

**Course : COMP6176 / Human - Computer  
Interaction**

**Year : 2019**

# **COGNITIVE ASPECTS**

**SESSION 03**

# LEARNING OUTCOMES

- LO 1: Describe the concept of interaction design
- LO 2: Use guidelines, principles, models, and framework related with interaction design

# OUTLINE

- Introduction
- What is Cognitive
- Cognitive Frameworks

# INTRODUCTION

*•Hafner ( 2004), a technology reporter," distracting oneself used to consist of sharpening a half-dozen pencils or lighting a cigarette. Today, there is a universe of diversion to buy, hear, watch and forward, which makes focusing on a task all the more challenging."*

•At its most extreme form, such behaviour has been found to be highly addictive : instead of focusing on our work, we're really waiting for the next hit – be it a new email, text, Facebook posting, news feed, and so forth.

# INTRODUCTION

- ✓ The study of human cognition can help to understand these and other new kinds of computer-augmented behaviours by examining human's abilities and limitations when interacting with technologies.
- ✓ Other ways of describing cognition are in terms of the context in which it takes place, the tools that are employed, the artifacts and interfaces that are used, and the people involved (Rogers, 2012)

# WHAT IS COGNITION ?

✓ Depending on when, where, and how it happens, cognition can be distributed , situated, extended, and embodied.

✓ There are **kind of cognitive processes** :

1. Attention
2. Perception
3. Memory
4. Learning
5. Reading, speaking, and listening
6. Problem-solving, planning, reasoning, and decision making.

# WHAT IS COGNITION ?

## ATTENTION

- ✓ It is the process of selecting things to concentrate on, at a point in time, from the range of possibilities available.
- ✓ Attention involves **auditory and visual senses**.
- ✓ An example of visual attention :
  - ❖ Scanning the football results in a newspaper to attend to information about how our team has done.
- ✓ The extent to which this process is easy or difficult depends on :
  - ❖ the clear goals
  - ❖ the way information is displayed can influence how easy or difficult

# WHAT IS COGNITION ?

## ATTENTION

✓ Example : Two different ways of structuring the same information at the interface Figure 03.01a more easier to find information than Figure 03.01b

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	774-8261	\$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

(a)

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

(b)

Figure 03.01 Two different ways at the interface



# WHAT IS COGNITION ?

## ATTENTION

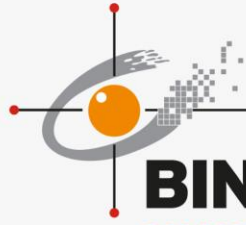
### Multitasking and Attention

- A main finding of research on the effects of multitasking on memory and attention is :
  - ✓ it depends on the nature of the tasks and how much attention each demands.
  - ✓ For example : listening to gentle music while working can help people tune out background noise, such as traffic or other people talking, and help them concentrate on what they are doing

# WHAT IS COGNITION ?

## ATTENTION

- However if the music is loud, like Drum and Bass, it can be very distracting.
- ✓ Design Implication for Attention
  1. Make information salient when it needs attending to at a given stage of a task.
  2. Use techniques like animated graphics, colour, underlining, ordering of items, sequencing of different information, and spacing of item to achieve this.
  3. Avoid cluttering the interface with too much information.
  4. Search engines and form fill-ins that are simple are much easier to use. (Ex: Google)



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# WHAT IS COGNITION ?(Your turn)

## DILEMMA

Is It OK to Use a Phone While Driving?

# WHAT IS COGNITION ?

## PERCEPTION

- ✓ How information is acquired from the environment via the different senses organs – eyes, ears, fingers and transform into experiences of objects , event, sounds, and tastes (Roth,1986).
- ✓ Involving other cognitive processes such as memory, attention, and language.
- ✓ **Vision** is the most dominant sense for sighted individuals, followed by hearing and touch.
- ✓ A general design principle is that :
  - ❖ Information needs to be represented in an appropriate form to facilitate the perception and recognition of its underlying meaning.

# WHAT IS COGNITION ?

## PERCEPTION

✓ In a study comparing web pages displaying the same amount of information, but which were structured using different graphical methods, it was found that people took less time to locate items from information that was grouped using a border (Figure a) than when using colour contrast (Figure b).

Webmaster Russian Athletics Go Shockers Degree Options Newsletter	Curriculum Emergency (EMS) Statistics Award Documents Language Center Future Shockers	Student Life Accountancy Mc Knight Center Council of Women Commute Small Business	Dance Gerontology Marketing College Bylaws Why Wichita? Tickets
Gelogy 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 Nrsing Opera Sports History Athletic Dept. Health Plan

(a) Grouped using a border

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

(b) Grouped using color contrast

# WHAT IS COGNITION ?

## PERCEPTION

- ✓ Design Implication for Perception :  
Representations of information need to be designed to be perceptible and recognizable across different media :
  1. icons and other graphical representations should enable users to readily distinguish their meaning.
  2. Bordering and spacing are effective visual ways of grouping information that makes it easier to perceive and locate items.
  3. Sound should be audible and distinguishable

# WHAT IS COGNITION ?

## PERCEPTION

4. Speech output should enable users to distinguish between the set of spoken words and understand the meaning.
5. Text should be legible and distinguishable from the background
6. Tactile feedback used in virtual environments should allow user to recognize the meaning of the various touch sensations being emulated.



# WHAT IS COGNITION ?

## MEMORY

- Memory involves recalling various kinds of knowledge that allow us to act appropriately.
- Example : it allows us remember someone's name
- It is not possible to remember everything that we see, hear, taste, smell, or touch .
- A filtering process is used to decide what information gets further processed and memorized.



# WHAT IS COGNITION ?

## MEMORY

- ✓ The filtering process work :
  - Initially, encoding take place determining which information is attended to in the environment and how it is interpreted.
  - The extent to which it takes place affects our ability to recall that information later.
  - The more attention that is paid to something and the more it is processed in term of thinking about it and comparing it with other knowledge, the more likely it is to be remembered.

# WHAT IS COGNITION ?

## MEMORY

- ✓ Another factor that affects the extent to which information can be subsequently retrieved is **the context in which it is encoded**.
- ✓ Sometimes it can be difficult for people to recall information that was encoded in a different context from the one they are currently in.
- ✓ Another memory phenomenon is that people are much better at **recognizing things than recalling things**.
- ✓ In particular, people are very good at **recognizing thousands of pictures** even if they have only seen them briefly before.

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# WHAT IS COGNITION ?

## MEMORY

- ✓ Design Implications for Memory
  1. Do not overload users' memories with complicated procedures for carrying out tasks.
  2. Design interfaces that promote recognition rather than recall by using menus, icons and consistently placed objects.
  3. Provide users with a variety of ways of encoding digital information ( e.g. Files, emails, images) to help them remember where they have stored them, through the use of categories, color, flagging, time stamping, icons, etc.

# WHAT IS COGNITION ?

## LEARNING

- ✓ Learning can be considered in terms of :
  1. How to use a computer based application
  2. Using a computer-based application to understand a given topic.
- ✓ A main observation is that people find it very hard to learn by following a set of instructions in a manual.
- ✓ Instead , they much prefer to learn through doing.
- ✓ GUIs and Direct Manipulation interfaces are good environments for supporting this kind of active learning by supporting exploratory interaction and allowing users to undo their actions.

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# WHAT IS COGNITION ?

## LEARNING

- ✓ One of the main benefits of interactive technologies such as web-based learning, multimedia and virtual reality is :
  - ✓ they provide alternative ways of representing and interacting with information that are not possible with traditional technologies e.g. books.
- ✓ The interactive technologies have the potential of offering learners the ability to explore ideas and concepts in different ways.
- ✓ E.g. interactive multimedia simulations have been designed to help teach abstract concepts( e.g. Mathematical formulae) that students find difficult to grasp.

# WHAT IS COGNITION ?

## LEARNING

- ✓ Design Implication for Learning
  - ✓ Design interfaces that encourage exploration
  - ✓ Design interfaces that constrain and guide users to select appropriate actions when initially learning.
  - ✓ Dynamically link concrete representations and abstract concepts to facilitate the learning of complex material.



# WHAT IS COGNITION ?

## READING, SPEAKING, AND LISTENING

- ✓ Reading, speaking and listening are three forms of language processing that have similar and different properties.
- ✓ One similarity is that the meaning of sentences or phrases is the same regardless of the mode in which it is conveyed.
- ✓ The ease with which people can read, listen, or speak differs depending on the person, task, and context.
- ✓ Specific differences between the three modes include :

# WHAT IS COGNITION ?

## READING, SPEAKING, AND LISTENING

- ✓ Specific differences between the three modes include :
  1. Written language is permanent while listening is transient.
  2. Reading can be quicker than speaking or listening , as written text can be rapidly scanned in ways not possible when listening to serially presented spoken words.
  3. Listening requires less cognitive effort than reading or speaking.
  4. Written language tends to be grammatical while spoken language is often ungrammatical.
  5. Dyslexics have difficulties understanding and recognizing written words, making it hard for them to write grammatical sentences and spell correctly.

# WHAT IS COGNITION ?

## READING, SPEAKING, AND LISTENING

- ✓ Many application have been developed to capitalize on people's reading, writing, and listening skills :
  1. Interactive books and web-based materials that help people to read or learn foreign languages.
  2. Speech-recognition systems that allow users to interact with them by using spoken command. (e.g. Google Voice Search app)
  3. Speech-output systems that use artificially generated speech
  4. Natural-language systems that enable users to type in questions and give text-based responses. (e.g. Ask search engine)
  5. Cognitive aids that help people who find it difficult to read, write, and speak.

# WHAT IS COGNITION ?

## READING, SPEAKING, AND LISTENING

- ✓ Many application have been developed to capitalize on people's reading, writing, and listening skills :
  6. Customized input and output devices that allow people with various disabilities to have access to the web and use word processors and other software packages.
  7. Interaction techniques that allow blind people to read graphs and other visuals on the web through the use of auditory navigations and tactile diagrams(Petrie et al, 2002).

# WHAT IS COGNITION ?

## READING, SPEAKING, AND LISTENING

- ✓ Design Implication for Reading, Speaking and Listening
  1. Keep the length of speech-based menus and instruction to a minimum.
  2. Accentuate the intonation of artificially generated speech voices as they are harder to understand than human voices.
  3. Provide opportunities for making text large on a screen, without affecting the formatting, for people who find it hard to read small text.

# WHAT IS COGNITION ?

## PROBLEM SOLVING, PLANNING, REASONING AND DECISION MAKING

- ✓ Problem solving, planning, reasoning and decision making are processes involving reflective cognition.
- ✓ They include thinking about what to do, what the options are, and what the consequences might be of carrying out a given action.
- ✓ They often involve conscious processes (being aware of what one is thinking about), discussion with others ( or oneself), and the use of various kinds of artifacts (e.g. maps, books, pen, and paper).

# WHAT IS COGNITION ?

## PROBLEM SOLVING, PLANNING, REASONING AND DECISION MAKING

- ✓ The extent of which people engage in reflective cognition depends on their level of experience with a domain, application, or skill.
- ✓ Novices tend to have limited knowledge and will often make assumptions about what to do using other knowledge about similar situations. They tend to act by trial and error, exploring and experimenting with ways of doing things.
- ✓ The Experts have much more knowledge and experience and able to select optimal strategies for carrying out their tasks.

# WHAT IS COGNITION ?

## PROBLEM SOLVING, PLANNING, REASONING AND DECISION MAKING

- ✓ Instead of providing ever more information to enable people to compare products when making a choice, a better strategy is to design technological interventions that provide just enough information and in the right form, to facilitate good choices.
- ✓ One solution is to exploit new forms of augmented reality technology that enable information-frugal information decision making. ( Rogers et al, 2010).



# WHAT IS COGNITION ?

## PROBLEM SOLVING, PLANNING, REASONING AND DECISION MAKING

- ✓ Design implication for problem solving, planning, reasoning, and decision making :
  1. Provide additional hidden information that is easy to access for users who wish to understand more about how to carry out an activity more effectively. ( e.g. Web searching).
- ✓ Use simple and memorable functions at the interface for computational aids intended to support rapid decision making and planning that takes place while on the move

# COGNITIVE FRAMEWORKS

- ✓ There are three early **internal frameworks** that focus **primarily on mental processes** together with three more recent external ones that explain **how human interact and use technologies in the context** in which they occur . They are :

Internal	External
Mental Models	Distributed cognition
Gulfs of execution and evaluation	External cognition
Information Processing	Embodied interaction

# COGNITIVE FRAMEWORKS

## a. Mental Models

- People primarily develop knowledge of how to interact with a system, and to a lesser extent, how that system works.
- The more someone learns about a system and how it functions, the more their mental model develops.
- If people could develop better mental models of interactive systems they would be in a better position to know how to carry out their task efficiently and know what to do if a system started malfunctioning.
- If interactive technologies could be designed more transparent then it might be easier to understand in terms of how they work and what to do when they don't.

# COGNITIVE FRAMEWORKS

## a. Mental Models

- Transparency involves including :
  - Useful feedback in response to user input
  - Easy to understand and intuitive ways of interacting with the system
- Providing the right kind and level of information in the form of :
  - Clear and easy-to-follow instructions
  - Appropriate online help and tutorials and Context-sensitive guidance for users.
  - Background information that can be accessed to let people know how something works and how to make the most of the functionality provided.
  - Affordances of what actions an interface allows (for example, swiping, clicking, or selecting).

# COGNITIVE FRAMEWORKS

## b. **Gulfs of Execution and Evaluation**

- The gulfs of execution and the gulf of evaluation describe the gaps that exist between the user and the interface (Norman, 1986; Hutchins et al 1986).
- The gulfs of execution describe the distance from the user to the physical system
- The gulfs of evaluation describe the distance from the physical system to the user. (Figure 03.01)



Figure 03.01 Bridging the gulfs of execution and evaluation

## b. Gulfs of Execution and Evaluation

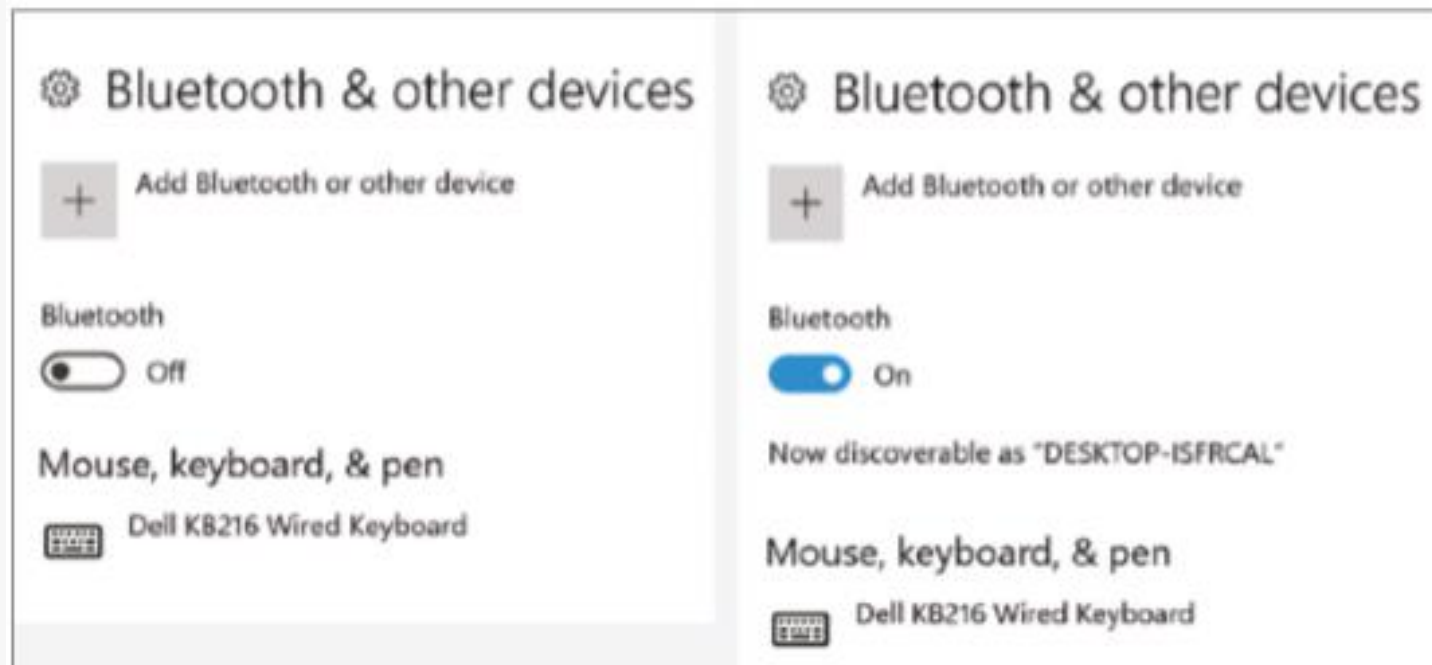


Figure 03.02 An example where the gulfs helped explain how a seemingly trivial design decision led to much user frustration

# COGNITIVE FRAMEWORKS

## c. Information Processing

- Information is thought to enter and exit the mind through a series of ordered processing stages (Figure 03.03)
- The information processing model provides a basis from which to make predictions about human performance.
- One of the first HCI models to derived from the information processing theory was **the human processor model**, which modeled the cognitive

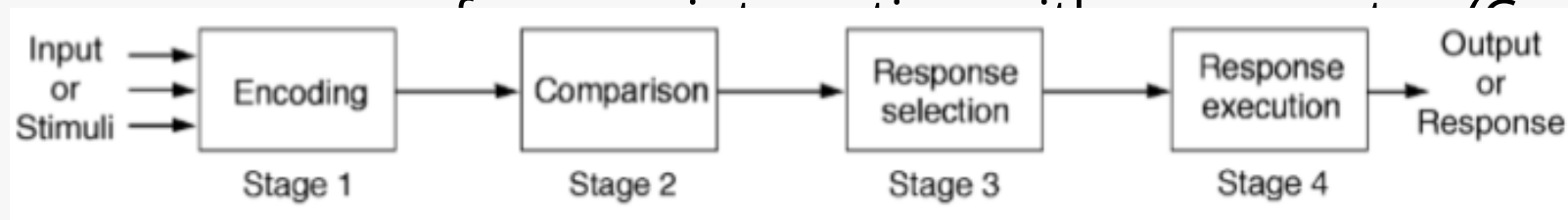


Figure 03.03 Human Information Processing Model



# COGNITIVE FRAMEWORKS

## d. Distributed Cognition

- The distributed cognition studies the nature of cognitive phenomena across individuals, artifacts, and internal and external presentation (Hutchins, 1995). (See Figure 03.04)

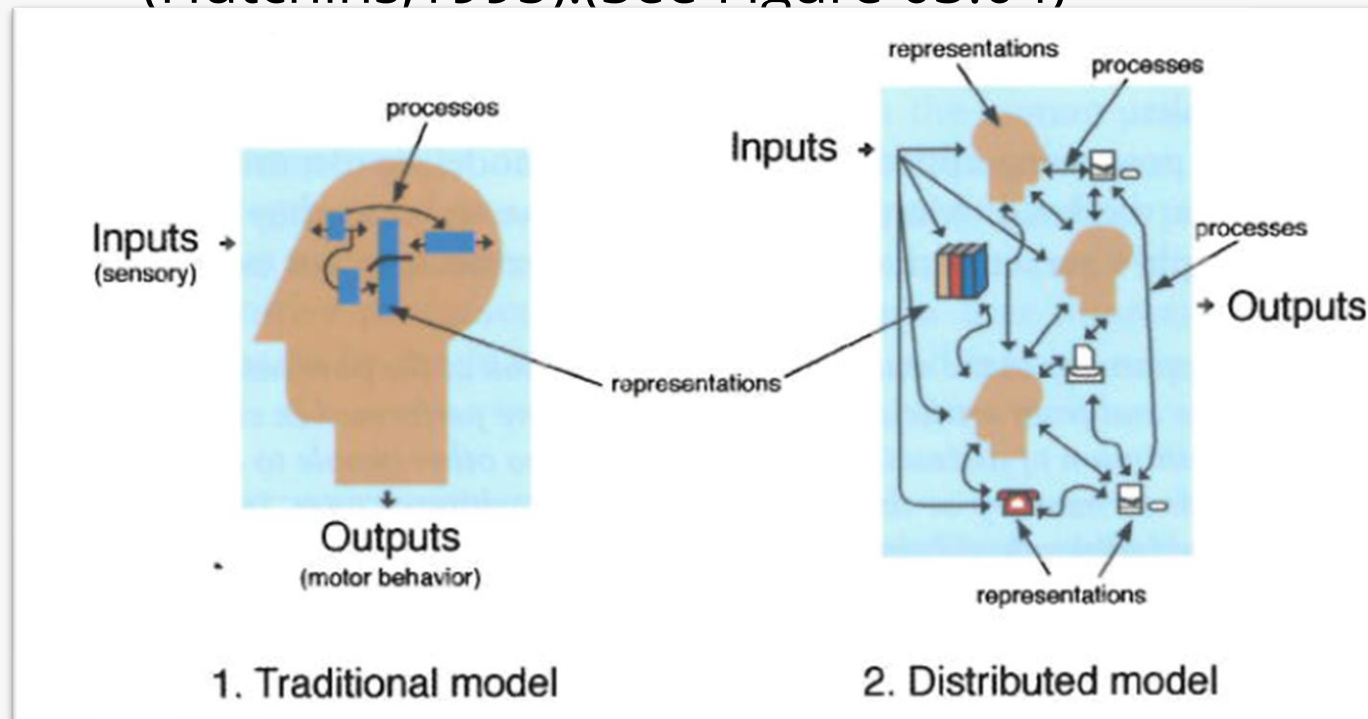


Figure 03.04  
Comparison of  
traditional and  
distributed  
cognition  
approaches



# COGNITIVE FRAMEWORKS

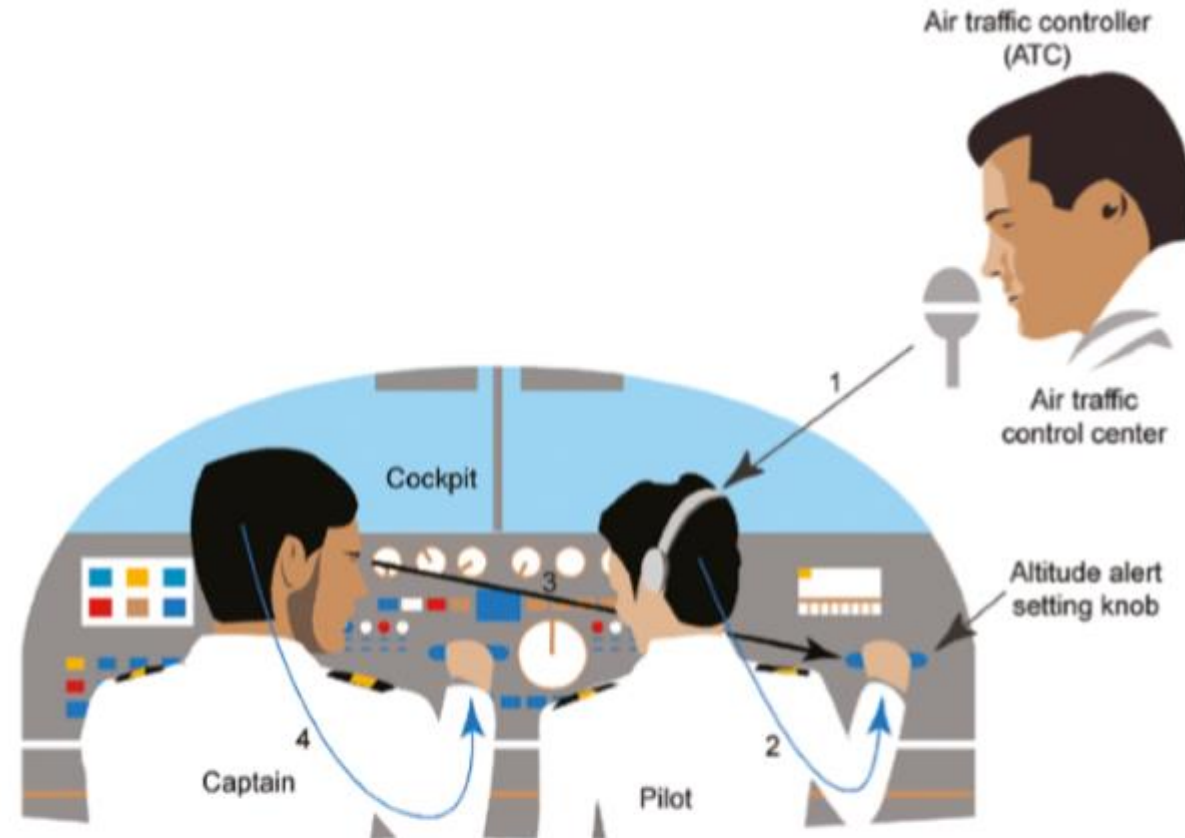
## d. Distributed Cognition

- An example of a cognitive system is an airline cockpit, where the top-level goal is to fly the plane (see Figure 03.05). This involves all of the following:
  - The pilot, captain, and air traffic controller interacting with one another.
  - The pilot and captain interacting with the instruments in the cockpit
  - The pilot and captain interacting with the environment in which the plane is flying (that is, the sky, runway, and so on)

# COGNITIVE FRAMEWORKS

## d. Distributed Cognition

Figure 03.05 A cognitive system in which information is propagated through different media



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)

# COGNITIVE FRAMEWORKS

## d. Distributed Cognition

- **A primary objective** of the distributed cognition approach is to describe these interactions in terms of how information is propagated through different media.

## e. External Cognition

- External cognition is concerned with explaining the cognitive processes involved when we interact with different external representations (Sciafe and Rogers, 1996).
- **A main goal** is to explicate the cognitive benefits of using different representation for different cognitive activities and the processes involved.

# COGNITIVE FRAMEWORKS

## e. External Cognition

- The main ones include :
  1. Externalizing to reduce memory load  
Use diaries, personal reminders, and calendar for acting as external reminders of what we need to do at a given time.
  2. Computational offloading  
It occurs when use a tool or device in conjunction with an external representation to help us carry out a computation.  
Example : using pen and paper to solve a math problem.

# COGNITIVE FRAMEWORKS

## e. External Cognition

- The main ones include :
  3. Annotating and cognitive tracing
    - Externalize the cognition by modifying representations to reflect changes that are taking place that wish to mark.
    - **Annotating** involves modifying external representations such as crossing off or underlining items. Example : Tablet PC enable users to physically annotate documents such as circling data or writing notes using styluses.

# COGNITIVE FRAMEWORKS

## e. External Cognition

- The main ones include :
  3. Annotating and cognitive tracing
    - **Cognitive tracing** involves externally manipulating items into different orders or structures. Example : In Scrabble, where shuffling around letters in the tray helps a person work out the best word given the set of letters ( Maglio et al, 1999)

## f. Embodied Interaction

- HCI which grew out of collaborations between computer scientists and psychologists, initially adopted an information processing perspective.
- Embodied interaction has been applied quite broadly to HCI, including work that focuses on the emotional quality of interaction with technology.(Hook,2008).

- Interaction Design 5th Edition 2019, Chapter 4
- <https://www.youtube.com/watch?v=ktgnhetc8gQ>
- <http://ir.lib.cyut.edu.tw:8080/bitstream/310901800/14308/4/c3.pdf>
- [http://www.zainbooks.com/books/computer-sciences/human-computer-interaction\\_6\\_cognitive-frameworks.html](http://www.zainbooks.com/books/computer-sciences/human-computer-interaction_6_cognitive-frameworks.html)