Cognitive Aspects

IF3151 Human Computer Interaction

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Overview

1

What is cognition?

2

Why it is important to understand in HCI

3

Describe how cognition has been applied to interaction design

4

Explain what are **mental models** and how to elicit them

5

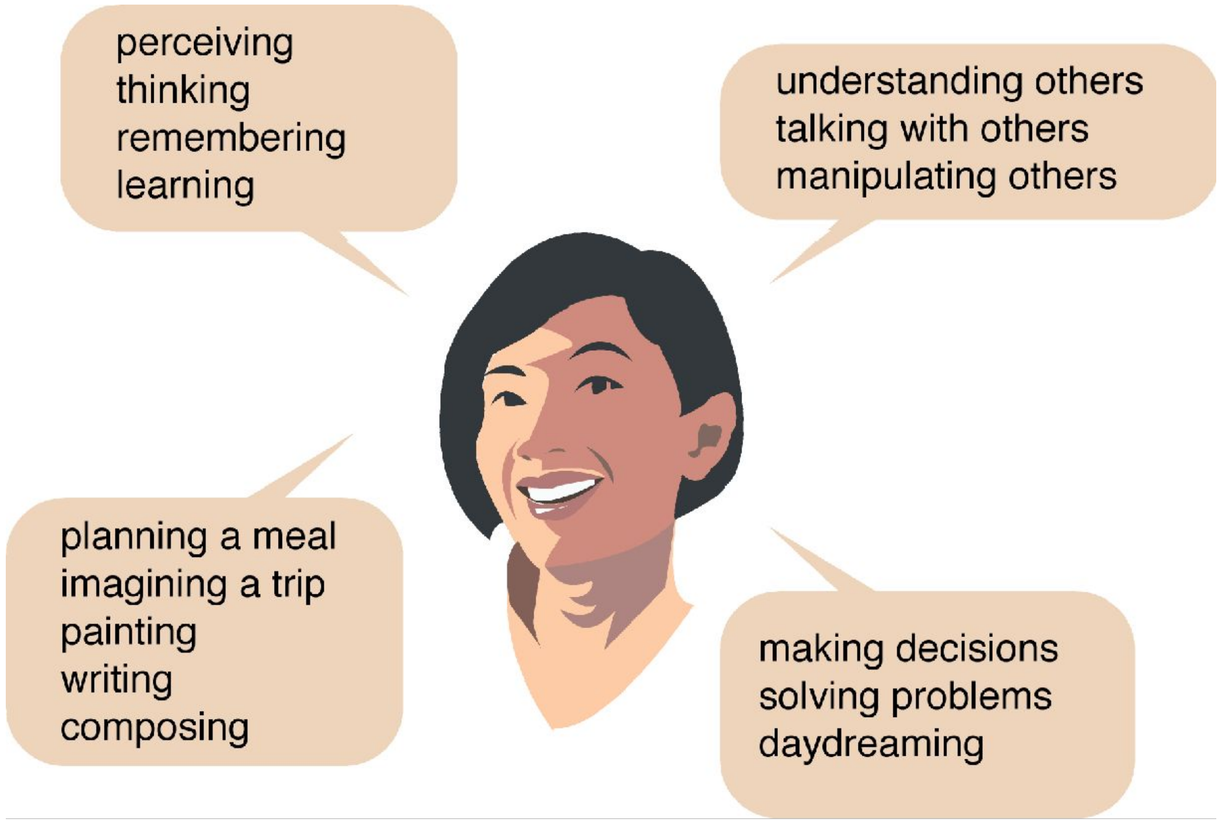
Cover relevant theories of cognition

What goes on in the mind?

Cognition are ….

Ways of classifying cognition at a higher level:
- Experiential vs. reflective cognition (Norman, 1993)
- Fast vs slow thinking (Kahneman, 2011)

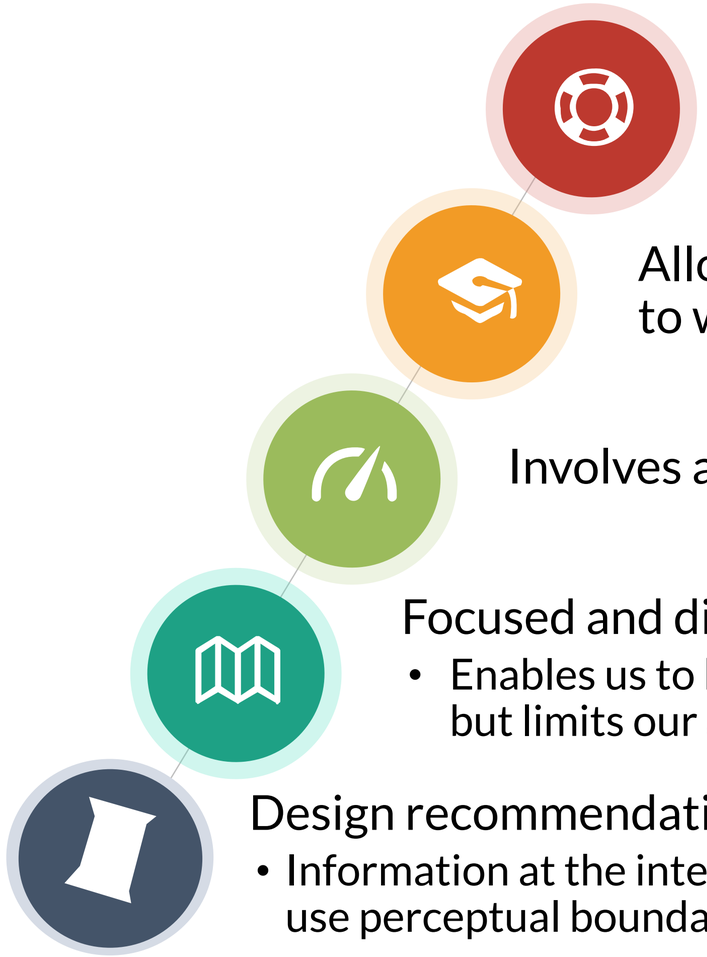
Which involves fast vs slow thinking?
- 2 + 2 =
- 21 × 29 =
- What color eyes do you have?
- How many colors are there in the rainbow?
- How many months in the year have 31 days?
- What is the name of the first school you attended?



Cognitive processes

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

Attention



Selecting things on which to concentrate at a point in time from the mass of stimuli around us

Allows us to focus on information that is relevant to what we are doing

Involves audio and/or visual senses

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

Design recommendation

- Information at the interface should be structured to capture users' attention, for example, use perceptual boundaries (windows), color, reverse video, sound, and flashing lights

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

Pennsylvania
Bedford Motel/Hotel: Crinaline Courts
(814) 623-9511 S: $118 D: $120
Bedford Motel/Hotel: Holiday Inn
(814) 623-9006 S: $129 D: $136
Bedford Motel/Hotel: Midway
(814) 623-8107 S: $121 D: $126
Bedford Motel/Hotel: Penn Manor
(814) 623-8177 S: $119 D: $125
Bedford Motel/Hotel: Quality Inn
(814) 623-5189 S: $123 D: $128
Bedford Motel/Hotel: Terrace
(814) 623-5111 S: $122 D: $124
Bradley Motel/Hotel: De Soto
(814) 362-3567 S: $120 D: $124
Bradley Motel/Hotel: Holiday House
(814) 362-4511 S: $122 D: $125
Bradley Motel/Hotel: Holiday Inn
(814) 362-4501 S: $132 D: $140
Breezewood Motel/Hotel: Best Western Plaza
(814) 735-4352 S: $120 D: $127
Breezewood Motel/Hotel: Motel 70
(814) 735-4385 S: $116 D: $118

Activity: Find the price of a double room at the Holiday Inn in Columbia

South Carolina

City	Motel/Hotel	Area code	Phone	Rates Single	Rates Double
Charleston	Best Western	803	747-0961	$126	$130
Charleston	Days Inn	803	881-1000	$118	$124
Charleston	Holiday Inn N	803	744-1621	$136	$146
Charleston	Holiday Inn SW	803	556-7100	$133	$147
Charleston	Howard Johnsons	803	524-4148	$131	$136
Charleston	Ramada Inn	803	774-8281	$133	$140
Charleston	Sheraton Inn	803	744-2401	$134	$142
Columbia	Best Western	803	796-9400	$129	$134
Columbia	Carolina Inn	803	799-8200	$142	$148
Columbia	Days Inn	803	736-0000	$123	$127
Columbia	Holiday Inn NW	803	794-9440	$132	$139
Columbia	Howard Johnsons	803	772-7200	$125	$127
Columbia	Quality Inn	803	772-0270	$134	$141
Columbia	Ramada Inn	803	796-2700	$136	$144
Columbia	Vagabond Inn	803	796-6240	$127	$130

Activity

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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

Design implications for attention

Context: Make information salient when it needs to be attended to at a given stage of a task

Use techniques to achieve this:

- For example, color, ordering, spacing, underlining, sequencing, and animation

Avoid cluttering visual interfaces with too much information

Consider designing different ways to support effective switching and returning to an interface

Perception

How information is acquired from the world and transformed into experiences

Obvious implication is to design representations that are readily perceivable, for instance:

- Text should be legible
- Icons should be easy to distinguish and read

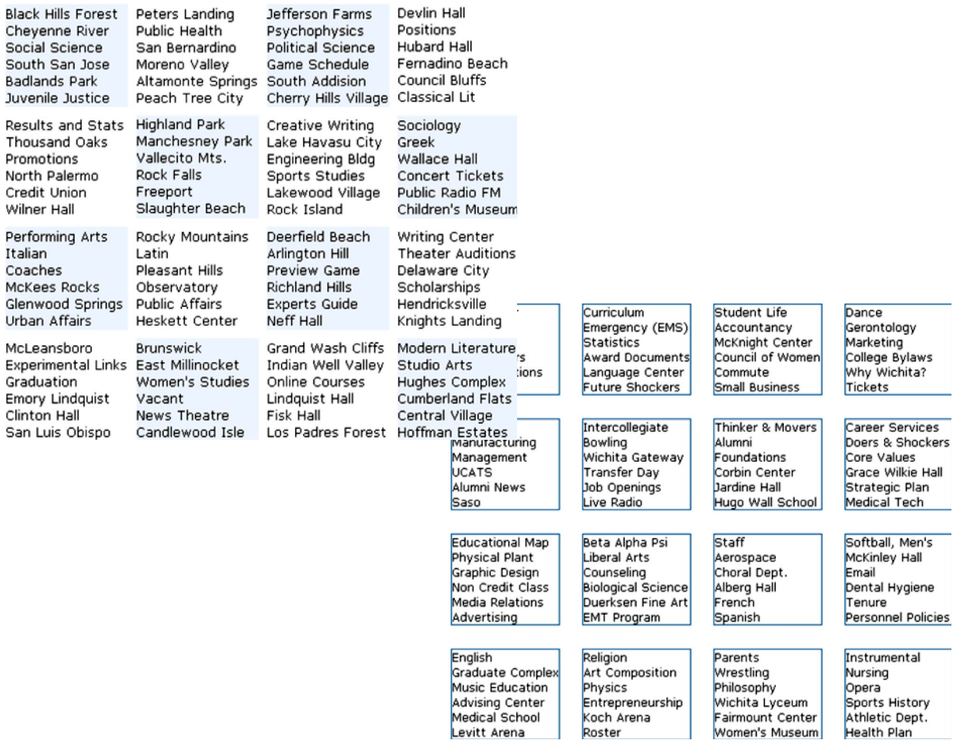
Is color contrast good?
Find **Italian**

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

Activity



Weller (2004) found people took less time to locate items for information that was grouped

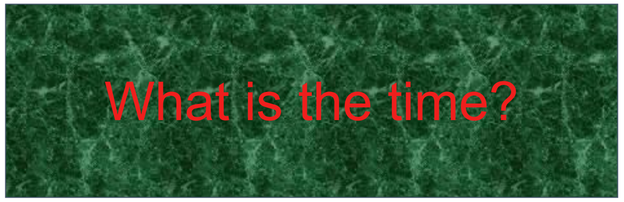
- Using a border (2nd screen) compared with using color contrast (1st screen)

Some argue that too much white space on web pages is detrimental to search process

- Makes it hard to find information

Do you agree?

Activity: Which is the easiest to read and why?



What is the time?

What is the time?

What is the time?

What is the time?

Design implications for perception

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

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

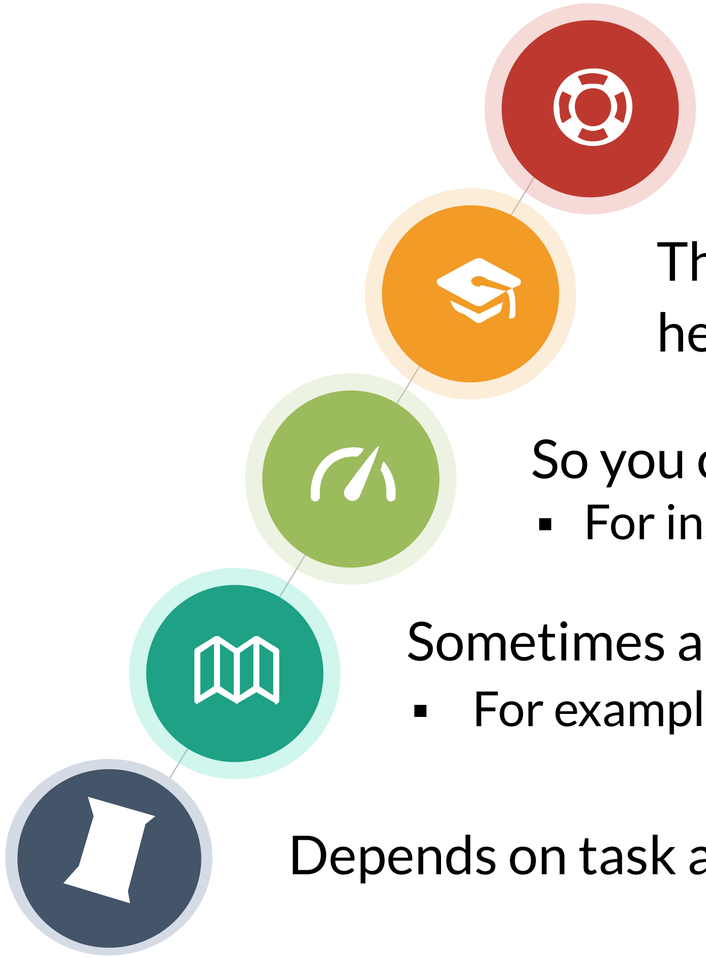
The problem with the classic ‘7,+ or – 2’

- George Miller’s (1956) theory of how much information people can remember
- People’s immediate memory capacity is very limited to 7, + or – 2
- Has been applied in interaction design when considering how many options to display
- But is it a good use of a theory in HCI?
- Is it helpful?

When creating an interface, should the designer…

- 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
- Not necessarily…

The reason is…



People can scan lists of bullets, tabs, and menu items for the one they want

They don’t have to recall them from memory, having only briefly heard or seen them

So you can have more than nine at the interface

- For instance, history lists of websites visited

Sometimes a small number of items is good

- For example, smart watch displays

Depends on task and available screen estate

Personal Information management

The design challenge here is deciding which is the best way of helping users organize their content so that it can be easily searched, for example, via folders, albums, or lists.

Is a growing problem for many users:

- They accumulate a vast numbers 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 (files and folders) most common means of encoding them, but can be difficult to remember, especially when you have 10,000s

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
- How might such a process be facilitated taking into account people's memory abilities?
- Smart search engines help with listing relevant files for partial name or when type in first letter

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

Digital Forgetting

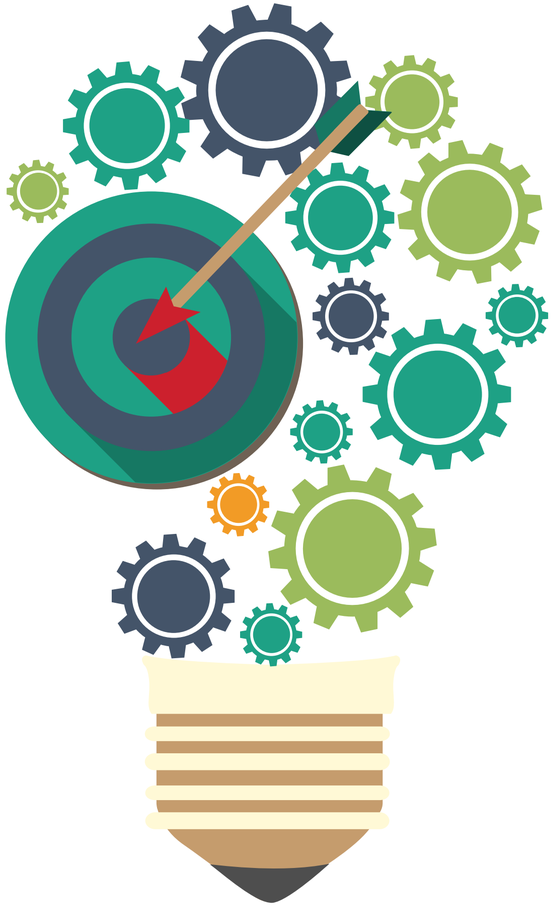
When might you wish to forget something that is online?

- When you break up with a partner
- Emotionally painful to be reminded of them through shared photos, social media, and so on.

Sas and Whittaker (2013) suggest ways of harvesting and deleting digital content

- For example, making photos of ex into an abstract collage
- Helps with closure

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 RemArc, which triggers long-term memory using old BBC materials

Design implications for memory

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

Learning

- Involves the accumulation of skills and knowledge involving memory
- Two main types:
  - Incidental learning (for example, recognizing people's faces, what you did today)
  - Intentional learning (for instance, studying for an exam, learning to cook)
  - Intentional learning is much harder!
  - Many technologies have been developed to help (for example, multimedia, animations, VR)
- People find it hard to learn by following instructions in a manual
- People prefer to learn by doing

Design implications for 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

Aplication

Voice user interfaces allow users to interact with them by asking questions

- For example, Google Voice, Siri, and Alexa

Speech-output systems use artificially-generated speech

- For instance, written text-to-speech systems for the visually impaired

Natural-language systems enable users to type in questions and give text-based responses

- Such as, chatbots

Design implications for reading, speaking, and listening

- 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

Problem-solving, planning, reasoning, and decision-making

- All these processes involve *reflective* cognition
  - For example, 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
  - Such as maps, books, pen and paper
- May involve working through different scenarios and deciding which is best option
- Weighing up alternatives

Design implications for problem-solving, planning, reasoning, and decision-making

Provide information and help pages that are easy to access for people who wish to understand more about how to carry out an activity more effectively (for example, web searching)

Use simple and memorable functions to support rapid decision-making and planning

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)
  - Instead, they now rely on a multitude of apps
  - This makes them increasingly anxious
  - They are unable to make decisions by themselves
  - They 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 attend?

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:

- Mental models
- Gulfs of execution and evaluation
- Distributed cognition
- External and embodied cognition

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**

Everyday reasoning and mental models

- You arrive home on a cold winter's night to a cold house.

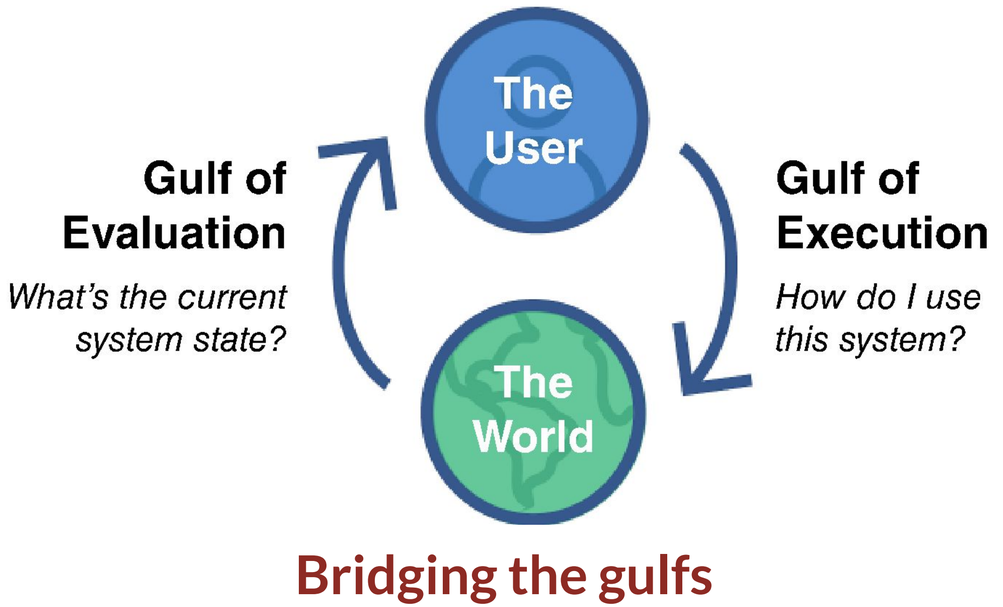
  How do you get the house to warm up as quickly as possible?
  - Set the thermostat to be at its highest? or
  - the desired temperature?

- 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?

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

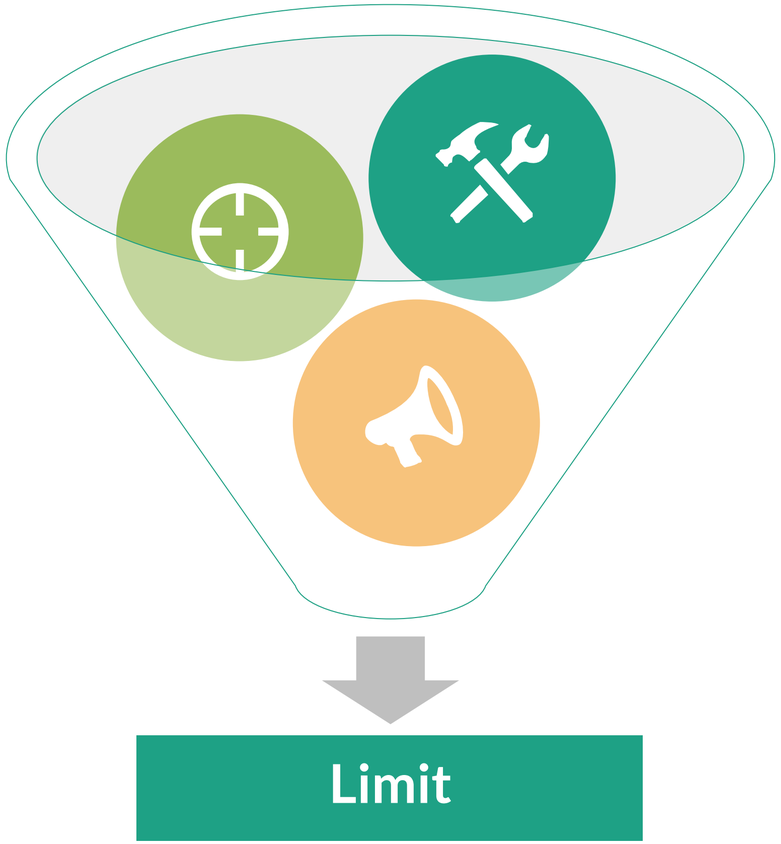
The gulf of execution
- The distance from the user to the physical system

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)

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

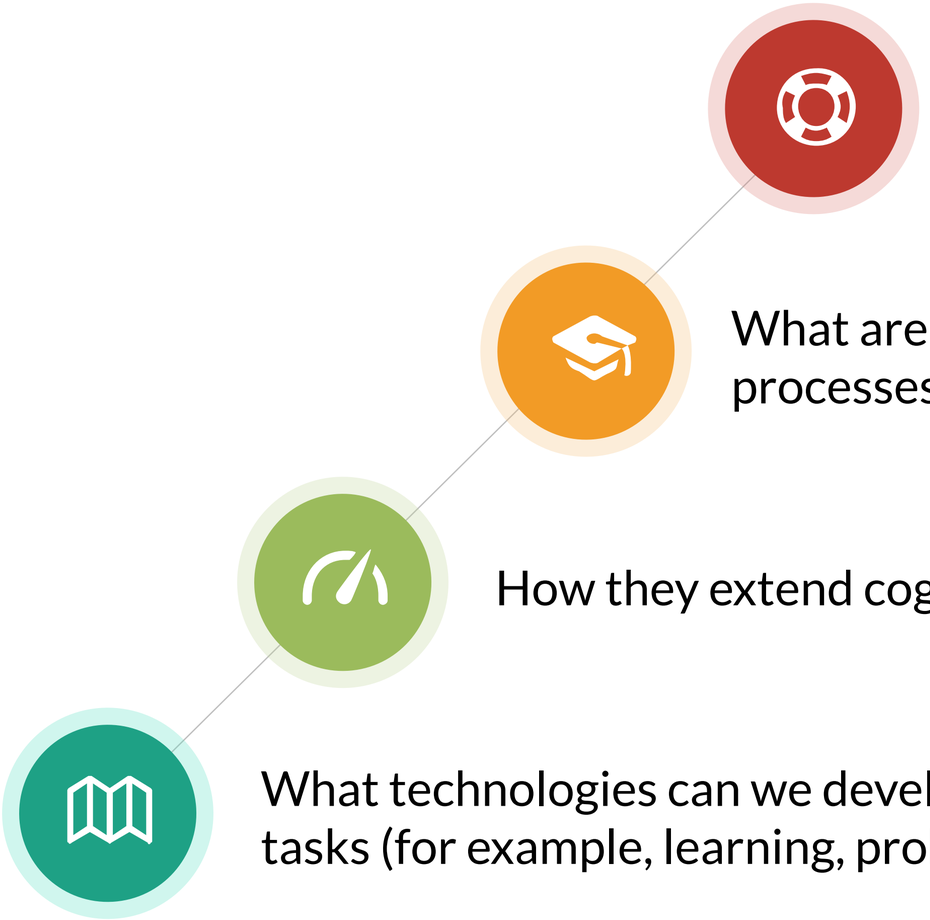
Distributed cognition

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)

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.

$$234 \times 456 = ??$$

$$CCXXXIIII \times CCCCXXXXXXVI = ???$$

- Which is easiest and why? Both are identical sums

Annotation and cognitive tracing

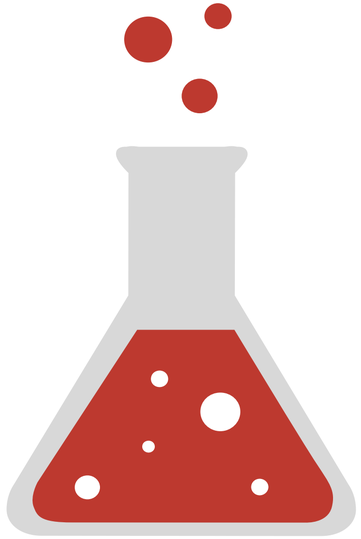
- Annotation involves modifying existing representations through making marks
  - For example, crossing off, ticking, and underlining

- 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



Creativity is the key to success
in the great education

Terima Kasih

Program Studi Teknik Informatika
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