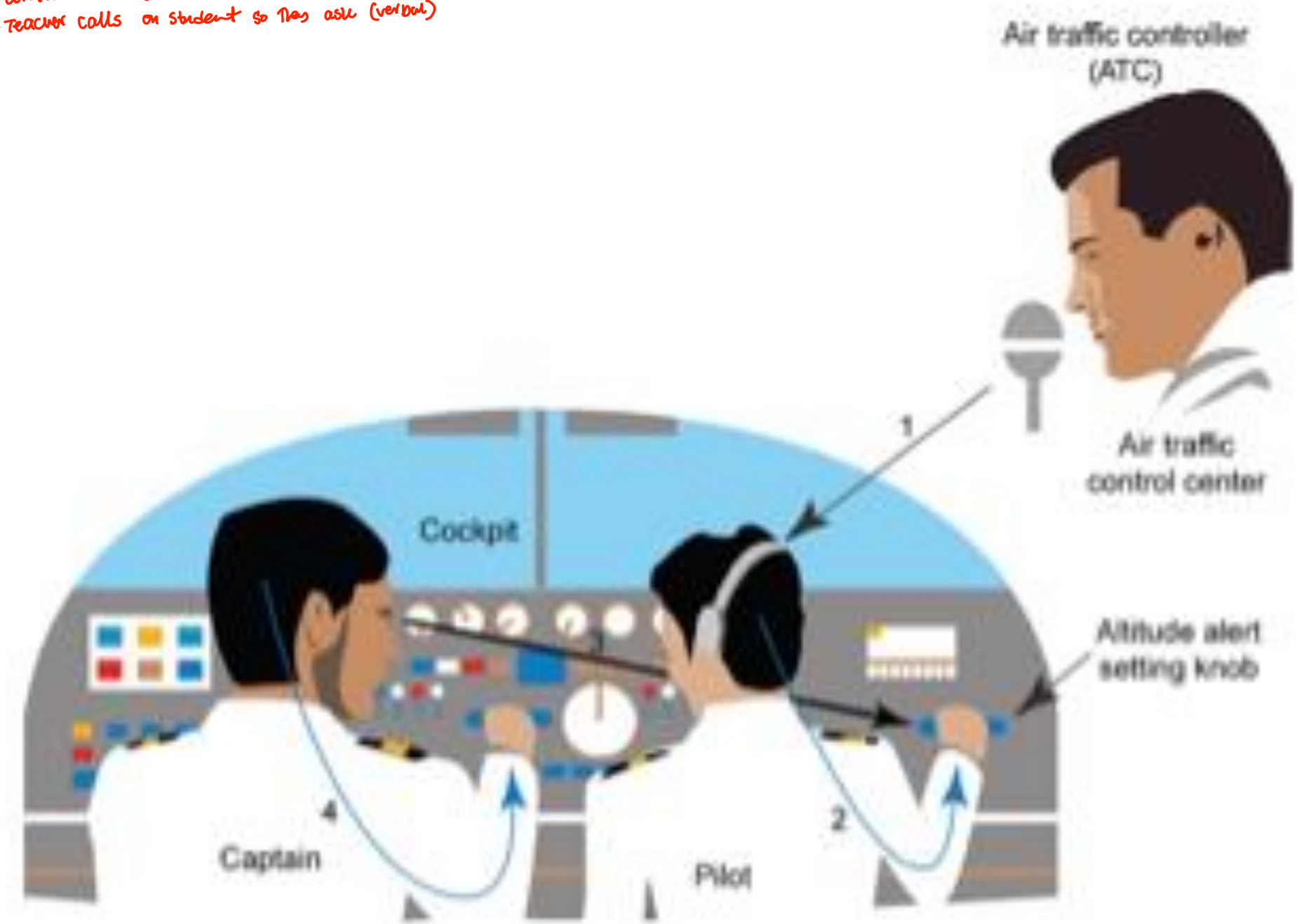
info shared across diff platform

- 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)

Lecture:
- confirmation (verbal, question)
- teacher calls on student so they ask (verbal)



Propagation of representational states:

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

2 Pilot changes altitude meter (mental and physical) process, then change

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

internal cognition (1-6)

5. External Cognition

Notes, sticky notes, schedule

- 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 technologies can we develop to help people carry out complex tasks (e.g. learning, problem solving, decision-making)?

Externalizing to reduce memory load

- **Diaries, reminders, calendars, notes, shopping lists, to-do lists**
  - written to remind us of what to do

- **Post-its, piles, marked emails**
  - where 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

6. Embodied interaction

- New approach to HCI
- User interfaces merge seamlessly with the physical world - make use the physical objects that surround us

Boulevard TV ads
Apple watch
Seamlessly integrated with day-to-day objects

Summary

- **Cognition involves several processes including attention, memory, perception and learning**

① Internal → 6
② External → just learned (outside)
③ Distributed → involves across several users

- **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**

- **This can lead to thinking about how to design better products**

Extra 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?