Human–Computer Interaction

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Introduction

Human–computer interaction (HCI) is a flourishing field of research about the interaction between human beings and computer technologies. HCI theories and research seek to understand the various rules that human beings employ to communicate with computers and explore creative ways of designing computer-based interfaces to improve usability and the quality of user experience. HCI applications are seen in many domains—information kiosks, computer terminals, interactive Web sites, electronic games, mobile devices and robots, to name a few. Humans are not only the end users of such technologies, but also an essential part of the design process. By investigating how humans use interactive, computer-based technologies, HCI design strives to create systems that can offer a smooth interaction between humans and computers.

HCI is an interdisciplinary field that incorporates cognitive psychology, behavioral science, anthropology, computer science, industrial engineering, sociology, communication, and many other disciplines. Research in the area mainly consists of two perspectives—computer science/engineering and social science/humanities—creating an "essential tension" that contributes to its vitality (Carroll, 2006). From the computer science/engineering perspective, HCI concentrates on interface and system design to optimize usability. Designers and engineers create software to build graphical interfaces and user-friendly systems (e.g., interactive features on Web sites, context-aware systems, information visualization, etc.) that facilitate the interaction between humans and computers. From the social-scientific/humanistic perspective, HCI examines the cognitive and behavioral processes of users when they communicate with machines or with each other via the help of these technologies, as well as the social structures that are built around these interactions. In order to achieve natural and smooth communication between humans and computers, designers commonly use the metaphor of interpersonal communication to inform the design of computers and related media interfaces.

HCI history

HCI is a continuously growing field with a history of more than four decades. Before the 1960s, the primary users of computers were programmers, whose central goal was to examine the interface characteristics that facilitated operation efficiency.

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The mid-1960s to 1970s were characterized by a focus on interaction between humans and computers, as new disciplines such as computer science, computer graphics, artificial intelligence, and information science contributed to HCI research. The study of HCI originated in the domain of engineering, focusing specifically on questions related to software development and the use of machines to achieve users' goals in an effective way. However, this did not capture the complete meaning of usability. As Bevan (2001) suggested in his article "International Standards for HCI and Usability," usability research should concern not only the use of the machine, but also the process of developing it, the user interface and interaction, and how well a user/organization can use it.

Without a clear definition of usability, the HCI field was both diverse and scattered in the beginning. The emergence of personal computers brought new challenges to the field regarding user interfaces and end-user application issues. In addition, the development of cognitive science, which incorporates psychology, linguistics, philosophy, and anthropology, made it possible to explain humans' mental and behavioral processes in the context of computer science and engineering. For example, discussions of how psychological research could be applied to human interaction with computers had already begun in the early 1970s at the Palo Alto Research Center (PARC) established by Xerox, which attempted to use common psychological principles to facilitate system operation (Card, Moran, & Newell, 1983).

The 1980s were characterized by Carroll (2003) as "the golden age" for HCI, as theories about interaction took hold and HCI itself formally became a discipline. The Association for Computing Machinery (ACM), the world's most famous professional computing society for academics and professionals, identified HCI as one of nine main areas of computer science (Denning et al., 1989). In addition, ACM created a department of "Human Aspects of Computing" in 1980. HCI researchers focused on improving the functionality of the machines to achieve ergonomic goals and to optimize usability (Rogers, 2012). A cornerstone of this approach is the GOMS (goals, operators, methods, and selection rules) model, which analyzes basic human actions during HCI to reduce unnecessary system interactions and improve interface design. However, the interaction between the computer and the human was simply a relationship of "using and being used," with human users performing the roles of programmers and operators, and computers serving as tools that were acted upon by humans.

As HCI research progressed, designers and engineers started to realize the significance of computers not only as information processors, but also as active agents capable of learning and solving problems. Interpersonal communication theories and models also began to emerge to explain the communication strategies that individuals used to pursue various goals via computers. In the HCI field, designers started to use metaphors (e.g., desktop, card stack, typewriter) as design tools for enhancing human understanding of computer-based technologies, by drawing analogies between the human world and the machine world. HCI researchers also started to employ social science research methods (e.g., survey, interview, experiment, ethnography) to better understand human users. However, HCI research in the 1980s was still considered the study of usability, which focused on ergonomic goals such as time studies (e.g., the Hick–Hyman law and Fitts's law, which described the time needed for a person to make certain actions based on different conditions), error recognition (e.g., the keystroke level model, which is a type of GOMS model that allows for error estimation), system diagnosis, and recovery (Carroll, 2003).

With the rapid development of personal computing technologies and the appearance of mobile and ubiquitous devices, HCI research continued to thrive in the 1990s. Computing and the Internet had gradually become part of people's everyday lives. Around the same time, another source of impetus for HCI development was the interdisciplinary growth and appeal of the social sciences. For example, Suchman (1987) applied conversation analysis from the interpersonal communication domain to HCI study and considered the interaction between humans and computers as a kind of conversation. Adopting methods from social psychology such as field study and ethnography, Suchman developed theories that could provide guidance for specific situations and problems relevant to human–computer interaction.

Since 2000, HCI research has been shifting its emphasis from simply conducting traditional usability tests to a new paradigm of studying "user experience"—how humans feel when interacting with computer-based technologies —and incorporating humans in the process of design. With greater recognition of the role that humans play in the interaction between user and computer, the use of interpersonal communication rules (e.g., politeness, gender effect) in interaction design has become crucial. In addition, scholars from communication have realized that the study of HCI can help us overcome common human constraints (e.g., limited experience, motivation, physical incapability) to facilitate the achievement of instrumental goals.

From interaction to communication

With the rapid advancement of computing technologies, especially the development of artificial intelligence and numerous interactive features in online media, there has been a marked increase in the richness of HCI. For example, in addition to processing simple commands programmed by humans, computing devices can now provide users with control over information, respond to user requests, and facilitate users' actions. Sundar and Nass (2000) found that the computer is perceived by users not only as a medium between information sources and receivers, but also as an independent source of information by itself. In the latter case, human users respond to computers using the same social heuristics that they would apply in traditional interpersonal communication. This transition from an inanimate interaction between the computer and the human to a type of "communication" between the two is primarily caused by the technological affordance of interactivity.

As HCI research progressed, researchers realized that the holistic approach to studying a technology as an object does not yield findings that can be generalized to other technologies (Nass & Mason, 1990). It is impossible to match up the study of individual technologies with the speed at which they are being updated or replaced. In moving away from the traditional object-centered approach to a variable-centered approach (Nass & Mason, 1990), researchers disaggregate technologies into specific attributes or variables for investigation. For example, in an object-centered framework, researchers may study the uses and effects of a smartphone as a whole, whereas under the variable-centered approach, specific components of smartphone technology, such as the interaction techniques available on the interface (e.g., swiping, tapping), the input modality (e.g., haptic, keyboard), and screen size of display, become the foci of study. Because the variable-centered approach concerns particular attributes of technologies rather than treating each technology as a whole, the specific effects of a given attribute can be generalized to subsequent devices that have the same attribute.

A number of such attributes related to the interface of computers have been studied over the years in the field of communication. These attributes are conceptualized as technological affordances, or features facilitating user actions (Norman, 1999). For example, computer peripherals such as mouse, keyboard, or monitors facilitate human actions such as scrolling, clicking, and viewing. These actions pertain to user navigation with and within the system. The provision of such affordances on the interface of a technology and the manner in which they are designed and displayed for the user can influence the nature of content and user interaction with that technology. In the early days of the Web, a joint issue of the *Journal of Communication* and the *Journal of Computer-Mediated Communication* identified five technological affordances as being critical: multimedia, hypertextuality, packet switching, synchronicity, and interactivity (Newhagen & Rafaeli, 1996). More recently, Sundar's (2008) MAIN model discussed four classes of affordances (modality, agency, interactivity, and navigability) as being key technological features that affect users' perceptions of systems. Among these affordances, interactivity has played an important role in the transition from computers as tools to the characterization of computer use as a social interaction.

Interactivity

Interactivity is a core concept of interface design and online communication today as well as a hotly debated topic in the academy. There have been many attempts at conceptualizing interactivity, from the degree to which an interface allows users to change the content in it to the number of interactive features provided by the interface (Sundar, 2007). In an attempt to further understand and explicate the affordance, researchers have created various typologies to capture the multiple dimensions of interactivity. McMillan and Hwang (2002) suggested that interactivity can apply to three kinds of interactions: user–user interaction, user–system interaction, and user–document interaction, with the first type implying interpersonal communication via the medium (commonly referred to as computer-mediated communication or CMC), and the latter two suggesting direct interaction with the system. Stromer-Galley (2004) argued that interactivity is comprised of two different phenomena: one as a process during human interaction (e.g., face-to-face communication with contingent responses), and the other as a product between technology and human user (e.g., clicking on a hyperlink in a Web site). The former definition refers to CMC, whereas the latter indicates HCI. From an HCI perspective, Sundar (2007) situated the concept of interactivity in the three fundamental elements of communication—source, medium, and message. Source interactivity is the degree to which the interface lets the user serve as the source of communication: for example, customize one's portal or write one's blog. Medium (or modality) interactivity refers to the various methods of interaction offered by the interface, such as clicking, scrolling, dragging, and hovering. Message interactivity is the interdependent exchange of messages between the user and the system (HCI) or between users (CMC).

Mirroring the manifold conceptualization of interactivity, the psychological effects of the affordance are also complex, as revealed by a vast body of experimental studies. For example, previous research has found that Web site interactivity can increase users' sense of identity and community (Sundar, Oh, Bellur, Jia, & Kim, 2012). Variations in the number of interactive features (e.g., 3D carousel, dragging, sliding, mousing over) have also been shown to influence users' memory, actions, and future use intentions toward Web sites and their content (Sundar, Bellur, Oh, Xu, & Jia, 2014). Higher levels of interactivity in an online shopping domain have also been found to elicit more positive attitudes and behavioral intentions toward both the Web site and the product advertised (Xu & Sundar, 2014). However, moderate levels of interactivity have been found in several studies to be optimal in terms of interface evaluation, compared to high and low levels of interactivity (Sundar, 2007)

Recent theoretical work tries to capture the complexity of these effects by proposing different psychological mechanisms for different types of interactivity (Sundar, 2007). While source interactivity affects engagement by providing user control, medium interactivity does so by expanding the user's "perceptual bandwidth" and message interactivity by increasing the contingency in the responses received by the user.

The "computers are social actors" paradigm

As computers have become more interactive, the study of HCI has shifted to examine the ways that our use of technology can be conceptualized as a social interaction. Specifically, a large body of research from the "computers are social actors" (CASA) paradigm has found that users respond to computers socially, just as they would respond to other humans (Reeves & Nass, 1996). As a result, many of the same interaction rules examined in past research on interpersonal communication can also be applied to predict how users will interact with and evaluate computers. Research from the CASA paradigm typically identifies established findings from social psychology and examines their generalizability to the domain of HCI. The resulting program of research has found that common interpersonal communication phenomena such as politeness, similarity-attraction, and reciprocity are generalizable to users' interactions with computers (Nass, 2010; Reeves & Nass, 1996).

Among the first tests of the CASA approach, one study examined if individuals would vary their evaluations of a computer's performance based on the norms of politeness. Participants first completed a series of tasks on a computer, then used either the same computer or a different computer to evaluate the computer's performance. Participants who completed the questionnaire on the same computer provided more positive, homogeneous evaluations than participants who completed the questionnaire using a separate computer. That is, they were more likely to provide "polite" evaluations if the computer directly inquired about its own performance than if a second, distinct computer conducted the interview.

Another common finding from the domain of interpersonal communication is that individuals are more likely to be attracted to people that are similar to the self. The generalizability of the similarity-attraction effect for HCI has been tested in the context of personality similarity. Specifically, participants were asked to complete an experimental task with a computer while varying the degree that the computer's personality was perceived as dominant or submissive. The dominance of the computer's personality was manipulated by adjusting the assertiveness of the computer's text (direct vs. tentative), the degree of confidence expressed by the computer (high vs. low), and the order of the interaction (first vs. second). Computers with an interaction style that matched the personality of participants were evaluated as more similar to the user, more socially attractive, and more emotionally satisfying than computers that communicated with an interaction style that did not match participants' personality.

Finally, past research from the CASA paradigm has also examined if the principle of reciprocity is generalizable to users' interactions with computers. Participants were asked a series of questions by a computer that either directly asked participants each question or preceded each request with a small, related disclosure. In addition, the interview sequence of the questions was varied such that the computer either immediately began with intimate questions or progressed in intimacy over time. Results revealed that participants provided the most detailed, frequent responses to computers that progressed from basic to more intimate questions compared to computers who began the interview with intimate questions. In addition, computers that preceded each request with a small disclosure elicited a greater rate of information disclosure from participants than computers that did not precede requests with a reciprocal disclosure.

Together, the CASA studies demonstrate the human tendency to treat computers as interpersonal partners in communication rather than as tools or instruments for accomplishing tasks.

Machine agency

Advances in interface technology have served to promote the impression of computers as autonomous communication sources, making users orient to them as psychologically relevant actors (Sundar & Nass, 2000). For example, modality enrichments to immersive virtual environments enable users to interact with computers represented by three-dimensional, anthropomorphic representations known as agents. Several studies have found that interaction rules related to nonverbal behaviors can be replicated in immersive virtual environments. For example, individuals are less likely to stand near an agent in a virtual environment if the agent maintains eye contact. Similarly, agents who mimicked the nonverbal behavior of their interaction partner are evaluated more positively and are more persuasive than agents whose nonverbal behavior is random. Finally, agents that have been digitally manipulated to facially resemble their user can elicit outcomes consistent with the similarity-attraction hypothesis, as past research has found that self-resembling agents elicit greater engagement and are evaluated more favorably than their non-similar counterparts (Blascovich & Bailenson, 2011).

Given users' tendency to assign human-like agency to machines, variations in the perceived characteristics of a machine can affect the nature of social responses shown by users. For example, computers with a human-like appearance or that speak with a human-like voice are evaluated as more competent, trustworthy, and more persuasive than less human-like interfaces. Increases in anthropomorphism are often accompanied by a heightened sense of social presence, or a perception of coexistence with an intelligent entity. However, the social behavior of the agent must also fulfill the expectations elicited by the anthropomorphism of its appearance in order to sustain a positive effect on user perceptions (Nass, 2010; Reeves & Nass, 1996).

In addition to varying the anthropomorphism of an interface, a computer can also elicit differential social responses based on variations in social categorization such as authority or group membership. In terms of expertise, a series of studies have found that agents categorized as "specialists" are more likely to elicit trust than agents categorized as "generalists." Group membership cues can also affect users' subsequent responses to computers, as past research has found that participants who believed their performance on a task depended on their collaboration as a "team" with a computer evaluated the computer as more friendly and more cooperative than participants who believed their work was evaluated independent of their computer's performance. Thus, an increased range of psychologically relevant sources has increased the variety of interaction heuristics that computers can elicit, each of which is associated with unique social responses that can be predicted according to existing research from interpersonal communication.

Conclusion

Although interpersonal communication has traditionally been based on the study of human communication, it has also contributed to our understanding of the ways that users interact with and evaluate computers, robots, and related media interfaces. Thus, the field of communication has significantly shaped the development of the HCI field from the view of computers as a communication medium to the view of computers as a psychologically relevant social actor (Sundar & Nass, 2000). As a result, prior findings of interpersonal communication have direct utility for the successful design and adoption of new communication technologies. Furthermore, given that users respond to computers according to predictable social rules of human–human interaction, the study of human–computer interaction can indeed advance our understanding of interpersonal communication between humans.

SEE ALSO: Politeness and Social Influence; Reciprocity/Compensation in Social Interaction; Virtual Teams

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