

CE 536 - Human-Computer Interaction

Lecture #1
Introduction to HCI

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Human-Computer Interaction

- HCI is a multidisciplinary field dedicated to the close examination, design, and assessment of interactions between humans and computers.
- It encompasses a wide array of aspects related to how humans engage with and utilize technology, with the aim of enhancing the usability, efficiency, and overall user experience of digital systems, applications, and devices.
- At the heart of HCI lies the principle of user-centered design (UCD).
 - This entails comprehending the requirements, behaviors, preferences, and constraints of users to create technology that is intuitive, effective, and satisfying for them.

Human-Computer Interaction

- To accomplish this, HCI draws on a variety of disciplines, including computer science, psychology, design, sociology, anthropology, and many more.
- Additionally, a profound attention to human factors, which encompass cognitive, physical, and social aspects of human behavior, is integral to HCI.

Human-Computer Interaction

- Given these considerations, HCI initially aimed to develop technology primarily with usability in mind.
- **Usability** pertains to how easily and efficiently users can complete tasks and attain their objectives using a specific system or interface. It can be assessed through techniques like user testing and expert evaluations.
- From a practical standpoint, HCI professionals concentrate on crafting user-technology interactions (e.g., the design of buttons, menus, touch gestures, voice commands, and other interaction methods), structuring and organizing information within digital systems to facilitate user navigation.

Human-Computer Interaction

- From the earliest stages, extensive user research (e.g., surveys, interviews, and observation) is employed to gain insights into user behavior, preferences, and pain points.
- Furthermore, HCI addresses ethical concerns linked to technology, such as privacy, security, and the societal impact of technology. Ethical considerations are particularly relevant in the design of systems that manage sensitive data or influence user behavior.

Human-Computer Interaction

- HCI emerged in the mid-1980s, but in today's digital era, it has become indispensable in the design of digital systems and devices that are integral to our daily lives.
- The digital age has seen HCI ascend to paramount importance, given the pervasive integration of technology into everyday activities.
 - This integration encompasses an array of technologies, including *smartphones*, *tablets*, *websites*, *software applications*, *wearable devices*, *smart appliances*, and newer technologies such as *virtual reality* and *artificial intelligence*.

Human-Computer Interaction

- In parallel, HCI propels technological innovation by perpetually seeking ways to enhance the quality of interaction between humans and machines, fostering the development of new technologies and paradigms, such as *touchscreens*, *voice recognition*, and *eXtended Reality (XR)*.
- In a nutshell, HCI aims to ensure that we can fully harness the potential of digital tools and systems while minimizing user frustration and access barriers.

The Main Aspects of HCI

- The Human
- The Computer
- The Interaction

The Human

- Understanding the human is a prerequisite for the design of technological systems that are perceivable, understandable, and operable. It encompasses several crucial aspects such as human sensation, perception, attention, memory, information processing, mental models, language, communication, decision-making, problem solving, error, and emotions.
- Sensation and perception are fundamental in HCI, influencing how users interpret information presented through digital interfaces, as well as impacting elements such as color, layout, and auditory feedback.
- Multiple senses, including vision, hearing, and touch, are relevant in HCI, especially in multimodal interfaces and interactions with advanced technology like robots and autonomous vehicles.

The Human

- It is necessary to present information in a way that aligns with human cognitive processes and minimizes cognitive overload.
- Addressing the limitations of human attention, designing to avoid cognitive overload, and recognizing the role of attention in tasks like visual search are essential.
- Memory, including sensory memory, working memory, and long-term memory, is integral to HCI, influencing how users interact with systems and remember information.

The Human

- Language and communication play essential roles in HCI, involving linguistic and communicative models in various activities and stages.
- HCI involves multiple languages that mediate communication between users, systems, and designers.
 - Users interact with systems through the user interface language, which specifies system state, user actions, and goal achievement.
 - Users themselves employ language to interact with the interface and express their intentions, while some designers offer scripting languages for end users to customize software behavior according to their needs.
 - Designers also employ various languages at different levels of abstraction, ranging from describing user-oriented qualities to specifying interaction mechanisms during design (i.e., define the system's user interface language, through which the state of the system is expressed, what the user can or should do, and how users will be able to express their intentions in order to achieve their goals).

The Human

- Emotional design focuses on creating products that evoke specific emotional responses from users through elements such as color schemes, visual aesthetics, and sound design.
 - Designing for emotions can improve engagement, usability, and decision-making.
- Consideration of cultural and ethical factors is essential in implementing emotional design, as it affects user experiences.
- Affective computing, a multidisciplinary field, seeks to imbue machines with the ability to interpret, respond to, and simulate human emotions.
 - This capability has applications ranging from virtual assistants providing emotional support to enhancing gaming or learning experiences.

The Human

- Another central component of HCI is mental models, representing users' perceptions and understanding of how a system works.
- Ensuring that a system's functionality aligns with users' mental models is essential for a positive user experience.
 - Differences between the system's conceptual model and the user's mental model can lead to interaction problems.
- On the contrary, properly leveraging mental models enhances collaboration among practitioners, reveals the motivations behind behaviors, and improves interaction performance.

The Human

- Human error is a significant concern in various domains, including safety-critical fields, healthcare, and consumer product usage.
 - Human errors can lead to accidents, safety issues, and user dissatisfaction. Understanding the various factors contributing to human errors, like performance-shaping factors, is essential for error prevention and control.
- In the interaction context, decision-making and problem-solving are fundamental, as they are also in human behavior in general.
- The design of interfaces that support informed decision-making and provide tools and feedback for problem-solving is essential.
 - The study of decision-making paradigms, such as normative, naturalistic, and process models, is integral to enhancing the quality of decisions and providing decision-aiding tools.

The Human

- When interacting with a system, humans, informed by the aforementioned mechanisms, proceed to accomplish concrete actions.
- HCI has evolved to recognize that human actions are more than just tasks; they involve meaningful interactions and experiences, a shift that acknowledges the contextual and subjective aspects of human-computer interactions.
- Future HCI research is expected to explore how technology transforms human agency, address the role of emerging non-human actors, and consider global implications for design, focusing on ethics, responsibility, sustainability, and inclusiveness.

The Human

- These aspects collectively shape the field of HCI, ensuring that technology interfaces are designed to optimize human capabilities and provide an effective, efficient, and enjoyable user experience, catering to the needs of all users.
- Particular emphasis is given to comprehending the characteristics and requirements of diverse target user groups, including children, older adults, and individuals at risk of exclusion.

The Computer

- The most versatile and dexterous end effectors for interaction are the human hands and fingers (MacKenzie, 2003).
 - The majority of input devices have been designed to respond to hand and finger movements, including switches, buttons, knobs, sliders, keyboards, mice, trackballs, touchscreens, styluses, pens, brushes, and joysticks.
- Other body parts such as the eyes, mouth, and even brain activity, have found use in input devices such as eye-trackers, mouth-operated interfaces, brain-computer interfaces, and voice and auditory interfaces, where sound serves as a medium for transferring information.
- Notably, some input devices rely on broader body-level movements, moving away from hand manipulations.
 - These devices involve motion detectors, mid-air hand-tracking sensors, and locomotion platforms that respond to body movements or gestures. These developments cater to various interaction preferences and applications.

The Computer

- In response to input devices, output devices aim to create human sensory experiences.
- Sight is the most prominent sense, and screen devices, including curved and foldable screens, projectors, and electronic ink displays, provide visual feedback.
- Virtual reality (VR) and augmented reality (AR) glasses offer immersive visual experiences.
- Hearing, our sense of sound, can convey a wide range of information.
 - Sound feedback serves as cues and alerts in video games, enhances immersion in VR experiences, and enables hands-free interaction with computer systems through speech feedback and voice commands. Speakers, headphones, earphones, piezoelectric transducers, and other sound output devices deliver audio information effectively.

The Computer

- Touch, or the haptic system, allows us to perceive tactile sensations such as pressure, texture, temperature, and vibration.
- Tactile feedback devices generate vibrations, force feedback devices provide macro physical sensations, and electrical muscle stimulation (EMS) stimulates muscle contractions.
- Smell and taste feedback devices are in the early stages of development due to their inherent complexity.
 - Replicating and controlling smells and tastes accurately pose significant challenges, but ongoing research aims to further explore these uncharted territories in human-computer interaction.

The Computer

- While the conventional setup involves users sitting in front of a screen using a mouse and keyboard, newer approaches leverage physical movement.
- These methods make use of locomotion and sensorimotor cues to enhance the interaction experience.
- This allows users to interact without the need for a mouse and keyboard, opening a world of possibilities for more engaging and immersive interactions.

The Computer

- Large displays, in this context, support collaboration.
 - They enable multiple users to interact together in front of the same system, viewing, discussing, and editing content in a shared environment.
 - Another critical aspect of large displays is their ability to provide immersive experiences, which allow users to reference their own bodies within the experience, encouraging also group interactions and discussions, proving powerful for industrial applications.
- Moreover, interaction with large displays has evolved to accommodate various interaction modalities suitable for different users and contexts.
 - Interaction modalities range from long-distance interactions using devices or gestures to close-proximity touch interactions.
 - With stereoscopic displays and multi-touch capabilities, research has explored touch metaphors that function both on or near the touch surface and for three-dimensional content presented at varying distances from the display surface.
 - In addition to touch, other modalities include mid-air gestures, controllers, and systems that use presence, pose, and gaze to determine user proximity and attention, initiating interactions based on the user's actions and intentions.

The Interaction

- In the domain of HCI, the focus is on the intricate relationship between humans and technology, exploring how people interact with computers and digital systems.
- HCI involves the study, design, and optimization of interfaces that bridge human cognitive processes and sensory perceptions with computer functionalities.
- It encompasses various input methods, from traditional ones like keyboards and mice to technologies like touchscreens and voice recognition.

The Interaction

- The interaction journey commences with information visualization, placing a significant emphasis on crafting user-friendly visuals to enrich usability, enhance the user experience, and foster inclusivity.
 - Particular attention is also paid to information **architecture and navigation design**.
- Furthermore, aesthetics in the realm of HCI hold immense importance, transcending mere visual allure to encompass emotional, sensory, and interactive dimensions of design.
 - They wield the power to boost visual appeal while simultaneously influencing user trust, credibility, usability, preference, and overall impressions.
 - Remarkably, users swiftly form judgments based on aesthetics, which thereby exert a profound influence on their holistic digital experience

The Interaction

- Traditional techniques provide users with foundational methods for engaging with computers and digital systems.
 - **Keyboard input**, a versatile mainstay, allows efficient text entry and commands, especially valuable for programming and command-line interfaces (CLIs).
 - The **mouse**, in tandem with Graphical User Interfaces (GUIs), revolutionized navigation through pointing, clicking, and dragging.
 - **Touch input**, introduced with touchscreen devices, offers a direct and intuitive interaction with content.
 - **Menu-based** interfaces create structured hierarchies for accessing functions and information, while CLIs remain a powerful choice for experts who value precision.
 - **Buttons** and **icons** in GUIs serve as intuitive visual cues for interacting with software.
 - **Scrollbars** facilitate content navigation, **checkboxes**, and **radio buttons** enable selection and setting choices, and **dropdown lists** simplify user decisions.
 - **Text fields** are versatile for text and data input, while **dialog boxes** manage messages and user input effectively.
 - **Hyperlinks** empower seamless web navigation.
 - **Drag-and-drop actions** streamline tasks like file management.

The Interaction

- The integration of contemporary approaches progressively enhances the user experience.
 - **Gestures** provide natural and intuitive ways for users to interact with computer systems. They leverage users' ability to convey intentions and manipulate objects through bodily movements.
 - **Voice user interfaces (VUI)** enable users to interact with technology using spoken language or vocal commands, but present distinct challenges due to their reliance on audio interactions without visual displays.
 - VUIs are suitable for scenarios where auditory acuity is primary, but designers should avoid them in contexts where noise, hearing-impaired users, or other limitations pose challenges.
 - **Wearable technologies** encompass devices worn on or within the user's body, ranging from smart clothing and accessories to implanted devices.
 - Usability is critical for wearable acceptance, considering customization, accuracy, and comfort. Privacy concerns and impacts on social interactions should also be considered. Wearables have applications in various fields, from healthcare and education to manufacturing, offering mobility and accessibility for diverse user demographics.

The Interaction

- To address the diverse range of existing interaction paradigms and promote digital accessibility, while accommodating a broad spectrum of user capabilities, **multimodal interfaces** have emerged.
 - These interfaces empower users to engage through multiple sensory channels or modalities, expanding the ways they interact with digital systems.
 - Within multimodal interfaces, users have the flexibility to select their preferred input or output modes, seamlessly transitioning between them to suit the demands of different tasks and physical environments.

The Interaction

- **Animation** serves as a complex instrumental affordance in HCI with three primary functions.
 - It draws **attention**,
 - depicts **spatial changes** over time,
 - and provides **expressiveness**, conveying meaning and facilitating user understanding.
- Animations can be used in various interface categories, aiming for various effects such as maintaining context continuity, enhancing the user experience, encoding data relationships, supporting visual discourse and storytelling, and serving as a teaching aid.
 - However, they can pose challenges in processing complex animated content, affecting perceptual, attentional, and cognitive processes.
 - Animations can elicit emotional responses, influenced by the movement of animated elements and the content's emotional context.

The Interaction

- **Help and user support** is a very important component of the design of a technological system or application.
 - It covers various forms of support, from addressing typing errors to offering comprehensive task explanations. Support mechanisms include online documentation, tutorials, animated demonstrations, command-based assistants, intelligent wizards, offline help centers, chatbots, and live chat.
 - Demographic factors such as age or disability need to be considered when emphasizing the role of help and support in creating inclusive systems.
 - Additionally, help and support can guide users toward eco-friendly behaviors and sustainable interactions.

HCI Research & Design Methods

- Inquiry Methods
 - Interview
 - Questionnaire
 - Contextual Inquiry
 - Focus Groups
- Design and Ideation Techniques
 - Brainstorming
 - Personas
 - Storyboarding
 - Journey Maps
- Inspection Methods
 - Expert-based
 - Heuristics analysis,
 - Cognitive walkthroughs, etc.
 - User-based
 - Think Aloud protocol,
 - Performance metrics (like time-on-task, task completion success rate, number of errors), etc.
- Modeling Methods
 - Task Analysis
 - User Modeling
 - Digital Representations of Human Body

Interaction Paradigms

- Desktop Computing
- Mobile Interaction
- Ubiquitous Computing: integrates microprocessors into everyday objects like lights, cameras, TVs, wearables, voice assistants, and sensors.
- IoT, Smart Cities and Urban Interfaces
- Automotive UIs
- Ambient Intelligence (or Assisted Living): various AI-infused applications and platforms that support their users in need in multiple activities, from health to daily living.
- Extended Reality
- Human–Robot Interaction
- Adaptive and Intelligent UIs
- Affective Computing: the study and development of technologies that can recognize, interpret, process, and simulate human emotions.
- Brain-Computer Interfaces
- Conversational Interfaces: allows people to interact with software, apps, and bots like how they interact with real people.
- Artificial Intelligence

Types of HCI Contributions

- Empirical
- Artifact
- Methodological
- Theoretical
- Dataset
- Surveys
- Opinions

Types of HCI Contributions

- **Empirical contributions:**

data (qualitative or quantitative) collected through any of the methods described in this lecture: experimental design, surveys, focus groups, time diaries, sensors and other automated means, ethnography, and other methods.

Types of HCI Contributions

- **Artifact contributions:**

the design and development of new artifacts, including interfaces, toolkits, and architectures, mock-ups, and “envisionments.”

- These artifacts, are often accompanied by empirical data about feedback or usage.
- This type of contribution is often known as HCI systems research, HCI interaction techniques, or HCI design prototypes.

Types of HCI Contributions

- **Methodological contributions:**

new approaches that influence processes in research or practice, such as a new method, new application of a method, modification of a method, or a new metric or instrument for measurement.

Types of HCI Contributions

- **Theoretical contributions:**

concepts and models which are vehicles for thought, which may be predictive or descriptive, such as a framework, a design space, or a conceptual model.

Types of HCI Contributions

- **Dataset contributions:**

a contribution which provides a corpus for the benefit of the research community, including a repository, benchmark tasks, and actual data.

Types of HCI Contributions

- **Survey/Literature review contributions:**

a review and synthesis of work done in a specific area, to help identify trends and specific topics that need more work.

- This type of contribution can only occur after research in a certain area has existed for a few years so that there is sufficient work to analyze.

Types of HCI Contributions

- **Opinion contributions:**

writings which seek to persuade the readers to change their minds, often utilizing portions of the other contributions listed above, not simply to inform, but to persuade.

A Brief History

TABLE 1.1

Technological Breakthroughs and HCI Milestones from 1940 until 2024

1940–1950	1941: Isaac Asimov describes the “Three Rules of Robotics” in his novel “I, Robot” 1945: Vannevar Bush – As We May Think introduces the Memex 1945 – 1950s: Bell Labs hires a psychologist to design telephone systems, UX work on touchstone keypads 1957: Human Factors Society is established in the US 1950: Alan Turing’s “Computing Machinery and Intelligence” article is published, introducing the concept of the Turing test to the wide public	
1950–1960	1958: ARPA (later renamed to DARPA) founded 1959: Shackel publishes “Ergonomics for a Computer” 1960: Licklider – “Man-Computer Symbiosis” is published 1960: Engelbart – “Special Considerations of the Individual as a User, Generator and Retriever of Information” is published	
1960–1970	1963: First GUI (Sunderland’s Sketchpad) 1966: Joseph Weizenbaum creates Eliza, the first natural language processing conversational agent 1968: The Mother of All Demos by Engelbart is presented 1968: Ivan Sutherland presents the first Head-Mounted Display “The Sword of Damocles” 1969-1971: ARPANET, precursor to the Internet is established 1970: Xerox Palo Alto Research Center (PARC) is established	
1970–1980	1971: Allen Newell writes the AIP Memo 1 that pushes to utilize psychology in Xerox Research to understand the nature of the human user 1973: Xerox Alto – first modern GUI is presented 1975: VIDEOPLACE, the first interactive VR platform is introduced by Myron Krueger 1980: Keystroke-level model by Card, Moran and Newell is published	
1980–1990	1981–1984: Xerox Star (’81), IBM PC (’81), Apple Lisa (’83), Apple Macintosh (’84) released; the personal computer era and <u>WYSIWYG GUIs</u>	
1990–2000	1982: “Human Factors in Computing Systems” conference in Maryland 1982: The Special Interest Group on Computer-Human Interaction (SIGCHI) is formed 1983: First CHI conference 1983: The Psychology of Human-Computer Interaction published 1984: First HCI International Conference 1986: User-Centred Design by Nielsen and Draper is published 1986: The “Super Cockpit” flight simulator is being developed, allowing pilots wearing a helmet to control the aircraft using gestures, speech and eye movements 1988: The Psychology (later Design) of Everyday Things by D. Norman is published 1988: Mark Weiser coins the term “Ubiquitous Computing” to describe interaction with invisible devices embedded in the built environment 1989: The World Wide Web is invented by Tim Berners-Lee 1990: The term “augmented reality” is coined by Tom Caudell to define the integration of computer-generated images into the real world 1991: World Wide Web opens to the public 1992: Louis Rosenburg creates the first AR system at the US Air Force Research Laboratory, a virtual flying training for Air Force pilots 1993: The first graphical WWW browser, Mosaic, is released 1993: The first smartphone, the IBM Simon, is released 1993: Jakob Nielsen publishes the seminal textbook ‘Usability Engineering’ 1994: Amazon.com is founded, marking the beginning of e-Commerce 1995: Windows 95 makes the WIMP paradigm ubiquitous 1995: Constantine Stephanidis introduces the concept of ‘User Interfaces for All’ 1995: Don Norman introduces the term ‘User Experience’ 1995: Navlab5, the first self-driving car is successfully piloted from Pittsburgh to San Diego 1995: Hiroshi Ishii pioneers the Tangible User Interface through his paper “Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms”	

A Brief History

TABLE 1.1 (Continued)

Technological Breakthroughs and HCI Milestones from 1940 until 2024

- 1997: Kismet, an expressive robot head, is designed by Cynthia Breazeal at the MIT Media Lab, marking a significant step in social robotics
- 1998: The term “ambient intelligence” is coined by the European Commission’s Information Society Technologies Advisory Group (ISTAG) to describe a vision of the future where technology would be embedded in our surroundings and would adapt to our needs and preferences
- 1999: The term “Web 2.0” is coined by Darcy DiNucci, marking a new era for more interactive online experiences
- 1999: Human-centered design is established as a standard through ISO 13407:1999 “Human-centred design processes for interactive systems”
- 1999: W3C publishes the Web Content Accessibility Guidelines, a set of recommendations for making web content more accessible to people with disabilities
- 1999: The term “Internet of Things” is coined by Kevin Ashton to describe a system where the Internet is connected to the physical world via ubiquitous sensors
- 1999: Sony introduces AIBO a four-leg robot dog showcasing the potential for robots in entertainment and companionship
- 2000–2010
- 2000: The first AR game is launched, named ‘AR Quake’, with players wearing a head mounted display and a backpack containing a computer and gyroscope
- 2000: Honda introduces ASIMO, the first humanoid robot that can run, walk, communicate with humans, recognize faces, environment, voices and posture
- 2003: MySpace is launched, mainstreaming social networking
- 2007: iPhone is released – smartphones as we know them dominate and the modern era begins
- 2008: Google releases the Android operating system
- 2010: Apple releases the iPad, the first successful tablet, essentially introducing that category of devices into the mainstream
- 2010: The definition of UX is included in the ISO standard ISO 9241-210:2010

2010–2025

- 2011: Apple releases Siri, an intelligent personal assistant generating responses and taking actions in response to voice requests
- 2011: The term responsive web design is established by Ethan Marcotte, to reflect the need for flexible HTML design supported by appropriate stylesheets (CSS) addressing the need for web pages that adapt optimally to the viewing medium
- 2012: Palmer Luckey designs the first prototype of the Oculus Rift headset and Oculus Touch controllers
- 2013: Release of Google Glass, a wearable AR technology in the form of smart glasses
- 2014: “Pepper”, the first personal humanoid robot that can read emotions is introduced by SoftBank robotics
- 2015: AR becomes popular in social networks through filters introduced by SnapChat
- 2015: Tesla introduces the “Autopilot” feature that enables hands-free control for highway and freeway driving, to be soon followed by automated driving features in models of other automobile companies, such as Volvo, Honda, and Mercedes
- 2015: Amazon launches its voice assistant, Alexa, integrated into the Echo smart speaker, that can interact with users using natural language
- 2015: The United Nations establish the 2030 Agenda for Sustainable Development with 17 Sustainable Development Goals at its core
- 2016: Pokemon Go, a popular game, is launched, mainstreaming AR technology
- 2016: Microsoft releases HoloLens, a wearable AR device, allowing users to scan their environment and create their own AR experiences
- 2018: Generative AI is made available to the wide public through ChatGPT, a Large Language Model (LLM) released by OpenAI
- 2021: OpenAI introduces DALL-E, a generative AI system creating images from text prompts
- 2023: Generative AI efforts expand with systems becoming readily available to end users for different purposes (e.g., Google Bard, Microsoft Copilot, MidJourney image generation platform, OpenAI Codex, Adobe Firefly, etc.)

Example

DEPTH VS BREADTH IN MENUS

Multiple research studies by different research teams, throughout the history of the HCI field, have examined the issue of the trade-off between depth and breadth in menus. Generally, tree structures in menu design can be implemented as narrow and deep (where there are fewer choices per level but more levels) or as broad and shallow (where there are more choices per level but fewer levels).

Figure 1.1 shows three menu structures.

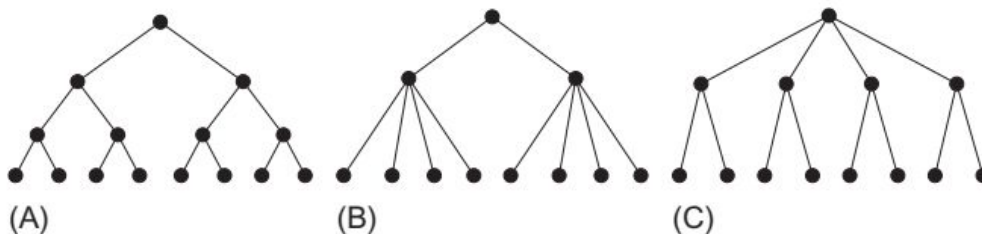


FIGURE 1.1

Types of tree structure in menu design: (A) narrow-deep: three levels with two choices at each level, (B) broad-shallow: two choices followed by four choices, (C) broad-shallow: four choices followed by two choices.

The research has consistently pointed to broad, shallow tree structures as being superior to narrow, deep structures. There are many possible reasons: users get more frustrated and more lost, the more levels they must navigate; users are capable of dealing with more than the 7 ± 2 options often cited in the research literature (since menus deal with recognition, not recall), and strategies for scanning can lead to superior performance. Different research methods and different research teams, examining different users, have all come to the same conclusion. So over time, the superiority of broad, shallow tree structures has become well-accepted as a foundation of interface design.

Exercise

Imagine that you are going to be researching the topic of why people choose to take part in an online community for parents of children with autism. What are some of the reference disciplines that you should be looking into? What types of people might you want to talk with? What types of metrics might be appropriate for understanding this community? Come up with three approaches that you could take in researching this online community.

Further Reading

- Read Chapter 01, Human-Computer Interaction: An Empirical Research Perspective, MacKenzie, I. S. (2024). Morgan Kaufmann.
- Read Chapter 01, Research Methods in Human-Computer Interaction, Lazar, J., Feng, J. H., Hochheiser, H. (2017). Morgan Kaufmann.
- Read Vol. 01, Chapter 01, Human-Computer Interaction: Foundations and Advances, Stephanidis, C., Salvendy G. (2024). Taylor & Francis.