Human Computer Interaction
CE 382

Course Instructor: Vincent M. Nofong, Ph.D.

July 11, 2024

Introduction

Outline

- Who I am
- Course Information and Outline of CE 382
- Expected Learning Outcomes
- Rules
- Chapter Two: Establishing Requirements

Introduction

About me

- Name: **Vincent M. Nofong, PhD**
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- Personal Website: https://vincentnofong.com/
- Uni website: https://www.umat.edu.gh/staffinfo/staffDetailed.php?contactID=385
- Office hours (Working days): **09:00 am - 16:00 pm GMT**
- Research interest: **data mining, trend prediction, classification, bioinformatics, artificial intelligence, machine learning**

Introduction

Course Information (CE 382)

- Credit hours: **3**
- Attendance: **10%**
- Continuous Assessment: **30%**
  - Quizzes - two or three
  - Group assignment - one (application development)
  - Group presentations
- End of Semester: **60%**

Introduction

Course Outline (CE 382)

1. Interaction Design
2. Establishing Requirements
3. Prototyping
4. Data Gathering and Analysis
5. Cognitive Aspects of Design
6. Social and Emotional Interactions
7. User Interfaces
8. Evaluations

Introduction

Expected Learning Outcomes (CE 382)

Students should understand and be able to:

1. Explain the characteristics of good and bad interaction design and use them to evaluate HCIs
2. Explain the characteristics of users that influence HCI and use them to inform user interface development
3. Explain, analyze and develop interaction evaluations
4. Explain and develop requirements for interaction design
5. Construct interactions using evaluation-based iterative process for directing the design of user interfaces.

Introduction

Reference Materials

1. Preece, J., Rogers, Y. and Sharp, H. (2023), Interaction Design: Beyond Human-Computer Interaction, John Wiley & Sons Ltd, Hoboken, U.S.A., 6th Edition, 716 pp. - slides are based on this reference
2. Lazar, J., Feng, J. H. and Hochheiser, H. (2017), Research Methods in Human-Computer Interaction, Morgan Kaufmann, Burlington, U.S.A., 2nd Edition, 560 pp.
3. Shneiderman B., Plaisant C., Cohen M. and Jacobs, S. (2016), Designing the User Interface, Pearson Publishers, 6th Edition, 616 pp.

Introduction

Rules

1. Feel free to ask questions in class, unless they are too "personal".
2. Students should not be late for lectures or practicals.
3. Students should attend all lectures and practicals.
4. **In case you are unable to attend lectures or will be late, send me an email - at least 30 minutes before lectures.**
5. Students should do and submit all assignments before the given deadline.
6. Unless otherwise permitted, students should not use their mobile phones in class - note usage of Laptops/Desktops is permitted.

HCI CE 382
Chapter Five: Cognitive Aspects of Design

Course Instructor: Vincent M. Nofong, Ph.D.

July 11, 2024

Cognitive Aspects of Design

What is cognition?

Cognitive Aspects of Design

What is cognition?

- Cognition encompasses various mental processes such as **thinking, remembering, learning, decision-making, and more**.
- Different ways to classify cognition include:
  - Experiential vs. reflective cognition (Norman, 1993): Distinguishes between immediate, intuitive experiences and deliberate, analytical thinking.
  - Fast vs. slow thinking (Kahneman, 2011): Describes the distinction between quick, instinctive thinking and deliberate, effortful thinking.

Cognitive Aspects of Design

Why understand users?

- Interacting with technology involves cognitive processes.
- It is crucial to consider the cognitive abilities and limitations of users.
- Understanding users helps:
  - Determine users' capabilities and limitations.
  - Identify and explain user problems.
  - Provide theories, models, guidance, and methods for designing better interactive products.

Cognitive Aspects of Design

Cognitive Processes

- Attention: The ability to selectively focus on relevant information.
- Perception: The process of interpreting sensory information and giving it meaning.
- Memory: The encoding, storage, and retrieval of information.
- Learning: Acquiring knowledge or skills through experience or instruction.
- Reading, Speaking, and Listening: Language-related processes involved in communication.
- Problem-Solving, Planning, Reasoning, and Decision-Making: Higher-level cognitive abilities used to solve problems, make plans, think logically, and make informed choices.

Cognitive Aspects of Design

Attention

- Selecting things to concentrate on from the surrounding stimuli.
- Enables us to focus on relevant information.
- Involves both audio and visual senses.
- Focused and divided attention allow us to be selective but limit our ability to track all events.
- Structuring information at the interface to capture users' attention:
  - Use perceptual boundaries such as windows.
  - Incorporate **color**, video, sound, and flashing lights.

Cognitive Aspects of Design

Attention - Activity 1: Find the price for a double room at the Quality Inn in Bedford

Cognitive Aspects of Design

Attention - Activity 2: 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

Cognitive Aspects of Design

Findings Based on Activity 1 and 2

- Tullis (1987) found that the two screens produced quite different results
  - Activity 1: Took an average of 5.5 seconds to search
  - Activity 2: Took 3.2 seconds to search
- Why, since both displays have the same density of information (31percent)?

Cognitive Aspects of Design

Findings Based on Activity 1 and 2

- Tullis (1987) found that the two screens produced quite different results
  - Activity 1: Took an average of 5.5 seconds to search
  - Activity 2: Took 3.2 seconds to search
- Why, since both displays have the same density of information (31percent)?
- Spacing:
  - In Activity 1, the information is bunched up together, making it hard to search
  - In Activity 2, the characters are grouped into vertical categories of information making it easier

Cognitive Aspects of Design

Designing for Attention

Cognitive Aspects of Design

Designing for Attention

- Make important information salient and noticeable.
- Use techniques such as color, ordering, spacing, underlining, sequencing, and animation to make elements stand out.
- Avoid cluttering the interface with excessive information.
- Keep interfaces simple and clean for improved usability.
- Consider designing interfaces that support effective switching between tasks and returning to previous contexts.

Cognitive Aspects of Design

Perception

- Perception involves acquiring information from the environment and translating it into meaningful experiences.
- Design representations that are easily perceivable by users.
- Ensure that text is legible and easily readable.
- Create icons that are distinct and recognizable.
- Consider visual clarity and use appropriate visual cues to enhance perception.

Cognitive Aspects of Design

Perception - Activity 3: 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

Cognitive Aspects of Design

Perception - Activity 4: Are borders & white space better?

Find "French"

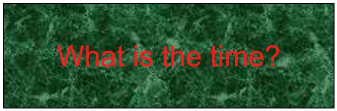
Webmaster	Curriculum	Student Life	Dance
Russian	Emergency (EMS)	Accountancy	Gerontology
Athletics	Statistics	McKnight Center	Marketing
Go Shockers	Award Documents	Council of Women	College Bylaws
Degree Options	Language Center	Commute	Why Wichita?
Newsletter	Future Shockers	Small Business	Tickets
Geology	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

Cognitive Aspects of Design

Findings Based on Activity 3 and 4

- Weller (2004) study on grouping and search efficiency found that:
  - People took less time to locate items when information was grouped using a border (Activity 4) compared to using color contrast (Activity 3).
  - The use of visual grouping techniques can enhance the search process and improve efficiency.
- White space and information retrieval:
  - Some argue that excessive white space on web pages can hinder the search process and make it difficult to find information.
  - The impact of white space on search efficiency is a topic of debate.
- Question for discussion:
  - Do you agree that too much white space on web pages is detrimental to the search process?

Perception - Activity 5: Which is the easiest to read and why?



What is the time?

What is the time?

What is the time?

What is the time?

What is the time?

Cognitive Aspects of Design

Perception - Design implications for user interface

- Icons should be designed to ensure users can readily distinguish their meaning.
- Utilize effective visual techniques such as bordering and spacing to group information and improve visual organization.
- Sounds used in the interface should be audible and distinguishable to provide meaningful feedback.
- When designing with colors, research proper color contrast techniques to ensure accessibility and usability.
  - For example, yellow on black or blue is suitable, while yellow on green or white should be avoided.
- Haptic feedback should be used judiciously, providing tactile feedback only when necessary to enhance the user experience.

Cognitive Aspects of Design

Memory

- Memory involves the processes of encoding and retrieving knowledge.
- Our memory selectively filters and processes information based on what we attend to.
- Recognition is often better than recall, meaning we can more easily recognize things rather than recalling them from memory.
- Interestingly, research suggests that we remember less about objects we have photographed compared to when we observe them directly with the naked eye (Henkel, 2014).

Memory: Context is Important

- The context in which information is encoded plays a significant role in its subsequent retrieval.
- People may find it challenging to recall information that was encoded in a different context. For example:
  - "You are on a train and someone comes up to you and says hello. You don't recognize him for a few moments but then realize it is one of your neighbours. You are only used to seeing your neighbour in the hallway of your apartment block and seeing him out of context makes him difficult to recognize initially"

Cognitive Aspects of Design

Memory: Recognition versus Recall

- Command-based interfaces often require users to recall information from memory, such as recalling a specific name from a large set of options.
- Graphical interfaces, on the other hand, provide visually-based options like menus and icons that users can browse through until they recognize the desired option.
- Web browsers enhance recognition memory by offering features like tabs and history lists of visited URLs, allowing users to easily recognize and revisit previously accessed web pages.

Cognitive Aspects of Design

Memory: The Problem with the Classic '7 ± 2' Theory

George Miller's (1956) theory of how much information people can remember:

- People's immediate memory capacity is very limited to 7 plus or minus 2 (7 ± 2).
- This theory has been widely used in interaction design to determine the number of options to display.
- However, its applicability and usefulness in the field of Human-Computer Interaction (HCI) are subject to debate.
- Questions arise regarding whether relying solely on this theory is a good approach in designing user interfaces.

Cognitive Aspects of Design

What Some Designers Do: The 'Rule of 7'

- Some designers adhere strictly to the "rule of 7" in UI design:
  - They limit the number of options on a menu, icons on a toolbar, bullets in a list, items on a pull-down menu, or tabs on a website page to only 7.
- However, this approach may not always be appropriate or effective.
- Limiting options to 7 based on this rule can be misleading and oversimplified.
- The "rule of 7" is not universally applicable and may not consider the complexity of the task or the cognitive abilities of the users.

The Limitations of the 'Rule of 7' in UI Design (1/2)

- The 'Rule of 7', which suggests limiting the number of items in an interface to 7±2, may not be ideal in UI design.
- People can easily scan lists, tabs, and menu items to locate the desired option, rather than relying on memory recall.
- This means that interfaces can accommodate more than nine items without overwhelming users.
  - For example, history lists in web browsers can include a larger number of visited websites.
- In some cases, a small number of items can be beneficial, such as on smartwatch displays where screen estate is limited.

The Limitations of the 'Rule of 7' in UI Design (2/2)

- The suitability of the 'Rule of 7' depends on the specific task requirements and the available screen space.
- It is important for designers to consider the context, user preferences, and usability testing when determining the optimal number of items in an interface.
- By blindly adhering to this rule, designers may inadvertently sacrifice functionality, user experience, and efficient navigation.

Digital Content Management: Organizing and Finding Files (1/2)

- With the increasing volume of digital content, users face challenges in managing and locating their files, including documents, images, music, videos, emails, and more.
- Remembering file names and storage locations can be difficult, requiring both recall-directed and recognition-based scanning processes.
- File management systems should be designed to support both memory processes effectively.
- Features like a search box and history list can aid in quickly locating files based on recall or recognition.

Digital Content Management: Organizing and Finding Files (2/2)

- To enhance file organization, users should be provided with options to encode files in richer ways, such as using colors, flags, images, flexible text, and time stamping.
- These features enable users to visually and contextually categorize and remember their files.

Memory Aids for Enhanced Recall (1/2)

- SenseCam, developed by Microsoft Research Labs (now Autographer), is a wearable device that automatically captures photos at intervals without user intervention.
- The digital images captured by SenseCam are stored and can be revisited using specialized software.
- Studies have shown that SenseCam can improve memory, particularly in individuals with dementia.
- Another memory aid is RemArc, which utilizes archived BBC materials to trigger long-term memory.

Memory Aids for Enhanced Recall (2/2)

- These memory aids offer innovative ways to support and enhance recall abilities.
- By capturing and reviewing visual stimuli, SenseCam helps individuals remember events and experiences that might otherwise be forgotten.

Figure 1: SenseCam Device and Picture Captured

Cognitive Aspects of Design

Design Implications for Memory Enhancement (1/2)

- Minimize Cognitive Load: Simplify task procedures to reduce the mental effort required for users to carry out tasks effectively.
- Emphasize Recognition: Design interfaces that prioritize recognition over recall, allowing users to easily identify and locate information without relying heavily on memory.
- Utilize Multiple Labeling Methods: Provide users with diverse options for labeling digital information to enhance recognition and retrieval.
- Use Folders and Categories: Organize files into folders and categories to facilitate efficient organization and navigation.

Design Implications for Memory Enhancement (2/2)

- Incorporate Color Coding: Apply color to visually differentiate and group related information, making it easier for users to identify and remember specific items.
- Implement Flagging and Bookmarking: To allow users flag or bookmark important content for quick reference and future retrieval.
- Utilize Time Stamping: Automatically record and display time stamps to help users track and recall the chronology of their digital information.
- Consider User Preferences: Provide customization options for labeling methods, allowing users to personalize their organization and retrieval strategies.

Cognitive Aspects of Design

Learning

- Learning involves acquiring skills and knowledge through memory processes.
- Types of Learning:
  - Incidental Learning: Unplanned and spontaneous learning that occurs through everyday experiences and observations.
  - Intentional Learning: Deliberate and purposeful learning, often involving studying or training.
- Various technologies have been developed to support and enhance the learning process.
  - Multimedia, Animations, Virtual Reality, etc.
- People tend to prefer learning through hands-on experiences rather than relying solely on instructional manuals or passive instruction.

Cognitive Aspects of Design

Design implications for Enhancing Learning

- Keep speech-based menus and instructions concise.
- Pay attention to the intonation of artificially generated speech voices, as they may be more challenging to understand than human voices.
- Allow users to increase the text size on the screen to improve readability.
- Design interfaces that encourage exploration and active engagement.
- Provide structured and guided learning experiences through interface design.
- Utilize dynamic linking of concepts and representations to facilitate understanding of complex material.

Cognitive Aspects of Design

Reading, speaking, and listening

The ease with which people can read, listen, or speak differs

- Many users prefer auditory information over written text.
- Reading can be faster compared to speaking or listening.
- Listening requires less cognitive effort than reading or speaking.
- Dyslexic individuals may face difficulties in understanding and recognizing written words.

Cognitive Aspects of Design

Reading, speaking, and listening - Applications

- Voice user interfaces allow users to interact with them by asking questions
  - E.g. Google Voice, Siri, Alexa
- Speech-output systems use artificially-generated speech
  - E.g. written text-to-speech systems for the visually impaired
- Natural-language systems enable users to type in questions and give text-based responses
  - E.g. chatbots

Cognitive Aspects of Design

Design implications - Reading, speaking, and listening

- Provide options for audio-based content to cater to users' preference for listening.
- Provide options to increase the size of text on the screen, ensuring that users with visual impairments can comfortably read the content.
- Design interfaces that facilitate efficient reading, such as clear typography and appropriate formatting.
- Use concise and accessible language for spoken instructions or text-to-speech functionalities.
- Incorporate features like dyslexia-friendly fonts or customizable reading settings to support users with reading difficulties.

Cognitive Prosthetic Devices: Implications for Designing Learning Technologies

- Increasing reliance on the internet and smartphones for information retrieval reduces the need for extensive memorization.
- The expectation of having internet access impacts our memory by prioritizing knowledge of where to find information online rather than storing it internally (Sparrow et al., 2011).
- Designing technologies to support learning should consider the shift in reliance on external information sources and the implications it has for the learning process.

Cognitive Aspects of Design

Dilemma: Impact of the App Mentality on Decision-Making

- The younger generation's growing reliance on apps is leading to increased risk aversion and difficulty in making independent decisions (Gardner and Davis, 2013).
- The abundance of apps provides ready-made solutions for various tasks, reducing the need for critical thinking and problem-solving skills.
- Relying heavily on apps can lead to anxiety and a lack of confidence in making decisions without app-based guidance.
  - Consider a scenario where a young adult relies heavily on a food delivery app for all their meals. They may become anxious and unsure when faced with the task of cooking a meal from scratch or making dietary choices without the app's suggestions. Any other examples?

Cognitive Frameworks: Understanding User Behavior at the Interface (1/2)

- Cognitive frameworks are utilized to explain and predict user behavior when interacting with interfaces.
- They are based on theories of behavior and focus on the mental processes that occur during interaction.
- These frameworks also consider the role of artifacts and representations in shaping user cognition.

Cognitive Frameworks: Understanding User Behavior at the Interface (2/2)

- Some of the most well-known cognitive frameworks include:
  - Mental models, which depict users' internal representations of how a system works.
  - Gulfs of execution and evaluation, which describe the gaps between users' intentions and the system's feedback. reading assignment
  - Distributed cognition, which explores how cognitive processes are distributed across individuals, artifacts, and the environment. reading assignment
  - External and embodied cognition, which recognize the role of external tools and physical interactions in cognitive processes. reading assignment

Cognitive Aspects of Design

Mental Models: Understanding User 'Understanding'

- Users develop an understanding of a system through learning and interacting with it.
- This understanding is often referred to as a mental model, which consists of:
  - Knowledge of how to use the system and what actions to take next.
  - Understanding of how the system works, particularly in unfamiliar or unexpected situations.
- Mental models enable users to make inferences and carry out tasks effectively.

Cognitive Aspects of Design

Everyday reasoning and mental models: Activity 6

1. 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?
2. 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 100 degrees (Celsius) first and then put it in (as specified by the instructions) or turn the oven up higher to try to warm it up quicker?

Activity 6: Thermostat Control Misconceptions (1/2)

- When asked how to heat up a room or oven that is thermostat-controlled, many people choose the option of increasing the temperature setting.
- This choice is based on the misconception that raising the temperature will heat the room or oven more quickly.
- This misconception stems from the general valve theory, where the "more is more" principle is commonly applied to various settings, such as gas pedals, gas cookers, taps, and radio volume.
- However, this mental model is incorrect when applied to thermostats, which operate based on an on-off switch mode.

Activity 6: Thermostat Control Misconceptions (2/2)

- These misconceptions can be attributed to the general valve theory being generalized across different settings, leading to erroneous mental models.
- Understanding the correct operation of thermostats and educating users about their functioning can help dispel these misconceptions and promote more efficient and effective use of thermostat-controlled systems.

Misconceptions in Understanding Interactive Devices (1/2)

- Users often hold erroneous mental models when it comes to understanding how interactive devices and computers work.
- These mental models are often poor, incomplete, easily confusable, and based on inappropriate analogies and superstition (Norman, 1983).
- For example, when using elevators and pedestrian crossings, many people tend to press the button at least twice.
- This behavior is driven by the misconception that pressing the button multiple times will make the lights change faster or ensure that the elevator arrives promptly.

Misconceptions in Understanding Interactive Devices (2/2)

- Similarly, users may have various other misconceptions about how interactive devices operate.
- These mental models can be influenced by limited knowledge, past experiences, and cultural factors.
- Understanding the kinds of mental models users have is crucial for designing user-friendly interfaces and providing appropriate feedback.

Designing UX for Better Mental Models (1/2)

- Clear and easy-to-use instructions should be provided to users to help them build accurate mental models.
- Appropriate tutorials and contextual-sensitive guidance can guide users in understanding how to interact with the interface effectively.
- Providing online videos and chatbot windows can offer additional support and assistance when users need help.
- Transparency in interface design is crucial to make the system intuitive to use.
- Interfaces should provide clear affordances that indicate the available actions, such as swiping, clicking, or selecting.

Designing UX for Better Mental Models (2/2)

- Consistency in design elements, terminology, and interactions across the system can help users form consistent mental models.
- User feedback and error messages should be informative and guide users towards the correct mental model.
- Conducting user testing and gathering feedback can identify areas where users struggle to build accurate mental models.
- Continuous improvement and updates to the UX based on user feedback can lead to the development of better mental models.
- Collaborating with users through co-design sessions and involving them in the design process can result in interfaces that align with their mental models.